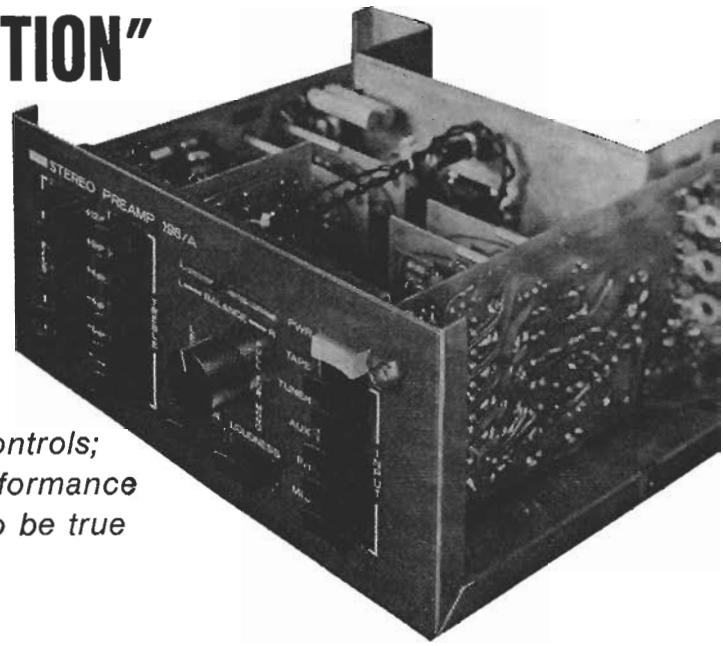
BUILD A "ZERO DISTORTION" STEREO PREAMP

by GARY KAY

Stereo preamp has push-button tone controls; printed-circuit board construction and performance specifications that are almost too good to be true



INTERESTED IN BUILDING A HIGH-quality stereo preamplifier for a price well under the cost of commercial units having comparable features? It's not just an ordinary preamp, but an attractive, easy to build unit based on state-of-the-art circuit design techniques that deliver noticeable advantages over conventional preamps.

Most preamps use a series of capacitor-coupled class-A amplifier stages using local feedback for equalization and to control the gain of the individual stages. The distortion and frequency response characteristics of this type of construction are not the best, and some designers are using operational amplifier integrated circuits. The operational amplifier technique works very well (see article on page 58 of this issue). The idea is to use feedback on an active device with a very high open-loop gain. The feedback controls the closed-loop gain, and greatly enhances the distortion, noise and frequency response characteristics of the device. Unfortunately, inexpensive IC's are inherently noisy and although the feedback helps, the noise is still at a level that makes it undesirable for use in high-quality audio equipment. The key to this preamp's operation is a unique gain module recently described in a British periodical ("Audio Preamplifier using Operational Amplifier Techniques" by Daniel Meyer, *Wireless World* magazine, July 1972). This gain module is actually a high-gain amplifier built using operational amplifier techniques but constructed from discrete components. It provides all of the advantages of high open-loop gain devices with the added bonus of low noise.

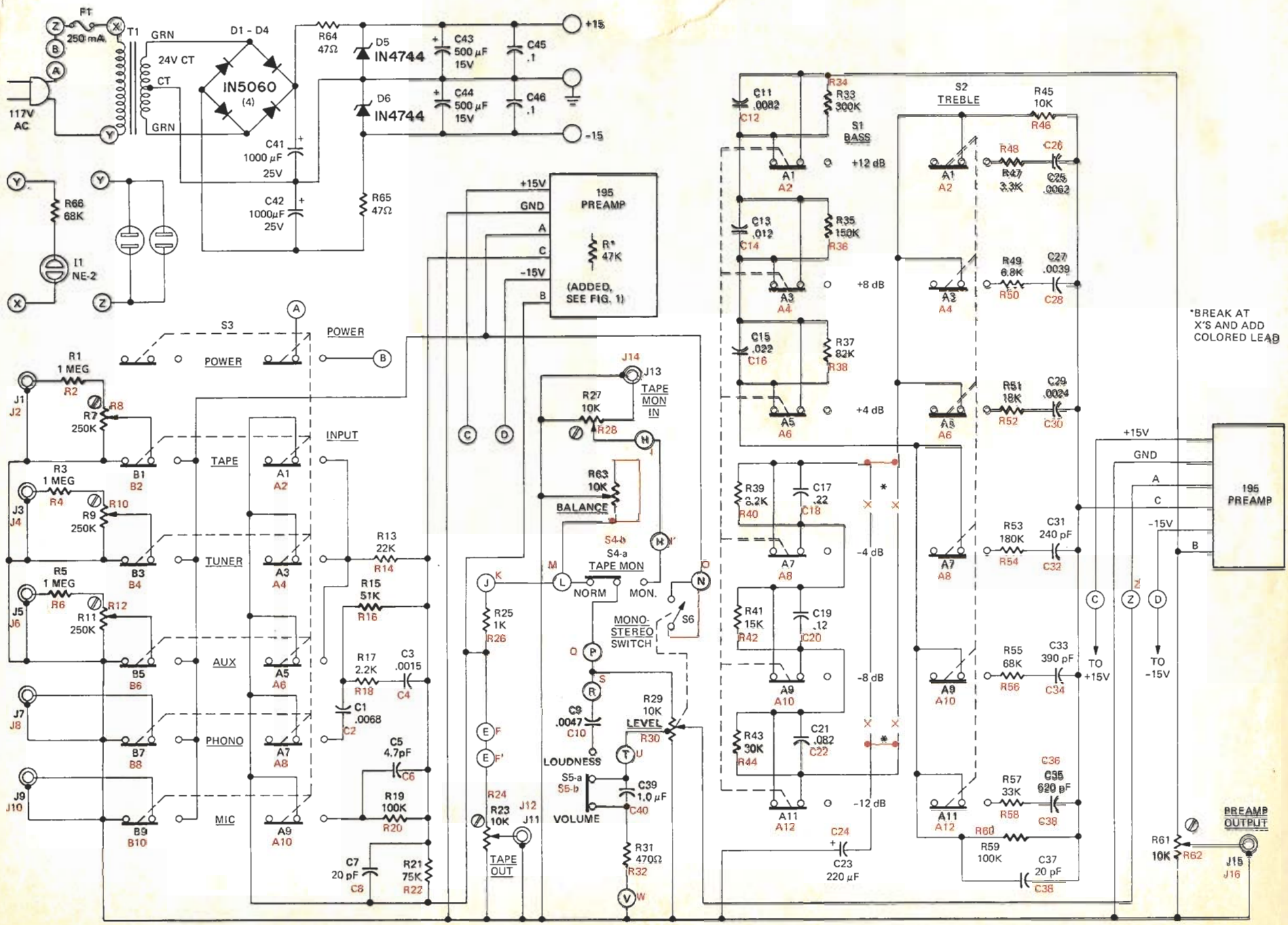
Each channel of this preamp uses two of these gain modules, which plug on to mother boards. In addition, all of the pushbutton switches as well as all of the input and output connectors are soldered directly to the circuit boards, reducing wiring to a minimum.

