HOW TO PASS
U. S. GOVERNMENT
WIRELESS LICENSE EXAMINATIONS

142 Actual Government Examination Questions
Answered for Elementary Students
of Radio Communication

FOURTH REVISED
EDITION

By E. E. BUCHER
Instructing Engineer
Marconi Wireless Telegraph Co. of America

WIRELESS PRESS, INC.
42 BROAD STREET, NEW YORK

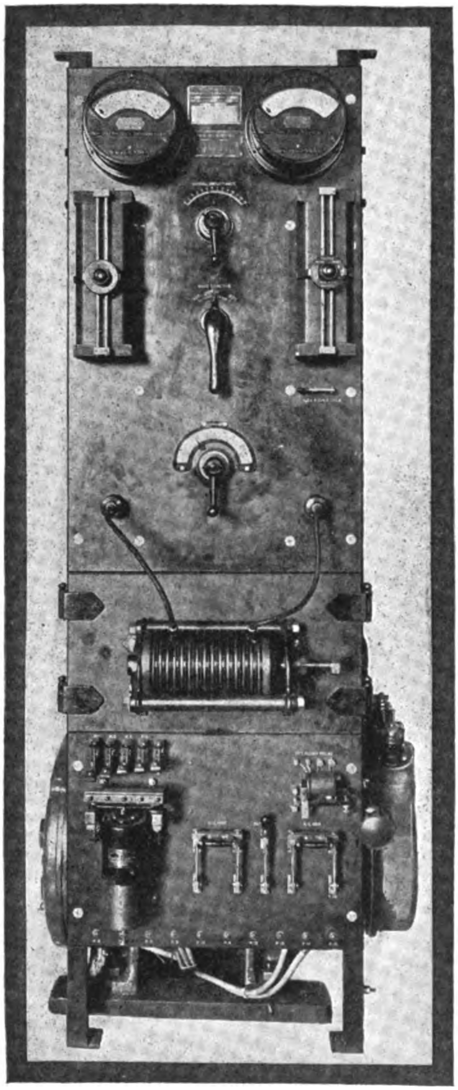


Fig. 1—Front view of the complete transmitter—the new Marconi standard 2 k.w. 500 cycle panel set

PREFACE

This little volume is not intended to equip the student for mastery of the technical applications of wireless telegraphy, but rather to aid those who contemplate taking the examination for a government license certificate and who, through lack of proper training or experience with commercial wireless telegraph apparatus, are unable to formulate complete explanations of the principles.

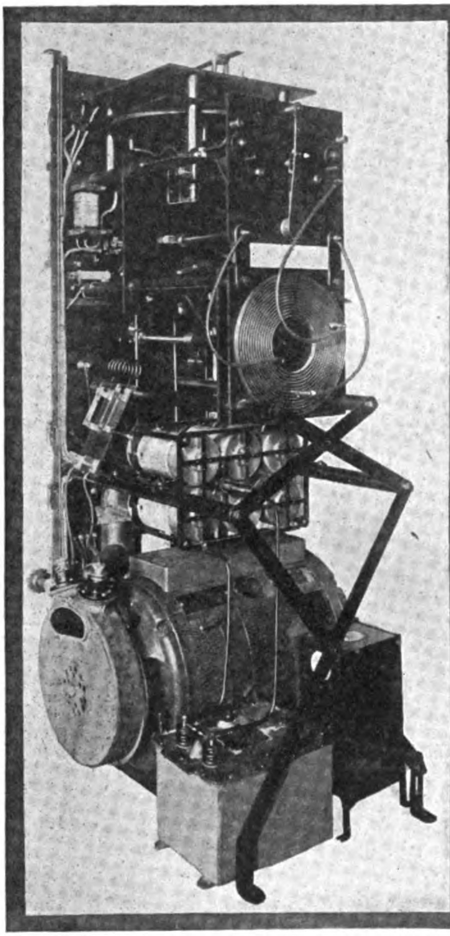
The information contained in the pages which follow should be of particular value to students in elementary technical schools or training schools, as well as those who have served apprenticeship at commercial or government stations and require further instruction in the essentials of the radio art.

In selecting the material the questions answered have been confined to those bearing on fundamental principles, although in some instances it was found desirable to insert details of modern commercial wireless telegraph apparatus. Full information as to the time and place of holding the examinations has not been included; an inquiry from the reader addressed to the Commissioner of Navigation, Washington, D. C., will secure the latest particulars.

The student should avoid memorizing the answers; the explanations given should be used only as the basis of private investigation and text book study.

THE AUTHOR.

New York City, N. Y., May, 1917.



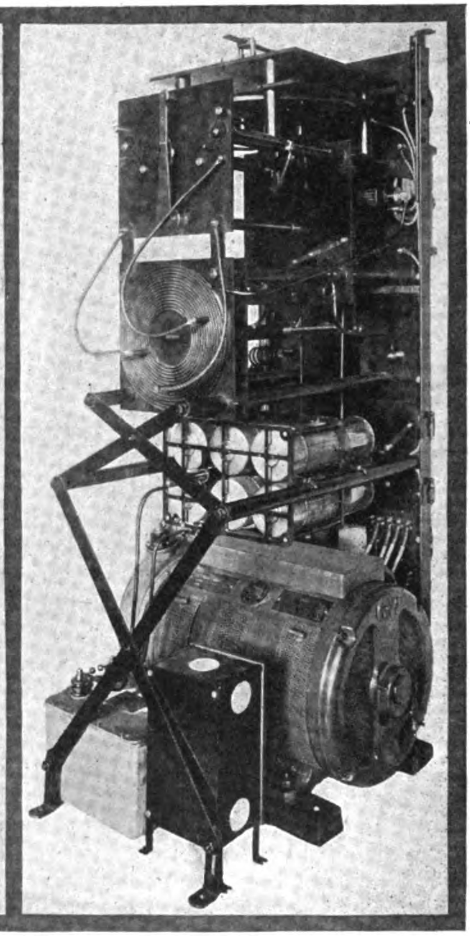


Fig. 2—Side view of the 2 k.w. panel set

Fig. 3—Back view of the equipment

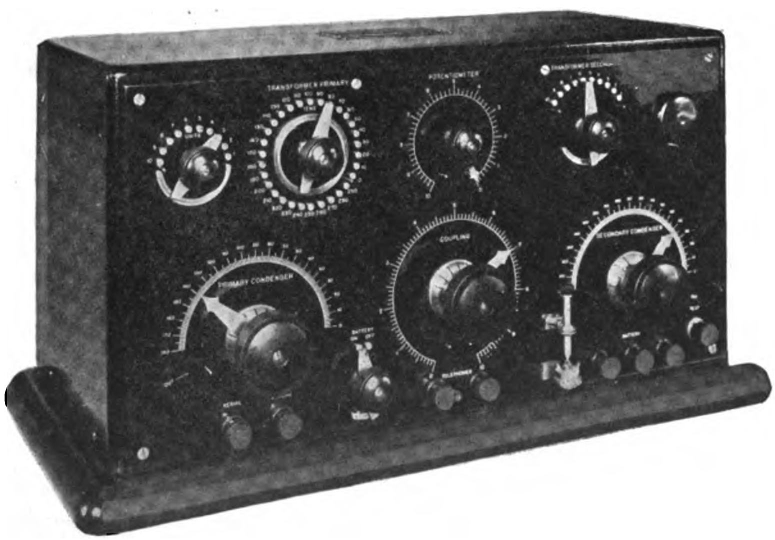
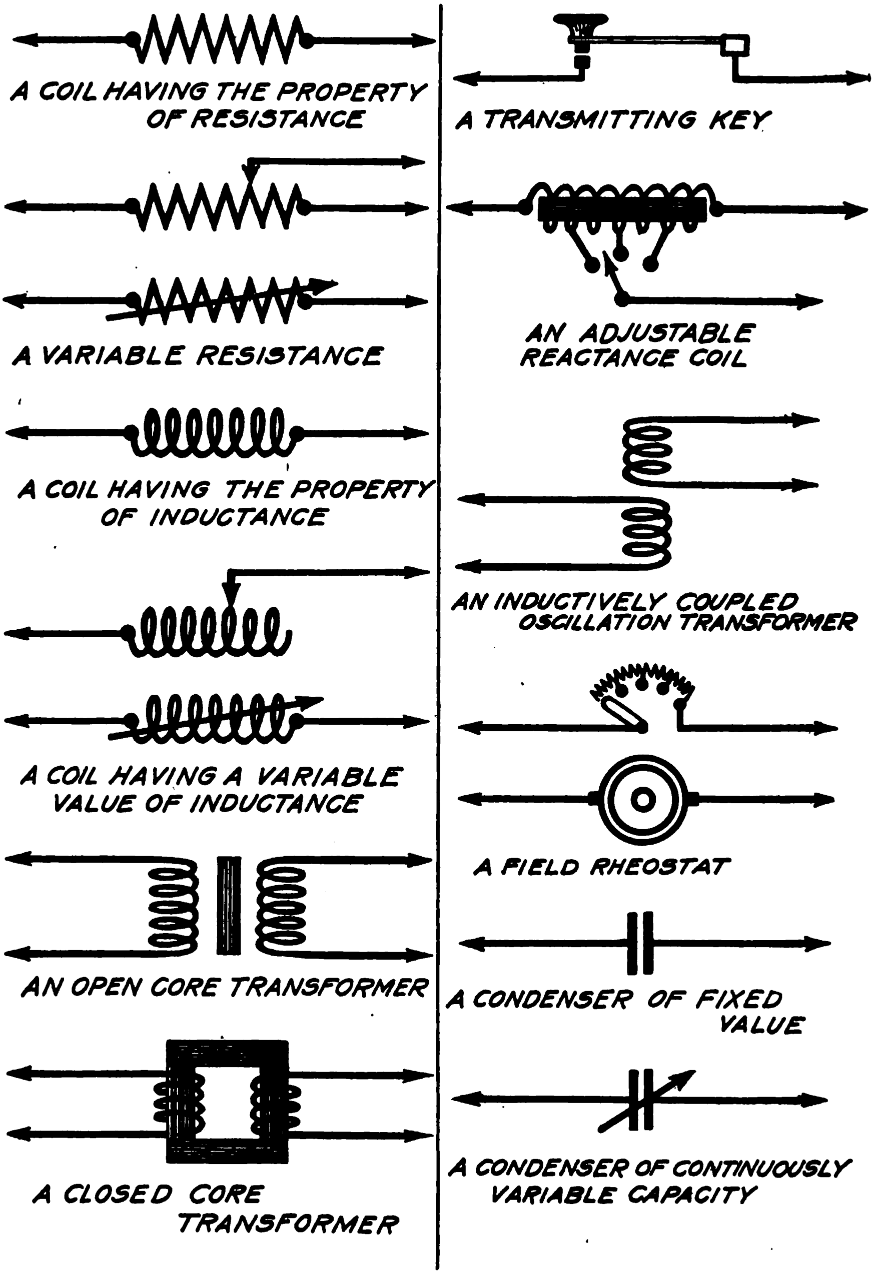
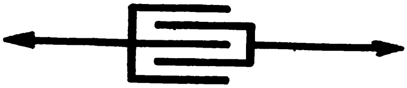


Fig. 4—Front view of the type 106 receiving iuner

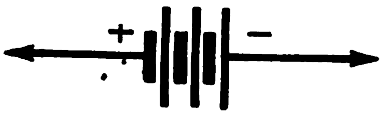
TABLE OF CONTENTS

EXPLANATION OF SYMBOLS
USED IN CIRCUIT DIAGRAMS

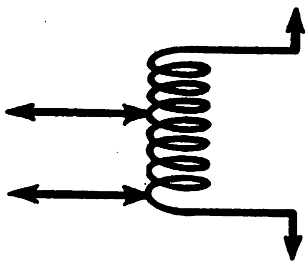




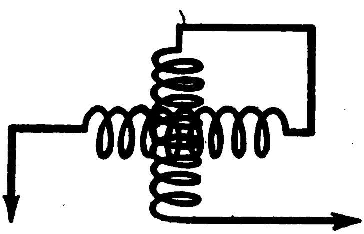
A CONDENSER, THE CAPACITY OF WHICH IS ADJUSTABLE BY STEPS.



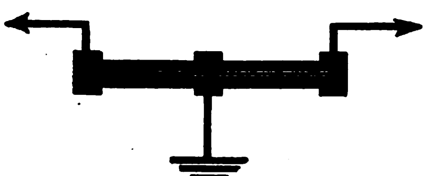
CELLS OF BATTERY CONNECTED IN SERIES



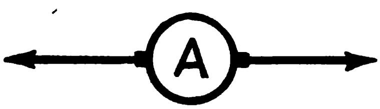
A CONDUCTIVELY COUPLED OSCILLATION TRANSFORMER



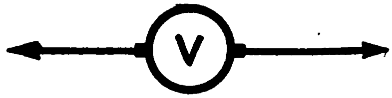
A "VARIOMETER INDUCTANCE



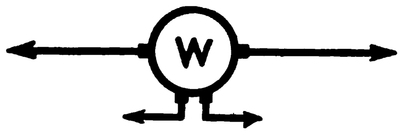
PROTECTIVE RESISTANCE ROD



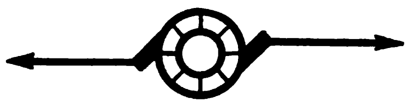
AMMETER



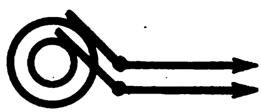
VOLTMETER



WATTMETER



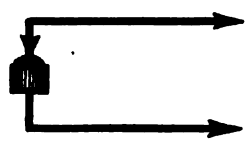
D.C. ARMATURE



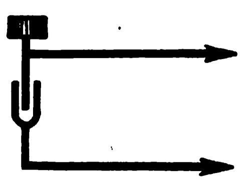
A.C. ARMATURE

INCANDESCENT LAMP.

RECEIVING HEAD TELEPHONE



CRYSTALLINE DETECTOR



ELECTROLYTIC DETECTOR.

DEFINITIONS

INDUCTANCE may be defined as the property of an electrical circuit by which enerby may be stored up in electromagnetic form.

SELF INDUCTION is the term applied to the phenomena resulting from the rise and fall of a magnetic field around a coil of wire through which a current is flowing. Self induction is defined as the property of an electrical circuit which tends to prevent a change of the electric current established in it.

MUTUAL INDUCTION is the term applied to designate the induction due to two independent electric circuits reacting upon each other. It is often defined as the electromotive force induced in one of the circuits when current in the other circuit is changing at a unit rate per second.

An **ALTERNATING CURRENT** is caused by an alternating electromotive force that gradually increases from zero to maximum value in one direction, then decreases to zero, rises again to maximum value in the opposite direction and again decreases to zero.

The **AMPLITUDE** of an alternating current is the term employed to express the highest potential or highest value of current reached during an alternation.

An **ALTERNATION** of current is one-half cycle, *i. e.*, the rise and fall of a current in one direction.

A **CYCLE** is a complete reversal of current, or two alternations.

The **PERIOD** of an alternating current is the time required for one cycle to pass through a complete set of values.

The **FREQUENCY** of an alternating current is the term employed to express the number of complete cycles taking place in a second of time.

A **HIGH FREQUENCY CURRENT** is one where several thousand or more oscillations take place in a second of time.

A **LOW FREQUENCY CURRENT** is generally considered one where no more than, say, 60 to 500 cycles take place in a second of time.

An **ELECTRICAL OSCILLATION** is the term applied to an alternating current having a frequency of several thousand cycles per second.

DAMPED OSCILLATIONS are those consisting of a series of alternating currents of gradually decreasing amplitude.

UNDAMPED OSCILLATIONS are alternating currents of high frequency, but having constant amplitude. The term is synonymous with **SUSTAINED OR CONTINUOUS OSCILLATIONS.**

OSCILLATORY CURRENTS of **AUDIO-FREQUENCY** are those corresponding to audible vibrations within the range of hearing of the human ear from 16 cycles to 10,000 cycles per second of time.

OSCILLATORY CURRENTS of **RADIO-FREQUENCY** are those corresponding to vibrations beyond the range of the human ear and above a frequency of 10,000 per second.

The **DAMPING FACTOR** is the ratio of the amplitude of current in one oscillation to that of the next oscillation in a decaying wave train.

The **LOGARITHMIC DECREMENT** is the Naperian logarithm of the ratio of the amplitude of one oscillation to that of the next oscillation in the same direction in a train of decreasing oscillations.

SPARK FREQUENCY may be defined as the number of individual spark discharges taking place across a spark gap in one second of time.

TONE FREQUENCY is a term synonymous with the term **SPARK FREQUENCY.**

WAVE TRAIN FREQUENCY is the term applied to designate total number of wave trains radiated from a wireless telegraph aerial per second.

An **OSCILLATORY CIRCUIT** is one which permits the free flow of electrical oscillations and generally consists of a coil of wire connected in series with a condenser, the entire circuit having a minimum value of resistance.

The **OSCILLATION CONSTANT** of an oscillatory circuit is the square root of the inductance value multiplied by the capacity value of that circuit.

SYNTONIC CIRCUITS are two or more oscillatory circuits having similar time periods or natural frequency of oscillation.

FLUX is the term which designates the total number of **Static or Magnetic Lines** of force in a given space.

FLUX DENSITY is the number of lines of force (**electrostatic** or **electromagnetic**) per square centimeter.

ELECTROMAGNETIC LINES OF FORCE may be defined as the state of strain existing about the poles of a permanent magnet, an electromagnet, or a wire carrying electric current.

ELECTROSTATIC LINES OF FORCE may be defined as the state of strain existing about a body holding an electrostatic charge.

RESISTANCE is that property of a conductor which tends to oppose the flow of electric current through it, the energy being consumed in the form of heat.

REACTANCE is the term applied to express the resistance of a wire to changes of current established in it.

IMPEDANCE is the term applied to express the total opposition of a circuit to a current of varying amplitude, due to the ohmic resistance and reactance of the circuit.

A **RESONANT CIRCUIT** is one having a definite time period of oscillation for any particular adjustment of inductance and capacity, and which can be adjusted so that capacity reactance and inductance reactance neutralize for any particular impressed frequency.

An **ELECTROMAGNETIC WAVE** may be defined as a propation of electrical energy through space, set into motion by the displacement current about a wireless telegraph aerial; or again, may be considered as a periodic alternation of the electric and magnetic conditions of the ether.

ELECTROMAGNETIC INDUCTION may be defined as the process by which electrical energy is transferred from one circuit to another by means of electromagnetic lines of force of varying density or changing strength.

The unit of electromotive force is the **VOLT**; by definition it is that electromotive force required to maintain a current of one ampere through a resistance of one ohm.

The unit of current is the **AMPERE**; that value of current which is maintained in a circuit having a resistance of one ohm by an electromotive force of one volt.

The unit of resistance is the **OHM**, which is a circuit of that resistance which allows one ampere to pass through it under an electromotive force of one volt.

The unit of power is the **WATT**, which represents the power expended in a circuit carrying one ampere under pressure of one volt.

The unit of quantity is the **COULOMB**, which is the amount of electricity that flows past any point in a circuit when the strength of the current is one ampere.

The unit of capacity is the **FARAD**. A condenser is said to have a capacity of one farad when one volt of electromotive force will place into it an electric charge of one coulomb.

The unit of inductance is the **HENRY**. A circuit is said to have inductance of one henry when, if the current flowing in it is changed at the rate of one ampere per second, the back electromotive force is one volt.

The **AMPERE HOUR** is the unit for expressing the quantity of current passing through a given circuit when one ampere flows throughout one hour of time.

An **ELECTRIC GENERATOR** or **DYNAMO** is a machine to convert mechanical energy into electrical energy.

An **ELECTRIC MOTOR** is a machine to produce mechanical energy from electrical energy.

An **ALTERNATOR** is a generator for the production of alternating current.

A **MOTOR GENERATOR** in wireless telegraph parlance is a machine to create an alternating current from a direct current source of supply.

A **STARTING BOX** is a resistance regulator to regulate the flow of current into an electric motor during the starting period.

A **FIELD RHEOSTAT** is a variable resistance employed to regulate the current flow in the field coil windings of a motor or a generator.

A **TELEGRAPH KEY**, in wireless parlance, is employed to interrupt the energy in the primary circuits of a radio transmitter, so as to form the dots and dashes of the Continental Morse Code.

A **TRANSFORMER** in a transmitting set is an apparatus to produce high voltage current from a source of low voltage current.

A **REACTANCE COIL** is a variable "choke" coil to regulate the current flowing in the primary or secondary windings of a transformer, also to place the circuit consisting of the alternator and primary winding of the transformer in resonance with the circuit containing the secondary winding of the transformer and the high potential condensers.

A **CONDENSER** is a device to store up electricity in electrostatic form, later to be discharged in the orm o radio frequency oscillations.

The **SPARK GAP** acts as a valve to keep the oscillation circuits idle during the charging period of a condenser, also to discharge the condenser in a closed oscillatory circuit at a certain rate per second.

An **OSCILLATION TRANSFORMER** in a radio transmitter is a device to transfer oscillation of radio frequency from a closed oscillatory or non-radiative circuit to an open oscillatory or radiative circuit; it is also used to regulate the wave length of the open and closed circuits and to alter the damping of the radiated wave.

An **AERIAL TUNING INDUCTANCE** is a coil of wire used to adjust the antenna system to a radiated wave longer than the natural or fundamental wave length.

A **SHORT WAVE** or **SERIES CONDENSER** is used to adjust the antenna system to period of oscillation corresponding to a wave length, less than the natural wave length of an aerial.

The **ANTENNA** or **AERIAL** is an elevated insulated conductor employed for the purpose of radiating energy in the form of electromagnetic waves, or in the case of the receiving aerial, for the absorption of energy from a passing electromagnetic wave.

A **CHANGE OVER SWITCH** or **TRANSFER SWITCH** is a device to shift the antenna connection from the sending to receiving apparatus and vice versa.

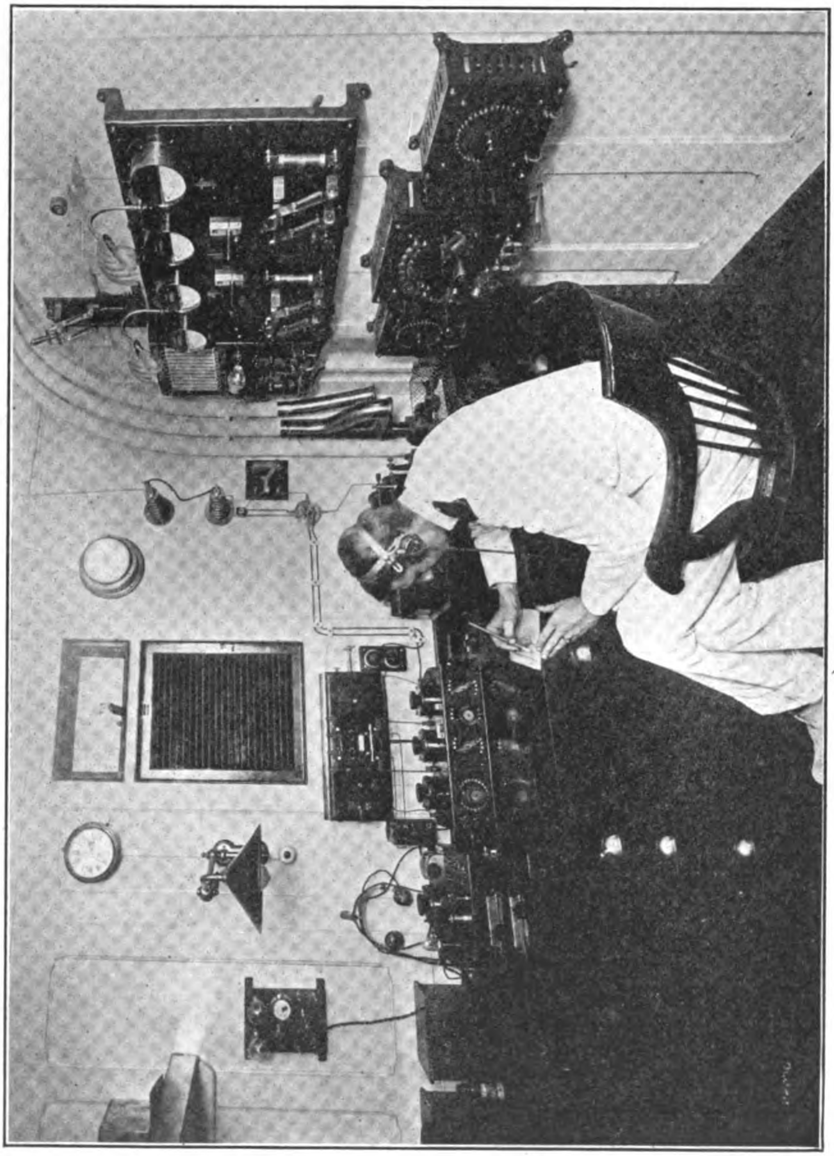
A **RECEIVING TUNER** is an oscillation transformer for transferring the energy absorbed by the receiving aerial from a passing electromagnetic wave to a local detector circuit, where it is made audible. It also allows the receiving operator to differentiate between and adjust to electromagnetic waves of different lengths, thereby avoiding interference.

A **RECEIVING DETECTOR** is a device to change the character of incoming electrical oscillations, so as to make them audible in the head telephones of a receiving set.

The **STOPPING CONDENSER** is used to prevent the battery current flowing through the tuning coil of the closed oscillatory circuit rather than through the crystal detector for which it is intended. The stopping condenser is sometimes connected in shunt to the receiving head telephones to amplify or intensify the signals.

A **POTENTIOMETER** is a variable resistance connected in shunt to a direct current source of energy, and is used to regulate the current flow through a receiving detector.

A **PROTECTIVE RESISTANCE ROD** is a carbon or graphite rod of high resistance, the terminals of which are connected to the leads of a power main, the middle point generally being connected directly to earth. It is used to prevent puncture of the windings of a motor generator by currents of high potential caused by electrostatic induction from the transmitting set when in operation.



A modern Wireless Telegraph set: The Marconi equipment on the Steamship Olympic.

Part I.

TRANSMITTING APPARATUS

1. Ques.—Draw a neat diagram of the apparatus and connections of a modern transmitting set from the source of power to the antenna circuit and give a brief explanation of its operation.

Ans.—The component parts of a complete transmitting set are clearly represented in the diagram of connections, Fig. 1, and are designated as follows:

AC—The alternator armature.
F—The field winding of the alternator.
R—A field rheostat.
R-1—A protective resistance rod.
V—A voltmeter in shunt to the terminals of the alternator.
A—An alternating current ammeter in series with the primary winding of the power transformer P.
W—A primary wattmeter for determining the watt input to the transformer.
R-2—A fixed resistance coil connected in series with the potential mains of the wattmeter.
X—A reactance coil connected in series with the primary winding of the transformer.
P—The primary winding of the power transformer.
S—The secondary winding of the power transformer.
C & C-1—High potential condensers.
D—A rotary spark gap (synchronous or non-synchronous).
L-1—Primary winding of the oscillation transformer.
L-2—Secondary winding of the oscillation transformer.
L-3—Aerial tuning inductance.
S-1—Short wave condenser.
S-2—A short circuit switch for the short wave condenser.
S-3 & R-3—A simple aerial switch for changing the apparatus from a sending to a receiving position.

The complete set may be divided into four main circuits.

One—The low frequency, low potential circuit, including all apparatus from the alternating current armature to the primary winding of the power transformer P.

Two—The low frequency, high potential circuit, comprising the secondary winding of the transformer S and the condensers C and C-1.

Three—The high frequency, high potential, closed oscillatory circuit, including the condensers C, C-1, the primary winding of the oscillation transformer L-1 and the rotary disc discharger D.

Four—The high frequency, high potential, open oscillatory circuit, including the short wave condenser S-1, the secondary winding L-2, the aerial tuning inductance L-3 and the antenna or aerial A-1.

