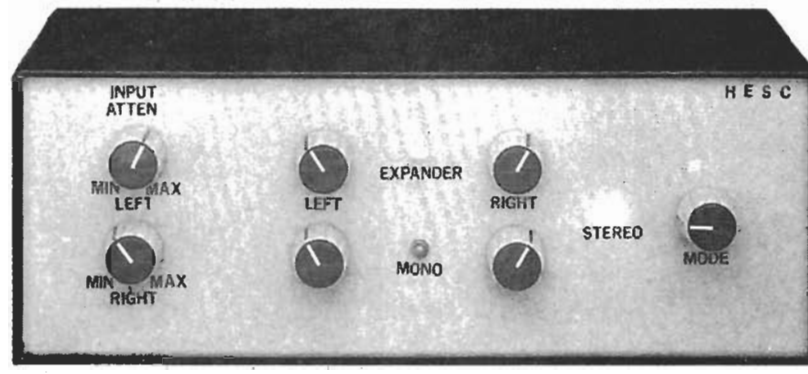
BUILD THIS AUDIO EXPANDER

PHILL HAUSMAN



Enhance stereo and mono audio, for under $30, with our one-chip audio processor.

IT SEEMS THAT EVERYBODY IS AN audio enthusiast these days. With compact discs, stereo TV, hi-fi video tapes, and laserdiscs cheaply available to the general public, nobody wants to settle for ordinary sound. If you build our audio processor, you won't have to settle for ordinary sound either! Our audio processor, which can be built in one evening, can be installed easily between any audio output source and any audio input source, and it can "supercharge" any mono or stereo audio signal.

Some of the many uses for the audio processor include enhancing the audio output from a stereo system or any scanner, shortwave, CB, or ham radio receiver. Stereo and mono TV sound can also be greatly enhanced; a pseudo-stereo effect can be added to a mono soundtrack, and if stereo audio is already in use, you can add enhanced stereo effects. The processor also has amazing effects on old mono or pre-Dolby cassette and 8-track tapes—it's great for doing restoration of old recordings.

Features

The audio processor provides a complete array of controls that give the user maximum flexibility in adjusting the processor. The unit has switch-selectable stereo sound from a stereo source, spatial (widened) sound from a stereo source, and pseudo-stereo sound from a mono source; LED's indicate which mode is selected.

The unit exhibits very low noise (−64 dB minimum) and low total harmonic distortion (maximum THD is 0.5% at 1000 Hz). The input and output resistance is 100 kilohms, which is the standard line-level resistance. The left and right channels provide a minimum of 60 dB separation, and there's an adjustable input attenuator for each channel, which provides a minimum of 70.0 dB attenuation. There's independent gain adjustment of the left and right channels in the spatial stereo mode, and independent gain adjustment of the left and right channels in the mono pseudo-stereo mode.

Theory of operation

The audio processor, whose schematic is shown in Fig. 1, is based on the Signetics/Philips TDA3810N stereo, spatial, pseudo-stereo processor IC. A block diagram of the chip is shown in Fig. 2. The device is essentially a system of internal op-amps used as active filters. The chip contains three op-amp stages, switching circuitry, power-supply regulation circuitry, and LED drivers.

The easiest way to understand how the chip works is to follow the audio signal through the chip for each individual mode.

Stereo mode

When the stereo mode is selected, the left input signal passes through input-attenuator R14, and is coupled via C4 to pin 2 of IC1 (the TDA3810N). The right input signal passes through R15 and C3 to pin 17 of IC1. The various active filters within IC1 serve as a unity-gain bandpass filter with a −3 dB low-frequency cutoff occurring at 20 hertz, and the −3 dB high-frequency cutoff occurring well beyond 20,000 hertz.

