Diodes fix levels for composite-video generator

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A composite video waveform, suitable for driving cathode-ray-tube monitors with RS170 video-input specifications, can be generated with a circuit that uses diodes to set the luminance and synchronization voltage levels. Schottky barrier diodes in the circuit provide fast, clean pulses free of overshoot and ringing, with rise and fall times of about 12 nanoseconds.

As shown in the composite video waveform example of

Fig. 1, the circuit fixes four discrete voltage levels—sync, blanking, black, and white. Since the design is intended for displaying digital alphanumeric data on the CRT, only the two extremes of the gray scale are supplied—black and white. However, the peak level of the video signal could be clamped to 2.5 volts, for example, to provide a gray output as well.

If the display of raster lines on the screen is not desired, control of the blanking level may be omitted; however, in a high-contrast CRT, for example, the lines should remain visible, as they counteract reflections off the CRT glass. Thus blanking is needed to eliminate the retraace that appears at higher brightness settings.

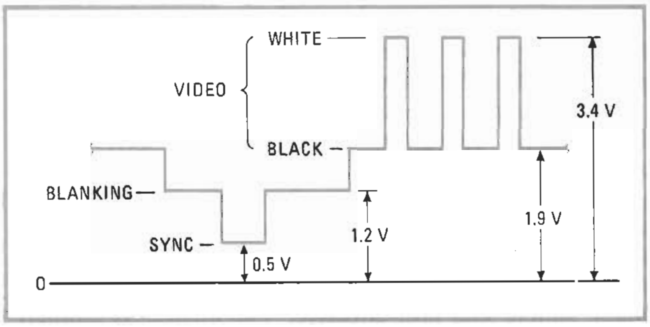
The schematic is shown in Fig. 2. The three inputs—sync, blanking, and video—are transistor-transistor-logic-compatible. Schottky-TTL inverters buffer the inputs for fast rise and fall times.

The most positive voltage, producing a white luminance level from a logic-1 video input, is established at approximately 3.4 volts by the R_1-R_2 voltage divider. The black level, corresponding to a logic-0 video input, is obtained from the 1.9-V total forward voltage drop of the two junction diodes and just one Schottky diode. The blanking and sync levels are determined by the other diode combinations, as shown in the figure.

The reverse-recovery time of the three-diode string in the video input is very fast, thanks to the Schottky diode characteristics. The rise time of the video pulses is determined mainly by the time constant of R_1 with the stray capacitance, indicated here by C_{stray}.

With such quick rise and fall times, the circuit is more than adequate for CRT displays of 80 characters per row. If only 40 characters per row are required, conventional silicon switching diodes such as the 1N914 may be substituted for the Schottky devices, though with a sacrifice in edge definition.

A series-complementary emitter-follower pair, made up of transistors Q_1, Q_2, and associated resistors R_3 through R_5, provides a high-impedance buffer for driving coaxial-cable lines. The 68-ohm resistor in series with the output increases the output impedance of the Q_2 follower, preventing oscillation in the event an unterminated cable is connected. □



1. Composite video waveform. Four voltages shown are compatible with CRT monitors having RS170 specifications. Waveform is typical of digital input to CRT, with only white and black displayed.

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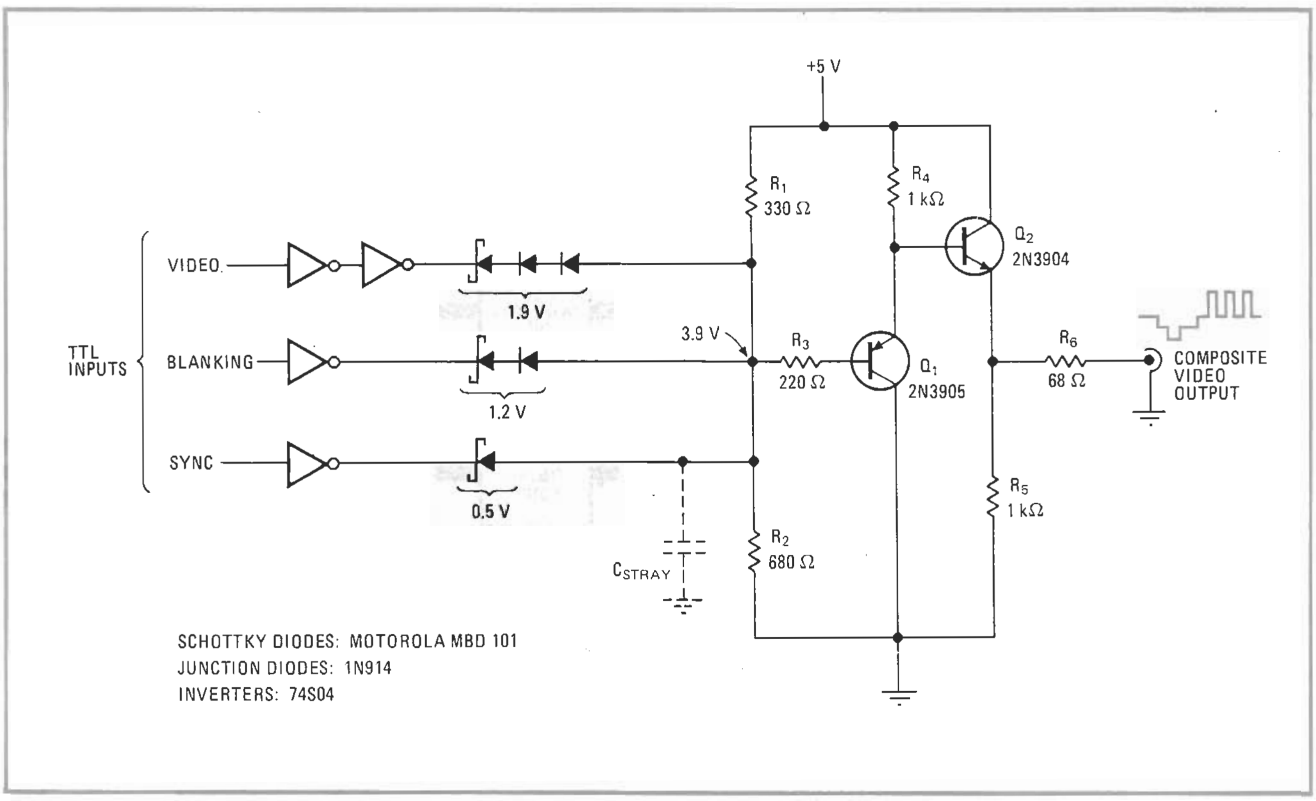


2. Video voltage-level generator. Voltage drops across diodes determine luminance and sync levels of the composite video waveform from TTL input signals. Blanking input is needed to eliminate retrace, if raster lines are brought up. Q_1 and Q_2 followers buffer the signal for driving a standard 75-Ω coaxial line, and output is short-circuit-proof.

LOW-COST TEST EQUIPMENT FOR TELEVIsion servicing has been available for many years. Today, it is possible to buy TV test generators—with dot-pattern, crosshatch-pattern, and even color-bar outputs—for less than $100. If you add in more features—such as a staircase-pattern output, RF *and* baseband-video outputs, and horizontal- and vertical-sync signals for oscilloscope triggering—the price can easily triple. And if you need an even more versatile instrument—and add in a multiburst-signal output and the means to interface the unit for gen-locking (we'll discuss that later)—then you can end up spending hundreds more.

The video test generator that we'll describe here will do all the things we've mentioned—and even more! Therefore, it can be used not only to service TV's and monitors, but also to test and align VCR's, video amplifiers, CATV systems—virtually all TV/video equipment. We will not only discuss how to build the generator, but also how to use it for testing video equipment.

