

The magnetic field surrounding a coil in an AC circuit is constantly changing, and constantly impedes the flow of current in the circuit because of the phenomenon of inductance mentioned above. The relationship between the voltage impressed on an ideal coil (that is, a coil having no resistance) and the current flowing in it is such that the current is zero when the voltage is at a maximum, and the current is at a maximum when the voltage is zero. Furthermore, the changing magnetic field induces a potential difference in the coil, called a back emf, that is equal in magnitude and opposite in direction to the impressed potential difference. So the net potential difference across an ideal coil is always zero, as it must necessarily be in any circuit element with zero resistance.

If a capacitor (or condenser), a charge-storage device, is placed in an AC circuit, the current is proportional to its capacitance and to the rate of change of the voltage across the capacitor. Therefore, twice as much current will flow through a 2-farad capacitor as through a 1-farad capacitor. In an ideal capacitor the voltage is exactly out of phase with the current. No current flows when the voltage is at its maximum because then the rate of change of voltage is zero. The current is at its maximum when the voltage is zero, because then the rate of change of voltage is maximal. Current may be regarded as flowing through a capacitor even if there is no direct electrical connection between its plates; the voltage on one plate induces an opposite charge on the other, so, when electrons flow into one plate, an equal number always flow out of the other. From the point of view of the external circuit, it is precisely as if electrons had flowed straight through the capacitor.

It follows from the above effects that if an alternating voltage were applied to an ideal inductance or capacitance, no power would be expended over a complete cycle. In all practical cases, however, AC circuits contain resistance as well as inductance and capacitance, and power is actually expended. The amount of power depends on the relative amounts of the three quantities present in the circuits.

## IX HISTORY

The fact that amber acquires the power to attract light objects when rubbed may have been known to the Greek philosopher Thales of Miletus, who lived

about 600 BC. Another Greek philosopher, Theophrastus, in a treatise written about three centuries later, stated that this power is possessed by other substances. The first scientific study of electrical and magnetic phenomena, however, did not appear until AD 1600, when the researches of the English doctor William Gilbert were published. Gilbert was the first to apply the term electric (Greek *elektron*, “amber”) to the force that such substances exert after rubbing. He also distinguished between magnetic and electric action.

The first machine for producing an electric charge was described in 1672 by the German physicist Otto von Guericke. It consisted of a sulphur sphere turned by a crank on which a charge was induced when the hand was held against it. The French scientist Charles François de Cisternay Du Fay was the first to make clear the two different types of electric charge: positive and negative. The earliest form of condenser, the Leyden jar, was developed in 1745. It consisted of a glass bottle with separate coatings of tinfoil on the inside and outside. If either tinfoil coating was charged from an electrostatic machine, a violent shock could be obtained by touching both foil coatings at the same time.

Benjamin Franklin spent much time in electrical research. His famous kite experiment proved that the atmospheric electricity that causes the phenomena of lightning and thunder is identical with the electrostatic charge on a Leyden jar. Franklin developed a theory that electricity is a single “fluid” existing in all matter, and that its effects can be explained by excesses and shortages of this fluid.