Distortionless Audio Compressor

JUST THE THING FOR HAMS, CB'ers, AND TAPE RECORDING FANS

BY CHARLES CARINGELLA, W6NJV

THE AUDIO COMPRESSOR is an important engineering instrument in every recording, television, and radio studio. By holding the output of a device at a given level for a given increase in input signal level, the compressor assures a smooth listenable product, without booms and overloading distortion. You can see how valuable a contribution a compressor would make to your own audio equipment—be it tape recorder, amateur radio or CB transmitter.

Once set up to operate with a tape recorder, the audio compressor will hold the recording level constant, without introducing noise or distortion. You can ignore the recording level meter on your recorder and there is no need to "ride" the recorder gain control. The compressor is particularly valuable when recording lectures, press conferences, family groups, etc. Smooth, professional results can be achieved when making stereo or multiple channel recordings. All it takes is one compressor in each channel and the work is done for you.

When used with amateur radio and CB transmitters, an audio compressor can provide as much as a 10-dB increase in signal strength at the receiving end. This is the next best thing to adding a kilowatt linear amplifier to your transmitter! The automatic limiting action also prevents overmodulation, without adding distortion to the transmitted signal.

Still another application for the audio compressor is with public address amplifiers. Here, the output of the system can be held constant regardless of input variations due to difference in voice levels and distance from the microphone. The unit also minimizes annoying feedback.

You can build your own audio compressor for less than $50 and it will be the equivalent of commercial units costing 4 or 5 times as much. Although the compressor is somewhat complex in theory, it is easy to build and use. It is simply installed between the microphone and the equipment. There is no need to dig into the equipment circuitry.

