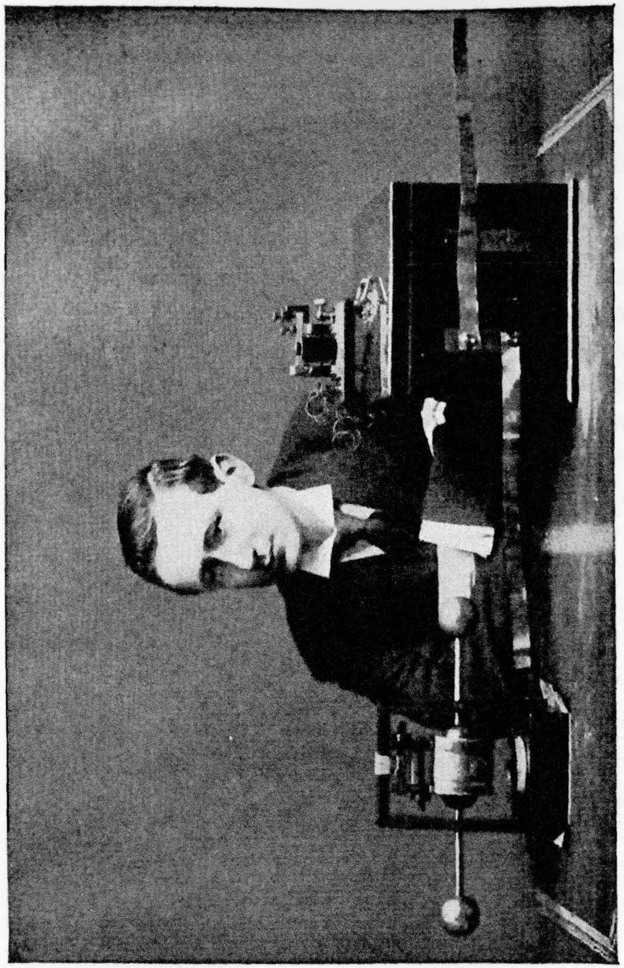


SIGNOR MARCONI AND HIS EARLIER APPARATUS FOR TELEGRAPHING WITHOUT WIRES.

CHAPTER III.

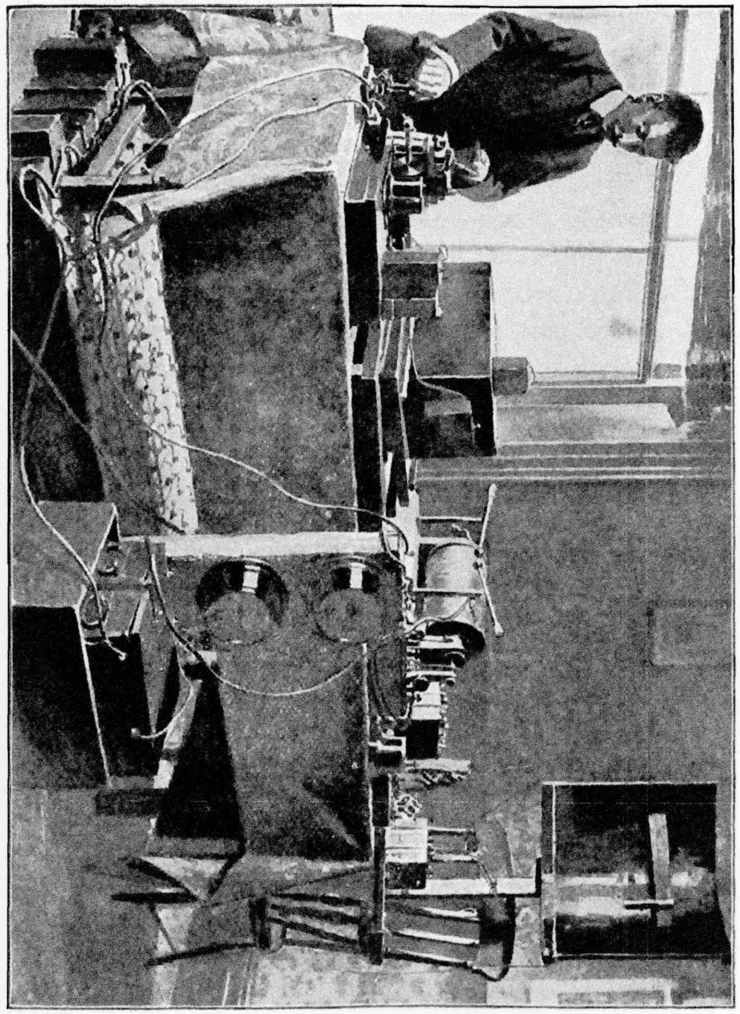
TELEGRAPHING WITHOUT WIRES.

How Marconi Sends Messages Through Space.

MARCONI was a mere boy when he first began to dream of the marvellous possibility of sending telegraph messages without wires. He was barely twenty-one, a shy, modest, beardless youth, when he went up to London from his quiet country home in Italy to tell the world about one of the greatest inventions of the century. A few months later this boy had set up his apparatus and was telegraphing all sorts of messages through the air, through walls, through houses and towns, through mountains, and even through the earth itself, and that with a mechanism hardly more complicated or expensive than a toy telephone. The present system of telegraphy by means of wires, the sending of long despatches over continents and under oceans, is quite wonderful enough in itself, but here was an inventor who did away entirely with wires and all other means of mechanical connection, and sent his messages directly through space. It is for this that Marconi was famous the world over at twenty-five.

