On the Relative Velocities of Sound Waves of Different Intensities.

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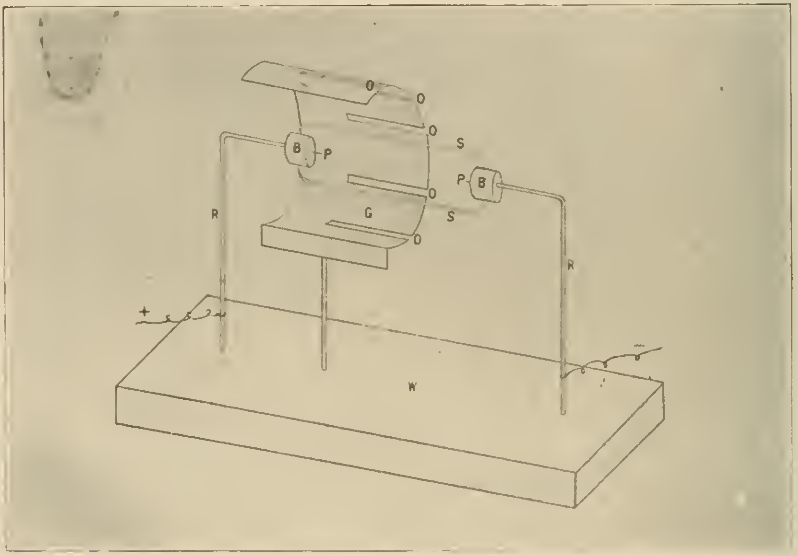
It appears that the first determination of the velocity of sound that can lay claim to any accuracy was made by Cassini, Maraldi, and LaCaille, of the Paris Academy, in 1738. By noting the time interval between seeing the flash of a cannon and hearing the report, with different distances between gun and experimenter, they arrived at the conclusion that the velocity of sound is independent of the intensity. This conclusion seems to have been accepted for more than a century. In 1864 Regnault determined the velocity of sound by firing guns reciprocally and using an electrical device for recording the instant of firing the gun and the arrival of the sound vave at the distant station. He found a small difference, about six parts in three thousand, in the velocities measured when the stations were 1,280 meters apart and when they were 2,445 meters apart, the former being the greater. The difference he attributed to the fact that the average intensity of the sound when the stations were nearest was much greater than when farthest apart, thus reaching the conclusion that the velocity of sound is a function of its intensity.

Regnault's conclusion accords with theory and with experimental results obtained by several later experimenters. Among these may be named Jacques at Watertown, Mass., 1879, who obtained velocities of 1,076 feet per second, and 1,267 feet per second, at points 20 feet and 80 feet respectively to the rear of a cannon fired with a charge of one and one-half pounds of powder. Wolfe and others have found varying velocities for explosion waves, a wave from an electric spark being of this nature. A fuller consideration of these experiments will be given when the writer has completed his experimental work on this subject.

The apparatus in use in this investigation, which is still in progress, is practically the same as described by the writer in a paper published three years ago under the title "A New Method of Photographing Sound Waves."[1] But three changes have been made in the apparatus there shown. One is the short-circuiting of the capacity by a high resistance and inductance to give better regulation of the time interval between the sound and illuminating

[1]Physical Review, Vol. XXXV, No. 5, Nov., 1912.

sparks, a method described elsewhere in these Proceedings. A second is a considerable increase in the two capacities, to obtain waves of greater intensity. A third is a modification of the sound gap, or rather a disposition of screens about the sound spark in order to obtain waves from the same spark of both great and small intensity. These waves are photographed on the same plate, enabling one to determine their relative velocities. A few of the results are given in this preliminary paper.



The details of the sound gap and screen are shown in Figure 31. A heavy spark is passed between the platinum terminals P-P. This produces a cylindrical sound wave shown in section at S, S. G is a cylindrical metal screen, which I shall call a grating, concentric with the spark axis, and having longitudinal slits or apertures O, O, cut in it, as shown in the figure, thus forming a sort of grating. The grating is so placed that it intercepts but one end, the left end in the figure, of the cylindrical wave, the right end or half spreading out the same as if the grating were not in use. I shall call this wave the main wave. Some of the energy of the left end of the wave is reflected by the grating, but some of it passes through the apertures which thus become sound sources, the waves spreading out in every direction from these sources. I shall call these waves wavelets.

The energy at any point in the wave front of the wavelets must be small compared to the energy at any point in the main wave, for two reasons. In the first place only a fraction of the energy of the original wave passes through the apertures. In the second place, what does get through spreads out to form the wavelets and thus greatly reduces the energy propagated in a particular direction. If the speed of propagation decreases with the energy of the sound wave, and, therefore, with the intensity, it would seem that our photographs should show two results: the velocity of a wavelet should be less than that of the main wave, and the wave front of a wavelet should not be circular, because the energy at a point in the wavelet falls off rapidly as the distance from the pole of the wave increases. One need not cite Stokes's law, for the pictures clearly indicate a variation in intensity along the front of the wavelets. Yet, taking into consideration the breadth of the apertures the wavelets are circular, showing that the velocity of the pole of the wave is not greater than the velocity tangent to the grating surface. Nor does the breadth of the aperture, and, therefore, the energy passing through, appear to make any difference in the velocity. It will be noted that the photographs show apertures of four different sizes.

The photographs show that the main wave and the poles of all the wavelets are tangent to one another, and since the wavelets are circular, that the velocity of the attenuated wavelet propagated tangent to the grating surface is not less than the velocity of the main wave of much greater intensity.

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