

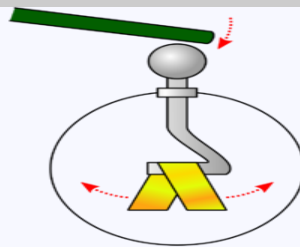
ELECTROMETER

Definition

An **electrometer** is an electrical instrument for measuring electric charge or electrical potential difference.

Basics

An **electrometer** is an electrical instrument for measuring electric charge or electrical potential difference. There are many different types, ranging from historical hand-made mechanical instruments to high-precision electronic devices. Modern electrometers based on vacuum tube or solid state technology can be used to make voltage and charge measurements with very low leakage currents, down to 1 femtoampere. A simpler but related instrument, the electroscopes, works on similar principles but only indicates the relative magnitudes of voltages or charges.



Gold-leaf electroscope

The gold-leaf electroscope was one of the first sensitive instruments used to indicate electric charge. It is still used for science demonstrations but has been superseded in most applications by electronic measuring instruments. The instrument consists of two thin leaves of gold foil suspended from an electrode. When the electrode is charged by induction or by contact, the leaves acquire similar electric charges and repel each other due to the Coulomb force. Their separation is a direct indication of the net charge stored on them. The leaves may be enclosed in a glass envelope to protect them from draughts, and the envelope may be evacuated to minimize charge leakage. A further cause of charge leakage is ionizing radiation, so to prevent this, the electrometer must be surrounded by lead shielding. It should be noted that this type of electroscope usually acts as an indicator and not a measuring device, although it can be calibrated. The Braun electroscope replaced the gold-leaf electroscope for more accurate measurements.

The most common radiation measurement device, and widely used in the nuclear industry, the Quartz Fibre Electrometer (or QFE) personal dosimeter, is actually a ruggedized, calibrated electroscope. It uses the leakage effect mentioned above to detect ionizing radiation.

The instrument was developed in the 1700s by several researchers, among them Abraham Bennet and Alessandro Volta.

Modern electrometers

In modern parlance, an electrometer is a highly sensitive electronic voltmeter whose input impedance is so high that the current flowing into it can be considered, for practical purposes, to be zero. They are of use in nuclear physics as they are able to measure the tiny charges left in matter by the passage of ionizing radiation. The most common use for modern electrometers is probably the measurement of radiation with ionization chambers, in instruments such as geiger counters.

Vibrating reed electrometers

Vibrating reed electrometers use a variable capacitor formed between a moving electrode (in the form of a vibrating reed) and a fixed input electrode. As the distance between the two electrodes varied, the capacitance also varies and electric charge is forced in and out of the capacitor. The ac signal produced by the flow of this charge is amplified and used as an analogue for the dc voltage applied to the capacitor.

The input resistance of the electrometer is determined solely by the leakage resistance of the capacitor (although its ac input impedance is clearly less than infinity).

For convenience of use, the vibrating reed assembly is often attached by a cable to the rest of the electrometer. This allows for a relatively small unit to be located near the charge to be measured while the much larger reed-driver and amplifier unit can be located wherever it is convenient for the operator.

Valve electrometers

Valve type electrometers use an unbiased vacuum tube with a very high gain (transconductance) and input resistance. The input current is allowed to flow into the high impedance grid, and the voltage so generated is vastly amplified in the anode (plate) circuit. The best examples of these valves have leakage currents as low as a few femtoamperes (10^{-15} amperes). This type of valve can be ruined by handling with ungloved hands as the salts left on the glass envelope can provide leakage paths for these tiny currents.

Solid-state electrometers

The most modern electrometers consist of a solid state amplifier circuit using FETs, connections for external measurement devices, and also possibly a display, data-logging connections, and/or a high-voltage supply. The amplifier magnifies small currents so that they are more easily measured. The external connections are usually of a co-axial or tri-axial design, and allow attachment of diodes or ionization chambers for radiation measurement. The display or data-logging connections allow the user to see the data or record it for later analysis. The high-voltage supply is an integral power supply which is used to supply a voltage to the ionization chamber or diode.

Solid-state electrometers are often multipurpose devices that can measure voltage, charge, resistance and current. They measure voltage by means of "voltage balancing", in which the input voltage is compared with an internal reference voltage source using an electronic circuit with a very high input impedance (of the order of 10^{14} ohms). A similar circuit modified to act as a current-to-voltage converter enables the instrument to measure tiny currents of the order of one femtoampere. Combined with an internal voltage source, the current-measuring mode can be adapted to measure very high resistances, of the order of 10^{17} ohms.

Finally, by calculation from the known capacitance of the electrometer's input terminal, the instrument can measure very small electric charges, down to a small fraction of a picocoulomb, on the terminal.

Experiments with an electroscope

1. Touch the terminal with a charged conductor. Electrons flow into or out of the electroscope until its potential equals that of the conductor. The net surplus or deficit of electrons on the leaves causes them to repel each other. The charge that transfers, and therefore the deflection, are functions of the original potential difference between the conductor and the uncharged electroscope.
2. Place an isolated, charged conductor in contact with the terminal. The proportion of the conductor's charge that ends up on the terminal depends on their relative capacitances. This charge remains on the electroscope when you take the conductor away. The electroscope indicates this charge.
3. Bring a charged insulator near to the terminal but don't allow any charge to transfer between them. In this case, the deflection indicates the net charge on the electrons that have been temporarily pushed towards or away from the leaves.

This charge is related to the charge density on the part of the insulator near to the terminal, and the relative shapes and positions of the two. What the electroscope is measuring in this case is quite vague, because there is no sharp boundary between the electron-rich and electron-depleted regions of the electroscope.

4. Place a charged insulator on or near the terminal, ground the terminal and then withdraw the insulator. This leaves the electroscope with a net charge. The electrons redistribute themselves over the terminal and the leaves, causing the leaves to repel each other. The deflection is monotonically related to the net charge left behind on the electroscope, in a similar way to the previous case.

History

An **E-meter** is an electronic device used during Dianetics and Scientology auditing. The device is a variation of a Wheatstone bridge, which measures electrical resistance. It is formally known as the **Hubbard Electrometer**, for the Church's founder, L. Ron Hubbard. Critics point to a lack of scientific basis for the E-meter and associated practices.

The Church of Scientology restricts the use of the E-meter to trained professionals, treating it as "a religious artifact used to measure the state of electrical characteristics of the 'static field' surrounding the body". The meter is believed to reflect or indicate whether or not a person has been relieved from spiritual impediment of past experiences. It can only be used by Scientology ministers or ministers-in-training and does not diagnose or cure anything. The E-meters used by the Church of Scientology are manufactured at the Church of Scientology's Golden Era Productions facility.

The device's primary component is an electrical measuring instrument called a Wheatstone bridge, which measures the subject's galvanic skin response. By inducing a tiny electrical current through the body, the device measures changes in the electrical resistance of the human body. According to Scientology doctrine, the resistance corresponds to the "mental mass and energy" of the subject's mind, which change when the subject thinks of particular mental images (engrams). The device also has such sensitivity that Hubbard claimed to be able to measure whether or not fruits can experience pain, claiming in 1968 that tomatoes "scream when sliced."

Source: <http://www.juliantrubin.com/encyclopedia/electronics/electrometer.html>