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Build a

9-BAND STEREO EQUALIZER

Overcomes
room
acoustic
problems



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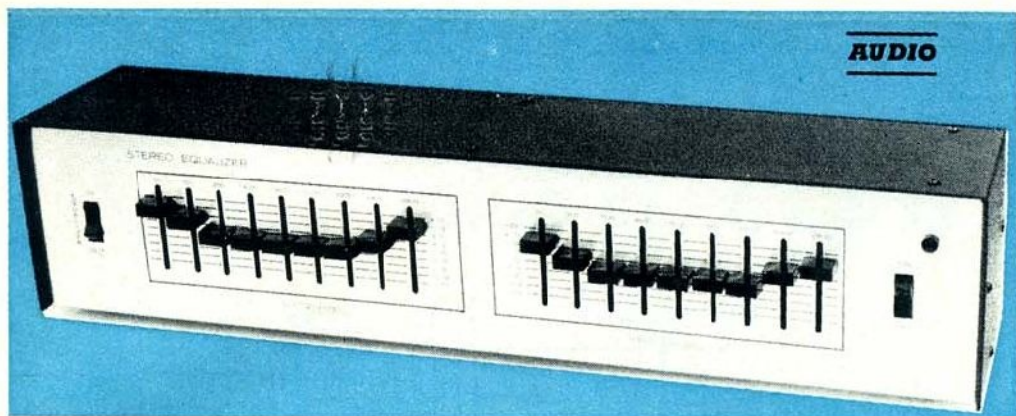
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BUILD THIS

NINE-CHANNEL STEREO EQUALIZER



Active op-amp filters produce very low distortion, no ringing. Eighteen independent control positions offer full flexibility.

BY GARY KAY

AN INCREASING number of audiophiles are adding equalizers to their hi-fi/stereo equipment. These auxiliary devices permit adjusting the response of the system in relatively small frequency increments to achieve a desired effect—whether it be to compensate for room acoustics or speaker deficiencies, or just to please their own personal tastes.

If you are contemplating adding an equalizer to your system, but are concerned about the cost of a commercial unit with enough flexibility, you will want to consider building the unit described here. Designed for a stereo system, it has nine 1-octave adjustments in each channel. Using integrated circuit (op amp) active filters, the equalizer has an internal ac power supply. Boost and cut limits are ± 12 dB; voltage handling limit is 2 V rms; and the total harmonic distortion is a low 0.05 percent.

The frequency response of the equalizer

is from 20 to 20,000 Hz (3 dB), hum and noise is 65 dB below 1 volt rms, input impedance is 100,000 ohms, and output impedance is less than 10,000 ohms. Connection to an operating audio system can be made between the preamp-out/power-amp-input jacks or between the tape-out/tape-monitor input jacks.

The nine gain controls are centered at 50, 100, 200, 400, 800, 1600, 3200, 6400, and 12,800 Hz. Although the lowest and highest frequency filters are bandpass types, their use in a feedback loop gives them a low-pass/high-pass response. The enclosure of the entire array of active bandpass filters in a feedback loop also provides low noise and distortion.

The arrangement of the potentiometer knobs for both channels on the front of the equalizer provides a true graphic representation of the tonal compensation. The equalizer can also be used in an electronic musical instrument system by connecting it

