"Note on a Magnetic Detector of Electric Waves, which can be employed as a Receiver for Space Telegraphy." By G. MARCONI, M.I.E.E. Communicated by Dr. J. A. FLEMING, F.R.S. Received June 10,—Read June 12, 1902.

The present note bears upon the special manner in which a core or rod of iron or steel placed in a varying magnetic field is affected by high-frequency oscillations transmitted from considerable distances.

The magnetisation and demagnetisation of steel needles by the effect of electrical oscillations has long been known, and has been noted especially by Professor J. Henry, Abria, Lord Rayleigh, and others. Mr. E. Rutherford also has described a magnetic detector of electric waves, based on the partial demagnetisation of a small core composed of fine steel needles, previously magnetised to saturation, and placed in a solenoid of fine copper wire connected to exposed plates. By means of a magnetometer Mr. Rutherford succeeded in tracing the effects of his electrical radiator up to a distance of ¾ mile across Cambridge.*

The detector which I am about to describe is, in my opinion, based upon the decrease of magnetic hysteresis which takes place in iron when, under certain conditions, it is exposed to the effect of high-frequency or Hertzian waves.

As employed by me up to the present, it has been constructed in the following manner:—On a core or rod consisting of thin iron wires are wound one or two layers of thin insulated copper wire. Over this winding, insulating material is placed, and over this again, another longer winding of thin copper wire contained in a narrow bobbin.

The ends of the winding nearest the iron core are connected to the plates or wires of the resonator, or as is the usual practice in long-distance space telegraphy, to earth and to an elevated conductor; or they may be connected to the secondary of a suitable receiving transformer or intensifying coil, such as are now employed for syntonic wireless telegraphy. The ends of the other winding are connected to the terminals of a telephone or other suitable receiving instrument. Near the ends of the core, or in close proximity to it, is placed a magnet, preferably a horse-shoe magnet, which, by a clockwork arrangement, is so moved or revolved as to cause a slow and constant change, or successive reversals, in the magnetisation of the iron core. I have noticed that if electrical oscillations of suitable period be sent from a transmitter according to the now well-known methods, rapid changes are effected in the magnetisation of the iron wires, and these

* See 'Phil. Trans.,' A, vol. 189 (1897), pp. 1—24.

changes necessarily cause induced currents in the windings, which induced currents in their turn reproduce on the telephone with great clearness and distinctness the telegraphic signals which may be sent from the transmitting station.

Should the magnet be taken away, or its movement stopped, the receiver ceases to be perceptibly affected by the electric waves, even when these are generated at very short distances from the radiator.

This detector has been successfully employed for some time in the reception of wireless telegraphic messages between St. Catherine's Point, Isle of Wight, and the North Haven, Poole, over a distance of 30 miles, and also between Poldhu, in Cornwall, and the North Haven, over a distance of 152 miles, of which 109 are over sea and 43 over high land. It has also been ascertained that signals can be obtained over these distances with the new detector when employing less power at the transmitting station than is necessary if a reliable coherer be substituted for the magnetic detector. I have had occasion to notice, however, that the signals audible in the telephone are weakest when the poles of the rotating magnet have just passed the core and are increasing their distance from it, whilst they are strongest when the magnet poles are approaching the core.

Very good results have also been obtained by keeping the magnet fixed, and using an endless iron rope or core of thin wires revolving on pulleys (worked by a clockwork arrangement), which cause it to travel through the copper wire windings, in proximity to a horse-shoe magnet, or, preferably, two horse-shoe magnets with their poles close to the windings, and with their poles of the same sign adjacent. In this case the copper wire windings are separated from the iron by means of a stiff, thin pipe of insulating material in order to prevent chafing of the wires. With this arrangement the signals appear to be quite uniform in strength.

There appears to be a certain magnetic force which gives best results, but different qualities of iron require different values. There would also appear to be a particular speed of revolution for the magnets employed which is more suitable than any other. I have obtained good results when causing the magnets to revolve at the rate of one revolution every 2 seconds, or, when using a moving core, by causing it to travel at a speed of about 30 cm. in 4 seconds.

Either iron or steel can be used for the cores or revolving rope, but I have observed that by far the best effects are obtained when using hard-drawn iron wires or iron wire that has been considerably stretched or twisted beyond its limits of elasticity prior to its employment.

