

Radio-Electronics®

FOR MEN WITH IDEAS IN ELECTRONICS

BUILD A "ZERO DISTORTION" STEREO PREAMP

ELECTRONIC CALCULATORS
From Fingers to LED's

OPERATIONAL AMPLIFIERS
10 Audio Circuits

DIGITAL IC BREADBOARD
Build It Yourself

THE TRANSISTOR
It's 25 Years Old



PLUS

Jack Darr's Service Clinic
Using A Color-Bar Generator
Step-By-Step TV Troubleshooting
Lou Garner's State of Solid-State

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December 1972

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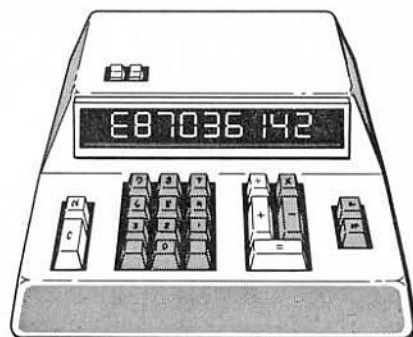
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CALCULATORS ARE BIG NEWS. See how they evolved from counting on your fingers (the first "digital" computer) to the modern electronic marvels we are using today.
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INTERESTED IN BUILDING A HIGH-quality 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

vices 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.

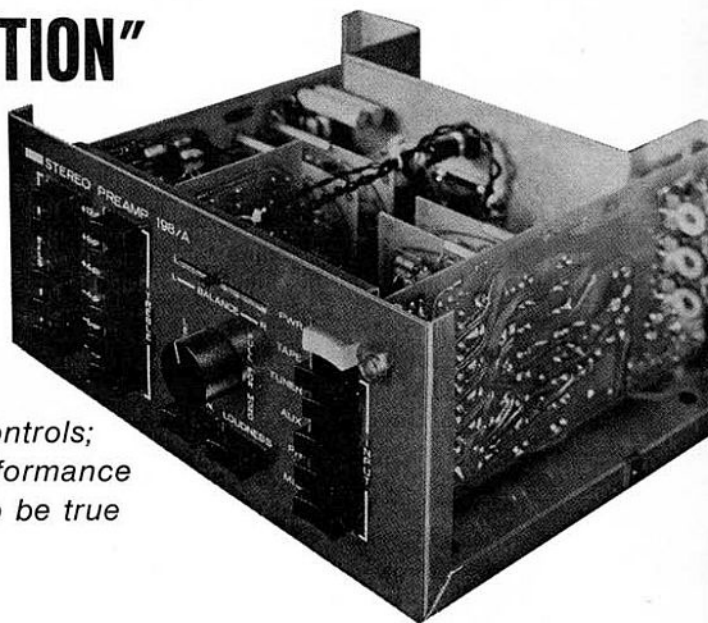
Functionally, the preamp has an internal power supply, pushbutton BASS and TREBLE switches, external BALANCE control, internal LEVEL controls on the TAPE, TUNER, AUX, and TAPE MONITOR inputs and the TAPE and PREAMP outputs. Switches are provided for POWER-OFF, TAPE MONITOR-NORMAL, LOUDNESS-VOLUME, and MONAURAL-STEREO modes. The power

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.

