THE MARCONIGRAPH

Vol. II.—No. 19. October, 1912. Subscription, 3/6 per annum, post free. Price 2d. Post Free 3½d.

# Wireless Telegraphy in Trinidad

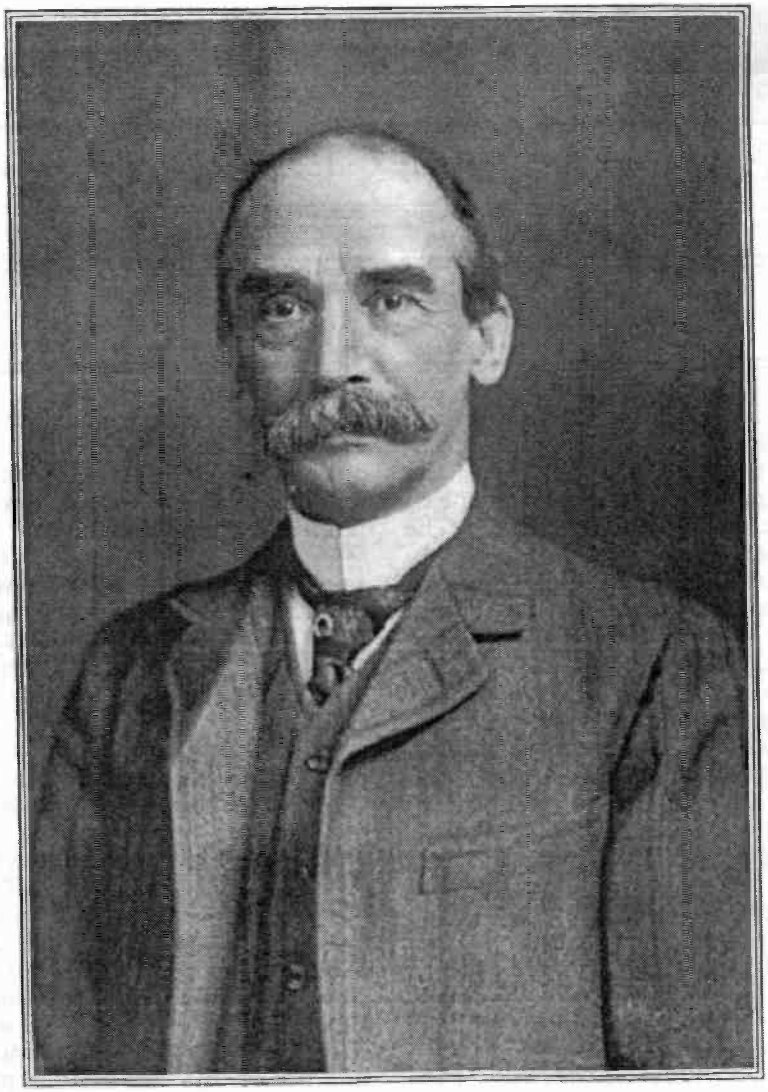
AMONG the latest contracts entered into by Marconi's Wireless Telegraph Company with the Crown Agents for the Colonies is a contract for the establishment of a radiotelegraphic station in Trinidad. The site for this station has not yet been definitely chosen. It is proposed to erect a 5-kw. set which will be capable of transmitting on any wave-length from 600 to 2,000 metres. The station will be capable of actuating acoustic receivers over the full range at 30 words per minute. The range of reception will cover all wave-lengths between 100 and 2,300 metres. The climate of the country is damp, and special attention must therefore be given to the materials used in construction of the apparatus and insulation.

The station will be designed to have a normal working range across open water of 350 nautical miles when communicating with a station similarly equipped with regard to mean height of aerial and the power and efficiency of the plant employed. The aerial will be of the T-shape multiple wire type, suspended between the masts, of which there will be two, each 200 ft. in height, of the tubular lattice-work type.

The generating plant will consist of a motor driving an alternating current generator of 5-kw. output at 500 volts, and a periodicity of 300. Another motor-generator set will be supplied for battery charging. The motor will run off existing alternating current supply mains and the generator will be capable of giving 10 kw. at 110/160 volts. The battery of accumulators will consist of 60 cells, having a capacity of 270 ampère hours at a three hours' discharge rate. The transformer will be of the single-phase closed iron circuit core type, capable of delivering 5 K.V.A. at either 7,000 or 14,000 volts, when supplied with alternating current energy at 500 volts and 300 cycles. In conjunction with the transformer a suitable air-cooled iron-core adjustable low-frequency inductance fitted with a controller switch will be furnished to enable the circuit to be brought into resonance with the alternator frequency.

An independent primary and secondary circuit type jigger will be supplied, the primary being provided with terminals, and an adjustable plug connection to afford a means of rapidly changing the number of turns of the primary winding included in the circuit, while the secondary will be provided with suitable plug sockets for connection at various points with the aerial tuning inductance. A special type of disc discharger will be installed to produce a musical note in transmission.

The disc discharger will be driven off an extension of the alternator shaft, and will consist generally of a rotating disc, of insulating material, carrying a number of metal studs bearing a direct numerical relation to the number of the alternating poles, these studs being caused to rotate at the speed of the motor generator set between stationary adjustable electrodes. The design of the disc will be such as to afford a spark frequency of 600 per second when running at a normal speed, and in correct phase relation to the alternator. Two types of receivers will be supplied, comprising : (*a*) Standard Marconi double-magnetic detector working in conjunction with a multiple tuner, and (*b*) a standard Marconi valve type receiver; the former will have a range of adjustment for wave-lengths of from 100 to 2,500 metres, while the latter will have a range of adjustment enabling it to receive all lengths between 600 and 1,600 metres.



Mr. JOHN BOTTOMLEY

# Mr. John Bottomley,

## Vice-President of the Marconi Wireless Telegraph Co. of America.

IF Mr. Bottomley, whose portrait appears on the opposite page, had failed to make a mark in the career that he had chosen for himself, it would have caused greater surprise than the fact that he is at the present moment one of the most important business men of New York; for his mother was Hannah Thomson (sister of William Thomson, afterwards Lord Kelvin), and, if heredity counts for anything, John Bottomley must have derived a large share of his intellectual capacity from his famous uncle.

He was born at Belfast, Ireland, in 1848, a fact which is not without its interest for those followers of Buckle who uphold that external circumstances play a great part in moulding a man, for it is remarkable that many of those who have in after years become the world's most notable men have spent their early life in Ireland, and, in the most impressionable stage of their careers, have been influenced by the spirit and cast of thought which is peculiar to that country.

Moreover, the young Bottomley had the even greater advantage of being educated at private schools in Belfast, where his individuality was less likely to be stamped into that dread matter-of-fact uniformity which is so often the price paid for a public school career, and it was only when he was old enough to look after himself and his opinions that he entered Queen's College. But he was still quite young when he went into business in connection with the largest business house in Ireland on a six years' apprenticeship, and here he made very good use of the opportunities which came his way, for when four years of service were expired his firm waived their right to the remaining two years of his apprenticeship, and placed him in charge of all the departments and establishing agencies throughout Ireland. In 1870 Mr. Bottomley took charge of the flax and grain exporting house of Cummings, a firm that did a large business with Russia and England, and had two important depôts at Riga and London.

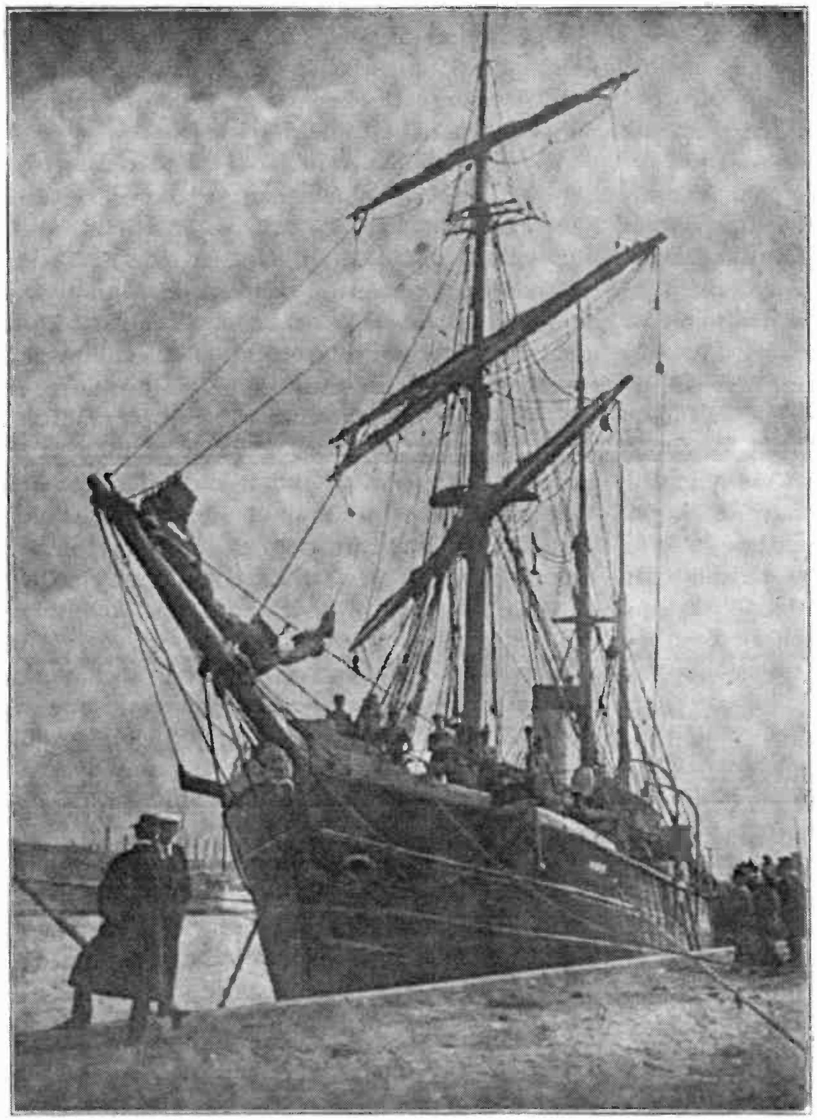
Any young man would have had reason to be proud of such achievement, and most would have been content to rest on their merits, but not so John Bottomley. In 1880 he went to America, took up the study of law, and was admitted to the Bar as soon as he had become a naturalised American subject. By so doing he achieved one of his most cherished ambitions, and was able for twenty-five years to practise indefatigably at the profession which he had adopted. It was in 1898 that he first met Mr. Marconi, and took up the very responsible task of introducing wireless telegraphy to the American world of commerce, and when the immense developments of the system required the reorganisation of affairs he became, in 1902, general manager, secretary, and treasurer of the Marconi Wireless Telegraph Co. of America. Since then he has been nominated as second vice-president of the company, which position he holds, in conjunction with many other important offices.

But Mr. Bottomley's interests are too wide to allow of his being entirely absorbed in any one particular occupation. He takes a keen interest in the social work of his city, and often this enables him to use his expert knowledge for the benefit of the community. He is president of the New York Electrical Society, vice-president of the Harlem Library, which is now incorporated with the Public Library, and is vice-president of the Harlem Dispensary, besides being trustee of the Empire Cities Savings Bank and a member of the Finance Committee. He is also a well-known figure at the Engineers and New York Athletic Clubs.

# Wireless to Aid Navigation in the Kara Seas

## Another Tour for the "Nimrod"

THE "Nimrod" was predestined to cold and ice and the wintry terrors of the frozen zone; but she has fulfilled more than her destiny, for under Sir Ernest Shackleton her voyages to the Antarctic have given her a conspicuous place in the rank of Antarctic discovery. With her triumphal return bearing the intrepid little band of explorers her work was not completed, nor was she to fall into the oblivion which generally is the fate of sea-going craft—a fate which overtakes even the gigantic man-of-war.



*The s.s. "Nimrod" prior to her departure for the Kara Seas.*

Now the "Nimrod" is to go to the Arctic Circle, and is to play her part in something more than discovery, for she carries on board the engineers and the apparatus which are ultimately to bring the lonely shores of the Kara Sea into touch with civilisation and the life of the greater world. Wireless stations are to be erected on the coast of North-Western Siberia; one on the island of Vaigats, another at Ugorski-Shar, and a third at Cape Maare-Saale. The two stations at Vaigats and Cape Maare-Saale are small power stations intended for communication with the 12-kw. station at Ugorski-Shar, and this, again, is to communicate directly with a fourth station of 16 kw., which is now being erected at Archangel by the Société Russe de Télégraphes et Téléphones sans fil.

The purpose of the Russian Government in erecting stations at such out-of-the-way places is the establishment of a secure means of communication in order to encourage the existing trade between Archangel and the Yenissei district, and it is expected that at no very future date other stations will be required to cope with an important and increasing trade.

As long back as 1895—that is, before the Trans-Siberian Railway was completed—Captain Wiggins, the celebrated navigator of the Kara Seas, urged that something should be done to make a waterway and open up communications for the conveyance of Siberian exports to the northern ports of Europe. He declared that the as yet incomplete Siberian Railway would make the opening up of such a route an urgent necessity, for it would be required to relieve the country of the enormous industry that would be developed in it by the railway. Agriculture would flourish a thousand times more than at that time, for the inhabitants would not be able to consume all they raised. Even at that moment they cultivated ten times more than they had need for, and it was impossible for the railway to carry the cereals to the sea-coast and the Baltic, as there would be sufficient traffic of other descriptions (more particularly passengers, and all the most fragile, costly, and best goods from England, and the urgent demands of tea transport) to later, after another cruise in the Kara Seas, was able to uphold and confirm his former opinion. Nor did the Government lose sight of the project, but—so complex are the worries of Ministers and so many the cares of the nation—it was impossible to further the scheme. Recently, however, as the result of an expedition which Captain Webster undertook in the "Nimrod" last year to the Kara Sea, a scheme has been provided for the running of ordinary tramp steamers between England and Nova Zembla, on the south-west of which there is a magnificent harbour, and from which goods would be transported to the Ob

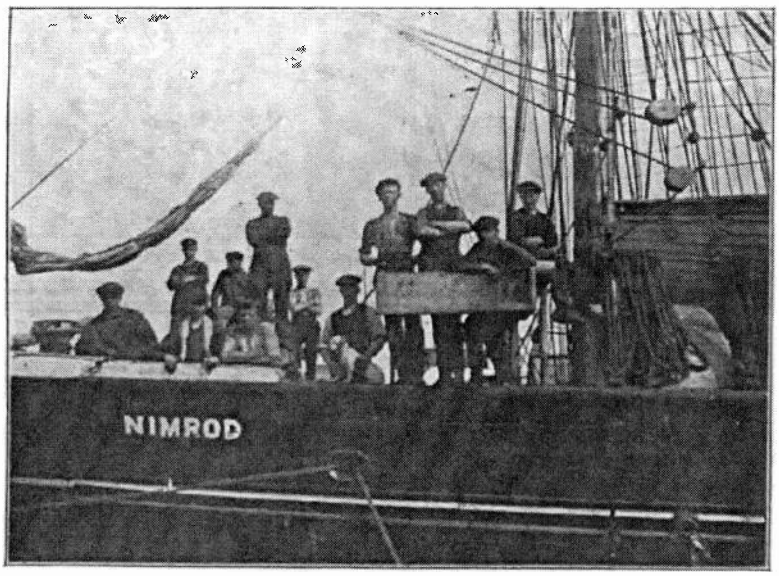
*Some of the Engineers of the Société Russe de Télégraphs et Télephones Sans Fil, with Mr. Eisenstein in the centre.*

monopolise its services. Nor was he alone in his opinion, for he had been able to convince the Russian Government that the scheme demanded immediate attention, and was of paramount importance, so much so that when the Minister of Finance at that time was interviewed on the proposals he is reported to have answered: "It is a serious and important thing for our country; we must open up this sea route immediately, and prove it either a great yes or a great no at once."

But the passing of years only made the necessity for such an enterprise more apparent, and Captain Wiggins, when speaking to the Geographical Society of Melbourne ten years and Yenisei in vessels specially adapted to resist the ice pressure. It is believed that they would be able to make three voyages each way during the season that navigation is possible, and when the Kara Sea becomes blocked it is suggested that the vessels could be employed in sealing. But another point has to be considered. It is doubtful whether it could ever have become part of a practical policy without the aid of wireless telegraphy, for the dangers of the ice-bound coast are many, and the rigours of the climate retard development. Wireless, however, makes no obeisance to the elements, and can brave the icy blasts of the Arctic Circle. Now, by the erection of these stations, communication will be set up by the port, and timely warning of the opening of the Kara Seas to navigation during the summer months, with regular reports as to the ice conditions prevalent, will be forthcoming.

The floating ice in the Kara Seas forms the chiefest peril. The Duc d'Orleans, who in 1907 undertook a cruise in the Kara Sea, has given some vivid descriptions of this dreary waste of black ice. Here is a characteristic passage:

" These ice floes, which are to be found in the centre of the Kara Seas, come from the coast of Siberia, which is low and sandy. They are formed by shingle and shells which have been covered up by snow. This has melted or been congealed by pressure into a thick mass of ice containing the silt. Again the sun and rains wash away the surface ice, and the *débris* becomes compacted into a horrible black soil. As this travels southward it is gradually broken up and diminished in thickness, until at last the whole of the ice is melted away, and the sediment sinks to the bottom to form the ooze of the Kara Sea. Though the phenomenon may be very interesting from the scientific point of view, from the picturesque standpoint it is deplorable. Nothing could be uglier or more depressing than this stretch of sea covered with heaps of dirty snow, and whenever a passing vessel dents into, or overturns, one of these lumps the sediment spreads out over the surface of the water, giving it a muddy chocolate colour. Often the ice-blocks would collect together in front of us, so that at times we could chase before us a whole bank of mud, and look very much as though we were one of those street-brushing machines which as they revolve send the immondices of big towns into the gutters."




*A portion of the crew.*

That is not the worst part of the ice difficulty. During the winter the greater part of the Kara Sea is impassable, and winter in these regions lasts a long time. The Ugorski Strait, for instance, is not open till about the middle of July, and ice begins to form again towards the middle of October. In an unfavourable year, however, it may hardly be open at all. A Russian flotilla of cargo boats and lightermen, which were laden with iron and stores for Yenisei, was unable to pass until September 3rd. However, the breaking up of the ice is usually very sudden, and is due to the fresh warm water discharged by rivers which, overrunning the cold sea water, quickly dissolves the ice, and this is characteristic of the coast all along Eastern Siberia.

Imagine a vessel carrying an important cargo being ice-bound for several months together, and it is easy to realise that traders are unwilling to face such risks. Now, however, they will be able to obtain accurate reports of the ice conditions, and their vessels need not sail until a clear passage is assured. By this means risk is brought to a minimum, confidence established, and thus trade develops apace.

The "Nimrod" is just the vessel for the work it has to do and the difficulties it has to encounter, and, considering these circumstances, it is difficult to overestimate the importance of such an expedition as that on which the "Nimrod" is bound. It has been necessary to transfer her to the Russian flag, and she has a crew of 17 men all told. She will carry besides a complement of 16 men, who are to carry out the purpose of the expedition, and who include the necessary engineers and mechanics, as well as a number of workmen who will erect the masts. Those of the two smaller stations will be of the lattice-work pattern, as they are easy of transport, while the masts of the two big stations at Ugorski-Shar and Archangel have, at the request of the Post Office, been specially constructed after the pattern of the Eiffel Tower—that is to say, without stays. The mast at Ugorski-Shar will be 75 metres (about 245 ft.) high, while at Archangel there will be three masts each 70 metres (about 230 ft.) high.

## A Wireless Girdle Round the Earth

**By F. M. Sammis***

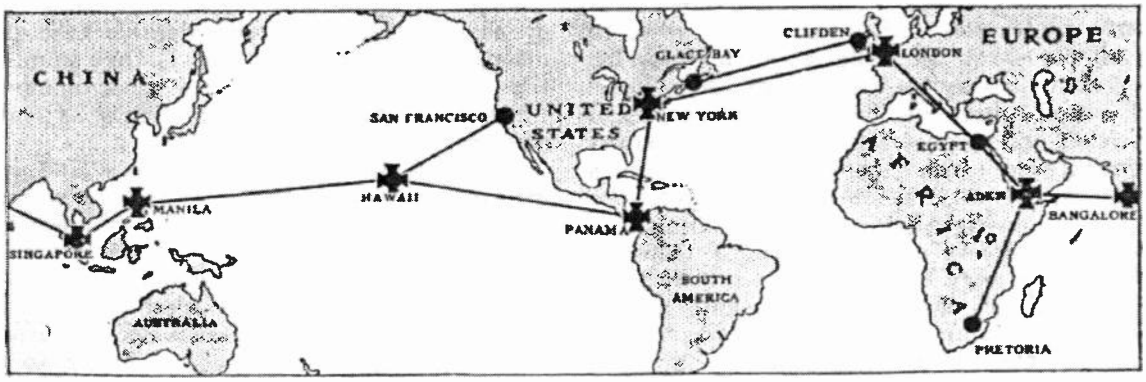
UNTIL the present time our country has not been entitled to boast of a real high-power (wireless) station, but now plans have been finished that will place the United States in the first rank with respect to both size and number of these modern high-power stations, and which, in conjunction with the stations being erected for the English Government, will provide a commercial service that will encompass the earth. This station will be near New York City, at Belmar, N.J., where 500 acres of land have been acquired upon which the masts and plants will be erected. Transmission will be effected to the Panama Canal Zone and thence to Hawaii.

The Hawaiian station will be one of the most powerful of the entire group, for, besides communicating with the station at Panama, it will be capable of working with San Francisco and the Philippine Islands, and with a station to be erected later in New Zealand. The Manila station is the last of the American group, and will connect to the east with the Singapore station of the English group. Unbroken communication will be maintained successively through the stations at Bangalore and Aden. At the latter station we may turn southward over the huge mountains of Abyssinia and the wilds of German East Africa to communicate with Pretoria in South Africa. It is probable that the station at Pretoria will be called upon to communicate with the proposed high-power station at Buenos Ayres soon to be started.

Retracing our steps to Aden on the Red Sea, we may talk with the station in Egypt to the north, and thence, by one tremendous leap, hurl a message with such force that it will cross the wide Mediterranean, ascend the boot of Italy, scale the ice-crowned Alps and drop quietly into London, all in less than one two-thousandth of one minute. Having arrived in England, we may take the present busy route from Clifden, Ireland, to Glace Bay, Nova Scotia, in order to talk with our Canadian neighbour, or we may utilise the new and more powerful station at London. By this means we arrive once more at our starting-point at Belmar. Thus with but nine stepping-stones we may trip around the earth. Still further stations are contemplated; in fact, the chain that girdles the globe will be but the main artery of a great system. Feeders and branch stations will be established in all countries, and a very comprehensive chain will be erected in South America in the near future.

With the establishment of this great network of stations will come an era of cheap communication, for wireless telegraphy may easily reduce the present cable rates. The cost of a submarine cable to cover a distance of 3,000 miles is anywhere from 7,000,000 dollars to 10,000,000 dollars, while the total cost of a pair of wireless stations to do the same work is but 600,000 dollars. The cable must handle a half-million dollars worth of business in order to earn enough to keep it in repair, while 2 per cent. of this amount will take care of the same item for the wireless. Two million words at 25 cents a word will earn only a sufficient sum to cover depreciation of the cable, while the same number of words at half-rate by wireless will produce enough to pay the depreciation charge and 35 per cent. on the investment besides.

The wireless system, in using Nature's ether as a conductor, has provided itself with a medium that requires no repairs. Surely we have here an accommodating servant by means of which we may from a single station talk with nations north, east, south, and west; we need no wires, no cables, no right of way and none of the expensive upkeep or repair that the older forms of communication require




*Large Stations to be erected.*

* Abstracted from an article by the Chief Engineer of the Marconi Wireless Telegraph Co. of America in *Popular Mechanics*.

# Unsolved Problems of Wireless Telegraphy

## Discussed before the British Association

ONE of the outstanding features of the British Association meetings last month was the joint meeting between sections A and G for the discussion of some of the unsolved problems of wireless telegraphy. From many points of view this discussion was one of the most important features of the Dundee meeting. Contrary to the usual custom, practical achievements were almost disregarded, and there was a total absence of those sensational announcements which have tended to become characteristic of public discussions on wireless telegraphy. The discussion was opened by Professor J. A. Fleming, who, in the all too short time allotted to him for his tale, went directly to the root of the matter, and raised questions which have perplexed physicists and engineers for years. The points discussed were: The "bending" of the waves to follow the contour of the earth, and the so-called "daylight effect," which makes it possible in certain circumstances to transmit signals for a very much greater distance by night than by day, using the same power. In Professor Fleming's opening remarks in the discussion on "Wireless Telegraphy and its Outstanding Problems" he endeavoured to elicit the opinions of mathematicians and others on the reasons why long-distance radio-telegraphy is possible.

