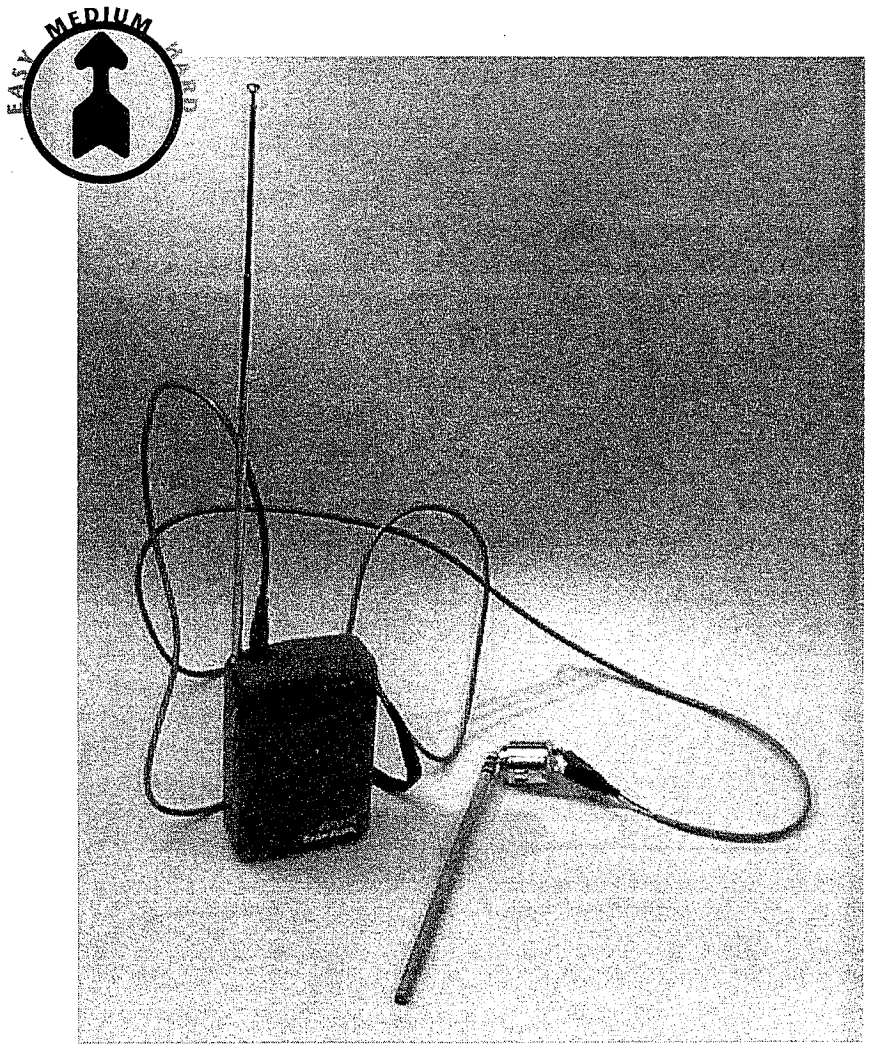
Sound Bite

A new way to listen to music.

When you listen to a radio, you expect to hear the sound coming from its speaker or headphones. But sound doesn't have to be transmitted through the air to be heard. In this snack, you pick up sound vibrations through your teeth!



Materials

- pushpin
- new wooden pencil with eraser
- small DC motor (e.g., RadioShack #273-223, 1.5–3 volt)
- small radio with headphone jack (e.g., RadioShack #12-799)
- audio cable, 6 ft (2 m), with a $\frac{1}{8}$-in phone plug (sometimes called a mini plug) on one end and two alligator clips on the other (e.g., RadioShack #42-2421)
- plastic wrap, enough to wrap around the bottom half of a pencil to provide a sanitary covering that you can bite on

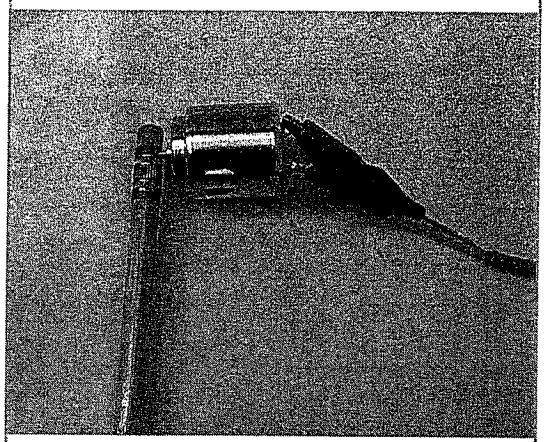
ASSEMBLY

1 Use a pushpin to make a hole in the metal jacket of the pencil where it holds the eraser, and then extend it on into the side of the eraser. Wiggle the pushpin around to enlarge the hole in the metal jacket until it is just big enough for the motor shaft to fit in. You don't need to remove any of the eraser material; you are really just creating a channel for the motor shaft to squeeze into.