A look at the output signals

The test signals that the generator provides include: multiburst, up/down step, gray level, dots, hatch, and color bars. Figure 1 shows those various test signals, as well as what they look like on a monitor or TV screen. Some typical uses for each pattern are also listed, but we'll discuss how to use the test signals in more detail later.

Along with the test signals, sync-generator reference signals (LS-TTL compatible) are also available at a rear-panel card edge. They include: composite sync, blanking, colorburst gate, horizontal drive, and vertical drive. Front-panel vertical-rate and horizontal-rate outputs are provided for convenient oscilloscope synchronization.

Also at the card edge are provisions for external digital inputs (three for each primary color, three for synchronizing the generator from a external source, and one external-audio input). Although it is not easy, it is possible, by interfacing the generator with a computer, to generate any real-time pattern or display desired.

The basic generator

A block diagram of the video test gen-

Build this low-cost, general-purpose video test generator and service TV receivers, video amplifiers, monitors, VCR's, and other video equipment.

GENE ROSETH

VIDEO TEST GENERATOR

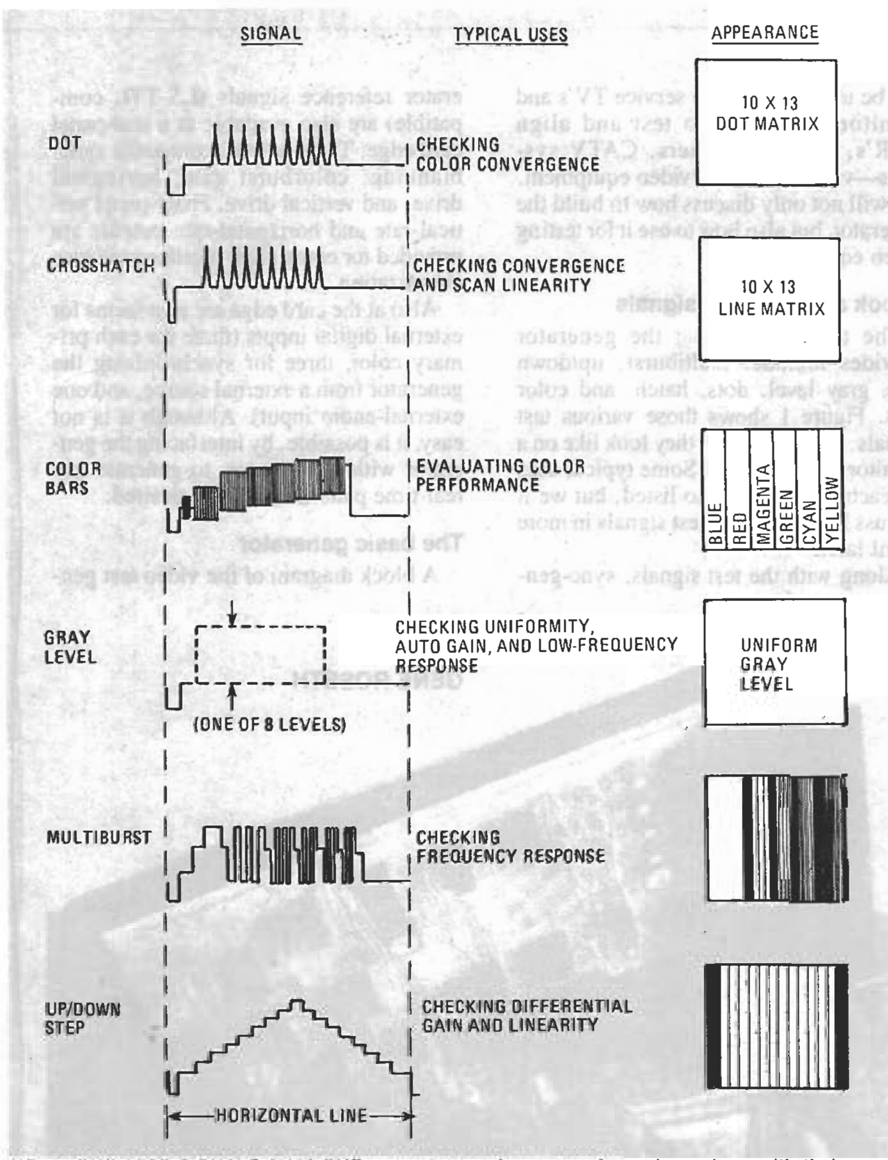


FIG. 1—THE TEST SIGNALS THAT THE generator produces are shown here along with their appearances on a TV screen, and some common test applications.

erator is shown in Fig. 2. We'll start with the 14.31818-MHz (we'll call it 14 MHz) oscillator, whose output is divided by 7 to provide the proper clock for the sync generator. The oscillator's output is also divided by 4 to generate the 3.579545-MHz color subcarrier. The divider, and thus the color subcarrier (at what we'll hereafter call 3.58 MHz) is synchronized with the sync generator by the field detector to maintain NTSC compatibility. It is then waveshaped and shifted in phase by 90° to act as a quadrature reference for the RF modulator section.

The four signal-generator blocks (multiburst, step/gray, color bar, and dot/hatch) receive timing information from the horizontal clock and the line counter. The signals that they produce are fed to a multiplexer that is controlled by switch S1. The multiplexer routes the selected test signal (or the external digital video signal) to a D/A converter and sync mixer.

The standard composite-video signal output from the sync mixer is buffered and is then sent to the video-output jack. It is also sent to an RF modulator (TV channel 3) and then to the RF-output jack. An audio signal is also modulated on the RF. That signal can be either a 1500 Hz internally generated sinewave, or any externally provided audio signal. Switch S3 selects between the internal and external signal.

The power supply for the generator provides +12 volts, −12 volts, and separate +5-volt rails for the digital and the analog portions of the circuit. Having separate +5-volt supplies minimizes crosstalk and prevents the various analog signals from being distorted by digital switching spikes.

A look at the circuit

A schematic of the video test generator is shown in Fig. 3. Since we started our look at the block diagram with the oscillator, we'll do the same here. Transistor Q4 and its associated components make up the crystal-controlled 14.31818-MHz oscillator that is the master clock for the test-generator system. The frequency of the oscillator can be fine-tuned by trimmer capacitor C22. The oscillator output is buffered by one of the AND gates in IC41 and is then fed to a countdown circuit made up of IC34 (an up/down synchronous counter) and IC35 (a dual J-K flip-flop).

Those IC's divide the oscillator's output by 7 to provide the 2.04545 MHz that the sync generator (IC36) needs. They are also used to divide the oscillator's frequency by 4 to provide 3.58 MHz for the color subcarrier. That 3.58-MHz signal is fed to op-amp IC40, which (along with its associated components) triangulates the signal. The output of the op-amp is fed to IC19. The nonlinearity of that IC is used to form a sinewave whose shape can be adjusted by R52.

The sinewave is then sent to the RF modulator, IC3. The network made up of C6, C7, R12, and R14 provide a quadrature phase relationship between pins 1 and 18 (the CHROMA-LEAD and -LAG pins) of the RF modulator.

Another countdown circuit is made up of IC23 and IC24. Its purpose is to "segment" each horizontal line to provide timing signals for the signal generators. The four-bit binary counter, IC38, serves a similar function. It provides timing signals by counting the individual horizontal scan lines produced by IC36.

A shift register, IC25, controls the timing of each of the five frequencies of the multiburst generator and its white flag (the beginning, white portion of the multiburst pattern). The multiburst frequencies originate in separate oscillators made up of IC28, IC29, and IC30 and their associated R-C networks. One half of both IC22 and IC26, and parts of IC21 and IC27, control the phasing and switching of the multiburst generator. The multiburst output is buffered by IC37 and is then sent to the multiplexer.

