BUILD THIS

TRIGGERED OSCILLOSCOPE

Part II—Construction details and calibration instructions for the low-cost scope that features a continuously displayed zero baseline.

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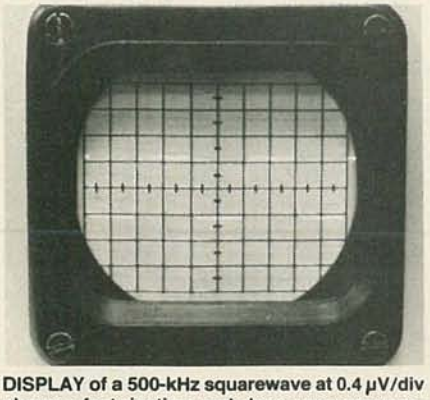
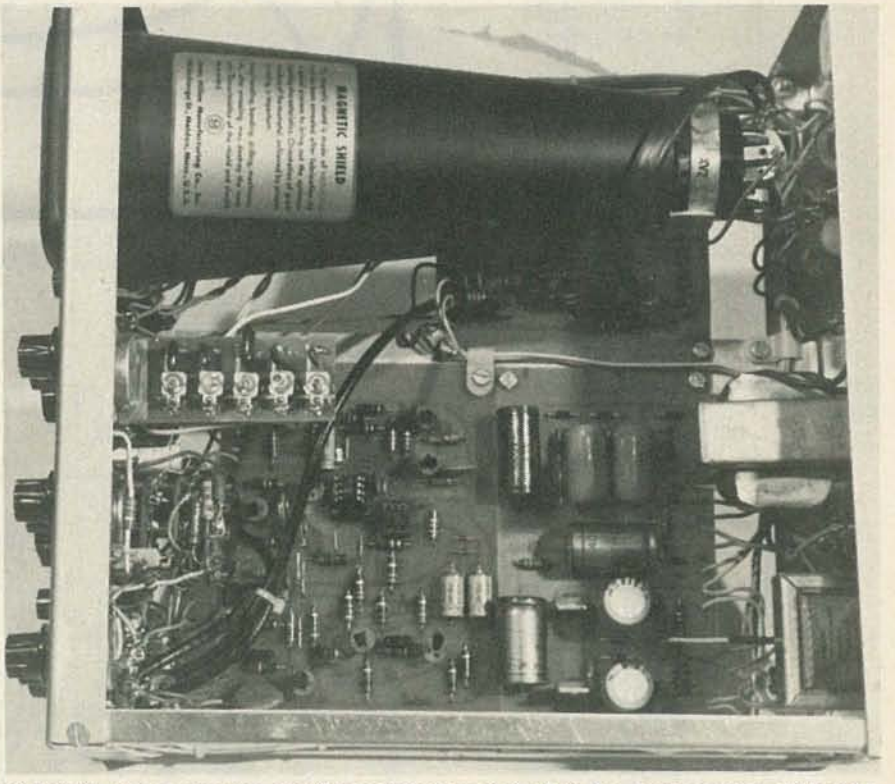
LAST MONTH WE DESCRIBED THE FEATURES of this inexpensive DC scope and went into detail on the operation of its various circuits. We continue this month by resuming our broken-off discussion with suggestions on selecting the CRT to meet your requirements.

Construction

Many types of CRT's have been used in this design, including 3BP1, 3EP1, 3ACP11, 3FP7, 3RP1, and 2AP1. Five-inch types can be used, but whatever is gained in screen size will be lost in sharpness of focus. The 3RP1A and 3WP1 are especially nice because they are flat-faced. The 3WP1 has about twice the deflection sensitivity of the others, and can be used to produce a scope with 5-mV sensitivity. The CRT must be shielded with MuMetal (nothing else will work) unless the power transformers can be located two feet from the CRT. Surplus houses that sell CRT's usually have fully formed shields.



DISPLAY of a 500-kHz squarewave at 0.4 μV/div shows a fast risetime and clean squarewave response.



TOP VIEW of the scope. The amplifier board is beneath the CRT. The power-supply board is at the rear near the transformers mounted on the back panel. The sweep board is up front near the controls. The attenuator board, with its five trimmers, is on a bracket held by the vertical-sensitivity control. Astigmatism control is on rear panel near base of the CRT.

