Wireless Telegraphy and Telephony

Massie
and
Underhill

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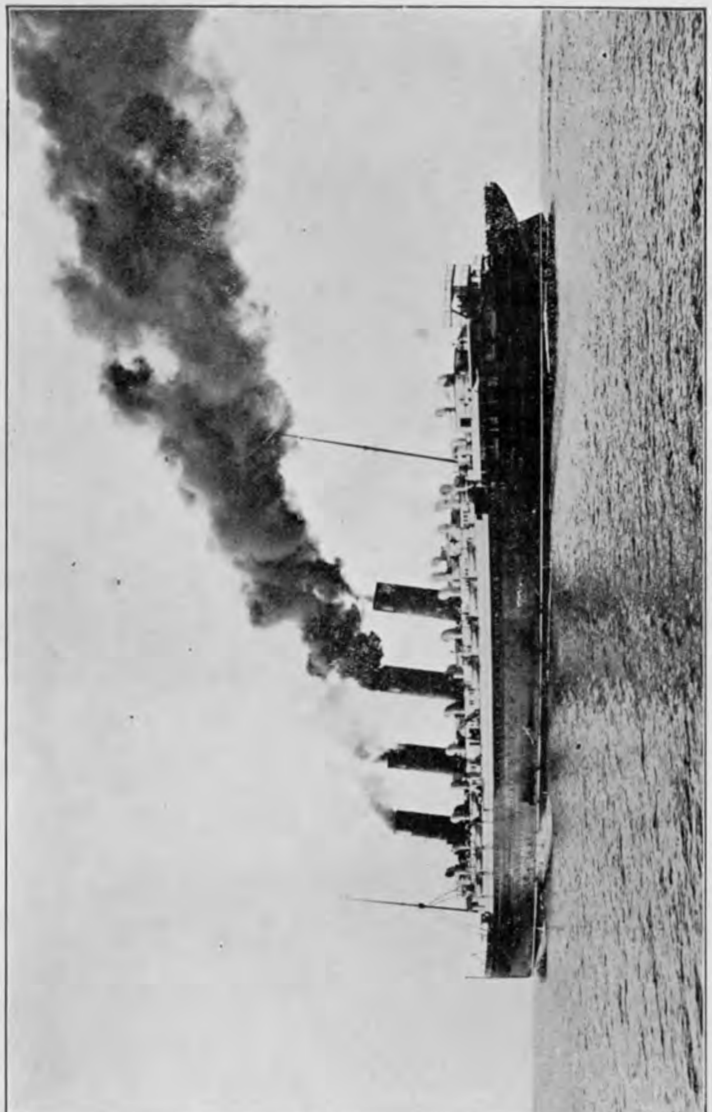

CUNARD S.S. MAURETANIA AT FULL SPEED. 790 FT LONG, 32,500 TONS GROSS WEIGHT, TRIAL SPEED 25½ KNOTS PER HOUR.

Frontispiece.

WIRELESS TELEGRAPHY

AND

TELEPHONY

POPULARLY EXPLAINED

BY

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WITH SPECIAL ARTICLE BY NIKOLA TESLA

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PREFACE

WIRELESS TELEGRAPHY is mentioned in almost every publication of to-day, and enters into conversation between all; yet how few really know what it means.

There have been several books written on the subject for the expert or technical man, but so far nothing has been written that explains it in a way that every one may understand.

In this book the authors use simple expressions, containing no technical words, so that all may obtain a clear idea of the inception and development of this much-talked-of art.

We here describe the substance through which signals are sent, the theory of the propagation of waves, method of generating and receiving the waves, the apparatus used, and, finally, the uses, limitations, and possibilities of wireless telegraphy both commercially and financially.

PROVIDENCE, R. I. — WALTER W. MASSIE.
NEW YORK. — CHARLES R. UNDERHILL.

July 15, 1908.

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WIRELESS TELEGRAPHY

CHAPTER I

THE SECRET OF WIRELESS TELEGRAPHY

1. NATURE'S WONDERFUL MEDIUM

THE term *wireless telegraphy* is commonly used in contradistinction to the electric telegraph in which it is necessary to employ a wire as an artificial conducting medium between stations.

Nature provides a medium, called the *ether*,* through which intelligence may be communicated over sea or land; and by means of which otherwise impossible results are accomplished. The ether exists between the planets and the stars, and all the other heavenly bodies, and has no conceivable end; hence when we speak of the ether, we tacitly refer to the universe.

This infinite sea of ether is continually in a state of intense turmoil, performing its mission of transferring

* This term *ether* has absolutely no connection with the drug of the same name.

energy, radiated from the sun, to our earth and the other planets, as well as other influences due to myriads of heavenly bodies outside of our own solar system.

Transmission of energy through the ether takes place in the form of wave motion, and these waves are known as *electromagnetic waves*. Since light is one form of wave motion, we may make use of it in illustrating the presence of ether, by describing the following well-known experiment.

An ordinary electric bell and small battery are placed in what is known as a receiver, the cover being a glass dome, and an air-pump is then started which will eventually pump out all the air from the receiver in which the electric bell is ringing. Although the cover, or glass dome, is over the bell, it can be plainly heard, and the clapper can be seen vibrating rapidly. As the air is pumped out, however, the sound of the bell becomes fainter and fainter, until, finally, it is no longer heard, although the bell can still be seen as plainly as before, and the clapper vibrating as rapidly as ever. Therefore it is very evident that something remains in the receiver after the air has been removed; for, while we cannot hear the bell, we can see it, and we could not see it if there were not some medium to convey the reflected light waves from the bell to the eye.

While the earth's atmosphere extends but a comparatively small distance, the extent of the ether is infinite.

The universe is a sea of absolute darkness, and if it were possible for us to place ourselves, say, midway between the moon and the earth (in which position we would be over one hundred thousand miles from any air), we would see all the heavenly bodies, and even our own forms, as the light waves would be intercepted and reflected by them; but, otherwise, all would appear as an intense starlit night, with the unusual features of having the sun visible in greatly increased brilliancy, as well as the moon appearing four times its usual size, and the novelty of seeing our own earth rivalling the moon in size and splendor, even under these conditions, more than tenfold.

Every manifestation of power on the earth at some time came through the ether in the form of waves, and even when we enjoy the cheerful sunshine we are, in reality, experiencing the result of the absorption of the ether waves from the sun by our own persons.

2. VIBRATIONS IN THE ETHER

Light, heat, and wireless waves are electromagnetic waves (and, therefore, wave motions of the ether), the only difference being in their relative rates of vibration; their velocity, in free ether, being the same, viz., 186,000 miles per second. They do not, however, traverse all substances with like velocities.

The sun is constantly disturbing the sea of ether, not by a single train of waves, but by wave trains of varying frequencies, and the higher rates of vibration are so intense that the mind can scarcely conceive them. When we think of 767 trillions of vibrations per second, it has little definite meaning to the lay mind; yet science has devised means to accurately determine so high a rate, which represents the extreme violet of the spectrum, and is the highest rate of vibration which our eyes are capable of detecting. The lowest rate of vibration to which our eyes are sensitive is 392 trillions per second, which represents the extreme red of the spectrum.

Our eyes are sensitive to all the other rates of vibration between the extreme violet and the extreme red, and all these complex waves, acting together, produce what we call daylight. The waves which produce a sensation of light when they fall upon the eye are, naturally, called light waves, although the photographic plate is affected by light waves which are outside the rates of vibration to which the eye is susceptible.

When the ether waves impinge upon a body of ordinary opaque mass, it may be warmed, the energy being transformed into heat. While the light waves may produce heat, there are also ether waves called *dark heat waves*, which come at a rate of vibration much too slow to produce a sensation of light.

We say that glass is transparent because it does not appreciably obstruct the ether waves. We may sit near a closed window and enjoy the warmth of the sun because the glass, being transparent, does not arrest the ether

waves, and, therefore, the glass is not warmed; but our own bodies, being opaque, do absorb them, thus producing heat, which our sense of feeling makes manifest to us.

The rate of vibration in the ether, as artificially produced in wireless telegraphy, is extremely slow as compared with that of the light waves, ranging from approximately 1,500,000 to 100,000 per second. The wave length, in any such case, is found by dividing the velocity by the rate of vibration; hence for the extreme violet of the spectrum, the wave length would be $\frac{1}{64000}$ inch, and for the extreme red, $\frac{1}{33000}$ inch, while those employed in wireless telegraphy vary from about 650 feet to nearly two miles.

As is well known, the ether in proximity to the earth is in continual disturbance, which creates the magnetic field surrounding the earth. This manifests its presence in many ways; the most common is its influence on the magnetized needle of a compass, which causes it to point north and south. Wireless waves are propagated through this magnetic field, and follow the curvature of the earth.

When we contemplate the wonders of nature, and gradually fathom her mysteries, that which before seemed impossible now becomes an established fact, and even so wonderful an art as wireless telegraphy loses its magic when we study into the laws which govern it, and see it take its place, with marvels of the past, in the service of man.

CHAPTER II

PRINCIPLE AND THEORY OF WIRELESS TELEGRAPHY

3. PRINCIPLE

THE art of wireless telegraphy is based upon wave motion, and an analogy is found in the wave motion of water, as the following explanation should make clear. Picture a small pond of still water, with a chip or twig floating upon its surface, in full view of the observer. Now if a stone be thrown into the water, the sudden impact of the stone would cause ripples, or small waves, to radiate from the point of impact of the stone with the surface of the water, the waves becoming weaker as the circles become larger, i.e., as the distance from the point of impact becomes greater. As the waves arrive at the point where the chip is floating, they will impart motion to the chip; hence the observer will be aware that there has been some disturbance in the water. (See Fig. 1.) After the waves have ceased, the chip will again lie motionless upon the surface of the water.

It is obvious that the distance over which the signals

may be sent by this means will depend (*a*) upon the force employed to start the waves, and (*b*) upon the lightness of the chip, or its sensitiveness to the motion of the waves. Moreover, if there were grass or other obstructions in the pond between the point where the waves are started and the point where the chip is located, some of the energy would be absorbed in swaying the grasses; hence the effect upon the chip would not be so great, and the signalling distance would be lessened. Or if there were an

FIG. 1.—WAVE MOTION IN WATER.

obstruction in the path of the waves, as, for instance, a protruding rock, the waves would be distorted by this obstruction; hence less energy would reach the chip.

It is also obvious that any number of chips might be placed at any number of points within the affected radius of wave motion, and all would be moved by the waves.

When it is considered that these water waves cover an ever-increasing area as the circles expand, and that the actual energy which disturbs the chip is an extremely small part of the total energy in the entire circular wave, it should be clear why so great an amount of energy is required at a wireless sending station in order to operate a very sensitive receiver many miles away.

If we consider that the light chip resting upon the surface of the water has practically no inertia, it will respond to almost any wave length, and, therefore, if the water were disturbed from some other source than the stone referred to, and while signals were being sent by means of the stone, confusion would result, as the chip would respond to the waves from both sources, and, for this reason, no accurate signals could be made out by watching the motions of the chip. However, this difficulty may be overcome by employing a transmitting device which will send out waves of a certain length, and a receiving apparatus which shall respond only to the wave length of the transmitter.

