Singing Tube Demonstration

Introduction

Mysteriously play an organ pipe without an organ! This demonstration uses heated air to produce vibrations inside a long tube. The vibrations, in turn, produce standing sound waves with a unique tone, or timbre (tăm′ br)—the same concept that produces sound from an organ pipe.

Concepts

- Sound waves
- Open-ended resonance tubes
- Wind
- Organ pipes

Materials (for each demonstration)

Metal tube, 2″ dia. × 17″
Metal wire disks, 2½″ diameter, 3
Bunsen burner, or portable laboratory burner
Heat-resistant gloves, or oven mitts
Paper clip, metal
Pliers, needle-nose, with wire cutters

Safety Precautions

The edges of the metal wire disks are sharp. Please handle with care. Follow normal Bunsen burner safety guidelines. The metal tube and wire disks will get hot while in the burner flame. Wear heat-resistant gloves and safety glasses when performing this demonstration.

Preparation

1. Obtain the metal wire disks. Handle them very carefully.
2. Carefully bend one of the disks into a bowl shape (similar to a watch glass shape). Put pressure on the center of the disk with your thumbs and then evenly bend the edges of the disk with your fingers to form a bowl. See Figure 1. Be very careful not to cut yourself on the wire edges.
3. Form a bowl shape that has a slightly larger diameter than the inside diameter of the metal tube. If the wire disk is bent too much, it can be flattened out and adjusted to the proper diameter.
4. Repeat steps 2 and 3 for the two remaining wire disks.
5. Place one disk on top of the other to make a stack of three disks.
6. Obtain a metal paper clip and needle-nose pliers with wire cutters.
7. Straighten out the paper clip.
8. With the wire cutters, clip off a 1–2 cm paper clip piece.
9. Insert this paper clip piece through the center of the wire disk stack so that it goes through all three disks. See Figure 2.
10. Use a needle-nose pliers to bend the inserted paper clip piece into a “C” shape to secure the wire disks together. See Figure 2.

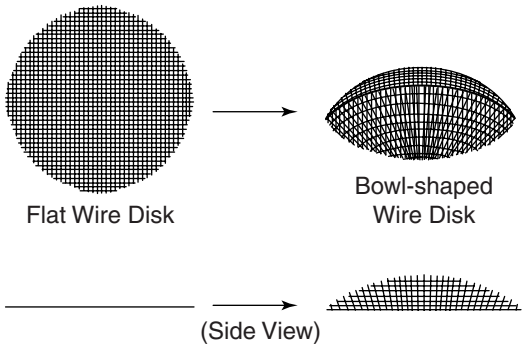

Figure 1.

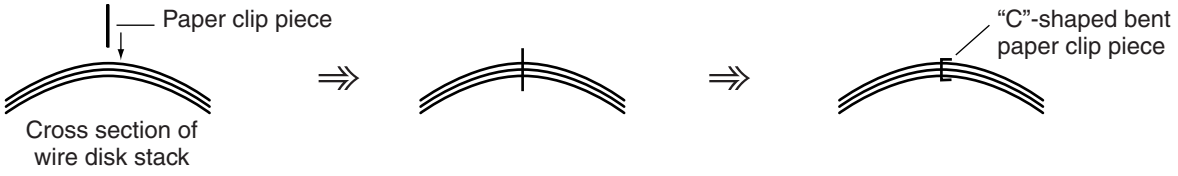

Figure 2.

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11. Insert the curved end of the wire disk "stack" into the end of the metal tube, opposite to the label. See Figure 3. Carefully push and "massage" around the edges of the stack evenly in order to slide the disks into the tube so that they remain parallel with the tube opening. (When you look inside the tube, there should be no gaps between the disks' edges and the wall of the tube.) The friction between the wall of the tube and the edges of the disks should keep them secure inside the tube. If the disks are loose or fall out, remove them and flatten them out slightly to increase their diameter so they fit snugly inside the tube. If the wire disks are pushed in crookedly, use pliers to remove them completely and begin again. Proceed slowly in order to keep the wire disks parallel with the opening of the tube.

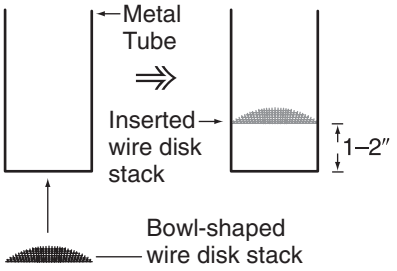

Figure 3.

12. Once the wire disks are inside the tube opening squarely, slide them down the tube so that they are about 1–2″ from the end of the tube. See Figure 3.
13. Set up a Bunsen burner or portable laboratory burner on a demonstration table.