The up/down-step and gray-level generator consists of IC20 (an up/down counter) and parts of IC21, IC22, and IC19. A one-Hz oscillator is formed by R28, R29, C13, and IC19; which, along with S2, allows the user to select one of eight gray levels by momentarily pushing S2. You can also step through each of the eight gray levels at a one-Hz rate by holding S2 closed. A provision (jumper JU1) is made for changing the source of the up/down control signal to IC20 (pin 5) from pin 9 to pin 8 of IC22. That has the following effect: Instead of the TV screen displaying the maximum white level at center screen and black at the extreme edges, the opposite occurs. (That is, black is displayed in the middle of the screen, stepping to

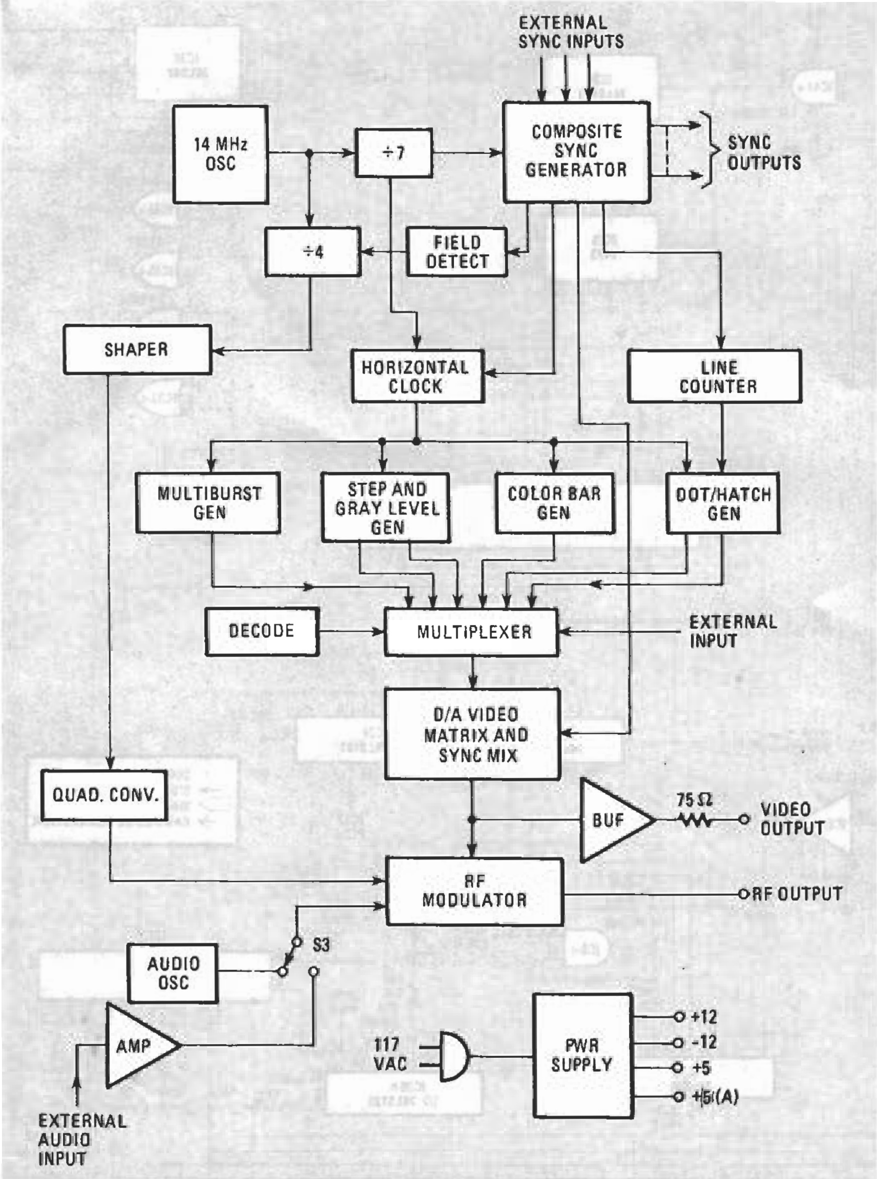


FIG. 2—A BLOCK DIAGRAM of the video test generator is shown here. Note that the power supply has two +5-volt outputs. That helps to keep digital switching spikes from distorting analog waveforms.

white at both edges.)

The dot- and hatch- pattern generator is made up of IC17 and part of IC5. Those IC's combine the outputs of the line counter and the horizontal clock at the proper times so that the hatch and dot patterns are produced. Those outputs are then sent to the multiplexer.

The color-bar generation is performed by a counter, IC16. It simply provides different binary states (which correspond to three primary and the three complimentary colors) to a multiplexer, which routes them to the color inputs of IC4, a TV video matrix D/A converter.

The multiplexer that we've mentioned is made up of IC7–IC15. It selects one of the signals from the signal generators (or the externally generated digital video signal at the edge connector) and then routes that signal to IC4.

The multiplexer is controlled by the function-select switch (S1) through the decoding network (D5–D14 and R20–R25). The operation is straightforward, except in the multiburst mode. In that mode, the decoding matrix changes its output state (and therefore the multiplexer input address) during the short time between each separate multiburst frequency. That causes the multiplexer to momentarily route a gray level "4" to the D/A video matrix which gives a more pleasing appearance to the multiburst display. That is, the displayed pattern will be black and gray instead of black and white. That function is performed by IC22, IC26, D4, and part of IC5.

Taking a closer look at IC4, we see that it encodes luminance and color-difference signals from 3-bit RGB inputs. It also mixes the various sync signals to form a standard, sync-negative, composite-video signal. The composite-video output signal goes to Q3 for output buffering and also to IC3 where it is RF modulated.

Transistor Q2 also receives composite video from pin 13 of IC3, but with the chrominance information included. The two signals are selected by part of IC2, depending on the function selected by S1. The reason that there are two separate paths for the video is because of bandwidth limitations of IC3. Either way, the video signal passes through emitter-follower Q1 and then is buffered for output by IC1, an LH0002 current amplifier. That IC can drive long lengths of coax without difficulty.

An audio oscillator (IC42 and associated components) produces about a 1500-Hz sinewave. That signal goes to S3, which is used to select between the internal audio source or an external signal from the edge connector. The selected signal is applied to Q5 whose collector-base capacitance acts as a varactor diode to modulate the audio subcarrier at IC3. Coil L2 can be used to adjust the frequency of the subcarrier, which is nominally 4.5 MHz. The RF carrier's frequency is adjusted at L1.

Building the generator

You must use printed-circuit boards for this project because the placement of many of the components is critical and will affect the generator's operation. Foil patterns are shown (half-size) for the two required double-sided boards in Figs. 4, 5, 6, and 7. Due to space restrictions, Figs. 6 and 7 are not shown in this issue. They will appear when the story continues in a future issue. If you are not equipped to etch boards, pre-etched, drilled, and silk-screened boards are available from the supplier indicated in the Parts List.

Installing the parts on the board is pretty much straightforward, but there are a few points that we'll mention in the following paragraphs. First, make sure that you follow proper soldering practices. In other words, avoid cold solder joints—make sure that the connection is properly heated *before* you apply solder. (Of course, when soldering transistors and other heat-sensitive components, try not to use too much heat. If possible, use a soldering heat sink.) Don't use so much solder that you form solder bridges between PC-board traces. Finally, it is a good practice to use sockets for all IC's.