Spatial mode

As shown in Fig. 3, when the spatial, or widened, stereo mode is selected, active op-amp circuits selectively remove certain parts of the audio spectrum. The effect is achieved by feeding the audio input to the non-inverting input of an op-amp. The inverting input is fed by the output of the internal buffer/amplifier coupled with a cross-channel signal through R2. Both channels operate in the same way. The gain of each channel can be adjusted independently: R3 adjusts the left channel and R1 adjusts the right channel.

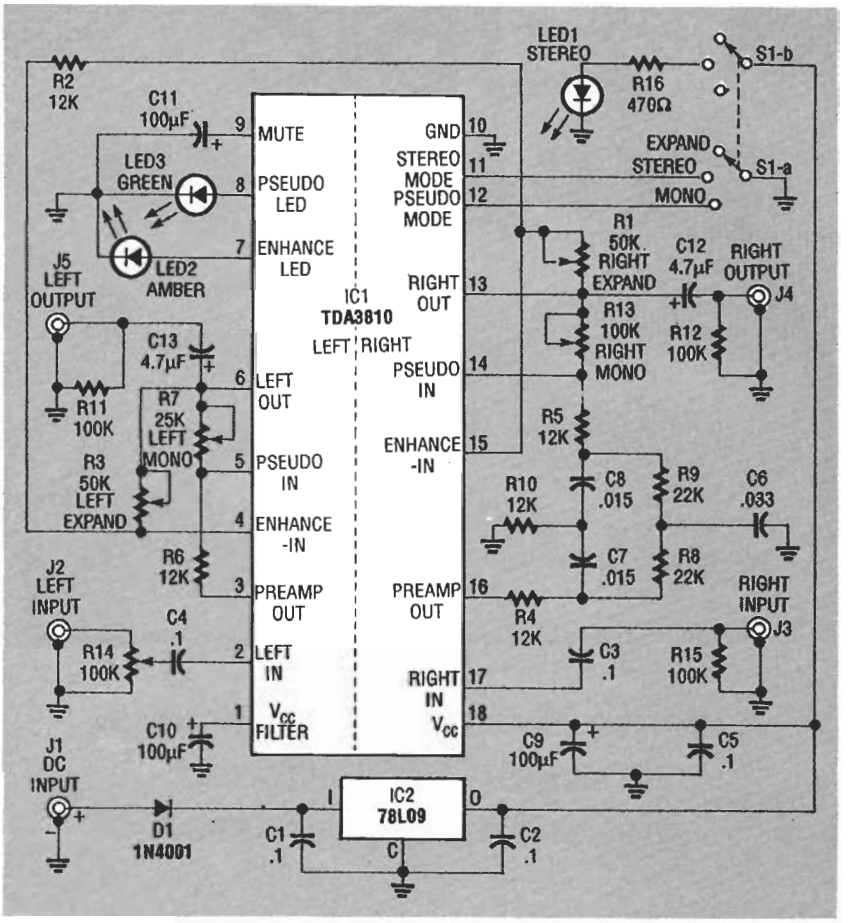


FIG. 1—THE AUDIO PROCESSOR is based on the Signetics/Philips TDA3810N stereo, spatial, pseudo-stereo processor IC.

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise noted.

R1, R3—50,000 ohms, panel-mount potentiometer
R2, R4–R6, R10—12,000 ohms
R7—25,000 ohms, panel-mount potentiometer
R8, R9—22,000 ohms
R11, R12—100,000 ohms
R13–R15—100,000 ohms, panel-mount potentiometer
R16—470 ohms

Capacitors

C1–C5—0.1 µF, 50 volts, metal film
C6—0.033 µF, 50 volts, metal film
C7, C8—0.015 µF, 50 volts, metal film
C9–C11—100 µF, 16 volts, electrolytic
C12, C13—4.7 µF, 35 volts, electrolytic

Semiconductors

IC1—TDA3810N audio processor chip (Philips)
IC2—78L09 9-volt regulator
D1—1N4001 diode
LED1–LED3—light-emitting diodes (use three different colors)

Other components

S1—DP3T panel-mount switch
J1—2.1 mm panel-mount power jack (optional)
J2–J5—panel-mount RCA jack
Miscellaneous: 18-pin IC socket, metal project case, 12-volt DC wall transformer (100-mA), 6 knobs, PC board, shielded cable, wire, solder, etc.

