RADIO QUIZ BOOK

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260 PRACTICAL QUESTIONS WITH ANSWERS

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NATIONAL RADIO INSTITUTE

WASHINGTON, D. C.

RADIO QUIZ BOOK

NEW RATING

RADIO OPERATORS' LICENSE EXAMINATIONS

260 Practical Questions With Answers—With 92 Illustrations on Commercial Radio Operating

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SECOND EDITION

By JAS. E. SMITH

President

NATIONAL RADIO INSTITUTE

WASHINGTON, D. C.

PREFACE

The purpose of this book is to furnish its readers with a suitable preparation in the operating principles, constructive features, diagrams of connection, maintenance and repair of Radio Equipment used in commercial stations. It also includes the essential laws governing Radio communication along with useful formulae and tables employed in the solution of Radio problems.

It is not intended as a text-book on Radio Telegraphy, but, as its name implies, it is a systematized review book answering many difficult questions in a clear and concise manner.

The questions have been developed from notes collected by the author during the past seven years while training several hundred students for the U. S. Government Radio Operators' License Examinations.

The numerous simple diagrams and many practical questions found in this book will prove most helpful to applicants for Radio Licenses.

In conclusion, I wish to express my appreciation and thanks to James A. Dowie, J. M. Chapple and W. S. Siddall of the National Radio Institute for the valuable aid rendered in the publication of this book.

Grateful acknowledgment is also extended to my colleague, Mr. E. R. Haas, for the incentive and valuable suggestions.

Washington, D. C., April, 1922.

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How to Become a Successful Radiotrician

Inside Facts Concerning the Profession of One of the Most Fascinating Vocations of Modern Times

It is the intention of this article to present to the young mind which is meditating on the choice of methods for becoming a real successful operator, some valuable information that, if it be heeded, will serve as a guide-book for directing him to the place he is most anxious to reach.

Hundreds of others have gone before you and the way is well defined if you will but follow the advice of those who have blazed the trail.

Perhaps you are a young man who has finished your high school or college training, 18 to 25 years of age, or perhaps you have been working at hard manual labor and desire a change where self-advancement can be had by faithful study. If you fall into either of these classes, the radio field offers you an opportunity for advancement in proportion to the effort applied by you.

You must first gain a sufficient knowledge of radio to pass the U. S. Government examination for a first-class commercial license.

The young man with a common grade school education is equipped to do this and can obtain this knowledge in either one of the following ways: Home-study either by a correspondence course or by books and natrometer (automatic sender of radio code), attend a residence school or by service in the Signal Corps of the Army or Navy.

You must attain a speed of 20 words (five letters per word) per minute in the sending and receiving of the international code. A practical knowledge of the principles of construction, operation and maintenance of radio apparatus, together with the laws of radio communication, is required in passing the government examination.

For full information regarding the time and places where these examinations are held please consult the chapter on radio laws.

When you have secured your radio operator's license it is but the commencement of your career. As an operator you have an opportunity of traveling to many foreign parts of the world, and if you are alert to make the most of your eyes, camera and notebook you may gather much valuable knowldge which will broaden your vision of this great world in which we live. If you will but make the most of the spare time which is available to an operator while sailing between ports you may study subjects allied with radio telegraphy that will fit you for future advancement.

We should recall that Edison, Theodore Vail and Hill were all telegraph operators, who attained high executive positions by hard study during their spare minutes. The positions they held in early life required long hours of constant toil, but in spite of all this they found time for self-improvement.

Radio is a stepping stone to greater heights if one will set himself justly to the task.

The operator of a large transatlantic ship forms the acquaintance of many of the world's big financial leaders. He may study their traits, characters and general bearings, points which will aid him in making a future success.

The radio operator is classed with the captain and officers, but his work and interests are very different. This makes it necessary for him to win a favorable place aboard the ship through his affable manner and congenial habits. Remember, your job does not end with the mere duty of receiving and sending during the hours on service. Your conduct and attitude during your entire stay aboard the ship will help or harm your rating for further employment.

Many bright young men go to sea as a radio operator with the idea that they are the finished and polished professional with a keen sense of their great importance due to their position. They show a marked dislike to receive orders even from the captain of the ship.

Right here the operator will make his worst mistake. For too much emphasis can not be placed upon obeying the captain's wishes. When the ship goes outside the three-mile line from shore he is king, he is law, he is emperor, he has the last and final word to say; in fact, he is lord of all he surveys. The entire ship and all it contains is absolutely under his supreme command.

Mark well these facts. What he says goes. He is usually a matured, well-seasoned, conscientious and experienced sea-dog. He will not abuse the authority vested in his position through the international mercantile marine law. There is an unwritten law that the captain and radio operator are the *last to leave the boat in case of shipwreck.*

Keep the apparatus under your charge well cleaned, polish the metal parts and contacts, have everything arranged orderly, so that the entire operating room looks as much if not more attractive than any other place aboard the ship. The operator should dress well, be neat and clean in his entire appearance, always ready with a pleasing reply to inquiring passengers. Be well informed of the construction, the working principles and the part which each piece of apparatus performs within the operator's room. Your ability as an operator will be largely judged by the outward appearance of the service rendered along with the results obtained. Become familiar with the wave lengths of stations which send daily messages, that will be of help and interest to you.

Attain proficiency in tuning quickly to these station's wave lengths. Know just how and where to make your receiver adjustments.

The operator should test his aerial once a week to insure good insulation with no defect that will cause leakage that might reduce the radiation or transmitting distance. Keep the aerial wire taut to avoid their touching the smokestacks and grounding the aerial. Inspect your lead—in insulator, ground or lightning switch, aerial and aerial insulators.

Test the aerial insulation according to the method explained under the chapter on aerials.

Weekly inspection should be made of the storage battery equipment and a daily test applied to the emergency set. Operate your set on the emergency source for a few minutes each day and any signs of weakness should be remedied at once.

Before reaching a large port the operator should inspect his stock of spare parts and any shortage should be filled while in port. Should the ship be docked for many days, and especially so if the power plant be shut down, care must be exercised in advance to have the storage batteries fully charged.

The successful operator will comply with all the suggestions offered here and many others which he must select as essential to his future advancement and reputation in the radio profession.

Definitions

ABSORPTION: That portion of the total loss of radiated energy due to atmospheric conductivity.

AERIAL: A system of wires insulated from and suspended at a certain height above ground but generally being connected through suitable apparatus to earth. Used to radiate energy in form of electro-magnetic waves from oscillations flowing along it and to receive energy in form of oscillations from ether waves passing across it.

AERIAL TUNING INDUCTANCE is a number of turns (in the form of a helix or spiral) of wire which can be adjusted to radiate waves longer than the fundamental wave length.

AERIAL TUNING CONDENSER: Variable condenser in aerial circuit. Used to vary oscillation constant of receiver.

An ALTERNATING CURRENT is one which gradually rises in value from zero to a maximum in one direction, then goes thru the same changes but in the opposite direction.

An ALTERNATION of current is one-half cycle, or a change from zero to maximum and back to zero in one direction.

An ALTERNATOR is a machine with a rotating element for the production of an alternating current.

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

The AMPERE HOUR is the unit for expressing the quantity of current passing through a given circuit, or ampere flowing for one hour of time. Amperes times hours equals ampere hours.

AMPERE TURNS: Expressed by the product of number of turns of, and the number of amperes flowing through, the coils of an electromagnet. Thus one ampere turn would be one ampere flowing through one turn.

AMPLIFIER: An instrument which modifies the effect of a local source of energy used as a rule to produce a larger indication than could be had from the incoming energy alone.

The AMPLITUDE of an alternating current is the maximum value or the highest point reached during an alternation.

The ANTENNA or AERIAL is one or more conductors insulated from the earth, employed to radiate electromagnetic waves, or to absorb energy from a passing electromagnetic wave.

ANODE OF A CELL: The positive pole of the cell.

ARC: The passage of an electric current of relatively high density thru a gas in which the material of one or both electrodes is volatilized and takes part in the conduction of the current, whether continuous or alternating.

AUDIBILITY: Measure of signal strength. Unit audibility being strength of received signals which just enables dots and dashes to be distinguished.

AUDION: A relay operated by electrostatic control of currents flowing across a gaseous medium. It consists of three electrodes in an evacuated bulb, one of these being a heated filament, the second a grid-like electrode, and the third a metal plate.

BRUSH OR CORONAL LOSSES: This is due to leakage of electric currents thru a gaseous medium.

BRUSHES: Fixed carbon blocks held in a position that makes contact with the commutator of a dynamo or motor for the purpose of collecting current generated by or supplying current to the machine when running.

CAPACITY: Power of containing. A condenser has unit capacity (farad) when a charge of one coulomb creates a difference of potential of one volt between its terminals. This farad being too large for practical purposes the microfarad is used.

CHOKE COILS: Coils wound to have great self-induction. Usually wound over an iron core which is generally composed of a bundle of wires or luminated sheets insulated from each other to prevent eddy currents. The function is to check by reaction the amount of current flowing in the circuit.

A CHANGEOVER SWITCH or TRANSFER SWITCH is a device to transfer the aerial connection from the sending to the receiving apparatus or vice versa.

A CIRCUIT BREAKER: A device to open or break a circuit when the current reaches a certain value.

COMPASS RADIO: A radio transmitting device for determining the direction of maximum radiation; also direction in which maximum energy is received.

COMMUTATOR: On a dynamo or motor refers to a number of copper strips fixed on a cylinder of insulator and parallel to the axis of armature shaft to which are affixed the ends of armature windings.

A CONDENSER consists of two or more conductors separated by an insulator and is used to store up electricity in electrostatic form and then discharged in the form of radio frequency oscillations.

A CONTINUOUS WAVE: One whose amplitude does not decrease as it travels (undamped).

CONVERTER: A machine similar in construction to a motor but being supplied with slip rings in addition to commutator. Used to convert D. C. to A. C., or vice versa.

CRYSTAL DETECTOR: A device used to rectify the oscillating currents to direct impulses which effect the telephone receiver and makes it possible to detect wireless waves.

COUNTERPOISE is a large amount of sheet metal or wires spread out in space and insulated from the ground, and acts as a ground to form one plate of the condenser, with the aerial as the other.

COULOMB is the unit of quantity of electricity and is the amount of electricity past a point in a circuit when current of one ampere flows for one second.

COUPLING: A measure of the mutual inductance between two oscillatory circuits. The connecting of two oscillatory circuits.

CYMOMETER: An instrument to determine the frequency of oscillations.

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

DAMPED OSCILLATIONS are those consisting of a series of oscillations which gradually decrease in amplitude.

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

DECREMETER: An instrument for measuring the logarithmic decrement of a circuit or of a train of electromagnetic waves.

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 damped wave train.

DIAPHRAGM: A thin plate used in telephone receivers, the vibration of which produces audible signals.

DIELECTRIC: The insulator between the plates of a condenser. Every insulator is a dielectric, even the rubber covering of a wire.

DIRECT CURRENT (D. C.): Current flowing continuously in one direction.

DISCHARGE: To dissipate electric energy from a cell, condenser, or any other charged body.

EDISON EFFECT: Flow of energy in the space surrounding the filament of an incandescent lamp bulb.

EDDY CURRENTS: Useless currents in the armature, pole pieces and magnetic cores or dynamos or other masses of metals.

ELECTROMAGNETIC LINES OF FORCE are those lines of force about the poles of a permanent magnet, an electromagnet, or a wire carrying electric current.

ELECTROLYTIC DETECTOR consists of a fine platinum wire just touching an electrolyte contained in a small platinum cup. Current from a battery which is connected to cup and point keeps point covered with small bubbles owing to electrolysis. Passing oscillations break through these bubbles, destroying their insulation and permit momentary current to flow through phones.

An ELECTRIC GENERATOR or DYNAMO is a machine to convert mechanical energy into electrical energy. The term generator may be applied to both direct and alternating current machines, while the term dynamo is usually applied to a direct current machine. The generator or dynamo operates on the principle of electromagnetic induction. It consists of a magnetic field, a revolving coil or wire, called an armature, a commutator or collector rings and a supporting frame and shaft. The magnetic field is produced by electromagnets arranged in the form of a circle, in the center of which the armature revolves. The revolving armature cuts the lines of force between the field poles and has a current induced in its turns. Brushes bearing on the commutator or collector rings collect the current thus induced.

An ELECTRICAL OSCILLATION is an alternating current of high frequency, usually 10,000 cycles or greater.

ELECTRON: Ultimate or final particle of negative electricity. An atom plus an electron is a negative ion. An atom minus an electron is a positive ion.

An ELECTROMAGNETIC WAVE is an electromagnetic disturbance traveling through space.

EXCITER: Small auxiliary dynamo used to excite magnetic field of some types of generators.

FARAD is the unit of capacity; a condenser of such dimensions that it will hold one coulomb of electricity when a pressure of one volt is applied across it, will have a capacity of one farad.

FADING SIGNALS whose strength slowly decrease through power at transmitting station is not varied. Is due to atmospheric changes.

FILAMENT: A fibre or thread made of carbon or fine metallic wire which glows when current passing through it heats it sufficiently.

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

The FREQUENCY of an alternating current is the term employed to express the number of complete changes or cycles taking place per second of time.

FUNDAMENTAL WAVE LENGTH is the wave length which the aerial and ground alone, without any added inductance or capacity will send out.

FLUX DENSITY is the total of number of lines of force (electrostatic or electromagnetic per unit of area (per sq. cm. or per sq. in.).

FLUX is the term which designates the total number of static or magnetic lines of force in a given space.

GALVANOMETER: An instrument used for detecting the presence of and ascertaining the force and direction of current in a circuit.

GASKETS: The insulating discs used to separate discharge discs of a quenched gap.

GRID: The frame of wire gauze or perforated metal tube placed between and insulated from the plate and filament of a valve, amplifier.

GROUND: An electrical connection (usually of low resistance) to the earth.

HENRY is the unit of inductance. A circuit is said to have inductance of one henry when one volt of pressure is required to make a change of one ampere in one second of time.

HETERODYNE: A method of detecting received oscillations usually undamped by causing them to interact with other locally produced sustained oscillations of slightly different frequency and generally of greater amplitude. The beat or resultant note is the difference between the frequencies of the two independent oscillations.

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

HYSTERESIS: Slowness or lagging behind when a change of condition is taking place in an electromagnetic circuit.

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

INDUCTANCE may be defined as the property of an electrical circuit which opposes a change of current in the circuit.

INDUCTION COIL: An instrument for producing high voltage impulses from low voltage current.

INSULATOR: A material through which electricity will only pass when under great pressure of voltage.

INTERRUPTER: An apparatus for breaking up a D. C. into a series of impulses, thus producing an intermittent current. See Induction Coil.

IONISATION: The splitting up of molecules into ions. Ionised air or gas becomes conductive.

JOULE: Unit of electrical work. Work done by one coulomb flowing under a pressure of one volt.

LOGARITHM (LOG): In the case of common logarithm (com log) is the power of ten (the base) which produces the number in question, *e. g.*, Log 100 equals 2, since 100 equals 10^2, 2 being the required power of 10 to produce 100 (10×10:100).

LOOP AERIAL: One similar to a frame aerial having several turns of wire wound in series on a frame, which form a closed circuit, part of which may be the ground.

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

MAGNETIC FIELD: The whole space over which a magnet exerts its magnetic influence.

MAGNETIC FLUX is the total number of lines of force in a magnetic circuit.

MICRO:

MICROPHONE: A sound magnifier. Varying pressure imposed by sound waves cause a diaphragm to equally vary its normal pressure or suitable conductors, this in turn equally varying the electrical resistance of the points of contact, thus permitting a current whose strength varies as the imposed sound waves to pass into a telephone.

MOLECULE: The smallest group of atoms of an element or compound which can exist by themselves.

An ELECTRIC MOTOR is a machine for converting mechanical energy into electrical energy.

A MOTOR GENERATOR consists of two machines joined together mechanically for changing electricity from one form to another.

MUTUAL INDUCTION is the production of an electric pressure in one circuit by another circuit close to it.

NON-SYNCHRONOUS: When two or more things are not in a similar condition or position at the same time.

OHM is the unit of resistance which an electric circuit offers to the flow of an electric current. A circuit which allows one ampere to flow thru it by a pressure of one volt is said to have one ohm of resistance.

OSCILLATORY CIRCUIT is one which allows the free flow of electric oscillation and generally consists of a few turns of wire in series with a condenser, the entire circuit having a minimum value of resistance.

The OSCILLATION CONSTANT of an oscillatory circuit is the numerical value obtained from the square root of the product of its inductance multiplied by its capacity.

OSCILLATORY CURRENTS are alternating currents of very high frequency ranging from ten thousand to several million per second, and are used in radio telegraphy.

An OSCILLATION TRANSFORMER consists of one or two coils of wire placed near to one another for transferring the energy from the closed circuit to the open or radiating circuit.

The PERIOD of an alternating current is the time required for one cycle or one complete change to take place.

PHASE: An A. C. is in phase when maximum E. M. F. and current are reached at same moment.

PHOSPHOR BRONZE: An alloy of phosphorus with copper and tin. Has great strength and can be hammered or rolled while cold. Largely used for aerial wire.

PLIOTRON: An amplifier or three electrode valve whose bulb is as near an absolute vacuum as possible, and is used for high power transmission.

POLARISATION: The partial changing of the polarity of a cell, due to hydrogen bubbles forming on the negative plate.

A POTENTIOMETER is a resistance joined across a direct current source of power, and having two lead wires, one a variable connection for supplying a desired potential or pressure to another circuit, a receding detector circuit in radio telegraphy.

A PROTECTIVE RESISTANCE ROD is a high resistance made of carbon, graphite or other material in the shape of a small rod. The ends of the rod are connected across the power circuit and the center of the rod is connected to earth. This device allows the high pressure electrical surges to find their way to earth and prevent grounding of the power apparatus and instruments.

PULSATING CURRENT: A current rising and falling regularly remains on one side of the zero line; that is, one which, though varying in intensity, always retains its characteristic, being either continuously positive or negative throughout its motion.

QUENCHED GAP: A spark gap consisting of a number of metal discs separated by insulating washers.

REACTANCE is the term applied to express the opposition which a circuit offers to the flow of current through the capacitance and inductance in it.

A REACTANCE COIL is a coil of wire, wound on an iron core, arranged so that either the number of turns can be varied or so the position of the iron core can be adjusted, thus varying the reactance in the circuit. It is employed to regulate the power input in a radio transmitter.

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.

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.

RECTIFIER: A device for converting alternating current into pulsating direct current.

RELAY: A device consisting of an electromagnet and two contacts, one of which is mounted on a movable arm and makes contact with the other when a current is flowing through the magnet coil.

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

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.

ROTOR: The moving part of an induction motor.

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.

SERIES CONNECTION: A number of instruments or cells connected up in a circuit having no shunts; that is, current must pass through each conductor successively.

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 the aerial.

SHUNT-PARALLEL: An alternate path for the current to pass in a circuit.

SILICON DETECTOR: A crystal detector in which a catwhisker makes contact with a piece of silicon.

SKIN EFFECT: The increased resistance of a conductor to high frequency currents to that offered to low frequency ones is due to the fact that H. F. C. travel on the surface of conductor, while the L. F. C. use the whole of the metal or "soak in."

SOLENOID: A coil of wire having the property of an electromagnet. An electromagnet without a core.

SPARK GAP: A mechanical device to allow the discharge of the transmitting condenser at regular intervals and to stop the flow of current between discharge intervals, thus permitting the condenser to receive a full charge.

SPARK FREQUENCY may be defined as the number of sets of spark discharges taking place across a spark gap per second of time.

SPECIFIC GRAVITY: The density of a solution as compared to water. It shows how many times heavier the substance is than an equal volume of water.

STATIC CHARGE: An electric charge at rest on the surface of a body.

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

STATOR: The stationary part of an electric motor or generator.

A STOPPING CONDENSER is usually a small low-voltage condenser used in the detector circuit to store up the small impulses of current in a wave train and then give this energy out in one discharge to the telephone receivers for operating the diaphragm, but may be any condenser used to store commercial frequencies and prevent them from flowing in a high-frequency circuit.

SYNTONIC CIRCUITS are circuits having same time periods or natural frequency of oscillation and are said to be in tune with one another.

A TELEGRAPH KEY is made of a small lever supported on a base by two cone-shaped bearings. On one end of the lever is mounted a round, smooth button, which can be operated up and down by the hand, causing a make and break of contact points fastened to the lever and base. This action interrupts the flow of current for making dots and dashes in the telegraph code.

A THERMO AMMETER employs the principle that a heated junction of two dissimilar metals sets up an E. M. F. which in this case is measured by a D. C. voltmeter.

THERMO-COUPLE: A junction of two dissimilar metals.

A TICKLER COIL is placed in the plate circuit of a vacuum tube re-back into the grid circuit in order to produce amplification and to enable the tube to generate oscillations of high frequency.

TIKKER: A device for interrupting the current induced in the receiv-to 1,000 times per second. Used with crystal detector for reception of un-ing set and is usually placed in the secondary circuit at the rate of 600 damped waves.

TONE FREQUENCY is the same as SPARK FREQUENCY.

A TRANSFORMER consists of two coils of wire insulated from one another and wound upon an iron core. Current flow pressure (110 or 220 volts) is supplied to one coil and high pressures or voltages (5,000 or 30,000 volts) are induced in the other coil for charging the transmitting condensers.

TUNING: The process of securing the maximum indication by adjusting the time period of a driven element.

ULTRAUDION: By DeForest Radio Telephone & Telegraph Company. The Ultraudion is an audion used in a circuit having a type of energy coupling so that a powerful relay action, or the production of sustained oscillations, may be obtained. In one of its present commercial forms its elements are connected in two circuits, so arranged that the energy coupling may be obtained through a bridging condenser in its plate-filament circuit.

VACUUM TUBE: Name usually given to a glass tube exhausted of air and grid inside used for detectors in radio work.

VALVE AMPLIFIER: A three-electrode vacuum tube of the Audion type is used to amplify either the incoming high frequency currents after rectification, or both rectification and magnification may be performed by the one tube.

VOLT: The unit of electric pressure. It is that pressure which forces one ampere through a resistance of one ohm.

WATT: The unit of electro power. A pressure of one volt causing a flow of one ampere is one watt of electric work or power. Volt times amperes equals watts.

WAVE CHANGER: A switch by means of which the wave of a transmitter may be rapidly changed from one wave length to another.

WAVE LENGTH: The distance one wave travels before the next starts from the point of origin.

WAVE TRAIN FREQUENCY is the term applied to designate the total number of wave trains being produced or acting per second in wireless transmission or reception.

WAVE METER: An instrument for measuring the wave lengths of radio transmitters and receivers.

DEPARTMENT OF COMMERCE

RADIO SERVICE

INTERNATIONAL MORSE CODE AND CONVENTIONAL SIGNALS

TO BE USED FOR ALL GENERAL PUBLIC SERVICE RADIO COMMUNICATION

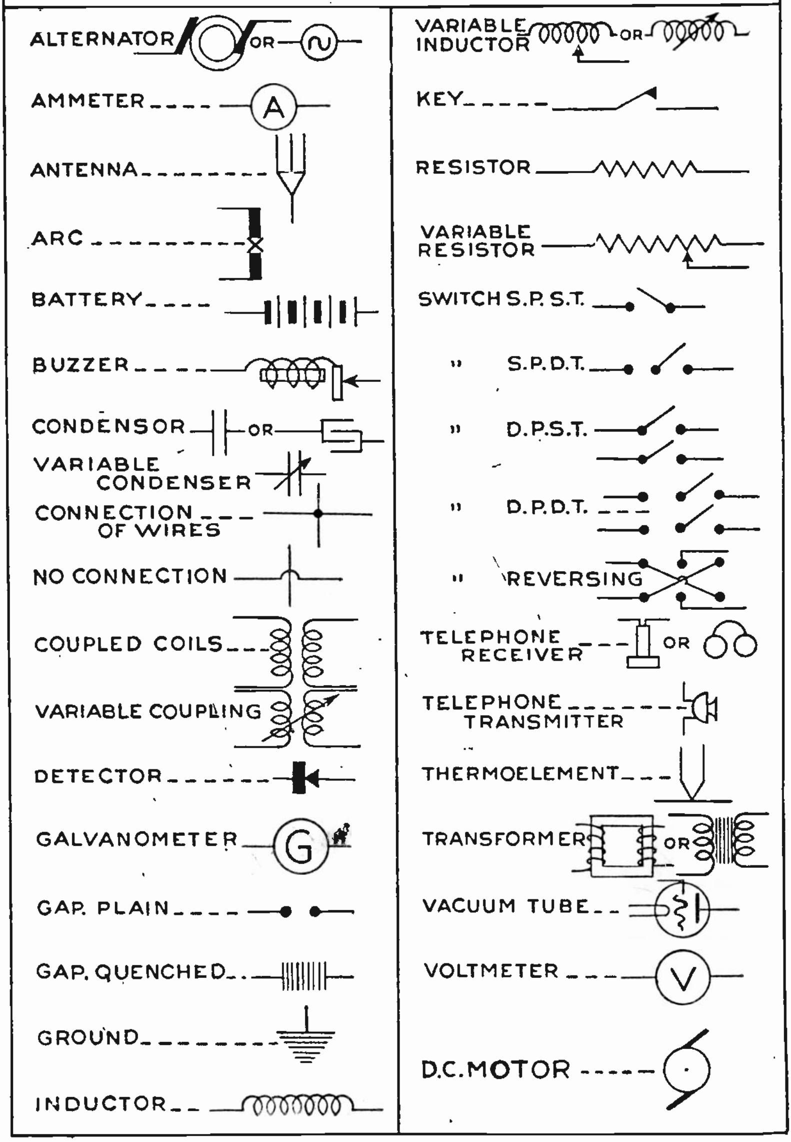
1. A dash is equal to three dots.
2. The space between parts of the same letter is equal to one dot.
3. The space between two letters is equal to three dots.
4. The space between two words is equal to five dots.

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	— — — — —

11—7019

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)	· · · — · —

KEY TO SYMBOLS OF APPARATUS



Measuring Instruments

Test Buzzer.

Question 1. What is the most important use of a test buzzer?

Answer. The majority of commercial radio receivers at the present time employ crystal detectors. The test buzzer is used primarily for adjusting the detector, so that the contact is on a sensitive spot of the crystal. Figure 1 shows the connection for the test buzzer. The high frequency buzzer is connected in series with a battery, inductance coil L and switch S. When the switch is closed oscillations flow through coil L which are inducted into the aerial circuit of the receiver through L, L_1, a single turn of inductance connected in the ground lead of the receiver. When the maximum intensity of signals is heard in the phones the detector is adjusted to its most sensitive spot.

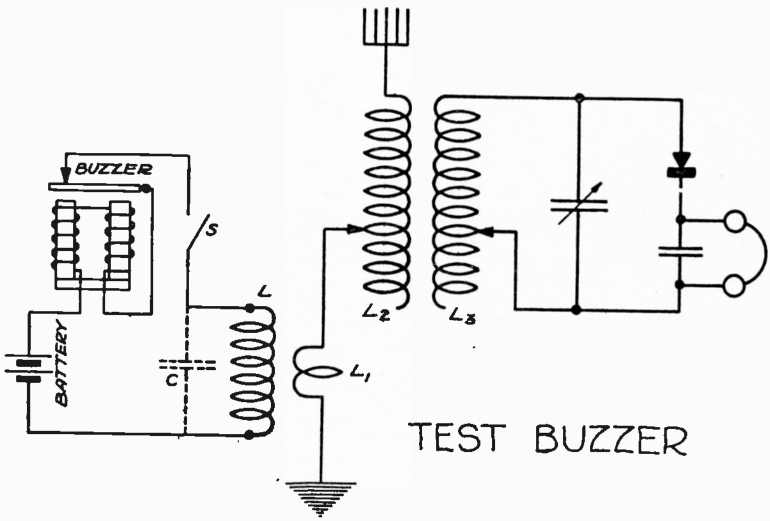


Fig. 1

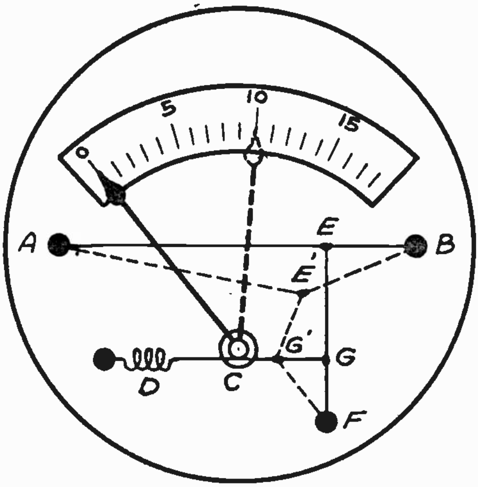
Question 2. Name another use of the test buzzer?

Answer. The test buzzer is also used as a part of a wave meter for calibration of the receiver. Referring to Figure 1, the condenser C shown in dotted lines is shunted across the inductance L. A change in the setting of the condenser changes the wave length of the test buzzer circuit and therefore the wave length of the oscillations induced in the receiver.

Hot Wire Ammeter.

Question 3. Describe a hot wire ammeter.

Answer. A fine wire is stretched between the two supports A and B of Figure 2, through which a certain portion of the antenna current to be measured is passed. This current in overcoming the resistance of the wire heats it. When a metal is heated it tends to expand, so that the wire AEB assumes the position shown in the dotted line AE′B. To this



HOT WIRE AMMETER

Fig 2

wire AB at point E is soldered a wire EF. To EF at point G is fastened a fine silk thread, which is passed once around spindle C on the indicating needle of the instrument. The slack in this thread is taken up by the spring D. When the wire AEB is heated and sags to the position shown, the wire EGF under the strain exerted on it by the spring D through the thread assumes the position shown by dotted line EG'F. Spring D in taking up the sag of the system caused by the expansion of AEB from the heat generated by the antenna current, causes the thread around the spindle C to revolve it, moving the needle to the position shown in the dotted line. The amount of heat generated depends upon the antenna current, so that the greater the current passed through the instrument the greater will be the deflection of the indicator.

The wire used in this hot wire ammeter is too small to carry all the antenna current, so it is customary to shunt AEB with a heavy wire to carry most of the current.

Question 4. Of what use is a hot wire ammeter in connection with radio transmitting apparatus?

Answer. A hot wire ammeter used to measure the current in the antenna system of the transmitter. The value of the current flowing in this system is usually indicative of the performance of the apparatus. This meter is employed in tuning a transmitter to resonance, so that the maximum value of current may be induced into the antenna circuit.

Question 5. In case your H. W. A. became defective what could be used in its place?

Answer. A small glow lamp shunted by a length of wire may be placed in the antenna circuit, as shown in Figure 3A. When the lamp glows the brightest the current in the antenna circuit is at its maximum and the open and closed circuits are approximately in resonance. A small spark gap, as indicated in Figure 3B or Figure 3C, also may be substituted for the hot wire ammeter. The resonance point is indicated by the maximum discharge across the gap.

