LOW-COST CONVERGENCE GENERATOR

Produces a clear pattern, dots, crosshatch, or vertical and horizontal lines, using RTL logic.

BY MICHAEL S. CHING

CONVERGENCE is that wonderful process by which the TV technician makes your color TV picture look like new again. It is actually a relatively simple set of checks and adjustments that are first made when the set is built and, of course, whenever the picture tube is replaced. However, component aging and mechanical shocks, particularly in portables, result in a gradual loss of the original adjustments. The change often takes place so slowly that many people don't notice the symptoms—color splotches, color fading, color fringes around figures on black and white, etc.

These problems can be easily detected and possibly corrected when you use the convergence generator described here. (Note that the generator is intended primarily as an aid in keeping the purity and convergence adjusted in an otherwise normally operating set. It is not meant to replace more complex color test equipment required to repair a malfunctioning set.) The generator is used simply by connecting it to the set's antenna terminals. The required adjustments can be made without removing the chassis from the cabinet.

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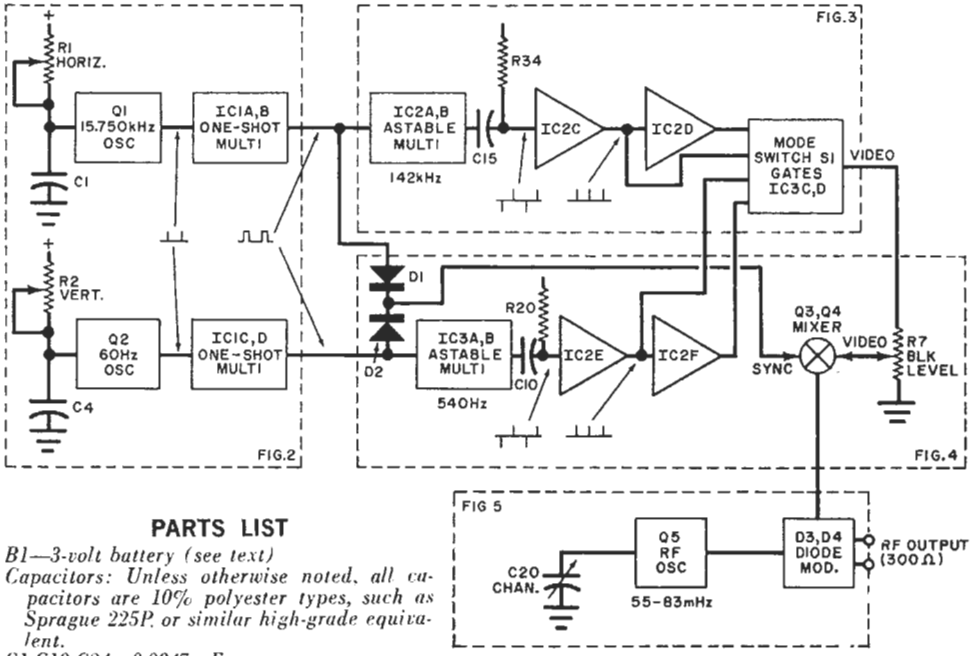
How It Works. The generator circuitry can be divided into four major sections which use a combination of digital and linear techniques: sync oscillators, video, video/sync mixer, and r-f. An overall block diagram is shown in Fig 1.

The sync oscillator section consists of two UJT oscillators and their respective monostable multivibrators (one-shots). The circuit containing *Q1*, *IC1A* and *IC1B* (Fig. 2) produces horizontal sync pulses 6 to 9