The vertical and horizontal output wires must run straight to the CRT and be kept away from each other and from other wiring and the chassis. The vertical and horizontal inputs should be kept short and separate from other wire bundles. The wires to and from the TRIGGER LEVEL switch carry fast squarewaves and must be shielded to prevent coupling to other wires. The wires to the VERTICAL VARIABLE GAIN control should be kept reasonably short. Other wiring should be bundled and laced in the interests of neatness.

The input attenuator and sweep-timing resistors must be held to 1% if good

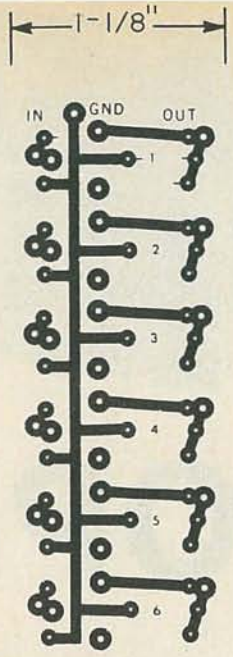


FIG. 6—FOIL PATTERN for the attenuator used in the vertical-sweep circuit.

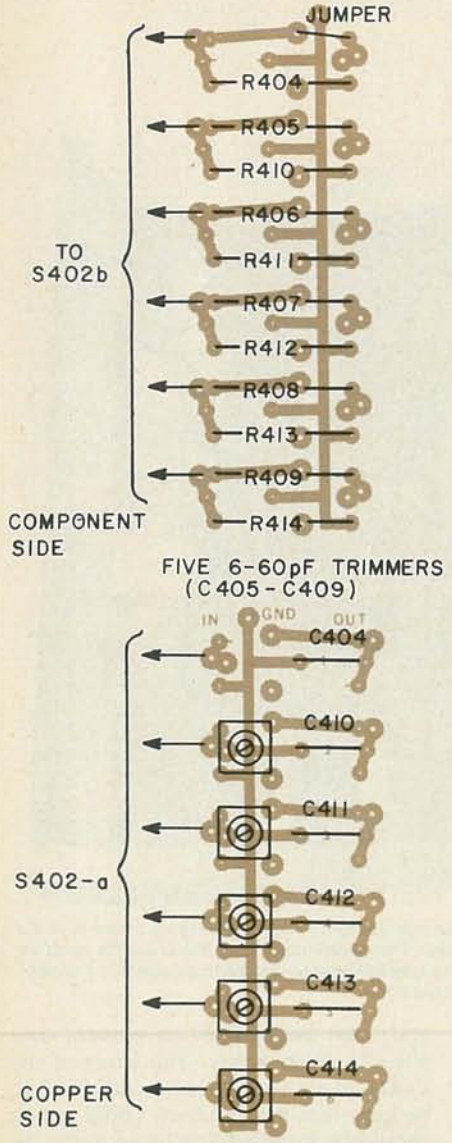


FIG. 7—COMPONENT PLACEMENT GUIDE for the vertical-input attenuator. The precision resistors are on one side and the frequency-compensating capacitors are on the other.

