# WIRELESS TELEGRAPHY

THE term "wireless telegraphy" is commonly applied to a system of signaling through space by means of electric waves. In 1864 Clerk Maxwell published his electro-magnetic theory of light, and predicted the existence of electric waves similar to light waves. In 1888 they were discovered experimentally by Heinrich Hertz at the University of Berlin.

When a spark jumps across a gap between two conducting surfaces, such as two metal balls, the electric charge of the two bodies oscillates back and forth and sends off into space ether waves, which travel with the speed of light. They differ from light waves only in being much longer, as they are from half an inch to many feet in length, while light waves are between 15 to 29 millionths of an inch long. These waves can be reflected by metals; refracted by prisms and lenses of wax; polarized by wood; and diffracted, just like light waves. They pass through wood, earth, stone, and such materials, but metals are opaque to them. When emitted from the summit of the aerial wire, or antenna, of a space-telegraphy apparatus, these waves move out in ever enlarging concentric circles, resembling nothing more closely than the effect on the surface of a pond produced by throwing a stone into the water. According to the most exact estimates, they vibrate at the rate of 230,000,000 per second, traveling outward from the emitting source, in all directions, at the rate of 186,400 miles per second.

When such electric waves strike a circuit of wire with the ends nearly touching, or two pieces of metal at the extremities of a gap in a circuit, a spark passes across the gap. A still better apparatus for detecting the presence of electric waves is the coherer, invented in 1897 by Guglielmo Marconi, which has made wireless telegraphy practicable. This is a small glass tube exhausted of air and filled with fine filings of nickel and silver. In the ends are silver plugs which come within about one millimetre of meeting.

The Marconi apparatus, as now used, consists of a wire reaching as high as possible into the air, usually suspended from a mast. This is connected with an induction coil having a spark gap, and when the spark passes the electric waves are sent out in all directions. The receiving apparatus is the coherer already described, in circuit with a battery and an electric bell, sounder, or telephone. When the electric waves from the oscillator reach the coherer it becomes a conductor, the circuit is completed, and the signal is given

There are other methods of electric signaling without wires which may become practically developed. W. H. Preece in England has sent messages several miles by two methods—conduction and induction. In the first the current is sent through the earth itself, and in the second a body charged with electricity induces the opposite charge in a similar body at a distance.

# GENERAL PRINCIPLES OF THE MARCONI SYSTEM

WORKING along the lines of a theory propounded by Prof. Joseph Henry, Hermann von Helmholtz, and several other electrical authorities, Dr. Heinrich Hertz demonstrated by a series of elaborate experiments that the discharge, or "shock," from a Leyden jar, or other form of condenser, is not a merely direct passage of energy from a point of high potential to one of lower potential, but consists rather in a "series of rapidly surging waves, oscillating until equilibrium is established." The same holds true for the effects given off from a momentary current in an electric circuit. In conducting his experiments he made use of the form of oscillator now almost universally employed in wireless telegraphy apparatus—a Ruhmkorff coil giving a very high-tension current in its secondary winding, the two poles of the secondary circuit ending in two highly polished brass balls. These two brass balls, the distance between which is adjustable, are held on the ends of rods holding sliding spheres, D, D. By altering the positions of these spheres, the oscillator may be tuned to the resonator. This resonator is a coil or open circuit, whose two terminals also end in brass knobs. With such a resonator, adjusted to the wave lengths given off by any particular oscillator, and placed within the discovered area of effect, the discharge will be followed by a spark between its knobs. The fact of wave motion was demonstrated by the fact that in some positions, near to the coil, no effect was noticeable, while at others, further from it, a spark was obtained—thus establishing the fact of loops and nodes. That these waves, like those of light, could be reflected, Hertz demonstrated by the use of polished concave metal mirrors, arranging his oscillator and resonator each in front of one of the mirrors. By placing the coil in front of a similar mirror with a prism of pitch at a determined distance, the fact of refraction of the waves was also demonstrated with the resonator, although in this experiment, as in the others, the dimensions of the resonator—which is to say, the total length of wire forming the

