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THE VINTAGE RADIO SERIES

Morgan McMahon has spent most of his life living in the future. He became a radio amateur back in the days when the local “ham” was considered the neighborhood nut. In World War II he worked with advanced electronic systems. He went into solid-state research after earning his master’s degree at the University of California. He taught the first transistor course given in the West, at UCLA.

Mr. McMahon’s career in industry has revolved around new business ventures and advanced technology. He helped start one semiconductor company. He then set up diode, transistor and integrated circuit operations for a major electronic manufacturer. He was Chief Scientist for the largest U.S. manufacturer of electronic parts. He is now a consultant.

Some years ago Mr. McMahon became interested in the history of electronics. To his surprise, the early days of this field were not at all well recorded. Harold Greenwood’s book, the only available history of wireless and radio, had gone out of print. Mr. McMahon enlisted the willing help of historians, collectors, historical societies, technical publishers and old-line manufacturers to assemble Vintage Radio. His aim is to help preserve this piece of our heritage in an enjoyable way, in a series of readable books.

Radio was the miracle of the age in the 1920's. In 1927 Sidney Gernsback wrote down all that was worth knowing about radio.

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If you're a nostalgia fan, you'll find many hours of enjoyment by poking around among people and things of another era. If you're a collector, this book helps you understand the "artifacts" you're after. If you're interested in radio history, this book is your time machine.
Sidney Gernsback's Radio Encyclopedia is the best available picture of radio's "state of the art" in the mid-1920's. It shows history and technology as seen through the eyes of people of those days, when radio was still weird and wonderful.

This book is another member of the Vintage Radio series, in which we capture the flavor, excitement and technology of the old days of radio, television and electronics. In this series we look at history by viewing the "artifacts" of earlier days; transmitters, receivers, old photos, old ads, old books, component parts and trivia. We tie it together with comments by eminent historians. Other books in the series are Vintage Radio (1887-1929), Radio Collector's Guide (1921-1932), and From Static To Snow (1930-1950).

We wish to thank Mrs. Gayle Rowland for bringing this book to our attention, and Mr. Paul Giganti for providing copies of the original for reproduction. Also we wish to thank Mr. M. Harvey Gernsback for his encouragement and his aid in tracking down reproduction rights.

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"A" BATTERY—An appliance for furnishing electrical current to light the filaments of a vacuum tube, and cause emission of electrons (see Theory of Vacuum Tube Operation). This battery may be in any of several forms, the method of connecting will depend on the voltage rating of the particular tube. If the tube is rated at 1.5 volts, a single dry cell may be used as in Fig. 4, or several may be connected in parallel (q.v.) shown in Fig. 6, the total voltage however, being only the voltage of one cell. Three dry cells connected in series (q.v.) will give 4.5 volts, Fig. 6. A connection for dry cells, known as series-parallel or multiple (q.v.). is shown in Fig. 7. This connection will also produce 4.5 volts and at the same time increase the life of the cells. Four dry cells connected in series will give six volts for use with a standard six-volt tube, Fig. 8. Dry cells are only used with six-volt tubes where the tube has a current rating of ¾ ampere, and seldom more than one tube is used in this manner.

In Fig. 2 a popular type of storage battery is shown. Batteries of this type come in many individual forms, the usual voltage being standardized at 6 volts. However, for use with certain tubes, 2 and 4 volt storage batteries are available. For general radio work, using the low-consumption tubes, the battery, as shown in Fig. 2, can hold a charge of from 60-80 amperes hours. (See Storage Battery.)

The other common form of "A" Battery is the dry cell, usually having a difference of potential (voltage) of 1.5 volts. Fig. 3 illustrates a popular type of dry cell. In connecting a number of cells for use with a vacuum tube,
Another connection for low voltage tubes can be made as illustrated in Fig. 10. Here only one cell of the storage battery is used. This cell can be used until exhausted when the other cells can be used in the same manner. When the three cells are exhausted, the storage battery may be charged by means of a charger (q.v.).

ABBREVIATIONS—A unit of current used in special theoretical work. It has a value of 10 amperes (q.v.) and is not generally used in electrical work.

ABBREVIATIONS, AMATEUR—The transmitting amateurs of the United States use their own peculiar abbreviations in their inter-communication work. These are used to lessen the interference between transmitting stations as it permits conversation in a much quicker manner. The abbreviations generally used are listed below. Simplified spelling is always resorted to, words being spelled according to their sounds. Some such words are given, but others are so obvious that they are not listed. There are also the standard "Q" signals adopted by the International Radiotelegraphic Convention, to be found in official publications and given under the heading "Abbreviations, International Radiotelegraphic Convention."

ACCW—A transmitter using rectified alternating current as the plate supply.

AFTRN or P.M.—Afternoon.

AMMTR—Ammeter.

ARRL—American Radio Relay League.

BCL—Broadcast listener, one who does not have a transmitting station.

BC STATION—Broadcast Station.

BFORE—Or B4—Before.

BLO—Blow.

BOTTLE or V.T.—Vacuum Tube.

C—See or Call.

CGE—Cape.

CM—City Manager of A. R. R. L.

CTPSE—Counterpoise.

CUL—See you later or call you later.

CW—Continuous wave transmitter.

DCW—A transmitter using direct current as the supply for the plate.

DM—District Manager of A. R. R. L.

DOPE—Information, or in another sense, a varnish for coating inducance coils.

DS—District Superintendent of the A. R. R. L.

DX—Distance, receiving or transmitting.

FB—Fine Business.

FONE—Phone.

GA—Good afternoon.

GLD—Glad.

GM—Good morning.

GN—Good night.

FRQ—Frequency.

HAM—Being a term for the transmitting amateur.

HI—High or I am laughing—it's funny, according to use in sentence.

HI LOS—High loss.

HR—Here.

HV—Have.

KCK BCK—Kick back.

KONGRATS—Congratulations.

KY—Key.

LW LOS—Low loss.

LW WVE—Low waves.

MGHT—Might.

MIKE—Microphone.

MSC—Message.

NITE—Night.

OM—Old man.

OP—Operator.

OPS—Operators.

ORS—Official Radio Station.

OT—Oscillation transformer.

OW—Female operator.

PEEP-PEEP—Continuous wave transmitter.

QCW—Listen for my CW transmitter.

QCW?—Shall I listen to your CW transmitter?

QRME—An operator who persists in interfering with other stations after being warned to stop.

QSR—I will relay the message.

QRS?—Will you relay the message?

QSS—You are fading.

QSS?—Is my signal fading?

RDO—Radio.

RECVR—Receiver.

RELY—Relay.

ROCKCRUSHER—Spark transmitter.

SA—Say.

SIGS—Signals.

SPIKE—Message file.

SPK—Speak.

SUREFIRE—Something positive in action.

THG—Thing.

THT—That.

TLL—Till.

TM—Traffic manager of A. R. R. L.

TMR—Tomorrow.

TRAFFIC—The handling of messages among the stations.

U—You.

UNLIS—Unlicensed.

UR—Your.

V/TLTR—Voltmeter.

WL—Will.

WRLS—Wireless.

WVL—Wavelength.

"X"—LICENSE—Experimental License.

YL—Young lady.

"Z"—Special license.

73—Best regards.

ABBREVIATIONS—RADIO—ELECTRICAL—A letter or group of letters of the alphabet arranged so that there is a definite electrical meaning when used in radio telegraphy or phonography. These abbreviations are the means by which technical writings are simplified, i.e., Alternating Current is simply A.C. when used in general telegraphy. As most of the latest radiotelegraphic books use these abbreviations, the following are given to aid the reader in understanding the various abbreviations:

A.C.—Alternating Current.

A.F.—Audio Frequency.

B.E.M.F.—Back Electromotive Force.


B.S.W.G.—Birmingham Standard Wire Gauge.

C.—Capacity.

C.G.S.—Centimetre-gramme-second (q.v.).

C.W.—Continuous Waves.

D.C.—Direct Current.

D.C.C.—Double Cotton Covered (Wire).

D.S.C.—Double Silk Covered.

E.—Induced Pressure (See Abvolt).

E.M.F.—Electromotive Force.

H.F.—High Frequency.

H.F.C.—High Frequency Current.

I.R.E.—Institute of Radio Engineers.

L.INDUCTION (in Formulas).

L.F.—Low Frequency.

L.F.C.—Low Frequency Current.

M.A.—Milliamperes.

Mfd.—Microfarad.

P.D.—Potential Difference.

R.—Electrical Resistance.


R.P.M.—Revolutions per Minute.

R.P.S.—Revolutions per Second.

S.G.—Specific Gravity.

S.H.M.—Simple Harmonic Motion.

S.S.C.—Single Silk Covered.

S.W.G.—Standard Wire Gauge.

W/L—Wavelength.

X's—Atmospherics.

ABBREVIATIONS, INTERNATIONAL RADIO TELEGRAPHIC CONVENTION—All messages and conversations are not transmitted in regular form, various forms of abbreviations being widely used to increase the speed of transmission and to reduce cost. It also has the tendency to decrease the interference as messages are sent swiftly in half the time. In wireless telegraphy, abbreviations have been adopted as international, and today there are very few ships or shore stations that do not use at least part of them daily. Below we give the International Radiotelegraphic Abbreviations as adopted at the International Radiotelegraphic Convention. An example of the use of the abbreviations is as follows:

A station wishing to learn the name of a ship which is seen off the coast, sends in code the letters QRA, which means, what is the name of your ship? The station or ship answers with the letters, QRA S.S. Lapland, thus in a few seconds the question had been answered.
ABSCISSA—A term in geometry adapted to radio use in making curves to show various values. The abscissae are the horizontal lines, and the ordinates are the vertical lines. In the diagram, the line AY is the axis of ordinates (q.v.) and the line AX the axis of abscissae. Fig. 2 shows a simple curve indicating the relation between voltage and current (amperes) in an arc (q.v.). The volts are given and ordinates are known, it is a simple matter to plot a series of points and then draw the curve through these points. (See curve.) Thus, in Figure 2, the curve shows the operation of the arc to be such that when the voltage is zero, the current is 20 amperes, waves of low or audio frequency (q.v.) are superposed or run together with them. Now, if we insert a microphone (q.v.) in the aerial circuit (q.v.) of the transmitting station, providing that the distance from that point to the instrument is such as to reproduce accurately the vibrations of the voice or music, it is possible to vary the current output of the system producing the high frequency currents, so as to transmit the voice vibrations. If the microphone has resistance, then, the high frequency power output is adjusted, (or, is apportioned) equally between the microphone and the transmitter. The result is the production of fairly well modulated waves. There are, however, better methods of modulating the waves for which see Modulation.

ABVOLT—The CGS unit (q.v.) indicating the pressure or induced E.M.F. (electromotive force) (q.v.) set up between the ends of a wire one centimeter long, moving with a speed of one centimeter per second across the magnetic lines of force (flux lines) (q.v.) of a uniform magnetic field of unit intensity or flux density. An abvolt is therefore a very small unit and 100,000,000 (100 meg.) are required to equal one volt. In all formulas for determining the output or E.M.F. that can be expected to be produced by a certain alternator (q.v.), the result is in abvols, and the complete formula usually provides for obtaining the actual volts. This is done by dividing the result in abvols by 100,000,000 or 100 meg. as it is generally expressed. (See Alternator also Induction.)

A.C.—Abbreviation for Alternating Current. (See Alternating Current.)

ACCELERATION—The rate at which the speed of a body in motion increases within a certain period of time. If we assume a train running at a certain rate of speed when the brakes are applied, the speed will decrease, and if measured over a period of one second, there will be a certain amount of decrease or a rate of decrease. This is known as negative acceleration or deceleration. When a train is speeding up there will be a definite increase in velocity. The rate of change of velocity per unit of time is the acceleration. (See Velocity also Frequency.)

ACCEPTOR—A supplementary combination of inductance (q.v.) and capacity (q.v.) tuned to the frequency of the desired signal and connected in series in the receiving antenna. Generally, a coil (q.v.) and condenser (q.v.) of a value to correspond with a certain given wavelength—literally to "accept" the desired signal. (See also Rejector.)

A series combination of inductance (q.v.) and capacity (q.v.) connected in series with a high-frequency C.M.F. When tuned to resonance with the impressed E.M.F., the inductance alone is charged to a low value, limited by the resistance of the system.

ACUMULATION OF ELECTRICITY—The process of storing electrical energy as (1) a storage battery (q.v.) in which electrical charges are placed or (2)—the collection of energy by a condenser (q.v.) wherein the electrons (q.v.)
or minute charges of electricity are stored up momentarily on the plates or electrodes of the condenser (q.v.) and then released into the circuit.

**ACCUMULATOR**—(See Storage Battery.)

**ACID**—An active chemical compound formed by combining hydrogen with various acid radicals. Acids are much used in radio, particularly in storage batteries (q.v.). The most commonly used acid in this connection is sulphuric acid—a compound or union of hydrogen, sulphur and oxygen in certain definite proportions as indicated by the chemical symbol H₂SO₄. (See Flux, Soldering.)

**ACIDIMETER or ACIDOMETER**—An instrument used to determine the specific gravity (q.v.) of an acid solution. It is similar to a hydrometer and used in the same manner. Much used for testing strength or purity of acids or solutions. Operates on the principle that the strength of an acid will be directly proportional to the quantity of carbonic acid gas which it will liberate from a carbonate of soda or potash. (See Hydrometer.)

**ACLINIC LINE**—An imaginary line on the earth's surface assumed as passing through points where there is no magnetic inclination or dip of the needle of a compass. (See Apogic Line.)

**ACOUSTICS**—The science of sound or the study of the cause and effect of vibrations which effect the hearing. Generally, including the production and transmission of sound.

**ACOUSTIC WAVE**—The term occasionally used to denote a sound wave.

**ACTINIC RAY**—A light ray or beam of invisible radiant energy (q.v.). Rays of light, generally considered as lying at the blue or extreme left of the spectrum (q.v.) and being of such short wavelength as to be invisible to the eye. These rays have the power to induce or bring about chemical action. The most powerful actinic rays are the violet (X Ray) and the ultraviolet.

**ACTIVE CONDUCTOR**—(See Conductor.)

**ACTIVE MATERIAL**—The spongy part of a plate of a storage battery. The part which changes in nature and appearance due to the flow of electric current and having the ability to redevelop the current by a secondary chemical change.

**ACTIVE PRESSURE**—The active electro motive force (q.v.) or the pressure which produces a current. The term is used to distinguish this pressure from one impressed on the circuit.

A component in phase with the current in an alternating current (q.v.)

**ACTIVE SPARK**—A spark produced from energy contained in a charged condenser, which produces active oscillations (q.v.).

Thus, the spark discharge from a coil without any method of storing energy will be "inactive." When a condenser is inserted in such manner as to allow it to store up energy and then discharge, the resultant spark will be "active."

*Fig. 1 shows a simple spark coil circuit with the secondary discharging across a gap. This is an Inactive Spark.*

**SPARK**—A light flash of electrical energy produced for a moment with the receipt or discharge of electricity. It is one of the most popular types of spark producing devices in use today and is commonly called a spark coil. A spark is produced by an electric circuit and is transferred across a neutral gap (q.v.).

**ACUMULATOR **—The term is sometimes used in a loose sense. The actual term should be "Battery," but the former term is still in legitimate use.

**ADAPTER**—A device similar in form to a vacuum tube socket. Usually comprises a cylindrical form or shell of either metal or insulating material with legs identical with the tips or legs of a vacuum tube. A receptacle is allowed for the insertion of a tube, and the lead from each tip recess is so connected to a leg or tip at its base, as to permit the use of a non-standard base tube in a standard socket (q.v.). The illustration shows adapter for U.V. 199 or C-229 type of tube. When it is desired to employ a tube having a non-standard base in a set already equipped with standard sockets, without the necessity of changing the sockets, an adapter may be used. (See Socket.)

**ADHESION ELECTRIC**—Affinity of one body for another due to dissimilar charges of electricity passing through or being carried by them. The electrical equivalent of magnetic attraction.

**ADJUSTABLE CONDENSER**—(See Variable Condenser.)

**ADJUSTABLE GRID LEAK**—A form of grid leak (q.v.) that can be easily adjusted over a wide range of values without removal from the circuit. The illustration shows one type of Adjustable Grid Leak.

**ADJUSTABLE RESISTANCE**—(See Variable Resistance.)

**ADMITTANCE**—The inverse of impedance (q.v.). In an alternating current (q.v.) the Admittance acts in the opposite manner to impedance. A circuit having low admittance is said to have relatively high Admittance.

**AERIAL**—A system of wires suspended in the air or in any form in which they may be insulated or kept free from surrounding objects, used for the purpose of receiving or transmitting impulses as in radio transmission and reception. The term Aerial is actually identical with Antenna, but due to the general English defition of Antenna, authorities are gradually coming to distinction between transmission and reception Aerial systems by referring to a receiving device of this nature as an Antenna, and when used to transmit, as an Aerial.

There are different types and forms of Aerials, varying mainly according to purpose and facilities. The stand-
ard and perhaps more commonly used receiving Aerial consists of a single wire as in Fig. 1 or several wires as in Fig. 2. The wire used is usually of copper, as this metal combines low resistance with economy, strength, and durability. The theory of the action of the waves either received by or transmitted from an Aerial system will be found under the heading "Electromagnetic Waves."

The exact type and extent of an Aerial will depend entirely on the available facilities and the particular purpose for which it is intended. These various forms will be taken up under their respective headings. In the receiving Aerials, Figs. 1 and 2, a certain definite wavelength (q.v.) is obtained by arranging a certain length to the wires of the Aerial system including the ground and lead-in. (See Fundamental Wave-Length of Aerials.) In the single wire Aerial, the lead-in is usually taken from the end nearest the receiving apparatus, but where a particularly long Aerial is to be used, it is customary to attach the lead-in at the centre of the suspended wire. The former is known as an inverted L type and the latter as a T type Aerial. These designations will apply as well where a number of wires are used as in Fig. 2.

Generally speaking, an Aerial should be as high above the ground as possible, of course within practical limits. From 25 to 100 feet is the most practical height to use. Where the Aerial is suspended at a substantial height the incoming waves will be less likely to be obstructed by surrounding trees or buildings, and in the case of transmission the same factor will apply, inasmuch as the waves may be obstructed in their transmission, if build-

In the case of the receiving Aerial a single wire may be from 75 to 150 feet in length, or if a number of wires are used, the over-all length may be considerably less. (See Fundamental Wave-Length.)
Fig. 1. The solenoid type loop aerial

Fig. 2. The spiral type loop aerial

Fig. 3. Method of employing the electric light line as an aerial with an aerial adapter. Above is shown the diagram of the condenser in connection with the aerial circuit of a radio set
AERIAL CAPACITY—(See Capacity of Antenna.)

AERIAL CIRCUIT—Consists of aerial and earth or ground, including all coils or inductances, condensers, etc., which may be connected with the aerial and earth and forming a direct path between those points.

AERIAL SWITCH—A device to transfer the aerial and ground connections from the transmitting circuit to the receiving circuit or vice versa. Its object is to separate the high tension current of the transmitter from the low tension of the receiver. The switch is usually installed in a convenient position so that the operator may change from transmitting to receiving by one motion of the hands.

Counterpoises

Lead In

Insulators

3 to 10' from the ground

Various Shapes of Counterpoises

To Set

Spreader

To Set

Insulators

To Set

Supports

Fig. 11. Different methods of arranging counterpoises for either transmission or reception

AERIAL TUNING CONDENSER—A condenser (q.v.), usually variable, connected in the aerial circuit (q.v.) for the purpose of adjusting the natural period of the receiving circuit to the period of the incoming waves (see Wavelength) or signals coming from the aerial. In the illustration is shown an Aerial Tuning Condenser.
Aerial Wire

Any capacitive (q.v.) means of establishing or varying the oscillation constant (q.v.) of the receiver.

AERIAL WIRE—The wire forming the aerial (q.v.). Copper is generally used for this purpose as it offers very little resistance (q.v.) to the feeble currents in receiving. The illustrations show various types of wire as used for aerials. Among them there are the solid copper wire, copper clad steel wire, stranded wire, braided wire and brass or copper strip.

AERO-FERRIC INDUCTANCE—The inductance (q.v.) of coils wherein the magnetic circuit (q.v.) is completed through both air and iron.

AERIAL TRANSFORMER—A transformer used in radio, having no metal core, the lines of force having their path through air. (See Amplifier, Radio Frequency.)

ALEXANDERSON, Ernst Fredrick Werner (1878)—Radio engineer and inventor. Born at Upsala, Sweden, January 25th, 1878, he was educated at the High School and University of Lund, Sweden, at the Royal Institute of Technology, Stockholm, and at Berlin. In 1902 he joined the General Electric Company, and has been for 22 years their consulting engineer. He holds the post of chief engineer to the Radio Corporation of America, and

Photo by courtesy of General Elec. Co.

E. F. W. Alexanderson

use a trailing wire antenna for any reason, a loop or coil of wire may be used, the results of course being less satisfactory. The metal frame of the plane is often used as a counterpoise (q.v.)

A. F.—Abbreviation for Audio-Frequency (q.v.)

AFTER-GLOW—Fluorescent phenomena in a vacuum tube after current has been withdrawn.

AGONIC LINES—Lines imagined as passing through points on the earth's surface where the magnetic inclination or dip of a magnetic needle (compass) is zero. (See Actinic Lines.)

AGING, VACUUM TUBE—Gradual diminishing of the brilliancy of a tube due to the deterioration of the filament (q.v.) and the coating or deposit on the bulb. A tube is said to be aging when it gradually loses its power to emit electrons (q.v.)

AIR CONDENSER—Condenser utilizing air as the dielectric. The majority of variable condensers used in radio work employ the air dielectric, that is, the space between plates is merely an air gap. Most fixed condensers (q.v.) use some substance such as mica, or sheets of waxed paper as a dielectric.

AIR CORE TRANSFORMER—A transformer used in radio, having no metal core, the lines of force having their path through air. (See Amplifier, Radio Frequency.)

ALBIZ, Count—Managing Director of the Compañía Nacional de Telegrafía sin Hilos in 1910, of Scotch origin. He was born in Madrid in 1858 and received a schooling at the Madrid University and London University College. He was a Tory member of Parliament.
is a member of the American Institute of Radio Engineers. Alexanderson has written many papers on electrical subjects before the chief technical societies of America.

Alexanderson is famous for his work on high-frequency alternators used in radio telegraphy. The Alexanderson alternator is connected directly or indirectly to the aerial and earth and constitutes the simplest possible connection for producing continuous or undamped waves. It is a machine of great speed and many field poles, and frequencies as high as 200,000 cycles are obtained. For long distance work, employing very long wave lengths, this high-frequency alternator is largely used. Alexanderson is also responsible for the magnetic amplifier, patented in 1913, and has carried out successful experiments on duplex wireless telephony. In the Alexanderson microphone transmitter the modulation is mainly effected by variations in the tuning of the aerial circuit.

**ALEXANDERSON ALTERNATOR** — A type of high-frequency alternator (q.v.) which produces continuous oscillations (q.v.)

**ALLOY** — A compound of two or more metals. (See Woods Metal.)

**ALTERNATING CURRENT** — An electric current that does not flow steadily in one direction—as from positive to negative—but completely reverses its direction or polarity (q.v.) at certain definite intervals. In other words, the current flows first in one direction and then reverses and flows in the opposite direction—these changes being referred to as changes of phase (q.v.). An electric current is either direct (q.v.), alternating, or pulsating. The latter is an alternating current that has been rectified. (See Rectified Current.) Practically the only direct current that is employed or appears in a radio receiver is that supplied by the “A” and “B” Batteries (q.v.). In an alternating current, the change in direction or polarity takes place in a steady, even manner.

An understandable analogy for alternating current is its comparison with a pendulum. In Fig. 1 the pendulum is supposed to be the alternating current or impulse. Now when the bob is swung from its natural (neutral) position A, which may be considered as zero value of voltage or current, it will move to a maximum point, either B or C. If we assume B to be the positive side, then the bob will move to B which will be the maximum positive amplitude (q.v.). It will then fall back to zero again and with the power behind it, the momentum in this case, will rise on the other side to C, which is the maximum negative amplitude. The bob will then fall back to A once more and will have undergone a complete change of direction and values; it will have gone through a cycle (q.v.). That is to say, it will have risen from zero A to positive maximum B, then back to A, rising on the other side to negative maximum C and back to A. Now the length of time required for this complete cycle (see Alternation), is known as the time period of vibration or phase change. If, for example, it required one-sixtieth of a second for this change to take place, then we say that the frequency (q.v.) is sixty cycles, because obviously, a change requiring one-sixtieth of a second will occur sixty times in one second.

The action of alternating currents may also be likened to that of ocean tides. In Fig. 2 the curved line represents the water in motion and is to be compared with current in motion in an alternating circuit. For the sake of clarity, we can assume that the tide rises and falls between two shore lines, A and B. At 12 noon the tide is at zero or “ebb” and there is no motion in either direction. Now the flow starts toward shore line A and grad-

A and B. At 12 noon the tide is at zero or "ebb" and there is no motion in either direction. Now the flow starts toward shore line A and grad-

### Fig. 1

- **TIME**
- **CURRENT**

### Fig. 2

- **SHORE LINE**
- **MAXIMUM**
- **MINIMUM**

### Fig. 3

- **TIME**
- **CURRENT**

Alternating Current

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**Note:** The diagrams and text are from a technical document discussing the principles of alternating current and its applications in radio telegraphy, specifically referencing the Alexanderson alternator and related concepts.
Alternating Current

through these changes E to F is 12 hours and is known as the time period or period (q.v.). Therefore, the time required for a complete change in the case of alternating current will be referred to as the period. The number of times that these changes take place within a certain time limit is known as the frequency (q.v.).

The current value in Fig. 3 is assumed to be 10 amperes, and the current value at any moment is shown as ordinates (q.v.). (vertical) while the time is shown in the Abscissas (q.v.) (horizontal). If the above curve is to be assumed as representing the Sine wave of an Alternating current, if its frequency of 60 times per second, the total time in the chart would be one-thirtieth of a second. Thus, Time A to C would be one-sixtieth second, the Time of one complete cycle. A B is a positive Alternation and B C a negative Alternation, D and E represent maximum current values in each direction.

If the above Sine Wave is to be used as an example of a high frequency oscillation, the Time of one cycle can be assumed as about 1 second. (See Frequency, Oscillation - Sine - Phase - Characteristic of Alternating Current.)

The frequency of an alternating current depends on the number of poles (field magnets) and the speed of rotation when the A.C. is generated by an alternator. (See Alternator.)

ALTERNATING CURRENT, THEORY OF PRODUCTION OF—Electric current in motion along a conductor always has a magnetic field (magnetic flux) surrounding it. If this current is passed near a number of turns of wire, the lines of flux will link with the wire turns in the circuit. The number of flux lines through a coil will depend upon the current. A change of current will change the number of linkages. If two turns of wire are used, the circuit will link twice with the same magnetic flux. Thus, a change in the current or a change in the number of turns of wire will alter the linkages.

Now in the case of Fig. 1, the magnet being placed near the coil causes lines of force to pass through the coil. Each turn of wire will link the flux lines. If there is any change in these linkages, the flux lines and wire turns will produce an E.M.F. (electromotive force) in the circuit of the wire turns. This is called an "induced current" because it is induced by the change in linkages. In Fig. 1, we have a galvanometer. Now, we have a magnet. When this magnet is moved toward or within the coil, a current is induced in the circuit by reason of the change in linkages. This current is always in a direction to oppose the change that causes it. (See Lenz Law.) "Whenever an induced current arises by reason of some change in the linkages, the magnetic field about the induced current is in such direction as to oppose the change." When the magnet is moved toward the coil, the change in linkages creates or induces a current that flows in the circuit in such a manner as to make A act as a North pole. As the North pole of the magnet is toward this point A, the similar poles will oppose each other according to the simple law of magnetic attraction and repulsion. Now if we attempt to withdraw the magnet, the change will alter the linkages again, this time creating an induced current that makes A act as a South pole, thus attracting the magnetic North pole and opposing it in the opposite manner, the change in linkages that have created the current.

We already know that if a conductor is moved across a magnetic field, an E.M.F. is induced in the conductor. The action is the same whether the conductor is moved through a magnetic field or vice versa. In Fig. 2, a magnet is shown in position on an axis—D for rotation within the loop A B. As the magnet is rotated, the North pole passes across A, an E.M.F. is created toward F in the same direction. As the position of the magnet reverses in rotation and S passes A while N passes B, a current is induced in the opposite direction, both times in accordance with the law previously stated. Thus, a meter is connected between the ends of the loop at E F and the magnet rotated, a current will be registered. With each half turn of the magnet, this current will reverse its direction. Therefore, we have produced an alternating current that changes direction with each reversal of the position of the magnets. This is the simple A.C. or Alternator. The illustration, Fig. 4, shows a standard type of low frequency alternator.

ALTERNATION—In an alternating current, it is the rise from zero to maximum amplitude and back to zero on either side, i.e., positive or negative directions. Two alternations—one positive and one negative—make a complete cycle. (See Alternating Current.)

ALTERNATOR—A machine for the purpose of changing mechanical energy into electrical energy. Fig. 1 shows an alternator in its elementary or simplest form—merely a conductor, B C moved across a magnetic flux (q.v.). (Note: For a complete explanation of the production of alternating currents, see Alternating Current, Theory of Production of.)

Here the conductor B C is moved to the right across the magnetic flux shown as dotted lines between N and S, the poles of the magnets. As the conductor moves across the flux lines of the magnet, an electro-motive force (q.v.) or electric current is set up or induced in the conductor, this force being in such a direction that the current produced will create a flux or magnetic field, in the same direction as the flux on the side of the conductor that comes first into contact with the flux lines N S on moving the conductor. In this case E.M.F. (electromotive force) is in the direction B to C in the conductor. In order to establish a circuit and utilize the current pro-
duced in this manner, it is only necessary to attach wires to both ends of the conductor as shown by the dotted loop. Now at this moment the conductor is being traversed by a current having a definite polarity, that is to say, it is flowing in one direction only. When the direction of the current and the direction of the flux lines is reversed, then the direction of the current in the conductor will be reversed and it will flow in the opposite direction. In other words, with every reversal of the position of the conductor in its relation to the magnetic flux lines, or the reversal of the direction of the flux lines, with respect to the conductor, the E.M.F. that is created will change its direction of flow. (See Alternating Current.)

In an alternator it has been shown that the result is approximately the same whether the magnet is rotated or the conductor is rotated through the magnetic flux. In either case the moving member is known as the rotor (q.v.) and the stationary member is called the stator (q.v.). The magnets producing the flux lines may be stationary or they may revolve; in either case they are referred to as the "field magnets." It has been shown that with every change in the relative position of the field magnets and the armature (q.v.), irrespective of which member is the rotating one, a change in direction of the induced E.M.F. takes place. Then it is apparent that in order to increase the number of changes, that is, to increase the frequency (q.v.), it is only necessary to use (1) a greater number of field magnets, or (2) have the armature or conductor pass the magnets more frequently by means of greater speed in the rotating member, or by means of both. Now each of these changes is an alternation (see Alternating Current) and two such changes will be a cycle (q.v.). Let us suppose that the moving member of a certain alternator has a rotary speed of 720 revolutions per minute and there are 10 poles or magnets. As frequency is figured in cycles per second, it will be necessary to reduce this number to the revolutions per second. Thus, there will be 12 revolutions per second. This figure multiplied by the number of poles (q.v.), which we assume as 10, indicates 120 alternations per second. As there are two alternations to each cycle (q.v.), the frequency in this case will be 60 cycles. The equation is as follows:

\[ F = \frac{P \times N}{60} \]

where \( F \) is the frequency, \( P \) the number of poles and \( N \) the speed of rotation per minute. The exact voltage or E.M.F. obtained will depend on the number of poles and the speed of rotation, and also on the distribution of the field windings and total flux from all the poles or magnets. In designing alternators the effective E.M.F. (electromotive force) is expressed by the formula:

\[ E = K P a N \]

where \( E \) is the effective electromotive force of the alternator, \( K \) represents the E.M.F. factor of the alternator. This factor depends upon certain characteristics of the poles and also the distribution of the windings on the armature. \( P \) is the number of poles of the field magnets. \( a \) is the number of lines of magnetic flux that flow from one pole across the gap to the armature—known as the useful magnetic flux per pole; (see Magnets). \( N \) is the speed of rotation of the rotor in revolutions per second. \( Z \) is the total number of conductors on the surface of the armature.

The use of the revolving armature type for comparatively small voltages is due, as mentioned previously, to the fact that they are easily constructed, and also the advantage that the exciter need not be an external source, but may be a separate winding with a commutator (q.v.) mounted on the main shaft. The revolving field type of course allows much greater space for the armature winding, inasmuch as the stationary member is not limited to any particular space, whereas the moving member must be arranged as small as possible to do away with mechanical troubles. Thus, the stationary armature can be wound and properly insulated for great voltages. For this reason the revolving field is generally used in high power work. Another point of importance is that when the armature revolves the windings must be made very carefully as the centrifugal force due to rapid rotation of the members places a great strain on them.

One of the widely used forms of alternator for extremely high frequencies, is the Alexander, named after its originator, Ernst Alexander (q.v.), a noted engineer. This machine is of the inductor type. It is a well-known fact that magnetism is more readily established through iron than through air, and therefore when a coil is placed in the air gap of a magnetic circuit, the lines of force or flux lines are greatly increased. Then when the iron is withdrawn, the flux lines fall to their original value. We have seen that as changes of flux take place throughout a magnetic circuit an electromotive force is induced in a coil or conductor (armature) surrounding the magnetic circuit. Now, if iron is periodically inserted into and withdrawn from the magnetic field, an alternating current will be set up in the coil surrounding the field. This principle is made up of in the inductor alternator and the field and armature thus remain stationary, contrary to the usual form of an alternator. Now if we arrange to have pieces of iron moved rapidly in the gap between field and armature, changes of flux will
take place. Obviously, it is easy in this manner to create many changes of flux within a certain time, and therefore the alternating current or up (E.M.F.) will have a high frequency as seen by the explanation of this phenomena given previously. Though moving pieces are so arranged that they practically close the gap between field and armature with only enough clearance to prevent the exciting member striking the stationary members. This is briefly the principle of the Alexanderson alternator. Fig. 4 shows the general plan of an inductor alternator. On the right shows the scheme of winding in slots around the entire armature, and as there are necessarily many windings in order to obtain the high frequency, they are generally single turns of wire, each turn having a separate slot.

The left is given a general idea of the arrangement of the rotor, which in this case, as explained previously, is neither field nor armature, but iron teeth arranged on the periphery of the moving disk. The field is increased or excited in the usual manner by means of a source of direct current. In the assembly, the relation of the moving disk to the field and armature is shown. Fig. 6 is a commercial type of the Alexanderson Alternator having a frequency (q.v.) of 100,000 cycles used for high power radio transmission (q.v.).

ALTERNATOR, SINGLE PHASE—(See Alternator.)

ALTERNATOR, POLYPHASE—(See Alternator.)

AMMETER OR AMPERE-METER—An instrument for measuring current in an amperemeter circuit. It is connected in series with a circuit. Exists in a variety of forms. The operation of the most commonly used type depends upon the fact that the force a magnetic exerted at the number of ampere turns (ampere-second) multiplied by the distance between the poles of the magnetic field causes the movement of the needle. The greater the current or mass through the coils, the greater will be its attraction for a balanced armature. Fig. 1 shows a common form of ammeter.

Photo by courtesy of Weston Elec. Inst. Co.

Fig. 1

AMPERE VOLT OR VOLT AMPERE—The expression sometimes used to denote watts (q.v.). For example 1 volt amperes will be one watt, as watts are equal to the product of the volts and amperes in D.C. circuits. (See Efficiency, also Watts.)

AMPLIFICATION CONSTANT—The factor expressing the maximum amplification (q.v.) with which it is possible to obtain a given vacuum tube. Thus, if a certain tube will permit amplification of eight times the original voltage, the amplification constant is said to be 8. (See Vacuum Tube.)

AMPLIFICATION FACTOR—The ratio of the change of its output voltage, between filament and plate of a vacuum tube to a small change of input sinusoidal voltage between filament and grid for a given constant plate current:

\[ Y = \frac{\delta V_p}{\delta V_g} \]

The ratio of power (radio signals), voltage or current output of an amplifying device to the power, voltage or current input delivered to the terminals. Generally speaking the degree of increase in amplitude or voltage insertion, amplification factor in the circuit. (See Amplification Voltage.)

AMPLIFIER—One of the most important features of the vacuum tube (q.v.) is its ability under certain conditions to amplify or increase the intensity of electric currents. Such tubes are generally referred to as amplifying tubes and an amplifier is understood to be one or more such tubes with the necessary associated circuits to accomplish amplification.

In the accompanying diagram a circuit of a typical oscilloscope (q.v.) with the primary characteristics of the system. In the case the radio frequency signals (q.v.) are impressed at the points A-B from the aerial and grid of the transformer. The signals at points C-D are audio frequency or voice frequency because they have undergone a change or rectification (q.v.). Now, if we consider only the solid lines, the circuit will be one of the usual detector circuit and the signals at C-D can be heard by merely connecting the phones at that point in place of the primary of the transformer—P-B. However, if we use these currents through the transformer and impressing them on the secondary circuit it is possible to obtain signals at points E-F of much greater volume and yet having the same general characteristics and sound. The signals or currents will have undergone amplification—the effect of the amplified tube on a local the amplitude of power increase the amplitude, but the form or nature of the signals or waves will remain the same. It is not entirely true as amplification is generally accomplished only at the expense of some slight changes in the character of the waves. They will, however, sound about the same in the phones at E-F as they will when the phones are placed at C-D, the volume at E-F being greater due to the am-
AMPLIFIER—Now, it must not be assumed that an amplifier in itself actually has the ability to increase power without some assistance. It is no more possible to obtain something for nothing in electricity than it is in mechanics. What actually takes place is that the amplifier, in conjunction with a transformer, controls the power—in this case, the voltage of a "B" battery—in such a manner as to boost or amplify the power of the signals without materially changing the nature of them. Therefore, an amplifier may be considered as a device which modifies the effect of an external source of power in accordance with the variations of input power, and produces an increased output power or a means of stepping-up or increasing the amplitude or volume of a signal or series of signals. (See Amplifier Action or Vacuum Tube.)

AMPLIFIER ACTION OF VACUUM TUBE—The tendency of a vacuum tube to increase the power or voltage of incoming signals under proper conditions. In the illustration is shown a simple vacuum tube circuit. The incoming signals are impressed on the tube at points A and B. Now it has been noted that small changes of voltage at the grid (q.v.) will produce much greater changes at the plate (q.v.) (See Vacuum Tube, Theory of Operation.) In other words, the constant changes in value of the incoming signals that are impressed at A-B will produce comparatively larger changes in the current at the plate and therefore larger changes of voltage in the output circuit at C-D. These changes will of course manifest themselves in the form of signals in the phones placed at C-D. Now if these voltages are impressed on a resistance (q.v.) of suitable value—which is the primary of an amplifying transformer—they can be sent to another tube and again amplified. (See Amplifier, Audio Frequency.) In other words the amplifying action of a vacuum tube means the ability of that tube to use input power—the power of the signals delivered to the tube—to control a local source of power such as the "B" battery voltage used on the plate of the tube, and deliver increased power. The signals to be increased or amplified in this manner may be Radio Frequency (q.v.) or Audio Frequency (q.v.), each instance requiring a different type of amplifier (q.v.). The radio frequency signals are amplified by means of a tube and suitable apparatus (transformer or resistance) before they have been changed to audio frequency. The signals that have been rectified (q.v.) or changed to audio frequency may be amplified by means of a similar arrangement of somewhat different type. The latter would be known as an audio frequency amplification. The increase in power is accomplished without any material change in the nature of the signals or wave form (q.v.).

AMPLIFIER, INTERMEDIATE FREQUENCY—An arrangement of a radio frequency amplifier used to increase the strength of signals at the intermediate frequency (q.v.) as used in a Super-Heterodyne receiver. This is usually a radio frequency amplifier using transformer coupling (q.v.) the transformers being designed to cover extremely high wave-lengths. (See Super-Heterodyne, also Transformer.)

AMPLIFIER, RADIO FREQUENCY—An amplifier used to increase the volume of the incoming signals at radio frequency (q.v.) before they have been rectified by the detector. In this illustration is shown a single stage of radio frequency amplification. This is the transformer coupled type. In this case the incoming signals of radio frequency are increased in strength and then passed on to the detector tube VT2. If further amplification is desired, more stages may be used, the number being held within certain limits due to distortion (q.v.). If more than three stages are used, it is often difficult to control the feed-back effect (q.v.) and efficiency is cut down.

AMPLITUDE—The current or voltage on an A.C. or H.F. circuit at any instant. The greatest vertical distance above or below zero of the crest or trough of a wave is the maximum amplitude of the wave. In the accompanying illustration the numerals at the left (ordinates q.v.) may be assumed to be volts, current (amperes), or voice vibrations. A is the zero point; B the maximum positive, C the maximum negative, and D the length of the wave. Thus, A-B will be the maximum positive amplitude, A-C the maximum negative amplitude, and D the wave length. B is known as the crest or Node—C is the trough or antinode.

X—Now if in a certain train or group of waves, the amplitude of one wave is less than the one immediately preceding it, there is said to be damping (q.v.), the degree of this damping or diminishing in amplitude being referred to as decrement (q.v.). Thus, if we assume that in Fig. 1 the current or amplitude of the first wave is 10 amperes, and the next wave has an amplitude of only 6 amperes, then the damping or decrement is 50 per cent, because the amplitude has decreased that much. Similarly, if the first wave amplitude were 10, and the second were 5 amperes, then the decrease
or decrement would be 10 per cent. In a damped wave the decrement or progressive decrease in amplitude must not exceed a value whose logarithm is 0.2. If it exceeds this value, it is said to be highly damped.

The degree of damping is governed by government statutes. (See Decrement and Alternating Current.)

ANALOGY—"Resemblance of properties or relations; similarity without identity"—Webster. Analogies are much used in radio work for giving simple examples of difficult subjects.

The most frequent analogy in the comparison of radio waves to water waves is:

ANALYSIS-ELECTRIC—(See Electrolysis.)

ANCHOR GAP—A small spark gap in aerial circuit used to automatically disconnect the transmitter when the receiver is being used, see illustration. The powerful transmission spark jumps the gap instead of passing through the instruments. The device is principally employed to protect the delicate instruments of the receiving set.

ANGLE OF LEAD OR LAG—In a circuit traversed by alternating current, the degree by which the current falls behind or advances ahead of the voltage in the circuit, due to the presence and effect of self-inductance or capacity.

When a coil of wire is traversed by alternating currents the self-inductance of that coil tends to make the current lag behind the applied E.M.F. (electro-motive force). When a condenser is inserted in the circuit carrying alternating currents, the capacity tends to accelerate the current and makes it precede the applied E.M.F.

X—The tangent of the Angle of Lag will be the ratio of the inductive reactance (q.v.) to the resistance of the circuit, therefore: Where θ is the

Phase Angle, \[ \tan \theta = \frac{\text{Reactance}}{\text{Resistance}} = \frac{2 \pi F L}{R} \]

The tangent of the angle of lag will be the ratio of the capacitive reactance to the resistance of the circuit. As:

Where \( \theta \) is the phase angle \( \tan \theta = \frac{1}{\text{Resistance}} \times \frac{2 \pi F C}{R} \)

These simple relations are true only when there is inductance or capacity in the circuit, and not both.

ANGLE, PHASE—The degree of difference in spatial phase, or two different currents or the angle of lead or lag in a circuit wherein the applied E.M.F. (Electromotive Force) does not reach maximum amplitude at the same instant as the current. (See Angle of Lag.) Thus, when the applied E.M.F. and the current reach negative and positive amplitudes simultaneously, there is no phase difference, hence no Phase Angle. However, if one current reaches a negative or positive maximum before or after the other current, then the currents are said to be "out of phase."

X—In the illustration it will be illustrating the angle of lead. The solid line marked with an arrow indicates the current phase, the dotted line representing the voltage.

noted that the current reaches maximum value ahead of the pressure. The angle of "lead" in this case is 45°. Therefore, the lead is the Phase difference or a 45° lead with respect to the voltage.

ANGULAR VELOCITY—Referring to a periodic alternating current, represents \( 2 \pi \times \) per second, the result being given in radians per second. Thus, \( V = 2 \pi \times F \). (See Simple Harmonic Vibration.)

ANION—The electro component. (See Electrolysis.)

ANODE—A positive electrode. In a vacuum tube the plate is sometimes termed the Anode, the opposite being cathode or negative element. (See Dry Cells, Storage Battery and Electrolysis.)

ANODE BATTERY—See Plate Battery.

ANODE CIRCUIT—See Plate Circuit.

ANODE CONTROL—See Plate Control and Modulation.

ANTENNA, COIL—See Loop Aerial.

ANTENNA CURRENT—See Plate Current.

ANTENNA—See Aerial.

ANTENNA RESISTANCE—Is usually considered as the total effective resistance of an antenna and the associated circuits to impulses at any particular wavelength. It, therefore, includes resistance of any sort, such as radiation resistance (q.v.), ground resistance (q.v.), etc. It is often referred to as the total loss, but this is not actually true, inasmuch as the power transmitted is in reality included in this figure known as Antenna Resistance.

It is regarded as an effective resistance which is equal numerically to the ratio of average power dissipated in the total antenna circuit, to the square of the effective current at the point of current maximum. In computations held to include radiation resistance, ground resistance, radio frequency resistance of conductors in antenna system, and the equivalent resistance arising from eddy currents, corona, dielectric loss, leaking inductors, etc.

ANTI-CAPACITY SWITCH—See Switch.

ANTINODES—Points of greatest amplitude in a train of waves or oscillations halfway between the Nodes or points at rest. Also called "loops."

ANTI-RESONANCE—See Parallel Resonance.

APERIODIC—Untuned. Without periodicity. Attaining repose without vibrations. (See Periodic.)

APERIODIC CIRCUIT—Untuned. A circuit that has no natural oscillating period (q.v.) of circuit has capacity (a condenser) and inductance (a coil) it has a definite period. If the circuit has capacity but no inductance, or inductance but no capacity, it is said to be Aperiodic. A current that has no period is also said to be Aperiodic.

The term aperiodic is generally applied to a circuit upon which are impressed R.F. oscillations differing considerably in frequency or period from the natural frequency or period of the circuit. The oscillations are said to be "forced."

X—Without periodicity—attaining repose without vibrations. A circuit in which an impressed potential will produce current that gradually diminishes in amplitude without reversing direction of flow. A non-resonant circuit.

APPLETON, Edward Victor—Born at Bradford, England, 1892, and educated at St. John's College, Cambridge, where he took first class honors in natural science. Appleton for some years made a special study of the thermionic valve (Vacuum Tube) on which he has become one of the leading authorities in Great Britain. He has been engaged in research work on valves at the Laboratories, Cambridge, and has contributed articles on the subject to a number of scientific journals. He is a member of the Thermionic Valve Sub-committee of the Radio Research Board of England.

ARC CHARACTERISTIC is the curve showing the relation between P.D. (q.v.) at the terminals of an arc (usually taken as abscissae) (q.v.) and the current through it (ordinates) (q.v.). When voltage and current are increased or decreased slowly while making the measurements, the curve is called the static characteristic, and is the same with or without falling current; when voltage and current are varied very rapidly, the curve is called the dynamic curve. He is a member of the rising voltage curve is different from the falling one.

The static characteristic has a negative gradient or slope, hence an arc is said to have a negative or falling characteristic. The dynamic characteristic is a curve enclosing an area whereas the static characteristic is purely linear.

ARC GENERATOR—A machine producing a powerful electric discharge in a gap separating two electrodes, the continued passage of current being due mainly to the heat produced at either one or both electrodes. It generates sustained or incandescent arcs (q.v.) and is used for radio transmission of considerable power. The positive electrode is water-cooled and the negative electrode being of carbon.

ARC GENERATOR SYSTEM—A system involving the use of the arc for the production of continuous or undamped oscillations.

ARC OSCILLATOR—See Oscillator.
ARC SPARK—A spark in which there is a slight arcing due to some current from the transformer leaking across a gap which is too small. Such a spark gives very poor production of active sparks, is generally due to insufficient capacity in the circuit and arises from volatilization of the metallic electrodes forming the spark gap.

ARC TRANSMITTER—See Arc Generator.

ARCO, Graf George Von—Born at Grassgorschutz, Schlesien, Germany, he was educated at Berlin University and the Technical High School, Charlottenburg.

Assistant to Professor Slaby, 1899, he was part inventor of the Slaby-Arco system of wireless telegraphy. He was appointed manager of the Gesellschaft fur Drahtlose Telegraphie, 1903, and first carried out a practical radio telephony demonstration over a distance of twenty-one miles in 1906. At the International Radio-telegraph Congress held at London in 1912 he exhibited a high-frequency alternator with static frequency step-up transformers as now used in the high-power station of Nauen, Germany. Arco has written a large number of papers on radio, including quenched spark signalling, high-frequency alternators, the Telefunken singing spark system, long-distance radio transmission, as well as being the author of a considerable number of patents, including a vacuum tube receiver circuit for high-frequency amplification patented in collaboration with Melsner in 1914.

ARGON—Chemical Symbol A. Atomic weight 39.9. A gaseous element, a component of the atmosphere. Pure Argon Gas is used commercially in certain types of transmitting tubes to prolong the life of the filament. Disintegration of a filament is often rapid under stress of the heavy currents used for transmission. This tendency to deteriorate is lessened by the use within the tube of pure Argon gas.

ARMATURE—The part of a dynamo machine in which the electromotive force is created due to electromagnetic induction. The term is also used to denote the piece of soft iron placed across the poles of a horseshoe magnet to prevent loss of magnetism.

In electrical machines it is commonly used to refer to the moving part (revolving armature type—see Alternator), and may be divided into two broad classes as: revolving or stationary. With regard to the core construction they are broadly classified as (a) Ring, force and conductors. The conductors are sometimes called "inductors" and the iron part the "Core." (See Armature.)

ARMOR—In electrical usage, a shield or protective covering for wire or cable. Usually a lead or aluminum wrapping in convolute form.

ARMSTRONG, Edwin H.—Born in the United States of America, December 18th, 1890. He was educated at Columbia University, where he specialized in radio engineering. He served under Professor M. Pupin at Columbia University in the Hartley Research Laboratory, and is a director of the American Institute of Radio Engineers, the medal of which he has been awarded. Armstrong began experiments with wireless at the age of fifteen, and in 1913, while he was still a student at Columbia, he discovered the now famous feed-back or regenerative circuit, which was the cause of litigation, spreading over a number of years in the United States of America, before his patents were upheld. In March, 1915, he described the circuits employed by him with the Pliotron or three-element vacuum tube. Armstrong was the first to reveal that, with a certain value of feed-back coupling between the plate and grid circuit, a vacuum tube would become a high-frequency generator. His patent was dated January 31st, 1913. His fame became world-wide when he announced his discovery of the super-regenerative circuit, one of the most widely discussed and important developments in radio. His paper on "Some Recent Developments of Regenerative Circuits," dealing with the super-regenerative circuits, was read before the Institute of Radio Engineers in New York on June 7th, 1922.

The originator of the super-regenerative circuit has a number of other important patents to his credit, some of which will undoubtedly have far-reaching effects. In conjunction with Professor Pupin he invented a method for the elimination of jamming, especially that due to statics.

ARMSTRONG CIRCUITS—The various circuits devised by E. H. Armstrong, an American engineer. The more important of these are the Regenerative,
Super Regenerative and Super Heterodyne. The principle of regeneration is one that has revolutionized the art of radio reception and broadcasting. The vast majority of present day receivers use regenerative circuits in one form or another. Basically, regeneration is the process of returning a certain portion of the unrectified or radio frequency (r.f.) current from the plate circuit of the detector tube to the grid circuit. This has the effect of reducing the resistance of the grid circuit and thus permitting more ready passage of the weak impulses. The result is not only to greatly increase the sensitivity of the detector to weak signals, but actually to step up or amplify the volume of the received signals.

In Fig. 1, coils L1 and L2 are the variable tuning units in conjunction with the variable condenser, C1; C2 and C3 are variable condensers of low capacity; L3 is the plate control for regenerative action.

ARRESTER—A device used for by-passing heavy electrical discharges in the atmosphere in the vicinity of the antenna when they strike the antenna.

It ordinarily consists of a small gap between two metallic points connected in series with the antenna and ground in order to protect the apparatus and property against danger. (See Lightning Arrester.)


ARTIFICIAL ANTENNA—See Mute Antenna.

ARTIFICIAL MAGNET—A magnet produced by magnetizing a piece of steel that previously had no magnetic attraction. May be produced by rubbing a natural magnet or another artificial magnet across a piece of hard steel in the same direction a number of times. (See Electro-magnet.)

ASSUMED DIRECTION OF CURRENT FLOW—The direction which an electric current is assumed to take in its flow. Current is generally considered as leaving the positive terminal of its source, flowing through the circuits external to the source, and thence to the negative terminal of the source. The direction of flow within the source itself is from the negative to the positive terminal. (See Theory of Current Flow.)

STATIC COILS—Coils wound in such a manner that, when connected together, they neutralize each other's effect and produce no external magnetic field. They are used in the measurement of inductance.

ASYMMETRIC CONDUCTOR—One that permits the flow of greater current in one direction than in another. Non-symmetrical as to conductivity.

ASYMMETRICAL EFFECT—The lack of symmetry in the directional effect in a loop or frame aerial due to lack of symmetry in construction. (See Loop Aerial.)

ASYNCHRONOUS—A term used in referring to AC (Alternating Current) motors or generators and also to dischargers used in radio transmission. As applied to alternating current machines it is signified that the speed of rotation of the machine does not have any definite relation to the frequency of the currents produced—thus, out of synchronism. (See Synchronous.)

An asynchronous radio circuit is one which is not tuned to, or in sympathy with, the frequency of the oscillations impressed on it. (See Aperiodic.)

ASYNCHRONOUS ROTARY DISCHARGE—A spark discharge produced at electrodes of a rotary discharge (q.v.) for transmitting radio signals, in which the spark rate or number of sparks per second has no relation to the frequency of the alternating current. (See Spark Discharge.)

ASYNCHRONOUS SPARK GAP—See Spark Gap.

ATMOSPHERIC ABSORPTION—The portion of the total reduction of radiated power due to atmospheric conductivity, reflection and refraction. The amount of this loss in radio transmission due to atmospheric factors. This applies only to electromagnetic waves (see q.v.) in motion in the ether and should not be confused with the reception losses due to atmospheric disturbances.

ATMOSPHERICS—See X's, Strays, Statics.

ATTENUATION—Of the electric or magnetic intensity or of the average energy density in electric waves refers to the reduction in strength with increase of distance traversed due to absorption or equivalent losses, as distinguished from the reduction in strength due to geometrical divergence. In space, the geometrical divergence of waves from a small source involves a diminution of the average energy density in accordance with the inverse square law; plane waves (e.g., radio waves) suffer no reduction by divergence, but undergo attenuation due to resistance and other line faults. (See Attenuation, Geometrical Divergence.)

ATTENUATION, GEOMETRICAL DIVERGENCE—The gradual decrease in strength of electromagnetic waves (radio signals) as the distance which they have traversed increases. The effect on the waves as they travel through the air is essentially the same as in the case of light waves. Now if a beam of light is viewed one mile from its source it will have a certain intensity, but if it is viewed again from a distance of two miles the intensity will be much less. In the case of radio waves, the intensity is said to decrease as the square of the increased distance traveled; that is to say, if they have a certain power at a distance of five miles from the transmitter, the same waves at twice the distance or ten miles will be found to have a strength of one-quarter as great. Similarly, if the waves travel fifteen miles or three times the distance, the signal strength will be only one-ninth that of the strength at a distance of five miles from the transmitter.

AUDIBILITY—The measure of strength of received radio signals as heard in a
AUDIBILITY (Radio Telegraph) — A measure of the ratio of the telephone current producing a signal in a telephone receiver to that producing a barely audible signal. (A barely audible signal is one which just permits the differentiation of the dot and dash elements of the letters sent in code.) In the simple shunted telephone method of measuring signals the audibility is defined as:

\[ s + t \]

where \( s \) and \( t \) are the impedances of shunt and telephone respectively.

AUDIBILITY FACTOR—A measure of signal strength obtained by observing the resistance to be placed in shunt with the telephones of a receiving station to reduce the signals to unit audibility. Approximately, the audibility factor is proportional to the power absorbed from the signal waves by the receiving apparatus. Unit audibility is the strength of signal at which dots and dashes can just be discriminated.

AUDIBILITY METER — A device for comparison of the strength of received signals, either from different stations or with different circuits by means of a variable resistance shunted (placed) across the phones. This resistance is decreased until the signals are just audible in the phones. Now, if another station is tuned in, or the circuit changed in some manner, the signals may either be entirely inaudible or they may be much louder, giving an idea of the comparative strength without actual measurement. A popular type of Audibility Meter is shown in the above illustration.

For measurements with an audibility meter, the following shunt formula is used:

\[ K = \frac{s + t}{s} \]

Where \( s \) is the impedance of the shunt resistance, and \( t \) the impedance of the phones, then \( K \) is the audibility constant. In general practice a series resistance is devised to compensate for the reduction in resistance of the shunt circuit, this keeping the impedance of the plate circuit constant.

AUDIO AMPLIFIER—An amplifier used to increase the volume of signals of audio frequency (q. v.). Audio amplifiers are connected in the circuit of the detector in place of the phones (input) as shown in Fig. 1. This is the standard two stage audio amplifier. The separate stages each consist of a vacuum tube, a transformer, a battery and a rheostat. The tubes are connected in a push-pull circuit.

Fig. 1. A standard two stage Audio Amplifier employing phone jacks for detector, first stage, and second stage Audio Amplifiers.

AUTO-COHERER — A coherer having automatic action to release the particles that cohere when circuit is established. Now obsolete. (See Coherer.)

AUTO DYNE RECEPTION—See Self-Heterodyne Reception.

AUTO INDUCTIVE COUPLING—See Coupling.

AUTOMATIC INTERRUPTER—A vibrating electro-mechanical device to make and break an electric circuit by using the energy passing through it. The most common example is that of a spark coil. An interrupter may be used for several purposes. In the case of a spark coil it is used to produce sparks for transmission of signals. In another form it may appear in a mechanical battery charger, in this instance being used to interrupt the alternating current and permit passage of the current in one direction only. A buzzer uses a type of interrupter—a vibrating device producing a buzzing sound having a pitch dependent on the rapidity with which the vibrations take place.

AUTOMATIC TRANSMITTER—An apparatus for operating a sending key mechanically. (See Wheatstone Transmitter.)

AUTOPLEX—A type of radio receiver employing one vacuum tube, operating

Noted for the fact that he is head of the U. S. Naval Telegraphic Laboratory, Washington, D. C., and for his work in measuring high frequency currents.
Auto-Receiver

tube, socket, batteries, etc. It is extremely critical in operation, but carefully tuned will give excellent volume under good conditions. Illustration shows the circuit diagram of the Autoplex receiver.

AUTO RECEIVER—A device for the automatic reception and recording of radio signals. It is essential in the reception of signals transmitted by an Automatic transmitter (see Wheatstone Transmitter) as the speed is too high to permit reception by ear. There are three general classes of automatic receiver: a resonance intensifier in conjunction with an inkling arrangement; a phonographic recorder and a recorder using photographic means. In the latter method, a powerful beam of light is projected on to a mirror which is arranged to respond to the signals in approximately the same manner as a mirror galvanometer. In the phonograph type, the signals are reproduced on a drum. (See Resonance Intensifier, Photographic Recorder, also Phonographic Recorder.)

AUTO TRANSFORMER—A device for charging voltage in a circuit carrying alternating currents. A form of transformer having but one winding, any part of which may be used as the primary and any part as the secondary. In Fig. 1, the two windings P and S are continuous, although different materials of wire may be used according to the purpose for which intended. In this case the voltage taken from the secondary D E will be less than the voltage impressed at A B, because the secondary has fewer turns of wire than the primary. Now in Fig. 2, this condition is reversed, and as the primary has only a few turns of wire and the secondary has a comparatively large number, the voltage obtained from D E will be greater than that impressed at A B. The voltage ratio is approximately proportional to the ratio of wire turns. Thus, if the primary has 100 turns of wire and a pressure of 100 volts is placed at A B, then the voltage at D E would be within certain limits about equal to the number of turns of the secondary. In other words, if the number of turns on the secondary is one-third the number of turns on the primary, then the voltage at D E will be approximately one-third that impressed at A B. The main advantage of the autotransformer is that a saving is accomplished by having the primary and secondary windings combined. The chief disadvantage is that where extremely high voltages are used there is always danger of the two windings becoming crossed or shorted. (See Short.) For this reason they are used mainly for comparatively low voltages. One of the most common forms is the step-down type, known as a "bell-rolling transformer." These are used to cut down the voltage of an electric light line to suitable value for use with small toys or bells. If the transformer is used to increase the voltage, it is known as a "step-up" transformer. (See Transformer—Radio, Audio.)

AUTO TRANSFORMER COUPLING—See Coupling.

B—Abbreviation for Baum, the scale used in a hydrometer (q.v.).

A. AMPERE—The standard ampere fixed by the British Association for the Advancement of Science.

BACK COUPLING—See Reactance Coils.

BACK ELECTRO-MOTIVE FORCE—An Electromotive force (E.M.F.) which opposes the original electromotive force. The more common term is "Counter E. M. F." In many arrangements of electrical circuits there will be an electromotive force set up in such manner as to oppose the impressed voltage or force. This will be true in the case of a choke coil in which any variation in the pressure or current of the transformer applied to the coil will result, under proper conditions, in the production of a back or counter-electromotive force that will oppose the change in the original force. This phenomena is frequently found in electrical circuits; at times introduced for a purpose and at others self-introduced, and therefore demanding consideration in design of apparatus. The armature of a motor creates a counter E. M. F. supposed to the impressed E. M. F. and upon which the driving power of the motor depends. When an external E. M. F. is impressed on a circuit in which there exists a local E. M. F., the flow of the current through that portion of the circuit containing the local E. M. F. will result in an increase or decrease of energy depending on whether the local E. M. F. is opposed to, or in the same direction as, the external E. M. F. (See Counter Electromotive force.)

BACK OSCILLATION—When the condenser of a transmitting circuit of the spark type discharges across the spark gap some of the high frequency current may flow back through the secondary of the transformer instead of taking its normal path across the gap. This back flow is usually referred to as Back oscillation or kick back, and is apt to break down (see Breaking Down of Insulation) the insulation of the transformer if not prevented or controlled. Back oscillation is retarded ordinarily by means of coils of wire having a certain arbitrary inductance value. When the high frequency discharge from the condenser has any tendency to break through, the retrace of these coils becomes so great that they act in effect as insulators. The capacity and inductance of these coils might create an oscillatory circuit of the same natural period as the primary oscillator, they are ab	united with non-inductive carbon resistances. These coils are termed "choke" coils.

BAKELITE—An insulating material having widespread use in radio. It possesses great strength and has a high dielectric (insulating) value together with the ability to withstand high temperatures. This material is furnished in many forms and under a variety of trade names, being considered one of the best of the insulating compounds.

Chemically known as Oxybenzylmethylenglycol anhydride. It is produced by the union under heat and pressure of phenol and formaldehyde together with a small percentage of some alkaline agent. In heat resisting up to about 500 degrees Fahrenheit—disintegration setting in somewhere above that point.

BALANCED CIRCUIT—An electric circuit arranged in such manner with relation to adjacent or neighboring circuits as to do away with the effect of mutual induction (q.v.).

BALANCED DETECTORS—A term applied to an arrangement of opposed rectifying detectors for reducing the effects of strong stray in receiving apparatus. The detectors must be balanced for violent electro-motive forces, but not balanced for the moderate E. M. F.'s due to the signals. Actually, a method of eliminating stray impulses in reception.

BALANCED METALLIC CIRCUIT—A circuit through conductors (wire or any metal) in which the total resist-
BALANCING—Any device forkeeping the plates accurately balanced in rotation at all points. Fig. 1 shows a form known as the "balanced plate" type. In this case the plates are so arranged that half the movable plates are on one side and half on the other side of the shaft.

Fig. 1. A "Balanced-Plate" type Rotary Condenser.

Principle plan of the Baldwin Receiver unit.

BALDWIN RECEIVER—Perhaps the most sensitive type of telephone receiver thus far developed. It employs what is known as a "balanced armature," the signals being produced by the vibrations of a diaphragm which is not acted on directly by the magnets. The illustration shows the general plan of a receiver of this type. The armature (A) is of soft iron and is pivoted between two U-shaped soft iron pieces (M1, M2) mounted on the ring-shaped horseshoe magnet (M) as indicated. The armature is acted upon by the magnets in response to incoming signals and the movement of this element in turn acts on the mica diaphragm (D) by means of a fine brass wire (C). The usual windings (R) are placed between the two pole pieces, the armature being mounted in a central slot. These receivers are much used both for head-phones and for loud-speaker units. In the latter case the mica diaphragm is generally made heavier to handle the more powerful vibrations due to the amplification of the signals.

When no fluctuating impulses (signals) flow through the windings (R), there is no magnetic stress on the armature (A), because this member is suspended centrally between the pieces (M1) and (M2), the magnetic attraction of which are equal. Now when a fluctuating impulse flows through the windings (R) it produces a magnetic flux which combines with the flux of the permanent magnet (M) and the total flux is distributed symmetrically or unevenly on both sides of the armature. The result is a rocking vibratory movement to this member which is in turn communicated by the juncture wire (C) to the diaphragm (D), producing the audible signal.

For a comparison of this action with the conventional telephone receiver action, see Telephone Receiver.

BALKITE BATTERY CHARGER—An electrolytic battery charger which makes use of a sulphuric acid solution and tantalum as the valve metal. Used for charging storage batteries from alternating current. See illustration.

BALLOON TUBE—An automatic means of regulating the filament current of vacuum tubes. The device is enclosed in a glass tube and is arranged to permit passage of interfering current. When the electromotive force increases beyond normal, the increased current raises the temperature and hence the resistance, so that the current is held to the normal value.

B. and S.—abbreviation for Brown and Sharpe Gauge (q.v.).

BAND OF FREQUENCIES—A continuous range of frequencies extending between two frequencies. (See Band of Wavelengths; also Band Pass Filter.)

BAND PASS FILTER—A filter arrangement designed to permit passage of all frequencies extending between two definite frequencies but excluding all other frequencies. (See Band of Frequencies.)

BAND OF WAVE-LENGTHS—A continuous range of wave-lengths extending between two definite wave-lengths. For example, the usual broadcast band of wave-lengths is an approximately 250 meters to 550 meters.

BANKED BATTERY—A battery that has its cells connected in parallel.

BANK WINDING—A form of winding for coils in which the turns are staggered so that two or more layers may be used without having large distributed capacity losses. The illustration shows method of bank winding for two layers. Note that in this form the electrostatic capacity between any two turns is only that between adjacent turns, representing only a small part of the total winding, whereas on the usual form of winding the adjacent turns would represent a good portion of the total inductance and hence the effect of distributed capacity would then be much greater. (See Distributed Capacity.)

BARRETER—A receiving instrument consisting essentially of a small mass of conducting material that is heated by the passage of an oscillatory current, and arranged so that the consequent alteration of electrical conductivity affects an indicating instrument, such as a telephone receiver or galvanometer.

BASKET COIL—Variometers—couplers, etc. (See Basket Wound.)

BASKET WOUND—A method of winding coils, such as variometers or varicouplers. The winding is a latticework of wires in skeleton form, the object being to save weight and eliminate large losses such as occur in the

![Method of bank winding wire on a coil form.](attachment:method_of_bank_winding.png)

Photo by courtesy of Facelet Products Co. A Balkite Battery Charger.

Note: The name Balkite is derived from the name of the man who perfected the process of extraction of tantalum from its ores.
Battery

There are two types of "B" batteries, viz., the dry cell type and the storage type. In order to obtain the high voltage required for vacuum tube plates, many small cells are connected in series. The usual method is to connect them together and seal in a square package. Often taps are brought out so that various voltages may be obtained for critical vacuum tubes. The most popular voltages which dry cell storage types. In order to obtain the high voltage required for vacuum tube plates, many small cells are connected in series. The usual method is to connect them together and seal in a square package. Often taps are brought out so that various voltages may be obtained for critical vacuum tubes. The most popular voltages which dry cell

"B" batteries give are 22½ and 45 volts. The storage "B" battery is similar to the ordinary storage battery with the exception that the cells are much smaller, but contain more cells in series. These can be charged in the same manner as the "A" or storage battery. In Fig. 1, we have a popular type of "B" battery. This is tapped in order that different voltages may be obtained.

"B" BATTERY—An appliance for obtaining electricity of sufficient voltage to supply the plate of a vacuum tube. There are two types of "B" batteries, viz., the dry cell type and the

The manner of connecting up the "B" batteries in radio receiving is shown in Fig. 2. Here one battery of

life of the "B" battery as the drain on the battery is much less, i.e., only

one vacuum tube is operated on each battery.

BATTERY OF ALTERNATORS—In ordinary electrical work such as house lighting, several alternators for the production of alternating current may be used together as one source of power. Also in high-power radio transmission, several high-frequency alternators may be used together to produce added power. (See High-Frequency Alternator.)

BATTERY TESTING INSTRUMENTS—The various devices used for determining the condition of batteries used as radio apparatus. (See Ammeter, Voltmeter, also Hydrometer.)

BEAT FREQUENCY—The frequency or number of vibrations per second of a series of oscillations representing the difference between two other series having different frequencies. It is numerically equal to the difference between the original two series of oscillations. Thus, if we have a series of oscillations having a frequency of 100,000 cycles per second, and combine it with another series having a frequency of 90,000 or 110,000 cycles, the beat frequency will be 10,000 cycles or the difference between the other two frequencies.

X. The frequency of recurrence per second of either maximum of addition or minima of opposition of two superposed periodic phenomena having the same nature but of different frequencies. The time measure of vibration of a beat or heterodyne. (See Heterodyne, also Beats.)

BEATS—When two sets of oscillations of different frequencies occur in the same system, the difference in the frequency or rapidity of vibration causes a new set of oscillations having a frequency equal to the difference between the original two sets. This may be accidental as in the case of certain types of receivers such as the regenerative type, in which case the beat oscillations are undesired and cause interference or disturbances in the set. Then again a beat frequency may be purposely introduced as in the case of the Super-Heterodyne receiver. Here we have the natural incoming oscillations from the antenna combined with a series of oscillations produced locally in the system. The result is a new set of oscillations where the incoming series and the locally produced series are not of the same frequency. (For more complete explanation see Super-Heterodyne Receiver.)

X. Where two periodic phenomena are superposed or run together and
the frequencies differ, the gradual change in phase difference produces a condition wherein the amplitudes are in opposition at one instant and in concurrence at a later instant with the various intermediate stages during the interval. (See Heterodyne, also Beat Frequency.)

BEG OHM—A resistance of one billion ohms. (See Megohm.)

BELIN, EDOUARD—French scientist, the inventor of what is considered the first practical system of radio transmission of photographs. The device can be used for sending photos by cable or telephone lines as well as radio. (See Transmission of Photographs by Radio.)

BELL, Alexander Graham (1847-1922)—Scottish scientist. Born in Edinburgh, March 3rd, 1847, he was educated at the High School and University and graduated as a doctor of medicine. In 1870 he went to Canada, and in 1872 became professor of vocal physiology in the University of Boston. In 1876 he exhibited his apparatus for the transmission of sound, afterwards developed into the telephone.

Bell was experimenting with an electric invention by means of which he hoped to make speech visible to the deaf. A delicate metal reed was caused to vibrate by spoken speech and to transmit an electric current to the opposite end of a wire. The vibrations of the first reed were reproduced in a second reed by a magnet. He found that it was possible to transmit not merely vibrations of the original reed, but to reproduce the sound itself in the vibrations of the second reed. In 1878 he invented the photophone, to enable sound to be transmitted by variations on a beam of light, and later a phonograph. Bell was the author of many scientific papers, was awarded the Albert Medal of the Royal Society of Arts in 1902 and the Hughes Medal of the Royal Society in 1918. He died Aug. 2nd, 1922.

BELLI, Dr. Ettore—Born in Foligno, Italy, April 13th, 1876. Educated at the University of Naples. Noted as Electrical Engineer to the Royal Italian Navy, and chief of the Naval Electrical Laboratory at Venice. Joint inventor with Captain Tosi of the "Radio-goniometer" (q. v.), a device for finding the direction of transmitted radio signals.

BELLI-TOSI AERIAL—See Goniometer.

BELLI-TOSI DIRECTION FINDER—See Goniometer.

BEZEL—In mechanics, generally a groove and flange made to receive a beveled edge. In its adaptation to radio some liberty was taken with its real meaning. Its significance in this context is a small metal ring having a wire mesh or glass center. It is fitted into a circular hole in the panel of a radio receiver and used as a peep hole to enable the operator to know at all times the conditions of the tubes, whether or not they are properly lighted.

BILLI CONDENSER—A variable condenser of low capacity, consisting of two brass tubes, one of which is arranged to slide in and out of the other for the purpose of varying the capacity. Such condensers were much used before the days of broadcasting, in conjunction with any circuit using a crystal and battery for detector. This type of condenser has long been obsolete in the United States.

BINDING POST—A screw and nut arrangement on electric units and radio apparatus to make convenient connections from an external source to the desired point within the apparatus. Binding posts are provided, for instance, to make handy connections from batteries to the set and from the aerial and ground leads. The illustration shows a popular type of binding post.

BI-POLAR—Having two poles. Usually a dynamo or motor whose armature rotates between a field magnet having only two poles. The most modern types are of the Multi-polar variety. (See Bi-polar Magnetic Field.)

BI-POLAR ARMATURE WINDING—An armature wound in a manner to permit its use with a dynamo having a bi-polar magnetic field.

BI-POLAR MAGNETIC FIELD—The magnetic field (q.v.) created between two magnetic poles. The illustration shows a common form of bi-polar magnet for a dynamo. Bi-polar magnetic fields are now used as a rule only for direct current machines of low power, such as those under 5 Kilowatts. (See Dynamo, also Generator.)

BI-TELEPHONE RECEIVER—A headset with two receivers or phones as generally used in radio. In the early days of radio transmission it was the custom to use only one phone.

BLONDLOT, Andre—French electrical expert. Born at Chaumont, France, in 1863, he graduated at Paris University, and studied electric waves, on which subject he early contributed a number of papers to various scientific journals. In 1893 he invented the oscillograph, an instrument somewhat similar to a mirror galvanometer, for showing curves of oscillating or alternating currents. This invention opened up a fresh field in the study of alternating currents. In the same year Blondel explained for the first time mathematically the effect of inertia in the shunting of alternators. He is responsible for a system of acoustically sympathetic wireless telegraphy, and for directed waves produced by a double aerial. In 1902 he patented a method for producing electric oscillations for wireless telephony, and has written many papers on microphonic control for transmitters, wireless telephony, the singing arc, etc.

BLONDOT, Professor Prosper Rene—French wireless expert. Born at Nancy, France, in 1849, studied at...
PARIS, and became professor at the faculty of sciences, Nancy, and afterwards Honorary Professor and Correspondent of the Institute of France. Blondlot was famous for his studies of electro-magnetic waves, particularly with regard to their speed, and the laws of propagation of wireless waves in various media.

BLOWER-MOTOR—A motor-driven fan used to deliver a high pressure blast at the spark gap to prevent arcing. (See Spark Gap, also Spark Discharger.)

BLOWOUT—See Magnetic Blowout.

BLUE GLOW—A condition within a vacuum tube when the vacuum has become poor. After continued use a tube will often hold a small percentage of gas, which causes a blue glow when current is passed through it. A tube in this condition is a poor detector or amplifier and should be replaced. The condition should not be confused with the glow often caused by an excessive voltage. In this latter case decreasing the voltage to a normal value generally permit the tube to be operated efficiently. The blue glow in this case is due to the oscillation of the residual gas by the excessively high potential impressed across the elements of the tube.

BOARD OF TRADE UNIT—B.O.T. 1,000 Watt Hours. One and a third Horse Power.

BODY CAPACITY—The effect of the human body when tuning a radio receiving set. The hand when placed on or near the controls very often tunes the tube to a frequency in keeping with the incoming signals. In the case of very sharp tuning this effect is more evident and is likely to cause howls due to self-oscillation. The holding is due to the production of an audible beat frequency in the system, caused by the combination of the local oscillations with the incoming signal oscillations. The remedy may be to shield the panel with metal in some cases, or to merely alter the direction of the leads from the tuning condenser. The effect is seldom of much importance to the phenomena, as a little practice enables the listener-in to compensate for it.

BOLITHO CIRCUIT—A super-regenerative circuit patented in England in 1919 by Captain J. B. Bolitho. The circuit was originally intended to operate a relay device. The circuit has been adapted to use as an amplifier for radio reception.

In the illustration the phones may be replaced by a loud speaker or relay. In operation the plate is held at a point just below that where oscillation sets in by means of T2 which is excited by an oscillator placed in the plate circuit and coupled by means of coil L4 to the tuned grid circuit through L2 and L3, the coupling, as explained, being so arranged that tube T2 is always just below the oscillating point. A reaction coil L4 is placed in the plate circuit of T2, its inductance serving as to support the magnetic linkage between coils L2 and L3. The frequency of the generator O is lower than that of the received signal, and when this is ascertained, the grids of both tubes T1 and T2 are joined together and the tube T2 maintains the circuit in a receptive condition when tube T1 is tuned just below the oscillating point.

The oscillator O makes the plate of T2 alternately positive and negative with the following effect: When the plate of T2 is negatively charged there is no current in the grid circuit, this coil is therefore not affecting coils L2 and L3, and permitting tube T1 to build up self-oscillation. When the plate is made positive by the action of the oscillator, current flows through coil L4, and as it is coupled in opposition to coils L2 and L3 it neutralizes the coupling between L5 and L3 and prevents transfer of energy between the grid and plate circuits of the tube T1. This tends to stop the self oscillation and makes the circuit receptive to the energy (signal) produced by outside signals in the aerial coil L1. The frequency, of course, is determined by the frequency of the oscillator O. The system is especially adapted to the reception of continuous wave signals. (See Super-regenerative circuit, also Feed-back and Regenerative circuits.)

BOLOMETER-Type of Wheatstone Bridge having an easily heated resistance, such as a very fine wire in one arm. (See Wheatstone Bridge.)

BOOSTER—An expression signifying a small development in conjunction with main dynamo to temporarily raise, when necessary, its normal pressure. It is generally a small dynamo driven by a motor supplied with energy from the main generator and thus becomes in effect a continuous current transformer. Frequent use is made of the charging accumulators of a generating plant. The term “Boost” is also used to denote increase or a stepping-up of any electrical quantity. (See Amplification.)

BORNITE—A crystal rectifier much used in radio reception. It is a natural sulphide of iron and copper, having a metallic blue lustre. This mineral is used in combination with zincite or copper pyrites as a crystal detector. Such combinations are generally known as "crystal to crystal" detectors to distinguish them from the ordinary variety using one mineral and a wire contact.

BORON—A non-metallic chemical element used in radio as one of the electrodes for the T. Y. K. Arc. Chemical symbol B, atomic weight 11.0, specific gravity 2.6.

B. O. T.—The customary abbreviation for Board of Trade Unit. The unit represents 1,000 watt hours. (See Board of Trade Unit.)

BOX AERIAL—A term occasionally applied to loop aerials. (See Loop aerial, also Frame Aerial.)

BRADFIELD INSULATOR—A particular form of Lead-in insulator, consisting of an ebonite tube provided with zinc cone and ebonite spark discs, for breaking up continuous streams of rays running down outside which might cause the aerial to become grounded. The whole is held in position, half way through roof of operating room, by means of a stuffing box. The aerial is led in by means of a conducting rod through center of tube. (See Péticois insulator.)

BRANLY COHERER—Early form of Marconi Coherer. (See Coherer.)

BRANLY, EDOUARD—French radio expert. Born at Amiens, France, Oct. 23rd, 1844. He was educated at Paris and afterwards became Fellow of the University, doctor of physical science, and doctor of medicine. Branly early made a study of electro-magnetic waves, and in 1890 and 1891 patented methods of operating a local relay circuit from a distance by means of wireless waves. In 1900 he was awarded the Grand Prix by the International Jury of Superior Precept Instruction for his exhibition of radio-conductors. Branly is the author of his very extensive series of observations on the electrical conductivity of loosely packed metal filings, and he made the extremely important observation that an electric spark at a dis-
tance had the power of suddenly chang-
ing the electric conductivity of loose masses of powdered conductors. To Branly is due the coherer named af-

BRAUN, FERDINAND — Professor at
the University of Strasbourg, and one of
the leading world authorities on Ra-
dio transmission. As early as 1899,
Braun was granted a patent for closed
oscillating systems with an inductively
coupled antenna. The system was
claimed by Braun to possess a much
greater efficiency than the directly
coupled systems. The Braun transmit-
ting set was manufactured by Siemens
and Halske, consisted of a large coil
worked into an electrolytic interrupter,
set of Leyden jars, enclosed in a spark
gap, oscillation transformer wound
with insulated wire placed in oil, and
for the receiving set the standard type
of coherer relay and Morse register.
In 1899 Braun established communi-
cation between Cuxhaven and Heligoland,
using aerial wires 90 feet high, and
the inductive coupled aerial connection
for transmitting. In 1903 Braun joined
with Slaby, von Arco, and Siemens
to form the Telefunken system of trans-
mision. Professor Braun was awarded
the Nobel prize with Marconi in 1909,
for his work in wireless. Braun has de-
vised a method of directional wireless
which depends upon the interference
of electric waves travelling in the same
direction but different in phase. Three
simple vertical wire aerials are set up
in positions corresponding to the angu-
lar points of an equilateral triangle,
and oscillations are created in these
which differ from one another in phase.
In 1897 Professor Braun published a
description of his cathode ray tube,
and afterwards pointed out, in 1902, how
such a tube could be used to trace the
forms of alternating current waves.

BRITISH STANDARD WIRE GAUGE
—The standard wire gauge of Great
Britain. The table shows the various
diameters in thousandths of an inch
(mils.).

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BREAK or BREAKER — See Circuit
Breaker.

BREAKDOWN POTENTIAL or
BREAKDOWN VOLTAGE—The volt-
age necessary to break down or punc-
ture a dielectric. The ability of any
insulating material to resist breakdown
is an important matter. An insulator
or dielectric material is usually given
a certain rating or point above which
it is likely to fracture. Thus, a cond-
der may have a breakdown rating of
600 volts. That is to say that volt-
ages up to 500 and slightly over may
be handled with safety, but any large
increase above that figure may result
in puncture of the material by the

breakdown of dielectric—The same effect as referred to under

WIRE GAUGES IN MILS.

The fundamental principles of broad-
casting are essentially those of radio
transmission, with the addition of
means of combining the speech or
music vibrations with the regular radio
waves. First we have to consider the
radio waves of high-frequency—alter-
ning current or that changes in direc-
tion many thousands of times each
second. These high frequency waves
are known as the carrier waves. The
frequency of these waves varies ac-
cording to the length of the waves
(wavelength), in the case of American
broadcasting stations, being between
250 and 860 meters in most cases,
which means a frequency range of
approximately 550,000 to 1,200,000
cycles.

Now by means of a microphone, a
device similar in principle to the
mouthpiece of an ordinary telephone,
but designed to handle large currents, the air pressure waves, i.e., speech or music, are converted into variations of electric current. By use of suitable amplifying apparatus, the strength of the electric waves radiated from the antenna is varied to correspond electrically to the acoustic or sound variations due to the speech or music being impressed on the microphone. The speech or music waves are low frequency waves, generally ranging between 100 and 4000 per second. Thus, while the carrier wave oscillations are of high frequency, the variations in it are low frequency, corresponding to the ordinary speech or music vibrations.

The process of varying the radiated wave in accordance with the sound waves is known as modulation. This adjustment is of the utmost importance, as defects here result in distorted or improperly modulated sound waves and the reproduction cannot be perfect. The reception of broadcast programs is essentially the same as that of ordinary radio signals, with the exception that care must be used at the receiving end to preserve the form of the original vibrations. When dot and dash signals are received, the tone is of comparatively little importance, whereas with voice or music it is essential that the tone quality be retained.

In broadcasting the high frequency oscillations are produced by means of a tube or group of tubes, practically identical with those used for reception, but designed to handle large currents and voltages. The majority of American stations use vacuum tubes of 250 watts power rating, one or more of them being used to obtain the total power required. These tubes are shown in the illustration, Fig. 1.

When a program is being broadcast, the operation is somewhat as follows: The artists are disposed before the microphone with due regard to the effect of certain instruments. That is to say, one type of instrument may be placed near the microphone, while another must be placed farther away, owing to the differences in tone and volume. This is done to prevent any one tone or range of tones from predominating. These speech or music currents are converted into electrical variations by the microphone and then increased many times in power or amplitude by means of a speech amplifier system, comprising vacuum tubes and the necessary associated circuits.

These amplified currents are applied to the grid of a control tube or bank of tubes and result in large variations in the plate current of the tubes. (See Theory of Vacuum Tube.) The control tubes are supplied with filament current from storage batteries or special low voltage D. C. generators, and the high voltage applied to the plates of the tubes is furnished by generators. This power will vary in most cases from about 1,000 to 5,000 volts. In some broadcasting stations, the power is obtained through high voltage direct current generators, while in others, the alternating current supply is stepped up or transformed through high voltage transformers and then rectified by means of special vacuum tubes.