4. SYNCHRONOUS WAVE MOTION AND TUNING

If a weight suspended by a spiral spring, or a rubber band, be given a blow so as to cause it to move up and down, the weight will oscillate uniformly; that is, a definite number of times per minute, the frequency depending upon the elasticity of the spring, or rubber band, and the weight of the suspended mass.

Now assume this device placed over the pond of still water, as depicted at the left in Fig. 2, and set in motion as described above. On each downward movement of the weight it will touch and disturb the water, and, since

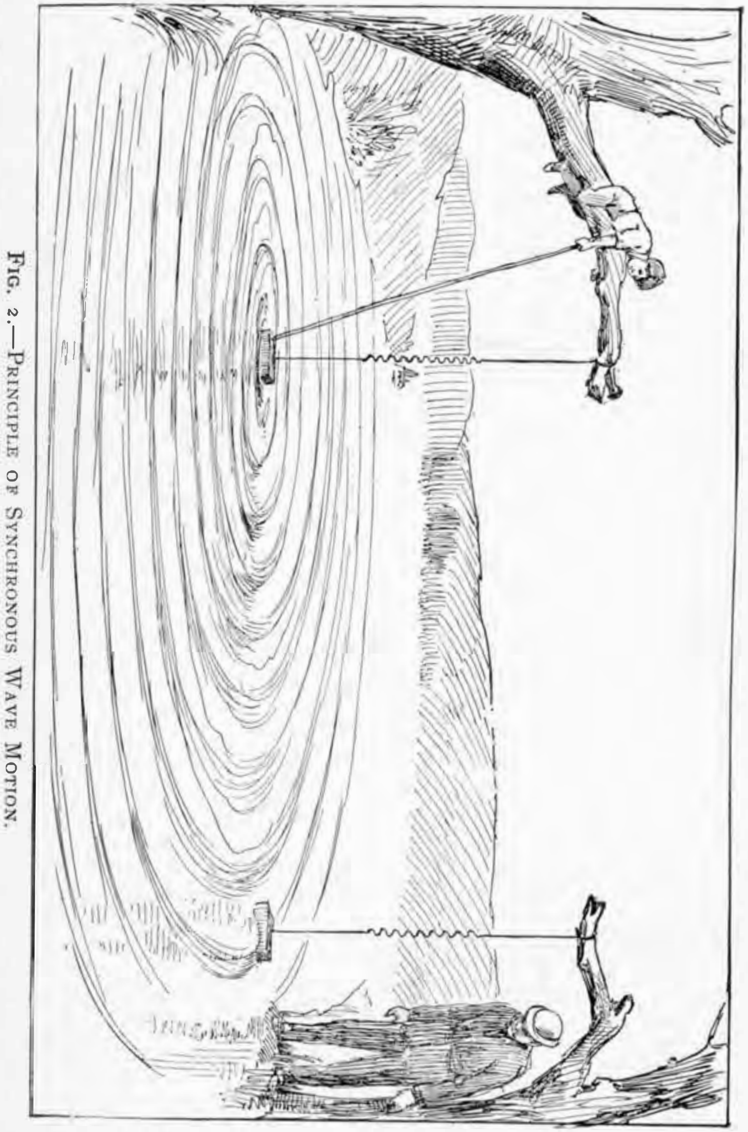

Fig. 2.—Principle of Synchronous Wave Motion.

it oscillates uniformly, it will create, or generate, a definite number of waves per minute, all being of uniform length and size.

If now we substitute a similar spring and weight for the chip as a receiving device (shown at the right in Fig. 2), and place this within the radius of the transmitted waves, these waves in passing will set it in motion, as it oscillates at exactly the same frequency as the transmitting weight. If the receiving device did not oscillate at the same rate as the transmitter, and, therefore, was not in harmony with the transmitted waves, these would tend to counteract any motion imparted to the receiving spring-suspended weight, as the following example should make clear. Assume the receiving weight to be of such dimensions that it will oscillate once per second. Now if the sending weight be generating waves at the rate of two per second, the first wave will give the receiving weight an upward motion at its own frequency; but just as it starts on its downward stroke, the second wave will strike it, thus preventing any further motion of the weight.

It is, therefore, evident that the oscillations of the receiving device would be destroyed if the frequency did not harmonize with that of the sending device. Tuning is absolutely necessary for the successful operation of wireless telegraphy, and it should be thoroughly understood before continuing.

5. THEORY

Wireless signals are a wave motion in, or disturbance of, the magnetic forces of the earth, and are propagated through this magnetic field, following the curvature of the earth, just as a tidal wave would follow the surface of the ocean. Practice indicates that the nodal points of the waves are at, or near, the earth's surface.

As explained in Chapter I, ether waves do not traverse all substances with like velocities; this explains why wireless signals are propagated many times farther over water than over land, as the waves traverse air and water at practically the same velocities. In land the waves travel at a much slower rate.

Now to produce, electrically, the results described by the analogy of water, we must employ means for creating waves in the earth's magnetic field, and use an electrical spring and weight, so to speak. The electrical spring effect is obtained by the electrical phenomena of *capacity*. Any surface of metal possesses capacity, which is the power to retain a charge of electricity. When this is disturbed it has the same elastic principle as the spring.

The inertia of the weight is represented, electrically, by the term *inductance*, which effect is produced when a constantly changing current is passed through a coil of wire. This causes the continually changing current to react upon itself, and, consequently, produces a retarding effect.

Referring to Fig. 3, let C represent a capacity connected to the ground MN through the adjustable inductance I. If means be employed to cause the residual charge of this capacity to oscillate, it will, in turn, cause a wave-like motion of the electromagnetic forces of the earth similar to the wave motion in water.

If either the capacity or inductance is increased, the vibrations will be slower, and the wave length will be

FIG. 3.—THEORY OF WIRELESS TELEGRAPHY.

greater. The waves thus generated are propagated through the earth's forces in ever-increasing circles, exactly as in the case of the water waves.

C' in Fig. 3 represents the receiving capacity connected to the ground through the inductance I', in the same manner as at the sending station. This capacity, of course, also contains a residual charge which is dormant under normal conditions, but as the wave front glides by the station, the rising and falling of the waves will impart a slight oscillatory motion to the residual charge.

Means for manifesting these oscillations permit us to correctly read all signals sent out from the transmitting station.

To clearly receive all signals transmitted from the sending station, it can be readily understood that the capacity and inductance must be adjusted to give exactly the same frequency; otherwise the natural frequency of the circuit would counteract the forced oscillations set up by the received waves, thus causing an interference or prevention of oscillations in this particular receiving station. Of course this would have no detrimental effect on other receiving stations which might be adjusted to harmonize with the waves.

CHAPTER III

THE APPARATUS USED

6. GENERAL OUTLINE

THE production of electromagnetic waves requires a source of current, means for interrupting a unidirectional current (or an alternating current may be used), means for changing the interrupted or alternating current into low-frequency high-pressure currents, means for transforming these into high-frequency high-pressure oscillations, and means for utilizing these oscillations to form the electromagnetic waves.

At the receiving station means must be provided for intercepting the waves, and retransforming them into electrical oscillations; means for detecting the enfeebled oscillations, and for manifesting and translating them into readable signals.

7. THE INDUCTION COIL

The function of the *induction coil* is to change, say, a battery current of low pressure and comparatively large flow, to a current of great pressure and small flow; or,

in other words, it transforms, or changes the character of, electrical energy.

An induction coil is shown in Fig. 7, at the left. This is also known as a Ruhmkorff coil in honor of its inventor. By its use electrical energy at pressures which might scarcely be felt even when placed across the tongue may be transformed into pressures so great as to render a person unconscious, or to even cause death.

Another form of induction coil is called a *transformer*. The Ruhmkorff coil is operated by means of an interrupted unidirectional current, while the transformer is operated by an alternating current, *i.e.*, a current which flows rapidly and alternately in opposite directions. Both of these devices are operated by, and consequently deliver, currents of very low frequency, as compared with the frequency required to generate the wireless waves.

8. LEYDEN-JAR BATTERY

A frequency of at least 100,000 vibrations per second is required to form the wireless waves, and since it is impossible to practically obtain this frequency by mechanical means, the Leyden jar is employed for this purpose. This device consists of two pieces of tin-foil separated and insulated from each other by glass, or other suitable material.

A group of these jars, when connected together, constitutes a *battery of Leyden jars*, which has the same effect as a much larger single jar. Instead of being in the form of a round jar, this device is sometimes made in a flat form; that is, the glass and, consequently, the sheets of foil are flat.

When the terminals of a Leyden jar are connected to a source of electrical energy, it will receive and retain a

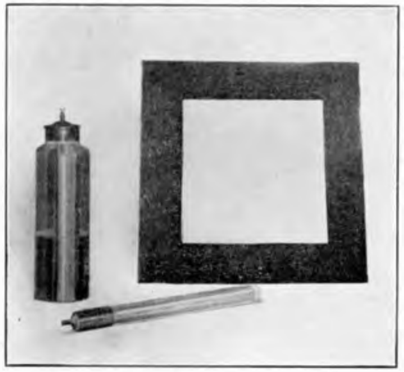

FIG. 4.—TYPES OF LEYDEN JARS.

charge equal in electrical pressure to that of the source of energy. If, after receiving a charge, its terminals be brought near one another, a sudden discharge takes place in the form of an electric spark which, while appearing to be single and momentary, has been found by experiment to consist of a series of alternating flashes in rapid succession, each flash lasting less than one hundred thousandth part of a second. The frequency of these oscillations is regulated by the capacity, or size,

of the Leyden jar; the smaller the capacity, the greater the frequency.

The oscillatory discharge of the Leyden jar was first noticed by Prof. Joseph Henry in 1842. Von Helmholtz in 1847 said: "We assume that the discharge of a Leyden jar is not a simple motion of the electricity in one direction, but a back-and-forward motion between the coat-

FIG. 5.—BATTERY OF LEYDEN JARS.

ings in oscillation, which becomes continually smaller until the entire *vis viva* is destroyed by the sum of the resistances." In 1853 Lord Kelvin proved the oscillatory discharge mathematically, and in 1859 Feddersen demonstrated it experimentally, by employing a rapidly revolving mirror.

9. THE SPARK-GAP

The device through which the oscillatory discharge of the Leyden jars takes place is known as the *spark-gap*. This consists of two metal rods insulated from one another, and with their ends about one inch apart, although this

FIG. 6.—SPARK-GAP WITH MUFFLER, SURROUNDED BY INDUCTANCE.

distance may be varied at will by means of an adjusting device.

As the high-frequency discharge across the spark-gap emits a loud, crashing sound, it is usually surrounded

by a "muffler" to deaden the noise. The muffler is shown in Fig. 6, and is provided with peep holes, in which glass or mica is set, in order that the operator may at all times be able to watch the condition of the "spark."

