EXPERIMENTS ON MECHANICAL MOMENTUM AND CENTRIFUGAL FORCE OF ELECTRONS.

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In the discovery and measurements of the mass of the electron by Professor J. J. Thomson and others, the deflection and acceleration of the electron by electric and magnetic forces have been used; but if the electron has true material mass, we should expect material inertia, with mechanical momentum and centrifugal force effects. James Clerk Maxwell describes an experiment in which he tried without success to detect a mechanical momentum in an electrical current (Treatise on Electricity and Magnetism, Vol. II, Sec. 574). In 1906 Prof. Ernest Fox Nichols described an experiment which he made to detect an electromotive force from centrifugal acceleration of electrons in a rotating disk. The experiment failed to show results owing to thermal disturbances at the brushes. The experiments described in this paper were begun before 1913-1914. In that year, the writer and Mr. P. L. Bayley carried on experiments to detect a change in an electric current through a rotating disk, and these and other topics formed the subject of Mr. Bayley's Master's thesis. The results were not decisive owing to imperfect and variable contacts with the rotating disk. (Thesis of P. L. Bayley, June, 1914, Univ. of Ill. Library.) A new contact plan was devised by experiments in the next few years, and this was used in 1920-1921 by Mr. C. C. Schmidt in experiments which were made and discussed for his Master's degree. His results were complicated. (Thesis of C. C. Schmidt, June, 1921, Univ. of Ill. Library.) These experiments have been continued with improved apparatus and new devices by the writer with the assistance of Mr. G. T. Lorance and Mr. K. H. Hubbard, graduate students.

We have used two methods of attack: First by testing for the production of a possible impulse current upon suddenly stopping a rapidly rotating coil,—the coil rotating in its own plane about an axis perpendicular to this plane. Several coils were used. The last and most satisfactory coil having an average diameter of 24.68

cm. with 748 turns of No. 22 copper magnet wire. In the arrangement which we have had, the axis is horizontal and perpendicular to the magnetic field of the earth. By using suitable external auxiliary magnetizing coils and a compensating coil in the circuit it was found possible to get rid of all induced currents. The connection with the ends of the coil was made by means of wires which came along the axis of the shaft, one wire from each end of the shaft. At each end of the shaft, a wire is stretched along the extension axis of the shaft, and is kept taught by a flat spring. The wire is connected at its outer end with a small swivel, so that it rotates quite freely with the shaft, even when the shaft is rotating at a high speed. The extended wire passes through a trough of mercury, the wire going through a cork at each end of the trough. The connections thus made were very constant, showing in many cases a change of only five thousandths of an ohm, between rest and full speed, or less than one tenth of one percent of the total resistance of the circuit. The galvanometer used was a four coil astatic mirror galvanometer, made by Coblentz, and sensitive to about 10^{-9} ampere. The galvanometer was shielded by soft iron shields from external magnetic disturbances. Many readings have been taken, but the quantity involved is so small, that we are yet uncertain that there is an impulse current, even when the coil is stopped in a fraction of a second from over 5,000 r. p. m. This part of the method of experiment is therefore yet in progress.

The second method of attack was to determine whether there is any change of electrical resistance in a rotating coil. A coil with a special zig-zag winding was prepared to avoid strains in the wire due to centrifugal forces. It was found that between a speed of 7,000 r. p. m. and rest, the change of resistance of the coil was not more than one hundredth of one per cent. The change in centrifugal acceleration was from about 4×10^7 cm. per sec. per sec. to zero. The original idea was that electrons in the wire might be forced to the outer section of the wire by centrifugal force, and this crowding to the outer section would be equivalent to decreasing the effective cross section and hence might increase the resistance. If such a change of resistance had been found, it would have been good evidence of centrifugal forces on the electrons.

The above results would seem to indicate that in metallic conduction, there is not a free flow of electrons along the wire, but more likely a passage of electrons from atom to atom, as assumed by J. J. Thomson in his second theory of metallic conduction. If this last theory of metallic conduction be true, the possibility of an impulse current at the stopping of a rapidly rotating coil is very doubtful.

A third method of attack depends on detecting a difference of electrical potential between the center and the rim of a rotating disk. According to the theory of centrifugal force acting on the free electrons, the rim of a rapidly rotating metal disk should be negative and the center positive. Nichols thought to detect such difference of potential by means of brushes connected to a sensitive galvanometer. He failed on account of thermal currents. We have constructed a special disk to test for a difference of potential by an electrostatic method. The middle of the disk is insulated from the rim, except for a wire connection. This connecting wire can be cut at the ends by knives, while the disk is running at a high speed. The insulated rim can be tested by an electrostatic multiplying method after the disk comes to rest. The two metal parts of the rotating disk, as it has been designed, are mounted on a hard rubber disk and shielded in a soft iron case, so as to avoid electromagnetic induction.