PROGRESS IN WIRELESS TELEGRAPHY.—II.*

A NOBEL PRIZE LECTURE.

BY GUGLIELMO MARCONI.

Concluded from Supplement No. 1782, Page 142.

A RESULT of scientific interest which I first noticed during the tests on the steamship "Philadelphia," and which is a most important factor in long-distance radio-telegraphy, was the very marked and detrimental effect of daylight on the propagation of electric waves at great distances; the range by night being usually more than double that attainable during daytime.[1] I do not think that this effect has yet been satisfactorily investigated or explained. At the time I carried out the tests I was of opinion that it might be due to the loss

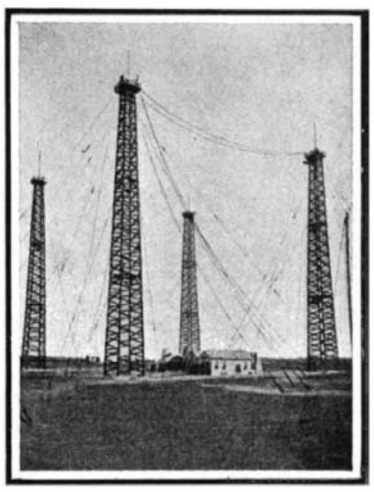

FIG. 15.

of energy at the transmitter, caused by the dis-electrification of the highly-charged transmitting elevated conductor under the influence of sunlight.

I am now inclined to believe that the absorption of electric waves during the daytime is due to the ionization of the gaseous molecules of the air affected by ultra-violet light, and as the ultra-violet rays, which emanate from the sun, are largely absorbed in the upper atmosphere of the earth, it is probable that the proportion of the earth's atmosphere which is facing the sun will contain more ions or electrons than that portion which is in darkness, and therefore, as Sir J. J. Thomson has shown[2], this illuminated and ionized air will absorb some of the energy of the electric waves. Apparently, the length of wave and altitude of electrical oscillations have much to do with this interesting phenomenon, long waves and small amplitudes being subject to the effect of daylight to a much lesser degree than short waves and large amplitudes. According to Professor Fleming, the daylight effect should be more marked on long waves, but this has not been my experience. Indeed, in some very recent experi-

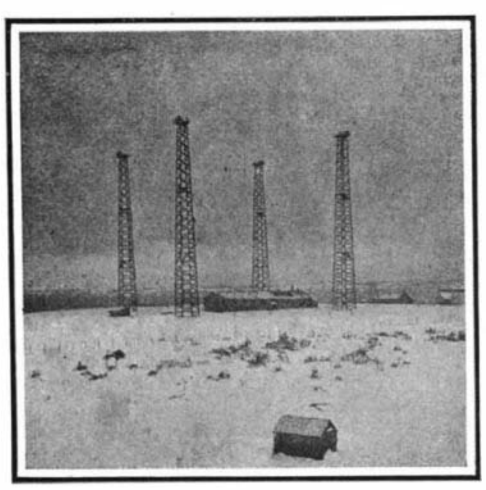

FIG. 16

ments, in which waves about 8000 m. long were used, the energy received by day was usually greater than at night. The fact remains, however, that for comparatively short waves, such as are used for ship communication, clear sunlight and blue skies, though transparent to light, act as a kind of fog to these waves. Hence, the weather conditions prevailing in England, and perhaps in this country (Sweden), are usually suitable for wireless telegraphy.

During the year 1902 I carried out some further tests between the station at Poldhu and a receiving installation erected on the Italian cruiser "Carlo Alberto," kindly placed at my disposal by H. M. the King of Italy.[3] During these experiments the interesting fact was observed that even when using waves as short as 1,000 feet intervening ranges of mountains, such as the Alps or Pyrenees, did not, during the night time, bring about any considerable reduction in the distance over which it was possible to communicate. During daytime, unless much longer waves and more power were used, intervening mountains greatly reduced the apparent range of the transmitter. Messages and press dispatches of considerable length were received from Poldhu at the positions marked on the map, which map is a copy on a reduced scale of the one accompanying the official report of the experiments—Fig. 16.

