The success so far achieved in isolating electric wave telegraphic stations has been based upon the principles of electric resonance and the fact that electric oscillations can be set up in a circuit having capacity and considerable inductance by feeble electro­motive impulses, provided they are of exactly the natural frequency of the said circuit. We may illustrate the matter as follows: A heavy pendulum possesses inertia and the property of being displaced from a position of rest but tending to return to it. These mechanical qualities correspond to inductance and capacity in electric circuits. Such a pendulum can be set in vigorous vibration even by feeble puffs of air directed against it, provided these arc administered exactly in time with the natural period of vibration of the pendulum.

Although inventors had more or less clearly grasped these prin­ciples they were first embodied in practice in 1900 by G. Marconi in an operative system of syntonic wireless telegraphy. His trans­mitter consists of a nearly closed oscillating circuit comprising a condenser or battery of Leyden jars, a spark gap, and the primary coil of an oscillation transformer consisting of one turn of thick wire wound on a wooden frame. Over this primary is wound a secondary circuit of five to ten turns which has one end connected to the earth through a variable inductance coil and the other end to an antenna. These two circuits are syntonized so that the closed or condenser circuit and the open or antenna circuit are adjusted to have, when separate, the same natural electrical time of vibration. The re­ceiving arrangement consists of an antenna which is connected to earth through the primary coil of an oscillation transformer and a variable inductance. The secondary circuit of this transformer is cut in the middle and has a condenser inserted in it, and its ends are connected to the sensitive metallic filings tube or coherer as shown in fig. 50. This receiver therefore, like the transmitter,

consists of an open and a closed electric oscillation circuit induc­tively connected together; also the two circuits of the receiver must be syntonized or tuned both to each other and to those of the transmitter.@@1 When this is done we have a syntonic system which is not easily affected by electric waves of other than the right period or approximating thereto. Marconi exhibited in October 1900 this apparatus in action, and showed that two or more receivers of different tunes could be connected to the same antenna and made to respond separately and simultaneously to the action of separate but tuned transmitters.

A. Slaby in Berlin shortly afterwards made a similar exhibition of syntonic electric wave telegraphy.@@2 O. Lodge had previously described in 1897 a syntonic system of electric wave telegraphy, but it had not been publicly seen in operation prior to the exhibi­tions of Marconi and Slaby.@@3 Lodge was, however, fully aware that it was necessary for syntonic telegraphy to provide a radiator capable of emitting sustained trains of waves. His proposed radiator and absorber consisted of two wing-shaped plates of copper, the transmitter plates being interrupted in the centre by a spark gap, and the receiver plates by an inductance coil from the ends of which connexions were made to a coherer. At a later date a syntonic system comprising, as above stated, an antenna directly coupled to a resonant closed circuit was put into operation by Lodge and Muirhead, and much the same methods have been followed in the system known as the *Telefunken* system employed in Germany.

A method of syntonic telegraphy proposed by A. Blondel (*Comptes rendus,* 1900, 130, p. 1383) consisted in creating a syntony not between the frequency of the oscillations in the sender and receiver circuits but between the groups of oscillations constituting the

wave trains; but, although other patentees have suggested the same plan, the author is not aware that any success has attended its use in practice. The only other suggested solution of the problem of isolation in connexion with wireless telegraph stations was given by Anders Bull *(Electrician,* 1901, 46, p. 573). Very briefly stated, his method consists in sending out a group of wave trains at certain irregular but assigned intervals of time to constitute the simplest signal equivalent to a dot in the Morse code, and a sequence of such trains, say three following one another, to consti­tute the dash on the Morse code. The apparatus is exceedingly complicated and can only be understood by reference to very detailed diagrams. (See *Principles of Electric Wave Telegraphy,* by J. A. Fleming, 1906, sect. 13, chap. viii.) By means of the Anders Kull apparatus several messages can be sent out simultaneously from different transmitters and received independently and simul­taneously upon corresponding receivers, while no ordinary non- syntonic or other receiver is able either to obscure the messages being sent to the Anders Bull receivers or to interpret those that may be picked up. Although complicated the apparatus seems to work fairly well.

*Practical Electric Wave Telegraphy.—*At this stage it may be convenient to outline the progress of electric wave telegraphy since 1899. Marconi’s success in bridging the English Channel at Easter in 1899 with electric waves and establishing practical wireless telegraphy between ships and the shore by this means drew public attention to the value of the new means of com­munication. Many investigators were thus attracted into this field of research and invention. In Germany A. Slaby and F. Braun were the most active. Slaby paid considerable attention to the study of the phenomena connected with the production of the oscillations in the antenna. He showed that in a simple Marconi antenna the variations of potential are a maximum at the insulated top and a minimum at the base, whilst the current amplitudes are a maximum at the top earthed end and zero at the top end. He therefore saw that it was a mistake to insert a potential-affected detector such as a coherer in between the base of the antenna and the earth because it was then subject to very small variations of potential between its ends. He overcame the difficulty by erecting a vertical earthed receiving antenna like a lightning rod and attached a lateral extension to it at a yard or two above the earthed end. To the outer end of this lateral wire a condenser was attached and the coherer inserted between the condenser and the earth. The oscillations set up in the vertical antenna excited sym­pathetic ones in the lateral circuit provided this was of the proper length; and the coherer was acted upon by the maximum potential variations possible. Passing over numerous inter­mediate stages of development we find that in 1898 Professor F. Braun showed that oscillations suitable for the purposes of electric wave creation in wireless telegraphy could be set up in a circuit consisting of a Leyden jar or jars, a spark gap and an inductive circuit, and communicated to an antenna either by inductive or direct coupling *(Brit. Pat. Spec.,* No. 1862 of 1899). When the methods for effecting this had been worked out practically it finally led to the inventions of Slaby, Braun and others being united into a system called the Telefunken system, which, as regards the transmitter, consisted in forming a closed oscillation circuit comprising a condenser, spark gap and in­ductance which at one point was attached either directly or through a condenser to the earth or to an equivalent balancing capacity, and at some other point to a suitably tuned antenna. The receiving arrangements comprised also an open or antenna circuit connected directly with a closed condenser-inductance circuit, but in place of the spark gap in the transmitter an electrolytic receiver was inserted, having in connexion with it as indicator a voltaic cell and telephone. In this manner the signals are read by ear. In the same way the arrange­ments finally elaborated by Lodge and Muirhead consisted of a direct coupled antenna and nearly closed condenser circuit, and a similar receiving circuit containing as a detector the steel wheel revolving on oily mercury which actuated a siphon recorder writing signals on paper tape. Arrangements not very different in general principle were put into practice in the United States by Fessenden, de Forest and others.

Hence it will be seen that the difference between various forms of the so-called spark systems of wireless telegraphy is not very

@@@1 See G. Marconi, *Brit. Pat. Spec.,* No. 7777 of 1900; also *Journ. Soc. Arts,* 1901, 49, p. 505.

@@@2 See A. Slaby, *The Electrician,* 1901, 46, p. 475.

@@@3 See O. Lodge, *Brit. Pat. Spec.,* No. 11575 of 1897.