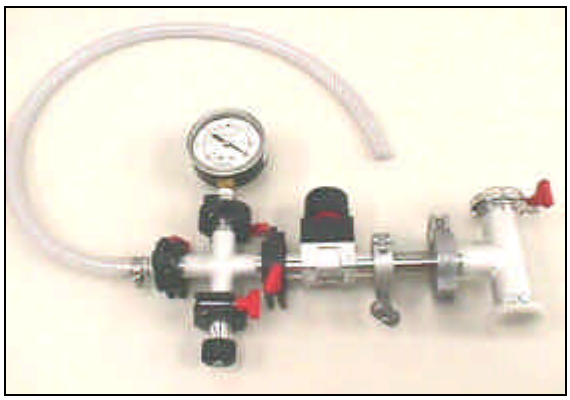
Is There Sound in a Vacuum?

Equipment List

- Electric door bell (6 V).
- Metal holder for doorbell with rubber O-ring support and foam isolation pad.
- Lantern battery (6 V). Everready 510S or equivalent.
- Nalgene plastic bell jar, ~6½inch diameter, ~7½inches high.
- Flat rubber gasket for belljar-to-baseplate seal.
- Plastic baseplate for bell jar with two electrical through-connections.
- Mechanical vacuum pump (1 CFM to 16 CFM) with oil mist filter on outlet.
- Vacuum connection: Tygon tubing (~5/8-inch O.D.), in-line vacuum shut off valve, vent valve on Tee fitting, hose clamps, KF connection adapter to mate with vacuum pump inlet.



Vacuum connection assembly: Vacuum gauge and vent valve (on cross), in-line vacuum shutoff valve, and vacuum pump connection (tee).

Vacuum pump and oil mist filter.

- Mechanical (dial) vacuum gauge (0-30 inches Hg or 100 kPa).
- Wire with battery clips to connect baseplate to battery.
- Wire with alligator clips to connect bell to baseplate.
- Screwdriver.

Preparation

1. Test battery by connecting wires to doorbell.
2. Check oil level in vacuum pump. Attach oil mist filter if not already on pump outlet.
3. Connect vacuum line to vacuum pump inlet.
4. Close vent valve (full clockwise) and vacuum shut off valve (full clockwise).
5. Plug in and turn on pump. Pump should pump quietly after less than a minute. If not check fittings for tightness.

6. Connect battery leads to underside of baseplate. **Figure 1**.

7. Turn base plate over. Connect Tygon vacuum line to baseplate connection (circled in Figure 1). Use a hose clamp and tighten carefully; it is easy for the hose to slip off of the baseplate connection.

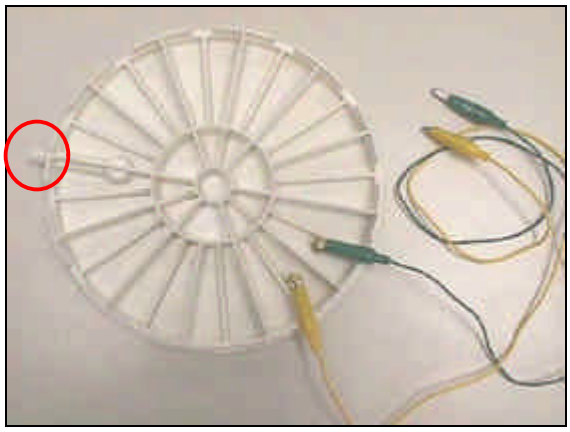


Figure 1

8. Connect bell wires to baseplate screw terminals and place bell support so that it rests on the foam pad on the baseplate and connect the bell connecting wires to the baseplate terminals: **Figure 2**.

Figure 2

9. Make sure that bell hangs freely from O-ring suspension as in **Figure 3** and does not touch the metal support.

The connection between the pump and the bell jar baseplate should look like **Figure 4.** It is better to locate the pump on the floor below the table to reduce the noise interference.