Besides having a large dynamic com-

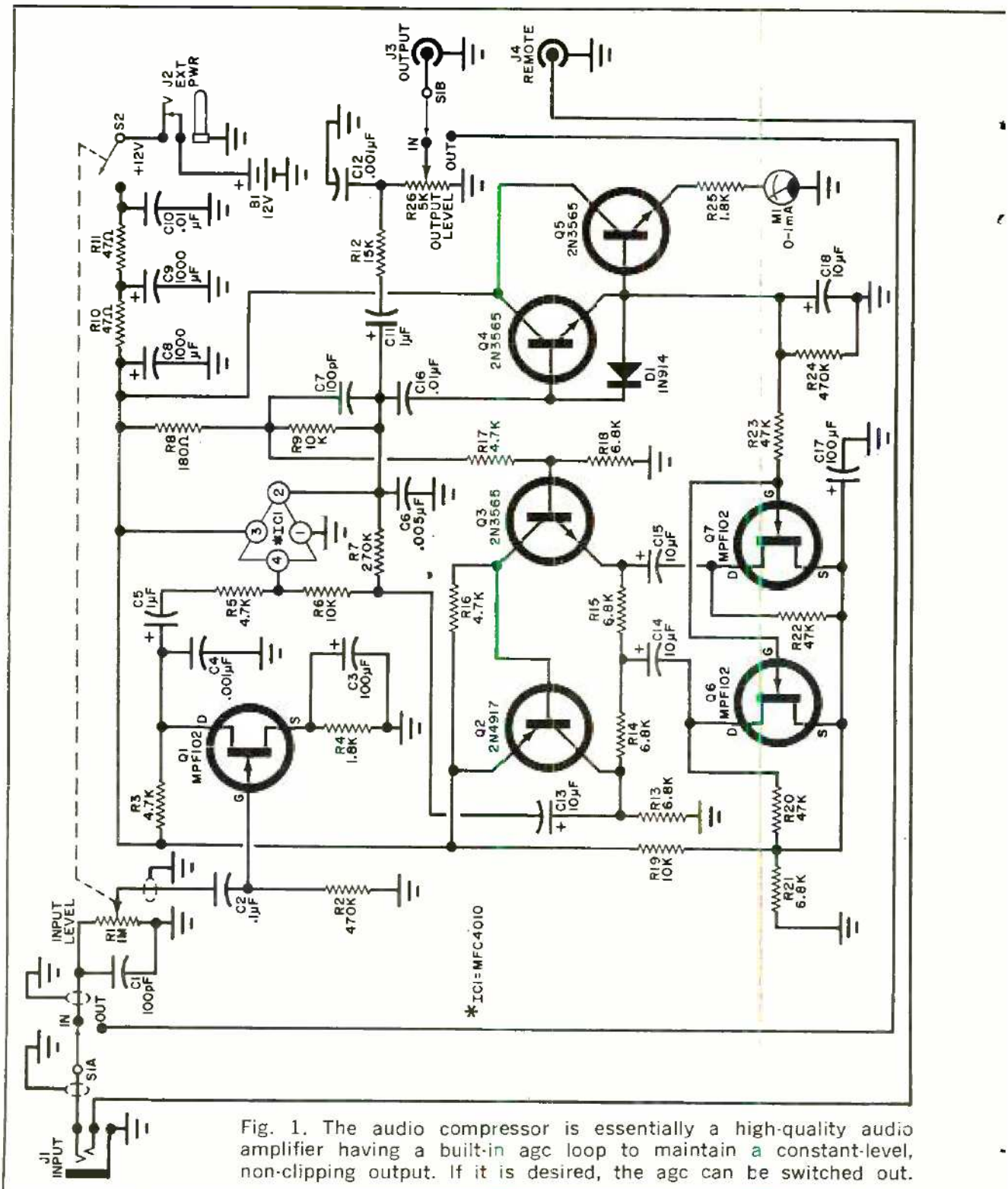


Fig. 1. The audio compressor is essentially a high-quality audio amplifier having a built-in agc loop to maintain a constant-level, non-clipping output. If it is desired, the agc can be switched out.

pression range (45 dB or more), the compressor described here also serves as a high gain preamplifier with approximately 46 dB of gain. This permits the use of practically any type of microphone, from low-impedance dynamics (200 ohms or more) to high-impedance crystal, ceramic, and dynamic types. An FET input provides a very low noise figure.

The completed unit, housed in a cabinet 5" x 2½" x 4½", can be operated from an internal 12-volt mercury battery for portable applications or any other 12-volt external supply.

Theory of Circuit Design. The compressor is basically an audio amplifier with an automatic gain control (agc) feedback

PARTS LIST

B1—12-volt mercury battery (Mallory 289 or similar)
C1,C7—100-pF ceramic disc capacitor
C2—0.1-μF miniature ceramic disc capacitor
C3,C17—100-μF, 12-volt miniature printed circuit electrolytic capacitor
C4, C12—0.001-μF ceramic disc capacitor
C5,C11—1-μF, 12-volt miniature printed circuit electrolytic capacitor
C6—0.005-μF ceramic disc capacitor
C8,C9—1000-μF, 12-volt miniature printed circuit electrolytic capacitor
C10,C16—0.01-μF ceramic disc capacitor
C13,C14,C15,C18—10-μF, 12-volt miniature printed circuit electrolytic capacitor
D1—1N914 silicon diode
IC1—Amplifier integrated circuit (Motorola MFC4010)
J1—3-way phone jack
J2—Closed-circuit coaxial power jack
J3,J4—Phono jack
M1—Milliammeter, 0-1 mA, 2800-ohm coil (Emico Model 12)
Q1,Q6,Q7—FET, n-channel (Motorola MPF102)
Q2—Pnp transistor (Fairchild 2N4917)
Q3,Q4,Q5—Npn transistor (Fairchild 2N3565)
R1—1-megohm potentiometer with spst switch for S2
R2,R24—470,000-ohm, ½-watt 10% resistor
R3,R5,R16,R17—4700-ohm, " " "
R4,R25—1800-ohm " " "
R6,R9,R19—10,000-ohm " " "
R7—270,000-ohm " " "
R8—180-ohm " " "
R10,R11—470-ohm " " "
R12—15,000-ohm " " "
R13,R14,R15,R18,R21—6800-ohm " " "
R20,R22,R23—47,000-ohm " " "
R26—5000-ohm potentiometer
S1—Dpdt rocker-type slide switch
S2—Spst switch, part of R1
Misc.—Chassis (5" x 2¼" x 1½"), knob, angle brackets (6), battery clips (2), rubber feet (4), hardware, wire solder, etc.
Note: The following are available from Caringella Electronics, Inc., P.O. Box 327, Upland, CA 91786: etched and drilled printed circuit board at $5.95; complete kit of parts less battery but including PC board, chassis, assembled power supply, and all hardware at $49.95. All prices postpaid. California residents, add 5% sales tax.

loop (see Fig. 1). The feedback provides a very fast attack time and a slow decay time. The fast attack means that the compressor can respond to a 20-dB increase in signal at 1 kHz in less than 1 millisecond. At 10 kHz, the attack time response is less than 100 microseconds. The fast attack time results in no loss of information at the beginnings of words or sounds. More important, since there is no "overshoot" of the signal associated with the attack, there is no evidence of popping or clicks in the audio signal, which is a drawback in many compressors.