The high frequency waves are applied to the antenna system tuned circuits and carefully modulated in accordance with the variations of the speech or music being transmitted. The action of the transmitter and the effect of the modulation must be carefully observed at all times during the transmission of programs. (See Harmonic Suppressor, also Oscillograph.) Fig. 2 shows the studio of a modern broadcasting station. It is interesting to note that these studios are very carefully arranged and the walls cushioned to prevent troublesome acoustic effects. There must be no reverberation—echoes—or the transmitted program would be distorted by the additional or repeated tones. Fig. 3 shows the main control panels. Fig. 4 illustrates the power generating system of a typical broadcasting station.

The radio waves generated and radiated from the broadcasting station travel away from the antenna at tremendous speed—that of light waves, or about 186,000 miles per second. These waves radiate off into space in
BROWN AMPLIFYING RELAY — An arrangement whereby the comparatively weak signals received by a crystal detector, usually of the carbon-radium type, may be amplified or increased in intensity, either to allow a recording machine to be used or merely to make the signals more readily audible in the ear phones. The device consists essentially of an arrangement for controlling and stepping up the vibrations in conjunction with a small battery or dry cell.

One example of such a relay is shown in the illustration. In this case the soft iron cores cc are magnetized by the passing currents, and the poles of which are marked n and s. R1 is a fine wire winding such as is ordinarily used in ear phones and R2 is a larger winding placed over the main magnets mm. Directly above the soft core cc with the windings R1 is placed an iron piece forming a contact D which touches lightly contact G. Contact G is of a special alloy of osmium and iridium and contact D is a piece of copper gauze, which in contact with G forms a microphone. The winding R2 is joined with the telephone P and the battery B, all in series with the microphone contact. When current (signal current) enters the leads A—E through the windings R1 the result is a change of flux in the core of the magnet which vibrates the tongue V. This in turn varies the current of the battery B and causes correspondingly greater sounds in the ear phones. These relays may be connected together to permit a much greater amplification of the original signals.

BROWN SHARPE GAUGE — The American wire gauge adopted as standard for wires for electrical purposes. Commonly known as B & S. The various sizes range from 40 to 0000, 46 having a diameter of .00314 inch and 0000 being .0005 inches in diameter. We refer to wire having a diameter of .00314 inch as being 40 B. & S. gauge. (See page 26 for table.)

BROWN, Sidney George—Born in Chicago, U. S. A., in 1873, of English parents, he was educated at Harrogate and London University. An early study was made by him of the subject of submarine telegraphy. During the investigations he invented the magnifying relay for cables. Another important invention is the table drum relay. In the year 1898 he invented the magneto shunt. Since that time many of his activities have been directed toward solving problems in telephone and wireless telegraphy.

In particular the radio experimenter will know the telephone receivers bearing his name and the important developments of the microphone relay. In the field of land telegraphy and telephony, his activities have resulted in the invention of such items as the carbon telephone relay system, which is largely used for land lines for both transmission and reception of telephony.

He is a Fellow of the Royal Society and Vice-President of the British Society of Great Britain. His writings on technical subjects are extensive, and numerous valuable patents have been taken out by him, including the vacuum tube oscillator and amplifier in 1916 and the carbon relay in 1918.

BRUSH—A device for collecting current from the commutator (q.v.) of a dynamo or supplying current to the commutator of a dynamo which is made up of a group of forms, the most common being carbon blocks or brass copper gauge. The illustration shows two different types. 

BRUSH ANGLE—The angle formed by a brush in its contact with the commutator. The angle is usually 45°. If the brushes do not bed properly, sparking is apt to occur.

BRUSH DISCHARGE—A faintly luminous discharge which takes place on the surface of conductors charged to high potential. Such discharge is often seen when the electric supply is first put on. This effect can be noted at times on the antenna of a powerful transmitting station. (See Corona.)

BRUSH HOLDING—Metal clamp capable of adjustment which holds the brush in position on the commutator of a dynamo or motor. (See Brush.)

BRUSH LOSS—The loss in watts or power due to the friction of the brushes against the commutator. This loss is at a minimum when the brushes make perfect contact at the proper angle.

BRUSH PRESSURE—A term used to designate the pressure with which the brushes bear on the commutator of a dynamo machine and the corresponding relationship to the voltage or electrical pressure delivered at the brushes.

B. S. G.—Abbreviation for British Standard Gauge of Wire, commonly known as B. & S. (See British Standard Wire Gauge.)

B. T. U.—Abbreviation for "British Thermal Unit," being the commonly used heat unit. The amount of heat required to raise the temperature of one pound of water one degree Fahrenheit at ordinary atmospheric pressure.

BUCHER, Elmer B.—Born Akron, Ohio, Nov. 11, 1885. Educated at Ohio State University, and private tutors. An American pioneer, Experimental Engineer with DeForest Wireless Telephone Company in 1903; constructed several high power stations in Middle West and Gulf Coast and later for United Wireless, which absorbed the DeForest Company, organized training school for United Wireless and instituted first radio schools for Y. M. C. A. in New York City. Supervised commercial operations and conducted research work for United Wireless; later instructing engineer Marconi Wireless Tel. Co. Technical Editor "Wireless Age" 1913 to 1919. Appointed California Engineer for newly formed Radio Corporation of America in 1920, and since 1922 has been in charge of general sales for that corporation. Author of numerous standard works on radio, including "Practical Wireless Telegraphy," "Wireless Experimenters' Manual," "Vacuum Tubes in Wireless Communication," and many others. Has numerous patents on radio systems and devices.

BUCKLED DIAPHRAGM—Warping of the diaphragm of a phone as used in radio. Excessive voltages if applied directly to the head-phones will expand the diaphragms. Any such defect may necessarily impair the operation of the part and it would be only in the case of a diaphragm that is bent or warped through rough usage or the application of too great voltages, it is best to replace it immediately.

BUCKLING OF PLATES—During discharge of a storage battery the plates gradually expand, owing to the fact that lead sulphate has about twice the volume of the same quantity of lead peroxide. Should this expansion or discharge take place too quickly, the plates will bend or buckle. (See Storage Battery.)

BUNSEN BURNER—A form of gas burner frequently used in radio construction for heating the soldering iron without electricity. An eligible, satisfactory arrangement of the parts, the gas is combined with the proper amount of air before the hot burning part. This is done by driving the gas through a tube with small holes drilled along its length. This method promotes complete combustion and gives a non-luminous flame that heats the soldering iron without
THE BROWN & SHARPE (B. & S.) COPPER WIRE GAUGE—Below is a comprehensive copper wire table, which is the standard one in use in the United States. The resistance and cross-sectional areas of various sizes of conductors are given, so that considerable calculating can be done with the data at hand. A mil means 1/1000 (one thousandth) of an inch. Hence a wire with a diameter of 9 thousandths of an inch could also be stated as having a diameter of 9 mils. The area of cross-section of the wire in circular mils is found by squaring the diameter in mils; thus the 9 mil conductor would have 9 times 9, or 81 circular mils area. This is the end area of the wire, of course, and is used in all electrical figuring. If the resistance per 1,000 feet of a certain size wire is, say, 50 ohms, then 500 feet of the same size wire would have a proportionately less amount of resistance, or ½ of 59 ohms, that is, 26 ohms. The resistance per foot is found by dividing the resistance in ohms per 1,000 feet by 1,000. This wire table is for bare copper wire. Conductors, according to the B. & S. standard gauge, have their sectional area in circular mils (Cir. Mils) for every 3 gauge sizes smaller wire; and double their sectional area in Circ. Mils for every 8 gauge sizes increase.

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BURSTYN, Dr. W.—Born in Austria, 1877. Educated at Vienna University. Noted as: Developer of the quenched spark method of radio transmission, upon which he worked in conjunction with Baron Lepel in 1907 to 1912.

BUS BAR—A single bar, usually copper, which serves as a common connector for a number of pieces of apparatus. Also referred to as Omnibus Bar.

BUS BAR WIRE—Square copper wire, usually tinned, much used in making radio connections. This wire is generally furnished in lengths of two or two and a half feet and is particularly efficient for radio work, as it offers a low resistance connection, makes a neat appearance, and is suitable for soldering at joints.

BUSHING—Pieces of insulating material, usually fibre or rubber composition, used to insulate parts of radio apparatus or in mounting machine screws or shafts of condensers and other devices. In this term is also applied to brass or other metal bearings through which the shaft of a piece of apparatus is run.

BUTT JOINT—A method joining two lengths of wire together by placing them end to end or at right angles and soldering the joint. The illustration shows a common butt joint.

BUZZER—An electric call signal device that makes a buzzing noise caused by the rapid vibrations of a contact breaker in a circuit using a small battery or cell. (See Testing Circuit.)

As the current flows from the posts A B the electro-magnets C and D are energized and draw down the vibrator spring F. This breaks the contact between E and F and as the current no longer flows the magnets release the spring F, which returns to its normal position and establishes the circuit once more. This making and breaking of the circuit takes place so rapidly that the vibrator makes a buzzing or humming sound, the speed with which it vibrates determining the pitch of the note. (See Frequency, also Vibration.)

BUZZER EXCITER—A method of using a buzzer to produce local signals in a crystal receiving circuit or to permit sensitive adjustment of the detector. The illustration shows a common method of producing signals to test the receiving set in this manner. In this case a small coil having a few turns of wire is placed in the buzzer circuit as indicated and a small one is placed in the ground lead of the receiving set. When the button is depressed the buzzer is set in vibration and a transfer of energy takes place between L1 and L2. This causes an oscillating impulse (q.v.) to flow through the receiver circuit. The detector can then be adjusted to the most sensitive point at which it can be left until outside signals are heard. Another but less efficient method of exciting the circuit is to connect a short length of wire from the contact point of the buzzer to the ground connection of the receiving set. The former system is much more practical and furnishes better test signals.

A diagram of a buzzer circuit.

CALCULATION OF CAPACITY—The mathematical or comparative determination of capacity. There are various formulas in use for calculating capacity under various conditions, such as for capacity of various types of condensers, or the capacity of a circuit. Rough approximations of capacity of condensers might be obtained by direct comparison with a known value. Other formulas are used for the calculation of antenna capacity. For determining the capacity of flat condensers, such as fixed condensers used in transmitting or receiving circuits, the following formula is generally used:

\[
S = 0.0085 K \frac{A}{r}
\]

In this case, \(S\) is the capacity in micro-microfarads; \(K\) the result in the usual units of micro-farads, divide the result by one million. \(A\) is the surface area of one plate in square centimeters; \(r\) is the thickness of the dielectric in centimeters and \(K\) a constant depending on the material between the plates of the condenser. (See Dielectric Constants.)

CAL-ELECTRICITY—Electricity produced in the secondary of a transformer due to changes in temperature of the core. This current is in addition to the current normally induced in the secondary. (See Transformer, Core, also Core Losses.)

CALIBRATION—A process whereby instruments such as galvanometers, ammeters, voltmeters, etc., are made to indicate certain values. Before such...
CALIDO

instruments can be made use of, it is necessary to mark the dials in such a manner that the indicator showing on the dial or scale will have a definite meaning in terms of electrical values. Thus, a voltmeter before calibration is shown in Fig. 1. When it is placed across a battery, the pointer will move to some position on the white space, but without indicating any definite value. Now by testing with another meter which is already marked or calibrated in volts, we find, for example, that when the pointer is at the middle point in its swing, it indicates 10 volts. Similarly various other positions are found to indicate one-half or one-third voltage by comparison with the standard. This is shown in Fig. 2. It will be understood that one of the small switches must be open at all times. The reading of the calibrated meter is taken with the other meter out of the circuit (switch open), then the reading is marked on the other meter at the point indicated with the calibrated meter of the same scale. Such a procedure can be followed throughout the entire range of the dial, and when thus marked in terms of a definite scale—a wavelength in meters in this case—the dial is said to be calibrated.

CALIDO—An alloy containing nickel and chromium with a small percentage of iron. The melting point is very high, about 1560 degrees centigrade. Calido wire is much used as a resistance, particularly for heating devices. The chief characteristic is as follows: maximum working temperature 1100 degrees centigrade; microhms per cubic centimeter degree centigrade, 100; temperature coefficient per degree centigrade, 0.0003; specific gravity, 8.2.

CALLAND CELL—A primary cell used in French telegraph work. It is a form of gravity cell having a negative electrode of copper and a positive electrode of amalgamated zinc, the electrolyte being zinc chloride. The cells of being water; the cupels per sulphate are used as a depolarizer. (See Gravity Battery.)

CALORIMETER—In electrical practice, an instrument used to measure the heat generated in a conductor carrying an electric current.

CAMBRIC, VARNISHED—Varnished muslin used for insulating. Also known as Empire Cloth. (See Spaghetti.)

CANAL RAYS—When an electric discharge takes place between the anode and a perforated cathode in a vacuum tube, fine pencils of light are seen to pass through the perforations in the cathode. These rays are called canal rays, and consist of positively charged particles. They produce phosphorescence on the wall of the tube.

Canal rays travel at a lesser velocity and in the opposite direction to the cathode rays. This fact and also the fact that the rays are deflected by powerulf electric or magnetic fields in the opposite direction to cathode rays, is taken as proof that they consist of positively charged particles. (See Cathode Rays.)

CAPACITANCE—A term very often used as synonymous with capacity. Due to the fact that capacitance may refer to the current carrying ability of a conductor and also to electrostatic capacity, it has been suggested that capacitance be used to refer only to electrostatic capacity of a body or device. Capacity would then refer to current carrying ability. (See Capacity, also Electrostatic.)

CAPACITIVE REACTANCE—That part of the reactance of a circuit carrying alternating current which is due to the capacity in the circuit. (See Reactance also Impedance.)

CAPACITIVE COUPLING—See Coupling.

CAPACITY—Generally speaking, the quantity of electricity in any form which a body is able to store or contain. The term is usually qualified to denote the particular case, such as electrostatic capacity, which is a measure of the ability a condenser to store energy in the form of electrostatic charges; also current-carrying capacity of a conductor, which is considered to be the ability of a wire to carry a certain amount of electric current without overheating. The tendency in electrical literature is generally to term capacitance as applying to the electrostatic capacity of a condenser. Thus, a certain condenser may have a capacitance of 2 micro-farads. The unit of electrostatic capacity is the farad. This is understood as the capacity of a condenser that will store one coulomb of electricity under an electromotive force of one volt. When V is expressed in volts, C in farads, and Q in coulombs, \[ C = \frac{Q}{V} \].

CAPACITY CIRCUIT—An electrical circuit in which the capacity is very large compared with the inductance. The inductance may be considered negligible.

CAPACITY CONVERSION FACTORS—In the calculation of capacity, as the capacity of a condenser, there are several different units. For instance, a farad is a large unit of capacity and is equal to one million microfarads, or conversely, a microfarad is equal to one millionth of a farad. In the same way a farad is equal to one billionth of an abfarad. The four units used in capacity measurement are the farad, microf,arad, micromicrofarad, stat farad and abfarad. The following gives the conversion factors for these various units:

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Conversion Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 farad</td>
<td>10^12 stfd.</td>
</tr>
<tr>
<td>1 abfarad</td>
<td>10^12 stfd.</td>
</tr>
<tr>
<td>1 microfarad</td>
<td>10^9 stfd.</td>
</tr>
<tr>
<td>1 milifarad</td>
<td>10^6 stfd.</td>
</tr>
<tr>
<td>1 picofarad</td>
<td>10^3 stfd.</td>
</tr>
</tbody>
</table>

In the table above, farad is abbreviated Fd.; abfarad is shown as abfd.; microfarad is mfd.; micromicrofarad is mmfd. and statfarad is stfd. In dealing with large figures containing many ciphers the amount is shown as 1,000,000 is 10^6 and 1,000,000,000 is 10^9, etc. (See Capacity, Farad, also Unit.)

CAPACITY EARTH OR GROUND—A substitute for the usual ground connection where the wires or plates are buried beneath the ground or attached to a water pipe. It is in effect a second aerial, and is placed either under the regular aerial or to one side. It is more used in radio transmission than in reception. (See Counterpoise.)

CAPACITY ELECTROSTATIC—See Capacity also Electrostatic Capacity.

CAPACITY FREQUENCY FACTOR—The relation between the apparent capacity of a condenser and its electrostatic capacity. (See Capacity, Condenser also Electrostatic.)

CAPACITY OF CONDENSERS IN PARALLEL—When several condensers are connected in parallel the resultant capacity is the sum of the individual capacities. It is written:

\[ C = C_1 + C_2 + C_3 \], etc.

It will be noticed that this resultant capacity of condensers connected in parallel is just the reverse of case for resistances, where the total resistance is less than that of the individual resistance in the parallel connection. (See Resistance Measurement also Capacity of Condenser in Series, also Condensers in Series and Condensers in Parallel.)
CAPACITY OF CONDENSERS IN SERIES—When several condensers are connected in series with each other the resultant capacity is always less than the capacity of the smallest condenser in the group. The capacity of condensers in series is given as follows:

\[
\text{Capacity} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \cdots + \frac{1}{C_n}}.
\]

The resultant capacity is thus the reciprocal of the sum of the reciprocals of the several capacities. (See Condenser, In Series.)

CAPACITY MEASUREMENT OF ANTENNA—A simple method for the measurement of the capacity of an antenna as given by Austin follows: The illustrations show the general arrangement. The inductance \( L \) in Fig. A is a coil that will increase the wavelength (natural) of the antenna system 4 or 5 times; \( C \) is a calibrated variable condenser and \( w \) a standard wavemeter. In operation the coil \( L \) is connected in the antenna circuit, the buzzer is used to excite the antenna circuit and the wavelength is measured by \( w \). The coil \( L \) is then taken out of the antenna circuit and shunted by the condenser \( C \). The condenser \( C \) is then varied until the wavelength of the combined coil \( L \) and condenser \( C \) is the same as that obtained before with the coil in the antenna circuit but without the variable condenser. The capacity of the condenser now will be approximately that of the antenna, ignoring the distributed inductance of the antenna system. Fig. A shows the first operation, the measurement of the antenna with the coil in the circuit, and Fig. B shows the measurement of the wavelength of the coil and condenser. (See Mutual Capacity, Wavemeter, Natural Wavelength, also Distributed Capacity.)

CAPACITY MUTUAL—See Mutual Capacity.

CAPACITY RESISTANCE—The resistance to alternating currents offered by a body possessing electric capacity. (See Capacity, also Resistance.)

CAPACITY SWITCH—Any switch used in a circuit to introduce or cut out capacity (condenser).

CAPACITY (UNIT OF)—The unit of capacity is the farad. A condenser has a capacity of 1 farad when 1 coulomb is required to raise its potential from zero to 1 volt. Since the farad is very large, its millionth part, or the microfarad is generally used.

CARBON—A non-metallic chemical element used for many purposes in electricity and radio. It exists in three forms, two crystalline and one non-crystalline. The first two are diamond and granulite, the third charcoal. Carbon is used as an electrolyte in a electric arc, as one of the poles in certain types of primary cells, as a material in place of wire for various forms of resistance, and as brush in motors and generators. (See Diaphragm, Carbon.)

CARBON RHEOSTAT—A rheostat or variable resistance using carbon in place of the customary wire. In its simplest form a carbon rheostat may be merely a piece of carbon having a sliding contact. This is shown in Fig. 1. Owing to the relatively high resistance of carbon used in this manner, such a controlling resistance will generally be termed a potentiometer (q.v.) and used as such.

The most practical form of a carbon rheostat is known as a carbon pile rheostat. This type uses a number of flat pieces of carbon of relatively low resistance placed together and arranged with a knob and screw in such manner that the pressure can be varied. This change in pressure alters the resistance of the mass and allows control of the current for vacuum tubes. This same principle is used for very high resistances of several megohms.

CARBORUNDUM—An abrasive material, a product of the furnace composed of silica and carbon. It is used in radio as a crystal rectifier, although the stray of radio has practically rendered it obsolete, many other better crystals being in use. The chief difficulty with its use as a rectifier or crystal detector was the fact that for efficient operation it required a cell or battery and potentiometer to regulate the current flowing through it. The simple crystal circuit using a carborundum detector is shown in the illustration. A is a tuning coil, \( D \) the carborundum crystal and contact, \( P \) a potentiometer and \( T \) the head phones. (See Rectifier, also Detector.)

CARDBOARD TUBING—Tubing made of laminations of paper pasted together. They are used for home made coils of all descriptions, and while not as efficient as the composition tubing, can be used for many purposes without any great loss. As a general rule it is better to use some of the numerous compositions, such as bakelite or rubber compounds.

CARPENTIER, JULES—French radio expert. Born in Paris, in 1854, he joined the Ecole Polytechnique in 1871, and in 1876 was appointed principal stores engineer of the Lyons Railway Company, making a special study of electricity. For his work in electricity he was honored in 1887 with the Legion of Honor. One of the early pioneers of radio in France, he founded the Compagnie Générale de Radiotelegraphie, afterwards absorbed in the Compagnie Generale de Telegraphe sans Fil. Carpenter is a member of the Academie des Sciences, Commander of the Legion of Honor, and President of many scientific societies.

CARRIER WAVE—The continuous wave (q.v.) of radio frequency generally thought of as carrying music waves from the radio broadcasting station. Actually it is a radio wave of high frequency, which is altered in amplitude by the number of speech transmitted. In action, this continuous wave has another wave superimposed on it. This other wave having wave form and amplitudes determined by the voice or other sounds being transmitted. The illustration shows the carrier wave, the waves representing speech or music and the combination of the two. This effect of varying the amplitude or strength of a continuous wave by means of some sort of program is known as modulation. (q.v.) The wave representing the speech or music is imposed on the car-
CARRYING CAPACITY—See Current Carrying Capacity.

CARTRIDGE FUSE—A fuse in which the fuse wire is surrounded by some non-inflammable substance, enclosed in a cartridge-like tube and having brass lugs soldered to caps at ends. Used to prevent the hot wire from "flying" when fused. (See Fuse.)

CASCADE—A term applied to pieces of apparatus connected together in series, particularly vacuum tubes. In this case, the arrangement would be such that each vacuum tube would amplify the signal output of the preceding tube. The tubes will be so connected that the output of one is introduced as input to the next and so on the total result being greatly increased signal strength from the output of the last tube. This term may apply to either radio frequency or audio frequency amplification. (See Amplifier, Radio Frequency, also Audio Frequency.) A simple cascade arrangement is shown in the illustration. Fig. 1 is a circuit with two stages of cascade radio frequency amplification, and Fig. 2 a circuit using two stages of audio frequency amplification with the usual detector tube in each case. A combination of both radio frequency and audio frequency stages of amplification might also be used, the term cascade amplification also applying here.

CATHODE or KATHODE—A negative electrode. The term is often applied to the filament of a vacuum tube to distinguish it from the anode or plate. (See Cell, Electrolysis, also Anode.)

CATHODE RAY TUBE—A vacuum tube having a high vacuum, that is from which practically all air has been exhausted, used in the production of a cathode rays. These tubes in their modern form are used for many purposes in studying the nature and form of electric waves. The illustration shows one of the latest types of tube, known as the Cathode Ray Oscillograph. This tube is used for the following purposes: examination of the wave forms of various rectifiers, study of wave forms of different types of generators, study of vacuum tube characteristics, examination of the characteristics of X-ray and other types of tubes, examination of radio frequency waves modulated as in broadcasting, measurement of hysteresis and dielectric loss in various materials, study of phenomena in arcs and sparks, together with numerous other associated effects.

The development of this tube is one of the marvels of science, enabling the research engineer to virtually see the electric wave, and to study exhaustively, electric phenomena otherwise invisible.

The Western Electric modification of the Braun Cathode ray tube or oscillograph, is a three electrode glass tube about 30 centimeters (about twelve inches) long, in the form of a cylinder an inch and three-quarters wide, shaped out in conical shape, the tube being about three and a half inches wide at the top. The cathode is a filament coated with active oxides and arranged to emit the number of electrons required for the cathode ray at a dull red heat. The anode or plate is a small platinum tube set very near the filament. Between the filament and the anodes is a small circular screen having a hole just a little smaller than the circular filament. A battery of several hundred volts is connected between the filament and plates with the positive terminal connected to the plate. The electrons emitted from the hot filament are controlled by this field in the same manner as in an ordinary vacuum tube. A small portion of these electrons pass completely through the tubular anode and constitute the cathode rays. These rays are passed between two pairs of deflecting plates set at right angles to each other, and fly against the large end of the tube. This end is covered with a fluorescent mixture which renders the rays visible. These rays are deflected in various ways. For example, if an alternating current is applied the visible spot on the screen will be drawn out into a line. (See Electron, Vacuum Tube, also Wave Analysis.)

CATHODE RAYS—The stream of electrons or electrical particles sent out from the cathode or filament of a vacuum tube. These rays are negatively charged. (See Cathode, Electrons, Vacuum Tube also Oscillograph.)

CAT-WHISKER—The fine wire used with certain crystal detectors to make contact with the crystal. Usually a springy metal such as phosphor bronze wire.

"C" BATTERY—One or more small cells having a voltage generally between 2 and 10 volts, used in the grid...
Circuit of an amplifier tube for the purpose of improving a negative potential on the grid of the tube. The method of connecting it in the circuit is shown in Fig. 2. Fig. 1 shows a typical 4½ volt "C" battery. (See also Grid Bias and "C" Battery Curve.)

"C" Battery Curve—In order to show the effect of a "C" battery on the consumption of current from the "B" battery in an audio amplifier, a curve (q.v.) may be drawn as in the illustration. In this case the test was made with a type UV 201A tube used as a one stage audio frequency amplifier in a conventional circuit. It is readily apparent on referring to the lines A and B that when the "C" battery is in use the consumption of current by the plate is much less than without it.

Cell—A cell is one of the four chief sources of electric energy. In a cell the energy is created by an electro-chemical process, using in its simple form two unlike metals immersed in a dilute acid or alkaline solution. In the illustration Fig. 1 the common form of electric cell is shown. C is a strip of carbon and Z a strip of zinc. These are placed in a jar in a conducting solution of sal ammoniac. If the exposed terminals from the carbon and zinc strips are connected together by a piece of wire, current will flow from one side of the cell to the other through the wire. The current flows from the carbon or positive pole to the negative pole of the cell.

In Fig. 2 a simple storage cell or secondary cell is shown. In this case the energy of the primary cell has been transferred to the secondary cell and stored in it. This process of placing electric charges in a secondary cell is known as charging, and the current stored up in it is known as the charge. Now, if the wire is connected from one terminal to the other it will be found that electric energy can be withdrawn in a similar manner to that of the primary cell. A secondary cell may contain several plates and several of these cells may be connected together to form a storage battery. (See Storage Battery, Current, Production of, also Anode and Cathode.)

Cell, Secondary

When a primary cell is connected to a storage or secondary cell, the current from the primary cell flows into the secondary cell and in effect deposit energy in that cell. Then when the charging force (the primary cell) is withdrawn, the secondary cell can be used in practically the same manner as the primary cell. A wire connected from one terminal to the other will permit passage of current. The action of storing up energy in a storage cell is approximately as follows: When the charging current flows from plate to plate through the solution in the secondary or storage cell, the plate connected to the positive (+) pole (carbon or copper) of the primary cell, receives a brown coating of peroxide of lead. At the same time the other plate becomes spongy or porous. Now if one plate has received a coating while the other remains unchanged as far as its surface is concerned—it acts as a primary cell if the charging source is taken away and the two terminals connected. It now has all the essentials of an ordinary chemical cell. As long as the coating of peroxide of lead remains on the surface of one of the plates, the cell will be capable of delivering current. When the coating has been worn off or eaten away the cell is said to be in a discharged condition. It will then be necessary to go through the same process of connecting a primary source to the terminals in order to again deposit peroxide of lead on one plate. It will therefore be evident that when the storage cell is charged, current is not actually stored in it, although in effect it has received potential energy. What has actually occurred is that the current supplied to the cell during the charging process has produced electro-chemical changes, making the plates dissimilar and thus producing a difference of potential. (See Current, Production of.) The voltage or electro-motive force of primary cells varies from .60 to 1.5 volts according to the nature of the elements used and the
grade of the electrolyte (q.v.). Secondary or storage cells of the lead plate type produce from 2.1 to 2.3 volts.

For the examination of the theory and action of a secondary cell, see Storage Battery. See also Electrochemistry, Lead Battery and Voltaic Cell.

CELL, THEORY OF PRIMARY.—It has been explained under the heading Cell, that a primary cell produces electrical energy by chemical action. The apparent action of a single cell is as follows: When the copper and zinc, or carbon and zinc placed in a cell are connected by a conductor (wire or other conducting object) the acid in the case of a sulphuric acid solution furnishes the electro-motive force required to cause the flow of current between the plates. When the solution is renewed or the current is maintained, the system is self-sustaining. For the completion of this circuit a conductor is necessary, which furnished by the electro-motive force required to cause the flow of current between the plates. When the solution is renewed or the current is maintained, the system is self-sustaining. When a cell is used it is a unit of electricity, and when a system of cells is used, it is a unit of work. The unit of work is the ampere.
taken into consideration. The plates of a storage battery require certain charging rates in amperes, depending on the number of the plates. That is to say, the manufacturer specifies that when charging, a certain number of amperes must be passed to the battery in this charging voltage source for a definite number of hours. This figure may be decreased but not increased. An unduly large storage battery will take a charge of five amperes without injury to the plates, which rate would be suitable for other batteries. Now the question of obtaining the proper amount of charging current arises. The majority of house lighting systems are equipped to deliver a voltage of from 110 to 125 volts. (Reference is now made only to direct current systems, alternating current chargers being taken up later on.) According to Ohm's Law (q.v.) the current flowing in a circuit is directly proportional to the voltage and inversely proportional to the resistance. Voltage is the product of resistance and the voltage or current in amperes. Therefore if we desire a current of five amperes from a source of 110 volts we have a resistance of about 22 ohms. Similarly we have a resistance of a value in ohms which, when multiplied by the current in amperes, will give the voltage in volts. In this case we have 110 volts. Conversely, we can divide the voltage—110 by the current—5 to obtain the current resistance of the battery. This would indicate a resistance of 22 ohms. There is another factor which enters into the problem however, the back pressure, or Counter Electromotive Force exerted on the charging source by the battery. In the case of a six volt storage battery this will be six volts. This must be subtracted from the voltage of the charging source to obtain the effective value of the source. The effective value in this case would be 110 — 6 or 104 volts. Then as explained before, dividing the voltage by the current required, we find that it is 104 ÷ 5 or approximately 21 ohms. Then by placing a resistance of 21 ohms in the circuit, as shown in the illustration, and connecting the battery as indicated, a charge of five amperes can be applied to the battery. Thus, the battery will be charging itself free of any auxiliary equipment by placing an ordinary electric lamp in series in place of the resistance. (See Lamp). The internal resistance of the battery is very small compared to that of the line resistance, and can be ignored. A point to remember is that the voltage of the charging source must always be higher than that of the storage battery, because, as explained above, the back or counter electromotive force of the battery, must be subtracted from the voltage of the charging source to indicate the effective voltage. Thus, if the battery exerts a counter electromotive force of six volts and the charging voltage source is only six volts the counter force would be equal to the charging force and there would be no charging current. When direct current is not available and alternating current is used to charge the battery, it will be necessary to change it to direct current. For this purpose it is essential that the charging source be used. This rectifier may be of a chemical, mechanical or electrical type. These various rectifier types are treated under their separate headings. (See Rectifier, Ballole, Tungst, Rectigon, Electrolytic Rectifier, Tube Rectifier.) CHARGING.—The act of expending electrical energy to place charge in or on a battery or body. The term is used generally to indicate the process of impressing electrical energy on the storage battery elements for the purpose of making the battery a secondary source of electricity. (See Charger, Chemical Rectifier, Tube Rectifier.) CHARGING BOARD.—A term used synonymously with charging panel to denote an arrangement for controlling the charging of storage batteries. It generally consists of an insulated panel with various switches, fuses and resistances thereon to limit the amount of current delivered, and at the same time furnish a ready means of connecting and disconnecting the various circuits connected through it. The fuses act as safety devices and break the circuit when too great a current is delivered. (See Fuse, Switch, Charger.) CHEMICAL RECTIFIER.—Device for charging alternating current to direct current. (See Electrophic Rectifier.) CHLORIDE BATTERY.—A type of storage battery for heavy duty operation. The positive plate is made of lead with a number of holes pierced in it and each filled with a coil of pure lead. The coil is forced into the holes during manufacture and is said to enable the battery to withstand heavy discharge without damage to the plates. (See Storage Battery.) CHLORIDE CELL.—A cell (q.v.) which uses in most cases, a positive plate having lead as the active material, the negative plate being made of metallic zinc. A solution of chloride of zinc is used, from which the name is derived. (See Chloride Battery.) CHOKER OR CHOKE—The action of a device in a circuit wherein it tends to choke, or hold back, certain forms of current or frequencies. Thus, when permitting others to pass freely, or to oppose fluctuations in the strength of the current passing through it in the circuit. CHOKER COIL.—A coil of wire possessing considerable self-inductance and relatively little resistance. These coils are used in various ways and for a variety of purposes. When connected in a direct current circuit, and possess- ing the proper value, they have a tendency to prevent any fluctuations in the current and thus keep the current as smooth. An example of its use is with a loud speaker. A condenser will permit passage of high frequencies (alternating currents) such as we find in radio reception, but will effectively block direct currents. On the other hand a choke coil will pass direct current without offering any appreciable resistance, but will retard the modulated currents (q.v.) It will be apparent then that by a proper combination of the two (Choke Coil and Condenser) as in the illustration, the direct currents can be shunted around the loud speaker and thus prevent injury to it, while the necessary modulated currents are allowed to pass through without difficulty. Another use for the Choke is in a circuit carrying alternating currents. In this case the choke will limit the current in the circuit without loss, whereas an ordinary resistance, while it would limit the current, would dissipate a certain amount of energy. Chokes may be made with iron cores of the open or closed type, for low frequency currents, or may only have air for the core when used in high frequency circuits. The closed core types may be used as the formula most commonly used in determining the inductance of a choke coil is in henries is as follows: 
\[
L = 1.257 \times \mu \times A \times N^2 \times 10^6
\]
Where \(L\) is the inductance in henries, \(\mu\) is the permeability. (This varies from about 1000 to 2000 in most cases). \(A\) is the effective area of the iron cross section (square centimeters). \(N\) is the number of turns of wire. \(I\) is the length of iron path (in centimeters). CHOKER, HIGH FREQUENCY — A choke coil of high self-inductance (q.v.) in parallel with it, the parallel combination will prevent puncture of the secondary windings of the transformer (q.v.). When the condensers in a transmitting circuit are charged or discharged, a brief pressure is exerted on the windings of the transformer, which may cause the high voltage. The illustration shows the position of these choke coils in the transmitting circuit. (See Back Oscillation.) CHOPPER.—A device used in the aerial circuit and a continuous wave (q.v.) transmitter to train two continuous trains of waves into separate groups and thus permit them to become audible. In the case of reception of ordinary damped waves (q.v.) the head phone produces signals that have a frequency of vibration equal to the number of wave trains per second. When the transmitted waves are con-
Circuit


CIRCUIT—The term one broken starting device prevents current from its source, through some electrical instrument or appliance and back to the starting point.

CIRCUIT BREAKER—Generally speaking, any device for automatically breaking or opening a circuit and thus preventing flow of current through the circuit. For a certain time, it may be a device similar to a switch, used to automatically open the circuit when the current falls below a certain point, or rises above a certain fixed value. Thus an overload circuit breaker is an arrangement which will automatically open the circuit if the current becomes too great. This is shown in Fig. 1. It is a simple form and consists of an electro-magnet which requires a certain force to operate it. When the current in the circuit reaches a certain point, the magnet operates, pulling down the bar "A" against the action of the spring "P," and thus breaking the circuit. As long as the current is not more than that fixed by the requirements of the circuit—the magnet being arranged in accordance with the particular requirements—the current flows, the breaker operating to open the circuit only when more than the desired current is introduced into the circuit. In the illustration we consider "S1" and "S2" as the source of current, "M" as an electro-magnet in series with the motor "D," and "A-B" a switch, in which "A" has attached to it a piece of soft iron. Now if the current required for the motor is ten amperes, the magnet can be so designed that it will not act on the bar "A" until 1.5 amperes flow through it. Thus, as long as the current is less than this, the circuit is continuous, but if the current is increased to 15 amperes, the magnet operates and attracts the bar "A," breaking its contact with "B" and thus opening the circuit. In Fig. 2 a simple underload breaker is shown. In this case the operation is the reverse of that of the overload breaker. Here the bar "A" is held down in contact with "B" by the magnet "M" thus keeping the circuit closed through the motor "D." Now assume that the motor requires ten amperes and the magnet requires the same amount to hold the bar "A" in place against "B." If then the current in the circuit falls below ten amperes, the magnet can no longer hold the bar "A" against the action of the spring "P" and it rises, breaking the contact between "A" and "B" and thus opening the circuit. These circuits are of course only assumed for the purpose of illustrating the theory of circuit breakers. Actually the system is generally much more elaborate. Circuit breakers are used for many purposes—chiefly to prevent any sudden increase or decrease of current in a circuit, and to control the flow of current for charging batteries. (See Charger-Storage Battery.)

CIRCUIT, BROKEN—A circuit that is not continuous, having been opened either purposely or due to some defect in the circuit. The term is usually applied where the circuit is opened by the breaking of a wire, or through a faulty contact.

CIRCUIT, OPEN—A circuit which is open and through which current cannot flow, or a circuit which is normally open but which can be closed at will by pressing a key or button. A common example of open circuit is in the case of an electric bell circuit. The illustration shows such a circuit. Normally it is open and current does not flow to the bell, but on pressing the button B, the circuit is closed and current passes to the bell. (See Circuit, also Closed Circuit.)

CIRCUITS, PARALLEL—Circuits starting at a common point and ending at a common point. The illustration shows three parallel circuits. Actually each one is a part of the whole circuit. (See Parallel Resistances.)

CIRCULAR MIL—The cross-sectional area of a wire is usually designated in terms of circular mils. A circular mil is the area of a circle having a diameter of one thousandth of an inch. Thus a wire having a diameter of one quarter of an inch is said to have an area of 250 circular mils.

CLEAT—A form of porcelain insulator used in house wiring. They are generally arranged in two parts, with corresponding grooves in which the wire is held, and are nailed or otherwise fastened to the wall. Clets are about the cheapest form of insulator and where the voltages used are low, are quite as effective as the more elaborate types. Clets are much used in radio work, both for insulating lead in wires coming from the aerial, and for insulating the aerial itself.

CLERK-MAXWELL, JAMES—Born at Edinburgh, Scotland, in 1831, and educated at Edinburgh and Cambridge University, he became Professor of Natural Philosophy at Aberdeen, 1865-69, and Professor of Physics and Astronomy at King's College, London, 1860-65. In 1871 he became the first holder of the new chair of experimental physics at Cambridge, where he died, November 15, 1879. Clerk-Maxwell was recognized in his later years as one of the greatest authorities on physics of his time, and his fame has been steadily increasing since his death. Radio owes Clerk-Maxwell a deep debt. Electricity was the chief study of his lifetime, and his first important paper on the theory of electromagnetism was communicated to the Royal Society in 1867. He published his "Electricity and Magnetism," a work on the subject which has never been surpassed. In it he formulated his famous electromagnetic theory of light and his theories on electric waves, which developed into the modern system of wireless telegraphy and telephony through the experiments of Hertz.

CLIMAX—A high resistance nickel steel alloy, used extensively in rheostats (q.v.). It is one of the finest electro-chromic and most practical alloys for low-temperature resistance wire. Its chief properties are as follows: Maximum working temperature 540 degrees centigrade, resistance in microhms per cubic centimeter at 20 degrees centi-
grade, 87.2; temperature coefficient per degree centigrade, .00054, and having a specific gravity of 8.14.

CLIPS—A clamp connector used for various purposes in radio receiving and transmitting circuits. (See illustration.) In a receiving set a clip may be used at the end of a flexible wire for the purpose of varying the connection to the various "B" battery taps; clips are very frequently used in

making the connections to the storage "A" battery, and for many other purposes about the receiving set. One of their principal uses in the transmitter is in connection with the leads to the oscillation transformer. Flexible leads with clips attached come from the other units of the transmitter and are clamped at will along the various turns of the oscillation transformer until the point giving the desired wave length or highest radiation reading is found.

CLOCKWISE—A term used to indicate that the rotating part of an electrical machine or instrument moves from left to right (when facing it), or as the hands of a clock. In the illustration the needle or pointer of the meter moves in a clock-wise direction. In an electrical measuring instrument this is always true where the zero point is at the left part of the dial. The opposite is known as counter-clockwise. When looking at the armature of a motor or generator, if the rotating part moves from left to right it is said to have a clock-wise motion.

CLOSE COUPLING The arrangement of two coils acting as primary and secondary, placed close together in such manner that the coupling or electrical relation between them is close. In the

illustration the secondary coil is shown entirely within the primary. In other words the transfer of energy will be large in this case as the coupling is

close. If the secondary is withdrawn a certain distance from the primary, the effect is referred to as loosening the coupling, and the coils are then said to be loose coupled, the transfer of energy from one to the other being considerably less than in the case of close or tight coupling. (See Coupling.)

CLOSED CIRCUIT—A circuit which permits the continuous flow of electricity. The illustration shows an or-

cidable length of time without the impairing effects of polarization (q.v.). An open circuit cell is one that can only be used intermittently, as for example, with an electric bell where the circuit is only closed for a brief period. If an open circuit cell is used in a circuit that remains closed for some time, polarization sets in and ruins the cell in a very short time. An open circuit cell might be used with the test buzzer (q.v.) because in this case the circuit is closed intermittently as the key is depressed. (See Cell.)

CLOSED CORE—A core (q.v.) used in transformers, chokes, etc., which is continuous, forming a closed magnetic path. The illustration shows the difference between a closed core and an open core. In the open core type, one end is the north pole, the other the south pole, whereas in the closed core,

there are obviously no poles. The closed core type is occasionally referred to as a non-polar core. (See Core, Transformer, also Choke.)

CLOSED CORE TRANSFORMER—A transformer (q.v.) having a closed core. In the illustration the magnetic path, or core, is continuous, being made of strips of uniform size. This form of core is known as "laminated." An efficient transformer is generally made with a closed core. A transformer may be for a variety of purposes, such as step-up, step-down, audio frequency or radio frequency. (See Transformer.)

C. M.—Abbreviation for circular mil. (q.v.)

Cm.—The abbreviation for centimeter, the unit of length in the C. G. S. system (q.v.).

COCKADAY CIRCUIT—A popular radio receiving circuit devised by the American experimenter, Lawrence M.
Cockaday. It includes several radical features not found in the usual systems. Receivers using this circuit are generally made in three, four or five tube types. The chief value of this circuit lies in its extreme selectivity. It is used as a four coil receiver, owing to the addition of a sensitizing circuit to the regular three circuit regenerative system. The diagram for the three tube receiver is given in Fig. 1. Here the primary or aerial tuning circuit is seen to have a single turn of wire, L1, wound around another coil L2, which is shunted by a variable condenser C1, thus forming a separate closed circuit, coupled very loosely with the antenna circuit. The primary, or antenna circuit, has in addition to the single turn, a bank of wound coil L3 connected in the ground side of the open circuit and tapped to permit coarse tuning. Thus, the primary is coupled inductively to the separate closed circuit, which in turn is inductively coupled to the grid or secondary circuit containing a coil L4 shunted by the condenser C2, allowing tuning.

The tone of the music is varied by means of the novel arrangement using a condenser C4 connected to a three point switch. When the switch is placed in the center position the condenser is eliminated from the circuit and the wiring is standard. With the switch on the top tap, the grid of the tube is connected to the ground, thus by-passing a portion of the oscillations and giving a smooth soft tone with a certain loss of volume. With the switch arm on the bottom tap, the grid of the last tube is connected to the plate circuit, thus producing a different note due to the added grid-plate capacity. The coil L2 in the grid circuit is tuned by means of C1, which is a variable condenser of .0005 mfd. capacity.

A peculiarity of the circuit is that the length of the antenna has no bearing on the tuning. This is due to the semi-a-periodic primary and the fact that the sensitizing or pick-up coil is only one turn of wire, the inductances of which, compared to the whole inductance of the aerial circuit, is so small that any change in the over-all inductance has little, if any, effect.

This circuit, while originally having three tubes, has been arranged in conjunction with a standard push-pull audio amplifier, as shown in Fig. 2, making a five tube set with great power and possessing the characteristics of the original circuit with increased amplification. (See Push-pull, Cockaday Coil also Regenerative Receiver.)

**COCKADAY COIL.**—The coil used in the Cockaday circuits. It comprises four windings, i.e. tapped primary, separate closed circuit coil, grid or secondary winding and a single turn looped around the closed circuit coil. (See Cockaday Circuit.)

**CODE.—**Telegraph codes consist of characters formed by combinations of dots, dashes and spaces which represent letters, numerals, and punctuation marks. These characters are sent out by the radio operator with the aid of electrical impulses, and by using suitable receiving apparatus the receiving operator hears the incoming signal and is thus able to interpret the various combinations of dots and dashes and reproduce the original message. The Morse Code of characters came into general use in wire telegraphy shortly after the establishment of that means of communication. In this system, which is also called the "American Morse Code," some of the characters are made up with so-called spaces which are part of the group signal, and are necessary in distinguishing those characters. The International Morse code is a modified form of the American Morse code, and no spaces are used in the characters of the International Code. The International Morse Code is used all over the world for radio telegraphy, and for wire telegraphy in almost every country except the United States, Canada and parts of Australia. The American Morse, owing to the fact that there are fewer dashes in the characters, is about

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**LETTERS**

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Morse and Continental Codes.
5% more rapid than the International Morse. The American Morse and International (Continental) Codes are given herewith.

COEFFICIENT—In algebra, a number or multiplier of a symbol. Thus in the expression 2x, the coefficient is 2.

COHESIVITY—In electricity, and in its radio application, it is a number expressing the relation or ratio between quantities, one of which is generally being unity (1) as a basis or standard for the coefficient. For example, if we assume a constant current of electric current, the resistance of the wire at 32 degrees Fahrenheit being one ohm. If the temperature of the wire at 32 degrees be unity, or one, then its resistance at any other temperature will be some number or coefficient times one.

To make this clearer, let us take the ratio of an inch to a foot. An inch is one-twelfth, or approximately 0.0833, of a foot. Any number of inches multiplied by this fraction will give another number in feet. Therefore we say that the coefficient, or multiplier, of an inch as compared to a foot is 0.0833. A coefficient is thus any number by which a quantity must be multiplied to give another quantity.

In radio the most common cases of coefficients are the following coefficients: efficiency, amplification, and mutual inductance (q.v.). (between the two coils, primary and secondary) and the square root of the product of the total self-inductances (q.v.) in the two circuits containing the coils. Similarly, the coefficient of amplification is the ratio of the effect produced with an amplifier (q.v. to the effect produced without an amplifier.

(See Mutual Induction Coefficient, also Self-induction Coefficient.)

COHEN, LOUIS, Ph. D.—Born in Russia, Dec. 16, 1870.

COHERER—A device formerly employed for detecting radio waves. In its original form it consisted of two metal rods separated by a narrow space in a glass tube and the gap between the rods filled with nickel and silver filings. It was found that when the electromagnetic waves of certain signals were passed through the coil an oscillatory movement of the particles of filings clung together and became conductors. Then by using some device such as the tapper hammer of an electric bell to strike the glass tube, again separating the particles after each signal, it was found possible to keep the coherer constantly in a state of change between a conductive and a non-conductive condition, thus making the signals audible. There are many variations of this device, which, however, is now obsolete. (See Marconi Coherer.)

COIL—A term having very broad application in electricity and radio. It may be used to designate any arrangement of a number of turns of wire, usually copper, and used for almost any purpose in the production of electric and magnetic phenomena. The most common significance of a "coil" in radio is in reference to a number of turns of insulated wire wound on a mounted on a frame which may be rotated. The term inductance coil is generally used, although actually, any coil of wire will have inductance. Coils come in countless numbers and variety for many purposes. A coil may be used not alone to resonate to adjust a receiver or transmitter to resonance with incoming or outgoing signals, it may be used to connect two circuits, in which case, it is known as a coupling coil; it may be used with a core (q.v.) of iron wire, or laminated pieces, as a choke coil, or it may be used in connection with high frequency apparatus such as used by physicians. Coils are generally referred to by individual names indicating their construction or use. (See Inductance, Tuning Coil, Brio-coil, Comb Coil, Honey Comb Coil, Pansiee Coil, Spider Web Coil, Lorenz Coil, Duo Lateral Coils.)

COIL, ANTENNA—Or Loop Aerial. An antenna (aerial) constructed by winding tubing in a square form. The coil (or loop) antenna, because of its comparatively small size, is often preferred. If one end of the coil is pointed toward the broadcasting station, the antenna (aerial) will pick up its signals with maximum intensity, but if the coil is rotated from that position the signals from that station will grow very faint. When the plane of the loop is at right angles with the intercepted signals no sound will be obtained. For this reason radio compass used at sea. (See Loop-Aerial.)

COLLECTOR RINGS—Insulated metal rings attached to the armature (q.v.) of an alternator (generator of alternating current) in such fashion that the alternating currents can be collected and communicated to the brushes without change, these rings are used to collect alternating current from that type of generator and brushes are used to collect direct current from a direct current generator.

COLLIDION—A solution used by surgeons to cover slight abrasions or wounds, and for the protective coating similar to skin. It has been adapted to radio use as an insulating coating and is used as a binder on coils of various forms. It has been found more efficient than shellac for this purpose. A solution of glycerine and polyethylene glycol in ether, with a certain amount of alcohol, depending on the purpose for which it is intended to be used as a coating for coils serves as an insulator and also to hold the coils in place, but it should be sparingly applied.

COMBINATION DETECTOR—A detector and amplifier in one. Instead of using crystals in contact, instead of one crystal with a fine wire to search out the sensitive spots. Some combination detector
tors are composed of silicon and antimony; zincite and boronite; lenzite and cerussite, and zincite and chalcopyrite. These detectors all function without a battery and are simple to operate.

COMMON CONNECTIONS—A term often applied to a connection that joins several points. For example, in most radio receivers the binding posts for battery connections are arranged so that the "B+" and the "A+" or "A-" are connected to the same point. That is to say the post is a common connection for these leads. The term is also applied to a battery, as a "B" battery, which is used for both detector and amplifier. It is then known as a common "B" battery. The other method would, of course, be to use separate batteries for the detector and amplifier.

COMMUTATOR—In general electrical use, a device for reversing the direction of electric currents in a circuit. A commutator as used with a generator usually consists of a number of pieces called segments, mounted on a circular form but can also be formed in the same manner. The illustration shows a common mon form. In the case of an ordinary motor, the commutator is employed to distribute the current to the windings and in a direct current generator it serves to furnish a reversed current to the brushes although the current collected from the windings of the armature is alternating.

COMPASS, RADIO—See Direction Finder, Generator, also Bellin-Ton Direction Finder.

COMPONENT—A part of the whole. In mechanics it is one of the parts of a stress or strain (mechanical force). In electricity, component currents are the several currents into which a single current may be assumed to be separated, so that if assumed to be acting together they would produce the equivalent effect of the actual current. Thus in an electric circuit components of electro motive forces are understood as the several components into which any electro motive force may be divided. Impedance is said to consist of two components, the actual resistance and the apparent resistance present in the opposition offered to the flow of current termed the reactance (q.v.) by a circuit. For instance, the total current in the parallel circuit shown is the current in the tube responding to high frequency grid voltages may be considered as made up of two components: a constant current and a high frequency component superimposed on it.

COMPRESSED AIR CONDENSER—A condenser which uses compressed air as the dielectric or insulating material between the plates. This type of condenser is used chiefly in transmitting circuits. (See Condenser.)
Compound Magnets

COMPOUND MAGNETS—A combination of several permanent magnets. (See Magnets, Compound.)

COMPOUND WOUND—A dynamo or motor field magnet wound with two field windings, one of which is connected in series, the other in parallel with the armature (q.v.).

CONDENSER—In electricity or radio practice a condenser consists of two or more conducting surfaces placed in relation to each other and separated by an insulating medium such as air, impregnated paper, mica, etc. The conducting surfaces are generally referred to as plates or electrodes (q.v.) and the insulating material is known as the dielectric (q.v.). Condensers are used in radio for a variety of purposes, their broad use being to allow tuning. In action, a condenser permits charges of electricity known as electrostatic charges (q.v.) to be stored up and released periodically, according to the frequency desired. They may also be used to exclude certain types of energy. (See Condenser, By Pass, also Filter.)

The action of a condenser may be likened to that of a spring when placed under a mechanical strain. In the illustration Fig. 1A a flat spring S is shown in a normal position, NB. In 1B a weight W is placed on the surface of the spring. This weight will force the spring down from its normal position to one of the positions (a), (b), (c) or (d), according to the force exerted and the strength of the spring. If a heavier weight is then placed on the spring it will depress still further until we can imagine a point P in Fig. 1C at which the elasticity of the spring is used up and the opposition is such that it will no longer depress and comes to rest. If the weight is removed the spring will fly back into normal position, Fig. 1D, and in doing so will vibrate back and forth a number of times, thus producing, or rather, returning the energy that was stored in it during the moment of stress.

Considered as analogous to a condenser, in the above case the weight can be likened to the electrical charge applied to the condenser, the resistance of the spring may be considered somewhat similar to the capacity of the condenser, or the power returned on release of the spring may be regarded as the electrical power released by the condenser when the charging force is removed. The capacity of the condenser then will be seen as the ability to store up energy placed in it.

In the case of the spring, if too great a force is exerted, it may break down or as would actually happen, the elasticity would be lost. The same applies in the case of a condenser. If the charging force is too great, it may exceed the dielectric strength of the condenser and result in puncturing the insulating material between the plates. (See Breaking Down of Dielectric.)

The energy obtainable from a charged condenser will be equal to the charge placed in it providing there is no leakage or other loss. In a well-designed condenser the leakage will be so negligible that it need not be taken into consideration.

The relation between the charge in a condenser, the voltage applied and the capacity of the condenser is expressed as \( Q = C \times E \), where \( Q \) is the quantity of the charge in coulombs, \( E \) the potential in volts and \( C \) the capacity in farads. (See Capacity, Condenser, Variable; Condenser Fixed; Condenser Transmitting, also Condenser Curves.)

CONDENSER, AIR—See Air Condenser.

CONDENSER, ANTENNA—See Aerial Tuning Condenser.

CONDENSER, BY-PASS—A condenser, usually of the fixed (q.v.) type, arranged in a circuit in such manner that currents of a certain frequency will pass freely around any obstructing object, as, for instance, a high resistance element necessary to the circuit. An example of the use of a condenser in this manner is shown in the case of a "B" battery where the battery has a high internal resistance. A fixed condenser is placed across the terminals of the battery without injury to it and offers a path of low resistance for the high frequency radio currents.

CONDENSER CURVES—Curves showing the relation of variations in wavelength, frequency, and capacity with rotation of the dial of a variable condenser. Three types of condensers are shown here, the compression, Fig. 1, the straight line capacity, Fig. 2, and the square law, Fig. 3. In Fig. 1A is shown the relation of capacity and wavelength changes when the dial of a sample compression condenser was rotated. The condenser was shunted across a fixed coil. It will appear that the increase in capacity is gradual at the lower part of the range but increases very rapidly at the upper ranges. This is due mainly to the relation of the curvature of the upper plate to the lower plate as will be seen from the illustration, Fig. 1. These condensers are very satisfactory on about the lower two-thirds of their range, but through the remainder of their range a very slight adjustment of the knob causes an extremely large change in capacity, making them very difficult to handle near their maximum capacity. Fig. 2 shows the shape of the variable plates in the straight line capacity condenser and Fig. 2A illustrates the relation of wavelength and capacity changes with rotation of the dial. Here the capacity depends upon the overlapping area and is therefore proportional to the angle of rotation of the movable plates. The capacity curve appears as a practically straight line running diagonally across the chart. The wave-length, however, changes rapidly at the lower range and very gradually at the upper range as indicated by the wave-length curve. Fig.
3 shows the shape and disposition of rotor and stator plates of a condenser so designed as to read directly in wavelength from the settings of the dial.

Fig. 20. Showing effect of straight line condenser on dial reading.

Such condensers are much used in wave meters (q.v.). Condensers are also made so that the frequency curve is a nearly straight line, varying more or less directly as the angle of rotation of the plates. Fig. 2B illustrates the result when an ordinary straight line capacity condenser is arranged with a dial calibrated directly in meters. It appears that the readings are buoyed at the lower range (A to B) and spread out at the upper ranges (C to D). The reason for this can readily be seen by glancing at the curve Fig. 2A.

CONDENSER, FIXED—A condenser which has a fixed or constant capacity, allowing no variation of the value. (See Condenser, also Condenser, By-Pass.)

CONDENSER, GRID—A condenser, generally of low capacity, of the fixed or variable type, used in series with the grid of the detector tube to prevent excessive charges from affecting the grid. These condensers generally have a capacity between .00025 and .0005 micro farads. Due to the blocking action of these condensers, a high resistance, known as a grid leak (q.v.) is placed across the condenser or from the grid to filament, thus allowing the accumulated charges to leak off the grid of the tube in time for the grid to be clear for the succeeding electric charge. The grid leak may be considered as a valve controlling the amount of energy that the detector can efficiently take care of without overload. (See Grid Leak.)

CONDENSER, IN PARALLEL—A condenser arranged in a circuit in such manner that the current is divided between it and the other condenser or coil with which it is connected. The illustration shows a variable condenser connected in parallel with a coil, both placed in series between aerial and ground and forming a tuned primary or aerial circuit. (See Parallel Connections.)

CONDENSER, IN SERIES—A condenser connected in a circuit with other condensers or coils in such manner as to form a continuous path, allowing the current to pass through each unit without dividing. The illustration shows a condenser connected in series with a tuning coil, aerial and ground, thus forming a tuned primary or aerial circuit. (See Condenser, in Parallel, also Series Connections.)

CONDENSER, MICA—A condenser, usually of the fixed type, employing sheets of mica as the dielectric or insulating material between the plates. The condensers of small capacity used in receiving circuits are generally made with mica as a dielectric, but owing to its cost and thickness it is seldom used in low-power, high-capacity condensers. Mica is also used in condensers for high-power work such as transmitting, when the capacity is low. (See Condenser.)

CONDENSER, PHONE—A fixed condenser of comparatively low capacity used across the telephone receivers to allow a by-pass for 1/10 the condensers of the currents and thus prevent undue strain on the phones. (See Condenser, By-Pass.)

CONDENSER, TRANSMITTING—See Condenser, Mica.

CONDENSER, VARIABLE—Any condenser so arranged as to allow variation of its capacity. This may be accomplished in many ways, the usual method being to have the plates divided so that one series is movable with respect to the others, the movement being with the rotation of the variable plates. (See Condenser.)

CONDUCTANCE—Sometimes called the small resistance to the flow of an electric current. A conductor (q.v.) is a body having large conductance and small resistance (q.v.) is one having negligible conductance. Conductance is thus the opposite of resistance. The unit of conductance is the mho, the reciprocal of ohm. The symbol is obviously derived from ohm, reversed. It is the conductance of a column of mercury 106.3 cm. (centimeters) long, 1 square mm. (millimeter) in cross-sectional area and of a weight of 14.4521 grams.

CONDUCTIVE COUPLING—The association of one circuit with another by means of inductances (coils) mutual to both circuits.

CONDUCTIVITY, SPECIFIC—The reciprocal of Specific Resistance; being a standard of reference for comparing the conductivities of various substances. (See Specific Resistance, Conductance.)

CONDUCTOR—Any substance that offers small resistance to the flow of electric currents may be termed a conductor. This term is the opposite of insulator, but there may be no line of demarcation between the two, since any insulator will prevent the passage of current when sufficiently high voltages are used. For all practical purposes, however, a conductor is considered as material that presents little difficulty to the passage of current. The most common conductor is copper, usually in the form of wire. An idea of the relative conductivity (power of carrying electric current possessed by various substances, pure copper being taken as standard) of various substances can be gathered from the table following. The materials on the left are comparatively good conductors given in the order of their conductivity, while those on the right are poor conductors and generally used for resistances. (See Note: A resistor is used to retard the flow of electricity without necessarily stopping it entirely, whereas an insulator is used to stop the passage of current.)

<table>
<thead>
<tr>
<th>Material</th>
<th>Conductivity (as a percent of pure copper)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silver</td>
<td>100</td>
</tr>
<tr>
<td>Copper</td>
<td>83</td>
</tr>
<tr>
<td>Brass</td>
<td>73</td>
</tr>
<tr>
<td>Gold</td>
<td>41</td>
</tr>
<tr>
<td>Aluminum</td>
<td>24</td>
</tr>
<tr>
<td>Zinc</td>
<td>22</td>
</tr>
<tr>
<td>Platinum</td>
<td>19</td>
</tr>
<tr>
<td>Iron</td>
<td>10</td>
</tr>
<tr>
<td>Nichel</td>
<td>5</td>
</tr>
<tr>
<td>German Silver</td>
<td>1</td>
</tr>
<tr>
<td>Platinum Silver</td>
<td>0</td>
</tr>
<tr>
<td>Manganin</td>
<td>0</td>
</tr>
<tr>
<td>Mercury</td>
<td>0</td>
</tr>
<tr>
<td>Graphite</td>
<td>0</td>
</tr>
<tr>
<td>Carbon</td>
<td>0</td>
</tr>
</tbody>
</table>

There are, of course, many other substances that can be classed as good conductors, or as poor conductors, but
the above are more generally known and a peculiar fact is that while good conductors become less conductive as their temperature is raised, insulators lose or gain their insulating properties as their temperature is raised. As too great current in a conductor will cause heat, and considerable, or even leading to burning of the conductor, it will be obvious that the fullest efficiency a conductor may be expected to carry the required current without undue heating. It is understood also that conductors in any part of a radio circuit are carefully guarded as to size and the effective cross-section of the conductor determined, in order to offer as small a part to heating. It must not be assumed from the foregoing that the larger the wire the greater its efficiency, in fact a large wire is often less satisfactory than a small one in high frequency circuits. When the conductor is to carry direct current the only consideration is to have the wire large enough to prevent heat losses and at the same time not be too large so that the conductor will carry high-frequency (q.v.) currents there are other factors to consider. High frequency currents are said to travel only on the outside of the wire (see Skin Effect) and therefore it is possible to use a fine wire for this purpose when the very low current values obtaining in reception are in question. A phenomenon that must be observed in high frequency circuits is called distributed capacity. (For more complete explanation of this subject see Low-loss Coils. See also Bus bar.)

CONNECTING UP or HOOKING UP—These general terms are used in radio to refer to the process of wiring a receiving or transmitting set in part of a receiver or other circuit.

CONSTANT—A quantity or magnitude, which does not vary, derived from actual experiment, which is included as a factor in most formulas for the purpose of bringing theoretical calculations into agreement with experience. Constants are used in radio calculations. As an illustration, different electric or insulating materials used in a circuit may produce different constants which must be taken into consideration when calculating the capacity of the condenser. Thus, a dielectric, such as ordinary paper when taken as the standard, the constant being stated as 1. Flint glass has a high dielectric value, its constant being stated as 10.10, other materials varying according to their comparison with air as a standard. (See Dielectric.)

CONSTANT CURRENT—An unvarying current. The term "constant" is applied to voltage when it is steady and unvarying. A current that is fixed and unvarying, or to almost any value that does not change.

CONSUMPTION, CURRENT—The term usually used to denote the current required or consumed by any part of an electrical circuit or by the circuit itself. Current in a circuit consumes a certain amount of energy because it dissipates it as heat energy. Thus, in the case of a vacuum tube, requires a certain amount of current to heat it to brilliance. If the filament thus requires one-quarter ampere of current at 6 volts, its current consumption is one-quarter ampere. (See Plate Consumption.)

CONSUMPTION, PLATE—The current required to energize the plate of a vacuum tube. (See Plate Consumption.)

CONTACT BREAKER—A contrivance for quickly and automatically making or breaking an electrical circuit normally existing between two contacts. (See Circuit Breaker.)

CONTACT DETECTOR—A form of crystal detector in which a small wire, or "catwhisker," as it is called, makes contact with the crystal in the detector and acts as a rectifier of the high-frequency waves received from the broadcasting station. (See Crystal Detector—The Theory.)

CONTACT POINTS, or SWITCH POINTS—Generally refers to a small flat-headed machine screw used as a contact point for a switch. The illustration shows the types mostly used.

Leads from various points of a tapped coil may be connected to several contacts in order to permit variation of the inductance. A "contact point" may also mean any point in an electrical circuit at which contact is made to close the circuit.

CONTACT RECTIFIER—See Contact Detector.

CONTACT RESISTANCE—When two connecting surfaces in a circuit carrying electric energy do not make absolute or perfect contact, a certain amount of resistance (q.v.) results. In any part of a radio circuit where two wires or conductors are joined to form a circuit, it is essential that they make a positive contact. The wires used for connections in a radio receiver are generally soldered or fastened tightly by nuts or bolts, or machine screws in order to form a good contact. If this is not done, energy may be wasted, due to the resistance at the point of contact.

CONTINUOUS OSCILLATIONS—Each oscillation or vibration being of the same amplitude as the preceding one. (See Sine wave.)

C. W.—Abbreviation for continuous wave (q.v.).

CONTINUOUS DIRECT CURRENT—A direct current which flows steadily without interruption or reversal. The current supplied from a battery for radio use is continuous direct current, while that portion of the high frequency alternating current which is rectified by a vacuum tube detector is called pulsating direct current, as there is an interval of time between the rectified half of the alternating wave, due to the other half not being rectified. (See Current, Pulsating Direct, Pulsating Current.)

CONTINUOUS WAVES—Also called Undamped or Sustained waves and usually referred to as C. W. Electromagnetic wave trains or oscillations (q.v.) of continuous waves are waves that do not die down with time, each of the oscillations having the same strength (amplitude) as that preceding it, and the same true of the complete cycle, consisting of one alternation or one circuit. Thus the waves are continuous or, constant, as far as amplitude is concerned. Now in Fig. B the amplitude of the oscillations increases with each succeeding alternation and hence with each succeeding cycle (two alternations). After a comparatively few oscillations the current has decreased to zero, that is, the oscillations have died out completely. In this case the period of the oscillations is called decrement or damping. Thus continuous waves may be considered as waves in which, with any train or group of oscillations, each succeeding oscillation has the same amplitude as that preceding it.

CONTINUOUS WAVES—KEY MODULATED—Continuous waves (q.v.) which have been broken into dots and dashes of the telegraph by means of a telegraphic key, these signals being made audible at the receiving end by the use of an oscillating receiver.

CONTINUOUS WAVES—MODULATED AT AUDIO FREQUENCY—The vibrations (q.v.) of waves radiated by a broadcasting station in accordance with the sound waves is known as modulation. Frequencies from 10,000 down to about 32 are audible to the human ear and are known as audio frequencies. Hence continuous waves which are modulated at audio frequencies are waves which have been modulated (varied) by having voice sounds imprinted on the microphone at the broadcasting station, which in turn causes the strength of the radiated electric and magnetic waves to vary, which in turn causes electrical to sound vibrations at the microphone.

CONTINUOUS WAVE SIGNALS—See Continuous Waves.

CONTINUOUS WAVE TRANSMISSION—System of radio telegraphy using waves as described under "Continuous Waves."

CONVECTION CURRENTS—When a hot and a cold body are separated by a fluid which is free to circulate, heat is transferred from the hot to the cold body by currents of the fluid itself flowing from one to the other; similarly, all parts of a fluid which is being heated quickly come to approximately
the same temperature. This transfer of heat by currents of the fluid itself is called "convection." In electricity "Convection Currents" are currents arising from the motion of charged particles thrown off in electrified streams, i.e., the flowing of charged air particles in streams from the pointed end of a high-tension electric conductor, sometimes called "electric wind."

CONVENTIONAL—This term is much used in radio to denote a form established by custom. A conventional circuit for some particular purpose is understood as a circuit which has been generally used and which is generally considered as standard. Broadly, the most common form or use of anything. The conventional method of amplifying signals of audio frequency is by means of audio frequency transformers. Any other means is unconventional, although it may produce similar results.

CONVERSION FACTORS—A numerical factor which gives relation between the magnitude of a quantity expressed in terms of one system of units, and the same quantity expressed in terms of any other system of units. For example, the cord is regarded in the United States as 3600/3937 meter (a meter is approximately 39.37 inches). We say, therefore, that the conversion factor between yard and the meter is 3600/3937 because any number of yards multiplied by this figure or factor will give the result in meters. (See Capacity Conversion Factors.)

CONVERTER—A term applied generally to any mechanical, electrical or electro-chemical device which will convert or change one form of energy to another. More specifically in electricity the word was applied to a dynamo motor designed with two armatures, mounted on one shaft, one being a motor armature driven by the original current, the other armature generates new current; this is also called a "motor-dynamo" and it can transform continuous (direct) current to higher or lower voltages, or, (2) a rotary electrical device used to change direct to alternating current, and vice versa. (See Rotary Converter.)

COORDINATES—A thing of the same rank with another thing may be termed a coordinate. For example, the means by which the position of any point as of a curve may be defined with respect to certain fixed lines. In the illustration Fig. 1 lines known as axes of coordinates are shown. Such a system of coordinates is called a coordinate system or a rectangular cartesian system (q.v.) showing the relation between varying values. If we assume the horizontal line of the graph as the abscissa and all distances measured parallel to this line will be known as ordinates; distances measured parallel to the vertical line of the graph are referred to as ordinate.

The line A-B is parallel to the axis of abscissas X and is therefore an abscissa. The line B-C is parallel to the axis of ordinates and is referred to as an ordinate. Now if we place a number of lines parallel to each axis (ordinates and abscissas) and assign to each of them a certain value, such as amperes, to each abscissa, and volts to each ordinate, a line can be drawn through a

\[
Y = \frac{3600}{3937}X
\]

to represent the various values of each quantity as related to the other. Thus, in Fig. 2 we have a purely hypothetical curve representing the assumed value of current in amperes under assumed voltages. In the example, the curve at point A shows approximately that amperes are being under a pressure of ten volts. This imaginary curve is, of course, shown merely for purposes of illustration, the meaning of coordinates, ordinates, abscissas, etc. (See Abcissae, Charactertic curve, also Graph.)

COPPER PYRITES—Sometimes referred to as Chalcopyrite. It is used in radio reception as one of the elements of a crystal rectifier (detector) generally in conjunction with zincite or telurium.

COPPER SULPHATE—A salt of copper. Also known as blue vitriol or copperas. A copper sulphate solution is sometimes used as a preservative for wooden arials. It is used in certain forms of rectifiers (devices for transforming chemical action into electric current) and also produces sulphuric acid when subjected to electrolysis (q.v.).

CORD, PHONE—The cord or flexible wire used to connect a handset (phone) or loudspeaker to the terminals of a receiver. Phone cord is usually copper tinned wrapped around a cotton cord, the whole covered by braided silk or cotton threads. It cannot be used to carry high currents, but is efficient for the comparatively low currents flowing through the phone circuit of a radio receiver. Some phone cords are also formed of a number of fine copper wires covered with a suitable insulating material.

CORE—The central portion of a piece of certain electrical apparatus. Thus the center of a coil will be the core, irrespective of its nature, whether air or iron. The core of a choke coil (q.v.) is usually made of a bundle of soft iron wires or round. The core of the closed type is called a laminated core, being made up of laminations or layers of the core metal. (See Choke or Choking Transformer, Closed Core.)

CORE LOSSES—The losses due to stray currents (q.v.) set up in an iron core while under the stress (strain) of a magnetic field (q.v.). Also losses due to hysteresis and eddy-currents. (See Magnetic flux, Eddy current, also Hysteresis.)

CORE TRANSFORMER (Iron)—A transformer having iron in the core over an iron core, the iron forming a path for the magnetic lines of force, as distinguished from a transformer in which there is no iron or so-called air core. (See Transformer.)

CORONA—The Latin word meaning crown, originally applied to the crown shaped lights occurring in the aurora borealis. In electrical parlance it refers to the luminous discharge which occurs along high tension transmission lines, or the aerial wires of a high power radio transmission station. (See Brush Discharge; also Corona Loss.)

CORONA LOSS—The energy loss due to corona discharge. (See Corona; also Brush Discharge.)

CORRECTION FACTORS—A formula for the measurement of certain values is generally made by using certain conditions or types of apparatus as a standard. For example a formula for calculating the inductance of a coil is made by using a given shape of coil as the standard. Therefore the formula will be essentially correct for this type of coil and its shape and other characteristics are the same. If, however, the nature of the coil to be tested differs from that of the standard coil the results produced by the formula, a system of correction must be used to adjust the formula to the particular coil. Thus the formula for inductance of coils takes into consideration the size of the wire or the number of turns, the length of the coil, its diameter and so on. However, it does not take into consideration the ratio between the length of the coil and its diameter. A correction factor (necessary consideration) is needed to correct the result of the formula to fit the individual coil. This correction factor is generally referred to as a constant (q.v.), its value being determined generally from a chart prepared to cover various ratios of length to diameter.

CORROSION—Chemical action which causes destruction of the surface of a metal by reaction with the surrounding medium. In the case of an iron generally rust, corrosion of copper being due to oxidation, or perhaps the action of oxygen in the current itself, is a case of galvanic (q.v.). This effect is very often noted in the case of an aerial wire where the wire is necessary exposed to the action of the atmosphere, rain, etc. The effect is particularly important and undesirable where the lead in wire is joined to the aerial.

If the two wires are not soldered securely or at all, corrosion may set in, which will produce in time a bad resistance connection and waste the valuable energy of the incoming signals. This is the main point of danger in an aerial system and the best protection is to solder the joint carefully. As a matter of fact the remaining trouble is of course may corrode to a considerable extent without disastrous effect. In the case of copper, the wire very quickly corrodes when exposed to air. This reason insulated wire is sometimes used for the aerial. As the current received by an aerial travels in the front face of the wire (see Skin Effect), and a corroded surface is not a particularly efficient conductor, there seems to be some basis for the use of insulated wire for this purpose. Another instance of corrosion is in a soldered joint in a receiving set. All soldered joints should be carefully wiped to remove any trace of acid flux (q.v.), which may remain to produce a destroying.
chemical effect on the wire and cause loss of energy. (See Electrolysis, also High Resistance, Joint.)

Coulomb—The practical unit for electrical quantity. It is defined as the quantity of electricity delivered by a current of one ampere flowing for one second. Therefore a coulomb of electricity will pass each second in a circuit having one ohm of resistance and a pressure of one volt. It is also used to express the quantity of electricity which a condenser having one farad of capacity will absorb when placed under a pressure of one volt. (See Capacity, Electro-static, Volt, Amper Hour, Practical Units, CGS Units.)

Counter Electromotive Force—Commonly known as Counter E. M. F. It is an opposing electromotive force which tends to resist or act against the original electromotive force. It may be introduced in a circuit to prevent any fluctuation of the original forming; when the Choke Electromotive Force, also Choke Coil.

Counterpoise—A counterpoise is generally a second aerial suspended either below the main aerial or to one side of it. It is used more often in transmitting stations in place of the usual ground connection, but is occasionally also used in reception where it is impossible to obtain an efficient ground. (See Aerial.)

Couple, Thermo Electric—See Thermo Couple.

Coupled Circuits—The term generally used to refer to circuits that are joined by coupling, (q.v.) In the illustration the primary circuit (of the aerial ground and tuning devices) is coupled or joined to the secondary circuit by inductive coupling. That is to say, the signals impressed on the primary circuit are transferred to the secondary circuit by means of inductive coupling, when the lines of magnetic force around the primary coil cut the secondary coil, a voltage is set up in this coil which causes a current to flow in the secondary circuit, and it is then said the coils are "inductively coupled," there being no connecting wires between them. Signals might be transferred to the secondary circuit by any of several means, in each case the method of joining the two for the purpose of effecting a transfer of energy is referred to as "coupling the circuits." (See Coupling.)

Coupler—See "Coupler—(Loose)" and "Coupler—(Various).

Coupler—(Loose)—A tuner used in a radio receiver. Coupling of a primary and secondary coil so constructed that the secondary coil slides on rods in and out of the primary coil. When the secondary is entirely within the primary the coupling is said to be "tight," and as the secondary is withdrawn from the primary the coupling becomes "loose," depending upon the distance which the coils are separated.

Coupler—(Vario)—Form of tuner used in a radio receiver, having primary and secondary coils arranged in such a manner that the secondary rotates on a shaft within the primary. The degree of coupling is governed by the variation of the angle between the axes of the two coils.

Coupling—The relation of one coil of wire carrying alternating currents to another in which energy is set up by the first coil. It is used to define the intimacy between the primary and secondary windings of various types of oscillation transformers, couplers and tuning devices. This transfer of energy may be produced in several ways, as by inductive coupling, conductive coupling or electro-static coupling. The more common method is to place the primary and secondary coils in close proximity and produce the energy in the secondary through induction.

The illustration Fig. 1 shows a simple two slide tuning coil which is divided into a primary and secondary by conductive coupling. Here the transfer of energy from the aerial and ground, or primary circuit, to the secondary circuit (detector and phones) is accomplished with little loss of energy as the circuit is through wire conductors. This is also known as direct coupling. Now in Fig. 2 a simple form of loose-coupler is shown. This device is made in numerous forms, the principle of operation however, being the same in all cases. Here one coil, the secondary in this case, is made to fit into the larger coil which is the primary. The energy delivered by the primary coil induces or sets up a similar current in the secondary by reason of its proximity. The efficiency of the secondary, however, will not be as great as in the case of Fig. 1 where it is transferred directly through a wire conductor. The coupling shown in Fig. 2 will on the other hand, permit much closer adjustment to the desired signals.

The other method is known as capacitive or electrostatic coupling. This is shown in Fig. 3. Here the secondary coil is not in direct inductive relation to the primary, in fact it might well be almost any distance away were it not for the loss in efficiency due to long connections. The connection between the primary and secondary coils is by means of condensers. The transfer takes place through these and is determined by the setting of the condensers. As in Fig. 1 coupling as so far explained is from a standpoint of maximum transfer of energy, the direct or conductive coupling system is best. The factor of transmission enters here however and must be considered. In order to eliminate undesired signals the various systems of coupling are reported. The next known that selectivity—the ability to tune out undesired signals while receiving the desired signals—is often obtained only at the expense of a certain amount of energy or volume. It is a safe assumption therefore, that if there is any such thing as maximum efficiency in tuning apparatus, it must be a general term covering both selectivity and volume.

Coupling in its various forms is intended to refer not only to receiving circuits but to transmitting circuits as well. Its application in transmitting is covered under the heading Spark Transmission (q.v.).

Coupling Coefficient—The closeness of coupling is specified by a quantity representing the ratio of energy transfer, or inductance between the two coils to the square root of the product of the two self-inductances. In its practical sense coupling coefficient refers to the inductive relation of two coils. Coupling coefficient is defined as the ratio

\[ X_m \]

Where \( X \) is the mutual or common reactance \( X \) is the mutual inductive or capacitive reactance in the primary circuit and \( X \), the similar reactance in the secondary circuit. (See Coupling, Mutual Inductance.)
COUPLING, DEGREE OF—The extent of relationship between coupled circuits. In a great number of circuits the coupling is arranged so that the currents may be adjusted either close or loose, as the requirements of the reception may be. Variable coupling may be obtained either by varying the distance between the two coils of a loose coupler, or by changing the angle between the coils of a turret coupler. (See Couplers.)

COUPLING TRANSFORMER—(OSCILLATION TRANSFORMER) This is the "tuner" of the transmitting and receiving circuits of primary and secondary windings usually of flat strips of copper, or copper ribbon, instead of wire, in order to reduce losses due to skin effect (q.v.). The primary coil receives the energy in the form of alternating currents from the generating device; the currents set up lines of force which interlink with the windings of the secondary coil connected in series with the antenna system, and in this manner the energy of the oscillation (alternating) current is transferred to the radiating system (aerial and ground) and thence into space. The purpose of the oscillation transformer is to produce a sharp wave which is readily tuned at the receiving end and causes a minimum of interference. The greater the distance between the primary and secondary coils the more sharply the wave becomes. A device serving the same purpose in a receiving set, i.e. to enable the receiver to separate sharply the received signals, is sometimes called a receiving transformer, although commonly known as a tuner, coupler, vario-coupler, etc.

C. Q.—Abbreviation of inquiry made in Morse telegraphy, meaning "Are you there? Do you desire to communicate with another station." (See Abbreviations.)

C. Q. D.—The original Distress Signal (q.v.) established in 1904 by the Marconi Company. The origin of this signal is said to have been developed from the use by telegraphers on land lines and during the C. Q. call when they wished everyone on their circuit to listen to their message being transmitted.

The signal C. Q. D. is now obsolete, having been replaced by S. O. S. at the International Radio Telegraph Convention held at Berlin, Germany, in July, 1908.

CRITICAL—A term often used in reference to the tuning qualities of a coil or set, and, less frequently, to indicate a vacuum tube that oscillates too freely. If a receiving set is not critical in adjustment it is said to tune broadly, that is to say, not sharp in tuning. A critical set has a very narrow margin of control in tuning—the particular signals being receivable within only a very few points on either side of their true wave setting on the tuning dials. If a set is difficult to tune it is termed "too critical." This means that it tunes too sharply and it is difficult to get proper results, due to the possibility of passing by signals unnoticed when turning the dials. Obviously there is a middle point wherein a set may be selective and yet not too difficult to tune. If a vacuum tube goes into oscillation (q.v.) too readily it is said to be critical. This effect is not desired in a tube except in rare instances. (See Resonance, Tuning, Brood, etc.)

CRITICAL CURRENT—The current required to bring about some particular state of oscillation in a circuit. In radio use, a common example is the exact amount of current needed by the filament of a vacuum tube to bring it close to the oscillating point (q.v.) without actually going into oscillation. (See Critical.)

CRITICAL POINT OF CURVE—The peak or point of maximum value in a curve showing the relation of any varying values. The illustration shows the curve indicating relation between voltage and signal strength in two types of vacuum tubes. The points marked "Peak" in each curve represent the critical points of the curves at which maximum audibility is obtained, any further increase in voltage not increasing the audibility. (See Characteristic Curve.)

CROOKES, SIR WILLIAM (1832-1919) English chemist and physicist. Born in London June 17th, 1832. Crookes was educated at the Royal College of Chemistry and afterwards became assistant in the meteorological department of the Radcliffe Observatory, Oxford. In 1855 he obtained a chemical post at Chester.

Crookes early began that series of brilliant researches which has left its mark on the scientific progress of the nineteenth century. In 1861 he isolated the new element thallium, during the investigation of the atomic weights of which he made the discovery of his radiometer. This led to his researches on the phenomena of electric discharges through highly exhausted tubes, or Crookes tubes. The illustration shows such a tube. When a current is passed through it, cathode particles travel along it. His discoveries on these phenomena led directly to the development by Sir J. J. Thomson of the now generally accepted electron theory. (q.v. In 1893 he began his study of the rare earths, and in 1892 he forecast radio telegraphy on the strength of Lodge's and Hughes' experiments.

Knighted in 1897, Crookes was awarded the Royal medal in 1875, the Davy medal in 1880, and the Copley medal of the Royal Society in 1904, and the O.M., in 1910. He died in London, April 4th, 1919.

CRYSTAL—A general radio term for a mineral used as a detector (q.v.) of radio signals. The Physicist F. Braun noted in 1874 that certain pairs of crystals would transmit so that only a small area of surface was in contact, offered high resistance to the passage of currents in one direction while permitting them to pass readily in the other. This was really the birth of the crystal detector, although radio was not then developed. There are a great many different minerals that will act as detectors for radio signals, some of which operate with a wire, or other metallic contact, others which require a combination of minerals, one in contact with the other. There are also numerous synthetic crystals such as carborundum. Then again some of the more common natural crystals are subject to treatment by heat, or other means, to change their nature or to make them suitable for radiotelegraphy.

The following crystals are most used in radio reception: galena, silicon, molybdenum, carborundum, zimnite, boronite, chalcopyrite, and cusnse. All of these are taken up under their respective headings. (See Crystal Detector, also Combining a Detector.)

CRYSTAL DETECTOR—A combination of a crystal rectifier with contact and supports, used to detect radio frequency oscillations. Detectors of this nature are made in a great variety of styles, and use various kinds of crystals. In the more widespread form...
the crystal detector consists of a crystal with rectifying properties, held in a cup or spring grip and arranged with a contact wire as shown in the illustration Fig. 1. This may be elaborated upon by supplying a series of flat springs to obtain very fine adjustment of the contact. Fig. 2 shows a combination detector, using two crystals, in contact with each other. This form has several advantages over the wire or cat-whisker (as the contact wire is called) type, chief among them the fact that it will withstand severe shocks without losing its adjustment.

Fig. 3 illustrates a popular form of fixed crystal detector, in which the contact seldom requires adjustment. This type is of advantage providing it can be made sufficiently sensitive. (See Carborundum, Vacuum Tube, also Crystal Receivers.)