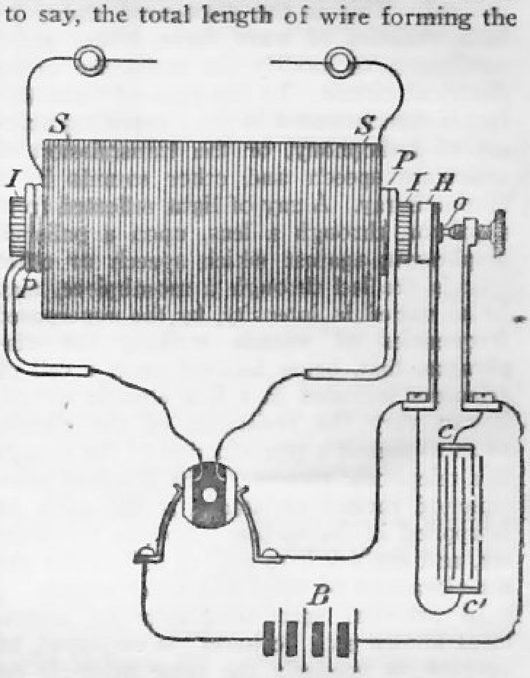


FIG. 1.—Diagram of an induction coil and attachments of the type employed on wireless telegraphy circuits. The parts are the battery (*B*); the iron core (*I*) composed of a bundle of wires; the primary winding (*PP*) connected to the terminals of the battery through the switch; the secondary winding (*SS*) wound over the primary; the iron hammer of the magnetic vibrater (*H*); the back stop of the vibrater (*O*) that adjusts the amplitude of the vibrations, breaking the primary circuit so many times per second, according to adjustment at *O*, thus enabling an induced alternating current in the secondary winding. The terminals of the secondary are led out to either side of a gap, across which a spark may arch, in length, according to the tension in the secondary. A condenser (*C C'*) is bridged between the leads of the primary circuit, being charged and discharged at each make and break, thus demagnetizing the core and allowing greater frequency of alternation in the secondary.

coil of its open circuit—must be in proportion with the wave lengths of the reflected vibrations, a principle still recognized in the various devices for obtaining syntonic, or tuned, effects between two wireless telegraph stations.

Although the Hertz open-circuit resonator, when attuned to the proper undulatory amplitude, can reveal the presence of a Hertzian wave of its own vibratory frequency—exhibiting the phenomenon found in a high-tension secondary coil, a spark between the terminals—it is not used as a receiving instrument in any system of wireless telegraphy. In receiving the impulses transmitted across a distance without wires, another principle—in which again light and Hertzian waves resemble one another—is utilized. This is the discovered ability of both varieties of wave force, under given conditions, to modify the resistance of an electrical circuit. In the case of light this fact is demonstrated in the interesting process of radiophony, or the transmission of articulate speech and other sounds by a luminous ray. A ray of light reflected from a mirror, through a lens, upon a polished diaphragm, against which speech or other sounds are led through a mouthpiece, may be so varied in intensity, by the superposed frequencies of sounds striking the diaphragm, that, being focused upon a cell of selenium included in a live electric circuit, it can vary the resistance of the circuit, so as to permit a reproduction of the sounds in a telephonic receiver. The involved principle of variant resistance is the same as is applied in the carbon telephone transmitter, and enables it to convey to line the exact vibrations of vocal and other sounds.

In practical space-telegraphy an instrument known as a "coherer" is employed, to operate on precisely the same principle on being affected by Hertzian impulses—namely, to modify the resistance of an electrical circuit. The coherer, as used by Marconi, is a modification of the apparatus called the "Branly tube." It consists of a vacuous glass tube at either end of which enter the conducting wires of the circuit. Each of these wires is joined to a silver plug, and the space between them is loosely filled with nickel filings. In normal condition the resistance to the electrical current offered by this device may be equal to several megohms, but, under the influence of magnetic force, or when exposed to the action of a Hertzian wave, the resistance is instantly lowered, being estimated, perhaps, only in units or tens of ohms. The conductivity thus produced continues after the cessation of the affecting impulse, or until the tube is tapped lightly, which act "decoheres" it. For this reason the decoherer is an essential part of all Hertzian telegraphic apparatus.