With the active encouragement and financial assistance of the Canadian government, a high-power station was constructed at Glace Bay, Nova Scotia, in order that I should be able to continue by long-distance tests with a view to establishing radio-telegraphic communication on a commercial basis between England and America.[4] On December 16th, 1902, the first official messages were exchanged at night across the Atlantic, between the stations at Poldhu and Glace Bay—Figs. 15 and 16. Further tests were shortly afterward carried out with another long-distance station at Cape Cod in the United States of America, and under favorable circumstances it was found possible to transmit messages to Poldhu, 3,000 miles away, with an expenditure of electrical energy of only about 10 kilowatts.

In the spring of 1903 the transmission of press messages by radio-telegraphy from America to Europe was attempted, and for a time the London Times published, during the latter part of March and the early part of April of that year, news messages from its New York correspondent sent across the Atlantic without the aid of cables. A breakdown in the insulation of the apparatus at Glace Bay made it necessary, however, to suspend the service, and unfortunately further accidents made the transmission of messages uncertain and unreliable. As a result of the data and experience gained by these and other tests which I carried out for the British government, between England and Gibraltar, I was able to erect a new station at Clifden in Ireland, and enlarge the one at Glace Bay in Canada, so as to enable me to initiate, in October, 1907, communication for commercial purposes across the Atlantic between England and Canada. Although the stations at Clifden and Glace Bay had to be put into operation before they were altogether completed, nevertheless comunication across the Atlantic by radio-telegraphy never suffered any serious interruption during nearly two years until, in consequence of a fire at Glace Bay this autumn, it has had to be suspended for three or four months. This suspension has not, however, been altogether an unmitigated evil, as it has given me the opportunity of installing more efficient and up-to-date machinery.

The arrangements of elevated conductors or aerials which I have tried during my long-distance tests are shown in Figs. 17, 18, and 19.[5] The aerial, shown in Fig. 19, consisted of a nearly vertical portion in the middle, 220 feet high, supported by four towers, and attached at the top to nearly horizontal wires, 200 in number and each 1,000 feet long, extending radially all round, and supported at a height of 180 feet from the ground by an inner circle of 8, and an outer circle of 16, masts. The natural period of oscillation of this aerial system gave a wave length of 12,000 feet. Experiments were made with this arrangement in 1905, and with a wave length of 12,000 feet, signals, although very weak, could be received across the Atlantic by day as well as by night. The system of aerial I finally adopted for the long distance stations in England and Canada is shown in Fig. 20. This arrangement not only makes it possible efficiently to radiate and receive waves of any desired length, but also tends to confine the main portion of the radiation to a given direction. The limitation of transmission to one direction is not very sharply defined, but the results obtained with this type of aerial are nevertheless exceedingly useful.

Many suggestions respecting methods for limiting the direction of radiation have been made by various workers, notably by Prof. F. Braun, Prof. Artom, and Messrs. Bellini and Tosi. In a paper read before the Royal Society in London in March, 1906[6], I showed how it was possible by means of horizontal aerials to confine the emitted radiations mainly to the direction of their vertical plane, pointing away from their earthed end. In a similar manner it is possible to locate the bearing or direction of a sending station. The transmitting circuits at the long-distance stations are arranged in accordance with a comparatively recent sys-

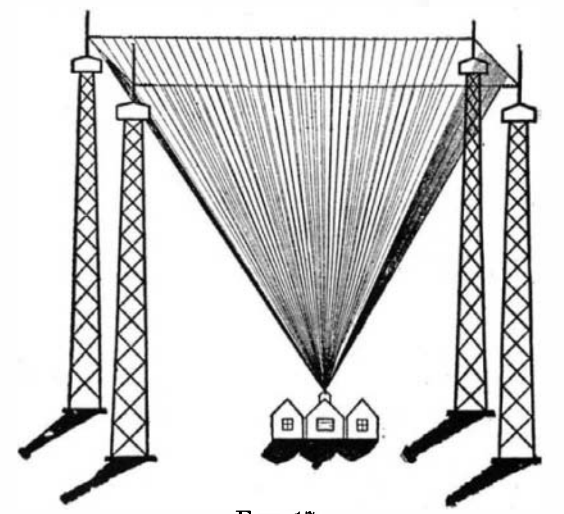

FIG. 17.