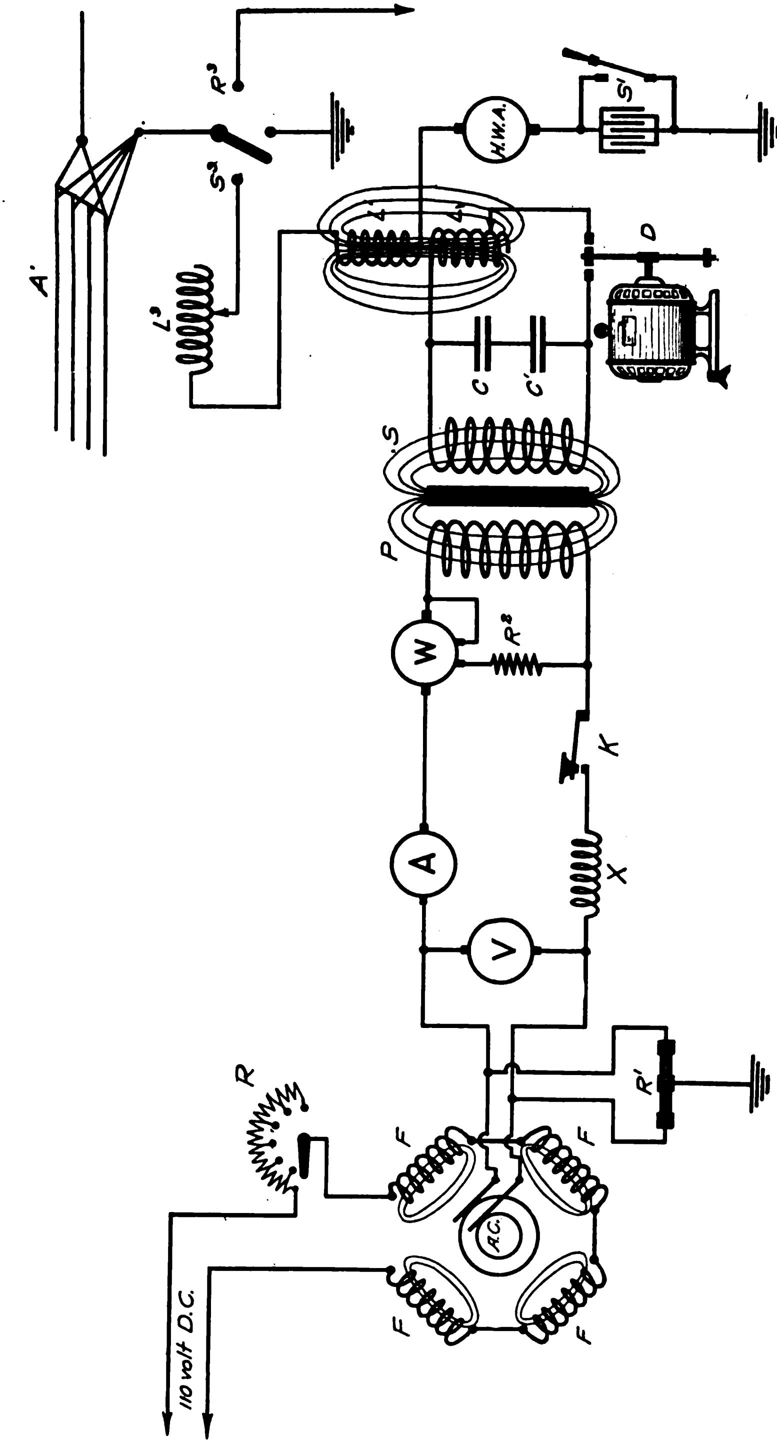


Fig. 1.

The action of this apparatus may briefly be described as follows:

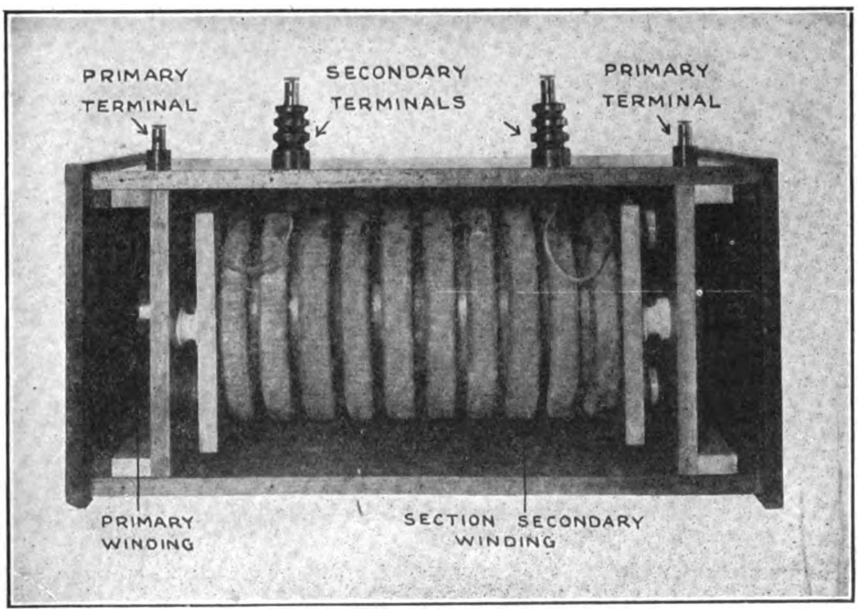
When the field windings of the generator are connected to a source of direct current, generally 110 volts, magnetic lines of force of a certain flux density are set up about the coils F, the strength of which may be regulated by the field rheostat R. With a given speed of the alternator, an increase of field strength will increase the voltage of the armature current; but if the strength of the field is decreased, the voltage falls correspondingly.

By rotating the armature coils through the magnetic field an alternating current is generated, the frequency of which is determined by the number of field poles and the speed of the armature.

When the key K is depressed, alternating current flows through the primary winding P of the open core transformer, setting up magnetic lines of firce which rise, fall and reverse in unison with the current. These lines of force in turn cut the secondary winding S, inducing in it a current of very high voltage—usually about 15,000 volts. In general practice the primary winding P consists of a few turns of rather coarse wire, while the secondary winding S may have many turns of very fine wire.

The reactance coil X regulates the flow of current through the primary winding of the transformer P, or is sometimes employed to place the circuit containing the alternating current armature and primary winding of the transformer in resonance with the secondary winding and condensers, thereby insuring a maximum degree of efficiency.

The potential developed by the alternator is measured by the voltmeter V, the current flow in amperes to the transformer by the ammeter A, and the total watt input to the transformer by the wattmeter W. The wattmeter has four binding posts or connections to the primary circuit, two of which are



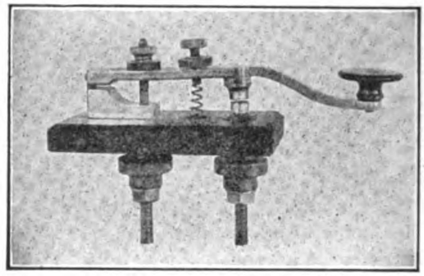
A high-potential transformer of the open-core type.

connected in series with the circuit under measurement and remaining two in shunt to the circuit.

The protective resistance rod, R, prevents a break-down of the insulation in the armature windings which might be caused by electrostatic induction from the transmitter.

The high voltage current induced in the secondary winding S by the primary winding P is stored up in the form of electrostatic lines of force in the condensers C and C-1.

When the highest possible potential for each alternation of charging current has been reached, the condenser discharges at regular intervals through the rotary spark gap D and the primary winding of the oscillation transformer L-1, producing radio frequent electrical oscillations of gradually decreasing amplitudes.



Transmitting key.

The time period or the wave length of the closed oscillation circuit may be changed by the variable tap-off on the coil L-1; if turns are added at L-1, the wave length of the closed oscillatory circuit is increased; it may be decreased either by reduction of the inductance of L-1, or the capacity of the condensers C, C-1. These two devices are often referred to as the frequency determining elements of the closed oscillatory circuit.

The high frequency surges flowing through the primary winding L-1 causes lines of force to cut the secondary winding L-2, setting up in the latter oscillations of similar frequency which traverse the open circuit as previously mentioned.

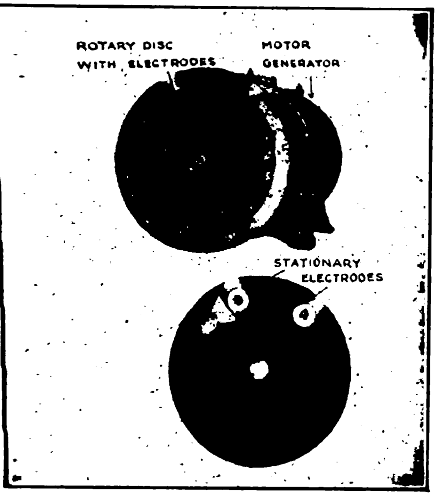
When the antenna is traversed by radio frequent oscillations a series of electromagnetic and electrostatic strains are set up in the space about the aerial; a corresponding series of wave motions are propagated through space at the speed of light and are generally known as "electric waves or electromagnetic waves." The velocity of propagation of electric waves is 300,000,000 meters per second.

The length of the wave radiated from the open or antenna circuit may be increased or decreased either by the aerial tuning inductance L-3 or the short wave condenser S-1. For wave lengths above the natural wave of the antenna, the aerial tuning inductance L-3 is cut in the circuit. and for wave lengths below the natural wave of the antenna the short wave condenser S-1 is connected in the circuit. A simple aerial switch is shown at S-3 and R-2. When thrown to the right the receiving apparatus is connected to the Aerial A-1, and when thrown to the left the receiving apparatus is disconnected and the transmitting apparatus connected to the aerial. When the blade of this switch is in the straight, vertical position, as shown in the drawing, the antenna is directly connected to the earth, affording protection in case of severe lightning.

Ques.—Assign numerical values to the various pieces of apparatus just described?

Ans.—This matter can be properly treated only by considering a specific case, but speaking generally of commercial wireless telegraph sets, the field windings of the generator are connected to a 110 volt source of direct supply. The voltage of the alternator varies from 110 to 500 volts, and the frequency from 60 to 600 cycles; thestandard frequencies being, 60, 120, 240, 480, 500 and 600 cycles. The secondary voltages of the high potential transformer vary from 10,000 to 30,000 volts, depending upon the design of the set.

The value of capacity of the condensers C, C-1 varies with each design and size of set, the actual value being contingent upon the frequency, the potential and the number of watts to be consumed. As an example: In the Marconi 1 K. W. 500 cycle set, the capacity of this condenser is .006 micro-farads, in the 2 K. W. 240 cycle set, .009 micro-farads, in the 2 K. W. 500 cycle set .012 micro-farads, and in the ½ K. W. 120 cycle set 0.01 micro-farads.



Synchronous rotary disc discharger.

If the disc discharger D is of the synchronous type and mounted on the shaft of the alternator AC, then the disc will have the same number of discharge electrodes as there are field poles in the generator.

In the average commercial ship set the winding L-1 may have inductance values ranging from 3,000 to 25,000 centimeters. The secondary winding L-2 may have somewhat similar values which generally is not variable.

In the Marconi service the short wave condenser S-1 has a capacity value of .0005 micro-farads, while the capacity of the aerial itself generally averages .001 micro-farads. The aerial tuning inductance L-3 may have values up to 60,000 or 70,000 centimeters, depending upon the range of wave lengths it is desired to obtain.

3. Ques.—What are the advantages or disadvantages of the anchor spark gap?

Ans.—The anchor gap may be employed in two ways, as shown in figures 2a and 2b. As used in figure 2a it permits the use of a single blade switch for changing the apparatus from the sending to receiving position. When the transmiting set (indicated to the left of the drawing) is in operation, the high frequency oscillations bridge the anchor gap flowing up and down the aerial circuit, but when the receiving switch S is placed in a receiving position, the signals are prevented from being earthed through the transmitter circuits by the anchor gap S. It will be readily understood how this does away with the necessity of an additional switch for disconnecting the transmitting apparatus from the antenna during the receiving period.

The anchor gap used in the manner in Fig. 2b is generally known as an "earth arrester." Due to the fact that it is placed at a point of low potential in the antenna system it permits the receiving apparatus to be connected directly about it without injury to the receiving circuit during the period of transmission.

Owing to the extreme shortness of the gap G, the potentials of the transmitting apparatus are readily discharged to earth; but the received signals, by reason of their relatively low potential, pass through the primary winding of the receiving transformer P. With this method of connection the complete transmitting and receiving set is available for "breaking in" purposes. It is evident that the moment the transmitting key is raised the receiving tuner is in a receiving position.

The anchor gap as originally constructed had three spark discharge electrodes, which allowed the aerial to be used as a loop for receiving purposes; the high frequency oscillations during the periods of transmission discharged through both gaps simultaneously, the aerial acting as any ordinary straightaway aerial.

The introduction of an anchor gap in series with the antenna circuit is equivalent to placing a certain amount of resistance in that circuit, and the oscillations are therefore more rapidly damped than if it were not used.

The anchor gap has been abandoned by the Marconi Wireless Telegraph Company of America.

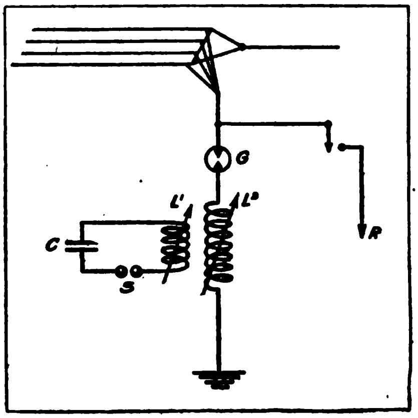


Fig. 2a.

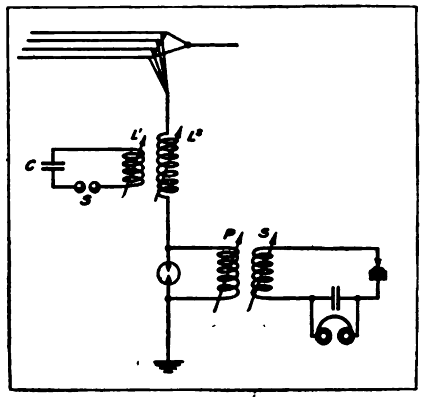


Fig. 2b.

4. Ques.—Name and describe three types of transmitter high potential condensers with which you are familiar.

Ans.—The three types of high potential condensers used in the wireless service at the present date are:

1. The oil plate condenser.
2. The leyden jar condenser.
3. The compressed air condenser.

The oil plate condenser consists of a sheet of glass, generally about 1/8 or 3-16 of an inch thick, coated on both sides up to within two or three inches of the edge with lead or tinfoil. A number of plates are usually connected in parallel and immersed in an oil having high insulating properties.

The leyden jar consists of a glass jar having thickness of about 1/8 of an inch, coated on the inside and outside with copper which is generally deposited by an electrolytic process.

The compressed air condenser consists of a number of interleaved steel plates enclosed in a steel cylindrical tank, which is pumped to an air pressure of about 250 or 280 pounds, the compressed air acting as the di-electric.

5. Ques.—Describe in detail a method for adjusting the transmitter to a given wave length.

Ans.—In tuning a transmitting set to resonance, three readings are necessary.

1. The wave length of the open circuit.
2. The wave length of the closed circuit.
3. The measurement of the radiated wave.

The wave length of the open circuit is measured as in Fig. 3. The antenna is represented at A, the aerial tuning inductance at L-2, and the secondary winding of the oscillation transformer at L-1. The primary of the oscillation circuit is designated at L. When taking this measurement the closed oscillation circuit is entirely disconnected from the primary of the oscillation transformer.

A small spark gap S is placed in series with the antenna, and is energized by an induction coil or transformer, the secondary of which is represented at F. When the induction coil is set into operation, radio-frequent oscillations traverse the open circuit, the period of which may easily be determined by varying the capacity of the variable condenser of the wave meter (as shown to the right of the drawing) until the point of resonance is obtained as indicated by the loudest sound in the head telephone.

The wave meter is now in resonance with the open circuit, and the wave length is indicated directly by the pointer above the scale on the variable condenser, or may be obtained by reference to the curve sheet which generally accompanies a wave meter. As the number of turns at L-1 are increased, it will be observed that the wave length of the open circuit is increased, hence, if a definite wave length is to be arrived at and the number of turns in this helix are not sufficient, a separate coil of inductance must be added as indicated at L-2. If L-1 is an inductance of fixed value, all the necessary changes will need to be made at L-2.

There are other methods by which the transmitting aerial may be set in excitation. For example: The aerial wire and the corresponding earth connection may be connected across the vibrator of an ordinary bell buzzer energized by two or three dry cells. Another method is to place a condenser of large capacity in series with the antenna system the terminals of the condenser in turn being connected across the vibrator of the buzzer. Owing to the high capacity of this condenser, the wave length of the antenna circuit is not appreciably altered and it will be set into excitation at practically its natural time period of vibration. Occasionally aboard ship the antenna circuit is set into excitation by means of the high potential transformer furnished with the transmitting set, but owing to the current output of the secondary winding difficulty is apt to be experienced in severe arcing at the gap, which may be eliminated to a certain extent by reduction of the alternator voltage or by the use of a very short spark gap made between two blunt electrodes. The arcing of the gap may be lessened also by substituting a rotary disc discharger for the plain gap.

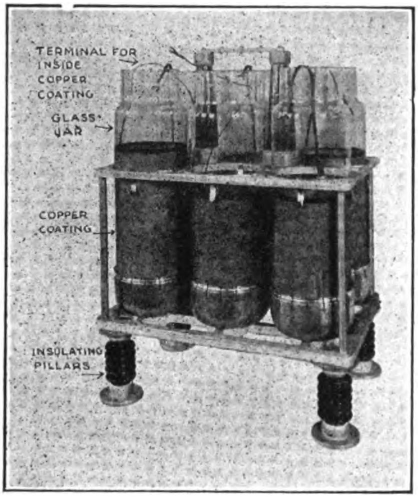
The closed circuit readings are made as in Fig. 4. The earth and antenna connections are removed from the helix, constituting the secondary of the oscillation transformer, an dthe spark gap of the power set energized in the regular manner. Instead of a detector this reading may be taken with a small lamp connected directly in series with the condenser and inductance coil of the wave meter.

As the capacity of the wave meter condenser is varied, the point of resonance between the wave meter and the circuit being measured is indicated by the maximum glow of the lamp. The resonant adjustment may also be determined by the crystal detector and head telephones.

When measuring the closed circuit care must be observed not to bring the wave meter inductance too close to the closed circuit, as the oscillations induced in it may be so strong as to burn out the light or puncture the insulation of the inductance coil. Several trial readings should be taken until the proper distance is found.

It will be found that if turns are added at the primary of the oscillation transformer, the wave length is increased. The wave length is likewise increased or decreased by increase or decrease of the condenser capacity.

In place of the glow lamp just described a hot wire milliameter having a range of 0 to 250 milliamperes may be used or, as an alternative, a small wattmeter having a range from .01 to 0.1 watt. The latter is generally connected to the secondary winding of a step-down transformer, the primary of which is connected in series with the wave meter circuit. Or, if desired, a Neon gas tube may be connected in shunt with the condenser of the wave meter for locating the position of resonance.



High potential condenser unit of .018 microfarads capacity.

After the two circuits have been independently adjusted to the same wave length, the transmitting set is coupled up in the regular manner as shown in Fig. 5.

The crystal detector of the wave meter is again switched into the circuit and the inductance coil of the wave meter held in the vicinity of the antennae.

When the transmitting key is depressed two resonant adjustments will be found on the wave meter, showing that two waves are being radiated.

This is due to the reaction of the magnetic fields of the closed and open circuits, one upon the other, causing the antenna to have two periods of oscillation, one of which is shorter than the individual adjustment of the circuits and the other longer.

For this reading the wave meter is preferably placed in inductive relation to the earth lead. If it is found that two wave lengths, widely separated, are being radiated from the antenna, the primary and secondary windings of the oscillation transformer are drawn apart; or, in other words, the magnetic coupling decreased until the wave meter indicates either a single wave of considerable intensity, or if two waves, the amplitude of the shorter must not exceed 10 per cent. of that of the longer. The relative intensity of the two waves is measured by a small wattmeter connected to a step-down transformer as previously described.

The method of tuning just described may be slightly altered. The closed oscillation circuit may be tuned to a definite wave length by means of a wavemeter

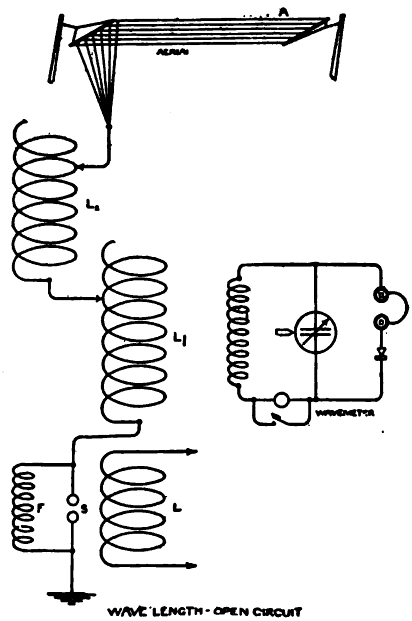


Fig. 3.

and the primary winding placed in inductive relation to the secondary winding of the oscillation transformer. A hot wire ammeter is then connected in series with the antenna circuit and the inductance values of the latter circuit altered until a miximum reading is secured.

This alone, however, does not insure that the wave radiated from this antenna complies with the government regulations, and it is therefore necessary to place a wavemeter in inductive relation to the earth lead of the open circuit and observe when the key is closed whether the decrement of the wave conforms with the statute requirements. It is of course understood that the coupling employed at the oscillation transformer influences the damping of the radiated wave.

A radio telegraph set may also be turned to resonance by means of a hot wire ammeter alone, but the operator adjusting a set by this method works at a disadvantage, because the hot wire ammeter does not indicate the character of the radiated wave, the degree of coupling, nor the length of the wave.

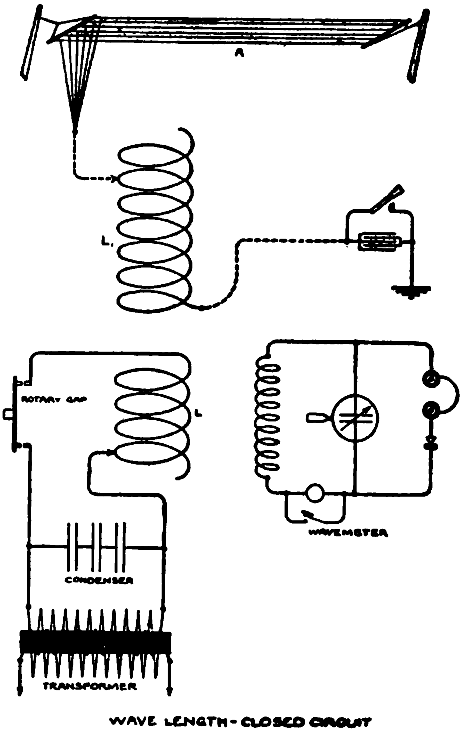


Fig. 4.

If it becomes necessary to tune a set in this manner, however, it may be accomplished as shown in the diagram, Fig. 6 (in which drawing the hot wire ammeter has been intentionally enlarged to give the reader an idea of the internal mechanism of the device).

A hot wire ammeter is a device which measures the current in a given circuit by causing that current to flow through a resistance wire. In passing through this wire, heat is produced, which causes the wire to expand; the expansion in turn is made to move a needle across a calibrated scale.

In adjusting a transmitting set to resonance by this method, the hot wire ammeter is placed either in series with the earth lead or the antenna lead. The contact clip of the primary winding of the oscillation transformer L is set at some definite point or the closed circuit may be adjusted to some definite wave length by means of a wave meter.

The contact clip of the aerial tuning inductance is placed at some point, say the middle of the helix, and a trial reading taken.

The number of turns at the aerial tuning inductance are then increased or decreased until a maximum deflection of the hot wire ammeter is obtained. This reading indicates that the circuits have practically the same period of oscillation and they are said to be in electrical resonance.

This calibration could be effected in the reverse manner: That is to say, a certain amount of inductance could be included in the open circuit helix and the contact clip of the closed circuit varied until the highest hot wire ammeter reading is obtained.

6. Ques.—Describe in detail a type of wavemeter with which you are familiar.

Ans.—The circuits of the Marconi wavemeter are clearly represented in Fig. 7. It consists of a variable condenser to which is connected an inductance coil of fixed value. The inductance is attached to the condenser by means of a flexible cord so it can be placed in any position desired, while the variable condenser is placed at some distance from the circuit to be measured. A carborundum crystal is connected in series with the head telephones as shown in the drawing. Both are then connected in shunt to the variable condenser. A small glow lamp is included in series with the coil, and may be cut out of the circuit by means of the switch indicated.

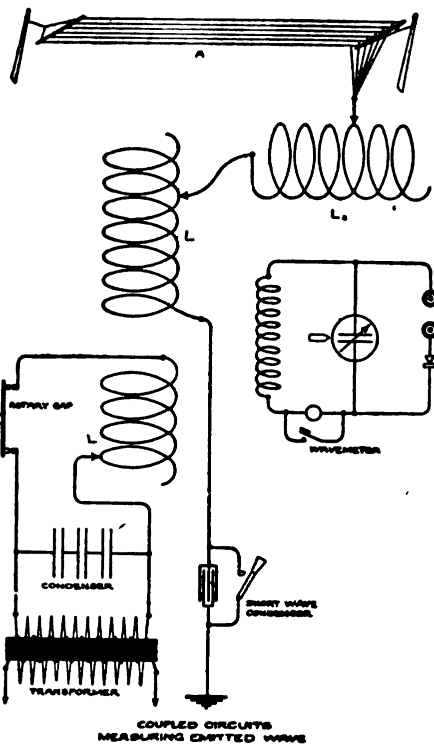


Fig. 5.

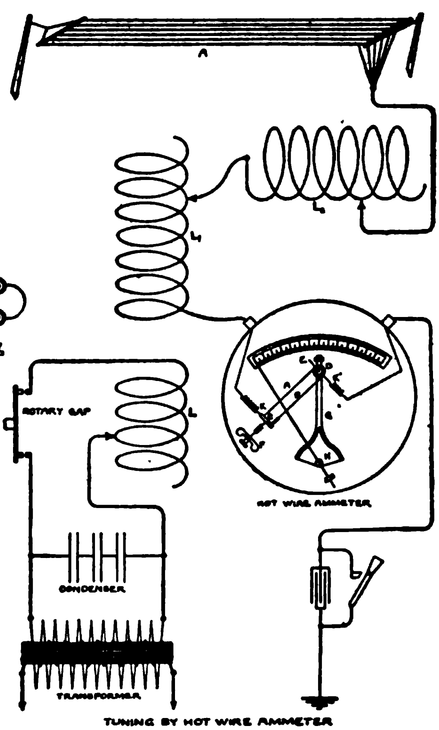


Fig. 6.

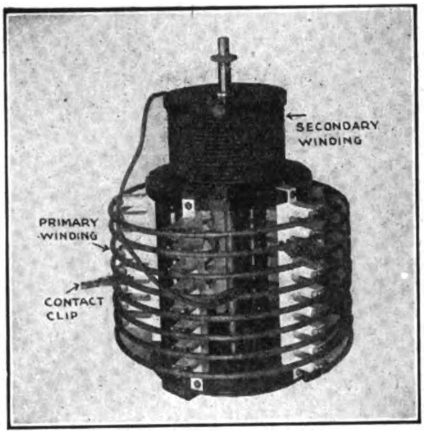
A scale is placed directly on the variable condenser, which in turn moves under a stationary pointer. The scale reading of the condenser may be graduated directly in wave lengths or the data may be plotted in the form of a curve in terms of an empirical scale on the condenser. These calibrations are obtained by comparing the wavemeter to a standard oscillatory circuit or by calculation of the constants in the wavemeter itself.

The point of resonance on the wavemeter may be located either by a lamp in series with the circuit, by a crystal detector and head telephones in shunt to the condenser, a hot wire milli-ammeter in series with the wavemeter, a

Neon gas tube in shunt to the variable condenser, or a crystal detector and head phones connected unilaterally to a binding post of the variable condenser.

Certain types of wavemeters have a variable inductance and a fixed capacity, while others may have a variable inductance and a variable capacity.

In using a wavemeter care must be taken that the coil of the wavemeter bears a certain relation to the circuit under measurement, otherwise it will not be cut by the lines of force.



A transmitter oscillation transformer of the inductively coupled type.

7. Ques.—Show by simple diagram a direct or conductively coupled transmitting set.

Ans.—The circuits for a set of this type are indicated in the drawing, Fig. 8. A portion of the turns of the helix AC are used for both the primary and secondary circuits. For example, the primary winding may include the turns from A to B, while the secondary winding includes the turns from A to C. Lines of force emanating from the primary winding cut the secondary winding in a manner very similar to the inductively coupled oscillation transformer. It should also be understood that a portion of the energy from the primary winding flows to the secondary. winding by direct conduction.

8. Ques.—If all your transmitting condensers were broken, including the spares, how would you connect up the set temporarily for transmitting? Give a simple diagram.

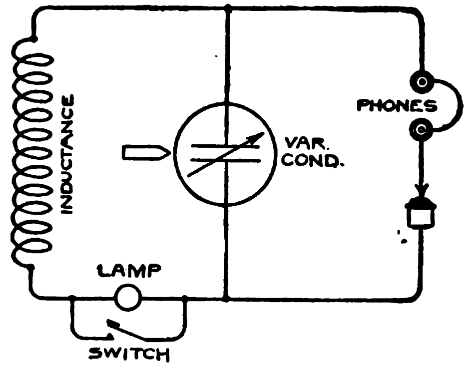
Ans.—Under these conditions it would become necessary to connect the secondary winding of the power transformer directly to a spark gap, which is in turn placed in series with the antenna, i. e., the plain aerial connection. (Fig. 9.)

Considerable difficulty is likely to be experienced with this method of connection by reason of arcing at the spark gap. Generally the capacity of the aerial is insufficient to handle the energy output of the transformer, and it may therefore become necessary, in order to secure a clear spark, to reduce the primary potential of the transformer by means of the generator field rheostat. Even with these precautions this arrangement is rather unsatisfactory for long distance work and probably could not be depended upon for a range of more than 40 to 50 miles.

Commercial transmitting equipments are equipped with auxiliary apparatus which is intended to be employed when an accident occurs to the power set.

9. Ques.—If your hot wire ammeter broke, what simple device could be put in its place to accomplish the same results as far as resonance is concerned?

Ans.—Several make-shift arangements may be employed as indicated in figures 10a, 10b, and 10c. The method shown in 10a is prefer-



MARCONI WAVEMETER.

Fig. 7.

able. Here a small glow lamp, M, is connected in series with the open oscillatory circuit of a transmitter and is shunted by a loop of wire, W, having the sliding contact, C. When such adjustments are made in the primary and secondary circuits of the oscillation transformer as to secure the maximum glow of the lamp, conditions of resonance between the primary and secondary circuits are indicated. It may be necessary as the point of resonance is approached to decrease the length of the shunt W to prevent the battery lamp burning out. In the method shown in figure 10-b a small spark discharge gap S is included in series with the antenna circuit. The values of inductance in the primary and secondary circuits are altered until the greatest volume of discharge is secured across the gap, which will, of course, approximately indicate resonance.