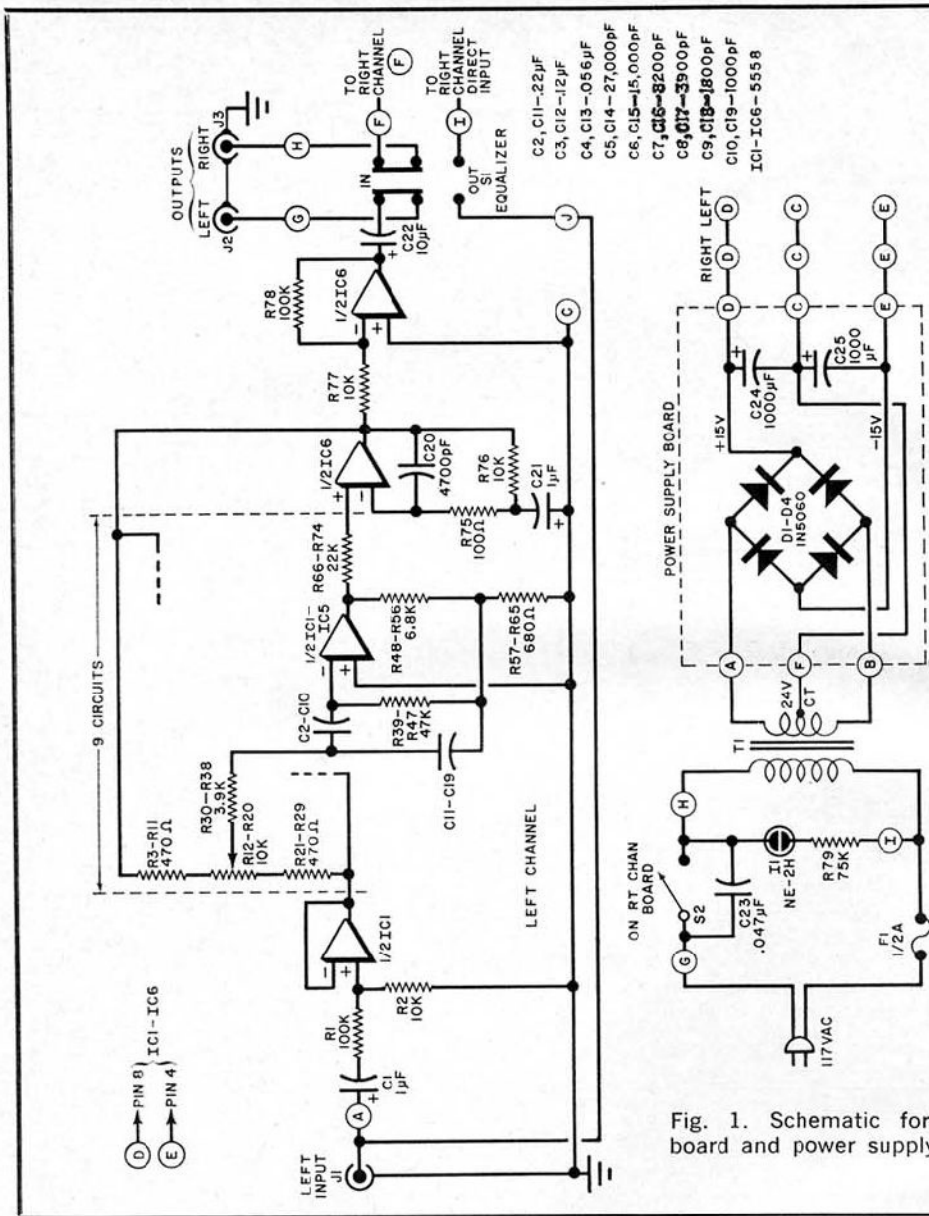


Fig. 1. Schematic for left pc board and power supply section.

between the preamp and the power amplifier.

How It Works. The schematics for one channel and the power supply are shown in Fig. 1. The input to the channel is coupled through capacitor *C1* to voltage divider *R1-R2*. One of the two op amps in *IC1* buffers the input from the voltage divider and provides a low-impedance source for the nine active filters. Each of the latter is composed of an operational amplifier ($\frac{1}{2}$ of *IC1* and both halves of *IC2-IC5*) with the related resistors and capacitors. The outputs of the

bandpass networks are then summed in one half of *IC6*, whose output is fed back through *R3-R11*. Slide potentiometers *R12* through *R20* vary the overall gain of the feedback loop at the operating frequency of each filter.

Since the filter circuit has unity gain at 0-dB equalization settings, it is necessary to follow the summer with an amplifier made up of the second half of *IC6*. The amplifier also provides the signal inversion necessary to keep the input and output signals in phase.

