TELEPHONE

OBJECTIVE:

You will understand how speech is transmitted electrically through wires and will demonstrate the principle on which the carbon microphone in a telephone's mouthpiece operates.

INTRODUCTION:

The development of the telephone was a revolutionary step forward from the telegraph (see 6.07). Instead of a coded sequence of signals, actual speech could be transmitted through wires.

Many scientists contributed to the invention of the telephone, and there are many conflicting accounts as to who played what role in its development. The Scottish-born American inventor Alexander Graham Bell (1847–1922) is normally credited with its invention. He patented the first telephone in 1876. His device worked on the principle of a reed vibrating in response to the human voice. The reed was close to an electromagnet which turned the vibrations into a varying electric current. This current was transmitted down a length of wire to a receiving apparatus. Here the electrical signals were turned back into sound by making an electromagnet vibrate another reed. Bell realized that his telephone worked when, after spilling acid, he called out to his assistant: "Mr. Watson, come here! I want you." Watson, who was in another room, heard the message clearly through the telephone receiver. Bell spent the year of 1877 traveling throughout the US and Europe demonstrating telephone designs that combined the mouth- and earpiece in a single projection from one end of a box (see figure 1).

Meanwhile, other scientists were working on the same project. In the late 1870s, American inventor Thomas Edison (1847–1931) designed a carbon microphone, which greatly improved sound quality and enabled telephone users to make calls over longer distances. (See Original Materials.) Having the mouthpiece separate from the earpiece was also an advantage. Figure 2 shows one of Edison's first commercial telephones, a wall-mounted model of about 1879. Most modern telephones still use carbon microphones like Edison's.

The basic principles behind these original systems are essentially the same as those in a modern telephone. Advances in electronics were essential, however, before the telephone could be used effectively across large distances. Dialling a number connects two handsets through a network of exchanges, which are now electronic and very fast. Modern telephone systems convert speech into digital (step-like) signals rather than the analog (continuously variable) signals previously used, making the signals cleaner and less subject to interference.

Figure 1

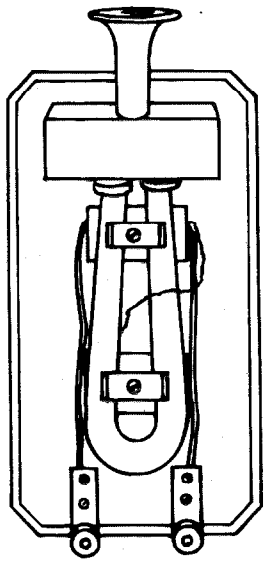
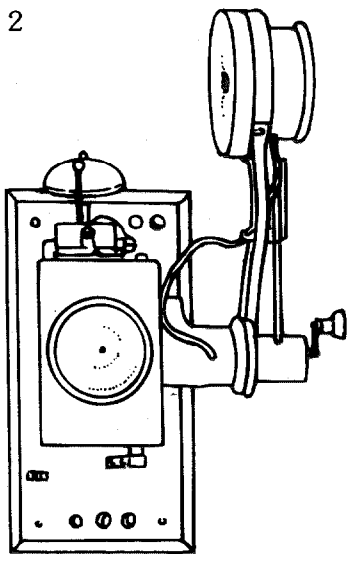


Figure 2



TIME NEEDED:

1 hour

MATERIALS:

graphite pencil sharpened at both ends
2 7.5cm lengths of 2mm-diameter copper wire
pliers
2 pieces of Funtak®
2 alligator clips
wooden block 15 cm x 8 cm x 1 cm
2 30cm lengths of bell wire
2 1m lengths of bell wire
wire strippers
crystal earpiece (e.g., from Radio Shack)
multimeter
AC power pack (1–2 V)
1.5V battery

Original Materials:

Re-creating Bell's original telephone is difficult and the resulting sound quality is very poor. Here you will demonstrate the workings of a carbon microphone—like that devised by Edison—which lies behind the diaphragm in a telephone mouthpiece and causes the diaphragm to vibrate when someone speaks into the mouthpiece. The vibrating diaphragm causes changes in pressure on the carbon particles. When the carbon particles are squeezed together they conduct a current better, and so a higher-than-normal current flows through the telephone wires. The current thus varies with the vibrations, and it is this varying current which causes a diaphragm in the earpiece to vibrate, re-creating the original sound.