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



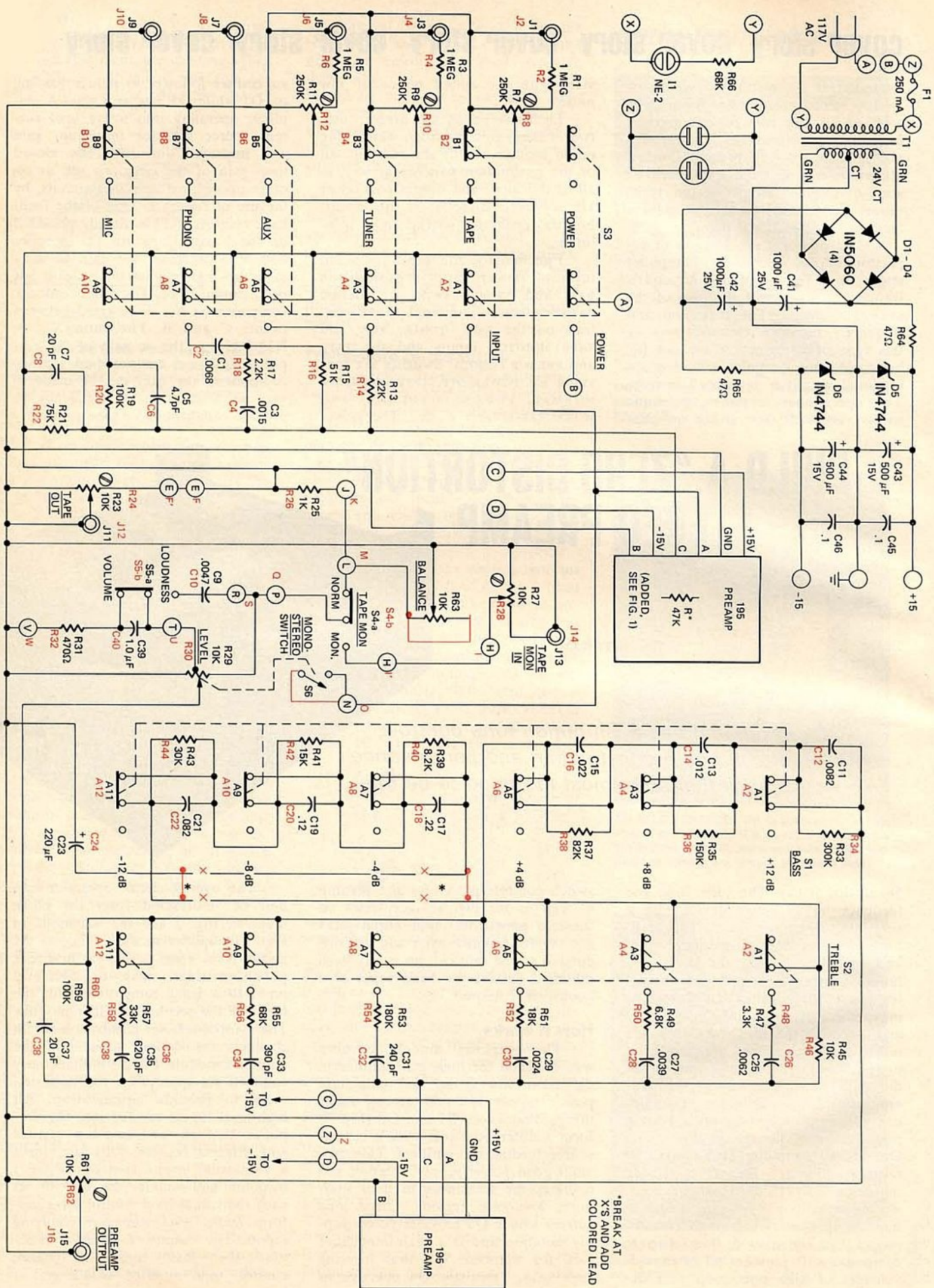
58 of this issue). The idea is to use feedback on an active device with a very high open-loop gain. The feedback controls the closed-loop gain, and greatly enhances the distortion, noise and frequency response characteristics of the device. Unfortunately, inexpensive IC's are inherently noisy and although 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 de-

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

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



*BREAK AT X'S AND ADD COLORED LEAD

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)
Humand Noise:	65dB below one volt on phono 75dB 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.

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 1/4-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 se-

cured 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

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.

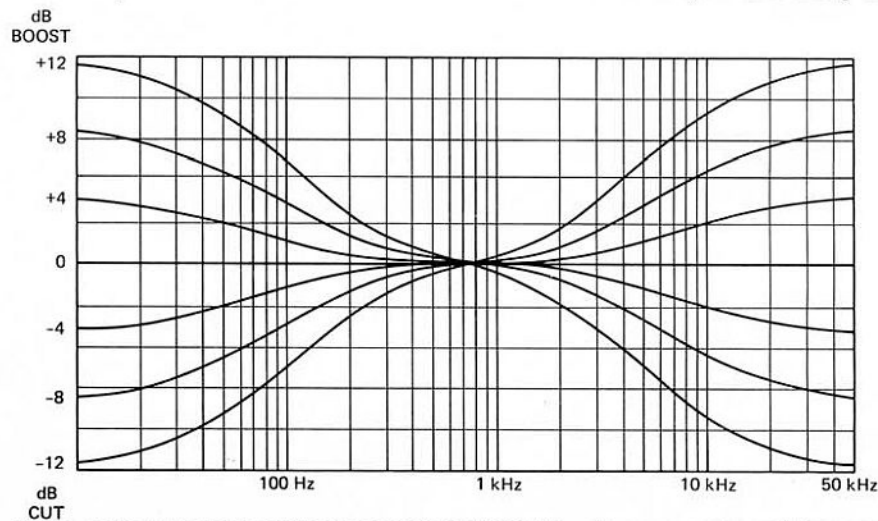
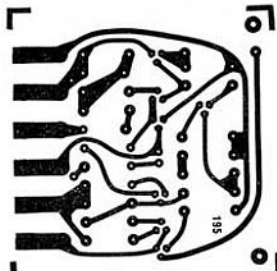
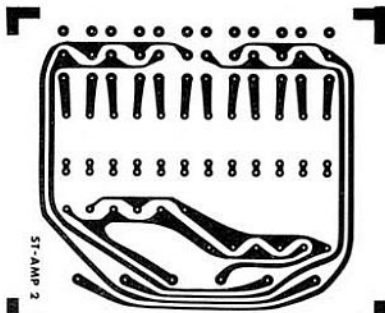


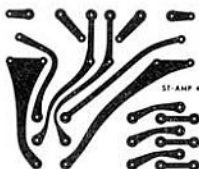
FIG. 3—COMPLETE TONE-CONTROL RESPONSE CURVE. There is one curve for each tone-control push-button selector position.



CIRCUIT BOARD B. Four are needed.



CIRCUIT BOARD C. One is required.

