WIRELESS TELEGRAPHY.

By G. MARCONI, Member.

"WIRELESS TELEGRAPHY," or telegraphy through space without connecting wires, is a subject which has attracted considerable attention since the results of the first experiments I carried out in this country became known. It is not my intention this evening to give my views on or discuss the theory of the system, with which I have carried out so many experiments, and by means of which I have worked various installations, but I hope to put before you some exact information of what has been done by myself and my

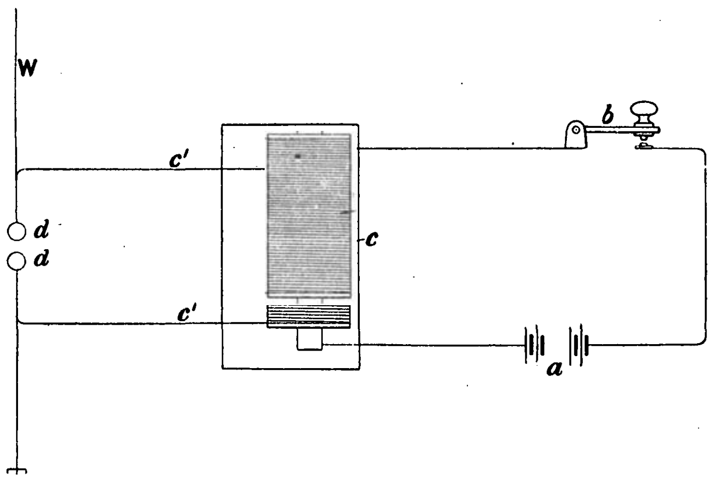

FIG. 1.

assistants during the last twelve months, and also some reliable data as to the means employed to obtain such results. Much has been published on the subject, I must say with varying accuracy, and there can hardly be any one here altogether ignorant of the general characteristics of the system.

Before I go into this subject further I wish to state that any success I have met with in the practical application of wireless telegraphy has been in a large measure due to the efficient co-operation which has been rendered by my assistants.

I think it will not be out of place if I give a brief description of the apparatus.

TRANSMITTER.—When long distances are to be bridged over and it is not necessary that the signals should be sent in one definite direction, I employ as transmitter an arrangement as shown in Fig. 1, in which two small spheres connected to the terminals of the secondary winding of an induction coil *c* are connected, one to earth and the other to a vertical conductor *W*, which I will call the aërial conductor.

Should it be necessary to direct a beam of rays in one given direction I prefer to use an arrangement similar to a Righi oscillator placed in the focal line of a suitable cylindrical parabolic reflector, *f* Fig. 2. The transmitter works as follows:—When the key *b* is pressed, the current of the battery is allowed to actuate the spark coil *c* which charges

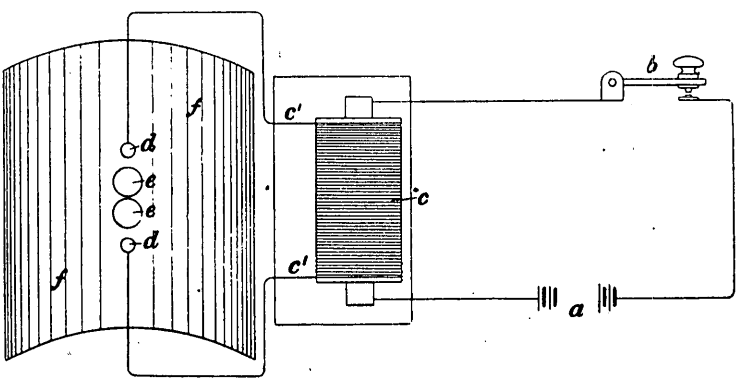

FIG. 2.

the spheres of the Righi oscillator or the vertical wire *W* which discharges through the spark gap.

This discharge is an oscillating one, and the system of spheres and insulated conductor becomes a radiator of electric waves. It is easy to understand how, by pressing the key for long or short intervals, it is possible to emit a long or short succession of waves, which, when they influence the receiver, reproduce on it a long or short effect, according to their duration, in this way reproducing the Morse or other signals transmitted from the sending station.