Note: The following items are available from HESC, PO Box 12649, Fort Wayne, IN 46864-2649:

- **A kit of parts including a PC board and all parts that mount on it (does not include potentiometers, project case, or wall transformer)—$19.95 + $3.05 S&H**
- **PC board and TDA3810N—$14.95 + $3.05 S&H**
- **TDA3810N—$7.00 postage paid**

Please allow 6 to 8 weeks for delivery.

Pseudo stereo mode

As shown in Fig. 4, when the mono pseudo-stereo mode is selected, the processor creates a "stereo" image using the various active filters differently on each channel. The left channel is fed through a flat-response amplifier (200 Hz to 20 kHz) to achieve a constant gain across the audio spectrum. The gain is adjustable via potentiometer R7, which controls feedback. The optimum setting recommended by Philips, the chip manufacturer, is +2.00 dB at 15 kHz; R7 gives an adjustment range of −69.0 dB to +6.0 dB at 15 kHz.

The right channel uses a twin-T notch filter to give the illusion of signal separation, or the pseudo-stereo effect. Between 100 and 1600 hertz, the notch filter attenuates the audio range by −33.0 dB at its lowest point, which occurs at about 450 hertz. The gain is adjustable by R13, which controls feedback. Philips recommends 0 dB at 15,000 Hz, although R13 gives a range of −68.0 dB to +6.0 dB. Figure 5 shows the frequency response of each channel.

Remaining circuitry

The TDA3810 contains a muting circuit with built-in hysteresis (controlled by C11) that prevents the status LED's from flickering when switching from mode to mode. Also included is the mode selection switch (S1-a and -b) and the corresponding status indicators LED1, LED2, and LED3.

The project requires an external power supply of +10.5–24.0 volts DC, which passes through polarity-protection diode D1 to the input of IC2, a 78L09 +9.0 volt DC, 0.1-amp voltage regulator. Capacitors C1 and C2 provide decoupling and anti-oscillation protection for IC2.

Construction

Most of the parts for the audio processor are available from many electronics distributors. A foil pattern is provided if you want to make your own PC board, or you can use the board available from the source men-

