INSTRUCTION MANUAL

Serial No. ______________

TYPE

RM 503

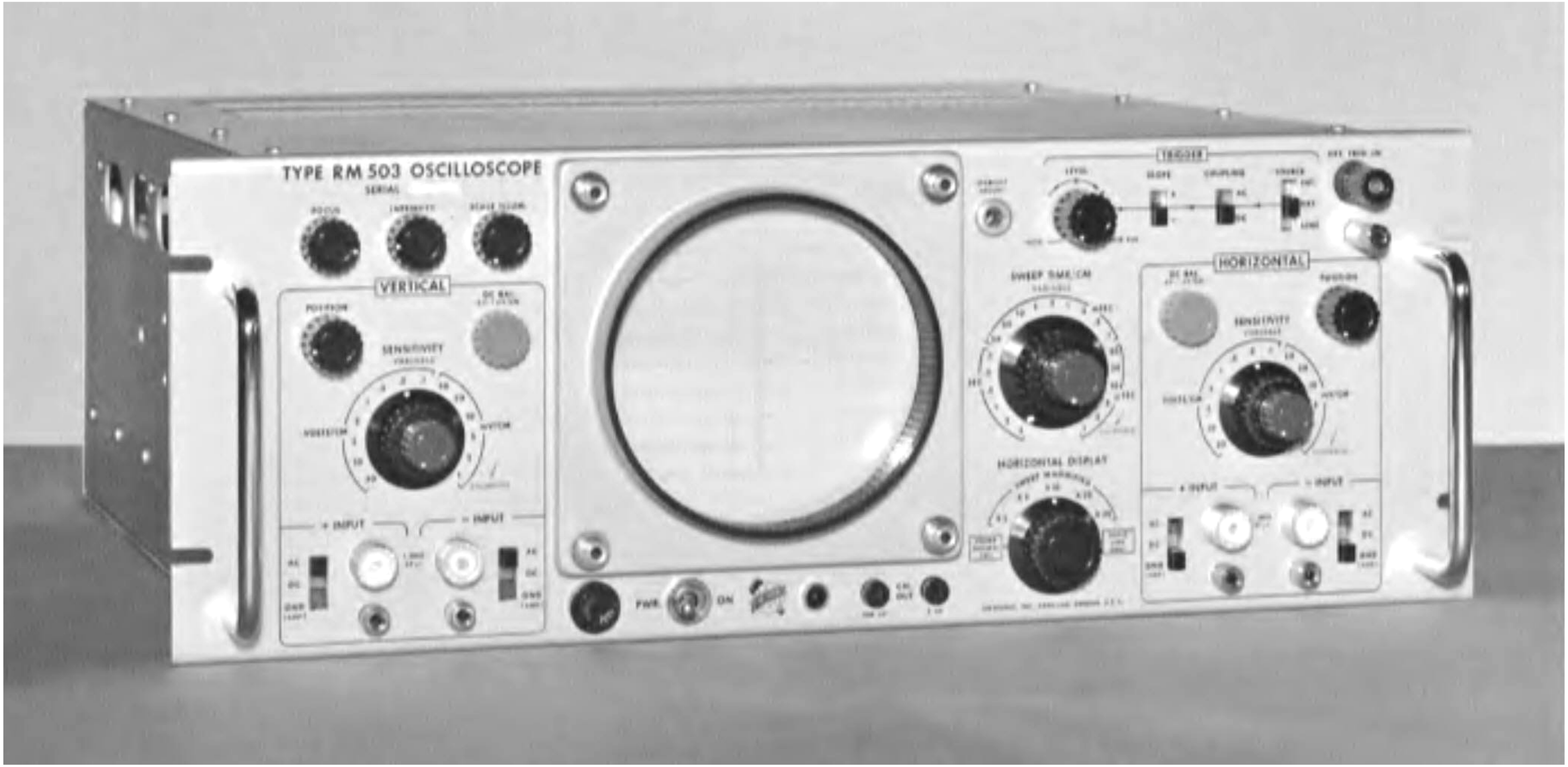
OSCILLOSCOPE

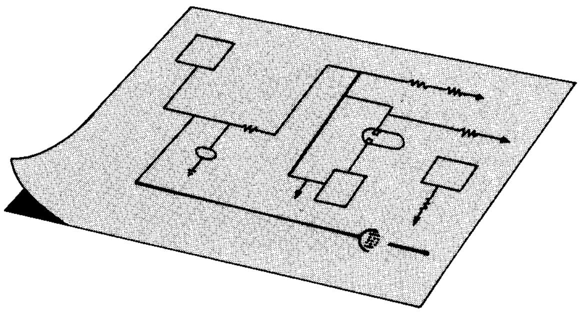
Tektronix, Inc.

S.W. Millikan Way ● P. O. Box 500 ● Beaverton, Oregon 97005 ● Phone 644-0161 ● Cables: Tektronix

070-0314-01

1068


TYPE RM 503 OSCILLOSCOPE
SERIAL
VERTICAL
SENSITIVITY
+ INPUT
− INPUT
TRIGGER
SWEEP TIME/CM
HORIZONTAL DISPLAY
HORIZONTAL
SENSITIVITY
+ INPUT
− INPUT
PWR.
ON



SECTION 1

CHARACTERISTICS

Introduction

The Tektronix Type RM503 Oscilloscope is a low-frequency, high-sensitivity laboratory instrument providing accurate measurements in the range from dc to 450 kc. Identical vertical and horizontal amplifiers may be used for accurate curve plotting in the X-Y mode of operation. Both amplifiers may be operated with single-ended inputs for conventional operation, or with differential inputs for cancellation of common-mode signals. Sweep rates to 1 microsecond per centimeter, combined with sweep magnification factors to 50, provide effective calibrated sweep rates to 0.1 microsecond per centimeter.

Vertical and Horizontal Deflection System

Input Impedance—1 megohm paralleled by 47 $\mu\mu$f.

Coupling—AC or DC.

Deflection Factors—Fourteen calibrated deflection factors from 1 millivolt to 20 volts per centimeter, accurate within 3%.

Bandpass—DC to $\leq$ −3 dB at 450 kc.

Differential Input Rejection Ratio—100 to 1 from 1 millivolt to 0.2 volt per centimeter sensitivity; 50 to 1 from 0.5 volt to 20 volts per centimeter sensitivity. The rejection ratios specified apply if the signal voltages at the INPUT connectors do not exceed the following limits: ±2 volts dc, or 4 volts peak-to-peak ac, at sensitivities of 1 millivolt to 0.2 volt per centimeter; ±20 volts dc, or 40 volts peak-to-peak ac, at sensitivities of 0.5 volt to 2 volts per centimeter; ±200 volts dc, or 400 volts peak-to-peak ac, at sensitivities of 5 volts per centimeter.

Triggering

Type—Automatic, or amplitude-level selection using preset stability.

Coupling—AC or DC.

Slope—Plus, from rising slope of triggering waveform, or minus, from negative slope of triggering waveform.

Signal Requirements—Internal: signal producing 0.5 cm vertical deflection. External: 0.5 volt to 10 volts of either polarity.

Sweep

Type—Miller Integrator.

Rates—Twenty-one calibrated sweep rates from 1 micosecond to 5 seconds per centimeter. Accuracy typically within 1% of the indicated sweep rate; in all cases within 3%.

Magnifier—Displayed waveforms can be expanded horizontally by a factor of 2, 5, 10, 20, or 50. Calibration of magnified sweep rates accurate within 5% of sweep rates which do not exceed the maximum calibrated rate of 0.1 microsecond per centimeter.

Amplitude Calibrator

Waveform—Square waves at approximately 350 cps.

Amplitude—5 millivolts and 500 millivolts peak-to-peak.

Cathode-Ray Tube

Type—T503P.

Phosphor—Type P2 normally furnished; P1, P7, P11, and P31 phosphors optional. Other phosphors available on special order.

Accelerating Potential—3000 volts.

Z-Axis Modulation—External terminal permits RC coupling to crt grid.

Graticule

Illumination—Variable edge lighting.

Display Area—Marked in 8 vertical and 10 horizontal 1 centimeter divisions with 2-millimeter markings on the center lines.

Power Supplies

Electronically regulated for stable operation with widely varying line voltages and loads.

Line Voltage Requirements—105 to 125 volts or 210 to 250 volts at 50-60 cycles. Will operate at line frequencies up to 800 cps with higher line voltages (see section 2).

Power Requirements—Approximately 110 watts.

Mechanical Specifications

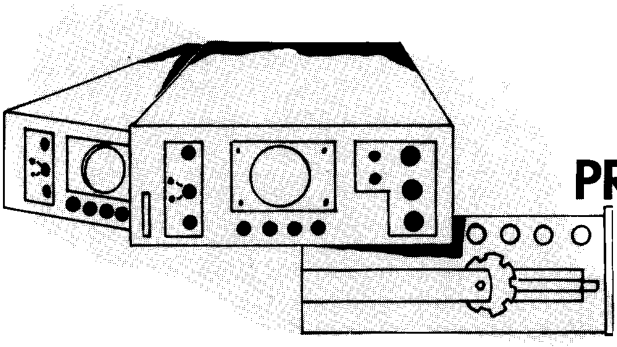
Construction—Aluminum alloy chassis and cabinet.

Finish—Photo-etched anodized panel, blue vinyl-finish cabinet.

Dimensions—16½" deep, 19" wide, 7" high. (additional depth of 3" required for power cord).

ACCESSORIES

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



SECTION 2

PRELIMINARY INFORMATION

Power Requirements

The Type RM503 Oscilloscope line transformer primary can be wired for either 117-volt or 234-volt operation, at a line frequency of 50 to 60 cps. At this line frequency, proper regulation of the power supply will be obtained at line voltages between 105 volts and 125 volts when the line transformer is wired for 117-volt operation and between 210 volts and 250 volts when the line transformer is wired for 234-volt operation. Fig. 2-1 shows the transformer connections required for each range of operation.

The Type RM503 Oscilloscope can be operated at any ac line frequency from 50 cps up to 800 cps, although higher line voltages are required at the higher line frequencies. At an ac line frequency of 400 cps, the nominal and lower and upper limits are about 10% higher than at 50-60 cps. At a line frequency of 800 cps, the nominal and lower and upper limits are about 15% higher than at 50-60 cps. At line frequencies between the specific values given, the required line voltages will be proportionately larger or smaller. For maximum dependability and long life, it is recommended that the line voltage be kept at or slightly below the nominal.

Fuse Requirements

Use a 1.25-amp slow-blowing type fuse when the Type RM503 is wired for 117-volt operation. Use a 0.7-amp slow-blowing type fuse when the Type RM503 is wired for 234-volt operation.

Thermal Cutout

A thermal cutout switch in the primary circuit of the power transformer, T601, protects the Type RM503 from over-heating. If the internal temperature rises above the rating of the thermal switch, the switch will disconnect the power and keep it disconnected until the temperature drops to a safe value.

Rack Mounting

The Type RM503 is ready for mounting in a standard 19-inch open or enclosed relay rack.

To mount the instrument directly to either type of rack, first select four screws from the hardware kit whose threads match the threads of the mounting holes in the rack. Align the slots at the sides of the front panel with the holes in the rack, at the desired height. Fasten the instrument to the rack with four mounting screws, cup washers, and plastic washers. The plastic washers are inserted between the cup washers and the front panel to prevent the cup washers from cutting into the front panel when the screws are tightened.

