On the Use of Nickel in the Core of the Marconi Magnetic Coherer.

By Arthur L. Foley.

The magnetic detector of electric waves, described and used by Marconi,* consisted of a "core or rod of thin iron wires on which were wound one or two layers of thin insulated copper wire. Over this winding insulating material was placed, and over this again, another longer winding of thin copper wire contained in a narrow bobbin." One terminal of the inside winding was connected to earth, the other to an elevated conductor. The ends of the outside winding were connected to a telephone. A horseshoe magnet, suitably placed, was moved by clockwork so as to cause a continuous change or successive reversals of the magnetism of the iron core. Electric oscillations of suitable period appeared to reduce the effects of magnetic hysteresis, hence the magnetism of the iron core increased or decreased suddenly with each spark of the transmitter, inducing a current in the outer winding connected to the telephone. Marconi had (June, 1902) used this apparatus for some months in the reception of wireless telegraph messages over a distance of 152 miles, and with less power employed at the transmitting station than would have been required had he used a reliable coherer instead of the magnetic detector.

Marconi noticed that "the signals 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." To obtain more definite results on this point I arranged to use a ballistic galvanometer instead of a telephone, and to take readings for various determined positions of the magnet and core.

The core, which was 5 cm. long, consisted of twenty-six pieces of annealed piano wire, .063 cm. in diameter. Over this was wound a single layer of two hundred turns of silk insulated copper wire No. 36, giving a total diameter of core and coil of approximately .4 cm. One end of the coil was connected to a vertical wire 200 cm. long; the other end was put to earth.

*Note on a Magnetic Detector of Electric Waves, by G. Marconi, Proceedings of the Royal Society, Vol. LXX, No. 463, July 29, 1902.

The outer or secondary coil, consisting of one thousand turns of No. 30 wire, was wound on a wooden spool of such dimensions that the coil itself was 1.7 cm. long and .6 cm. in diameter (inside). The terminals of this coil were connected to a Rowland D'Arsonval galvanometer through a key arranged to short-circuit the galvanometer after each throw of the needle. This brought the needle to rest very quickly, and permitted the position of the magnet to be changed without affecting the galvanometer.

The induction coil (one inch) of the transmitter was operated by a storage cell and was adjusted to give a 2 mm. spark between two small brass spheres, one connected to a vertical wire 200 cm. long, the other to earth. The distance between the transmitter and receiver was varied from two meters to twenty meters. The results given in this paper were obtained when the distance was made five meters. No effort was made to "tune" the circuits.

The magnet was made from a bar of steel 1.6 cm. square and 3.7 cm. long, bent so as to make a horseshoe magnet about 16 cm. long with parallel legs 4.8 cm. apart. The primary and secondary coils were fastened in place on a board grooved and graduated so that the magnet could be slid back and forth in the same horizontal plane with, and in a direction at right angles to, the iron core, and placed at any desired distance from it. The graduations extended from 0 to 12 cm., zero distance corresponding to contact between the ends of the magnet and the core.

To get a reading the galvanometer was first short-circuited and the magnet placed in position. The short circuit was then broken, the transmitter operated as long as the deflection of the needle was increasing, and the throw observed.

Table I gives the throws of the galvanometer for the given distances between the magnet and core.

A. When the magnet is placed 10 cm. from the core and moved one space nearer each successive reading.

B. When the magnet is placed in contact with the core and is moved one space farther from it each reading.

C. When the magnet is removed some distance after each reading and the transmitter operated before the magnet is placed in position for another reading.

D. When the magnet is turned over (the field reversed) between readings.

TABLE I.

Distance.	A	B	C	D
0.0 cm	2.0 cm.	....	....	7.6 cm.
0.5 "	2.3 "	0.8 cm.	4.0 cm.	7.9 "
1.0 "	2.0 "	0.9 "	3.2 "	6 1 "
2.0 "	1.3 "	1.0 "	2.0 "	3.5 "
3.0 "	0.4 "	0.9 "	1.2 "	1.6 "
4.0 "	0.3 "	1.0 "	1.0 "	1.1 "
5.0 "	0.2 "	0.6 "	0.5 "	0.8 "
6.0 "	0.1 "	0.4 "	0 3 "	0.6 "
7.0 "	0 0 "	0.3 "	0 2 "	0.4 "
8.0 "	0.0 "	0 2 "	0 2 "	0.3 "
9 0 "	0.0 "	0.2 "	0.1 "	0.25 "
10.0 "	0.0 "	0.1 "	0.1 "	0.2 "

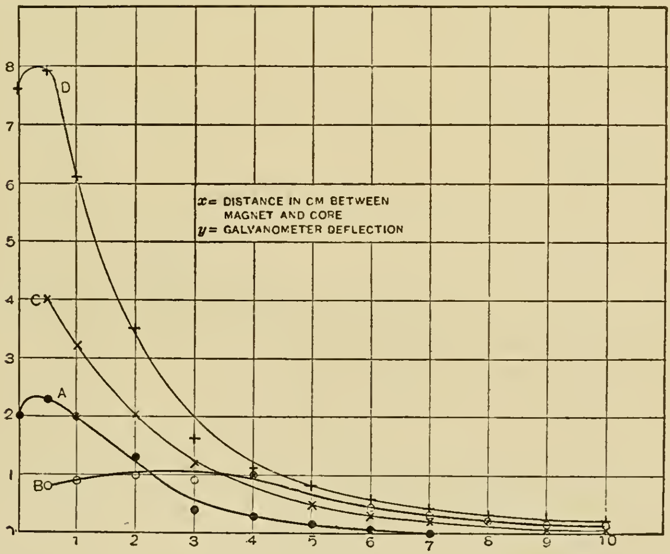

Fig. 1.