Now we can discuss the parts-placement diagrams. There are three, even though you might have expected two. Figure 8 shows the on-board component placement for what we'll call board A and the inter-board jumpers to board B. Figure 9 shows the off-board components for Board A and also 37 on-board jumpers. That brings us to board B, whose parts-placement diagram (both on- and off-board components) is shown in Fig. 10. (Note that Figs. 8, 9, and 10 will appear in a future issue.)

Assembly consists mainly of inserting

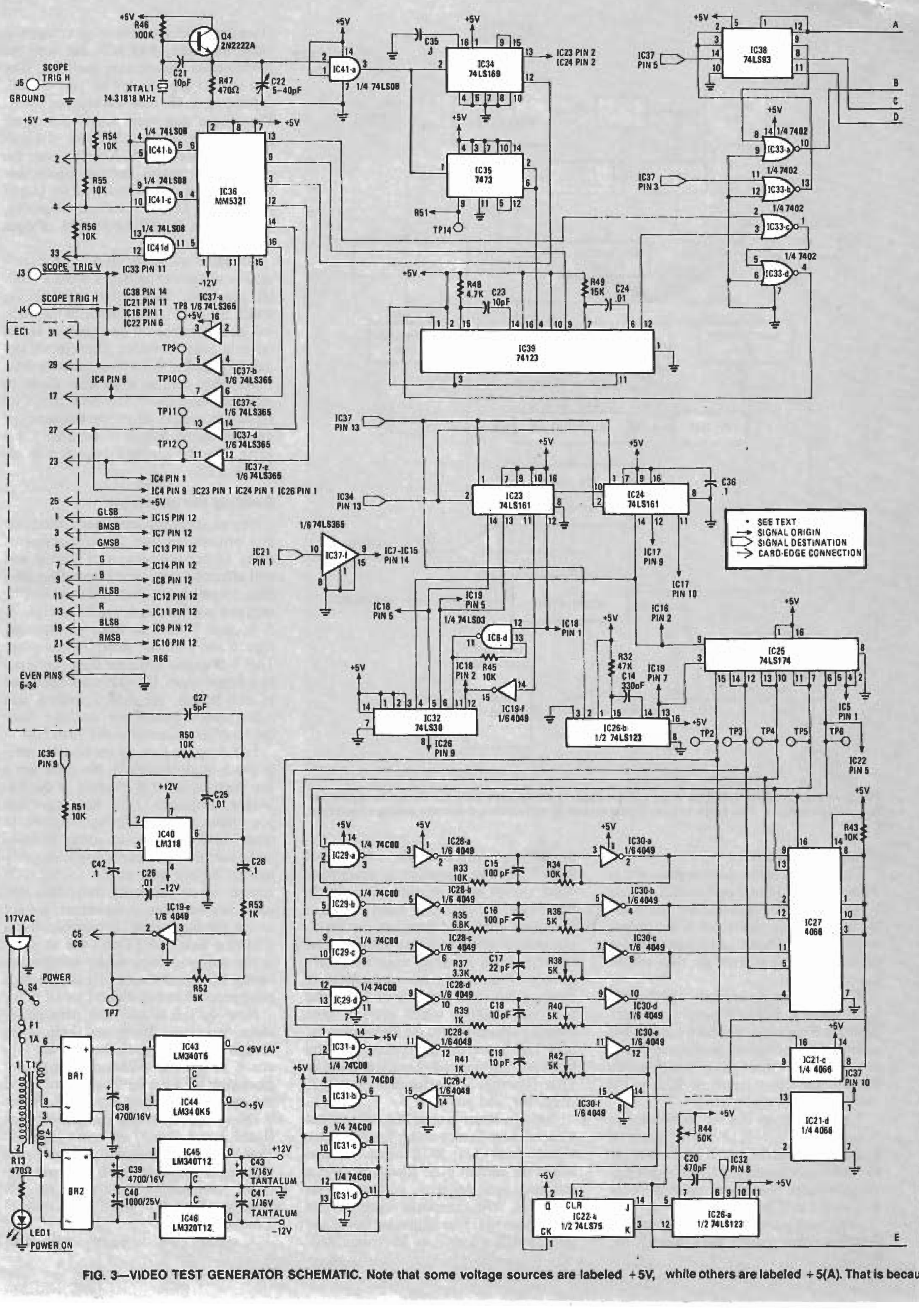
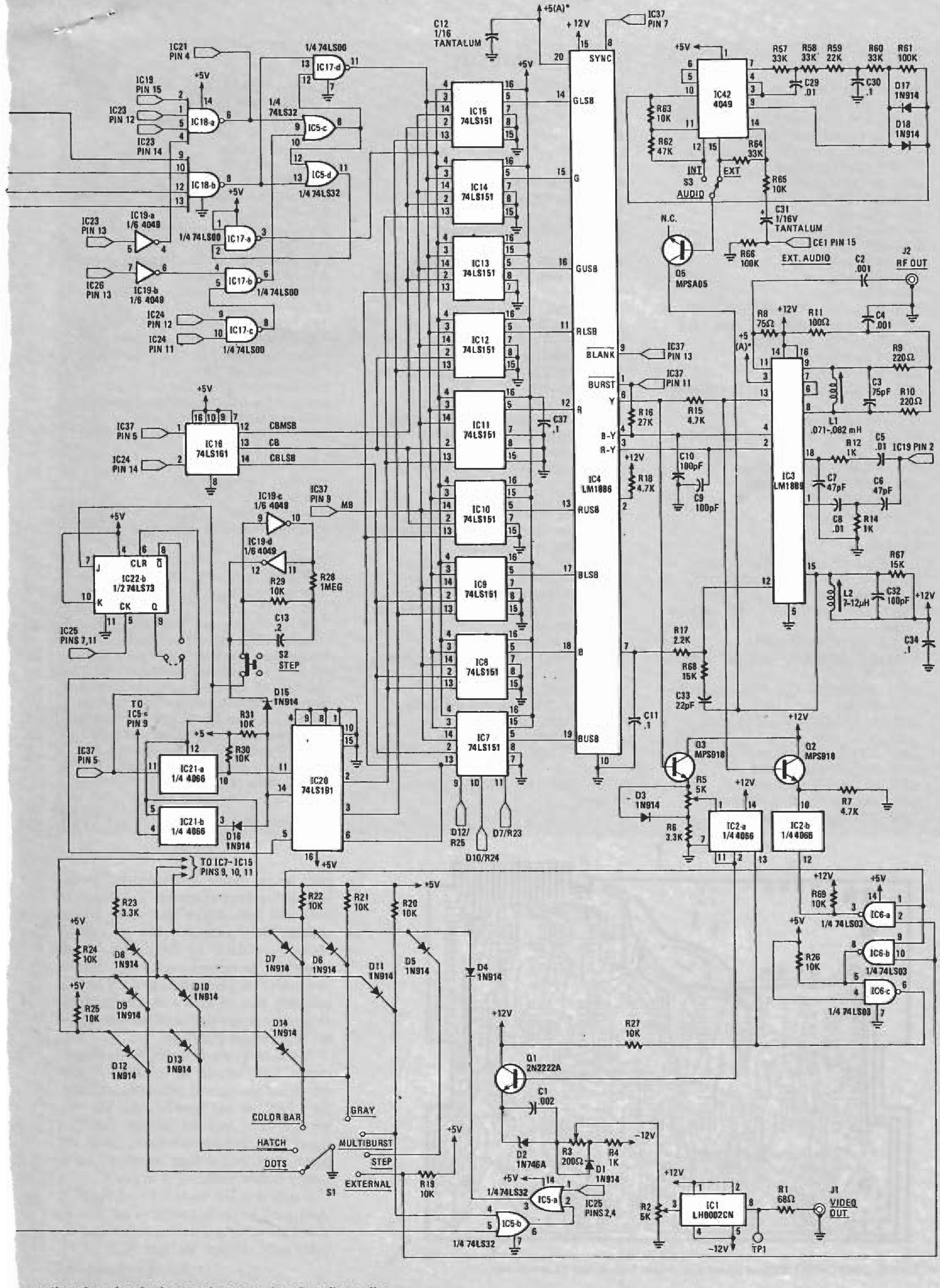


FIG. 3—VIDEO TEST GENERATOR SCHEMATIC. Note that some voltage sources are labeled +5V, while others are labeled +5(A). That is becau-



...s mentioned previously, there are two separate +5- volt supplies.

