MANUAL

MELDE'S EXPERIMENT

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MELDE'S EXPERIMENT

Aim: - To determine the frequency of a vibrating bar, or tuning fork using Melde's arrangement.

Apparatus:- Battery Eliminator, Connecting wires, Metre Scale, thread, pan, weight box, Smooth pulley fixed to a stand, electrically maintained vibrator or a tuning fork.

Description: - An electrically maintained tuning fork consists of an electro – magnet between the two prongs of a tuning fork without touching either of the prongs, as shown in fig.1. To one of the prongs a thin brass plate with an adjustable screw is riveted on it. By adjusting the screw, contact is established with the thin brass plate.

Electrical connections are made as shown in fig.1. The electrical current flows through the circuit energising the electro magnet there by pulling both the prongs inwards. The circuit is broken immediately at the point S, the electro-magnet loses its magnet magnetism and the prongs fly back to its position. Consequently contact is once again established at S, the circuit is closed and the process repeats automatically as before. This causes the prongs of the tuning fork to vibrate.

One end of thin thread is connected to a small screw provided on one of the prongs of the tuning fork. The other end of the thread is connected to a light pan and the thread is passed over a small friction free pulley fixed on to a stand kept at distance of 3 to 4 meters from the fork. Small weights are placed in the pan so that sufficient tension is created to the string. The tension in the string can be altered by changing the weights in the pan.

The tuning fork (or a single vibrating bar) is arranged as shown in fig. 1 (a) for longitudinal vibrations, i.e., the vibrations of the prongs are parallel of the length of the string. After noting the observations in the position, the tuning fork is arranged as shown in fig. 1(b) for transverse vibrations; i.e., the vibrations of the prong are perpendicular to the length of the string. It is to be noted that the cases, the stretched string should vibrate at right angle to its length (and both the cases are transverse vibrations of the stretched string) in case the stretched string after forming loops rotates, then small weights are either to be added in to the pan or removed from the pan to create sufficient tension in the string and the loops formation is vertical.

Theory:-

(a) **Transverse arrangement:** The fork is placed in the transverse vibrations position and by adjusting the length of the string and weights in the pan, the string starts vibrating and forms many well defined loops. This is due to the stationery vibrations set up as result of the superposition of the progressive wave from the prong and the reflected wave from the pulley. Well defined loops are formed when the frequency of each segment coincides with the frequency of the fork. The frequency η of the transverse vibrations of the stretched by tension of T dynes is given by :

$$\eta = \frac{1}{2l}\sqrt{T/m}$$

$$\eta = \frac{1}{2}\left(\frac{\sqrt{T}}{l}\right)\frac{1}{\sqrt{m}} \qquad \text{.. (1)}$$

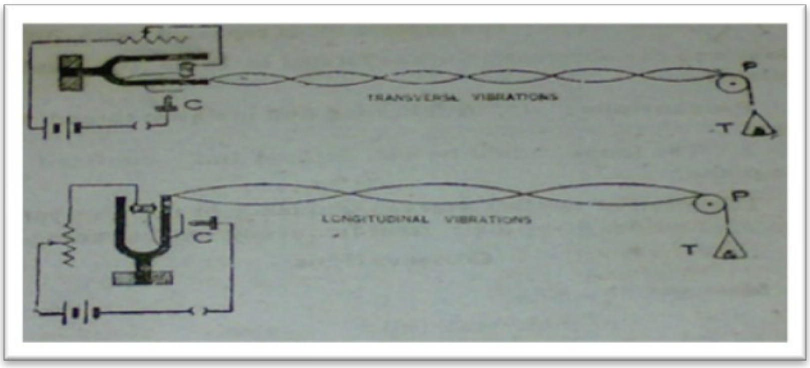
Where m=mass per unit length of the string

L=length of the single loop

(b) **Longitudinal arrangement :**

When the fork is placed in the longitudinal position and the string makes longitudinal vibrations, the frequency of the stretched string will be half of the frequency (η) of the tuning fork. That is, when well defined loops are formed on the string, the frequency of each vibrating segment of the string is exactly half the frequency of the fork.

During longitudinal vibrations, when the prong is in its right extreme position the string corresponding to a loop gets slackened and comes down and when the fork is in its left extreme position, the slackened string moves up to its initial horizontal thereby completing one vibration, the string goes up, its inertia carrying its onwards and thereby completes only a half vibration



Observations:

1. Mass of the string (Thread) = w = ...gm.
2. Length of the (thread) string = y = ...cm.
3. ∴ Linear density of the thread = $\left(\frac{w}{y}\right)$ = ...gm/cm.
4. Mass of the pan (correct to a mg) = m = ...gm

Table 1 – Transverse arrangements

S.No	Load applied into pan M gm.	Tension T=(M+m)g dynes	No. of loops 'x'	Length of 'x' loops=d cm.	Length of each loop /=d/x cm.	√T	$\frac{\sqrt{T}}{l}$

Average of $\frac{\sqrt{T}}{l}$ =

The average value of $\frac{\sqrt{T}}{l}$ is substituted in equation (1) and the frequency of the fork or vibrator is calculated.

Hence, the frequency of each loop is $\eta^1 = \frac{1}{2l}\sqrt{T/m}$

Hence, the frequency of the vibrator is $\eta = 2\eta^1 = \frac{1}{l}\frac{T}{\sqrt{m}} = \left(\frac{\sqrt{T}}{l}\right)\frac{1}{\sqrt{m}}$ .... (2)

Procedure:

The apparatus (tuning fork or vibrating bar) is first arranged for transverse vibrations, with the length of the string 3 or 4 meters and passing over the pulley. The electric circuit is closed and the rheostat is adjusted till the fork vibrates steadily. The load in the card board pan is adjusted lowly, till a convenient number of loops (say between 4 and 10) with well defined nodes and maximum amplitude at the antinodes are formed, the vibrations of the string begin in the vertical plane.

The number of loops (x) formed in the string between the pulley and the fork are noted. The length of the string between the pulley and the fork (d) is noted. The length (l) of a single loop is calculated by:

$$l = \left(\frac{d}{x}\right) \text{ cm.}$$

Let m = mass of the card board pan

M = load added into the cardboard pan

∴ Tension, T = (M + m) g dynes

Where g = acceleration due to gravity at the place.

The experiment is repeated by increasing or decreasing the load M, so that the number of loops increases or decreases by one. The experiment is repeated till the whole string vibrates in one or two loops and the observation is recorded in Table 1. Next, the fork or vibrator is arranged for longitudinal vibrations & the observations are recorded in Table 2

At the end of the experiment, the mass m of the cardboard pan, the mass of the string (w) and the length (y) of the string are noted

Table 1 – Longitudinal arrangements

S.No	Load applied into pan M gm.	Tension T=(M+m)g dynes	No. of loops 'x'	Length of 'x' loops=d cm.	Length of each loop /=d/x cm.	$\sqrt{T}$	$\frac{\sqrt{T}}{l}$

The average value of $\frac{\sqrt{T}}{l}$ is substituted in equation (2) and the frequency of the fork or vibrator is calculated.

Applications:

Vibrations of bars or roads, vibrations of metallic plates, vibrations of bells, Vibrations of diaphragm, forced vibrations of a sound box in a gramophone or a loud speaker in a radio etc.

In the case of a rectangular bar the frequency of vibrations is proportional to the length of its side in the plane of vibration, and inversely proportional to the breadth in that plane. The frequency is independent of the thickness at the right angles to the plane of vibrations. The vibrations produced in bridges of the road ways and railways can be experienced while standing on it when a heavy vehicle or a train passes over it.