I have used cores generally consisting of about thirty hard-drawn iron wires of approximately 0·5 mm. in diameter, with a winding on them made up of a single layer of silk-covered copper wire 0·019 cm. in diameter and of a total length of 2·4 metres. The other winding, connected to the telephone, has consisted of similar wire, and I have been in the habit of employing a sufficient number of turns of it to give a resistance about equal to that of the telephone used.

It would, no doubt, be possible to obtain the signals by causing the iron core to act directly on a telephone diaphragm, and in this case the secondary winding on the core could be omitted. The length of the electric waves used in the experiments between St. Catherine's Point and North Haven was about 200 metres. If longer waves are employed, it is desirable that the length of the winding nearest the iron should be increased.

This detector, as I have already stated, appears to be more sensitive and reliable than a coherer, nor does it require any of the adjustments or precautions which are necessary for the good working of the latter.

Further advantages in its use become apparent when it is employed in connection with my syntonic system of space telegraphy. According to this system, electrical syntony between the transmitter and receiver is dependent on the proper electrical resonance of the various circuits of transformers used in the receivers. With certain coherers one difficulty has been that it was not always possible to restore them by mechanical tapping to the same electrical resistance which they possessed before being affected by the transmitted electric waves, the result being that the secondaries of the receiving transformers were at certain times open and at other times closed by a variable resistance, thus causing an appreciable variation in their natural period of electrical oscillation.

The magnetic detector which I have described possesses, on the other hand, a practically uniform and constant resistance much lower than that of a coherer in its sensitive condition, and, as it will work with a much lower E.M.F., the secondaries of the tuning transformers can be made to possess much less inductance, their period of oscillation being regulated by a condenser in circuit with them, which condenser may be much larger (in consequence of the smaller inductance of the circuit) than those used for the same period of oscillation in a coherer circuit, with the result that the receiving circuits can be tuned much more accurately to a particular radiator of fairly persistent electric waves.

The considerations which led me to the construction of the above-described detector are the following:—It is a well-known fact that after any change has taken place in the magnetic force acting on a piece of iron, some time elapses before the corresponding change in the magnetic state of the iron is complete. If the applied magnetic force be either subjected to a gradual increase followed by an equally gradual diminution, or caused to effect a cyclic variation, the corresponding induced magnetic variation in the iron will lag behind the changes in the applied force. To this tendency to lag behind, Professor Ewing has given the name of Magnetic Hysteresis.

It has been shown also by Gerosa, Finzi, and others that the effect of alternating currents or high-frequency electrical oscillations acting upon iron is to reduce considerably the effects of magnetic hysteresis, causing the metal to respond much more readily to any influence which tends to alter its magnetic condition. The effect of electrical oscillations probably is to bring about a momentary release of the molecules of iron from the constraint (or viscosity) in which they are ordinarily held, diminishing their retentiveness, and consequently decreasing the lag in the magnetic variation taking place in the iron.

I therefore anticipated that the group of electrical waves emitted by each spark of a Hertzian radiator would, if caused to act upon a piece of iron which is being subjected at the same time to a slowly varying magnetic force, produce sudden variations in its magnetic hysteresis, which variations would produce others of a sudden or jerky nature in its magnetic condition. In other words, the magnetisation of the iron, instead of slowly following the variations of the magnetic force applied, would at each spark of the transmitter suddenly diminish its magnetic lag caused by hysteresis.

These jerks in the magnetic condition of the iron would, I thought, cause induced currents in a coil of wire of strength sufficient to allow the signals transmitted to be detected intelligibly on a telephone, or perhaps even read on a galvanometer.

The tests to which I have referred above confirm my belief that the magnetic detector can be substituted for the coherer for the purposes of long-distance space telegraphy.

"A Note on the Effect of Daylight upon the Propagation of Electromagnetic Impulses over Long Distances." By G. MARCONI, M.I.E.E. Communicated by Dr. J. A. FLEMING, F.R.S. Received June 10,—Read June 12, 1902.

During some long-distance space telegraphy tests carried out towards the end of February last between a transmitting station situated at Poldhu, on the coast of Cornwall, and a receiving station on board the U.S. s.s. "Philadelphia" travelling from Southampton to New York, I had the opportunity of noticing for the first time in my experience, considerable differences in the distances at which it was possible to detect the received oscillations during daylight, as compared with the distances at which the effects could be obtained at night.

Before describing the results obtained, it may be useful if I give a