Functionally, the preamp has an internal power supply, pushbutton BASS and TREBLE switches, external BALANCE control, internal LEVEL controls on the TAPE, TUNER, AUX, and TAPE MONITOR inputs and the TAPE and PREAMP outputs. Switches are provided for POWER-OFF, TAPE MONITOR-NORMAL, LOUDNESS-VOLUME, and MONAURAL-STEREO modes. The power switch controls power for the preamp as well as for two ac receptacles on the rear panel. All input-output jacks are the RCA-phono type and are orientated so the unit can be nearly flush mounted against the back panel of a bookshelf if desired.

How it works

The amplifier module circuitry was designed for high gain, minimum distortion, low noise, and maximum power supply isolation among other things. Transistors Q1 and Q2 (Fig. 1) form a differential pair with a current source feeding the emitters. This provides good power-supply isolation and operates the transistors in their optimum low-noise region. Active load current source Q3 provides power supply isolation and is a high-impedance load for transistor Q1, thus insuring high gain. Transistor Q4 operates as an emitter follower to reduce loading on Q1 while Q5 acts as a class-A amplifier operating into active load current source Q6, for maximum gain and improved linearity. The closed loop gain of the circuit is set, as on other operational amplifier circuits, by the use of feedback. One of the feedback resistors, R13 is already provided on the board. Capacitor C3 in series with R13 decreases the gain to unity at dc no matter what the ac gain has been chosen to be. The other feedback component(s) X_{cb}, is inserted between points C and B. The ratio X_{cb} + R13/R13 sets the ac gain of the amplifier. If X_{cb} is composed of reactive components the gain can be made to vary as a function of frequency to provide equalization or tone control.

The overall circuit operation can best be understood from the block diagram, Fig. 2 and the schematic in Fig. 3. Amplifier module 1 boosts the audio level from either a magnetic phono cartridge, mike, or high-level input to a level compatible with the input of the second amplifier module. The input-selector-pushbutton-switch channels the desired input into the amplifier module 1 and simultaneously connects the appropriate feedback network to provide equalization. All high-level inputs are fed into the amplifier through a 1-megohm resistor and trimmer resistor. This guarantees a minimum input impedance of 1 megohm and enables the user to set each individual level control for a uniform audio level whenever changing inputs. The output of amplifier module 1 then passes through a balance control, tape monitor switch and a


F1
250 mA
T1
GRN
24V CT
CT
GRN
117V AC
D1 - D4
IN5060
(4)
R64
47Ω
D5
IN4744
D6
IN4744
C43
500 µF
15V
C44
500 µF
15V
C45
.1
C46
.1
+15
-15
C41
1000 µF
25V
C42
1000µF
25V
R65
47Ω
R66
68K
I1
NE-2
+15V
GND
A
C
-15V
B
195
PREAMP
R*
47K
(ADDED, SEE FIG. 1)
S3
POWER
POWER
R1
1 MEG
R2
R7
250K
R8
J1
J2
B1
B2
TAPE
A1
A2
R3
1 MEG
R4
R9
250K
R10
J3
J4
B3
B4
TUNER
A3
A4
R5
1 MEG
R6
R11
250K
R12
J5
J6
B5
B6
AUX
A5
A6
J7
J8
B7
B8
PHONO
A7
A8
J9
J10
B9
B10
MIC
A9
A10
INPUT
R13
22K
R14
R15
51K
R16
R17
2.2K
R18
C3
.0015
C4
C1
.0068
C2
C5
4.7pF
C6
R19
100K
R20
C7
20 pF
C8
R21
75K
R22
J14
J13
TAPE MON IN
R27
10K
R28
R63
10K
BALANCE
S4-b
S4-a
TAPE MON
NORM
MON.
MONO-STEREO SWITCH
S6
R25
1K
R26
R24
R23
10K
J12
J11
TAPE OUT
C9
.0047
C10
LOUDNESS
S5-a
S5-b
VOLUME
R29
10K
LEVEL
R30
C39
1.0 µF
C40
R31
470Ω
R32
C11
.0082
C12
R34
R33
300K
S1
BASS
+12 dB
C13
.012
C14
R35
150K
R36
+8 dB
C15
.022
C16
R37
82K
R38
+4 dB
R39
3.2K
R40
C17
.22
C18
-4 dB
R41
15K
R42
C19
.12
C20
-8 dB
R43
30K
R44
C21
.082
C22
-12 dB
C24
C23
220 µF
S2
TREBLE
R45
10K
R46
R48
3.3K
C26
C25
.0062
R49
6.8K
R50
C27
.0039
C28
R51
18K
R52
C29
.0024
C30
R53
180K
R54
C31
240 pF
C32
R55
68K
R56
C33
390 pF
C34
R57
33K
R58
C36
C35
620 pF
C38
R60
R59
100K
C37
20 pF
C38
*BREAK AT X'S AND ADD COLORED LEAD
+15V
GND
A
C
-15V
B
195
PREAMP
TO +15V
TO -15V
PREAMP OUTPUT
R61
10K
R62
J15
J16

