INTRODUCTION TO METER MOVEMENTS

Electrical measuring instruments are required to measure values of current, voltage, power or other quantities dependent on these. They commonly give indication by means of a pointer moving over a calibrated scale, but instruments are in use with a numerical indication and no moving parts.

METERS WITH MOVING PARTS

To give a stable reproducible indication, three forces must act on the pointer :-

1. A deflecting force, whose magnitude is dependent on the electrical quantity being measured. Electromagnetic or electrostatic principles are used to create this force. With no other force on the pointer, any small deflecting force would drive the pointer to its extreme limit.
2. A controlling force to oppose the deflecting force, whose magnitude is dependent on deflection. This makes the deflection dependent on the amplitude of the electrical quantity.
3. A damping force to make the pointer settle quickly on its final position.

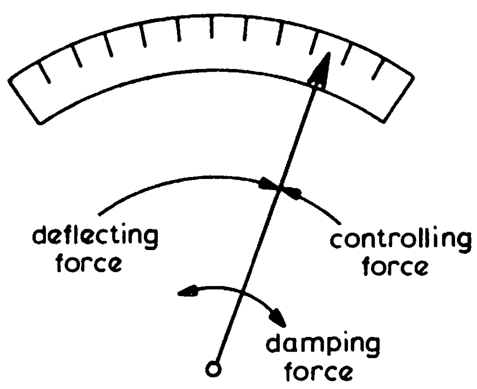

Figure 1

INTRO TO METER MOVEMENTS

THE MOVING COIL MOVEMENT

This is illustrated in Figure 2. The deflecting force is produced by passing the current being measured through a coil able to rotate in the magnetic field generated by a permanent magnet. The force is proportional to the current and thus makes deflection of the coil from its rest position proportional to the current. The controlling force is provided by hairsprings, which also make electrical connection to the coil. The damping force is generated by the eddy currents induced in the aluminium former on which the coil is wound. Any movement of the coil results in a current in the former, which in turn produces a force which opposes the original motion.