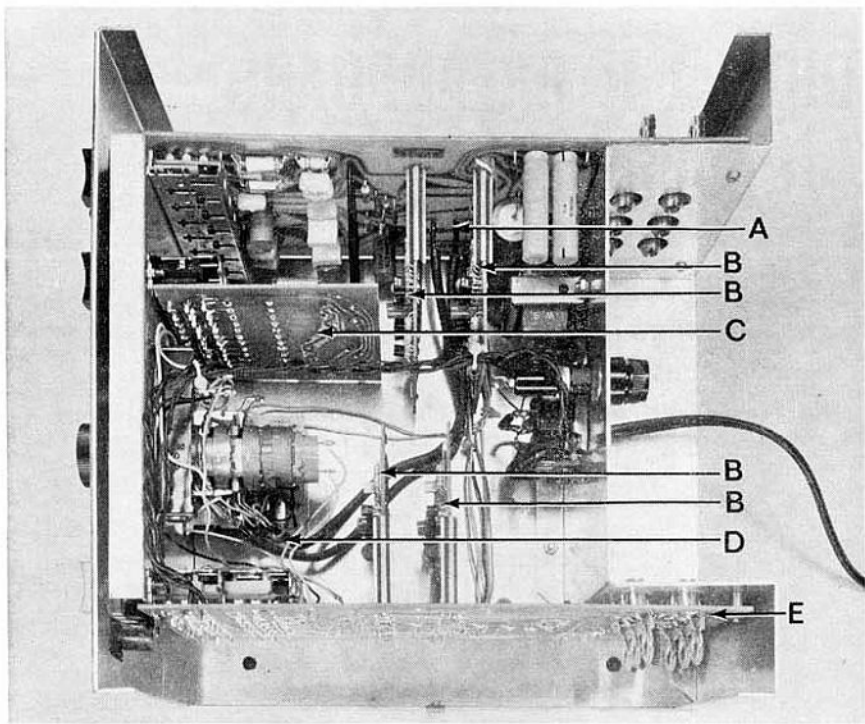


CIRCUIT BOARD D.

All boards shown one-half actual size.

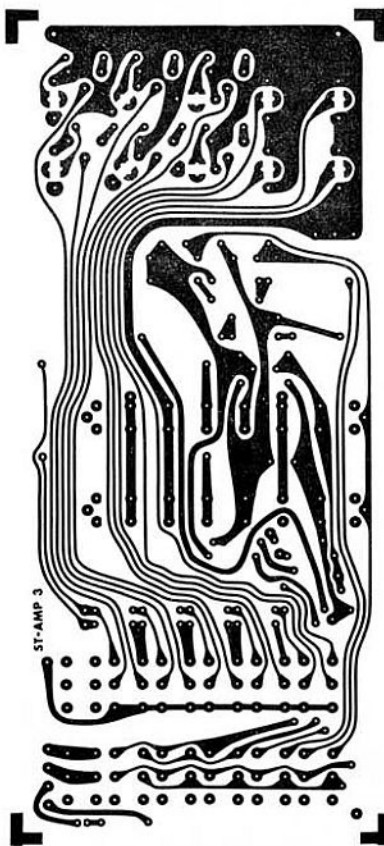


CIRCUIT BOARD A.



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.

60c ■ JAN. 1973

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SPECIAL ISSUE - COLOR TV 1973

