To Find the Speed of Sound in air at Room Temperature Using a Resonance Tube by two Resonance Positions

Aim

To find the speed of sound in air at room temperature using a resonance tube by two resonance positions.

Apparatus

Resonance tube, two timing forks of known frequencies 512 Hz and 480 Hz, a rubber pad, one thermometer, plumb line, set squares, water in a beaker.

Theory

Let l_1 and l_2 be the length of the air column for the first and the second resonance respectively with a tuning fork of frequency v.

Then, $\lambda = 2(l_2 - l_1)$

The speed $v = \nu\lambda$

or $v = 2\nu(l_2 - l_1)$; which can be calculated.

Diagram

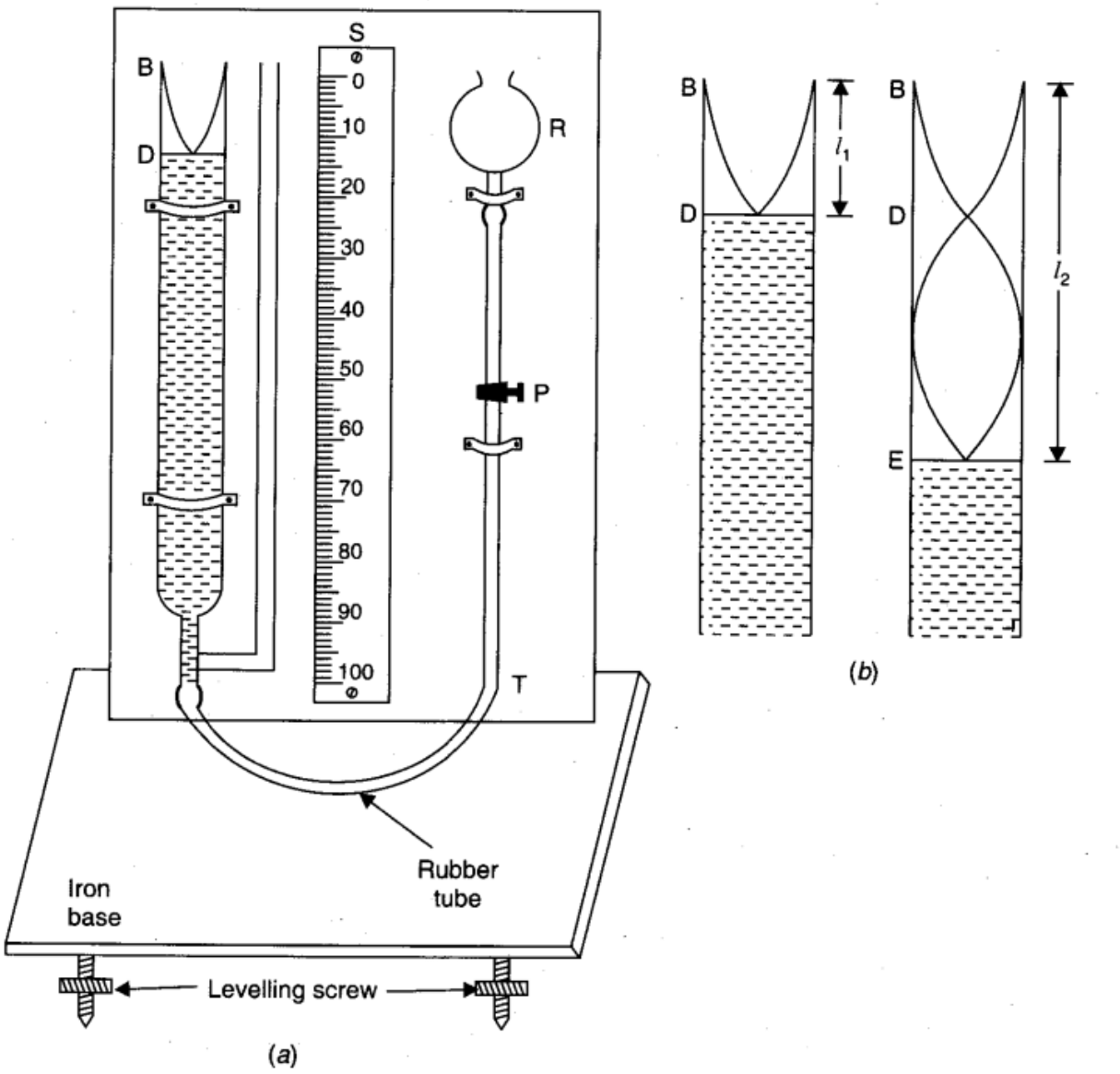

Fig. Resonance tube.

Procedure

1. Set the resonance tube vertical by making the base horizontal, using levelling screws. Test it with plumb line.
2. Fix the reservoir R in the upper most position.
3. Loose the pinch cock P completely and fill the reservoir and metallic tube completely with water by a beaker.
4. Tight the pinch cock, lower the reservoir and fix it in the lowest position.
5. Take tuning fork of more frequency. (It will be smaller in size and will give shrill sound). Vibrate it with a rubber pad and hold it with its vibrating prongs in vertical plane just over the end of the metallic tube.