The data of Table I are plotted in Fig, 1. A comparison of curves A and B shows that the sensitiveness of the magnetic detector depends upon both the distance and direction of motion of the moving magnet. When the magnet is near the core the detector is more sensitive when the magnet is approaching, but when some distance from the core the detector is more sensitive when the magnet is receding. Both curves indicate a maximum of sensitiveness at a distance from the core, the distance being less when the magnet is approaching than when receding.

Removing the magnet and operating the transmitter tended to demagnetize the core. Then when the magnet was placed in position and the transmitter again operated, as in Curve C, there was a relatively greater change in the magnetism of the core than was obtained under the conditions of Curves A and B. Hence the deflections in column C are greater than those in A or B. It is evident that the relative change in the magnetization of the core would be greater still where the magnetic field is reversed after each reading, as in Curve D.

Since nickel is more susceptible than iron in weak magnetic fields, and less susceptible in strong fields, it occurred to the writer that a more uniform sensibility for varying distances between the moving magnet and core might be obtained by making the core of nickel.

Four cores were made, each one being 5 cm. long, approximately .4 cm. in diameter, and being wound with two hundred turns of No. 36 copper wire.

Core 1 consisted of 26 pieces of piano wire, .063 cm. in diameter.

Core 2 of 10 pieces of piano wire and 10 pieces of nickel wire, .082 cm. in diameter.

Core 3 of 2 pieces of piano wire and 13 pieces of nickel wire.

Core 4 of 14 pieces of nickel wire.

Table II gives the deflections at various distances between the magnet and each of the four cores, the magnet being moved one space at a time and having its poles reversed after each reading. The data for three of the cores is plotted in Fig. 2.

TABLE II.

Distance.	Core 1. Fe.	Core 2. Fe & Ni.	Core 3. Fe & Ni.	Core 4. Ni.
0.0 cm	7.6 cm.	10.2 cm.	7 5 cm.	6.1 cm.
0.5 "	7.9 "	9.5 "	7.5 "	9.0 "
1 0 "	6 1 "	8.0 "	7 2 "	8.9 "
2.0 "	3.5 "	4 6 "	4.0 "	4 7 "
3.0 "	1 6 "	3 0 "	2.0 "	1.35 "
4.0 "	1 1 "	1 7 "	1.0 "	0 7 "
6.0 "	0 6 "	0.5 "	0.4 "	0 35 "
8 0 "	0 3 "	0 2 "	0 2 "	0.2 "
10.0 "	0.2 "	0 1 "	0 1 "	0.1 "

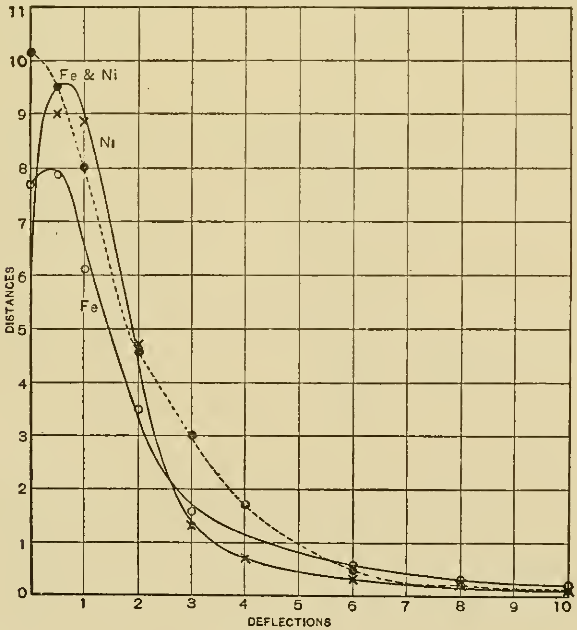

Fig. 2.

The sensitiveness of the detector with a nickel core was not very different from the sensitiveness when an iron core was used. Contrary to expectations, however, the sensitiveness with the nickel core appeared to be the greater in strong fields and with the iron core in weak fields. Both showed a maximum of sensitiveness at a short distance from the magnet, the maximum for nickel being the farther removed. The nickel core proved to be more sensitive than the iron core for distances up to 2.5 cm.

When the detector was worked with the mixed core of iron and nickel wires the deflections of the galvanometer increased as the magnet approached the core, even up to the point of contact. The curve (Fe & Ni, Fig. 2) lies above the Fe curve at all points and above the Ni curve at most points, showing that a mixed core consisting of annealed piano wire and hard-drawn nickel wire produced a more sensitive detector than was obtained by using a core of piano wire only.

The detector gave small deflections of the galvanometer when I used an antimony core; also when I used a core of iron filings contained in a thin-walled glass tube. In both cases deflections were obtained only when the magnet was near the core. A core of bismuth gave no deflection.

It is probable that the form of the curve of Figs. 1 and 2 depends upon other points than those considered in this paper, as for instance, the frequency and intensity of the oscillations sent out by the transmitter and the annealing of the steel wires used in the core.

Since electric oscillations appear to "have the power of reducing the effects of magnetic hysteresis," it has occurred to the writer to test their effect upon the hysteresis loss of transformers, armatures, etc. Some experimental work on this subject has been done, but I am not yet ready to announce results.

Physics Laboratory of Indiana University, April, 1903.