PARTS LIST

All resistors ¼-watt, 5%, unless noted
R1—68 ohms
R2,R5,R36,R38,R40,R42,R52—5000 ohms, trimmer potentiometer
R3—200 ohms, trimmer potentiometer
R4,R12,R14,R39,R41,R53—1000 ohms
R6,R23,R37—3300 ohms
R7,R15,R18,R48—4700 ohms
R8—75 ohms
R9,R10—220 ohms
R11—100 ohms
R13,R47—470 ohms
R16—27,000 ohms
R17—2200 ohms
R19, R20–R22, R24–R27, R29–R31, R33,R43,R45,R50,R51,R54–R56, R63 R65,R69—10,000 ohms
R28—1 megohm
R32,R62—47,000 ohms
R34—10,000 ohms, trimmer potentiometer
R35—68,000 ohms
R44—50,000 ohms, trimmer potentiometer
R46,R61,R66—100,000 ohms
R49,R67,R68—15,000 ohms
R57,R58,R60,R64—33,000 ohms
R59—22,000 ohms

Capacitors
C1—0.002 µF, ceramic disc
C2,C4—0.001 µF, ceramic disc
C3—75 pF, mica
C5,C8,C24–C26,C29—0.1 µF, ceramic disc
C6,C7—47 pF, ceramic disc
C9,C10,C15,C16,C32—100 pF, ceramic disc
C11,C28,C30,C34–C37,C42—0.1 µF, ceramic disc
C12,C31,C41,C43—1 µF, 16 volts, tantalum
C13—0.2 µF, ceramic disc
C14—330 pF, ceramic disc
C17,C33—22 pF, ceramic disc
C18,C19,C21—10 pF, ceramic disc
C20—470 pF, ceramic disc
C22—5–40 pF, trimmer capacitor
C23—10 pF, ceramic disc
C27—5 pF, ceramic disc
C38,C39—4700 µF, 16 volts, electrolytic
C40—1000 µF, 16 volts, electrolytic

Semiconductors
IC1—LH0002CN current amplifier (National)
IC2,IC21,IC27—4066 quad bilateral switch
IC3—LM1889 TV video modulator
IC4—LM1886 TV video matrix D/A converter
IC5—74LS32 quad OR gates
IC6—74LS03 quad NAND gates
IC7–IC15—74LS151 one-of-eight selector/multiplexer
IC16,IC23,IC24—74LS161 synchronous 4-bit counter
IC17—74LS00 quad NAND gates
IC18—74LS20 dual 4-input NAND gate
IC19,IC28,IC30,IC42—4049 hex inverting buffer
IC20—74LS191 synchronous up/down counter
IC22—74LS73 dual J-K flip-flop
IC25—74LS174 hex D-type flip-flop
IC26,IC39—74LS123 dual retriggerable monostable multivibrator
IC29,IC31—74C00 quad NAND gates
IC32—74LS30 8-input NAND gates
IC33—7402 quad NOR gate
IC34—74LS169 4-bit synchronous up/down counter
IC35—7473 dual J-K flip-flop
IC36—MM5321 TV camera sync generator (National)
IC37—74LS365 hex bus driver
IC38—74LS93 4-bit binary counter
IC40—LM318 op-amp
IC41—74LS08 quad AND gate
IC43—LM340T5 5-volt regulator, T0-220 case
IC44—LM340K5 5-volt regulator, TO-3 case
IC45—LM340T12 12-volt regulator, TO-220 case
IC46—LM320T12 12-volt negative regulator, TO-220 case
Q1,Q4—2N2222A
Q2,Q3—MPS918
Q5—MPSAO5
D1,D3–D18—1N914 or 4148
D2—1N746A
S1—7-position rotary switch (Allied 7471001 or similar)
S2—pushbutton switch, normally closed
S3—SPDT toggle switch
S4—SPST toggle switch
LED1—standard red
T1—Transformer (Triad F-166XP or similar), primary: 117 volts; secondary: 24 volts, center-tapped, .125 amps; 9 volts, center-tapped .5A
BR1,BR2—bridge rectifier, 1.5 amps
L1—0.071–0.082 mH adjustable coil (J.W. Miller 48A778MPC or similar)
L2—7–12 µH adjustable coil (J.W. Miller 23A105RPC or similar)
XTAL1—14.31818 MHz crystal
F1—fuse, 1 amp, pigtail leads
J1—BNC jack
J2—type N jack
J3–J5—standard tip jacks

Miscellaneous—Heat sinks, cabinet (Pactec CM86-225), power cord, strain relief, T0-3 mounting kit, IC sockets, etc.

The following are available from Jengco, 3232 San Mateo, Suite 75, Albuquerque, NM, 87110: Complete kit including PC boards, all components, cabinet (no IC sockets), $295; Etched, drilled, and silkscreened PC boards (boards A and B), $49.50; Complete test generator, assembled and tested, $395. Please add 5% for postage and handling, New Mexico residents add 4.25% sales tax, allow 6–8 weeks for delivery.

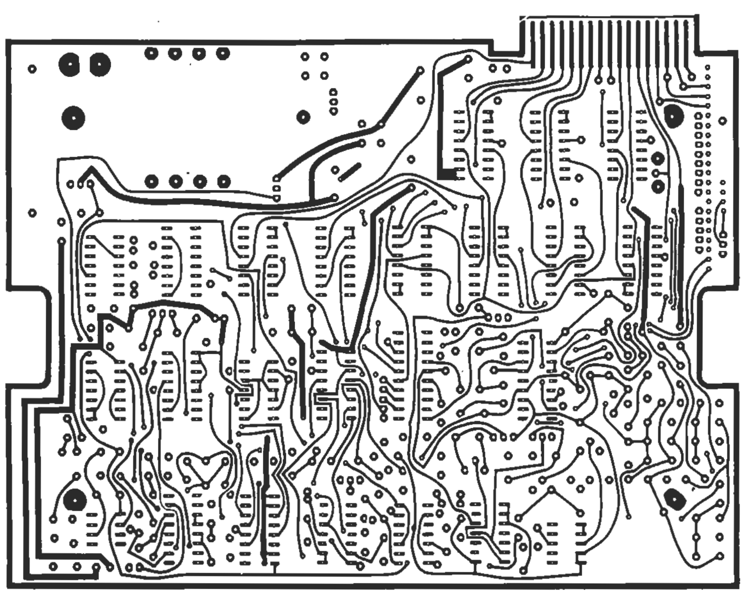


FIG. 4—THE COMPONENT SIDE of board A is shown here at half its actual size.

parts in the board and soldering them. Follow the three diagrams and the parts list, and and solder the parts where shown. Make sure that you are careful about the polarity of the diodes, transformer T1, polarized capacitors, and the two bridge rectifiers (BR1 and BR2). It is probably best to start with the resistors. Definitely do *not* start with the jumpers—we'll get to those shortly.

