## A Electrical Properties of Solids

The first artificial electrical phenomenon to be observed was the property displayed by certain resinous substances such as amber, which become negatively charged when rubbed with a piece of fur or woollen cloth and then attract small objects. Such a body has an excess of electrons. A glass rod rubbed with silk has a similar power; however, the glass has a positive charge, owing to a deficiency of electrons. The charged amber and glass even attract uncharged bodies (*see* Electric Charges *below*).

Protons lie at the heart of the atom and are effectively fixed in position in solids. When charge moves in a solid, it is carried by the negatively charged electrons. Electrons are easily liberated in some materials, which are known as conductors. Metals, particularly copper and silver, are good conductors. *see* Conductor, Electrical.

Materials in which the electrons are tightly bound to the atoms are known as insulators, non-conductors, or dielectrics. Glass, rubber, and dry wood are examples of these materials.

A third kind of material is called a semiconductor, because it generally has a higher resistance to the flow of current than a conductor such as copper, but a lower resistance than an insulator such as glass. In one kind of semiconductor, most of the current is carried by electrons, and the semiconductor is called n-type. In an n-type semiconductor, a relatively small number of electrons can be freed from their atoms in such a manner as to leave a “hole” where each electron had been. The hole, representing the absence of a negative electron, is a positively charged ion (incomplete atom). An electric field will cause the negative electrons to flow through the material while the positive holes remain fixed. In a second type of semiconductor, the holes move, while electrons hardly move at all. When most of the current is carried by the positive holes, the semiconductor is said to be p-type.

If a material were a perfect conductor, a charge would pass through it without resistance, while a perfect insulator would allow no charge to be forced through it. No substance of either type is known to exist at room temperature. The best conductors at room temperature offer a low (but non-zero) resistance to the flow of current. The best insulators offer a high (but not infinite) resistance at room temperature. Most metals, however, lose all their resistance at temperatures near absolute zero; this phenomenon is called superconductivity.

## B Electric Charges

One quantitative tool used to demonstrate the presence of electric charges is the electroscope. This device also indicates whether the charge is negative or positive and detects the presence of radiation. The device, in the form first used by the British physicist and chemist Michael Faraday, is shown in Figure 1. The electroscope consists of two leaves of thin metal foil (*a*,*a*_) suspended from a metal support (*b*) inside a glass or other non-conducting container (*c*). A knob (*d*) collects the electric charges, either positive or negative, and these are conducted along the metal support and travel to both leaves. The like charges repel one another and the leaves fly apart, the distance between them depending roughly on the quantity of charge.

Three methods may be used to charge an object electrically: (1) by contact with another object of a different material (for example, touching amber to fur), followed by separation; (2) by contact with another charged body; and (3) by induction.

Electrical induction is shown in Figure 2. A negatively charged body, *A*, is placed between a neutral conductor, *B*, and a neutral non-conductor, *C*. The free electrons in the conductor are repelled to the side of the conductor away from *A*, leaving a net positive charge at the nearer side. The entire body *B* is attracted towards *A*, because the attraction of the unlike charges that are close together is greater than the repulsion of the like charges that are farther apart. As stated above, the forces between electrical charges vary inversely according to the square of the distance between the charges. In the non-conductor, *C*, the electrons are not free to move, but the atoms or molecules of the non-conductor are stretched and reoriented so that their constituent electrons are as far as possible from *A;* the non-conductor is therefore also attracted to *A*, but to a lesser extent than the conductor.

The movement of electrons in the conductor *B* of Figure 2 and the reconfiguration of the atoms of the non-conductor *C* give these bodies positive charges on the sides nearest *A* and negative charges on the sides away from *A*. Charges produced in this manner are called induced charges and the process of producing them is called induction.