Safety Precautions

Adult supervision required. Please read and copy the safety precautions at the beginning of this book. Electricity can be dangerous. Use no more than a 2V supply—higher voltages can cause damage to hearing.

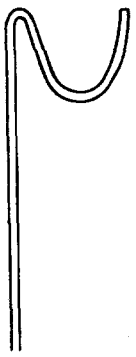
PROCEDURE:

Part 1

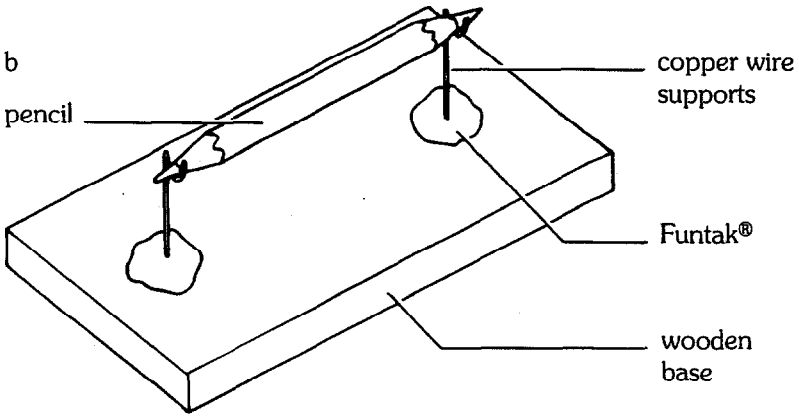
1. Use pliers to bend the two lengths of copper wire into u-shapes to form supports for the pencil (see figure 3a).
2. Using Funtak®, secure the two supports into an upright position on the wooden base just far enough from one another so that the sharpened pencil rests on both (see figure 3b).