The young inventor is described as being tall and slender, and dark of complexion. Although he bears an Italian name and was born in Bologna, Italy (in 1874), and educated at Bologna, Leghorn, and Florence, he is only half Italian, his mother being an English woman. He speaks English readily and fluently, and he appears to like London better than his native land. His first experiments were carried on in the fields of his father's estate, and consisted merely of tin boxes set up on poles of varying heights, one of which was connected with a crude transmitting machine, and the other with an equally crude receiver, which he himself had manufactured.

Before going into the details of Guglielmo, or William, Marconi's apparatus and telling more of his astonishing successes, it may be well to look somewhat into the theories on which he bases his work. It must be understood, however, that Marconi was not the first to suggest wireless telegraphy, nor to signal experimentally for short distances without wires; but he was the first to perfect a system and to put it into practical operation, and to him, therefore, belongs the laurels of the inven-



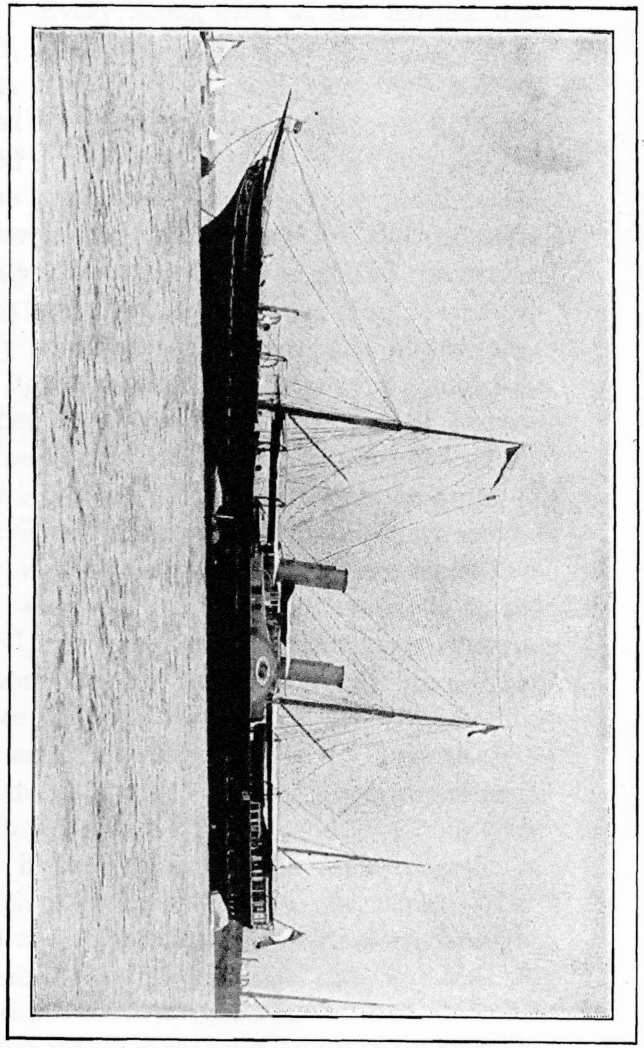
THE WIRELESS TELEGRAPH STATION AT POOLE, ENGLAND, SHOWING SENDING AND RECEIVING INSTRUMENTS. IN RIGHT-HAND CORNER IS THE COPPER REFLECTOR USED IN DIRECTING WAVES.

tion. Our own Prof. S. F. B. Morse, the inventor of telegraphy, experimented with wireless signals, and so did Dr. Oliver Lodge and W. H. Preece of London, Thomas A. Edison, Nikola Tesla, Professor Trowbridge of Harvard, and others.

In sending messages through space, Marconi deals with that mysterious all-pervading substance known as the ether. In the English language the word "ether" has two totally different meanings. It is the name of a clear, colorless liquid, which is used in surgical operations for easing a patient of pain. Every one has heard of "taking ether." This liquid, however, has nothing to do with the present subject, and it should be entirely dismissed from the mind. The ether which carries Marconi's messages is a colorless, odorless, unseen, inconceivably rarefied substance which is supposed to fill all space. Scientists know almost nothing as to its properties, but they do know that it will vibrate, and they have called these vibrations electricity, heat, and light.

It seems strange enough that we should use the ether every time we build a fire under the tea-kettle, every time we read by the light of a gas-jet, every time we talk over the telephone, and yet know next to nothing about it.

Throw a stone into a pond and you will produce a series of small waves or ripples—in other words, water vibrations. Strike a bell and vibrations in the air bring the sound to your ear. In a similar way ether has its own peculiar vibrations. For instance, a star millions of miles away starts the enormously rapid vibrations of light, and these vibrations finally reach our eyes, as the ripples in a pond reach the shore. We do not really see the star; we are merely conscious of light waves in the ether. In the same manner ethereal vibrations bring us the heat and light of the sun, and the awful energy of the lightning stroke. From this we know that the ether extends everywhere through space, and that the sun and the earth and the stars are set in it, like cherries in a jelly. Light will pass through such a hard, brittle substance as glass, heat will go through iron, and electricity "flows" in a copper wire. These facts show us that the ether must be inside of the glass and the iron and the copper, else the vibrations would not go through. In the same way the air is full of ether, and so are our bodies and everything else, for science knows nothing which entirely resists the passage of heat, light, and electricity. We call some substances solids, owing to their hardness, but so far as the ether is concerned there is no such thing as a



THE ROYAL YACHT "OSBORNE," FROM WHICH THE PRINCE OF WALES TELEGRAPHED WITHOUT WIRES.

The sending and receiving wire is suspended from the rope connecting the two mast-heads, and can be distinguished by the wire cone near the top. From a photograph by A. E. Beken.