10. PRODUCTION OF OSCILLATORY DISCHARGE

In Fig. 7 is shown the induction coil, Leyden jars, and spark-gap properly connected to produce the oscillatory

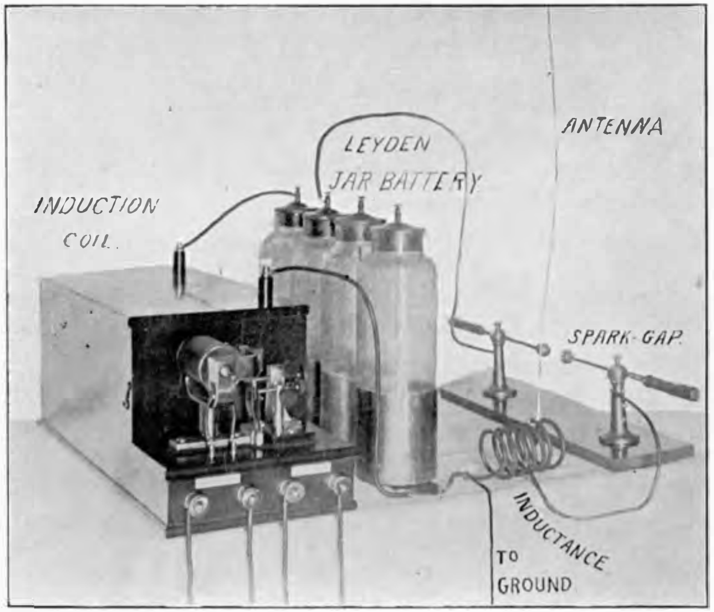

FIG. 7.—CONNECTIONS OF APPARATUS TO PRODUCE THE OSCILLATORY DISCHARGE.

discharge. This takes place in the following manner. In Art. 7 we explained how, by means of the induction coil or transformer, a current of low pressure is transformed into a current of high pressure, but of low frequency, and this high-pressure current is utilized to charge the Leyden jars.

When the Leyden jars are fully charged (which action takes place almost instantaneously), the resistance of the spark-gap is "broken down," and the oscillatory discharge takes place between the points of the spark-gap.

II. THE INDUCTANCE

In order to successfully utilize the high-frequency oscillations due to the discharge of the Leyden jars across the spark-gap, a controlling device is necessary which shall vary the electrical inertia of the circuit into which these oscillations are to be delivered.

Adjustment is obtained by varying the number of turns of wire in the oscillating circuit. In Fig. 7 the inductance is represented by the spirals in the connecting wire between the Leyden jars and the spark-gap. In practice the inductance usually consists of a dozen or so turns of copper wire, about $\frac{1}{8}$ inch in diameter, wound spirally around a wooden frame. In Fig. 6 the inductance is shown placed around the spark-gap; this, however, is simply a matter of design.

Referring again to Fig. 7, one side of the inductance is permanently connected to the ground. There are two other wires flexibly connected to the inductance,

one of which is connected to the spark-gap; the other is the *antenna*. These wires are so arranged that they

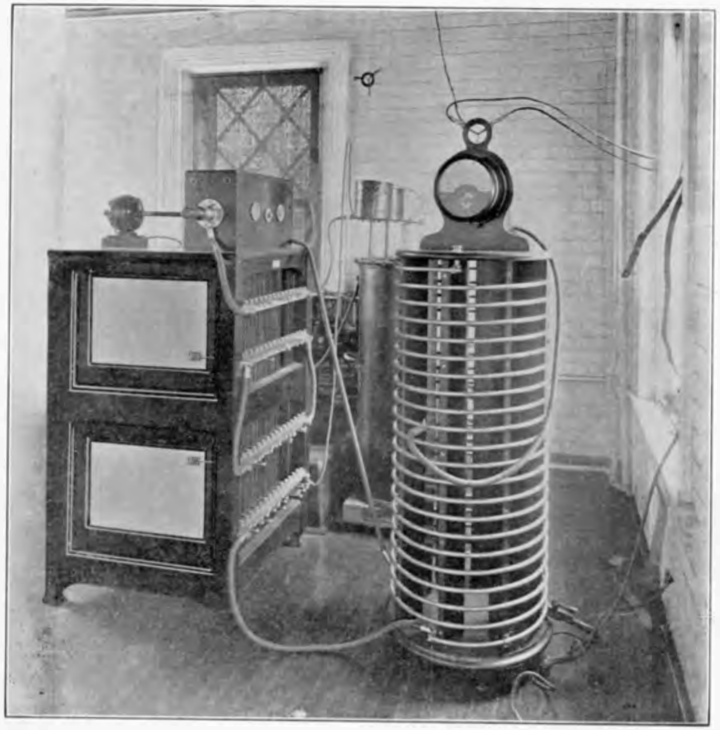

FIG. 8. — HIGH-POWER OUTFIT, WITH ROTATING SPARK-GAP MOUNTED ON LEYDEN-JAR BATTERY FRAME, AND HOT-WIRE CURRENT METER MOUNTED ON INDUCTANCE FRAME. —*Navy Yard, Washington, D. C.*

may be connected to any point on the spirally wound wire of the inductance.

12. THE ANTENNA

What is probably the most striking characteristic of a shore station is the very tall mast which towers above the operating building. This mast supports a wire, or group of wires, known as the *antenna*.

The antenna possesses electrical capacity (also inductance), and, therefore, when connected with other apparatus, as in Fig. 7, it disturbs the earth's magnetic field, as was fully described in Art. 5.

The antenna is connected to the inductance through one of the flexible connections, as shown in Fig. 7. The length of the antenna varies according to conditions, the supporting mast in some cases being nearly 200 feet high, and in at least one case the height is 418 feet. The antenna is sometimes attached to captive baloons or to kites, and suspended in this manner for temporary service, as in military operations. On boats the antenna is attached to the masts.

13. TUNING THE TRANSMITTING APPARATUS

As explained in Art. 5, it is necessary to have the oscillations of the Leyden jars in synchronism with the antenna circuit. The adjustment is made on the inductance coil as shown in Fig. 7. It can be readily seen that the Leyden jars and antenna circuits can be adjusted independently of one another, but always having more or less

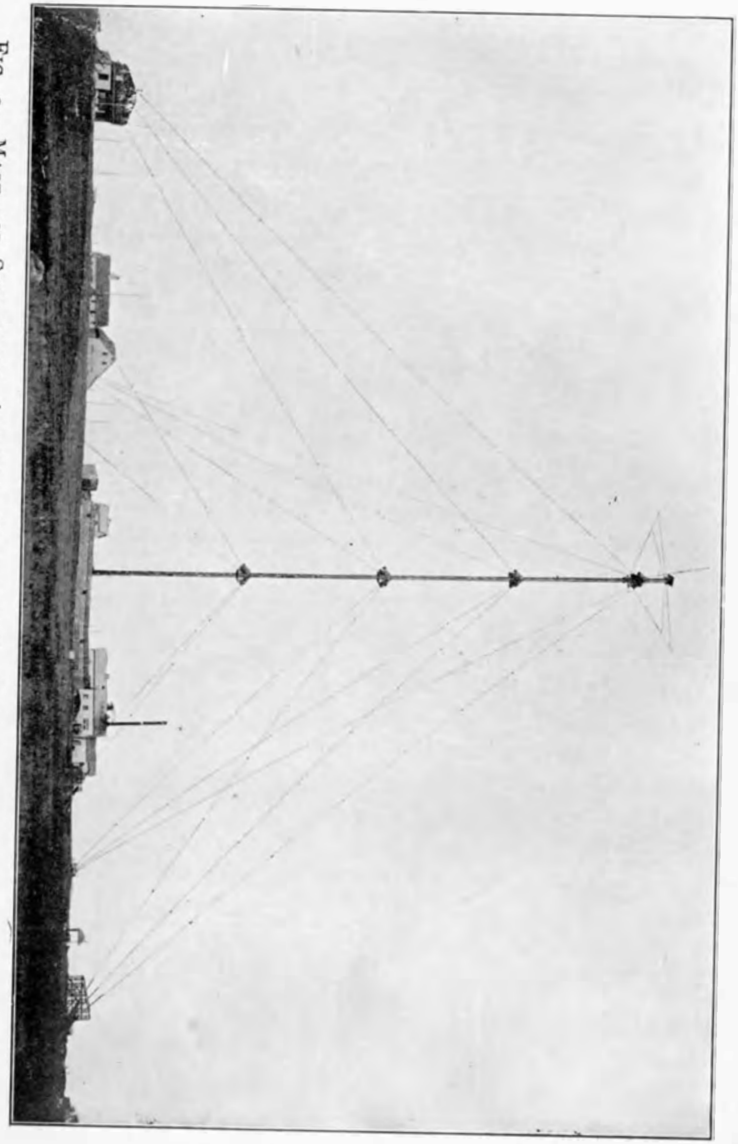

Fig. 9.—Mast for Supporting Antenna, Fessenden Trans-Atlantic Station, Brant Rock, Mass.

turns of the inductance coil common to both circuits When the two circuits are adjusted to the same frequency, the discharge of the Leyden jars, through the few turns of wire in the inductance, will induce oscillations in the

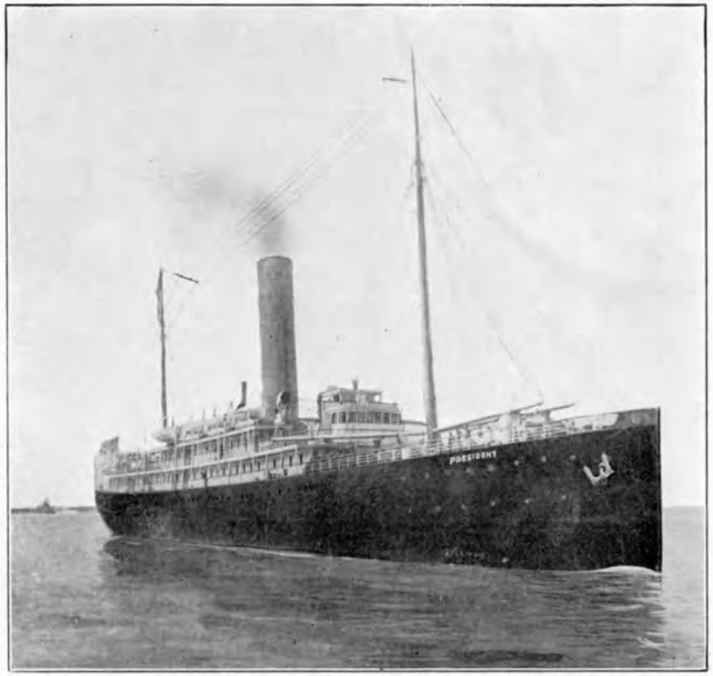

FIG. 10.—METHOD OF SUSPENDING ANTENNA BETWEEN MASTS OF VESSELS.

antenna, which in turn cause the disturbance in the magnetic field of the earth.