Figure 3

a

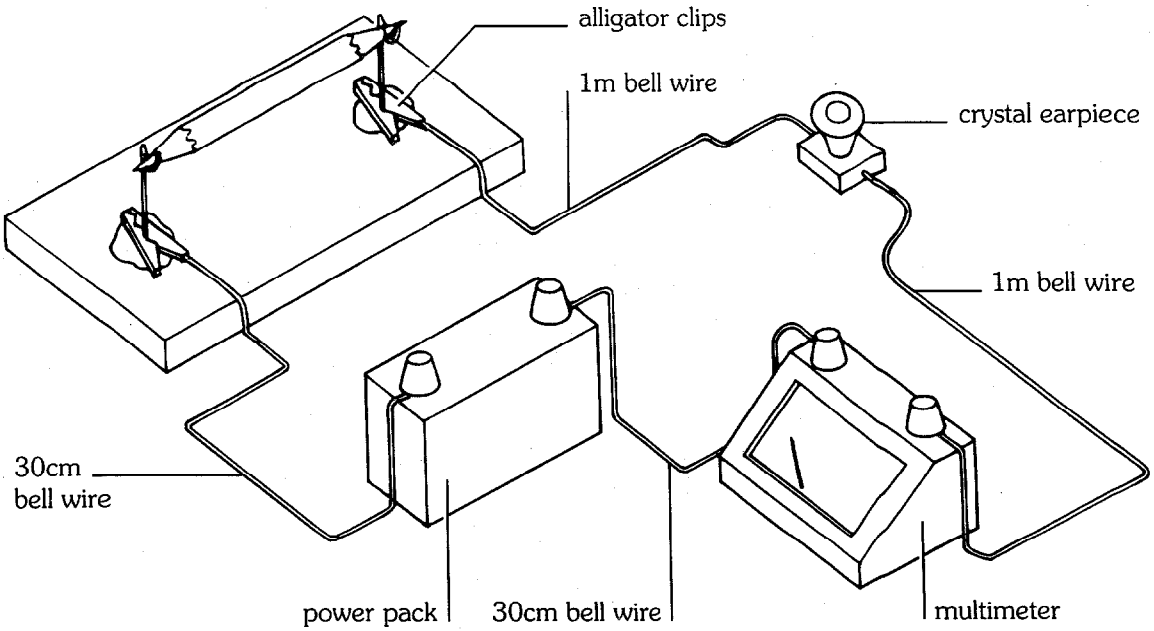


b



3. Use wire strippers to strip 3 cm of insulation from each end of the four lengths of bell wire. Attach an alligator clip to one end of one 30cm wire and one end of one 1m wire, and use the clips to attach these wires to the two copper supports. Attach the other end of this 30cm wire to the power pack, and the other end of this 1m wire to the crystal earpiece. Use the other 1m wire to connect the earpiece to the multimeter, and the other 30cm wire to connect the power pack to the multimeter, as shown in figure 4.
4. Put the earpiece on your ear and then gently tap the wooden base with a knuckle. Observe the reading on the multimeter as you do this, and note what you hear at the same time.

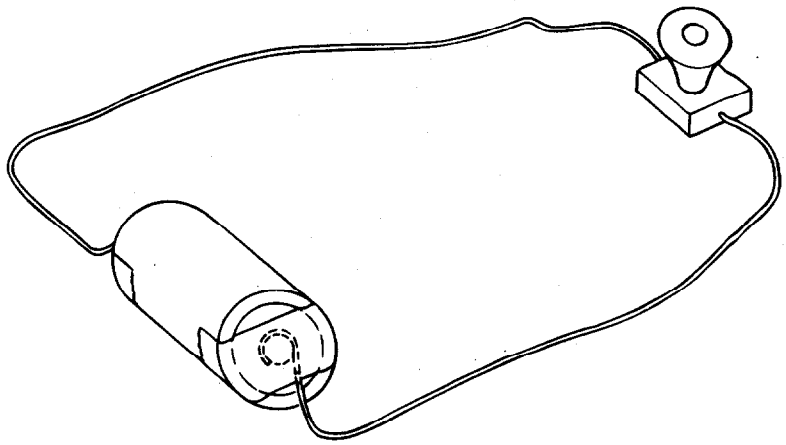
Figure 4



Part 2

5. Disconnect the wires in the circuit. Using the two 1m lengths of bell wires, connect the battery to the crystal earpiece (see figure 5), and put the earpiece in your ear. Note what you hear when connecting the battery, when the circuit is complete, and when disconnecting the battery.
6. Replace the battery with the power pack set at 1 or 2 volts. Repeat step 5.

Figure 5



ANALYSIS:

1. What was the multimeter reading when you tapped on the base in step 4? What did you hear? Explain why this happened. (Hint: Graphite in the pencil is a good conductor; air is a poor one. What might cause changes in the amount of current flowing through the pencil?)
2. In steps 5 and 6, what did you hear when the circuit was connected? What did you hear when the circuit was complete? What did you hear when the circuit was disconnected? Account for these differences. (Hint: An electrical circuit has background noise caused by the random movement of electrons in the circuit. An alternating current changes its direction of flow sixty times a second.)
3. What disadvantages are there in having the sending and receiving equipment connected by wires? Do some research. Which forms of one-to-one communication overcome these problems?

OUR FINDINGS:

Click on above link to see what we found.

SPECIAL SAFETY NOTE TO INVESTIGATORS

Each invention 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 investigation. 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 when you are constructing or demonstrating a model invention. 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 carrying out the project, whether or not something seems dangerous to you at a given moment.

We have been quite sparing in prescribing safety precautions for the individual projects. 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 project 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 carrying out these projects. Be sure to check the individual projects 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 projects
—Read the instructions before you start
—Know the hazards of the procedures and anticipate dangers

PROTECTING YOURSELF:
—Follow the directions step-by-step; do only one project 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 or bench
—Use knives and other sharp or pointed instruments with caution
—Pull plugs, not cords, when removing electrical plugs
—Clean glassware before and after use
—Check glassware for scratches, cracks, and sharp edges
—Clean up broken glassware immediately
—Do not touch metal conductors
—Use only low voltage and current materials such as lantern batteries
—Be careful when using stepstools, chairs, and ladders
—Never look directly at the sun with your observation devices

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