A few notes are in order: All resistors, except R15, should be installed so that they stand on one end. The POWER indicator, LED1, should have its leads left long enough to be inserted through the front panel hole. For safety's sake, insert the pigtail fuse into a short length of shrink tubing before soldering it in place.

It is best to use sockets for all the IC's. And don't forget that some of the IC's are static-sensitive and should be handled accordingly. Those include IC2, IC19,

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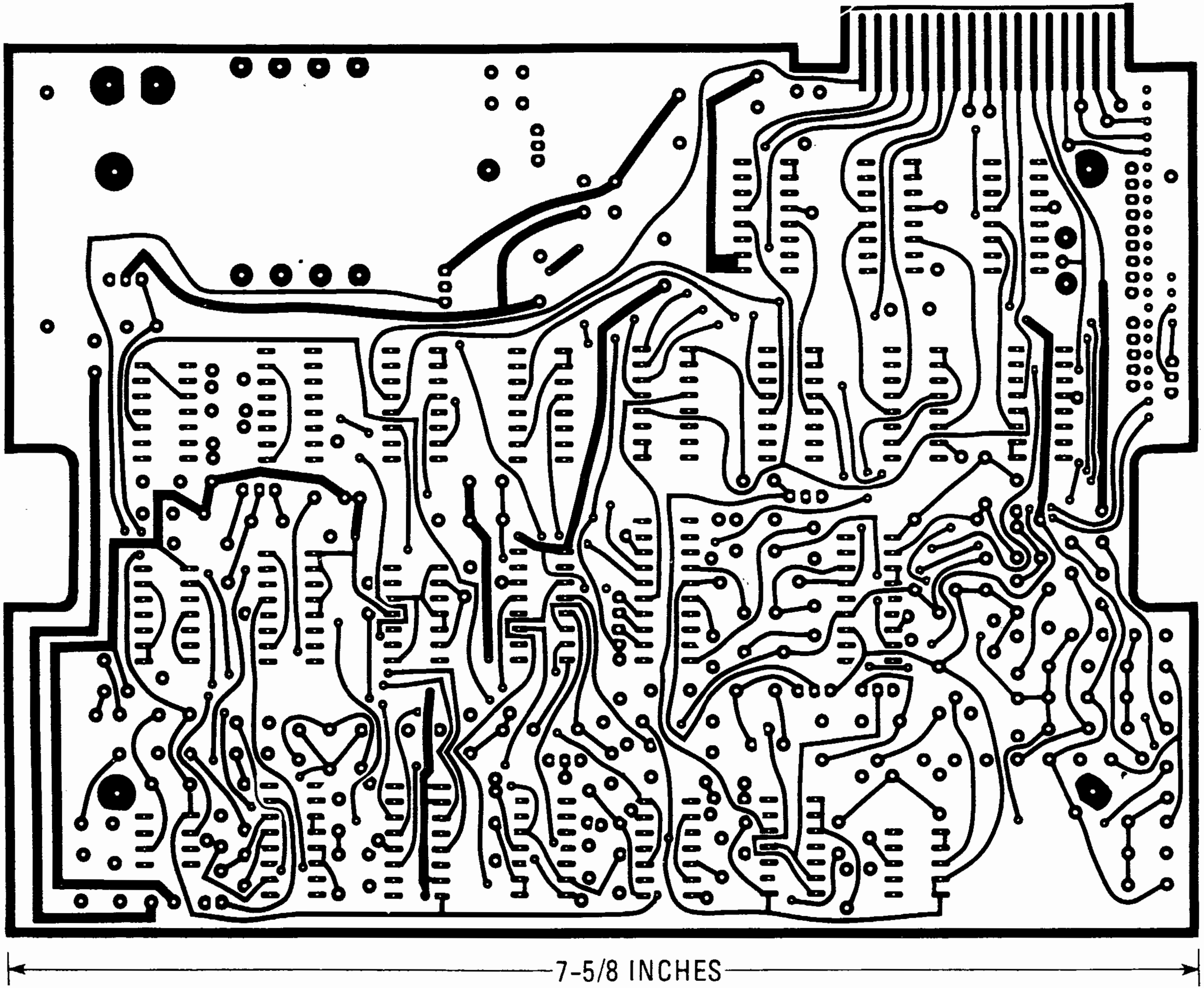

FIG. 4—THE COMPONENT SIDE of board A is shown here at half its actual size.

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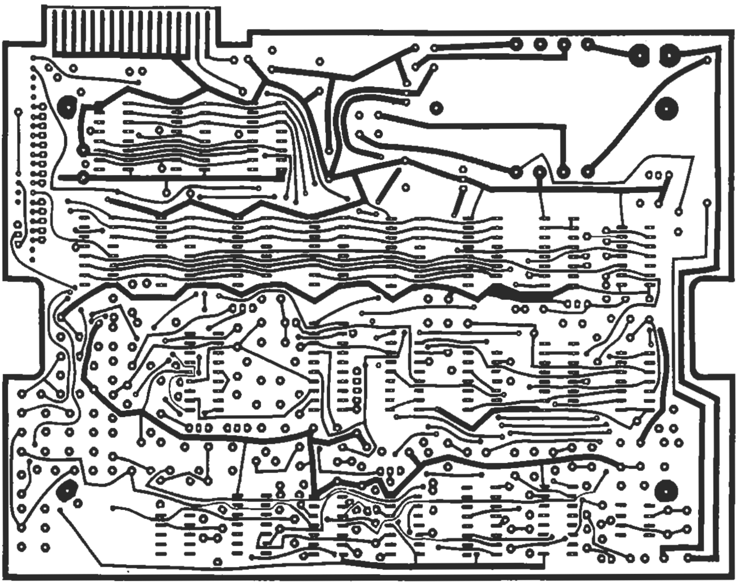

7-5/8 INCHES

FIG. 5—THE SOLDER SIDE of board A is shown here, also at half its actual size.

IC21, IC27–IC31, IC36, and IC42. The IC's in the TO-220 cases (IC43, IC45, and IC46) mount with the metal tab either to the top of the board (IC46,) or to the right of the board (IC43 and IC45) as shown in the parts-placement diagrams.

We'll assume that you have all of the on-board components mounted on both boards. The next step is to install the 37 jumpers on board A, using No. 26 wire. Their connections are marked on the parts-placement diagram in Fig. 10. Some of the jumper ends, as indicated, also serve as test points. Leave some extra bare wire protruding through the component side of the board for that purpose.

When all the board-A jumpers are mounted, the inter-board jumpers should be installed. Of course, before you install the jumpers, you must decide how you will mount the boards in a cabinet. Figure 11, not shown in this issue, shows how the boards are mounted in the author's prototype. Board A is mounted on the bottom half of the cabinet on ⅛-inch spacers, and board B mounts without spacers in a complimentary fashion on the top half. The 26 inter-board signal wire connections (No. 26 wire) are 3¼ inches long; and the two inter-board power wire connections (No. 20 wire) are 4 inches long. If you keep the connections to that length, they will fold neatly when the two halves of the cabinet are joined. Yet you will still have easy access to both boards (for alignment and service) when the cabinet is open. Note that IC44 is mounted on the rear panel of the cabinet. Be sure to use a heat sink and a TO-3 mounting kit. Apply silicone grease between case and heat sink for good thermal transfer, and use at least No. 22 wire for connection to the board.

The other off-board connections include the front-panel components: switches S1–S4, and jacks J1–J5. Use No. 26 wire for those, except J2; use a short piece of minicoax (RG-174) for that connection. Use a strain relief for the power cord on the back panel and your construction should be complete.