COLOR TV TEST JIGS

Leave The Pix Tube Behind

AUTOMATIC COLOR CONTROLS

See How They Work

ADD-ON DIGITAL READOUT

Tells Receiver Frequency

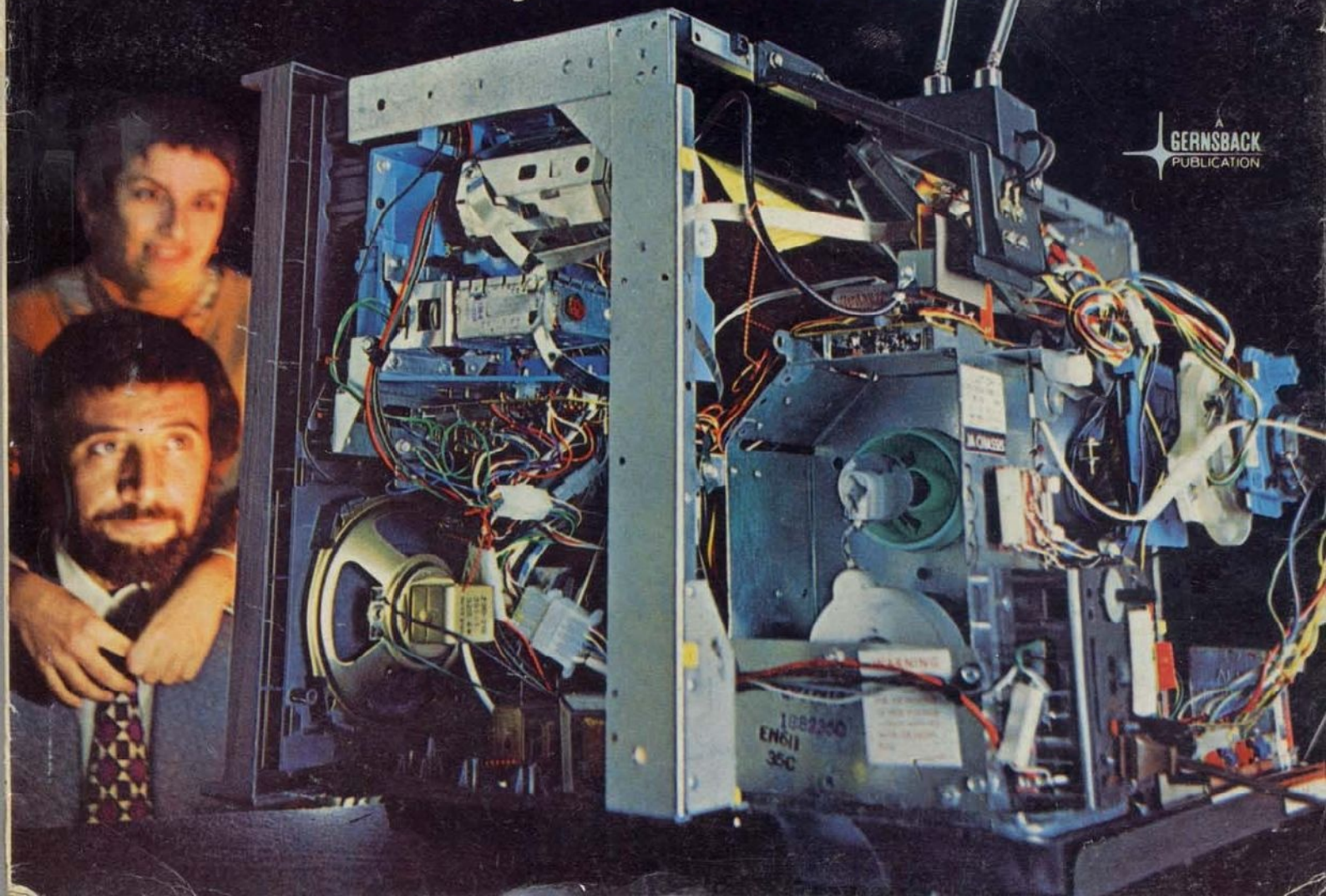
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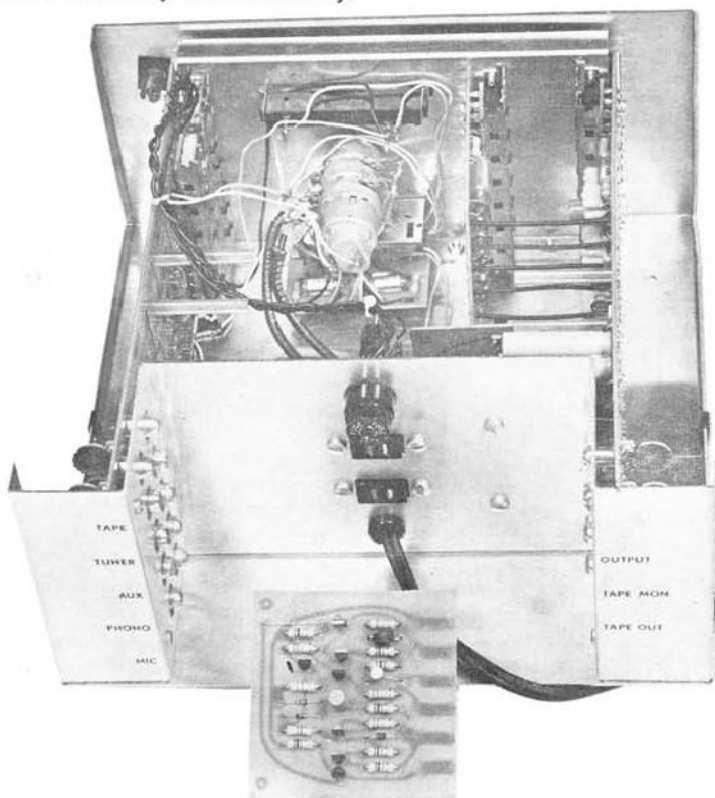


BUILD A "ZERO DISTORTION" STEREO PREAMP

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.



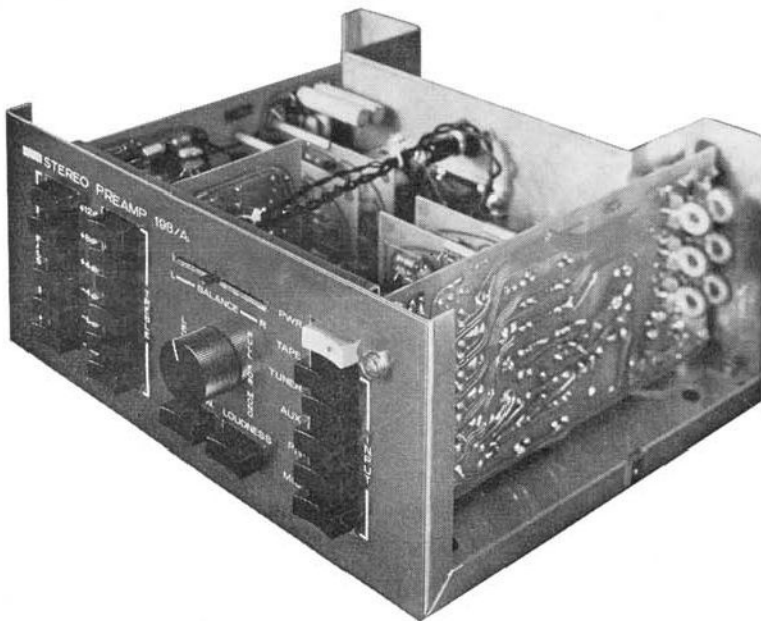
THIS VIEW OF THE PREAMPLIFIER shows how the cable connectors (phono-type jacks) are recessed for protection against mechanical damage. The input connectors are on the left; output on the right.