tem for producing continuous or slightly damped oscillations, which I referred to in a lecture before the Royal Institution of Great Britain on March 13th, 1908. An insulated metal disk A, Fig. 21, is caused to rotate at a high rate of speed by means of an electric motor or steam turbine. Adjacent to this disk, which I will call the middle disk, are placed two other disks C' and C'', which may be called polar disks, and which are also revolved. These polar disks have their peripheries very close to the surface or edges of the middle disk. The two polar disks are connected by rubbing contacts to the outer ends of two condensers K, joined in series, and these condensers are also connected through suitable brushes to the terminals of a generator, which should be a high-tension continuous current generator. On the middle disk a suitable brush or rubbing contact is provided, and between this contact and the middle point of the two condensers an oscillating circuit is inserted, consisting of a condenser E in series with an inductance, which last is inductively connected with the radiating antennæ. The apparatus works probably in the following manner: The gen-

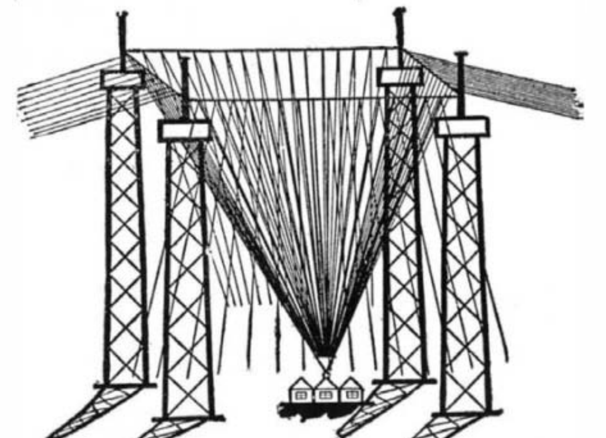

FIG. 18.

erator charges the double condenser, making the potential of the disks, say C' positive and C'' negative. The potential, if high enough will cause a discharge to pass across one of the gaps, say, between C' and A. This charges the condenser E through the inductance F, and starts oscillations in the circuit. The charge F in swinging back will jump from A to C'', the potential of which is of opposite sign to A, the dielectric strength between C' and A having meanwhile been restored by the rapid motion of the disk, driving away the ionized air. The condenser E therefore discharges and recharges alternatively in reverse directions, the same process going on so long as energy is supplied

* Address delivered in Stockholm by Mr. Marconi on the occasion of the awarding of his share of the Nobel prize.

[1] See Proceedings of the Royal Society, Vol. LXX., "A Note on the Effect of Daylight upon the Propagation of Electro-magnetic Impulses." G. Marconi, June 12th, 1902.

[2] See Philosophical Magazine, August, 1902, Ser. 6, Vol. IV., p. 253, J. J. Thomson, "On Some Consequences, etc."

[3] See "Revista Marittima," Rome, October, 1902.

[4] See paper read before the Royal Institution of Great Britain by G. Marconi, March 3rd, 1905.

[5] See also lecture before the Royal Institution of Great Britain by G. Marconi, March 13th, 1908.

[6] "On Methods whereby the Radiation of Electric Waves may be Mainly Confined, etc." "Proceedings" of the Royal Society, A. Vol., 77, 1906.

to the condensers *K* by the generator *H*. It is clear that the discharges between *C′* and *C″* and *A* are never simultaneous, as otherwise the center electrode would not be alternatively positive and negative.

