of the immersed portion of the fine platinum wire. This opinion is shared, both on experimental and theoretical grounds, by M. Dickmann (*Physikalische Zeitschrift*, August 15, 1904). F. K. Vreeland ("The Principles of Wireless Telegraphy," McGraw Co., 1904, pp. 188-191) believes that it is an electrolytic device depending for its action upon polarization.

To determine the precise nature of the action, experiments were carried out by the author in the Research Laboratory of the American De Forest Wireless Telegraph Company. While conducting these experiments the writer was indebted for valuable suggestions to Dr. Lee de Forest, and to Mr. Greenleaf Whittier Pickard. Mr. Pickard has also made a series of experiments, the results of which are in complete accordance with those here described. These experiments show beyond a doubt that the detector is electrolytic in its action, and not a heat operated device. Its operation apparently depends upon the polarization by electrolysis of that portion of the surface of the fine platinum wire which is in contact with the electrolyte. The ability of the device to detect wireless telegraph signals is explained if we assume that the e.m.f. generated in the aerial wire by the received Hertzian waves causes a partial breaking down of the polarization layer enveloping the immersed part of the fine platinum wire, and thus reduces the apparent resistance of the local circuit. The electrolytic polarization theory of action is supported by the following facts, which I have ascertained in the course of my experiments:

1. It is found that the device is *not reversible*; that is, if the fine wire is made the cathode of the cell and the stouter

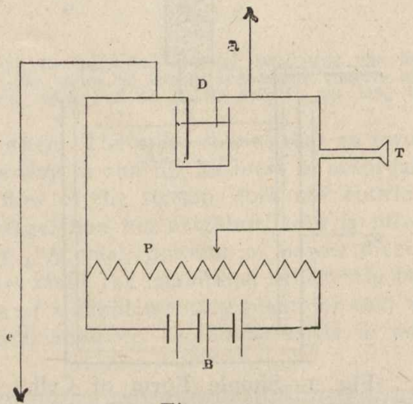

Fig. 2.

platinum wire the anode, the device responds only very faintly to Hertzian wave signals. This fact shows that it cannot be simply a heat-operated device, for if it were the heat generated would depend only upon the rapidly oscillating current flowing through it, and this would be independent of the polarity of the cell.

2. I find that the fine wire forming the anode of the cell must be made of a metal which is chemically inert in the electrolyte. Since the fine wire is the anode of the cell, oxygen is liberated at its surface. It is found that if the metal of the wire is of such a nature that the oxygen liberated at its surface combines with it, the device will not respond, even although the wire be fine enough to respond if it were of platinum. For instance, I found that, using fine wires or filaments of the same diameter, platinum, carbon and aluminum will respond, whereas iron will not. Aluminum probably responds in virtue of the existence of the well-known film of oxide which is formed upon it. These facts seem to show that a film of gas or its equivalent is necessary at the surface of the fine wire to produce the result. If it were a heat effect a slight chemical reaction at the surface would not have any appreciable effect upon the heat produced by the rapidly oscillating current passing between the surface of the fine wire and the surrounding electrolyte.

3. The device, when used in the usual manner with a local battery, has a very high *apparent* resistance, very much greater than that which could be due to its true ohmic resistance. The value of this apparent resistance also depends upon the method of measuring it, having its smallest value when the cell does not have an opportunity to become polarized. It is also found that this apparent resistance depends upon the amount of the e.m.f. in the local circuit, apparently *increasing* very rapidly as the local e.m.f. is *decreased*. It may increase from a few thousand ohms for a local e.m.f. of four volts to several million ohms for a fraction of a volt.

4. I find, after most careful and elaborate experiments, that the sensitiveness of the device to Hertzian waves depends only upon the *area* of the minute platinum surface forming the anode and not upon its *shape*. For instance, it is found that if a one-mil platinum wire is sealed into a capillary glass tube, and the end of the capillary tube is filed off squarely, the cross-section of the one-mil wire which is exposed will form an anode which is quite as sensitive as an anode formed by a fine platinum wire 3/1000 of an inch long and only 38/1,000,000 of an inch in diameter. Although the shape of these two surfaces is entirely different, the area is of the same order, namely, about one-millionth of a square inch.

5. From the behavior of the detector in the field, it appears to be a potential-operated device, and not a current-operated device, as it should be, if its action were due to a heat effect. It is found that this detector will respond very well without any ground connection, which it would not be likely to do if it were a current-operated device.

6. It is found that the detector will respond when the electrolyte in which the fine wire is immersed is actually boiling. This could not happen if its action were due to heat, as is believed by Prof. Fessenden, since the electrolyte being at or near the boiling-point, the heat alleged by him to be developed at the anode by the Hertzian currents would cause a boiling of the liquid at the minute surface of the anode and thus interrupt the action. The apparent increase of resistance of the device when receiving is actually very great, and can be approximately estimated by observing the *change* in the current in the local circuit when the instrument is responding. The apparent change in resistance, of course, depends upon the intensity of the incoming Hertzian waves, and therefore upon the intensity and distance away of the source. Under ordinary circumstances the resistance often drops to one-half or one-third of its original value. If the device were heat-operated such a change as this in the resistance would represent a considerable amount of heat developed at the anode, and if the electrolyte were already at or near its boiling-point, it would certainly cause an evolution of vapor at the anode and a consequent interruption of the action. This, as I have stated, does not occur, even when the electrolyte is boiling violently, if proper precautions are taken in making the experiment. If a fine platinum wire is used, dipping just beneath the surface of the electrolyte, trouble may be experienced owing to the fact that when the liquid is boiling violently, its surface is disturbed, and the point may fail to make contact with the liquid. This difficulty may be overcome by using an anode of a form already described, namely, a one-mil platinum wire sealed into a capillary glass tube, and filed off squarely at the end. It is found that when this is immersed to a slight depth beneath the surface it will respond with perfect regularity, no matter how violently the electrolyte may be boiling.

7. A beautiful proof that it is not a heat device is an experiment that I have performed showing that it will work perfectly even when the electrolyte has a zero temperature coefficient of resistance. For this purpose I used 2½ per cent. solution of hypophosphorous acid. The electrolyte has a zero temperature coefficient of resistance at about 60° C. Below this temperature its resistance coefficient is negative, and above it positive. I observed the response of the device when using this electroylte, from temperature of room (about 30° C.) to its boiling point, in the neighborhood of 100° C. There was no trace of a minimum of response, much less was there a zero point of response, anywhere between these temperatures. I determined the temperature of minimum resistance for this electrolyte by a separate experiment.

8. I will now describe what I regard as the most beautiful and conclusive of all the experiments. It is well known that when two bright platinum surfaces are im-