RECEIVER.—One of the principal parts in my receiver is the sensitive tube or coherer or radio-conductor, which was discovered, I think I am right in saying, by Professor Calzecchi Onesti, of Fermo,[1] and was improved by Branly,

[1] See *Nuovo Cimento*, series 3, vol. xvii., Jan.–Feb., 1885; and ditto, Jan.–Feb., 1896.

and modified by Professor Lodge and others. The only form of coherer I have found to be trustworthy and reliable for long distance work is one designed by myself as shown in Fig. 3. It consists of a small glass tube, four centimetres long, into which two metal pole pieces, j^1 j^2, are tightly fitted. They are separated from each other by a small gap,

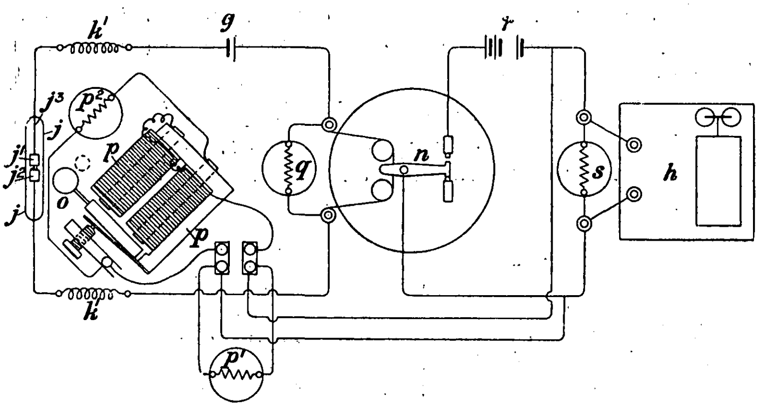

FIG. 3.

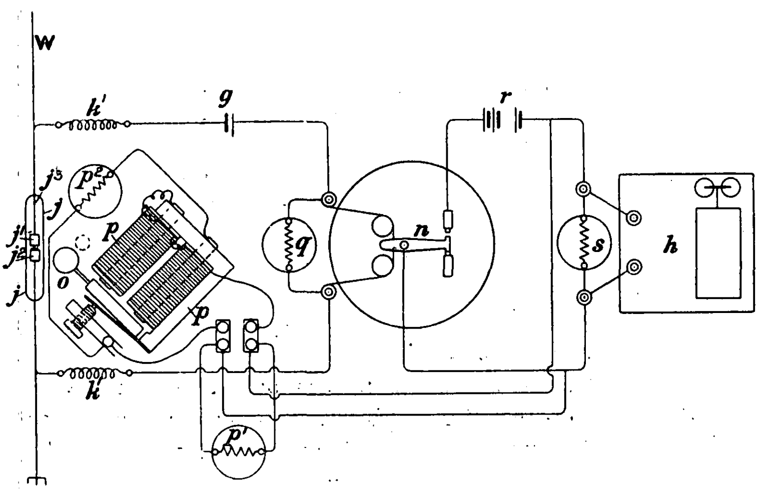

FIG. 4.

which is partly filled with a mixture of nickel and silver filings. This coherer forms part of a circuit containing the local cell and a sensitive telegraph relay actuating another circuit, which circuit works a trembler p or decoherer and a recording instrument h.

In its normal condition the resistance of the filings in the tube *j* is infinite, or at least very great, but when the filings are influenced by electric waves or surgings, cohesion instantly takes place, and the tube becomes a comparatively good conductor, its resistance falling to between 100 and 500 ohms. This allows the current from the local cell *g* to actuate the relay *n*.

One end of the tube is connected to earth and the other to a vertical conductor similar to that of the transmitter Fig. 1, or if reflectors are used a short strip of copper is connected to each end, Fig. 5. The length of these strips of copper must be carefully determined, as good results cannot be obtained unless they happen to be of the proper length,

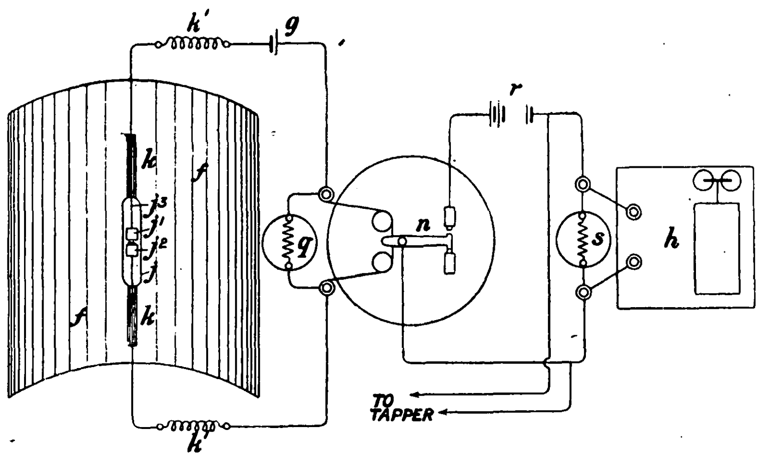

FIG. 5.

which will cause them to be in tune or syntony with the transmitted oscillations.