In all systems of space-telegraphy to the present time the tall aerial wire, or antenna, is an essential feature. This wire is carried into the air on a pole or mast, the height of this, relatively at least to other parts of the apparatus, having a very definite effect on the distance of the transmission, also on the selective efficiency, as will be presently explained. Of the three prominent systems, the Marconi, the Slaby-Arco, and the Braun, the first two earth the extremity of the secondary circuit extension opposite to the aerial wire. The Braun system avoids this feature, with several resulting advantages, according to published claims.

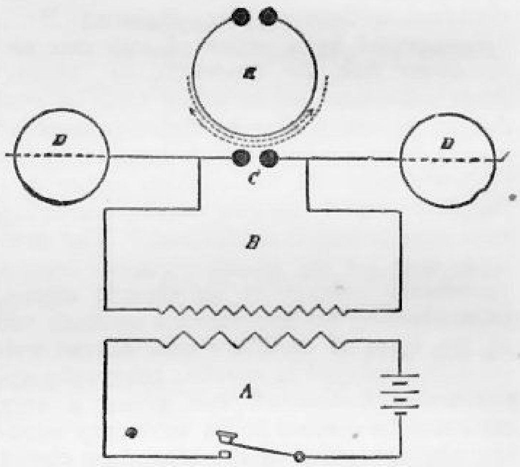


FIG. 2.—Diagram of the Hertz oscillator and resonator as used in wireless telegraphy. *A* is the primary circuit including battery and hand key; *B*, the secondary circuit, including the spark gap *C* and the adjusting balls, *D D*. *E* is the resonator. Dotted arrows show the directions of the alternating induced currents.

The general features of a Marconi nonselective space-telegraphing apparatus are shown in Fig. 3. Here, as may be readily seen, the transmitting apparatus is essentially a Hertz oscillator with one extremity, A, of the oscillator circuit extended vertically into the air; the other, B, grounded. The key, C, for closing the primary circuit of the coil, is used to tap out the Morse signals, which are transmitted through space in the form of successive undulations. At the receiving station the coherer, C, is included in series between the aerial, A, and the ground, B. It is also included in the circuit of the battery, D, with the inductive resistances, or reactance coils, E E, connected to its terminals for the purpose of preventing the Hertzian impulses from leaking into the battery circuit. At each moment of coherence the immense resistance of the coherer is broken down and current from battery, D, moving unobstructed, energizes the relay, F, closing the circuit of battery, G. Current from this battery energizes the sounder, H, delivering the Morse messages, also the magnet, K, operating the decoherer, and causing its clapper, L, to lightly tap the coherer tube. Bridged upon this circuit are the non-inductive resistances, M and N, which act to prevent sparking at the sounder and decoherer contacts. Another such coil, P, is similarly run parallel to the relay, F.

The apparatus arrangements thus shown agree in all essential particulars with those used by Marconi to the present time, and, with such variations as can increase the message-carrying power of the vibrations, are adequate to all requirements in short-distance space-telegraphy. Indeed, the most important differences between the Marconi and other systems are found, not in the methods of transmitting and receiving, but in the peculiar devices adopted to attain the end of selective, or syntonic, signaling through space. That this problem is by no means a simple one is evidenced

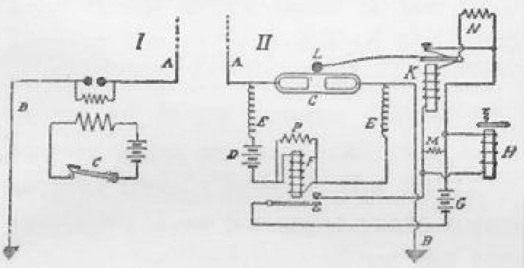

FIG. 3.—Diagram of the transmitting (*I*) and receiving (*II*) stations of a Marconi wireless telegraph circuit. In *I*, *A* is the aërial wire; *B*, the grounded wire; *C*, the Morse telegraph key in primary circuit. In *II*, *A* and *B* same as before; *C*, the coherer; *D*, battery in circuit with coherer; *E E*, inductive resistances; *F*, relay closing circuit of battery, *G*; *H*, the sounder; *K*, magnet of decoherer, *L*; *M*, *N*, *P*, non-inductive resistances to prevent sparking.

by the number of widely divergent methods adopted by experimenters in their efforts to perfect its solution.