PARTS LIST

R1 thru R6—1 megohm 1/4-W 10%
 R7 thru R12—250,000-ohm trimmer
 R13, R14—22,000-ohm 1/2-W 5%
 R15, R16—51,000-ohm 1/2-W 5%
 R17, R18—2,200-ohm 1/2-W 5%
 R19, R20, R59, R60—100,000-ohm 1/2-W 5%
 R21, R22—750,000-ohm 1/2-W 5%
 R23, R24, R27, R28, R61, R62—10,000-ohm trimmer
 R25, R26—1,000-ohm 1/2-W 10%
 R29, R30—10,000-ohm audio taper pot with 5,000-ohm tap with pull switch
 R31, R32—470-ohm, 1/2-W 10%
 R33, R34—300,000-ohm 1/2-W 5%
 R35, R36—150,000-ohm 1/2-W 5%
 R37, R38—82,000-ohm 1/2-W 5%
 R39, R40—8,200-ohm 1/2-W 5%
 R41, R42—15,000-ohm 1/2-W 5%
 R43, R44—30,000-ohm 1/2-W 5%
 R45, R46—10,000-ohm 1/2-W 5%
 R47, R48—3,300-ohm 1/2-W 5%
 R49, R50—6,800-ohm 1/2-W 5%
 R51, R52—18,000-ohm 1/2-W 5%
 R53, R54—180,000-ohm 1/2-W 5%
 R55, R56—68,000-ohm 1/2-W 5%
 R57, R58—33,000-ohm 1/2-W 5%
 R63—10,000-ohm linear taper slide pot
 R64, R65—47-ohm 1/2-W 10%
 R66—68,000-ohm 1/2-W 10%
 R*, R°—47,000-ohm 1/4-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

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



- *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— $\frac{1}{4}$ -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- μ F tantalum electrolytic
- C2—5-pF disc
- C3—33- μ F @ 6-V electrolytic
- R1, R3, R9, R10, R11, R13—1000-ohm $\frac{1}{2}$ -W 10%
- R2—47,000-ohm $\frac{1}{2}$ -W 10%
- R4, R5—22,000-ohm $\frac{1}{2}$ -W 10%
- R6—15,000-ohm $\frac{1}{2}$ -W 10%
- R7—8200-ohm $\frac{1}{2}$ -W 10%

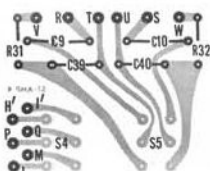
- R8—10,000-ohm $\frac{1}{2}$ -W 10%
- R12—4700-ohm $\frac{1}{2}$ -W 10%

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

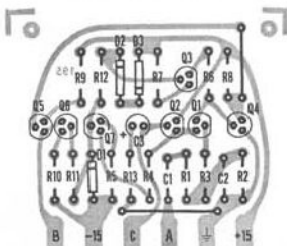
The two 47,000-ohm resistors are used only on the two input modules and are connected across capacitor C3 (see Fig. 1) on the foil side of the board.

R-E

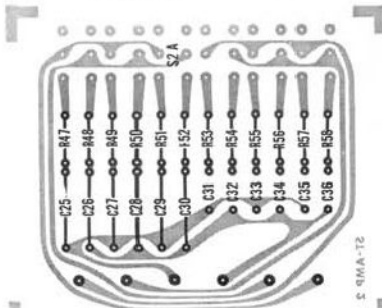
All boards shown one-half actual size.



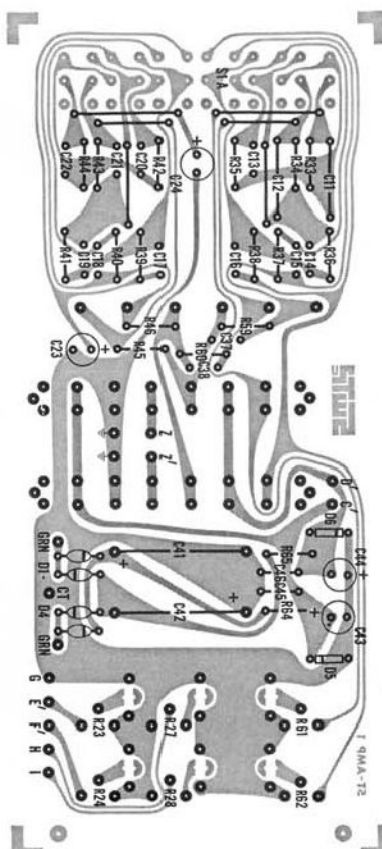
CIRCUIT BOARD D.