All the electro-magnetic apparatus in the receiver is shunted by non-inductive resistances in such a manner that there may be no sparking at contacts and no sudden perturbations or jerks caused by the local battery current near the coherer.

I find that the relay tapper and telegraphic instrument, if not properly shunted, produce disturbing effects, the result of which is to prevent the coherer from regaining its sensitive condition after the receipt of electrical oscillations.

No such trouble is experienced when suitable shunts are used, and I attribute to their action in very great measure the success which has been attained with this system.

Small choking coils *k' k'* are introduced between the coherer and the relay. They compel the oscillating current due to the electric waves to traverse the coherer rather than waste its energy in the alternative path afforded by the relay.

The oscillations induced on the strips *k k* or aërial conductor *W*, which acts as resonator, by the radiation from the oscillator affect the sensitive tube. This effect on the tube consists, as we have said, in a great increase of its conductivity, thus completing the circuit and allowing the current from the cell to actuate the relay. The relay in its turn causes a larger battery *r* to pass a current through the tapper or interrupter *p*, and also through the electro-magnets of the recording instrument *h*.

The tapper or trembler is so adjusted as to tap the tube and shake the filings in it. If in the instant during which these various actions take place, the electrical oscillations had died out in the resonator, the shake or tap given to the tube by the hammer *o* would have restored it to its normal high-resistance condition, and the Morse instrument or recorder would have marked a dot on the tape, but if the oscillations continue at very brief intervals, the acquired conductivity of the tube *j* is destroyed only for an instant by the tap of the trembler, and immediately re-established by the electrical surgings, and therefore the relay tapper and telegraph instrument are again actuated, and so on until the oscillations from the radiator have ceased.

The practical result is that the receiver is actuated for a time equal to that during which the key is pressed at the transmitting station. For each signal, however short, the armatures of the relay and tapper perform some very rapid vibrations dependent on each other. For it is the action of the relay which starts the tapper, but the tapper by its action interrupts the relay.

The armature of the Morse recording instrument being rather heavy, and possessing a comparatively large inertia, cannot follow the very rapid vibrations of the tongue of the relay, but remains down all the time, during which the rapidly intermittent action of the receiver lasts. In this way the armature of the inker gives a practically exact reproduction of the movements of the key at the transmitting end, dashes coming out as dashes, and dots as dots.

Much has been said and written about coherers being very unreliable and untrustworthy in their action, but I must confess that this has not been in any way my experience. Provided a coherer is properly constructed and used on a suitable receiver, it is just as certain in its action as any other electrical apparatus, such as an electro-magnet or an incandescent lamp. I have coherers which were made three years ago that are now quite as good if not better than they were at that time, and we have had tubes working for months in most important installations without ever giving trouble. At the installation my Company have erected at the South Foreland Lighthouse, which, as you probably know, is working to the East Goodwin Lightship, the coherer was mounted on the receiver when we first started in December of last year, and has done its work in a most satisfactory manner ever since.

I must call your attention to the object and function of the vertical wire *W*. It has been by means of this addition to the apparatus, that we have been able to telegraph over distances which have been so far unattained, I think I am right in saying, by any other method of space telegraphy. The way I came to appreciate the great importance of the addition of the conductor *W* and earth connection *E* to the apparatus was as follows:—

(I take this data from a copy of a letter I wrote to Mr. Preece in November, 1896.)

When carrying out some experiments in Italy in 1895, I was using an oscillator having one pole earthed and the other connected to an insulated capacity, the receiver also earthed and connected to a similar capacity. The capacities were in this case cubes of tinned iron of 30 centimetres side, and I found that when these were placed on the top of a pole 2 metres high, signals could be obtained at 30 metres from the transmitter. With the same cubes on poles 4 metres high, signals were obtained at 100 metres, and with the same cubes at a height of 8 metres, other conditions being equal, Morse signals were easily obtained at 400 metres. With larger cubes of 100 centimetres side, fixed at a height of 8 metres, reliable signals could be obtained at 2,400 metres all round, equal to about one mile and a half.

These results seemed to point out that a system of transmitter and receiver designed according to the lines on Fig. 1, *i.e.*, a radiator of the Hertzian type having one pole earthed and the other connected to a vertical, or almost vertical, conductor, or to a lofty capacity area, and a resonator consisting of a suitable receiver having similarly one terminal connected to earth and the other to an insulated vertical conductor, constitute a system of transmitter and receiver capable of giving effects at far greater distances than the ordinary systems of Hertzian radiators and resonators.

