actual displacement. For instance, if the intake stroke of a piston completely filled the cylinder with fuel/air mixture at ambient pressure, it would be 100% efficient.

Normally, aspirated engines are those that draw the fuel/air mixture into the cylinders by the partial pressure created on the downstroke of the piston. During the downstroke in a four-stroke cycle, the pressure in the cylinder becomes less than that of the ambient air, so the fuel/air mixture is "sucked" into the cylinder through an intake valve. Such engines are never 100 percent efficient, for a number of reasons.

At high RPM, the entire operation happens so quickly, the mixture simply doesn't have enough time to fill the cylinder before the intake valve slams shut. Under the best of conditions, the airflow is slowed by obstacles such as bends in the manifold. Even if 100 percent efficiency were possible, there still is the problem of decreasing air density, which accounts for as much as 50 percent loss of power at 12,000 feet.

The solution to some of those problems is the turbocharger. Instead of mechanical linkage connecting the unit to the engine, a free-turning, vaned wheel is placed directly in the engine exhaust stream, as depicted in Figure 7-2. The turbine wheel, driven by engine exhaust, is connected to the impeller portion of a centrifugal compressor assembly. The impeller directs ambient air to the spinning compressor axis. The air is spun at a very high velocity, forcing it outward and causing increased pressure. This high-pressure air then is ducted through the intake manifold of the engine to the various cylinders, as shown in Figure 7-3.

Using engine exhaust to power a turbocharger makes it seem like you're getting something for nothing, but there are disadvantages. One of the major problems is the adverse operating conditions of the turbocharger itself. The turbine and compressor routinely rotate at speeds in excess of 100,000 RPM. The turbine, which drives the entire unit, is subjected to extremely high engine-exhaust temperatures.

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Fig. 7-2. *Basic turbocharger diagram.*