Removal of Top and Bottom Panels

The top and bottom panels of the Type RM503 Oscilloscope are held in place by small flat-head screws. To remove the panels, first remove the screws. Then slide the panels back and lift free of the instrument. The panels can be replaced by reversing the order of removal.

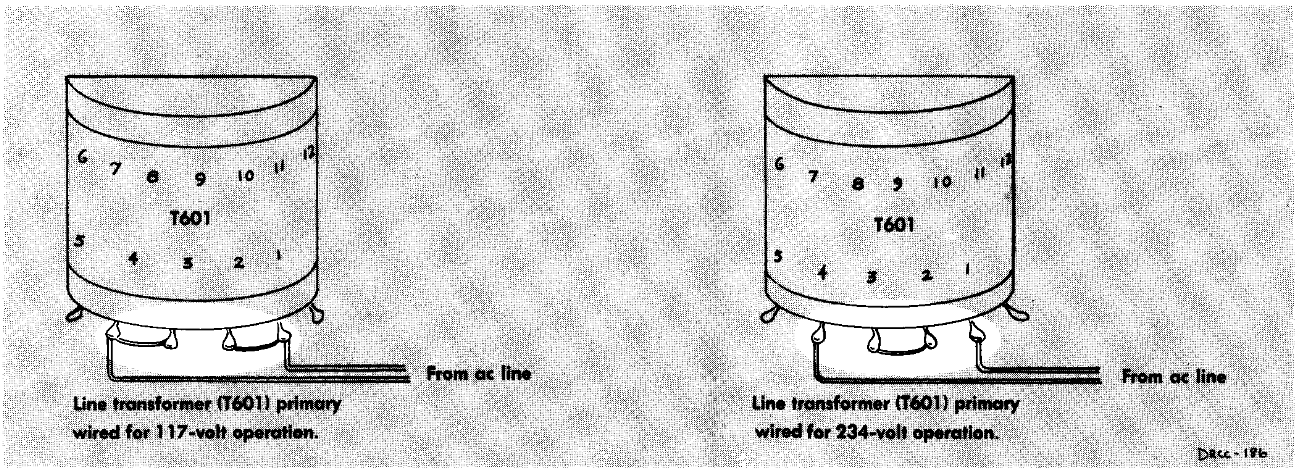
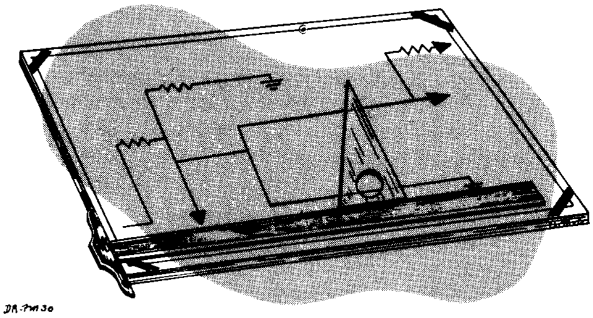


Fig. 2-1. Line transformer wired for 117- and 234-volt operation.



SECTION 4

CIRCUIT DESCRIPTION

VERTICAL AMPLIFIER

General Description

The Vertical Amplifier consists of two opposing input circuits and two dc-coupled, push-pull amplifiers. The maximum overall gain of the Vertical Amplifier is on the order of 25,000, which provides the required 25 volts per centimeter of deflection at the crt from each millivolt of signal at the inputs (with the SENSITIVITY control in the 1 mV/CM position).

The Input Amplifier consists of two stages, a cathode-coupled paraphase amplifier stage and a pair of transistors. The combined gain of the two stages is controlled by negative feedback. The output from the Input Amplifier drives the Output Amplifier which, in turn, drives the crt deflection plates. Changes in Vertical Amplifier sensitivity are accomplished by input attenuation and by negative feed-back in the Input Amplifier. Vernier attenuation is accomplished by degeneration in the cathode circuit of the Output Amplifier.

Input Circuits

The two input circuits allow the Input Amplifier to be operated either as a single-ended cathode-coupled paraphase amplifier or as a differential amplifier. For single ended operation, the signal is applied to one of the two input connectors and tho other is grounded. For differential operation, signals are applied to both input connectors and the amplifier amplifiers the difference between them. The two input switches permit both inputs to be either ac or dc coupled, or one ac coupled and the other dc coupled. The lower bandpass limit of the inputs when ac coupled is about 10 cps.

In the 1 mV/CM to .2 VOLTS/CM positions of the SENSITIVITY control, the signal is applied "straight through" to the grid circuit, or circuits, of the Input Amplifier; the changes in sensitivity are accomplished by changes in negative feed-back within the amplifier. In the .5 VOLTS/CM to 2 VOLTS/CM positions of the SENSITIVITY control, a X10 attenuator is inserted in the input circuits and the negative feed-back values of the 1 mV/CM to .2 VOLTS/CM positions are repeated. In the 5 VOLTS/CM to 20 VOLTS/CM positions, a X100 attenuator is inserted in the input circuits and the negative feedback values are repeated again.

The attenuators are both resistance and capacitance dividers. For dc and low frequency signals, the attenuators act purely as resistance dividers, since the impedance of the capacitors is so high that it can be neglected. For higher frequency signals, however, the impedance of the capacitors is less, and their effect on the circuit is more pronounced. Near the upper-frequency range of the amplifier, the impedance of the capacitors becomes so low, compared to the resistance of the circuit, that the attenuators become capacitance dividers.

In addition to providing the proper degree of attenuation, the resistance values of the attenuators are chosen so as to provide a constant 1 M input resistance, regardless of the setting of the SENSITIVITY control. The capacitance of the attenuators is also adjusted to provide a constant input capacitance of 47 $\mu\mu f$ regardless of the setting of the SENSITIVITY control.

Input Amplifier

The Input Amplifier amplifies the potential difference between the two grids of V434. When one grid goes positive and the other goes negative with respect to ground, the output of the stage is proportional to the sum of the amplitudes of the two signals. When both grids go positive or both go negative, the output is proportional to the difference between the amplitudes of the two signals. In single ended operation, a signal is applied to one grid while the other grid circuit is grounded; therefore, the output is proportional to the amplitude of the one signal applied. The output of V434, then, is a push-pull signal to the bases of the transistors, Q454 and Q464, regardless of whether the Input Amplifier is being operated single-ended or differentially.

The gain of the Input Amplifier is varied (in steps) by changing the value of R408. This varies the amount of negative feedback applied to the cathode circuit of the first stage from the output of the second. This feedback is applied through R457 and R467 to the parallel network of R419 and L419 (in series) and R408. As the value of R408 is increased, the amount of negative feedback voltage is increased, limiting the gain of the amplifier. Dc balance of the Vertical Amplifier is accomplished by means of the COARSE DC BAL. (VERT.) control and the DC BAL. control. Proper adjustment of these two controls sets the two ends of R408 at the same potential so that there is no current flowing through it. This provides vertical stability of the trace throughout the range of the SENSITIVITY control.

The second stage of the Input Amplifier is provided with a positive feedback path from the collector of each side to the base of the other. This positive feedback path is adjusted, by varying the value of R460, to set this second stage for infinite gain. Thus, the second stage provides its own driving current and none is diverted from the plate circuits of the first stage. The negative feedback through the first stage of the amplifier prevents the infinite-gain second stage from oscillating. The effect of R460 is most pronounced in the 1 mV/CM position of the SENSITIVITY control since there is the least amount of overall negative feedback in this position.

Output Amplifier

The Output Amplifier is the stage that drives the vertical deflection plates of the crt. The gain of this stage can be adjusted by means of the .2 V GAIN. ADJ. (VERT.), R478, and the VARIABLE control, R488.

Vertical positioning of the crt beam is accomplished by means of the cross-coupled dual POSITION control, R470. Adjustment of this control varies the current through the Output Amplifier tubes thereby changing the average dc voltage at each of the plates inversely to the other. At the same time, through feedback in the Input Amplifier, the control also produces a small push-pull change in voltage at the grids of the Output Amplifier to maintain the cathodes at the same potential as the current is changed.

Trigger Pickoff

The output from V474, one side of the Output Amplifier, is applied through a divider network made up of R490, R491, and R492 to the SOURCE switch, SW5. Thus, when the SOURCE switch is in the INT. position, the output of the Output Amplifier is applied to the Sweep Trigger to start the Horizontal sweep.

HORIZONTAL AMPLIFIER

X-Y Operation

When the Type RM503 Oscilloscope is set for X-Y operation (HORIZONTAL DISPLAY switch in the HORIZ. AMP. ONLY position), the Horizontal Amplifier is virtually identical to the Vertical Amplifier. A given signal or signals applied to the Horizontal Amplifier inputs will produce the same deflection as the same signal or signals applied to the Vertical Amplifier inputs, except, of course, that the deflection will be in the X (horizontal) plane rather than the Y (vertical) plane. This mode is used for plotting two voltage functions against one another.

Sweep Operation

When the Type RM503 Oscilloscope is set up for sweep operation, the Horizontal Amplifier is used to amplify the sawtooth waveform from the Sweep Generator. In this mode of operation the Horizontal Input Amplifier is connected for single-ended operation. The sawtooth waveform is applied to one grid of the Input Amplifier and the other grid is grounded. Neither of the input attenuators is used.

The feedback circuits which control the gain of the Horizontal Amplifier operate in the same manner for sweep operation as for X-Y operation, except that a different set of resistors is used in the Input Amplifier cathode circuit. Also the VARIABLE control in the cathode circuit of the Output Amplifier is shorted out. In sweep operation, the POSITION control varies the dc potential on the active grid of the Input Amplifier rather than the current through the two halves of the Output Amplifier.

SWEEP TRIGGER

The Sweep Trigger circuit consists of the Trigger Input Amplifier, V24, and the Trigger Multivibrator, V45. The Trigger Input Amplifier amplifies (and, when desired, inverts) the incoming triggering signal and applies it to the input of the Trigger Multivibrator. The Trigger Multivibrator produces a negative-going rectangular pulse whose leading edge is coincident with the point on the triggering signal at which it is desired to start the horizontal sweep. This leading edge is then differentiated to produce a sharp negative spike which triggers the Sweep Generator.

Trigger Source

The triggering signal from which the rectangular output pulse is produced may be obtained from any one of three sources. When the SOURCE switch is in the INT. position, the signal is obtained from the Trigger Pickoff circuit of the Vertical Amplifier. When the SOURCE switch is in the EXT. position, the signal may be obtained from an external source through the EXTERNAL TRIG. IN connector on the front panel. When the SOURCE switch is in the LINE position, the signal is obtained from one side of the 6.3 volt ac filament heater circuit.

Trigger Slope

The negative-going pulse is initiated at the output of the Trigger Multivibrator (plate of V45B) only when there is a Negative-going signal at the input of the Trigger Multivibrator (grid of V45A). However, it is desired to be able to start the sweep during either a positive-going or negative-going portion of the triggering signal. Therefore, some provision must be made for choosing between inverting or not inverting the triggering signal in the Trigger Input Amplifier. This is done by means of the SLOPE switch.

