and varying from point to point. This periodic distribution in time and space constitutes an electric wave proceeding out­wards in all directions from the sending antenna. If we con­sider the lines of magnetic force in the neighbourhood of the receiving antenna wire we shall see that they move across it, and thus create in it an electromotive force which acts upon the coherer or other sensitive device associated with it.

*Marconi’s System of Wireless Telegraphy.—*Marconi’s system of electric wave telegraphy consists therefore in setting up at the transmitting station the devices just described for sending out groups of damped electric waves of the above kind in long or short trains corresponding to the *dash* or *dot* signals of the Morse alphabet. These trains are produced by pressing the key in the primary circuit of the induction coil for *a* longer or shorter time and generating a long or short series of oscillatory electric sparks between the spark balls with a corresponding creation of trains of electric waves. At the receiving station he connected, as stated, one end of the sensitive tube to earth and the other to the antenna, and improved and applied a device of Popoff for automatically tapping the tube after each electric impact had rendered it conductive. He caused the relay in series with the sensitive tube to set in action not only a telegraphic instrument but also the electromagnetic tapper, which was arranged so as to administer light blows on the under side of the sensitive tube when the latter passed into the conductive con­dition. The effect was to print a *dash or dot* on a strip of telegraphic paper, according as the incident electric wave train lasted a longer or shorter time. In addition he added certain spark-generating coils across the contacts of the relay and tapper. He thus pro­duced in 1896 for the first time an operative apparatus of electric wave telegraphy. Its simplicity and compactness recommended it immediately for communication between ship and shore and for intermarine communication generally. Marconi’s earliest experi­ments with this apparatus were made in Italy. In 1896 he came to England and gave demonstrations to the British postal telegraph department and other officials. Some of these experiments were made on Salisbury Plain and others in the Bristol Channel between Lavernock and Flat Holm and Bream Down in 1897. Early in 1898 permanent stations were established between Alum Bay and Bournemouth, a distance of 14½ m., where successful results were obtained. Later the Bournemouth station was removed to Poole Harbour, and the Alum Bay station to Niton in the Isle of Wight, the distance being thus increased to 30 m. In December 1898 communication was established by the Marconi method be­tween the East Goodwin lightship and the South Foreland light­house; and this installation was maintained for upwards of a year, during which it was the means of saving both life and property. In March 1899 communication was effected by his system between England (South Foreland lighthouse) and France (Wimereux, near Boulogne), a distance of 30 m. He kept up the communication for six months, in all weathers, and found that ordinary commercial messages could be transmitted at the rate of 15 to 20 words a minute. In January 1901 he established communication by his system between the Lizard in Cornwall and Niton in the Isle of Wight, a distance of 200 m. A full account of the development of his system was given by him in an article published in the *Fortnightly Review* for June 1902; see also a paper by him in the *Journ. Inst. Elec. Eng.,* 1899, 28, p. 273. About this time he intro­duced various improvements into the receiving apparatus. Instead of inserting the sensitive tube between the receiving antenna and the earth, he inserted the primary coil of a peculiar form of oscilla­tion transformer and connected the terminals of the tube to the secondary circuit of the transformer. Lodge had previously sug­gested the use of transformed oscillations for acting on the coherer (see *British Patent Spec.,* No. 11575 of 1897), but it is not every form of oscillation transformer which is suitable for this purpose.

Marconi’s successes and the demonstrations he had given of the thoroughly practical character of this system of electric wave telegraphy stimulated other inventors to enter the same field of labour, whilst theorists began to study carefully the nature of the physical operations involved. It was seen that the effect of the impact of the incident electric waves upon the vertical receiving wire was to create in it electrical oscillations, or in other words, high frequency alternating electric currents, such that whilst the potential variations were a maximum at the top or insulated end of the antenna the current at that point was zero and at the base the potential variation was zero and the current amplitude a maxi­mum. Hence devices for detecting the oscillations in the antenna are merely very sensitive forms of ammeter and voltmeter. It was also recognized that what is required at the transmitting end is the establishment of powerful electric oscillations in the sending antenna, which create and radiate their energy in the form of electric waves having their magnetic force component parallel to the earth's surface and their electric component perpendicular to it.

*Transmitting Apparatus.—*We now consider the more recent appliances for electric wave telegraphy under the two divisions of transmitting and receiving apparatus. First as regards the transmitting part, one essential element is the *antenna, aerial,* or *air wire,* which may take a variety of forms. It may consist of a single plain or stranded copper wire upheld at the top by an insulator from a mast, chimney or building. The wire may have at the upper end a plate called a “ capacity area,” electrically equivalent to an extension of the wire, or part of the wire may be bent over and carried horizontally. In many cases multiple antennae are used consisting of many wires arranged in cone or umbrella-rib fashion, or a metal roof or metallic chimney may be employed (see fig. 39). In any case the antenna serves as one surface of a condenser, the other surface of which is the earth. This condenser is charged elec­trically and then suddenly discharged and violent electrical oscillations are set up in it, that is to say, electricity rushes to and fro between the antenna and the earth. This creates rapid variations in electric and magnetic force round the antenna and detaches energy from it in the form of an electric wave. The antenna has at one moment a static electrical charge dis­tributed upon it, and lines of electric force stretch from it to the surrounding earth. At the next instant it is the seat of an electric current and is surrounded by closed lines of magnetic force. These static and kinetic conditions succeed each other rapidly, and the result is to detach or throw off from the antenna semi-loops of electric force, which move outwards in all direc­tions and are accompanied by expanding circular lines of magnetic force. The whole process is exactly analogous to the operation by which a violin string or organ pipe creates an air or sound wave. The violin string is first drawn on one side. This strain corresponds to the electrical charging of the antenna. The string is then suddenly released. This corresponds to the electrical discharge of the antenna, and the subsequent string vibrations to the electrical vibrations. These communicate their energy to the surrounding air, and this energy is conveyed away in the form of air waves.

There are three ways in which the antenna may be charged:—

(i) It may be separated from the earth by a pair of spark balls which are connected respectively to the terminals of an induction coil or transformer, or other high tension generator. If these spark balls are set at the right distance, then when the potential difference accumulates the antenna will be charged and at some stage suddenly discharged by the discharge leaping across the spark gap. This was Marconi's original method, and the plan is still used under the name of the direct method of excitation or the plain antenna.

(ii) The antenna may have oscillations excited in it inductively. F. Braun suggested in 1898 that the oscillatory discharge of a Leyden jar should be sent through the primary coil of a transformer and the secondary coil should be interposed between the antenna and an earth connexion.@@1 Marconi@@2 imparted practical utility to this idea by tuning the two circuits together, and the arrangement now employed is as follows:— A suitable condenser C, or battery of Leyden jars, has one coating connected to one spark ball and the other through a coil of one turn with the other spark ball of a discharger S. These spark balls are connected either to the secondary circuit of an induction coil I, or to that of an alternating current transformer having a secondary voltage of 20,000 to. 100,000 volts. Over the coil of one turn is wound a secondary circuit of 5 or 10 turns, of which one end is connected to the earth through a variable inductance and the other end to an antenna or radiating wire A (see fig. 40). These two circuits are so adjusted that the *closed* oscillation circuit, consisting of the condenser, primary coil

@@@1 See *German Patent* of F. Braun, No. 111578 of 1898, or *British Specification,* No. 1862 of 1899.

@@@’ See *British Pat. Spec.,* G. Marconi, No. 7777 of 1900.