An EQUALIZER IN-OUT switch (*S1*) is pro-

PARTS LIST

For equalizer boards (1 of each for each board):

C1,C21—1- μ F, 50-volt electrolytic capacitor

C2,C11—0.22- μ F capacitor

C3,C12—0.12- μ F capacitor

C4,C13—0.056- μ F capacitor

C5,C14—27,000-pF capacitor

C6,C15—15,000-pF capacitor

C7,C16—8200-pF capacitor

C8,C17—3900-pF capacitor

C9,C18—1800-pF capacitor

C10,C19—1000-pF capacitor

C20—4700-pF capacitor

C22—10- μ F, 60-volt electrolytic capacitor

IC1-IC6—5558 op amp IC

J1,J2—Audio connector

Unless otherwise noted, resistors are $\frac{1}{4}$ -watt.

R1,R78—100,000-ohm

R2,R76,R77—10,000-ohm

R3-R11,R21-R29—470-ohm

R12-R20—10,000-ohm slide potentiometer

R30-R38—3900-ohm

R39-R47—47,000-ohm

R48-R56—6800-ohm

R57-R65—680-ohm

R66-R74—22,000-ohm

R75—100-ohm

Following components on right board only:

C23—0.047- μ F capacitor

I1—Neon lamp (NE-2H) and holder

R79—75,000-ohm resistor

S2—Dpdt switch

Following component on left board only:

S1—Dpdt switch

Following on power supply:

C24,C25—1000- μ F, 25-volt electrolytic capacitor

D1-D4—1N5060 rectifier diode

F1—0.5-A fuse and holder

T1—Transformer; secondary: 24 VCT, 80 mA

Misc.—Suitable enclosure, knobs for slide potentiometers (18), rubber feet (4), line cord, mounting hardware, etc.

Note—The following are available from Southwest Technical Products, 219 W. Rhapsody, San Antonio, TX 78216: Circuit boards (#216-3B) at \$11.75 (1 lb); complete kit with case (#216) at \$99.50 (4 lb). Add sufficient amount to cover shipping according to weights given.

vided so that the unit can be bypassed if desired.

Construction. Three printed circuit boards are used: one each for left channel, right channel, and power supply (see Fig. 2). By mounting all of the switches and controls on the circuit boards, wiring is kept to a minimum.

When mounting the components on the boards, be sure to orient the diodes, integrated circuits, and electrolytic capacitors properly. See the component layout diagrams in Fig. 2.

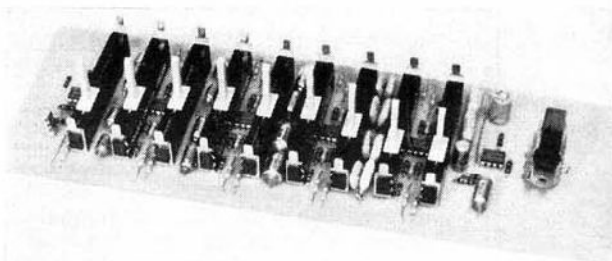


Photo of left-channel board including S1.

Several jumpers are used on the two equalizer boards, as indicated by the solid lines on the component layout diagrams. The jumpers can be made by stripping the insulation from the ends of short lengths of #24 hook-up wire.

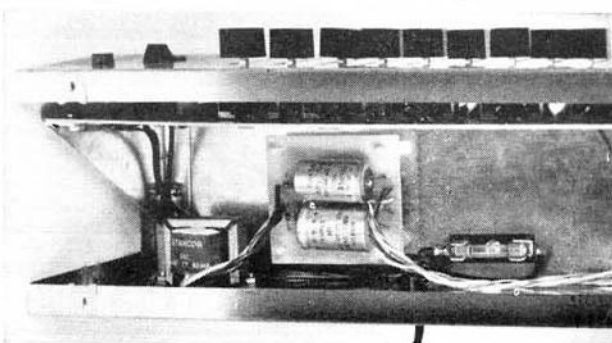
The pc boards with the slider potentiometers attached can be mounted in the chassis in one of a number of ways. They can be mounted one above the other, or, as shown in the photo of the prototype, they can be side-by-side. In either case, be sure that sufficient room is left in the slots for the potentiometer arms so that they slide smoothly without binding.

