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Wireless Telegraphy

BY

A. FREDERICK COLLINS

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MANUAL
OF
WIRELESS TELEGRAPHY

A. FREDERICK COLLINS

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PREFACE

As every one interested in wireless telegraphy is aware, there are numerous books on the subject; but while this is true, there is very little information available for those who are, or who desire to become, operators.

In preparing this manual my purpose has been to give detailed and explicit instructions for wiring the various types of sending and receiving apparatus now in general use, the adjustment of the instruments, tuning and syntonizing the circuits, testing the devices, and finally the management of ship and shore stations.

The most proficient operators are those who combine theory with practice, and if the principles involved in the system he is working are clearly understood, the adjustment and manipulation of a set will be rendered much easier than where the results are striven for blindly. Hence if this book is carefully studied and the instructions are faithfully followed, many of the difficulties usually encountered can be easily overcome

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or circumvented by the operator, and he will be able to send and receive messages with a greater degree of accuracy and over considerably longer distances than would otherwise be possible.

I desire to acknowledge my indebtedness to General James A. Allen, Chief Signal Officer, U. S. A.; Lieutenant O. P. Jackson, U. S. N.; the late Lieutenant J. M. Hudgins, U. S. N.; Messrs. John Bottomly, W. W. Bradfield, and E. J. Watts, of the Marconi Company; Professor Reginald A. Fessenden, of the National Signalling Company; Dr. Lee De Forest, of the American De Forest Company; Mr. Thomas E. Clark, of the Clark Engineering Company; and Mr. Walter W. Massie, of the Massie Wireless Telegraph Company, all of whom contributed much valuable information.

A. FREDERICK COLLINS.

THE ANTLERS, CONGERS, N. Y.
August 1, 1906.

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MANUAL OF

WIRELESS TELEGRAPHY

CHAPTER I

A SIMPLE WIRELESS TELEGRAPH SYSTEM

A WIRELESS TELEGRAPH operator must not only be able to send and receive messages, but he must also be thoroughly familiar with the apparatus employed, so that should occasion require, as, for instance, when a new set arrives from the makers, he can install the instruments, adjust them to their maximum efficiency and sensitiveness, and overhaul them when they get out of order.

While a complete equipment of instruments such as is used for commercial work is more or less complicated to the beginner, if he will bear in mind that all the different types are evolved from and still retain the same simple original features that made wireless telegraphy possible, and that the improvements in the art are responsible for the additional arrangements, it will not

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be difficult for him to grasp the more complex details after a simple system is understood.

Diagram of a Simple Transmitter.—For this reason careful study should be devoted to the following diagrams, Figs. 1 and 2, which when taken together represent a

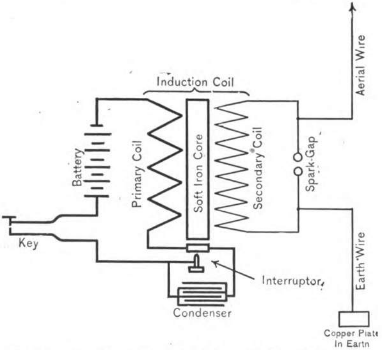

FIG. 1.—Transmitter of a Simple Wireless Telegraph System.

wireless telegraph system in its simplest form; and having these well in mind it will be easy for the student to follow the connections of any system now in use, since all are merely modifications of one of the two fixed types.

By referring to Fig. 1 a diagram of the *transmitting apparatus* for sending wireless messages will be seen.

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The different parts of the instrument are clearly marked, and it will be observed that the *aerial wire*—which is simply a bare copper wire suspended vertically in the air by a mast, and insulated from it—is connected to one of the *spark-balls*, forming one side of the *spark-gap*. To the opposite spark-ball a similar copper wire is connected which leads to the earth and is there attached to a metal plate, usually of zinc or copper. This is termed the *earth-wire*. This part of the transmitter comprises the *oscillator system*, and in this case it is also called the *radiator*, since it radiates the energy into space.

On opposite sides of the spark-gap formed by the brass balls, or spheres, the terminals or ends of the wire of the *secondary coil* of an *induction coil* are connected. In the diagram the secondary is indicated by a fine zigzag line, since this coil is built up of fine wire. The circuit derived by connecting the secondary coil with the spark-gap is termed in wireless telegraph parlance the *charging system*. The *inductor*, or *primary coil* of the induction coil, is shown as a heavy zigzag line, and the ends of this coil are connected to a battery, or other source of electromotive force, and a telegraph key through the medium of an *interruptor*. This constitutes the *energizing system*. Although the primary and secondary coils are portions of different circuits or systems of the transmitter, they are allied very closely in the apparatus and together with the *interruptor* and its *condenser* make up the induction coil.

The battery connected to the primary coil generates

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the initial current that flows through the circuit when it is closed, and it is this current that energizes the secondary coil which in turn charges the radiator system. The telegraph key is, of course, employed to break up the current from the battery that flows through the primary coil, into the alphabetic code of dots and dashes. The aerial wire and the earth-wire coupled through the spark-gap form an *open circuit*, for, as may be readily seen, they end abruptly; the secondary coil and the spark-gap connected together form a *closed* circuit, as well as the primary coil and its connections through the key and battery. Since the aerial and earth wires are located outside the station, the open circuit produced is sometimes termed the *external circuit*, while the primary and secondary circuits are likewise occasionally referred to as *internal circuits*, these being located within the station.

If the embryo operator will remember that the primary circuit, the secondary circuit, and the radiating system, i.e., the aerial and earth wires and the spark-gap, may be considered as distinct circuits, just as the fire-box, boiler, and engine may be treated as individual parts of a whole, he will be able to gain a clearer conception of the system formed when they are joined in combination.

Diagram of a Simple Receptor.—The *receptor*, as the entire receiving arrangement is designated, comprises, as Fig. 2 shows, a similar aerial wire and a similar ground-wire to those employed in the transmitter. The aerial wire is connected with one side of the *coherer*, the other side of which is *grounded*, by the wire leading to the

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earthed metal plate. This forms an open circuit and is termed the *resonator system.* It corresponds to and receives the energy emitted by the radiator system. From opposite sides of the coherer wires lead to a dry cell

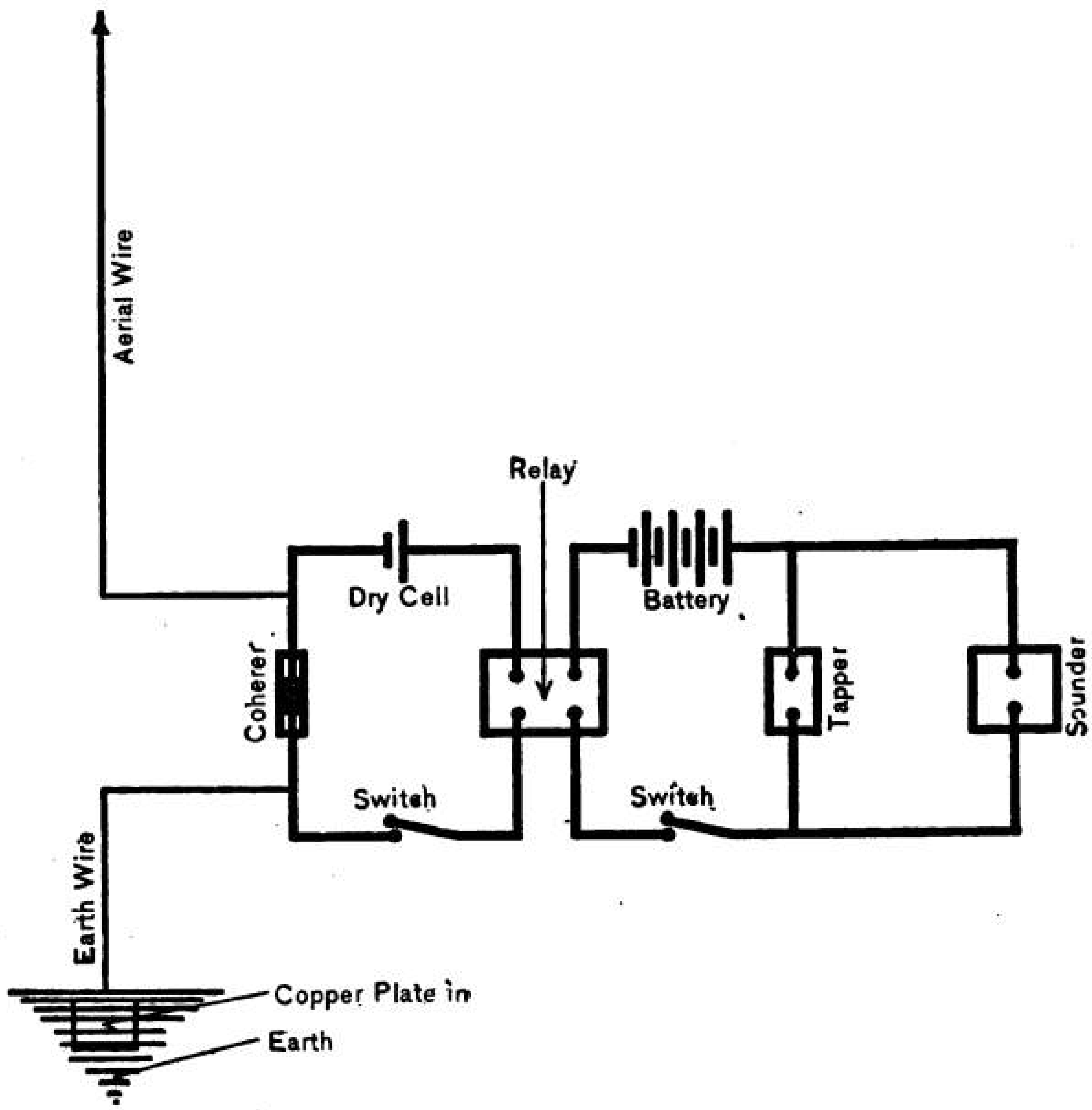

FIG. 2.—Diagram of Simple Receptor.

and the magnets of a *relay*, and these are connected when a message is to be received through a small switch. A second circuit is provided by connecting the contact-points of the relay with a battery of dry cells and a buzzer, sounder, or Morse register which indicates the signals.

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Across this circuit and parallel with it there is a vibrating *tapper* for decohering the filings of the coherer so that another impulse can be received.

When the energy radiated by the aerial wire of the sending station impinges upon the aerial wire of the resonator system the filings of the coherer are drawn together; when this action takes place the current from the dry cell flows through the relay magnets, the *armature*, carrying a platinum point, is drawn down by magnetic attraction, and the stationary and movable points are brought into contact with each other, closing the circuits in which are inserted the Morse register or indicating device and the decoherer tapper.

An Experimental Wireless Telegraph Set. — An experimental set may be constructed at a small cost, and much valuable experience can be gained with it. An induction coil, or Ruhmkorff coil, giving a ½-inch spark, can be purchased from a dealer in electrical supplies for five or six dollars. A coil of this size will give excellent results for 50 or 100 feet without earthing the spark-gap of the transmitter or the coherer of the receptor, but by merely placing the metal plates, which should be about 12 inches on the side, on the floor; aerial wires 12 or 15 feet in length should be provided, and suspended by insulators from the walls. Intervening objects, such as walls, windows, etc., will not interfere with the transmission of the waves and hence the sender and receiver can be placed in different rooms. This size coil with masts will also work satisfactorily over water a distance of ¼

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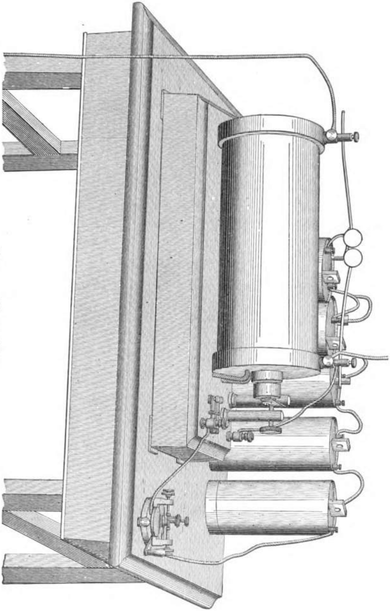

Fig. 3.—Transmitter.

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mile if aerial wires 25 to 30 feet high, and rectangular earth-plates 3×4 feet, are used.

Having obtained the coil it will be necessary to provide the brass balls for the spark-gap as shown in the photograph Fig. 3; the balls may be ½ or ¾ of an inch in diameter, and these are fitted to the coil by attaching stiff brass wires to them and through the binding posts that form the terminals of the secondary coil. An ordinary Morse telegraph key and a battery of six or eight dry cells connected in series with the primary posts of the induction coil completes the transmitter, except that of attaching the aerial and ground wires to the stiff wires carrying the spark-balls.

The coil is furnished with an *interruptor*, a device which automatically makes and breaks the current flowing through the primary coil when the key is depressed, and the *spring vibrator* must be so adjusted that when the telegraph key is open the stationary contact point just touches the bit of platinum soldered to the spring carrying the armature. (See Interruptor.) The spark-gap balls should be so adjusted that they are not more than ⅛ inch apart, as this gives much better results than when set at their greatest distance, namely, ½ inch, the reason being explained in the elementary theory to follow. The coil and the key should be mounted on a base of wood.

If the apparatus is to be used out-of-doors the aerial wires of both the sender and receptor must be suspended from masts by glass insulators, or from a convenient

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pole projecting from a third or fourth-story window or the top of a house, and the wire fastened to the opposite side of the spark-gap to the sheet of metal embedded in the earth or immersed in the water, as the case may be. The radiator and resonator wires leading from the instruments inside the station to the outside must be exceedingly well protected by glass or porcelain insulators from the building and mast or the high-tension energy will be dissipated before it can send out effective waves.

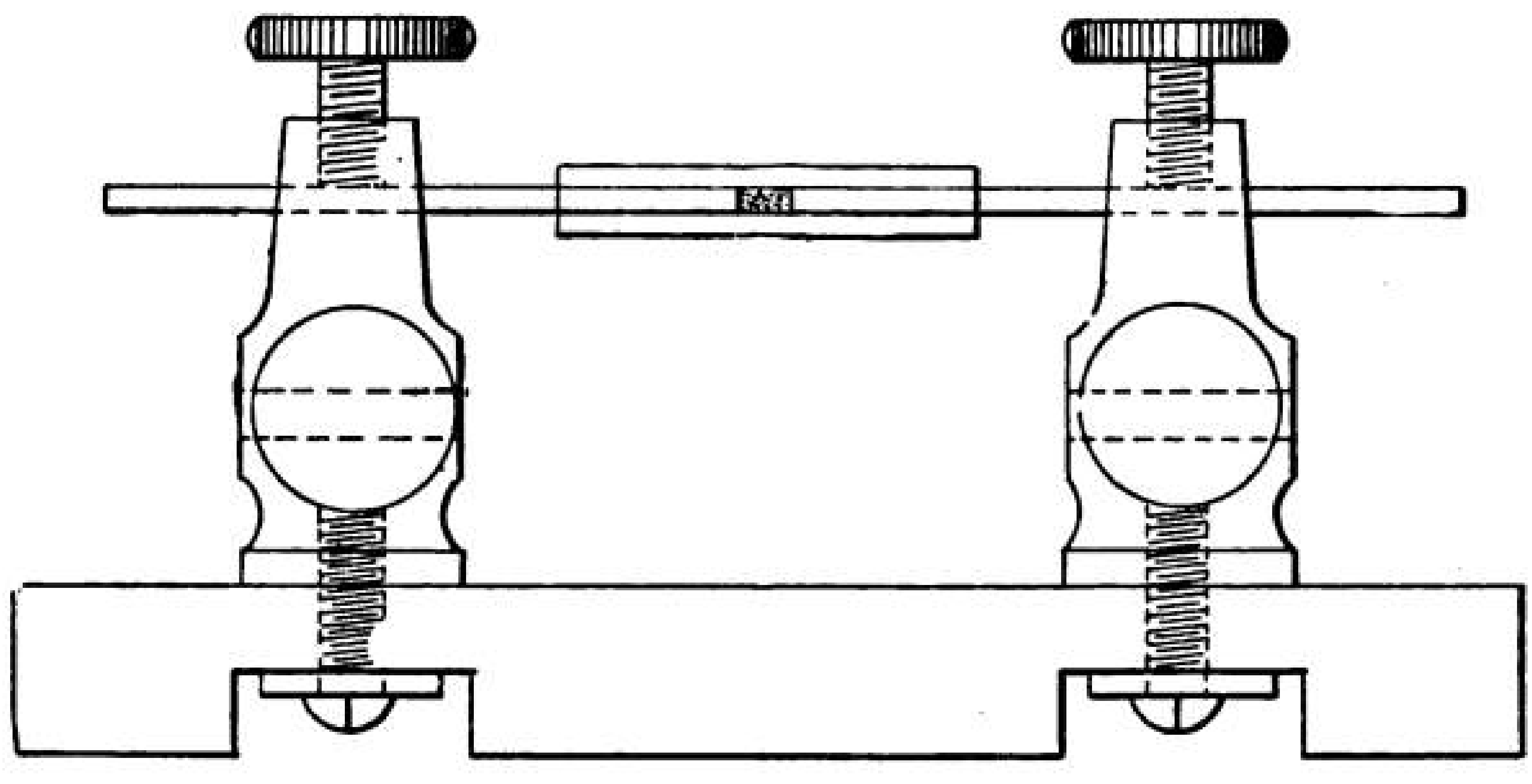

Fig. 4.—A Simple Coherer.

Nearly everything needed for the receptor can be purchased in the open market, unless it is the coherer; and this, besides being easily made, is well worth while for the experience gained. A simple one is made of two binding posts, having two set screws and two holes in each for the insertion of wires, and these are screwed to a base of wood 2 inches wide, 3 inches long, and ½ inch thick, at a distance of 2 inches, as shown in Fig. 4; two brass wires $\frac{1}{16}$ inch in diameter and 1½ inches long are

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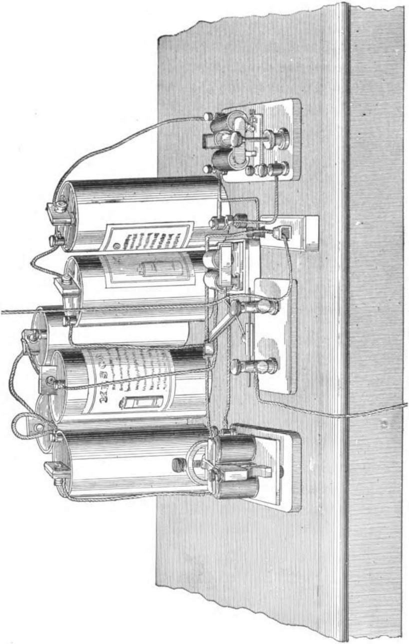

FIG. 5.—Simple Reoeptcr.

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inserted in the upper hole of each binding-post; these wires are termed *conductor-plugs* and fit snugly into a bit of glass tubing 1 inch long; before the plugs are inserted, however, a pinch of nickel and silver filings in equal proportions are placed in the tube; the filings are best made with a clean, coarse file, using a nickel five-cent piece and a silver dime.

The relay, known as a *pony relay*, is wound to a resistance of 150 ohms, and its cost is in the neighborhood of $2.50. Relays having a higher resistance can be purchased which makes them more sensitive, but the one mentioned will give excellent service. The tapper can be supplied by using an ordinary electric bell from which the gong has been removed. Instead of a Morse register as is used in long distance sets and which cost about $40.00, a Morse telegraph sounder, costing $1.75, can be substituted, or what is even better and cheaper for the experimental set is a buzzer, costing only 50 cents. The resistance of the magnet coils of the buzzer and the tapper should be the same, since they are worked in parallel from the same battery. The resistance may be 4 ohms, the usual value, though if they are more it is not material. All these instruments may be purchased from a supply-house.

The base of the coherer should be screwed to a base-board large enough for the tapper, the relay, and the buzzer. The tapper is attached to the base-board so that the hammer, which was intended to tap the gong, will instead tap the glass tube of the coherer. The

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relay may be placed conveniently on the right, and the buzzer or sounder, if the latter is used to indicate the signals, on the left, all being plainly shown in the photograph Fig. 5. The instruments should now be connected up as illustrated in the diagram Fig. 2; the aerial wire and the earth-wire are inserted in the upper holes of the coherer binding posts, as are also the ends of the wire that connects the coherer, the dry cell and the relay magnets.

The binding posts of the relay contacts are connected with the posts of the buzzer and dry battery of four cells, with the tapper connected in parallel. When the instruments are properly connected up it is best to test them in a room, with the sender and receptor not too far apart. To adjust the coherer and relay is the most difficult and tedious process involved in getting the instruments to work, and is only accomplished by practice and perseverance; by heeding the following suggestions, however, much time and trouble may be saved.

The screws of the relay are first adjusted so that the armature will have a free movement of only $\frac{1}{32}$ of an inch, and when the platinum point of the armature is drawn into contact with the stationary point the armature just clears the polar projections of the magnets. The tension of the coiled spring attached to the armature must be very feeble and only enough to draw the latter back from the magnets when there is no current flowing through them. This done, connect in the two dry cells with the coherer, through the switch; then unscrew one

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of the conductor-plugs of the coherer and, gently twisting the wire, force it in the glass tube against the filings until the current begins to flow through the circuit and the magnets of the relay attract the armature. Tap the coherer with a pencil while adjusting to keep the filings decohered. When the proper balance is secured between the coherer and the relay, the latter should operate when the switch is closed, for the potential of the current from the dry cell is sufficient to cohere the filings, and when this takes place the relay will close the second circuit. Under these conditions if the key of the transmitter is pressed, a spark will pass between the spark-balls and the tapper and buzzer of the receptor will operate in unison with it.

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CHAPTER II

ELEMENTARY THEORY

First Principles.—In ordinary telegraphy a direct current generated by a battery or a dynamo is employed to send the alphabetic code over the wire, the dots and dashes being formed by making and breaking the circuit by means of a key. In the telephone a direct current is also employed as the initial source of energy, but this is transformed into an alternating current by a small induction coil before the undulations representing articulate speech are transmitted over the circuit. In the wireless telegraph a direct current is used primarily and this is transformed into alternating currents, when these are converted into oscillating currents and the latter are finally metamorphosed into electric waves which are then propagated through space. It will thus be observed that the principles underlying wireless telegraphy are more involved, and the apparatus for producing these changes of energy successively are more complex, than in ordinary telegraphy and telephony. If, however, the action of low-voltage direct and low-frequency alternating currents are mentally clear to the student, the phe-

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nomena of electric oscillations and electric waves will follow logically and be easily understood.

Direct Current. — Electricity flowing continuously through a wire in one direction is termed a *direct current*. Such a current may be generated by a battery or a dynamo

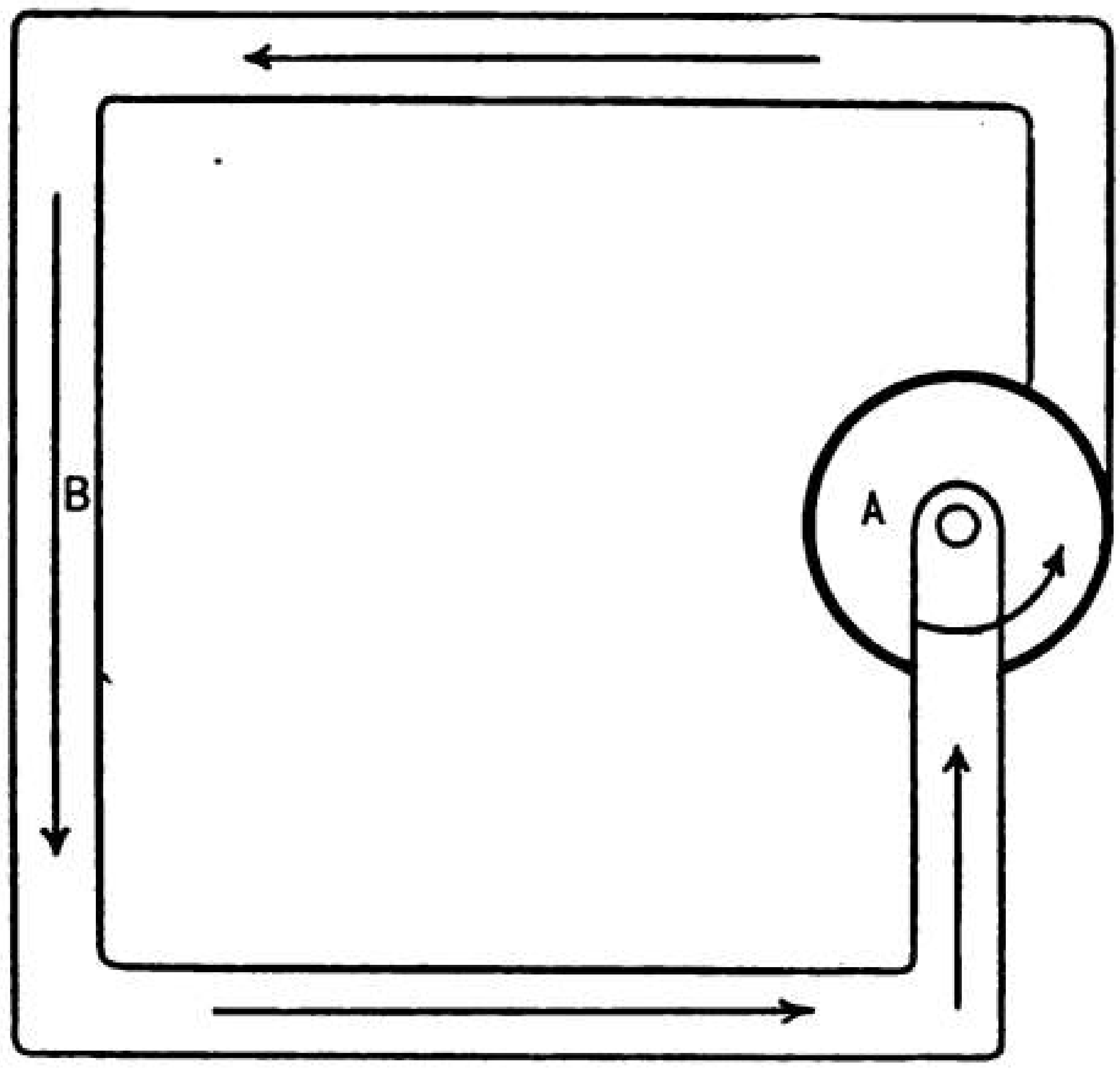

FIG. 6.—Hydraulic Analogue of a Direct Current.

and although there is no movement of matter along the circuit, yet the energy flows through the molecules of wire very much as water flows through a pipe. The action of a direct current may therefore be graphically illustrated in the following manner: Let *A*, Fig. 6, represent a centrifugal pump, and *B* a continuous pipe connecting the outlet of the pump with its own inlet. If now the pipe and the pump are filled with water and the wheel of the pump is rotated, then obviously the

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water will flow through the circuit in the direction indicated by the arrows. In order to cause the water to circulate, an expenditure of energy is of course required and hence the wheel of the pump must be connected to some external source of power.

Similarly, now, if one of the elements of a battery *A*, Fig. 7, is connected by a length of wire *B* to its opposite

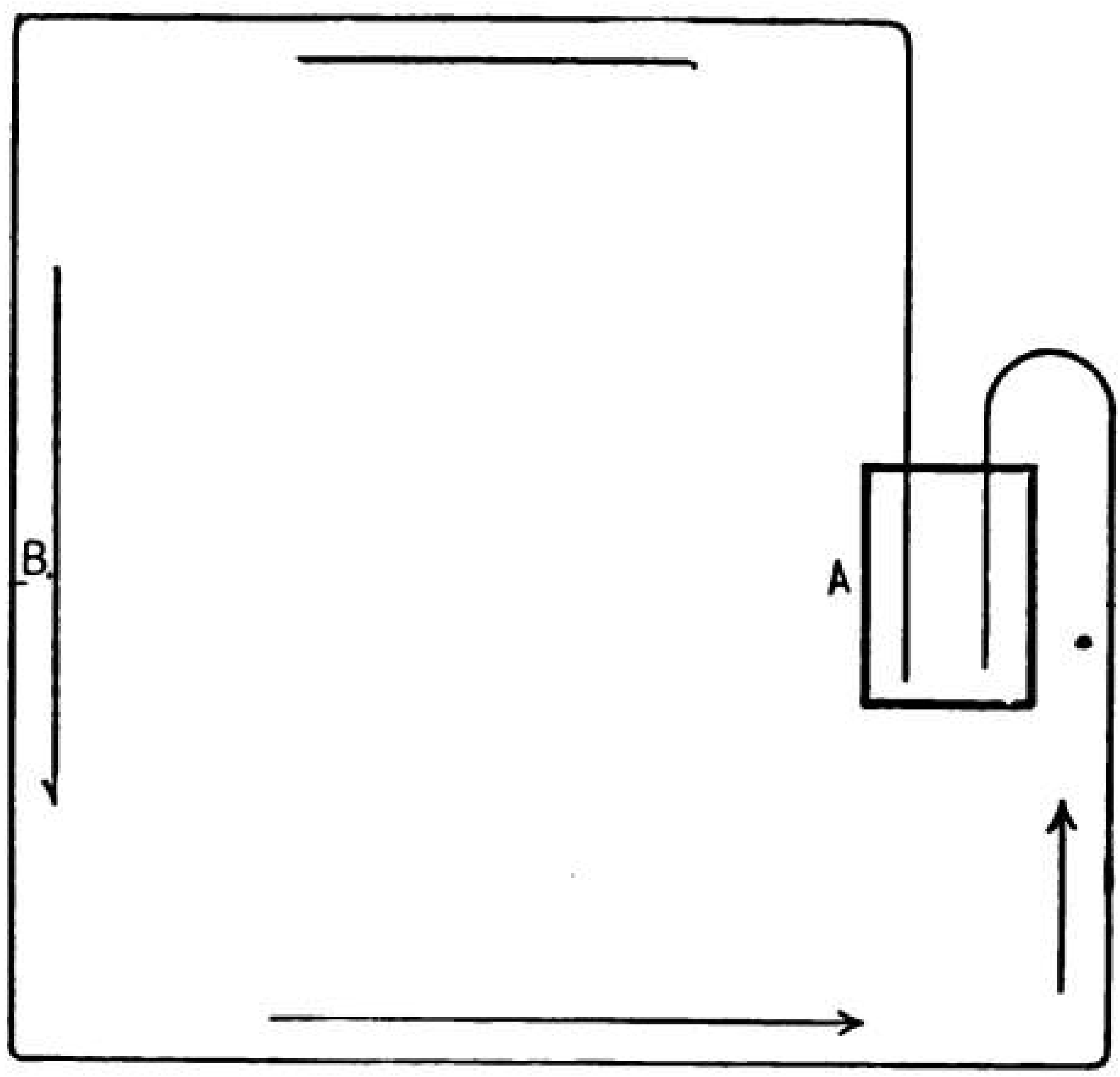

FIG. 7.—Direct Current Produced by a Voltaic Cell.

element, the chemical action of the battery will generate a continuous current, and this will flow through the wire circuit unidirectionally as the water flowed through the endless pipe. A direct current dynamo can be substituted for the battery, and the current generated by the coils of wire moving through the magnetic field will flow through the circuit as before.

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Alternating Currents.—If the continuous water-pipe *B* is connected to a valveless reciprocating pump *A*, as indicated in Fig. 8, instead of the centrifugal pump shown in Fig. 1, the water in the pipe will obviously

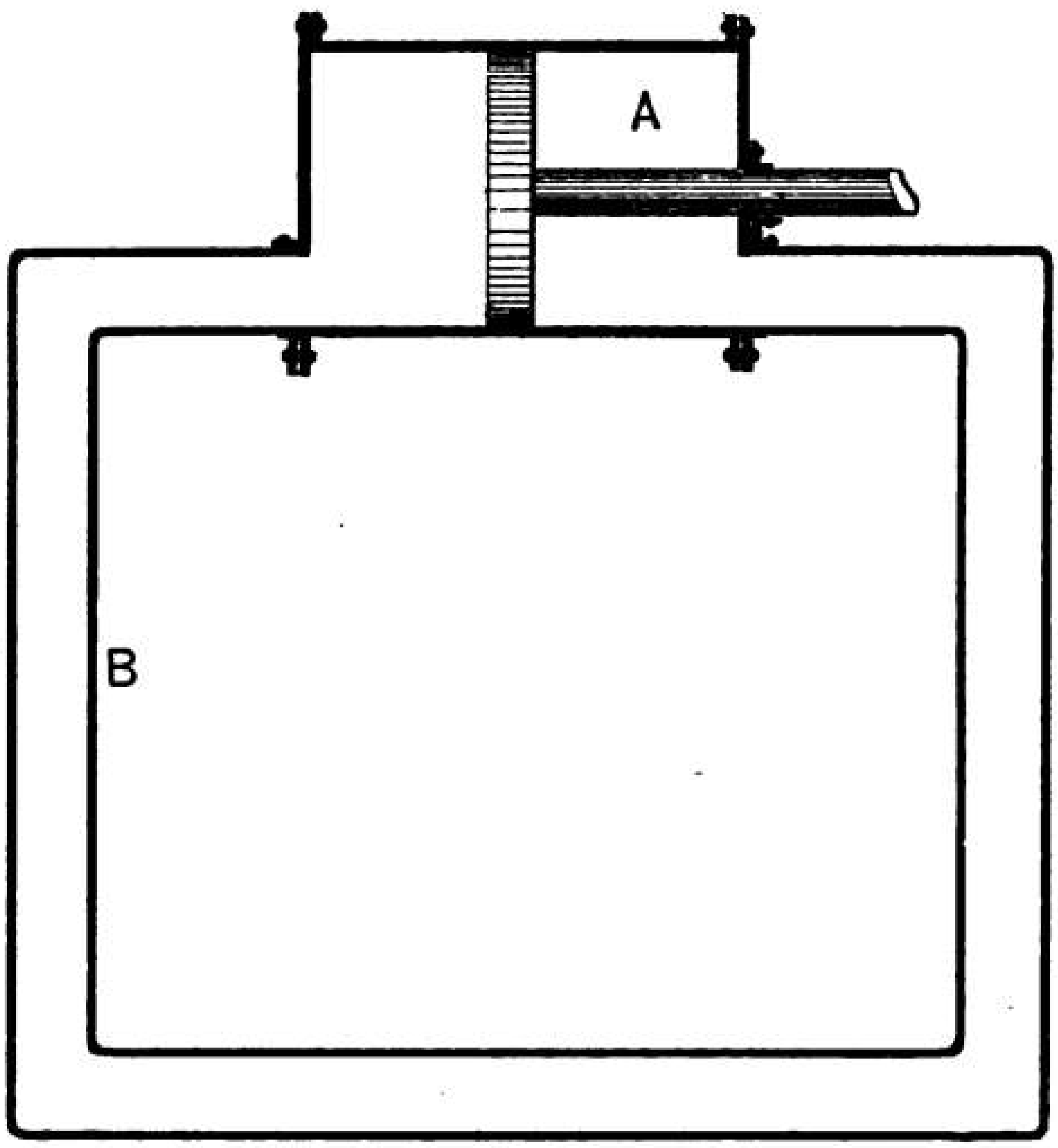

FIG. 8.—Hydraulic Analogue of an Alternating Current.

flow first in one direction and then in the other, alternating with every reversal of the piston.

Likewise if a wire *B* is attached to the secondary terminals *A* of an induction coil as in Fig. 9, the current flowing through it will move to and fro, alternating in its direction periodically. It is this low-frequency current that is employed to charge the oscillation system of a wireless telegraph transmitter. It is possible to

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illustrate in a measure the transformation of an interrupted low-voltage direct current into alternating high-potential currents as produced by the induction coil, but the analogue becomes as intricate and difficult of comprehension as the electric action which it is intended to represent, and it must be borne in mind that hydraulic

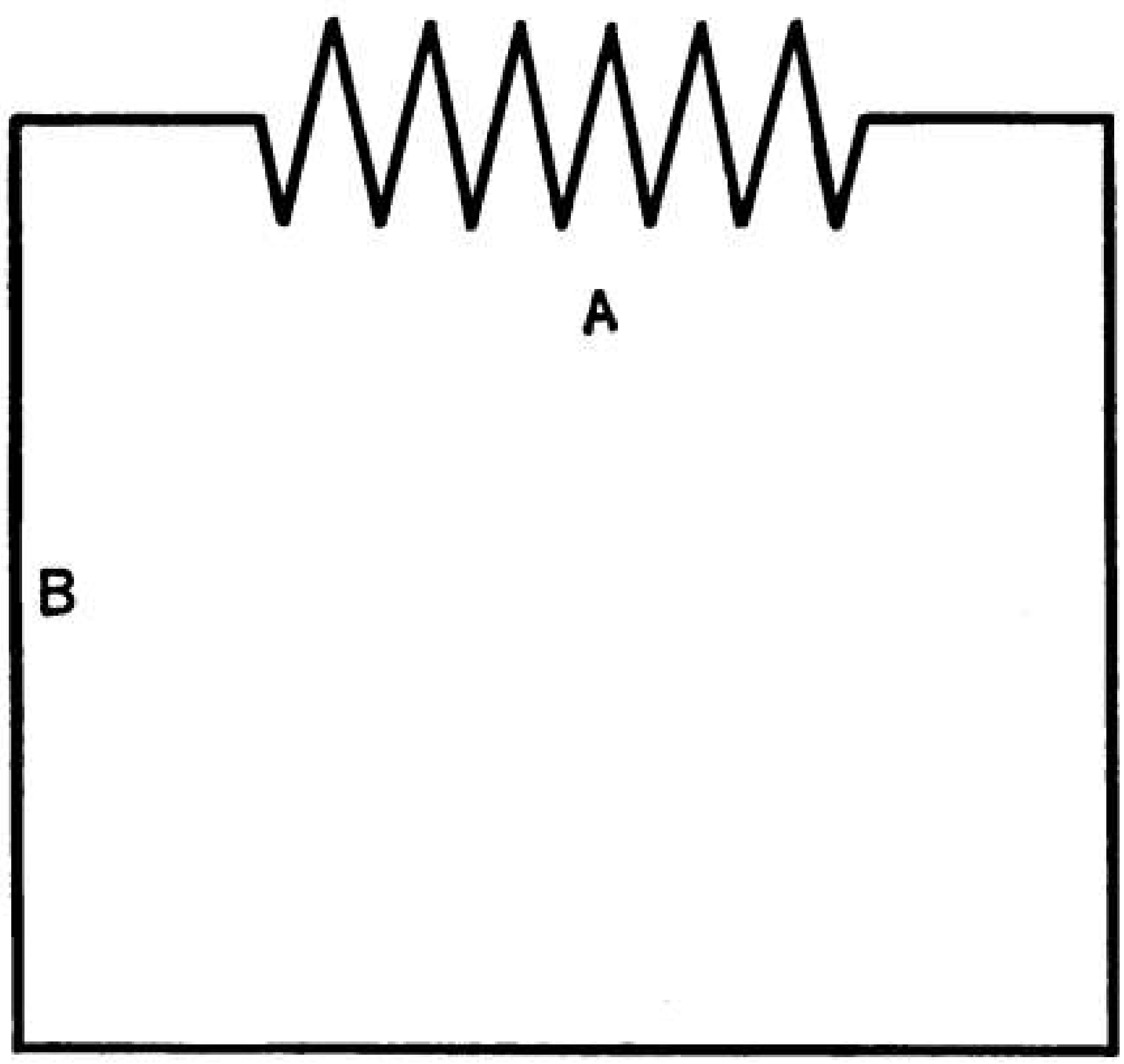

Fig. 9.—Alternating Current Produced by Secondary of an Induction Coil.

analogies must not be taken too literally, since with electricity there is no tangible transfer of matter.

Electric Charges.—When a Leyden jar is charged by an induction coil one of the coatings will be positively electrified and the other and opposite coating negatively electrified, the glass jar separating the two coatings of tin-foil forming an inductively insulating medium between them. When the high-potential currents produced at the terminals of the secondary of the induction coil,—and

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these currents, which, as previously cited, are of an alternating character,—are impressed upon the aerial wire and the earthed wire, these receive and store up the energy exactly like the coatings of a Leyden jar; when these opposite arms or wires are changed to their maximum capacity and to the opposite signs, namely, positively and negatively, the charges rush together in their efforts to equalize the differences of potential and break down or disrupt the air-gap between the balls and a brilliant spark takes place.

Electric Sparks. — If it is desired to produce light-waves, it is only necessary to ignite some substance that will burn with a bright flame, as a pine knot or a stream of gas under pressure; or an electric current may be used to heat the filament of a lamp to incandescence or produce an arc between carbons; but the long invisible electric waves required in wireless telegraphy cannot be obtained in this manner. For many years prior to their discovery it was believed that waves of great length could be set up in the ether, but it was a matter of much speculation as to how to proceed. This and many other things that are of importance in sending and receiving wireless telegraph messages were ascertained by Heinrich Hertz, a young professor at Bonn University, Germany, in 1888.

The electric spark or *disruptive discharge* provides the means for setting the charged arms of the aerial-wire system into motion, when the energy thus released becomes oscillatory and is emitted as electric waves.

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There are many forms of the disruptive discharge from the long, attenuated, ribbon-like sparks shown in Fig. 10 to the thick, white, luminous discharge produced by passing the same amount of energy through a shorter spark-gap as shown in Fig. 11. The characteristics of the discharge are changed somewhat by the type of interruptor used; where the initial current is made and broken by a mechanical vibrating spring interruptor the spark is bright, zigzag in form, and gives forth a sharp, crackling sound when the oscillator-balls are not drawn too far apart, but if a Wehnelt electrolytic interruptor is used the discharge is less brilliant, its path arcuated, and its sound hissing.

The object of using balls at the spark-gap instead of points or disks is that the latter dissipates much of its energy in *brush discharges*, that is, electrified particles of air are thrown off especially from the positive terminal immediately the system is charged, and this greatly weakens the effectiveness of the succeeding disruptive discharge. Where balls are used there are no sharp points or edges to aid a brush or *convective discharge* and which reduces in this way the resistance the air offers to the passage of the current, but permits the charges of the oscillator system to reach their highest values before disruption.

Electric Oscillations.—When a disruptive discharge takes place between the spark-balls of an oscillation circuit all the energy contained in the charge is not consumed in breaking down the air of the gap. On the

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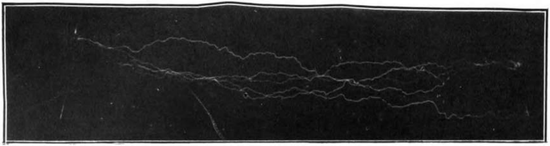

FIG. 10.—Long Thin Spark.

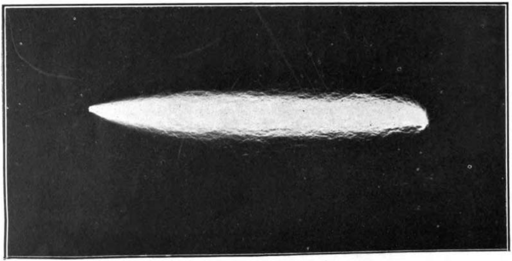

FIG. 11.—Short Thick Spark.

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contrary a very small amount of the total charge of electricity thus set into motion is used for the purpose. What becomes of the rest of the charge that is not consumed? At the instant the spark springs across the gap it burns out the air and the heated particles that result provide almost as perfect a conductor for the high-tension current as though a copper wire connected the spark-balls. In other words, there is for the succeeding instant no longer a break in the oscillator system, but a practically continuous conductor is formed, and this being the case, the static charges, now combined in an active and pertinacious current under high pressure, rushes first to one end of the aerial wire, then back through the spark-gap, now of no appreciable resistance, thence to the end of the earth-wire, and repeats this process two or more times before its energy is damped out.

Surging high-potential currents of this kind are termed *electric oscillations*, and a clearer idea of why and how an electric current oscillates through an aerial and earthed-wire system when released by a disruptive discharge is shown in Fig. 12. Let *A* represent a balance having a lever of equal arms resting on a fixed knife-edge; *B*, Fig. 13, is understood to be an oscillator system charged by an induction coil. It will be observed that in one of the pans of the balance there is a small weight, and this draws one arm down while of course the other arm is raised proportionately, the resultant being a difference of level. In this case the force of gravity tends to equalize the two ends of the beam, bringing it to the same level.