The best results have, however, been obtained by an arrangement, as shown in Fig. 22, in which the active surface of the middle disk is not smooth, but consists of a number of regularly spaced copper knobs or pegs, at the ends of which the discharges take place at regular intervals. In this way it is possible to cause the groups of oscillations radiated to reproduce a high and clear musical note in a receiver, and thereby it is easier to differentiate between the signals emanating from the sending station and noises caused by atmospheric electrical discharges. By this method very efficient resonances can be also obtained in appropriately designed receivers.

With regard to the receivers employed, important

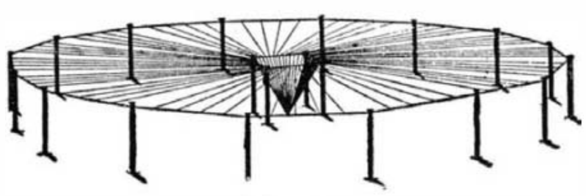

FIG. 19.

changes have taken place. By far the larger portion of electric wave telegraphy was, until a few years ago, conducted by means of some form or other of coherer, or variable contact either requiring tapping or self-restoring. At the present day, however, I might say that in all the stations controlled by my company my magnetic receiver is almost exclusively employed, Fig. 23.[7] This receiver is based on the decrease of magnetic hystereses which occur in iron when under certain conditions this metal is subjected to the effects of electrical waves of high frequency. It has recently been found possible to increase the sensitiveness of these receivers, and to employ them in connection with a high-speed relay, so as to record messages at great speed.

A remarkable fact, not generally known, in regard to transmitters is that none of the arrangements employing condensers exceeds in efficiency the plain elevated aerial or vertical wire discharging to earth through a spark gap, as used in my first experiments, Figs. 2 and 3 (*ante*). I have recently been able to confirm the statement made by Prof. Fleming in his book, "The Principles of Electric Wave Telegraphy," 1906, page 555, that with a power of 8 watts in the aerial it is possible to communicate to distances of over 100 miles. I have also found that by this method it is possible to send signals 2,000 miles across the Atlantic with a smaller expenditure of energy than by any other method known to myself.

The only drawback to this arrangement is that unless very large aerials are used, the amount of energy which can be efficiently employed is limited by the potential, beyond which brush discharges and the resistances of the spark gap begin to have a deleterious effect. By means of spark gaps in compressed air and the addition of inductance coils placed between the aerial and earth, the system can be made to radiate very pure and slightly damped waves, eminently suitable for sharp tuning. In regard to the general working of wireless telegraphy, the widespread application of the system and the multiplicity of the stations have greatly facilitated the observation of facts not easily explainable. Thus it has been observed that an ordinary ship station utilizing about half a kilowatt of electrical energy, the normal range of which is not greater than 200 miles, will occasionally transmit messages across a distance of over 1,200 miles. It often occurs that a ship fails to communicate with a nearby station, but can correspond with perfect ease with a distant one.

On many occasions last winter the steamship "Car-

FIG. 20.

onia," of the Cunard Line, carrying a station utilizing about half a kilowatt, when in the Mediterranean off the coast of Sicily, failed to obtain communication with the Italian stations, but had no difficulty whatsoever in transmitting and receiving messages to and from the coasts of England and Holland, although these latter stations were considerably more than 1,000 miles away and a large part of the continent of Europe and the Alps lay between them and the ship.

Although high power stations are now used for communicating across the Atlantic, and messages can be sent by day as well as by night, there still exist short periods of daily occurrence during which transmission from England to America, or *vice versa*, is difficult. Thus, in the morning and evening, when, in consequence of the difference in longitude, daylight or darkness extends only part of the way across the ocean, the received signals are weak, and sometimes cease altogether. It would almost appear as if electric waves, in passing from dark space to illuminated space, and *vice versa*, were reflected in such a manner as to be diverted from their normal path. It is probable that these difficulties would not be experienced in telegraphing over equal distances north and south, on about the same meridian, as in this case the passage from daylight to darkness would occur almost simultaneously over the whole distance between the two points.