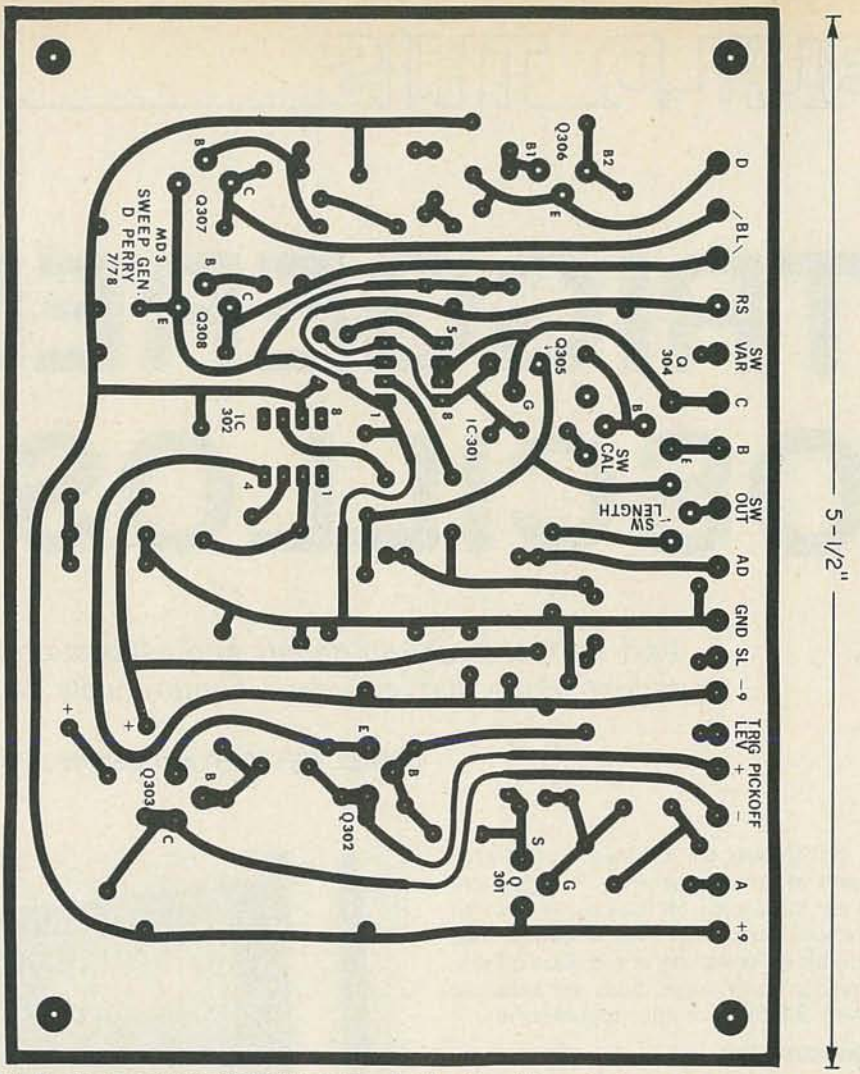


FIG. 8—THE SWEEP-GENERATOR PC-board foil pattern. The pads along the top edge are for connections to off-the-board components and leads to other circuit boards.

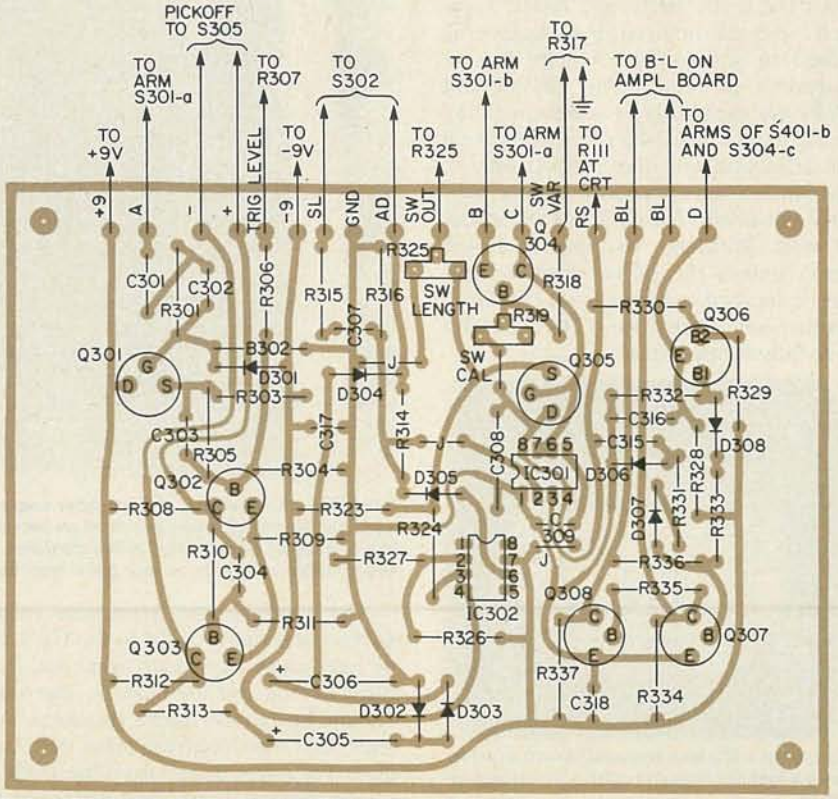


FIG. 9—HOW THE COMPONENTS ARE PLACED on the sweep-generator PC board. Note the positions of the three jumpers.

