MUTUAL INDUCTANCE

The basic principle of electromagnetic induction was first demonstrated by Michael Faraday. His experimental apparatus, which resembled the arrangement shown in **Figure 13,** used a coil connected to a switch and a battery instead of a magnet to produce a magnetic field. This coil is called the *primary coil,* and its circuit is called the *primary circuit.* The magnetic field is strengthened by the magnetic properties of the iron ring around which the primary coil is wrapped.

A second coil is wrapped around another part of the iron ring and is connected to a galvanometer. An emf is induced in this coil, called the *secondary coil,* when the magnetic field of the primary coil is changed. When the switch in the primary circuit is closed, the galvanometer in the secondary circuit deflects in one direction and then returns to zero. When the switch is opened, the galvanometer deflects in the opposite direction and again returns to zero. When there is a steady current in the primary circuit, the galvanometer reads zero.

The magnitude of this emf is predicted by Faraday's law of induction. However, Faraday's law can be rewritten so that the induced emf is proportional to the changing current in the primary coil. This can be done because of the direct proportionality between the magnetic field produced by a current in a coil, or solenoid, and the current itself. The form of Faraday's law in terms of changing primary current is as follows:

$$\text{emf} = -N\frac{\Delta\Phi_M}{\Delta t} = -M\frac{\Delta I}{\Delta t}$$

The constant, M, is called the **mutual inductance** of the two-coil system. The mutual inductance depends on the geometrical properties of the coils and their orientation to each other. A changing current in the secondary coil can also induce an emf in the primary circuit. In fact, when the current through the second coil varies, the induced emf in the first coil is governed by an analogous equation *with the same value of* M.

mutual inductance

the ability of one circuit to induce an emf in a nearby circuit in the presence of a changing current

The induced emf in the secondary circuit can be changed by changing the number of turns of wire in the secondary coil. This arrangement is the basis of an extremely useful electrical device: the transformer.

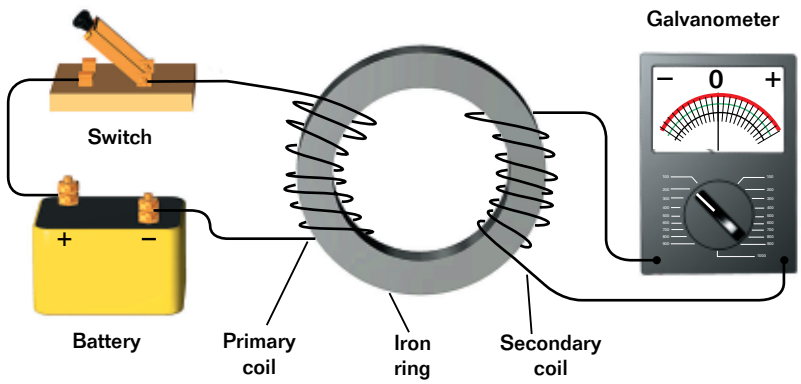

Figure 13
Faraday's electromagnetic-induction experiment used a changing current in one circuit to induce a current in another circuit.