Compression is accomplished by a form of negative feedback, part of the output signal being fed back out of phase with the input. The amount of negative feedback increases as the signal level goes up and vice versa. The net result is that the compressor output remains constant as the input signal varies.

Field effect transistor Q1 provides a high input impedance (on the order of 0.5 megohm) and keeps the "front end" noise to an almost unmeasurable level so that there is none of the "rushing" sound commonly associated with transistor amplifiers. The input level control is adjusted by potentiometer R1.

Integrated circuit IC1 is a high-gain amplifier with low output noise. The IC package contains three npn transistors and five resistors. The audio signal from the output of IC1 is coupled to the output level control, R26. The combination of R12 and C12 provides high frequency roll off above 20,000 Hz.

Part of the output signal is also fed to the base of transistor Q3. Resistors R8, R9, R17, and R18 set the forward bias for Q3 and also divide the output signal so that it is at the proper level. Transistors Q2 and Q3 form a variable gain amplifier whose output provides negative feedback to the input of IC1. The gain of the feedback amplifier is varied by changing the effective resistance in series with bypass capacitors, C14 and C15. This resistance is provided by Q6 and Q7, which are controlled by a dc voltage that is a function of the output signal.

Part of the output is fed to diode D1 and transistor Q4 through capacitor C16. The diode and transistor form a voltage doubling rectifier (with very low output impedance) which controls Q6 and Q7. The time constant of R24 and C18 determines the decay time of the compressor.

Transistor Q5 serves as a dc current amplifier to drive the compression indicating meter. The meter indicates only during compression and not when the circuit is amplifying in the linear region.

Capacitors C8 and C9 and resistors R10 and R11 provide filtering for the 12-volt supply so that a simple transformer and