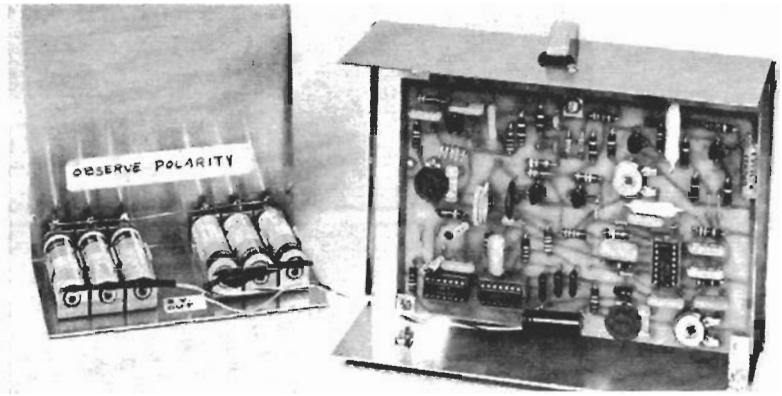
PARTS LIST

B1—3-volt battery (see text)

Capacitors: Unless otherwise noted, all capacitors are 10% polyester types, such as Sprague 225P, or similar high-grade equivalent.

C1,C10,C24—0.0047-μF
C2,C5,C7,C16—0.01-μF
C3,C23—0.0022-μF
C4—0.47-μF
C6—0.22-μF
C8,C9—0.033-μF
C11,C19,C28—0.001-μF
C12,C13,C14—100-pF mica (no substitute)
C15—10-pF mica (no substitute)
C17—200-μF (minimum), 6-V electrolytic
C18—68-pF disc ceramic
C20—2.4-24.5-pF miniature variable (Johnson Type U, #189-569-1, or similar)
C21—33-pF disc ceramic
C22—10-pF disc ceramic
C25—7-45-pF ceramic trimmer (Centralab Type 825 or similar)
C26,C27—0.1-μF
D1-D4—Silicon diode (1N914 or similar)
IC1,IC3—Integrated circuit (HEP570, MC724P)
IC2—Integrated circuit (HEP573, MC789P)
L1—5 turns of #20 bare wire, ¼" diam. by ⅜" long. Tap 4 turns from collector end as described in text.
Q1,Q2—UJT (HEP310)
Q3-Q5—Transistor (2N3904, 2N4124, HEP55)
Resistors: Unless otherwise noted, all resistors are 10% carbon, ¼ or ½ watt.
R1,R2—50,000-ohm potentiometer
R3,R4—500,000-ohm trimpot, horizontal mounting
R5,R6—25,000-ohm trimpot, horizontal mounting
R7—500-ohm trimpot, vertical mounting
R8,R14—1000-ohm
R9,R15—100-ohm
R10,R12,R17—4700-ohm
R11—5100-ohm
R13—15,000-ohm
R16—3900-ohm
R18—6800-ohm
R19,R34—39,000-ohm
R20,R24—22,000-ohm
R21—10,000-ohm
R22—47-ohm
R23,R25,R30—330-ohm
R26,R29—1500-ohm
R27,R28—680-ohm
R31—470-ohm
R32—27,000-ohm
R33—33,000-ohm
S1—4-pole, 6-position non-shorting rotary switch (Centralab PA-2011 or similar)
Misc.—Suitable chassis (7" x 5" x 3" will do but will not hold optional size D cells); 14-pin DIP sockets (3); TO-18 or TO-5 socket (5) (PC board is designed for 0.280" pin.); battery holder (2) for 3 penlite (AA) cells (Keystone #171) or optional holder for 2 size D cells (Keystone #176).

Fig. 1. This is the logic flow diagram of the convergence generator. The boxes in dashed lines show the four major sections: at left, the sync oscillators; upper right, horizontal drive; below that, the vertical drive; and, lower right, the r-f section. Some typical waveshapes are also shown to indicate circuit operation.



Six AA cells, wired to provide three volts, were used in the prototype.

microseconds wide at a pulse repetition frequency of 15.750 kHz. Capacitor *C1* charges through resistors *R1* and *R10*. When the voltage across *C1* reaches the peak point voltage of the UJT (about 2.4 volts), the UJT makes a rapid transition into the negative resistance region, resulting in the discharge of *C1* through the emitter-*B1* junction. The positive spike appearing at base one is coupled to the IC dual-NOR gate one-shot for shaping into a pseudo-horizontal sync pulse. The output of a NOR gate is high (about 2.9 V) only if both inputs are low (less than 0.4V). For all other input conditions, the output is low (less than 0.3 V). When two NOR gates are connected as shown in Fig. 2, gate *IC1A* is biased on (output low) and gate *IC1B* is biased off (output high). A positive pulse from the UJT causes the output of *IC1B* to switch to the low state, pulling terminal 13 of *IC1A* down through capacitor *C3*. With both inputs of *IC1A* now low, its output is high. The one-shot remains in this state until *C3* has charged to above 0.4 V (6 to 9 microseconds), at which time the one-shot returns to its original state. This sequence is repeated for each triggering spike from the UJT, 15,750 times per second.