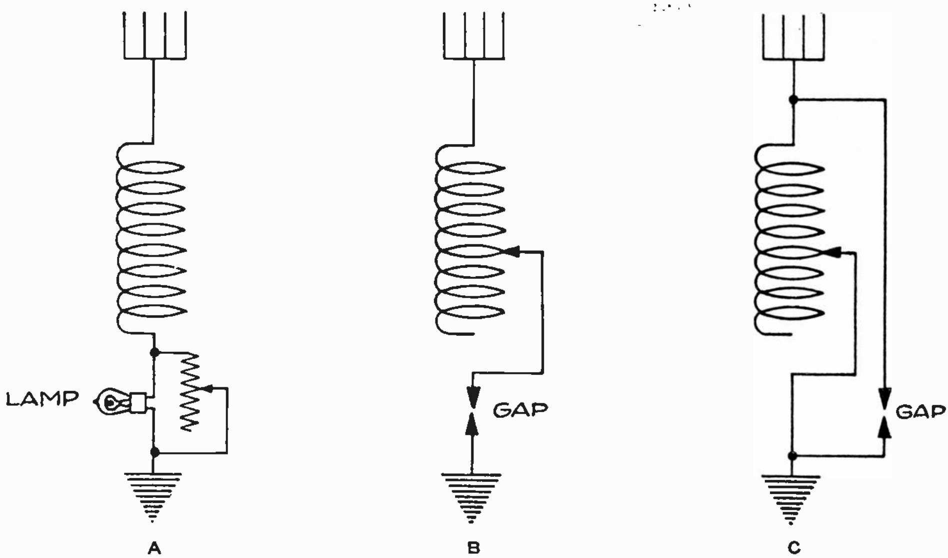


Fig. 3

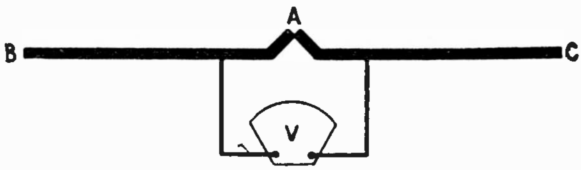


Fig. 4.

Thermo Couple Ammeter

Question 6. Describe a thermo couple ammeter.

Answer. A thermo couple ammeter makes use of the heated juncture of two dissimilar metals. In Figure 4, points B and C representing the terminals of the instruments are connected in the antenna circuit in the usual manner. Wires BA and AC are different metals, such as iron and constantin (a nickel alloy) or antimony and bismuth. The high frequency current heats these wires, raising the temperature of the junction and this causes an E. M. F. between B and C which is indicated by the volmeter V. This voltmeter is calibrated in *amperes*, indicating the amount of current in the antenna circuit which caused the heating of the thermo-couple.

Wave Meter.

Question 7. Explain the construction of a wave meter.

Answer. The outward appearance of a wave meter is shown in Fig. 5. It consists of an oscillatory circuit formed by a variable capacity and an inductance (usually fixed in series) and a means of indicating the flow of current in the circuit. By adjusting the variable condenser different frequencies may be obtained.

Referring to Figure 6A shows the elementary circuit of the wave meter, and (b), (c), (d) and (e) show it in its various forms.

The current indicating device in a wave meter may be one of two types,

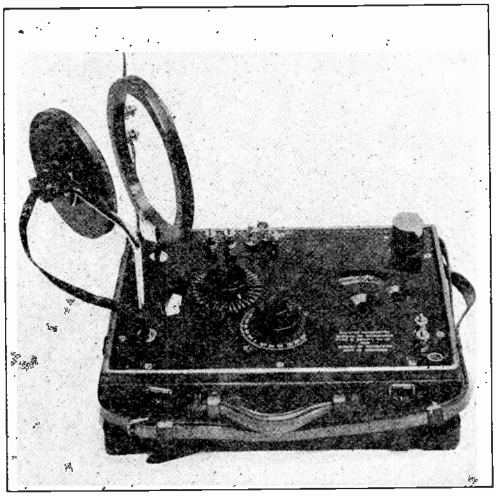


Fig. 5.—Kolster Decremeter and Wavemeter (Exterior View). Courtesy of the Bureau of Standards.)

visual or auditory. The visual type usually comprises small ammeter calibrated in either fractions of an ampere or in divisions proportional to the square of the current. The latter calibration causes such an instrument to be termed a watt meter, for power in watts is equal to the square of the current times the resistance. Another visual type makes use of a small lamp as indicated in Figure 6C.

The auditory method comprises some form of detector and a pair of telephone receivers (see Figure 6B).

In order that a wide range of wave lengths may be measured with the instruments, it is customary to provide several inductances of different sizes which are used for various ranges of wave lengths.

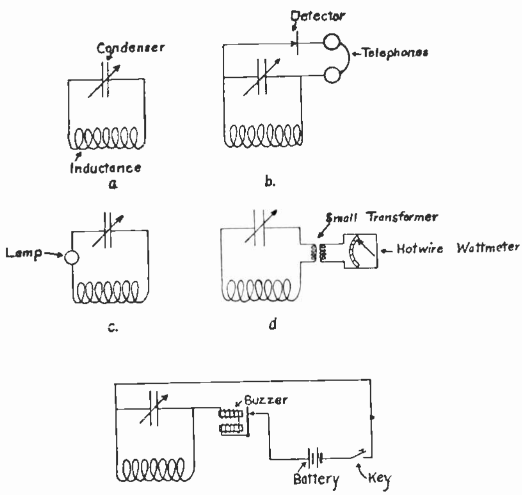


Fig. 6

The calibration of the wave meter may be reduced in two ways—either by engraving the wave lengths of the meter for different condenser settings directly on the condenser scale or a curve of the wave lengths for different readings of the condenser in degrees may be plotted and drawn.

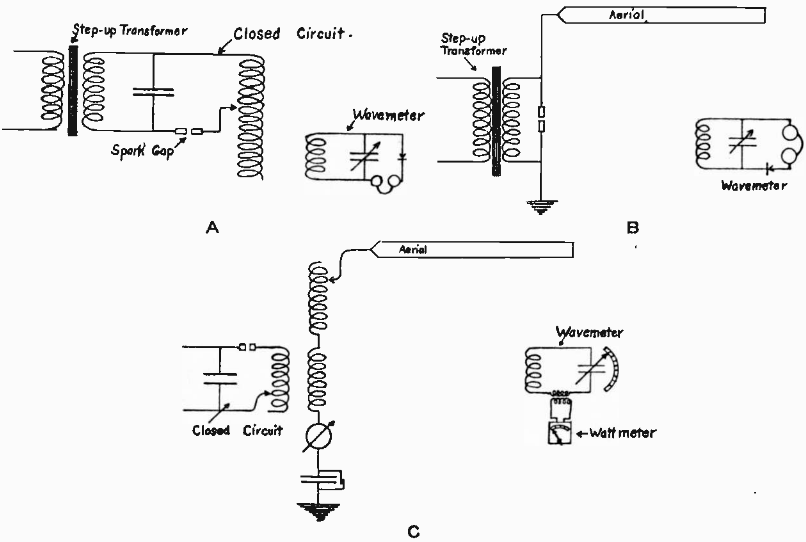


Fig. 7

Question 8. Describe how you would adjust a transmitter to a given wave length by the use of a wave meter.

Answer. To tune a set to a given length, such as 600 meters, a number of measurements must be taken. The closed oscillation circuit, consisting of condenser, primary of the oscillation transformer and the spark gap, which must be tuned to 600 meters. In this circuit the inductance is the only variable element. The variation is made possible by means of clips attached to the leads from the condenser and spark gap. As shown in Fig. 7A, the wavemeter, with detector and phone attached, is placed in inductive relation to the closed circuit. To tune to 600 meters, the pointer of the wavemeter condenser is adjusted to 600 meters and the detector adjusted to a sensitive condition. With the aerial and ground disconnected from the secondary of the oscillation transformer, the key of the transmitter is depressed, causing a discharge to occur across the gap and oscillations to flow in the closed circuit. The clip attachment on the inductance of the transmitter closed circuit is changed from turn to turn until the loudest sound is heard in the phones of the wavemeter. If the pointer of the wavemeter condenser is now varied to wave lengths to either side of the 600-meter and the signals from the transmitter remain loud, it is an indication that the wavemeter is in too close proximity to the transmitting set. Remove to a greater distance until the signals are heard loudest only at the 600-meter position. *The closed circuit is now adjusted to 600 meters.*

The aerial circuit must now be tuned to resonance with the closed circuit, but before this can be done, the natural wave length of the aerial circuit should be determined; otherwise we may find that our aerial is too large for adjustment to a 600-meter wave length.

The natural wave length of the aerial circuit is that length of wave it will radiate with no added inductance or capacity.

To measure the natural wave length it is necessary that we cause oscillations to flow in the aerial circuit. If we place a spark gap in series with the aerial and ground leads and then connect the secondary terminals of an induction coil or step-up transformer to either side of the gap we will have a *"plain aerial transmitter."* If current is supplied to the primary of the step-up transformer, the aerial and ground will be charged. The discharge of this condenser across the gap consists of a series of oscillations.

If the wave meter is placed in inductive relation to the earth lead, and the condenser pointed varied until the loudest sound is heard in the phones, we may read the natural wave length from the wave meter scale. Such a circuit is shown in Fig. 7B. Suppose we find the natural wave length to be 400 meters. To adjust the aerial circuit to 600 meters it will be necessary to add concentrated inductance in the form of a coil of wire. This coil of wire may be wound in the form of a helix, with one layer of bare wire having a space of an inch or more between turns. This coil should be wound on a cylindrical frame of hard rubber or other good insulator. In modern sets the *spiral* type of coil is employed extensively, copper ribbon being wound in the shape of a spiral on an insulating frame. This inductance employed for loading (sometimes termed an "aerial tuning inductance") is varied by means of a clip in connection to the different turns.

In Fig. 7C is shown the closed circuit (tuned to 600 meters) in inductive relation to the aerial or open circuit. In the aerial circuit we find the loading coil (aerial tuning inductance) in series with the aerial and the secondary of the oscillation transformer. The two circuits may be put in resonance by the following procedure:

Trains of oscillations are set up in the closed circuit by pressing the transmitting key and, as the primary of the closed and the secondary of the oscillation circuits are in inductive relation, energy will be transferred to the aerial circuit. A hot wire ammeter is in series with the aerial circuit and registers the strength of the induced current. Note the reading given by this instrument and then vary the clip connection on the aerial tuning inductance, adding more and more turns. As the natural wave length was 400 meters, if we add turns of inductance, the wave length of the open circuit will approach that of the closed circuit. When the reading of the ammeter is a maximum, the two circuits are in resonance. That is, if we increase or decrease the number of turns we now have on the aerial tuning inductance, a drop in the ammeter reading will occur.

Now that the closed and open circuits are in resonance, the only remaining measurement to be made is that of the *"radiated wave."*

Apparently, we should have a radiated wave equal to that of the closed and open circuits, but such may not be the case. Due to the mutual induction between the primary and secondary, there will be a transfer of energy from the aerial circuit back into the closed, if the two coils are in too close inductive relation. The result of this action is that there may be a radiation of two waves of different lengths by the aerial. One of these waves will be greater and one less than the wave length to which the set is tuned. The oscillations set up in the closed circuits by the discharge of the condenser set up lines of magnetic force about the secondary and induce oscillations in it. These oscillations in turn set up lines of force about the primary and current is thus transferred back, the amount being dependent on the closeness of coupling. The inductive action of the secondary on the primary alternately assists and opposes the oscillating current in the closed circuit.

This mutual induction between the two circuits is alternately (many thousands of times per second) added to and subtracted from the self-induction (inductance) of the aerial circuit.

The wave length of any circuit depends on the value of the inductance and capacity, and if the inductance is increased and decreased many thousands of times per second, the wave length will be increased and decreased at the same rate. The addition or subtraction of the mutual induction causes two or more waves to be radiated by the aerial.

The Government regulations define a pure wave as that radiated by a transmitter when the energy in any of the lesser waves (less in energy) does not exceed 10 per cent of that in the greater wave.

If the coupling of the oscillation transformer is decreased (the coils separated) we may cause the radiation of practically one wave length, but it will cut down the transfer of power to the aerial circuit. We compromise by radiating more than one wave length, but limiting the energy in the lesser waves.

As shown in Fig. 7C, we place the wave meter and watt meter attachment at a considerable distance from the transmitter, so that it may be affected by the radiated wave only. The key of the transmitter is pressed and the pointer of the wave meter moved over the scale, noting at the same time the reading of the watt meter. There will be two or more points on the scale of the wave meter at which the watt meter gives a high reading. Note the wave lengths and the reading of the watt meter. We desire to get a radiated wave of 600 meters, and if the wave lengths radiated are above and below this length, the coils of the oscillation transformer must be separated until the wave meter shows a maximum of 600, and also that the watt meter at any other wave length is less than 10 per cent of that at 600 meters.

The regulation requiring a pure wave is necessary in order that interference to stations operating on other wave lengths may be reduced.

To summarize the above:

To tune a station it is necessary—

1. To measure the wave length of the closed oscillatory circuit.
2. To measure the natural wave length of the aerial circuit.
3. To tune the open and closed circuits to resonance.
4. To measure the radiated wave and determine whether it complies with the Government regulations for a "pure" wave.

The apparatus necessary for the above measurements are:

1. Wave meter.
2. An attachment consisting of a detector and phones.
3. An attachment consisting of a watt meter and small transformer.

Question 9. Explain how you would calibrate a receiving set.

Answer. To *calibrate a receiver*, a wavemeter, with a buzzer, battery and key attached, is placed in inductive relation to the aerial circuit of the receiver. In Fig. 8 is shown the arrangement used. When the key of the buzzer is depressed, the condenser of the wavemeter is charged and oscillations will occur in the circuit. Weak waves will be radiated, their length being dependent upon the value of the inductance and the wavemeter capacity. Setting the wavemeter pointer at some low wave length, we adjust our receiver until the signals from the wavemeter are loudest. At this point the receiver and wavemeter are in resonance and

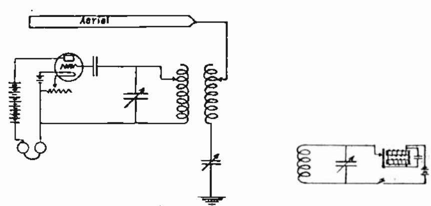


Fig. 8

the four variables are marked with this value of wave length. The wavemeter is set at another value and the receiver again adjusted. This procedure is carried out over the entire range of the receiver. A fixed value of coupling may be employed for the entire range of wave lengths, but the student should remember that a change in the coupling will make necessary a readjustment of the values of inductance and capacity.

The calibration of a receiver must necessarily vary with its design and construction, but the principle is the same in all cases. The calibration of the aerial circuit will only be true for the given aerial, but the calibration of the secondary circuit is true, no matter what aerial may be used.

Question 10. Explain how you would measure the wave length of a distant transmitting station.

Answer. For this purpose the same instruments as those used in the calibration of a receiver are employed (see answer to question 8.) After the transmitting station has been properly tuned in at the receiver, the wavemeter is set in operation by depressing the key of the buzzer. The wavemeter is placed in inductive relation to the aerial circuit of the receiver and the movable plates of the condenser slowly rotated until the maximum signal strength is heard in the telephone of the receiver. By noting position of the pointer of the wave meter condenser, the wave length of the waves radiated by the wavemeter and therefore the wave length to which the receiver is tuned may easily be determined.

Decremeter.

Question 11. Describe some form of decremeter in use at the present time.

Answer. A decremeter consists of a wave meter equipped with a current indicator, such as a watt meter. A small step-down transformer is connected in the wave meter circuit. Across the secondary of this transformer is placed a small hot wire watt meter usually ranging from .01 watt to .1 watt.

Question 12. Explain how the logarithmic decrement of damping is measured.

Answer. The coil of the wave meter is placed in inductive relation to the antenna circuit of the transmitter and the transmitter set in operation. The key is depressed, causing oscillations to flow in the antenna circuit and, consequently, waves to be radiated. The pointer of the wave meter is moved over the scale until the pointer of the watt meter indicates a maximum reading. Note the capacity in microfarads of the condenser scale and the reading of the watt meter at this resonance position. Now move the pointer of the wave meter to a point of less capacity where the reading of the watt meter falls to one-half of the reading at the resonance point. Insert the two capacity readings of the wave meter condenser in the following formula.

$$Dt + Dw = \frac{Cr - Cl}{Cr} \times 3.1416$$

where

Dt = logarithmic decrement of the transmitter.

Dw = logarithmic decrement of the wave meter.

Cr = capacity of wave meter condenser at resonance (highest reading of watt meter).

Cl = capacity of wave meter condenser when the reading of the watt meter falls to one-half of its value at resonance.

Question 13. What are the U. S. regulations in regard to the logarithmic decrement of transmitters?

Answer. At all stations the logarithmic decrement per complete oscillation shall not exceed two-tenths (0.2) except when sending signals of distress and messages relating thereto.

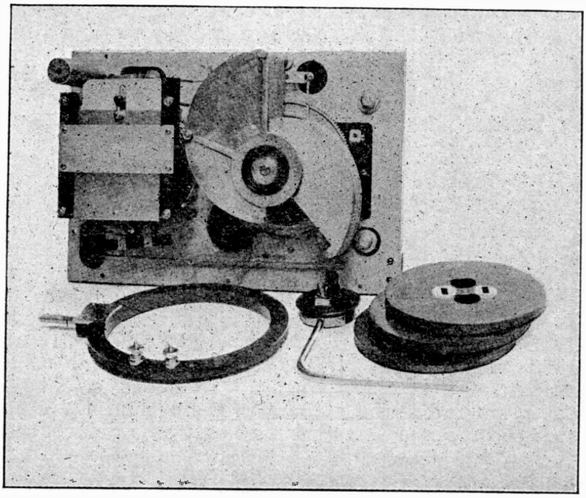


Fig. 9.—Kolster Decremeter and Wavemeter (Interior View. (Courtesy of the Bureau of Standards.)

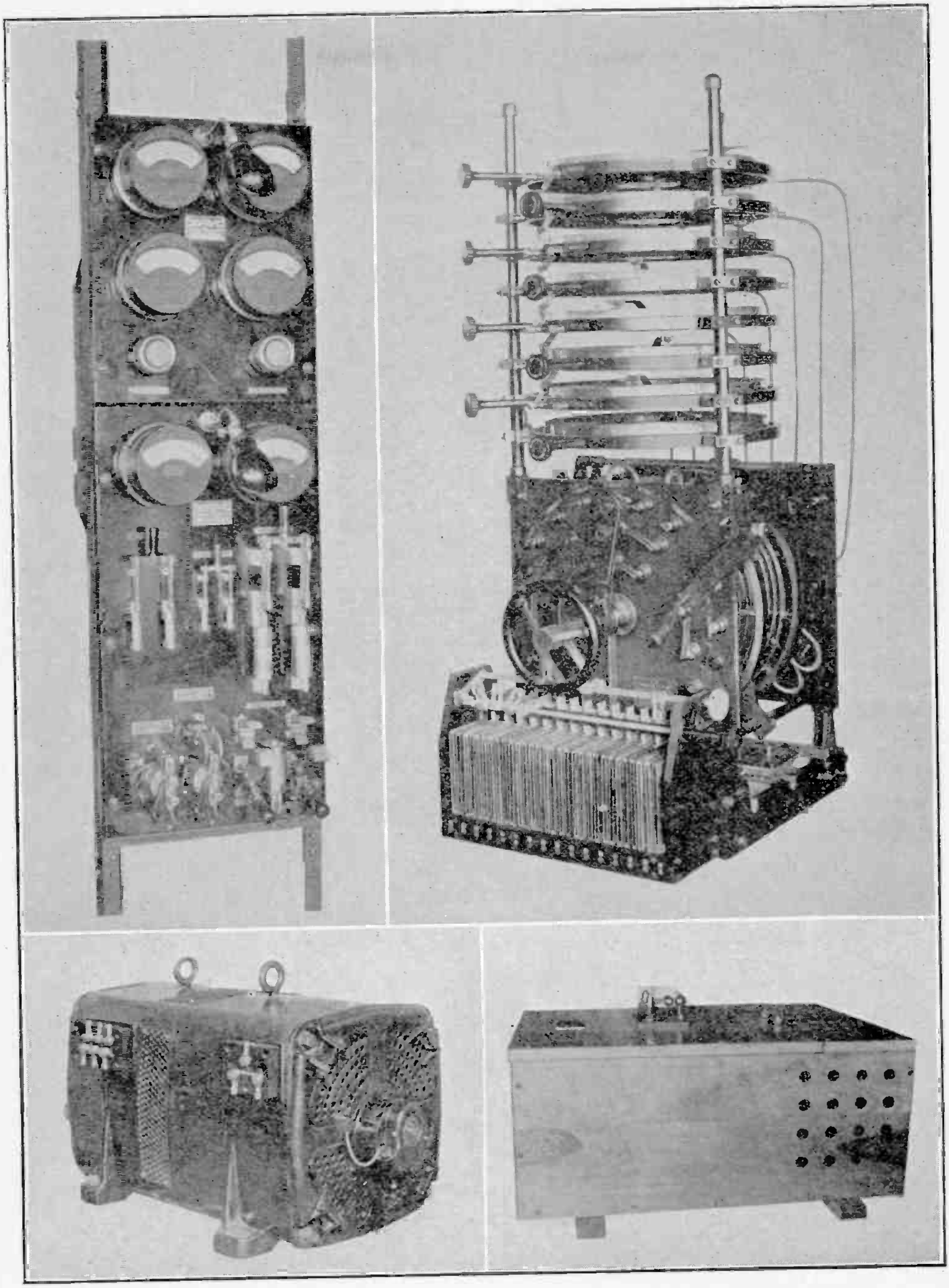


Fig. 10.—½ K. W. Transmitter with Motor Generator and Transformer at the Bottom.

Transmitters

Question 14. Name the parts of the main transmitter of a modern radio installation.

Answer.

1. The direct current line switch.
2. The starting box.
3. The motor generator.
4. The field rheostat.
5. Protective devices.
6. The alternating current line switch.
7. Measuring instruments:
    a. Ammeter.
    b. Volt meter.
    c. Watt meter.
8. Reactance regulator.
9. Key.
10. Step-up transformer.
11. Safety gap.
12. Choke coils.
13. Condensers.
14. Spark gap.
15. Oscillation transformer.
16. Aerial tuning inductance.
17. Short wave condenser.
18. Hot wire ammeter.
19. Ground.
20. Antenna.

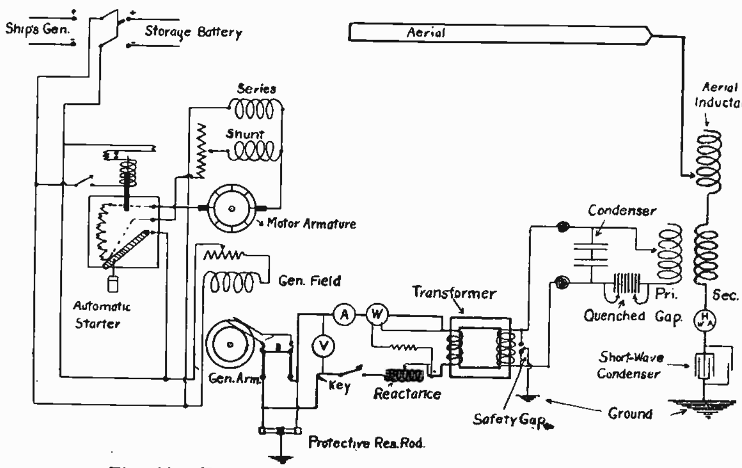


Fig. 11.—Fundamental Circuit Diagram of Transmitter.

Question 15. Draw a diagram of the main transmitter of a modern radio installation.

Answer. See Figure 11.

Question 16. Describe and explain the functions of the various parts of the transmitter.

Answer. The direct current line switch connects the motor to the source of direct current, whether it be the storage battery or the ship's generator.

The starting box reduces the flow of current through the motor armature during the starting period. As the motor speeds up the counter e. m. f. produced in the motor armature increases in value and acts as a resistance, so that the resistance of the starting box is gradually cut out of the circuit as the speed of the motor increases.

The motor generator consists of a motor and generator on the same shaft and frame. The motor is driven from a source of direct current having a potential of 110 volts. The modern generator is of the 500 cycle type, delivering 120 volts.

The field rheostats are employed to control the motor and the generator. The motor field rheostat regulates the speed of the motor generator and consequently controls the frequency, while the generator field rheostat controls the voltage of the generator and consequently the power delivered.

The alternating current line switch enables the generator armature to be disconnected from the primary of the step-up transformer.

The protective device may be either of the resistance rod or condenser type. The function of the protective device is to conduct to the ground those high frequency, high voltage currents induced in the motor or generator circuits from the closed or open oscillatory circuits.

The measuring instruments employed in the circuit connected to the armature of the generator are: The volt meter, connected across the leads from the collector rings; the ammeter, in series with the circuit, and the watt meter, in series and in shunt with the circuit. A frequency meter is sometimes used in series with the circuit.

The reactance regulator is a device placed in series with the primary of the transformer for regulation of the current flowing therein. It consists of one or more layers of heavy insulated wire wound over an iron core. The rise and fall of the lines of force about the coil acts as a resistance to the flow of alternating current through the coil.

The transmitting key is employed to make and break the current flowing in the primary winding of the step-up transformer. This key is the same as the regular telegraph key with the exception that it is of heavier construction and is provided with much larger contacts.

The step-up transformer is used to raise the alternating current supply from 110-120 volts up to 7,500-30,000 volts. The primary consists of a comparatively few turns of heavily insulated wire about an iron core. The secondary consists of many hundreds of turns of small wire ranging from Number 28 to 32.

The safety gap acts as a protective device for the condensers. When the spark gap is lengthened abnormally the spark jumps across the safety gap, thereby preventing the condensers from being punctured or the secondary of the step-up transformer from being burned out.

The choke coil is a term applied to the form of reactance connected in the leads from the secondary of the step-up transformer. The function of the choke coil is to prevent the passage of the high frequency, high potential energy of the closed oscillatory circuit back into the secondary winding.

The condenser in many ships sets consists of a battery of copper-plated Leyden jars. A new type of condenser which is rapidly coming into use is the Dubilier mica condenser. It has the advantage of being self-healing in case of being punctured and of being economical of space. The function of the condenser is to produce high frequency oscillations.

The function of the spark gap is to prevent the discharge of the condenser until the latter is charged to the proper potential and then to form an easy path for the discharge, after which it returns to its state of high resistance. A quenched spark gap consisting of a number of copper discs separated by washers of micanite, fiber or other insulating material is often employed.

The oscillation transformer consists of the primary of the closed circuit and the secondary of the open circuit. It is so constructed as to allow a variation of the coupling between the two coils. The primary is used to transfer the energy from the closed circuit to the open circuit and also to provide the inductance of the closed circuit. The secondary absorbs the current from the closed circuit.

The aerial tuning inductance is used to tune the aerial circuit to a wave length longer than the natural wave length.

Question 17. What is the effect of starting a motor too quickly?

Answer. In case the fuses are of such a high current carrying capacity that they do not blow, there will be severe sparking at the commutator or perhaps some of the armature coils will be burned out.

Question 18. What is the effect of starting a motor too slowly?

Answer. The resistance coils in the starting box will become overheated and probably one or more coils burned out.

Question 19. How can the speed of a motor be reduced?

Answer. The speed may be reduced by cutting out resistance in the motor field rheostat, thus allowing more current to flow through the field coils. If, after all the resistance is cut out, the motor does not run slowly enough external resistance should be connected in series with the motor armature.

Question 20. How can the speed of a motor be increased?

Answer. By placing a resistance in series with the motor field.

Question 21. What would you use to clean the commutator of a motor?

Answer. Fine sandpaper with a piece of canvas to give it a final polish. Emery cloth should never be used for this purpose.

Question 22. What are some of the causes of a sparking commutator?

Answer. Dirty commutator, dirty brushes, worn commutator, brushes out of position or a raised insulating wedge.

Question 23. What treatment should a hot bearing receive?

Answer. A mixture of oil and powdered graphite should be applied to the bearing in generous quantities.

Question 24. What is the function of a starting box?

Answer. A starting box is used to cut down the current flow through the armature during the starting period, thereby preventing an abnormal current from flowing through the armature due to the lack of counter emf at this time.

Question 25. What is the most frequent cause of the overheating of a generator?

Answer. This is due to an abnormal value of current being taken from the generator. Improperly fitted bearings also cause overheating.

Question 26. What would be the probable causes of the release magnet of a starting box losing its magnetism after the motor is running at full speed?

Answer. An open circuit in the motor field circuit or a short circuit in the release magnet.

Question 27. In case one of the resistance coils in a starting box burned out, how could the starting box be temporarily repaired?

Answer. The burned out coil may be located by means of a battery and telephone receiver. The coils should be tested by placing the battery and receiver connected in series across the contacts of the starter, taking two at a time. A burned out coil is indicated when there is no click in the receiver as the contacts are touched with the wire. When the burned out coil is located, a jumper should be placed around it temporarily.

Question 28. What is the function of the commutator of a motor?

Answer. To maintain the polarity of the armature in such relation to the field poles that there will be a constant attraction and repulsion.

Question 29. How may the frequency of an alternating current generator be varied?

Answer. By varying the speed of the armature.

Question 30. For what purpose is direct current used in an alternating current generator?

Answer. For exciting the field coils.

Question 31. How may the power of an alternator be reduced without reducing the frequency of the machine?

Answer. By inserting more resistance in series with the generator field by means of the generator field rheostat.

Question 32. Describe a fuse and explain how it operates.

Answer. A fuse consists primarily of a short length of lead or soft alloy of such a size that it will melt when a certain value of current passes through it. In the event of a short circuit or when too much current is being drawn from the circuit in which it is placed it will melt, thereby opening the circuit and protecting it from possible damage.

Question 33. What attention should be given a motor generator to keep it in proper running order?

Answer.

1. Keep the motor generator dry and free from dust and grease.
2. Keep all connections tight.
3. See that the thrust bearings on the end of the bearings prevent end play of the armature.
4. See that protective condensers or resistance rods are properly connected and that they do not come loose from vibration.
5. Keep bearings well oiled and see that rings carry oil properly.
6. Keep a close watch on the valves of the petcocks to see that they do not jar loose and allow oil to leak out.
7. Keep contacts of automatic starter clean and properly adjusted so that they make contact at the proper time.
8. See that the brushes fit evenly. To make them fit, place a piece of emery cloth between commutator and brush with the rough side up and then pull backward and forward until brush fits the curved surface of the commutator.

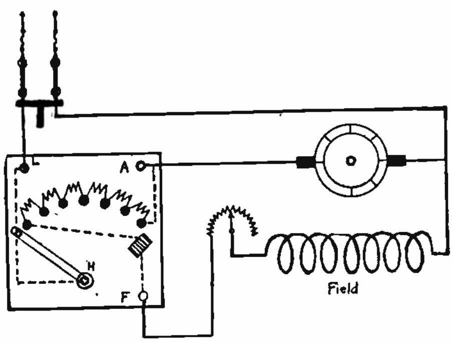


Fig. 12.—Simple Shunt Wound Motor Generator.

9. Keep the commutator cleaned and polished. Clean with fine sand-paper, never with emery cloth. Polish with a coarse piece of canvas.
10. Do not over-speed motor. After operating a set for a time, the sound will indicate the proper speed to run the motor generator.
11. In case of burn-out of coils in field rheostat or starter, shunt by means of a piece of copper wire.