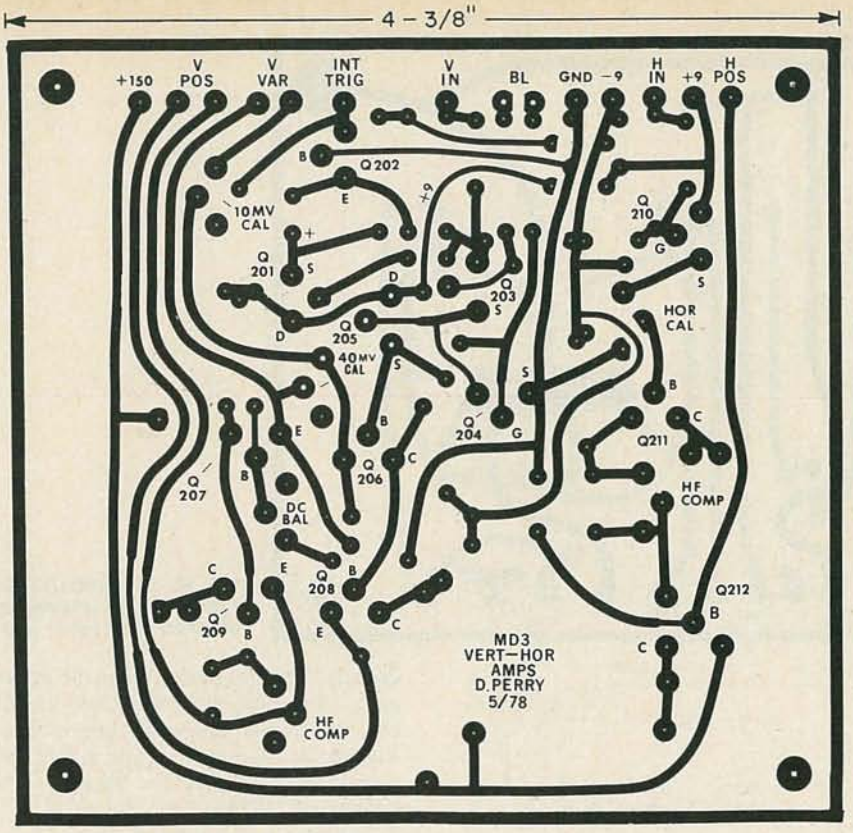
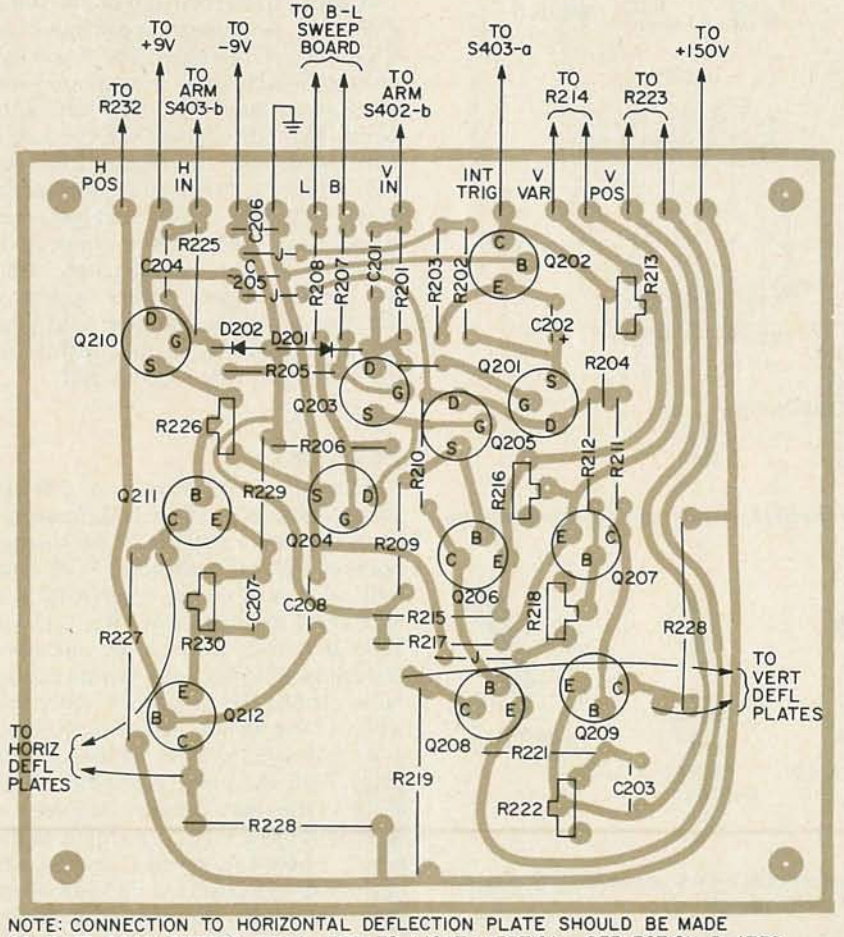


