



FIGURE 16–47 Inside a laser printer: A movable mirror sweeps the laser beam in horizontal lines across the drum.

of paper which has been positively charged more strongly than the selenium, so the toner particles are transferred to the paper, forming the final image. Finally, step 5, the paper is heated to fix the toner particles firmly on the paper.

In a color copier (or printer), this process is repeated for each color—black, cyan (blue), magenta (red), and yellow. Combining these four colors in different proportions produces any desired color.

A *laser printer*, on the other hand, does not use a hard copy original but instead accepts a computer output which programs the intensity of a laser beam. The process is much the same as for a photocopier, involving a selenium-coated drum and toner powder, but the formation of the image onto the drum is different. The thin beam of light from a laser is focused by lenses to a fine point. By means of a movable mirror, the laser beam is scanned from side to side across the drum in a series of horizontal lines, each line just below the previous line. As the beam sweeps across the drum, the intensity of the beam is varied (by the computer output), being strong for a point that is meant to be white or bright, and weak or zero for points that are meant to come out dark. After one sweep, the drum rotates very slightly, and another horizontal sweep is made, and then another and another, Fig. 16–47. As the drum turns, a complete image is formed on it. The light parts of the selenium become conducting and lose their electric charge, and the toner sticks only to the dark, electrically charged areas. The drum then transfers the image to paper, as in a photocopier.

An inkjet printer does not use a drum. Instead nozzles spray tiny droplets of ink directly at the paper. The nozzles are swept across the paper, each sweep just above the previous one as the paper moves down. On each sweep, the ink makes dots on the paper, except for those points where no ink is desired, as directed by the computer. The image consists of a huge number of very tiny dots. The quality or resolution of a printer is usually specified in dots per inch (dpi) in each (linear) direction.

 **PHYSICS APPLIED**
Laser printer

 **PHYSICS APPLIED**
Inkjet printer

Summary

There are two kinds of **electric charge**, positive and negative. These designations are to be taken algebraically—that is, any charge is plus or minus so many coulombs (C), in SI units.

Electric charge is **conserved**: if a certain amount of one type of charge is produced in a process, an equal amount of the opposite type is also produced; thus the *net* charge produced is zero.

According to the atomic theory, electricity originates in the atom, which consists of a positively charged nucleus surrounded by negatively charged electrons. Each electron has a charge $-e = -1.6 \times 10^{-19}$ C.

Electric **conductors** are those materials in which many electrons are relatively free to move, whereas electric

insulators are those in which very few electrons are free to move.

An object is negatively charged when it has an excess of electrons, and positively charged when it has less than its balanced number of electrons. The net charge on any object is zero or a whole number times $+e$ or $-e$. That is, charge is **quantized**.

An object can become charged by rubbing (in which electrons are transferred from one material to another), by conduction (which is transfer of charge from one charged object to another by touching), or by induction (the separation of charge within an object because of the close approach of another charged object but without touching).