Question 34. Draw a diagram showing the connections of a motor starter.

Answer. See Figure 12.

Question 35. Explain the construction of a hand motor starter.

Answer. The Cutler-Hammer hand starter is shown in Figure 13. It consists of several coils of resistance wire, a handle, contact studs and a small electro-magnet.

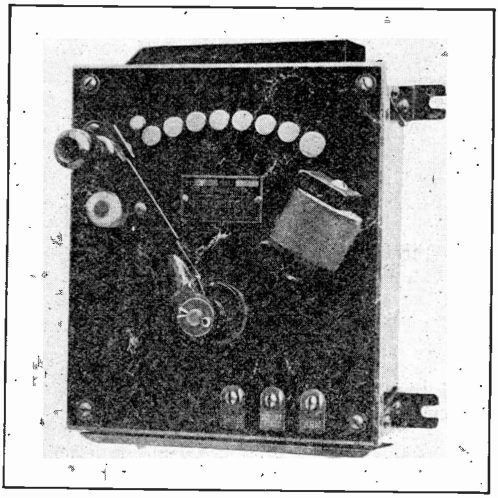


Fig. 13.—Cutler-Hammer Hand Motor Starter.

The terminals of the resistance coils are soldered to the studs on the back of the panel. As the handle passes over the contacts on the face of the panel, connection is made to the coils. When the handle is on the first contact all the resistance wire is in series with the armature and the current flow is minimum, but as the handle moves over each successive contact the corresponding resistance coil is removed from the circuit. The small magnet holds the handle in the running position. In case the current in the line fails for any reason, this magnet being in series with the field winding will lose its power and allow the handle to fly back to the off position.

Question 36. What three types of motor generators are now in use?

Answer.

a. Shunt wound motor and shunt generator.
b. Shunt motor, compound wound generator.
c. Motor with differential compound field winding and shunt generator.

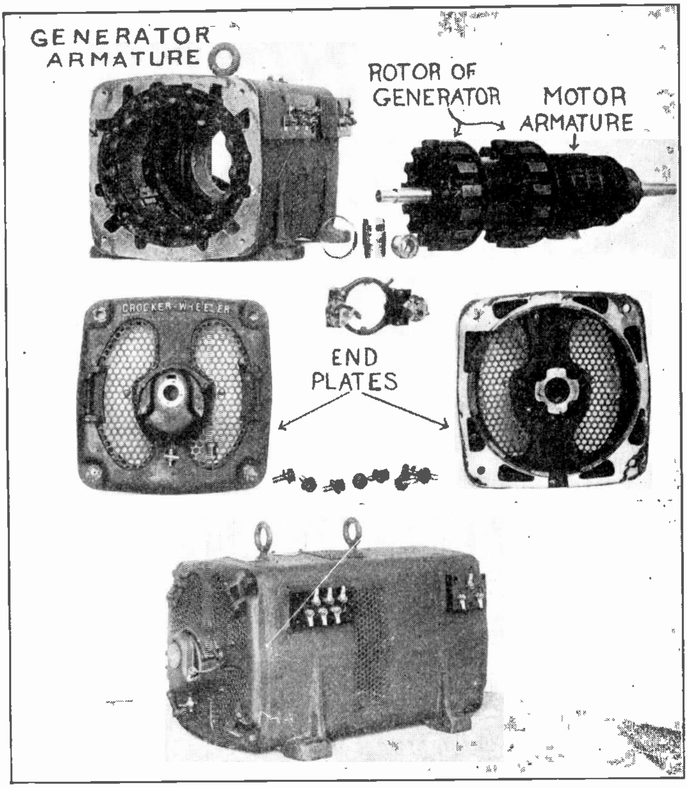


Fig. 14.—Exploded and Assembled Views of a Two Kilowatt, Five Hundred Cycle Motor Generator of the Inductor Type.

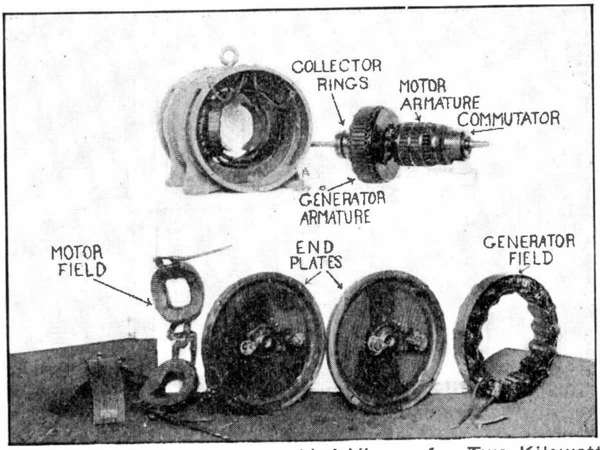


Fig. 15.—Exploded and Assembled Views of a Two-Kilowatt, Five Hundred Cycle Motor Generator Having Revolving Armature. (Courtesy of Crocker-Wheeler Company, Ampere, New Jersey.)

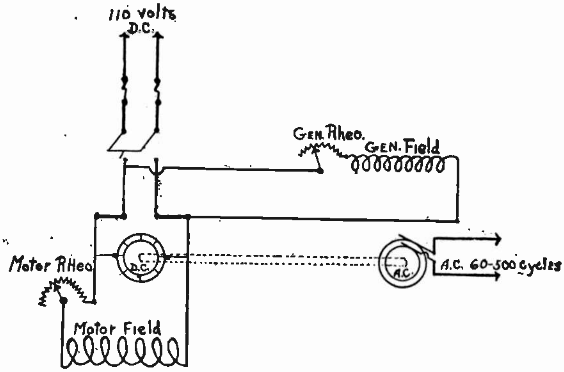


Fig. 16.—Shunt Wound Motor and Shunt Generator.

Question 37. What is the advantage of a compound wound motor?

Answer. Such a machine gives practically a constant speed under a varying load.

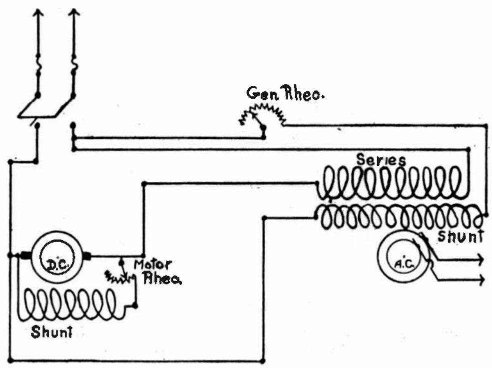


Fig. 17.—Motor Generator with Compound Generator Field Windings.

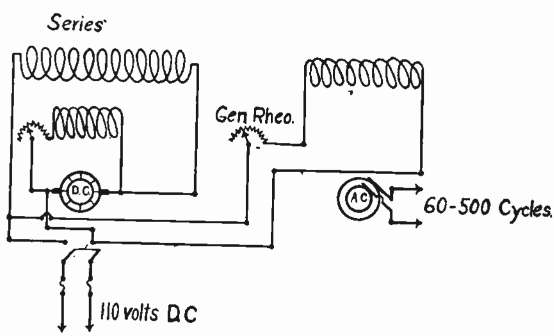


Fig. 18.—Circuits of Motor Generator with Differential Field Winding.

Question 38. How may a field coil be tested to find out whether it is short circuited or open?

Answer. By means of a lamp connected in series with the field coil and a 110-volt circuit. If the lamp glows brilliantly when the circuit is closed, the coil is shorted. If it does not light at all, the field coil is open. If the coil is neither shorted nor open, the lamp will just glow a dull red.

Question 39. If the motor refuses to start when the starting box handle is pulled over, what may the trouble be?

Answer.

1. Fuses blown.
2. A burned-out resistance coil in the starting box.
3. A burned-out release magnet.
4. An open circuit in the field windings.
5. An open circuit in the motor field rheostat.
6. An open circuit in the connecting wires.
7. The power being off.
8. A "frozen" shaft due to hot bearings.

Question 40. If the circuit breaker in the motor supply circuits should trip or the fuses blow when the starting handle is pulled over, what may be the possible causes of the trouble?

Answer.

1. Pulling the handle over too rapidly.
2. A short circuited or grounded coil.
3. A "frozen" shaft.
4. An open field circuit due to an open in the field winding burned-out release magnet coil.

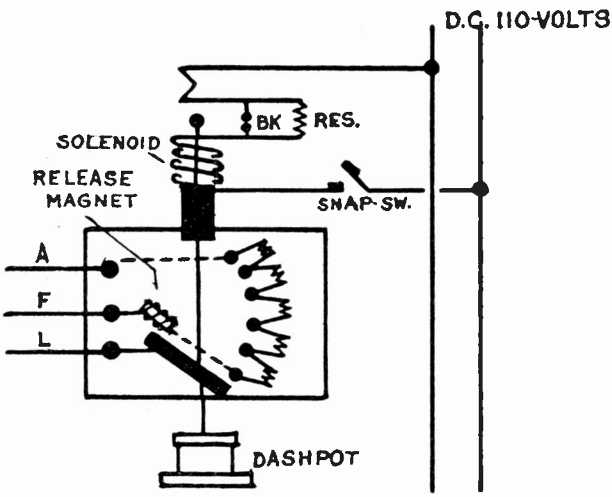


Fig. 19.—Cutler Hammer Automatic Motor Starter.

Question 41. Describe by the aid of a diagram an automatic starter.

Answer. In Figure 19 is shown one type of automatic starter used on 2 K. W. sets. A solenoid is arranged so as to cause an arm to move upward and short circuit the resistance coils. This motion is gradual and serves the same purpose as pulling the handle over by hand. To prevent the solenoid from pulling the arm up too quickly, a dash pot is used. A rod attached to the starter arm is fastened to the piston of a small cylinder. As the starter arm moves up, the piston moves also and tends to produce a vacuum in the cylinder, but due to a small leak in one end of the cylinder the arm is allowed to move slowly upward. The cylinder is called a dash pot and in some cases is filled with o'l instead of air.

Question 42. What would happen in the case of a short circuit in the armature coil of a motor or generator?

Answer. This short circuited coil would have an excessive flow of current through it, causing a smoke with odor due to the burning insulation on this coil. On stopping the revolving armature this coil could be detected by inspection.

Question 43. What are the causes of severe sparking in the form of a ring of fire around the commutator?

Answer. An open circuit in an armature coil.

Question 44. Explain the difference between a no-voltage and a no-field release magnet for a motor starter?

Answer. A no-voltage release magnet is placed directly across the line and opens the circuit in case the voltage ceases, while the no-field release opens the circuit in case the field current becomes low either due to a break in the field or the line voltage being removed. The latter method is preferable.

Question 45. Explain the parts and construction of a step-up transformer.

Answer. A step-up transformer consists of three parts: (1) A primary winding of a comparatively few turns of copper wire of rather large diameter; (2) a secondary winding of a large number of turns of small wire, 28-32 gauge; (3) a core of soft iron.

Question 46. What types of step-up transformers are used in radio transmitters?

Answer. Open and closed core types of transformers.

Question 47. How may the current supplied to the step-up transformer be reduced?

Answer. By inserting more resistance in series with the generator

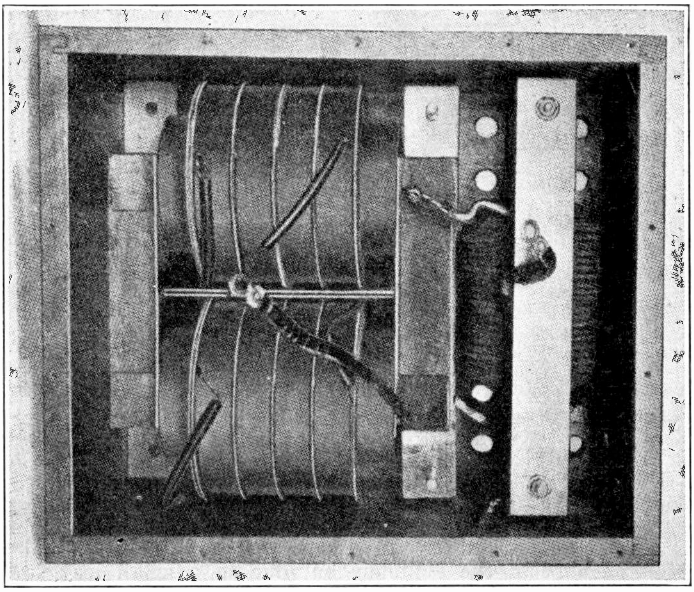


Figure 20.—Closed Core Transformer.

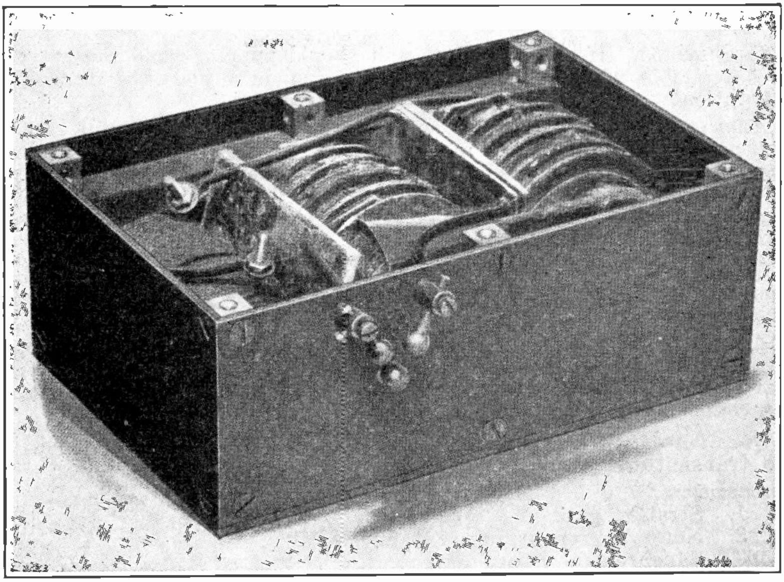


Fig. 21.—Closed Core Transformer.

field by means of the generator field rheostat or by adjusting the value of inductance in the reactance coil inserted in series with the primary winding of the transformer.

Question 48. How may the primary of a power transformer be tested for an open circuit?

Answer. By use of an ammeter in series with the winding. If there is no deflection of the ammeter, the winding is open. If an ammeter is not available, a lamp may be substituted for it. If the lamp glows brilliantly, there is no open circuit in the winding.

Question 49. By what means may an operator tell whether the secondary is burned open or short circuited?

Answer. What is known as the "flash test" can be made by placing the safety gap terminals of the transformer close together and then pressing the key. If a good spark is obtained, the secondary winding is in good condition, but if a straggly spark or no spark at all is obtained the secondary is open or short circuited at some point.

Question 50. What is the secondary voltage of transformers used in radio work?

Answer. 7,500-30,000.

Question 51. What is a common cause of puncturing of condensers?

Answer. A spark gap so adjusted that the distance between the electrodes is too great for the voltage to jump.

Question 52. What is a safety gap used for?

Answer. In modern sets the condenser and also the transformer secondary are protected by the safety gap. The terminals of this gap are placed at a slightly greater distance apart than the electrodes of the spark gap in the oscillatory circuit. Hence if for any reason there is an abnormal widening of the main spark gap, or if there is an opening in the oscillatory circuit, the transformer will discharge across the safety gap, thus not only preventing the puncturing of the condenser, but also protecting the secondary windings from short circuit.

Question 53. If one condenser unit should puncture and there are no spares available, what adjustments should be made to place the transmitter in operation?

Answer. The loss of a condenser in the closed circuit will mean a reduction of the wave length in that circuit. In order that the set may operate the normal wave length, inductance must be added at the primary of the oscillation transformer. In practice, the operator adds inductance until the hot wire ammeter gives the highest reading, thus indicating that the open and closed circuits are in resonance.

Question 54. In case all the condenser jars became punctured or broken and no spares were available, how could the transmitter be operated temporarily?

Answer. A direct aerial connection is the only feasible plan for operating the set. That is, the spark gap is placed in series with the aerial, aerial inductance and ground, the secondary terminals of the transformer being connected to either side of it.

Question 55. Name the various types of spark gaps employed in radio transmitters.

Answer.

1. Straight gap.
2. Non-synchronous rotary gap.
3. Synchronous rotary gap.
4. Quenched gap.

Question 56. Describe the two types of rotary spark gaps.

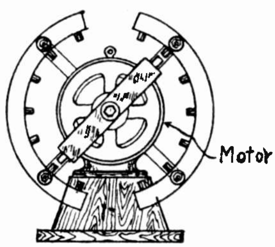


Fig. 22.—Non-synchronous Gap.

Answer. One type of non-synchronous gap is shown in Figure 22. A number of electrodes are placed in the shape of a circle on two semicircular frames in such a way that the electrodes face the center of a circle. A metallic bar is placed on the shaft of a small motor and revolves within the circle of stationary electrodes. The metallic bar has an electrode on either end. This bar is driven by a motor at a speed of 1,800 to 2,500 revolutions per minute. By the use of this gap a more musical note may be obtained from a low-frequency source of current than with a straight gap. It also has the advantage of cooling itself and thus quenching the oscillations in the closed circuit after the aerial is set into oscillation.

The synchronous gap consists of a disc placed on the shaft of the motor generator and a number of electrodes equal to the number of field poles on the alternator. The disc being on the shaft must revolve at the same speed as the armature. Two stationary electrodes are placed as shown in Figure 23, being separated from the revolving electrodes by about .005 of an inch. At the instant an alternation is produced by the generator, two electrodes on the disc are brought opposite the stationary electrodes, the condenser being charged by the alternation will discharge across the

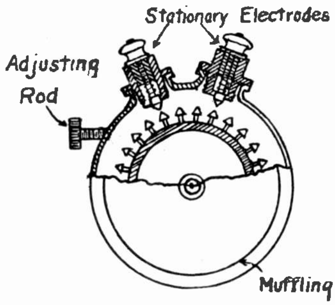


Fig. 23.—Synchronous Rotary Gap.

gaps. The reason that this type of gap is called *synchronous* is that there is a discharge of the condenser for every alternation of the generator. An adjusting handle is shown in the figure, which allows the most suitable sparking point to be found.

The advantage of this gap is that it gives a uniform discharge and each discharge has the same power as another.

Question 57. What adjustments should be made in the coupling when changing from a synchronous rotary gap to a quenched gap?

Answer. The coupling should be increased.

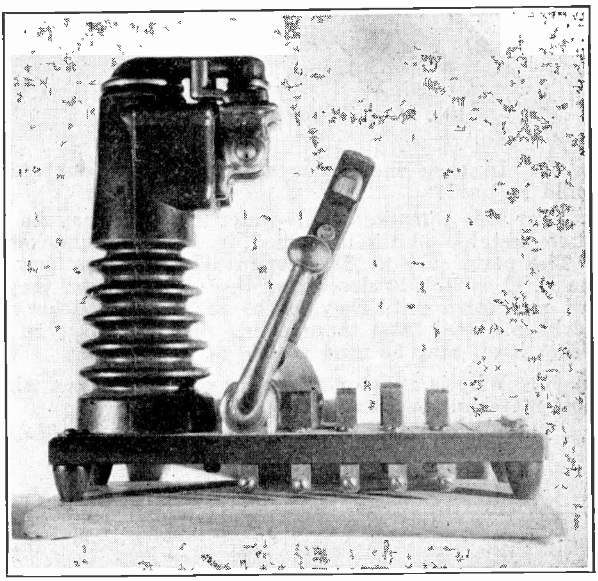


Fig. 24.—Aerial Changeover Switch.

Question 58. What would be the result of a short circuited field coil on a generator?

Answer. A very noticeable reduction in the A. C. voltage and power.

Question 59. In case your generator voltage indicated a small amount (5-15 volts), but showed no change on moving the field rheostat handle, what is the trouble?

Answer. No pressure on the D. C. supply source or a break in the circuit. The small voltage is due to residual magnetism in the pole pieces.

Question 60. What provision is made on an automatic starter to regulate the rapidity with which the starting resistance will be cut out of the circuit?

Answer. In some cases this provision is made by an adjusting nut or screw on the armature which the solenoid attracts. This regulates the distance from the armature to the solenoid. In the case of the dash pot type of starter, a small valve regulates the flow of air into the chamber, thus regulating the speed of operation.

Question 61. How would you test for a grounded armature coil in a motor?

Answer. Figure 25 shows a test for a grounded coil. An incandescent lamp is connected in series with one lead from a 110-volt source and the two remaining terminals are connected, one to the frame and the other to the coil at fault. If the lamp lights, there is a ground.

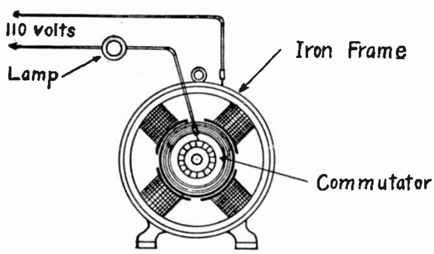


Fig. 25.—Test for Grounded Coil.

Question 62. In case the motor starter burned out entirely, what substitute could be used?

Answer. For this purpose a salt-water rheostat may be used. This consists of two metallic plates immersed in a wooden bucket filled with salt water. The plates are at first separated as far as possible. After the main line D. C. switch is closed and the motor starts, they are slowly moved toward each other until they touch. A metallic bucket may be used if it is properly insulated from the ground. In case this type of bucket is used, the bucket itself may be used as one of the plates.

Question 63. Why is a motor generator necessary for a wireless transmitter on most merchant vessels?

Answer. The power supplied by the ship's generator is usually direct current.

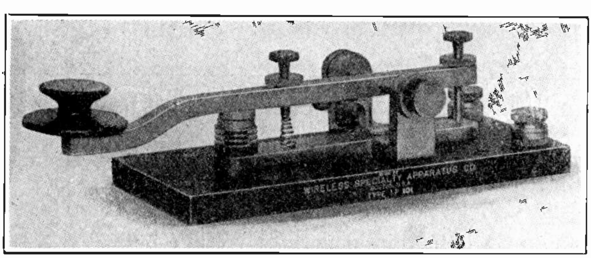


Fig. 26.—Wireless Telegraph Key.

Question 64. Describe a quenched spark gap.

Answer. As shown in Figure 27 this type of gap consists of a number of copper discs from three to six inches in diameter and separated by insulating washers of micanite, treated paper, fiber or other insulating material. A groove is cut in each plate over which the inside edge of the washer rests. This prevents the spark discharging at the very edge

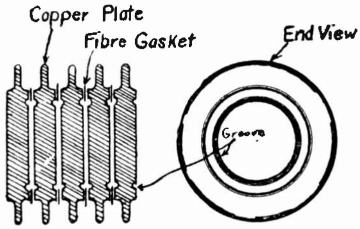


Fig. 27.—Quenched Gap.

of the washer, which would soon cause a short circuit. The plates and washers are assembled in an iron rack and are compressed by means of a pressure bolt, leaving a space of about .01 of an inch, which is airtight, between the sparking surfaces.

Question 65. What are the advantages of a quenched gap?

Answer.

1. It quenches the oscillations in the closed oscillatory circuit at the completion of the discharge and thus allows the aerial circuit to oscillate at its own frequency and damping.
2. Due to the above, the primary and secondary may be placed in very close inductive relation to each other, thus insuring a maximum transfer of energy to the aerial and hence a larger radiation of energy.
3. It has no moving parts.
4. It is noiseless.
5. It is synchronous if adjusted properly.
6. It allows the employment of low voltage transformers.

Question 66. Name the types of condensers used in radio transmitters.

Answer.

1. Leyden jar condenser.
2. Glass plate condenser.
3. Compressed air condenser.
4. Dublier mica condenser.

Question 67. Describe the various types of condensers.

Answer. The Leyden jar condenser consists of a jar covered on the inside and outside with thin copper foil, usually deposited by an electrolytic process.

The glass plate condenser is made up of a number of glass plates coated on both sides with copper, lead or tin foil up to within two inches or so of the edge.

The compressed air condenser consists of a number of steel plates placed in a steel cylindrical tank, into which air is pumped to a pressure of about 250 pounds. The compressed air acts as a dielectric.

The mica condenser, as the name indicates, employs mica for its dielectric.

Question 68. What is the disadvantage of the glass plate condenser?

Answer. In case it becomes punctured, it is very difficult to locate and remove the punctured section.

Question 69. What does the closed circuit of a transmitter consist of?

Answer. The condenser, spark gap and primary of the oscillation transformer.

Question 70. What is the function of the oscillation transformer?

Answer. To transfer the energy from the closed circuit to the antenna circuit and also to provide a means of tuning the two circuits.

Question 71. What is the effect of connecting two condensers of equal capacity in series?

Answer. The total capacity is reduced to one-half that of one of the condensers.

Question 72. What connection is sometimes made with condensers in order to reduce the strain on any unit?

Answer. The complete condenser unit may be made up of a number of banks connected in series.

Question 73. How may an oscillation transformer be adjusted in order to reduce the power of a transmitter?

Answer. The decrease in the coupling (moving coils further apart) will reduce the power.

Question 74. Under what circumstances is a condenser used in series with the antenna circuit of a transmitter?

Answer. When it is desired to transmit on a wave length lower than the natural wave length of the antenna.

Question 75. After the coupling of a transmitter has been adjusted so that the closed and open circuits are in resonance, what effect has an increase of coupling upon the radiated wave?

Answer. Waves of two frequencies of oscillation will be radiated and the energy will be distributed over a wide range of wave lengths, thus decreasing the efficiency of the transmitter and causing considerable interference.

Question 76. Under what circumstances is the coupling of a transmitter increased in order to send out a broad interfering wave when the energy is distributed over a wide range of wave lengths?

Answer. When sending distress signals.

Question 77. What provision is made in modern commercial radio transmitters for changing the wave length of the radiated wave?

Answer. Many transmitters employ what is known as a wave-changing switch, which is operated by a handle on the front of a panel. This handle controls the movement of a shaft to which a number of blades are connected, making connection in various positions to multiple contacts. In the different positions indicated on the front of the panel, this switch makes variations in the size of the transmitting condenser, varies the number of turns of inductance in the primary and secondary of the oscillation transformer and in some cases places a condenser in series with the antenna and a reactance coil in series with the power transformer for transmission for short distances.

Question 78. After the primary and secondary circuits of a transmitter have been tuned to a given wave length, what is the usual method of placing the circuits in resonance?

Answer. The coupling between the two coils of the transformer is varied until the aerial ammeter indicates a maximum value of current.

Question 79. For what purpose is an aerial tuning inductance used?

Answer. To increase the wave length of the open oscillatory circuit.

Question 80. Show by a diagram a conductively coupled transmitter.
Answer. See—

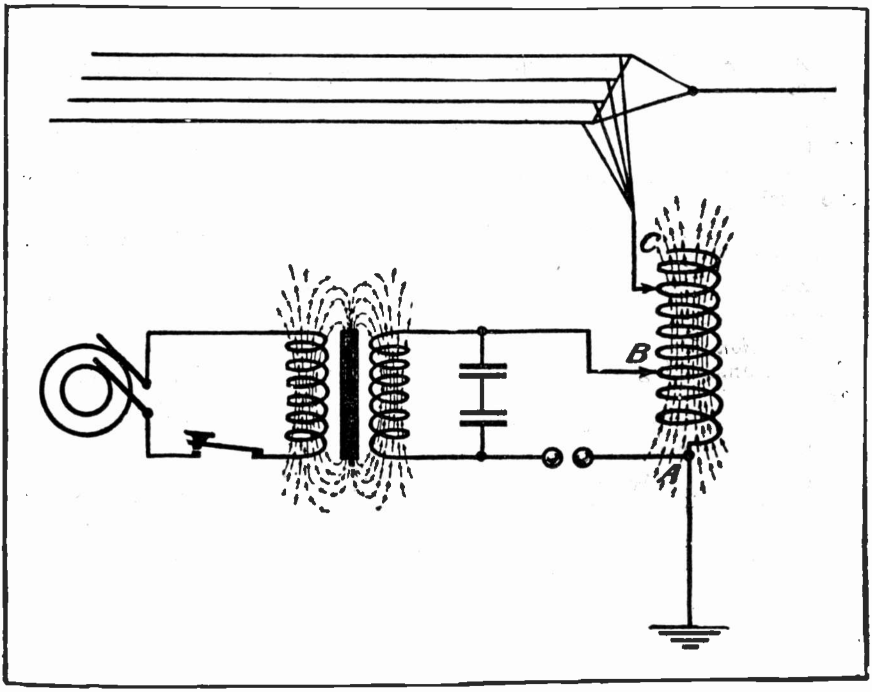


Fig. 28.—Conductively Coupled Transmitter.

Question 81. What instruments are necessary to adjust a transmitter to a given wave length?

Answer. A wave meter for tuning the circuits and an aerial ammeter for placing the circuits in resonance.

Question 82. What objections are there to the use of a plain aerial transmitter?

Answer. The principal objection is that such a transmitter radiates a highly damped wave which causes much interference. Another objection to the plain aerial transmitter is that it imposes a great strain upon the aerial insulation which is likely to cause a breakdown.

Question 83. Why are high frequency spark discharges employed in preference to low frequency ones?

Answer. The advantages of the high frequency spark are as follows:

1. Sending is accomplished more easily with high frequency spark discharger than with the low frequency type.
2. The signals from a high frequency spark are more easily read through atmospheric disturbances.
3. The average telephone receiver is more sensitive to a high frequency than to a low frequency.
4. For a given number of watts a lower potential is employed, which permits the use of a smaller condenser and reduces the strain on the apparatus as a whole.

Question 84. How may the power of a quenched spark type of transmitter be reduced by adjustment of the gap.

Answer. This is accomplished by a decrease of the number of gaps in use and a corresponding reduction of the alternator voltage.

Question 85. Define *spark frequency.*

Answer. The spark frequency is the number of sparks bridging the gap of the closed oscillatory circuit per second of time.

Question 86. What relation does the spark frequency of a synchronous transmitter bear to the frequency of the alternator?

Answer. There are two spark discharges for each complete cycle, or one discharge for each alternation.

Question 87. What effect has an increase in the antenna current of a transmitter upon the range of the station?

Answer. Usually an increase in the amount of energy radiated results in an increase in the range of the station.

Question 88. Why is it necessary in some cases to reduce the capacity of the transmitting condenser when operating on a wave length of 300 meters?

Answer. In order to permit enough turns to be used in the primary of the oscillation transformer to transfer the energy to the secondary.

Question 89. With everything else remaining the same, what effect has an increase in capacity upon the wave length of the closed circuit of a transmitter?

Answer. An increase in capacity increases the wave length of the closed circuit.

Question 90. How can an operator tell when his transmitting condenser is punctured?

Answer. There will be little or no discharge at the spark gap when the key is pressed.

Question 91. Which is most efficient, a conductively coupled or inductively coupled transmitter?

Answer. Inductively coupled.

