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HOW TO CONSTRUCT AN EFFICIENT WIRELESS TELEGRAPH APPARATUS AT A SMALL COST.

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SINCE the practical introduction of wireless telegraphy in 1896, great progress has been made, not only in spanning great distances, but in syntonizing or tuning a certain receiver to respond to a given transmitter.

To follow up the intricacies of wireless telegraphy there can be no better method than to build an apparatus and make the additions from time to time as they are published in the *SCIENTIFIC AMERICAN*. To telegraph a mile or so without wires by what is known as the etheric wave or Hertzian wave system is not difficult; indeed, the apparatus required is but little more complicated than the ordinary Morse telegraph, and is so simple that the reader need have no difficulty in comprehending every detail; if, on the other hand, one wishes to work out the theory involved, it becomes such a difficult task that the master physicists have yet to solve it. It is the practical and not the theoretical side of wireless telegraphy we have to deal with here.

The instrument that sends out the waves through space is termed the transmitter, and this I shall first describe. It consists of an ordinary induction or Ruhmkorff coil (see Fig. 1) giving a half-inch spark between the secondary terminals or brass balls. Such a coil can be purchased from dealers in electrical supplies for about \$6. A larger-sized coil may, of course, be used, and to better advantage, but the cost increases very rapidly as the size of the spark increases; a half-inch spark coil will give very good results for a fourth to half a mile over water, and the writer has transmitted messages a mile over this sized coil.

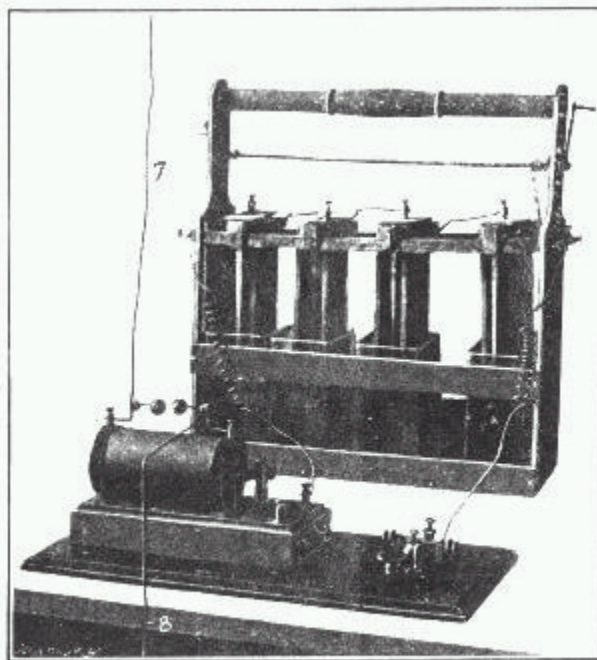
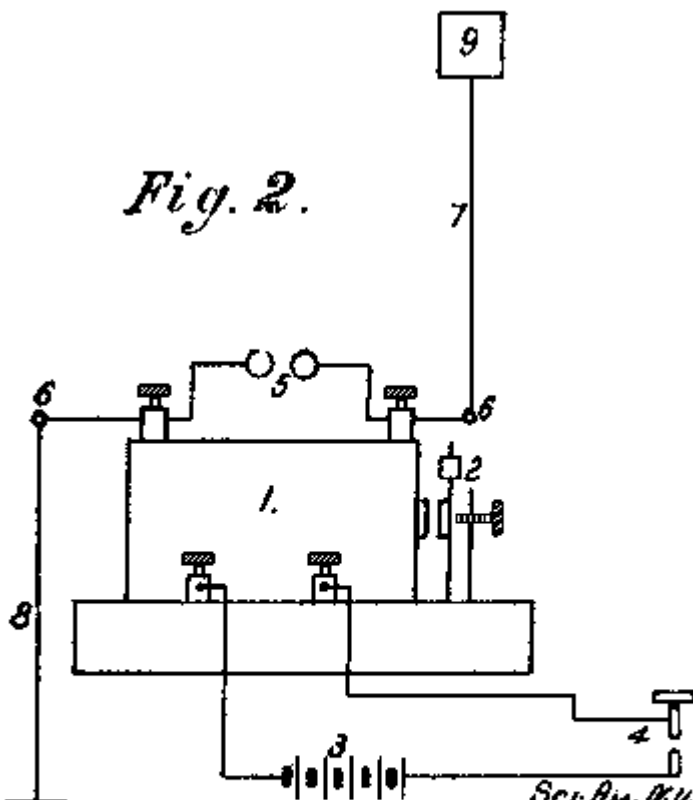


FIG. 1.—CHEAP RUHMKORFF COIL GIVING ½-INCH SPARK.