If desired this discharge gap may be placed in shunt to the secondary winding of the oscillation transformer, as shown in figure 10-c. Again variation of the inductance values in either the open or closed circuits is made until the greatest volume of discharge is secured across the gap.

10. Ques.—What are the advantages of the high frequency spark discharger?

Ans.—The advantages are three-fold: First: The signals from a high frequency spark are more easily read through atmospheric disturbances; Second: The average commercial head telephone is more sensitive to a high frequency spark than to one of low frequency; Third: It is decidedly easier to formulate the characters of the telegraphic code owing to the smoothness of the spark discharge.

There is an added advantage in the use of high frequency sparks which should not be passed over; namely, for a given number of watts a lower potential is employed, which reduces the strain on the insulation of the apparatus as a whole and permits the use of a smaller condenser.

11. Ques.—Describe some form of quenched spark gap and explain its advantages.

Ans.—(The construction of the quenched spark gap will be better understood from the photograph, Figure 11.) It consists of a number of copper plates with cooling flanges carefully ground and mounted in a rack. These plates are separated by insulating washers, so that the spark discharge surfaces are separated by about 1-100 of an inch. When the plates are mounted in the frame they are pressed closely together by means of a bolt at the end of the casting.

The quenched spark gap possesses several advantages:

(1) The oscillations in the condenser circuit are rapidly damped out, allowing the antenna circuit to swing in its own natural period of vibration without reaction on the closed circuit.

(2) It therefore emits a single wave length in the antenna circuit.

(3) It is noiseless in operation.

(4) It permits the use of transformers having low voltage secondaries, an obvious advantage.

12. Ques.—What instruments are required to adjust a transmitter to a certain definite wave length?

Ans.—A wavemeter comprising a coil of inductance and a variable condenser in connection with a crystalline detector and head telephone. Also a hot wire aerial ammeter to measure the current in the antenna circuit.

13. Ques.—In case of distress aboard ship how would you adjust a transmitter for maximum radiation and a broad interfering wave?

Ans.—This is best accomplished by an increase of coupling; that is to say, the secondary winding of the oscillation transformer should be telescoped inside the primary winding, making sure first that the circuits are in resonance.

An increase of coupling means that energy is being extracted from the closed circuit at a more rapid rate and the damping of the circuit is therefore increased, resulting in a broader wave.

14. Ques.—Name some disadvantages of the plain aerial transmitter.

Ans.—The principal objection to this type of transmitter is that through its inherent characteristics a highly damped interfering wave is given off from the antenna circuit. This is largely due to the insertion of the spark gap in series with the path of the high frequency oscillations.

Furthermore, when the plain aerial connection is used, the antenna insulation is subjected to a considerable strain from the low frequency high potential current which is superimposed upon the high frequency oscillations flowing in that circuit, and this may result in a complete breakdown of the aerial insulation.

The plain aerial type of transmitter—even as an auxiliary set—has been abandoned by the Marconi Wireless Telegraph Company of America.

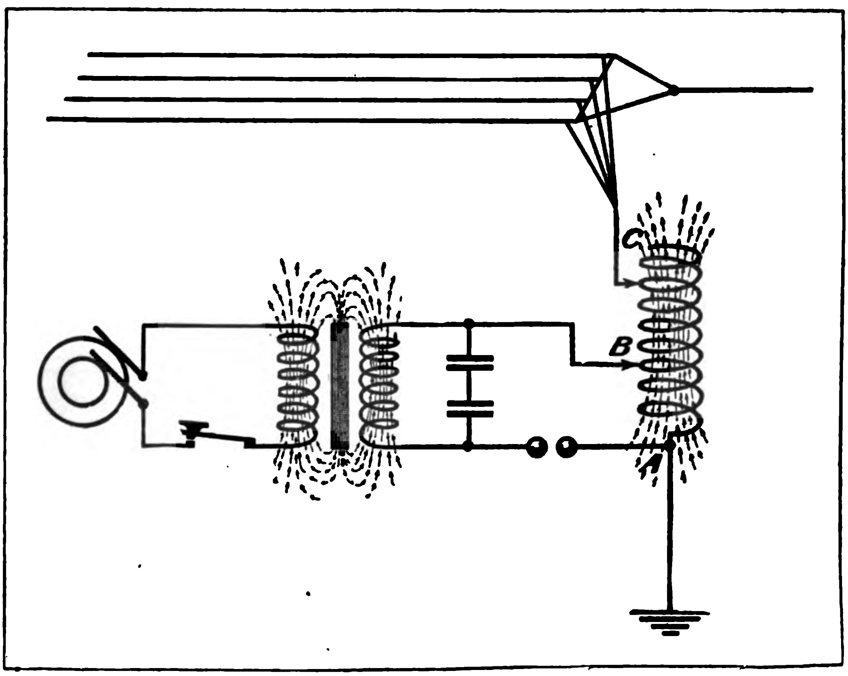


Fig. 8.

15. Ques.—What is meant by the natural period or fundamental wave length of an antenna?

Ans.—The natural period of an antenna is the time required in fractions of a second for a complete oscillation to traverse the aerial circuit. The fundamental or natural wave length is the wave length of the antenna due to its inductance and capacity without the addition of an aerial tuning inductance or a short wave condenser in series.

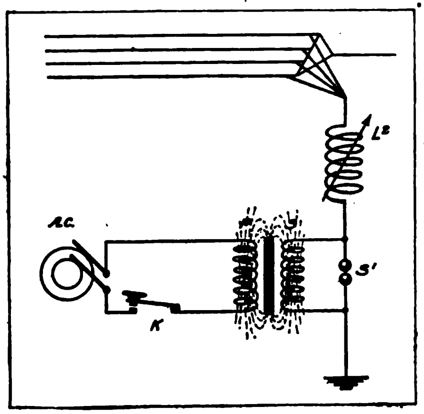


Fig. 9.

16. Ques.—Why is alternating current used as a source of power in radio telegraphic work?

Ans.—By the use of alternating current high voltages are obtained without the troublesome interrupter which is necessary when the induction coil operated by a magnetic interrupter is the source of high potential energy.

The amount of energy that may be handled by the magnetic or electrolytic interrupter is limited to about 1 K. W., whereas with the alternating current transformer any amount of energy up to 500 K. W. may be handled.

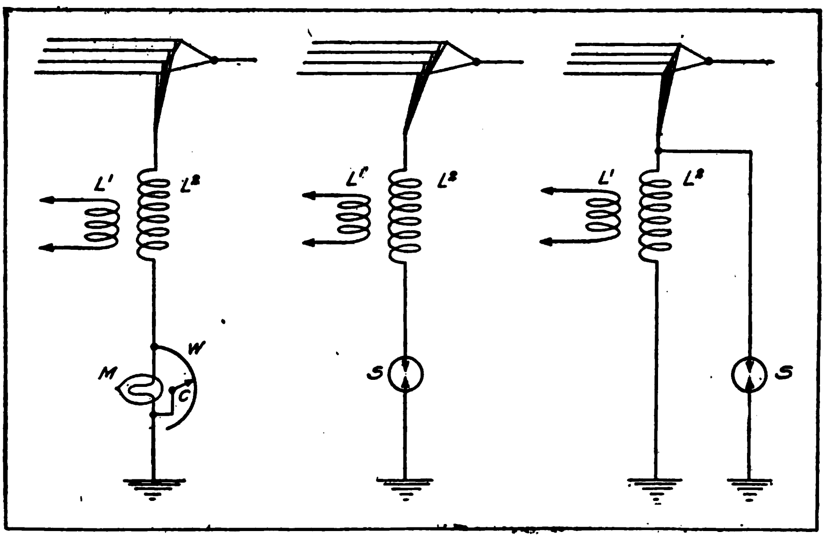


Fig. 10a. Fig. 10b. Fig. 10c.

17. Ques.—If your spark suddenly stopped while sending, give the order in which you would look for the trouble and the method of repair for each possibility.

Ans.—The source of trouble may be traced in the following order: If the motor generator itself has not ceased operations from a blown fuse at the D. C. switch, the fuses in the circuit from the alternating current armature may have blown or the line to the generator field windings may have been interrupted at some point. Or there may be an open circuit in the primary winding of the transformer, or a short circuit in the secondary winding.

If the equipment contains a stationary spark gap there is a possibility that the spark electrodes may have fallen together, thereby short-circuiting the transformer. Or perhaps while sending the high potential condensers may have punctured. Leakage through the walls of the spark muffler may be experienced or the insulating bushings around the high potential terminals of the transformer may break down, causing leakage through the lid.

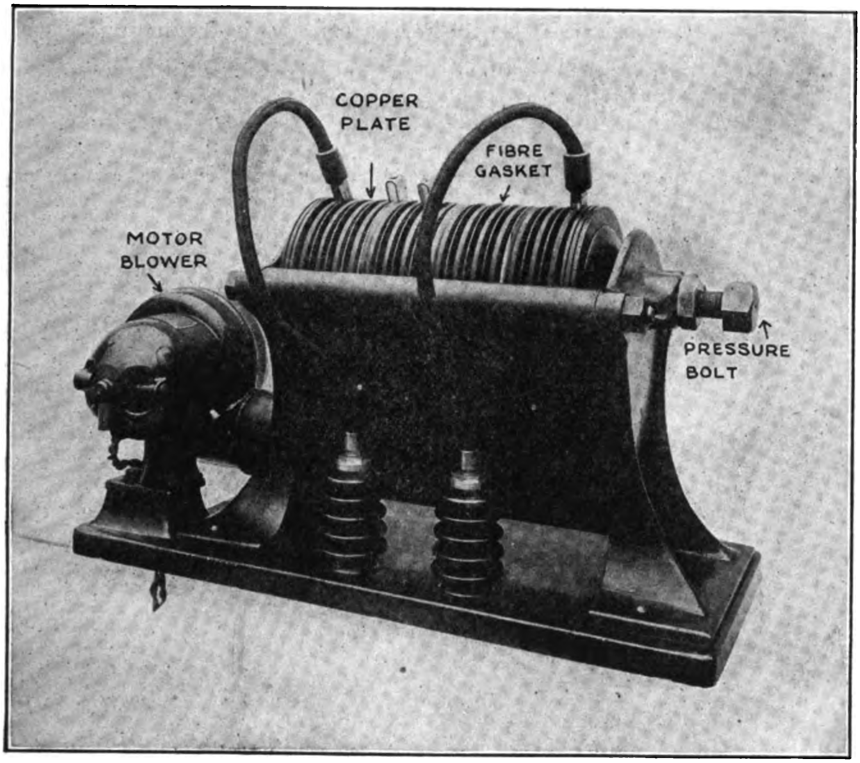


Fig. 11—A modern series or quenched spark discharger with motor blower.

The remedy for a blown fuse is obvious; it only needs to be replaced. Should a test indicate that the generator field winding is open, it is probable that the generator field rheostat is burned out. The burnt-out section may be located by a battery and telephone test circuit and then shunted by a piece of wire. If the test indicates a short circuit in the primary winding of the transformer, it can readily be removed and repaired by the operator at sea. A greater difficulty is encountered should the test indicate a burnt-out secondary winding. If the transformer is wound in sections, as many high potential transformers are, the burnt-out section can be located and should then be removed from the magnetic field of the primary winding, the remaining secondary windings being connected in series and the transformer operated at a lower potential.

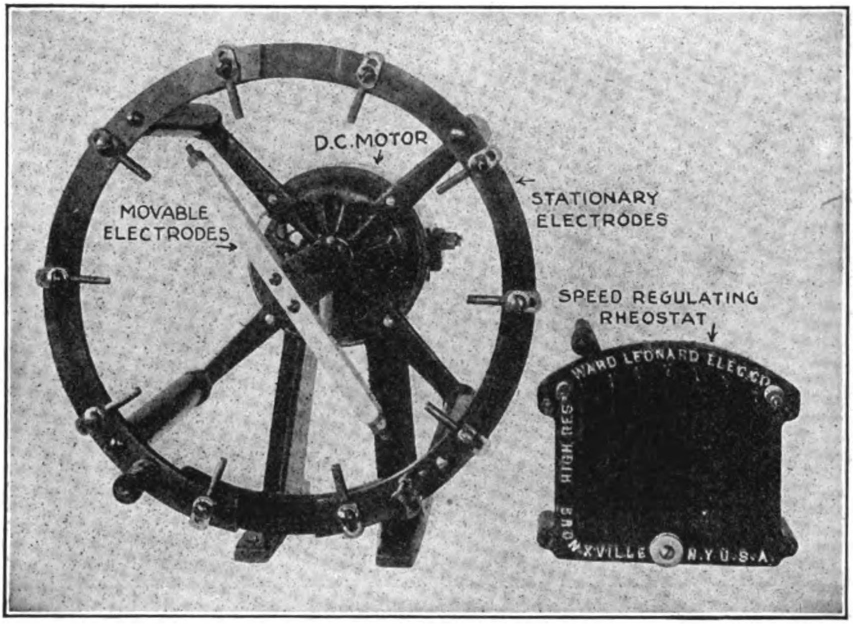
Punctured condensers should be replaced by the spares ordinarily furnished to each vessel. If no spares are available a parallel connection of the remaining condensers could be made, affording the same capacity as that previously used; but the transformer must then be operated at a lower primary voltage. Often leakage in the spark gap muffler may be stopped by wiping it out with a piece of dry waste, but if the leakage is abnormal, the muffler may be removed entirely and the spark gap temporarily supported and operated in the open air.

18. Ques.—What is the effect of opening a spark gap too wide?

Ans.—The strain on the condensers is increased to a considerable degree and a puncture may result; furthermore, the spark note becomes rough, irregular and of disagreeable characteristics. The secondary windings of the transformer are also subjected to abnormal strain and a break-down of the insulation may result.

19. Ques.—What is meant by the term, wave train frequency?

Ans.—The number of wave trains radiated from an antenna per second of time. It is, in reality, a function of the spark frequency of the set, for whenever a single spark discharge takes place at the spark gap a train of



A non-synchronous rotary spark discharger.

waves is radiated from the antenna. In the case of a 500 cycle synchronous transmitting set, giving 1,000 sparks per second, the wave train frequency would be 1,000 per second.

20. Ques.—What is the effect of connecting two equal parallel banks of transmitting condensers in series?

Ans.—The total capacity of the condenser is reduced to one-half of one bank, but the strain of the transformer voltage on the dielectric is equally divided between the two units, thereby protecting the condensers from possible puncture.

21. Ques.—On what occasion would you change the wave length of your transmitting set to other than normal?

Ans.—By the rules of the London Convention the normal wave lengths for a vessel are 300 and 600 meters, either one of which is to be used for calling purposes. The convention regulations also specify that any wave length between 300 and 600 meters may be employed for communication after the call has been effected.

In case of accident to the antenna at sea, if, for example, a portion of it were blown away, on account of the reduced wave length of the aerial, the aerial tuning inductance might not have sufficient turns to allow the antenna circuit to be readjusted to the normal wave length. These conditions imposed, the open and closed circuit must be adjusted to any wave length which the equipment affords, the open and closed circuits being turned to resonance by a glow lamp or a hot wire ammeter as previously described.

It is possible that a number of the transmitting condenser jars may be punctured and the wave lefigth of the closed circuit reduced by such an amount that a normal wave length canot be attained. If so, the wave length of the antenna circuit must be decreased to meet these conditions to effect resonance.

22. Ques.—What is the effect on the adjustment of a transmitter if the coupling is considerably increased?

Ans.—Electro magnetic waves of two frequencies will be radiated from the antenna, and if the coupling is close, the energy will be distributed over a wide range of wave lengths, causing considerable interference.

When the open and closed circuits have been individually adjusted to resonance, an increase of coupling results in a corresponding change in the effective self-inductance of either circuit, thereby throwing them slightly out of resonance.

23. Ques.—How do you reduce the power of a transmitting set for short distance work?

Ans.—It is customary to use a reactance coil connected in series with the primary winding of the power transformer to regulate the current flow, but from a working standpoint this method is impractical. When the power is reduced by this means in certain types of apparatus, a total readjustment of all the variable elements in the transmitter is required.

Lacking a reactance coil, the power input to the transformer may be reduced by a decrease in the voltage of the alternator. This is accomplished by insertion of a variable resistance or rheostat in the generator field winding circuit.

In present day Marconi equipments, the effective range is decreased as follows: In the rotary disc discharge type of transmitting apparatus, the secondary winding of the oscillation transformer is so constructed that it may be placed directly at a right angle to the primary winding or at any intermediate position as desired. In this way the current in the antenna circuit can be progressively decreased from a maximum value to a zero value. In the reduction of power by this method no changes are required in the adjustment of the remainder of the transmitting equipment.

In the quenched spark type of apparatus the method is somewhat different: the effective range of the set is reduced by a decrease of the number of gaps in use and a corresponding reduction of the alternator voltage.

24. Ques.—How are very high voltages produced for radio telegraphic purposes?

Ans.—Either by means of a step-up alternating current transformer or by an induction coil fitted with a magnetic or electrolytic interrupter.

25. Ques.—Name some commercial frequencies which are employed in radio telegraphic work.

Ans.—60, 120, 240, 480, 500 and 600 cycles.

26. Ques.—Why is the cut-over or transfer switch sometimes called the antenna switch, and what is its object? Give a simple diagram of connections.

Ans.—A simple diagram of connections for a modern Marconi aerial change-over switch is shown in Figure 12, the functions performed by the various contacts being clearly designated on the drawing. When the blades

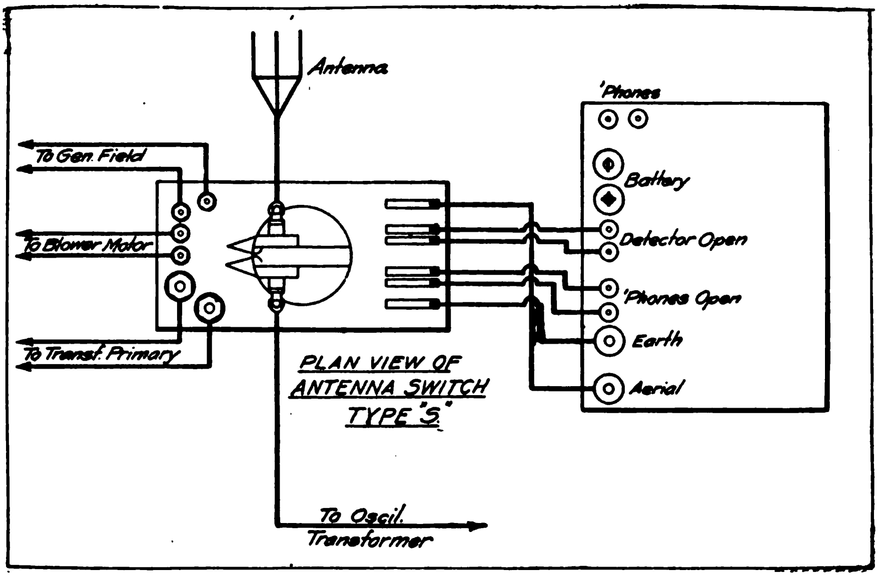


Fig. 12.

of this switch are thrown upward the apparatus is in a receiving position, and when pressed downward the apparatus is in a transmitting position.

The antenna or aerial switch was primarily intended for the purpose of disconnecting the receiving apparatus from the antenna while transmitting, or vice versa. It is self-evident that the receiving apparatus cannot be connected to the antenna circuit during the period of transmission, and it therefore not only becomes necessary to disconnect the receiving apparatus from the antenna, but also to protect the receiving detector from the oscillations of the nearby transmitter.

A proper aerial switch performs the following functions:

During the period of transmission it disconnects:

1. *The antenna from the primary winding of the receiving tuner.*
2. *The earth-leads from the primary winding of the receiving tuner.*
3. *Disconnects and short circuits the receiving detector.*
4. *Closes the circuit to the primary winding of the transformer.*

During the period of reception, the antenna switch:

1. *Opens the circuit to the primary winding of the power transformer.*
2. *Connects the aerial leads to the primary winding of the receiving transformer.*
3. *Connects the other terminal of the primary winding to earth.*
4. *Puts the receiving detector into the circuit for use.*
5. *Disconnects the aerial from the secondary winding of the transmitting oscillation transformer.*

An antenna switch may also be fitted with auxiliary contacts to operate a distantly controlled automatic motor starter, a motor blower or any other

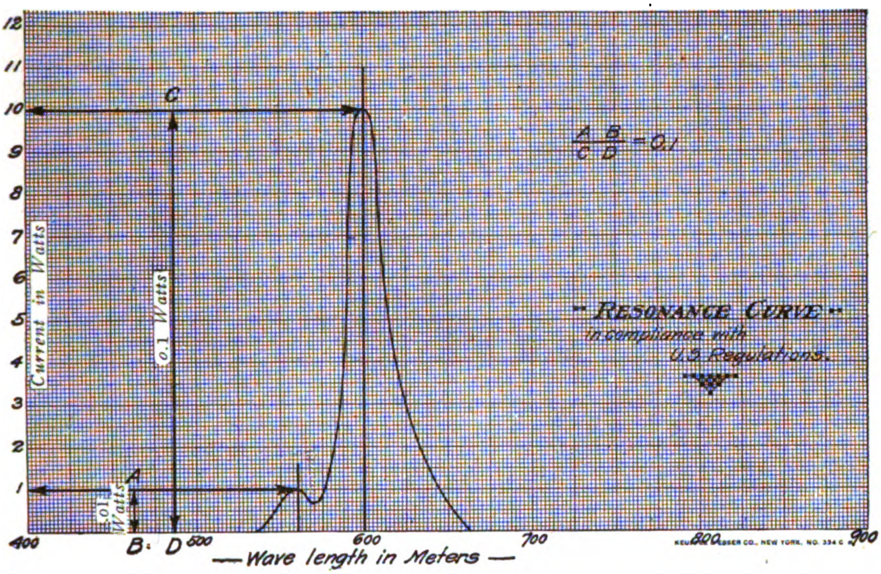


Fig. 13.

auxiliary device required in connection with a transmitting or receiving set.

27. Ques.—What is the most common cause for the break-down or puncture of high potential condensers?

Ans.—An abnormally widened spark gap is most productive of punctured condensers.

28. Ques.—What is meant by a pure wave in radio telegraphy?

Ans.—The emitted wave is considered as being "pure" when, if there are waves of two frequencies present, the energy in the lesser wave is in amplitude less than 10% of that in the greater wave.

(A resonance curve of an emitted wave having these characteristics is indicated in figure 13.)

29. Ques.—What is the effect on the wave length of a transmitting set if a few condensers are removed from the closed oscillatory circuit and the set retuned at the antenna circuit?

Ans.—The wave length of the closed oscillatory circuit is reduced and the wave length of the open oscillatory circuit must be decreased by the same amount to maintain conditions of resonance. This may be accomplished by putting less turns in the aerial tuning inductance or, if necessary, by the insertion of a short wave condenser.

When this change has been made, the coupling between the primary and secondary windings of the oscillation transformer must be increased to maintain normal radiation.

30. Ques.—Show by simple diagram an inductively coupled transmitter.

Ans.—The complete circuits for this type of transmitter are clearly indicated in Fig. 14, the primary winding of the oscillation transformer being represented at L-1, the condensers at C, C-1, and the spark gap, comprising the closed oscillatory circuit. The open oscillatory circuit, or antenna circuit is designated by the secondary winding L-2, the aerial tuning inductance L-3 and the short wave condenser C-2.

31. Ques.—How would you test for an open circuit in either the primary or secondary winding of the power transformer, or an induction coil?

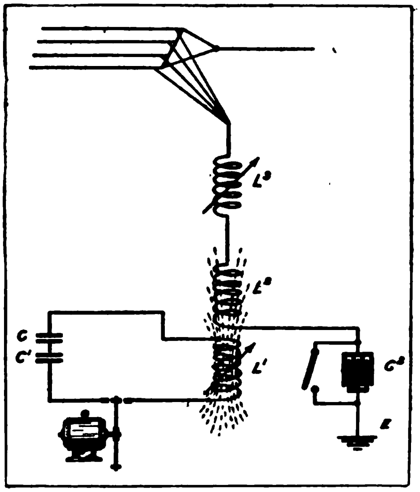


Fig. 14.

Ans.—For the primary winding an open circuit is made manifest through observation of the ammeter on the switchboard which, of course, would not indicate when the transmitting key is depressed. Should there be any doubt as to the accuracy of the ammeter, a 16 candle power incandescent lamp may be inserted in series with the primary winding; if the lamp does not light to brilliancy, the operator is assured that the primary circuit is open.

A similar test might be applied to the primary winding of an induction coil; a 110 volt direct current circuit in series with which is connected a 16 C. P. lamp being used for testing purposes.

It is not likely that the secondary windings of an induction coil or transformer will burn "open"; they are more apt to become short circuited. The better method for determining the condition of the secondary winding of a transformer or an induction coil is to supply normal current to the primary winding and note by a flash test the length of spark discharge obtained at the secondary terminals. Of course the actual length varies with the size of the set and the potentials employed, but if the gap is shortened down to, say, 3-16 of an inch and no discharge occurs, it is a fair indication that the secondary winding is short circuited, or perhaps burned "open."

32. Ques.—Name and describe the types of spark gap dischargers with which you are familiar.

Ans.—In the commercial service of to-day four distinct types of spark dischargers are employed: (1) the plain spark discharger; (2) the non-synchronous rotary spark discharger; (3) the synchronous spark discharger; (4) the quenched spark discharger.

The plain dischargers generally consists of two brass electrodes, slightly round at the tips, having a diameter in the smaller sets of about ¼ of an inch. These are simply adjusted in length until the note of spark is clear.

The non-synchronous rotary spark gap generally consists of a disc containing a number of spark electrodes mounted on the shaft of a D. C. motor. There are also two stationary electrodes for completing the circuit. The non-synchronous rotary discharger is generally run at such speed as will give about 400 spark discharges per second in the closed oscillatory circuit, the sparks taking place on various portions of the cycle of charging current. The non-synchronous discharger is used to produce a musical note from a 60 cycle source of current supply.

The synchronous rotary spark discharger is similar in construction to the non-synchronous type, with the exception that it is mounted on the end of the motor generator shaft and has the same number of electrodes as there are field poles in the generator. In this manner a spark is produced every alternation of the charging current, which gives a note of musical pitch. The synchronous discharger also gives oscillations of increased amplitude.

The quenched spark discharger completely described in the answer to question No. 11 is generally employed in connection with 500 cycle current supply, but recent quenched sets of the Marconi Company use a frequency of 120 cycles. When properly adjusted the quenched spark discharger is synchronous, giving one discharge per alternation of the charging current. Plain spark discharges are often supplied with an air blast to prevent arcing and to give clearness of note.

33. **Ques.—What is meant by the term spark frequency?**

Ans.—The spark frequency of a radio set is the number of sparks bridging the gap of the closed oscillatory circuit per second of time. It is to a great extent a function of the alternator frequency, but not necessarily so.

34. **Ques.—Describe a method for protecting high potential condensers from puncture.**

Ans.—They may be equipped with spark discharge safety gaps or the complete unit may consist of two or three banks in series parallel, thereby dividing the voltage between them.

35. **Ques.—How would you determine whether your transmitting station is emitting a pure wave?**

Ans.—This is best determined by means of a decremeter. A decremeter is nothing more than a wavemeter in series with which is connected an indicating device by which the amplitude of current of the radiated wave may be measured. A reading of the current corresponding to the position of resonance on the wavemeter may be compared with a reading at such wave length where the current value in the indicating instrument drops to one-half the value at resonance. The data so obtained is sufficient to be inserted in the well known Bjèrknes formula for obtaining directly the logarithmic decrement of damping.

36. **Ques.—What is the effect of placing a condenser in series with the antenna?**

Ans.—The total effective capacity of the antenna is decreased and therefore the wave length.

37. **Ques.—How can a transmitting set be plainly marked for a quick change from one wave length to another?**

Ans.—This data is best obtained by means of a wave-meter, the closed and open oscillatory circuits being calibrated in advance and the corresponding wave lengths either marked on the apparatus itself or placed on a reference-card and posted in the radio room. The latter method is the one at present in use. There is, however, no reason why the oscillation transformer cannot be directly marked on both the primary and secondary windings so that quick changes of wave lengths can be made as desired.

38. Ques.—What is the advantage in having more than one wire in the antenna for transmitting purposes?

Ans.—An increase in the number of wires of an antenna increases the capacity, decreases the effective inductance, and decreases the high frequency resistance. For these reasons a slight increase of transmitting range is experienced.

39. Ques.—Describe the use of a loading coil and its effect.

Ans.—If by this term reference is made to the aerial tuning inductance, it has the effect of increasing the wave length of the open oscillatory circuit.

NOTE.—Use of the term "loading coil" is improper; for any coil having inductance, regardless of the circuit in which it is used, puts an effective "load" on the circuit; therefore the term cannot be confined alone to the aerial tuning inductance.

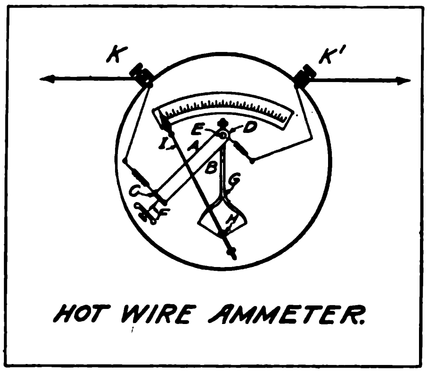


Fig. 15.