There are several means by which it may be determined when the two circuits are in harmony with one

another. One method is to insert a hot-wire current meter between the antenna and the inductance, which will indicate the strength of the oscillatory current set up in the same. By manipulating the flexible connections, a maximum reading will be obtained, which will indicate that the two circuits are in synchronism.

In the other method a device is used which accurately indicates the wave length. With this instrument the frequency of one circuit can be measured, and then the other circuit adjusted to give a corresponding wave length.

Since the wave length is dependent on the frequency of oscillations, which in turn is dependent upon the capacity and inductance of the oscillatory circuits, it should be clear that the larger the antenna, the longer will be the wave length, and, necessarily, the greater the capacity of the Leyden jars. The power required is always in proportion to the wave length; that is, for the most efficient results.

In practice it is customary to use a short wave length for low-power short-distance equipments, and a long wave length for high-power long-distance systems. This may be readily understood when we consider that more energy is required to make long, deep waves in water, than is required for the short and shallow waves.

14. THE RECEIVING APPARATUS

While some wireless systems employ separate antennæ for sending and receiving the messages, the same antenna is used for both purposes in most cases, and we may, therefore, describe the receiving apparatus in the inverse order of the transmitting system.

Art. 5 explains how the oscillations are set up in the receiving antenna and, also, how they must be adjusted

FIG. 11.—MICROPHONE WITH TELEPHONE RECEIVERS CONNECTED.

to the same frequency as that of the passing waves from the transmitting station. Referring to Fig. 3, C' represents the antenna connected through the adjustable inductance I'. Adjustably connected with this inductance is also a small capacity, called a *condenser*, which with the inductance forms a closed oscillating circuit. The vibratory motion in the antenna is adjusted by moving the connection y. The frequency of the closed circuit is adjusted by changing the position of point x. In

practice the condenser is also adjustable so as to increase the range of wave length.

When the two circuits are adjusted to harmonize with the received waves, an electrical pressure is created in the condenser, which pressure can be detected and made manifest by suitable apparatus. This part of the system is called a *detector*.

15. DETECTORS

The function of the detector is to respond to, and make manifest in some manner, the electric oscillations set up

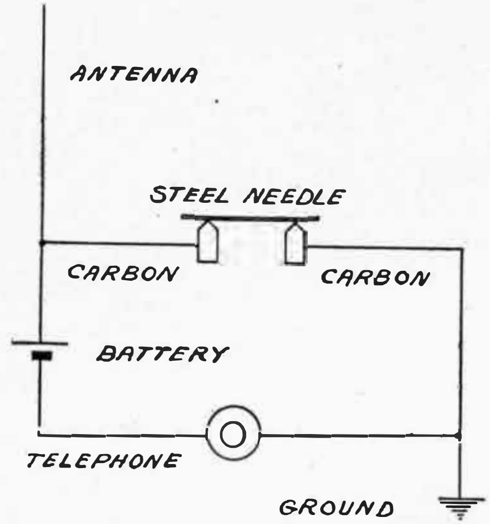

FIG. 12.—MICROPHONE CONNECTIONS.

in the receiving circuits. There are many devices that will serve this purpose. They are used in connection with a telephone receiver, the telephone being sensitive to very weak currents of electricity, which are made manifest by a "noise" in the telephone receiver. This

FIG. 13.—DETECTOR MOUNTED ON WAVE METER.

noise, or buzzing sound, corresponds to the sound of the spark at the sending station; thus an operator may often recognize a distant station by the sound of the "spark" in his telephone receiver.

One type of detector is known as the *Microphone.*

This, in one of its simplest forms, comprises two blocks of carbon with sharp edges, across which rests a steel needle. This type is illustrated in Fig. 11, and its simplest connections are shown in Fig. 12. The steel needle resting across the carbon blocks forms an imperfect contact. When the high-frequency oscillations pass through the carbons and the needle, the contact is greatly improved,

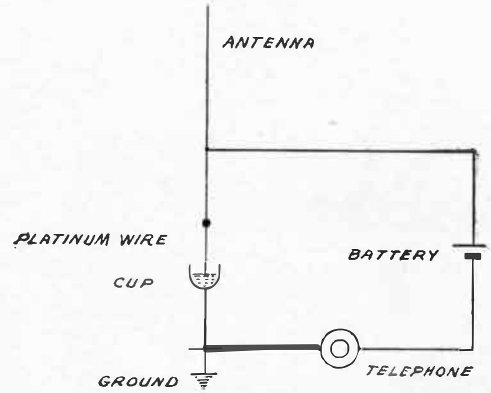

FIG. 14.—CONNECTIONS OF ELECTROLYTIC DETECTOR.

with the result that the local battery current will be strengthened in nearly direct ratio to the improved contact. This change of current causes a sound in the telephone receiver.

Another type used in connection with the telephone receiver is called the *Electrolytic Detector.* This consists of a small cup containing nitric or other acid, into which the end of a very fine platinum wire is slightly immersed. Fig. 14 shows the principle. It will be observed that the connections are very similar, although the principle is quite different from that of the microphone. In the electrolytic detector, a film of gas forms between the end of the platinum wire and the acid, which acid is a conductor of electricity. This film of gas insulates the plati-

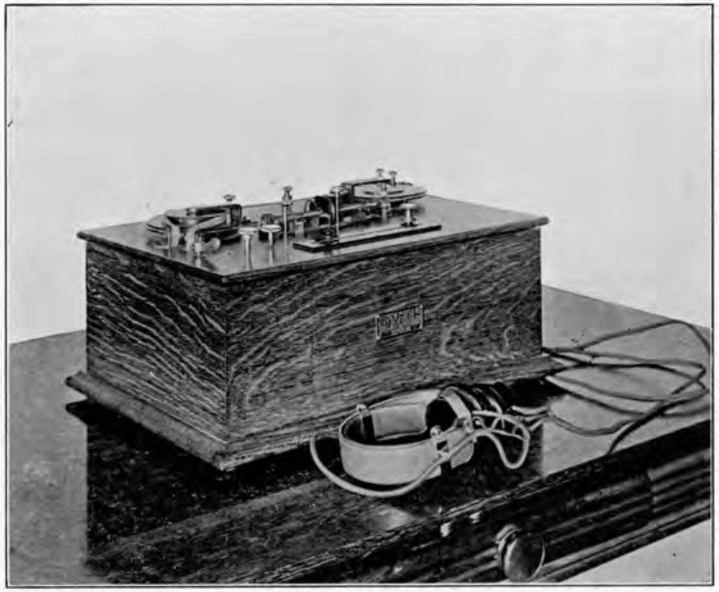

FIG. 15.—MAGNETIC DETECTOR.

num wire from the acid. Hence there will be practically no current flowing through the telephone receiver. In the presence of the high-frequency oscillations, however, the resistance of the gas film is reduced, which allows an increased battery current to flow through the telephone receiver. The sudden rush of the battery current through

the telephone receiver produces sound, as already described.

The platinum wire employed in the electrolytic detector

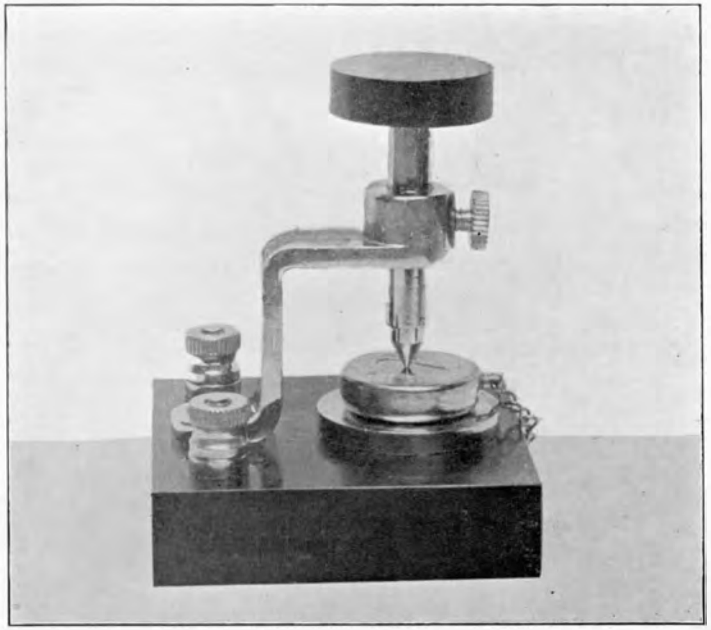

FIG. 16.—SILICON DETECTOR.

is so fine, and the method of its manufacture so unique, that we here describe it.

A heavy platinum wire approximately one one-hundredth of an inch in diameter is coated with a suitable thickness of silver. The combined silver and platinum wire is then drawn down to the desired diameter. The close-fitting silver jacket prevents the rupturing of the platinum wire within during the drawing process. The silver is then removed by immersing in nitric acid, which leaves the platinum only. Platinum wires have thus been drawn down to .00006 of an inch.

Another type, known as the *Magnetic Detector*, is based upon the phenomena that certain magnetic characteris-

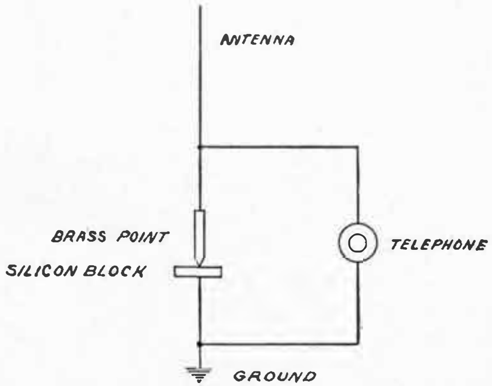

FIG. 17.—CONNECTIONS OF SILICON DETECTOR.

tics in iron undergo a change under the influence of the high-frequency oscillations. This detector is illustrated in Fig. 15. It requires no local battery, but must be rotated by means of clockwork or a small electric motor. The regular telephone receiver is also used with this detector.

What is probably the simplest type of all is known as the *Silicon Detector*.* This consists of a piece of silicon

* Patented by Prof. G. W. Pickard.

with a brass point resting against it. In the presence of the high-frequency oscillations, the particles at the point of contact are heated, which causes a sound in the telephone receiver. The silicon detector is illustrated in Fig. 16, and Fig. 17 shows its connections.

CHAPTER IV

METHOD OF OPERATING

16. SWITCHING DEVICE

WHILE, as before stated, in some cases separate antennæ are used for sending and receiving, it is common practice to use the same antenna for both. This is accomplished by means of a switching device so arranged that when the transmitter is connected in, the receiver is cut out. This is absolutely necessary, as otherwise the delicate receiving apparatus would be destroyed should the high-power currents of the transmitter pass through it.

17. SENDING THE MESSAGE

In Fig. 18 are shown several types of *keys* used in wireless telegraphy. The operator sends the message by pressing the key lever downward, or allowing it to remain up for certain periods of time. Pressing the key lever downward for a brief interval represents a dot, and a longer period of depression, a dash. The proper arrangement of dots and dashes forms letters, and combinations of letters of course form words, etc., the letters being

spaced by holding the key lever up for a given period of time, and the words being spaced by still longer periods.