With the SLOPE switch in the — position, V24 is a cathode-coupled amplifier and the triggering signal is applied to the grid of V24A. The signal at the plate of V24B is in phase with the incoming triggering signal. Thus, the negative-going portion of the signal at the input to the Trigger Multivibrator corresponds to the negative-going portion of the incoming triggering signal. With the SLOPE switch in the + position, the triggering signal is applied to the grid of V24B, and V24B becomes an ordinary plate-loaded amplifier. The signal at the plate of V24B is opposite in polarity from the incoming triggering signal. Thus, the negative-going portion of the signal at the input to the Trigger Multivibrator corresponds to the positive-going portion of the incoming triggering signal.

Trigger Level

The LEVEL control, R17, varies the bias on the tube to which it is connected. This in turn varies the quiescent voltage at the plate of V24B about which the signal varies. Since the Trigger Multivibrator is triggered at a given dc level, varying the dc voltage about which the triggering signal varies in effect varies the instantaneous voltage level of the signal at which the Trigger Multivibrator is triggered. Thus, through the use of the SLOPE and LEVEL switches it is possible to trigger the Trigger Multivibrator at virtually any point on either a positive-going or negative-going portion of the triggering signal.

Triggering Multivibrator

The Trigger Multivibrator operates as follows: In the quiescent state, that is, ready to receive a signal, V45A is conducting and its plate voltage is down. This holds the grid of V45B below cutoff, since the two circuits are dc-coupled. With V45B in a state of cutoff, its plate voltage is up.

The negative-going portion of the signal from the Trigger Amplifier drives the grid of V45A in a negative direction, and the cathodes of both tubes follow the grid down. At the same time the plate voltage of V45A starts to rise. This causes the grid voltage of V45B to rise. With the grid of V45B going up and its cathode going down, V45B starts to conduct. As V45B starts conducting, its cathode starts going up, taking the cathode of V45A up with it. With the grid of V45A down and its cathode up, V45A cuts off. This causes the plate of V45A, and therefore the grid of V45B, to go farther in a positive direction, and causes V45B to conduct heavily. This creates a negative step at the plate of V45B. The transition occurs very rapidly, regardless of how slowly the signal at the grid of V45A falls initially.

When the signal at the grid of V45A goes in the positive direction, just the opposite chain of events will occur. V45A will start conducting again, and V45B will cut off. The result is a positive step at the plate of V45B. This step is also differentiated to form a positive spike but this spike is bypassed to the +250-volt supply by D44 and is not used.

Automatic Triggering

When the LEVEL control is turned fully counterclockwise, the AUTOMATIC switch, SW17, is activated and converts the Trigger Multivibrator from a bi-stable configuration to an astable (free-running) configuration. (This should not be confused with the action of the FREE RUN switch, shown on the Sweep Generator diagram, which causes the Sweep Generator to free-run). This is accomplished by coupling the grid circuit of V45B to the grid circuit of V45A via R40. In addition, the dc coupling between the Trigger Input Amplifier and the Trigger Multivibrator is removed when the switch is in this position.

To understand the operation of the Trigger Multivibrator in the free-running mode of operation, first assume that V45B is cut off and V45A is just being driven into cutoff by the charge on C31. The voltage at the plate of V45A starts to rise, carrying with it the voltage at the grid of V45B. So V45B starts to conduct, causing a negative step at its plate. Since the two grids are coupled through R40, the grid of V45A will start moving positively at the same time as does the grid of V45B. However, the time constant of the R40-C31 network is such that it takes about 0.01 second for the voltage at the grid of V45A to rise exponentially from its starting point, below cutoff, to a point where the tube will start conducting.

When V45A does start conducting, its plate voltage will drop, carrying with it the grid of V45B. V45B will cut off, causing a positive step at its plate. At the same time that the grid of V45B goes negative, the grid of V45A will also start negative. Once again, it will take about 0.01 second for C31 to charge up sufficiently to cut V45A off. When V45A does cut off, the cycle starts over.

Hence, in the absence of a triggering signal, the Trigger Multivibrator free-runs at about 50 cps. However, since the triggering signals from the Trigger Input Amplifier are still coupled to the Trigger Multivibrator through C31, any triggering signal over 50 cps in frequency will produce synchronized operation of the Trigger Multivibrator. The 50 cps free-running sweep produced in the absence of a triggering signal provides a base line from which to make voltage measurements and also indicates that the instrument is adjusted to display any signal that might be applied to the input.

SWEEP GENERATOR

The Sweep Generator, upon receipt of a trigger pulse from the Sweep Trigger, produces a linearly rising (sawtooth) voltage which is applied through the Horizontal Amplifier to the crt deflection plates. This causes the spot to move from left to right on the crt screen and form the sweep. The amplitude of the sawtooth voltage is about 100 volts. Its rate of rise is controlled by the values of the Timing Capacitor and Timing Resistor switched into the circuit by the SWEEP TIME/CM switch on the front panel.

The Sweep Generator consists of three main circuits; the Sweep-Gating Multivibrator, the Miller Runup Circuit, and the Hold-Off Circuit. The Sweep-Gating Multivibrator consists of V135A, V135B and V145A. The essential components of the Miller Runup Circuit are: the Miller Runup Tube, V160A; the Runup Cathode Follower, V160B; the Disconnect Diodes, V152A and V152B; the Timing Capacitor, C160; and the Timing Resistor, R160. The Hold-Off Circuit consists of the Hold-Off Diode, V152C; the Hold-Off Cathode Follower, V145B; the Hold-Off Resistor, R181; and the Hold-Off Capacitor, C160 (the Hold-Off Circuit makes use of some of the same timing capacitors as the Miller Runup Circuit).

In the quiescent state, that is, when no sweep is being generated, V135A is conducting and V145A is cut off. The plate of V145A is at about −2.5 volts with respect to ground. The Disconnect Diodes are conducting and hold both sides of the Timing Capacitor at about −2.5 volts. With its cathode grounded and its grid at −2.5 volts, V160A is conducting heavily and its plate is at about +30 volts.

Sweep Generation

A negative trigger pulse, arriving at the grid of V135A from the Sweep Trigger circuit, causes the Sweep Gating Multivibrator to switch rapidly to its other state. That is, V135A cuts off and V145A conducts. As V145A conducts, its plate voltage goes down, cutting off the Disconnect Diodes. When the Disconnect Diodes cut off, the plates of the Timing Capacitor are no longer held at —2.5 volts, and the Timing Capacitor starts to charge toward the instantaneous potential difference between the —100-Volt supply and the potential on the cathode of V160B. However, as the lower plate of the Timing Capacitor starts to move in a negative direction, it takes the grid of V160A with it. This produces a positive swing at the plate of V160A which is coupled, through B167 and V160B, to the upper plate of the Timing Capacitor. This increases the voltage to which the Timing Capacitor is trying to charge. The effect is to "straighten out" the charging curve by increasing the charging voltage with each increment of charge on the capacitor. The positive voltage swing on the upper plate of the Timing capacitor also tends to prevent the lower plate from swinging negatively. Since the gain of V160A is about 200, the potential on the upper plate moves about 100 volts with respect to ground while the potential on the lower plate moves about one-half volt. The result is an extremely linear ramp at the cathode of V160B, which is applied through the Horizontal Amplifier to the horizontal deflection plates of the crt.

Sweep Length

The length of the sweep, that is, the distance the spot moves across the crt, is determined by the setting of the SWP. LENGTH control, R176. As the sweep voltage rises linearly at the cathode of V160B, there will be a linear rise in the voltage at the wiper arm of the SWP. LENGTH control. This will increase the voltage at the plate, and therefore the cathode, of V152C and at the grid and cathode of V145B. As the voltage at the cathode of V145B rises, the voltage at the grid of V135A will rise. When the voltage at this point rises to a point where V135A comes out of cutoff, the Sweep-Gating Multivibrator will rapidly revert to its original state with V135A conducting and V145A cut off. The voltage at the plate of V145A will then rise, carrying with it the voltage at the plates of the Disconnect Diodes

V152B starts conducting, and brings the grid of V160A quickly back up to its quiescent level. The rise in voltage at the grid causes the tube to conduct more, so the plate voltage drops, carrying with it the grid and cathode of V160B. When the voltage at the cathode of V160B returns to about —2.5 volts, V152A conducts, clamping the voltage at this point. The circuit has now returned to its quiescent level and is ready for the next trigger.

Hold-Off

The Hold-Off Circuit prevents the Sweep Generator from being triggered during the sweep retrace interval. It does this by holding the grid of V135A positive enough to keep V135A in conduction until after the Miller Runup Circuit has stabilized in the quiescent condition.

Under quiescent conditions, normal conduction through V152B allows the Hold-Off Capacitor, C160, to be charged to about 70 volts. During the latter part of the sweep, the rising voltage at the cathode of V152B discharges this capacitor to a lower voltage, in the vicinity of about 55 volts. At the end of the sweep, when the voltage at the cathode of V160B drops, the voltage at the SWP. LENGTH wiper arm also drops and V152B cuts off. The cathode tries to follow the drop in voltage at the plate but is held up by the charge on the Hold-Off Capacitor. The Hold-Off Capacitor charges again exponentially toward 100 volts, carrying the cathode of V152B and the grid of V145B negative. The cathode of V145B, and therefore the grid of V135A, follows the grid of V145B. At some point in this exponential charging curve, depending upon the settings of the STABILITY ADJUST control and the FREE RUN switch, the grid of V135A will become negative enough that a negative trigger pulse coming from the Sweep Trigger circuit can again take V135A into cutoff.

The hold-off time, then, is determined by the value of C160 switched into the Hold-Off Circuit by the SWEEP TIME/CM switch. The amount of hold-off time required is determined by the sweep rate. For this reason the SWEEP TIME/CM switch changes the amount of capacitance in the Hold-Off Circuit simultaneously with that in the Timing Circuit.

Sweep Stability

The STABILITY ADJUST control, R111, regulates the dc level at the grid of V135A. This control is adjusted so that the voltage at the grid of V135A is just high enough to prevent the circuit from free running. When it is adjusted in this manner, a swep can be produced only when a negative trigger pulse from the Sweep Trigger can drive V135A into cutoff. Turning the LEVEL switch full clockwise closes the FREE RUN switch and shorts out R11. This places a more negative voltage on the grid of V135A such that V135A cuts off immediately upon decay of the hold-off voltage, at which time the next sweep is initiated. The result is a free-running sweep whose period is the total of the sweep time plus the hold-off time at any given setting of the SWEEP TIME/CM switch. (This is compared to a maximum repetition rate of about 50 cps when the LEVEL switch is turned fully counterclockwise to the AUTO. position).

Unblanking

The positive rectangular pulse appearing at the cathode of V135B during sweep time is applied as an unblanking pulse to the crt. Action of this pulse is discussed under the description of the crt circuit later in this section. It should be noted that, when the HORIZONTAL DISPLAY switch is in the HORIZ. AMP ONLY position, the Sweep-Gating Multivibrator is disabled, and there is no current flowing through V135A or 145A. Therefore, the cathode of V135B is held at +225 volts and the crt is continuously unblanked.