Procedure

1. Light the Bunsen burner and adjust it to obtain a blue flame.
2. Wearing heat-resistant gloves or oven mitts, hold the metal tube at one end and position the other end of the metal tube vertically over the Bunsen burner flame to directly heat the wire disks inside the tube. See Figure 4.
3. Heat the wire disks for 10–15 seconds. Swirl the tube slightly to evenly heat the entire disk surface.
4. Remove the tube from the Bunsen burner flame and continue to hold it vertically. In a few seconds, a loud tone will begin to reverberate from the tube. The sound will last for several seconds (10–30 sec.), depending on how quickly the wire disks cool.
5. When the sound disappears, repeat steps 16–18 as often as necessary to reheat the wire disks and reproduce the sound.

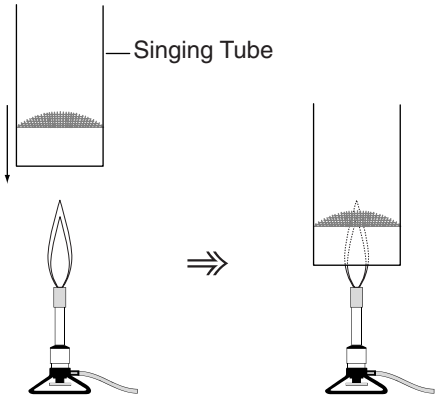

Figure 4.

6. **After the initial demonstration, perform this variation:** After heating the wire disks, remove the tube from the burner flame and immediately tip the tube 90° so that it is parallel to the floor. Notice that no sound resonates from the tube!
7. Quickly, but steadily, rotate the tube to the vertical position. The sound gradually increases in volume as the tube rotates towards the vertical position. (This should be done in 5–10 seconds—before the wire disks cool off.)
8. Discuss the observations with your students.

Disposal

The materials are completely reusable and should be saved for future demonstrations.

Tips

- Do not allow the metal tube to get too hot. The heat may scorch the tube label, heat-resistant gloves, and/or lab table it is stored on between trials.
- The Singing Tube can be silenced quickly, if it is too loud, by turning it horizontally, or by covering one of the ends (preferably the cool end).
- Pretend to pour sound into a beaker, or from a beaker into the tube. When the Singing Tube is "singing," begin to pour the "contents" of the tube into a beaker by rotating the tube 90°, with a beaker at the top opening of the tube. As the tube rotates, the "singing" decreases and makes it appear as if you are emptying the sound from the tube into a beaker. Reverse the process by pretending to pour sound into the tube. Start with a heated tube held horizontally and then quickly, but steadily, rotate it to the vertical position as you hold the lip of a beaker near the "top" of the rotating tube. The volume of the "singing" increases, simulating the act of pouring sound into the tube.

Discussion

The open tubes in this demonstration act in a similar manner to the flue-type organ pipe (see Figure 5). In a flue-type organ pipe, a stream of air is directed against a sharp edge in an opening of the pipe. The sharp edge creates turbulent, complicated swirls of air which set up vibrations in the air column. The vibrations that are at the correct resonance frequency of the pipe (depending on the length of the pipe, the design of the pipe, and the air temperature) will resonate and produce a very loud tone. The tone is not a specific fundamental frequency, but it is a combination of the different harmonics that the column will allow. The fundamental frequency is usually the most prominent frequency in a resonating column. The shorter the pipe, the higher the vibrational frequency must be to produce resonation inside the column. Therefore, a short column will produce a higher pitch than a long column.

The Singing Tube is an example of an open-ended resonating air column. When the metal wire disks are heated, and then removed from the heat source, the metal will retain the heat for a time. This heated metal will heat the nearby surrounding air, which then rises through the tube. As the hot air rises, cooler air from the room will flow into the tube from the bottom and through the wire mesh. When the air flows through the wire mesh it becomes turbulent. The swirling turbulent air sets up vibrations inside the tube, and the correct vibrational frequencies will begin to resonate loudly inside the tube to produce a note, just as in the organ pipe. When the tube is tilted parallel to the ground, the heated air does not rise through the column to cause a large inflow of cooler air through the wire mesh. Without the rush of cool air through the tiny holes, no vibrations, and therefore no sounds, are produced.

NGSS Alignment

This laboratory activity relates to the following Next Generation Science Standards (2013):

Disciplinary Core Ideas: Middle School
MS-PS4 Waves and Their Applications in Technologies for Information Transfer
PS4.A: Wave Properties

Disciplinary Core Ideas: High School
HS-PS4 Waves and Their Applications in Technologies for Information Transfer
PS4.A: Wave Properties

Science and Engineering Practices
Asking questions and defining problems
Developing and using models
Constructing explanations and designing solutions

Crosscutting Concepts
Patterns
Energy and matter
Structure and function
Stability and change

Acknowledgment

Flinn Scientific would like to thank David Katz, Pima Community College, Tucson, Arizona, for providing us the idea for this demonstration.

Reference

Tipler, Paul A. *Physics for Scientists and Engineers*, 3rd Ed., Vol. 1; Worth Publishers: New York, 1990; pp 452–457.

The *Singing Tube Demonstration* is available as a demonstration kit from Flinn Scientific, Inc.

Catalog No.	Description
AP6312	Singing Tube Demonstration Kit
AP6305	Triple Singing Tubes

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.