The proper arrangement of the dots, dashes, and spaces constitutes a *code*. The Morse code is extensively used in America, while a modification of it, called the Continental code, is employed in England and on the

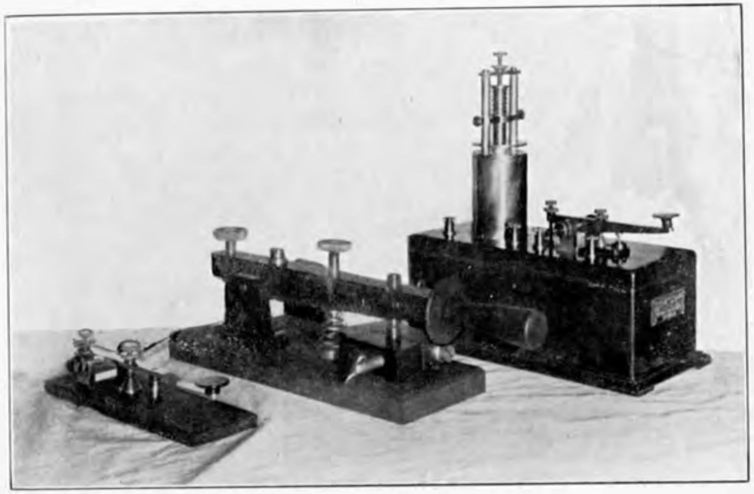

FIG. 18.—TYPES OF KEYS.

continent of Europe. These are shown in Fig 19. When the key lever is depressed, two insulated pieces of platinum, called contacts, touch one another, closing the low-pressure circuit of the induction coil or transformer.

When an operator desires to communicate with another station, he first "listens in" by connecting his receiving system with the antenna and the ground, and placing the telephone receiver to his ears. He then adjusts his receiving circuits for various wave lengths and, if he hears no signals, he assumes that no one else is sending within his radius. He therefore "throws in" the transmitting apparatus, which action automatically disconnects the receiving side. He then sends the letters which constitute the "call" of the station desired, signing the letters designating his own station, after sending the call several times. He then listens in again, and if the operator at the desired station has heard his call, the latter answers, and regular telegraphic communication ensues.

Some wireless systems are so arranged that no switching is necessary. The operators can "break" one another, by keeping the telephone receivers over their ears all the time. If the receiving operator should wish to correct the sender, he does so by pressing his key; this is heard by the sending operator when his key is in normal position.

Tuning not only increases the radius of operation, but maintains secrecy as well. By means of careful tuning, two distant stations may be sending simultaneously, and if they employ different wave lengths, the operator at the receiving station may, by adjusting his apparatus to the wave length of the station with which he desires to communicate, "tune out" the other message, receiving only the one desired.

However, if the stations above referred to be quite

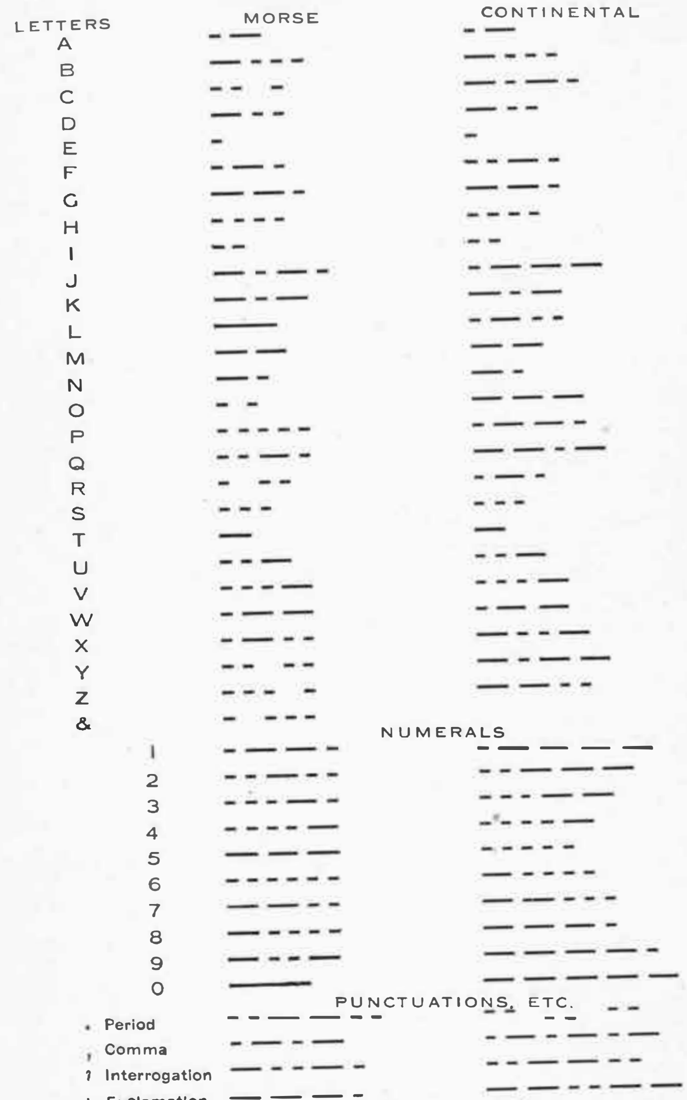

FIG. 19.—WIRELESS TELEGRAPH CODES.

near one another, as in the case of two or more boats passing a shore station, the operator may not be able to tune out the undesired party, owing to their proximity, and the apparatus is then said to be operated by "forced oscillations." Nevertheless an operator may receive the desired message by concentrating his mind upon the sound of the "spark" of the desired transmitting station, but this may only be done when the sounds of the "sparks" are dissimilar, or one is louder than another, owing to different strengths, or to varying distances.

CHAPTER V

HISTORICAL

18. EARLY ATTEMPTS

Attempts to establish communication electrically through a natural medium (that is, without the use of a wire connecting the stations) were made in the beginning of the nineteenth century.

Some inventors worked on the principle of the conducting power of the earth, and others upon the principle of electrostatic or electromagnetic induction. Of these latter types the Phelps and Edison systems were devised with a view of telegraphing to moving trains, while the Preece system was employed to communicate between an island and the mainland, utilizing both of the above principles.

The vertical aerial wire was first employed by Dolbear in 1886 in connection with a peculiar conduction system. Mr. Edison in 1891 proposed to support vertical wires by captive baloons, in connection with an induction telegraph.

Thus it is seen that the antenna (or vertical wire, as it was then called) was proposed before the principle of the real wireless telegraph was discovered, as the following retrospect will show.

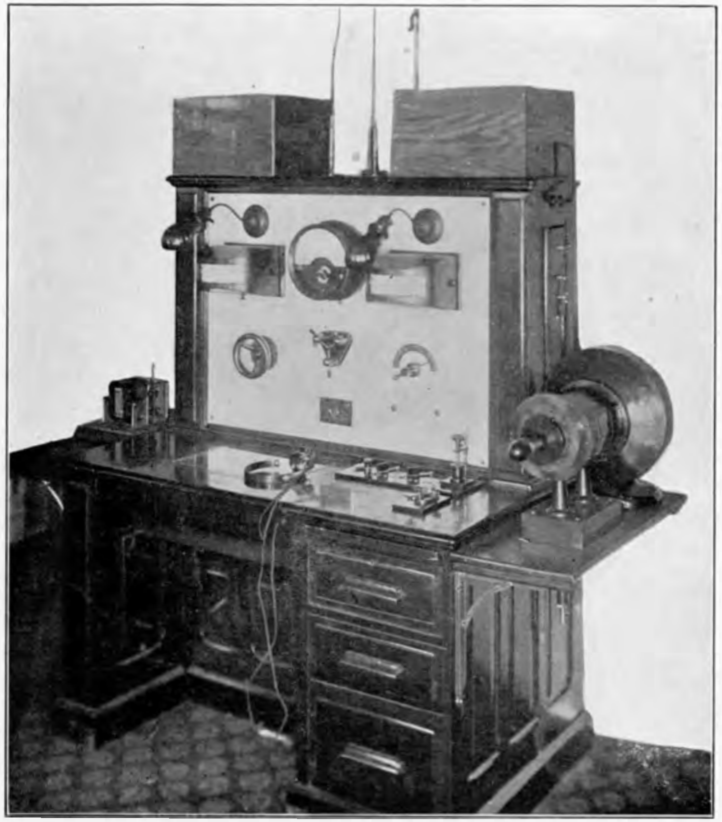

FIG. 20.—WIRELESS OPERATOR'S DESK, SIGNAL CORPS U. S. A.

19. DEVELOPMENT OF WIRELESS

Although Clerk-Maxwell proved the electromagnetic theory of light, mathematically, in 1864, it was not experimentally demonstrated that electric waves exist in free ether until 1888, when this great discovery was made by Professor Hertz.

The apparatus used by Professor Hertz, to generate the high-frequency oscillations, was, naturally, a simplified form of the generating apparatus of to-day, but without any antenna or ground connections. For a detector he employed a loop of wire with the ends nearly touching one another. When the generator, or "oscillator," was set in operation, and the loop of wire was held near it, minute electric sparks were seen to pass between the ends of the wire constituting the loop, and the existence of the free ether waves was thus proved.

So great a discovery naturally set scientists, the world over, to experimenting, and in 1890 Dr. Branly discovered that loose metal filings, which normally have a high resistance, become fairly good conductors of electricity in the presence of electric oscillations. Dr. Branly demonstrated this by placing the filings between metal plugs in a glass tube, the device (which he called a Radio-Conductor) being connected in circuit with a battery and electric indicator. Professor Lodge called the Branly device a Coherer, and as it was found to be more sensitive than the Hertz detector, Professor Lodge combined the Hertz oscillator with the coherer in 1894, this forming the first complete wireless set.

