INSTRUCTION MANUAL

Serial Number ____________

TYPE

RM 529

OSCILLOSCOPE

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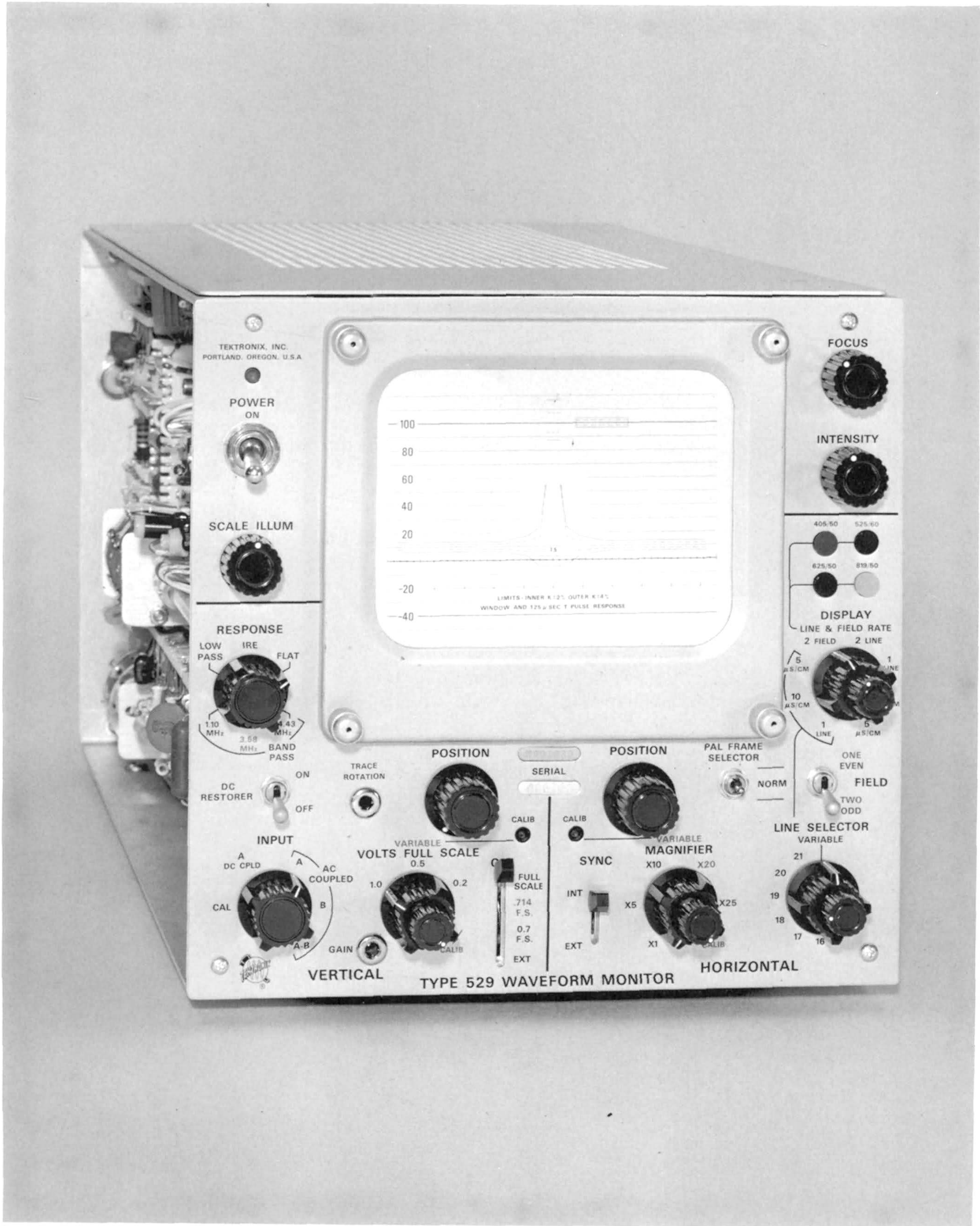


Fig. 1-1 Type 529 Waveform Monitor.

Fig. 1-1. Type RM529 Waveform Monitor.

SECTION 1
CHARACTERISTICS

General Information

The Tektronix Type RM529 Waveform Monitor is a self-contained cathode-ray oscilloscope specifically designed for video-waveform monitoring at television transmitters and studio facilities. With this monitor, any portion of the television-signal waveform can be displayed on a 5-inch rectangular cathode-ray tube.

A frequency-response switch is included which enables the selection of several frequency-response characteristics including that characteristic recommended by the IEEE Standards Committee for standardized pulse-level measurements.

An internal 30-kHz amplitude calibrator provides 0.714-volt or 1.0-volt pulses for calibrating the vertical amplifier. The sweep system provides calibrated sweeps which eliminates the need for time markers.

The following characteristics apply over an ambient temperature range of 0° C to 50° C. Warm-up time for the given accuracies is 20 minutes at 25° C, ±5° C.

The performance requirements throughout this manual are stated in either percentage or IEEE units. The compatible dB point is also inserted using the formula: $dB = 20 \log \frac{E1}{E2}$

NOTE

On instruments with the Serial Numbers below 400, the following control names and labels are used:

1. The HIGH PASS position of the RESPONSE switch is labeled CHROMA.
2. The IEEE position of the RESPONSE switch is labeled IRE.
3. The VOLTS FULL SCALE switch is labeled MAG.
4. The 1.0, 0.5 and 0.2 positions of the VOLTS FULL SCALE switch are labeled X1, X2 and X5 respectively.
5. The FULL SCALE position of the CALIBRATION switch is labeled F. S.
6. The FIELD switch is labeled FIELD SHIFT.
7. The ONE and TWO positions of the FIELD switch are labeled EVEN and ODD respectively.
8. The LINE SELECTOR variable control is labeled DELAY.
9. The LINE SELECTOR .125 H/CM and LINE SELECTOR .25 H/CM positions of the DISPLAY switch are labeled DELAYED LINE .125 H/CM and DELAYED LINE .25 H/CM respectively.

VERTICAL DEFLECTION SYSTEM

Characteristic	Performance Requirement	Supplemental Information
Frequency Response FLAT (1 V gain sensitivity)	Flat to within +0%, −1% (0.1 dB) from 50 Hz to 6 MHz. Flat to within +0%, −3% (0.3 dB) from 6 MHz to 8 MHz.	
FLAT (0.2 and 0.5 gain sensitivities)	Flat to within +0%, −1% (0.1 dB) from 50 Hz to 6 MHz.	
LOW PASS	Down not less than 80% (14 dB) at 500 kHz or above.	
HIGH PASS	3.58 MHz center frequency 15% to 35% down in amplitude + and − 400 kHz.	
IEEE	See Fig. 1-2.	
Transient Response		
High Frequency	T/2 pulse must be between 94 and 100 IEEE units high for 100 IEEE units of bar signal amplitude applied and have less than or equal to 3 IEEE units of overshoot.	Any ringing as observed on the test oscilloscope (Type 547 with 1A1 plug-in used for check) must be added to the overshoot tolerance.
Middle Frequency	Top of bar signal must be flat within ± ½ IEEE unit.	Flatness measured at +100 IEEE unit graticule line.
Gain Sensitivity	1 V—Adjustable to 1 V. 0.2 V—Adjustable to 0.2 V. 0.5 V—less than ±3% error.	
Variable Gain Sensitivity	Must attenuate the gain by a ratio of at least 2.5:1.	Ratio of maximum amplitude to minimum amplitude.

HORIZONTAL DEFLECTION SYSTEM

Characteristics	Performance Requirement	Supplemental Information
Calibrated Sweep Rates		
×1	Adjustable to 0.125 H/CM.	
×5	Should be within ±3% of 0.025 H/CM.	
×25	Should be within ±3% of 0.005 H/CM.	
Staircase (RGB-BW) Relay	When relay K501 is energized, sweep will be at either line or field rate (depends on DISPLAY switch setting), and 2.5 cm or less in length.	
Line Selector (Variable)		
Minimum Delay	Line selection will start on or before the 15th line of either field.	
Discrete Line Selector (SN 2997-up)	Sweep will start on the line indicated by the LINE SELECTOR (switch) position on both fields.	
Field Selector		
ONE	Sweep is triggered by field one.	
TWO	Sweep is triggered by field two.	

TRIGGERING

External Trigger	Stable triggering must be obtained on an input composite video signal ≤ 250 mV to ≥ 1 V in amplitude.	
Internal Trigger	Stable triggering must be obtained on an input composite video signal ≤ 200 mV to ≥ 1 V in amplitude	

AMPLITUDE CALIBRATOR

Signal Accuracy		
.714 FS	Adjustable to 0.714 V.	
FULL SCALE	Within ±1% of 1 V.	
Frequency		Approximately 30 kHz.

POWER SUPPLY

Power Source	115 VAC, ±10%, 50 to 60 Hz.	Can be connected for 230-VAC operation.
Power Source Fuse	Type 3AG, 1.25 A slow-blowing.	Type 3 AG, 0.6 A slow blowing for 230-VAC operation.

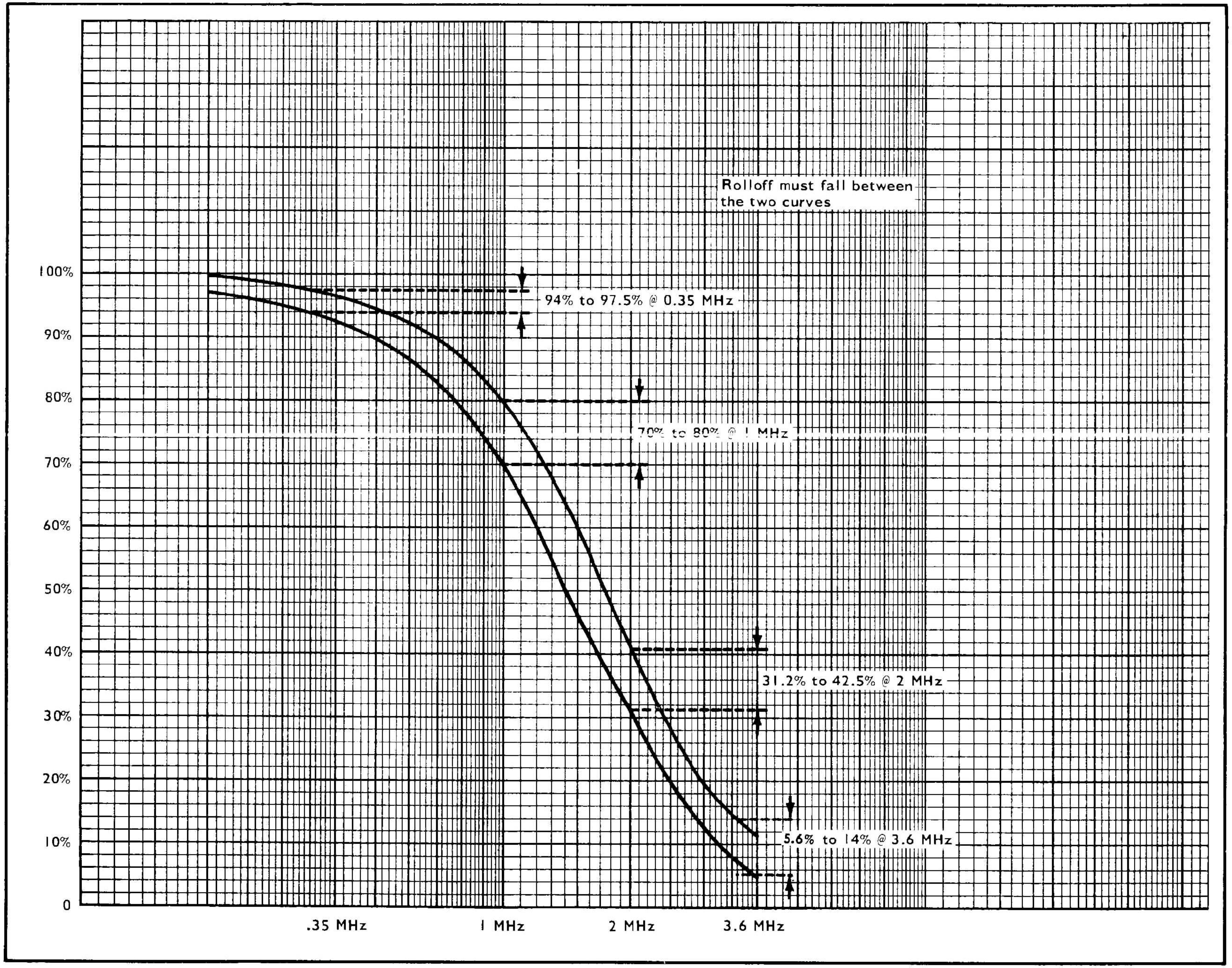


Fig. 1-2. IEEE 1958 Standard 23s-1.

Characteristics—Type RM529

CATHODE-RAY TUBE

Characteristics	Information
Tube Type	T5291-31 rectangular, glass envelope.
Phosphor	P31 standard. Others available on special order.
Accelerating Potential	Approximately 5300 V.
Graticule Type	External. See Standard Accessories list for graticules.
Scan Area	The equivalent of 7 or more centimeters of vertical area and the equivalent of 10 or more centimeters of horizontal area.
Graticule Illumination	Variable edge lighting.
Unblanking	DC used on all sweep rates with AC coupled brightening pulses for line Selector modes of operation.
CRT Beam Rotator	Electrical. Will vary the beam across horizontal by 1° in either direction (total range is equal to or greater than 6°).

MECHANICAL CHARACTERISTICS

Characteristics	Information
Construction	Aluminum-alloy chassis and panel.
Finish	Anodized panel.
Overall Dimensions (measured at maximum points)	5¼ inches high, 19 inches wide, 20 inches long (includes front panel knobs).

Standard Accessories

Information on accessories for use with this instrument is included at the rear of the mechanical parts list.

SECTION 3
CIRCUIT DESCRIPTION

General Information

The Type RM529 Waveform Monitor circuits contain both vacuum tubes and transistors. Portions of both the vertical and horizontal systems contain amplifiers with special feedback for gain stability independent of tubes or transistors. Several multivibrators in the trigger and horizontal systems provide precise display triggering. Refer to the block and circuit diagrams at the back of this manual during the following circuit descriptions.

All connectors are rear-panel mounted. Four of the input circuits are 75-ohm coaxial loop-through; two VIDEO INPUTS, EXT NEG SYNC INPUT and EXT CAL INPUT. The Staircase Input (J501) is a special nine-pin socket (see Staircase Input discussion in Section 2 for mating connector). The VIDEO OUTPUT coaxial jack has a 75-ohm unbalanced output impedance.

BLOCK DIAGRAM

The (VERTICAL) INPUT switch selects either of two video signals, or the A signal minus the B signal, or the CALIBRATOR signal, (the calibrator signal can be from an external source) and applies it to the input of the preamplifier. The preamplifier and magnifier supplies the signal to both the response filters and the sync amplifier. The response filter passes the signal on to the output amplifier and to the CRT deflection plates. The output amplifier also supplies the signal to the keyed DC restorer circuit. The sync amplifier supplies an AC-coupled signal to the VIDEO OUTPUT jack (with an open circuit gain of 2, and 75-ohm loaded gain of 1 referred to the video input), and an AC-coupled signal to the sync separator.

The sync separator regenerates the horizontal sync pulses so their shape and amplitude is always the same. Plus and minus regenerated horizontal sync pulses are available for operating the keyed DC restorer circuit. Minus H pulses are used when displaying video, and plus H pulses are used when displaying the calibrator.

The keyed DC restorer circuit holds the display steady at the video back-porch level or the negative level of the internal calibrator. The circuit operates by controlling the DC level of the preamplifier and magnifier minus input. The video input signals are AC coupled, but the preamplifier and magnifier, response filters, and output amplifier are DC coupled. The DC-restorer circuit virtually eliminates display shift with change in signal amplitude, but response time is slow enough for hum or tilt to be observed.

The sync separator —H signal is used by the trigger selector matrix, when the display is of a line nature (undelayed). The +H signal does not go directly to the trigger selector matrix, but to the vertical sync separator, and then to both the field 1 recognition circuit and the field trigger generator (Q375-Q385). The field trigger generator triggers the sweep gating multivibrator via the trigger selector matrix for field displays (undelayed), and triggers the sweep gating multivibrator through the delay generator and trigger selector matrix for delayed field displays.

The sweep gating multivibrator and sweep generator triggering source and sweep rate is set by the front-panel DISPLAY switch. Triggers are received by the sweep gating multivibrator, which allows the sweep generator to run and drives the unblanking amplifier to turn on the CRT beam at the time of the sweep. The unblanking amplifier also sends a brightening pulse to the CRT and the VIDEO OUTPUT jack during delayed line modes. The sweep generator drives both the horizontal amplifier and the staircase amplifier. The staircase amplifier is inserted between the sweep generator and the horizontal amplifier when external control (through J501) switches the sweep generator function to read the red, blue, green (and black-white SN787-up) portions of a color studio camera.

The high voltage supply contains the CRT high-voltage power supply. A portion of the power-supply circuit forms the calibrator signal at the $\simeq$ 30 kHz rate of the high-voltage oscillator. An external calibrator signal can be substituted for the internal signal.

VERTICAL AMPLIFIER

The video input circuits of the vertical amplifier are shown in simplified form in Fig. 3-1. The 10-ohm resistor in Fig. 3-1A is optional, but necessary in the event there is any AC potential difference between the input coaxial cable and the Type RM529 chassis. It presents any cable-to-chassis signal differentially to the vertical amplifier so the signal will not become part of the display. (Any signal on the outside of the braid of a coaxial cable is also on the center conductor, but with the same polarity. The equal signals are applied to the + and — input terminals, and cancelled by the differential rejection characteristics of the vertical amplifier.) The A-B input of Fig. 3-1B does not use the 10-ohm resistors because the cables are likely to have the same unwanted information. Since the unwanted information appears on both center conductors, it is presented to the vertical amplifier in differential form and cancelled.

Operating With the DC Restorer Circuit Off

Operation of the vertical amplifier will be described first with the DC restorer circuit turned off.

The input signals are AC coupled to both the + and — input grids of V113 and through C104 and C204, see 1 megohm return to ground. The rest of the vertical amplifier is DC coupled.

Preamplifier. The preamplifier consists of two input cathode followers (V113A and V113B), and two-transistor amplifiers Q114 and Q214. The preamplifier is shown in simplified form in Fig. 3-2A. The cathodes of V113 return to the same constant-current circuit to which the emitters of Q114-Q214 return. The VOLTS FULL SCALE control between emitters of Q114-Q214 couples the signal between emitters, causing both sides of the amplifier to have an output signal when only one input receives a signal.

The tubes serve basically as impedance transformers, changing the 1-megohm input resistance to about 400 ohms to drive

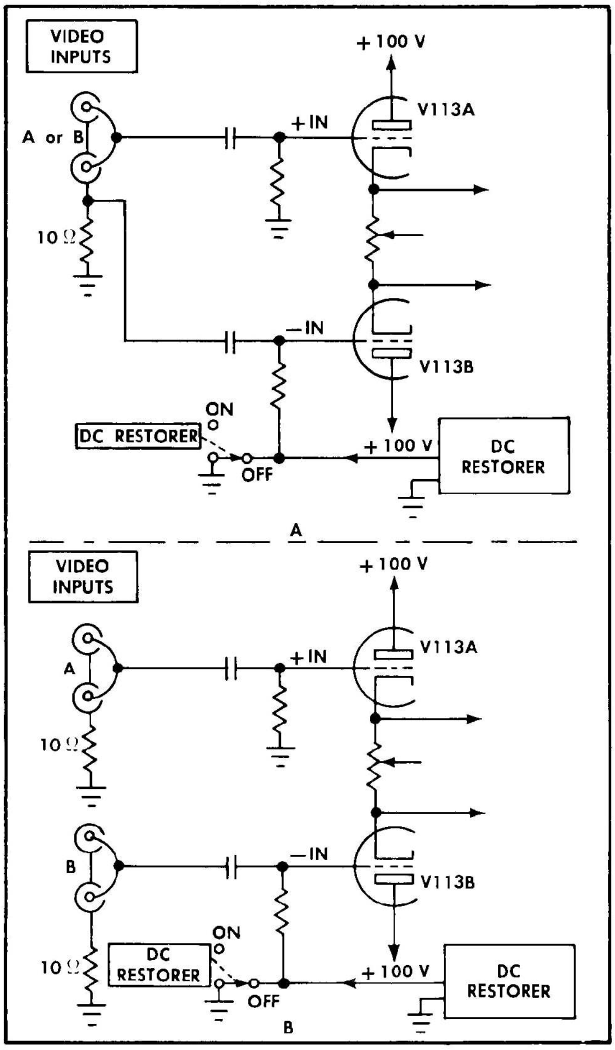


Fig. 3-1. Simplified vertical amplifier input circuits.

