SOUND DOES NOT TRAVEL THROUGH A VACUUM

TOPIC:

Sound

SCIENTIST:

Robert Boyle 1627–1691

INTRODUCTION:

In the late 1650s the English physicist Robert Boyle became interested in experiments that were being carried out in Europe concerning the nature of a vacuum. These experiments had been started by Otto von Guericke (see 1.021). Guericke invented an air pump which made it possible to create an artificial vacuum, something thought impossible a few years previously because of the widespread belief in the doctrine of Aristotle (384–322 BC) which stated that "nature abhors a vacuum." Boyle and fellow scientist Robert Hooke (see 1.026) improved the European air pump so that it was able to produce an almost complete vacuum. When air was pumped out of the glass globe on top of the pump, animals placed inside the globe suffocated and lit candles were extinguished. Boyle then showed that if a small bell (which had some means of ringing it from outside) were placed inside the globe, the sound it produced decreased as air was withdrawn from the globe. (Some authorities credit Guericke with this discovery.) Boyle had shown, in his experiment which you will now repeat, that sound, unlike light, is dependent on some medium for its transmission and will not pass through a vacuum.

TIME NEEDED:

45 minutes

MATERIALS:

9V high-pitched buzzer (*e.g.*, from Radio Shack)
9V battery
piece of bell wire 60 cm long
wire strippers
Plexiglas® tube 30 cm long, with an internal diameter of 5 cm
2 stoppers to fit tube, one with a hole through it
copper or glass tubing 6 cm long to fit through stopper
vacuum tubing 1.5–2 m long
2 hose clamps to fit around vacuum tubing
screwdriver
laboratory vacuum pump or Mityvac® hand pump
ring stand and clamp
transparent tape

Original Materials:

Boyle used a glass globe from which the air was removed by a vacuum pump. The glass globe contained a bell (see figure 1).