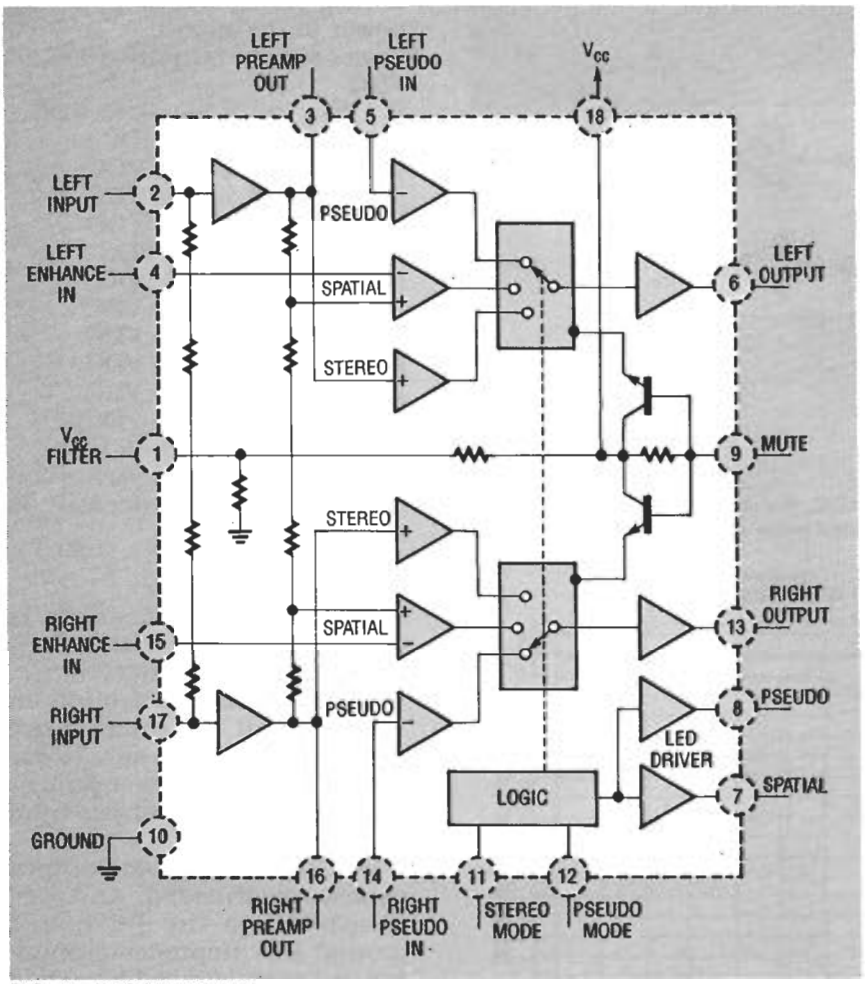


FIG. 2—BLOCK DIAGRAM OF THE TDA3810N. The device contains three op-amp stages, switching circuitry, power-supply regulation circuitry, and LED drivers.

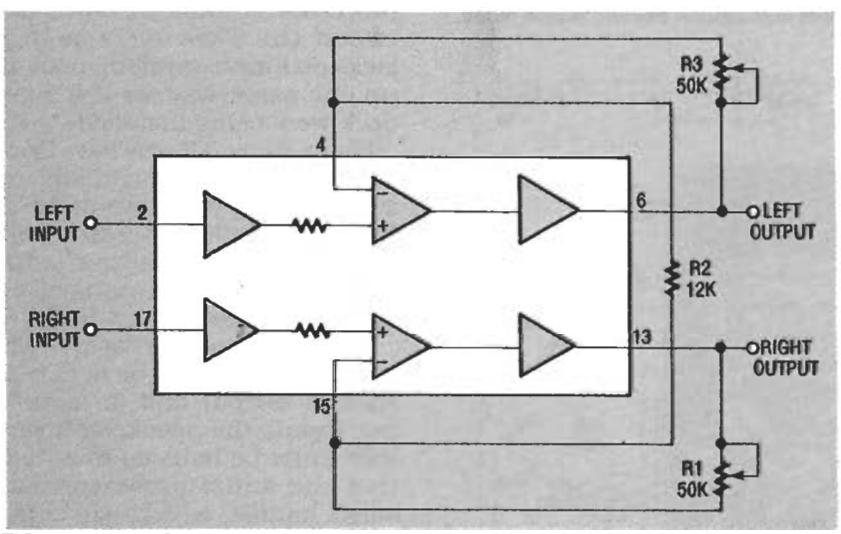


FIG. 3—IN THE SPATIAL STEREO MODE, active op-amp circuits selectively remove certain parts of the audio spectrum.

tioned in the Parts List.

Because this is an audio project, component tolerances and the matching of component values between the left and right channels is important. All resistors should be within 5 percent of the listed value, and it's a good idea to check them. Be sure to use high-quality capacitors, as poor-quality capacitors can adversely effect the overall frequency response of the circuit's processor.

Following the parts-placement diagram in Fig. 6 as a guide, install all resistors and capacitors, paying attention to the polarity of the electrolytics. Also mount diode D1, observing its polarity. Mount the 78L09 voltage regulator (IC2) with the flat side pointing toward the outside edge of the PC board. It's a good idea to use a socket for IC1, and you can install it now and then insert the IC. Observe the proper pin-1 orientation when putting the chip in its socket.