2 Insert the motor shaft carefully into the hole you have made.

3 Locate a radio station with a clear, strong signal. Leave the radio on.

Figure 1



Pencil, motor, and alligator clips

4 Insert the phone plug on the audio cable into the headphone jack on the radio. Connect the alligator clips at the other end of the cable to the two terminals of the motor. (When you insert the phone plug into the headphone jack, the external speaker is disconnected; the same thing happens when you use headphones.) Figure 1 shows the pencil, motor, and alligator clip assembly.

5 If more than one person will be experimenting with this snack, each person should have his or her own piece of plastic wrap for covering the bottom half of the pencil. If you can find straws big enough to fit over the pencil, you can use them instead of plastic wrap, or you can improvise your own covering.

To Do and Notice

With the radio at medium to high volume, bite down on the pencil. You can either place the bottom end in your mouth as if it were a straw, or put the pencil sideways in your mouth like a dog bone as shown in figure 2. Try both, and use whichever gives you the best results. You should hear the radio playing in your ears! If you have trouble hearing the radio, try plugging your ears with your fingers to drown out any competing external noise. (If you continue to have trouble, see the Helpful Hint.)

Experiment with the following: Try putting the pencil behind your ear against your skull, then hold the pencil against your forehead; notice which position produces the clearest sound. You might also put the motor itself directly against the bones in your head.

Figure 2 *Bite firmly on the pencil and sound will fill your head.*

What's Going On?

The output from the radio, in the form of a changing electric current, is sent through the audio cable to the motor. When the electric current passes through the coils of the motor, these coils act as electromagnets. Since the

Helpful Hint

If you can't hear the radio, try drilling a hole through the pencil with a $\frac{1}{16}$-inch drill bit about an inch (2.5 cm) from the eraser and insert the shaft of the motor at that point.

Newer radios that have weaker outputs from the headphone jacks may not work with this snack. If necessary, use older radios or try different radios until you find one that works.

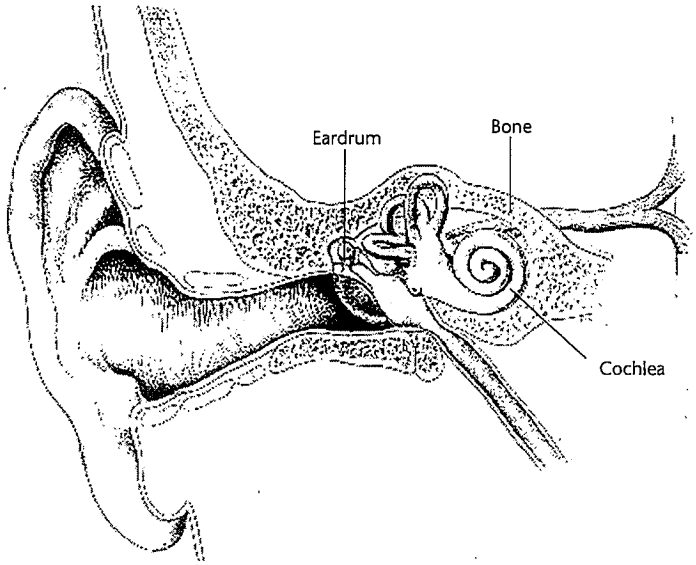


Figure 3 *The cochlea of the inner ear is surrounded by bone. Vibration of the bone vibrates the cochlea, which senses the vibration as sound. Normally, sounds are transmitted from the eardrum to the cochlea by three small bones in the inner ear.*

Did You Know?