In 1895 Count Popoff attached a vertical wire to one side of the coherer of the Lodge receiver, and connected

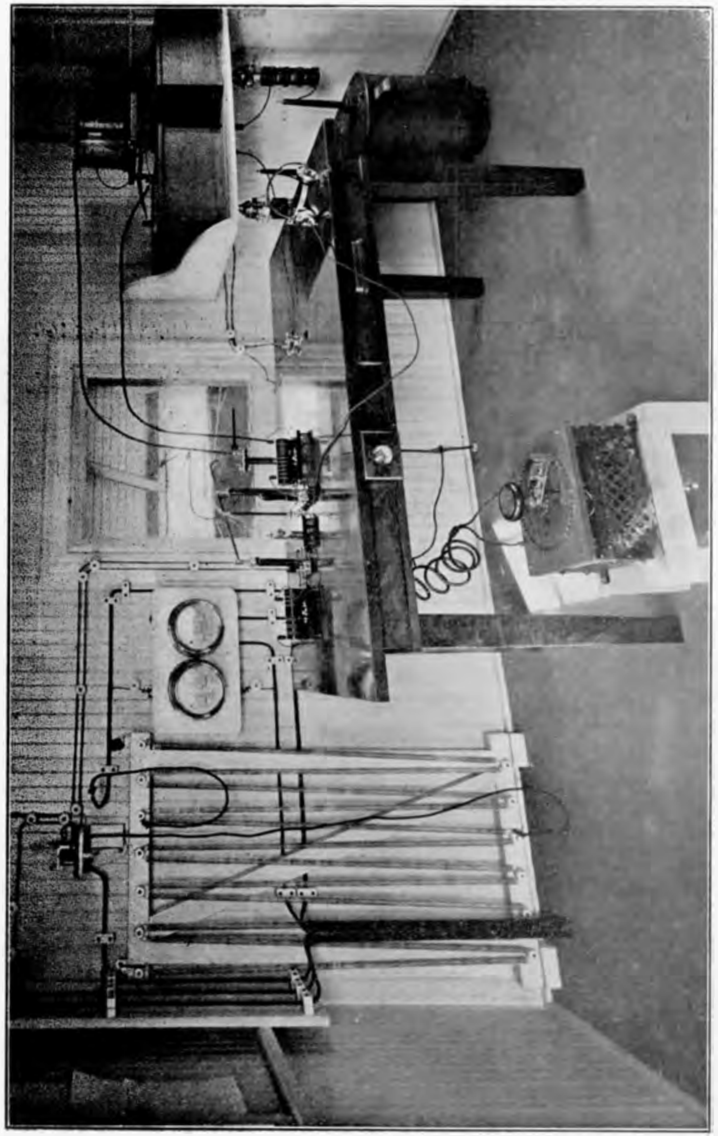

Fig. 21.—Interior of Experimental Wireless Station.

the other side to the ground. This device was used in meteorological work to detect the approach of thunderstorms. He was, therefore, the first to use an antenna in connection with the real wireless telegraph.

Having thus increased the working range of the receiver, it only remained to connect an antenna to the transmitter; this was done by Marconi in 1896. Since that time improvements have been made in the transmitting and receiving devices, and the distances of communication have been increased from a few hundred feet to several thousand miles.

The development of very sensitive detectors has had much to do with the progress of wireless telegraphy. The Fessenden *electrolytic* detector is, probably, the most efficient type.

Nikola Tesla has rendered important service in the development of high-frequency apparatus, and is now experimenting with a system to transmit power without the use of wires.

CHAPTER VI

THE USES OF WIRELESS TELEGRAPHY

20. PUBLIC SERVICE

THAT branch of the wireless service which probably appeals most to the reader is the public service. A comparatively few years ago, when the tourist bade his friends adieu as the steamer started on its ocean voyage, it was with the knowledge that they and the rest of the world would be as dead to him until he should arrive at his destination, at some distant port across the ocean, or, perhaps, far down the coast. Important events might develop in his business, or other personal matters come up, which only he could control; yet he would remain in absolute ignorance of the facts until the steamer arrived in port, when it might be too late for him to do anything to advantage in the matter.

Wireless telegraphy has changed all this, however. The tourist crossing the ocean, or the business man travelling along the coast, goes with a feeling of perfect security. He goes with the knowledge that he may keep in constant touch with his family and his business, and may even

send social messages just for the novelty of it. If he is delayed by fog or snow-storm on a short trip, he sends a "wireless," stating the facts, and making a new appointment, and the probable time of his arrival.

But the use of wireless telegraphy, which should appeal

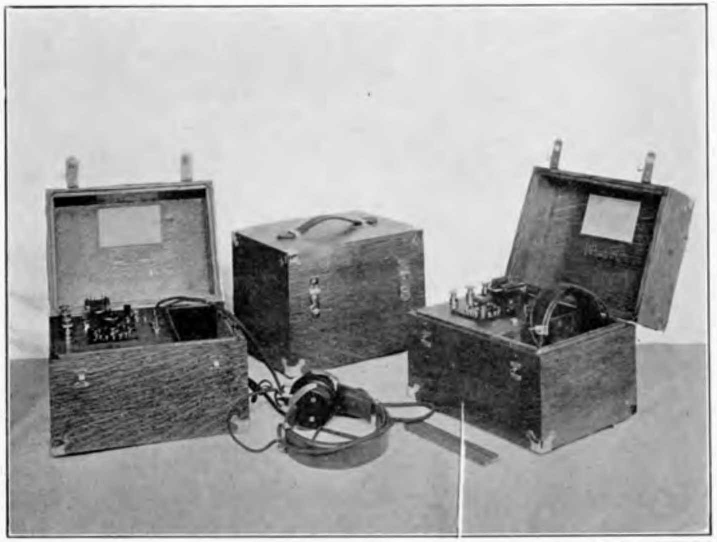

FIG. 22.—PORTABLE RECEIVING OUTFITS.

the strongest to the travelling public, is its inestimable value in case of accident.

21. VALUE TO SHIPOWNERS

What mostly concerns owners of vessels is the fact that their steamers may keep in constant communication with the office of the steamship company, and in case of accident assistance may be secured very quickly, by appealing to other vessels which may be within useful distance, or through shore stations.

When the operator on a coastwise steamer is reporting to the shore station at regular intervals, it gives assurance that if anything should happen to the steamer, aid would be quickly forthcoming, and the lives of the passengers and crew would be saved, as would also the hundreds of thousands of dollars represented in the steamer and valuable cargo.

This gives the passengers an assurance of safety, and the owners and Marine Insurance Companies a knowledge of increased protection; hence the owners should have less insurance to pay.

When equipped with the wireless telegraph, a tug may take in tow, say, several barges laden with coal, from a southern port, and proceed northward along the coast, the captain having not the slightest idea where the coal will be sold. The agents are busy, however, and soon the captain receives an order by wireless where to drop a portion of his tow. After making this delivery, he proceeds on his way, and receives his wireless orders from time to time, until all his coal is disposed of. Had it not been for the wireless, he could not have proceeded until all, or at least a part, of the coal was sold; thus much time and money may be saved.

Again, a steamer might proceed from a southern to a northern port in winter, and after the vessel was well up the coast, news might be received at the steamship office

that the harbor of destination was ice-bound. A short message by wireless would halt the steamer, thereby saving much coal and other expense.

22. TELEGRAPHING OVER LAND

While greater distances may be covered by wireless telegraph over water, as was explained in Art. 5, it is also

FIG. 23.—PORTABLE SIGNAL CORPS U. S. A. OUTFIT "ON THE MARCH."

used to a considerable extent in telegraphing over land. While as yet it has not entered into very active competition with the regular wire service, it fills a great demand in communicating over wild countries, where the installation and maintenance of a regular telegraph or telephone line would be impracticable. It is also much cheaper

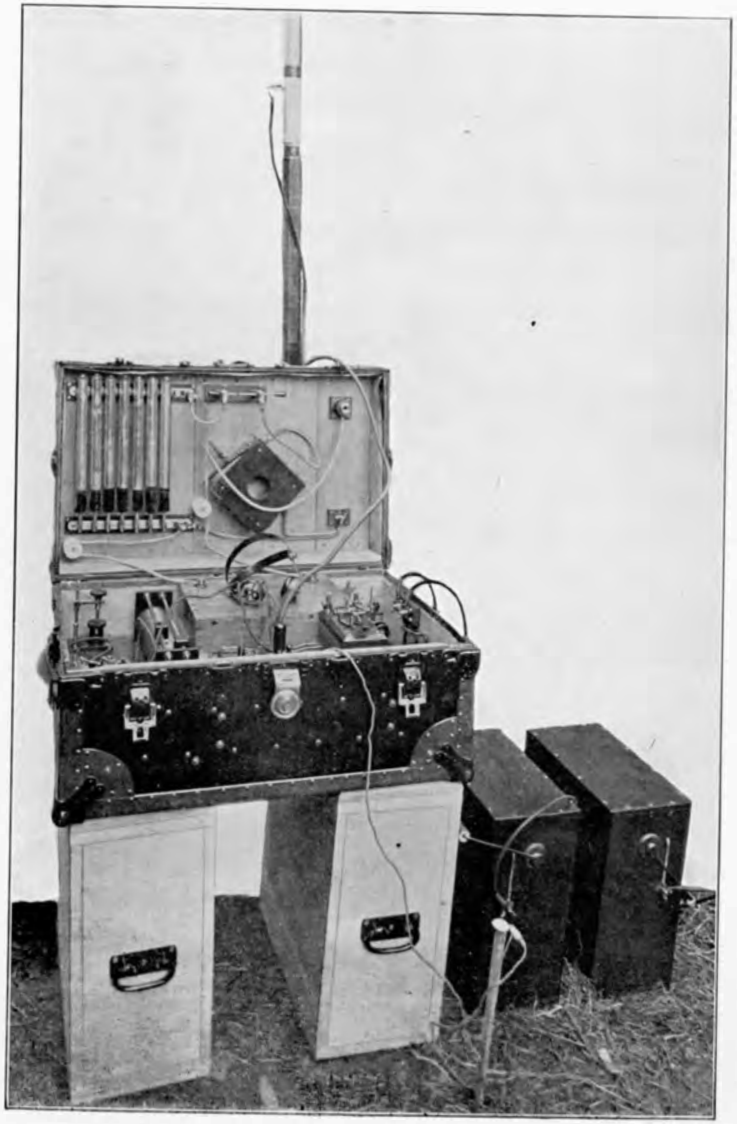

FIG. 24.—PORTABLE SIGNAL CORPS U. S. A. OUTFIT "READY FOR BUSINESS."

than the wire equipments, where the volume of business is not too great, and the distance warrants its use.

Excellent results are reported from Alaska, where a wire equipment would be well-nigh impossible, owing to the heavy sleet and snow-storms, and to the further fact that

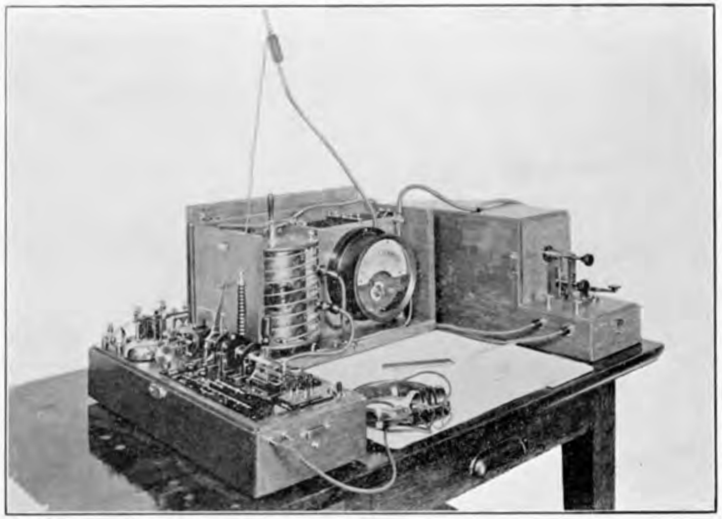

FIG. 25.—COMPLETE PORTABLE OUTFIT.

the natives steal the wires. It is but natural that the wireless should be installed in districts where there has previously been no telegraph system whatever, and for this reason its use is common in sections like Central and South America.