FIG. 10—PRINTED-CIRCUIT FOIL PATTERN for the board for the horizontal and vertical deflection circuits.



NOTE: CONNECTION TO HORIZONTAL DEFLECTION PLATE SHOULD BE MADE SO THAT BEAM SWEEPS FROM LEFT TO LIGHT; VERTICAL DEFLECTION PLATES SHOULD BE CONNECTED SO THAT POSITIVE INPUT TO VERTICAL AMPLIFIER PRODUCES UPWARD DEFLECTION OF BEAM.

FIG. 11—THE DEFLECTION-AMPLIFIER board has three jumpers and six trimmers for circuit calibration and adjustments. Leads to CRT deflection plates should be as short as practical to minimize stray capacitance.

TABLE 1 TROUBLESHOOTING CHART

Vertical: 50mV P-P, 1kHz sineware input; R214 at min resistance, S401 at DC

Horizontal: 2V P-P, 1kHz sineware to EXT HOR, S403 at 0.4V/DIV

Sweep: 2V P-P, 1kHz sinewave at EXT TRIG; + SLOPE, AUTO, 0.4ms/DIV, DC GND

Power Supply - 100 Board

TEST POINT	VOLTAGE DC	VOLTAGE AC P-P	POSSIBLE CAUSE
C103	−1100	40	D101 thru D106
D107A	−950	<1	D107-D113 C105, T101, CRT
C107	+145	<1	D114, C106
C108	−19	0.6	D115, D116
C110	+18	1	D118, D119
Q101E	−9.4	<5m	D117, Q101
Q102E	+9.4	<5m	D120, Q102

Trig & Vert Amp - 200 Board

Q201S	+1 to +2	=5m	
Q202C	+5	=2	
Q205G	0	50m	D201, Q205
Q205S	+1 to +2	45m	Q205
Q206E	Follows 0.6V below Q205S		
Q207E	+0.5 to +1.5	=0	R218
Q206C Q207C	=4	1.0	Q205, R215, R217
Q208C Q209C	75	50	Q208, Q209, R224

Horiz Amp - 200 Board

Q210S	+1 to +2	1.5	Q210, D202
Q211C Q212C	+75	60	Q211, Q212, R229

Sweep - 300 Board

Q301G	0	2	Q301, D301
Q301S	+1 to +2	1.8	Q301
Q302B	−1 to −3 Varied by R307		
Q302C Q303C	+1 to +9 SQR		Q302, Q303
C306	+8	0	D302, D303
Q304B	+7.3 to +8.5 Varied by R317		
R320-R322	+1.5 DC across R_T AT CAL		
IC301 pin 6	0 to +6 RAMP		Q304
Q305S	+1 to +7 RAMP		Q305
IC302 pin 6	+9 to −9 SQR		IC302, R327
IC301 pin 3	0 to +9 SQR		IC301
Q306E	0 to 7 RC Charge; Q306, R278		
Q306BI	+5 SPIKE		Q306
Q307C Q308C	0 to +9 SQR		Q307, Q308