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If the weight is removed gently and gravity is permitted to equalize the difference of level slowly, the beam will

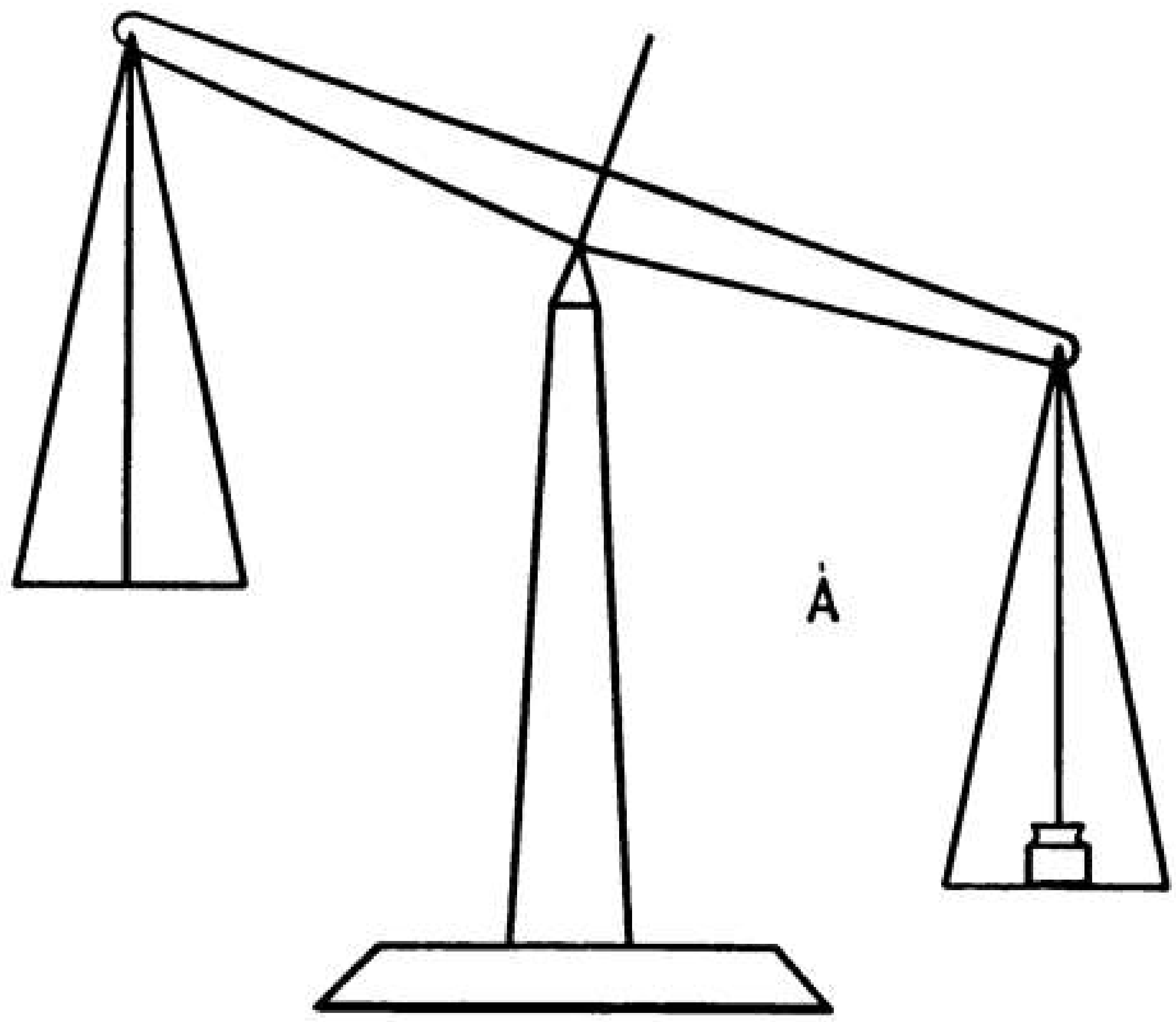

FIG. 12.—Analogue of Electric Oscillations.

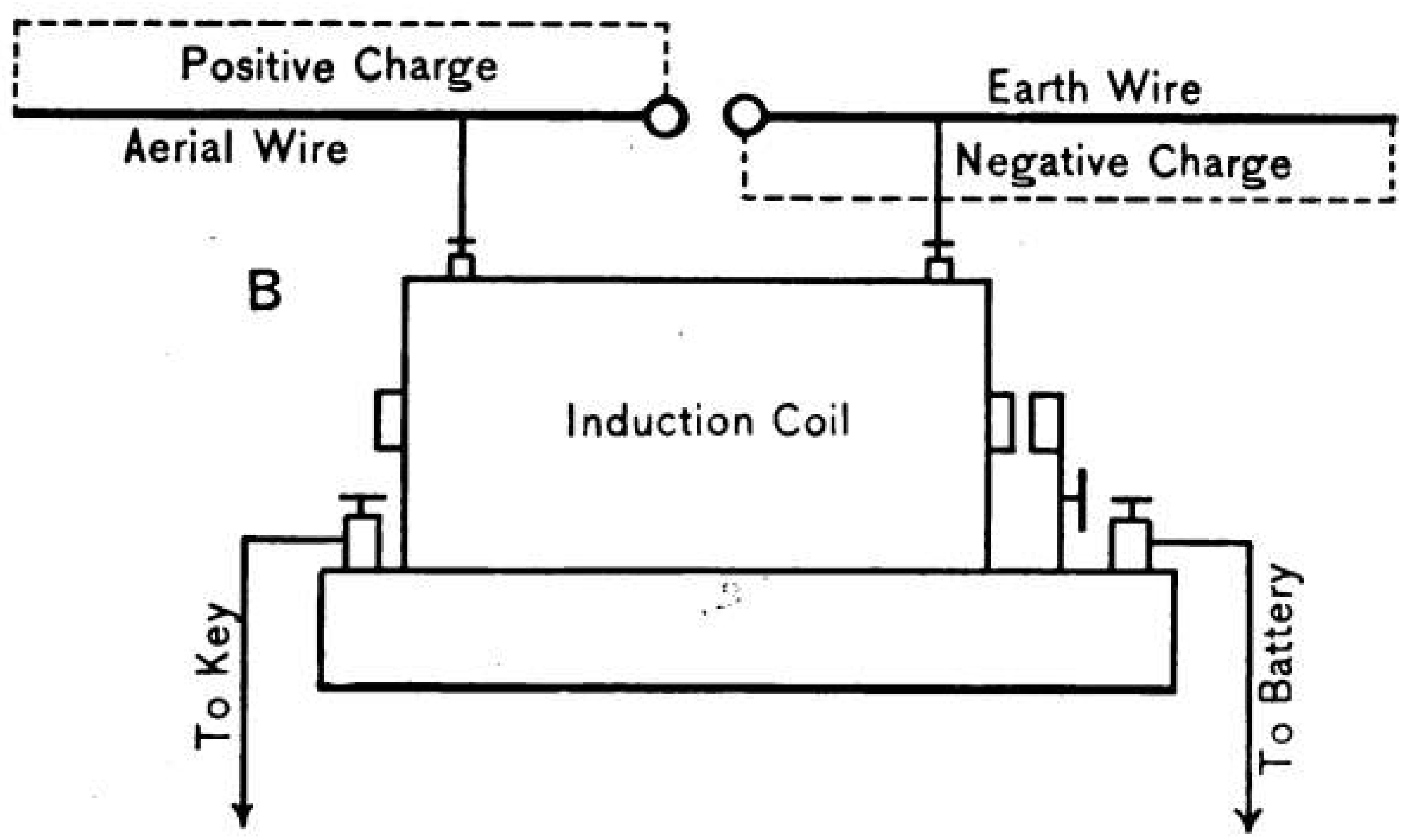

FIG. 13.—Diagram showing how Oscillations are Produced.

come to rest when the balance has been established and there will be no further movement; if, however, the

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weight in the pan is removed quickly, the upper end of the beam will drive the lower end upward not only to its normal level but beyond, and then the process is reversed and the opposite end overshoots its level, and so several swings or oscillations of the beam will take place before it comes to rest.

Exactly so with electric oscillations in an aerial and earthed-wire system; before the disruptive discharge takes place, which is equivalent to removing the weight from the pan of the balance, one side is charged positively or, for the sake of following more closely the analogue above, it is high, and the opposite side negatively or low; under this condition the spark is produced releasing the pent-up energy of either arm, and these, now joined in an electric current, seek to equalize the difference of potential and to restore the electric level. If the resistance of the spark-gap is not too great, the current will swing to and fro several times, or oscillate, before coming to rest.

The electric oscillations in a radiator system may range from 100,000 to 1,000,000 times per second, depending upon the electrical dimensions of the aerial and earthed wire, or its *inductance*, *capacity*, and *resistance*. In the case of the balance its physical properties determine the period or length of time of each oscillation. Likewise the electrical properties, namely inductance, capacity, and resistance, of an oscillator system determine the period of each oscillation of the surging current.

Electric Waves.—When an electric oscillation surges through the radiator system of a wireless telegraph

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transmitter a small portion of its energy is used up by the various opposing forces or resistances which it has to overcome. But what becomes of that portion that is not required for this purpose? If a metal rod is heated, let us say, to redness, it will send out the energy impressed upon it in the form of waves in the air, and any object if not too far away will receive the transmitted waves and be heated to a certain extent by it. Similarly the aerial wire of an oscillator system will radiate the energy impressed upon it in the form of electric waves in the ether. These waves are emitted at right angles to the aerial wire, and like light and all other waves propagated by the ether they travel at a velocity of about 186,500 miles per second. The lengths of electric waves vary inversely with the period of oscillation producing them, and therefore to determine the wave-length it is only necessary to divide the velocity by the number of waves per second. The wave-lengths employed in wireless telegraphy are from 200 feet to one fourth of a mile, and to obtain the most efficient waves the period of oscillation must be in accord with the electrical properties of the radiating system where there are two oscillating circuits coupled together. Like light-waves, electric waves may be reflected, refracted, and polarized, provided the mirror, prism, or polarizing grid is of a size commensurate with the length of the waves.

Propagation of Electric Waves. — There are two theories to account for the manner in which electric waves traverse distances so great that the curvature of

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the earth rises higher than the aerial wires. The writer believes the waves are in all essential respects like those of light, and that when two stations are located closely enough so that the sending and the receiving aerials are in a direct visual line the waves are propagated in a straight line, as shown in the diagram Fig. 14. If, on the other hand, the receiving aerial is so far distant from the sending station that the earth rises like a hill between them, then the electric waves travel onward until the higher strata of the ether are reached, which act as a reflector, when their direction is then changed and they are propagated back to the earth's surface. This is termed the *free-wave theory.*

A second theory, and one much more widely held, accounts for their transmission over obstacles by assuming the electric waves to slide over the surface of the earth or sea. As the spark-gap of the oscillator system is located very near ground, considering the height of the radiating aerial, it is assumed that the waves are emitted only from this part of the system and are virtually cut in half as shown in Fig. 15, while the lower half of the waves would exist only as an image or reflection of the upper half. The earth or sea is not a perfect conductor, but is sufficiently so to permit the waves to skim over their surfaces. This is briefly the *sliding half-wave* theory of electric-wave propagation. Fortunately for those who practice wireless telegraphy these theories may be entirely ignored, for after the electric waves have left the radiating aerial until they again impinge

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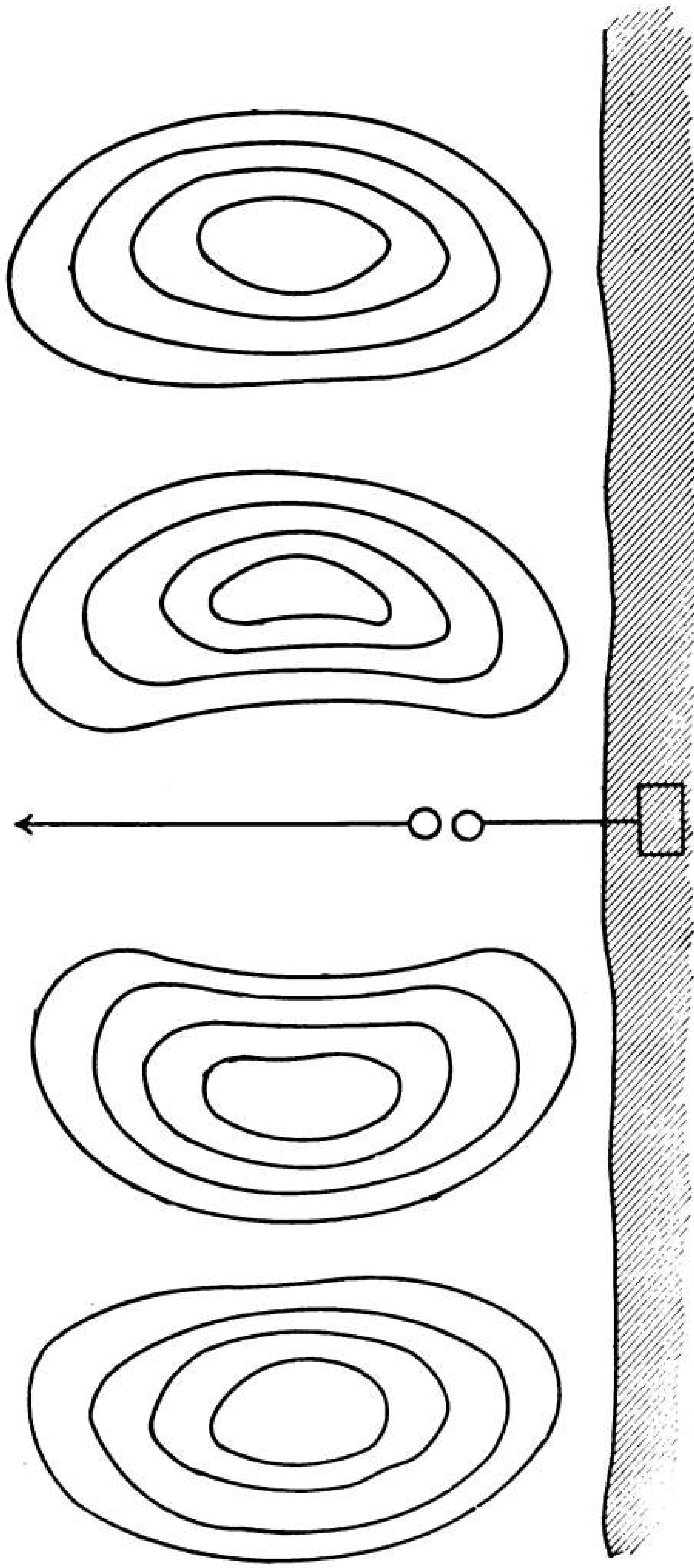

Fig. 14.—Free Electric Waves.

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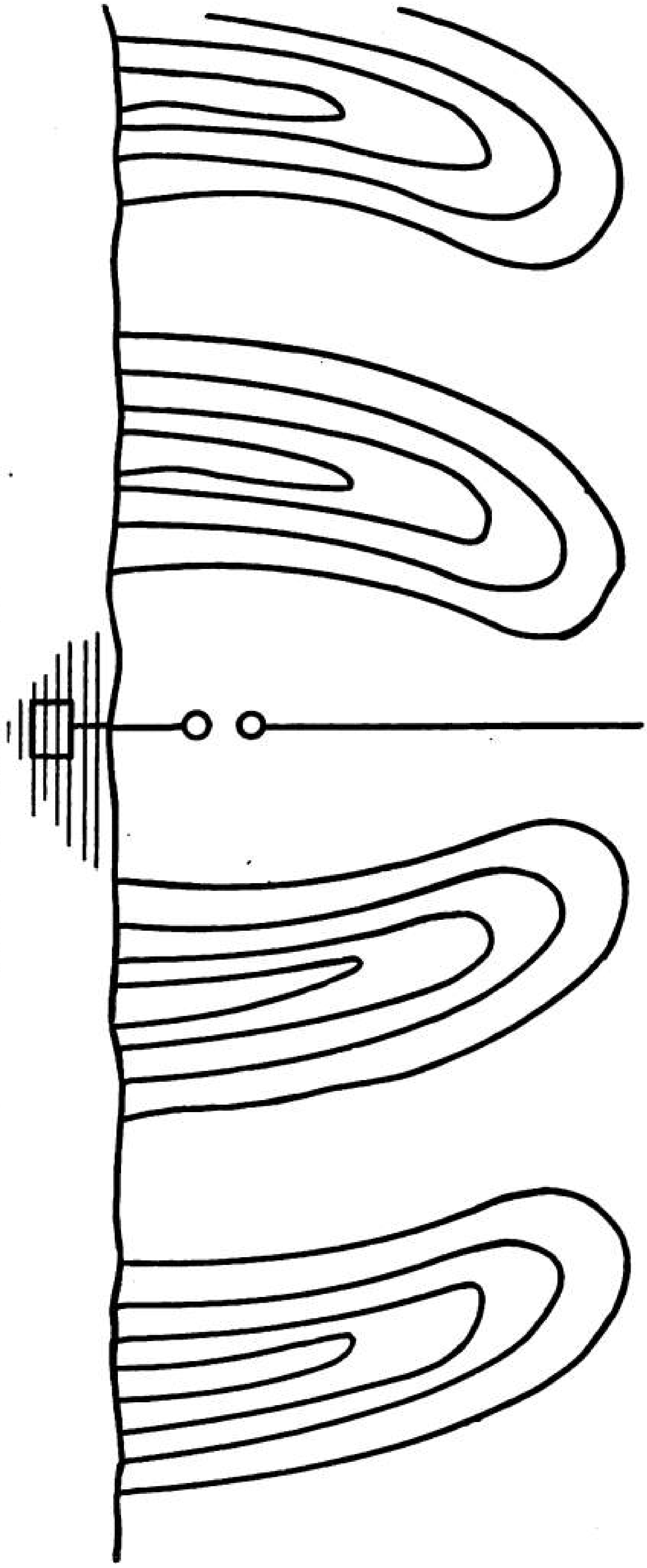

FIG. 15.—Sliding Electric Waves.

upon the receiving aerial they need not concern the operator.

The Ether.—It is impossible to say of what the ether is composed, but it is a substance that is fifteen trillion times lighter than the air, and when set into vibration produces and propagates light and all other electromagnetic waves of whatever length. The following illustration may make its functions clearer.

When a message is sent from one station to another by wireless telegraphy the waves of course travel through the air; but, while this is true, the air really has nothing to do with their transmission. That is to say, the air cannot propagate electrical energy as it does mechanical energy. If a bell is rung in a globe from which the air has been exhausted, its vibrations cannot be heard, for sound waves are conveyed through space by the particles of air; oppositely, if an incandescent light is placed in the globe and a vacuum produced by means of an air-pump, its light will shine forth even better than if the air was present, for there is then nothing in the glass but the ether.

The source of light and the eye constitute in reality a wireless outfit, the first sending out trains of waves through the ether like a radiating aerial wire, and the eye receives them very much like a coherer; hence the latter is sometimes termed an electric eye. Light waves and waves sent out by a wireless transmitter are identical in every particular except that of wave-length, the first being excessively short and the last exceedingly long.

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Light waves are produced by infinitely minute charges of electricity upon atomic matter that have been set into motion by the application of heat or by other means. These charges move with extreme rapidity, the slowest capable of impressing the human sight, vibrating 400 billion times per second, and the fastest 750 billion times per second; these vibrations send out in the first instance waves in the ether that approximate 271 ten-millionths of an inch in length, which gives us the sensation of red light, and in the last case, waves 165 ten-millionths of an inch in length, that are seen as violet light. If the electric charges vibrate faster than those giving violet light or slower than those producing red light, they are not visible, for the eye is not designed to receive them. Shorter waves than the visible violet give rise to ultra-violet radiations, and like those immediately lower than the visible red, or infra-red as they are termed, they are invisible. Yet the last-named waves may be measured by the ten-millionths of an inch.

When the length of the waves reaches a value approximating a thousandth of an inch, an inch, a foot, a rod, or a mile they can no longer be seen or felt, and their presence can only be indicated by some physical apparatus such as a coherer. Waves of this length are set up by oscillating currents surging on the surface of masses, such as wires instead of gaseous atoms, and it is the former we have to deal with in wireless telegraphy.

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The Constants of the Oscillation Circuit.—These are its resistance, inductance, and capacity, and may be compared to the dimensions of a mass, hence they are sometimes referred to as the electrical dimensions of a circuit. These constants determine how the current shall be damped out and what its rate of oscillation shall be, as will be seen by a perusal of the following.

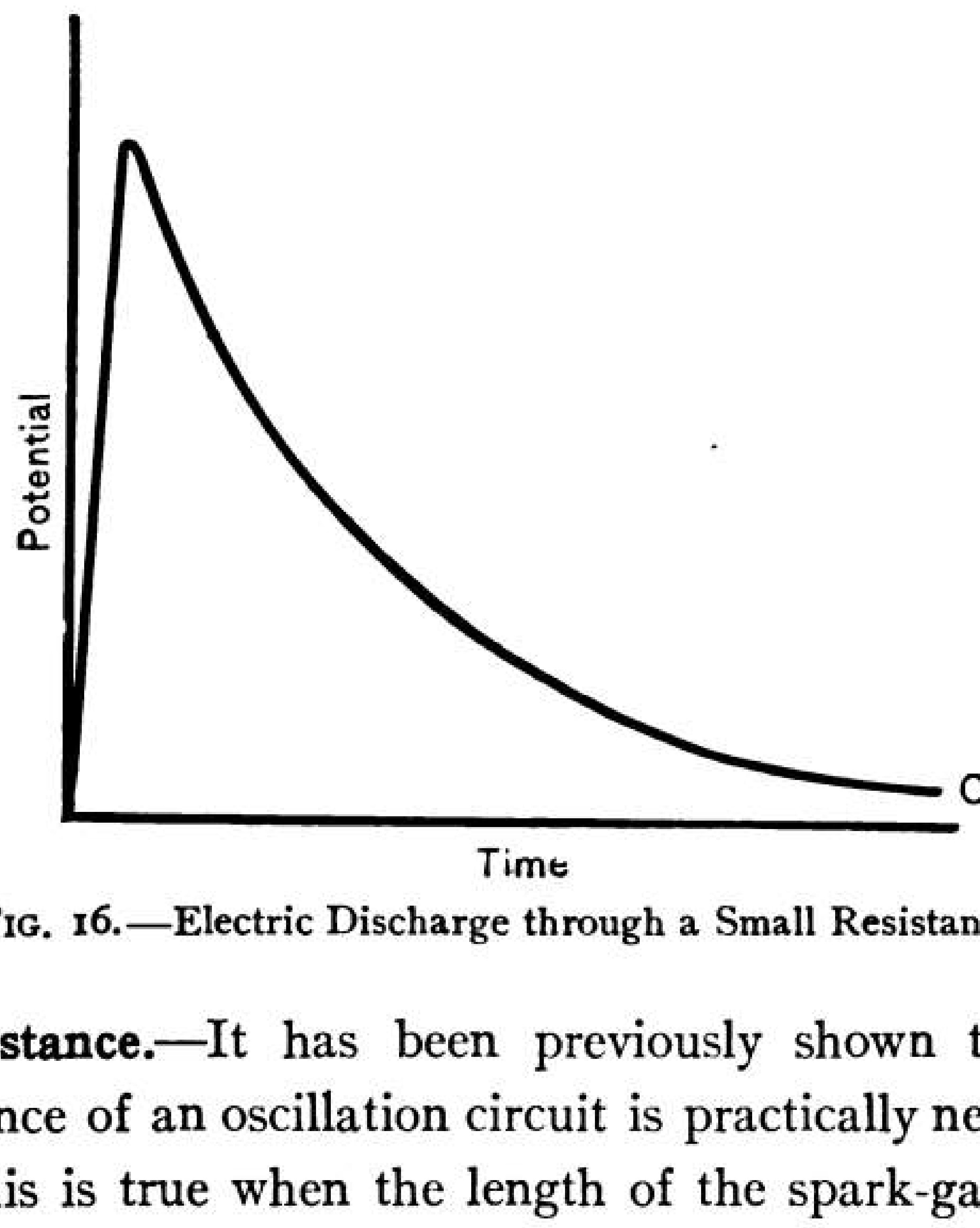

FIG. 16.—Electric Discharge through a Small Resistance.

Resistance.—It has been previously shown that the resistance of an oscillation circuit is practically negligible, and this is true when the length of the spark-gap is cut down to its proper working value. The resistance of the spark-gap may, however, be so great that the disruptive discharge will not set up an oscillating current but a *unidirectional current*, or a current flowing in one direction only, just as we have seen how the beam of a balance

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may come to rest in a single swing. When an electric discharge takes place through a large resistance the current describes a smooth curve, as shown in Fig. 16; but when the discharge is through a small resistance, then it becomes periodic and oscillates until it reaches zero, as shown in Fig. 17. The unit of resistance is the *ohm.*

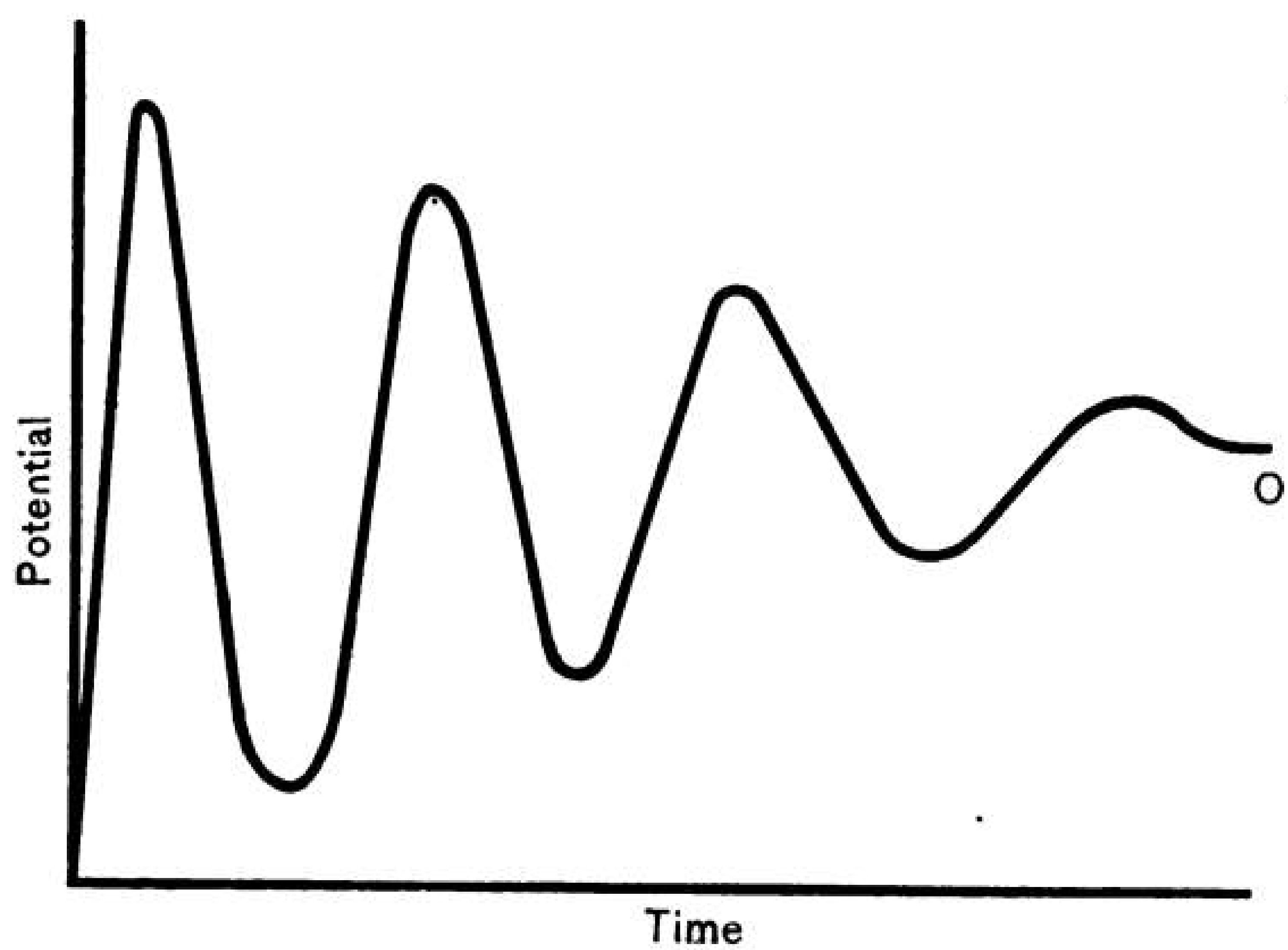

FIG. 17.—Electric Discharge through a Large Resistance.

Capacity.—The capacity of an oscillation circuit is its property to retain a charge of electricity, and to an extent where its pressure or potential is high enough to break down the air of the spark-gap. By increasing the capacity of the oscillation system, as by inserting a condenser or adding to the length or surface of the aerial wires, the energy of the oscillations may be increased, and of course in this way the effectiveness of the waves radiated will

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be increased. Charging the aerial-wire system consists of distributing the high-potential active energy from the terminals of the secondary of an induction coil over the surface of the aerial and earth wires, the interposed spark-balls, and condenser and inductance coil, if these are included. The greater the capacity the slower will be the period of the oscillations, since the charging process must be repeated after each disruptive discharge. The unit of capacity is the *farad*, but, as this is too large for ordinary purposes, a *microfarad*, or one millionth of a farad, is used instead.

Inductance.—A current of electricity always requires a certain length of time to start and, once in motion, a certain length of time to stop. In this respect it is like the inertia of matter; for instance, a ball cannot put itself into motion, and when thrown into the air it has no power to stop, and would not if the resistance of the air and action of gravity did not combine to make it. Electricity acts similarly. The *self-induction*, as this property of the electric current is called, depends largely upon the form of the wire, that is, whether it is straight or coiled, and the material surrounding the circuit, though usually this is air and represents unity. The inductance of a circuit, like capacity, has the property of slowing down the oscillations. The value of the practical unit of inductance is the *henry;* the henry, like the farad, may be too great for convenience, when it may be expressed by some practical dimension, as a *millihenry*.

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Open and Closed Oscillation Circuits. — In simple open-circuit systems where the spark-gap is placed directly between the aerial and earthed wires and the secondary terminals connected thereto, the constants of resistance, capacity, and inductance determine the period of oscillation and consequently the emitted wave-length,

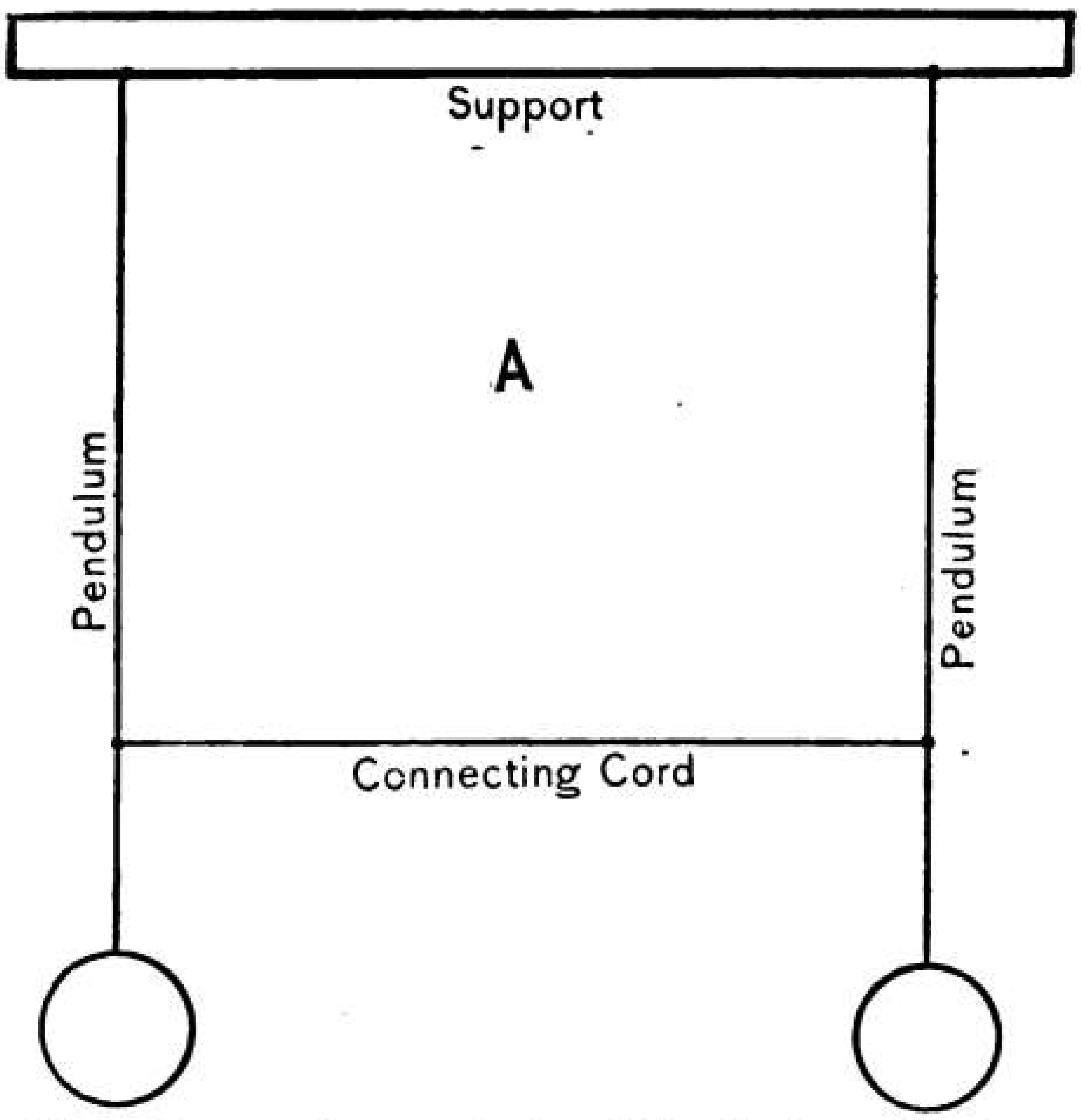

FIG. 16.—Analogue of Tuned Oscillation Circuits.

just as a piano-string will vibrate to its own natural period and send out sound-waves of a predetermined length. In nearly all commercial systems there are two oscillation circuits and these are *coupled*, or connected together. Under these conditions the two circuits—usually a closed one and an open one—must be tuned to each other.

An analogous case is that of two pendulums, see dia-

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gram Fig. 18, with the free ends connected by a cord. If the pendulums are of the same length, size, and weight, then they would swing, with the cord binding them together, in unison; but if one of the pendulums was shorter or lighter than the other, then their periods

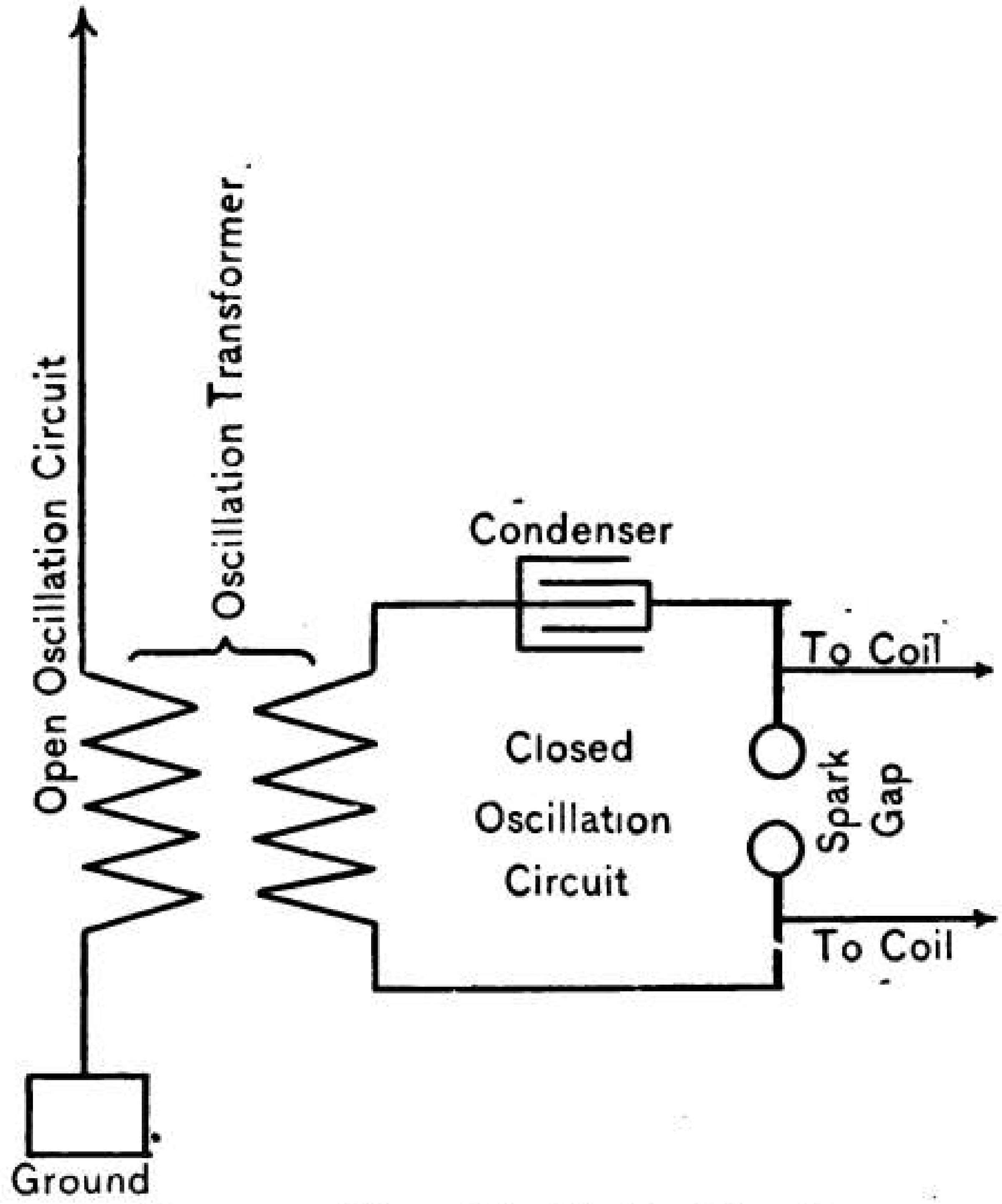

FIG. 19.—Tuned Oscillation Circuits.

of oscillation would vary, and if coupled together with a cord they would oppose each other, so that neither would swing normally; in other words, they would be out of phase, just as electric oscillations are when the circuits have different dimensions. In order that a larger amount of energy may be delivered to the radiating aerial and to better sustain the oscillations set up in it, commercial

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installations have an open and a closed oscillation circuit coupled together, as shown in Fig. 19.

The spark-gap in this case is placed in the closed circuit, as is an *adjustable condenser* formed of a Leyden-jar battery and a *variable inductance coil.* Before the disruptive discharge takes place the secondary of the induction coil charges the battery of Leyden jars until the potential is sufficient to produce a disruptive discharge. When the spark passes the oscillating current surges through the closed circuit. The large capacity of the Leyden-jar battery permits a much larger quantity of energy to be utilized; the aerial and earth wires being connected to the closed circuit through the inductance coil as shown, the oscillations are impressed upon it when it radiates them into space as electric waves. Like the pendulums the open circuit must be in tune with the closed circuit, so that the period of oscillation of each may be identical.

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CHAPTER III

THE APPARATUS OF A COMMERCIAL SYSTEM

The Induction Coil.—This is the chief piece of apparatus used in the transmitter of a wireless telegraph system. Where the distance between the sending and receiving stations is not great the coil is generally provided with a vibrating spring interruptor mounted on the same base, while the interior of the base contains the condenser. Such a coil is shown in the experimental transmitter previously described, and coils of this type may be purchased in the open market in sizes ranging from those giving a ½-inch to a 12-inch spark.

In the usual commercial systems the induction coil, *interruptor*, and *condenser* are mounted separately. An induction coil proper consists of a *core* formed of a bundle of soft-iron wires, and upon this are wound two layers of heavy insulated wire termed the *primary coil*, or *inductor*, the ends of which are brought out and attached to binding-posts as shown in Fig. 20. The long fine insulated wire forming the *secondary coil* is wound around the primary coil but is, at the same time, carefully insulated by a tube of glass, hard rubber, pasteboard, or micanite. The

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ends of the secondary coil are connected to insulated binding-posts.

The secondary coil of a commercial transmitter is wound with a larger wire than the ordinary coil and will not give as long a spark as the latter, for the number of turns of wire are fewer and the potential or voltage is thereby cut down; but this is more than compensated for, as the discharge is heavier, caused by a greater

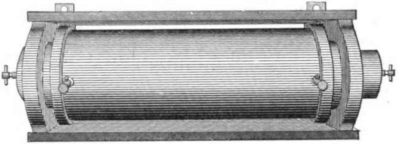

FIG. 20.—Induction Coil.

amount of current developed. As the induction coil is, in nearly every instance, employed to charge a battery of Leyden jars, the latter discharging its energy by sparking across the gap, this construction is admirably adapted to the class of work for which it is designed.

Interruptors.—There are three general types of interruptors found in wireless telegraph stations; these are (*a*) the *vibrating spring*, (*b*) the *mercury turbine*, and (*c*) the *electrolytic interruptors.*

(*a*) Of the vibrating-spring interruptor there are numerous modifications, but the simplest and most widely used form is that shown in Fig. 21; it is sometimes

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termed a Neef hammer interruptor, in honor of Neef, who invented it. It consists of a steel spring with one end rigidly atached to a post or standard, while the free end carries a disk of soft iron called an ***armature.*** A second standard carries a screw having a platinum

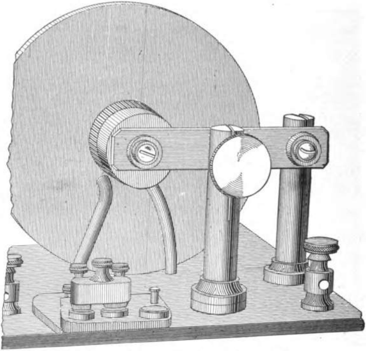

FIG. 21.—Vibrating-spring Interruptor.

point which makes contact with the vibrating spring by means of a bit of platinum soldered to the latter. When a current flows through the interruptor and primary of the induction coil, the core of the latter is magnetized and attracts the armature, drawing the spring forward and breaking the current between the contacts. The core

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now demagnetized, releases the armature, and the elasticity of the spring causes it to again make contact with the stationary point. In this interruptor there is only one adjustment to make, and this is done by means of the screw carrying the movable contact-point.

(*b*) The mercury turbine interruptor is most frequently used in commercial wireless stations. This device is capable of making and breaking the primary current from 10 to 10,000 times per second. Its construction is comparatively simple and its action effective. In the base of an iron containing vessel having a ribbed bottom six pounds of pure metallic mercury are placed. Through the center of the vessel is a revolving worm or a small centrifugal pump attached to a steel spindle driven by an electric motor. Above the worm or pump is a tube or nozzle, also attached to the spindle, and when the latter is rotated at a high speed the mercury contained in the well is raised until it reaches the nozzle, when it is projected against the side of the vessel. A sector or segment of metal sets inside the vessel, from which it is insulated, and in such a position that the mercury is thrown against it, thus completing the circuit, and breaks it when it has passed the segment and impinges on the side of the vessel. By varying the speed of the shaft to which the nozzle is attached, and the length of the segment, the number of interruptions may be changed at will. When installed on shipboard, the interruptor with its motor, which is connected direct to the spindle, is swung in gimbals, as may be seen in Fig.

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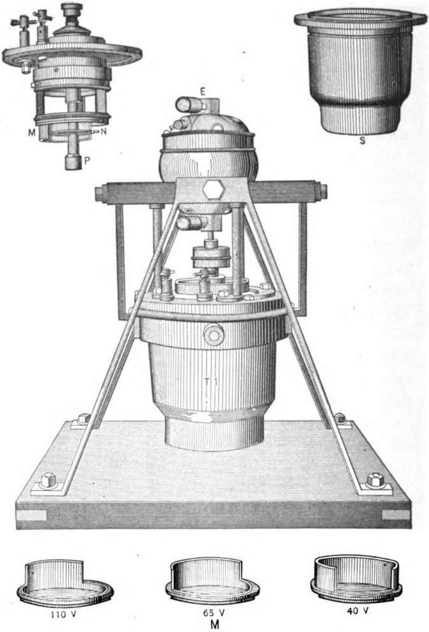

FIG. 22.—Mercury Turbine Interruptor with Electric Motor.

*T*1, Mercury Interruptor; *E*, Electric Motor; *M*, Segments; *P*, Centrifugal; *N*, Nozzle Pump; *S*, Cast-iron Vessel.

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22. The motor is an ordinary direct-current machine wound to operate on the same voltage as the primary of an induction coil, since both are included in the same circuit. Where the voltage of the primary is low the segment must be increased in length; that is to say, for a potential of 110 volts the segment must be a quarter of a circle, and for 55 or 60 volts it must equal the half of a circle.

(*c*) Some makers of apparatus prefer the electrolytic interruptor to the one just described, for in this type there are no moving parts. The interruptor is made up of a vessel containing a solution of dilute sulphuric acid, called the *electrolyte*, and in this is immersed a platinum anode, or positive terminal, having a surface of about $\frac{3}{16}$ of a square inch, and a lead cathode, or negative terminal, of 144 square inches. When these electrodes are connected in series with the primary coil and a source of electromotive force of 40 volts, interruptions will take place through the formation and collapse of bubbles on the platinum anode. A photograph of this interruptor is shown in Fig. 23.

Condensers.—An induction coil if it is to render efficient service must have an interruptor that "makes" and "breaks" the current with extreme suddenness; but even in the mercury-turbine and electrolytic interruptors the time required to effect the break is large when compared with zero, i.e., absolute instantaneousness. Where the source of current, the primary of the coil, and the interruptor are connected in series the voltage rises in

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virtue of the inductance of the primary due to the number of turns of wire of which it is formed, and as a result of this an excessive spark takes place at the interruptor contacts.