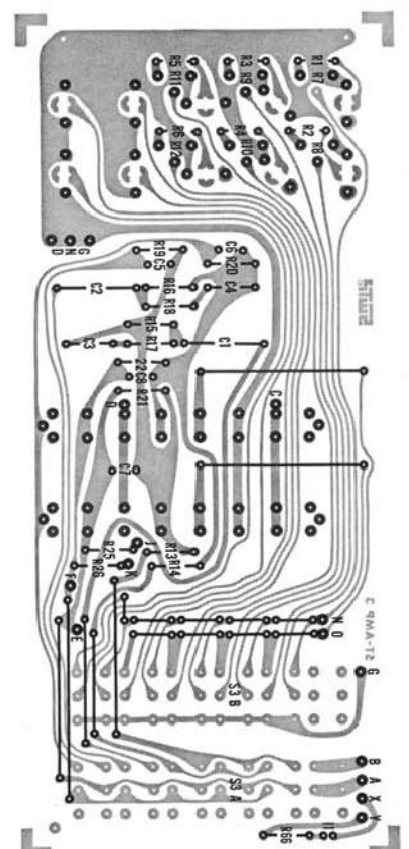
CIRCUIT BOARD B. Four are needed.



CIRCUIT BOARD C. One is required.



CIRCUIT BOARD A.



CIRCUIT BOARD E.



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Circle 73 on reader service card

by DON LANCASTER

HERE ARE THE FINAL DETAILS TELLING how to build the mainframe for your grinchwal digital test equipment mainframe. Plug-ins start in February.

Preliminary checkout

You'll need a previously tested and working counter module and your power supply for checkout. Hookup the circuit of Fig. 4-a and check out the counting unit for normal brightness, counting, and "hold-follow" operation. Next checkout the reset and lamp test modes. Finally, check the overflow lamp by resetting the counter and watching it light and stay lit on count number 10,000.

Now, go to the circuit for Fig. 4-b. Doublecheck the voltages on your PC board for IC1, making sure you have -12 volts only on pin 16, +6 only on pins 7 & 15, and ground only on pins 2, 3, 5, and 6. You can now solder IC1 in place using a small iron and fine solder. When you reapply power, the counter should promptly start running at a 100-Hz rate. If it doesn't, first make sure you are in the FOLLOW position, and then try several adjustments of the trimmer capacitor. In case of difficulty, the 1-MHz

BUILD GRINCHWAL

oscillator output may be monitored with an oscilloscope with a 10x probe directly on pin 10 of IC1.

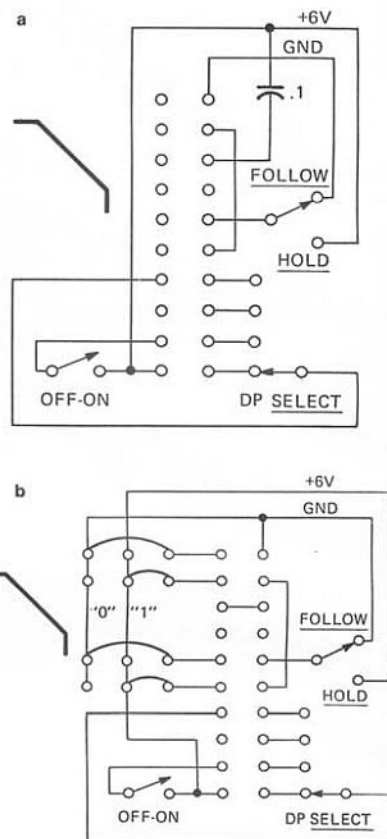


FIG. 4—WHEN UNIT IS ASSEMBLED test for proper operation with these two circuits.

When you switch off the +6-volt line, the -12-volt line is also switched off through "relay" Q2 and Q3. A connector PC pattern for the plug-in is shown in Fig. 5.

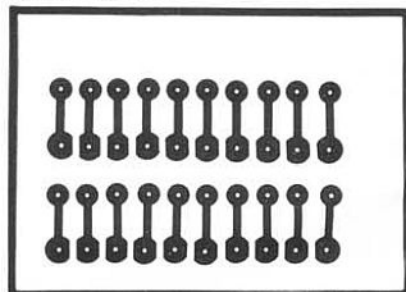


FIG. 5—CONNECTOR FOIL PATTERN. Each plug-in will use one of these connectors.

NOTE: The following are available from Southwest Technical Products, 219 West Rhapsody, San Antonio, Texas, 78216: PC Board, etched and drilled No. DGM-b, \$4.85 postpaid. Circuit board for readouts, No. DGR-b, \$3.85 postpaid. Kit of parts for readout, No. DR-C, \$34.50. Kit of parts for mainframe and timebase plug-in, including case and front panel, No. DM-C, \$26.75, less readouts and batteries, postpaid.

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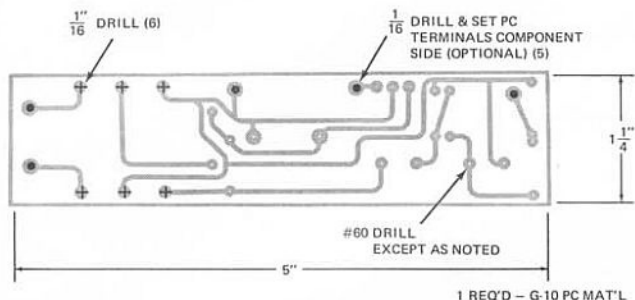
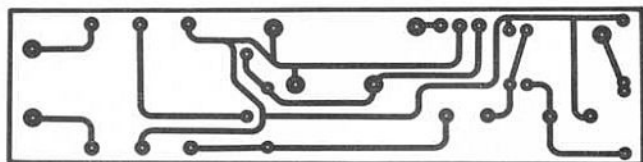
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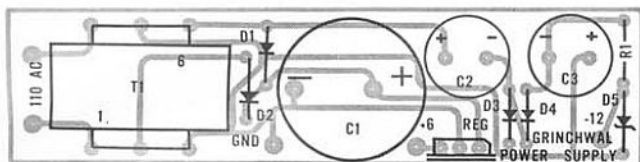
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Circle 74 on reader service card