CRT CIRCUIT

The crt in the Type RM503 Oscilloscope makes use of an extra set of deflection plates for unblanking during sweep time. One of these plates has a fixed potential of about +225 volts on it; the other is tied to the cathode of V135B in the Time-Base Generator. Quiescently, this latter plate is held at a relatively low potential, in the vicinity of +80 volts. Therefore, the electron beam in the crt is deflected and absorbed by the +225-volt plate; none of it reaches the screen. During the sweep time, however, the unblanking pulse from V135B raises the potential of the second plate from +80 volts to about +225 volts. When this happens, both unblanking deflection plates attract the electron beam in the same amount with the net result that the beam is not deflected toward either plate, but passes on through to the crt screen.

The INTENSITY control varies the control grid of the crt from about —20 volts to —150 volts with respect to the cathode. Connections are provided on the rear of the oscilloscope cabinet to couple an ac signal to the control grid to provide intensity modulation of the trace if desired.

CALIBRATOR

The calibrator provides a 500-millivolt square wave and a 5-millivolt square wave for use in calibrating the gain of the Horizontal and Vertical Amplifiers. The two amplitudes are obtained by tapping off at different points in a voltage divider network.

The square wave is produced by the turning off and on of B886. This is accomplished by the combined action of B886, B883, and C883. B886 and B883 are neon tubes which nominally drop about 60 volts when they are conducting. However, if they are not conducting, they require about 80 volts across them to start conduction.

During the time that B886 is turned off, B883 is conducting. This causes C883 to discharge which allows both plates of B883 to move in a positive direction (60 volts apart). When the common connection at the top of the two neon tubes reaches a potential of about +80 volts with respect to ground, B886 conducts. The current through R886 and R887 produces a 0.5-volt drop across them and the voltage at the upper end of B886 is, therefore, about +60.5 volts with respect to ground. Since the upper plate of C883 is now at about +20 volts with respect to ground, the potential across B883 is only about 40 volts, and B883 stops conducting. With no current through B883 to maintain the charge on C883, the upper plate of C883 starts to move in a negative direction. The upper end of B883 is held steady at +60.5 volts by the drop across B886, R886, and R887, so when the upper plate of C883 becomes —20 volts with respect to ground, B883 conducts. This drops the voltage at the upper end of the two neon tubes to +40 volts, and B886 cuts off, completing one cycle of the square wave.

It should be noted that the potentials mentioned in the foregoing discussion (except the drop across R886 and R887) are typical nominals only, and may vary considerably among different unit. The only effect will be a slight variation in the frequency and symmetry of the output waveform.

The CAL. ADJ. control, R880, provides a means of adjusting the voltage drop across R886 and R887 by controlling the current through them.

POWER SUPPLY

T601 provides filament power for the graticule lights and all of the tubes, except the first stage of the Input Amplifier, and B+ voltage (about 500 volts) for the power supply oscillator tube, V620. The rest of the voltages used in the oscilloscope are provided by the secondary of T620.

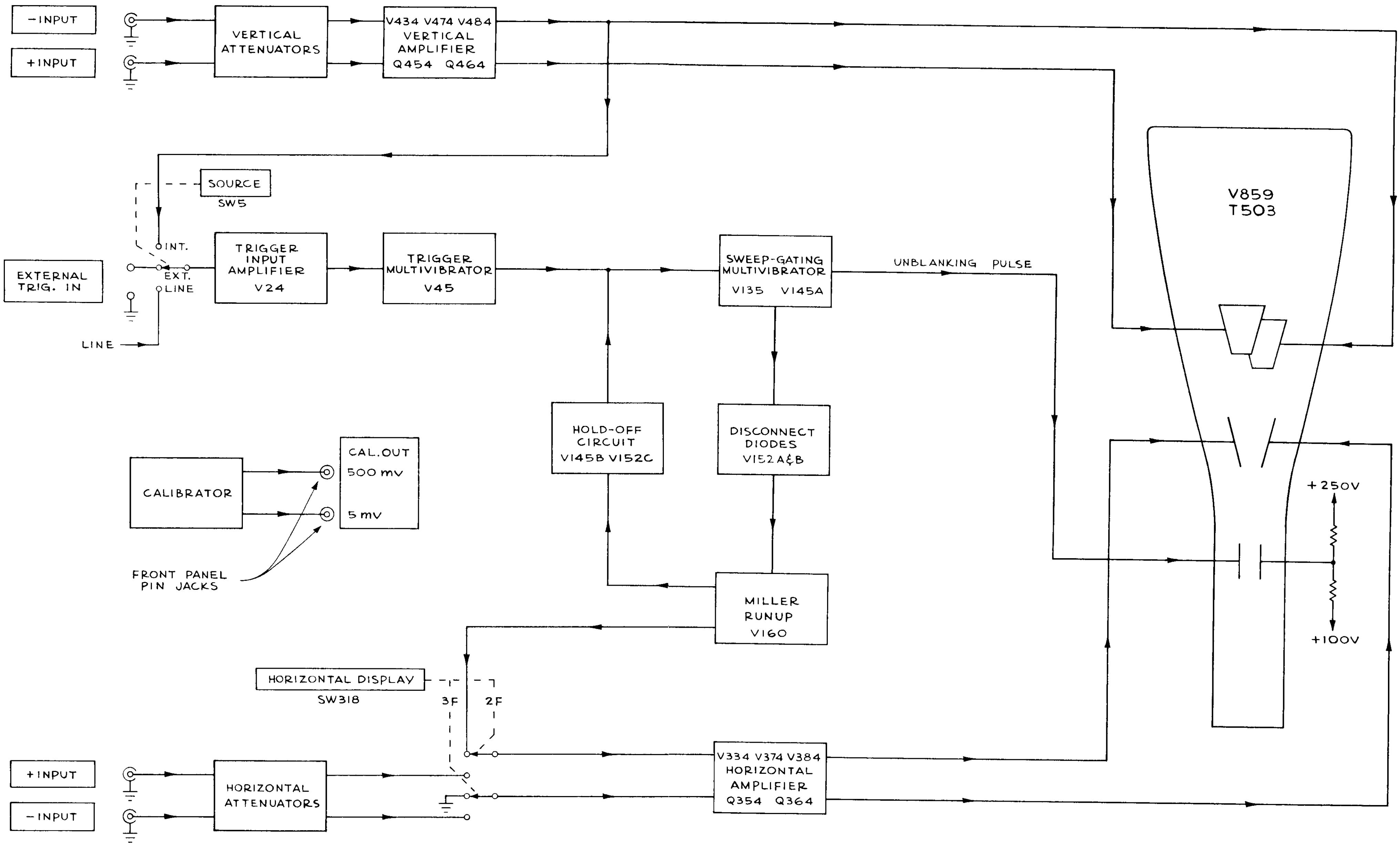
V620, the primary of T620, and part of the secondary of T620 form an Armstrong oscillator circuit to drive T620 at about 25 kc. Each of the outputs of the secondary of T620 bears a fixed turn ratio to the others such that a change in one effects a proportional change in each of the others. Adjustment and regulation of all of the ouput voltages, then, are accomplished through adjustment and regulation of just one output, the —100 volt output. This, in turn, is referenced to the 85-volt drop across the voltage regulator tube, V659.

Adjustment of the output voltages is accomplished by means of the —100 V ADJ. control as follows. Moving the wiper arm of the —100 V ADJ. control in a positive direction reduces the bias on V635B. This, in turn, lowers the voltage at the plate of V634B and, therefore at the grid of V634A. This causes an increase in voltage at the plate of V634A which, in turn, increases the screen voltage of V620. Increasing the screen voltage of V620 increases the G_m, and therefore the gain, of the tube, and thereby increases the amplitude of oscillations in the secondary of T620. This results in greater output from all of the supplies.

Regulation is accomplished in virtually the same manner. A lowering of the source voltage to which the oscilloscope is connected, or a lowering of any of the output voltages due to loading, causes the volts per turn in the secondary of T620 to decrease. This causes the —100-volt supply to drop (move positively) with the resulting rise in the grid voltage of V634B.This results, as before, in a rise in the screen voltage of V620 and an increase in the amplitude of oscillations, bringing the power supply outputs back to their nominal values.

An increase in any of the output voltages, whatever the reason, has the opposite effect on the screen voltage of V620 and decreases the amplitude of oscillations in T620.

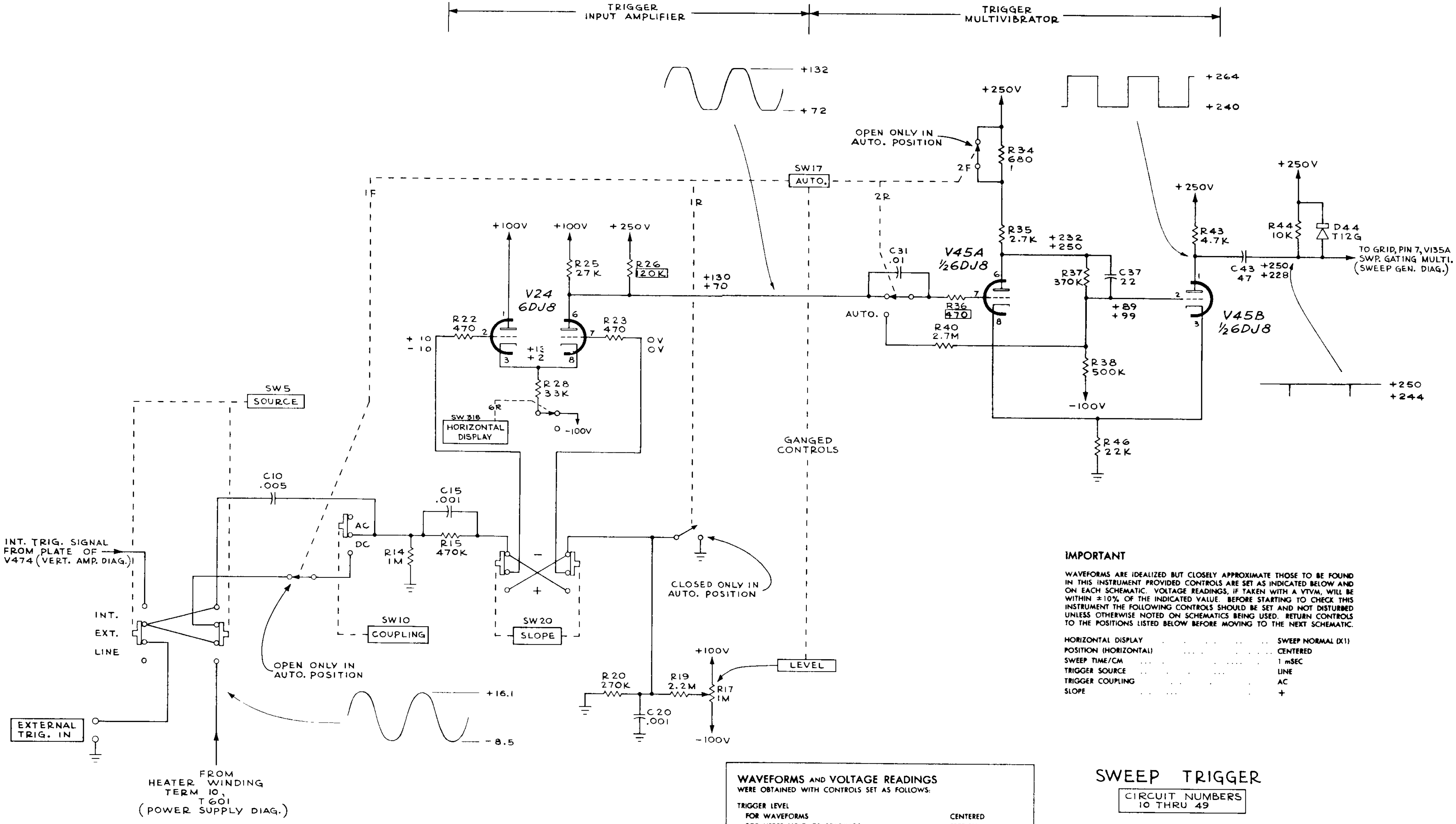
Regulation of the power supply outputs will be accomplished as long as the source voltage remains between 105 and 125 for 117-volt operation, or between 210 volts and 250 volts for 234-volt operation.