Another curious result, on which hundreds of observations continued for years leave no further doubt, is that regularly, for short periods, at sunrise and sunset, and occasionally at other times, a shorter wave can be detected across the Atlantic in preference to the longer wave normally employed. Thus, at Clifden and Glace Bay, when sending on an ordinary coupled circuit arranged so as simultaneously to radiate two waves, one 12,500 feet, and the other 14,700 feet, although the longer wave is the one usually received at the other side of the ocean, regularly about three hours after sunset at Clifden and three hours before sunrise at Glace Bay the shorter wave alone was received with remarkable strength, for a period of about one hour. This effect occurred so regularly that the operators tuned their receivers to the shorter wave at the times mentioned as a matter of ordinary routine.

With regard to the utility of wireless telegraphy, there is no doubt that its use has become a necessity for the safety of shipping, all the principal liners and warships being already equipped, its extension to less important ships being only a matter of time, in view of the assistance it has provided in cases of danger. Its application is also increasing as a means of communicating between outlying islands, and also for the ordinary purposes of telegraphic communication be-

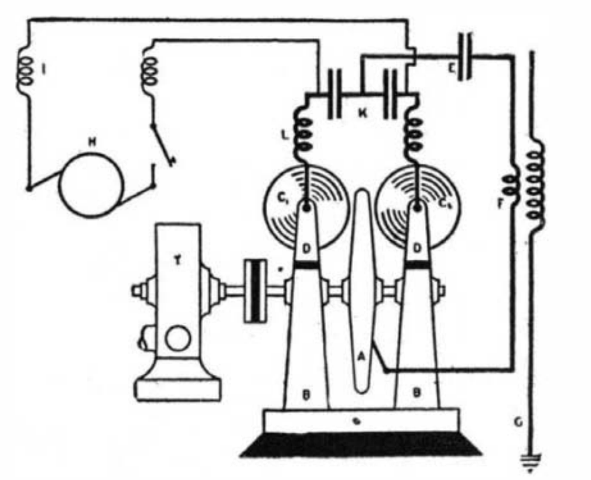

FIG. 21.

tween villages and towns, especially in the colonies and in newly-developed countries. However great may be the importance of wireless telegraphy to ships and shipping, I believe it is destined to an equal position of importance in furnishing efficient and economical communication between distant parts of the world, and in connecting European countries with their colonies and with America. As a matter of fact, I am at the present time erecting a very large power station for the Italian government at Coltano, for the purpose of communicating with the Italian colonies in East Africa and with South America.

Whatever may be its present shortcomings and defects, there can be no doubt that wireless telegraphy even over great distances has come to stay, and will not only stay, but continue to advance. If it should become possible to transmit waves right round the world, it may be found that the electrical energy traveling round all parts of the globe may be made to concentrate at the antipodes of the sending station. In this way it may some day be possible for messages to be sent to such distant lands by means of a very small amount of electrical energy, and therefore at a corresponding small expense. But I am leaving the regions of fact, and entering the regions of speculation, which, however, with the knowledge we have gradually gained on the subject, promise results both useful and instructive.

[7] "Proceedings" of the Royal Society. "Note on a Magnetic Detector of Electric Waves." G. Marconi, Vol. LXX., 1902, page 341.

BAMBOO PAPER.

CONSUL S. C. REAT, of Tamsui, furnishes the following information concerning Formosan bamboo pulp and the manufacture of paper therefrom in Japan:

Will the world's future supply of paper pulp be derived from the bamboo forests of the tropics instead of being drawn from the forests of the temperate zones? A tentative affirmative answer to this question could be made by the Mitsu Bishi Paper Mill Company, which has recently made very satisfactory experiments with bamboo pulp at its scientific station near Kobé, Japan.

This company has the utmost confidence in the results of its experiments with bamboo pulp. It has been granted a perpetual lease of 8,000 acres of bamboo forest in Formosa, and is now engaged near Kagi in installing the machinery for a plant with a capacity of 300 tons of bamboo pulp a month, and the capacity can easily be enlarged to 600 tons a month.