The vertical sync oscillator is similar to the horizontal except that the output pulses are about 0.5 milliseconds wide with a pulse repetition frequency of 60 Hz.

The video section consists of horizontal and vertical astable multivibrators, *RC* differentiators, and logic gates. The horizontal astable (*IC2A* and *IC2B* in Fig. 3) is synchronized to the horizontal frequency through *C11*, *R3*, and *C12*. Its output is thus fixed at an integral multiple of the horizontal line frequency of 15.750 kHz. Potentiometer *R5* and resistor *R32* set the output frequency by controlling the charging current to *C14*. For the component values shown in Fig. 3, the nominal frequency is

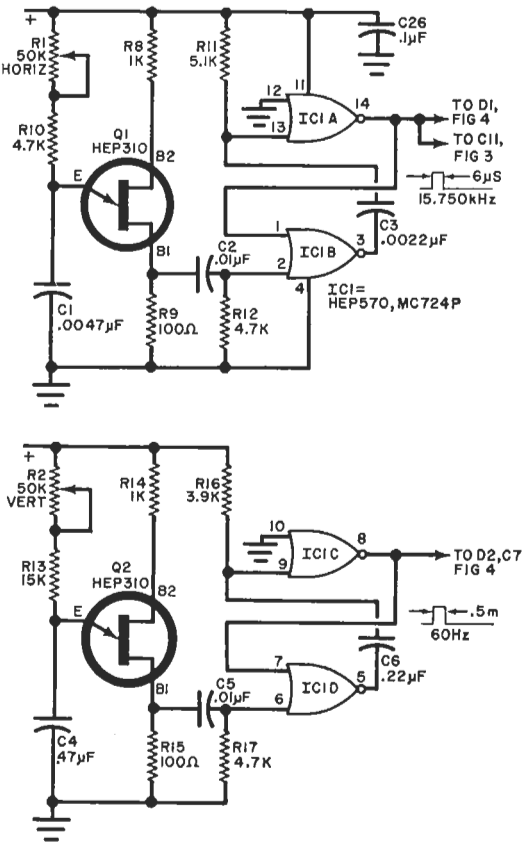


Fig 2. Horizontal and vertical oscillators feed one-shot multivibrators.

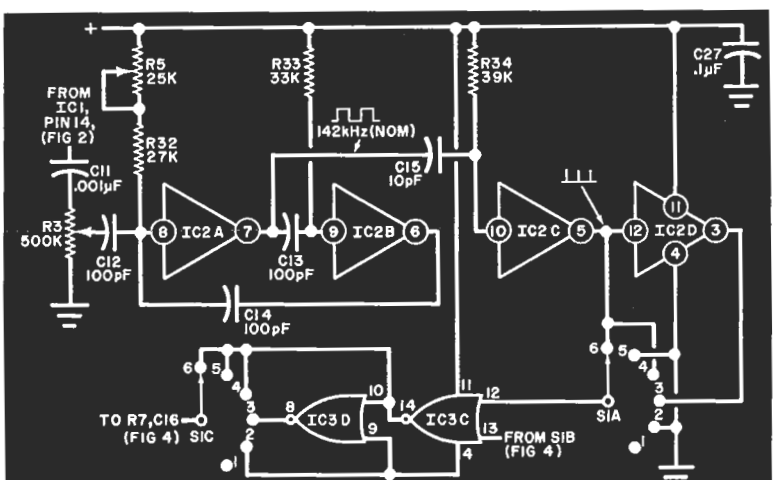


Fig. 3. Horizontal astable output determines width of vertical lines.

