WIRELESS TELEGRAPHY WITH A RELAY-
TELEPHONE RECEIVER.

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THE relay-telephone receiver for wireless telegraphy consists essentially of a dry cell, a high resistance relay, and a telephone receiver. Hence in simplicity it excels most if not all devices which depend upon the use of the ordinary coherer. A study of coherers, their construction and uses, has led to the conclusion that a single-contact coherer, such as that described by Guthe and Trowbridge in "The Theory of the Coherer,"¹ would be the most sensitive to electrical displacements. But the difficulties to be overcome in the practical use of such a coherer are many. It must be automatically decohering, and not require continued adjustment.

A coherer may be used for the detection of electrical waves in two general ways. First, it may be adjusted until the initial resistance is infinite, and yet the particles are close enough together to be cohered by the wave. With a multi-contact coherer this condition is fairly easy to meet, and it is quite possible also with a single-contact coherer, although frequent adjustment is generally necessary, since all depends on one gap at the contact place. If this gap becomes a little too great, the instrument is no longer sensitive. Hence decoherence of a single-contact coherer, however it is accomplished, is liable to change the gap at the contact place and destroy the sensitiveness.

Second, a coherer may be adjusted so that its original resistance is high but finite. In this case a very slight change of the current through the coherer produces large fluctuations of the resistance. When in this condition, the instrument is by far more sensitive to electric waves than when used with the initial resistance infinite. This adjustment is not very difficult to obtain, but it is very difficult

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to decohere without destroying the contact altogether. This is especially true of a single-contact coherer, which is liable to be located in a building more or less subject to jars and vibrations.

While experimenting with single-contact coherers, the secondary circuit of a relay was used, but with rather poor success. This coherer action of a relay contact was observed some years ago, but was not very thoroughly investigated. The practical difficulty with the relay was, as with other coherers, that decoherence was liable to destroy the adjustment, and the platinum contacts did not seem as sensitive to electrical waves as a nickel coherer.

So nickel contacts were substituted for the platinum, and the result was a very sensitive coherer. The contacts were then reversed, so that the relay *open'd* circuit on the down stroke as an electric bell does. Then the relay, a sensitive telephone receiver, and a dry cell, were connected as shown in Fig. 1, the primary of the relay being in series with its secondary and the telephone. Fig. 2 shows the arrangement of the contact of the relay.

Fig. 1.

Fig. 2.

The condenser across the primary terminals of the relay makes the signals received sharper, for it counteracts the E.M.F. of self-induction of the relay, which would of itself cohere the secondary for fine adjustments.

The box relay used had a resistance of 179 ohms, and the telephone receiver had 100 ohms, while the apparent resistance of the contact varied from 350 to 30 ohms.

To adjust this receiver, the contacts were brought very close together, and the spring was tightened until the purring which first occurred in the telephone just ceased. A little practice made this adjustment easy and permanent. The whole receiver, excepting

the vertical wire and the ground connection, could be set up and adjusted in five minutes.

When a wave strikes this receiver there is heard in the telephone a rattle or purring noise, which ceases when the wave ceases. It is strong or faint, according to the distance from the sending apparatus.

It is so sensitive as to be affected by a spark from another relay secondary at a distance of one hundred feet. The sending apparatus used in nearly all of the tests to which this receiver was subjected, consisted of a four-inch induction coil run from a 100-volt A. C. circuit by means of the carbon interrupter described in the February number of this journal. To this coil were connected inductance and capacity in the proportion to get oscillations.

The inductance was made large enough to be well within the limit of the critical relations $R^2 < \frac{4L}{C}$, where R = resistance of spark gap and circuit, L the inductance, and C the capacity of the condenser, including the vertical wire. The period of the waves used as calculated from the approximate formula $T = 2\pi \sqrt{LC}$, was 0.9×10^{-6} seconds. A 35-foot vertical wire was used, and a $\frac{1}{4}$ -inch spark between brass knobs one inch in diameter. One side of the coil was grounded.

A test made at a windmill one mile from the laboratory gave very satisfactory results with nine feet of vertical wire at the receiving end.

The sending and receiving circuits were not in synchrony during any of the tests made.

At a distance of four miles from the laboratory the receiver required thirty-two feet of vertical wire, while at any point within one-half mile, no vertical wire at all was required, but a good ground from one side of the relay secondary to the steam pipes of the building in which the receiver happened to be located was found necessary. Several trials at a distance of less than one-quarter of a mile with a ground on a hydrant or a long rod driven several feet into the earth gave very poor results unless a vertical wire was used. This led to the conclusion that the steam pipes in the buildings where the other tests were made acted as vertical wires, or at least carried oscillations which affected the relay coherer.

It was found unnecessary to ground directly on the steam pipes. One side of the relay secondary was connected to an *open* coil of a few turns of wire, insulated, and a radiator was connected to one end of another open coil surrounding the first. The receiver worked nearly as well as with the direct ground.

An ammeter reading to ten thousandths of an ampère, was put in series with the relay while signals were sent every second. The fluctuations of the needle showed negative coherer action to take place nearly as often as positive. Therefore the primary of the relay was cut out, and the coherer worked rather fainter, but very regularly and consistently, taking any number of signals without being touched. It was thought at first that the primary of the relay was necessary to produce decoherence. But while it does increase the effect and render the instrument more sensitive, it is not by any means a necessity. In other words, the single-contact coherer, if properly adjusted, is automatic, and depends equally upon the positive and negative cohering effects of successive waves. This curious behavior is perhaps made clearer by reference to the two following curves. These were obtained by the method used by Guthe and Trowbridge, with some slight modifications. R_1 is the relay,

Fig. 3.

whose secondary S is in series with a 2-volt cell at B and a resistance box R_2 . The condenser C is connected through the charge and discharge key K to the secondary terminals S and the galvanometer G . The ammeter at A reads to ten thousandths of an ampère, and by using a shunt reads up to 1.50 ampères. The series of observations for these curves extended over a range of current from 0.00005 to 1.50 ampères, but those of the series were chosen which covered the range within which the instrument is used in practice. From these curves we see that between the limits of 250 to 100 ohms a very slight change in current causes a very great change in

resistance. This suggests, but does not explain. A series of experiments are now being conducted in view of determining the relation between these curves, which are a fair sample of many others taken since, and those obtained by Guthe and Trowbridge. The writer has obtained many curves similar to their's but under very different conditions from those under which these curves were taken. It seems that the behavior of a coherer carrying a very small current at low E.M.F. is very different from the behavior of the same coherer *after coherence*, or when carrying larger currents.

Fig. 4.