The "Magic-Film" Speaker

Have fun experimenting with this unusual speaker

BY MARC SPIWAK

A speaker is a speaker is a speaker—or is it? Most of you are probably familiar with an ordinary audio speaker. You know, the kind that you find in any radio, stereo, or TV. And while there are certainly differences in the quality of different speakers or, more specifically, the quality of the sound that they can reproduce, most speakers are basically very similar in their construction. However, that's not so with the *Magic Film Speaker* that we'll describe in this article. That speaker, which you can build, uses piezoelectric film to reproduce sound. To be a little more precise, what you build is a circuit that allows you to use piezoelectric film as a speaker.

The piezoelectric-film speaker circuit is designed by Heathkit, and sold in kit form (as item number SK-120). The ordering information for the kit can be found in the Parts List. However, because some of you may want to build the circuit from scratch, we have provided complete construction details, as well as a source for the piezoelectric film (see the Parts List).

In order to understand how the device works, you will first have to understand what piezoelectric film is and how it works. Before we discuss the piezoelectric film, however, let's first talk about how an ordinary speaker works.

Speakers in General. A common everyday speaker is usually a shallow conical disc, or diaphragm, that vibrates back and forth within its housing in tune with the audio signal that is presented to it. (An audio signal is basically a complex AC signal.) The vibrations reproduce sound by sending sound-pressure waves through the air that vary along with the audio signal. The sound waves reach your eardrum (which is connected to your brain), which translates the waves into sounds that you have come to understand. Now let's see how the speaker diaphragm is made to move back and forth.

We all know how an electromagnet works, and that magnets can be made to attract or repel one another. If you were to make an electromagnet using some insulated wire and a nail, you'd find that when current is passed through the wire in one direction, one end of the nail would attract one pole of a magnet while the other end would repel it. If you reverse the current flow, the opposite would be true.

Figure 1 shows a cut-away view of the average speaker. There you can see what is called the *moving coil*; a hollow cylindrical coil that surrounds, but is not attached to, a fixed magnet. The moving coil is attached to the diaphragm, and is allowed to move back and forth around the fixed magnet. When it moves it takes the diaphragm with it.

When an audio or AC signal is passed through the moving coil, it tries to repel and attract the fixed magnet—just like the electromagnet made from the wire and nail. But since the fixed magnet is stationary, the diaphragm is forced to move back and forth in time with the oscillations of the audio signal. As the diaphragm oscillates, it creates the

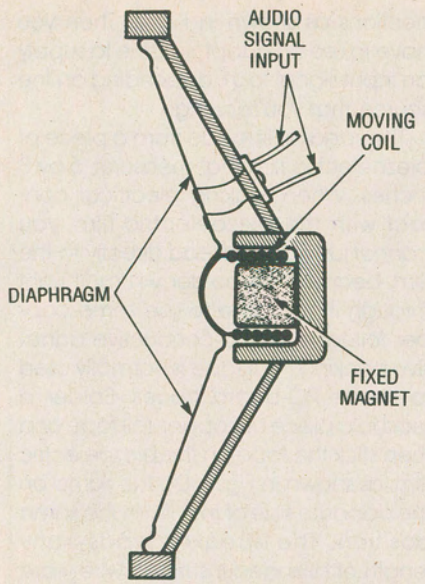


Fig. 1. Here is a cut-away side view of the average speaker.

pressure (or sound) waves that are detected by the ear. Now let's see what piezoelectric film is, and how we can make it behave like a speaker.

Piezoelectric Film. A piezoelectric material has the ability to turn a mechanical force into electricity, and it can also produce a mechanical force when subjected to electricity. Sometimes the material is a rigid ceramic or crystal-like substance, as is the case with a quartz crystal. But in this project, we are going to use a piezoelectric substance made from a flexible plastic film.

Piezoelectric film contains *dipoles* that are produced in the material's crystalline structure. A dipole is a molecule that has opposite polarity on either end (see Fig. 2). The film is metallized on either side so that a voltage can be placed across the film. The voltage causes the dipoles to align, and the material to change in shape as shown in Fig. 3 (as it gets thinner, it gets longer and wider). When an audio or AC signal is placed across the film, the film changes shape in accordance with the signal. As the voltage polarity reverses, the film bends in the opposite direction. And, as you might have guessed, the film can produce sound waves much like a regular speaker.