142 kHz (nine cycles between horizontal sync pulses). The 142-kHz rectangular pulses are differentiated by *C15* and *R34*. The resulting spikes are shaped and inverted by *IC2C*. The width of the output spikes from *IC2C* determines the width of the vertical lines on the TV screen.

A second inversion for the dot pattern is performed by *IC2D*.

The vertical astable (Fig. 4) is similar except that it is synced to nine times the frequency (540 Hz) of the vertical oscillator. The rectangular, 540-Hz pulse train is differentiated by *C10* and *R20* before shaping and inversion by *IC2E*. The width of the pulse from *IC2E* determines the width of the horizontal lines on the TV screen.

Generation of the actual video waveform associated with each of the five display modes is accomplished by sections of *S1* and NOR gates *IC3C* and *IC3D*. The video output waveform is then combined with the sync pulses at the common-collector junction of *Q3* and *Q4* (Fig. 4).

The sync pulses are added to the video waveform to produce a composite wave with negative-going sync pulses and positive-going video spikes. Diodes *D1* and *D2* comprise a diode gate so that either horizontal or vertical sync pulses can turn on *Q3*. With *Q3* saturated, its collector is at a potential less than 0.3 V. In the absence of either horizontal or vertical sync pulses, *Q3* is cut off and the collectors of *Q3* and *Q4* rise to a voltage determined by the setting of *R7*. (Thus *Q4* is biased in its linear region.) When the video logic signal is high, *Q4* is biased to produce approximately 1.5 V at its collector. When the logic signal is low, *Q4* is cut off and its collector rises to 3.0 V. If the resulting composite video waveform were applied to the appropriate stage in the receiver's video amplifier section, the generator's test pattern would appear on the screen. However, to preclude the need to make internal connections to your set, the generator contains an r-f section.

The r-f section consists of an oscillator and a diode modulator (Fig. 5). Oscillator *Q5* is operated in the tapped Hartley configuration. The frequency is adjusted by *C20* and trimmed by *C25*. The r-f output is coupled by *C19* to the diode modulator.

With a high signal (3 volts) applied through *R31*, the output terminal has a low ac impedance to ground through *D4* (forward biased) and *C22* and a high impedance to the r-f oscillator due to diode *D3* (which is reverse biased).

When the modulating waveform goes low (less than 1.5 volts), diode *D4* is cut off and diode *D3* conducts. This allows the flow of radio-frequency current from the oscillator to the output terminal. The negative modulation convention used in American TV broadcasting translates an increase in the r-f amplitude into a decrease in brightness of the trace. In this way, the complex modulating signal is converted into a black-and white pattern on the TV screen.