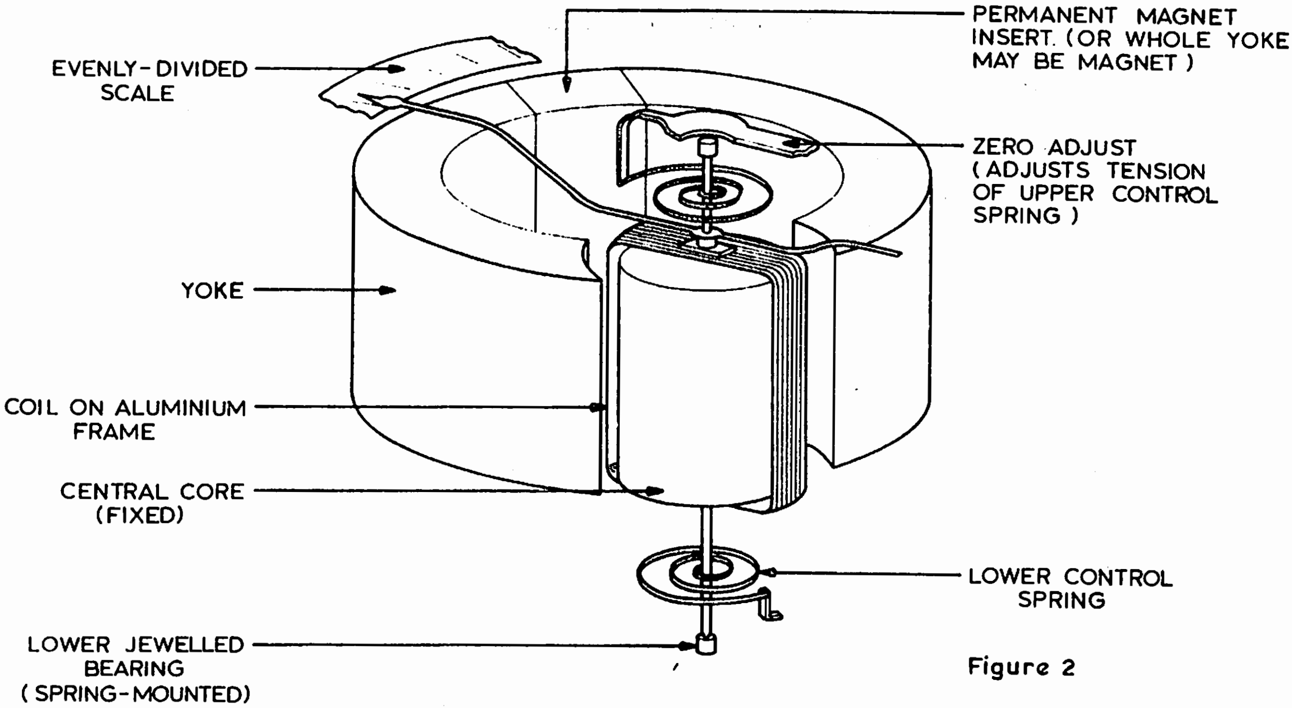

Figure 2

Moving coil meters usually have a uniform scale extending over a 90° arc. Due to the inertia of the moving parts, they indicate the average value of a varying current; they give no deflection for alternating currents above a few Hertz.

Factors affecting sensitivity :-

a) Strength of the magnetic field - cobalt steel alloys are used to make magnets with high remanence and coercivity. The polepieces are shaped to produce a uniform field and are separately machined from a magnetically soft steel. This steel is also used to fill the space within the coil, creating a narrow air gap and hence increasing the flux density.

b) Low controlling force - achieved with weak hairsprings, but then low friction becomes important. Good bearings are essential and the meter must be used in the correct orientation.

c) Turns on coil - to keep the coil small and light, with many turns, very fine wire must be used. This limits the current which can be carried safely and increases the meter resistance. To make the overall meter resistance independent of temperature, an additional swamp resistance of low temperature coefficient is added in series.

The most sensitive meter movements commonly available require about 50 μA to deflect the pointer to the end of the scale. The sensitivity of a movement is defined as the current required for full scale deflection (f.s.d.).

General Usage

The moving coil movement is compact, light, sensitive and can be made accurate to within 1%, but it is both electrically and physically fragile. It is frequently built into equipment to monitor circuit conditions, and is used as the basis of portable test instruments.

THE MOVING IRON METER

This also uses electromagnetic principles and is illustrated in Fig. 3. The deflecting force is generated by the repulsion of two iron plates magnetised by a coil carrying the current to be measured. One plate is fixed, the other attached to the pointer. The controlling force is derived from hairsprings; since the coil is fixed, they do not carry current.