The following is a report of Professor Fleming's remarks:

In opening a discussion on the present state of the theory of wireless telegraphy and its outstanding problems, I am to some extent embarrassed by the wide field which presents itself for consideration. I venture to think that we may best take advantage of the simultaneous presence here of physicists, mathematicians, engineers, and electricians if we endeavour to focus attention in the first place on some of the chief scientific problems which are yet unsolved in connection with it.

### Scope of the Inquiry.

Perhaps a word of explanation may be offered on the reason for giving prominence to the scientific aspect of the subject rather than its practical achievements. The achievements loom large in the public eye, and are astonishing, but experts in radiotelegraphy are well aware that many of the scientific phenomena are still imperfectly understood. If we are to overcome present difficulties and limitations, and make fresh advances, it can only be by a thorough comprehension of the physics of wireless telegraphy. Hence it will be more to our advantage to bring combined scientific thought to bear upon the matters on which even leading experts differ or are ignorant, rather than let our symposium resolve itself into a discussion on apparatus or systems, or the recitation of performances and record of results. As the only type of wireless telegraphy which has any considerable theoretical interest at the present time is that involving the application of unguided electromagnetic waves, our attention will doubtless be chiefly directed to it.

Speaking, however, in this place and city, we can hardly forbear to mention the name of that learned and indefatigable philosopher, James Bowman Lindsay, who made Dundee his home for 33 years. Quite independently he re-invented the telegraphic methods by which Morse and Gale in 1842 had sent electric currents across rivers, and he read a Paper to the British Association, at their Aberdeen meeting in 1859, "On the Transmission of Electricity through Water," in which he described his experiments, and even made the bold suggestion of using conduction through sea water to telegraph across the Atlantic. He carried out successful experiments here across the Tay and at Aberdeen across the Dee, but the subsequent development of submarine cable telegraphy caused these early suggestions for a rudimentary form of telegraphy by conduction through water to fade from view.*

Lindsay suggested putting a plate in the sea at Cornwall and another in the sea at Scotland and connecting them by a wire having a battery in circuit. Two other stations were then to be similarly connected on the coast of America, and a receiving instrument to be included in that second circuit.

Neither this nor the later discovered method of utilising the inductive effect of intermittent or alternating currents, which was initiated by Trowbridge, especially developed by Sir William Preece, improved by Sir Oliver Lodge, and used

* *See* B.A. Report, Aberdeen, 1859, p. 13.

by Rathenau, Stevenson, Edison, and many others, was available for more than small distances, nor did they provide a compact and

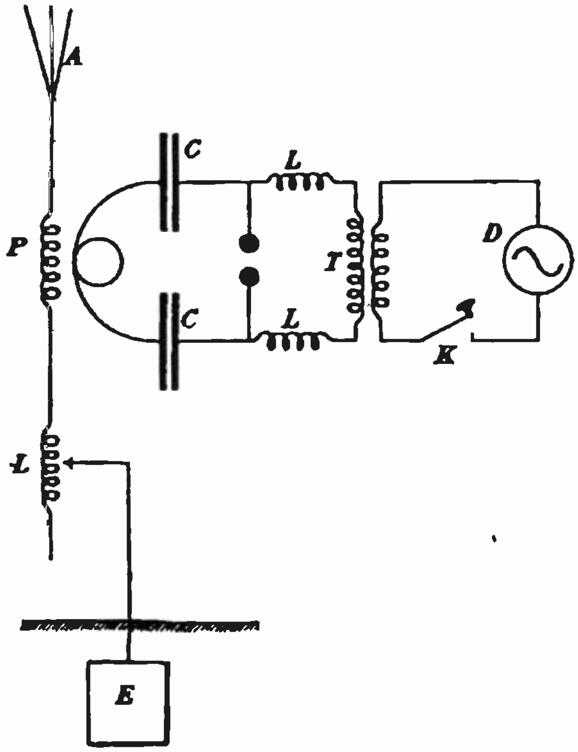



*Fig. 1.*

generally applicable method for effecting communication between ships at sea.*

### The New Era.

Starting from the discoveries of Hertz and his followers, we enter a new era. Apart from Marconi's improvements in the metallic filings coherer of Hughes, Branly, and Lodge, the important element in the arrangements by which in 1896 he applied purely scientific knowledge of Hertzian electric waves to practical electric wave or radiotelegraphy, was the introduction of the long, nearly vertical aerial wire as a radiator, combined with a metal plate above or buried in the earth as the balancing capacity. In this wire high-frequency oscillations are created; originally by using the wire itself as one electrode of an air condenser and the earth as the other, but later on by inducing oscillations in the wire by means of the dead-beat or oscillatory discharge in another condenser circuit including a spark-gap coupled to the air wire circuit. Although enormous ingenuity has been expended in improving or varying every element in the appliances, we can say that, with the exception of a small number of stations using the Duddell-Poulsen arc generator, nearly all the practical wireless telegraphy in the world is at present (1912) conducted by the following apparatus, which can be explained with the aid of Figs. 1 and 2:

At each station there is a transmitter which comprises three elements.

1. A source of high E.M.F. which may be a continuous-current dynamo and storage battery, an alternator (D, Fig. 1) and transformer, or a battery and induction coil giving continuous, alternating or interrupted high-tension E.M.F.

2. A condenser in which the generator stores an electric charge to be suddenly released when a certain potential is attained across a spark-gap in the form of an electric discharge passing through a coil in series with the condenser.

3. An open or radiative circuit coupled to the condenser circuit, comprising an antenna or arrangement of elevated air wires, a balancing capacity or counterpoise often buried in the earth, the two being connected through an adjustable inductance coil.

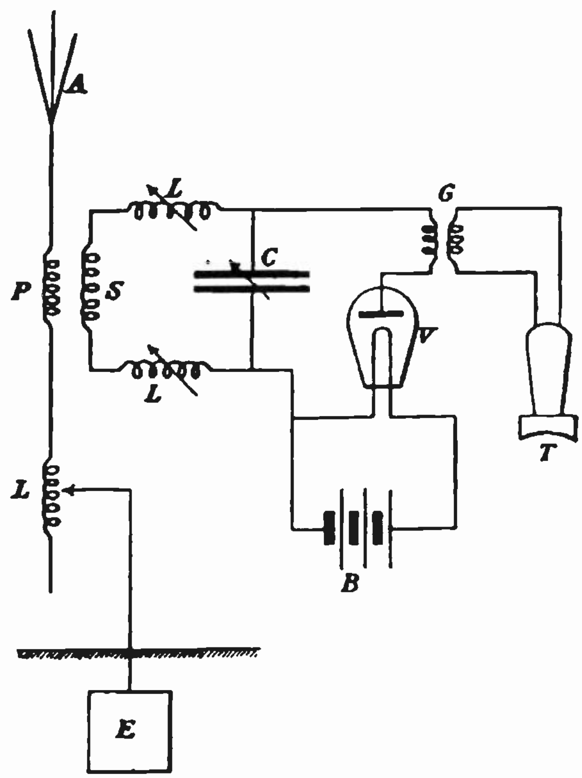



*Fig. 2.*

At the receiving station we have also three elements, as shown in Fig. 2:

1. An absorbing antenna, by which the

* The inductive method appears, however, to have a future in connection with telegraphic and telephonic communication with moving railway trains, and has recently been revived again under the name of the "Railophone," based on inventions by Mr. von Kramer and Dr. G. Kapp.

radiation from the transmitter is picked up, creating in it high-frequency oscillations.

2. A condenser circuit having variable capacity and inductance coupled to the antenna and syntonised to it.

3. Some form of oscillation detector connected in series or parallel with the above condenser, which is affected by the oscillations, and sets in operation a recording or indicating device which makes a visible or audible signal.

Generally speaking, at any one station the radiating and absorbing antennæ are one and the same, and used for both purposes alternately, and each station has both transmitting and receiving apparatus. The functions are, however, not identical. What is required in the transmitting antenna is a certain height and also free or insulated ends. In the receiving antenna not only height but surface is required, although this antenna can be laid parallel with and close to the earth, and earthed at both ends; but provided it is half a wave-length in length it will still absorb a considerable amount of energy from electric waves arriving in its own direction.*

In the next place, as to exact details, the following information may be useful to those who are not wireless telegraph engineers:

**The Antenna.**

The antenna consists of a large number of hard-drawn copper wires, which are upheld by masts or towers in such fashion that the wires form a sort of fan elevated in the air; or they may rise up for a certain height and then be bent downward on all sides, like the ribs of an umbrella. In the case of our battleships they are groups of parallel wires kept separate by wooden stars and stretched between the masts and then led downwards to the bow and stern of the ship. In the high-power Marconi stations they rise up vertically for a certain distance and are then stretched horizontally for a distance about five times greater parallel with the ground.

In long-distance stations the wooden or steel lattice towers, or tubular masts, required to sustain these wires are elaborate structures 100 ft. to 400 ft. or more in height, and have to be well stayed to resist wind.

Associated with the antenna is a counterpoise or balancing capacity, which may consist of insulated wires stretched a little way above the earth, or radiating wires or metal nets laid in the earth, or sheets or nets of metal laid on the ground, or even the metal hull of a ship.

* Numerous patents have been taken out for methods of using one antenna at the same time for sending and receiving. The inventions of Mr. Marconi in connection with this matter are both practical and important, and are being carefully developed by him.

This counterpoise is connected to the antenna through a variable inductance coil. In virtue of the capacity of the antenna with respect to the earth or the counterpoise, the whole system has a natural time period of electrical oscillation.

It may be compared with an elastic steel strip held at the bottom in a vice and loaded at the top, which can be set in vibration by small blows administered to it at the proper rate.

There are certain rates of antenna oscillation reserved for certain purposes.

Thus, for ship or coast signalling, antennæ are used having natural time periods of one millionth or one half-millionth of a second, and for large power stations the time period may be as large as one hundred-thousandth or one fifty-thousandth of a second.

**Excitation of Oscillations.**

In nearly all cases these oscillations are excited in the antenna by the intermittent discharge of a condenser. They are, therefore, damped or decadent trains of free oscillations, separated by intervals of silence. The group frequency, as it is called, or number of the trains of oscillations, is now usually 500 to 1,000, since when using the telephone as a receiver the group frequency is preferably that frequency for which the telephone is most sensitive. Each train of oscillations may comprise 30, 50, or 100 oscillations having the antenna frequency. The antenna is, therefore, set in electrical vibration, so that trains of electric currents run up and down it intermittently, say 500 times a second, each train consisting of 50 or more decadent oscillations, whilst each oscillation or single current occupies a time between one fifty-thousandth of a second and one two-millionth of a second for its complete to-and-fro cycle.

These high-frequency currents in the antenna are created by the induction of a nearly dead beat, or else an oscillatory discharge of a condenser. In small installations the condenser is a collection of Leyden jars, or, more conveniently, glass plates coated with thin sheet zinc or tin, the plates being immersed in a metal or stoneware box of oil.

In the case of some high-power stations Mr. Marconi employs large air condensers consisting of sheets of metal hung up on insulators in a room. At Nauen, and at the Eiffel Tower stations, tubular or plate-glass condensers are used.

The condenser is charged by the source of E.M.F. to a high potential and then discharged across a spark-gap with or without oscillations, and this discharge passes through a coil which may be one coil of a two coil transformer, the secondary being inserted in the circuit of the antenna, or else a single coil transformer, then called an auto-transformer, may be made to do duty for the two separate coils in the circuits of the antenna and the storage condenser.

### The Spark-Gap.

An important element is the spark-gap. In early days, when only small powers were employed, this consisted simply of two stationary brass balls. When large power first began to be applied, as at the Poldhu station in 1901, it was soon found that the oscillatory discharge started an electric arc across the balls, which had to be extinguished before the condenser could again become charged. Also the balls became rapidly worn away. To remedy these defects various inventions were introduced. An air blast was applied to the spark-gap to quench the arc.

I devised for the Marconi Company in 1902 a discharger with revolving balls or discs driven by an electric motor, which overcame some of the difficulties, and this type of slowly-rotating disc discharger, using low-frequency sparks, was used for some considerable time at Poldhu.

Later on Mr. Marconi invented his high-speed studded disc discharger, which is far more efficient, and creates a quenched musical spark of the required character. In this discharger a steel disc having studs on it revolves at a high speed between two other revolving electrodes, and the passage of the studs starts a condenser discharge in which any true arc is instantly quenched. The kind of discharge required for effective work is one in which rapidly repeated, strong, highly-damped discharges take place in the primary condenser circuit, and these excite prolonged trains of free oscillations in the antenna. This is only possible if any true arc discharge in the primary circuit is entirely prevented. This is also achieved by the Wien or Telefunken, the Peukert and Von Lepel dischargers, consisting of flat metal plates in close proximity. In these dischargers the discharges succeed each other with great regularity and at the rate of several hundred per second. When the condenser circuit is properly tuned to the antenna circuit, and coupled to it not too strongly (with about 20 per cent. coupling), we have powerful intermittent oscillations set up in the antenna, each group being very feebly damped and of uniform oscillation frequency. These rapidly succeeding groups of oscillations are cut up into groups of groups in accordance with the signals of the Morse alphabet by means of a key placed in some part of the circuit.

### Uninterrupted Oscillations.

Although nearly all the radiotelegraphy in the world is now conducted by means of these intermittent condenser oscillations, great efforts are being made to perfect suitable high-frequency high-power alternators, producing persistent or uninterrupted oscillations, and the advent of a commercial machine of this kind will no doubt make it a formidable rival to the existing methods.

Deferring for the moment the consideration of what takes place in the space between the sending and receiving antenna, we may complete our description of the receiving apparatus.

In the sending antenna we have very powerful high-frequency currents at the base and high potentials at the free or upper end. Even in small stations the sending antenna current may have a value of 5 to 10 amperes, whilst in large stations the antenna current at the earthed end is 50 to 100 amperes, and large enough to raise to incandescence quite large rods of arc light carbon.

There is, therefore, a considerable expenditure of power in the antenna. A part of this is spent in heating the antenna, but a large proportion is radiated. Nevertheless, the overall efficiency of the usual wireless telegraph transmitter using the ordinary unquenched condenser spark—meaning by that the ratio of power radiated from the antenna to power supplied by the operating dynamo or battery—is at present probably not more than 20 to 25 per cent. in actual practice, though much higher efficiencies, even up to 75 per cent., have been claimed for the quenched spark system. But the evidence for these high efficiencies is somewhat imperfect.

An extremely small fraction of the whole radiated energy is picked up by the receiving antenna. In this latter we have currents created which are measured in microamperes, or at best in fractions of a milliampere. If the receiving antenna is properly tuned to a closed condenser circuit inductively coupled to it, the energy picked up by the receiving antenna accumulates in the associated condenser circuit.

### Detecting Feeble Currents.

In this last we then have feeble currents circulating which imitate in mode of variation those of the distant transmitting antenna. To detect them it is now most usual to employ a telephone in series with some form of current rectifier, which is shunted across the condenser in the closed secondary receiving circuit, or else some form of current operated detector, such as Marconi's magnetic detector, which is placed in the condenser circuit.

If we merely connect a telephone across the condenser circuit no sound will be produced in it, because the frequency of the current oscillations in the receiving condenser circuit is too high to affect a telephone. If, however, we insert some device in series with the telephone which acts like a valve it will rectify the groups of oscillations into prolonged gushes of electricity in one direction, which, coming at the rate of the much lower spark frequency, say about 500 or 1,000 per second, create in the telephone a shrill sound. As these groups are interrupted at the sending station in accordance with the Morse signals, the receiving operator hears long or short musical sounds, which he can interpret into the letters of the alphabet.

Amongst the rectifiers much used, my own oscillation valve, invented in 1904, or glow-lamp detector, is an interesting example. It consists of a little electric glow lamp having a metal plate or cylinder sealed into the glass bulb. When the filament is incandescent the space between the filament and the plate has a unidirectional conductivity, and will allow negative electricity to pass from the filament to the plate, but not in the opposite direction.

Another large class of oscillation rectifiers are the crystal and contact rectifiers, the first of which—viz., carborundum—was discovered by Dunwoody, others by Pierce and Pickard. Thus, for instance, a copper point pressed against a small mass of molybdenite is a good rectifier. Also the minerals chalcopyrite, zincite, bornite, anatase and hessite possess similar properties, and a very sensitive rectifier is made by a slight contact between two small masses of zincite and bornite. Another rectifier is the galena plumbago rectifier. Also a gold point pressed very lightly against an artificial surface of iron pyrites (ferric disulphide) makes an excellent detector.

### Marconi's Magnetic Detector.

In spite of much valuable work done by Prof. G. W. Pierce, G. W. Pickard, and others, the action of these crystal rectifiers is by no means fully elucidated. It appears not to be thermo-electric, since in general the rectified current is in the opposite direction to the thermo-electric current produced by heating the junction.

In addition to these glow-lamp and crystal rectifiers, another much used detector is Marconi's magnetic detector, in which a slowly-moving band of iron wires passes across the poles of a pair of horseshoe magnets. The wire at that place is embraced by two other coils of wire, one in series with the oscillating circuit of the receiver and the other with a telephone. When trains of oscillations are set up in the receiving antenna a listener at the telephone hears a sound due to the sudden change in the magnetic state of the iron. The simplicity and absence of any difficult adjustments make this magnetic detector one of the most useful for general purposes.

The wireless message is thus picked up at the receiving station by hearing telephonic sounds due to a greater or less number of trains of high-frequency oscillations in the transmitting antenna corresponding to *dashes* or *dots* in the Morse alphabet.

These long or short groups of oscillations in the transmitting antenna create similar groups in the receiving antenna, which, when rectified, cause gushes of electricity in one direction through the telephone, and therefore make sounds like ticks or musical notes of long or short duration. The pitch of this note is the frequency of the spark at the sending station.

### A Sensitive *Call* Signal.

One of the practical difficulties not yet quite overcome is the invention of a suitably simple and sensitive *call* signal. At present the operators have to sit with the telephone on their heads waiting for any message which may begin, and this is expert work which cannot be deputed to anyone else.* Another requirement is a simple and yet sensitive relay, by which the messages may be printed down on paper tape. The photographic method, employing the Einthoven galvanometer, is effective but rather elaborate.

The recently-invented alternating-current resonance relay of Dr. Kapp and Mr. H. Von Kramer can be operated with an alternating current having a frequency of about 100 and one-fifth of a milliampere in value. What is required is a relay sensitive to currents of a frequency varying between 50 and 500 or so, and a strength of about one-tenth of a micro-ampere.

Having thus outlined the manner in which the radiotelegraphic message is sent, I now pass on to propound for your discussion certain imperfectly solved scientific questions. The first of these is :

By what mechanism or process are the signals conveyed across the intervening space between the transmitter and the receiver ?

### Hertzian Waves.

Most persons would say at once by electromagnetic or Hertzian waves, produced in the æther, and the answer is no doubt correct as far as it goes. The action of the sending antenna on the receiving antenna is not merely an instance of one electric current inducing another in a secondary circuit, as in the magnetic induction form of telegraphy. In

* The Marconi Company have recently introduced a call instrument, in which a signal equivalent to a prolonged *dash* on the Morse code deflects a galvanometer, which in turn closes a bell-battery circuit and rings a bell. The difficulty is, however, to prevent atmospheric discharges from making a false call, but render it sensitive only to a pre-arranged signal.

radiotelegraphy the energy sent out from the sender no doubt departs from it entirely and exists for a time in a medium before it reaches the receiver. The question is, what is that medium? The whole of the actions in the sending antenna by which the distance effect is produced are consistent with the assumption that electromagnetic waves are sent out from it. But are these waves, strictly speaking, Hertzian waves or space waves? What part, if any, does the earth play in the process? Are the very long distances which can be covered by modern radiotelegraphy consistent with the properties of pure Maxwellian or Hertzian waves produced in the æther? These are the first unsettled questions I wish to throw down for discussion. As soon as Transatlantic signals had been received by the means already described physicists began to ask how such waves, if they are true electromagnetic waves, are propagated one-eighth of the way round the earth. Since then Mr. Marconi has achieved the feat of receiving signals in South America from his Clifden station in Ireland at a distance of 6,000 miles. The problem now is to explain how this effect travels one-quarter of the way round the earth. It suggests at once the query, Could it go half-way round? Can wireless signals be received in New Zealand from England, and may we look forward, not merely to Transatlantic or Transpacific, but to transterrestrial wireless telegraphy to the Antipodes as a practical possibility? The answer to these questions is necessarily connected with that to the more general question, How does the sending antenna affect the receiving antenna at any distance? In a year or more, when the Imperial wireless scheme comes into operation, and the long-distance stations are completed, London will speak to Aden, Aden to Bangalore and Pretoria, Bangalore to Singapore, and from thence the step will be easy to Australia and New Zealand. It is possible that we may yet communicate from London direct to Melbourne without the intermediate stations. In text-books and lectures it has been usual, for the sake of simplicity, to treat the problem of radiotelegraphy as if the earth were a perfectly conducting sphere immersed in free æther. A very little practical experience showed wireless telegraphists that the electric condition of the atmosphere greatly affected it, and that the receiving apparatus, so sensitive to waves intelligently sent out from transmitting stations, picked up in addition all manner of vagrant waves set going by atmospheric discharges; also, early attempts at long-distance radiotelegraphy led Marconi to the discovery of the great influence of daylight upon the distance attainable. If, however, we leave out of account for the present these atmospheric and daylight disturbances, to which we shall return presently, we have still to face the fact that the nature of the terrestrial surface between the sending and receiving station affects the result very appreciably.

**Over Land and Sea**

Very early in the practical experience of radiotelegraphy it was found that it could be conducted more easily over sea than over land, and more easily over ordinary wet soil than over very dry sandy soil. But apart altogether from this last effect, it has always been felt that there was something surprising in the fact that it is possible to detect electromagnetic waves created at a distance of one-eighth to one-quarter of the way round the world. It has been generally assumed that this was wholly due to an abnormally large diffraction effect. The first question of importance is, then, whether diffraction can occur to an extent sufficient to account for the observed facts? The determining factor as regards diffraction is the ratio of wave-length to the earth's diameter.

In the early attempts at long-distance wireless telegraphy wave-lengths of 2,000 ft. to 3,000 ft. were used, but at the present time wave-lengths from 10,000 ft. to 20,000 ft. are employed, or, say, one-thousandth of the earth's radius.

Consider for one moment an optical analogue. The mean wave-length of visible light is about 1/50000 of an inch. Suppose a luminous point of infinitely small magnitude were placed at the pole on the surface of a smooth sphere $\frac{1}{4}$ in. in diameter, or about the size of a pea, in a region otherwise not illuminated. This corresponds to the case of electric waves 1,000 metres in wave-length sent out from a radiotelegraphic station on the earth's surface. Would there be any light due to diffraction at the Equator or even at 45° latitude of this small sphere? It is essentially the province of the mathematical physicists to give us a solution of the above question, but the answer would, I think, be in the negative. To make the case comparable with that of the longest electric waves used for terrestrial radiotelegraphy the sphere would have to be only 1 mm. in diameter. The answer is then not quite so obvious.

The first attempt at the problem in the case of radiotelegraphic waves was made by Prof. H. M. Macdonald in 1903 and 1904.

Last year he published another Paper * in the Transactions of the Royal Society on the same subject. In this last Paper a table is

* *See* Prof. H. M. Macdonald "On the Diffraction of Electric Waves Round a Perfectly Reflecting Obstacle." "Trans." Roy. Soc., London, 1910, Vol. CCX., A, p. 113.

given for waves of two wave-lengths—viz., 0·2 mile and 0·25 mile, showing the ratio of the calculated amplitude of the received oscillations at a point at certain distances measured along a great circle of the earth to the amplitude which would exist if the earth were absent. For the two wave-lengths and for a distance of 651 miles the ratios are respectively 0·06 and 0·07, or, say, 1 : 14. It may be remarked, however, that the wave-length now used at Marconi's Clifden station in Ireland is nearly 4 miles, and that the maximum distance at which signals have been received is 6,000, and not 600 miles. Hence, before Prof. Macdonald's table can be brought into comparison with the latest practice, his wave-lengths must be increased 20 times and his maximum distance 10 times.