No force of linemen is required in connection with a wireless equipment, and so long as the station itself remains in working order, floods, snow-storms, tornadoes, and even earthquakes may occur without interfering with the wireless service, while any of the above disturbances usually suspend the wire business for days at a time, and communication is restored only after a considerable outlay of money.

In military operations portable outfits are used which may be set up, and messages transmitted and received upon a few minutes' notice, while on the march or on the battle-field. Before the advent of wireless telegraphy, it was necessary to string wires over long distances and at great risk, and even then the enemy might at any moment cut the wires.

Now that wireless has entered the field of commercial competition with the trans-Atlantic cables, its progress will be watched with the greatest interest.

CHAPTER VII

POSSIBILITIES AND ABUSES* OF WIRELESS TELEGRAPHY

23. COMMERCIAL CONDITIONS

To state that the wireless telegraph of to-day can produce no better results than is being accomplished practically, is erroneous in every sense of the word. Experimentally, wireless telegraphy is far in advance of the practical work.

The faith of investors in wireless has been greatly shaken by their bitter experience with worthless wireless stock, which they were induced to purchase through the gross misstatements of certain stock companies, and their continued efforts to unload this stock upon an innocent public.

This has, naturally, brought about a period of inactivity as regards the extension of wireless telegraphy, for loss of confidence will cause the suspension of even the oldest and most firmly established business of any character.

* See article by Frank Fayant in Success Magazine, June, 1907.

Financiers who ordinarily would be eager to grasp an opportunity of this kind now have no faith in the commercial prospects of wireless, as certain stock companies have not used the proceeds from the sale of stock in the development of their business.

The officers and directors of telegraph and cable companies have also done a great deal to bring about the present conditions, by making statements which they knew to be wrong; but no doubt they felt they were justified in thus protecting their own interests. This is decidedly a very poor policy on their part, as they could greatly increase the value and earning power of their stock by utilizing wireless telegraphy in connection with their present service. However, their continued antagonism is only tending to force the wireless companies to take the initiative in establishing a service that will prove a powerful and successful competitor. The telegraph and cable companies should bear in mind the opposition with which the efforts of Morse and Field were met in the early days of the arts of land-wire and cable telegraphy.

24. THE PRESENT STATE OF THE ART

Wireless telegraph to-day is in practical use over both sea and land. The ocean liners, as well as the coastwise vessels, keep in constant communication with land stations, and thus render valuable service both to ship-

owners and the public. It is in use over land, contrary to statements of those who are foolishly trying to belittle the art, and as an example we will site the government stations at Washington, D. C., and Brooklyn Navy Yards, which stations are in constant communication both day and night, and can work with each other regardless of the interference of surrounding stations. This is by no means the limit of what can be done over land.

Regardless of any statement to the contrary, wireless telegraphy is not limited to one line of communication between two points. It may be duplexed; that is, two or more messages may be sent and received simultaneously. It can successfully compete with cables on all points.

It is true that some of the stock companies have established communication over great distances of water, but results obtained with such installations should not be accepted as conclusive proof of what can be done, as these stations were installed more with an object of bolstering up their stock, than any intention of establishing a sound commercial business.

The high-power stations of these companies are equipped with crude apparatus, that is more crudely installed, and depend more on the high power of their stations, than on perfected apparatus, to establish communication. Stations of one of the stock companies are equipped with 500-horsepower apparatus, which is used to communicate over a distance of less than 2000 miles, while one of our well-known inventors, representing a close corporation, has communicated over a distance of 3300 miles with less than 40 horsepower.

The Marine Insurance Companies are also doing their share towards belittling the value of wireless telegraphy, for although it can be proved that it has saved them thousands and thousands of dollars, they refuse to acknowledge it to be a safeguard to vessels, and will not lower the insurance rates to vessels equipped with wireless apparatus.

To cite a case: On a recent trip the steamer *City of Puebla* encountered a vessel that met with a mishap and was floundering about in the sea in a helpless condition. A wireless message was at once despatched to the nearest life-saving station, and in due time assistance arrived. The position of the floundered vessel was such that a vessel of heavy draught, such as the *City of Puebla*, could be of no assistance. In answer to the despatch a light vessel was sent out and the vessel and crew were saved from destruction.

Some of the coastwise vessels on the Pacific coast have repeatedly communicated with the government stations over distances ranging from 1600 to 2200 miles, with only a 4-horsepower outfit. This shows very clearly the difference in work, and results accomplished, between the stock companies and the close corporations.

25. INTERFERENCE AND GOVERNMENT REGULATION

There has been much discussion regarding the regulations of wireless by governments, owing to the value of the art in time of war. For this reason certain governments have proposed to control and regulate the transmission of wireless messages at all times, which action would necessitate a license on the part of an operating company for each station equipped and in operation. Moreover, the government would have the right to grant or refuse such license as it saw fit.

This agitation has been caused by legitimate wireless companies transmitting messages at a time when it would be convenient for the government stations to transmit messages, but owing to the fact that the wave lengths of the government and the independent stations were approximately the same, or owing to the proximity of the stations, it was impossible for both the government and independent stations to operate simultaneously.

The question then arises whether, in time of peace. regular commerical wireless messages, which protect the lives of the passengers and crews of the steamers equipped with wireless, are not just as important as government wireless messages. If competing wireless companies have to wait for one another to transmit their messages, there appears to be no good reason why the government cannot do the same—in time of peace.

It would be interesting to know whether the various government officials are acting blindly, or are knowingly attempting to force legislation which will have the immediate effect of arresting the development of a valuable art and deprive the public of a service that would in time give them trans-oceanic telegraphy at one-tenth the rates now paid for cable service.

This agitation, which would give the government full control of the wireless field, deals with existing conditions without considering the fact that wireless is still in its infancy, and is making enormous strides towards perfection each year.

Where would our telegraph service be to-day had the government taken control of it in the forties, and said there could be only one wire between two places? It is true there is a great deal of interference between wireless stations to-day, but is it to the best interests of all to have the government take control and say there shall be only one station in a locality, for the reason that another near-by station would cause interference?

It would be far better to let the situation stand as it is, and give inventors an opportunity to overcome the present difficulties; and from our practical experience in this field, we believe that it will not be many months before this is accomplished. Under such an act we would be compelled to go to the government for a license whenever we wished to build a station, in which case a permit would be granted if the station was to be in a locality distant from other stations.

For instance, assume that we should desire to establish an independent trans-Atlantic wireless service, and we should apply to the government for a permit, the locality being, say, somewhere on the New England coast. There are already numerous stations the entire length of the coast, and if we were fortunate enough to obtain a permit at all, it would be with restrictions to hours during which none of the other stations would care to operate. Moreover, is it to be supposed that the telegraph and cable companies would, should a law controlling wireless be enacted, remain passive and allow us to establish trans-Atlantic service, when a protest and a little influence used in Washington would prevent it?

The telegraph and cable companies have been very persistent in publicly ignoring wireless telegraphy as a competitor, but a recent circular issued to the managers of all its offices by the Western Union Telegraph Company indicates the real attitude. In this circular it is ordered that all messages offered by the Marconi Company for transmission to points on this side must be treated as local messages, be dated at Glace Bay, N. B., and be charged for at the local rate. "Code messages cannot be accepted in such messages, which must be fully addressed in accordance with the rules governing the transmission of domestic messages. If the Marconi wishes to give any indication of other origin, they must do so in the body of the message. The message must be checked at full commercial rate, whether addressed to a newspaper, individual, or firm. Messages addressed to parties on the other side, routed via Marconi wireless or Glace Bay, cannot be accepted. We will, however, of course accept messages addressed to the Marconi Company, or any one else at Glace Bay, but no other direction or indication can appear in the address. Such messages should be checked at full commercial rates, and the tolls to Glace Bay only collected. We cannot under any circumstances accept the Marconi tolls or anything beyond Glace Bay on these messages, but must treat them solely and wholly as local messages between the point of origin and Glace Bay."

It is very easy to read between the lines and note that the telegraph companies are realizing their danger from competition; and with the government innocently acting in their interest, the public would be deprived of all the benefits of legitimate competition.

As for the development of wireless telegraphy, we have only to compare the present conditions in Great Britain and this country. When the Marconi Company was first formed it obtained a license or contract from the English government; as a result it is the only company to-day in England, and the English battle-ships have only such apparatus as the Marconi Company can give them. On the other hand, in the United States there are now seven or eight companies in vigorous competition, which has resulted in improvement of apparatus and increase of efficiency to such an extent that our

navy to-day stands first in wireless and holds the record for long-distance communication. Our merchant marine is also getting the advantage of competition and receiving wireless service at reasonable rates, while the English merchant marine is compelled to use the Marconi system or none, and at whatever price demanded.

As to the grievance of the government with respect to interference, we may cite a case that happened on the Sound last fall. A government message was being sent from Washington to Newport via Fire Island (all land stations); complaint was made because Sound boats interfered with the transmission, and it was asked that boat work should cease when government plants were sending. In time of peace, and when both the Western Union and Postal Telegraph Companies are rendering efficient service between Washington and Newport, is it just to make such a demand and use wireless to the detriment of the service of boats which are dependent wholly upon the wireless?

*Any regulation of wireless telegraphy should be based on a full recognition of the fact that the art is now in its infancy, and that its proper development demands freedom from every unnecessary restraint. Assuming that the government has some sort of prescriptive right to an art with which a long line of scientists and inventors has endowed the world, it does not follow that this right

* From editorial in Electrical World, March 21 1908.

cannot be exercised with due regard to the use of the same art for non-governmental purposes. If in time of peace occasions arise of sufficient importance to call for a temporary preëmption of the ether by the government, any inconvenience thereby occasioned to commercial and private interests can be borne with some equanimity. But there should be some assurance that such interruptions are incident to matters of real importance—that all private interests are not sacrificed to routine communications that might just as well be transmitted by wire, or by trivial communications between officials. By defining in some manner the nature of government communications by wireless, and requiring a copy of every communication to be filed for critical examination as to its real importance, a gross abuse of the wireless privilege by an over-officious or inconsiderate official would be averted.

In other words, in time of peace the preëmption of the ether on the part of the government should only be for emergency purposes, and any official making an emergency call should be held strictly responsible for the rightful use of the privilege. In time of war, of course, wireless telegraphy would, in common with all the peaceful arts of civilization, have to resign any claim to consideration; but as a recompense it should not be held in abeyance in time of peace in accordance with what appears to be a policy for the exaltation of the military over the other classes of American people—which classes

would be the ones to give their resources and offer up their lives in national defence, and not even balk if the nation should become committed through vainglorious bravado to a war of foreign aggression. None will, we believe, deny the need of some regulation of wireless telegraphy, but the character of such regulation should be the subject of careful discussion in which the interests of the art and of the people as a whole should receive merited attention. A means to this end would be the authorization by Congress of a commission to study the subject and report recommendations, the membership to be so chosen that the military and bureaucratic elements shall not dominate. We sincerely hope that no action will be taken by Congress until the subject of regulation has received in this country much broader and much wiser consideration than is evidenced in the bills thus far offered at Washington.