The results I have referred to also show that the distance at which signals could be obtained varied approximately with the square of the distance of the capacities from earth, or perhaps with the square of the length of the vertical conductors. This law has since been verified by a careful series of experiments and found correct, and has furnished us with a sure and safe means of calculating what length the vertical wire should have in order to obtain results at a given distance. It is well to know that the said law has never failed to give the expected results across clear space in any installation or experiment I have carried out, although it usually seems that the distance obtained is slightly in excess of what one might expect. I find that with parity of other conditions a vertical wire 20 feet long at the transmitter and receiver is sufficient for communicating one mile, 40 feet at each end for 4 miles, and 80 feet for 16 miles and so on. An installation is now working over a distance of 18 miles with a vertical wire 80 feet high at each installation station.

Professor Ascoli[1] has confirmed this law and demonstrated mathematically, using Neumann's formula, that the inductive action is proportional to the square of the length of one of the two conductors if the two are vertical and of equal length, and in simple inverse proportion of the distance between them. Therefore, the intensity of the induced oscillation does not diminish with the increase of distance if the length of the vertical conductors is increased in proportion with the square root of the distance. That is, if the height of the wire is double, the possible distance becomes quadrupled.

Should it be necessary to rig up an installation at a distance of say 32 miles, such as is about the distance

[1] See *Elettricista*, August number, 1897. (Rowe.)

between Folkestone and Boulogne, it is easy to find that a vertical wire 114 feet long would be quite sufficient for that purpose.

Such laws are applicable only when apparatus properly constructed is employed. With apparatus in which some or several improved details are omitted I find it quite impossible to obtain anything like the results above mentioned. If, say, the impedance coils $k' \, k'$ are omitted the distance (other conditions being equal) is reduced to almost half its original value.

I must also call your attention to such cases as when obstacles like hills or mountains, or large metallic objects, happen to intervene between the places between which it is desired to establish communication. With all other forms of Hertzian transmitters and receivers with which I have experimented I find it to be quite impossible to obtain any results if a hill, mountain, or large metallic object intervenes in any way between the two stations. I am not aware whether any satisfactory results have been obtained by others where such obstacles have intervened, but when the vertical wire system is employed it becomes easy to telegraph between positions screened from each other by hills or by the curvature of the earth. In such cases it seems to be a marked advantage if the aërial conductor is thick or if a capacity area is placed at the top of it.

I am rather doubtful as to the correct explanation that can be given to this effect. I think there can be very little doubt as to the complete opacity, to electric waves, of a hill three miles thick, or of, say, several miles of sea-water. A solution of this difficulty might be given by attributing the results to the effect of the diffraction of such long waves as those radiated by a conductor 100 ft. long, but in that case it is difficult to explain why other forms of Hertzian transmitters and receivers, also giving long waves, do not act when such obstacles intervene. A way out of the difficulty may be arrived at if we suppose that the electrical oscillations are transmitted to the earth by the earth wire *E* of the transmitter and travel in all directions along the surface of the earth till they reach the earth wire of the receiving instrument, and by travelling up the said wire to the coherer thus bring about its action. This was the first explanation I came to during my early experiments. I, however, do not wish to say that I hold entirely to this view at present, although I have not yet found any other perfectly satisfactory explanation of the phenomena.

It is well, also, to note that a horizontal wire, even if supported at a considerable height from earth, seems to be of little or no practical utility in increasing the range of signals. If, say, a vertical wire 30 ft. long is employed at both stations, and to the top of this is added a horizontal length of 300 ft., as shown in Fig. 6, the distance obtained is greater with the vertical wire without the horizontal length than it would be if both were employed. These results show that with this system it is not sufficient to use a horizontal radiating or collecting wire, as such a wire would be of no utility for long-distance signalling.

I believe that the exceedingly marked advance made by

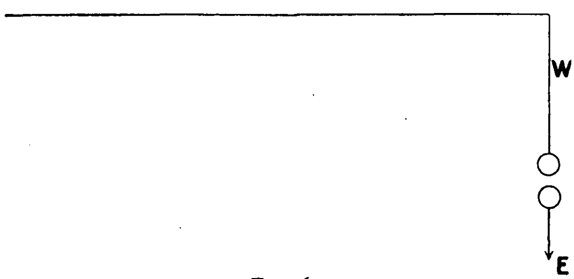

FIG. 6.

the adoption of the vertical conductor is due to the fact that the plane of polarisation of the rays radiated is vertical, and that therefore they are not absorbed by the surface of the earth, which acts as a receiving conductor placed horizontally. As the maximum effect is obtainable when the conductors of the transmitter and receiver are parallel, this makes it necessary to have a vertical conductor connected to one pole of the coherer.