6. Loose the pinch cock to make water level fall down in the metallic tube. Tight the pinch cock when some sound is heard in metallic tube.
7. Vibrate the tuning fork again and put it as before. Loose the pinch cock a little to make water level fall by 1 mm. Note change in loudness of sound.
8. Repeat step 7 till sound heard from the metallic tube has maximum loudness (The air column is in resonance with the tuning fork).
9. Note the position of water level in glass tube against metre scale S (using set square). Record it in 'first resonance—water level falling' column.
10. Lower the water level by about 1 cm and tight the pinch cock.
11. Raise the reservoir and fix it again in upper most position.
12. Repeat step 7. This time water level will rise. Raise it by 1 mm and note the change in loudness of sound.
13. Repeat step 12 till sound heard from metallic tube has maximum loudness again.
14. Note the position of water level in glass tube against metre scale S (step 9). Record it in 'first resonance—water level rising' column.
15. Lower the reservoir and fix it in the lowest position.
16. Lower the water level to about three times the reading for first resonance.
17. Repeat steps 5 to 9. Record the water level position in 'second resonance—water level falling' column.
18. Repeat steps 10 to 14. Record the water level position in 'second resonance—water level rising 1 column.
19. Repeat steps 13, 14 and 18 three times.
20. Repeat steps 5 to 19 with second tuning fork of lower frequency.
21. Note and record frequency of tuning forks which is engraved on them.
22. Find temperature of air in air column of the resonance tube by suspending a thermometer in it.
    (Note. Find this temperature in the beginning and at the end. Use its mean in calculation.)
23. Record your observations as given below.

Observations

Temperature of air in air column :
(a) in the beginning, t_1 =…….°C
(b) at the end, t_2 = ……°C

Mean temperature, $t = \frac{t_1 + t_2}{2} = 30°C$

Frequency of first tuning fork, $\nu_1 = 512$ Hz

Frequency of second tuning fork, $\nu_2 = 480$ Hz

Table for resonant length of air column

Frequency of tuning fork v (Hz)	*Resonance*	*No. of observations*	*Position of water level at resonance*			*Mean length (mean of three observation in column 4c) l (cm)*
			Water level falling (cm)	*Water level rising (cm)*	*Mean (cm)*	
512	First	1. 2. 3.				$l_1' = 16.1$
	Second	1. 2. 3.				$l_2' = 50.3$
480	First	1. 2. 3.				$l_1'' = 17.3$
	Second	1. 2. 3.				$l_2'' = 53.9$

(**Note.** *The ideal observations are as sample.*)

Calculations

From first tuning fork,

$$v_1 = 2\nu_1 (l_2' - l_1') = 35020.8 \text{ cm s}^{-1}$$

From second tuning fork,

$$v_2 = 2\nu_2 (l_2'' - l_1'') = 35136.0 \text{ cm s}^{-1}$$

Mean velocity at room temperature,

$$v = \frac{v_1 + v_2}{2} = 35078 \text{ cm s}^{-1}$$

Result

Velocity of sound in air at room temperature
= 35078 cm/s = 350.78 m/s

Precautions

1. Resonance tube should be vertical.

2. Pinch cock should be tight.
3. Tuning fork should be vibrated gently by a rubber pad.
4. Prongs should be vibrated in a vertical plane above the mouth (end) of the metallic tube.
5. Prongs should not touch the end of the metallic tube.
6. Reading for water level falling and rising should be noted.
7. Reading should be noted using a set square.
8. While measuring air temperature, thermometer bulb should not touch water or sides of resonance tube.

Sources of error

1. Resonance tube may not be vertical.
2. Pinch cock may be loose.
3. The edge of open end of metallic tube may not be at zero of metre scale (but this error becomes eliminated in $(l_2 - l_1)$.
4. Air in air column is denser than open air outside. This may reduce velocity.
5. Air in air column has humidity. This may increase velocity.

Viva Voce

Question. 1. What is the principle of the working of the resonance tube ?
Answer. It works on the principle of the resonance of the air column with tuning fork.

Question. 2. What is resonance of the air column?
Answer. It is the phenomenon in which frequency of air column becoming equal to that of the tuning fork.

Question. 3. What types of waves are produced in the air column ?
Answer. The waves produced in the air column are longitudinal stationary waves.

Question. 4. What is the position of the nodes and the antinodes in the air column ?
Answer. The node lies at the surface of the water level. Antinode lies at the open end of the metallic tube.

Question. 5. Does the antinode lie just at the edge of the open end of the metallic tube ?
Answer. No. It lies above the edge of the open end of the tube.

Question. 6. Why is it so ?
Answer. It is so because the sound wave reflects back in the air column from a region slightly above the edge, because the tube medium continues up to that region.

Question. 7. What is the name of the distance of this region from the edge of the end of the metallic tube ?
Answer. It is called end correction. Its value is 0.3 times the internal diameter of tube.

Question. 8. Explain end correction.
Answer. It is due to downward reflection of sound wave from slightly above the end of the tube.

Question. 9. Do you find the velocity of sound in air column or in water column ?
Answer. The velocity is found in air column above the water surface.

Question. 10. What are the possible errors in the result ?
Answer. There are two possible errors :
(1) The enclosed air in air column is denser than outer open air. It may reduce the velocity of sound.
(2) The enclosed air above water column has humidity. It may increase the velocity of sound.

Question. 11. Will the result be effected if we take some other liquid than water ?
Answer. No, because we need only resonant length of the air column which will be same in both cases.

Question. 12. Will the result be effected if we take metallic tube of different diameter ?
Answer. Observations will change due to change of end correction ($x = 0.3\ D$). But result will not be effected because the formula used eliminates the end correction.