### Diffraction of Waves

In this recent Paper he refers to the previously published 1904 Paper, in which he showed that the effect at a point on a perfectly conducting sphere due to a Hertzian oscillator near its surface was negligible in comparison with the effect which would have been produced at that point if the sphere were removed, when the point is at some distance from the oscillator and the radius of the sphere is large compared with the wave-length.*

The same problem has also been discussed by Prof. H. Poincaré,† whose recent decease we have so greatly to deplore, in a series of interesting lectures and papers. In his latest memoir, "On the Diffraction of Hertzian Waves," in the "Jahrbuch der Drahtlosen Telegraphie" for 1910, p. 445, Prof. Poincaré reaches the conclusion that the amplitude of the oscillations at a point on the earth's surface which is separated from a transmitting station by an angle, $\phi$, measured along a great circle through the stations, is proportional to an exponential function, $\epsilon^{-mw\frac{\phi}{3}}$, where $m$ is some numerical constant and $w$ is a complex quantity, whose real part is proportional to the frequency. This, at any rate, agrees with one result of practical experience—viz., that to effect radiotelegraphy over long distances large wave-lengths are necessary. But it is difficult to extract from his conclusions means to enable us to predict the exact extent to which diffraction really exists for waves 2 to 4 miles in length.

The problem of the bending of electric waves round the earth has also been discussed by Dr. J. W. Nicholson in a series of able and critical Papers.*

The conclusion arrived at by him after considering the work of Macdonald and Poincaré as the result of his own analysis can best be expressed in his own words (*see* "Phil. Mag.," Vol. XIX., pp. 277–278, 1910).

He assumes that an oscillator is placed near the surface of the sphere with its axis radial, and he says: "On the confines of the geometrical shadow, within a cone of small angle, cutting off but a small portion of the terrestrial surface near the oscillator, true diffraction bands are found, arising from terms now important, in which the order and arguments are nearly equal. But within the shadow beyond the extreme generators of the cone the extinction of the waves is very complete." "The harmonics of a high order are found to be so disposed as to neutralise one another in a remarkable way, and the intensity of the diffracted light at a distance of a few thousand miles round the surface sinks to a minute fraction of its value when the sphere is absent. Thus it is improbable that diffraction can explain the effects unassisted by reflection from an ionised layer in the upper atmosphere or by some other cause."

### Mathematical Explanations

If this result is confirmed for wave-lengths of 4 miles or one-thousandth part of the earth's mean radius, then it will follow that ordinary diffraction is incapable of explaining long-distance radiotelegraphy, and we must look to some other cause. Before discussing the alternative which has been suggested both by Prof. Poincaré and Dr. Nicholson, I should like to draw your attention to an explanation of a quite different nature, due to Prof. A. Sommerfeld, of Münich. Mathematicians who have dealt with the problem under the assumption of a perfectly conducting earth and a Hertzian oscillator entirely disconnected from it, have assumed conditions which do not hold good in practice. Hence the attempt to explain long-distance radiotelegraphy by the aid of diffraction may be a quite unnecessary effort. The actual earth has a crust composed of materials which chiefly owe their conductivity to water. When free from water these materials composing the igneous and sedimentary rocks (apart from metallic veins and oxides and sulphides of heavy metals), such as granite, gneiss, quartz, slate, chalk, and sandstone, are very fairly good insulators. Although sea water is a conductor, it has a dielectric constant ($K=80$) very far from infinite. More-

* *See* H. M. Macdonald, "Proc." Roy. Soc., London, Vol. LXXI., A, p. 251, 1903; Vol. LXXII., A, p. 59, 1904. The conclusions in the first Paper were subjected to some criticism by Lord Rayleigh and Prof. Poincaré.

† *See* Prof. H. Poincaré, "La Lumiere Electrique," Vol. IV., 1908, p. 323, December 12th; also "Comptes Rendus," April 29th, 1909 and "Jahrbuch der Drahtlosen Telegraphie," Vol. III., p. 445, 1910.

* *See* Dr. J. Nicholson, "Phil. Mag.," 1910, Vol. XIX., pp. 276, 435, 516, 757.

over, at no very great depth in the crust the temperature is sufficiently high to exclude the presence of liquid water, and therefore of any conduction due to it.

The numerical values which have been given for the materials composing the earth's crust are only very approximate. Experimentalists have mostly measured the resistance and dielectric constant of dry samples with continuous or direct currents. They have omitted to take account of the fact that non-metallic materials, such as quartz, felspar, mica, slate, etc., increase in conductivity with rise of temperature, and also have a conductivity for alternating currents quite different from that for direct currents.

**Rocky Materials as Insulators.**

In the majority of cases these rocky materials are very good insulators. Thus, dry granite has a dielectric constant about 7 to 8, and a specific resistance which may be as high as 1,000 megohms per centimetre cube, and dry slate has a dielectric constant of about 12 and specific resistance of about 500 megohms per centimetre cube.*

The problem of the propagation of electric waves over the earth's surface involves, therefore, three important factors which greatly influence the result. First the imperfect conductivity and rather high dielectric constant of the earth, making it a semi-dielectric. Secondly, the effects of atmospheric ionisation, natural electrification and sunlight; and thirdly, the earth's curvature. The German mathematical physicists have of late years considered the first of these factors very carefully, and arrived at some interesting results which I will endeavour to epitomise. Prof. A. Sommerfeld published in 1909 a very able Paper on the propagation of the waves in wireless telegraphy over the earth's surface.†

He supposes that a small Hertzian oscillator is placed with axis vertical at the flat boundary surface of two media, each having conductivity $\sigma$, dielectric constant K and permeability $\mu$, and that the bounding surface is plane and indefinite. Taking E as the electric force and H as magnetic force, we have at any point in space the two circuital or Maxwellian equations fulfilled—viz.,

$$K\dot{E}+4\pi\sigma E=c \text{ curl } H$$
$$-\mu\dot{H}=c \text{ curl } E,$$

where $c=3\times10^{10}$. The quantities E, $\sigma$ and K are measured in electrostatic units and $\mu$ and H in electromagnetic. Hence, if E and H are both simple harmonic quantities of frequency $n$, varying as the real part of $\epsilon^{-jpt}$, where $p=2\pi n$, and if we write

$$k^2=\frac{\mu K p^2+jp4\pi\sigma\mu}{c^2},$$

we have $\quad k^2H=\text{curl}^2H,$
$\quad k^2E=\text{curl}^2E.$

If we then take the magnetic force to be the curl of a vector potential $\Pi$, and bear in mind that for vector fields with no divergence the operator

$$-\text{curl}^2=\nabla^2=\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}+\frac{\partial^2}{\partial z^2}\right),$$

we see that $\Pi$ satisfies the differential equation.

$$\nabla^2\Pi+k^2\Pi=0, \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

and that $\quad H=\text{curl } \Pi \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$

and $\quad E=\frac{c}{4\pi\sigma-jpK}\nabla^2\Pi \quad . \quad . \quad . \quad . \quad (3)$

If $r^2=x^2+y^2+z^2$, then a particular solution of (1) is

$$\Pi=\frac{1}{r}\epsilon^{jkr}.$$

To obtain a solution applicable to the case in question we have to satisfy the boundary conditions.

These conditions are that the horizontal component of the electric force and the vertical component of the magnetic flux or induction must be continuous across the boundary. Taking suffixes 1 and 2 for the air and earth regions, these boundary conditions are

$$\Pi_1=\Pi_2,\quad \frac{\mu_1}{k_1^2}\frac{\partial\Pi_1}{\partial z}=\frac{\mu_2}{k_2^2}\frac{\partial\Pi_2}{\partial z}.$$

Sommerfeld then shows that a solution of equation (1) is

$$\Pi=CJ_0(\lambda r)\epsilon^{\sqrt{\lambda^2-k^2}\,z},$$

where $r^2=x^2+y^2+z^2$, and $\lambda$ is an arbitrary parameter, and $J_0(\lambda r)$ is a Bessel's function of zeroth degree. By a series of difficult transformations, the validity of which must be tested by our pure mathematicians, Sommerfeld then proves that $\Pi$ can be expressed as the sum of three quantities P and Q, such that

$$\Pi=P+Q_1+Q_2,$$

where the quantities $Q_1$ and $Q_2$ correspond to space waves (Raumwellen) and P to a surface

---

* *See* "Dielektrizitäts Konstante und Leitfahigkeit der Gesteine," by Heinrich Löwy. "Annalen der Physik," Vol. XXXVI., 1911, p. 125, for a number of measurements of the dielectric constants and conductivity of earth's crust materials.

It has been shown recently, in a Paper by the present writer, assisted by Mr. Dyke, that the alternating-current conductivity of insulators is a function of the frequency, and not by any means identical with the direct-current conductivity. *See* "Journal" Inst. Elec. Eng., 1912, "On the Power Factor and Conductivity of Dielectrics for Alternating Electric Currents." In the case of such substance as marble, slate, and probably others the conductivity appears to increase with the frequency up to a certain point and then diminish again.

† "Ueber die Ausbreitung der Wellen in der Drahtlosen Telegraphie." "Annalen der Physik," 1909, Vol. XXVIII., p. 665.

wave (Oberflächenwellen). If we take the permeability everywhere to be unity, then Sommerfeld shows that

$$P = C\epsilon^{-j\frac{\pi}{4}}\sqrt{\frac{2\pi}{sr}}\,\epsilon^{jsr \mp \sqrt{s^2-k^2}\,z}$$

where $s = \sqrt{\frac{k_1^2 k_2^2}{k_1^2 + k_2^2}}$ and $C = \frac{k_1^2 k_2^2}{(k_1^2 - k_2^2)\sqrt{k_1^2 + k_2^2}}$

Hence, if we write $a = C\epsilon^{-j\frac{\pi}{4}}\sqrt{\frac{2\pi s}{r}}$,

it follows that the components of the magnetic and electric forces at the bounding surface at a distance $x$ are given by

$$H_y = a\,\epsilon^{jsx - \sqrt{s^2-k^2}\,z},$$

$$E_x = \mp\frac{jp}{ck^2}a\sqrt{s^2-k^2}\,\epsilon^{jsx \mp \sqrt{s^2-k^2}\,z},$$

$$E_z = \frac{p}{ck^2}as\,\epsilon^{jsx \mp \sqrt{s^2-k^2}\,z}.$$

Hence the amplitudes all vary as $1/\sqrt{r}$, and the energy, therefore, inversely as $r$.

This shows that this part of the radiation is a surface or cylindrical wave which follows round the surface, and is quite analogous to the electromagnetic waves produced on wires. These waves are the "Oberflächenwellen." They are very rapidly damped in a downward direction.

They are propagated with a velocity V, such that $V = p/s$, and since $s$ is in general a complex quantity, they suffer damping in a horizontal direction or in the direction of propagation.

The other quantities, $Q_1$ and $Q_2$, correspond to space waves (Raumwellen). Sommerfeld shows that

$$Q_1 = \frac{C_1}{r^2}\epsilon^{jk_1 r}$$

and

$$Q_2 = \frac{C_2}{r_2}\epsilon^{jk_2 r - \sqrt{k_2^2 - k_1^2}\,z}$$

in the upper medium or air.

Hence the amplitudes of the forces derived from this part of the total potential vary inversely as the square of the distance.

It is, of course, not new to suggest that the waves involved in radiotelegraphy resemble electric waves on wires or are surface waves. It was long ago surmised that the sending antenna, the earth and the receiving antenna might be regarded as one single oscillator in which oscillations were set up. This view has been held, amongst others, by A. Blondel, E. Lecher, and F. G. Baily.*

Prof. Baily pointed out in 1903 that the energy of surface waves would decrease only inversely as the distance, and, therefore, at large distances survive when space waves would have vanished. The strict mathematical proof of their possibility has, however, been only lately given.

**Space and Surface Waves**

The space waves are subject to diffraction, and are hindered by obstacles. On the other hand, the surface waves pass round and are unhindered, apart from damping, by the curvature of the surface; also, owing to the surface waves decreasing in amplitude less fast with distance, the surface waves survive when the space waves are extinguished. If, then, Sommerfeld's investigation is valid, we need no longer seek for an explanation of such achievements as the detection of electromagnetic waves one-quarter of the way round the earth in any abnormal diffraction. If Sommerfeld is right, diffraction has nothing to do with the matter. The effect at such distances is entirely due to these "Oberflächenwellen," or surface waves, which, like electric waves on wires, are propagated along the surface, no matter what the curvature may be.

There is a certain analogy between these space and surface electric waves, and corresponding effects in the case of earthquakes. From the time of Poisson it has been known that a shock communicated to an elastic solid created in it two waves, one of dilatation and one of distortion, travelling at different speeds through the mass. In 1885 Lord Rayleigh showed that, in addition, there was a surface wave dependent on the fact that the surface can be distorted, and resists distorsion with a different elasticity to that of the interior of the mass.

These effects are recognised by seismologists as represented in the preliminary tremors and main shock in an earthquake.

In this case two kinds of disturbance are found to be propagated through the earth with velocities of 10 km. and 5 km. per second respectively; also another main shock arrives later which moves with a speed of about 3 km. per second. The latter is a surface wave travelling along the surface crust of the earth, and the two former are space waves travelling through the mass.

In the same manner we can say that in wireless telegraphy we are concerned with three waves—one travelling through the air above the earth, the second through the crust of the earth, and the third a surface or cylindrical wave which is confined to a limited region at the boundary of the two dielectrics.

To obtain numerical values we must know the dielectric constant (K) and conductivity $\sigma$ of the earth's crust materials. I find the

* See A. Blondel, "Comptes Rendus du Congres de Nantes," 1898; also E. Lecher, "Physik. Zeitschr.," Vol. III., p. 273, 1901; and Prof. F. G. Baily, "Trans." Royal Scottish Society of Arts, February 9th, 1903.

dielectric constant of dry slate is about 12, and that of ordinary white marble not specially dried is about 8. Most dry rocks, such as granite, have a dielectric constant near 9.

These constants are generally taken to be approximately as follows :

| | | |
|---|---|---|
| Sea water ...... | $K=80$ | $\sigma=10^{-11}$ E.M. unit. |
| Fresh water ... | $K=80$ | $\sigma=10^{-14}$ ,, |
| Damp soil ...... | $K=20$ | $\sigma=5\times10^{-14}$ ,, |
| Dry rocks or soil | $K=4$ to 8 | $\sigma=10^{-15}$ or less E.M. unit. |

The conductivities are given in C.G.S. electromagnetic units. It is probable that the conductivity of sea water is greater than $10^{-11}$, for this value implies that the resistivity is 100 ohms per centimetre cube. Also the conductivity of many dry rocks is certainly less than $10^{-15}$. Hence the above values are only very rough. It must be remembered that a conductivity reckoned in electromagnetic units has to be multiplied by $9\times10^{20}$ to convert it to electrostatic units.

If we take $\mu=1$, and for air $K=1$ and $\sigma=0$, it is easy to see that the ratio $k^2_2/k_1^2=K+j2c\lambda\sigma$, where $\sigma$ is the conductivity of the earth in electromagnetic units and $\lambda$ is the wave length.

Also the *numerical distance* $\rho=\frac{k_1^2}{k_2^2}\frac{k_1}{2}r.$*

For air, $k_1=2\pi/\lambda$, and hence we have

$$\rho=\frac{\pi}{\lambda}\frac{r}{K+j2c\lambda\sigma}.$$

Thus, for sea water, $K=80$, $\sigma=10^{-11}$, and if the wave-length $\lambda=2$ km. and the actual distance $r=2{,}500$ km., we have $\rho=\frac{1}{30}$.

If $r=10{,}000$ km. and $\lambda=4$ km., we have $\rho=\frac{1}{16}$.

On the other hand, for dry soil, for which $K=4$, $\sigma=10^{-16}$ for waves 2 km. in length and $r=2{,}500$ km. we have $\rho=300$.

Hence, when the earth's surface is a good conductor, the *numerical distance* $\rho$ is a small quantity, and when it is a bad conductor $\rho$ is a large quantity.

Now, Sommerfeld shows that at or near the earth's surface the vector potential $\Pi$ can be expressed in the form

$$\Pi=(u-jv)\,e^{jkr}\frac{1}{r}.$$

The quantity $u$ concerns the space waves and $v$ the surface waves, and he proves that

$$u=1-2a^2+\frac{2\,.\,2}{1\,.\,3}a^4-\frac{2\,.\,2\,.\,2}{1\,.\,3\,.\,5}a^6,\ \&c.,$$

$$v=a\sqrt{\pi}\left(1-a^2+\frac{a^4}{1\,.\,2}-\frac{a^6}{1\,.\,2\,.\,3}+\&c.\right)$$

where

$$ja^2=\rho=\left(\frac{k_1^2}{k_2^2}\frac{k_1^2-k_2^2}{k_2^2}\frac{k_1}{2}\right).$$

When the lower dielectric has a rather large conductivity, as in the case of sea water, the expression for the numerical distance reduces to

$$\rho=\frac{\pi}{2c\sigma\lambda^2}r.$$

Hence we see that an increase in the wave-length $\lambda$ reduces the values of $\rho$ and $a$, and hence the value of $v$.

Sommerfeld has plotted out two curves which represent the variation of $u$ and $v$ with $\rho$, and it is seen from them that for very small "numerical distances" the space waves predominate, for mean values of $\rho$ the surface waves, and for large values of $\rho$ the space waves again.

The conclusion, however, is that for the achievement of long distances in radiotelegraphy waves of long wave-lengths are necessary, as shown by experience.

### Sommerfeld's Investigations

On the other hand, the radiation from the antenna decreases with increasing wave-length. Hence there is probably a certain maximum wave-length which is most effective for signalling over a given distance and surface.

It is suggested, however, that long-distance radiotelegraphy is chiefly effected by means of the surface waves, or "Oberflächenwellen," of Sommerfeld, which fall off in amplitude inversely as the square root of the distance, and are not limited by diffraction, as they follow round the surface. The earth's curvature limits the range of the space waves seriously, but does not so limit the surface waves.

One difficulty in reading Sommerfeld's Paper is that he does not sufficiently translate his mathematical analysis into physical concepts. Hence it is desirable to consider a little in general terms how these surface waves arise.

If we have two media of different dielectric constants in contiguity, and if a line of electric force crosses the boundary, then it is well known that the conditions to be fulfilled are that the tangential component of the electric force on either side of the boundary must be continuous, and also the normal component of the electric displacement or flux must be continuous. This involves a refraction of the line of electric force in crossing the boundary. It is bent away from or towards the normal, and if $K_1$ and $K_2$ are the dielectric constants, and $\theta_1$ and $\theta_2$ the angles the line makes with the normal, then $K_1\cot\theta_1=K_2\cot\theta_2$. The law of refraction of light is $\mu_1\sin\theta_1=\mu_2\sin\theta_2$. Hence, in the case of light, the velocities of the rays in the two media respectively are proportional to the sines of the angles of incidence and refraction. In the case of the electric force the velocities are inversely as the square roots of

* This quantity $\rho$, which Sommerfeld calls the *numerical distance*, is a function of the real distance $r$ and the quantities $k_1$ and $k_2$, which are determined by the nature of the soil.

the tangents of the angles of incidence and refraction of the lines of electric force. If, then, we consider a Hertzian oscillator which is partly in one medium and partly in another of greater dielectric constant, there will be a distortion at the boundary of the loops of electric force which are thrown off at each oscillation. If the upper medium is air and the lower medium is a material of greater dielectric constant, then, corresponding to a normal semi-loop of electric force in air, there will be a completing semi-loop in the other material which is sheared backward, as shown

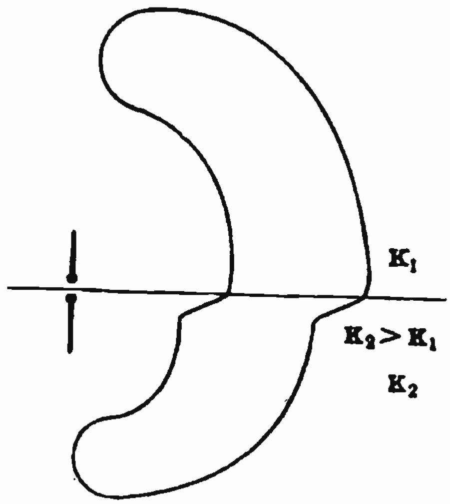



*Fig. 3.*

in Fig. 3. If in the air at the boundary surface the force is normal to the surface, it will not be normal just below that surface in the medium of greater dielectric constant. It will have a longitudinal component. As the oscillations take place these longitudinal components of the force are periodic in space and time, and constitute the surface wave which is similar to the electric waves produced on wires.

### The Earth as a Conductor

If the earth were a perfect conductor, say a ball of copper, at the absolute zero of temperature, these surface waves would be confined merely to the surface skin. In the case of the actual earth, even sea water is a sufficiently poor conductor to allow the penetration of the surface wave to some little depth in it. Although the "numerical distance" is small, it is not so small as to extinguish altogether the surface wave.

The objection has been raised that no experimental proof has been given of the actual existence of Sommerfeld's surface waves. Against this it should be noted that Sommerfeld has carefully explained that the surface waves are not separated sharply from the space waves, and may be regarded merely as a particular distribution of the moving electrostatic field near the common surface of the air and earth and accompanying electric currents in the earth. It is easy to prove that we can have surface electromagnetic waves on a *sheet*, similar in nature to electromagnetic surface waves on wires, of the existence of which we have abundant experimental proof. An argument in favour of the existence of these surface waves may perhaps be derived from the experience that high antennæ do not seem necessary for the *reception* of signals even over long distances, thus indicating that there is a concentrated electric and magnetic field near the surface of the earth.

P. Epstein has delineated from Sommerfeld's equations a portion of the field of electrostatic force round an oscillator placed, first, over a perfectly conducting earth, and, secondly, over an earth of finite conductivity.* In the first case the loops of lines of electrostatic force are seen to terminate perpendicularly on the earth, and are divided symmetrically by the surface plane. In the second case they are distorted, so that the lines at spaced intervals do not terminate perpendicularly. If, however, they have a component parallel to the earth's surface, this is equivalent to a combination with a true space or Hertzian wave of a surface wave similar to the electric waves on wires, which latter can travel along the guiding surface irrespective of curvature of that surface.

### Surface Waves and Distance

If these conclusions are valid, there is nothing to prevent the surface waves going half round the earth. It may, therefore, be quite possible to communicate by radiotelegraphy direct from England to New Zealand. There is one matter which may be of importance. Since the surface waves started from any one point reach an antipodal point by different paths, it may be that, unless the position of the receiving station is rightly selected, interference will arise between surface waves reaching it by different lengths of path, and hence extinction of signals for some places but not others in the same region. According to this theory, then, we need not endeavour to explain long-distance radiotelegraphy by diffraction, because true space waves are very little concerned with it.

---

* *See* P. Epstein, "Kraftlinien diagramme für die Ausbreitung der Wellen in der drahtlosen Telegraphie bei Berucksichtigung der Bodenbeschaffenheit," "Jahrbuch der Drahtlosen Telegraphie," Vol. IV., p. 176, 1910. Epstein has, however, only delineated the field in the air. He ought to have indicated the nature of the field just below the surface in the sea or earth as well as to show the refraction of the lines of force at the surface.

We pass on, then, to consider the next question—viz., the influence of the nature of the surface in radiotelegraphy. Why, for instance, it is conducted with certain wave-lengths so much more readily over sea than over land ?

This matter has been particularly considered by Dr. Zenneck in an interesting Paper. Assuming, for the sake of simplicity, a plane earth and plane electromagnetic waves, he discusses the effect of the conductivity and dielectric constant of the earth's crust on the wave propagation.* Starting from the same equations as Sommerfeld, he arrives at an expression which enables him to calculate the damping of the waves along the horizontal boundary surface. He shows that this damping is determined by the dielectric constant and conductivity of the earth's crust. He calculates the distance the plane wave must travel before its amplitude is reduced to $1/e$ of that at the transmitter, and exhibits the results for various values of the dielectric constant and conductivity in the form of curves. Waves 1,000 ft. in length over a sea surface would travel 10,000 km. before reduction to $1/e$ in amplitude, but over very dry soil only for 10 km. or less. The analysis shows that there is a considerable penetration of the wave into dry soil, but into so good a conductor as sea water the penetration is at most a metre or two. Moreover, Zenneck shows that over sea surface the lines of electrostatic force terminate nearly perpendicularly to it, but over a dry surface this is not the case. There is, then, a considerable rotating component, and the direction of the electric force is represented by the rotating radius vector of a semi-ellipse, the major axis of which slopes forward in the direction in which the wave is travelling. Zenneck's results have been extended by F. Hack, who has shown that underground moisture has the same effect as surface moisture in preventing degradation of amplitude.

### Theory and Practice

The general result of these investigations compared with practical experience is to show that we can by no means consider the earth to be a perfect conductor in the case of radiotelegraphy, but that it has an extremely influential action in degrading the amplitude of the waves, deforming the travelling electrostatic field and in creating a type of surface wave which attenuates much less fast than a pure Hertzian wave, and can travel round the curvature of the earth quite easily.