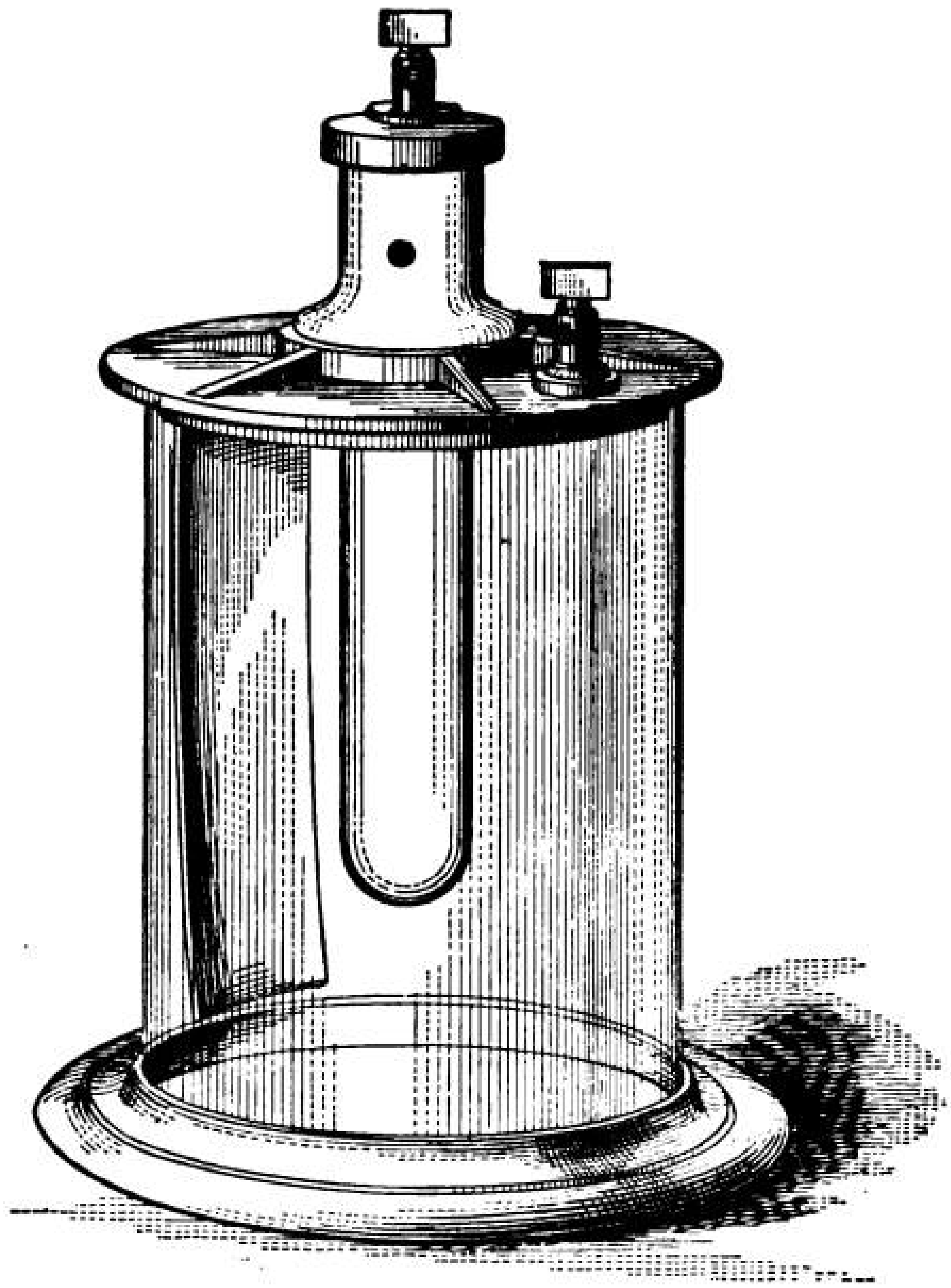

FIG. 23.—Electrolytic Interruptor.

(*a*) To prevent this a condenser is *shunted* across the interruptor where the break occurs. Condensers for this purpose are made of sheets of tin-foil, these being alternately connected and separated from each other by sheets of mica. After the condenser is thus built up it is immersed in a melted insulating compound under

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pressure and the air is exhausted by means of an air-pump. This is done to prevent the bubbles of air from remaining between the successive leaves of tin-foil, which, if left there, when the condenser is charged might serve as a conducting path for the energy and so disrupt it.

(*b*) A Leyden-jar battery, Fig. 24, is a condenser

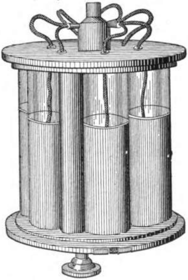

FIG. 24.—Leyden-jar Battery.

capable of withstanding high potentials and is formed of a number of glass jars each having an inside and an outside coating of tin-foil. Such a battery is inserted in the closed oscillating circuit and is charged by the secondary of the induction coil, and when this charge reaches a certain critical value it discharges through the spark-gap. The jars supplied with the outfits vary in number from three to seven, according to

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the size of the equipments. These are mounted in a case or cylinder, their inner and outer coatings being connected in parallel.

(*c*) In the resonator system between the coherer and the earth-plate a small condenser, built up of sheets of tin-foil and oiled paper, is inserted. Its purpose is to prevent the atmospheric electricity accumulated by the aerial wire from passing through the coherer, as well as the current from the dry cell in the coherer circuit from short-circuiting through the tuning coil to the earth.

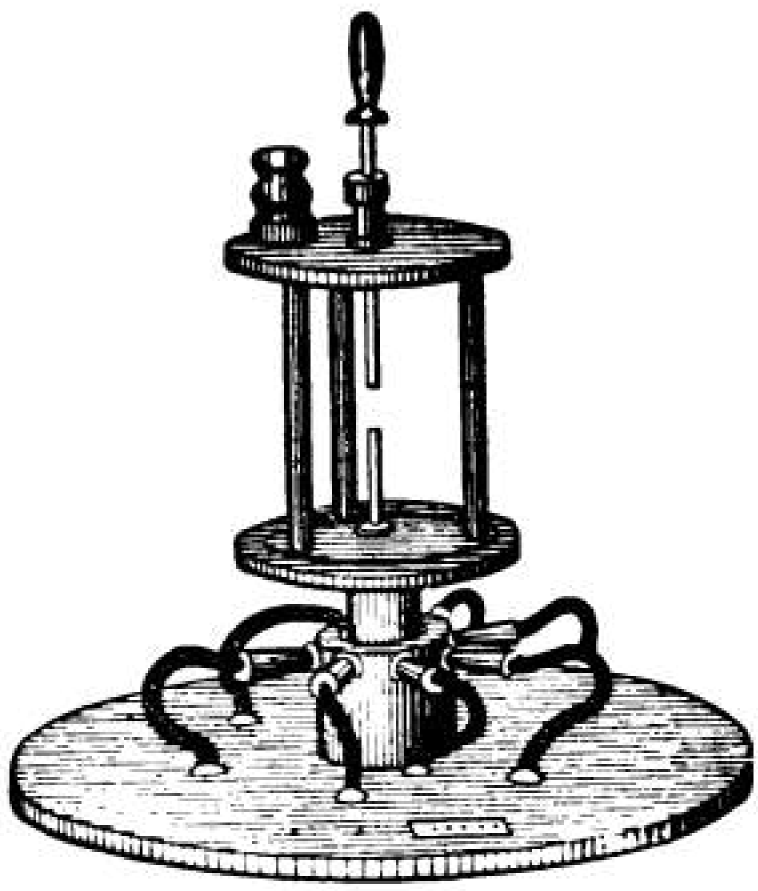

FIG. 25.—Adjustable Spark-gap.

Spark-gaps.—In some systems the spark-gap consists merely of two brass balls an inch or so in diameter, mounted on brass rods in alignment and sliding through insulated supports. In others they consist of a pair of vertical zinc rods with rounded ends, oppositely disposed, and one of which is movable; these are enclosed in a circular box having a mica peep-hole and mounted on top of a pasteboard case containing the Leyden jars

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and on which the inductance coil is wound. The object of enclosing the spark-gap is to deaden the sound of the

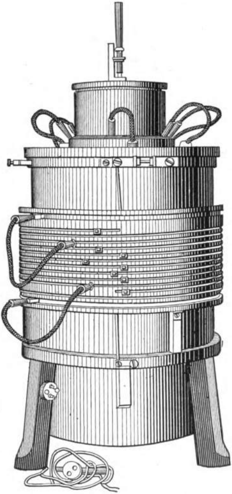

FIG. 26.—Leyden-jar Battery and Variable Inductance Coil.

disruptive discharge, while a view of the spark may be had through the mica window. Fig. 25 shows the spark-gap with the case removed.

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Inductance Coils. — In order to *tune* the open and closed circuits of a transmitter or a receptor to the same

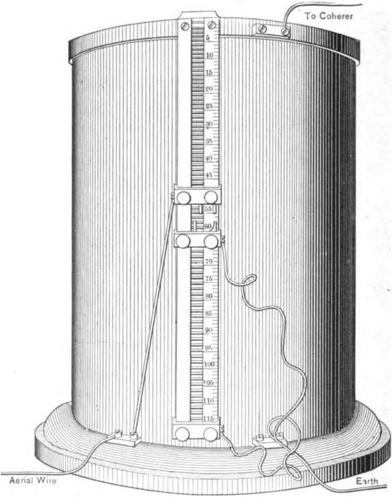

FIG. 27.—Tuning Inductance Coil for Receptor.

period of oscillation, and *syntonize* the receiving apparatus of one station with the sending instruments of a distance station, inductance coils, sometimes termed *tuning coils*, are supplied.

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(*a*) In the transmitter the inductance coil is made of four or more turns of heavy bare copper wire wound spirally on an insulated frame or an ebonite ring surrounding the pasteboard cylinder containing the Leyden jars, as shown in Fig. 26. The ends of the coil are permanently connected with the Leyden jars and the earth, while the other connections are made with flexible cords having spring clips or plugs attached; these will.

enable the operator to vary the value of inductance at

(*b*) The inductance coil for tuning the receptor consists of much finer and longer wire wound spirally on a hexagonal or cylindrical frame of ebonite or wood, as shown in Fig. 27. The turns of wire are of course insulated from each other; the inductance is varied by means of sliding contacts.

Morse Keys.—There are two types of telegraph keys used in wireless transmitters, and the one chosen must depend upon the kind of receptor that is used.

(*a*) Where an electrolytic or other self-restoring detector is employed the key usually has the appearance of an ordinary Morse key for wire telegraphy. From the lever of the key, however, there projects beneath an arm of metal extending into a compartment filled with oil. On the end of the arm is a platinum point, and this makes contact with a similar stationary point, the break taking place in the oil. With this key currents of 5 or 6 amperes may be broken, and it is capable of very rapid manipulation.

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(*b*) The type of key used where a coherer and *Morse register* form the indicating apparatus of a receptor is shown in Fig. 28. It is a Morse key but, unlike the other, it is of large dimensions. The handle is of hard rubber; the lever is some five inches in length, and across the contact-points of the key, in some systems, a condenser is fitted to reduce the spark, while in others a

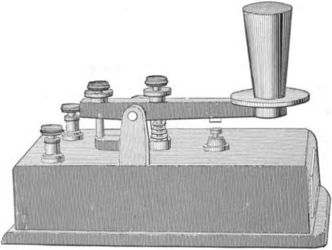

FIG. 28.—Morse Key.

magnetic blowout is provided for the same purpose. The blowout consists of an electromagnet with pointed poles placed at right angles to the contact-points. When the circuit is broken the current is shunted through the coils of the magnet and the magnetic field blows out the spark. A key of this type will break a current of 8 or 10 amperes continuously, but is designed for slow operation.

Wave Detectors.—There are three types of wave detectors in common use in wireless receptors, namely,

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the *coherer*, the *electrolytic*, and the *magnetic detectors*. The first is utilized in connection with a relay and a Morse register, while the second and third are employed with telephone receivers.

(*a*) The coherer, Fig. 29, consists of a small glass tube having terminal conductor-plugs of silver, beveled at the ends to form a V-shaped pocket. Leading-in wires are sealed in the ends of the tube, and these are attached to the conductor-plugs as shown. The pocket or space formed

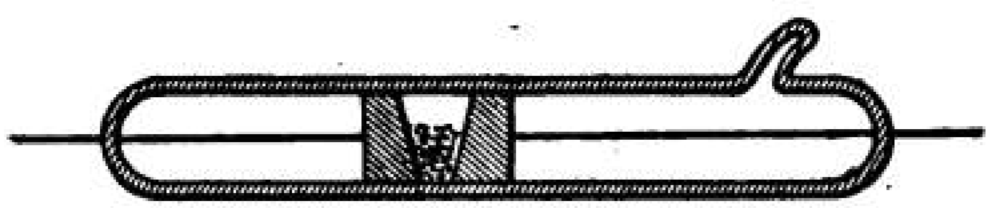

FIG. 29.—Marconi Coherer.

by the approaching ends of the plugs contains a small quantity of nickel and silver filings. The teat projecting at right angles to the tube is the part where the coherer was attached to the air-pump and was sealed off after the tube was partially exhausted, which prevents the oxidization of the enclosed filings.

(*b*) The electrolytic detector, Fig. 30, is not unlike the electrolytic interruptor previously described, though on an exceedingly small scale. Into a small platinum vessel a little larger than the end of an unsharpened lead-pencil, and which forms the cathode or negative terminal, a very fine platinum wire a few thousandths of an inch in diameter is just immersed in the solution or electrolyte; of the latter there are several different kinds, some using dilute acid and others dilute alkaline

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solutions. The electrolyte is supplied by the makers as well as extra platinum points, so that the operator will

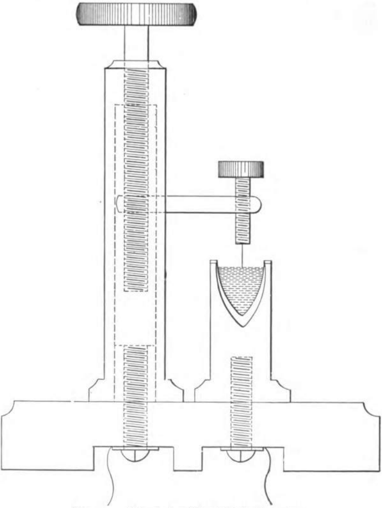

FIG. 30.—Fessenden Electrolytic Detector.

have no difficulty in this respect. These detectors are provided with a screw by which the fine platinum wire is raised or lowered in the electrolyte.

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(*c*) The magnetic detector has found an extended use in one of the commercial systems. It consists of a small glass tube, Fig. 31, on which is wound a primary made of a single layer of wire, the terminals leading

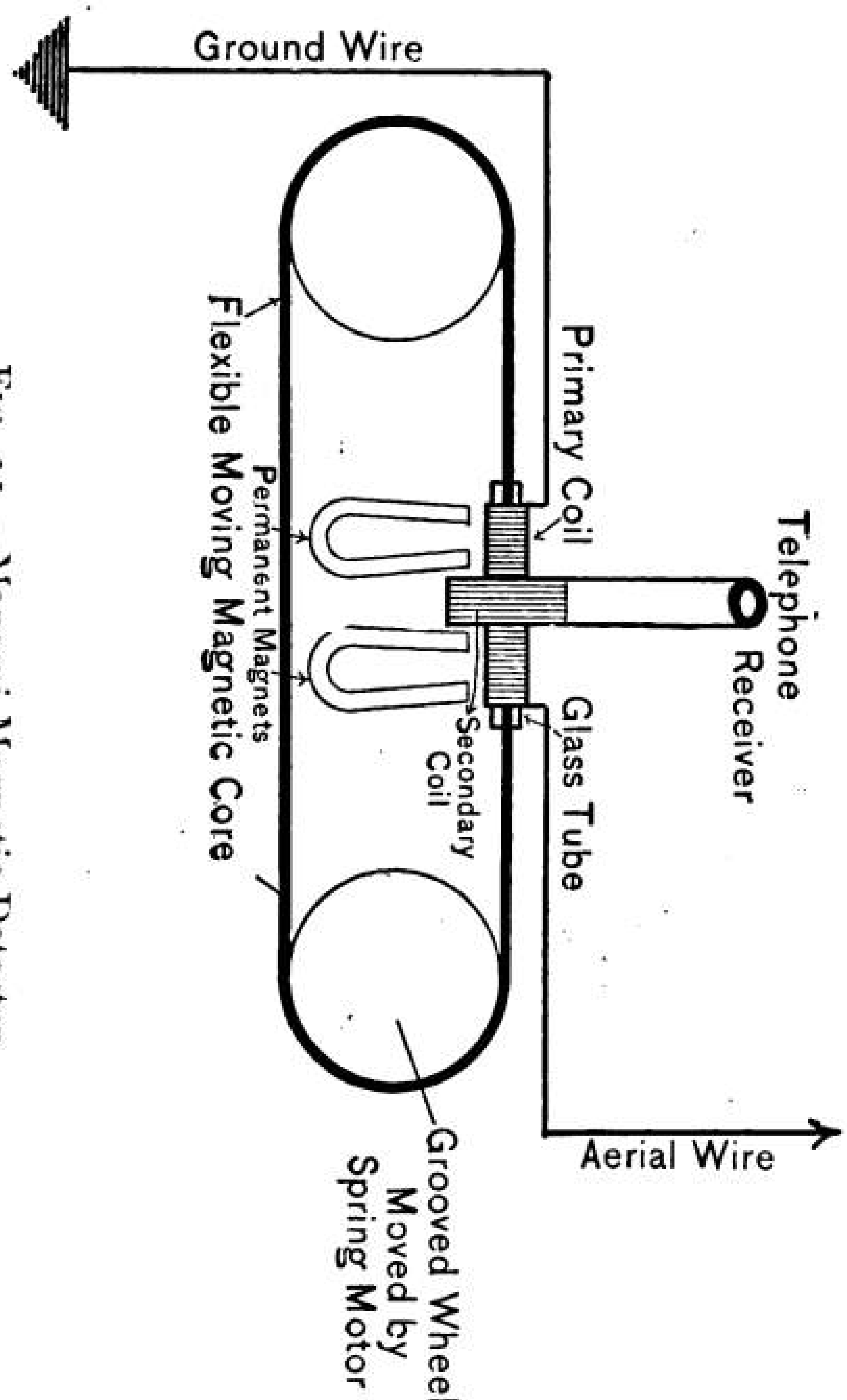

Fig. 31.—Marconi Magnetic Detector.

to the aerial and earth wire either directly or through a compound resonator circuit. A second coil of wire is slipped over the primary, and the terminals of this connect with a telephone receiver; two grooved wheels

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4 inches in diameter are connected by a flexible cord formed of iron wires, which is made to travel through the glass tube by means of a spring motor enclosed in a case, while two steel hoseshoe magnets are placed closely to the moving band of wire and adjusted until the maximum effect is obtained.

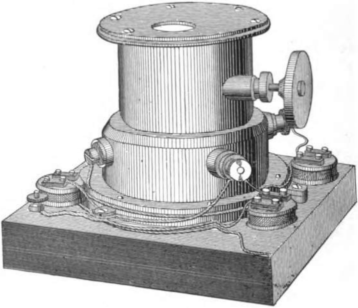

FIG. 32.—Polarized Relay.

Relays.—The relay used in ordinary telegraphy is not nearly sensitive enough for wireless work and hence a *polarized relay* is used; a polarized relay has a permanen steel magnet and an electromagnet so arranged that both poles of the latter are N, or positive, when no current flows through the magnet coils. When the coherer which is connected in series with the coils of the relay and a

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dry cell permits the current to complete the circuit, the electromagnet is energized and one of the poles changes its polarity to S, or negative, and the other to increase its N, or positive, intensity. The armature lever is free to swing between the poles of the electromagnet within narrow limits, and when the poles become magnetic the movable contact-point attached to the armature is drawn into contact with a stationary point, and in this way closes the circuit in which the tapper and Morse register are placed. A polarized relay is shown in Fig. 32.

Tappers or Decoherers.—When the filings of a coherer are drawn together or cohered by the electric oscillations set up in the resonator circuit and the impulse printed by the Morse register, there can be no further indications of the incoming waves until the filings are broken apart or decohered, restoring them to their original loose state and high resistivity. To accomplish this it is only necessary to gently tap the coherer tube. It would of course be impracticable to do this manually and so an automatic tapper was devised. The tapper is very similar in construction to a vibrating electric bell or the vibrating spring interruptor previously described. The vibrating armature carrying the hammer is short compared with that in a bell, and its vibrations are very rapid. Attached to the base on which the tapper is mounted is a holder for the coherer, as in Fig. 33.

Morse Registers.—In the two principal foreign systems that are used in this country the Morse register, or Morse writer as it is sometimes termed, is used to print the

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message on a tape of paper. These registers are usually constructed to release the spring mechanism, that draws the tape under the inked disk, automatically, but in some cases the spring motor is released by the operator.

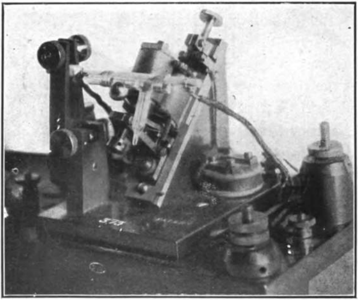

FIG. 33.—Marconi Tapper.

A Morse register is shown in Fig. 34 and comprises the spring motor that moves the paper and the electrically operated mechanism that prints the dots and dashes upon it. The spring motor is placed inside a brass case which serves to support the spindles; the case is fitted with a glass top to keep out the dust and yet enables the operator to see its various parts. To one of the spindles projecting outside of the brass case a toothed wheel serves to draw the paper from the roll under the

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inked surface of a steel disk which prints the message in dots and dashes upon it. The tape should move at a slow rate of speed compared with the vibrations of the hammer of the tapper, otherwise there will be a succession of dots where these should run together and make dashes. The coils of the register, like those of the tapper, are wound to about 12 ohms, since the two instruments are connected in parallel.

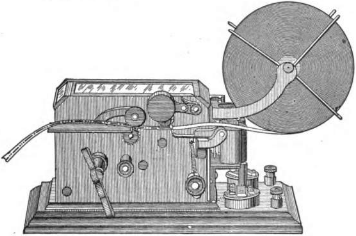

FIG. 34 —Morse Register.

Telephone Receivers.—Where a detector of the self-restoring type is employed in receiving, the difference between its maximum resistivity before the electrical oscillations are set up in the receiving wire and its maximum conductivity after the oscillations have broken it down is not sufficiently great to permit the slight difference in the current from the dry cell to operate a relay however sensitive the latter may be. A telephone receiver is an instrument noted for its marvelous sensitiveness and is

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therefore well adapted to use in connection with it. The telephone receiver used is generally of the watch-case type, connected to a band of spring-steel which holds it comfortably on the head and closely to the ears; hence this form is known as a *head-telephone*, and is the kind worn by telephone operators.

Switches.—Wireless receptors are supplied with a special switch for cutting in or out the aerial wire, and is arranged so that it simultaneously cuts out or in the interruptor and key of the sending circuit. The design of this switch makes it impossible for the sending and receiving apparatus to be connected at the same time with the aerial wire. There is also a *change-over* switch for connecting the spark-gap and the coherer to the earth-plate when sending or receiving, as the case may be.

Resistances.—Besides the regular rheostats connected in the primary and motor circuits of the sending apparatus there is a *non-inductive resistance*, namely, a resistance of fine wire formed by doubling the wire and winding it back on itself on a spool so that both ends are brought to the outside. This resistance is only used when messages are to be received from a near-by station and the received wave is likely to be so strong that it will injure the coherer.

Choking Coils.—In some receptors *choking coils* are introduced into the circuits to cut off the oscillations set up in them by the sparks produced on the break of the relay and tapper contacts. These coils are also wound non-inductively of very fine silk-covered wire.

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Polarized Cells.—In other systems *polarized cells* are employed instead of choking-coils to prevent the sparking of the contacts from affecting the coherer. Polarized cells are small glass vessels in which a pair of platinum wires are immersed in a dilute solution of sulphuric acid. A battery of four or five of these cells is connected across the relay contacts.

Dry Cells.—The dry cells that furnish the current for operating the relay, tapper, and Morse register are the ordinary kind used for ringing bells, etc. One cell is used in the coherer and relay circuit, and four or five cells, connected in series, make up the battery to operate the tapper and register circuits. When fresh the cells develop about 1.5 volts.

Instruments. — Other than the apparatus described above there are various instruments sent with each outfit to facilitate the making of adjustments and insure the proper working of the equipment.

(*a*) To ascertain the sensitiveness of the relay a coil having a total resistance of approximately 40,000 ohms is sometimes supplied by the makers; this is termed a *relay-testing coil*, and besides the end terminals there are usually two others, so that several values may be obtained.

(*b*) An ordinary ammeter and voltmeter are useful, though not always furnished, for determining the current and voltage of the primary circuit. A *hot-wire ammeter* is necessary to show when the sending circuits are in tune; this ammeter is made to read from 2 to 4 amperes according to the *shunts* used, the long shunt

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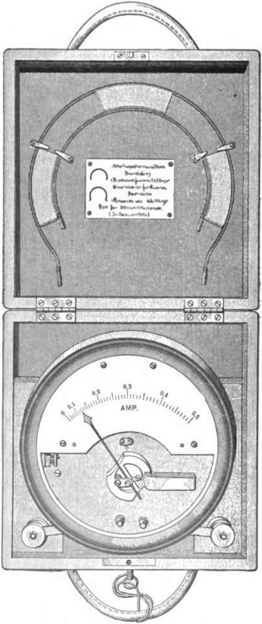

Fig. 35.—Hot-wire Ammeter.

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reading 0.04 ampere and the short shunt 0.08 ampere. The hot-wire ammeter is shown in Fig. 35.

(c) For tuning the resonator system of the receptor some kind of a tuning device is necessary; these differ in various makes, but the one shown in Fig. 36 will serve

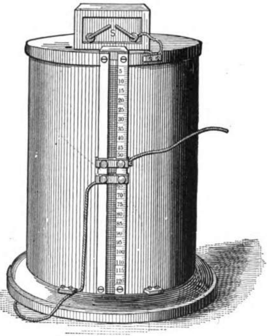

FIG. 36.—Tuning Device.

to indicate the general design. It includes an inductance coil of the same value as the one used in the receptor, a condenser having practically the same capacity as that of the coherer, and a needle-point spark-gap that can be adjusted. Its uses and the method of using it, as well as the other instruments and apparatus described, will be found in the succeeding chapters.

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(*d*) To test the working properties of the coherer a *testing-box*, or *buzzer*, is employed. This is a small box of wood with a buzzer inside. A buzzer is made like an electric bell, having an electromagnet and a vibrating armature but no gong; inside with the buzzer is a dry cell; these are connected in series with a push-button projecting through the lid. When the button is pushed minute sparks are set up at the contact-points when the break occurs and miniature trains of electric waves are sent out in consequence.

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CHAPTER IV

THE AERIAL-WIRE SYSTEM

The Signaling Distance.—The aerial-wire system is understood to include an oscillation circuit from the top of the wire to the plate in the ground and hence comprises the aerial wire, the spark-gap, or detector, where a simple open circuit is used, or an inductance coil, where a *compound*, i.e., an open and a closed circuit are coupled together.

The successful transmission of wireless messages depends largely upon the condition of the aerial-wire system, and the operator, if he wishes to obtain the best results, must not overlook the necessity of keeping them perfectly insulated from the mast, building, and trees. It is not enough to know that the wires have been put up properly, for moisture may collect upon the suspension insulator that joins the top of the wire to the tail-block; and if this occurs and is not attended to, much of the energy otherwise available for radiation is lost. For this reason the aerial wire should be arranged with a tail-block on the cross-tree or topgallant-mast so that it may be lowered for inspection and hoisted up again.

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The distance to which the waves may be radiated depends on several factors, such as the initial energy or amount of power used, whether the transmission is to take place over salt water or the surface of the ground, the kind of system used, the height, form, and dimensions of the aerial, etc. Roughly it may be said that, with a given amount of power, instruments of standard make, and all other things being assumed equal, the distance to which signals can be sent increases as the square of the length of the aerial wire that sends out the waves; or in other words, if the wire is 20 feet in height and will send messages one mile, then a wire 40 feet in height will send them four miles, and one 80 feet in height will carry waves 16 miles, and so on. This deduction holds good only in the case of a single-wire aerial, for where the aerial is formed of more than one wire, or carries a cage at the top or other capacities at its lower end, the arrangement permits a greater amount of energy to be radiated and the law is no longer tenable.

Electric waves are propagated to much longer distances over the surface of salt water than over fresh water, snow, or land. Considerable difference in the signaling distance is found to exist due to the condition of the weather as well as to the different seasons of the year, as, for instance, it may be cited that the effective range is cut down during the heated period of the summer months. A marked difference is also noticed according to whether the messages are sent during the day or night, the longest distance being attained after the sun has gone down.

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This effect is attributed to the dissipating influence of daylight on the oscillating currents set up in the aerial wires.

The Aerial Wire.—The term *aerial wire* is used to designate the wire or wires leading from the instruments in the operating-room to the masthead outside which supports it. The aerial may be formed of one or more wires, those generally used being made of phosphor-bronze and having a diameter of about $\frac{3}{16}$ of an inch. As we have seen, the length of the aerial wire, where this is single, determines the wave-length to be sent out; in some installations two aerial wires are used, and these are connected together, usually through the medium of a small spark-gap, at the bottom before they enter the station. Other systems employ aerials that are connected to wire cages at the upper end which increases their capacity, and they not only send out a longer wave but waves of greater power. Where an aerial is formed of a number of wires these should be arranged at a goodly distance from each other, for unless this is done their combined capacity will not be multiplied by their individual capacities.

The distance over which it is possible to send will depend, as we have seen, on the length and the number of wires of the aerial, as well as on the amount of current the induction coil is capable of delivering to the oscillation circuits. The capacity of an aerial wire system is of the utmost value in transmitting, for upon this depends the amount of energy radiated. In receiving, however,

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large capacity aerials are not needed, and it is often well, where two or more wires form the aerial to cut one of them out, especially if they are provided with cages.

Forms of Aerials.—On land stations the aerial usually consists of one or two wires with or without cages. These hang vertically from the cross-trees of the mast or nearly so, for the operating room is generally located near the mast. Fig. 37 shows such an aerial. Wherever possible the aerial wire should be suspended vertically, but on board ship the masts are not high enough to obtain the proper elevation and the aerial wires are run at an angle as in Fig. 38, which shows the arrangement on the U. S. S. *Topeka.* It will be seen that each of the two wires forming the aerial are given added capacity by cylindrical cages built up of eight wires attached to metal rings, the latter having diameters of about 2 feet, while the length of the cage is about 50 feet.

The wires are brought together at the top and at the bottom of the cages, the lower ends connecting with the single wire aerials and the upper ends to an insulated support holding them apart. A small spark-gap separates the two aerials at the top, and while one of them is led into the operating room to the apparatus, the other is separated from it by a similar spark-gap at the base. It is assumed that the discharge of high potential energy across these spark-gaps sets up more vigorous oscillations in the aerial wires and causes them to emit more energetic waves.

Besides the single and double aerials and those equipped

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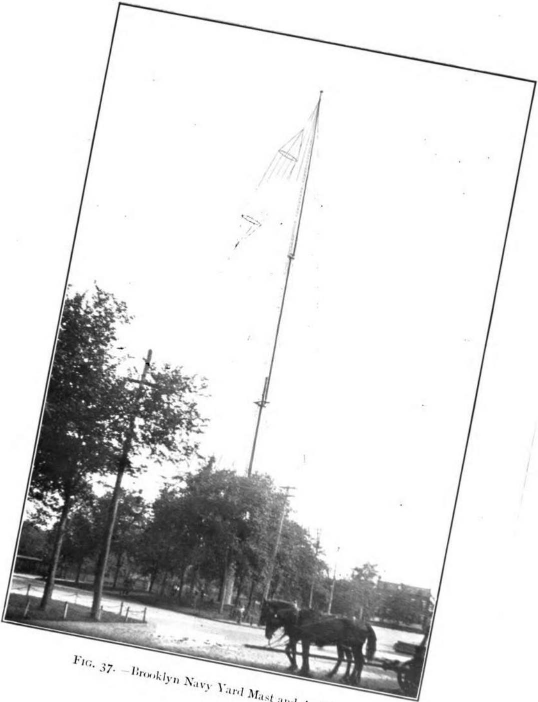

FIG. 37.—Brooklyn Navy Yard Mast and Aerial.

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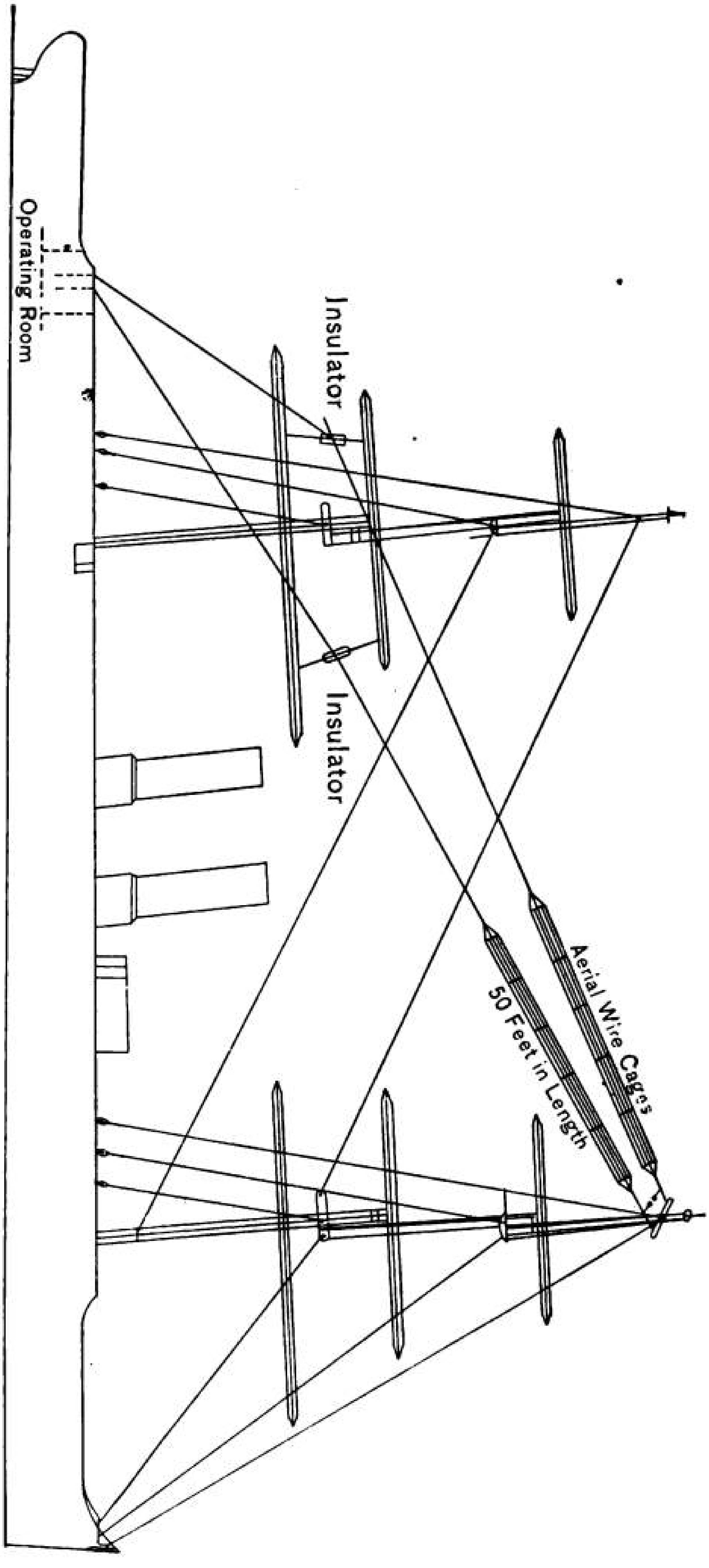

FIG. 38.—Arrangement of Aerial Wires on U. S. S. *Topeka*. (Courtesy of Lieut. Hudgins, U. S. N.)

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with cages as described above there are other forms used. Occasionally three or more wires are stretched parallel with each other, when it is called a *grid*, but more often we find the wires spread out as in Fig. 39, when it is termed a *fan* aerial. The latter has found considerable favor for stations ashore and is sometimes

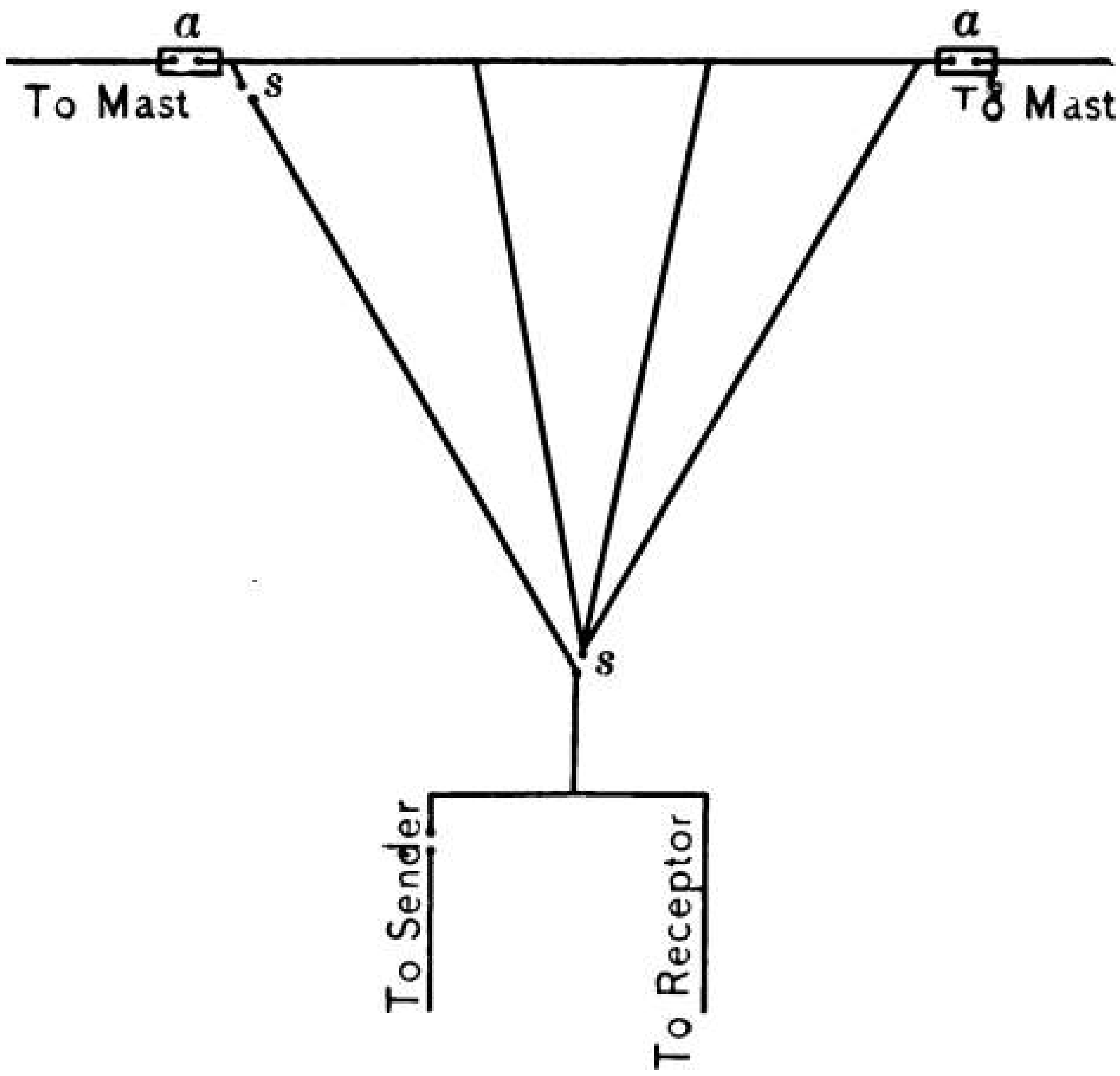

FIG. 39.—A Form of Fan Aerials. *aa*, Insulators; *ss*, Small Spark-gaps.

used on board ship where the rigging will permit. When the fan aerial is employed for land-stations two masts are set up, or a building may suffice for one of the sustaining heights and only one mast is required. When a fan aerial of five or six wires is used only one wire is connected to the transmitter, the others being insulated by a small spark-gap except when the disruptive dis-

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charge takes place, and then they are set into oscillation by the energy breaking it down.

Where one of the sustaining structures is higher than the other, as the illustration Fig. 40 shows, the longest wire is connected direct to the spark-gap of the transmitter, and the shorter ones are insulated from it by

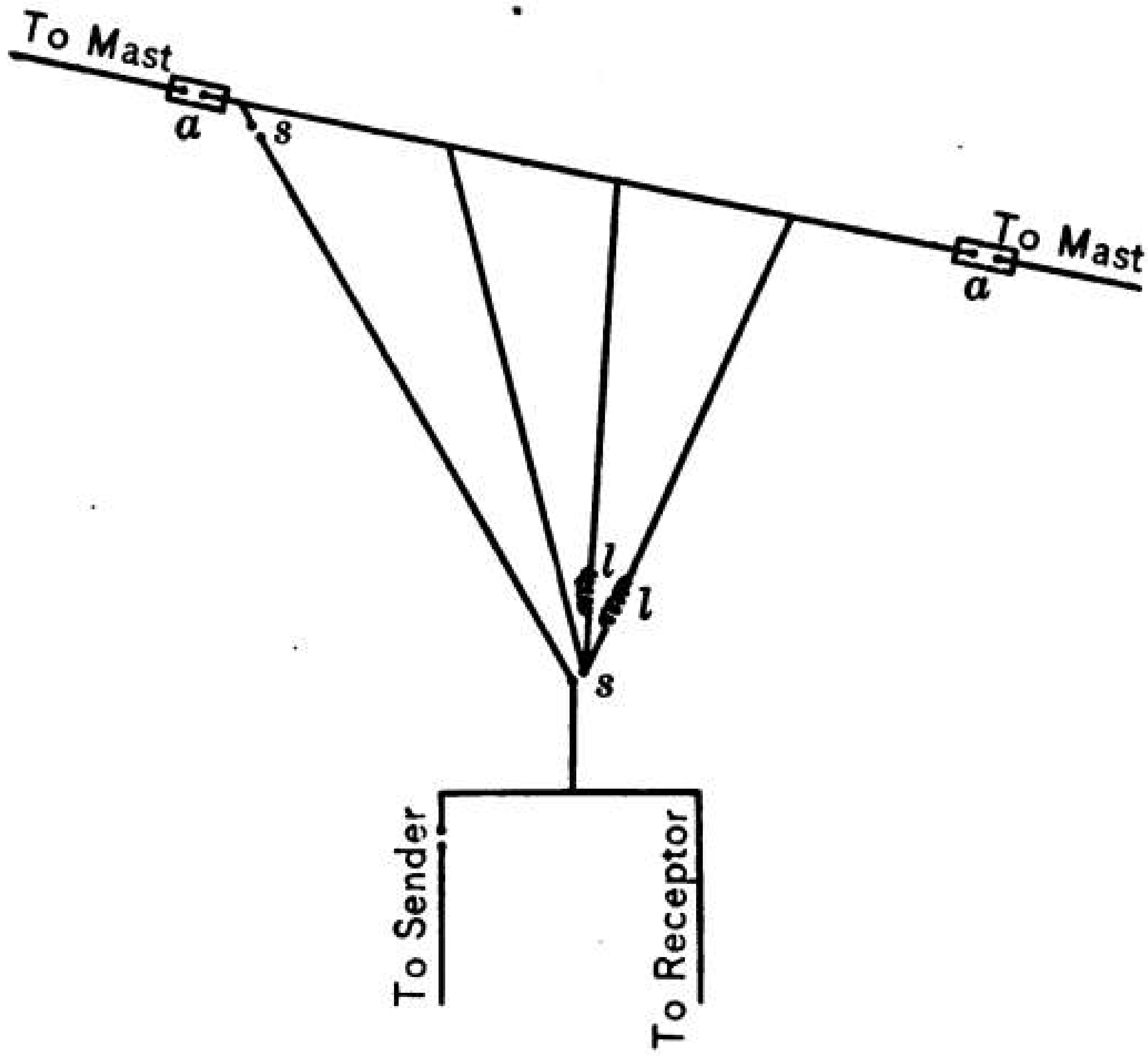

FIG. 40.—Another Form of Fan Aerial. *aa*, Insulators; *ss*, Small Spark-gaps; *ll*, Turns of Wire to Increase Inductance.

the smaller gaps, as stated above; but in order that the waves radiated by each of the wires may be of the same length a few turns are given the shorter ones near the lower end, the added inductance giving them practically the same value as the longer and straight ones.

The Mast.—In fitting a ship with wireless apparatus the masts are generally high enough to serve to sustain

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the aerial wire; on shore the mast can be of any height, and this depends to some extent on the distance to be covered; masts are seldom less than 90 feet in height or more than 210 feet. When this height is reached and it is desired to signal farther the electrical dimensions of the aerials must be increased by adding more wires and by installing a transmitter of greater power. It is not desirable to make the mast of iron or steel, as some of energy of the electric oscillations set up in the aerial is absorbed by the mass of metal and the radiation is cut down in consequence. The masts are best made of good, clear pine and may be built up of three or four sticks; three sections are ample if the mast does not exceed a height of 180 feet, which is the highest used in the United States Navy, the lowest approximating 130 feet. The mast should be supported by two sets of rigging, that of the lower mast being of wire cable and that of the topgallant-mast of hemp rope.