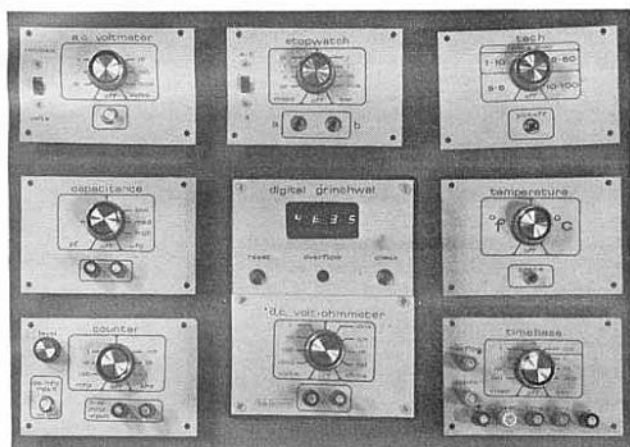
DIGITAL TEST EQUIPMENT



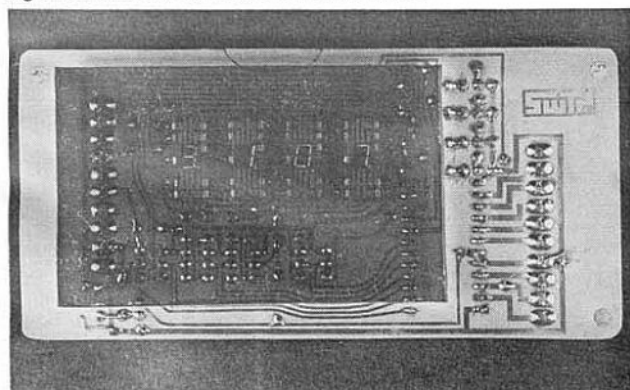
1 REQ'D - G-10 PC MAT'L



POWER SUPPLY CIRCUIT BOARD DETAILS. Three diagrams are shown. At the top is the foil pattern for the board. Next is the drilling guide. Last is a diagram showing parts placement on the circuit board.



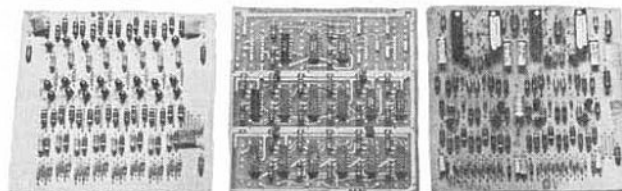
THESE ARE SOME OF THE PLUG-INS that go along with the Grinchwal digital instrument. You'll want to have them all.



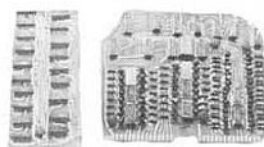
AN ASSEMBLED READOUT BOARD. The numerals are illuminated for this photo. Do not operate your unit out of its case.

(continued on page 96)