BLOCK DIAGRAM

GAB
12-5-62

TYPE RM503 OSCILLOSCOPE



IMPORTANT

WAVEFORMS ARE IDEALIZED BUT CLOSELY APPROXIMATE THOSE TO BE FOUND IN THIS INSTRUMENT PROVIDED CONTROLS ARE SET AS INDICATED BELOW AND ON EACH SCHEMATIC. VOLTAGE READINGS, IF TAKEN WITH A VTVM, WILL BE WITHIN ±10% OF THE INDICATED VALUE. BEFORE STARTING TO CHECK THIS INSTRUMENT THE FOLLOWING CONTROLS SHOULD BE SET AND NOT DISTURBED UNLESS OTHERWISE NOTED ON SCHEMATICS BEING USED. RETURN CONTROLS TO THE POSITIONS LISTED BELOW BEFORE MOVING TO THE NEXT SCHEMATIC.

HORIZONTAL DISPLAY	SWEEP NORMAL (X1)
POSITION (HORIZONTAL)	CENTERED
SWEEP TIME/CM	1 mSEC
TRIGGER SOURCE	LINE
TRIGGER COUPLING	AC
SLOPE	+

SWEEP TRIGGER

CIRCUIT NUMBERS 10 THRU 49

WAVEFORMS AND VOLTAGE READINGS
WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

TRIGGER LEVEL	
FOR WAVEFORMS	CENTERED
FOR UPPER VOLTAGE READINGS	FREE RUN
FOR LOWER VOLTAGE READINGS	CCW BUT NOT SWITCHED TO AUTO

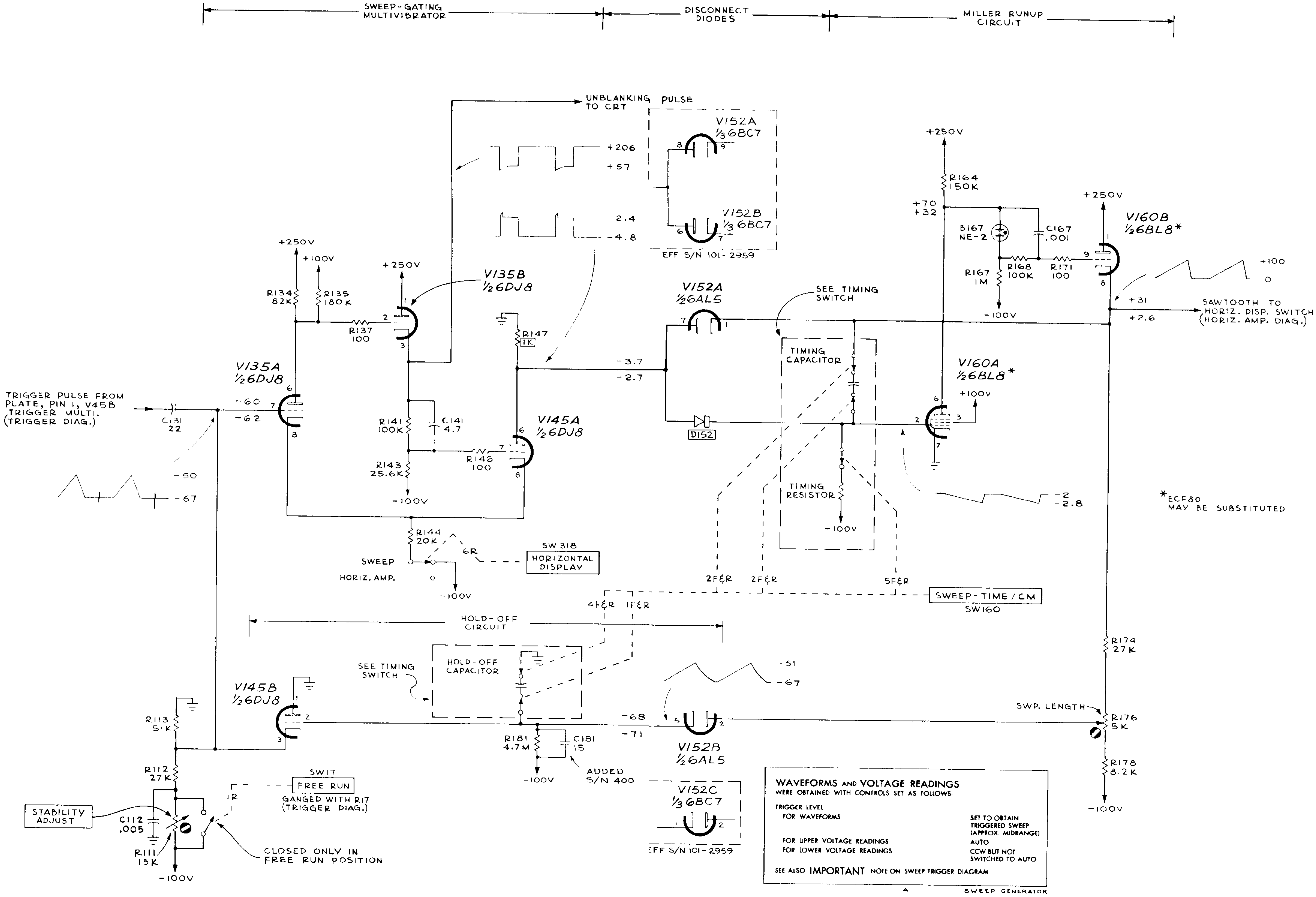
SEE ALSO **IMPORTANT** NOTE ON THIS DIAGRAM

A SWEEP TRIGGER

SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED WITH BLUE OUTLINE.

