

[COMMUNICATED AFTER ADJOURNMENT BY PROF. W. M. STINE.]

PROF. W. M. STINE :— Perhaps the most elaborate investigations of the “Edison Effect” have been carried out by Professor J. A. Fleming. In a lecture before the Royal Institution, in 1890,¹ he developed about all the leading facts which he has since elaborated.² His experiments, together with those detailed in the paper under discussion, reveal a large number of facts, interesting alike to the student of physics and the manufacturer and user of the incandescent lamp.

In Professor Anthony's paper before the INSTITUTE in 1894, it was stated that carbon was removed from the filament through the action of convection currents. This was taken exception to at the time, and the evidence from experiments on the “Edison Effect” clearly disprove this assumption. In one of the lamps employed by Professor Fleming, containing a sealed-in aluminium plate, this accidentally vaporized, coating the walls with metallic aluminium, and leaving a well-defined molecular shadow of the filament. It may then be held that in the high vacuum of an incandescent lamp, metals or carbon brought to incandescence truly vaporize, and the molecules leave the surface and travel in straight lines, having a fairly free molecular path. Nor can the driving off of carbon molecules from the filament be regarded as an electrical act; it is rather due to evaporation at high temperature, and can be assisted by electrical repulsion but to a limited extent, since the voltage in lamp filaments is usually very low. This is confirmed by the present paper. Mr. Howell found the “Edison Effect” to be as strong between the filament legs of a 40-volt lamp as one operated at 140 volts, it being assumed that the temperature of incandescence was the same in each case. In a curve given by Professor Fleming, the “Edison Effect” is approximately a linear function of the volts between the lamp terminals. The temperature of the filaments in such a case is itself almost a linear function of the volts. His curve actually bends slightly downwards,³ showing the influence of increased heat losses by radiation. Had the evaporation been influenced by the highest voltage to any appreciable extent, the curve must have bent *upwards*. Again, were the discharge of the molecules due to their static charges, the “Edison effect” would occur in a filament of uniform cross-section about equally over the entire surface. Another noteworthy experiment of Fleming was to seal similar filaments in the end of an egg-shaped tube. These were heated to incandescence by battery currents. A single cell of battery connected to points on the two filaments, which were at equal potentials, was able to send a marked current through the tube. This experiment establishes

1. Reprinted in *Scientific American Supplement*, August 23, 1890.

2. *Phil. Mag.*, July, 1896.

3. *Phil. Mag.*, July, 1896, p. 57.

two facts: that incandescent carbon fills a vacuum tube with a carbon atmosphere of high conducting power, and that this vapor conducts an electrical current much as does a solid conductor.

Perhaps the most singular phenomenon in this connection is the unilateral nature of electrical discharge from an incandescent source. The carbon vapor itself conducts equally well in any direction, but the discharge takes place only from the negative side of the filament. This, again, is another proof that the "Edison Effect" is not a static one, since the entire filament would be covered with a static discharge of the same sign. Guthrie long since showed that an incandescent conductor would discharge negative but not positive electricity. The action of the Crookes tube with cold electrodes is, in the main, of a similar nature. These facts indicate, as Lord Kelvin pointed out some years since, that there is a radical difference in character between positive and negative charges. It is probable that we shall yet find in such facts as these the explanation of the nature of electrical conduction.

A very significant statement is made on page 39 of the present paper, in connection with the sudden appearance of the blue glow in the lamp. The same thing is frequently seen in Röntgen tubes. With a very high vacuum scarcely any current passes. If the tube is heated, the vacuum is lowered gradually until a critical point is reached. At this point a blue glow suddenly appears about the anode, and the resistance of the tube very materially decreases, with an equal suddenness. At this point the atmosphere seems to cease carrying the current by moving electrical charges, and becomes, in a sense, a true conductor.

Another interesting effect is, the larger the conducting plate sealed into the bulb, the greater the flow of current. The subject is one of great practical importance. It clearly points out the value of high exhaustion for lamps. That a lamp containing an atmosphere of a heavy, non-conducting gas, such as bromine, exhibits these effects but feebly, is also significant. High efficiency lamps, even with excellent vacuum, ought not to be pushed to a high filament temperature, or they become to a certain extent short-circuited. This indicates an unfortunate limit to the increase of the efficiency of carbon filaments. It is probable that though the "Edison Effect" may be decreased, it can never be wholly avoided, since a carbon burned in the air will exhibit the effect while it lasts. Lamps containing heavy non-conducting gases in their bulbs, as Professor Anthony has shown, do not blacken to any extent. The present paper shows how small the "Edison Effect" is in them.