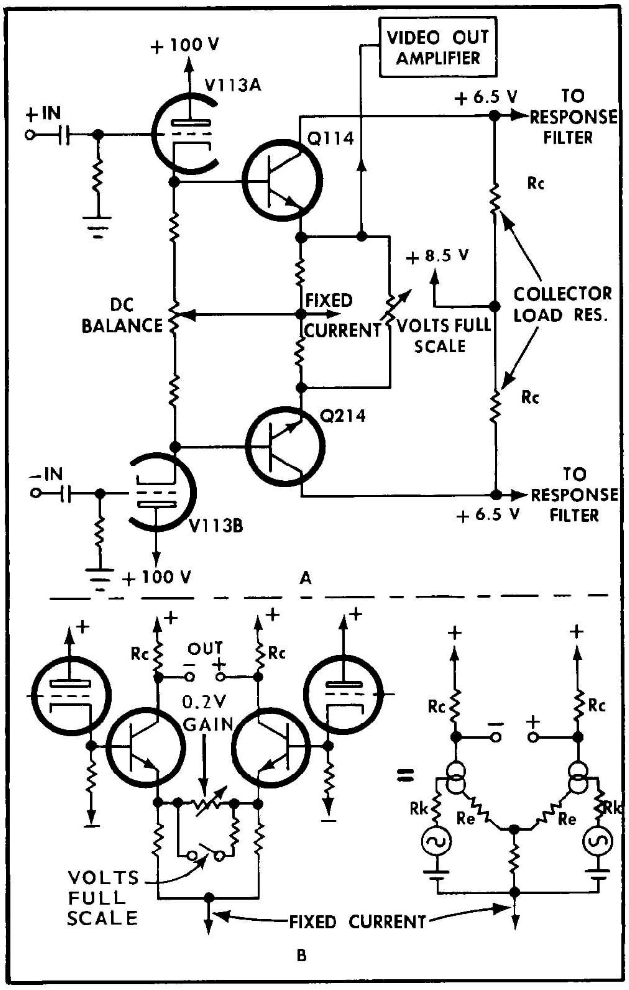


Fig. 3-2. Simplified circuit (SN 1600-up). Some circuit values are different in earlier SN instruments.

each transistor base. The cathode-return resistors have a value about 20 times the cathode-follower output impedance; therefore, do not attenuate the signal significantly. Each cathode follower passes about 93% of the input signal to the following transistor base.

The emitter resistors would normally cause considerable degenerative effect, and would thus keep the stage gain very low. However, the VOLTS FULL SCALE resistance between the two emitters also couples the signal from one side to the other. Fig. 3-2B shows a simplified concept of the VOLTS FULL SCALE control signal path. If, in this theoretical circuit, the VOLTS FULL SCALE resistor were made zero ohms, the input signal to one transistor base would divide equally between the two halves of the stage. Fig. 3-2B shows the internal emitter resistance in series. Thus, VOLTS FULL SCALE equal to zero ohms degeneration on one side of the amplifier is the emitter resistance of the other side. This causes both sides of the amplifier to have gain. The emitter return resistors are many times greater than the emitter internal resistance, and, therefore, do not attenuate the signal when the VOLTS FULL SCALE resistance is low. The actual minimum VOLTS FULL SCALE resistance is about 590 to 600 ohms between emitters setting the push-pull output signal equal to about 2 times the single-ended input signal.

A typical single input signal will cause the following action (assume the VOLTS FULL SCALE resistance to be 600 ohms): Q114 base is driven in the positive direction 1 volt and its emitter follows it nearly 1 volt. The 600-ohm resistor allows the emitter current to increase and the emitter voltage to follow the base voltage nearly one volt. The increased forward bias of Q114 is about 0.02 volt. The signal current is essentially 1.66 mA greater than the static current. The only source for the signal current is the emitter of Q214; therefore, both transistors receive the same amount of signal current (but of opposite polarity) for a single input signal. The result is that both collector resistors have a 1.66 mA signal current. The collector of Q114 goes negative, and the collector of Q214 goes positive producing a push-pull output signal about 2.2

volts peak to peak. Since the collector load resistors have equal and opposite current changes, the voltage at their center does not change. A common-mode signal reaching the preamplifier would change the voltage at the junction of the collector load resistors, and degrade the common-mode rejection of the amplifier except for presence of the constant current stage.

The high-frequency gain of the preamplifier is adjusted to equal the low-frequency gain by making the RC time constant of the emitter circuit equal to the RC time constant of the collector circuit. The cathode followers' output impedance allows the Miller capacitance of the transistors to affect the high-frequency response. To minimize the Miller effect, the transistor stage is neutralized by C113 and C213. The variable capacitors (C118B and C118C) across the VOLTS FULL SCALE resistors R118B and R118C permit the preamplifier frequency response to be properly adjusted. There is no need for a variable capacitor across R118A, due to wiring stray capacitance.

In the event of minor differences in bias of the input cathode followers, (and the resultant output voltage difference) the DC BAL control (R115) is set to create a compensating change in current in the cathode return circuit. The DC BAL control final setting is correct if the trace does not shift when changing the VOLTS FULL SCALE switch position (with the DC RESTORER OFF).

The high impedance of the preamplifier transistor collectors allows the output voltage to be varied a slight amount without significant change in current. The VAR DC BAL control slightly alters the voltage balance of the preamplifier output to allow the output amplifier VARIABLE control (between emitters of Q144-Q244) to be adjusted without shifting the trace position.

Constant Current Stage. The constant current stage cancels any push-pull output from the preamplifier in the event both input leads receive equal amplitude-equal polarity signals. The circuit causes the voltage of the constant current leads of Fig. 3-2 to shift and follow any common-mode input voltages. (The high collector resistance of Q114 and Q214 prevents any change in the preamplifier output voltage.) Fig. 3-3 shows simplified connections between the constant current stage and the preamplifier. Assume both input leads to be positive. The result is that both collector-load resistors receive an increase in current. The increased current pulls down on R121. R122 divides the change to the base of Q124. Q124 base goes negative and causes its collector to go positive an amount equal to the original common-mode signal. This cancels its effect and returns the current in the collector-load resistors to the original value. The input cathode followers' negative supply is the same as Q114-Q214 negative supply, to assure signal linearity in the event of common-mode signal cancellation by Q124.

The principal reason for keeping the common-mode currents out of the preamplifier is that even though the currents may be equal, the collector load resistors may not be precisely equal, and equal currents would generate unequal output voltages. The circuit does stop the preamplifier output from moving positive or negative with common-mode signals.

Response Filters. The frequency response of the overall monitor is altered for special purposes by the RESPONSE switch and its filters.

The FLAT position of the RESPONSE switch gives the widest

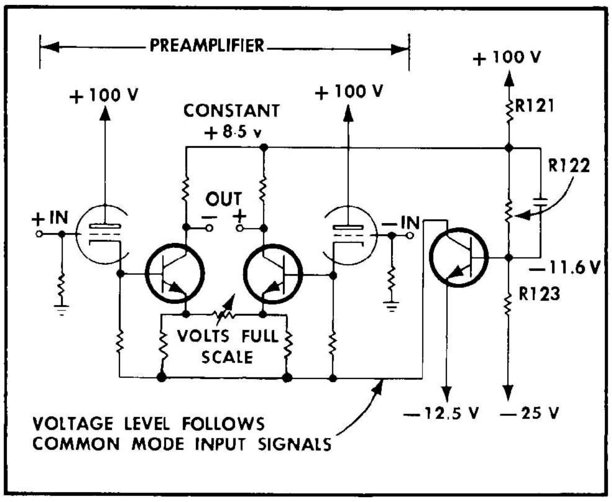


Fig. 3-3. Simplified constant current stage connections on preamplifier.

bandwidth, with a direct connection from the preamplifier to the output amplifier.

The IEEE position of the RESPONSE switch inserts components that cause the overall monitor bandwidth to be low-pass to agree with 1958 Standard 23S-1.

The LOW PASS position of the RESPONSE switch inserts components that alter the overall response so that it is about 12-dB down at 500 kHz.

The HIGH PASS position of the RESPONSE switch inserts a critically-coupled transformer between the preamplifier and the output amplifier, making the overall monitor bandpass about 800 kHz centered at 3.58 MHz. The DC level at the input of the output amplifier is maintained by connecting the center of the primary and secondary windings together at a cold RF point.

Output Amplifier. The output amplifier includes two sets of push-pull amplifiers, each with variable emitter coupling to vary the gain. The first amplifier is Q144-Q154 and Q244-Q254. The second amplifier is driven by the first, and is a combination of transistors and tubes giving a large voltage output swing.

The driver portion of the amplifier has negative feedback from the collector of Q154 to the emitter of Q144 (and from Q254 to Q244). The negative feedback makes the input impedance at the base of Q144 very high and the output impedance at the collector of Q154 quite low. The high input impedance prevents loading of the response filters. The low, output impedance is needed to drive the base of Q164 (and Q264). R154 is the negative feedback path and is also the collector load resistor for Q154 (see Fig. 3-4).

The VARIABLE gain control (concentric with the VOLTS FULL SCALE switch) varies the emitter-to-ground degeneration between Q144 and Q244 to vary the overall vertical amplifier gain by a 2.5:1 ratio. The VARIABLE control mechanically switches R241 into the circuit in the CALIB position, and out of the circuit (SW240 closed) when not in the CALIB position. If the VARIABLE control is counterclockwise at lower than cali-

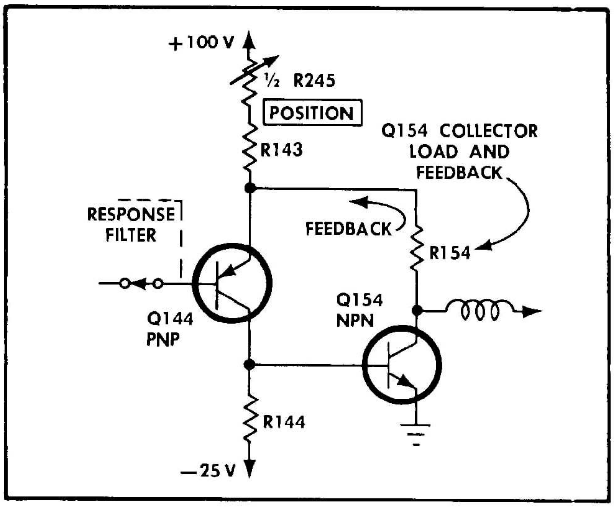


Fig. 3-4. Simplified one-half output driver stage.

brated gain, clockwise rotation can increase the monitor gain so it is greater than normal. Then, as the clockwise end of rotation is reached and the control is rotated to snap into the CALIB position, the overall gain drops about 70% as R241 is switched into the circuit. At the same time a second part of SW240 closes and turns on the front-panel CALIB neon lamp.

The output driver signal is coupled to the base of Q164 (Q264) of the output cascode amplifier. The combination of a transistor (supplying cathode drive) and a tube not only gives stable gain but also gives the wide voltage output swing. This amount of swing can only be obtained by a cascode amplifier consisting of a tube and transistor. The output cascode stage also has emitter-to-emitter degeneration used to adjust the overall vertical amplifier gain to match the CRT deflection factor. The emitter circuit also contains the HF COMP capacitors that permit the output stage high-frequency gain to be adjusted a bit higher than the low-frequency gain. This adjustment helps make the bandpass correct for the FLAT position of the RESPONSE switch.

While reading the following description of the cascode stage operation, keep in mind that (1) a transistor's emitter follows its base, just as a tube's cathode follows its grid—if the return circuit is a higher impedance than the internal emitter or cathode impedance, and (2) a transistor's collector has quite a high impedance, as high as the plate impedance of some triode tubes.

A signal that drives the base of Q164 in the positive direction causes several simultaneous circuit changes. The emitter voltage of Q164 follows the base voltage, with emitter voltage change about 2 percent less than base voltage change, offset by normal silicon transistor bias. The positive swing of Q164 base drives the grid voltage of V164 positive the same amount, and the cathode of V164 follows, lagging its grid about 20 percent. The 20 percent positive bias occurring in V164 as a result of cathode-follower action increases plate current, and the consequent plate current increase causes the output plate voltage to drop in the negative direction an amount determined by R162 and Ohm's Law.

Push-pull signals that drive the bases of Q164-Q264 drive the two halves of the output stages equally. (The degenerative action of the resistors between emitters is one half what it would be if only one base received a signal). The signal voltages at Q164-Q264 bases cause plate-current changes of V164 and V264 to be about 3.3 mA per centimeter of spot deflection each, producing a push-pull voltage output to the CRT deflection plates of about 20 volts per centimeter. The peaking coils in each plate circuit compensate for deflection-plate capacitance, and aid in obtaining flat frequency response of the vertical amplifier.

Positioning the CRT display (with DC RESTORER OFF) is by current injection into the emitter circuits of Q144-Q244 through R143 and R243. The POSITION control (R245) sends current toward the cascode output stage bases, but this current does not affect the display position so long as the DC restorer is off. Voltage changes at the bases of Q164 and Q264 do not significantly affect the positioning circuit because of two germanium diodes D271-D272, which limit the voltage difference between R149-R249 junctions with R148-R248. The two diodes appear on the DC restorer diagram.

Operation With DC RESTORER ON

The DC restorer circuit provides an automatic DC positioning voltage to the −input grid of V113B. The source of DC positioning voltage is the signal in the base circuit of the output cascode stage. The signal is usually composite video (sometimes it is the calibrator). The DC restorer circuit positions the CRT display firmly around the level of the composite video horizontal sync pulse back porch. Because of these facts, the restorer must look at the video only at the correct time. The DC restorer circuit is keyed by the horizontal trigger system to sample the video back porch for about 0.4 μs, and remember the DC level until the next horizontal sync pulse occurs.

When the DC restorer circuit is on, a current injection path through R148 and R248 into the input of the DC restorer Comparator permits the POSITION control to operate. The positioning current changes the DC level of the composite video at the point where it is looked at by the restorer.

Video Output Amplifier. The video output amplifier receives its signal from the emitter of Q114. The input impedance of Q174 is greater than 50 kΩ due to the large amount of emitter degeneration, which loads Q114 lightly. Q174 produces an inverted current drive to the feedback amplifier Q184-Q193 of essentially 1 mA per 1 volt. The emitter impedance of Q174 is R172-R173 in parallel, or 1.06 kΩ. Since the collector current of Q174 changes linearly with base-voltage drive, the signal-source resistance of Q184 base is 1.05 kΩ. Then, the voltage gain of Q184-Q193 (set by the feedback resistance divided by the input resistance) is 2.2 kΩ/1.06 kΩ or about 2.06. Assuming 3% signal loss in the preamplifier, the gain from input to Q193 collector is 2. R198 in series with a 75-ohm load makes the overall gain 1. The feedback (R192) makes the video output amplifier have a very low output impedance. Thus, the amplifier is matched to the output coaxial line by inserting a series 75-ohm resistor (R198). The reactance of C198 is so low at the frequencies passed by the circuit that it does not increase the output resistance over that of R198. R199 assures that C198 is properly charged.

The video output amplifier also serves as an internal trigger amplifier. The output lead to the sync clamping amplifier (diagrammed with the sync separator) rests at −5 volts.

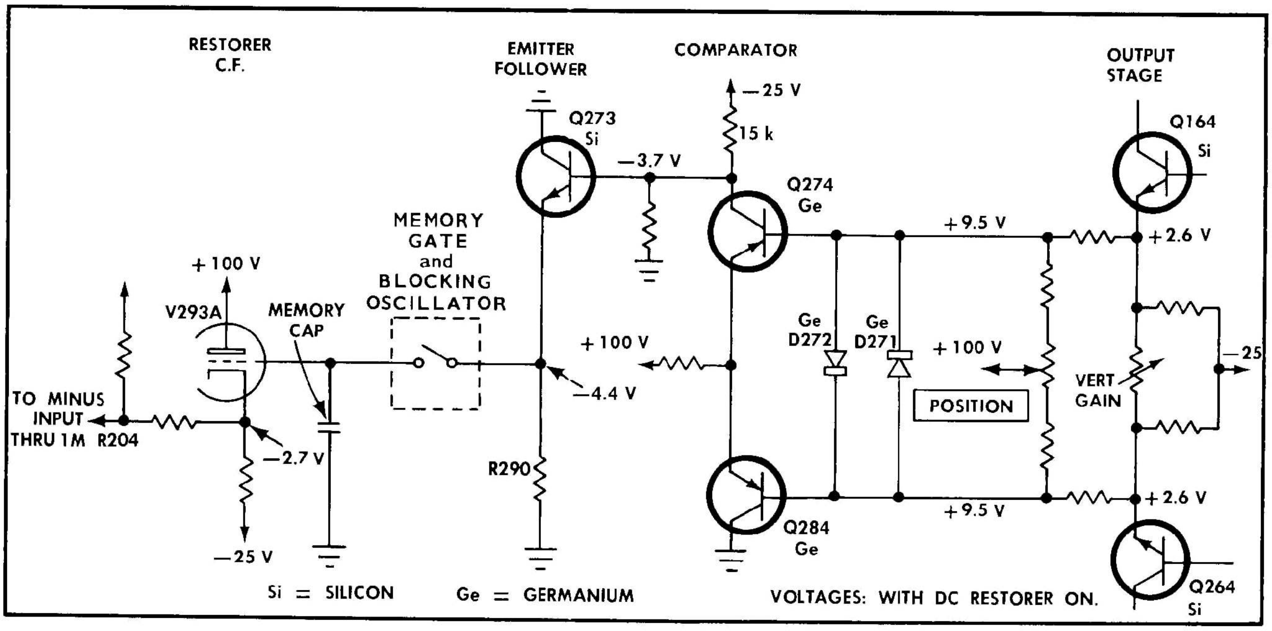


Fig. 3-5. Simplified keyed DC Restorer circuit.

The sweep generator applies a positive pulse to the video output jack when operating in a line selector mode. The intensifying pulse amplitude is about 0.2 volt at the video output jack (0.1 volt when loaded with 75 ohms). The value of the pulse is set by current from a +100-volt pulse in the sweep generator unblanking circuit applied through R476 diagrammed near the unblanking amplifier with the sweep generator to the 75-ohm output resistor R198. The very low output impedance of the video output amplifier prevents the intensifying pulse from disturbing the internal triggering signal.

Keyed DC Restorer

The keyed DC Restorer circuit includes the DC restorer Comparator, the blocking oscillator, and the restorer cathode follower. Voltages and waveforms on the DC restorer diagram were taken with the DC restorer circuit on. The simplified diagrams of Fig. 3-5, 3-7 and 3-8, and waveforms of Fig. 3-6 will help during the following discussion of the DC restorer circuit operation.

The DC restorer comparator is a dual-input single output amplifier that amplifies a small part of the composite video which is normally near the CRT screen center. The signal peaks are limited by parallel back-to-back germanium diodes D271-D272 (see Fig. 3-5). One of the two diodes conducts whenever the voltage across them exceeds 0.2 to 0.3 volt. When the diodes are not conducting, the comparator bases are fed push-pull signals from the two bases of the output amplifier cascode stages. When a diode is conducting, the two bases of the comparator amplifier are essentially shorted together, and there is no gain. When the signal at the base of Q274 goes negative (and the signal at the base of Q284 goes positive) D271 conducts. The opposite polarity signal causes D272 to conduct. The peak-to-peak signal input to the comparator is, therefore, limited to about 0.45 volt. The comparator output signal is typically 4.2 volts peak-to-peak at the emitter of the emitter follower (Q273). The comparator functions in the same manner as the differential preamplifier previously described, except there is just one output lead. Fig. 3-6 shows the signal as it enters the memory gate. The other waveforms of Fig. 3-6 are discussed with the blocking oscillator below.