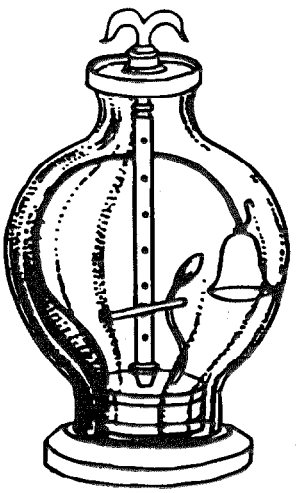


Figure 1

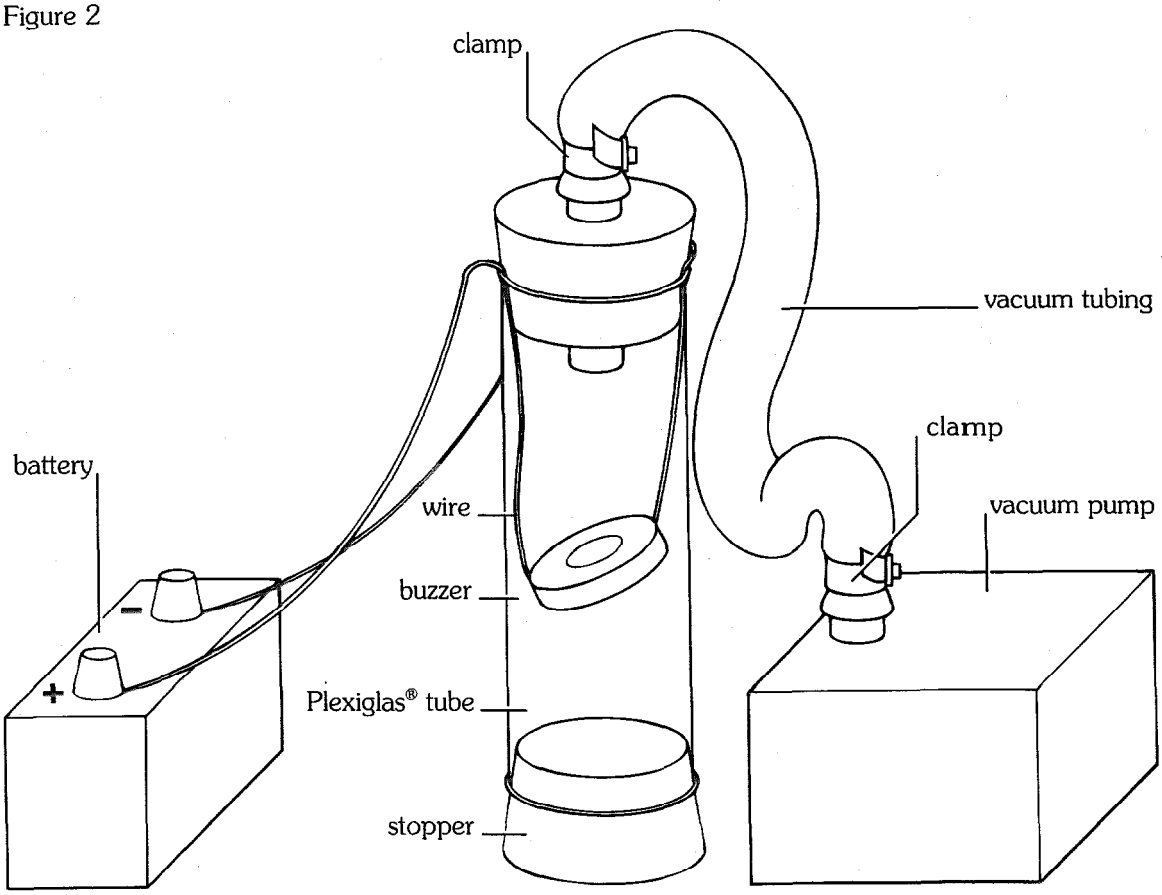
Safety Precautions

Adult supervision required. Please read and copy the safety precautions at the beginning of this book. Take care when pushing glass tubing through a stopper.

PROCEDURE:

1. Cut the bell wire into two equal halves. Use the wire strippers to strip 3 cm wire from the four ends of the wires.
2. Attach one end of each of the wires to the buzzer.
3. Ask the adult to push the copper or glass tubing through the stopper with the hole. Make sure 2 cm of tube is protruding from the top of the stopper.
4. Push the solid stopper into one end of the Plexiglas® tube.
5. Clamp the Plexiglas® tube in the vertical position with the solid stopper at the bottom.
6. Pick up the buzzer by its wires. Lower it into the tube until it is positioned centrally and halfway down the tube (see figure 2). Make sure it does not touch the sides.

Figure 2



7. Now position the wires so that they exit the tube on opposite sides. Push the other stopper into the tube so that the wires are fixed into position and the buzzer is still hanging centrally.
8. Ask the adult to push one end of the vacuum tubing over the copper or glass tubing pushed into the stopper. Secure it with a hose clamp and tighten the clamp using the screwdriver.
9. Attach the other end of the vacuum tubing to the vacuum pump. Secure it with a hose clamp tightened using the screwdriver.
10. Connect two ends of the two lengths of wire to the battery. Record what happens when you do this. (Note: If the buzzer does not produce a sound at this point do not proceed with the experiment. Instead, check the connections until it does produce a sound.)

11. Ask the adult to turn on the vacuum pump. Listen to and look at the buzzer in the tube. Record what happens as the air is removed from the tube.
12. Ask the adult to gradually let the air back into the tube. Record what happens.

ANALYSIS:

1. What happened when you connected the buzzer wires to the battery?
2. What happened when a) air was removed from the tube and b) air was allowed back into the tube?
3. Why was it important to ensure that the buzzer was not touching the sides of the tube?
4. What conclusions can you draw from this experiment?
5. How do you know that light *does* travel through a vacuum?

OUR FINDINGS:

Click on above link to see what we found.

SPECIAL SAFETY NOTE TO EXPERIMENTERS

Each experiment includes any special safety precautions that are relevant to that particular project. These do not include all of the basic safety precautions that are necessary whenever you are working on a scientific experiment. For this reason, it is absolutely necessary that you read, copy, and remain mindful of the General Safety Precautions that follow this note.