PARTS LIST

R1 thru R6—1 megohm ¼-W 10%
R7 thru R12—250,000-ohm trimmer
R13, R14—22,000-ohm ½-W 5%
R15, R16—51,000-ohm ½-W 5%
R17, R18—2,200-ohm ½-W 5%
R19, R20, R59, R60—100,000-ohm ½-W 5%
R21, R22—750,000-ohm ½-W 5%
R23, R24, R27, R28, R61, R62—10,000-ohm trimmer
R25, R26—1,000-ohm ½-W 10%
R29, R30—10,000-ohm audio taper pot with 5,000-ohm tap with pull switch
R31, R32—470-ohm, ½-W 10%
R33, R34—300,000-ohm ½-W 5%
R35, R36—150,000-ohm ½-W 5%
R37, R38—82,000-ohm ½-W 5%
R39, R40—8,200-ohm ½-W 5%
R41, R42—15,000-ohm ½-W 5%
R43, R44—30,000-ohm ½-W 5%
R45, R46—10,000-ohm ½-W 5%
R47, R48—3,300-ohm ½-W 5%
R49, R50—6,800-ohm ½-W 5%
R51, R52—18,000-ohm ½-W 5%
R53, R54—180,000-ohm ½-W 5%
R55, R56—68,000-ohm ½-W 5%
R57, R58—33,000-ohm ½-W 5%
R63—10,000-ohm linear taper slide pot
R64, R65—47-ohm ½-W 10%
R66—68,000-ohm ½-W 10%
R*, R*—47,000-ohm ¼-W 10%
C1, C2—.0068-μF polystyrene
C3, C4—.0015-μF polystyrene
C5, C6—4.7-pF disc
C7, C8, C37, C38—20-pF disc
C9, C10—.0047-μF polystyrene
C11, C12—.0082-μF polystyrene
C13, C14—0.012-μF metalized polycarbonate
C15, C16—0.022-μF metalized polycarbonate
C17, C18—0.22-μF metalized polycarbonate
C19, C20—0.12-μF metalized polycarbonate
C21, C22—0.082-μF metalized polycarbonate
C23, C24—220-μF @ 6.3V electrolytic
C25, C26—.0062-μF polystyrene
C27, C28—.0039-μF polystyrene
C29, C30—.0024-μF polystyrene
C31, C32—240-pF polystyrene
C33, C34—390-pF polystyrene
C35, C36—620-pF polystyrene
C39, C40—1-μF 15 volt electrolytic
C41, C42—1000-μF 25 Vdc electrolytic
C43, C44—500-μF 15 Vdc electrolytic
C45, C46—0.1-μF
D1 thru D4—1N5060 silicon diode or equal
D5, D6—15-V 1-W Zener diode, Motorola 1N4744 or equal
*S3—5-station dpdt tandem plus 1 station push-to-lock pushbutton switch
*S1, S2—6-station dpdt pushbutton switch
*S4, S5—dpdt pushbutton switch
S6—spst pull switch mounted on the rear of level control
F1—¼-amp fuse
T1—24-volt 80 mA ct transformer 117 Vac primary
LM1—neon lamp NE-2

*S1 thru S5 are being custom made for Southwest Technical and no substitutes are available.

Parts List No. 195 Preamp Module

Q1, Q2, Q6, Q7—2N5210 Motorola
Q3, Q4, Q5—2N5087 Motorola
D1—4.7-V 400mw Zener diode Motorola MZ-70-4.7 or equal
D2, D3—1N914 diode or equal
C1—4.7-μF tantalum electrolytic
C2—5-pF disc
C3—33-μF @ 6-V electrolytic
R1, R3, R9, R10, R11, R13—1000-ohm ½-W 10%
R2—47,000-ohm ½-W 10%
R4, R5—22,000-ohm ½-W 10%
R6—15,000-ohm ½-W 10%
R7—8200-ohm ½-W 10%
R8—10,000-ohm ½-W 10%
R12—4700-ohm ½-W 10%