Blocking Oscillator. The blocking oscillator is normally biased to cutoff by current through R282 and D282. A negative pulse applied to the base of Q280 will cause it to conduct and go through one cycle of oscillation. The negative pulse arrives at the base of Q280 through a diode switching network from the sync regenerator (diagrammed with the sync separator).

Assume the vertical INPUT switch is at A, as shown in Fig. 3-7. The diode switching circuit then reverse biases D285 about 45 volts and reverse biases D286 about 1 volt. Regenerated horizontal sync pulses arriving at C285 and C286 have a peak-

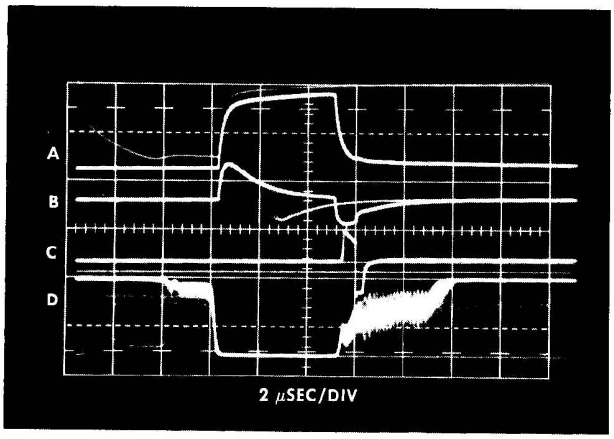


Fig. 3-6. Time-coincident waveforms of keyed DC Restorer.

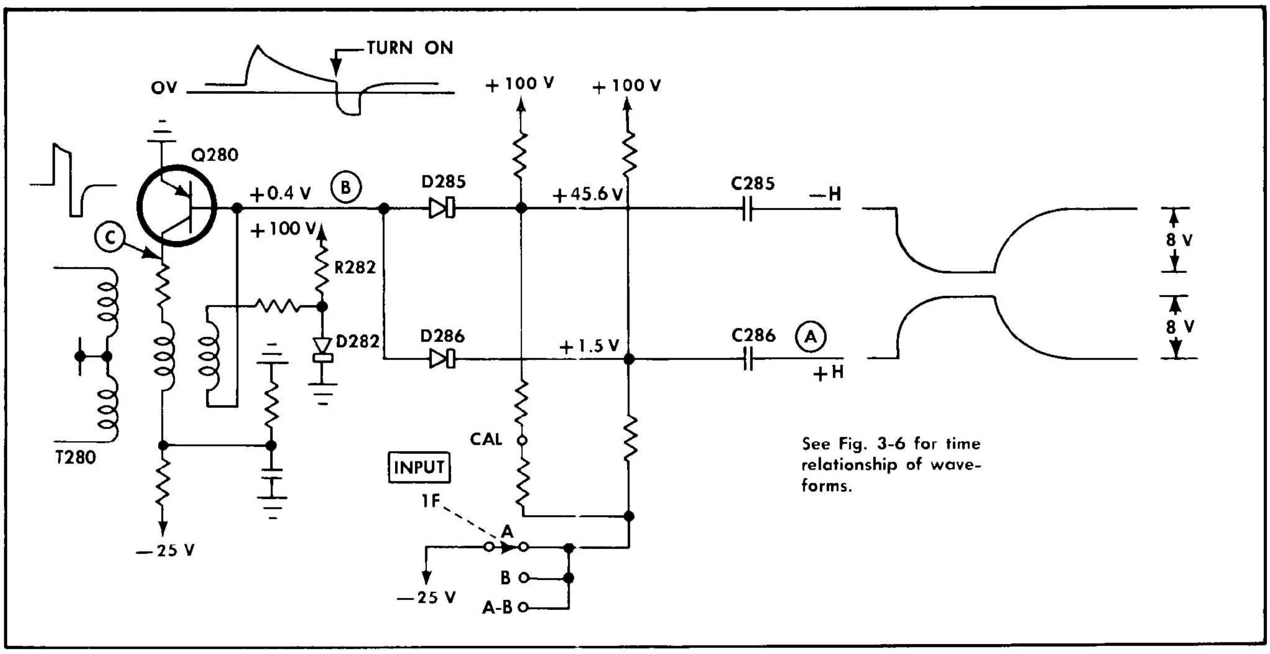


Fig. 3-7. Operation of Diode switch feeding Blocking Oscillator.

to-peak amplitude of about 8 volts. Thus, the —H pulse will not cause D285 to conduct, but the +H pulse will cause D286 to conduct at the end of the pulse as it goes negative. C286 charges almost the full 8 volts of the +H pulse rise, and then causes the cathode of D286 to fall about 7 volts. The base of Q280 does not fall as much as 8 volts because of the low base-to-emitter impedance at the time of turn on.

The blocking oscillator turns on at the time the composite video horizontal sync pulse ends and starts toward the back-porch level. The back-porch level occurs about 0.25 μs later, so the blocking oscillator does not sample the video at the time of turn-on. As Q280 conducts, the L/R time constant of the collector circuit inductance and resistance keeps Q280 conducting for about 0.6 μs before the base drive decays. As Q280 regenerative base turn-on drive is stopped, the collector current drops rapidly. Dropping collector current is transformer-coupled back to the base of Q280 as a fast turn-off signal. The collector voltage waveform is shown in Fig. 3-6. Changing collector current is also transformer-coupled to the tapped secondary that drives the memory gate.

Memory Gate. The memory gate consists of the center-tapped secondary of T280 with its DC level set by the emitter follower, two parallel RC circuits and two silicon diodes. As Q280 is turned on, the secondary voltage of T280 reverse biases D292 and D293 and no current flows. As Q280 stops conducting, the secondary of T280 drives D292 and D293 into conduction and at the same time charges both C292 and C293 to about 7 volts. (The energy for charging the two capacitors comes from the core of T280.) D292 and D293 are computer diodes with equal forward drop at the time they conduct, making the voltage at their junction with C294 equal to the voltage at the center of T280 secondary. Thus, during the backswing time of T280, the voltage at the center of T280 secondary appears at C294. The backswing lasts for about 0.4 μs, which is plenty of time to fully charge C294 to the voltage of the emitter follower. During each backswing, C292 and C293 are recharged to replace the small amount of voltage discharged by the resistors R292 and R293. The time constant of the two RC circuits is 1 ms each, many times longer than the 63.5 μs between sampling times.

Memory Circuit. The memory circuit includes the memory capacitor C294 and the grid of V293A. Since D292-D293 are silicon diodes with very high reverse leakage, the memory capacitor charge is essentially constant between samples.

The four waveforms of Fig. 3-6 (taken with a four-channel oscilloscope) show the time-coincidence of the DC restorer circuit. Note that some of the color burst is seen by the memory gate and memory capacitor. The reactance of the memory capacitor is about 440 ohms at 3.58 MHz; and the sampling diodes are turned on hard by T280 secondary so there is no color-burst rectification. Thus, the DC restorer circuit acts upon the average voltage of the color burst, keeping the display at the same stable position with or without the color burst.

Restorer Cathode Follower. The restorer cathode follower acts as an impedance transformer that couples the sampled and stored voltage into the vertical amplifier minus input grid. The two resistors, R298 and R299, offset the DC level of V293A cathode to the correct value for the minus input, setting the minus grid to essentially ground voltage when the system is correctly balanced.

Restorer Operation on Calibrator Signal. This mode of restorer operation uses the —H regenerated horizontal sync pulse to fire the blocking oscillator. The —H signal starts negative at the same time calibrator signal goes negative. The blocking oscillator fires as the —H signal goes negative, causing the DC restorer circuit to sample the signal voltage about 0.88 μs after the beginning of the calibrator negative

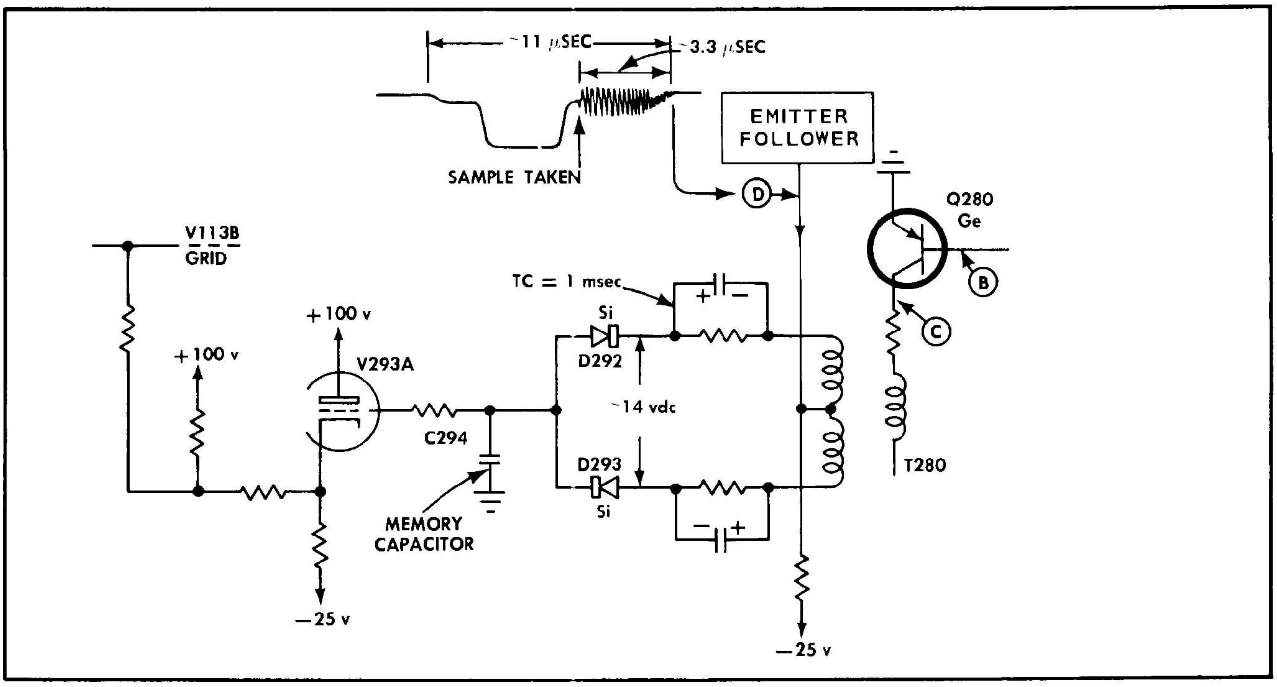


Fig. 3-8. Sampling and memory portions of DC Restorer circuit.

half-cycle. Thus, the display is stabilized at the bottom of the calibrator signal and held in the same position as the back porch.

Sync Separator

The sync separator processes composite video so the sweep generator is triggered properly for the various modes of the DISPLAY switch.

The input to the sync clamping amplifier can be from one of two sources; the internal trigger signal from the video output amplifier or an external sync input, usually composite video. The selection of source is made by the SYNC switch. Source switching is by diodes, and the actual SYNC switch is isolated from the video leads by R305. When the SYNC switch is set to INT, D301 is back biased and D304 is forward biased. The signal passes through forward-biased D304 into the grid of V293B. When the SYNC switch is set to EXT, D304 is back biased and D301 is forward biased, so the signal passes through D301. The internal-external sync selection can be made from the front panel for all vertical input modes except when viewing the calibrator signal. When the vertical INPUT switch is at CAL, the sync input is automatically switched over to internal.

Sync Clamping

The sync clamping amplifier has two feedback loops. One is a normal type consisting of R315, with the gain of Q314 set by R315 and the transconductance of V293B.

A feedback amplifier of the type in the sync clamping amplifier, shown in Fig. 3-9, has low input impedance called virtual ground, and a low output impedance. The virtual ground is easy to visualize when we find equal and opposite currents in the input resistor (R_i) and the feedback resistor (R_f). Assume R_f of Fig. 3-9 to be 22 kΩ and R_i to also be 22 kΩ. A one-volt IN signal will cause 0.045 mA to flow in R_i. The transistor collector will change voltage level (also 1 volt) until an opposite 0.045 mA flows in R_f at which time the input signal is balanced, so none is left for the base. When $R_i = R_f$ the voltage gain is unity.

V293B cathode output impedance is approximately equal to 1/Gm or typically 1/0.001 S[1] = 1000 Ω. (Normal range of

[1] siemens = mho

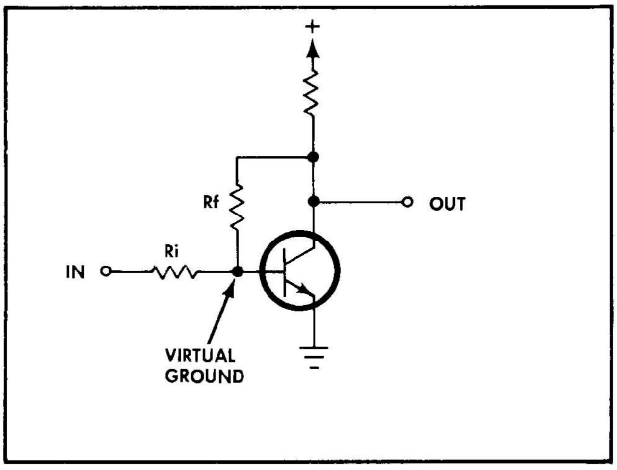


Fig. 3-9. Simplified Feedback amplifier.

output resistance between tubes will be from about 600 to 1200 Ω). The cathode-follower output resistance can be considered directly in series with the input grid for calculating signal current to the base of Q314. Thus, the typical voltage gain of Q314 is $\frac{22\ k\Omega}{1\ k\Omega} = 22$.

A second feedback loop around the Sync Clamping Amplifier is composed of R317, R318 and C317. This loop acts as a DC restorer for signals into the rest of the triggering circuitry. Negative-going composite video at the grid of V293B causes the collector of Q314 to go positive. As each negative-going sync tip occurs, C304 charges slightly positive, then as the collector voltage of Q314 falls, C317 gains a negative charge that is the average of the input signal amplitude. C304 thus receives a charge as each sync tip occurs, then discharges through R317 to C317 at all other times. The discharge current for C304 is approximately proportional to video level. The effect of the action just described is that C304 acts as a DC restorer for the Sync Clamping Amplifier for a wide range of signal levels. Restorer action thus holds the Sync Clamping Amplifier output (at the sync pulse tips) at a stable level of about —0.5 volt.

Any large noise pulses riding on the negative-going composite video will cause the collector of Q314 to go positive enough to back bias D318; while at the same time, the large negative going pulse at the grid of V293B will cause D317 to be forward biased. Forward biased D317 will now cause the charge rate of C304 to be limited by R319.

Video stripping occurs in the Sync Clamping Amplifier as the input signal goes positive, because available Q314 collector current through R314 is all taken by the feedback resistor R315. As V293B cathode applies positive-signal turn-off current to the base of Q314, Q314 collector goes negative until the current in R315 equals the current in from V293B cathode. At that point, the collector voltage stops going negative and the remaining positive signal input to V293B grid is not amplified. Thus, the DC-restored sync tips out of the Sync Clamping Amplifier have a maximum peak amplitude of about 13 volts with the video information removed from large signals.

Sync Regenerator

The Sync Regenerator is a Schmitt multivibrator whose operation is bistable due to the DC coupled input signal from Q314 collector. Q335 conducts when the base of Q325 is near ground, and Q325 conducts when the input is more negative than about —4 volts. Output signals are each about 8 or 9 volts peak to peak. The TRIG MULTI BIAS control is adjusted for proper triggering on low-level video sync signals in case the Sync Regenerator input signal is less than normal.

Assume Q325 is conducting. As the input signal goes positive, current in Q325 is reduced, allowing its emitter to go positive and its collector to go negative. Q325 emitter is coupled to Q335 emitter and Q325 collector is coupled to Q335 base. Initially the back bias at the base-emitter junction of Q335 prevented it from conducting. As Q335 bias reaches the point of conduction, regenerative action flips the conduction from Q325 to Q335 rapidly. As long as a sync tip holds the base of Q325 up near ground, Q335 will conduct. As Q325 base starts negative, Q325 begins to conduct and a second regenerative action switches Q335 off and Q325 on. The regenerative path is between the emitters of Q325-Q335 and from the collector of Q325 to the base of Q335.

Both the +H and —H signals are available for the keyed DC Restorer circuit previously described, and for the rest of the triggering circuitry.

FIELD SELECTOR

The Field Selector circuit includes the Vertical Sync Separator, the Field 1 Recognition circuit and the Field Trigger Generator.

Vertical Sync Separator. The Vertical Sync Separator is primarily a differentiator and an amplifier biased off about 3 volts. The differentiator, C341-R341, shifts the signal output DC level depending on the pulse duty cycle. If the incoming square-wave signal negative peaks are of longer duration than the positive peaks, the output will be more positive than negative. Likewise, if the incoming signal positive peaks are of longer duration that the negative peaks (vertical sync), the output will be more negative than positive. During the time C341 receives only regenerated horizontal sync pulses, the signal at the base of 344 shifts between about 2 volts negative and 6.5 volts positive and Q344 does not conduct. As the vertical sync group occurs, the signal at the base of Q344 shifts to between about 6 volts negative and 2.5 volts positive, turning Q344 on hard each time the signal goes below about —3.5 volts.

Both the Field 1 Recognition circuit and the Field Trigger Generator require a single pulse, the first of the vertical sync pulses. The parallel combination of R346-D346 and the capacitance of C347 allow only the first vertical pulse to pass through. As the collector of Q344 rises positive 20 volts, D346 passes the whole pulse to C347 (and C351). C347 charges to more than half the peak voltage of the first pulse. The very high reverse resistance of D346 and the resistance of R346 let C347 keep its charge. The second vertical sync pulse is, thus, not able to be coupled on since the cathode of D346 is already several volts more positive than it was before the arrival of the first pulse. (Some of the second pulse gets through the coupling capacitors, but does not affect the following circuits.) R346 discharges C347 (and C351) before the next vertical pulse arrives.

Field 1 Recognition. The field 1 recognition circuit is a one-shot multivibrator (mono-stable) with two input paths. The single vertical sync pulse that arrives through C351 to the base of Q355 turns Q355 on and Q365 off. The switching action is regenerative due to emitter coupling, and coupling from Q355 collector to Q365 base. C360 was initially charged to about 13 volts. As Q355 collector falls, the base of Q365 is taken about 11 volts negative. The FIELD 1 SYNC control (R360), in series with R361, starts the base of Q365 back toward ground, discharging C360. As the voltage at the base of Q365 nears a value that would cause Q365 to turn on, a positive pulse coupled to the base through C361 will turn it on and reset the multi. The time constant of C360 and R360-R361 is set such that the multi is reverted at the end of the last vertical equalizer pulse. (The waveform near the collector of Q365 on the diagram at the back of this manual shows capacitively-coupled pulses that pass through C361 and the base-to-collector capacitance of Q365. This is normal and does not indicate Q365 to be defective). As Q365 collector goes negative at the end of the last equalizing pulse, C364 and R368 form a negative pulse that ramps up for a period of 50 to 55 μs. C370 couples differentiated —H pulses and adds them to the ramp at the junction of R369 and D370. If a horizontal pulse occurs during the time the ramp is running up, the output through D370 is more negative than at any other time. A two-field interlace horizontal sync pulse occurs in the middle of every other ramp.

All the other negative pulses at the junction of R369-D370 charge C371 (through R372) to an essentially stable DC voltage (R371 does not appreciably discharge C371 between pulses). As a field 2 occurs, the more negative pulse that coincides with the field 1 recognition ramp is coupled through D371 to the base of Q375, flipping the field trigger generator so that Q375 conducts.

Field Trigger Generator. The field trigger generator is a bistable multivibrator that changes state each time a positive pulse arrives through C347 from the vertical sync separator. The triggering pulse is coupled to the bases of Q375-Q385 through diodes D374-D384 and the RC networks of C375-C385. The positive-polarity pulse turns off the conducting transistor regardless of which is conducting. The pulses arrive at a 60-hertz output rate, causing the field trigger generator to have a 30-hertz output rate at each collector.

If Q375 is off when the negative-going field 1 signal from the field 1 recognition circuit arrives at the base of Q375, Q375 will be turned on. A positive signal from the sync separator to each collector at the start of each field, and a negative pulse to Q375 base at each field 1 assures that the field trigger generator output is always related to field 1 and field 2 of the composite video. The collector of Q375 always goes positive (toward ground) at the beginning of each field 1. The collector of Q385 always goes positive at the beginning of each field 2.

