PRELIMINARY NOTE ON THE ELECTROMAGNETIC INDUCTIVE PROPERTIES OF A CATHODE RAY SOLENOID

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That a cathode ray solenoid should possess electromagnetic inductive properties of a magnitude that can be measured (or rather detected) by a suitably high sensitivity galvanometer has been more or less apparent to one of the writers for a number of years. It was suggested by Rowland's classical experiments on the equivalence of a moving charge to a current of electricity. However, it was not until recently that it was decided to put the experiment to a test. That the electron composing the cathode ray beam is deflected by either an electrostatic or a magnetic field is well known, and, in itself, is evidence enough of its equivalence. If now the cathode ray beam be used to induce a current in a neighboring wire through its purely electromagnetic action, then such an induced current should be regarded as additional evidence of the equivalence of a moving charge to a current of electricity.

The arrangement of the apparatus, Fig. 1, proposed to test this point, is to form within a suitably designed cathode ray discharge tube, by means of a powerful external magnetic field (in which H is of the order 50 gausses), a cathode ray solenoid having the approximate dimensions: length,

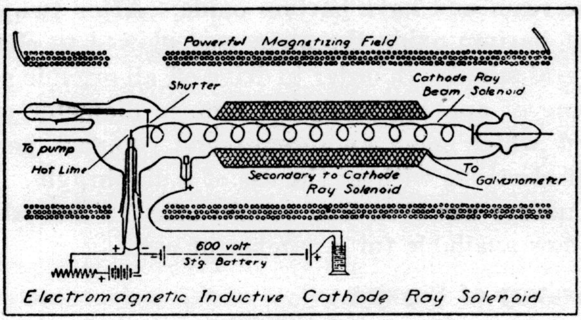

FIGURE 1.

40 cm.; diameter, 2 cm.; and pitch, 1 cm. This solenoidal beam is made to pass through a glass tube, which is an

extension of the discharge tube, and which carries over a considerable portion of its length a secondary of many turns of copper wire. The cathode ray solenoid, i. e., the spiral cathode ray beam within, is thus made the primary of a vacuum cored transformer, the secondary of which is connected to a low resistance high sensitivity galvanometer. The charge caused to circulate through the galvanometer on interrupting the cathode ray beam, or on allowing it to pass, is, to a first approximation,

$$Q = K_2 d = 4\pi \frac{n_1 \; n_2 \; A \; I}{10^9 \; R} \quad . \; . \; . \; . \quad (1)$$

where n_1 is the number of turns per centimeter length of the primary, n_2 the total turns in the secondary, A the mean area of the primary, I the current in amperes flowing through the cathode ray solenoid, and R the total resistance in the secondary. Since the secondary has a comparatively low resistance the damping of the galvanometer will be considerable, and hence its ballistic constant, K, becomes a function of the resistance R. Under these conditions the galvanometer may be calibrated readily and thus the order of the deflection that should result on making or on interrupting the beam, for a given current I, becomes known.

As in experiments of this kind, it is wise to test the set-up before going farther and get some idea of the magnitude of the quantity of electricity induced in the secondary by known values of I made or broken in the primary, i. e., to see whether the effect sought will produce measurable deflections of the galvanometer. To make this preliminary test we placed down through the central tube, where the cathode ray spiral was supposed to go, a copper wire spiral having the same pitch (turns per centimeter) and diameter as the proposed solenoidal cathode ray spiral. Then, on making or breaking the current through this, we read the corresponding induced current in the secondary,—this being proportional to the deflection of the galvanometer. Thus deflections of the galvanometer were obtained for a number of different values of I in the primary. The values are contained in Table I.

TABLE I

I amperes in primary	Galvanometer deflections in mm.	Galv. deflec. in mm. calculated by means of equation (1)
.1	27.5	29.7
.05	13.5	14.85
.035	10.0	10.39
.015	3.8	4.45
.005	1.0	1.48

We see from this table that in order to get a galvanometer deflection of about 27mm. the equivalent current flowing through our cathode ray solenoidal beam must have the value of .1 ampere, while .005 ampere will give a deflection of only 1 mm. Intermediate values of I give intermediate deflections. Obviously, the current must exceed .005 ampere in order to be detected, and to be measured with fair accuracy the current flowing through the beam should be of the order of .05 ampere.

Two methods are available for the interruption of the cathode ray beam. The simplest, from a manipulative standpoint, is to break, at some external point, the high potential direct current supplied to the hot lime cathode. However, the most effective and theoretically correct method is to interrupt the beam by a shutter just before it enters the tube on which the secondary is wound. This shutter is operated from the outside through a ground joint. The general arrangement of the various connections is shown in Fig. 1.

In this preliminary report we may say that the order of magnitude of the cathode ray current that we were able to get in the few trial runs thus far made was about .005 ampere,—thus the effect was just detectable. We expect to increase the current flowing through the electron solenoid at least ten times, by using a larger source of electrons and also by introducing hydrogen into the tube. When this is done no difficulty will be experienced in measuring quantitatively the effect sought.

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