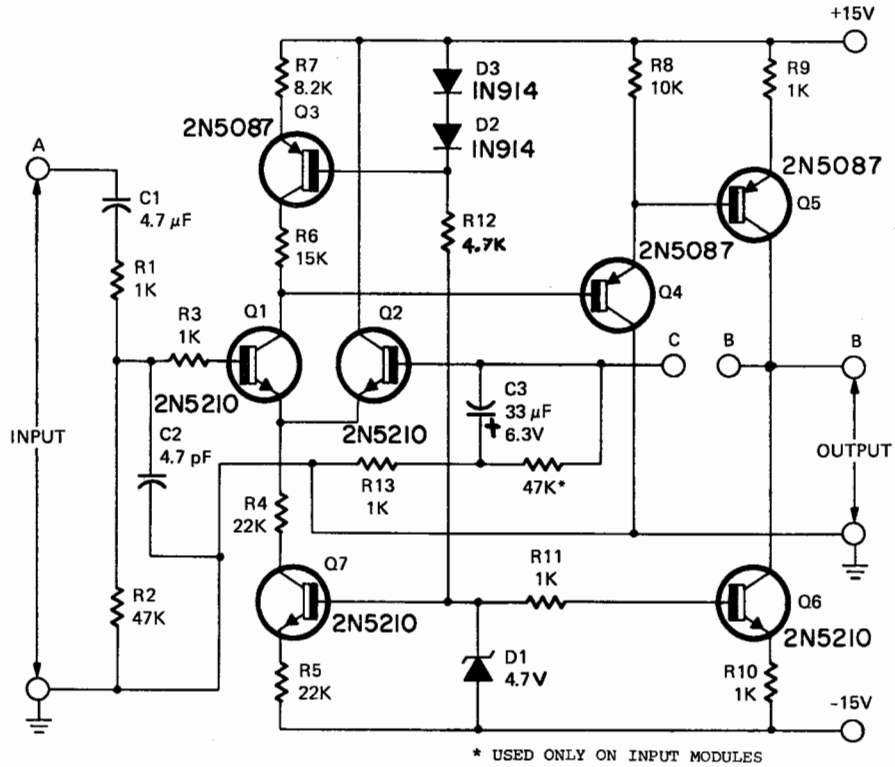


FIG. 1—AMPLIFIER MODULE CIRCUITRY. Four of these modules are needed; two for each channel. Note that pne 47,000-ohm resistor is used only in the input modules; it is not needed in the output modules.

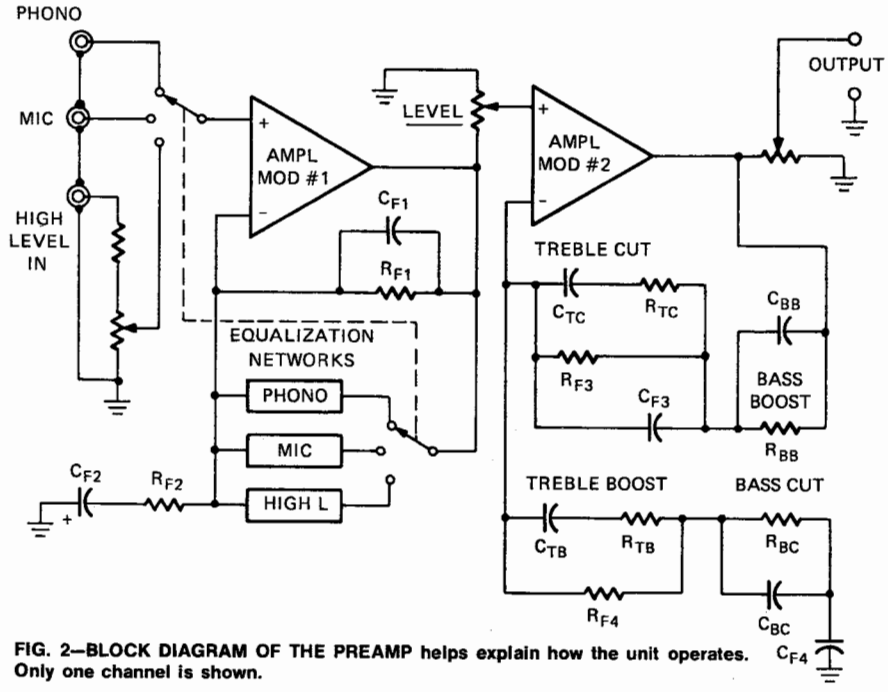


FIG. 2—BLOCK DIAGRAM OF THE PREAMP helps explain how the unit operates. Only one channel is shown.

level control. The LEVEL control normally operates as a volume control unless the LOUDNESS switch is depressed. The loudness circuit introduces a slight bass and treble boost on the lower end of the level control which is contoured to compensate for the low- and high-frequency deficiencies of the human ear at low sound pressure levels.

The output of the level control is then fed into amplifier module 2 which provides more gain and also introduces the desired bass and treble compensation. By switching different resistor-capacitor combinations into the feedback loop, the gain of amplifier module 2 is made vary with frequency thus providing a convenient means of introducing bass and treble boost or cut. Tonal increments are 4 dB with a maximum boost and cut of +12 dB and -12 dB respectively. A complete tone control response curve is shown in Fig. 3. Operating the unit with all switches out will provide flat response making the unit ideal for situations where no boost or cut can be

SPECIFICATIONS

Sensitivity:	Phono—2.0 mV at 1-kHz for 1.0 V rms out Mic—1.0-mV for 1.0-V rms out Aux, Tape, Tuner—200-mV for 1.0-V rms out maximum sensitivity—adjustable for less
Frequency Response:	Down 3 dB at 5 Hz and 80 kHz
Total Harmonic Distortion:	At 1.5 V rms out, less than 0.02% on all inputs
Max Input:	70 mV (phono)
Hum and Noise:	65 dB below one volt on phono 75 dB below 1V on all other inputs
Input Impedance:	Phono—47,000 ohms Mic—47,000 ohms Aux, Tape, Tuner—1 megohm
Output Impedance:	10,000 ohms or less
Power Required:	117 Vac, 0.5 A
Dimensions:	10″ W x 5″ H x 10″ D

The right and left channels are identical electrically. Codes, terminal markings and wiring shown in solid black are for the left channel. Codes shown in color are for the right channel. Constructors using the PC board patterns supplied will note minor differences in the right- and left-channel signal paths through the tone controls. In the left channel, the signal goes from the arm of the +4 dB TREBLE switch to the arm of the −12 dB BASS switch. In the right-channel wiring, the signal from the arm of the +4 dB switch goes to the normally closed terminal on the −4 dB BASS switch. These and other wiring differences between the two channels are indicated by "X" break points and colored circuit lines. For example BALANCE control R63 is connected between terminal L in the left channel and terminal M in the right channel. Similarly, S6 is connected between terminals N and O.

tolerated such as in professional audio work.