Field shift switching is the selection of the correct field trigger generator output pulse by a dual input single output diode switch. Positive-going trigger pulses are needed by the sweep generator and by the delay generator. Thus, to trigger on a field 1, the field shift switch causes Q375 collector signal to be coupled on, and for a field 2, Q385 collector signal to be coupled on.

Assume a field 2 trigger is selected. The CRT display will start the sweep on a field 2 and show the field 1 at center screen. The FIELD switch (set at TWO) applies a negative bias to D377 anode, assuring that it cannot conduct the signal from Q375 collector to the following circuits. D387 will pass the positive portion of the differentiated Q385 collector signal. Differentiation of Q385 collector signal is by C384 and the parallel resistance of R388 and R379-R389. As Q385 collector rises, C384 couples the first of the full step through to D387 and the rest of the circuit. C384 soon charges, dropping the voltage at the cathode of D387 back to ground level. As Q385 collector falls, D387 disconnects the signal from the rest of the circuit and R388 recharges C384 for the next positive pulse. The contacts of K385 are described with the staircase amplifier later in this section.

Line Selector (SN 1910-up)

The line selector circuit includes the delay generator and the line pickoff circuit. The selected line-trigger pulses occur once each field, at an adjustable time interval after each vertical sync pulse.

Delay Generator. The delay generator is normally biased so Q405 is conducting and Q415 is cut off. Q415 collector rests at +24 volts because of the voltage divider R414, R415, R418 and Q420. (The LINE SELECTOR variable control current from —25 volts through R428 to the junction of R419-C419 will not take the junction significantly below ground, because a 24-volt drop exists across R415 and another of up to 25 volts across R428). Q405 collector rests at —1 volt, holding Q415 base of about —2.6 volts by the drop across R405-R406. Q414 is saturated (collector voltage pulled down very near emitter voltage) due to base current through R417. Thus, the emitter and collector current of Q405 is set by R419 and the —24 volts at Q414 collector. The delay generator will remain in this condition until a positive trigger pulse arrives at the base of Q415.

As a positive pulse turns on Q415, the current through Q414-R419 shifts to Q415, and Q405 turns off. As Q415 collector starts negative, C417 couples the voltage change into the base of Q414 in a direction to reduce its collector current. As the base of Q414 is taken far enough negative to almost turn off its collector current, the drop in Q415 collector voltage is nearly eliminated until the current through R417 discharges C417. As C417 discharges a bit, the base voltage of Q414 turns on a bit more current. The current of Q414 is also the current in Q415, which again pulls down on C417. The result of the feed-back just described is that C417 is discharged in a very linear manner by current through R417. The voltage at the junction of C417-R417 remains essentially constant while the collector of Q415 pulls the other side of C417 negative at a rate set by the current through R417.

When the collector voltage of Q415 reaches ground level and stops going negative, current through R417 raises the base voltage of Q414 and increases its current. Increased current in Q414 pulls both Q415 emitter and base elements negative, allowing the collector to go negative also. The common emitter-to-emitter lead of Q405-Q415 drops negative until Q405 again turns on. The collector voltage of Q405 drops and quickly turns Q415 off, letting its collector voltage rise in the positive direction as R414 charges C417 to its original state. (C414 cancels Q415 initial negative collector surge caused by shifting Q414 current from about 5 mA in Q405 to about 0.27 mA in Q415. Without C414, the collector voltage of Q415 would drop sharply negative at the time Q415 was triggered into conduction.) C417 charging current is limited only by R414 since the negative end of the capacitor is tied to —25 volts through Q414 base-emitter junction.

Line Selector (SN 100-1909)

The line selector circuit includes the delay generator and the line pickoff circuit (blocking oscillator). The selected line-trigger pulses occur once each field, an adjustable amount of time after each vertical sync pulse.

Delay Generator. The delay generator is normally biased so Q405 is conducting and Q415 is cut off. Q415 collector rests at +24 volts because of the voltage divider R414, R415-D415. The LINE SELECTOR variable control current from —25 volts through R428 to the junction of R415-D415 will not take the junction significantly below ground because a 24 volt drop exists across R415 and another of up to 25 volts across R428.) Q405 collector rests at —1 volt, holding Q415 base at about —2.6 volts by R405-R406. Q414 is saturated (collector voltage pulled down very near emitted voltage) due to base current through R417. Thus the emitter and collector current of Q405 is set by R419 and the —24 volts at Q414 collector. The delay generator will remain in this condition until a positive trigger pulse arrives at the base of Q415.

As a positive pulse turns on Q415, the current through Q414-R419 shifts to Q415 and Q405 turns off. As Q415 collector starts negative, C417 couples the voltage change into the base of Q414 in a direction to reduce its collector current. As the base of Q414 is taken far enough negative to almost turn off its collector current, the drop in Q415 collector voltage is nearly eliminated until the current through R417 discharges C417. As C417 discharges a bit, the base voltage of Q414 turns on a bit more current. The current of Q414 is also the current in Q415 which again pulls down on C417. The result of the feed-back just described is that C417 is discharged very linearly by current through R417. The voltage at the junction of C417-R417 pulls the other side of C417 negative at a rate set by the current of R417.

When the collector voltage of Q415 reaches ground level and stops going negative, current through R417 raises the base voltage of Q414 and increases its current. Increased current in Q414 pulls both Q415 emitter and base elements negative, allowing the collector to go negative also. The common emitter-to-emitter lead of Q405-Q415 drops negative until Q405 again turns on. The collector voltage of Q405 drops and quickly turns Q415 off, letting its collector voltage rise in the positive direction as R414 charges C417 to its original state. (C414 cancels Q415 initial negative collector surge caused by shifting Q414 current from about 5 mA in Q405 to about 0.27 mA in Q415. Without C414, the collector voltage of Q415 would drop sharply negative at the time Q415 was triggered into conduction.) C417 charging current is limited only by R414 since the capacitors negative end is tied to —25 volts through Q414 base-emitter junction.

The blocking oscillator section of the delay generator and its signals are shown in Fig. 3-10. The knee of waveform C where D415 stops conducting is adjustable by the LINE SELECTOR variable control. The knee is the point at which R415-R428 voltage division of the sawtooth output waveform causes the voltage at the blocking oscillator input to start negative. Negative differentiated horizontal sync pulses (waveform B, with their positive peaks removed by D427) are added to the sawtooth so that the blocking oscillator will fire at the time of a horizontal sync pulse. As the base of Q420 is pulsed far enough negative to cause it to conduct, transformer regenerative feedback turns it on hard. The collector is held stable for a short period of time by C424, causing the emitter to go sharply negative until it is more negative than the base. This turns off the drive and T420 aids in quickly turning off the pulse. R420 helps dissipate base winding inductive energy and D420 helps dissipate emitter winding energy so a second ringing type pulse is not generated. The negative emitter pulse is coupled to the trigger selector switch through R436-C436.

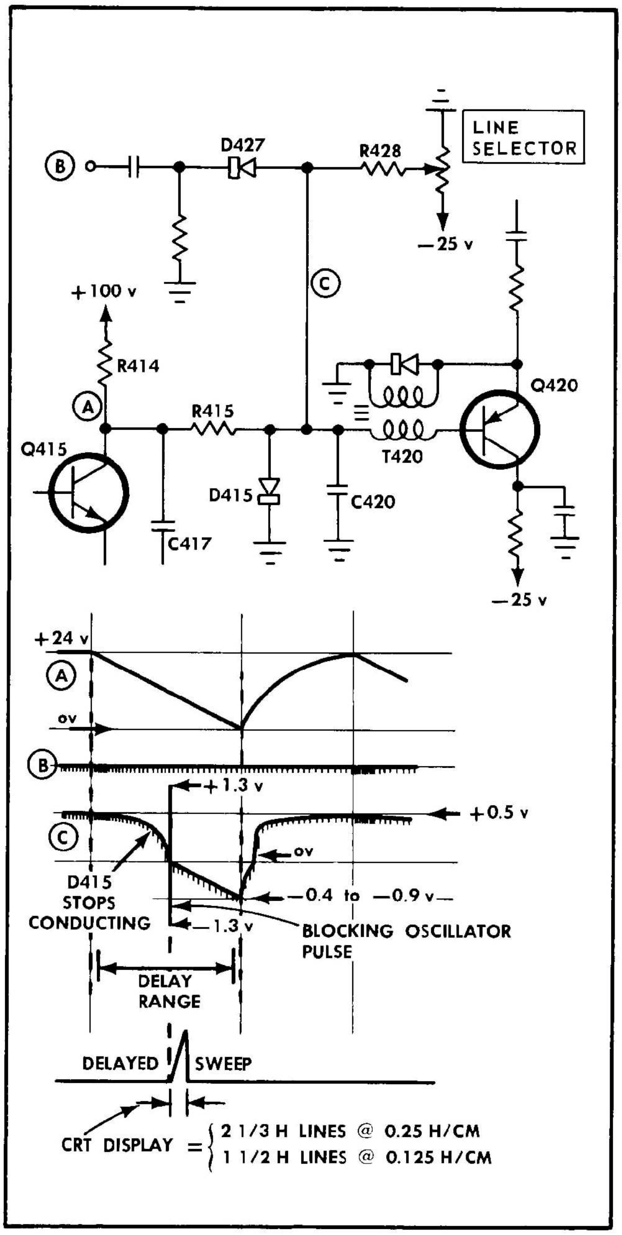


Fig. 3-10. Blocking oscillator section of the Delay Generator (SN 100-1909) and waveforms.

Sweep Generator (SN 2997-up)

The sweep generator is a triggered sweep system for all positions of the DISPLAY switch except the 2 FIELD position, at which it is a recurring synchronized sweep. Positive field-trigger pulses prevent the sweep from operating in 2 FIELD and both LINE SELECTOR positions (LINE SELECTOR set to a line, lines 16 through 21). Negative line-trigger or selected line pulses start the sweep in all other modes of operation. The sweep rate at 2 LINE permits viewing the interlacing of the color burst. The sweep rate at 0.125 H/cm permits a look at

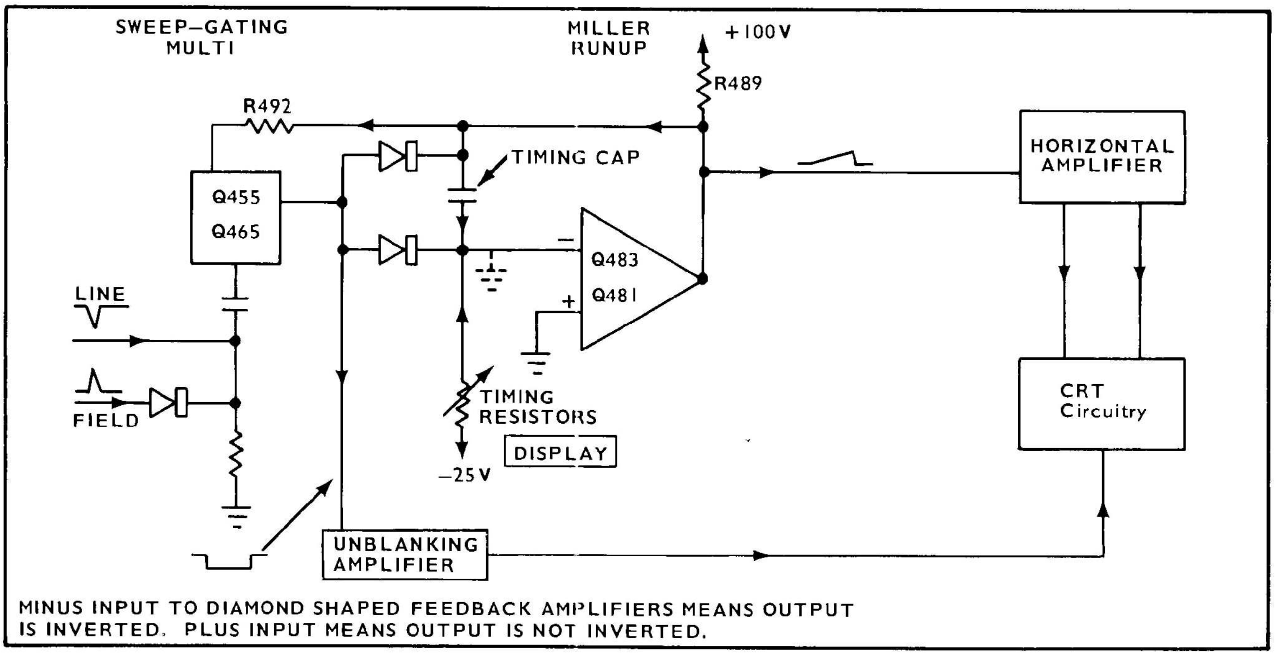


Fig. 3-11. Simplified Sweep Generator.

every other horizontal line displaying a non-interlaced color burst. Refer to the simplified sweep generator diagram of Fig. 3-11 and the complete diagram at the back of this manual during the following circuit description.

Trigger Selector Matrix

Selection of recurrent negative line trigger pulses at the beginning of each horizontal line, or of selected line pulses, is made in a diode switching network of the DISPLAY switch.

When the DISPLAY switch is at a LINE SELECTOR position and the LINE SELECTOR switch is set to a line (lines 16 through 21) position, both D430 and D436 are reverse biased so that no negative triggers get to the sweep gating multi. At the same time, D452 is forward biased through R450 so positive field triggers are available to the sweep gating multi.

When the DISPLAY switch is at its LINE SELECTOR positions and the LINE SELECTOR switch is set to VARIABLE, the cathode of D430 is raised about 9.5 volts positive and the diode is reverse biased so it cannot conduct negative line triggers to the sweep gating multi. D436 does conduct negative selected line pulses to the sweep gating multi.

When the DISPLAY switch is at 2 FIELD, both D430 and D436 are reverse biased, so that no negative triggers get to the sweep gating multi. At the same time, D452 is forward biased through R450 so positive field triggers are available to the sweep gating multi.

Sweep Gating Multi

The sweep generator is operated in two basically different modes of operation as suggested earlier. The sweep gating multi operation is altered from a triggered system for 2 LINE, .25 H/CM, .125 H/CM and both LINE SELECTOR positions of the DISPLAY switch with the LINE SELECTOR switch set to VARIABLE to a stopped-sweep system for both LINE SELECTOR positions of the DISPLAY switch when LINE SELECTOR switch is set to a line (lines 16 through 21), and to a free-running stopped-sweep systems for 2 FIELD displays.

2 LINE DISPLAY. (Vertical INPUT switch at A, DISPLAY switch at 2 LINE.) The sweep generator is held in one state by the sweep gating multi until the arrival of a negative trigger pulse. Before receipt of a trigger pulse, the following conditions exist:

a. Q455 is conducting, Q465 is in a state of non-conduction.

b. Both disconnect diodes are conducting. D482 is applying positive turn-on current from R468 to the miller runup input base, while D481 is limiting the turn-on current, as the collector of Q481 pulls down and takes some of the current flow from R468.

c. Q481 collector voltage is at about +1 volt, so that essentially no current is delivered through R520 (see horizontal amplifier diagram) to the horizontal amplifier.

d. The unblanking amplifier output is near ground, turning off the CRT beam.

e. The CRT horizontal deflection plates hold the blanked beam at the left side of the CRT (depending upon the setting of the POSITION control).

Q455 is held in conduction by current through the series resistors R464-R465 and D466, limited by R470 current into the base-emitter junction of Q474. The base turn-on current to

Q455 is enough to saturate it; however, D455 bypasses some of the intended base current when the collector voltage drops slightly below D466 anode voltage. This prevents the transistor from saturating. (If Q455 were to saturate, the base-emitter junction would hold so many carriers that the transistor could not be turned off quickly.) The fact that Q455 collector voltage is near ground assures that no current reaches the base of Q465, and Q465 remains cut off.

As the negative-going line trigger pulse arrives at the base of Q455 through C452, Q455 is turned off. The voltage rise at the collector of Q455 is coupled to the base of Q465, turning it on. As the current begins to flow in Q465, its collector voltage drop aids in turning Q455 off and the switching action takes place very rapidly. (Consider the emitter of Q465 as grounded; the components in its emitter circuit are used in 2 FIELD and LINE SELECTOR operation when LINE SELECTOR switch is set to a line, line 16 through 21 and are of no importance in 2 LINE operation.)

Miller Runup

As Q465 collector voltage falls below about +1.3 volts, D464 conducts and takes the anodes of the disconnect diodes toward ground. Both D481 and D482 stop conducting. The timing resistor current that had been flowing through D482 is immediately transferred to the base of Q483. The current that had been flowing in D481 through Q481 is cancelled by a slight drop in voltage at the base of Q481. As Q483 base starts negative, the base of Q481 also starts negative and reduces its collector current, causing its collector voltage to start positive. The timing capacitor couples the positive voltage of Q481 collector back to Q483 base, essentially stopping its negative travel. The result is that the timing capacitor receives a charge at a rate set by the timing resistor, creating a very linear positive-going sawtooth voltage at the collector of Q481. The miller runup circuit can be defined as a feedback amplifier, with the feedback element a timing capacitor, and the input resistor a timing resistor; the input signal is the —25-volt supply (see Fig. 3-9 and associated text for description of a feedback amplifier).

The sweep voltage rises positive until R492 raises the base voltage of Q455 far enough to revert the sweep gating multi. As Q455 conducts, the collector voltage of Q465 raises in the positive direction. D464 stops conducting and R468 raises the base voltage of Q483 positive through D482. This causes collector current in Q481 to increase rapidly. This collector current discharges the timing capacitor at a linear rate set by R468. As Q481 collector voltage approaches the voltage at the base of Q483, D481 takes some of the R468 current and stops the rundown. (D486 offsets the base voltage of Q481 in a direction to limit the quiescent current in D481, permitting the next sweep runup to start linearly.) The rate of rundown is slow enough that the sweep is triggered every other horizontal sync pulse, presenting a non-interlaced color burst. The sweep generator then waits for another negative line-trigger pulse to turn off Q455 and start the cycle over again.

2 FIELD DISPLAY. Operation of the sweep gating multivibrator is changed from a state where a trigger is required to start the sweep, to a condition where the sweep starts automatically, and is stopped by a trigger pulse. If the sweep is not running when the DISPLAY switch is set to 2 FIELD, Q465 of the sweep gating multi is not conducting. The DISPLAY switch connects R461A to the —25-volt supply and the emitter voltage starts negative. D461 is reverse biased, and the rate of fall is set by the time constant of R461A-C463. Approximately 1 millisecond after Q465 emitter voltage starts negative, the sweep gating multi switches so that Q465 is on and Q455 off. The sweep voltage runs up as described for 2 LINE operation.

The DISPLAY switch also changes the output of the trigger selector matrix, forward biasing D452 through R450 so that positive pulses will come through D452, and will turn on Q455 to stop the sweep. The positive pulse that turns Q455 on occurs at every other vertical sync pulse. The sweep is stopped, runs down very rapidly (due to additional rundown current from R453 in parallel with R468), waits 1 millisecond and automatically starts again, just before the video portion of the next field.

In the event vertical input composite video stops, the sweep will continue to cycle, but instead of positive pulses stopping the sweep, Q455 is turned on by sweep voltage feedback through R491-R492 in the same manner as described for 2 line operation. Thus, the Type RM529 Monitor will show a sweep without vertical information when the DISPLAY switch is set to 2 FIELD, but requires a trigger signal from the sweep to operate in all other positions of the DISPLAY switch.

With the INPUT switch set to CAL, R469 is placed in parallel with R468 so the rundown rate will be rapid enough to prepare the sweep to run again at the next calibrated signal transition. This assures a cleanly triggered calibrator display without the possible jitter caused by a longer rundown.

The runup rate of the miller runup circuit is slowed by adding C483 across the timing capacitor used in 2 LINE operation. C483 does not affect the sweep voltage peak value, but changes only the rate at which the spot moves across the CRT. Television systems with different time per field than the 30-hertz U. S. A. rate require a change in the value of C483 to change the sweep rate. For longer time per field, increase C483 value; for less time per field, decrease C483 value. Modification of C483 is normally made at the factory at time of purchase.

The miller runup circuit drives the horizontal amplifier and staircase amplifier.