The only problem is that piezoelectric film requires a high voltage to produce the desired effect, therefore a common 1-volt peak-to-peak audio signal will not do the job. What we need is a "high-voltage" audio amplifier to make the film act like a speaker. With that in mind, let's take a look at the circuit that is used to drive the film speaker.

Circuitry. The schematic diagram for the amplifier is shown in Fig. 4. An audio signal is input at J1, an RCA jack. A voltage divider, consisting of R1 and R2, provides a load for the signal source; R2 (a 2000-ohm potentiometer) also serves as a volume control. The signal is amplified by U1, an LM386 low-power audio amplifier. Power is supplied by the 9-volt battery, B1, while capacitor C1 is used to filter the supply line. The amplifier gain is set to about 60 by R3 and C3. Resistor R4 and capacitor C4 cause low frequencies to be amplified more than high ones to improve the speaker's sound.

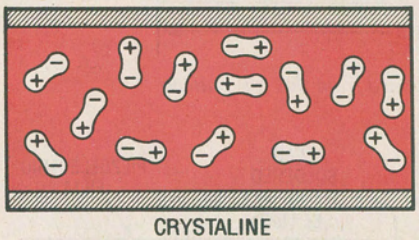


Fig. 2. Piezoelectric film contains dipoles; a molecule that has a natural opposite polarity on either end.

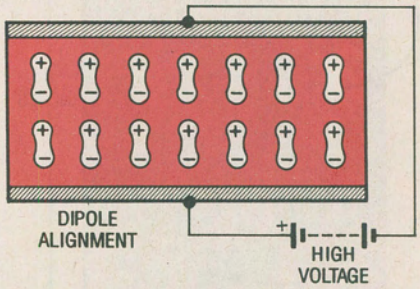


Fig. 3. A voltage causes the dipoles to align, and the material to change its shape.

PARTS LIST FOR THE MAGIC FILM SPEAKER

RESISTORS

(All fixed resistors are ¼-watt, 5% units, unless otherwise noted.)
R1—8200-ohm
R2—2000-ohm, potentiometer
R3—470-ohm
R4—22,000-ohm
R5, R6—10-ohm
R7—470-ohm, ½-watt

CAPACITORS

C1, C5—0.1-µF, ceramic-disc
C2, C3—10-µF, 35-WVDC, electrolytic
C4—.01-µF, ceramic-disc
C6—100-µF, 25-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

U1—LM386 low-power audio amplifier, integrated circuit
T1—1:10 step-up audio transformer
S1—SPST switch
B1—9-volt transistor-radio battery
J1—Phono jack
SPKR1—Piezoelectric film, see text
Printed-circuit materials, 8-pin IC socket, speaker-lead wire, 9-volt battery holder and connector, foam-rubber feet, etc.

Note: The Magical Film Speaker (kit SK-120) is available for $21.95 from Heathkit, Heath Company, Benton Harbor, MI 49022; Tel. 800-253-0570. The kit includes everything in the Parts List, except the 9-volt battery.

Piezoelectric film is available from Atochem North America, 3 Parkway, Philadelphia, PA 19102. Contact them directly for pricing and other information

Components R5, C2, and C5 stabilize the amplifier, while R6 and the primary of T1 act as a load for U1. DC voltage is blocked from the primary of T1 by C6,