To the casual student the most immediate expedient would seem to be found in making the aerial wires of different lengths, using a given length for transmitting signals to a receiving station with the same length, thus securing, so far as musical analogy holds good, a common amplitude and frequency between the two. That this consideration has a very definite bearing on the matter can not be denied, but, taken by itself, it is not sufficient to all requirements. Mr. Marconi explains this fact in the following words: "A dead-beat radiator—*i.e.*, one that does not give a train or succession of electrical oscillations—is not suitable for tuned or syntonic space-telegraphy. . . . A transmitter consisting of a vertical wire

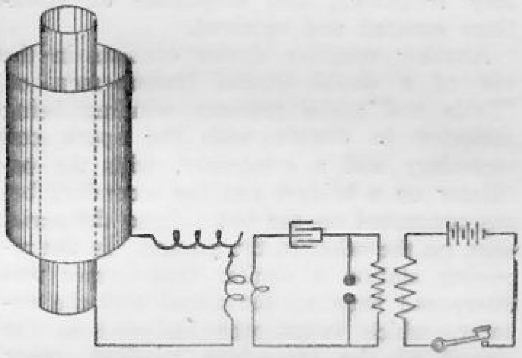

FIG. 4.—Transmitter station of Marconi wireless telegrah, equipped with combined cylinder and transformer apparatus for syntonic selective signaling.

discharging through a spark-gap is not a persistent oscillator. Its electrical capacity is comparatively so small and its capability of radiating waves so great that the oscillations which take place in it must be considerably damped. In this case, receivers or resonators of a considerably different period or pitch will respond and be affected by it."

With the obvious aim of increasing the oscillatory power of the transmitter, Marconi devised the double cylinder arrangement, shown in Fig. 4. Two concentric metal cylinders were used, the inner one connected to earth, the outer to the antenna, with the oscillator circuit bridged between. In explaining the theory of this apparatus, Mr. Marconi says: "One necessary condition of this system is that the inductance of the two conductors should be unequal, it being preferable that the large inductance should be joined to the non-earthed conductor. I assume that in order to radiate the necessary amount of energy, it is essential that there should be difference in phase of the oscillations in the two conductors, as otherwise their mutual effect would be to neutralize that of each other." With the first experimental use of such an apparatus, using cylinders seven meters in height, he states that the "signals were not interfered with or read by other wireless telegraph installations worked by my assistants or by the Admiralty in the immediate vicinity," between St. Catherine's, Isle of Wight, and Poole, a distance of three miles.

Such a system is thus selective, in the sense that it secures exclusiveness. In order to secure complete selectiveness between a large number of stations, so equipped, it would be necessary, of course, to vary the apparatus in regard to its capacity, oscillatory frequency, and amplitude of vibrations emitted and received.

Another selective device consists in the use of a double-wound transformer, or "Tesla coil"; the primary winding being included in circuit with the spark coil secondary and a condenser, with the oscillator on a bridge, and the secondary being connected on the one side to the aerial wire, on the other to the ground. In the receiving station a similar transformer was interposed between the aerial and the coherer, which latter was included in the circuit of the secondary winding, other arrangements being virtually the same as in non-selective receiving apparatus. On the point of adjusting this apparatus, Mr. Marconi says: "The period of oscillation of the vertical conductor can be increased by introducing turns of wire, or decreased by diminishing their number, or by introducing a condenser in series." It is essential, however, that the two electrical circuits of the transmitter should be tuned to the same period, or octave, of electrical oscillations, which is to say, that there should be a predetermined fixed relation between the number of turns in the transformer primary and secondary. The condenser bridged on the coherer circuit has the effect of making the tuning more marked, "by increasing the capacity of the secondary resonating circuit of the transformer." Briefly described, the peculiar resonance of any given selective station is proportionate to the windings, with which, as in the Braun system, the oscillatory intensity may be stepped up or stepped down.

Source:NewAmericanEncyclopediaofSocialandCommercialInformation:1908