Experimental science can be dangerous, and good laboratory procedure always includes carefully following basic safety rules. Things can happen very quickly while you are performing an experiment. Things can spill, break, even catch fire. There will be no time after the fact to protect yourself. Always prepare for unexpected dangers by following basic safety guidelines the *entire* time you are performing the experiment, whether or not something seems dangerous to you at a given moment.

We have been quite sparing in prescribing safety precautions for the individual experiments. We made this choice for one reason: We want you to take very seriously every safety precaution that is printed in this book. If you see it written here, you can be sure that it is here because it is absolutely critical to your safety.

One further note: The book assumes that you will read the safety precautions that follow, as well as those in the box within each experiment you are preparing to perform, and that you will *remember* them. Except in rare instances, these precautions will not be repeated in the procedure itself. It is up to you to use your good judgment and pay attention when performing potentially dangerous parts of the procedure. Just because the book does not say BE CAREFUL WITH HOT LIQUIDS or DON'T CUT YOURSELF WITH THE KNIFE does not mean that you should be careless when simmering water or stripping an electrical wire. It does mean that when you see a special note to be careful, it is extremely important that you pay attention to it.

If you ever have a question about whether a procedure or material is dangerous, wait to perform it until you find out for sure that it is safe.

GENERAL SAFETY PRECAUTIONS

Accidents caused by carelessness, haste, insufficient knowledge, or taking unnecessary risks can be avoided by practicing safety procedures and being alert while conducting experiments. Be sure to check the experiments in this book for additional safety regulations and adult supervision requirements. If you will be working in a lab, do not work alone.

PREPARING:
—Clear all surfaces before beginning experiments
—Read the instructions before you start
—Know the hazards of the experiments and anticipate dangers

PROTECTING YOURSELF:
—Follow the directions step-by-step; do only one experiment at a time
—Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eye wash, and first-aid kit
—Make sure there is adequate ventilation
—Do not horseplay
—Wear an apron and goggles
—Do not wear contact lenses, open shoes, loose clothing, or loose hair
—Keep floor and work space neat, clean, and dry
—Clean up spills immediately
—Never eat, drink, or smoke in laboratory or work space
—Do not eat or drink any substances tested unless expressly permitted to do so by a knowledgeable adult

USING EQUIPMENT WITH CARE:
—Set up apparatus far from the edge of the desk
—Use knives and other sharp or pointed instruments with caution
—Pull plugs, not cords, when removing electrical plugs
—Don't use your mouth to pipette; use a suction bulb
—Clean glassware before and after use
—Check glassware for scratches, cracks, and sharp edges
—Clean up broken glassware immediately
—Do not use reflected sunlight to illuminate your microscope
—Do not touch metal conductors
—Use only low voltage and current materials such as lantern batteries
—Be careful when using stepstools, chairs, and ladders

USING CHEMICALS:
—Never taste or inhale chemicals
—Label all bottles and apparatus containing chemicals
—Read labels carefully
—Avoid chemical contact with skin and eyes (wear goggles, apron, and gloves)
—Do not touch chemical solutions
—Wash hands before and after using solutions
—Wipe up spills thoroughly

HEATING SUBSTANCES:
—Use goggles, apron, and gloves when boiling water
—Keep your face away from test tubes and beakers
—Never leave apparatus unattended
—Use safety tongs and heat-resistant mittens
—Turn off hot plates, bunsen burners, and gas when you are done
—Keep flammable substances away from heat
—Have fire extinguisher on hand

FINISHING UP:
—Thoroughly clean your work area and glassware
—Be careful not to return chemicals or contaminated reagents to the wrong containers
—Don't dispose of materials in the sink unless instructed to do so
—Wash your hands
—Clean up all residue and put in proper containers for disposal
—Dispose of all chemicals according to all local, state, and federal laws

BE SAFETY CONSCIOUS AT ALL TIMES