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METHODOLOGICAL NOTES

EFFECT OF THE JOINT MOTION OF A SOUND SOURCE AND RECEIVER ON THE PHASE DIFFERENCE BETWEEN THEIR OSCILLATIONS

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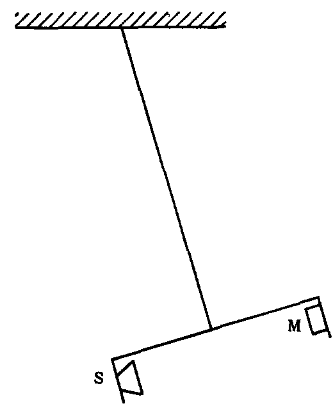
THIS demonstration is based on the fact that when a loudspeaker and microphone move at a common velocity v in the direction of sound propagation an extra phase difference,

$$\Delta\varphi=\frac{\omega l}{c-v}-\frac{\omega l}{c}\approx\frac{\omega l v}{c^2},$$

arises between the vibrations emitted by the loudspeaker and those received at the microphone. Here ω is the angular frequency, c is the velocity of sound in air, and l is the distance between the speaker and the microphone.

For the purpose of observing this effect a speaker and microphone are fastened to a board (l = 70 cm) that is attached to a pendulum rod 1.6 m long (see the figure); the pendulum period is 2.5 sec. The speaker is connected to a sound generator (ν = 10 kc/sec). The signal received by the microphone is augmented by a resonance amplifier. The ellipse displayed on an oscilloscope screen demonstrates the phase difference between the amplified microphone signal and the vibrations of the sound source.



To begin with, the pendulum remains at rest while a small variation of the generator frequency produces a slanted line on the screen. Next, while the pendulum is swinging freely the straight line becomes a periodic ellipse. For example, if the pendulum rod is initially inclined at 30° and the velocity of the board is of the order 2 m/sec through the equilibrium position, then the additional phase difference is of the order of 50°. Subsequently the board bearing the speaker and microphone is rotated until it is perpendicular to the plane of pendulum oscillations; then no additional phase difference is observed.

This demonstration can be utilized both in a mechanics course and in an optics course when the basic principles of the Fizeau and Michelson experiments are being explained.

536.7 + 538.3

TWO LECTURE DEMONSTRATIONS

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1. A wheel with rubber spokes operated as a cyclic heat engine. Utilizing the characteristic increase of tension that accompanies the heating of stretched rubber, an ingenious demonstration of a heat engine becomes possible.[1]

A light wheel (weighing about 60 g) consists of a central disk 5 cm in diameter, a rim of 22 cm o.d. and 20 cm i.d., and four rubber spokes 3–4 cm wide. The rim and central disk each consist of two layers of Duralumin 0.3 mm thick. The spokes, made of surgical-glove rubber, are fastened between these layers by means of cement and light clamps that press the layers together (Fig. 1). The wheel can be rotated about its horizontal axis with very little friction. The center