The slides should be identified on the front panel as to center frequency and the amount of boost (+12 at the top) and attenuation (-12 at the bottom).

The power supply can be mounted in any convenient spot in the chassis, but be careful to keep leads carrying audio signals as far as possible from the supply, to avoid hum.

Operation. If the stereo system has separate components, attach the equalizer between the preamp and the power amplifier. Alternatively, it can be connected to the tape-out and the tape-monitor input jacks. If neither of these is possible, it will be necessary to find the spot in the equip-

Prototype arrangement of power supply.



PROJECT EVALUATION (A Hirsch-Houck Labs Report)

The equalizer lives up to its specifications very easily—usually with a good margin of safety. All of the octave controls have ranges of at least 12 dB and most are about 14 dB. The frequency response is "dead flat" with the equalizer switched out (± 0.5 dB, 20 Hz to 20,000 Hz) and has a few bumps when it is switched in with the controls set to indicated center points. Even so, it is within ± 0.75 dB, which is not bad at all.

The center points of the equalizer controls are a little off, usually by 10 to 20%, which, of course, is of no practical importance. Needless to say, almost any sort of curve can be generated, depending only on the user's talent and patience. The frequency response with controls centered rises outside the audio band at both ends, but is within 3 dB of the 1000-Hz level (unity gain) from 20 Hz to 190 kHz.

The 2-volt signal limit is evidently based on the input level, allowing for all or many of the octave controls to be at full boost. This is ultra-conservative, but it seems to be the only explanation for a 2-volt rating on a unit which has virtually no distortion up to the 10-volt maximum of our audio signal generator. Up to an output of about 4 volts (1000 Hz, all controls centered), the THD is entirely noise and hum, as indicated by the 6-dB/octave negative slope of the distortion-vs-level curve. At an output of about 7 volts, we begin to have distortion overcoming noise, with a reading

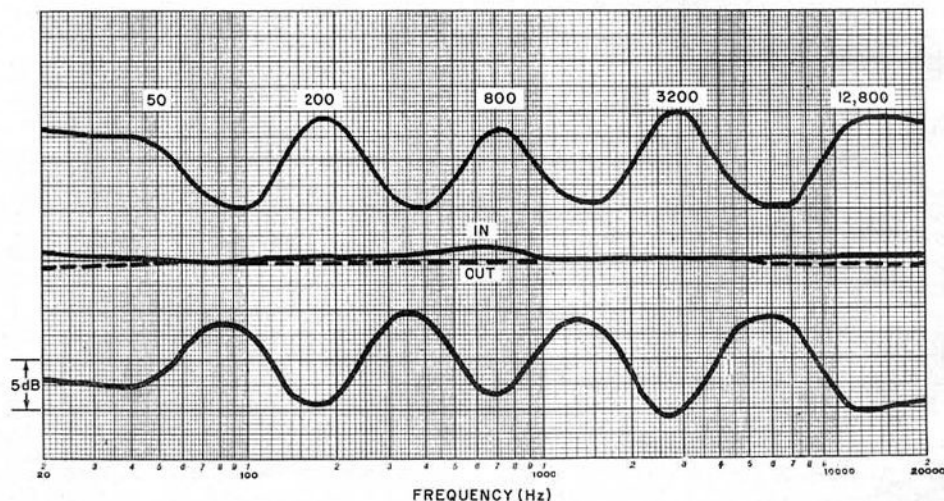
of 0.0075%. At the maximum test limit of 10 volts, the total harmonic distortion was all of 0.0095%!