Construction. A printed circuit board us-

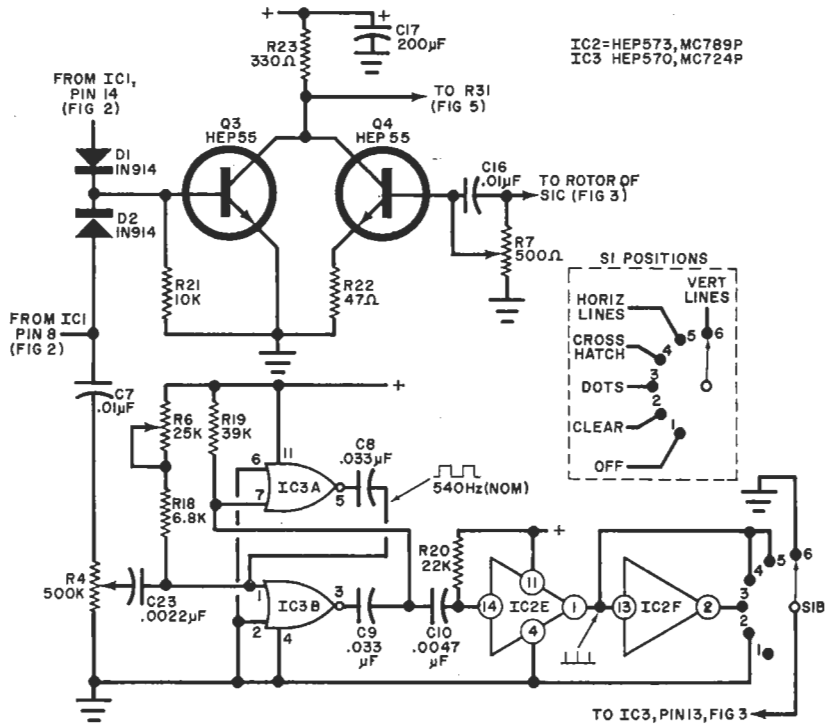


Fig. 4. A 540-Hz oscillator driven by vertical determines horizontal line width.

ing the pattern shown in Fig. 6 is recommended. The dots for diodes *D1* to *D4* designate the cathode ends. Diode cathodes can be identified by the end marked with a line or a dot. Be sure to observe polarities, especially on *C17*. Sockets should be used for all the semiconductors and IC's. Use heat sinks for *D1-D4* when soldering.

Note that *R1* and *R2* are wired so that resistance decreases in the clockwise direction. Use minimum-length leads of about #22 solid wire. Use short lengths of stranded wire to connect the battery holder. In the prototype, two triple penlite-cell holders were used. These are OK for light usage of the generator (about ½ hr each time). If you expect heavier usage, two D cells will be needed—in an optional holder.

To wind *L1*, use any 1-watt carbon resistor as a form and five turns of #20 bare