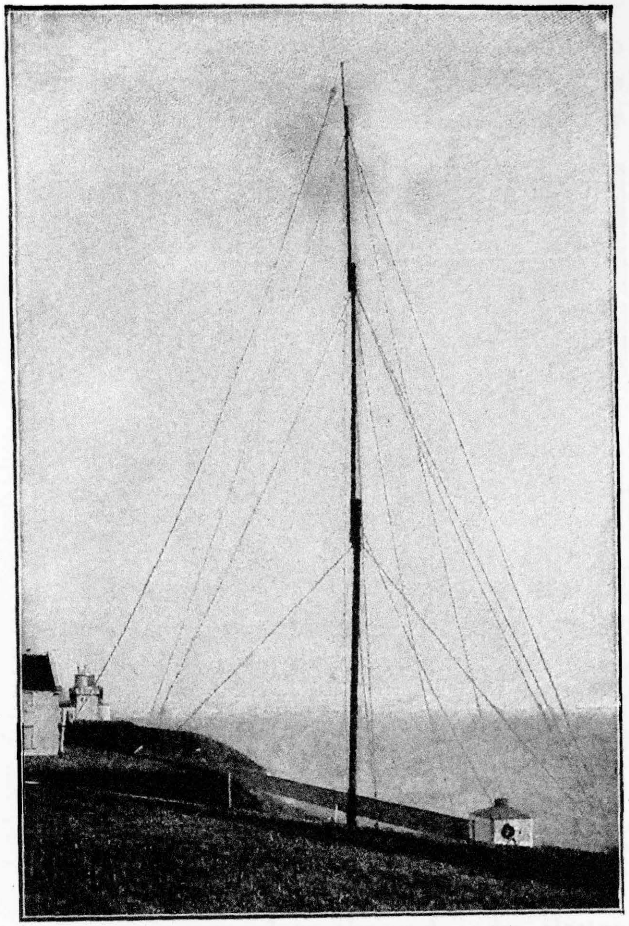
solid. Every atom, even of the hardest diamond, is afloat in ether.

But if heat, light, and electricity are all caused by ether waves, how can we tell them apart?

The larger the stone you throw into the pond the larger the waves produced and the more rapidly they travel. In a similar way ether waves are of widely different lengths and rapidity or frequency. Vibrations of one speed give light, another speed give heat, and still another give electricity. Science has learned by a series of wonderful experiments that if the ether vibrates at the inconceivable swiftness of 400 trillions of waves every second, we see the color red, if twice as fast we see violet. If more slowly, from 200 to 400 trillions to the second, we experience the sensation of heat. If more rapidly than violet, we have what science knows as "unseen light"—the actinic rays and, probably, X-rays. Our eyes will take in only seven colors with vibrations from 400 to 800 trillions a second. If our eyes were better we might see other degrees of vibrations, such as X-rays and various electrical currents, and know new colors, stranger and more beautiful, perhaps, than any that we now see.

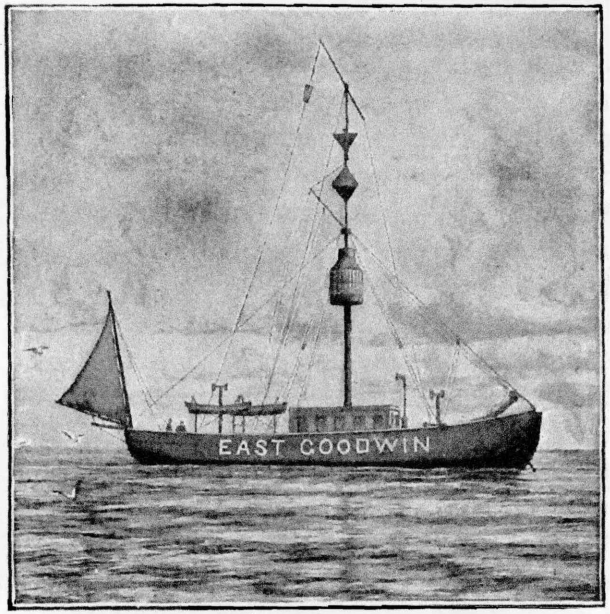
Ether waves should not be confused with air waves. Sound is a result of the vibration of the air; if we had ether and no air we should still see and feel heat and electricity, but there would be nothing to hear. Air or sound waves are very slow compared with ether waves. A man's ordinary voice produces only about 130 waves a second, a woman's shrill scream will reach 2,000 vibrations—a mere nothing compared with the hundreds of trillions which represent light. Nor do air waves travel as rapidly as ether waves. In a storm the ether brings the flash of the lightning long before the air brings the sound of thunder, as every one knows.

Now, to get down to electricity. Certain vibrations of the ether are recognized as electricity—and there are many kinds of electrical waves to correspond with different degrees of vibration. Inventors have been able to utilize electricity by producing these ether waves by artificial means. I have compared the ether to a jelly. The electrician merely jars this jelly, and the vibrations which we know as a "current" are produced. A current does not really pass through a telegraph wire—it does not flow like water in a pipe,—although our common language has no other means of expressing its passage. In reality a vibration is started at one end of the wire, and it is the



MAST AND STATION AT SOUTH FORELAND, NEAR DOVER, ENGLAND, USED BY MARCONI IN TELEGRAPHING WITHOUT WIRES ACROSS THE CHANNEL TO BOULOGNE, FRANCE.

wave that travels. Set up a row of toy blocks. Tip over the first one, and it will tip over the second, and so on to the end. The blocks stay where they are, but the motion or