When we continue, we'll discuss how to check out and align the generator, and we'll show you Figs. 6–11. **R-E**

"It looks as if his horizontal hold needs some adjusting."

VIDEO GENERATOR

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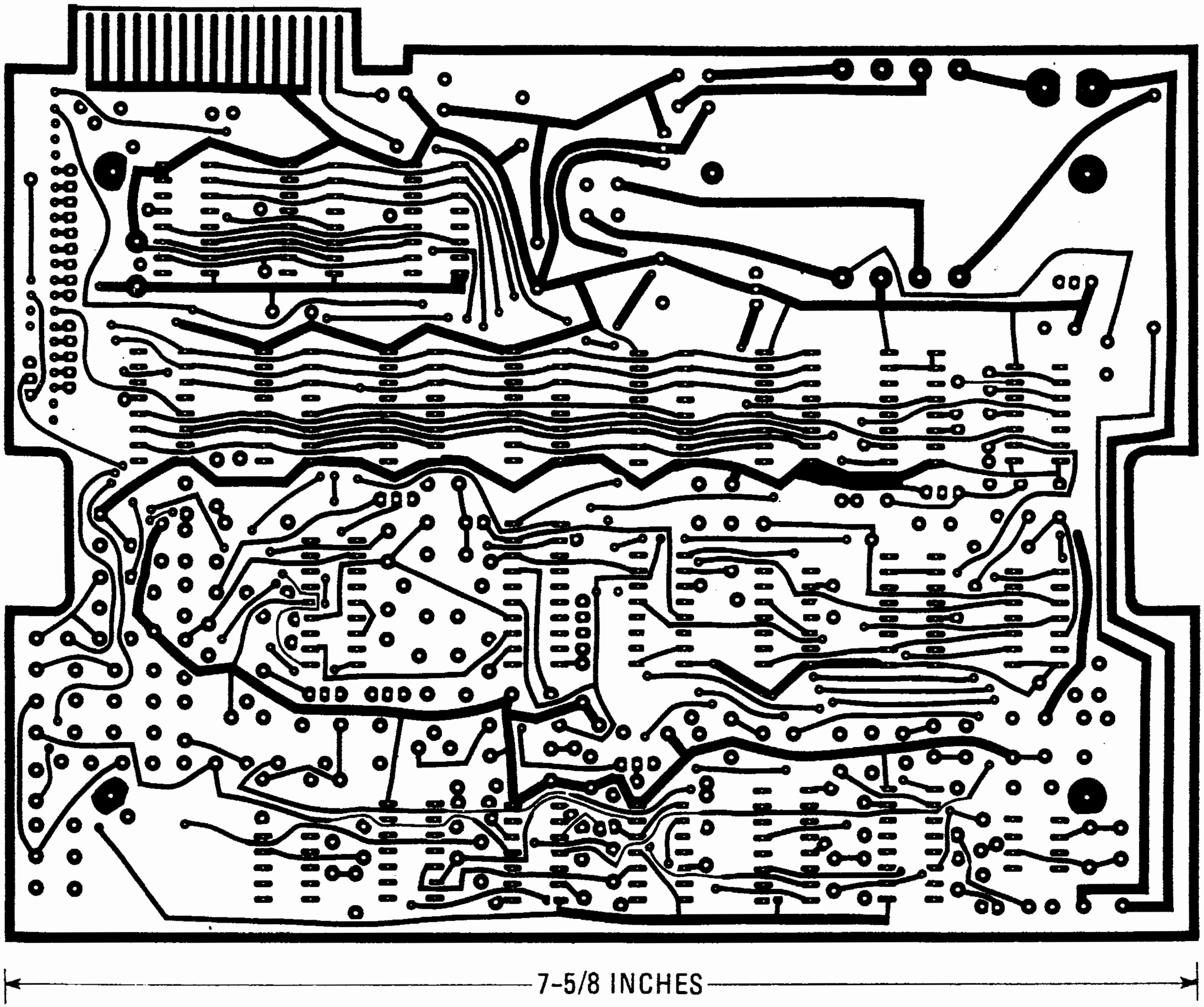
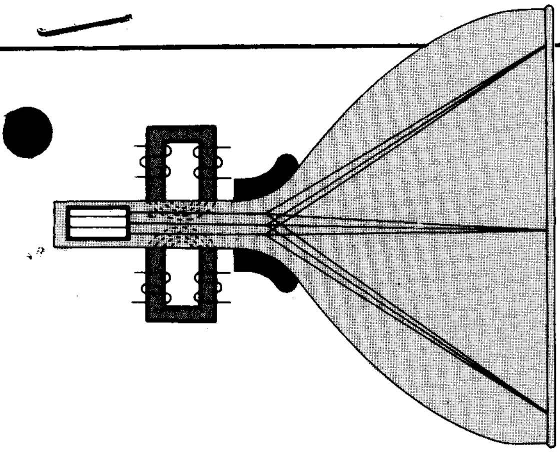


7-5/8 INCHES

FIG. 5—THE SOLDER SIDE of board A is shown here, also at half its actual size.

BY JAMES B. PENNY



A LOW-COST DOT/BAR GENERATOR

Build this essential instrument for setup and convergence of color TV for $15.

A DOT/BAR video signal generator is an essential piece of test equipment for the setup and convergence of a color-TV receiver or monitor. The generator can also be used to adjust horizontal and vertical linearity of monochrome receivers and monitors.

The circuit (Fig.1) shown here can be built for about $15, and is small enough to be permanently installed in a color-TV cabinet. It can also be housed in a small case (including a 9-volt battery) for portable use. Since the output is video, some form of FCC-approved r-f modulator is required if you wish to inject the signal into the antenna of a TV receiver.

Circuit Operation. Oscillator *IC1* is preset to 251,752 Hz (16 times the horizontal scanning rate) by the setting of potentiometer *R1*. When a 555 is operated with D17 as shown, the data sheet formulas for frequency are not valid, and the frequency of oscillations becomes more dependent on the supply voltage. The output of *IC1* (pin 3), drives 12-stage counter *IC2* to generate the other frequencies required to create the composite video output signal. Various *IC2* outputs are diode OR'ed to produce the proper pulse widths.

Horizontal and vertical video components are combined in NOR gate *IC3A*, while the horizontal and vertical sync components are mixed in *IC3B*. Output transistors *Q1* and *Q2*, arranged as an AND gate, combine video and sync into composite video and provide sufficient drive for a 75-ohm output load.

With *S1* in its center (off) position, the video display will be white dots on a black background. The other positions of *S1* yield horizontal or vertical white bars on a black field. These are the output signals most commonly used for static and dynamic convergence of color receivers. They can also be used to set linearity of monochrome receivers.

The values of *R9* and *R10* determine the base currents of *Q1* or *Q2*, and their connections to *IC3* determine positive or negative video. Resistor *R11* determines the blanking (black) level of the display. Resistor *R12* determines the peak-to-peak output voltage level, while *R13* determines the output impedance.

When powered by 9 volts, the values shown for *R9* through *R13* provide a nominal one volt peak-to-peak composite video with negative-going sync into a 75-ohm load.

If *R9* is disconnected, the unit becomes a sync generator. Increasing the value of *R3* (retuning *R1*) will increase the width of the bars or dots. Eliminating *D9* will increase the height of the bars or dots.

Construction. The circuit can be assembled using any type of wiring technique; the foil pattern shown in Fig. 2 may be used. This illustration also shows component installation.

