Cavendish employed a Leyden jar for his source of electricity, and measured the resistance of the conductor simply by sending the charge of the jar through the conductor and his own body, and estimating the intensity of the shock; his results, so far as they apply to solutions of salts, were not improved upon until Kohlrausch took up the matter in 1857. Cavendish appears to have understood the theory of divided circuits and practically to have arrived at Ohm's law, though he did not formerly enunciate the law.

The relation between the electro-motive force in a circuit and the current produced by it is expressed by Ohm's law. As ordinarily enunciated this law is as follows:—

The current in any conductor is equal to the electro-motive force between its extremities divided by its resistance.

From this it follows that the current in any simple circuit is equal to the whole E.M.F. around the circuit divided by the whole resistance of the circuit.

Ohm's law may be converted into the following statements:

The resistance of a conductor is equal to the electro-motive force between its extremities divided by the current produced in it.

As no method by which resistance is to be measured has yet been explained, it may appear at first sight, that Ohm's law simply gives a definition of the measure of resistance, and this is all that is formally stated, but, like Newton's laws of motion, there is more implied in the law than appears on the surface. The fact that resistance is an attribute which may be assigned to a conductor without qualification as regards the current flowing in it, implies that the resistance of a conductor is constant so long as its temperature, mechanical condition, etc., remain unchanged. Hence, in the same conductor the current will be proportional to the electro-motive force between its extremities. Hence, if the E.M.F, be doubled, the current also will be doubled, and so on, and this is the law implied in the statement.

The clearest conception of the meaning of Ohm's law, may perhaps be gained by considering what is implied in its denial. Thus, if we deny that the current is proportional to the electro-motive force, we may hold that if the E.M.F. is increased, the current will be increased in a higher or in a lower ratio. Both these views have been maintained. According to the first hypothesis, the resistance of a conductor will diminish as the current in it is increased, as though the increased E.M.F. partially broke down the resisting power of the conductor. According to the second hypotheeis, the resistance will increase with the increase of the current. Now the measurement of the resistance of a conductor is an operation which can be carried to a higher degree of accuracy than any other physical measurement, except, perhaps, the measurement of mass by weighing. Thus, the equality of the resistances of two wires can be ascertained to within one part in a million. It is, therefore, possible to apply very severe tests to Ohm's law, but the law holds good under the most severe tests which have yet been applied.

When a current flows along a wire and can only enter or leave the wire by the ends, there will be the same current across every section of the wire. If the wire be of the same material throughout and of uniform thickness, there is no reason why the potential should fall more rapidly in one part of the wire than in another. Thus, there will be a steady fall of potential at a uniform rate, from the ends at which the current enters to that at which it leaves the wire. Hence, the difference of potential between any two points in the wire is proportional to the distance between the points. But the current in every portion of the wire is the same; hence, for any length of the wire, the difference of potential between its extremities is proportional to its resistance, and therefore the resistance of any portion of the wire is proportional to its length.

If the resistances of a round wire and a ribbon of the same material and having the same sectional area, be compared, they will be found to be the same, length for length. But if the sectional area be the same, the surface of the flat ribbon will be very much greater than that of the round wire. Hence, it follows, that the resistance of a wire depends on its sectional area and not on its surface, and the conduction of electricity is a phenomenon which takes place uniformly throughout the substance of a conductor and not on its surface. It follows, therefore, that two wires of the same length, material and section, placed side by side and having both their extremities joined, will be electrically equivalent to a single wire of double the sectional area of either, and so on. But if a given electro-motive force act between their extremities, the two wires will carry twice the current that either wire would carry, and so on if there are more than two wires. Hence, the resistance of the compound conductor will be inversely proportional to the number of wires. It follows, therefore, that the resistance of a single wire of given length and material will be inversely proportional to its sectional area. Hence:—

The resistance of a conductor of uniform section is directly proportional to its length, and inversely proportional to its sectional area.

Thus, if two wires are taken, one, say, 100 times as long as the other, and of 100 times the sectional area, the resistances of these wires will be the same whatever be the strength of the currents flowing through them, if Ohm's law is true, *but not otherwise*. The experiment has been tried by Prof. Chrystal in the Cavendish laboratory (with slight necessary modifications due to the heating of the fine wire), the wires being balanced against one another, and very strong, and comparatively feeble currents being sent through the wires in rapid succession, when it was found that precisely the same adjustment produced a balance both for the strong and feeble currents, though the currents in the fine wire were such as to raise the wire to a red heat. This experiment, therefore, proved the truth of Ohm's law to a very high order of approximation. The method of comparing resistances will form the subject of a future lecture.

When a number of conductors are connected so that the same current flows through each in succession, they are said to be arranged *in series*, and the *resistance* of the compound conductor is the sum of the resistances of its constituents.

When a number of conductors are so connected that the current divides itself between the conductors, part flowing through one and part through another, they are said to be arranged *in multiple arc*, and the *con-*