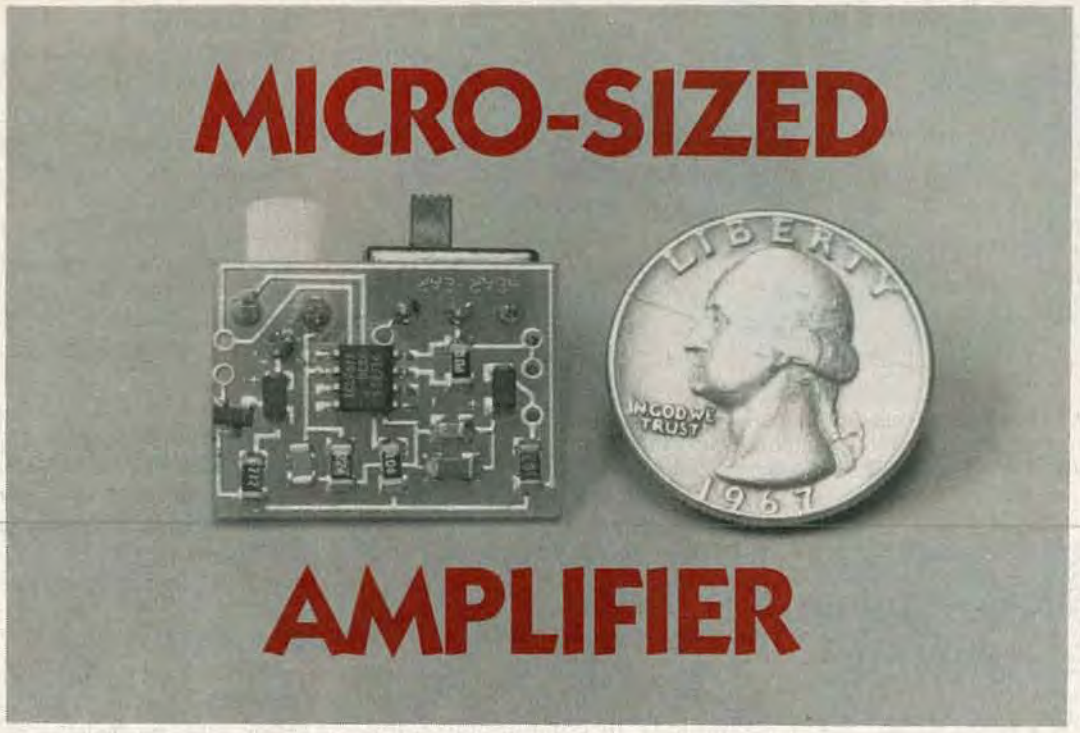
MICRO-SIZED AMPLIFIER



Because it uses surface-mount technology, this micro-size amplifier is not much larger than your thumbnail; but it can make your ears super-sensitive.

FRANK POLIMENE

BECAUSE THEY'RE SO TINY THAT THEY CAN be tucked directly inside the ear, high-gain micro-amplifiers add greatly to the quality of life for the hearing-impaired. For others—those who can still hear the TV without cranking up the volume so high that it can be heard down the block—micro-amps can be lots of fun, because they make possible projects that couldn't be done using conventional-size, or even miniature amplifiers.

As a general rule, commercial super-gain micro-amps are usually a component part of a larger, relatively expensive device, such as a hearing aid, a long-range Big Ear-type microphone, or a surface-microphone super-snooper device that you can use to listen through walls or to monitor your own heartbeat. However, if you'd like to experiment with a micro-amp that's so small that it can almost hide behind a quarter, you can build an SMT (*S*urface-*M*ount *T*echnology) version of the amplifier shown in Fig. 1 for under $20.