CRYSTAL DETECTOR—THEORY OF OPERATION—Theory of operation of a device used to detect radio waves, usually comprising a crystal in combination with a metallic contact, or, in some cases, two crystals arranged to rest against each other. In action this device serves to rectify the incoming signals, that is to say, it changes their nature from an alternating current to pulsating direct current. The incoming waves or signals consist of a series of alternations, the current flowing in one direction, then reversing and flowing in the opposite direction along the circuit of the receiver. The changes of direction take place many times per second and would not be audible in the head phones in their original state. The crystal, as used in radio reception, has the peculiarity of furnishing a ready path for the flow of current in one direction while offering high resistance to its change in the other. Now an alternation (q.v.) is a rise in current from minimum to maximum in one direction and back to minimum or zero, repeating the process in the other direction. Two of these alternations, one in a positive direction and the other in the negative direction constitute a cycle. (q.v.) If the crystal will permit the passage of current in one direction only, it is apparent that only half of each cycle can pass through; the other half of each cycle being lost or blocked out by the action of the crystal.

The illustration “A” gives a graphic representation of the radio frequency oscillations as they move over the aerial circuit. The curves above the line show the current in a positive direction while those below the line show it in the opposite or negative direction. If the signals or waves in this state were sent through a telephone receiver or head phone in a radio receiving set no sounds would be reproduced. Then again if the incoming oscillations were continuous, the rectified current would merely act on the diaphragm of the phone and hold it in a certain position as long as the signal persisted. This of course would not create any audible or intelligible sounds. If, however, the incoming oscillations are in the forms of groups or trains of waves, in any one of which the successive oscillations were less or greater than the previous ones, the current would be a series of pulses in the phone as indicated in C. These pulses would occur as often as the trains of oscillations occur (for more complete explanation of the difference between continuous and damped waves, also Damped Waves, also Continuous Waves). It will therefore appear that a crystal detector can be used to rectify damped waves. When the rectified portion of a damped wave train reaches the phones the diaphragm is depressed and held until the train has died out, at which point the diaphragm is released until another train reaches it. This creates the audible signals and the number of trains occurring each second will determine the number of depressions of the diaphragm and hence the pitch of the audible signals. (See Crystal Receiver, Crystal Detectors, also Tickler.)

CRYSTAL RECEIVERS—A crystal receiver is the complete set of apparatus for receiving broadcast programs or spark transmission (signals), employing a crystal as the detector or rectifier. The set comprises a crystal detector, tuning device, diaphragm, and loud speaker. The diaphragm and loud speaker are used to convert the electrical impulses into sound waves. A crystal detector receives the radio waves and converts them into a stream of electric charges. The tuning device is used to vary the frequency of the oscillations, thereby producing audible sound.

CURRENT—A term used in electrical practice to signify the rate at which electricity flows from point to point in a circuit. The current in a circuit may be likened to the water flowing in a pipe. In this case the water would represent the electricity, the force or pressure represents the voltage, the pipe can be compared to the conductor or wire through which the electricity flows, and the current can be likened to the discharge from the pipe over a given period of time, that is the cubic feet of water per second. For practical purposes the unit of current is considered as the Ampere. This is the rate of flow of electricity when one coulomb (q.v.) passes a given point in the circuit each second. It will thus be apparent that while the ampere is often considered as the amount of current in a circuit, in reality it is the rate of flow of the electricity, the coulomb being the definite unit of quantity. Electric current is of course invisible. The only means of determin-
ing when there is current in a circuit is by its observing its effect and its always apparent by one or more of a number of effects. For example, if current is flowing in a wire or other conductor and a compass is placed near the conductor in such a position that the axis on which the needle revolves is parallel to the axis of the wire, the needle will be deflected. If the current reverses and flows in the opposite direction, the needle will be deflected in the opposite direction. The effect of current is also apparent by reason of the heat which it generates in passing through a wire or conductor. If the wire is comparatively small and the current correspondingly large, the heat may be sufficient to be noticeable by placing the hand on the conductor. When the current is small, it can be detected by means of delicate instruments. This heating effect is made use of in various types of ammeters. The effect of current may also be noted in an incandescent lamp. In this case, the current is made to flow through a fine wire inside a globe from which the air has been extracted, and the heat generated by the passing current causes the filament, or fine wire, to glow. It is a well-known fact that heat causes expansion and this expansion of a fine wire is the principle on which one type of current measuring device operates. Current is divided broadly into two divisions, direct and alternating. These two classes may again be separated into several further groups such as high and low frequency alternating, continuous and pulsating. Each phase or characteristic of current is taken up more in detail under its particular heading in this encyclopedia. (See Current, Direction of Flow, also Current, Production of.)

CURRENT, ALTERNATING—A current which does not flow steadily in one direction but changes its direction in the circuit periodically. (See Alternating Current.)

CURRENT, CARRYING CAPACITY OF WIRE—The amount of current which a wire or other metallic conductor will carry without over-heating. Whenever current flows through a conductor, heat is generated. The amount of heat will be directly proportional to the resistance of the conductor and the square of the current in it. Now the resistance of a conductor depends on its cross-sectional area, length, and also its nature. It is therefore correct to state that the heating will depend on the amount of current flowing and the cross-section and length of the wire. Obviously, a large wire will carry more current without over-heating, than will a small wire. Thus, it is necessary when choosing wire for a conductor to carry a certain amount of current, to select a wire of a cross-section sufficient to carry the desired amount of current without undue heating.

The following formula for determining the current carrying capacity of various sizes and kinds of wire uses a certain factor D, which is the permission temperature above the surrounding medium—such as air, earth or water. Where d is the diameter of the conductor in inches, T—the permissible rise in temperature in degrees centigrade, N the resistance of conductor in ohms per mil-foot at final temperature, and A the amount of current in amperes, then for solid conductors:

\[ I = \frac{K \sqrt{Dd^4}}{r} \]

and for stranded conductors:

\[ I = \frac{K \sqrt{Dd^4}}{r} \]

K is a constant (q.v.) depending upon the condition of the surface of the wire and upon the amount of heat convection due to air currents. Values of the constant K for air differ according to different authorities from 800 to 1000, the former referring to still air and the latter to open air.

Table of current carrying capacities follows:

| Wires and Cables, Insulated: Carrying Capacities, in Amperes, allowed by The Regulations of The National Board of Fire Underwriters for Interior Copper Conductors. (For Aluminum 84 Per Cent of These Currents is allowed.)
| Single Conductor Cables or Each Conductor of Multiple Conductor Cables.

**A. W. G.**

<table>
<thead>
<tr>
<th>Area in Circular Mils</th>
<th>Table A Rubber Insulation</th>
<th>Table B Varnished cloth</th>
<th>Table C by other insulation</th>
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Varnished cloth smaller than No. 6 may be used by special permission only.

CURRENT, CONVECTION—See Convection Current.

CURRENT, CRITICAL—See Critical Current.

CURRENT DENSITY—The number of amperes passing through a wire conductor per square inch of area of the conductor. For example, if a conductor is a wire or bar of copper having a cross section of one square inch, and ten amperes are passed through it, the current density will be ten amperes per square inch.

CURRENT, DIRECT—Current that flows steadily, and only in one direction. (See Direct Current.)

CURRENT, DIRECTION OF FLOW (ASSUMED)—In electrical practice the assumed direction of flow of current is often referred to. This refers to the fact that direct current is assumed to flow from the positive pole of a battery, or other source of electrical energy, to the negative pole and thence back through the battery from negative to positive. This assumed action is shown in the illustration Fig. 1, where the arrows indicate the assumed direction of flow. Now while the current is stated as flowing from positive to negative outside the source, it is the generally accepted theory that the electron stream moves in the opposite direction, or from negative to positive. In other words, the current as we use...
can be likened to a salmon swimming up a rapid. The movement of electrons can be compared to that of the water in the rapids and while the fish actually swim against the stream, and the electric current flows against the electron flow, the water and the electron stream perpetual furnish the potential of motion in each instance. The reason for the contradiction lies in the unfortunate arbitrary choice of positive and negative signs before electrons were known. (See Electron.)

CURRENT, EDDY—See Eddy Currents.

CURRENT, HIGH FREQUENCY—A current that changes direction many times each second. In radio usage, currents having a frequency over ten thousand cycles per second are considered high frequency or radio frequency currents. (See Frequency, Radio Frequency also Low Frequency.)

CURRENT, HIGH TENSION—Alternate term High Pressure. When the voltage, tension, or pressure, in a circuit is comparatively low, the current is said to be a low pressure or low tension current. When the voltage is high, the current is said to be of high tension or high pressure. Thus, as applied to radio usage, a dry cell or storage battery giving, respectively, one and a half and six volts for a certain type, are said to produce low tension or low pressure current. A "B" battery (q.v.) giving from 22½ to 45 volts (the usual value) furnishes high tension or high pressure current. While there is not a very great difference in voltage between the small "B" battery and an "A" type storage battery, the ratio of voltage to current in a "B" battery is far greater than in the ordinary case of the "A" battery and this must be taken into consideration. In general electrical practice, the "A" and "B" types are not so arbitrary, and high tension currents might be taken as those above a pressure of several thousand volts.

CURRENT, LOW FREQUENCY—An alternating current that changes its direction of flow comparatively few times per second. In commercial electrical work any frequency up to about 500 cycles per second is considered as low frequency current. In radio phase-ology audio frequency (Q.v.) currents are termed low frequency. For ordinary radio practice low frequency may be considered as any frequency below about 10,000 cycles. (See Oscillation also Oscillatory current.)

CURRENT, OSCILLATORY—See Oscillatory Current.

CURRENT, PRIMARY—A current which flows directly from its source, such as a cell or generator. The current obtained from any source through a direct conducting circuit is termed a primary current. (See Secondary Current, also Induced Current.)

CURRENT, NATURE OF ELECTRIC—As explained in the heading Current, electric current is manifest or understood by its effects. It may be apparent through the production of heat or light, by producing mechanical action such as required to operate a bell or move an electric motor, or, again, by producing chemical changes (See Electrolysis), and still further in its disastrous effects on the human body when the current has sufficient intensity. Without any actual or visible form of manifestation it can be understood on the electron basis. It will be understood that an electron (q.v.) small as it is, contains a charge of electricity. When a sufficient number of these electrons move in motion in a conductor (Note: current consists of electrons in motion) the current becomes highly visible and measurable. As an instance of this fact a current of one ampere intensity (one coulomb per second) is about the same as the electrons flow past a given point in the circuit each second. When the electrons are non-conducting, say in a conductor, no current flows in the circuit. If no current is being carried by the conductor, the electrons may move about, but they do not progress along the conductor.

CURRENT, PRODUCTION OF ELECTRIC—An electric current is produced in a conductor by applying an electro-motive force (voltage) at points of the conductor or by maintaining a difference of potential (q.v.) between two points. In the first example we can assume a metal ring or closed coil of wire with a wire magnet which will be pushed or perhaps in the core of which a magnet is being excited, or in the general sense any complete circuit through which the magnetic lines of force are being varied. In the second instance the difference of potential may be due to a primary (q.v.). Thus, the first case can be understood as referring to any mechanical means of producing current, such as generators. The other general method is by use of a voltmeter, that is, by chemical action. There are four important methods of producing an electro-motive force. The first is by friction, the apparatus used in this connection being termed a static machine; the second is by chemical action, as a primary or secondary cell; third, by the use of a wire, i.e. dynamo and generators, and fourth, by thermal action—known as a thermo-junction which is the wiring of two unlike metals in a conductor circuit so that by heating one of the points of joining a direct current will be set up in the circuit. (See Static Electricity, Generator, Thermo Couple, also Current and Electro-Motive Force.)

CURRENT, PULSATING DIRECT—When an alternating current is rectified by means of any device which permits current to flow in only one direction, the resultant current will move only in one direction, hence it is known as a direct current but unless both negative and positive halves of the cycle (q.v.) are rectified or changed to direct current, the resultant current will appear as a series of pulses in one direction. The most common application of this is found in the case of a crystal rectifier, or detector, receiving radio signals or broadcasting.

When the incoming waves, or high frequency oscillations (q.v.) are impressed on the detector, due to its peculiar properties they can only pass through it in one direction. In other words, granting that the incoming signal, or current, reverses its direction a great many times each second it will be obvious that at any instant in the cycle (q.v.) current is moving in a certain definite direction, as from positive to negative, or vice versa, as stated, due to the peculiar properties of the detector the incoming signal current can only pass through the detector when the current is flowing in the correct direction. This means that only half of the wave (q.v.) is passed through and rectified. The result is a series of direct current surges through the balance of the circuit, each surge of current being followed by a space or time interval while the opposite half of the cycle or opposite alternation (q.v.) is blocked by the uni-directional nature of the crystal. These surges are then audible in the head phones, as they will actuate the diaphragm (q.v.) whereas a high frequency alternating current such as the original impulse from the broadcasting station would be inaudible. For a more complete explanation of this action see Rectifying, Operation of crystal detector (See also, Rectifier, Full Wave Rectification and Rectifying Tube.)

CURRENT, SECONDARY—A current produced by a primary current (q.v.) acting on a secondary circuit which does not receive its energy by direct connection with the primary source. The illustration shows both primary and secondary currents and the man-

Diagram showing how crystal detector converts alternating high frequency current into pulsating direct current.

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PRIMARY CURRENT

SECONDARY CURRENT

A.C. GENERATOR

NO ACTUAL CONNECTION BETWEEN PRIMARY AND SECONDARY CIRCUITS

Induction showing primary and secondary currents and the manner of production. It will be understood that the primary current in this case must be a varying current. (See Induced Current, also Inductive Coupling.)
CURRENT, THEORY OF ELECTRIC

—Under Electromotive force it  be explained that voltage or pressure is the result of a difference of potential (the power possessed by a charge of electricity for doing work) between two points in a conductor. Electric current will flow from the point of higher pressure or voltage to the point of lower pressure, the flow continuing as long as the difference is maintained. This action is the same as with water, which will always seek to move from a high point to a lower point. The flow of current is thus an effort to equalize the two potentials. (See Current, Assumed Direction of Flow, also Pressure and Voltage.)

CURVE—A straight or curved line showing the relation between various electrical phenomena or the characteristics (relation of changing values) of an electrical instrument. (See Characteristic Curve, also Sine Wave.)

CURVE OF SINES—A curved line representing the vibration of a body that oscillates like a pendulum. The illustration shows the curve of sines which may be used to represent an alternating current. (See Alternating Current, also Sine Wave and Simple Harmonic Vibrations.)

CUT OUT—An electrical device to interrupt the flow of current through apparatus or instrument, either automatically or by hand; a switch.

CYCLE—In electricity, a period of time during which certain changes take place in an alternating current, (q.v.) the same changes occurring again in each successive cycle. We can imagine an alternating current as travelling along a wire in the form of a wave. One half of the wave being in one direction and the other half being in the opposite direction. That is to say, the current flows from positive to negative for one half of the cycle and then in effect, flows from negative to positive the other half of the cycle. (It will be understood that actually current always flows in the same direction, but the action of alternating current is due to a reversal of polarity at the source.) The difference between direct and alternating current is that, in the case of direct, the polarity always remains the same at the source and hence the direction of flow of the current is always in one direction, whereas with alternating current, the polarity changes twice each cycle due to changes at the source, and thus it flows in one direction for a certain fixed period, then reverses and flows in the opposite direction. In the illustration the current is shown as a sine wave. (q.v.) We assume that this represents an alternating current of 110 volts pressure such as in the average house lighting system. Now we consider the wave as a circle. The current flows in a positive direction toward its maximum value and at the 90° it has reached the positive maximum. It then falls back to zero at 180 degrees and reverses, rising to maximum on the negative side which it reaches at 270 degrees. It then falls back to zero at 360 degrees having completed a cycle or two alternations. The operation is repeated over and over a certain number of times each second. Thus, the rise and fall from A to B or 180 degrees is one alternation, the rise and fall from B to C is another alternation, the two alternations, one positive and one negative making a complete cycle. If sixty of these cycles occur each second we say that the frequency (q.v.) is sixty cycles. (See Alternating Current, Phase, Sine Wave.)

CYMMOMETER—The name given a type of wave-meter designed by Dr. J. A. Fleming. It is used to measure the wave-length of oscillatory (vibrating) circuits. (See Wave-Meter.)

D—The symbol of electric displacement (q.v.); also occasionally used as a symbol for diameter in electrical calculations.

DAMPED OSCILLATIONS—Electrical oscillations which die away, each succeeding oscillation in a group having lesser amplitude (q.v.) or strength than the preceding one. (See Damped Waves.)

DAMPED WAVES—Radio waves in the form of successive trains or groups, in each of which the amplitude or strength decreases with each successive wave. When electrical oscillations are caused by a single impulse, they do not continue indefinitely, but decrease in amplitude or die away. Thus, if oscillations are started in an antenna or other circuit by a discharge from a condenser (see spark discharge), each electrical shock causes a train of oscillations which die away more or less gradually. Fig. 1 shows a pendulum which is given a momentary impulse. Now as this source of power is only momentary the pendulum will not swing from A to D indefinitely. If the first swing under the impulse carries the pendulum the entire distance A to D, the next swing will cover a lesser arc and so on until the movement has died out altogether. Now in Fig. 2, the graphic illustration of a train of damped waves shows that each crest is a little lower than the one preceding it and after a short period the waves have died out alto-

Damped Waves

CYMOSCOPE—A term used to designate an instrument which enables one to see the effect of electrical waves or to detect their presence. The original form was merely a loop of wire not completely closed as shown in Fig. 1. When held close to a transmitter of short waves a small spark will pass between the ends of the loop providing the wave-length is properly adjusted. This was the form used by Hertz (the discoverer of magnetic waves which form the basis of radio telegraphy and telephony) in his early experiments. The more modern form is shown in Fig. 2 where a small lamp is made to light by holding the loop close to the transmitter. A complicated arrangement used to actually see the waves and study their form is called the Oscillograph. (See Oscillograph, also Cathode Ray Tube.)

![Fig. 1. Early type of cymoscope used to indicate resonance in a circuit.](image1)

![Fig. 2. More modern form of cymoscope.](image2)
DAMPING

Damping—A tendency of oscillations to diminish. If the amplitude of an oscillation is so small as to be detectable only with difficulty, the oscillation is said to be damped. The degree of damping is indicated by the rate at which the motion decreases, and is a measure of the effectiveness of the damping process. The ratio of the amplitude of oscillation at any time to the amplitude at the beginning is called the decrement of the oscillation. If this ratio diminishes steadily as time goes on, the oscillation is said to be logarithmically damped. If it diminishes at a constant rate, it is said to be exponentially damped. If it diminishes in any way other than exponentially or logarithmically, it is said to be non-exponentially damped.

DAMPING DECREMENT—See Decrement, Logarithmic.

DAMPING WAVES—Term commonly used to denote the decrease in amplitude of a train of oscillations as in radio transmission. If the oscillations persist at constant amplitude or strength, the oscillation is considered to be undamped. But if the amplitude of each succeeding oscillation is less than that of the preceding one, there is said to be damping and the oscillations are logarithmically damped; if they decrease at a rate dependent on the degree of damping, the oscillations are exponentially damped. If the oscillations die out rapidly they are said to be highly damped; if they die out slowly the damping is said to be feeble.

DAMPER—A device for reducing the amplitude of oscillations. In electronic circuits, it is usually a coil or a capacitor, or both, in series with the circuit. The damping is produced by the energy lost in the damper. The decrement of the oscillations is usually less than 20 for a well-designed damper.

Damping factor—the ratio of the amplitude of oscillation at any time to the amplitude at the beginning. The damping factor of a well-designed damper is usually less than 20.

DAMPER coil—A coil of wire is used as a damper in electronic circuits. It is usually a coil of fine wire with a small number of turns. The damping is produced by the energy lost in the damper.

Damping constant—the constant of proportionality between the rate of change of the amplitude of oscillations and the amplitude of the oscillations. The damping constant is usually less than 20 for a well-designed damper.

Damping coefficient—the constant of proportionality between the rate of change of the amplitude of oscillations and the amplitude of the oscillations. The damping coefficient is usually less than 20 for a well-designed damper.

Damping capacity—the constant of proportionality between the rate of change of the amplitude of oscillations and the amplitude of the oscillations. The damping capacity is usually less than 20 for a well-designed damper.

Damping resistance—the constant of proportionality between the rate of change of the amplitude of oscillations and the amplitude of the oscillations. The damping resistance is usually less than 20 for a well-designed damper.

Damping inductance—the constant of proportionality between the rate of change of the amplitude of oscillations and the amplitude of the oscillations. The damping inductance is usually less than 20 for a well-designed damper.

Damping capacitance—the constant of proportionality between the rate of change of the amplitude of oscillations and the amplitude of the oscillations. The damping capacitance is usually less than 20 for a well-designed damper.

Damping resistance capacity—the constant of proportionality between the rate of change of the amplitude of oscillations and the amplitude of the oscillations. The damping resistance capacity is usually less than 20 for a well-designed damper.

Damping constant resistance—the constant of proportionality between the rate of change of the amplitude of oscillations and the amplitude of the oscillations. The damping constant resistance is usually less than 20 for a well-designed damper.

Damping constant capacitance—the constant of proportionality between the rate of change of the amplitude of oscillations and the amplitude of the oscillations. The damping constant capacitance is usually less than 20 for a well-designed damper.

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Damping constant resistance capacitance resistance capacity—The constant of proportionality between the rate of change of the amplitude of oscillations and the amplitude of the oscillations. The damping constant resistance capacitance resistance capacity is usually less than 20 for a well-designed damper.
after the impressed voltage is removed.

It will be noted that the decrement (q.v.) or the rate of decay of the oscillations directly meets the number of oscillations in the wave train that will be useful in transmitting signals. For instance, in certain oscillations from the figure, should represent the smallest voltage that will operate a detector, it is evident that all oscillations in the wave train that have smaller amplitudes will be useless. Consequently, the lower the decrement of the wave, the greater will be the number of oscillations before the amplitude becomes too small for useful purposes. This is shown as a greater part of the energy in the wave can be utilized.

**DECOHERER**—In the type of detector, now obsolete, known as the decoherer, the incoming signals caused the particles of nickel and silver filings in the glass tube of the device to cohere or cling together. (See Coherer.) In order to place the coherer in its original state after each impulse, it was necessary to have some means of separating the particles. These were known as decoherers and were in many different forms, some as separate attachments, others as a part of the detector or coherer. (See Detector.)

**DECOMPOSITION, ELECTROLYTIC**—The decomposition of chemicals taking place in a cell due to the action of the electrolyte. (See Cell, also Electrolysis.)

**DECREMENT**—A term used to indicate the rate of decay or dying out of an electrical oscillation that is subject to damping. (See illustration.) In the illustration is shown a series of damped waves. It will be noted that the distance from the zero to the crest of wave (C-D) is less than the one preceding it (C-1). This distance represents the amplitude and the ratio of any amplitude to the one preceding it is constant, that is the decay or decrease in amplitude is constant. The *Naperian Logarithm* (q.v.) of the ratio of any wave to the wave preceding it,—is called the *logarithmic decrement*. The damping of a train of waves is an important consideration as it affects the tuning qualities to a great extent. This is covered by a U. S. Government Statute Concerning Transmitting Stations, decreeing that the logarithmic decrement per complete oscillation must not exceed 0.2, which means that for each single spark discharge from the transmitter there must be not less than 24 complete oscillations in the *antenna system*. (See Oscillations, Damping, *Naperian Logarithm*, *Sharp Wave*.)

**DECEREFTR**—An instrument used to measure the decrement or degree of damping in an oscillatory current. Such devices may be made in several different forms. Some types are direct reading in terms of the logarithmic decrement, while others require mathematical reduction from the readings of a dial. All deceretors operate on the basis of comparison of the resistance of the current in a tuned circuit with that in a circuit out of tune by a known or unknown percentage. (See Logarithmic Decrement, also Damping.)

**DE FOREST, DR. LEE**—Electrical engineer; b. Council Bluffs, Ia., Aug. 26, 1873. Grad. Yale (Shelley Scientific), Ph. B., 1896; Ph. D., 1899. Inventor of the De Forest system wireless telegraphy and founder Am. De Forest Wireless Telegraph Co., which was adopted largely by U. S. Gov't.; also demonstrated to the British, Danish, German, Russian and Indian Gov'ts., first used by the U. S. Signal Corps in the war maneuvers and in Alaska. 1905 invented the Audion or three-electrode vacuum tube. 1906-09 was the pioneer

**DEIONIZATION**—The action of returning a mass of gas that has become ionized (breaking up of the atoms of gas into positive and negative ions, being the elements to which and to whose motion, under the action or electric forces, is supposed to be due their electric conductivity) to its orig.

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The same ideas hold when the generator has more than two poles; in this case a full 360 electrical degrees is taken to represent the armature motion from across two adjacent pairs of poles, so that the complete cycle of voltage or current is generated. In a four pole machine, therefore, a full revolution of the armature could be represented by 2 x 360 or 720 electrical degrees. This corresponds to 2 complete cycles. Or, looking at it the other way, the whole number of coils drawn from the circle as shown, give the points on the curve.

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DELTA—The fourth letter in the Greek alphabet. The capital letter delta (Δ) is used as a symbol for delta connection of three phase alternating current generators or transformers. The small or lowercase delta (δ) is used as a symbol for Logarithmic decrement.

DELTA CONNECTION—A in a three phase alternating current system, where three coils are mounted symmetrically around a shaft rotating in a magnetic field, the connection or grouping of the windings is called delta after the Greek letter which the grouping somewhat resembles. The illustration shows delta grouping in a three phase system. The sum of the instantaneous Electromotive Forces of the three coils is zero, or in other words the sum of the Electromotive Forces of any two coils is equal and opposite to that of the other coil, the line voltage thus being equal to the phase voltage. (See Alternator, Poly-phase.)

DEMONETIZATION—The act of returning a body to its unmagnetized state or of reducing the degree of magnetization. In the case of phonographs used in radio reception the permanent magnets are often weakened or demagnetized by connecting them in the electron-tube circuits in the wrong way. (See Magnetization, also Telephone Receiver.)

DENSITY, CURRENT—See Current Density.

DIFFUSION, FLUX—See Flux Density.

DENSITY OF ELECTROSTATIC CHARGE—The electrostatic charge per unit area. (See Electrostatic Charge, also Condenser.)

DEPOLARIZATION—In an electric cell hydrogen bubbles form on the surface of the positive electrode and unless some arrangement is made to counteract this effect, the usefulness of the cell will soon be impaired due to the insulating action caused by this film of gas, known as polarization. Usually some means of oxidizing is employed to act upon the hydrogen as fast as it is produced on the positive electrode, thus preventing or reducing the effect of polarization. (See Cell, also Polarization, and Depolarizer.)

DEPOLARIZER—The oxidizing agent or other means used in a cell to counteract the effect of polarization. Bleomochrome of potash or peroxide of manganese is commonly used for this purpose. (See Dry Batteries, also Polarization.)

DETECTOR—A device for converting oscillating currents of high frequency (radio waves) into a form suitable for operating a telephone receiver or sensitive microphone. It is often referred to as a rectifier, because it serves to change the incoming currents (oscillating or pulsating direct currents. Detectors vary in type and efficiency, ranging from the now obsolete coherer, to the modern sensitive regenerative vacuum tube. The different types of detectors are taken up under their various headings. (See Crystal Detector, Vacuum Tubes, Electrolytic Detector.)

DETECTOR CIRCUIT—That part of the circuit in a radio receiver which contains the detector (q.v.). The detector circuit may be closely coupled to the balance of the receiving circuit by means of a tuning coil or it may be inductively coupled by a vacuum coupler or loose coupler. (See Coupling).

DETECTOR, DAMPED WAVE—Any special type of detector, such as a crystal, etc., used for reception of damped waves. (See Tücker, also Heterodyne, and Vacuum Tube.)

DETECTOR, VACUUM TUBE—The vacuum tube used as a detector of radio frequency (alternating current) oscillations. A vacuum tube may be used to change or rectify the high frequency alternating currents received at the aerial to pulsating direct currents (q.v.) capable of operating a telephone receiver or recording device. Former vacuum tubes were made for an individual purpose, such as radio frequency amplifier, audio frequency amplifier, or detector, the amplifier tubes being highly exhausted and the detector tube having a low vacuum and requiring no special current adjustment. Of late tubes have been developed to such an extent that no special tube is necessary for the detector circuit, the tube being adaptable for almost any purpose. Fig. 1 shows the ordinary circuit for a vacuum tube detector. This method is not much used now since the advent of regeneration, except where stages of regeneration are used ahead of the detector to amplify the incoming signals. In this case incoming signals are impressed on the grid of the right hand vacuum tubes and the resultant variations of potential at this point control comparatively large currents at the plate. "Pulsating direct current" is used. (See Vacuum Tube, Theory of Detector Action.)

Used in this manner the tube is a considerable improvement over the crystal detector in point of sensitivity. However, by means of regeneration, the sensitivity may be increased many times. Fig. 2 shows a simple regenerative circuit. In the former case the received currents passed through to the plate of the vacuum tube are fed back by means of the coil L2 and by being impressed against the grid, further amplification can be attained. (For complete explanation see Regenerative, Theory of Operation of Vacuum Tube, Detector, Pulslating Direct Current, also Crystal Detector.)

DETUNING—The opposite of tuning (q.v.). The term is applied to the selective inductive inductance or capacity or both, to throw the receiver out of resonance with the particular signals to which it is tuned and hence to be done to decrease the volume of the signals or it may be employed to eliminate or reduce interference from undesired signals. For example, a station operating with a wavelength of 400 meters might interfere with reception of a station operating on 360 meters, providing it has sufficient power, or the receiver in no particular selective. If the radio receiver is detuned slightly below 360 meters, the desired signals will still come in, though at lesser volume, but the interfering signals will be lost entirely. Tuning is the act of producing resonance and detuning is the act of destroying resonance. In the case of a heterodyne receiver (q.v.) the heterodyne circuit is slightly detuned from the incoming oscillations, thus producing a difference in frequency or beat frequency (q.v.). (See Resonance, also Dead-space.)

DIAGRAM—A system of lines drawn to represent the circuit or connection for radio receivers or transmitters or associated apparatus, etc. Diagrams may be in any of several forms, the two common methods being known as schematic and perspective. In the schematic form, symbols are generally used to represent the various parts of the apparatus, whereas in the perspective form, drawings of the apparatus are used. Fig. 3 shows a typical schematic diagram of a simple crystal receiver. Here the tuning coils, de-
DIAL.—Devices used to control the movement of condensers or other moving parts of radio apparatus. Most dials are made of a composition such as Bakelite or hard rubber; some are made of metal. The periphery is generally spaced off in numbers from 0 to 100 or 180, for purposes of keeping a record of the positions at which the various stations are received. Dials may be arranged to have the readings refer to definite values by means of calibration (q.v.). (See Dial Vernier. See Log.)

DIAL, VERNIER.—A term incorrectly applied to a dial arranged with slow-motion linkage in order to permit very fine adjustment. The illustrations show two types of vernier dials. Vernier dials are generally used on variable condensers and occasionally on other instruments, where close adjustment is necessary. They are particularly useful in the case of a Super-Heterodyne receiver, the oscillator control being critical, and the wavelength control as well, in certain cases. (See Dial, also Critical.)

DIAMAGNETIC MATERIAL.—Substances not readily susceptible to magnetization, i.e., those which do not pass magnetic lines of force, but rather are repelled by a magnetic pole, is said to be diamagnetic. Its permeability, or ability to permit magnetism to pass through it, is considered negative or less than unity (air). Diamagnetic substances are apparently repelled from the poles of a magnet. If placed in a magnetic field they have a tendency to diminish the magnetic induction (q.v.). (See Paramagnetic, also Permeability.)

DIAPHRAGM.—A thin disk, generally of soft iron used in telephone receivers and electromagnets disk with a piece of soft iron attached to it. Another type employs a small iron armature suspended on a pivot, and attached to a mica diaphragm by means of a delicate lever, at right angles to the armature. The vibrations of the armature in the magnetic field of the magnet are communicated to the diaphragm by means of this lever. (See Baldwin Receiver.) Another type is of metal with fine corrugations and still another is a mica or parchment diaphragm used for soft iron in the center. (See Microphone, Telephone Receivers.)

DIAPHRAGM, CARBON.—A phone diaphragm in the form of a thin carbon disc. (See Diaphragm.)

DIELECTRIC.—This term is rather broadly used in electrical work to indicate a non-conductor or insulator. A dielectric may be a solid, liquid or gas and is generally employed to separate two conducting surfaces. The most common instance of the application of a dielectric is in the case of a condenser. Here the plates are separated by a dielectric material, the nature of this material having an important part in determining the capacitance of the condenser. A variable condenser for receiving purposes generally employs air as the dielectric. That is, the two sets of plates are kept from actual contact while one is being rotated, by an air space. In fixed condensers the dielectric is usually wax, mica, glass, or compressed air, depending on the purpose for which the condenser is to be used and the dielectric strength necessary. While we refer to a dielectric as a non-conductor or insulator, there is actually no dividing line between conductors and insulators, practically any dielectric permitting passage of a certain amount of current; under the proper conditions. If a substance is a very good insulator it is said to have good dielectric properties, while one that is a poor conductor permits leakage of current is a corresponding poorly poor dielectric. (See Insulator, Conductor, Resistor, also Dielectric Coefficient and Constant.)

DIELECTRIC ABSORPTION.—The tendency of the dielectric in a condenser to apparently absorb a certain amount of the power applied to it. When a condenser is charged by a direct current source such as a battery, the instantaneous charge is often followed by a small charging current of such magnitude, that steadily decreases as it flows into the condenser. This additional charge is in effect absorbed by the dielectric of the condenser. The reverse effect is obtained when the condenser is discharged. This instantaneous discharge being followed by a steadily decreasing additional discharge. It will be apparent, that if the condenser is charged from an alternating current source, such as by radio frequency current, the dielectric will show a tendency to withhold a portion of the charge, and as the charging and discharging goes on rapidly due to the rapid reversal of the current (see High Frequency Alternating Current), the dielectric will continue to hold back this portion of the power as long as the charging and discharging process persists. This loss, due to the absorption in the dielectric, must not be confused with the losses due to faulty dielectric materials. In a certain portion of the current is allowed to leak away by conductance through or on the surface of the insulator. Dielectric absorption is often referred to as dielectric viscosity or hysteresis because of its similarity to viscosity in liquids. Viscosity is the property possessed by liquids to resist deformation. The usual method of measuring viscosities is by measuring the time taken by a known volume of the liquid, at a known temperature, in flowing through an apparatus of known form and dimensions under a known pressure. Thus tested, water will flow rapidly, while cylinder will flow sluggishly, and hence is said to possess great viscosity. (See Condenser, also Dielectric.)

DIELECTRIC COEFFICIENT AND CONSTANT.—The specific inductive capacity of a dielectric, its dielectric constant, its dielectric constant being equal, the constant being the dielectric value of the material as compared with air at ordinary pressures and temperatures as the standard (1). The table of constants for the more important dielectric materials follows. It will be seen that glass, oil, and mica have the highest values, for which reason they are used in the formation of the Specific Inductive Capacity, Dielectric, also C. G. S.)
Dielectric Constants

<table>
<thead>
<tr>
<th>TABLE OF DIELECTRIC CONSTANTS</th>
<th>Air at Ordinary Pressure</th>
<th>(Taken as the Standard)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dielectric Constant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malin</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Celluloid</td>
<td>1.555</td>
<td></td>
</tr>
<tr>
<td>Parrafine (clear)</td>
<td>1.68</td>
<td>2.32</td>
</tr>
<tr>
<td>Beezamite</td>
<td>1.86</td>
<td></td>
</tr>
<tr>
<td>Parrafine Wax</td>
<td>1.9936 to 2.32</td>
<td></td>
</tr>
<tr>
<td>Parraffen Paper</td>
<td>3.65</td>
<td></td>
</tr>
<tr>
<td>Hard Rubber (Ebonite)</td>
<td>2.05 to 3.15</td>
<td></td>
</tr>
<tr>
<td>Elastomer</td>
<td>2.22 to 3.40</td>
<td></td>
</tr>
<tr>
<td>Gutta Percha</td>
<td>2.46 to 4.20</td>
<td></td>
</tr>
<tr>
<td>Shellac</td>
<td>2.74 to 3.60</td>
<td></td>
</tr>
<tr>
<td>Olive Oil</td>
<td>3.00 to 3.16</td>
<td></td>
</tr>
<tr>
<td>Glass (Low Frequency)</td>
<td></td>
<td>3.25 to 4.00</td>
</tr>
<tr>
<td>Glass (High Frequency)</td>
<td></td>
<td>4.21</td>
</tr>
<tr>
<td>Mica (Pure Sheet)</td>
<td></td>
<td>4.00 to 8.00</td>
</tr>
<tr>
<td>Porcelain</td>
<td>4.38</td>
<td></td>
</tr>
<tr>
<td>Castor Oil</td>
<td>1.80</td>
<td></td>
</tr>
<tr>
<td>Flint Glass, very light</td>
<td>6.57</td>
<td></td>
</tr>
<tr>
<td>Flint Glass, light</td>
<td>6.65</td>
<td></td>
</tr>
<tr>
<td>Flint Glass, medium</td>
<td>7.40</td>
<td></td>
</tr>
<tr>
<td>Flint Glass, double extra</td>
<td></td>
<td>10.10</td>
</tr>
</tbody>
</table>

DIELECTRIC VALUES—See Table of Constants under "Dielectric Coefficient and Constants."

DIELECTRIC HYSTERESIS—When the electric field in a dielectric material is varied rapidly, as when the condenser is charged by high frequency currents, hysteresis occurs. This is due to the nature of the material itself, and is termed dielectric hysteresis which is synonymous with dielectric absorption (q.v.).

DIELECTRIC STRENGTH—When an electric field is established in a dielectric, that is to say, a charge is applied to a condenser, and the field attains a certain maximum value, this dielectric ceases to be an insulator and becomes, in effect, a conductor. This condition generally is accompanied by a puncturing of the dielectric material. When the charge applied to a condenser is too high the spark will burn through the dielectric and the condenser is then said to have broken down. In some cases the condenser may be permanently ruined by this action, and in others, the dielectric may be conductive at a certain voltage, while remaining effective as long as the voltage is held below the safety point. The particular voltage (critical voltage) or field intensity at which the breakdown of the dielectric occurs is called the dielectric strength of the material. (See Dielectric Strength.)

DIFFERENCE FREQUENCY—The frequency of oscillations produced by superposing oscillations of one frequency on oscillations of a different frequency. In Super-heterodyne receivers the action is based on the production of a difference or beat frequency. If the incoming oscillations from the antenna are combined with oscillations from an unmodulated source, the difference frequency produced locally in the receiver, a new series of oscillations will be produced, these oscillations having a frequency numerically equal to the difference in frequency between the two other sets of oscillations. (See Beat Frequency, also Super-Heterodyne.)

DIODE—A thermionic vacuum tube having only two electrodes, namely filament and crystal. Diode and crystal vacuum tubes were known as Fleming Valves and contained a hot filament and cold plate but no grid as found in the three electrode vacuum tube in general use. Several types of diode are still in use as detectors, their chief value lying in their low current requirements and the careful adjustments as in the case of a crystal detector. (See Triode, Vacuum Tube, also Fleming Valve.)

DIPLEX RECEPTION OR TRANSMISSION—The simultaneous reception or transmission of two series of signals by or from a single operating station. The systems are so arranged that two messages may be sent or received at the same time without interfering with each other. (See Duplex Signalling.)

DIRECT CONDUCTIVE CIRCUIT—Any circuit having a direct conductive path and not depending on capacity or electromagnetic coupling. A metallic, conducting circuit.

DIRECT COUPLING—The coupling or relation between two or more coils or circuits, wherein the connection is metallic. In the illustration Fig. 1 is shown a two slide tuning coil. In this case A-B is the primary or primary circuit and C-D the secondary or detector circuit. The two circuits are joined together by metallic connection.

DIRECTIONAL—The effect of an aerial wherein waves are transmitted better, or entirely, in one direction as compared with another, or received from a certain direction, depending upon the type and direction of aerial. (See Antennal, also Receiving Aerial.)

DIRECTIONAL EFFECT OF ANTENNA—An effect of an antenna (aerial), for reception or transmission wherein signals from a certain direction are more readily received than from another direction, or in the case of transmission, for range being greater in a certain direction.

DISCHARGE—Generally speaking, a comparatively sudden passage of electricity. The term has been applied to a storage battery will mean merely the effect of releasing the electrical charge stored up in it, in this case the discharge not being necessarily rapid. A condenser has the ability to hold charges of electrical energy and to release them suddenly when the proper contact is made. The term "discharge" as applied to a transmitter indicates the passage, usually in the form of a spark or succession of sparks, of the electrical energy across a gap between electrodes. The illustration shows spark discharge from spark coil. (See Spark Discharger, Storage Battery, also Discharger.)

DISCHARGER—Any device allowing a path for an electrical discharge. The term may be considered roughly a synonym for spark gap. Usually two or more electrodes, either stationary or rotary, spaced a short distance apart to permit the released electrical energy to bridge the space and thus complete an oscillatory circuit. (See Disc Discharger, Storage Battery, also Discharger.)

DISC DISCHARGER—A form of discharger employing one or two rotating discs carrying the sparking surfaces. With the advent of modern undamped transmission methods, these dischargers are gradually passing out. (See Synchrotron.)

DISPLACEMENT CURRENT—A current which flows for a short interval in an insulating material or dielectric when an electric field force is impressed across it, or when the intensity of the electromotive force impressed across it is increased or decreased. This displacement current will flow only when the impressed electromotive force is altered in intensity. After the initial current due to the sudden change in the electromotive force being impressed across the material, the dielectric material or insulating material will remain in a state of strain as long as the charging force persists without further change in intensity, and no further displacement current will flow. (See Current, also Dielectric.)
DISRUPTIVE VOLTAGE—The voltage sufficient to disrupt or break down a sample of dielectric material under given conditions. Known also as breakdown potential. For example, if a positive voltage of 1000 volts is applied and an improved dielectric material of 500 volts minimum, the disruptive voltage is said to be 1000. (See Break Down Potential.)

DISTRESS—See Phase Displacement, also Phase Angle.

DISRUPTIVEreakdownpositive

BREAKDOWNpotential.

DISTRIBUTED CAPACITY—The condenser effect in a coil of wire. Any coil of wire possesses inherent capacity to a certain extent, depending on its particular shape and size. In the case of a coil of wire wound on a cylindrical form as indicated in the illustration (See Radio Frequency Amplifiers.)

Fig. 1. Cell showing effect of distributed capacity between winding.

DISTRIBUTED INDUCTANCE—In a long cable or any great length of wire used for electrical purposes, additional inductance (wire) distributed through- out the entire length to compensate for the inherent capacity of the line. (See Distributed Capacity.)

DISTRIBUTED CURRENT—When the current in a line is not uniform, due to the time constants being different for various parts of the line, the current is said to be distributed.

DISTRIBUTED CURRENT EFFECT—The effect of distributed current on a coil of wire is to cause a shift in the magnetic field, which in turn affects the inductance of the coil.

DISTRIBUTED CURRENT THEORY—A theory advanced by W. C. D. in 1877, explaining electrostatic conduction by the assumption that a substance in solution or separated into positive and negative ions, these ions carrying their respective charges in opposite directions. (See Electrolytic Action.)

DISTRIBUTED DISTORTION—Lack of purity or faithfulness in the reproduction of a vibration or series of vibrations. The most common application of the term in broadcast reception is in the case of reproduction by a loud-speaker. It will very often be found that music or speech not perfectly reproduced due to any of a variety of causes. Vacuum tubes may themselves cause distortion; too small a grid current applied to the plate of a tube may result in distortion; many transformers used in audio frequency amplifier circuits may distort notes of certain frequencies, or it may be due to self-oscillation or regeneration in the receiving set. This effect is also caused by inefficient transmitting (broadcasting) apparatus, or by lack of careful adjustment. The transformers or their music into electrical impulses and its subsequent transmission and reception are attended by many difficulties.

The control of wave form in broadcasting is known as modulation. (q.v.)

If the transformation of speech or music is imperfect, the reproduction of the original voice or music vibrations, the problem of accurate reproduction is entirely dependent on the receiving apparatus. Distortion may often be traced to the diaphragm of the loud-speaker, certain types being more efficient in this respect than others. (See Loud-speakers.) If the ordinary type of disc diaphragm is used, it may become necessary to equalize the volumetric and in the reproduction of music or speech being reproduced. (See Wave Form, Modulation, also Amplifier.)

DISTORTION SIGNAL—At the International Radio Telegraph convention held at The Hague, May 1910, the call letters CC Q D S, established by the Marconi Co. in February, 1904, as the official distress call, were superseded by the letters S O S as the Marine distress signal.

SO S is the International distress call used by all radio vessels requiring assistance. The letters have no particular significance, being chosen mainly for their distinctive sound. In the International Morse code, S O S is composed of three dots, three dashes and three dots, this being an unusual combination which permits easy recognition among other messages and calls. When distress signals are heard, the nearest government transmitting station generally sends out immediate notification to all broadcasting stations in the vicinity to suspend operations until the ship has been located and assistance rendered.

DOUBLE AMPLIFICATION CIRCUIT—Also known as dual amplification circuit. The arrangement whereby a single vacuum tube or several tubes may be made to do double duty, acting as both radio frequency and audio frequency amplifiers. (See Reflector.)

DOUBLE COIL DANCE WIRE—Abbreviation D. C. C.—Cotton covered copper wire wound around a suitable form for all and forms of inductance. The insulating covering is composed of two distinct types of material, wound in opposite directions to prevent loosening. Such wire is obtainable in a variety of sizes according to the standard gauge. (See Wire Gauge.)

DOUBLE FREQUENCY OSCILLATIONS—Sometimes referred to as a double humped wave. (See Radio Frequency Oscillations.)

DOUBLE MODULATION—Successive modulation of a radio frequency alternating current at two lower frequencies. The intermediate frequency is usually above audio frequency and the lowest frequency is customarily within audio limits or a combination of audio frequencies, as in the case of radio double modulation resulting from two frequencies, generally due to too close coupling of the oscillatory circuits. When the coupling between the open and closed oscillatory circuits is too tight, the open circuit often oscillates at two frequencies, resulting in the radiation of an irregular or impure wave. The illustration Fig. 1 shows in graphic form, such an irregular wave. The two peaks of resonance explain the term double humped wave. Fig. 2 shows a second curve illustrating two frequencies.

In this case however, the amplitude of the second wave is considerably less than that of the first or main wave. According to U. S. Government regulations, if the amplitude of the lesser wave is not more than 0.1 of the amplitude of the main wave, it is said to be pure. In other words, where there are two frequencies, but the strength of one less than one tenth that of the other, it is considered negligible as it cannot be expected to cause any appreciable interference. (See Resonance, Amplitude, Decrement, etc.)

DOUBLE GRID TUBE—A vacuum tube having two distinct grid members. In addition to the usual filament and plate elements. Such a tube is used in circuits where the customary "A" battery is not employed, the extra grid acting as a booster for the electron flow, the "A" battery furnishing a small positive potential to the plate. (See Solodyne, also Theory of Vacuum Tubes.)

Fig. 2. Resonance curve showing second wave of negligible proportion.
Double Pole Switch

telephony (broadcast). (See Modulation.)

DOUBLE POLE SWITCH—A switch used in electrical practice and in radio installations having two poles or connections, thus permitting both sides of a circuit to be opened or closed simultaneously.

DOUBLE RANGE METERS—Meters used for electrical measurements, arranged to read to two scales. As an example, the voltmeter shown has two local readings, one in fine degrees for a maximum of 7.5 volts, the other a coarser scale for maximum of 150 volts. Three binding post connectors are furnished, one being a common positive for both scales. A meter for almost any measurement might be made to have double range, although such instruments are generally confined to measurement of current in amperes and pressure in volts—i.e., ammeters and voltmeters. (See Meter.)

DOUBLE SLIDE TUNER—A tuning coil provided with two sliding contacts, generally used in crystal receivers.

A typical 4-wire aerial showing lead in and method of installing lightning switch.

The illustration shows a common type of two slide tuner. (See Coupling Crystal Receiver, also Tuning.)

DOUBLE THROW SWITCH—A switch so arranged that a circuit or a certain instrument is connected in either of two different positions by throwing the switch lever. The illustration shows a single pole double throw switch. (See Switch.)

DOWN LEAD—More commonly known as lead-in. The wire running from the aerial to the receiving or transmitting apparatus, whereby the signal energy is either collected from, or fed to, the aerial. The illustration shows a typical down lead or lead-in for a receiving set. Obviously the chief difference between such a lead for receiving purposes and for connecting a transmitter to the antenna is the matter of insulation used in transmitting require careful insulation and much heavier apparatus all around. The illustration shows a complete details relating to transmission, etc., see Aerial.)

DRIFT, AVERAGE ELECTRON—The assumed rate of flow or drift of electrons under average or specific conditions. (See Electronic Flow. Also Current, Assumed Direction of Flow.)

DRIVER—A term broadly used to denote any system used to produce oscillations (vibrations) of a local nature. More specifically, it pertains to producing oscillatory currents as used to test or make measurements in radio circuits. A buzzer connected inductively to a circuit to produce oscillations in that circuit for the purpose of making measurements of capacity, wavelengths, etc. Another meaning might be a circuit involving a vacuum tube and the necessary apparatus to make it oscillate at a given or variable frequency. The term may be used to signify the tube circuit used to produce local oscillations in the case of a super-heterodyne (q.v.). Here the driver produces a series of oscillations of a frequency different from the incoming oscillations, the difference between the two being known as the beat frequency. (See Heterodyne, Local Oscillations, Buzzer, Electrotone.)

DRIVER CIRCUIT—The circuit of the apparatus used to produce oscillations for purposes of test or measurement, or, in the case of a super-heterodyne, to produce a beat effect. (See Driver.)

DRUM ARMATURE—A form of armature winding in the approximate shape of a drum. (See Armature.)

DULL AMPLIFICATION—The process of obtaining both radio frequency and audio frequency amplification from the same tube instead of using two separate tubes. (See Dual Amplification Circuit, also Reflex.)

DUGIBLIER, WILLIAM—President and technical director; born, New York, July 25, 1888. Educated New York Schools, Technical Inst. and Cooper Union; Chief Engineer of Continental Wireless Tel. & Tel. Co.; 1893 President of Com. Wireless Tel. Co.; at present Technical Director of Dubilier Condenser and Radio Corp. of New York, The Dubilier Condenser Company Ltd. of London, The Deutsche Dubilier Kondensator Gesellschaft in Berlin, La Protection Electrique Capart-Dubilier in Paris. Has obtained over three hundred patents and applications of electrical devices, which have been purchased or licensed by many companies. Member American Institute Electrical Engineers, Inst. of Radio Engineers, Honorary Member of Societe Academique D'Histoire Internationale. Member of Royal Society of Arts.

DUCON—Trade name of a device which can be fitted to any electric light socket and made to serve in place of the usual outdoor light socket. This attachment consists essentially of two condensers, so arranged as to prevent the passage of any direct current or low frequency alternating current from the lighting main to the receiving set, but at the same time to permit passage of the incoming radio signals, the electric light line acting, therefore, as a aerial. (See Adapter, Aerial.)

DUDDELL SINGING ARC—Also called Musical arc. A device which produces a source of direct current through a resistance and shunted by a condenser and inductance in series. An oscillating current is thus produced in the condenser circuit, the result being a singing note corresponding in pitch to the frequency of the oscillations in the condenser circuit. The schematic arrangement is shown by the illustration. (See Arc Generator.)

DULL EMITTER—The English term for vacuum tubes having thorniated filaments and operating with low current consumption. While the term is generally used only to designated tubes requiring only one or two dry cells to operate, it may apply as well to storage battery tubes where the current requirements are low. (See Filament, Thoriated.)

DULATERAL COILS — An alternate term for honey-comb coils; inductances wound in diamond-shaped form to reduce the distributed capacity effect. (See Honey-Comb Coils.)
DUPLEX TELEGRAPHY OR DUPLEX TELEPHONY—The simultaneous transmission of signals or telephony in both directions between two stations. (See Diplex Reception or Transmission, also Telephony.)

DUST CORE—A form of core for certain types of transformers, employing iron filings or dust in place of the customary iron wire or laminations. Iron dust is used occasionally where simplicity of construction is desired, the assembly of such a core being obviously much easier than with wire or laminated types. (See Core.)

DX—The popular term for long distance referring to the transmission or reception from distant points of radio signals or broadcasting.

DYNAMIC CHARACTERISTIC—The curves obtained by impressing an alternating E. M. F. (electromotive force) on the grid of a vacuum tube, as distinguished from the curves by application of a steady direct potential. When alternating potentials such as sine waves are impressed on the grid of a tube, the curve resulting is apt to take an entirely different form from that of the curve showing static characteristics (q.v.). (See Vacuum Tube characteristics.)

DYNAMIC CONDENSER—A term occasionally applied to a synchronous motor, where power factor is close to unity (in alternating current circuits, the ratio of the electric power in watts to the apparent power in volts ampere is known as the power factor). Used in this manner the motor has the effect of shifting the current phase in a manner similar to that of a condenser. (See Angle of Lead or Lag.)

DYNAMIC ELECTRICITY—A term sometimes used for electric currents to distinguish them from static electricity (q.v.).

DYNO—A machine for converting mechanical energy into electrical energy. It is also known as a dynamos, but usually confined to machines for generating direct current. The action of a dynamo is in the production of an electromotive force in a conductor moving in a magnetic field. Fundamentally, a dynamo is a machine that generates alternating current, but instead of collecting this current by means of rings, which would cause alternating current to flow in the external circuit, a device known as an armature is employed in such a manner that the current collected by brushes and delivered to the external circuit is direct—that is, it flows more or less steadily in one direction. Thus the kind of current delivered for use depends on the method used to collect them. (For more complete explanation of the production of alternating current see Alternating Current, Theory of Production.) In the case of a dynamo, the essential parts are the field magnets, the armature and the commutator. Now in the case of an alternator, each end of the loop or armature is connected by a brush bearing against a collector ring and the end of each loop is always connected to the same brush. This results in an external current that changes its direction with each reversal of direction of the induced electromotive force. If the external current is to be direct it is necessary to have some means of collecting the current through one brush at the positive instant and the other at the negative instant. This is done by means of an armature, which is in effect a switching arrangement, so designed that it will reverse the connections of the external circuit at the instant of reversal of current in the armature. The illustration shows a single wound dynamo. MM are the field magnets, FF the field windings, BB the brushes, A the armature and C the commutator. (See Alternator, Armature, Generator.)

DYNO-METER—A delicate and accurate instrument for measuring the amount of currents and voltages of alternating current. Such instruments depend upon the action of a circuit carrying current upon another circuit or upon the current itself. Essentially it comprises two coils, one fixed and the other movable. This system of measurement is used in a wattmeter, where it is necessary to measure the instantaneous current and voltage, i.e., power. (See Wattmeter, also Electro Dynamometer.)

DYNO-MOTOR—A direct current machine which acts either as a motor or dynamo. It has an armature with two separate windings and two separate commutators, one at each end of the armature. Either winding may be used as a motor and the other as the generator winding. Each winding is used to convert high voltage direct current into low voltage direct current or vice versa, thus performing the same function with direct current as a power transformer performs for alternating current. (See Converter.)

DYNATRON—A form of vacuum tube generally used for producing oscillations as in radio telephony, wherein the phenomena of "secondary electron emission" is used. This form of tube the electrons traveling at high speed from the hot filament or cathode are made to collide with a metallic surface. The collision of these electrons on the surface of the interposed element has the effect, under proper conditions, of jarring other electrons out of the metal. The secondary emission thus obtained depends upon the speed of the original electrons which collide with the metal surface. Normally, these secondary electrons will immediately re-enter the surface from which they were emitted, but if another electrode of higher potential is in the vicinity they will travel toward it in the same manner as the electrons are attracted to the plate of an ordinary three element tube. A standard tube can be connected as shown in the illustration to act as a dynatron. Here the filament F emits electrons, some of which pass through the grid G and collide with the plate P. This collision with the plate P may jar loose from the surface additional electrons, which normally would immediately re-enter P. However, as the grid G is held at a higher potential (higher positive voltage) than the electrodes will be drawn to it. A tube arranged in this manner may be used for practicably any one of the oscillations of the standard tube, such as regenerative detector, detector of continuous waves or as a generator of high frequency oscillations, but it has not been shown to have any advantages in this respect, being used mainly as an oscillator (q.v.). (See Electron Emission, Vacuum Tube, etc.)

DYNE—The unit of force in the absolute or CGS system of units. It is defined as the force which, acting on a mass of one gram for one second, will impart to the mass a velocity of one centimeter per second. (See CGS System, also Force.)

DYK—Common symbol for Electromotive force (q.v.)

EAR CUSHION—Pads or cushions of soft rubber used in conjunction with head-phones to prevent unpleasant pressure against the ears and also to exclude outside sounds when listening in.

EARTH—An alternate term for ground, where the earth or any metallic connection thereto is used as a return in transmission or reception of electromagnetic waves. (See Ground.)

EARTH CURRENTS—See Ground Currents.

EARTH, DEAD—See Ground.

EARTH DETECTOR—See Ground Detector.

EBONITE—See Insulating Materials.

EBURN—An insulating compound used for screen or insulating waveguide. (q.v.). (See Insulating Materials.)

EDDY CURRENT LOSS—The portion
Eddy Currents

of the total loss in electrical apparatus due to Eddy Currents (q.v.).

EDDY CURRENTS—Currents induced in the mass of a solid conductor due to the action of a varying magnetic field. The extent of the exhauster of eddy currents will be found in the case of a dynamo or generator. Here the use-

for the generation of energy in the armature is produced by the motion of the arma-

ture in the magnetic field. At the same time currents are generated in the iron core due to its motion in the magnetic field. As all currents gen-

erated in an electrical machine are pro-

duced at the expense of some amount of energy, and since the Eddy currents cannot be gathered or put to useful account, in this case, they present a loss. This loss usually is ap-

parent in the form of heat. If the core is made up of solid metal it will be obvious that a good closed path is offered for eddy currents produced. Now if the core is composed of a number of sheets or laminations, insulated by thin layers of paper or by an in-

sulating scale (as Transformer Steel) the path of the eddy currents is par-

tially broken and the effect is reduced. Eddy currents are produced in the core of a transformer due to the same cause—the vibrations of the magnetic field in which the core is located. In order to reduce the effect, laminated cores are employed as in the case of many generating machines. Eddy cur-

rent loss is often given as the loss in watts per pound of core material at 10,000 gausses (q.v.) and 60 cycles for a sheet 0.0141 inch or 0.0058 centi-

ometers thick. Where eddy currents are usually productive of losses they are put to useful account in certain types of instruments. For example, the eddy currents produced in the metal frame of a moving coil meter may be em-

ployed to damp or retard the free oscillations of the needle. (See Damp-

ing of Instruments.) Eddy currents are also used in a form of speed in-

dicator where the reaction of eddy cur-

rents created in a moving diak are made to deflect a pivoted, spring con-

trolled, magnetic needle. (See Core Loss, Hysteresis, also Foucault Cur-

rents.)

EDDY CURRENT COEFFICIENT—The coefficient or numerical multiplier, generally termed X, used in calculations of eddy current loss. Its numerical value depends upon the specific resistance (q.v.) of the iron used in the core of the machine in question, the char-

acter or wave shape of the induced voltage, the distribution of magnetic flux (q.v.) in the core material, the degree of insulation between sheets, where laminations are used, and upon the flux distribution (q.v.) due to the shape of the magnetic circuit. Its value will also vary according to the units used in the computation.

EDDY CURRENT LOSS, FORMULA FOR CALCULATING—A commonly used formula for calculation of eddy current loss is the following: \[ P = v^2 (\tau FB) \]

Here the loss is expressed in watts as P, \( \tau \) is the number of cycles per second, \( B \) the magnetic flux density (q.v.) in gausses and \( \epsilon \) the eddy current coefficient.

EDGE EFFECT—The effect on the ca-

pacity of a condenser due to the cur-

rent in the windings of the plates. This effect is not very pronounced where there is considerable

dielectric surface (insulating material) extending beyond the edge of the plates. (See Distributed Capacity.)

EDISON BATTERY—A number of Edi-

son cells grouped together in one case to supply various currents and volt-

ages as in radio. The illustration shows an Edison "B" battery, used to supply potential to the plates of vacuum tubes. (See "A" Battery, "B" Battery, Plate, Filament, also Storage Battery.)

EDISON CELL—A storage cell employing electrodes of nickelled steel and a solution of potassium hydrate for the electrolyte as distinguished from the usual type of storage cell using lead plates and dilute sulphuric acid as the electrolyte. The chief point of su-

periority of this type of cell is its com-

parative ruggedness, due in a large degree to steel construction and also... "redom

ferred to as the positive pole because it is positive in its relation to the ex-

ternal circuit. Similarly the positive electrode connection will be known as the negative pole.) The potassium hydrate or hydroxide which takes the place of the acid solution used in the lead plate type of cell acts as a pres-

ervative of the steel elements. This naturally means greater life; in fact, it is not subject to the chemical de-

terioration of other cells. The illustra-

tion shows a cell with part of the sides cut away to show the interior con-

struction. (See Edison Battery.)

EDISON, THOMAS ALVA—Born 1847. An inventor famous for his experi-

ments in applied electricity. He began life with newspaper work which he soon abandoned for telegraphy, mak-

ing many original inventions in duplex systems of operation. After a varied experience in that line he came to New York in 1871, where his talents were recognized and he had opportunity to profitably develop his ideas. The dup-

lex telegraph was made a success the following year, and two years later the quadruplex; and thereupon he be-

gan manufacturing on a large scale for the Union Telegraph Co. In 1876 he gave up his factory, and estab-

lished his experimental station at Menlo Park, N. J., where for several years he worked upon the problem of the incandescent electric light, exhibi-

ting a successful bamboo filament lamp in Paris in 1881. He invented the pho-

tograph in 1878. He superintended the construction of the first incandes-

cent lighting station in New York in 1882. Moving his laboratory to Or-

ange, N. J., he established there a large plant for electrical experiment and invention and as a result of his labors there he has taken out 400 pat-

ents. Among his inventions may be further named: a type of dynamo, a micro-

phone, the chemical electrical meter, an electric pen, the mimeo-

ograph, the magnetic ore separator, dead beat galvanometer, the electric
toedo, a telephone transmitter, and a storage battery. His chief fame came with his development of the tele-

graph, his invention of the incandes-
cent lamp and the phonograph.
EDISON EFFECT—The blackening of the inner surface of an electric light bulb during use. Edison noticed that after the lamp had been burned for some time a coating of black formed on the inner surface and increased in density, becoming finally almost opaque. Edison's experiments, followed by those of Professor Fleming (q.v.) resulted in the determination of the Fleming valve (q.v.), it having been determined that the black coating was due to the discharge of electrons from the hot filament. (See Vacuum Tube, Electron Emission, etc.)

EFFICIENCY—A very flexible term in electrical practice. Generally speaking, the ratio of useful output of any piece of apparatus to total input. Efficiency is customarily expressed in terms of percentage. Thus, broadly, a piece of apparatus may produce as useful output 80 per cent of the total input. (See Power Factor.)

EFFECTIVE ELECTROMOTIVE FORCE—The square root of the mean square of the full alternating current wave. Usually abbreviated R.M.S. (root—mean—square). The effective value of the E. M. F. (electromotive force) is used when the square root of the mean of the squares of the instantaneous values over a complete cycle is desired. Also see Electromagnetic Voltage.

EGG INSULATOR—A name applied to a certain type of strain insulator due to its egg-like form. The illustration shows such an insulator. The two connections to the insulators are so arranged that the wires will still be loosely supported, even when the egg is punctured, so that the insulator breaks. (See Insulator, also Insulation of Aerial.)

ELASTICITY—A property of matter which permits it to resist any change in shape or bulk and permits it after such a change to return to its original state. This property of materials by virtue of which they are enabled to return to their original state after the force causing the distortion has been removed is a very important one in all branches of engineering. Its chief application in radio is in the making of aural and aerial Guy wires. While the average aerial installation does not represent any serious problems in stress, the larger aerial systems of commercial stations must be carefully designed in this respect. For example, a guy wire of one material may have more elasticity than one of similar size in another material. The amount which the wire will stretch under a certain load may be determined by use of a table giving the elasticity of various metals. (See Elasticity.)

ELECTRIC ABSORPTION—An effect in condensers. That quality of a condenser by means of which it absorbs or "holds" the charge indicated by the capacitance, and conversely, retains part of the charge when the condenser is momentarily discharged. This effect is more apparent in cases where a solid dielectric material is used. In fact, air condensers have little electric absorption. The reason for this is that mica or other solid dielectrics are capable of causing greater leakage than air dielectric after the condenser has received a charge. (See Soaking in, also Dielectric Absorption.)

ELECTRIC DISPLACEMENT—A term proposed by Maxwell to denote a quantity expressing the state or condition of a dielectric in an electric field in accordance with the supposition that such a field is created by the transfer of positive electricity to one end of the field force and negative electricity to the other end of the so-called tubes of force (q.v.). (See Displacement Current, also Electrostatic Induction, and Flux Density, Electrostatic.)

ELECTRIC ELASTICITY—In a dielectric material, the property which permits it to arrest passage of a displacement current (q.v.) due to electric stress. It is equivalent to the electric stress divided by the electric strain. (See Dielectric, also Displacement Current.)

ELECTRIC FIELD—The area surrounding an electrified body in which the electrical influence of the body can be measured or noticed. Also any area or region in which there is an electric force either steady or varying in intensity. For example, the insulating surface of a condenser (material separating the plates) contains an electric field existing between the plates. An electric field always surrounds a wire or other conductor carrying electric current. (See Field, Magnetic Field, Electrostatic; also Flux.)

ELECTRIC INDUCTION—The transfer of an electric state, such as charged or electrified body to a non-electrified body without electrical contact. (See Induction.)

ELECTRICITY—The term given to an invisible form of energy. Electricity is not tangible to the human senses, but its effects can be detected. The phenomenon of electricity is regarded as due to the separation and independent movement of constituent parts of atoms termed electrons. While electricity is really an intangible thing so far as the human perceptions are concerned, it is obtainable to science not only through its effects or manifestations of energy, but has actually been reduced to quantities. The mass of electricity has been determined, as has also the rate of flow, etc. We have units which are used for the basis of all calculations in electricity. Thus, voltage is regarded as the propelling force; the quantity of electricity is given by the current or rate of flow of electricity is given in amperes, etc. Each term for the various electrical quantities is based on a certain unit which represents definite values under given conditions. The universally accepted theory in chemistry is that all matter is made up of molecules, which in turn are composed of one or more atoms. These atoms no longer exist in the minute solar systems made up of positive and negative electrical particles. (For more information of the electron theory see Electron Theory; see also Magnetism, Current, Voltage.)

ELECTRO-CHEMICAL CONDENSER—See Electric Condenser.

ELECTRO-CHEMICAL EQUIVALENT—The amount of a substance liberated by electrolytic action (electrolysis) by the passage of one coulomb (q.v.) of electric current. It represents the weight in grams of each element of a solution of an electrolyte (q.v.) which is deposited by one coulomb of electricity. It has been determined that one coulomb will liberate 0.0001056 grams of hydrogen, which is therefore used as the electrochemical equivalent of hydrogen. Electro-chemical equivalents are much used in applying the law of electrolysis. This law states that the amount (weight) of an ion liberated at an electrode each second during electrolysis is equal to the strength of the current (amperes) multiplied by the electrochemical equivalent. The corresponding equivalents of other elements compared to hydrogen may be determined by multiplying the figure 0.0001056 by the atomic weight of the other element in grams and dividing the result by the equivalent (q.v.) of the element in question. (See Electrolysis, also Electrolyte.)

ELECTRO-CHEMICAL SERIES—A table of metals arranged in order with the potential they produce in a particular electrolytic solution.

ELECTRO-CHEMISTRY—The science dealing with chemical changes due to electricity or effected by means of electricity. See Electrolysis, also Cell, and Storage Batteries.

ELECTRODE—The conductor through which electric current enters or leaves an electrochemical device. They are placed on the pole or terminal of the current carrying conductors separated by a medium through which electric current can flow from one to the other. The most common usage of the term is in referring to the positive and negative poles (q.v.) of a primary or storage cell. In the case of a dry cell, the two electrodes are the carbon rod or block in the center and the zinc container in most cases. In radio it is used to designate the filament and plate elements of a vacuum tube. The filament is termed the cathode, or negative electrode and the plate is the positive electrode or anode. The illustration shows an ordinary dry cell or primary cell with the two electrodes designated as positive and negative electrodes. The anode is called the Cathode, Battery, Electrolysis, Positive Electrode and Negative Electrode.

ELECTRODYNAMICS—Term used to denote electric currents or the forces exerted by one current upon another. ELECTRO-DYNAMICS—A branch of the science of electricity dealing with electricity in motion; the study of the force exerted by electric currents upon each other. The study of electricity was first accorded serious attention when the French scientist, A. M. Ampere (q.v.) announced the result of 59
his investigations in collaboration with D. F. J. Arago. Ampere stated in 1820 that parallel conductors through which electric currents were flowing in the same direction had a tendency to be attracted to each other and to be repelled when the currents were flowing in opposite directions. The subject is discussed under various separate headings. (See Ampere, Electricity, Magnetism.)

**ELECTRO-DYNNOMETER**—A device for measuring the current and voltage in a circuit; that is, the actual power in a circuit. It is a form of wattmeter (q.v.) designed to indicate the power in watts. It is of particular importance in measuring the power in alternating current circuits. In the case of direct current, the watts in the circuit are the product of the volts multiplied by the amperes, the result being the actual power. In the case of alternating current, however, the product of the volts and amperes is not necessarily, in fact, seldom, the true power or watts. Here we have the problem of true watts and apparent watts, or volts and amperes. The meter and ammeter are connected in a circuit and read separately, the readings indicate the maximum voltage and the maximum current or amperage. The product of these two values is the power in watts in a direct current circuit. If the current is an alternating one, the true watts or actual power will be the product of the instantaneous values (q.v.) of voltage and current. Under certain conditions in a circuit carrying alternating currents, the current may lag behind or precede the voltage. In other words, the maximum value of

Illustration showing the action of ions in a primary cell.

**ELECTRODYNAMOMETER** with the current or moving coil shown by heavy lines and the stationary or voltage coil by light lines.

**current** is not reached at the same moment as the maximum value of the voltage. In this case the true watts can only be determined by obtaining the values of volts and amperes at the same instant and then separating.

The electro-dynamometer shown in the illustration gives the instantaneous values, or rather their product, and thus indicates the power or true watts. Here the heavy lines represent the current or moving coil and the light lines the stationary or voltage coil. (See Dynamometer, also Wattmeter.)

**ELECTROLINES**—A term advanced by Professor J. A. Fleming (q.v.) to designate the lines of electric force radiating from an electron. These lines are pictured as analogous to long straight wires extending in all directions from the center of a small sphere. (See Electrons, also Electromagnetic Waves.)

**ELECTROLYSIS**—The decomposition of a compound substance, generally a liquid, into its component parts by the action of an electric current passing through it. While electrolysis is an undesired effect in certain phases of electrical power work, causing composition of grounded structures, its application to radio is mainly in the case of cells for producing an electromotive force or furnishing current for lighting tubes. The constituent elements of a chemical compound such as used in a wet cell or electrolyte for the production of electric current, are known as ions (q.v.). These ions, which are separated during electrolysis, are of two kinds. The electric-positive ions are known as cations, and the electric-negative ions are known as anions. The electric-positive ions appear at the cathode or negative electrode during electrolysis and therefore are considered as derived from the negative electrode and are therefore of negative origin. This is easily understood when the ions are considered as moving from the positive electrode or to the negative. Thus the ions appearing at the negative electrode have come from the positive electrode and are therefore considered electric-positive in nature. The diagram shows the action of the ions in a typical primary cell (q.v.). The ions are considered as carrying the current through the electrolyte—each ion carrying a fixed charge of electricity of positive or negative nature. An ion is capable of carrying only a certain fixed charge of electricity and therefore any increase in the current will necessarily be accomplished by an increase in the number of ions. (See Primary Cell, Electrolyte, Electrolytic Detector, Interrupter and Condenser.)

**ELECTROLYTE**—The liquid decomposed during electrolysis, that is, the exciting fluid or solution in a wet cell or primary cell. The liquid used in any primary, secondary or electrolytic cell. (See Cell, also Storage Battery.)

**ELECTROLYTIC ACTION**—The decomposition of a chemical compound (electrolyte) into its constituent elements—ions, by the passage of an electric current through it. (See Electrolysis, also Cell.]

**ELECTROLYTIC BATTERY CHARGER**—A device for converting alternating current such as supplied for house lighting purposes, to direct current for the purpose of charging storage bat-

teries. Essentially one or more cells containing an electrolyte and two metal electrodes, generally lead and aluminum, so arranged that current can only pass in one direction, thus making it uni-directional and suitable for charging batteries. Such chargers are arranged to rectify either one-half of the alternating current cycle or both halves of the wave. (See Charger, Storage Battery, Electrolytic Rectifier, Electrolysis.)

**ELECTROLYTIC CELL**—An arrangement of two electrodes in an electrolyte through which electric current can be passed to produce electrolysis. When the electrolyte is decomposed or separated into ions by the action of the current, and at each of the electrodes of the kind or the substances of which the electrolyte is composed accumulates. Such a cell is often used to measure electric current, as the amount of a substance deposited on the electrode depends directly on the amount of current passed through the electrolyte. (See Electrolisis.)

**ELECTROLYTIC CONDENSER**—A form of condenser making use of two electrodes placed in an electrolyte and used for alternating current circuits of high voltage and low frequency, low voltage and high frequency, and of high voltage and high frequency. The action of such an arrangement as a condenser depends on the fact that the passage of certain forms of alternating currents through it, a gas is formed around the electrodes, causing polarization (q.v.) and opposing the current. This polarization creates a very good insulating medium and a condenser of such nature can be made to have very high capacity. An electrolytic condenser may be used to prevent sudden surges in the circuit due to lightning or other causes. The polarization is instantaneous when any surge of voltage takes place and thus forms an automatic safety device which operates instantly and returns to its normal characteristics as a condenser as soon as the surge has passed. (See Capacity, also Condenser.)

**ELECTROLYTIC CONDUCTION**—The action in an electrolyte of the ions that have been separated carry positive and negative electric charges in opposite directions to the electrodes. (See Electrolysis.)

**ELECTROLYTIC DETECTOR** A device which converts high frequency currents into direct current pulsations.
cup of acid solution, generally either nitric or dilute sulphuric. The wire is lowered until it just touches the acid solution and must be very carefully adjusted as it has a tendency to burst the glass tube. When a current of electrolytic current is passing through the detecting wire it causes the rectifying action and makes the signals audible in the head phones. There are several theories regarding the action of the electrolytic detector, but the most probable one being that the contact of the wire on to a very thin film of the electrolyte gives the effect of a very small electrolytic condenser. (q.v.) When the high frequency currents are passed through the detector there is a polarizing action which causes high resistance to current in one direction but not in the other. (See Detector, also Polarization.)

**Electrolytic Interrupter**—A device using electrodes immersed in an electrolyte for the purpose of interrupting or breaking up the flow of current. It is used mainly for induction lighting high voltages. The common form comprises a lead plate as a cathode or negative element and a lead plate forming the anode; a glass or porcelain tube in which it is tightly imbedded, both immersed in an electrolyte of dilute sulphuric acid. When current passes through, bubbles form on the platinum electrode causing temporary stoppage of the current. The bubbles are automatically dissipated and the current flows again, this operation occurring at rapid intervals and giving as many as 1000 interruptions per second. (See Interrupter, also Induction Coil.)

**Electrolytic Rectifier**—A device for changing alternating current into direct current by use of electrodes placed in an electrolytic solution. The action of such electrolytic cells or rectifiers is to permit current to pass only in one direction, thus suppressing one half of each cycle and producing a direct current. The illustration shows one of the customary arrangements for electrolytic rectification, being an electrolytic cell with two electrodes, one being anode and the other cathode or electrode. One or more lamps are placed in series or shunt in the circuit to furnish the proper direct current flow. A positive pole of a storage battery is connected to the aluminum plate as shown and the lead being usually connected to the other side of the alternating current line and back to the negative side of the battery. At one instant current flows in the normal direction through the battery, but when the current reverses the flows in the opposite direction through the electrolytic cell, oxygen is given off at the aluminum electrode and forms a thin film of aluminum oxide which acts as an insulator and prevents the passage of the current in that direction. Thus with one cell one half of each alternating current cycle is stopped or cut off when the aluminum electrode is made positive and the result is an intermittent direct current suitable for charging batteries. Such rectifiers are also used for supplying current to the filaments of vacuum tubes, or voltage to the plate members of the tubes, particularly for transmitting. (See Electrolytic Rectifier Full Wave, also Blikie Battery Charger.)

**Electrolytic Rectifier Full Wave**—This system is much used for charging storage batteries from an alternating current house lighting supply. Four cells are used in this instance. The electrolyte may be a solution of hydrochloric or sulphuric acid, or a saturated solution of sodium phosphate or bicarbonate of soda. Each cell has two electrodes, one iron or aluminum and the other lead. The positive pole of the storage battery is connected by wires to the electrodes of two cells and the negative pole is connected to the aluminum electrodes of two cells. By this means both halves of the alternating current cycle are rectified to direct, pulsating current. This is known as full wave rectification (q.v.) (See Charge, Storage Battery, Blikie Battery Charger, also Rectifier.)

**Electro-Magnet**—A magnet using a curved or straight piece of soft iron or other magnetic material so arranged as to become magnetized by the passage of electric current through a coil of wire surrounding it. The illustration shows one of the commonest forms of electro-magnet. This type is used in a bell or buzzer to draw down the vibrator bar and break the circuit. (For explanation of action see Buzzer.) When the current is withdrawn from an electro-magnet, the magnetic force or attraction ceases. Electro-magnets are used for various purposes in radio, such as for test buzzers, head phones, relays, etc. (See Magnet, also Magnetic Lines of Force.)

**Electromagnetic Control**—The control of various switches and other apparatus by means of electromagnetic, usually through an auxiliary contact at a distant point. (See Remote Control, also Electromagnet.)

**Electromagnetic Field**—The space understood to be filled with electromagnetic lines of force. (See Flux, also Lines of Force.)

**Electromagnetic Flux**—The distribution of the lines of force through an electromagnetic field. (See Flux, also Lines of Force.)

**Electromagnetic Impulse**—An impulse or electromagnetic disturbance conveyed to the ether from a conductor carrying high frequency currents. Another term for the electromagnetic waves involved in radio. (See Electromagnetic Waves.)

**Electromagnetic Induction**—The production of electric currents through a change in a magnetic field (q.v.). Its production is due to a change in the number of lines of force that link the conductor and creating an induced current. This current will persist only so long as the conductor continues to be moved in the magnetic field. That is to say when there is no longer any change in the magnetic lines of force linking the conductor, there will be no current induced. The discovery of electromagnetic induction and formulation of its laws was primarily due to the scientist Faraday (q.v.). Faraday's law governing electromagnetic induction follows: "The induced electromotive force around any circuit is the rate of the decrease of the total flux of magnetic induction through the circuit." (See Induction, Flux, and Lines of Force.)

**Electromagnetic Instruments**—Electrical measuring instruments such as voltometers, ammeters, etc., which depend for their action on the exertion of electromagnetic forces upon iron armatures. (See Ammeter, Voltmeter.)

**Electromagnetic Microphone**—A type of microphone in which the sound waves due to speech or music cause vibrations of a suspended coil in a magnetic field. The resulting minute waves of electromotive force corresponding in form to the original sound waves are used to operate a microphone used in radiophone (broadcasting) transmission when purity of sound is an important consideration. Such a microphone requires that the induced...
currents be heavily amplified. (See Microphone, also Speech Amplifier.)

**ELECTROMAGNETIC RADIATION**—The propagation or radiation of electromagnetic waves through the air. (See Electromagnetic Waves, also Ether.)

**ELECTROMAGNETIC ATTRACTION**—The attraction existing between unlike poles of electromagnets. This attraction is identical with that of two unlike poles of ordinary magnets. (See Magnetic Attraction and Repulsion.)

**ELECTROMAGNETIC REPULSION**—The tendency of two like poles of electromagnets to act against or repel each other. (See Magnetic Attraction and Repulsion.)

**ELECTROMAGNETIC SWITCH**—A switch for breaking electrical circuits by the action of an electromagnet. (See Electromagnet, also Remote Control.)

**ELECTROMAGNETIC THEORY OF ELECTRICITY**—The theory that electricity, as evidenced by electrical phenomena, is a fundamental substance, as is air. It also is a continuous and measurable quantity such as time, place, and velocity that can be determined by any scientific method. (See Electromagnetic Waves.)

**ELECTROMAGNETIC UNITS**—The fundamental or absolute units employed in the electromagnetic system. These units are: length, mass, and time. The term centimeter is the unit of length, gram is the unit of mass, and second is the unit of time. (See Direct Current System.)

**ELECTROMAGNETIC WAVES**—The term applied to the energy radiated from an antenna in radio transmission. It travels in the form of waves. One-half the energy of such a wave is electrical and the other half is electromagnetic. Electromagnetic waves travel through the air at the speed of light or approximately 186,000 miles per second. These waves are propagated at the frequency of the electrical forces, i.e., their direction changes many thousand times each second. This will be better understood by means of the illustration showing the arrangement of the electric and magnetic field around a radiating antenna. Here the lines represent the electric field and the shaded portion the magnetic field. The lower loops or "feet" of these waves are assumed to pass over the surface of the earth which is a conductor. Thus when electromagnetic waves are being radiated from an antenna, circular distributions of electric charges are in the earth's surface around it. A, this changes being alternately negative and positive, the bands of charge spreading out or radiating from the antenna in the manner shown in the illustration. These waves are subject to various influences which have a tendency to refract or reflect the waves much in the manner of light waves. As these waves move out from the antenna they gradually increase in height, although the distance between the "feet," i.e., from one wave to another, remains the same. This distance is known as the wave-length. (See Reception of Electromagnetic Waves, also Wave-length, Radiation Transmission.)

**ELECTROMETER**—An instrument used for measuring potential differences (voltage), and, in certain cases, current, or power in watts. The operation of the instrument depends upon the attraction or repulsion of electric charges and it may be used for either direct or alternating current measurements. (See Voltmeter, Electrostatic.)

**ELECTROMOTIVE FORCE**—Symbol $E$ or $e$, is a force of an electric cell, and is measured in volts. It is the electrical pressure which is required to maintain a current of electricity through a conductor. Electromotive force is commonly referred to in terms of volts and is abbreviated E.M.F. The electromotive force in electricity is analogous to the difference of level which produces pressure in pipes carrying water. For this reason electromotive force is frequently referred to as "water pressure." Electromotive force is produced by a difference of potential, and this in turn sets up the flow of current. The illustration Fig. 1A shows a simple primary cell or electrolytic cell, and Fig. 1B is the analogous action of two tanks holding water, connected by a pipe and so arranged that the water level in one tank is higher than in the other, thus having a difference of level. Let $A$ be the tank at a higher level of the other tank, and $B$ be the tank at a lower level of the other tank. If the pressure is sufficient, the water will flow through the pipe from $B$ to $A$ and then back into tank $B$. This movement of water is analogous to the flow of electricity. In the case of the cell Fig. 1A there are two electrodes, one of which is at a higher potential than the other. That is to say, one is in a state of higher potential than the other and this difference of potential is what causes the flow of electricity. If the two electrodes, one positive and the other negative, are immersed in an electrolyte solution, the flow of electric current which is produced by the difference of potential is called an electromotive force. This force is in the direction from the point of greater potential to point of lesser potential as in the case of the water, and causes a flow of current in that direction. Here the flow is from $B$ to $A$, just as the electrolytic solution and from $A$ to $B$ externally through the conductor $C$. This flow of current is due to the presence of the electrolytic solution and from $A$ to $B$ externally through the conductor $C$. Thus as long as there exists a difference of potential, current will flow in an attempt to equalize the potentials. (This statement holds true only under ideal conditions. See Polarization.) This flow of current in the illustration Fig. 1A is according to Ohm's law (q.v.), i.e., a difference of potential of one volt will cause one ampere to flow through the external circuit when the resistance of the circuit is one ohm. (See Ampere, Ohm, Volt, Resistance.)

**ELECTRON**—The smallest negative charge of electricity known. An English investigator, Dr. Johnstone Stoney, is credited with having named the electron, although it was so named by him in anticipation of its being isolated and measured. Hence, in 1874, to the electron was assumed. The earliest assumptions were due to Sir J. J. Thomson and others, who actually measured and studied the minute particles of negative electricity. (See Electron Theory.)

**ELECTRON FLOW**—The theory of movement of free electrons through a conductor. (See Direct Current Theory.)

**ELECTRON EMISION**—The emission or discharge of electrons or minute particles of negative electricity from a heated metal element, i.e., a cathode in a vacuum tube. The emission of electrons in a vacuum tube is the basis of operation of all vacuum tubes in radio. (See Electron Theory, also Vacuum Tube, Theory of Operation.)

**ELECTRON THEORY**—The assumption that the atoms of all substances contain one or more particles of negative electricity, which is of course paramount to heat and light and all matter is electricity. These particles are known as electrons, and while the assumption is referred to as a theory, it has been rather definitely proven by numerous experiments, and electrons have actually been measured. Under the electron theory it is assumed that the charge carried by a single electron is the smallest possible charge which can exist in nature and that no charge of electricity exists or can be produced which is not an integral mul-
ELECTROSTATIC Induction

Electrostatic Induction

Illustration showing the electron, or negative particle, revolving around the proton or positive nucleus.