GAB 364

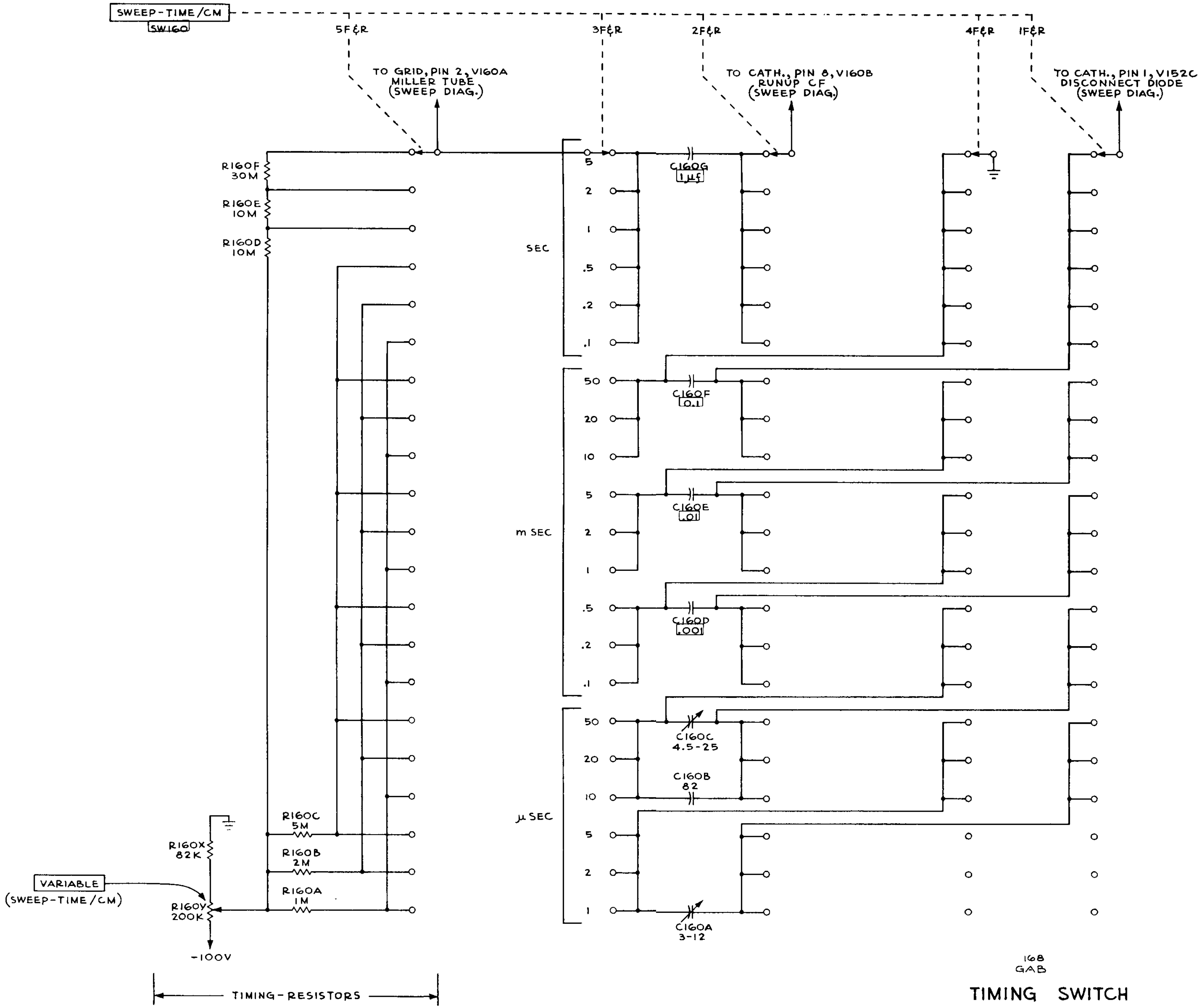
TYPE RM503 OSCILLOSCOPE



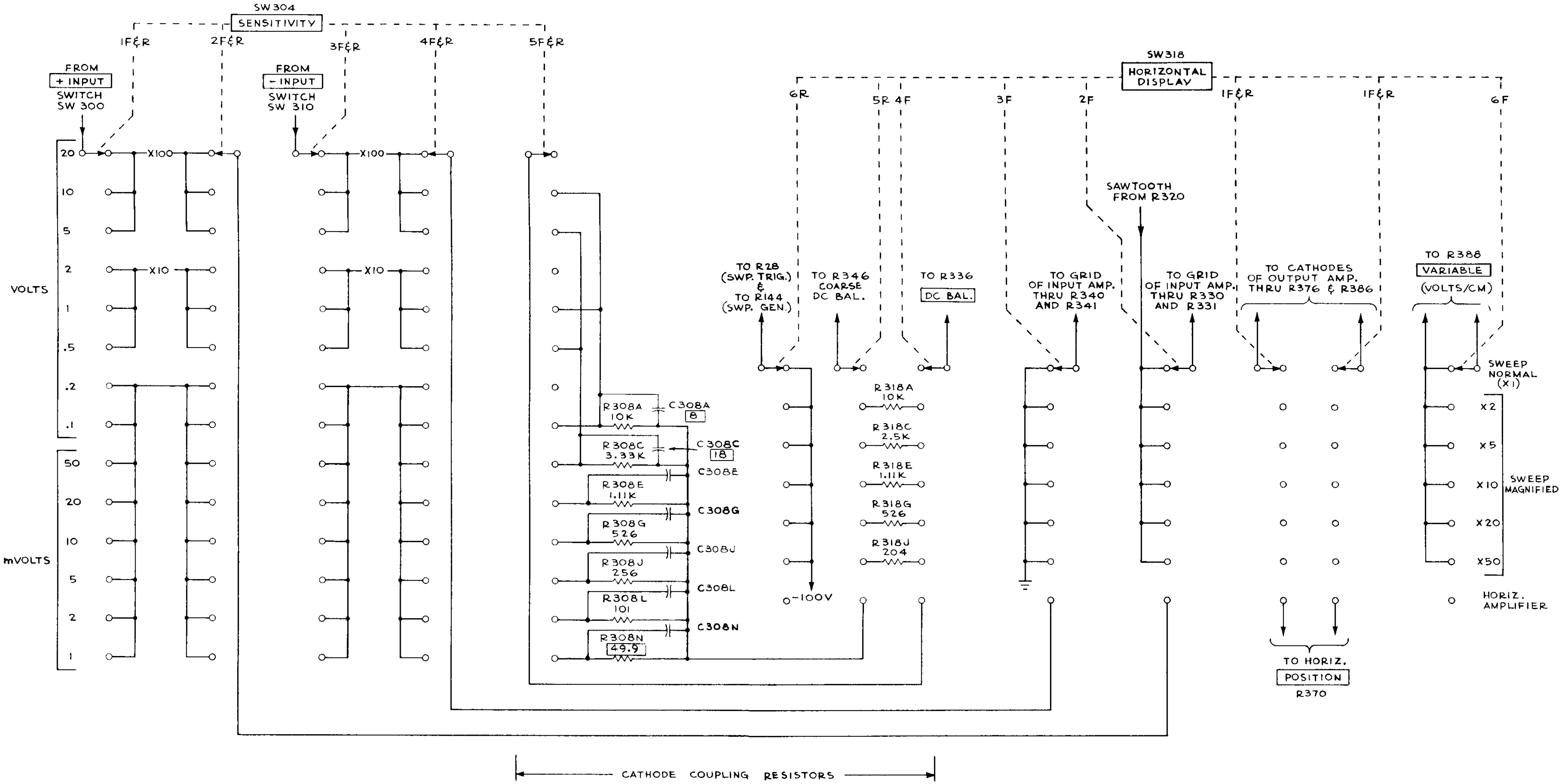
TYPE RM503 OSCILLOSCOPE

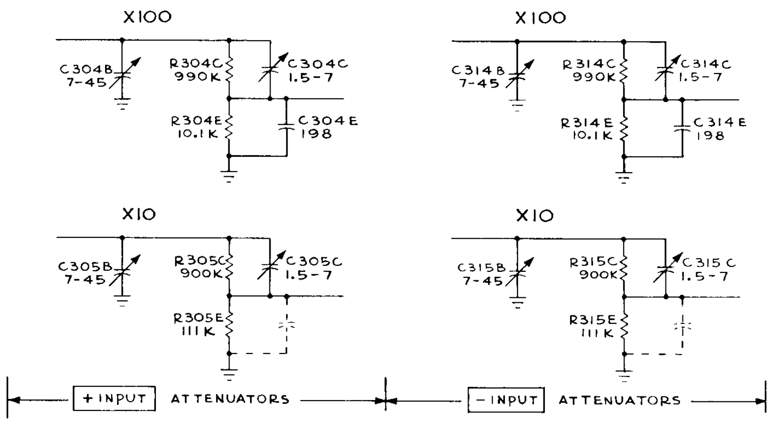
CIRCUIT NUMBERS 110 THRU 185

SWEEP GENERATOR



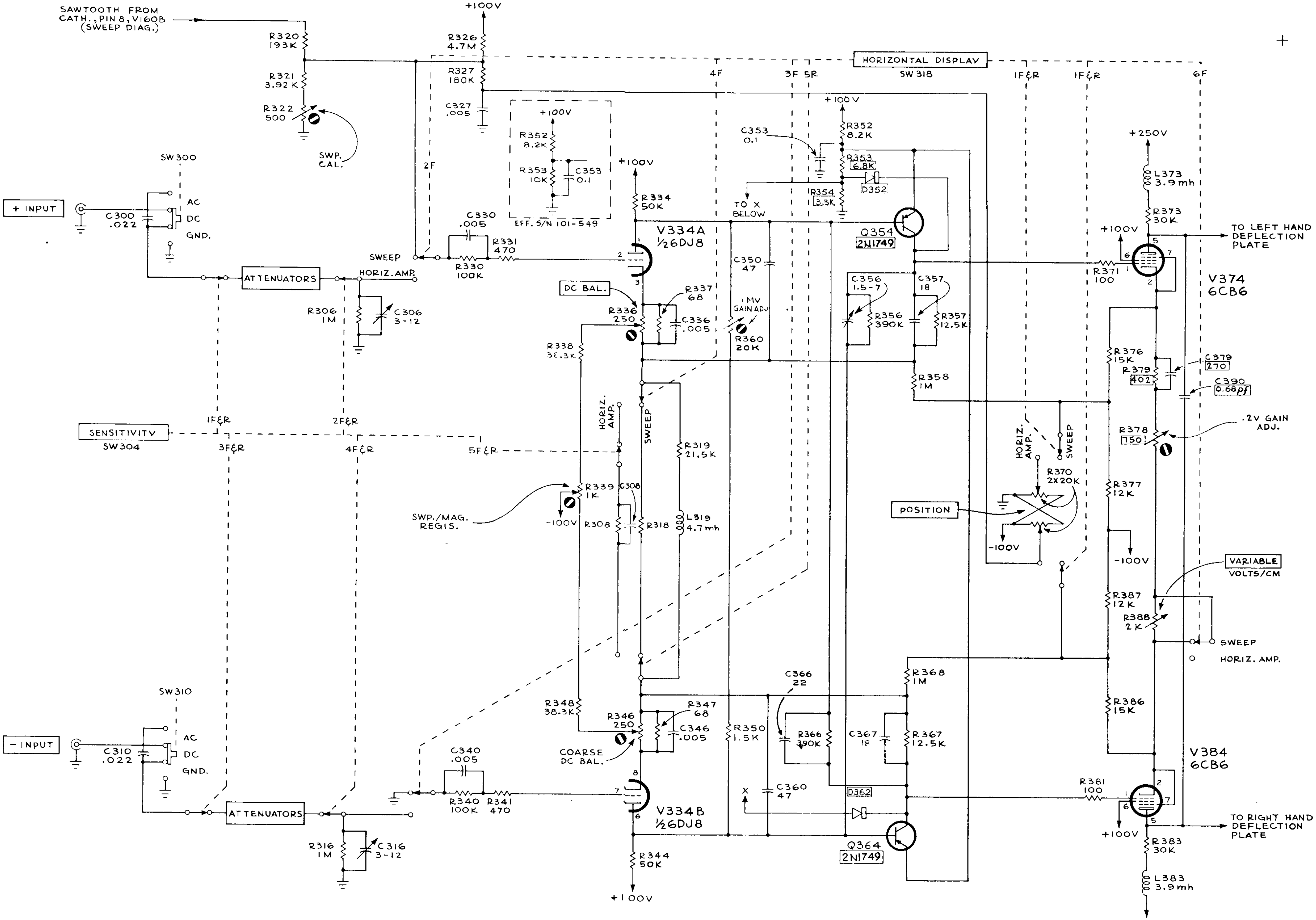
TIMING SWITCH





GAB
367

HORIZONTAL DISPLAY SWITCH
HORIZONTAL AMPLIFIER ATTENUATOR SWITCH



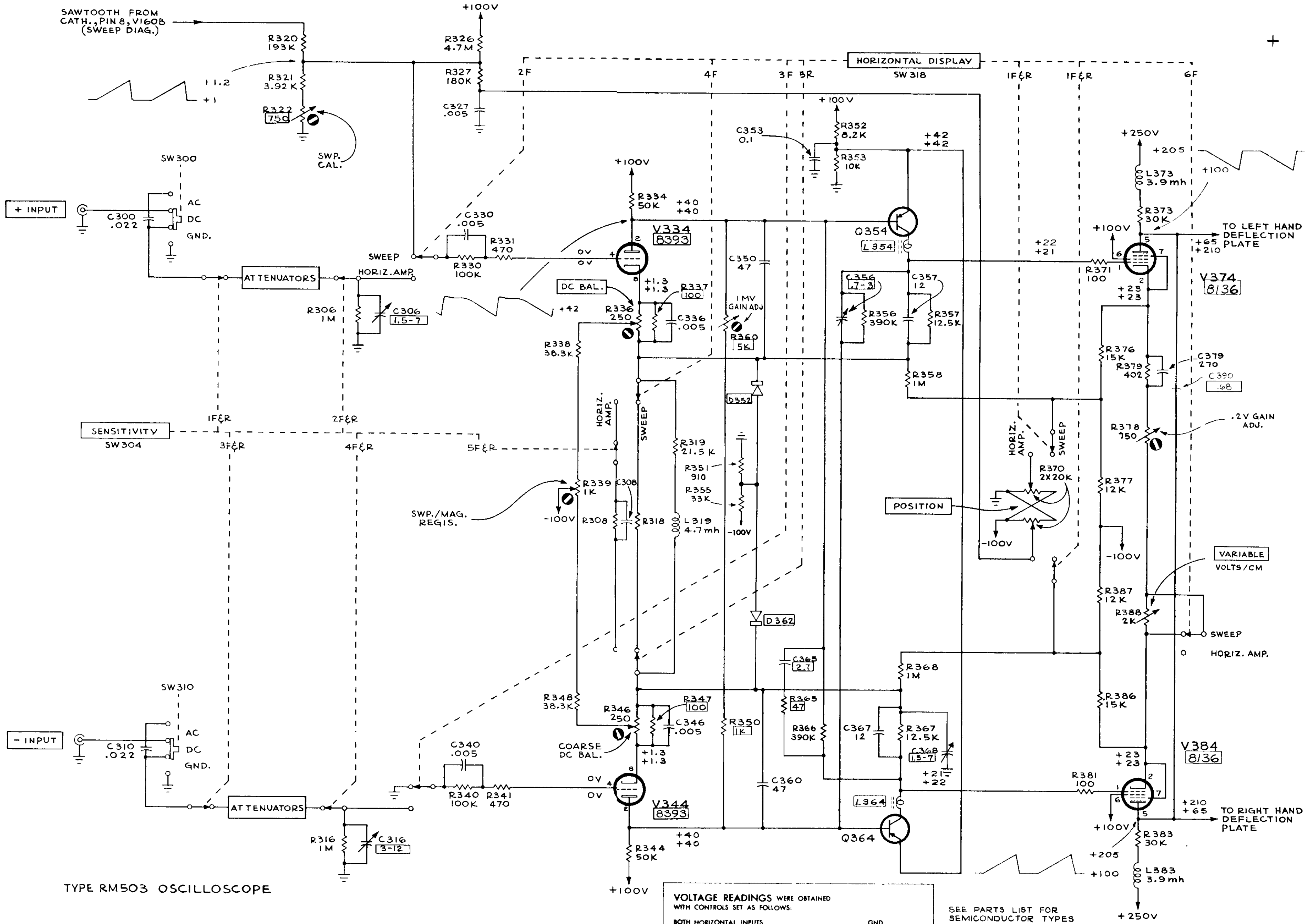
HORIZONTAL AMPLIFIER

EFF. S/N 101 - 1094

CIRCUIT NUMBERS 300 THRU 399

SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED WITH BLUE OUTLINE.

