SOME UNTENABLE ACOUSTIC THEORIES.

Abstract.

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The fact that the mathematical theory of acoustics is based on the assumption of infinitely small displacements of the vibrating particles and the further fact that experiments have proven that these displacements are actually exceedingly small except in the case of very loud sounds, are known and accepted by all physicists. Nevertheless, many of us persist in making deductions and forming mental pictures entirely at variance with these facts.

In some former publications[1] I have taken exception to several generally accepted notions as to how sound waves act when passing into and through tubes, horns, etc. I hold that sound waves do not pass through a "condensing" horn like water passes through a funnel. Several physicists with whom I have talked recently had seen nothing wrong with the "condenser" theory. They thought of sound waves in a funnel as if they were air disturbances caused by moving a piston back and forth in one end of the funnel. Whether this conception is a true or a false picture of what happens in the case of audible sound waves depends altogether on how the piston moves. If it moves with the proper frequency and with very small amplitude then the disturbance is a sound wave and it obeys the laws of sound waves. But if the piston is moved slowly or through a considerable distance, then the disturbance is not propagated as a sound wave at all. In the latter case the air would move largely as a mass, and the velocity of its motion would be greatest in the small part of the funnel. In the former case, if the sound were not very intense,[2] the wave would travel more slowly in the smaller part of the funnel. If a hole were made in the side wall of the small cylindrical end of a funnel a slow motion of the piston producing compression would cause the air to flow out of the hole. A rapid motion would cause air to flow in at the hole (Bernoulli's principle). Many other differences might be noted. In fact the two cases are wholly different. Pressure is the important consideration in one case, inertia in the other. One is a case of mass motion; the other of molecular motion.

When a sound wave strikes a wall the wall should not be thought of as vibrating as a whole, even if the wall be thin. The wave strikes one side of the wall and causes the molecules to vibrate harmonically. The disturbance is propagated through the wall as a wave and the

[1] The Velocity of Sound Waves in Tubes. Proc. Ind. Acad. Sci., 1918, pp. 205-213. A Photographic Study of Sound Pulses Between Curved Walls and Sound Amplification by Horns. Phys. Rev., S. S., Vol. 20, No. 6, Dec., 1922.

[2] A Photographic Method of Finding the Instantaneous Velocity of Spark Waves. Phys. Rev., N. S., Vol. 16, No. 5, pp. 449-463.

molecules on the two opposite faces are not in the same phase. To say they are vibrating together is equivalent to saying that the velocity of sound in the wall is infinite. Of course, if the wall were very thin the phase difference on the two faces would be very small and the wall would be moving *approximately* as a whole. But if the wall happened to be a half wave in thickness the molecules on the two faces would be *moving in opposite directions all the time.*

Another mistaken idea is that sound, because of its considerable wave length, can not be reflected appreciably with a small reflector. Except in so far as the coefficient of reflection varies with frequency (and the rate of variation is generally small), the per cent of sound energy reflected by a given reflector is entirely independent of the fact that sound waves are long waves. The per cent of sound energy reflected is a function of the coefficient of reflection and the solid angle subtended by the reflector as seen from the sound source, rather than the size of the reflector. Diffraction as the waves leave the reflector is quite another matter. Even if the sound source is at the focus of a parabolic reflector a large amount of energy is lost by diffraction. Nevertheless, a considerable quantity of the reflected energy continues in the direction of the axis of the parabola and is added to the energy originally started in that direction.

The common megaphone shows that small reflectors function with considerable efficiency. We use a still smaller one when we place our hand to our ear to aid our hearing.

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