Electrostatic Induction—The production of a charge in a body due to the presence of an opposite charge in a nearby conductor, or synonymous with displacement in the case of a conductor, Electrostatic Induction is the basis on which condensers operate. In the illustration Fig. 1 is a simple circuit containing a source of potential, which in this case is a battery. As the circuit is closed through the key a momentary flow of current takes place. This flow of current is accompanied by a condition of electric strain in the insulating material of the condenser. The electrically strained dielectric or insulating material exerts a back pressure against the pressure or force of the battery, and when this back pressure is equal to the original battery pressure the flow ceases. The amount in this displacement is known as electric displacement and this displacement can be transmitted or passed on to neighboring parts of the medium and thence into space. Under the proper conditions this displacement and the magnetic field which accompanies it may be detached from the circuit and move independently in space. This is the fundamental process in the radiation of electromagnetic waves (q.v.). Now, in Fig. 2, A and B represent two conductors, both insulated. If conductors

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tor A has a positive charge and is brought close to conductor B, although not touching it. The result is a displacement of electric charge resulting in the near side of conductor B acquiring a negative charge. This displacement causes a further supply of electricity. In this manner, it is actually possible to store the electricity by electrostatic induction between two conductors or plates, by reason of the strain in the insulating medium—air in the case of the two conductors. This displacement of electricity similar to the electrostatic induction between conductors A and B is negative, positive, or zero depending on to which side of B, the positive or negative potential difference of A has been increased and in order to maintain the constant potential it must be brought about and maintained in a manner similar to that which is brought about by the passage of an electric current through a constant resistance will be equal to the square of the current. (See Black.—Induced Voltage.)

**ELECTROSTATIC LEAKAGE**—The gradual loss through leakage, of the electrostatic charge in a body, due to the ability of any substance to gain the discharge of this electric current is impossible to obtain. (See Electrostatic Induction.)

**ELECTROSTATIC LINES OF FORCE**—The electric lines traverse the electrostatic field. That is to say the electrostatic flux (q.v.)

**ELECTROSTATIC STRAIN**—The strain or state of stress in which a body is placed when an electrostatic field. In a condenser, the strain experienced by the dielectric (q.v.) when the condenser is in a state of charge. (See Condenser, also Capacity Electrostatic.)

**ELECTROSTATIC SYSTEM**—The electrostatic system of C.G.S. units. One of the absolute unit systems in electrical practice. (See C.G.S., also Electromagnetic units and Electromagnetic Units.)

**ELECTROSTATIC UNITS**—A system of measurement used in electrical engineering based on the unit of electric quantity under the C.G.S. system (q.v.). This unit quantity of electricity is the quantity of electric charge which, placed on a small sphere, will repel an equal quantity of electricity of the same sign (both negative or both positive) on another sphere which is at a distance of one die. (q.v.)*

**ELECTROSTATIC VOLTMETER**—A meter for measuring voltage, depending for its action on the electrostatic system. It is fixed and a plate connected respectively to the two poles or terminals between which the source of potential is connected. (See Black.—Voltage.)

**ELECTROSTATIC WATTMETER**—A type of wattmeter depending on the electrostatic action between two sets of fixed and moving plates. (See Electrostatic Force, also Voltmeter.)

**ELECTRO-THERMAL METER**—The term sometimes applied to a hot-wire ammeter (q.v.) or voltmeter operating on the principle that generated by the passage of an electric current through a constant resistance will be equal to the square of the current. (See Black.—Induced Voltage.)

**ELEMENT**—A term primarily applied in chemistry to the substances which are not subject to decomposition by electric current. (See Electrolysis.) These elements are hydrogen, helium, etc. The term is also used quite generally to denote a number of objects such as electrodes in a primary cell or the plate, grid and filament members of a vacuum tube. (See Cell, also Vacuum Tube.)

**EMANATE**—To flow forth or proceed, as from a source.—Webster. Thus, emanating, issuing from, the discharge (q.v.) of emanations from a hot filament in a vacuum tube. The throwing off of electrons. (See Electron Emission.)

**E.M.F.**—The abbreviation for electromotive force. The practical unit of E.M.F. is the volt. (See Electromotive Force, also Volt.)

**EMISSIVITY**—The term pertaining to the amount of energy lost. Used chiefly to designate the emission of electrons from the filament of a vacuum tube. If a tube is being heated, the flow of these electrons between filament and plate is controlled by the grid. (See Electron Emission, also Vacuum Tube, Power Rating, also Vacuum Tubes.)

**EMISSIVITY OF FILAMENT**—The ability of a filament to emit electrons when heated by an electric current. (See Electron, also Vacuum Tube.)

**EMPIRE CLOTH OR PAPER**—A closely woven paper or cloth, with two or more films of an oxidized oil, or a tough paper treated with some oxidized oil. Empires are used as insulating materials for transformers, condensers and various other devices requiring thin insulating sheets. (See Transformer, Condenser, also Transformer, Hysteresis and Wattmeter.)

**ERG**—The fundamental unit of mechanical work under the C.G.S. system (q.v.). This is defined as the work done by a force of one dyne (q.v.) when the body producing the force and the body on which the force acts are one centimeter apart. (See Joule, also Practical Units.)

**E.S.U.**—Abbreviation sometimes used for electromagnetic units (q.v.). (See Electromagnetic Units.)

**ETHER**—A term used to denote the supposed or hypothetical medium by means of which electromagnetic and light waves are propagated. (See Ether Waves.)

**ETHER WAVES**—A term sometimes applied to electromagnetic or radio waves on account of the assumption that they travel through the supposed medium ether. The assumption of an all-pervading medium such as ether has been the basis of the major part of the extensive research work carried on with light and electromagnetic waves for many years. Various experiments have been shown beyond reasonable doubt that there is some such medium, capable of conducting or rather permitting passage of light waves and radio waves. (See Ether Waves.)

**ENDODYNE**—A term occasionally used to describe reception of radio signals by means of locally generated oscillations such as the heterodyne (q.v.), but wherein these oscillations are created by a circuit or system that is independent of the receiving circuit and not a separate arrangement. (See Self Heterodyne.)

**ENERGY**—The capacity for doing work in an electric sense. Energy is energy furnished to a body by means of work done on it. Thus, if a ball is thrown into the air, the energy in the work, and the ball itself in traveling performs work, the means of doing this work being the energy. There are two kinds of energy, potential and kinetic. In the case of potential, the kinetic, the energy of a body due to motion. Kinetic energy belongs properly in the realms of mechanics and so will not be covered here with only this brief mention.

When we speak of a difference of potential in a pair of conductors, we are in effect in effect that the body or cell has potential energy. That is to say, the energy is present although not active. If, now, a wire is connected across the two terminals of the cell, the difference of potential will cause electric current to flow from one focal point to the other. Actually, in a cell of this type, we have chemical energy stored up. When a circuit is completed, some chemical energy is converted into electrical energy or creates the difference of potential, which in turn causes current to flow and electrical work is thus done. (See Potential, also Voltage and Generator.)

**EPSTEIN HYSTERESIS TESTER**—A device for measuring hysteresis and Eddy current loss in a sample of sheet iron by using an alternating current in a vacuum. (See Hysteresis.) The device is useful for determining the properties of samples of iron, particularly those to be used for transformers, inductors, also Transformer, Hysteresis and Wattmeter.)

**EQUIVALENT RESISTANCE** The value of resistance which a resistance would be required to have in order to permit the same quantity of current to flow with the current which is being measured, for example, the same amount of force (voltage) as in the case of a piece of apparatus wherein there are other factors besides, but which can be determined the amount of current. (See Impedance, also Reactance.)

**E.R.G.**—The fundamental unit of mechanical work under the C.G.S. system (q.v.). This is the unit of work done by a force of one dyne (q.v.) when the body producing the force and the body on which the force acts are one centimeter apart. (See Joule, also Practical Units.)

**EXCELSIUS**—A type of direct current dy-
FARAD—The abbreviation for dielectric field intensity. In meter and cgs systems, it is also used as the symbol for the unit of magneto-motive force, the gilbert (q.v.). The small or lower case f is sometimes used to denote the farad, the practical unit of electrostatic capacity (q.v.) and also as a symbol for frequency (q.v.).

FADING—The tendency of radio signals to decrease in volume or amplitude, or to fade. The strength of a signal is seldom the same at different hours of the day or night, generally being stronger during the dark hours of the night. This has been attributed to a variety of causes, the most plausible being that the air is more free of disturbances during the night and thus permits more ready passage of the waves through the ether. The difference in the strength of signals in the daytime and at night is sometimes very pronounced, but the phenomenon of fading is usually noticed only when distant signals are being received. It has been fairly definitely established that fading of signals is due to the refraction of the transmitted waves. (See Wave Distortion, also Reflection and Refraction.)

FALL OF POTENTIAL—See Potential Drop.

FAN AERIAL—An aerial, usually for transmission, constructed in the shape of a fan. (See Aerial.)

FAN CONNECTOR—A small triangular or fan-shaped piece of metal arranged with several holes along one edge, with screw threads for fastening each in the several wires of the lead-in of a multiwire aerial. The lower apex is fitted with some sort of connecting device to permit a single wire to be led in to the receiver. (See Lead-In.)

FARADAY, MICHAEL. Born 1791, died 1877. An English scientist famous for his discoveries in chemistry, electricity and magnetism. He first produced the rotation of the magnetic needle around the electric current in 1821, based upon Oersted's discovery of electromagnetism in 1820; he discovered electromagnet induction (1831), a principle upon which is founded the development of dynamo machinery; specific inductive capacity (1838); magnetic polarization of light (1846); diamagnetism (1846). He was a brilliant experimenter, and contributed greatly to the knowledge upon which is based present-day practice of electricity.

FEED-VOLTAGE MODULATION—A process of modulating or varying the amplitude of a radio frequency alternating current to correspond to any wave form of speech vibrations as in radio broadcasting. The system involves the introduction of additional power into the circuit of the radio frequency generator until the desired wave form variations are obtained. This is done particularly in the case of a vacuum tube transmitter in which case the voltage supplied to the plate of the primary of the coupler to the secondary by means of inductive coupling and tuned by the condenser C. A grid con-

FEEDLY DAMPED—In spark transmission, signals that are only slightly damped. Where each succeeding oscillation in a train of oscillations is of slightly lesser amplitude (q.v.) than the one preceding it, the signals are said to be slightly damped to distinguish them from signals that are highly damped and thus die out quickly. (See Damping, also Damped Waves.)

FEED—In electrical parlance, to furnish with a current of electricity. (See Feed-Back.)

FEED-BACK—A term applied in radio to the coupling of one circuit to another, whereby a portion of the current present in one circuit is fed back or returned to the other circuit. The common use of the term is in reference to regeneration, where a certain portion of the radio frequency current present in the plate circuit of a detector is returned to the grid circuit of the tube by some form of coupling between the two circuits. It may also apply to the tendency of high-frequency currents to become transferred from one circuit to another due to undesired coupling between two or more circuits. The illustration shows a single feed-back or regenerative circuit. The incoming signal energy is transferred from the circuit of the plate to the grid portion of the circuit.
Ferro-Magnetic Modulator

tube is altered (increased or decreased) to accomplish the purpose. (See Modulator.)

FERRO-MAGNETIC MODULATOR—A device for modulating or varying the amplitude of radio frequency current to correspond in wave form to the speech or musical vibrations in broad-casting. The system makes use of what is known as the hysteric energy absorption of iron, or in some cases utilizes the variation of inductance of iron-core coils. (See Modulation, also Ferro-Magnetic Substances.)

FERRO-MAGNETIC SUBSTANCES—Elements or compounds such as iron, nickel, cobalt and others which are strongly attracted by magnetic fields of force. Such substances vary widely in their magnetic properties when subjected to temperature changes. Soft iron loses its magnetization almost immediately on removal of the magnetizing source, and for this reason it is used as a pole piece in an electromagnet. (See Electromagnet, also Magnetism and Magnetic Properties.)

FESSENDEN, REGINALD AUBREY—Canadian-American Radio expert. Born at Milton, Canada, October 6, 1866, and educated at New York and Paris, France. Fessenden became inspecting engineer for the Edison Company, New York, and afterwards professor of electrical engineering at Western University, 1892. Professor Fessenden is the author of a well-known system of wireless, and it is briefly described some of the patents bearing his name. In 1906 and 1907 Fessenden invented a number of microphone transmitters which carried heavy currents for long periods, and also a heavy current telephone relay which allowed the controlling of heavy currents by means of small currents originating in an ordinary telephone circuit or coming from a telephone line. One of these transmitters was called by Fessenden a trough transmitter. It consisted of a galena piece to which were clamped two plates having platinum-iridium electrodes. Through a hole in the center of the plate passed a rod attached at one end to a diaphragm, teaspoonful of carbon granules in the center space. It was able to carry as much as 15 amperes continuously without articulation falling off, and had the advantage that it never packed. By a combination of the trough transmitter and a direct-current relay, Fessenden produced a transmitting relay for magnifying very feeble currents. An amplification of fifteen times is possible without any loss of distinctness. Fessenden is also responsible for a duplex system of Radio telephony, and the heterodyne method of reception is due to him. Fessenden has written largely on radio subjects, and is one of the most authoritative on both transmission and reception.

FIBER—A term used for a variety of substances, composed of fine slender thread-like materials, particularly a composition of vulcanized or compressed paper. It is much used in radio as an insulating material for panels and connection blocks. It is not as efficient as insulating medium as bakelite, but has the advantage of being very easy to drill. (See Bakelite.)

FIELD—The space occupied by electric or magnetic lines of force. (See Electric Field.)

FIELD DENSITY—The strength of an electric or magnetic field. It is measured by the number of electric or magnetic lines of force contained in a given cross-sectional area. (See Density, Flux, also Electric Field and Field, Magnetic.)

FIELD, ELECTRIC—The space traversed or occupied by electric lines of force. (See Electric Field.)

FIELD, ELECTROMAGNETIC—The total area traversed by electromagnetic lines of force. The region in which electromagnetic lines of force are exerted. (See Field, also Electrostatic Force.)

FIELD, ELECTROSTATIC—The region in which electrostatic forces are present or exerted. The total area traversed by electrostatic lines of force. (See Field, also Electrostatic Flux.)

FIELD MAGNET—An electromagnet, usually a core of soft iron surrounded by a winding of insulated wire, employed in generating machines to produce a strong magnetic field. As the armature of this device involves conducting surfaces pass through the magnetic field created by the field magnets. This field may be merely the ordinary magnetic force due to permanent magnets, but is usually due to the powerful magnetic lines of force resulting from passage of electric current through electromagnets. (See Alternator, also Alternating Current, Theory of Production and Electromagnet.)

FIELD, MAGNETIC—The region through which magnetic flux passes. Usually refers to the space (air) through which the magnetic flux lines pass as distinguished from the activity in the iron path itself. (See Field, also Magnetic Flux.)

FIELD REGULATOR or RHEOSTAT—Any device for varying the magnetic strength of the field magnets in a dynamo or electric motor, by which variations in wave lengths may be accomplished in the operation or performance of the machine. A field rheostat is often used in an electric motor to control the strength of the field and thus either increase or decrease the speed of the machine without the necessity of changing the applied voltage. If the strength of the field (magnetic) is reduced by insertion of resistance, the armature or rotating part speeds up in an attempt to generate the same counter-electromotive force (q.v.), which means a less magnet. On the other hand, if the resistance is removed—that is, the strength of the field increased—the fact that the armature is running through a stronger field reduces the speed of rotation, the same counter-electromotive force being present. The use of a field rheostat or rheostat in connection with a generator is for the purpose of varying the output voltage with the necessity of altering the speed of the machine. The illustration shows the connection of a field rheostat or regulator in the circuit of the shunt wound generator. (See Generator, Rheostat, Resistance.)

FILAMENT—A fine wire, one of the elements of a vacuum tube, which is heated to throw off electrons. The term is also used to refer to the fine wire used in the incandescent lamp. The filament of a vacuum tube is generally made of tungsten and is supported by glass pillars within the tube in such manner as to be insulated from the other elements. Filaments are made to be heated with various voltages from 1.1 to 6 volts in most receiving tubes, but much higher in the case of high power transmitting tubes. The filament may consume considerable current as in the old styles of six-volt tubes which consumed one ampere. The modern transmitting type illuminated filaments, tungsten treated with thorium, which permits maximum efficiency with a minimum of current consumption. When the filament is heated in the vacuum tube, by having the proper amount of gas, the electrons are thrown off and fill the space between filament and grid and plate to fill the illuminated filament. (See Electron Theory, also Vacuum Tube, Theory of Operation.)
FILAMENT BATTERY—The battery or cell used in lighting the filament of a vacuum tube. These range from a dry battery (q.v.) having a voltage of one and a half volts, to storage batteries of six volts. Filament batteries are connected across the filament of a vacuum tube in the manner shown in the illustration. The rheostat is inserted to permit the supply of current to the filament to be varied and thus change the operation of the tube. (See Filament, as Vacum Tube, Theory of Operation.)

FILAMENT CONSUMPTION—The amount of current consumed by the filament of a vacuum tube. The current requirements of vacuum tubes are always stated by the manufacturer, either in amperes or fractional amperes, or in the case of extremely low consumption, in thousands of an ampere (milliamperes). Some typical examples are the UV201A and C201A types, which require one-quarter ampere at five volts; the WD11 and 12 and C11 and 12 types, which require one ampere at approximately 1.1 volts, and the UV200 and C200 tubes, which require one ampere at six volts. Of the so-called standard types, the UV199 and C199 tubes consume the least current, requiring but sixty milliampères or 0.06 ampere, with from three to four and a half volts. The statement that a certain tube consumes one-quarter ampere indicates that in operation one-quarter ampere is consumed each hour, this current being supplied by dry cells or storage batteries known as the "A" battery (q.v.).

It will be apparent from the above that the more current consumed by the filament the greater will be the drain on the dry cells or storage battery. For this reason, and also to lengthen the life of the filaments, it is well to operate the tubes at the lowest efficient brilliancy. The brilliancy of the filament may be controlled by adjustment of the filament rheostat. In the illustration the usual "A" battery, which in this case is a dry cell, is shown connected to the filament of a vacuum tube with a rheostat in series between one filament anode and the negative terminal of the dry cell. Now as the arm of the rheostat is moved from A toward B resistance is introduced into the circuit between the filament and dry cell. As this resistance increases the current in the circuit of the filament will decrease, according to Ohm's Law (q.v.); i.e., Current = Voltage/Resistance, the current in amperes or fractional amperes and the resistance in ohms. (See Amperes, Current, Filament Resistance or Rheostat and Vacuum Tube.)

FILAMENT CURRENT—The current used to light the filament of a vacuum tube. Different tubes require different amounts of current; that is, one tube may consume a small fraction of an ampere and another may require a full ampere. Of the tubes most commonly used, the UV199 type uses the least current, this tube requiring only 0.06 of an ampere each hour. The WD11 and 12 types operate with a filament voltage of 8 volts, although it is often used with three dry cells in series which deliver 4 2/3 volts; the WD11 and 12 require 1.1 volts each, which is usually furnished by a dry cell, while the UV201A type is operated with a six-volt storage battery. (See Vacuum Tubes, Types of, also Vacuum Tube, Theory of Operation.)

FILAMENT FORMULA FOR ELECTRON FLOW—The extent of electron emission—that is, the number of electrons—emitted from a hot filament in a vacuum tube is subject to certain definite laws. In ordinary practice the actual number of electrons are not referred to, the ability of the filament to emit electrons being measured in fractional amperes of output current. Thus a tube filament having a diameter of 0.0125 centimeters operating with a power dissipation of 3.1 watts per centimeter of length, has been found to emit a current of 0.03 amperes. This result was obtained with a filament having a clean surface and with no absorbed gas on its surface. The formula for electron flow most commonly used is as follows:

\[ J_n = \frac{A}{d^2} \times \frac{1}{e^3} \]

where \( J_n \) is the electron current in milliampères per square centimeter of filament surface, \( T \) is the absolute temperature and \( A \) and \( d \) depend on the metal used for the filament.

FILAMENT RESISTANCE or RHEOSTAT—A device placed in the filament circuit of a vacuum tube, connected between the filament battery and either filament lead on the tube socket for the purpose of controlling or curtailing the filament voltage. The illustration Fig. 1 shows one type of filament rheostat which is used to permit variation of the filament current. Fig. 2 shows the manner of connecting such resistance in the filament circuit of a vacuum tube. Fig. 3 illustrates a type of filament control known as an automatic rheostat. In this form of filament resistance a fine wire plug is usually filled with an inert gas. The wire has the property of increasing its resistance rapidly with any increase in the current passing through it. It is thus possible to arrange such a device to pass only a fixed amount of current for any type of vacuum tube. The device is thus not only an automatic rheostat, but also a safety valve which prevents excessive current reaching the filament and injuring it. These controls are coming into widespread use due to these features and the fact that they reduce the number of controls necessary to operate a receiver. Fig. 4 shows a resistance which is used in series with a rheostat having small resistance in order to enable its use with tubes requiring less current to operate. (See Filament, also Vacuum Tube.)

FILAMENT, THORIUM—A filament or heating element of a vacuum tube in which a certain amount of thorium (q.v.) has been incorporated. The introduction of this rare metal into the filament in small quantities gives it the property of emitting electrons at a relatively low temperature. From a practical standpoint this permits a vacuum tube to be operated with a low filament consumption (q.v.). A common example of the use of thorium in filaments is that of the UV201A or C201A vacuum tubes, which operate with a filament voltage of 5 volts and...
FILTER—In a radio, a device arranged to permit passage through an electrical circuit of currents of certain frequencies, while excluding others of different frequencies, or any device for producing smooth direct current from alternating current drawn from the source such as a direct current dynamo, or for smoothing out rectified direct current. Filters of one sort or another are much used where rectified direct current or direct current from a generator is to be used for operation of tubes in radio transmisson or reception. In the case of rectified direct current, that is the current derived from any device for changing alternating to direct current, there is always present a tendency on the part of the current to surge or ripple. In other words, it is not smooth and of constant voltage; or there may be present a generator hum which will seriously interfere with proper operation of a tube. The conventional method of filtering rectified direct current for use as plate supply of vacuum tubes is in receiving sets. This system may also be used in connection with the output of a direct current generator or dynamo. A filter circuit may be arranged to pass only certain frequencies (see Band Pass Filter) or it may be made to pass either high or low frequencies. (See Filter, High Pass; also Filter, Low Pass.)

FILTER, BAND PASS—See Band Pass Filter.

FILTER CONDENSER—The condenser, either fixed or variable, forming a part of a circuit for filtering. (See Filter, also Acceptor, Wave Trap and Rectifier.)

FILTER, HIGH PASS—A filter circuit arranged to permit current above a certain frequency to pass freely while blocking out or attenuating all frequencies below it. (See Filter, also Filter, Low Pass.)

FILTER, LOW PASS—A filter circuit arranged to permit currents below a certain frequency to pass freely while blocking currents of higher frequency. (See Filter, High Pass; also Fixed, also Variable.)

FIXED COILS—Inductance coils as used in radio circuits, having no mechanical means of varying such as in a variable, or movable coil. (q.v.) The majority of tuned radio frequency receivers employ fixed coils shunted by variable condensers. These are known as tuned radio frequency transformers. (q.v. See Coupler, Looper, also Coupling, Varior.)

FIXED CONDENSER—A condenser having a certain definite or fixed value of capacity. Any condenser that is not variable. (See Condenser, also Condenser, Variable.)

FIXED RESISTANCE—Any resistance device having a fixed or non-variable value. (See Rheostat, also Potentiometer.)

FIXED SPARK GAP—A fixed spark gap. (q.v.) A spark gap used in transmission of radiotelegraphic signals in which the electrodes or sparking surfaces are not moved during operation. (See Disc Discharger.)

FLAME MICROPHONE—A type of microphone, for radio telephone transmission, wherein the height of a coal gas flame is varied by and according to the speech fluctuations and the resulting sound made audible by means of a selenium cell and phones. (See Microphone, also Selenium Cell.)

FLASH SIGNALING—See Code, also Morse Light.

FLAT-TOP AERIAL or ANTENNA—An aerial, generally composed of a number of wires placed adjacent to each other equally spaced on a spindle or hoop and suspended parallel with the earth. A flat-top aerial may be of the kind known as the T-type aerial (q.v.) or in the form of an inverted L. (See Aerial.)

FLAT TUNING—A term sometimes applied where the resonance curve (q.v.) has a flat top, that is where the peak of resonance is not sharply defined. The effect is known as broad tuning. (q.v.) (See Resonance, also Tuning.)

FLEMING, JOHN AMBROSE. British radio expert. Born in Lancaster, England, November 29, 1849, he was educated at University College, London, the Royal School of Mines, and St. John's College, Cambridge. From 1873-74 Fleming was demonstrator at the Royal College of Chemistry, and in 1877 he began work under Clerk-Maxwell at the Cavendish Laboratory, Cambridge. There he carried out a series of experimental researches on the British Association Standards of Electrical Resistance. In 1881 Dr. Fleming was appointed the first professor of mathematics and physics at University College, Nottingham, but the following year he joined the Edison Electric Light Company, and on the amalgamation of the Edison and Swan Companies, he was appointed advising electrical post for twenty years. In 1885 Fleming was appointed to the newly founded professorship of electrical engineering at University College, London, and he was entirely responsible for the design and equipment of the new electrical and engineering laboratories which were opened in 1893. In 1892 he was elected Fellow of the Royal Society.

John Ambrose Fleming.

Dr. Fleming has written a very large number of papers and books on wireless telegraphy and telephony, and his "Principles of Electric Wave Telegraphy" is the standard treatise on the subject. He has also published an "Elementary Manual of Radio Telephony" and Radiotelegraphy; "The Wonders of Wireless Telegraphy"; "The Thermionic Valve and Its Development"; "A Pocket Book for Wireless Telegraphists," and other books. As a lecturer at the Royal Society of Arts he has obtained a world-wide reputation for his lectures on electric oscillations and electric waves, Hertzian wave telegraphy, high-frequency measurements, etc. He has given many lectures on wireless at the Royal Institution.

Fleming was awarded the Hughes gold medal of the Royal Society in 1910 as an acknowledgement of the value of his work in electrical science and engineering, and he has twice been awarded the Institution Premium of the Institution of Electrical Engineers, the highest award for communications papers, and he is an Albert Gold Medalist of the Royal Society of Arts awarded to him for the pioneer invention of the thermionic valve.

FLEMING'S RULE—A rule for determining the direction of the induced current (q.v.) in a circuit. Hold the right hand so that the fingers point in the direction of the magnetic lines of force and the thumb will point in the direction of the induced current.
hand as shown in the illustration with the thumb, forefinger and middle finger as nearly as possible at right angles to each other. If the thumb is then pointing in the direction of motion of the conductor and the forefinger points along the direction of the magnetic lines of force, the middle finger will then point in the direction of the induced electromotive force. (See Induced Current, also Electromotive Force.)

FLEMING VALVE—The forerunner of the modern vacuum tube. It was invented in 1904 by Professor J. A. Fleming and was for a short time used as a detector in place of the customary crystal detector. The effectiveness of the discovery of the Fleming valve lies chiefly in its influence on the course of radio development, as in itself it was not nearly as efficient as a good crystal detector. As a result of the discovery of the Fleming valve, however, many leading scientists bent their efforts toward the discovery of better methods of detecting radio waves, culminating in the type of tube designed by Dr. Lee De Forest.

The Fleming valve consists essentially of an incandescent lamp using a filament of carbon, tungsten or tantalum which can be rendered incandescent by an electric current. The filament is sealed in a glass tube which is highly evacuated, that is from which practically all air has been excluded. Surrouding the filament, but separated from it is a metal cylinder, both ends of the filament and the plate being attached to outside connections by means of leads sealed in the tube. The illustration, Fig. 1, shows the general arrangement of such a tube. The operation of the tube is due to the emission of electrons from the heated filament. It was demonstrated by several investigators that a filament made of certain metals has the property of throwing off minute particles of negative electricity as electrons when heated to a relatively high temperature. It was also found (see Electron) that these electrons were thrown off in greater profusion when the filament was placed in high vacuum. It was also found that a space charge of negative electrons from the filament (q.v.) would in time leave it positively charged, this charge having an attraction for the negative electrons as they were thrown off from the filament. Hence it was necessary to apply a charge of negative electricity to the filament. The electrons were now found to escape in great number, but had the effect of forming a space charge (q.) of negative electricity around the filament, which in time served to repel the escape of more negative electrons. To counteract this tendency a strong positive charge was applied to the metal plate surrounding the filament. This made the plate positive in respect to the electrons and served to attract them away from the filament. The stream of electrons thus affords a path for current to flow from filament to plate, and the action of the tube as a detector of high frequency waves depends on this principle. If the tube is connected as indicated in the illustration, Fig. 2, it will serve to rectify the incoming signals, that is change them from high frequency alternating currents, to pulsating direct current. The action is as follows: The aerial is connected to the secondary circuit of a transformer; B and C are variable condensers, F the filament of the Fleming valve, B the battery for lighting the filament of the valve and also to supply voltage to the plate, T a pair of headphones, P a 400 ohm potentiometer and R a standard filament rheostat. The incoming signal in the form of high frequency currents, change direction many times each second. Thus, at one instant the plate will have a positive charge while the next instant it will have a negative charge as a result of the changes in direction of the currents impressed across the tube from the antenna circuit. While the plate is positive, electrons will be attracted away from the filament, which at that instant will be negative with respect to the plate. The current thus flows for an instant, stopping when the impressed current changes its direction and makes the plate negative. In this manner we have a flow of current from filament to plate in one direction in the form of surges appearing at every alteration or change of current. The diaphragms of the phones will respond to these uni-directional surges and will give out sounds almost identical with the original signals transmitted. The tube thus serves as a rectifier of the incoming signals and is known as a detector of high frequency waves, or oscillations. The Fleming valve principle is used in rectifying tubes for changing alternating current to direct current for charging batteries, its use as a detector for radio reception having died out almost entirely. (See Charger, Storage Battery, Detector, Tuner, Radio Vacuum Tube.)

FLEWELLING CIRCUIT—A modification of the Armstrong Super-regenerative circuit, as figured by the American experimenter, Flewelling. In this system, the tendency toward self-oscillation (q.v.) is retarded by the use of fixed condensers which are arranged to have a damping (q.v.) effect on the grid of the detector tube, automatically rounding the flow of current in the tube. The circuit controls the self-oscillation of the tube without the necessity for the separate control tube used in the Armstrong circuit. The illustration shows the original Flewelling circuit. It is essentially a standard regenerative circuit with certain necessary modifications.

The coils L1 and L2 give magnetic coupling between the plate circuit and the grid circuits or condensers C1, C2 and C4 are of the fixed type and afford a pair of relatively low impedance (q.v.) for the high frequency currents. C5 is the customary grid blocking condenser which a grid leak is shunted. The usual construction requires T, the plate battery B and the filament battery A are included in the circuit in the customary manner. The coils L1 and L2 may be two honey-comb coils having respectively 50 and 75 turns. The tuning condenser C5 is shown as 0.0005 mfd. for the broadcast band of wave-lengths and the loop may be almost any form.

In operation three forms of current pass through the plate circuit including the coil L2, namely, the direct current from the plate battery B, the unidirectional surges of rectified current due to the action of the tube as a rectifier and the high frequency alternating currents transferred through the medium of the magnetic coupling of the two coils L1 and L2. The direct current is present only in the plate circuit, the condensers C2, C and C4 blocking the direct current from the grid circuit. These condensers also block the rectified currents but afford two paths for the high frequency currents or oscillations. The condensers C2, C3 and C4 have definite values, respectively .005, .006 and .006 micro-farads, to allow a by-pass through the grid to the filament, thus causing accumulation of electrons on the grid and stopping oscillation of the tube. The charge then leaks off by means of the grid leak connected across C5, the tube then building up oscillations in the main circuit and continuing the process during operation. The by-pass resistance connected across C5 is variable and permits control of the by-pass of high frequency current of the grid. Careful adjustment is necessary to obtain maximum signal strength without distortion. (See Armstrong Circuits, Regenerative Circuit, Armstrong Super-Regenerative Circuit.)

FLEX—Term used in Great Britain and occasionally in this country to refer to a number of small wires twisted or stranded together to form a single flexible conductor. (See Flexible Wire.)

FLEXIBLE LEAD—Any conductor, particularly when the connections from rotary parts of a coupling are made in which the conductor is made up of a number of fine wires in such a way
Flexible Wire

that the necessary bending in operation of the unit will not snap the wire as would be the case with a solid conductor. (See Flexible Wire.)

FLEXIBLE WIRE—Any conductor composed of a number of fine wires to permit constant handling and bending without a break. (See Flexible Wire.)

FLOAT, BATTERY—Term sometimes applied to the bulb or float in a hydro-meter for testing the condition of water. (See Hydro-meter.)

FLOW OF CURRENT—An expression used to denote the passage of electric current along a conductor. (See Current.)

FLOW OF MAGNETIC FLUX — The passage of lines of magnetic force through any magnetic circuit. (See Flux.)

FLUCTUATING CURRENT—An electric current that does not have steady value, rising and falling in strength or presence. A current that is not constant. (See Constant Current, also Voltage, Constant.)

FLUORESCENT SCREEN—A screen or surface coated with fluorescent material, as used to exhibit shadows cast by rays from various types of tubes. Its application in radio is chiefly in the form of cathode or screen. (See Cylindrical Cathode.)

FLUX—A very broad term in physics. The three more common examples of flux are: (a) to denote electro-magnetic flux (q.v.), (b) a substance used in soldering for the purpose of making the solder flow readily and making of lines of force to pass around the parts being united, and (c) in metal smelting, a mineral—customarily chalk or lime—used to absorb and dispose of them in the form of slag.

Flux is also used to refer to the amount of heat or light flowing or passing through a given distance or area in a given time. (See Electrostatic Flux, Flux Density, also Flux, Magnetic.)

FLUX DENSITY—the number of lines of force per square centimeter of sectional area of a magnetic path. The unit of flux density in the C.G.S. (Centimeter Gram Second) or electro-magnetic system of units is the Maxwell. It is also referred to as the "line." As a magnetic flux is merely the effect of magnet-motive force, we can take the rule that the magnet-motive force is 1,257 x ampere turns as the rule for determining the intensity or density of magnetic flux. (See Flux, Field, Magnetic, also Ampere, Turna and Maxwells.)

FLUX DISTRIBUTION—The distribution of lines of force in a magnetic or electrostatic field of force. (See Field, also Flux.)

FLUX, ELECTROSTATIC—Another term for electrostatic displacement as in the case of a condenser. The density of electrostatic flux refers to the intensity of electrostatic force. (See Electrostatic Flux, Flux Density, Field, Electric.)

FLUX LEAKAGE—Any loss or dissipation of flux caused by the existence of iron. (See Flux, Electrostatic, also Flux, Magnetic.)

FLUX LINES—The lines of force in a field. A field in which electrostatic or electromagnetic force is exerted. An alternate term for lines of force. (q.v.)

FLUX, MAGNETIC—Term used to denote the grouping of magnetic lines of force in a magnetic field. (q.v.)

magnetic flux is in the case of an ordinary bar magnet as shown in the illus-
Frequency

The four element tube has an additional grid element. The illustration shows one form of tube having a double plate. Such a tube can be used for high and low frequency amplification and as a detector simultaneously or it may be used in conjunction with the Solowyn system which does not use the customary B battery to supply potential to the plate element. (For more complete explanation of the action of a four element tube in the latter manner see Solowyn.)

Fourth Circuit—A method of controlling oscillation of a regenerative detector used in the Cookaday Circuit. (q.v.) See Free Oscillations.

Frame Aerial—An alternate name for loop aerial, a type of aerial consisting of a number of turns of wire wound on an insulated frame and used in place of the regular outdoor aerial with sensitive receiving sets. (See Loop Aerial.)

Free Alternating Current—Term applied to alternating current assumed to be produced by the application of an impulse of electricity to an oscillatory circuit. (q.v.) See Free Oscillations.

Free Electrons—Name given to the outer electrons of an atom, which become detached under various chemical transformations and are assumed to participate in electrical effects or phenomena. Free electrons are so named to distinguish them from the bound electrons of the proton or positive nucleus of an atom. (See Electron, also Proton.)

Free Magnetism—The portion of magnetism that follows the magnetic path of the metal of a magnetized body, but leaves the surface of the magnet. Sometimes referred to as surface magnetism. (See Magnetism.)

Free Oscillations—Oscillations having the natural frequency of the circuit in which they occur. (See Forced Oscillations.)

Frequencies—The plural of the term denoting the number of complete cycles per second in an alternating current.

In referring to vibrations, particularly audible vibrations, the term frequency is used to denote all the frequencies that are normally considered audible. (See Frequency.)

Frequency—A term adopted from academic English to use in electrical practice. Thus, the number of times a certain action is repeated per unit of time. In the case of an alternating current (q.v.) the current reverses its direction of flow at certain definite intervals. If the reversing process takes place 120 times per second—that is 60 reversals from negative to positive and vice versa—then the frequency of the current is said to be 60 cycles. In ordinary commercial practice the majority of alternating current generators produce an alternating current or E.M.F. having a frequency from 25 cycles per second to 50 cycles per second. In radio transmission the alternating current or E.M.F. (Electro Motive Force) has an infinitely higher frequency—the reversals take place in thousands of times each second. (See Alternating Current, Theory of Production, also Alternation and Periodicity.)

Frequency, Audio—In radio, a frequency within the limits at which audible sounds are produced. It is generally considered as a frequency above 10,000 cycles per second, although some authorities refer to frequencies up to 16,000 or 20,000 cycles as being within the limits of audibility. For ordinary practice, the human ear is capable of hearing sounds only up to about 2,500 cycles per second. In receiving sets the audio frequency circuit has an audio frequency range. In this part of the circuit only currents of audio frequencies are present. (See High Frequency Component of Plate.)

Frequency Circuit, Radio—The circuits in a receiver in which only high or radio frequency currents are supposed to be present. (See Feedback, Audio Frequency, also Illustration in connection with Frequency Circuit, Audio.)

Frequency, Fundamental—The frequency of the fundamental wave. (See Fundamental Frequency.)

Frequency, Group—The frequency of the separate trains of waves in radio communication. (See Group Frequency, also Wave Train.)

Frequency, High—Frequencies over certain definite limits, generally from 10,000 to 20,000 cycles per second in radio usage. Commonly used as synonymous with radio frequency. This frequency is the opposite of low or audio frequency. (See Frequency, also Audio Frequency, also Limits of Audibility.)

Frequency, Low—Frequencies below certain limits, generally 10,000 or 20,000 cycles per second. (See Frequency.)

Frequency Meter—A device for indicating the frequency of an alternating current in cycles per second. The most simple form uses a system of tuned, vibrating reeds. The illustration shows a frequency meter of the

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Illustration by Courtesy of J. C. Biddle, A vibrating reed type of frequency meter.
reed type. These reeds may be arranged to respond to various frequencies, such as the reeds in various musical instruments. These reeds are acted upon by an alternating current magnet. When the reed is struck by an alternating current sent through the windings, the reed nearest to that frequency is thrown into sympathy with the vibration due to the alternating magnetic effect on the magnet. Such magnets and also those of the induction type are used for comparatively low frequencies such as occur in commercial lighting systems. Fixed or resonant frequencies used in radio communication somewhat different systems are used.

**FREQUENCY, RADIO**—An alternating current or electromotive force above certain definite limits, generally above 10,000 or 20,000 cycles per second. The lines of demarcation between audio frequency and radio frequency is not very sharply defined, as, in radio usage frequencies that are actually inaudible to the human ear may yet be referred to as audio frequencies. The term is used to distinguish between the fixed or audio currents and the high frequency oscillations such as are impressed on the antenna in receiving or transmitting. (See Audio Frequency, also Frequency, Low.)

**FREQUENCY, UNIT OF**—Frequency of alternating currents is expressed in cycles per second and is generally written f. (See Frequency, also Cycles.)

**FREQUENCY, VARIATION OF POWER FACTOR WITH**—When a condenser is charged and dielectric absorption (q.v.) is allowed to take place, it will be accompanied by a loss of power which is apparent in the form of heat produced in the condenser. This loss of power varies with the frequency of the current impressed on the condenser and it is therefore said that the power factor varies with the frequency. (See Condenser, also Dielectric Absorption.)

**FULL LOAD CURRENT**—The current delivered by an electrical source, such as a dynamo or generator operating at its maximum load. The maximum current obtainable from an electrical source.

**FULL WAVE RECTIFICATION**—In rectifying alternating current, the process of rectifying both the positive and negative alternations or half cycles. The majority of rectifiers for charging storage batteries rectify only a half wave, or half cycle, and thus do not utilize the full alternating current cycle. (See Rectifier, Full Wave, also Charger, Storage Battery.)

**FULLER CELL**—A type of primary cell formerly much used in telephone, telegraph, and amateur work. (See Cell, Open Circuit.) A zinc electrode cast in the shape of a cone is at the end of a soft copper wire and rests at the bottom of a porous cup immersed in a dilute solution of sulphuric acid. The carbon electrode is in an outer jar in a bichromate solution. (See Cell.)

**FUNDAMENTAL FREQUENCY**—The frequency or number of cycles per second of the fundamental wave. (See Frequency, also Fundamental Wave.)

**FUNDAMENTAL UNITS**—Units based on the fundamental quantities of length, mass, and time. Under the C.G.S. system the unit of length is the centimeter; of mass, the gram; and of time, the second. In absolute system of units. (See Centimeter-Gram-Second.)

**FUNDAMENTAL WAVE**—In an alternating current, the component of the wave form that is a pure sine wave of the principal frequency. Upon this principal frequency the various higher frequencies (harmonics) may be superimposed. These harmonics which when combined with other frequencies which are a whole multiple of it produce the harmonious note. These terms are derived from acoustics in which the fundamental is the pure sound wave or pure sine wave. (See Wave of Alternating Current or EMF.)

**FUNDAMENTAL WAVELENGTH**—Term used to denote the wave-length at which the inductance and capacity of a coil or antenna would be in resonance. In referring to antennas the fundamental wave-length is the wave-length corresponding to the frequency at which free oscillations will occur. This is often referred to as the natural wave-length and the corresponding frequency is referred to as the natural frequency of the antenna. For practical purposes the fundamental wave-length of an aerial (antenna) may be computed from the following. For practical purposes the fundamental wave-length of an aerial (antenna) may be computed from the following. If the antenna is of the T type, the wave-length of the flat portion would be considered as half of the total horizontal length or 50 feet instead of 100 feet. The illustration shows method of measuring length. (See Wave-length Calculation for Antennae.)

**FUSE**—A device used in electrical circuits to prevent the passage of excessive currents. Generally a strip of fusible metal, commonly lead with a small percentage of tin, enclosed in a fiber or insulated fireproof container and inserted in the circuit. When the temperature, due to excessive current, reaches a certain limit, the fuse "blows" causing a break in the circuit. It is thus possible to limit the current flowing in a circuit to a definite maximum in order to protect instruments from excessive charges. The most common use is in commercial lighting and heating systems where the current on any line is generally limited to ten or twenty amperes for the protection of the lines leading in to the building.

While dissecting the legs of a frog, they came by accident into contact with dissimilar metals which caused muscular action in them. Galvani thought that he had discovered electricity in animal matter. Volta attributed the action to the metallic contact and thereupon constructed his voltaic pile, the forerunner of the primary cell.
GALVANOMETER—An extremely sensitive instrument used for detecting and measuring electric currents and also for indicating the direction of the current's flow. When the indicating coil is suspended in the field of the earth's field and points north and south when at rest. When an electric current is passed through the galvanometer winding the needle is deflected over a graduated scale the extent of the deflection depending on the force which reflects a beam of light from a fixed lamp. It is so arranged that the lamp is provided with a lens and the beam is so reflected that a visible spot of light is seen on a scale and deflected when the moving element (carrying the mirror) swings with the passage of current. At the exact instant the beam is a sharp image fine of wire stretched in front of the lamp. This type of galvanometer may also be arranged so that the reflection of a fixed scale may be observed in the mirror by means of a small telescope arrangement. (See Galvanometer.)

GAMMA—The third letter in the Greek alphabet. (See Gamma Type Antenna.) The lower case gamma \( \gamma \) is used as a symbol for conductivity. (q.v.)

GAMMA TYPE ANTENNA—An alternate name for the inverted \( L \) type of antenna, so called because the third letter in the Greek alphabet, \( I \), resembles an inverted \( L \), and a single wire antenna with lead-in from one end is in the shape of an inverted \( L \). (See \( T \) Type Aerial.)

GAP—See Spark Gap, also Lightning Gap.

GAP, AIR—Term applied to the gap between sections of an iron core as in a transformer for the purpose of preventing saturation. Also applied to speak dischargers where a space is provided between the electrodes across which the spark jumps in operation. The term is used as well in referring to the radial depth of the space between surfaces of the rotor and stator in generating machines or motors. (See Spark Gap, also Rotary Gap.)

GAP ARRESTER—A form of lightning arrester (q.v.) in which small air gaps are provided between non-arcing metal electrodes. (See Arrester.)

GAP, MICROMETER—A small gap designed to protect apparatus from excessive potentials. (See Safety Gap.)

GASEOUS—one of the nature of a gas, having no natural physical boundaries but accommodating itself to the shape of the container, expanding to the dimensions of any space in which it may be confined.

GASEOUS TUBE—A term sometimes applied to a vacuum tube in which a certain amount of gas is present. Such tubes under ordinary conditions are not efficient amplifiers in vacuum tube use, the minute gas atoms presenting a more or less effective obstacle to the free passage of the electrons. (See Vacuum Tube, Theory of Operation.)

GAS RECTIFIER—The term applied to a vacuum tube which is only partially exhausted of its residual gas. They are also known as soft tubes and are generally used as detectors although their tendency now is toward hard or highly evacuated tubes due to their adaptability to all purposes in radio receivers whereas the soft tubes do not function well as amplifiers. (See Vacuum Tube.)

GASSING—When the charging current is continued, a fully charged storage battery has taken a normal charge the free liberation of oxygen and hydrogen takes place and a gas is present in the form of gaseous emanation or liberation of bubbles from the electrolyte. The same effect may be noted when a battery is charged at higher rate than the normal charging rate stated by the manufacturer, and under certain conditions may occur at the later stages of charging, even when the battery is not fully charged. In a storage battery that is in good condition it is a fairly accurate indication of a full charge. (See Charging, also Rate of Charging.)

GAUGE, WIRE—The various systems of measurement used for denoting the physical dimensions of wire. The standard gauge in the United States is known as the B & S or Brown and Sharpe gauge. (See Brown & Sharpe Gauge.)

GAUSS—The term adopted by the American Institute of Electrical Engineers as applying to the magnetic flux density. (q.v.) It is written \( B \) or \( \mu \) and is also used in conjunction with the Gilbert to denote magnetizing force, one gauss being one gilbert per centimeter. It is incorrectly used to apply to magneto motive force. (See Centimeter Gram Second or C. G. S.)

GENERATOR—Any machine for producing electric energy. Usually a device for converting mechanical power into electrical energy. It may apply to a vacuum tube used to generate oscillations as in transmission or for heterodyne action. (See Heterodyne, also Vacuum Tube generator.)


GILBERT — Symbol F, is the unit of magneto-motive force adopted by the American Institute of Electrical Engineers. (See Magneto-motive Force.) It is equivalent to 4π/10 or .7983 ampere turns. (See Ampere Turns.)

GLASS PLATE CONDENSER — A condenser, generally of the heavy duty fixed type, consisting of alternator layers of metal or foil and thin glass sheets as the dielectric. Glass plate condensers are mainly used for transmitting; glass having a very high dielectric constant. Such condensers may be immersed in oil to stand higher potentials without breaking down. (See Condenser, also Dielectric Coefficient and Constant.)

GLASS SILENCER — A glass tube having wooden ends with holes just permitting discharge electrodes or rods to pass, used in conjunction with spark coils and gaps or to enclose the sparking surface and thus dampen the noise of the sparking. (See Spark Gap.)

GLOW DISCHARGE — See Corona.

GLIDING THEORY — A theory regarding the propagation of electromagnetic (radio) waves, which assumes the waves as following the curvature of the earth and not being subject to refraction due to objects in their path or by any reflecting surface above the earth. This theory has been discarded; due to observations of phenomena of transmission it now is generally assumed that there must be a reflecting surface high in the atmosphere. However, it is considered probable that the waves do not extend very high as a general rule, the exceptions being the cases of extreme distance transmission in certain directions. In the upper atmosphere, due to the rarification of the atmosphere ionization (q.v.) is very pronounced and the air may become a conductor; a conducting region or layer may impose serious obstacles to the electromagnetic waves and thus limit their transmission to a certain restricted zone. In the majority of cases this ionized region may thus be regarded as damping or absorbing the waves, and in others it may conceivably intensify or concentrate them in one direction, producing ripples of transmission over extreme distances with low power. For more complete discussion along these lines see Heaviside Layer, also Refraction and Reflection of Electromagnetic Waves.

GOLD LEAF ELECTROSCOPE — A very sensitive device for determining the presence of electric charge. It comprises, essentially, two strips of gold foil joined at one end by a conductor and suspended in a glass jar. When an electric charge is present the two strips of foil have a tendency to repel one another, and thus, by divergence, change the presence of the charge. (See Galvanometer.)

GOLDSCHMIDT ALTERNATOR — One of the first alternators for generating high frequency currents suitable for continuous wave radio transmission. It was designed by Rudolph Goldschmidt in 1912 and was used mainly in Europe. This machine operated on a frequency step-up principle. A single-phase alternating current was first produced, the frequency being about ten thousand cycles. This was afterwards possible frequency obtainable with an ordinary type of alternator. By means of a cascade effect, obtained by an arrangement of tuned circuits connected to stator and rotor of the alternator, a much higher frequency could be impressed on the antennas to radiate continuous waves. The machine had a number of disadvantages which limited its commercial value; but it is true that the air gap between rotor and stator was necessarily very small — a difficult matter for a single-phase machine, the rotor of which weighed several tons. (See Alternator, Continuous Waves, also Goldschmidt, Rudolph.)

GOLDSTREMT, RUDOLF — Born March 19, 1876, at Neu-Buckow, Mecklenburg, Germany. After finishing his education at Wiener Municipal School, he studied engineering at Charlottenburg and Darmstadt Technical High School. In Darmstadt he obtained his degree as electrical engineer in January, 1898, and then became assistant to Professor Kittler. In 1900 he obtained a traveling fellowship scholarship, which enabled him to visit engineering works in Belgium, England, and France. In the same year he was appointed engineer in the laboratory of the Allgemeine Elektrizitaets-Gesellschaft in Berlin. In 1901-2 he occupied the position of chief laboratory engineer and designer at Kolben & Co., Ltd. in Prague. He came to England in connection with the Willesden Electricity Supply Station and was later appointed chief engineer to Messrs. Crompton & Co., of Chelmsford. In 1905 he joined the Westinghouse Company in Manchester. After private preparations for the passed the German-France-examination and obtained the degree of Dr. Eng. In 1907 he returned to Germany as lecturer at Darmstadt Technical College. Here he practiced as a consulting engineer, and also pursued the development of several inventions concerning himself with the invention and design of high-frequency alternators for wireless telegraphy. In 1911 he became manager of the "Hochfrequenz-Machinen Aktiengesellschaft für drahtlose Telegraphie" in Berlin, a company which was the realization of his inventions in wireless telegraphy. In this position he established two wireless telegraph stations in the Province of Hanover, and Tuckerton, New Jersey, for wireless communication between Germany and America.

more or less accurately the direction from which the signals are coming. The three stations compare notes on the respective directions and any one of them can readily plot out lines running on a chart from each station in the directions indicated by the goniometers. Then by simple triangulation the location of the ship can be figured, enabling those on the vessel to be instructed accordingly and go to their rescue. There are, of course, many other uses that occur in everyday practice. Goniometers are also much used by radio inspectors to locate stations that are interfering, using an unlicensed transmitter, or are otherwise not complying with the regulations.

The illustration Fig. 1 shows the general arrangement of a goniometer and Fig. 2 shows the loops to which coils L and L1 are connected.

Fig. 1 shows the general arrangement of the instrument. Here, coils L and L1 are the main windings of the goniometer. They are wound in two sections with condensers C and C1 inserted between the sections of the two windings for purposes of tuning. Coil L2 is the exploring coil. This is connected to the receiving apparatus, which is the customary detector circuit. Coils L and L1 are connected to the two loop aerials shown in Fig. 2. Here it will appear that the loops are placed at right angles, their relation in this respect being variable. In operation the coils L and L1 have mutual inductance, as they are placed at right angles. The Exploring coil L2 can be rotated through a complete circle and the pointer indicates the angle with relation to the fixed coils. When one of the two loops points in the direction of a transmitting station it will pick up the signals, the other being at that moment inoperative, as it is at right angles to the first, as previously explained. If the exploring coil L2 is now turned until maximum signal strength is obtained, the pointer will be in the direction of the plane of the loop. If the advancing wave strikes the two loops simultaneously at any angle, a resulting magnetic field will be set up in the coils L and L1 of the goniometer, the field having a direction at right angles to the direction from which the waves are advancing. Now when the exploring coil L2 is turned to allow maximum signal strength due to this field (permitting maximum inductive transfer), the pointer will be in the direction of the transmitting station. The direction indicated by the pointer is, of course, not the geographical direction, but this can readily be determined by means of a compass. It also appears from the foregoing description that the pointer will indicate two directions of the transmitting station in the same geographic plane. In other words, the pointer may be, for example, directly north and south.

GRAMME ARMATURE—A form of ring type armature (q.v.) used in generators, named for its originator. (See Generator.)

GRANULAR CARBON—The carbon grains used in a telephone transmitter to vary the resistance between the electrodes. The highest grade is made by carbonizing pure anthracite coal in an electric furnace, after which it is screened and graded. (See Microphone, Carbon.)

GRANULAR COHERER—A form of coherer (q.v.) used in the early days of wireless. It employed carbon granules between two electrodes, the whole enclosed in a glass tube. (See Detector.)

GRAPH—The presentation in diagrammatic form of facts, formulas, etc., particularly in the electrical and mechanical fields. Graphs are much used in radio to give graphic illustrations of various functions, such as the relation of currents and voltages. For this purpose ruled and squared paper is used. One of the most common and useful forms of graph is known as a characteristic curve of a vacuum tube. These curves may show the relation of changing values, such, for instance, as the relation of grid voltage to plate current, indicating certain of the operating characteristics of the vacuum tube. (See Characteristic Curve, also Sine Curve.)

GRAPHITE RESISTANCE—A form of resistance composed of graphite, used in any of several ways in radio circuits. The most common usage is in the form of a grid leak (q.v.). Here it may take the form of a thin sheet of paper coated with graphite or a glass tube filled with graphite and some binding medium. Such resistances are used in resistance coupled amplifiers (q.v.), in which case they are interposed between the plate and "B" battery and couple the successive stages of amplification. (See Resistance, also Resistance Coupled Amplifier.)

GRASSOT FLUXMETER—An instrument used to measure the strength of magnetic fields and the regions around magnetic poles. It is of particular value in the study of the relative strengths of various magnets. The instrument comprises a very sensitive galvanometer of the moving coil type, with a special exploring coil. This coil is introduced into the magnetic field to be measured and readings of the proportionate strength of the field are obtained directly from the scale of the galvanometer, which is appropriately divided. The field strength is obtained by dividing the deflection value in Maxwell turns (q.v.) by the area of the loop in which the exploring coil is placed and the number of turns of the coil. (See Galvanometer, also Flux Density.)

GRAVITY BATTERY—A combination of gravity cells. A group of cells, each cell having two different electrolytes which remain separated without use of a diaphragm due to their difference in specific gravity. (See Gravity Batteries.)

GRAVITY CELL—A type of primary cell (q.v.) in which the specific gravity of one electrolyte is less than the other, which causes the lighter electrolyte to float on top of the heavier fluid. One of the typical examples of gravity cells is the Daniell's Cell (q.v.). (See Secondary Cell.)

GRID—Generally, any system of wires placed parallel to each other and in the same plane, as a mesh. Specifically in radio usage, the fine network of wires interposed between the filament and plate elements in a vacuum tube. It may be in the form of a flat network of wires or in the form of an oval cylindrical mesh completely surrounding the filament and in turn surrounded by a similarly shaped plate of metal. The illustration shows the form taken by a typical grid member in a modern type of vacuum tube. If the plate is not shown in order to permit the grid member to show more clearly.

In receiving circuits the grid acts as a valve to control the flow of electrons from hot filament to cold plate. When signals are impressed on the signal grid they are tuned by the customary agencies and passed to the grid circuit (q.v.). As the incoming signals are in the form of high frequency oscillations (q.v.) changing their polarity (direction) many thousands of times each second, it will be apparent that the grid is altered rapidly from positive to negative and back. As the electrons flowing from the filament are negative, the grid will thus have a tendency to retard or increase the flow. That is to say, at the instant the grid is positive it will attract more electrons, but when it is momentarily negative the like charges will repel each other and less electrons will flow, signals being held back to the filament. (See Grid Battery, Grid Bias, also Vacuum Tube, Theory of Operation of.)

GRID BATTERY—A battery of small cells connected in the grid circuit of a vacuum tube to place a negative or positive bias or charge on that element. The illustration Fig. 1 shows a small four and one-half volt battery inserted in such a manner that a nega-
Grid Bias

In this case the characteristic curve (q.v.) of the tube is assumed to indicate that more difference in current occurs between points B and C than between A and B in Fig. 2. For this reason a negative potential is applied as shown in Fig. 1. (See Grid Bias.)

GRID BIAS—A potential of a few volts, generally from four to six, applied to the grid of a vacuum tube to influence its operation by making it more or less negative. The grid bias is usually negative and determines the point of the characteristic curve at which the tube will operate. In a sensitive receiver, and particularly where a tube is used as an amplifier (q.v.), it is essential to obtain as great a change of grid current as possible. (Note: The greater the change of grid current, the greater the change in plate current and hence the more powerful will be the output.) By applying a negative potential on the grid it is possible to hold it at the point of maximum response. (See Grid Battery, also Vacuum Tube, Theory of Operation of.)

GRID LEAK—A high resistance placed in the grid circuit of a vacuum tube to permit the electrons forming the grid current to leak off after each cycle, thus preventing their accumulating on the grid in such numbers as to stop the flow of current. The electrons being negative, a surplus of them on the grid member of the tube would act as a barrier to the free flow of other electrons from the filament through the grid to the plate, thus diminishing the plate current toward zero. It will be understood that a heavy negative charge on the grid will repel a like or negative charge, in this case the negative electrons being thrown off by the hot filament.

The grid leak may have a value ranging from about 250,000 ohms to several million ohms. The value of a grid leak is generally stated in megohms—one megohm being one million ohms. Thus a tube with 2,500,000 ohms resistance would be referred to as a 2 1/2-megohm leak and, similarly, obtaining a resistance of two million ohms would be referred to as a two-megohm grid leak.

Such resistances are furnished in many forms, the most common being a strip of paper impregnated with graphite or some similar high resistance preparation, the tube and sealed to prevent moisture from affecting the value. The illustration, Fig. 1, shows a tubular type of grid leak.

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For experimental work a fairly satisfactory grid leak can be made by the simple expedient of drawing a line on a piece of cardboard with a soft pencil,—the graphite mark acting as the resistance. At each end of the cardboard is placed a binding post in contact with the graphite, each binding post being connected to opposite sides of the grid condensers. Variable grid leaks, the resistance of which can be changed at will, are also furnished in an infinite variety of types, two of which are shown in Fig. 2. (See Variable Grid Leaks, also Grid Control.—Resistance.)

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GRID POTENTIAL, MODULATION OF—In the transmission of undamped waves (q.v.) generated by a vacuum tube, the process of varying or modulating the potential of the grid element of the tube circuit is known as grid modulation. In this method an alternating potential may be applied to the grid circuit, the frequency of this varying
GRID POTENTIOMETER—A potentiometer—a variable resistance unit—Fig. 1, used in the grid circuit of a vacuum tube for the purpose of controlling the potential applied to the grid. The conventional method is to place the potentiometer across the “A” battery with the center or variable contact arm connected to the grid of the tube in place of the usual connection to either positive or negative filament lead. This is shown in the illustration, Fig. 2. Here the customary circuit is shown for the “A” battery to light the filament of the tube. Pri. and Sec. are respectively primary and secondary of the transformer (either radio-frequency or audio-frequency) and C the center arm of the potentiometer. The center arm may be moved either to the right or left, permitting either negative or positive potential to be applied to the grid. This system is much used in amplifying tube circuits to control the tension of the tube as an amplifier. Another method would be to connect one of the ends of the potentiometer to the negative lead of the “A” battery and the center arm to the grid leak. In this way the potentiometer would be acting as a pure variable resistance, the potential applied to the grid being always negative, but susceptible of variation within the limits of the resistance and the voltage of the “A” battery. (See Grid Bias, Grid Battery, also Modulation.)

GRINDER—Term occasionally applied to one of the various forms of atmospheric disturbance known under the general heading of static. This form of static is more prevalent in warm weather and does not appear to have its origin in local electric storms. Its effect is to produce, at distant points, sounds of definitely indefinite pitch. (See Strays, also Static.)

GROUND—The earth considered as an electric conductor. In radio it is considered as the return circuit for electromagnetic waves. (See Ground Connection, also Theory of Propagation of Electromagnetic Waves.)

GROUND CLAMP—A strip of metal, generally copper, having some sort of arrangement for fastening rigidly to a water or steam pipe to form the ground connection for a radio receiver. The illustration shows a conventional form of clamp. (See Ground Connection.)

GROUND WIRE—The wire connecting a receiving or transmitting set to the earth. The underwriters specify not less than No. 14 B & S gauge copper wire. (See Ground Connection.)

GROUP FREQUENCY—The number of separate trains or groups of waves per second in a damped or undamped system of radio transmission. This frequency is to be distinguished from the frequency of the individual waves. Thus in a spark transmitter, for example, the condenser in the transmitting circuit will be momentarily charged and discharged. The discharge will occur in the form of trains of oscillations, each oscillation having a certain defi-
Half Wave Rectification—The process of changing alternating currents to pulsating direct currents wherein only one-half of the full alternating current or wave is rectified, the other portion being blocked by the action of the rectifier. In the illustration is shown a typical half wave rectifier.

The upper graph represents an alternating current and the lower graph shows the form taken by the current after passing through a half wave rectifier.

Hammer Break—A magnetically operated device for making and breaking contact in an electrical circuit. Hammer breaks are essentially the same as a vibrator or buzzer break but are made to withstand heavy current without undue arcing, and hence are much slower in action. (See Buzzer; also Spark Coil.)


Hand Capacity—See Body Capacity.

Hard Drawn Wire—In radio usage generally confined to hard drawn copper wire, i.e., copper wire that has been hardened by repeated drawing without being annealed. It is used chiefly for aerials. (See Aerial.)

Hard Tube—A vacuum tube is said to be hard when it has been evacuated of all gases to a high degree. The opposite is a soft tube, one in which the vacuum is not of a very high order and more or less gas particles are present. Hard tubes are used for amplifiers, both audio and radio frequency, while the soft tubes are used mainly as detectors or oscillators. Hard tubes may be used with high plate voltages, whereas soft tubes require comparatively low plate voltages, the tubes having a tendency to turn blue (see Blue Glow) under the influence of high plate potentials. (See Detector, also Amplifier.)

Harmonic Current—An alternating current which can be represented by a sine harmonic or sine curve. It may be considered as an alternating current, the waves of which are sinusoidal or uniform. (See Simple Harmonic, also Sine Curve.)

Harmonic Motion—A term signifying any periodic oscillatory motion, as, for example, the vibrations or beating of a pendulum. The illustration shows the manner of indicating simple harmonic motion. The direct or A-B represents 360 degrees of a circle, or, if it is assumed to represent a sine wave of alternating current, it will represent one complete cycle. Curves representing harmonic motion are used extensively in radio engineering to illustrate, in graphic form, the oscillations of an alternating current. (See Sine Wave, also Simple Harmonic Vibration and Oscillations.)

Harmonics—Oscillations to which a circuit will respond in addition to the basic or fundamental oscillations. The effect is similar to that in sound, where, for instance, the primary or fundamental tone struck by an instrument might be accompanied by a number of tones of a higher pitch. In sound these harmonics are principally the third, fifth, seventh and the octave. In radio, a circuit might respond to oscillations at a frequency either higher or lower than the fundamental frequency, as, for example, one third, one fifth or one seventh, or, again, double or treble the original frequency. As a concrete example, with a fundamental wave-length of 240 meters, the harmonics might be

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**H**—The chemical symbol for hydrogen. In electrical and radio usage it is the symbol for magnetizing force or magnetic field intensity, adopted as such by the International Electrotechnical Commission and by the American Institute of Electrical Engineers. It has also been used for E. C. as the symbol for Henry (q.v.). (See Magnetic Field.)

**Rectified D.C.**

The upper graph represents an alternating current, and the lower graph shows the form taken by the current after passing through a half wave rectifier.
40 meters or 80 meters. The corresponding frequencies would be approximately 1,550,000 cycles, 1,500,000 cycles and 3,750,000 cycles. (See Harmonic Suppressor, Side Bands, also Harmonic Motion, Oscillations, Wave-length.)

HARMONIC SUPPRESSOR—A device used in radio transmission and in laboratory work, for the purpose of eliminating undesired frequencies (wave-lengths). Essentially such a device is a filter (q.v.) so arranged as to suppress or eliminate certain frequencies or harmonics (q.v.). In radio broadcasting it is particularly essential that all undesired frequencies or harmonics be suppressed. Basically the system involves a special coil shunted by a condenser and tuned to the frequency of the interfering wave the main tuning circuit at the same time being adjusted to the desired frequency. (See Broadcasting, General Treatise on Methods, also Transmission and Radio Telegraphy.)

HAZELTINE NEUTRODYNE RECEIVER—The radio receiver designed by Professor Hazeltine, employing the Neutrodyne circuit. Essentially these are five-tube receivers employing two stages of tuned and neutralized radio-frequency amplification with the conventional detector and two audio-frequency stages. In addition to the five-tube Neutrodyne receiver there are numerous types involving the Neutrodyne principle in conjunction with reflex systems. (See Neutrodyne.)

HEAD TELEPHONE OR HEADPHONES—Telephone receivers arranged with a band to fit over the operator's head, thus leaving him free to use of both hands. Head-phones are used in commercial radio work, the operator being free to handle a key or the controls of the receiver or transmitter. They are also used in broadcast reception where the strength of signals is not sufficient to permit the use of a loud speaker, and also in some cases to tune in distant signals before attaching a loud speaker. (See Watch Case Receivers.)

HEAVISIDE, DR. OLIVER—Born in London on May 13, 1850, Dr. Heaviside was engaged in telegraph work for a few years, but after 1874 he lived in retirement studying Clerk-Maxwell's theory and applying it to telegraph and wireless problems. Elected a Fellow of the Royal Society in 1891, he was also Paraly Medallist of the Institution of Electrical Engineers and Hon. Ph.D. of Gottingen University. The name of Prof. Heaviside is primarily associated with: the theory, propounded by himself, of the existence of a permanently ionized layer in the upper atmosphere capable of deflecting electro-magnetic waves and thus permitting wireless communication round the earth.

HEAVISIDE LAYER—An assumed layer or stratum of the atmosphere supposed to exist from fifty to one hundred miles above the earth's surface according to the Heaviside Theory. Heaviside's theory supposes this stratum to consist of heavily ionized gas which is conductive and acts as a gigantic reflector of electromagnetic waves (radio waves). It is this layer which is supposed to reflect the electric waves and force them to follow the curvature of the earth. This theory partially explains—true—why radio signals are transmitted over great distances instead of being radiated off into space and lost. It has been accepted by a number of eminent scientists. Elihu Thompson has proposed an alternative theory which assumes the waves as attached to the earth and gliding along over the surface. (See Gliding Theory.)

HEAVISIDE LAYER THEORY—The theory of an upper ionized stratum from fifty to one hundred miles above the earth's surface, which is assumed to act as a reflector of radio waves and thus force them to follow the curvature of the earth. None of the theories thus far advanced has been proven, but it has been definitely established that these waves do follow the curvature of the earth. (See Heaviside Layer, also Gliding Theory.)

HEDGECOGH TRANSFORMER—A type of audio transformer so called because of its peculiar construction. The core is cylindrical in shape and consists of a great number of soft iron wires around which is a bobbin holding the primary and secondary windings. After the windings are completed the wires forming the secondary are now covered with insulating material and the secondary is wound. (See Audio-Frequency, also Transformer.)

HEIGHT OF AERIAL—The elevation of an aerial system as used in radio transmission or reception. The effective height is roughly considered as the height above the earth or surrounding objects. The transmission of wireless energy is constant power is dependent upon the height of the aerial, other factors of

radiation being unchanged. In other words, increase of height increases the range within certain limits. (See Radiation from Antenna, also Transmission.)

HEISING, RAYMOND A.—Electrical Engineer, born Albert Lea, Minn., Aug. 10, 1888. Educated University of N. D., Elec. Engineer, 1912; University of Wisc., M.S., 1914 Grad. Work in Physics, Research and Development of Radio, 1912—1914, Trans-Atlantic test in 1915; for Army and Navy use during War, aeroplane. chaser, intership communication; since War continued research and development ship to shore use, trans-Atlantic test, 1928. Author of several technical papers; numerous circuits used in present broadcasting stations.

HEISING MODULATION—A system of modulating radio currents for radio transmission, such as broadcasting, developed by R. A. Heising. The fundamental principle is shown by the illustration. Here the customary antenna and ground are connected with a high-frequency alternator, A; the field of the alternator, F, is connected to the grid return and filament of the vacuum tube circuit, and through the "B" battery BB to the plate P of the tube. The microphone circuit comprises a...
**Helix**

**HENRY**—The shape assumed by a line or a wire wound in a single layer around a cylinder. Generally speaking, a solenoid (q.v.). A device in the form of a helix was formally used in transmitting circuits to vary the inductance, or, practically speaking, the wavelength. It usually was a number of turns of heavy copper or aluminum wire wound on an insulating form. Clips were provided to permit a variation in the contact point and hence any necessary change in the value of the inductance. (See Oscillation Transformer.)

**HENRY, JOSEPH**—Born in 1797, died in 1878. An American Physicist, noted for his researches in electromagnetism. He developed the electromagnet which had been invented by Sturgeon in England, so that it became an instrument of far greater power than before. In 1851 he employed a mile of fine copper wire on an electromagnet, causing the current to attract the armature and strike a bell, thereby establishing the principle employed in modern telegraph practice. He was a professor at Princeton in 1832 and during his experimenting there he devised an arrangement of batteries and electromagnets embodying the principle of the telegraph relay which made possible long distance transmission. He was the first to observe magnetic self-induction, and performed important investigations of oscillatory electricity. Blazing electric discharges (1842), and other electrical phenomena. In 1846 he was chosen secretary of the Smithsonian Inst. at Washington, an office which he held until his death. As chairman of the U. S. Lighthouse Board he made important tests in marine signals and lights.

**Joseph Henry.**

In meteorology, terrestrial magnetism and acoustics he carried on important researches. Henry enjoyed an international reputation and is acknowledged to be one of America's greatest scientists.

**HENRY**—The unit of inductance, named after the American physicist, Joseph Henry, who first produced high frequency oscillations in 1832. A coil of wire is said to have an inductance value of one henry when a current passing through it changes at the rate of one ampere per second and an electro motive force of one volt is produced. As the henny is too large a unit for practical purposes, the thousandth part of a henry, known as the millihenry, or the millionth part, known as the micro-henry, are more commonly used. Another much-used term is the centi-meter, which is the thousandth part of a micro-henry. The abbreviation for henry is H, and for micro-henry μH. (See Centimeter Gram Second, Centimeter, also Inductance.)

**HERTZ, HEINRICH RUDOLF**—Born 1857, died 1894. A German physicist noted as the discoverer of electromagnetic waves (1886) which form the basis of wireless telegraphy. He found that waves produced by the spark of a simple device called the oscillator could be detected by a loop or square of wire known as the resonator, and he was able to show the reflection, refraction, diffraction and polarization of the waves. These remarkable discoveries demonstrated the practical possibilities of radio-telegraphy. He also made valuable experiments with electric phenomena in vacuum tubes.

**Hertzian Waves**—Term occasionally applied to radio or electromagnetic waves, they being named after Dr. Heinrich Rudolph Hertz owing to his extensive researches into electromagnetic waves. (See Hertz, also Clerk-Maxwell, and Ether Theory.)

**HETERODYNE**—The term originally applied by Fessenden to a method of reception of electromagnetic waves, wherein the principle of Beats (q.v.) was employed. It is derived from the words "hetero," meaning other or different, and "dyne," meaning power.

**Heterodyne Receiver**—A receiver for electromagnetic radio waves employing the heterodyne principle. The illustration Fig. 1 shows the original form of heterodyne receiver, wherein the local oscillations were produced by means of a direct current arc gap and associated circuits, and combined through a common circuit with the oscillations in the antenna circuit. Here the heavy lines represent a conventional crystal receiver circuit. L1 and L2 are respectively primary and secondary of a vario-coupler. C is a variable tuning condenser, D the crystal detector and T the head phones. If the dotted line is assumed as a connection to the ground, this will constitute a complete receiver. For the heterodyne purpose, however, a special coil L3 is employed in the ground circuit. Coupled to this is the secondary L4. C1 is another tuning condenser and A is an arc gap fed by 110 volts direct current. In operation the circuit represented by the light lines acts as a generator of undamped oscillations, these oscillations being supplied to the antenna circuit and the frequency varied by means of the condenser C1 and the coil L4. If the receiving tuner is tuned to a certain wave-length corresponding to incoming signals, and the generator system tuned to a different frequency, the difference between the two frequencies will be a beat frequency which will be present in the detector circuit. This new series of oscillations will be rectified by the detector D and will be audible in the head phones, T. The action of the system is shown by the series of curves given in Fig. 2. Here the incoming oscillations (signals) from the antenna are shown by the heavy line at the top of the illustration. These oscillations are of continuous amplitude or undamped (g.c.). Graph 2 shows the local oscillations. If we measure the distance from A to B represents the time, it will be apparent that there are more oscillations per unit of time in the case of the incoming signals—

![Diagram](https://via.placeholder.com/150)

**Fig. 1**—The original form of heterodyne receiver.
HETERODYNE

HETERODYNE, a wave-length

resulting from interaction of the two upper series of oscillations and the frequencies corresponding to the numerical difference. When the two upper groups of oscillations are opposed, the beat current is zero, and when they are in phase with or other, the beat current is maximum. When rectified by the crystal detector action the beats take the form shown in graph 4. The lower half of each cycle having been submerged. The telephone current of a periodic nature is indicated by the bottom graph, the original signals being represented in the phones by a series of contractions of the diaphragm. (See Heterodyne, also Beats and Super Heterodyne.)

HETERODYNE, SELF—See Self-Heterodyne.

HETERODYNE WAVE-METER—A wave-meter—device for measuring the wave-length of coils, circuits or incoming and outgoing signals—which utilizes the principle of Beats. The action is as follows: It has already been explained under Heterodyne Receiver that the local oscillations and the incoming oscillations are opposed, the beat current is zero. It follows, then, that with a pair of these phons connected in the circuit the beat signals will be audible only when the two frequencies are different. Now if it is alternately represent for varying the frequency of the local oscillations, in practice a combination of coil and crystal, the local circuit can be tuned to a point where the two frequencies concur or are similar and no beat is audible. As the frequency is progressively increased and instance in a circuit, and as wave-length can easily be figured when the frequency of the local generating system is known, the wave-length of the incoming signals must be that of the local circuit when the beat is zero. The condenser dial on the heterodyne wave-meter can thus be calibrated directly in meters and a nearly true reading of the wave-length of the incoming signal obtained. (See Beats, also Heterodyne and Wave-meter.)

HIGH FREQUENCY.—A very general term applied to alternating electric currents. As a rule, alternating currents having frequencies above one hundred thousand cycles per second are referred to as high frequency currents. When the frequency is extremely high, of the order of hundreds of thousands of cycles, the current is usually referred to as high frequency, oscillatory current. There is no definite level or line of distinction between high and low frequency currents. In radio practice, the audio frequency currents are generally limited to the order of a thousand cycles per second and known as low frequency currents. The radio frequency currents above the above thousand are considered as the high frequency currents, although these may lie anywhere on the level or line of demarcation between the two areas. (See Audio Frequency, also Radio Frequency and Frequency.)

HIGH FREQUENCY ALTERNATING CURRENT—See High Frequency Current.

HIGH FREQUENCY ALTERNATOR—A device which takes current from the alternating current machine or alternator, designed to produce currents having high frequencies, generally above one thousand cycles per second. Such machines are used in high power radio telegraph transmission (not broadcasting) producing undamped or continuous waves. (See Alternator, also Alexanderson Alternator.)

HIGH FREQUENCY AMPLIFICATION.—The process of stepping up or amplifying radio frequencies of high frequency. In radio circuits, the high frequency currents are known as radio frequency oscillations. The radio frequency (low frequency) currents and the high or radio frequency currents are usually in different parts of a circuit. Both sets of alternating currents having a frequency above, say, twenty thousand cycles per second as represented on the scale below that limit as audio frequency, it is easy to consider the radio frequency currents as existing in all stages between the aerial and the detector. Beyond the detector, the alternating currents having become uni-directional, we can consider these currents as being audio frequency currents. Thus we have a definite dividing line in audio frequency. As in practice, but one detector, the detector or rectifier marking the transition from radio frequency to audio frequency. Thus, any means of audio frequency amplifying before they reach the detector will be known as high frequency amplification. (See Audio Frequency Amplifier.)

HIGH FREQUENCY BUZZER—A buzzer (q.v.) designed to produce a very high note. The term "high frequency" buzzer, or buzzers, indicates that the pitch or frequency (vibration) of the buzzer is high in comparison with the ordinary buzzer, the sounds of course being actually produced in a crystal. The general scheme of such a buzzer is about that of the ordinary type as used in telephone bell systems and signal systems, the armature, however, being very thin and thus permitting rapid make and break for the current. Such buzzers are used extensively in connection with crystal receivers for the purpose of testing and also for code practice. (See buzzer also High Frequency and Armature.)

HIGH FREQUENCY COMPONENT OF PLATE.—The high-frequency currents present in the plate of a vacuum tube, radio tube or plate tuner, as distinguished from the audio or low frequency currents. (See Frequency Components, High Frequency, and Regeneration.)

H.F.C.—Abbreviation used abroad and occasionally in the United States for high frequency current. The common term in radio frequency current and no abbreviation is used as a rule. (See Radio Frequency Current, also High Frequency.)

HIGH FREQUENCY CURRENT—Alternating currents having frequencies above 100 cycles per second, as, for example, the radio frequency currents employed in radio transmission, which are usually above one hundred thousand cycles per second. (See High Frequency, also Low Frequency and Radio Frequency.)

HIGH FREQUENCY MODULATION.—The term oscillation is generally applied to an alternating current of very high frequency. Thus radio frequency currents having frequencies above one hundred thousand cycles per second, are called high frequency oscillations. (See Oscillation.)

HIGH FREQUENCY RESISTANCE—Resistance to the passage of alternating currents of high frequency. Said of a material or apparatus. The resistance of a certain conductor or part of an electrical circuit, as in radio, may be comparatively higher in the case of high frequency currents than in the case of alternating currents of low frequency. This is due to the "skin effect" (q.v.) it being a phenomenon of radio frequency currents whose currents have a tendency to concentrate near the surface of the conductor. For this reason, conductors are more averse to certain high frequency radio frequency resistance, as obviously the surface on which the currents can travel is restricted. (See Alternator, also Skin Effect and Resistance.)

HIGH PASS FILTER.—An arrangement of electric circuits designed to permit transmission of alternating currents while at the same time presenting high resistance or impedance to alternating currents of low frequency, generally within certain definite limits. (See Filter also Filter, High Pass.)

HIGH PRESSURE.—A term occasionally used to denote high potentials or voltages. (See High Tension, also High Voltage.)

HIGH POTENTIAL.—One of the several terms used to indicate high voltage. (See High Potential Battery, also High Voltage.)

HIGH POTENTIAL BATTERY—Another term for "B" battery, the battery used to supply potential to the plate of a vacuum tube or plate tuner. "B" battery (q.v.) is used here, only in a comparative sense, the voltage of the battery being high in proportion to that of the filament or "A" battery. High potential batteries for radio usage are generally furnished in blocks of 220 or 45 volts. (See Battery, High Voltage, High Tension and "B" Battery.)

HIGH RESISTANCE—The property of any circuit whereby it offers considerable opposition to the flow of electric currents. There is no very distinct line of demarcation between high and low resistance. One of the common applications of the term is in the case of a grid leak or grid resistance. Here the resistance may be upward of a half million ohms, running Into several million ohms in certain cases. An example of low resistance elements is that found in the cathode or anode filament current. Here the resistance is relatively low, rarely more than thirty or forty ohms. The low resistance of the magnet windings in headphones (as used in radio) is one thousand ohms. The resistance of a battery is also used in a comparative sense in respect to various instruments or parts of radio circuits. Here the resistance in most cases should be as low as possible, and therefore a resistance of even a few ohms may be referred to as high. While resistance, in general, can be considered as the feature of resistance coils and units, the opposition to currents of alternating as well as direct currents (alternating currents) may be of the utmost importance, and it is often the case that a circuit has little direct current resistance but very high resistance or impedance (q.v.) to high frequency currents. (See Resistance, Inductance, also Skin Effect.)

HIGH RESISTANCE JOINT—Any connection between two wires or conductors which offers considerable opposition to the passage of current due to defective contact or imperfect connection through solder or other medium in many cases. When bare wires are joined they should be carefully scraped and soldered. Too much solder is a bad feature, as the resistance of the soldered joint will be higher than that of the copper wire. (See Corrosion, also Soldered Joints.)
HIGH VACUUM—A term applied to vacuum tubes when they have been highly exhausted of air. That is, an almost perfect vacuum. When a vacuum tube has a very good vacuum—has been highly evacuated of gases—it is generally called a "hard" tube. A high vacuum is essential in tubes to be used as amplifiers or for transmission. (See Vacuum Tubes, Theory of Operation.)

HIGH VOLTAGE—A very indefinite term, used in ordinary electrical practice to denote voltages above 600, but applied in radio practice to much lower potentials, as, for example, a "B" battery, which is generally referred to as a high voltage battery, despite of being generally below 100 volts. The term used in this sense is one of comparison with the low voltage of a storage or other type of "A" battery. (See Voltages, also Potential.)

HIGHLY DAMPED WAVES—An expression applied to waves or trains of waves wherein the amplitude or strength of each succeeding oscillation or train of oscillations is greatly decreased. If the progressive decrease in amplitude or strength is very gradual, that is, if the waves die out slowly, they are said to be freely damped, but if they die out rapidly they are referred to as being highly damped. (See Damped Waves, also Decrement and Amplitude.)

HOGAN, JOHN L.—American radio expert. Born at Philadelphia, Pa. He was educated at Sheffield Scientific School, Yale University, where he made a special study of physics and mathematics. In 1906 he became assistant to Dr. Lee De Forest, and in 1909 he joined the National Electric Signalling Co. In 1914 he was appointed chief research engineer to the International Radiotelegraphic Company. Hogan has written many articles on radio and is a past president of the Institute of Radio Engineers, member of the American Institute of Electrical Engineers, of the American Association for the Advancement of Science, of the Radio Club of America and other societies.

HOMOPOLAR—Synonymous with unipolar. Having high voltage. Said of a dynamo having its conductor or armature rotating around a single pole of a field magnet. (See Multi-Polar.)

HONEYCOMB COIL—A coil used in radio, having a peculiar construction. somewhat similar to a honeycomb. The illustration shows a typical honeycomb coil used as an inductance in receiving circuits. The object of this staggered winding system is to reduce the self-capacity between wires to a minimum without reducing the inductive value. The chief value of such a winding method is that it permits the retaining of high inductance value in a limited space, without undue high frequency resistance (q.v.). (See Inductance, Distributed Capacity and High Frequency Resistance.)

HOOK UP—The general term in the United States to designate the diagram for any complete radio receiver or transmitter, or for any specific part of such a circuit. Thus, when we refer to a hook-up for Receiver, we mean a diagram, either schematic (using symbols for the parts) or perspective (showing pictures of the parts) which gives the various parts necessary and the manner of connecting them to each other to form the complete circuit. Similarly we may use the term "hook-up" to describe a sketch or circuit for connecting various instruments such as ammeters, or voltmeters, wattmeters and the like. (See Circuit, also Diagram.)

A high potential insulator.
HORSEPOWER—The unit of power used in the United States and Great Britain. It is defined as the power required to lift 550 pounds to a height of one foot in one second, or similarly, 33,000 pounds to that height in a minute. The term “foot-pounds” is derived from this value. Thus, one horsepower is the power required to perform 550 foot-pounds of work per second of time. (See Horse Power, Electrical.)

HORSEPOWER, ELECTRICAL—The unit of electrical work similar to the mechanical horse power. It is actually mechanical horse power expressed in watts (q.v.). One electrical horse power is equivalent to 746 watts. In the centimeter gram second (q.v.) system of units, the unit of work is the erg. This unit is too small for ordinary usage and the customary unit is the watt, which is equal to 10^{7} ergs per second. The unit used in electrical power work is still larger; it is the kilowatt or one thousand watts. (See Units, also Horse.)