Before proceeding to describe the results obtained under various conditions by means of what we may call the vertical wire system, I think it desirable to bring before you some observations and results I have obtained with a system of Hertzian wave telegraphy, which was the first with which I worked, and in which parabolic reflectors are used to control the propagation and intensify the effects obtained when comparatively short electric waves are employed for signalling. As in ordinary optics, so also in the optics of electro-magnetic oscillations, it is possible, as has been shown by Hertz, to reflect the waves radiated from the oscillator in one definite direction only. This can be done, as you know, by using convenient reflectors, similar to those used for projectors, but preferably, for economical reasons, made of copper or zinc, instead of silver amalgam or silver. Except when very small radiators of the Righi or Lebedew type are employed, it is desirable to use cylindrical parabolic reflectors, and it is with reflectors such as I here exhibit that the trials to which I am alluding have been carried out. The advantages obtainable by their use are obvious.

In any other system intended for the transmission of telegraphic signals by means of electric waves through space, the waves have been allowed to radiate in all directions, and would affect all suitable receivers within a certain radius, which of course is dependent on the power of the radiator or transmitter and on the sensitiveness of the resonator or receiver. It is, however, possible, by means of syntonising arrangements, to prevent, to a certain extent, messages affecting instruments or receivers for which they are not intended, and therefore to select any receiver by altering the wave length of the transmitter. By means of reflectors it is possible to project the waves in one almost parallel beam which will not affect any receiver placed out of its line of propagation, whether the said receiver is or is not in tune or syntony with the oscillation transmitted. This would enable several forts, or hill-tops, or islands to communicate with each other without any fear of the enemy tapping or interfering with the signals, for if the forts are on small heights the beam of rays would pass above the positions which might be occupied by the enemy. An illustration of the possibility of directing these waves can be shown by the action of the receiver, which in this case rings a bell only when the radiator in the reflector is directed towards it. These results are much more marked in an open space than in a lecture theatre, as the walls, gilt hangings, &c., tend to reflect the rays in all directions and may alter the results.

In experiments carried out over a distance of 1¾ miles, I noticed that only a very small movement of the transmitting reflector was sufficient to stop the signals at the receiving end, which could be only obtained within a latitude of 50 ft. to the right or left of what was believed to be the centre of the beam of reflected radiations.

There exists a most important case to which the reflector system is applicable, namely to enable ships to be warned by lighthouses, light-vessels, or other ships, not only of their proximity to danger, but also of the direction from which the warning comes. If we imagine that *A* is a lighthouse provided with a transmitter of electric waves, constantly giving a series of intermittent impulses or flashes, and *B* a ship provided with a receiving apparatus placed in the focal line of a reflector, it is plain that when the receiver is within range of the oscillator the bell will be rung only when the reflector is directed towards the transmitter, and will not ring when the reflector is not directed towards it. If the reflector is caused to revolve by clockwork or by hand, it will therefore give warning only when occupying a certain sector of the circle in which it revolves. It is therefore easy for a ship in a fog to make out the exact direction of point *A*, whereby, by the conventional number of taps or rings, she will be able to discern either a dangerous point to be avoided or the port or harbour for which she is endeavouring to steer.

I have not up to the present attempted to signal any greater distance than about two miles with reflectors, but I am of opinion that across clear space it will be quite possible to obtain satisfactory results at far greater distances, especially if the reflectors are accurately made any larger than those I have used. By means of the same apparatus exhibited here I have succeeded in signalling over a distance of 2½ miles, without of course the use of any real "base" lines, which were supposed to be essential for any distance greater than a few feet.

It was by means of reflectors I obtained the results over 1¾ miles mentioned by Mr. Preece at the British Association meeting of 1896.

I have, however, dedicated more time to the other system *i.e.*, the vertical wire system.

A station at Alum Bay, Isle of Wight, and another at Bournemouth, the distance between them being 14½ miles, were erected at the beginning of last year in order to test the practicability of the system under all conditions of weather, and also to afford an opportunity of proving that "Wireless Telegraphy" was not a myth but a working reality. I believe some details of the special conditions of these stations would be of interest. The installation at Alum Bay is in the Needles Hotel, and the Bournemouth station (which has lately been transferred to the Haven Hotel, Poole, thereby increasing the distance to 18 miles), was at Madeira House, South Cliff. At each station a pole 120 feet high was used, which supported the aërial conductor, usually a stranded conductor of 7/20 copper wire insulated with rubber and tape. A 10″ induction coil is used at each station, worked by a battery of 100 Obach cells "M" size, the current taken by the coil being at 14 volts from 6 to 9 amperes. The spark discharge takes place between two small spheres about 1″ in diameter, this form of transmitter having been found more simple and more effective than the Righi oscillator I had previously used. The length of spark is adjusted to about 1 centimetre; this, being a much shorter spark than the coil can give, allows a good margin over for any irregularity that might be caused by the break. No care is ever taken to polish the spheres *d d* at the place where the spark occurs, as the results seem decidedly better with dull spheres than with polished ones.