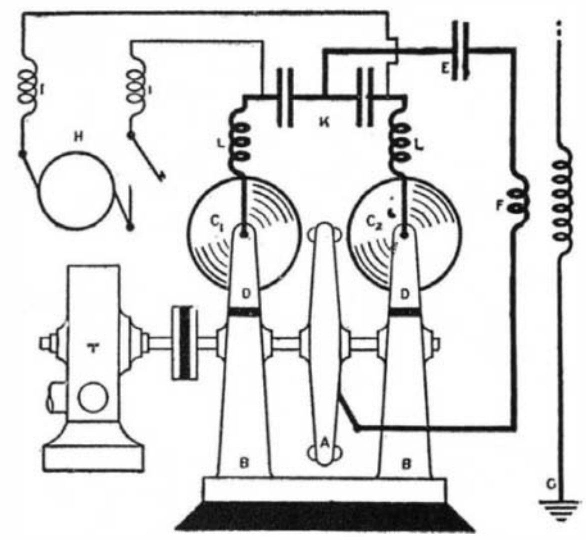

FIG. 22.

The making of paper from bamboo is not a recent discovery. For generations the Chinese have carried on this industry in their homes, but their methods are exceedingly primitive—no chemicals entering into their process. The Chinese use only bamboo shoots, for the evident reason that the shoots can be more readily worked up.

The new company will use all kinds of bamboo, young and old, but particularly a variety called "kei chiku," of which there is an unlimited quantity. The question of the supply of raw material will never puzzle the company, for the growth of bamboo is very rapid. It verily grows inches in a night.

The experiments so far have been made by mixing bamboo pulp and wood pulp in varying proportions, according to the quality of paper desired. But it is intended later to make paper entirely from bamboo pulp; the only difficulty standing in the way of that process now is that the cost of an entire bamboo paper is more than the cost of wood-pulp paper. It is expected that all the machinery of this company will be installed and the plant will be in full operation by June, 1910. The process employed will be a modified sulphite, specially prepared by the company from bamboo. There are eight different stages in the manufacture: (1) The preparation of the bamboo by chopping into small pieces from one to two inches in size; (2) cooking or digesting in a digester with sulphite of calcium; (3) washing with water; (4) bleaching with powder or electricity and washing again; (5) drawn through a machine to press into the form of web; (6) drying by steaming; (7) rolled by winding machine, or cut into sheets.

The pulp will be shipped to Japan in the form of rolls or sheets, where it will be manufactured into two grades of paper—news and book. On the Formosan pulp factory, and on the mills at Kobé, where the finished bamboo product will come forth, much interest will be centered by the great paper industries of the world.

At Haltem, in Westphalia, near the site of the Aluso fortress, erected by Drusus in the year 11 B. C., was

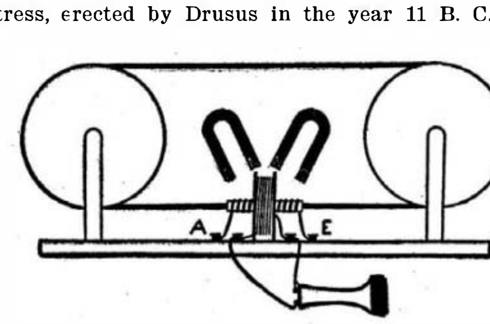

FIG. 23.

recently found a bronze vessel containing a dried black mass, which Prof. Kassner has decided to be Roman ink. The mass was found to consist chiefly of soot and tannate of iron. It also contained smaller quantities of ferric oxide, copper oxide, clay, magnesia, gypsum, phosphoric acid, carbonic acid, alkalies, and sand. These ingredients probably represent chiefly accidental impurities which have found their way into the old inkstand, but some of them may be due to the chemical action of the ink on the bronze vessel. The presence of an aromatic substances suggests that the ink was imported from Italy, where the use of perfumed ink was common.