The output level control is provided at the output of amplifier module 2 to allow the user to set the maximum output level of the preamp to match the maximum input requirements of the power amplifier with which the preamp is being used.

Construction tips

The prototype was built using 0.050″ aluminum for the three main chassis panels and subpanels. The cover is from a vinyl covered piece of wood with an aluminum foil shield cemented to the inside. The front panel of the unit is made from a piece of 0.025″ plated brushed steel which was lettered and cemented to the aluminum panel.

There are eight circuit boards in the unit. Four for the preamp switching circuitry, the other four are identical and are the gain modules.

Assemble all eight boards making sure to orientate all diodes, transistors, and electrolytic capacitors correctly. All trimmer resistors on the boards as well as resistor R66 and lamp LM1 are attached and soldered from the foil side of the board. Insert jumper wires on the boards where indicated by a solid line connecting pads printed on the component side of the board. On two of the four high-gain amplifier boards omit the jumper connecting pad C to ground. On the other two boards attach and solder a 47,000 ohm ¼-watt 10% resistor across electrolytic capacitor C3. The two boards without the jumpers are used on the left side of the unit when viewed from the front while those with the resistor added are used on the right side. All chassis members are held together by 6-32 hardware while the circuit boards with the pushbutton switches are secured with 4-40 hardware.

All chassis hardware should be orientated and attached as shown in the photos. All wiring is No. 24 or No. 26. The only exceptions are the wires going to the power switch terminals A and B. These should be No. 18. The two pairs of wires running to the LEVEL control should be shielded cable, and the wires connected to the terminals of the ac receptacles, should also be No. 18. Use twisted pairs where shown in the photos and route the twisted pairs along the top plane of the chassis. All other wires are routed along the lower chassis surface.

Using the preamp

Insert the four gain modules into the mounting slides and orient the boards so the component sides are toward the front of the chassis. Set all trimmer resistors so the tab on the knurl of the controls is about halfway between its two end points. Set all tone control switches so the response is flat and be sure LOUDNESS and TAPE MONITOR switches are not depressed. Press the LEVEL control switch in so the unit operates in a stereo mode and set the control in the fully counterclockwise position. Set the BALANCE control to its midway position and depress the PHONO input selector. Attach the patch cords of your turntable to the phono inputs of the preamp. Plug in the line cord and depress the power switch. Using a vom or scope, check the dc voltage level at the preamp output on both the left and right channels. This voltage should be well under 0.1 volt dc. If it is not, unplug the unit and recheck all construction steps. If this measurement is correct, put a record on the turntable and monitor the ac voltage. As the LEVEL control is advanced the meter should show a fluctuating reading of around 0.25 volts rms. If you are using a

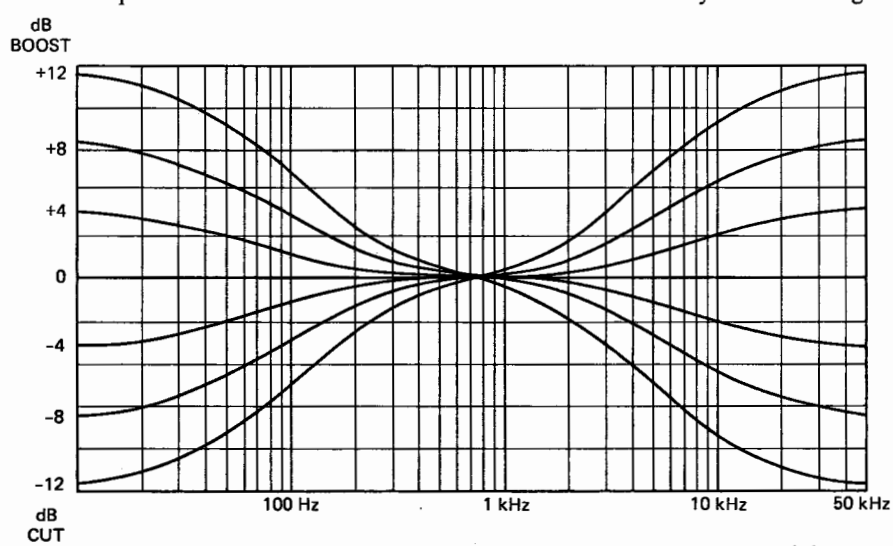
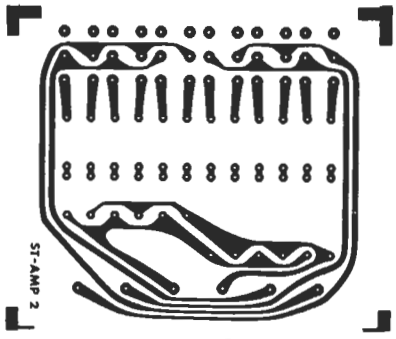
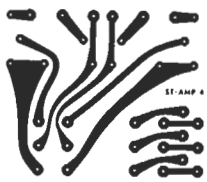


FIG. 3—COMPLETE TONE-CONTROL RESPONSE CURVE. There is one curve for each tone-control push-button selector position.

CIRCUIT BOARD B. Four are needed.