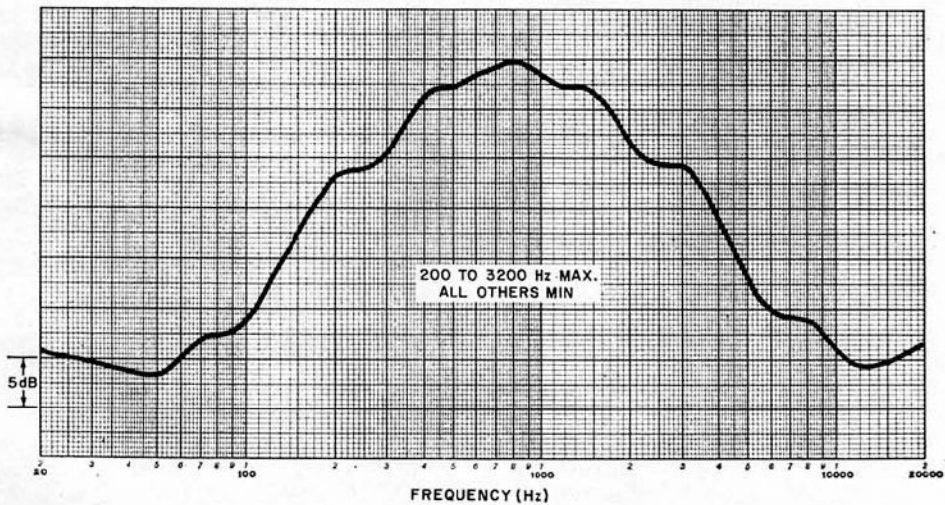
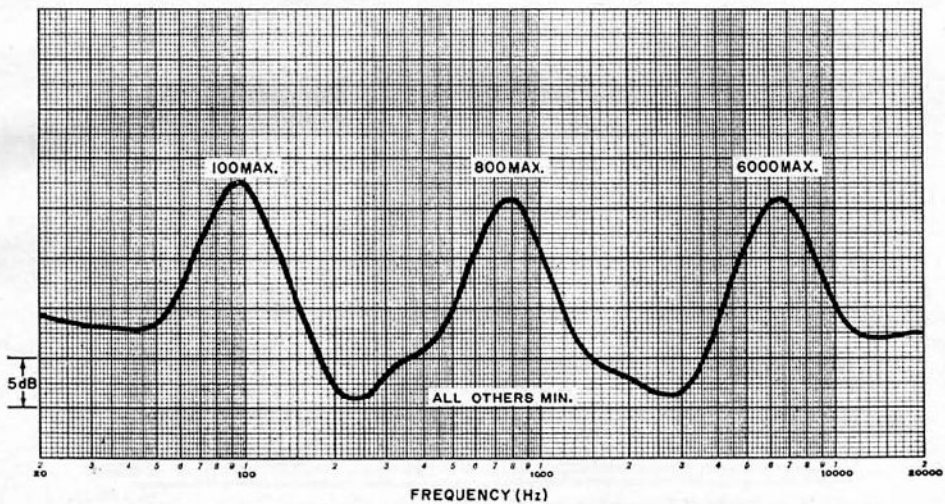
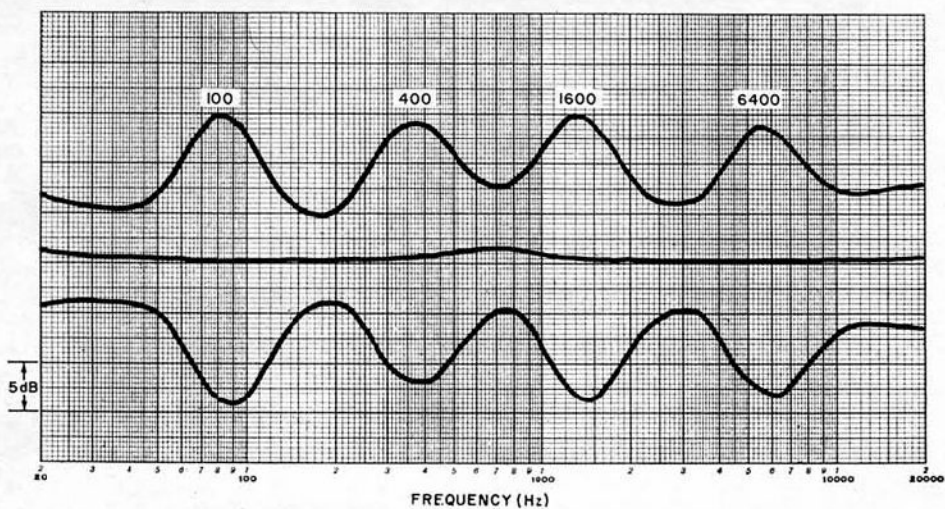
The unweighted noise level in the output was 66 dB below 1 volt (just a little below the specified rating). When the measurement bandwidth was restricted to 250 to 20,000 Hz, to exclude hum and ultrasonic random noise, the measurement was 74 dB below 1 volt.