An aerial hot wire ammeter.

40. Ques.—If the coupling of the transmitting apparatus is increased what effect will it have on the wave length?

Ans.— It will have a tendency to set up two waves in the aerial circuit, thereby increasing the interference and perhaps decreasing the over-all efficiency of the set.

41. Ques.—Describe a hot wire ammeter and its uses in connection with a transmitting apparatus.

Ans.—The mechanism of the Roller-Smith hot wire ammeter is clearly indicated in figure 15.

A wire, AB, of high resistance, is secured at one end to plate C, passed around to pulley D, secured to a shaft E and its free end brought back again and mechanically (but not electrically) attached to the same plate C. Plate C is kept under stress by the spring which constantly tends to pull it in a direction at right angles with the axis of the shaft E. To the shaft E is likewise secured an arm G, bifurcated at one end and counterweighed at the other. Between the extremities of the bifurcated end and the arm G is another shaft H, on which is a small pulley and attached thereto the needle I, which gives the desired indication; a fine silk fibre is attached at one end to one of the arms of G, then passes around to the pulley and the shaft H, and finally has its other extremity secured to the other arm. The current to be measured flows through the wire A only entering at K and leaving at K-1.

When A is heated by the passage of the current it expands, making A's tension relatively less than that of B, and equilibrium can be restored only when the pulley D rotates sufficiently again to equalize the same. The rotation of D carries G with it, and G in moving causes the silk fibre to rotate the shaft which carries the needle. The movement of the needle is then dependent upon the amount of expansion in A.

A hot wire ammeter may be employed for placing the open and closed oscillatory circuits in resonance, but it must be remembered that it does not indicate the degree of coupling nor the character of the emitted wave. It is especially useful in quenched spark gap sets and is the only visible means of indicating that this apparatus is performing its proper function. The hot wire ammeter is often used (in the form of a milli-ammeter) in wavemeter circuits for indicating the value of current flowing.

42. Ques.—How can you tell if your antenna is radiating? Describe the apparatus used.

Ans.—One cannot tell if the antenna is radiating unless communication is established with a distant radio station. It is a well-known fact that some aerials radiate better than others, and it is also possible that there may be considerable current flow in an antenna circuit with poor radiation.

When a transmitting set is first tuned to resonance if proper note is taken of the antenna current and similar values are not obtained under normal conditions, it is a fair indication that something is wrong either in the antenna circuit or in the spark-producing circuit, and therefore normal radiation is not taking place.

43. Ques.—What are the uses of a lightning switch?

Ans.—It is employed to disconnect the aerial from all radio apparatus during severe lightning, at the same time connecting the aerial directly to earth.

44. Ques.—What is meant by the frequency of an alternator?

Ans.—The number of complete alternations of current flowing in and out of the armature windings in a second of time.

45. Ques.—Explain the object and operation of a circuit breaker.

Ans.—A circuit breaker is a device designed to take the place of a fuse in a circuit. Briefly, it may be described thus: A small electromagnet in series with the line from the generator is made to operate, through an intricate mechanism, two large contact surfaces, which when the current in the magnet exceeds a certain amount are tripped and the circuit forcefully opened by means of a large spring.

It is customary when a circuit breaker is employed to include in the circuit a fuse of slightly larger amperage capacity than that of the circuit breaker. In case the circuit breaker should become inoperative the fuse will blow, protecting the generator from short circuit. The average circuit breaker is adjustable over a certain range of amperes and may therefore be set to open the circuit when more than a predetermined amount of current flows in that circuit.

46. Ques.—Sketch a circuit showing the connections of the primary ammeter, voltmeter and wattmeter.

Ans.—This query is fully covered in the answer to question No. 1.

47. Ques.—How do you decrease the power for working near a land station?

Ans.—By inserting a reactance coil in series with the primary winding of the transformer, by reduction of the alternating current voltage of the generator, or by decreasing the coupling of the transmitter oscillation transformer.

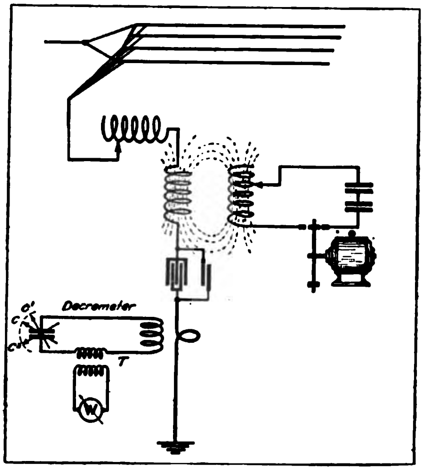


Fig. 16.

48. Ques.—Explain briefly how the logarithmic decrement of damping is measured.

Ans.—There are several methods for obtaining the measurement of the decrement of damping, the most practical one being the following:

The instrument used is ordinarily known as a decremeter, and this is nothing more than a wavemeter equipped with a current-reading device by which the current flowing in the wavemeter circuit under certain conditions may be accurately measured.

The method for obtaining the decrement is shown in Figure 16, where the complete circuits of a radio transmitter are shown to the right of the drawing. To the left of the drawing is indicated the circuit of a wavemeter, consisting of a variable condenser and the fixed coil of inductance. A small step-down transformer, T, has its primary winding connected in series with the condenser and inductance of the wavemeter, while the secondary winding is connected to a small hot wire wattmeter having a range of from .01 watt to .1 watt.

The inductance coil of the wavemeter is placed in inductive relation to the earth lead of the antenna circuit at any given station. After the proper values of coupling are obtained a measurement of the corresponding current is taken when the condenser of the wavemeter is adjusted to resonance with the antenna circuit.

After this reading has been observed the condenser of the wavemeter is turned to a point above resonance where the current value, as indicated by the hot wire wattmeter, is decreased one-half the value obtained at resonance. The condenser is then turned to a position below the point of resonance where the wattmeter again falls to one-half the reading of current value obtained at resonance. If the condenser of the wavemeter is calibrated so that the capacity value corresponding to the scale reading is known, then we may substitute the data so obtained in the following formula:

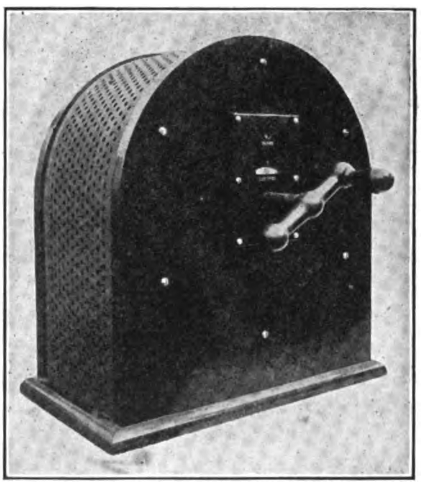
$$\delta_1 + \delta_2 = 1.57 \times \frac{C_1 - C_2}{C}$$

where

δ_1 = the decrement of the aerial circuit.
δ_2 = the decrement of the wavemeter.
C_1 = the capacity of the condenser above resonance.
C_2 = the capacity of the condenser below resonance.
C = the capacity of the condenser at resonance.

In modern decremeters the decrement of the instrument itself is either directly affixed to the condenser scale or tabulated in curve form for reference. If the decrement of the decremeter is known the value may be subtracted from that obtained in the above formula and the result will be the decrement of the circuit under measurement.

NOTE.—According to the U. S. regulations, the decrement of the emitted wave shall in no case exceed 0.2.



An aerial tuning inductance of the continuously variable type (flat spiral) for transmitter.

49. Ques.—Describe the nature of a spark discharge in a radio telegraph transmitter.

Ans.—The spark discharge of a radio transmitter consists of a series of electrical discharges from a positive to a negative terminal of the gap. When the electro-static energy stored up in the condenser reaches a certain critical value of potential the gas in the immediate vicinity of the spark gap becomes ionized, forming a conducting path for the passage of electrical energy.

Assume, for example, a 500 cycle transmitter: If adjusted synchronously, the spark will discharge first in one direction and then in the opposite direction, 1,000 times per second, that is to say, there is one spark for each alternation of charging current. The individual spark (of each alternation) is composed of a series of decaying high frequency electrical oscillations, having a frequency of vibration dependent upon the inductance, capacity and resistance of the closed oscillatory circuit.

In commercial practice when the transmitter is adjusted to the standard wave length of 600 meters, from 24 to 100 complete oscillations take place per individual spark.

It should be kept in mind that the frequency of the alternator for a radio telegraph transmitter is dependent upon the revolutions per second of the armature and the number of field poles, or

$$N = \frac{P \times R}{2}$$

where P = the number of field poles of the alternator.
R = the revolutions of the armature per second of time.

The frequency of the radio circuit, assuming the resistance to be negligible, is:

$$N = \frac{5{,}033{,}000}{\sqrt{LC}}$$

where L = the inductance in centimeters.
C = the capacity in micro-farads.

However, the number of complete radio frequency oscillations taking place per spark is given by the following formula:

$$M = \frac{4.605 + \delta}{\delta}$$

where δ = the Napierian logarithm of the ratio of two successive oscillations in the same direction in a wave train.

The oscillations of radio frequency comprising the individual spark discharge are not therefore to be confounded with the spark frequency. The frequency of the former is determined by the electrical dimensions of the discharge circuit, but of the latter by the speed and the number of field poles in the alternator.

50. Ques.—How may the resonance curve of a radio transmitter be plotted, and what is the value of it?

Ans.—A resonance curve, such as indicated in Fig. 13, shows, in a general way, the distribution of energy in the radiated wave. It also allows the measurement of the relative energy in the two waves (if present) and a calculation of the logarithmic decrement of the oscillations.

The data for a resonance curve is generally obtained by connecting a hot wire ammeter or hot wire wattmeter in series with the circuit of the wavemeter. The wavemeter is then placed in inductive relation to the circuit under measurement and set to be in resonance to either of the radiated waves. When the transmitting apparatus is in operation (the spark discharging across the gap), the corresponding current reading in the wattmeter is observed. Similar readings are made at frequencies off resonance, the corresponding current reading being observed and the resultant data plotted in curve form.

The diagram of connections, Fig. 16, is applicable for the plotting of a resonance curve as well as for the measurement of the logarithmic decrement. It is not necessary to plot a complete curve for the determination of the decrement. Several readings may be taken about the peak of each wave, and the corresponding ammeter or wattmeter deflection is observed.

Resonance curves are sometimes called audibility curves for the reason that they indicate the relative strength of signals to be obtained at receivers adjusted to wave lengths off resonance. A curve which is "sharp" is said to have a high audibility factor, while one that is relatively "broad" is indicated as having a low audibility factor. The sharper the curve the greater will be the decrease in amplitude of current at a given frequency of resonance.

A resonance curve is, in reality, a graphic equation showing the relation between wave length and current amplitude in the wave radiated of the transmitter.

51. Ques.—Describe the method for adjustment of a quenched spark discharger for a clear note and maximum current value in the antenna circuit?

Ans.—To secure the maximum efficiency from a quenched spark discharger extremely careful regulation of the inductance values in the open and closed oscillatory circuits must be made. In addition, the degree of coupling is critical. The final position of the coupling and the values of self inductance in either circuit are located at that point where the maximum value of current is indicated by the aerial hot wire ammeter. All other adjustments remaining equal, the note of the quenched spark transmitter is a direct function of the secondary voltage of the transformer. With a given number of gaps and conditions of resonance between the open and closed circuits, the voltage of the A.C. generator must be carefully regulated by means of the A.C. field rheostat. If a clear note cannot be obtained with a normal current flowing in the primary circuit of the transformer, say, for instance, the wattmeter indicated less than normal flow, then additional gaps should be cut in and the A. C. voltage increased until the note is clear. If the open and closed oscillatory circuits are in dissonance, the note will be irregular and of unstable characteristic. At a given station the character of the note may be obtained by listening in on a receiving apparatus which is in inductive relation to some portion of the transmitter circuit.

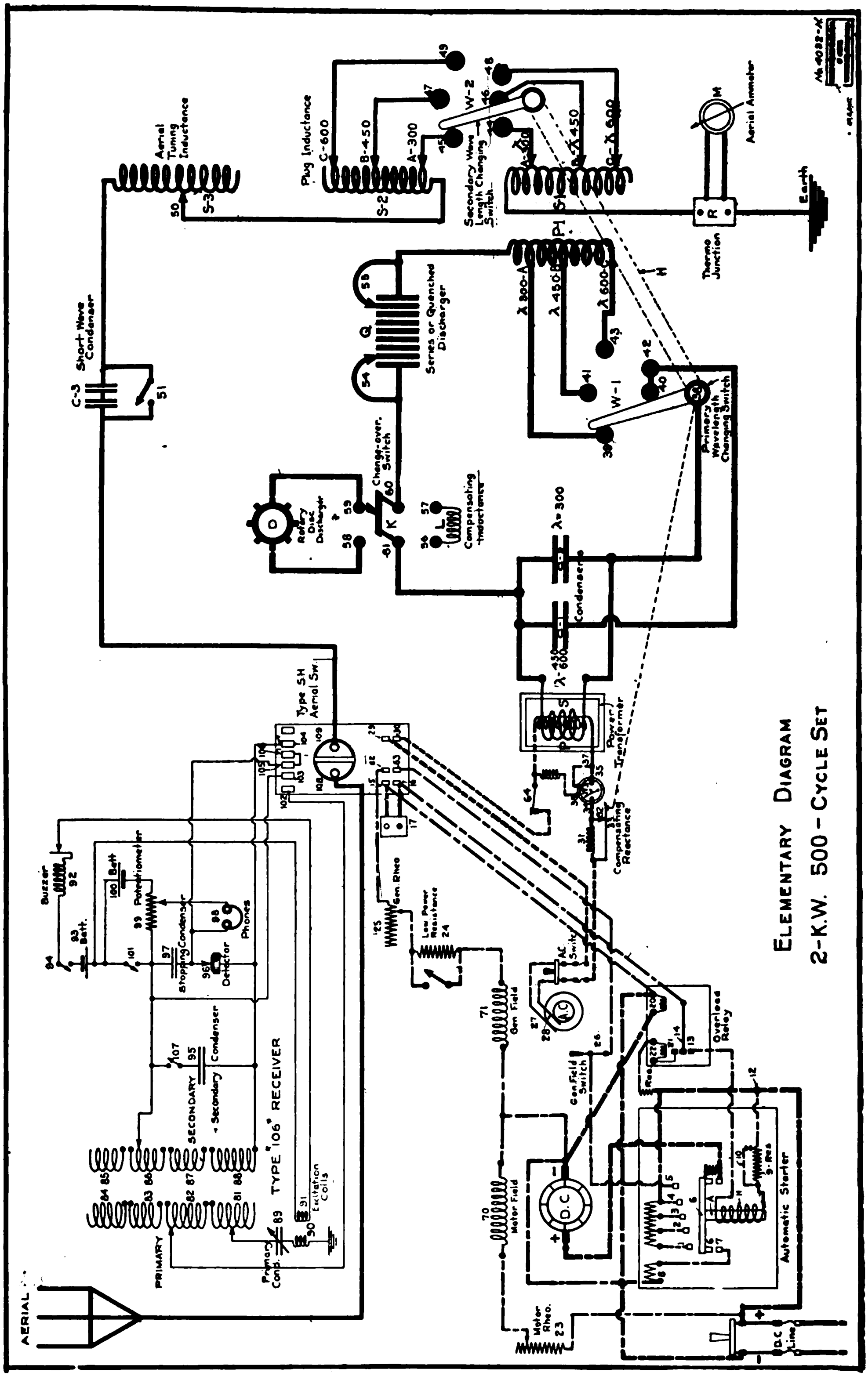
52. Ques.—The transmitting apparatus at a given station is adjusted to the standard wave length of 600 meters. Explain the steps necessary to readjust the complete system to the standard wave length of 300 meters?

Ans.—In the latest types of Marconi equipment, the complete operation is performed by a single high potential switch fitted with blades and multiple contacts. In apparatus lacking this feature the following individual operations must be performed. Generally it is necessary to:

(1) Insert a series condenser in the antenna system.
(2) Select a new value of inductance at the aerial tuning inductance.
(3) Reduce the value of inductance at the primary winding of the oscillation transformer or in certain cases reduce the capacity of the transmitting condenser.
(4) Place the primary winding in closer inductive relation to the secondary winding.

In addition, the reduction of the capacity of the condenser may require the insertion of a reactance coil in series with the primary winding of the power transformer to prevent arcing, or perhaps a readjustment of the spark gap length, or a reduction of the A.C. generator voltage.

A complete record of the necessary alterations and readjustments for the circuits is posted in the radio room for handy reference.



ELEMENTARY DIAGRAM
2-K.W. 500-CYCLE SET

Fig. 17.

53. Ques.—In the usual commercial radio outfit a short wave condenser of 3 or 4 jars connected in series, is employed. Why are they thus connected?

Ans.—A condenser of the correct value of capacity, consisting of a single plate or single leyden jar, could not withstand the potential of the antenna circuit; hence 3 or 4 plates are connected in series in order that the potential may be equally divided between the plates.

54. Ques.—Under what conditions of service is the short wave condenser employed?

Ans.—It is generally required for transmitting at the wave-length of 300 meters, because the usual ship's aerial has a natural wave-length of excessive value for direct operation on the 300 meter wave. Occasionally the series condenser is required for operation at the wave length of 450 meters.

55. Ques.—What effect upon the range of a station has an increase of current in the antenna circuit?

Ans.—At a given station an increase of current flow permits a greater distance to be covered, but so far no uniform law can be laid down for determining the range, as it is dependent on many factors external to both the transmitting and receiving stations. Vessels supplied with 500 cycle transmitters can be expected, with a current flow of 18 amperes in the antenna circuit, to transmit to a distance of 600 miles in daylight and from 1,500 to 3,000 miles after dark. The ½ K.W. 500 cycle set manufactured by the Marconi Company, frequently transmits a distance of 550 miles in daylight and from 1,500 to 2,500 miles after dark. A transmitting set giving an antenna current of 3 amperes can easily do 100 miles. The decrement of the emitted wave, as well as the actual current in the antenna circuit, and also the frequency of the source of current supply, are important factors in determining the range of a given station.

56.. Ques.—Does a wave of high decrement refer to a "broad" wave or a "sharp" wave?

Ans.—If the emitted wave of a given station posseses a high decrement, it will tune broadly at the receiving apparatus, but if of low decrement, sharp syntony is observed. Modern ship transmitters have a decrement value lying between .05 and .09 for each complete oscillation. The value of the decrement varies with each change of wave-length.

57. Ques.—Give a complete circuit diagram of a modern commercial radio transmitting and receiving set complete, explaining in detail the function of each part of the equipment.

Ans.—The circuits of the Marconi 2 K.W. 500 cycle panel transmitting set are given complete in Fig. 17.

The set possesses several distinctive features: (1) 3 standard wave-lengths of 300, 450 and 600 meters are provided, the connections for which may be shifted by the single switch handle H operating conjointly the switch blades W-1 and W-2. This switch not only makes the necessary changes of inductance in the primary and secondary circuits of the transmitter, but also reduces the condenser capacity from 6 jars to 3 jars at the wave-length of 300 meters and simultaneously connects a reactance coil in series with the primary winding of the high potential transformer. (2) The rotary disc discharger or synchronous spark gap is fitted with air circulating blades for cooling the plates of the quenched spark gap. (3) The motor generator is fitted with an automatic motor starter, which in connection with an overload relay magnet serves as a circuit breaker in case of overload. (4) The motor is fitted with an electrodynamic brake, bringing it to a full stop in 12 seconds. (5) The aerial ammeter is an instrument of the direct current type connected to a specially constructed thermojunction, which in turn is connected in series with the aerial system. (6) An extra resistance coil connected in series with the generator field winding permits the set to be operated at very low values of power. (7) A wattmeter is supplied by means of which the input to the primary winding of the transformer can be observed.

These features having been carefully considered, the details of the drawing, Fig. 17, will be clear from the following explanation:

It will be observed from the drawing that the field winding of the motor is connected in shunt with the D.C. line through the regulating field rheostat 23. When increased values of resistance are added in series at 23, the speed of the motor is increased and consequently the frequency of the generator. The generator field winding is similarly connected in shunt to the D.C. line through the low power resistance 24 and the voltage regulating rheostat 25. This circuit continues to the contacts of the antenna switch 62 and 63 through the control switch 26 and finally to contact 5 of the automatic starter. By this connection the circuit to the generator field winding remains open until the bar 6 attached to the plunger A of the automatic starter has touched point 5. When the bar of the automatic starter is in contact with point 4, the D.C. armature is connected directly to the main D.C. line.

By an increase in the resistance value of the rheostat 25, the voltage of the A.C. generator is reduced and it can be increased correspondingly by a reduction of resistance. In order that low values of voltage may be secured at the terminals of the alternator, an external fixed resistance 24 is connected in series with the generator rheostat and is shunted by the switch as indicated in the drawing.

The overload relay employed in conjunction with the automatic starter has the magnet winding 20, which may be called the tripping magnet, and the second magnet winding 22, which may be called the holding magnet. Winding 20 is in series with the D.C. armature on the negative side of the line. If more than a predetermined number of amperes flow through this winding, the lever 14 is raised in a vertical position, breaking the circuit of the solenoid winding 11 through the contacts 13 and 14. Immediately afterward the circuit through winding 22 is closed through contacts 14 and 21. This causes the lever 14 to be held in that position until either the main D.C. line switch or the starting switch 17, is opened.

One terminal of the solenoid winding 11 is connected to the positive pole of the D.C. line at point 12. The circuit continues through the fixed resistance 9, shunted by the switch 10, through the contacts 13 and 14 of the overload relay, through contacts 15 and 16 of the antenna switch, to a terminal of the winding 20, which is of negative polarity. Hence it is readily observed that the solenoid winding is connected in shunt to the D.C. line when either contacts 15 or 16 or the starting switch 17 is closed.

The switch 10 in shunt to the resistance 9 is automatically opened by the plunger A of the automatic starter when it is in the full vertical or running position.

The resistance coils of the motor starter, connected in series with the D.C. line to the armature, are progressively cut out of the circuit at contacts 1, 2, 3 and 4 by the bar 6. When the circuit to the solenoid 11 is closed, the plunger A with the bar 6 moves in a vertical position, the speed of acceleration being regulated by a vacuum chamber. When contact is made between the bar 6 and point 1, the circuit to the armature includes the entire set of resistance coils.

When the circuit to the winding 11 is interrupted, either at point 17 or at the aerial switch contacts 15 and 16, the plunger A drops downward and through the medium of contacts 6 and 7, the resistance coil 8 is connected in shunt with the D.C. armature. At this stage of operation the momentum of the armature causes it to become temporarily a D.C. generator and a considerable value of current flows for the moment through the resistance 8. The magnetic field thus set up in the armature causes a powerful dragging action on the field poles bringing the armature to a quick stop. To be more explicit, when the handle of the type SH aerial change-over switch is thrown to a transmitting position, the motor generator is automatically started, provided the main D.C. line switch is closed. It will be brought to a quick stop when the antenna switch is placed in the receiving position, provided the switch 17 remains open. If the switch 17 is closed, the motor generator can be held in a continuous state of operation during the receiving period.

When it becomes necessary to make repairs or adjustments to the generator, or the A.C. power circuits, the generator field switch 26 should be open. When the motor generator is to remain idle for an indefinite period, the main D.C. line switch should be opened to break the circuit to the field winding of the motor.

The high potential transformer has the primary winding P and the secondary winding S. The alternating current from the brushes 27 and 28 is fed to the primary winding of the transformer through the antenna switch 29 and 30, the transmitting key 64, the compensating reactance 31 and the primary wattmeter W3.

The wattmeter has 4 terminals; 34 and 35 are connected in series with the A.C. line to the transformer, and 36 and 37 are placed in shunt to the primary winding. The latter are known as the *potential leads* and the former the *current leads.*

The compensating reactance 31 is shunted by the switch at contacts 32 and 33. When the primary wave-length changing switch W-1 is placed in the 300 meter position, the contacts 32 and 33 are forcibly opened, thereby connecting a reactance coil in series with the primary winding of the transformer.

The closed circuit of this transmitter comprises the high potential condenser units, C-1 and C-2, each containing 3 jars of .002 microfarads capacity. When operating on the 300 meter wave, the condenser unit C-2 is connected to the secondary winding of the high potential transformer. The closed oscillatory or spark gap circuit can be further traced through the wave-length changing switch W-1, through contacts 38 and 39, to a small portion of the primary winding of the oscillation transformer, P-1, as indicated at A. The circuit continues to a terminal of the quenched spark gap 55.

When the blades 60 and 61 of the switch K are thrown to connect to the contacts 58 and 59, the synchronous rotary disc discharger D is connected in series with the condensers and the primary winding of the oscillation transformer.

When this discharger is in use, the quenched spark discharger is short-circuited by the leads 54 and 55. When the switch blades 60 and 61 are thrown in the opposite direction; that is to say, connected to contacts 56 and 57, the compensating inductance L is connected in series with the condenser circuit to make up for the length of leads from the points 58 and 59 to the rotary discharger. By this means the wave-length of the closed oscillatory circuit remains constant regardless of the type of spark discharger employed. When it is desired to radiate energy at the wave-length of 450 or 600 meters, the switch handle W-1 is moved to the 450 meter or 600 meter position, whereupon the condenser units C-1 and C-2 are connected in parallel between the contacts 38 and 40, also between 40 and 42. The closed oscillatory circuit then continues to contact 41 through the fixed tap-off B for the 450 meter wave and through contact 43 to the tap-off C for the 600 meter wave.

A somewhat similar function is performed by the switch W-2, in connection with the secondary winding S-1 and the aerial tuning inductance S-2; that is to say, corresponding values of inductance are selected at S-1 and S-2, so that the proper degree of coupling for maximum antenna circuit is secured for each change of wave-length. Thus the circuits for the 300 meter position are closed through contacts 44 and 45, for the 450 meter wave between contacts 46 and 47 and for the 600 meter wave between 48 and 49. Closer variation of the antenna inductance can be made by the continuously variable aerial tuning inductance S-3, having the sliding contact 50.

The antenna system also includes the short wave condenser C-3, which consists of 4 standard leyden jars of .002 microfarads each, connected in series. This condenser is shunted by means of a flexible lead 51.

The complete circuits for the type 106 receiving tuner are also given in Fig. 17. This tuner is constructed so that the degree of coupling between the primary and secondary windings can be altered as desired by means of a specially constructed rack and pinion. Referring to the drawing, the complete primary circuits are represented by the units 81, 82, 83 and 84. Unit 81 is connected to the terminals of a 10-point multiple switch and comprises 10 turns of wire. Units 82, 83 and 84 are progressively added in the circuit, 10 turns at a time, by means of a second multiple point switch known as the "tens" switch. Unit 84 is an aerial tuning inductance, which is mounted separate from the primary windings 81, 82 and 83.

The antenna system also includes the variable condenser 89, which is automatically short-circuited when in the "out" position.

The coupling coil 90 is connected in series with the earth lead and in inductive relation to the excitation coil 91. The coil 91 is connected in series with the buzzer 92 and energized by the battery 93. The circuit is closed by the switch 94. When the buzzer is put into operation, impulses of current flow through the coil 91, which set up a potential in the coil 90, causing the open oscillatory circuit of the receiving system to be set into excitation at its natural time period of vibration.

The secondary winding of the receiving tuner comprises the coils 85, 86, 87 and 88, the inductance value of which can be altered by the multiple point switch as indicated.

It will now be observed that the primary and secondary windings are divided into units, thereby eliminating to a considerable extent the effect of dead ends. To this end a revolving switch of the barrel type operates in conjunction with the inductance changing switches of either winding connecting the several units in the circuit when required.

The secondary system of this tuner comprises the shunt variable condenser 95, the crystalline detector 96, the stopping condenser 97, the head telephones 98, the potentiometer 99 and the battery 100. The circuit from the battery to the potentiometer is interrupted by the switch 101.

The circuits of the type 106 receiving tuner are protected during the periods of transmission by means of the aerial changeover switch. When this switch is in the transmitting position the connection to the aerial post of the receiver is broken at contact 102, and the head telephones are short circuited by the contacts 103 and 104. Contacts 105 and 106 are connected together by a small jumper on the switch. When contacts 103 and 104 are shunted the detector, fixed stopping condenser and the secondary inductance of the receiving tuner are short-circuited. The shunt variable condenser 95 can be turned to the off position where it is entirely disconnected from the secondary inductance.

58. Ques.—Give explicit instructions for the tuning of a commercial set of this type to the three standard wave-lengths.

Ans.—The process is as follows: When the quenched spark discharger is employed the primary winding of the oscillation transformer P-1 remains at a fixed mechanical position relative to the secondary winding S-1. Inasmuch as different degrees of coupling are required for different values of inductance in the primary and secondary winding in order that the maximum value of antenna current may be obtained, it is the work of the installer or inspector to select such values of inductance by means of the variable tap-off connections at points 44, 46 and 48, also at 45, 47 and 49, to obtain the necessary coupling between P-1 and S-1 without shifting the mechanical positions of these windings.

Complete resonance is maintained in the antenna system by means of the plug connection to the inductance S-2. The aerial tuning inductance S-3 is only intended to make-up for the variation of wave-length in the antenna system as it may be altered by local conditions, such as proximity to the dock buildings or a metallic structure during the process of tuning.