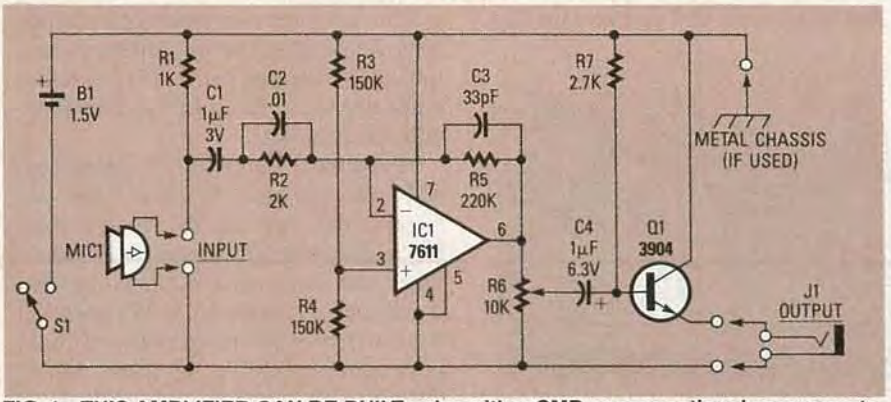


FIG. 1—THIS AMPLIFIER CAN BE BUILT using either SMD or conventional components. Even IC1 and Q1 are available in both SMD and conventional sizes.

If the amplifier was assembled using standard technology it would occupy a space of approximately four square inches; but, by using surface-mount technology we will build the amplifier, including through-hole devices S1 and R6, on a ¾ × 1-inch PC board. Then we'll show you how to use the micro-amp for both a home-brewed Big-Ear type microphone and a super-snooper.

Really small

The operational amplifier (IC1) and transistor (Q1) shown in Fig. 1, as well as all the capacitors and fixed-resistors, are available in both conventional and SMD (*S*urface-*M*ounted *D*evice) versions.

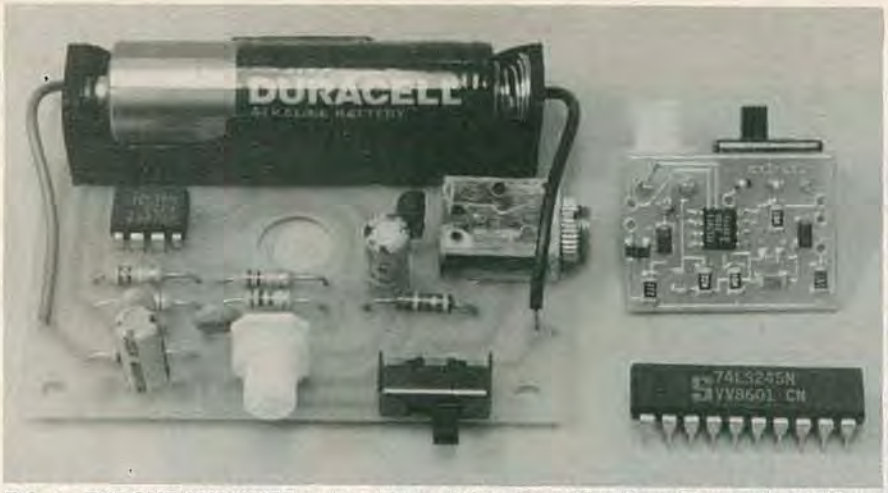


FIG. 2—THE SMT AMPLIFIER on the right and the conventional amplifier on the left have the same performance, although the conventional amp's PC board has room for a battery holder and an output jack. The 20-DIP IC also serves to illustrate the small size of the SMT amplifier.

FIG. 3—THE COMPLETE SMT AMPLIFIER, including an N-battery and an earphone jack, can be assembled in a small plastic pill box.

SMD-type capacitors and resistors are called *chips*; hence, an SMD-type resistor is called a *chip resistor*.

Figure 2 shows the SMT amplifier on the right and the same circuit, made using conventional miniature components, on the left. Note that when using conventional parts, the PC board gets so large that's its easy to install the battery holder and an output jack for the headphones directly on the board. Obviously, for the SMT amplifier the battery (B1) used for the power supply and the microphone (MIC1) must be external to the amplifier. The 20-pin DIP IC, also seen in Fig. 2, shows the relationship in size between the entire SMT amplifier and a single conventional integrated circuit.