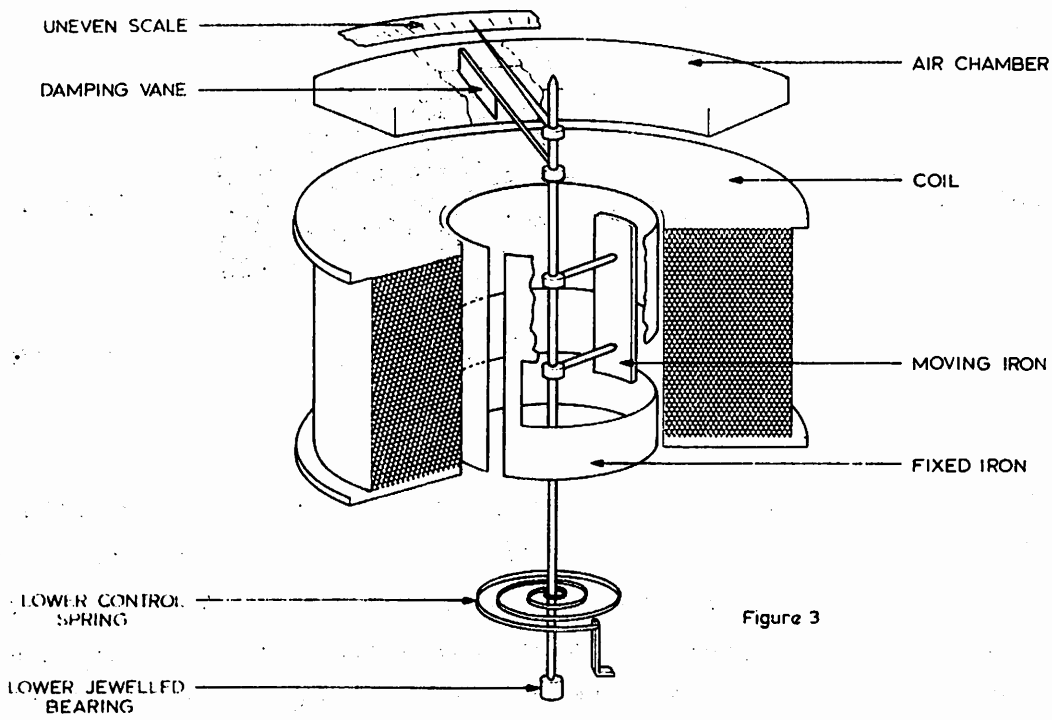

Figure 3

The damping force cannot be derived from eddy currents as in the moving coil instrument, since the magnetic field is much weaker. Usually air damping is used; a vane connected to the pointer moves against the air resistance in a partially enclosed chamber.

Since the iron plates are always magnetised similarly with respect to each other, the force between them is repulsive irrespective of the direction of current in the coil. The meter thus indicates alternating currents, producing a steady deflection which is proportional to the average value of the square of the current. This gives rise to a non-linear scale which may be calibrated in r.m.s. values, but the linearity may be improved by shaping the iron plates.

General Usage

The moving iron meter is not as sensitive as the moving coil, but will tolerate quite large overloads. It is used primarily for fixed monitoring in medium and high power circuits.

THE ELECTROSTATIC VOLTMETER

The deflecting force is caused by the attraction between two plates carrying opposite charges. One plate is fixed, the other attached to the pointer. The controlling force is applied by hairsprings and the damping force by air vane as in the moving meter (Fig. 4).

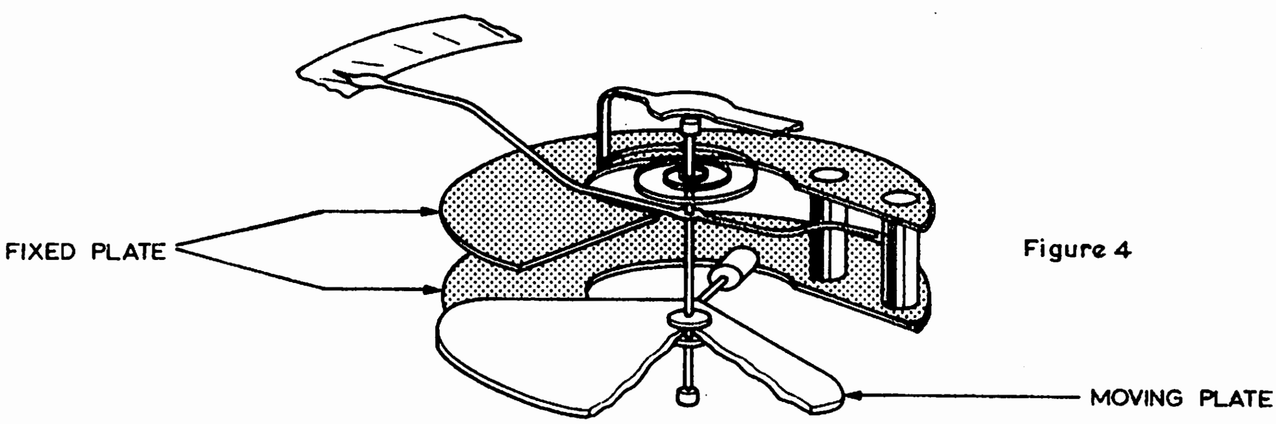

Figure 4

The attractive force is small and dependent on the voltage between the plates. Apart from the charging current, the meter takes no power from a d.c. source and very little from an a.c. source. It is therefore often used to measure high impedance, high voltage supplies as found in television receivers and monitors. The sense of the deflecting force is independent of the polarity of the applied voltage and the deflection proportional to the voltage squared. The scale is thus non-linear and can be calibrated in r.m.s. units.