To make clear the process of tuning, assume, for example, that at the wave-length of 600 meters, 8 turns are connected in the secondary winding S-2 by the variable tap-off connected to the switch point 48; likewise 6 turns at the tap-off connection to switch point 49, and suppose further that when this particular value of turns is in use the coupling between the primary and secondary windings is found to be too large for the maximum current value in the antenna circuit, then the number of turns of the winding S-1 connected to point 48 is reduced and a corresponding increase made at the tap-off connected to 49, so that conditions of resonance are maintained in the antenna system. Since the self-inductance of the secondary winding S-1 is thus reduced, the degree of coupling between P-1 and S-1 is decreased, even though the windings P-1 and S-1 remain in a fixed mechanical position. Similar selections of turns are made at the two remaining wave-lengths, such values of inductance being taken at S-1 and S-2 by the variable tap-offs to give the proper degree of coupling for maximum current in the antenna system. The positions of the tap-offs in the secondary winding, as indicated in the drawing, are not necessarily the relative positions for the various wave-lengths. The actual position, of course, must be determined by the inspector.

It will aid the inspector in determining when the proper value of inductance has been selected at S-1, if, during the process of tuning, the coupling between P-1 and S-1 is mechanically altered. Suppose, for example, that if P-1 is withdrawn from S-1 at a given standard wave-length, an increase of antenna current takes place; then the value of inductance at S-1 for that wave-length must be decreased and the mechanical relation between P-1 and S-1 brought back to the normal position.

It is preferable that the antenna system be tuned so that, at all standard wave-lengths, the continuously variable aerial tuning inductance S-3 has from 3 to 5 turns included in the circuit. This will allow the correct number of turns for variation of inductance in the antenna circuit below and above normal to make up for the alteration in wave-length by the presence of metallic structures at the dock. The proper use of the aerial tuning inductance S-3 will assist the inspector in determining the necessary values at points A, B or C, or at S-2 for a given standard wave-length. If, for example, 8 or 9 turns are required at S-3 for obtaining resonance, the number of turns may be reduced at that point and an increase made at S-2.

It will now be understood that when it becomes necessary to change from one standard wave-length to another, it is only necessary to throw the wave-length changing switch W-1 from one position to the other, with the exception that on the 300 meter position, the short wave condenser C-3 must be thrown in series with the antenna system by opening up the flexible contact 51.

When the synchronous rotary spark discharger is in use, the windings P-1 and S-1 must be separated considerably, in order that the antenna may emit a pure wave in compliance with the U. S. Regulations.

The relative positions of the primary and secondary windings for the rotary spark discharger are indicated on the coupling scale affixed to the coupling handle. It is sometimes possible to find a fixed position for the 450 and 600 meter waves with the rotary gap, but it is generally observed that the coupling must be changed for the 300 meter position.

It should be understood that the synchronous rotary gap is only to be used as an auxiliary, in case of accident to the quenched spark discharger. Care should be taken to adjust this gap so as to avoid an abnormal brush discharge at the condenser and also to maintain a pure note. The character of the note can be obtained by listening in the head telephones of the receiving set. Particular care should be taken to keep the gap between the stationary and movable electrodes at a minimum, not over .005 of an inch.

59. Ques.—State the average number of amperes to be expected in the antenna circuit with the two kilowatt, 500 cycle transmitting set at the three standard wave-lengths.

Ans.—For the average ship's aerial adjusted to the wave-length of 600 meters, an antenna current varying between 14 and 18 amperes can be expected with the quenched spark discharger in use. At the wave-length of 450 meters, the current varies between 9 and 14 amperes, but at the wave-length of 300 meters, the actual current flow depends upon whether or not the series condenser is connected in the antenna system. With the short wave condenser in use, the antenna current at the wave length of 300 meters varies between three and five amperes, but if the aerial is of such dimensions that it can be operated at the wave-length of 300 meters without a short wave condenser, a current of eight or nine amperes may be expected.

60. Ques.—Why is it necessary to reduce the coupling between the primary and secondary windings when the rotary spark discharger is used in place of the quenched spark discharger?

Ans.—Due to the fact that there is little or no reaction between the antenna circuit and the spark gap circuit, the quenched spark discharger permits a closer degree of coupling than is possible with gaps of the ordinary type. But when the rotary disc discharger is in use, an interchange of energy takes place and consequently, in order that the antenna system may emit a single wave, the coupling between the primary and secondary windings must be reduced considerably.

61. Ques.—Why is it necessary to reduce the condenser capacity of the two kilowatt, 500 cycle set when operating on the 300-meter wave?

Ans.—To permit a sufficient number of turns at the primary winding of the oscillation transformer, to transfer energy to the secondary winding without exceeding the wave-length of 300 meters which would be the case if the full value, .012 microfarads, were in use.

Part II.

MOTOR GENERATORS

62. Ques.—If the motor runs too fast, how can you reduce the speed?

Ans.—The speed may be reduced, first, by cutting out all resistance in the motor field rheostat and, if this is not sufficient, include an external resistance in series with the main D.C. line.

63. Ques.—How would you increase the voltage of an alternating current generator?

Ans.—By decreasing the resistance in the generator field rheostat, allowing more current to pass to the winding.

64. Ques.—How can the speed of a motor be increased?

Ans.—By inserting resistance in series with the motor field circuit at the motor field rheostat.

65. Ques.—What materials should be used for cleaning a commutator?

Ans.—A piece of very fine sandpaper pressed in position by a straight edge. Occasionally a piece of canvas is used to give a final polish to the commutator.

Emery paper should not be used under any conditions.

66. Ques.—What happens when an "open" occurs in one of the armature coils?

Ans.—An open circuit armature is always manifested by severe sparking at the commutator; generally a halo of fire takes place around the entire circumference, the motor turning over at a very slow speed. If allowed to run for a few moments the commutator will be ruined and the remaining windings probably burn out.

67. Ques.—What is a generator or a dynamo?

Ans.—It is a device to convert mechanical power into electrical power.

68. Ques.—What are some of the causes and remedies for a sparking commutator?

Ans.—A sparking commutator may be due to several causes: (1) dirty brushes, (2) dirty commutator, (3) a grooved commutator due to excessive wear, (4) a raised insulating wedge, (5) brushes out of position of neutral field, (6) a partially short-circuited field coil, (7) a brush wedged in the brush holder so that it cannot move freely.

The remedy in each case is obvious; for instance, a grooved commutator should be placed in a lathe and turned to smoothness; an ill-fitting brush should be filed down so that it will rest easy in the brush holder; if the brushes are shifted out of the neutral field they should be placed back again, etc.

69. Ques.—What is the function of a starting box? And how is it constructed? Give circuit diagram.

Ans.—The starting box for a motor consists of a series of fixed resistance coils so arranged that they may be progressively cut out of the circuit extending from the D.C. power mains to the motor armature. The starting box also contains a release magnet which holds the starting arm in the full running position under normal conditions. If, however, the field circuit to the motor should open, as by the burning out of the field rheostat, the release magnet will lose its magnetism, thereby releasing the arm, which automatically breaks the D.C. line to the motor armature. (Fig. 18.)

The purpose of the starting box is to cut down the current flow to the armature during the moment of starting; without it an abnormal value of current would flow, due to the almost complete absence of the counter-electro-

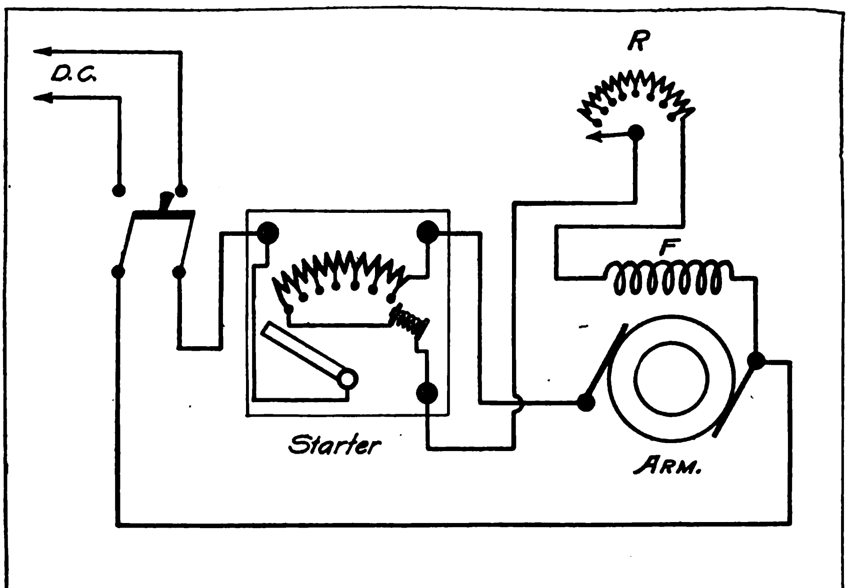


Fig. 18.

motive force in the armature windings. To some extent the resistance of the coils in the starting box takes the place of the counter-electromotive force, which is later to be generated by the armature when in rotation.

70. Ques.—Suppose one of the resistance coils burned out in your starting box, how would you temporarily repair the fault?

Ans.—With starting boxes employed in commercial wireless telegraph sets of to-day, the burned-out coil is located and a shunt circuit placed around it. The starting of the motor will not be too rapid, as all motor generators in wireless telegraph service generally start without load.

71. Ques.—Name some of the causes of the overheating of a generator.

Ans.—This is generally due to excessive current being taken from the armature circuit.

Generators frequently become hot from improperly fitted or cut bearings.

72. Ques.—If, after the motor has been brought to full speed, the starting lever flies back to the off position when released, what would be the trouble and how could you repair it temporarily?

Ans.—This may be due to a short circuit in the release magnet of the starting box or to a sudden opening up of the field circuit to the motor.

The remedy is obvious; if the field coil circuit is open, say at the field rheostat, the burned-out coil should be located and bridged. If the release magnet is the cause of the trouble, the handle of the starting box might temporarily be tied in place so as to remain in the full running position, making sure that the field circuit is again closed.

73. Ques.—Give a sketch of a generator and the voltage regulator connection.

Ans.—(This is fully covered in Ques. 1, Part 1.)

74. Ques.—What is the effect of starting a motor too quickly?

Ans.—Generally it results in the blowing of the fuses in the motor circuit. If, however, the fuses are of excessive current carrying capacity, severe sparking will be evidenced at the commutator, and in extreme cases injury might be done to the windings of the armature.

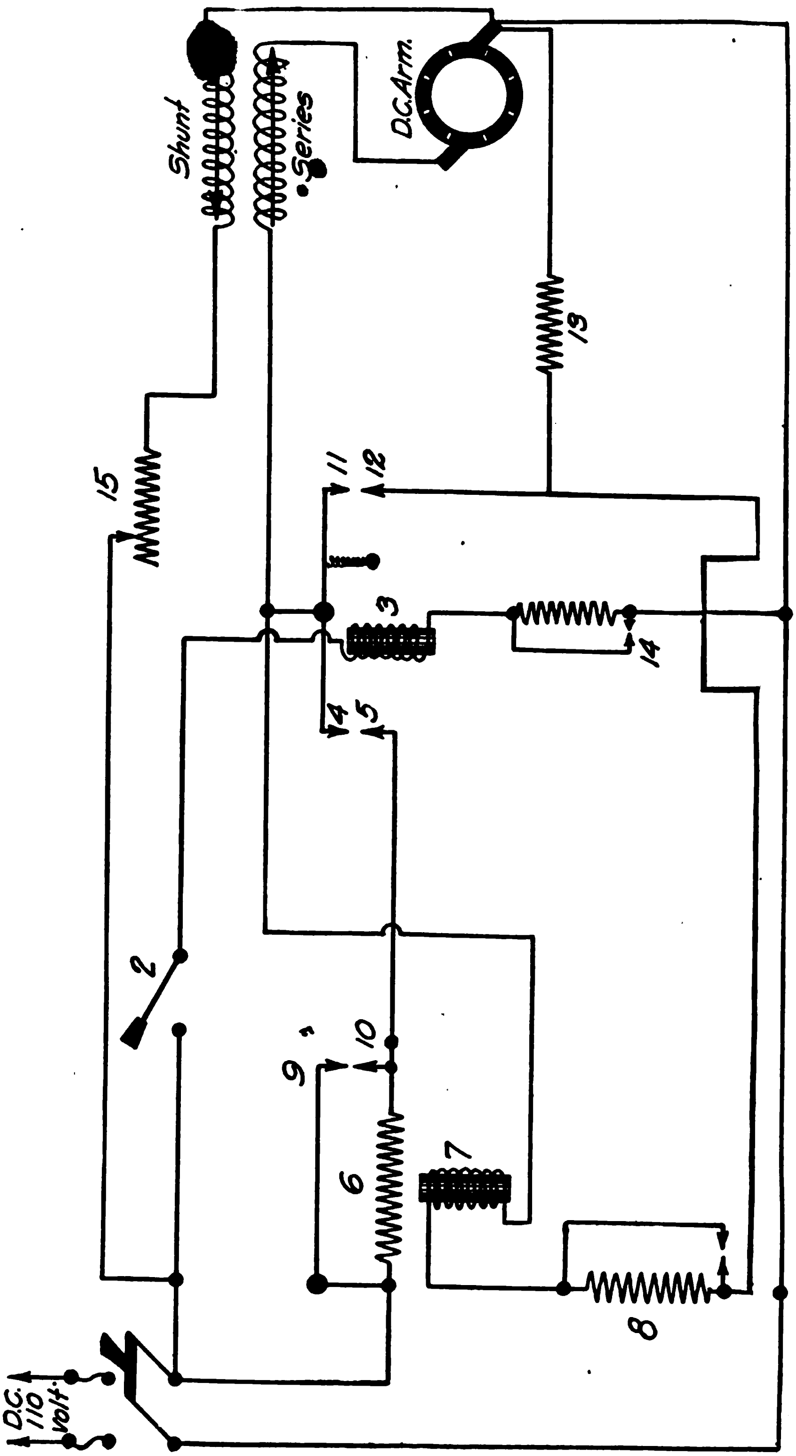
75. Ques.—Suppose, in starting a motor, the circuit breaker tripped and the fuses blew, where would you look for the trouble and why?

Ans.—This condition is more apt to obtain if the handle of the starting box is pulled over too quickly when the motor is started. Under such conditions, the armature will take an abnormal value of current as the proper speed has not been attained to generate sufficient counter-electromotive force to prevent the opening of the circuit breaker.

Of course similar effects would be observed if there was a short circuit in the motor armature or in the shunt field windings.

76. Ques.—How should a hot bearing of a motor generator be treated?

Ans.—The proper treatment depends upon how far the cutting of the bearing has proceeded; if not too serious, powdered graphite may be mixed with the oil and fed in generous quantities. Finely powdered sulphur mixed with oil has been known to be most effective in smoothing down an injured bearing.



— AUTOMATIC MOTOR STARTER —
MARCONI ½ K.W. PANEL SET.

77. Ques.—What is the function of the commutator in a motor?

Ans.—The function of the commutator is to maintain the polarity of the magnetic flux of the field poles and the armature core in such relation to one another that there will be a constant attraction or repulsion between the magnetic fields causing rotation of the armature. For instance, consider any single field coil and suppose it is of north polarity; then the commutator maintains the flux so that the portion of the armature approaching that of the north pole is of south polarity causing attraction, while the portion of the armature on the opposite side is of north polarity causing repulsion. The necessary change of current in the coils of the armature to bring about this condition is made by the commutator.

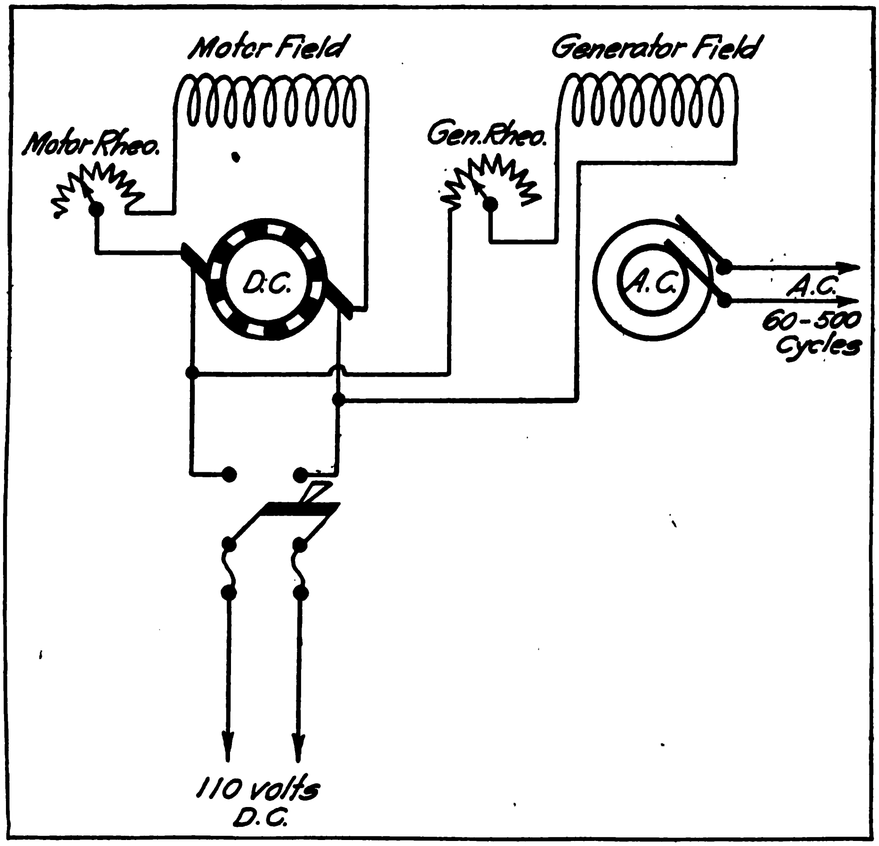


Fig. 20.

78. Ques.—In case the motor field rheostat or generator field rheostat should burn out, what apparatus can be employed as a substitute?

Ans.—Commercial motor generators generally require from 2 to 3 amperes in the field windings; hence for either winding 3 or 4 16 c. p. incandescent lamps connected in parallel and then in series with the field winding will allow this value of current to pass. It is not probable that the entire field rheostat is damaged by a burn-out and it is quite easy, by means of a battery and telephone, to locate the burnt-out portion, which may be cut out of the circuit by means of a "jumper" soldered across the studs on the face of the rheostat.

To locate the burnt-out portion by means of battery and telephones, the terminals of the testing circuit are shunted across successive contacts, until an "open" is indicated by no sound in the head telephones.

79. **Ques.—Show a circuit diagram of an automatic starter of the type used in commercial radio sets.**

Ans.—The circuits of the single step starter, employed in the ½ K. W. panel sets of the Marconi Company, are indicated in the diagram Fig. 19 and an explanation follows:

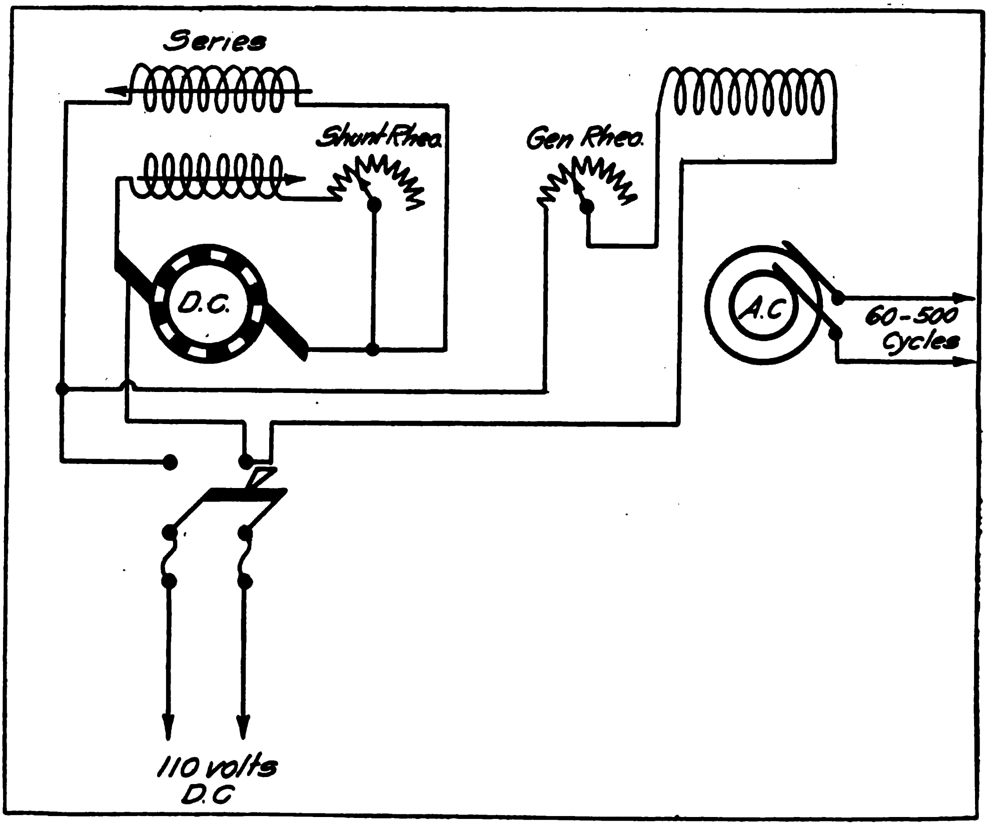


Fig. 21.

When the starting switch 2 is closed, the solenoid 3 is connected in shunt to the D. C. line. The flux from this solenoid attracts the lever 4 making contact with point 5, thereby closing the circuit from the D. C. line to the motor armature through the resistance coil 6. Simultaneously the solenoid 7 is connected in shunt to the D. C. line (through the lever 4), which attracts the lever 9 making contact with point 10, thus cutting the resistance 6 out of the armature circuit, whereupon the motor is connected directly to the main D. C. line. It will thus be understood that the lever of solenoid 3 is used to open and close the main power circuit, while the lever of solenoid 7 cuts out the resistance in series with the motor armature. The solenoids 3 and 7 have the resistance coils 14 and 8 respectively, which are connected in series with their respective windings automatically by the levers 4 and 9. This prevents the solenoid winding from over-heating.

The automatic starter also includes the elements of an electrodynamic brake. When the starting switch 2 is open, lever 4 drops back, also lever 9, and contact is made between the points 11 and 12 connecting the resistance coil 13 in shunt to the motor armature and the series winding. The motor armature thus temporarily becomes a generator and, owing to the power expended in the generation of an electrical current through the resistance 13, a powerful braking action is set up against the armature, bringing it to a quick stop. The resistance coil 15 is the motor field rheostat, by means of which the speed of the motor can be regulated over certain limits.

80. Ques.—Give a simple circuit diagram of 3 types of motor generators and explain the circuits briefly.

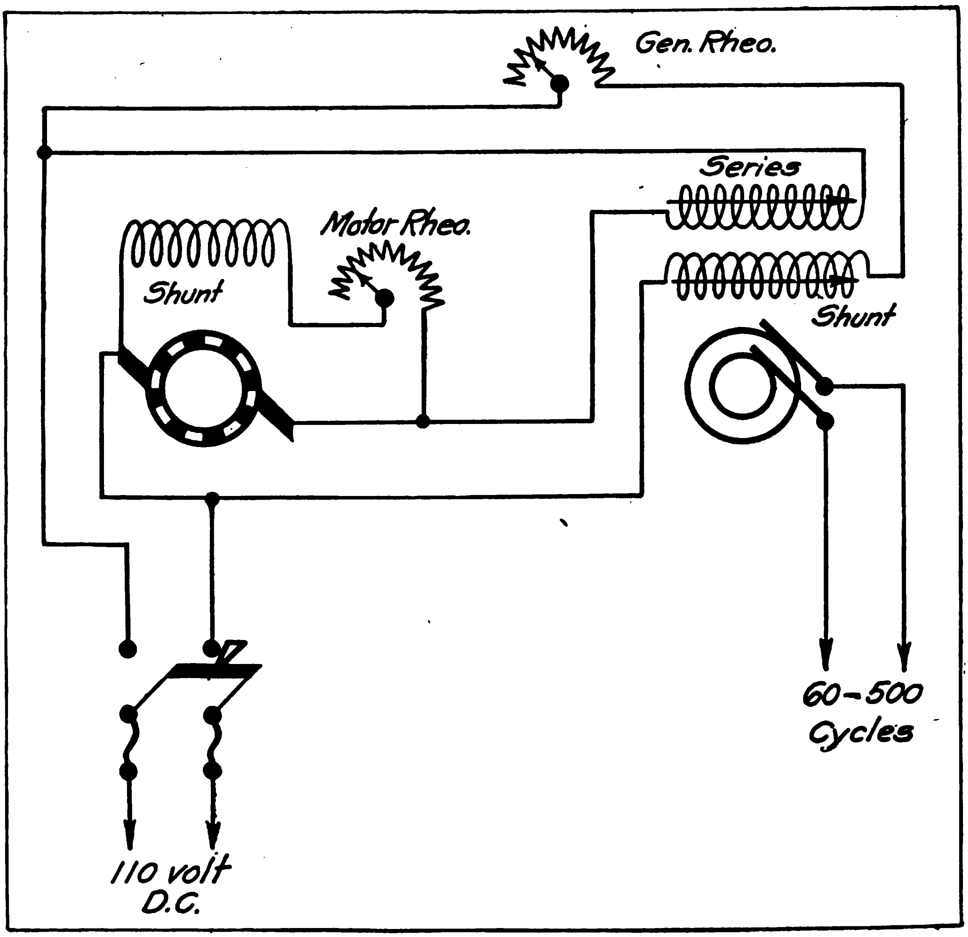


Fig. 22.

Ans.—The circuits for a simple shunt wound motor generator are indicated in Fig. 20. In this type the motor has a shunt winding connected across the armature terminals with a regulating rheostat connected in series. The field winding of the generator is connected in shunt to the D. C. power line to the motor. A regulating rheostat is connected in series. If resistance is added in the circuit at the motor rheostat, the speed of the motor is increased and consequently the frequency. If resistance is added in series at the generator rheostat, the density of the lines of force about the field poles is decreased, resulting in a decrease of voltage across the armature terminals.

Another type of motor-generator is indicated in the diagram Fig. 21. In this case the motor has a differential winding; a series winding connected in series with the D. C. armature and a shunt winding connected directly across the armature brushes. The two windings are made on a single field pole with current passing in the direction so that the fluxes of the two coils oppose; hence the flux produced by the series winding has a weakening effect upon that of the shunt winding. Therefore when the motor generator is subjected to a variable load, the shunt winding is weakened to the proper degree by the series winding thereby maintaining a fairly constant speed. As in the first type mentioned, the field winding of this generator is connected directly to the D. C. line with a regulating rheostat in series.

The circuit for a third type of standard commercial generator is indicated in Fig. 22. The generator has two field windings, a series winding connected in series with the motor armature and a shunt winding connected directly across the D. C. line. The windings are disposed on each field pole of the generator so that the lines of force of the series winding and those of the shunt winding are addditive. When a motor generator of this type is subjected to load there is a tendency towards a decrease in speed, but there will then be an increase of current flow through the series winding (because it is connected in series with the armature) which has the effect of increasing the number of lines of force around the generator armature, thereby maintaining the voltage of the alternator fairly constant under a variable load. The motor in this case has a simple shunt winding with a speed regulating rheostat connected in series. The voltage of the generator may be increased or decreased by means of the generator field rheostat indicated in the drawing.

Part III

STORAGE BATTERIES AND THE AUXILIARY SET

81. Ques.—What is meant by the specific gravity of tne electrolyte in a storage cell?

Ans.—It is the density or weight of one cubic centimeter of the solution as compared with one cubic centimeter of chemically pure water and is obtained or measured by the hydrometer.

82. Ques.—What is the normal voltage of a lead cell fully charged?

Ans.—Fully charged and on open circuit, the voltage is about 2.08 volts, but with new cells immediately after the charging current is cut off, the cells may indicate as much as 2.5 or 2.6 volts per cell.

83. Ques.—What is meant by the capacity of a storage cell?

Ans.—The capacity of a storage cell is determined by the quantity of current, in ampere hours, which may be taken from it under normal conditions. An ampere hour is the quantity of current passing through a circuit in one hour's time when the strength of the current is one ampere. Certain commercial wireless telegraph sets employ a storage battery unit of 60 ampere hours capacity; for example, 7½ amperes of energy may be taken from this cell for a period of 8 hours, or 1 ampere for a period of 60 hours. This ratio does not hold good at all discharge rates.

84. Ques.—What is meant by the normal rate of discharge of a storage battery?

Ans.—It is the current in amperes which may be taken from the cell without injury to the plate. The normal rate is generally indicated by the maker of the cell.

85. Ques.—How do you keep the quantity and the specific gravity of the electrolyte correct?

Ans.—Specific gravity readings are obtained by means of an instrument known as a hydrometer, which consist of a glass tube, loaded at one end with mercury or lead shot and having a calibrated scale giving by direct reading the gravity of the solution. This bulb is lowered into the solution and the gravity determined by noting the scale reading at the level of the liquid. If, after a battery is fully charged, the specific gravity is below normal, it is then necessary to add a small amount of acid. In ordinary service, however, the operator is only required to add water from time to time to take the place of that lost by evaporation.

86. Ques.—What kind of water do you put into storage cells?

Ans.—Chemically pure water, free from mineral properties, but as this cannot always be obtained, the purest water available may be used.

87. Ques.—Name two distinct types of storage cells and what precautions are necessary to keep them in good condition.

Ans.—There are two distinct types of cells, the lead cell with an acid solution, and the nickel-iron cell with an alkali solution, the latter being known as the Edison cell.

Both types of cells must be supplied with water from time to time to take the place of that lost by evaporation.