Why so small?

While most of us can understand the reasons for using surface-mount technology in commercial equipment, it's logical to ask what real value or purpose there is for the hobbyist to use SMT to build what is essentially a simple electronic circuit. First, it gives you a chance to build a practical device that could not be easily done using conventional-size components. Second, using SMT provides both acquaintance and experience with the latest manufacturing technology used in consumer and professional equipments.

The complete amplifier assembly (Fig. 3) that is used for for both the Big Ear-type microphone and the super-snooper is a good example of why a hobbyist would use SMT construction. The entire amplifier, including its battery and headphone jack, is so small it can be assembled in a plastic pill box that can be glued to the front of a Big Ear-type microphone, or carried in a shirt pocket.

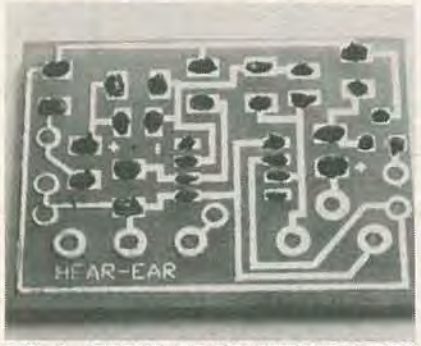


FIG. 4—DROPS OF SOLDERING PASTE are applied only to the components' soldering pads.

The amplifier

Sound detected by the electret microphone (MIC1) is fed to IC1's input through resistor R2, and capacitors C1 and C2. Resistors R2 and R5 determine the overall stage gain, while C2 partially determines the amplifier's frequency response. To ensure proper operation using a single-ended power supply, R3 and R4 simulate a null condition equal to half the power supply's voltage at IC1's non-inverting input.

The output of IC1 is transferred to emitter-follower amplifier Q1 via volume control R6. The high-Z-in/low-Z-out characteristic of the emitter-follower matches the moderately high-impedance output of IC1 to a low-impedance headphone load.

Stop and think

One note of caution on the SMT amplifier. There is a practical limit as to how small the battery can be. While N-size and larger batteries work fine, the small 1.5-volt button cells don't have sufficient ampacity (current-capacity) to provide a low-distortion output. So when figuring how you'll house the amplifier, keep in mind that the battery will be about the same size as the amplifier, or larger. Also, the battery's life depends on the type that you use. You can expect about 12–24 hours of continuous use from a small watch battery, and two months or more from a D-type Alkaline flashlight battery. Keep in mind that the distortion is a good indicator of the battery's condition: A dramatic increase in distortion means that the battery is pooped out.

Construction

The most important part of both the long-range Big Ear microphone and the super-snooper is the SMT micro-amplifier, so we'll cover the amplifier construction first.

It is almost impossible to create an SMT foil pattern "by hand," so we suggest that you use the double-size PC-board template shown in PC Service. Just make certain that you scale it down by a factor of 0.5. We suggest that a professional photographic positive or negative be used. Most copy houses and photographic dealers can use the PC Service template to prepare a negative or positive "stat."

PARTS LIST

Resistors are ⅛-watt chip-type unless otherwise noted.
R1—1000 ohms
R2—2000 ohms
R3, R4—150,000 ohms
R5—220,000 ohms
R6—10,000-ohm miniature control, Mouser ME322-9400 or equivalent
R7—2700 ohms
Capacitors are chip-type rated at least 6.3 volts.
C1, C4—1 μF
C2—0.01 μF
C3—33 pF
Semiconductors
IC1—ICL7611DCBA, operational amplifier (Intersil)
Q1—MMBC3904, PNP transistor
Other components
B1—1.5-volt battery, see text
J1—Miniature phone jack
MIC1—electret microphone, Mouser 25LM042 or equivalent
S1—SPDT, miniature switch, Mouser 10SP018 or equivalent
Miscellaneous: printed-circuit board materials, 1-oz. solder paste, 32-ohm stereo headphones, solder, etc.
Note. The following components are available from BCT Electronics, 8742 Belair Rd., Baltimore, MD 21236:
Etched and drilled printed-circuit board, $3.95; IC1, $3.95; complete kit including solder paste, $14.95. Add $1.50 postage and handling for each order. Maryland residents must add 5% sales tax.

