CATHODE RAY OSCILLOSCOPE

TYPE 531/541

INSTRUCTION MANUAL

TEKTRONIX, INC.

MANUFACTURERS OF CATHODE-RAY AND VIDEO TEST INSTRUMENTS

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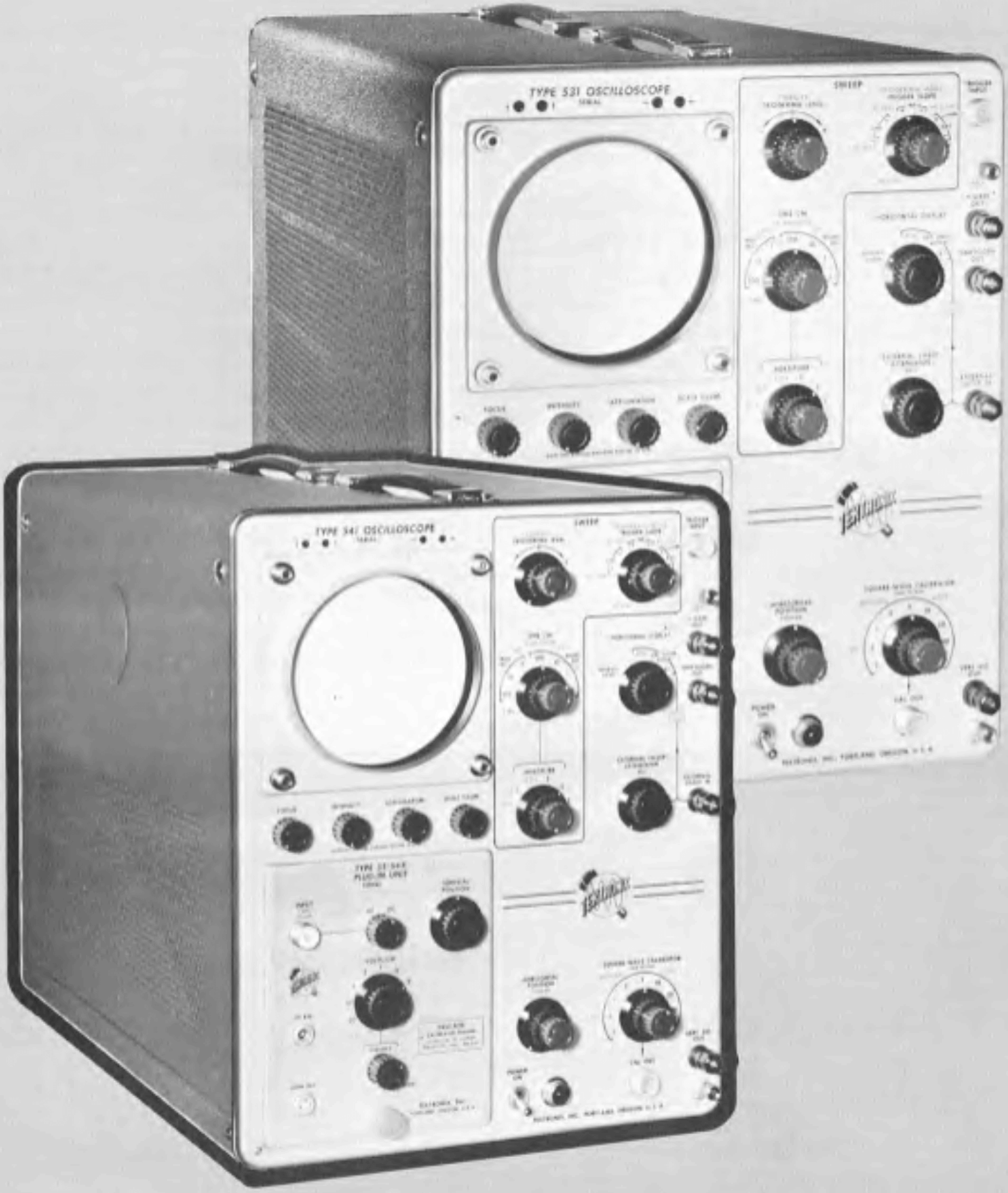

TYPE 531 OSCILLOSCOPE
TYPE 541 OSCILLOSCOPE

SECTION 1
GENERAL DESCRIPTION

NOTE

The Types 531 and 541 are high-speed laboratory oscilloscopes, designed for general laboratory use. Their extremely fast rise-time, wide sweep-speed range and 10-kilovolt accelerating voltage permit accurate analysis of many types of waveforms. Additional adaptability is provided by plug-in preamplifiers which extend the use of these oscilloscopes to practically all laboratory-oscilloscope applications. Accurately calibrated sweep speeds and vertical-deflection sensitivity permit quantitative time and amplitude measurements to be made.

CHARACTERISTICS

Cathode-Ray Tube

A Tektronix 5-inch post-deflection acceleration cathode-ray tube is furnished with the instrument. With 10-kv acceleration potential the trace is bright enough that a single sweep can be photographed with a P11 screen even at the fastest sweep speeds. A P2 phosphor is furnished unless other phosphors are specially requested.

Vertical-Deflection System

A dc-coupled vertical amplifier in the main unit is adjusted for optimum transient response and wide passband. A plug-in channel-switching unit provides a dual-trace presentation for repetitive signals. Input to the vertical-deflection system must be made through one of the available types of plug-in units.

Horizontal-Deflection System

Sweep Circuit

The linear sweep generator is a Miller runup generator with excellent linearity, and the extremely wide speed range of .02 microseconds per centimeter to 12 seconds per centimeter. Twenty-four calibrated sweep speeds are available accurate within three per cent. The main sweep control has eight positions, .1, 1, 10, and 100 microseconds per centimeter, 1, 10, 100 milliseconds per centimeter, and 1 second per centimeter. Three multiplier-switch positions 1, 2, and 5 times, provide a total of twenty-four speeds. Remaining positions of the multiplier switch provide continuously adjustable multipliers of 1 to 2.5 times, 2 to 5 times, and 5 to 12 times so that the above range is also covered continuously. The five-times sweep magnifier increases the maximum sweep speed to .02 microseconds per centimeter.

Magnifier

Sweep magnification is produced by increasing the sweep output amplifier gain five times. The center two centimeters of the trace is expanded to 10 centimeters. Any one-fifth of the sweep so magnified can be positioned to show on the screen by means of the HORIZONTAL POSITION control.

DC-Coupled Unblanking

The unblanking square wave is dc-coupled to the grid of the cathode-ray tube to assure uniform unblanking bias for all sweep times and repetition rates.

Triggering System

The sweep can be triggered by a wide range of triggering voltages either derived internally from the signal to be displayed, or through a front-panel connector from an external source. The circuit permits the sweep to be triggered from any selected point along the triggering waveform. A recurrent triggering arrangement which runs at a fifty-cycle repetition rate will synchronize with repetitive trigger signals from sixty cycles to two megacycles.

Horizontal-Deflection Amplifier

A dc-coupled horizontal-deflection amplifier provides horizontal sensitivity of 2 volts per centimeter to approximately 15 to 20 volts per centimeter, continuously adjustable by means of a ten-to-one continuously adjustable control and a 10X and 1X switched attenuator.

Because this amplifier was designed for optimum performance with a sweep sawtooth, its performance with sine waves is limited. This sine-wave limitation can best be defined by an amplitude-frequency product, which can be exceeded only at the expense of considerable distortion. The amplitude-frequency product is 2.4 centimeter-megacycles. Thus a full 10-centimeters of deflection can be used at 240 kc, and a 2.4-mc sine wave can be viewed if the amplitude is one centimeter peak-to-peak or less. The amplifier frequency response to a sine wave is down less than 30% at 400 kc when the amplitude is within this limitation.

Output Waveforms Available

Front-panel connectors provide a positive-going sawtooth, a positive gate synchronized with the sweep, and a signal derived from the displayed vertical signal. The calibrator provides an adjustable amplitude symmetrical square wave with a repetition rate of about one kilocycle. The amplitude is adjustable in twenty steps between .2 millivolts and 100 volts.

Power Supply

All dc voltages are regulated to accommodate line-voltage variations between 105 and 125 volts or 210 volts to 250 volts, 50 to 60 cycles, ac, and for the differences in dc loads imposed by the different plug-in units.

Power Consumption

At 117 or 234 volts, 475 watts with plug-in unit in place.

Cooling

Safe operating temperature is maintained with filtered, forced-air ventilation. A thermal disconnect device turns off the ac power in the event the fan fails or the air intake becomes blocked.

Illuminated Graticule

The graticule is accurately scribed in centimeters and fifths of centimeters. The scribed lines can be edge-lighted either by white or by red light. A green filter is supplied to increase contrast in the presence of room brightness. At extra cost, a light shield is available constructed so that it will slip on over the graticule bezel.

Mechanical Characteristics

Construction

The cabinet and chassis are made of electrically-welded aluminum alloy.

Finish

Photo-etched anodized aluminum-alloy panel, wrinkle-enameled cabinet.

Dimensions

24 inches long, 13 inches wide, 16-3/4 inches high.

Weight

61-1/2 pounds.

FUNCTIONS OF FRONT-PANEL CONTROLS AND CONNECTORS

TRIGGERING MODE (red knob)--Five-position switch arranges trigger circuits for five kinds of triggering: DC, AC SLOW, AC FAST, AUTOMATIC and HF SYNC. In Type 531 instruments, S/N 101-6010 and in Type 541, S/N 101-5414, AUTOMATIC is labeled AC AUTO. In Type 531, S/N 101-592, there is no HF SYNC position.

TRIGGER SLOPE--Six-position switch selects source of trigger signal and converts to negative-going output, either negative-going or positive-going input.

TRIGGER INPUT--UHF coax connector to triggering circuits through EXT positions of TRIGGER SLOPE switch.

STABILITY (red knob)--Control for adjusting the stability of the sweep circuits for a stable display. The control has a PRESET position suitable for most triggering applications. Type 531, S/N 101-6710, and Type 541, S/N 101-5942, have no PRESET position on the STABILITY control.

TRIGGERING LEVEL--Potentiometer determines part of triggering waveform where sweep triggers.

TIME/CM--Eight-position switch selects timing capacitors to determine sweep speeds, and determine duration of trigger holdoff period.

MULTIPLIER--Six-position switch. Three positions place precision charging resistors in series with timing capacitors to determine sweep speeds in conjunction with selected timing capacitor. Three positions, marked in red, place adjustable charging voltages in series with timing capacitors for continuous control of sweep speeds.

5X MAGNIFIER--Two-position switch removes or inserts feedback in sweep amplifier to change sweep speeds by a factor of five.

HORIZONTAL DISPLAY--Three-position switch connects sweep amplifier to internal sweep generator in one position, or to front panel connector directly or through 10-1 fixed attenuator in second and third positions.

EXTERNAL SWEEP ATTENUATOR, 10-1---Continuously adjustable gain control on horizontal amplifier. Switched out of circuit for internal sweeps.

EXTERNAL SWEEP IN--Front-panel connector to horizontal amplifier through HORIZONTAL DISPLAY switch. Magnifier must be switched to ON for undistorted 10-cm deflection.

VERT. SIG. OUT--Front-panel connector supplies signal from vertical amplifier via trigger cathode follower.

HORIZONTAL POSITION--Positions trace along horizontal axis.

VERNIER (red knob)--Fine adjustments of horizontal positioning, with five times the resolution of the coarse adjustment.

SQUARE-WAVE CALIBRATOR (red knob)----Three-position switch turns on calibrator plate voltage and switches in or out 1000-to-1 voltage divider to give either volts or millivolts output.

SQUARE-WAVE CALIBRATOR (black knob)---Nine-position switch selects nine taps on precision voltage divider in calibrator circuit. Provides accurate voltages of .2, .5, 1, 2, 5, 10, 20, 50, and 100 volts in VOLTS position, or millivolts in the MILLIVOLTS position of the red concentric control knob.

CAL OUT---UHF coax front-panel connector from the calibrator.

+GATE OUT---Front-panel binding post supplies positive 20-volt square pulse, dc-coupled through cathode follower, synchronized with the internal sweep.

SAWTOOTH OUT---Front-panel binding post supplies 150-volt positive-going sawtooth dc-coupled through cathode follower, synchronized with the internal sweep.

POWER---On-off switch in primary of power transformer and ventilating-fan lead.

FOCUS--Adjustable voltage for the cathode-ray tube focusing grid.

INTENSITY--Bias adjustment to cathode-ray control grid.

ASTIGMATISM-Adjustable voltage for the astigmatism grid of the cathode-ray tube.

SCALE ILLUM--Adjustable series resistor controls voltage across graticule lights. Beam-position indicators, unlabeled, marked with arrows. The arrow nearest the illuminated indicator shows which way the beam is off the screen if it cannot be seen.

Rear of Cabinet

CRT CATHODE--Binding post connects to crt cathode through high-voltage capacitor. Input impedance 8 k to 15 k. Discharge time constant about 15 milliseconds.

SECTION 3
CIRCUIT DESCRIPTION

BLOCK DIAGRAM

The Block Diagram shows interconnections of the functional parts of the oscilloscope, except the power supplies. Functions of the switches are shown instead of their actual connections.

Plug-In Preamplifiers

In the upper left of the Block Diagram is shown the vertical-deflection system. The block labeled "Plug-Ins" represents one of the plug-in preamplifiers available. Connections for power in and signal-out are made through a multiple-contact mating plug and socket. Output from these units is push-pull at low impedance.

Main-Unit Amplifier

The main-unit amplifier amplifies the signal and drives the delay line which terminates in the vertical deflection plates. The trigger pick-off circuits obtain a sample of the vertical signal for triggering the sweep.

Delay Line

In the Type 531, the balanced 24-section lumped-section delay line adds 1/4 microsecond of delay to the signal so that the sweep circuits will have time to get the cathode-ray spot unblanked and sweeping before the signal reaches the vertical-deflection plates.

In the Type 541, a balanced 50-section delay line adds .2 microseconds of delay for sweep unblanking purposes.

Trigger Cathode Followers

The trigger signal from the main-unit amplifier passes through two cathode followers. The first applies the signal at low impedance to the trigger amplifier and the second connects to the front-panel VERT. SIG. OUT binding post.

Trigger Amplifier

The trigger amplifier provides either in-phase or inverted output in order to provide negative-going output for either negative-going or positive-going input trigger signals.

Trigger Shaper

The trigger-shaper amplifier makes a sharp pulse from the trigger signal at a time during the sloping part of the trigger signal determined by the setting of the triggering-level control. A sharpened negative-going pulse triggers the multivibrator.

Multivibrator

The multivibrator turns on the sweep generator and generates the crt-tube unblanking pulse when it is switched from its quiescent state. The sharp negative-going trigger signal from the trigger-shaper circuit trips the multivibrator, which thereafter stays in the second state until the sweep generator reverts it to its quiescent state.

Sweep Generator

The sweep generator is a Miller integrator that produces a positive-going sawtooth about 150 volts peak-to-peak. The sweep generator turns itself off when it reaches a prescribed level determined by the sweep-length control, by transmitting a signal through the trigger-holdoff circuits to the multivibrator.

Trigger Holdoff

The trigger-holdoff circuit transmits the sweep turn-off signal to the multivibrator but briefly holds off subsequent trigger signals from starting the sweep again until all parts of the circuit have reached their quiescent states.

Sweep Amplifier

The sweep amplifier converts the sawtooth output of the sweep generator into push-pull output at low impedance at the level required to sweep the beam across the crt-tube screen. The amplifier gain can be increased by a factor of five for sweep magnification. The horizontal-positioning control operates on this stage.

Unblanking

The multivibrator generates the positive-going unblanking pulse at the same time it turns on the sweep generator. The positive pulse is transmitted by means of two cathode followers through a floating high-negative-voltage supply to the control grid of the crt tube.

External Sweep Amplifier

The external sweep amplifier provides a means of using external sweep voltage. It includes a fixed attenuator and an adjustable attenuation control. Choice of internal or external sweep can be made by means of the HORIZONTAL DISPLAY switch. The sweep magnifier must be used with external sweeps.

Calibrator

The calibrator has no internal connection to the vertical amplifier system. It consists of a symmetrical multivibrator with a cathode-follower output tube whose cathode resistor is a calibrated voltage divider.

POWER SUPPLY

Plate and Heater Power

The 60-cycle 117/234-volt transformer has five separate high-voltage windings. AC output from each winding is rectified through separate bridge-connected full-wave selenium rectifiers. Rectified dc output is filtered with capacitors and regulated by means of series-regulator tubes. Four positive-voltage supplies giving 100 volts, 225 volts, 350 volts and 500 volts, are all referred to the negative 150-volt supply for regulation. The negative 150-volt supply is referred to a gas regulator tube.

Seven heater windings on the same transformer furnish heater voltage to all tubes using ac in the main unit and the plug-in units. Two of these windings are also used to supply a selenium bridge rectifier which supplies dc voltage for the delay-line driver tubes.

Cathode-Ray Tube High-Voltage

A 60-kc vacuum-tube oscillator has the primary of a step-up transformer for its oscillator inductance. A sample of the rectified secondary voltage is compared to a stable dc source, and the difference is kept constant by an electronic circuit that adjusts the oscillator amplitude of oscillation in the direction to reduce any change.

A voltage tripler vacuum-tube rectifier provides positive 8650 volts for the post-deflection acceleration electrode of the crt tube. Two negative supplies, insulated from each other, supply the crt-tube cathode at -1350 volts and control grid at -1450 volts. The control-grid supply is free to assume a voltage 1550 volts more negative than its positive terminal. The positive terminal is raised more positive by the positive unblanking pulse and the negative terminal and crt-tube control grid therefore also follow the same positive pulse 1550 volts below.

VERTICAL-DEFLECTION SYSTEM

GENERAL

In the Type 531, the dc-coupled, push-pull main Vertical Amplifier provides the necessary gain to drive the Delay Line and the vertical deflection plates of the crt. The main units of the Vertical Amplifier in Serial Numbers 101 through 7600 are the Input Amplifier and Delay Line Driver stage, V508 and V509; the Delay Line Output Cathode Followers, V558A and V558B, the Output Amplifiers, V570 and V580 and the Output Cathode Followers, V606A and B. The other circuits are the Internal Trigger Amplifier, V527, the Internal-Trigger Cathode Follower, V535A and the Vertical-Signal-Out Cathode Follower, V535B.

In Serial Numbers 7601 and up, the Vertical Amplifier Main Units are the Input Amplifier stage V504 and V524, the Driver Cathode

Follower stage, V533B and V543B, and the Output Amplifier stage V554 and V564. Other circuits in this serial number range are the Trigger Pickoff Amplifier V584, the Trigger Cathode Follower, V593A, the Vert. Sig. Out Cathode Follower, V593B, and the Indicator Amplifier and Lamps V533A and B536A, and V543A and B546, respectively.

Vertical Amplifier Circuit Details Type 531, S/N 101-7600

In Type 531, S/N 101 through 7600, signal input from the plug-in units is connected through terminals 1 and 3 to the grids of input amplifiers V508 and V509. The cathodes of these two tubes are connected through a degenerative rc network, R502, R503, R504 and C503. This network lowers the amplifier gain about two per cent except during the first 1/4 microsecond for a step signal, to compensate for a response characteristic of cathode followers used elsewhere in the vertical amplifier system.