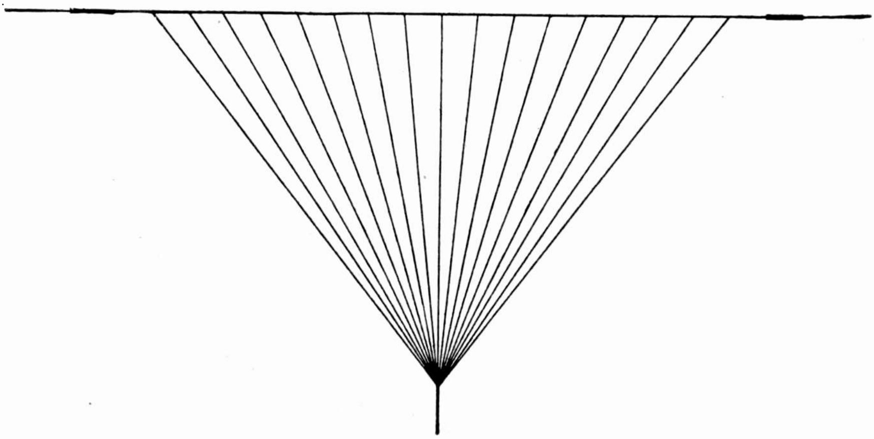


Fig. 29.—Vertical or Fan Aerial.

Question 92. How may a synchronous rotary spark gap be adjusted to synchronism?

Answer. The position of the stationary points should be varied until the spark takes place at the point of maximum voltage or at the peak of the alternation.

Question 93. What is the function of an antenna?

Answer. To radiate energy in the form of electromagnetic waves or to absorb part of the energy radiated from a distant transmitter.

Question 94. Name the four types of aerials in general use.

Answer.

1. Vertical or fan aerial.
2. Umbrella aerial.
3. The inverted "L" aerial.
4. The "T" aerial.

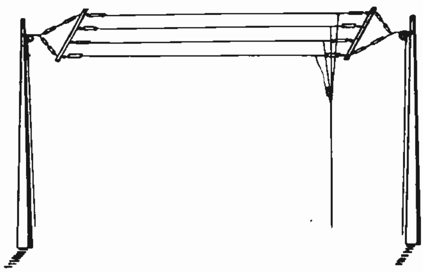


Fig. 30.—Inverted "L" Aerial.

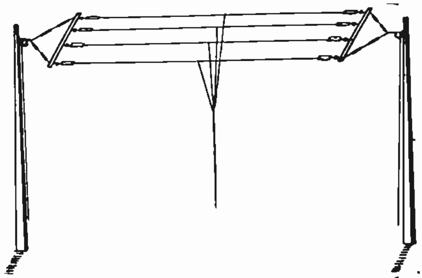


Fig. 31.—The "T" Aerial.

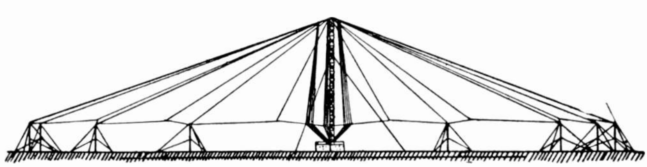


Fig. 32.—Umbrella Aerial.

Question 95. What types of aerials are used on ships?

Answer. The inverted "L" and "T" types.

Question 96. Why should all the joints in an aerial be soldered?

Answer. To prevent corrosion where the splices are made and to reduce the resistance to the lowest value by insuring good contact. In receiving, the resistance due to corrosion of the wires at the joints tends to weaken the strength of the signals.

Question 97. What care is necessary to keep an aerial in good condition?

Answer. Insulators should be inspected occasionally to see that they are not leaking, the lead-in wires should be well guyed to prevent their swinging and touching metal stays and the guy wires should be kept taut.

Question 98. How would you test an aerial to determine if it was leaking?

Answer. A spark gap may be placed in series with the antenna and the open circuit energized by the secondary winding of a power transformer. If the insulators leak the current will not jump the gap. If a good spark is obtained at the gap it indicates that there is nothing serious the matter with the antenna insulation.

Question 99. How could a leaking insulator be repaired temporarily?

Answer. It may be temporarily repaired by scraping the charred surface and painting with an insulating varnish or vaseline.

Question 100. What effect has the height of an antenna upon the range of a station?

Answer. Usually the higher the antenna the greater will be the range, but this rule does not apply in all cases.

Question 101. Define fundamental wave length of an aerial.

Answer. The length of wave radiated by an oscillatory circuit consisting of merely an aerial and ground is called the natural wave length.

Question 102. Has the insulation of an antenna any effect upon the range of a station?

Answer. The range of a station is decreased considerably if the antennae insulation is poor.

Question 103. What is the natural wave length of the average ship antenna?

Answer. 325 meters.

Question 104. How many wires are used in the average ship aerial.

Answer. 2-8.

Question 105. What is the capacity of the average ship antenna?

Answer. .001 microfarads.

Question 106. What functions does the modern antenna switch perform?

Answer. During the period of transmission it—

1. Disconnects the antenna from the primary winding of the receiving tuner.
2. Disconnects the earth leads from the primary winding of the receiving tuner.
3. Disconnects and short circuits the primary winding of the receiving tuner.
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 receiving transformer.
2. Connects the aerial leads to the primary winding of the receiving transformer.
3. Connects the other terminal of the primary winding of the receiving transformer to the earth.
4. Puts the receiving detector into the circuit for use.
5. Disconnects the aerial from the secondary winding of the transmitting oscillation transformer.

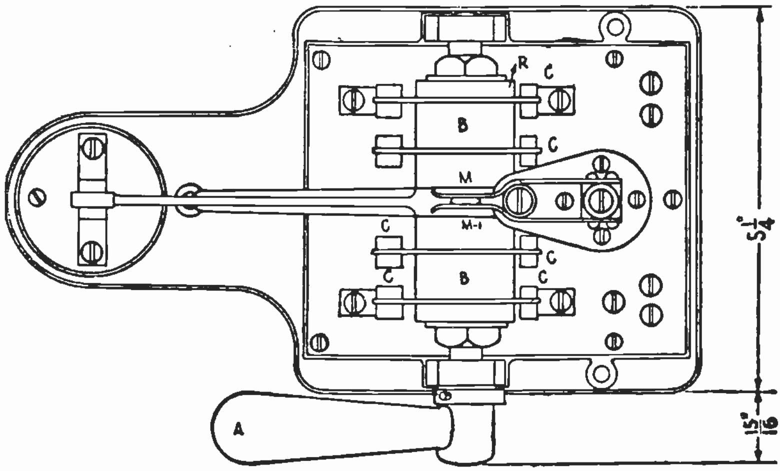


Fig. 33.—Top View Antenna Switch.

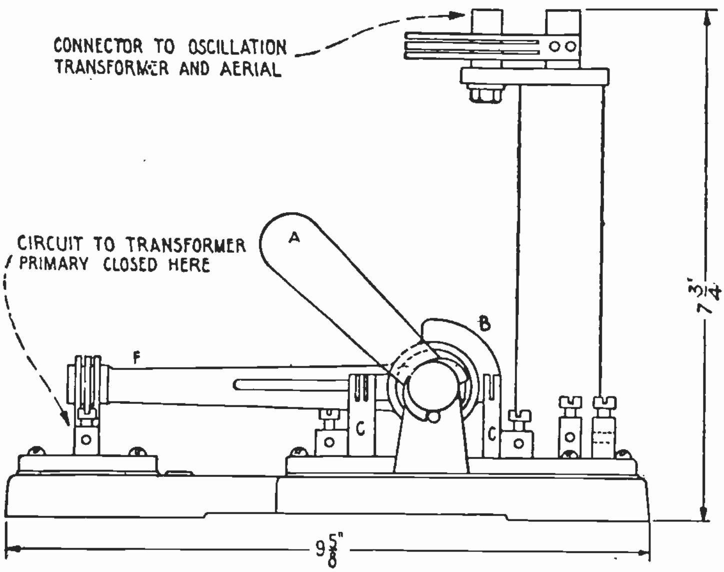


Fig. 34.—Side View Antenna Switch.

Question 107. What is the function of the lightning switch?

Answer. To disconnect the antenna from the rest of the radio installation and ground it during severe thunder storms, when the lightning is likely to damage the set.

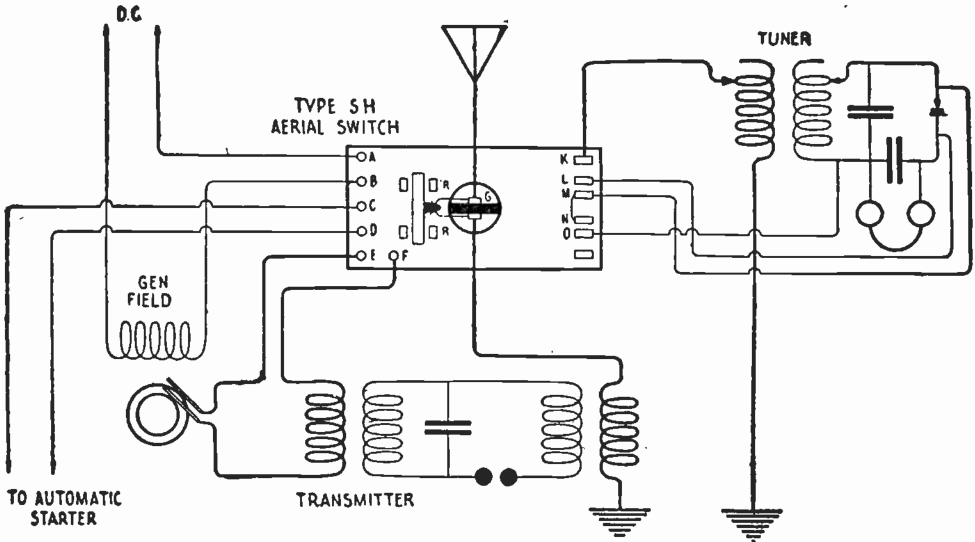


Fig. 35.—Wiring Diagram for Type "S" Antenna Switch.

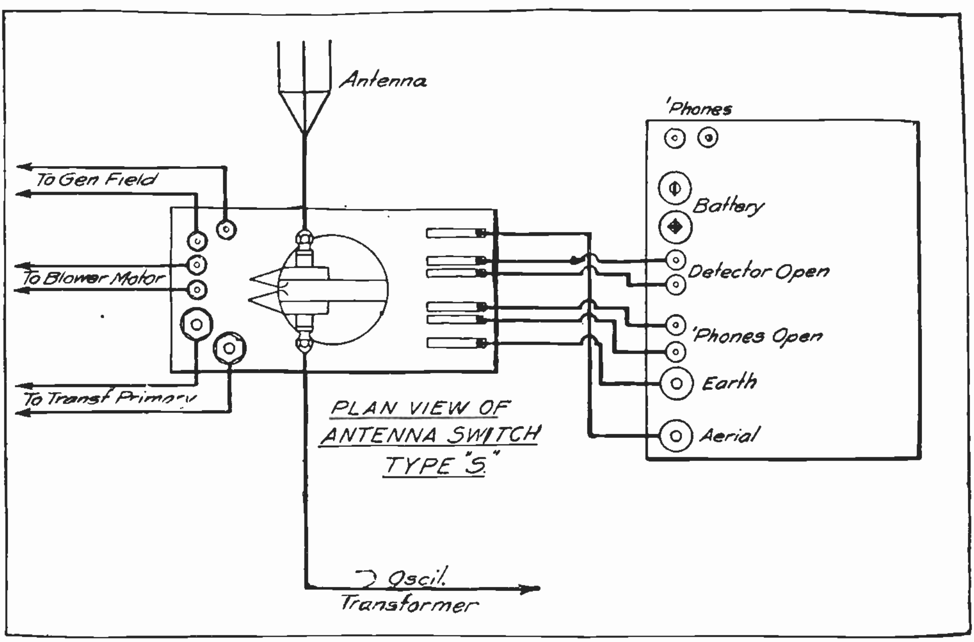


Fig. 36.—Connections of Type "S" Antenna Switch.

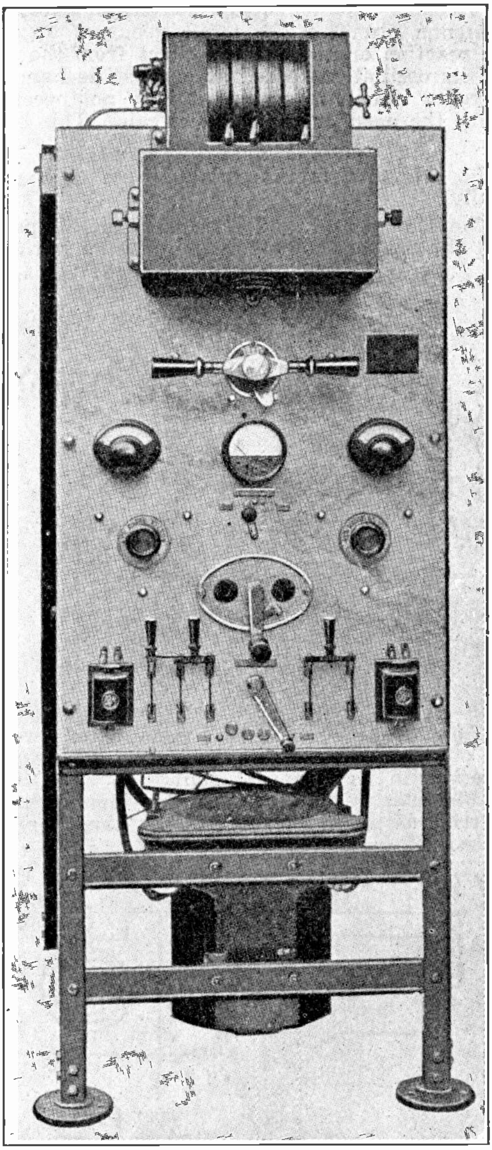


Fig. 37a.—Front View of 1 K. W. Simpson Type Transmitter.

Question 108. Who invented the impulse excitation system?

Answer. The impulse type of excitation was conceived by Sir Oliver Lodge in 1898.

Question 109. What is the working principle of this method?

Answer. The closed circuit (the source of production of the oscillation) consists of large resistance, large capacity and low inductance, which causes high decrement with only one-half of an oscillation of large power.

This acts like a hammer blow on the open or aerial circuit to set up oscillations in the antenna circuit. The oscillations set up in the aerial are quite free from reaction or interference effect from the closed circuit, due to the fact that its oscillation ceased at once. The hammer-blow effect of the closed or exciter circuit is such that it is not necessary for it to be in resonance with the open or radiating circuit. This eliminates the tuning of circuits.

Question 110. Name a few American types of impulse transmitters used commercially.

Answer. The Thompson impulse transmitter, Simpson mercury valve transmitter and the Haller-Cuningham impulse excitation transmitter.

Question 111. Make a drawing to illustrate the Thompson impulse transmitter.

Answer. See Figure 37.

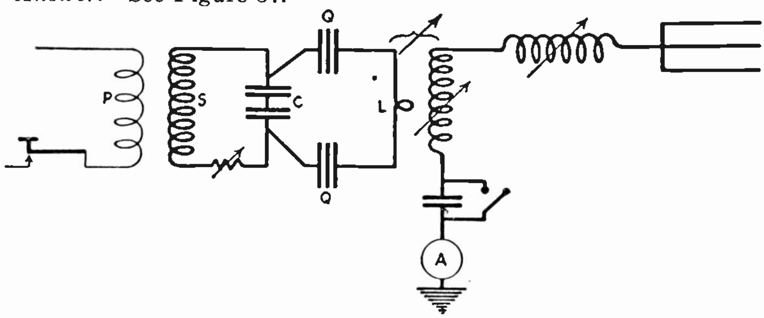


Fig. 37. Thompson Impulse Transmitter.

Question 112. State the essential features of this transmitter.

Answer. The closed circuit CQLQ consists of two condensers, two spark gaps and one turn of inductance and has a tune period corresponding to 700 meters with no means of tuning it. The open circuit has a range of 250 to 600 meters. The frequency of impulse in the closed circuit must not be great, if so, it will not allow time for the condenser to charge and discharge.

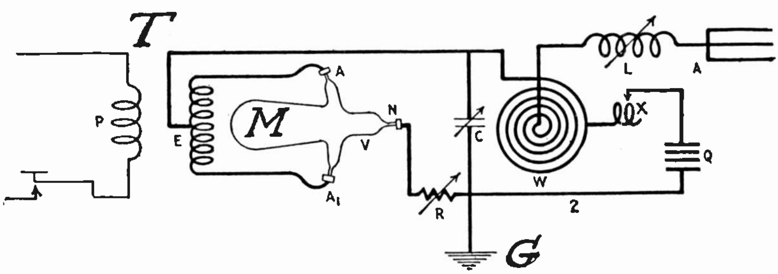


Fig. 38.—Simpson Impulse Transmitter.

Question 113. Explain the parts of the Simpson mercury valve transmitter.

Answer. Figure 38 shows the parts of the Simpson mercury valve transmitter, which consists of the step-up transformer T with the secondary coil connected to the mercury valve M. From the mid point E of the secondary a wire is brought to the condenser C and spiral inductance W. R is a variable resistance. XQC and W form the closed circuit. The open or antennae consists of ALWC and ground G.

Arc Transmitters

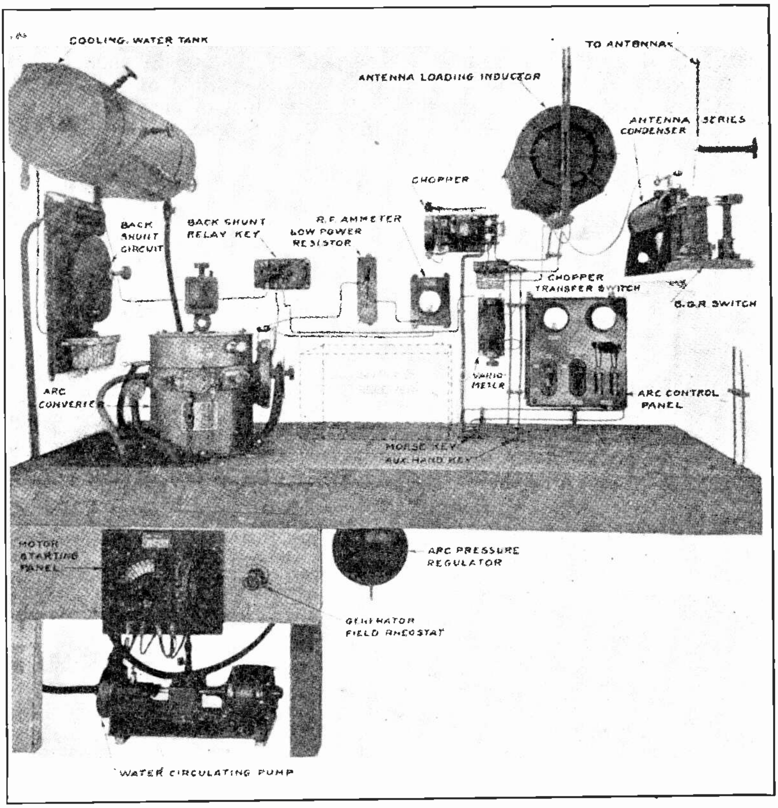


Fig. 39.—The Arc Transmitter.

Question 114. What type of arc transmitter is most commonly used in land and ship stations of the United States?

Answer. The Poulsen arc, manufactured by the Federal Telegraph Company.

Question 115. Name the main units of an arc transmitter.

Answer.

1. A source of direct current.
2. An arc converter.
3. An antenna loading inductance.
4. A signalling device.

Question 116. Describe the motor generator set used with an arc transmitter.

Answer. The motor generator usually employed consists of a four-bearing, direct-connected machine, having a 115-volt direct current motor mounted on the same base as a direct current generator, giving about 550 volts. Excitation for the generator is obtained from the 115-volt direct current supply.

Question 117. Describe and explain the arc converter.

Answer. The arc converter has a water-cooled air-tight bronze chamber in which the arc burns between a carbon and a water-cooled copper electrode. The copper electrode is termed the *anode*, while the carbon one is the *cathode*. Field or magnet coils which energize the two poles of a magnetic circuit are located above and below the arc chamber. These poles project into the chamber, one on either side of the arc in such a manner as to form a magnetic blow-out, which blows the flame of the arc to one side. These field coils are connected in series in the positive side of the direct current generator feeder circuit. The copper anode is insulated

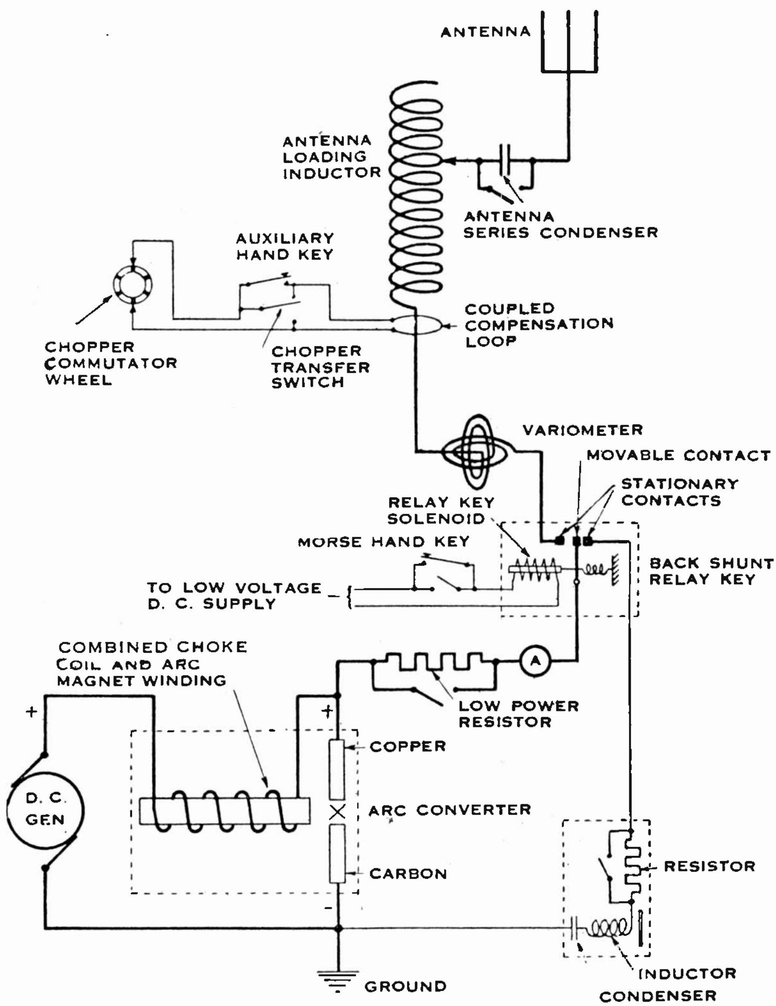


Fig. 40.—Back Shunt System of Arc Transmitter.

from the arc chamber by two ebony asbestos insulating blocks. The copper tip is renewable, though in ordinary service it will last for months. The negative electrode, or carbon cathode, is held in a carbon holder, which slides in a water-cooled sheath. A handle of insulating material is provided by means of which the distance between the carbon electrode and the copper electrode may be varied to strike the arc and adjust the arc length. There is a small direct current motor connected through worm gears so as to slowly rotate the carbon, so that it may burn evenly.

A glass cup for holding alcohol or kerosene is placed on top of the arc converter and feeds liquid through a passage in the upper magnet pole. Hydrocarbons, such as alcohol, kerosene or producer gas, must be supplied the arc slowly but continuously while it is operating, in order

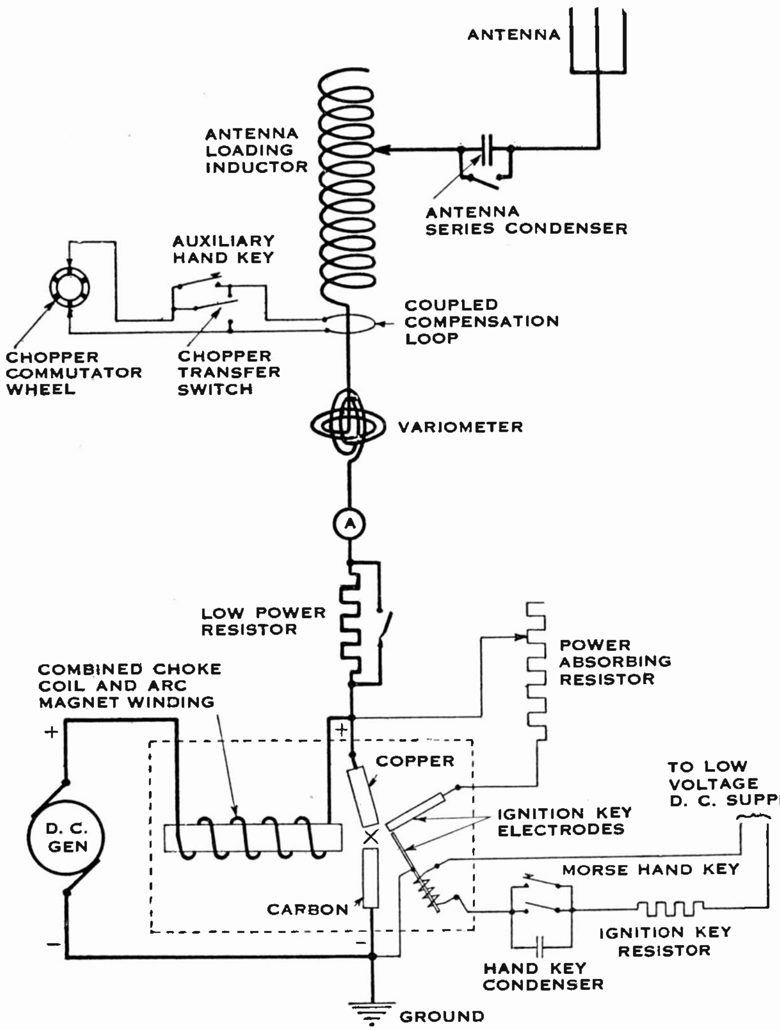


Fig. 41.—Ignition Key System of Arc Transmitter

that there may always be hydrogen atmosphere within the chamber. A poppet valve is provided, which relieves the pressure in case of an explosion or in case an excess amount of hydrocarbons is admitted.

A thermo-syphon or circulating system is used for cooling the arc converter.

Question 118. What methods of signalling are employed in the low power (2 K. W.) arc transmitters?

Answer.

1. The back shunt method.
2. The ignition key method.
3. The straight compensation method.
4. The inductive compensation method.
5. The chopper method.

Question 119. What is the function of the arc?

Answer. It converts the power supplied by the direct current into radio frequency energy with undamped current in the antenna circuit.

Question 120. Describe the various methods of signalling.

Answer. In the "back shunt" system, what is termed as a back shunt relay key is employed. A solenoid operating on a low voltage source of direct current controls a movable contact which, when the direct current supply line to the solenoid is open, connects a local circuit consisting of an inductance, a capacity and a resistance across the terminals of the arc. This circuit is regulated to approximately the same resistance, so that the radio frequency current remains at the same value whether the arc is operating on the antenna circuit or the back shunt circuit system. When the direct current supply circuit is closed by means of a Morse key, the switch blade connects the arc into the antenna circuit. The switch arm is so arranged as to make contact with the antenna circuit before it breaks with the local circuit and vice versa, so that the arc is in an oscillatory circuit at all times, but is only radiating when connected in the antenna system. This type of signalling device is usually only employed on the 2 K. W. transmitter.

In the ignition key method, a resistance is arranged so that it may be shunted about the arc when the sending key is up. This resistance is of such value that it will take the same amount of current as the arc

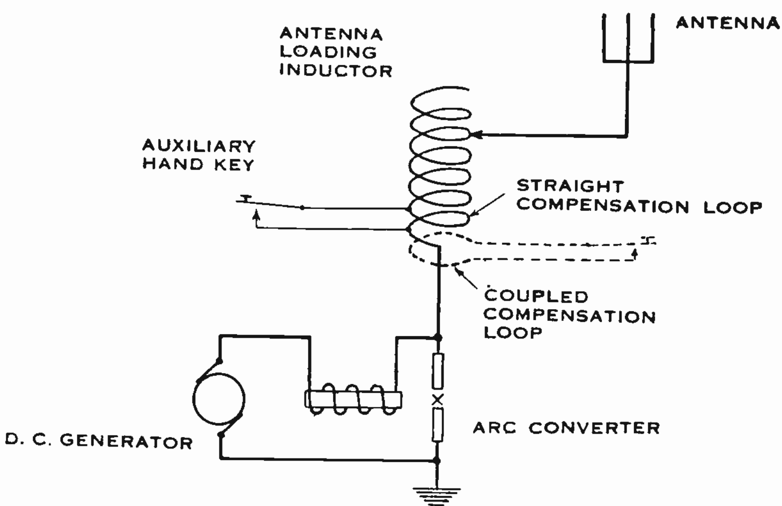


Fig. 42.—Circuit Using Inductive Compensation Loop.

absorbs when operating. When the key is depressed, two auxiliary contacts in series with the resistance are opened, causing a momentary arc to be formed, which is blown between the copper and carbon electrodes. This ignites the arc and oscillations are produced as olng as the key is depressed. As soon as the signalling key is up, the arc is again shunted by the resistance.

In the straight compensation method, a key is used so short circuit a number of turns in the antenna loading inductance when transmitting. In this system the energy is radiated on two wave lengths: one when the key is not depressed and the other, somewhat lower than the first, when the key is closed for transmitting. The receiving operator tunes to the lower wave.

The inductively coupled compensation method performs approximately the same function as the one just described. Instead of short circuiting part of the antenna inductance itself, a turn of inductance is placed in inductive relation to the antennae inductance, which may be short circuited by means of a sending key, thus altering the length of the radiated wave.

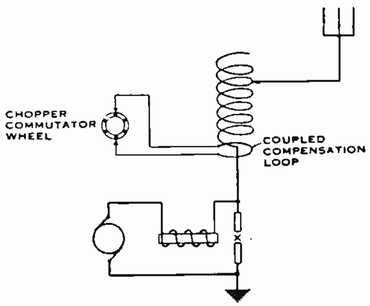


Fig. 43.—Connection of Chopper Commutator.

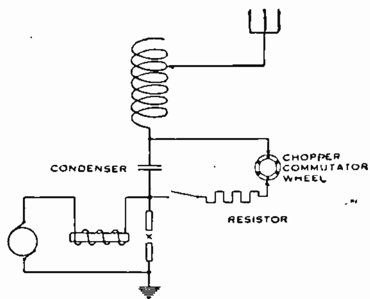


Fig. 44.—Connection of Chopper Commutator and Resistor.

Question 121. How may an arc transmitter be made to produce signals which are audible when a crystal detector is used in the receiver?

Answer. By using a chopper at the transmitter. Such a device is usually connected across an inductive compensation system, so that the wave length may be alternately changed from the compensation wave to the signalling wave 400 to 1,000 times per second.

Question 122. How would you set an arc transmitter in operation?

Answer. In starting the arc, the water-cooling system is placed in circulation, the motor generator started, the aerial circuit connected and all necessary switches closed. The arc gap is adjusted to the proper length and the power switch closed. The arc is started by bringing the electrodes together and then quickly separating them. After the arc begins to burn, lengthen the gap until the maximum radiation (or the safe value of radiation, as stated by the manufacturers of the apparatus) as indicated by the hot wire ammeter is reached. The alcohol, kerosene or whatever hydrocarbon is used for the hydrogen supply should be allowed to flow freely into the chamber while starting the arc, but the flow may be reduced considerably after the arc has started.

