It is thus incumbent on industrial managements to recognize the trend toward more noisy occupations and toward compensation for industrial hearing loss; to understand the medical, legal, and engineering developments relative to industrial noise; and to examine their own operations in the light of these developments.

I. Fundamentals of Noise

Noise is frequently defined as any unwanted sound. This, however, is a functional definition and not a physical one. The question of whether a sound is wanted or not depends not only on the individual, but also on the circumstances. Let us momentarily bypass the subjective portion of the problem and examine the physical nature of sound.

A. WHAT IS SOUND?

Sound is a traveling disturbance, which usually appears as variations in the pressure and density of the atmosphere. A source of sound that is familiar yet physically simple is the tuning fork. When struck, the tines vibrate to and fro, setting the surrounding air into motion. The relative motion of the air in neighboring regions causes pressure fluctuations above and below atmospheric pressure. These pressure fluctuations, known as *compressions* (regions of increased pressure) and *rarefactions* (regions of reduced pressure), travel outward from the source in all directions and produce a *sound wave* (see Figure 1).

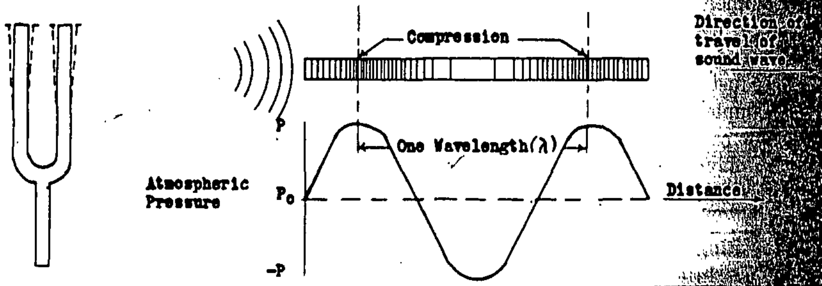

Figure 1. A schematic representation of a sound wave generated by a tuning fork and a plot of the sound pressure against distance at one instant of time. (After Pietrasanta.)[1]

B. PURE TONES

The sound produced by a tuning fork is a simple tone, pure and steady. In fact, it is often called a pure tone. The pressure variations for such a tone follow the sine wave pattern shown in Figure 1. This figure shows the pressure pattern

[1] A. C. Pietrasanta, Some fundamental principles of noise control, *Refrig. Eng.*, 62, 87, 100 (April, 1954); **62,** 56, 96, 98, 102 (May, 1954).

at a certain instant. Since the entire sound wave is travelling away from the source at a speed of about 1100 feet per second (the velocity of sound at freezing (32° F.) is 1087 feet per second, and it increases about one foot per second for each degree Fahrenheit increase in temperature), the pressure pattern an instant later would show the sine wave displaced slightly to the right.

C. FREQUENCY

Were the tuning fork smaller, the vibrations would be more rapid. More cycles, complete to and fro vibrations of the tines, would occur in a second. The frequency of the sound, which is the number of cycles per second (c.p.s.), would, therefore, be higher.

D. WAVE LENGTH

By the time this higher frequency sound wave has advanced the same distance as the one shown in Figure 1, more cycles of compression and rarefaction of the atmosphere would have been emitted by the source. In order that this increased number of cycles exist in the same space, the distance from the peak of one compression to the peak of the next must be smaller. This distance between compressions is called a wave length and is designated by the symbol λ (lambda). Its relationship to the frequency, f, and the speed of sound, c, is given by the equation:

$$f\lambda = c \qquad (1)$$

For instance, for a frequency of 1100 c.p.s. the wave length is one foot; 110 c.p.s. the wave length would be 10 feet. In both cases the frequency times the wave length is equal to the speed of sound, and this relationship holds no matter what the frequency.

E. SOUND PRESSURE

It is easy to see that these two related quantities, frequency and wave length, do not describe completely the tone produced by the tuning fork. The fork may be hit lightly and produce a faint sound, or firmly and produce a loud sound. Both sounds will have exactly the same frequency and wave length since the tines will vibrate to and fro the same number of times in a second. The harder the fork is struck, however, the greater the distance the tines travel during each cycle. This increased distance travelled by the tines will cause greater pressure fluctuations above and below atmospheric pressure. Thus the harder the tines are struck, the greater the height of the sound wave shown in Figure 1.

The difference between the atmospheric pressure and the actual pressure during a rarefaction or compression resulting from a sound wave is called the *sound pressure*. A convenient way to measure this sound pressure is in fractions of a bar, which is a unit of pressure equal to atmospheric pressure (bar comes from the same Greek word as does the word barometer, the instrument that measures