Delay Line

The 24-section, 1/4-microsecond delay line introduces an additional 1/4 microsecond of delay to permit the sweep generator and unblanking circuits to get going before the triggering signal gets to the deflection plates, so that the leading edge of the signal can be observed. The triggering signal is taken push-pull from the mid-point of the first delay-line section so that the capacitance of the grids of trigger amplifiers V527A and V527B can be part of the delay-line shunt capacitance. The line is terminated by R938 and R940, with C938 and C940 to correct the phase angle of the terminating impedance. Output is taken from the mid-point of the last delay-line section so that the input capacitance of cathode followers V558A and V558B can be part of the line shunt capacitance.

Delay-Line Output Cathode Followers

Cathode output from V558A and V558B is connected through peaking coils L557 and L558 to the grids of V570 and V580. Gain of this stage can be adjusted over a small range by an internal screwdriver adjustment, R574, labeled AMPL GAIN, which adjusts the amount of degeneration in the common-cathode circuit. L570 and L580 are adjustable peaking coils.

DC-Shift Compensation

A long-time-constant change in gain which is characteristic in high-conductance stages is compensated for by an rc network, R595, R596, R597, C595A and C595B. A screwdriver adjustment on R596, labeled DC SHIFT COMP permits the amount of compensation to be adjusted to accommodate tube differences.

Output Cathode Followers

Plate output from V570 and V580 is applied to the vertical-deflection plates of the cathode-ray tube through cathode followers V606A and V606B, and through peaking coils L643 and L635 and damping resistors R634 and R635.

Off-Screen Trace Indicator

Neon glow lamps B628 and B629 are connected between cathodes and +225 volts. The cathodes are somewhat higher than +225 volts when the spot is centered. If the cathode of either tube rises much above this voltage so that the spot is not visible on the screen, the neon glow lamp at that cathode will glow and show which direction off the screen it is positioned.

Internal-Trigger Pickoff

Internally derived triggering voltage is taken from the vertical-deflection signal through V527A and V527B, which are connected in order to produce single-ended output from push-pull input. Cathode follower V535A supplies the signal to the INT. positions of the TRIGGER SLOPE switch, SW1.

Vertical-Signal Output

The vertical-deflection signal present at the internal-trigger amplifier is capacitively coupled to the VERT. SIG. OUT binding post via cathode followers V535A and V535B.

Vertical Amplifier Circuit Details Type 531, S/N 7601 and up

In Type 531, Serial Numbers 7601 and up, the signal input from the plug-in unit is coupled through terminals 1 and 3 of the interconnecting plug to the grids of the Input Amplifier stage. The plate circuit of this stage is compensated for both high-frequency attenuation and dc shift.

High-frequency compensation is provided by the series-shunt peaking coils L506 and L523. These coils extend the bandwidth of the amplifier by reducing the high-frequency attenuation caused by the stray capacitance in the circuit.

Dc shift in the amplifier tubes--a condition whereby the dc (and extremely low-frequency) transconductance is less than at mid-frequencies--is compensated for by a dc "boost" network. R507 and C507A, in the plate circuit of V504, and R524 and C507B, in the plate circuit of V524, shunt the plate-load resistors in each circuit. The extremely long time constant of the circuit is such that the plate-load resistance remains 1.8 kilohms in the range from dc to a fraction of a cycle, but reduces in value to a minimum of 1.77 kilohms for frequencies above this range. The slightly higher plate-load resistance, in the range from dc to a fraction of a cycle, compensates for the slightly reduced transconductance of the tubes in this range, so that the gain remains substantially constant from dc to the upper limit of the amplifier.

The Input Amplifier is coupled to the Output stage by the Driver C.F. stage V533B and V543B. This cathode-follower stage provides the necessary low impedance to drive the Output Amplifier. The Output Amplifier is the driving source for the Delay Line and the vertical deflection plates in the crt. The gain of this stage is adjusted by means of R570, the GAIN ADJ., which varies the degeneration in the cathode circuit. This control is adjusted so that the vertical deflection on the crt agrees with the plug-in unit's VOLTS/CM calibration when the VARIABLE control is set to the CALIBRATED position. R553 and R563 are the terminating resistors for the Delay Line; they are also the plate-load resistors for the Output Amplifier.

Beam-Position Indicators

The beam-position indicators B536 and B546, located on the front panel above the crt, indicate the relative vertical position of the trace with respect to the center of the graticule. When the beam is centered vertically, the potential across either neon is insufficient to light it. As the beam is positioned up or down the screen, however, the grid voltage for the Indicator Amplifiers, obtained from a tap on the Delay Line terminating resistors, will change. The current through one amplifier will increase, and the current through the other will decrease. Hence, the voltage across the neon will increase, causing it to light, and the voltage across the other will decrease, causing it to remain extinguished. The neon that lights will indicate the direction in which the beam has been moved.

Trigger Pickoff

When internal triggering of the Time Base Generator is employed (black TRIGGER SLOPE knob in either the + or -INT. position), a "sample" of the vertical signal is used to develop the triggering pulse. This "sample", obtained from the Driver C.F. stage, is amplified by the Trigger Pickoff Amplifier and coupled through the Trigger C.F. to the Time Base Trigger circuit.

The "sample" of the vertical signal is also ac coupled, through V593B and C599, to a front-panel jack labeled VERT. SIG. OUT.

Delay Line

The output signal from the Vertical Amplifier is coupled through the Balanced Delay Line to the vertical deflection plates of the crt. The function of the line is to delay the arrival of the waveform at the deflection plates until the crt has been unblanked and the horizontal sweep started. This delay insures that the very "front" of fast vertical signals can be observed. The line is adjusted, by means of the variable capacitors connected across the line, for optimum transient response.

Type 541 Vertical Deflection System

General

The dc-coupled, push-pull, main Vertical Amplifier provides the necessary gain to drive the Delay Line and the vertical deflection plates of the crt. In Type 541, Serial Numbers 101 through 6474, the main units of the Vertical Amplifier are the Input Amplifier Stage V1025B and V1040B, the cathode follower stages V1050 and V1052, and the 6-section Distributed Amplifier Output stage. Other circuits of importance are the Balance Amplifier, V1060, the Internal Trigger Amplifier, V1066, Internal Trigger C.F., V1052B, Vertical Signal Out C.F., V1050B, and the Indicator Amplifiers and Lamps, V1025A and B1010 and V1040A and B1014, respectively.

In Type 541, Serial Numbers 6475 and up, the main units are Input Amplifier Stage V1014 and V1024, cathode follower stages V1033 and V1043, plus the 6-section Distributed Amplifier output stage. Other important circuits are the Trigger Pickoff Amplifier, V1064 and V1054, the Trigger Pickoff C.F. V1223A, and Indicator Amplifiers and Lamps, V1084A and B1083, and V1084B and B1087, respectively.

In all Type 541 instruments, the vertical amplifier has separate preamplifier units that can be plugged into the main unit. These units provide a variety of passbands and sensitivities and allow for future developments in preamplifiers. The plug-in units develop balanced push-pull output which is maintained push pull throughout the remainder of the amplifier. The units contain sensitivity adjustments and positioning controls.

VERTICAL AMPLIFIER CIRCUIT DETAILS
Type 541, S/N 101 through 6474

In Type 541, Serial Numbers 101 through 6474, signal input from the preamp is connected through terminals 1 and 3 to the grids of input amplifiers V1025B and V1040B. The cathodes of these two tubes are connected together through the degenerative network, R1026, R1027 and R1028. R1027 labeled GAIN ADJ. is variable to allow the amplifier gain to be varied over a small range. L1022 and L1041 provide series peaking for the stage. Triodes V1050A and V1052A provide the low impedance necessary for driving the distributed-amplifier grid line.

Beam-Position Indicators

Triodes V1025A and V1040A have as their plate loads neon glow lamps B1010 and B1014 across 1-megohm resistors. When the trace is centered, the plate current is insufficient to ignite these lamps, but as the trace is positioned off the screen vertically the current through one triode will increase causing the corresponding lamp to glow showing which way the trace is off the screen.

Trigger Pickoff

The trigger pickoff tubes, V1060 and V1066, convert the push-pull vertical signal on the distributed-amplifier grid lines to single-ended output without disrupting the balanced configuration of the grid lines. The trigger cathode follower supplies the amplified vertical signal at low impedance to the oscilloscope trigger circuits and to the vertical-signal-out cathode follower. This cathode follower applies a sample of the vertical signal, somewhat limited in passband, to the front-panel binding post labeled VERT. SIG. OUT.

DC-Shift Compensation

DC-shift compensation is accomplished in two ways and corrects for two different time constants. The series combination of R1080 and C1045B on plate line L1080, and R1084 and C1050B on plate line L1083, lowers the termination resistance of these lines to all but the very low frequencies. They provide a time constant which corrects for the initial dc shift in the amplifier. The second time constant is corrected by R1045 and C1045A and R1050 and C1050A. These rc networks have a negligible loading effect on the distributed-amplifier plate lines, but provide low-frequency positive feedback to the input-amplifier plates. This feedback corrects for the longer-time-constant dc shift. R1059, labeled DC SHIFT COMP. permits the amount of compensation to be adjusted to accommodate tube differences.

Distributed Amplifier

The output amplifier is a six-section, balanced, distributed amplifier. The grid lines are driven by V1050A and V1052A through rc frequency-compensating networks. The plate lines, L1080 and L1083, drive the delay line directly. Each section of the plate lines is tuned for optimum response to a square wave by trimmers connected line-to-line.

Termination Network

Unless the plate lines are terminated at the reverse end with a resistance equal to their characteristic impedance, signals traveling the reverse direction down the line will be reflected and appear in the output. Since resistors are not available, in a suitable power rating, which appear resistive over the wide passband of the Type 541, an adjustable terminating network is used. The coils, L1070 and L1071, are wound with resistance wire and have a total resistance of 595 ohms. Each section has a characteristic impedance which is approximately equal to the impedance of the plate lines less the series dc

resistance between it and the plate lines.

VERTICAL AMPLIFIER CIRCUIT DETAILS
Type 541, S/N 6475 and up

In Type 541 instruments, Serial Numbers 6475 and up, the signal input from the plug-in unit is coupled through terminals 1 and 3 of the interconnecting plug to the grids of the Input Amplifier stage. R1027 varies the cathode degeneration, and thus sets the gain of the stage to agree with the Preamplifiers front-panel calibration when the VARIABLE knob is in the CALIBRATED position.

The Input Amplifier is coupled to the Distributed Amplifier by the cathode followers V1033 and V1043. The cathode followers isolate the Distributed Amplifier from the Input Amplifier, and provide the necessary low-impedance drive for the Distributed Amplifier's grid lines.

High-frequency compensation for the Input Amplifier is provided by the variable peaking coils L1014 and L1024. Variable inductors L1036 and L1046 provide additional peaking at the very high frequencies.

Output Stage

The output stage is a 6-section Distributed Amplifier. The tapped inductors in the transmission line, between each grid and between each plate, isolate each section from the capacitance of the adjacent sections.

The input signal for each tube is obtained from the grid line, which is driven by the cathode followers V1033 and V1043. The amplified signal at each plate, fed to the plate line, becomes an integral part of the wave traveling down the line toward the deflection plates.

The vertical signal is delayed 0.2 microsecond between the input to the grid line and the vertical deflection plates. This delay insures that the very "front" of fast vertical signals can be observed. About 0.015 microsecond of the total delay time occurs in the Distributed Amplifier; the remaining 0.185 microsecond occurs in the Delay Line.

The tapped inductors between each section of the Distributed Amplifier provide about 0.003 microsecond of delay. By making the delay time in the grid and plate lines equal, the signal arriving at each plate, through the electron stream of the tube, will be synchronous with the signal moving down the plate line from the preceding sections.

DC Shift Compensation

DC shift in the amplifier--a condition whereby the dc and very low-frequency transconductance is less than at mid-frequencies--is compensated for in two ways. R1090 and C1093B, in plate line L1104, and R1095 and C1093D in plate line L1114, form a low-frequency boost network; the time constant of this network is such that the termination resistance of the line is increased in the range from very low frequencies to dc. A longer time constant, for extremely low-frequency and dc compensation, is provided by R1092, R1094 and C1093A, in one plate line, and by R1097, R1099 and C1093C in the other, which provide a small amount of positive feedback from the plate lines to the plate circuits of the Input Amplifier. A variable resistor R1091, the DC SHIFT COMP. control, is connected between the two networks to adjust for the proper amount of compensation.

Beam-Position Indicators

The beam-position indicators, B1083 and B1087, located on the front panel above the crt, indicate the relative vertical position of the trace with respect to the center of the graticule. When the beam is centered vertically, the potential across either neon is insufficient to light it. As the beam is positioned up or down the screen, however, the current through the Indicator Amplifiers, and hence the voltage across the neons, will change. The voltage across one neon will increase, causing it to light, and the voltage across the other will decrease, causing it to remain extinguished. The neon that lights will indicate the direction in which the beam has been moved.

Trigger Pickoff

When internal triggering of the Time Base Generator is desired (black TRIGGER SLOPE knob in either the + or - INT. position), a "sample" of the vertical signal is used to develop the triggering pulse. This "sample" is obtained from the trigger pickoff circuit consisting of the Trigger Pickoff Amplifier V1054 and V1064, and Trigger Pickoff C.F. V1223B

This "sample" of the vertical signal is also ac-coupled, through V1223A and C1228, to a front-panel jack labeled VERT. SIG. OUT.

Delay Line

The output signal from the Vertical Amplifier is coupled through the balanced Delay Line to the vertical deflection plates of the crt. The function of the Delay Line is to retard the arrival of the waveform at the deflection plates until the crt has been unblanked and the horizontal sweep started. This delay, as mentioned previously, insures that the very "front" of fast vertical signals can be observed. The line is adjusted, by means of the variable capacitors connected across the line, for optimum transient response.

The entire Delay Line, which includes the plate line in the Distributed Amplifier, is reverse-terminated in its characteristic impedance. The Termination Network, shown on the Vertical Amplifier diagram, is designed to dissipate both the dc and signal energy in the line by presenting a constant resistance over the frequency range of the amplifier. The terminating resistors R1071 and R1073 are specially made, wirewound, noninductive, distributed resistors. The 600 ohms total resistance in each is "tapered", or distributed, in steps. The largest segment of the terminating resistance appears nearest the line; the smallest segment appears at the opposite end. Each step of the resistance is then tuned, by means of the variable capacitors, so that the network will present an optimum load to the line.

CALIBRATOR

The calibrator is a symmetrical multivibrator with V670A and V670B connected so it will turn cathode follower V246A on and off as it oscillates. During the negative pulse at multivibrator V670A, the grid of the cathode follower is driven well below cutoff, so the cathode is at ground voltage. During the positive pulse at the multivibrator the plate is cut off and rests slightly below +100 volts. The voltage of the plate during cutoff is determined by the setting of R679, part of a divider between +100 volts and ground. R679 is a screwdriver adjustment labeled CAL ADJ. Cathodes of the multivibrator are returned to -150 volts. The multivibrator frequency is about one kilocycle.

Cathode follower V246A has a tapped calibrated voltage divider for its cathode resistor. When the CAL ADJ. control is properly set, the cathode follower cathode is at +100 volts when V670A is cut off. Taps on the divider divide the 100 volts down to 50, 20, 10, 5, 2, 1, .5, and .2 volts. A second divider with a division ratio of 1000 to 1, can be switched in if desired to divide these voltages into millivolts. C682 from the cathode-to-ground corrects a slight overshoot. No internal connection from the calibrator to the vertical-deflection circuits is provided.

HORIZONTAL-DEFLECTION SYSTEM

SWEEP CIRCUITS

Trigger Amplifier

The TRIGGER SLOPE switch selects the source of triggering voltage and arranges the trigger-amplifier input circuit to produce negative-going output for either negative-going or positive-going portions of the input signal.

The trigger amplifier, V8, is a grounded-grid cathode-coupled linear amplifier. A capacitor, C3, can be switched into the grid circuit to remove the dc component of the trigger signal. Output is always taken from the A-section plate, but the TRIGGER SLOPE selector connects either the A-section grid or the B-section grid to the input signal source. For positive-going signals connection is made to the A-section grid, and for negative-going signals connection is made to the B-section grid, and in each case the opposite grid is connected to an adjustable dc bias source, adjustable by means of the TRIGGERING LEVEL control. R14 adjusts the bias on one half or the other of V8 to adjust the dc level of the A-section plate output. The dc level of the plate output is important to the circuit operation in three of the five positions of the TRIGGERING MODE switch because in these three switch positions the input grid to the trigger shaper stage, V20A, is dc-coupled to the plates of V8. The effect of the dc level is shown in a later paragraph.

Triggering Mode Switch

The TRIGGERING MODE switch, SW5, has five positions marked in red in the upper right-hand

corner of the instrument panel: DC, AC SLOW, AC FAST, AUTOMATIC, and HF SYNC. This switch arranges the circuits of the trigger-amplifier and trigger-shaping stages to accommodate the five types of triggering.

DC, AC Slow and AC Fast

When the TRIGGERING MODE switch is in the DC position, the triggering signal is direct-coupled through the trigger amplifier so that the dc component of the signal is applied to the trigger shaper. In the AC SLOW position, C3 removes the dc component of the signal, and in the AC FAST position, C4 and R6 form an rc filter to remove the low-frequency component of the triggering signal and allow fast recovery of the trigger circuits in the presence of dc level changes.

In these three positions, the trigger shaper, V20, is connected as a bistable multivibrator. In the quiescent state between triggers, the pentode section is conducting and its plate is therefore down. The grid of the triode section is dc-coupled to the pentode-section plate through divider R34, R35, R36, which holds the triode-section grid below plate-current cutoff. The negative-going trigger signal at the pentode grid raises the pentode plate which carries the triode grid positive into plate-current conduction. This also raises the triode cathode which is coupled to the pentode cathode through C28, R28, so that current is further reduced in the pentode, and the pentode cuts off. The transition is made very rapidly, regardless of how slowly the pentode grid signal falls. R28, connected between the two cathodes, is adjustable so that the trigger sensitivity can be adjusted. This is a screwdriver control marked SENSITIVITY on the chassis. No cathode current flows from the cathode not conducting through R28 when the trigger shaper is in either stable condition, so its effect is to lower the cathode voltage of the tube not conducting. For example, when the triode section is not conducting and its grid is below its cathode by the amount determined by plate current through R24, its cathode is below the cathode of the pentode section. R28, R27 form a voltage divider that places the triode cathode about two volts lower than the pentode cathode. This places the triode grid and cathode two volts closer together. The larger R28 becomes, the closer to conduction the triode will be. Increasing R28 therefore increases trigger sensitivity.

The steep negative-going step at the plate of the triode section is differentiated in an rc circuit, including C58 shown in the sweep diagram, with a time constant of about a tenth microsecond, and the sharpened pulse trips the multivibrator. The circuit will respond to trigger signals with a frequency up to 2 mc.

The TRIGGERING LEVEL control, R14, adds a bias to the plate-output signal of the inverter stage, V8. This changes the level of the cathode of the shaper stage, V20, and therefore changes the level on the triggering signal that must be reached to return the shaper-stage cathode to the transition point. For example, to adjust the triggering level so that triggering will occur at a point four volts positive on the positive-going portion of a 10-volt peak-to-peak trigger-input signal, the triggering-level bias would therefore rise about 20 volts. Positive-going input would become negative-going output, which starting 20 volts higher than the zero level, would need to drop twenty volts to return to the transition point and trigger the shaper stage.