Question 123. Of what use is a variometer in series with the antenna circuit of an arc transmitter?

Answer. Inasmuch as the oscillations of an arc transmitter are undamped, the signals from such a transmitter will tune very sharply at the receiver. The variometer is used so that the sending operator may vary the wave lengths slightly when calling a station, thus making it easier for the receiving operator to pick up the call. A notching device built in the variometer handle holds it in a central position when he has established communication.

Question 124. What is the rated output of a standard 2 K. W. arc transmitter?

Answer. It is designed to give 5½ amperes to the antenna circuit when operated continuously for a period of five hours. It will deliver 7 amperes for a period of two hours and a maximum of 8 amperes for short overloads.

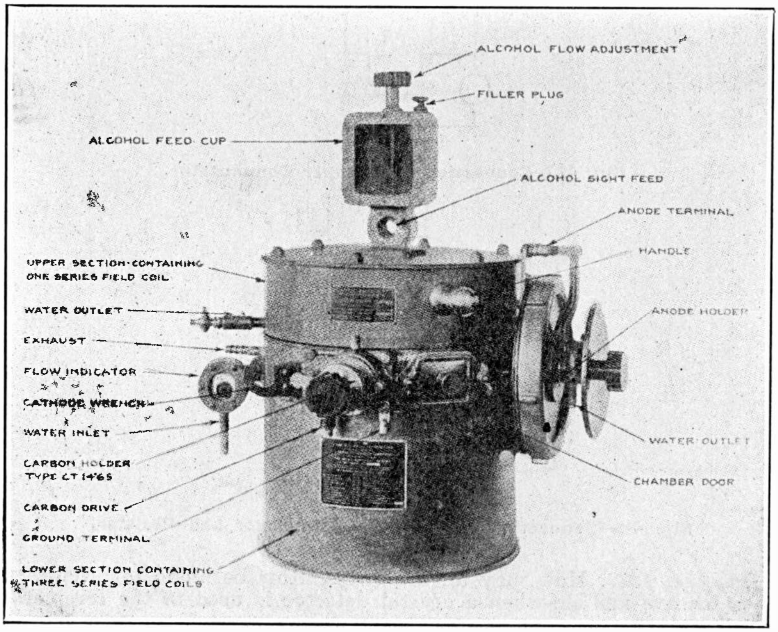


Fig. 45.—The Arc Converter.

Question 125. Describe completely a 2 K. W. arc converter unit.

Answer. The chamber of a 2 K. W. arc transmitter is made in two sections, with the upper half hinged so that it may be swung back and the entire interior exposed for inspection and cleaning.

The top and bottom plates of the chamber are made of bronze and water cooled. The center section of the chamber consists of a cast iron ring which is not water cooled as it is far enough away from the arc flame to not require it. The bronze cooling plates of the chamber are cast in two parts, which are bolted together with gaskets to provide water-tight joints. The lower water-cooled bronze plate is bolted directly to the cast iron chamber ring, while the upper water-cooled plate rests on the ring, with a gasket to make an air-tight joint, and is attached directly to the hinged upper section of the arc. The construction of the chamber insures uniform water-tight casings throughout and makes it possible to repair any leaks that might develop.

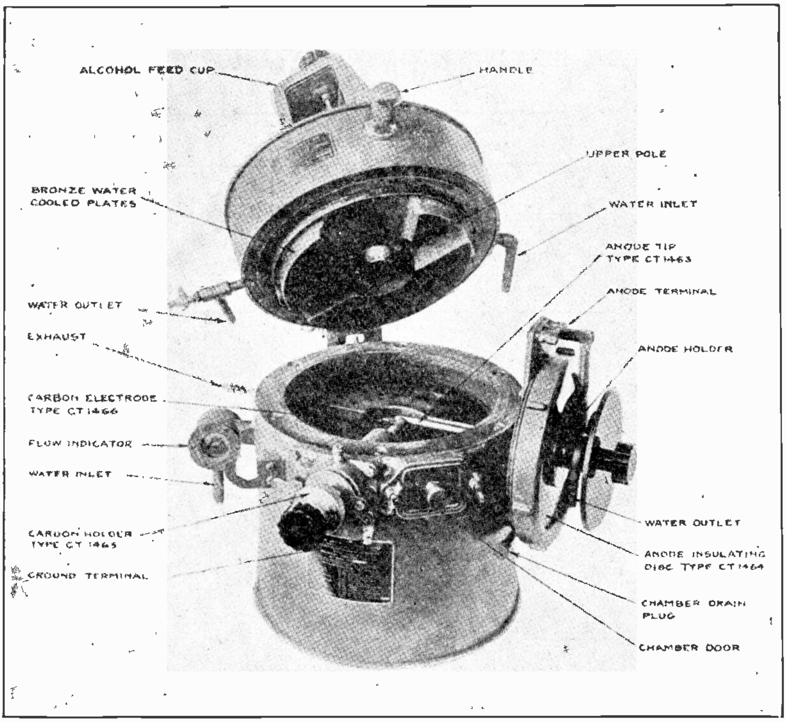


Fig. 46.—View of Interior of an Arc Chamber.

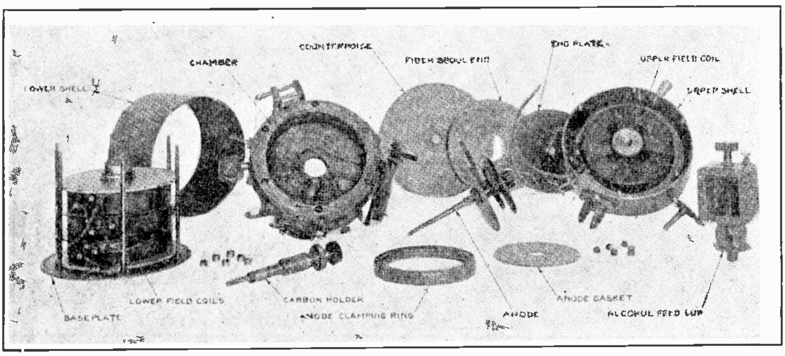


Fig. 47.—Exploded View of Arc Transmitter.

The 2 K. W. unit has a closed magnetic circuit. In other words, the path through which the magnetic flux travels is made entirely of iron, except for the air gap between the magnet poles. One magnet pole projects

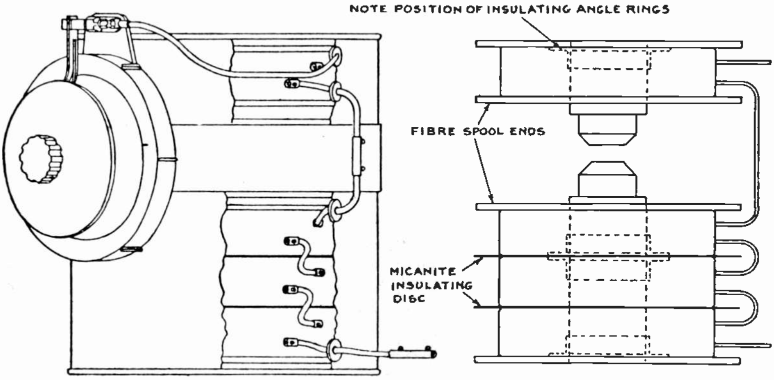


Fig. 48.—Views of Arc Chamber.

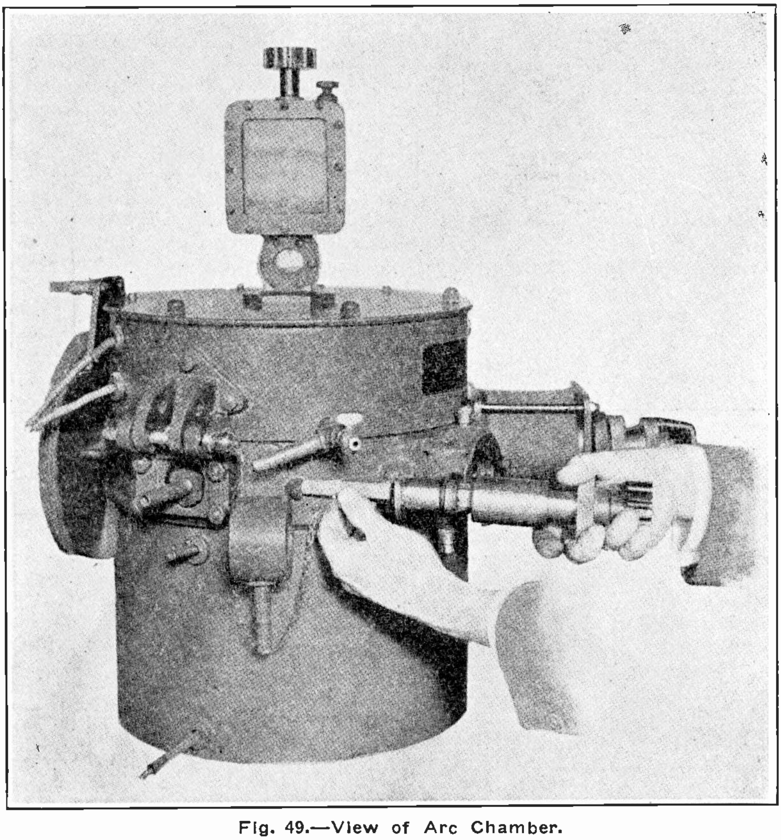


Fig. 49.—View of Arc Chamber.

into the lower half of the arc chamber and the other pole projects into the upper half of the chamber.

The electrodes of the arc are located in the air gap between the two magnet poles, in a manner which subjects the arc flame to a very strong transverse magnetic field. The steel shield which surrounds the field coils of the arc, provides a closed return path for the magnetic flux.

The field winding of the 2 K. W. unit is constructed of four form-wound coils, three of which are placed in the lower half of the chamber and one is placed in the upper hinged half. The coils are insulated by means of micanite rings and fiber discs.

The anode constitutes the positive electrode of the arc converter unit. It consists of a water-cooled copper tip, supported by a suitable holder, which is insulated from the arc chamber by means of a bakelite disc. This copper tip is brazed to a short piece of brass tubing and this unit, which is known as the anode tip, is renewable when it becomes worn after a long period of operation. The tip is cooled by water which is forced through a small brass tube inside the main outer tube of the anode holder. A small gasket serves to make a water-tight joint between the anode tip and the anode holder.

A proper circulation of water is of great importance in operation, as the tip may be melted by the intense heat of the arc flame if insufficiently cooled.

The anode holder is provided with two hose nipples, one for the inlet and one for the outlet of the cooling water.

The negative electrode of the arc converter unit is called the cathode. It consists of a carbon held in a removable carbon holder. The carbon is clamped in the holder by means of a split taper collet and lock nut. A special wrench and gauge is attached to one side of the chamber for use in clamping the carbon in its holder and securing the proper amount of projecting carbon. This feature is illustrated in Figure 49.

The carbon holder is provided with a molded bakelite knob by means of which the inner portion of the holder may be screwed in and out, in order to adjust the length of the arc flame during operation. When the carbon holder is in position in the arc converter unit, it is slowly rotated by means of a worm gear mechanism, which transmits motion to the carbon holder through a keyway. By means of these gears, the carbon is rotated very slowly in order that it may burn evenly.

The carbon holder is located in proper position by means of a latch, shown in Figure 50. When it is desired to remove the holder, it is merely necessary to push upward on the latch, which releases it and allows it to be withdrawn. The holder is held out against the latch by means of a spring and may be pushed inward against the force of the spring for striking and starting the arc flame.

The holder should never be removed immediately after operation. Two minutes should be allowed to enable the carbon to cool, as otherwise its red heat will ignite the gaseous mixture formed by the admission of air through the removal of the carbon holder, causing an expolsion. The same precaution of allowing the carbon to cool should also be observed in connection with opening the upper half of the arc chamber.

The hydrocarbon gas which is necessary for the efficient operation of the arc flame is supplied through the decomposition of alcohol. The alcohol container, which is mounted on top of the arc converter unit, is provided with a needle valve and sight feed glass, by means of which the flow of alcohol may be adjusted and observed. The alcohol reaches the chamber through a small hole in the upper magnet pole and drips directly in the region of the arc flame. When it comes in contact with the flame it is decomposed and a certain amount of hydrocarbon vapor is released.

Either grain or denatured alcohol may be used. When the transmitter is first started after a long period of rest, it is necessary to permit the alcohol to drip rather rapidly into the chamber, but after the arc has been running for a few minutes the rate of flow may be reduced to only

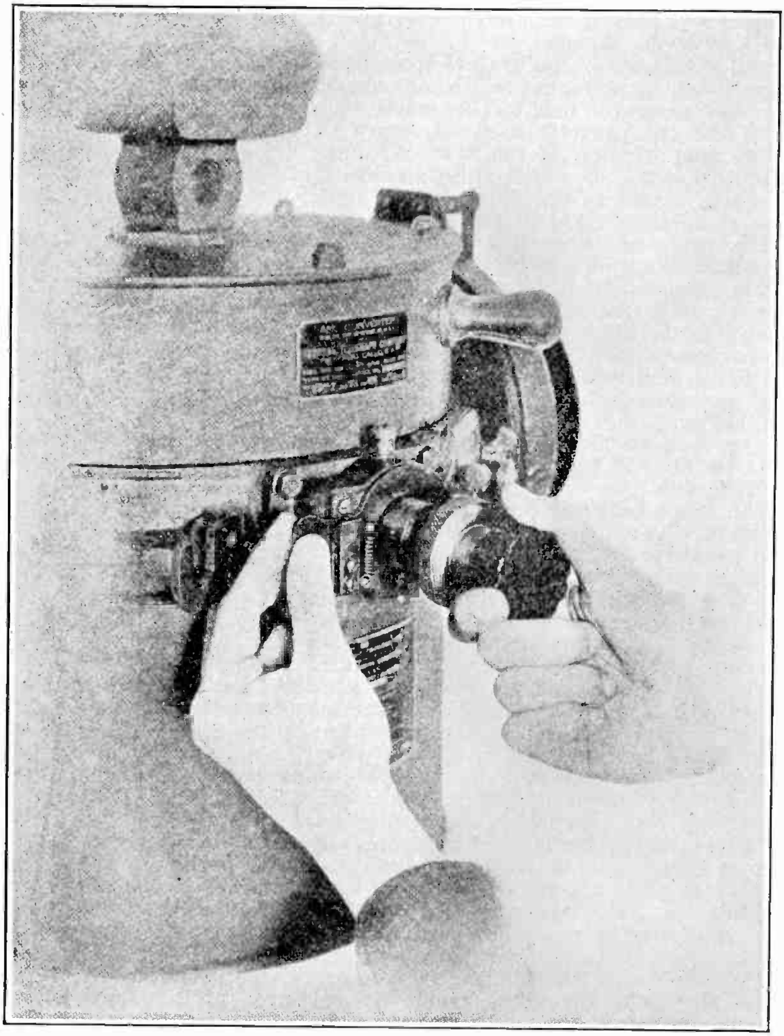


Fig. 50.—Adjustment of Arc Length.

a few drops per minute, which is sufficient to maintain full antennae current and keep the arc operating smoothly. Some of the 2 K. W. transmitters are provided with an alcohol container having a magnetically controlled valve, which automatically starts and stops the flow of alcohol.

Question 126. How is the pressure inside the chamber kept constant?

Answer. The 2 K. W. arc converter unit is provided with a hose nipple, by means of which a hose connection may be made to a unit known as the exhaust receiver or pressure regulator.

This exhaust receiver consists of a cast aluminum receptacle in two parts, separated by a rubber diaphragm. The larger of these two parts is connected by the hose to the chamber and receives the exhaust gasses therefrom. The smaller part provides a space within which the rubber diaphragm may pulsate in order to make up for variations in chamber gas pressure. As the arc flame operates and the volume of gases within

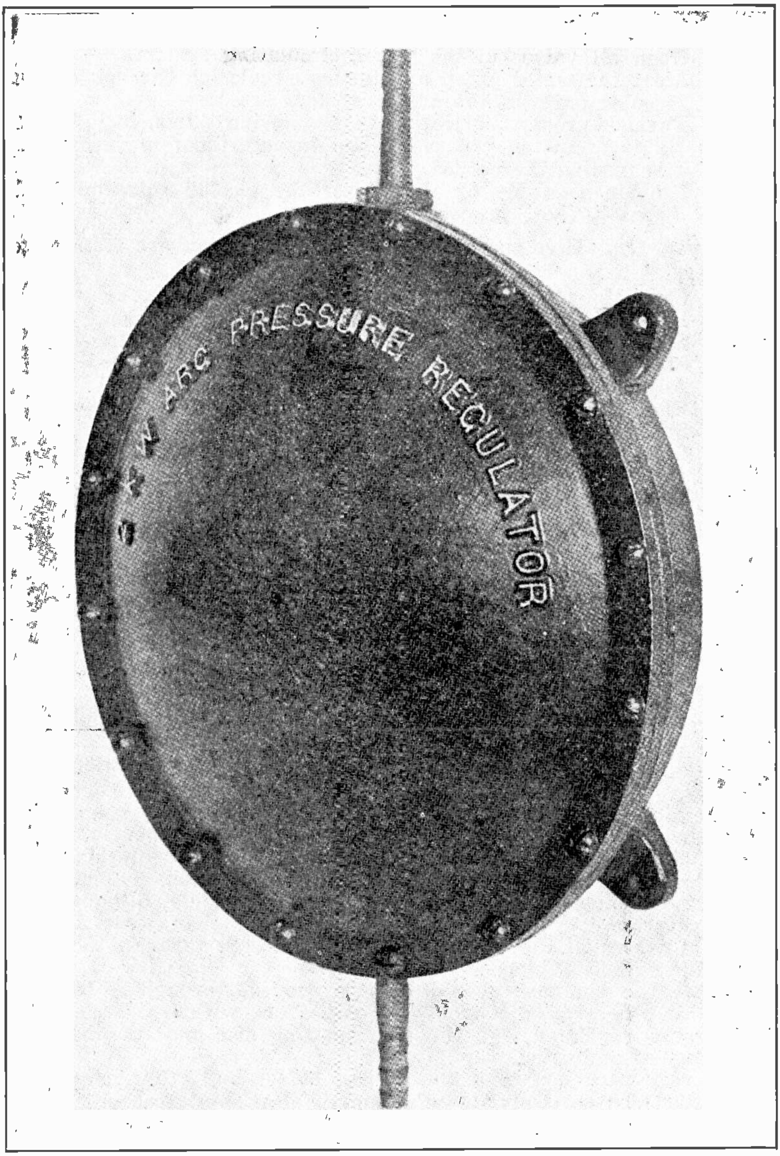


Fig. 51.—Pressure Regulator.

the chamber fluctuate, this light rubber diaphragm pulsates back and forth, thus keeping the chamber gases at nearly the same atmospheric pressure at all times. A second hose nipple having a very small hole provides an outlet for the excess gases, which are conducted through a second rubber hose to an opening beyond the operating room.

Question 127. Name five precautions to be taken on starting an arc transmitter.

Answer.

1. Make sure of ample water supply in tank.
2. Open all valves in the water circulating system.
3. Start the water pump and insure circulation through all water-cooled parts of the arc converter.
4. Furnish proper lubrication to all moving parts, including bearings of motor generator, and inspect them to insure the oil is feeding the needed parts.
5. Provide a supply of alcohol for the alcohol container and see that it feeds properly.

Question 128. Give the operations for starting an arc transmitter.

Answer.

1. Close the main line switch.
2. Place the change-over switch in the sending position.
3. Start the motor generator; set and adjust the voltage.
4. Start the alcohol feed.
5. Adjust the carbon to position.
6. Close the main switch to the arc.
7. Strike the arc and adjust its gap.
8. Close the arc starting resistor switch and adjust the arc flame for maximum antenna ammeter reading.
9. Transmit signals by use of Morse hand key.

Question 129. What should be done in stopping transmission with the arc?

Answer.

1. Open the arc main line switch, which automatically opens the arc starting resistor.
2. Open the main supply switch, which releases the motor starter handle.
3. Turn off the alcohol feed in case there is no automatic stop.
4. Throw the change-over switch to ground or receive position. This also stops the circulating feed pump.

Question 130. What care should be given the arc converter unit?

Answer. During ordinary operation, the only parts which should require attention are the chamber and the electrodes. The chamber must be kept clean, water-tight and air-tight. A tight chamber is absolutely necessary for successful operation. If air is allowed to leak into it through loose joints, the arc flame becomes fussy, noisy and unsteady. It furthermore causes the carbon to wear away rapidly, although during normal operation it will tend to build up rather than wear away. The presence of water in the chamber may be detected through the wearing away of the carbon electrode.

In case the chamber should become flooded, through a burned out anode tip or other cause, it should be wiped out with a dry cloth before restarting the arc flame. The anode insulating disc and its gaskets must also be removed and dried.

It is very necessary that the carbon holder and other moving parts of the cathode be carefully and thoroughly cleaned at frequent intervals.

Proper lubrication of the gears and other moving parts is, of course, necessary to insure their long life.

Question 131. If the motor generator is running and no hiss develops when striking the arc, what may the trouble be?

Answer. The generator may not be generating or may not be generating enough voltage.

The various switches in the arc supply circuit may not be closed or the fuses in the generator circuit may be blown.

There may be an *open* in the generator circuit.

Question 132. If the generator is running and the arc hisses but fails to remain lit, what may the trouble be due to?

Answer. There may be a break in the oscillatory circuit due to the fact that the antenna switch is not in the transmitting position or there may be other breaks in the circuit.

The gap distance may be too wide.

The generator voltage may be low. A voltage of at least 300 should be supplied the arc.

Question 133. What may be the cause of the circuit-breaker opening upon starting the arc?

Answer. Too much power may be being used. A starting resistance should be placed in series with the arc and set to the proper value.

Question 134. What may be the trouble if the arc flame goes out while in operation?

Answer. This condition is sometimes due to water being admitted into the arc chamber from a melted anode. The melting of the anode may be caused by a lack of water circulation or pressure or the negative side of the current supply from the generator being connected to the anode.

The arc flame going out while in operation may also be due to too great a distance between the electrodes, the grounding of the anode, or to the fact that the cathode is not revolving, thus causing the carbon to be consumed only on one side and eventually resulting in a short circuit between the electrodes.

Question 135. What is the range of wave lengths and how is the change made?

Answer. The 2 K. W. ship sets have a range of 450 to 2,400 meters, usually divided up as follows: 450, 600, 800, 2,000, 2,250 and 2,400 meters and designated by markers fastened to the turns of the antenna loading inductor. The change is made by attaching an adjustable lead wire to the place on the loading coil bearing the desired wave length marker. Be sure the generator is disconnected from the arc when this change is made.

Question 136. Name a few important points to consider when installing an arc set.

1. A good ground connection.
2. Ample clearance between antenna loading inductor and surrounding objects.
3. Connections for chopper circuit as short as possible.
4. Place water pumps so driving shaft is in a vertical position.
5. Place water tank above arc chamber with space to fill it.
6. Power absorbing resistor to be located to allow good air circulation for removing heat.
7. Ground the following parts: Frames of arc converter, arc control panel, motor generator; the bases of change-over switch, loading inductor, antenna series condenser and all free metal objects near high-voltage parts.

Question 137. State a few safeguards for the proper upkeep of an arc set.

Answer.

1. Avoid overloading the arc converter.
2. Do not open the arc chamber immediately on shutting down (allow two or three minutes for cooling).
3. Clean the antenna insulator at frequent intervals.
4. Keep the arc chamber clean.
5. Provide ample lubrication.
6. Do not feed too much alcohol to the chamber.
7. Never take the apparatus apart except to clean or repair it.

Tube Transmitters

Question 138. Give an elementary diagram of a vacuum tube transmitter.

Answer.

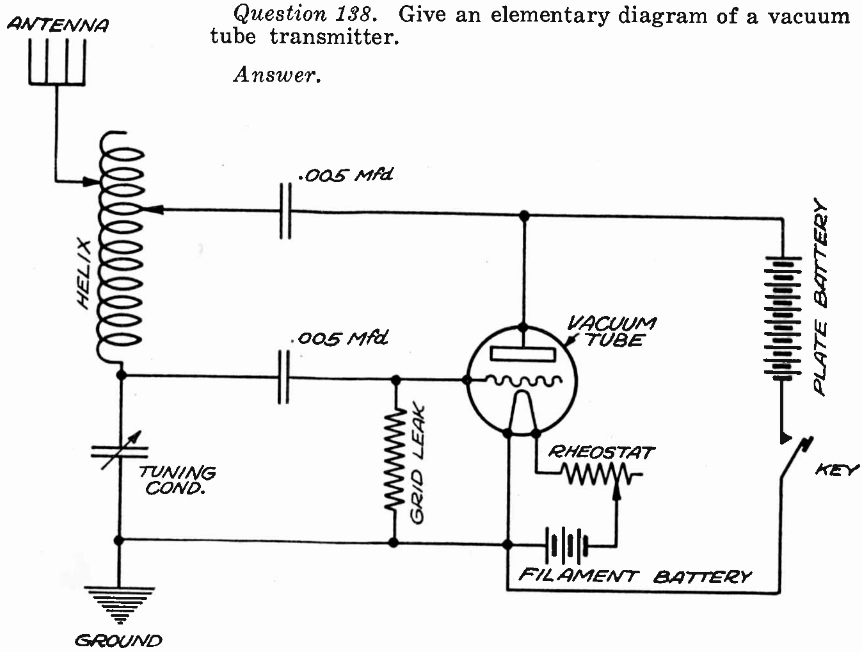


Fig. 53.—Three Electrode Tube Connected Up for Transmitting Purpose.

Question 139. Describe the parts of this transmitter.

Answer. Referring to the diagram in Figure 53 for the previous question, a conductively coupled circuit is shown. The size of the wire composing the inductance coil L depends upon the output of the tube. In case a single 5-watt tube is used the winding may consist of a number of turns of magnet wire as small as No. 20. However, for the larger type of transmitter, this inductance is usually made of edgewise wound copper strip.

The direct current supply also varies with the type of tube employed. In the case of the 5-watt tubes on the market at the present time, the direct current voltage is about 350. Other sized tubes require voltages of 500, 1,000, 1,200, 1,500, 2,000, 3,000, etc

If an ammeter is employed in the aerial circuit for the low power tubes, it will read from 0 to 1 ampere. It may be of the familiar hot-wire type.

The vacuum tube is of more rugged build than receiving tubes its size depending on power desired. A 5-watt tube is slightly larger than a receiving tube of the common type.

The filament battery should deliver 6 volts for the small tube and somewhat higher voltages for the larger tubes.

The source of direct current may be batteries, motor generator or rectified alternating current.

The key may be placed in the aerial lead or in the lead from the filament to the center of the plate battery.

Question 140. Explain how a circuit such as shown in Figure 53 produces undamped waves for telegraphy or telephony.

Answer. As long as the filament of the tube is burning there will be a weak direct current flowing in the plate circuit, viz,: Plate, filament, direct current source, from B to C on the inductance coil back to the plate. This direct current is the result of the attraction by the plate of the electrons thrown off by the filament. The passage of electrons from filament to plate allows the flow of current from the plate to the filament, thence about the circuit as above described. The strength of this circuit depends on the filament temperature and the voltage of the direct current source.

The grid lies between the filament and the plate and has a very important effect on the plate current. The fundamental principle of the vacuum tube is that a small change in the grid potential causes a comparatively large change in the plate current.

Suppose a slight change in the grid voltage is brought about by opening a switch or varying the capacity of the grid circuit, so that a negative charge is placed on the grid. This negative charge will repel the electrons and decrease the number reaching the plate. A decrease in the plate current for telegraphy and to some extent telephony.
ance coil from B to C will induce in the turns A to B a current which will cause a still greater negative charge on the grid. This will reduce the plate current still more.

Finally, due to the peculiar characteristics of the tube, this decrease of plate current ceases and as a result the negative grid voltage drops from lack of support. The plate current then will rise in value inducing a current in the inductance coil which will place a positive charge on the grid. The current in the plate circuit will continue to rise to a certain limit, and the grid voltage will again collapse. This action continues with the result that the pulsating current in the plate circuit causes high frequency oscillations in the grid circuit. The energy of these oscillations is transferred by conductive coupling to the aerial circuit and hence will set up electromagnetic waves.

Question 141. What is meant by I. C. W.?

Answer. By I. C. W. we mean interrupted continuous waves. Such waves occur in groups and can be received on a common crystal or audion receiver. Inn small tube transmitters I. C. W. may be radiated by placing a buzzer in the aerial circuit or in the lead to the filament from the direct current source in Figure 53. The make and break of the buzzer contacts serve to chop up the continuous oscillations into groups.

Question 142. Define the term "modulation," as employed in connection with radio telephony.

Answer. Voice "modulation" is the superimposing of voice vibrations on the radio frequency oscillations generated by the V.T. transmitter. As the voice vibrations vary in amplitude, the modulating agency gives a corresponding amplitude to the emitted waves.

Question 143. How can alternating current be employed as a source of high voltage for a V. T. transmitter?

Answer. Although direct current has been considered as a necessity for C. W. transmitters of the tube type, yet late developments indicate that alternating current will undoubtedly be the prevailing source of current is the result. This decrease of current in the turns of the induct-

In Figure 54 a self-rectifying C. W. tube set is shown.

With this arrangement the tubes that generate the oscillating current also rectify the alternating current for the plate circuits.

The choke coils L_2 and L_3 prevent the oscillations from entering the step-up transformer. The transformer steps the 110 volts up to about 350 or 400 volts on each secondary. L_3 is a 30 henry reactance which prevents the alternating current hum from being bothersome.

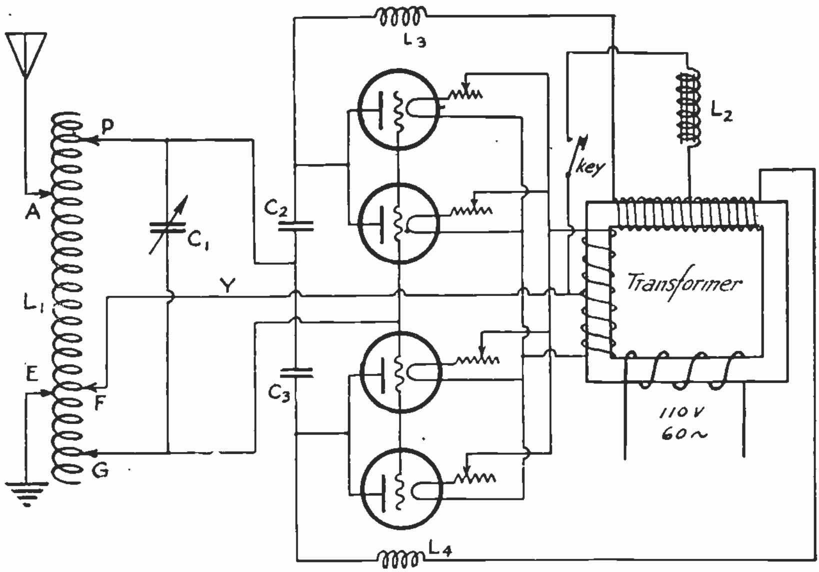


Fig. 54.—A Self-rectifying C. W. Tube Transmitter Operated on 60 Cycle A. C. (By Courtesy of the Q. S. T. Magazine.)