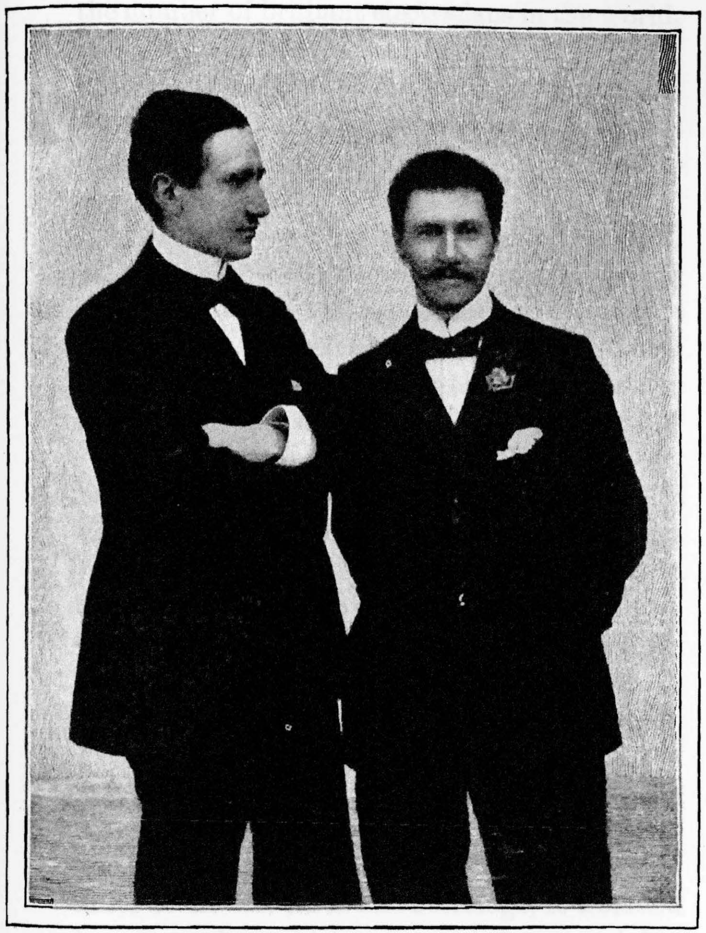


THE GOODWIN SANDS LIGHTSHIP.

Struck in a collision on April 28, 1899, the lightship used her Marconi apparatus (shown suspended by a spar from the masthead), and so got help from shore, twelve miles away.

wave goes onward to the end. An electric wave is, of course, invisible. Imagine a cork on the surface of a pond at any distance from the place where a stone is dropped; the cork, when the wave reaches it, will bob up and down. Now, though we cannot see the electric wave, we can devise an arrangement which indicates the presence of the wave exactly after the manner of a cork.

Electric waves were discovered in 1842 by Joseph Henry, an American. He did not use the phrase "electric waves"; but he discovered that when he produced an electric spark an inch long in a room at the top of his house, electrical action was instantly set up in another wire circuit in his cellar. There was no visible means of communication between the two circuits, and after studying the matter he saw and announced that the electric spark set up some kind of an action in the ether, which passed through two floors and ceilings, each fourteen inches thick, and caused "induction."—set up what is called an induced current—in the wires in the cellar. This fact of induction is now one of the simplest and most commonplace phenomena in the work of electricians. Edison has already used it in telegraphing from a flying train. Hertz, the great German investigator, developed the study of these waves, and announced that they penetrated wood and brick, but not metal. The "Hertzian wave" is, indeed, an important feature of wireless telegraphy. Strange to say, however, considering



Marconi.

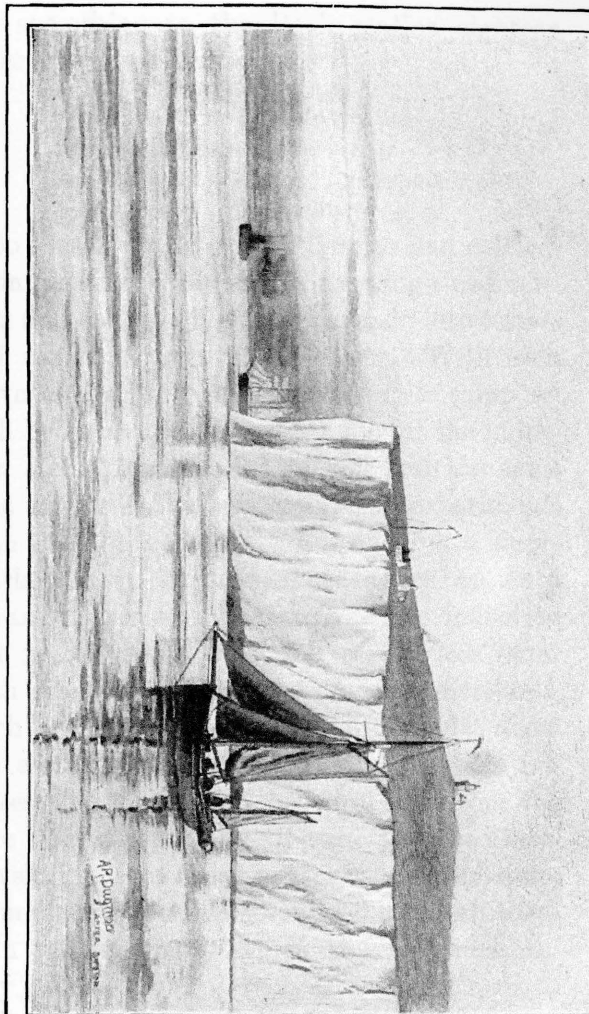
WILLIAM MARCONI AND HIS ASSISTANT, A. E. BULLOCKE.

the number of brilliant electricians in the world, and the great interest in electrical phenomena, it was left to the young Italian, Marconi, to frame the largest conception of what might be done with electric waves, and to invent instruments for doing it.