With the generator powered and *S1* in

PARTS LIST

C1—100-pF, disc ceramic
C2—0.1-µF, disc ceramic
C3—220-µF, 35-volt electrolytic (optional)
D1 through D17—1N914 silicon diode
IC1—555 timer
IC2—CD4040, 12-stage ripple counter (CMOS)
IC3—CD4001, quad 2-input NOR gate (CMOS)
Q1, Q2—2N5449 npn silicon transistor
The following resistors are ¼-watt, 10%:
R2—10,000 ohms
R3,R13—75 ohms
R4, R11—2200 ohms
R5, R6, R7—100,000 ohms
R8—27,000 ohms
R9, R10—1000 ohms
R12—470 ohms
R1—10,000-ohm trimmer potentiometer
S1—Spdt, center-off switch
Misc.—battery holder, suitable enclosure, interconnect cable, mounting hardware, etc.

Note—A complete kit of parts including drilled pc board, is available for $14.95 plus $1.50 P+H within the continental US from ABCOR Inc., Box 58216, Houston, TX 77058. Texas residents, please add 5% sales tax. The r-f modulator is available from ABCOR, or M&R Enterprises, PO Box 1011, Sunnyvale, CA 94088 for $24.95 with 60-dB isolation switch and cables. Modulator only is $14.95.

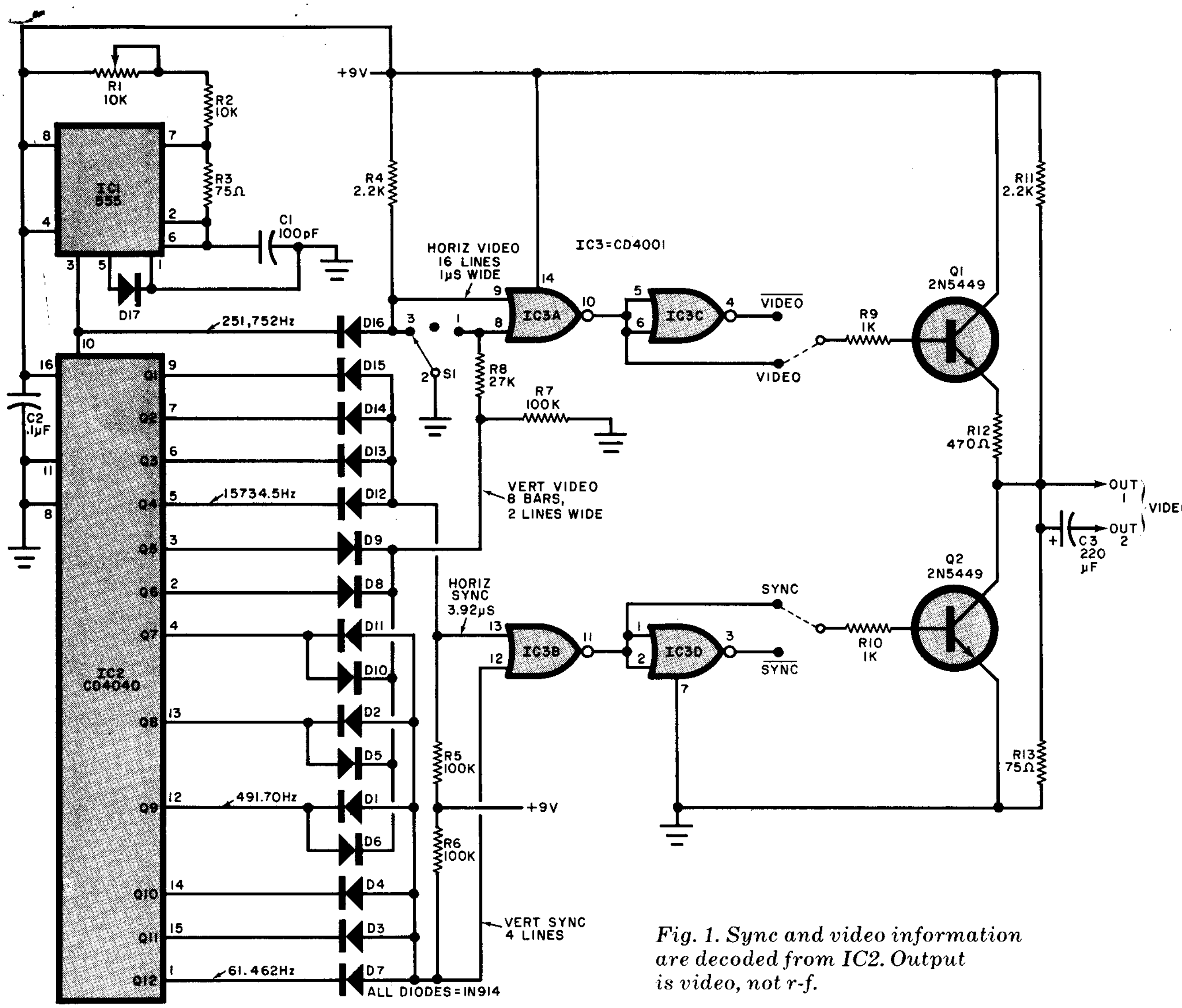


Fig. 1. Sync and video information are decoded from IC2. Output is video, not r-f.

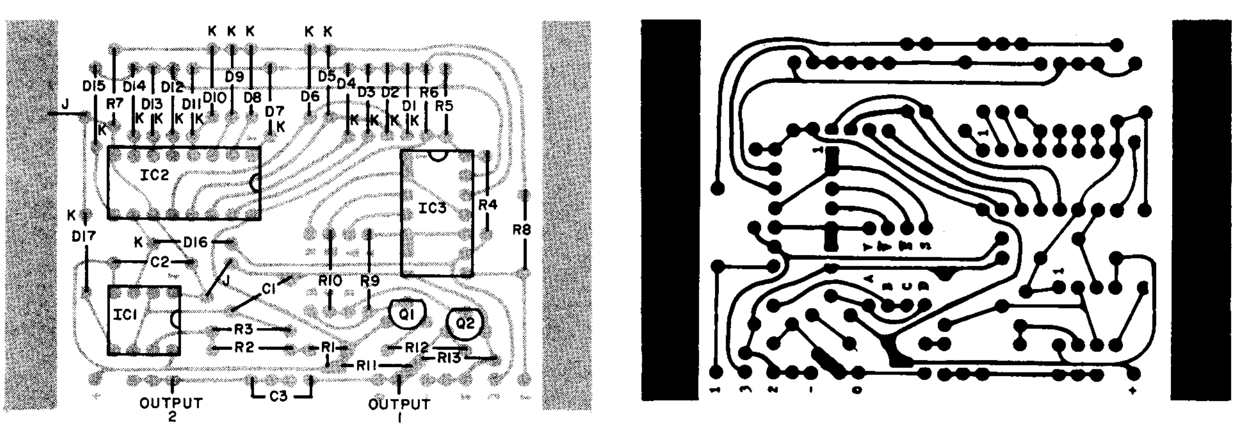


Fig 2. Actual-size foil pattern and component installation for the generator. The two large end bars are used for mounting, and are not required for operation.

the center position, connect the generator to the *video* input of the receiver to be checked, and turn on the power. Adjust *R1* until the sync locks and a stable pattern appears on the screen.

With the manual provided by the color-TV receiver manufacturer or other source, the generator can now be used for convergence. In a monochrome system, the bars or dots can be used in conjunction with the linearity controls to set up the screen for proper proportions.

Two video outputs are provided: One (out 1) is dc coupled to the output stage, while the other (out 2) is dc isolated from the output stage. Use either one, depending on the type of input required. If the video stage will not tolerate a dc offset, then use output 2. If the video stage has capacitor input, use output 1. ◇