The lead cell must be placed on charge when the voltage of the cell has dropped to 1.8 volts. The Edison cell must be placed on charge when the voltage has dropped to .9 volt per cell. The full charged voltage of an Edison cell is 1.2 volts, the lead cell about 2.08 volts.

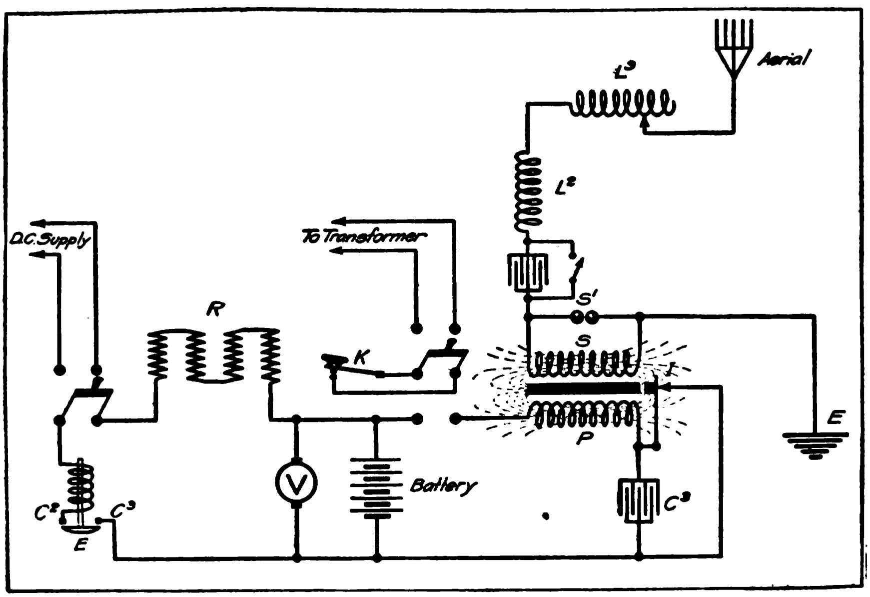


Fig. 23.

88. Ques.—How, by the readings of the voltmeter, can anyone determine the condition of a storage battery or any one cell of this storage battery?

Ans.—It is difficult to ascertain the exact condition of a storage cell by means of a voltmeter alone, except under the following conditions: If, in the original installation, the storage cells composing the unit were all in proper condition and properly charged, then indirectly the voltmeter may be used as a gauge to determine the general condition of the cells. If a voltmeter alone is used for this purpose, the storage cells should be put on a normal load; that is to say, a normal number of amperes should be taken from the cells and a voltmeter reading taken at that particular instant. If, under these conditions, the voltage of the cell is below 1.8 volts, it is quite necessary that it immediately be placed on charge.

89. Ques.—Draw a complete circuit diagram of a modern auxiliary or emergency apparatus and describe briefly the action.

Ans.—Rapid changes have recently taken place in the design of this apparatus. Formerly a high potential induction coil energized by from 16 to 30 volts of storage battery had its secondary terminals directly connected to the electrodes of the spark gap, which in turn was connected in series with the antenna circuit.

While the apparatus had a surprisingly effective range when so connected, considerable difficulty was experienced with the breaking down of the aerial insulation, particularly in damp weather.

The complete circuits for the apparatus used in this manner are indicated in the drawing, Fig. 23, where a plain spark discharger, S-1, is connected in series with the open oscillatory circuit of the regular power set.

The secondary winding of the induction coil is represented at S and the primary winding at P; the magnetic interrupter at I, and the condenser in shunt C-3.

A number of storage cells (16 to 30 volts) are connected in series and are also placed in series with the D. C. line through the charging resistances R. The circuit from the D. C. line also includes the underload circuit breaker B. A small scale voltmeter, V, is connected in shunt to the battery.

A D. P. D. T. switch, when thrown in the "up" position, connects the transmitting key, K, in series with the power transformer of a standard set, and in the "down" position the key is placed in series with the primary winding of the induction coil.

When the transmitting key is depressed and the interrupter is in proper adjustment, lines of force rise and fall about the primary winding, which in turn cut the secondary winding, S, inducing in it currents of very high potential.

When this winding is connected to the spark gap, the antenna system is charged and in turn discharges at its own period of oscillation, producing high frequency electrical oscillations of a definite wave length, normally 600 meters.

The resistance coils R, of fixed value, are used for regulating the current flowing through the storage cells during the charging period.

The underload circuit breaker, E, automatically disconnects the cells from the D. C. line if the voltage of the line drops below a certain value.

When the battery cells are placed on charge the plunger of the circuit breaker must be pressed upward until the circuit is closed through the contacts C-2 and C-3.

To eliminate all possibility of antenna leakage, the induction coil of the auxiliary set is for the present connected as shown in the diagram Figure 24. In the center of the cut is shown a standard condenser rack, generally consisting of from 6 to 12 Marconi leyden jars which discharge through the rotary spark gap D, and the primary winding of the oscillation transformer L. L-1 is the secondary winding of the oscillation transformer which is connected in series with the antenna. The power transformer for charging the leyden jars is shown to the left of the drawing; to the right an induction coil operated by direct current from storage cells.

A plug connector, H, is attached to the high potential insulator A. One terminal of the secondary winding of the power transformer is connected to the high potential insulator B, and one terminal of the secondary winding of the induction coil to the high potential insulator C. B and C are fitted with sockets to take the plug connector H.

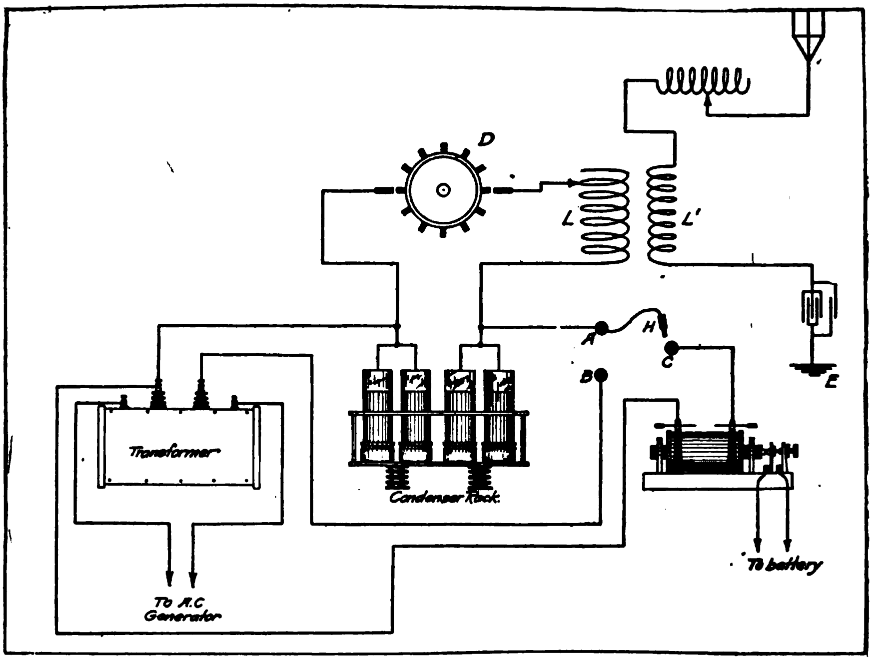


Fig. 24.

In case of accident to the power set the same condensers, spark gap and oscillation transformer are energized by the induction coil, the connections for which are shifted at A, B, C.

When the auxiliary coil is employed in this manner, the disc discharger D is stopped and the movable electrodes set in such relation to the stationary electrodes as to give a very short spark gap. The vibrator of the coil is then adjusted and the length of the gap at D regulated until the spark note is clear and regular. The coupling between L and L-1 is increased until maximum radiation, as shown by the aerial hot wire ammeter, is obtained. It is at once evident that the problem of antenna leakage is solved and the auxiliary set is in operative condition under all weather conditions.

No changes of the constants of the closed or open oscillatory circuit are required, for the set has been previously adjusted to wave lengths of 300 and 600 meters and conditions are therefore not altered.

The very latest type of Marconi auxiliary apparatus comprises a sixty cell storage battery connected in series which are employed as the source of energy for the motor-generator.

90. Ques.—Explain the points of difference between the lead storage cell and the Edison storage cell.

Ans.—The positive plate of the lead cell generally consists of a number of plates in which the active material is peroxide of lead, while the negative plate consists of spongy lead. The electrolyte generally consists of a 16% solution of sulphuric acid, having a specific gravity in case of the chloride cells of 1.210.

The normal voltage of a lead cell on open circuit when fully charged is about 2.1 volts; the cell is said to be discharged when the voltage has dropped below 1.8 volts per cell.

On the other hand, the Edison cell uses an alkaline electrolyte consisting of a 21% solution of potassium hydrate mixed with a small amount of lithium hydrate.

The active metals of this cell are nickel and iron, but are used in the form of nickel hydrate and iron oxide.

The negative electrode consists of a nickel-plated steel grid, into the pockets of which are placed and hydraulically pressed the perforated corrugated steel pockets which have been filled and packed with iron oxide to which has been added a small percentage of metallic mercury.

The positive electrode consists of a nickel-steel grid to which are secured perforated steel tubes reinforced by steel seamless springs. These tubes are filled with alternate layers of nickel hydrate and very thin flaked nickel, firmly and carefully packed by a loading machine.

The normal fully charged voltage of an Edison cell is 1.2 volts, but the cell is said to be discharged when the voltage is dropped to .9 volts.

The actions taking place during the charge and discharge of these two cells will be briefly described: When a lead storage cell is put on discharge, the current is produced by the acid in the electrolyte going into and combining with the lead of the porous part of the plate called "Active Material." In the positive plate, as stated before, the active material is lead peroxide and in the negative plate it is metallic lead in a spongy form.

When the sulphuric acid in the electrolyte combines with the lead in the active material, a compound known as "Lead Sulphate" is formed.

As the discharge progresses the electrolyte become weaker by the amount of the acid used in the plate, which incidentally produces the compound of acid and lead called "Lead Sulphate." This sulphate continues to increase in quantity and bulk, thereby filling the pores of the plate. As the pores of the plate become filled with sulphate, the free circulation of acid in the plate is retarded; and since the acid can then not get into the plates fast enough to maintain the normal action, the battery becomes less active, as is indicated by a rapid drop in voltage.

During the charging period, direct current must pass through the cells in the direction opposite to that of discharge. This current will reverse the action which took place in the cells during discharge. It will be remembered that during discharge the acid of the electrolyte went in and combined with the active material, filling its pores with sulphate and causing the electrolyte to become weaker. Reversing the current through the sulphate in the plate restores the active material to its original condition and returns the acid to the electrolyte. Thus, during charge, the electrolyte gradually becomes stronger as the sulphate in the plate decreases, until no more sulphate remains and all the acid has been returned to the electrolyte, when it will be of the same strength as before the discharge and the same acid will be ready to be used over again during the next discharge. Since there is no loss of acid by this process, none should ever be added to the electrolyte.

The whole object of charging, therefore, is to drive from the plates the acid which is absorbed by them during discharge.

It will now be readily understood how the specific gravity of the electrolyte rises and falls with the charge and discharge and, therefore, it is quite evident that the hydrometer can be used to determine the actual condition of a storage cell.

In the case of an Edison cell, the action taking place is somewhat different. The first charging of an Edison cell reduces the iron oxide to metallic iron, while converting the nickel hydrate to a very high oxide black in color. On discharge, the metallic iron goes back to iron oxide and the high nickel oxide goes to a lower oxide, but not to its original form of green hydrate. On every cycle thereafter the negative charges to metallic iron and discharges to iron oxide, while the positive charges to a high nickel oxide. Current passing in the direction of charge or discharge decomposes the potassium hydrate of the electrolyte and the oxidation and reductions of the electrodes are brought about by the action of its elements. An amount of potassium hydrate equal to that decomposed is always reformed at one of the electrodes by a secondary chemical reaction, in consequence there is none of it lost and its density remains constant.

The eventual result of charging is therefore the transference of oxygen from the iron to the nickel electrode, and that of discharging is a transference back again.

91. Ques.—Describe the use of an ampere hour meter in connection with storage cells.

Ans.—The ampere hour meter is an instrument to register the quantity of current passed through a storage cell during charge and the quantity of current taken from it during discharge. It consists, essentially, of a small motor, unique in construction, connected in series with the charging circuit to the cells. The rotation of the motor causes the movement of a pointer over a dial, slowly indicating the number of ampere hours of current flowing. When the cells are placed on charge the direction of the rotation of this motor is reversed, and in consequence the pointer will move towards the zero position. When the zero position is reached, an auxiliary contact is closed which trips the underload circuit breaker in the charging circuit, thereby disconnecting the cells from the charging source. Since it is not possible to withdraw an equivalent amount of current from a storage cell as is supplied to it on charge, the ampere hour meter is fitted with a compensator which, in effect, causes the pointer of the meter to return more slowly to the zero position than is required to bring it from that position to a certain value of ampere hours during discharge, hence the period of charge is greater than the period of discharge.

92. Ques.—Without a hydrometer, ampere hour meter, or any sort of indicating instrument whatsoever, how may a radio operator determine when the charge of a storage cell is complete?

Ans.—In the case of lead cells, this condition may be determined by noting the period of gassing. More clearly, if the charge be continued for a period of from 2 to 4 hours beyond the time at which gassing begins, the operator is assured that the charge is quite complete.

93. Question—Why is an under-load circuit breaker employed in series with the charging circuit to the battery?

Ans.—This breaker prevents the battery from discharging back into the ship's generator and reversing its polarity. When the voltage of the charging source falls to a value slightly below that of the battery, the tripping mechanism of the circuit breaker opens and disconnects the generator from the battery.

Part IV.

ANTENNAE OR AERIALS

94. Ques.—Name and describe by diagram three types of aerials in general use.

Ans.—Excepting certain high power stations, the inverted L, flat top aerials are universally used. What is known as the inverted L type is shown in Fig. 25. A T-shaped flat top aerial is shown in Fig. 26. The plain vertical fan aerial is indicated in Fig. 27.

95. Ques.—Name the advantages or disadvantages of the three types of aerial indicated in the reply to question 94.

Ans.—The vertical aerial is said to be the best radiator of electromagnetic waves, but it is not convenient to install one of this type aboard the average vessel; hence the flat top aerial is employed, which probably possesses a greater value of capacity than could be obtained by a vertical aerial in the same space. A flat top aerial of the inverted L type has a longer natural wave-length than one of similar dimensions of the T type, there-

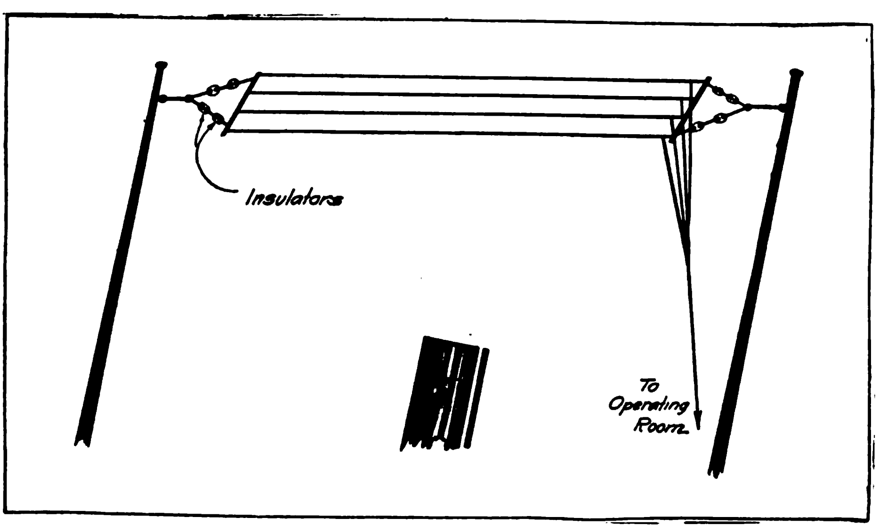


Fig. 25.

fore when the aerial of a ship is to be operated at the wave-lengths of 300, 450 and 600 meters, it may be more feasible to bring in the lead-in wires from the center of the flat top portion, in order that the wave-length of 450 meters may be obtained without resorting to a series condenser.

The flat top aerial of the inverted "L" type possesses directional characteristics radiating the greater portion of the energy in the direction opposite to the free end. The aerial of the "T" type radiates equally from both ends.

The vertical aerial possesses the advantage that it radiates practically with equal strength in all directions; hence for all conditions of radio service it may be preferred.

A flat top aerial of a given value of inductance and capacity is less expensive to erect than one of the vertical type of the same value because generally such values are obtained in the former with a rather low supporting structure, but for equivalent values with a vertical antenna, an aerial mast or tower of very great height is required.

96. Ques.—What is the average capacity of the aerials used in commercial marine service?

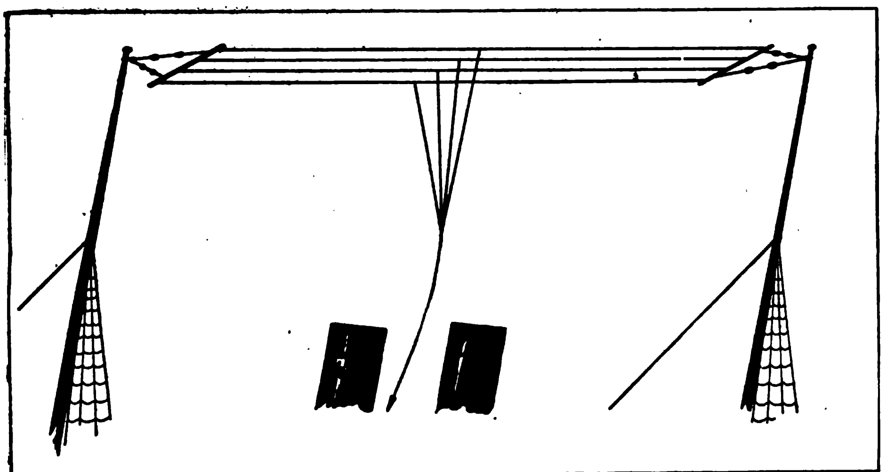


Fig. 26.

Ans.—The value lies between .0008 microfarads and .001 microfarads. The average ship aerial has a fundamental wave-length of about 325 meters.

97. Ques.—Why should all the joints in antenna wires be soldered?

Ans.—This is done to prevent losses of energy due to corrosion. This precaution must particularly be taken into account with receiving aerials; an unsoldered joint is not so disastrous to the transmitting apparatus as to the receiving equipment.

98. Ques.—What is the effect on radiation and range if the insulation of the antenna is poor?

Ans.—It will reduce the range considerably. Energy leaking over the insulators may be considered as so much lost and thereby the range of the set is materially decreased.

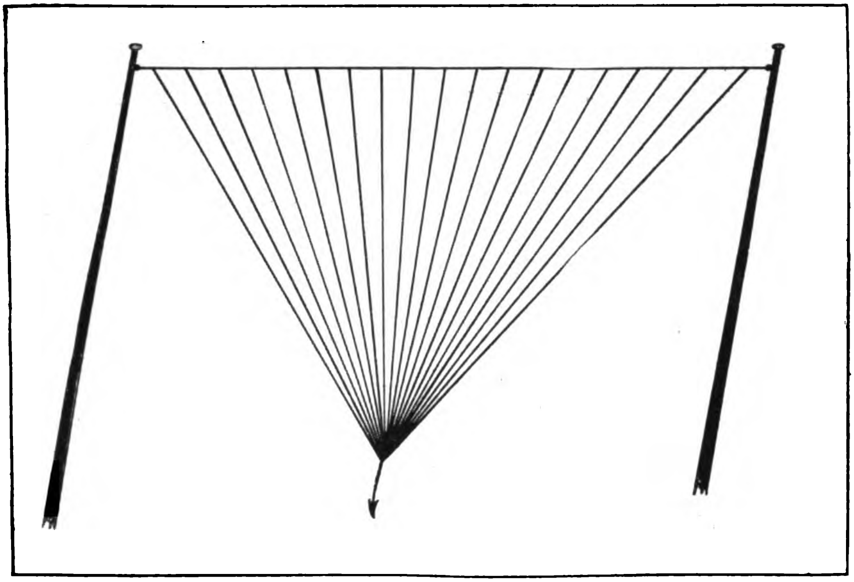


Fig. 27.

99. Ques.—Name some preventatives and temporary remedies for leaking antenna insulation.

Ans.—Slight carbonization of the insulators may be remedied by simply scraping the burned portion, covering it with a special insulating compound as furnished by the Marconi Company. If, however, the insulator is burned beyond this remedy, a piece of marlin rope soaked in oil may be used in place of the insulators as a temporary repair.

Excessive leakage at the insulators may sometimes be stopped by a decrease of the coupling at the transmitting apparatus. While the effective range is of course decreased, it may permit of communication taking place, when otherwise it would not be possible.

100. Ques.—What effect has the height of an antenna upon the range of the station?

Ans.—Sufficient data has not been obtained to answer this question, quantitatively, but, generally speaking, as the height of the aerial is increased, an increase in the range of the station may be expected. The greater the height of the aerial, the greater will be the displacement current set up about the aerial.

101. Ques.—How would you test the insulation of an antenna?

Ans.—This is most effectively tested by inserting a spark gap in series with the antenna and energizing the aerial circuit with the high potential from the secondary winding of an alternating current transformer. If the antenna insulators leak, the energy, instead of discharging across the spark gap, will pass across the insulators down the rigging and thence into the hull of the ship, partially or completely short-circuiting the transformer.

Part V.

RECEIVING APPARATUS

102. Ques.—Draw a complete circuit diagram of a modern radio receiver, showing the apparatus and connections from the antenna to the earth. Give a brief explanation of its operation.

Ans.—A complete diagram of the apparatus of a modern radio telegraphic receiver is shown in the drawing, Fig. 28. The two principle circuits are:

1—The open oscillation circuit, often referred to as the "antenna circuit" or the "aerial circuit," which absorbs energy from the passing electro magnetic wave.

2—The closed oscillation circuit, sometimes referred to as the "local detector circuit," in which radio signals are made audible.

The open oscillation circuit comprises the aerial tuning inductance L-3, the primary winding of the tuning transformer L-2, and the short wave variable condenser C-1. These three pieces of equipment are known as the frequency determining elements of the antenna circuit.

The local detector circuit comprises the secondary winding L-4, the variable condenser in shunt C-2, the fixed or stopping condenser C-3, the detector D, the head telephones, the potentiometer, Pot, and three cells of the battery, Bat.

The wave length of the antenna circuit may be altered by the aerial tuning inductance L-3, the short wave condenser C-1, or at the primary winding of the receiving transformer L-2. The wave length of the local detector circuit may be altered by the variable secondary winding L-4 and the variable condenser in shunt C-2.

It is essential for the maximum strength of signals that the open and closed oscillation circuits be in exact resonance and in resonance with the transmitter. This is accomplished when the variable condensers and inductances of the two circuits are so adjusted that the greatest possible response is received in the head telephones from a given station.

When a distant transmitting station is sending, the electro static and magnetic lines of force radiated from the aerial, charge and cut the antenna at the receiving station and induce in it radio-frequent electrical oscillations which have maximum amplitude when the receiving antenna is in resonance with the transmitting station's aerial.

The oscillations induced in the open oscillatory circuit are partly transferred by electromagnetic induction from the primary winding L-2 to the secondary winding L-4, and when the coupling between the two windings is of small value the oscillations may be increased in amplitude by use of the condenser C-2. The energy stored up in the condenser C-2, per train of waves, overflows to the crystal detector D, where it is rectified and changed into a series of direct current impulses. It is very probable that the passage of the uni-directional impulses of current through the crystal detector, D, in some way alters the strength of the local battery current through the head telephones and thereby produces audible sounds. It is especially important that the correct potential be applied to the carborundum crystal from the local battery, Bat, and also that the current flow in a definite direction; the proper direction being best determined by experiment.

When the distant transmitting station is fitted with a 500 cycle synchronous rotary spark discharger, 1,000 wave trains are released from the antenna per second. These 1,000 wave trains send 1,000 pulses of current (direct current pulses) through the head telephones, creating audible sounds, having the characteristics of the spark at the distant transmitting station.

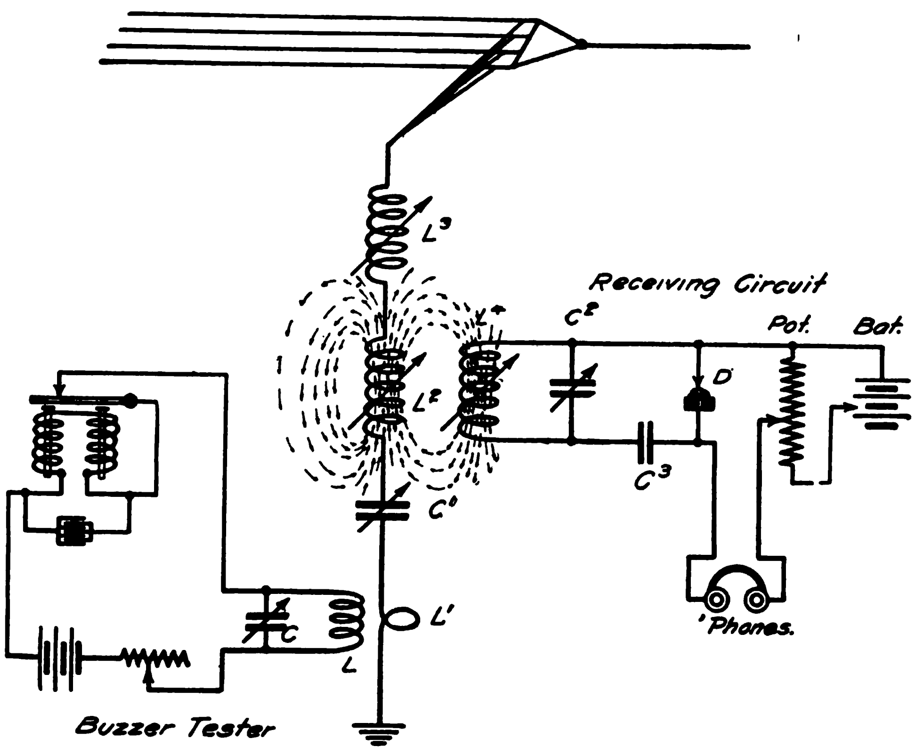


Fig. 28.

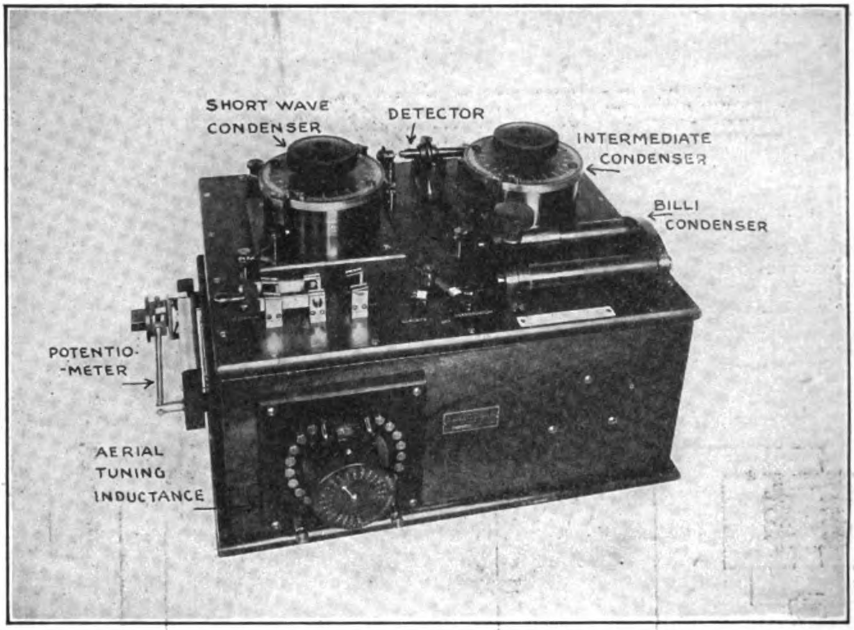
The potentiometer, Pot, is for the purpose of regulating the flow of current through the carborundum crystal D.

The fixed stopping condenser C-3 prevents the current from the local battery circuit flowing through the tuning coil L-4, instead of through the detector D as required.

When crystals of silicon, perikon, galena, etc., etc., are employed as the detecting elements, the local telephone circuit, comprising potentiometer and battery, is generally connected around the fixed stopping condenser. With this connection the local battery current flows through the tuning coil L-4, and is, therefore, sometimes useful in locating an open circuit in that winding. There is also a fixed resistance of 1,800 ohms, connected in series with the potentiometer, Pot, for the purpose of reducing the voltage of a single cell of battery to a minimum value. The diagram shown in Fig. 28 is suitable for the electrolytic as well as for the carborundum detector.

It should be added that the aerial tuning inductance L-3 is for the purpose of adjusting the antenna circuit to wave lengths beyond the natural wave of the antenna itself, while the short wave condenser C-1 allows the reception of wave lengths shorter than the natural wave of the antenna.

Occasionally, loading coils are inserted in series with the local detector circuit, but in the ordinary commercial outfit, for ranges of wave lengths up to 3,000 meters, such coils are not required.



Marconi (type 103) receiving tuner.

103. Ques.—What is the effect of tightening the coupling of the receiving tuner?

Ans.—It has the effect of increasing the damping of the receiving set as a whole, making it responsive to a number of wave lengths, and thus making unnecessary precise adjustments of the tuning elements to pick up any particular transmitting station nearby.