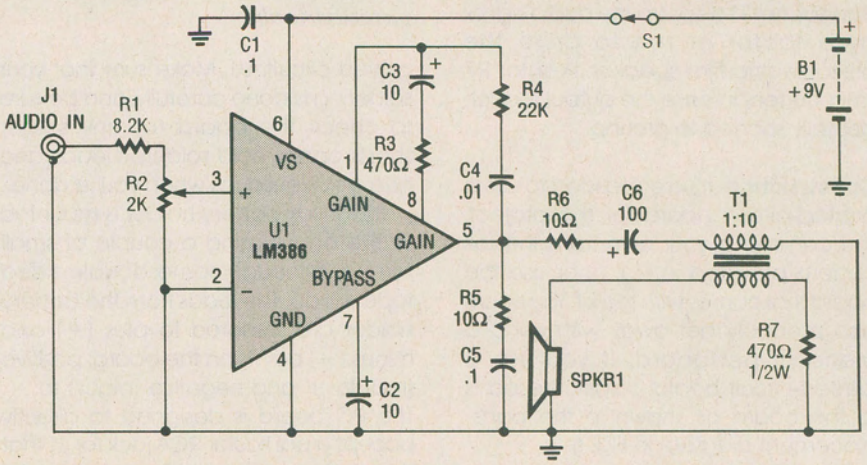


Fig. 4. Shown here is the schematic diagram for the amplifier portion of the project. An audio signal is fed to the circuit via J1 and is highly amplified to operate the film speaker.

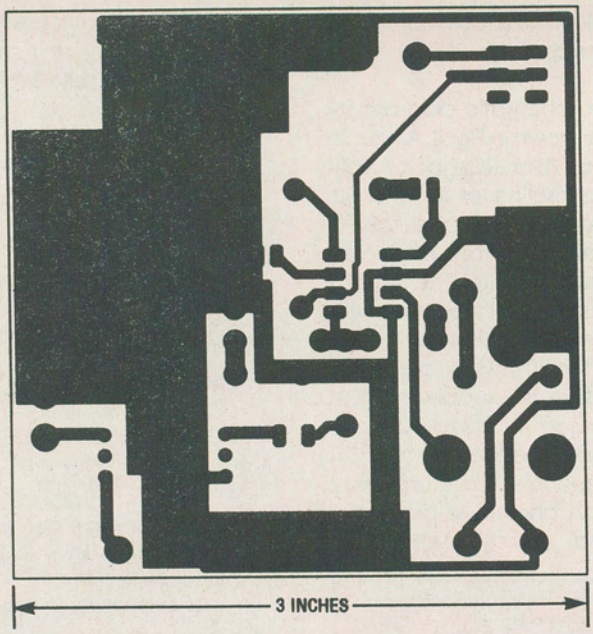


Fig. 5. You can make your own printed-circuit board from this foil pattern.

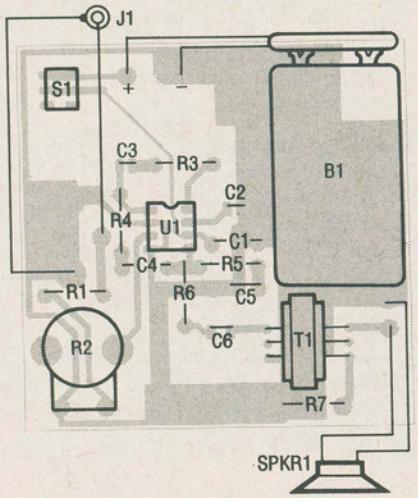


Fig. 6. Solder the components to the board using this parts-placement diagram as a guide.

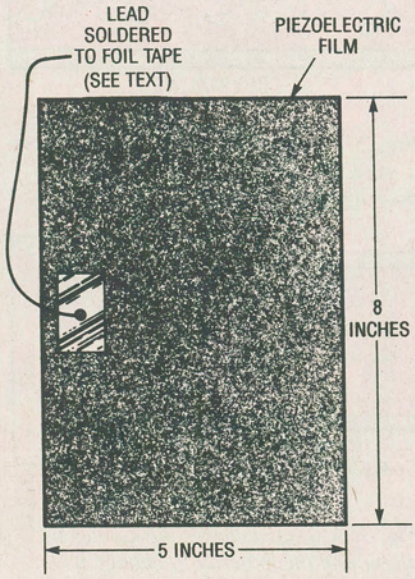


Fig. 7. Solder a lead to a piece of copper-foil tape and then stick the tape on the piezoelectric film.

allowing only audio to be coupled to T1. Transformer T1 steps up the audio signal by a factor of ten to drive the piezoelectric-film speaker. Resistor R7 limits current in case the output is accidentally shorted to ground.

Construction. It's a good idea to use a printed-circuit board for this project. You can make your own from the foil pattern provided in Fig. 5, or use the board that comes with the kit. You could also probably get away with using a piece of perfboard. If you use a printed-circuit board, solder the parts to the board as shown in the parts-placement diagram in Fig. 6.