Automatic

In the AUTOMATIC position of the TRIGGERING MODE switch, the plate of the pentode section of the trigger-shaper, V20, drives the grid of the triode section just as it does in the AC SLOW position. But in addition, it also drives its own grid through R20, a high resistance of several megohms.

When the transition takes place and the plate of the pentode rises, for example, the triode grid also rises carrying with it the right-hand end of R30. The left-hand end of R30 is connected to the pentode grid through R21. The time constant of the rc circuit between the triode grid and ac ground through C20, R30, and R21, is of such length that it takes about .01 seconds for the pentode grid to rise exponentially from its starting point below cutoff to a point where plate current can flow. During the .01-second period, the pentode grid rises, but the triode grid remains at a constant voltage until the next transition, when pentode plate current begins to flow.

When pentode plate current flows, the pentode drops, forcing the triode grid down, and thus the right-hand end of R30 is forced down. The left-hand end of R30 and the pentode grid immediately begin to drop exponentially toward

pentode cutoff. When the pentode grid reaches cutoff again it has completed one cycle of the approximately 50-cycle sawtooth. The range of pentode grid voltage between pentode cutoff and triode cutoff is about six volts for the AUTOMATIC circuit. This is increased from about 1/4 volt for the DC and AC SLOW circuit connections by addition of R23 to the plate load of the pentode.

Since the pentode grid is never more than six volts from cutoff, a trigger signal with a peak-to-peak voltage of six volts or more can drive the grid to cutoff at any time during the negative-going excursion and produce a trigger output. Smaller trigger signals can also trigger the shaper but only if they occur at a time when the grid is within their peak voltage of cutoff. The duty cycle of operation of the sweep is somewhat reduced therefore with smaller trigger signals.

This circuit configuration is useful because with it the sweep can be synchronized with repetitive signals over a range of frequencies without readjustment. When not triggered externally, the sweep continues at a fifty-cycle rate, and in the absence of any vertical signal, generates a base line that shows that the oscilloscope is adjusted in order to display any signal that might be connected to the vertical-deflection system.

HF SYNC

When the TRIGGERING MODE switch is in the HF SYNC position, the trigger-amplifier and trigger-shaper stages are bypassed and the trigger signal is applied directly to the sweep multivibrator. In this position the STABILITY control is set so the sweep is superimposed on the negative-going trigger-holdoff waveform at the grid of V58A and will cause the multivibrator to synchronize at a submultiple of the triggering-signal frequency. This circuit is suitable for signals in excess of five megacycles.

Multivibrator

The dc-coupled multivibrator, shown in the sweep-generator diagram, turns on the sweep generator upon receipt of a negative trigger from the trigger shaper, and holds off subsequent trigger signals until after the sweep is completed. The multivibrator consists of V58 and V70 with both common-cathode and plate-to-grid coupling. Plate-to-grid coupling is by means of a cathode follower. V58A is the positive-going half of the multivibrator which in the quiescent state is conducting. V70 is the negative-going half of the multivibrator which in the quiescent state is cut off.

In the quiescent state V58A is conducting and its plate is down. Cathode-follower, V58B, holds the grid of V70 below cutoff through voltage divider R65, R66. The plate load of V58A includes L61 to speed the rise of plate voltage, and R62 which raises the plate voltage a few volts above +100 when the plate is cut off. The use of cathode-follower V58B, between V58A plate and V70 grid, isolates the positive-going plate from the capacitances of the various loads that require a positive-going pulse, and thereby permits a steeper positive step. The voltage divider in the cathode of the cathode follower is compensated by C65 for the shunt capacitance-to-ground of the grid of V70.

While V70 is cut off its plate rests at -3.2 volts, because of diode current in V80A and V80B, which flows through R69. When the negative trigger pulse from the trigger-shaper stage reaches the grid of V58A, an amplified positive pulse results at V58A plate. The amplified positive pulse at V58A plate is coupled through cathode follower V58B to the grid of V70. This raises the common-cathode voltage which further raises the plate voltage of V58A. The biases and plate loads are adjusted so that when V58A is conducting, the grid of V70 is held below cutoff, and when V70 is conducting, the cathode of V58A is held above cutoff.

There are thus two stable states, in either of which the multivibrator will remain until a signal of the proper polarity and amplitude at the grid of V58A switches it to the other state. To return the multivibrator back to the quiescent state with V58A conducting, a positive voltage is required at the grid of V58A which is high enough to cause plate current to flow. The positive voltage for returning the multivibrator to its quiescent state is supplied from the sweep generator when it has completed its sweep.

Stability Cathode Follower

The STABILITY control, R43, and PRESET STABILITY control, R49, adjust the grid voltage of cathode follower V40A, which in turn determines the quiescent grid voltage of positive

multivibrator V58A at about -64 volts, just above the threshold of triggering. Holdoff cathode follower V40B is normally cut off and does not contribute to the quiescent level of V58A grid.

Sweep Generator

The sweep generator is a Miller integrator circuit. The circuit includes disconnect diodes V80A and V80B, cathode-follower coupler V85, timing capacitor C99, and the Miller tube, V90. In the quiescent state between sweeps, the plates of diodes V80A and V80B rest at 3.2 volts. Very little current flows through V80A to the grid circuit of V90, and V90 grid therefore rests at about -3.3 volts. More current flows through V80B so that its cathode is therefore at about -5 volts. The timing capacitor, C99, which is connected between these two points, therefore has only about 1.7 volts of charge.

The grid of cathode-follower V85 is connected to the plate of Miller tube V90 through neon glow tube B95. The grid of V90 therefore follows the plate changes of V90 but remains 55 volts below the plate. C95, R95 is a network around B95 to improve the risetime.

The -3.3-volt bias on the grid of V90 places the tube in the class-A region of its operating characteristic, where the plate-to-cathode voltage is inversely proportional to the grid-to-cathode voltage. The negative step from the multivibrator to the plates of diodes V80A and V80B lowers the plates below their cathodes, and they no longer conduct. The Miller-tube grid, and plate-coupling cathode follower, are thus released to seek their own voltage levels. The grid of Miller tube V90, which is returned to -150 volts through R99, starts negative. When the grid starts negative the plate starts positive carrying cathode-follower V85 grid and cathode capacitor C99 positive which thus tends to prevent the Miller tube grid from going negative.

The gain of the Miller tube as a class-A amplifier is so high that the plate signal coupled back through charging capacitor C99 keeps the grid voltage constant within a fraction of a volt. Meanwhile, C99 is charging with current flowing through R99 from the -150-volt bus. Since the grid of V90 remains constant within a small fraction of a volt, the current through R99 remains constant, and C99 thus charges at a constant rate. As C99 charges, the voltage of the upper end therefore rises linearly. Any departure from a linear rise of the cathode of cathode-follower coupler V85 will result in a change in grid voltage in the direction that will produce a change in plate voltage the right amount to correct the departure difference. A bootstrap capacitor, C96, increases the plate current in V90 at the higher sweep speeds to help maintain a linear voltage rise.

The linear rise of the cathode of V85 is used as the sweep sawtooth. Charging capacitor C99 is selected by means of a step switch, SW55, labeled TIME/CM on the front panel. Charging resistor R99 is also selected by a step switch so that both the size of the capacitor being charged and the current charging the capacitor can be selected to cover a wide range of sawtooth slopes.

The cathode of V85 continues to rise linearly until a positive step from multivibrator V70 returns the disconnect-diode plates back to their quiescent state which raises the Miller tube grid. When the Miller tube grid rises, its plate drops carrying cathode-follower V85 with it until its cathode clamps again through V80B at the quiescent level of -3.3 volts.

Sweep Length

The positive step from multivibrator V70 occurs when a positive step is delivered to the grid of multivibrator V58A. The sawtooth to the multivibrator is delivered through cathode followers V40B and V55B from a tap on the cathode-load resistor of coupling cathode follower V85. This tap is adjustable by means of potentiometer R88, labeled SWEEP LENGTH on the chassis, a screwdriver adjustment. When the voltage of this tap is properly set the sawtooth will terminate when the spot has passed the right-hand limit of the cathode-ray screen. C54 on the grid of V40B retards the return of V58A grid to the quiescent level after the passage of the positive pulse. This holds off any trigger signals from retriggering the multivibrator until all other capacitances in the circuit have had time to reach their quiescent voltage level. Proper sizes of capacitor C54 are switched with the TIME/CM switch so that more recovery time is permitted for the slower sweeps and the least necessary recovery time is allowed for the faster sweeps.

Sync Amplifier

Synchronizing pulses for the Dual-Trace plug-

in unit are supplied by V78. When the negative multivibrator, V70, generates its positive plate step, it also generates a sharp differentiated positive trigger voltage at its screen, because of L72 and damping resistor R72 which connect the screen to +100 volts. The positive screen trigger pulse is coupled to the grid of V78 through C78. Grid bias of about -5 volts is set by divider R78, R79, between ground and -150 volts. Plate voltage and cathode return circuits are completed in the plug-in unit. The negative plate pulse is used for synchronizing the dual-trace unit.

Sweep Amplifier

Amplifier

Input to the sweep amplifier is selected by one of the sections of the HORIZONTAL DISPLAY switch, SW110. This switch connects the amplifier input to the sweep generator output in the position marked INTERNAL SWEEP, and through an amplifier and attenuator to a front panel connector marked EXTERNAL SWEEP IN, in the positions marked EXT SWEEP ATTEN, X10, and X1.

A cathode follower, V240B, feeds the selected signal to a second cathode follower, V240A, which in turn feeds a common-cathode, grounded-grid phase inverter, V265A and V272A. Gain of the phase-inverter stage can be adjusted by adjusting R266 and R270, labeled SWP CAL and MAG GAIN on the chassis, which determine the degree of coupling between the two cathodes. Output from the phase-inverter stage is applied to the horizontal-deflection plates of the cathode-ray tube through cathode followers, V265B and V272B. Bootstrap capacitors, C278 and C286, increase the plate current in the phase inverter stage at the higher sweep speeds to maintain a linear rise in the sweep waveform.

Magnifier

A negative voltage feedback network, made up of R259 and the parallel resistance of R260 and R254, accurately determines the gain of the sweep amplifier. This negative feedback can be disconnected by means of SW254A, labeled 5X MAGNIFIER, ON and OFF, in red on the front panel. When the feedback is removed, the gain of the amplifier is increased by a factor of five for the magnified sweep. R266 and R270 between cathodes of the phase-inverter stage V265A and V272B are also switched by the 5X MAGNIFIER switch, to permit the gains to be individually adjusted in order to keep the ratio of gains exactly five times for the two positions while permitting the spot speeds to be accommodated to the graticule. An internal screwdriver adjustment, R262, labeled SWEEP MAG REGIS, adjusts the bias of the degeneration cathode follower so that it is the same for both switch positions. This permits the magnified and normal sweep traces to be kept in accurate register, so that the center portion of the normal sweep will be centered when magnified.

Gated CF Current Booster

Cathode current for cathode follower, V265, which drives the negative-going, left-hand plate of the crt, is determined by the plate current of pentode V282. The pentode is used because its plate current remains nearly constant over a large range of plate voltage, so that the cathode-follower current is kept nearly constant even though its cathode voltage drops through a range of about 150 volts. For the fastest sweeps, the maximum permissible continuous current through these tubes is too small to discharge the capacitance of the crt deflection plate and its associated wiring at the required rate. To increase the current through these tubes to the required value, a positive, flat-topped pulse is applied to the grid of the pentode during the period of the sweep. The positive pulse is derived by differentiating the positive-going sawtooth, through an rc network. Its amplitude is thus proportional to sweep speed. For the fastest sweep, the tube current is several times normal, but at the reduced duty cycle of the sweep, is well within the average dissipation limit of the tubes.

Beam-Position Indicators

Two neon glow lamps, B292 and B293, connected across the deflection plates and biased slightly below the average dc voltage of the plates, indicate which direction the spot is off the screen if it cannot be seen. If either plate assumes a voltage much higher than the average voltage, the glow lamp connected to that plate will glow.

Positioning

Horizontal positioning of the trace is adjustable through cathode follower V246B which sets

the dc grid voltage of input cathode follower V240B. The grid voltage of the positioning cathode follower is determined by potentiometer R250, labeled HORIZONTAL POSITION on the front panel, and by R248, labeled VERNIER in red on the front panel, which will move the spot about one-fifth as far as R250.

External Sweep Amplifier

When the HORIZONTAL DISPLAY switch, SW100, is in either of the EXTERNAL positions, the EXTERNAL SWEEP IN binding post connects to an auxiliary sweep amplifier not otherwise used. The external sweep signal input can be attenuated ten times if desired with one position of the switch. R101, R102 is the 10X attenuator network. The network can be frequency compensated by adjusting C101.

The sweep signal is applied to the grid of V105A, a cathode follower whose cathode output feeds the grid of V115B. This tube, with V115A, forms a cathode-coupled grounded-grid amplifier. The gain of this stage can be adjusted over a ten-to-one range by varying R117, which forms the major part of the coupling between the two cathodes.

V115A grid is grounded as far as the sweep signal is concerned, by the low cathode impedance of V105B. The cathode resistor of V105A and V105B includes potentiometer R111, labeled EXT. AMP. DC BAL. on the chassis, the movable arm of which is returned to -150 volts. When the arm is adjusted in one direction, resistance is added to one cathode and subtracted from the other. When properly adjusted, R111 sets the dc levels of V115A and V115B equal, so that no dc current flows through the 10-1 gain adjustment, R117. When no dc current flows through this resistor, it can be varied without changing the dc level of the plate output of V115A.

Note that the external-sweep signal must not have a dc component of its own or the dc balance will be upset, and adjustment of the 10-1 gain control will position the trace horizontally.

POWER SUPPLY

Transformer

Plate and heater power for the main unit and the plug-ins is provided by a single power transformer, T700. The primary is wound with two equal 117-volt windings that can be connected either in parallel for 117-volt operation, or in series for 234-volt operation. The power supply will operate satisfactorily over the voltage ranges 105 to 125 volts and 210 to 250 volts, 50 to 60 cycles. The secondary contains five separate high-voltage windings and seven separate heater windings.

Rectifiers

The ac voltage from the high-voltage windings is rectified by bridge-connected full-wave dry-disk selenium rectifiers.

Regulation, -150-Volt Supply

All dc voltages furnished by the power supply are regulated either in the power supply or in the circuit it supplies. Reference voltage for the regulators is established by means of a gas-diode voltage stabilizer that determines the grid potential of a comparator amplifier, V712, in the -150-volt supply. The grid potential of V712A established by the gas diode is compared against the grid voltage of V712B. The grid voltage of V712B is obtained from a divider, R715, R716, R718, which divides down the voltage of the -150-volt bus being regulated. R716, labeled -150 ADJ. on the chassis, is a screwdriver adjustment which determines the percentage of voltage division that appears at V712B, and thereby determines the total voltage across the divider.

The voltage difference between the two grids of V712 appears as an amplified error signal at V712B plate. The amplified error signal is further amplified in V700, which is dc connected to V712B plate and to the grids of series tubes, V725, V726, and V727.

The series tubes change their plate-to-cathode resistance according to their grid-to-cathode voltage. The dc-coupled amplified error signal at their grids controls their plate resistance in order to introduce a change of drop through the tubes in the right direction to correct any difference in voltage between the two grids of the comparator tube. C707 and C717 bypassing the dc-coupled dividers, increase the ac gain of the feedback loop and thereby reduce ripple.

C115 connected between the -150-volt bus and ground keeps the output impedance down at frequencies above cutoff for the regulator feedback amplifiers. The screen of V700 has a small amount of the ripple that exists ahead of the regulators connected to it through R278. The phase of the amplified ripple voltage that appears at the plate of V700 is such as to out-phase most of the ripple at the -150-volt bus. R724 bypassing the series tubes reduces the amount of load current through them.

+100-Volt Supply

The comparator tube in the +100-volt supply, V742, compares its grounded cathode to the tapped-down voltage of divider, R750, R751, connected between the -150-volt bus as a reference voltage and the +100-volt bus to be regulated. The tapped-down point is a volt or so below ground. The screen of V742 receives a sample of the ripple signal through R744 to provide an out-phasing signal that reduces the output ripple at the +100-volt bus. High-frequency gain of the feedback loop is increased by C750, and C715A reduces the high-frequency output impedance.

+225-Volt Supply

Rectified ac from terminals 7 and 14 is added to the regulated dc of the +100-volt supply to provide about 320 volts to the plate of series tube V748A. The comparator tube is V765 and an additional gain stage with V757 increases the feedback-loop gain. C770 and C763 increase the ac gain, and C751B provides low output impedance at high frequencies. Unregulated voltage taken from a point ahead of the series tube supplies the regulator for the cathode-ray tube supply. R762 reduces the load current through the series tube.

+350-Volt Supply

Rectified ac from terminals 5 and 10 of transformer T700 is added to the unregulated input to the +225-volt series tube, and applied to the plates of series tube V784. The comparator tube is V782. Screen injection of ripple voltage is used. C787 increases ac gain and C751C lowers high-frequency output impedance. R785 reduces load current through the series tube.

+500-Volt Supply

Rectified ac from terminals 20 and 21 of transformer T700 is added to the regulated side of the +350 supply, and applied to the plate of series tube V794. The comparator tube is V791 with screen injection of ripple. C797 increases ac loop gain, and C790B in series with C751C to ground, reduces output impedance at high frequencies. C795 reduces load current through the series tube.

Time-Delay Relay

A thermal-delay relay, K700, delays application of high voltage to the external circuits for about 25 seconds so that the heaters have time to get up to temperature. The dc current to the heaters of the plug-in units bypasses the regulator tube, V748B, through R749 during this period. If the ac circuit is momentarily broken the thermal-delay relay operates and again waits for 25 seconds after reapplication of the ac before completing the dc high-voltage circuit connection.

High-Voltage Supply

Accelerating voltages for the cathode-ray tube are obtained by rectifying a 60-kc high ac voltage produced by a vacuum-tube oscillator. V803 is the oscillator tube connected as a Hartley oscillator with the primary of transformer T801 as the tapped inductor, and C806 as the capacitor.

A voltage-tripler rectifier, consisting of V821, V822, V823, C821, C822, and C823, supplies about 8650 volts positive for the post-deflection accelerating anode of the cathode-ray tube.

High-Voltage Regulator

A sample of the cathode voltage is tapped off by means of R814, R812, and adjustable R811, and applied to the grid of comparator tube V810A. The cathode of V810A is connected to -150 volts, and the grid is compared to that voltage. The difference voltage is amplified in the comparator tube and amplified again in shunt-regulator tube V810B, whose plate voltage determines the screen voltage of oscillator V803.

If, for example, the high voltage should become too high, it would make the grid of the comparator tube more negative with respect to its cathode. When the grid drops, the plate rises, thereby raising the grid of V810B. When its grid rises its plate drops, thereby dropping the screen voltage of the oscillator tube, and reducing

the amplitude of oscillation. The reduction of primary voltage of T801 reduces the high voltage, thereby correcting the original departure. C814 at V810A grid, reduces noise and hum.