Having purchased the coil, it will be found necessary to supply the oscillators, as the brass balls are termed, since coils of the smaller size do not include them. The brass balls should be half an inch in diameter and solid; they may be adjusted to the binding posts of the secondary terminals by brass wires, as shown in the diagrammatic view, Fig. 2. It will require two cells of Bunsen battery to operate the coil, or three cells of Grenet or bichromate of potash battery will operate it nicely. An ordinary Morse telegraphic key is connected in series with the battery and induction coil, as shown in the diagram. Now when the key, 4, is pressed down, the circuit will be opened and closed alternately--like an electric bell--by the interrupter, 2, and a miniature flash of lightning breaks through the insulating air-gap between the balls or oscillators, 5, and this spark or disruptive discharge sends out the etheric waves into space in every direction to a very great distance.

The oscillators should be finally adjusted so that not more than an eighth of an inch air-gap separates

them. The reason the distance between them is cut down from a half to an eighth of an inch is because in wireless telegraphy it has been found that a "fat" spark emits waves of greater intensity than a long, attenuated one. The balls are termed oscillators, since, when the electric pressure at the balls becomes great enough to break down the air between them, the electric wave oscillates or vibrates very much as a string of a musical instrument oscillates when struck; in other words, it vibrates back and forth, very strongly at first, growing lesser until it ceases altogether.

The coil and key may be mounted on a base of wood 8 inches wide by 17 inches long and $\frac{3}{4}$ inch thick (Fig. 1). This, with the battery, constitutes the wireless transmitter complete, with the exception of an aerial wire leading upward to a mast 30 or 40 feet high, or the wire may be suspended outside a building. At the upper end of the wire a copper plate 12 inches square should be soldered; this is the radiator, and sends out the waves into space; another wire, 8, leading from the instrument is connected with a second copper plate, 9, buried in the earth. The wires are then connected to the oscillators--one on either side, as shown in Fig. 2, 6,6. The aerial and earth wires may be soldered to a bit of spiral spring, as this forms a good connection and one that can be readily removed if necessary. The transmitter may be set on a table or other stationary place, but for convenience it is well to have the coil and key mounted on a separate base.

To the receiving device there are more parts than to the transmitter, and to simply gaze upon the cut, Fig. 3, it would be almost impossible to obtain a correct idea of the connections. To the layman the most mysterious part of the whole system of wireless telegraphy is the most simple and the easiest understood. I refer to the coherer. Fig. 4 is a diagrammatic view of an experimental coherer, one that is suitable for the set in hand, for it is inexpensive, easy of adjustment and quite sensitive. A coherer, reduced to its simplest parts, consists of two pieces of wire, brass or German silver, 1-16th inch in diameter, forced into a piece of glass tubing, with some silver and nickel filings between the ends of the wire at the point, 7.

The brass standards shown, 1, in Fig. 4, together with the set screws and springs, are merely adjuncts attached to the coherer wires to obtain the proper adjustment and to then retain it. The filings may be made from a nickel five-cent piece and a silver dime, using a coarse file. The amount of filings to be used in the coherer can be roughly estimated by having the bore of the tube 1-16th of an inch in diameter, and after one wire plug has been inserted, pour in enough of the filings to have a length of 1-16th inch. Before describing the function of the coherer, it will be well to illustrate the connection of the relay, tapper, sounder and coherer, and batteries. As shown in Fig. 3