The first tests were made between the Isle of Wight and a steamer, the height of the mast on the boat being about 60 ft. Readable signals were obtained up to a distance of 18 miles from Alum Bay. During the course of these experiments, I had the pleasure of the company and assistance of Captain Kennedy, R.E., who was good enough to draw a map showing the course of the steamer. It has apparently been thought that weather or varying conditions of atmospheric electricity may interfere with or stop the signals transmitted by this system, but experience of over fourteen months of continual everyday work has brought me to the conclusion that there is no kind of weather which can stop or seriously interfere with the working of such an installation. We have given demonstrations to several eminent scientists, who came down and wanted a show, often when we did not expect them, but on no occasion have they found any difficulty in the work of transmitting and receiving messages between the two stations.

In September of last year, in consequence of the expiration of our lease at Madeira House, Bournemouth, we transferred that station, as I have said, to the Haven Hotel, Poole, thereby increasing the distance to 18 miles. Experiments and tests are carried out daily between the two stations, the improvement in apparatus having allowed us to reduce the height to 80 ft. at each end. An average of fully 1,000 words are daily transmitted through the ether each way.

In the spring of last year Lord Kelvin inspected our station at Alum Bay, and he was kind enough to express himself as highly pleased with what he saw. He sent several telegrams to his friends, including Mr. Preece and Sir George Stokes, and insisted on paying 1s. royalty on each message, wishing in this way to show his appreciation of what was done and to illustrate its fitness at that time for commercial use.

We are now working at experiments directed towards still further reducing the height necessary for a given distance, and also a good deal on syntonic systems.

In May of last year Lloyds desired to have an illustration of the possibility of signalling between Ballycastle and Rathlin Island in the north of Ireland. My assistants, Mr. Kemp and the late Mr. Glanville, installed the instruments at Ballycastle and at Rathlin Island. The distance between the two positions is 7½ miles, of which about 4 are overland and the remainder across the sea, a high cliff also intervening between the two positions. At Ballycastle a pole 70 ft. high was used to support the wire, and at Rathlin a vertical conductor was supported by the lighthouse 80 ft. high. Signalling was found quite possible between the two points, but it was thought desirable to bring the height of the pole at Ballycastle to 100 ft., as the proximity of the lighthouse to the wire at Rathlin seemed to diminish the effectiveness of that station. At Rathlin we found that the lighthouse-keepers were not long in learning how to work the instruments, and after the sad accident which happened to poor Mr. Glanville that installation was worked by them alone, there being no expert on the island at the time.

Following this, in July we were requested by a Dublin paper, the *Daily Express*, to report from the high seas the results and incidents of the Kingstown Regatta. In order to do this we erected a land station, by the kind permission of the harbour-master at Kingstown, in his grounds, where a pole 110 ft. high was placed. A steamer, the *Flying Huntress*, was chartered to follow the racing yachts, the instruments being placed in the cabin. The height of the vertical wire attainable by the mast was 75 ft. A telephone was fixed from our land station at Kingstown to the *Express* office in Dublin, and as the messages came from the ship they were telephoned to Dublin, and published in succeeding editions of the evening papers.

The relative positions of the various yachts were thus wirelessly signalled while the races were in progress, sometimes over a distance of ten miles, and were published long before the yachts had returned to harbour. During the several days the system was in use between the tug and the land station, over seven hundred messages were sent and received, none requiring to be repeated. On trying longer distances it was found that with a height of 80 ft. on the ship and the same height as already stated on land, it was possible to communicate up to a distance of 25 miles, and it is worthy of note in this case that the curvature of the earth intervened very considerably at such a distance between the two positions. On one occasion, on a regatta day, I had the pleasure of the company of Professor G. F. Fitzgerald, of Trinity College, Dublin, on the ship, who, as would be expected, took a very great interest in the proceedings.

Immediately after finishing at Kingstown I had the honour of being asked to install wireless telegraph communication between the Royal yacht *Osborne* and Osborne House, Isle of Wight, in order that her Majesty might communicate with H.R.H. the Prince of Wales, from Osborne House to the Royal yacht in Cowes Bay, and during the trips His Royal Highness frequently took. The working of this installation was a very pleasant experience for me, and it afforded also an opportunity of more thoroughly studying the effect of intervening hills.