LINE SELECTOR DISPLAY. Operation of the sweep gating multivibrator is changed from a state where a trigger is required to start the sweep, to a condition where the sweep gating multivibrator starts automatically, runs until a —H pulse latches it and causes it to switch and start the sweep voltage running up. After the sweep voltage has run up, the sweep gating multivibrator is reset by a field selected frame rate trigger pulse. If the sweep is not running when the DISPLAY switch is set to the LINE SELECTOR position (LINE SELECTOR switch set to line 21), Q465 of the sweep gating multi is not conducting. The DISPLAY switch connects R461A to the —25-volt supply through R461B, R461C, R461D, R461E, R461F and R461G (if FIELD switch is set to 2) and the emitter voltage starts negative. D461 is reverse biased, and the rate of fall is set by the time constant of C463-R461A, R461B, R461C, R461D, R461E, R461F and R461G. At a time which is determined by the setting of the LINE SELECTOR switch and the FIELD switch, after Q465 emitter voltage starts negative, it will be negative enough to be latched by one of the —H pulses applied through C462 to the emitter of Q465. The latching by the —H pulse causes the sweep gating multi to switch so that Q465 is on and Q455 off. The sweep voltage runs up as described for 2 LINE operation. After the sweep voltage has run up, the sweep gating multi is reset by a field selected frame rate trigger pulse.

Since the VIT LINE SEL RANGE control, R458, varies the base voltage of Q465 only a small amount, it is used to set the exact time that Q465 will turn on.

The DISPLAY switch also changes the output of the trigger selector matrix, forward biasing D452 through R450 so that positive pulses will come through D452, and will turn on Q455 to stop the sweep. The positive pulse that turns Q455 on occurs at every other vertical sync pulse. The sweep is stopped, runs down, waits for the time set by the LINE SELECTOR switch and the FIELD switch, then automatically starts again, just before the desired horizontal line.

Unblanking Amplifier

The unblanking amplifier (Q474) responds to the sweep gating multi (Q465) collector signal. When there is no sweep, the CRT beam is pulled away from the deflection plates and phosphor screen, preventing any spot from being seen. Q474 collector is near ground at the time of no sweep, turning off the CRT beam. As the sweep gating multi switches states to start a sweep, Q474 is biased to cutoff and its collector rises to +101 volts, limited by conduction of D474 and D475.

The unblanking amplifier provides two more output signals during line selector sweep operation. One is the video output intensification discussed with the vertical amplifier description. The other increases the CRT beam current to intensify the CRT trace for the short duration of the line selector sweeps.

The collector signal of Q474 does not pull down on the trace intensification line; rather, that line is pulled down by R476 and the —5 volts of the video output amplifier circuit between sweeps when the DISPLAY switch is set to either Line Selector position. The collector voltage of Q474 is near ground most of the time in line selector modes, because of the short-duration sweeps recurring at the 30-hertz rate (once every 33.3 ms). The trace intensification line (at R477-R478 junction) drops to +5 volts in about 2.6 ms as the combination of R476-R477 discharges C478 and changes the charge on C477.

As the sweep starts, Q474 collector rises quickly, sending an integrated pulse to the CRT grid circuit. R478 permits the step to rise abruptly to +22 volts, then continue to rise at an RC rate. The rising signal to the CRT grid is required to keep the cathode current constant during the intensification period, assuring a uniform CRT intensity throughout each sweep.

R476 also conducts current into the 75 ohms of the VIDEO OUTPUT connector, adding about 0.1 volt to the video output to intensify a line of the studio monitor, identifying which line the Type RM529 Monitor is viewing.

Sweep Generator (SN 100-2996)

The sweep generator is a triggered sweep system for all positions of the DISPLAY switch except the 2 FIELD position, at which it is a recurring synchronized sweep. Positive field-trigger pulses stop the sweep in 2 FIELD operation. Negative line-trigger or selected line pulses start the sweep in all other modes of operation. The sweep rate at 2 LINE permits viewing the interlacing of the color burst. The sweep rate at 0.125 H/cm permits a look at every other horizontal line displaying a noninterlaced color burst. Refer to the simplified sweep generator diagram of Fig. 3-11 and the complete diagram at the back of this manual during the following circuit description.

Trigger Selector Matrix

Selection of recurrent negative line trigger pulses at the beginning of each horizontal line, or of selected line pulses, is made in a diode switching network of the DISPLAY switch.

When the DISPLAY switch is at either of its LINE SELECTOR positions, the cathode of D430 is raised about 9.5 volts positive and the diode is reverse biased so it cannot conduct negative line triggers to the sweep gating multi. D436 does conduct negative selected line pulses to the sweep gating multi.

When the DISPLAY switch is at 2 LINE, .25 H/CM, or .125 H/CM, D436 cathode is reverse biased about +29 volts to prevent selected line pulses from getting to the sweep gating multi. D430 does conduct negative line-trigger pulses to the sweep gating multi.

When the DISPLAY switch is at 2 FIELD, both D430 and D436 are reverse biased so that no negative triggers get to the sweep gating multi. At the same time, D452 is forward biased through R450 so positive field triggers are available to the sweep gating multi.

Sweep Gating Multi

The sweep generator is operated in two basically different modes of operation as suggested earlier. The sweep gating multi operation is altered from a triggered system for line displays to a free-running stopped-sweep system for 2 field displays.

2 LINE DISPLAY. (Vertical INPUT switch at A, DISPLAY switch at 2 LINE.) The sweep generator is held in one state by the sweep gating multi until the arrival of a negative trigger pulse. Before receipt of a trigger pulse, the following conditions exist:

a. Q455 is conducting, Q465 is in a state of nonconduction.

b. Both disconnect diodes are conducting. D482 is applying positive turn-on current from R468 to the miller runup input base, while D481 is limiting the turn-on current, as the collector of Q481 pulls down and takes some of the current flow from R468.

c. Q481 collector voltage is at about +1 volt, so that essentially no current is delivered through R520 (see horizontal amplifier diagram) to the horizontal amplifier.

d. The unblanking amplifier output is near ground, turning off the CRT beam.

e. The CRT horizontal deflection plates hold the blanked beam at the left side of the CRT (depending upon the setting of the POSITION control).

Q455 is held in conduction by current through the series resistors R464-R465 and D466, limited by R470 current into the base-emitter junction of Q474. The base turn-on current to Q455 is enough to saturate it; however, D455 bypasses some of the intended base current when the collector voltage drops slightly below D466 anode voltage, which prevents the transistor from saturating. (If Q455 were to saturate, the base-emitter junction would hold so many carriers that the transistor could not be turned off quickly.) The fact that Q455 collector voltage is near ground assures that no current reaches the base of Q465, and Q465 remains cut off.

As the negative-going line trigger pulse arrives at the base of Q455 through C452, Q455 is turned off. The voltage rise at the collector of Q455 is coupled to the base of Q465, turning it on. As current begins to flow in Q465, its collector voltage aids in turning Q455 off and the switching action takes place very rapidly. (Consider the emitter of Q465 as grounded; the three components in its emitter circuit are used in 2 FIELD operation and are of no importance in 2 LINE operation.)

Miller Runup

As Q465 collector voltage falls below about +1.3 volts, D464 conducts, and takes the anodes of the disconnect diodes toward ground. Both D481 and D482 stop conducting. The timing resistor current that had been flowing through D482 is immediately transferred to the base of Q483. The current that had been flowing in D481 through Q481 is cancelled by a slight drop in voltage at the base of Q481. As Q483 base starts negative, the base of Q481 also starts negative and reduces its collector current, causing its collector voltage to start positive. The timing capacitor couples the positive voltage of Q481 collector back to Q483 base, essentially stopping its negative travel. The result is that the timing capacitor receives a charge at a rate set by the timing resistor, creating a very linear positive-going sawtooth voltage at the collector of Q481. The miller runup circuit can be defined as a feedback amplifier, with the feedback element a timing capacitor, and the input resistor a timing resistor; the input signal is the —25-volt supply (see Fig. 3-9 and associated text for description of a feedback amplifier.)

The sweep voltage rises positive until R492 raises the base voltage of Q455 far enough to revert the sweep gating multi. As Q455 conducts, the collector voltage of Q464 rises in the positive direction. D464 stops conducting and R468 raises the base voltage of Q483 positive through D482. This causes collector current in Q481 to increase rapidly. This collector current discharges the timing capacitor at a linear rate set by R468. As Q481 collector voltage approaches the voltage at the base of Q483, D481 takes some of the R468 current and stops the rundown. (D486 offsets the base voltage of Q481 in a direction to limit the quiescent current in D481, permitting the next sweep runup to start linearly.) The rate of rundown is slow enough that the sweep is triggered every other horizontal sync pulse, presenting a non-interlaced color burst. The sweep generator then waits for another negative line-trigger pulse to turn off Q455 and start the cycle over again.

2 FIELD DISPLAY. Operation of the sweep gating multivibrator is changed from a state where a trigger is required to start the sweep, to a condition where the sweep starts automatically, and is stopped by a trigger pulse. If the sweep is not running when the DISPLAY switch is set to 2 FIELD, Q465 of the sweep gating multi is not conducting. The DISPLAY switch connects R461 to the —25-volt supply and the emitter voltage starts negative. D461 is reverse biased, and the rate of fall is set by the time constant of R461-C461. Approximately 1 millisecond after Q465 emitter voltage starts negative, the sweep gating multi switches so that Q465 is on and Q455 off. The sweep voltage runs up as described for 2 LINE operation.

The DISPLAY switch also changes the output of the trigger selector matrix, forward biasing D452 through R450 so that positive pulses will come through D452, and will turn on Q455 to stop the sweep. The positive pulse that turns Q455 on occurs every other vertical sync pulse. The sweep is stopped, runs down very rapidly due to additional rundown current from R453 in parallel with R468, waits 1 millisecond and automatically starts again, just before the video portion of the next field.

In the event vertical input composite video stops, the sweep will continue to cycle, but instead of positive pulses stopping the sweep, Q455 is turned on by sweep voltage feedback through R491-R492 in the same manner as described for 2 line operation. Thus, the Type RM529 Monitor will show a sweep without vertical information when the DISPLAY switch is set to 2 FIELD, but requires a trigger signal for the sweep to operate in all other positions of the DISPLAY switch.

With the INPUT switch set to CAL, R469 is placed in parallel with R468 so the rundown rate will be rapid enough to prepare the sweep to run again at the next calibrator signal transition. This assures a cleanly triggered calibrator display without the possible jitter caused by a longer rundown.

The runup rate of the miller runup circuit is slowed by adding C483 across the timing capacitor used in 2 LINE operation. C483 does not affect the sweep voltage peak value, but changes only the rate at which the spot moves across the CRT. Television systems with different time per field than the 30-hertz U.S.A. rate require a change in the value of C483 to change the sweep rate. For longer time per field, increase C483 value; for less time per field, decrease C483 value. Modification of C483 is normally made at the factory at time of purchase.

The miller runup circuit drives both the horizontal amplifier and the staircase amplifier.

Unblanking Amplifier

The unblanking amplifier (Q474) responds to the sweep gating multi (Q465) collector signal. When there is no sweep, the CRT beam is pulled away from the deflection plates and phosphor screen, preventing any spot from being seen. Q474 collector is near ground at the time of no sweep, turning off the CRT beam. As the sweep gating multi switches states to start a sweep, Q474 is biased to cutoff. Its collector rises to +101 volts, limited by conduction of D474 and D475.

The unblanking amplifier provides two more output signals during line selector sweep operation. One is the video output intensification discussed with the vertical amplifier description. The other increases the CRT beam current to intensify the CRT trace for the short duration of the line selector sweeps.

The collector signal of Q474 does not pull down on the trace intensification line; rather, that line is pulled down by R476 and the —5 volts of the video output amplifier circuit between sweeps when the DISPLAY switch is set to either Line Selector position. The collector voltage of Q474 is near ground most of the time in line selector modes, because of the short-

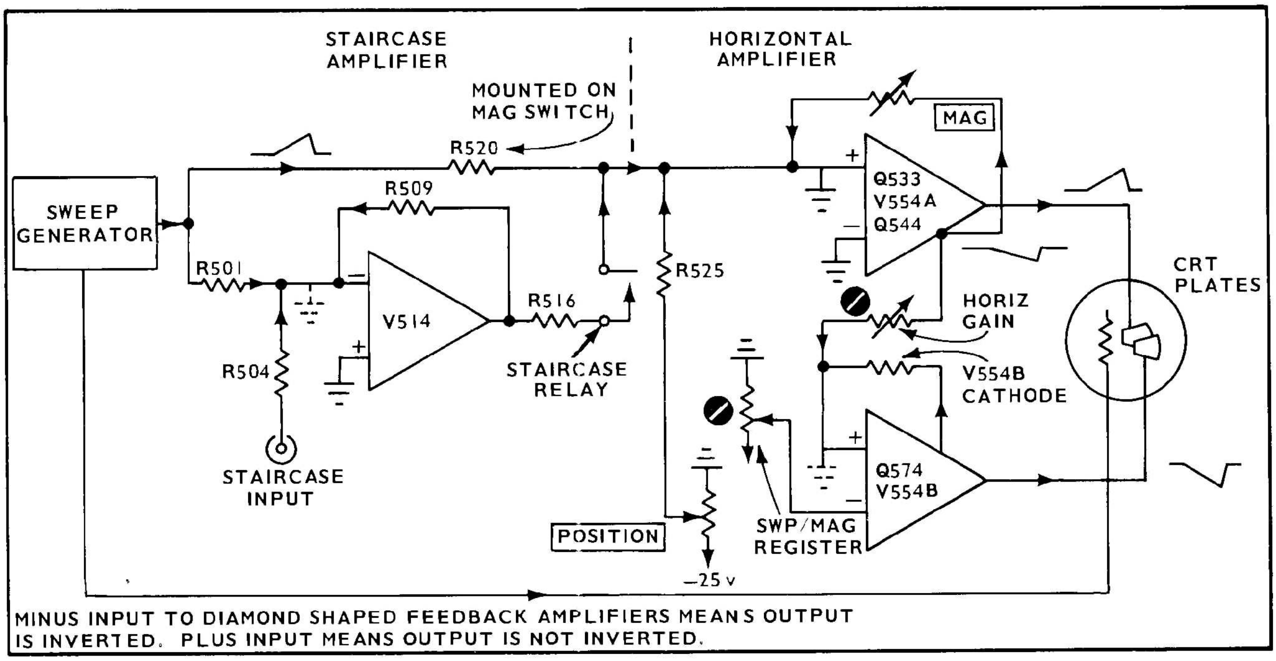


Fig. 3-12. Simplified Horizontal Amplifier.

duration sweeps recurring at a 30-hertz rate (once every 33.3 ms). The trace intensification line (at R477-R478 junction) drops to —5 volts in about 2.6 ms as the combination of R476-R477 discharges C478 and changes the charge on C477.

As the sweep starts, Q474 collector rises quickly, sending an integrated pulse to the CRT grid circuit. R478 permits the step to rise abruptly to +22 volts, then continue to rise at an RC rate. The rising signal to the CRT grid is required because the high-voltage power supply does not follow the increased current immediately, and the increasing grid signal turns on the CRT at about the same rate as the supply current decreases, assuring a steady CRT intensity throughout each sweep.

R476 also conducts current into the 75 ohms of the VIDEO OUTPUT connector, adding about 0.1 volt to the video output to intensify a line of the studio monitor, identifying which line the Type RM529 Monitor is viewing.

Horizontal Amplifier

The horizontal amplifier circuit includes the horizontal amplifier and the staircase amplifier. Refer to the simplified horizontal amplifier diagram of Fig. 3-12 and the complete diagram at the back of this manual during the following circuit description.

Horizontal Amplifier. The horizontal amplifier is a combination of feedback and paraphase amplifier. The base of Q533 is the virtual ground summing input terminal to the whole amplifier. Voltage gain of the overall amplifier is the ratio of the MAG resistance to the input resistance of R520. The DC level of the output (positioning) is through R525 to the base of Q533. The input to a feedback amplifier can have several input resistors and signals. The gain of each is the ratio of feedback resistor to input resistor. Feedback is from V544A cathode to the base of Q533. V544A cathode is also the signal source for the inverting half of the amplifier, through the HORIZ GAIN control R558-R568 to the base of Q574. Feedback in the inverting half of the amplifier is the cathode resistance of V554B to the base of Q574. The SWP/MAG REGIS control sets the DC balance of cathode voltages of V544A/V554B so the display center does not shift as the MAG switch is changed.

The sweep sawtooth enters through R520. Q533 is an emitter follower and current-gain transistor, driving the inverting amplifier Q544. Q544 signal output receives current gain in the cathode of V544A, assuring linear feedback from a low impedance. The plate of V554A provides a +150-volt swing that would be impossible to achieve with transistors. It acts in a normal vacuum tube fashion, with the input grid signal appearing inverted at the plate output.

The HORIZ GAIN resistance is degenerative to V554A, and is the signal coupling path to Q574. The signal from V554A cathode to Q574 base runs negative, increasing the current in Q574 collector. The collector voltage of Q574 becomes less negative and drives the grid of V554B to increase V554B current, raising the cathode to the level it had before the signal started negative. Note that the base of Q574 acts as a virtual ground for signals. V544B grid swings about 6.6 volts, turning on plate current so the plate swings about —150 volts.

Staircase Amplifier (SN 787-up)

V514 is a feedback amplifier with two input resistors to sum the sawtooth and studio color camera staircase voltages. When 25 volts is applied between pins D and E of J501, K385 causes R516 to become the third input to the horizontal amplifier. V514 inverts the sawtooth voltage so that the summed sawtooth signal to Q533 base is one-fourth its normal amplitude. The external input negative staircase signal is also inverted by V514.

With the staircase most positive, the sweep runs for the period of 1 field, and is reverted by a vertical sync trigger. At the time the sweep is reverted, the staircase drops negative to its second level. The sweep starts again, but begins one-fourth of the way across the CRT due to the staircase positioning signal. Again the sweep runs for 1 field, is reverted and the staircase drops to its third level. Once again the sweep starts, but one-half of the way across the CRT. Again the sweep runs for 1 field, is reverted and the staircase drops to its fourth level. Once again the sweep starts, but three-fourths of the way across the CRT. Thus, the three-color and black-white camera signals can all be viewed in one CRT display.

The staircase level shift takes about 800 μs. With the sweep gating multi operating in 2 FIELD, the sweep restarts in about 1 millisecond, so the change in staircase is not seen because the CRT beam is blanked off at the same time.

Closing the staircase relay also changes the timing resistor of the sweep generator so the sweep rate is twice as fast as that for 2 FIELD operation. The relay also changes the operation of the field selector to put out a positive pulse at each vertical sync pulse time instead of at every other one. Thus, the sweep recurs at a 60-hertz rate, taking four sweeps to get across the CRT.

Staircase Amplifier (SN 100-786)

V514 is a feedback amplifier with two input resistors to sum the sawtooth and studio color camera staircase voltages. When the control lead, pin D of J501, is externally grounded, K385 causes R516 to become the third input to the horizontal amplifier. V514 inverts the sawtooth voltage so that the summed sawtooth signal to Q533 base is one-third of its normal amplitude. The external input negative staircase signal is inverted by V514.

With the staircase most positive, the sweep runs for the period of one field, and is reverted by a vertical sync trigger. At the time the sweep is reverted, the staircase drops negative to its second level. The sweep starts again, but begins one-third of the way across the CRT due to the staircase positioning signal. Again the sweep runs for one field, is reverted and the staircase drops to its third level. Once again the sweep starts, but two-thirds of the way across the CRT. Thus, the three color camera signals can all be viewed on one CRT display.

The staircase level shift takes about 800 μs. With the sweep gating multi operating in 2 FIELD, the sweep restarts in about 1 ms, so the change in staircase is not seen because the CRT beam is blanked off at the same time.

Closing the staircase relay also changes the timing resistor so the sweep rate is twice as fast as that for 2 FIELD operation. The relay also changes the operation of the field trigger generator to put out a positive pulse at each vertical sync pulse time instead of at every other one. Thus the sweep recurs at a 60-hertz rate, taking three sweeps to get across the CRT.

Power Supply

The low-voltage power supply provides regulated —25 volts, +100 volts, and unregulated +360 volts to the circuits of the Type RM529. The —25 volt supply is the reference voltage for the +100-volt supply and the calibrator circuit.

The Type RM529 is powered by a dual primary power transformer for operation on either 115 or 230 volt 50-60 hertz line. Refer to the Operating Instructions section of this manual for converting from one supply voltage to the other.

—25-Volt Supply

Voltage for the —25-volt power supply comes from the full-wave rectifier system of D610-D611 and C610. Voltage across C610 is nominally 35 volts.