THE THERMOCOUPLE METER

A thermocouple is a junction of two dissimilar metals which, when heated, generates an e.m.f. The current produced by this e.m.f. can be measured with a moving coil meter.

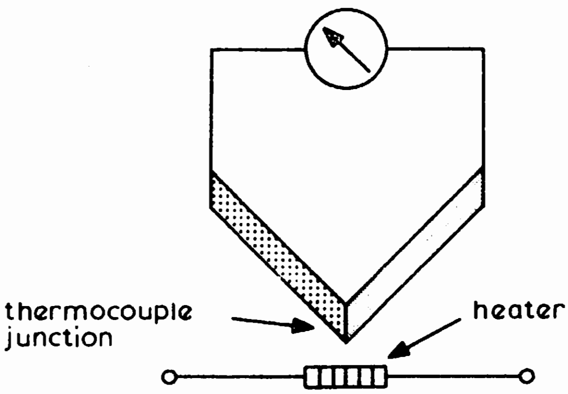

Figure 5

The current being measured is passed through a small heating element very close to the thermocouple. The heat produced is proportional to the square of the current and is independent of the waveshape. The meter thus indicates the true r.m.s. value of any waveform from d.c. to radio frequencies with an accuracy of up to 1%.

The thermocouple meter is used for accurate r.m.s. measurements and for radio frequency measurements in MF and HF transmitters. Usually the thermocouple is small enough to fit inside the case of a conventional moving coil meter.

METERS WITH NO MOVING PARTS

These meters measure voltage using electronic circuitry and give a reading on electrically activated numerical displays.

In a typical instrument a train of pulses is generated whose length is proportional to the voltage being measured. The pulses are counted and the total displayed as a measure of the voltage.

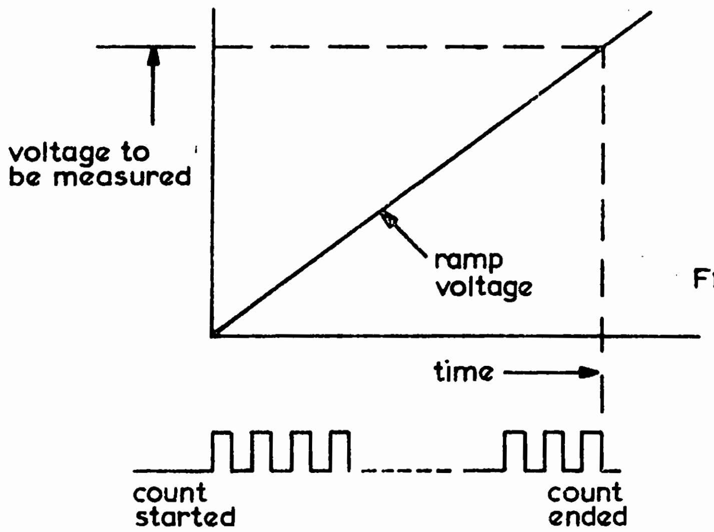

Figure 6

A ramp voltage is generated within the instrument which increases from zero to a maximum at a constant rate. A pulse generator is started at the same instant and is stopped when the ramp voltage is equal to the voltage being measured. The pulses are counted digitally and the total displayed using liquid crystal, l.e.d. or similar devices.

The digital voltmeter can measure to a greater accuracy than any mechanical instrument and is useful in test areas where readings have to be taken frequently. Due to its method of operation it takes measurements at intervals, which can give confusing readings with slowly varying voltages.

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