It should be understood that when the coupling is increased the mutual inductance between the primary and secondary windings is increased, and the energy from the antenna circuit is extracted more rapidly than under conditions of lesser coupling.

103. Ques.—Draw a neat diagram of a buzzer-testing circuit, showing its position with relation to the tuner in order to calibrate the receiving set or to test the sensitiveness of the receiving detector.

Ans.—The tuned buzzer circuit is perhaps the most convenient and practical of all testing devices. A complete diagram of connections is shown in Fig. 28, where the tuned buzzer testing apparatus is placed in inductive relation to the earth of the open oscillation circuit at any receiving station.

The open oscillation or antenna circuit is indicated by the elements L-3, L-2, C-1 and the aerial. The local detector circuits by the elements L-4 and C-2; also C-3, D, Pot and Bat.

To the left of the drawing is a wave meter, comprising the fixed inductance coil L, and the variable condenser C, which is set into excitation by the high pitched buzzer and battery.

When the buzzer is properly adjusted and placed in vibration, radio-frequent electrical oscillations flow through the coil L and are transferred by electromagnetic induction to the antenna circuit of the receiving apparatus through the single turn of wire L-1.

These oscillations will reach their maximum amplitude in the antenna circuit when the variable elements of that circuit are so adjusted that it has the same time period of oscillation, or same wave length as the wavemeter. But the signals in the head telephones will have the maximum intensity when the closed oscillation or detector circuit, comprising principally the elements L-4 and C-2, are in exact resonance with the antennae circuit.

It is obvious that the advantages of this testing apparatus are twofold; for the operator is not only enabled to pre-adjust the circuit of his receiving tuner to a definite wave length, but also may obtain the best point of adjustment on the crystal detector. Thus the receiving set may be calibrated and the corresponding wave length adjustment directly marked on the scale of the variable elements.

It will be observed from the drawing that the magnets of the buzzer are shunted by a condenser of 2 microfarads capacity; this is intended to absorb the counter electromotive force of the buzzer windings and thus prevent sparking at the vibrator.

104. Ques.—How would you determine at your receiving station if a distant transmitting station is emitting a pure wave?

Ans.—If a slight change of wave length in either the primary or secondary detector circuit is sufficient to eliminate the signals of this transmitting station, it may be taken as a fair indication that the stations radiates a pure wave; particularly so if there is but one point on the tuner where the signals from this station become audible.

If there are two distinct point on the receiving tuner where the distant station can be heard, or if the signals are audible, even when the circuits are thrown considerably out of resonance with the distant station, it is a fair indication that this station does not emit a pure wave in compliance with the U. S. regulations.

105. Ques.—What is the advantage of varying the coupling of the receiving tuner?

Ans.—This feature enables the receiving operator to cut out interfering stations. It not only enables him to change his apparatus from a "broad" adjustment to a "sharp" adjustment, but also allows the separation of stations having different degrees of damping, even when these stations operate on the same wave lengths.

If the signals from a transmitting station are strong and at the same time severe atmospheric electricity is encountered, judicious use of the coupling feature allows the receiving operator to eliminate atmospheric disturbances and still read the signals of the transmitting station.

106. Ques.—Of what use is a buzzer and battery in connection with the receiving set?

Ans.—It enables the operator to pre-adjust his receiving detector to the maximum degree of sensitiveness, giving assurance that a calling station will be heard.

107. Ques.—How can a receiving apparatus be marked for showing the position of different standard wave length adjustments? Give a sketch.

Ans.—A complete answer is given in the diagram, Fig. 28, where a wave-meter becomes a small transmitting set emitting waves of definite length, the corresponding positions for which may be plainly marked upon the receiving tuner during calibration.

It is not absolutely necessary to calibrate a receiving set by this method. For instance, certain transmitting stations with wave lengths definitely known, may be adjusted to the maximum strength of signals on the receiving apparatus and the corresponding positions of all variable tuning elements noted and tabulated for future reference.

108. Ques.—Describe fully the actions and circuits of an inductively coupled receiving tuner.

Ans.—(This question is fully covered in the answer to question 102).

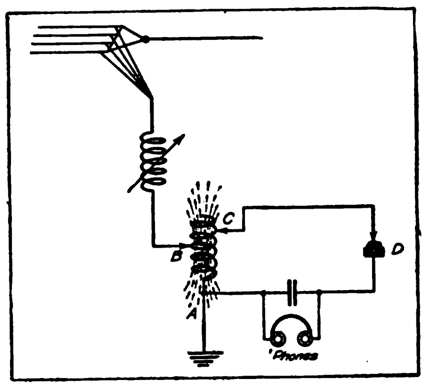


Fig. 29.

109. Ques.—If your head telephone circuit is found open, where is the trouble most likely to be and how would you remedy it?

Ans.—The trouble is generally located in the telephone cord at the metallic tips or at the binding posts on the receiver cases. If the difficulty is found to be beyond repair, leads of ordinary wire may be substituted for the cord.

110. Ques.—Describe fully a direct coupled receiving tuner and give a diagram.

Ans.—The circuits for a receiving tuner of this type are clearly shown in Fig. 29, where a single coil of wire is used for both the primary and secondary winding. The primary winding includes whatever number of turns are in use between the points A and B; the secondary winding the turns between points A. and C. A portion of the energy absorbed from a passing wireless wave flows into the local detector circuit by direct conduction and the remainder is set up by electromagnetic induction.

The open circuit also includes an aerial tuning inductance. The local detector circuit comprises the turns from A to C, the crystal detector D, the fixed condenser and the head telephones in shunt.

A direct coupled tuner is generally considered as being one giving "broad" adjustments, but this is not necessarily true. If the aerial tuning inductance, as indicated in Fig. 29, is included in the antenna circuit, a minimum number of turns may be employed in the primary winding A to B, while the additional turns necessary to reach a certain wave length may be inserted at the aerial tuning inductance.

Since under these conditions the mutual inductance between the primary and secondary turns is small, the coupling is of low value. It will now be readily understood how the value of the coupling may be altered as desired.

111. Ques.—If the natural period or the fundamental wave length of an antenna is too long to receive short wave lengths, how would you proceed to adapt it to short wave lengths without shortening the antenna?

Ans.—A condenser of variable capacity should be connected in series with the antenna circuit. In this manner the total effective capacity of the antenna is reduced and the wave length correspondingly.

112. Ques.—What is the least number of pieces of apparatus with which you can receive signals? Give a simple diagram and the connections.

Ans.—Generally when replying to this query the simple sketch shown in Fig. 30 is given. In this arrangement a detector of the crystalline type is connected in series with the antenna circuit and then shunted by a pair of head telephones. This is found in actual practice to be an exceedingly inefficient arrangement of apparatus and does not allow the reception of messages over sufficient distances to be of much actual value. It is far preferable to employ some such circuit as shown in Fig. 31, where a single slide tuning coil or at least a variable "tap-off" tuning coil is employed to transfer energy to the receiving detector.

Any available makeshift coil may be used for this purpose as an auto-transformer, and the results obtained will be more satisfactory than with the connections shown in the diagram, Fig. 30.

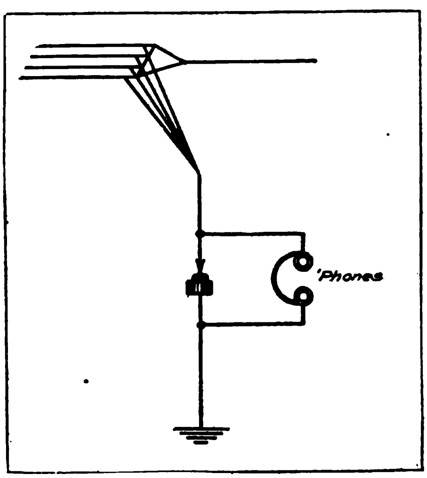


Fig. 30.

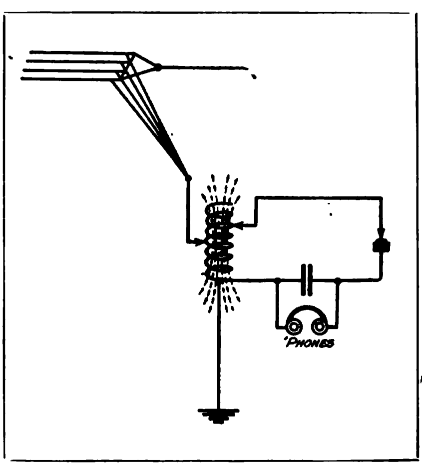


Fig. 31.

113. Ques.—What precautions do you take to protect your receiving detector from being injured by nearby strong signals?

Ans.—The coupling between the primary and secondary winding should be reduced to a minimum value or the circuits of the receiver thrown out of resonance. Either method will have the effect of reducing the strength of the received energy.

114. Ques.—For general listening in, would you use loose or tight coupling?

Ans.—Tight coupling is preferable, as under these conditions stations having different wave lengths may be heard without making special adjustments at the receiver.

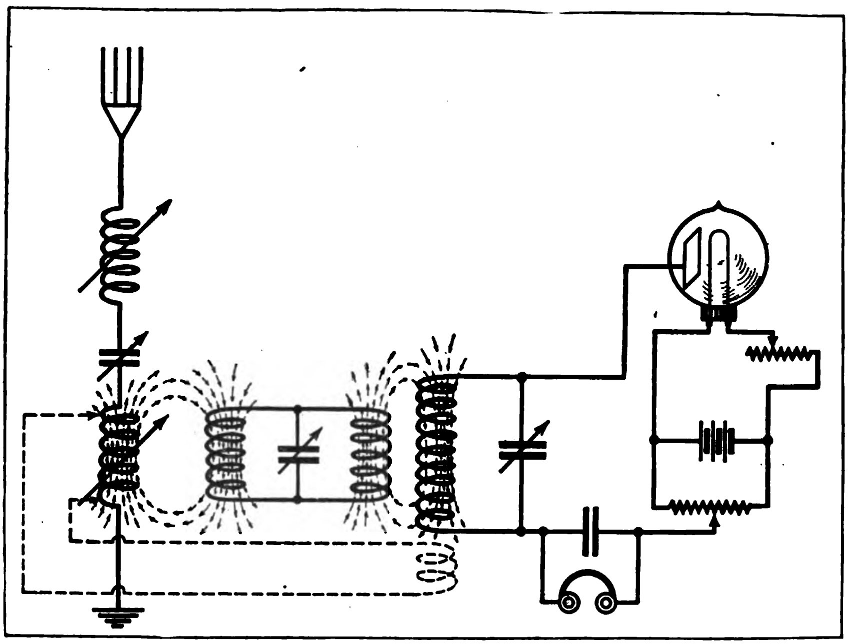


Fig. 32.

115. Ques.—Name three types of receiving detectors with which you are familiar, and give a simple diagram showing how each is connected to the tuner and potentiometer if required.

Ans.—The receiving detectors in general use to-day are:
(1.) The carborundum crystal.
(2.) The Fleming oscillation valve.
(3.) The silicon or perikon detector.
A circuit suitable for the carborundum crystal is already indicated in the drawing, Fig. 28.

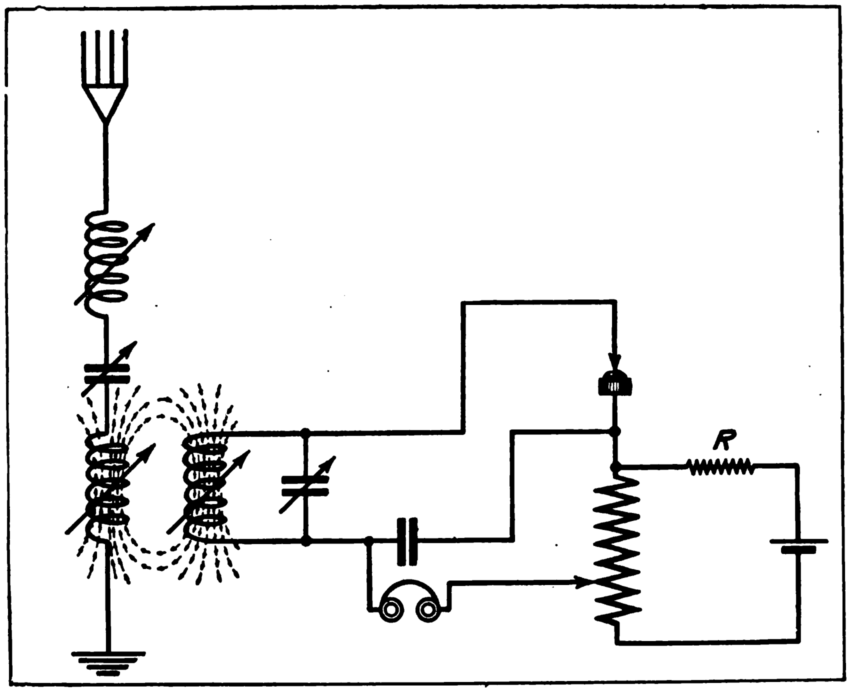


Fig. 33.

The circuits generally employed in connection with the Fleming oscillation valve are shown in Fig. 32 (on the page following).

A circuit particularly adapted to silicon and perikon detectors is clearly indicated in Fig. 33. It will be observed that the head telephones, potentiometer, battery and fixed resistance R are connected in shunt to the telephone condenser.

116. Ques.—Name some of the crystal detectors.

Ans.—Carborundum, galena, silicon, perikon, molybdenite, cerusite, ferron, etc.

117. Ques.—Describe fully how signals are obtained with an inductively coupled receiving tuner.

Ans.—(This question is fully covered in the answer to question 102.)

118. Ques.—Why are high resistance telephones used in radio telegraphic receivers?

Ans.—They are generally more sensitive. It is, however, not the resistance value that determines the actual degree of sensitiveness; it is the magnetizing flux generated that determines the degree. When a receiving telephone is used with a crystalline detector of high resistance, extremely feeble currents pass and in consequence to produce a magnetizing flux of considerable strength a great number of turns of wire must be employed; that is to say, the ampere turns determine the total flux. To secure the necessary ampere turns the coils must possess a fairly high value of resistance, hence it is customary to express the sensibility of the telephone in terms of resistance rather than in terms of actual flux density. With a receiving detector of the vacuum valve type which passes a considerable amount of current, telephone receivers of low resistance value may be employed for obvious reasons. It is not alone the ampere turns or the magnetizing flux which determine the sensibility of the telephone, but it is also governed by the reluctance of the magnetic circuit and the weight or thickness of the diaphragm. All these factors must be taken into consideration.

119. Ques.—What effect has a reversal of battery current in a receiving set on a crystalline detector?

Ans.—It results in a decrease of sensitiveness. With all crystalline detectors employing local battery current it is essential that the flow take place in a certain direction. The proper direction is best determined by experiment during the reception of signals from a distant transmitting station. The connections from the battery to the potentiometer should be reversed and corresponding readjustment of the potentiometer made until the maximum strength of signals from a given station is obtained.

A similar procedure is followed with all receiving detectors requiring local battery current.

Part VI.

RADIO LAWS AND REGULATIONS

120. Ques.—Does the coast station or the ship station determine the order in which radiograms shall be transmitted?

Ans.—The coast station.

121. Ques.—How many times may a radiogram be repeated?

Ans.—Three times.

122. Ques.—What are the regulations regarding the secrecy of radiograms?

Ans.—According to the U. S. regulations, the contents of messages must not be divulged except to the person or persons to whom the same may be directed or their authorized agents, or to another station employed to forward such message to its destination, unless legally required so to do by the court of competent jurisdiction or other competent authority.

Any person guilty of divulging or publishing the contents of any message may be punished by a fine of not more than $250.00, or imprisonment for a period of not exceeding three months, or both, in the discretion of the court.

123. Ques.—How much time must elapse between calls, if no acknowledgment is received, according to the International Regulations?

Ans.—If the station called does not answer the call transmitted three times with intervals of two minutes, the call shall not be resumed until after an interval of 15 minutes, the station issuing the call having first made sure that no radio correspondence is in progress.

124. Ques.—Explain the cable count and how it is used to determine the charges due on radio-telegrams?

Ans.—The so-called cable count is the method of determining charges as at present in use by the cable companies.

In the cable count, all words including the address and the signature are counted for and charged, in contrast to the U. S. land line wire companies' method of charging for only the words in the body of the message.

In the cable count system, messages are divided into three main classes:

(1.) Plain language.

(2.) Code language.

(3.) Cipher language.

Plain language is that which offers an intelligible sense in one or more of the languages authorized for international telegraphic correspondence. For messages written entirely in plain language, the maximum length of a chargeable word is fixed at fifteen letters or characters. Messages containing one or more code words are code messages.

Code languages may consist of words belonging to one or more of the following languages: English, French, German, Italian, Dutch, Portuguese, Spanish and Latin. The use of words of other languages is not allowed. Code languages may also consist of artificial words; that is, groups of letters so combined as to be pronounceable in at least one of the eight admitted languages. In code language messages, each code word (whether genuine or artificial) of ten letters or less, is counted as a word, and no code word of more than ten letters can be accepted. If any words in plain language and of more than ten letters each are used in code messages, they should be counted at the rate of ten letters or fraction of ten letters to a word.

Cipher language is formed of groups of figures or groups of letters or of words, names, expressions or combinations of letters not complying with the conditions of plain or code language. The accented letters are not admitted. Each group of figures or letters is charged at the rate of five figures or five letters, or fraction of five to the word. Figures and letters in the same group must be counted separately. Example: A5B—count three words.

Combinations of two or more plain language words or alterations of words contrary to usage or combinations of alterations of words concealed by reversing the order of the letters or syllables are not admitted.

When a message consists of mixture of three designated types of messages, they are charged for as follows:

In messages written in a mixture of plain, code and cipher languages, the passages in both plain and code language are charged as code language, and the passages in cipher language are charged as cipher language.

In messages written in plain language and cipher language, the passages in plain language are counted as plain language, and the passages in cipher language are counted as cipher language.

125. Ques.—What is the International Regulation regarding the use of superfluous signals?

Ans.—The exchange of superfluous signals and words is prohibited to all licensed stations.

126. Ques.—What is meant by the signal "P R B?"

Ans.—This combination of letters infers that the ship wishes to communicate by means of the International Signal Code.

127. Ques.—When at sea, how would you find out which is the nearest shore station?

Ans.—In totally strange countries this might be ascertained by sending out the International call of inquiry, "C Q," which is an invitation for any stations in the vicinity of the sender to transmit and reply to his call.

It would be possible to secure from the steamship captain the approximate latitude and longitude of the vessel, and then by reference to the navigator's map, locate the position of prominent land stations which are known to exist in certain vicinities.

Whether or not land stations exist within range may be determined from the International Call Book, or the U. S. list of calls, which generally give the range of the various land stations under normal conditions.

Maps showing the location of prominent commercial and naval stations are furnished by the Marconi Wireless Telegraph Company and also by the Hydrographic Office.

With all these means available the operator would have little difficulty in determining the nearest shore station within range.

128. Ques.—What is the International normal wave length for ship stations?

Ans.—For commercial ship stations, 300 and 600 meters, for naval stations between 600 and 1,600 meters; and in special instances commercial ship stations may be allowed to operate on wave lengths above 1,600 meters.

129. Ques.—In general usage what wave lengths should be used in calling the land stations?

Ans.—In calling a land station, if possible, the normal receiving wave length of that station should be used.

In commercial service, with 98% of the installations the 600 meter wave is used entirely.

130. Ques.—Give as many of the International Abbreviations as you can, stating their meaning.

Ans.—(See Government forms 772 and 733 in the rear of this book.)

131. Ques.—How can you communicate with a foreign vessel, the operator of which does not speak English?

Ans.—Use the International abbreviations as specified by the London Radio Telegraphic Convention.

132. Ques.—Give the regulations for answering a call.

Ans.—The called station shall answer by making the signal:

— · — · —

followed by the call letters of the corresponding station, transmitted three times; the word "from" (de), its own call letters, and the signal

— · —

133. Ques.—What is the preliminary call signal?

Ans.—

— · — · —

134. Ques.—What is the law in regard to the amount of power to be used in the vicinity of naval stations?

Ans.—No station on shipboard when within 15 nautical miles of a naval or military station shall use a transformer input exceeding 1 K. W., nor within five nautical miles of such a station, a transformer input exceeding ½ K. W., except for sending signals of distress or signals or radiograms relating thereto.

135. Ques.—What would you do under various circumstances if you heard a ship making a distress call? Answer fully.

Ans.—The operator receiving a call of distress should first determine from the distressed vessel if his ship is the nearest one. Care should be observed in this respect not to cause unnecessary interference with another vessel which may be very close to the one in distress. In fact it is well for the receiving operator to pause a few seconds before answering a distress call to see if some other ship station is not in the immediate vicinity of the one sending the distress call. If not, every effort should be made by the receiving operator to ascertain full particulars from the distressed vessel, receipt of which should be immediately acknowledged. Full information should then be conveyed to the master of the vessel and from that time on the radio operator should work under the master's direction.

136. Ques.—Give the regulations for calling a shore station.

Ans.—The call shall comprise the signal:

— · — · —

the call letters of the station called, transmitted three times, the word "from" (de), followed by the call letters of the sending station, transmitted three times.

137. Ques.—What is the law in regard to the amount of power to be used in the primary of the transformer for transmitting at a certain distance?

Ans.—All stations are bound to carry on radio correspondence with a minimum of energy necessary to insure safe communication.

138. Ques.—What are the signals to terminate a radio telegram?

Ans.—

· — · — ·

139. Ques.—What are the U. S. requirements for the distance to be covered by an emergency or auxiliary apparatus for distress purposes?

Ans.—Emergency apparatus must have a daylight range of at least 100 miles and must be capable of transmitting continuously for a period of four hours.

The International Convention requirements are that the emergency apparatus must be capable of functioning for at least six hours and have a minimum range of 80 nautical miles in a case of ship having constant radio service, and 50 miles while the ship station has a service of limited duration.

140. Ques.—What is the rule about intercommunication?

Ans.—Commercial radio stations are bound to communicate with one another regardless of the system of wireless telegraphy employed.

141. Ques.—Why does the law state that a low decrement must be used?

Ans.—A transmitting station emitting a wave of low decrement will tune "sharply" at a distant receiving station and therefore cause little interference.

142. Ques.—Name some of the penalties to which a radio operator is subject according to the U. S. regulations.

Ans.—For a general violation of the stipulations in the U. S. Act of August 13, 1912, the operator may be subjected to a general fine of $25, and for repeated violations of such regulations, the license may be suspended or revoked.

For malicious interference the operator is subject to a penalty of $500 with one year imprisonment, or both, in discretion of the Secretary of Commerce. For sending out fraudulent distress signals the penalty is $2,500 fine or five years imprisonment, or both.

Part VII.

GENERAL INFORMATION CONCERNING OPERATORS' LICENSE EXAMINATIONS

The Government operator's license certificate has 8 gradations:

1. **Commercial extra first grade.**
2. **Commercial first grade.**
3. **Commercial second grade.**
4. **Commercial cargo grade.**
5. **Commercial temporary permit.**
6. **Experiment and instruction grade.**
7. **Amateur first grade.**
8. **Amateur second grade.**

To pass the **commercial extra first grade examination,** the applicant must be able to copy messages in the Continental Morse Code at a speed of 30 words per minute and the American Morse Code at a speed of 25 words per minute. He must have complete knowledge of the technical details of commercial apparatus and also of the International Radio Laws and Regulations. The queries for this examination are wider in scope than those for the usual first grade license and a higher final percentage in the examinations is required. A grade of at least 80% must be obtained.

To qualify for **commercial first grade license** the applicant must pass a satisfactory examination in the adjustment, operation and care of commercial radio apparatus, including the correction of faults and change from one wavelength to another. He must be able to transmit and receive in the Continental Morse Code at a speed of at least 20 words per minute (5 letters to the word). He must have complete knowledge of the use and care of storage batteries or other auxiliary power apparatus. He must be fully informed on the International Regulations in force applying to radio communication. He must also know the requirements of the Act of Aug. 13, 1912.

The requirements for **a second grade license** are similar to those for a first grade license with the exception that a certificate will be issued to an applicant possessing less ability in the telegraph code. In fact, the license is granted if the applicant is able to copy 12 words per minute. The technical examination for a commercial second grade license is not so comprehensive as that for a first grade license.

A **commercial cargo grade license** is issued to an applicant who can recognize distress signals at a speed of about 5 words per minute. The applicant must also be sufficiently familiar with the continental Morse code to recognize the radio call letters of the vessel on which he desires to operate, when sent slowly and repeated several times. He must be able to determine by a buzzer when his detector or receiving apparatus is properly adjusted to receive signals.

Commercial temporary permits are issued by the Collector of Customs in a given port and are only given to those who can fully satisfy the Collector that they have sufficient knowledge of the radio telegraphic art to manipulate a commercial equipment. Such permits are usually issued for one trip of a vessel.

The **experiment and instruction grade license** is issued to experimenters and instructors of scientific attainment in radio communication, whose knowledge of the radio law satisfies the radio inspector or the examining officer, provided they are able to transmit and receive in the Continental Morse code at a speed sufficient to enable them to recognize distress calls or the "keep out" signal. The operator's license for this grade is a commercial license endorsed by the Secretary of Commerce, with a statement of the special purpose for which it is valid.

To obtain an **amateur first grade certificate** the applicant must have a sufficient knowledge of the adjustment and operation of the apparatus which he wishes to operate, and of the regulations of the International Convention and Acts of Congress in so far as they relate to interference with other radio communication and impose certain duties on all grades of operators. The applicant must be able to transmit and receive in the Continental Morse at a speed sufficient to enable him to recognize distress calls or the official "keep out" signals. A speed of at least five words per minute (five letters to the word) must be attained.

The requirements for the **second grade amateur license** are the same as for the first grade. The second grade license will be issued only where an applicant cannot be personally examined or until he can be examined. The examining officer or radio inspector is authorized in his discretion to waive an actual examination of an applicant for an amateur license if the amateur for adequate reasons cannot present himself for examination, but in writing can satisfy the examining officer or radio inspector that he is qualified to hold a license and will conform to its obligations.

EXAMINATIONS

The code test for operators' examinations shall consist of messages with call letters and regular preambles, conventional signals and abbreviations and odd phrases, and shall in no case consist of simple connected reading matter. The test will be conducted by means of the omnigraph or other automatic instrument wherever possible.

The test shall continue for five minutes at a speed of 20 words, 12 words and 5 words per minute, respectively, for the commercial first, second and lower grades; and to qualify, the applicant must receive 20, 12 or 5 words in consecutive order.

An applicant will be given credit for the maximum speed he can attain.

The practical and theoretical examination shall consist of seven comprehensive questions under the following headings and values:

A—Experience	20
B—Diagram of Transmitting and Receiving Apparatus	10
C—Knowledge of Transmitting Apparatus	20
D—Knowledge of Receiving Apparatus	20
E—Knowledge of the Operation and Care of Storage Batteries	10
F—Knowledge of Motors and Generators	10
G—Knowledge of the International Regulations Governing Radio Communications and the U. S. Radio Laws and Regulations	10

Seventy-five constitutes the passing mark for the first grade commercial; sixty-five constitutes the passing mark for the second grade commercial.

Applicants who fail to attain 20 words a minute in the code test but who obtain a mark of between 65 and 75 in the written examination may be issued second grade licenses if they can receive at least 12 words a minute.

Examinations are held at the following U. S. Navy Yards:

Boston, Mass.
New York.
Philadelphia, Pa.
Norfolk, Va.
Charleston, S. C.
New Orleans, La.
Mare Island, Cal.
Puget Sound, Wash.

Also at the following naval radio stations:

San Juan, P. R.
Colon, R. P.
Honolulu, H. T.
Key West, Fla.

Also at the following U. S. Army stations:

Fort Omaha, Neb.
Fort Wood, N. Y.
Fortress Monroe, Va.
Fort St. Michael, Alaska.
Fort Valdez, Alaska.

Examinations are given at the Bureau of Navigation, Department of Commerce, Washington, D. C.; also by radio inspectors at their offices, and elsewhere by special arrangement.

AMATEUR STATION LICENSES

Special amateur stations may be licensed by the Secretary of Commerce, to use a longer wave-length and a higher power on special application. Applications for this class from amateurs with less than two years' experience in actual radio communication will not be approved. The applicant must state the experience and purpose of the applicant, the local conditions of radio communication, especially of maritime radio communication in the vicinity of the station, and a special license will be granted only if some substantial benefit to the art or to commerce, apart from individual amusement, seems probable.

Special amateur coast stations must be operated by a person holding a commercial second grade license or higher. Inland stations may be operated by persons holding amateur second grade licenses or higher.

General amateur stations are restricted to a transmitting wave-length not exceeding 200 meters and a transformer input not exceeding 1 K. W.

Restricted amateur stations within five nautical miles of a naval or military station are restricted to a wave-length not exceeding 200 meters and to a transformer input not exceeding ½ K. W.

Amateur first or second grade operators or higher are required for general and restricted amateur stations. The license does not specify the number of operators required, but provides that the station shall at all times while in operation be under the care of an operator licensed for that purpose. The grade and number of operators as required by law is determined by the service of the station.

General and restricted amateur station licenses are issued directly by radio inspectors. Station licenses of all other classes are issued from the office of the Commissioner of Navigation, Department of Commerce. Applications and forms are forwarded by radio inspectors, with recommendations by them.

Applications for station licenses of all classes should be addressed to the U. S. Radio Inspector for the district in which the station is located, who will forward the necessary blank forms and information.

The owner of an amateur station may operate his station in accordance with the laws if his application for a license has been properly filed but has not been acted upon. An application for an **operator's license** must also have been filed and every effort made to obtain the license before the station may be operated. (Additional information concerning all licenses may be obtained from the booklet entitled "Radio Communication Laws of the U. S. and the International Radio Telegraphic Convention" on sale by the Government Printing Office, Washington, D. C.)

