A Standard for the Measurement of High Voltages.

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Modern developments in the generation, transmission, distribution and utilization of electricity at high voltages have greatly outstripped the accurate measurement of such voltages. Those familiar with the very accurate standards and measurements of voltage, current and power at low potentials may be surprised to learn that the recognized standard for the determination of high voltages is the needle or sphere spark gap. In other words the voltage if measured simply by the distance that it will cause a spark to jump in air between needle points or spheres under specified conditions.

It is hardly necessary to point out that such a standard is readily affected by temperature, humidity and barometric changes, not to mention the presence of other conductors which may be in the immediate vicinity. It is therefore not readily reproducible and it is most difficult to make the two standards agree at 50 kilovolts at which voltage both should be accurate.

With these facts in mind, an attempt is being made in the electrical laboratories of Purdue University to develop a more satisfactory standard for the measurement of high voltages which is based upon the fundamental principles of the electrostatic field. Although many forms of electrostatic voltmeters have been developed in the past, in the endeavor to commercialize them and make them compact, the very uniform field upon which their accuracy depends has been sacrificed. No attempt has been made to make the standard voltmeter described herein portable or a thing of beauty, for it is believed that such qualities are quite subordinate in the consideration of a primary standard.

If a perfectly uniform electrostatic field is produced between two parallel metal plates it can be readily shown that the force action between such plates expressed in dynes is

$$P = \frac{AE^2K}{8\pi t^2}$$

where A = area of plate in square centimeters
E = potential expressed in electrostatic units
K = dielectric constant (unity for air)
t = distance between plates in centimeters.

The following relation exists, therefore, between the electro-motive force applied to the plates expressed in volts and the force in grams exerted between the plates.

$$E = 47098\, t \sqrt{\frac{P}{A}}$$

If the plates are made of very great area, it may be assumed that the electrostatic field at their center is uniform provided that the plates are not far apart.

In the apparatus constructed at Purdue University a circular disc of very small area was cut from the center of the lower horizontal plate and this disc was mounted upon a float supported in a tank filled with oil in such a manner that its surface is horizontal and concentric with the stationary plate but with its plane a small fraction of an inch below that of the stationary plate.

When an electromotive force is impressed upon the two stationary plates the movable disc is attracted by the upper plate and may be lifted into the plane of the lower plate by raising the voltage to the proper value. This condition can be readily detected by means of a telescope sighted along the surface of the lower stationary plate.

With the plates very near together, and a voltage sufficiently low to be readily standardized, the force necessary to raise the disc may be calculated from the above equation. If now an unknown high voltage be impressed upon the plates which have in the meantime been sufficiently separated to bring again the disc into alignment with the lower plate, the force will of course be the same as before and the new voltage may be determined by the relation $E^1 = \frac{t^1 E}{t}$ the voltages being directly proportional to the distances between plates.

Such a voltmeter has been constructed and the ratio of impressed voltages to distance between plates required for a balance has been found to follow surprisingly close to a straight-line law when a previously determined and constant value of force is used. Further studies are now being made to determine the range within which this apparatus may be considered standard for given dimensions of plates and further refinements are being made in its construction, method of reading, and calibration.

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