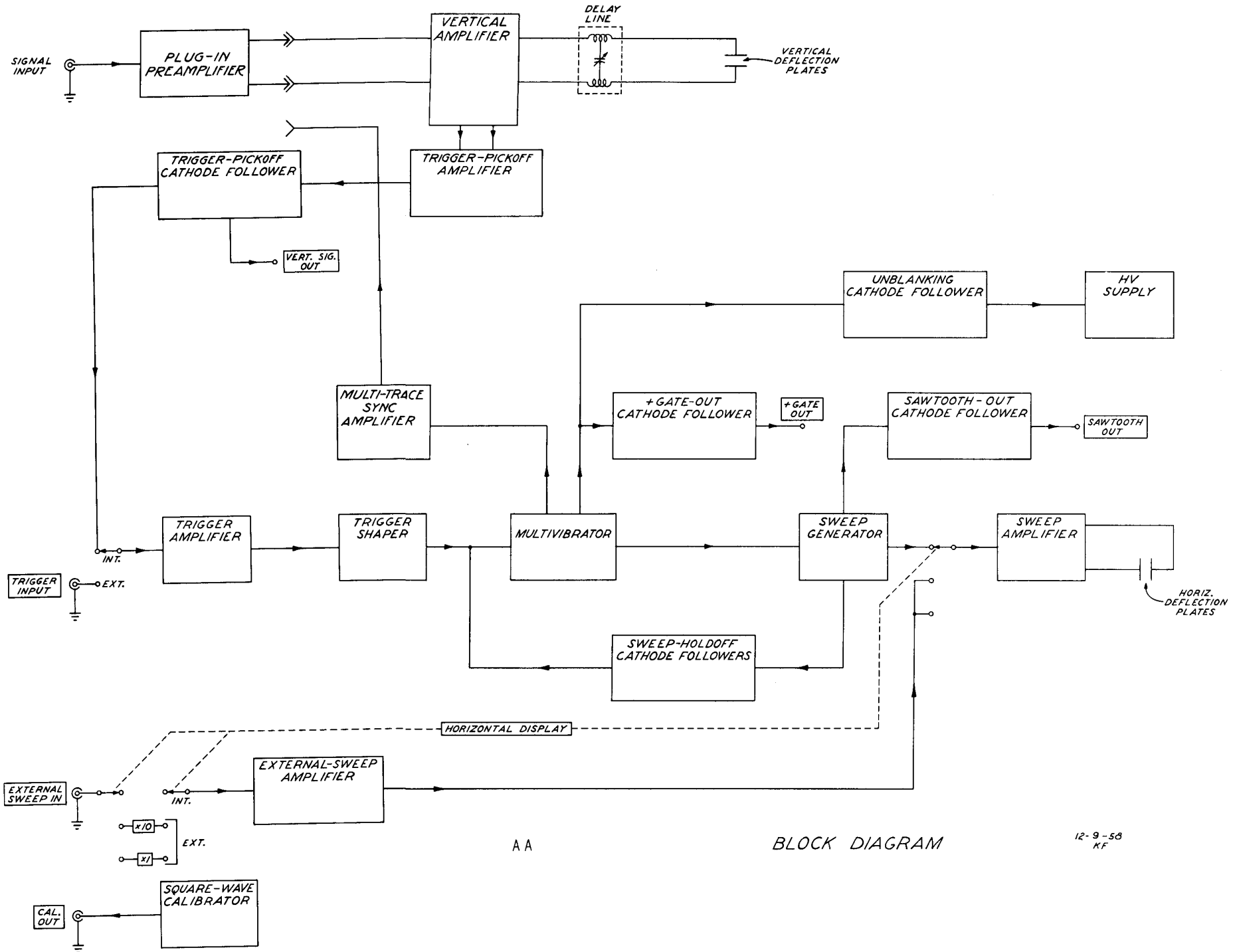
CRT SUPPLY

Unblanking

The control-grid voltage is produced by a winding and rectifier, V824, similar to the cathode supply, but insulated from it. The positive end of the control-grid supply is connected to the cathode of unblanking cathode-follower V54A, and the negative end at -1450 volts is connected to the control grid through potentiometer R831, labeled INTENSITY on the front panel. When the unblanking pulse is produced at the cathode of the unblanking cathode follower, it drives the whole grid-voltage supply with it, winding, filter, potentiometer, so that the same pulse appears at the cathode-ray tube grid 1550 volts below. Since this is a dc connection, the unblanking pulse may have any duration with no change in grid voltage. C834 transmits the leading edge of the unblanking pulse to reduce unblanking time for fast sweeps, and R834, R835, and R830, provide the right time constant to prevent overshoot.

CRT Geometry Adjust

The second-anode voltage required for best linearity at the extremes of deflection may vary somewhat between tubes. R861, a screwdriver control, labeled GEOM. ADJ. on the chassis, permits this voltage to be adjusted.



AA

BLOCK DIAGRAM

12-9-58
KF

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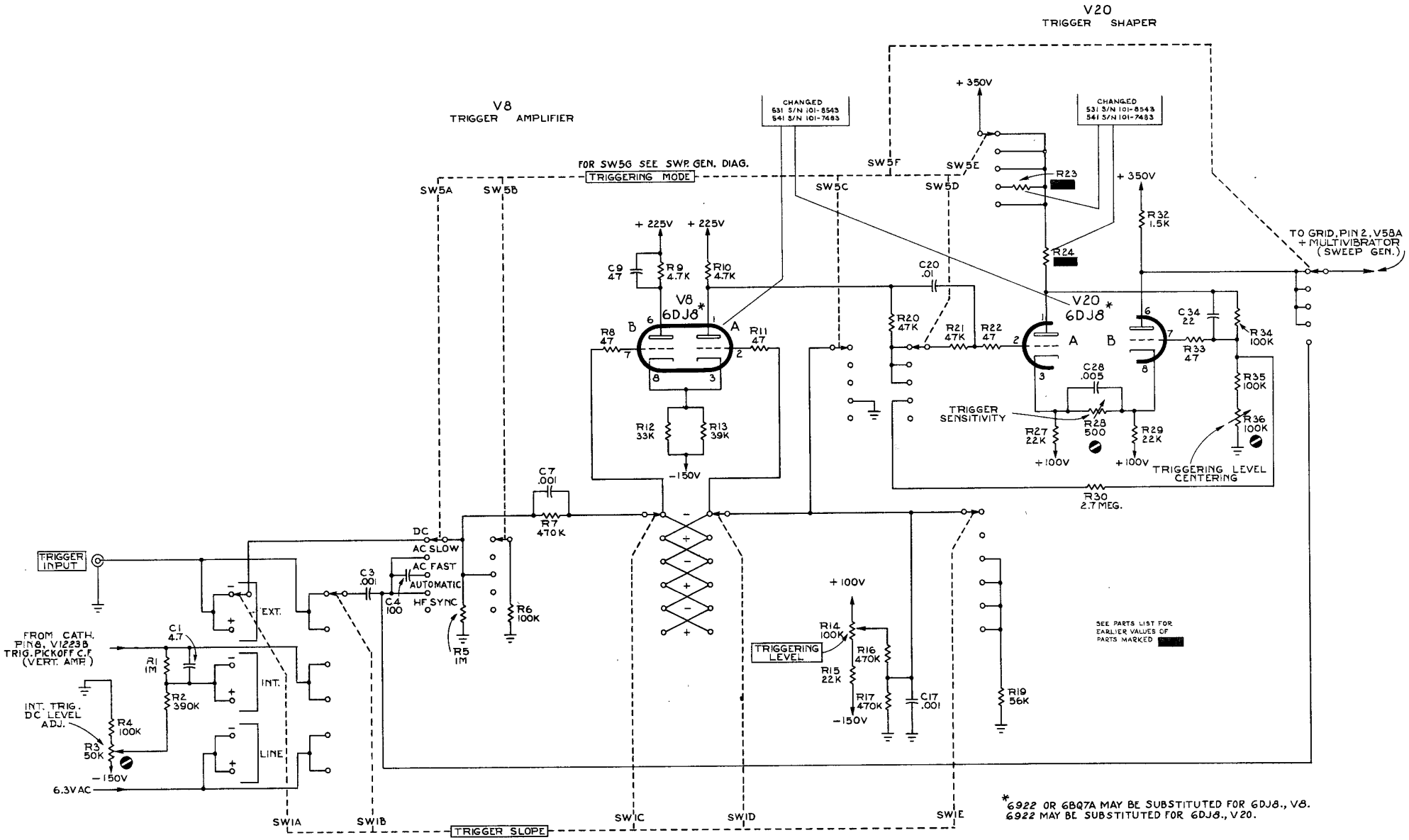
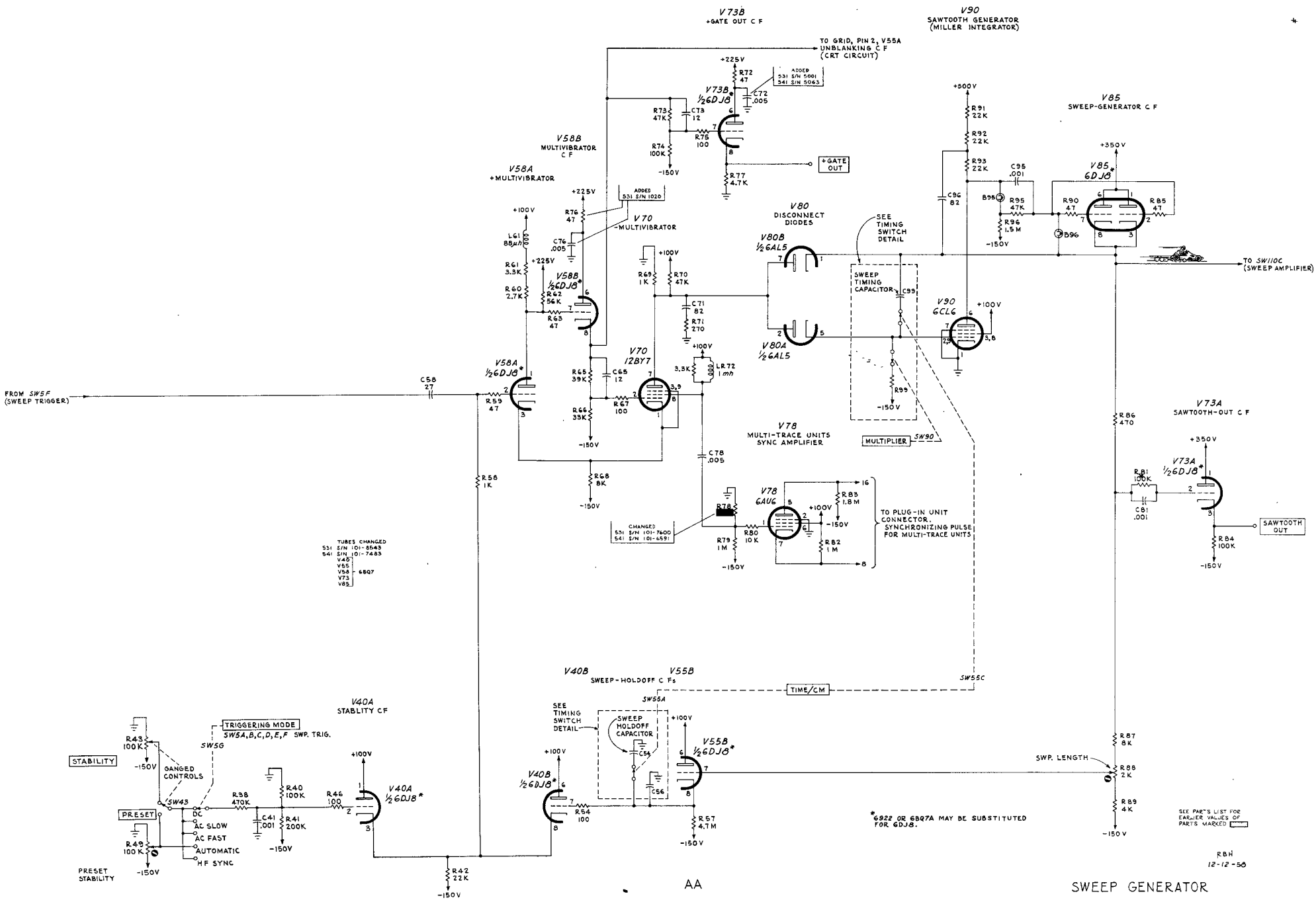
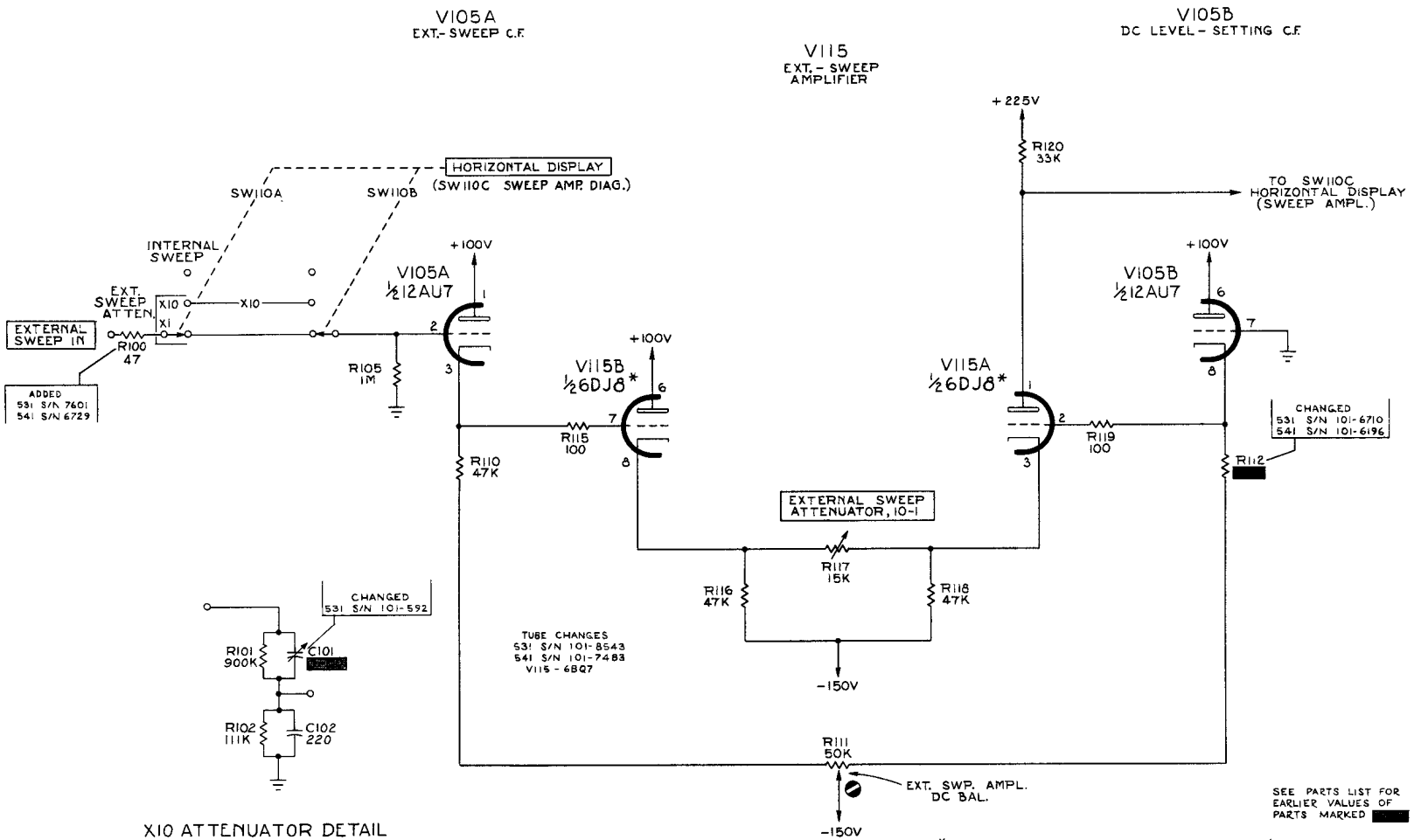
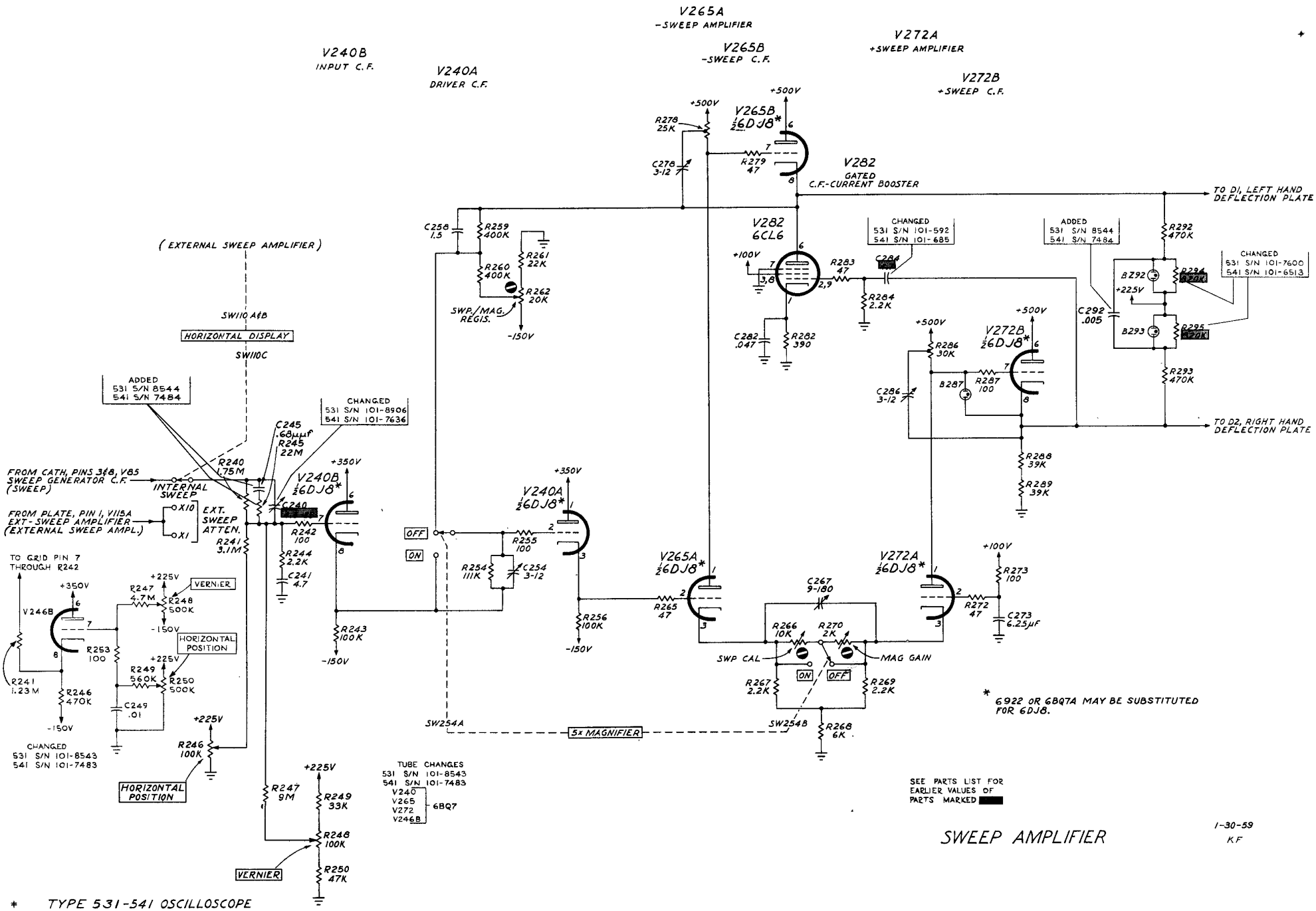