HORSESHEW MAGNET—A magnet (q.v.) in the shape of a horseshoe or letter U, both poles being brought nearer together so that they may act on the armature or “keeper.” Generally a magnetized steel bar which retains its magnetism for a long period. The illustration, Fig. 1, shows a permanent horseshoe magnet. Such magnets are also used with external power, then being termed electromagnets. In this case the magnet is made of soft iron. The illustration, Fig. 4, shows a horseshoe electromagnet. Here the magnetic attraction is supplied by application of an external electric force to the windings WW, and the magnet being of soft iron, loses its magnetic attraction almost immediately upon withdrawal of the electric current, magnetizing force. (See Telephone Receiver, also Electromagnet.)

HOT-WIRE AMMETER—An ammeter, or instrument for measuring electric current in amperes, which depends for its action on the expansion of a fine wire under the influences of the heat produced in it, by the passage of the electric current to be measured. In the illustration the current to be measured is passed through the fine resistance wire A-B. P is a pointer moving over a graduated scale, and attached at its other end to a coiled spring S, which in turn is attached to the wire A-B by the silk thread T. The tendency of the spring is to move the pointer to the right, but owing to the pull of the thread in the normal position of the wire A-B, the pointer rests at zero at the left of the scale. As current is passed through the wire A-B, it heats and expands, thus permitting more or less slack to occur in the thread T and allowing the spring S to move the pointer over the scale toward the right. As soon as the current is withdrawn, the wire cools and contracts to its former size, thus again restoring the tension to the thread and

Illustrations: Fig. 1. A permanent horseshoe magnet.
Fig. 2. A horseshoe electromagnet.
Hot Wire Instruments

Returning the pointer to zero. Hot Wire instruments are used for measurement of currents at radio frequency, that is, extremely high frequency as in radio transmission. The average ammeter using a coil of fine wire would not be adaptable to this use, as the high voltage, high frequency current would burn out the coil. In addition to this, the length of these windings would affect the circuit and probably throw it out of resonance (q.v.). (See Ammeter or Ampere Meter, Frequency, Resonance, also Instrument Shunts.)

Hot Wire Instruments—Current measuring instruments which utilize the tendency of a fine wire to sag or expand under the heat caused by passage of an electric current through it. Such instruments may be used for direct or alternating current. (See Hot Wire Ammeter.)

Hot Wire Oscillograph—See Oscillograph.

Hot Wire Telephone—See Telephone.

Hot Wire Wattmeter—An instrument used to measure combined volts and amperes, i.e., watts in a circuit. It comprises essentially a mirror which is deflected according to the difference in expansion of two fine wires. (See Hot Wire Instruments, also Wattmeter.)

Hour Meter, Amperes—An instrument used extensively in connection with storage batteries, to measure the input or output in amperes per hour. (Ammeter or Ampere Meter.)

House Mains—A term much used in connection with storage battery charger and battery elimination devices. The term implies the main circuit of any standard house lighting system, either direct or alternating current. Thus in the case of a rectifier for charging storage batteries from alternating current, a lead is provided for connecting to the house mains, offering a means for introducing the current into the circuit. (See Current Direct, also Alternating Current and Chargers, Storage Battery.)

Howling—The general term used to indicate the production of howling in or by a radio receiver. Howling is usually caused by feed-back effects (q.v.). The most common example of howling is in the case of a regenerative receiver. Here the detector tube may have a tendency to generate its own oscillations. As long as these oscillations are in phase with the incoming signals, the receiver will be a howl resulting from the beats (q.v.) established owing to the difference between the two sets of oscillations. This is essentially the principle of heterodyne or "beat" reception, but in the case of a heterodyne, the effect is utilized, whereas in the case of a regenerative receiver it is undesirable. Interaction between various parts or different parts of the circuit may often lead to howling. (See Feed-Back, also Regeneration, Reflex, Beats and Resonation.)

H. P.—Abbreviation sometimes used in radio for high potential or high pressure. In mechanics it is the standard abbreviation for horse power.

Hozier-Brown Detector—A form of electrolytic detector, which, however, does not use a liquid electrolyte. It consists of a small pellet of lead oxide held more or less rigidly between two electrodes, one platinum and the other lead. (See Detector, also Electrolytic Detector.)

Hydrogen—a gaseous chemical element. The symbol is H and its specific gravity is taken as 1, that of air being 14.4. It is colorless, tasteless and odorless and is the lightest known body. Hydrogen is a constituent of water, which is composed of one atom of oxygen and two atoms of hydrogen according to the chemical formula for water, H₂O. Hydrogen is used in radio transmission in connection with arc generators. (q.v.) (See Poulsen Arc.)

Hydrometer—An instrument used to measure the specific gravity (q.v.) of a liquid. In radio it has an extensive use in connection with storage batteries, on the bulb is released some of the energy stored in the cell and the float rises more or less within the barrel in proportion to the specific gravity or density of the electrolyte. With the hydrometer held in the manner shown, that is, upright, the numbers just at the level of the liquid indicate the specific gravity. Thus, if the reading is 1250° or higher the battery is considered in fairly good operating condition—full charge being 1250° to 1300°. If the reading is below 1200° it indicates the need of charging, these levels not being arbitrary, but one being indicated by a reading of 1150° or lower. The use of a hydrometer is generally advisable and the reading accurate under ordinary conditions. However, water has just been placed in the battery, the reading may not be accurate for several hours due to the fact that the water and acid may not mix immediately. (See Storage Battery Tests, also Electrolyte.)

Hydroscopic Effect—The effect in many substances of absorbing or moisture. In the case of films or tubes for radio coils and inductances this moisture is particularly undesirable, as obviously, moisture lowers the dielectric value of the form and may cause it to warp. (See Bakelite, also Forming.)

Hysteresis—The tendency of magnetization to lag behind the magnetizing force as, for instance, in an iron core in a transformer (q.v.). When the core of such a transformer is undergoing rapid reversals of magnetism, there is often an expenditure of energy which is not useful for work which is done into heat, thus representing a loss in power. This effect is more noticeable with certain qualities of iron. In other words, when the core of a transformer or armature core is subjected to hysteresis, it is taken into consideration and the iron must be of high quality to hold these losses to a minimum. (See Eddy Currents, also Core, Transformer.)

Hysteresis Coefficient—The amount of energy wasted or lost in the process of magnetizing and de-magnetizing a unit volume of magnetic material is referred to as the hysteresis coefficient of that material. (See Hysteresis, also Coefficient.)

Hysteresis Loop—Graphic illustration of losses due to hysteresis in any sample of core material. Loops are plotted in graphic curves of cycles of magnetization. (See Curve, also Hysteresis.)

Hysteresis Losses—The energy wasted or lost through hysteresis. (See Hysteresis.)

Hysteretic Lag—The lagging of magnetization due to the effect of hysteresis. (See Hysteresis, also Magnetization.)
I—The abbreviation adopted by the International Electrotechnical Commission (q.v.) and American Institute of Electrical Engineers, to denote current in amperes. The small or lower case (i) may also be used where the capital letter is not advisable. (See Current.)

I ARMATURE—An armature used in generating machines, having a core resembling the letter I in shape. (See Armature, also Core.)

I.C.W.—The customary abbreviation for "interrupted continuous waves." This is a system of radio transmission wherein the waves are modulated at a constant low frequency. (See Interrupted Continuous Waves, also Modulation.)

IDLE CURRENT—A name often applied to the component of an alternating current which contributes nothing to the power. This is also known as the wattless component (q.v.) or the wailless current (q.v.). It represents the component which, being in quadrature with the electromotive force in the circuit, thus has no active value—adds nothing to the total power. (See Current, also Electromotive Force and Alternating Current.)

I.E.C.—The abbreviation for International Electrotechnical Commission, the body which suggested the international electrical and magnetic abbreviations and symbols. (See Symbols, also Units.)

IMPACT OR SHOCK EXCITATION—The method of producing free oscillations (q.v.) in a circuit by means of an exciting current of short duration compared to that of the resultant oscillations. The term is a general one and broadly covers the various methods of generating oscillations in which an oscillatory circuit is thrown into electrical vibration at its natural or fundamental frequency by means of an electromotive shock or exciting force of short duration. Also covers the term Impulse Excitation. (See Oscillations, also Fundamental Frequency.)

IMPACT TRANSMITTER—Apparatus for transmitting radio waves wherein the transfer of energy from the primary or exciting circuit to the oscillatory circuit takes place during one pulse or vibration of the exciting current. (See Impact or Shock Excitation, also Transmitter.)

IMPEDANCE—The total resistance to the flow of alternating current in a circuit. Impedance combines the ohmic resistance and the apparent resistance due to self-induction. When a direct electromotive force is impressed on a circuit, the current flowing in that circuit depends directly on the ohmic resistance of the circuit. The formula is according to Ohm's law $I = \frac{E}{R}$.

I represent the current in amperes, $R$ the resistance in ohms and $E$ the electromotive force in volts. Now if this direct electromotive force is replaced by an alternating EMF (electromotive force) and the ohmic resistance remains the same, the total resistance of the circuit to the alternating EMF will nevertheless be greater than in the case of direct current. Now the ohmic resistance is still the same but we have added to it the apparent resistance due to the self-induction of the circuit. In other words the inductance of the circuit has a marked effect on the current flowing in the circuit.

What actually occurs is that the self-induction sets up a counter-electromotive force (q.v.) which continues to act against the impressed EMF as long as the flow of current persists. The result is a reduction in the current flowing in the circuit, the EMF having been, in effect, reduced, and hence according to the law above, $I = \frac{E}{R}$ the current is less. This added resistance, due to self-induction, is referred to as reactance and the flow of current actually wastes or dissipates a certain amount of energy. In the alternating current circuit, the ohmic resistance has the same effect. The reactance, however, does not dissipate energy. It merely reduces the effective EMF by means of the counter EMF and thus necessitates the application of a higher impressed voltage in order to maintain the same flow of current.

This is one of the major advantages of alternating over direct current. Alternating current can be transformed readily and can also be readily controlled by means of a reactance or choke coil, which by creating a counter EMF limits the current flowing in the circuit without dissipating any great amount of energy. (See Alternating Current, Current Direct, Choke Coil, and Reactance.)

IMPEDANCE COIL—A coil of wire or inductance coil, generally wound on an iron core, used in alternating current circuits to limit the current flowing in the circuit. In action such a coil serves through the medium of its self-induction, to create a counter electromotive force which acts against the impressed EMF (electromotive force) and thus reduces the current in the circuit according to ohm's law that the current is equivalent to the EMF in volts, divided by the resistance in ohms. An impedance coil is also known as a choke coil although the two may have somewhat different meanings. For example, a choke coil might be used in either direct or alternating current circuits, whereas an impedance coil as its name indicates, offers impedance, an effect only present in alternating current circuits. The simplest formula for impedance of a coil is the following: Impedance $= \sqrt{R^2 + X_L^2}$. Here it is

![Schematic diagram of an impedance coupled audio frequency amplifier.](image)

in an alternating current circuit is thus governed by the ohmic resistance and the reactance. The application of the term "apparent resistance" to describe the added resistance due to self-induction, is a concession to the fact that it is not actually resistance in the proper sense of the word. In a direct current circuit, the resistance assumed that the current takes the form of a sine wave (q.v.), then $R$ is the resistance of the coil, $L$ the coefficient of self-induction in henries and $p$ is $2\pi$ times the number of alternations per second. (See Choke Coil, Alternating Current, Current Direct, Reactance, Impedance, also Impedance Coupled Amplifier.)
Impedance Coupled Amplifier

- A system of amplifying radio signals, voice or music, whereby the successive stages are coupled or joined by means of transformers. This system is much used in audio amplifiers, where the amplification is often much more uniform over the necessary range of frequencies than could be obtained by ordinary vacuum tube amplifiers. This is also known as choke coil coupling or choke coil coupling. The illustration on the preceding page shows a typical impedance coupled amplifier for audio frequency currents. It will be noted that the impedances are necessary owing to the lower amplification per stage. Using this system, two stages are necessary in place of the customary two stages of transformer coupled amplifier, but there is a schematic diagram of the circuit for such an amplifier, the impedances 1, 2 and 3 are in the form of a transformer. (q.v.) R1, R2 and R3 are grid leaks ranging in value between one quarter megohm and one and one-half megohms total. C3 and C4 are storage condensers of about 1 microfarad capacity each. The variations in potential are transferred successively from stage to stage, the amplification factor being roughly the sum of the individual factors of the tubes. In other words, the ratio of the width of the impedances is one to one, or unity, and therefore no voltage amplification takes place. The resistances are the usual grid leaks and the condensers C1, C2 and C3 are blocking condensers. (See Tuned Impedance, also Amplifier and Vacuum Tube Amplifier (q.v.))

Impedance Factor—Ratio of the impedance to the ohmic resistance in an alternating current circuit. (See Reactive Loads.)

Impedances, Matched—Arrangement of an amplifying circuit and the choice of an audio transformer or loudspeaker with due regard for the impedances of the circuit. Thus if the impedance of a certain amplifier tube is 10,000 ohms, the resistance of the loudspeaker unit being used is 2,500 ohms, then for maximum response which would be obtained in the transformer (q.v.) the impedance of the primary of the transformer should be equivalent to 2,500 ohms. (See Matched Impedances.)

Impregnated Insulating Materials—Cloth or paper impregnated with an oil or resinous substance to render it moisture proof and improve the insulating properties. Cardboard is sometimes treated in this manner and used for tubing to wind inductance coils. (See Empire Cloth and Masonite Insulation.)

Impressed Electromotive Force—The term used to distinguish the electromotive force (electromotive force) impressed on a circuit from a certain point in an electrical circuit from the counter or back-electromotive force due to the current through the circuit. The term is sometimes used when a direct current is applied in a circuit, but it should be remembered that when a counter EMF (electromotive force) is present. (See Counter Electromotive Force, also Choke and Reactance Resistor.)

Impressed Field—An electric or magnetic field of force impressed on or applied to a system for the purpose of producing other fields of force. (See Field.)

Impulse—Electrically, an electromotive force which produces an impulsive rush or discharge of electricity. The term is used to distinguish between this form and an electromotive force producing a steady flow of current. (See Current, also Electromotive Force.)

Impulse EMF.—The more specific term designates an EMF (electromotive force) which produces an impulsive rush or discharge of electricity. It is applied technically, as having a maximum value which is large compared with its average value, the average value being taken over a time equivalent to one time constant (q.v.) of the circuit on which the EMF is impressed. (See Current, also Electromotive Force.)

Impulse Excitation—Method of exciting or starting oscillations in a circuit, such as the aerial circuit of a transmitter, by introducing a surge of impulse EMF (electromotive force) rather than by application of oscillations of the frequency of the circuit.

Connections of buzzer for generating damped oscillations suitable for testing by impulse excitation.

This system of impulse or shock excitation may be used for testing purposes and also has application in connection with testing or comparing of wavemeters. The impulse generator is a buzzer connected with the necessary components to form a source of high frequency oscillations. This system is capable of producing through the pickup coil L1 currents by shock excitation. These currents can be used in a variety of ways for testing purposes. In operation the condenser is charged to the voltage of the battery at the instant the buzzer contact is open and when the contact closes, discharges through the coil L1 thus furnishing a series of oscillations to surge through the coil and by inductive coupling any other coil placed in proximity to it. (See Buzzer, Noise Exciter.)

Induced EMF—The term used to designate any wire wound coil as used in radio practice for tuning units, inductive couplers and any variety of purpose. Actually the term is derived from self-induction or self-inductance, a property of a coil of wire by virtue of which it sets up a counter EMF (electromotive force) which serves to oppose the change in flux or voltage through it. When a certain circuit has inductance, it is to say that a number of turns of wire self-induction are present in the circuit. The greater the inductance in a circuit the greater its opposition to the passage of an alternating current. The unit of inductance is the Henry. This is defined as the self-induction of a circuit or coil when an induced EMF is one volt with the induced current varying at the rate of one ampere per second. (See Alternating Current, Henry, also Inductance Coils.)

A type of antenna induction coil used in radio transmission.

Inductance, Antenna—Inductance (coil) placed in antenna circuit of transmitting set for purpose of increasing wavelength of the open antenna circuit to any desired level. It is generally referred to as an antenna loading inductance or loading coil. In high power transmitting stations it is very often the case that the natural period or fundamental wavelength of the antenna is not as great as the intended operating wavelength, when this is the case a loading inductance is used to bring it up to the desired value. In other instances the fundamental wavelength is too high, in which case a condenser is placed in series to reduce the wavelength and then a few turns of inductance placed in series with the condenser and antenna for the purpose of tuning. Such inductances must be of very heavy gauge wire when high power is used, generally consisting of a comparatively few turns of heavy copper ribbon mounted on high tension insulators. The illustration shows a cross sectional form of antenna inductance used in radio transmission. (See Loading Inductance, also Tuned Antenna.)
INDUCTANCE COILS—Any coil of wire wound in such a manner as to possess the property of self-induction. Such a coil may be in almost any conceivable form, providing the turns are separated or insulated from each other. Inductance coils are a very necessary part of radio circuits, being used in conjunction with condensers to obtain resonance or selectivity. Such coils can also be arranged as separate circuits and placed in inductive relation to each other, thus permitting energy present in one to be transferred through induction to the other. The

Low-loss air-wound inductance coil made especially for tuned radio frequency work.

most common example of inductance in a receiving set is that of a tuning coil or vario-coupler. The illustration shows several forms of inductances known as tuning inductances. (See under separate headings—Loading, Tuning, Tapped, also Inductance, Units of.)

INDUCTANCE, DISTRIBUTED—Added inductance distributed throughout the length of a cable or telephone line to compensate for the capacity of the line. (See Distributed Inductance.)

INDUCTANCE, LOADING—Literally an inductance to load a circuit. The term is used to designate any inductance coil or unit used in series with the antenna for the purpose of increasing the wavelength of the circuit. (See Inductance, Antenna.)

INDUCTANCE, MEASUREMENT OF—Any process or means of determining the inductance value of a coil or circuit. The usual method is by formula. (Fully described under Measurement of Inductance.)

INDUCTANCE, MUTUAL—Symbol M. The number of linkages of flux lines or the flux that is common or mutual to two circuits which are adjacent to each other or inductively coupled. It is generally defined as the amount of the flux (q.v.) which is common to two linked circuits per unit of current flowing in the inducing circuit. In the illustration circuit A contains an inductance L which is being traversed by an alternating electromotive force. Circuit B contains merely an inductance L and a measuring device, M. Now, as the alternating E.M.F. passes through coil L, it sets up a field of force, or rather flux lines as shown. These lines link with coil L and an alternating E.M.F. is set up. Now, suppose that the inducing current flowing in circuit A is changing at the rate of one volt per second and an E.M.F. of one volt is induced in the circuit B, or rather in coil L. We then say that the mutual inductance of the two circuits will be one henry. This is the same unit used for self-inductance and in fact, mutual inductance and self-inductance are virtually the same thing.

The effect of mutual inductance must be taken into consideration when measuring the fundamental wave-length, capacity or inductance of an antenna. That is to say, where a number of parallel wires are used, the mutual inductance reactance by using the formula \( x = 2\pi fL \), where \( \pi \) is a constant equal to 3.1416, \( f \) is the frequency in cycles per second, and \( L \) is the inductance of the circuit in henry's (q.v.). This formula is sometimes abbreviated by substituting the symbol \( \omega \) (omega) for \( 2\pi f \). From the formula it can be seen that the inductance reactance increases directly with the frequency of the current flowing. (See Current, also Electromotive Force, Inductance, Reactance.)

INDUCTANCE, RECEIVING—Broadly, any form of inductance used in receiving circuits. The term thus includes all types of coils for tuning purposes, such as couplers, tuned transformers, variometers, etc. The illustration shows a common form of tuning inductance. Here the coil L is an inductance in the aerial circuit and L is the coil in the secondary circuit. Here the energy from the aerial traverses coil L and by induction is transferred to coil L. (See Tuning Coil, Vario-Coupler, Receiving Circuit.)

INDUCTANCE, SELF—Symbol L. An alternate term with self-induction for the inductance (q.v.) due to the field of force produced by the circuit itself. It is virtually the same as mutual inductance. For example, in a coil of wire being traversed by alternating currents the adjacent turns may act upon each other on the principle of mutual inductance between two separate adjacent circuits. The induced currents are the result of self-induction. (See Self-Induction, also Mutual Inductance and Induction.)

INDUCTANCE, TAPPED—Any type of inductance having taps for connecting at different points on the coil in order to vary the inductance value. The illustration shows a form of tapped inductance. Here the taps at different portions of the coil are connected to switch points and the switch lever permits instantaneous change to any of the available values. (See Inductance Coils, also Tuning Coil.)
INDUCTANCE, Units of

INDUCTANCE, UNITS OF—The measuring units for inductance. The practical unit is the henry (H), the value of inductance which, if current varies at the rate of one ampere each second, results in an induced electromotive force (q.v.) of one volt. When we speak of an induced E.M.F. of one volt, the volt is used as a practical unit. Under the electromagnetic system of units, the absolute unit of induced E.M.F. is known as the abvolt. This unit is very small, 100,000,000 of them being required to equal one volt. We thus say that the volt of induced E.M.F. is equal to 1x10^9 abvolts. The electromagnetic unit of E.M.F., or the abvolt, is defined as the E.M.F. induced in a conductor cutting one line of magnetic force each second. As we have shown that one volt is equal to 1x10^9 abvolts of induced E.M.F., and since one ampere is equal to 1x10^3 abamps of current (see Units, Electromagnetic) then the unit of inductance or one henry = 1x10^-9 or 1x10^-10 abhenrys. The unit of inductance (the henry) being too large for practical purposes, the milli-henry (one-thousandth henry) or the micro-henry (one-millionth henry) are commonly used. Occasionally the centi- henry is used as a measure of inductance, being the thousandth part of a micro- henry or a milli-micro-henry. The milli-henry is written as 1x10^-3 henry, the micro-henry as 1x10^-4 henry, and the centi-henry as 1x10^-5 henry. (See Induced Current, Induced E.M.F., Induction, Electromagnetic, also Units.)

INDUCTANCE, VARIABLE—Any coil possessing self-inductance and being arranged in such a manner that the value of the inductance can be changed at will. The simplest form of variable inductance is the sliding contact tuner. This is merely a coil of wire of any pre-
determined value (maximum) mounted and arranged with a sliding contact moving over the wires, which are bared of insulation at a certain point to permit contact. By using the sliding contact as one connection and either end of the coil as the other lead, the effective value of the inductance in the circuit may be varied within the limits of the coil itself. Other forms of variable inductance include the variometer, vari-coil coupler and various modifications. The illustration shows the two more common forms of variable inductance. (See Inductance, and Inductance Coils.)

INDUCTANCES IN PARALLEL—Coils possessing the property of self-induction or self-inductance, connected in parallel or shunt to each other. The illustration shows two standard coils connected in a circuit in this manner. The effective inductance is less than that of either coil alone. (See Inductance Coils.)

INDUCTANCES IN SERIES—Coils possessing the property of self-induction, connected in series in a circuit. The illustration shows two coils con-
nected in series in a circuit. Here the effective inductance value is the sum of the separate inductances. (See Inductance Coils.)

INDUCTION—The influence exerted by one field of force (electromagnetic or electrostatic) on another or on a con-
ductor. Whenever a magnetic field interlinked with an electric circuit is changed, an electromotive force (q.v.) is induced in that circuit. The mag-
netic field is considered to originate from the heart of the conductor, spreading out concentrically from the conductor as the current increases and shrinking back into the center of the conductor as the current decreases. In either case, the conductor is cut by the magnetic field, and in accordance with the law of electromagnetic induc-
tion (q.v.) an electromotive force is in-
duced in the circuit proportional in amount to the rate of change of the magnetic field and acting in a direction which would, by producing a cur-
cent, tend to oppose the change. A bothersome type of electromagnetic induction sometimes occurring in radio takes place when a radio aerial is run parallel to a high-tension line or even a trolley line. The varying field of force about the high-tension line sets up, by induction, a corresponding field in the parallel aerial, thus causing a disturbing hum in the loud speaker.

Such a condition can usually be elimi-
nated by running the aerial at right angles to the power line. By doing this, induction between the two conductors is reduced to a minimum.

Electrostatic induction is a re-
arrangement of an electrostatic field whereby a body in the neighborhood of a charged body will have an opposite charge induced on it. An induction machine (q.v.), known as the Wim-
hurst utilizes the principle of electro-
static induction.

INDUCTION BRIDGE—Also called in-
ductance bridge. A balance arranged similarly to a Wheatstone Bridge (q.v.), used in induction measurement. (See Induction, Electromagnetic, also Induction Density.)

INDUCTION COIL—A form of trans-
former, having a primary winding ar-
ranged with a means of making the direct current applied to it, pulsate.

Essentially a transformer with open magnetic circuit, carrying a pulsating direct current which induces a high voltage, alternating current in the sec-
condary by means of the step-up effect of the windings. The illustration shows a typical form of induction coil and the associated circuits for producing high voltages. Here, there are two windings, a primary and a secondary, over and insulated from a core, com-
posed of a number of soft iron wires. The primary is arranged with a key, K, and a battery, B, to supply direct current to the circuit. When the key is depressed the current flows through the primary circuit, including the contact C and the vibrator V. The core becomes "saturated" (q.v.) or magnetized and attracts the armature or spring V. As this spring is drawn toward the core it breaks the contact between the spring and the contact post. This, of course, breaks the circuit from the bat-
INDUCTION, INDUCTION, INDUCTION

Fig. 1. Same coil, showing cutting of field due to the rotation of the coil.

A common type of induction machine known as the Wimshurst.

MAGNET

MAGNET

**INDUCTION, Mutual**—The interference or mutual effect between two electric or magnetic fields, due entirely to their proximity and without electrical contact. The mutual induction or electromagnetic influence of one circuit upon another is measured by the coefficient of mutual inductance or induction. (See Mutual Induction, also Mutual Induction Coefficient, and Mutual Inductance.)

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INDUCTIVE REACTANCE—The value in ohms of the inductance in an electric circuit is the ratio of the electromotive force to the flowing current. It is the part of the total impedance in an alternating current circuit that is dependent upon the presence of inductance in the circuit. (See Inductance Reactance, Ohm, Impedance.)

INDUCTION REGULATOR—A system of regulating the voltage in alternating current circuits, employing a choke coil with removable core, or some form of variable ratio transformer which will assist or oppose the current by readjustment of the ratio. (See Choke Coil, Reactance, and Variable Ratio Transformer.)

INDUCTION SCREEN—A metal screen or shield placed between two electrically or magnetically coupled systems, to reduce the effect of induction between them. A common example of this is in radio usage, where a plate of metal separates two coils, the plate being generally grounded, or the provision of a metal shield (q.v.) entirely around each coil. The mutual inductance of the fields of the coils, which leads to losses or howling, especially in tuned radio frequency amplifiers (q.v.). (See Induc- tion.)

INDUCTION UNIT—The Henry, defined as the induction in a circuit when the electromotive force induced in that circuit is one international volt (see volt) while the inducing current varies at the rate of one ampere per second. (See Henry, also Self-induction.)

INDUCTION VOLTMETER—See Induction Wattmeter, also Induction Instruments.

INDUCTION WATTMETER—An instrument for measuring the power delivered to a circuit. The induction type wattmeter operates on a principle used in the induction motor, a magnetic body attached to a pointer being rotated by a changing magnetic field. (See Induction Motor, also Wattmeter.)

INDUCTIVE CAPACITY—Generally referred to as the specific inductive capacity of any dielectric, or the dielectric qualities of a substance. It is the quantity of any dielectric substance by reason of which it is capable of taking an inductive action through it. The term is more or less synonymous with Dielectric Constant, the latter, however, being generally used. In other words, the ratio of a material's inductive value representing its comparative specific inductive capacity with some material taken as a standard. (See Dielectric Coefficient and Constant, also Specific Inductive Capacity.)

INDUCTIVE CIRCUIT—An electrical circuit possessing inductance but lacking capacity. (See Inductance, also Capacity.)

INDUCTIVE CONNECTION—A connection between two circuits only through the property of inductance and without any metallic contact. The two coils of inductivity or primary and secondary, of a vario-coupler as used in radio receiving circuits, are said to have inductive connection where the windings are separate. The term inductive meaning will be in one electrical circuit and the secondary coil will receive energy from it through inductive means. (See Induction, Coupling, Vario-Coupler.)

INDUCTIVE COUPLER—The inductances or coils placed in inductive relation with each other for the purpose of transferring energy by electromagnetic coupling. Any device consisting of a primary and secondary inductance and used to transfer energy from one circuit to another is referred to as an inductive coupler. (See Coupler, Induction, Vario-Coupler.)

INDUCTIVE COUPLING—The coupling or connection between two circuits by means of electromagnetic induction.  

The most common example of inductive coupling is in radio receiving circuits where coupling coils are used to associate the aerial or aerial circuit with the secondary circuit. In the illustration L1 is the primary of a vario-coupler and L2 the secondary. The primary is inserted between the ground and aerial and the secondary is connected to the grid and filament of the detector tube. The variable condenser C1 tunes the primary circuit, the primary coil also being variable by means of taps if desired. The variable condenser C2, together with the condenser and grid lead GL are the customary elements in the detector grid circuit. As the high frequency currents traverse the primary circuit, passing through coil L1, lines of force are set up and shown and some of these lines embrace the secondary coil L2, inducing similar currents in the secondary or vacuum tube circuit. The balance of this circuit is not shown for obvious reasons. This type of coupling between circuits is much more selective than stray or mutual coupling. (See Coupling, also Conductive Coupling.)

INDUCTIVE DISTURBANCE—The disturbing effect of an unwanted electrical force set up in radio broadcast or telegraph reception due to induction from nearby power or telephone lines. This sometimes occurs when an aerial is strung close to and parallel with a line carrying high voltages, and occasionally is experienced with telephone wires near the receiver. (See Induction.)

INDUCTIVE DROP IN VOLTAGE—The drop or diminution of voltage in an alternating current circuit due to the presence of inductance. Inductance in a circuit carrying alternating current lends by reason of the self-induction to set up a counter-electromotive force which opposes the original E.M.F. (electromotive force), thus reducing the effective voltage in the line. (See Inductance, also Inductance Reactance.)

INDUCTIVE EMF—The electromotive force set up in a circuit by an inductive current. That is to say, the electromotive force induced in a circuit. (See Induction, Induced EMF.)

INDUCTIVE REACTANCE—The reactance or portion of the total impedance in a circuit, due to the presence of self-inductance. (See Inductance Reactance, also Impedance.)

INDUCTIVE RESISTANCE—A resistance element possessing inductance, as for example a transformer which also has the property of self-inductance. (See Resistance, also Inductance.)

INDUCTIVE RISE—The rise in voltage noted in transferring power from one alternating current apparatus due to the presence of a leading current (q.v.). (See Inductance, also Transformer and Form of Lead on Winding, or Lead Constant, also Inductive Capacity.)

INDUCTIVITY—Another term used alternately with dielectric constant and conductive capacity, referring to the dielectric properties of materials. (See Dielectric Constant or Reactance, also Inductive Capacity.)

INDUCTOR—The coils or conductors in which current is induced through electromagnetic inductive means. (See Inductive Motor.) Any conductor in which current is induced due to a change in magnetic flux may be called an inductor. (See Induction, Inductor Alternator, and Induction Motor.)

INDUCTOR ALTERNATOR—An alternator for producing high frequency currents. It employs a disk or field windings on projections inside the stator, the rotor consisting of a drum carrying magnetic materials. By using a rotor of solid steel, very high speeds and consequently high frequency currents are obtainable. The Alternator-Generator Alternator is an inductor type alternator. (See Alternator, also Inductor.)

INDUCTOMETER—A device or instrument used to measure self- or mutual inductance. The basic principle depends on the relation of two coils, a primary and secondary, one of which can be moved in relation to the other, the inductance, either self or mutual, being registered on a scale calibrated in units of inductance. (See Inductance, also Inductance, Self.)

INERTIA—In physics, the property of a body which resists any change of motion. (See Inertia, Electric.)

INERTIA, ELECTRIC—Term occasionally applied to the inductance of condensers (q.v.). When a current in a circuit possessing inductance and the circuit is broken, current continues to flow for a while in the same direction as before that in this instance the resistance alone will not stop the flow of current on the instant of breaking the circuit, an interval of time being required as in the act of bringing to rest a moving material. (See Inertia, Inductance, Self, also Resistance.)

INERTIA, ELECTROMAGNETIC—The same as electric inertia, being, in effect, the energy required to start or stop a current in a circuit possessing self-inductance. (See Inertia.)

INFERRED ZERO—A term used in connection with certain instruments having extremely high sensitivity, where the zero is removed from the scale. In a galvanometer, for example, the zero position is on a scale usually assumed, an electrical or mechanical force being applied to bring the zero off the scale, and the pointer travels a part of the full range of the full scale being utilized. (See Galvanometer.)

INFLUENCE—A broad term signifying action at a distance, as by electrostatic induction, without actual physical contact. It is considered as the effect of a charged body on a
neutral body or conductor coming within its field. (See Field, also Induction.)

INFRA-RED RAYS—The heat waves or rays which lie between light waves and the ultramagnetic (radio) waves. The infrared lies at the extreme high-frequency end of the invisible spectrum, the wave-length being extremely high and the frequency conversely low. (See Wave, also Ether Waves.)

INFRA-SATURATION PART OF CHARACTERISTIC—In a characteristic curve of a vacuum tube, this is the portion over which the tube is operable, or the operating portion of the curve. (See Characteristic Curve, also Vacuum Tube, Theory of Operation.)

INITIAL MAGNETIZATION — The initial stages of magnetization as distinguished from the effect after saturation has been approached or reached. (See Saturation, Magnetic.)

INPUT—Generally speaking, the energy absorbed by a machine as distinguished from the output energy. (See Input Voltage, etc.)

INPUT CIRCUIT OF VACUUM TUBE — A vacuum tube circuit are generally divided into three separate groups or circuits. The first is the circuit including the filament, i.e., the "A" battery circuit through the filament. The second is the circuit between filament and grid and the third is the circuit between filament and plate. The filament is a source of heat (hence the word filament) and this circuit because the incoming oscillations are impressed on this circuit. The filament plate circuit is known as the "B" battery because it is a rectified or amplified current that is taken across the plate and filament. The illustration shows the input and output circuits, the former in heavy lines and the latter in light lines. The input circuit of a tube is also known as the grid circuit. (See Grid, Filament, Plate, also Vacuum Tube, Theory of Operation.)

INPUT VOLTAGE — The voltage impressed on a circuit or machine as distinguished from the output voltage. (See Input.)

INSTANTANEOUS CURRENT — The value of current in an alternating current circuit measured at any instant, as distinguished from the average current value. (See Instantaneous Values.)

INSTANTANEOUS VALUES — The actual values of a varying current, E.M.F (electromotive force), etc., measured at any instant. This value may be anything from zero to maximum or peak. It must be remembered that in an alternating current the current and voltage are both variable from rising to a maximum in one direction, then falling to a minimum, and then rising to a maximum in the other direction. Thus, a wattmeter measures the actual value of current and voltage at each instant and the instantaneous torque at each instant is proportional to the instantaneous power. The average torque acting on the moving element during each cycle of the current and voltage is then proportional to the average power. If we measure an alternating current with an ammeter, and then measure the voltage with a volt-meter, the product of the two will be the apparent power, (apparent watts). It should be noted that these instruments measure effective and not instantaneous values. In order to ascertain the true waffe (q.v.), it is necessary to multiply the apparent watts by the power factor. 1 wattmeter measures true watts. (See Effective Electromotive Force, Power Factor, also Wattmeter.)

INSTANTANEOUS VOLTAGE OR PRESSURE — The voltage or pressure in an alternating current circuit measured at any instant, as distinguished from the average value of E.M.F. (electromotive force). (See Instantaneous Values.)

INSTRUMENTS, MEASURING — In electricity or radio, any device or instrument for recording or indicating values, such as an ammeter for indicating the current in amperes, or a voltmeter to indicate the electromotive force in volts. (See Ammeter, Ampere Meter, Voltmeter, Wattmeter.)

INSTRUMENT SHUNTS — In electrical measuring instruments, a branch conductor, generally of relatively heavy wire or metal strip, joining the meter circuit at two points and forming a parallel circuit, thus dividing the current and protecting the delicate windings of the instrument. (See Shunt, also Ammeter, Ampere Meter, Voltmeter, Wire Ammeter.)

INSULATE — To provide a protective covering or shield for a part or conductor, preventing flow of electricity from it or the passage of electricity through it. A conductor of electric currents is generally insulated to prevent the flow of electricity through contact with other parts or conductors except where contact is intended to be made. (See Insulating.)

INSULATED WIRE — Wire, generally copper, covered with insulating material to protect it from the electric current. Standard insulated wire of the heavier gauges is usually covered with an inner covering of rubber and an outer covering of braided cotton. (See Lead, Insulation.)

INSULATING COMPOUND — Liquid or easily liquefiable mixture of some insulating material, used in radio to coat cardboard tubes and to cover any open point of contact in an otherwise insulated conductor or part. Coils are very often coated with an insulating liquid and quick-drying substance. This serves to hold the windings in place and also acts as a protective covering. A very valuable illustration of an insulating liquid is shown in the illustration. Here an insulator is wound on a form of stiff paper or cardboard tube and after being completed is coated with one or two treatments of collodion or similar liquid. (Shellac introduces losses through the medium of distributed capacity.) The form is then cut away and the coil remains self-supporting as shown. This method produces a coil having the least possible dielectric and distributed capacity loss for a cylindrical shape. (See Dielectric, Insulation Coils, Low Loss Coils, Collodion.)

INSULATING MATERIALS — Non-conducting substances, for example, glass, hard rubber or porcelain, which do not carry electric currents. Strictly speaking, there are no perfect insulating materials. There are insulators are certain gases, although at low pressure these may act as very good conductors. Some insulating materials in radio are the following: mica, glass, bakelite and hard rubber, the insulating values being in that order.

The insulation of the insulating property of a material we are actually referring to its resistance, that is, resistance to the passage of electric currents and poor ones being relatively good conductors. When specific resistance is used extensively in connection with the insulating properties of materials. This term is defined as the resistance of a material of unit length and unit cross-sectional area at a given temperature; the value being given in ohms. (See Dielectric Coefficient and Constant, Table of, also Ohms, Resistance and Conductance.)

INSULATING PROPERTY — The ability of any material to insulate electric currents. Accepting mica as an insulator, we may say that its property is superior to glass or hard rubber. (See Insulating Materials, also Dielectric Coefficient and Constant and Insulation of Aerial.)

INSULATION — Broadly any material or gas used to insulate electric currents. In radio, insulation plays an important part, providing protective coverings or separators between conductors of the electric current and between the conductors and the ground. Insulation is really a material or gas having extremely high specific resistance; the better the insulating property, the higher the resistance to passage of electricity. There is no clearly defined limit of demarcation between an insulator and a conductor, or a poor insulator being to some extent a conductor. (See Bakelite, Conductor, Dielectric Coefficient and Constant, Insulations of Aerial, Panel.)

INSULATION OF AERIAL — The means used in connection with an aerial for reception or transmission of radio waves, to prevent leakage or ground-
Insulation Resistance

Insulation Resistance—The actual resistance in ohms, generally megohms, of the insulation of any conductor or piece of apparatus. If we assume two conductors, carrying separate currents and crossed so that the only protection would be the actual insulation of the wires, the insulation resistance would be the actual resistance in megohms from one path to the other. Conceivably a small current might leak from one conductor to the other, this current, of course, depending on the resistance of the insulation. The term “insulation resistance” is most easily understood when it is considered that an insulator or insulating material is merely a very poor conductor, or one having extremely high resistance to electric currents, there being actually no perfect insulator. (See Insulation, Insulated Wire, also Insulation Resistance.)

Insulation Tester—An instrument or set of meters for testing the resistance of an insulator in fractional ohms, generally megohms. (See Insulation Resistance.)

Insulator—Any substance having insulating properties. Insulators are used to keep electric currents flowing in predetermined paths. It is necessary to use insulators on all electric circuits in order to prevent grounds, leakage and short circuits. Insulators are of the utmost importance in radio. At the transmitting end, where high voltages as well as high frequencies are used, the insulators must be specially designed to prevent leakage. A typical installation of insulators in use on the aerial system of a modern broadcasting station utilizes a 12-inch pyrex insulator at each end of each wire between the spreaders. A standard porcelain 9-inch insulator is used every 14 feet on each guy wire. At each end of each guy wire a standard 24-inch pyrex insulator is used. Insulators used on receiving antennas are made of porcelain, pyrex, rubber and composition. These are usually about 4 inches in length. Sometimes porcelain tubes are used as insulators to bring a lead-in (q.v.) into a building. The insulator is generally supported by a flat window lead-ins.

Insulator, Lead-In—The insulating tube through which a lead wire conducting surface. (See Lead-In Insulator.)

Integrating Detector—The name sometimes given to any detector which yields a response proportional to the total energy received from a spark train rather than to the maximum value of the current or voltage in the train.

Integrating Instruments—Meters so designed as to record the total amount of electrical energy being consumed in a circuit. These instruments are also known as recording watt-hour meters (q.v.), integrating watt-hour meters, and sometimes are simply referred to as watt-hour meters (q.v.).

Broadly speaking the integrating wattmeter is a type of small motor whose rotations are counted by means of a worm on the armature shaft engaging a set of cogs working a counter. The construction is such that the average torque (q.v.) exerted by the motor is proportional to the average power taken by the load. In other words, the motor rotates at a speed directly proportional to the energy being expended. For direct current work, integrating wattmeters are either of the commutator type (q.v.) or of the no-commutator type, such as the Thomson, Westinghouse and Duncan meters or of the no-commutator type, such as the Amsler. The commutator type instruments are based on the dynamometer (q.v.) principle. Meters of the no-commutator type are essentially motors whose armatures always cut the same direction flux. That is to say, they are essentially homopolar (q.v.) motors. The principle of operation of these meters is the law of motor action which states that a conductor, free to move and carrying a current whose direction of flow is at right angles to a fixed magnetic field, will exert a force on the conductor in a direction at right angles both to the direction of current flow and to the field. For alternating currents, the integrating wattmeters, are of the induction (q.v.) type. The principle of operation of these meters is identical to that of adding up shunt and series windings stationary and so related and located to produce a rotating field acting as a definite and rotatable secondary. In the induction meter the secondary consists of a light aluminum disc. These meters may be single phase (q.v.) or polyphase (q.v.) construction. (See Electro-dynamometer.)

Integrator—A device which automatically, by means of clockwork, sets up and records on a dial items of calculation or measurement. The system used in a recording or integrating wattmeter. (See Integrating Wattmeter.)

Intensification—Broadly an intensifying or increasing of the density of electric currents. Occasionally it is used in radio it refers to the tendency of radio signals to increase in intensity under certain conditions. The phenomena of intensification is naturally closely related to fading, as obviously the intensification process must necessarily follow or be followed by it. The tendency toward intensification is more pronounced toward night and generally on the shorter wave lengths, it being noted that quite often signals from a distant station will be increased in volume or intensity as much as fifty per cent or more between the late afternoon and late evening. While the periodic fading of signals and the subsequent increase in volume or intensity over regular periods, usually of a few minutes' duration, may be considered as fading and intensification, it is preferable to think of fading as one operation together with the subsequent increase in volume, and the term intensification as referring strictly to the change to greater volume that takes place toward night. (See Pading, also Phenomena of Electric Wave Propagation.)

Intensity of Electric Current—A term more or less in use to imply the strength of an electric current in amperes, the symbol for current being derived from it. (See Ampere, Current Density, also Intensity of Field.)

Intensity of Field—The intensity or strength of the force exerted in a magnetic field. It is measured by its action or effect on a unit pole placed at any point in the field, the intensity of the field, of course, varying at different points. (See Flux Density, Intensity of Magnetic Flux.)

Intensity of Magnetic Flux—The strength of the force exerted in a magnetic field. It is measured by its action or effect on a unit pole placed at any point in the field, the intensity of the field, of course, varying at different points. (See Flux Density, Intensity of Magnetic Flux.)

Intensity of Magnetization—The density of force per unit cross-sectional area of a magnetized material. The extent of the effect of magnetization on a material placed in a magnetic field of force. This applies only to magnetic material and should not be confused with the lines of force due to a field arising from the presence of neighboring magnets. (See Magnetization, also Intensity of Magnetic Flux.)

Interference—The interruption or interference with desired electromag-
ngetic waves by undesired or extraneous waves. The interference of undesired broadcast or radio-telegraph signals with the desired signals. Also, broadly, the detrimental effect of power waves and other electric circuits on radio communication. Interference is encountered in receiving sets having poor selectivity (q.v.). In some instances interference may be due to the fact that another transmitter is operating on the desired wave-length and being sufficiently close as to make it practically impossible to obtain clear signals from the desired station. Ordinarily, and where the effect is due to lack of sharp resonance or tuning, certain changes can be made in the receiver to sharpen the tuning, or if the disturbance is due to the transmitting stations and the receiver is normally sharp, various circuits can be employed to filter out the undesired signals. (See Interference Preventer, also Wave Trap.)

INTERFERENCE ELIMINATOR—A device or system as shown in the illustration for reducing or preventing reception of undesired signals in radio work. Practically all interference eliminators make use of a separately tuned inductance across the aerial and ground and in parallel with the receiving set. The inductance is usually tuned by means of a variable condenser which allows it to be tuned to the interfering signal. The interference can thus be by-passed to the ground. Interference eliminators of the kind described are generally known as wave traps (q.v.). A special form of interference due to atmospheric and electrical disturbances is known as static (q.v.). (See Static Eliminator.)

INTERFERENCE PREVENTERS—Any arrangements either within the receiving set, or external to the set, for limiting or preventing interference. In addition to interference eliminators (q.v.) and static eliminators (q.v.) various other methods are utilized in radio to prevent interference. Thus the arrangement of a receiving set to give sharp tuning and great selectivity, results in the prevention of much interference. A number of interference preventers which have been used, is the utilization of filter circuits which can be tuned to pass any desired frequency and exclude all others. The use of the loop aerial (q.v.) results in great selectivity. The loop has a pronounced directional effect and this in itself acts to narrow the field of stations offering possible interference. For example, if two stations very nearly the same wave length are in opposite or different directions and are sending at the same time, the loop permits selection of the station wanted, with no interference from the others.

INTERMEDIATE CIRCUIT—A closed circuit consisting of two inductance coils shunted by a variable condenser. One coil acts as primary to the secondary coil of the detector circuit and produces a coil acts as secondary to the primary of the aerial circuit. A circuit such as this is sometimes referred to as a multiple tuner intermediate circuit and is used as an interference eliminator.

INTERMEDIATE FREQUENCY—This is a frequency higher in number of oscillation than audio frequency (q.v.) but lower than radio frequency (q.v.). It is generally around 30,000 cycles or 100,000 microwaves. In the super-heterodyne (q.v.) the incoming signal is converted from the broadcast frequency to the so-called intermediate frequency at which it can be amplified by means of fixed wave transformers to almost any extent desired. The method of converting the incoming signal in a super-heterodyne from radio frequency to intermediate frequency is by the beat method. In this case an oscillating circuit controlled by means of a variable condenser so as to obtain any desired frequency, is brought into interference with the first detector and produces a beat note (q.v.) for the intermediate frequency which has all the characteristics of the original signal. In this way, no matter what the frequency of the received signal may be, the intermediate frequency amplification is always carried on at a fixed wave-length thus securing for high efficiency. (See Beat Frequency Oscillator.)

INTERMEDIATE FREQUENCY AMPLIFIER—An arrangement of tubes and transformers for stepping up the current, used in the super-heterodyne (q.v.) circuit. The intermediate frequency amplifier is located between the first detector and the second detector. (See Intermediate Frequency.)

INTERMEDIATE TRANSFORMER—The name given to the transformers used in the intermediate frequency amplifier (q.v.) of the super-heterodyne circuit. Intermediate transformers are often referred to as intermediate frequency transformers. They are radio frequency transformers (q.v.) but have an iron core and instead of 10,000 micro-watts maximum of 650 or 600 meters they are designed to cover wave-lengths of 10,000 meters or higher. (See Intermediate Frequency.)

INTERMITTENT CURRENT—A current which flows irregularly or which is interrupted at intervals or without continuity. The current obtained from a magneto generator (q.v.) is an interrupted or intermittent current. Such a current may be either alternating or direct. A magneto generator constructed to give direct current is equipped with a two segment commutator having a stationary brush in contact with it. (See Pulsating Current.)

INTERNAL RESISTANCE—Resistance within an electric source. In the case of a primary cell such as a dry battery, the internal resistance causes an interference with the flow of current. This varies in amount with the construction and materials of the battery.

INTERNATIONAL MORSE CODE—This is also known as the Continental code. (See Code.)

INTERPOLER—A small magnetic pole placed between the main field poles of an electric generator for the purpose of obtaining better commutation. Interpolide windings are connected in series with the armature winding and the load. The action of the interpole is exactly analogous to the shifting of the brushes, but when interpoles are used, brush shifting is dispensed with and the magnetic flux is shifted instead.

INTERRUPTED CONTINUOUS WAVES—abbreviation I.C.W.—These waves are obtained by the modulation at audio frequency, during signalling, of an otherwise continuous wave (q.v.). (See Continuous Waves Key Modulated, also Continuous Waves Modulated at Audio Frequency.)

INTERRUPTED WAVES—abbreviation I.—Interrupted waves are waves produced by modulation at audio frequency, of otherwise continuous waves. (See Interrupted Continuous Waves.)

INTERPUTER—A combination of an electromagnet with a vibrating armature which carries a contact point on a piece of spring steel fastened to the armature. When the electromagnet attracts the armature, the contact points are drawn apart thus interrupting the circuit. This action is only momentary for the spring again brings the circuit back to its original condition. The most important use of the interrupter is as a rectifying valve (q.v.) in electrical chargers. A typical vibrator panel is shown in the illustration. The armature, A, is the moving element. This carries at its outermost end a heavy Tungsten contact, B, which is caused to vibrate in synchronism with the supply current, by the fluctuating current which the current from the transformer has of the correct polarity and value the actuating coil attracts the armature, closing the charging circuit, to the battery through the fixed contact, D. The contact end of the armature, A, vibrates within the air gap of the pole shoe, G.

A common use of the interrupter is in the ordinary electric bell. In this
Interrupter, Electrolytic

The apparatus, the electromagnet pulls the armature carrying the spring and contact point, breaking contact and opening the circuit. This immediately de-energizes the magnet since its coils are in series with the circuit. The spring tension pulls the armature back to its original position thus again closing the contact. As soon as the contact is closed, the electromagnet is again energized and it again attracts the armature, opening the circuit. This action keeps on indefinitely as long as a difference of potential is maintained at the terminals of the bell.

The interrupter is used in the induction coil (q.v.) for breaking up the direct current into a series of impulses, thus producing an intermittent current. (See Circuit Breaker.)

Interrupter, Electrolytic—A jar containing a diluted sulphuric acid as the electrolyte, a large sheet of lead as one electrode and a platinum needle point introduced through a glass tube as the other electrode. If these electrodes are connected through an inductance to a source of current supply, the current in the circuit will be rapidly interrupted. Electrolytic interrupters are suitable for radio transmitters using small spark coils, and are also used in X-ray work. (See Electrolytic Interrupter.)

Inverted "L" Aerial—A flat top aerial (antenna) in which the down lead is tapped off one end of its horizontal span. (See Length of Aerial, Horizontal Aerial.)

Inverse Duplex Circuit—A circuit in which the vacuum tubes are utilized both for radio frequency and for audio frequency amplification as in the reflex (q.v.) circuit with this important differentiation that the first radio frequency tube is utilized as the second audio frequency tube and the second radio frequency tube is used as the first audio frequency tube. In the ordinary reflex circuit the first radio frequency tube is also the first audio tube and the second radio frequency tube is the second audio tube. The inverse duplex circuit has the advantage over the reflex in that the tubes which are reflexed operate more efficiently since the relatively weak current passes through the same tube as the stronger audio currents and vice-versa. The inverse duplex circuit is the invention of David Grimes.

ION—An atom of matter carrying an electron or an atom deprived of electrons. Monad-ion refers to a unit charge, dyad-ion, divalent carries two units, the triad-ion carries three unit charges. The positive ion is an atom minus an electron. A negative ion is an atom plus an electron. (See Anion, also Cathode, Electron, Electrons Theory.)

Ionization—sometimes spelled Ionisation—The splitting up of molecules into ions (q.v.). Ionization may apply either to a chemical compound or to a gas. When an electric current is passed through an electrolyte (q.v.) it is called electrolytic ionization. When they allow the flow of electricity. A gas may be made conductive by passing X-rays (q.v.) through it, by the action of ultra-violet light, by subjecting it to radium rays, by passing rays from radium, by the action of electricity. (See Electrolysis, Electrolytic Action, also Valve Detectors.)

1.R. DROP—The voltage drop due to the resistance in a current-carrying conductor. It is directly proportional to the current flowing in the circuit multiplied by the resistance of that circuit.

1.R. LOSS—The power loss in any circuit due to the resistance offered to current flow. It is proportional to the square of the current flowing in the circuit multiplied by the resistance of the circuit. Whenever current flows there is an IR loss. This is measured in watts (q.v.) or kilowatts (q.v.)

Iron Pyrites—Formula FeS—This is a mineral, a disulphide of iron, found in quartz veins. It is extensively used in radio as a crystal detector mineral but has been almost entirely superseded by vacuum tube detectors. Iron pyrites is flaked with shiny spots which have the appearance of gold, and for this reason it is sometimes called "fools gold." Iron pyrites is very hard and brittle. The present commercial use of iron pyrites is in the production of sulphuric acid. Ferrous Sulphide, FeS, has also been employed in the past as a radio detector. This substance is chemically formed by fusing equal quantities of sulphur and iron together. The resultant substance has a smooth surface. (See Crystal Detector.)

Isochronous—A term applied to two or more oscillatory circuits, meaning that they have the same natural frequency (q.v.). Stated in another way, two or more radio frequency circuits are isochronous when they are in electrical resonance (q.v.). Circuits are said to be in resonance when they have the same oscillation constant (q.v.). The oscillation constant of a circuit is equal to the square root of the product of the inductance multiplied by the capacity of that circuit. Circuits having equal oscillation constants will have the same discharge frequency.

Iso-Dynamic Lines—Lines on a magnetic map of the earth are lines of the same magnetic intensity. In other words, these lines pass through points of equal horizontal component of the earth's magnetic field.

Isogonic Lines—Lines on a magnetic map passing through points of equal declination.
**ISOTHERMS**—Lines on a meteorological chart joining all points having the same temperature.

**ISOTROPIC CONDUCTIVITY**—Equal conductivity in every direction. A conductor is said to be isotropic when it offers the same resistance to the flow of an electric current in every direction through its mass.

**JACK**—An arrangement of spring terminals as shown in the illustrations which can be connected together or separated thus closing or opening circuits through the insertion of a plug which also forms a part of the circuit. The plug (q.v.) has a tip and a sleeve at one end (that is at the end inserted into the jack) and at the other end it has the two terminals for connecting the apparatus to be cut into the circuit. As an example, the terminals of the plug may be connected to a loud speaker (q.v.). The jack in this case is of the open circuit variety. That is to say, the springs of the jack are separated when not in use and the circuit is normally open. When the plug is inserted, the tip of the plug makes contact with one spring and the sleeve makes contact with the other thus closing the circuit through the loud speaker. In cases where the plug is used to open a circuit, that is to make the jack springs break contact with each other, the jack is called a closed circuit jack since its spring terminals are normally making contact. In cases where the jack is used not only to put the loud speaker in the circuit, but also to act as a filament switch, it is known as an automatic filament control jack. Jacks which are used to control a single circuit only, are referred to as single circuit jacks. Those controlling two or more circuits simultaneously are known as multiple circuit jacks. Jacks are usually mounted on a panel so that the plug can be inserted from the outside of the panel while the spring terminals are concealed behind the panel.

**JANET, PAUL**—Born in Paris, January 10, 1863. Educated at Lycee Louis-le-Grand and at the high school. He was Professor of Physics at the University of Paris and University of Grenoble. Professor Janet was the author of several important works, and first to make the experiments in electrical resonance successful. The results of these experiments are applied in present day wave meters.

**JAR**—A unit of electrostatic capacity. It is mainly used in the British Naval service. One jar equals 1000 centimeters which equals .0011 microfarads (q.v.).

**JIGGER**—A term generally accepted to denote an oscillation transformer (q.v.). Used for transforming trains of oscillations from one circuit to another. Dr. J. Erskine Murray refers to high frequency oscillations as Jigs. Jiggers are also known as magnetic coupling transformers (q.v.). They are also sometimes referred to as auto-jiggers.

**JOULE**—symbol J—The practical unit of electrical energy. It is equal to 10^-7 ergs (q.v.). The joule is also the unit of electrical work. It is equal to the work done or the heat generated by a watt second (q.v.); or an ampere (q.v.) flowing for a second through a resistance of one ohm (q.v.). Expressed another way the joule is the work done by one coulomb (q.v.) flowing under the pressure of one volt (q.v.). One joule is equal to .7372 foot pounds, or .24 calories (q.v.).

**JOULE EFFECT** or JOULEAN HEATING—This occurs when an electric current traverses a resisting conductor. The rate of generation of heat in the conductor by a steady current equals the square of the current multiplied by the resistance.

**JOULES EQUIVALENT**—The amount of energy equal to heat.

**JOULES LAW**—The heat produced in an electric circuit is directly proportional to the square of the current, to the resistance of the conductor and to the time of current flow.

**KANALSTRAHLEN**—A German word meaning Rays of Canal. It has been found that by perforating the cathode of a tube producing cathode rays (q.v.), faint luminous streaks will come through these perforations in a direction opposite to that of the cathode rays. These are called kanalstrahlen. They communicate a positive charge to an insulated conductor. In terms of the electron theory (q.v.) they are positively charged ions (q.v.) The cathode particle is an electron traveling in one direction, and the kanalstrahlen particle traveling in the opposite direction is what remains of the atom which has lost an electron.

**KATHODE**—This is a negative electrode (q.v.). (See Cathode, also Electrosis.)

**KATHODE OF CELL**—The positive pole of a cell. This is indicated by the plus (+) sign. (See Cell.)

**KATHODE RAYS**—The stream of electrons (q.v.) thrown off by the kathode of a vacuum tube. These produce a glow when they strike the walls forming the tube. They can be deflected by a magnet. (See Cathode Rays.)

**KATION**—The charged particles or ions (q.v.) moving in the direction of the cathode (q.v.). (See Cation.)

**KEEPER**—The piece of iron used to close a magnetic circuit to protect it from external disturbances. The term keeper is generally used to refer to such a piece of iron when used with a permanent magnet such as a horseshoe magnet. In the case of the piece of iron which closes the magnetic circuit of an electromagnet, this is more often referred to as an armature (q.v.). The keeper may be used with a straight bar magnet also. In this case, two bar magnets are laid side by side with un-like poles adjacent and two keepers are used, one at each end. The use of a keeper avoids the demagnetizing effect of leakage lines (q.v.). (See Horseshoe Magnet.)

**KEEPER**

At left is shown keeper used with a horseshoe magnet. At right two keepers are shown used with two bar magnets.
Kelvin, Lord

KELVIN, LORD (William Thomson) was born at Belfast in 1824; he entered Glasgow University as a student at 10 years of age; graduated at Cambridge in 1845. When only 22 years of age he was called to occupy the chair of natural philosophy in the University of Glasgow, a chair which he adorned by his genius for fifty years. He was for 40 years or more regarded as the acknowledged leader of British science on its physical and mathematical side. His great inventions in telegraphy, his magnetic compass and sea sounding apparatus brought him fame and fortune. He was knighted in 1866; and in 1892 was raised to the peerage as Baron Kelvin of Largs; he died on December 17, 1907.

KELVIN'S BRIDGE—A method of measuring low resistance in which the voltage drops, produced by the same current in the resistance under test and in a standard low resistance slide wire are balanced against each other. This bridge is a modification of the Wheatstone Bridge (q.v.) and was designed by Lord Kelvin to eliminate the errors introduced when measuring resistances much less than one ohm (q.v.). In the case of the Wheatstone Bridge, such resistances could not be measured accurately on account of the errors produced by the terminal and contact resistances.

KELVIN'S ELECTROSTATIC VOLT-METER—A voltmeter used for measuring high, and in some cases low, alternating current voltages. It is constructed on the principle of an air condenser. One type of electrostatic voltmeter is a high potential instrument having the needle made of a thin aluminum plate suspended vertically on delicate knife edges, with a pointer extending from the upper part to a scale. Two quadrant plates, metallically connected together, are placed on either side of the needle and parallel to its face. These serve as one terminal of the circuit to be measured. The needle acts as the opposite terminal. When there is a difference of potential between the needle and the plates, the needle is deflected out of its neutral position. The value of the scale indications can be changed by hanging calibrated weights on the bottom of the needle.

KENOTRON—A type of vacuum tube rectifier (q.v.) in which the vacuum is extremely high and the discharge is carried almost entirely by electrons, not by gas ions. In these tubes, the plate current is always less than that actually emitted by the hot filament. Kenotrons are made sufficiently large to rectify several kilowatts.

KENNELLY, A. E.—Anglo-American radio expert. Born at Colaba, Bombay, December 17, 1861, he was educated in England, Belgium, France and Italy. In 1876 he became a telegraph operator in the employ of the Eastern Telegraph Company, and in 1886 became the principal electrical assistant to Thomas Alva Edison in the laboratories at Orange, N. J., a post he held until 1892.

He was engineer-in-chief with E. J. Houston, of the Thomson-Houston Company, for the laying of the cables from Vera Cruz to Campeche, 1902. Since 1902 he has been Professor of Electrical Engineering at Harvard University, and since 1914 professor of the same subject at Massachusetts Institute of Technology.

Kennelly has written a large number of books on electricity and radio, and is the author of one of the standard elementary text-books on same. He has written a very large number of papers on radio, and he is an authority on alternating currents.

He is past president of the American Institute of Electrical Engineers, was president in 1916 of the Institute of Radio Engineers, and vice-president of the International Electrical Congresses, held in Paris and Turin. He is a member of many scientific societies, and has received many honorary degrees. In 1921 he was appointed a delegate to the Interallied Radio Technical Committee in Paris.

KEY—A form of switch for conveniently and quickly opening and closing a transmitting circuit, in the act of transmitting signals. An operating, or telegraph, so-called Morse key is a form of tapping key designed especially for the rapid sending of signals by the dot and dash code. A tapping key has one contact carried by a springy strip...
contact both on the right and on the left side. Such a key requires only half the tutorial of the ordinary transmitting key and thus facilitates high-speed manual transmission of code signals.

**KEY SWITCH—**A type of switch adapted for operation by a removable portion in the form of a handle or key. In radio work, key switches are sometimes used to lock a receiving set so that it cannot be operated unless the filament circuit is closed by the insertion and turning of the key. Such switches are generally operated by a hollow slotted key, although there are other types on the market. In the key fits a projection or pin on the spindle or shaft of the switch which carries the movable contact. When the key is inserted into the socket and turned, it turns the shaft and brings the movable contact against a fixed contact. Key switches are also used for turning on or off electric lights and for locking or unlocking the ignition systems of automobiles.

**KILO—**Symbol K—A prefix placed before the name of a unit to indicate the multiple 1000 or 10^6. In cases where standard units are too small for convenient use, it is customary to utilize this prefix as, for example, in stating the voltage of a high-tension transmission line. This would often be given as 10 kilovolts (K.V.) rather than as 10,000 volts. In like manner, in referring to large amounts of power, it would be preferable to give the amounts in kilowatts rather than in watts. To be able to express 10,000,000,000 watts would be to divide by 1,000, thus converting to 10,000 kilowatts.

**KILAMPERE-TURN—**One kiloampere-turn is equivalent to 1,000 ampere-turns. In referring to the magnetic circuits of electrical machinery it is usual to specify the magnetomotive forces in kiloampere-turns rather than in ampere-turns. (See ampere-turns, also magnetomotive-force.)

**KILOCYCLE—1,000 CYCLES—**Two immediately succeeding half waves of an alternating current constitute a cycle (q.v.). The number of cycles per second is called the frequency (q.v.). In house-lighting and similar circuits, where a comparatively low frequency is used, it is usual to refer to the frequency in cycles per second. However, in radio circuits, where currents as high as 300,000,000 cycles per second are used, it is preferable to express the frequency by 1,000, thus converting to kilocycles. If the wave-length in meters is known, it is possible to determine the frequency in kilocycles. This is calculated as follows: The speed of light is 186,000 miles per second. Observations have shown that this is practically the same as the velocity of electromagnetic or radio waves. Expressed in meters this is equal to 300,000,000 (appx.) meters per second. Assuming that a transmitting station is using a wave-length of 600 meters, the frequency will be obtained in cycles per second by dividing the velocity of the waves by the wave-length in meters.

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### Kilocycles to Meters, or Meters to Kilocycles

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**Kilocycle**
Kilovolt-ampere—The unit of electrical power is the kilovolt-ampere. One kilovolt-ampere equals 1,000,000,000 joules. The power is measured in kilovolt-ampere (q.v.). Kilovolt-ampere is abbreviated kVA.

Kilovolt—abbreviated K.V.—The kilovolt is an electrical potential of one thousand volts. Kilovolts are used to measure high-potential circuits. The kilovolt is abbreviated kV.

Kilowatt—Abbreviation kW.—The kilowatt is a unit of electrical power equal to a kilowatt-horsepower, which is equal to 277,778 watts. The kilowatt is abbreviated kW.

Kilowatt-hour—The energy expended when work is done for one hour at the rate of one kilowatt. It is possible to calculate the energy expended in a kilowatt hour by using the formula:

\[ \text{Energy} = \text{Power} \times \text{Time} \]

where Power is in kilowatts and Time is in hours.

Kilowatt-hours are equal to 1,000,000,000 joules.

Kilowatt-hour is abbreviated kWh.

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L—The symbol of inductance ($L$) or mutual inductance ($M$) in general, the co-efficient $L$ by which the rate of change of current in any circuit must be multiplied to obtain the value of the self-induced electromotive force ($q.v.$) is called the coefficient of self-induction or simply the inductance. (See Self-induction, coefficient.)

Lag—One alternating current quantity reaching its maximum at a later time than a second alternating current quantity. As an example, the current is said to lag behind the impressed voltage when maximum current occurs after maximum voltage. In other words, the current and voltage in such an alternating current circuit are out of phase. In the above example since the current lags behind the voltage, the voltage is said to lead the current ($q.v.$) in an alternating current circuit will cause the current to lag behind the impressed voltage. Capacity ($Q$) in such a circuit will cause the current to lead ($Q$) the impressed voltage. The word lag may be applied to magnetic quantities in the same manner.

Thus, one magnetic flux may lag behind another as in the case of an induction motor where the induced magnetic flux ($q.v.$) lags behind the impressed magnetic flux. Another type of magnetic lag is the radiation of magnetic effects behind their causes, often called hysteresis ($q.v.$) in the magnetized substance. (See Lead, also Leading Current.)

Laminated—Composed of a number of thin plates, one on top of another. Examples of laminated construction are laminated brushes, laminated cores, laminated conductors, etc.

Laminated Core—An arrangement of sections plates or stampings forming the core of a transformer, or of an armature of a motor or generator. Cores are laminated in this way, principally to reduce eddy current ($q.v.$) losses. In the case of an armature core, this must be laminated parallel to the direction of rotation (in other words, perpendicular to the axis of rotation). Laminations are insulated from each other by means of japanned varnish, shellac or simply rust.

Lamp Bank—A bank of incandescent lamps arranged so that they can be connected in series or parallel. Lamp banks are used in laboratories in conjunction with electrical machinery under test. In this case, the lamps act as the load, the more lamps being connected in parallel, the greater the amount of current being drawn. Lamp banks are sometimes connected in series in a circuit for the purpose of reducing voltage. An example in this connection is the use of a lamp or bank of lamps in charging a 60-volt storage battery from a 110-volt direct current source. Lamp banks are sometimes called lamp panels or lamp batteries.

Langmuir, Irving—American radio authority. Born at Brooklyn, New York, January 31, 1881, he was educated at the School of Mines, Columbia University, and was for some time assistant to Professor Crookes at the University of Gottingen. In 1906-9 he was instructor in chemistry at the Stevens Institute of Technology, and in the latter year he became a research assistant to the General Electric Company, at Schenectady. He has carried out a series of brilliant researches on apparatus used in wireless telegraphy and telephony, on electron discharge apparatus, atomic and molecular structure, etc.

Langmuir has paid particular attention to high-vacuum valves, and is the inventor of the Langmuir valve. To him is due the discovery that by treating the tungsten oxide used in the construction of tungsten filaments with certain compounds of thorium the filament becomes thoriated tungsten and the electronic emission is enormously increased. These filaments are the ones used in dual filament valves, the electrons being given off at comparatively low temperatures. Langmuir is the author of many papers to scientific and technical journals, including those on pure electron discharge, thermionic currents in high vacua, etc. He is also well known for his mercury condensation pump for high vacua.

Lap Winding—An armature winding in which the opposite ends of each coil are connected to adjoining commutator segments. As a result the windings lap back and upon themselves forming loops. Lap winding is also called loop winding, parallel winding and multiple winding. In the elementary form of lap winding the method of connection to the commutator bars is as follows: One side of a coil is connected to a commutator bar, and the other side of the coil, which is located 180 electrical degrees (the distance from the center of a north pole to the center of the adjacent south pole) away, has its end connection brought back and soldered to the next adjacent commutator segment. This method of overlapping the ends is continued all the way around the armature until all the slots have been filled and the circuit has been closed on itself. The coils must all be symmetrical. This means that if there is a forward throw of a certain num-
Law of Electromagnetic Induction

Law of Electromagnetic Induction, also known as Faraday's Law of Generator Action, states that the electromotive force induced in a conductor cutting the magnetic field is proportional to the rate of change of the magnetic flux through the conductor. The induced electromotive force is given by the equation:

\[ E = N \frac{dB}{dt} \]

where:
- \( E \) is the electromotive force induced in the conductor,
- \( N \) is the number of turns of the conductor,
- \( B \) is the magnetic flux density,
- \( t \) is the time.

Law of Induced Currents—Faraday's Law of Induction states that the induced electromotive force (emf) in a conductor cutting the magnetic field is proportional to the rate of change of the magnetic flux through the conductor. The induced emf is given by the equation:

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- \( t \) is the time.
LENZ'S LAW—An induced current always tends to stop the motion which produces it. Stated in another way, whenever current flows in a conductor, due to electromagnetic induction, the action between the magnetic field which is being cut and the field around the conductor is always such as to tend to oppose further motion of the conductor. The following is still another way of stating Lenz's Law: The field due to the induced current always acts to prevent a change of the original field.

LEYDEN JAR—A condenser consisting of a glass jar, an inner conductor and an outer coating of tinfoil covering the bottom and the sides nearly to the neck.

A small leyden jar.

A brass rod terminating in an external knob passes through a wooden stopper and is connected to the inner coating by a loose chain. This condenser received its name from Leyden, the city in which it was invented.

L. F. C.—Abbreviation for Low Frequency Current. (See Frequency, Low, also Frequency.)

LIGHT—Radiant energy or visible radiation which affects the eye so that objects become visible. Light consists of ether vibrations varying between 400 billions per second producing waves 271 ten-millionths of an inch in length and giving red light, up to 750 billions per second producing waves of 165 ten-millionths in length, giving violet light. Faster or slower vibrations produce waves not visible to the human eye. Shorter waves are called ultraviolet rays, while those immediately above the red rays are known as infra-red rays. The speed of light waves is identical with that of other electromagnetic waves and electricity, and is 186,000, or 300,000,000 meters per second.

LIGHT LINE AERIAL—A device which acts as an aerial for a radio receiving set and which utilizes the electric lighting system by means of a plug to which a condenser is attached. The plug is inserted in any lighting socket and the aerial connection of the receiving set it attached by means of a flexible lead to one terminal of the condenser. (See Adapter, Aerial.)

LIGHTNING ARRESTER—(Also called lightning protector.) A device for protecting radio or other electrical apparatus from lightning or from atmospheric discharges. Radio lightning arresters are provided with two terminals, one being connected with the aerial and the other directly to a ground. Between these terminals is a medium which offers practically no resistance (or technically speaking, which offers low impedance (q.v.)) to the flow of very high frequency currents such as lightning discharges. However, the medium acts as an insulator to the normal operating currents. Hence, during the ordinary reception of radio signals, the currents flow past the arrester to the receiving instrument but they are unable to pass through the insulating medium of the lightning arrester to the ground. When there is a lightning discharge, the arrester offers the shortest and most direct path to the ground and hence the dangerous current now seeks the apparatus but proceeds directly to the upper terminal of the switch is usually connected to the aerial, the central terminal to which the aerial臂 is connected, leads to the radio set and the lower terminal is connected to the ground. In most installations the lightning switch is mounted outside the building in which the radio apparatus is located. (See Ground Switch.)

LIKE CHARGES—Bodies which carry like electrostatic charge (q.v.) exert a repulsion against each other.

LIKE POLES—Like magnetic poles repel one another. This is one of the laws of magnetism. (See Magnetism, Laws of.)

LIMITING VOLTAGE OF BRUSH DISCHARGE—The potential at which a brush discharge passes into an arc or spark. Brush discharges and arcs may be reduced in radio transmitting apparatus by eliminating sharp points or edges on conductors and by coating the edges of metal plates with paraffin. (See Brush Discharge.)

LIMITING VOLTAGE OF GLOW DISCHARGE—The potential at which the glow gives place to the brush discharge (q.v.) in a high tension line or in a radio transmitting aerial (q.v.). (See Corona.)

LIMITS OF AUDIBILITY—The limiting frequencies (q.v.) at which audible sounds are produced. These range from 500 to 1000 cycles per second up to as high as 10,000 cycles per second. Audio frequencies (q.v.) are sometimes defined as those conveniently heard in the telephone. (See Frequency, High, also Frequency, Low.)

LINE—A conducting wire between terminals in a system of electric communication or distribution. The positive wire is sometimes specifically referred to as the line and the return wire as earth. In many cases the earth or ground is used in the place of a return wire.

LINE OF FORCE—A theoretical conception used to map out a magnetic field and to show the direction along which the magnetism acts. Lines of force are conceived as forming closed loops and the path along which a line of force can pass is called the magnetic circuit (q.v.). The positive direction of the lines of force is arbitrarily taken as that in which the north-seeking end of a compass moves. Lines of force are represented
Linear Oscillator—See Oscillator, Linear.

LINE RADIO—Also known as Wired Wireless—A system of communication devised by Major General George O. Squier which permits the transmission of electromagnetic waves along a wire or conductor. Instead of the waves traveling along a predetermined path, viz: the conductor, it is possible to transmit either code or speech by wired wireless. Vacuum tubes are used as oscillators at the transmitting end and a specially designed tube set is used at the receiver. When code transmission is desired, a telegraph key is inserted in the circuit so that it alternately stops and starts the oscillating waves. This produces dots and dashes and in this way it is possible to send code using undamped radio frequency waves.

When it is desired to telephone, the key is omitted and the radio frequency or carrier waves (q.v.) are produced continuously except when they are varied or modulated in amplitude corresponding to the sound or voice at the transmitting end. The wave which passes from the transmitting end of the wire to the receiving end of the wire and is called the carrier wave. In a wave, this wave is analogous to the wire which carries the voice current in wire telephony. Line radio can be transmitted over ordinary telephone or telegraph lines at the same time as these lines are being used for their ordinary purposes and without any interference whatsoever. High-tension lines are also used for transmission of wired wireless.

LIQUID BARRETER—An electrolytic detector which utilizes a very fine platinum or silver wire, which is covered with a small deposit of zinc in nitric or sulphuric acid. These detectors were formerly used to some extent in receiving wireless code messages. The principle of the barreter type was invented and named by Fessenden (q.v.). The illustration shows a diagram of the glass barreter jar. The barreter jar is a platinum glass-aneode, cathode and sulphuric acid electrolyte.

LITZENDORF—abbreviated Litz—A German term, meaning insulated wire. The high frequency conductor built up of a number of very fine conducting strands. The individual strands are enameled and the conductor is so constructed that each strand comes to the surface or very near the surface at regular intervals. This gives the conductor the property of conductors the strands are braided so as to form a woven tube. The strands are usually covered by a single braided silk wrapper. The use of litz tends to reduce skin effect (q.v.). This type of wire has been found to be especially useful when used in the construction of loop antennas (q.v.).

LOADSTONE—also spelled Lode-stone—From ore which shows magnetic properties. The word loadstone is derived from a word meaning leading stone and refers to the property of a compass of pointing to the north magnetic pole. The loadstone is usually referred to as a natural magnet. (See Magnetite, also Magnet.)

LOADING—Adding capacity or inductance to a transmission line. Inductance coils (q.v.) called loading coils are used to increase the inductance and condensers are used to increase capacitance. A loading coil may be used to increase the wave length (q.v.) of an antenna by placing it in series to the lead-in (q.v.) and the receiving set. In the case of a transmitting antenna, the loading coil may be used to tune the aerial for resonance (q.v.) at a desired frequency. An example of the use of loading is that of the addition of a loading coil to a wave guide is one for the purpose of enabling the set to receive higher wave lengths.

LOADING INDUCTANCE—An inductance coil used to increase the wave length of a radio wave. It is usually referred to an inductance coil used in connection with a radio receiving set for increasing its wave length or frequency range. Sometimes the term loading coil is applied to a unit consisting of an inductance coil, mounted beneath a panel in a small cabinet. On the outside of the panel is a contact arm and a number of studs. These latter lead to taps taken from the inductance coil. By moving the contact arm from one stud to another it is possible to vary the loading in the circuit as desired. A loading coil connected in series with the aerial will increase the natural wave length of the aerial. (See Loading, also Inductance, Antenna.)

LOCAL ACTION—Electrochemical action within a cell, usually at the positive plate, which does not add to the useful output of the cell. Zinc is the material usually employed for the positive plate. This zinc practically always contains impurities such as carbon, iron or lead. If the zinc is immersed in the electrolyte, there is a difference of potential between the zinc and the electrolyte. Small local currents flow from the zinc through the electrolyte to the impurities and back to the zinc again. These currents serve no useful purpose and moreover use up the zinc and the electrolyte.

Local action can be practically eliminated by coating the surface of the zinc with mercury. This is called amalgamation. In secondary cells or accumulators (q.v.) local action is due to the action which takes place between the load of the positive and the coating of lead sulphate.

LOCAL OSCILLATIONS—Oscillations set up in the vicinity of a receiving set for test purposes or within the set, as in the super-heterodyne, to produce oscillations differing in frequency from the incoming oscillations so as to establish a beat frequency. Local oscillations may be produced by means of a buzzer. This is a method frequently used in testing. The use of such oscillations enables a manufacturer to test his work in the laboratory. In test these sets for selectivity, etc., without waiting for actual broadcasting. In the super-heterodyne (q.v.) local oscillations are produced by a suitably arranged vacuum tube. (See Driver.)

LOCUS—The path of a moving point. It is a geometrical figure. In mathematical language, the locus of an equation is the curve that contains all the points whose co-ordinates satisfy the equation. The circle is defined as the locus of all points in a plane equidistant from a fixed point in the plane called the center.

LODGE, SIR OLIVER—British Physicist and radio pioneer, Born at Penk-
TEGRATED ON THE blackboard in the foreground is a diagram known as a "log" showing the variation in the radio business.

The diagram is a graphical representation of data, with the "axis of dollars" referred to as the "ordinate." The horizontal lines are called "abscissas." The graph shows the variation in the radio business over a period of time, with the years on the horizontal axis and the radio business value on the vertical axis.

The diagram is divided into five divisions, each labeled with a different color. Each division represents a different aspect of the radio business, such as sales, profits, and expenses.

The diagram is useful for visualizing the trends in the radio business and identifying periods of growth and decline. It is a common tool used in business and economics to analyze and present data.
Various stations are thus located by points on the chart until enough points are obtained to draw the curve. If the points do not give a smooth curve, it is necessary to approximate a curve, that is to draw it so as to pass through as many of the points as possible. This has been done in Figure 4.

Sometimes points are obtained that do not seem to have any meaning, such as the point A in Figure 4. This point may have been subject to inaccuracies in reading the dial, or perhaps the operator did not read the wave length correctly from the list of stations. There is always the possibility, also, that he did not plot the point properly. He has plotted the point A as 251 meters at a setting of 20 when it might have been 355 meters at 20 on the dial, in which case it would have fallen directly upon the curve. If none of these difficulties can be found with the point A it can be discarded, however, because it is an absurd point, as the 12 other points, which determine the curve, will testify. Generally it is not good practice to discard points, but the experimenter must learn to use his good judgment.

for this is, that although these sets are supposed to tune to stations with identical dial settings, many of them do not do so, a difference as great as 10 divisions on the dial after being found. A three dial log is shown in Figure 5. Separate charts may be used for each dial, or, for convenience, as has been done in Figure 6, the three charts may be combined into one. If the difference between the dial settings is very small, say only a division or two, one curve will be sufficient.

Many things can be learned from studying the curves obtained. Take for instance, Figure 2. This is practically a straight line at the higher wave lengths, changing from about 500 meters to about 400 in 55 divisions of the dial. In the remaining 35 divisions of the dial the wave length changes from 400 to 250. In the first case there was a range of 100 meters for 55 divisions and in the latter case a range of 150 meters in 35 divisions. This is because the curve bends downward. At the low dial settings a small change in the dial reading means a relatively large change in wave length, while at the upper end of the dial the same change in dial reading will mean a relatively small change in wave length. The reason why the stations are so crowded at present, at the small end of the dial, is then very apparent, i.e.,

To illustrate, a station operating on a 200 meter wave corresponds to a frequency of 1500 kilocycles (1 kilo-
cycle equals 1000 cycles), and a station on 500 meters corresponds to a frequency of 1,363.5 kilocycles. In other words the difference in wave length is only 20 meters whereas the difference in kilocycles is 136.5. These two wave bands are at the low end of the present broadcast wave band. Now at the high end of the band we find a wave length of 600 meters corresponds to 500 kilocycles, and a wave of 580 meters corresponds to 517.2 kilocycles, or a difference of but 17.2 kilocycles for the 20 meter difference in wave length. At the lower end of the broadcast band between 200 and 220 meters we found a difference of 20 meters equalled 136.5 kilocycles. This indicates that as the wave length becomes lower the difference in frequency becomes very high.

To bring this most strongly to the mind, go down to the extremely low wave of 5 meters. Here the frequency is found to be 60,000 kilocycles. Going up to 25 meters, this corresponds to 12,000 kilocycles, so that for this difference of 20 meters there is the tremendous difference of 48,000 kilocycles. The accompanying illustration, Figure 6 will explain the matter very clearly.
According to the frequency allocation as made by the Government, which places broadcast frequencies 10 kilocycles apart, on the upper 10 divisions of the dial there is room for approximately 2 frequency channels whereas on the lower 10 divisions of the dial there is room for roughly 14 frequency channels. This shows very clearly that we would have to be able to separate 14 stations on the lower 10 divisions whereas we have only 2 to separate on the upper 10 divisions of the dial.

So it will be understood why turning the dial past the degree or two at the low setting causes a relatively large change in frequency, tuning in perhaps several stations within one degree of the dial, while at the higher settings, due to the small difference in frequency, as stated, on the higher waves, it may be necessary to turn the dials two or three degrees on either side of the peak of the broadcast wave before it is tuned out. (See Dial.)

LOGARITHM—abbreviation LOG—The power to which a number (defined as a base) must be raised in order to equal a given number. As an example, given the number 100, assume that it is desired to determine the logarithm of this number to the base 10. When 10 is used as a base, the logarithms obtained are said to belong to the common or Briggs system. Then the exponent or power which will raise 10 to the value of 100 is known as the logarithm of 100. Obviously, 10 equals 100, therefore 2 is the logarithm of 100. Logarithms are used in the processes of multiplication, division, raising to powers and taking roots. The whole number, or integer part of a logarithm is called its characteristic and the fractional part, is referred to as its mantissa. The characteristic of

a number greater than unity is positive and is one less than the number of figures to the left of the decimal. The characteristic of a number less than unity is negative and is one greater than the number of ciphers between the decimal and the first significant figure. A table of logarithms gives the mantissas only, the characteristic being determined as indicated above.

Logarithms are also used which have as their base the number 2.718+ These are called natural or Napierian logs. The base number is usually represented by the symbol e (epsilon). The natural logarithm of any number may be found from a table of common logarithms by dividing the common log by the logarithm of 2.718 or simply by multiplying the common log by 2.30259. The symbol ln, is often used for the natural logarithm and the abbreviation log without a subscript is usually used for the logarithm to the base 10. (See Napierian Log, also Mantissa, and Log Table.)

LOGARITHMIC CURVE—A curve which has no definite minimum in a decreasing curve, or no definite maximum in an increasing curve. A logarithmic curve may be further defined as a curve whose ordinates increase arithmetically while its abscissas increase geometrically. A series of damped electrical oscillations diminish according to a logarithmic law and hence a curve drawn tangent to the successive maximum displacements will be a logarithmic curve.

LOGARITHMIC DAMPING—See Damping.