The physical packaging of the equalizer is unconventional, since it is too wide to sit on top of a receiver or any other component. The controls operate very smoothly, and have a nice "feel." On the assumption that it will be connected into a tape monitoring circuit, it would have been nice to have included tape input and output jacks and a monitor switch, to replace those used on the amplifier or receiver (standard practice on most such accessories). On the other hand, the equalizer can just as well be placed between preamp and power amplifier, since it can handle any signal levels there and will not add to audible noise.

Square-wave tests showed virtually no distortion other than that introduced by the frequency shaping. No ringing was visible with the controls centered.

In quality of performance, this equalizer is comparable to commercial units costing twice as much. This one boasts separate adjustments for the two channels and nine bands per channel instead of five.





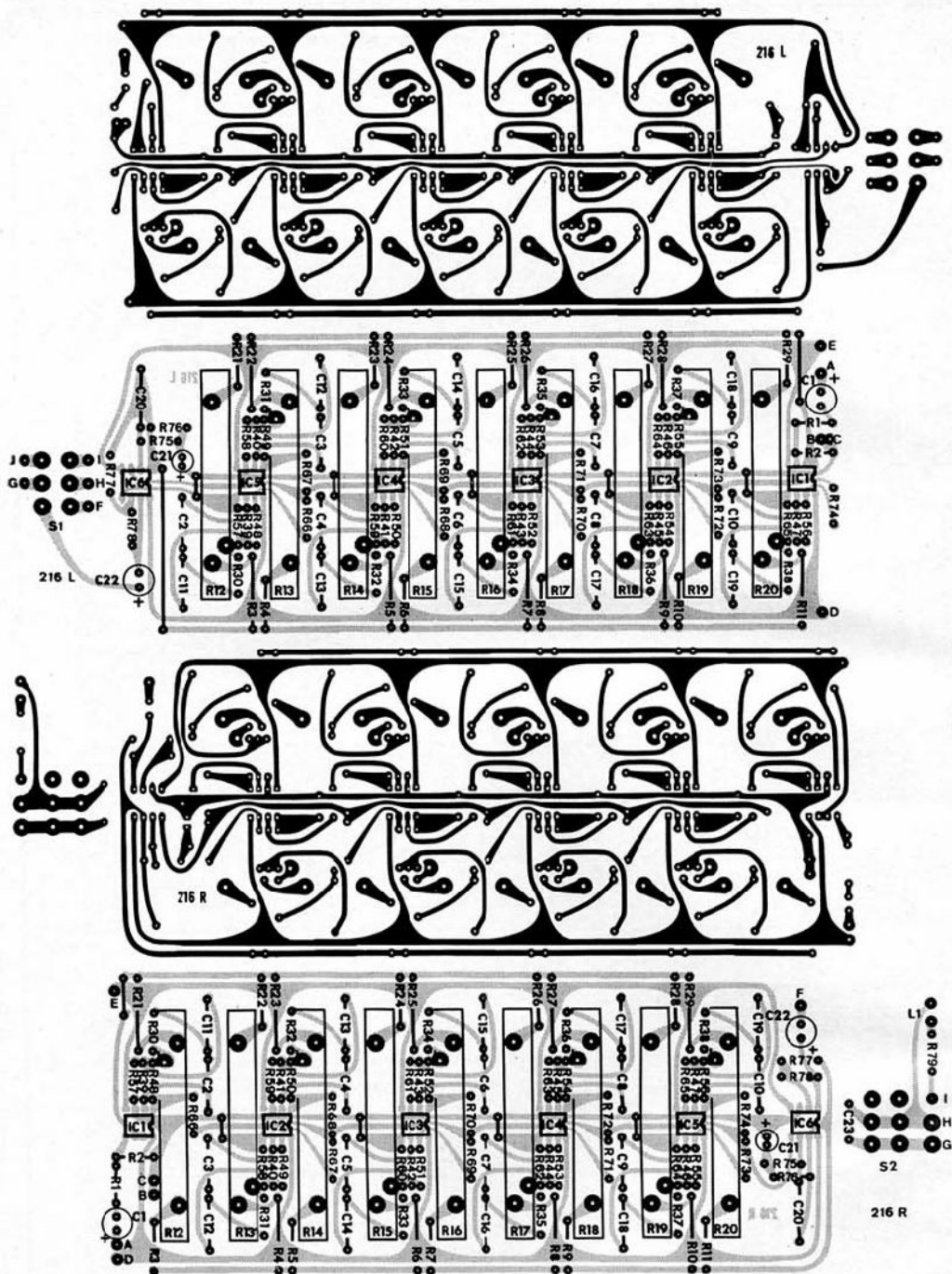


Fig. 2. Foil patterns and component layouts (left at top) are shown half-size. A foil pattern for the power supply is not shown, but one can be made easily.

ment where the preamp feeds the power amplifier. In any case, the input level to the equalizer should not exceed 2 volts rms.

After installation, set the audio system tone control for flat response. Using just the equalizer's controls for tone compensa-

tion will provide a better graphic representation of the equalization preferred.

Compensating for room acoustics is a bit tricky, but it can be accomplished by using a sound pressure level meter and test record. ♦

Partners in Scientific Calculations



MITS 7440 Desk-Top Scientific Calculator—

The 7440 Scientific Calculator does the basic arithmetic functions plus ten transcendental functions. Algebraic problem entry with two deep nesting parentheses makes it possible to enter a problem just the way you would write it. Either floating decimal mode or scientific notation. A separate memory register can be used for storage of an intermediate result or of a constant. Trigonometric functions can be performed using either degree or radian entry. There is also a radian mode indication. A separate π key, and factor reversal ($x \leftrightarrow y$) are also featured.