INTERNATIONAL RADIOTELEGRAPHIC CONVENTION

LIST OF ABBREVIATIONS TO BE USED IN RADIO COMMUNICATION

ABBREVIATION.	QUESTION.	ANSWER OR NOTICE.
PRB	Do you wish to communicate by means of the International Signal Code?	I wish to communicate by means of the International Signal Code.
QRA	What ship or coast station is that?...........	This is........
QRB	What is your distance?........................	My distance is........
QRC	What is your true bearing?....................	My true bearing is........degrees.
QRD	Where are you bound for?......................	I am bound for........
QRF	Where are you bound from?.....................	I am bound from........
QRG	What line do you belong to?...................	I belong to the........Line.
QRH	What is your wave length in meters?..........	My wave length is........meters.
QRJ	How many words have you to send?..........	I have........words to send.
QRK	How do you receive me?........................	I am receiving well.
QRL	Are you receiving badly? Shall I send 20?..... • • • — • for adjustment?................	I am receiving badly. Please send 20. • • • — • for adjustment.
QRM	Are you being interfered with?................	I am being interfered with.
QRN	Are the atmospherics strong?................	Atmospherics are very strong.
QRO	Shall I increase power?........................	Increase power.
QRP	Shall I decrease power?........................	Decrease power.
QRQ	Shall I send faster?............................	Send faster.
QRS	Shall I send slower?............................	Send slower.
QRT	Shall I stop sending?..........................	Stop sending.
QRU	Have you anything for me?....................	I have nothing for you.
QRV	Are you ready?.................................	I am ready. All right now.
QRW	Are you busy?..................................	I am busy (or: I am busy with......). Please do not interfere.
QRX	Shall I stand by?..............................	Stand by. I will call you when required.
QRY	When will be my turn?........................	Your turn will be No. ....
QRZ	Are my signals weak?..........................	Your signals are weak.
QSA	Are my signals strong?........................	Your signals are strong.
QSB	Is my tone bad?...............................	The tone is bad.
QSB	Is my spark bad?..............................	The spark is bad.
QSC	Is my spacing bad?............................	Your spacing is bad.
QSD	What is your time?............................	My time is........
QSF	Is transmission to be in alternate order or in series?	Transmission will be in alternate order.
QSG	....	Transmission will be in series of 5 messages.
QSH	....	Transmission will be in series of 10 messages.
QSJ	What rate shall I collect for............?...........	Collect........
QSK	Is the last radiogram canceled?..............	The last radiogram is canceled.
QSL	Did you get my receipt?.......................	Please acknowledge.
QSM	What is your true course?.....................	My true course is........degrees.
QSN	Are you in communication with land?.........	I am not in communication with land.
QSO	Are you in communication with any ship or station (or: with........)?	I am in communication with ....(through ....).
QSP	Shall I inform........that you are calling him?	Inform........that I am calling him.
QSQ	Is........calling me?..........................	You are being called by........
QSR	Will you forward the radiogram?..............	I will forward the radiogram.
QST	Have you received the general call?............	General call to all stations.
QSU	Please call me when you have finished (or: at ....o'clock)?	Will call when I have finished.
*QSV	Is public correspondence being handled?.......	Public correspondence is being handled. Please do not interfere.
QSW	Shall I increase my spark frequency?..........	Increase your spark frequency.
QSX	Shall I decrease my spark frequency?..........	Decrease your spark frequency.
QSY	Shall I send on a wave length of......meters?	Let us change to the wave length of......... meters.
QSZ	....	Send each word twice. I have difficulty in receiving you.
QTA	....	Repeat the last radiogram.

*Public correspondence is any radio work, official or private, handled on commercial wave lengths.

When an abbreviation is followed by a mark of interrogation, it refers to the question indicated for that abbreviation.

11—8096

INTERNATIONAL MORSE CODE AND CONVENTIONAL SIGNALS

TO BE USED FOR ALL GENERAL PUBLIC SERVICE RADIO COMMUNICATION

1. A dash is equal to three dots.
2. The space between parts of the same letter is equal to one dot.
3. The space between two letters is equal to three dots.
4. The space between two words is equal to five dots.

A	• —
B	— • • •
C	— • — •
D	— • •
E	•
F	• • — •
G	— — •
H	• • • •
I	• •
J	• — — —
K	— • —
L	• — • •
M	— —
N	— •
O	— — —
P	• — — •
Q	— — • —
R	• — •
S	• • •
T	—
U	• • —
V	• • • —
W	• — —
X	— • • —
Y	— • — —
Z	— — • •
Ä (German)	• — • —
Á or Å (Spanish-Scandinavian)	• — — • —
CH (German-Spanish)	— — — —
É (French)	• • — • •
Ñ (Spanish)	— — • — —
Ö (German)	— — — •
Ü (German)	• • — —
1	• — — — —
2	• • — — —
3	• • • — —
4	• • • • —
5	• • • • •
6	— • • • •
7	— — • • •
8	— — — • •
9	— — — — •
0	— — — — —

Period	• • • • • •
Semicolon	— • — • — •
Comma	• — • — • —
Colon	— — — • • •
Interrogation	• • — — • •
Exclamation point	— — • • — —
Apostrophe	• — — — — •
Hyphen	— • • • • —
Bar indicating fraction	— • • — •
Parenthesis	— • — — • —
Inverted commas	• — • • — •
Underline	• • — — • —
Double dash	— • • • —
Distress Call	• • • — — — • • •
Attention call to precede every transmission	— • — • —
General inquiry call	— • — • — — • —
From (de)	— • • •
Invitation to transmit (go ahead)	— • —
Warning—high power	— — • • — —
Question (please repeat after ......)—interrupting long messages	• • — — • •
Wait	• — • • •
Break (Bk.) (double dash)	— • • • —
Understand	• • • — •
Error	• • • • • • • •
Received (O. K.)	• — •
Position report (to precede all position messages)	— • — •
End of each message (cross)	• — • — •
Transmission finished (end of work) (conclusion of correspondence)	• • • — • —

D—

PRACTICAL EQUATIONS FOR RADIO TELEGRAPHY

For Condensers in Parallel.

$$C = C_1 + C_2 + C_3 \text{ (etc.)}.$$

Where C = Resultant capacity.

C_1, C_2, C_3 = Capacity of individual condenser units.

For Condensers in Series.

$$C = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}}$$

Where C_1 C_2 C_3 = Capacity of individual condenser units.

For Wave Length.

$$\lambda = \frac{V}{N}$$

Where λ = Wave length in meters.

N = Frequency in cycles per second.

V = Velocity of propagation of electro-magnetic waves in ether (300,000,000 meters per second).

Similarly $N = \frac{V}{\lambda}$

and $V = N\lambda$

For Time Period of an Oscillation Circuit.

$$T = \frac{1}{N}$$

Where T = Time in fraction of a second.

N = Frequency of vibration.

Also $T = \frac{\sqrt{L\,C}}{5033000}$

Where L = Inductance in centimeters.

C = Capacity in micro-farads.

For Wave Length of an Oscillation Circuit.

$$\lambda = 59.6 \sqrt{L\,C}$$

Where λ = Wave length in meters.

L = Inductance in centimeters.

C = Capacity in micro-farads.

For Oscillation Constant of a Radio Frequency Circuit.

$$O = \frac{5033000}{N}$$

Where O = Oscillation Constant.
N = Frequency of vibration.

For Damping of a Radio Frequency Circuit.

$$\delta = \frac{\pi}{2} R^1 \sqrt{\frac{C}{L}}$$

Where δ = Logarithmic decrement.
R^1 = High frequency resistance of the circuit.
C = Capacity in farads.
L = Inductance in henries.

Damping of Coupled Circuits by Wavemeter.

$$\delta_1 + \delta_2 = \frac{C_1 - C_2}{C} \times 1.57$$

Where δ_1 = Decrement of the circuit under measurement.
δ_2 = Decrement of the decremeter or wavemeter.
C_2 = Capacity of the condenser of the wavemeter at a point below resonance where the reading of a wattmeter connected in series with the wavemeter falls to one-half the value obtained at resonance C.
C_1 = Capacity of the Condenser at a point above resonance where the wattmeter reading falls to one-half that at resonance.
C = Capacity of the condenser at resonance.

For Capacitance of an Aerial.

$$C = \frac{\lambda_1^2 - \lambda_2^2}{\lambda_2^2} \times C_1$$

Where C = Capacity of the aerial in mfds.
λ_1^2 = Square of the natural wave length of the aerial.
λ_2^2 = Square of the wave length of aerial with C_1 in series.
C_1 = Condenser of known capacity connected in series with the aerial.

For the Inductance of an Aerial.

$$L = \frac{\lambda_1^2}{\lambda^2_2 - \lambda_1^2} \times l$$

Where L = Inductance of the aerial system in cms.
λ_1^2 = Natural wave length of the aerial squared.
λ_2^2 = Wave length of the aerial with l in series (squared).
l = Inductance coil of known value.

Capacity Required to Reduce the Wave Length on Aerial to a Certain Value.

$$C_1 = \frac{\lambda_1^2 \times C_2}{3552\ LC_2 - \lambda_1^2}$$

Where C_1 = Capacity of the series condenser in microfarads to reduce the wave length.

λ_1^2 = Square of the reduced wave length value desired.
L = Inductance in centimeters of the aerial to be reduced.
C_2 = Capacity in mfds. of the aerial to be reduced.

Capacity of a Flat Plate Condenser.

$$C = \frac{KA2248}{T \times 10^{10}}$$

C = Capacity in microfarads.
A = Area of dielectric in use in square inches.
T = Thickness of dielectric in inches.
K = Dielectric constant of the insulating medium (generally varies from 6 to 9).

Watts Flowing in an Oscillatory Circuit.

$$W = CV^2N.$$

Where W = Watts.
C = Capacity of the condenser in microfarads.
V^2 = Kilovolts of the charging potential.
N = Cycle frequency of the charging source.

Co-Efficient of Coupling for Two Coupled Circuits.

$$K = \frac{\lambda_2^2 - \lambda_1^2}{\lambda_2^2 + \lambda_1^2}$$

Where λ_2 = Longer wave length.
λ_1 = Shorter wave length.

Wave Length of an Aerial with Condenser of Known Capacity in Series.

$$\lambda = 59.6 \sqrt{L \frac{CC_2}{C + C_2}}$$

λ = Wave length in meters.
L = Inductance of aerial in cms.
C = Capacity of aerial in mfds.
C_2 = Condenser of known capacity connected in series.

Inductance of an Oscillatory Circuit of Known Wave Length.

$$L = \frac{\lambda^2}{3552\ C}$$

L = Inductance in cms.
λ = Wavelength of the circuit in meters.
C = Capacity of condenser in microfarads.

For Radiation Resistance of Flat Top Aerial.

$$R = K \frac{h^2}{\lambda^2}$$

K = A constant—1600.
λ = Wavelength of aerial in meters.
h = Height of aerial in meters.

Number of Complete Oscillations in an Oscillatory Circuit When the Last Oscillation Has Attained a Value of .01 of the Amplitude of the Initial Oscillation.

$$M = \frac{4.605 + \delta}{\delta}$$

Where δ = logarithmic decrement of the circuit under measurement.

Inductance of a Coil.

$$L = \frac{(\pi D N)^2}{1000} l \left[1 - 0.424\left(\frac{D}{l}\right) + 0.215\left(\frac{D}{l}\right)^2 - 0.0156\left(\frac{D}{l}\right)^4\right]$$

L = Inductance in centimeters.
D = Diameter of coil in centimeters.
l = Length of coil in centimeters.
N = Number of turns per centimeter of length.

Current in Amperes in a Closed Oscillatory Circuit.

$$I = \frac{6 \pi 10^2 CE}{\lambda}$$

Where I = Current in amperes.
C = Capacity in microfarads.
E = Sparking voltage.
λ = Wave length in meters.

Number of Watts in Closed Oscillatory Circuit to be Transferred to the Antenna Circuit.

$$W = \left(\frac{1}{2} \frac{CE^2 f}{1{,}000{,}000} - I_e^2 \times \frac{1{,}000{,}000.\ \lambda.\ \delta}{3\ C} \right)$$

Where W = Watts.
C = Capacity condenser in primary circuit.
E^2 = Sparking voltage.
I_e^2 = The effective current in the primary current or closed circuit.
δ = Decrement of the primary circuit.
f = Spark frequency.
λ = Wave length in meters.

Watts Radiated from a Flat Top or "T" Aerial.

$$W = \frac{h^2}{\lambda^2} I^2 \times 1578.$$

Where h^2 = Height of the aerial in meters.
λ = Wave length of the aerial in meters.
I^2 = Hot wire ammeter reading in amperes at the base of the aerial.

Austin formula for calculation of the current to be expected in the receiving aerial under given conditions.

$$I_r = \frac{h_1 h_2 I_s\ 3.92}{\lambda\ D.\ \epsilon^{\frac{0.0474\ D}{\sqrt{\lambda}}}}$$

Where I_r = Current in the receiver aerial in micro amperes.
h_1 = Height of sending aerial in feet.
h_2 = Height of receiving aerial in feet.
D = Distance of transmission in kilometers.
λ = Wave length in meters.
Σ = Base of the Naperian system of logarithms.
I_s = Current in sending aerial.

FOR ORDINARY POWER WORK

Frequency of an Alternator.

$$F = \frac{P \times S}{2}$$

Where F = Frequency in cycles per second.
P = Number of field poles on the alternator.
S = Speed of the alternator in revolutions per second.

Ohms Law for Direct Current.

$$I = \frac{E}{R}$$

Where I = Current in amperes.
E = Electromotive force in volts.
R = Resistance in ohms.

Similarly $R = \frac{E}{I}$

and $E = I \times R$

For Watts in D. C. Circuit.

$W = I \times E.$

Where W = Watts.
I = Current in amperes.
E = Electromotive force.

Also $W = I^2 R.$

Where R = Resistance in ohms.

Again $I = \sqrt{\frac{W}{R}}$

Ohms Law for Alternating Current.

$$I = \frac{E}{Z}$$

I = Current in amperes.
E = Electromotive force in volts.
Z = Impedance in ohms.

Also, $Z = \frac{E}{I}$

And $E = I \times Z$

For Impedance.

$$Z = \sqrt{R^2 + (2\pi FL)^2}$$

Where Z = Impedance in ohms.
R = Resistance in ohms.
$2\pi FL$ = Reactance of circuit in ohms.

For Reactance.

$$X = 2\pi F L.$$

Where X = Reactance of circuit in ohms.
F = Frequency in cycles per second.
L = Inductance in henries.

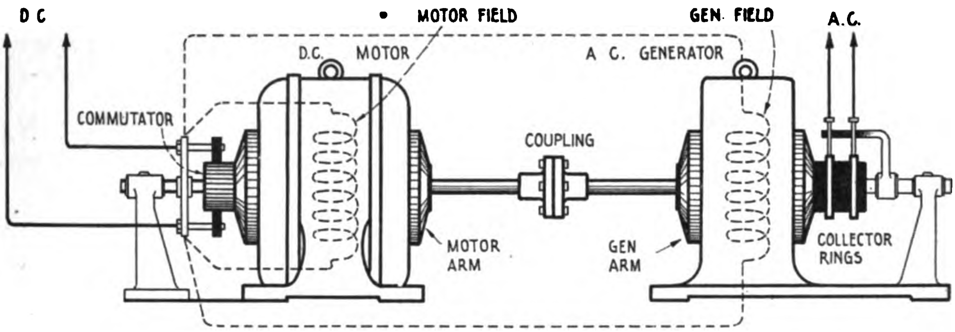
or $X = \sqrt{Z^2 - R^2}$

Inductance of a Circuit by the Voltmeter and Ammeter Method.

$$L = \frac{\sqrt{E^2 - I^2R^2}}{I^2 (2\pi n)^2}$$

Where L = Inductance in henries.
E = Potential applied.
I^2 = Current flowing.
R^2 = Resistance of coil or circuit in ohms.
N = Cycle frequency.

Fig. 34 showing general construction of a motor-generator (with inside bearings removed for clearness). The motor is supplied with direct current and the generator armature delivers alternating current at frequencies varying from 60 to 500 cycles and at



voltages varying from 110 to 500 volts according to the design. The terminals of the generator field winding are shunted across the D.C. power mains with a field rheostat (not shown) connected in series for regulating the A.C. voltage. A motor starter and field rheostat are required for the motor.

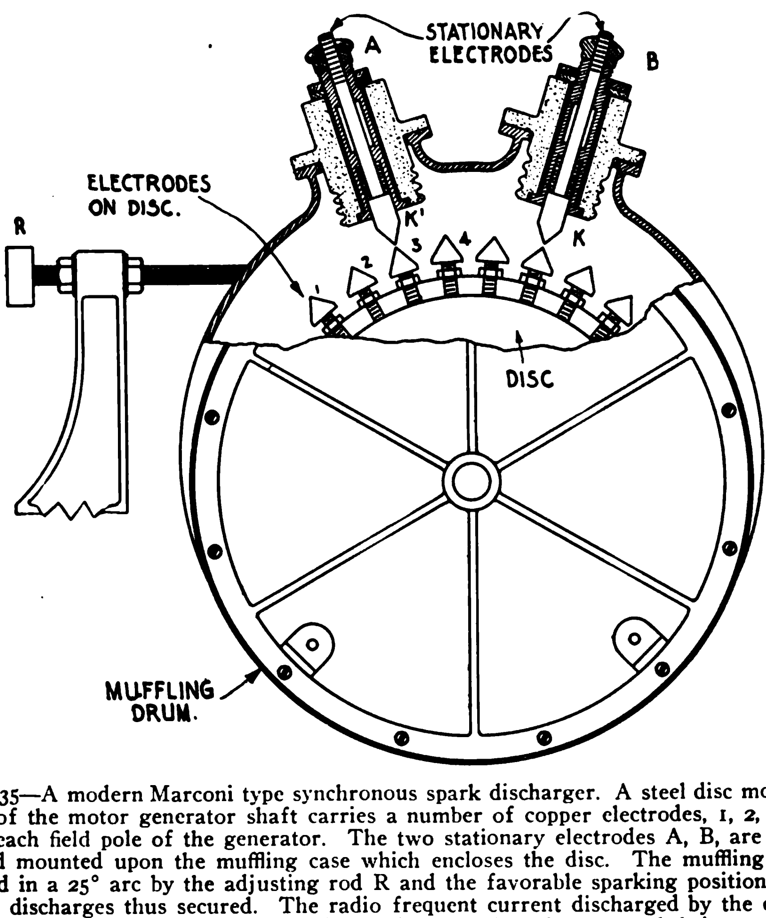


Fig. 35—A modern Marconi type synchronous spark discharger. A steel disc mounted on the end of the motor generator shaft carries a number of copper electrodes, 1, 2, 3, 4, etc., one for each field pole of the generator. The two stationary electrodes A, B, are insulated from and mounted upon the muffling case which encloses the disc. The muffling case can be shifted in a 25° arc by the adjusting rod R and the favorable sparking position for synchronous discharges thus secured. The radio frequent current discharged by the condenser passes from one electrode through the disc and out at the other, a spark being secured for each alternation of the charging current. The distance between moving and stationary electrodes does not exceed .01 inch.

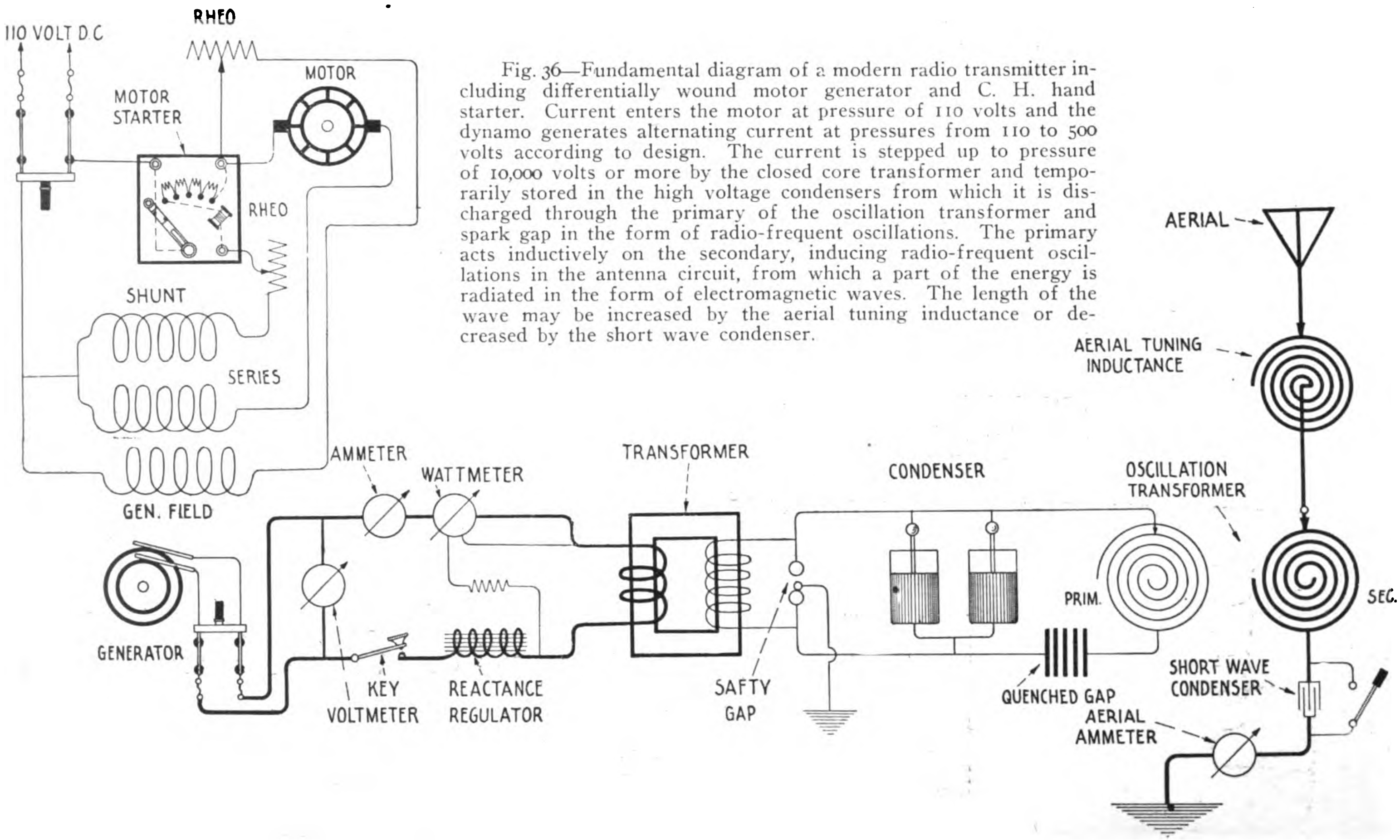
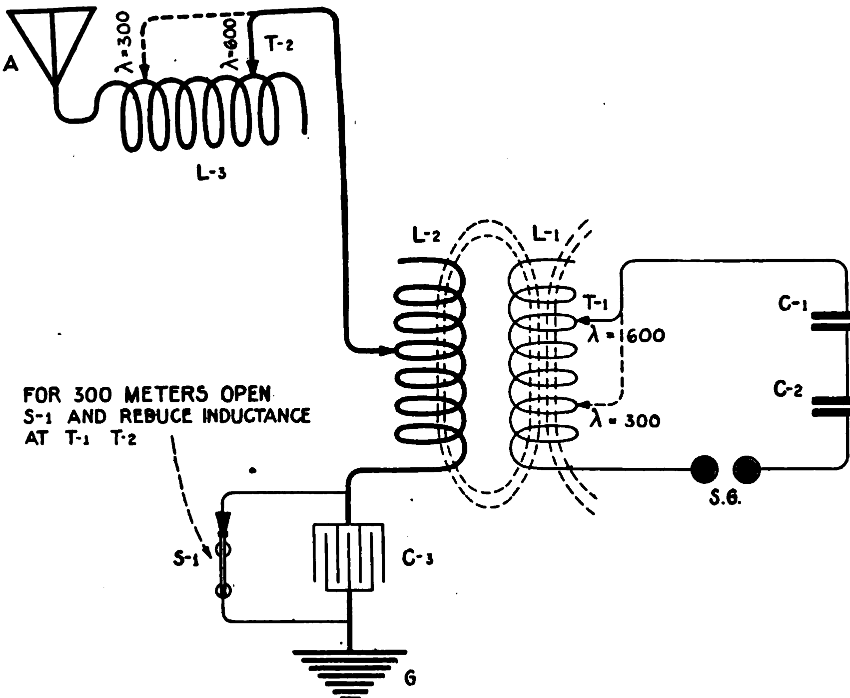


Fig. 36—Fundamental diagram of a modern radio transmitter including differentially wound motor generator and C. H. hand starter. Current enters the motor at pressure of 110 volts and the dynamo generates alternating current at pressures from 110 to 500 volts according to design. The current is stepped up to pressure of 10,000 volts or more by the closed core transformer and temporarily stored in the high voltage condensers from which it is discharged through the primary of the oscillation transformer and spark gap in the form of radio-frequent oscillations. The primary acts inductively on the secondary, inducing radio-frequent oscillations in the antenna circuit, from which a part of the energy is radiated in the form of electromagnetic waves. The length of the wave may be increased by the aerial tuning inductance or decreased by the short wave condenser.

Fig. 37—Showing how a radio set is adjusted to radiate either a 300 or 600 meter wave. For the 300 meter wave, the switch S-1 is open and lesser values of inductance are cut in at the aerial turning inductance and at the primary winding of the oscillation transformer.



If the combined capacity of C-1 and C-2 exceeds .01 microfarad, it is reduced approximately one-half for 300 meters. In modern Marconi sets all these changes are effected simultaneously by simply throwing a switch.

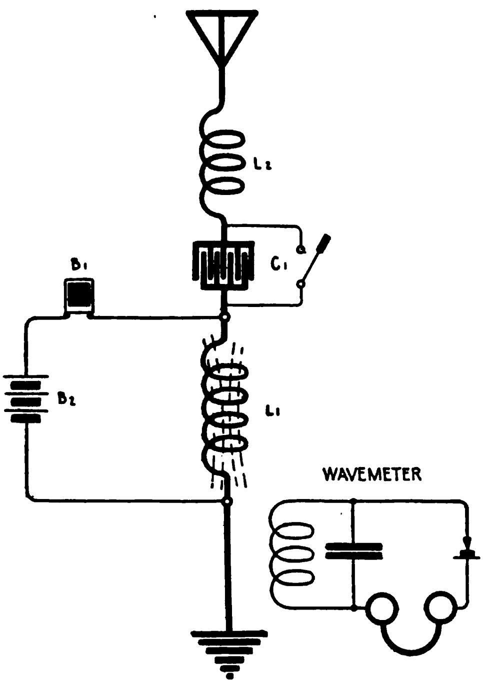
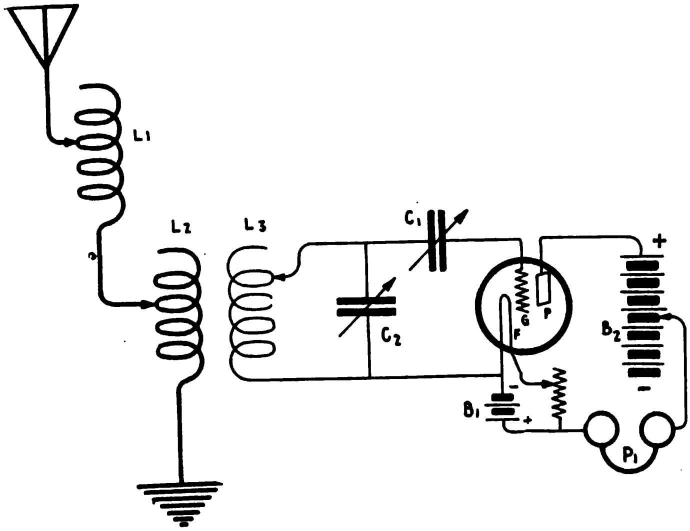


Fig. 38—Diagram showing how the wave-length of the transmitting or receiving antenna circuit may be measured by a wavemeter and buzzer "exciter." When the buzzer is set into vibration the varying magnetic flux threading through L^1 sets up a potential difference which charges the antenna system, the latter being set into oscillation at its own natural period. By placing the wavemeter in inductive relation to the antenna the length of the radiated wave is readily determined.

Fig. 39—Fundamental diagram of the three element valve often called the "electron relay." The valve consists of the tantalum or tungsten filament F, the platinum or tungsten grid G and the nickel or copper plate P. The local telephone circuit includes the high voltage battery B-2 (from 35 to 300 volts), the telephone P-1, the 6 volt battery B-1 and the filament rheostat. According to Armstrong, the filament when brought to incandescence,



throws off electrons which bombard the plate P and the grid element which is directly in their path, receives a negative charge which decreases the local battery current. If an alternating E. M. F. be impressed between the grid and filament, the positive alternation increases the local battery current and the negative alternation causes a decrease. In order to receive signals from spark stations, the detector must be connected in a circuit which will permit an accumulative effect for each group of oscillations. This condition is met if the local circuit includes the grid condenser C-1. The incoming oscillations are rectified by the valve action between the grid and filament and the grid condenser receives a negative charge. The charge accumulated for each group of oscillations, leaks off the grid and decreases the local battery current at audio-frequent rates. The note of the distant spark station is therefore faithfully reproduced.