The above circuit, with the exception of the self-rectifying feature, is known as the Hartley.

It will be noted that two tubes are in parallel on each side of the circuit. That is the high voltage secondary of the step-up transformer has its two outer terminals each leading to a pair of plates. Hence, either one pair or the other is charged positively, the result being that both sides of the alternating current source are utilized in producing oscillations. The circuit outside of the self-rectification feature is very similar to Figure 53.

As illustrated the filaments are lighted by alternating current as well. The condensers C_2 and C_3 are to prevent short circuit of the secondary of step-up transformer.

Question 144. Give diagram of a system in which one tube is an oscillator and the second a modulator.

Answer.

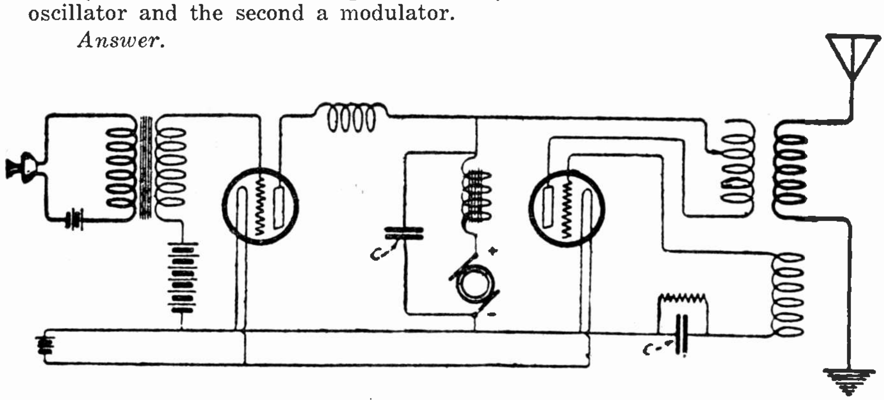


Fig. 55.—Modulating Circuit for a Radiophone Transmitter. (Courtesy of the Wireless Age.)

Question 145. Over what range of wave lengths is the V. T. transmitters adapted?

Answer. The V. T. transmitter has been developed to radiate waves from 50 to 3,000 meters in length.

Question 146. What is the purpose of a milliammeter in the plate circuit?

Answer. The plate milliammeter indicates the magnitude of the plate current and hence assists the operator to properly adjust the transmitter. When the transmitter of a radio phone is spoken into, the plate milliammeter will indicate whether or not the set is functioning properly.

Question 147. What care must be taken of a V. T. transmitter?

Answer. The proper value of filament current can be best determined by means of a volt meter, as a certain per cent change in voltage will cause less change in the filament temperature than the same per cent change in current.

The life of tungsten filaments is very much shortened by using filament current above the normal value.

The tubes should not be confined in an unventilated space, as undue heating may cause breakdown or production of gas in the tube.

Do not exceed the high voltage rating for the tube, except for short periods, as deterioration is bound to occur.

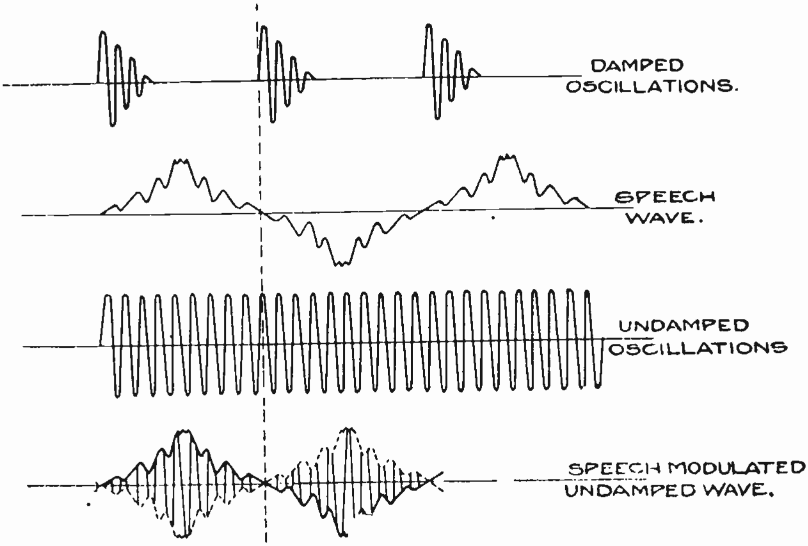


Fig. 55-A.—Diagram illustrating speech wave, undamped waves and speech modulation.

Question 147-A. Show three wave forms to illustrate the speech wave, undamped waves and modulated wave for a radio transmitter.

Answer. See Fig. 55-A.

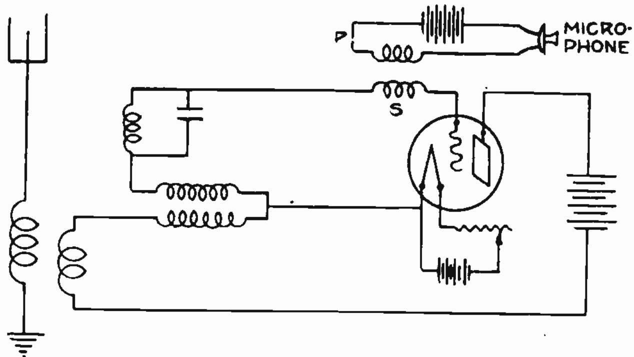


Fig. 55-B.—Diagram of simple microphone transmitter.

Question 417-B. Draw a diagram of a simple transmitter with a microphone to modulate the radio frequency currents produced in the aerial through mutual inductance.

Answer. See Fig. 55-B.

Receivers (Damped)

Question 148. Draw a complete diagram of a modern radio receiver.
Answer.

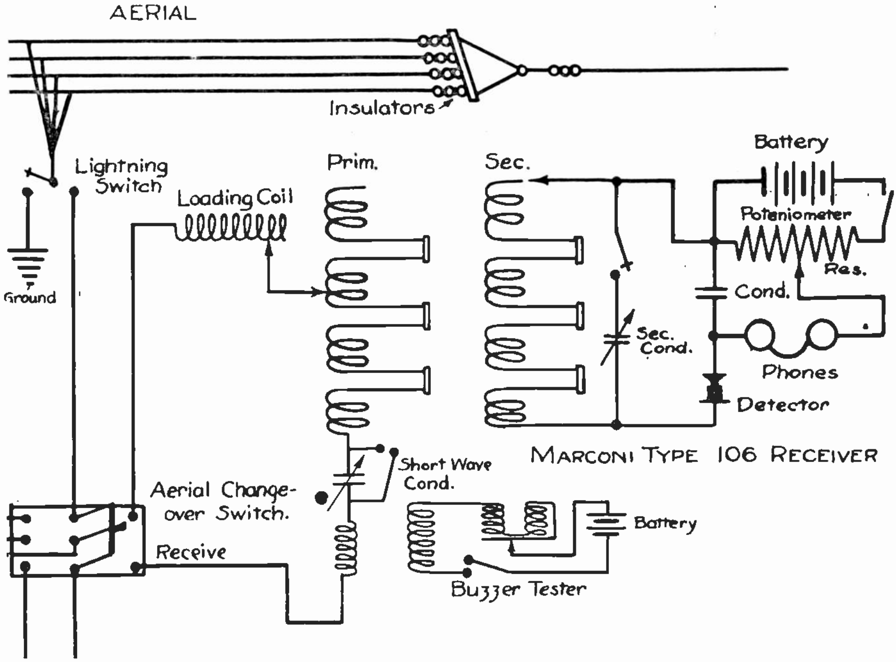


Fig. 56

Question 149. What is the function of a loose coupler in a receiver?
Answer. The loose coupler in a receiver corresponds to the oscillation transformer in a transmitter. Its object is to provide a means of tuning the open and closed circuits and to transfer the energy from the antenna circuit to the local detector circuit.

Question 150. Into what four types may receiving circuits be classified?

Answer.

1. Simple receiver (Figure 57).

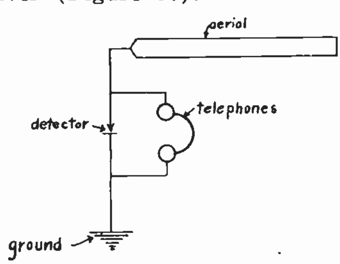


Fig. 57.—Simple Single Circuit Receiver.

2. Conductively coupled receiver (Figures 58 and 59).
3. Inductively coupled receiver (Figure 60).
4. Capacitatively coupled receiver (Figure 61).

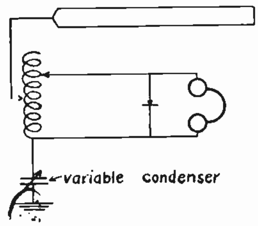


Fig. 58. — Conductively Coupled Receiver (Called Double Slide Turner).

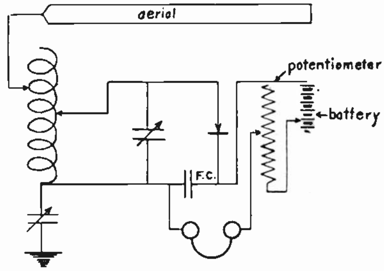


Fig. 59.—Conductively Coupled Receiver with a Crystal Detector and Potentiometer.

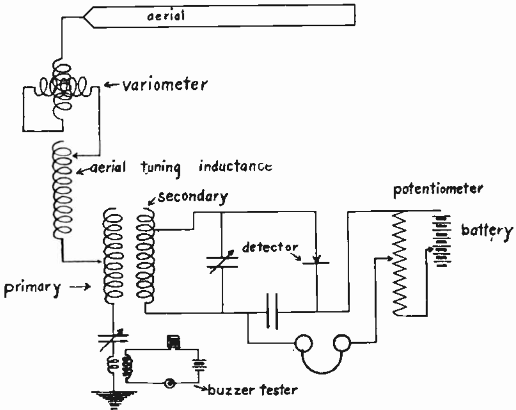


Fig. 60.—Inductively (or Magnetically) Coupled Receiver.

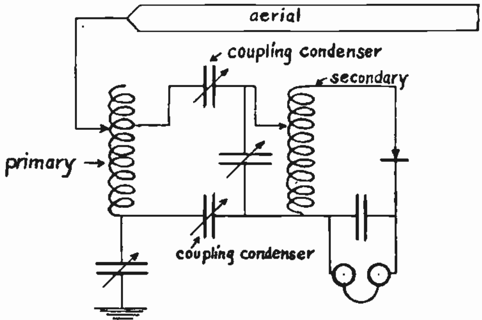


Fig. 61.—Statically (or Capacity) Coupled Receiver

Question 151. For what purpose is a crystal detector used in receiving circuits?

Answer. To convert the incoming radio frequency current into a current that is audible in the telephone receivers. (See Figure 62.)

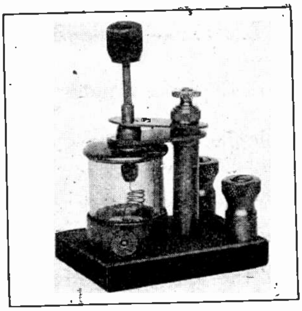


Fig. 62.—An Inclosed Type of Crystal Detector.

Question 152. What is the effect of tightening the coupling of a loose coupler?

Answer. It makes the receiver responsive to a wide range of wave lengths without delicate adjustments of the tuning elements because it increases the damping of the receiver as a whole.

Question 153. Should loose or tight coupling be used for general listening-in?

Answer. Tight coupling is preferable because a wide range of wave lengths may be received without close tuning.

Question 154. What is the advantage of having the coupling of a receiving transformer variable?

Answer. It enables him to tune his receiver "sharply," thereby eliminating much interference from undesired stations even though they may be operating on the same wave length as the station it is desired to receive. This is due to the fact that each transmitter has a different degree of damping.

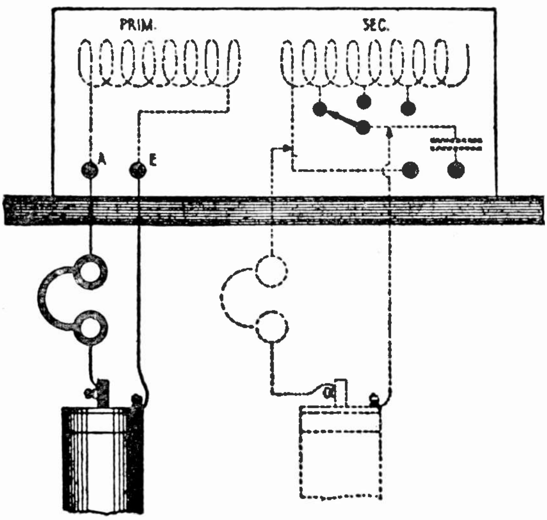


Fig. 63

Question 155. How could signals be received whose wave length is shorter than the natural wave length of the receiving antenna?

Answer. By inserting a variable condenser in series with the antenna circuit.

Question 156. What are the least number of pieces of apparatus necessary to receive signals?

Answer. A pair of telephones and a crystal detector connected as a series circuit with aerial and ground.

Question 157. Name some crystal detectors.

Answer. Galena, silicon, carborundum, perikon, molybdenite, cerusite, ferron.

Question 158. What is the use of a potentiometer in a receiving set?

Answer. Some crystals such as carborundum require an initial battery voltage for sensitive operation. A potentiometer regulates the flow of battery current across the crystal.

Question 159. How would you locate an open in a receiving tuner?

Answer. With a battery and telephone receiver connected as shown in Figure 63, the inductance changing switch is varied from point to point until there is no click in the telephone receiver when the battery circuit is broken. The contact point on the switch where the circuit tests "open" is obviously the point at which the coil is broken.

Question 160. How would you test for a break in the telephone cords?

Answer. The flexible leads may be broken while the insulation about the leads remains good. The connections between the tips and the flexible leads or between the leads and the receiver cases may be broken. A simple test for the telephones is made by touching the tips of the terminals of a dry cell. A further test for poor leads can be made by connecting the tips to the terminals of a dry cell and then shaking the cords. If a rasping sound is heard in the receivers, a renewal of cords is necessary. If the receiving cords need renewal and no spares are available, ordinary insulated wire may be employed.

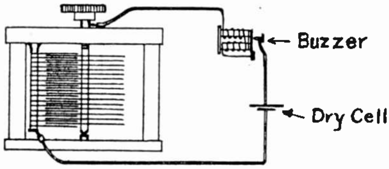


Fig. 64

Question 161. How may a test be made to determine if a variable condenser is short circuited?

Answer. An arrangement similar to that shown in Figure 64 may be employed. If the buzzer is set in operation as the moving plates are rotated the condenser is short circuited.

Question 162. Why are the windings of head telephones for wireless receivers of high resistance?

Answer. The magnetizing force of any current carrying coil depends on the number of ampere-turns. Hence to get the loudest response in a telephone from very weak signals, it is necessary to use many hundreds of turns of wire, and due to the limited space we must use very small insulated wire. The smaller the wire, the greater the resistance, which accounts for the fact that all sensitive telephones are of very high resistance (1,500-2,000 ohms).

Question 163. What is the use of the variable condenser in shunt to the secondary winding of a receiving transformer?

Answer. The variable condenser in shunt to the secondary of the receiving set serves to add capacity to the circuit and permit a finer degree of tuning of the secondary circuit than could be obtained by only varying the value of the inductance of the secondary.

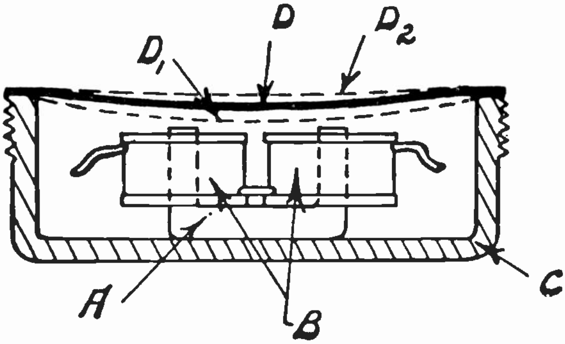


Fig. 65.—Constructive Features of a Telephone Receiver.

Question 164. Explain how you would adjust a crystal detector to its maximum degree of sensitiveness?

Answer. Set the test buzzer into operation and alternately place the detector contactor or cat-whisker upon various points on the crystal until the maximum strength of signals from the buzzer are heard in the telephone receivers.

Question 165. What is the function of a telephone receiver?

Answer. To convert electric currents into sound.

Question 166. Explain the construction and operation of a telephone receiver.

Answer. A telephone receiver consists essentially of an electromagnet and a diaphragm.

Figure 65 shows a section of a receiver. The diaphragm D usually consists of a circular piece of very thin sheet iron supported by the shell of the receiver, so that it is very close to the ends of the magnet. The iron core of the electromagnet is to a certain extent permanently magnetized, so that normally the diaphragm is pulled slightly toward the magnet as indicated by D. As a current is sent through the coil of the magnet so that the lines of force set up assist those of the permanent magnet, the strength of the magnet will be increased and the diaphragm will be pulled closer to the magnet as in position D_1. However, when the current flows in the opposite direction, the lines of force set up by the coil oppose those of the permanent magnet, thus decreasing the total strength of the magnet and allowing the diaphragm to spring farther away from the pole and take the position of D_2.

Question 167. Give a diagram of a receiver circuit employing a three-element vacuum valve detector.

Answer. See Figure 66.

Question 168. Explain the action of a vacuum tube detector in a receiving circuit.

Answer. When the filament is burning, electrons are thrown off, which are attracted to the plate due to the fact that it is charged positively by the battery. A flow of negative electricity is said to flow from the filament to the plate, but as we usually consider the current as flowing from the positive pole of a battery to the negative pole, we consider

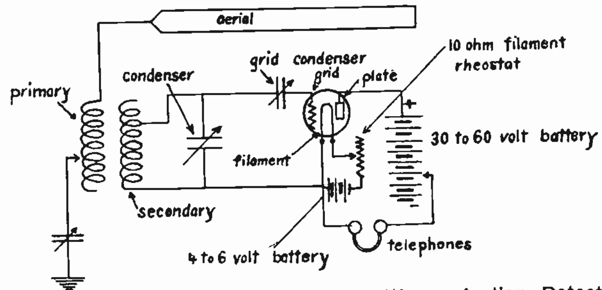


Fig. 66.—Receiving Circuit Diagram with an Audion Detector.

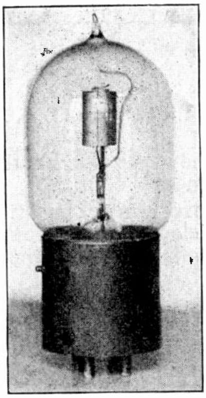


Fig. 67.—External View of an Audion Bulb.

the current as flowing from the plate to the filament and thence through the phones back to the battery. Therefore, as long as the filament is burning there will be a flow of current through the phones; but, owing to the fact that it is steady, there will be no vibration of the diaphragm.

If oscillations are flowing in the receiver circuits, alternate positive and negative charges will be given to the grid. When the grid is charged negatively, no current flows from the grid to the filament, but when the grid is positively charged current passes from the grid to the filament. In other words, when the grid is charged negatively, the electrons will be repelled and no negative flow of electricity will occur; but when the grid is charged positively the electrons will be attracted and a negative flow to the grid will take place.

During the times that the grid is charged negatively no current passes; therefore, a negative charge piles up in the grid condenser on the side next to the grid. This negative charge causes a decrease in the flow of electrons to the plate and consequently the flow of current from the plate to the filament is reduced. After a train of oscillations has passed, the negative charge leaks off and the plate current returns to normal. Thus, each train of oscillations reduces momentarily the flow of current through the plate circuit. This reduction of current causes a click in the telephone receivers, the number of clicks per second being dependent upon the number of trains of oscillations.

Question 169. Explain the construction and name the parts of a three-element vacuum tube.

Answer. A three-element vacuum valve consists of an evacuated glass tube, in which are mounted a tungsten filament, a coil or perforated

Question 173. What are some of the advantages of the undamped wave system?

Answer.

1. As the waves are of constant amplitude there is no decrement and consequently they are confined to one wave length or frequency.
2. Being continuous, the amplitude need not be so great, and therefore lower potentials may be employed.
3. Radio telephony is made possible.
4. The tone of the received signals can be controlled by the receiving operator.
5. The efficiency of the undamped system is far greater than that of the damped.

Question 174. Name the different methods by which sustained oscillations are made audible in the telephone receivers.

Answer. 1. By means of a chopper in either the transmitting or receiving set. In the receiving set this device is usually called a "tikker" and is operated in conjunction with a crystal detector as shown in

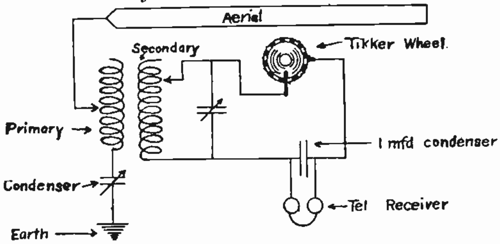


Fig. 70.—Diagram of Connections for a Tikker.

Figure 70. A small metal disc having teeth cut in its periphery is mounted on a shaft of a small electric motor, the spaces between the teeth being filled with an insulating material. A spring brush bears on the edge of the disc, alternately making and breaking contact with the disc. A second brush makes continuous contact with the side of the disc. The rotation of the disc interrupts the continuous wave oscillations at a frequency varying between 400 and 1,000, so that when rectified by the crystal detector the signals are audible in the telephone receiver.

2. By means of a slipping contact detector, which operates on practically the same principle as the tikker, except that it depends upon plate called a grid and a cylinder or plate of metal called the plate. The grid is placed between the filament and the plate. (See Figure 67.)

Question 170. What is the function of the filament rheostat?

Answer. To regulate the brilliancy of the filament. If the brilliancy of the filament is increased, more electrons will be thrown off.

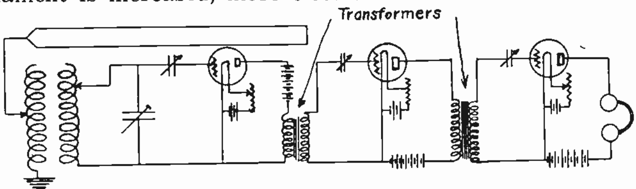


Fig. 69.—Diagram of a Two-step Cascade Amplifier.

Question 171. Draw a diagram of a complete receiver employing a two-stage cascade amplifier.

Answer.

Question 172. What is the function of the grid leak?

Answer. When placed around the grid condenser it allows the negative charges stored up in the grid condenser to leak off after the passage of a train of oscillations.

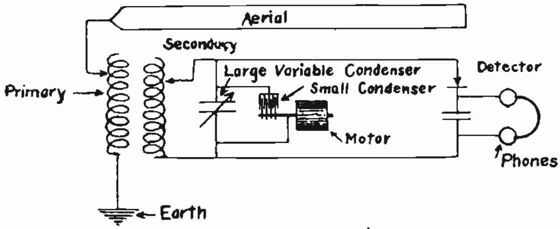


Fig. 71.—Receiving Circuit Using a Rotating Plate Condenser.

the varying resistance between a slipping contact on a groove in a rotating pulley to interrupt the continuous wave current so that the signals in the telephones are of an audible frequency.

3. By means of a rotating plate condenser (See Figure 71). The value capacity of the large variable condenser is so adjusted that the addition of the maximum value of the rotating condenser will place the secondary circuit in resonance with the incoming signals. Thus, for each revolution of the condenser shaft there will be an impulse of the telephone diaphragm. The tone of the signals may be varied by varying the speed of the rotation of the condenser shaft.

4. By means of the Goldschmidt tone wheel.

5. By means of a heterodyne receiver, which makes use of a local source of radio frequency current in combination with the incoming wave to produce a beat note in telephone receivers. The frequency of the beat note is equal to the difference between the frequency of the incoming signals and the frequency of the superimposed current.

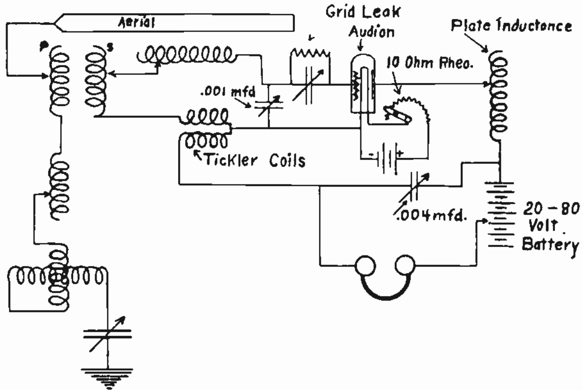


Fig. 72.—Wiring Diagram for a Regenerative Audion Hook-up.

6. By means of the regenerative vacuum valve, which also employs the principle of the production of the beat note.

Question 174-A. What is the function of a tickler coil in a vacuum valve receiver.

Answer 1. To transfer part of the energy of the oscillating plate current set up by the incoming oscillations back into the grid circuit, thus producing amplification.

2. To enable the tube to generate oscillations of high frequency.

Question 174-B. Explain the "B" battery and its use.

Answer. The "B" battery of 20 to 200 volts is connected in the plate circuit. This battery supplies the current which flows in the phone circuit. The increase or reduction of the current at an audio frequency produces signals in the telephones. The positive side of the battery is connected to the plate.

Question 174-C. Make a drawing to illustrate a closed coil (loop) aerial connected to an audion receiver.

Answer. See Fig 72-A.

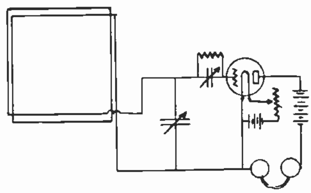


Fig. 72-A.—Diagram of Loop Aerial and Audion Detector.

Question 174-D. Make a drawing for an audion detector receiver with one step of amplification.

Answer. See Fig. 72-B.

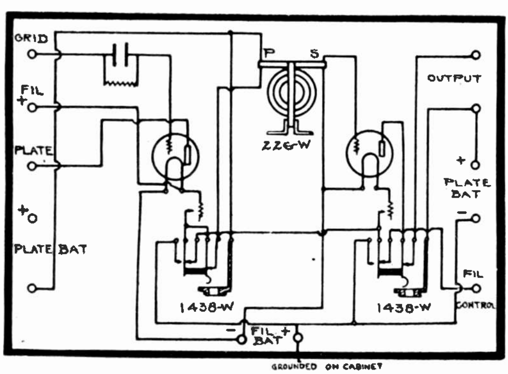


Fig. 72-B.—Diagram of connections of Audion and one step of Amplification

Question 174-E. Make a drawing of a single circuit regenerative audion receiver.

Answer. See Fig. 72-C.

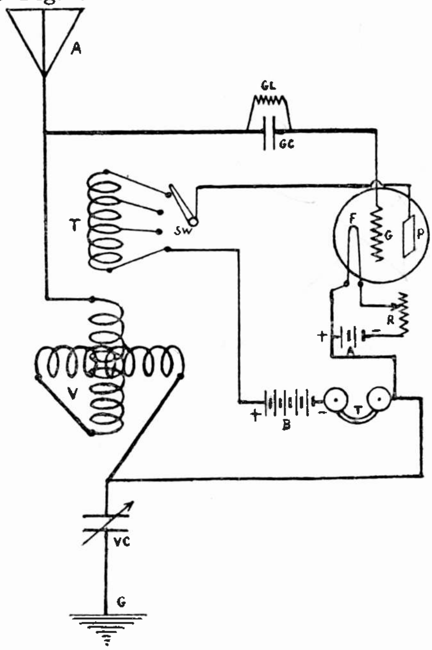


Fig. 72-C.—Diagram of single circuit Regenerative Audion Receiver

Question 174-F. Show by a diagram the hook-up for a DeForest three-coil (Honeycomb) audion receiver.

Answer. See Fig. 72-D.

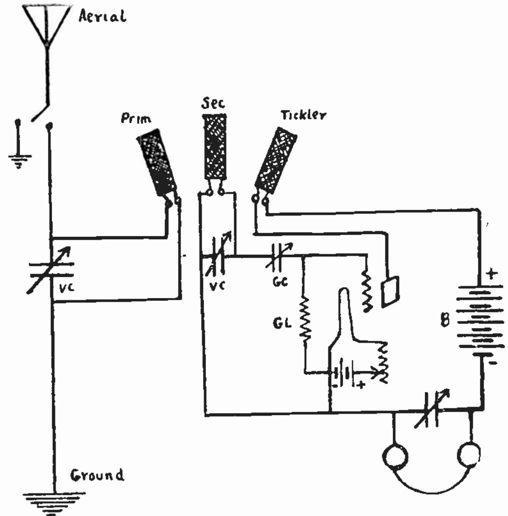


Fig. 72-D.—DeForest honeycomb coil type of receiver.

Question 174-G. Show the complete diagram of connections for a Radio-phone Receiver (vario coupler, two variometer type) with two stages of amplification and loud speaker.

Answer. See Fig. 72-E.

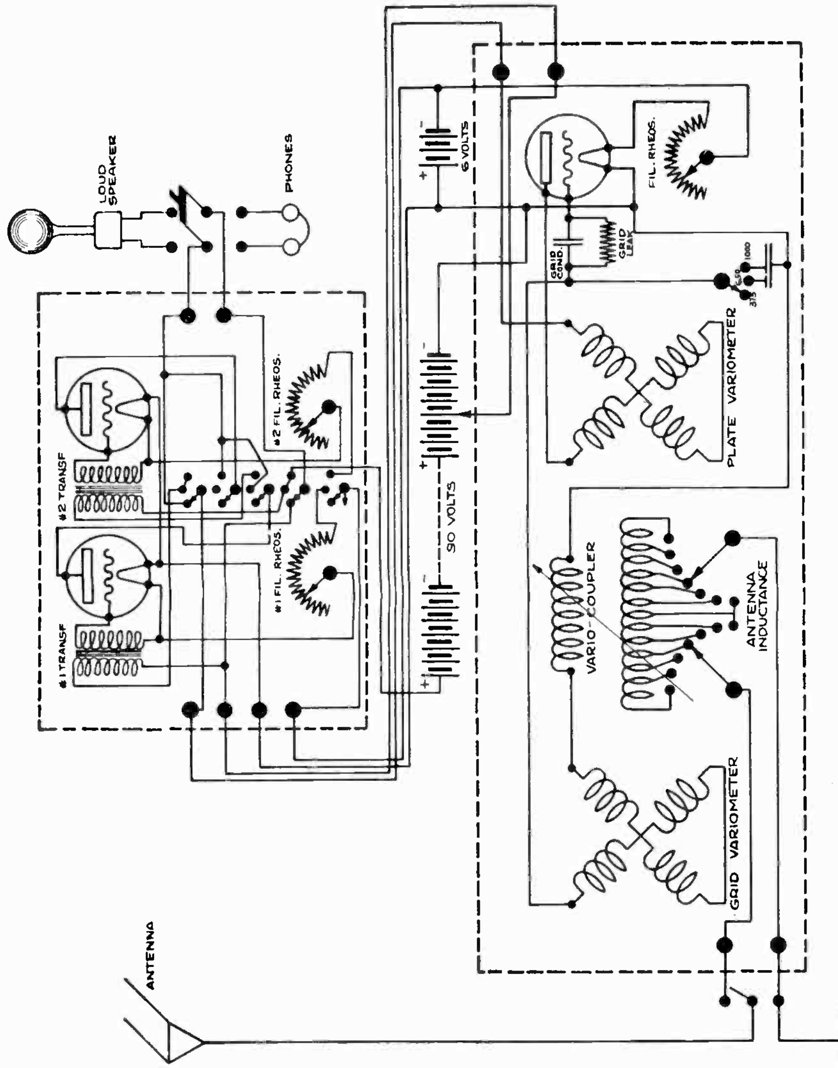


Fig. 72-E.—Diagram of Radiophone receiver with two stages of amplification with loud-speaking horn or phones

RADIO LAWS and REGULATIONS

Question 175. What is the normal wave length for ship stations?