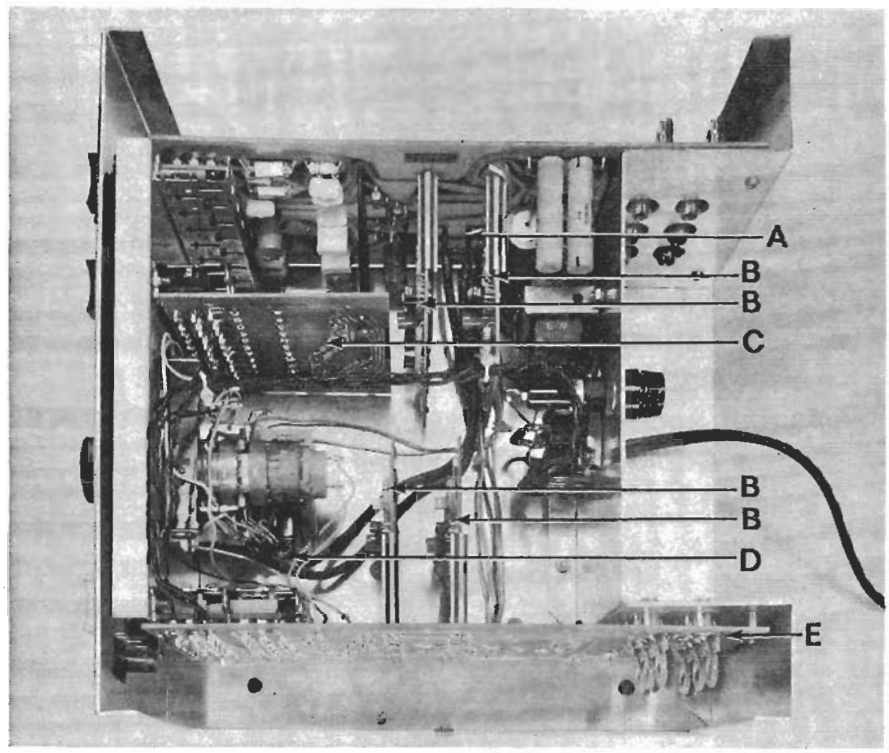
CIRCUIT BOARD C. One is required.



CIRCUIT BOARD D.

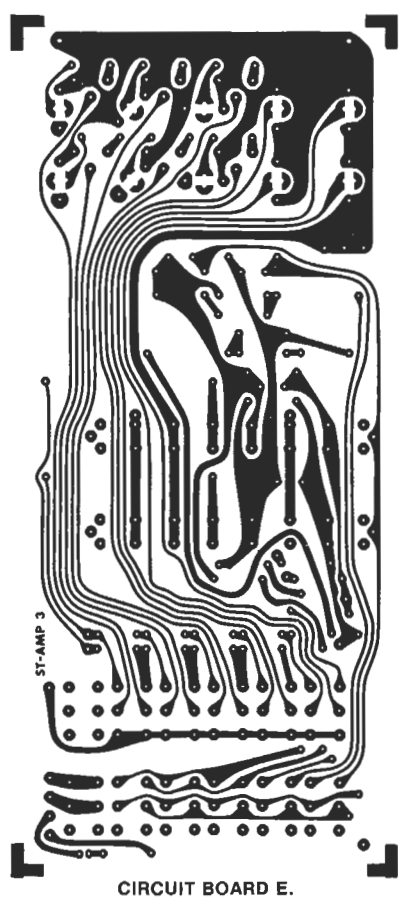
All boards shown one-half actual size.

CIRCUIT BOARD A.



INTERIOR PHOTO OF FINISHED PREAMPLIFIER. Each circuit board is identified by letter. These letters match the circuit boards shown on this page. All circuit board patterns are shown exactly half size.

The following parts for this preamp are available from Southwest Technical Products Corp., 219 W. Rhapsody, San Antonio Texas 78216. Complete set of 9 printed-circuits, drilled, with socket clips. No. 198-cb $17.50
Set of 9 circuit boards, socket clips, 3 pushbutton switches, and volume control (dual control with push-pull switch). No. 198-SW $34.50
Complete kit of all parts including cabinet and front panel. No. 198-k $69.50



CIRCUIT BOARD E.

scope, you should see a normal audio trace. If everything still looks OK, remove power, and connect the output of the preamp to the input of your power amplifier. Turn the LEVEL control down near low volume, apply power, set the trimmer resistors to give the desired amount of preamp gain. Connect all other input devices to the preamp and set the appropriate input level controls to give the desired amount of gain. After setting all trimmer resistors, secure the cover. The only precautions to be noted are to 1.) Be careful of 117-volt power wires when adjusting the trimmer resistors 2.) Do not repeatedly turn the unit off and on 3.) Keep the unit away from components generating strong magnetic fields such as power transformers, line cords, etc. **R-E**

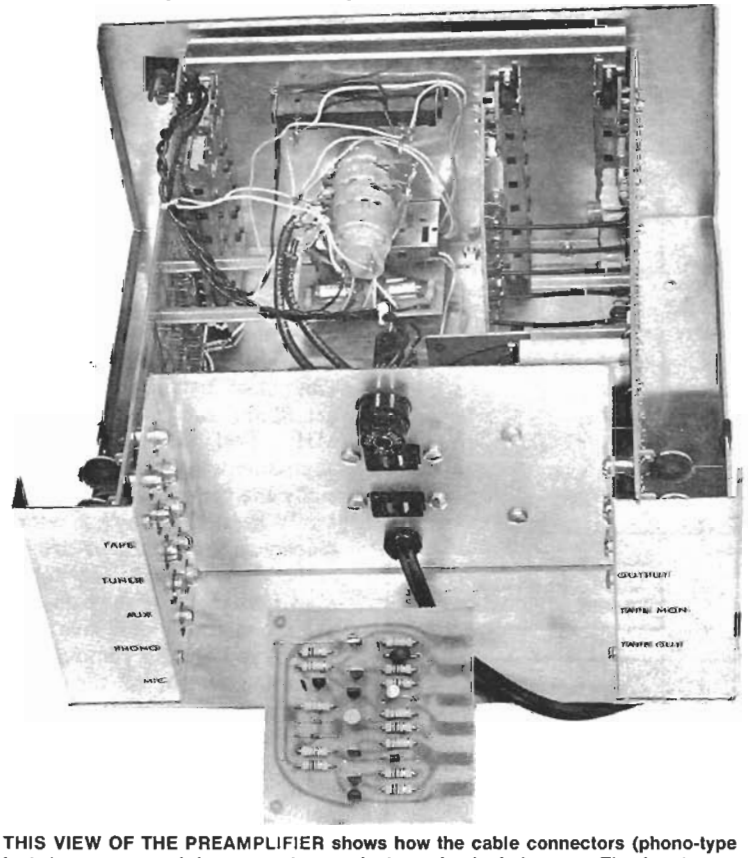
Space limitations did not permit us to include, in this issue, some additional photographs of the assembled tuner. We also omitted parts placement diagrams that show where to position the various component parts on the printed-circuit boards. All of this information will be presented in the January 1973 issue. The information presented here will permit you to get started.