Figure 3

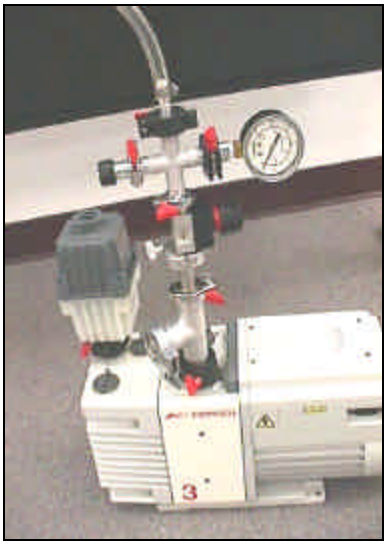


Figure 4

Vacuum gauge reading atmospheric pressure

Vacuum gauge reading vacuum (30 inches Hg)

Demonstration

1. Connect bell to battery. While is bell ringing, place bell jar over bell assembly, making sure that that the bell jar is centered on the black rubber gasket.
2. Open vacuum shutoff valve. By the time the pressure gauge reads 15 inches Hg the sound will fade.
3. Note that although the bell cannot be heard, you can verify that it is still ringing– the clapper is hitting the bell and sparks are visible at the interrupter contact.
4. To emphasize the silence, close vacuum valve shut off valve and turn off the pump.
5. Slowly open the vent valve. The bell will become audible again when the pressure reading reaches about 15 inch Hg (one-half of atmospheric pressure).

Things to Ponder

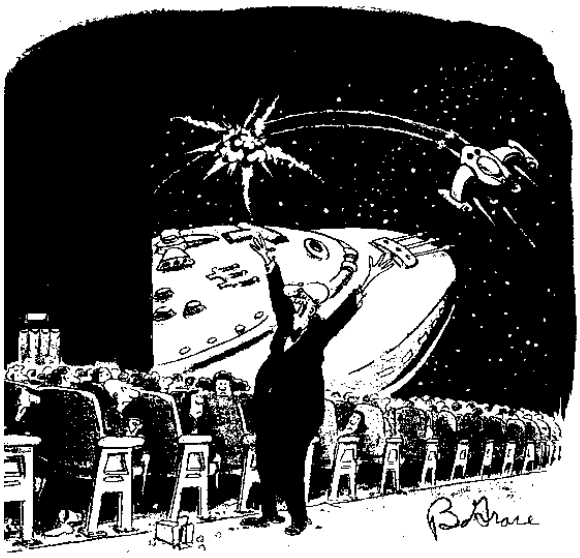
If the bell was touching the bell jar could you hear it ringing in a vacuum? Try it.

If an astronaut working outside the Space Station pounds a wrench on a bolt, will there be a sound?

What is Sound?

Sound is a wave motion or vibration in a medium and is similar to wave ripples in water. The medium can be solid, liquid or gas. Sound waves are transmitted through air, water (like an underwater speaker), and metal (tapping on a water pipe). High pitched sounds have a higher vibration *frequency* than low pitched sounds. Loud sounds have a higher vibration *amplitude* than softer sounds. The sound waves are vibrations of molecules in the medium. The motion is transmitted by successive collisions between the molecules. The sound waves travel outward from the source of the sound. If there is no medium– as in a vacuum– there will be no sound transmission.

The first phonograph records had up-and-down ripples on the surface. The ripples that were picked as vibrations of a phonograph needle connected to a thin diaphragm. The diaphragm vibrations were amplified by a metal horn. No electricity required.



"Stop the movie! Stop the movie! Explosions don't go boom in a vacuum!"

Is there really sound in space?

Actually...yes!!

What is sound? It is a pressure wave. So long as you have some kind of gaseous medium, you will have the possibility of forming pressure waves in it by 'shocking' it in some way.

In space, the interplanetary medium is a very dilute gas at a density of about 10 atoms per cubic centimeter, and the speed of sound in this medium is about 300 kilometers/sec. Typical disturbances due to solar storms and 'magneto-sonic turbulence' at the earth's magnetopause have scales of hundreds of kilometers, so the acoustic wavelengths are enormous. Human ears would never hear them, but we can technologically detect these pressure changes and play them back for our ears to hear by electronically compressing them.

From *Ask the Space Scientist* at
www.spacehab.com/sk/frplay.htm
All answers are provided by Dr. Sten Odenwald (Raytheon STX) for the NASA IMAGE/POETRY project.