Marconi's reasoning was exceedingly simple. The ether is everywhere; it is in the air and in the mountains and in houses as well as in a copper wire. Electricity must, therefore, pass through the air and the mountain as well as through the wire. The difficulty lay in making an apparatus that would produce a peculiar kind of wave, and to catch or receive this wave in a second apparatus located at a distance from the first. This he finally succeeded in doing by the use of waves similar to those produced by Hertz, which he excited in a specially constructed apparatus. These waves have a frequency of about 250 millions every second. From the generating apparatus this peculiar current is communicated to a wire which hangs from the top of a long pole or mast, or from a kite, and it passes by induction, through miles of air and earth and buildings, to a second hanging wire, which conveys it to a receiving instrument, where the signals are registered. To understand this transfer we must understand exactly what induction means. An electrical current may be *conducted* through copper wire, water, iron, or any other good "conductor." In *induction* the current passes directly through the ether. When a current of electricity passes through a wire, magnetism is present around that wire; and if another wire be brought within the magnetic field of the charged wire and placed parallel with it, it will also become charged with electricity. That is *induction*, and it enables Marconi to send his messages across the Channel from England to France, from ships on the sea to shore, from light-house to light-house, and across wide stretches of open country.

And now, having come to an understanding of the theory of sending messages without wires, we may take a look at Marconi's actual apparatus as it is now transmitting messages from the Needles in Alum Bay, at the extreme west end of the Isle of Wight, eighteen miles across the Channel, to Poole on the mainland of England.

From the very peak of Marconi's telegraph mast at the Needles hangs a line of wire that runs through a window into the little sending-room. Here two matter-of-fact young men are at work as calmly as any ordinary telegraphers, talking through the ether. One of them has his fingers on a black-handled key. He is say-



SOUTH FORELAND, THE ENGLISH STATION FROM WHICH MESSAGES WERE SENT WITHOUT WIRES TO BOULOGNE, FRANCE, THIRTY-TWO MILES AWAY. THE MAST SUPPORTING THE VERTICAL WIRE IS SEEN ON THE EDGE OF THE CLIFF.

ing something to the Poole station eighteen miles away in England.

"Brripp—brripp—brripp—brrrrrr.
Brripp—brripp—brripp—brrrrrr—
Brripp—brrrrrr—brripp. Brripp—brripp!"

So speaks the sender with noise and deliberation. It is the Morse code working—ordinary dots and dashes which can be made into letters and words, as everybody knows. With each movement of the key bluish sparks jump an inch between the two brass knobs of the induction coil, the same kind of coil and the same kind of sparks that are familiar in experiments with the Röntgen rays. For one dot, a single spark jumps; for one dash, there comes a stream of sparks. One knob of the induction coil is connected with the earth, the other with the wire hanging from the masthead. Each spark indicates a certain impulse from the electrical battery; each one of these impulses shoots through the wire, and from the wire through space by vibrations of the ether, travelling at the speed of light, or seven times around the earth in a second. That is all there is in the sending of these Marconi messages. Any person of fair intelligence could learn to do it, Morse code and all, in a few hours.

After sending a message the young operator switches on to the receiver, which is contained in a metal box about the size of a valise. The same perpendicular wire from the masthead serves to receive messages as well as to send them, but the instruments within the office for sending and for receiving are quite different.

The receiving apparatus is kept in a lead box to protect it against the influence of the sending machine, which rests beside it on the table. You can easily believe that a receiver, sensitive enough to record impulses from a point eighteen miles away, might be disorganized if these impulses came from a distance of two or three feet. But the lead box keeps out these nearby vibrations.

The coherer is the part of the receiving apparatus which makes wireless telegraphy possible, and to it more than to anything else has Marconi given his attention. He did not make the first coherer, but he made the first one that was practically useful, and to this great and important invention he owes his success.

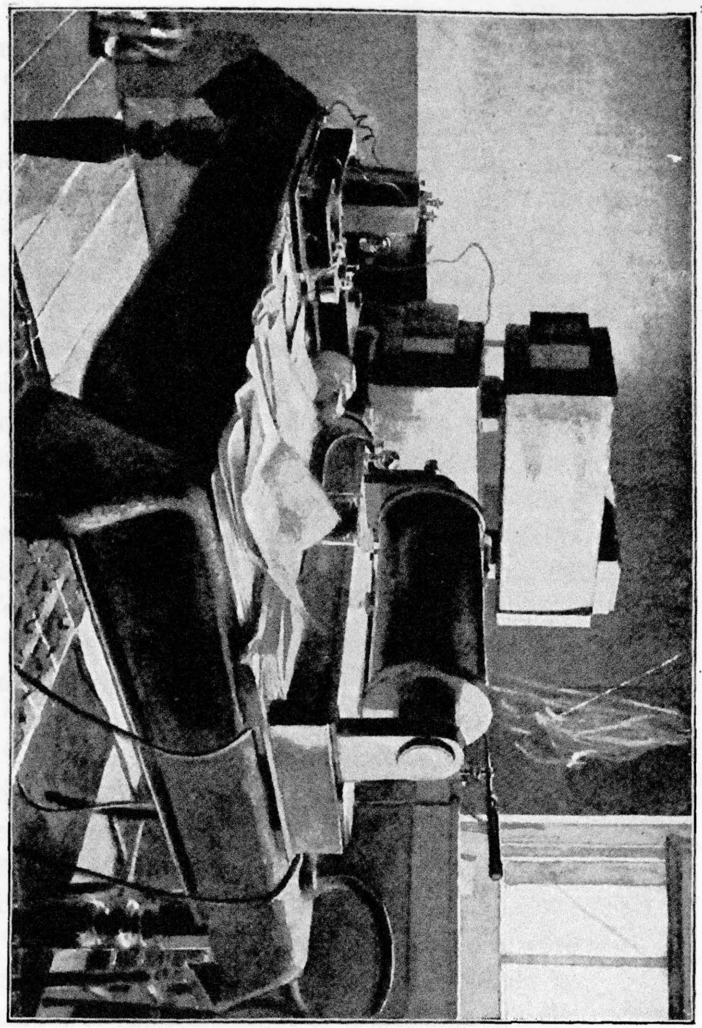
I will try to give a clear idea of what this coherer is like, and why it is so important. It consists of a tube made of glass, about the thickness of a thermometer tube, and about two inches long. It seems absurd that so tiny and simple an affair can come as a benefit to all