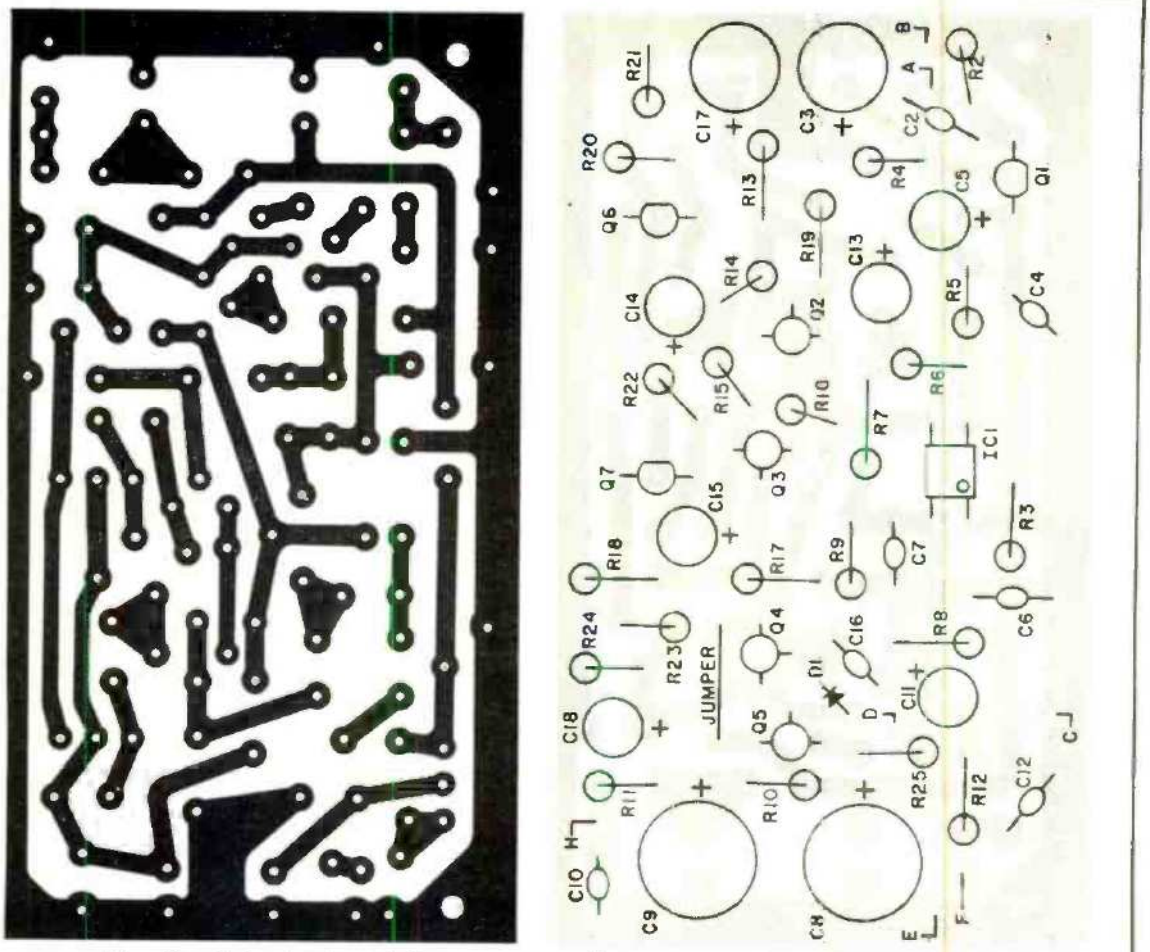


Fig. 2. Actual size foil pattern and component installation for the audio compressor. Observe the current polarity of electrolytic capacitors and all semiconductors including IC audio amplifier.

full-wave rectifier can be used as a supply instead of the battery. Capacitor C10 provides r-f bypassing when the compressor is used in conjunction with transmitting equipment.

A 3-way jack is used for the input connection. The remote line, running to J4, is used for push-to-talk operation. The compressor can be bypassed by placing S1 in the OUT position.

Although the compressor is rated at 45 dB compression range, it is capable of producing as much as 50 dB. Total harmonic distortion is extremely low and must be measured with sophisticated laboratory equipment. It cannot be seen on an oscilloscope.

Construction. All of the circuit components, with the exception of *C1*, are mounted on a circuit board whose foil pattern is shown in Fig. 2. Capacitor *C1* (r-f bypass) is mounted directly across the input level control *R1*, as shown in Fig. 3.

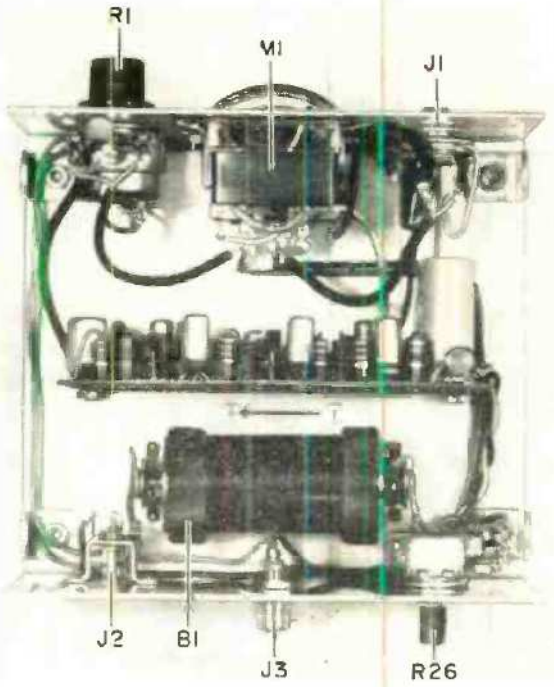


Fig. 3. Although any method of installation may be used, this is a view of prototype.