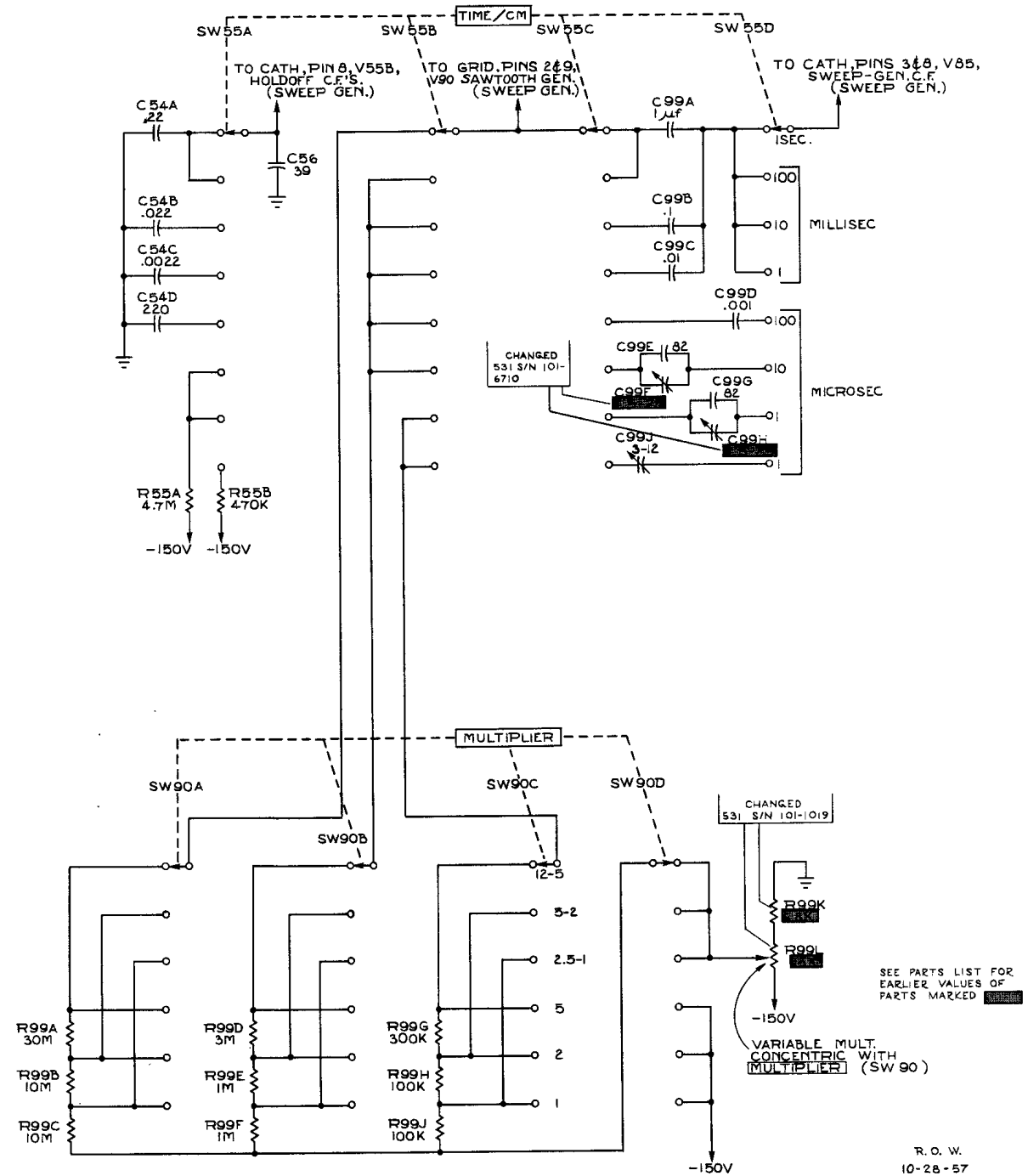
+ TYPE 531-541 OSCILLOSCOPE AA SWEEP TRIGGER

12-11-58
R.O.W.


V73B
+GATE OUT C F
V90
SAWTOOTH GENERATOR
(MILLER INTEGRATOR)
TO GRID, PIN 2, V55A
UNBLANKING C F
(CRT CIRCUIT)
+225V
R72 47
ADDED
531 S/N 5001
541 S/N 5063
V73B*
½6DJ8
C72 .005
R73 47K
C73 12
R75 100
R74 100K
-150V
+GATE OUT
R77 4.7K
V58B
MULTIVIBRATOR
C F
V58A
+MULTIVIBRATOR
+225V
ADDED
531 S/N 1020
+100V
R76 47
V70
MULTIVIBRATOR
L61 88μh
C76 .005
R61 3.3K
+225V
R60 2.7K
V58B*
½6DJ8
R62 56K
R63 47
V80
DISCONNECT
DIODES
V80B
½6AL5
SEE
TIMING
SWITCH
DETAIL
SWEEP
TIMING
CAPACITOR
C99
V90
6CL6
+100V
V80A
½6AL5
R69 1K
+100V
R70 47K
C71 82
R71 270
+100V
V70
12BY7
3.3K
LR 72
1 mh
V58A*
½6DJ8
C65 12
R65 39K
R67 100
R66 39K
-150V
R68 8K
-150V
C78 .005
R58 1K
R59 47
C58 27
FROM SW5F
(SWEEP TRIGGER)
V78
MULTI-TRACE UNITS
SYNC AMPLIFIER
MULTIPLIER
SW90
R99
-150V
V78
6AU6
R78
R79 1M
-150V
R80 10K
R83 1.8M
-150V
+100V
R82 1M
16
8
TO PLUG-IN UNIT
CONNECTOR.
SYNCHRONIZING PULSE
FOR MULTI-TRACE UNITS
CHANGED
531 S/N 101-7600
541 S/N 101-6591
TUBES CHANGED
531 S/N 101-8543
541 S/N 101-7483
V40
V55
V58
V73
V85
= 6BQ7
V85
SWEEP-GENERATOR C F
+500V
R91 22K
R92 22K
R93 22K
C96 82
C95 .001
B98
R95 47K
R96 1.5M
-150V
B96
+350V
V85*
6DJ8
R90 47
R85 47
TO SW110C
(SWEEP AMPLIFIER)
V73A
SAWTOOTH-OUT C F
R86 470
+350V
V73A
½6DJ8*
R81 100K
C81 .001
SAWTOOTH
OUT
R84 100K
-150V
V40B
SWEEP-HOLDOFF C Fs
V55B
SW55C
TIME/CM
SW55A
SEE
TIMING
SWITCH
DETAIL
SWEEP
HOLDOFF
CAPACITOR
C54
C56
+100V
V55B
½6DJ8*
+100V
V40B*
½6DJ8
R54 100
R57 4.7M
-150V
SWP. LENGTH
R87 8K
R88 2K
R89 4K
-150V
*6922 OR 6BQ7A MAY BE SUBSTITUTED
FOR 6DJ8.
SEE PARTS LIST FOR
EARLIER VALUES OF
PARTS MARKED
RBH
12-12-58
V40A
STABILITY C F
TRIGGERING MODE
SW5A,B,C,D,E,F SWP. TRIG.
SW5G
STABILITY
R43 100K
-150V
GANGED
CONTROLS
SW43
PRESET
R49 100K
-150V
PRESET
STABILITY
DC
AC SLOW
AC FAST
AUTOMATIC
HF SYNC
R38 470K
R40 100K
C41 .001
R41 200K
-150V
R46 100
+100V
V40A*
½6DJ8
R42 22K
-150V
AA
SWEEP GENERATOR
TYPE 531-541 OSCILLOSCOPE
A1

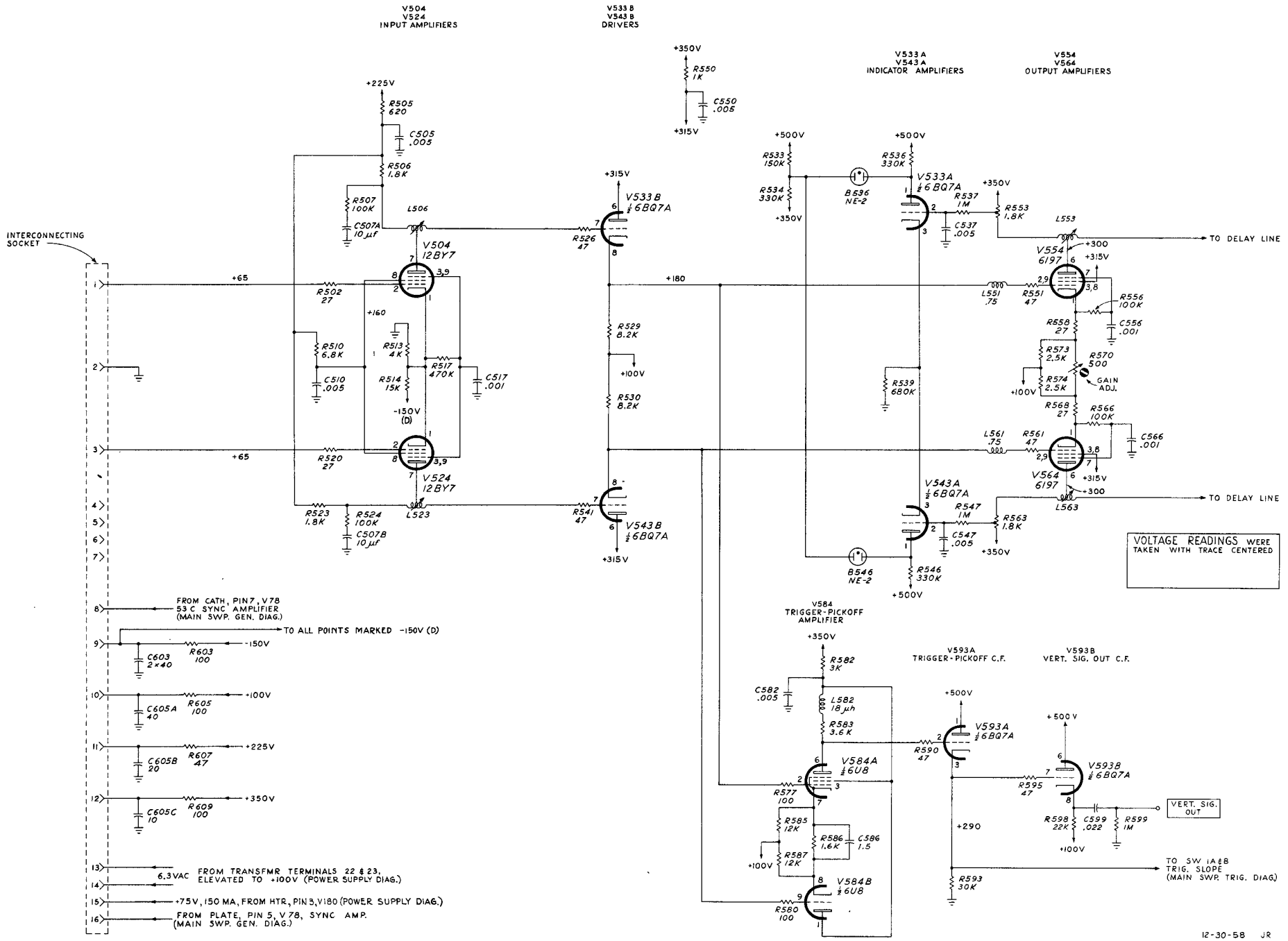

V105A
EXT.- SWEEP C.F.
V115
EXT.- SWEEP
AMPLIFIER
V105B
DC LEVEL - SETTING C.F.
+225V
R120
33K
TO SW110C
HORIZONTAL DISPLAY
(SWEEP AMPL.)
HORIZONTAL DISPLAY
(SW110C SWEEP AMP. DIAG.)
SW110A
SW110B
INTERNAL
SWEEP
EXT.
SWEEP
ATTEN.
X10
X1
EXTERNAL
SWEEP IN
R100
47
ADDED
531 S/N 7601
541 S/N 6729
+100V
V105A
½12AU7
R105
1M
V115B
½6DJ8*
R115
100
R110
47K
V115A
½6DJ8*
R119
100
+100V
V105B
½12AU7
CHANGED
531 S/N 101-6710
541 S/N 101-6196
R112
EXTERNAL SWEEP
ATTENUATOR, 10-1
R117
15K
R116
47K
R118
47K
-150V
TUBE CHANGES
531 S/N 101-8543
541 S/N 101-7483
V115 - 6BQ7
CHANGED
531 S/N 101-592
R101
900K
C101
R102
111K
C102
220
X10 ATTENUATOR DETAIL
R111
50K
EXT. SWP. AMPL.
DC BAL.
-150V
SEE PARTS LIST FOR
EARLIER VALUES OF
PARTS MARKED
*6922 OR 6BQ7A MAY BE SUBSTITUTED
FOR 6DJ8.
R.O.W.
12-10-58


V240B
INPUT C.F.
V240A
DRIVER C.F.
V265A
-SWEEP AMPLIFIER
V265B
-SWEEP C.F.
V272A
+SWEEP AMPLIFIER
V272B
+SWEEP C.F.
V282
GATED
C.F.-CURRENT BOOSTER
(EXTERNAL SWEEP AMPLIFIER)
SW110 A&B
HORIZONTAL DISPLAY
SW110C
FROM CATH, PINS 3&8, V85
SWEEP GENERATOR C.F.
(SWEEP)
FROM PLATE, PIN 1, V115A
EXT-SWEEP AMPLIFIER
(EXTERNAL SWEEP AMPL.)
INTERNAL SWEEP
EXT. SWEEP ATTEN.
X10
X1
TO GRID PIN 7 THROUGH R242
VERNIER
HORIZONTAL POSITION
SWP./MAG. REGIS.
OFF
ON
SWP CAL
MAG GAIN
SW254A
SW254B
5x MAGNIFIER
TO D1, LEFT HAND DEFLECTION PLATE
TO D2, RIGHT HAND DEFLECTION PLATE
ADDED 531 S/N 8544 541 S/N 7484
CHANGED 531 S/N 101-8906 541 S/N 101-7636
CHANGED 531 S/N 101-592 541 S/N 101-685
ADDED 531 S/N 8544 541 S/N 7484
CHANGED 531 S/N 101-7600 541 S/N 101-6513
CHANGED 531 S/N 101-8543 541 S/N 101-7483
TUBE CHANGES 531 S/N 101-8543 541 S/N 101-7483
V240 V265 V272 V246B 6BQ7
* 6922 OR 6BQ7A MAY BE SUBSTITUTED FOR 6DJ8.
SEE PARTS LIST FOR EARLIER VALUES OF PARTS MARKED
SWEEP AMPLIFIER
1-30-59
KF
* TYPE 531-541 OSCILLOSCOPE