The —25-volt regulator consists of a comparator that compares a portion of —25 volts (divided by R624-R626 and the —25 VOLTS/CAL AMPL control R620) against the voltage of a precision zener diode D614. D614 zener voltage is about 9.1 volts. The comparator output at Q616 collector is inverted and amplified by Q634, which drives the series transistor Q637 in a direction to compensate for changes in the output voltage.

Assume the —25-volt supply level decreases and the voltage goes slightly positive. Q626 turns on harder, reducing the current in Q616 so its collector goes positive. Q634 turns on harder and pulls Q637 base in the negative direction, causing it to conduct harder, raising the output voltage back to its proper negative level. Since the collector of Q637 is grounded, the whole supply is moved by the emitter of Q637 to make the correction. R617-C617 at the base of Q634 reduce the feedback loop high-frequency gain for more stable operation with high-frequency load transients. C620 and C626 aid in reducing the high-frequency output impedance of the supply.

The —25-volt supply is the voltage source for the heaters of V113 and V293. R621 across V293 heater compensates the heater voltage for current taken by the constant current stage of the vertical preamplifier.

The value of the —25-volt supply directly sets the peak-to-peak amplitude of the calibrator signal; therefore the control used to adjust the supply is labeled —25 VOLTS/CAL AMPL. See the Calibration procedure for adjustment.

+100-Volt Supply

Voltage for the +100-volt supply is provided by the full-wave bridge rectifiers D640A-B-C-D and C640. The voltage across C640 is nominally 130 volts.

The +100-volt regulator compares a portion of the +100 volts (referenced to the —25-volt supply through the divider R641-R642) to ground at the emitter of Q644. Q643 is an emitter follower acting as an impedance transfer device to raise the base impedance of Q644 base to prevent loading the divider. Q644 amplifies and inverts any change at the base of Q643 and applies the change directly to the base of Q647. Q644 collector current is the total base current of Q647. Q647 emitter voltage follows the inverted correction signals, changing the level of the whole supply when needed.

Assume that the load increases, taking the +100 volts slightly negative. Q643 drives Q644 base negative, increasing its collector current. Increased Q644 collector current means increased base current in Q647, raising the emitter positive the correct amount to restore the output voltage.

Fuse F648 protects Q647 from accidental short circuit of the +100-volt supply bus.

C649 and C644 aid in reducing the supply high-frequency impedance. R644 limits the peak current through C644 to the base of Q643 in case the supply is accidentally shorted.

R646-C646 decouple the +100-volt bus for peak current of the CRT unblanking circuit.

+360-Volt Supply

Voltage for the +360-volt unregulated supply is provided by the full-wave bridge rectifiers D650A-B-C-D and C650A (C650 below SN 787). The voltage across C650A (C650 below SN 787) is nominally 255 volts, which is added to the +100-volt supply. The supply is used by the CRT high-voltage supply and the vertical output stage, whose current passes through the beam rotator coil.

Beam Rotator Coil. The rectangular CRT is not easily rotated physically. Also, the trace changes its alignment with the graticule slightly, depending upon the monitor's relation to the earth's magnetic field. Thus, a coil is included around the CRT proper, allowing the operator to adjust the trace alignment with the graticule.

CRT Circuit and Calibrator

The Type T5290 (V859) cathode-ray tube is a rectangular, flat-faced, mono-accelerator, deflection-blanked type, designed especially for the Type RM529 Waveform Monitor. Acceleration voltage is 5500 volts with —5300 V at the cathode, and nominally +200 volts at the deflection plates. The phosphor is aluminized, permitting bright displays and preventing any chance of phosphor damage at any position of the INTENSITY control.

The bias network consisting of R855, R856 and R857 insures uniform intensity of the CRT horizontal trace. This is accomplished by varying the voltage applied to the fixed unblanking plate.

The beam is blanked between sweeps by special deflection plates (located in the focus gun area of the tube) that pull all electrons away from the screen. Special intensifying circuits described with the sweep generator automatically brighten selected line displays for easy viewing of fast sweeps at low-repetition rates.

High-Voltage Power Supply and Calibrator

High-Voltage Power Supply. The high-voltage supply is actually a cathode-modulated amplifier with positive feedback sustaining oscillation. The cathode modulation is voltage feedback from the high-voltage output that controls the level of oscillation. The calibrator transistor Q874 is directly in the feedback path that sustains oscillation.

As the monitor is turned on, V800B is turned off due to its cold heater. The voltage divider of R875-R876 turns on Q874 so its collector voltage is about —10 volts. Q874 collector is directly connected to the grid of V800B. V800B will conduct with its grid at —10 volts. As V800B warms up and pulls plate current, Q874 collector receives a transformer-coupled turn-off signal and its collector voltage turns on V800B even more. The secondary of T801 is a tank circuit, resonant at about 30 kHz. Thus, Q874 first receives a turn-off pulse, and then as T801 secondary swings through a cycle, Q874 is turned on full, turning V800B completely off. The cycle of oscillation repeats, heating the cathodes of V822 and V832. As they conduct, high voltage is developed that soon reduces current in V800A and Q804 to limit the current of V800B. Any further changes in output high voltage will change the conduction level of V800B to correct and restore the supply voltage.

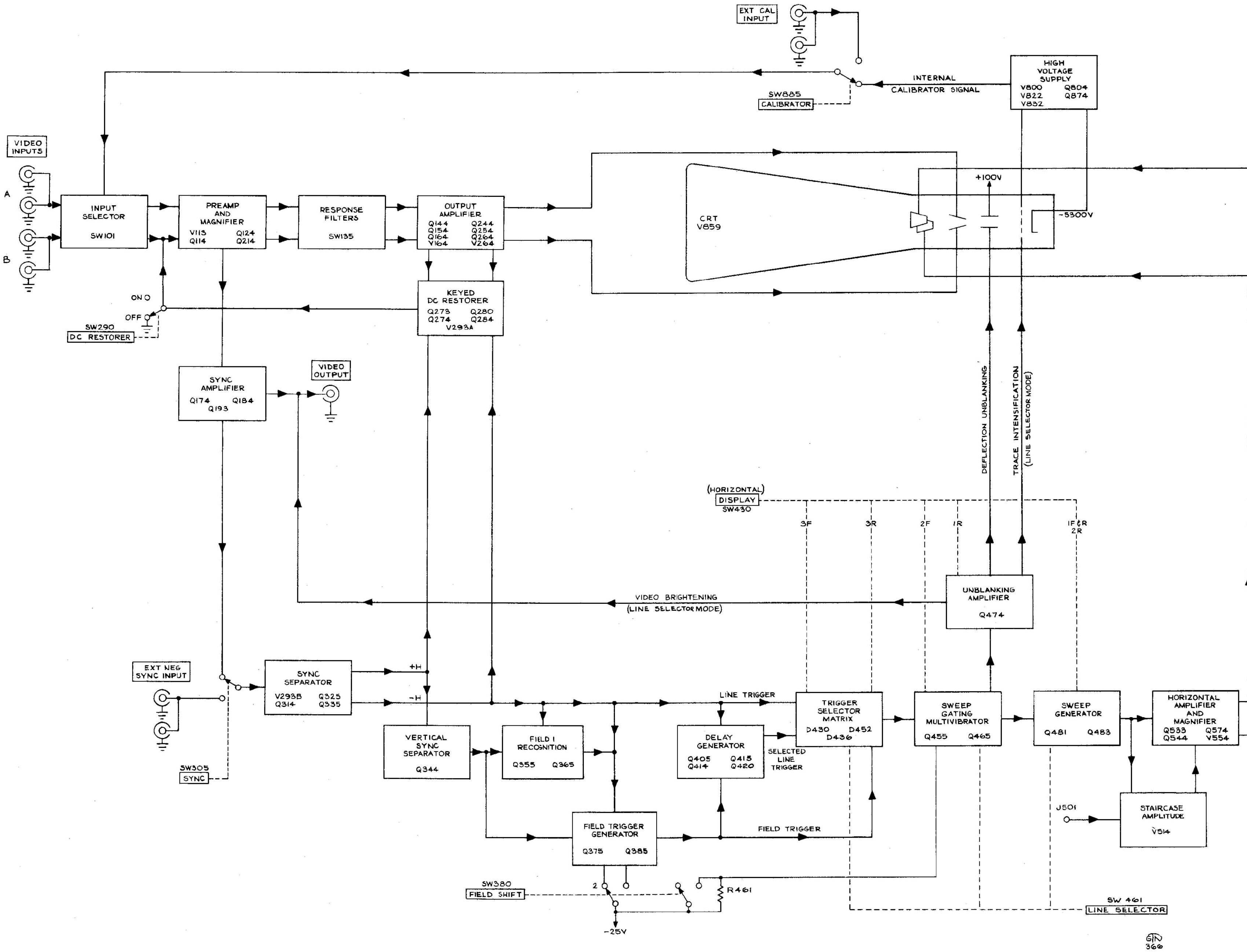
V822 and V832 are the diodes of a half-wave voltage doubler with C837 and C848, the main filter capacitors. C837 also couples fast output voltage changes to the control tube V800A.

The multiple-resistor bleeder of R834 through R847 also provides voltage division for the INTENSITY and FOCUS controls. C849 assures that there is no voltage ripple between the cathode and grid of the CRT, which would otherwise intensity-modulate the trace.

Neon bulbs placed across the ASTIG control assure that the voltage of the astigmatism element remains constant to the average voltage of the vertical defective plates, which also use the unregulated +360-volt supply.

Calibrator. The calibrator voltage is a secondary benefit of the high-voltage oscillator. Q874 collector voltage swings between about ground and the —25-volt supply, providing a stable square wave. D881 sets the ground level, and the —25-volt supply sets the negative level. R881, R885 and R886 divide the 25-volt swing for use in the vertical amplifier when the VOLTS FULL SCALE control is at 1.0. As the gain of the vertical amplifier is increased with the VOLTS FULL SCALE switch, R882 and/or R883 reduce the calibrator output amplitude to keep the display on the CRT screen.

External calibrator signals see a 1-megohm load when the switch is set to EXT.



TYPE RM529 WAVEFORM MONITOR

G_1

BLOCK DIAGRAM

IMPORTANT

VOLTAGE AND WAVEFORM CONDITIONS

Circuit voltages measured with a 20,000 Ω/volt VOM. All readings in volts. Voltages are measured with respect to chassis ground unless otherwise noted.

Waveforms shown are actual waveform photographs taken with a Tektronix Oscilloscope Camera System and Projected Graticule.

Voltages and waveforms on the schematics (shown in blue) are not absolute and may vary between instruments.

The test oscilloscope used had the following characteristics: Minimum deflection factor, 0.02 volts/division using a 10X probe; frequency response, dc to 30 MHz; sweep rates, 5 ms to 20 μs; sweep magnification, X1, X20 and X100. AC input coupling was used.

To indicate true time relationship between signals and to obtain stable displays, the test oscilloscope was externally triggered through X1 probe form:

1. Collector of Q325 (-H signal) for all waveforms except those at the junctions of C198 and R198, C364 and R365, C417 and the Collector of Q415.

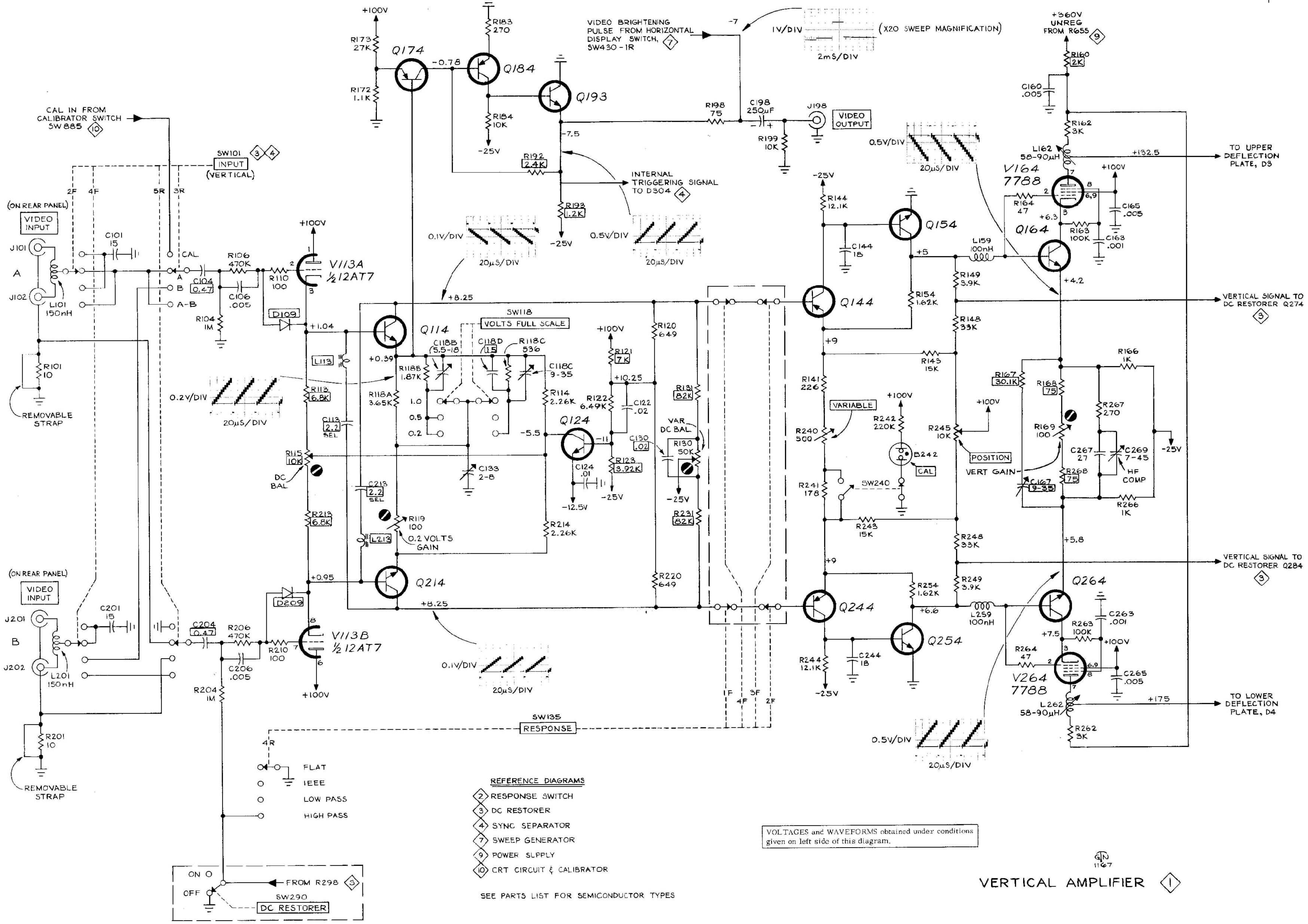
2. Collector of Q344 for waveforms at the junctions of C198 and R198, C364 and R365, C417 and the collector of Q415.

Voltage readings and waveforms were obtained using the following control settings, unless otherwise noted on the individual diagrams.

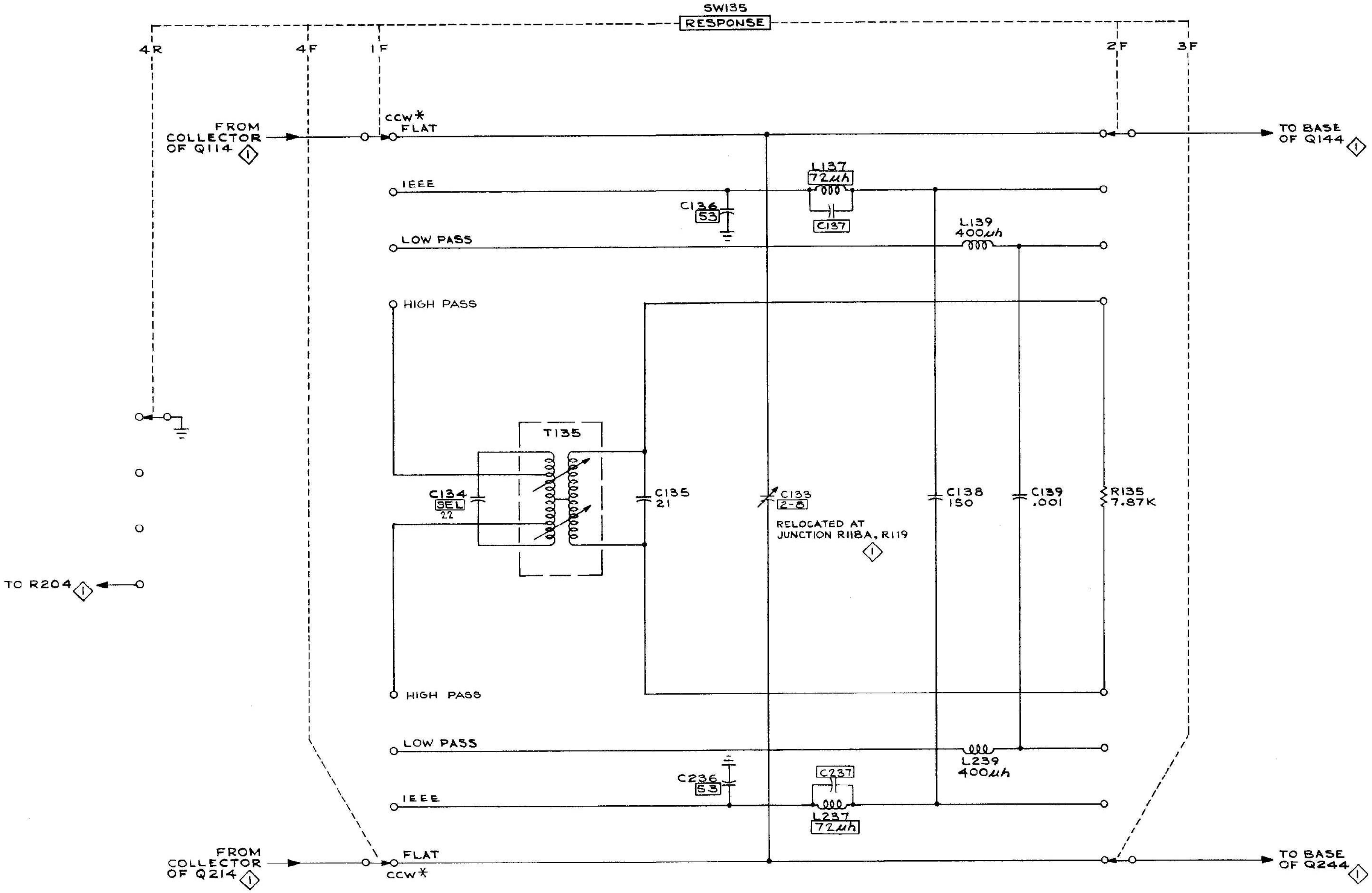
For waveforms, 1-volt of modulated staircase was connected to the left VIDEO INPUTS A connector. The right VIDEO INPUTS A connector was terminated into 75 ohms.

For voltage readings, no input signal or termination was connected to the instrument.