A metal enclosure will provide the best shielding from interference. However, a plastic box will probably be acceptable as well. Prepare the enclosure by laying out the front and rear panels for drilling. After drilling, deburr and clean the enclosure. The author mounted solder posts at each point on the board that must be hard-wired to another component. That made it easy to mount the board, jacks, and controls in the case, and then do the point-to-point wiring. Otherwise, all wires will have to be soldered to the board before mounting it in the enclosure. In either case, mount the completed PC board to the enclosure using appropriate hardware.

If you haven't done so yet, mount all of the potentiometers, jacks J1–J5, the LED's, and switch S1 to the enclosure. Then solder all cables and wires from the board to the jacks and controls. Following Fig. 6, pay careful attention to the places where shielded cable must be used. Hook-up wire can be used for all other connections. When connecting the feedback gain-control potentiometers (R1, R3, R7, and R13), wire them so their resistance *increases* as they are turned clockwise. Figure 7 shows the inside of the completed prototype.

Testing

When the project is complete, check all components for proper location and polarity, and also check your soldering. Using a DC voltmeter, check for the fol-

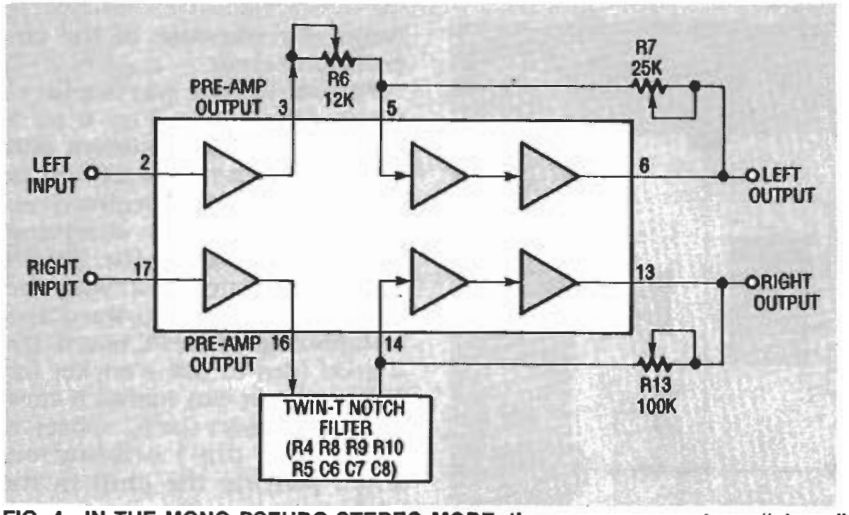


FIG. 4—IN THE MONO PSEUDO-STEREO MODE, the processor creates a "stereo" image using the various active filters in different ways on each channel.

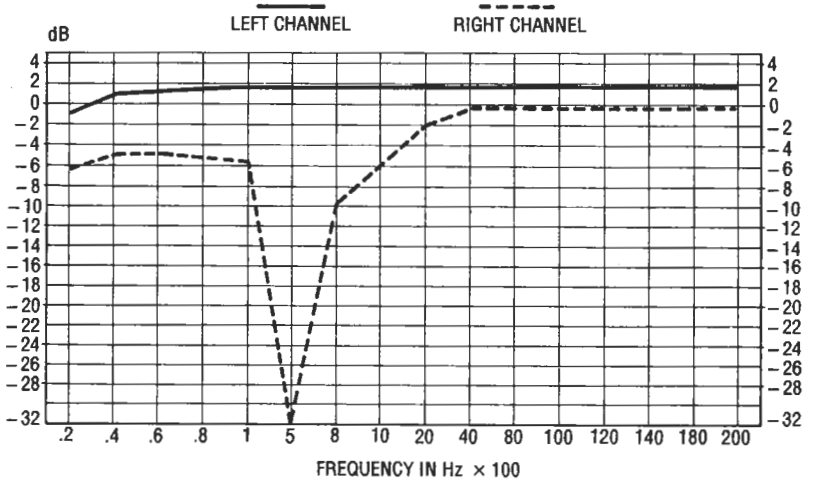


FIG. 5—FREQUENCY RESPONSE of each channel in the mono pseudo-stereo mode.