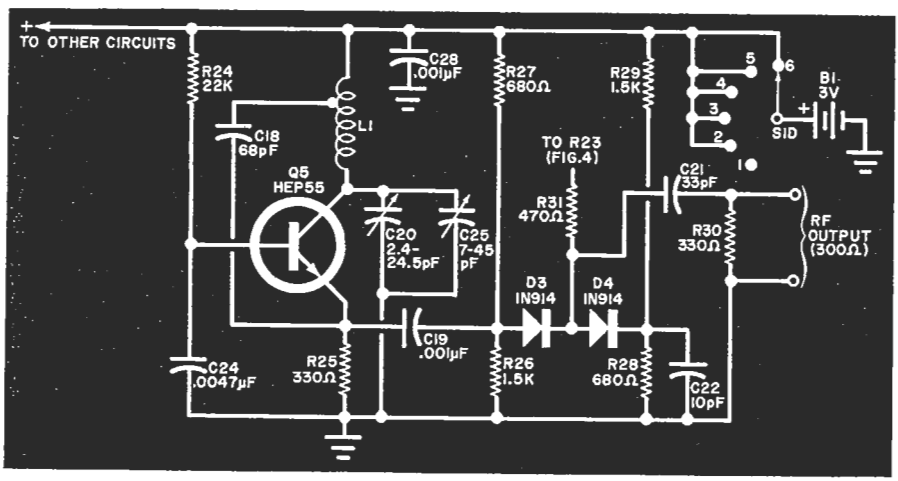
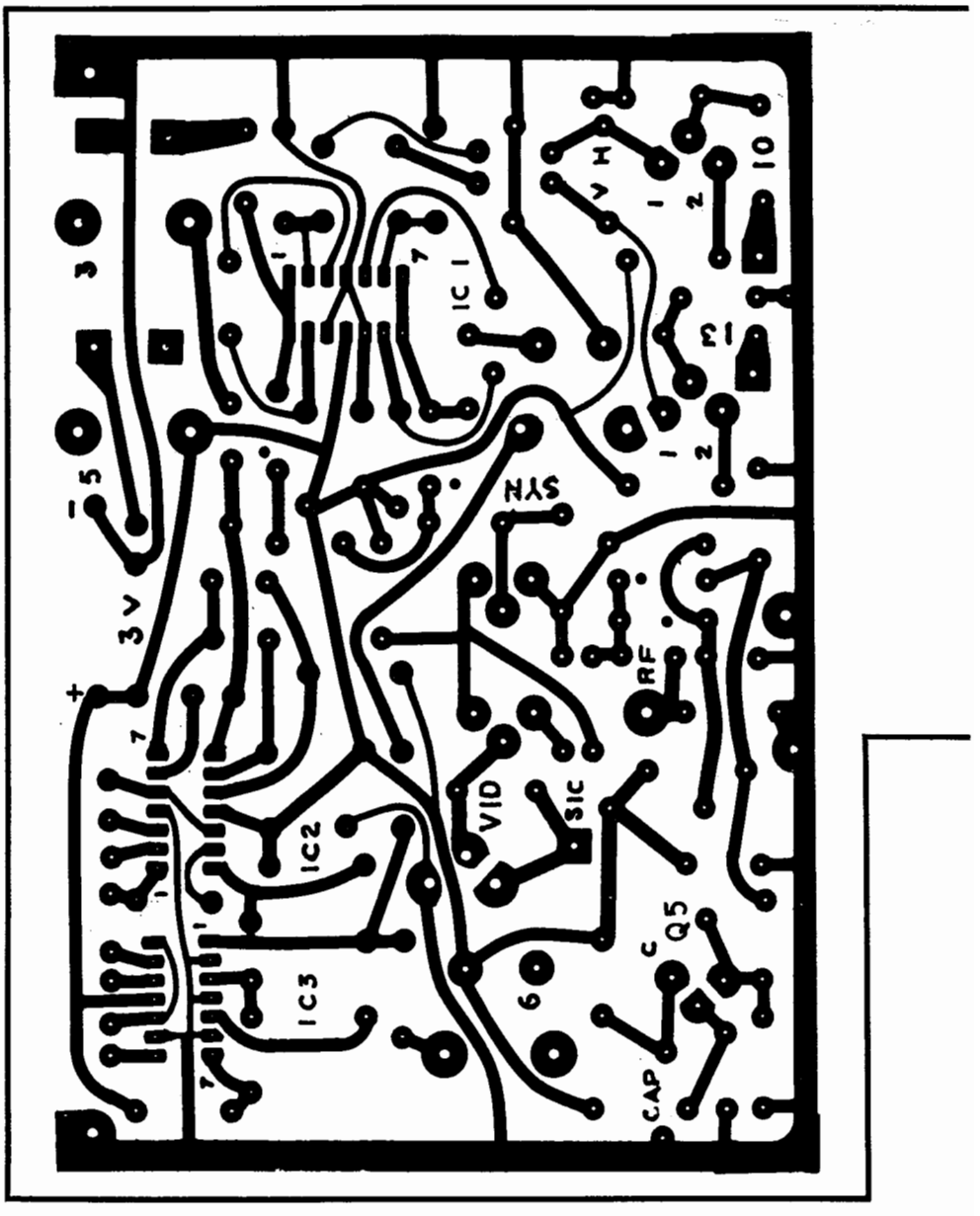


Fig. 5. Output of r-f oscillator and dual-diode modulator circuit drives the TV set.



wire (close-wound, with one turn touching the other). Then carefully spread the coil until the ends are ⅜-inch apart. Bend the end leads to the proper angle and remove the resistor before mounting the coil. Before the coil is soldered to the board, solder one lead of *C18* to the coil, four turns from the end connected to the collector of *Q5*. Note that this lead of *C18* does not go through the board, but directly to the coil.

The stationary plates of *C20* are connected to the collector of *Q5;* and the rotating plates to the ground bus on the board. These two points are marked "CAP" in Fig. 6. Capacitor *C25* is soldered directly across *C20*.