LOGARITHMIC DECREMENT—The Napierian logarithm (q.v.) of the ratio of any maximum to the next following maximum, with the current in the same direction in a decaying wave train. In other words the logarithm of the ratio of two maxima, one cycle apart. The rapidity with which the oscillations decay depends not only on the resistance of the circuit, but on the inductance as well. The greater the resistance and the smaller the inductance, the more rapid is the damping and the rate at which the oscillations increase. If the resistance, inductance and capacity of the circuit have fixed values, each successive maximum of current is the same fraction of the preceding maximum as the latter is of the maximum immediately preceding it. Thus, if the second maximum is 75 percent of the first maximum, the third will be 75 percent of the second, etc. The numerical value of the rate of decrease in this case is .75 and the natural logarithm of .75 is the logarithmic decrement or simply the decrement. (See Decrement, also Damped Waves.)

LOG TABLE—A tabulated arrangement of logarithms which gives the mantissas (q.v.) only. The numbers whose logarithms are to be looked up are arranged for convenience in consecutive order. (See Logarithm.)

LOMBARDI, DR. LUIGI—Italian radio authority. Dr. Lombardi was born at Dronero, August 21, 1876. He graduated from the Royal Engineering School at Turin, Italy. He was Professor of Electricity at the Zurich Polytechnical School, Zurich, Switzerland, and also at the Royal Polytechnic School, Naples, Italy. Dr. Lombardi published many scientific papers including a study of condensers for trans mission and he also invented a special high-tension electrical condenser.

LONGITUDE—The distance east or west of a meridian passing through Greenwich, England, measured in degrees, minutes and seconds.

LOOP ANTENNA—A loop aerial—also called Coil Aerial or simply Loop.—A receiving or transmitting aerial (q.v.) consisting essentially of one or more turns of wire connected to the radio set so as to form a closed circuit. The loop acts as a simple inductance coil. The ordinary radio aerial acts as a huge condenser with the aerial system as one plate of the condenser and the ground or counterpoise (q.v.) as the other. Electromagnetic waves reaching the aerial set up an electromagnetic force between the wires forming the upper plate of the condenser and the ground, or lower plate of the condenser. This action takes place through electrostatic induction (q.v.). In the loop apparatus, magnetic induction (q.v.) sets up an induced electromagnetic force thus causing alternating current to flow to the detecting apparatus. While coil antennas may be used for transmitting, their use in this connection is rather limited. On the other hand, the use of the loop for radio receiving is widespread. The greater the area enclosed...
Loops

by a loop the greater the amount of energy it will receive. Loops more than two feet in diameter are usually constructed entirely of galvanized wire. A common type of loop shown in the illustration is 36 inches high and 28 inches wide. It consists of turns of wire wound in the same vertical plane and held in place by pol-

ishing the loops with a rubber strip. It has heavy cast base permitting rotation of the loop as desired. This loop folds up so as to fit into a four inch tube. In another type of loop, sometimes called the box type, the wires are wound so as to lie in the same horizontal plane instead of the vertical plane. The use of Litzsederhaft

(q.v.) for winding loops has been found to add to their efficiency. Loops are common on superhu-
dyne (q.v.) sets, reflex (q.v.) sets and in some tuned radio frequency (q.v.) sets. These latter generally require an extra stage of amplification, although a tuned radio frequency set having only five tubes (detector, two stages of radio frequency and two stages of audio frequency) will operate on a loop and give especially good results when used with the new power tube. As a general rule, it may be stated that any set which will give good re-
sults with a loop, will give better re-
sults, insofar as distance is concerned, with an outside aerial. For this reason loop operating sets are quite generally constructed with extra winding posts for connecting aerial and ground. The loop is connected directly into the grid circuit, while the aerial and ground are connected to the circuit through an inductance such as an oscillograph or antenna coupler. Loops may be used with satisfactory results inside of buildings. Where a compact, portable and selective aerial is desired, the loop is especially useful. The use of the loop, results in a marked directional effect and also has a tendency to re-
duce static (q.v.) and other forms of interfer-
ence (q.v.). Loops are em-
ployed in wireless direction finders or radio compasses (q.v.) and are also used as aerials in submarine and aero-
plane work. Where the loop is used as an aerial in a wireless set it may be wound on the inside of the plane or it may be wound on a small frame and placed in the rear of the plane. (See Coil Antenna also Loop Antenna.)

LOOPS—The points of greatest ampli-
tude in a wave train. Sometimes called antinoises. The term loop is also used in describing the electrostatic field spreading out from a charged aerial. Each time an aerial is charged (for example by induction coil) and dis-
carged across a spark gap a group of gradually decaying oscillations is pro-
duced in the aerial called a train of oscilla-
tions. The interval of time which elapses between a flow of the electricity in the aerial in one direc-
tion, and a succeeding similar move-
ment is called the periodic time and the reciprocal of this is called the fre-
quency. For example, if the periodic time is one-millionth of a second, the frequency is one million. The diagram shows the manner in which semi-loops of electric force represented by the dotted lines move away from the aerial which is represented by the short black line.

Semi-loops of electric force represented by the dotted lines move away from the aerial represented by the short black line.

I. LORENTZ COIL.—A form of low loss in-
ductance coil, having an air core and of cylindrical shape, being wound in a single layer, with turns slightly kinked to make the coil self-supporting. (See Coil, Inductance Coils, also Low Loss Coils.)

II. LOUD SPEAKER—A sound producing device for converting audio frequency currents into sounds loud enough to be heard by a large number of people. Nearly all loud speakers utilize an electromagnet in order to directly or indi-
rectly cause a diaphragm to vibrate. The audio frequency currents flow through the windings of the electromagnet and the vibrations of the di-
aphragm correspond to the minute changes and fluctuations of the cur-
rent thus accurately reproducing sounds. In loud speakers which utilize a metallic diaphragm, the electromagnet directly actuates the diaphragm. In other types, the diaphragm may be of mica, as in the Baldwin unit type, or of parchment or wood as in the cone type speakers. In these speakers, the electromagnet actuates an armature which in turn actuates the diaphragm through a lever action. In certain loud speakers, the electromagnet is very powerful and has a very small coil of fine wire attached to a diaphragm but not touching the poles of the magnet. The small coil is con-
ected to the radio set or amplifier and the fluctuating audio frequency currents pass through it. These cur-
rents force the coil out of the strong magnetic field in the air gap. In mov-
ing, it moves the diaphragm to which it is attached. Speakers of this nature are sometimes called electrodyna-
ic speakers. They are also referred to as power speakers. Such speakers give plenty of volume and in certain makes are reasonably good in tonal quality but have the disadvantage that the electromagnet must be ener-
gized from a source of current such as the storage battery. A loud speaker

has been developed in England called the Crystavox for use with crystal sets. This consists essentially of an electromagnetically operated speaker connected with a microphonic relay. The relay is actuated by a storage bat-
tery and from it feeds the incoming signals from the crystal set, passing them along with increased strength to the electromagnet of the loud speaker. Still another type of speaker which has been used to a limited extent abroad, dispenses entirely with the electromagnet as the actuating source of diaphragm vibration. In this type, electrostatic principles are involved. An air-core cylindrical drum, over which a band of copper or similar metal is wound, is revolved at a uniform rate by a small motor or by clock-
work. To one end of the band a dia-
aphragm is fastened mechanically. The other end of the band is secured by a fairly stiff spring. Current from the receiving set is led to the cylinder by means of a brush contact and as the current fluctuates the attraction of the band to the cylinder fluctuates with it and the drag on the diaphragm due to the rotation is increased and decreased. The use of the motor diaphragm is the most serious disadvantage in this type of loud speaker.

Having discussed the various types

of loud speakers, from the standpoint of principles of operation, the more important of these will now be con-

sidered from the constructional stand-

point. The early forms of directly actuated metallic diaphragm, electromagnetically powered loud speakers consisted es-
sentially of a watch, a microphone receiver, or a pair of receivers attached to a horn. The purpose of the horn was to disperse and distribute the sounds caused by the vibration of the diaphragm. One of the first im-

provements was to modify the shape of the horn to act as a resonant cavity for sound waves. Further, the horn was made of a material more nearly with correct acoustical principles. Another improvement was to introduce an adjustment by means of which the air gap could be varied. In some cases this was accomplished by moving the magnet closer to the diaphragm and by drawing diaphragm closer to the magnet) and of preventing sticking of dia-

phragm or rattling, on local stations. The ordinary metallic diaphragm has one frequency to which it will respond most strongly. This is called its reso-

nant frequency. Special speakers

A high and a low pitched speaker connected in parallel for simultaneous reproduction.

A loud speaker of the horn type having curved cast metal neck and spun brass bell.

A loudspeaker of the horn type having curved cast metal neck and spun brass bell.
called tuned receivers have been designed in England which permit the resonant frequency to be varied in one type, the variations of the magnetic field operate a vibrating reed attached to a non-magnetic diaphragm. The resonant frequency can be varied by adjusting the position of the vibrating reed with a set screw. Another method of getting rid of resonant points in diaphragms has been to use corrugated instead of flat diaphragms. In some of these diaphragms the center is left flat, the remainder of the diaphragm being corrugated with concentric circles either evenly spaced or spaced in section at radii bearing a ratio to each other corresponding to prime numbers. In some cases corrugated diaphragms with corrugated edges are used. The material as well as the shape of the horn have been found to materially affect the sound reproduction. Horns are constructed of metal, fibre, composition, hard rubber, wood, etc. In general the horn should be of a material which will not give out metallic sounds. The tone arm which carries the speaker unit at one end and the speaker at the other is usually constructed of cast metal such as a lead alloy or aluminum. The requirement here is that it must be of anacoustically "dead" material. In some cases the speaker unit and sound chamber are coned in an aurally pleasing manner. A specially designed cabinet thus forms a cabinet speaker. Loudspeaker units are also made especially for use in conjunction with the sound chamber of a phonograph. These are referred to as phonograph attachments. They are ordinarily attached to the phonograph tone arm being put in place of the phonograph reproducer. Some phonographs are now made with provision for attachment of the speaker unit without removal of the reproducer. There is also an attachment on the market for use in conjunction with a phonograph which has provision for conveniently changing over from the reproducer to the speaker unit or vice versa. Cone speakers may be of the single cone variety or of the double cone style. In these speakers a metal rod extends from the armature and is rigidly fastened to the center of the cone. The most common type of cone speaker has a parchment diaphragm. This seems to give excellent reproduction especially for tones in the lower register. Its points of disadvantage are that it is affected by moisture and temperature change and furthermore seems to bring out static interference more clearly than some other types. Another type of cone speaker uses a teak wood diaphragm. Some of these speakers have a small fastening screw at the point of attachment between the cone and the diaphragm. This is provided so that tension can be removed from the diaphragm during shipment and also if the speaker is to remain in a room where change in temperature may take place. A cylindrical parchment speaker which utilizes the same principle as the cone speaker, has recently been placed on the market. Its chief point of difference is that the parchment is not under tension as in the case of the cone speaker. Large volume loud speakers are provided with power amplifiers which are often an integral part of the speaker itself. One of the most recent loud speakers is contained in a large cabinet and contains apparatus for utilizing ordinary lighting circuits for operating the set and speakers. The power amplifier unit is also contained within the speaker cabinet and the design of the speaker is such that it can handle any volume without distortion. The rectifier is arranged to supply not only the necessary voltages for the power amplifier but also plate voltage for practically any type of receiving set. (See Horn, Loudspeaker, also Distortion.)

LOUDSPEAKER UNIT—The sound reproducing unit attached to the tone arm of the horn type speaker or to the diaphragm of the cone type speaker. Various types of units are described under the heading Loudspeakers.

LOW FREQUENCY—See Low Frequency Current.

LOW FREQUENCY CURRENT—An alternating current of less than 10,000 cycles. In radio work the alternating currents used are often classified as low frequency currents and high frequency currents. While there is no fixed value separating high and low frequencies, 10,000 cycles is generally taken as the dividing line. Thus audio frequency currents are considered as low frequencies and radio frequency currents are high frequencies. The term low frequency current as applied to power and lighting circuits refers to circuits having frequencies of 25, 60, etc., cycles per second. (See Current, High Frequency.)

LOW FREQUENCY IRON CORE INDUCTANCE—A variable inductance having an open-ended iron wire core. This inductance is used with spark transmitters to transformer circuit in resonance with the alternating current frequency.

LOW LOSS COILS—Inductance coils (q.v.) having low resistance and specially wound so as to reduce to a minimum condenser effect and hence dielectric losses. The term low loss has been used rather loosely but for practical purposes coil losses should be taken as referring to self-capacity, often called distributed capacity (q.v.) ohmic resistance, skin effect (q.v.) in the wire due to the effects of frequency and leakage and absorption in or through the insulating materials upon which the coil is built or with which the wire is coated. It is impossible to obtain a coil having pure inductance only, it is feasible to design the coil so that the various losses will be reduced to a minimum. Often, it has been found that a design which will greatly reduce one type of loss will result in an increase of another. The illustrations show various types of low loss coils together with curves showing comparison of winding loss tests. Figure 1 shows the results of an investigation regarding the distributed
capacity of various coils. This was obtained by making measurements of
the inductance of the coils. If the self-capacity of the coil is very small,
amounts to anything, the curve showing the relation between inductance
and frequency will bend upward as the frequency increases, and the
give any idea of what value the self-capacity may have, but simply show
whether the inductance varies or not, which is one method of determining
how harmful is the effect of the distributed capacity. The more sharply
the curve bends upward the less desirable is the coil. In general, the
smaller the size of the wire (for sizes smaller than about No. 16 B & S) the
higher the resistance. The larger the wire and the thinner the insulation,
the greater is the skin effect. The greatest inductance is obtained for a
given amount of wire when the coil has a true cylindrical shape. The
skin-effect in multi-layer coils is much greater than in single-layer coils.
The effect of coil capacity on insulation or leakage in insulation is small
compared with the skin-effect except in multi-layer coils, where the dis-
tributed capacity may become very great. To keep the physical size of
toroidal coils within practical limits the diameter of the turns must be rel-
atively small, so that many more turns are required to obtain a given inductance.

LOW TENSION—abbreviation L.T._
A comparatively low voltage. A cir-
cuit supplied by a low voltage battery
such as the filament circuit of a vac-
uum tube is called a low tension cir-
cuit. In electrical engineering work,
any circuit of 600 volts or under is
considered to be a low tension circuit.

LUGS—Metal projections used for per-
manently connecting conductors with electrical apparatus. In one type of
lug, the metal is bent over at one end to form a tube into which the conduc-
tor can be soldered, while the other
end is flat and has a hole drilled to receive any desired terminal.

MAGNET—A piece of iron or steel hav-
ing the power to attract other pieces
of iron and to attract or repel other
magnets. Natural magnets are known
as Loadstones (q.v.). (See Electro-
magnet, also Permanent Magnet and
Temporary Magnets.)

MAGNET WIRE—Insulated wire for
the construction of magnet coils. In
radio extremely fine wire is used to
wind the coils of the electromagnets
used in headsets and loud speaker
units. The most common insulation
used in radio work for magnet wire
is enamel. Other types of magnet
wire utilize a single cotton covering,
a double cotton covering or a silk cov-
ering. (See Enamelled Wire.)

MAGNETIC ATTRACTION AND RE-
PULSION—The mechanical force
tending to draw together two magnetic
poles of unlike polarity, or to force
apart two magnetic poles of like po-
larity.

MAGNETIC BLOWOUT—An electromag-
net with its pole pieces placed so
that the direction of the magnetic
field will be at right angles to the
movement of the ions in an electric
arc. The coil of this magnet is ener-
gized in some cases in series with the

line and acts to expel or blow out the
arc. In the series arrangement, the

MAGNETIC BLOWOUT—An electromag-
net with its pole pieces placed so
that the direction of the magnetic
field will be at right angles to the
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arc. The coil of this magnet is ener-
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MAGNETIC BLOWOUT—An electromag-
net with its pole pieces placed so
that the direction of the magnetic
field will be at right angles to the
movement of the ions in an electric
arc. The coil of this magnet is ener-
gized in some cases in series with the

MAGNETIC COUPLING—See Coupl-
ing.

MAGNETIC COUPLING TRANS-
FORMERS—See Coupling Trans-
former, also Jigger.

MAGNETIC FIELD—The whole space
over which a magnet exerts a force.
The space traversed by the magnetic
flux. Wherever magnetism is present
the space in the immediate vicinity is
MAGNETIC FLOW—The passage of magnetic lines through a magnetic circuit. This term is sometimes used in the place of magnetic flux. (See Flux Magnetism.)

MAGNETIC FLUX—Symbol φ—The total magnetism present at any cross-section perpendicular to the lines of force. Magnetic flux is analogous to current flow. That is to say, it is convenient to consider a flow of magnetism in the same way as electricity is considered to flow. The unit of magnetic flux in the c.g.s. (centimeter gram second system) electromagnetic system is the maxwell (q.v.) or simply the line. The unit of magnetic flux in the practical system is also the maxwell. (See Line of Force, Alternator, also Flux, Magnetism.)

MAGNETIC FLUX DENSITY—The number of lines of force per unit cross-sectional area of a magnetic path. The gauss (q.v.) is the unit of magnetic flux density. It is equal to one line (q.v.) per square centimeter.

MAGNETIC FORCE—The force with which a magnet attracts or repels any piece of iron or steel. The intensity of a magnetic field at any point as measured by the force which it would exert upon a unit magnetic pole if placed at that point.

MAGNETIC FORCE DUE TO CURRENT—The magnetic force due to current flow which can be determined mathematically for any point in the surrounding medium. Consider any closed stream line of electric current surrounded by a medium having uniform magnetic properties. It can be demonstrated that each elementary length of the current stream line, dl, contributes to the magnetizing force, H, at any point T, an amount dH = \((\sin \theta) dl\) per r.

\[ H = (\sin \theta) \frac{dl}{r} \]

where I is the current flowing along this stream line, r is the distance from T to dl, and \(\theta\) (theta) is the angle between r and dl. The direction of dH is perpendicular to the plane of r and dl. The total magnetic force at T is the vector sum of dH for all the elementary lengths into which the current line is divided.

MAGNETIC Hysteresis—The opposition which minute particles of a magnetic material offer to being magnetized or to having their magnetization changed. It is sometimes referred to as molecular friction or as magnetic lag. (See Hysteresis.)

MAGNETIC INDUCTION—See Induction, also Diamagnetic Material.

MAGNETIC INDUCTIVE CAPACITY—Symbol u (mu)—Also termed Magnetic Inductivity. Names sometimes used instead of Flux Density (q.v.). The ratio between the number of lines of force per unit area passing through a magnetic substance and the magneticizing force which produces them. Stated another way, it is the ratio of flux density to magnetic force. It can be considered as a measure of the ease with which magnetism passes through any substance. The magnetic inductive capacity of air is taken as unity. The term magnetic inductive capacity is analogous to specific inductive capacity (q.v.) which is the ratio of the dielectric constant of a material to that of a vacuum.

MAGNETIC INTERRUPTER—A device energized by an electromagnetic key for interrupting a circuit. (See Interrupter.)

MAGNETIC KEY—An electromagnetic adjacent to and transmitting key for reducing or eliminating sparking due to the self-induction of the heavy currents which are interrupted. A form of magnetic key is shown in the illustration. The key is composed of a system of field magnets and is usually attached to the lever armature. The key is placed over a spring armature C and a platinum contact A. If the key is released so as to move upward, the contact A still remains touching A as the magnetic action due to the current continues to hold down the armature C and hence with the spring with the contact A. Not until the alternating current reaches a zero value is the armature released. This releases A, from A as an instant of zero current and hence there is no spark.

MAGNETIC LEAKAGE Flux—Magnetic flux which serves no useful purpose. There are no substances which will prevent the passage of magnetic flux. This fact introduces a certain amount of difficulty into practical magnetic circuit calculations, since it is impossible to confine magnetic flux to a predetermined magnetic path. Since there is no magnetic insulator there will always be a certain amount of leakage flux. However this can be reduced to a minimum by proper design of the magnetic circuit. Magnetic Leakage is also referred to as Stray Flux.

MAGNETIC LINES OF FORCE—See Line of Force, also Electromagnet.

MAGNETIC MOMENT—The product of the strength of pole of a magnet and its virtual length. The torque exerted by a magnetic field upon a magnet depends upon the magnetic moment.

MAGNETIC NEEDLE—A light, thin steel magnet mounted on a pivot or suspended so as to be free to move. It takes a position pointing to the magnetic north.

MAGNETIC POLES—Points on a magnet where the lines of force leaving or entering the iron are called the magnetic poles, like a magnetic needle, that end which tends to point north is called a north or positive pole, that one which tends to point south is called a south or negative pole. A unit magnetic pole is defined as one which, when placed at a distance of one centimeter from a like pole of equal strength, will repel it with the force of one dyne. The north magnetic pole of the earth is situated at latitude 70 North and longitude 97 West. The south pole is located at latitude 70 South and longitude 102 East. It is noted that the magnetic poles do not coincide with the geographical poles. (See Induction, Magnetic.)

MAGNETIC PROPERTIES—Materials are classified according to whether or not they offer a good path for the magnetic lines of force. Substances of comparatively low reluctance (q.v.) are termed magnetic. They are also onl referred to as ferromagnetic. They include iron, steel, nickel, cobalt, manganese, chromium, magnetite, certain alloys of copper and aluminum (called Heusler Alloys), and certain other oxides. These magnetic laws governing these substances cannot be set forth by means of magnetization curves. Substances having high reluctance are termed non-magnetic. For commuting purposes, air is the most important non-magnetic substance. However, practically all substances, with the exception of the ferro-magnetic ones, follow the same magnetic laws as air. While the reluctance of a non-magnetic substance is constant, the reluctance of magnetic substances varies, as the amount of flux (q.v.) in the substance changes. Although air and a vacuum have no reluctance, certain with the exception of the ferro-magnetic ones are classified as non-magnetic substances and are non-ductile. The reluctance of magnetic flux, when compared to iron, etc., nevertheless they are by no means magnetic insulators. There are no substances which will absolutely prevent the passage of magnetic flux. (See Ferro-Magnetic Substances.)

MAGNETIC PYRITES—See Pyrites. (See Ferro-Magnetic Substances.)

MAGNETIC STORM—Sudden and irregular variations of the earth's magnetic field. Magnetic storms are sometimes coincident with the appearance of sun spots. These storms often disrupt telegraph service and also cause much interference with radio communication.

MAGNETISM—A phenomena exhibited by certain materials which is characterized by the attraction or repulsion of soft iron or of conductors carrying electricity. Magnetism is one of the manifestations of electricity, since a current of electric flow is also linked with a magnetic field (q.v.). (See Free Magnetism, Magnet, also Magnetic Properties.)

MAGNETISM, LAWS OF—Like magnetic poles repel one another; unlike magnetic poles attract one another. The force exerted by two magnetic poles is proportional to the product of their strengths and is inversely proportional to the square of the distance between them. (See Like Poles.)
Magnetite

MAGNETITE—symbol Fe₃O₄. A mineral composed mainly of magnetic oxide and found in magnetized condition it is known as a lodestone (q.v.) or a natural magnet. It is a black brittle substance having a specific gravity of 5.1.

MAGNETIZATION—(also spelled Magnetisation)—The process of generating magnetism. The act of rendering an object magnetic. According to Ewing's theory, a substance which is magnetized has its molecules rearranged so that they assume a magnetic dipole. Each molecule lying in line with or parallel with its neighbor. In this rearranged position each molecule adds its separate magnetic force to every other one and the cumulative effect of this is that the substance possesses the properties of a magnet. (See Demagnetization.)

MAGNETO GENERATOR—A small generator consisting essentially of an armature rotating between permanent magnets. Usually of the horse-shoe type. Magnets are mainly used for motor generation, medical coils, bell ringing, etc. for high explosives. (See Intermittent Current.)

MAGNETOMOTIVE FORCE OR DIFFERENCE OF MAGNETIC POTENTIAL—The abbreviation m.m.f. The one causing magnetic flow. Magnetomotive force is the magnetic cause, while flux (q.v.) is the magnetic effect, just as an electric current, electromotive force (q.v.) is the cause and current is the effect. The c.g.s. (centimeter gram second) unit of magnetomotive force is the gilbert (q.v.). The unit ordinarily employed in practical calculation is the ampere-turn (q.v.). (One ampere-turn is equal to 1.2566 gilberts.) An ampere-turn consists of a current of one ampere flowing through one complete turn of a conductor. The expression "turn" means that the conductor is wound in a solenoid. That is to say, it is wrapped around a core which may consist of air or of any other substance. Magnetic field is therefore the result from ten ampere-turns consisting of ten ampere-turns flowing through one turn of the core, or one ampere-turn consisting of one ampere flowing through ten turns. (See Force, Magnetomotive.)

MAGNIFIER, OR RELAY—An apparatus for intensifying the variations of a current. The term magnifier has been incorrectly used for amplifier (q.v.). Owing to second unit of this characteristic and the decimal 25578 is the mantissa. (See Logarithm.)

MARBLE—The name given to any limestone sufficiently compact to permit being polished. Pure marble is white, the abundance of iron giving the different colors. Marble is used extensively for switchboard work and when so used must be free from metallic veins. Where currents carrying 1000 volts or more earth wires were used, the switchboard should be saturated with an insulating varnish and baked. Inasmuch as the marble shows oil spots, it is sometimes stained and given a finish called a marine finish.

MARCHANT, EDWARD WALTER. British radio expert. Born in 1876, he was appointed superintendent of the laboratory and workshops of Lord Blythswood at Renfrew, where he carried out many experiments in wireless telegraphy. He became chief assistant at Finsbury Technical College, 1900, under Professor Silvanus P. Thompson and the following year was appointed lecturer in electro-technic at University College, Liverpool. In 1902 he was appointed the first professor of electrical engineering at the university.

Marchant was for some time closely associated with W. Duddell in developing the oscillograph, and the two read a joint paper on the study of the electric and magnetic properties of the Institution of Electrical Engineers, of which institution Marchant became vice-president and his assistant, Sir George Thomson, has written many papers on radio, which contributed an article to the proceedings of the Royal Society on the magnetic behaviour of iron under oscillographic discharge of a condenser.

MARCONI FILINGS COHERER—Also called Marconi Coherer—A detector of electric waves consisting of fine nickel and silver filings contained in a suitable glass tube between two electrodes consisting of two silver plugs. These two plugs and connected by platinum wires brought out through the sealed ends of the tube, which is carefully exhausted of its air. The metallic filings in a loose condition have feeble conductivity for the current from a single field, but when an electric oscillation is passed through the coherer, the filings cling together or cohere on contact and so conduct electricity better and they will then pass sufficient current from a single dry cell to operate a telegraphic relay. To bring these filings back to a non-conductive condition, the tube is tapped by an electromagnetic tapper, similar to an electric bell with the gong removed. The Marconi coherer is now obsolete. (See Coherer.)

MARCONI, GUGLIELMO. Italian-Irish radio pioneer. Guglielmo Marconi was born at Bologna, Italy, April 25, 1874, and was educated at the Lephorn Technical College. He was appointed Professor of Radio. From his earliest years he was keenly interested in communication by means of Hertzian waves, and began his brilliantly successful series of experiments in June, 1895. These first experiments were carried out on his father's estate near Bologna. Marconi soon found that the Hertzian form of resonator gave only feeble signals at a distance, and he substituted a vertical wire, with the result that in 1896 he was able to transmit signals a distance of one and a half miles. About the same time he improved the Branly coherer, which he used as a detector, and invented an electric tapping device to decohere the filings.

This early apparatus of Marconi, from which has sprung the far-flung wireless chain of to-day, consisted of a coherer, a relay, a decoherer, and a Morse printing instrument, all working from storage batteries. Between the coherer and the relay Marconi inserted a choke coil, and this had a very marked effect on the receptivity of his set. By close attention to the details of his system he was able to carry on his signals at greater ranges than had up to this time been accomplished by other experimenters.

The transmitting apparatus used by Marconi in these early efforts consisted of a large spark gap to which the sender and earth were connected. The high-tension current for this gap was provided through an induction coil from batteries. The spark gap consisted of a ball discharge of four brass balls. The two middle balls were separated by a small space filled with varnish and the actual spark, jumping from the two end balls to the middle ones and through the varnish, producing a high-frequency spark.

Marconi came to America in 1896, where he took out the first patent ever granted for a practical system of wireless telegraphy. He made a number of experiments at Westbourne Park, and demonstrated his system before Sir William Thomson and other officials at the Post Office. In the following year he increased the range of his apparatus to nine miles and other experimenters tried the spark coil and kite to raise the vertical aerials. In July, 1897, in demonstrating before the Italian Government, he covered 12 miles between warships, and he began to install a number of his sets for lighthouses, and the success of his experiments led to stations being erected for the corporation of Trinity House.

In 1899, the first proof of the advantages of wireless over other forms of communications came with the saving of the lives on board the ship Eros, off the coast of Bermuda, in 1899.
Goodwin lightship. The latter was equipped with one of Marconi’s trans-
mitters and was used to communicate with the South Foreland light-
house and summon assistance.
Marconi lies not so much in his inventions, as in his far-
sightedness in being the first man to realize the immense commercial pos-
tibilities of radio, and to make the best use of all the scientific effort of his
time to further the object he had in view.
Marconi has received innumerable honors from all countries. He holds
the honorary degrees of universitv all over the world, and the freedom of a
large number of cities. In 1900 with
Professor Braun, he was awarded the
Nobel Prize, and in 1914 he was given the Honorary Knighthood
of the Grand Cross of the Victorian
Order. He has been awarded the
Albert Medal of the Royal Society
of Arts, the Gold Medal of the Institute
of Radio Engineers of New York, the
John Henry Pepper Gold Medal for the inven-
tion of wireless telegraphy, and the
Franklin Gold Medal of the Franklin
Institute of Philadelphia. He was
appointed a delegate to the Peace Conference, and signed on behalf of Italy. He is chairman of
the board of directors of the Mar-
coni Company.

MARINE TYPE CHARGING PANEL — A switchboard equipped with resist-
antive and inductive pilot lights,
voltmeter and necessary switches.
Manipulation of the switches allows the
battery to be placed on chargers or
on the line. By throwing a switch on
this board, it is also possible to work
the wireless transmitter either from
the switchboard or from the stor-
age battery.

MASS — The quantity of matter which a
body contains. Physical quantities
such as force, velocity, etc., are
expressed in terms of mass, and
time. The unit of length is the cen-
timeter; of mass, the gram; and of time,
the second. Hence this system of
measurement is known as the C.G.S.
(centimeter-gram-second) system.
The gram is equal to 15.422 grains and
represents the mass or quantity of a
cubic centimeter of water at 4 degrees
centigrade.

MASTER-OSCILLATOR SYSTEM — A
radio telephone transmitting circuit in
which a small extra excitation is used
to supply the power to excite the
circuit. This extra oscillator or
exciter is referred to as the master-
oscillator. The master-oscillator sys-
tem has several advantages over the
self-excited system. Changes in an-
tenna constants, such as might be
caused by a swaying aerial or
lead-in (q.v.) do not affect the trans-
mission where the former system is used.
In addition the master-oscillator system
is more convenient to work with and
the adjustment for maximum output
for different wave lengths and
antenna resistances is more easily made.

MASTER-OSCILLATOR SYSTEM AMPLIFIER — In the master-oscillator
system, the tube acts as an amplifier of the power supplied by the
small extra excitation. For a con-
tinuous excitation the amount of
power is insufficient to supply the losses in
its own oscillating circuit and those of
the grid circuit of the power tube.

MASTS, ERECTION — The
erected masts are generally used in
tubular steel masts. In some cases tubular
metal masts in telescoping sections

fits, these are made in sections which
 can be fitted together like a fishing
rod. Guy ropes or wires are necessary in
practically every instance. In erect-
ing a mast, it is usual not to
make the installation too rigid, but rather
to allow some freedom of movement so
that the mast may sway slightly in
the wind. Where a one-wire aerial is
being erected this is fixed and fastened to
any support available. In marine con-
struction, the ship’s masts are used to
support the flagstaff, and is usually
stretched between the two booms or
spreaders from which halyards run to
the masts. (See Aerial.)

MATCHED IMPEDANCES — Circuits
balanced or matched so that the total
impedance of one circuit will equal the
impedance of another circuit with
which it is coupled. (See Impedances,
Matched.)

MAXWELL — symbol \( \mu \) — The unit of
magnetic flux (q.v.). It is also known
as the line (q.v.). One maxwell is
equal to one line of force. (See Flux
Density, also Kiloline.)

MAXWELL’S CORKSCREW RULE — If
the direction of travel of a right-
handed corkscrew represents the di-
rection of current in a straight conduc-
tor, the direction of rotation of the
corkscrew will represent the direction
of the magnetic lines of force.

MAXWELL’S LAWS — The magnetic
fields surrounding parallel currents in
the same direction will react upon each
other in such a way that the conduc-
tors will tend to move together. In the
case of parallel currents in opposite
directions, the fields between the two
conductors will be in the same direc-
tion and will merge together, thus tend-
ing to push the conductors apart.
The magnetic fields around two conductors
at an angle will react upon each other in
such a way as to tend to bring the
conductors parallel to each other.

MAXWELL’S LAW OF MOTOR AC-
TION — A conductor carrying a cur-
rent whose direction of flow is at right
angles to a magnetic field, will tend
to move out of this field.

MAXWELL’S RULE — Every portion of
a circuit is acted upon by a force urg-
ing it in such a direction that it encloses
the greatest possible num-
er of lines of force.

MAXWELL TURNS — The deflection
value in a ballistic galvanometer or
fleming’s coil. This depends upon
the number of turns in the exploring
coil and the instantaneous value of the
flux in the coil linked with this coil.
(See Grassot Fluxmeter.)

MACLACHLAN, NORMAN W. — British
radio authority. Born at Longtown,
Cumberland in 1898, and educated at
Carlisle Grammar School and the
George Watson and the Heriot Watt
College, Edinburgh, and Liverpool
University. He was appointed lec-
turer in Engineering and Mathematics
at Newcastle University. In 1913
MacLachlan was appointed super-
visor of classes in engineering subjects
in the Liverpool Technical Institutes,
and after the Great War, during
which he was engaged in aeronautical
research and the study of anti-sub-
marine devices, he made a special
study of magnetos at the National
Physical Laboratory, Teddington. Ap-
pointed research engineer to the Mar-
coni Company, he is the author of
many papers on wireless and electrical
subjects in the journal of the Institu-
tion of Electrician Engineers, and in
other scientific journals, including those
on Characteristic Curves of a Poulsen
Amp, the Magnetic Behavior of Steel at
very High Frequencies; and Theory of
Iron-cored High Frequency Trans-
formers. He has taken out a number of
radio patents.

MEASUREMENT OF INDUCTANCE —
Some methods of measuring inductance
(also applicable to the measurement of
capacity) are various bridge meth-
ods; by measuring the voltage, cur-
rent, power, and frequency; and by
the wave meter method. Connections
in one bridge method for measuring
inductance are similar to those of
the ordinary Wheatstone Bridge (q.v.).
A coil having a known inductance is
balanced against the inductance to be
measured. A device called the Secoh-
meter is in use to increase the sensi-
tivity of bridge measurement of induct-
ance. The Secohmeter serves the pur-
pose of making an alternating cur-
rent to use in measurements of self-
induction and of commuting such
portion of this current as flows in the
galvanometer circuit to a direct cur-
rent. When a source of alternating
current of known frequency is avail-
able the following method is con-
venient. Place the inductance across
the alternating current mains, meas-
ure the power absorbed, the current
flowing, the voltage across the un-
known inductance and the frequency
of the circuit. Then the inductance
is equal to the reactance, \( x \), divided by

Illustration of Maxwell’s corkscrew rule. When current flows from C to D, magnetic
lines reorient the wire in the direction of the
curved arrow MN.
Measurement of Wave Length

$$L = \frac{x}{2\pi} \sqrt{\frac{E}{1 - (Power)^{1/2}}}$$

The inductance L should be expressed in henries. This method gives results directly in wave lengths but is not adapted to measurements of low values of inductance. Small inductances are more usually measured by bridge methods. In the wave meter method, a condenser is discharged through a specific circuit containing a known capacity and by means of a wave meter measuring the wave length. The expression for the number of oscillations of the circuit containing both inductance and capacity is given by the formula

$$n = \frac{L}{2\pi \sqrt{CL}}$$

and the wave length is equal to the velocity of propagation divided by the number of waves and called λ the wave length we have

$$\lambda = V \times 2\pi \sqrt{CL}$$

In this last equation, everything is known but the inductance which can be calculated. (See Inductance, Measurement.)

MEASUREMENT OF WAVE LENGTH

The usual method of measuring an unknown wave length is by means of a wave meter. The apparatus required in this connection is a hot wire ammeter indicator in a coupled circuit, or crystal detector and telephonic system excited by an alternating circuit supplied by electron tube. A wave meter placed in inductive coil or antenna carrying radio current will show decided increase of current in its own coil and condenser when it is tuned to resonance with the source. The wave length is read directly from the wave meter setting for resonance or from a calibration curve. A receiving set can be used to measure the wave lengths of received waves if it is first standardized in terms of wave lengths. The operator listens in through the head set attached to the receiving set. At the wave meter condenser knob is turned the loudest sound is heard when the wave meter circuit is of the same wave length as that for which the receiving set is adjusted. The wave length is then read from the wave meter scale or calibration curve. Continuing in this manner, the receiving circuit can be calibrated as a wave meter by setting it at many different adjustments and reading the wave lengths at resonance each time. The wave length of a wave is determined by an antenna when no added inductance or capacity is inserted in the antenna circuit, is known as its fundamental wave length. For a single vertical grounded antenna the fundamental wave length is slightly greater than four times the length of the wire. The approximate constant often used is 4.2 and this applies also to "L" or "T" type of antenna. In this case the lead in wire, the total length being measured from the transmitting apparatus up the lead-in wire to the end of the flat top. It is of course, more accurate to measure the wave length radiated from an antenna directly by use of a wave meter. The wave length coil needs merely to be brought near the antenna or lead-in wire and the condenser of the wave meter adjusted to give maximum current in the wave meter indicator. The wave length corresponding to the wave meter setting is equal to the length of the waves radiated by the antenna. The fundamental wave length of the antenna may be determined by gradually decreasing the number of turns in the loading inductance (q.v.), measuring the wave length for each setting of the leading coil. The fundamental, then, is the wave length corresponding to zero turns and is found at the point where the extension of the curve cuts the wave meter axis. (See Measurement of Inductance, also Formula.)

MECHANICAL MIXTURE—A mixture of two or more elements which leaves them essentially unchanged. This is sometimes incorrectly called a mechanical compound. Sugar and sand mixed together give an example of a mechanical mixture. A chemical compound is formed when two or more substances are chemically combined to form another substance having different characteristics. Thus iron fillings and sulphur can be combined to form a third substance unlike either of the original two.

MEG OR MEGA—symbol M—The prefix in the metric system used to denote one million times (10^6) that unit, as for example megohm (q.v.) mega-volt, meger, etc.

MEGGER—Instruments used for measuring insulation resistance or in general any resistance by the direct deflection of a pointer on a scale. The Ewing shunt type is made in two forms (1) the megger insulation testing set and (2) the bridge-megger testing set in which the megger is coupled with (1) those of a Wheatstone Bridge (q.v.). Both types consist of an ohmmeter in the mov magnet type combined in one box with a hand driven generator for providing the necessary testing voltage and current. When the handle of the generator is not being turned, the pointer is entirely free and will rest anywhere on the scale. See Megger. The general underlyin the construction and operation of the megger are shown in the illustra Megger. The megger is a combination of a magnet ten generator (q.v.) shown at the right, with an ohmmeter and a megger meter to the left, in a magnetic circuit common to both and consisting of two pairs of field poles braced by strong bar magnets, NS, NS respectively. Two field magnets in series. In the right hand one, and rotated by a folding handle and spur gearing D, is the armature of the generator, with its brush gear B, and terminal bars marked + and -. In the left hand field is the current coil A, pressure coil P, and compensating coils C and L and also the compensating pointer which is connected to resistances Q and R, a guard plate G, and the only two external terminals L and E. In the diagram the meter is connected to the Wheatstone Bridge. It differs from the ordinary megger in outward appearance merely by the addition of two pairs of terminals and of two switches, one of which is the ratio switch of the Wheatstone Bridge and the other is a two-way change-over switch. This latter when set to "Megger" prepares the instrument for measuring insulation resistance as it is a mechanical compound consisting of two windings of the constant voltage generator in series through which the current flows to the terminals, marked Line and Earth, the only two available for connection. When the change-over switch is set to "Bridge" the instrument is ready for Wheatstone Bridge work, the two windings of the ohmmeter coil being connected in parallel in order to increase the current obtainable from it. In this case the ohmmeter part is changed into a measuring instrument and the bridge and the arms of the bridge are switched into their appropriate places in the circuit and connected to the terminals marked L and E at the end.

MEGOM—One million ohms. This unit is usually employed in the measurement of insulation resistance of electrical conductors. It is also used in measuring grid leaks (q.v.), etc. See Ohm, also Begohm.

MEGOMITE, also spelled Megohmite—A mixture of micanite, obtainable in several forms, one of which is known as hard megohmite and is used in the insulation of mica built up of shellac. Flexible megohmite consists of sheets of mica itself, insulation paper, with some more mica covered with linen, is called microfina.

MEISNTER, ALEXANDER.—Austrian radio expert. Born at Vienna, 1868, he was educated at the Technical High School and University of Vienna. He joined the Telefunken Company in Berlin, 1901, and is one of the leading authorities in wireless radio. To him is due a large number of wireless inventions, including the Telefunken resonator and magnetic spark, interference preventers, the direct current cathode valve relay for the reception of the Morse Code, etc. In 1913 he invented the generation of oscillations by means of the three-electrode valve circuit. He holds many patents, including spark gap for wireless excitation, quenched-spark signalling in conjunction with G. Von Arco, etc., and is the inventor of the method for scientific journals and societies on the subject.

MEGNETIC ARC RECTIFIER (MERCURY VAPOR CONVERSION)—A device for changing alternating current to direct current, which depends for its action upon the electrical conductivity of the mercury arc in an exhausted vessel. An idea of the principle of operation of the mercury arc rectifier may be obtained from the illustration. Assume an instant when the current begins to flow from A and B being the mercury cathode. Following the direction of
the arrows still farther, the current passes through the lead J, through the revolving toothed wheel A to the positive terminal G on the transformer. A little later when the impressed electromotive force falls below a value sufficient to maintain the arc against the counter electromotive force of the arc and the lead, the reactance E which heretofore had been charging, now discharges, the discharge current being in the same direction as formerly. This serves to maintain the arc in the rectifier until the electromotive force of the supply has passed through zero, reverses and builds up to such a value as to cause A to have a sufficiently positive value to start an arc between it and the mercury cathode B. The discharge circuit of the reactance coil E is now through the arc A'B, instead of through its former circuit. Consequently the arc A'B is now supplied with current, partly from the transformer and partly from the reactance coil E. The new circuit from the transformer is indicated by the arrows enclosed in circles. The amount of reactance inserted in the circuit reduces the pulsations of the direct current sufficiently for all ordinary commercial purposes. The mercury rectifier is used in small sizes for charging storage batteries from alternating current circuits and in the larger sizes for operating direct current arc lamps from alternating circuits and also in electric traction work in the place of rotary converters in the substations or even on the train itself.

**MERCURY INTERRUPTER (MERCURY JET INTERRUPTER)—**A contact breaker in which contact is made between moving metallic contacts and a jet of mercury provided by a small centrifugal pump driven by the same motor as the contacts. When the winding of an induction coil is supplied with a continuous current it is necessary to interrupt the current at a point that a secondary voltage shall be induced in the secondary winding. The mercury interrupter offers a satisfactory method of accomplishing this. In one type of mercury interrupter a stream of mercury is forced from a jet against a metal plate, and the strength of the stream of mercury is interrupted by a toothed wheel of insulating material so that the electrical circuit is periodicaly made and broken between the mercury and the metal plate. In some forms of mercury interrupters, the jet itself revolves, the mercury impinging against a fixed metal plate. The mercury interrupter is used in operating X-ray bulbs from an induction coil where the source is direct current. A form of mercury interrupter is shown in the illustration. A is a tooth-shaped wheel made of insulating material. This wheel is driven by a small motor and the number of revolutions can be varied within wide limits. A small centrifugal pump forces the mercury upon the jet; the revolving wheel A interrupts the contact of the mercury with the plate C. The wheel A can be raised or lowered, thereby enabling the duration of contact of the mercury with the plate to be varied without altering the number of interruptions in a given time.

**Mesh Grouping**—A method of connecting coils in a polyphase circuit whereby they form a closed circuit and have the wires attached to the points of junction between the coils. The term mesh is used interchangeably with delta. (See Delta Connection.)

**Meter**—An instrument used to make measurements. (See ammeter or ammeter, double range meters, integrating wattmeter, voltmeter, wattmeter, watthour.)

**Meter (Measure)—**A unit of length in the metric system (q.v.). One meter is equal to 100 centimeters or 39.37 inches. It is equal to the length of a standard platinum bar, kept in Paris, and representing approximately a ten-millionth of the quadrant of the earth's meridian measured from the equator to the pole through Paris. Wireless waves are usually measured in meters. The length of a wave is the distance, usually measured in meters between two points in the successive waves where the disturbance is at a maximum or at a minimum or between any two points of equal disturbance. There is a fixed relationship between the length of a single wave, the frequency of oscillation and the velocity of the wave. Thus if 3,000,000 waves pass a given point in one second, each wave must be 100 meters long since the velocity of radio waves is equal to 300,000,000 meters per second.

**METER—**The product of the antenna current in amperes at the point of maximum current and the antenna effective height in meters, for any radio transmitting station. It constitutes a factor for indicating the radiating strength of radio transmitting stations.

**Metric System**—A system of measurement in which the meter is the fundamental unit of length and in which all the units both fundamental and derived are divided diametrically and higher units are formed in multiples of ten. (See Centimeter Gram Second.)

**Microphone**—A sound magnifier. The ordinary form of microphone consists of an anhydrous silicate of aluminum and potash or sodium. Mica has very high insulating qualities and can withstand high temperatures. Mica obtained in the natural state is separated into laminations which are sorted and graded. These are then cemented together to form plate or flexible mica of any desired thickness or purity. Mica is used in radio work as the dielectric of small fixed condensers. It is also used as the sound producing diaphragm in certain types of head sets and loud speakers.

**Microphone—**An instrument for measuring extremely small currents. (See Ampere.)

**Microfarad**—abbreviation Mfd.—An unit of electrical capacity equal to one-millionth of a farad. Since the farad is too large for most practical measurements, the microfarad is generally used. (See Farad, also Mfr.)

**Microhm**—A unit of resistance equal to one-millionth of an ohm (q.v.).

**Micro Meter**—An instrument for making minute measurements. Usually controlled by an accurate screw of fine pitch.

**Micrometer Spark Gap**—A miniature adjustable spark gap of about four-hundredths of an inch placed in the aerial circuit of a multiple tuning system to break the heavy current for one track to earth by sparking across its points.
MILS—Microphonic—One thousandth of a microphone. See Microphonic.

MILLI-AMPERE—One-milliamphere (q.v.) is a conductor having a current of one milliampere. See Milli-amp.

MICROPHONE, CARBON—See Microphone, Carbon.

MICROPHONE TRANSMITTER—See Microphone.

MICROPHONIC JUNCTION—A loose contact between conductors, mobile that feeble vibrations vary its resistance.

MICROPHONIC RELAY—An instrument for magnifying the variations of a given current by passing it through an electromagnet that acts on the diaphragm of a microphone. The resistance variations are reproduced in the current produced by a constant voltage impressed on the microphone (q.v.). In general a microphonic relay can be described as a microphone combined with a telephone so that a message is transmitted over the telephone by the microphone over one another line.

MIL—A unit equal to one thousandth part of an inch.

MIL-FOOT—A wire one foot long having one mil of resistance may be measured in ohms (q.v.) per mil-foot. This refers to a conductor having a cross-sectional area of a rectangular mil (q.v.) and a length of one foot.

MILLI—The prefix placed before the name of a unit to indicate one thousandth part of that unit, as for example milli-amperc (q.v.).

MILLI-AMPERE—One thousandth of an amperes (q.v.). Sometimes abbreviated to milli-amp.

MILLI-MICRO—A prefix denoting one thousandth of a microampere (q.v.).

MILLI-VOLT—One thousandth of a volt.

MILLS, CIRCULAR—See Circular Mile.

MIRROR GALVANOMETER—A galvanometer for measuring very small currents which utilizes a reflected beam of light for a pointer. In one type of mirror galvanometer a fixed nearly circular magnet is used and a coil of wire is suspended in its field. When the current flows through the coil it sets the mirror so as to set its axis in the direction of the magnetic force. This movement can be observed by means of a beam of light reflected from a mirror fixed to the coil. See Galvanometer.

MINERAL—An insulating compound that may be nearly circular in sections and which is not a mineral. See Mineral.

MINERAL—A nomenclature for Magnetomotive force (q.v.).

MODULATED CURRENTS—Currents which have their amplitude periodically varying in the case of the carrier current used in radio telephony which is varied or modulated in accordance with variations of a microphone. If a sound wave actuates a microphone, its inward and outward displacements varying in the aerial circuit, results in a high frequency current in the aerial of variable amplitude, called a modulated high frequency signal. This illustration shows an extremely simplified diagram of the apparatus in a broadcasting station. The initial impulse that starts a radio signal towards the receiving set is furnished by the voice of the speaker or singer or by some other sound originating in the studio. This sound strikes the microphone, the operating element of which is a thin metal diaphragm. The sound waves cause this diaphragm to vibrate. In doing so, the disk causes changes to take place in its circuit. Pulsa- tions of current are set up, the pulsations corresponding in strength to the variations of the spoken word, music or other sound as the case may be. These fluctuations are quite weak when they first come from the microphone and therefore they must be strengthened. They go through what is known as a voice amplifier which utilizes vacuum tubes to make the current stronger. The next piece of apparatus to consider is the oscilator (q.v.). This consists of one or more vacuum tubes arranged in a circuit of such a type that the tubes, when lighted and properly furnished with a high voltage, is prevented from generate another current, alternating in character, which is said to be oscillating at a frequency. Upon the current so generated, the voice current is impressed or superimposed. This current is known as modulation (q.v.). The current from the oscillator is known as the carrier wave (q.v.) current and when voice currents are impressed upon it, it is known as modulated radio frequency current. This current flows in the aerial and there sets up waves.

MODULATION—Variation of current or wave form to conform to sound waves or to other predetermined forms. Various forms of modulation are dot and dash modulation, chopper modulation, beat, modulated sound, modulation (q.v.) (See Distortion, Double Modulation, also Modulation Frequency Ratio.)

MODULATION, DOUBLE—See Double Modulation.

MODULATION FREQUENCY RATIO—The ratio of modulation frequency to wave frequency. An alternating current is said to be modulated when the amplitude of its oscillations is varied periodically. The frequency at which the variations occur, is to say the modulation frequency is necessarily less than the frequency of the alternating current which is being modulated. The nature of the variations may assume practically any form. As examples, there are dot and dash modulation, chopper modulation, buzzer modulation and speech modulation (q.v.).

MOLECULE—The smallest group of atoms in an element or compound which can exist by themselves. A familiar analogy states that if a drop of water is comparable to the size of the earth, its component molecules would be the size of base-balls.

MOLYBDENUM—A light gray sulphide of Molybdenum. It is used as a rectifier detector in contact with copper. See Molybdenum.

MOUNTING CONDENSER—A condenser in which the dielectric thickens out at the edges. It is essentially a form of Lecher made of a glass tube, especially thickened at the neck where the dielectric stress is greatest, coated inside and out with metal foil. The dielectric is mica and is known as universal. Several current motors are classified as shunt, series and compound. This classification is arrived at by determining in what manner the field windings are connected. In the shunt motor the field windings are connected in series with the armature winding and the line. Compound motors have a shunt winding in parallel with the brushes and a series winding in series with the armature and the line. Compound motors may be further classified as differentially compounded and cumulatively compounded. A differentially compounded motor is one in which the series field windings are connected as to oppose the shunt field. A cumulatively compounded motor is one in which the series field aids the shunt field by falling slightly as the load increases. The speed of the series motor decreases with the load.

The differential motor may be constructed so that an absolutely constant speed will be maintained at all loads. The speed of the cumulative motor decreases rapidly as the load is increased. Alternating current motors are of the series type, the induction type, commutator type, synchronous type and repulsion type. There are a number of possibilities. Alternating current motors such as single phase induction, polyphase induction, repulsion type and even the ordinary direct current series motor wind a brushes. Alternating current will operate but at a low power factor, with a large eddy current loss and sparking at the commutator. In order to adapt the series motor for universal use, the windings and field structure must be laminated (q.v.) in order to avoid eddy currents (q.v.); and the brushes are designed to turn to avoid too great self-induction (q.v.) and consequently low resistance (q.v.). Sparking at the brushes can be avoided to at least by designing the motor for a small field flux and with but a few turns in series in each armature coil.
MULTIPLE SERIES—See Series Parallel.

MULTIPLIER—A resistance placed in series with a voltmeter for limiting and controlling the amount of current flowing through the voltmeter windings. This resistance may be either internal (enclosed by the voltmeter case) or external.

MULTI-POLAR—Having more than two poles. Usually a generator or motor whose field magnet has more than two poles. Small machines may be made with two poles, bi-polar (q.v.), but all others have more poles, that is to say they are multi-polar. The use of multi-poles results in a lighter machine and incidentally there is a saving of inductive effect and a reduction in sparking. If there are too many poles, however, there will be excessive leakage flux between the poles. (See Homo-polar.)

MUSICAL SPARK—A spark giving a regular distinct musical note. This may be produced by a high speed rotary discharge, a quenched gap (q.v.) or an arc.

MUSICAL SPARK SIGNALS—Signals in which the sparks occur at regular intervals of time and fast enough to give a musical note. Usually the spark rate is between 100 to 1200 discharges per second.

MUTE ANTENNA—A local circuit or resistor used in testing transmitting apparatus. The mute antenna in this case is substracted in the place of the actual antenna. It is also referred to as a dummy aerial, phantom antenna, mock antenna, or artificial antenna.

MUTUAL CAPACITY—The capacity effect of one conductor upon another one in the same electrostatic field. The mutual capacity is not the same as the capacity of the two wires regarded as the two plates of a condenser, one positively charged while the other is charged negatively. It really represents a decrease in the capacity of one of the wires with respect to earth caused by the presence of the electrostatic field of the other. The total capacity of the two wires is diminished by overlapping of the two individual fields. (See Capacity Measurement of Antenna.)

MUTUAL INDUCTANCE—Symbol M—The magnetic flux that is common or mutual to two inductively coupled circuits. The mutual inductance of two circuits is the change in the interlinkage of flux that takes place in one circuit for a change of unit current in the other. This is also called the coefficient of mutual induction or the mutual induction coefficient. The units of mutual inductance are the same as those of self-inductance. (See Inductance, Mutual; Self-Inductance, Induction, Coupling, Induced E.M.F., Induction, Mutual; Coefficient, and Mutual Induction Coefficient.)

MUTUAL INDUCTION—The interaction between two current-carrying coils, not having direct metallic connection. The reactance of a coil such as shown in the illustration at A, is reduced by the proximity of another coil, A1, if the circuit of the latter contains no external source of electro-motive force, such as an alternator. The reason for this lessening in the primary resistance is that the flux excited by the first coil induces a current in the second coil and this current opposes the action of the primary current. As a result the total electro-motive force (q.v.) is reduced. The reactance of the coil A, is reduced by the proximity of coil A1, since the circuit of A1 contains no source of electromotive force. The effect of the secondary coil depends not only upon its distance from the primary coil but also upon R, Xs and X1. The presence of the iron core greatly increases the action. The reactance of the coil A, is reduced by the proximity of coil A1, since the circuit of A1 contains no source of electromotive force. The effect of the secondary coil depends not only upon its distance from the primary coil but also upon R, X5 and X1. The presence of the iron core greatly increases the action.

force (q.v.) induced in the first coil is reduced. The effect of the secondary coil is a function of the proximity of the two coils, the self-resistance of the primary coil, and the inductance of the secondary coil. In other words, the mutual inductance may be undesired as in the case where a radio antenna parallels a power line. (See Inductance, Mutual; Mutual Inductance, also Mutual Induction Coefficient.)

MUTUAL INDUCTION COEFFICIENT—Another name for mutual induction (q.v.) That coefficient by which the rate of change of the current in a circuit must be multiplied to give the electromotive force induced in an adjacent circuit. From the principle of conservation of energy, it can be shown that the mutual inductance of a circuit with respect to a second circuit is equal to the mutual inductance of B with respect to A. (See Mutual Inductance, Induction, Mutual; Self-Inductance, Induction, Coefficient, also Coupling.)

NAGYAGITE—A mineral containing lead, gold, antimony, sulphur, and tellurium. It receives its name from the location of its discovery near Nagyag in Transylvania. It is also known as blister ore or leaf tellurium, and has been used as a crystal rectifier in conjunction with zincite.

NALLY, Edward Julian—American radio pioneer. Born April 11th, 1859, in Philadelphia, he joined the Western Union Telegraph Company in St. Louis and worked his way up in the telegraph service until in 1913, he was appointed vice-president and general manager of the Marconi Wireless Telegraph Company of America. Nally was one of the first to see the possibilities of wireless, and under his control the first commercial wireless communications was made between the United States and Japan, in 1914, and in 1920, he founded the first commercial wireless service between the United States and Great Britain, and afterwards to other countries. He was appointed the first president of the
lightning produces a sharp snap. Another type of stray cause loud crashes in the speaker.

**NATURAL MAGNET**—A substance which possesses in a natural state the properties of a magnet. Such a substance is called a magnetic oxide of iron which also called magnetite (q.v.). (See Lodestone.)

**NATURAL FREQUENCY**—The frequency at which oscillations occur in a circuit. If L, C, and R are respectively the inductance, capacity, and resistance of a circuit, the frequency of oscillations in the circuit will have the frequency:

\[
\frac{1}{2\pi} \sqrt{\frac{1}{LC} - \frac{1}{R^2}}
\]

This is the natural or fundamental frequency of the circuit. The natural frequency of an aerial is the frequency corresponding to the natural wave length. (See Natural Wave Length, also Measurement of Wave Length.)

**NAPERNIAN BASE**—The base of the so-called natural system of logarithms (q.v.). It is usually represented by the symbol e (epsilon) and is numerically equal to 2.718 approx. (See Damped Waves.)

**NAPERNIAN LOG**—See Napierian Logarithms.

**NAPERNIAN LOGARITHMS**—Also called Natural Logarithms. Logarithms to the base e. Logarithms constitute a tabular system of numbers, by which the operation of multiplication can be performed by addition, division by subtraction, involution by a single multiplication, and evolution by a single division. John Napier, Laird of Merchiston, Scotland, is generally regarded as the inventor of logarithms. The logarithms set forth by Napier were those of the hyperbolic functions. Later on Napier's logarithms were adapted to positive integers, using as a base the number 2,718 approx. and these logarithms are now called natural or Napierian logarithms. (See Decrement, also Logarithms.)

**NATIONAL ELECTRIC CODE**—A uniform code of rules, based upon the requirements of fire underwriters, for the electric wiring and electric installations in buildings. Unless these rules are complied with fire insurance will not be issued or if issued previously will not be renewed. The National Electric Code contains a section covering special requirements for radio installations. The code is revised annually to meet new conditions and requirements. Copies of the code can be obtained from local insurance agents or from the National Board of Fire Underwriters at New York or Chicago.

**NATURAL ELECTRIC WAVES**—Wireless waves due to natural causes such as lightning discharges. When received in the radio apparatus, they are called strays (q.v.), static (q.v.), atmospheres, \( X \) (q.v.), and various other names. There are many different causes for these stray waves. Some produce a grinning noise in the loud speaker, others a hissing noise often associated with snow or rain. Nearby

removed. The ions therefore have very nearly the same weight as the gas atoms. The hydrogen carriers, on the other hand, may consist of an atom or molecule to which has been attached an electron. It is also possible that the attraction between an electron and the neutral gas molecules can result in the formation of clusters consisting of more than one molecule held together by the electron. These negative carriers, therefore, move as slowly as, and often more slowly than, positive ions and consequently have a relatively great effect in countering the tendency of the positive carriers to produce the negative space charge of the electrons. (See Electron Theory, also Natural.)

**NEGATIVE CORPUSCLE**—The natural unit of negative electricity. The electron (q.v.). It is more usual to refer to the negative corpuscle simply as the corpuscle. This was the name given by Sir J. J. Thomson to the carriers of electricity shot off from the cathodes in vacuum tubes. The corpuscles were found to have a charge equal to the electron and a mass which is of that of the hydrogene carrier—about on 1/400.

**NEGATIVE ELECTRODE**—In a primary cell (q.v.) the cathode (q.v.) which is the carbon, copper, etc., electrode is the negative electrode, while the pole of this electrode is the positive pole, since it is positive in relation to the external circuit. In a secondary or storage cell, the spongy lead plate, which is the anode during discharge, is called the negative electrode. "The positive pole" is the negative pole.

**NEGATIVE ION**—An atom, which is the smallest particle of an element capable of existing, plus an electron (q.v.). (See Atom, Cathode, Electron Theory, also Ion.)

**NEGATIVE POLE**—The south-seeking end of a magnet. In a generator, the terminal into which the current returns from the external circuit. In a storage cell, the terminal of the negative plate. In a primary cell, the pole of the positive plate.

**NEGATIVE RESISTANCE**—A current proportional to the voltage. In a vacuum tube or an arc in which current decreases as voltage increases. The emission of electrons from cold electrodes under the impact of a direct current. As a result, the electron emission (q.v.) or delta rays results in a negative resistance or falling charge. The presence of sec.
NEGATRON—An English vacuum tube containing a filament, a grid and two plates. This tube was devised by J. Scarff, who used it for containing negative resistance (q.v.) characteristics. The two plates are fixed one on each side of the filament. The accompanying illustration shows a typical negatron. The bulb is tubular in shape and the four electrodes are plainly shown. The grid, in this tube, is a metal rod.

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NEON LAMP—An incandescent lamp in which a reddish light is produced by the incandescence of neon gas at low pressure. This lamp has very low current consumption and has been applied to pilot lights, signs, etc.

NEON TUBE—A vacuum tube containing the gas neon at low pressure used in the Fleming Cymometer (q.v.) etc. In this instrument, which is used to measure the frequency of electric waves, wavelength, etc., a capacity formed by one brass tube sliding over another can be varied simultaneously with an inductance consisting of an iron core solenoid and arranged so that the point at which resonance takes place is indicated by the glowing of the neon tube and can be read from a calibrated scale.

NERNST LAMP—An incandescent lamp in which the incandescent body consists of a strip of material composed of a mixture of oxides of metals such as zirconium, magnesium and other refractory oxides. The incandescent portion of the lamp is called the glower and is conductive only at a high temperature. Consequently it has to be heated by an auxiliary heating coil. The heating coil is automatically cut out of the circuit when the current starts to flow through the glower.

NEUTRAL BODY—A body void of electrification. A charged body which loses its electrification is said to be discharged or neutralized. All matter is capable of electrification.

NEUTRAL LINE OF MAGNET—The middle portion between the two magnetic poles of a bar magnet, where there is no manifestation of magnetism.

NEUTRAL WIRE—A middle wire, in a three wire system (q.v.) of power distribution, which is kept at a potential mid-way between the positive and the negative mains. In the three-phase system of alternating current distribution, the conductor connected to the neutral point of a "star" or "Y" connected alternator is also known as the neutral wire. The neutral wire is here also known as the common return.

A three wire system with unbalanced load, showing neutral wire.

A three wire system with unbalanced load, showing neutral wire.

Fig. 1. A portion of a receiving circuit. Dotted line shows tube capacity represented by an equivalent condenser used in radio reception in which radio frequency amplification is used for neutralizing the effects of capacity of the tube and its socket. Figure 1 shows a portion of a receiving circuit. In this diagram the tube capacity is represented by a condenser shown in dotted lines. By studying this circuit, it can be seen that a closed oscillatory circuit exists, made up of the inductances and capacities in the plate and grid circuits. Just as radio frequency currents can pass through condensers in a receiving set, so they can pass through or across the vacuum tube from the plate to the grid, which forms a condenser. This condenser effect is the reason why radio frequency amplifiers oscillate. A difference of potential occurs in the plate side of the coil in the plate circuit. Instead of this being hand ed on to the next tube for additional amplification, a portion of this potential leaks through the capacity of the tube and its socket and affects the grid in such a way that trouble is experienced with self-oscillation. In the neu trodyne circuit, the...
Nichrome Wire

inter-element capacity of the amplifier's vacuum tubes is neutralized by methods of special condensers called neutrons. The capacity of these is very low, being practically equal to the internal capacity of a vacuum tube. By reason of this equality, any tendency of a large amount of radio frequency current being leaked through the tube by the grid is defeated and instead is neutralized by the combination of the neutralizing capacity of the inter-element capacity of the vacuum tube and the secondary windings of the frequency by transformers. This effect is in reality a bucking one, since the current is made to take two paths. Each neutralizing condenser must be adjusted so that its capacity will equal that of the vacuum tube it is connected with. Since it is impossible for a neutraloyce circuit to oscillate, there is no radiation of energy from the set, with consequent disturbance of other receiving sets in the vicinity.

The neutraloyce circuit was invented by Professor L. A. Hazeltine. The technique involved building three of the five tubes, employing two stages of tuned and neutralized radio frequency amplification with detector and audio frequency stages. (See Hazeltine Neutraloyce Receiver.)

NICHROME WIRE—A nickel-chromium-steel alloy wire, which is able to withstand a bright red heat in the atmosphere without oxidizing. Nichrome is practically non-corrosive. It has a high melting point, about 1550 degrees Centigrade and is used extensively in electrical heating appliances and resistance elements.

NIGHT EFFECT—Changes in the strength of radio signals noticeable only at night time. This effect is known as fading (q.v.). Fading does not generally occur in the immediate vicinity of the transmitting station. It seems to happen more often on wave lengths below 400 meters. A certain station is being received with normal intensity, when suddenly the sound becomes very faint and in a few minutes they may again become normal or may even become stronger than usual. In some cases the variations from strong signals to weak take place every few minutes while in other cases there may be an interval of several hours. It has been observed that fading takes place over land more often than in radio transmission at sea.

NOBLE, Sir William—British engineer. Born in 1861 and educated at Gordon's College, Aberdeen, he thereafter entered the Aberdeen telegraph office. In 1899 he was appointed engineer for the northeastern area of Scotland, rising to chief engineer service until he became chief engineer in 1919. He retired from the Post Office in 1922, and became a director of the British Broad
tee Company and of the British Broadcasting Company. Sir William Noble has written many articles on telegraphy and telephony and is considered to be an authority on these subjects.

NODES—In a wave form, such as shown in the illustration which represents an alternating current sine wave, the zero points. Thus in the alternating current sine wave, the points of zero current or potential, at C, G, and E, are nodes, and the points B, D, and F are the anti-nodes (q.v.).

![Diagrammatic illustration of the principle of the Noden valve.](image1)

**NODEN VALVE**—An electrolytic rectifier (q.v.) which allows only current in one direction to pass through. This rectifier utilizes an aluminum rod or cylinder as a cathode and the anode may be of iron, lead or of carbon. Ammonium chloride is used as the electrolyte. The principal operation of this rectifier depends upon the fact that the current in the positive direction is stopped at the aluminum plate through the formation of an insoluting crust of aluminum phosphate and aluminum oxide. These two substances present an extremely high resistance to the current in the positive direction, but the compounds dissolve again upon reversal of the current. By suitably combining two or more cells, both the half waves of an alternating current can be rectified. In Fig. 1 is shown the principle upon which the device operates, and Fig. 2 shows a hook-up for connecting four cells to obtain full wave rectification. (See Electrolytic Rectifier Full Wave, also Rectifier.)

NON-CONDUCTOR—See Insulator.

NON-INDUCTIVE COIL—A coil having negligible inductance. Such a coil may be wound by doubling the wire upon itself and then winding the two parallel halves side by side.

NON-Oscillator—Prevented from oscillations or vibrations. Without periodicity, that is to say, aperiodic (q.v.). A current which is uniform in direction and flow and free from oscillations is said to be a non-oscillatory current. A non-oscillatory circuit is one in which an impressed effect will produce current that gradually diminishes in amplitude without reversing its direction of flow. The wave is called an aperiodic circuit (q.v.). Such a circuit can have no natural period of oscillation.

NON-PERIODIC—See Aperiodic, also non-oscillatory.

NON-Radiative Antenna—A combination of capacity and inductance equivalent to that of an aerial, used to test transmitting apparatus without radiating waves. (See Mute Antenna.)

North Magnetic Pole—A point on the earth at latitude 70 degrees North, longitude 97 West. The north magnetic pole does not coincide with the North (geographic) pole. (See Magnetic Poles.)

North Pole—See Magnetic Poles, also North Magnetic Pole.

Null Method—An electrical method of testing in which adjustments are made so that zero deflection is obtained in a galvanometer pointer when a Wheatstone Bridge (q.v.). This is sometimes referred to as the zero method. (Null is also a German word meaning zero.)

Octahedrite—Chemical Symbol TIO—Titanium dioxide, an eight sided crystal, which has been used as a crystal detector for detecting and rectifying radio currents. (See Crystals.)

Oersted—The unit of reluctance (q.v.). The reluctance or in other words, the resistance offered by a cubic centimeter of vacuum. Unit of magnetic motive-force (q.v.) will generate a unit of magnetic flux (q.v.) through unit reluctance. The oersted was named after the Danish physicist, H. C. Oersted.

Ohm—Symbol Ω (Omega)—The unit of electrical resistance. It is the ratio of unit electromotive force (q.v.) to unit current. The ohm is the basis of the entire electrical system of units and the volt and the amper are defined in relation to it. Very elaborate apparatus is required in order to determine the ohm absolutely. However, resistances can be compared easily and once the standard is determined it is a simple matter to make duplicates. In accordance with an act of Congress the ohm was adopted as a legal unit and defined as follows: The unit of resistance which shall be equal to the international ohm, which is substantially equal to one thousand million units of resistance of the centi-
The ohmmeter—An instrument used to measure resistance directly in ohms. It is particularly adapted for measuring high resistances, although certain types of ohmmeters are made for measuring lower resistances. In one form of ohmmeter, the moving system is deflected by forces due to currents in two coils at right angles to one another. These carry currents in one case proportional to the current through the conductor under test, and in the other case proportional to the potential drop across it in effect, a spiral form of galvanometer (q.v.) and when combined with a hand driven generator gives the voltmeter-megger (q.v.). The bridge type ohmmeter depends upon the Wheatstone Bridge (q.v.) principle. In this instrument, however, the resistance remains constant and the bridge arms are formed by a wire, called a slide wire, resistances being varied by means of a moving contact as shown in the illustration. This type of instrument is often referred to as a wire ohmmeter. While a straight slide wire is used in some types, in others the wire is wound on an insulating cylinder. In the Weston direct-reading ohmmeter, there is a permanent magnet and a moving coil having two windings and an adjustable magnetic shunt. Provisions are made for connecting an unknown resistance and an auxiliary battery in the circuit of the instrument. A checking plug is provided for checking the accuracy of the instrument before use: When the key is closed, the battery current is divided between two windings. The magnetic force exerted on the one winding, which is in series with a fixed resistance, tends to deflect the pointer upward, while the force exerted on the other winding tends to return to its zero. With the correct battery voltage, an adjustable magnetic shunt may be added to adjust the pointer to full-scale position. When the plug is shifted to the low range position, a resistance equal to that of the low range is removed from the circuit whose magnetic force tends to deflect the pointer toward the zero position. By connecting a resistance equal to that of the low range across the unknown binding posts, the previous condition is restored and the pointer will go back to the full scale position. For values of resistance lower than this the opposing force will be greater and hence the coil will be brought back to a lower position on the scale. At zero resistance across the unknown binding posts, the magnetic forces of the two windings will balance each other, thus causing the coil to stand at zero on the scale. The Vawter indicating ohmmeter is of the galvanometer type and utilizes two coils carried by a shaft and moving in the field of a permanent magnet. A specially shaped core is used to give the desired scale characteristics. By making connections to the coils through spirals of negligible length, the position of the pointer does not depend upon the value of the current nor on the strength of the permanent magnet.

**OHMIC COUPLING**—See Resistance Coupling.

**OHMIC DROP**—The fall in potential which occurs when an electric current flows through a resistance. (See IR Drop.)

**OHMIC LOSS**—Power or energy loss due to the resistance which an electrical circuit offers to the flow of current. (See IR Loss.)

**OHM'S LAW**—Current flowing in a conductor will increase directly with increase of voltage and will decrease directly with increase of resistance. In other words, voltage is the cause, while current is the effect. The effect is directly dependent upon the cause and inversely dependent upon the opposition offered to the cause. Ohm's law is the fundamental law of electrical engineering. Ohm's law can be stated as an equation as follows:

\[
\text{Current (in amperes)} = \frac{\text{Voltage (in volts)}}{\text{Resistance (in ohms)}}
\]

or

\[
\text{Voltage} = \text{Current} \times \text{Resistance}
\]

**Resistance** = Current

The above three equations all mean the same thing and serve to express in various forms, the idea expressed above. Ohm's law can be applied to every conductor, provided that the conductor stays at a constant temperature. However, there is no internal electromotive force in the conductor and that the distribution of the stream lines in the conductor remains unchanged. Ohm's law is easy to understand and easy to apply. Thus in a particular circuit, a certain voltage causes a certain current to flow. Double the voltage will cause double the current to flow, if the resistance is the same. If the resistance is doubled, however, the same voltage will result in only half the current flow. Double voltage and double resistance results in unchanged current flow. Ohm's law applies to a portion of an electrical circuit as well as to the entire circuit. Care must be taken when applying the law to only part of the circuit, to consider only the resistance, current and voltage of that part.

**OMNIBUS BAR**—A conducting bar of copper, mounted in back of a switchboard, or small panel, with a connecting wire or common connector for two or more pieces of apparatus. This term is more usually applied to the latter (q.v.).

**OMNIGRAPH**—An instrument which sends code (dots and dashes) mechanically. It is usually operated by clockwork and is connected with a buzzer. It employs metal disc records each of which has a series of notches which correspond to the dots and dashes of the telegraph code. The omnigraph is used by beginners in learning the code and is also used to test the speed of reception of applicants for radio operators' licenses.

**ONDROGRAPH**—An instrument for automatically recording the wave forms of varying currents, especially alternating currents which are alternating rapidly. This form of curve tracer was invented by Hospitalier.

**ONDODOTER**—Another name for a wave meter (q.v.).

**OPEN ANTENNA**—According to the report of the Institute of Radio Engineers standardization committee, this is a condenser antenna, that is to say an antenna consisting of two capacity areas. Antennas may be subdivided into two general classes, those which act principally as condensers, usually simply called condenser antennas, and those which act principally as inductances. These latter are loop antennas (q.v.), coil antennas (q.v.). When electric waves reach a conductor antenna, they set up an alternating electromotive force between the wires forming the upper plate of the condenser and the ground or the lower plate of the condenser. As a result of this alternating electromotive force, alternating current will flow in the antenna system. (See Aerial.)

**OPEN CIRCUIT**—An electrical circuit which does not offer any path for the flow of electricity. There may be one or more breaks in the path. An open circuit is often referred to as a broken circuit. Open circuits often cause trouble in radio apparatus. They may be caused by breaking out of a winding, to a connection coming off a terminal, to a soldered connection breaking loose or to similar causes. The method of testing for an open circuit is to connect a battery and a headset in series with the circuit in question. If there is a short on the headset, there is evidently a break in the circuit.
OPEN-CORE TRANSFORMER—A transformer in which the (useful) magnetic circuit is partly through iron and partly through air, instead of entirely through iron as in the closed-core transformer (q.v.). It is sometimes referred to as a polar transformer. In one type of open-core transformer the arrangement is similar to that of an induction coil (q.v.), a low iron core, filled with soft iron wires being employed to concentrate the magnetic field.

OPPOSING ELECTROMOTIVE-FORCE—See Back Electromotive-force.

OPTPHONE—An instrument utilizing a telephone receiver controlled by the variations of resistance of a selenium cell (q.v.) by means of which the blind are enabled to read ordinary type, through the sense of hearing.

ORDINATE—A mathematical term used in radio in making logs (q.v.) or other curves. Defined in mathematical language, the ordinate is that one of the coordinates of a point which is drawn parallel to a line (called the axis of ordinates) to the point from the other

axis (called the axis of abscissas) or from the plane of the other axis of coordinates, assumed as a basis of reference. This definition will be clearer if reference is made to the accompanying illustration. The dotted line drawn from the point A to the axis of

abscissas is the ordinate of the point A.

OSCILLATING CURRENT—An alternating current of high frequency, consisting of a succession of waves of constant length. In some cases, the term oscillating current refers particularly to a current whose amplitude is decreasing in constant proportion due to damping. (See Oscillation, Oscillation Frequency, also Logarithmic Decrement.)

OSCILLATING IMPULSE—An oscillating current set up for the purpose of producing electric waves.

OSCILLATING VALVE—See Oscillator, also Vacuum Tube.

OSCILLATOR—A device or apparatus for producing electric oscillations. The vacuum tube (q.v.) under correct conditions may be used to produce oscillations. The term tube, which possesses inductance, capacity and resistance, means that the tube will oscillate with the desired frequency and finally the tube must have certain characteristics which when combined with the constants of the oscillatory circuit, will determine the amplitude of the oscillations. Oscillations may also be produced by means of a high frequency alternator and by a direct current generator and electric arc. (See Alternator, also Alexanderson.)

OSCILLATOR, HERTZIAN—Two insulated rods, with axes in line, with their nearer ends forming a spark gap and their outer ends bearing plates or balls to give the system the required capacity. The overall length is usually less than 60 ft., and the maximum frequency 150 Mc. It constitutes an open oscillator. A Hertzian oscillator is sometimes called a
dipole. When the rods are brought near each other but not in actual contact and the conductors are connected to the terminals of an induction coil (q.v.) a succession of snarks can be caused to jump the gap and these set up electric waves in the ether (q.v.).

OSCILLATOR, LINEAR—The straight wires connected on either side of the spark gap of an induction coil, traversed by oscillations. Linear oscillators are of the open type. As used by Hertz, they consisted of two rods, having a spark gap between their adjusted ends, while their outer ends terminated in plates or balls in order to increase the capacity of the system.

OSCILLATORY HIGHNESS—In this type of oscillator, the spark gap is established between two metal spheres placed between two smaller spheres. (See Oscillator, also Oscillator, Hertzian.)

OSCILLATOR, THERMIONIC—A vacuum tube used to generate continuous oscillations. (See Oscillator.)

OSCILLATORY CURRENT—In this type of oscillator possessing inductance (q.v.) and capacity (q.v.), the electrical constants being such that an oscillatory current can be set up. The accompanying
The oscillograph shown in Fig. 1 is a simple electric oscillograph. It consists of a moving coil mirror galvanometer, a rotating or vibrating mirror and a moving photographic plate. Figure 1 illustrates the principle of the oscillograph and the curves it produces. The oscillograph was invented by M. A. Blondel in 1893. By means of the oscillograph the wave form of a current may be shown as a curve and its characteristics may thus be examined and studied. In order to form the curve it is necessary to have simultaneous motion in two directions. The vibrator of the oscillograph which consists of a delicate coil of wire, with mirror attached, is made extremely light so that the moving system will have as little inertia as possible. The coil is placed in a powerful magnetic field and when an oscillating current is passed through it, it oscillates in synchronism with the current. A spot of light focused on the mirror is made to fall on a screen at the predetermined distance from the vibrator. This spot of light traces out a straight line on the screen. Substituting a photographic film for the screen and arranging the film so that it will move in a vertical path across the moving beam of light (which is assumed to be moving from right to left across the screen) a curve is traced on the film. The commercial form of oscillographs are provided with apparatus where the curve may be examined without the necessity of photographing it. In these the beam of light is reflected from a rotating or vibrating mirror in a cathode voltage such a way that it receives a horizontal and an up and down motion and is focused onto a curved plate of glass. Tracing paper may be stretched over the glass so that the image of the spot of light traces a visible curve on it. The curve being repeated very rapidly appears to be standing still and hence it is possible to trace over it with a pencil or even to place a piece of photographic paper on the curved glass and make a record of the curve in this way. The motion picture camera has been applied to the oscillograph and is used where longer records are required. It should be noted that oscillographs which utilize a moving coil, such as the Duddell or Blondel type, will work over a band of frequencies up to a maximum of about 300 cycles per second. Inasmuch as the oscillations common in radio work are of much higher frequency than 300 cycles, it has been found necessary to use an oscillograph whose recording parts are without appreciable weight. The use of electrons as moving parts has solved this difficulty. A Frenchman, Alexander Dufour, in 1909, invented the Braun tube to the construction of an oscillograph which has no appreciable inertia and which is capable of operating at a frequency up to a million cycles per second. This device uses only minute amounts of energy in its operation and therefore does not disturb the original circuit. It is able to register both voltage and current simultaneously and is arranged so that a single impulse is sufficient for a photographic impression. The Dufour oscillograph consists essentially of glass plates fitted by means of a ground joint into a bronze chamber. The upper glass plate is fixed and an anode and the other plate has one pair of deflecting plates for electrostatic deflection of the electron stream. Two of the coils are placed so that one is for magnetic deflection and these are placed outside the tube and slightly below the deflecting plates. In order to photograph the oscillations, a drum is used which is provided with a film magazine allowing six films to be taken in succession. When such examinations of the oscillographs are to be made, a fluorescent screen is turned up to position covering the opening into the interior of the drum thus preventing the films from being exposed when the screen is in use. After the films are put into the drum, this is placed within the bronze chamber and locked into position. The opening in the lid is used to close the opening and the film changing mechanism is operated by means of external controls. Glass windows on either side of the bronze chamber allow the fluorescent screen to be seen. The accompanying sketch shown at Fig. 2, gives a diagrammatic representation of the operation of the Dufour oscillograph.

OSMOSIS, ELECTRIC—When an electric current is passed through an electrolyte having an anode on one side of a porous diaphragm and a cathode on the other side, there is a tendency for the liquid to pass through the diaphragm towards the cathode rather than towards the anode. This phenomenon is known as electric osmosis.

OPHONE—A device for the hard of hearing, which utilizes an extremely sensitive microphone connected to a two-stage vacuum tube amplifier. The invention uses dry cells and batteries are contained in the case with the microphone. A small telephone receiver completes the apparatus.

OUDIN RESONATOR—A device used for obtaining high-frequency brush discharges. Discharges of this nature are used in the investigation of resonance effects and also in medical work. The accompanying diagram explains the principle of the Oudin resonator.
**Output**

B D is an uninsulated coil of copper wire wound on an insulating core with each turn separated from the next adjacent one. At B, the helix is connected to an induction coil and it is tapped by means of a sliding contact at C. The sliding contact is connected through a condenser to the induction coil H, with a spark gap G in parallel.

**PACKING—(referring to a microphone).**

The tendency of carbon granules in a microphone to settle or pack. In this position they are no longer sensitive and do not readily respond to the vibrations of the diaphragm. Packing may be caused by irregularity in the sizes of the carbon granules. It may be remedied by gently tapping the microphone.

**PANCAKE COIL—A flat inductance coil.**

Coils of this type are used in radio receiving sets as radio frequency transformers, also as antenna couplers and oscillator couplers. They may be basket wound (q.v.), spider wound, etc. In wireless transmitting apparatus, aerial tuning inductions, loading inductions, and oscillation transformers (illustrated) are frequently of the pancake coil type. (See Induc-\(\text{tance, Antenna.}\))

**PANEL—A board of insulating material carrying the controlling or measuring devices of an electric circuit.**

The panel for controlling the charging of storage batteries is called a charging panel. A panel carrying generator controls is referred to as a generator panel. Where only a single panel is used this is usually called the switchboard. The usual switchboard comprises a number of panels. Switchboard panels are commonly made of marble. The usual varieties available are white Italian, pink or grey Tennessee and blue Vermont marbles. Plain slate is sometimes used for panels where the voltage is not too high. When the panels do not require a finish, soapstone is sometimes used. The front of a radio receiving set on which the dials and rheostat controls, etc., are mounted is also called a panel. These panels are usually made of Bakelite, hard rubber, composition or similar insulating substances, although a number of sets are being made with metal panels. The horizontal panel on which the sockets and transformers are usually mounted is known as the sub-panel (q.v.).

**PANNILL, Charles Jackson—American radio pioneer.**

Born in Petersburg, Virginia, May 18, 1879. He entered the American Navy, 1898. In 1902 he took a post under Professor R. A. Fessenden and carried out a series of wireless experiments at Hampton Roads, later inaugurating wireless communication between New York and Philadelphia. Pannill was the first man to install wireless on the battleships of the U. S. Navy. In 1914, he carried out a series of communication experiments between various parts of the United States, and became a radius advertiser to the United States Government, 1914, and assistant director of Naval Communications, 1916. Pannill is a fellow of the Institute of Radio Engineers and a member of the Washington Society of Engineers.

**PAPER CONDENSER—A fixed condenser, usually made of tin foil and utilizing a dielectric of paraffin-waxed paper.**

The 1 microfarad by-pass condenser is a typical example of a paper condenser. (See Condenser, By-pass.)

**PARALLEL—See Parallel Connection.**

**PARALLEL CONNECTION—Two or more parts of an electrical circuit so connected that the current divides between them.**

This is also known as a multiple (q.v.) connection, divided circuit or divided circuit. Each member of parts of a circuit are connected in parallel, the same potential is impressed on each part. The current flowing in each branch will depend upon the impressed voltage and the resistance of each branch. (See Circuits, Parallel.)

