RESISTANCE.

Equipment.

1 4-volt storage battery.
1 VT-1 vacuum tube.
1 VT-1 vacuum tube socket, attached to small board; the filament terminals on the socket should be wired to Fahnestock terminals on the board.
1 voltammeter, Weston model No. 280.
2 5-foot lengths No. 18 B. & S. magnet wire.
2 1-foot lengths No. 18 B. & S. magnet wire.
1 5-foot length No. 32 B. & S. magnet wire.
1 10-foot length No. 32 B. & S. magnet wire.
2 battery clips.
1 resistor (approx. 0 to 20 ohms).

Information.

Electrical resistance and conductors.—It is well known that pipes offer opposition or resistance to the flow of water through them, due to the friction between the running water and the sides of the pipes. In a somewhat similar way all bodies offer some opposition to the passage of an electric current through them. Hence all conductors of electricity, even the best, offer some opposition to the flow of an electric current. This opposition is termed the electrical resistance of a substance. Electrical resistance is measured in units called *ohms*. The resistances of different conductors vary according to the substances of which the conductors are composed. A pure silver conductor, for instance, offers less resistance to a flow of current than any other conductor of the same size. Due to its low resistance, silver makes the best conductor of electricity. For this reason silver is used as a standard with which to compare the resistances of other conductors. Next in order to silver in its readiness to conduct electricity ranks copper. While its resistance is higher than that of silver, yet it is somewhat lower than the resistance of any other substance. Because of this low resistance, together with its comparatively small cost, copper wire is the most commonly used conductor of electricity in general use. Other substances which may be used as conductors, but which offer higher resistances than do silver and copper, are mentioned here in the order in which their resistances compare with that of silver beginning with the material having the least resistance. These substances are: Aluminum, zinc, brass, platinum, iron, nickel, tin, lead, German silver, and carbon.

Resistance of wire.—The resistance of a conductor depends not only upon the nature of the substance of which it is made but also upon the size and length of the conductor. Thus the resistance of a copper wire depends upon its size (or cross sectional area) and its length. If two pieces of copper wire have the same length, but the diameter of the one is greater than the diameter of the other, then the resistance of the larger wire will be less than will that of the smaller wire. That is, the resistance of a wire conductor decreases with any increase in the size (or cross sectional area) of the wire. Also a piece of copper wire of a certain diameter and 10 feet long

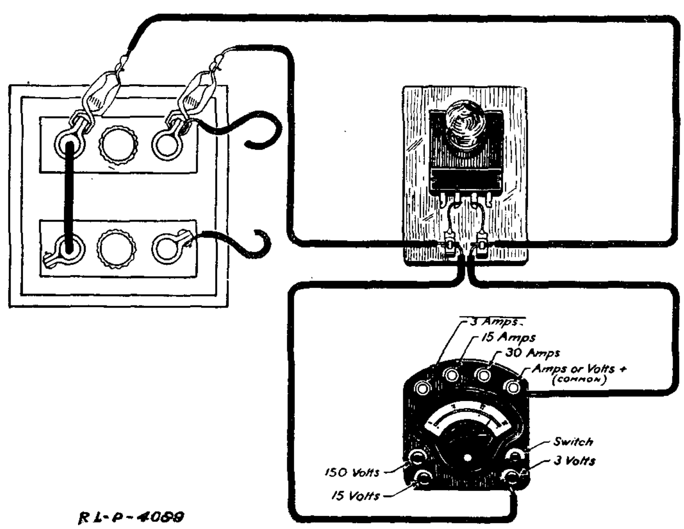

Fig. 12.—Method of measuring the voltage at the filament terminals of a vacuum tube or lamp.

will have a greater resistance than another piece of copper wire of the same diameter but only 1 foot long. In other words the resistance of a wire conductor increases with the length of the wire.

Directions.

1. The object of the following experiments is to show the effect of resistance in an electrical circuit. Attach a battery clip to one end of each of the two 5-foot lengths of No. 18 magnet wire. Open the 4-volt storage battery box and attach one of the clips to the positive terminal of one cell and the other clip to the negative terminal of the same cell. Connect the wires leading from the cell to the two Fahnestock terminals leading to the vacuum tube socket. (See Fig.