A=anode B=base C=collector
E=emitter G=gate S=source

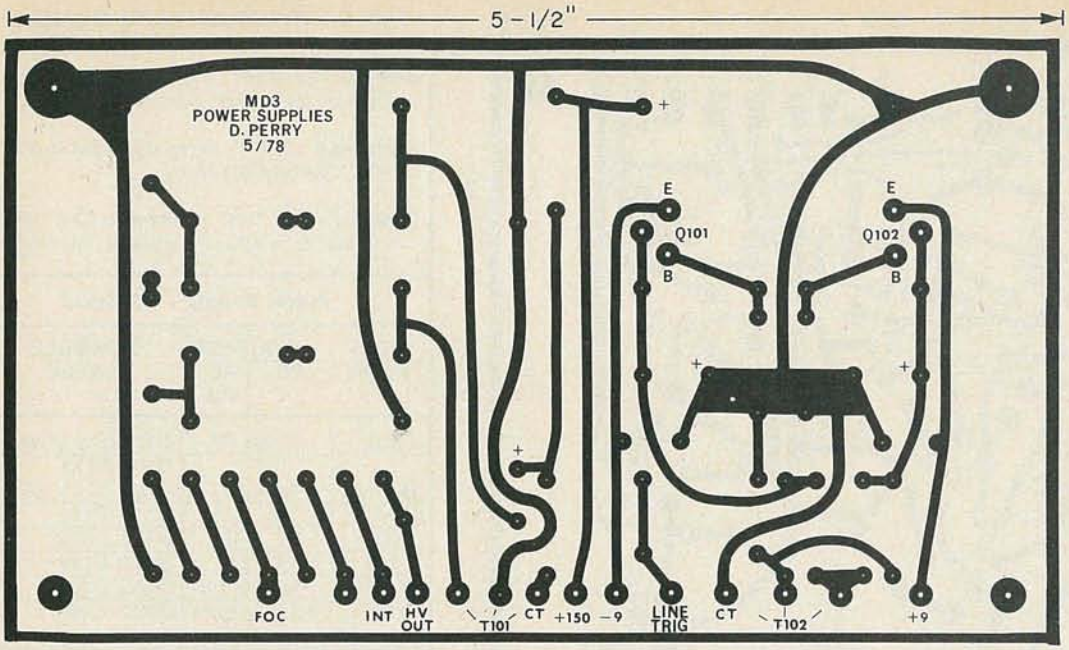


FIG. 12—THIS PRINTED-CIRCUIT PATTERN simplifies construction of the power supply.

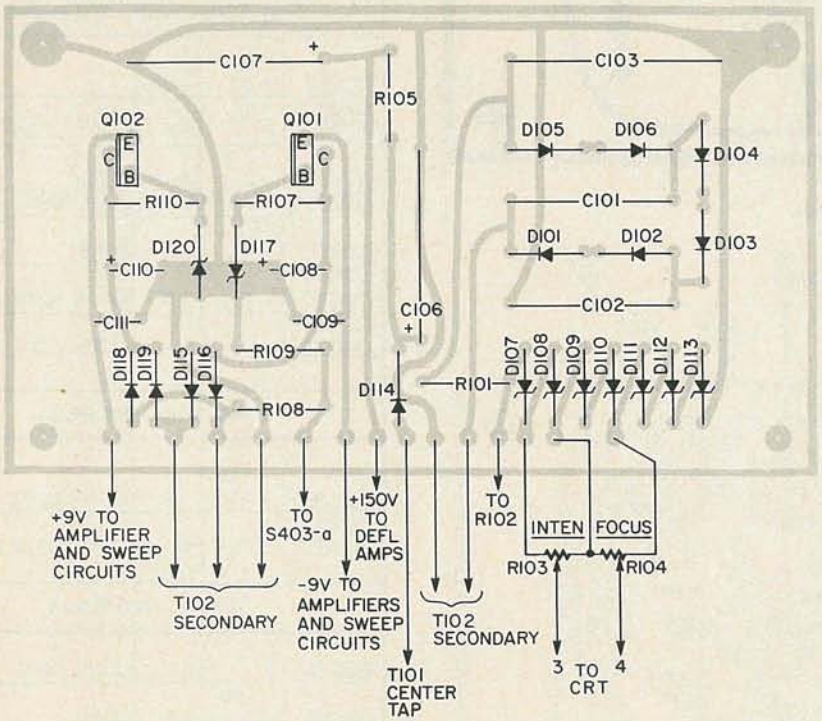
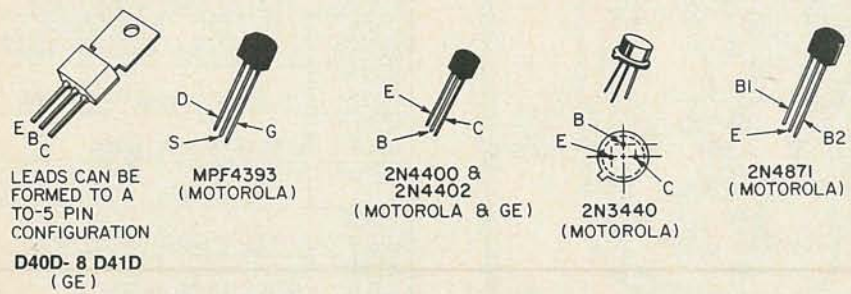