If you don't want to go through the hassle of making the board yourself, it can be ordered from the source given in the Parts List.

Although commercial SMT printed-circuit assemblies are made using a variety of methods, most use some kind of solder mask and/or automatic adhesive dispensing, and a pick-and-place machine to put the parts on the board. But you'll have to put the parts in place one at a time by hand, so you'll have to provide a way to position the component, hold it in place, and make it ready for careful soldering.

The positioning, holding, and prefluxing is done with a special kind of solder paste that contains tiny balls of solder mixed with flux. (The mixture forms a paste that's similar in consistency to smooth peanut butter.) It is usually supplied in jars or cans, but is also available in syringe-type dispensers for precise paste delivery.

Most electronic supply stores now carry some variation of SMT solder paste as a stock item. But a note of caution: Solder paste has a relatively short shelf-life—6–12 months after it's been opened—so purchase the minimum amount possible and store it in the refrigerator when not in use.

Mix the solder paste thoroughly. Place a small amount on a piece of aluminum foil and allow it to reach room temperature. Stir the paste with a toothpick until it reaches a smooth consistency; then, as shown in Fig. 4, place small drops of the paste only on the soldering pads that will be used for the SMD's.

If in the process of applying the paste to the PC board you mess up, simply use a toothpick to move or remove the paste. If the mess is beyond control, use a tissue to mop up all the paste and start over.

Using tweezers, position an SMD over its pasted pad and gently press the SMD into the paste. The paste will hold the part in position until it's soldered. If positioning the components causes the solder paste to slop onto adjacent traces, use a toothpick to clean the area between the traces.

Soldering

Position the parts on the PC board as shown in Fig. 5. The SMD's don't have to be perfectly centered on the pads because the paste will pull them into position during the soldering process. After all the SMD's have been placed, prepare the soldering device—a hot plate that's topped with a shallow aluminum pan or a skillet—by preheating the pan or skillet with the hot plate's temperature control set to HIGH. (Solder melts at approximately 400°F.) Pick up the completed board with tweezers and place it on the pan or skillet with the board's flat side down (component side up).

It will take from 20 to 50 seconds for the solder to melt. Then remove the board quickly to prevent the components from overheating. Set the board aside to cool. Next, using a low-wattage soldering iron, install switch S1 and volume-control R6. Microphone MIC1, battery B1, and output-jack J1, are connected through wires that are hand-soldered to their respective PC-board terminals.

Finally, as shown in Fig. 3, install the amplifier, along with B1 and J1, in a small plastic pill box.

The reflector

Details for building the prototype Big Ear-type reflector are shown in Fig. 6. The reflector is an 11-inch aluminum bowl. Actually, unlike a parabolic reflector—which is really what's needed—the bowl-shaped reflector used for our prototype Big Ear-type microphone doesn't sharply focus the arriving sound into the microphone. But the back of the bowl *does* have the approximate shape of a small parabolic reflector, and the tube that supports the microphone and its amplifier housing can be positioned for optimum sound pickup—so the assembly really can function as a moderately sensitive Big Ear.