BUILD A "ZERO DISTORTION" STEREO PREAMP

by GARY KAY

Part 2—The wrap-up of construction details on the novel laboratory-grade stereo preamplifier featured in last month's issue.

The photographs and parts placement layouts wrap-up the story on the stereo preamplifier featured on last month's cover. Designed around discrete semiconductors instead of IC's, this lab-quality stereo preamplifier uses a modular concept based on plug-in PC boards for simplicity, ease of construction and troubleshooting; and push-button bass, treble and function controls for versatility and resetability.



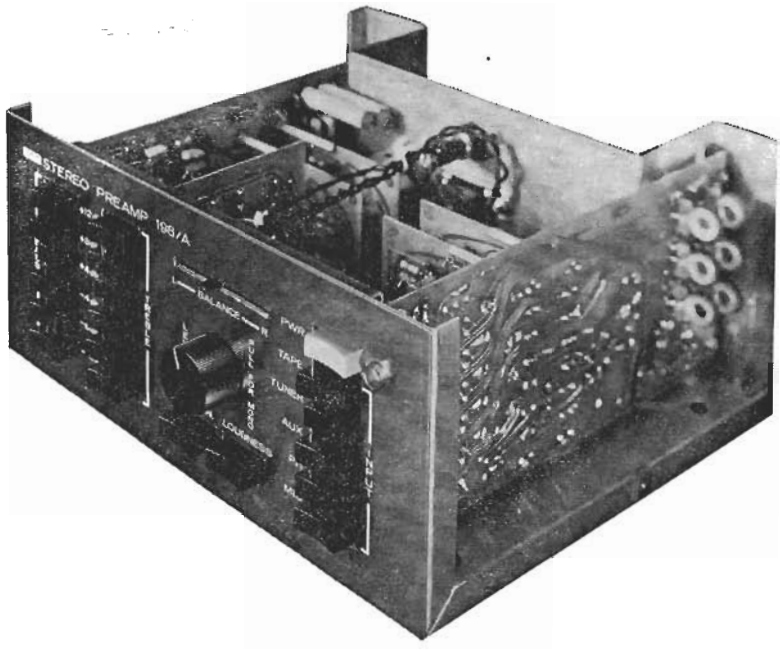
THIS VIEW OF THE PREAMPLIFIER shows how the cable connectors (phono-type jacks) are recessed for protection against mechanical damage. The input connectors are on the left; output on the right.

The following parts for this preamp are available from Southwest Technical Products Corp., 219 W. Rhapsody, San Antonio Texas 78216. Complete set of 9 printed-circuits, drilled, with socket clips. No. 198-cb $17.50
Set of 9 circuit boards, socket clips, 3 pushbutton switches, and volume control (dual control with push-pull switch). No. 198-SW $34.50
Complete kit of all parts including cabinet and front panel. No. 198-k $69.50

PARTS LIST

R1 thru R6—1 megohm ¼-W 10%
R7 thru R12—250,000-ohm trimmer
R13, R14—22,000-ohm ½-W 5%
R15, R16—51,000-ohm ½-W 5%
R17, R18—2,200-ohm ½-W 5%
R19, R20, R59, R60—100,000-ohm ½-W 5%
R21, R22—750,000-ohm ½-W 5%
R23, R24, R27, R28, R61, R62—10,000-ohm trimmer
R25, R26—1,000-ohm ½-W 10%
R29, R30—10,000-ohm audio taper pot with 5,000-ohm tap with pull switch
R31, R32—470-ohm, ½-W 10%
R33, R34—300,000-ohm ½-W 5%
R35, R36—150,000-ohm ½-W 5%
R37, R38—82,000-ohm ½-W 5%
R39, R40—8,200-ohm ½-W 5%
R41, R42—15,000-ohm ½-W 5%
R43, R44—30,000-ohm ½-W 5%
R45, R46—10,000-ohm ½-W 5%
R47, R48—3,300-ohm ½-W 5%
R49, R50—6,800-ohm ½-W 5%
R51, R52—18,000-ohm ½-W 5%
R53, R54—180,000-ohm ½-W 5%
R55, R56—68,000-ohm ½-W 5%
R57, R58—33,000-ohm ½-W 5%
R63—10,000-ohm linear taper slide pot
R64, R65—47-ohm ½-W 10%
R66—68,000-ohm ½-W 10%
R*, R*—47,000-ohm ¼-W 10%