mankind; yet the chief virtue of Marconi's invention lies here in this fragile coherer. But for this, induction coils would snap their messages in vain, for none could read them. In each end of this tube there is a silver plug, the two plugs nearly meeting within the tube. In the narrow space between the plugs nestle several hundred minute fragments of nickel and silver, the finest dust, siftings through silk, and these enjoy the strange property (as Marconi discovered) of being alternately very good conductors and very bad conductors for the Hertzian waves—very good conductors when welded together by the passing current into a continuous metal path, very bad conductors when they fall apart under a blow from the electrical tapper which is a part of the receiving apparatus. One end of the coherer is connected with the wire which hangs from the mast outside, the other with the earth and also with a home battery that works the tapper and the Morse printing instrument.

And the practical operation is this: A single vibration comes through the ether, down the wire and into the coherer, causing the particles of metal to stick together or *cohere* (hence the name). Then the Morse instrument prints a dot, and the tapper strikes its little hammer against the glass tube. That blow jars apart or *decoheres* the particles of metal, and stops the current of the home battery. And each successive impulse through the ether produces the same curious coherence and decoherence, and the same printing of dot or dash. The impulses through the ether would never be strong enough of themselves to work the printing instrument and the tapper, but they are strong enough to open and close a valve (the metal dust), which lets in or shuts out the stronger current of the home battery—all of which is simple enough after some one has taught the world how to do it.

Mr. Cleveland Moffett, who has made a personal study of wireless telegraphy with Mr. Marconi and his assistant, Dr. Erskine-Murray, says that even the curvature of the earth itself seems to make no difference in the transmittal of messages.

"We have telegraphed twenty-five miles from a ship to the shore," Dr. Murray told Mr. Moffett, "and in that distance the earth's dip amounts to about 500 feet. If the curvature counted against us then, the messages would have passed some hundreds of feet over the receiving station; but nothing of the sort happened. So we feel reasonably confident that these Hertzian waves follow around smoothly as the earth curves."



THE APPARATUS EMPLOYED AT SOUTH FORELAND LIGHTHOUSE FOR COMMUNICATING WITH THE GOODWIN SANDS LIGHTSHIP AND WITH BOULOGNE.

Drawn from a photograph.

"And you can send messages through hills, can you not, and in all kinds of weather?"

"Easily. We have done so repeatedly."

"Then if neither land nor sea nor atmospheric conditions can stop you, I don't see why you can't send messages to any distance."

"So we can," said the electrician—"so we can, given a sufficient height of wire. It has become simply a question now how high a mast you are willing to erect. If you double the height of your mast, you can send a message four times as far. If you treble the height of your mast, you can send a message nine times as far, and so on up. To start with, you may assume that a wire suspended from an eighty-foot mast will send a message twenty miles. We are doing about that here."

"Then a mast 160 feet high would send a message eighty miles?"

"Exactly."

"And a mast 320 feet high would send a message 320 miles; a mast 640 feet high would send a message 1,280 miles; and a mast 1,280 feet high would send a message 5,120 miles?"

"That's right. So you see if there were another Eiffel Tower in New York, it would be possible to send messages to Paris through the ether and get answers without ocean cables."

"Do you really think that would be possible?"

"I see no reason to doubt it," answered Dr. Erskine-Murray. "What are a few thousand miles to this wonderful ether, which brings us our light every day from millions of miles away?"

One of the greatest of present difficulties is that of securing secrecy in the transmission of these ethereal messages. The vibrations from the perpendicular wires are transmitted equally well in every direction, exactly as circular waves are produced when a stone is thrown in the water. Therefore any one may set up a receiver anywhere within the range of the waves, and take the message. Thus, in times of war, communications between battleships or armies might be at the mercy of any one who had a Marconi receiver, although, of course, generals and admirals might use cipher despatches.

Marconi realizes the very great importance of sending messages in one and only one direction. Light waves can be reflected by a mirror, and thrown upon one particular spot. Every boy who has played in school with a bit of looking-glass knows this fact well. Now, electricity, which is also produced by vibrations in the ether, can also be reflected.

Marconi has been experimenting with a copper reflector, by means of which he throws a peculiar kind of electrical wave directly through space to the distant receiver. In this way a message may be aimed in any direction by simply turning the reflector a little, and no one but the man at the receiver can know what is being sent. This exceedingly important feature of the work is, however, still in an experimental stage, and the inventor who is successful in making a really practical reflecting apparatus will win a fortune.

