large changes in volume, the pressure built up in the throat of the horn is no longer sinusoidal, as can be seen from Fig. 9.11. The pressure wave so generated travels away from the throat toward the mouth.

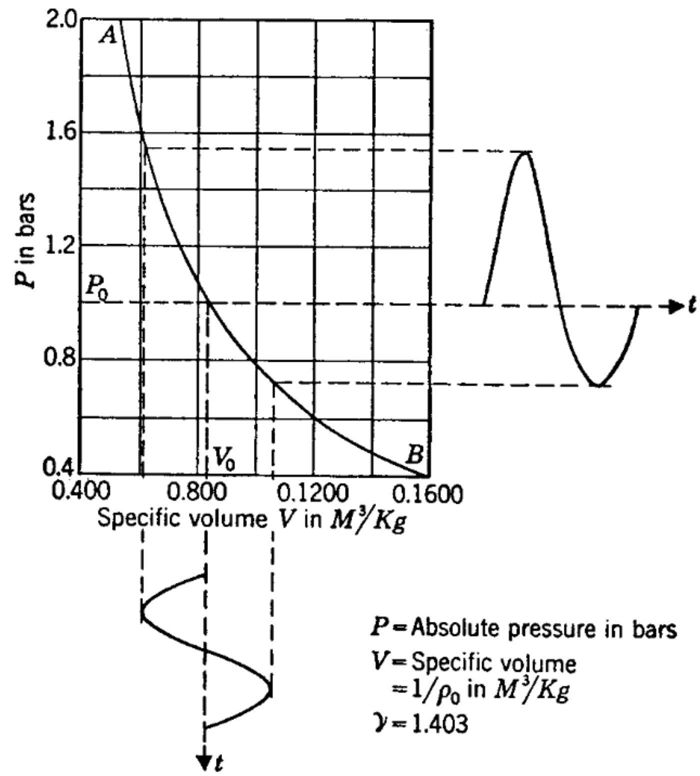

FIG. 9.11. Plot of the gas equation $PV^\gamma = 1.26 \times 10^4$, valid at 20°C. Normal atmospheric pressure (0.76 m Hg) is shown as $P_0 = 1$ bar.

If the horn were simply a long cylindrical pipe, the distortion would increase the farther the wave progressed according to the formula (air assumed)[3,4]

$$\frac{p_2}{p_1} = \frac{\gamma + 1}{\sqrt{2}\gamma} k \frac{p_1}{p_0} x = 1.21k \frac{p_1}{p_0} x \tag{9.31}$$

where p_1 = rms sound pressure of the fundamental frequency in newtons per square meter
p_2 = rms sound pressure of the second harmonic in newtons per square meter
P_0 = atmospheric pressure in newtons per square meter
$k = \omega/c = 2\pi/\lambda$ = wave number in meters^{-1}
γ = 1.4 for air
x = distance the wave has traveled along the cylindrical tube in meters

[3] A. L. Thuras, R. T. Jenkins, and H. T. O'Neil, Extraneous Frequencies Generated in Air Carrying Intense Sound Waves, *J. Acoust. Soc. Amer.*, **6**: 173–180 (1935).

[4] L. H. Black, A Physical Analysis of the Distortion Produced by the Non-linearity of the Medium, *J. Acoust. Soc. Amer.*, **12**: 266–267 (1940).