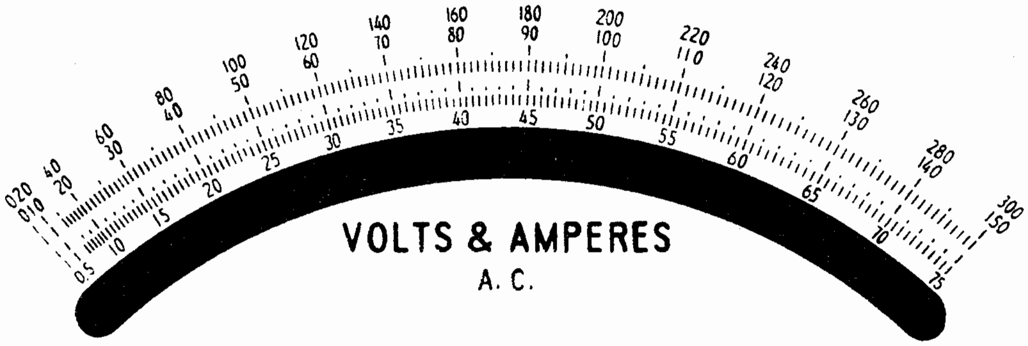
NORTHERN ALBERTA INSTITUTE OF TECHNOLOGY
EDMONTON ALBERTA

ELECTRONICS DEPARTMENT



ELECTRICAL MOVEMENTS

There are five basic, common electrical "movements"—devices which move when an electrical voltage or current is applied to them. Every metrologist (i.e., every scientist, engineer or technician who measures what he is doing) should know the principles and applications, advantages and limitations of these five electrical movements. Four are still in common, everyday use.

The five (Figure 1) are:

A. PERMANENT-MAGNET MOVING-COIL (also called PM/MC or D'Arsonval movement).

B. ELECTRODYNAMIC (also called dynamic or dynamometer movement).

C. MOVING IRON (also called moving iron vane).

D. MOVING MAGNET (also called polarized iron or polarized iron vane).

E. ELECTROSTATIC.

Of the five, only the electrostatic uses the attraction or repulsion forces between charges; the other four use the forces due to the interaction of currents and magnetic fields, created by magnets (in PM/MC or moving-magnetic types) and/or currents in coils (dynamic or moving-iron types).

PRINCIPLES

As shown in Figure 1, the motion of each movement is caused by forces due to the interaction of currents and fields, as follows:

ELECTROSTATIC MECHANISM

The electrostatic mechanism (Figure 14) resembles a variable capacitor. Of all the mechanisms used for electrical indications it is the only one that measures voltage directly, rather than by the effect of current.

The torque resulting from the attraction between fixed and movable plates is a function of the voltage between the plates, the plate area and, inversely, the distance between plates. For greater sensitivity, this distance must be reduced, clearances permitting, or the plate area (and thus the weight) must be increased.

Although not an "electrical movement," the gold-leaf electroscope (Figure 15) operates on the same principle; like charges on the ends of the lead causes a separation of the ends.

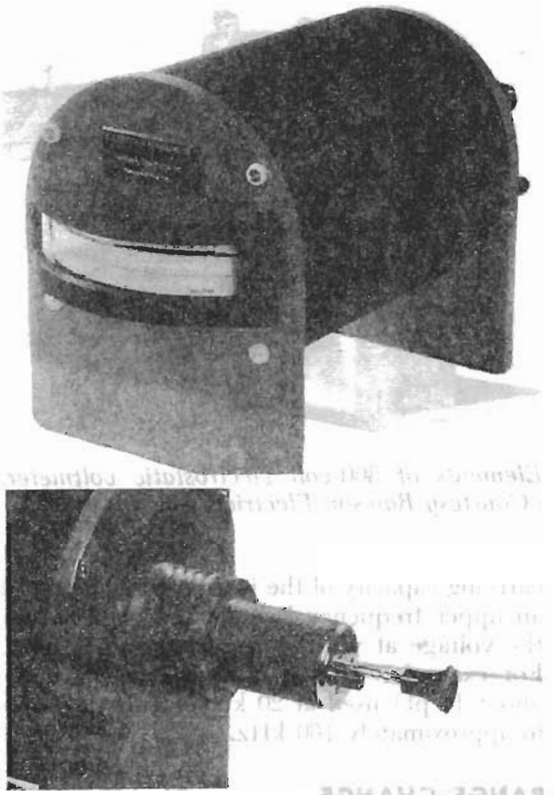
The electrostatic voltmeter measures RMS voltage, whether the voltage is DC, sinusoidal AC, or pulse type. The pulse type of voltage wave usually has an RMS value which is small compared to the peak value (the ratio of peak to RMS may be as much as one thousand to one).

Two phenomena place an upper limit on the use of the electrostatic voltmeter. The first is the effect of loading on the circuit being measured. The voltmeter is a capacitor whose capacitance lies between the limits of 225 pf (for the 120-volt instruments) to about 10 pf (for the 100 kv). In the radio-frequency range, this reactance must be considered.

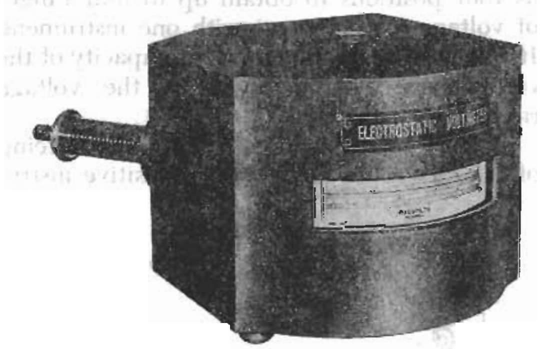
The second limitation is that the instrument and its leads behave like a resonant or partially-resonant transmission line, and a voltage distribution along the line results which is not constant. Thus the instrument may indicate a voltage which is not the same as that to which the leads are connected.

Since the electrostatic voltmeter as a circuit element is a high-quality capacitor, the power taken by the instrument is negligible. Of course, in exchange for this high power sensitivity, the electrostatic voltmeter requires that the necessary charge be supplied from the circuit under measurement, whether the measurement is alternating current or direct current. On direct current, only the initial charging circuit is required, whereas on alternating current, a capacitive alternating current flows, as in any capacitor. The capacitive current is negligibly small at power or audio frequencies, and electrostatic voltmeters are used even at radio frequencies.

Electrostatic instruments have an inherent limitation in frequency based on the current-



Model KVE electrostatic voltmeter has range to 100 kv, AC/DC. Accuracy is 1% full scale. Rear view (bottom) shows range changer by moving electrode position (Courtesy Hallmark Standards Inc.)



Model ESH 30-kv electrostatic voltmeter, discussed in text. (Courtesy The Singer Co., Metrics Div.)

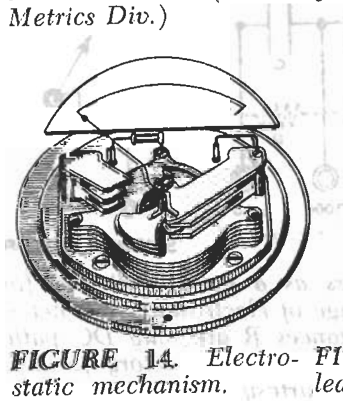


FIGURE 14. *Electrostatic mechanism.*

FIGURE 15. *Gold-leaf electroscope.*