TYPE 531-541 OSCILLOSCOPE AA

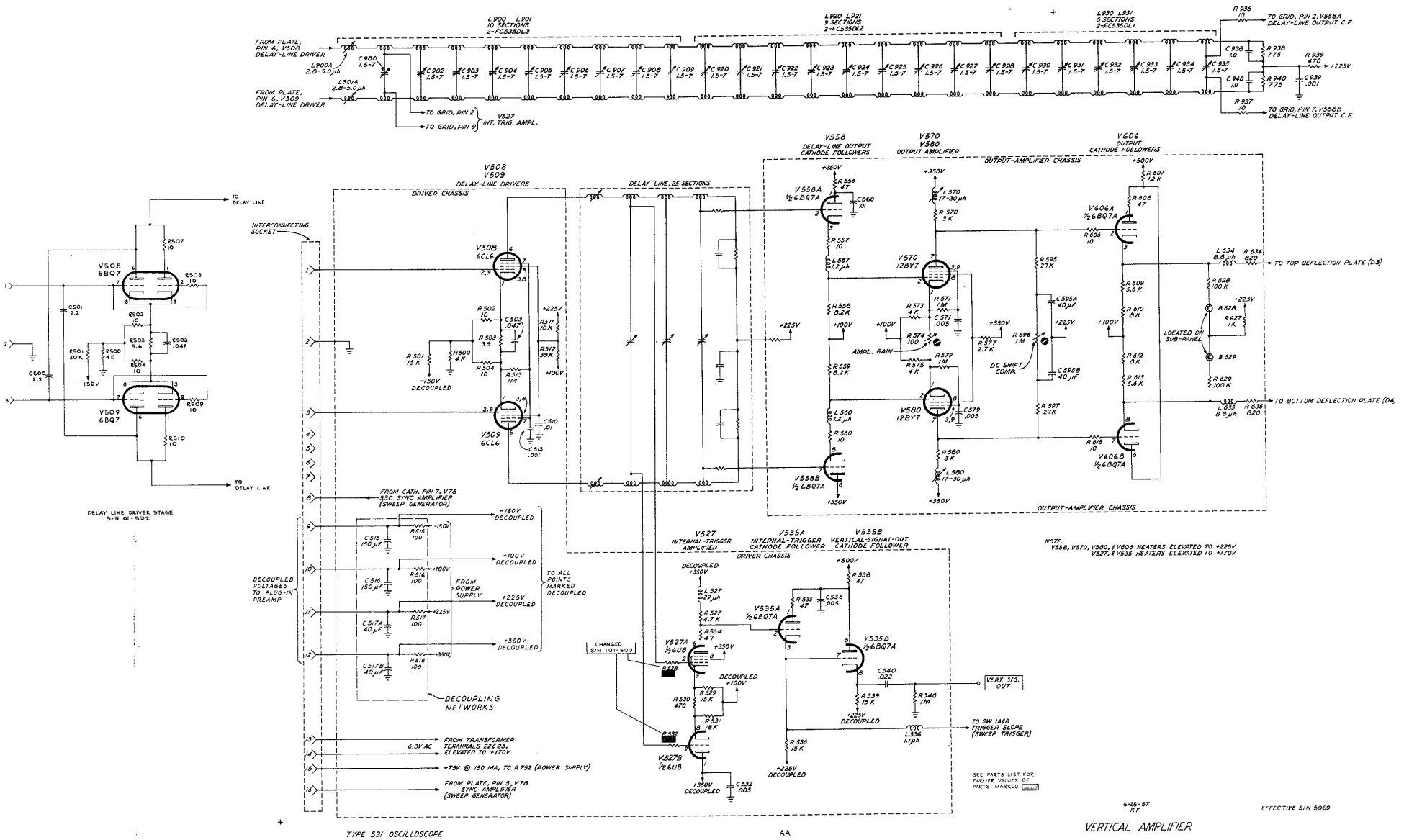
SWEEP TIMING SWITCH

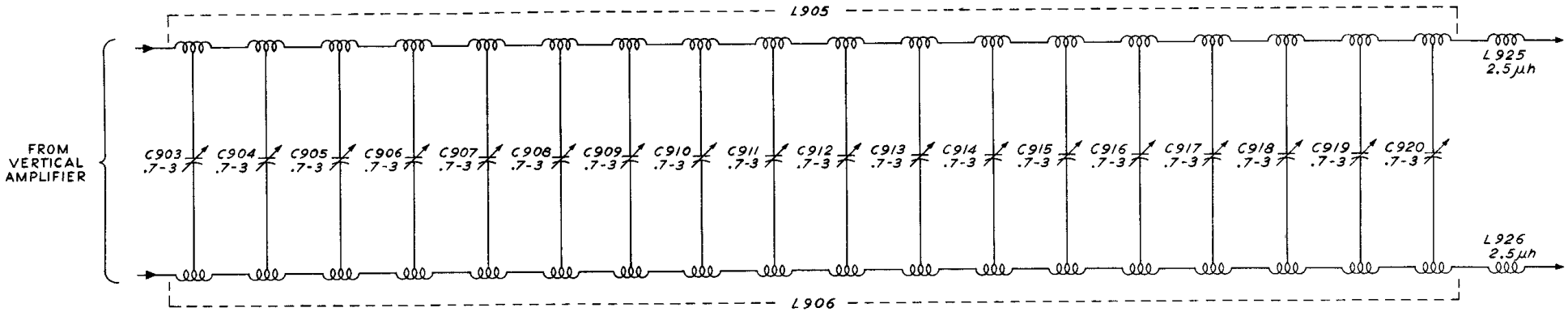


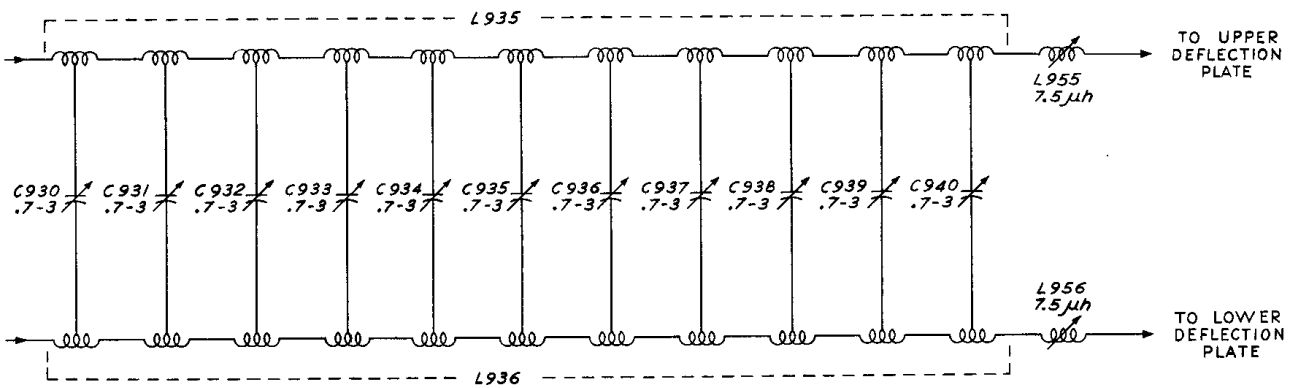
TYPE 531 OSCILLOSCOPE S/N 7601 & UP

A A

VERTICAL AMPLIFIER


L900 L901
10 SECTIONS
2-FC5350L3
L920 L921
9 SECTIONS
2-FC5350K2
L930 L931
6 SECTIONS
2-FC5350J1
FROM PLATE, PIN 6, V508 DELAY-LINE DRIVER
FROM PLATE, PIN 6, V509 DELAY-LINE DRIVER
L900A 2.8-5.0 µh
L901A 2.8-5.0 µh
C900 1.5-7
C902 1.5-7
C903 1.5-7
C904 1.5-7
C905 1.5-7
C906 1.5-7
C907 1.5-7
C908 1.5-7
C909 1.5-7
C920 1.5-7
C921 1.5-7
C922 1.5-7
C923 1.5-7
C924 1.5-7
C925 1.5-7
C926 1.5-7
C927 1.5-7
C928 1.5-7
C930 1.5-7
C931 1.5-7
C932 1.5-7
C933 1.5-7
C934 1.5-7
C935 1.5-7
C936 10
C940 10
R936 10
R938 775
R939 470
R940 775
C939 .001
R937 10
TO GRID, PIN 2, V558A DELAY-LINE OUTPUT C.F.
+225V
TO GRID, PIN 7, V558B DELAY-LINE OUTPUT C.F.
TO GRID, PIN 2
TO GRID, PIN 9
V527 INT. TRIG. AMPL.
V508 6BQ7
V509 6BQ7
C501 2.2
C502 2.2
R501 20K
R502 10
R503 5.6
R504 10
R505 4K
C503 .047
R507 10
R508 10
R509 10
R510 10
-150V
TO DELAY LINE
DELAY LINE DRIVER STAGE S/N 101-5932
INTERCONNECTING SOCKET
V508 6CL6
V509 6CL6
DELAY-LINE DRIVERS
DRIVER CHASSIS
DELAY LINE, 25 SECTIONS
R501 15 K
R500 4 K
R502 10
R503 3.9
R504 10
R513 1M
C503 .047
R511 10K
R512 .39K
C510 .01
C513 .001
-150V DECOUPLED
+100V
+225V
V558 DELAY-LINE OUTPUT CATHODE FOLLOWERS
V570 V580 OUTPUT AMPLIFIER
V606 OUTPUT CATHODE FOLLOWERS
OUTPUT-AMPLIFIER CHASSIS
V558A ½6BQ7A
V558B ½6BQ7A
V570 12BY7
V580 12BY7
V606A ½6BQ7A
V606B ½6BQ7A
+350V
+500V
R556 47
C560 .01
L557 1.2 µh
R555 8.2K
R559 8.2K
L560 1.2 µh
R560 10
R570 3K
L570 17-30 µh
R590 3K
L580 17-30 µh
R571 1M
C571 .005
R573 4K
R574 100
R575 4K
R579 1M
C579 .005
AMPL. GAIN
DC SHIFT COMP.
R577 2.7K
R596 1M
R595 27K
C595A 40 µF
C595B 40 µF
R597 27K
R607 1.2K
R608 47
R606 10
R609 5.6K
R610 8K
R612 8K
R613 5.6K
R615 10
L634 8.8 µh
R634 820
L635 8.8 µh
R635 820
R628 100K
R627 1K
R629 100K
B628
B629
LOCATED ON SUB-PANEL
TO TOP DEFLECTION PLATE (D3)
TO BOTTOM DEFLECTION PLATE (D4)
OUTPUT-AMPLIFIER CHASSIS
NOTE: V558, V570, V580, & V606 HEATERS ELEVATED TO +225V V527, & V535 HEATERS ELEVATED TO +170V
DECOUPLED VOLTAGES TO PLUG-IN PREAMP
FROM CATH, PIN 7, V78 53C SYNC AMPLIFIER (SWEEP GENERATOR)
-150V DECOUPLED
+100V DECOUPLED
+225V DECOUPLED
+350V DECOUPLED
TO ALL POINTS MARKED DECOUPLED
FROM POWER SUPPLY
C515 150 µF
C516 150 µF
C517A 40 µF
C517B 40 µF
R515 100
R516 100
R517 100
R518 100
DECOUPLING NETWORKS
6.3V AC
FROM TRANSFORMER TERMINALS 22 & 23, ELEVATED TO +170V
+75V @ 150 MA, TO R752 (POWER SUPPLY)
FROM PLATE, PIN 5, V78 SYNC AMPLIFIER (SWEEP GENERATOR)
V527 INTERNAL-TRIGGER AMPLIFIER
V535A INTERNAL-TRIGGER CATHODE FOLLOWER
V535B VERTICAL-SIGNAL-OUT CATHODE FOLLOWER
DRIVER CHASSIS
DECOUPLED +350V
DECOUPLED +100V
+225V DECOUPLED
+350V DECOUPLED
L527 .29 µh
R527 4.7K
R534 47
V527A ½6U8
V527B ½6U8
R528
R529 15K
R530 470
R531 18K
R532
C532 .005
CHANGED S/N 101-600
R535 47
C538 .005
V535A ½6BQ7A
V535B ½6BQ7A
R538 47
C540 .022
R539 15K
R540 1M
R536 15K
L536 1.1 µh
VERT. SIG. OUT
TO SW 1A8 TRIGGER SLOPE (SWEEP TRIGGER)
SEE PARTS LIST FOR EARLIER VALUES OF PARTS MARKED
6-25-57 K F
EFFECTIVE S/N 5969
TYPE 531 OSCILLOSCOPE S/N 101-7600
AA
VERTICAL AMPLIFIER