HIRSCH-HOUCK LABORATORIES
Project Evaluation

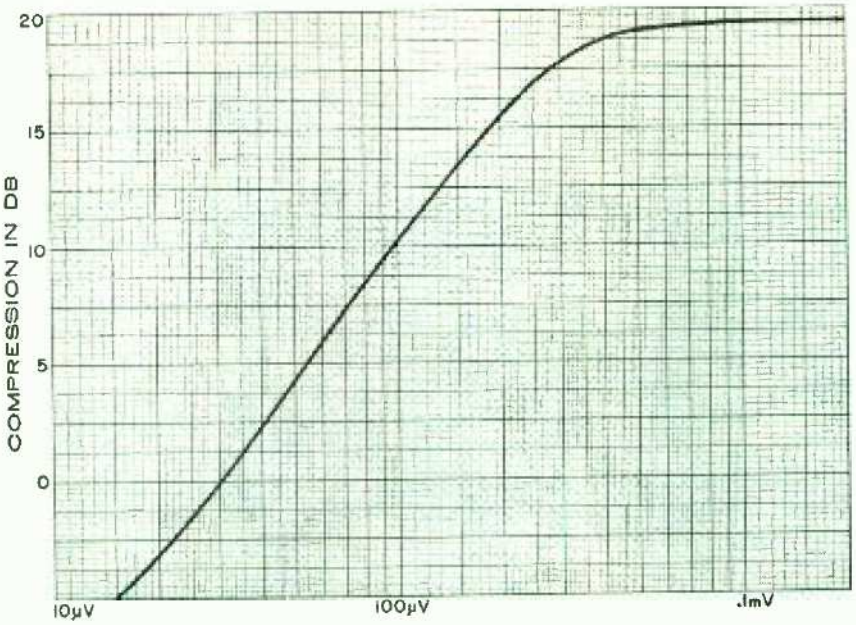
As claimed, this is a nondistorting compressor. The maximum output level was too low for us to make distortion measurements, but visually it looked perfect on a scope no matter what the degree of compression.

The gain in the linear portion is very good, 45 microvolts being required for 10 millivolts output—about 46 dB. Compression begins at about 300 microvolts. The maximum output at full compression is 60 millivolts.

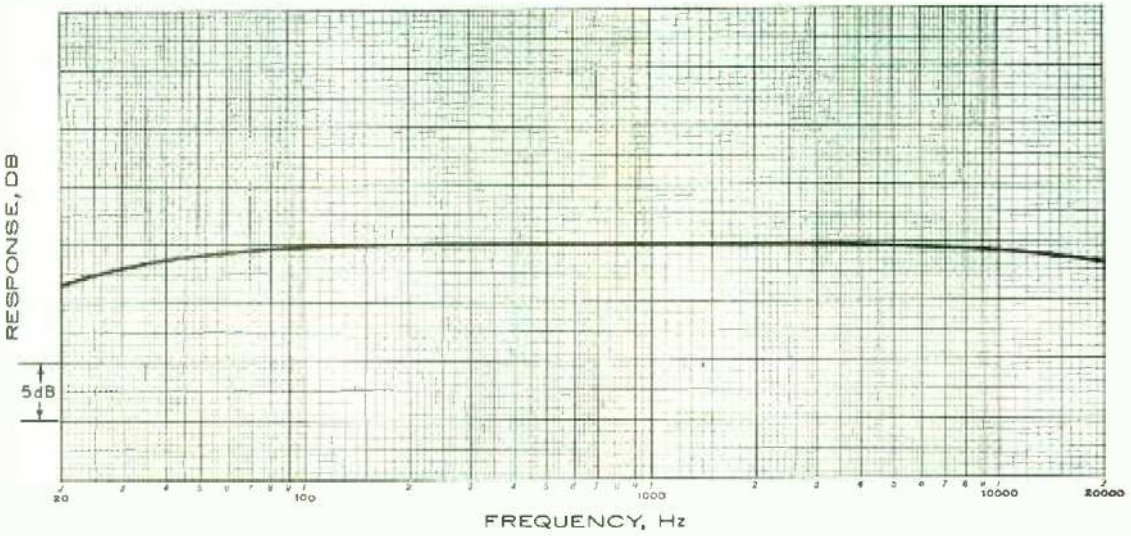
We passed a 10-kHz tone burst through the compressor to measure the attack time. It would seem to be about 100 microseconds.

When the input level control is set below maximum (the usual condition), the frequency response is quite flat—down 1.5 dB at 35 Hz and 20 kHz. However, at maximum input level, the highs rise and keep rising to a maximum of +9 dB at 30 kHz. The rather high input impedance seems to be responsible for the rolloff, which is of little practical importance since one would hardly use it "wide open."