On the whole, we may say that the theory as given by Zenneck and Sommerfeld is a valuable attempt to bridge over a very serious gap in our knowledge of the reasons for certain well-ascertained facts in radiotelegraphy. Nevertheless, there are still unexplained difficulties.

Another unsolved problem in radiotelegraphy is the explanation of the effects of the atmospheric conditions and daylight upon it.

The suggested explanations are in many respects imperfect. In the earliest days of radiotelegraphy it was found that atmospheric electric discharges produced irregular and false signals which sometimes greatly interfered with working. These were more objectionable at the time when the receiving instrument was a coherer of some kind associated with the Morse printer. Nowadays, when the reception is by telephone, it is usual to have the spark frequency at the sender high enough to give a shrill note in the telephone. The receiving operator can then distinguish to a great extent between the clear musical note of the right signals and the lower squeaks or grunts in the telephone due to atmospheric discharges. Nevertheless, at certain times and in certain regions the so-called atmospherics present serious obstacles to radiotelegraphic communication.

### Effect of Sunlight

When we turn to the effect of sunlight on the propagation of radiotelegraphic waves, which was discovered and described by Mr. Marconi in 1902,* we find that even after ten years we are still, intellectually speaking, very much in the dark as to the reason for this daylight effect.

The first observation made by him in 1902 was that, by night, signals could be received over sea from the Poldhu station at a distance of 2,099 miles, whereas by day the same kind and type of signal ceased to be detectable at about 700 miles. Also that at the time when the sun rose over the sending station the signals at 700 miles distance quite quickly became very weak.

Of recent years he has noticed that in the morning or evening, when the boundary between light and darkness occurs about half-way across the Atlantic, signals sent across become very weak.

Also he has noticed that, in sending with a

* J. Zenneck, "Ueber die Fortpflanzung ebener Elektromagnetischer Wellen langs ebenen Leiterflache und ihre Beziehung zur drahtlosen Telegraphie," "Ann. der Physik," Vol. XXIII., p. 846, 1907. This Paper was freely translated, with expository notes, by J. A. Fleming, entitled "The Function of the Earth in Radiotelegraphy," *see* "Engineering," June 4th and 11th, 1909.

* *See* G. Marconi, "Proc." Roy. Soc., Lond., June 12th, 1902. "A Note on the Effect of Daylight upon the Propagation of Electromagnetic Influences over Long Distances."

coupled transmitter radiating waves of two wave-lengths, whereas the longer wave-length is the one generally received, there are certain periods at sunrise and sunset when the shorter wave gives the best signals.

It has also been pointed out both by Mr. Marconi and G. W. Pickard that, soon after the time of sunrise at the sending station, there is a very pronounced decrease in the strength of the signals received a few hundred miles or at some considerable distance from a power station, but that after sunrise there is a partial recovery of strength. There is also a gradual rise in the strength of the signals soon after sunset, and a very pronounced maximum value after or about midnight. An interesting curve

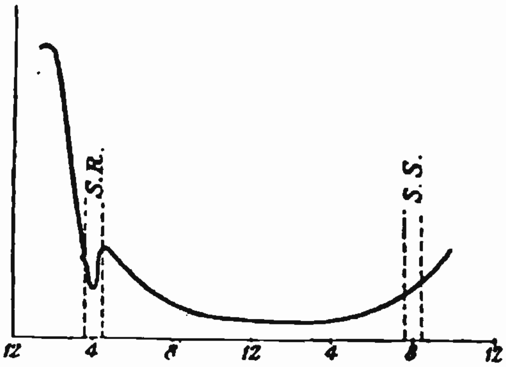



*Fig. 4.*

(Fig. 4) has been given by Prof. Pierce, in his book on "Wireless Telegraphy," p. 135, taken from Pickard's observations, showing the general variation of the strength of received signals at a distance of 600 miles from the Marconi station at Glace Bay during the hours of the day and night. It appears that the current in the receiving telephone at midnight was about 30 times greater than by day.

### Mr. Marconi's Theories

Two theories have so far been proposed to explain this effect:

1. The original suggestion of Mr. Marconi (which has been tentatively adopted by Prof. Zenneck) was that it is due to the effect of light in discharging the sending antenna, so that it does not reach at each oscillation such a high potential by day as in darkness.

2. The theory that the daylight effect is due to the ionisation of the air by sunlight, giving it increased conductivity and so producing absorption of the electric waves.

Neither of these theories seems to meet all the facts. If the daylight effect were an action of light on the sending antenna alone, it should be produced independently of the distance of the receiving station, whereas it is essentially a cumulative or long-distance effect.

Again, so far as measurements of the electric conductivity of air have been made, they do not give support to the theory that the daylight effect is due to air conductivity produced by ionisation, because measurements of this conductivity show it to be too small to account for the observed wave attenuation.

Prof. G. W. Pierce has made calculations which show that the air conductivity would have to be 100,000 times greater than it actually is to account for even a part of the observed effect at 3,000 km. distance.

Prof. Zenneck also agrees that atmospheric conductivity by ionisation cannot account for the phenomena.

Let us in the first place consider theoretically the propagation of an electromagnetic wave through a medium possessing dielectric constant (K) and conductivity ($\sigma$).

It is quite easy to obtain an expression for the absorption coefficient of such a medium. Starting from the Maxwellian equations as above, we have the quantity denoted by $k$ on a previous page defined by the equation

$$k^2 = \frac{\mu K p^2 + j 4\pi\mu\sigma p}{c^2}.$$

Since $k$ is a complex it can be represented by $k = \alpha + j\beta$.

Hence we have

$$\beta^2 = -\frac{\mu K p^2}{2c^2} \pm \sqrt{\frac{16\pi^2\sigma^2\mu^2 p^2}{4c^4} + \frac{\mu^2 K^2 p^4}{4c^4}},$$

and if $\frac{\sigma}{pK}$ is a small quantity, as it is when the conductivity is small, and the frequency $p/2\pi$ is large, we have then

$$\beta = \frac{2\pi\sigma}{c\sqrt{K}}.$$

If we consider a plane wave, the amplitude of which varies as $\epsilon^{j(kx-pt)}$, it attenuates in amplitude to $1/\epsilon$ of its initial value in travelling a distance

$$1/\beta = \frac{c\sqrt{K}}{2\pi\sigma}.$$

If $\rho$ is the resistivity in ohms per centimetre cube, then $\rho = (9 \times 10^{11})/\sigma$, and we have

$$\frac{1}{\beta} = \frac{\rho\sqrt{K}}{60\pi}.$$

We can, therefore, determine at once the absorption effect of any conducting dielectric of which the resistivity in ohms per centimetre cube and the dielectric constant are known. Thus, supposing the dielectric constant is 9, and the resistivity 500 megohms per centimetre cube, the value of $1/\beta$ would be nearly 80 km., or 50 miles. This is, then, the distance in which the wave amplitude would be reduced to about one-third of that at the origin. It is clear, therefore, that to propagate waves for any considerable distance through the earth's crust the specific resistance would have to be as high as 1,000 megohms per centimetre cube; also, it is evident that unless the resistivity of the air, as produced by ionisation, is less, say, than 20,000 megohms per centimetre cube, or considerably less than $10^{20}$ electromagnetic units, the ionisation cannot be the cause of the daylight absorption.

I believe no one has observed so low a resistivity for air near the earth's surface, or even 1,000 ft. up, as $10^{19}$ C.G.S. electromagnetic units per centimetre cube. The point, however, requires further investigation. On certain assumptions this atmospheric resistivity can be determined by elevating a captive balloon to the required level by a wire and measuring the potential of the balloon when the wire is insulated and also the current flowing through the wire when the wire is earthed. The ratio of the current in amperes to the potential in volts gives us the total conductivity S of the air. If C is the electrical capacity of the balloon, and if $\sigma$ is the conductivity of the air, then it can easily be shown that $S=4\pi C\sigma$ (*see* J. A. Fleming, "Principles of Electric Wave Telegraphy and Telephony," 2nd edition, p. 725). Accordingly, $\rho=4\pi C/S=4\pi CI/V$, where I is the total electric current flowing along the wire to the earth and V is the potential of the balloon.

### Atmospheric Electricity

Some useful measurements of this kind, made by Messrs. A. J. Makower, W. Makower, W. M. Gregory, and H. Robinson in 1910 ("An Investigation of the Electrical State of the Upper Atmosphere made at Ditcham," *see* "Quarterly Journal of the Royal Meteorological Society," Vol. XXXVII., October, 1911), showed that the total resistance from a certain kite at a height of 1,400 ft. on a certain day was 1,000 megohms. Assuming a kite capacity of 100 electrostatic units, this corresponds to a resistivity of the air equal to $12{\cdot}5\times10^{11}$ ohms, which seems rather small. A plane electric wave would, however, have to travel nearly 60,000 kms. in this air to have its amplitude reduced to $1/\epsilon$. Hence, even this conductivity is not enough to account for the observed attenuation by daylight of long radiotelegraphic waves.

Unless, therefore, there is very much greater atmospheric conductivity than 1 billionth of a mho (1 bimho) per centimetre cube, at or about 1,000 ft. or so above the earth's surface, it does not appear as if air conductivity caused by ionisation due to ultra-violet light could account for the diminished amplitude of radiotelegraphic waves during daytime.

The careful measurements of the air conductivity at various heights and at various hours of the day and night over sea and land would give us valuable data for further testing this matter.

Sommerfeld suggests that the daylight reduction is due to the increase in the value of the coefficient $k$ for the air by the production of conduction due to ionisation. The effect of this is to increase the value of the "numerical distance," and, therefore, to reduce the intensity both of the surface and space waves. He supports this view by an observation made by Ebert, who states that he measured the conductivity of the air in brightest sunshine at a height of 2,500 metres during a balloon ascent, and found it to be 23 times greater than at the ground level.*

It is possible that some part of the effect may be due to actions taking place quite close to the sending antenna. This view may be supported by the interesting observations made during the nearly total solar eclipse on April 17th last on the effect of the temporary diminution of daylight on the strength of radiotelegraphic signals.

### At Eiffel Tower

Whilst visiting the Eiffel Tower station at Paris, Commander Ferrié, who is in charge of this station, informed me a slight increase in the strength of the signals at distant receiving stations had been noticed at the time of greatest observation of the sun at Paris.

Also in Denmark Mr. H. Schledermann stated that observations made between the Royal Dockyard station in Copenhagen and the Blaavands Huk lighthouse on the North Sea at 300 km. distance showed that during totality the signal strength was increased.

Also in England Dr. Eccles noted an increase in the strength of atmospheric strays and signals from Clifden, observed in London during greatest obscuration. These observations show that even a partial diminution of the sun's light is sufficient to increase the strength of radiotelegraphic signals, possibly by an action on the air between the station, and especially on that near the transmitting station.

I suggest that it would be well worth while to erect temporary transmitting stations on and off the line of totality during the future total solar eclipses for the purpose of observing the effect of radiotelegraphic signals sent out from them to other receiving stations.

Another possible explanation of this daylight diminution has, however, occurred to me which I should like to submit to you. It is well known that sound is better heard when the

* *See* "Ann. der Phys.," Vol. V., p. 724, 1901.

wind is blowing from the source to the observer than when it blows in the opposite direction. It is also known that there are curious vagaries in sound transmission whereby loud sounds are heard sometimes better at great than at short distances. These effects were explained by Sir George Stokes as due to the fact that the velocity of sound is greater when moving with the wind than against the wind. Now, owing to friction and other causes, the velocity of the wind is generally greater at a height above the earth's surface than at the ground level. Hence, if a sound wave is travelling outwards from a centre against the wind, the upper parts move more slowly than the lower parts of the wave front, and hence the ray direction is tilted up and the sound passes over the observer's head.

### Ionisation of Upper Layers of Air

The suggestion I venture to make is that, when the upper layers of the air are ionised, the ions act as condensation nuclei for water vapour, and the presence of these numerous water spherules gives the upper air a larger dielectric constant.* Therefore an electric wave moves more slowly in it than in non-ionised air. Hence, if a plane wave is moving parallel to the earth's surface, and the upper layers of air are ionised by light, the greater velocity of the wave front at the lower levels causes it to slope backwards and the direction of the ray is elevated, so that it may pass over above the receiving antenna and not affect it.

Suppose, for the sake of simplicity, we consider a plane wave of vertical height $h$ moving between two places at a distance D. Let V be the velocity in non-ionised air and $V_1$ that in ionised air, and K and $K_1$ the corresponding dielectric constants. Let the upper part of the wave be in the ionised air and the lower part in non-ionised air, and let these two regions shade into one another. Then, if in a time $t$ the lower part moves forward a distan e $V_1t=x_1$, the upper part moves a less distance, $V_1t=x_1$, and the wave front slopes backwards by angle whose tangent

$$\frac{V-V_1}{h}t=\frac{V-V_1}{V}\cdot\frac{x}{h}=\left(1-\frac{\sqrt{K}}{\sqrt{K_1}}\right)\frac{x}{h}.$$

Therefore, at a distance D, the normal to the earth end of the wave front will intersect the vertical at a height $h_1$, such that

$$\frac{h_1}{D-x}=\left(1-\frac{\sqrt{K}}{\sqrt{K_1}}\right)\frac{x}{h}.$$

Suppose the height of the receiving antenna is H and that $H-h'=y$, then we have

$$y=H-\frac{1}{h}\left\{\left(1-\frac{\sqrt{K}}{\sqrt{K_1}}\right)(Dx-x^2)\right\}.$$

The quantity $y$ is a measure in a certain sense of the effect which would be produced on a receiving antenna placed at the distance D. If, then, $K=K_1$, or if there is no ionisation, $y$ has a maximum value equal to H. Also, if K and $K_1$ have any assigned ratio, $y$ has the same maximum value H, for $x=0$ and $x=D$, but a minimum value for $x=D/2$. Again, if $x=D/2$ and D and $h$ are constant, then $y$ is less the greater the ratio of $K_1$ to K.

Accordingly, if in the upper region of the air the ionisation of the air by ultra-violet light increase the dielectric constant so as to retard slightly the wave velocity, the wave front would be tilted backwards, and at long distances the waves might pass so far above the receiving antenna as to weaken very greatly the signals.

This tilting up of the ray will occur when the ionisation of the upper air has taken place over a part of the interval between the stations. It will be most pronounced when the greatest difference exists between the dielectric constant at the earth level and that at a level a few miles up in the air. At very large distances, say 2,000 miles, an extremely small difference in the dielectric constant of the air at low and at high levels would be sufficient to give the wave

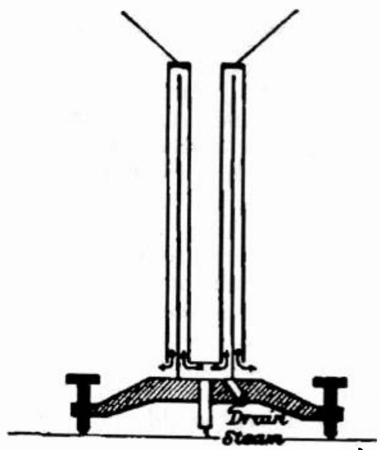



*Fig. 5.*

front a sufficient tilt to make the waves pass far above a receiving antenna 200 ft. high, and so weaken immensely the received signals, because the effect is cumulative, and noticeable, therefore, only at very great distances. As an experimental contribution to the subject, I have made some preliminary observations on the dielectric constant of air filled more or less with damp steam or warm mist. A tubular condenser was constructed (Fig. 5) of such kind that steam from a small boiler could be blown

* *See* Sir J. J. Thomson, "Conduction in Gases," p. 217, who says that air exposed to ultra-violet light may be regarded as full of extremely minute drops of water.

between the tubes, and the tubes were so supported that the condensation of the steam could cause no loss of insulation. The electrical capacity of this condenser was determined carefully by the Fleming and Dyke capacity bridge, using a telephone as detector and alternating currents having a frequency of 2,760.* Employing all necessary precautions, and comparing the dielectric constant taken as unity of air nearly saturated with water vapour with air having water globules or damp steam in it, we found that the dielectric constant of air filled with water spherules varied from 1·026 to 1·004, according to the amount of damp steam present in the space. In other words, an electric wave would travel more slowly in the steam-impregnated air than in the ordinary saturated air in the ratio of 980 to 1,000, or 998 to 1,000, or anything between these limits.

If, then, we consider a plane electromagnetic wave travelling with plane vertical, and its lower end in ordinary air and its upper end in air containing minute water spherules, the upper end would travel more slowly than the lower, and the wave front would acquire a backward tilt sufficient in a distance of a few hundred miles to carry the wave right above an ordinary receiving antenna. If the ionisation of the upper air by ultra-violet light results in the production of condensation nuclei which condense water vapour round them, then it is highly probable that the upper levels of the air have a slightly greater dielectric constant than the lower, and a difference of even a very small fraction of 1 per cent. will be cumulative in its action on the wave in giving the wave front a backward tilt in travelling over long distances.

### Transatlantic Experiments

Mr. Marconi states that over the Atlantic he has found the maximum daylight effect to occur when the shadow boundary was about half way across the Atlantic, the sending station being in daylight and the receiving station in darkness. I think the well-known "sunrise nick" in the signal intensity curve is due to the fact that the effect is at a maximum when the greatest difference exists between the state of the upper air as regards ionisation and that near the earth. Later in the day convection currents arise to churn up the air and bring it more into a homogeneous condition, which, whatever may be the state of ionisation, is unproductive of any tilt in the wave front.

* For a description of this bridge and method of using it, *see* the Paper by J. A. Fleming and G. B. Dyke on "The Power Factor and Conductivity of Dielectrics for Alternating Electric Currents of Telephonic Frequency and at Various Temperatures," "Journal," Inst. Elec. Engineers, 1912.

It has been frequently suggested that an explanation of long-distance radiotelegraphy may be found in the reflection of the electromagnetic waves at the under surface of a layer of ionised air in the upper atmosphere. No proof, however, has been given that this hypothetical layer of ionised air has a sufficiently defined surface to cause wave reflection. It is true that refraction may produce a change of ray direction which simulates reflection, as in the case of the phenomenon of the mirage. In this case the intense heat of the earth expands the layer of air next to it, and lowers its refractive index. Hence, the lower end of a plane wave of obliquely incident light travels faster than the upper end, and may do so to an extent sufficient to swing the ray right round, as if it were reflected from the layer of heated air. For a similar effect to occur with radiotelegraphic waves it would be necessary for the upper end of the wave front to travel much *faster* than the lower end. In other words, the upper end must be in a region of less dielectric constant than the lower end. We have no proof that this is the case. Hence it is also improbable that anything like copious reflection of long electromagnetic waves could take place at the under surface of a layer of ionised air producing an inverted mirage effect. This point, however, is one open for discussion.

There is no doubt, however, that the earth's atmosphere contains something which acts at times towards radiotelegraphic waves like a fog or mist towards light waves.*

### Freak Messages

There are also occasions of unusual transparency when waves of 300 or 600 metres in length seem to travel round the world in an extraordinary manner. Ships provided with the ordinary ship transmitters and receivers occasionally pick up signals sent 1,000 miles away. This is not due to special operative skill, but to a temporary transparency of the atmosphere to radiotelegraphic waves.

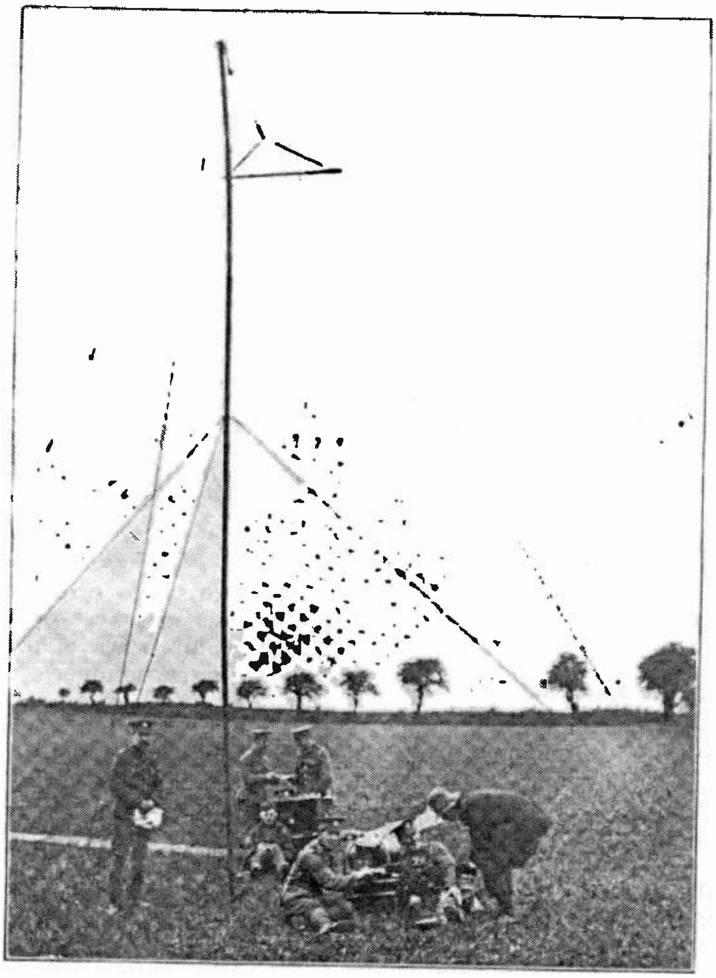
The next question to which I should like to direct attention is to the present state of the theory of directive antennæ. I need not go very fully into the early history. Mr. Marconi pointed out in 1906 the special qualities of an antenna consisting of a long wire arranged so that part is vertical, but the greater part horizontal, and that radiation takes place most energetically in the opposite direction to which the free end of the horizontal wire points.†

* Interesting observations have been made on this matter by Admiral Sir Henry Jackson, F.R.S., *see* "Proc." Roy. Soc., Lond., Vol. LXX., p, 254. 1902.

† *See* G. Marconi on methods whereby the radiation of electric waves may be mainly confined to certain directions, etc., "Proc." Roy. Soc., Lond., Vol. LXXVII., p. 413, 1906.

# Lessons from the Army Manœuvres

THE Army Manœuvres in East Anglia have been carried out with a zeal and thoroughness which leaves little to be desired, and as a result much has been learned regarding the entirely altered conditions of modern warfare. Two great factors have revolutionised military tactics—they are aeroplanes and wireless telegraphy, for by their agency nothing can be hid from the alert commander, and it has been proved beyond the shadow of a doubt that the result of a campaign will be little affected by chance, and will depend entirely on the efficiency of the Army and the resource of the scout-line. Arrangements were made for each of the contending armies to be supplied with a strong scout detachment: that of the Red Army including one wireless telegraph company, two signal companies, and two flights of aeroplanes, and an airship; while to the Blues were apportioned three wireless telegraph companies—two of which were supplied by the Territorial engineers, two aeroplane flights, and the "Gamma" airship.



*A Marconi Cavalry Station at the Manœuvres.*

But nothing helped scout work so much as wireless, and it was used more extensively than ever on this occasion. The Army is now equipped with three different types of portable stations. There are the pack-sets for cavalry, which can be in action within 10 minutes from halting, and have a transmission range of 50 miles; three such sets have been in use, and two others have been arranged for cart transport for use with Infantry.

The former were largely used by reconnoitring Cavalry detachments, and with conspicuous success. Here is one instance of its usefulness. A reconnoitring detachment was able, by skilful manœuvring, to get round, without interception, to the flank of the enemy. Here they were able to make important observations, and the information they obtained was, by means of their station, transmitted over the heads of the enemy to the Cavalry head-quarters. Then, again, the low masts of the station were found of great advantage, for they seldom reached beyond the topmost boughs of the surrounding trees, and, with a woody background, were entirely out of observation by the enemy. On more than one occasion the reconnoitring party were surprised in their apparent security, and a hasty retreat had to be made to avoid capture. Then the quickness with which the apparatus could be packed up was a quality that could not be too highly appreciated, for it allowed the party to get clear away, where a more intricate or heavier outfit would have meant either the capture of the party or the loss of the station to the enemy.

There were also in use two cart sets. These were found of immense service when erected at a stationary base, whence it was possible to maintain communication between military outposts who—from the nature of their service—were frequently required to change their position. The cart set is altogether heavier and a more intricate type of station, much less adaptable for swift transport. It has, however, great powers of transmission, for its range exceeds 200 miles—a useful asset indeed. It is designed for wheel transport, and is not difficult of erection, for it can be got into working order within the space of 15 minutes.

The motor-car set was here, there, and everywhere, and was found peculiarly serviceable in field work, for it combined the two advantages of the pack and the cart sets, and having a wide range (about 200 miles) it could be transported and erected with incredible swiftness in the most out-of-the-way parts in the field of operations, and communicate with headquarters from distances beyond the range of the pack sets, while the fact that its musical note was found to be peculiarly distinct commended it highly to the operating engineers and officers in charge.