**PARALLEL RESISTANCES—Resistances connected so that their terminals have the same potential difference between them. The greater the number of resistances in parallel, the less

![](https://example.com/image.png)

**OUTPUT CIRCUIT OF VACUUM TUBE—The filament-plate circuit as differentiated from the filament-grid or input circuit.**

(See Input Circuit of Vacuum Tube.)

**OUTPUT, TRANSFORMER—The product of the voltage at the secondary terminals of a transformer by the current flowing in the secondary winding.**

The output of a transformer is always less than the input by an amount equal to the losses. The efficiency of a transformer is the ratio of its useful output to the total input. (q.v.)

**OVERLOAD RELEASE—A electromagnetic device which is used to cause a motor starter handle to return to the off position when the current exceeds a predetermined overload value.**

The overload magnet is usually arranged so that too strong a current will result in short-circuiting the no-volt release thus switching off the driving current. One form of overload release consists of two circuits, one series with the line and the armature. This magnet is arranged to attract a pivoted keeper which closes the current flows. The pivoted arm, when attracted by the magnet, makes connection between two contacts and is then released by the holding magnet when the circuit is closed. Therefore, when more than the allowable current is drawn from the line, the overload magnet attracts its pivoted keeper which closes the circuit short-circuiting the holding magnet. The contact arm is then released by the holding magnet and the arm is pulled back to the off position, thus cutting the line off. Another form of overload release utilizes an electromagnet to attract a pivoted arm, arranged so that this will break the circuit between the motor and the line. This results in operating the no-volt release. (See No-Volt Release.)

**OVERTONE CURRENTS—Alternating currents which have harmonic frequencies of a higher value than the fundamental or first harmonics.**

**OVERTONES—Higher harmonics associated with the first harmonic. The term particularly refers to sound waves. In various musical instruments, different overtones are brought out and this results in each instrument having its own tone characteristic.

![](https://example.com/image.png)
will be the total resistance of the circuit. If there are three resistances in parallel of $\frac{1}{4}$, $\frac{1}{2}$ and $\frac{1}{5}$ ohm, respectively, then the total resistance is equal to the reciprocal (one divided by a number) of the sum of the separate reciprocals. In this case the sum of the reciprocals is $2 + \frac{1}{2} + \frac{1}{5} = 10$, and the reciprocal of this is 0.1, so that the total resistance of this parallel circuit is one-tenth of an ohm. It can be seen that the total resistance of any circuit having a number of resistances in parallel is less than the resistance of any one of its branches. (See Circuits Parallel, also Parallel Connection.)

PARALLEL RESONANCE—When a concentrated capacity and a concentrated inductance are connected in parallel between terminals to which an alternating electromotive force is applied, and the inductance or capacity or frequency is varied, the condition of parallel resonance exists when the current supplied by the source is a maximum. It should be noted that in series resonance, the total current supplied by the source flows through both the inductance and the capacity whereas in parallel resonance the current supplied by the source is the vectorial sum of the currents, one flowing through the capacity and the other through the inductance.

PARAMAGNETIC—Having a permeability greater than unity. Magnetic as opposed to diamagnetic. The term paramagnetic is used in some cases to apply to substances which have only a slightly greater permeability than air such as liquid oxygen, the rare magnetic metals (ununoctium). If used in this sense it does not include ferro-magnetic substances (q.v.). (See Diamagnetic materials.)

PARTIAL—An acoustical term denoting any one of the natural vibrations of which a body is capable. An electrical oscillator (q.v.) possessing distributed capacity and inductance has, theoretically, an infinite number of possible frequencies, each of which is called a resonant frequency. The lowest frequency is called the fundamental. (See Harmonics, Harmonic Current, Overtones, and Fundamentals.)

PARTITION INSULATOR—An ebonite tube having a metallic rod running through its center with wing nuts at each end by means of which a circuit is completed for connecting a circuit through a wall or partition.

P.D.—Abbreviation for potential difference. (See Potential, Difference of.)

PELTIER EFFECT—The change in temperature, either heating or cooling, at the junction of two unlike metals, depending upon whether an electric current originating from an external electromotive force, is sent through the junction in one direction or the other. The Peltier effect is the opposite of the thermo-electric effect.

PERCENTAGE COUPLING—The coefficient of coupling between the primary and the secondary of an oscillation transformer in a wireless transmitting system. When the primary winding is placed close to the secondary, the coupling is said to be close or tight. When the two windings are apart the coupling is said to be loose. With the ordinary spark gap in the closed circuit, if the primary and the secondary windings are closely coupled a broad wave will be radiated from the aerial system. If they are loosely coupled, a sharp wave will be radiated.

(Please note: the remaining text appears to be missing or incomplete.)

PHANTOM AERIAL—See Mute antenna.

PHASE—A particular state of a regularly recurring cycle of changes. In simple harmonic motion, uniform circular motion, or in periodic changes of any magnitude varying according to a simple harmonic law (as for example an alternating current) the position of a point in the periodic stage to which the rotation, oscillation or variation has advanced, considered in relation to the position of instant of starting or to some other standard position. This relationship is usually expressed in angular measure. Defined in electric terms, phase is the angle usually measured as an angle, of the base of any ordinate (q.v.) of an alternating current wave shown by sine curve.

PHASE ANGLE—The angle, cycle, etc., illustrated by means of sine curves.

PHASE DISPLACEMENT—Cycles per second-frequency. Phase displacement, cycle, etc., illustrated by means of sine curves.

PHASING—See Phase Angle.

PERMANENT MAGNET—Hardened steel which when magnetized retains its magnetism after the removal of the magnetizing force. The usual method of making permanent magnets is to place the steel in a powerful electromagnetic field. They can also be made by stroking with another magnet. Permanent magnets are used in all electromagnetically operated devices and loud speakers. (q.v.) (See Magnet, Electromagnet, also Temporary Magnets.)

PERMEABILITY—The permeance (q.v.) existing between the opposite faces of a cube of the substance each side of which is one centimeter in length. Since the permeability of air is assumed to be unity, the permeability of any substance is the ratio of the flux or magnetic induction in the substance which would exist in air if the magnetomotive force and flux path remained unchanged. PERMEANCE (q.v.) is a property of a magnetic circuit which allows the flow of magnetic flux. Its reciprocal is reluctance (q.v.) which is the property of a magnetic circuit by which it resists the flow of magnetic flux.

PERMITTANCE—A synonym for capacitance (q.v.) or capacitance (q.v.). This property is possessed by every electrical circuit, but does not manifest itself unless there is a change in voltage. The greater the permittance of a circuit, the greater will be the opposition offered to a change in voltage in the circuit. (See Dielectric Coefficient and Constant, Inductive Capacity, also Inductive.)

PERMITTIVITY—See Dielectric Coefficient and Constant, Inductive Capacity, also Inductively.

PETICOAT INSULATOR—An insulator having two or more flanges or petticoats arranged on top of the other for the purpose of reducing leakage and preventing the accumulation of moisture. Petticoat insulators are usually made of porcelain. Insulators used in low tension service are termed of the petticoat type, in such cases being constructed of glass. (See High Tension Insulator, also Insulator.)
Phase Angle

Magnitudes having maximum and minimum values occurring simultaneously are said to be in phase. If they do not occur simultaneously, they are out of phase. Waves having maximum or minimum values of two sinusoidal alternating quantities of the same frequency occurring simultaneously, the two quantities are said to differ in phase by the angle between their nearest negative maxima or their nearest positive maxima, or any other nearest corresponding values. The quantity whose maximum value occurs first is said to lead (q.v.) the other. The quantity whose maximum value occurs later is said to lag (q.v.). Where one quantity lags behind another by 90° or multiples thereof, the values are said to be of opposite phase. An alternating current may be single phase or polyphase. Another term for polyphase is multiphase. In a three-phase alternating current system the three separate currents differ in phase time each other by 120°. In a polyphase system, if the various phases each carry or supply equal current, the resultant isomagnetic field is zero.

PHASE ANGLE—See Phase.

PHASE DISPLACEMENT—The difference in phase or the phase angle between two alternating quantities, such as voltage and current, of the same frequency. Such quantities do not pass through their respective maximum or minimum values at the same time. The instantaneous values of any sine-shaped wave can be represented as being proportional to the sine of an angle, a measure of angular displacement. It is 360° or 600 radians. When two quantities are out of phase, the respective angles corresponding to the maximum instants are unequal, the difference between the two angles being called the phase displacement or the phase difference. In the accompanying illustration, the current and voltage relationship in an alternating current circuit are shown by the two sine curves. As can be seen, the current and voltage are out of phase, the phase displacement being equal to the angle \( \phi \), in this case 90° (\( \frac{\pi}{2} \) radians). The current reaches its maximum value a half cycle later than the voltage. In this case the current leads the voltage by the angle \( \phi \), the voltage leading. When the current is 90° ahead of the voltage, since the angle of lag of the current is 90°, the current and voltage are said to be in quadrature. In an alternating circuit having pure inductance and no resistance (a theoretical circuit, since all electrical conductors have some resistance), the current would lag 90° as in the example given. (See Lag, Lead, Leading.)

PHENOMENA OF ELECTRIC WAVE PROPAGATION—Electric waves are created by electric oscillations (q.v.). They are often referred to as radio waves. Electric waves, light waves, and radiated heat waves are included in the general term electromagnetic waves (q.v.). The velocity of electric waves is the same as that of light waves, 300,000,000 meters per second, or 186,000 miles per second (approx.). Electric waves used for radio work have frequencies from about 19,000 cycles per second to 3,000,000 cycles per second. Since the velocity of electric waves is known, it is possible to calculate the length of a wave if the frequency is known. Thus if the electric wave has a frequency of 10,000 cycles per second, the wavelength is obtained by dividing the velocity in meters per second by the frequency in cycles per second, which gives in this case a wavelength of 30,000 meters. Electric waves are in reality a combination of electromagnetic and electrostatic disturbances in space. The displacements are at right angles to the motion of the wave train. The electric field and the magnetic field are at right angles and travel together. They spread out or expand from the point of disturbance just as water waves spread out from a point where a stone strikes the surface of the water. Electric waves are propagated from an aerial when certain forms of alternating current flow in the aerial. Since the frequency of the propagated waves is proportional to the frequency of the current in the aerial, high frequency current must flow in the aerial to produce high frequency electric waves used in radio. Such current may be produced by a high-frequency generator, by a direct current generator and an electric arc, or by means of vacuum tubes. The latter offer the simplest means of producing the rapidly varying currents. Electric waves may be classified as continuous and discontinuous. Examples of the former are the waves produced by a high frequency alternator, an oscillating vacuum tube or a Poul sen arc. Examples of the latter are the waves produced by a condenser discharge in a spark circuit. In these the amplitudes of the waves diminishes in each wave train and the waves are referred to as damped waves. The high frequency current used to produce continuous waves is called radio telephony. The radio telephony is modulated in accordance with the vibrations of a microphone (q.v.). At a receiving station the waves are sent out from the aerial and these correspond in wave form to the variations of the sound waves. The sensitive apparatus at the distant receiving set picks up or interprets the modulated electric waves, converts them to high frequency electric currents which are rectified into direct currents capable of actuating a 'phone and usually amplified so that they have energy enough to operate a loud speaker. (See Oscil lator, Carrier Wave, also Modulated Currents.)

PHILLIPS, Raymond—British radio expert. Born: October 6, 1879, he was educated at Edgebaston, Birmingham Schorne College, Buckinghamshire, and Windsor High School. For three years he was engaged on railway construction and repairs, with special application to electric railways. In 1902 he invented a single circuit train control and a number of appliances for electric railways which were widely adopted. In 1906 he undertook the study of wireless and specialized in the control of mechanisms at a distance by electric waves. He holds a patent for a system for controlling airships by radio and by means of a working model demonstrated how an airship could be thus controlled. During the World War he was inspector of ordnance machinery and in 1921 was appointed a member of the Inter-Allied Commission of Control in Germany. He is the author of many articles on the control of machines by electric waves.

PHONOGRAPHIC RECORDING—This refers to the amplifying of code signals by means of relays in tandem until the sounds produced in a telephone receiver are loud enough to sustain a distinct record on the wax of a phonograph. The signals can be received at high speed and thereafter read at low speed. Instead of a phonograph a telegraphophone may be used.

PHOTO-ELECTRIC EFFECT—A change in the electrical conductivity of a gaseous or solid substance when radiations of certain wavelengths come in contact with them. This refers particularly to rays of the visible spectrum and ultra-violet and infra-red rays.

PHOTOGRAHIC RECORDER—A device for recording high-speed wireless messages by recording the deflections of a sensitized galvanometer moving photographic film. (See Auto-Receiver.)

PICKARD, Greenleaf Whittier—American radio inventor. Born: October 28, 1878, in Portland, Maine, on February 14, 1877, and was educated at Westbrook Seminary, Lawrence Scientific School, Harvard and Massachusetts Institute of Technology. He made a special study of wireless telegraphy and telephony and has taken out many United States and foreign patents for radio inventions. He is noted for his pioneer work in radio telephony. Pickard began radio work in 1899 at Blue Hill observatory, Milton, Massachusetts, under a grant from the Smithsonian Institute. He was on the engineering staff of the American Telephone and Telegraph Company from 1902 to 1906. Later he was connected with the Wireless Special Radio Apparatus Company, a radio engineering firm. He has an extensive practice as a patent expert in radio telephony. In 1906 he was invited to become a member of the American Institute of Electrical Engineers, a Member of the American Chemical Society and also a member of the Society of Chemical Industry.

PIG-TAIL—A flexible braided or
also used on the carbon brushes of motors and generators. (See Flexible Lead.)

**PITCH**—Frequency of vibration of a sound. A shrill note is said to be of high pitch, a bass note of low pitch. The pitch of an armature winding refers to the distance from the center of a winding to the center of the next winding.

**PLAIN AERIAL**—An aerial having the transmitting or receiving circuit connected directly to it without the utilization of inductive coupling or any intermediate tuned circuit. An example of a plain aerial is one used to transmit code, having a spark gap in series with the aerial and the ground.

**PLATE**—The anode or positive electrode of a vacuum tube. The vacuum tube plate is usually made of nickel. The shape of the plate varies according to the type and construction of the tube; in some tubes the plate is tubular; in others flat. When the cathode or filament is heated, it emits electrons which pass to the grid or through the grid to the plate, depending upon the grid charge. In power tubes (transmitting) it is necessary to use some cooling device to conduct away the heat dissipated at the plate. In some cases a blast of air is used or the plate may be constructed so that it is free to circulate. Other methods of preventing overheating of these tubes are increasing the area of the plate and in some cases creating the inner layer of a tubular plate, or blackening the surface of the plate to increase its heat emissivity.

**PLATE BATTERY**—The battery, usually referred to as the "B" battery having its positive terminal connected to the plate of the three-electrode vacuum tube and its negative terminal leading to the filament. The purpose of this battery is to keep the plate voltage positive with respect to the filament so that the electrons will be attracted sufficiently to the plate. Plate batteries are usually dry cells although there are a number of storage plate or "B" batteries on the market, both of the acid and the alkaline types. It is possible to dispense with the plate battery by using a "B" eliminator, which is connected to the ordinary line-lighting circuit. (See "B", Battery.)

**PLATE CIRCUIT**—The circuit connected to the plate (q.v.) or anode of a three-electrode vacuum tube. See Plate Circuit, Diagram of a Vacuum Tube.

**PLATE COMPONENT, HIGH FREQUENCY**—The radio frequency current which flows in the plate circuit of a vacuum tube. (See High Frequency Component of Plate.)

**PLATE CONSUMPTION**—This refers to the current which flows in the plate of a vacuum tube. Increasing the grid voltage tends to increase the plate consumption. An increasing plate voltage also increases the plate current, but tends to decrease the relatively small grid current. (See Consumption, Current; also Consumption, Plate.)

**PLATE CONTROL**—The vacuum tube starts oscillating at a plate voltage which will depend on the adjustments of the circuit. When the plate voltage is raised, the oscillation current becomes greater, increasing in direct proportion.

**PLATE CURRENT**—The current in the plate circuit of a vacuum tube. The plate current passing between the plate and the heated cathode is the plate current.

**PLATE IMPEDANCE**—The total resistance offered to alternating current between the filament and the plate in a vacuum tube. It is often referred to as the tube impedance. The impedance is independent of the alternating current input voltage.

**PLATE VOLTAGE**—The voltage of the plate of a vacuum tube above the filament. The potential difference between the plate and the filament. This term is usually referred to the voltage of the "B" battery (q.v.) connected to the plate, as for example, if the 220-volt terminal of the battery is connected to the plate of the detector tube, the plate voltage is said to be 220 volts. Soft tubes, formerly used as detectors, operated best at this voltage. Most of the amplifier tubes now used as detectors operate best with 45 volts on the plate, although these tubes vary individually, some operating better with slightly increased voltage and others with slightly reduced voltage, say 50 or 45. The plate voltage generally used on the amplifiers is 90 volts. The new power reception tubes use plate voltages up to 135 volts.

**PILODYNOATRON**—A special vacuum tube, designed by A. W. Hull, having two grids instead of one. This tube utilizes the normal amplifying property of the vacuum tube to obtain a very high voltage gain, as high as 1,000 fold. When such high amplification is obtained, however, the operating adjustments are so very carefully made that some kind of adjustment is necessary.

**PILOTON**—A name given to a highly evacuated vacuum tube used for transmitting purposes. PILOTON is capable of developing as high as 500 watts output since they are so highly exhausted that several thousand volts may be applied to the plate and also since they can carry a plate current of nearly one-half an ampere.

**PLUG-IN COIL**—A plug-in coil, often of the push-pull type, which can be plugged into a socket, thus permitting it to be quickly and conveniently changed to suit the requirements of a circuit. Plug-in coils are used in some circuits in receiving sets designed for operation on widely varying wave bands.

**PLUG-IN TRANSFORMER**—A plug-in transformer (q.v.) specifically used as a radio frequency transformer. Its design is so simple that it is usually simple method of determining polarity is to place the two terminals of a plug-in transformer, close together and observe the manner in which electric and magnetic fields are set up by a current passing through it. For example, if a transformer is connected to a battery so that it is charged through the primary of the transformer, when the current passes through a certain direction through the secondary winding, the right-hand rule will show that a magnetic field will be set up around the secondary winding. On the other hand, if the secondary is reversed, the field will be reversed; hence, it is possible to determine which is the positive pole or terminal of a direct current, and which the negative pole. There are various methods of indicating polarity. A volt meter or an ammeter will show the direction of current flow. An extremely simple method of determining polarity is to place the two terminals of the transformer and connect a battery, a coil of wire, and an ammeter. The terminal of the transformer which is charged by the battery (or a coil of wire) will be the positive one and the other terminal will be the negative one.

**POLARIZATION**—In magnets the differentiation between North Pole and South Pole. In electrical devices or circuits, the differentiation between positive and negative poles. It is often necessary to determine which is the positive pole or terminal of a direct current circuit, and which the negative pole. There are various methods of indicating polarity. A volt meter or an ammeter will show the direction of current flow. An extremely simple method of determining polarity is to place the two terminals of the transformer and connect a battery, a coil of wire, and an ammeter. The terminal of the transformer which is charged by the battery (or a coil of wire) will be the positive one and the other terminal will be the negative one.

**POLARIZATION, ELECTRIC**—The state of a dielectric when subjected to electrostatic forces. The condition is synonymous with electric displacement.

**POLARIZED RELAY**—A relay in which a magnetic core is placed between poles of two electromagnets. When current passes, one pole may change, so that the arm is attracted by one and repelled by the other.
other. A polarized relay is much more sensitive to weak currents than the ordinary relay.

POLES—See Magnetic Poles.

POLYPHASE—Referring to an alternating current system in which the circuits are divided up into two or more branches having their currents displaced in phase from each other. The term polyphase has the same meaning as polyphase. (See Phase.)

POLYPHASE ALTERNATOR—An alternating current generator wound in such a way that it supplies two more currents which differ in phase (q.v.) from each other by definite phase angles. The usual form of polyphase alternator is the three-phase alternator.

PORCELAIN CLEAT—See Cleat.

POSITIVE ELECTRODE—In a primary cell, the zinc plate or anode (q.v.) is the positive electrode, while the pole of this electrode is the negative pole (q.v.) because it is negative in relation to the external circuit. In a storage cell, the lead peroxide plate, which is the cathode during discharge, is considered the positive electrode and its pole the positive pole.

POSITIVE TERMINAL POLE—The pole or terminal out of which current is intended to flow. This is more or less of a handy convention, but is contrary to the present day knowledge of electrical force inasmuch as electrons move from negative to positive.

POTENTIAL—See Potential, Electric.

POTENTIAL DIFFERENCE OF—Abbreviation P.D.—Difference of electrical level. Theoretically the potential difference between two points in an electric field is measured by the work done by the electric field on a unit charge of positive electricity moved from one point to another without disturbing the field. Potential difference is measured in volts. It may refer to any two points in a circuit, even though there is no source of electromotive force between these points. When applied to circuit between two points not possessing a source of electromotive force, the potential difference between the two points under consideration is equal to the product of the current flowing through the cell and potential of the circuit between the two points. In the case of an open circuit, such as the terminals of a cell, the potential difference is equal to the electromotive force. (See Potential, Electromotive forces, also Volt.)

POTENTIAL DROP—The fall in voltage in a circuit due to the resistance of the conductor. (See Potential, Electric; also Potential, Difference of.)

POTENTIAL, ELECTRIC—Electrical pressure, or the degree of electromotive force (q.v.). Potential is electrical level. Electrical potential can be compared with the "level" of water. Thus it is customary to measure the height or head of water above sea level, which is assumed as an arbitrary base. In a somewhat similar manner, the potential of the earth is taken as zero and all potential is measured from this as an arbitrary base. With this understood, it is no longer necessary to refer to the degree of electromotive force, but simply to the electromotive force or the potential. (See Potential, Difference of, also Volt.)

POTENTIAL ALERVEY — Energy of position. When energy is available for the production of work, it is referred to as potential energy. Energy at work is kinetic energy (q.v.).

Fig. 1. Tuned radio frequency circuit showing use of potentiometer to control oscillations.

Fig. 2. A simple form of potentiometer used for electrical measurements.

POTENTIAL RECTIFIER — A crystal (q.v.) or other form of rectifier which requires an initial current to pass through it to become sensitive.

POTENTIOMETER (Potential Divider)—A resistance connected across a battery or other source of electromotive force and moved with a slider so that the voltage on another circuit may be varied from zero to the full potential of the battery. A gas discharge or other detector vacuum tube is used, the purpose of the potentiometer is to permit a close adjustment of the-master battery (q.v.) potential. The potentiometer circuitry or other source of electromotive force and equipped with a slider so that the voltage on another circuit may be varied from zero to the full potential of the battery. Its resistance being so high that its power consumption is practically negligible. In tuned circuits for measuring potential difference.

Using certain accessories, laboratory potentiometers can be used to measure voltages over all ranges, and by applying Ohm's law (q.v.) the measurements obtained can be used to determine a wide range of current values.

The simplest form of potentiometer used for electrical measurements is shown in Fig. 2. In this instrument, a constant current from the battery B is flowing. F is a regulating resistance used to compensate for the variations of the electromotive force of the battery. The current in AC is checked for constancy by noting that the drop in potential between the two points selected in it is equal to the electromotive force of a standard cell. If the standard cell is connected in the circuit GHJ at J and the regulating resistance is adjusted until the sensitive galvanometer shows no deflection.

With the assumption that AC has a uniform resistance throughout its length, and the current in it remaining constant, it is obvious that any other voltage not greater than the drop between A and C can be measured by connecting the battery at J and shifting the points G and H until the galvanometer again comes to a balance.

A direct reading scale may be placed between A and C. For ordinary potentiometer measurements, the drop between A and C is made about 1/4 volts as this is approximately the electromotive force of a standard Clark cell.

POULSEN ARC—An arc usually burned in hydrogen between a rotating carbon cathode and a water-cooled copper anode in a magnetic field. This arc is connected to an oscillating circuit, and, due to its instability it maintains a continuously fluctuating disturbance which is utilized for the production of continuous waves for radio telegraphy and telephony.

POULSEN, Valdemar—Danish radio pioneer. Born in Copenhagen, November 23, 1869; he was educated at Copenhagen University and in 1893 he joined the Copenhagen Telephone Company. In 1903 he invented his famous system of arc transmission. Poulten is a fellow of the Danish Society of Sciences. In 1900 he was awarded the Grand Prix at Paris.
POUNDAL.—A unit of force. That for which a mass of one pound gives it a velocity of one foot per second. It is equal to the weight of a pound mass divided by the acceleration of gravity on this earth, or 13,855 dynes or approximately half an ounce.

POWER.—The rate of doing work. A certain amount of work is done in a day or in a week. In the former case, more power is expended than in the latter case. Mechanical power is measured in horsepower (h.p.). One horse power is equivalent to 33,000 foot-pounds per minute. Since power is work done in a unit of time, the corresponding unit of power must contain a time element and a work element. Work is a measure of force expended through a distance. Hence the foot-pound measures work. Electrical power is the product of voltage times amperage. It is measured in watts (w). (See Kilowatt.)

POWER AMPLIFIER.—See Power Amplification.

POWER AMPLIFICATION.—Amplification by means of apparatus consisting of a combination of power vacuum tubes, which can carry larger currents than the ordinary tubes and specially designed transformers. Power amplifiers are used in the transmission of speech and music by large radio stations.

POWERS—The apparent power and the power factor (q.v.) in an alternating current circuit. At any instant, the apparent power, inasmuch as it takes into account the phase displacement (q.v.) between the current and the voltage, is the product of the product of the apparent power and the power factor (q.v.). (See Kilowatt.)

POWER, TRUE.—The product of the apparent power and the power factor (q.v.) in an alternating current circuit. At any instant, the apparent true power, inasmuch as it takes into account the phase displacement (q.v.) between the current and the voltage, is the product of the power and the current. A voltmeter and ammeter cannot be used to measure power, however, since the product of the two readings is not given by the true power.

POWER TUBE.—See Vacuum Tube, Power.

PRACTICAL UNITS.—In the practical system of electrical units, the ohm is the unit of the ampere and the volt is the fundamental units. While the practical system is based originally on the Centimeter Gram Seconds system, it is in no way dependent upon these systems. The flow of electricity along a conductor is analogous to the flow of water through a pipe. In order to make water flow, a pump is often used to force the water from one part of a system to another. Similarly, electrical pressure must be applied in order for an electric current to flow.

PRESSURE.—See Potential, Electric.

PRESSURE, ELECTRICAL.—The term is synonymous with voltage (q.v.) or electromotive force (q.v.). Electrical pressure is the cause of current flow. It is measured in volts (q.v.). The flow of electricity along a conductor is analogous to the flow of water through a pipe. In order to make water flow, a pump is often used to force the water from one part of a system to another. Similarly, electrical pressure must be applied in order for an electric current to flow.

PRIMARY CELL.—A device for transforming chemical energy into electrical energy. A mass of two conductors placed in a liquid which acts chemically on one conductor, or more often on both conductors, is used up and the liquid is also consumed. In many types of primary cells these can be replaced. The liquid is called an electrolyte (q.v.). In some cases an acid is used while in others a salt solution is the electrolyte. (See Cell, Cell Secondary; Cell, Theory of Primary: Electrolysis, Local Action, Polarization, also Electrolysis.)

PRIMARY CIRCUIT.—A circuit supplying current to another which is called the secondary circuit. The two circuits are usually coupled by means of a transformer, the primary winding being in the primary circuit and the secondary winding being in the secondary circuit.

PRIMARY CURRENT.—See Current, Primary.

PRIMARY ELECTRONS.—The main stream of electrons given off by the hot filament of a vacuum tube, as differentiated from the electrons (q.v.) which may be detached from the plate by the impact of the primary electrons. (See Negative Resistance.)

PRINCIPLE OF PRIMARY INDUCTANCE.—A variable inductance in the primary circuit of a radio transmitter. It is also referred to as the aerial tuning inductance. The aerial inductance coil may be continuously variable utilizing a sliding contact which bears on an edgewise copper strip or it may be of the drum type, in this case being made of stranded copper cable. (See Inductance Coils, also Pancake Coils.)

PRINCE, Charles Edmund.—British radio expert. Born in 1874 at Cape Town and educated at Clifton and Faraday House, he joined the Marconi Wireless Telegraph Company in 1907, where he was concerned chiefly in research work on wireless telephony. In 1909 he carried out experiments in Italy and Switzerland with the first Marconi Field Station and made a number of valuable improvements in the Bellini-Tosi direction finder. In the World war, he joined the Royal Flying Corps and in 1916 he installed the first radio telephone on aircraft.

PRINTER, MORSE.—See Morse Inker.

PROTON.—A unit of positive electricity. The smallest quantity of positive electricity capable of existing in a free state. A minute particle or quantity of positive electricity carried by the nucleus of a hydrogen atom. (See Electrons Theory, also Free Electrons.)

PULSATING CURRENT.—A periodic current, that is to say a current passing through the successive equal cycles of values, the average value of which is not zero. A pulsating current is the sum of an alternating and a direct current. A current which varies regularly in magnitude is said to be pulsating while if it remains the same in magnitude it is called continuous. (See Continuous Direct Current, also Current, Pulsating Direct.)

PULSATING DIRECT CURRENT.—See Pulsating Current.

PUPIN, Michael.—American radio authority. Born in Hungary, October 4th, 1858, he came to the United States at the age of 10, and was educated at Columbia University. He also studied at Oxford University, England. In 1891 he was appointed professor of mathematical physics at Columbia University, where he carried out an important series of researches in radio telegraphy and telephony. He is the holder of a large number of patents relating to telephony and radio, has done valuable research work on reso-
Push-Pull Amplification

PUSH-PULL AMPLIFICATION — A method of connection in a vacuum tube receiving set, for supplying more power to the loud speaker than that ordinarily obtainable from a one or two stage audio amplifier. In the push-pull amplifier two tubes are used in the final stage of the amplifier, connected in such a way that they are used alternately on the two halves of each audio frequency cycle. A push-pull amplification circuit is shown in Figure 1. The first tube at the left gives the first stage of amplification and the other two in combination give the second stage. An ordinary audio frequency amplifier transformer is connected to the grid and filament of the first tube. Special transformers are usually used for the other two transformers. These have connections brought out from the center point of one of the windings as shown. The transformer between the two stages has a split secondary while the last transformer has a split primary. In cases where a tapped wound transformer is not available, two transformers can be used instead. In this case the two primary windings are connected in a way that the two secondary windings are also connected in series. Figure 2 shows the method of connecting two transformers for this purpose, a connection being made to the mid-point between the secondary windings. It is essential that the two windings in series be connected so that they are continuous in the same direction around the transformer cores. In theory, the push-pull amplifier uses one tube during half of the cycle and the other tube during the other half of the cycle. While the terminal of the secondary transformer winding leading to the grid of the tube is at a positive potential with respect to the middle of the winding, the tube is effective. During the remaining half of the cycle when the terminal is negative with respect to the tap, the tube is not operating. The action however is such that one tube is effective at all times. Although ordinary amplifier tubes can be used in the push-pull amplifier circuit it is desirable to use special power tubes which have a high amplification coefficient.

![Diagram of a push-pull amplification circuit.](image)

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QUADRANT—A term formerly in use as the unit of inductance (q.v.), now called the henry (q.v.). Inductance has the same dimensions as length and the unit is a one square centimeter of magnetic circuit, being approximately the length of one quadrant of the earth.

QUADRANT ELECTROMETER—A sensitive electrometer (q.v.) which in its calibrated form is known as an electrostatic voltmeter (q.v.). In the usual type, the "needle" consists of a thin aluminum plate suspended on delicate knife edges, with a pointer extending from the upper part to a scale. Two pairs of quadrant plates, having opposite faces metallically connected together, are placed on either side of the movable plate and parallel to its face. Each pair is insulated from the other pair. When the pairs of quadrants are subjected to a difference of potential, the needle, if highly charged, will be attracted into one pair or repelled out of the other. (See Kelvin's Electrostatic Voltmeter, Voltaic.)

QUADRATURE—The differing in phase (q.v.) of two alternating current quantities by 90 degrees. For example, when the current lags behind the impressed voltage by 90 degrees, as in the case of pure inductance in a circuit, the current and voltage are said to be in quadrature. (See Lead, Llag, also Leading Current.)

QUANTITY OF ELECTRICITY—When referring to static electricity, it is the amount of the charge. Referring to electricity in motion, or an electric current, it is the amount of current flowing in a given time. Quantity of electricity is measured in coulombs (q.v.). The coulomb is the quantity of electricity which has passed when a current of one ampere flows for one second. The symbol which is usually used to signify quantity of electricity is Q.

QUANTUMETER—A type of ballistic galvanometer in which the swing of the moving system is proportional to the quantity of electricity passing through the instrument. A galvanometer of this type is used for magnetic testing in the case of the fluxmeter (q.v.).

QUARTER PHASE—A two-phase alternating current system having two currents differing in phase by 90 degrees or, in other words by one-quarter of a cycle.

QUARTZ LAMP—A mercury vapor lamp which utilizes a tube of quartz instead of a glass container. Increased current densities can then be employed, since higher temperatures can be used with quartz than with glass.

QUARTZ OSCILLATOR—The piezoelectric quartz plate may be used as a resonator (q.v.) or as an oscillator (q.v.). When used as an oscillator it may be used either as a master oscillator controlling the frequency of a radio transmitting station's output or as a frequency indicator. All three of these uses are applicable to the work of maintaining station frequencies constant. The applicability of the piezoelectric quartz as a frequency indicator in broadcasting stations has been tested carefully by the United States Bureau of Standards, and found to be useful and satisfactory. This method gives a means of maintaining an extremely accurate check of the transmitting station frequency. (See Master-Oscillator System, also Frequency Meter.)

QUENCHED GAP—See Quenched Spark Gap.

QUENCHED SPARK—See Quenched Spark Gap.

QUICK-BREAK SWITCH—A switch provided with auxiliaries contacts which are released after the main contacts. The auxiliary contacts are separated rapidly, regardless of the speed with which the switch handle is pulled. This action is obtained by the tension of a spring connected between the main switch blade and the auxiliary blade. This shows the illustration.

QUIESCENT AERIAL—In a radio telephone transmitter, an aerial operated in such a manner that the carrier wave is suppressed when transmission is not actually taking place.
“R”—Symbol for resistance (q.v.)

RADIANT ENERGY—Energy transmitted through space by means of vibrations of the ether, such as electromagnetic energy, light or heat. (See Airy’s Law.)

RADIANT HEAT—Infra-red radiation (q.v.) as for example radiation from substances at temperature insufficient to cause visible light rays.

RADIATING CIRCUIT—An electrical circuit which emits energy in the form of either waves. In a transmitting system, the aerial circuit, any circuit which radiates energy is a radiating circuit.

RADIATION—The transference of energy in waves through space which is not necessarily occupied by matter. Transference of energy through ether (q.v.). Electric or electromagnetic radiation refers to the radiation by means of electromagnetic induction. The radiation field is transmitted by wave motion. Various types of electromagnetic waves may be sent out by a radiating system. In one system the waves are known as damped waves (q.v.) in another undamped waves (q.v.) are used.

RADIATION EFFICIENCY—The radiation efficiency of an antenna at a given wave length is the ratio of the power radiated to the total power delivered to the antenna (resistance).

RADIATION FROM ANTENNA—In the case of a simple vertical antenna, electromagnetic waves are radiated in semi-loops since the lower end of the aerial is grounded. Fig. 1 gives an idea of the way in which the intertwined electric and magnetic fields radiate from the antenna. It should be noted that the electric and the magnetic fields are in planes which are at right angles to each other. The electric lines are shown in elevation while the magnetic lines appear in plan, with the wave form common to both being shown between. At any single point in space, the lines rate as close together as bellows. After the wave has travelled a certain distance, the lines can be regarded as sections of planes and the electric lines can be represented by the diagram shown in Fig. 2. The magnetic lines be represented in the figure, provided this is considered to have been rotated about its horizontal axis through an angle of 90° if desired, in a direction which may be open or closed coil type, the radiation will take place in the same general way, loops formed and detached as described. (See Electromagnetic Waves, also Height of Aerial.)

RADIATION RESISTANCE—the radiating current at the point of maximum current. The property of an antenna by means of which radiation of energy takes place. Some of the power supplied to a circuit, carrying radio currents, is radiated in the form of electric waves. The radiation is a measurement of the useful work obtained from the circuit. The greater the power radiated in conjunction with the power multiplied in the circuit itself, the better will be the transmission. At any frequency, the power radiated is proportional to the square of the current flowing, hence the radiative effect may be regarded as causing artificially, an increase in the effective resistance of the circuit. This resistance increase is known as “radiation resistance” as being proportional to the square of the frequency or inversely proportional to the square of the wave length. (See Radiation Resistance.)

RADIATION TRANSMISSION—See Radiation from Antenna.

RADIO—The transmission of intelligence by means of electromagnetic waves through the ether. Radio falls under two general classifications; radio telephony (q.v.) and radio telegraphy (q.v.). (See Radio Channel, Radio Communication, Radio Control, also Radiophone.)

RADIO-ACTIVITY—The emanation of energy by certain substances, such as radium, caused by a continuous detachment of electrons from the substance.

RADIOCAST—A term sometimes used instead of Broadcast (q.v.). To transmit speech, music, or other sounds by radio telephony (q.v.).

RADIO CHANNEL—A band of wave lengths or frequencies of a width sufficient to permit of its use for radio communication without the radiation of subsidiary waves of more than a certain intensity at wave lengths or frequencies outside of such a band.

RADIO COMMUNICATION—The transmission of intelligible signals by means of electromagnetic waves. The signals may be in the form of code as in radio telegraphy or in the form of speech or music as in radio telephony. They may be transmitted through the ether (q.v.) without the use of intervening conductors as in ordinary radio, or along conductors as in wireless (q.v.).

RADIO COMPASS—A simple form of radio direction finder used for guiding purposes. The radio compass depends for its principle of operation upon the directional effect of a coil antenna, the coil mounted on a vertical axis so that it may be rotated freely, is an essential part of the radio direction finder. By rotating the coil while a particular station is transmitting, it is possible to fix the line of transmission in any other direction. The coil may be mounted so that the maximum signal will be received when the transmitting station lies in the plane of the coil. The device may also be set for minimum signal reception in which case the transmitting station lies in a plane perpendicular to the face of the coil. It is possible to obtain a much sharper determination of direction by the coil on the minimum position and this method is generally used for direction finder work. (See Goniometer.)

RADIO CONTROL—The control of motor driven devices such as marine vessels, airplanes, automobiles, etc., by means of special radio receiving apparatus designed to respond to radio impulses. A radio controlled automobile is an example of the radio controlled vehicle. John Hays Hammond, Jr. (q.v.) has invented radio controlled ships and also radio controlled air craft.

RADIO FREQUENCY—A term in the electromagnetic spectrum used to describe waves having a frequency from 20,000 to 2,000,000 cycles per second. There is no hard and fast rule regarding the upper and lower limits, since much higher or much lower frequencies may still be considered as radio frequencies. (See High Frequency Current.)

RADIO FREQUENCY CURRENT—An alternating current having a frequency of from 20,000 to 2,000,000 cycles per second. There is no hard and fast rule regarding the upper and lower limits, since much higher or much lower frequencies may still be considered as radio frequencies. (See High Frequency Current.)

RADIO FREQUENCY SELECTIVITY—The radio frequency selectivity of a simple element of a transmitting or receiving device is the ratio of resonant response (in terms of effective voltage or current measured at the radiating or receiving element) to non-resonant response. The radio frequency components of the elements of that system are tuned to one percent of the resonant frequencies in this case, a simple element refers to a combination of an inductance, a capacitance and optionally a resistance. (See Amplifier, Radio Frequency.)

RADIO FREQUENCY SIGNALS—The signals used in radio transmitting circuits. The currents flowing in the antenna circuit are radio frequency currents corresponding to the currents flowing in the transmitting circuit. (See Amplifier, Radio Frequency.)

RADIO Goniometer—See Goniometer.

RADIOGRAM—A message sent in code by radio. A radio telegraphic message.

RADIOGRAPH—A radiographic "lighthouse" intended to aid navigation by emitting characteristic signals. By estimating the bearings of two charted radiohapes, the mariner may determine the position of his ship.

RADIO TELEGRAPH—The transmission of messages by means of electro-
magnetic waves using dot and dash code signals. A transmitter furnishes a source of high frequency alternating current which oscillates rapidly in the antenna system thus sending out electric and magnetic waves. These waves are intercepted at the receiving station by the receiving aerial. At the receiving aerial, the electromagnetic waves are changed into alternating current which is rectified by a detector in the receiving apparatus, then amplified and sent on to the receiver (q.v. or loud speaker (q.v.). Of course, a means of interrupting the current to produce dots and dashes must be provided; this is done in a radio by a suitable circuit and suitable tuning devices are used in both the transmitter and the receiver.

RADIO TELEPHONY—The transmission of speech, music, or other sounds by means of electromagnetic waves is called telephony.

In the standard systems of radio telephony continuous waves are used of a much higher frequency than those of audible sound. Single or a group of these is modulated by the connection of a microphone in the transmitting circuit. The resulting compound waves is similar to that employed in radio telegraphy and is arranged so that the head set or loud speaker responds to the current in the receiving waves and reproduces the sounds as originally produced at the transmitter.

RADIO TELEGRAPHY—the sending of signals, speech, music, or other sounds by means of electromagnetic waves is called telegraphy.

RATIO—Relative values of quantities of the same kind, or number of times one quantity is contained in the other.

RATIO OF TRANSFORMATION—the ratio between the primary and secondary windings of a transformer. This defines the ratio of the primary to the secondary voltages. Thus if a transformer has a ratio of transformation of 1:3 then the secondary will have three times as many turns as the primary and the secondary voltage will be approximately one third of the primary voltage.

RATIO OF UNITS—the ratio of the unit pole in the electromagnetic system to the unit pole in the electrostatic system, or of the unit charge in the electromagnetic system to the unit charge in the electrostatic system. Its numerical value is approximately 3 x 10^9.

RAYLEIGH, John William Strutt—British physicist, born at Longford Green, Essex, November 12th, 1842. He was educated at Trinity College, Cambridge. Rayleigh was appointed Cavendish professor of experimental physics in succession to Clerk-Maxwell; a position he held until 1894. In 1887 he became professor of natural philosophy at the Royal Institution and was appointed president of the Royal Society in 1905. In 1908 he was appointed Chancellor of Cambridge University, and died June 19, 1919. Throughout his life Rayleigh was considered by many to have been one of the most brilliant experimental physicists of the nineteenth century. He not only had a remarkable power of mathematical analysis, but was equally skilful in experimental work and in the carrying out of his theoretical researches. Many of his experiments were made with home-built apparatus. He threw a fresh light on nearly every branch of physics, from the theory of gaseous wave theories and electric and magnetic problems. Due to the care with which he carried out his experiments, he was the first to detect the presence of neon in the atmosphere, this being the forerunner of the discovery of a number of other rare gases in the atmosphere. The Rayleigh balance for absolute current measurement is as well known as it is important. Lord Rayleigh was one of the original members of the Order of Merit. In 1882 he was awarded the Royal Medal, in 1899 the Copley Medal, the Roy Medal, and in 1904 the Nobel Prize for Physics.

REACTANCE—That property of an electric circuit, aside from its ohmic resistance, which tends to oppose the flow of an alternating current. Mathematically, reactance is defined as the square root of the difference between the square of the impedance (q.v.) and the square of the effective resistance of a given portion of an electric circuit. Expressed as an equation, reactance X = \sqrt{Z^2 - R^2} where Z is the impedance and R the resistance of the part of the circuit under consideration. Reactance due to capacitive and inductive reactance is known as condensative reactance. The reactance of a condenser of capacity C to an alternating current (of sine wave form) of frequency f is expressed by the equation Xc = \frac{1}{2\pi fC}. Reactance is measured in ohms.

REACTANCE COIL—REACTANCE COIL—Terms used in England to describe the tickler coil (q.v.) used in regenerative sets to couple back part of the energy in the plate or output circuit to the input circuit.

RECTIFIER, FULL WAVE—A device for converting alternating current to direct current in which both positive and negative alternations are utilized. This differs from the half-wave rectifier which rectifies by suppressing alternate waves. (See Full Wave Rectifier, Rectifier, Full Wave.)
Rectifying Action

Wave Rectification, also Half Wave Rectifier.

RECTIFYING ACTION OF CRYSTAL DETECTOR—The crystal detector has the property of allowing radio frequency alternating currents to pass through it in one direction only. In other words the alternating current is rectified. See Crystal Detector Theory of Operation, Crystal Detector, Crystal Rectifier, Rectified Signals, also Rectified Current.

RECTIFYING TUBE—A vacuum tube used to convert alternating current into direct current. Rectification can be accomplished by a two-ray tube, having filament and plate. In this case the electron flow is from the hot filament to the plate. A two-ray tube made especially for rectifying purposes is known as the kenotron (q.v.). Another recent type of rectifying tube, known as the helium tube (trade name, Raytheon) utilizes a different operating principle, known as the "short path" principle, whereby the rarefied gas acts as an insulator between points which are in close proximity. This is in apparent contradiction of the observed phenomenon that the smaller the distance between two points the more readily a spark will jump between them due to the ionization of the gas. How-}

ever, if the distance is small enough and a suitable gas is used at a low enough pressure, an electron may encounter no gas molecules in its path between the points and there will be no ionization by collision. Consequently, the inert gas helium, may be made to act as a perfect insulator at low pressures. Furthermore, he has found that when a larger electrode of a gas conduction tube is negative, there is a greater current flow than when the smaller electrode is negative and that the smaller the positive relative to the negative electrode, the smaller is the ionization and hence the more complete is the rectification. Figure 1 shows a typical helium tube, while Figure 2 illustrates its construction. The two small positive electrodes A, A, are carried through two small glass tubes imbedded in a lava insulating block L so as to project very slightly into a lava cup C whose walls constitute the negative electrode being connected to the negative terminal through the base. The diameters of the small wires and the diameters and positions of the holes whereby they enter the cup are so proportioned as to give the necessary short path to the negative electrode. The cup C contains helium gas at such low pressure as to prevent gaseous conduction.

This gives an insulance of great reliability and long life and makes possible extra long anode surfaces which reduce the back current to a negligible quantity.

Fig. 2. Construction of the Raytheon tube.

RECTIFYING VALVE—This usually refers to a rectifying tube (q.v.) though it may refer to an electrolytic rectifier (q.v.)

RECTICON—The trade name of a storage battery charger which utilizes the vacuum tube rectifier principle. (See Charger, Storage Battery, also Rectifying Tube.)

RED MAGNETISM—An obsolete term for the lines of force coming from the north pole of a magnet.

REDUCE WAVE-LENGTH OF AERIAL—The wave-length of an aerial may be reduced by the use of series condensers. However, this method should be avoided where possible, since it results in a loss of power. Shortening the aerial is a preferable method of reducing wave-length.

REFLECTING GALVANOMETER—See Mirror Galvanometer.

REJECTION—Radio waves are reflected and also refracted when they pass into a region of different dielectric constant. A perfect conducting sheet would reflect all of the wave energy striking it. A conductor parallel to the direction of propagation of a wave serves to guide the direction of the wave. The reflection and other modifications of radio waves serves to explain fading (q.v.) and other irregularities of broadcast signals. It has been found that broadcast signals will have most uniform intensity when long waves are used and during the daytime. Moreover, transmission will be better over a uniform conducting surface, such as the ocean. It is assumed that the space through which a radio wave travels is bounded by the surface of the earth and by an upper region which during the day is a fairly good conductor. The transmitted waves are guided by the two conducting mediums but in addition are assisted materially by reflection especially during the time that the air is partially ionized by the radiation of the sun.

REFLECTION COEFFICIENT—(Of a surface of discontinuity between two media.) The ratio of the reflected field intensity near the surface to the incident field intensity near the surface.

REFLEX—See Reflex Circuit.

REFLEX CIRCUIT—A radio receiving circuit invented by Marius Latour in which the vacuum tubes are made to perform double duties as both radio and audio frequency amplifiers. The incoming radio frequency current is amplified at radio frequency, rectified by a detector (which may be a crystal detector) and then amplified at audio frequency, using the same tube.

A typical reflex circuit using one tube and a crystal detector.

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A typical reflex circuit using one tube and a crystal detector.
REJECTOR

REGENERATION—The

in

addition
tistance
cacity
producing
Back,
Coupling,
Circuits.)
Feed-Back
(See
Armstrong
Circuits,
Feed-Back,
Feed-Back
Coil,
Feed-Back
Coupling,
Feed-Back
Effect,
also
Regenerative
Circuit.)
Fig. 1. An acceptor-rejector circuit used as a wave trap.

REGENERATIVE—See
Regenerative
Circuit.

REGENERATIVE CIRCUIT—A method of connecting up vacuum tubes for radio reception in which the amplified variations of the plate circuit are superimposed inductively on the grid or input circuit thus producing a re-inforcing effect which results in increased sensitivity. (See Armstrong Circuits.)

REINARTZ CIRCUIT—A selective regenerative circuit devised by John L. Reinartz in which a spider-web inductance coil acts as primary, secondary and tickler. Capacity feed-back (q.v.) is accomplished by means of a variable condenser. In the improved Reinartz a varicoupler is used, connected as a variometer, in addition to the condenser feed-back.

REJECTOR—See
Reactor
Circuit.

REJECTOR CIRCUIT—A circuit consisting of a combination of inductance and capacity for filtering out or preventing the passage of currents of certain frequencies. This circuit is used in connection with a radio receiving set to obtain greater selectivity. The inductance and the capacity are arranged in parallel to form a resonant circuit. The constants of this circuit are so chosen that at the particular frequencies to be filtered, the capacity current will exactly equal the inductive current, thus giving zero resultant current. The primary application of the rejector circuit is as an interference eliminator (q.v.) or wave trap (q.v.). Figure 1 shows the application of the rejector circuit applied to a radio receiving set. The circuit shown is a combination acceptor-rejector circuit. The rejector circuit is shown in heavy lines. The inductance and the capacity are connected in parallel with each other and with the acceptor circuit and this latter is inductively coupled to the receiving set circuit. Both the acceptor and the rejector circuits are tuned to the wave length of the receiving aerial. By using more than one

REJECTOR CIRCUIT
ACCEPTOR CIRCUIT

Fig. 2. A rejector circuit designed to filter out undesired spark signals.

rejector and acceptor circuit increased selectivity can be obtained. A rejector circuit used to filter out undesired spark signals is shown in Figure 2. A small inductance of about ten turns is employed in this circuit and this is inductively coupled to a closed tuned circuit and wired in series with the aerial, and the aerial terminal of the set. If a spider-web coil is used in the closed circuit, a suitable value for broadcast wave lengths is 50 turns coil, placing the aerial coil in such a position as to get closest coupling. The variable condenser should have a capacity of .0005 mfd. (See Acceptor.)

RELAY—An electromagnetic device by means of which contacts in one circuit are operated by a change in conditions in the same circuit or in one or more associated circuits. (See Magnifier.)

Resinous Electricity

A telegraphic relay.

RELUCTANCE—Magnetic resistance. The reluctance of a magnetic circuit is analogous to electrical resistance. All magnetic circuits offer reluctance to flux. The name rel is widely used as the unit of reluctance. The rel is the reluctance of a magnetic circuit which will have one line of force in it, upon application of one amper-turn. The rel can also be specified as the reluctance of a cylinder of air, or of any other non-magnetic material, one square inch in cross-sectional area, and 3.10 inches long. The reluctance of a magnetic circuit is equal to the magnetomotive force (q.v.) divided by the reluctance. (See Magnetic Properties.)

RELUCTIVITY—The reluctance (q.v.) per unit length and per unit cross-section. The reluctance of an outstriped magnetic circuit per cm². Reluctivity may be defined as specific magnetic resistance. It is the reciprocal of electrical conductivity.

REMANENCE—The term applied to the magnetism remaining in a magnetic circuit when the magnetizing force is removed.

REMOTE CONTROL—A control system whereby a radio transmitting or receiving apparatus may be operated at any desired distance from the apparatus. The chief advantage of remote control lies in the fact that the high tension apparatus and the tall aerial masts may be located in outlying districts whereas the studio can be located at any desired, convenient point. In addition it is possible to broadcast concerts, theatrical entertainments, prize fights, etc., direct from the scenes of action by utilizing remote control.

REPEATING COIL—A transformer of usual ratio used in telephone practice.

RE-RADIATION—The relaying of a radio wave through the action of a receiver employing regeneration. This phenomenon is most commonly observed in receivers of the super-heterodyne type.

RESIDUAL CHARGE—The residual electricity retained by a condenser after discharge. This is also known as electric residue or soakage. After the condenser is discharged in the ordinary way, the residual charge permits a second discharge, smaller than the first. (See Soaking in.)

RESIDUAL MAGNETISM—The magnetic force retained by iron, after the magnetizing force is withdrawn. After a mass of iron has become magnetized, some of the magnetism will remain, even though the magnetizing force has been taken away. The amount of residual magnetism depends on the quality of the iron. Pure wrought iron, in general, retains very little residual magnetism, whereas wrought iron which has gone through a hardening process, or which contains a large percentage of impurities and also cast iron possesses a much larger amount of residual magnetism.

RESINOUS ELECTRICITY—An obsolete term for negative electricity, adopted because of the fact that resinous bodies become negatively charged by friction. (See Vitreous.)

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RESISTANCE

RESISTANCE—Symbol $\Omega$ (Omegas)—

Every conductor of electricity offers opposition to the flow of electricity. Resistance is a property of the conductor itself. It increases with increased length of conductor, decreases with increased cross-sectional area, and is greater or less depending upon the material of the conductor. Resistance is measured in ohms. (q.v.) The ohm is equal to $10^{-6}$ C.G.S. electromagnetic unit.

RESISTANCE BOX—A box containing a number of wire coils of known resistances connected in various combinations, by means of switches or plugs, to produce any desired total resistance.

RESISTANCE COUPLED AMPLIFIER—A type of amplifier (q.v.) which utilizes high resistances for interstage coupling. Resistance coupled amplifiers are non-inductive and the purity of tone obtainable and the absence of distortion. In addition radio receivers of this type are comparatively inexpensive to build. It should be noted, however, that with resistance coupled amplification, the amplification per tube is much less than with transformer coupled amplification and furthermore the drain on the "B" batteries is also much greater. Of course, a resistance box.

A resistance box.

causes a voltage drop to take place in two places in the tube. The total resistance of the plate circuit is equal to the internal resistance of the tube plus the resistance added to the resistance $R$, and if the number of tubes in an amplifier. In order to do this the grids of the tubes must be separated electrically from the high voltages of the power-supply cabling tubes, but only as far as the steady voltage is concerned, while the fluctuating voltage of these plates must be impressed on the grids of the following tubes. This is done by introducing condensers between the two resistances. These effectively block the direct currents while they afford easy passage to alternating currents. Figure 3 shows the introduction of the condenser between the plate resistance and the grid resistance. Inspection of this diagram shows that although tube No. 1 remains the same, the plates instead of being connected directly to the grid of tube No. 2 is separated from the latter by means of the condenser C. If voltage fluctuations now occur across the resistance $R$, they will also be effective across the grid and filament of tube No. 2, because R exerts its influence between plate and filament of tube No. 1. As the condenser, C, couples the grid voltages only, the voltage fluctuations against $R$ are then effective across the filament and grid of tube No. 2. The value of $R$ is shown to be 90,000 ohms. It is assumed that tube No. 2 be provided with a grid leak, $R$, for the accumulated negative charges will leak off the grid to the filament. This grid leak at the same time serves the purpose of a by-pass for voltages, occurring due to possible leaks in the condenser C, which would tend to make the grid positive, thus allowing a grid current to flow and stopping the perfect action of the tube as an amplifier. Since the grid leak $R$, is a direct shunt across the grid and filament of tube No. 2, it must have a relatively high value in order to retain the highest possible amplification. $R$, should have a value lying between 600,000 and 2,000,000 ohms. If this resistance is made variable, it will be possible to control the resulting amplification completely. The value of the condenser C, must be chosen so that its resistance to the flow of alternating current will be as low as possible. Figure 4 shows three stages of resistance coupled amplification, all used to give proper grid bias. The value of the resistance $R$, in the plate circuit of the tubes is 100,000 ohms and the value of the resistance in the grid circuits is 1,000,000 ohms (1 megohm). The condenser C has in each case a capacity of 0.001 microfarad. The filament of the "C" battery is about 4½ volts, but this should be determined by experiment for best results.

Fig. 4. Diagram showing three stages of resistance coupled amplification.

Fig. 2. The resistance coupled amplifier circuit with the introduction of a grid leak and condens. The reasons for this are explained in the accompanying text.

"B" battery has 90 volts and if $R$ is equivalent to the plate resistance at that moment the voltage drop across the tube will be 45 volts with the same drop across $R$. Theoretically it is possible to vary the voltage drop across $R$ from zero to almost 90 degrees. Discounting the small resistances of the "A" and "B" batteries, a changing voltage will occur across the filament and plate when the grid potential varies, and also the resistance $R$. Naturally these last variations depend upon the tube resistance and upon the value of the resistance $R$. These variations will be largest when $R$ has a greater resistance than that of the tube. The resistance of impedance of the tube is constantly in a state of change and can assume very high values. For this reason the value of $R$ should be equal to the higher values of the tube impedance in order to maintain maximum effectiveness. As used with ordinary amplifier tubes, a value of 100,000 ohms has been found to give satisfactory results. The next step is to apply the voltage variations across $R$ to the grid circuit of the next tube. In Figure 2, the resistance $R$, lies in the grid circuit of tube 2 as well as in the plate circuit of tube 1. Hence the magnified changes in tube 1 are transferred from $R$ to the grid and filament of tube 2, thus the latter tube will be affected directly by the output circuit of the first tube and thus there will be amplification in both tubes thereby causing a resultant magnified signal to be heard.

RESISTANCE COUPLING—RESISTIVE COUPLING—The transference of electrical energy from one circuit to
another, by means of resistance compatible by so-called "amplifier." (See Resistance Coupled Amplifier.)

**RESISTANCE, HIGH FREQUENCY**—The increased resistance of a conductor to alternating electromotive force is the skin effect due to the skin of current. Skin effect becomes more pronounced, the greater the frequency of the impressed electromotive force. Skin effect increases with increased cross-section of the conductor, with increased conductivity of the conductor and with increased magnetic permeability (q.v.). As a result of skin effect, the actual resistance of a conductor to alternating currents is greater than to direct currents.

**RESISTANCE OF GROUND CONNECTION**—The connecting wire leading from the radio apparatus to the ground should be of low resistance. If possible, the ground should be made large as a means of keeping down the loss of resistance. The usual way to obtain a ground is to fasten a copper strap or ground clamp (q.v.) around a water or a steam pipe.

**RESISTANCE (RADIATION)**—This is the ratio of the total energy radiated (per second) by the antenna to the square of the root-mean-square current at a potential node (generally the ground connection).

**RESISTANCE, RADIO FREQUENCY**—The ratio of the heat produced per second, in watts, to the square of the root-mean-square current (radio frequency), in amperes, is a conductor's resistance.

**RESISTIVITY**—See Resistivity of a Material, also Resistivity, Surface.

**RESISTIVITY, SPECIFIC**—Symbol \( \rho \) (rho)—The resistance in ohms of unit length and unit cross-section of the material under consideration. Resistivity may be measured in ohms per inch cube or per centimeter cube, but more commonly it is measured in ohms per mill-foot (q.v.). The material of a conductor has an important bearing upon the resistivity of the conductor. Thus, the length and unit cross-section of aluminum has about one and one-half times the resistivity of copper having the same dimensions. Platinum has about six times the resistance.

**RESISTIVITY, SURFACE**—Referring to insulating surfaces, surface resistivity is the resistance between two opposite edges of a surface film, 1 centimeter square. Surface resistivity depends to a considerable extent on humidity.

**RESONANCE**—A condition which exists in an electrical circuit where the frequency of the applied electromotive force is the same as the natural frequency of the circuit. Resonance is the cumulative effect produced by a pe- riodic force. It is so adjusted that the frequency of the effect that the circuit can attain the highest value. The effect measured is usually the current and the effect which allows maximum current, is said to be in resonance with the force, or with the circuit from which the force is derived. The effect of resonance is to bring the current into phase with the electromotive force. Resonance produced has the effect of bringing the reactance due to the inductance (reactive reactance) in ex- act opposition to the root-mean-square capacity (capacity reactance). The total reactance is therefore zero and therefore the current is equal to the resistance. When two or more circuits have the same natural frequency they are said to be in resonance. Resonance of a circuit to a given exciting electromotive force is that condition due to variation of the inductance or capacity in which the result does not last current (or voltage) in that circuit is maximum. Instead of varying the inductance and the capacity, the frequency of the exciting field may be varied. The condition of resonance is determined by the frequency at which the current or voltage is maximum.

**RESONANCE CURVE**—A curve showing the relationship between the current inductance circuit and the frequency of the induc- tance circuit. In the case of two oscillating circuits placed near each other so that

oscillations in one circuit will induce oscillations in the other, the induced oscillations will be weak or strong depending upon the geometrical relationship between the two circuits. The capacity and the inductance of the second circuit can be varied until it is exactly in tune with the first one. The resonance curve is obtained by measuring the current in the second circuit for various noted oscillation constants, and plotting the curve with the ordinates representing the current and the abscissae representing the natural frequency of the second circuit. The diagram shows a typical resonance curve. The peak of the curve is the point where the two circuits are in tune, or in other words, the resonance frequency. (See Resonance, Surface.)

**RESONANT, RESISTANCE**—An automatic receiver used for the reception of high-speed radio telegraph signals.

**RESONANT, TRANSFORMER**—Any loose-coupled tuning inductance having a primary and secondary each with a variable condenser in the circuit. Tuning the secondary circuit brings it in resonance with the primary, thus enabling signals to be heard with greatest volume.

**RESONANT—See Resonance.**

**RESONATOR**—A device for detecting by resonance, oscillations produced by an oscillator. This term is also used to refer to the sound box employed with the telephone.

**RESONATOR, ACoustic**—A vessel containing a volume of air which can easily be set into vibration by sound waves or by the oscillation of a solid object. Typical forms are cylindrical or spherical and the air is applied to a small tube opening into the air chamber.

**RETARDATION COIL**—A reactance coil used in a circuit for the purpose of selecting only those currents which vary at different rates.

**RHEOSTAT**—A variable resistance used to control current flow. Rheostats may be made of resistance wire or of carbon taps. The latter is used in direct current circuits. Rheostats are connected in series with the fila- ments of vacuum tubes, to protect the elements from possible damage to the filament in the event of a short circuit. (See Form Factor.)

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**Root-Mean-Square**

A rheostat constructed of resistance wire.

R. M. S.—Abbreviation for Root Mean Square (q.v.)

**ROBINSON, Joseph Harrison Thomson**—Born in 1880, he was educated at Liverpool and Cambridge Universities. He carried out many physical re- searches at the Cavendish Laboratory, Cambridge, and did a great deal of work on thermionics and other problems. He is a Fellow of the Royal Society and a Fellow of the Institute of Phys- ics. He has several radio patents to his credit and is an expert on electrical, optical, and acoustical sciences.

**ROBINSON, James**—British radio in- ventor. Born in 1884, he was educated at Durham and Gottingen. He was appointed lecturer in physics at Durham University, 1906-07, and later to a chair in physics, 1910-12, and lecturer in physics at the East London College, London University, 1913. He published a book known chiefly for his direction finding apparatus. He is a member of the Institute of Electrical Engineers.

**ROBINSON, Samuel S.—Rear-Admiral, U.S.N.**—He was born May 10th, 1867, and was educated at the United States Naval Academy, from which he graduated. He wrote the Manual of Wireless Telegraphy for Naval Electricians, and was in charge of the Bureau of Equipment, Navy Department.

**ROOT MEAN SQUARE**—The square root of the mean value of the square of an alternating current or voltage. An alternating current whose root mean-square value is the same has the same heating effect as a direct current of the same amplitude. Root mean square is also used as a measure of sound intensity or virtual value. The root mean square is derived as follows. In electrical measurements, it is necessary to compare direct and alternating currents. Moreover, the same units of measurement, the ampere (q.v.) and the volt (q.v.) are used in referring to both direct and alternating currents. However, in a direct current, a certain voltage will produce a steady current, whereas in an alternating current, both the voltage and the current are changing in magnitude and direction. The common basis of measurement is found in the value of the alternating current's mean, which is the same as the square root of the mean square. Stated in concise terms, it is necessary to find the root mean square. An alternating current having the same effect as that of an ampere would have a root mean square value of .707 amp. (See Form Factor.)
ROOT-MEAN-SQUARE VALUE—See Square-Root.

ROTARY CONDENSER—A synchronous motor used on a power line to advance the phase (q.v.) of the current. At a point there is an improvement in the power factor (q.v.). The action of the synchronous motor is similar to that of a condenser, whence the name rotary condenser.

ROTARY CONVERTER—A device for converting alternating current into direct current or vice versa. The rotary converter is also known as a synchronous converter. It is built like a direct current generator, except that it has certain groups of conducting segments of the armature, connected to slip rings. Two, three, four, or six rings may be used. When the armature is rotated there is an alternating voltage between the rings. If the converter is driven by a motor or by an engine, it may be used as a double current generator, direct current being obtained from the brushes and alternating current from the slip rings (collector rings). When the collector rings are supplied with alternating current, the converter runs as a synchronous motor and direct current can be obtained from the brushes on the collector rings. It must be understood that there is only one set of windings on the rotary converter which act simultaneously on the commutator, armature current, and direct current generator. A converter which is used to convert direct current to alternating current is called an inverted converter. In the single-phase converter, there are two slip rings connected to the windings, and as many equal spaced taps as there are poles. In the three-phase converter, three rings are used, with the even taps connected to each pair of poles. The single phase rotary converter must be brought up to synchronism by external power as it will not start itself. The polyphase converter will start itself from the alternating side, but since it draws a very great lagging current, it should be started whenever possible from the direct current side (inverter).

ROTARY CURRENT—A term infrequently used to denote polyphase (q.v.) current.

ROTARY DISCHARGER—A rotating disc discharger used in wireless transmitters in which the sparks occur between metal studs mounted on a motor or driven disc (fig. 6). The disc is called a discharge wheel.

ROTARY FIELD—A magnetic field rotating in space. It may be due to rotating windings or stationary windings properly connected which poly-phase currents are flowing.

ROTARY GAP—A form of rotating spark gap utilizing two or more rotating discs carrying studs between which the sparks pass. Spark gaps of this type were formerly used in wireless telegraph transmitters. (See Discharger, also Disc Discharger.)

ROTARY HYSTERESIS—Hysteresis (q.v.) produced by a rotating field as distinguished from that produced by a changing field.

ROTARY SPARK GAP—See Rotary Discharger.

ROTARY TACKER—A ticker (q.v.) in which the interruptions are produced by the chattering of a springy brush on a rapidly rotating metal wheel.

ROTOR—The part of any electrical apparatus. It may refer to the revolving portion of a motor (q.v.) or generator (q.v.) or to the movable part of a variable condenser (q.v.). The rotor in a direct current motor or generator is the armature. In an alternator or other current motor the rotor may be either the armature or the field.

ROTOR, GROUNDED CONNECTION—This refers to the grounding of the rotors of variable condensers in a radio receiving set. This is often done to eliminate hand capacity. Sometimes the rotors are connected to the shielding, which is grounded.

ROUGH CALIBRATION—Meters such as voltmeters, ammeters, etc., are often calibrated by comparison with standard instruments. In case such instruments are not available, it may be necessary to use some other method for calibration. As an example of rough calibration, an experimental wave meter could be compared with one in use in various broadcasting stations whose wave lengths are known. (See Calibration.)

RUHKORFF COIL—See Induction Coil.

RUTHERFORD, Sir Ernest—British physicist. Born at Nelson, New Zealand, he was educated at Canterbury College, Christchurch, New Zealand University, and Trinity College, Cambridge. From 1898 to 1907 he held the position of Moore professor of physics at Manchester University. In the latter year he was appointed Cavendish professor of physics and director of the Cavendish laboratory at Cambridge. Rutherford is an extremely brilliant physicist, and has carried on several important researches on the ultimate composition of matter. Many of these experiments have confirmed the theories of Thomson and others. Some of Sir Rutherford's experiments have revolutionized the theories of matter. He has received many honors for his brilliant researches including the Nobel prize for chemistry awarded him in 1908. He has written extensively on radio activity, his books including "Radioactivity and some of its applications," 1906; "Radioactive Substances and their Radiations," 1913; as well as many papers for technical journals. Sir Ernest was knighted in 1914.

SAFETY GAP—A spark gap which is connected in parallel with a condenser or other apparatus, and which protects the apparatus from the excessive voltage. When the voltage exceeds a predetermined limit, the gap breaks down, thus passing the excess current to the apparatus. (See Gap, Micrometer.)

SAL AMMONIAC—A term commonly used for ammonium chloride. This substance is a white crystal, very soluble in water, and is used as an electrolyte in primary cells and in many electroplating processes. (See Cell.)

SATURATED—The magnetic condition of a substance when increase of magnetic force produces no further increase in flux density. A point is reached in every magnetic material where further increase of magnetic intensity will not produce any increase of flux density. At this point, the material cannot be saturated. Cast iron becomes saturated at a lower flux density than steel or wrought iron.

SATURATION—See Saturated.

SATURATION, MAGNETIC—See Saturated.

SECONDARY CELL—A unit consisting of a spongy lead and positive plate, the negative electrode immersed in an electrolyte (q.v.) which becomes active only after the passage of an electric current. The electrodes are of metal or of a metallic compound. An electric current, flowing into a secondary cell causes certain chemical actions to take place whereby the chemical energy is transformed into chemical energy. This process is termed "charging." After the cell is charged, the reverse action takes place and chemical energy is transformed into electrical energy. In this case, the cell is able to deliver an electric current to an outside circuit. This process is termed "discharging." The secondary cell is also known as an accumulator or storage cell. However, the cell does not store electricity. It merely holds or stores the chemical energy for immediate transformation into electrical energy. It is usual practice for several positive plates to be connected together to form one positive electrode and for several negative plates to be connected in parallel to form a single negative electrode. The storage battery consists of two or more storage cells. The operation of the storage cell depends upon the fact that certain metals immersed in an electrolyte may differ in potential. In the secondary cell, no electrical action occurs until after charging. Thereafter, chemical action maintains a difference of potential until the metal has been retransformed. While the negative electrode is used up to a certain extent during the process of discharging, it is replaced electrochemically during the charging process, due to the flow of current through the electrolyte in the opposite direction to that of discharge. The oxide in the positive cells are the lead cell and the nickle-iron-alkaline (or Edison Cell). In lead cells, the material which changes to oxide is the spongy lead and the positive electrode is of lead peroxide. The electrolyte is dilute sulphuric acid and following chemical action takes place within the lead cell. When the cell is charged, hydrogen is released at the negative plate, and oxygen at the positive plate. The oxygen combines with the lead of the positive plate to form lead peroxide while the hydrogen reduces the oxide in the negative plate. When the cell is discharged, both electrodes undergo reactions like those of the charged cell with the liberated hydrogen combines with the oxygen to form water. Care must be taken not to allow the cell to discharge too far as in this case, too great an amount of lead sulphate may form and this may cause buckling of the plates or may make it very difficult to recharge the cell. The indications of completely charged cell are increased gassing of electrolyte together with a stop in the rising of the voltage and the specific gravity. In the nickel-iron secondary cell, the active materials are of nickel and iron. Nickel hydrate forms the active material of the positive plate, while iron oxide forms the active material of the nega-
tive plate. The electrolyte is a 21 per cent. solution of potassium hydroxide combined with a small amount of lith- ium hydroxide. The chief advantage of the Edison cell (q.v.) is that it can be left idle indefinitely in a fully charged, semi-charged, or fully discharged state without harm to the cell. In addition it is lighter and smaller than the same capacity lead cell. The unit used requires twice the capacity of storage cells is the ampere-hour (q.v.). This is based on the rate of discharge necessary for measurement in the eight-hour rate. As an example, an 80 ampere-hour storage battery will furnish a continuous current of 10 amperes for eight hours. If the battery is discharged at a more rapid rate, it will not have the rated capacity.

SECONDARY—the current flowing in the secondary windings of inductive apparatus. Current induced in a secondary winding due to the action of primary current. (See Current, Primary.)

SECONDARY ELECTRON EMISSION—See Secondary Electrons, also Secondary Emission.

SECONDARY ELECTRONS—Electrons emitted by the plate of a vacuum tube when struck by an electron beam from the filament. (See Negative Resistance, also Secondary Emission.)

SECONDARY EMISSION—Electron emission in which the exciting agency is bombardment of the emitting material by electrons. The emission of electrons from cold electrodes under the impact of other electrons. (See Negative Resistance.)

SELECTIVE—See Selectivity.

SELECTIVITY—The sharpness with which a receiving set can be tuned to a particular wavelength. A selective set is one which tunes sharply, whereas a non-selective set is much broader. Too long an aerial will often result in making a set tune broadly. A short aerial makes the receiving set more selective but reduces the volume.

SELECTOR—A tuning device connected in a receiving circuit for the purpose of eliminating undesired stations. (See Wave Trap.)

SELENIUM CELL—A cell constructed of one or more of the metal selenides. This metal is extremely sensitive to light. In its crystalline form, it is a conductor, its conductivity varying with the amount of light allowed to fall on it. As a result it is possible to use it as a current in a circuit by varying the light. The selenium cell thus offers a means of transmitting pictures by wire or radio. Selenium cells are also being used in experimental devices for the transmission of motion pictures and for recording (q.v.).

SELF-CAPACITY—the capacity of a circuit or a portion of a circuit. Every electrical circuit possesses inherent capacity, which varies in degree, depending upon the shape, size, etc., of the portion. Self-capacity is also referred to as distributed capacity (q.v.). In general self-capacity is detrimental, especially in radio circuits, since it introduces reactance. By using special forms of windings, the self-capacity of coils can be greatly reduced. (See Low (Coil).)

SELF-EXCITED GENERATOR—a generator which depends upon its own current for its field excitation. Such a generator must build up its magnetic field and hence its voltage, gradually. In order to get a start, it depends upon the residual magnetism (q.v.) present in the iron of the poles. There are three types of self-excited generators, the shunt generator (q.v.), the series generator (q.v.) and the compound generator. (See Compound Wound.)

SELF-HETERODYNE—a system of reception of continuous wave signals by the production of audio frequency beats, through the use of a device which is both a radio frequency generator and a detector of the audio frequency beat currents produced.

SELF-INDUCTANCES—See Inductance, Self.

SELF-INDUCTION—Inductance due to the field produced by the circuit itself. Changes in current are always accompanied by self-induction. When the current is decreasing, the electromotive force of self-induction is in the same direction, thus tending to prevent the decrease. When the current is increasing, the electromotive force of self-induction tends to prevent the increase. (See Induction, Self; Mutual Inductance, also Induction.)

SELF-INDUCTION COEFFICIENT—the ratio of the number of lines of induction produced by a current flowing in the circuit divided by the current in the circuit. The coefficient of self-induction of a conductor of finite cross-section may be defined as the ratio of twice the energy of the magnetic field produced by the circuit flow, to the square of the current. The following factors affect the coefficient of self-induction, and hence the inductive reactance of the conductor:

(a) The size and shape of the circuit, the permeabilities of the surrounding medium and the core of the circuit itself. Where the skin effect is large, the frequency of the current and the specific resistance of the conductor will an affect the coefficient of self-induction.

SELF-Oscillation—the tendency for the vacuum tubes in a radio receiving set to act as generators of radio frequency oscillations. (See Body Capacity, also Boltho Circuit.)

SENSITIVITY—Points on the meter of a crystal detector which show a greater response to incoming oscillations than others. Dust, grease, or dampness reduce the sensitivity of these spots and therefore the crystal should be properly protected.

SEPARATELY EXCITED GENERATOR—a generator in which current for producing the magnetic field is obtained from some source external to the generator itself. This source is either another generator or else a storage battery. Separately excited generators are generally used only for special work such as battery charging, electroplating and testing.

SERIES—See Series Connection.

SERIES CONNECTION—When two or more parts of an electrical circuit are so connected that the same current Series connection. In order to connect primary or other cells in series, it is necessary to connect the positive terminal of one to the negative terminal of another, etc. In this case, the total voltage of the battery equals the sum of the separate voltages.

SERIES GENERATOR—a generator in which an exciting winding is connected in series with the armature and the load. This type of generator is of small commercial importance being used mainly for certain constant current systems.

SERIES MOTOR—a commutator-type motor having the field and armature windings connected in series. Ordinarily, the series motor is a current-regulating motor, but with minor modifications, such as lamination of the field as well as armature, this motor can be used for alternating current also. With the applied voltage constant, the greater the load, the less will be the speed of a series motor. As the load is lessened, the motor will speed up, and if the load is entirely removed, it will "run away." The (self) characteristic is the most important feature of a series motor. Instead of varying directely with the current in the shunt motor, the torque increases with the square of the current.

Hence, if the current is doubled, the torque will be increased four times, while if the current is quadrupled, the torque will be increased eight times. For the same current, the torque of the series motor is higher than that of the shunt and in addition, the series motor has a much better starting torque.

SERIES-PARALLEL—This refers to a circuit which is a combination of

The current in a circuit is increased in series by connecting cells in series, and decreased in parallel by connecting cells in parallel. A series circuit has no effect on the current through the circuit, while a parallel circuit has no effect on the voltage drop across the circuit. In a series circuit, the current is the same through all the components, but the voltage drops are different. In a parallel circuit, the voltage drop is the same across all the components, but the current is different. (See Series Connection, also "A" Battery.)

SERIES RESONANCE—When a single lumped capacity and a single lumped inductance are connected in series between two terminals, such that alternating electromagnetic force is applied, and the inductance or capacity or frequency is varied, an oscillation or condition of series resonance exists, when the current is a maximum. (See Resonance, also Resonance Curve.)
SHARPNESS OF RESONANCE—A quantity expressing the fractional change of current in a simple series circuit for a given fractional change in either capacitative or inductive reactance.

SHARPNESS OF TUNING—See Selectivity.

SHARP WAVE—A wave in which the energy radiated is confined to a single frequency of oscillation. Tight coupling of the oscillation transformer tends to give a broad wave, whereas loose coupling gives a sharp wave. (See Decrement.)

SHORT—See 138

SHOCK—See 138

SHUNT—A circuit for connecting a load across the terminals of a cell or motor. A simple shunt consists of a conductor attached to the armature terminals. The resistance of the shunt winding is used as the percentage of the load current flows through it.

SHUNT WOUND GENERATOR—A generator in which the field winding is shunted across the armature terminals. The resistance of the shunt winding is made high enough so that only a small percentage of the load current flows through it.

SHUNT WOUND MOTOR—A motor in which the field winding is connected in parallel with the brushes (and the armature winding). The speed of a shunt motor is practically constant, but falls to a slight extent as the load is increased. The drop in speed may be only a few per cent between no load and full load, for large motors; while for small ones it may be as high as 15 per cent. As the load on a shunt motor is increased, the torque of the motor develops will increase and the armature current will also increase in almost direct proportion.

S.I.C.—Abbreviation for Specific Inductive Capacity (q.v.).

S.I.D.E. BANDS—A group or band of frequencies formed by the interaction of the Carrier Wave (q.v.) and the modulations above and below the main carrier wave frequency. (See Harmonics.)

SHIELDING—Metallic screening placed around radio apparatus to prevent interference from stray electromagnetic or electrostatic fields. In radio sets, the inside surface of the panel is often shielded by means of a metallic lining, thus eliminating body capacity. It is usual to ground the shielding. In sets having more than two stages of radio frequency amplification complete shielding is essential. (See Induction Screen.)

S.H.M.—Abbreviation for Simple Harmonic Motion (q.v.).

SHOCK EXCITATION—See Impact Excitation.

SHORT—See Short Circuit.

SHIELDED TRANSFORMER—An audio or radio frequency transformer surrounded by a metal casing. Shielding of radio frequency transformers prevents interference from external fields and also keeps body capacity from affecting the tuning. Audio frequency transformers are shielded mainly to prevent interaction between the flux from the transformer and other parts of the radio set.

SIMPLE HARMONIC MOTION—Ab- brilliation S.H.M.—The motion executed by the foot of a perpendicular let fall on the diameter of a circle from a particle moving with uniform velocity in that circle. The piston rod of a steam engine, turning a crank uniformly approximates a simple harmonic motion.

SIMPLE HARMONIC VIBRATIONS—The vibrations of a body such as a tuning fork which follow the law of simple harmonic motion (q.v.). (See Angular Velocity, also Simple Harmonic.)

SIMPLE WAVE—A wave having no alternation of current, also Simple Wave.

SIMPLE WAVE—A wave having no alternation of current, also Simple Wave.

SINE CURVE—A curve whose perpendicular at any point is proportional to the sine of the angle corresponding to that point. The sine curve is used to represent the changes in direction and strength of an alternating current or voltage. The coil illustrated at the left in the accompanying diagram generates a sine wave current as it revolves through the magnetic field shown by the arrows. When the coil is moving parallel to the magnetic flux, no electromagnetic force is induced and hence current flow is zero. As the coil is rotated in a clockwise direction, it cuts the flux at a greater and greater angle, until the maximum is reached when the flux is cut at a right angle. This gives a gradually increasing electromotive force (and hence current) until at maximum it is zero. When the angle at which flux is cut decreases, the electromotive force decreases until the direction of the inertia of the coil moves parallel to the flux, at which point electromotive force is again zero. Then when the coil starts to cut the flux in the opposite direction electromotive force is reversed, increasing to a maximum and then decreasing to zero thus completing the cycle (q.v.). Current or electromotive force in one direction (positive) is represented by the height of the ordinates of the sine curve above the line, while current in the re-
verse direction is represented by the height of the ordinates below the line. The horizontal distances (abscissae) represent time, generally measured in phase angles (position of coil at any particular instant). (See Alternating Current, also Curve of Sines.)

SINE WAVE—As referring to an alternating current, a sine wave or a simple alternating current, is a current whose wave shape is sinusoidal. The wave shape is the shape of the curve obtained when the instantaneous values of the current of plot against time in rectangular co-ordinates. The wave shape is independent of the frequency and of the scale to which the curve is plotted.

SINE WAVE OF ALTERNATING CURRENT OR E.M.F.—See Sine Wave.

SINGING ARC—See Duddell Singing Arc.

SINGING SPARK—A spark used in a wireless telegraph transmitter which produces a singing note in the receiving head set. A spark which occurs at regular intervals and at an audible frequency such as that obtained in a quenched spark system of wireless telegraphy.

SINGLE CIRCUIT TUNER—A regeneration receiving circuit in which the antenna and grid circuits are conductively coupled. Feedback (q.v.) is obtained by placing the plate circuit in inductive relation with the primary.

SINGLE-PHASE—This term is used to refer to an alternating current, an alternating current system, or to alternating current apparatus. A single phase system or circuit is made up by a single alternating current circuit and therefore against an applied force. A single phase circuit is usually supplied through two wires. The currents in these two wires count outwardly from the source, differ in phase by one-half a cycle (180 degrees). In the single phase generator the voltage per phase is the same as the voltage between the lines and the current per phase is the same as the current per line. Since there is a great saving of copper in the use of three phase transmission of power, three phase generators are more frequently used than single phase machines. (See Alternator.)

SINGULAR VIBRATION—See Simple Harmonic Motion.

SIPHON RECORDER—A moving coil galvanometer originally used for recording messages sent over long submarine cables. The received currents are passed to a coil suspended in a strong magnetic field. This coil carries a fine glass syphon which discharges ink onto a moving paper tape. In case of a call in the signal, the dots and dashes are usually indicated by opposite deflections, which result in a wavy line being produced on the tape.

SKINDERVIKEN TRANSMITTER BUTTON—A small carbon grain microphone (q.v.) button less than an inch in diameter and about half an inch high containing a polished metal button affixed to a mica diaphragm and a surrounding case of brass, the space between the case and the polished button being partially filled with a good grade of carbon granules. The button is very sensitive to sound waves when it is attached to any form of a diaphragm, thus making it applicable wherever a sensitive telephone transmitter should be used. Fig. 1 shows the external appearance, full size, of the Skinderviken button. This transmitter button has a number of applications in radio work and can be used in connection with speech amplifiers, or for inter-departmental telephone circuits. A very simple circuit closer is mounted in the handle of the microphone which in this particular case is simply an ordinary piece of wood hollowed out to receive the switch and the button. This wooden handle is then fastened to the rubber case of a telephone receiver. The coils and magnets in the telephone receiver are removed, a small hole is drilled or punched in the diaphragm, and the transmitter button is fastened as indicated in the diagram.