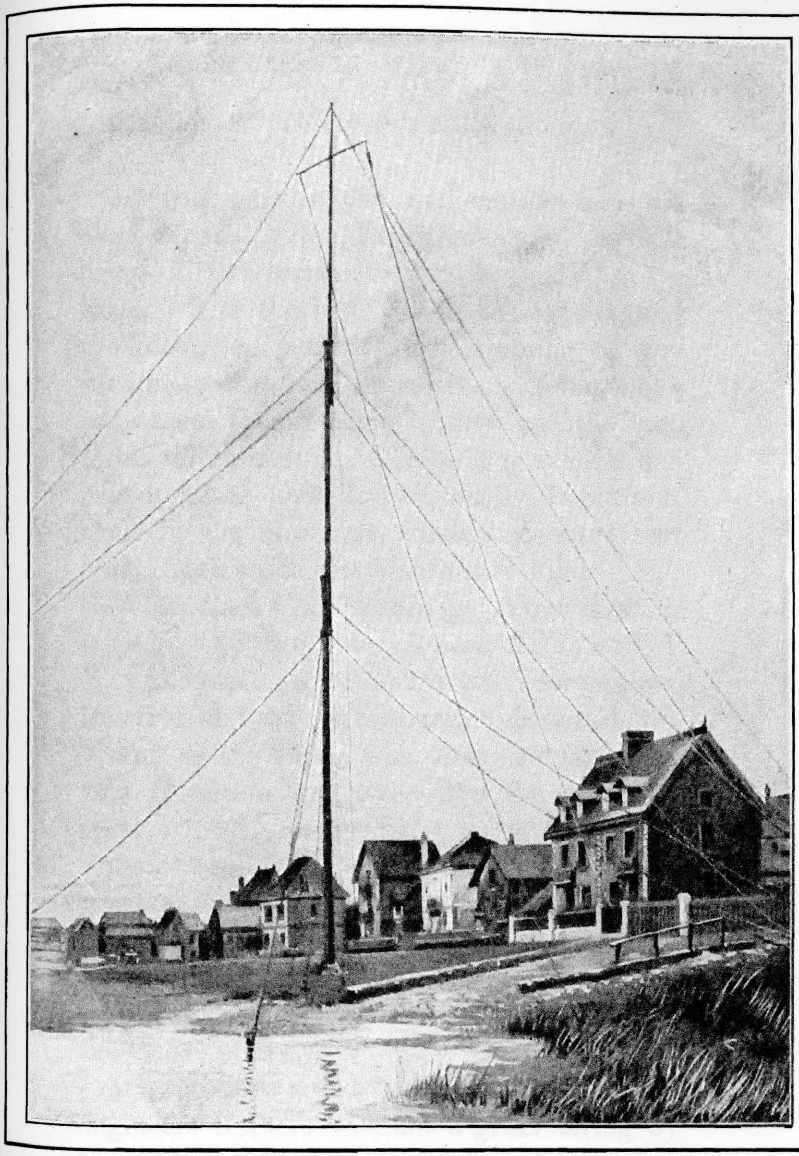
The practical uses of wireless telegraphy are many. In December, 1898, the English lightship service authorized the establishment of wireless communication between the South Foreland lighthouse at Dover and the East Goodwin lightship, twelve miles distant. This was installed in the usual way without difficulty, and has been in operation ever since, the lightship keepers learning to use the instruments in a few days. And before the apparatus had been up six months several warnings of wrecks and vessels in distress reached shore, when, but for the Marconi signals, nothing of the danger would have been known.

Another application of wireless telegraphy that promises to become important is the signalling of incoming and outgoing vessels.

With Marconi stations all along the coast, it would be possible for all vessels within twenty-five miles of shore to make their presence known and to send or receive communications.

So apparent are the advantages of such a system that in May, 1898, Lloyds began negotiations with the Wireless Telegraph Company for setting up instruments at various Lloyds stations; and a preliminary trial was made between Bally-castle and Rathlin Island in the north of Ireland. The distance signalled was seven and a half miles, with a high cliff intervening between the two positions, and the results of many trials were absolutely satisfactory.

We come now to that historic week in March, 1899, when the system of wireless telegraphy was put to its most severe test in experiments across the English Channel between Dover and Boulogne. These were undertaken by request of the French Government, which was considering a purchase of the rights to the invention in France. At five o'clock on the afternoon of Monday, March 27th, everything being ready, Marconi pressed the sounding-key for the first cross-channel message. The transmitter sounded, the sparks flashed, and a dozen eyes looked out anxiously upon the sea. Would the message carry all the way



THE MAST AND STATION AT BOUOLGNE, FRANCE, USED BY MARCONI IN TELEGRAPHING WITHOUT WIRES ACROSS THE CHANNEL.

Drawn from a photograph.

to England? Thirty-two miles seemed a long way!

Marconi transmitted deliberately a short message, telling the Englishmen that he was using a two-centimetre spark, and signing three V's at the end. Then he stopped, and the room was silent with a straining of ears for some sound from the receiver. A moment's pause, and then it came briskly, and the tape rolled off its message. There it was, short and commonplace enough, yet vastly important, since it was the first wireless message sent from England to the Continent: First "V," the call; then "M," meaning "Your message is perfect"; then, "Same here, 2 c m s. V V V.," the last being an abbreviation for two centimetres and the conventional finishing signal.

And so the thing was done; a marvellous new invention was come into the world to stay.

On the following Wednesday Marconi did a graceful thing by sending a complimentary message to M. Branly (in Paris), the inventor of the original coherer, which Marconi had improved upon. He also sent a long message to the Queen of Italy.

Mr. Moffett asked one of Marconi's chief engineers if there was not a great saving by the wireless system over cables.

"Judge for yourself," was the answer. "Every mile of deep-sea cable costs about £150; every mile for the land-ends about £200. We save all that, also the great expense of keeping a cable steamer constantly in commission making repairs and laying new lengths. All we need is a couple of masts and a little wire. The wear and tear is practically nothing. The cost of running is simply the cost of home batteries and operators' keep."

"How fast can you transmit messages?"

