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THE MODE OF CONDUCTION IN GASES ILLUSTRATED BY THE BEHAVIOUR OF ELECTRIC VACUUM TUBES.

BY

SIR OLIVER LODGE.

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The Mode of Conduction in Gases illustrated by the Behaviour of Electric Vacuum Valves. By Sir OLIVER LODGE.

ASSISTED by Mr. E. E. Robinson, I have during the past few years made many experiments in connexion with electric vacuum valves, and have arrived at a view or theory concerning their action which may be worth setting down with as much brevity as is consistent with clearness.

The main points to bear in mind are three:—

(1) One is that the current in vacuum-tubes is mostly conveyed unobtrusively by positively charged carriers or atoms, which travel from anode to cathode as best they can,—readily taking a roundabout path if necessary, *i. e.* if any serious obstruction exists in a more direct path.

(2) The second point is quite familiar, and is that from the surface of the cathode a bombardment of negative corpuscles or electrons occurs from every place at adequate tension, and issues everywhere perpendicular to the surface without regard to destination.

At high vacua these projectiles travel with prodigious speed for a considerable distance, and they have the effect of blocking the path by driving back any small bodies such as atoms advancing in an opposite direction.

The negatively-charged projectiles carry only an insignificant proportion of the whole current, though they may assist in propelling uncharged atoms towards the anode, where they can become positive ions.

(3) The third point essential to an explanation is that circulation of material in the tube is necessary, so as to maintain a constant supply of positively charged ions, and to enable them to act as carriers.

This last statement needs expansion :—

However plentifully electrons are supplied to the cathode by the source of current, they do not spontaneously escape from the metal (except under some stimulus such as ultra-violet light provides) unless positively charged ions are in their neighbourhood, *i. e.* unless the tension $2\pi\sigma^2$ rises to a critical value.

In an active vacuum-tube the continual presence of such ions near the cathode depends on their having been able to travel from the anode ; nevertheless they are not atoms of the anode itself, but are gas atoms which have become positively charged by contact with it,—each of them having presumably given up an electron to the metal.

It is at the surface of the anode therefore that the separation of electricities really takes place, under stress of the applied E.M.F. The ions then migrate to the cathode, and extract from it an electron apiece, thereby becoming neutral again.

A constant diffusion of uncharged atoms towards the anode and of positively charged ions away from it is therefore essential to the passage of current. The cathode bombardment roused by the presence of the advancing ions can be so planned or directed as to assist or to oppose the necessary circulation. The projectiles may assist by mechanically propelling uncharged atoms towards the anode, or they may oppose by mechanically driving back charged ions which are trying to advance away from it.

In doing the latter it would seem as if they ought to neutralize opposing charges and thus convey some current ; but the evidence points to the supposition that such flying neutralization is rare,—it either does not occur or is but a small fraction of the whole. The impacts shake, but perhaps do not electrify or discharge, the ions : most of the interchange of electricity seems to go on only at or close to the metal surfaces.

If now a cathode is mounted so as to fire down a narrow tube along which the positive carriers must come, it acts like a park of Maxim guns obstructing a troop of infantry ; and

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