Wood, Tooth, and Bone

During the normal hearing process, sound waves spiral through the ridges of your outer ear, bounce around in your ear canal, and vibrate your eardrum as they make their way to the cochlea—and ultimately to your brain. During their journey from the external ear to the cochlea, sounds are amplified more than one hundred times. The sound waves you hear when you bite the pencil, in contrast, are not amplified nearly as much because they are conducted to the cochlea directly through wood, teeth, and bone.

electric current is constantly changing, the strength of the electromagnetic fields is constantly changing also, in synchronization with the radio output. The interaction of these constantly changing electromagnetic fields with the permanent magnets in the motor causes the motor to physically vibrate. The motor vibrations are transmitted to the pencil and then to your teeth and jawbone. Eventually the vibrations stimulate the nerve endings in your cochlea, which is part of your inner ear (see figure 3). The nerve impulses sent by the cochlea along the auditory nerve to your brain are then interpreted as sound, just as if they had been caused by sound waves entering your ear.

So What?

There are two types of hearing loss, conductive and sensorineural. In *conductive hearing loss,* sound vibrations are not being transmitted from the outer ear to the cochlea. In *sensorineural hearing loss,* the brain is not receiving nerve signals from the inner ear, even though sound vibrations may be reaching the cochlea. For people with permanent conductive hearing loss, there are hearing aids that vibrate the bones of the skull. The vibrations travel through other bones until they reach the inner ear.

Hearing aids that rely on bone conduction of sound have been available for awhile. The first one—called an "acoustic fan"—appeared around 1900 (see figure 4). The hard-of-hearing person held the base of the device between his or her teeth and inclined the fan-shaped part toward the source of a sound. As in this snack, the sound vibrations traveled from the teeth to the jawbone and finally to the inner ear.

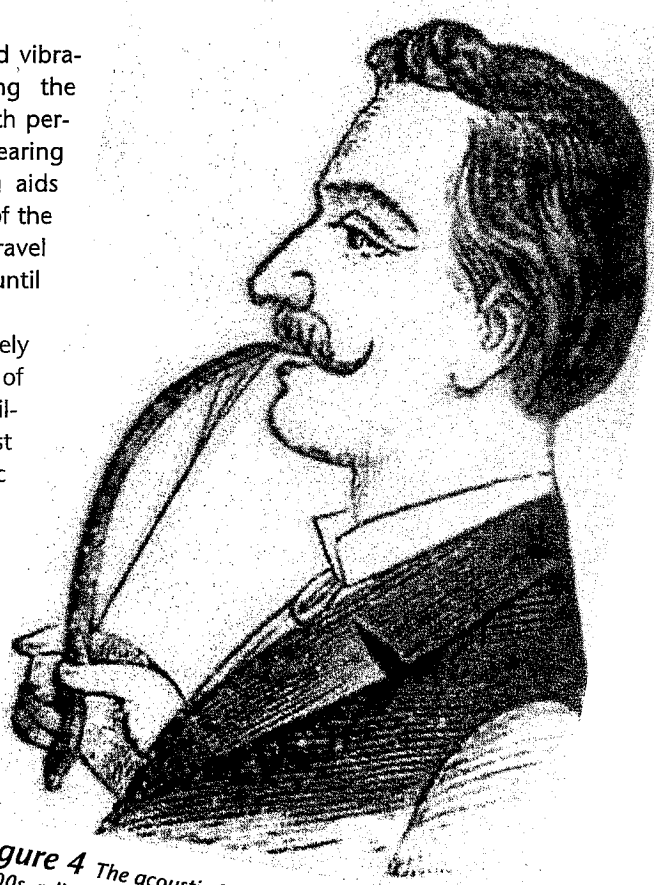


Figure 4 *The acoustic fan, a hearing aid used in the early 1900s, relied on bone conduction.*

Going Further

Motor Autopsy

If you have never seen the inside of a small electric motor such as the one used in this snack, try taking one apart. Use a broken one if possible, but a new one is not very expensive; its loss is well worth the experience.

Check Your Hearing

If you have access to a tuning fork, you can perform two simple hearing tests, the Rinne Test (pronounced reh-NAY), and the Weber Test, both of which distinguish between conductive and sensorineural hearing loss. Look them up on the Web to learn how to perform them.

Credits & References

The original inspiration for Sound Bite was the Bite-a-Phone in *The Dick and Rae Physics Demo Notebook* (see below). Gabe Espinda, Tien Huynh-Dinh, Eric Kielich, and James Kliewer contributed to the evolution of the present version.

Carpenter, D. Rae Jr., and Richard B. Minnix. *The Dick and Rae Physics Demo Notebook.* Lexington, Va.: Dick and Rae, 1993. A rich resource for teachers, this book contains more than 600 demonstrations from two decades of workshops given by the authors at Virginia Military Institute. Send inquiries to Dick and Rae, Inc., VMI Mallory Hall, Lexington, VA 24450.