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Questions.

(1) *Look at the table which you have completed. Is there a difference in the readings of the voltmeter in Directions 2 and 4? If there is a difference, to what is it due?*

(2) *Why did the filament light up in the experiment under Direction 4, but not light in the experiment under Direction 5?*

(3) *What does the voltmeter show regarding two pieces of wire which are of the same length but of different sizes?*

(4) *Which wire delivers the smallest amount of current to the tube, the 5-foot No. 32 wire or the 10-foot No. 32 wire?*

(5) *What is the object in placing a resistance in a circuit?*

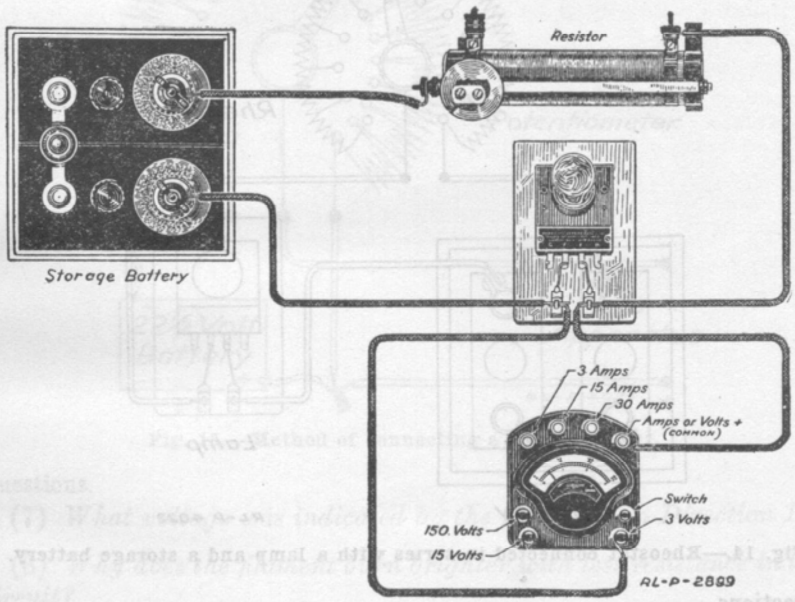

Fig. 13.—Method of connecting a resistor in series with a vacuum tube and storage battery.

Information.

Resistors.—If a certain length of resistance wire, for example, German silver wire, is inserted in a vacuum tube circuit in which a current is flowing, the pressure at the terminals of the tube will be reduced, and at the same time the flow of current through the tube will be reduced. If the length of the resistance wire is increased the voltage and current will be still further reduced. Fig. 13 shows a resistance inserted in series with a VT–1 vacuum tube and battery. The resistance in this case is a device known as a *resistor* or *rheostat*.

The *resistor* consists of a tube of insulating material upon which is wound a number of turns of German silver or composition resistance wire. The ends of the coil thus formed are fastened to connecting terminals attached to the ends of the tube. A fastening device at each end of the tube supports a slide rod placed above the coil. A slider makes connection between the slide rod and the resistance wire by means of a contact spring attached to the slider. The number of turns of resistance wire, in other words the length of the wire in use, may be varied by moving the slider. The storage battery in Fig. 13, is a 4-volt battery. The filament of the tube shown requires only 2.5 volts in order to burn at proper brilliancy.

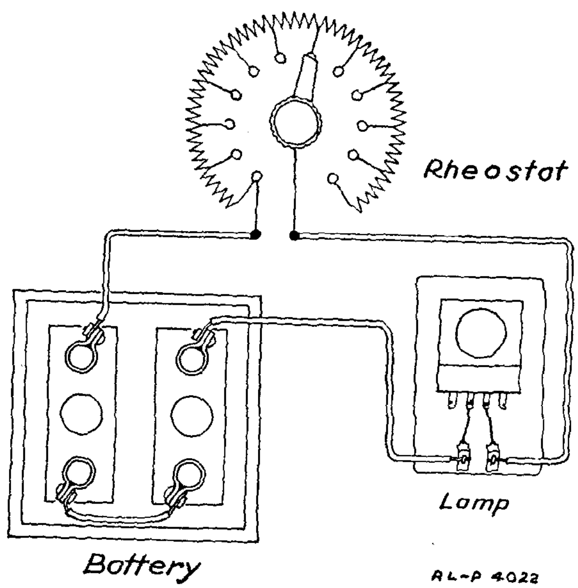

Fig. 14.—Rheostat connected in series with a lamp and a storage battery.