Another interesting episode of the manœuvres was the work carried out conjointly between airship and wireless. The "Gamma" airship more particularly did great service to the Blues by reconnoitring and discovering the position of the enemy and reporting continually by wireless to the headquarters.

*Transporting a Wireless Station over difficult ground.*

## The Panama Canal Act

THE text of the new Panama Canal Act, which was signed on August 26th, at Washington, by President Taft, has now been published. The Act, which provides for "the opening, maintenance, protection, and operation of the Panama Canal, and the sanitation and government of the Canal Zone," has aroused a good deal of attention throughout Europe and America. Section 6 deals with the erection and working of wireless telegraphic installations at suitable places along the Panama Canal, subject to the International Convention and the Act of Congress to regulate radio-communication, and if necessary by further agreement with the Republic of Panama.

The following is the official text of that portion of the section relating to wireless telegraph installations:

That the President is authorised to cause to be erected, maintained, and operated, at suitable places along the Panama Canal, and the coast adjacent to its two terminals, in connection with the operation of said canal, such wireless telegraphic installations as he may deem necessary for the operation, maintenance, sanitation, and protection of said canal. If it is found necessary to erect such installations upon territory of the Republic of Panama the President is authorised to make such agreement with said Government as may be necessary, and also to provide for the acceptance and transmission by said system of all private and commercial messages, and those of the Government of Panama, on such terms, and for such tolls as the President may prescribe; *Provided*: That the messages of the Government of the United States and the Departments thereto, and the management of the Panama Canal, shall always be given precedence over all other messages. The President is also authorised in his discretion to enter into such operating agreements, or leases, with any private wireless company as may best assure freedom from interference with the wireless telegraphic installations established by the United States.

# The Lighter Side of Wireless

## A Code of Morals.

(Via Wireless.)

Adapted by Thos. Appleby.

*With apologies to Kipling.*

NOW Jones had left his new-wed bride to keep his house in order,
And hied away to the Hurrum Hills above the Afghan border
To sit on a rock with his Wireless ; but ere he left he taught
His wife the working of the Code that sets the miles at naught.

And Love had made him very sage, as Nature made her fair ;
So Cupid and Apollo linked, per Wireless, the pair.
At dawn, across the Hurrum Hills, he flashed her counsel wise—
At e'en the Wireless waves still bore her husband's homilies.

He warned her 'gainst amorous youths in scarlet clad and gold,
As much as 'gainst the blandishments paternal of the old ;
But kept his gravest warnings for (hereby the ditty hangs)
That snowy-haired Lothario, Lieutenant-General Bangs.

'Twas General Bangs, with Aide and Staff, that tittupped on the way,
When they beheld a Wireless-Spark tempestuously at play ;
They thought of Border risings, and of stations sacked and burnt—,
So stopped to take the message down—and this is what they learnt :

" Dash dot dot, dot, dot dash, dot dash dot " twice. The General swore.
" Was ever General Officer addressed as 'dear' before ?
'My Love,' i'faith ! 'My Duck,' Gadzooks ! 'My darling popsy-wop !'
Spirit of great Lord Wolseley, who is on that Mountain top ? "

The artless Aide-de-camp was mute ; the gilded Staff were still,
As, dumb with pent-up mirth, they booked that message from the hill ;
For, clear as summer's lightning flare, the husband's warning ran :
" Don't dance or ride with General Bangs—a most immoral man."

At dawn, across the Hurrum Hills, he flashed her counsel wise—
But, howsoever Love be blind, the world at large hath eyes.
With damnatory dot and dash he Wirelessed his wife
Some interesting details of the General's private life.

The artless Aide-de-camp was mute ; the shining Staff were still,
And red and ever redder grew the General's shaven gill.
And this is what he said at last (his feelings matter not) :
" I think we've tapped a private line. Hi ! Threes about there ! Trot ! "

All honour unto Bangs, for ne'er did Jones thereafter guess
By word or act official who read off that Wireless ;
But the tale is on the Frontier, and from Michni to Mooltan
They know the worthy General as " that most immoral man."

---

## Signs of the Times.

The Priest of Urim and Thummim ! An excellent name ! A name that conjures up visions of the prophet, with his wild eye "in a fine frenzy rolling," and his skinny hand clutching ecstatically at the void. But there you are mistaken, dear reader, for the prophet has climbed down from the exalted heights of soothsaying and subjected his soul to the pen—he has written a book. It is called " The Signs of the Times." The purpose of the book is evident from its very title, and the expectant are not disappointed when the pages are cut and the secrets disclosed.

Many and awful are the prognostications which animate the printed words and make them dance before a perfervid imagination like demons in their cohorts. You see, the whole gist of the book is that the world—the great Babylon—is rushing headlong to its ruin. The heavens are eloquent with disaster. The earth is full of the signs of the times; and these are interpreted for the uninitiated by the Priest of Urim and Thummim. "Mankind," he cries, "is too presumptuous." "He has the audacity to invent," and—looking round for an example—he espies the aerials fitted to the roof of Marconi House, and therefrom takes his cue. Wireless telegraphy, he assures his readers, is the leading example of such presumption. "We" (he uses the impressive plural, but it is doubtful whether he intends the apostolic or the journalistic "we")—"*We* could have propounded the theory about the time its inventor was at school, but refrained because its consequences were so manifestly dangerous." Ah! What a thing it is to be a prophet. But it is a thousand pities that the foreseeing one should have waited for the accomplished fact before he gave us the benefit of his inspiration. Then we might have nipped this awful invention in the bud. As it is, Marconi now "girdles the earth in 40 minutes," and has given us edged tools to play with. For terrible beyond conception are to be the results of wireless telegraphy: "It will disturb the omnipresent ethers of space. . . . It will loosen the polar ice-packs and bring them into warmer seas. . . ."

But wireless would be a mere bagatelle if its damaging powers could do so little. Fortunately, the priest can assure us that it will cause earthquakes, landslides, volcanic upheavals, tidal waves, and pit accidents, etc., etc., etc.

Well—well. The fervent minds of the age have at least one consolation. Whatever else we may have to suffer, the times are not going to be dull.

## A Unique Record.

THE s.s. "Miltiades," on its arrival recently, made a unique wireless record *en route*. From the time she left London until her arrival in Hobson's Bay, Port Melbourne, she was in constant wireless communication with either ships or land stations. Had the vessel been journeying by the Suez route there would not have been anything very wonderful in this, but she came via the Cape of Good Hope, and across the long stretch of the Southern Ocean to Melbourne, where it is almost the universal rule for vessels to sight nothing but sea and sky. She was accompanied at some distance suitable for the interchange of wireless signals by the New Zealand Shipping Co.'s "Rotorua." The result was that not a day passed without the wireless apparatus being in use. Right until the "Miltiades" sighted Cape Otway she interchanged signals with the "Rotorua," and then she dashed a message of farewell to her fellow voyager, and got into touch with the steamer "Themistocles" at Port Melbourne. The "Miltiades" had five days of easterly gales after leaving Capetown. This achievement has inspired "Max A." to contribute the following to the *Melbourne Punch*:—

There's a message goes through the trembling
air,
"Hello, 'Miltiades!' Are you there?"
Vast and lone in the heaving green
Under the stormy sky,
And never a sail nor smoke is seen,
Nor ever a ship goes by;
But the message rides o'er the shaken seas,
"Hello! 'Miltiades!'"

No day comes but that whisper wings
Its wondrous way, where the good ship flings
Spume and spray from her pitching prow,
Smoke and soot from her fires;
For man has conquered all distance now
With one little span of wires;
And speaks with one faint touch of the keys,
"Hello! 'Miltiades!'"

There is no spot now where a man may go,
Be it burning desert or Polar snow,
But there the voice of a friend will come
Bidding him hope for aid;
There is no place now where the world is dumb,
Or lonely, or left afraid;
But universal are words like these,
"Hello! 'Miltiades!'"

And planet to planet yet shall call,
With mind triumphant across them all;
Spinning around their lord the sun,
Each in its own great track,
The outward message each day will run,
And the answer come dancing back,
As it danced on the rolling southern seas,
"Hello! 'Miltiades!'"

THE MARCONIGRAPH

An Illustrated Magazine for all interested in WIRELESS TELEGRAPHY, published monthly by MARCONI'S WIRELESS TELEGRAPH COMPANY, LIMITED, Marconi House, Strand, London, W.C.

Telegraphic Address ........." Expanse, London."
Telephone No. ..................City 8710 (Ten Lines).
Codes used ........................Marconi, A.B.C. (4th edition), Western Union.

Subscription rate............3s. 6d. per annum, post free.
Single Copies..................2d. each, by post 3½d.
Subscription Rate in the United States and Canada........................ $1 per annum, post free.
Europe ...........................fr. 4.80 per annum, post free.

All communications relating to Subscriptions, Advertisements and other business matters, to be addressed to "The Publisher, 'The Marconigraph,' Marconi House, Strand, London, W.C."

All Editorial communications to be addressed to "The Editor, 'The Marconigraph,' Marconi House, Strand, London, W.C."

The Editor will be pleased to receive contributions; and Illustrated Articles will be particularly welcomed. All such as are accepted will be paid for.

## CONTENTS





### The Share Market

London: September 24th.

The market in the various Marconi issues has been fairly active during the past month. There has been a considerable rise in prices since our last issue, although, owing to adverse rumours which should not be taken seriously, there has been a slight set-back from the highest figures.

There has been good investment buying, both from home and abroad, on the anticipated results of the large work that is being done by the parent Company and its subsidiaries, more especially the American Company, which has made some important extensions.

The prices as we go to press are: Ordinary, $5\frac{1}{8}$; Preference, $4\frac{1}{4}$; Canada, 24s.; Spanish, $1\frac{1}{16}$; American, $1\frac{7}{8}$.

### "The Marconigraph."

Wireless developments continue unabated; and every month the task of squeezing all the latest information between the covers of THE MARCONIGRAPH becomes more and more difficult. Last month the only alternative open was to increase the number of pages to sixty-four. This month the difficulty has recurred, and has once again been overcome by the addition of more pages, and the number is now seventy-two. This increase is due in some measure to the extra space necessitated by an account of the proceedings at the annual meeting of the British Association, which included an important discussion on Wireless Telegraphy. This was opened by Professor Fleming, who is well known to our readers, and his remarks are of such great interest that they have been published *in extenso* in this number.

### Admiralty Wireless Expert

The Admiralty give notice that, with the concurrence of the Treasury, the post of Expert in Wireless Telegraphy has been removed from Schedule B of the Order in Council of January 10th, 1910. That schedule empowers the Civil Service Commissioners to make appointments to certain offices without the nominees having to pass a Civil Service examination. The appointment of Expert in Wireless Telegraphy, which is at present held by Mr. H. A. Madge, who is attached to H.M.S. "Vernon," has hitherto been made in accordance with the provision of Schedule B of the Order in Council of January 10th, 1910, but future appointments will be made as a result of Civil Service examinations.

**Accident to Mr. Marconi**

Rome, September 26th.

A motor-car, in which Mr. Marconi was proceeding with Mrs. Marconi from Coltano to Genoa, came into collision with another car near Borghetto. Mr. Marconi sustained an injury to his right eye. He was conveyed in a car belonging to the local naval commander to the naval hospital, where he received first aid. The injury is being examined by doctors, but is not thought to be dangerous. Mrs. Marconi escaped unhurt.

**New French Naval Wireless Station**

The Minister of Marine has decided upon the creation at Barfleur Point of a wireless telegraphy station for the exclusive use of the Maritime Prefecture in time of peace, and of the Commander-in-Chief of the defence service in time of war, when communicating with ships at practice or employed on any service in the Channel. The transmitting range of the new post is only to be about two hundred miles—that is to say, the distance separating Cherbourg from Brest on the one hand and Dunkirk on the other.

**Wireless and Weather**

In an article which appeared in THE MARCONIGRAPH fourteen months ago, we gave some indication as to the extent to which wireless telegraphy aided meteorology. The preparation of charts issued from the Meteorological Office is largely dependent upon telegraphic reports from different regions. Until the advent of wireless, however, large regions were left untouched, and instead of possessing precise data from such areas as is now available by means of Marconi wireless telegraphy, the Meteorological Department had to depend to a large extent upon empirical data.

From an examination of the Seventh Annual Report of the Meteorological Committee to the Lords Commissioners of His Majesty's Treasury, it is possible to glean some interesting figures relating the wonderful progress which has been made in the development of the application of wireless telegraphy to meteorology. During the year ending March 31st last 68 wireless telegrams were received from ships of His Majesty's Navy, and 4,922—or nearly 1,000 more than in the previous year—from Atlantic liners.

Only 232 out of the total of nearly 5,000 messages reached the office in time to be included in "to-day's" map in the daily weather report—*i.e.*, within about four hours of the time of taking the morning observations; 2,352 messages, or rather less than half the total, reached the office in time to be included in one of the two maps for "yesterday" shown in the daily weather report. As the forecasts are prepared within about two hours of the time of observing, it is evident that very few messages reached the office in time to be of direct and immediate application in the preparation of forecasts or the issue of storm warnings.

Nevertheless, there were again a number of occasions on which the messages were of great assistance to the forecaster They often gave the earliest observations of the westerly or north-westerly winds in the rear of a depression, and so put him in a position to forecast the early extension of these winds to western districts. Such cases occurred on May 2nd, July 14th, July 24th, Steptember 1st, November 28th, and January 15th. On other occasions the extension of southerly winds to some distance from our western coasts increases the probability of a continuance of southerly winds over the British Isles for the whole 24 hour period covered by a forecast. Such cases occurred on December 1st, January 8th, and March 1st.

Wireless reports have also proved valuable in connection with the issue of a "further outlook," especially when it takes the form of a notification of a probable spell of fair weather. Such a notification would not be issued if wireless reports showed the existence of important disturbances over the ocean.

The number of occasions on which wireless reports conveyed information which would have been useful, but came to hand after the issue by the Meteorological Department of forecasts, was unfortunately considerable. A conspicuous example occurred in connection with a gale one November night. Wireless reports received subsequently indicated a very deep disturbance in Long. 25° W. Had this information been in the hands of the forecaster sufficiently early, storm warnings would have been issued to all Scottish coasts. As it was a severe gale occurred, for which no fore-warnings were issued. This incident only shows the great services which wireless reports can render in forecasting weather reports. There have been innumerable instances where the wireless messages have been of great service in connection with the issue of the modifications of spells of settled weather, and it would be possible to cite many recent occasions on which the wireless messages were of great assistance to the forecasters.

# Long Distance Wireless Telegraphy

**Important Commercial Developments**

## The Norwegian Contract

THE announcement made in the Press on the sixth of September that a contract had been signed between the Norwegian Government and Marconi's Wireless Telegraph Company, Ltd., marks another important stage in the development of Trans-Atlantic communication. The necessity for some direct means of communication between America and Northern Europe had long been recognised, and M. Heftye, the Director of Norwegian Telegraphs, was pursuing a progressive and far-sighted policy when, at the request of the Government, he entered into negotiations, and finally effected a sound business transaction with Marconi's company for the opening up of a commercial telegraph service between Northern Europe and America. By the terms of the agreement Marconi's Wireless Telegraph Company are to build two high-power wireless stations. One is to be erected on a site yet to be chosen in Norway, and for this they are to receive the sum of £70,000, exclusive of site foundations and buildings. The site of the other is in the vicinity of New York, and in this case the expenses incurred by the purchase of land and the cost of the building will be covered by a royalty of 10 per cent., which is to be allowed on the gross receipts of the enterprise. The stations are to be erected as quickly as possible, and must be completed within twelve months from the time that the foundations and buildings are ready.

It has further been arranged that the receipts of the joint stations will be pooled and divided equally between the Marconi Wireless Telegraph Company of America and the Norwegian Government. This agreement will remain in operation for the period of 25 years, and at the end of that time the Norwegian Government will have the right to renew it.

The Norwegian station will in all probability be erected at Bergen, and will be the central station for the whole of Scandinavia, Russia, and possibly for all the important other districts of North Europe. Here local stations will be established, which will communicate with the Norwegian centre. Thence messages will be sent direct to the station at New York—that is to say, they will be transmitted over a distance of 3,750 miles. To enable this to be accomplished satisfactorily the stations are to be supplied with very powerful apparatus, and when the line of communication is completed the Norway-American "call" will be one of the longest links in the world's chain of wireless telegraphy.

## Trans-Pacific Wireless

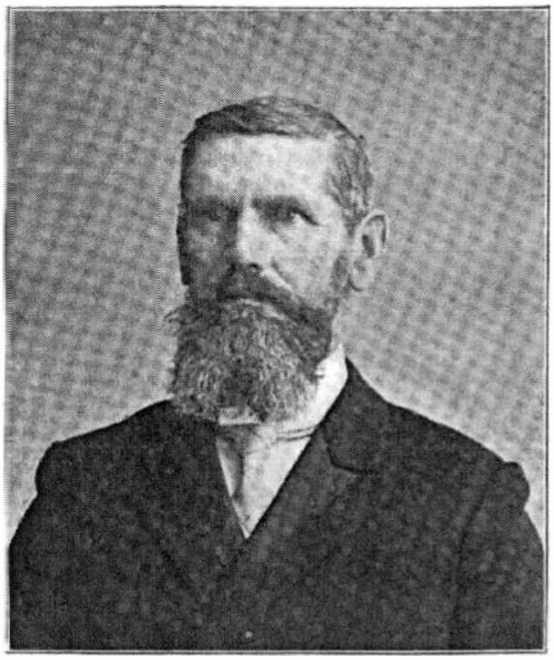
With regard to the reports of long-distance wireless communication across the Pacific (between San Francisco and Honolulu), which the Federal Wireless Telegraph Company claim to have established by means of the Poulsen system, Marconi's Wireless Telegraph Company, Ltd., are erecting at these places stations of the same type as those which it is proposed to construct for the British Imperial scheme. The new Marconi station at Honolulu has been so designed as to enable wireless communication to be established at a little later date with similar stations to be erected by the Marconi Company at Yokohama and in the Phillipine Islands.

The Marconi Wireless Telegraph Company of America have commenced proceedings for infringement of patent against the Federal Wireless Telegraph Company.

## Obituary

IT is with great regret that we record the death of M. Homberger, which took place on August 17th at Berne. M. Homberger was one of the secretaries of the Bureau International de l'Union Télégraphique, which he represented at the International Radio-telegraphic Conference in London in June last.

It was while staying in London that M. Homberger met with a serious accident and was compelled to return to Berne before the



*M. Homberger.*

termination of the Conference, much to the regret of his fellow-delegates, who thereby lost the assistance of a foremost authority on International Radiotelegraphy. M. Homberger was born at Zurich in 1854, and entered the telegraph service of the Swiss Federal Administration in 1871, thence he entered the International Bureau of the Telegraph Union, to which he was ultimately appointed first secretary. In this capacity he took part in the International Telegraph Conferences of Budapest (1896), London (1903), Lisbon (1908), in addition to the Congress held in London this year.

## Cargo Equipment at a Newcastle Exhibition

AN electrical exhibition was held at Newcastle-on-Tyne during the past month, and the two exhibits of Marconi's Wireless Telegraph Company made a strong appeal to the thousands of visitors. Indeed, so keen was the interest displayed in these two stands that they were often difficult to approach on account of the huge crowds which su-r rounded them, and the demand for copies of THE MARCONIGRAPH sorely taxed the resources of the Publisher. The two stands were at opposite corners of the exhibition hall, and were in constant wireless communication. By these exhibits the company also brought to the notice of the shipping section of the Tyneside community what they have been able to accomplish in the direction of facilitating the installation of wireless telegraph apparatus on cargo vessels. By this new apparatus a message might be sent clearly over a circle of 150 miles, and might be received from shore or ship 1,500 miles away. The apparatus referred to is known as the Marconi ½-kw. cargo set. This is a small power installation designed to produce transmitting waves of 250 and 600 meters, or any intermediate wave with a simple change-over from one to any other. The working transmitting range depends upon the height, length, and shape of the aerial. The receiving apparatus provides for tuned reception of all waves between 250 and 1,600 metres. The working receiving range is also dependent on the aerial. The transmitting plant consists of a rotary converter which gives an alternating current output of ½-kw. It is of the vertical type, and occupies a minimum of floor space. The armature is of a special design, and differs from the ordinary converter by giving at the slip rings a constant alternating current voltage independent of the direct current imput voltage. The machine is designed to suit the direct supply available on the ship. It has eight poles, and runs at 2,250 revolutions per minute, thus giving a spark frequency of 300 per second.

It is stated that since the beginning of 1909—that is, during a period of three years—the passengers on no fewer than twenty-two shipwrecked vessels have owed their lives to the fact that the ships were equipped with a wireless telegraph system, and were consequently able to send out messages for assistance.

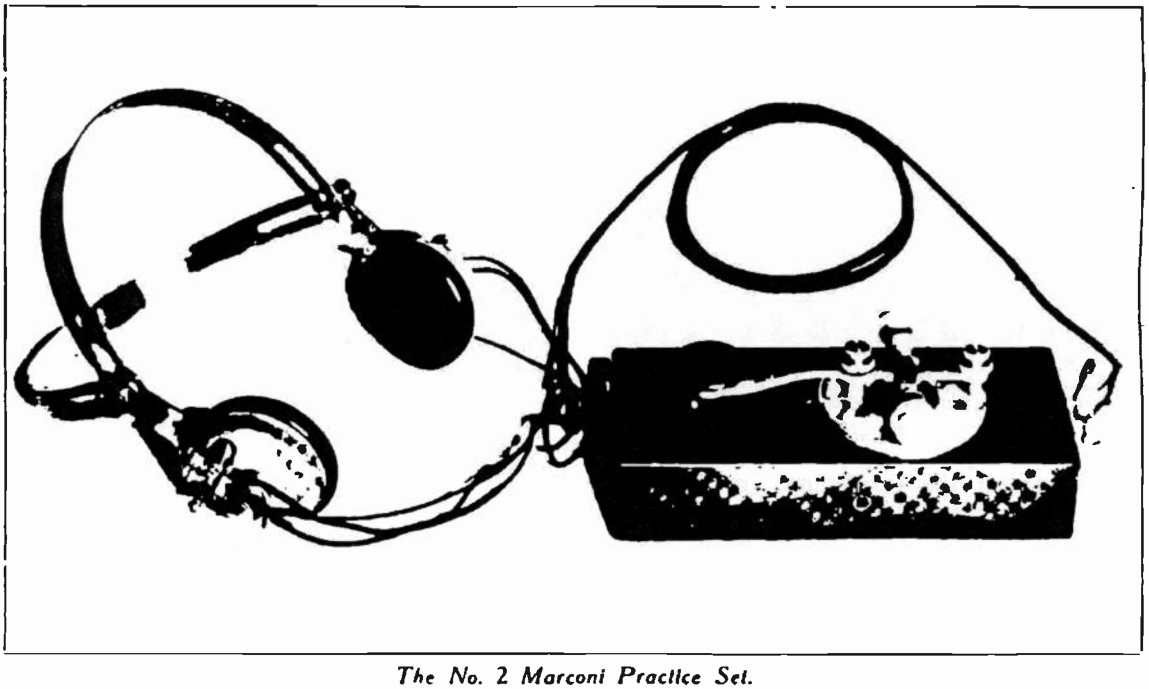
According to a vote taken among a thousand prominent men of science throughout the world by a popular Chicago magazine, wireless telegraphy is considered the greatest of the seven wonders of the modern world. The following list shows the order of importance of the seven achievements which are considered the most won erful: 1, wireless; 2, the telephone; 3, the aeroplane; 4, radium; 5, antiseptics and anti-toxins; 6, spectrum analysis 7, X-rays.

# A New Practice Set for Learners

## With Notes on the Morse Code

THE problem which had faced those who were desirous of learning how to send and receive wireless signals—and their number must have increased very considerably of late by the multiplication of Boy Scouts companies—has probably deterred many private persons from pursuing a practical training in wireless telegraphy. The smallest wireless station at present available is known as the " Knapsack " station. This has already fully proved its value, and seems destined to become an indispensable portion of the outfit of Territorial and Boy Scout companies. But the cost of such a station would probably be too heavy an outlay for many persons, whose main object is to receive instruction in the Morse code as applied to wireless telegraphy.