Be sure to observe proper component polarity—especially with the integrated circuit, U1. Make sure that your soldering is done carefully, and be sure to check the board for any solder shorts, opens, cold-soldered leads, and heavy flux buildups when you're done.

The 9-volt battery holder is mounted to the board using a couple of small screws, although some double-sided tape will do. The leads from the battery holder are soldered to plus (+) and minus (–) points on the board; positive (red) to + and negative (black) to –. The PC board is designed to directly accept a particular RCA jack for J1 that is included in the kit. If you use a different RCA jack, simply solder the connections as shown in Fig. 6. Then you have to use an adapter cable to supply an input signal to J1, depending on the source that you're using.

The speaker is made from a piece of piezoelectric film that measures 5 by 8 inches. When making electrical contact with the piezoelectric film, you *cannot* just solder a lead directly to the film, because the solder will melt right through it. You have to use some copper-foil tape with a conductive adhesive backing; that tape is normally used to repair PC-board traces. Solder a lead to a piece of copper-foil tape and then stick the tape on the piezoelectric film, as shown in Fig. 7. Do the same on the opposite side of the film in the same position. The speaker leads—any length of stranded insulated wire—are soldered to the points indicated in Fig. 6, with the lead on the exposed surface of the film going to the upper speaker pad.

The film needs something to help it hold its shape. The kit comes with a thin piece of styrofoam, and the film already has an adhesive backing on one side. If you're building the project from scratch, try using the bottom of a styrofoam meat-packing tray—the thinner the better. Or try attaching the film to a sheet of glass or some other unusual surface—a balloon, for instance. To adhere the film to the styrofoam pad, try using a "roll of adhesive" sold in art-supply stores—it's like tape without the tape—just glue on a paper backing. Whatever kind of adhesive you use, be sure apply only a thin layer and try not to trap any dirt or air bubbles between the film and the backing.

Finish up by placing foam-rubber feet on the bottom of the board. The feet will provide a steady base for the project.

Operation. Because the unit has a volume control, almost any audio-signal source will work; an earphone jack, an output from a tape deck or CD player, etc. With the power off, and the volume control set at mid-point, connect an audio signal to J1. Turn on the power and you should hear the audio. You will notice that by bending the speaker film, the volume will vary. Try doing something unusual like mounting the speaker in a picture frame. You could also mount it curved on a piece of cardboard to achieve maximum volume. Then plug it in to your TV's earphone jack for a unique novelty item. ■

PCI Paint & Coatings Industry

Company News: Elf Atochem North America

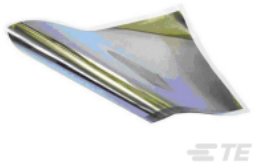
July 24, 2000

Elf Atochem North America has been renamed ATOFINA Chemicals.

Elf Atochem North America, Philadelphia, has been renamed ATOFINA Chemicals Inc. as a result of the merger of Elf Atochem's parent company, Elf Aquitaine, and TotalFina. The former Fina Oil & Chemical Co. has been renamed ATOFINA Petrochemicals Inc. The companies' corporate parent, Paris-based ATOFINA, is the world's fifth-largest chemical company, with annual sales of $17 billion.

Product Details

PIEZO FILM SHEETS



MEAS

Piezo film sheets are available in different film si zes and thicknesses.

Piezo Film Sensor Type: Sheet

Compatible Parts & Tooling

DATASHEET

DIGITAL DATASHEET

TE Model / Part #

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These sensors can be fabricated into simple transducers, or for use as full size sheets for applications such as speakers. Metallization options include a compliant silver ink as well as sputtered metallization. The silver ink is best for applications where mechanical stress is being applied. Silver ink also lends itself to custom metallization patterns for easy lead attachment. The thin, sputtered metallization is more brittle and used where signal to noise requirements dictate very low mass loading by the electrodes. Our standard sputtered metallization is 700 Å of copper covered with 100 Å of nickel, which has good conductivity and is resistant to oxidation. Other metallizations such as gold are available on a custom basis with a set-up fee. For the sputtered Metallized film, there is no border.

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