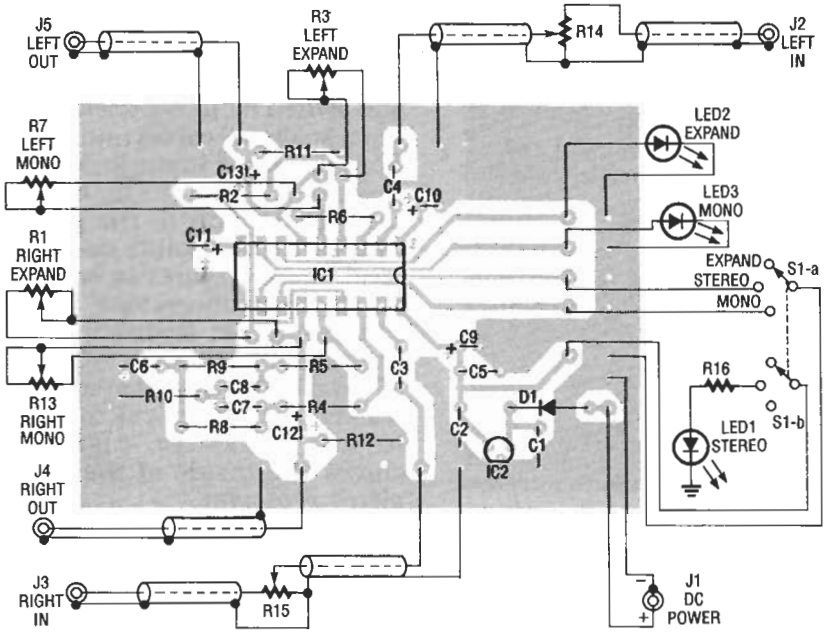


FIG. 6—PARTS-PLACEMENT DIAGRAM. Pay attention to those controls that require shielded cable for connection to the PC board.

lowing voltages after applying power to the circuit:

Power-supply output—10.5–24 VDC
IC2 output—8.55—9.45 VDC
IC1 pin 1—4.2–4.8 VDC
IC1 pin 2—4.2—4.8 VDC
IC1 pin 3—4.2—4.8 VDC
IC1 pin 4—4.2—4.8 VDC
IC1 pin 5—4.2–4.8 VDC
IC1 pin 6—4.2–4.8 VDC
IC1 pin 13—4.2–4.8 VDC
IC1 pin 14—4.2–4.8 VDC
IC1 pin 15—4.2–4.8 VDC
IC1 pin 16—4.2–4.8 VDC
IC1 pin 17—4.2–4.8 VDC
IC1 pin 18—8.55–9.45 VDC

If all of those voltages are correct, the audio processor is ready to use.

Installation and use

If the audio processor is placed near a TV set and tends to pick up stray interference, move the processor around on the TV until the interference disappears. Also, be sure to use a well-filtered DC power pack or power supply to eliminate hum from the AC line.

Be sure all input and output cables are shielded, and well grounded to the PC board ground foil. Improper grounding can cause ground loops and other noise problems that are hard to track down. When the processor is to be installed between the TAPE IN/TAPE OUT jacks on a stereo system, hook it up the same way as if a tape deck were being installed.

Some stereo TV sets have line-level output jacks on them. In that case, all you have to do is install the audio processor unit between the TV's output jacks and the stereo's auxiliary or tuner input jacks.

If the audio processor unit will be installed between a speaker output and an amplifier input, the speaker output level must be reduced to a level that the audio processor can safely handle, which is a maximum of 2 volts rms. Always set the input-attenuator potentiometers to maximum attenuation before applying an input signal to the processor. Connect all mono audio sources to both of the inputs.