Answer. 600 meters.

Question 175-A. What other wave lengths are used?

Answer. 300 and 450 meters or wave lengths in excess of 1,600 meters.

Question 176. What is meant by a pure wave?

Answer. A wave such that when the energy is radiated in two or more wave lengths, the energy in no one of the lesser waves exceeds 10 per cent of that in the greatest.

Question 177. What is the international signal of distress?

Answer. · · · — — — · · ·

Question 178. What is the U. S. Regulation in regard to the amount of power to be used in the vicinity of government stations?

Answer. No station on shipboard, when within 15 nautical miles of a naval or military station, shall use a transformer input exceeding one kilowatt nor, when within 5 miles of such a station, a transformer input exceeding one-half kilowatt, except for sending signals of distress or signals or radiograms relating thereto.

Question 179. What is the law in regard to the use of unnecessary power?

Answer. In all circumstances, except in case of signals relating to vessels in distress, all stations shall use the minimum amount of energy necessary to carry out any communication desired.

Question 180. How should the transmitter be adjusted for sending distress signals?

Answer. When sending distress signals, the transmitter of a station on shipboard may be tuned in such a manner as to create a maximum of interference with a maximum of radiation, i, e., broadly tuned.

Question 181. What is the law in regard to the secrecy of messages?

Answer. No person or persons engaged in or having knowledge of the operation of any station or stations shall divulge or pubilsh the contents of any messages transmitted or received by such station, except to the person or persons to whom the same may be directed, or their authorized agent, or to another station employed to forward such message to its destination, unless legally required to do so by the court of competent jurisdiction or other competent authority. Any person guilty of divulging or publishing any message, except as herein provided, shall, on conviction thereof, be punished by a fine or not more than two hundred and fifty dollars or imprisonment for a period not exceeding three months, or both fine and imprisonment in the discretion of the court.

Question 182. Explain how to call another station.

Answer. 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.

Quesion 183. Explain how a call should be answered.

Answer. The call 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 — · —.

Question 184. What signal shall terminate the transmission of a radiogram?

Answer. · — · — ·

Question 185. In calling another station, what wave length should be used?

Answer. If possible, the normal wave length of the station being called should be used. This is almost always 600 meters.

Question 186. How many times may a call be repeated?

Answer. If a station called does not answer the call transmitted three times at intervals of two minutes, the call shall not be repeated until after an interval of fifteen minutes, the station issuing the call having first made sure of the fact that no radio correspondence is in progress.

Question 187. Does the ship station or the coast station determine the order in which radiograms shall be transmitted?

Answer. The coast station.

Question 188. What signals should be used to terminate the transmission of a series of radiograms?

Answer. The call letters of the sending station and the signal — · —.

Question 189. How many times may a radiogram be repeated?

Answer. A radiogram shall be transmitted three times at the request of the receiving station. If in spite of such triple repetition the signals are still unreadable the radiogram shall be canceled.

Question 190. What is the rule in regard to intercommunication?

Answer. All commercial radio stations are bound to communicate with each other regardless of the type or system of radio apparatus employed.

Question 191. Name and describe the system used in determining the number of words in a radiogram.

Answer. The cable count shall be observed, and all words in the address, text, and signature must be counted and charged for. In the cable count system, messages are divided into three classes; *i. e.*, messages in plain language, code language or cipher. (1) Radiograms in plain language are those composed of words, figures, and letters which offer an intelligible meaning in any of the European languages or Latin. The words and letters must be written in Roman characters. In case of unfamiliarity with the language being sent, the sending operator's statement that a message is in "plain language" shall be accepted. The presence of trademarks or of abbreviated expressions current in the country, as fob, uss, cod, etc., does not alter the character of a plain language radiogram, but the presence of code words in an otherwise plain language message subjects all the words in the message to a 10-letter count. The maximum length of a chargeable word in plain language is limited to fifteen letters or characters. (2) Code language is composed of real words not forming intelligible phrases or of artificial words consisting of groups of letters which must be selected from or pronounceable in any of the following languages: English, French, German, Dutch, Italian, Spanish, Portuguese, and Latin. If unpronounceable groups appear in code messages, such groups will be subject to the 5-letter count. (1) Cipher is composed of (*a*) Arabic figures or groups, or series of Arabic figures having a secret meaning, or letters or groups, or a series of letters having a secret meaning; (*b*) combinations of letters not fulfilling the conditions applicable to plain language or code counted at five letters or figures to a word. Letter and figure cipher can not be combined in one group.

Question 192. Give as many of the international abbreviations as possible.

Answer.

List of Abbreviations to be Used in Radio Communications

Abbreviation.	Question.	Answer or Notice.
C Q	— · — · — — · —	Signal of enquiry by a station desiring to communicate.
T R	— · — ·	Signal announcing the sending of particulars concerning a station on shipboard (Art. XXII).
(!)	— — · · — —	Signal indicating that a station is about to send at high power.
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? Is my spark bad?	The tone is 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	Dd 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.
QTE	What is my true bearing?	Your true bearing is............degrees from............DF station (Radio Compass Station).

Abbreviations.	Question.	Answer or Notice
QRHH	What tune shall I adjust for?	Adjust to receive on tune ....
QRLL	Request permission to test .... minutes.	Permission to test granted.
QTC	Have you anything to transmit?	I have something to transmit.
QTF	What is my position?	Your position is .... latitude .... longitude.

Question 193. What ships are required by law to carry radio sets?

Answer. Ships licensed to carry or carrying 50 or more persons, including passengers or crew, or both, except for ships plying between ports less than 200 miles apart.

Question 194. What class of radiogram has priority over all others?

Answer. Distress signals or radiograms relating to ships in distress have precednce over all others.

Question 195. What is a sharp wave?

Answer. By the term "sharp wave" is meant that the energy radiated is confined principally to one frequency or to one wave length. If the logarithmic decrement is .2, the Department of Commerce considers that the station is radiating a "sharp wave."

Question 196. To whom can an applicant apply for information concerning examinations or licenses?

Answer. To the U. S. Radio Inspector of the District in which they live. This official has his office in a custom house.

Question 197. What are the regulations and what is the penalty for interfering with radio communication?

Answer. The law states that an operator shall not wilfully or maliciously interfere with any other radio communication. An operator convicted of such misdemeanor shall be punishable by a fine of not exceeding $500 or imprisonment for not to exceed one year, or both.

Question 198. What is the rule regarding any false or fraudulent signals?

Answer. The Government regulations stipulate that a person, company or corporation of the United States shall not knowingly utter or transmit, or cause to be uttered or transmitted, any false or fraudulent distress signal or call or false or fraudulent signal, call or other radiogram of any kind. The penalty for transmitting false or fraudulent distress signals is a fine of not more than $2,500 or imprisonment for not more than five years, or both. The penalty for other false or fraudulent signal call or other radiogram shall be a fine of not more than $1,000 or imprisonment for not more than two years or both for each and every offense.

Question 199. What is the rule concerning superfluous signals?

Answer. The transmission of superfluous signals by any ship or coast station is absolutely prohibited; trials and practices are forbidden, except under such circumstances as to preclude the possibility of interference with other stations.

Question 200. What was the London Convention, and where was it held?

Answer. The London Convention was held in London in 1912, and was a conference of representatives of the principal countries of the world. The convention made certain provisoins for the regulation of radio communication and took effect in the United States on July 9, 1913.

Question 201. Is it necessary that there be a station license in addition to an operator's license?

Answer. Yes. A station must have a license as well as the person who operates the apparatus.

Question 202. What wave length and method would you use in calling for radio compass bearings?

Answer. In calling for radio compass bearings 800 meters is now very generally used. To obtain bearings the direction-finding station is called in the usual manner on 800 meters and the call followed by OTE? If told by the direction-finding station to "K" the ships, operator may follow the procedure outlined below:

(*a*) Transmit the ship's call for 30 seconds.

(*b*) Make dashes, each dash 5 seconds long, for one minute, with the ship's call after each dash.

(*c*) Terminate with the signal "K" (Go ahead).

Question 203. What is the difference between the United States and the International regulations for the use of emergency equipment?

Answer. The United States law requires an auxiliary power supply, independent of the vessel's main electric power plant, must be provided, which will enable the sending set for at least four hours to send messages over a distance at least 100 miles, day or night, and have sufficient communication between the operator and bridge shall be maintained at all times. The International regulations state that ships shall have auxiliary radio installations for distress signals. Such emergency installation shall have its own source of power, be capable of quickly being set into operation, of functioning for at least six hours, and have a minimum range of 80 nautical miles for ships of continuous service and 50 miles for those of limited service.

Question 204. How are receiving stations protected from the use of high power by nearby stations?

Answer. Every station which has occasion to transmit a radiogram requiring the use of high power must first send out three times the signal of warning — — · · — —, with the minimum of power necessary to reach the neighboring stations.

Question 205. What should an operator do with his Commercial License Certificate during service?

Answer. An operator should frame his operating license and place it in the radio station for inspection by Department of Commerce officials.

Question 206. To whom is the radio operator responsible while at sea as an operator?

Answer. The radio operator aboard ship is responsible to the master of the vessel.

Question 207. What is the new method of rating wireless operators?

Answer. Licenses to radio operators after June 30, 1921, will certify to—first, efficiency in radio communication (class); second, duration and quality of service (grade).

Question 207-A. What is the rule governing the transmission of long messages?

Answer. When the message contains more than 40 words, the sending station should interrupt the transmission by the signal UD after every 20 words and should not resume the transmission until the receiving station acknowledges the receipt of the last word with the signal K (to go ahead).

Question 207-B. What would you do if you heard a ship sending out a distress call SOS? Answer fully.

Answer. Cease all communication and listen in to determine position and all details. Full information should be immediately conveyed to captain of ship. From that time the operator should work under his orders. Do not answer call unless your call letters are sent out from ship in distress.

Efficiency

The standards of efficiency established by international conventions are as follows:

First Class (Article X, Radio Convention, 1912).—(*a*) Adjustment of the apparatus and knowledge of its functioning.

(*b*) Transmission and acoustic reception at the rate of not less than 20 words a minute.

(*c*) Knowledge of the regulations governing the exchange of radio correspondence.

Second Class (Article X, Radio Convention, 1912).—Ability to transmit and receive at a rate of only 12 to 19 words a minute but who, in other respects, fulfill the requirements mentioned above.

Watchers' Class (Article XXXV, Safety at Sea Convention, 1914).—Ability to receive and understand the radiotelegraph distress signal and the safety signal.

Extra First Class.—In addition to these the Department of Commerce will continue the issuing of licenses certifying to—

(*a*) Adjustment of the apparatus and knowledge of its functioning.

(*b*) Transmission and acoustic reception at the rate of not less than 30 words per minute, Continental Morse, and 25 words per minute, American Morse (five letters to the word).

(*c*) Knowledge of the regulations governing the exchange of radio correspondence which will be designated commercial extra first class.

Service

Hitherto the duration and quality of service has been shown by the indorsements on the license of the operator. These indorsements will be made as heretofore, and license of the several classes above enumerated will be graded also as follows:

Third Grade.—Less than 6 months satisfactory commercial service and (a speed of 12 words a minute in the second class).

Second Grade.—Six months or more satisfactory commercial service in the third grade and a speed of 20 words a minute.

First Grade.—A year or more satisfactory commercial service in the second grade and a speed of 25 words a minute.

Satisfactory service as an operator in any branch of the Federal service shall be deemed equivalent to like commercial service.

Outstanding Licenses

Outstanding licenses will be valid until they expire, when the renewal will show the grade to which the operator is entitled.

Radio Compass

Question 208. For what uses is the radio compass employed?

Answer. 1. To enable the operator to determine the direction and preferably the location of a transmitting station.

2. As a directive receiver to reduce interference from transmitters whose signals are not desired and whose location is not in a direct line between the desired transmitting station and the receiving station.

Question 209. Upon what principle does the radio compass operate?

Answer. Upon the principle that when a coil is turned so that the plane of its windings is perpendicular to the direction of an electric wave traveling from a distant source, the induced E. M. F. is at a minimum, but when the coil is turned so that the plane of its winding is parallel to the direction of wave travel, the lines of force cutting the coil will be at a maximum and the induced current will be at a maximum value.

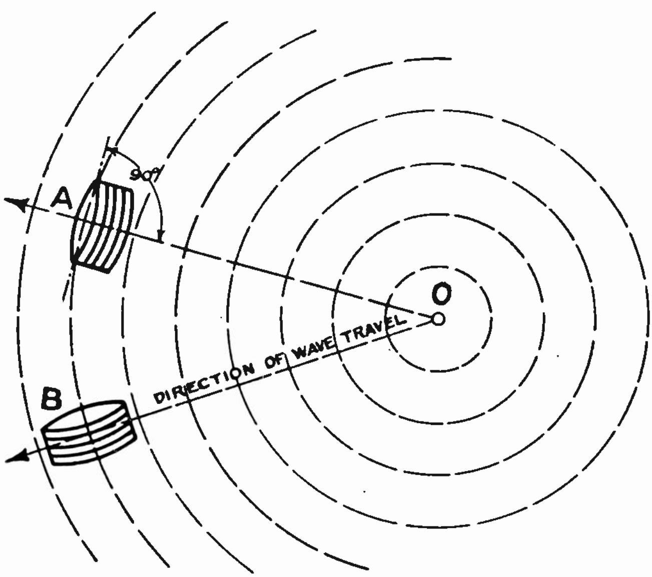


Fig. 73.—Showing Coil in Two Positions Relative to Field of Transmitting Antenna. (Courtesy of Robinson's Manual of Radio Telegraphy.)

This can be better illustrated by the use of a diagram. In Figure 73 point O is a transmitting station sending out electric waves as indicated by the dashed circular lines. If a coil is arranged as shown at A, theoretically there will be no lines of force cutting the coil and if additional instruments were added as shown in Figure 74 (showing the elementary diagram of the instruments as connected when used in a radio compass station) the signal strength in the telephone receivers would be at a minimum. However, if the coil were rotated 90 degrees as shown in B, the signal strength would be at its maximum because the maximum number of lines of force would be cutting the coil.

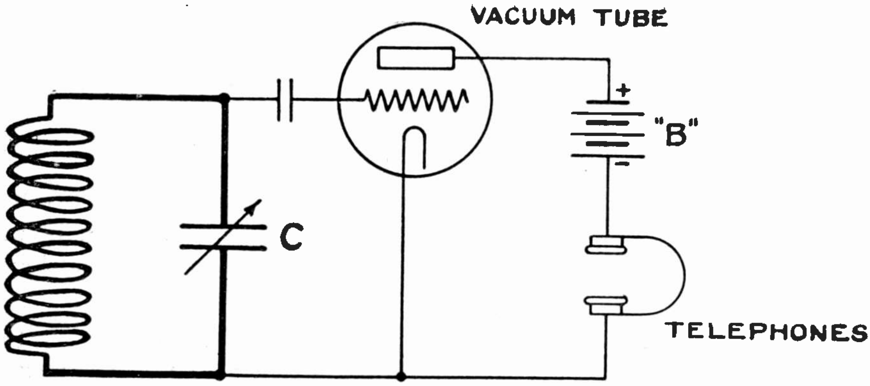


Fig. 74.—Arrangement of Tuning Coil and Detector. (The A or Filament Battery is Omitted Here. See Figure 66 for These Connections.) (Courtesy of Robinson's Manual of Radio Telegraphy.)

In the operation of such a coil when used in a radio compass station, there is what is termed as a "broad maximum." That is, there is not a critical position in the rotation of the coil at which the signal intensity, as indicated in the receiver, is of such a maximum value that it is readily distinguished from other values of intensity occurring while the coil is rotated for a number of degrees on each side of it. However, it is possible to obtain a critical position of the coil when it is rotated so that the plane of turns is at right angles to the incoming signals. This is what is known as a "sharp minimum," and in practical operation of the radio compass the settings of the coil when the signal strength is minimum are used for direction finding. By using the minimum rather than the maximum signal values much more accurate bearings may be taken.

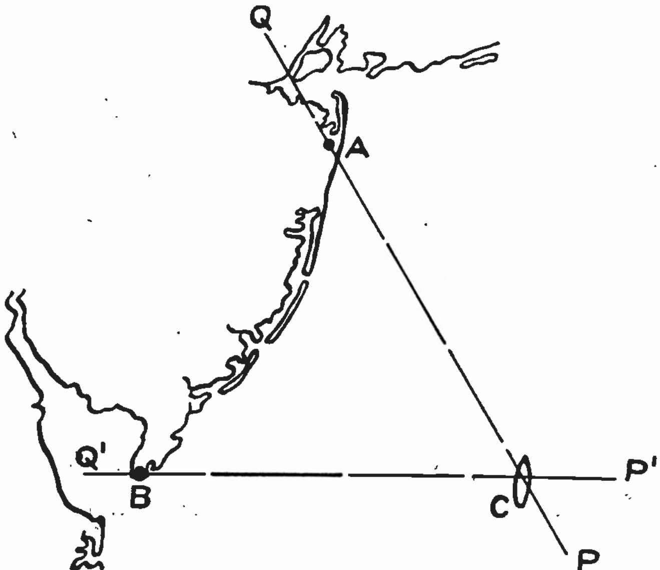


Fig. 75.—Method of Determining Absolute Direction and Location of Transmitting Station. (Courtesy of Robinson's Manual of Radio Telegraphy.)

Question 210. In the rotation through of a coil used for direction finding purposes, what takes place?

Answer. Two minimum and two maximum positions of the coil may be found, each pair being 180 degrees apart. This method of operating a compass station is known as the bilateral method and will indicate only the line of bearing of the transmitting station. As two minimum positions are found by this method, the bearing as indicated by the position of the coil may be either correct or there may be an error of 180 degrees. Therefore, when the general direction of the transmitting station is unknown, no practical results may be obtained by means of the bilateral method.

Question 211. Under what circumstances may the bilateral method be used for determining the position or bearing of a transmitting station?

Answer. By using two or more compass stations employing this method. A general idea of how such bearings may be obtained is shown in Figure 75. In this diagram A and B are compass stations, located some distance apart, while C is the transmitting station. Both A and B may obtain a line of bearing of the transmitting station, as shown by QP and Q_1P_1.

Communication is established between the two stations by land line, submarine cable, etc., so that the operator at one of the stations may possess both the lines of bearing. By plotting them on a chart, and noting the point of intersection between the two converging lines, he may easily determine which minima indicates the true bearing and which is ambiguous. Thus the position of the ship may be determined. Usually, the compass stations on the coast of the United States are able to obtain bearings of a ship, which, when worked out on a chart, will give the position of the ship accurate to within a mile or so of its true position.

When three compass stations are used the lines of bearing of the transmitting station from the various compass stations will not usually meet in a single point when plotted on a chart, but will form a triangle. In such cases, the center of the triangle is taken as the position of the ship.

Question 212. What recent invention has made the use of a direction finding coil practical for radio compass work?

Answer. The invention of the vacuum valve and its use as an amplifier. The efficiency of a coil when used in this manner for receiving purposes is very small, so that in order to produce signals in the receiving telephones of readable intensity a number of stages of amplification are necessary.

Question 213. What wave length is used in the United States for radio compass work?

Answer. 800 meters.

Question 214. What difficulty is sometimes encountered when radio compass stations are operated on shipboard?

Answer. The huge mass of metal in the vicinity of the station usually distorts the wave from the transmitter, so the bearings obtained are not accurate.

Question 214-A. Explain the method of obtaining bearings from a radio compass station on the coast of the United States.

Answer. To obtain bearings, the direction finding station should be called on 800 meters in the usual manner, and the call followed by the signal "QTE?" meaning "What is my true bearing?" When told by the direction finding station to "K" (go ahead), the ship's operator should follow the procedure outlined below:

(a) Transmit the ship's call signal for 30 seconds.

(b) Make dashes, each dash five seconds long, for one minute, with the ship's call signal after each dash.

(c) Terminate with the signal "K" (go ahead).

If satisfactory bearings are obtained, the operator at the direction finding station will call the vessel in the usual manner and reply "QTE," followed by the true bearing in degrees (0 to 359) spelled out in words, and the name of the direction finding station from which the bearing was obtained; otherwise a repetition will be requested.

The ship's operator should acknowledge receipt of the bearings by answering the direction finding station in the usual manner and repeat, in numerals, the bearing received. This procedure enables all stations concerned to check the bearings.

All United States direction finding stations keep watch and transmit on 800 meters for merchant vessels, and this wave should be used for calling and answering and carrying on all communication with these stations.

Storage Batteries

Question 215. For what purposes are storage batteries used in a radio transmitter on shipboard?

Answer. Storage batteries are used as an emergency D. C. source of supply in case a current supply is not available from the ship's dynamo, and is often used for emergency lighting of the ship.

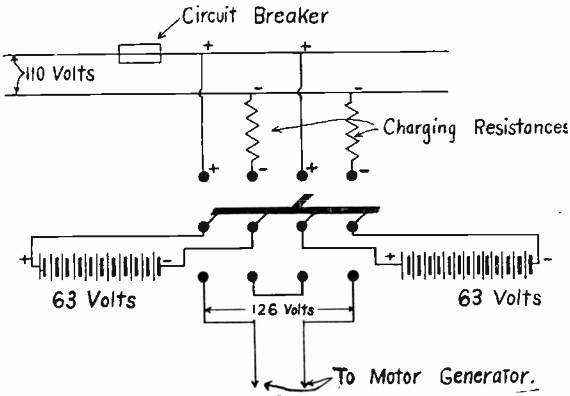


Fig. 76.—Charge and Discharge Switch Connections.

Question 216. Draw a diagram showing the connections for charging and discharging a battery of storage cells to be used as an auxiliary source of current for a marine transmitter.

Answer.

When the switch is in the upward position the two banks of batteries are charging in parallel. When the switch is thrown downward they are discharging in series.

Question 217. Explain the constructive features of a hydrometer with syringe, and tell how it is used.

Answer. The hydrometer consists of a glass tube containing a graduated scale (marked 1.000 to 1.300 on paper) within, and the lower part of the tube being enlarged to about twice its diameter, and contains lead shot or some heavy substance that will cause it to stand upright as it sinks in the electrolyte. The hydrometer may be placed in the solution where the cells have open tops, but usually the solution is drawn up into the chamber of a syringe, as shown in Fig. 77, containing the hydrometer.

Question 218. Explain the essential parts of a lead cell.

Answer. The lead cell consists of two plates, the positive, lead peroxide, and the negative, spongy lead, immersed in a 20 per cent solution of sulphuric acid (4 parts of distilled water and 1 part commercial pure acid).

Question 219. What is meant by the electrolyte of a cell?

Answer. The fluid in the cell consisting of a solution of sulphuric acid in the case of the lead cell.

Question 220. What are the materials used in an Edison cell?

Answer. The positive plates of an Edison cell are made of nickel oxide, and negative plate is iron oxide. Both are immersed in a 21 per cent solution of caustic potash, with a small per cent of lithium.

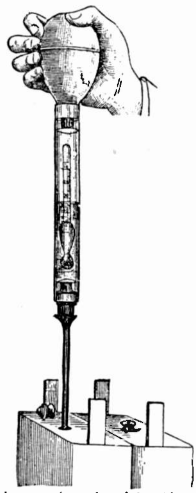


Fig. 77.—Battery Hydrometer Inside the Barrel of a Syringe.

Question 220a. What is meant by local action in a cell?

Answer. It is a chemical action taking place between some metal impurity within the cell and one of the plates. This action reduces the strength of the cell and causes a permanent injury to the plate acted upon.

Question 221. How is the capacity of a storage cell rated?

Answer. In the number of ampere-hours of current which may be taken from it under normal conditons. An ampere-hour is the amount of current passing through a circuit in one hour when the current strength is one ampere. (Amperes × hours = ampere-hours.)

Question 222. Give the ampere-hour minimum capacity for storage battery auxiliary sets supplying current for ½ KW, 1 KW and 2 KW transmitters, respectively.

Answer. ½ KW—60 ampere-hours.
1 KW—80 ampere-hours.
2 KW—140 ampere-hours.

(Larger sizes may be installed for lighting of ship in emergency cases.)

Question 223. What is the purpose of an underload circuit breaker in charging circuits?

Answer. It is essential that the voltage of the charging source be greater than that of the battery being charged. In case the charging voltage drops below that of the storage battery, there would be a flow of current from the battery back through the charging generator. This action would probably depolarize the generator field and at the same time run down the battery. To prevent this an underload circuit breaker is employed, which opens the line to the generator when the voltage of the generator falls below that of the battery.

Question 224. What is meant by the normal rate of discharge of a storage cell?

Answer. The number of amperes, which may be drawn from the cell without injury to the plates. This varies with the different makes of cells. The value may be found by dividing the capacity in ampere-hours by the hours rating of the cell. (Cells are usually rated on a 5 or 8 hour basis.)

Question 225. Define specific gravity of an electrolyte.

Answer. The weight of a volume of the electrolyte as compared to the weight of an equal volume of water as a standard. It indicates the strength of the solution and is measured by a hydrometer. It shows how many times heavier the substance is than water.

Question 226. Compare the *lead* and *Edison* types of storage cells.

Answer. The lead cell has a maximum voltage of 2.1 and a minimum of 1.7. The Edison cell has a maximum voltage of 1.2 and a minimum of .9. The lead cell should be charged and discharged at or near the normal rate. The Edison cell may be overcharged or overdischarged, or even short circuited, without injury to the plates. The lead cell, if allowed to remain idle, will lose its charge, and if left in a partially discharged or discharged condition for any length of time, deterioration of the plates will take place. The Edison cell will retain its charge for a long time and is not damaged by being left in a discharged condition.

Question 227. What care should a lead cell receive?

Answer.

1. The lead cell should be kept clean and dry, allowing no dust or debris to collect on the tops.
2. The electrolyte should be kept one-half inch above the tops of the plates.
3. The specific gravity should be 1.205 to 1.215 for the fully charged cell and should never drop below 1.18.
4. The cell should not be permitted to remain idle for any great length of time without being charged.
5. Keep terminals and connections tight and free from corrosion.
6. Be sure that the polarity of the charging current is correct.
7. Never allow the voltage to drop below 1.8 per cell.
8. Keep flames away from the battery while charging.
9. Do not overdischarge, undercharge, or overcharge.

Question 228. What kind of water should be used in a cell?

Answer. Chemically pure water.

Question 229. What is the cause of a cell becoming sulphated?

Answer. Insufficient charging or allowing it to remain in a discharged condition.

Question 230. Explain the purpose, construction and operation of an ampere-hour meter.

Answer. The ampere-hour meter is a device employed to measure the quantity of electricity flowing in a circuit. It measures the quantity of electricity placed in or taken from a battery by measuring the product of the current in amperes and the time in hours. In one form, it operates similarly to a motor, consisting of a copper disc arranged so as to float in a pan of mercury. A spindle extends through the center of the disc and rests in jeweled bearings. A permanent magnet is placed on either side of the disc, producing a magnetic field at right angles to the disc. The current to be measured is caused to flow from one side of the mercury pan through the mercury to the disc, through the disc and out the mercury to the other side of the pan. The current flowing through the disc has a magnetic field about it, which interacts with the one produced by the permanent magnet, causing the disc to revolve in the same manner as the armature of a motor. The speed of this motor will be proportional to the current strength, and as each revolution corresponds to a certain quantity of electricity, by proper connection of the spindle to an indicating dial we may measure the quantity of current flowing through the meter.

Question 231. What is a trickling charge?

Answer. It is a very slow charge, caused by a small current ¼ to ½ ampere flowing thru the battery for long periods of time. It usually refers to the constant charge allowed to flow thru an auxiliary circuit, having a small lamp in series between 110 volts source and the battery itself.

Question 232. What is buckling, and how caused?

Answer. It is the bending or warping of the plates which sometimes causes them to touch one another. This forms a short circuit and injures the battery. Buckling is caused by overheating of the plates and usually results from too great a current flow, either in charge or discharge.

Question 233. What is sulphating?

Answer. Sulphating takes place only in the lead cell, and is the formation of a light yellow, nearly white, scale on the surface of the plates. It is due to overdischarge or allowing the cell to stand long in a discharged condition. Sulphation is an injury to a cell.

Question 234. What tests will show the discharged condition of a lead cell?

Answer. A voltmeter reading of 1.8 or less, with a hydrometer reading of 1.18 or less.

Question 235. If a lead storage battery is not used for several months, with no means of charging for this period, what should be done?

Answer. The battery should be fully charged, the electrolyte removed, and distilled or pure water put in place of the solution. On putting the battery back in service give the battery a small charge while the water is present, remove the water and return the electrolyte, with the proper specific gravity, 1.22. Now discharge the battery and then give it a good overcharge. It is now ready for use.

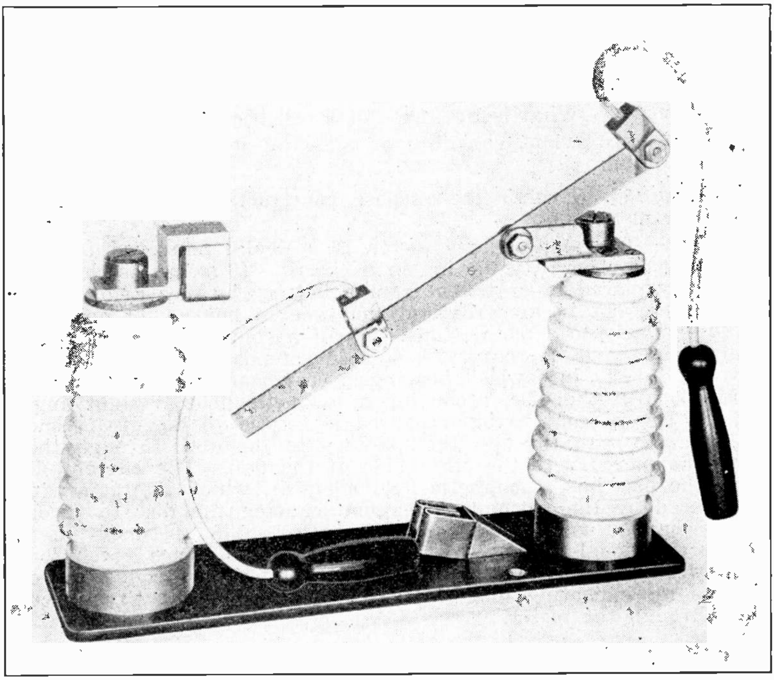


Fig. 78.—Lightning Switch.

Question 236. In the construction of a cell what factor determines its capacity?

Answer. The number of square feet of active positive plate surface, which depends on the size and number of positive plates used in the cell. It is common practice to allow six to eight amperes per square foot of positive plate surface. The thickness or amount of material (active lead) will determine the time in hours for charge or discharge.