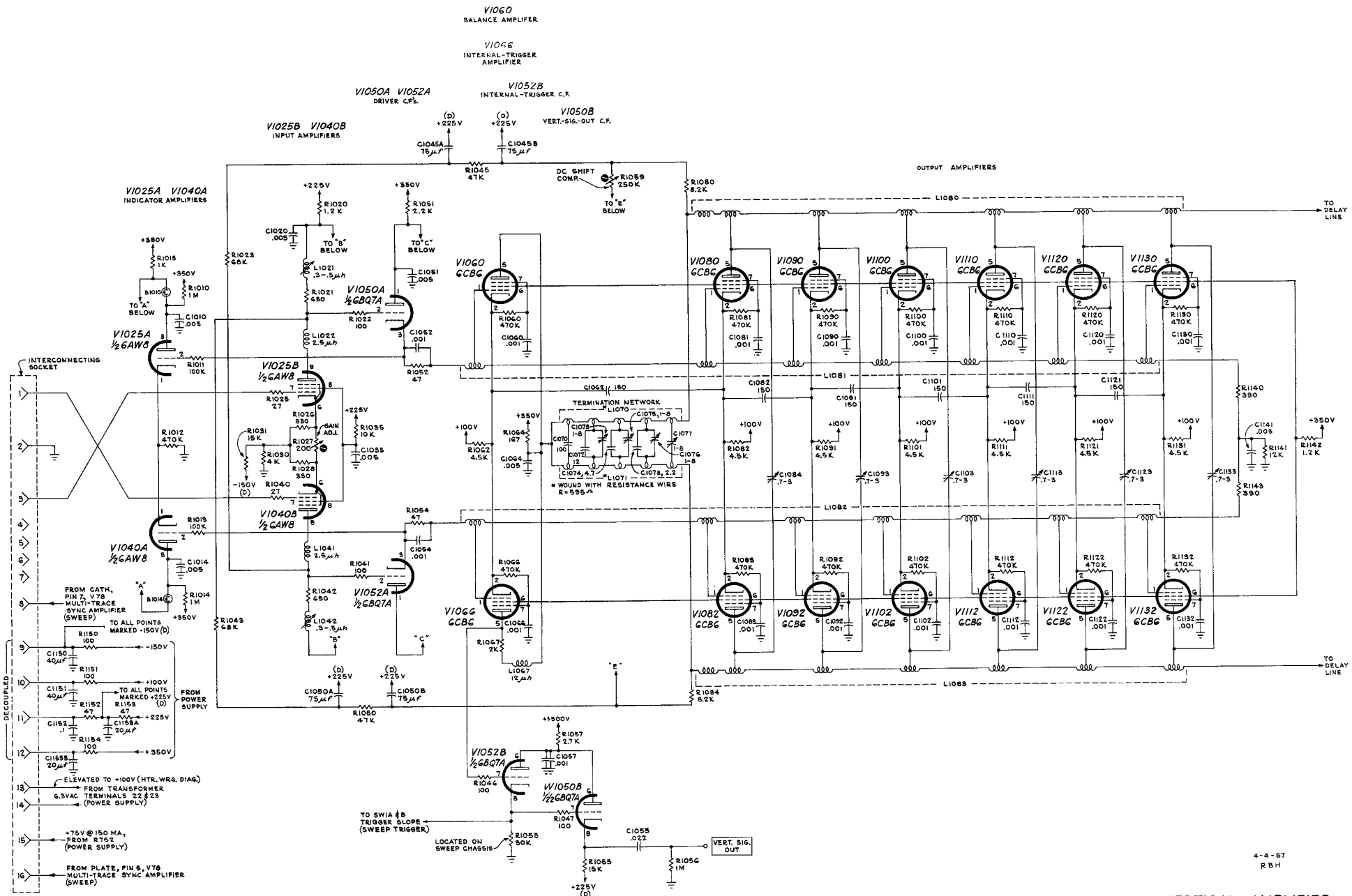
11-29-57 JR

AA

DELAY LINE NETWORK

TYPE 531 OSCILLOSCOPE

S/N 7601 & UP

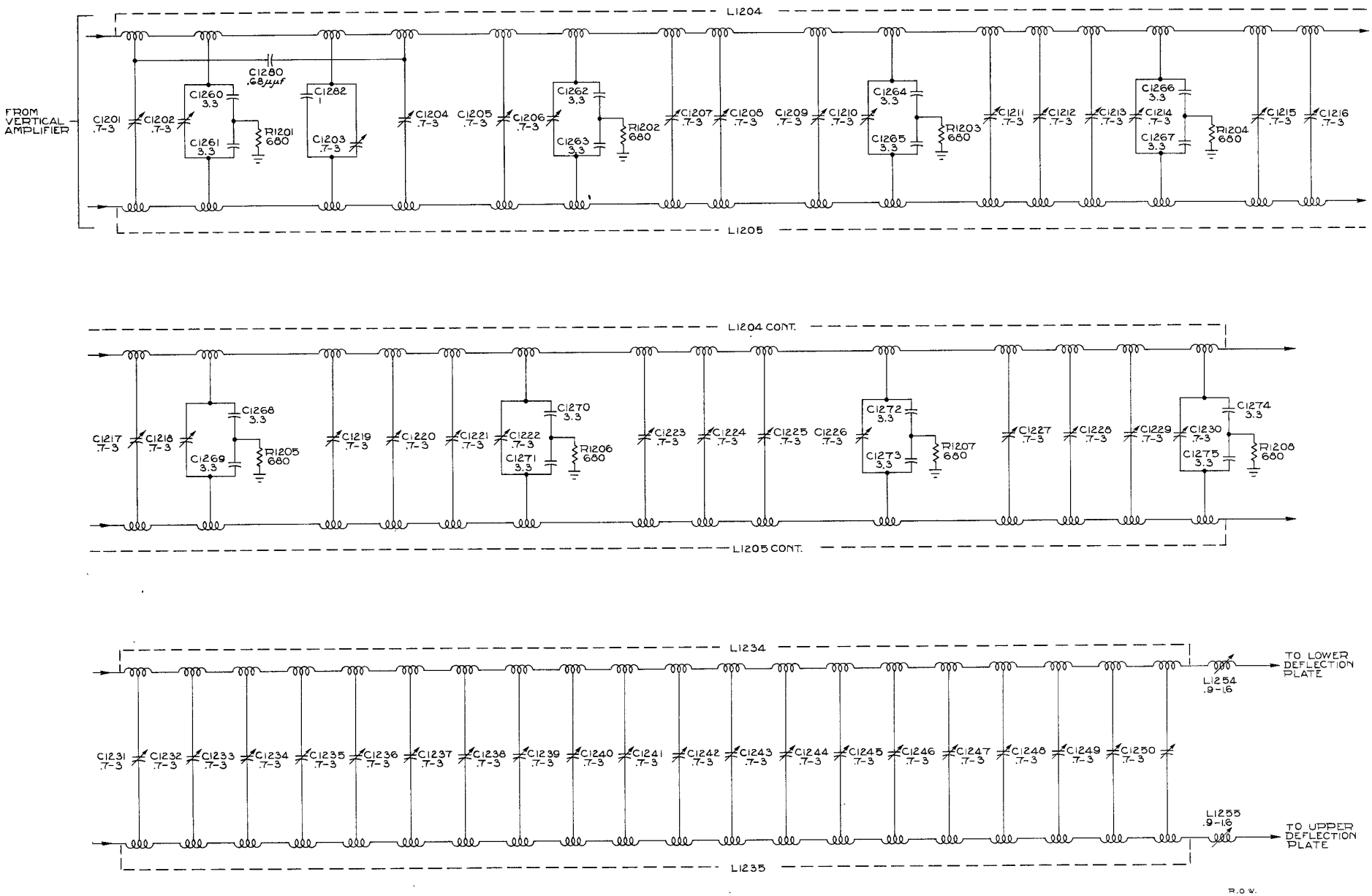


TYPE 541 OSCILLOSCOPE

S/N 101-6474

A A

VERTICAL AMPLIFIER



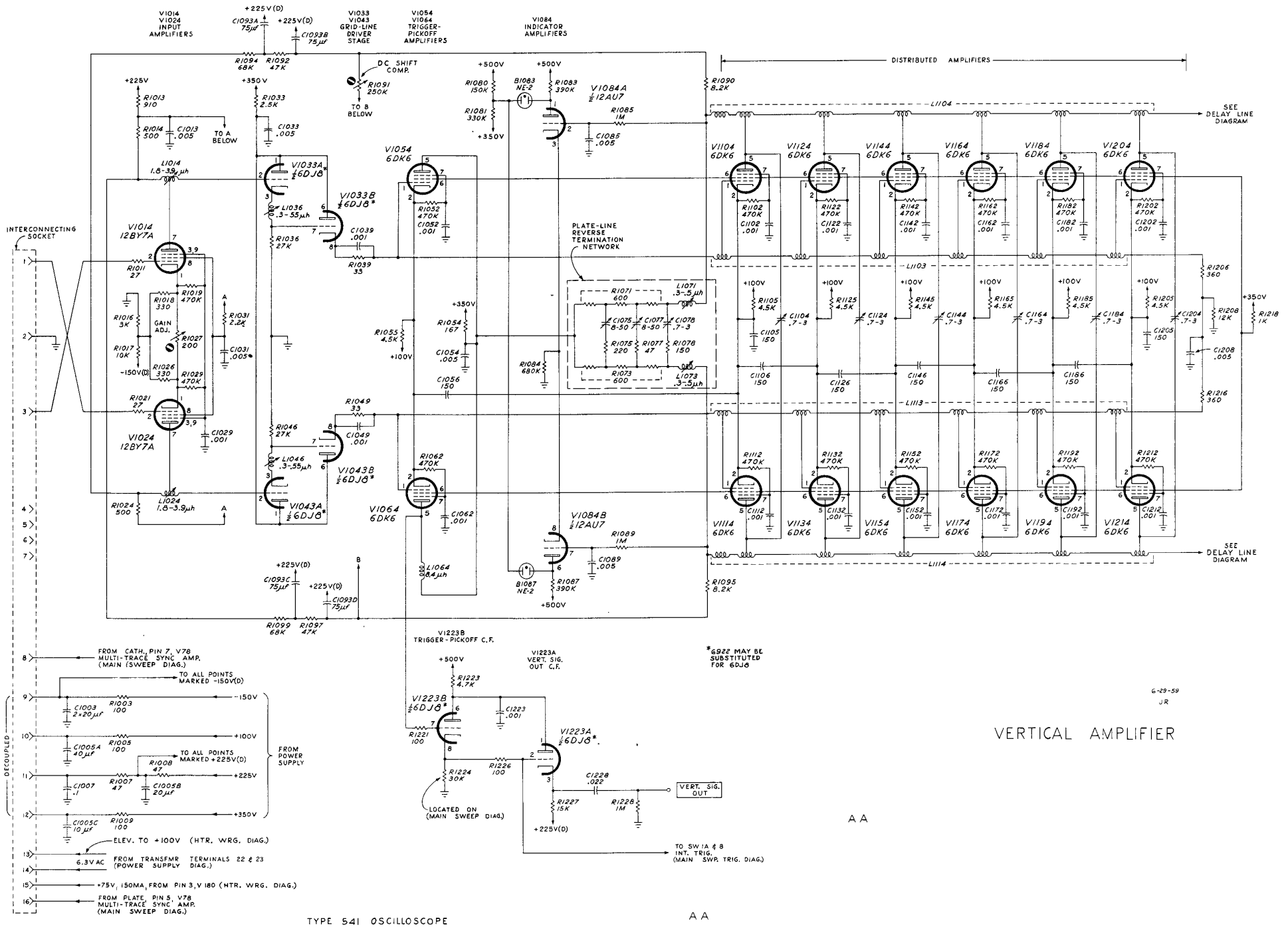
R.O.V.
2-16-56

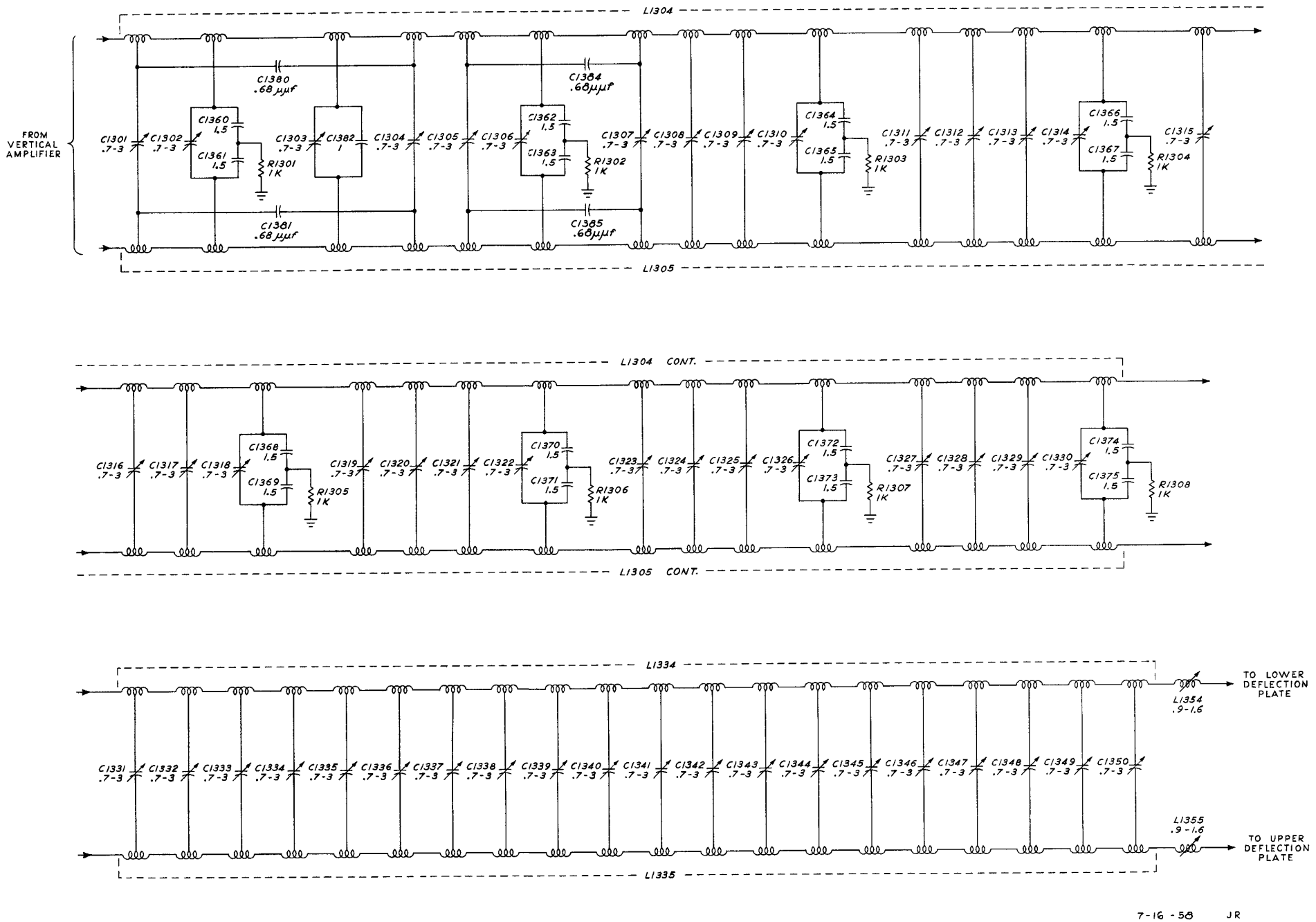
TYPE 541 OSCILLOSCOPE

S/N 101-6474

DELAY LINE NETWORK

AA


V1014 V1024 INPUT AMPLIFIERS
V1033 V1043 GRID-LINE DRIVER STAGE
V1054 V1064 TRIGGER-PICKOFF AMPLIFIERS
V1084 INDICATOR AMPLIFIERS
DISTRIBUTED AMPLIFIERS
INTERCONNECTING SOCKET
DC SHIFT COMP.
TO A BELOW
TO B BELOW
GAIN ADJ.
PLATE-LINE REVERSE TERMINATION NETWORK
SEE DELAY LINE DIAGRAM
V1014 12BY7A
V1024 12BY7A
V1033A ½6DJ8*
V1033B ½6DJ8*
V1043A ½6DJ8*
V1043B ½6DJ8*
V1054 6DK6
V1064 6DK6
V1084A ½12AU7
V1084B ½12AU7
V1104 6DK6
V1124 6DK6
V1144 6DK6
V1164 6DK6
V1184 6DK6
V1204 6DK6
V1114 6DK6
V1134 6DK6
V1154 6DK6
V1174 6DK6
V1194 6DK6
V1214 6DK6
V1223B TRIGGER-PICKOFF C.F.
V1223A VERT. SIG. OUT C.F.
*6922 MAY BE SUBSTITUTED FOR 6DJ8
FROM CATH., PIN 7, V78 MULTI-TRACE SYNC AMP. (MAIN SWEEP DIAG.)
TO ALL POINTS MARKED -150V(D)
TO ALL POINTS MARKED +225V(D)
FROM POWER SUPPLY
DECOUPLED
ELEV. TO +100V (HTR. WRG. DIAG.)
6.3V AC FROM TRANSFMR TERMINALS 22 & 23 (POWER SUPPLY DIAG.)
+75V, 150MA, FROM PIN 3, V 180 (HTR. WRG. DIAG.)
FROM PLATE, PIN 5, V78 MULTI-TRACE SYNC AMP. (MAIN SWEEP DIAG.)
LOCATED ON (MAIN SWEEP DIAG.)
VERT. SIG. OUT
TO SW 1A & 8 INT. TRIG. (MAIN SWP. TRIG. DIAG.)
6-29-59
JR
VERTICAL AMPLIFIER
AA
AA
TYPE 541 OSCILLOSCOPE
S/N 6475 & UP

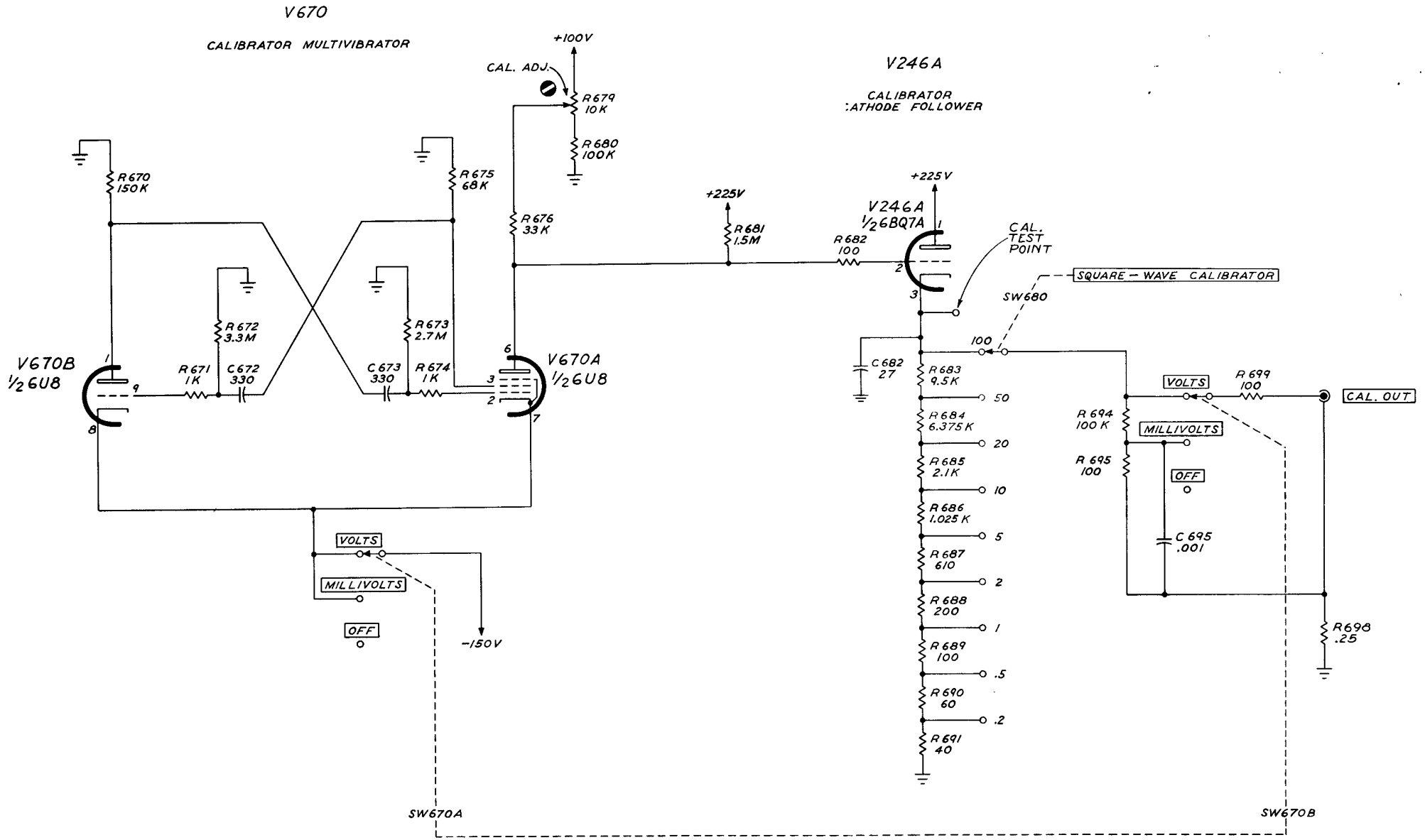


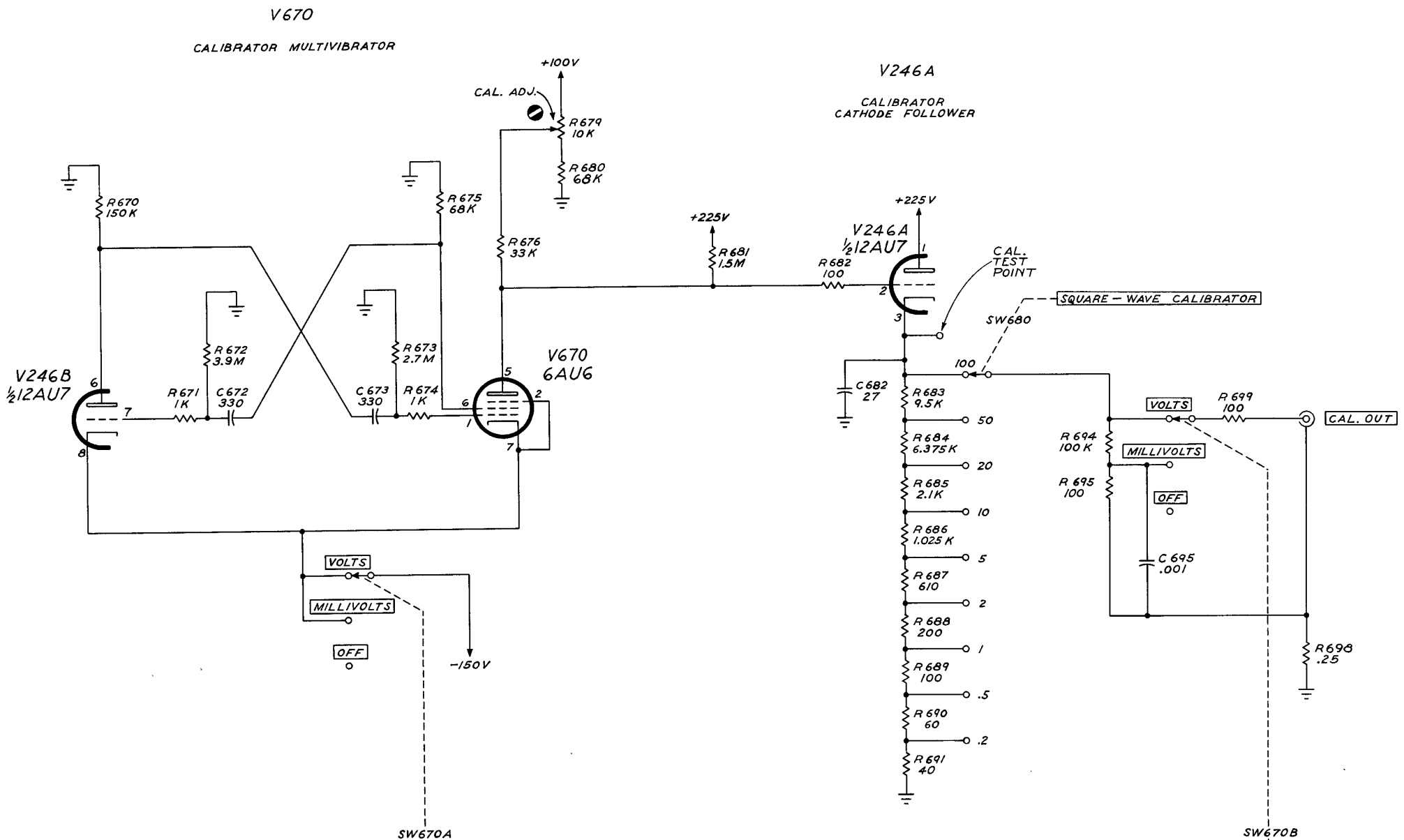
7-16-58 JR

TYPE 541 OSCILLOSCOPE
S/N 6475 & UP

AA

DELAY LINE NETWORK


V670
CALIBRATOR MULTIVIBRATOR
+100V
CAL. ADJ.
R679 10K
R680 100K
R670 150K
R675 68K
R676 33K
+225V
R681 1.5M
V246A
CALIBRATOR CATHODE FOLLOWER
V246A 1/2 6BQ7A
+225V
R682 100
CAL. TEST POINT
SQUARE-WAVE CALIBRATOR
SW680
V670B 1/2 6U8
R671 1K
C672 330
R672 3.3M
C673 330
R673 2.7M
R674 1K
V670A 1/2 6U8
C682 27
R683 9.5K
R684 6.375K
R685 2.1K
R686 1.025K
R687 610
R688 200
R689 100
R690 60
R691 40
100
50
20
10
5
2
1
.5
.2
VOLTS
MILLIVOLTS
OFF
-150V
R694 100K
R695 100
C695 .001
R699 100
CAL. OUT
R698 .25
SW670A
SW670B
TYPE 531-541 OSCILLOSCOPE
531 S/N 101-8544
541 S/N 101-7484
AA
CALIBRATOR
12-10-56
KF