One of the requirements to insure good transmission is to keep the mast well away from structures of all kinds, and wherever possible there should be no obstructions between the sending and receiving stations; of course this is not practicable in signaling over land, and the distance is therefore very much cut down when compared with telegraphy over the sea, where the line of propagation is clear. In the U. S. Navy the mast on shipboard from which the aerial wire is suspended is required to be not less than 130 feet above load-water-line, and the rigging of all the mast-poles is set up with

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hemp rope instead of wire, as well as all the other rigging of the ship, so that there will be as little absorption of energy as possible.

In commercial systems the height of the mast is often less or more than that specified by the Navy. A mast of 190 to 210 feet is best constructed of four poles set in cross-trees and supported by fids, or bars of iron with a shoulder at one end to sustain the topmast over the head of the lower mast; the mast is guyed to braces, and these, if on a sandy seacoast, must be sunk from fifteen to twenty feet deep. The guys may be of hemp or wire rope with hemp terminals spliced in about 100 feet from the ground; the purpose of combining the wire with hemp is to provide proper insulation for the aerial wires, which are supported by a cross-tree near the top, holding them out so that they cannot come in contact with the guys.

Methods of Suspension.—Where the aerial wires are attached to the cross-tree of the topgallant-mast it must be well insulated. A simple method for suspending aerial wires is shown in Fig. 41; the mast, topgallant-yard, the insulator, aerial wire and its cage are all named in the drawing, so that it will be readily understood when it is said that the insulator, which is of heavy glass or porcelain, is attached to the yard by a loop of tarred rope running through its center. The upper end of the wire to which the cage is made fast is turned over the outside of the insulator, having a groove cut in it, and twisted fast. Another way is to use an insulator formed of a hard-rubber block say a foot long, 4 inches

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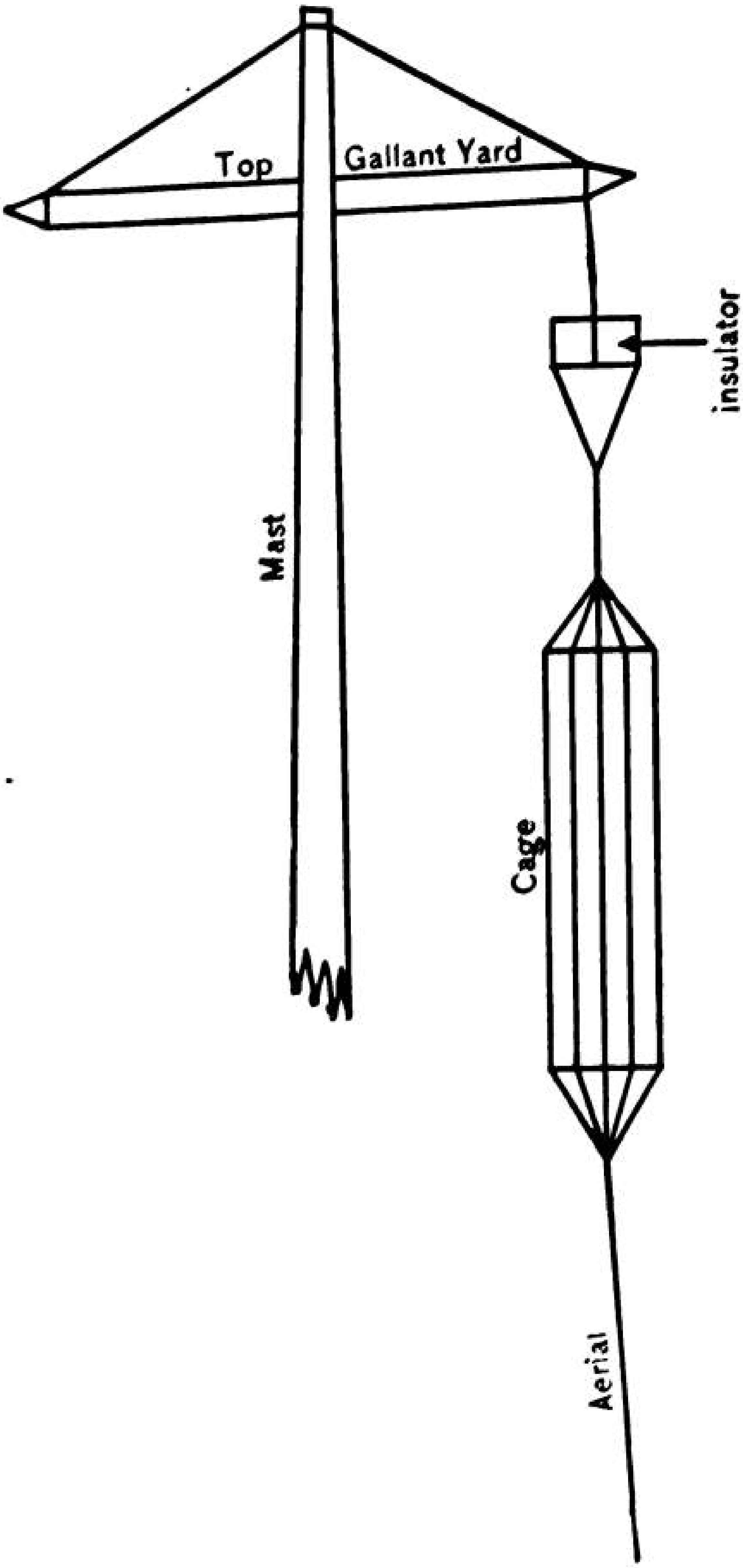

FIG. 41. – A Simple Method of Suspension.

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wide, and an inch thick; the aerial is attached to one end of this, while a hemp rope running through a tail-block is connected with the other end, as in Fig. 42. Where there is a possibility of the aerial wires touching the side

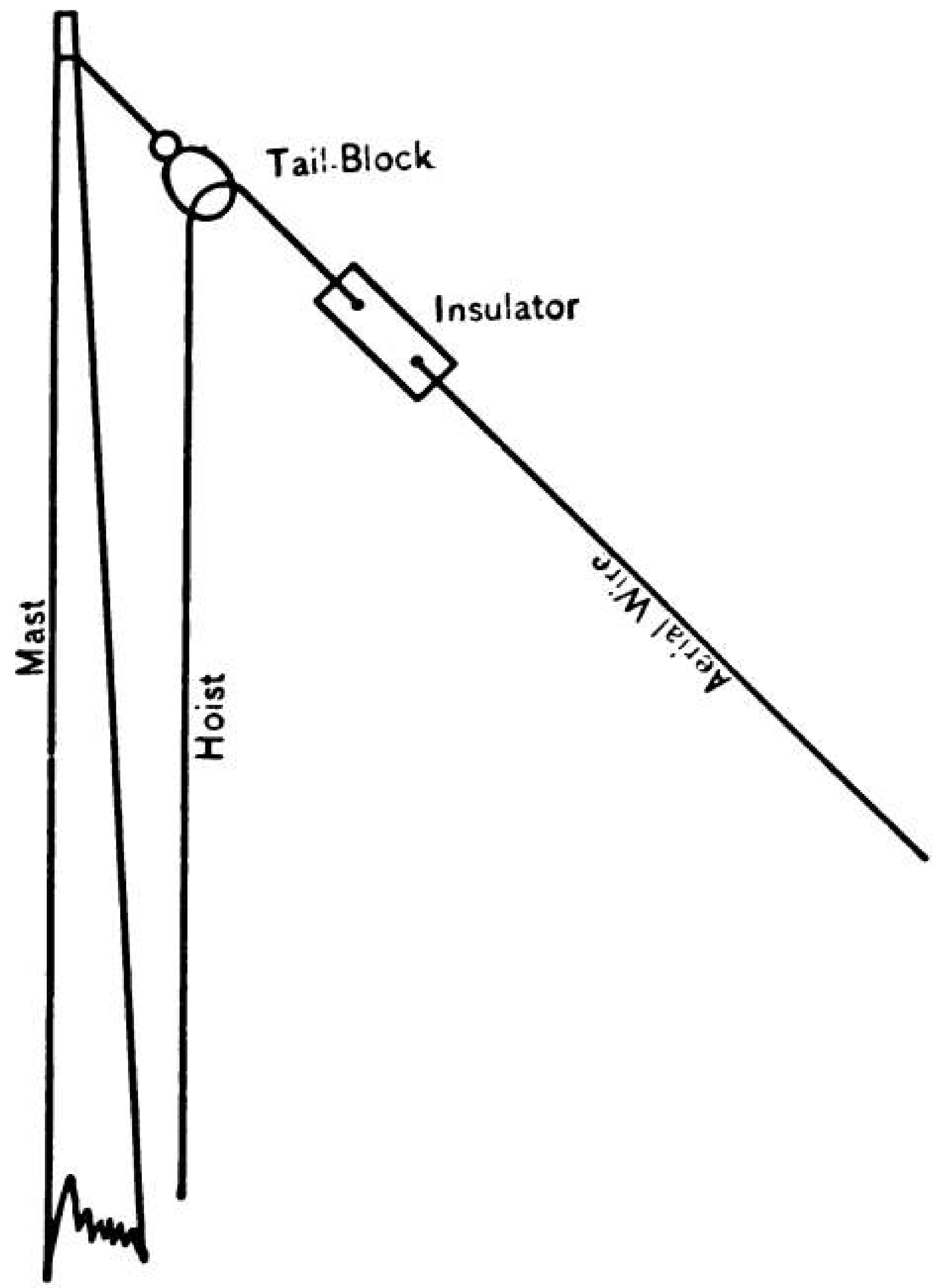

FIG. 42.—A Suspension Insulator.

of a building or the rigging of a ship they must be well protected by insulators. A method to prevent leakage where the aerial wire leads in the station from the mast to the instruments is shown in Fig. 43, the rattail, or

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leading-in wire, passing through a porcelain or hard-rubber bushing inserted in a hole cut in the center of the window pane.

The Earthed Terminal.—A good *earth* is quite as

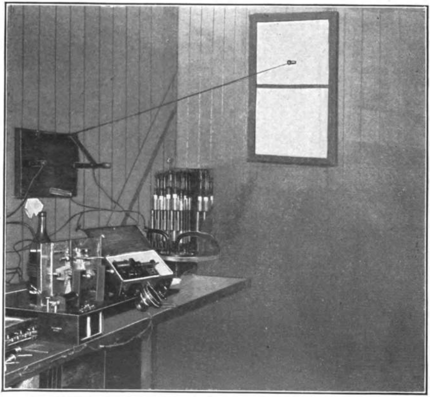

Fig. 43.—Leading-in Method.

essential to the successful operation of a wireless system as a good aerial. Sheets of copper or zinc, preferably the former, are embedded in damp earth, and this forms a very good earth connection. A shore station set of

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instruments should have from 100 to 150 square feet of such surface buried deeply enough to insure a permanently damp connection between the soil and the plates of metal. Copper usually comes in rolls having a width of about 2 feet, and a sufficient number of rolls of the heaviest copper or zinc should be connected together by strips 5 or 6 inches wide cut from the plates and soldering the latter securely together. From the different plates forming the 'earth' similar strips are soldered, and these are led up to the surface, where they are connected together and then to a wire leading to the instruments. Sometimes the plates are set in the ground vertically, though more often they are placed hoizontally; but this is largely a matter of choice modifiable by conditions, and it makes little difference so long as they are well grounded. Frequently places will be found where it is not possible to obtain a good earth, and in such cases a larger amount of surface is necessary, and a switch can be arranged between the earthed plate and the receiver so that the coherer may be cut out entirely when sending; where a good earth cannot be had it has been found an excellent plan to provide the transmitter and receptor with separate earth-plates. The difficulties of finding a good earth is not encountered on board ship, for all that is necessary is to simply connect the earthed terminal to the nearest pipe or other piece of metal connected with the hull of the ship.

The Operating Room.—In this room the apparatus is installed and operated; it may be of any size, though

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preferably isolated from everything else, and it should have not less than 40 or 50 square feet of floor surface. On shore, small buildings of convenient size and location are often put up expressly for the purpose; the operating room should not be too far away from the mast, a hundred feet being the greatest distance, and the earthed plates should be embedded as closely as may be. A well designed operating room especially built should have windows on three sides and not only be well lighted, but ventilated and kept perfectly dry. Through the window nearest the mast a hole for the aerial leading-in wire must be cut, as previously described. Fig. 44 shows the Brooklyn Navy Yard station. When the apparatus is installed on board ship the best place for the operating-room is between the upper deck and the next one below, the rat-tail of the aerial wire passing through insulators of porcelain or hard rubber in the upper deck. The instruments should be mounted on a rigid bench, the height of an ordinary table, and this may extend from one end of the room to the other, if the room is not too large; a couple of drawers beneath the table will be found handy for tools, extra parts, etc. The current for shore stations is obtained whenever possible from the regular mains at 110 volts pressure, but often the station is located in some isolated and inaccessible place where there is no central station, and here a small gasoline or oil engine coupled to a direct-current dynamo generating 1000 to 2000 watts supplies the initial energy. Such units should be installed in a separate house, at

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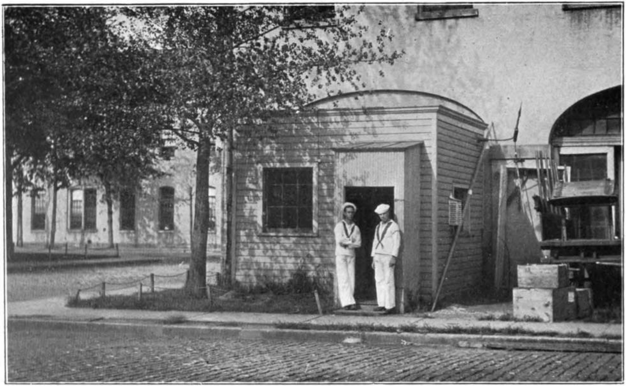

Fig. 44.—Brooklyn Navy Yard Station.

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least 100 feet from the operating-room, so that the noise of the engine will be muffled—a desirable feature always, but an absolute necessity where the receptor is of the electrolytic or magnetic detector type. Right here I may say that the young man who expects to become a proficient wireless operator should read up and become familiar with the construction of small gasoline and oil engines and dynamos.

Aerial Wires and Earths in Field Work.—While the Signal Corps of the United States Army have some permanent wireless stations, their equipments are chiefly portable and adapted to field work. Under the trying conditions of warfare masts would be too cumbersome to transport and require too long a time to set up. Balloons and kites are therefore called into use to raise the aerial wire. The balloons used are small silk bags inflated with hydrogen gas; these are sent up when there is not enough breeze to elevate a kite. The aerial wire is usually a single, bare No. 14 stranded aluminum, steel, or copper wire 500 or 1000 feet in length and serves not only as an aerial wire, but in the place of the kite string as well. In light breezes the tailless kite known as a Malay or Eddy kite is used, an idea of which may be gained from Fig. 45; a Blue Hill box-kite is designed to fly in a wind having a velocity of 30 or 40 miles per hour; it is shown in Fig. 46. The aerial wires may be attached directly to the string of the kite after it is started and up in the air a few feet. These kites are fitted with a *bridle* having a loop to which the kite-string is attached. The

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aerial and ground cable are provided with *plugs* to plug into the aerial switch and to the ground connection of the coil.

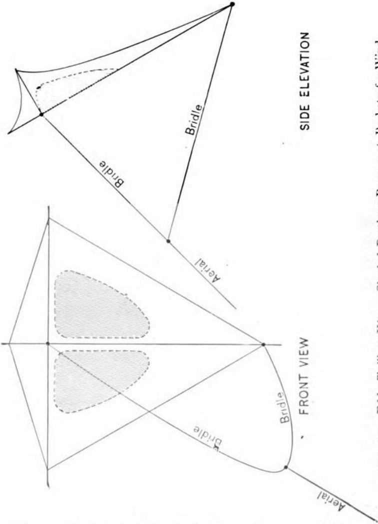

FIG. 45.—Eddy Tailless Kite. Shaded Portions Represent Pockets for Wind.

The earthed terminals of field outfits are seldom embedded in the earth; the terminal wire or cable is attached to a roll of wire netting, like that used for chicken fences, and this is spread out evenly on the ground or dropped into water, if there is any; or what is just as good is to spread the netting out on a grassy plot, which provides

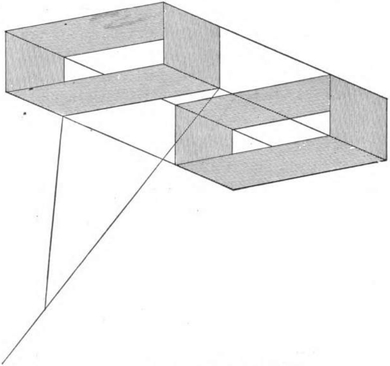

FIG. 46.—Blue Hill Box-kite.

an excellent earth, for grass and other growing vegetation are conductors of electricity, and as the meshes of the wire net come in contact with the thousands of blades of grass, and these in turn have roots in the damp soil underneath, a good ground is assured.

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CHAPTER V

WIRING DIAGRAMS FOR TRANSMITTERS

Wiring Diagrams.—It is not often that an operator, especially if he is a beginner, is called upon to undertake the installation of a wireless set unless it is under the direction of an experienced man "higher up." In commercial companies the experts selected for this important work are chosen as a rule from the ranks of the operators, the preference naturally being given to those who have shown a special aptitude for this class of work. In the United States Navy wireless telegraphy is under the supervision of the Bureau of Equipment, and officers versed in this branch of the art look after the installations of different ship and shore stations, while in the Army it is attended to by the Signal Corps and likewise in charge of competent officers.

It will be found useful, however, for the operator to know how the instruments are wired, and a necessity to understand their connections; but without a wiring diagram of the specific form of apparatus he is working with, the novice would be lost in the maze of wires about him if he were given charge of a station. When a begin-

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ner accepts his first position, or an operator goes from one company to another, he will, it is safe to say, receive some instruction relative to the station he is to have charge of, and this may continue until he becomes perfectly familiar with the apparatus installed. By studying the wiring diagrams to follow, the operator will have little difficulty in tracing out the connections of any system he may be called upon to work. As to the placing of the apparatus on the operating table there is no hard-and-fast rule to be adhered to, but on the other hand the operator must use his best judgment and meet the circumstances in the most practical way. The photograph Fig. 84 shows the interior arrangement of the operating-room on board the U. S. S. *Prairie* and gives an excellent idea of the proper disposition of the instruments on the table. The key is conveniently placed about the middle of the table, with the transmitting apparatus on the left-hand side and the receiving apparatus on the right-hand side. In shore stations there is more room, but it is doubtful if this is of any material advantage, for it is well to have the apparatus set up so that it forms a compact unit, since then every part is under the immediate and constant observation of the operator.

Wiring Diagram of an Ordinary Induction Coil, Interruptor and Condenser.—Where an ordinary induction coil is employed in sending, the spring interruptor is mounted on the same base, at the end of the coil, and the condenser is placed in the base, which is made hollow to receive it. By referring to the diagram Fig. 47 it will

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be seen that one terminal of the primary of the induction coil leads direct to one of the binding-posts, placed on the outside and end of the base; the other terminal of the primary coil is connected to the fixed end of the vibrating spring; the current is completed through the adjusting screw and its support, which is connected to

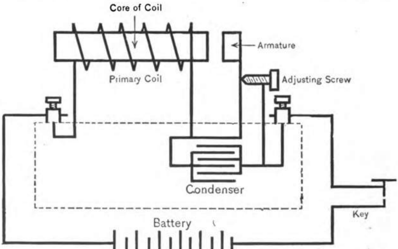

FIG. 47.—Wiring Diagram of Induction Coil, Interruptor, and Condenser. Dotted Lines Show Base of Coil.

the opposite binding post, also on the outside. Shunted around the spring and the adjustable screw is the condenser. The wiring, in so far as possible, is concealed in the base of the coil, leaving the binding posts only exposed, and to these are attached the key and the battery.

Wiring Diagram of Induction Coil with Independent Spring Interruptor.—While in the improved type of induction coil the spring interruptor is generally mounted

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on the base with it, it is also occasionally mounted separately, this being possible since its action does not depend on the magnetization and demagnetization of the core

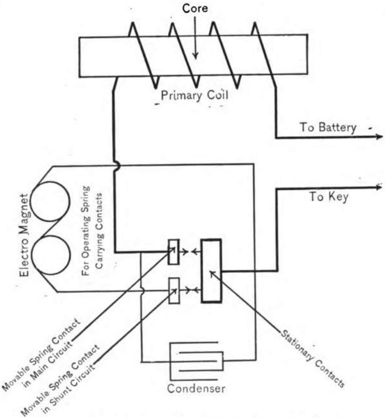

FIG. 48.—Wiring Diagram of Induction Coil with Independent Interruptor.

of the coil. The independent interruptor is provided with two sets of make-and-break contacts, the first formed of heavy platinum wire and placed in the main circuit, as indicated in Fig. 48 by the heavy lines, and the second

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of lighter platinum points, as shown by the light lines. Following the heavy lines it will be seen that the battery or other source of electromotive force is connected on one side to one terminal of the induction coil, its opposite end leading to the heavy platinum movable contact attached to the upper part of the stiffest of the two springs; when the spring is in its normal position, namely, when there is no current flowing through the circuit, it makes contact with the heavy platinum stationary contact-point which is connected to the battery. Under these conditions the smaller contacts in the shunt circuit are also in contact; thus both the main circuit through the primary of the induction coil and the shunt circuit through the electromagnet are closed in so far as the contact-points are concerned, but open through the key. When the circuits are closed by means of the key the current flows through the shunt as well as the main circuit and hence energizes the coil and the electromagnet, when the latter breaks both circuits by attracting the armature carried by the spring on which are attached the movable contacts. The condenser, frequently an adjustable one and mounted in a separate box, is shunted across the main contact-points as shown.

Wiring Diagram of Induction Coil with Mercury Turbine Interruptor.—Where a mercury turbine interruptor is used it is connected in series with the primary coil, the key, and the source of current, as in a simple spring interruptor. A condenser is shunted around the interruptor in the same manner. Since a small motor

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is required to rotate the interruptor, a circuit is led off from the main line to the motor, while a variable resistance or rheostat is inserted to regulate the current, all of which is shown in Fig. 49.

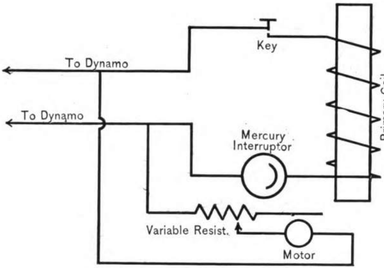

FIG. 49.—Wiring Diagram with Mercury Turbine Interruptor.

An Induction Coil with Electrolytic Interruptor.—Where an electrolytic turbine interruptor is used it is connected in series with the primary coil, the key, and the source of current, as in a simple vibrating-spring interruptor. Since an electrolytic interruptor has a small inherent capacity of its own, it is not absolutely necessary to use a condenser shunted around it, but a small condenser can be used to some advantage.

Keys.—As previously stated in the chapter on Apparatus some systems of wireless telegraphy provide keys

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with condensers to cut down the sparking at the contact-points; many are furnished with magnetic blowouts, and again in others the break takes place under oil.

(*a*) Where a condenser is used it is shunted around the contact-points of the key just as in the case of the interruptor, and as the condenser is in the base of the key, the connections are always made by the makers.

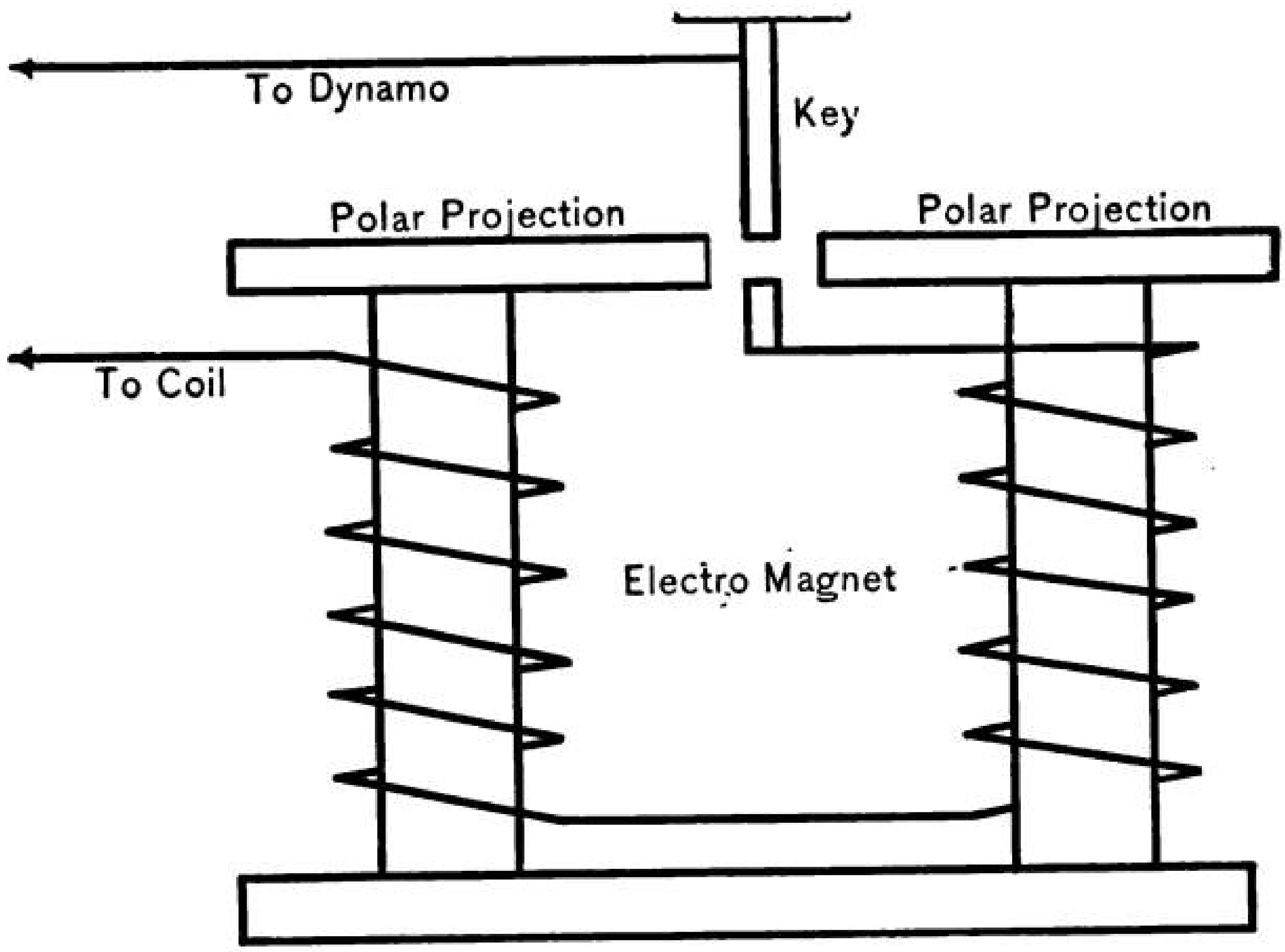

FIG. 50.—Connections of Key and Magnetic Blowout.

(*b*) This latter statement is also true where a magnetic blowout is used, but since new phenomena are involved the above diagram, Fig. 50, may prove of value. It will be observed that the coils of the magnets, the polar projections of which are oppositely disposed at right angles to the contacts of the key, are connected in series with the key, coil, and source of energy. The diagrammatic

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sketch of the circuit shows the actual position of the magnets, the contacts of the key, and the connections.

(*c*) Where oil-keys are used they are connected in series with the primary and source of energy, as in the two preceding cases.

Diagram of the Primary or Low Tension Circuits.— The wiring of the primary circuits of an induction coil transmitter is well brought out in the diagram Fig. 49. Some details are lacking, but these are supplied and will be found in the diagram showing the complete transmitter.

Diagram of the Secondary or High Tension Circuits.— The terminals of the secondary coil are connected with the spark-balls forming the gap through which the spark takes place. From one of the spark-balls a wire leads to the inner coatings of the battery of Leyden jars, these being connected in parallel by means of chains and plugs. The outer coatings of the Leyden jars, also in parallel, are connected to the aerial wire through a cut-out spark-gap, as shown in Fig. 51; the lower end of the aerial is connected with the earth through the inductance coil by means of a flexible wire ending in a plug or spring contact. A transmittter having its open and closed oscillation circuits connected in this manner is termed a *close coupled* system and is of course a compound system.

Diagram of Loose Coupled Oscillation Circuits.— Another method of coupling oscillation circuits much in favor at present is shown in Fig. 52; here the secondary of the induction coil connects with the spark-gap and

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forms a closed circuit through the primary winding of a high-potential and high-frequency transformer. One end of the secondary winding connects with the aerial and the opposite end of the earth. The purpose of

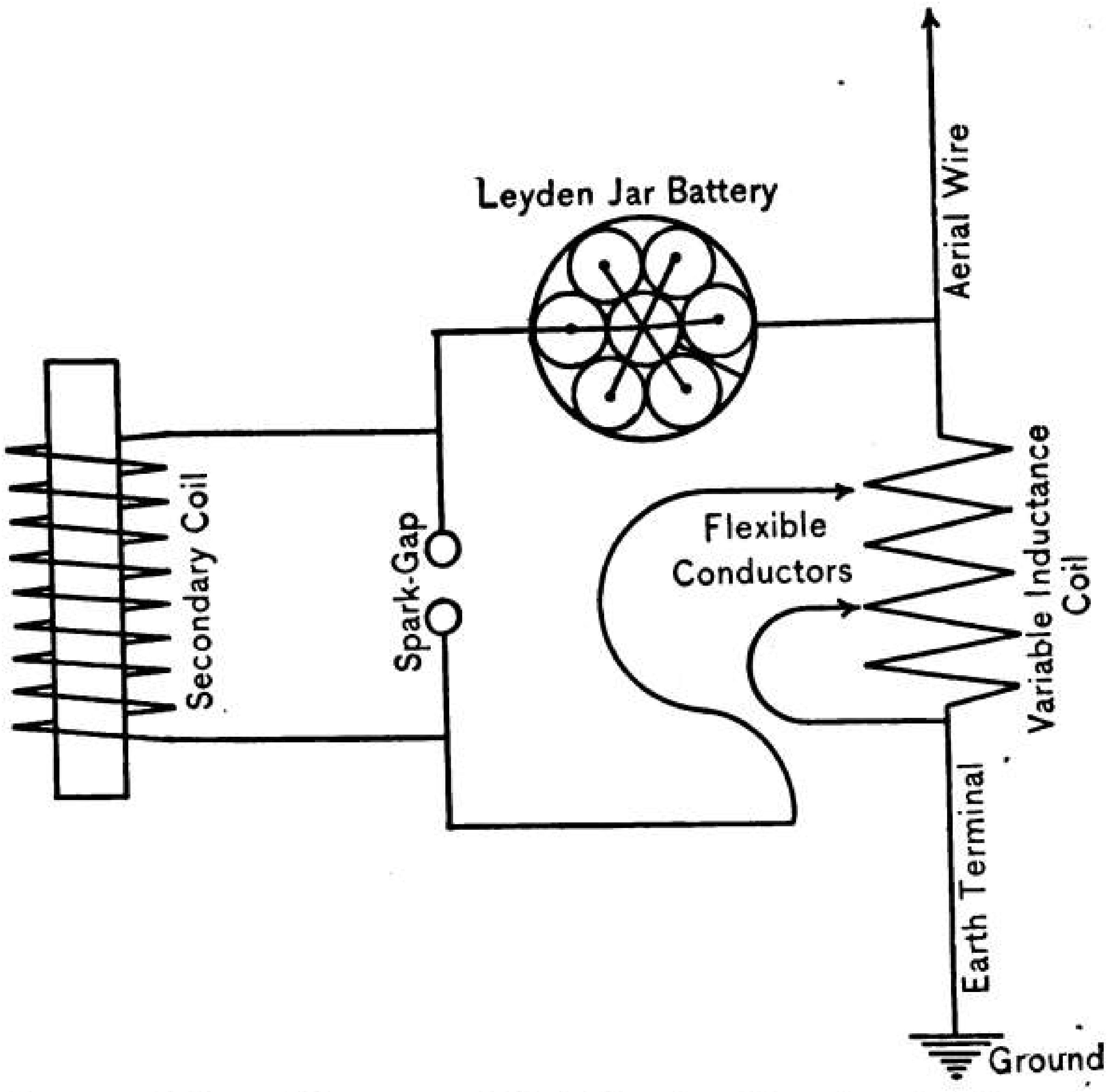

FIG. 51.—Wiring Diagrams of High Tension Close Coupled Circuits.

interposing this transformer is so that the potential of the oscillations set up in the closed circuit may be increased in the open circuit.

Diagram of an Alternating-current Transformer Transmitter.—Very often instead of the ordinary induction coil excited by a direct current a transformer of the core

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type or of the shell type is employed to energize the aerial-wire system. There may be cited three reasons for

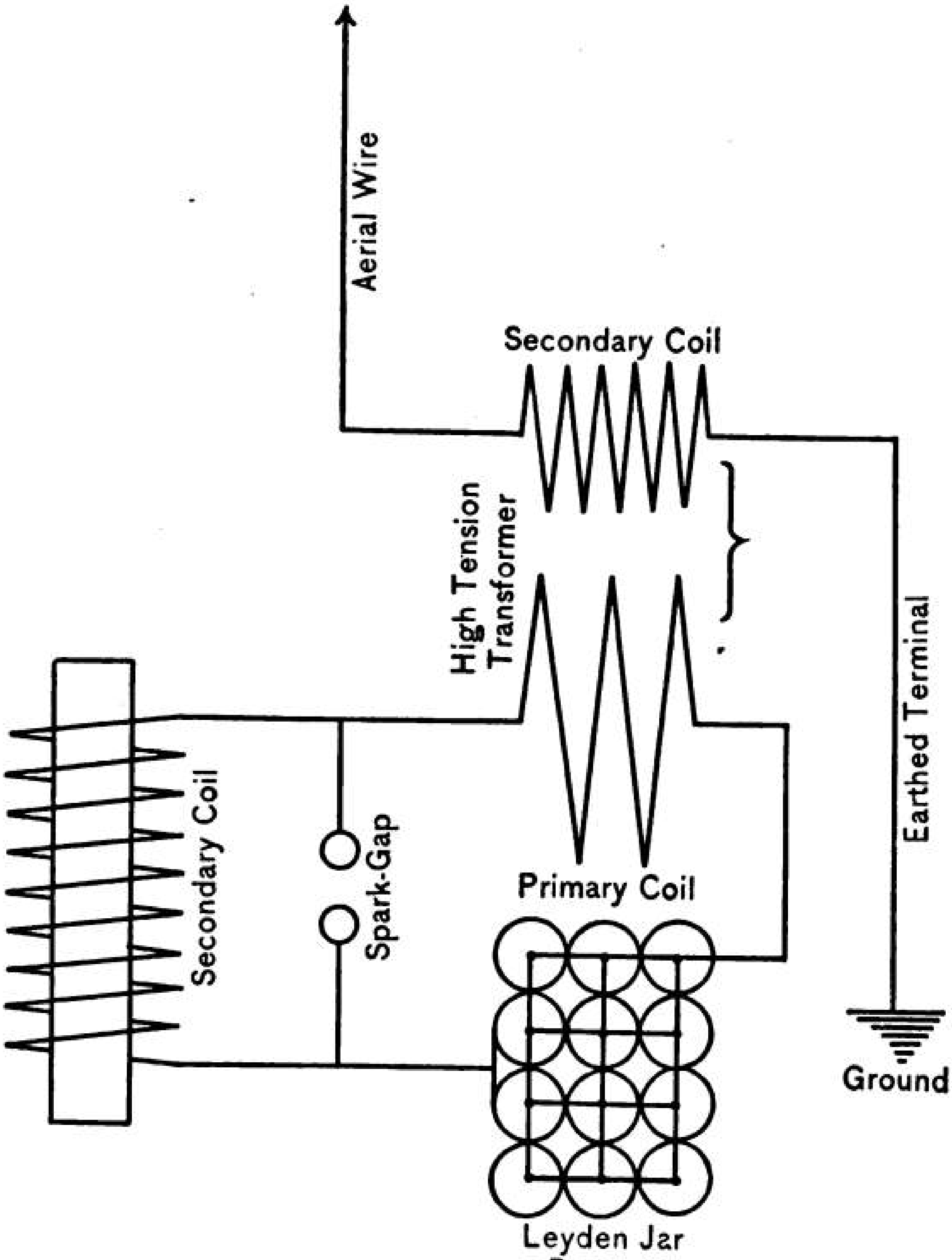

FIG. 52.—Diagram of Loose Coupled Transmitter.

the use of this arrangement, namely: (1) there are places where only alternating current is available; (2) the interruptor of the direct current induction coil, which is some-

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times a very troublesome device, is done away with; and (3) larger amounts of energy may be transformed from the initial current into electric oscillations. A transmitting system of this kind in its simplest form is shown in Fig. 53, and a reference to the diagram will make the connections clear; the terminals of the alternating current generator or lines lead to and connect with the primary of the transformer through the medium of a pair of choke coils, the latter being made like those described on page 58, except that they are larger and better insulated. The secondary of the transformer is connected to the spark-gap as in the case of an ordinary induction coil and a battery of Leyden jars in parallel with the spark-gap as shown. The aerial wire is connected to one side of the spark-gap, and the grounded wire to the opposite side. In tuned transmitters using alternating current, the secondary coil of the transformer, Leyden-jar battery, and inductance coil are connected as in the diagram Fig. 51 or 52.

Wiring Diagram of a Complete Telefunken Transmitter.—A complete transmitting apparatus such as is largely used in the United States Navy is shown in Fig. 54. It is a combination of the primary circuits Fig. 49 and the secondary circuits Fig. 51 coupled together and with all the details of the system added. Following the primary circuit from the mains it will be seen that one side leads to a rheostat, for regulating the current flowing through the primary coil and interruptor, thence the circuit continues through the primary, the interruptor,

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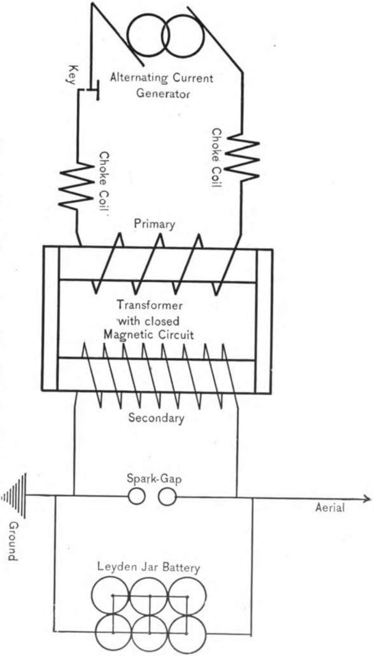

FIG. 53.—Wiring Diagram of an Alternating-current Transmitter.

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the key, the blowout magnet coils, and to the fixed contact of the aerial switch. From the other fixed contact

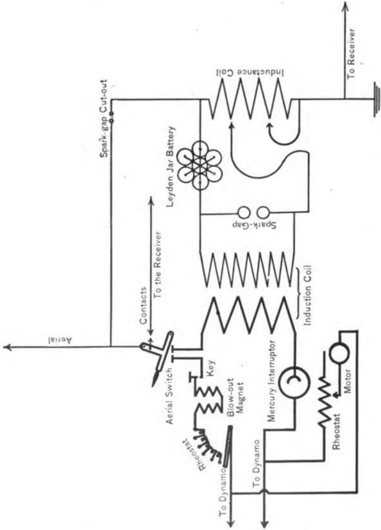

FIG. 54.—Complete Wiring Diagram of a Telefunken Transmitter.

of the aerial switch the circuit leads back to the mains, as shown by the heavy lines. A second circuit, indicated

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by the fine lines, is derived from the main circuit, and this conducts the current to the motor for rotating the turbine interruptor, these being connected by a belt illustrated by the dotted lines. Interposed in this circuit is a rheostat for controlling the speed of the motor. The secondary of the coil is connected with the spark-gap, and in parallel with the latter is the Leyden-jar battery and the variable inductance coil with its flexible conductors.

From a point between the Leyden-jar battery and the inductance coil a wire connects with the aerial, though the open circuit is broken by the spark-gap cut-out, the purpose of which is to prevent the impressed oscillations set up in the aerial when receiving from flowing through the transmitter. On the other hand the minute spark-gap does not prevent the oscillations set up by the transmitter from surging through the system.

Wiring Diagram of a Complete Clark Transmitter.— For the Army the apparatus is made as compact and portable as possible so that it may be transported on the backs of mules or if necessary may be carried by men. The transmitter shown in Fig. 55 is one form of the apparatus used. The transmitter comprises three units or cases containing the apparatus besides the storage battery, aerial wire, and kites. The cases are made of oak and are provided with strong shoulder straps for carrying them. The first case contains the induction coil, and its dimensions are 8½ inches in height, 21 inches in length, and 8½ inches in width; it weighs 60 pounds. The second case contains the

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key, interruptor, etc.; this case is arranged to fold back and allow ready access to the operating parts. The outside measurements are 8 inches in height, 16 inches in length, and 9½ inches in width, while its weight is 30 pounds. The third case contains two half-gallon Leyden-jars carefully mounted within it, a step-up transformer,

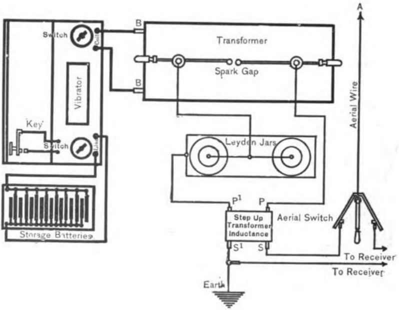

FIG. 55.—Clark Portable Army Set.

and inductance coil with the aerial switch and ground-plug connections. These are arranged in the top of the case, which is divided into compartments, with a shelf, the latter being used to support the rear part of the case for the step-up transformer and inductance coil. This coil is supported on hard-rubber pillars placed in sockets at the bottom of case. Its size is as follows:

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$15\frac{1}{2}$ inches in height, $20\frac{1}{2}$ inches in length, and $7\frac{3}{4}$ inches in width, the whole weighing 20 pounds. The figure represents the top elevation of the apparatus, the only connections shown being those exposed when the cases are open and those connecting the different cases. The storage battery is connected with the binding posts, marked "Line," of the case containing the key and interruptor; from the binding posts of this case, marked "Coil," these devices are connected to the binding posts of the primary of the induction coil. From the standards supporting the spark-gap balls a high-tension circuit is formed by connecting one side to the inner coatings of the pair of Leyden-jars and the opposite side of the spark-gap to the binding post of the case containing the step-up transformer and inductance coil, marked *P*. The outer coatings of the Leyden-jars are connected to the binding post marked *P'*. From this case the terminal marked *S* leads to one side of the aerial switch, and the opposite terminal, marked *S'*, leads to earth.

Diagram of a Complete Marconi Transmitter. In the Marconi system as now installed on Atlantic liners the transmitter comprises an induction coil giving a 10-inch spark and provided with a simple spring interruptor mounted on the base with the coil and operated by the core of the latter. The source of energy is taken from the mains of the ship's generating unit. The primary circuit includes a primary coil, a key, and the source of energy. The terminals of the secondary coil lead to a spark-gap, and in parallel with this circuit are connected

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in an inductance coil and a battery of Leyden-jars, the outer coatings leading to one side of the spark-gap and

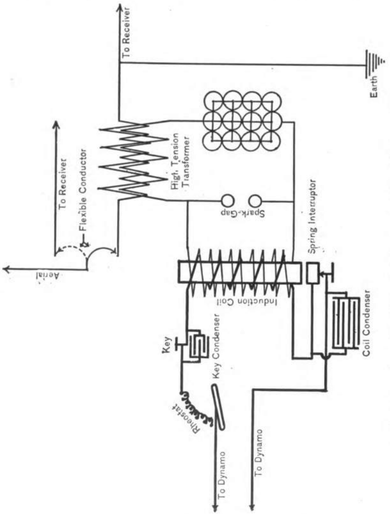

FIG. 56.—Complete Wiring Diagram of a Marconi Transmitter.

the inner coatings to one terminal of the inductance coil. There are twelve of the jars, and a switch is arranged on top; the three jars on either end may be cut in or

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out according to the capacity desired. The inductance coil forms the primary of a high-tension transformer the secondary of which connects the aerial with the ground terminal. In this system the inductance coil is not wound around the Leyden-jars, but the transformer is mounted in a case and attached to the wall. The wiring diagram is shown in Fig. 56.

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CHAPTER VI

WIRING DIAGRAM FOR RECEPTORS

Circuit Connections.—In order to master with the least difficulty the various connections of a wireless telegraph receptor, the student should bear in mind that the receiving devices, like those of the transmitter, may be divided into two general classes, namely, those that are not tuned and those that are tuned, or in other words into simple open circuit resonators and those having compound systems. These systems may again be subdivided into those that use detectors of the coherer type in conjunction with relays and Morse registers, and those that use auto-detectors of the electrolytic and magnetic types in combination with ordinary telephone receivers.

The wiring of a simple open circuit resonator is fixed in its arrangements, and there is nothing for the operator to adjust except the relay and instruments in the low-voltage or internal circuits. This style of equipment is very seldom found in use, unless in some antiquated station, but an understanding of its connections will enable the beginner to grasp the more complex systems

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of tuned receptors, even as it furnished in the earlier history of the art a stepping stone for the improvements that have resulted in tuning as we know it to-day. Those receptors in which tuned *resonators*, as the aerial wire system of receptors are termed, may employ either a detector of the coherer type with a relay and a Morse register in the internal circuit, or an auto-detector and telephone receiver, depending on the make of apparatus installed and the class of work they are intended for. Thus in the Navy a printed record of the message received is considered desirable, and nearly all of the equipments in use are of this type; in the commercial world, as on ocean liners, preference is given to the telephone receptor, though occasionally the coherer and Morse register are used, while in the Army the telephone receptor is employed almost altogether.