POWER and SCALE ILLUM	2/3 clockwise
FOCUS	Midrange
INTENSITY	Adjusted for normal display brightness
GAIN	As is
VERTICAL Controls	
RESPONSE	FLAT
DC RESTORER	ON
INPUT	A
VOLTS FULL SCALE	1.0
VARIABLE (VOLTS FULL SCALE)	CALIB
CAL	.714 F.S.
POSITION	Midrange
HORIZ Controls	
POSITION	Midrange
SYNC	INT
MAG	X1
DISPLAY	LINE SELECTOR .25 H/cm
LINE SELECTOR (SWITCH)	Variable
FIELD	TWO
VARIABLE (LINE SELECTOR)	Fully clockwise



VERTICAL AMPLIFIER 1



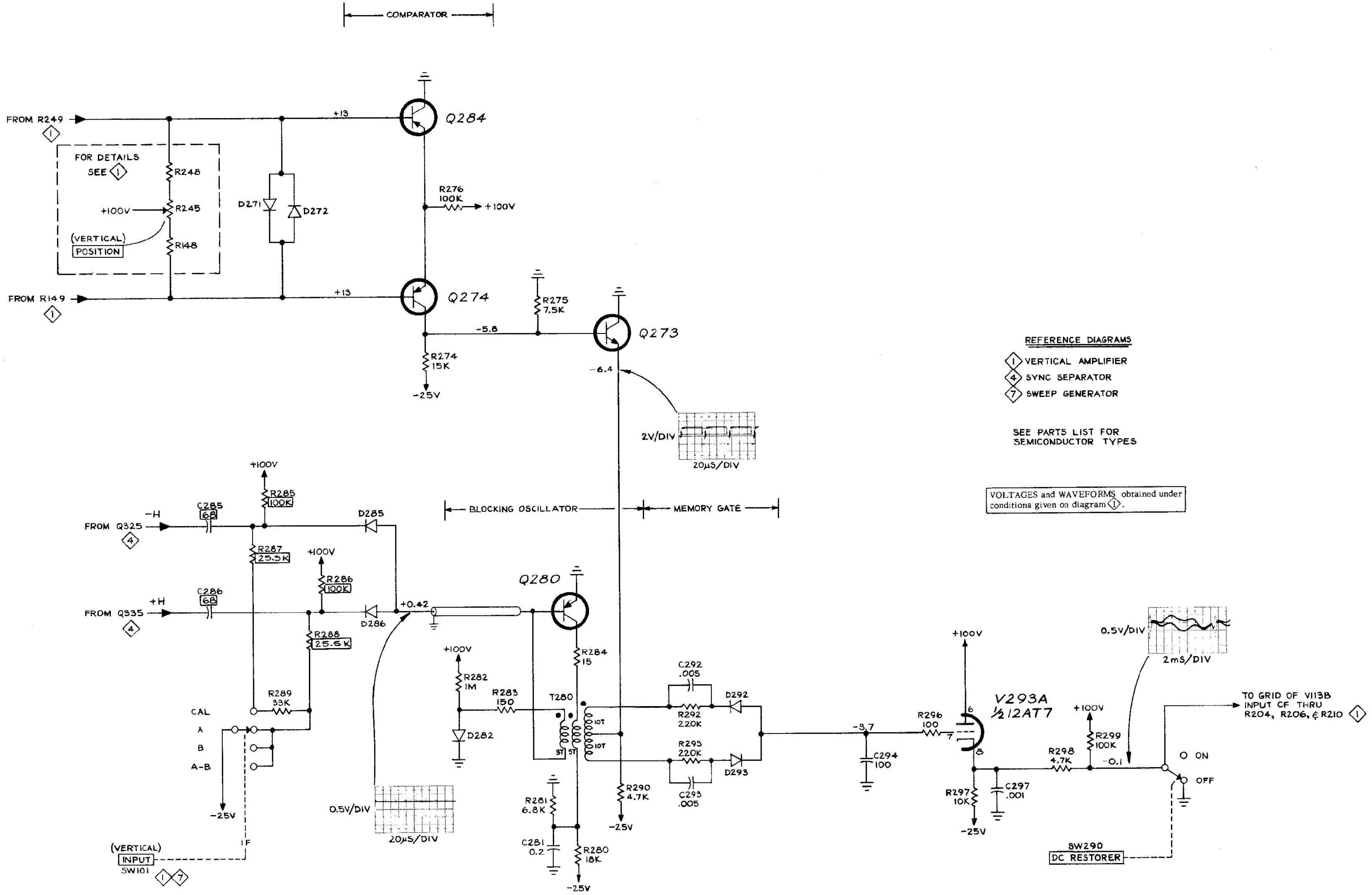
NOTES:
1. ALL INACTIVE FILTER SECTIONS GROUNDED AT INPUT AND OUTPUT
2. SWITCH IS MOUNTED IN INSTRUMENT WITH WAFER 4 NEAREST FRONT PANEL
3. * SWITCH ROTATION AS VIEWED FROM INDEX END OF SWITCH - THIS POSITION IS CLOCKWISE ON FRONT PANEL

REFERENCE DIAGRAM
1 VERTICAL AMPLIFIER

MRH
268

RESPONSE SWITCH 2

TYPE RM529 WAVEFORM MONITOR



REFERENCE DIAGRAMS
1 VERTICAL AMPLIFIER
4 SYNC SEPARATOR
7 SWEEP GENERATOR

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

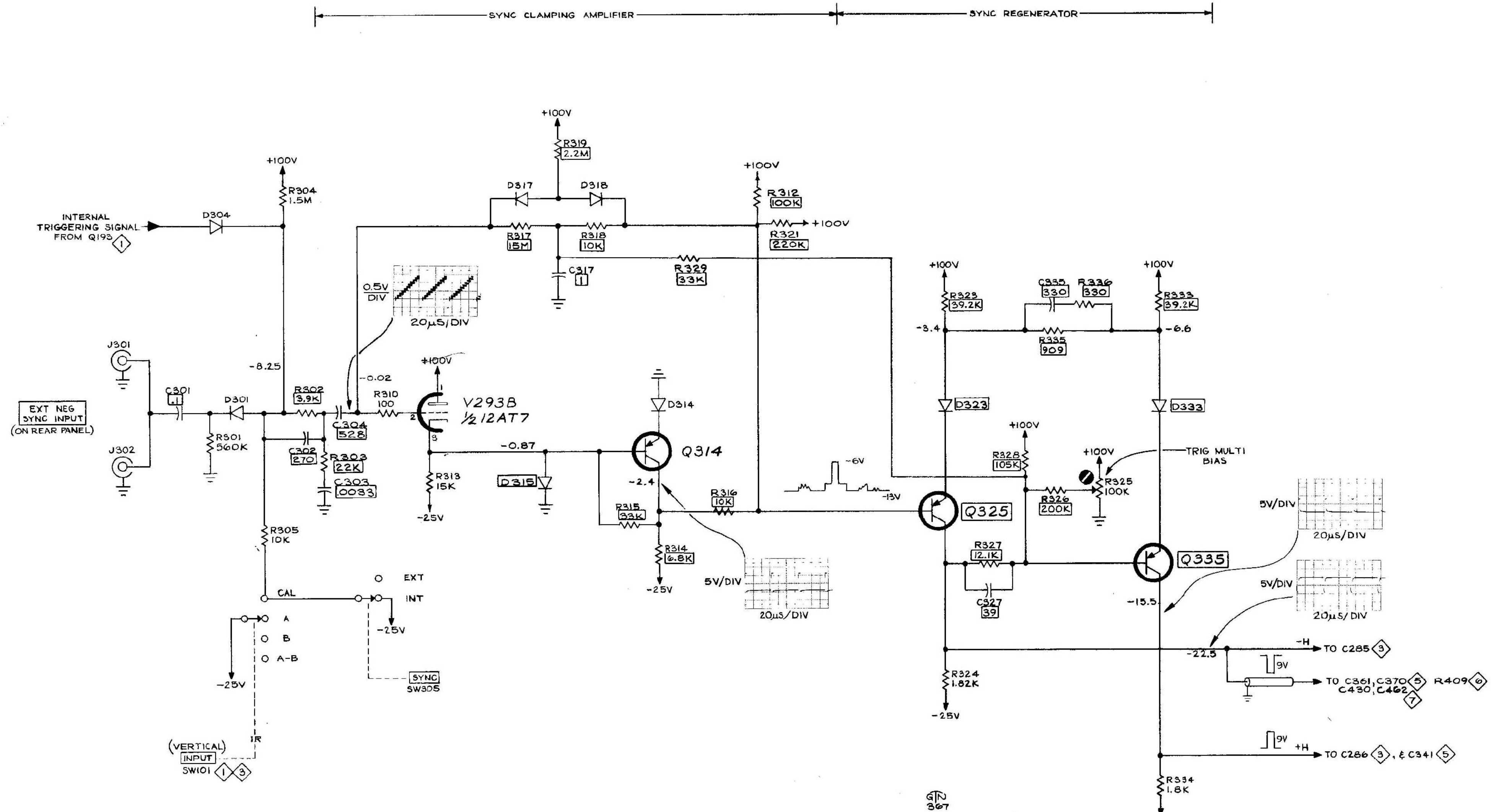
VOLTAGES and WAVEFORMS obtained under conditions given on diagram 1.

H2

966

DC RESTORER 3

TYPE RM529 WAVEFORM MONITOR



SYNC SEPARATOR ⟨4⟩

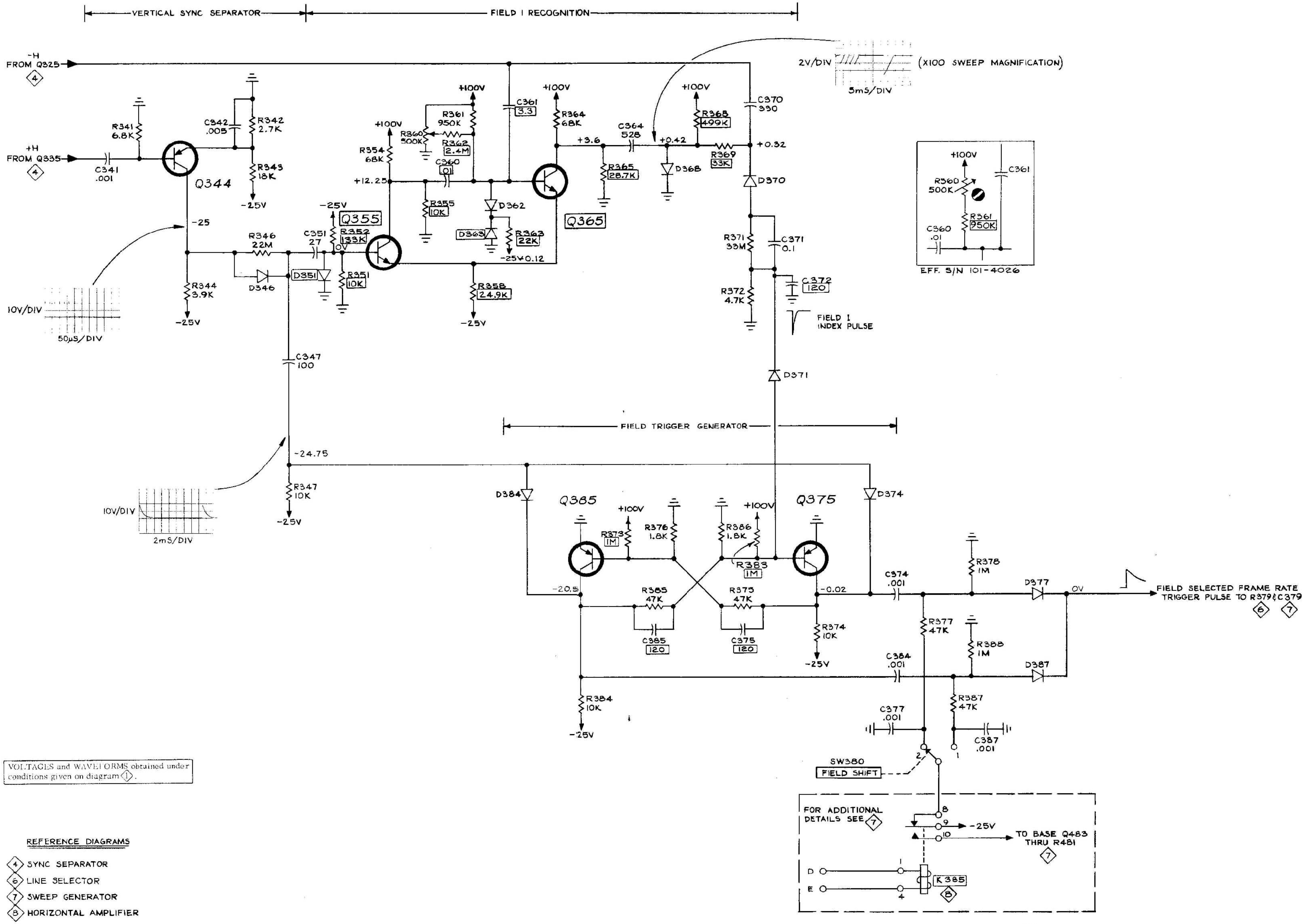
REFERENCE DIAGRAMS

- ⟨1⟩ VERTICAL AMPLIFIER
- ⟨3⟩ DC RESTORER
- ⟨5⟩ FIELD SELECTOR
- ⟨6⟩ LINE SELECTOR
- ⟨7⟩ SWEEP GENERATOR

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

VOLTAGES and WAVEFORMS obtained under conditions given on diagram ⟨1⟩.

TYPE RM529 WAVEFORM MONITOR



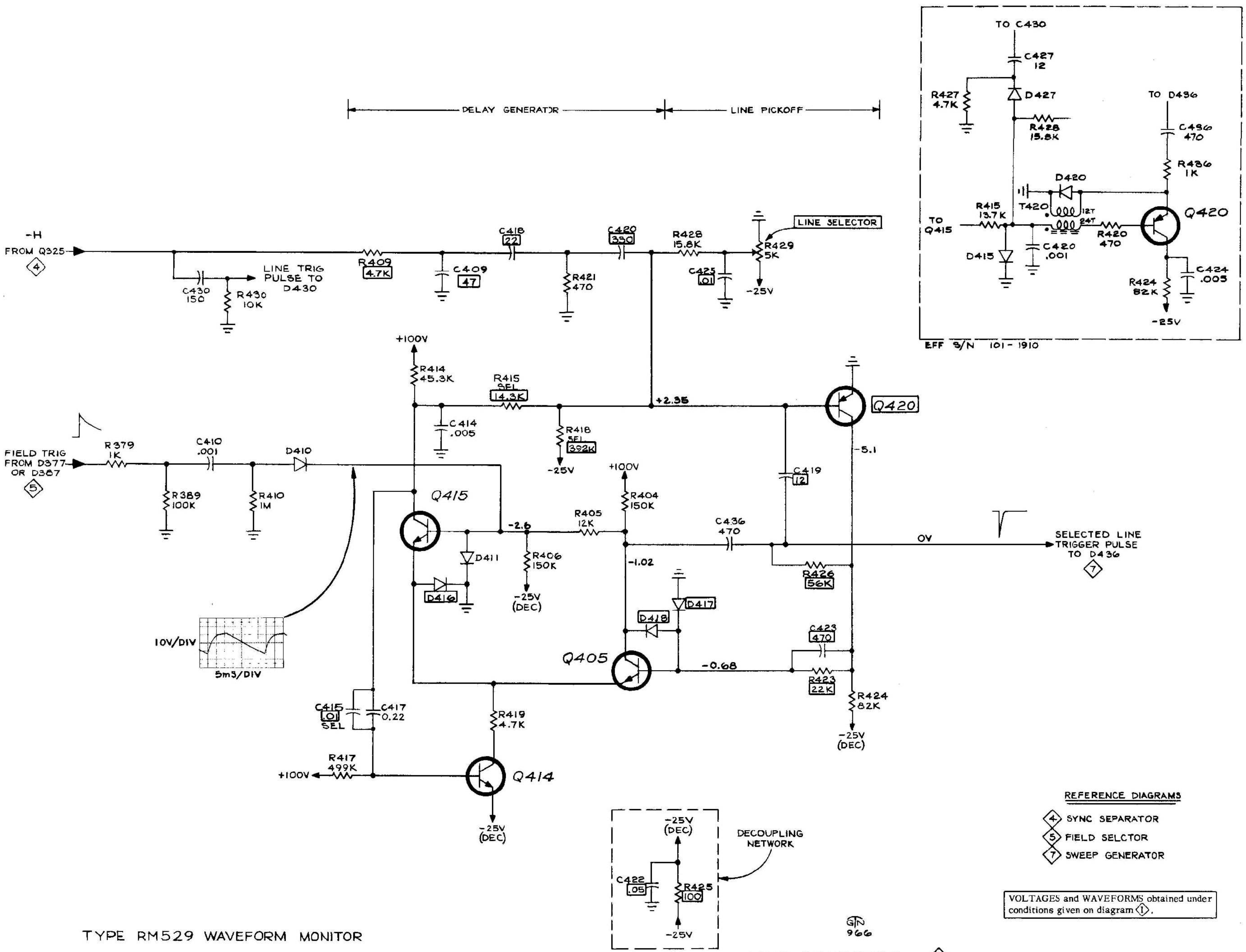
VOLTAGES and WAVEFORMS obtained under conditions given on diagram 1.

REFERENCE DIAGRAMS

4 SYNC SEPARATOR
6 LINE SELECTOR
7 SWEEP GENERATOR
8 HORIZONTAL AMPLIFIER

GTN 868

FIELD SELECTOR 5



REFERENCE DIAGRAMS

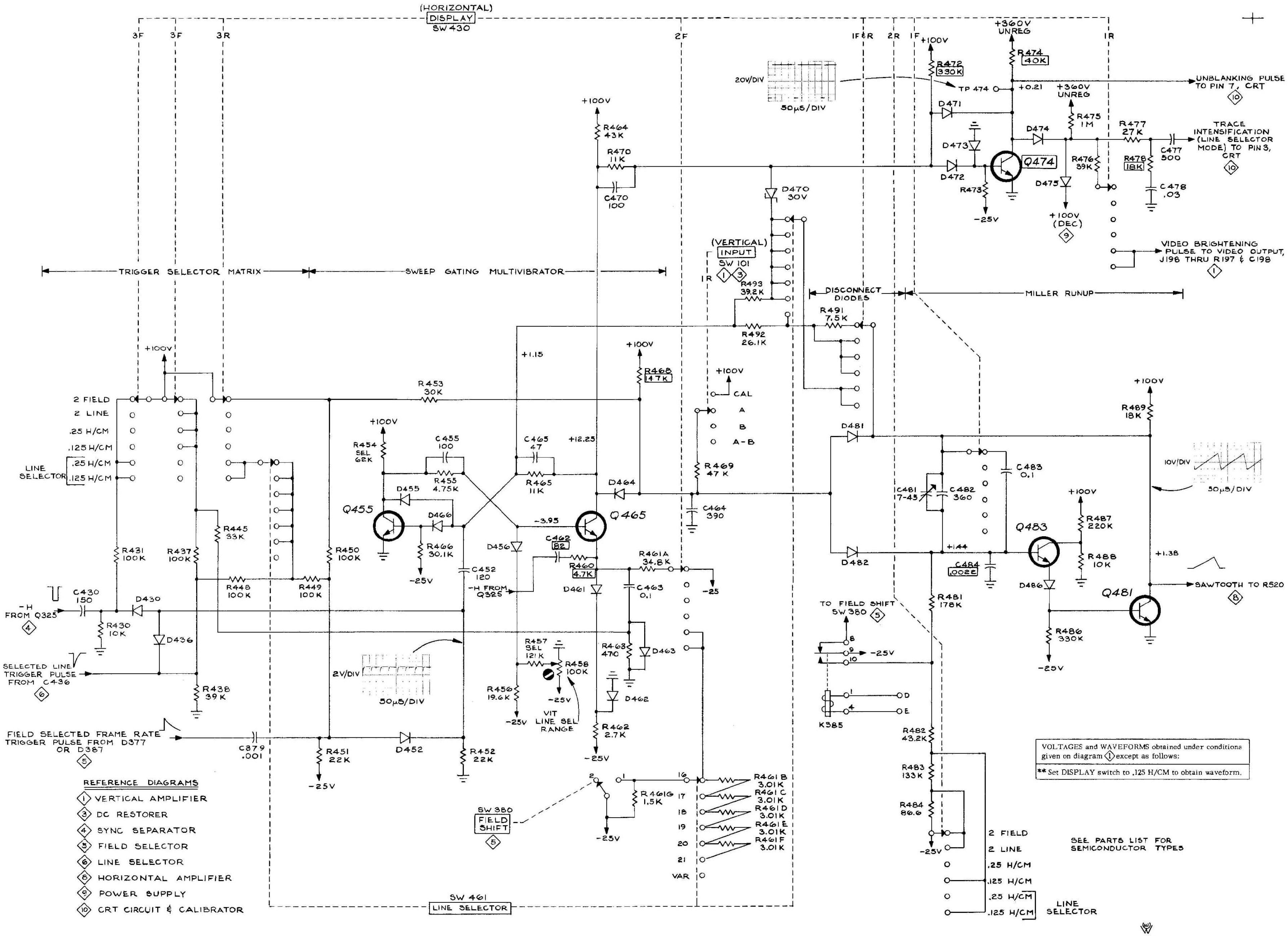
4 SYNC SEPARATOR
5 FIELD SELCTOR
7 SWEEP GENERATOR

VOLTAGES and WAVEFORMS obtained under conditions given on diagram 1.