Operation. Before turning on the generator, check the battery polarity and voltage. There should be 3.0 V between the positive side of the battery and ground on the board. To check the completed generator, connect it to either a black-and-white or a color TV set. (Because of the very low r-f power output and the dc blocking capacitor *C21*, the generator cannot damage the

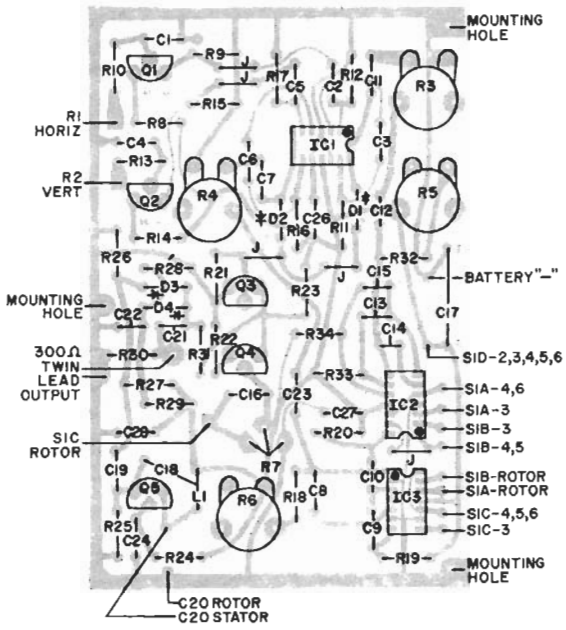


Fig. 6. The actual-size foil pattern (at left) and component installation (above).

TV set, even if the generator is not properly adjusted.)

Before getting into the operation of the generator, let's summarize the front panel controls and their functions. First, there is the MODE switch (*S1*). Besides turning the power on and off, it is used to select one of five displays: clear white screen (CLR), dot array (DOT), crosshatch (CH), horizontal lines (HL), and vertical lines (VL). The CHNL control varies the r-f carrier frequency over the range of three vhf channels (18 MHz). The HORIZ control varies the frequency of the horizontal sync oscillator about a nominal 15.750 kHz. The VERT control varies the frequency of the generator's vertical sync oscillator about a nominal 60 Hz. When adjusting either the HORIZ or VERT control, you may find more than one setting which results in sync of the pattern. Use the setting that results in the most stable display.

Make the following preliminary potentiometer adjustments:

1. Set *R7* about ⅔ up from the grounded end. This potentiometer sets the black level of the composite TV signal.
2. Set *R4* fully counterclockwise.
3. Set *R3* fully clockwise.
4. Set *R5* and *R6* to midrange.
5. Disconnect the vhf antenna from the set and attach the generator to the antenna terminals on the set.
6. Turn on the TV set and put it on either channel 2 or 3, whichever is unused in your area. Turn the generator MODE switch to CLR.
7. With the plates of *C20* (CHNL control) fully meshed, adjust trimmer *C25* until the test signal from the generator appears on the screen with little or no buzzing from the set. This should be a clear raster—a completely white screen. Whether it is or not, continue to the next step.
8. Turn the MODE switch to the HL position. Adjust the VERT control to stop any vertical motion of the test pattern. Adjust the HORIZ control to eliminate any diagonal lines or "tearing" of the pattern. You should now see horizontal lines.
9. Touch up the adjustment of the CHNL control to eliminate any noise and to provide the clearest display. You may now prefer to decrease the TV's brightness control and increase the contrast to get white horizontal lines on a black background.
10. Trimpots *R4* and *R6* are used to set the stability and number of horizontal lines, respectively, though there will be some interaction between them. Adjust them for 9 or 10 horizontal lines and the best stability. Use the VERT and HORIZ controls to maintain vertical and horizontal sync as necessary.
11. Turn the MODE switch to the VL position. If vertical lines do not appear, touch up the HORIZ control.
12. Trimpots *R3* and *R5* are used to set the stability and number of vertical lines. Adjust them for 9 or 10 vertical lines and the best stability.
13. Turning the MODE switch to the CH position should now produce a 9 by 9 or 10 by 10 crosshatch pattern. Touch up the adjustment of the CHNL, HORIZ, and VERT controls as necessary. Trimpot *R7* may be reset slightly to provide the best balance between sync stability and pattern contrast.
14. Turning the MODE switch to DOT or CLR should produce a 9 by 9 (or 10 by 10) array of dots or a clear raster, respectively.

Always turn the MODE switch off when not using the generator.

Once the potentiometers on the board and *C25* have been set, the cabinet can be closed. Mark the positions of the HORIZ and VERT dials where sync was obtained for future use. ◈