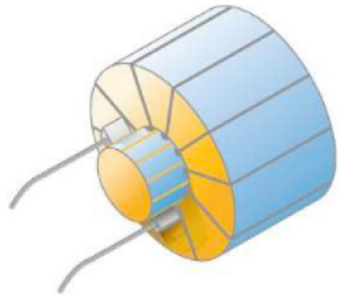

FIGURE 20–37 Motor with many windings.

Most motors contain several coils, called *windings*, each located in a different place on the armature, Fig. 20–37. Current flows through each coil only during a small part of a revolution, at the time when its orientation results in the maximum torque. In this way, a motor produces a much steadier torque than can be obtained from a single coil.

PHYSICS APPLIED
AC motor

An **ac motor**, with ac current as input, can work without commutators since the current itself alternates. Many motors use wire coils to produce the magnetic field (electromagnets) instead of a permanent magnet. Indeed the design of most motors is more complex than described here, but the general principles remain the same.

* Loudspeakers

A **loudspeaker** also works on the principle that a magnet exerts a force on a current-carrying wire. The electrical output of a stereo or TV set is connected to the wire leads of the speaker. The speaker leads are connected internally to a coil of wire, which is itself attached to the speaker cone, Fig. 20–38. The speaker cone is usually made of stiffened cardboard and is mounted so that it can move back and forth freely. A permanent magnet is mounted directly in line with the coil of wire. When the alternating current of an audio signal flows through the wire coil, which is free to move within the magnet, the coil experiences a force due to the magnetic field of the magnet. As the current alternates at the frequency of the audio signal, the coil and attached speaker cone move back and forth at the same frequency, causing alternate compressions and rarefactions of the adjacent air, and sound waves are produced. A speaker thus changes electrical energy into sound energy, and the frequencies and intensities of the emitted sound waves can be an accurate reproduction of the electrical input.

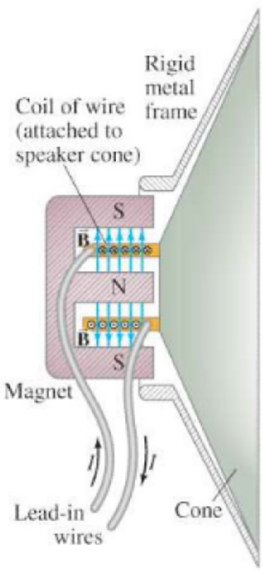

FIGURE 20–38 Loudspeaker.

* 20–11 Mass Spectrometer

PHYSICS APPLIED
The mass spectrometer

A **mass spectrometer** is a device to measure masses of atoms. It is used today not only in physics but also in chemistry, geology, and medicine, often to identify atoms (and their concentration) in given samples. As shown in Fig. 20–39, ions are produced by heating, or by an electric current, in the source or sample S. They pass through slit s_1 and enter a region where there are crossed electric and magnetic fields. Ions follow a straight-line path in this region if the electric force qE (upward on a positive ion) is just balanced by the magnetic force qvB (downward on a positive ion): that is, if $qE = qvB$, or

$$v = \frac{E}{B}.$$

Only those ions whose speed is $v = E/B$ will pass through undeflected and emerge through slit s_2. (This arrangement is called a **velocity selector**.) In the semicircular region, after s_2, there is only a magnetic field, B', so the ions follow a circular path. The radius of the circular path is found from their mark on film (or detectors) if B' is fixed; if instead r is fixed by the position of a detector, then B' is varied until detection occurs. Newton's second law, $\Sigma F = ma$, applied to an ion moving in a circle under the influence only of the magnetic

FIGURE 20–39 Bainbridge-type mass spectrometer. The magnetic fields B and B' point out of the paper (indicated by the dots).