Directions.

8. Replace the 10-foot No. 32 wire with the 5-foot No. 18 wire so that the connections will be the same as originally made in Direction 4. Cut one of the 5-foot leads in the middle and remove the insulation from the ends of the wires. Connect these ends to the resistor exactly as shown in Fig. 13, making sure the slider on the resistor is placed at the terminal end of the rod. Press the button switch on the meter and note the reading. Note whether or not the filament of the tube is lighted.

Question.

(6) *What is the reading of the voltmeter?*

Directions.

9. Move the slider about one-fourth of an inch toward the opposite end of the rod and notice any change in the voltmeter reading as well as any change in the lighting of the filament.

10. Move the slider gradually in the same direction until the filament of the tube glows a bright red. *Caution:* Do not move the slider beyond a point at which the voltmeter needle swings to the end of the scale (3 volts), as there will then be danger of burning out the filament of the tube.

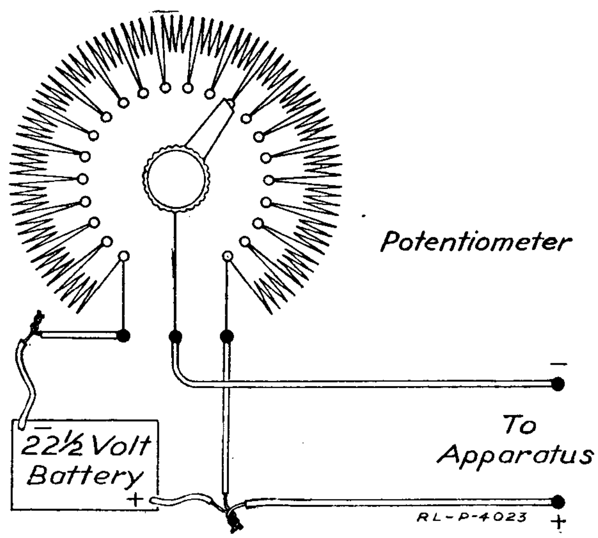

Fig. 15.—Method of connecting a potentiometer.

Questions.

(7) *What voltage was indicated by the voltmeter in Direction 10?*

(8) *Why does the filament burn brighter with less resistance in the circuit?*

(9) *Why is it necessary to use a resistor in this circuit?*

(10) *Does the voltage reading of the meter increase or decrease as the filament of the tube burns brighter?*

Information.

Resistances, Rheostats, Potentiometers.—Resistances or rheostats are also made in a circular form. Taps are taken off from a resistance winding and connected to switch points. The amount of resistance included in a circuit is varied by turning a rotary switch arm which makes contact with the switch points. A rheostat of the circular type properly connected in series with a VT–1 vacuum tube and battery is shown in Fig. 14.

Another method of connecting resistance in a circuit is shown in Fig. 15. The resistor when used in this manner is called a *potentiometer*. With the connections shown, it is possible to obtain any voltage desired from zero up to the full voltage of the battery. The potentiometer is similar in construction to the rotary type of rheostat. The resistance wire of the potentiometer is much greater than that of the rheostat. This high resistance is necessary due to the fact that the wire is connected directly across the terminals of the battery. As shown in Fig. 15, the resistance winding of the potentiometer is connected directly across the 22½-volt battery. The switch arm is connected to one terminal of the apparatus to be used while the other terminal is connected to one side of the battery. By turning the switch arm the voltage delivered to the terminal of the apparatus is varied accordingly.

Questions.

(11) *Why is the circular form of rheostat more practical for use in a radio set than the straight type resistor?*

(12) *Why could not a potentiometer, used as in Fig. 15, be constructed with a low resistance similar to a rheostat?*