The subject has a fascination for many thousands of people, who would undoubtedly take a keener practical interest in wireless telegraphy were they acquainted with the fact that there is obtainable apparatus that will bring their hobby within range of even the most limited purses. This is now possible by means of the Marconi Practice Set, which can be used for the twofold purpose of giving and receiving instruction in telephone Morse signalling, and for testing both the keenness and speed of operators. The set has been carefully designed and constructed, and is in every respect up to the high standard of all apparatus manufactured at the famous Chelmsford works. Some people entertain the idea that because such apparatus is small and inexpensive, and intended to be used by learners, that anything cheap will answer the purpose. Such an idea, however, is not only erroneous, but is positively harmful to those who take a serious interest in wireless telegraphy, for they might be disagreeably surprised to discover, at a time when they desired to put their training to some practical purpose, that the signals used by a wireless station were of an entirely different kind from those with which they were familiar through using a toy practice set purchased without any consideration. What this defect would mean to Boy Scouts or to the electrical amateur is sufficiently obvious without labouring the point. With the Marconi Practice Set there is no danger of such a thing happening, for with this instrument it is possible to reproduce almost exactly



*The No. 2 Marconi Practice Set.*

the kind of signals obtained with wireless telegraph stations. Thus, anybody learning to communicate with this apparatus will have an excellent training for working on a wireless station when the opportunity arises.

There are two forms of Marconi Practice Set, that known as No. 2 being the cheaper of the two. It is shown in the accompanying illustration, and its compactness will at once impress the reader. The apparatus is enclosed in a highly finished teak box, on which is mounted the operating key. Enclosed in the box is the battery, which is very easily removed when required for replacement. The terminal block fitted in the end of the box is made to slide, and by this means it is possible to vary the strength of signals in the telephone. The adjusting screw of the buzzer can easily be reached by a small screw-driver through a bushed hole in the side of the box. A single headpiece is provided with the instrument, but a double headpiece, such as is illustrated, can be supplied if required. Owing to its extreme portability and low price, the instrument is admirably suited for instruction in the reception and transmission of wireless messages, and it will be found to be of special advantage to Scout and Cadet corps.

As the Practice Set which we have just described is primarily intended for the reception and transmission of Morse signals, it might be advisable to reproduce here the International Code for the benefit of those who are now, for the first time, attracted to the subject. It will be seen that the signals are merely an arrangement of dots and dashes representing letters of the alphabet. The following notes respecting spacing and length of signals should be remembered: (1) A dash (—) is equal to three dots (. . .); (2) the space between the signals which form the same letter is equal to one dot; (3) the space between two letters is equal to three dots; (4) the space between two words is equal to five dots. Letters of the alphabet are shown in he following table:

| | | | |
|---|---|---|---|
| a | · — | n | — · |
| ä | · — · — | ñ | — — · — — |
| á or å | · — — · — | o | — — — |
| b | — · · · | ö | — — — · |
| c | — · — · | p | · — — · |
| ch | — — — — | q | — — · — |
| d | — · · | r | · — · |
| e | · | s | · · · |
| é | · · — · · | t | — |
| f | · · — · | u | · · — |
| g | — — · | ü | · · — — |
| h | · · · · | v | · · · — |
| i | · · | w | · — — |
| j | · — — — | x | — · · — |
| k | — · — | y | — · — — |
| l | · — · · | z | — — · · |
| m | — — | | |

There is a simple rule by which it is easy to memorise code figures. Thus the figure 1 is represented by one dot, four dashes; 2, two dots, three dashes; 3, three dots, two dashes; 4, four dots, one dash. The figure 5 is represented simply by five dots. From 6 to 10 the order of dots and dashes is reversed, as follows: 6, one dash, four dots; 7, two dashes, three dots; 8, three dashes, two dots; 9 four dashes, one dot; 10, five dashes. The following table will show this more clearly:

| | | | |
|---|---|---|---|
| 1 | · — — — — | 6 | — · · · · |
| 2 | · · — — — | 7 | — — · · · |
| 3 | · · · — — | 8 | — — — · · |
| 4 | · · · · — | 9 | — — — — · |
| 5 | · · · · · | 0 | — — — — — |

In addition to the alphabet and figure code, there is a special code for punctuation and other signs, which it is not necessary to trouble the reader with at this early stage.

---

## The Chelmsford Mast

THE steel mast, 450 ft. in height, which has been erected by Marconi's Wireless Telegraph Company at their new works at Chelmsford, has now been completed, and forms a land mark which can be seen for many miles round. The mast, which has been erected under the supervision of the company's staff, weighs 70 tons, and is composed of steel flanges formed in four sections, bolted together after being hoisted into position. The inside diameter of the mast is 3 ft. 5 ins., and the outside diameter of the flanges 4 ft. 6 in. Over two thousand 2-in. bolts were used in the construction of the mast, and the steel cable supports are attached to four huge concrete anchor blocks, each representing a weight of 120 tons. In connection with each of these anchor blocks, 260 small piers of asbestos and mica plates, covered with lead caps, have been erected on four feet of concrete, and the remainder of the block built over them. The effect of the little piers is to give the perfect insulation which is so necessary to the effective working of the wireless telegraphy.

The 250 ft. mast, which has recently been used by the company, is now being taken down, and another mast of 450 ft. will shortly be erected.

(Continued from page 271.)
Also, by the law of exchanges, a bent antenna which radiates unequally absorbs unequally in different azimuths. The question is as to the explanation of the action of this bent antenna.

### The Bent Antenna

In 1906, starting from a suggestion by Sir Joseph Larmor, I gave a theory based on the view that the bent antenna is equivalent to a combination of an open and closed circuit, and assumed the earth to be a perfect conductor. The objection has been raised to this theory that it implies that the directivity should fall off with distance.

Experiments have not yet been made, as far as I am aware, on a sufficiently large scale and at sufficiently great distances to settle this point, and the experimental problem is undoubtedly complicated by the effect of the nature of the soil surface over which the waves travel in different dielectrics or regions. Nevertheless, Mr. Marconi's experiments show that the directivity persists for several hundred miles. Recently the problem has been discussed by H. von Hoerschelmann in the "Jahrbuch der Drahtlosen Telegraphie" (*see* Vol. V., p. 15, 1901). According to his theory, the effect of a bent antenna is entirely due to vertical electric currents which are produced in the earth just under the horizontal part of the bent antenna. Hence the directivity depends on the conductivity of that region of the earth.

Starting from the same system of equations as Sommerfeld, he obtains expressions for the vector potential, or Hertzian function, which show that the function which determines the vertical field in the earth and in the air is dependent on the azimuthal angle in such manner that there is no directivity if the earth is a perfect conductor, but that, if the earth has a finite conductivity under the antenna, then an unsymmetrical radiation takes place, and the directivity once created persists even though the waves travel out later on over a good conducting surface. The mathematical work in Hoerschelmann's Paper needs careful consideration by pure mathematicians to test whether the transformations of the Besselian functions he employs are valid and his analysis correct. He points out that, as a consequence of his theory, a bent antenna situated over a sea surface should not have the same degree of directivity as one situated over a poor conducting soil. These conclusions could easily be checked experimentally.

### The Function of the Earth

The general result of all the theoretical investigations of Zenneck, Sommerfeld, and Hoerschelmann is to show that the function of the earth in radiotelegraphy is by no means confined merely to guiding a space wave, but that it fulfils a most important function in assisting to create surface waves and in permitting earth currents which have directive effect. Recent experiments with antennæ laid on the ground or under the ground by Dr. Kiebitz have turned attention afresh to the matter, although many of Kiebitz's results seem only a repetition of those obtained by Marconi in 1906 with antennæ laid on the ground or a little above it.*

Kiebitz used as receiving antennæ long wires carried on insulators placed in ditches about 1 metre deep. The ends of the wires were earthed through condensers. The receiving appliance was at the centre.

By such antennæ properly oriented he found he could receive signals from all the principal radiotelegraphic stations in England, France, and America.

There is no need to assume that these received waves are propagated through the deep strata of the earth. The effects are exactly what might be expected from waves travelling over the surface.

The chief interest of Kiebitz's experiments lies in the confirmatory proof they give that an elevated antenna is not necessary for *reception*. On the other hand, for long-distance *transmission* an elevated aerial wire or one raised above the earth is requisite.

The chief problem yet to be faced in connection with sending antennæ is to find a form of antenna which will radiate a large power, say 100 kw. to 500 kw., at a relatively low frequency or long wave-length consistently with high antenna efficiency.

There is room for an immense amount of research yet on improved forms of antenna. When we consider that the function of a sending antenna is something like that of a gas mantle or gas fire radiator—viz., to transform into radiation of desired wave-length as large a fraction as possible of the supplied energy—and remember what has been done in the corresponding luminous problem, it is easy to see that countless questions of great practical value in connection with antennæ for radiotelegraphy remain unsolved.

The ingenious method of directive telegraphy due to Bellini and Tosi deserve mention, and suggest that in the case of wireless plant erected on ships means for instantly locating the direction of the arriving waves is a matter of the greatest importance. Although the practical problem is to some extent solved,

* *See* Dr. F. Kiebitz, "Recent Experiments on Directive Wireless Telegraphy with Earthed Antennæ," "The Electrician," March 8th, 1912.

there is abundant room for further invention in connection with it.

### Wireless Telephony

We can hardly leave this discussion without some mention of the state and prospects of wireless telephony. The essential condition of success in transmitting speech is the possession of means for creating undamped oscillations or alternating currents of a frequency not less than 20,000. When the Poulsen arc generator was first introduced, it was hailed as a solution of the problem, but practical experience has shown that, whilst experimental feats can be performed with it, it has not the simplicity and ease of manipulation required for commercial work. The modification recently introduced by Mr. E. L. Chaffee, consisting of a copper-aluminium arc in damp hydrogen, the arc being formed between two closely adjacent plane surfaces, appears to be an improvement. The practical solution seems, however, to be in the perfection of some simple easily-managed form of high-frequency alternator. The ingenious inventions of Goldschmidt in utilising the properties of the polyphase motor to increase frequency have been developed by the Lorentz Company of Berlin, and seem likely to result in the production of a practical form of extra high-frequency alternator suitable for radiotelegraphy and radiotelephony.

In addition to the generator, inventors have wrestled with the difficulties of making a microphone transmitter which shall be able to carry a large current without heating. To conduct wireless telephony over any distance we have to modulate in accordance with the wave form of the speaking voice a very large antenna current. The problem has to some extent received solution in the liquid microphone of Majorana, the relay microphone of Dubilier, and a recently invented heavy current microphone of Rühmer.

We seem to be, however, on the track of mechanical means for generating undamped oscillations and microphonic means for modulating them, and wireless telephony is, therefore, even now a practical matter for a few hundred miles of distance. It is quite within possibility it may yet be conducted across the Atlantic.

As regards other inventions, we are still in want of more simple means for recording telegraphic messages. Since the coherer fell out of use the reception is mostly conducted by ear. Somewhat elaborate photographic methods, suitable for large land stations which employ the Einthoven string galvanometer, have been introduced; but what is still required is a means of calling up the operator and of recording the message on board ship which is at least as sensitive as the telephone plus the human ear for ordinary shipboard communication.

The receiver current is, however, very small, and available power is at most a few microwatts in the form of a current of a few microamperes.

There are, therefore, innumerable practical and scientific problems in connection with radiotelegraphy which await solution. These require mathematical, physical, and radiotelegraphic knowledge of a high order to overcome them.

### A Committee Required

This leads me to make a final suggestion. Generally speaking, our method of attacking these problems is by individual isolated efforts. The pure mathematician, however, often sets himself to solve a problem that is too far removed from the actual facts of Nature to be useful, and the physicist to investigate something which is out of touch with immediate technical requirements, whilst the wireless telegraphist, by sheer power of perseverance, backed by financial resources and aided by the unconscious cerebration of genius, manages to arrive at useful results by an expensive, circuitous route, but often cannot explain them when found. I am convinced, however, that most valuable results would ensue from the close co-operation of the pure mathematician, physicist, and practical radiotelegraphist. Why should not a British Association Committee on Radiotelegraphy be formed on the same lines as the British Association Committee on Electrical Units? If such a Committee had on it one or two eminent pure mathematicians, physicists, practical radiotelegraphists, and perhaps a flying man or two to assist in atmospheric exploration, and if they were content to work in hearty co-operation, what valuable work might be done. They might publish at intervals joint reports. The mathematicians would carefully scrutinise such Papers as that of Zenneck, Sommerfeld, and Hoerschelmann, or go over the ground again, and make sure of their logical solidity. The physicists might determine dielectric constants and conductivity for high-frequency currents of air in various states of ionisation, of soils, and earth-crust materials. The radiotelegraphists might collect accurate data on the practical side of the subject, and would keep the others from straying into barren regions of investigation. No one man has sufficiently extensive abilities to enable him to reap in all fields of this large subject, but the conjoint labours of such a union would enable more valuable work to be done in two years than they could separately achieve in ten, and I therefore venture to invite your consideration of the suggestion.

The basis for all technical achievements is a true scientific knowledge of facts and principles, and what body so fitted to advance it in this case as the British Association for the Advancement of Science?

What is required in the present state of radiotelegraphy is to restrict everywhere the mere useless amateur playing with wireless telegraphy, such as that which has become an intolerable nuisance in the United States, but is wisely held in check by our Wireless Telegraph Acts in Great Britain. At the same time, all reasonable opportunities should be afforded to serious investigators.

Since the above remarks were put in type a Paper has been published by Dr. Eccles

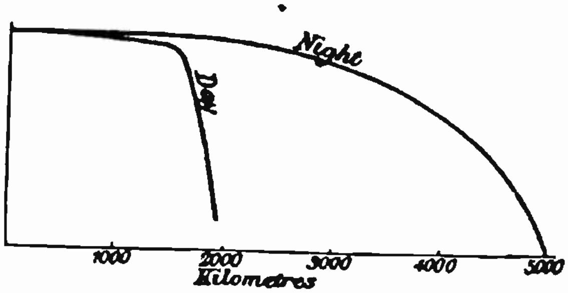



*Fig.* 6.

(*see* "Proc." Roy. Soc., Vol. LXXXVII., A., p. 79, 1912). "On the Diurnal Variations of Electric Waves occurring in Nature and on the Propagation of Electric Waves round the Bend of the Earth," in which a theory is developed of electric wave propagation in ionised air. He gives a mathematical proof that, under certain assumptions as to the mass of these ions, the wave velocity would be increased as compared with that in unionised air, and hence that a plane vertical wave front travelling with lower end near the earth's surface and upper end in air, more or less ionised, would be caused to lean forward by the increased velocity of the upper end. Hence he proves that according to wave-length and circumstances the wave may be better able to follow round the earth's curvature, or may be prevented from doing it. On this basis he has developed a theory of long-distance radiotelegraphy and of the inhibition of daylight upon it.

The chief criticism to which I think this theory is open is that he assumes that the dielectric constant of the air is unaffected by the ionisation or by the condensation of water vapour upon the ions. This is not a safe supposition to make. We know that in the case of solutions in a state of ionisation, such as dilute solutions of metallic hydrates in water, the dielectric constant of the solvent is considerably increased. As a rule, anything which increases conductivity in a dielectric increases also the dielectric coefficient, or at least diminishes in effect the wave velocity. Hence ionisation may do so in the case of air. If the dielectric constant K is increased by ionisation, then in the expression given by Dr. Eccles for the wave velocity, that velocity may be more reduced by this increase in K than it is increased by the presence of the ions.

**Discussion**

CAPT. H. RIALL SANKEY, who followed Dr. Fleming, said his first duty was to apologise for the absence of Mr. Marconi, who had fully intended to be present to take part in the discussion, but at the last moment was called away to the Continent. He had only been able to discuss a few of these matters with Mr. Marconi at the last moment. This absence was really very unfortunate, because many of the questions raised by Prof. Fleming Mr. Marconi could no doubt have answered. The first few questions put by Prof. Fleming were more or less mathematical and theoretical, and he could not say much about them. He would point out, however, that various improvements were being effected, based on experimental results, and that the Marconi Company at the present moment were carrying out a large number of experiments in long-distance transmission under all sorts of conditions in different parts of the world, and in different directions. There was, for instance, a great difference between the case of transmission north and south, and south and north, to what there was east and west. No doubt that might have something to do with the daylight effect referred to by Prof. Fleming, but many of these questions were still very obscure, and the Marconi Company hoped, by these experiments, to have in the immediate future, or, at any rate, shortly, data which would answer many of them. Isolated results were of little use. It was the combination of data such as he had referred to that would really yield the results that were wanted. As regards tuning, variation in the wave-lengths, which was one of the methods of removing interference at stations, was not by any means the only way. There was the tuning by means of the musical note, which Prof. Fleming had referred to. The spark-gap was arranged to give a certain number of train of waves per second. Prof. Fleming had said from 400 to 500 was usual for telegraphy, but the note had been worked up to 1,000, and although it penetrated through atmospherics better than the lower notes, it produced a very disagreeable sensation in the ear of the observer, and for that reason operators did not particularly like that note. The directional aerial also helped to reduce interference, but quite recently a new arrangement had been adopted by means of "balancing" aerials. One was placed at right angles to the other, and in that way interference was reduced, or, in fact, done away with entirely, so that it was possible to have duplex transmission and reception. If there was time Mr. Pletts, who was one of the chief technical engineers of the Marconi Company, would explain the arrangement. There was also another method. Suppose there were three signals being received, and they only wanted to hear one of them, and do away with the other two. There was an arrangement by means of which the two signals they did not want to hear could be opposed in three receivers, and thus annulled. The third signal, which they did want to hear, was reduced in strength, but it could be heard. As regards the probability of replacing the telephone for receiving, within the last few months a photographic arrangement had been devised, which worked admirably; but a few days ago a new arrangement had been devised, which the Marconi Company thought would replace the photographic arrangement. There was a great objection to a mere photographic record, because it simply recorded everything—the signals that were wanted and those which were not wanted. The human ear could distinguish the signals it wanted to hear, and leave out those which were not wanted, very much in the same way that a bandmaster could hear one instrument and leave all the others out; but photographic arrangements recorded everything. This new arrangement, however, would be such that, whilst it recorded everything, it would also give the advantage of a telephone in a sense, and pick out the signals required.

As to the possibilities for producing a suitable signal to avoid the necessity for the receiving operator constantly listening at the telephone, he thought Prof. Fleming meant by that a matter which was discussed at the International Radiotelegraph Conference in London for calling up ships at sea in cases of distress; the question was a little ambiguous. That arrangement had already been devised, and was working satisfactorily, but so far it had not been applied in practice. Dealing with the question of the localisation of the position of the transmitting station, and the determination of its distance, it was rather difficult to say whether the last word had been said on the Bellini-Tosi radiogoniometer, or, in fact, on any matter referring to wireless telegraphy or anything else; but that particular arrangement could now give bearings to within one or two degrees of accuracy, which was quite as good as one could get from a compass, so that, from the practical point of view, he thought one could say that that was the last word. As regards telephony, the Marconi Company had succeeded at Chelmsford up to a distance of 300 kms. The Marconi Company did not think that wireless telephony had by any means reached its practical limits, but, at the same time, they rather thought that practically it would be a long time before it came into use; in fact, he would almost say that the better it was the worse it would be practically, unless they could tune out all other conversation, because everyone would be using it, and there would be so much noise that they would not be able to hear themselves speak.

The last point was about the committee referred to. Undoubtedly such a committee could do excellent work in many of the directions referred to by Prof. Fleming, as, for instance, in the measurement of received signals. He thought it must be borne in mind that there was a great difference between receiving wireless signals and transmitting them. Receiving apparatus was small, and could be established without difficulty, whereas the transmitting apparatus for long distances required special knowledge and skill. From the commercial point of view—*i.e.*, when working day and night, and without undue repetition, wireless telegraphy, up to a range of 1,000 kms., was quite easy, and the apparatus for that purpose was standardised. The real difficulties began when the ranges were above 2,000 kms. The curve in Fig. 6 illustrated this point. During the day signals dropped right off just about a range of 2,000 kms., and that indicated the reason that great difficulties occurred after a range of 2,000 kms. These difficulties were bound up in the questions asked by Dr. Fleming, and hence, unless this committee could command the use of apparatus for long-distance transmission, and practically had unlimited capital, they could not hope to obtain the data to answer the majority of the questions asked by Prof. Fleming. They would have to have the whole world as a laboratory, and work with all sorts of wave-lengths, and then they would find themselves in conflict with the International Convention, which prescribed certain waves, and also find themselves in opposition to all the different wireless stations all over the world. At the same time, data of this kind was now being collected by the Marconi Company, and in the future would be published.

There is no space to report the discussion which followed, and we must therefore hold over the remainder of the report of this interesting meeting until the next issue of The Marconigraph, when we hope to publish some interesting experiments made by Dr. W. H. Eccles and Mr. A. J. Makower, in which spark-gaps immersed in running liquid are used for the production of electrical oscillations.

## Correspondence

**Daylight Effect on Radiotelegraphic Waves**

*(To the Editor.)*

SIR,—After perusing the interesting article on "The Effect of Daylight on Radiotelegraphic Waves," from the pen of Dr. W. H. Eccles in your last number, I take the opportunity, previously neglected, of placing on record that I arranged a series of tests, carefully planned beforehand, to observe the effect, if any, of the solar eclipse of April 17th last on X's at wireless stations. Simultaneous observations were made at the Caister station, at Cullercoats, and at a temporary installation on the outskirts of Birmingham. The observations at Caister were taken by myself, personally, whilst those at Birmingham were taken by a skilled observer (Mr. L. B. Turner, M.A.), and at Cullercoats by the officer-in-charge. Unfortunately I have not got the records by me whilst writing this, but the procedure was to take exact time from the Eiffel Tower time signals and make continuous observations for some time before, during and after the eclipse, noting the precise time and character of each X registered. At Caister, at least, the conditions for making observations (for which the magnetic detector was used in preference to a crystal) were good by reason of the isolated position of the station and its immunity from any effects due to switching on and off electric lights, etc., during the period of semi-obscurity; also for the reason that no secondary disturbances from neighbouring conductors of any magnitude were possible. The results were completely negative. At Caister some few X's of a very faint and unpronounced nature were certainly observed both before, during, and after the eclipse. There were possibly rather more of them during the eclipse, but not sufficient to draw any inferences from. At Birmingham and Cullercoats no X's were recorded on the magnetic detectors. In all three cases the wave-length adjustment of the receiver was of the order of 500-600 metres, the aerials being grounded through the magnetic detectors during the observations.

Too much precaution cannot be taken in tests of this kind to guard against local and secondary disturbances.

Yours, etc., J. E. TAYLOR.

Engineer-in-Chief's Office, G.P.O.,

London, E.C.

---

*(To the Editor.)*

SIR,—I have read the article of Dr. Fleming on "The Effect of Daylight upon Radiotelegraphic Waves" in your issue of August, and was particularly interested in the section headed "Conductivity of the Air," as I have been engaged, together with my brother, for some years in carrying out experiments on the electrical state of the atmosphere by means of kites and balloons, and have deduced from these a value for the specific resistance of air, which does not agree very well with the figure $10^{10}$ ohms per centimetre cube as adopted in the article in question.

In one experiment made by us it was found that the current flowing down a steel kite-wire with the kite at a height of 1,400 feet, when the kite-wire was earthed through a resistance of 1,200 megohms, had about one-third of the value that was measured when the kite-wire was directly earthed. This would point to the fact that the total resistance of the air concerned in this circuit was about 600 megohms.

This figure is confirmed by other measurements, of which the following is typical.

A kite was flying at a height of about 1,000 ft., and it was found that when it was directly earthed through a galvanometer, a current of about 20 micro-amperes flowed down the wire. The kite-wire was then insulated from earth at its base, and connected to a Kelvin electrostatic voltmeter, and the potential measured was 20,000 volts.

Assuming that the potential of the air round the kite in these two measurements to be the same, we get by ohm's law a value of 1,000 megohms for the total resistance of the air in circuit.

The two values of 600 megohms and 1,000 megohms are in sufficient agreement for it to be assumed that the total resistance of the air-circuit is of the order of 1,000 megohms.

The specific resistance of the air may now be calculated with the aid of this figure.

Our kites and balloons all had a collecting area of about 150 sq. ft., and so may be taken roughly as spheres of 100 cm. radius. The total resistance of the air may therefore be approximately calculated by integrating from the surface of a sphere of 100 cm. radius to one of infinite radius, and this figure should be 1,000 megohms.

We thus have, if $\rho$ is the specific resistance of air per centimetre cube, and $r$ the radius of the sphere in centimetres

$$\int_{100}^{\infty} \frac{\rho \, dr}{4\pi r^2} = 1000 \times 10^6$$

This gives approximately $\rho = 10^{13}$ instead of the value, $\rho = 10^{10}$ adopted by Dr. Fleming.

It thus appears that there is still no certainty as to the correct value to be given to the conductivity of air, and any results based upon an assumption of a value for this quantity must be considered doubtful until the question of the conductivity of the air has been more definitely settled. Yours, etc.,

A. J. MAKOWER.

South-Western Polytechnic Institute.