GAB
364



TYPE RM503 OSCILLOSCOPE

VOLTAGE READINGS WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

BOTH HORIZONTAL INPUTS	GND
SENSITIVITY	.2 VOLTS/CM
HORIZONTAL POSITION	
FOR UPPER VOLTAGE READINGS	CW
FOR LOWER VOLTAGE READINGS	CCW
HORIZONTAL DISPLAY	HORIZ. AMPLIFIER (SWEEP DISABLED)

SEE ALSO **IMPORTANT** NOTE ON SWEEP TRIGGER DIAGRAM

HORIZ. AMP.

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

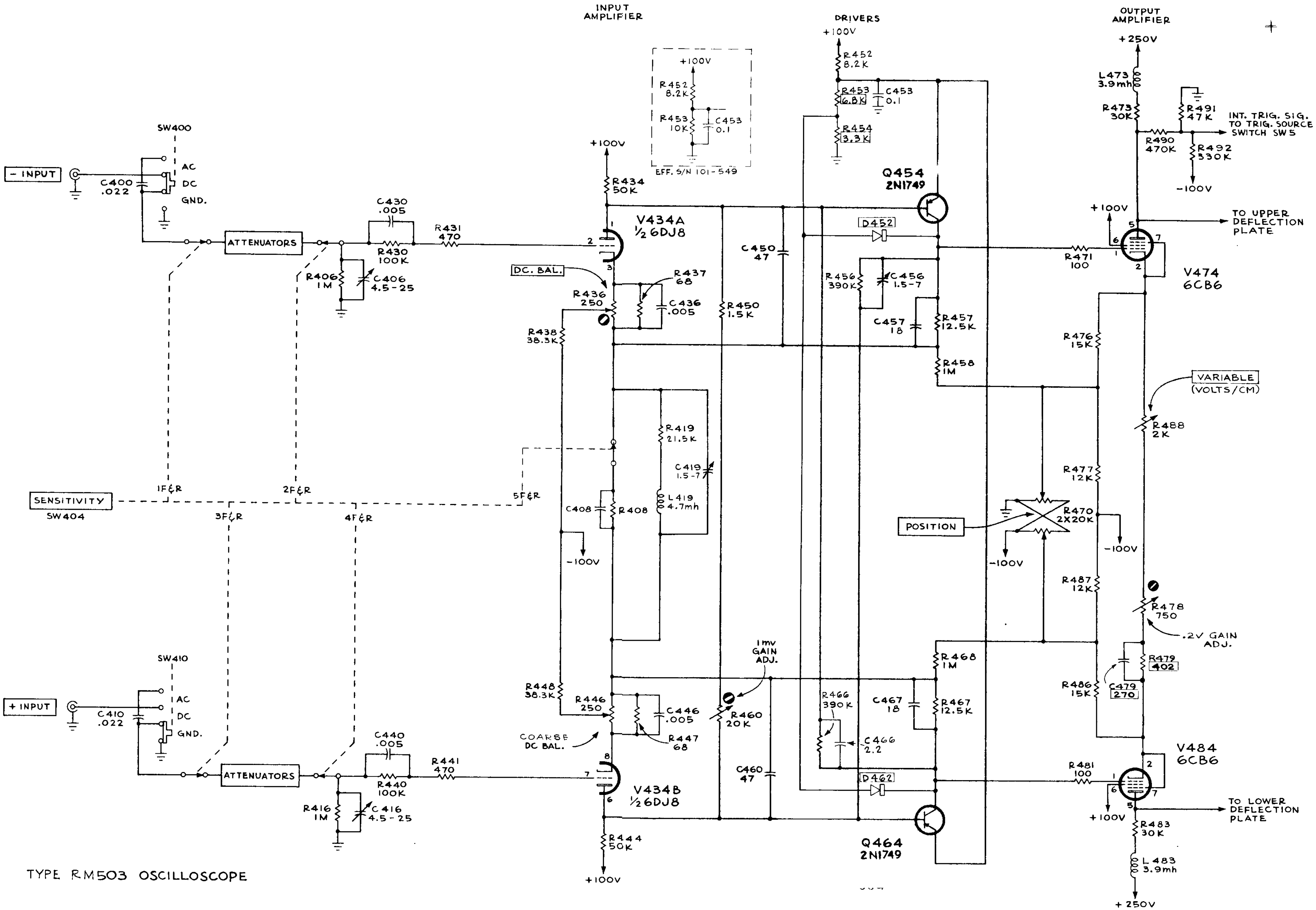
H

HORIZONTAL AMPLIFIER

EFF. S/N 1035 - UP

CIRCUIT NUMBERS 300 THRU 399

568 GAB

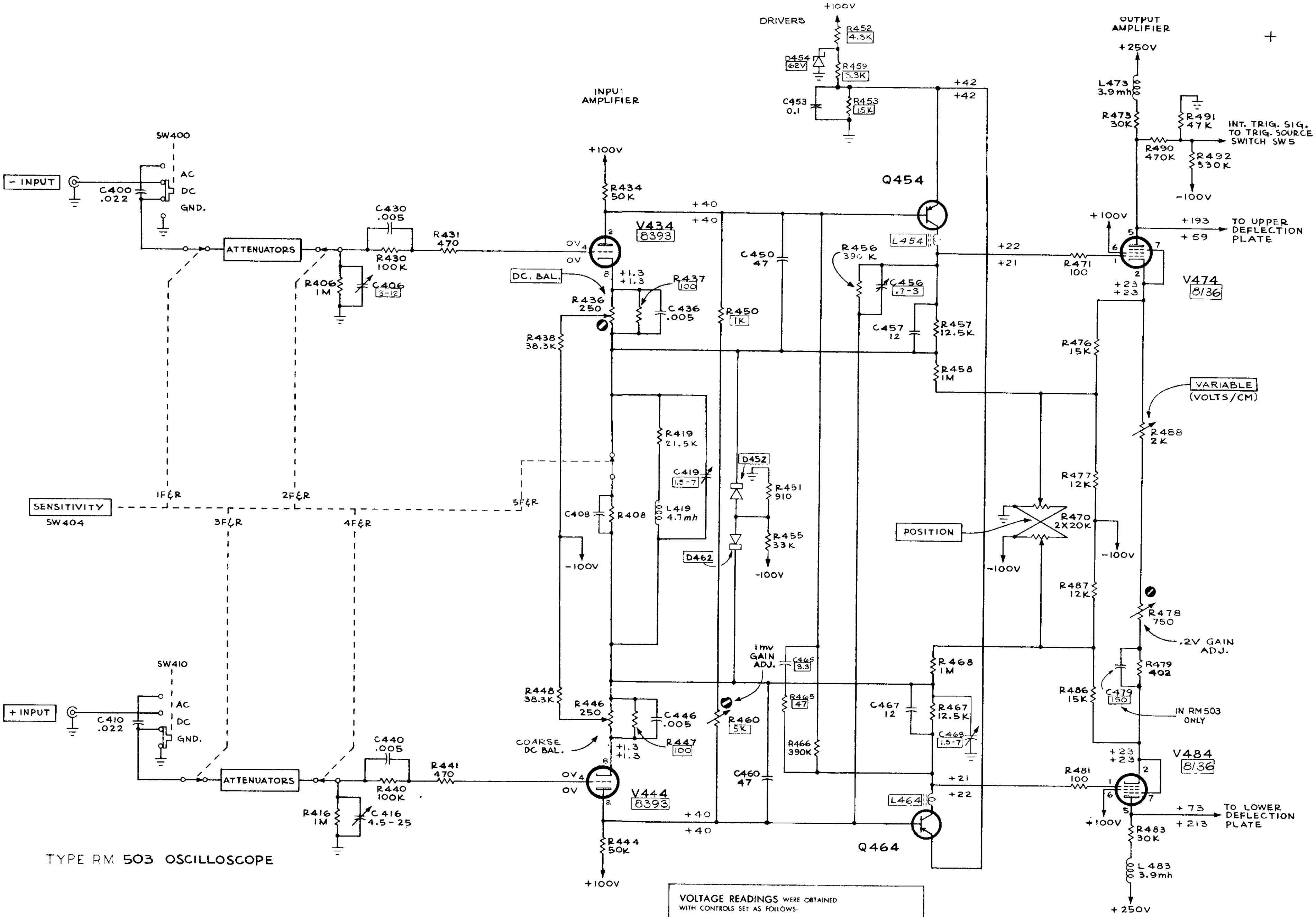


TYPE RM503 OSCILLOSCOPE

VERTICAL AMPLIFIER

EFF. S/N 101-1094

CIRCUIT NUMBERS 400 THRU 499



TYPE RM 503 OSCILLOSCOPE

VOLTAGE READINGS WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

BOTH INPUTS	GND