Another method of attaching the transmitter button to a telephone receiver is illustrated in the diagram in Fig. 7. Here the transmitter button is mounted on a brass strip which is bent so that the center of the button will rest upon the diaphragm of the telephone receiver fixed to the base. A threaded rod and nut regulate the pressure of the button against the diaphragm. In the event that it is not desired to make any changes to a pair of telephone receivers, the transmitter button can be fastened in the shell of an old receiver, B in Fig. 8, and the head phone may be rested on the shell. For
use with a Baldwin receiver, a microphone transmitter button is fastened to it in the following manner: The diaphragm of the Baldwin receiver is first removed, and a thin rod is soldered to the lever, as indicated in Fig. 9. The transmitter button is then soldered to the rod as shown. Another way of making a loud speaker set from an ordinary one-tube receiving set is illustrated in Fig. 10. Where a phonograph is available, the hook-up illustrated may be employed, placing the reproducer of the phonograph on the receiver, which should be placed in a suitable position on the turntable. Inasmuch as the movement of the diaphragm of the seventy-five ohm receiver is an up and down one, the reproducer of the phonograph should be turned as it would be for "hill and dale" records. A tiny drop of solder should be dropped upon the diaphragm of the seventy-five ohm receiver and a small nick placed in the center of the solder for receiving the needle of the phonograph reproducer. Very often it is desired to further amplify the music or sounds picked up by a transmitter button. For this purpose, microphone transformers, or as they are better known, modulation or telephone induction transformers, are employed. In Fig. 11 this instrument is illustrated, together with the circuit for its use. Here the incoming radio signals are made to operate the microphone fastened to the receiver. The current which the microphone passes then goes through the primary of the microphone transformer, the second-

Fig. 9. Button attached to Baldwin 'phone.

Fig. 10. Loud speaker operation from 1-tube set.

Fig. 11. An effective radio amplifier.

Fig. 12. A single stage amplifier.

Fig. 13. A 2-stage vacuum tube amplifier.

Fig. 14. A tuning fork oscillator.

Fig. 15. Transmitter button used as radio detector.

Fig. 16. A code practice machine.

Fig. 17. Use of button in Heising modulation system.

Fig. 18. Method of varying grid voltage of oscillator tube.

Fig. 19. Method of modulating output current.

Fig. 14 shows the transmitter button connected in a radio circuit for use as a detector of radio waves. Fig. 16 shows a method of making a code practice device. An audio frequency howl is produced which will enable an instructor to teach an entire classroom the radio code. Sometimes the key, instead of interrupting the circuit, merely shunts a small portion of the current, passing through the transmitter button, and for this purpose the key would have to be placed directly across the transmitter button and in series with a small resistance. Fig. 17 shows how the transmitter button may be used in Heising modulation. Fig. 18 indicates its adaptation to the variation of grid voltage of the oscillator tube and Fig. 19 shows how the transmitter button may be hooked up to modulate the output current. These last three figures indicate the use of transmitter buttons in vacuum tube transmitters.
SKIN EFFECT — The name given to the crowding of alternating or oscillatory currents into the surface layers of a solid conductor. This phenomenon increases with increased frequency. As a result the resistance of solid conductors is much higher at high than at low frequencies. (See High Frequency, also High Frequency Resistance.)

SLABY-ARCO-VACUUM SLOTS — Channels cut in the armature core discs and into which the windings fit.

SOFT SOLDERING — The process of joining two or more conductors or other metallic surfaces by means of solder, so as to give a good electrical or mechanical connection, or both. After the surfaces to be united are carefully cleaned, a flux is applied to dissolve the oxides which occur on the surface of the parts to be joined with solder.

SOLDERING FLUX — A substance used to dissolve the oxides on the surfaces of the metals to be soldered. When these oxides are dissolved, the flux enables the solder to enter the minute pores of the metal surface, effectively sealing it against the penetration of oxygen. Fluxes range in character from very strong acids to strong acid bearing substances. For radio use it is necessary to use a flux which is not corrosive and which in use will leave a residual matter that will have no tendency to collect moisture, dust, or other foreign material. Rosin has been found to be very suitable as a flux in radio soldering. (See Flux, Soldering.)

SOLOMONID — A coil of wire of helical form used as an electromagnet, generally to attract a movable iron plunger, which is drawn within the solenoid when the current flows through the windings. The solenoid never has a fixed core. A coil wound on a cylinder so as to give uniform magnetic field within it when traversed by a current is often called a straight solenoid.

SOLODYNE — A radio circuit which dispenses with high-tension or "B" batteries and which utilizes a double grid vacuum tube. The solodyne principle is also known as the Unidyne. The theory of the solodyne is as follows: The small plate current due to the electron emission from the lighted filament passes through the tickler coil which feeds back to the main grid circuit in the usual way, the primary of a step-up transformer, through the telephone receivers, and then back again to the filament of the tube. The electron stream passing from the filament to the plate inside the tube must pass the two grids. The first of these, which may be referred to as the additional grid, is primarily made positive by connecting it directly to the positive terminal of the "A" battery. This in itself tends to assist the electron stream, to reduce the resistance of the vacuum of the tube. But the additional grid is assisted in its work by having impressed upon it the stepped up voltage from the plate circuit, due to the secondary of which is in direct connection with the additional grid. Thus building up process is introduced, every possible electron primarily due to the electron emission of the filament of the tube being made use of and ultimately passing through the telephone receivers to be reproduced in the form of audible signals. The main grid functions in the usual manner, except that this too, can be made to help the additional grid as well, by giving it a strong positive bias. A typical Solodyne circuit is shown in the accompanying diagram.
shown in Figure 1. In this circuit L and L' may be honeycomb coils or a varico-coupler. In Figure 2 is shown the

Cowper Solodyne circuit which utilizes standard tubes. In this diagram, the numbers printed near each coil indicate the size of honeycomb or duo-lateral coils to use in each circuit. (See Four Element Tube.)

Cowper Solodyne circuit which utilizes standard tubes. In this diagram, the numbers printed near each coil indicate the size of honeycomb or duo-lateral coils to use in each circuit. (See Four Element Tube.)

SOUNDER—An instrument used for receiving telegraph signals which utilizes the attraction of an armature by an electromagnet to make sounds as the armature hits against stops at the beginning and end of each current impulse. The sounds thus produced form the characteristic dots and dashes of the telegraph code and can be easily read by the experienced telegraph operator.

SOUND WAVE—A wave of alternate condensation and rarefaction through an elastic body such as air, water, etc. Sound waves travel at the rate of 1030 feet per second in air.

SPOON-B—An instrument used for receiving telegraph signals which utilizes the attraction of an armature by an electromagnet to make sounds as the armature hits against stops at the beginning and end of each current impulse. The sounds thus produced form the characteristic dots and dashes of the telegraph code and can be easily read by the experienced telegraph operator.

SOUND WAVE—A wave of alternate condensation and rarefaction through an elastic body such as air, water, etc. Sound waves travel at the rate of 1030 feet per second in air.
transmission. It refers to the Group Frequency of the wave train rather than to the waves themselves.

SPARK RECORDER—An instrument for recording telegraph signals, in which sparks from an induction coil pass through and mark a paper tape carried on a drum which turns under a metallic pointer. The use of a spark recorder dispenses with the use of ink, thus doing away with the friction of the pen on the paper.

SPARK TRANSMISSION—A wireless telegraph transmitting system which uses a succession of spark discharges in an oscillating circuit, to produce oscillations. These traverse an aerial system and a series of short trains of damped waves are emitted.

SPECIFIC GRAVITY—abbreviation S.G. —The weight of a body compared with that of another, having equal bulk, considered as a standard. The standard for liquids and solids is water, while hydrogen or air is the standard for gases. The specific gravity test of the radio storage battery is an important means of testing the condition of the battery. A hydrometer (q.v.) is used for this purpose.

SPECIFIC INDUCTIVE CAPACITY—symbol k—abbreviation S. I. C. —A measure of the degree to which a body permits electrostatic induction through it. The ratio between the capacities of two conductors, one employing the material under consideration as the dielectric and the other using an air or vacuum dielectric. The Specific Inductive Capacity of a material is the inductivity (q.v.) of that material relative to that of air. (See Inductive Capacity also Dielectric Coefficient or Constant.)

SPECIFIC RESISTANCE —The resistance in ohms, of unit length and unit cross-section of a conductor. (See Resistivity of a Material, also Resistivity, Surface.)

SPECTRUM—An image formed by rays of light or other radiant energy in which the parts are arranged according to their refrangibility or wave length. The image may be visible or invisible. The arrangement is such that all parts of the same wave length fall together, while those of different wave lengths are separated from each other forming a regular series. The spectrum produced by the light of the sun through a triangular glass prism and falling on a screen is one of the most common forms. The various colors, since they are unequivocally refracted, are spread out into a band, showing the seven rainbow colors. The red is at one end (that of the least deviation), while the violet is at the other end.

SPEECH AMPLIFIER—An audio frequency amplifier designed especially for public address systems, where addresses are to be heard over a comparatively wide area. By means of speaking apparatus it is possible for one speaker to address an unlimited number of listeners.

SPEECH MODULATION—The modulation of radio frequency currents, as utilized in radio telephony. The production of speech modulated waves can be for a source of undamped waves and a method of causing variations in the current output of this source which will accurately correspond to the vibrations of the voice. The source of undamped waves may be a high-frequency alternator or an electron tube generator, the latter being in most common use. The radio frequency antenna current may be varied by inserting a speech-controlled variable resistance, such as a microphone, in the antenna circuit at the transmitter. The microphone may be put in the direct current power supply of the generating system, so that the radio frequency output of the system will be varied as the power input is varied. (See Modulation, also Modulation Frequency Ratio.)

SPEECH VIBRATIONS—The wave corresponding to a given sound. There are various methods of obtaining graphically the picture of the wave form of any particular sound. One method is to make a phonograph record of the sound and then as the sound is reproduce from the record, to magnify the movement of the needle, using a lever to trace the form of the waves.

SPIDER WEB COIL—A form of inductance coil in which the wires are wound on a frame consisting of radiating arms similar to the spokes of a wheel. The wire is wound in successive turns in and out around the arms, starting from the center, until it reaches the ends of the arms. An odd number of turns is used so that alternate turns will follow the same wave; that is to say, adjacent turns will be on opposite sides and separated by an arm. Coils of this type have comparatively low distributed capacity and in addition have the advantage of being extremely compact. Figure 1 illustrates the frame on which the wire is wound. This is known as the spider. A spider cut from 3/4 inch bakelite, as shown in Figure 2, can also be used, although, owing to a smaller number of divisions, the latter does not have such a large inductance as the former. In winding the wire is fastened around one of the pegs and is then taken in and out around the pegs, as shown in Figure 3. When starting the second turn, the wire will be around the pegs opposite way to the first turn, and all successive odd-number turns will be on the same side as No. 1, while all successive even number turns will be on the same side as No. 2. The finished coil is shown in Figure 4. Spider web coils are also known as basket wound (q.v.), basket woven, or stagger wound coils.

SPLICE—A method of joining two or more conductors by interweaving or entwining the strands, in a similar manner to that of splicing a rope.

SPREADER—A spar or pole used on an aerial, where two or more wires are used, to keep these wires properly spread out and parallel to each other.

SQUIER—MAJOR-GENERAL SIR GEORGE OWEN—American radio authority. He was educated at the Johns Hopkins University and became a research student under Professor Rowland and Sir William Preece at the British General Post Office. In 1904 he published his famous paper on the absorption of electromagnetic waves by living vegetable organisms and showed how trees could be used for the reception of radio messages. In 1911 he read a paper on multiple telephone before the American Institute of Electrical Engineers. In 1912 he was awarded the Elliot Cresson Gold Medal for his researches in multiplex telephony and in 1919 the Franklin Medal of the Franklin Institute. Major-General Squier was awarded
Squirrel Cage Ind. Motor

the K. C. M. G. for distinguished services during the World War. He is a member of the National Academy of Sciences and the International Technological Commission. He is the inventor of Line Radio (q.v.), which is also known as Wired Wireless, Wire-Radio Telephony, Guided Wave Telephony, and Current Telegraph.

SQUIRREL CAGE INDUCTION MOTOR—A type of induction motor having a rotor consisting of copper bars connected to rings at each end, so as to form a short-circuited system. There are no windings in this type of rotor nor are there any external connections through slip rings. These motors are used for constant speed work where starting is necessary only at infrequent intervals. The squirrel cage motor draws a large starting current, but has a relatively small starting torque. It is possible, however, by properly designing the rotor so as to have enough resistance, to use small motors of this type for loads requiring frequent starting, rapid acceleration and high starting torque.

SQUIRREL CAGE ROTOR—See Squirrel Cage Induction Motor.

STAR GROUPING—A method of connecting up polyphase apparatus or circuits. One end of each phase is connected to a common point, usually called the neutral point. This method of connection is called a "Y" grouping, in the case of a three-phase system.

STATIC—An irregular disturbing noise, heard in the radio loud speaker or head set due to atmospheric discharges, lightning and similar phenomena. A common form of static produces an intermittent crashing sound. Other types cause grumbling noises or hissing sounds. Nearby lightning is usually accompanied by a sharp snap in the loud speaker. Various methods have been devised for eliminating or reducing static at the receiving station. It must be said that any of these has been entirely successful. The combination of coil and ground aerials results in the reduction of static: also the use of beat reception, using continuous waves as in certain methods of wireless telephony, static is also referred to under various other names, such as strays, atmospheres, X’s, etc.

STATIC CAPACITANCE—C—The curves obtained by the use of a steady direct-current potential for showing the performance, efficiency, etc., of vacuum tube. The static characteristics of the tube itself are obtained when the resistance of the external circuit is very small in comparison to the plate resistance of the tube. In cases where the external circuit contains resistance the true characteristic could not be obtained using direct current. In this case, an alternating electromotive force is impressed on the grid and the curves obtained are known as dynamic characteristics (q.v.).

STATIC ELECTRICITY—Electricity which is stored in a circuit, manifesting itself in the form of charges at high potential. Electricity, as produced by frictional or influence machines.

STATIC ELIMINATORS—A device for eliminating or reducing the effect of static (q.v.). Various circuits have been proposed for accomplishing static elimination. Some of the most recent and successful of these are the McCas anti-static circuits described in the July, 1925, issue of Radio Review, on page 63. There are two types of McCas circuits, one applicable to radio telegraphy and the other to radio telephony. Both have for their object the reduction of signal static ratio. The wiring diagram shown is that of a standard five-tube neonodyne receiver plus a McCas anti-static device of the receiver type. In this diagram T.a is the detector tube, T.b and T.c are the two radio-frequency amplifier tubes, T.d is the detector tube and T.e and T.f are the two audio-frequency amplifier tubes. The circuit from tube T.b on is unchanged and is the same as any standard neonodyne receiver. The input circuit of tube T.b, however, and also the antenna circuit, have been altered to make possible the installation of the anti-static device. For the neonotformer which usually couples the first tube of a neonodyne to the antenna circuit, the coils L.o, L.s and L.p have been substituted. These coils may either be homemade coils or honeycomb coils. If honeycomb coils are selected each may have fifty turns. The coupling between L.s and L.p should be fixed so that the coils are about an inch apart and some arrangement should be made for changing the coupling between L.o and L.s. If homemade coils are used each coil should have approximately sixty turns of No. 22 d. c. c. wire on a three-inch diameteter tube and they should be coupled the same as the honeycomb coils. The coils L.r and L.e are also coupled and may be either 50 and 10 turn honeycomb coils, respectively, or 60 and 10 turn homemade coils wound on a three-inch diameteter tube with No. 22 d. c. c. wire. The coupling between these coils is not variable. After the proper value of coupling has been found by experiment it may be made permanent.

Coils L.o and L.s are also shown coupled in the diagram. They may be 50 and 75 turn honeycomb coils, respectively, or 60 and 90 turn homemade coils wound on a three-inch diameteter tube with No. 22 d. c. c. wire. The coupling between these coils is also fixed after the proper value has been determined by experiment.

The proper values for the various capacities used in this circuit are as follows: C.o .001 mfd. (43 plate); C.s .000035 mfd. (17 plate); C.r .0005 mfd. (17 plate); C.d .00036 mfd. (17 plate).

In building this set it is advisable to place both the anti-static device and the receiver in the same cabinet. This cabinet must be shielded and the shield should be connected to the ground. It is also advisable to shield the anti-static device from the receiver proper. The batteries should also be shielded either by placing them inside the cabinet or in metal boxes which are connected to the ground. The wires from the battery to the set may be effectively shielded by using BX cable, the outside covering of which should also be connected to the ground. For the phone wires special phone cords which are shielded with a flexible copper braid are desirable.

STATOR—The stationary plates of a rotary condenser. The fixed portion of a motor or a generator, which carries a winding. In induction motors, that portion of the motor which is fixed in position and which carries the winding connected to the external circuit. (See Rotor, also Alternator.)

STATOR PLATES—The plates of a condenser which remain stationary in position as differentiated from the plates which rotate. (See Shielding, also Stator.)

STOPPING CONDENSER—A condenser which opposes or prevents the flow of direct current, but which allows alternating current to flow in a circuit.

STORAGE BATTERY—See Secondary Cell.

STORAGE BATTERY TESTS—The testing instrument most commonly used in storage battery work is the hydrometer (q.v.). The purpose of the hydrometer is to determine the state of the charge of the battery, as indicated by the relative specific gravity of the electrolyte. The specific gravity of a fully charged battery is not a fixed
value but depends entirely upon the standard specific gravity employed by its manufacturer which may be anywhere from 1.250 to 1.300. The user should always ascertain the correct specific gravity for the make of battery before attempting to test it with a hydrometer. A voltmeter may be employed as a means of testing a storage battery provided it is of the proper type and is used correctly. It must be accurate with sufficient length of scale to read tenths of a volt clearly. Voltmeters are obtainable which may be used for both the "A" and "B" batteries of dry or storage. It is not possible to test the storage "A" battery with cheap types of so-called pocket voltmeters. It must be kept in mind that a voltmeter reading on a storage "A" battery is of no value only when the battery is either charging or discharging, except when the battery is practically dead. A voltmeter reading taken when the battery is not connected to the circuit, either charging or discharging, may be misleading. If a reading is taken with the filaments lit, the voltmeter indicates a full six volts, the battery is charged. Under the same conditions, if the voltmeter lags appreciably below six volts the battery should be charged in order to keep it in the best condition. When it falls to 5.4 volts the battery is discharged and cannot possibly operate the set with any degree of satisfaction. When the battery is connected to the charging circuit and the voltmeter shows from 7.5 to 7.8 volts the battery is fully charged. It is possible to test roughly without instruments. If neither a hydrometer nor a voltmeter is handy it is possible to recognize the necessity for charging by the fact that the amplifying rheostats have to be moved forward of the normal working position indicating low voltage and that the battery must be charged. When the battery is on the charging line, being charged at the ordinary rate of the commercial charger, and all of the cells of the battery are bubbling, this is an indication that the battery is charged. An interesting meter has recently been placed on the market which should prove of considerable use to owners of storage batteries. It is an ammeter of special design which is to be connected in series with the storage battery on charge. There is a third terminal on back of the instrument by means of which the same instrument can be used to measure the current consumption of the filaments. By pressing a small button in the center of the meter, the needle swings over to the right-hand portion of the scale and indicates whether the battery is fully charged, half charged or low.

STORAGE CELL—See Secondary Cell.

STRAIN INSULATOR—An insulator used under tension, as for example the insulators to which the guy wires of an aerial are attached. The simplest form of strain insulator consists of a central core of stranded wire, helically covered with an insulating layer at each end. Where the aerial guy is fastened to a strain insulator, the purpose of the insulator is to prevent the guy from having a natural wave length nearly the same as the wave length of the antenna. A common form of strain insulator is of nearly spherical form and is so grooved as to carry the two wires firmly, without permitting them to come into contact.

STANCED WIRE—A wire made up of a number of smaller wires, twisted or braided together. An uninsulated, large stranded wire is generally referred to as a bare cable. Strand wires are of four general classes; (1) wire braid, (2) bunched wire, (3) rope-lay cables, (4) concentric-lay cables. Wire braid is used to afford protection to the insulation of various types of cable. In flat form, it is used as a flexible lead. Bunched wire is a type of cable also referred to as a cord. This form of cable is very flexible, since the individual wires are small. Rope-lay cables are made up of a central core of stranded wire, having one or more layers of stranded wire wound helically about it. Concentric-lay cables are formed in the same way as the rope-lay type, except that the core and layers are of individual solid wires instead of stranded. Stranded wire is very often used in radio work as aerial wire. It has the advantage of being flexible than solid wire and it also has a lower resistance at high frequencies because of skin effect (q.v.). A greater cross-sectional area is available in the stranded conductor than in the solid conductor of the same weight, for carrying current. If used for radio frequency currents, however, it is essential that the individual strands be enameled if the lower resistance is to be maintained.

STRAV CURRENTS—Currents induced by stray magnetic fields such as eddy currents. Such currents always result in an energy loss. In electric railway systems, the currents returning through the earth, through piping, etc., rather than through the path provided are known as stray currents.

STRAY FLUX—Magnetic flux which is not usefuly employed. The leakage flux or leakage lines (q.v.) which stray from the closed magnetic path provided in a transformer or other electromagnetic apparatus. (See Magnetic Leakage.)

STAYS—Atmospheric disturbances which manifest themselves as noises in the radio loud speaker or head set. (See Static.)

This is the rear view of the Callies Super. Note particularly the long wave transformers at the rear of the set and how they support the sub-panel.

Super-Heterodyne Receiver—A circuit used in radio reception in which the wave lengths of the incoming signals are increased to several thousand meters, by the aid of a local source of oscillations. It is a recognized fact that radio signals at "radio frequencies," that is, the original signals as they are impressed on the receiving set from the aerial, must be amplified or built up in some way to operate the detector. However, signals at low wave lengths such as in use for broadcasting, cannot be amplified very efficiently at radio frequencies. By changing the waves from the ordinary broadcast band between about 200 and 550 meters wave lengths of from 4,500 to 10,000, it is possible to obtain more complete amplification. As a result, that the receiver is more sensitive and greater distance can be received. In the super-heterodyne receiver, a difference frequency, termed a heterodyne note, is created. This is done by an arrangement for generating oscillations locally. When the incoming oscillations are combined or superimposed with the local oscillations in such a manner that there is a difference in frequency, this difference will be in the form of a new set of oscillations. If the receiver is arranged in such a form that the new set of oscillations has a comparatively low frequency, the wave length will be correspondingly high. In a standard super-heterodyne receiver the action can be imagined as follows: the signal energy
Super-Heterodyne Receiver

from a certain transmitting station is gathered on an antenna or loop aerial. These signals are tuned in by means of a condenser in the case of a loop aerial, or by a regular tuning device such as a coupler and condenser in the case of an outside antenna. The energy thus obtained is passed through to the grid member of a vacuum tube, which is known as the first detector tube. (In some cases the energy is first amplified by a radio frequency amplifier with coupled coils in the grid and plate circuits, with a variable condenser (the heterodyne condenser) connected across them, having a suitable value for obtaining any desired frequency. The audio frequency signals are now amplified by one or two audio frequency amplifiers consisting of amplifying tubes and transformers and the resulting signals, speech or music local frequency. In this way, the difference between the incoming oscillations and the locally generated oscillations may be adjusted to a prearranged value or frequency. In inductive relation to the grid and plate coils, another coil is arranged, referred to as a pick-up coil. The energy obtained from the first detector tube signals having a frequency equal to the difference between that of the incoming signals and the local oscillations, is sent to a filter transformer or tuned filter. The construction of this filter and the number of windings used is of the utmost importance, as it determines the frequency of the new set of oscillations and will permit the passage of no other frequency than the desired band. This is a very essential feature, as it is necessary to pass only the desired frequency in order to permit maximum transfer of energy. The energy at this predetermined frequency is then passed to the intermediate frequency amplifier (q.v.) After being amplified or built up by the intermediate frequency amplifier consisting of tubes and transformers, the energy is then passed to the second detector tube and rectified or changed from radio frequency. The audio frequency signals are now amplified by one or two audio frequency amplifiers consisting of amplifying tubes and transformers and the resulting signals, speech or music.
are used to operate the loud speaker. Figure 1 shows the general arrangement of the various sections of an unit of a typical Super-Heterodyne receiver. To go a little more fully into the action of the receiver, let us suppose that a station is broadcasting on a wave length of 400 meters. Every wave length is equal to a certain frequency.

That is to say, every wave has a certain number of vibrations per second. The frequency of a wave 400 meters in length will be about 750,000 cycles or 760 kilocycles. By adjusting the wave length condenser, the aerial or loop circuit is placed in resonance with this particular wave length or frequency. This energy is passed through the oscillator pick-up coil and the local oscillations super-imposed on it.

The oscillator condenser, let us say, has been adjusted to permit the oscillator circuit to produce oscillations of a frequency such that the difference between the incoming oscillations and the ones being tuned in is in resonance with the windings of the tuned filter. For instance let us suppose that the tuned filter is arranged for tuning to 10,000 meters which corresponds to 30,000 cycles.

Now the oscillator circuit must be tuned either 30,000 cycles above or below the incoming frequency. In other words, if the incoming wave frequency is as stated—780,600 meters, the oscillator circuit will be tuned to either 780,600 or 720,000 cycles so that the difference between the two frequencies will be 30,000 cycles. No matter what the frequency of the incoming oscillations, the local oscillating circuit will operate in such a manner to produce the definite difference of 30,000 cycles. These signals will then be passed to the intermediate frequency amplifier and built up before being passed to the second detector tube for rectification.

After this, the signals that are now of the order of audio can be further amplified or built up by the audio frequency amplifier. The two operations that are of the utmost importance in receiving with the super-heterodyne are first, the tuning of the incoming signals so that the adjustment of the oscillator circuit to produce the difference between two frequencies accomplishes what is called the “tuning” problem. Figure 2 shows the hook-up of a typical Super-Heterodyne receiver.

SUPER-REGENERATION—See Super-Regenerative Circuit.

SUPER-REGENERATIVE CIRCUIT—A radio receiving circuit which permits reception under conditions of operation, which in an ordinary regenerative set would result in howling. In the regenerative set, which is tightly coupled, the signal strength increases to a maximum, and thereafter a still further increase in regeneration will result in greatly increased signal strength for a minute fraction of time, followed by violent oscillations. In the super-regenerative circuit, the signals are received at a point of very slight amplification by suitably controlling the set. The great advantage of the super-regenerative circuit is that it has the enormous amplification obtainable. Another advantage is the fact that radio code signals are not amplified to the same extent as radio telephony. The super-regenerative circuit was devised by Major Armstrong. The Fleeting Circuit (q.v.) is a modification of the Armstrong circuit. (See Armstrong Circuits.)

**SURFACE MAGNETISM—A synonym for Free Magnets.**

**SUSTAINED WAVES—Continuous or undamped waves.** Waves in which similar current cycles follow each other continuously instead of being broken up into groups like damped sound waves (q.v.). The sustained waves may be interrupted by means of a sending key and thus used for sending radio telegraph messages or they may be modulated and thus utilized in radio telephony. Sustained waves are obtained by the use of high frequency alternators, arc condensers, or thermionic electron tubes (vacuum tubes). The use of sustained waves has made radio telephony practicable. Sustained waves permit sharper tuning, require less energy at the transmitter than in the case of undamped waves, and permit the use of "beat" reception and other sensitive methods of reception. (See Continuous Waves.)

S.W.G.—Abbreviation for Standard Wire Gauge. The full name of this wire gauge is the British Standard Wire Gauge. It is also referred to as the New British Standard, the Imperial Wire Gauge, or the English Legal Standard. It is the legally adopted standard of Great Britain. The following is a chart of the Standard Wire Gauge (B. & S. Gauge) and the American Wire Gauge:

<table>
<thead>
<tr>
<th>American Wire Gauge</th>
<th>Standard Wire Gauge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gauge No.</td>
<td>Dia. in Mils</td>
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<tr>
<td>10</td>
<td>102</td>
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<tr>
<td>11</td>
<td>91</td>
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<td>26</td>
<td>15.9</td>
</tr>
<tr>
<td>27</td>
<td>14.2</td>
</tr>
</tbody>
</table>

**SWITCH**—A device for conveniently making or breaking an electrical circuit. Switches must be designed to carry their rated current without overheating or undue voltage drop, to handle overloads, to prevent arcs on opening the switch, and to be opened and to properly insulate live parts when switch is open. The most common form of switch is the knife switch (q.v.). A switch which opens or closes but one circuit, that is, operating in only a single position, is called a single throw switch. One operating when thrown in either of two positions is called a double throw switch (q.v.). A switch which controls only one side of a circuit is a single pole switch; both sides of a circuit, a double pole switch. The abbreviation for a single pole, single throw switch is S. P. S. T. The abbreviation for a double pole, double throw switch is D. P. D. T., etc., where a variety of types of switches ranging from oil switches used to handle enormous currents to the small push button or snap switches for turning on or off electric lights. Among the switches used in radio work may be mentioned the ground switch (q.v.), aerial switch (q.v.), quick break switch (q.v.) and anti-capacity switch. This latter usually consists of a small handle with a cam attached to its other end which serves to press together or release spring contacts. The electrical capacity between the springs is low, due to the construction used. The plug (q.v.) and jack (q.v.) constitute a form of switch extensively used in radio equipment. The push-pull switch, operating as its name implies, is often used to control the flashing lighting circuits of radio receiving sets.

**SWITCHBOARD**—In its broadest sense, this term is applied to any collection of control, operating, and measuring apparatus mounted on a panel or panels for the purpose of starting, stopping or other control of an electric installation. In a small electric plant, all control and switch gear
may be mounted on a single structure, which is referred to as the switchboard. Switchboards are used at the radio broadcasting station to carry the various meters, control rheostats, switches, etc. (See Panel.)

The use of symbols has been standardized and results in clearer and more easily drawn diagrams. A table of symbols is given below:

### Table of Radio Symbols

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Symbol" /></td>
<td>ANTENNA</td>
</tr>
<tr>
<td><img src="image2" alt="Symbol" /></td>
<td>LOOP ANTENNA</td>
</tr>
<tr>
<td><img src="image3" alt="Symbol" /></td>
<td>&quot;A&quot; BATTERY DRY CELL</td>
</tr>
<tr>
<td><img src="image4" alt="Symbol" /></td>
<td>&quot;A&quot; BATTERY STORAGE</td>
</tr>
<tr>
<td><img src="image5" alt="Symbol" /></td>
<td>&quot;B&quot; BATTERY</td>
</tr>
<tr>
<td><img src="image6" alt="Symbol" /></td>
<td>BUZZER</td>
</tr>
<tr>
<td><img src="image7" alt="Symbol" /></td>
<td>CHOKE COIL AUDIO FREQ.</td>
</tr>
<tr>
<td><img src="image8" alt="Symbol" /></td>
<td>INDUCTANCE COIL FIXED</td>
</tr>
<tr>
<td><img src="image9" alt="Symbol" /></td>
<td>INDUCTANCE COIL TAPPED</td>
</tr>
<tr>
<td><img src="image10" alt="Symbol" /></td>
<td>CONDENSER FIXED</td>
</tr>
<tr>
<td><img src="image11" alt="Symbol" /></td>
<td>CONDENSER VARIABLE</td>
</tr>
<tr>
<td><img src="image12" alt="Symbol" /></td>
<td>CONNECTION</td>
</tr>
<tr>
<td><img src="image13" alt="Symbol" /></td>
<td>VOLT-METER</td>
</tr>
<tr>
<td><img src="image14" alt="Symbol" /></td>
<td>CRYSTAL DETECTOR</td>
</tr>
<tr>
<td><img src="image15" alt="Symbol" /></td>
<td>GRID LEAK FIXED</td>
</tr>
<tr>
<td><img src="image16" alt="Symbol" /></td>
<td>GRID LEAK VARIABLE</td>
</tr>
<tr>
<td><img src="image17" alt="Symbol" /></td>
<td>JACK SINGLE CIRCUIT</td>
</tr>
<tr>
<td><img src="image18" alt="Symbol" /></td>
<td>JACK DOUBLE CIRCUIT</td>
</tr>
<tr>
<td><img src="image19" alt="Symbol" /></td>
<td>JACK FILAMENT CONTROL</td>
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<td><img src="image21" alt="Symbol" /></td>
<td>POTENTIOMETER</td>
</tr>
<tr>
<td><img src="image22" alt="Symbol" /></td>
<td>RECEIVERS TELEPHONE</td>
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<tr>
<td><img src="image23" alt="Symbol" /></td>
<td>RHDESTAT</td>
</tr>
<tr>
<td><img src="image24" alt="Symbol" /></td>
<td>RESISTANCES</td>
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<td><img src="image25" alt="Symbol" /></td>
<td>SWITCH FILAMENT</td>
</tr>
<tr>
<td><img src="image26" alt="Symbol" /></td>
<td>SWITCH S.F. S.T.</td>
</tr>
<tr>
<td><img src="image27" alt="Symbol" /></td>
<td>SWITCH S.F. D.T.</td>
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<tr>
<td><img src="image28" alt="Symbol" /></td>
<td>SWITCH D.P. S.T.</td>
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<tr>
<td><img src="image29" alt="Symbol" /></td>
<td>TRANSFORMER AUDIO FREQ.</td>
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<tr>
<td><img src="image30" alt="Symbol" /></td>
<td>TRANSFORMER RADIO FREQ.</td>
</tr>
<tr>
<td><img src="image31" alt="Symbol" /></td>
<td>TRANSFORMER TUNED RADIO FREQ.</td>
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<td><img src="image32" alt="Symbol" /></td>
<td>VACUUM TUBE</td>
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<tr>
<td><img src="image33" alt="Symbol" /></td>
<td>VARIO-METER</td>
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<td><img src="image34" alt="Symbol" /></td>
<td>VARIO-COUPLED</td>
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<tr>
<td><img src="image35" alt="Symbol" /></td>
<td>LIGHTNING ARRESTER</td>
</tr>
<tr>
<td><img src="image36" alt="Symbol" /></td>
<td>GROUND</td>
</tr>
</tbody>
</table>

**SWITCHGEAR**—Apparatus used in connection with the control of an electrical installation, such as switches, rheostats, starters, circuit breakers, etc.

**SYMBOLS**—Conventional signs used in radio hook-ups to represent various electrical and radio apparatus. The

**SYNCHRONOUS**—As applied to alternating currents, these are said to be synchronous when of the same frequency (q.v.) and exactly in phase (q.v.).

**SYNCHRONOUS DISCHARGER**—A rotary gap discharger driven by a synchronous motor from the same line supplying the transformer in a radio telegraph transmitting system or a rotary gap mounted on the shaft of the alternator supplying the 500 cycle or
TABLE OF DIELECTRIC STRENGTH

- A table showing the voltages at which certain thicknesses of various materials will break down or puncture. The following table has been obtained from Pender's Handbook for Electrical Engineers.

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>DIELECTRIC STRENGTH</th>
<th>Spacing thickness K v. per mm.</th>
<th>(A)</th>
</tr>
</thead>
<tbody>
<tr>
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Telephone, Tuned

(q.v.) used in radio broadcasting is a modification of the telephone trans- 
mitter.

TELEPHONE, TUNED—See Tuned Telephone.

TELEPHONY, RADIO—See Radio Tele-
phony.

TELEVISION—Electric vision at a dis-
tance. The transmission by wire or by radio of vision—that is to say the ability to see objects at any distance by changing the light waves to elec-
tric currents or to electromagnetic waves, transmitting these to the dis-
tance invisibly and then retransforming them back to the original light waves. Television is still in the experimental stage. Of course, the sending of pictures by radio has been accomplished by Capt. Ranger, in this country, Baird in France, Karolus in Germany, and several others. Both Belin and Baird have been working on the problem of television and are reported to be nearing success. In this country, Mr. C. Francis Jenkins, of Washington, D. C., has constructed a compact apparatus (that is in its present stage) which will send motion pictures by radio. This is practically the last word in the

present development of television. It is possible to broadcast a film picture with this device at the rate of sixteen pictures per second showing the mov-
ing outlines as silhouettes, but without the intermediate tones. The method by which a photograph is transmitted by radio in the Jenkins system may be 
illustrated by the example of a coin covered by a thin sheet of paper on which serried pencil lines are drawn. The design of the coin appears in lines varying in intensity. The variations in the lines may be transformed into pulsing electric current by means of a light sensitive cell passing over the lines in question. Place the lines end to end and the current can modulate a carrier wave. The forming of the con-
tinuous line presented a difficulty which was solved in the following way. The inventor proceeded along the line that a prism bends a ray of light and that an image will appear upon a photo-

graphic lens placed before a picture. From this it follows that a prism placed near a lens will cause the image to be displaced sideways, the extent of the displacement being dependent on the angle of the prism. If the prism could change its angle, the result would be motion on the part of the picture. The prism used is circular, with rapid change of form across the prismatic section. Around the circumference of the disc, the prism changes in thick-

ness according to a graduated scale. Revolving the disc causes the image to move in a straight line. When the end of the prism passes the lens, there is instantaneous snapping back of the picture and the journey is repeated. If a small hole be made in the screen, the light from a given point on the picture will pass through and can be made to operate a light sensitive cell at the back of the screen. When the image is made to move down over the screen by the prismatic ring, the aperture will admit light of varying intensity, ac-
cording to the light value along a line crossing the picture. This means that the light falling on the photo cell as the image travels will represent a line across the picture from top to bottom. This leads to the creation of the suc-
cessive lines that make up the picture as a whole. The image is moved along from side to side by means of a second prismatic ring working along at right angles to the first, but at much lower speed. This second prism makes but one revolution during the time that the first makes one hundred, producing the hundred lines assumed to be necessary for making the picture. The cell used may be selenium or thallium oxide. The former requires twenty minutes to

cover the picture, the latter six. It is obvious that to reproduce the picture at the other end the process must be reversed, the lines being replaced side by side by means of a pair of prismatic
disks similar to those at the transmitting end. As noted before, the main difference between sending photographs and motion pictures is in the necessary speedup up. For this purpose, Mr. Jenkins uses a potassium light-sensi-
tive bulb, the action of which is much more rapid than that of either selenium or thallium oxide. The cell is composed of a bulb with its inner surface coated with metallic potassium. The bulb has a high vacuum. The device has two electrodes, one being a wire through the stem, ending in a loop in the center of the bulb; the other passing through the side of the bulb and connecting with the potassium deposit. Absence of the potassium from a small part of the surface forms a "window" opposite the last named contact. Application of a positive potential to the central electrode, attended by connection with the potassium coating, permits no cur-
tent to flow as long as no light enters the bulb. The admission of light frees electrons from the potassium, in num-
bers proportionate to the strength of the light. In this way a current flows through the bulb which light actuates as a "window." In this cell, there is no appreciable lag due to the amazing speed of the electrons.

The sending station has a motion picture projector, a small machine used to cut up the image, a light-sensitive cell, and a transmitting station has a radio receiving set, a machine for reassembling the picture, and a screen for the reproduction of the image.

The lamp required for the receiving station must be able to pass swiftly from darkness to extreme brilliancy, and the ordinary filament lamp could not attain the tremendous speed in-
volved. The lamp used by Mr. Jenkins is the creation of Professor McFarlane Moore, and is capable of handling com-
plete cycles at the rate of 75,000 to the second. This lamp has a glass bulb containing two concentric cylinders, the larger almost filling the bulb, and the smaller almost filling the larger. The inner cylinder has a small axial hole, drilled almost to the bottom and forming a deep cup. The principle of this lamp is much the same as that of the Amrad "Oy" valve.

It is a truism that the fundamental principle of cinema pictures is that the human eye continues to see an image
after that image itself has disappeared. In the case of an electric space, the green and red second, the image lasts for at least one-sixteenth of a second as visualized by the lens. But it assumes that if 10,000 dots of light and shade are transmitted successively on a screen with sufficient speed, the eye will see the picture to which the eye is accustomed; one dot is on the screen at a time. He therefore, aimed at flashing the 10,000 dots on and off within the space of one-sixteenth of a second.

Theoretically, this feat might be accomplished by slowing the slow-moving revolving rate to 900 revolutions per minute, keeping the faster disc at a rate exactly one hundred times greater. But the rapidity of this operation is obtained by the centrifugal force before the attainment of a speed of 96,000 revolutions per minute.

Mr. Jenkins gets over this difficulty by the use of forty-eight lenses attached to a large aluminum disc rotating in front of the prismatic disc, thus giving the effect of a slow-moving lens. Each of these forty-eight lenses makes a line across the plate, which thus becomes the screen of the motion picture apparatus. This makes it possible to photograph and reproduce one-eighth of that which would otherwise be required, that is, to one 2,000 revolutions per minute.

At the receiving station, the modulator wave is received by a set but slightly different from many in common use. The last amplifier tube is one of 6 watts. By the use of the McFarland Moore light already described, the modulator is placed in the plate circuit of the last valve and is transformed into light, and the rays are diffused over the screen provided by the prismatic disc and similar to those used at the sending station. In actual practice, the picture appears on a screen about 6 in. by 8 in. More powerful lamps would allow of larger pictures.

The process described is for sending photographic pictures. But it can also be used for the sending of direct lines without the intervention of photography. All that is done in this case, is to remove the projector and focus the lens so that it will throw the view as an image.

So far as radio features of the transmission are concerned, there is little to be explained. At the receiving station the circuit resembles the superheterodyne. The picture is at 75 kilocycles frequency and does not interfere with broadcasting.

The carrier wave may be modulated with voice frequency, so that the voice can travel with the picture, which enables vocal explanations to be given simultaneously with the flashing of the film or the actual scene being transmitted.

TEMPORARY MAGNETS — Magnets which lose their magnetic properties as soon as the magnetizing force is removed. Soft iron displays the properties of a temporary magnet and hence is ideal for use as the core of electromagnetic apparatus. (See Magnet, Electromagnet, also Permanent Magnet.)

TERMINAL — A binding post or other fitting attached to the electrodes, ends of wires, etc., of electrical apparatus so as to permit the external circuit to be connected to the apparatus.

TESLA COIL — An oscillation transformer for producing high potential d-c voltages from medium voltages of low potential. The Tesla Coil or Tesla Transformer, as it is sometimes called, is somewhat similar to the ordinary transformer, although it is much more heavily insulated and has the ends of the secondary connected to a condenser which discharges across a spark gap, thus increasing the rapidity of the oscillations, which then passes into a secondary induction coil. This second coil has no iron core. The Tesla Coil consists essentially of a primary winding having a relatively small number of turns of heavy wire and a secondary having a large number of turns of fine wire. An air, glass, or ebonite dielectric separates the primary and the secondary. Due to the thickness of the dielectric, there is no possibility of a direct discharge between the two windings. The primary winding and the secondary winding consist of but one layer each. The primary winding forms part of an ordinary oscillation discharge circuit. A high frequency electromotive force is induced in the secondary winding, due to the high frequency oscillating currents which flow in the primary winding thus setting up an oscillating magnetic field. Due to the high ratio between the windings of the primary and the secondary, very high voltages are set up in the secondary, in some cases as high as a million volts, and hence a very powerful brush discharge can be obtained.

TESLA, NIKOLA — American electrical and radio expert. Tesla was born at Smiljan, in Jugo-Slavia, 1857, and was educated at Graz and Prague Universities. He entered the Austrian Tele- graph Service and in 1884 he came to the United States where he became an assistant to Edison. He specialized in the study of high frequency and high potential alternating currents. Tesla is noted for his many revolutionary inventions which include polyphase al-
Theory of Prop. Electromagnetic Waves

Latter or generator of high frequency oscillations, as an amplifier, as an electrostatic voltmeter, as a voltage and current regulator, a power limiting device, etc.

THEORY OF PROPAGATION OF ELECTROMAGNETIC WAVES

Waves are due to vibrations caused by an oscillating electric charge in a circuit, the transmitting medium. The current flowing in the aerial is oscillating (sinking and rising) at an enormous high frequency and in addition to its induction field, the aerial has an induction field of long duration which spreads out in all directions from the aerial. The strength of the radiation field decreases in inverse proportion to the distance from the aerial. At any given point the strength is directly proportional to the frequency. The transmission of electromagnetic waves is considered as due to the motion of the lines of force. There is a displacement of electricity along these lines against the elastic force of the medium, termed for convenience the ether (q.v.). Displaced electricity continuously tends to go back to its position of rest under the action of the elastic forces. There is pressure at right angles to the lines of force in addition to the tension along them. The pressure may be considered as due to the repulsion between the displaced charges of the same sign in neighboring lines of force.

THEORY OF RECEPTION OF ELECTROMAGNETIC WAVES—An electromagnetic wave cuts across a receiving aerial, the electric field intensity along the aerial alternates in value. There is an alternating potential between the aerial and the ground which gives rise to the flow of an alternating current. Another explanation is based on the principle of induction. The magnetic and electric fields, in cutting the aerial, induce electromotive forces which cause a current to flow. This is radio frequency current and it is passed to the grid of the detector tube and rectified as explained under Theory of Detector Action (of Vacuum Tube). (See Electromagnetic Waves.)

THEORY OF VACUUM TUBE OPERATIONS—See Theory of Operation of Vacuum Tubes.

THERMAL—Parenthetic to heat. There are electrical and radio devices which depend upon heating or thermal properties. The thermal ammeter (q.v.) is described in the Hot-Wire Ammeter. The thermal detector is taken up under Barreter and Liquid Barreter.

THERMAL AMMETER—A current meter, in which the current or a fixed proportion of the current in question, passes along a fine wire. This heats the wire, causing it to expand or sag. This deffects a pointer or mirror across a calibrated scale. The thermal ammeter can be used for measuring direct or alternating currents. (See Electrothermic Temperature, also Hot-Wire Ammeter.)

THERMAL DETECTOR—A radio detector (q.v.) which depends for its operation upon the heating of a fine wire by the passage of electrical oscillations. (See Barreter.)

THERMAL JUNCTION—THERMOELECTRIC JUNCTION—The contact point or joining point of the two dissimilar metals of a thermo-electric couple (q.v.). (See Klemencic Theory of Junction.)

THERMAL TELEPHONE—A telephone receiver in which the movements of the diaphragm are regulated by the variations of expansion of a wire heated by the telephone currents thus reproducing sound waves. In another type of thermal telephone, the diaphragm is dispensed with, sound waves being reproduced directly through the expansion and contraction of air in contact with the heated wire. This device is also known as a thermal receiver or a hot-wire telephone.

THERMIONIC EMISISON—The emission of a stream of negative electrons from a heated filament (cathode) in a vacuum tube.

THERMO-ELECTRIC COUPLE—THERMO-COUPLE—A pair of dissimilar metal pieces placed in contact and connected by electrical conductors in a closed circuit. When the junction of the two dissimilar metals is heated, an electromotive force results.

THERMO-ELECTRIC CURRENT—A current which is caused to flow due to an electric potential set up at the junction of two dissimilar metals when these metals are at different temperatures. (See Electrothermic.)

THERMOPILE—A device for magnifying the effect of the thermo-couple by connecting a number of these in series and experimentally to alternate junctions to the heat, thus causing the electromotive forces to add up.

THOMSON EFFECT—The phenomenon of the appearance or disappearance of heat when a current flows from a cold towards a hot part of a conductor. If copper is unequally heated, heat is liberated at a point where the current and the heat flow in the same direction, and is absorbed when they flow in opposite directions. The Thomson effect is measured by what is termed "the specific heat of electricity."

THERMION—A rare metal which in certain compounds is thermoelectric. This metal has a specific gravity of eleven and an atomic weight of 232.5. Thermium is used for coating Weisbach molten and is also used in conjunction with the coating of the tungsten filaments used in vacuum tubes. (See Thermonic Treatment of Filaments.)

THERMION TREATMENT OF FILAMENTS—A compound of thermium (ThO) is used extensively in the manufacture of filaments for vacuum tubes. Sometimes thoronitrile is used for this purpose. The filament so treated is termed thoriated tungsten. Since the rate of electron emission from a thoriated tungsten filament at a given temperature is several thousand times greater than in the case of the unalloyed filament, it is possible to use the former at a much lower temperature. (See THERMION.)

THREE CIRCUIT TUNER—A regenerative circuit (q.v.) in which the primary, the secondary or grid circuit, and the plate circuit are capable of being tuned in resonance with each other without resonance.

THREE-ELECTRODE THERMIONIC TUBE—An evacuated bulb or vessel containing a combination of a heated cathode, a plate or anode, and a grid. This tube can be used with minor modifications as a rectifier (q.v.) or detector of radio signals, an amplifier (q.v.), an oscillation generator (oscillator q.v.), an electrothermic generator (q.v.), as a power limiting device, etc.

THREE WIRE SYSTEM—In direct current work, a system of two wires carrying electrical energy, which utilizes three wires, one of which is maintained at a potential, midway between the other two. A part of the load is connected between one wire and the neutral and part between the other wire and the neutral. As a result the neutral wire of the three wires carries current equal to the difference in the loads. The main advantages of this system are a saving in current and availability of double voltage. Thus 110 volts may be required for lights, whereas 220 may be wanted for electric motors. In radio work, current work reference is sometimes made to a two-phase three wire system. In this system the current work is divided equally between the two phases, which differ in phase by ninety degrees. Each current has a separate outgoing wire, but unites in a common return wire. (See Neutral Wire.)

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TINER or TIKKER—A form of interrupter or an equivalent apparatus, used in circuited wave telegraphy. It is really a commutator interrupter. In a commercial type illustrated, a disk is mounted on a motor shaft. The disk has a number of teeth filled in between with fibre or other insulating material. The radio frequency currents flow from one brush to the other through the disk which interrupts them at the rate of 1500 to 3000 times per second. A charge is built up in the condenser C by resonance with the aerial system and this discharges into the telephone condenser C, at regular intervals. The telephone condenser then discharges through the head set, thus producing a single sound corresponding to the charge accumulated. Since the tickler discharges the condenser, C, at different places on the cycle of the incoming oscillations the note produced is not uniform and is hard to read through atmospheric interference. (See Chopper.)

TIKKER—TIKKER COIL.—A coil placed in the plate circuit of a regenerative receiver and coupled inductively in the grid coil in order to obtain regeneration. (See Feed-Back, Feed-Back Coil, Feed-Back Coupling, Regenerative Coupling which is a Regenerative Transformer, also Regeneration.)

TIME CONSTANT—The ratio, in an electric circuit of the inductive elements to the resistance, expressed in henries to the resistance in ohms. It is the time, in seconds, required for a current to attain 63.2 per cent of its ultimate value as given by Ohm's Law. (See Impulse E.M.F.)

TOUCH WHEEL—An apparatus used in the reception of wireless telegraph signals in continuous wave systems, utilizing a wheel in which the conducting teeth are separated by insulating material. A brush is used to make contact with the wheel. The tone wheel is similar in principle to the tickler (q.v.) except that it converts the incoming oscillations to audio frequency currents, thus doing away with the non-uniform note of the tickler. In addition to this the tone wheel utilizes more of the incoming energy than does the tickler. The tone wheel is run at such a speed that the frequency of the interruptions differs slightly from that of the incoming oscillations thus giving beats, from which produce audio frequency currents which can be heard in the telephone receiver. Since the tone wheel mechanically converts radio frequency currents into audio frequency currents it is sometimes called a frequency transformer.

TORQUE—The moment of a system of forces tending to produce rotation. It is usually measured in foot-pounds. Torque may also be defined as that which produces or tends to produce torsion. Thus if a force acts at a tangent to the periphery of a circle, thus producing a turning moment about the center of the circle, the product of the force and the radius of the circle is called the torque.

TRAIN RADIOGRAPHIE—Communication by means of radio between moving trains and ordinary land-line telephone systems. This system is in operation commercially in Germany on trains operating between Berlin and Hamburg. The voice frequency currents from the telephone are impressed on a carrier wave by a method similar to the Siemens modulation (q.v.) system. Each train has a special wave length assigned to it. The modulated wave is emitted through a four-wire antenna, strung along the roads of two coaches. The nearby telegraph wires pick it up and carry it to the receiving sets, located in stations along the line. The ground for the system is obtained through contact of the car wheels with the rails. In reverse order, the voice frequencies of messages from the telephone at the other end are modulated on the carrier wave (using a different frequency broadcast) and the telegraph switchboard. They are then transmitted over the wires and inductively to the train. An arrangement is provided to prevent interference between the sending and the receiving equipment.

TRANSFORMER—A type of induction apparatus, usually stationary, having primary and secondary windings, ordinarily insulated from each other. These are made of sheet iron or copper. The function of the transformer is to change the electrical energy either increasing or decreasing the voltage, current, frequency or phase. Transformers can only be used in connection with alternating currents. Transformers for changing voltage have a different number of turns in the primary than in the secondary. In the step-up transformer, the primary usually consists of a small number of turns of comparatively heavy wire, while the secondary consists of a larger number of turns of fine wire. The ratio of the turns of the primary and secondary windings determines the ratio between the input and the output voltages; thus a 10 to 1 step-up transformer could be used to increase a voltage of ten to a secondary voltage of 100. There are various methods of exciting transformers, according to their operating characteristics, according to their method of changing voltage and also the construction. Transformers which are meant to give a constant voltage on the secondary side are known as constant potential transformers. Those which give constant current are called constant current transformers. Transformers may be air cooled, water cooled or oil cooled. In some cases a natural air draft is used as in transformers of the smaller types. Larger transformers may be designed with special ducts through which blowers force a current of air. Oil cooled transformers may have the cores and windings immersed in oil, or the oil may be circulated through external coils. Water cooled transformers have in them, or have pipes carrying running water submerged in the oil. According to the shape of the core and the shell type, the core type transformer is used mainly for high voltage, low capacity work, while the shell type is used for low voltages and high capacities.

Transformers find a wide application in radio apparatus, the vacuum transformers are used to couple audio frequency circuits for example in the case of audio frequency amplifiers. Audio transformers have an iron core and may be shielded or unshielded. Radio frequency transformers are used to couple radio frequency circuits. They are usually of air core type, although in some instances iron cores are used. Transformers are also used in alternating current chargers, in "A" and "B" battery eliminators and in generator sets directly from alternating current house-lighting circuits. (See Charger, Storage Battery, Alternating Current Transformer, Jigger, Intermediate Transformer, Inductive Coupler, Oscillating Transformer, Core Transformer, Ratio of Transformation, also Shielded Transformer.)

TRANSFORMER COUPLING—A method of transferring the electrical energy of an alternating current from one circuit to another inductively by means of a transformer, one of whose windings is connected in one circuit, the other winding being connected in the second circuit. Radio frequency circuits are usually coupled by radio frequency transformers and frequency transformers being used to couple audio circuits. (See Coupling, also Amplifier, Intermediate Frequency Transformer.)

TRANSFORMER STEEL—A special steel usually containing a high silicon content, used for stamp connected transformer laminations. (See Eddy Currents.)

TRANSFORMER STEEL, SPECIAL—See Reso- nant Transformer.

TRANSMISSION—As applied to radio communication, this is the sending of signals, speech or music from one point to another by the use of electromagnetic waves. (See Radio Telephony, Radio Telegraphy, Theory of Propagation of Electromagnetic Waves.)
Transmission of Photographs by Radio

TRANSMISSION OF PHOTOGRAPHS BY RADIO — Various methods have been devised and are now in use for the transmission of photographs by radio. Among these may be mentioned the systems of Bellin (q.v.), Baird, and Jenkins. The principles underlying the Jenkins system are explained under the heading of Television. Using the system developed by Capt. R. H. Ranger, photographs were transmitted by radio from Honolulu to New York, a distance of 5,136 miles. Recently commercial picture transmission service has been inaugurated between New York and London using the Ranger apparatus. Two distinct methods have been applied for reproducing the picture in the process of transmission. One arrangement consists of putting a non-conducting deposit upon a metal foil which is traversed by a stylus, while the other method makes use of an opaque image deposited upon a transparent film which is traversed by a beam of light, the light interruptions being recorded by a light sensitive cell. The Ranger system makes use of this latter method. The images are photographically recorded upon a celluloid sheet large enough to accommodate easily a picture of half-plate size. In the case of sketches and written messages the image for transmission is made directly by writing upon a piece of transparent film with a dense black ink. The image is then secured to the face of a glass cylinder, and by means of a lamp, focusing lens and reflector prism, a narrow pencil of light is passed through the film. The cylinder is mounted on a carrier which is caused to be moved backward and forward so that the beam of light is concentrated in turn on all parts of the picture. A rotary motion is applied, as well as the transverse motion, the cylinder being given a slight rotation whenever it completes each transverse motion. The beam of light is passed through a special photo-electric cell. This consists of a spherical globe, coated on the inside with potassium hydroxide, which is very sensitive to light. The coating is connected to the grid of a vacuum tube, while an "electron collector" near the center of the tube is joined to the plate of the first amplifier. When no light is falling on the deposit on the inner surface of the globe, the grid acquires a negative charge, stopping the flow of electrons between the collector and plate, and hence no current flows in the external circuit. The ray of light, however, causes an electron stream to pass between the coating and the collector, and since the coating is connected to the grid, the electron flow constitutes a discharged circuit, so that the grid becomes less negative. The first amplifying tube is a direct current potential amplifier, and is resistance coupled. The grid and plate connections of the amplifier are connected across a condenser which becomes discharged with the fall in the grid to plate resistance of the valve brought about by the grid potential fluctuations. A charging circuit is connected to the condenser and is controlled by a valve, the grid circuit of which operates by variations of the potential across the condenser. The charging current is fed through the plate circuit of this valve, in which a relay is connected, which works through other mechanical relays in each time the stylus completes a forward and backward movement across the paper. A small flashing neon lamp is used to indicate the correct speed of the film. TRANSMITTER — An apparatus for sending out electrical messages. As applied to radio telegraphy or radio telephony, the transmitter refers to the entire sending apparatus. The term transmitter is often used to refer to a telephone transmitter (q.v.). (See Automatic Transmitter, also Wheatstone Transmitter.) TRANSMITTING AERIAL — A wire, or more usually a group of wires, suspended at a suitable height and connected to the sending apparatus. The purpose of the aerial is to facilitate the radiation of the electromagnetic waves generated by the high frequency oscillating current which flows in the aerial. (See Directional, also Receiving Aerial.) TRANSMITTING JIGGER — An oscillation transformer (q.v.) having a variable secondary, permitting of various degrees of coupling, by adjustment between the two circuits. (See Jigger.) TRANSMITTING KEY — A telegraph key, used in the sending of radio code adjustment of the driving motor. This key must be of rather heavy construction since it handles larger currents than those used in ordinary wire telegraphy. When the key is closed, the circuit is broken by the key down for a longer or a shorter period, the dots and dashes of the continental code are reproduced. (See Code, Key, Key High Speed.) TRANSMITTING TUBE, POWER RATING — The useful power output from an oscillating tube is the power expended by the oscillating current in the resistance of the output circuits. The power input to the tube, not counting that expended in heating the filament, is the product of the plate supply voltage and the average plate current during an oscillation. TREMBLER — A spring metallic blade carrying a soft iron armature. The spring makes contact with a fixed contact point, but when current passes through the electromagnet, the armature is attracted and the contact is broken to a radio receiving set. The normal position, re-establishing the contact and the same process is re-
peated again and again. (See Interrupter.)

TRIGGER BATTERY—A term (seldom used) denoting a small battery inserted in the grid circuit to give the grid its initial charge when a tube is being used for radio transmission. In this connection, the battery is used to replace the potentiometer. (See Grid Battery, also Grid Bias.)

TRIODE—A name used to designate the three-electrode type of thermionic tube. Other names sometimes applied to the same device are audion (q.v.), audionet, aerotron, electron relay (q.v.), electron tube (q.v.), pilotron (q.v.), thermionic valve, octicon (q.v.), vacuum tube (q.v.), etc. (See Three-Electrode Thermionic Tube.)

TRUE POWER—The product of the apparent power and the power factor (q.v.) in an alternating current circuit. (See Power, True, also Power, Apparent.)

"T" TYPE AERIAL—See "T" Antenna.

TUBE OF FORCE—A theoretical conception, similar to Line of Force (q.v.) used in mathematical considerations of electrostatic or electromagnetic fields.

TUBE RECTIFIER—A vacuum tube or gas filled tube used to change or rectify alternating current to direct current. The principle of the operation of the vacuum tube rectifier is the fact that the electrons will flow from the hot filament to the plate, but not in the reverse direction. Tubes are made for half-wave or full-wave rectification. (See Rectifying Tube.)

TUNED TRANSFORMER—See Resonance Transformer.

TUNGAR—A trade name for a two-electrode vacuum tube especially
deign for rectifying purposes. Tun- gar tubes are made in two amperes and five amperes capacities. They can be used in chargers (q.v.) and also in radio sets operating directly from the lighting socket without the use of batteries. (See Rectifying Tube.)

TUNING—The process of regulating the inductance and the capacity of a radio circuit in order to be in unison with a desired wave length.

TUNING, BROAD—Reception of a signal over a wide range, that is on a number of wave lengths, rather than on a single one. A receiving set which tunes broadly cannot be used where the broadcasting stations are transmitting on wave lengths near to one another. Too long an aerial may re- sult in a receiving set tuning broadly. (See Selectivity.)

TUNING COIL—A coil of wire so arranged that each turn is electrically insulated from its neighbor and with a device by which contact may be made to bring any desired number of turns into the circuit so as to increase or decrease the inductance of a radio
ULTRA-AUDION—A name sometimes applied to the vacuum tube used in connection with heat reception for supplying local oscillations. In general, however, the name ultra-audion applies to a circuit for radio reception. (See Ultra-Audion Circuit.)

ULTRA-AUDION CIRCUIT—A type of circuit used for long wave radio reception which uses a form of regeneration, without calling for the introduction of auxiliary equipment in the circuit. A typical ultra-audion circuit is illustrated. It will be noticed that a steady current is caused to flow in the circuit, through the spark induction coil B. This attracts the armature A, drawing the electrodes apart. The spark of the spark coil current at its interrupter induces a high electromagnetic force which, acting through the coil and the spark gap in series, breaks down the film on the gap electrodes. The power supplied to the gap is 500 volts and 0.2 amperes. A condenser of approximately 36 mfd. is used in the primary oscillating circuit.

T.Y.K. sets have been used only in small units, having a range of 30 or 40 miles. Several unusual features appear in the circuit shown in the accompanying illustration, which gives the circuit diagram of the T.Y.K. arc.

UMBRELLA ANTENNA—An antenna, the conductors of which form elements of a cone with the apex at the top to which the down lead (q.v.) is connected.

UNDAMPED—See Undamped Alternating Current, also Undamped Waves.

UNDAMPED ALTERNATING CURRENT—Periodic current (i.e., current passing through successive equal cycles of values) whose average value is zero.

UNDAMPED OSCILLATIONS—Oscillations which are sustained. Undamped alternating current (q.v.). Oscillations such as are generated by a vacuum tube oscillator or by an arc generator.

UNDAMPED WAVES—Continuous waves. Waves in which similar current cycles follow each other continuously instead of being broken up into groups. (See Sustained Waves, Decadent Wave, also Damped Waves.)

UNITS—Specified amounts of physical quantities used as a basis of measurement. (See Practical Units.)

UNITS, ELECTROMAGNETIC—See Electromagnetic Units.

T.Y.K. Arc

Circuit so as to tune it to the desired wave length. A variable inductance (q.v.) used for tuning an oscillatory circuit. (See Lengthening Coil.)

T.Y.K. ARC—A transmitting arc used for radio telephony invented by W. Torikata, E. Yokoyama and M. Kitamura of Japan. This arc uses magnetic and brass electrodes instead of copper-carbon electrodes. A circuit diagram of the T.Y.K. system is shown in the illustration. The materials used for the electrodes are such that a high resistance film forms on their surfaces. This requires a temporary high voltage to start the discharge. This is accomplished as follows: An armature, A, is attached to one of the electrodes. The two electrodes are in contact, and while one terminal of the secondary goes to the grid, the other terminal, which usually goes to the filament, in this case goes to the plate. Thus there is a direct plate-filament circuit which does not involve the plate and filament batteries in the usual manner.

ULTRADYNES—A modification of the super-heterodyne circuit (q.v.), which uses the modulation method to produce beats. In this method the incoming signal is caused to modulate the oscillations produced locally in a similar way to that in which the speech or music modulate the carrier wave of a broadcast station. It is claimed that this method is simpler than the ordinary super-heterodyne and also more sensitive to weak signals.

The circuit of the improved model L-2 Ultradyne, incorporating regeneration is shown below. The long wave intermediate transformers are accurately tuned to a wave length of 3000 meters. Referring to the diagram, it will be noted that a special form of oscillator, comprising a grid and plate coil, are used together with an oscillator tuning condenser connected across the grid coil. The first tube, which is usually the detector in the standard super-heterodyne circuit, is known as the modulator tube. (See Super-Heterodyne Receiver.)

This shows the hook-up of the Ultradyne super-het. This set is not radically different from the average super-heterodyne. The heteroformers are of the tuned air core type and the filter is shown at the input side of the circuit. Aerial and ground as well as loop may be used with this set and instead of the first detector the inventor uses a tube known as the "modulator."
VACUUM TUBE AMPLIFIER, THEORY OF—The vacuum tube may be used as an amplifier or magnetifier because of the fact that under proper conditions, a small variation of the electromotive force applied between the filament and the grid produces a very large variation in the current flowing in the plate circuit. It is usual to use several amplifying tubes together, suitably coupling the plate of one tube to the grid of the next, thus increasing the amplification to the desired value.

VACUUM TUBE CHARACTERISTICS Performance curves of vacuum tubes. These are obtained experimentally by keeping the filament current constant and applying various known voltages between the plate and the filament and between the grid and the filament and reading the resultant currents that flow to the plate and the grid. The various values obtained are then plotted on cross-section or graph paper. Such curves are convenient for determining the operating characteristics of a particular vacuum tube under consideration. (See Characteristic Curves.)

VACUUM TUBE GENERATOR—The vacuum tube can be used to produce sustained oscillations without the necessity of supplying potential variations to the grid from an external source. This can be accomplished as a direct result of the amplification properties of the vacuum tube, since the energy of the output circuit is greater than the energy of the input circuit and part of this output energy may be returned to the input to produce constant amplification.

VACUUM TUBE, POWER—A tube of special design, made for use in the last audio stage of a radio receiving set, which will handle greater current than the ordinary amplifying tube, thus resulting in more volume and at the same time clearer and more satisfactory tone reproduction. Power tubes now on the market require higher plate voltages than conventional tubes, ranging from 135 volts upward. The amount of grid bias or "C" battery ranges from approxi-
Vacuum Tubes, Types of

Vacuum tubes are of various types and designs depending upon the work which they must do. They may be divided into two general classes, receiving tubes and transmitting tubes.

VALENCY—The property possessed by elements in combining with or replacing other elements in a certain definite proportion. Also referred to as valence. (See Electro-Chemical Equivalent.)

VALVE—This generally refers to a vacuum tube used as a detector or rectifier. The name valve is used in many foreign countries to refer to the thermionic vacuum tube, as used for any purpose.

VALVE DETECTOR—See Valve.

VARIABLE CONDENSER—A condenser having rotatable or movable metal plates and an air dielectric. Both the stationary and rotating plates may be made of brass, copper or aluminum. Bakelite, fibre or composition are used to insulate the stationary from the movable plates. Turning the movable plates either increases or decreases the capacity of the condenser. Variable condensers are primarily used in radio for tuning (q.v.). They are constructed so as to have straight line frequency characteristics either by undercutting a portion of the movable plates or else by making these of a variable thickness.

VARIABLE GRID LEAK—A variable high resistance unit designed to be placed in the grid circuit of a vacuum tube used as a detector. Certain types of variable grid leaks may have their resistance varied from ¼ megohm to 10 or more megohms by merely tightening a thumb-screw. (See Grid Leak, also Adjustable Grid Leak.)

VARIABLE RATIO TRANSFORMER—A transformer in which the ratio between the primary and the secondary windings can be varied, usually by means of suitably located taps.

VARIABLE RESISTANCE—Both the rheostat and the potentiometer used in radio work, are variable resistances. Variable resistances are usually of high resistance wire type, with a sliding contact so that the resistance can be easily altered.

VARIO COUPLER—A tuner formerly used in radio receiving sets, having a primary and a secondary coil inductively coupled, with the secondary arranged so as to be rotatable within the primary. The amount of coupling depends upon the variation of the angle between the axes of the two coils.

A standard form of vario coupler.

VARIMETER—A tuner, similar to the vario-coupler, except that the primary and secondary coils are electrically connected.

A varimenter.

The characteristics of these vacuum tubes are given in the vacuum tube chart on page 187. The first tube is of the dry-cell type, requiring a 4½-volt “A” battery for lighting the filament. SVA is a standard 3-volt tube. SVX is a power amplifier which can be used in the last stage of any audio-frequency amplifier. There is no necessity of changing any of the wiring in the set for the addition of more “B” battery, as binding posts are included on the tube itself. SVA has a sponge rubber ring included as a part of the base which tends to absorb all vibrations which might otherwise cause the tube to become noisy. The next type of tube is for use as a detector only. The last is the well-known 201-A type, which can be employed as a detector or an amplifier.
VECTOR—A graphical illustration used in mathematical calculations, consisting of a line with an arrow-head at one end, used to show by means of its length, direction and the angle between itself and another vector or vectors, the magnitude, direction and phase angle of alternating current quantities.

V E L O C I T Y — The distance passed through in a certain time. Velocity is measured in feet per second, miles per hour, etc.

VIBRATION—A to and fro motion. An oscillating or swinging motion.

VITREOUS—Consisting of or pertaining to glass. (See Resinous Electricity.)

V O L T—The practical unit of electro motive force (q.v.). The volt is a measure of the electromotive force which will cause a current of one ampere to flow through a resistance of one ohm. It is equal to 10⁶ absolute electromagnetic units (Abvolts).

V O L T A G E — The electrical pressure or the electromotive force between two points in an electrical circuit, measured in volts.

V O L T A G E , C O N S T A N T — A steady unvarying electrical pressure or electro motive force, as differentiated from a pulsating or fluctuating voltage.

W A L L T U B E — See Partition Insulator.

W A T C H C A S E R E C E I V E R — A telephone receiver having a shape somewhat similar to a watch. Watch case receivers are compact in construction and are the usual type used in the radio telephone head set.

W A T T — The unit of electric power. One Joule (q.v.) per second. To find power in watts, multiply current in amperes by electromotive force in volts. One hundred and forty-six watts are equivalent to one electrical horsepower.

W A T T H O U R — The commercial unit of electrical work. The work done in one hour by a current of one ampere flowing between two points of a conductor having a difference of potential of one volt.

W A T T — H O U R M E T E R — An integrating meter which measures energy in watt-hours or in kilowatt-hours. (See Integrating Wattmeter.)

W A T T , I N T E R N A T I O N A L — Symbol W. The energy expended per second by an unvarying electric current of one international ampere under an electromagnetic pressure of one international volt. 1 W = 1 Joule per second = 10⁶ ergs per second.

W A T T L E S S C O M P O N E N T — W A T T L E S S C U R R E N T — The component of an alternating current which is in quadrature with the voltage. (See Reactive Component.)

W A T T M E T E R — An instrument designed to measure the power being expended in an electrical circuit. The most common form of direct current watt meter is of the dynamometer type. This has two coils, one fixed and one movable, one coil being connected so as to exert a force proportional to the current flowing in the circuit, and the other coil exerting a force proportional to the electromotive force. The induction type of wattmeter is in general use for alternating current circuits. (See Electro-Dynamometer, Dynamometer, also Induction Wattmeter.)

W A T T S E C O N D — A unit of electrical energy, representing the energy expended by one watt flowing for a second. The watt second is the same as the Joule (q.v.) and is usually applied to the measurement of heat developed by an electric current.

W A V E — A periodic alternation of an alternating current. As applied to an electric or electromagnetic disturbance, an electric wave is an undulatory movement of the ether, radiated from conductors carrying electrical oscillations.

W A V E A N A L Y S I S — A study of the wave form of an alternating current or other type of wave. The wave form of commercial alternating current used for lighting purposes approximates a sine curve (q.v.). A convenient instrument for the analysis and study of alternating current wave form is known as the oscillograph (q.v.).

W A V E L E N G T H A L O C A T I O N S — In order to prevent radio transmitting stations from interfering with each other, or creating interference at a receiving station, various wave length bands have been allotted to each type of service. The following table shows the present short wave assignments and the service for which they are used:

W A V E L E N G T H — Symbol λ (lambda). — The distance between two successive antinodes (q.v.) in the same direction. In referring to the wave length of electrical oscillations in a circuit, this means the length of the waves in free space that would have a frequency corresponding to the given oscillations. Electromagnetic waves used in radio work have frequencies from 10,000 to 3,000,000 cycles per second. Since these waves have a velocity of approximately 300,000,000 meters per second, it is possible to calculate the length of a wave by dividing the velocity by the frequency. In other words meters per second divided by cycles per second gives length of the wave in meters. Thus a wave having a frequency of 100 kilocycles (100,000 cycles) will have a wave length of 3,000,000 divided by 100,000 or 30,000 meters.

W A V E L E N G T H A L O C A T I O N S — In order to prevent wireless telegraph stations from interfering with each other, the Waves are allotted as follows:

W A V E L E N G T H S — Symbol λ (lambda). — The distance between two successive antinodes (q.v.) in the same direction. In referring to the wave length of electrical oscillations in a circuit, this means the length of the waves in free space that would have a frequency corresponding to the given oscillations. Electromagnetic waves used in radio work have frequencies from 10,000 to 3,000,000 cycles per second. Since these waves have a velocity of approximately 300,000,000 meters per second, it is possible to calculate the length of a wave by dividing the velocity by the frequency. In other words meters per second divided by cycles per second gives length of the wave in meters. Thus a wave having a frequency of 100 kilocycles (100,000 cycles) will have a wave length of 3,000,000 divided by 100,000 or 30,000 meters.

W A V E L E N G T H A L O C A T I O N S — In order to prevent radio transmitting stations from interfering with each other, or creating interference at a receiving station, various wave length bands have been allotted to each type of service. The following table shows the present short wave assignments and the service for which they are used:
WAVES, ELECTROMAGNETIC—Periodic electromagnetic disturbances progressive through space. (See Wave.)

WAVES, SUSTAINED—See Sustained Waves, also Continuous Waves.

WAVE TRAIN—A series of waves. An example of a wave train is the series of disturbances set up by each spark in a spark system of radio telegraphy.

WAVE TRAP—A device consisting of a variable condenser and coil, usually connected in the antenna circuit of a receiving set, to eliminate interference from undesired stations. (See Filter, Condenser, Resonator, also Rejector.)

WAVE WOUND—A class of drum armature in which connections produce a "stepping forward" in a zig-zag wave line all the time. Also called Series and Two Circuit Windings.

WEBER—The Practical Unit (q.v.) of magnetic flux. The engineer's unit is the "line" which is also the electromagnetic unit. 1 Weber is equal to 106 electromagnetic units (or "lines").

Weight is produced by a current of one ampere flowing through a circuit having one henry of inductance.

WEINER BREAK—An electrolytic interrupter (q.v.).

WHEATSTONE BRIDGE—An instrument for measuring resistance in which the current from a battery divides into two parallel circuits, each given directly in wave lengths or frequencies or both.

WAVEMETER CALIBRATION—Wave-meters may be calibrated by comparison with a standard wavemeter. An accurate method of calibrating a wavemeter, known as the Three-Way Method is shown in the accompanying diagram. In this illustration A is the standard wavemeter, B the wavemeter to be calibrated, and C is a condenser and coil of size permitting resonance with A. To calibrate, the buzzer should be put in operation, varying the capacity of the condenser C' until L/C' is in resonance with L/C as noted in the head set. The wavemeter B should then be put in inductive relation to C and the condenser C varied until the wavemeter A resonates with C. The wave length of B is now the same as A. This procedure should be carried out over the whole range of the condenser C'.

WAVE MOTION—A disturbance of the equilibrium of a medium or body, extended or propagated from point to point with a continuous motion, each particle vibrating only on each side of its position of equilibrium, while each phase of vibration moves onward. Examples of wave motion are the propagation of electromagnetic waves, or the waves on the surface of a body of water.

WAVES, CONTINUOUS—See Continuous Waves.

WAVES, CONTINUOUS, KEY MODULATED—See Continuous Waves, Key Modulated.

WAVES, CONTINUOUS, MODULATED AT AUDIO FREQUENCY—See Continuous Waves at Audio Frequency.

WAVE LENGTH Calc. for Ant.

<table>
<thead>
<tr>
<th>Wave-length in Meters</th>
<th>Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>109-105</td>
<td>Relay broadcasting only.</td>
</tr>
<tr>
<td>105-587</td>
<td>Public toll service. Government mobile, and point-to-point communication by electric power supply utilities and point-to-point and multiple address message service by press organizations only.</td>
</tr>
<tr>
<td>85.7 - 75.0</td>
<td>Amateur, Mobile, mobile, naval aircraft, and naval vessels working aircraft only.</td>
</tr>
<tr>
<td>75.0 - 66.3</td>
<td>Public toll service, mobile Government point-to-point and point-to-point public utilities.</td>
</tr>
<tr>
<td>66.3 - 60.0</td>
<td>Relay broadcasting only.</td>
</tr>
<tr>
<td>60.0 - 54.5</td>
<td>Public toll service only.</td>
</tr>
<tr>
<td>54.5 - 52.6</td>
<td>Relay broadcasting only.</td>
</tr>
<tr>
<td>52.6 - 42.8</td>
<td>Point-to-point only.</td>
</tr>
<tr>
<td>42.8 - 37.5</td>
<td>Amateur and Army mobile only.</td>
</tr>
<tr>
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Radio broadcast stations work within the wave length band of 200 to 545 meters at intervals of 10 kilocycles. 600 meters is reserved for distress signals. The higher wave lengths are allocated to various marine, government, university, aircraft and other uses.

WAVE LENGTH CALCULATION FOR ANTENNA—For the ordinary vertical wire grounded antenna, the fundamental wave length is slightly greater than four times the length of the wire. A constant suggested is 4.2 and applies approximately also to flat top antennas having vertical lead in. For other calculations see Fundamental Wave Length.

WAVE LENGTH, FUNDAMENTAL—See Fundamental Wave Length.

WAVE LENGTH, NATURAL—In a loaded antenna (that is with series inductance or capacity) the natural wave length corresponds to the lowest free oscillation. (See Natural Wave Length.)

WAVE LENGTH OF STATIONARY S.H.M. WAVES—On a straight wire, the smallest distance between two points where the disturbance is of the same amplitude and phase; or, since consecutive loops (q.v.) are in opposite phases, the wave length is double the distance between consecutive loops or consecutive nodes (q.v.). (See S.H.M.)

WAVEMETER—A radio instrument for measuring frequency. A calibrated resonator of variable frequency, capable of any excitation by the oscillation under test, combined with a means of indicating the attainment of resonance. The calibration may be...
divided into two "arms" capable of being adjusted so that there is no difference of potential between the dividing points on both sides. The point of zero difference of potential is indicated by the absence of deflection of a galvanometer placed across the dividing points. The ratio of the resistance of the two parts of the arms is then the same, so that if the resistance of three of the arms is known, that of the fourth arm (i.e. the resistance to be measured) can be determined.

WHEATSTONE TRANSMITTER—An apparatus for delivering telegraphic currents to a line at high speed. Control is effected by aid of a moving perforated paper tape, prepared according to a code.

WHIPPING—The binding of string or small wire round the end of a rope or multiple wire to prevent the ends from fraying out.

WIMSHURST—A type of Induction or Influence Machine consisting, in a simple form, of two discs of material revolving in opposite directions. These carry a number of equal sectors which form combined inductors and carriers. There are usually two collectors on the back of brushes. (See Induction Machines.)

WINDOW LEAD-IN—A form of inductor for passing an aerial lead-in through a window. In some cases porcelain tiles are used as window lead-in's. A common form of window lead-in consists of a flat copper conductor covered with woven cotton insulation.

WIRED WIRELESS—A method of transmitting radio messages, in which the waves are guided by wires instead of radiating from and through the ether. (See Line Radio.)

WIRE GAUGE—A device for measuring the diameter of a round wire in accordance with a predetermined scale. The gauge commonly used in this country is the Brown and Sharpe (B. & S.) or American gauge.

WIRELESS TELEGRAPHY—Also known as wireless telegraphy (q.v.).—A system of telegraphy, utilizing electromagnetic waves set up by oscillating circuits to transmit messages. The waves generated at the transmitting station spread out from the aerial (q.v.) in all directions.

X, Y, Z

X—Symbol for Reactance (q.v.).

"X" RAYS—Also called Roentgen Rays. Electric waves of much higher frequency than light, produced by the striking of cathode rays upon a solid substance. These rays are not deflected by electric or magnetic fields and possess the property of penetrating solid substances which could not be penetrated by ordinary light rays. The use of the "X" Rays permit photographs to be taken of bones or other parts of the human body which could not be seen in any other way.

X'S—Disturbances of an erratic nature heard from time to time in the 'phones of loud speaking of a radio receiving set, due to storms, electric disturbances, etc. (See Atmospheres, Natural Electric Waves, Static, also Strays.)

YAGI SPARK GAP—A form of spark gap originated by H. Yagi. It is a quenched spark gap, the electrodes of which are aluminum and brass. The gap functions in an atmosphere of coal gas.

"Y" GROUPING—See Star Grouping.

YODE—A piece of soft iron used in certain forms of electromagnets to yoke two parallel cores together magnetically. The cores of the ordinary electric bell are fastened together at one end by means of a yoke.

YOKOJAMA, EITARO—Japanese radio expert. He was born in 1888 and was educated at the Engineering College of the Tokyo Imperial University. While at college he specialized in radio. He was appointed to the Electrical Technical Laboratory of the Japanese Ministry of Communications, to carry out research work in wireless telegraphy and telephony. He was one of the inventors of the TVK oscillation gaps for radio telephony, for which he received many distinctions. He was a member of the Council of the Radio Section. Yokojama, who is one of the most brilliant Japanese radio experts, is head of the Institute of Radio Engineers and of many other scientific societies.

ZEEMAN EFFECT—Doubling of the spectral lines of light sources when placed in a strong magnetic field.

ZENNECK, J.—German wireless expert. He was born April 16th, 1871, at Wurttemberg and was educated at Technical University. In 1905 he was appointed assistant in the Physical Institute in Strassburg, and held until 1909, when he carried out a series of tests in radio telegraphy in the North Sea. In 1905 he was appointed assistant professor of physics at the Institute of Technology, Brunswick and was appointed professor at Munich in 1913. Professor Zenneck has written a number of authoritative books on wireless and also a large number of articles on electro-magnetic oscillations.

ZERO BEAT RECEPTION—The detection of continuous modulated waves using a local source of high frequency current having a frequency equal to that of the incoming wave. When this continuous voltage is impressed on the incoming modulated voltage, (both of the same frequency) the output of the detector contains a current of audio frequency similar in character to the modulated current at the transmitter.

ZERO METHOD—A method of measurement in which various adjustments are made until the current flowing through a galvanometer is reduced to zero, and is then measured. (See Wheatstone Bridge, q.v.)

ZINC—A metallic element. Its chemical symbol is Zn. In color, zinc is bluish-gray. It is practically non-corrosive in the atmosphere, is capable of taking a high polish, is unaffected by water, but is soluble in nitric acid and in soda and potash solutions. Pure zinc is attacked very slowly by sulphuric acid, but this feature is one of the greatest in the application of zinc in radio work and in electrical work generally. Zinc is one of the most important components of most dry cells. It forms the negative terminal in most "B" batteries. Zinc in rod form is used in most forms of wet cells.

ZIRCONIUM—One of the metallic elements. Its chemical symbol is Zr, and its atomic weight is 91.6. Zirconium is an iron-gray powder in one form, or it may be made to crystallize. The crystals look like antimony, are very brittle and extremely hard, being capable of scratching glass and rubies. Zirconium resembles thorium in many of its chemical properties. For the control of the vacuum in high vacuum tubes, a quantity of thorium or zirconium is included in the tube. These metals combine with hydrogen, oxygen, nitrogen, etc., to form compounds of very low vapor pressure.
# SUPPLEMENT

## CLASSIFIED INDEX TO S. GERNSBACH'S RADIO ENCYCLOPEDIA

In the following index various co-related subjects have been gathered together for the convenience of the reader or student, under appropriate headings. Thus, under the heading of "Circuits," every circuit contained in the Encyclopedia is listed. Other important subjects are similarly treated. Where the reader is interested in but a single item such as, for example, "Bolitho Circuit," this can be found more conveniently by referring to the Encyclopedia itself, which, of course, is arranged in alphabetical order. All separate and unrelated headings or subjects should be looked up in this manner, that is by referring directly to the Encyclopedia, as these are not listed in the index.

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OTHER VINTAGE RADIO BOOKS


We are always looking for new material and ideas for future books. We will be releasing new books from time to time. If you have suggestions or want further information, please write to Vintage Radio, Box 2045, Palos Verdes Peninsula, California 90274.
OTHER INFORMATION SOURCES

Vintage Radio books are the standard references on early wireless and radio equipment. However, there are some excellent narrative books available from other publishers. Erik Barnouw's series "A Tower in Babel", "The Golden Web" and "The Image Empire" (Oxford University Press, N.Y.) is a very interesting factual history of broadcasting. Ron Lackman's "Remember Radio" (G.P. Putnam's Sons, N.Y.) and Jim Harmon's "The Great Radio Comedians" and "The Great Radio Heroes" (Double-day and Co., Garden City, N. Y.) are entertaining and informative memory trips. Jane Morgan's "Electronics in the West" (National Press Books, Palo Alto, Calif.) is a very readable history of some of the people who are now "folk heroes" of radio and electronics.

Old magazines, books and manuals are good sources of fun and information. Some people are publishing reprints of manuals.

Interesting ads can be found under "radio" in antique and collectibles periodicals. You will find advertisements for old books, magazines, radios, parts, tapes of old programs, restoration services, information services, old-time radio premiums and other interesting memorabilia.

If you are seriously interested in radio history and collecting, write to the Antique Wireless Association, Holcomb, N.Y. 14469; The Antique Radio Club of America, 516 Country Lane, Louisville, Ky. 40207; or the Canadian Vintage Wireless Association, P.O. Box 51, Station R, Toronto, Ontario, M4G 2E6.