Diagram of a Simple Open Circuit Resonator.—Since the received waves are transformed into electric oscillations in the receiving aerial before there can be any electrical manifestations in the local circuit, the aerial and earthed wire must be connected directly or indirectly to the detector. Where the aerial wire is connected directly to one side of the coherer and the ground-wire to the opposite side, as in Fig. 57, the resonating system cannot be tuned to the length of the wave received and much of the energy is thereby wasted. Systems utilizing simple open circuit radiators and resonators have been almost entirely supplanted by tuned apparatus of more recent date.

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Elementary Diagram of the Detector and Cell Circuit. In order that the effects of the oscillations set up in the aerial wire system may be translated into the alphabetic code and perceived either visually or audibly an

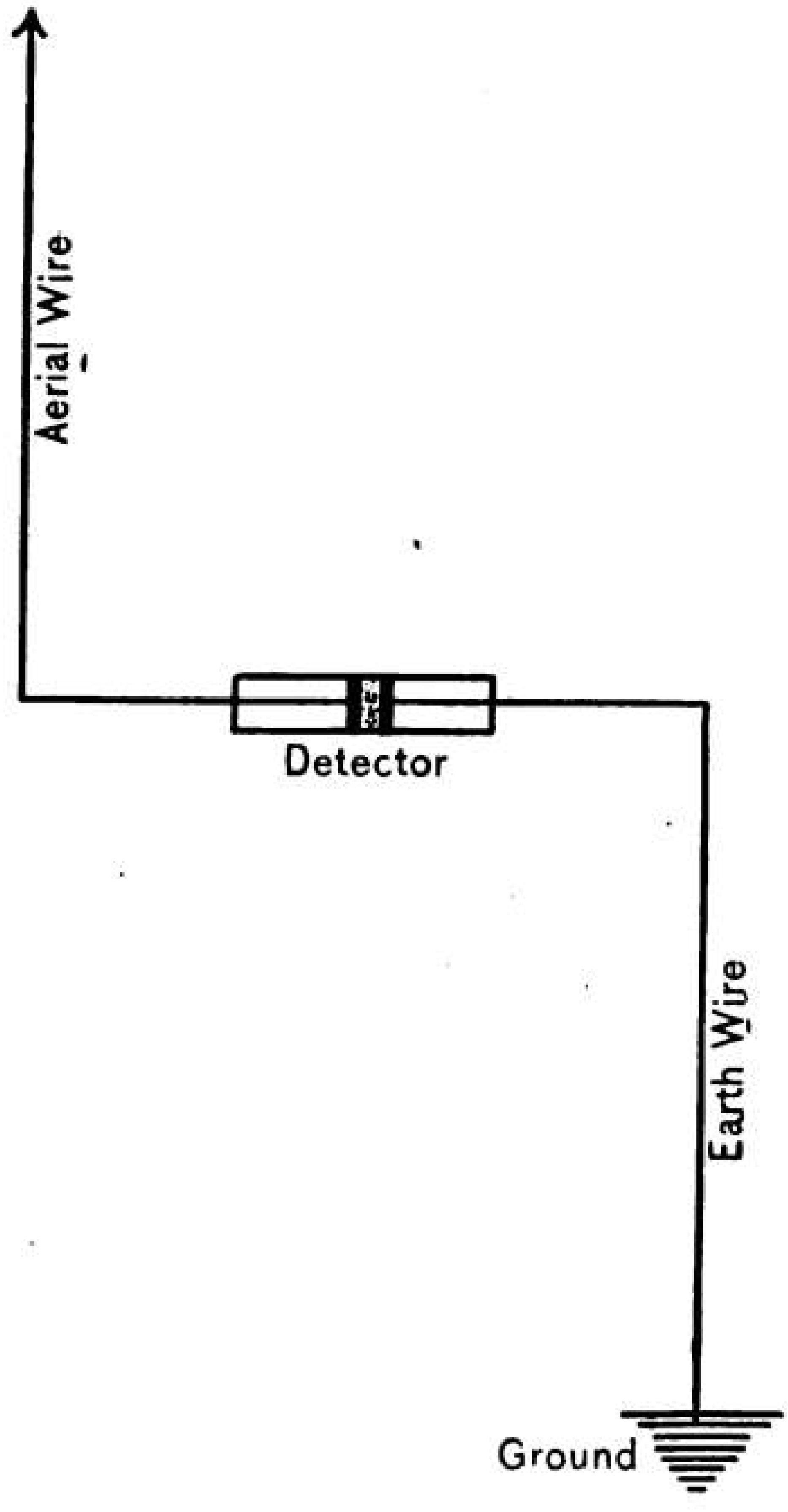

FIG. 57.—Simple Open Circuit Resonator.

internal circuit is provided by connecting the coherer, a dry cell, and some kind of an indicating device, such as a galvanometer, a telephone receiver, or a relay working a register as shown in Fig. 58, assuming that the resona-

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tor system used is of the simple open circuit type above described. That all of the energy of the oscillations may be impressed on the coherer, non-inductive resistances, or choke-coils as they are called, or polarization-cells,

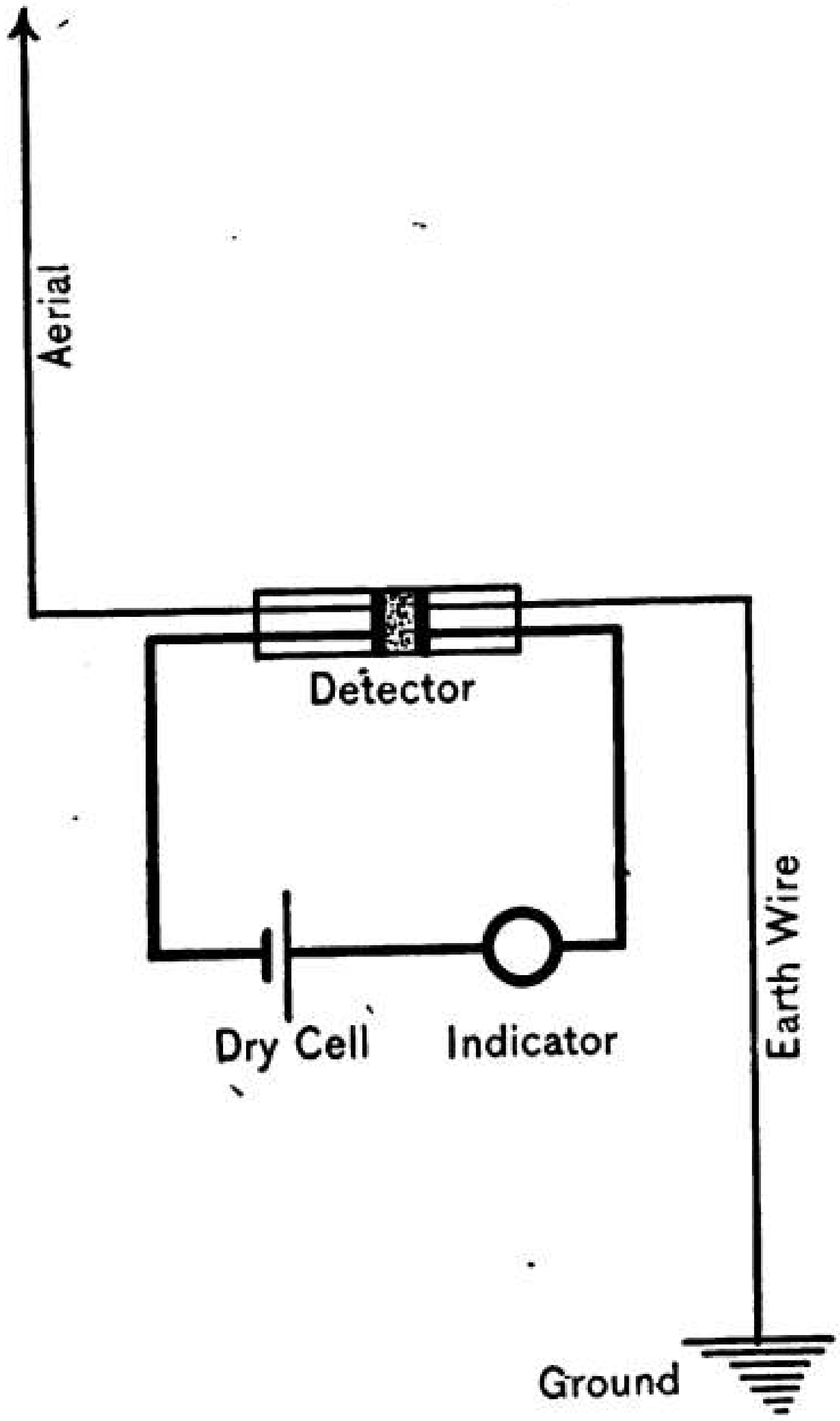

FIG. 58.—Diagram of Detector and Cell Circuit.

are usually inserted in the internal circuit to prevent the oscillations from surging through the instruments which offer a path of less resistance.

Diagram of a Compound Circuit Close Coupled Resonator.—The general diagram Fig. 59 is of a com-

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pound-circuit resonator system in which the aerial wire connects with one end of an inductance coil, while the opposite end of the latter leads to earth. This comprises that part of the resonator equivalent to the open

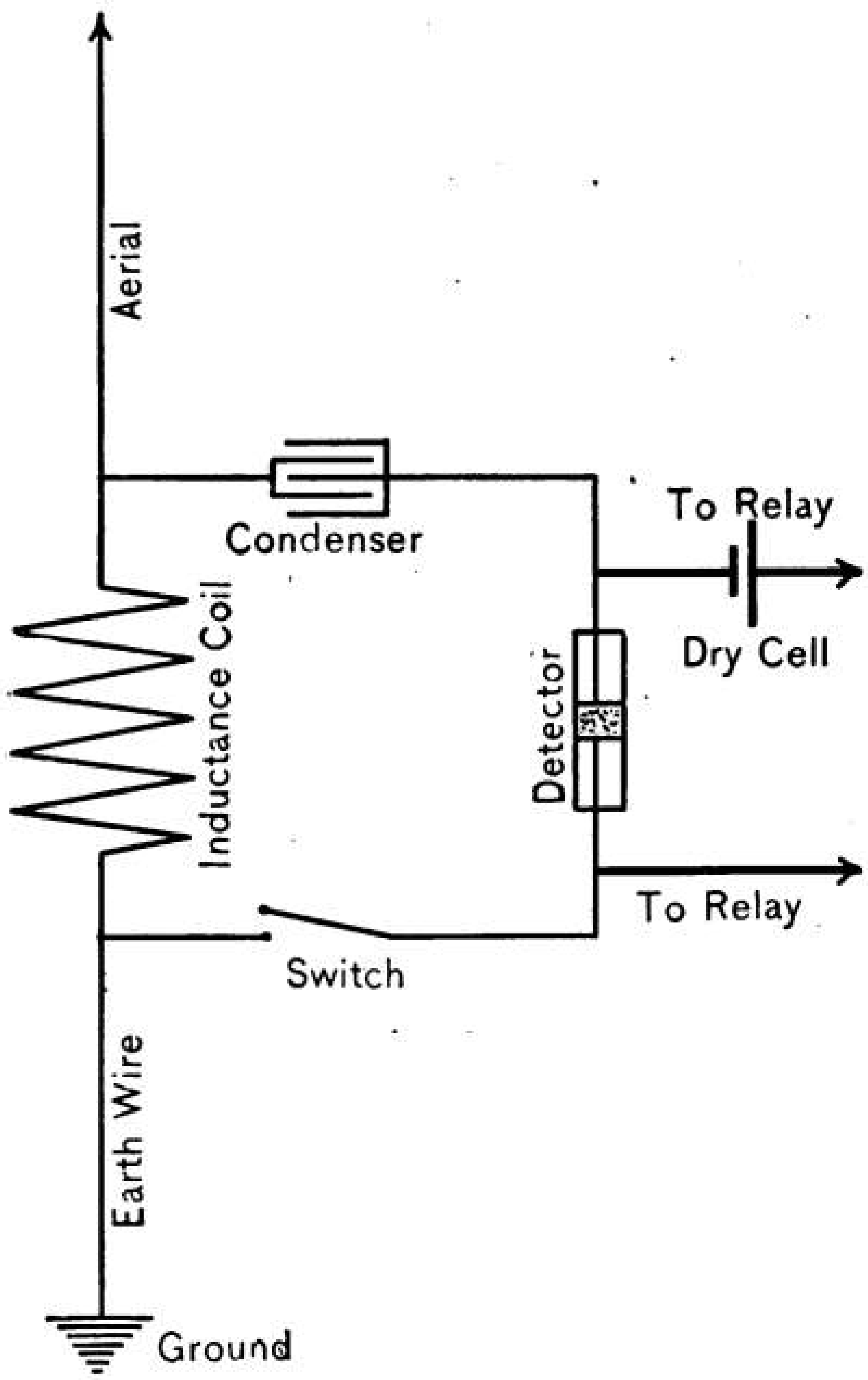

FIG. 59.—Compound Close Coupled Resonator System.

circuit, the closed circuit being formed by connecting the inductance-coil, the coherer or other detector, and the condenser in series, as shown in the diagram. Since the open circuit and closed circuit are connected directly

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to each other, it is termed a *close-coupled system.* This is the form of oscillating circuits used in the receptors in the Telefunken system. In the actual receptor means are provided for varying the value of inductance as in the case of the oscillators, and the capacity is also made adjustable, or should be.

Diagram of a Compound Circuit Loose Coupled Resonator.—In a compound circuit resonator where a loose coupling is used it is understood to mean that the aerial wire connects with an inductance coil and the latter with an earthed terminal as in the former instance, but this inductance not only serves to tune the circuit, but also as the primary coil of a small transformer, the latter sometimes being called a *jigger.* The secondary of the transformer makes up a closed circuit with the coherer through one or two small condensers, as shown in Fig. 60. In practice the condensers and the coils are arranged so that their values may be changed and the periods of oscillation in the open and closed circuits may be tuned to each other and so be productive of the best results.

Wiring Diagram of Relay Connections.—Of the instruments used in a printing receptor the relay only has double contacts. Relays of whatever type, ordinary or polarized, are provided with four binding-posts, the coils of the magnet being connected to the first two, while the armature lever carrying on its end a platinum point and the stationary platinum point with which it makes contact are connected to the other two posts, as shown in Fig. 61. The coherer and the dry cell are connected

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in series with the relay magnets and the Morse register, tapper, and battery in parallel with the contact points.

Wiring Diagram of the Coherer and Relay Circuits of a Telefunken Set.—The coherer and relay circuits of

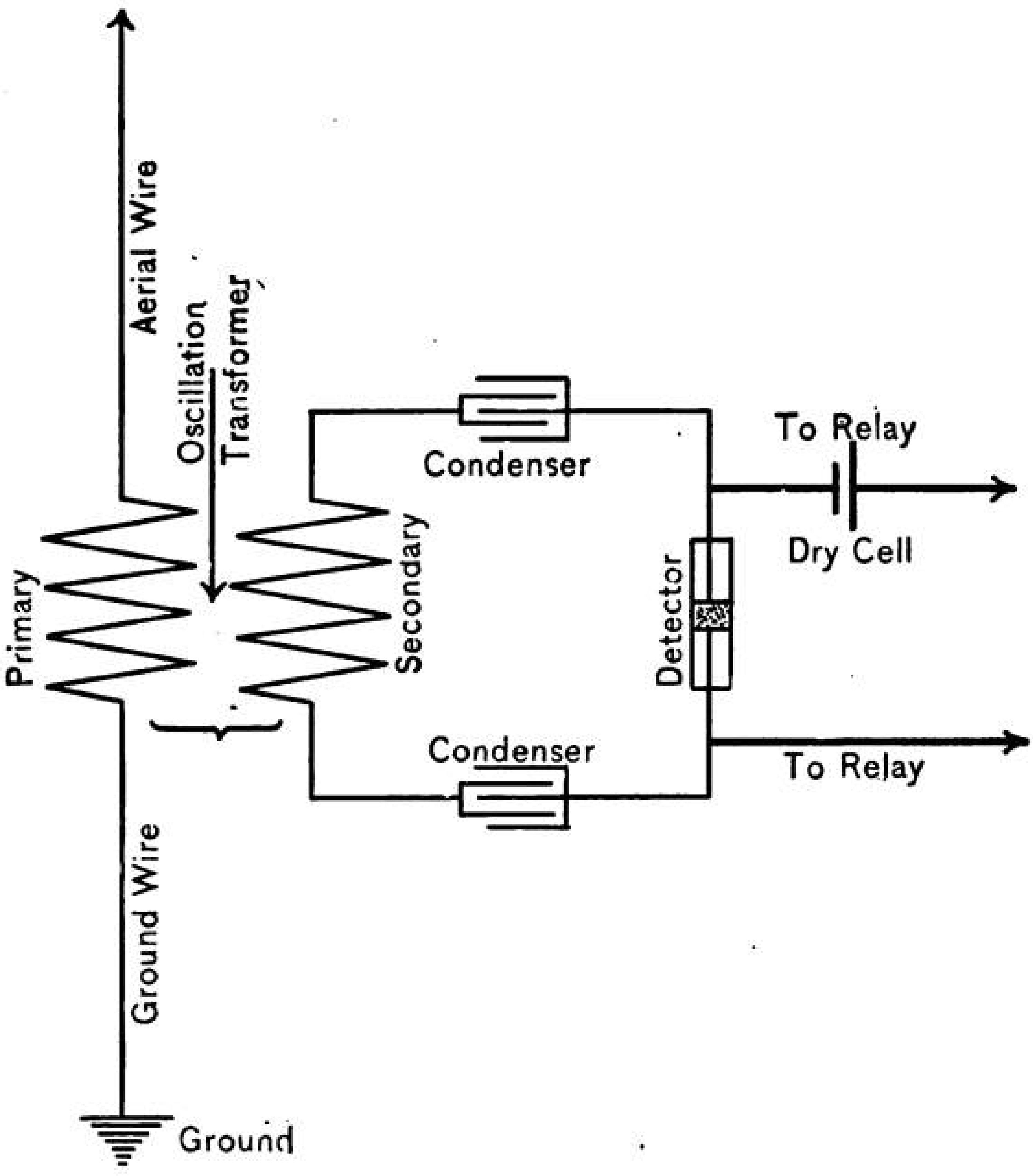

FIG. 60.—Compound Loose Coupled Resonator Circuit.

a receptor as chiefly used in the Navy is shown in Fig. 62, and while the receptors of this type in other systems may not be connected exactly as in this one, there is very little difference and the accompanying diagram will suffice

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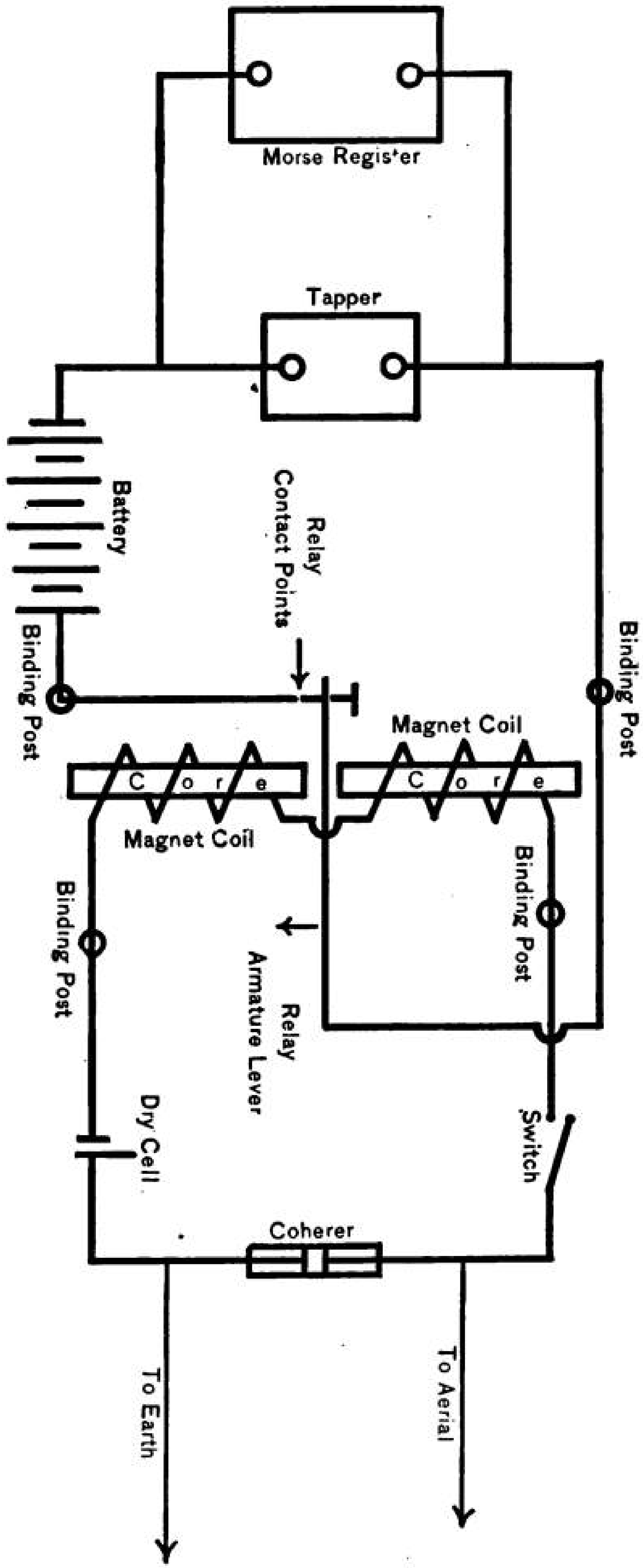

FIG. 61.—Wiring Diagram of Relay Connections.

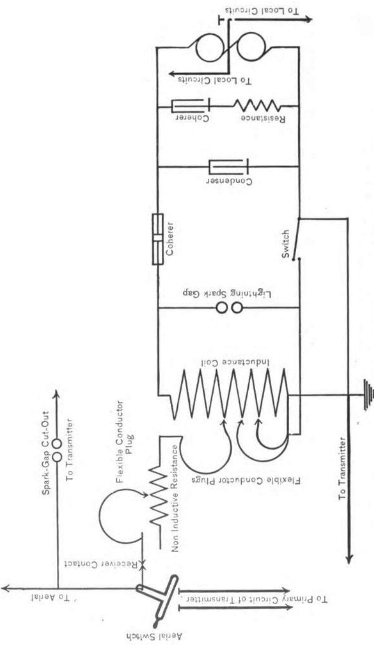

FIG. 62.—Wiring Diagram of Aerial-wire System, Coherer, and Relay Circuits.

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to enable the operator to connect up any receptor using a coherer and relay. The tuning coil is provided with three adjustable plugs all of which are connected with flexible conductors; the upper plug leads to the aerial through a variable non-inductive resistance, the purpose of which is to cut down the energy of the received electric waves when the distance between the transmitting station and the receiving station is comparatively short; a second and shorter aerial wire may be used instead of the long-distance aerial with the resistance thrown in if preferred, and some of the Atlantic liners are thus equipped. The two lower plugs, also fitted with flexible conductors as mentioned above, are connected to the lower end of the tuning-coil, which in turn leads to earth.

The ends of the tuning coil are connected in series with the coherer, dry cell, coils of the relay, and a small variable resistance, this arrangement forming the closed circuit. Bridged across this closed circuit is a small spark-gap, so that in case an electrical storm should occur, or when the atmospheric conditions are such that the aerial system becomes unduly charged by electricity, these charges instead of passing to the earth through the coherer, which would render it unfit for further use by destroying its sensitiveness, will pass through the alternative path offered by the spark-gap, since static charges suddenly released will break down a thin film of air rather than force its way through the filings of a coherer. It may again be asked why it does not dissipate its energy into

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the earth through the inductance coil, but it must be remembered that inductance has a very great retarding influence on a high-frequency current.

Also bridged across the closed circuit and in parallel with the spark-gap is a pair of small condensers that may or may not be adjustable, but should be in order to obtain the best results. These small condensers not only tend to check the discharge of atmospheric electricity through the coherer, but they also serve to prevent the current from the dry cell from leaking through the earth connections and tuning coil.

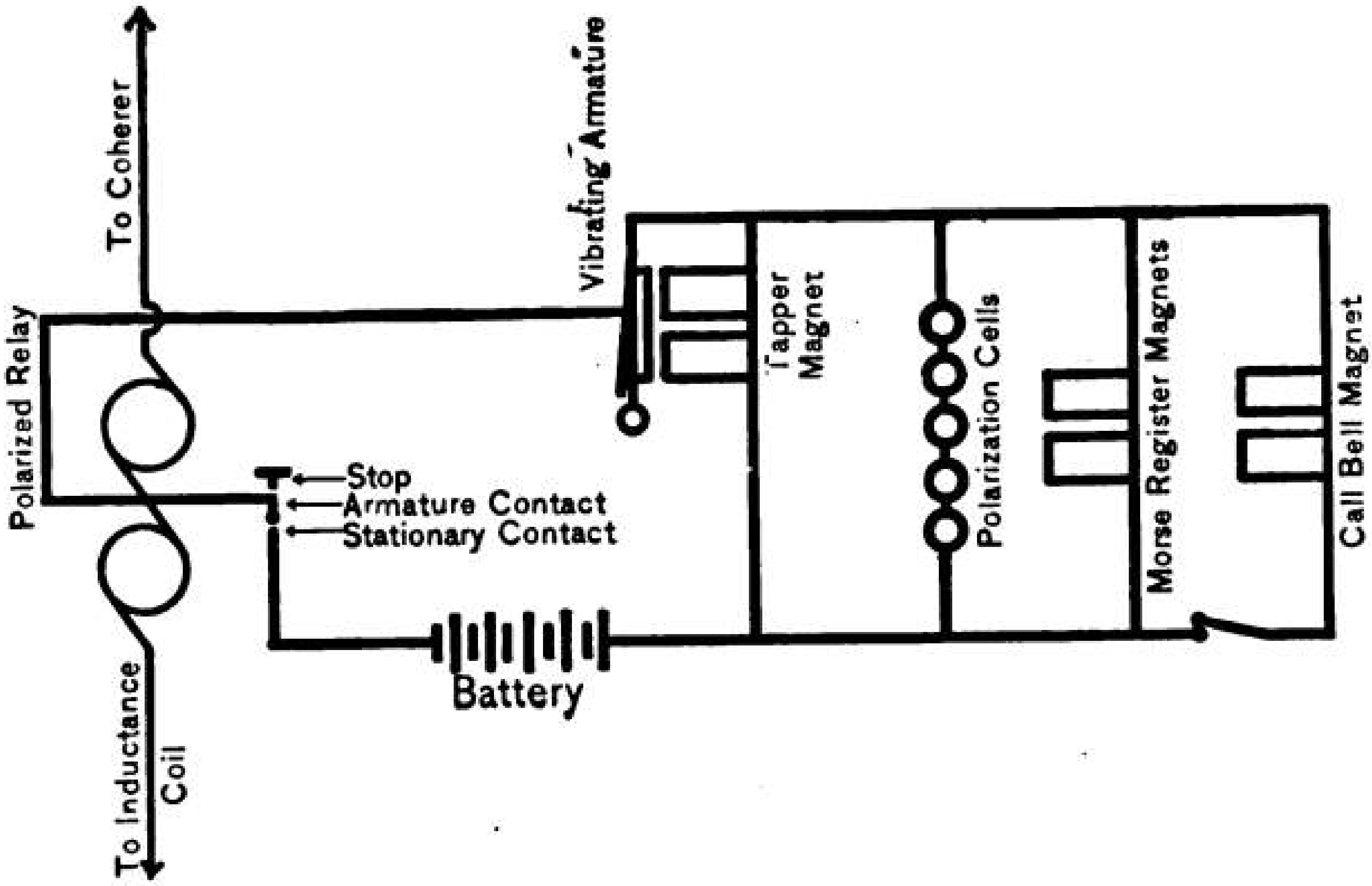

FIG. 63.—Wiring Diagram of Internal or Local Circuits.

Wiring Diagram of Internal Circuits.—The internal circuits, that is those that are closed through the medium of the relay, include the tapper, polarization cells, Morse register and a call bell. These are connected up in parallel, as indicated in the diagram Fig. 63, and are consequently

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operated from the same battery of dry cells. The polarized cells are connected in series, and these are placed across the contact-points of the relay; they absorb the excess energy produced by the condenser action of the circuit, which would otherwise cause an excessive spark to pass between the relay contacts and set up oscillations of small magnitude but amply great enough to affect the filings of the coherer, just as would a received impulse.

The magnets of the decoherer or tapper, the Morse register, and the call-bell are wound to the same resistance, since these are energized by the same battery. A switch is provided so that the bell can be cut out after ringing up the operator.

Wiring Diagram of a Complete Receptor.—This is shown in Fig. 64 and is a combination of Figs. 62 and 63 coupled together, when they present a much more complex aspect than do the different circuits shown separately. All the apparatus above described except the tuning coil is mounted on the receptor stand, as is also a switch, especially designed for the purpose, for breaking the connection of the aerial in receiving and which simultaneously closes the primary circuit of the sending apparatus.

Wiring Diagram of a Marconi Receptor with Auto-detector.—In the Marconi system now in commercial use in this country a magnetic detector is employed, and the following connections shown in Fig. 65 are used. A tuning coil is connected to the aerial wire by a flexible conductor terminating in a plug. A second flexible wire

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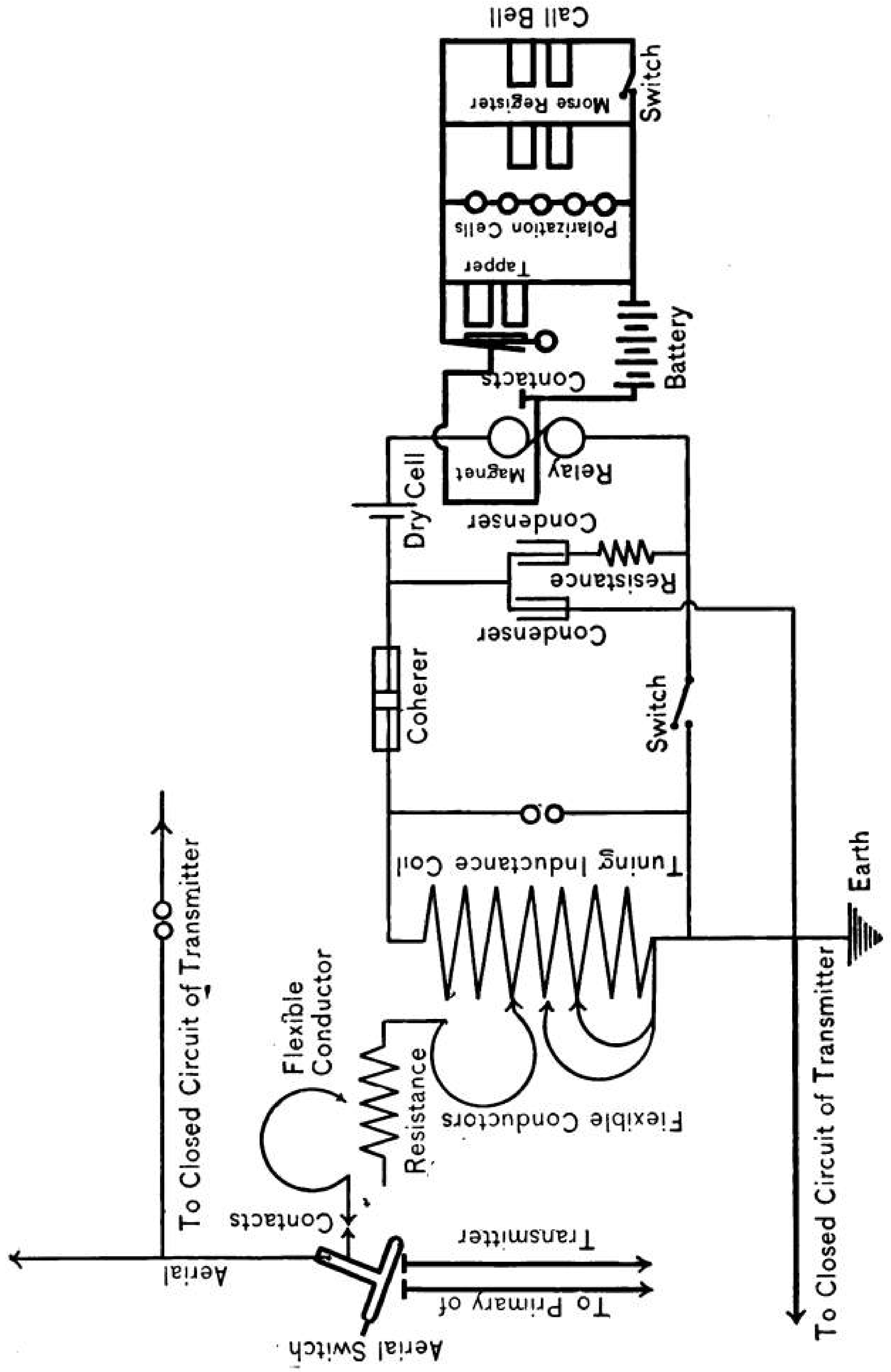

FIG. 64.—Complete Wiring Diagram of a Telefunken Receptor.

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with a plug end makes contact with one of the middle turns of wire and leads to the earth direct. A third

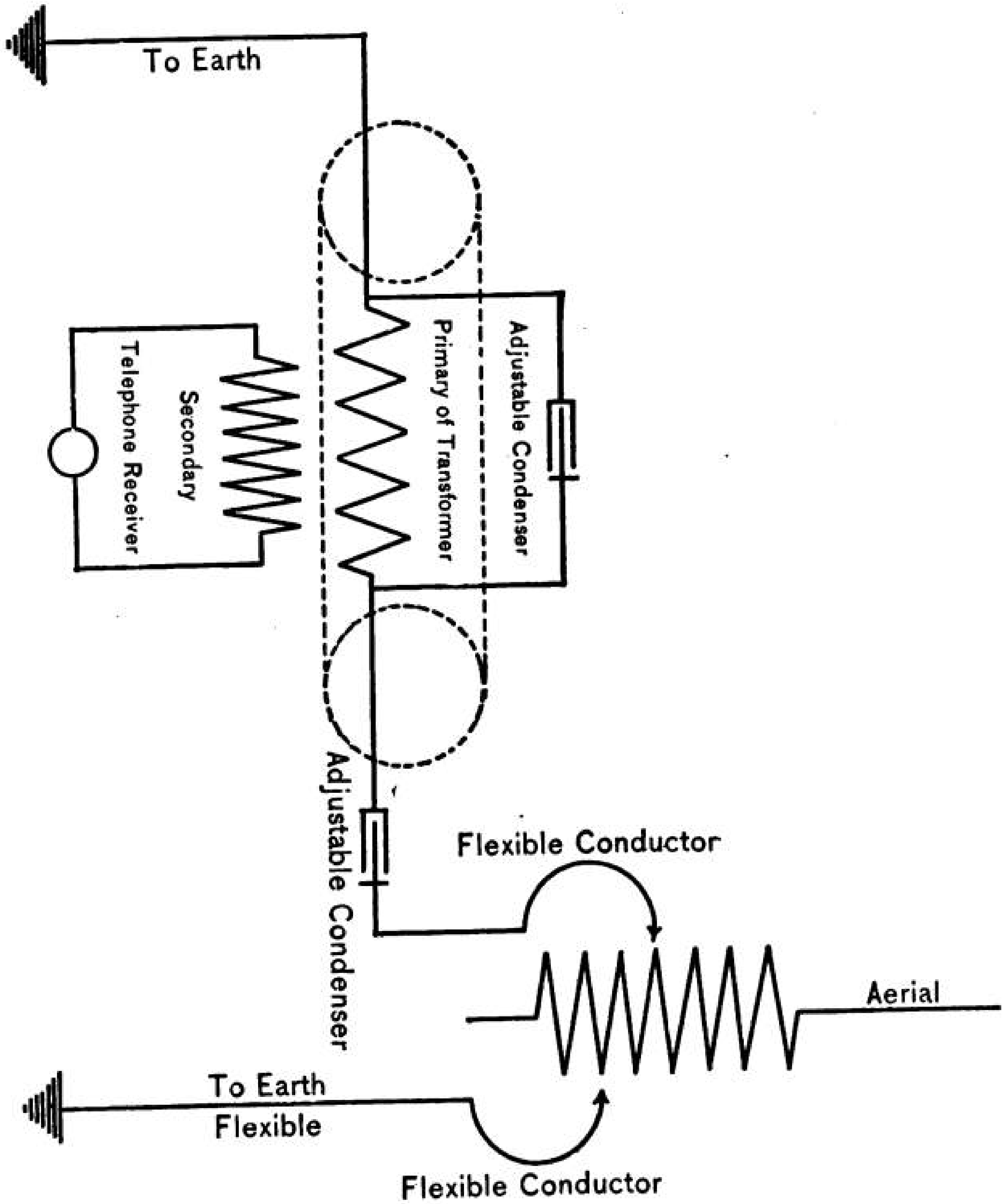

FIG. 65.—Wiring Diagram of Marconi Magnetic Receiver.
Dotted lines show moving iron core.

flexible wire with a plug end makes connection with a lower turn of the inductance coil; this last named conductor leads to a small adjustable condenser, which in turn connects to one end of the primary of a small transformer coil, while its other end is joined to a second earth-

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terminal; shunted around this primary coil is a second adjustable condenser. Around the primary of the transformer coil is wound a secondary coil of finer wire, the terminals of which connect to the binding-posts of a telephone receiver. An electrolytic detector may be connected up in practically the same manner.

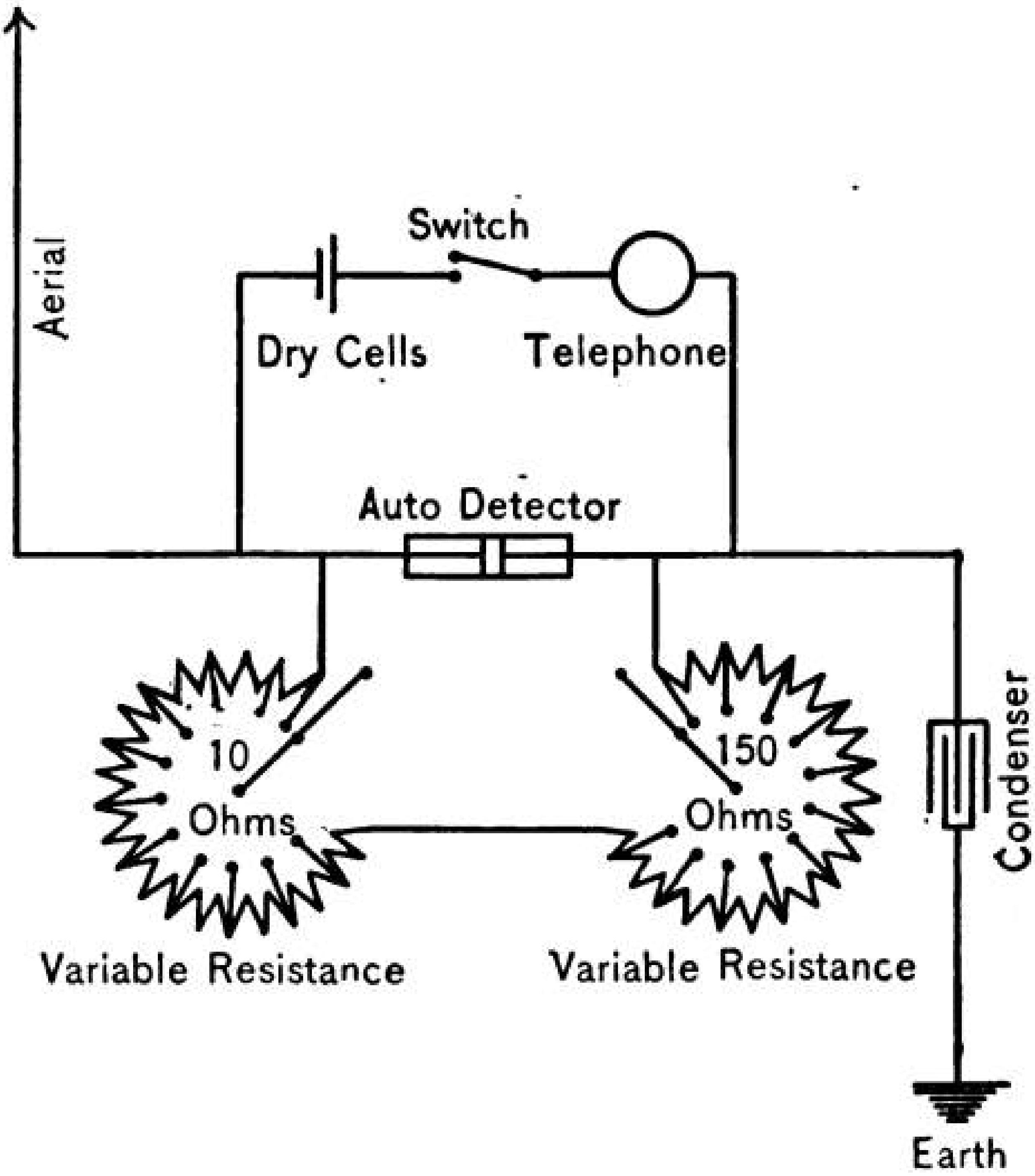

FIG. 66.—Wiring Diagram for Receptors with Auto-detector. Shunt Circuit to be Used with Electrolytic Detector.

Diagram of a Clark Portable Receptor for Field Work.—This set is used to a considerable extent in the Army. It consists of an oak case enclosed in a weatherproof canvas bag strapped down and provided with a heavy leather handle for carrying. It is not necessary

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to remove the oak case from the canvas bag to receive, though where possible it is better to do so. The receiver-case is divided into two parts, namely, the case itself and the top or cover. The top is held down by two catches on the sides, and fastened at the back by a pair of hinges.

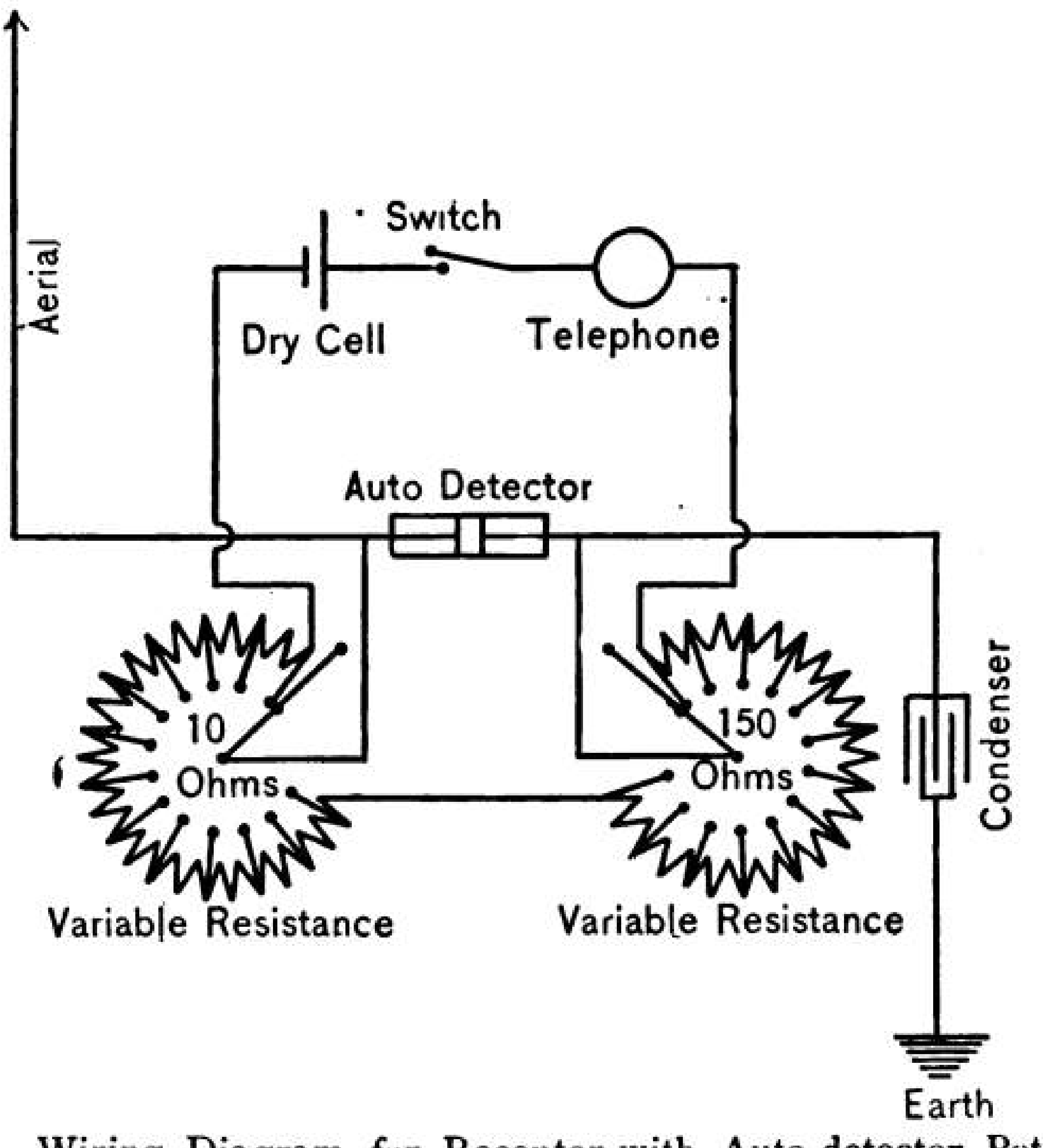

FIG. 67.—Wiring Diagram for Receptor with Auto-detector Potential Circuit best adapted to Microphone Detectors.

