A STATIC BALANCE ELECTROMETER METHOD OF MEASURING DIELECTRIC CONSTANTS OF ELECTROLYTES

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Abstract

The differential idiostatic electrometer method devised by A. P. Carman has been arranged so that readings can be made with conducting electrolytes by static balance. The thermal disturbances have been controlled by a special cooling water jacket, around the vessel containing the tested solution. A diagram showing the connections and special arrangements is given.

THE differential electrometer method[1] of measuring the dielectric constants of liquids was first used with liquids of poor conductivity such as water and alcohol. When electrolytes of considerable conductivity are used,

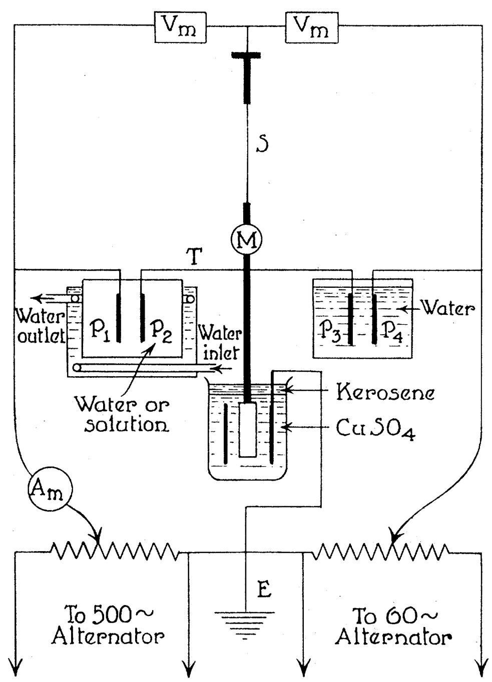

Fig. 1. Arrangement of apparatus.

the electric currents between the plates of the electrometer cause serious thermal disturbances. To avoid these disturbances Schmidt[2] used the device of first-throw readings, thus taking readings rapidly and assuming

[1] A. P. Carman, Phys. Rev. 24, 396 (1924).

[2] C. C. Schmidt, Thesis deposited in University of Illinois Library, May 15, 1927; A. P. Carman and C. C. Schmidt, Phys. Rev. 30, 922–930 (1927).

constancy of conditions for the short time of the observations. This method of first-throw readings and instantaneous balance is, however, open to serious objections and therefore a method of static balance has been developed. Several changes in the apparatus and connections have also been made. In describing the method, Fig. 1 will be useful.

The needle system consists of the bar T, carrying the platinum plates P_2 and P_3. The fixed plates P_1 and P_4 are placed so as to produce equal opposing torques or balance on the needle system. The differences of potentials between the two pairs of plates immersed in water are respectively V_1 and V_2. When one pair of plates is immersed in water and the other pair in the solution, the balancing potentials are V_1' and V_2'. It is easy to deduce the relation

$$\frac{k'}{k}=\left\{\frac{V_2}{V_1}\right\}^2 \div \left\{\frac{V_2'}{V_1'}\right\}^2$$

where k and k' are respectively the dielectric constants of water and of the solution.[3] The importance of the potential readings is seen directly from the above equation.

One of the immediate effects of heating the electrolyte is to change its electrical resistance, and thus to change the difference of potentials between the plates. Hence a first problem in a static balance is to control the temperature of the solution under test. This was done by surrounding the walls and bottom of the thin glass vessel containing the solution, with a metal jacket, through which a continuous stream of water flows. The glass vessel was sealed tightly in this jacket by tape and asphalt. The water came from a large elevated tank in which the level was kept constant. The solutions of concentrations below 0.012 normal solution were cooled by having tap water stored in the tank flow through the jacket. Ice was used in the tank water for higher concentrations in which more heat was generated. Convection currents in the solution at first disturbed the balance of the immersed plates. These convection currents were due to temperature gradient when the cooling water entered at one side of the jacket and escaped at the other side. This difficulty was completely overcome by admitting the cooling water through numbers of small holes in a copper tube at the bottom of the jacket, and allowing this water to escape through holes in a similar ring tube at the top of the cooling jacket. A copper-constantin thermocouple, enclosed in a thin glass tube, gave the temperature of the solution between the plates. These temperatures were read to two-tenths of a degree Centigrade. By this arrangement it was possible after practice to maintain the temperature of the solution practically constant for almost any time. With thermal equilibrium in the solution under test, it is thus possible to get a sensitive balance with conducting solutions as definite and stable as with a non-conducting liquid. A number of new arrangements are shown in the figure and need not be described further.

[3] E. B. Rosa (Phil Mag. (5) **31,** 188 (1891)) in his valuable pioneer work on the dielectric constants of electrolytes proved experimentally the theoretical relation, $F=AKV^2$, for the force between immersed plates, showing also that the force does not depend on the electric currents passing.