"Just now at the rate of about fifteen words a minute; but we shall do better than that, no doubt, with experience."

"Do you think there is much field for the Marconi system in overland transmission?"

"In certain cases, yes. For instance, where you can't get the right of way to put up wires and poles. What is a disobliging farmer going to do if you send messages right through his farm, barns and all? He can't sue the Hertzian waves for trespass, can he? Then see the advantage, in time of war, for quick communication, and no chance that the enemy may cut your wires."

"But they may read your messages."

"That is not so sure, for besides the possibility of directing the waves with reflectors, Marconi is now engaged in most promising ex-

periments in syntony, which I may describe as the electrical tuning of a particular transmitter to a particular receiver, so that the latter will respond to the former and no other, while the former will influence the latter and no other. That, of course, is a possibility in the future, but it may soon be realized. There are even some who maintain that there may be produced as many separate sets of transmitters and receivers capable of working together as there are separate sets of Yale locks and keys. In that event, any two private individuals might communicate freely without fear of being understood by others. There are possibilities here, granting a limitless number of distinct tunings for transmitter and receiver, that threaten our whole telephone system—I may add, our whole newspaper system."

"Our newspaper system?"

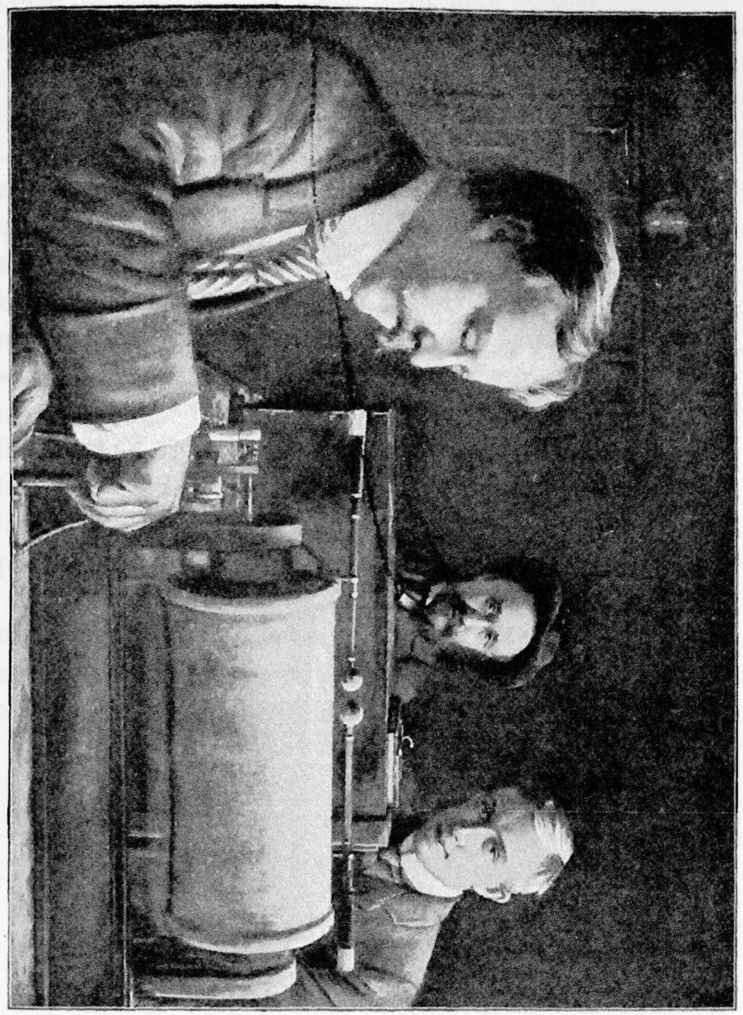
"Certainly, the news might be ticked off tapes every hour right into the houses of all subscribers who had receiving instruments tuned to a certain transmitter at the news-distributing station. Then the subscribers would have merely to glance over their tapes, and they would learn what was happening in the world."

"Will the wireless company sell its instruments?"

"No, it will rent them on a royalty, as telephone companies do, except, of course, where rights for a whole country are absolutely disposed of."

There was further talk of the possibilities in wireless telegraphy, and of the services Marconi's invention may render in coming wars.

"If you care to stray a little into the realm of speculation," said the engineer, "I will point out a rather sensational rôle that our instruments might play in military strategy. Suppose, for instance, you Americans were at war with Spain, and wished to keep close guard over Havana harbor without sending your fleet there. The thing might be done with a single fast cruiser in this way: Supposing a telegraphic cable laid from Key West, and ending at the bottom of the sea a few miles out from the harbor. And supposing a Marconi receiving instrument, properly protected, to be lying there at the bottom in connection with the cable. Now, it is plain that this receiver will be influenced in the usual way by a Marconi transmitter aboard the cruiser, for the Hertzian waves pass well enough through water. With this arrangement, the captain of your cruiser may now converse freely with the admiral of the fleet at Key West or with the President himself at Washington, without so



TRANSMITTING INSTRUMENT AT BOULOGNE STATION.

Drawn from a photograph.

much as quitting his deck. He may report every movement of the Spanish warships as they take place, even while he is following them or being pursued by them. So long as he keeps within twenty or thirty miles of the submerged cable-end, he may continue his communications, may tell of arrivals and departures, of sorties, of loading transports, of filling bunkers with coal, and a hundred other details of practical warfare. In short, this captain and his innocent-looking cruiser may become a never-closing eye for the distant American fleet. And it needs but little thought to see how easily an enemy at such disadvantage may be taken unawares or be led into betraying important plans."

And here, I think, we may leave this fascinating subject, in the hope that we have seen clearly what already is, and with a half discernment of what is yet to be.