# Wireless Training in Heswall Nautical School

A HOME Office Blue-book gives an interesting account of the work carried on at the Akbar Nautical School, at Heswall, Cheshire. There is, in addition to an excellent wireless equipment, a Marconi portable wireless telegraph apparatus, a lifting kite, and a new wireless mast. Signalling and radiotelegraphy are the *forte* of the school. Day and night watches are kept in the wireless room, and a careful record of all messages received is made. Last year an average of 622 messages—and some of them very long ones—were received weekly. Four boys gained and all school business was conducted by wireless. The portable apparatus worked excellently during the whole time, and was specially commended by Capt. E. G. O. Beuttler, the Captain Superintendent of the School.

There are 235 boys at Heswall, and 25 of these receive instruction in wireless telegraphy. They live in bedrooms apart from the other boys, and receive wireless instruction during the whole of the day. "Watch" is maintained in the instrument room throughout the 24 hours, and a log kept of all messages received, which reach the school from stations so far

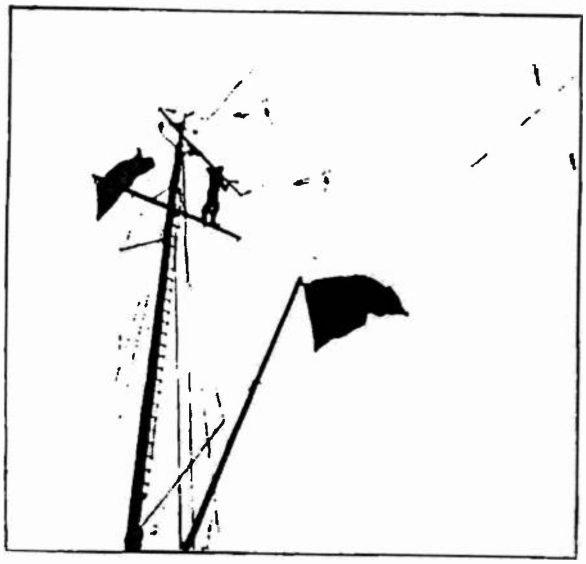
*Heswall Boys with their Portable Marconi Set.*

the Postmaster's certificate of proficiency in radiotelegraphy. The boys complete their course of instruction at the Marconi School in Liverpool.

It may interest our readers to know a little more about the wireless training at the Heswall Nautical School, which has been commented upon so favourably in an official document. The portable station shown in the accompanying illustration is of the Marconi type, and was fitted up in camp by the boys this year. During the fortnight's camp constant communication was maintained with the school, distant as Paris, Germany, Poldhu, and elsewhere.

The tuition received by the boys at Heswall extends over a period of from two to three years, at the end of which time the pupils sit for the Post Office Examination at Seaforth. There are two class rooms fitted up at the school with modern wireless apparatus, and the power for the main set is supplied by an 80-volt dynamo. The addition of a portable wireless set will still further increase the value of the instruction given to the boys, and it has already proved its advantage. During the past summer a sham fight was held between the school and some Liverpool Territorials. The former took out their field guns, also their portable wireless set, and by means of this they were able to communicate the movements of the "enemy" to the school, thus enabling reinforcements to be brought up. The sham fight ended in victory for the Heswall boys, and it is no exaggeration to state that the wireless set contributed largely to this victory.

The wireless instruction at Heswall is given with a highly commendable practical



*One of the Heswall Boys at a Masthead attending to Insulators.*

object, and will result in the addition to the *personnel* of the mercantile marine of a highly useful class. In due course the boys will be qualified to take up positions as wireless operators in small cargo boats, and when not engaged in wireless duties they will be able to assist on the bridge or to carry out clerical duties. The time is perhaps not far distant when the demand for men will become very great, and in fitting the boys for such duties Capt. Beuttler and the officials at Heswall are performing a duty of great national importance.

---

Addressing the members of the Bradford Post Office Telegraph Messengers Institute, Mr. A. B. Walkley, the Assistant Secretary of the General Post Office, who is well known as the famous dramatic critic, pointed out that the Admiralty, in throwing open a certain number of posts for wireless operators in the Navy to boy labour, had provided a means for diverting the stream of boys drifting into blind-alley occupations.

## The Office Window

UNDER the above heading there appears every morning in the *Daily Chronicle* a column of bright and interesting gossip. The proposed Imperial scheme of wireless telegraphy has prompted the writer of those notes to delve into the early history of the telegraph, with the result that there appeared on August 19th some interesting sidelights upon the history of the subject.

* * *

Wireless telegraphy round the Empire was far beyond the dreams of our grandfathers. Lord Cardwell told Sir Mountstuart Grant Duff that, when he was at the Board of Trade, he thought it right to circularise the other offices about the principles on which telegraphic concessions should be given, calling attention, among other things, to the inconvenience that would arise if the right of communicating with Malta were monopolised by a telegraphic company, which should use it as a stage on the road to India. That afternoon Sir Charles Wood met him at the House, and asked him if he had taken leave of his senses. "Why?" asked Cardwell. "Why? Because you sent us that circular—which contemplated the telegraph being extended to India."

* * *

For centuries before Marconi wireless telegraphy has been known, and the mystery of swift communication has puzzled many civilised explorers of barbarian regions. In the heart of Africa a missionary discovered the method of hollowing a large gourd, which was then dried, and round it was stretched the skin of a kid, hard and thin as parchment. Beaten with a padded drumstick this instrument gives a sound which can be heard eight miles away. And each village contains the expert who can tap the message and send it on.

* * *

That is obviously the origin of the Morse code, which is the dot and dash, the flag wag, the flash and dark of the lantern, and all the systems that depend on the intervals of sight and sound. There are probably many people like myself who seldom go into a post office without noting involuntarily the tap on the telegraphic instrument, and reading off by the sound the intimate message of strangers. I have heard many curious communications at the price of a halfpenny stamp.

---

We have received the March-April 1912 Edition of the *Revue de L'Armée Belge*, a bimonthly publication, which contains the first portion of an article dealing with the Marconi portable wireless telegraph stations. A full account is given of the successful demonstrations with Marconi portable apparatus carried out in Belgium during the early part of this year.

## East Coast Defence

IT was decided some time ago that a chain of wireless telegraphic stations should be established along the East Coast, and three of these are already erected and in working order. These are situated at Dover, Ipswich, and Grimsby respectively. It has now been decided to add another to this link that is ultimately to extend to the Orkney Islands, and a site for this has just been secured at Stockton. According to a special correspondent of the *Newcastle Chronicle*, it was at first suggested that this station should be based upon the mouth of the Tyne, but after the experts of the Admiralty and the War Office had carefully considered the matter for some time it was decided that the Tees offered better facilities.

### New Wireless Station

The work of building this station is to be taken in hand almost immediately. Like the stations now in existence, it will be controlled jointly by the Admiralty and the War Office, but the cost of its construction will fall upon the first-named body. The site that has been decided upon extends to some seven acres, and preliminary work upon the preparation of the ground is to be commenced immediately. The plant to be erected will be of the most powerful and latest pattern, and not only will it be possible to maintain from this station constant touch with the whole of the fleets operating in the North Sea, but direct communication with the Admiralty buildings in London. It will likewise be possible to maintain communication with the stations at Dover, Ipswich, and Grimsby, as well as with the next northerly station to be constructed, which will be situated on the Firth of Forth, close to the new naval base at Rosyth.

There is at the present time a departmental committee sitting at the War Office to consider recent developments in wireless telegraphy and its better application to military purposes, but it is not proposed to await the publication of the report of this committee before proceeding with the Stockton station, since it will be quite possible to introduce any modification that may be suggested into the installation as its erection goes forward.

The site selected is admirable from every point of view, and is so completely isolated upon all sides that the presence of unauthorised strangers could be immediately detected and steps for their removal instantly taken.

The Stockton station will be entirely self-contained in every respect, the whole of the electric current necessary will be manufactured on the spot, and the whole of the plant will be in duplicate, in order to prevent any breakdown through an accident to the machinery. The entire station will be lighted by electricity, and this will be supplied from an independent installation to that which supplies the current for the telegraphic work. When the station is completed it will be manned night and day, and will be made use of almost from the first. The staff, in the first place, will be mainly supplied by trained men of the Wireless Company of the Royal Engineers from Aldershot, with additions from the naval ratings as may be necessary. It will not be possible, however, for any ships of the mercantile marine to use this station for the transmission of messages.

### Its Use to Merchantmen

It is realised, however, that many occasions might arise when merchantmen trading in the North Sea and the Baltic might be able to communicate information of the most vital importance, and it is therefore proposed in due course to erect a subsidiary plant, capable of receiving these messages, and this would be available for general use, as well as for communications it was desired to pass on to the naval authorities. This work, however, is not to be taken in hand in the first place, since, first of all, it is desired to press forward the work of linking up the whole of the East Coast by means of these wireless stations for purely defensive purposes. By the addition of general receiving stations, however, some amount of revenue would accrue that would go to the reduction of the cost of their construction and maintenance. In addition to the wireless plant itself, the new station at Stockton will be very completely equipped with ordinary telegraphic machines, including a special wire to London to be used in conjunction with the wireless apparatus when the occasion demands, as well as long-distance telephones, etc.

There is no intention at the present time of placing any armaments in this station, though in the event of a naval war in the North Sea the place would, of course, be very strongly garrisoned. Quarters are to be built, however, for a detachment of the Royal Garrison Artillery, that will be charged with its protection in time of peace, and this garrison will be drawn from the two companies of Royal Garrison Artillery now maintained at Tynemouth. The Tyne detachment of Electrical Engineers will also be trained here, and advantage of this will probably be taken year by year, in order to afford men willing to qualify as wireless operators for service in time of necessity with the necessary facilities for learning.

## Ocean Journalism.

THE first ocean newspaper to be published was a little sheet known as the *Trans-Atlantic Times*, which made its appearance on November 15th, 1899, on board the American liner "St. Paul." On this voyage the "St. Paul" carried Mr. Marconi and two of his engineers, returning from America, where they had been carrying on experiments with wireless telegraphy. The particular object of their visit to America had been to report the yacht races for the Associated Press, and, as success had crowned their efforts, they were looking for new worlds to conquer. It was then that they decided to publish a newspaper on board ship, which they were able to do by obtaining the latest news from the Marconi station at the Needles. From this small beginning the idea gradually grew, until the erection of high-power stations at Poldhu and Cape Cod made possible the constant reception of news from land and a daily issue. The *Trans-Atlantic Times* was therefore the progenitor of the daily wireless newspapers which are so important a feature of many liners on the North and South Atlantic routes, and of which there has since been a further development recently in the appearance of the *Cunard Daily Bulletin* in a revised and considerably improved form. A special correspondent of the *Daily Mirror*, who crossed the Atlantic on the "Caronia," sent to his paper the following account of editing in mid-Atlantic. The correspondent's message was sent from lat. 47 N., long. 22.11 W., and reached the *Mirror* office *via* the "Mauretania."

### Purser Journalist.

"We have just published a sixteen-page daily newspaper in the mid-Atlantic, and we feel very proud of it.

"A Cunard purser is a wonderful man, almost as used to dealing with emergencies as a sea scout, but he cannot set up type. When I am not on the 'Caronia' Purser McCubbin is the editor. Even when I am he wants me to do the work, which is a way really capable editors have.

"The manner in which 'Mac,' as everyone calls him, deals editorially with a difficult problem in international diplomacy or decides how much space a murder in New Orleans is worth would shame most London journalists.

"It was nearly one o'clock this morning when the Marconi operator woke us up and handed us a long message. It had been flashed dot, dash, dash, dot, dash, nearly 1,000 miles over the ocean from a room at the Poldhu wireless station which overlooks beautiful Mullion Cove, on the Cornish coast. A wireless operator had been sitting tapping at a desk, and here a few minutes later was the world's news of the night waiting to be edited in the middle of a prairie of tossing waves.

"'Hallo, Jack Johnson's wife has committed suicide!' said the purser. 'We ought to put that at the top of a column.' So we did.

"'That's a terrible affair in Jersey City,' he went on. 'Countess said to have been murdered by a lawyer. We'd better head the paper with that.'

"Then there was the question of how much space to give to the fact that Christabel Pankhurst has been found in Paris, and the problem of deciding whether there would be war in the Balkans or not.

"The purser settled off these as easily as Napoleon would have done.

### "Printed on 'B' Deck.

"Upstairs in the Marconi house on the upper deck the operator, Leith, was still taking down more news—the price of De Beers in London when the market closed that afternoon, and the late quotations for December cotton in Liverpool.

"Then upstairs we went with our copy to the printing room on 'B' deck. The wet wind made our hair feel like sodden hay.

"'Be careful,' shouted the purser, 'and hold on to that article on the Maine State election; we don't want it blown overboard, or we shan't go to press to-night.'

"In the printing house forward the printer was setting up the news about Jack Johnson's wife from a frame of loose type. Outside in the darkness was the fury of the wind and the soapsud whiteness of ploughed waters.

"On the port side was a single light. Some liner was on her way to Liverpool. Below nearly 2,000 souls were sleeping, and all the time Marconi's wonderful machines were tapping out more news.

"An hour or so later a Harrild crown folio platen press, driven by a one-horse-power motor, was printing the papers, and at nine this morning a newsboy came to my state-room door with a score of copies in his hand.

"'*Cunard Daily Bulletin*, sir; *Cunard Daily Bulletin*, sir,' he said. 'Twopence halfpenny.'

"That was two hours ago. Now Mr. J. S. Patterson, of Memphis, Tennessee, is reading words of comfort about cotton, for he has got a straddle, which means he has sold October cotton and bought December bales, and is looking for the difference in price to widen.

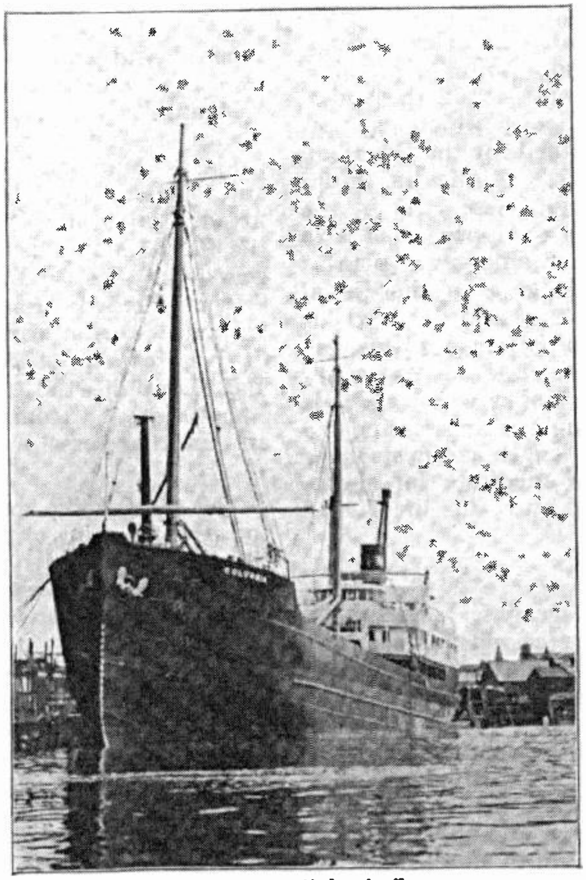
"Judge O'Neill, too, a staunch Democrat from Scranton, Pennsylvania, is discussing the news of the election in Maine with a banker from Montgomery, Alabama.

"Thanks to Marconi our smokeroom is just like a West End club with a tape machine."

# Maritime Wireless Telegraphy

AS an illustration of the use of wireless in such emergencies as labour troubles the following incident is of interest. The Aberdeen liner "Gothic" was due to proceed direct to London during the recent Dock Strike, where its reception might not have been cordial. The aid of wireless was called in, and the "Gothic" landed her passengers at Plymouth, whence they proceeded to London by train. The Union Castle liner "Dover Castle" also landed her passengers at Plymouth, and did not call at Southampton.

An example of the use of wireless telegraphy in regions difficult of access is afforded by the determination to explore the unknown territories of Canada, and for this purpose to erect wireless stations in the far north and west which would be in direct communication with a central bureau at Ottawa. Exploring parties would then report to these stations, and all information of importance be immediately communicated to headquarters. Proposals have been made to erect stations at the following points: Cape Chadleigh, 1,100 miles from Ottawa; Charles Island, 1,170 miles, both on the north of Ungava; at Lake Garryl, 1,700 miles; Borman, on the Mackenzie, 2,300 miles; and Fort Resolution, on the Great Slave Lake, 1,830 miles.



*The S.S. "Columbia".*

The s.s. "Columbia," shown in the accompanying illustration, has been equipped by the Marconi Wireless Telegraph Company of America with a 2-kw., 240 cycle ship set for the Olsen and Mahoney Company.

This month's list of vessels already equipped with wireless apparatus by Marconi's Wireless Telegraph Company is a large one. There are three for the P. & O. Steam Navigation Company—the "Sudan," "Nore," and "Syria," bound for China. Several vessels are destined for America, all passenger boats, the "Bogota" and "Duendes" belonging to the Pacific Steam Navigation Company, and the "Clyde," belonging to the Royal Mail Steam Packet Company; but in this instance only emergency plant has been added to the already existing set. There is, besides, the "Itassuce," now being built for Messrs. Lages at Troon. The Cunard Company have also had their magnificent first-class liner the "Carmania" equipped with wireless, and the Brazilian Government have ordered a 1½-kw. set and emergency plant for the "Guarany," while Messrs. Andrew Weir & Co. have supplemented the existing installation on their cargo steamer "Luceric"—trading between New York and the East—with an emergency set. The Australian Government have had their coasting vessel "West Australia" equipped, as also the Union Castle Mail Steamship Company their luxuriant vessel the "Balmoral Castle," plying between Southampton and South Africa. There are two Indian transports, the "Rewa" and "Rohilla," belonging to the British India Steam Navigation Company, and Messrs. Yeoward Bros. have commissioned the "Ardeola," a passenger vessel visiting the Canaries, to be likewise equipped. All of these vessels, excepting in the case especially mentioned, are provided with a 1½-kw. set and an emergency plant. Of the vessels with equipment yet to be completed, there are destined for American shipping the trader "Huanaco," belonging to the Pacific Steam Navigation Company, and the "Druba," of the Royal Mail Steam Packet Company, whose existing apparatus will be supplemented with emergency plant, while another boat belonging to this line, the "Desna," will be fitted with the full 1½-kw. set and emergency plant. Two Australian vessels will be fitted up—the "Indrapura," of the Australasian United Steam Navigation Company and the Indra Line respectively; and the Far Eastern service is represented by the "Simla" and "Nile," of the P. & O. Steam Navigation Company, the "Drumcree," belonging to Messrs. Chadwick & Sons, and the P. & O. transport ship "Dongola." The Plant Line have commissioned the equipment of the "Evangeline," which is now building at Glasgow, destined for the Canadian route, while the "Dakar," of Messrs. Elder Dempster, is for the Gold Coast. As in the case of the vessels already equipped, each is to be installed with 1½-kw. and emergency plants; the "Agadir" alone, belonging to the Royal Mail Steam Packet Company, and destined for Moroccan trade, is supplied with a 1½-kw. set and emergency plant; this is a set especially designed for use on cargo vessels where space is of importance, and although not possessing the same advantages of wave-length as the stronger equipment, it is entirely adequate for short-distance communication and all life-saving purposes.

The Compagnie de Télégraphie Sans Fil, of Brussels, have recently received instructions for the equipment with Marconi apparatus of a number of important vessels for Continental owners. Among these are three Swedish steamers, belonging to the Rederiaktiebolaget Lulea Ofoten, of Stockholm, with 1½-kw. sets and emergency gear. These ships are now being built—two in Newcastle-on-Tyne and one in Gothenburg. They will be engaged in the iron ore trade, and will sail between Narvik in the north of Norway and Rotterdam, and will occasionally have to cross the Atlantic. The two steamers building at Newcastle will be ready for the end of this year, and the one in building at Gothenburg at the end of January.

The Compagnie de Télégraphie Sans Fil are at present fitting in Spain eight steamers of the Islena Maritima (of Palma de Mallorca, Baleares), four with 1½-kw. sets, the s.s. "Rey Jaime I," "Rey Jaime II," "Miramar," and "Bellver," and four with ½-kw. cargo sets, the s.s. "Luleo," "Cataluna," "Balear," and "Isleno." They are also starting the fitting with ½-kw. sets of four vessels for the La Maritima, Compania Mahonesa de Vapores, Mahon, Baleares—the s.s. "Mahon," "Monte Toro," "Isla de Menorca," and "Menorquin." They will further have to fit with the 1½-kw. set and emergency gear four steamers of the Sociedad de Navegacion é Industria, Barcelona—the s.s. "Hesperides," "Delfin," "Atlante," and "Reina Victoria."

In Holland the same company have orders for fitting seventeen cargo boats of the Stoomvaart Maatschappij Nederland—the s.s. "Krakatau," "Sumatra," "Lombok," "Celebes," "Kangean," "Karimata," "Nias," "Kambangan," "Billiton," "Boeton," "Batjan," "Riouw," "Rotti," "Radja," "Karimoen," and two unnamed, and eleven boats of the Rotterdamsche Lloyd—the s.s. "Medan," "Menado," "Gorontalo," "Bandoeng," "Merauke," "Pontianak," "Samarinda," "Madioen," "Soerakarta," "Ternate," and "Palembang," of which several are already fitted. They have also fitted four boats of the K.W.I.M. with 1½-kw. sets and emergency gear—the s.s. "Prins der Nederlanden," "Prins Fredrik Hendrik," "Oranje Nassau," "Prins Maurits," and will very soon have to fit five steamers of the Koninklijke Paketvaart Maatschappij—the s.s. "Tasman," "Van Lansberghe," "Rumphius," "Melchior Treub," and another vessel not yet named.

The remarkable extension of commerce and the strengthening of the Imperial bond between the Mother Country and the Colonies in the Antipodes is in no small measure due to the genius and enterprise of such shipping lines as the White Star. It was on the great ocean route to the far-off distant islands that the fortunes of the White Star Line were established by the acquisition, about the middle of last century, of a line of Australian clippers which were subsequently succeeded by steam tonnage. The history of this trade has been one of continuous development. The White Star Line have under construction, by Messrs. Harland & Woolf, Ltd., of Belfast, a vessel for their Australian service, via the Cape, which is far in advance of the fine steamers at present trading on the route. The new vessel will be known as the "Ceramic," and her gross tonnage will exceed 18,000—that is to say, she will be half as large again as the present White Star steamers. She will have accommodation for a large number of passengers, and several capacious refrigerating holds for fruit, meats, and other Australian products, as well as a large capacity for general cargo. A Marconi wireless set will form part of the equipment of the "Ceramic."

# The Compulsory Equipment of Ships

## An Example from the United States

THE Wireless Ship Act which came into operation in the United States on July 1st, 1911, seems to have worked very smoothly. A full year had been given to allow ocean passenger steamships to get ready for it. The result was that there was ample time in which to provide the necessary equipment. In addition, there was general willingness to comply with the new law. In his annual report, the Commissioner of Navigation points out that at the present time 488 ocean passenger steamships departing from United States ports are equipped with wireless, compared with 370 such vessels before the Act took effect. The commissioner does not ascribe this increase as being wholly due to the law, but rather to the appreciation by owners of the economies in dispatch, in securing pilots and loading berths possible by the use of wireless. Moreover, the demands of the public travelling by sea on small steamers have impelled owners to equip their vessels with wireless telegraph apparatus. The commissioner proceeds to discuss the general effect of the new Act.

### Mutual Usefulness of Wireless

The efficiency of wireless apparatus, he states, and the skill of operators on shipboard concerns the wireless company which leases the apparatus and furnishes the operator, and also concerns the owner and master of the vessel. To the inquiry, then, whether Government supervision is needed in addition to that prompted by self-interest, the commissioner replies " that it has been deemed necessary as well as humane both here and abroad to provide for Government inspection of the hulls, boilers, machinery, and equipment of vessels, and to examine the qualifications of their officers in the interest of the safety of life of those on board. The same reasons prompt Federal inspection of wireless apparatus." There are other reasons, however. The seaworthiness of a vessel, in the main, concerns only those on board that particular vessel. Sound boilers and adequate pumps protect the lives on board the ship equipped with them. Efficient wireless apparatus and skilled operators not only protect the lives of passengers on board ships where they are employed, but insure prompt aid in peril to those on board of other steamships. The commissioner considers that the mutual usefulness of wireless apparatus in time of danger to two or more steamships or to a shore station affords a special reason for Government inspection. In fact, the general equipment of ocean passenger steamships with wireless apparatus takes its place, and at insignificant cost to the Government, among the several services which Congress maintains with liberal appropriations for the safety of life and property on the water.