In this installation induction coils capable of giving a 10-inch spark were used at both stations. The height of the pole supporting the vertical conductor was 100 feet at Osborne House.

On the Royal yacht *Osborne* the top of our conductor was suspended to the main mast at a height of 83 ft.

from the deck, the conductor being very near one of the funnels, and in the proximity of a great number of wire stays. The vertical conductor consisted of a 7/20 stranded wire at each station.

The Royal yacht was moored in Cowes Bay at a distance of $1\frac{3}{4}$ miles from Osborne House, the two positions not being in sight of each other, the hills behind East Cowes intervening. This circumstance would have rendered direct signalling between the two positions impossible by means of any flag, semaphore, or heliograph system. Constant and uninterrupted communication was maintained between the Royal yacht and Osborne House during the sixteen days the system was in use, no hitch whatever occurring.

One hundred and fifty messages were sent, being chiefly private communications between the Queen and the Prince. Many of these messages contained over a hundred and fifty words, and the average speed of transmission was about fifteen words per minute.

By kind permission of the Prince of Wales I will now read to you some of the telegrams which passed between the Royal yacht and Osborne House.

August 4th.

From DR. FRIPP *to* SIR JAMES REID.

H.R.H. the Prince of Wales has passed another excellent night, and is in very good spirits and health. The knee is most satisfactory.

August 5th.

From DR. FRIPP *to* SIR JAMES REID.

H.R.H. the Prince of Wales has passed another excellent night, and the knee is in good condition.

The following telegram was sent during a cruise, and while the Royal yacht was under way, as you will see from the context.

August 10th.

From H.R.H. THE PRINCE OF WALES *to* DUKE OF CONNAUGHT.

Will be very pleased to see you on board any time this afternoon when the *Osborne* returns.

This telegram was sent when the yacht was off Bembridge, at a distance of about seven or eight miles from Osborne.

On August 12th the *Osborne* steamed to the Needles, and communication was kept up with Osborne House until off

Newton Bay, a distance of seven miles, the two positions being completely screened from each other (even to the tops of the masts) by the hills lying between. At the same position we found it quite possible to speak with our station at Alum Bay, although Headon Hill, Golden Hill, and over five miles of land lay directly between. The positions were eight and a half miles apart. Headon Hill was 45 ft. higher than the top of our conductor at Alum Bay station, and 314 ft. higher than the vertical wire on the *Osborne*.

The yacht on the same trip proceeded till about three miles past the Needles, communication having been maintained during the whole trip. Another day, when I did not happen to be on board, the yacht went on a cruise round Bembridge and Sandown, communication being maintained with Osborne House, although more than eight miles of land lay between the two positions. The Prince of Wales and other members of the Royal Family, especially the Duke of York, made much use of the system, and expressed themselves as highly satisfied with its practicability.

I consider these results rather interesting, as doubts have been expressed by some as to whether it would be possible by this system to telegraph over long stretches of land.

Results across hills were also obtained near Spezia by officers of the Italian Navy, using my system.

In December of last year my Company thought it desirable to demonstrate that the system was quite practical and available for enabling telegraphic communication to be established and maintained between lightships and the shore. This, as you are probably aware, is a matter of much importance, as all other systems tried so far have failed, and the cables by which some three or four ships are sometimes connected are exceedingly expensive, and require special moorings and fittings, which are troublesome to maintain and liable to break in storms.

The officials of Trinity House offered us the opportunity of demonstrating to them the utility of the system between the South Foreland Lighthouse, and one of the following light-vessels, viz., the *Gull*, the *South Goodwin*, and the *East Goodwin*. We naturally chose the one furthest away—the *East Goodwin*—which is just 12 miles from the South Foreland Lighthouse.

The apparatus was taken on board in an open boat, and rigged up in one afternoon. The installation started working from the very first without the slightest difficulty. The system has continued to work admirably through all the storms, which during this year have been remarkable for their continuance and severity.

On one occasion during a big gale in January, a very heavy sea struck the ship, carrying part of her bulwarks away. The report of this mishap was promptly telegraphed to the Superintendent of Trinity House, with all details of the damage sustained.

The height of the wire on board the ship is 80 ft., the mast being for 60 ft. of its length of iron, and the remainder of wood. The aërial wire is let down among a great number of metal stays and chains, which do not appear to have any detrimental effect on the strength of the signals. The instruments are placed in the aft-cabin, and the aërial wire comes through the framework of a skylight, from which it is insulated by means of a rubber pipe. As usual, a 10-inch coil is used, worked by a battery of dry cells, the current taken being about 6 to 8 amperes at 14 volts.