GN 966

TYPE RM529 WAVEFORM MONITOR

LINE SELECTOR 6

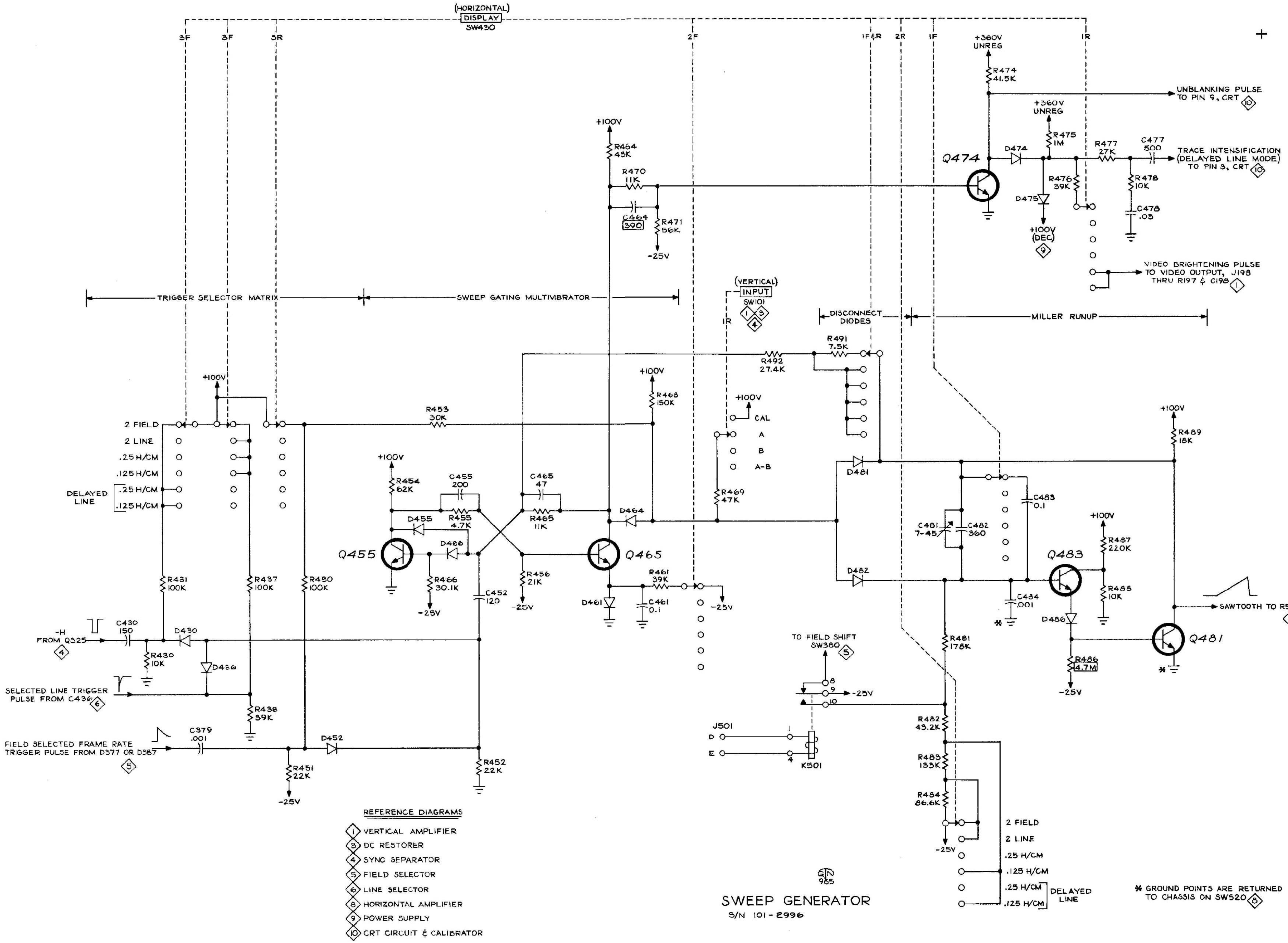


TYPE RM529 WAVEFORM MONITOR

SWEEP GENERATOR 7

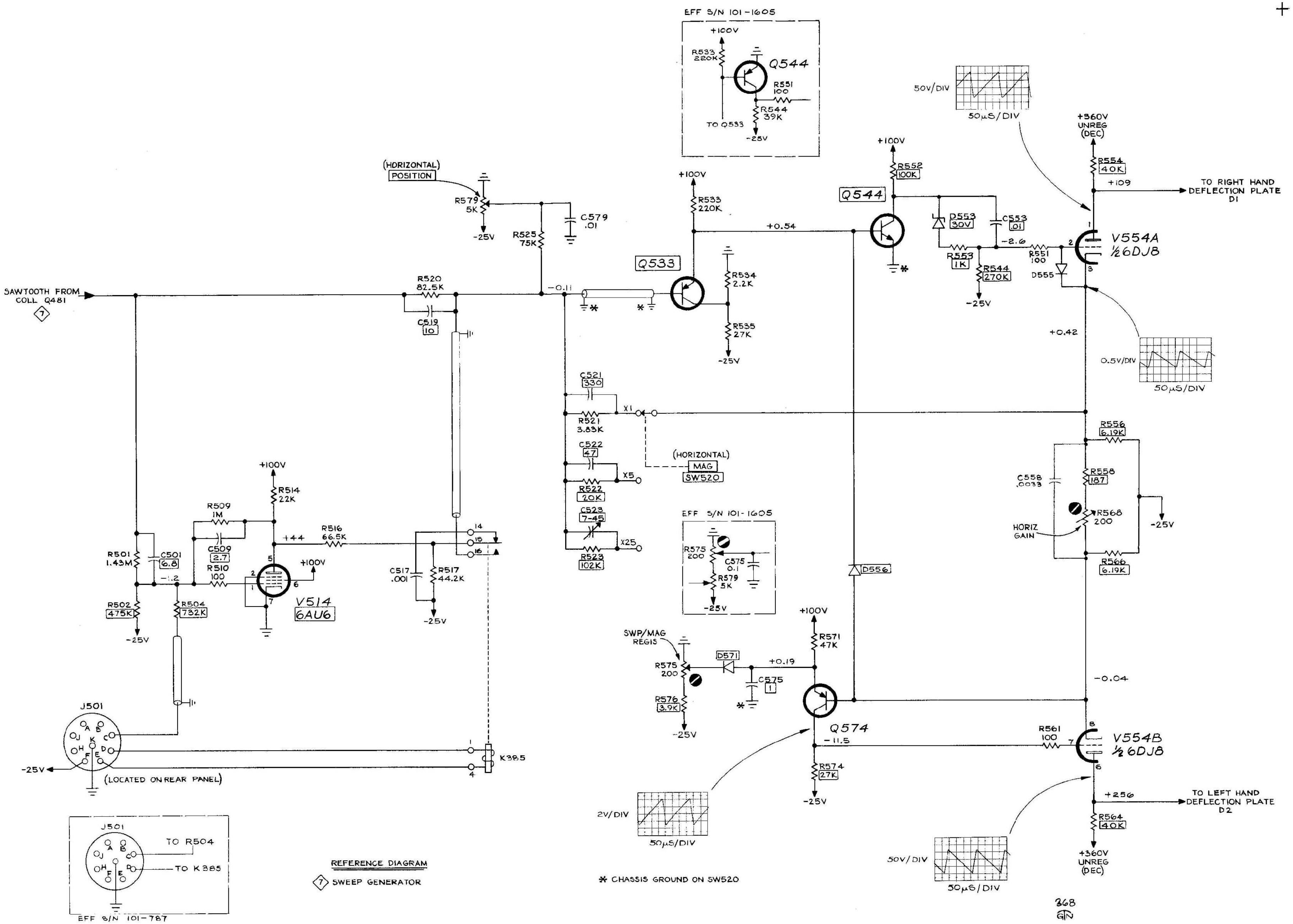
S/N 2997-UP

867



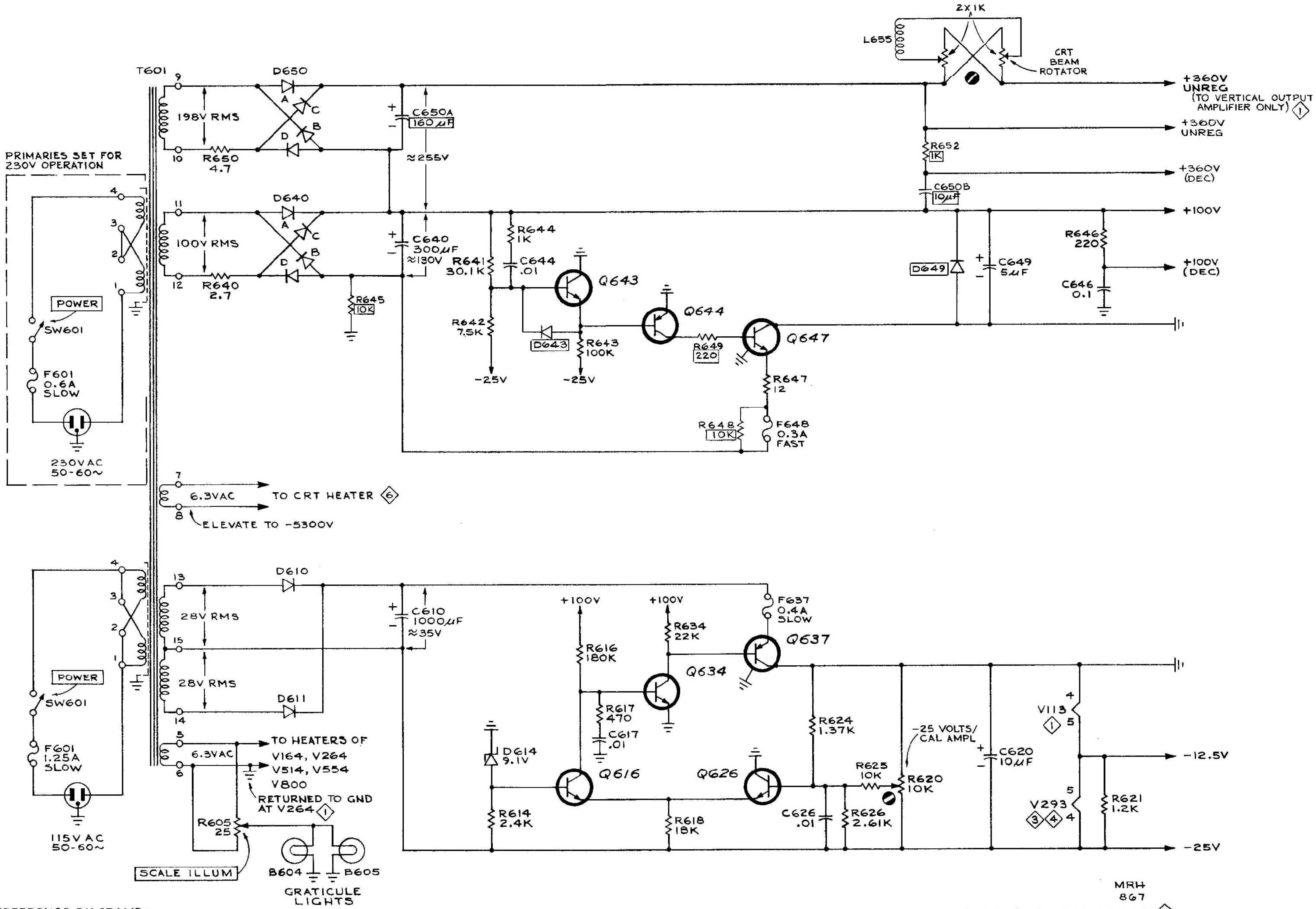
SWEEP GENERATOR

S/N 101-2996



SEE PARTS LIST FOR SEMICONDUCTOR TYPES

HORIZONTAL AMPLIFIER ⑧

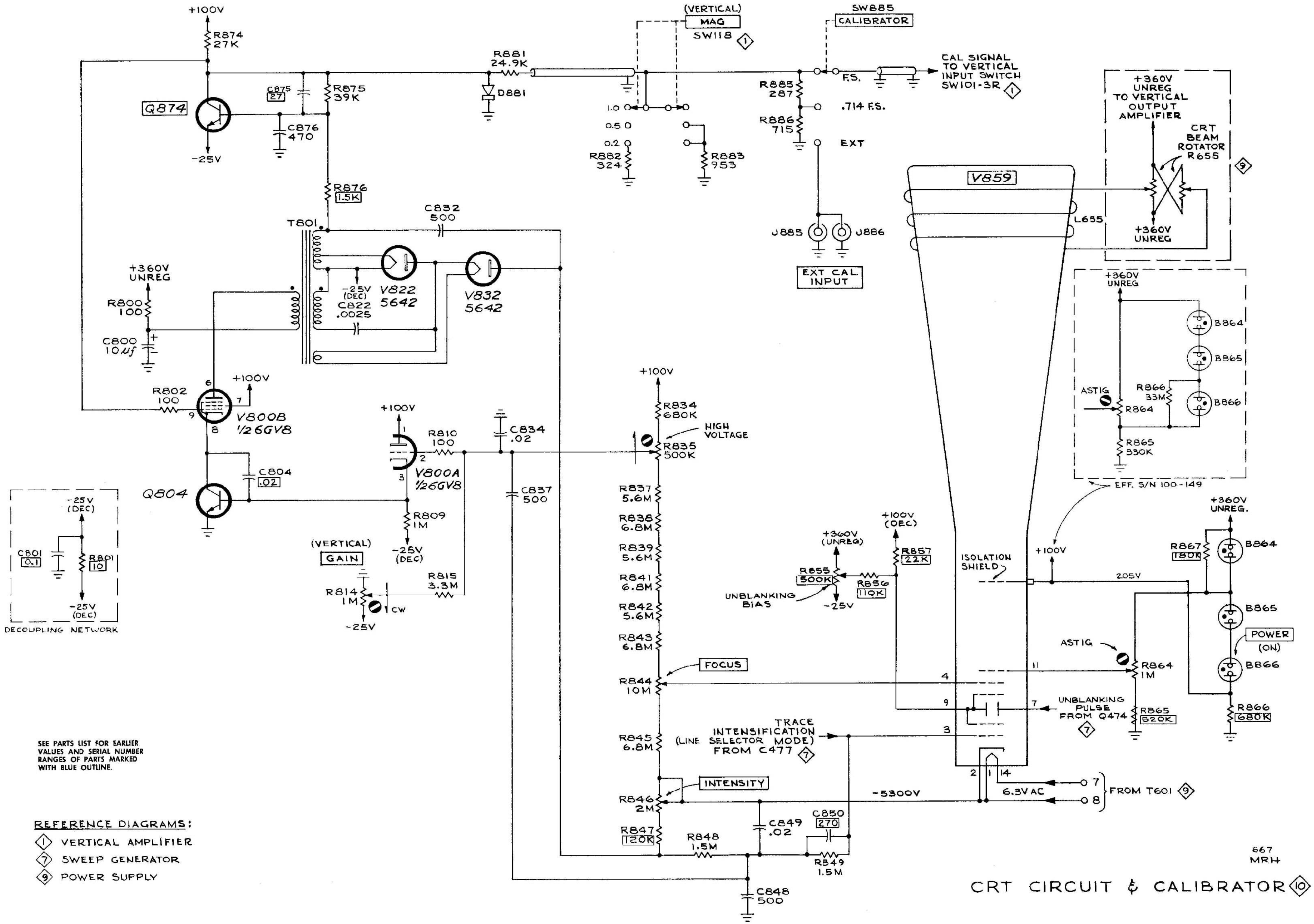


MRH 867

POWER SUPPLY 9

REFERENCE DIAGRAMS:
1 VERTICAL AMPLIFIER
3 DC RESTORER
4 SYNC SEPARATOR

TYPE RM529 WAVEFORM MONITOR



SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

REFERENCE DIAGRAMS:
- ⟨1⟩ VERTICAL AMPLIFIER
- ⟨7⟩ SWEEP GENERATOR
- ⟨9⟩ POWER SUPPLY

CRT CIRCUIT & CALIBRATOR ⟨10⟩

TYPE RM529 WAVEFORM MONITOR

TYPE RM529 TENT SN 7020

PARTS LIST CORRECTION

CHANGE TO:

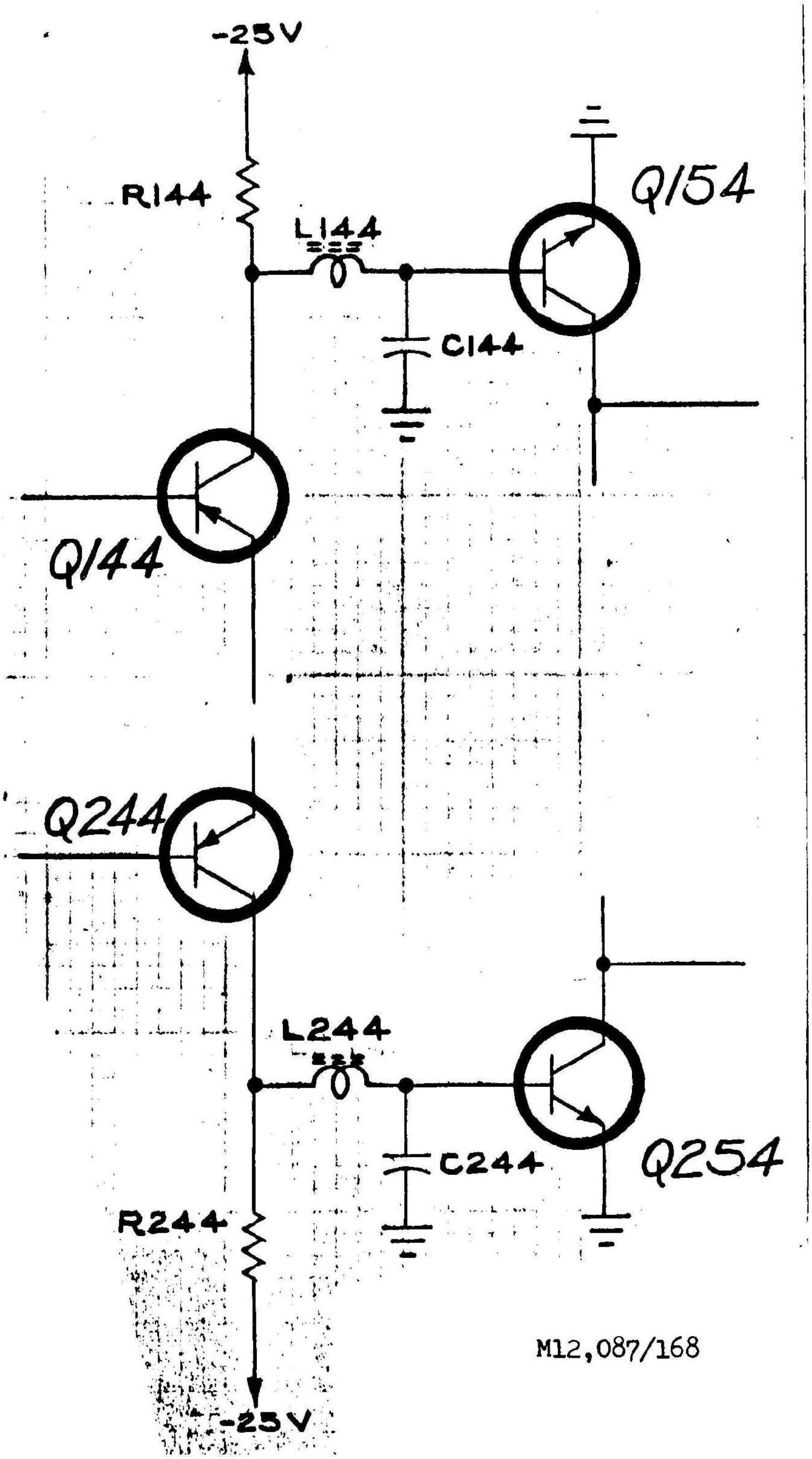
R844	311-0505-01
R846	311-0043-02

TYPE RM529   TENT SN 7410

PARTS LIST AND SCHEMATIC CORRECTION

ADD:

L144	276-0507-00	Ferramic Suppressor	.6 µH
L244	276-0507-00	Ferramic Suppressor	.6 µH



PARTIAL
VERTICAL AMPLIFIER

M12,087/168