88. The "alpenhorn" (Fig. 12–38) was once used to send signals from one Alpine village to another. Since lower frequency sounds are less susceptible to intensity loss, long horns were used to create deep sounds. When played as a musical instrument, the alpenhorn must be blown in such a way that only one of the overtones is resonating. The most popular alpenhorn is about 3.4 m long, and it is called the F sharp (or G flat) horn. What is the fundamental frequency of this horn, and which overtone is close to F sharp? (See Table 12–3.) Model as an open tube.

FIGURE 12–38 Problem 88.

89. Room acoustics for stereo listening can be compromised by the presence of standing waves, which can cause acoustic "dead spots" at the locations of the pressure nodes. Consider a living room 5.0 m long, 4.0 m wide, and 2.8 m high. Calculate the fundamental frequencies for the standing waves in this room.

90. A dramatic demonstration, called "singing rods," involves a long, slender aluminum rod held in the hand near the rod's midpoint. The rod is stroked with the other hand. With a little practice, the rod can be made to "sing," or emit a clear, loud, ringing sound. For a 90-cm-long rod, (*a*) what is the fundamental frequency of the sound? (*b*) What is its wavelength in the rod, and (*c*) what is the traveling wavelength in air at 20°C?

* 91. The intensity at the threshold of hearing for the human ear at a frequency of about 1000 Hz is $I_0 = 1.0 \times 10^{-12}\,\text{W/m}^2$, for which β, the sound level, is 0 dB. The threshold of pain at the same frequency is about 120 dB, or $I = 1.0\,\text{W/m}^2$, corresponding to an increase of intensity by a factor of 10^{12}. By what factor does the displacement amplitude, A, vary?

* 92. A plane is traveling at Mach 2.0. An observer on the ground hears the sonic boom 1.5 min after the plane passes directly overhead. What is the plane's altitude?

* 93. The wake of a speedboat is 15° in a lake where the speed of the water wave is 2.2 km/h. What is the speed of the boat?

Answers to Exercises

A: 1 km for every 3 s before the thunder is heard.
B: 4 times as intense.
C: One-quarter its original value; 6 dB.
D: 257 Hz.
E: 6 Hz.
F: (*a*) 1717 Hz, (*b*) 1483 Hz.