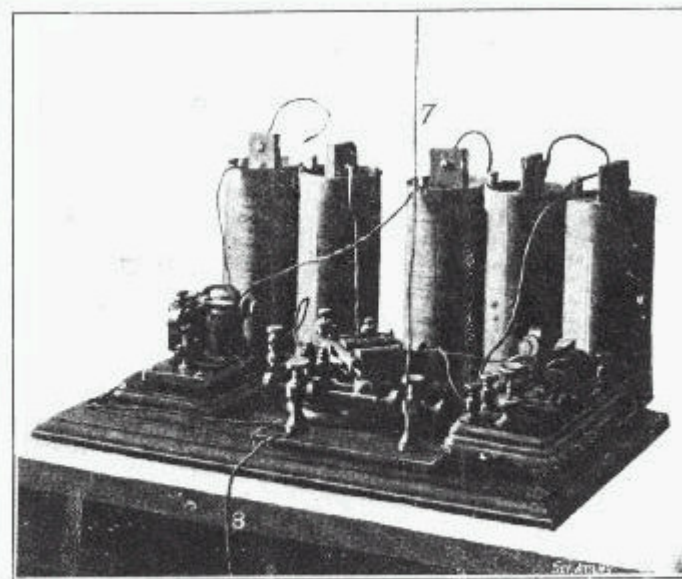


FIG. 3.-SET OF RECEIVING APPARATUS FOR WIRELESS TELEGRAPH.

the tapper--the central instrument back of the coherer--is improvised from an old electric bell, the gong being discarded. The relay, on the right, should be wound to high resistance, about 100 ohms. It is listed as a "pony relay," and, like all other parts of the apparatus except the coherer, it may be purchased of any dealer in electrical supplies. The sounder, on the left, is an ordinary Morse sounder of 4 ohms resistance. The tapper magnets should be wound to 4 ohms. All should now be mounted on a base 10 by 16 inches and connected up as the diagram, Fig. 5, illustrates; that is, the terminals of the coherer are connected in series with two dry cells, 2, and the relay, 3. From the relay a second circuit, also in series, leads to the tapper, 6, thence to a battery of three dry cells, 5, and on to the sounder, 4, and finally back to the relay, 3. This much for the two electric circuits. The puzzling part to the novice in wireless telegraphy lies in the wires, 7 and 8, branching from the coherer. These have nothing to do with the local battery circuits, but lead respectively up a mast equal in height to the one at the transmitting end and down in the ground, as before described. These are likewise provided with copper plates. As shown in the engraving, Fig. 3, the connections are all made directly between the relay, coherer, sender, tapper, and batteries for the very sensible reason that they are connected together with a deal less trouble than by the somewhat neater method of wiring under the baseboard. This, however, is a matter of time, taste and skill.

Fig. 4.

Now let us see what the functions of each of the appliances constituting the receiver are, their relation to each other, and

finally, as a whole, to the transmitter a mile away. To properly adjust the receiver to the transmitter it is well to have both in the same room--though not connected--and then test them out. The relation of the coherer to the relay and battery circuit may be likened to that of a push-button, the bell and its battery. Coherer and push-button normally represent the circuit open. When one pushes the button, the circuit is closed and the bell rings; when the Hertzian waves sent out by the distant transmitting coil reach the coherer, the particles of metal filings cohere--draw closer together--thus closing the circuit, and the relay draws its armature to its magnets, which closes the second circuit, and then the tapper and sounder become operative.

