THE VELOCITY OF SOUND IN GASES AT LOW PRESSURES*

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Recent measurements of the velocity of sound (Abbey and Barlow 1948; Maulard 1949), indicate that at pressures below 15 cm. Hg there is an increase of velocity unaccounted for by theory. In 1948 the author measured the velocity of sound in a tube 7 cm. in diameter at a frequency of 1000 c/s. A change in velocity at pressures below 20 cm. Hg was observed for several gases investigated. For air, the velocity increased by 9 m. sec.$^{-1}$ at a pressure of $0 \cdot 5$ cm. Hg. It was suggested that the increase might be due to an error in the tube correction.

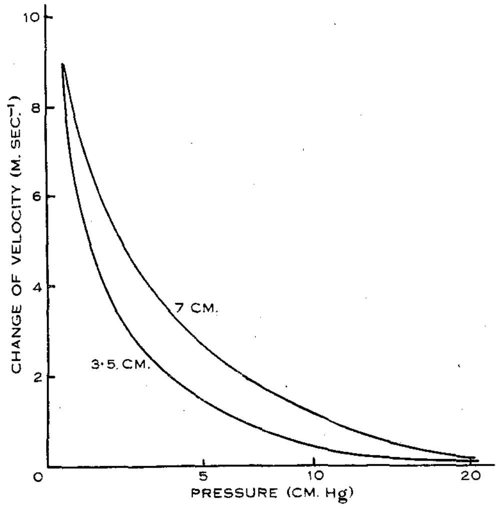

Fig. 1.—Velocity changes in 7 and $3 \cdot 5$ cm. diameter tubes.

Later, Maulard (1949), in France, measured the time taken for a pulse to travel a measured distance in a tube 8 cm. in diameter. The method was not sensitive enough for measurements to be made below a pressure of 4 cm. Hg, but at this pressure the velocity had increased by about 14 m. sec.$^{-1}$. The probable reason for this discrepancy between the results of Maulard and the author arises from the difference between the methods used, and will be discussed later in this communication.

As the tube correction is inversely proportional to both the diameter of the tube and the square root of the frequency, an error in this formula will be more appreciable for small diameters and low frequencies when the correction becomes large. Both these factors have been studied in a further series of measurements.

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Effect of Tube Diameter

A new apparatus was constructed with the same principle of operation as previously, but with the following modifications in design. The tube diameter was reduced to 3·5 cm. It was not lagged but was painted black and measurements were made in a room where the temperature was constant. The tube did not have a rubber section as before, but the speaker was mounted inside the tube on three small pieces of sponge rubber. The microphone was a light crystal earphone, also mounted on sponge rubber. This construction gave a better

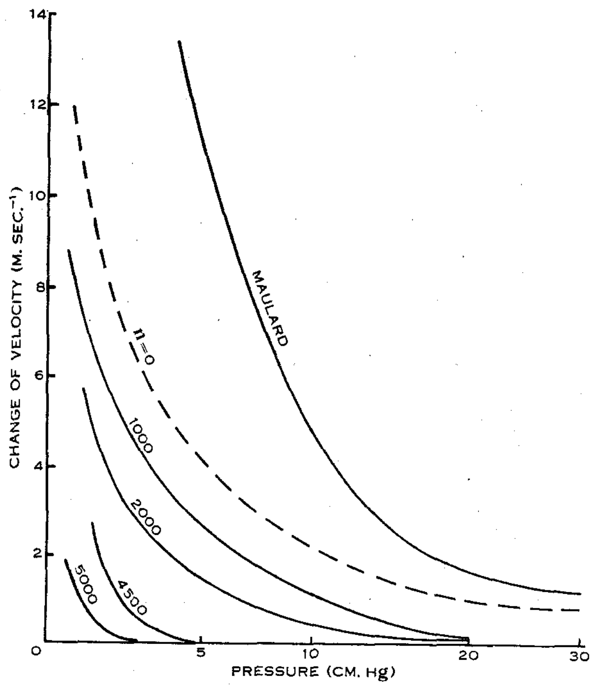

Fig. 2.—Velocity changes for different frequencies.

protection against the vibrations being transmitted through the walls of the tube. A microphone preamplifier increased the sensitivity for measurements at lower pressures.

The results of measurements in air are shown in Figure 1 compared with the previous results for the 7 cm. tube. The velocity increase is slightly less for the smaller diameter tube, but this is not considered significant within the limits of experimental error. These results indicate that the effect is not due to the tube correction alone.

Effect of Frequency

Using the apparatus with the 7 cm. tube described in the previous paper, the velocity of sound in air was measured at frequencies of 2000, 4500, and 5000 c/s. The different frequencies were obtained by changing the value of the inductance and capacitance in the tuned circuit of the amplifier. The results of these measurements are shown in Figure 2. It was found that the velocity change becomes smaller as the frequency increases. Assuming this dependence on frequency continues uniformly for frequencies less than 1000 c/s., a curve for zero frequency was obtained. This limit is shown by the dotted curve in Figure 2.

This frequency dispersion gives a possible explanation for the higher increase of velocity with pressure reported by Maulard. His results, as shown in the curve in Figure 2 would correspond to a very low frequency. This agrees with his description of the pulse, the wavelength of which corresponds to a frequency of about 200 c/s. The observed increase of pulse length with distance of propagation would be expected both from the above effect and the tube correction which is also a function of the frequency. Maulard's results still lie beyond the zero frequency limit however, but experimental error (2 m. sec.$^{-1}$), the uncertainties associated with measuring a pulse containing a range of different velocities, and the possible error in extrapolation to zero frequency may account for this remaining discrepancy.

References

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Maulard, J. (1949).—*C.R. Acad. Sci. Paris* **229** : 1, 25.