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In the stereo mode, the only adjustments are the input-attenuator controls (R14 for the left and R15 for the right). For a line-level input, set them for 0 attenuation. Other higher-level sources should be adjusted as desired by the user (without exceeding the 2-volt rms maximum input limit).

In the spatial stereo mode, the input attenuator controls should be adjusted the same way as in the stereo mode. The spatial controls (R3 for the left and R1 for the right) can then produce very interesting spatial effects. Also, adjusting the input-attenuator controls produces interesting effects due to the cross-channel coupling provided by resistor R2. Experiment with those four controls to determine their optimum settings.

In the mono pseudo-stereo mode, the input-attenuator controls should be adjusted the same way as in the stereo mode. The pseudo stereo controls (R7 for the left and R13 for the right) should be set as follows: R7 should be set to give a +2.0 dB higher output level versus the right output channel control (R13). For example, set R7 for an output of +2.0 dB, and set R13 for an output of 0 dB. The specific levels are not critical; just keep a 2.0 dB differential between the left and right output channels.

When using a mono input source, the spatial stereo mode will produce some very interesting and useful effects. The input attenuator controls will also have interesting effects.

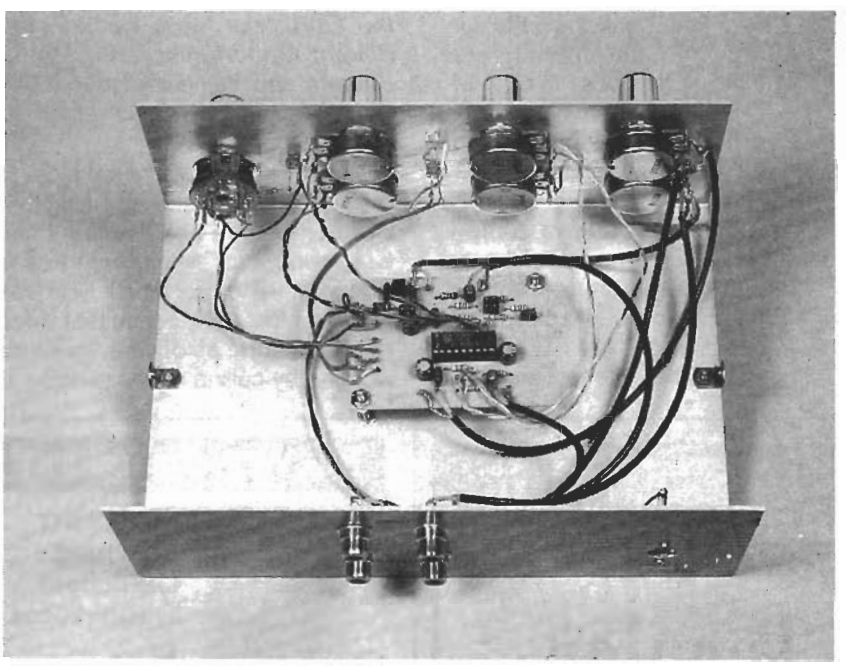
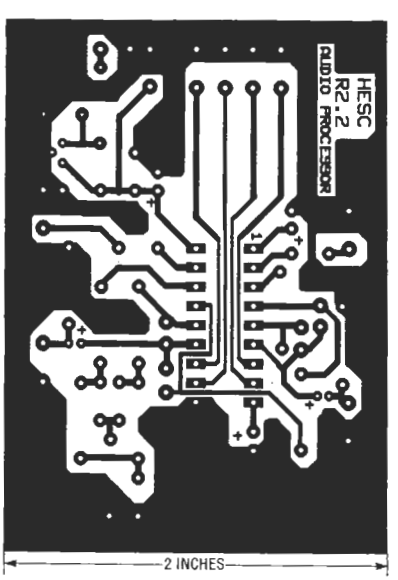


FIG. 7—A METAL ENCLOSURE provides the best shielding from interference. Here's the inside of the completed prototype.



FOIL PATTERN for the audio processor.