between the acid and the copper, the potential of the zinc plate will be lower than that of the copper and a quadrant electrometer will be capable of measuring this difference of potential which will be the electromotive force of the cell. If the copper and zinc are connected by a wire a current will flow from the copper to the zinc along the wire, lowering the potential of the copper and raising that of the zinc, so that the equilibrium between the metals and the acid becomes disturbed, electricity flows from the zinc to the acid and from the acid to the copper, so that the potential of the acid near the zinc is raised above that of the acid near the copper, and a current therefore flows through the acid from the zinc to the copper thus completing the circuit.

If a plate of copper and a plate of zinc be connected together, and the free end of the copper plate dipped into one vessel of dilute sulphuric acid and the free end of the zinc plate into another vessel of the same liquid, the acid into which the zinc is dipped will be at a higher potential than that into which the copper is dipped. If now a connection is made between the two vessels of acid, by inverting a syphon filled with acid so that one leg is in one vessel and the other in the other, electricity must flow from the acid in the vessel in which the zinc dips to that in the other vessel, the equilibruim will be disturbed and a continuous current will flow through the circuit as before.

In the frictional electric machines, in the Voss and Holtz machines, in the replenisher and electrophorus, the electrical energy developed is derived from the work done by the agent in overcoming the electrical attractions and keeping the machine in motion, or, in the case of electrophorus, in raising the carrier plate in opposition to the attraction of the electrified ebonite. In the case of a thermo-electric couple the energy of the current is derived from the heat absorbed at the hot junction on account of the Peltier effect, or absorbed as the current flows from hot to cold or cold to hot along the metals on account of the Thomson effect. In the Voltaic circuit the energy of the current is derived from the chemical action which takes place between the metals, or one of the metals, and the acid (or electrolyte). That the energy of the current in ordinary batteries is due to the solution of the zinc in the acid was shewn by Dr. Joule, who determined the amount of heat developed by a pound of zinc in sulphuric acid. He then immersed a battery in a calorimeter, and determined the whole amount of heat developed for each pound of zinc dissolved when the wire throgh which the current flowed was wholly contained within the calorimeter. The amount of heat so obtained was the same as when the zinc was dissolved in the acid without the production of any current. On causing the current from the battery to pass out of the calorimeter and to flow through a wire immersed in a second calorimeter, the heat developed in the battery for each pound of zinc dissolved was less than before, but the deficiency was exactly compensated by the heat developed by the current in the external wire, and communicated to the water of the second calorimeter. From these experiments it appears that when a battery is employed in sending a current the heat corresponding to the chemical action taking place in the battery is not wholly developed within the battery, but a portion of it is employed in making the current flow through the circuit, and is reconverted into heat wherever the current does work against resistance.

Faraday shewed that when a pound of zinc is dissolved in a battery a definite quantity of electricity passes round the circuit. This will be referred to again in speaking of Faraday's law of electro-chemical equivalents. The electromotive force of the battery is the number of units of work done on the unit of electricity in going round the circuit. Hence when a pound of zinc is dissolved in a single cell, the electrical work done is proportional to the E.M.F. of the cell, being equal to the product of this E.M.F. and the number of units of electricity which flow round the circuit for each pound of zinc dissolved, and which is the same for all batteries. Now it is clear that this work cannot exceed the energy developed by the whole amount of chemical action which takes place in the cell in consequence of the solution of the pound of zinc. Thus the nature of the chemical action taking place in the cell fixes a superior limit to the E.M.F. obtainable therefrom. For example, if zinc is dissolved and free hydrogen liberated, the work done in the cell is that due to the combination of zinc with sulphion, (SO_4) diminished by the energy absorbed in liberating the equivalent of hydrogen from the sulphion. If instead of liberating the hydrogen as free gas it is allowed to combine with oxygen (*i.e.* burnt) within the battery, the work done by the combination of the zinc with the sulphion will not have to be diminished by so large a quantity and the E.M.F. of the cell may be considerably increased. Thus, in Groves' cell in which the liberated hydroged is burnt at the expense of the oxygen of nitric acid, and in the "bichromate battery," in which the hydrogen combines with the oxygen of potassic bichromate, the E.M.F. is greater than that which would be developed if the same plates (zinc and platinum or zinc and carbon) were simply plunged in dilute sulphuric acid.

Def. The resistance of a conductor is that property in virtue of which a finite electro-motive force is incapable of doing more than a finite amount of work in sending electricity through the conductor.

Def. The conductivity of a conductor is the inverse of its resistance, *i.e.*, if the resistance be denoted by R the conductivity will be represented by $\frac{1}{R}$

All bodies possess a certain amount of resistance, and only a certain amount, though the interval between the best conductors (such as copper) and the best insulators, or worse conductors, such as sulphur or paraffin wax, is very great indeed. The resistance of a bar of glass is not less than 600,000,000,000,000,000,000, 000,000 times that of a bar of copper of the same dimensions.

The first measurement of the resistance of conductors were made by Henry Cavendish, who not only compared the resistance of metallic wires but also of liquids (electrolytes), especially of solutions of common salt. These measurements were undertaken mainly in connection with his experiments on the torpedo, which led to the measurement of the resistance of sea water. From Cavendish's results it appears that the conductivities of saline solutions of different strengths are nearly proportional to the per centage of salt present, a fact recently rediscovered by Kohlrausch. Though