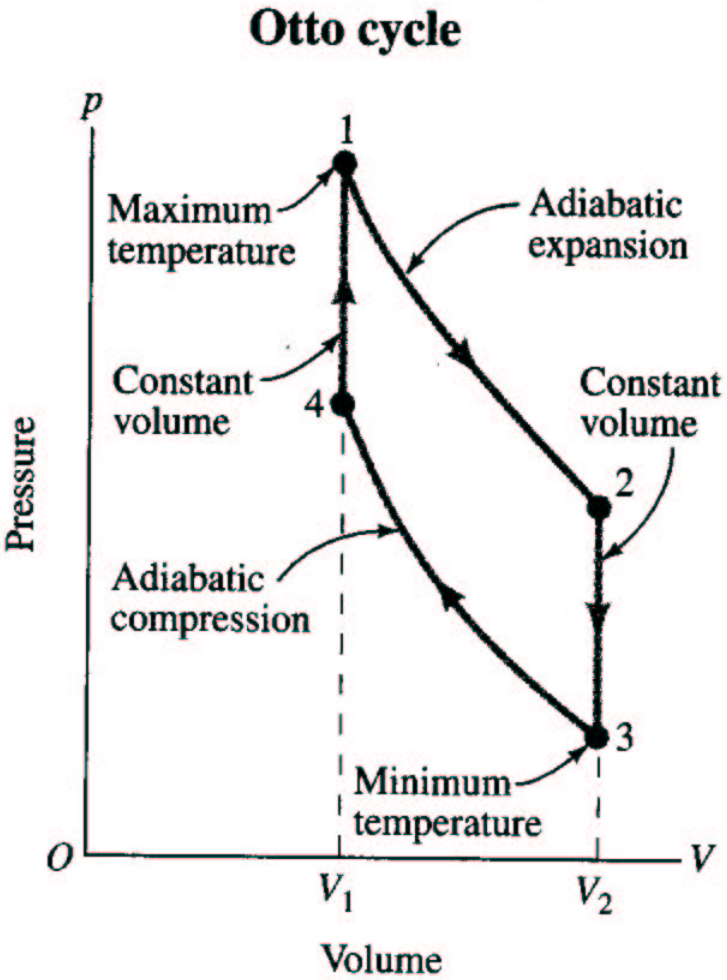


**FIGURE 20AB–2** The Otto cycle, for the engine designed by Nikolaus Otto in 1876.

**31.** (II) The Otto cycle, represented in Figure 20AB–2, runs between minimum and maximum volumes $V_1$ and $V_2$ and minimum and maximum temperatures $T_1$ and $T_2$, respectively. (a) Show that the efficiency is given by $\eta = 1 - (T_2 - T_3)/(T_1 - T_4)$. (b) Show that if the working fluid of the cycle is an ideal gas, the efficiency of this cycle can alternatively be written as $\eta = 1 - (V_1/V_2)^{\gamma-1}$, where $\gamma = C_p/C_V$. The efficiency of this cycle is thus *independent* of the temperatures between which it operates, depending instead only on $\gamma$ and on geometry. The ratio $V_2/V_1$ is the compression ratio. A typical compression ratio is 8, and $\gamma = 1.4$, which gives a predicted efficiency of 56 percent.