26. THE OUTLOOK AND PROPHECY

As before stated, it is the lack of capital behind private or legitimate enterprise that is holding back the development of wireless telegraphy; but even with this handicap, we firmly believe that, within five years from date, we will see it successfully competing with cables and trunk lines, and that our trans-Atlantic rates will be cut down to one-fifth of what they are to-day.

From our experience and observations we are thoroughly convinced that within ten years the laying of trans-ocean cables will be a thing of the past, for while the use of the present cables will undoubtedly be continued, the wireless will be installed and maintained at a cost less than what would be the interest on the cost of a cable.

The art of wireless telegraphy is still young. Scarcely a decade has passed since its practical value was first demonstrated. Important improvements are continually

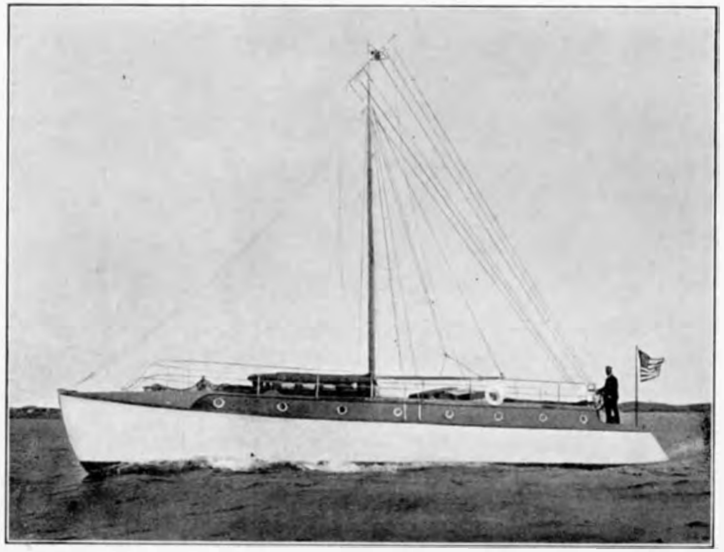

FIG. 26.—"SEA OTTER." THE FIRST MOTOR YACHT EQUIPPED WITH WIRELESS TELEGRAPHY.

being made, and when more is known of the nature of the wonderful ether, more astounding discoveries in the field of wireless will undoubtedly be made, and this, together with the opening up of new channels for the application of the art, compels us to take a decidedly optimistic view.

WIRELESS TELEPHONY

SINCE wireless telegraphy has become so successful, it is but natural that wireless telephony should follow, just as the telephone followed the telegraph. In the ordinary wire telephone a transmitter is employed which varies the intensity of the electric current in the wire in direct ratio to the changes in the intensity of the sound waves set up by the human voice. All the undulations and tones of the voice are, therefore, transformed into complicated electric currents which, in passing through the telephone receiver, cause the diaphragm of the receiver to vibrate in unison with these complex currents, thereby reproducing articulate speech.

The high-frequency oscillations employed in wireless telegraphy are so rapid that the human ear cannot detect their presence in a telephone receiver. Therefore it is plain that if means be employed to vary the intensity of these high-frequency oscillations by a telephone transmitter actuated by the human voice, the received waves may be made to so operate a telephone receiver connected to a regular wireless detector, that articulate speech may be reproduced in the telephone receiver.

The first problem was to find means for generating a continuous flow of electromagnetic waves, without sufficient interruptions to cause a sound in the telephone receiver, excepting that caused by speech. It will be recalled that the sound heard in the telephone receiver employed in wireless telegraphy is due to the interruption of the waves; hence the sound heard at the receiving wireless telegraph station corresponds to the sound of the interrupted "spark" at the transmitting station.

The principal method employed for producing a continuous wave train is obtained by the use of an arc light. In this case, however, one carbon and a rod of copper are employed instead of the usual two carbons.

The electric arc is connected to a condenser which produces the high-frequency oscillations. By these means a nearly continuous train of waves is radiated from the antenna.

A regular transmitter is connected in the antenna circuit as shown in Fig. 27, which when spoken into varies the strength of the high-frequency oscillatory current passing through it, thus varying or damping the electromagnetic waves. Almost any type of wireless telegraph receiver can be used as a wireless telephone receiver.

Communication cannot be carried on over so great distances by the wireless telephone as by the wireless telegraph, owing to the fact that the best results in wireless telegraphy are obtained by using sustained uniform

waves, whereas in wireless telephony the waves are damped, or, in other words, their form is changed by the effects of speech in the transmitter. Moreover, so great

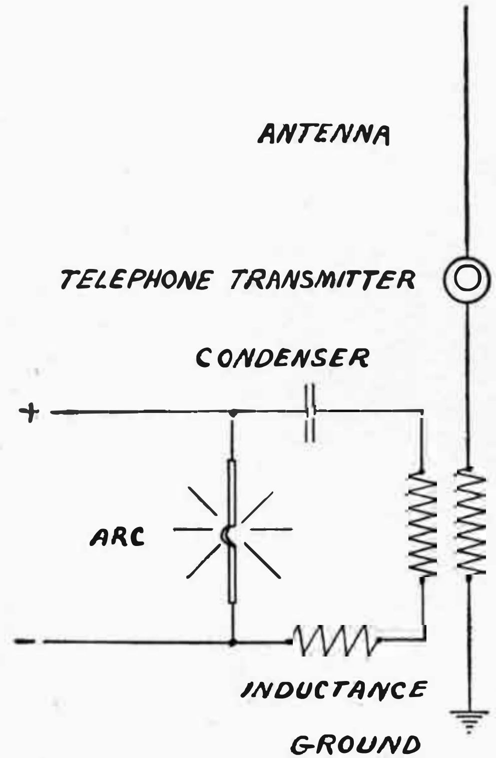

FIG. 27.—WIRELESS TELEPHONE TRANSMITTER CONNECTIONS.

an amount of energy cannot be handled with the wireless telephone, as with the wireless telegraph.

While wireless telegrams have been successfully transmitted and received over a distance exceeding 3000 miles, the wireless telephone has only been successfully used up to distances barely exceeding 20 miles, and those used in the U. S. Navy are only guaranteed to operate five miles.

It is particularly adapted for service between the vessels constituting fleets, and for use on ferry-boats, tugs, etc., in harbors.

However, the art is young, and no doubt the distance will be increased after we have obtained a better knowledge of the ether.

THE FUTURE OF THE WIRELESS ART

MR. NIKOLA TESLA, in a recent interview by the authors, as to the future of the Wireless Art, volunteered the following statement which is herewith produced in his own words.

"A mass in movement resists change of direction. So does the world oppose a new idea. It takes time to wake up the minds to its value and importance. Ignorance, prejudice and inertia of the old retard its early progress. It is discredited by insincere exponents and selfish exploiters. It is attacked and condemned by its enemies. Eventually, though, all barriers are thrown down, and it spreads like fire. This will also prove true of the wireless art.

"The practical applications of this revolutionary principle have only begun. So far they have been confined to the use of oscillations which are quickly damped out in their passage through the medium. Still, even this has commanded universal attention. What will be achieved by waves which do not diminish with distance, baffles comprehension.

"It is difficult for a layman to grasp how an electric cur-

THE TESLA WIRELESS PLANT ON LONG ISLAND.

rent can be propagated to distances of thousands of miles without diminution of intensity. But it is simple after all. Distance is only a relative conception, a reflection in the mind of physical limitation. A view of electrical phenomena must be free of this delusive impression. However surprising, it is a fact that a sphere of the size of a little marble offers a greater impediment to the passage of a current than the whole earth. Every experiment, then, which can be performed with such a small sphere can likewise be carried out, and much more perfectly, with the immense globe on which we live. This is not merely a theory, but a truth established in numerous and carefully conducted experiments. When the earth is struck mechanically, as is the case in some powerful terrestrial upheaval, it vibrates like a bell, its period being measured in hours. When it is struck electrically, the charge oscillates, approximately, twelve times a second. By impressing upon it current waves of certain lengths, definitely related to its diameter, the globe is thrown into resonant vibration like a wire, stationary waves forming, the nodal and ventral regions of which can be located with mathematical precision. Owing to this fact and the spheroidal shape of the earth, numerous geodetical and other data, very accurate and of the greatest scientific and practical value, can be readily secured. Through the observation of these astonishing phenomena we shall soon be able to determine the exact diameter of the planet, its configuration and volume, the extent of its elevations and depressions, and to measure, with great precision and with nothing more than an electrical device, all terrestrial distances. In the densest fog or darkness of night, without a compass or other instruments of orientation, or a timepiece, it will be possible to guide a vessel along the shortest or orthodromic path, to instantly read the latitude and longitude, the hour, the distance from any point, and the true speed and direction of movement. By proper use of such disturbances a wave may be made to travel over the earth's surface with any velocity desired, and an electrical effect produced at any spot which can be selected at will and the geographical position of which can be closely ascertained from simple rules of trigonometry.

"This mode of conveying electrical energy to a distance is not 'wireless' in the popular sense, but a transmission through a conductor, and one which is incomparably more perfect than any artificial one. All impediments of conduction arise from confinement of the electric and magnetic fluxes to narrow channels. The globe is free of such cramping and hinderment. It is an ideal conductor because of its immensity, isolation in space, and geometrical form. Its singleness is only an apparent limitation, for by impressing upon it numerous non-interfering vibrations, the flow of energy may be directed through any number of paths which, though bodily connected, are yet perfectly distinct and separate like ever so many cables. Any apparatus, then, which can be operated

through one or more wires, at distances obviously limited, can likewise be worked without artificial conductors, and with the same facility and precision, at distances without limit other than that imposed by the physical dimensions of the globe.

"It is intended to give practical demonstrations of these principles with the plant illustrated. As soon as completed, it will be possible for a business man in New York to dictate instructions, and have them instantly appear in type at his office in London or elsewhere. He will be able to call up, from his desk, and talk to any telephone subscriber on the globe, without any change whatever in the existing equipment. An inexpensive instrument, not bigger than a watch, will enable its bearer to hear anywhere, on sea or land, music or song, the speech of a political leader, the address of an eminent man of science, or the sermon of an eloquent clergyman, delivered in some other place, however distant. In the same manner any picture, character, drawing, or print can be transferred from one to another place. Millions of such instruments can be operated from but one plant of this kind. More important than all of this, however, will be the transmission of power, without wires, which will be shown on a scale large enough to carry conviction. These few indications will be sufficient to show that the wireless art offers greater possibilities than any invention or discovery heretofore made, and if the conditions are favorable, we can expect with certitude that in the next few years wonders will be wrought by its application."

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