The amplifier's cabinet is cemented to the back of a 7-inch length of ½-

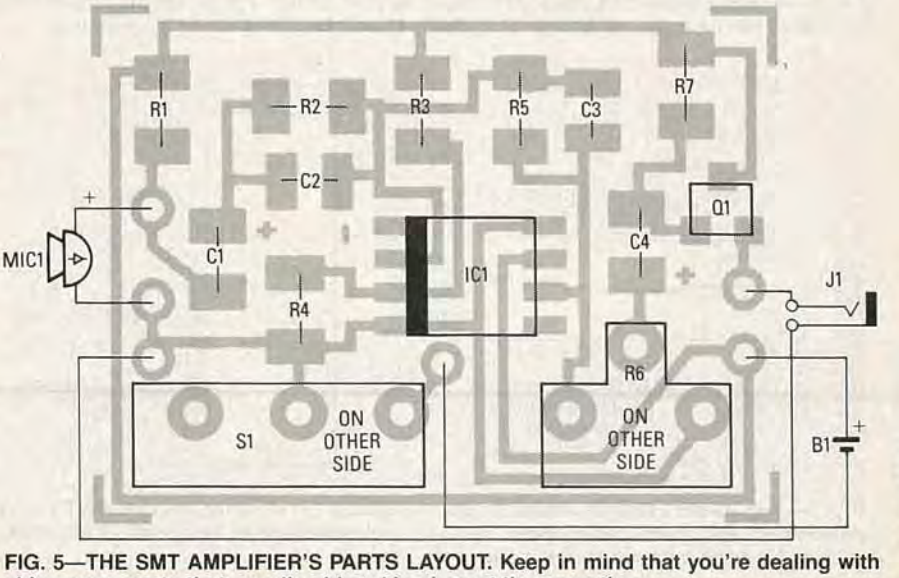


FIG. 5—THE SMT AMPLIFIER'S PARTS LAYOUT. Keep in mind that you're dealing with chip components that are all soldered in place at the same time.

inch copper tubing. Microphone element MIC1 is secured inside a ⅜-inch rubber grommet that's cemented inside the tubing with silicon rubber adhesive or hot-melt glue. The front of the microphone should be flush with the front of the grommet, which is set back about ¼-inch from the input end of the tubing. The details for the amplifier assembly and the microphone installation are illustrated in Fig. 7.

As shown in Fig. 6, the microphone assembly is supported by three bands formed from ¼-inch copper tubing. One end of each band is screwed to the bowl; the other end is soldered to a ½-inch solder-type copper coupling. The microphone's pickup is optimized by sliding the amplifier assembly back and forth in the coupling until the best sound pickup is attained. The actual Big Ear-type microphone prototype is shown in Fig. 8.

Snooping

A super-snooper's amplifier is built the same way as for the Big Ear, with the exception that the microphone is not installed in a pipe that's attached to the amplifier. Instead, using the same mounting arrangement shown in Fig. 7, install the microphone in a 1-inch length of ½-inch plastic tubing, PVC, or ABS pipe. Connect the microphone to the amplifier's input through approximately two feet of shielded cable. Since the amplifier is intended for listening to weak sounds, expect to hear considerable distortion if someone speaks directly into the microphone, or even nearby. As a general rule, use the super-snooper for monitoring weak sounds, such as your own heartbeat, and adjust volume-control R6 for the minimum usable gain.