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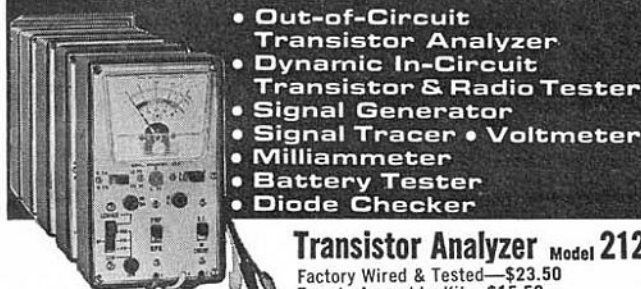
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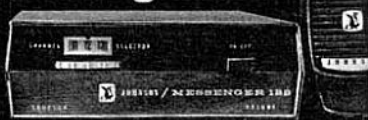
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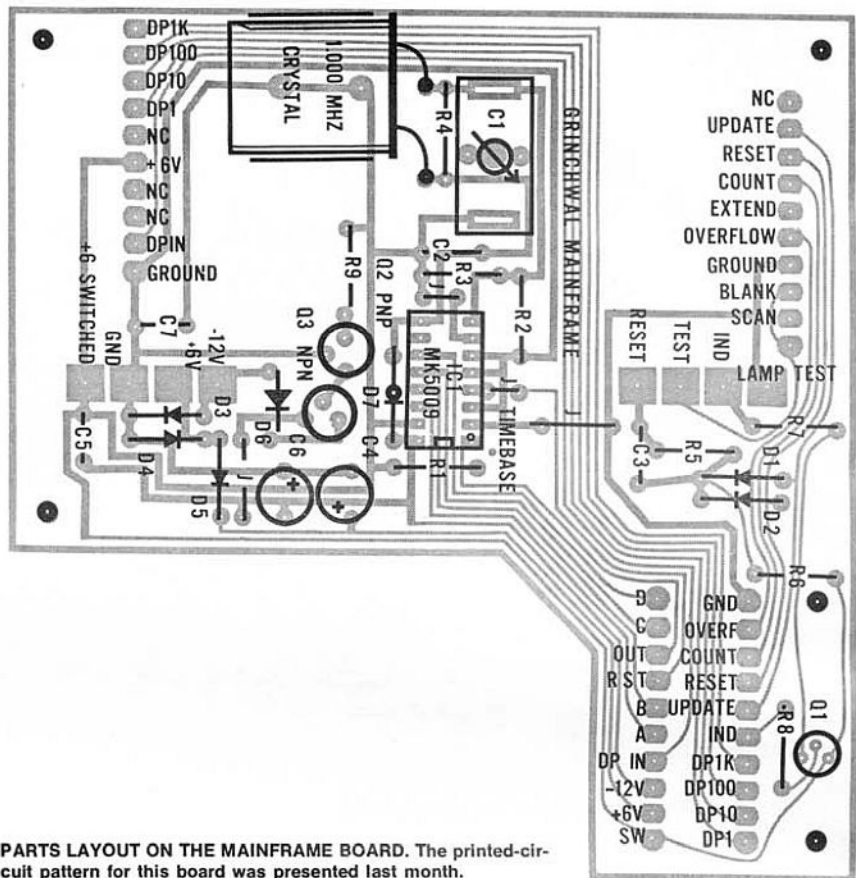
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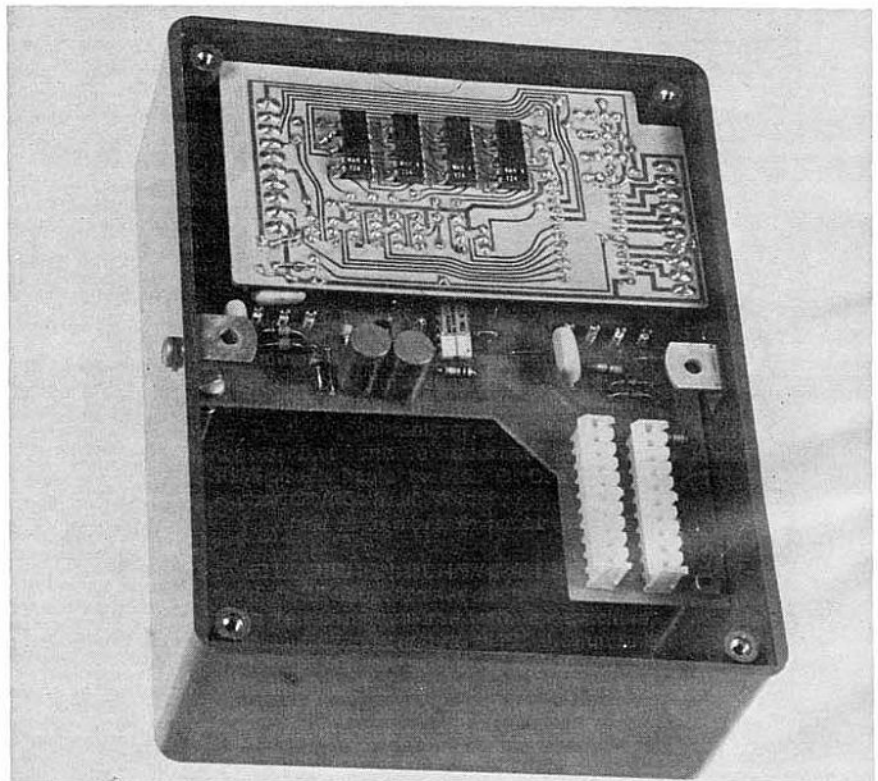
Circle 77 on reader service card

GRINCHWAL TEST EQUIPMENT

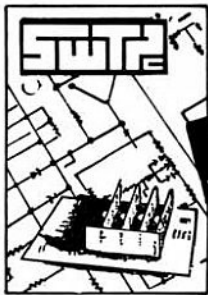
(continued from page 95)



PARTS LAYOUT ON THE MAINFRAME BOARD. The printed-circuit pattern for this board was presented last month.



COMPLETED MAINFRAME WITH front panel removed to show the location of major components inside the case.



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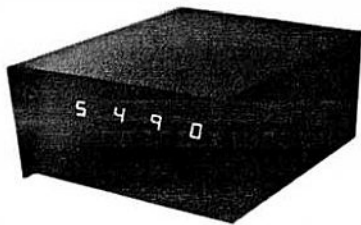
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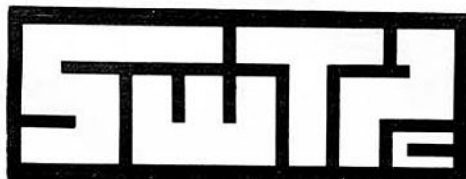
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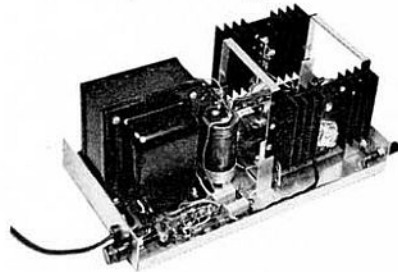
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