In another part of his report the Commissioner of Navigation notes that there have been only three cases in which non-compliance has been alleged, and that these are awaiting the decision of the courts. One case was that of the American mail steamship " Zulia," which cleared from Mayaguez, Porto Rico, for New York, with a crew of 53 men and 31 passengers. The parts of the wireless apparatus were on board, but had not been put together, and there was no operator. The plea of the owners was that they did not suppose that Mayaguez was a port of the United States, and that they intended to put the apparatus in commission at New York. They were asked to give a bond or £1,000, the maximum penalty.

### How the Rules Work

In the case of another American steamship, the " Lexington," the alleged infraction of the law arose in a curious way. At Savannah, a port of call, the wireless operator left the ship for a " trolley trip " of a few hours, and when he returned to the wharf the ship had sailed for Philadephia. His absence was not discovered until the vessel was well down the river. The case, says Mr. Chamberlain, had its effect, as in another instance an American steamship, discovering when the vessel was ten miles out at sea that the operator was not on board, promptly returned to port. The third case is that of the British steamship " Templemore," a cargo boat not equipped for wireless. She, it is alleged, cleared from Baltimore for Liverpool with a crew, nominally, of 75 men. These apparently included four well-known residents of Baltimore, not connected, so it is said, with either the ship or her cargo, who were entered on the ship's articles at a shilling a month. The master was advised that he would carry such men at his own risk, and the question whether there was an infringement of the law remains to be determined. It is stated that in several cases where the crew and passengers numbered 50 or more, and the ship was not equipped for wireless, the excess over 49 were compelled to go ashore and take another vessel.

An interesting section of the report is that in which the qualifications of operators are discussed. In the opinion of the commissioner the simplest and most thorough method of securing the employment of skilled operators is to provide for Government examinations and the issue of Government certificates of skill in radio-communication, similar to the licences issued to the masters, mates and pilots of steamboats. The Berlin Radiotelegraphic Convention of 1906 provides in the service regulations (VI, 3, 4) as follows:

3. The service of the station on shipboard shall be carried on by a telegraph operator holding a certificate issued by the Government to which the vessel is subject. Such certificate shall attest the professional efficiency of the operator as regards:

(a) Adjustment of the apparatus;

(b) Transmission and acoustic reception at the rate of not less than twenty words a minute;

(c) Knowledge of the regulations governing the exchange of wireless telegraph correspondence.

4. The certificate shall furthermore state that the Government has bound the operator to secrecy with regard to the correspondence.

### Operator's Certificates

As more than half of the ocean passenger steamers subject to the Act are under flags other than that of the United States, the Department of Commerce and Labour notified foreign Governments and collectors of customs that wireless operators holding valid certificates issued by foreign Governments which had ratified the Berlin Convention would be recognised as persons skilled in the use of wireless apparatus, unless in specific cases there should be good reason to doubt the operator's skill and reliability. The foreign Governments concerned readily adjusted themselves to this arrangement. Those nations which had not hitherto issued certificates to skilled operators arranged for their own Government examinations—usually by their naval officers—and issued the necessary certificates. France, Italy and Holland, with others, followed this course; Great Britain had already issued such certificates. So far as foreign ships are concerned, this regulation of the department has worked satisfactorily.

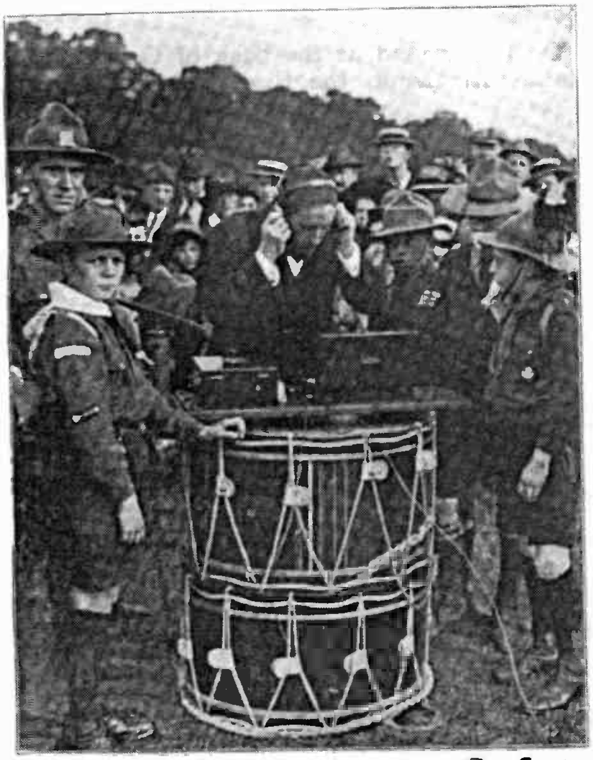
The Berlin requirements were adopted substantially as the test of skill for American operators. The use of apparatus and the employment of operators under the Berlin Convention is voluntary; the Act of June 24th, 1910, made both obligatory under heavy penalty in the case of certain ocean passenger steamers. At the outset, accordingly, it seemed best to require a speed of 15 words American Morse or 12 words Continental Morse in receiving and transmitting messages. By July, 1912, the speed requirement was increased to the Berlin standard. The Continental or International Morse Code is used generally by foreign operators, and is prescribed by the Berlin Convention. It is also prescribed by the wireless regulations of the United States Navy. Experts are disposed to regard messages thus transmitted as less liable to error than by the American Morse Code, which is preferred by American operators generally because it permits of more rapid transmission. The department's regulations, accordingly, permit the examination of operators in either code. In another year it is expected that American ship operators generally will have become proficient in the Continental Morse so as to take or receive messages in that code at the rate of 20 words a minute, five letters to the word.

### Projected Legislation

To try to carry out so far as possible in the United States the purposes of the Berlin Convention, the Department of Commerce and Labour, in conjunction with the Treasury Department, the War Department and the Navy Department, prepared a Bill to regulate radio-communication. This Bill was introduced in the Senate on March 17th, 1910. It was discussed at length before the Senate Committee on Commerce and passed the Senate unanimously on June 16th, 1910. A similar Bill was reported to the House of Representatives on April 1st, 1910, but was held over for the Senate Bill, which did not reach the House in time for action before final adjournment on June 25th, 1910. The Bills were accompanied by reports from committees which set forth the provisions and purpose of the Bill. The Bill provides, in brief, for Federal licences for the operation of wireless apparatus at ship or shore stations and for Federal licences for wireless operators. The President is authorised to establish regulations to prevent interference with messages relating to vessels in distress or of naval or military stations, and severe penalties are imposed for uttering false or fraudulent distress calls and messages. Distress messages and naval and military messages have priority. The general administration of the Bill is intrusted to the Secretary of Commerce and Labour, and the measure itself is carefully drawn within the commerce clause of the Constitution. The commissioner hopes that the Bill may be passed at the coming session of Congress, as six months' notice should be given before enforcement.

# Wireless for Boy Scouts

THERE are few who will gainsay the great social importance of a movement such as the Boy Scouts, and those who have given time, goodwill, and money, deserve the



*Major J. E. Cochrane giving Instruction to Boy Scouts*

thanks of the community for their timely aid, because the movement should, if coming events cast their shadows before, result in a complete change for the better of social and—it must follow—economic ideas, especially from the standpoint of the masses.

Scouts and scout masters are well in front of their watchword. They have let no opportunity for the betterment of their service go by, and a good instance of their determination to make the most of opportunities is their attitude towards wireless telegraphy. They have realised its advantages for their scouts, and are well aware that this means of signalling will supersede the laborious and uncertain semaphore and other methods of eye signalling.

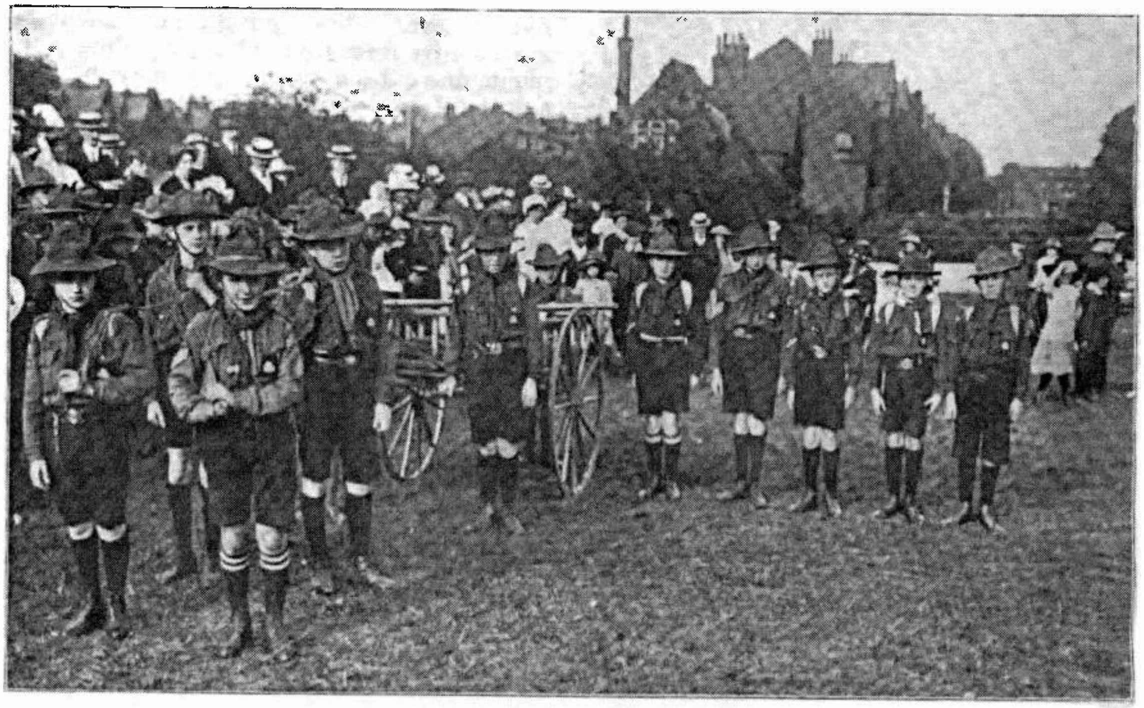
Captain Walter Masterman and Mr. Godfrey C. Isaacs, managing director of Marconi's Wireless Telegraph Co., Ltd., have conjointly presented a complete portable knapsack station to the British Boy Scouts Organisation. This station was designed particularly for employment by scouts, for it is extremely portable and easy of manipulation. The distance over which the apparatus will work ranges from five to seven miles, and the instrument cases are so arranged that when once the adjustments have been made they may be closed, and the station worked without difficulty, whatever climatic conditions may prevail. As regards its portability, the station can be divided either into four loads of approximately 20 lbs. each, or eight loads of 11 lbs. each, and the units of which it is composed are so shaped that they can be conveniently carried in any ordinary haversack or valise.

The introduction of practical wireless to the Boy Scouts was made recently on Tooting Common, when the proceedings were watched by a large number of spectators. About one hundred and fifty Boy Scouts were present, and Major J. E. Cochrane, of the Marconi staff, gave them a practical demonstration of the working of the instruments. First, the transmission and receiving stations were erected some considerable distance from each other, and the boys were shown how to fix the aerials, lay the earth sheets, and test the appliances.

*Scout Offerweld sending messages to another party some distance away*

When all preliminaries were satisfactorily completed, communication was inaugurated between the two stations, and each patrol in turn received a practical lesson in the forwarding and receiving of messages. The boys showed remarkable aptness, considering that this was the first time they had practised with a real set, and they readily appreciated the advantages of such an aid to scouting; for by means of a station like this scouts could in wartime direct gun-fire, and communicate with the main body of the army, while the erection of the station would occupy not more than ten minutes in the hands of experienced lads.

But, great as is the enthusiasm for wireless scouting which has been aroused by the presentation of the set already mentioned, an even greater impetus has been given to the boys to obtain proficiency in the art by the offer of Marconi's Wireless Telegraph Company to present a complete wireless outfit to that troop of Boy Scouts which shall provide the first scout able to pass the examination of a second-class operator.



*The Stockwell Wireless Section of the British Boy Scouts*

---

To ensure efficient and reliable wireless telegraph communication between H.M. ships of war and ships of the British Mercantile Marine when required, periodical practices will take place from October 1st, at 8.30 a.m. and 2.30 p.m. daily, when any single man-of-war or one man-of-war in a fleet in company detailed by the senior naval officer present will make the call CCCC, followed by her own commercial call sign, indicating that she is prepared to carry out an exercise with any British merchant ship within range. On a British merchant ship receiving this call she will answer and say whether she is prepared to proceed with the exercise.

On the ground at the back of Government House, Aldershot, the three Telegraph Companies, with a small detachment from the Balloon Company of the London District R.E., have encamped for their annual summer training. The companies are practically at full strength, nearly four hundred being under canvas, and, with one or two exceptions, all for the full term of fifteen days. Major H. E. Leaf, A.M.Inst.C.E., is Camp Commandant, with Capt. H. Lee-Wright as adjutant. Capt. S. W. Humphrey, A.M.Inst.E.E., is with the Wireless Company in command, Capt. M. McC. Bidder is in charge of the Air-Line Company, and Major J. J. F. O'Shaughnessy, M.Inst.E.E., is in command of the Cable Company.

## Movements of Engineers

H. B. T. Childs is temporarily attached to the Canadian Marconi Co., superintending the erection of steel masts at Louisburgh, Cape Breton.

R. R. Cooke has completed his foreign service leave, after superintending the erection of Marconi stations in India for the Indian Telegraph Department, and is now attached to the Head Office Engineering Staff in connection with the Imperial chain of wireless stations.

S. T. Dockray, C. H. Keith, and R. H. Strickland have arrived at Valparaiso to commence the construction of two 200 H.P. and several smaller stations for the Chilian Government.

P. Eisler has completed the inspection of the Marconi stations in the Canary Islands, and has returned to the head office of the Compania Nacional de Telegrafia sin Hilos, in Madrid.

C. James is at Accra, West Africa, superintending the construction of a wireless telegraph station for the Crown Agents for the Colonies.

S. F. Kos, having completed his leave after foreign service, superintending the erection of wireless telegraph stations at Balik Papan and Tarakan for the Bataffsche Petroleum Maatschappy, has taken up duty in the Head Office.

J. J. Leary, having completed reconstruction of Poldhu station, is inspecting the balance of material for shipment to Chili in connection with the company's contract with the Chilian Government for two large and several small stations, of which work he will be in charge.

J. D. White has taken over charge of Poldhu station in place of Mr. Leary.

E. S. D. Marden has returned from Teneriffe, and is now on leave.

H. McCullough and S. L. Dashwood have completed their foreign service leave after work in India, and are temporarily attached to the Poldhu station.

R. K. Rice has returned from Colombo, after completing the erection of a 5-kw. station at that place, and is now temporarily attached to the Head Office Engineering Staff.

H. J. Round has returned from foreign service leave, after completing the work of inspecting and overhauling the 140 H.P. stations built by the company in Brazil in 1908 for the Madeira-Mamore Railway Co., and has now gone to Coltano, Italy, on special work.

A. G. Savill has completed overhauling Varna station, and is now at Rome making the final test of the new Rome station with Poldhu.

R. N. Vyvyan has returned from Norway, having selected the sites for the Norwegian Transatlantic stations, and has resumed duty as superintending engineer for the Imperial Scheme of Wireless Telegraph Stations.

D. Paton has been selected for duty in Chili, and will probably take charge of the Government school at Valparaiso.

## Movements of Operators

F. J. Lovatt, from the Liverpool School to the "Cestrian."

G. N. McCormack, from the "Munster" to the "Connaught."

W. Raw, from the "Burutu" to the "Empress of Britain."

J. O'Sullivan, from the Liverpool School to the "Empress of Britain."

W. H. Lithgow, from the Liverpool School to the "Hermione."

A. F. Jamieson, from the "Ortega" to the "Haverford."

J. D. Lovelock, from the Liverpool School to the "Haverford."

H. J. Lightfoot, from the "Antony" to the "Manco."

F. N. Calver, from the "Oropesa" to the "Antony."

E. Erbach, from the Liverpool School to the "Arabic."

J. Ralphs, from the Liverpool School to the "Bohemian."

V. F. Evans, from the "Arabic" to the "Burutu."

J. G. Crawford, from the "Bohemian" to the "Canada."

H. W. Rice, from the "Canada" to the "Cestrian."

S. W. Brown, from the "Gloucestershire" to the "Deseado."

F. James, from the "Farquah" to the "Duendes."

R. V. McCreath, from the "La Marguerite" to the "Hubert."

T. Evans, from the "Persic" to the "Arabic."

L. A. Hancock, from the "Armenian" to the "Tunisian."

T. Evans, from the "Arabic" to the "Canopic."

M. A. Preston, from the "Canopic" to the "Arabic."

H. O. Wilson, from the "Ortega" to the "California" (P.S.N.).

H. Munroe, from the "California" (P.S.N.) to the "Ortega."

H. C. Sequeira, from the "Empress Queen" to the "Armenian."

P. O'Keefe, from the Liverpool School to the "Baltic."

J. G. Wasley, from the "Winifredian" to the "Campania."

W. C. Obey, from the "Campania" to the "Carpathia."

G. Arrowsmith, from the Liverpool School to the "Mauretania."

R. W. Renshaw, from the Liverpool School to the "Merion."

S. C. Howes, from the "Carpathia" to the "Munster."

T. G. Threlkeld, from the "Merion" to the "Oropesa."

F. W. Garwood, from the "Ambrose" to the "Persic."

F. R. V. Vick, from the Liverpool School to the "Cameronia."

A. Matthews, from the Liverpool School to the "Athenia."

D. H. Sinclair, from the London School to the "Ausonia."

A. S. Rawlings, from the "Commonwealth" to the "Nile."

G. K. Barber, from the "Sardinian" to the "Agadir."

L. W. G. Alford, from the "Vauban" to the "Agadir."

R. F. Osborn, from the "Californian" to the "Themistocles."

Wm. Crabb, from the "Montrose" to the "Tainier."

J. R. Bamford, from the "Tunisian" to the "Guarany."

C. C. Goulding, from the "Galician" to the "Marmora."

W. Groves, from the "Zealandic" to the "Otway."

P. B. Martin, from the "Scotian" to the "Mount Temple."

H. J. Gallagher, from the "Success" to the "Persia."

H. T. Sayer, from the "Minneapolis" to the "Galway Castle."

G. Balding, from the "Galway Castle" to the "Galician."

G. Walters, from the "Maloja" to the "Moldavia."

C. H. Whitaker, from the "Vauban" to the "Sicilian."

A. E. Bright, from the "Majestic" to the "Volturna."

W. A. Needs, from the "Galeka" to the "Dover Castle."

C. S. C. Nixon, from the London School to the "Dongola."

W. W. Ward, from the London School to the "Danube."

R. J. Thompson, from the "Sicilian" to the "Wilcannia."

V. W. Ball, from the "Dover Castle" to the "Corinthian."

R. V. Patrick, from the "Briton" to the "Kenilworth Castle."

H. A. Whitmore, from the "Araguaya" to the "Amazon."

S. D. Sloggett, from the "Asturias" to the "Araguaya."

T. G. Petersen, from the "Arlanza" to the "Aragon."

C. T. Sanders, from the "Amazon" to the "Arlanza."

E. H. King, from the London School to the "Araguaya."

F. J. Henderson, from the "Rotorua" to the "Syria."

W. J. Hicks, from the "Saturnia" to the "Intaba."

A. C. Williams, from the "Otway" to the "Intaba."

## Marconi Athletic Club, London.

The opening match of the football season took place at the club's ground, Acton Town, on Saturday, September 14th, when Cadogan were the visiting team, and an exciting game resulted in a win for the home club. In the initial half the play was very fast and interesting, only one goal being scored, and it was obtained by the homesters. After the change of ends, Sharpley, the Marconi centre forward, scored a fine goal, running through the defence in great style. The third goal was obtained from a free kick. Just before the final whistle went the visitors scored their only goal, and a very enjoyable game ended with a win of 3—1 in favour of the home club.

Matches have been arranged with Shakespeare Athletic and Ealing Y.M.C.A. for A. Team, and West End F.C. and Rathleigh for B. Team during September. On October 5th a concert will be held at the George Hotel, Strand, in connection with the football section of the Athletic Club.

## Marconi Athletic and Cycling Club, Chelmsford.

Since last month's notes appeared the local athletic event of the season has been held, with somewhat indifferent results so far as the athletes of Marconi's are concerned.

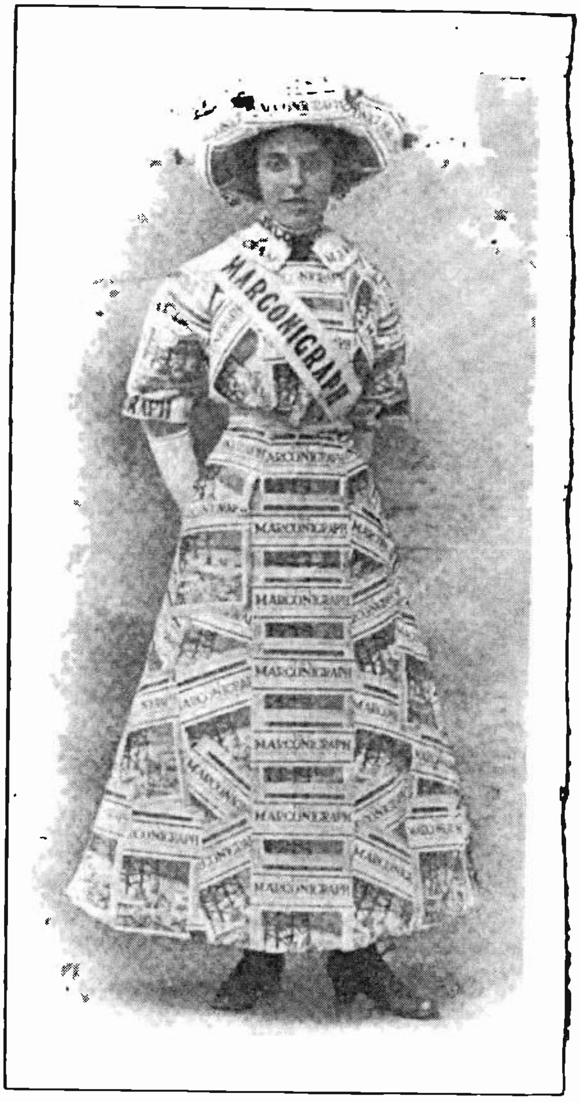
The Chelmsford United Works Sports were held on the Wood Street ground, on August 31st, with Mr. C. Mitchell (Marconi's) as president. The competing firms were: Arc Works, Christy's, Hoffmann's, Marconi's, and the National Steam Car Co. Some very good racing was witnessed, the times, particularly in the sprints, being quite fast. The most notable performance of the day was that by E. H. Barnes (Arc Works), who won the Quarter Mile Flat Championship, the Half-Mile Flat Handicap, and the One Mile Flat Handicap, both the latter being from scratch.

In the totals for the day, Hoffmann's competitors were placed 18 times; Arc Works, 17; Marconi's, 7; National Steam Car Co., 4; and Christy's, 1. Mr. T. Wenden was the most successful competitor for Marconi's; he obtained seconds in the 100 Yards Handicap, the 120 Yards Hurdle Handicap, and the 220 Yards Flat Handicap. In each case he was beaten by inches only.

The principal cause of the comparatively poor show of the Marconi Club was lack of training, due to extreme pressure at the works. Had the athletes been as fit as those of other clubs it is confidently expected that a much better result would have been recorded in this report.

At the Fancy Dress Carnival in the evening the Marconi Club fared much better, as Miss Ward, costumed in MARCONIGRAPH covers, obtained firsts in both the Fancy Dress for Ladies and Decorated Cycles for Ladies. Mr. D. King also took a first for Decorated Cycles for Gentlemen as a wireless telegraph station. In addition to the above, the club gained one first and three seconds in other classes.

September 7th saw the opening of the football season. The first team visited the Arc Works ground in quest of North Essex League points, and obtained a mild revenge for the beating received at the athletic meeting, in this case taking the two points with a comfortable win of four goals to nil. The second team were victorious in their first match, beating the Army Service Corps by two goals to nil.




*Miss J. E. Ward who obtained Two First Prizes.*

On September 14th the first team visited Heybridge, and, to the astonishment of the town, soundly trounced the home team by five goals to one, thus obtaining a further brace of North Essex League points. The second team made a highly creditable draw with Baddow Albion. The club is looking forward to the visit of the Marconi House Club.