Question 237. How many lead cells and what size are used for a 1 K. W. set?

Answer. Sixty E. S. B. type MV-9 lead cells joined in series, with a capacity of 80 ampere-hours.

Question 238. State the type, capacity and number of Edison cells used for a 1 K. W. set.

Answer. One hundred B 4 H Edison cells of 80 ampere-hours capacity connected in series.

Question 239. Name a few commercial makers, and state the types with capacity rating used for wireless purposes.

Answer. The Electric Storage Battery Company:

Type.	Max. amps.	Amp. hrs.	Size wire to use.
MV-7	40	65	10
MV-9	60	85	8
MV-13	70	125	6
MV-15	80	150	6

NOTE.—Type MV includes MVS and MVY.

Question *240.* State three indications to show that a lead cell is fully charged.

Answer. Gassing of the cell (boiling action of the solution), provided the charging current is small. Specific gravity of 1.220 or greater, as read by a hydrometer, or a voltage of 2.1 or greater, as read from a voltmeter.

Question 241. In cases where a radio station is to be closed for several months and there is no available means of charging the storage batery, what care should be given the cells?

Answer. The battery should be fully charged, then the electrolyte removed from each cell and distilled or pure water put in its place. This prevents the sulphating action on the battery plates.

Question 242. How should the cells be treated when being put back into service?

Answer. The cells should be given a slight charge while the plates are in the water (very weak acid solution due to the water absorbing much of the acid held by the plates), then discharged and recharged to maximum capacity. Now replace the water with the regular battery electrolyte and discharge the cells. Next, give the entire battery a good overcharge (until each cell shows a gassing action). The battery should now be in good working condition. If not, discharge and then recharge a second time.

Question 243. Name a few of the physical characteristics of a lead.

Answer. The positive plate (lead peroxide or red lead) is a reddish brown color when fully charged and becomes a lighter brown color on discharge. The negative plate (pure spongy lead) is steel gray in color. The electrolyte is colorless (like water), but has an oily appearance.

Question 244. What special precaution should be taken when working around a charging lead battery??

Answer. Never light a match or allow a flame of fire within a room where lead cells are charging. The gases given off by the battery when mixed with air form an explosive mixture.

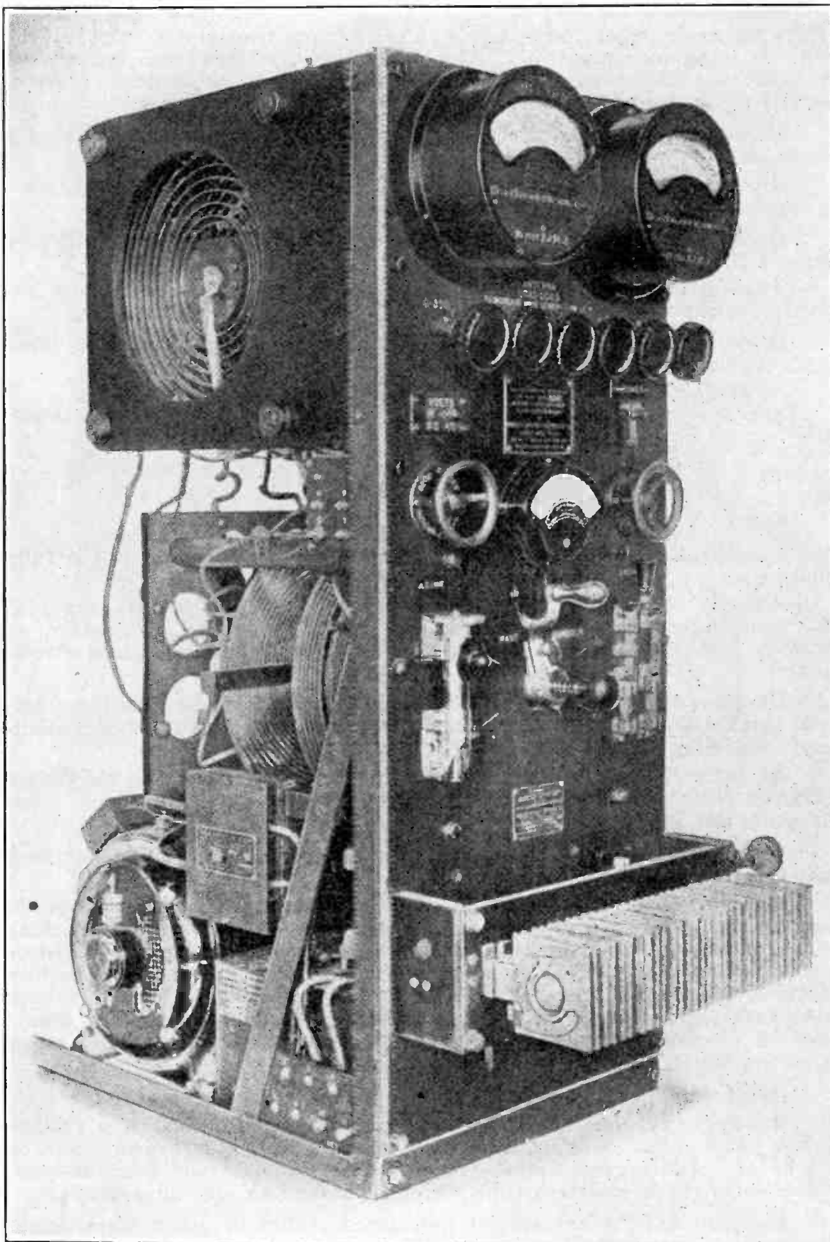


Fig. 79.—½ K. W. Transmitter.

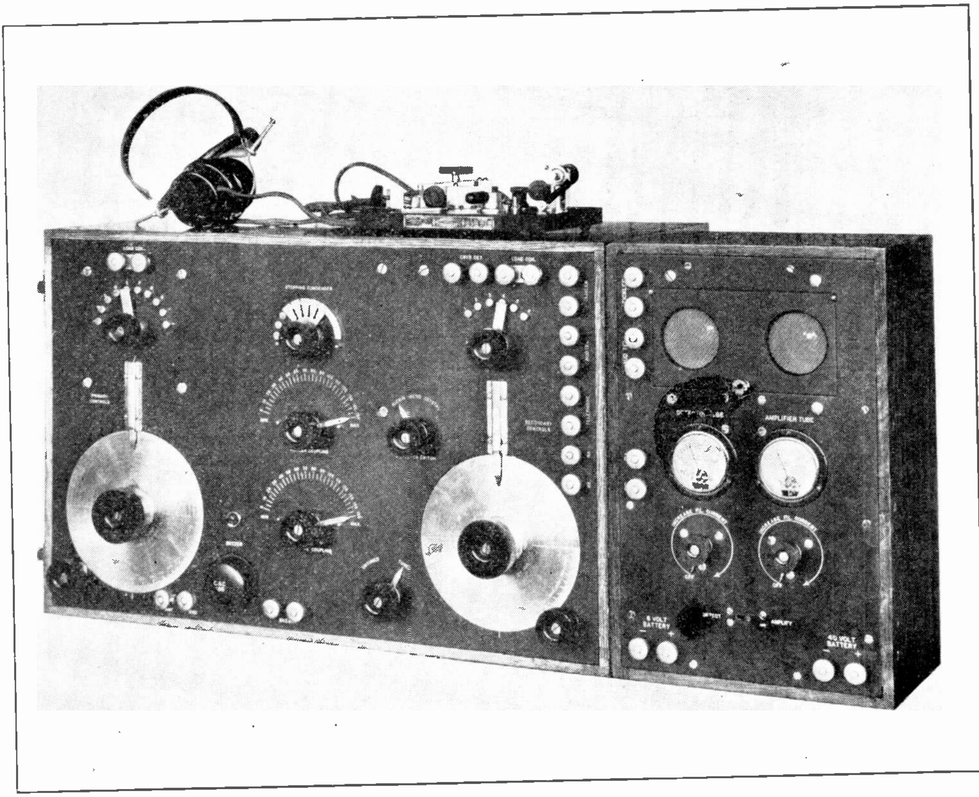


Fig. 80.—Cabinet-type Receiver.

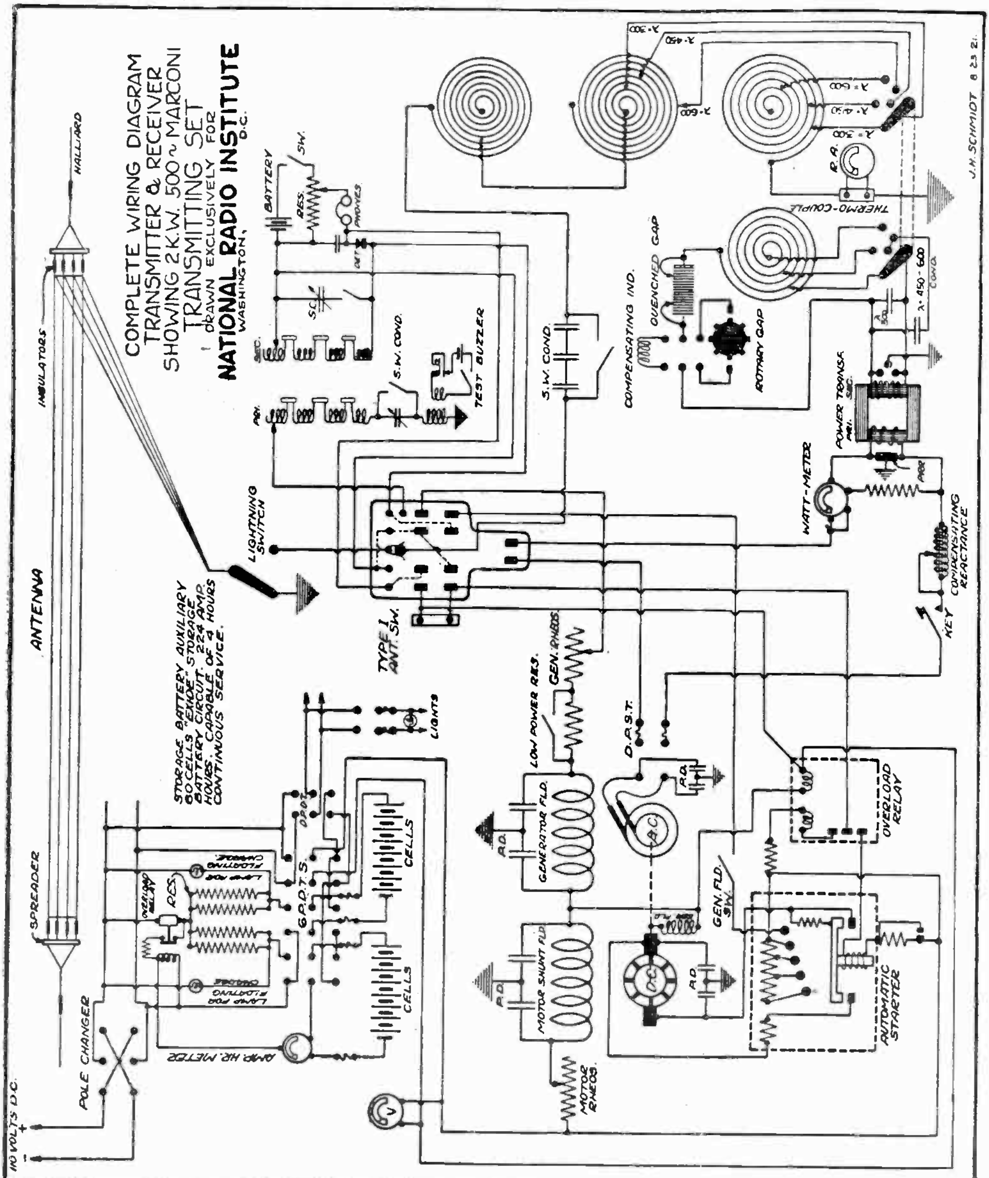

COMPLETE WIRING DIAGRAM
TRANSMITTER & RECEIVER
SHOWING 2 K.W. 500~ MARCONI
TRANSMITTING SET
DRAWN EXCLUSIVELY FOR
NATIONAL RADIO INSTITUTE
WASHINGTON, D.C.
ANTENNA
HALLIARD
INSULATORS
SPREADER
LIGHTNING SWITCH
TYPE 1 ANT. SW.
STORAGE BATTERY AUXILIARY
60 CELLS "EHOE" STORAGE
BATTERY CIRCUIT. 224 AMP.
HOURS. CAPABLE OF 4 HOURS
CONTINUOUS SERVICE.
LIGHTS
D.P.D.T.
G.P.D.T.S.
CELLS
OVERLOAD RELAY
RES.
LAMP FOR FLOATING CHARGE
POLE CHANGER
110 VOLTS D.C.
AMP. HR. METER
BATTERY
SW.
RES.
PHONES
DET.
S.C.
SEC.
PRI.
S.W. COND.
TEST BUZZER
COMPENSATING IND.
QUENCHED GAP
ROTARY GAP
POWER TRANSF.
WATT-METER
COMPENSATING REACTANCE
KEY
THERMO-COUPLE
R.A.
λ-450-600 COND.
λ-300
λ-450
λ-600
LOW POWER RES.
GEN. RHEOS.
D.P.S.T.
P.D.
A.C.
GENERATOR FLD.
MOTOR SHUNT FLD.
MOTOR RHEOS.
D.C.
GEN. FLD. SW.
AUTOMATIC STARTER
OVERLOAD RELAY
V
J.H. SCHMIDT 8 23 21.

Fig. 81.

Miscellaneous Questions

Question 245. What are the proper steps to take when seeking an examination for a Radio Operator's License?

Answer. First secure a letter from the school, Radio Company, or any institution which can certify that the candidate has had a systematic training in Radio. Second, write the U. S. Radio Inspector for your district, asking where and when you may be given the examination. Third, report promptly at the time and place appointed by the inspector. Provide yourself with a few sharp pencils and a small ruler.

Question 246. How is the examination conducted?

Answer. The examination is divided into three parts. Part One is a test of your ability to receive the International Code and abbreviations. The applicant must copy it in a neat and readable form, with the proper spaces where they occur. Part Two is a test of your ability to send. Part Three consists of answering 20 to 50 practical questions and making drawings (which include wiring diagrams) involved in the installation, operation and maintenance of commercial Radio transmitting and receiving apparaus.

Question 247. How much time is required to complete this examination?

Answer. From three to seven hours, according to the ability of the applicant.

Question 248. What are the most important points to observe in taking the examination?

Answer. Neatness, write with care and leave a space between answers.

ACCURACY. Make the wiring diagrams of the transmitter and receiver correct in every detail.

THOROUGHNESS.—Be sure to answer every question in the way it is requested on the examination. After you have completed your writing, begin with Question 1 and read them over and read your answer to each in the order of the question. This will serve as a check for omissions and misspelled words.

Question 249. What type of commercial transmitter and receiver should the applicant be familiar and able to explain?

Answer. The one given in Figure 81, or any other standard set in general use on ships of the present time.

Question 250. After the applicant has taken his examination, what must he do?

Answer. He must wait for a report of his percentage grade on the examination. If he receives a passing grade the license is sent to him at the same time; then he must sign it before a notary public, who must sign his name in two places (on the front and also the back of the license), and attach his seal. Then the license should be returned immediately to the Radio Inspector for his final signature. He will then return it to you.

Radio Equations and Tables

$$\text{Amperes} = \frac{\text{volts}}{\text{Ohms.}}$$

$$\text{Watts} = \text{Volts} \times \text{Amperes.}$$

$$\text{Frequency} = \frac{\text{Velocity}}{\text{Wave length.}}$$

$$\lambda = 1885\sqrt{C \times L}$$

When

λ = wave length in meters.
C = capacity in microfarads.
L = inductance in microhenries.

Energy in a condenser.

$$E = \tfrac{1}{2}CV^2$$

where:

E = energy in joules.
C = capacity of condenser in farads.
V = voltage to which condenser is charged.

Resistances in parallel.

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Where

R = Total resistance.
R_1, R_2, R_3 = separate resistances.

Resistances in series.

$$E = E_1 + E_2 + E_3$$

Where

E = total voltage across resistances.
E_1, E_2, E_3 = voltages across separate resistances.

Horse-power

$$\text{H. P.} = \frac{\text{Watts}}{746}$$

Percentage of coupling between two circuits.

$$k = \frac{\lambda_1 - \lambda_2}{\lambda_0} \text{ (approximately)}$$

Where:

k = percentage of coupling between the two circuits.
λ_1 = wave length of the longer of two resulting waves.
λ_2 = wave length of the shorter of two resultant waves.
λ_0 = wave length of each of the circuits taken separately.

Frequency of an alternator

$$F = \frac{P \times N}{2} \text{ or } F = \frac{P \times N^1}{120}$$

Where

F = frequency in cycles per second.
P = number of poles.
N = Revolutions per second.
N^1 = Revolutions per minute.

Dielectric Constants

Substance	Dielectric Constant
Air	1.00
Paper (dry)	1.5
Paper (treated as used in cables)	4.
Paraffin	2 to 3.3
Ebonite	2 to 3.2
Petroleum	2.1
Transformer oil	2.5
Mica	4 to 8
Glass	4 to 10
Water	81

Abbreviations of Units

Unit	*Abbreviation*	*Unit*	*Abbreviation*
Amperes	amp.	meters	m.
Ampere—hours	amp.—hr.	microfarads	mf.
centimeters	cm.	millihenries	mh.
cycles per second	$\sim$	millimeters	mm.
kilometers	km.	square centimeters	$cm.^2$
kilowatts	kw.	volts	v.
kilowatt—hours	kw.—hr.	watts	w.
Kilovolt—amperes	kva.		

Relative resistance of chemically pure metals at 32° Fahrenheit.

Metal	*Relative Resistance*	*Resistance in microhms per cubic inch*
Silver (annealed)	1.000	.5904
Copper (annealed	1.063	.6274
Silver (hard drawn)	1.086	.6415
Copper (hard drawn)	1.086	.6415
Gold (annealed)	1.369	.8079
Aluminum (annealed)	1.935	1.144
Zinc (pressed)	3.741	2.209
Platinum	6.022	3.555
Iron (annealed)	6.460	3.814
Lead	13.050	7.706
German silver	13.92	8.217

Voltages in power transformer

$$\frac{E}{E^1} = \frac{T}{T^1}$$

Where

E = Voltage in primary.
E^1 = Voltage in secondary.
T = turns in primary.
T^1 = turns in secondary.

Capacity of condensers in parallel

$$C = C_1 + C_2 + C_3$$

C = Total capacity.

C_1, C_2, C_3 = Capacities of separate condensers.

Capacity of condensers in series

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

Where

C = total capacity

C_1, C_2, C_3 = Capacities of separate condensers.

Standard wave lenths corresponding to various oscillation frequencies.

Wave length in meters	*Frequency in cycles per second*
200	1,500,000
300	1,000,000
450	666,666
600	500,000
1,000	300,000
2,000	150,000
3,000	100,000
6,000	50,000
8,000	37,500
10,000	30,000

WAVE LENGTHS OF SHIP AERIALS

Type	*Length of Flat Top*	*Height of Flat Top*	*No. of Wires*	*Natural Wave length*	*Capacity mfds.*
	Feet	*Feet*			
L.....	208	96	6	374	.00128
T.....	200	125	6	368	.00145
L.....	150	87	4	355	.00115
L.....	200	90	6	360	.0015
L.....	120	100	6	325	.00132
T.....	130	92	4	285	.00075
T.....	250	150	4	426	.00096
L.....	200	90	6	360	.0023
L.....	125	55	6	230	.00085
L.....	151	110	6	290	.0009
L.....	200	98	6	425	.0024
L.....	170	85	4	380	.00082

Radiation

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

where

w = energy radiated in watts.

h = height of aerial in meters.

λ = wave length of aerial in meters.

I = current in amperes at base of aerial.

Inductance of a coil

$$L = \frac{(5 \times d \times N)^2}{s + \frac{d}{3}}$$

Where:

L = inductance in centimeters.
d — diameter of coil in inches.
N = total number of turns.
s = length of coil in inches.

Capacitance of an aerial

$$C = \frac{\lambda 1^2 - \lambda_2^2}{\lambda_2^2} \times C_1$$

Where

C = capacity of aerial in mfds.
λ_1^2 = square of natural wave length of aerial.
λ_2^2 = square of wave length with C_1 in series.
C_1 = condenser of known capacity connected in series with the aerial.

Inductance of an aerial.

$$L = \frac{\lambda_1^2}{\lambda_2^2 - \lambda_1^2} \times L_1$$

Where

L = inductance of aerial system in cms.
λ_1^2 = square of natural wave length of antenna.
λ_2^2 = square of wave length of antenna system with L_1 in series.
L_1 = inductance of known value.

SPARKING DISTANCES

Volts	*Distance inches*	*Centimeters*
5,000	.225	.57
10,000	.470	1.19
15,000	.725	1.84
20,000	1.000	2.54
25,000	1.3	3.30
30,000	1.625	4.10
35,000	2.000	5.10
40,000	2.45	6.20
45,000	2.95	7.50
50,000	3.55	9.00
60,000	4.65	11.80
70,000	5.85	14.9
80,000	7.10	18.0
90,000	8.35	21.2
100,000	9.60	24.4

Approximate capacity required to reduce the wave length of an 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 series condenser in mfds necessary to reduce aerial to certain wave length.
λ_1^2 = square of the reduced wave length desired.
L = inductance in centimeters of the aerial to be reduced.
C_2 = capacity in mfds of the aerial to be reduced.

TIME SIGNALS.

The stations listed below send time for 5 minutes, starting at five minutes before the time set opposite each station. Each tick of a standard clock is transmitted as a dot, omitting the 29th second of each minute, the last five seconds of each of the first four minutes,. and finally the last ten seconds of the last minute. A dash is sent at the time given opposite the station.

Station.	Call.	Wave Length.	Time.
Washington, D. C.	NAA	2500	Noon, 10 P.M., 75th Meridian, Standard Time.
Key West, Fla.	NAR	1500	Noon, 10 P.M., 75th Meridian, Standard Time.
New Orleans, La.	NAT	1000	Noon, 75th Meridian, Standard Time.
Darien, C. Z.	NBA	4000 undamped.	1 P. M., 75th Meridian, Standard Time.
North Head, Wash.	NPE	2800	Noon, 120th Meridian, Standard Time.
Eureka, Cal.	NPW	2000	Noon, 120th Meridian, Standard Time.
Pt. Arguello, Cal.	NPK	1512	Noon, 120th Meridian, Standard Time.
San Diego, Cal.	NPL	2400	Noon, 120th Meridian, Standard Time.
		9800 undamped.	
San Francisco, Cal.	NPG	2400	Noon, 10 P.M., 120th Meridian, Standard.
Great Lakes, Ill.	NAJ	1512	11 A.M., 90th Meridian, Standard Time.

MISCELLANEOUS DAMPED WAVE STATIONS.

Location.	Call.	Wave Length.
Arlington, Va., U. S.	NAA	2500
New Orleans, La., U. S. A., "WNU"	NJK	1800
Apia, Samoa	VMG	2000
Clifden, Ireland	MFT	6000
Glace Bay, N. S.	GB	7500
Nauru, Pacific Ocean	VKT	2200
Poldhu, Ireland	MPD	2800
Rabaul, Pacific Ocean	VJZ	2900
Yap, Pacific Ocean	....	1800
Coltano, Italy	ICI	6500
Berlin, Germany	LP	5500
Mexico City, Mexico	XDA	4000
Petrograd, Russia	TSR	5000 & 7000

HIGHPOWER RADIO STATIONS.

UNITED STATES AND POSSESSIONS.

Location.	Call.	Wave Length.
Annapolis, Md.	NSS	16900
Arlington, Va.	NAA	6000
Balboa, C. Z.	NBA	7000
Boston, Mass.	NAB	5700
Cavite, P. I.	NPO	12000
Charleston, S. C.	NAO	4700
Cordova, Alaska	NPA	7600
Great Lakes	NAJ	5700
Guam, Marianna Islands	NPN	5000
Guantanamo, Cuba	NAW	4500
Key West, Florida	NAR	6500
Marion, Mass.	WSO	11500
New Brunswick, N. J.	NFF	13600
New Orleans, La.	NAT	5500
Pearl Harbor, Hawaii	NPM	11000
Puget Sound, Wash.	NPC	5250
San Diego, Cal.	NPL	13300 and 9800
San Francisco, Cal.	NPG	8600 and 4800
San Juan, Porto Rico	NAU	5250
Sayville, L. I.	NDD	11600 and 9800
Tuckerton, N. J.	NWW	9200
Tutuila, Samoa	NPU	6000 and 3000

GREAT BRITAIN AND OTHER COUNTRIES.

Location.	Call.	Wave Length.
Barrington Passage, N. S.	VCU	5000
Bermuda, W. I.	BZR	5000
Camarron, Wales	MUU	14000
Christiana, Jamaica	BZQ	5000
Hong Kong, China	BXY	5000
Horsea, England	BYC	4500
Punta, Delgada, Azores	BWP	2000
Singapore, Malay Peninsula	VPW	3400
St. Johns, Newfoundland	BZM	5000
Eiffel Tower, Paris	FL	10000
Lyons, France	YN	15500
Nantes, France	VAUA	9000 and 11000
Rome, Italy	IDO	11000
Hanover (Eilvese), Germany	OUI	15000
Nauen, Germany	POZ	12600
Funabashi, Japan	JJC	7700
Stavanger, Norway	LCM	9500 and 12000
Java, Dutch East Indies	PMM-PMX	6100

INFORMATION

Concerning the Places and Methods of Conducting the Examinations

The Radio Service comes under the Bureau of Navigation in the Department of Commerce, Washington, D. C.

The United States is divided into nine (9) Radio Districts as given below:

District 1—BOSTON, MASS.:

Maine, New Hampshire Vermont, Massachusetts, Rhode Island, Connecticut.

District 2—NEW YORK, N. Y.:

New York (County of New York, Staten Island, Long Island, and counties on the Hudson River to and including Schenectady, Albany, and Rensselaer), and New Jersey (Counties of Bergen, Passaic, Essex, Union, Middlesex, Monmouth, Hudson, and Ocean).

District 3—BALTIMORE, MD.:

New Jersey (all counties not included in second district), Pennsylvania (Counties of Philadelphia, Delaware, all counties south of the Blue Mountains, and Franklin County), Delaware, Maryland, Virginia, District of Columbia.

District 4—SAVANNAH, GA.:

North Carolina, South Carolina, Georgia, Florida, Porto Rico.

District 5—NEW ORLEANS, LA.:

Alabama, Mississippi, Louisiana, Texas, Tennessee, Arkansas, Oklahoma, New Mexico.

District 6—SAN FRANCISCO, CALIF.:

California, Hawaii, Nevada, Utah, Arizona.

District 7—SEATTLE, WASH.:

Oregon, Washington, Alaska, Idaho, Montana, Wyoming.

District 8—DETROIT, MICH.:

New York (all counties not included in second district), Pennsylvania (all counties not included in third district), West Virginia, Ohio, Michigan (Lower Peninsula).

District 9—CHICAGO, ILL.:

Indiana, Illinois, Wisconsin, Michigan (Upper Peninsula), Minnesota, Kentucky, Missouri, Kansas, Colorado, Iowa, Nebraska, South Dakota, North Dakota.

Applicants desiring to make further inquiry or arrange for an examination should write to Radio Inspector, Custom House, with the name of the city given as Headquarters for your district except in the following cases:

Savannah, Ga., Address to 205 Citizens' Bank Bldg., Norfolk, Va.
Detroit, Mich., " " Federal Building.
Chicago, Ill., " " Federal Building.
Seattle, Wash., " " 2301 L. C. Smith Bldg.

Copies of the Radio Law, or the Radio Call Book, can be purchased from Supt. of Documents, Washington, D. C., at 15 cents per copy.

Which Apparatus Purchases Do You Want to Save Money On?

ARE YOU planning to build a receiving set, a sending set or to purchase apparatus of any kind? If so, let us show you how you can save money regardless of the price you intend to pay. Don't jump at the first suggestion you may receive for filling your requirements. There are many conditions to be considered which only experienced operators and radio experts know to exist.

A lot of money is wasted every year by radio students, amateurs and experimenters because they sometimes depend on making a good guess at what would satisfy them best. It is not necessary for you to take a chance like this. Beside making sure that you are going to get the right kind of apparatus at the very lowest price, you want to feel that your purchase will entitle you to a little more than a customers' attention.

Free Service in Outlining Hook-Ups and Furnishing Diagrams

Expert advice on the right apparatus to buy, how to construct a set, operate and maintain it regardless of the size, will be given by us free to anyone who applies for it. You may have a set already which is not giving you the service which you think it ought to. Tell us about it, your location, hook-ups, and we will see if we can help you out.

You may be in the market for radio apparatus and don't know exactly what you should buy. If you will tell us from how many meters you want to receive and how far you want to send, we will give you the information you need to buy the apparatus—we will recommend the set to you.

Any service which we may render in this way, that is, by furnishing diagrams, giving advice on the proper material to buy or how to construct a set, will not cost you anything. We are going to be a real friend of the amateur, of the young fellow with the wireless hobby who knows nothing about radio, as well as the concern which is going to or who has installed very expensive apparatus.

We have the men who know the game from A to Z. These men are at your service. All you need to do is to write us.

Aerial Wire, per 100 feet	$1.25
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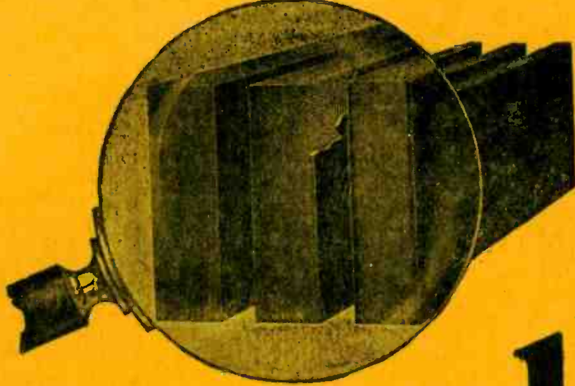
Brandes Phones	10.00
A. & P. Detector Tubes	5.00
A. & P. Amplifying Tubes	6.50
2,000 Ohm Phones, Navy Type, Adj. Headband	5.50
3,000 Ohm Phones, Navy Type, Adj. Headband	6.00
Bakelite, ¼ inch, per square inch, .03; 3-16 inch	.02½
Receiving Transformers	9.00
Tuning Coils	4.50
Oscillation Transformer	5.00
Antennae Switches	4.50
Amplifying Transformers	7.50
Rembler Rheostats	1.00
Radio Corps Patentometers	3.00
U. V. 200 Audion Detector	5.00
U. V. 201 Audion Detector and Amplifier	6.50
U. V. 202 5-Watt Power Tubes	8.00
DeForest A. C. Rectifier Tubes	9.00
Audion Control Panels	9.00
Audion Tube Sockets	1.50
Variable Condenser 23 Plate, 0005 mfd	4.00
Buchers Practical Wireless Telegraphy	2.25
Buchers Wireless Experimenter's Manual	2.25
Buchers Vacuum Tubes in Radio Communication	2.25
Consolidated Radio Call Book	1.50

Sales Department

National Radio Institute

Washington, D. C.



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