It is often possible to compute the sound intensity from the sound pressure by using the equation:

$$I = (1.52\ p)^2$$

where I is the sound intensity in μwatts per square foot, p the sound pressure in μbars, and the constant 1.52 holds for normal atmospheric conditions. Very close to a sound source and in regions where the reflection of sound from other surfaces is important this equation will not be correct. However, in the intermediate region between these two extremes it will be at least approximately right.

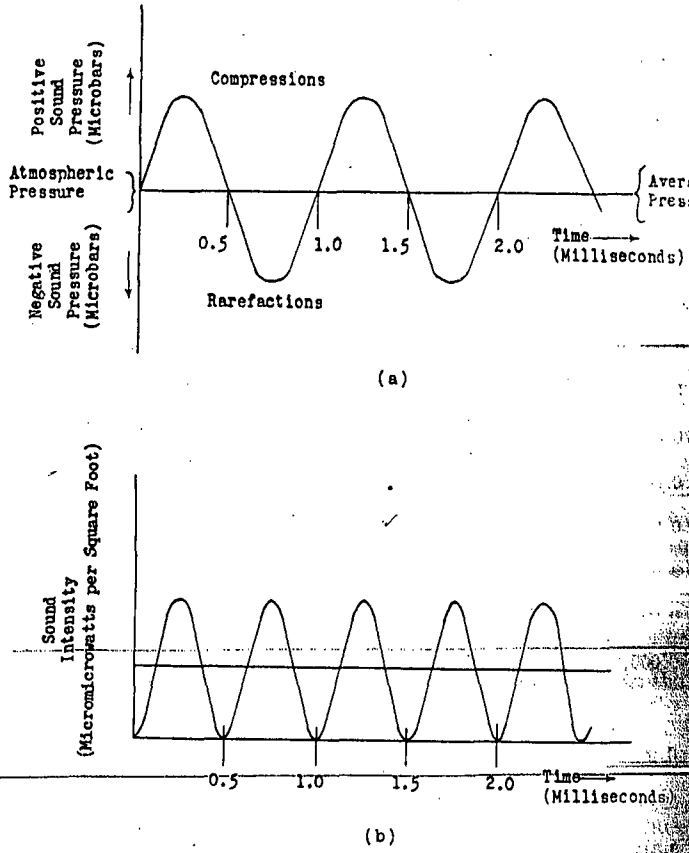


Figure 2. (*a*) Variations in *sound pressure* measured at a fixed point resulting from the passing of a 1000 c.p.s. wave; (*b*) variations in *sound intensity* measured at a fixed point resulting from the passing of a 1000 c.p.s. wave.

As an example let us compute the sound intensity that is equivalent to the faintest sound discernible by a listener with acute hearing. Usually this listener can just barely hear a 1000 c.p.s. tone when the maximum pressure increase above and decrease below atmospheric pressure is about 0.00028 μbar (see Figure 2). Inserting this pressure in the equation gives a maximum sound intensity of 0.181 $\mu\mu$watt per square foot ($\mu\mu$watt is an abbreviation for micromicrowatt).

Notice in Figure 2 that the sound intensity is not steady, but varies in a pulsating fashion. With each rarefaction or compression a pulse of sound energy is carried away from the sound source. The average intensity is one half the maximum intensity. For more complicated sounds the average intensity is usually a great deal more meaningful than is the maximum intensity.

H. THE R.M.S. SOUND PRESSURE

Sound-measuring instruments are designed to measure the r.m.s. sound pressure as closely as possible. The abbreviation r.m.s. stands for root-mean-square, which means that the sound pressures are first squared, then averaged, and finally the square root of the average is taken (the words "average" and "mean" are synonymous). In the example worked out above the barely audible 1000 c.p.s. tone had a maximum sound pressure of 0.00028 μbar. The equivalent r.m.s. sound pressure is 0.0002 μbar.

I. COMPLEX SOUNDS

Sounds measured by these instruments are rarely as simple as that produced by the tuning fork (Figures 1 and 2). Even the note of a violin is more complicated than the pure tone, for it is made up of a number of pure tones whose frequencies are related by simple numbers. As an example, consider the musical tone in Figure 3a. It may be formed by adding together the three pure tones shown in Figure 3b. Any change in the sound pressure or frequency of these components would alter the resulting sound.

A pure tone sounded at the frequency of the lowest component, in this case 100 c.p.s., would have the same pitch as the combination of tones. However, the combination will be a richer, more musical sound than the single tone. This 100 c.p.s. tone is called the fundamental. The 200 and 300 c.p.s. tones are called the second and third harmonics, respectively. The number of the harmonic can always be computed by finding the number of times the frequency of the fundamental may be divided into the frequency of the harmonic. If the frequency of one sound cannot be related simply to the frequency of another, the combination of the two will be discordant. We then say that the sounds are inharmonically related.

Notice that the peak pressure variation caused by the combination of tones (Figure 3a) is only slightly greater than the peak pressure variations caused by the fundamental alone (Figure 3b). However, if we express the sound wave in