On the top of the cover all the receiving instruments are mounted and wired on the under side, so that the wiring is all concealed. This receptor is provided with a simple microphone detector, or auto-coherer, the conductor-plugs of which are made of steel and the granules in the pocket, of carbon. This is mounted in a pair of stan-

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dards supported on a hard-rubber base, and is connected in series with a pair of head telephone receivers.

This receptor set is supplied with a call bell having an ordinary coherer and a relay, and the connections are so made that by inserting a plug in the circuit the filings, coherer, and relay are cut out, and when the plug is withdrawn from the spring-jack the filings, coherer, and relay are cut in. Diagrams of the connections are shown in Figs. 66 and 67, the first representing a wiring diagram for a shunt-circuit receptor, and the second for a potential-circuit receptor. The aerial wire may be connected plain as shown, or, better, through a tuning inductance coil. These diagrams may also be used with the Massie microphonic, Fessenden electrolytic, de Forest responder and other auto detectors. The shunt diagram shown in Fig. 66 is best adapted for microphonic coherers, and the potential diagram in Fig. 67 for electrolytic and other types of detectors.

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CHAPTER VII

THE APPARATUS IN ACTION

Preliminary Remarks.—Having explained the elementary theory upon which the transmission and reception of electric waves are based, and having described the various apparatus used for setting up and indicating these waves, it will be well, before the methods of adjusting the instruments are discussed, to follow out in detail the processes involved when the apparatus is in action; to do this we must begin by following the low-voltage current as it is delivered by the generator through the induction coil, or transformer, at the sending station, and then ascertain how the energy of the impressed oscillations is supplemented by a small direct current from a dry cell at the receiving station.

Action of an Induction Coil.—The principal functions in the conversion of a low-voltage current into a high-tension charge—such as we have immediately prior to the transformation of the static charge into kinetic energy, i.e., electric oscillations, by the electric spark, or disruptive discharge—take place through the medium of the induction coil and hence is due to mutual induction. The making and breaking of the primary circuit by the interruptor, and the re-

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duction of the spark between the contact-points of the latter by means of the condenser, are details that are not only interesting in their theoretical aspects, but of vital importance in the successful working of the transmitter. Before considering the action of these devices a brief summary of the principles of mutual induction will serve to make the operation of an induction coil comprehensible and the more complex phenomena of the interruptor and condenser understandable.

(*a*) When the key is made to close the primary circuit see Fig. 68, and the direct current is permitted to flow

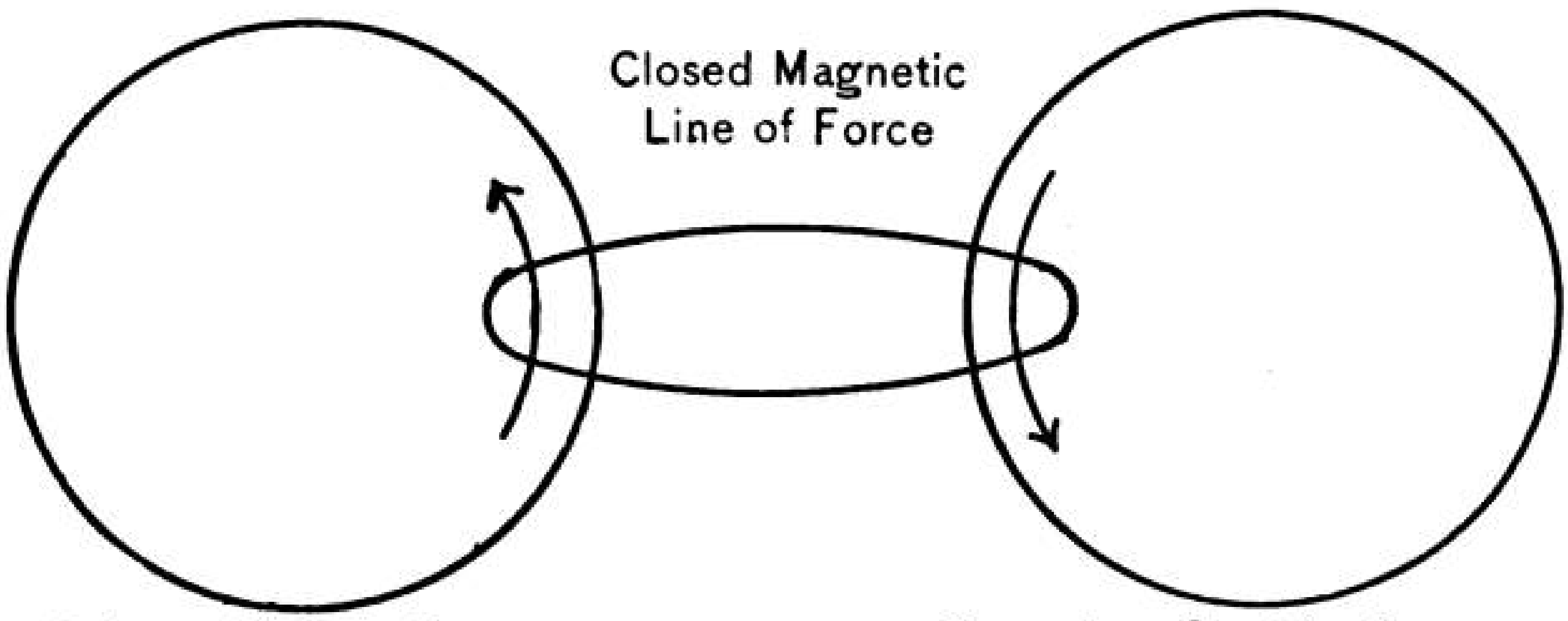

Fig. 68.—Transformation of Electric Current into Magnetic Line of Force, and the Latter Back into an Electric Current.

through the inductor or primary of the induction coil, a large per cent of the electric energy is transformed into magnetic energy in the form of closed or elliptical lines of force that expand like those produced on the surface of a pond when a stone is dropped into it. If a core of soft iron is placed inside the primary coil, these magnetic lines of force may be concentrated, for iron possesses a greater permeability than air and the non-magnetic metals. Fig.

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69 shows how the magnetic lines of force which are formed at right angles to the diameter of the turns of wire are carried through the iron core and form closed loops through the air surrounding it.

(*b*) Let us ascertain now what the action will be when there is another or second coil of wire slipped on and over

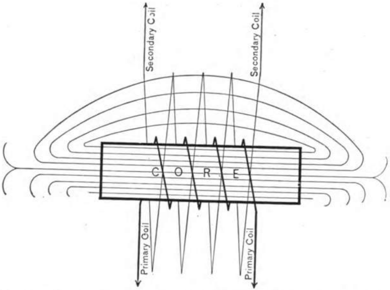

FIG. 69—Diagram showing How Magnetic Lines of Force are Set Up in the Core of a Coil, and How the Loops Intersect the Secondary Coil.

the first or pimary coil. Assuming that the circuit is closed through the key, and that the electric current is converted into the magnetic lines of force as explained, the latter in passing from one pole of the core to the other will intersect or thread through the secondary coil; when this condition of affairs takes piace the magnetic energy will be transformed back into an electric current in the outer

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coil. The current thus set up, however, is of but momentary duration and takes place only on closing the primary circuit or on breaking it, the current flowing first in one direction and then in the other, for there must be either a rise or a fall in the intensity of the magnetizing force in order to produce an electric current in the turns of wire intersecting it.

(*c*) If an induction coil was wound with a primary and a secondary coil of the same number of turns of wire, the potential or voltage impressed on the former would be developed at the terminals of the latter, if we regard the losses due to the transformation as negligible. In this case the ***ratio of transformation***, as it is termed, would be unity, for the law of transformation states that the ratio is directly proportional to the number of turns of wire on the primary and the secondary coils, while the amount of energy delivered at the terminals of the secondary is practically equal to that which flows through the primary; consequently the potential of the secondary may be exceedingly great when compared with that of the primary, the amount of current being, of course, relatively less.

Action of the Condenser.—The condenser shunted around the interruptor is inactive when the make-and-break points of the latter are in contact and the full value of the current is flowing through the primary circuit, but the instant the contact-points begin to separate or break, the increased resistance causes the primary current to begin to charge the condenser, and this continues until the charge is maximum or the fixed and movable points of

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the interruptor again make contact. An interruptor where the break takes place suddenly, requires a condenser of much smaller capacity than where the break consumes a longer time; this must not be taken to mean the period of interruption, that is, the length of time to complete the cycle between a make and a break, but the time measured from the instant the break begins to take place until the current ceases to flow between the contact-points.

The reason a smaller condenser can be used where the break is sudden is that there is less time for the potential of the primary to rise to a point where it can produce an excessive spark. Without the condenser it is impossible to break the circuit very quickly, for, though the mechanical portion of the interruptor works at the same speed, the large spark produced between the contact points heats the air between them, rendering it a good conductor, and the current continuing to flow prevents the potential from falling from its highest value to its lowest value in the shortest possible time. On the other hand the condenser should have the smallest capacity that will effectually reduce the sparking at the interruptor contacts. When these conditions are properly fulfilled the secondary coil will develop a potential difference at its terminals that will give the longest spark possible with the coil used.

Action of a Transformer.—Where a transformer is used instead of an induction coil there is of course no interruptor, and in order to obtain the maximum and minimum values of electromotive force necessary to energize the secondary coil a generator producing an alter-

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nating current must be resorted to; this arrangement is shown in Fig. 53, Chapter V. Here the same laws of mutual induction are in evidence as in the case of the induction coil. Where transformers are employed the potential at the terminals of the secondary coil seldom exceeds 50,000 volts, and more often only 25,000 volts are developed. That a greater amount of energy may be utilized in the production of the oscillating currents, the terminals of the secondary are connected with the inside and outside coatings of a battery of Leyden jars; when the latter are charged to their maximum capacity they discharge across the spark-gap of the oscillation system.

The Action of a Simple Sending System.—In one of the earlier chapters the first principles of the disruptive discharge, electric oscillations and electric waves were discussed and their elementary theoretical functions were stated. A simple oscillation circuit together with the high-tension secondary circuit and low-voltage primary circuit is shown in Fig. 70; it will be observed that these are drawn as separate parts, for, while they are physically connected at all times and electrically connected part of the time, there are certain periods when their functions are quite as distinct as though the circuits were entirely removed from each other.

For instance, after the secondary is energized by the action of the current flowing in the primary, it charges the opposite arms of the oscillation circuit formed by the aerial wire on the one side and the earthed termal on the other. The high-potential energy alternately changes its

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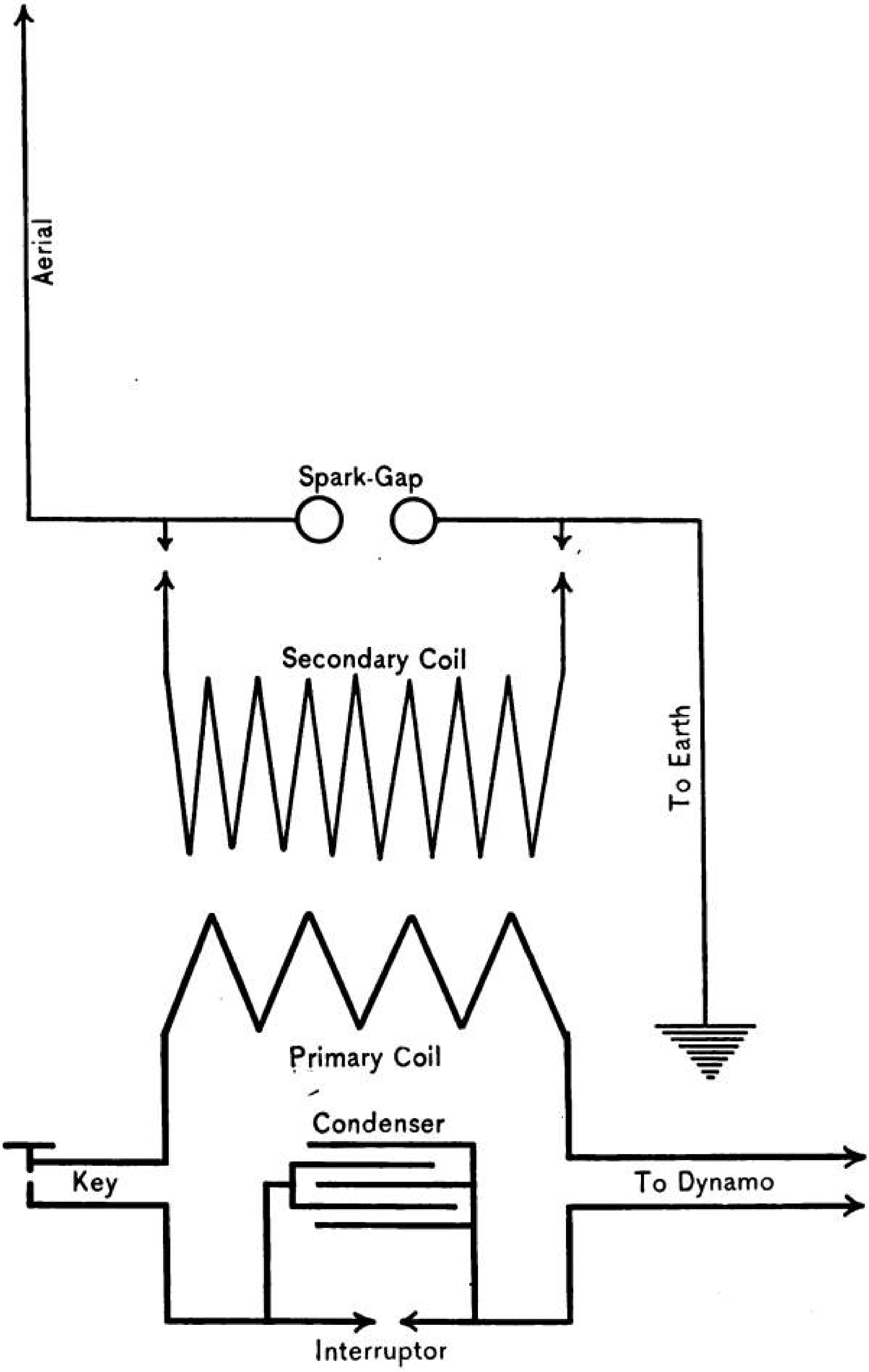

FIG. 70.—Diagram of Action of a Simple Sending System.

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direction, as we now know, each time the primary circuit is made and broken, hence its frequency of alternation is comparatively low. When this low-frequency but high-potential current flows into the oscillation system its energy is no longer kinetic but static, and is therefore at rest, like a gas under pressure, until it becomes sufficiently great to puncture the insulating partition of air in the spark-gap.

When this action takes place the static now becomes kinetic energy, and an exceedingly high frequency of alternation is produced in the circuit, when it is termed an oscillating current. As this high-frequency and high-potential current oscillates through the aerial-wire system its energy is changed into an altogether different form, very much as in the case of low-voltage current electricity changing into magnetic lines of force, in that it sets up a disturbance in the ether and at right angles to the wire conducting the oscillations, but instead of closed lines of force the propagation assumes the form of undulations termed electric waves.

Action of a Compound Close Coupled Sending System. —Where an open and a closed circuit are coupled together, as shown in Fig. 71, the spark is produced in the closed circuit, and the high-potential and high-frequency currents surging through the system thus formed is imparted to the open-circuit system, which radiates the energy as electric waves. It will be observed by referring to the diagram that a second closed circuit is formed by the spark-gap in series with the secondary of the induction

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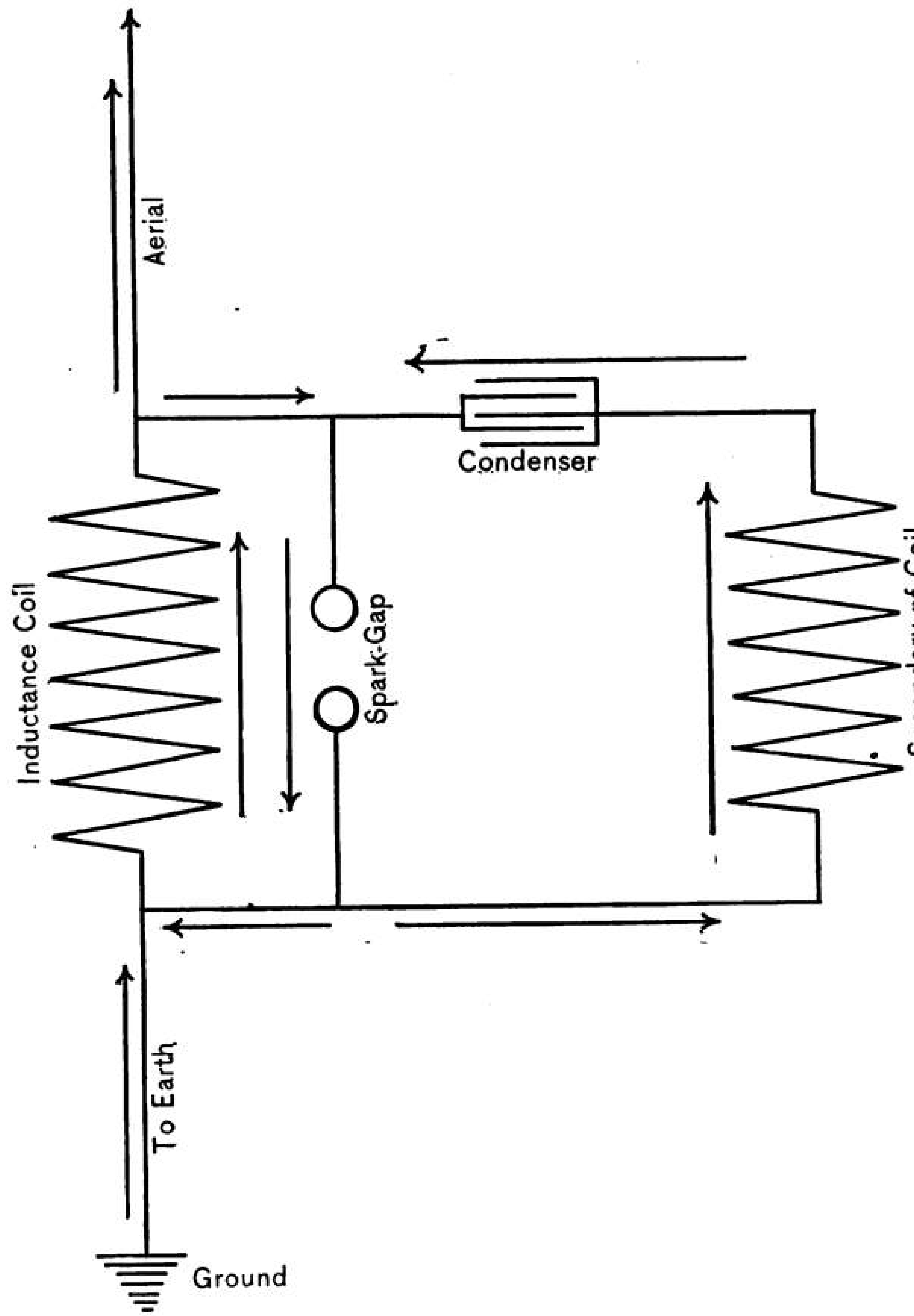

Fig. 71.—Diagram of Action of Compound Close Coupled Sending System.

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coil, but it should be understood that the oscillations cannot surge through this closed circuit, for the inductance of the secondary is so excessive for the enormously high frequency oscillations that it acts as a choke-coil, with the result that the greater portion of the energy is confined to the open and closed oscillation circuits. Before the oscillations can be communicated to the aerial and earthed wires it must surge through the Leyden-jar battery and the inductance coil. As these are, respectively, variable and adjustable, the closed circuit can be, and indeed it must be, tuned to the period of oscillation best adapted to the aerial-wire system. When tuning is effected the oscillations of the closed circuit will flow through the open circuit in the same period of time, and there will be no opposition currents to waste the energy, but instead the maximum amount will be available for radiation from the aerial.

Action of a Compound Loose Coupled Sending System. —In loose coupled systems where a high-frequency and high-potential transformer is used to further increase the potential of the oscillations impressed on the open circuit by the closed circuit, the action is a little different from that just described. The secondary of the induction coil of course performs the same functions as before, charging the Leyden-jar battery until the energy becomes great enough to produce the spark. The high-frequency current surges in the closed system as above stated, but the energy, instead of being directly impressed upon the open or radiating circuit, is transformed into oscillations of

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higher potential, while its frequency remains constant by a specially designed transformer, the action being very similar to that produced by an interrupted or alternating current in its conversion by an induction coil; in other

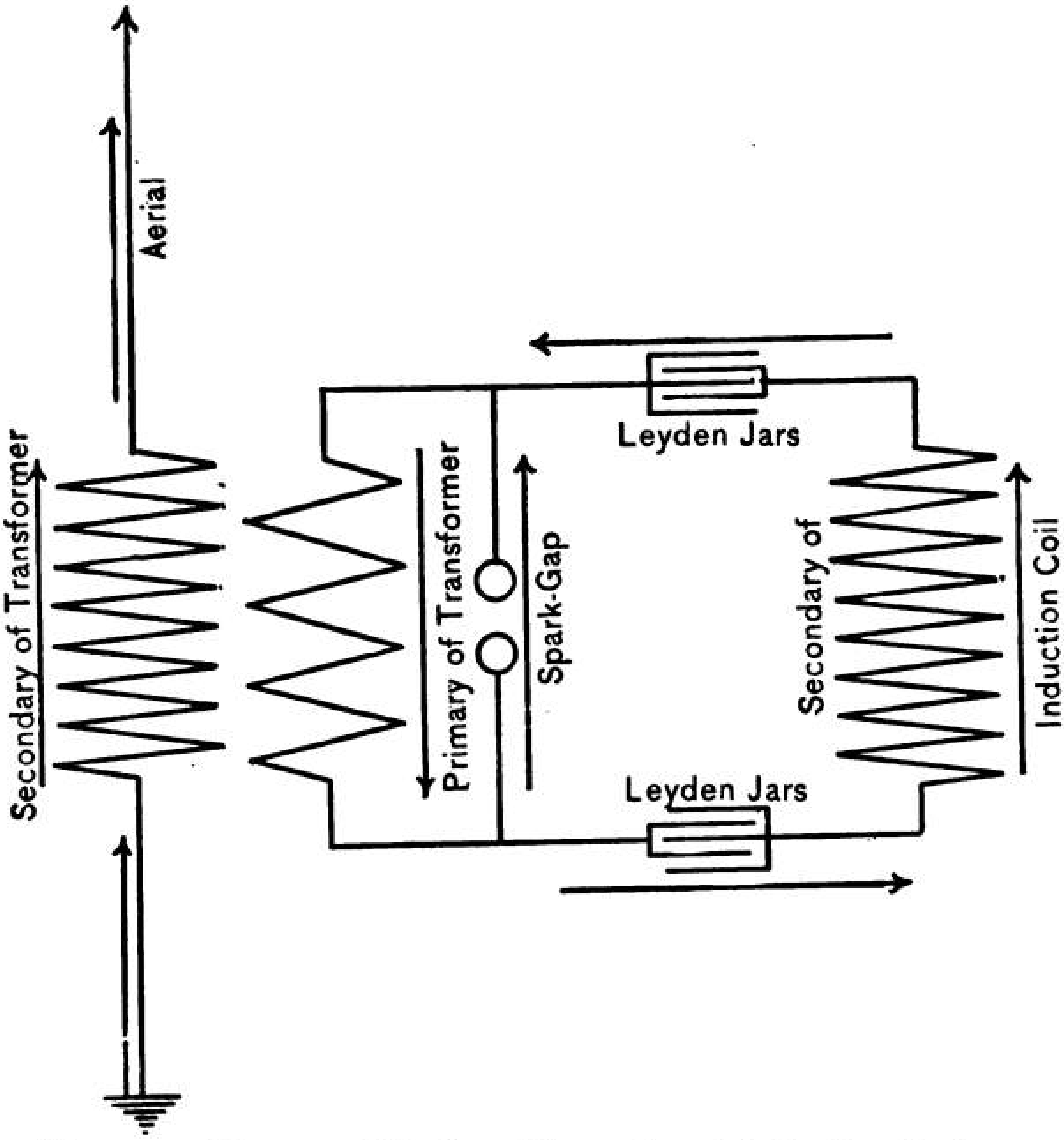

FIG. 72.—Diagram of Action of Loose Coupled Sending System.

words, the primary coil links the turns of the secondary coil with a rapidly oscillating magnetic flux, which produces in the secondary coil of the transformer, due to its greater number of turns of wire, oscillations of higher potential, and the energy of these is damped out by the

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aerial wire in the usual way. Fig. 72 indicates the direction of the current during one half a cycle.

Action of a Receiving System.—When the electric waves that are radiated by the aerial wire of a distant station impinge upon the aerial wire of the receiving station, the energy of which they are built up is converted into electric oscillations, very much in the manner that magnetic lines of force are changed into electric currents when they intersect a wire conductor. These oscillating currents in the resonator or receiving aerial have exactly the same frequency as the oscillations in the radiating aerial that emitted them, provided, of course, that the oscillator and resonator have the same relative values of inductance, capacity and resistance. For a diagram of a simple open-circuit resonator see Fig. 2.

Action of a Compound Close Coupled Receiving System.—Where the receiving system comprises an open and a closed circuit, as shown in Fig. 73, the electric oscillations set up in the open circuit are impressed directly on the closed circuit, the action being diametrically opposite to that which takes place in the transmitting oscillation system; the advantage of coupling the two circuits together is that in the open circuit, as we have learned, the electric oscillations are damped out in two or three swings; but where these are impressed on the closed circuit they are damped out very slowly and produce a cumulative effect on the coherer or other detector.

Action of a Compound Loose Coupled Receiving System.—Where an oscillation transformer, or jigger, is

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used to couple the open circuit with the closed circuit, forming a compound resonator loosely coupled, as shown

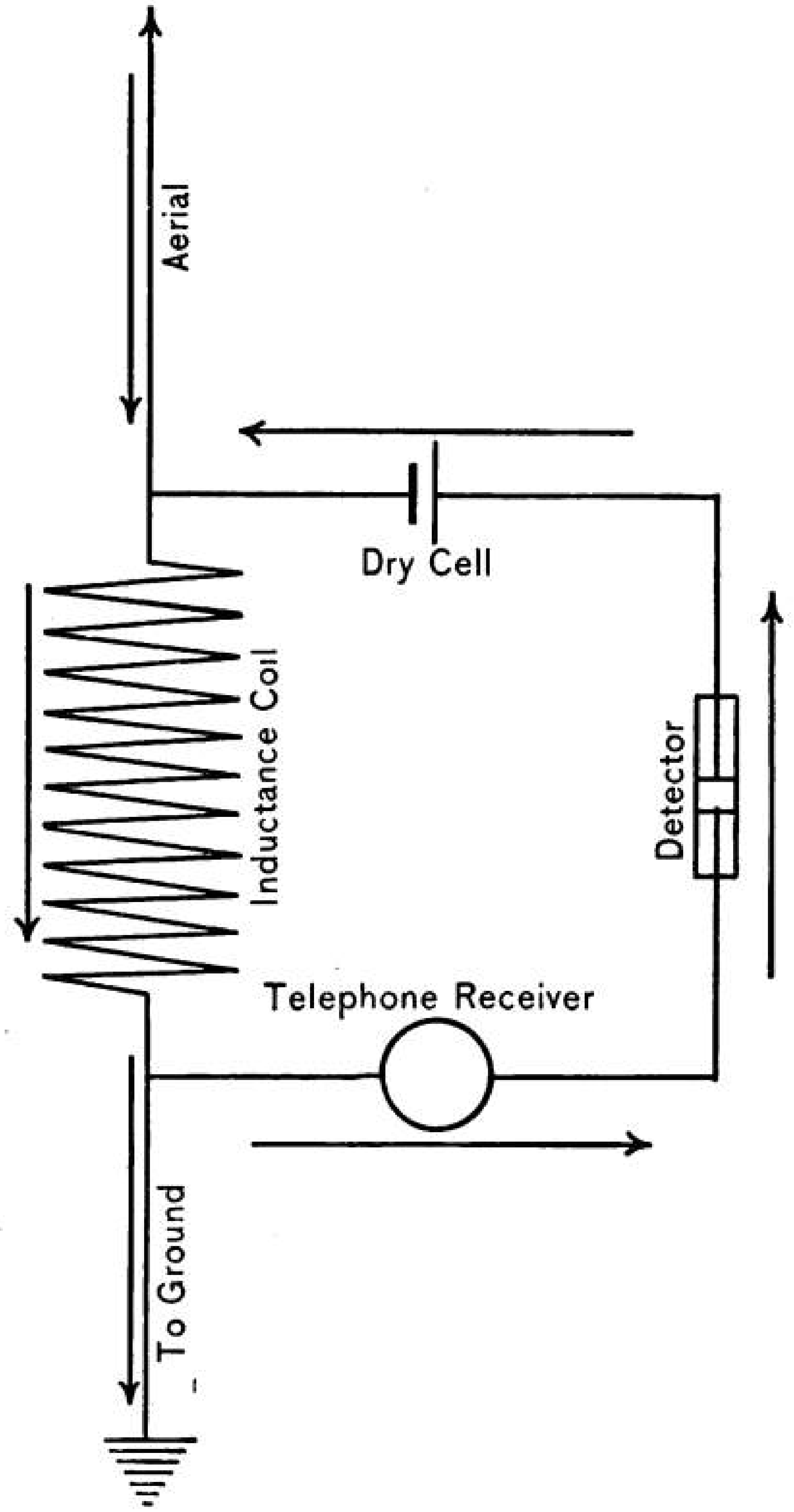

FIG. 73.—Action of a Compound Close Coupled Resonator.

in Fig. 74, the oscillations are transformed by mutual induction from the open to the closed circuit, and there

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they surge with even greater persistency than in a close-coupled system; but there is a greater loss of energy in

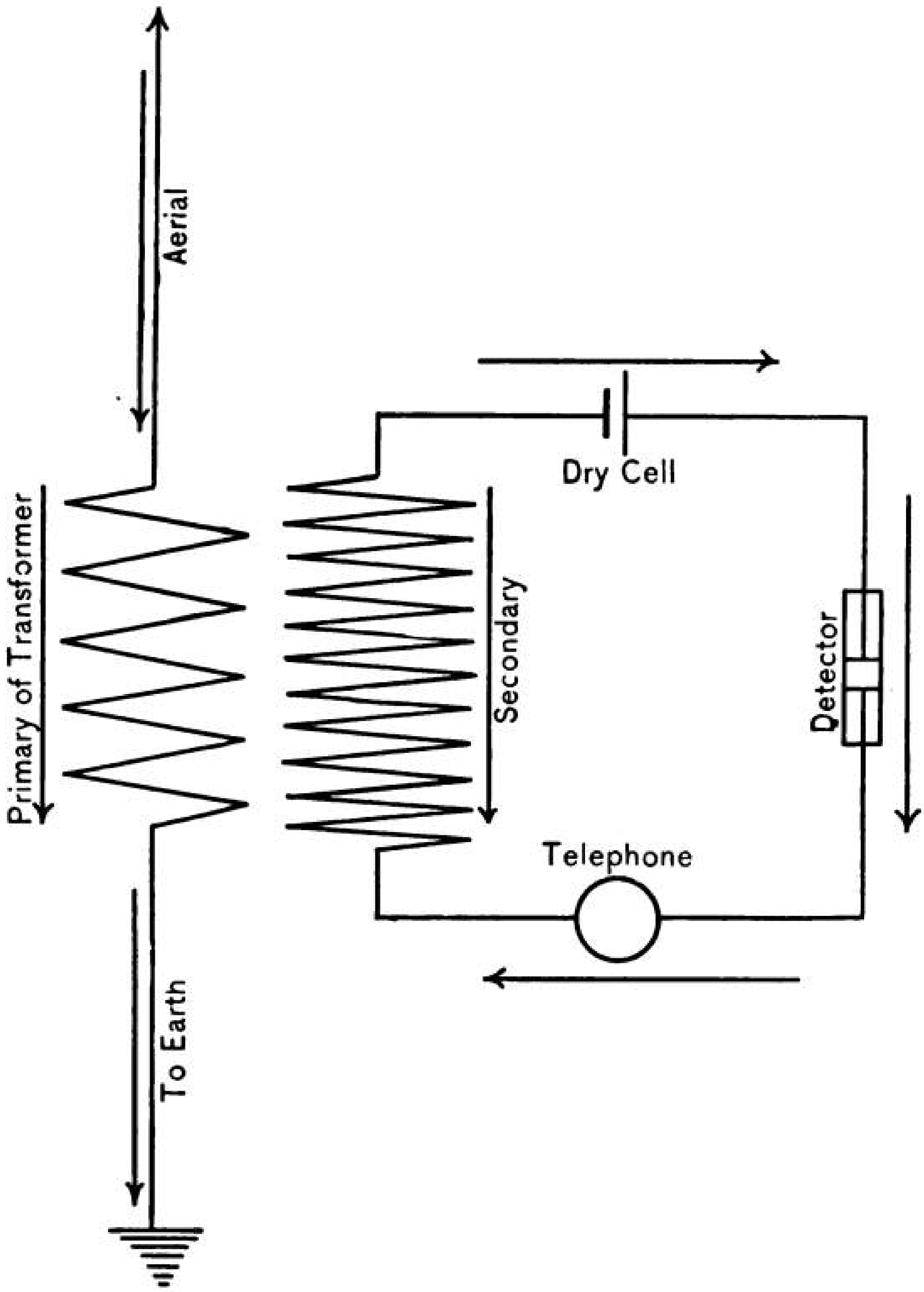

FIG. 74.—Action of a Compound Loose Coupled Resonator.

transformation, so that one scheme is about as effective as the other.

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Action of a Coherer.—When an oscillating current of either a plain or compound circuit receiving system surges through the coherer, as described earlier in this work, the filings are drawn together as though they were magnetized, and, following this, the minute sharp edges are welded, forming a practically continuous conductor until the coherer is tapped back. To perform this action of reducing the resistance of the coherer filings is the sole function of the oscillating current in the receiving aerial. The coherer simply acts as a delicate relay, for it permits the utilization of a current of much greater strength than the oscillating current has, and, being a direct current, it is adapted, where the other is not, to operate a polarized relay, when all the current needed can be supplied.

Action of the Polarized Relay.—When a current from a dry cell is allowed to flow through the coherer by the action of the oscillating current, the former passes through the coils of the relay magnet. Since both poles of the electromagnet are of the same polarity when there is no current flowing, the armature carrying the movable contact-point will remain stationary; but when the current flows through the coherer one of the poles of the electromagnet changes to the opposite sign, when the armature is attracted by the one and repelled by the other, throwing it into contact with the stationary point and so closing a second internal circuit.

Action of the Tapper.—In the circuit which is closed by the relay contact-points are the dry battery, tapper, and Morse register. When the relay closes the second circuit

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a portion of the current from the battery of dry cells flows through the coils of the tapper magnet, causing the armature carrying the hammer to be attracted to its poles when it strikes the coherer; the blow breaking the filings apart, the coherer and relay circuit is broken, which in turn breaks the circuit in which the tapper is placed. As the tapper has a vibrating armature like an electric bell, it may strike the coherer half a dozen times before the circuit is finally broken.

Action of a Morse Register.—The Morse register, being placed in a circuit parallel with the tapper, of course receives its pro rata of the current, and simultaneously the current, flowing through its magnet, releases a spring motor that carries the tape forward, and at the same time a lever fixed to the armature, through which the band of paper slides, carries the latter upward into contact with an inked disk, which prints the message in dots and dashes. The time constant of the vibrating armature of the tapper must be low compared with that of the armature lever; that is, the first must be able to strike three or four strokes while the latter moves up and down once, or else the dots will not properly run together to form a dash when a succession of oscillating currents representing a dash is received.

Action of an Electrolytic Detector.—Detectors of this type may be connected directly to the aerial and earthed wires or in coupled systems, as in the case of the coherer. When the current from the dry cell flows through the detector minute bubbles of gas, due to polarization, are

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formed on the point of the fine platinum wire when the current is practically cut off; now when an electric oscillation surges through the detector it breaks through the insulating film of gas and permits a momentary current from the dry cell to flow through the telephone receiver when the sound of the sending spark is heard. (See Fig 30.)

Action of a Magnetic Detector.—In this detector the moving band of soft-iron wire (see Fig 31) is constantly magnetized by two small horseshoe magnets; the primary coil through which the band travels is connected to the aerial and earthed wires, and the terminals of the secondary wire to the telephone receiver. Now when there are no oscillatory currents surging through the resonator the magnetic intensity remains unchanged, and no sound is heard in the telephone receiver; but when the oscillations take place these vary the magnetism of the wire band when alternating currents are induced in the secondary coil, and, flowing through the telephone receiver, are rendered audible.

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CHAPTER VIII

ADJUSTING AND OPERATING THE INSTRUMENTS

Notes on Adjusting.—The adjustments required for the proper working of the sending and receiving instruments comprise (*a*) those of the low-voltage circuits of the induction coil, (*b*) those of the high-potential circuits of the oscillator, (*c*) those of the low-voltage circuits of the receptor, and (*d*) those of the high-frequency circuits of the resonator. The simplicity or complexity of the adjustments depends largely on the nature of the system employed. Where simple open-circuit oscillators and resonators are used there are no adjustments to be made, if we except that of the spark-gap, as the values of inductance, capacity, and resistance are fixed; the older forms or systems of wireless telegraphy utilized these definitely fixed radiator and receptor circuits, but the more recent modifications are provided with compound circuits, and these require adjustment in order to obtain the most favorable results. In the older makes of apparatus the coherer, tapper, and Morse register were used for receiving the messages, but this complicated apparatus has been largely superseded by the more simple and rapid auto-

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detector and telephone receiver, the number of adjustments having in consequence been greatly reduced. The low voltage or internal circuits of the transmitter remain practically the same as in the beginning of the art, but here the adjustments are few and easy to make.

Adjustment of Instruments in the Primary Circuit.—The adjustments of the transmitting apparatus, where the aerial wire and earthed terminal are connected direct to the spark-gap, are confined to the primary circuit. A rheostat is connected in the primary circuit, and enough resistance should be thrown in to prevent excessive sparking at the contacts of the interruptor, or, where a mercury-turbine or electrolytic interruptor is used, the amount of current needed can be roughly estimated by the sparking at the contacts of the key. A volt meter shunted across the circuit, and an ammeter in series with it, are useful instruments to measure the initial energy used, but they are not always to be found in the different stations

(*a*) When the amount of current flowing through the primary circuit seems to be about right the interruptor is adjusted; if it is of the vibrating spring type, the adjusting screw should be turned so that it will start easily and quickly when the key is depressed, closing the circuit, and a partial turn one way or the other will often reduce the sparking between the platinum contact-points to a minimum without appreciably affecting its starting action.

(*b*) Where a mercury turbine interruptor is used the adjustments are limited to increasing its speed of rotation and varying the length of its segment. Where a potential

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of 110 volts is the initial pressure the shortest segment furnished with the device, which is a quarter of a circle in length, should be used; if the current is taken at 60 or 65 volts, then the longest segment, which has a length of half a circle, is best adapted. The speed of the turbine is important, and as this depends on the motor, see Fig. 49, the latter is regulated by a small rheostat. The speed of the turbine should be run up until a white spark is produced, when it will emit a continuous sound, and the ear soon becomes trained to know that this is the proper kind for good working. The current can now be further increased until the ammeter shows that 8 to 10 amperes are flowing through the primary of the coil.

(*c*) An electrolytic interruptor requires practically only one adjustment, and that is to raise or lower the platinum anode, though the electromotive force may be varied with excellent results; a potential of at least 40 volts is required to operate it properly. Nearly all electrolytic interruptors are provided with a cooling-worm, and the operator should see that there is a stream of water flowing through it; otherwise the electrolyte will become heated, and this diminishes the rate of interruption, and, if permitted to continue, will cause it to stop altogether.

(*d*) The contacts of the Morse key soon become roughened by the heating action of the sparks on breaking contact, and must be looked after; when their opposed surfaces become uneven they should be put into condition with a file. This also applies to the platinum contacts of the vibrating spring interruptor.

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(*e*) Where an adjustable condenser is shunted around the break of the interruptor a much more satisfactory spark can be obtained across the discharge-gap than with a condenser having a fixed value; a lever is so arranged that any value may be had from zero up to its full capacity, though of course this is obtained by steps.

Adjusting the Spark-gap.—Since, in a simple open-circuit oscillator, the aerial wire and the earthed terminal are fixed to opposite sides of the spark-gap, there is nothing to adjust but the length of the spark. The spark-gap should be cut down when sending messages to about $\frac{1}{20}$ to $\frac{1}{5}$ of the longest sparks the coil is capable of giving; if too long a spark-gap is used, the resistance offered to the released charge is so great that the current may not oscillate, but will simply pass through the system in one direction. But when the spark-length has been cut down the operator must see that the necessary amount of resistance is in the primary circuit; for, should it be worked with an overload, the coil may be injured, due to static strains set up within it.

To Tune a Compound Circuit Transmitter.—The following method of tuning applies to the tuning of either close- or loose-coupled oscillation circuits. The primary circuits are adjusted as described in the preceding paragraphs, and it now becomes necessary to tune the closed circuit to the open circuit. The hot-wire ammeter is provided with several shunts, and the shortest of these should be placed in the instrument, in accordance with the instructions accompanying it; it is then ready to be

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connected in circuit with the aerial wire, as shown in Fig. 75. The contact-plugs or spring-clips should be placed together on the middle turns of the inductance coil and their positions varied, not relatively, but they should be

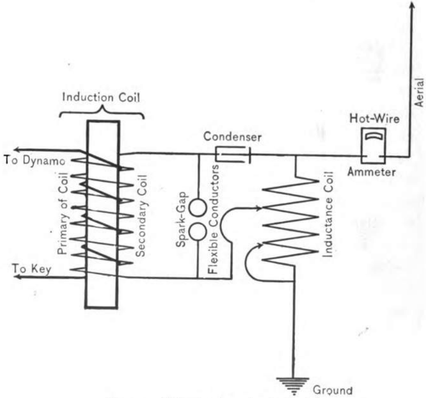

FIG. 75.—Hot-wire Ammeter in Aerial.

moved together until a point is found where the reading of the ammeter is the highest; to ascertain this the primary circuit must be closed by the key for a sufficient length of time to permit the needle of the ammeter to come to rest.

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Having gotten the best results in this manner, a longer shunt may now be inserted in the ammeter and the upper contact-plug or clip moved gradually away from the lower contact, when a position will soon be reached where the reading of the ammeter will give a still higher value, showing that now the open-circuit aerial-wire system and the closed oscillation-circuit are more or less accurately tuned to the same periods. If the interruptor is of the mercury-turbine or electrolytic type, it may be further adjusted and a greater amount of energy can be used; then the upper plug or clip may again be adjusted until the reading is maximum, when the circuits may be said to be fairly well tuned. As the hot-wire ammeter is not a very accurate instrument, several readings should be taken to determine the value of the current energy of the oscillations surging in the aerial wire, and the mean reading taken as standard.

To Adjust the Aerial-wire System to Emit a Given Wave-length.—The best results are obtained in wireless telegraphy when the transmitter and receptor are tuned to the same wave-length; when they are thus tuned so that they will be co-resonant they are said to be *syntonized.* Where only two stations are engaged in communication the receiver can be tuned to the same period of oscillation as the sender, as will be described presently; but when a receptor is to receive messages from two or more transmitters, it then becomes necessary to tune each of the latter to emit waves of a length suitable for the receptor.

It has been previously stated that a plain aerial wire

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system, that is, one in which there is neither induction coil nor condenser inserted, will emit a wave approximately four times its length, and therefore where two or more sending stations are to be used in connection with one or more receiving stations the aerial wires of the former should be practically the same length. While it is comparatively easy at shore stations to have the aerial wire of the same length, on board ship the conditions met with are very different; yet, as, for instance, in the Navy and the mercantile marine service, it is essential that all stations, both on ship and shore, should use the same wave-length.

(*a*) This is accomplished in the following manner: First, a wave-length should be selected that is equal to or a little longer than that emitted by the longest of the aerial wires used. A tuning-device, of which one form is shown in perspective in Fig. 36 and diagramatically in Fig. 76, is called into action. This device comprises an adjustable spark-gap formed of needle-points, a condenser of small capacity, and a portable tuning-coil of the same relative proportions as the tuning-coil used in the receiver, namely, each turn of wire represents a length of one meter. The length of each turn of wire is really only 90 centimeters, but by adding the increased value given by the inductance each turn will increase the length of the wave emitted by the aerial 4 meters; as each tuning-coil has 100 turns of wire, any wave-length from that produced by the plain aerial wire up to 400 meters, when all the inductance is thrown in, may be had at will.