The 14-digit LED display provides ten-digit precision for mantissa and two-digit precision for exponent. There is full sign change capability for both mantissa and exponent, and full chain calculation with any sequence of functions desired. Also featured are automatic error indications for overflow, underflow, and forbidden operations. The 36-key keyboard has separate clear and clear entry keys to prevent having to clear the whole problem in the event of an erroneous entry. The calculation range is 10⁹⁹ to 10⁻⁹⁹.

KEYBOARD FUNCTIONS:

Sine • Arcsine • Cosine • Arccosine • Tangent
 • Arc tangent • e^x • \ln^x • \log_{10}^x • x^y • \sqrt{x} , $1/x$
 • Addition • Subtraction • Multiplication • Division

SIZE: 8 1/2" x 12" x 3 1/2"

PRICE: Kit \$199.95 Assembled \$299.95

Warranty: Full two-year warranty on assembled units, ninety days on kits.
 Prices subject to change without notice. Available from your local Olson Electronics Dealer.



MITS 7440 Programmer Desk-Top Computer—

The programmer can program the 7440 to do extremely long or often used calculator operations. Instead of repeatedly entering into the calculator a formula in which only certain variables change, a formula can be entered once into the programmer and then be stored and run at will.

The programmer automatically executes all steps of the program until it sees a location within the formula where a variable is to be entered. It then halts execution, but once the variable is entered into the calculator, the continue key is pressed again and all remaining steps of the formula are executed until the programmer sees another variable entry or an "End of Program" command.

FEATURES:

256 programming steps with option of expandability to 512 steps • Program code for each function key on the calculator • Constant power to the RAM's precludes destruction of stored programs • Sixteen-key array to enter the address or instruction in hexadecimal • Six annunciator lights to give clear identification of programmed pauses; two to indicate a halt or end of program • Two RUN modes of operation: Continuous or step • S-Key to halt execution anywhere in the program.

Kit: Programmer . . . \$199.95 — Expansion . . . \$79.95
 Assembled: Programmer . . \$299.95—Expansion . . \$129.95

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