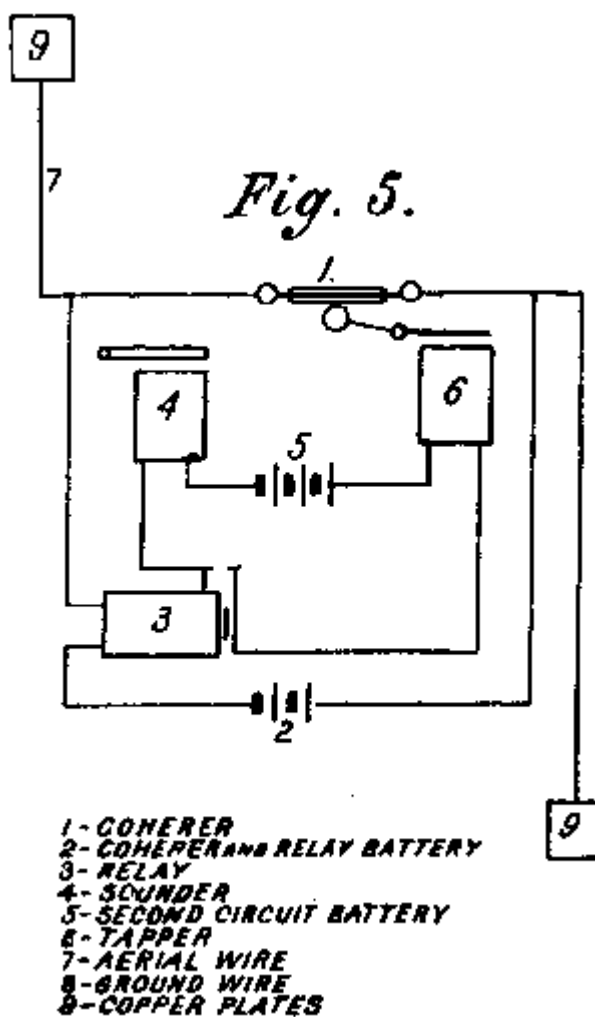
The purpose of the tapper is to decohere the filings after they are affected by the etheric waves each time, otherwise no new waves would manifest themselves. The relay is necessary, since the maximum and minimum conductivity of the coherer, when normal and when subjected to the action of the waves, is not widely divergent, and therefore an appliance far more sensitive than an ordinary telegraphic sounder is needed; this is provided by a relay, which, while being much more sensitive, has the added advantage of operating a delicately-poised lever or armature instead of the heavy one used on the sounder. Signals can be read from the tapper alone, but to produce dots and dashes--the regular Morse code--a sounder is essential.

The adjustment of the coherer and its relation to the relay is not as difficult as the final adjustment of the sounder and tapper, but if the following rules are adhered to carefully, the result will be a successful receiver.

First arrange the adjusting screws of the relay armature so that it will have a free play of only 1-32d of an inch, when the armature is drawn into contact with the second circuit connection, just clearing the polar projections of the magnets; have the tension of the spring so that it will have only "pull" enough to draw back the armature when there is no current flowing through the relay coils. Now connect the two dry cells in series with the coherer, Fig. 5. Unscrew one of the top set-screws, 2, Fig. 4, and then screw up the inner screw, 3, until the current begins to flow through the circuit and pulls the armature of the relay to the magnets. Tap the coherer with a pencil while turning the screw of the coherer to prevent premature cohesion, which is apt to occur by pressure. When absolute balance is secured between the coherer and the relay, connect in the battery of the second circuit, which includes the tapper and the sounder. When the relay armature is drawn into contact, closing the second circuit, both the tapper and the sounder should operate, the former tapping the coherer and the latter sounding the stroke. The adjustment of the sounder requires the most patience, for it is by the most delicate testing alone that the proper tension is obtained. This is done by the screw regulating the spring attached to the sounder lever.

When all has been arranged and the local circuit of the transmitter is closed, the spark passes between the oscillators, waves are sent invisibly through space by the aerial and earth plates, and radiating in every direction, a minor portion must come into contact with the receiving aerial and ground plates, where they are carried by

conducting wires to the coherer, and, under the action of the waves, the filings cohere, the relay circuit is closed, drawing the armature into contact, closing the second circuit when the tapper operates, striking the coherer tube and de-cohering the filings; at the same time the lever of the sounder is pulled down, and, by the law of inertia, it will continue to remain down, if a succession of waves are being sent by the transmitter, assuming the key is being held down, producing a dash, notwithstanding the tapper keeps busily at work decohering in response to the continuously closing circuit caused by the waves; but the sounder--sluggish in its action--when once drawn down, will remain so until the last wave is received and the tapper decoheres for the last time, finally breaking the second circuit for a sufficient length of time to permit the heavy lever to regain its normal position.



All these various actions require a specific time in which to operate, and so the transmitting key must be operated very slowly, each dot and dash being given a sufficient length of time for the passage of a good spark. With the Marconi, Slaby, Guarini and all other systems of wireless telegraphy now in use, only twelve to fifteen words per minute can be sent. It is also well to remember that the higher the wires leading up the mast are, the further the messages will carry. Wireless transmission over water can be carried to about ten times as great a distance as over land.

Wireless telegraphy is very much like photography and everything else worth knowing. To know it well requires care, patience and practice, and the more one keeps everlastingly at it, the greater the results will be.

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