Various members of the crew learned in two days how to send and receive, and in fact how to run the station, and owing to the assistant on board not being as good a sailor as the instruments have proved to be, nearly all the messages during very bad weather are sent and received by these men, who, previous to our visit to the ship, had probably scarcely heard of wireless telegraphy, and were certainly unacquainted with even the rudiments of electricity. It is remarkable that wireless telegraphy, which had been considered by some as rather uncertain, or that might work one day and not the next, has proved in this case to be more reliable, even under such unfavourable conditions, than the ordinary land wires, very many of which were broken down in the storms of last month.

The instruments at the South Foreland Lighthouse are similar to those used on the ship, but as we contemplate making some long distance tests from the South Foreland to the coast of France, the height of the pole is much greater than would be necessary for the lightship installation.

We found that 80 ft. of height is quite sufficient for speaking to the ship, but I am of opinion that the height available on the ship and on shore would be ample even if the distance to which messages had to be sent were more than double what it is at present.

Service messages are constantly passing between the ship and the lighthouse, and the officials of Trinity House have been good enough to give expression of their entire satisfaction with the result of this installation. The men on board send numerous messages almost daily on their own private affairs; and this naturally tends to make their isolated life less irksome.

My Company has been anxious for some time to establish wireless communication between England and France across the Channel, in order that our French neighbours might also have an opportunity of testing for themselves the practicability of the system, but the promised official consent of the French Government has only been received this evening. Otherwise this communication would have been established long ago. The positions for the stations chosen were situated at Folkestone and Boulogne, the distance between them being 32 miles. I prefer these positions to Calais and Dover, as the latter are only separated by a distance of about 20 miles, which is only slightly more than we are doing every day at Poole and Alum Bay, and as we find that distance so easy we would naturally prefer further tests to be made at much greater distances.

We did ask for permission to erect a station at Cherbourg, the corresponding station to be at the Isle of Wight, but the French authorities stated that they would prefer us to have our station in that country in some other position on the north coast.

My system has been in use in the Italian Navy for more than a year, but I am not at liberty to give many details of what is done there. Various installations have been erected and are working along the coast, two of these being at Spezia.

Distances of 19 miles have been bridged over in communicating with war vessels, although 10 miles have been found quite sufficient for the ordinary fleet requirements.

Other installations are now contemplated in this country for commercial and military purposes, and I am confident that in a few months many more wireless telegraph stations will be established both here and abroad.

Supplementary Note, added March 30th, 1899.

As the installation in the neighbourhood of Boulogne has been started since I read my paper, if I may I would like to add that France and England were successfully connected on Monday, the 27th of March. The station on the English side is situated at the South Foreland Lighthouse, near Dover, and that on the French side at the Châlet L'Artois, Wimereux, near Boulogne. The instruments were sent over from London the previous Monday in charge of two assistants, a house having been taken to serve as a station. A suitable pole was then erected, and at 5 o'clock on the 27th, within a week from the time the instruments left London, perfect telegraphic communication was established between the two points. The first messages passed in the presence of the Committee appointed by the French Government, viz., Colonel Comte du Pontavice de Heussey, Captain Ferrié, and M. Voisenet. The first message was sent from France to England, and the reply was promptly returned by my assistant-in-charge at the South Foreland Lighthouse. There has not been the slightest hitch in the communication since, and it will no doubt be interesting to know that yesterday, the 29th, operations were conducted by two French officers, Captain Ferrié, of the French Engineers, sending from the English side to M. Voisenet, French Telegraph Engineer, on the French side. These gentlemen kept up a telegraphic correspondence for several hours, and they and numerous others have expressed themselves as highly satisfied with the successful start and working of the installation.

The CHAIRMAN : I have the pleasure to announce that, as a great number of people have been turned away from the door this evening owing to there being no room for them, Mr. Marconi has very kindly consented to give his paper again at a date which we hope to be able to fix very soon. The Chairman.

Dr. J. A. FLEMING: I am sure, sir, we shall all desire to present to Mr. Marconi our hearty congratulations on the magnificent success he has obtained in carrying out his most interesting experiments. Dr. Fleming.

He is in such complete possession of the field that there is very little any of us can add in the discussion of his paper except by way of confirmation or questions to elicit more information. There are one or two points, however, on which I should like to make a remark or two. First, as to the transmitter. I believe in his earlier experiments Mr. Marconi made use of a Righi transmitter in which the central spark