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In the Navy the ships are equipped with aerials having a length, where possible, of 50 meters, and the wave is of course about four times this length, or 200 meters; the inductance and capacity of this open circuit are equal approximately to those of a closed circuit containing seven 1-gallon Leyden jars and one turn of inductance. To tune

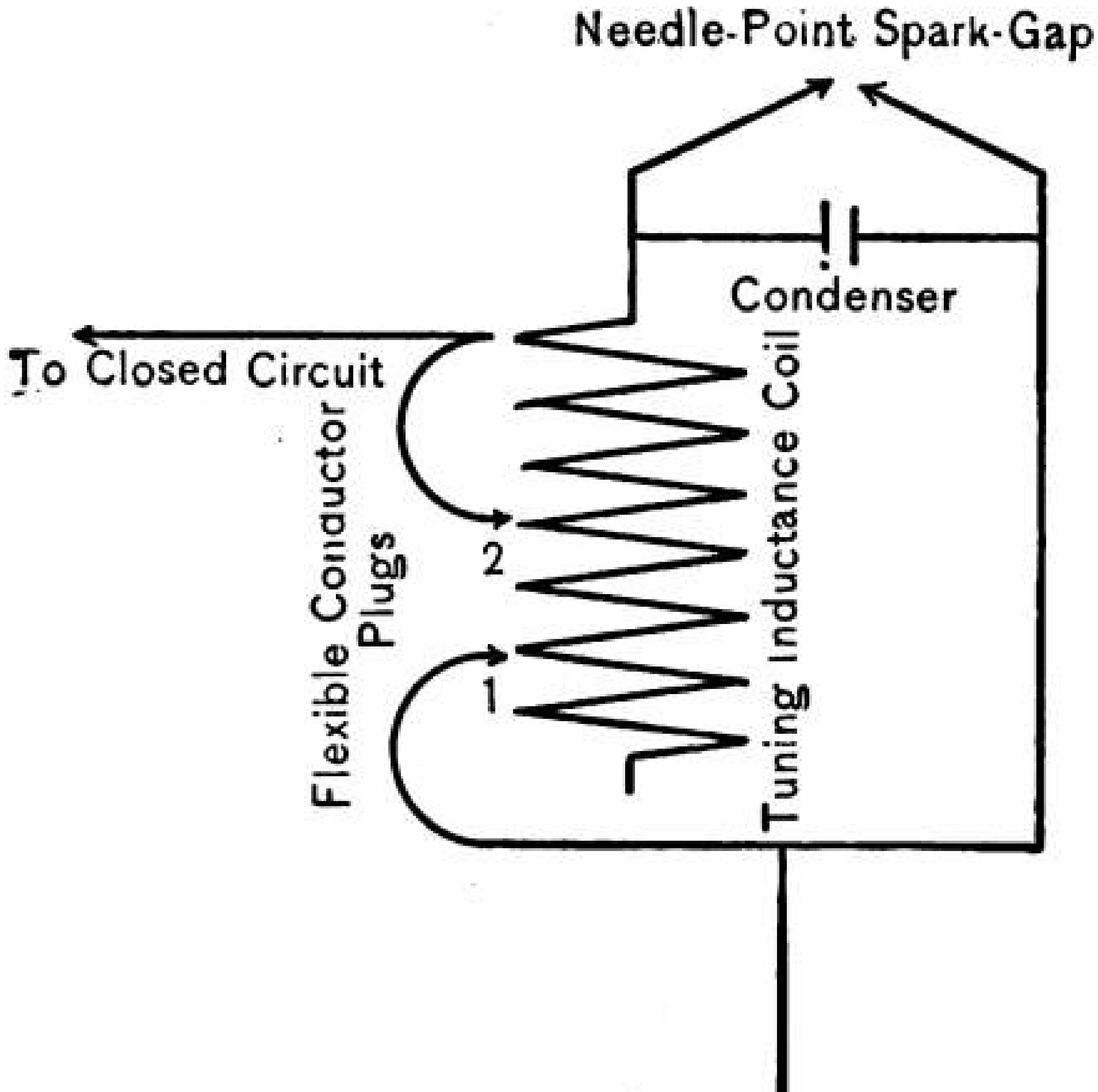

FIG. 76.—Tuning Device.

an aerial that is less than 50 meters in length so that it will emit a wave of 200 meters, the tuning-device shown diagrammatically in Fig. 77 is connected to the closed circuit formed of the Leyden-jar battery, the spark-gap, and the inductance coil, all of which are included in the cross-sectional drawing in the same figure. The sliding contacts 1 and 2 on the coil of the tuning-device are

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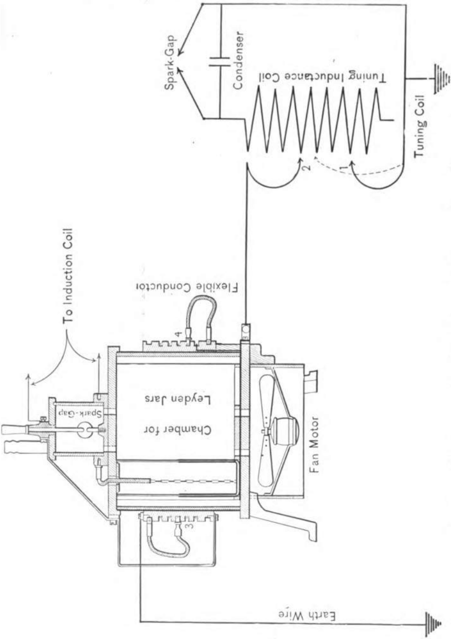

FIG. 77.—Adjusting the Aerial-wire System to Emit a Given Wavelength.

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brought closely together, as shown in the dotted line, and set at a point equal to about one-fourth of the wave-length it is desired to use.

The plugs or clips 3 and 4 of the large sending inductance coil are also brought together on the middle turn; the terminals of the sending spark-gap, on top of the Leyden-jar battery or wherever it may be placed, are now brought very closely together but without making contact, and the aerial wire disconnected. All the resistance in the primary circuit should be thrown in and the induction coil set into operation; the transmitting key is pressed into contact and the resistance gradually cut out until a good spark is produced in the regular spark-gap. The small needle-point spark-gap of the tuning-device is opened to about 2 centimeters, and the plug-contacts 3 and 4 of the sending inductance coil are adjusted until a spark is produced in the needle-point spark-gap; continue to increase the length of this spark-gap and to change the position of the plugs on the sending inductance until the longest spark obtainable between the needle-points is produced. When the position of the plugs 3 and 4 on the sending inductance coil gives the greatest potential between the terminals of the tuning inductance coil, shown by the longest sparks between the needle-points, then the closed circuit of the transmitter is adjusted to the required wave-length.

(*b*) This done, it is now necessary to adjust the aerial wire to the closed circuit; the tuning-coil device may now be disconnected from the closed circuit and the aerial

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wire connected to the end of the sending inductance coil, as shown in the wiring diagrams for close coupled oscillators, see Fig. 51. The hot-wire ammeter is now connected in series with the aerial wire, as described in this chapter under the caption *To Tune a Compound-circuit Transmitter*, and shown in Fig 75. The terminals of the spark-gap are drawn apart until a gap of 0.5 centimeter in length is formed, and, after switching on the current, the resistance offered by the rheostat should be cut out until a heavy discharge is produced. Closing the primary circuit by means of the key, the plug 4 is moved away from 3 toward the bottom of the inductance coil, until the hot-wire ammeter shows the highest reading. When this point is obtained the aerial wire will then be in tune with the closed circuit, and the wave emitted by the aerial wire will have the length previously decided upon. The necessity of determining with precision the positions of the plugs or clips on the sending inductance coil cannot be too strongly impressed upon the operator, for on the nicety with which this is done depend the harmonious relations between the open and closed oscillation circuits, and once that these adjustments have been made, the operator should never change them unless a new wave-length has been chosen, when the tuning process must be done all over again.

To Tune the Receiving Circuits.—As we have seen above, the transmitter is syntonized to the receptor, instead of the latter to the former; for this reason all that is needed by way of adjustment is to tune the closed to

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the open circuit of the resonator or receiving circuits. In the tuning device there is a small condenser which has a capacity about equal to that of an ordinary coherer, although these vary to some extent. If now the sending aerial is syntonized accurately to the receiving aerial-wire system, then the latter will require little adjustment other than to slide the contact-points 1 and 2 of the receptor tuning-coil (Fig 27) to a point indicating the wave-length selected on the graduated scale. As contact 2 is immediately above 1, the inductance value of the few turns from 1 to 2 is the same, or should be, as that portion of the earthed terminal of the sending circuit.

The varying capacities of different coherers render it almost impossible to syntonize the transmitter and receptor with absolute accuracy, and the best way to test out their co-resonant qualities is by the empirical method of experiment. This consists of having some sending station using the requisite wave-length to assist in trying it out. To make the test the sending station should be located about a quarter of its normal signalling distance away from the receiving-station, or, say, 30 miles at the shortest, or 40 miles at the longest range. A certain test letter is chosen, for instance, the letter S, represented by three dots; the operator at the sending-station sends this letter over and over with a few minutes intervening between each transmission, so that the receiving operator will have ample opportunity to adjust the tuning coil; after the test letter has been sent several times the operator at the transmitting station should cut down the initial

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current until the intensity of the spark is only half of that ordinarily used in transmission; by careful tuning the operator at the receiving station will secure a nice degree of resonance, and when the sending operator cuts out the resistance in the primary circuit the messages will come in loud and clear.

Adjustment of the Receiving Instruments.—The oscillator and the resonator circuits of the sending and receiving stations having been properly tuned and syntonized, the receiving instruments must be adjusted. If these include a coherer, relay, tapper, and Morse register, considerable care must be exercised to keep them all in working order, but where an auto-detector, like that of the electrolytic or magnetic type, is used, these are greatly simplified.

(*a*) *The Coherer.*—This is adjusted before it leaves the hands of the makers, but if the conductor-plugs are bevelled, forming a V-shaped pocket for the filings, the operator is enabled to increase or decrease its sensitiveness within certain limitations, these changes being made by merely turning the coherer partially around on its longitudinal axis.

(*b*) *The Relay.*—The principal adjustment of the internal circuit containing the coherer, dry cell, and relay is made by means of a large milled screw projecting from the case of the relay. By turning this screw the position of the armature between the poles of the magnet is varied, and in this way a very sensitive adjustment can be had and one in which the feeblest current

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flowing through the coherer will affect. The relay should be tested frequently, once a day at least, and this may be done in one of two ways; namely, (1) by placing it in series with a resistance of 20,000 to 40,000 ohms, or so, with a single dry cell, when, if it is in good working order, it should readily respond; and (2) by grasping the binding-posts of the relay magnet-coils and permitting the current to flow through the body, when, if it is adjusted to its maximum sensitiveness, it should likewise operate. Its sensitiveness must, however, be just below that point at which its armature vibrates or chatters when the circuit is broken.

(*c*) *The Tapper.*—This must be adjusted so that it taps the coherer a sharp quick blow. Some tappers have three adjusting-screws: (1) the screw moving the coherer to and from the hammer; (2) the screw for moving the poles of the magnet to and from the armature; and (3) the screw carrying the stationary point that makes and breaks the circuit formed between it and a spring attached to the armature. The tapper will not need to be adjusted often, and a little practical experience will make this easy.

(*d*) *The Morse Register.* — The adjustments of the register are the most numerous and complicated, in virtue of the fact that it is actuated electrically and operated mechanically. Like all other parts of the sending and receiving apparatus, there are slight differences in the design of registers, but the usual type is provided with these adjustments: (1) a screw on the upper end of the

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lever to which the armature is attached; this is to limit the distance to which the armature can be drawn away from the poles of the magnet; (2) a screw at the opposite end of the same lever to limit the approach of the armature to the poles of the magnet; this screw, when the armature is attracted by the magnet, strikes a pin projecting outside the brass case, which in turn releases the mechanism of the spring motor which feeds the tape; (3) a screw for adjusting the tension of the spring that controls the upward pull of the armature, and this also regulates the pressure with which the paper tape is brought to bear against the revolving inked disk; (4) a small weight that slides on a rod for governing the speed of the motor through an escapement, so that the normal speed with which the paper travels may be varied; (5) a screw for adjusting the pressure exerted on the paper fed by a toothed wheel, through a smooth wheel above it; and (6) a screw for adjusting the length of the paper that shall run out after the electrical mechanism has ceased to act.

Should the register fail in any of its operations, some one of the following troubles may account for it: (1) The current of the dry battery may be two weak to pull down the armature, and this may be due to the latter having too much play, hence the screw in the upper end of the lever should be adjusted so that the armature has a very limited movement. (2) If the armature strikes after it is drawn down by the action of the magnet, then the screw in the lower end of the armature lever requires

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adjusting, so that the latter just clears the surfaces of the poles of the magnet. (3) Not only may the battery be weak or the armature too far removed from the magnet, but the spiral spring whose tension controls the free movement of the armature may be too great and should be slackened; these comprise the adjustments for the electrical portion of the register. (4) If the escapement and small weight that governs its movements will not act, it is due probably to the sticking of the releasing mechanism. The cover of the register case must be removed and an examination of the former will no doubt reveal the cause; it may be due to dust having accumulated therein, or the adjusting-screw on the lower end of the armature lever which strikes it may be in or out too far. (5) If the armature, releasing mechanism, and motor work all right, but the tape does not travel as it should, then look to the spring controlling the pressure of the feeding wheels: this should not be too weak nor yet again too strong. (6) The screw for adjusting the margin of the paper may be screwed in or out so far as to cause it to strike. The author has seen beginners work over these adjustments without success, only to find that a screw had been turned to the right or left so far that it seemed to him who made the attempt that no amount of adjusting could get it back into its normal position. There is a happy middle road in making adjustments, and the operator must see that he keeps to it. Then, even if the adjustments have been correctly made, there is the possibility that too much friction is being exerted on some

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of the spindles, and when every other means has failed the register must be taken apart, cleaned, oiled, and set up anew.

Testing the Receptor.—Finally, the coherer, relay, tapper, and battery must be adjusted so that they will work in unison, and if the preceding instructions are carried out, a little patience and practice, both of which are absolutely essential to the making of a capable operator, will result in an efficiently acting apparatus. When each of the instruments has been adjusted the coherer and relay circuit should be closed and then the devices tested out collectively. This may be done by holding the buzzer or testing-box a foot or two away from the coherer and pressing the button; if the relay is properly adjusted, the waves sent out by the buzzer will act upon the coherer, and the other appliances will respond. If the instruments do not respond, the relay should be readjusted until these do.

Adjustment of an Electrolytic Detector Receptor.—Where an electrolytic detector and a telephone receiver are employed as a receptor all the complicated adjustments of the coherer and Morse register are wiped out. A variable resistance is inserted in the internal circuit containing the detector and receiver, and half of the resistance should be thrown into the circuit; then the fine platinum wire point which dips in the electrolyte is adjusted by means of a fine screw, until the oscillations set up in the aerial by the incoming waves produces the loudest sound in the telephone receiver. Then by vary-

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ing the resistance in the circuit a point will soon be reached where the intensity of the sounds are maximum, when it is ready to receive.

Adjustment of a Magnetic Detector Receptor.—This is by far the simplest receptor as far as adjustment is concerned, and fortunate is the operator whose lot it is to be in charge of a station where it is used. After the magnets are placed and the speed of the flexible band of iron wire is regulated it is in working order.

Learning the Alphabetic Codes.—As in ordinary telegraphy, wireless messages are sent and received in alphabetic code, that is, in dots and dashes. There are three different dot-and-dash codes used, namely, the Morse, the Continental, and the Navy Signal. The two latter codes are used in preference to the Morse, since the latter has spaces as well as dots and dashes to represent the letters. To learn to send and receive in code the beginner should procure a telegraph key and connect it in series with a buzzer and one or two dry cells, as shown in Fig. 78. A high speed is not necessary in sending wireless messages, but accuracy is of the greatest importance. To insure a readable message care must be taken to make the dots and dashes of even length, equally spaced, and clear-cut; the key must be firmly pressed down, held in contact the required length of time and then released. A speed of twelve words per minute is rapid enough for a system using a coherer and Morse register, and when this can be accomplished without effort the manual part of the beginner's work is done, and then he can readily

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get up to a speed of sending thirty or thirty-five words per minute, which is required in systems using auto-detectors and telephone receivers. Practice is the great teacher, and practice alone will insure the proper style of sending.

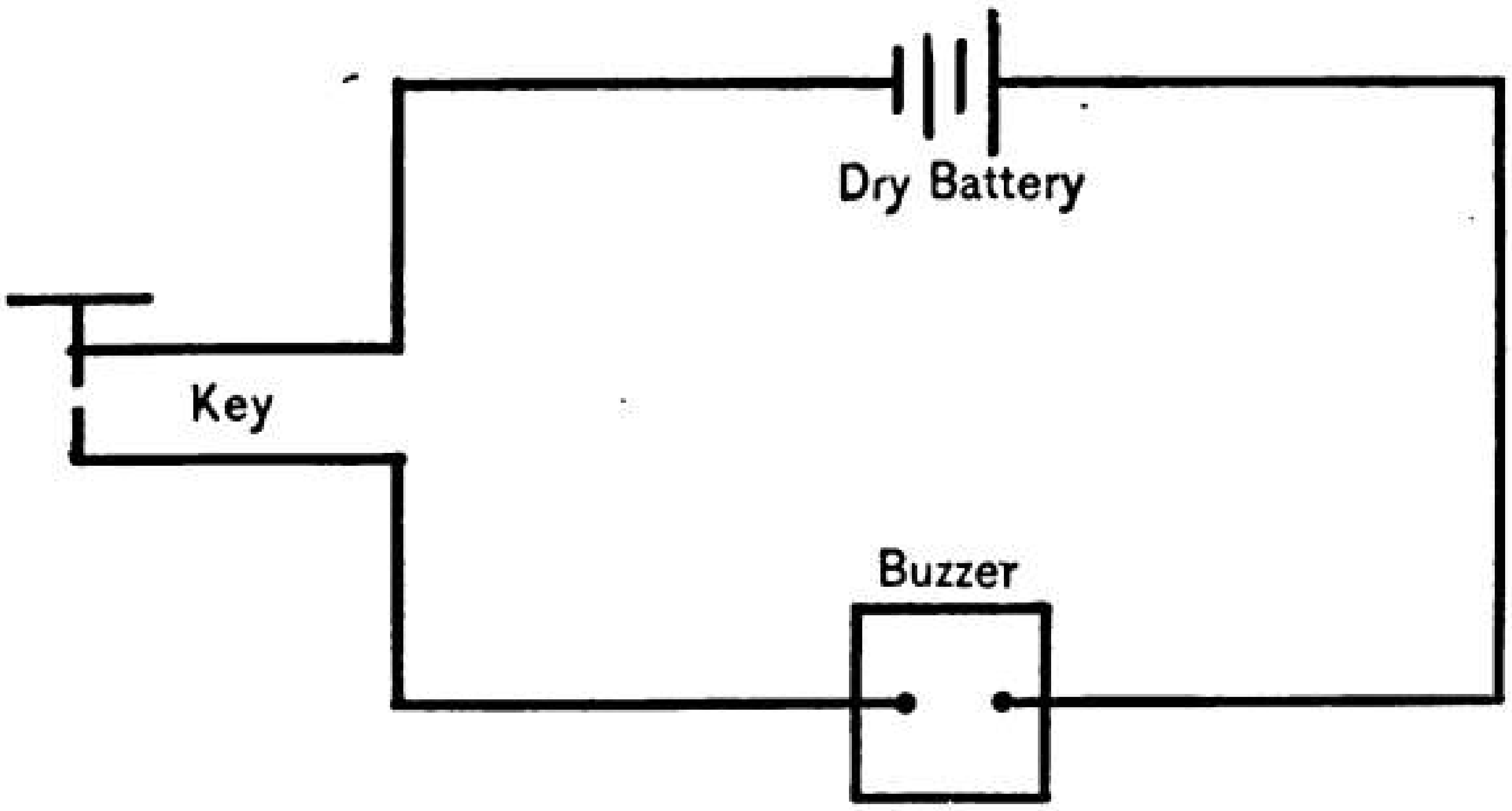

FIG. 78.—Learner's Set.

Wireless Telegraph Codes. — The three different telegraphic codes are given on pages 156, 157 and 159, but it is best for the beginner to learn to send in one of these first—preferably the Continental, because it is the most widely used—before attempting the others.

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CHAPTER IX

DIFFERENT MAKES OF EQUIPMENT

Various Systems.—After the first practical system of wireless telegraphy was put into operation in 1896 by Marconi, inventors and scientists in almost every civilized country became imbued with the spirit of the new work and bended their efforts toward improving the apparatus so that the distance of transmission could be extended, that greater accuracy in working could be effected, that the speed of reception could be increased, and finally that a means for obtaining selectivity might be found. These efforts led to many different designs of equipments, though all used the same fundamental principles as the one originally devised; hence the number of different so-called systems.

The principal improvements that have been made during the past decade are those relating to the use of coupled open and closed oscillation circuits, and the employment of auto-detectors in combination with telephone receivers instead of the more complicated coherer and Morse register receptors. The systems that concern the operator are those now in use in the United States,

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and at present these are: (1) the Marconi, (2) the Telefunken, (3) the Fessenden, (4) the De Forest, (5) the Clark, and (6) the Massie. In England there are two systems in extensive use, namely, the Marconi and the

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 ··· ·	& · ···	
1 ·——·	2 ··—··	3 ···—·	4 ····—	PERIOD ··——··	INTERROGATION —··—·	
5 ———	6 ······	7 ——··	8 —····	COMMA ·—·—	EXCLAMATION ———·	
9 —··—	0 ——			COLON —·—··	SEMICOLON ·····	

FIG. 79.—Morse Alphabetic Code.

Lodge-Muirhead; in France, the Branly-Popp, the Rochefort, and the Tissot; in Russia, the Popoff; in Spain, the Cervera-Baveria; while each of the countries cited has a number of lesser known systems; the details of these are not described, for the reason that the average operator in this country would probably never have occa-

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sion to work them, and even if he should, a knowledge of the various arrangements herein described would enable him to adjust and operate them without a great deal of trouble. The origin and rise of the system he is using makes not only interesting reading, but the operator

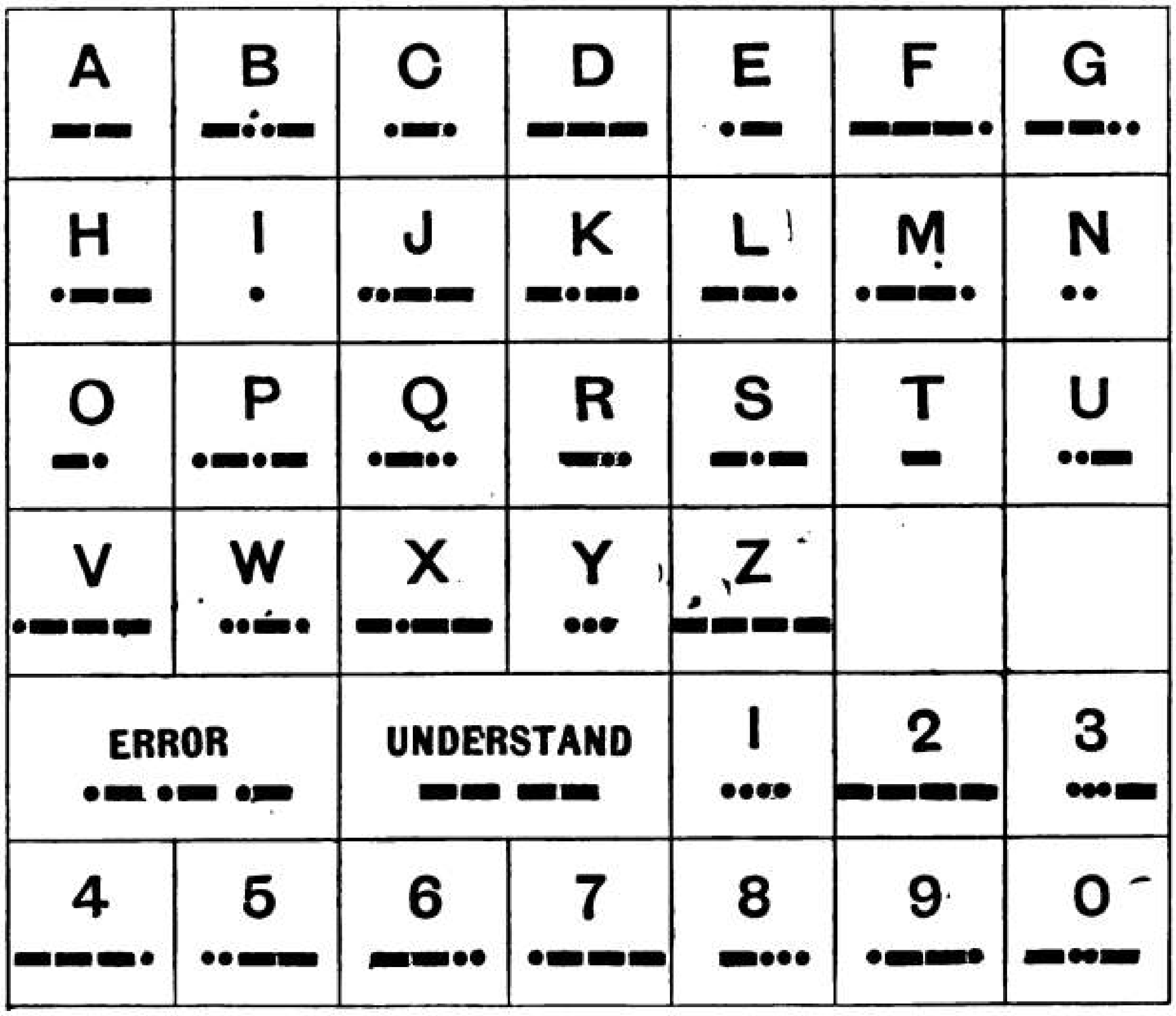

FIG. 80.—Navy Wireless Telegraph Code.

should be generally informed concerning it, and a short description embodying the main points of each will be found under the following captions.

The Marconi System.—Wireless telegraphy is not as old as some of the works giving an historical retrospect of the art would tend to have us believe, neither did it come as a spectacular surprise, as is sometimes stated.

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As a matter of fact it rests upon a knowledge that dates back just eighteen years from the present writing. Its evolution came about in this manner: In 1888 Heinrich Hertz, a professor in Bonn University, Germany, concluded from a series of experiments he had made that the electric oscillations set up in an open circuit by means of a disruptive discharge radiated their energy through space not as static induction or magnetic lines of force, but as electric waves that travelled at the speed of light. These classic experiments created a profound impression in scientific circles, and were being repeated by professors of physics in different European colleges for the benefit of interested students. It was thus that William Marconi witnessed the production of Hertzian waves in the lecture-room of the Bologna University, Italy, presumably some time in 1894. The young man—he was then only twenty years old—conceived the idea of employing the waves for signalling without wires, and his first attempts in this direction were made shortly thereafter, or in 1895. Having been successful in these primal attempts, he went to England in May, and in June, 1896, he applied for a patent.

The first experiments the young inventor made after arriving in London were for the authorities of the British Post-office, when he telegraphed without the aid of wires with the new devices between the General Post-office and the Thames Embankment, a distance of 300 feet. Demonstrations on a larger scale were now in order, and these were conducted for the benefit of the War Office and the

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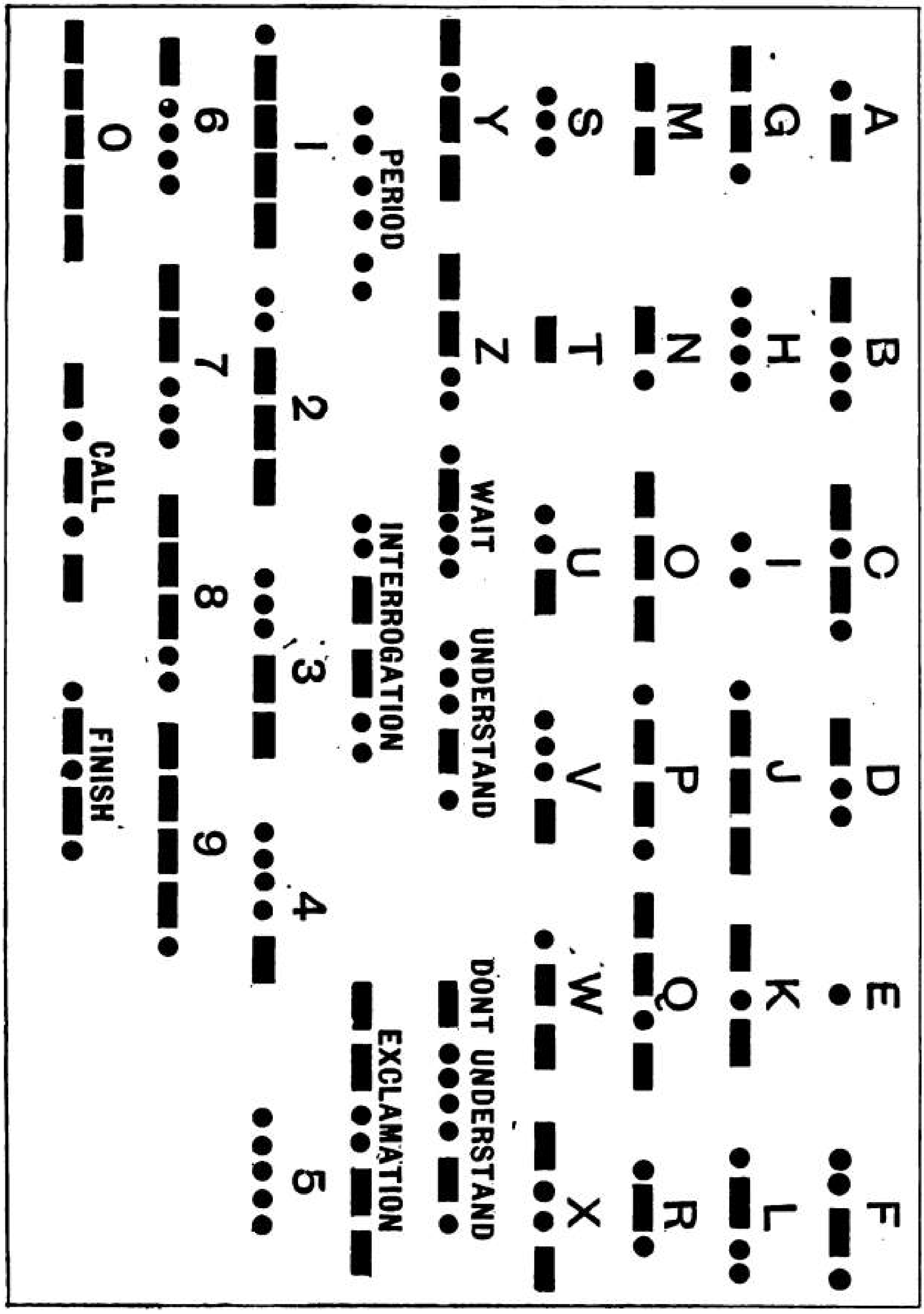

FIG. 81.—Continental Wireless Telegraph Code.

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Admiralty, the place selected being over Salisbury Plain, across a distance of about two miles. The aerial-wire system was not used in these primitive tests, but the waves were reflected by large parabolic mirrors. The result of the tests were satisfactory, but it was not until the following year that the mirrors were dispensed with and the aerial wires and earthed terminals were substituted in their stead when messages were transmitted between Lavernock and Flat Holm, a distance of about three miles, with aeriel wires at the transmitting and receiving ends approximating 150 feet in height. This was the real beginning of the wireless telegraph in its commercial form. In the same year the distance was increased to eight miles, when messages were transmitted between Lavernock and Brean Down, the aeriels being sustained in the air by means of kites.

It was during these latter trials that Dr. Adolph Slaby of Germany was present, an event that was to have an important bearing on the wireless situation a few years later, for on returning to Germany he immediately set to work and evolved a 'new system,' as we shall see presently. From the results achieved on this memorable occasion the Marconi system could no longer be considered an experiment but a commercial fact. The inventor next visited his native land, and at Spezia, Italy, where a shore station was established and two Italian battle-ships had been placed at his disposal, he proved conclusively that his system was effective over a distance of twelve miles.

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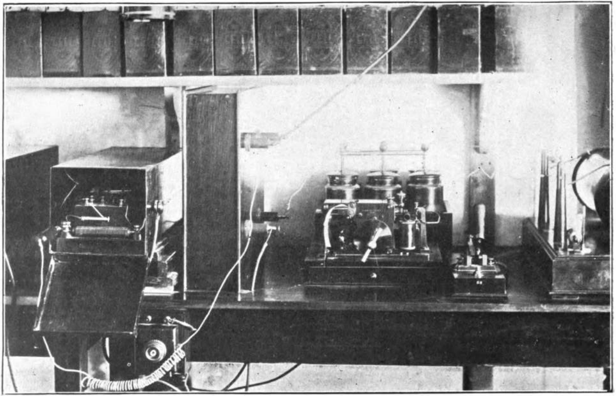

FIG 82.—Interior of a Marconi Station.

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It was at this important period of development that the Wireless Telegraph and Signal Company, Limited, was formed in London and incorporated in July 1897, with a capital of £100,000; later the capital was increased to £300,000 and the name changed to Marconi's Wireless Telegraphy Company, Limited. The new company erected two stations 14 miles apart, one at Bournemouth and the other at Alum Bay, Isle of Wight, and here a long series of tests were made during all weathers and seasons of the year. It was while these trials were in progress that the distance was increased to 18 miles, when messages were exchanged with an outgoing steamer. Lloyd's Corporation, in May 1898, now became interested in the new method of transmission and had equipments installed at Ballycastle and Rathlin Island in the north of Ireland. The system was next used to report the Kingston Regatta for the *Daily Express* of Dublin, and more than 700 messages were sent between the ship that carried the apparatus and the shore station; then, a month later, the apparatus was used for the benefit and behoof of royalty; it was installed in the royal residence at Osborne and on the royal yacht *Osborne*, where the Prince of Wales, now King Edward, was on board suffering from a serious accident, and here again communication was successfully maintained.

To demonstrate the value of the new telegraphy more thoroughly than it had yet been, the Marconi Company, in December 1898, installed instruments at the South Foreland Lighthouse and the East Goodwin Lightship,

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which lay to some 12 miles away. Its usefulness was conclusively proven when a steamer that had stranded on the Goodwin Shoals was saved a loss of over £50,000 due to a single short wireless message. This was only one of the numerous incidents where it served to save not only property, but lives as well.

The achievement that astounded the world came shortly afterward, taking place on March 27, 1899, when Marconi successfully communicated between Dover on the British side of the English Channel and Wimereaux on the French side, a distance of 30 miles. The first application of wireless telegraphy to the Navy was made during the British Naval Manœuvres in 1899. Three cruisers were equipped with the necessary apparatus, and a record distance of 85 miles was covered, when one of the ships received her orders from the flagship of the fleet at that distance. Immediately after followed the introduction of wireless telegraphy in America, when Marconi superintended the reporting of the International Yacht Races at New York, where in less than five hours more than four thousand words were despatched between the ship carrying the apparatus and the shore station, from whence the messages were transmitted over line wires to the *New York Herald.*

Notwithstanding the continued success of the system, it was 1901 before any serious effort was put forth to establish it commercially, and it was then decided by the Marconi Company not to sell the instruments outright, but to lease them. Stations were set up along the

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FIG. 83.—Marconi Magnetic Detector.

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Atlantic seaboard both in America and in England, and these formed a comprehensive system of shore stations commanding the most important shipping routes. Through a deal with Lloyd's the Marconi Company secured a contract in which the former are bound not to use any other system for a period of fourteen years, and not to communicate with ships equipped with any other apparatus than the Marconi. Thus an agreement was reached that has effectually prevented any other company from competing in the wireless transmission of messages between ships and shore stations of the trans-Atlantic fleet.

At the present time the ordinary ship and shore stations of the Marconi Company employ induction coils giving a spark of 10 or 12 inches; these are fitted with vibrating-spring interruptors operated by the core of the coil, and a key with large contact-points having a condenser shunted around them. The oscillation system of the transmitter has long since been changed from a simple open circuit to a compound loose-coupled circuit, though occasionally a close-coupled system is used. The inductance coil and high-potential transformer are mounted distinct from the Leyden-jar battery, which is made up of a dozen ½-gallon jars. Both the old and the new style receptors are installed in each station, that is, the coherer and Morse-register receptor and the magnetic detector and telephone receiver apparatus, either of which may be used as desired. In either case the aerial wire is connected to the detectors through a closed circuit by a high-frequency transformer or jigger. An adjustable induct-

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ance coil and variable condenser having sliding contacts permits the receiver to be tuned. The coherer and Morse register receptor, though installed, is seldom used now, for the magnetic detector receptor, owing to its extreme simplicity, its accuracy, and its speed, has virtually replaced the other and more complicated one.

The Telefunken System.—In the preceding historical retrospect it was mentioned that certain experiments in the very beginning of Marconi's success were witnessed by Dr. Adolph Slaby, a professor at that time in the Technical High School in Berlin. Mr. Fahie, in his admirable work *A History of Wireless Telegraphy*, gives some valuable points bearing on the origin of what is now known as the Telefunken system. He says that on Slaby's return to Germany after witnessing Marconi's experiments in England, the former, in September, 1897, engaged in some very instructive experiments in the vicinity of Potsdam, first between the Matrosenstation and the church at Sacrow, 1.6 kilometers, and then between the former place and the castle at Pfaueninsel, 3.1 kilometers. Other experiments followed at which the Emperor of Germany was present and who, being impressed with what he had seen, put a number of sailors and the large royal gardens at Potsdam at his disposal. The experiments which followed took place at the Naval Station, where the receiver was located, and Peacock Island, where the transmitter was set up. Continuing his researches, he proceeded early in October to make some tests over an open stretch of country free from all inter-

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vening obstacles, between Rangsdorp (sending station) and Schönerberg (receiving station), a distance of 21 kilometers; the aerials used were made of double telephone wires, and these were raised by captive balloons to a height of 300 meters. It is reported that under these conditions the communications were always clear and accurate.

Dr. Slaby now colloborated with Count Georg Arco, and in the next two years they had built up a system using a close-coupled oscillator and resonator which they described shortly after Marconi made known his compound system, or, to be more exact, in 1900. Their apparatus took on a definite form, in which the inductance coil was wound around the case containing the Leyden jars, and a mercury-turbine interruptor was substituted for the vibrating-spring interruptor. This system was adopted by the German Navy, and was exploited by the Allgemeine Electricitäts-Gesellschaft (General Electric Company) of Berlin.

About this time Prof. Ferdinand Braun of the University of Strassburg, Germany, brought out a tuned system in which the open and closed circuits were loosely coupled through the medium of a high-potential transformer, and this gave rise to another system; Prof. Braun's arrangement was taken over by the Siemens and Halske Company of Berlin, and equipments were installed in many places throughout Germany.

The patents of the Slaby-Arco people and the Braun interests seemed to conflict, and in 1903 the feeling became

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so intense that a test of the merits of each faction was aired in the German courts. After this unprofitable procedure it was deemed advisable to amalgamate the companies, and so the Slaby-Arco and the Braun-Siemens and Halske systems were taken over by the Gesellschaft für Drahtlose Telegraphie (Wireless Telegraph Company) of Berlin, and the equipment designated by a name that Dr. Slaby had always favored, that is, "spark-telegraphy," or, as it is called in German, the Telefunken system. This make of apparatus is sold outright, and the Bureau of Equipment of the United States Navy has purchased a large number of sets. The instruments this company are sending out are beautifully finished, but are more complicated than those of any of the other systems now in use in the United States, for the reason, as a reference to the wiring diagrams will show, that the transmitter is furnished with a mercury-turbine interruptor, a motor for its operation, and a magnetic blowout for the key, while the receiver still retains the earliest form, having the coherer, relay, tapper, and the Morse register. The latter arrangement, slow as it is in operation, is preferred by the naval authorities to a receptor using an auto-detector and telephone receiver, for the former records the messages on a tape and therefore leaves no possibility for error on the part of the receiving operator.

The Fessenden System.—This system is the result of a long series of experiments begun by Prof. Reginald Fessenden of Pittsburgh in 1899, and is controlled by the National Signalling Company of Washington, D. C.

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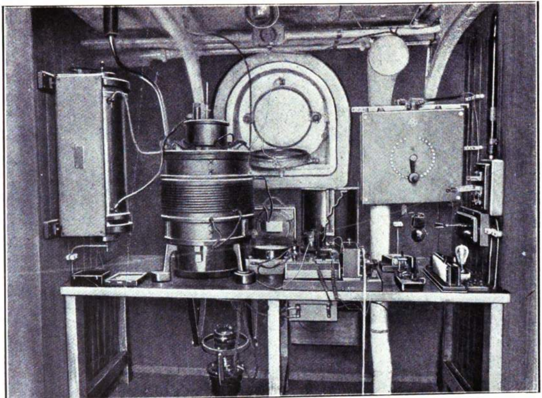

FIG. 84.—Interior of a Telefunken Station.

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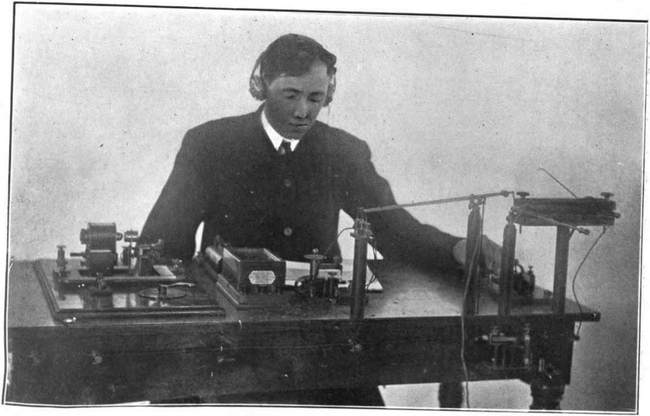

Fig. 85.—Interior of a Fessenden Station.

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FIG. 86.—Interior of a De Forest Station.

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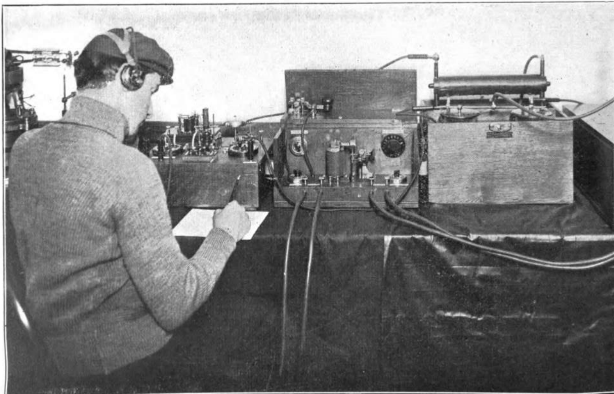

Fig. 87.—Clark Portable Army Set.

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The chief difference between this and the systems described lies in the use of the electrolytic detector and telephone receiver in the receptor. It is the result of five years' experimental work, including a year's test under actual working conditions at Fortress Monroe, Virginia; this was followed by exacting tests between Fessenden's New York and Philadelphia stations, where the distance overland is 90 miles and the height of the aerials 90 feet. Experiments are now being conducted between stations located on either side of the Atlantic Ocean, looking toward the establishment of a cableless system of wireless telegraphy between the United States and the British Isles.

The De Forest System.—Like the preceding, this system is also of American design and is due to Dr. Lee De Forest of Chicago, Ill. It is at present promoted by the American De Forest Wireless Telegraph Company of New York City. The transmitter of the De Forest system employs a primary alternating current instead of a direct current, and a transformer instead of an induction coil. In the receptor a modified form of the electrolytic detector is used. The De Forest Company have a number of stations along the Atlantic seaboard and distributed throughout the Eastern States for communication between cities.

The Clark Portable System.—This is the portable system described in previous chapters. It was designed by Mr. Thomas E. Clark and is manufactured by the Clark Engineering Company of Detroit, Michigan. Many sets have been purchased by the Signal Corps of the United States Army, and it is used to some extent in the United States Navy.

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CHAPTER X

SUGGESTIONS TO OPERATORS

General Information.—The Marconi system is operated in conjunction with the Western Union and Postal Telegraph Companies in the United States, with the Postal Telegraph Offices in Great Britain, and with the Inland Telegraph and International Cables throughout the world. Operators on board ship can therefore accept telegrams from passengers for transmission to any part of the world. Through rates to all points are furnished by the company to the pursers and operators of the ships, and are simply the usual land telegraphic rate plus the wireless or sea rate.

Telegrams from persons on shore to passengers on ships should be addressed in the following manner: (1) name of passenger, (2) name of ship, and (3) name of shore station through which it is desired to communicate, thus:

John R. Collins,
Steamship Lucania,
Sagaponack Wireless Station.

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No 1—50. 1-5-06-20M. **Sent date**........................

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA.

27 WILLIAM STREET (Lord's Court Building), NEW YORK.

No. 12/20 Siasconset STATION Sept 30 1906

Prefix S Code M Words 7

Office of Origin New York City

Service Instructions:

CHARGES TO PAY		
Marconi Charge	3	00
Other Line Charge	–	-
Delivery Charge	–	-
TOTAL	3	00

Station sent to	Time Sent	By whom sent
La	12.10 p m.	D7

READ THE CONDITIONS PRINTED ON THE BACK OF THE FORM.

To: Evelyn Collins S. S. Lucania

meet me at Holland House

on arrival

A. Frederick Collins

FIG. 88—Obverse Side of a Marconi Blank.

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Operators should despatch telegrams strictly in the order received from the public, and as the time of communication is at present naturally limited, no time must be wasted. Fig. 88 is a reproduction of the obverse side of a wireless telegram form. A receipt for the sum charged for each message is given on board ship by the purser or operator, and on shore, subject to the usual conditions exacted by the collecting office. These conditions appear on the reverse side of the telegram form Fig. 89, and the operator should have the person who sends the message sign it.