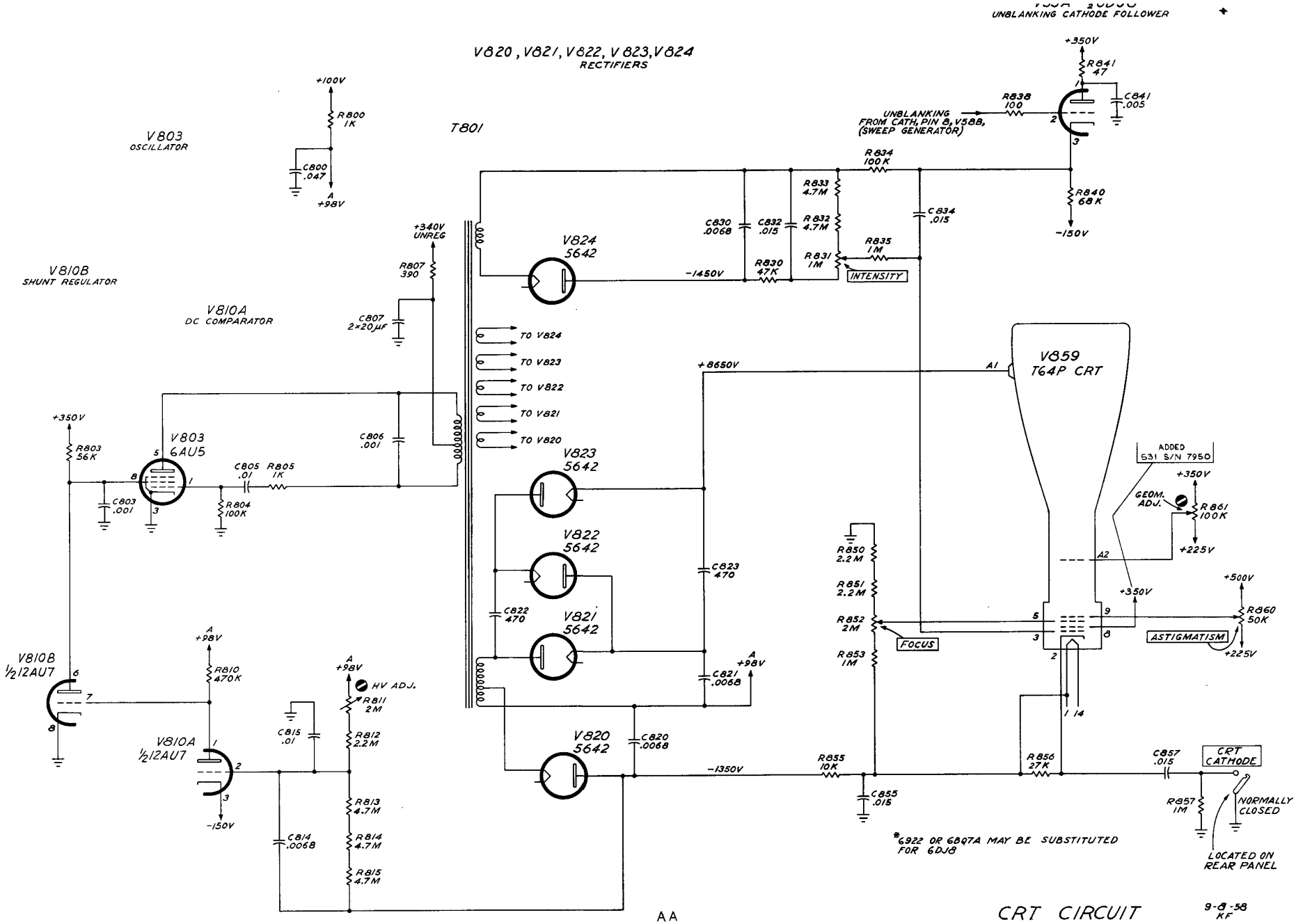
TYPE 531-541 OSCILLOSCOPE

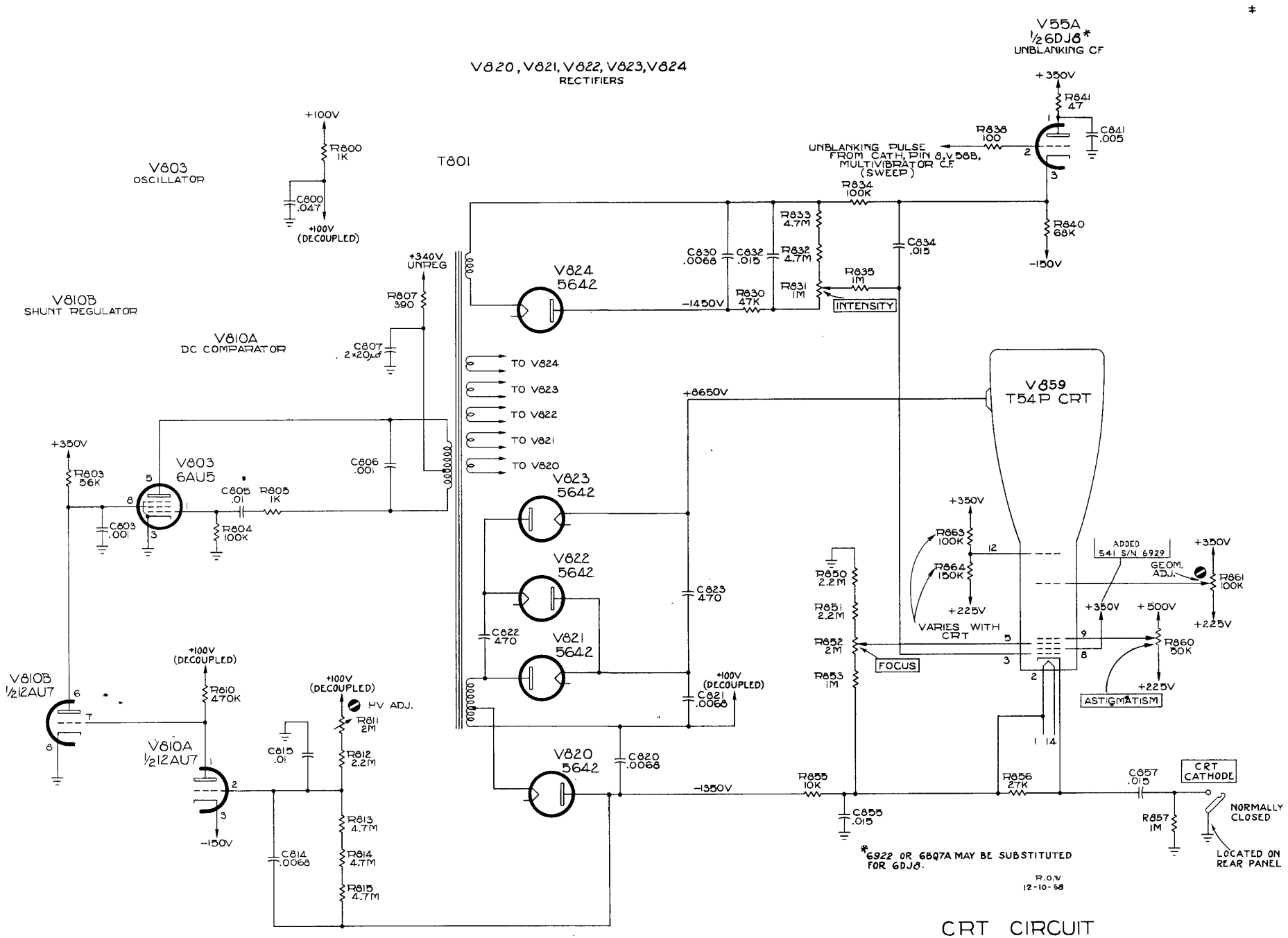
531 S/N 8545 & UP
541 S/N 7485 & UP

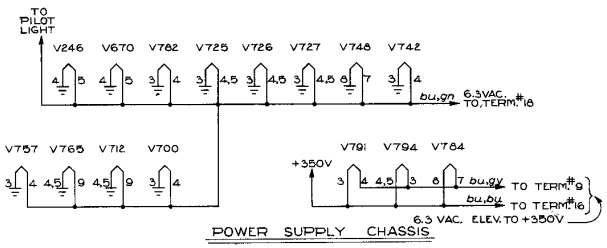
A

CALIBRATOR

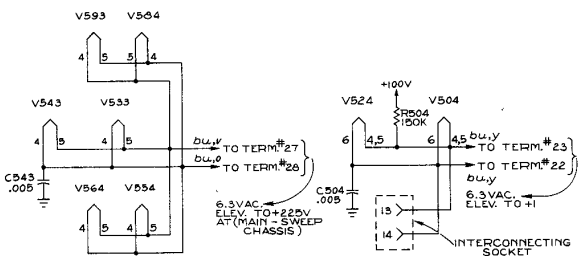
4-10-59
KF


V820, V821, V822, V823, V824
RECTIFIERS
UNBLANKING CATHODE FOLLOWER
V803
OSCILLATOR
T801
V810B
SHUNT REGULATOR
V810A
DC COMPARATOR
V803
6AU5
V824
5642
V823
5642
V822
5642
V821
5642
V820
5642
V859
T64P CRT
V810B
1/2 12AU7
V810A
1/2 12AU7
+100V
R800 1K
C800 .047
A +98V
+340V UNREG
R807 390
C807 2×20 µF
TO V824
TO V823
TO V822
TO V821
TO V820
+350V
R803 56K
C803 .001
C805 .01
R805 1K
R804 100K
C806 .001
+8650V
C823 470
C822 470
C821 .0068
C820 .0068
-1350V
-1450V
R830 47K
C830 .0068
C832 .015
R833 4.7M
R832 4.7M
R831 1M
R834 100K
C834 .015
R835 1M
INTENSITY
R838 100
UNBLANKING FROM CATH, PIN 8, V58B, (SWEEP GENERATOR)
+350V
R841 47
C841 .005
R840 68K
-150V
ADDED 531 S/N 7950
+350V
GEOM. ADJ.
R861 100K
+225V
A1
A2
+500V
R860 50K
+225V
ASTIGMATISM
+350V
R850 2.2M
R851 2.2M
R852 2M
R853 1M
FOCUS
R855 10K
C855 .015
R856 27K
C857 .015
CRT CATHODE
R857 1M
NORMALLY CLOSED
LOCATED ON REAR PANEL
A +98V
R810 470K
C815 .01
HV ADJ.
R811 2M
R812 2.2M
R813 4.7M
R814 4.7M
R815 4.7M
C814 .0068
-150V
*6922 OR 6BQ7A MAY BE SUBSTITUTED FOR 6DJ8
AA
CRT CIRCUIT
9-8-58
KF
TYPE 531 OSCILLOSCOPE

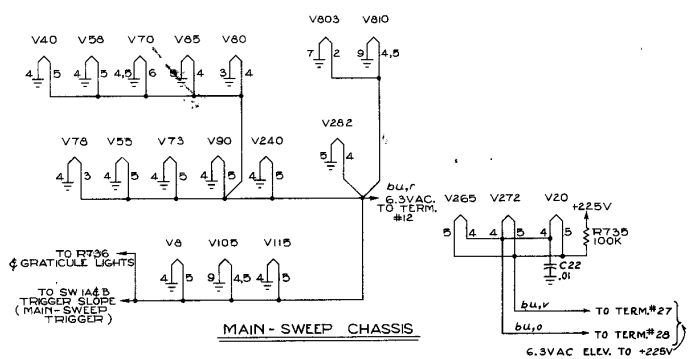

V820, V821, V822, V823, V824
RECTIFIERS
V55A
½6DJ8*
UNBLANKING CF
+350V
R841
4.7
C841
.005
R838
100
UNBLANKING PULSE
FROM CATH, PIN 8, V55B,
MULTIVIBRATOR C.F.
(SWEEP)
R834
100K
R833
4.7M
R832
4.7M
R831
1M
R835
1M
INTENSITY
R840
68K
-150V
C830
.0068
C832
.015
C834
.015
-1450V
R830
47K
V824
5642
V803
OSCILLATOR
+100V
R800
1K
C800
.047
+100V
(DECOUPLED)
T801
+340V
UNREG
R807
390
C807
.2×20μf
V810B
SHUNT REGULATOR
V810A
DC COMPARATOR
TO V824
TO V823
TO V822
TO V821
TO V820
+8650V
V859
T54P CRT
+350V
R803
56K
V803
6AU5
C805
.01
R805
1K
C806
.001
C803
.001
R804
100K
V823
5642
V822
5642
C822
470
C823
470
V821
5642
+100V
(DECOUPLED)
C821
.0068
V810B
½12AU7
+100V
(DECOUPLED)
R810
470K
+100V
(DECOUPLED)
HV ADJ.
R811
2M
V810A
½12AU7
C815
.01
R812
2.2M
R813
4.7M
R814
4.7M
R815
4.7M
C814
.0068
-150V
V820
5642
C820
.0068
-1350V
+350V
R863
100K
R864
150K
+225V
VARIES WITH
CRT
ADDED
541 S/N 6929
GEOM.
ADJ.
+350V
R861
100K
+225V
R850
2.2M
R851
2.2M
R852
2M
R853
1M
FOCUS
+350V
+500V
R860
50K
+225V
ASTIGMATISM
R855
10K
C855
.015
R856
27K
C857
.015
CRT
CATHODE
R857
1M
NORMALLY
CLOSED
LOCATED ON
REAR PANEL
*6922 OR 6BQ7A MAY BE SUBSTITUTED
FOR 6DJ8.
R.O.W
12-10-58
CRT CIRCUIT
TYPE 541 OSCILLOSCOPE
AA



POWER SUPPLY CHASSIS



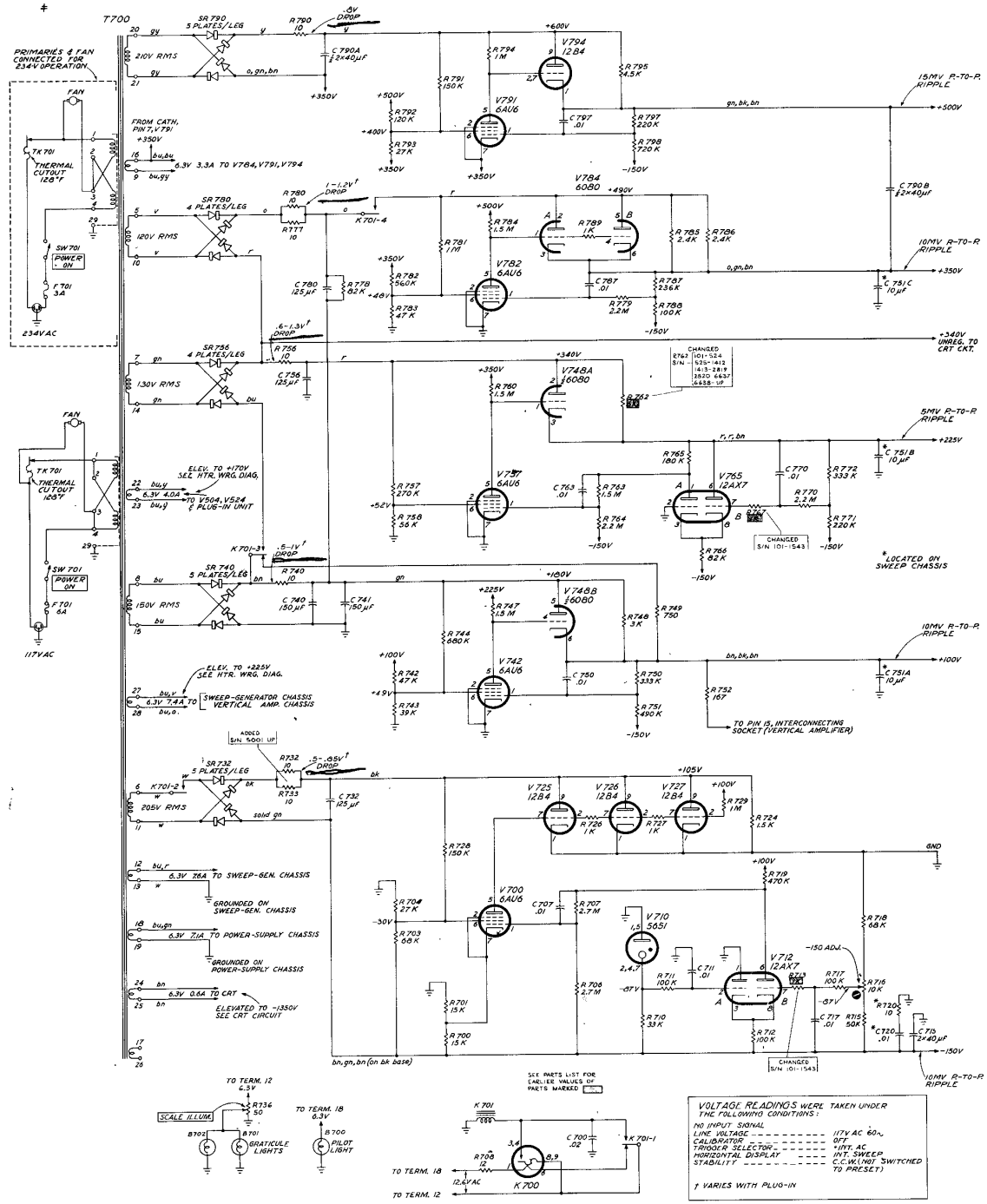
VERTICAL AMPLIFIER CHASSIS



MAIN-SWEEP CHASSIS

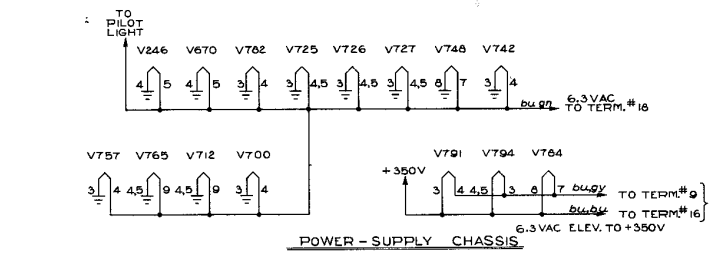
R.O.W. 12-6-58

TYPE 531 OSCILLOSCOPE HEATER WIRING DIAGRAM

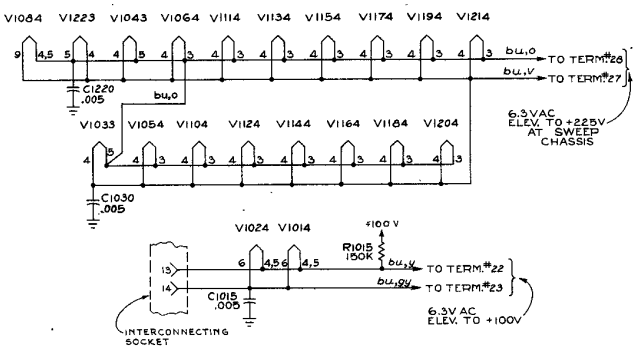


AA

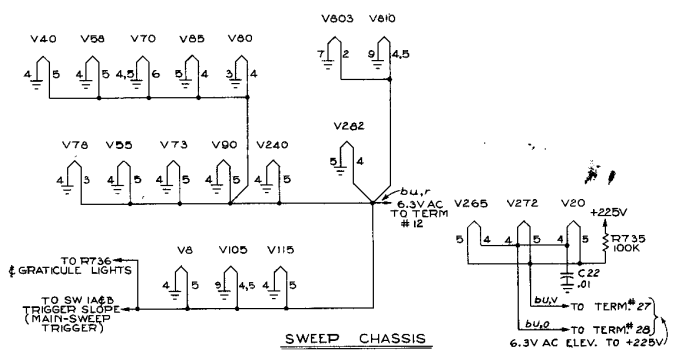
LV POWER SUPPLY



POWER - SUPPLY CHASSIS

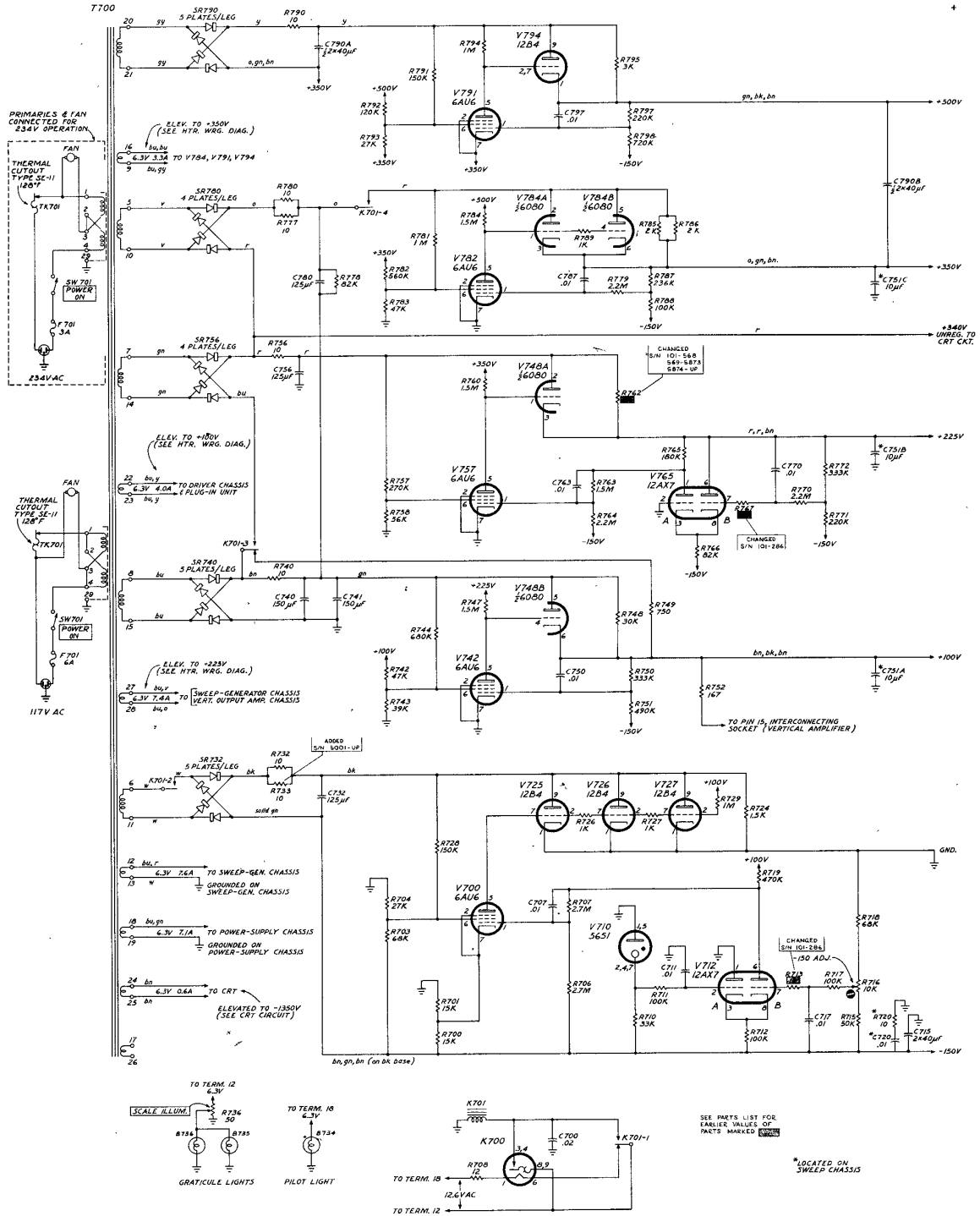


VERTICAL AMPLIFIER CHASSIS



SWEEP CHASSIS

R. O. W.
12-10-58



TYPE 541 OSCILLOSCOPE

HEATER WIRING DIAGRAM

AA

LV POWER SUPPLY 12-18-58 KF