C1, C2—.0068-μF polystyrene
C3, C4—.0015-μF polystyrene
C5, C6—4.7-pF disc
C7, C8, C37, C38—20-pF disc
C9, C10—.0047-μF polystyrene
C11, C12—.0082-μF polystyrene
C13, C14—0.012-μF metalized polycarbonate
C15, C16—0.022-μF metalized polycarbonate
C17, C18—0.22-μF metalized polycarbonate
C19, C20—0.12-μF metalized polycarbonate
C21, C22—0.082-μF metalized polycarbonate
C23, C24—220-μF @ 6.3V electrolytic
C25, C26—.0062-μF polystyrene
C27, C28—.0039-μF polystyrene
C29, C30—.0024-μF polystyrene
C31, C32—240-pF polystyrene
C33, C34—390-pF polystyrene
C35, C36—620-pF polystyrene
C39, C40—1-μF 15 volt electrolytic
C41, C42—1000-μF 25 Vdc electrolytic
C43, C44—500-μF 15 Vdc electrolytic
C45, C46—0.1-μF
D1 thru D4—1N5060 silicon diode or equal
D5, D6—15-V 1-W Zener diode, Motorola 1N4744 or equal



*S3—5-station dpdt tandem plus 1 station push-to-lock pushbutton switch
*S1, S2—6-station dpdt pushbutton switch
*S4, S5—dpdt pushbutton switch
S6—spst pull switch mounted on the rear of level control
F1—¼-amp fuse
T1—24-volt 80 mA ct transformer 117 Vac primary
LM1—neon lamp NE-2

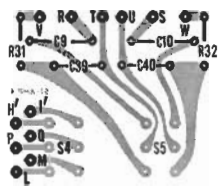
Parts List No. 195 Preamp Module

Q1, Q2, Q6, Q7—2N5210 Motorola
Q3, Q4, Q5—2N5087 Motorola
D1—4.7-V 400mw Zener diode Motorola MZ-70-4.7 or equal
D2, D3—1N914 diode or equal
C1—4.7-μF tantalum electrolytic
C2—5-pF disc
C3—33-μF @ 6-V electrolytic
R1, R3, R9, R10, R11, R13—1000-ohm ½-W 10%
R2—47,000-ohm ½-W 10%
R4, R5—22,000-ohm ½-W 10%
R6—15,000-ohm ½-W 10%
R7—8200-ohm ½-W 10%
R8—10,000-ohm ½-W 10%
R12—4700-ohm ½-W 10%

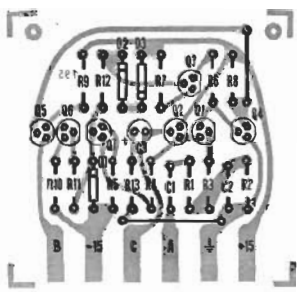
*S1 through S5 are being custom-made for Southwest Technical and no substitutes are available.

The two 47,000-ohm resistors are used only on the two input modules and are connected across capacitor C3 (see Fig. 1) on the foil side of the board. **R-E**

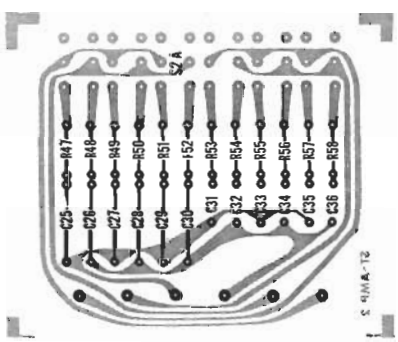
All boards shown one-half actual size.



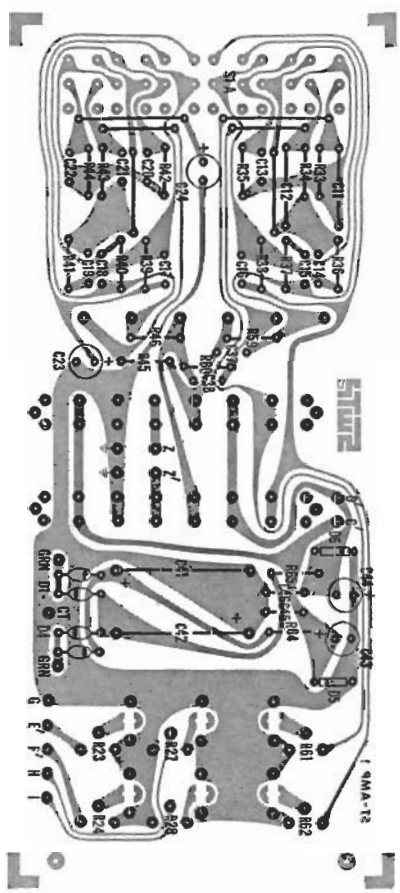
CIRCUIT BOARD D.



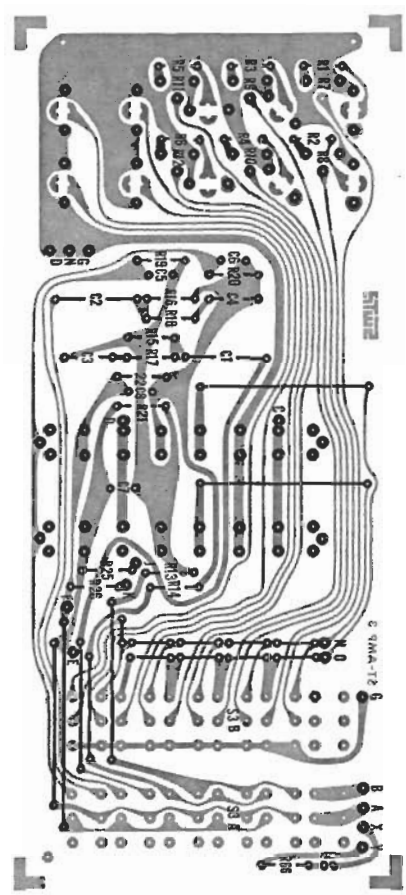
CIRCUIT BOARD B. Four are needed.



CIRCUIT BOARD C. One is required.



CIRCUIT BOARD A.



CIRCUIT BOARD E.