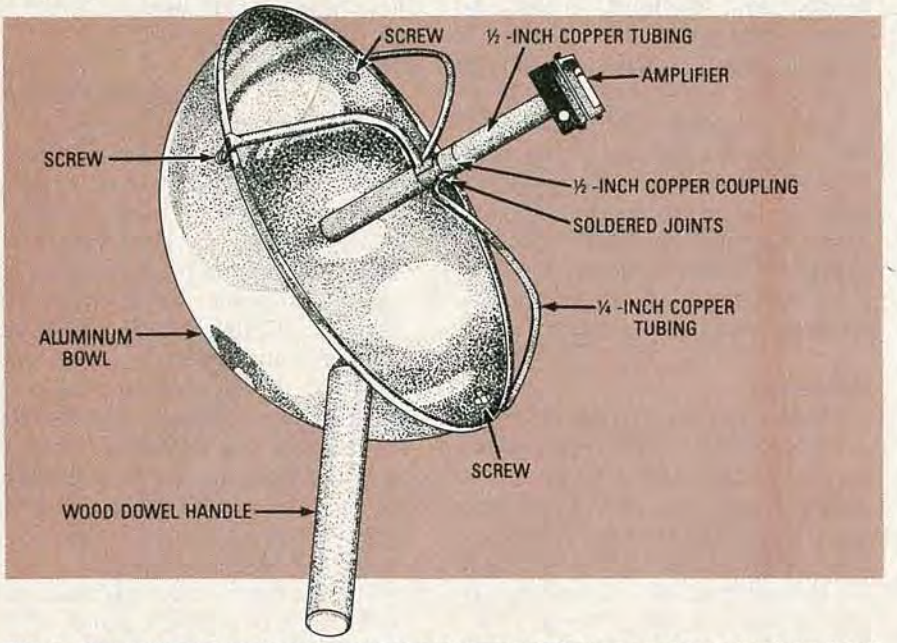


FIG. 6—THE BIG EAR-TYPE MICROPHONE'S REFLECTOR is actually an aluminum bowl, so it does not have the sensitivity of a parabolic-reflector long-range microphone.

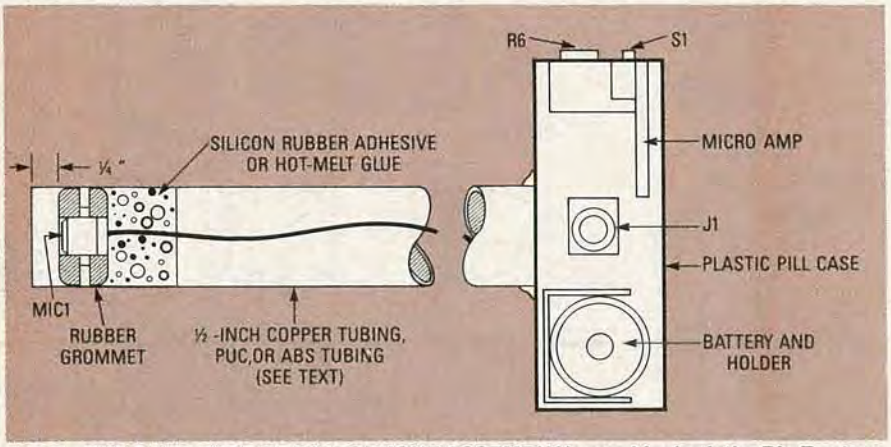


FIG. 7—THE SAME TYPE OF MICROPHONE ASSEMBLY is used for both the Big Ear-type microphone and the super-snooper. The only real difference is the length of the tubing used to hold the microphone element.

FIG. 8—THE PROTOTYPE BIG EAR-TYPE microphone. The tubing containing the microphone and the amplifier is positioned for optimum sound pickup.

Unusual snooper

Figure 9 shows an unusual kind of snooper; one that you can wear in a crowd and no one will be the wiser. A complete circuit, including the microphone, and a power source, is built into both "headphones" of a *radio headset*; one of those listen-while-you-jog radios. Simply strip out the guts from both earpieces—taking care not to damage the headphone unit itself—and install our micro-amp, a microphone, and a button-cell. **R-E**

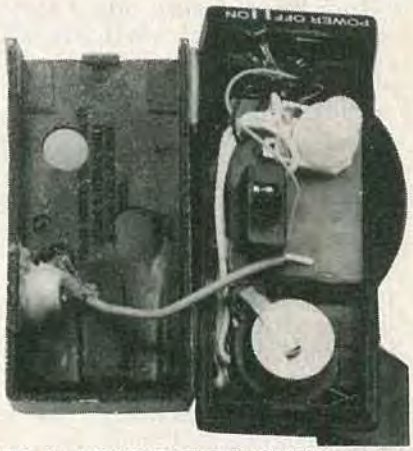


FIG. 9—USING BUTTON POWER, you can install the micro-sized amplifier in place of a headset radio.