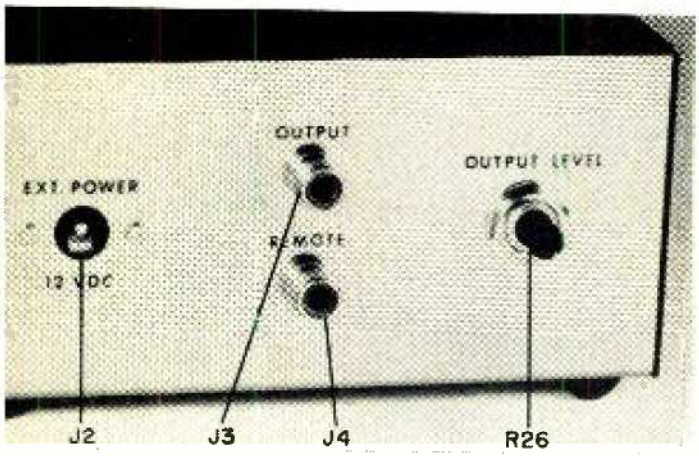
We made tape recordings of voice with the compressor, and they sounded fine —no distortion, just a bit of "breathing" on extreme compression.



Input versus compression showing the smooth curve of an excellent no-distortion setup.



The frequency response of the compressor is just as good as most high-quality audio systems so that it is top notch for musical recordings.



The rear apron of the compressor chassis showing the jack for external power supply input, terminals, and output level control.

Mount all of the transistors first. Space each one about ¼" away from the board and make sure they are properly oriented. The IC should rest flat against the board. Mount *D1* vertically. Use a heat sink on all semiconductor leads during the soldering operation.

The capacitors should be flush against the board. Observe the polarities of electrolytics. All of the resistors are mounted vertically with one end flush against the board. Use shielded wire between *J1* and *S1* and between *S1* and *R1*.

Attach all the connecting leads to the board before installing it in the cabinet. Use shielded wire for the input line.

The prototype cabinet was made of two pieces of 0.050" sheet aluminum, though a standard chassis box can be used. The circuit board was mounted vertically using two angle brackets. Due to the high gain and high input impedance of the circuit, it is extremely important that the entire circuit be completely shielded in a metal box. This is important if you plan to use the compressor in a custom installation or within existing equipment.

Use shielded cable for the input and output connections.

TECHNICAL SPECIFICATIONS

Compression Range: 45 dB minimum
Sensitivity: Approximately 300 microvolts for compression
Frequency Response: −3 dB at 20 Hz, −1.5 dB at 20,000 Hz, in linear region of amplification and in compression region
Total Harmonic Distortion: At 1 kHz, 0.1% in linear region, 1.5% in compression
Input Impedance: 0.5 megohm
Output Impedance: 5000 ohms
Attack Time: Less than 1 millisecond for 20 dB change at 1kHz
Release Time: Approximately 2 seconds

Use. With a 12-volt battery installed, or some other 12-volt supply attached, plug a microphone into the compressor and connect the compressor output to the equipment to be used. Place *S1* in the OUT position to bypass the compressor. Talk into the microphone at close range and set the gain control on your equipment for the proper operating level. If you are using a tape recorder, you will be watching the recording level meter; if you are using a transmitter, you will probably be watching a modulation indicating meter.

Now, turn on *S2* but leave *R1* and *R26* fully counterclockwise. Place *S1* on the IN position. While speaking into the mike, advance *R1* until the compression meter begins to kick upward. Now advance the output level control, *R26*, until the meter on your equipment reads the same as when the compressor was bypassed. Flip *S1* back and forth to see how the signal looks with and without compression.

The compression meter not only indicates the fact that the signal is being compressed, but also when the signal is overdriving the compressor. In that case the meter reads off scale. Compression will begin at an input of about 300 microvolts; and the compressor will be overdriven when the input exceeds about 60 millivolts. When the meter on your recorder or transmitter indicates the presence of a signal but there is no indication on the compression meter, the compressor is simply acting as an amplifier.

While operating the compressor, adjust the input level control (*R1*) for the amount of sensitivity required. This will vary according to the type of microphone used. background noise, etc. A 200-ohm dynamic mike will drive the unit into compression but is not as sensitive as a high-impedance dynamic mike or a crystal or ceramic one. If you need more sensitivity from a low-impedance mike, use a step-up transformer on the input to the compressor.

Telephone conversations can be recorded by hooking the input of the compressor either directly to the phone line or to a telephone pickup coil. ◈