SENSITIVITY	2 VOLTS/CM
VERTICAL POSITION	
FOR UPPER VOLTAGE READINGS	CW
FOR LOWER VOLTAGE READINGS	CCW

SEE ALSO IMPORTANT NOTE ON SWEEP TRIGGER DIAGRAM

VERT. AMP

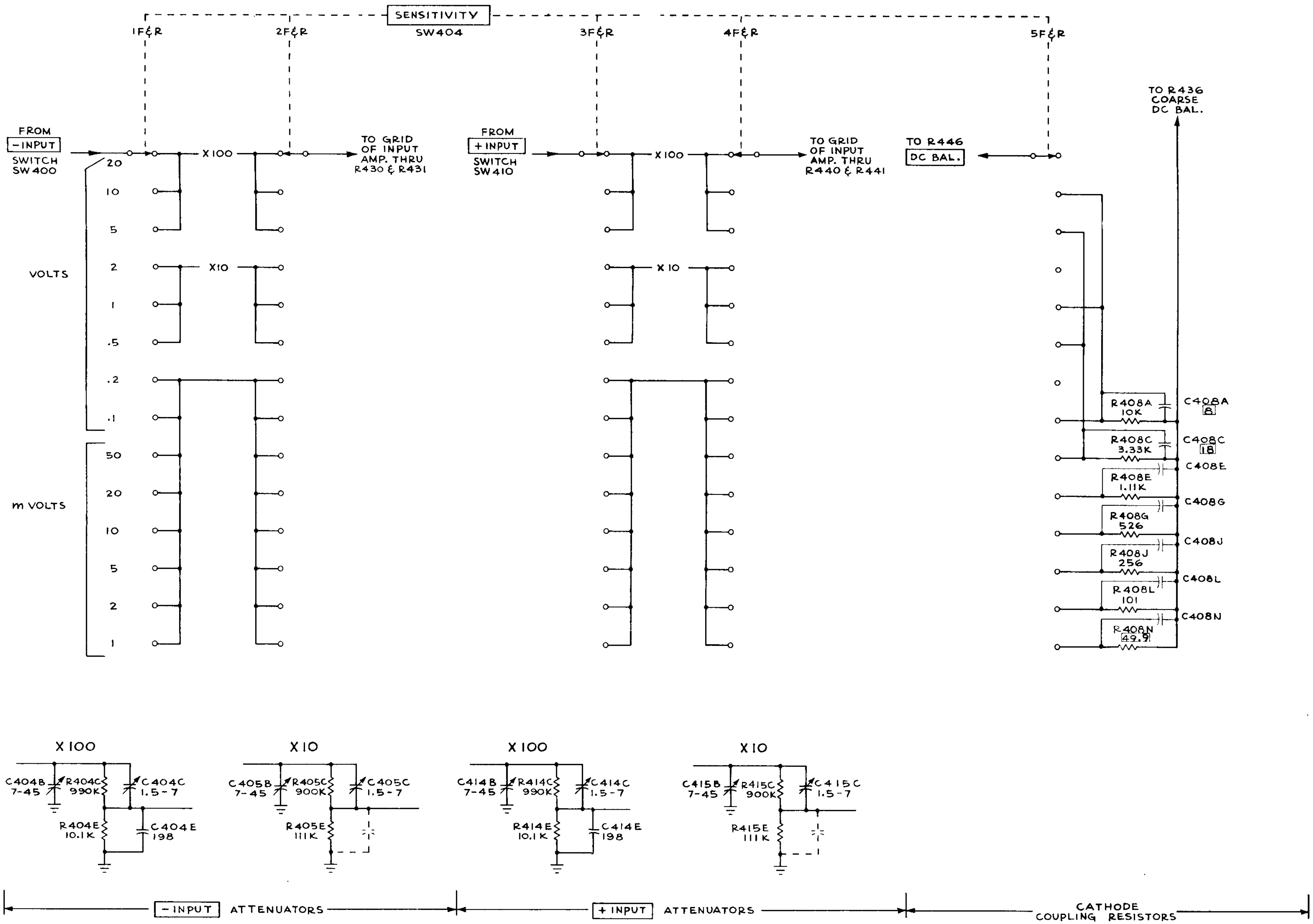
568

H_1

VERTICAL AMPLIFIER

EFF. S/N 1095-UP

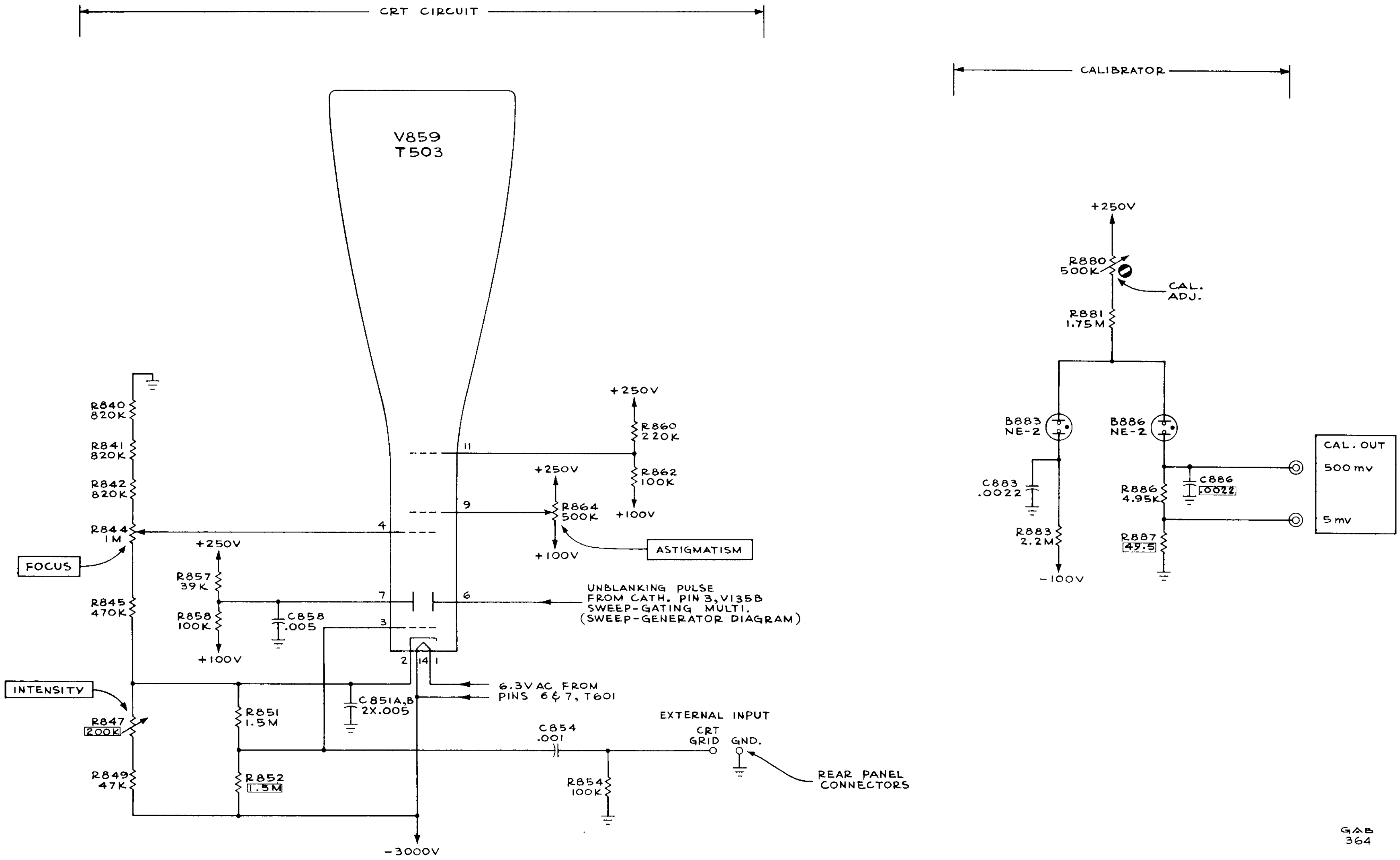
CIRCUIT NUMBERS 400 THRU 495



GAB
367

TYPE RM503 OSCILLOSCOPE

VERTICAL AMPLIFIER ATTENUATOR SWITCH



CRT CIRCUIT & CALIBRATOR

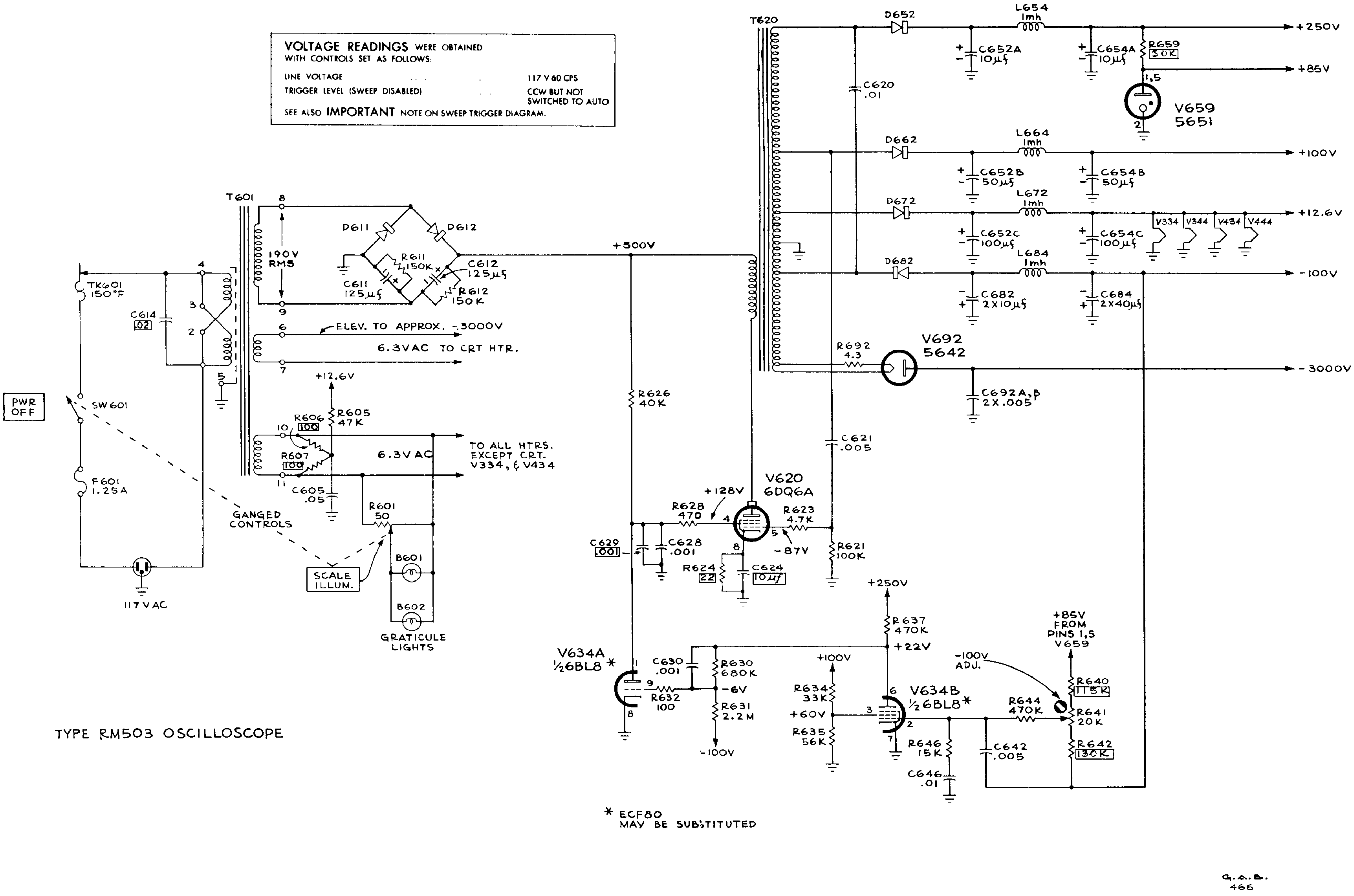
CIRCUIT NUMBERS
840 THRU 889

TYPE RM503 OSCILLOSCOPE

VOLTAGE READINGS WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

LINE VOLTAGE	117 V 60 CPS
TRIGGER LEVEL (SWEEP DISABLED)	CCW BUT NOT SWITCHED TO AUTO

SEE ALSO IMPORTANT NOTE ON SWEEP TRIGGER DIAGRAM.



TYPE RM503 OSCILLOSCOPE

POWER SUPPLY

CIRCUIT NUMBERS 600 THRU 699