Should any telegram that is accepted by or to any of the associated companies' stations fail to reach its destination and the non-delivery is proved to be in any way due to negligence on the part of the company's employees, the amount paid will be refunded to the sender when he presents the receipt for the sum paid.

Rates for Wireless Messages.—Wireless communication is now open through the new Marconi station at Sea Gate, Long Island, and New York Harbor. Messages may be sent to outgoing or incoming steamers when they are down the Bay, or at any time when the vessels are at a point between their docks and Babylon, Long Island. The map shown in Fig. 90 indicates the location of the Marconi marine service stations on the Atlantic seaboard. Messages to outgoing and incoming steamers can also be sent *via* Babylon, L. I., when ships are about five hours from New York City; *via* Sagaponack, L. I., when eight hours from New York; *via* Siasconset, Mass.,

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MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA.

27 WILLIAM STREET (Lord's Court Building), NEW YORK.

CONDITIONS UNDER WHICH MESSAGES ARE ACCEPTED.

Neither the Marconi Wireless Telegraph Company of America nor any Telegraph Company or Government Telegraph Administration or other Company or person whatsoever concerned in the forwarding of this telegram shall be liable for any loss, injury, or damage, from non-transmission or non-delivery or neglect in relation to this telegram, or delay or error or omission in the transmission or delivery thereof, through whatever cause such non-transmission, non-delivery, neglect, delay, error, or omission shall have occurred.

The Company reserves to itself the right to refuse to transmit any message.

Having read the above conditions I request that this telegram may be forwarded according to the said conditions by which I agree to be bound.

Signature, ...

Address, ...

FIG. 89.—Reverse Side of a Marconi Blank

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when fourteen hours out; and through Sable Island, *via* Camperdown, Nova Scotia, when forty hours from New York. The rates for such messages are as follows: For ten body words, address and signature not included, $2.00 is charged plus the land-line charges *via* Sea Gate, Babylon, or Siasconset, and $4.00 and land charges *via* Sable Island.

Messages destined for all Atlantic liners routed *via* Sea Gate, Babylon, Sagaponack, or Siasconset may be filed at any office in the United States of the Postal Telegraph Cable Company or the Western Union Telegraph Company. Those routed *via* Sea Gate or Sable Island can be filed at any office of the Western Union Company, the operators at these offices having full instructions as to the sending of such messages. Long-distance telegrams may now be sent to certain ships carrying Marconi long-distance receiving apparatus throughout the whole course of the voyage across the Atlantic. The ships so equipped are the Campania, Lucania, Etruria, Umbria, Caronia, and Carmania of the Cunard Line; and the Amerika, Deutschland, Bluecher, Moltke, and Kaiserin Augusta Victoria of the Hamburg-American Line. These vessels can be reached at any time by long-distance wireless during the entire voyage in either direction. Messages for these ships must be filed at the office of the American Marconi Company, 27 William Street, or the Company's head office, 18 Finch Lane, London. Messages from points outside of New York to these vessels are sent to New York in care of the Marconi Company.

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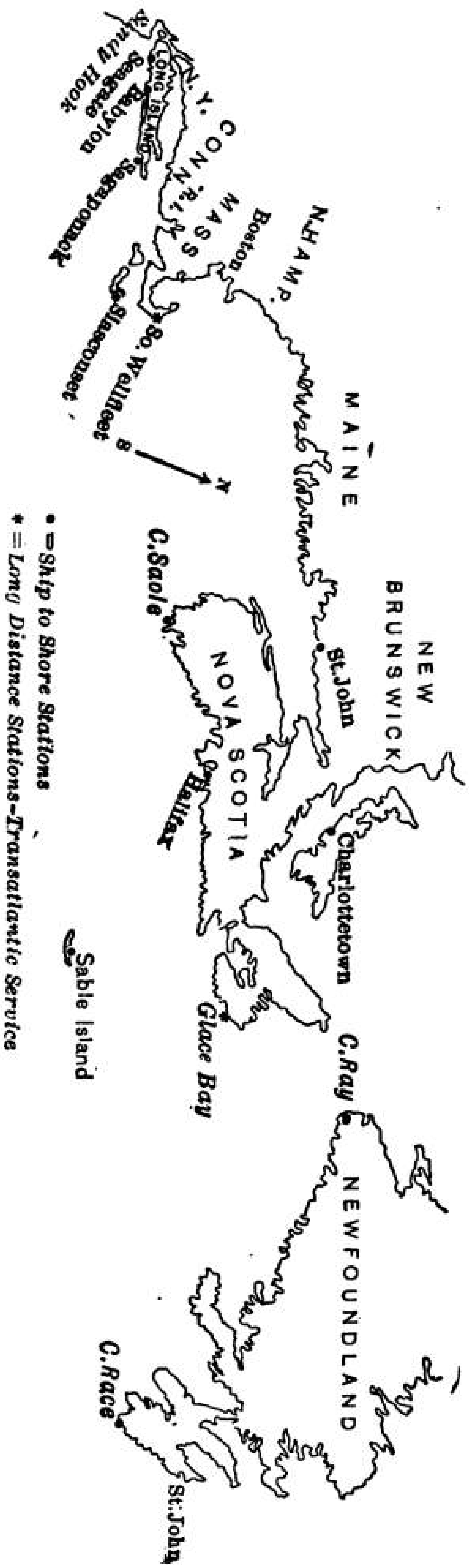

FIG. 90.—Outline Map showing Location of Marconi Marine Service Stations.

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List of Stations Equipped with Marconi Apparatus

IN THE UNITED STATES

Sea Gate, Long Island.	Siasconset, Mass.
Babylon, " "	South Wellfleet, Mass.
Sagaponack, " "	

IN CANADA

St. John, N. B.	Whittle Rock, Labrador.
Fame Point, N. B.	Point Amour, "
Sidney, N. S.	Belle Isle, "
Cape Breton, N S.	Battle Harbor, "
Sable Island, N. S.	Chateau Bay, "
Halifax, N. S.	Seal Island, "
Cape Rich, Newfoundland.	Venison Island, "
Cape Ray, "	Charlottetown, "
Cape Race, "	Indian Harbor, "
Grosse Isle, Quebec.	Domino, "

IN THE BRITISH ISLES

Broomfield,	Frazerburgh,
Brookhaven,	Frinton,
Caister,	Gibraltar,
Chelmsford,	Gull Light-vessel,
Cross Sand Light-vessel,	Haven Poole Harbor,
Culver Cliff,	Holyhead,
Dover,	Innistrahull,
East Goodwin Light-vessel,	Liverpool,
Fastnet Light-house,	Lizard,

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IN THE BRITISH ISLES

Malin Head,
Malta,
Niton, Isle of Wight,
North Foreland,
Plymouth,
Poldhu, Cornwall, Eng.,
Portland,
Portsmouth,
Ram's Head,
Roche's Point,
Rosslare, Ireland,
Scilly Islands,
Seaforth,
Sheerness,
South Goodwin Light-vessel,
Sunk Light-vessel,
Tongue Light-vessel,
Withernsea.

IN ITALY

Asinara,
Bari,
Becco di Vela,
Campo Alle Serra,
Capo Mele,
Capo Sperone,
Cozzo Spadaro,
Forte Spuria,
Messina,
Monte Cappuccini di Ancona,
Monte Mario,
Palmaria,
Ponza,
Reggio,
San Guiliano di Trapani,
Santa Maria de Leuca,
Torre Piloti di Malamocco,
Viesti,
Villa San Giovanni.

IN CHINA

Hong-Kong,
Pekin,
Tientsin.

IN EGYPT

Port Said,
Port Tewfik.

IN GERMANY

Borkum Isle,
Borkum Riff.

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IN CONGO FREE STATE

Ambrizette, Banana.

IN BELGIUM

Nieuport.

IN HOLLAND

Amsterdam.

IN MONTENEGRO

Antivari.

A List of Liners Carrying Marconi Apparatus

ABERDEEN LINE.

Steamship Iranda, Steamship Inkosi.

ALLAN LINE

Steamship Bavarian,
" Tunisian,
Steamship Victorian,
" Virginian.

AMERICAN LINE

Steamship Philadelphia,
" New York,
Steamship St. Louis,
" St. Paul.

ANCHOR LINE

Steamship Caledonia, Steamship Columbia.

ATLANTIC TRANSPORT LINE

Steamship Minneapolis,
" Minnehaha,
Steamship Minnetonka.

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BELGIAN MAIL-PACKETS

SS. Princesse Clementine,
" La Flandre,
" Princesse Henriette,
" Princesse Josephine,
" Leopold II.,
SS. Marie Henriette,
" Prince Albert,
" La Rapide,
" Ville de Douveres,
" Princess Elizabeth.

CIE. TRANSATLANTIQUE

Steamship La Savoie,
" La Lorraine,
" La Touraine,
Steamship La Bretagne,
" La Gascogne.

CUNARD LINE

Steamship Campania,
" Carpathia,
" Caronia,
" Carmania,
" Etruria,
" Ivernia,
Steamship Lucania,
" Netonia,
" Pannonia,
" Slavonia,
" Saxonia,
" Umbria.

HAMBURG-AMERICAN LINE

SS. Amerika,
" Blücher,
" Deutschland,
SS. Kaiserin Auguste Victoria,
" Moltke.

HOLLAND-AMERICAN LINE

SS. Potsdam,
" Ryndam,
" Nieuve Amsterdam,
Steamship Noordam,
" Statendam.

NORDDEUTSCHER LLOYD

SS. Kaiser Wilhelm II.,
" Kronprinz Wilhelm,
" Grosser Kurfürst,
SS. Kaiser Wilhelm der Grosse.

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RED STAR LINE

Steamship Finland,
" Kroonland,
Steamship Vaderland,
" Zeeland.

REID NEWFOUNDLAND COMPANY

Steamship Bruce.

WHITE STAR LINE

Steamship Oceanic,
" Baltic,
" Cedric,
Steamship Celtic,
" Teutonic,
" Majestic.

CANADIAN GOVERNMENT LINE

Steamship Minto,
" Canada,
Steamship Stanley.
" Lady Laurier.

CANADIAN PACIFIC RAILROAD

SS. Empress of Brittain,
SS. Empress of Ireland.

COMPAGNIE DI NAVIGAZIONE

Steamship La Veloce,
" Nord America,
Steamship Citta da Napoli.

COMMERCIAL CABLE COMPANY

Cable Steamer Mackay-Bennett.

NAVIGAZIONE GENERALE ITALIANA

Steamship Sardegna,
" Lombardia,
" Liguria,
Steamship Sicilia,
" Umbria.

How Ships are Located in the Atlantic Ocean.—With all these liners crossing and recrossing the Atlantic Ocean means must be provided so that the operator at any shore station, or on board any ship, may be able to quickly

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ascertain the position of any ship at any given time. To enable them to do this, the Marconi Company furnishes operators in charge of stations at the beginning of every month with a communication chart, as shown in Fig. 90. The chart measures 14×20 inches, and should be framed and hung on the wall or kept within easy reach.

Assuming that a message has been received at the Sagaponack Station for transmission to the Cunard Liner Umbria, the operator at the former looks on his chart to ascertain the ship's whereabouts in the ocean lane; he may find that it is several hundred miles out of the reach of his station, but that the New York of the American Line is, we will say, about midway between Sagaponack and the Umbria. The operator then signals the New York, and when this vessel responds he transmits the message with instructions to repeat it to the Umbria. In a like manner any ship in the entire Atlantic service can be located and gotten in touch with. Toward the end of the month the vessels may be found dropping behind their schedule according to the communication chart, but this is easily corrected by checking them off with a pencil and the chart thus kept fairly accurate. A thorough study of the chart reproduced will prove of much value to the operator who desires a position with the Marconi Company.

Offices of the Marconi International Marine Communication Company, Limited

Head Office:

18, Finch Lane,

London, E.C., England.

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The Marconi Wireless Telegraph Company of America,
27 William Street,
Lord's Court Bldg.,
New York City.

The Marconi Wireless Telegraph Company of Canada,
1724 Notre Dame Street,
Montreal, Canada.

La Compagnie de Telegraphie sans Fil,
48 Rue de Mamur,
Brussels, Belgium.

La Compagnie Française Maritime et Colonial de Telegraphie sans Fil,
59 Rue de Provence,
Paris, France.

Compagnie Internazionale Marconi per le Communicazioni Marittime,
Piazza de Pietra 26,
Rome, Italy.

List of Stations Equipped with the De Forest System

ON THE ATLANTIC SEABOARD

Atlantic City, N. J.	Mobile, Ala.
Boston, Mass.	New Haven, Conn.
Bridgeport, Conn.	New Orleans, La.
Cape Hatteras, N. C.	New York.
Charleston, N. C.	Philadelphia.
Galilee, N. J.	Portland, Me.
Galveston, Tex.	Providence, R. I.
Havana, Cuba.	Quogue, L. I.
Key West, Fla.	Savannah, Ga.
Manhattan Beach, L. I.	Washington, D. C.

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STATIONS IN THE INTERIOR

Bay View, N. Y.	Fort Worth, Tex.
Buffalo, N. Y.	Hartford, Conn.
Chicago, Ill.	Kansas City, Mo.
Cleveland, Ohio.	Paterson, N. J.
Colorado Springs, Col.	Pike's Peak, Col.
Cripple Creek, Col.	St. Louis, Mo.
Dallas, Tex.	Springfield, Mo.
Denver, Col.	Springfield, Mass.

ON THE PACIFIC COAST

San Francisco, Cal. Seattle, Wash.

UNITED FRUIT LINE

Port Limon, Costa Rica. Boca del Toro, Panama

A List of Ships Carrying De Forest Apparatus

CONSOLIDATED COAL CO. (B AND D)

Savage (Tug).

MAINE STEAMSHIP COMPANY

Steamship Horatio Hull, Steamship North Star.

MALLORY STEAMSHIP LINE

Steamship Concho, Steamship Denver.

NEW YORK & PORTO RICO STEAMSHIP LINE

Steamship Coamo, Steamship Ponce.

P. & O. STEAMSHIP COMPANY

Steamship Mascotte, Steamship Olivette.

QUEBEC STEAMSHIP COMPANY

Steamship Bermudian, Steamship Trinidad.

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SAVANNAH LINE

SS. City of Atlanta, SS. City of Columbus.

STANDARD OIL COMPANY

SS. Astral, SS. Col. E. L. Drake,
Barge 92, " Capt. A. F. Lucas,
" 95, " Maverick.

Head Office:

American De Forest Wireless Telegraph Company,
42 Broadway,
New York City.

List of United States Navy Ship and Shore Stations and Type of Apparatus Installed

The number and type of wireless telegraph stations installed in the United States Navy, given below, include some stations now under contract, and the table is believed to be practically accurate:

System.	Ships.	Shore.	Total.
Telefunken	40	17	57
Shoemaker	10	3	13
Massie	—	10	10
De Forest	2	5	7
Fessenden	3	—	3
Rochefort (not yet installed)	—	3	3
Stone	1	1	2
Lodge-Muirhead	—	2	2
Clark	—	1 (portable)	1
Totals	56	42	98

List of Wireless Telegraph Stations Controlled by the United States Army.—The Signal Corps has stations

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working at St. Michael, Alaska, and Safety Harbor, Alaska, the latter being the landing point for Nome. Wireless communication between these two stations was established by the Signal Corps in August, 1904. Since that time the service has been continuous, there not having been a single day's interruption in the transaction of a large volume of business. The stations are equipped with small power plants, in which gasoline engines are the motive power, giving about three kilowatts effective energy for operating the transmitting devices. The system used in these stations is largely composite, most of it having been originated and constructed by Captain L. D. Wildman of the Signal Corps, who had charge of them. Some De Forest and some Fessenden devices are made use of in these stations.

At present the Signal Corps is proceeding with the construction of wireless stations at Zamboanga and Jolo, Philippine Islands, these stations to have the same capacity and power as the Alaskan stations above named. There are small stations for the use of the Coast Artillery and local work at the following points: Forts Hancock, Wadsworth, Wood, Schuyler, Trumbull, Michie, Terry, and Wright, New York; Benicia Barracks, Fort Mason, and Alcatraz Island, California; Forts Worden and Flagler, at the entrance to Puget Sound. All of these stations are largely composite in their equipment, apparatus having been purchased from Fessenden, De Forest, Massie, and Clark. The stations at Forts Wright and Schuyler are about one and one-half kilowatts, and have in the past

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been generally in free communication with each other, the distance being about 100 miles.

Where to Apply for Positions.—Applicants for positions with the Marconi Company should apply to W. W. Bradfield, Esq., Chief Engineer, the Marconi Wireless Telegraph Company, Limited, Lord's Court Building, New York City. Beginners are preferred who have a fair working knowledge of electrical apparatus, and who can send and read in both the ordinary Morse and the Continental codes. Those who are accepted are given a course of instruction at the Babylon Station, Long Island, covering a period of a month or so, under the guidance of the chief operator at that station. Applicants for positions with the de Forest Company should address Dr. Lee de Forest, American de Forest Wireless Telegraph Company, 42 Broadway, New York. Those desirous of securing places with the Fessenden Company are advised to communicate with Prof. Reginald Fessenden, National Signalling Company, Eighth and Water streets, Washington, D. C. Operators wishing to enlist in the United States Navy must meet the following requirements:

DEPARTMENT OF THE NAVY,
BUREAU OF NAVIGATION,
WASHINGTON, D. C.

1. A candidate for enlistment as an electrician for wireless telegrapher must have a working knowledge of telephones, measuring-instruments, call-bells, etc., and be able to connect up same to batteries and make minor repairs to them. Familiarity with ordinary telegraph instruments, while an aid in acquiring a working knowledge of wireless telegraphic instruments, is not an essential qualification for enlistment as a wireless telegraph operator.

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2. Applicants for enlistment must be able to write legibly and be good spellers.

3. Applicants will be enlisted as electricians, third class, at $30 per month, and, if practicable, given a course of instruction on some cruising ship or wireless telegraph shore-station already equipped, and as found qualified will be assigned to cruising-ships as needed, either in charge of the station or as assistants to the electrician in charge.

4. Men detailed as operators will be eligible to promotion to higher ratings of the electrical branch when they qualify as operators, and have served the required probationary time under the regulations, through the successive grades to chief electricians at $60 per month, when they prove their ability to take charge of the wireless telegraph station and interior communication on board ship and have been assigned to duty.

(Signed) H. C. Taylor,
Chief of Bureau.

Any request made to the Bureau of Navigation, Navy Department, Washington, D. C., in reference to entering the naval service, will receive prompt attention. Receiving ships and recruiting stations are located throughout the country, and recruiting parties make occasional visits to the large and small cities. Upon application to the Bureau of Navigation, a booklet containing full information will be sent free of charge.

Applicants desiring to enlist in the United States Army may address General James A. Allen, Chief Signal Officer, U. S. Army, Washington, D. C.

War Department,
Office of the Chief Signal Officer,
Washington, D. C.

Enlistment Circular.

The following information is published to answer, in general, inquiries regarding employment or services in the Signal Corps of

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the Army. Civilians are not employed, but enlistments of desirable persons will be made as privates, and promotions to the higher grades made on merit as vacancies occur and the soldier's qualifications, conduct, and service justify. Promotions are usually rapid in the case of men of high character who show proficiency in special phases of electrical or other Signal Corps work. The grades and pay of enlisted men of the Signal Corps are as follows:

	In U. S.	Abroad
Master signal electricians, per month	$75.00	$90.00
First-class sergeants, " "	40.00	54.00
Sergeants, " "	34.00	40.80
Corporals, " "	20.00	24.00
First-class privates, " "	17.00	20.40
Privates, " "	13.00	15.60

with a slight increase each month after three years' service. All enlisted men, in addition to their regular pay, receive rations, quarters, clothing, fuel, bedding, medicine and medical attendance, when required.

Owing to the professional and technical nature of the service in the Signal Corps, a large proportion of the enlisted men are non-commissioned officers. The clothing allowance of a first-class private is about $138.00 for one enlistment; of a corporal, about $141.00; of a sergeant, about $141.00; and the portion of this not used in purchasing clothing is paid to the soldier in cash on discharge. When on detached service at a station where there are no troops, as many of the Signal Corps operators are, the soldier draws $1.15 per day as commutation of rations and quarters. Every soldier is privileged to deposit his savings with any army paymaster, and for sums so deposited, for the period of six months or longer, will be paid interest at the rate of 4 per cent per annum.

After thirty years' service a soldier is entitled to be retired, and to receive monthly during life three-quarters of the regular pay he was receiving at date of retirement, and in addition $9.50 per month as an allowance for clothing and subsistence. Non-commissioned officers not more than thirty years of age are eligible for examination after two years' service for commission in the line of the army.

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Applicants for enlistment must be between 21 and 35 years of age. They must be unmarried, of good antecedents and habits, and free from bodily defects and diseases. They must be citizens of the United States, or have made legal declaration of their intention to become citizens of the United States, and must be able to speak, read, and write the English language.

It is necessary that the applicant furnish a certificate of good moral character, with particular reference to sobriety, and also his experience, if any, as an electrician, telegraph operator, or lineman. Enlistments are for three years. Recruits, as a rule, are first sent to one of the Signal Corps Schools of Instruction, where they remain about six months, to fit them for duty in the United States, Philippines, or Alaska, or wherever the exigencies of the service may demand. These schools are located at Fort Wood, New York Harbor; Omaha Barracks, Nebraska; and Benicia Barracks, California, where courses are given in telegraphy, including wireless, military signalling, electricity, photography, line construction, general instructions concerning the care and handling of Government property, and rendering the necessary reports; handling moneys received at military telegraph offices, as well as practical military instruction covering the duties of a soldier. The opportunities for making use of any special aptitude are most excellent, and in many cases have led to rapid promotion and most agreeable service.

Probably no other branch of the Government service gives its men such an opportunity for travel and seeing the world. The care and operation of a complete network of cable and telegraph lines, and the installation of the fire-control system in the seacoast defences, take them to all parts of the United States, the Philippine Islands, and Alaska. Upon expiration of term of service the Government returns a soldier to the original place of enlistment, or allows him in cash an amount sufficient to pay his transportation there. If you desire to enlist, application in your own handwriting should be made to this office, accompanied by the certificate above referred to, and if satisfactory you will be furnished instructions as to the recruiting officer to whom to apply, etc.

Applicants must defray their own expenses to the place of enlist-

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ment, as their fitness for military service can only be determined by a physical examination.

(Signed) A. W. Greely,
Brigadier-General, Chief Signal Officer, U.S.A.

List of Books on Wireless Telegraphy.

A History of Wireless Telegraphy. By J. J. Fahie (England). Published by Dodd, Mead & Co., New York. Price $1.50. 325 pages; 3 periods; 5 appendices; about 50 illustrations.

Every operator should read this book. It contains a history of wireless telegraphy from 1838 to 1899; it covers the subject thoroughly, and brings out the early work of Marconi very fully. An appendix contains valuable papers by Lodge, Branly, Hughes and others, as well as a reprint of Marconi's first patent.

Signalling Through Space Without Wires. (3d edition .) By Oliver J. Lodge (England). Published by D. Van Nostrand Co., New York. Price 6 shillings. 133 pages; 9 chapters; 66 illustrations.

An account of the work of Hertz and the men who succeeded him. As Hertz discovered the means to produce electric waves and to receive them, it behooves every operator to learn of his work and to reverence him. The book also contains the particulars of the first work done along the line of tuning and syntonization.

Electric Waves. By Heinrich Hertz (Germany). English Translation by D. E. Jones (England). Published by Macmillan Co., New York. Price $3.00. 279 pages; 14 chapters; 40 illustrations.

This book contains the classic papers of Hertz on his researches on the propagation of electric action through

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space. It is of necessity a mathematical treatise, but there are many portions that can be read with profit by the ordinary operator. If possible, this he should do, for the whole structure of wireless telegraphy rests on the foundation laid by Hertz.

Les Applications Practiques des Ondes Electrics. By Albert Turpain (France). Published by C. Naud, Paris, France. Price 12 francs. 412 pages; 6 chapters; 271 illustrations.

A French book that contains an account of the work from 1897 to 1902, especially of the developments in Europe during this period.

Modern Views of Electricity. By Oliver J. Lodge (England). Published by the Macmillan Co., New York. Price $1.50. 422 pages; 15 chapters; 55 illustrations.

The object of this book is to explain without technicalities the most advanced thought on electrical subjects at the present time. The work is divided into four parts, i.e., (1) Electricity Under Strain; (2) Electricity in Locomotion; (3) Electricity in Whirling Motion or Magnetism; and (4) Electricity in Vibration, or Radiation, commonly called Light. All these are treated in a more or less popular manner, and are adapted to those who have some acquaintance with the ordinary facts and phenomena of electrical science.

Onde Hertziane e Telegrafo Senza Fili. By Oresta Murani (Italy). Published by Ulrico Hoepli, Milan, Italy. Price 2 l. c. 341 pages; 9 chapters; 170 illustrations.

A popular treatise in Italian on wirelesss telegraphy.

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Die Telegraphie ohne Draht. By Adolph Prasch (Germany). Published by A. Hartleben, Leipzig, Germany. Price 8 marks. 265 pages; 2 parts; 202 illustrations.

Gives a description of the work done up to 1902; it is printed in German and contains a few mathematical formulæ.

Die Telegraphie ohne Draht. By Agusto Righi and Bernhard Dessau (Italy and Germany). Published by Friedrick Vieweg & Sohn, Braunschweig, Germany. Price 16 marks. 481 pages; 13 chapters; 258 illustrations.

This book is also in German and is much more pretentious than the preceding volume, besides bringing the art up a year later, and up to and including Marconi's experiments on the Carlo Alberta. The Marconi, Slaby-Arco, and Braun-Siemens and Halske systems are very fully treated.

La Télégraphie sans Fils. By André Broca (France). Published by Gauthier-Villars, Paris, France. Price 10 francs. 234 pages; 12 chapters; 52 illustrations.

A simple treatise in French on electric waves and their application to wireless telegraphy.

The Use of Wireless Telegraph Apparatus. By Lieutenant J. M. Hudgins, U.S.N. Published by the Navy Department. 29 pages; 3 chapters; 36 illustrations.

These instructions were written by the late Lieutenant Hudgins for the guidance of officers and others in the U. S. Navy in charge of wireless telegraph apparatus on board ship and at shore stations.

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Wireless Telegraphy: Its Origin, Development, Inventions, and Apparatus. By Charles Henry Sewell (United States). Published by D. Van Nostrand Co., New York. Price $1.50. 229 pages; in 4 parts; 85 illustrations.

The first book on wireless telegraphy published in the United States. The author's aim was to present a comprehensive view of the subject, giving its history, principles, and possibilities in theory and practice.

Wireless Telegraphy: Its Theory and Practice. By William Maver (United States). Published by The Maver Publishing Co., New York. Price $2.00. 199 pages; 15 chapters; 121 illustrations.

Contains an account of all the wireless systems at the time the text was prepared, and gives a theoretical and practical statement, as free as can well be from formulæ, written in a manner designed to be clear to the general reader.

The Story of Wireless Telegraphy. By A. T. Story (English). Published by D. Appleton & Co., New York. Price $1.00. 215 pages; 12 chapters; 56 illustrations.

This is just what its name indicates—wireless telegraphy from its earliest conception to 1904, told in the simplest language.

Maxwell's Theory and Wireless Telegraphy. By Frederick K. Vreeland (United States). Published by the McGraw Publishing Co., New York. Price $1.50. 225 pages; 2 parts; 145 illustrations.

First part is a translation of Poincairé's physical treatment of Maxwell's theory—the latter being the basis of

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Hertz's deductions and experiments—and its application to some modern electrical problems. The second part shows how the principles are applied to wireless telegraphy.

Wireless Telegraphy and Telephony. By Domenico Mazzotto (Italian). Translated by S. R. Bottone (English). Published by Whittaker & Co., London. Price 6 shillings. 415 pages; 12 chapters; 253 illustrations.

A clearly written work on wireless telegraphy, covering the whole general scheme, together with a chapter on the new art of wireless telephony.

Traité Elémentaire de Télégraphie et de Téléphonie sans Fil. By E. Ducretet (France). Published by R. Chapelot & Co., Paris, France. Price 3 francs. 89 pages; 7 chapters; 30 illustrations.

Principally devoted to a description of Capitaine E. Ducretet's wireless telegraph and telephone experiments.

Wireless Telegraphy and Telephony. By Maurice Ernest (English). Published by *Electricity*, London. Price 1 shilling. 32 pages; 9 chapters; 12 illustrations.

An exposition of the methods and instruments used in the Orling-Armstrong system of wireless telegraphy and telephony through the earth.

Wire and Wireless Telegraphy. By Edmund B. Moore (United States). Published by the Reporter Publishing Co., Springfield, Vt. Price $1.00. 38 pages; 5 chapters; 12 illustrations.

This book should stimulate every boy to get down to business. It was written by a boy of only sixteen years of age and published by him unaided and alone.

Wireless Telegraphy. By Richard Kerr (England). Published by Seeley & Co., London. Price, 3 shillings. 116 pages; 9 chapters and appendix; 17 illustrations.

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A little work treating of the different schemes by which man has sought to telegraph without wires.

Wireless Telegraphy. By S. W. de Tunzlemann (England). Published by "Knowledge," London. Price 3 shillings. 104 pages; 8 chapters; 30 illustrations.

A popular exposition of the principles of wireless telegraphy.

Wireless Telegraphy and Hertzian Waves. By S. R. Bottone (England). Price 3 shillings. 120 pages; 37 illustrations. 1900.

An attempt to set forth in simple language the elementary principles upon which wireless telegraphy depends.

The A B C of Wireless Telegraphy. By Edward Trevert. Published by Bubier Publishing Company, Lynn, Mass. Price 75 cents. 7 chapters; 20 illustrations.

A plain treatise on electric-wave signalling and the theory, method of operation, and construction of various pieces of the apparatus employed.

Wireless Telegraphy. By Gustave Eichhorn (Germany). Published by J. B. Lippincott Co., Philadelphia. Price $2.75. 116 pages; 11 chapters; 79 illustrations.

A mathematical treatise presenting the fundamental principles of electric-wave action as applied to the Telefunken system of wireless telegraphy.

Wireless Telegraphy: Its History, Theory, and Practice. By A. Frederick Collins of New York. Published by the McGraw Publishing Co. Price $3.00. 299 pages; 20 chapters; 323 illustrations.

With the exception of the present volume it is the most

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recent work, in this class of literature, published in the United States. Every chapter begins with a brief history of the individual subject; it is then treated theoretically and mathematically; its experimental investigation follows, the chapter finally closing with the practical workings of the apparatus. The chapter on *Capacity*, *Induction*, and *Resistance* defines these terms and explains their effects on electrical oscillations; also how to calculate the constants of an aerial wire, and how to measure the capacity, inductance, and resistance values of aerial systems, all in simple and concise language.

The theory of the *Induction Coil* is probably more fully treated in this than in any other work, while a separate chapter tells how to build coils from a half-inch up to the largest sizes, giving sparks especially adapted to wireless transmission. Twenty-five different kinds of electric-wave detectors are fully explained and illustrated. The chapters on *Transmitters* and *Receptors* classify all the different makes of apparatus, and in such a way that the reader can instantly ascertain the characteristic features of any one of the numerous systems and wherein it is alike or different from those of any other make.

In the chapter on *Subsidiary Apparatus* each specific part of the complete equipment is minutely described and illustrated, except *Oscillators* and *Detectors*, since these are treated exhaustively in distinct chapters. For instance, nine different styles of keys are considered; three different types of condensers; high- and low-potential transformers; decoherers; relays, ordinary and polarized; indicators,

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including Morse registers, telephone receivers, and siphon-recorders; as well as tuning-coils, choking-coils, polarized cells, screening boxes, and the alphabetic codes used in wireless.

Aerial Wires and *Earths*, *Resonance* and *Syntonization* are dealt with in separate chapters in all their phases, and this is the only work containing the history, theory, and practice of these hitherto little understood subjects. In conclusion, the last chapter is devoted to *Wireless Telephony*, and contains all the information, such as speaking arcs, selenium cells, etc., that is available at this writing.

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GLOSSARY OF WIRELESS TELEGRAPH WORDS, TERMS, AND PHRASES

Adjustable condenser. See Condenser.

Aerial. A word much used instead of the longer term *aerial wire.*

Aerial switch. A switch used to throw the aerial wire into connection with the spark-gap and out of connection with the detector, and vice versa.

Aerial wire. The wire suspended from a mast, kite, or balloon, and connected with the spark-gap when sending and the detector when receiving. When sending it is often termed a *sending wire;* also a *radiator.* When receiving it is sometimes termed the *receiving wire* or *receiving aerial;* also an *antenna.* It may be termed a *vertical wire,* whether sending or receiving. If formed of one or two parallel wires it is termed a *plain aerial;* if more than two parallel wires a *grid;* then there is the *fan-shaped aerial, cylindrical, inverted pyramid,* and *rectangular* aerials. Aerials are usually, but not always, open circuit, that is they are insulated from everything and end abruptly at the top. A *closed-circuit aerial* indicates that it forms a loop at the top.

Air-gap. Wherever a high-tension circuit is broken and the connection is made by a high-potential discharge sparking across the gap the space is termed an *air-gap* or a *spark-gap.* Such an arrangement is used to cut out the transmitter from the receiving aerial, so that the received energy may not be dissipated in the sending circuits.

Alternations. A current that changes its direction slowly, as produced by a commercial alternating generator, is termed an *alternating current;* a current that surges through a circuit with

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high frequency is called an *oscillating current;* while a charge moving to and fro rapidly enough to produce light is termed a *vibration.*

Anode. The point or path by which a direct current enters the electrolyte or other medium; it is the positive pole of the spark-gap, but is used chiefly to indicate the fine point of an electrolytic detector or the smaller terminal of an electrolytic interruptor. The negative electrode is called the *cathode.*

Antenna. The receiving aerial—never the sending aerial; so called from the feelers attached to the heads of insects, to which it is likened in reaching out and receiving the electric impulses.

Barretter. A name given by Fessenden to his electrolytic detector.

Battery. Three kinds of batteries are used in wireless telegraphy: i.e. (1) *dry batteries*, (2) *storage batteries*, and (3) *Leyden-jar batteries.* 1 is used in the receiving circuit in connection with the tapper and Morse register; 2 is sometimes used to supply the initial energy for operating the induction coil, and 3 in the high-tension circuit of the transmitter.

Battery circuit. Usually refers to the internal circuit of a receptor, which includes the tapper and Morse register.

Bridle. A cord attached to a kite that holds the latter at the proper angle in the wind; the kite-cord is attached to the bridle.

Brush discharge. See Discharge.

Buzzer. A vibrating arrangement like an electric bell, but without the gong. The testing-box for the coherer is often called a *buzzer.*

Capacity. Any object that possesses the property of being charged with electricity; hence an aerial wire, a condenser, or a metal plate are called capacities for short when this is meant.

Capacity cage. A cylindrical cage made of wire and placed at the top of the aerial wire to give it additional capacity.

Cathode. The negative terminal of an electrolytic detector or an electrolytic interruptor; it is always the larger terminal in these instances. See Anode.

Circuit. Any electrical conductor through which a current can flow. A low-voltage current requires a loop of wire or other conductor, both ends of which are connected to form a continuous circuit;

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this is termed a *closed circuit*. When the current is oscillatory it will surge through a wire open at both ends; this is an open circuit. Where a closed circuit and an open circuit are coupled together they form a *compound circuit*. When the closed and the open circuits are joined directly together they form a *close-coupled circuit;* when they are joined through a transformer-coil they form a *loose-coupled circuit*.

Circuit. The primary circuit of the transmitter and the circuit of the receptor containing the dry battery are sometimes called *battery circuits;* also *low-voltage circuits;* also *local circuits;* also *internal circuits*.

Circuits. The open and closed circuits in which the oscillations of the transmitter and the receptor surge are termed *high-tension circuits;* also *external circuits*. The high-tension circuits of the sender form the *oscillation circuits*, called for short the *oscillator*; the aerial-wire system of the receiver is termed the *resonator circuit* or merely the *resonator*.

Circuits. A *parallel circuit* is one in which a number of circuits have all their positive poles connected together; also termed a *multiple circuit*. A *series circuit* is one through which the current passes without being divided; a continuous circuit. A *shunt circuit* is a branch or additional circuit through which a portion of the main current passes.

Closed circuit. See Circuit.

Compound circuit. See Circuit.

Close-coupled circuit. See Circuit.

Condenser. All conducting objects with their insulation form capacities, but a condenser is understood to mean two sheets or plates of metal placed closely together, but separated by some insulating material. (1) When paper is used as the dielectric it is termed a *paper condenser;* (2) where mica is used it is termed a *mica condenser;* and (3) where glass jars are coated nside and out with tinfoil it is termed a *Leyden-jar condenser*, o battery, because this kind was first made in Leyden, Germany. When the capacity of the condenser can be varied it is termed an *adjustable condenser*.

Convective discharge. See Discharge.

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Discharge. (1) A faintly luminous discharge that takes place from the pointed positive terminal of an induction coil, or other high-potential apparatus, is termed a *brush discharge.* (2) A continuous discharge between the terminals of a high-potential and high-frequency apparatus is termed a *convective discharge.* (3) The sudden breaking-down of the air between the balls forming the spark-gap is termed a *disruptive discharge;* also termed an *electric spark;* also *spark*, which is even shorter.

Disruptive discharge. See Discharge.

Damping. The degree to which the energy of an electric oscillation is reduced or lessened. In an open circuit the energy is damped out very quickly, that is, in one or two swings; while in a closed circuit it is greatly prolonged, the current oscillating twenty times or more before the energy is dissipated.

Electrodes. Either of the ends or terminals immersed in the electrolyte of either an electrolytic interruptor or electrolytic detector. Occasionally the terminals forming the spark-gap are called electrodes.

Electric oscillations. A current of high frequency that surges through an open or closed circuit. (1) An electric oscillation may be set up by releasing a charged wire or other capacity by means of a disruptive discharge; under these conditions, oscillations not only have a high frequency, but a high potential. (2) When electric waves impinge on an aerial wire or other resonating system, they are transformed into electric oscillations of a frequency equal to those emitting the waves, but, owing to the very small amount of energy received, the potential is very low. (3) *Prolonged* or *sustained oscillations* are those in which the damping factor is small; *damped oscillations* are those that are quickly transformed into electric waves. See Damping.

Electric spark. See Discharge.

Electric waves. When an electric oscillation surges through a wire, some of its energy is transformed into waves in the ether, very much as an ordinary electric current is converted into magnetic lines of force (see Electric oscillations). (1) *Free electric waves* are waves that are not guided by the conducting medium of either metallic conductors or the earth's surface. (2) *Sliding*

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electric waves are waves that slide along wires or the earth's surface. (3) *Trains of electric waves* are a series of waves sent out by constantly recurring electric oscillations due to a succession of electric sparks.

Earth. A word used to indicate the place in which the aerial-wire system forms a connection with the earth.

Earthed terminal. The wire connecting the plate buried in the earth and the aerial wire; also used to indicate the wire with the plate attached; also called a *ground,* also *earthed connection.*

External circuit. See Circuit.

Earth-plate. A sheet of metal or wire-netting used to form a contact with the earth or water for the aerial-wire system.

Feeble oscillations. See Oscillations.

Frequency. The number of reversals of an electric current per second. (1) A *low-frequency current* usually implies an alternating current of commercial frequency. (2) A *high-frequency current* indicates a frequency which can only be obtained by a disruptive discharge.

Ground. Used instead of "earth." See Earth.

Hertzian waves. Same as electric waves; so called after Hertz, who discovered them.

High frequency. See Frequency.

High potential. See Potential.

High pressure. See Potential.

High tension. See Potential.

High voltage. See Voltage.

Inductance. The characteristics of a circuit which cause the magnetic induction of a current to accentuate the value of its electromotive force. It is the inductance of a circuit that retards or holds back a current on making the circuit, and gives it increased momentum on breaking the circuit which produces the "extra-current" effect. *Self-induction* is the inductive effect of a current acting on itself that causes its electromotive force to rise with an increasing or decreasing magnetic field.

Inductance coil. A coil of wire used to provide additional inductance for the aerial-wire system. *Variable inductance coil* is a coil

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arranged with plugs or clips, so that the value of inductance may be changed.

Induction. See Mutual Induction.

Interference. The crossing of two trains of electric waves that tends to diminish or increase the intensity of the other. It is the untoward interference between electric waves from different stations that makes selective signalling so difficult a problem.

Internal circuit. See Circuit.

Jigger. A name given by Marconi to a small oscillation-transformer

Juice. A vulgar word much used by operators and others for electric current.

Kinetic. In motion or active; opposed to static or stored-up energy; an electric current is kinetic; a charge is static.

Leyden-jar battery. Two or more Leyden jars coupled together.

Local circuit. See Circuit.

Loose-coupled circuit. See Circuit.

Low frequency. See Frequency.

Low potential. See Potential.

Low tension. See Potential.

Low voltage. See Voltage.

Maximum. The greatest quantity, amount, or degree attainable.

Mica. A mineral that may be split into thin transparent or translucent sheets, forming a most excellent insulation; sometimes called *isinglass*.

Micanite. A compound having mica for a basis; it can be moulded into any form or shape desired. Largely used for insulating tubes between the primary and secondary of induction coils.

Minimum. The smallest quantity, amount, or degree attainable.

Mutual induction. Induction produced between two circuits in proximity with each other by the mutual interaction of their magnetic fields.

Non-inductive resistance. A coil of wire wound double, starting with the loop; such a coil possesses resistance but not inductance. See Resistance.

Ohmic resistance. See Resistance.

Open circuit. See Circuit.

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Oscillation. See Electric Oscillation.

Oscillator. A circuit designed especially for oscillating currents.

Oscillator balls. The balls of the spark-gap.

Oscillation circuit. See Oscillator

Parallel circuit. See Circuit.

Period. The time that elapses between two successive phases of an oscillation.

Plain aerial. See Aerial.

Potential. Electrical energy under pressure but not in motion. Ordinary or *low potentials* are those at the terminals of commercial generators; *high potentials* are produced by induction coils and similar devices. The word *tension* is used synonymously with *potential*. See Voltage.

Radiator. The aerial wire when connected with the sending apparatus.

Radiator system. The aerial-wire system and other high-tension circuits of a transmitter.

Rat-tail. The wire connecting the aerial wire with the sending or receiving apparatus.

Receiving aerial. See Aerial.

Receptor. A term proposed by the author for the entire receiving apparatus; the purpose was to differentiate the receiving apparatus as a whole from the telephone receiver, which is more often called simply a *receiver*.

Resistance. That property of an electric circuit which opposes or resists the passage of an electric current. The *ohmic resistance* of a circuit equals the electromotive force divided by the current. See Non-inductive Resistance.

Resonator. The aerial-wire system and other high-frequency circuits of a receiving apparatus; also *resonating system*.

Rheostat. A resistance to cut down the current; an *adjustable resistance* is one that can be varied within certain limits.

Ruhmkorff coil. Same as induction coil; so called from Ruhmkorff, who built the earliest practical coils.

Selective. When two or more messages sent at the same time can be received without interference, the systems are said to be selective. See Interference; Tuning; Syntonic.

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Shunts. Resistances for altering the sensitivity of a hot-wire ammeter or other instrument.

Spark. See Discharge.

Spark-balls. Same as oscillator-balls.

Spark-gap. The space between the terminals of the secondary of an induction coil where the disruptive discharge or spark takes place.

Static. Electricity at rest; opposed to kinetic.

Striking distance. The distance the spark passes between the oscillator-balls.

Syntonic. When a sending and a receiving station are each adjusted to a certain wave-length, they are said to be *syntonized*, or in *syntony* with each other; as, a *syntonic system*. See Tuned; Selective.

System. The connection or manner of arrangement of parts of the sending and receiving apparatus as related to the whole, or the parts so related collectively, as the aerial-wire system.

Time-constant. (1) The time counted from the instant of closing an electric circuit which the current requires to rise to about $\frac{2}{3}$ of its maximum value. (2) The time required for the charge of a condenser, or other capacity to fall to about half its maximum value. (3) *High time-constant:* when the time required for a certain function of either electrical or mechanical action takes longer than half of its mean time. Any constant movement that is relatively slow is said to have a high time-constant. (4) *Low time-constant:* when the time required for a given function of either electrical or mechanical action takes less than half of its mean time; any constant movement that is relatively rapid is said to have a low time-constant.

Transformer. A primary and secondary coil for stepping up or down a primary alternating current. The term *induction coil* is used to mean a coil using a direct primary current, and converting this into alternating currents of higher potential by means of an interruptor (see Induction Coil). A transformer requires no interruptor, since the initial current is alternating.

Tuning. When the open and closed oscillation circuits of a transmitter or receptor are adjusted so that both will permit the

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electric oscillations to surge through them with the same frequency, they are said to be *tuned*. *Tuning* refers only to the adjustment of the sending circuits, or of the receiving circuits, while *syntonization* refers to the adjustment of the sending to the receiving circuits.

Unidirectional discharge. See Discharge.

Variable inductance coil. See Inductance Coil.

Vertical wire. See Aerial.

Value. The amount or quantity or magnitude or number.

Vibrations. The exceedingly rapid succession of to-and-fro movements over the same path. Light-waves are vibrations of the ether. Oscillations are much slower than vibrations, and alternations are very slow compared to oscillations

Voltage. The electromotive force expressed in volts.

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