POTENTIOMETER

OBJECT:

To measure the Emf of an unknown cell using a potentiometer.

APPARATUS:

Slide wire potentiometer, battery or power supply, rheostat, double pole-double throw (DPDT) switch, standard cell, unknown cell, galvanometer, key switch and a multimeter.

THEORY:

In an earlier experiment, a voltmeter was used to measure the voltage across a circuit element with the assumption that the voltmeter itself did not affect the measurement. This is not the case. The accuracy of the voltmeter reading depends on the instrument being used and the circuit on which readings are being made and, therefore, the current drawn with respect to the current in the circuit. We saw, also that the Emf (Electromotive force) of a source differed from the voltmeter reading because of the internal resistance of the source. A device which overcomes these drawbacks is the potentiometer. The potentiometer operates on the principle of adjusting opposing voltages until they are exactly equal. At that point the net current is zero and there is, therefore, no voltage drop because of any internal resistance.

In this experiment, the potentiometer consists of a long uniform wire with a constant current in it and a method for inserting, sequentially, a standard cell for calibration and the unknown cell for measurement. The resistance of the wire is uniform and, therefore, any particular length, L, will have a resistance proportional to that length. Since, from Ohms Law, voltage is proportional to the resistance (assuming constant current), the voltage across the length, L, is proportional to L and $V = kL$, where V is the voltage in volts, L is the variable length of wire in meters and k is the proportionality constant in volts per meter. If a parallel circuit is connected to the wire with a sliding contact, galvanometer, and standard voltage source (see diagram below), the sliding contact may be adjusted to a length of wire in which the voltage drop is just equal to that of the standard cell. At this point, there is no net current in the parallel circuit and

$$Emf = kL. \qquad\qquad (eq\ 1)$$

Since the Emf and L are known, k can be calculated. Substitution of an unknown cell through a similar procedure will enable one to determine the Emf of that unknown cell.

PROCEDURE:

1. Connect the circuit as shown in Figure I. Voltage supply is set at its appropriate value, so the current is fairly small. This is to protect the galvanometer.
2. Close the DPDT switch to the standard cell side and calibrate the potentiometer by finding what length of wire corresponds to the voltage of the standard cell. This is done by finding the location of the sliding contact where the galvanometer does not deflect when the key switch is closed.

3. Calculate the constant, k, using the emf of the standard cell and the length, L_S measured to the sliding contact - use Eq. 1.
4. Throw the DPDT switch to connect the unknown battery in the circuit and move the sliding contact until the galvanometer indicates zero current as in Step 2. (Do not adjust R_t since this will change the voltage across the potentiometer wire and upset your calibration). Read the length L_u , measured to the sliding contact.
5. Calculate the emf of the unknown battery. emf $= k\ L_U$
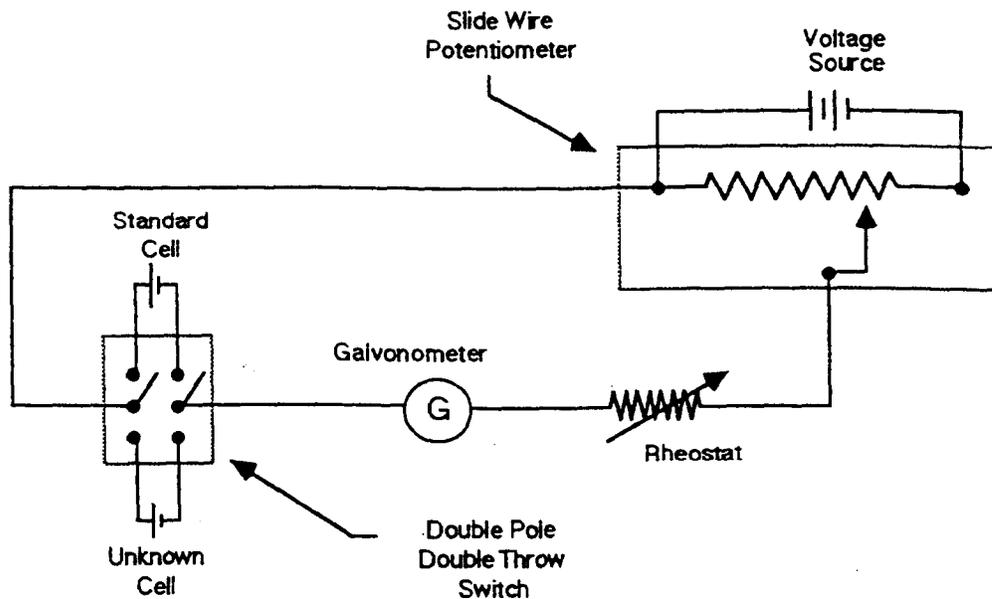6. Now measure the voltage of the unknown battery with the voltmeter. Explain the difference.

Figure I. Slidewire Potentiometer Circuit