FIG. 13—POWER-SUPPLY COMPONENT LAYOUT is simple. Be careful; some of its voltages are dangerous.



PHYSICAL OUTLINES AND PINOUTS for the discrete devices used in the scope as active circuits. Be especially careful with the installation of the look-alike plastic devices.

calibration accuracy is expected. The timing capacitors must at least be in the same ratio, so if one is 7% high, strive to make them all 7% high. If a ×10 probe is to be used, the fixed frequency-compensating capacitors (C^B) must be held to 5% tolerance.

The scope is constructed on four PC boards. The foil patterns for the attenuator, sweep circuits, deflection amplifiers, and power-supply PC boards are in Figs. 6, 8, 10, and 12, respectively. The component layouts for those circuit boards are in Figs. 7, 9, 11, and 13.

Initial checkout

A spot can be focussed on the screen with only the power-supply board and CRT circuitry wired in. The 9-volt supplies will each need a temporary 470-ohm load if they are to be tested at this point. Now disconnect the primary of T101 to disable the high-voltage supplies while the sweep and low-level amplifiers are tested. The troubleshooting chart (Table 1) shows the voltages to be expected at various test points. Once the Schmitt trigger, sweep generator, baseline generator, and low-level amps are determined to be functioning, the high voltage can be reconnected.

Calibration

Vertical: First display a 200-kHz squarewave and adjust high-frequency compensation control R222 for sharpest corners with no overshoot. With range S402 at 1 V/div and variable R214 at maximum resistance, inject a 2.12 volt RMS (6.0 volts P-P) 100-Hz sinewave, and adjust R216 for a six-division display. Now change the range to 4 V/div and, with variable R214 at minimum resistance (÷4), adjust R213 for a six-division display. With the input grounded, adjust R218 so the trace remains stationary as R214 is rotated. The final step is to display a 1-kHz squarewave, and on each of the ranges from 0.1 to 10 V/div adjust the corresponding trimmer capacitor for the best squarewave with no rounding or overshoot.

Horizontal: With the horizontal atten-

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uator switch S403 at 0.4 V/div, connect a 20-kHz squarewave to the external horizontal input and adjust R230 so the display consists of two dots on the screen. Misadjustment will cause "tails" at the outside or inside of the dots indicating overshoot or rounding. Now apply a 1.41-volt RMS (4.0 V P-P) 100-Hz sinewave and adjust R226 for a ten-division horizontal line. Change S403 to 2 V/div and apply a 1-kHz squarewave, adjusting C403 for two dots with no tails as above.

Sweep: First set SWEEP LENGTH control R325 for an 11-division horizontal line. Then, with variable SWEEP TIME control R317 at minimum resistance and a 60-Hz line display, set SWEEP RANGE switch S304 to 4 ms/div and adjust SWEEP CALIBRATE control R319 so two complete cycles occupy 8.33 divisions. Now display a 100-kHz squarewave, set S304 to 1μs/div, and adjust C314 for one full cycle over ten divisions. Finally, vary the generator frequency slowly. If double traces appear at the right of the screen it will be necessary to lower the value of R327 to hold off trigger during retrace. If R327 is too low, the 555 will not trigger at all.

Now that the scope is calibrated, its ready to be put into active duty on your workbench. You should recalibrate the scope periodically to be sure of optimum performance, but the scope should provide years of trouble free service. **R-E**