

CATHODE RAY OSCILLOSCOPE

TYPE 531/541

INSTRUCTION

MANUAL



TEKTRONIX, INC.
MANUFACTURERS OF CATHODE-RAY AND VIDEO TEST INSTRUMENTS

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NOTE

This instruction manual has been prepared to cover TEKTRONIX Type 531/541 Oscilloscopes of all serial number ranges. Text, diagrams, and parts lists have been expanded to incorporate all circuit modifications adopted during the course of manufacture. The serial ranges of instruments to which various modifications were applied before shipping from the factory have been noted wherever necessary.

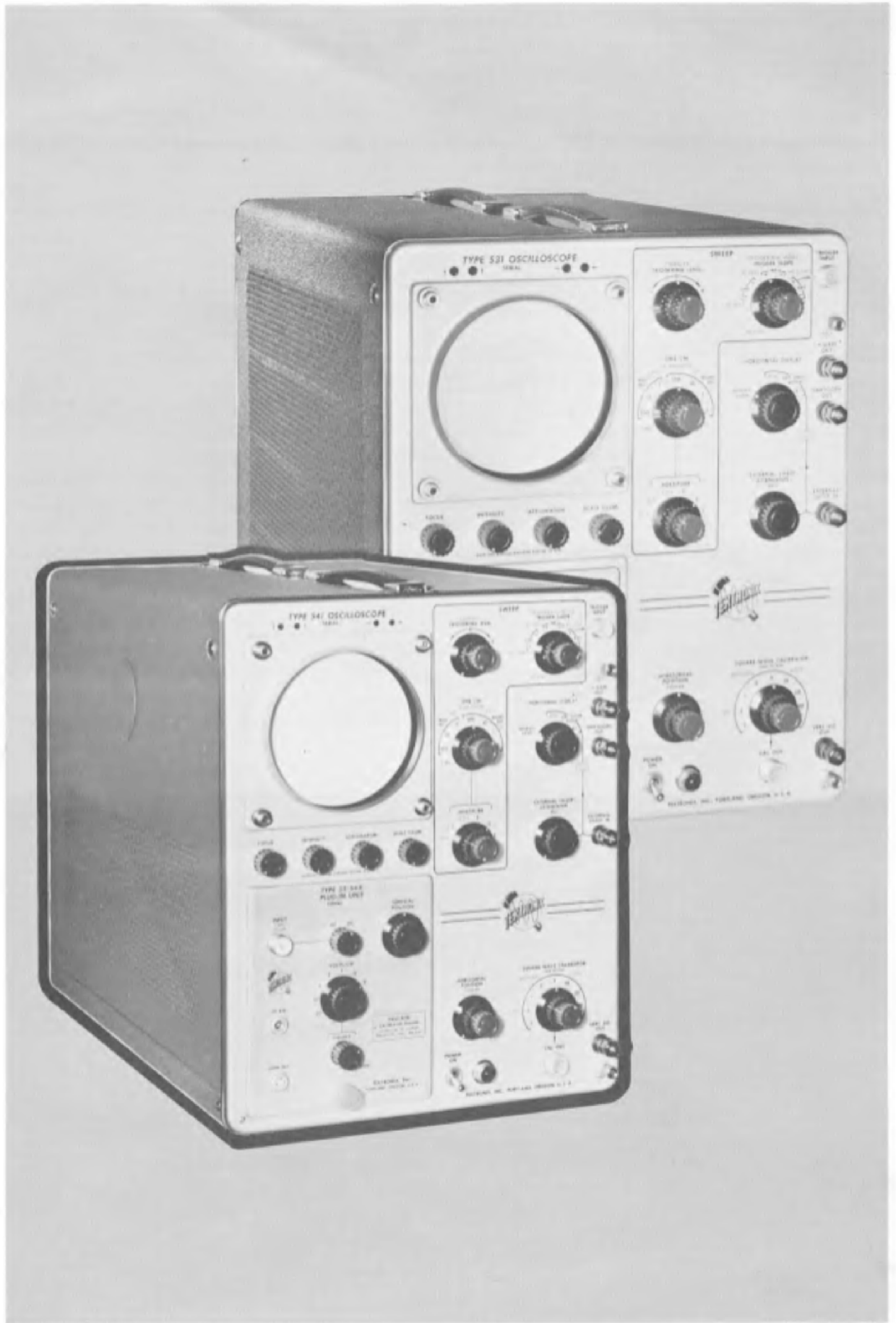
However, because many instruments have been modified in the field and out of serial sequence, component values and circuitry of a given instrument may differ considerably from those indicated in this manual for its serial number. The user is urged, therefore, to enter whatever changes may be necessary to bring this manual into agreement with the present circuitry of his oscilloscope.

When ordering parts, always include the following information:

1. Instrument Type (531/541).
2. Instrument Serial Number (as, S/N 9999).
3. Part Circuit Number (as, R999).
4. Part Description (value, type, rating, tolerance, etc.).
5. The 6-digit TEKTRONIX part number (as, 999-999).

SAFETY NOTICE

This oscilloscope employs dangerously high voltages. Since some maintenance must of necessity be performed with the case removed, great care should be taken. Use only insulated tools, stand on a dry floor and if possible keep one hand in your pocket. Care should also be used in making any connections to the deflection plates of the cathode-ray tube through the access panel. It is advised that the access panel never be removed until the power has first been turned off. The instrument should not be operated with this protective cover removed.



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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 Unblinking

The unblinking square wave is dc-coupled to the grid of the cathode-ray tube to assure uniform unblinking 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 2

OPERATING INSTRUCTIONS

PRELIMINARY INSTRUCTIONS

Cooling

The Oscilloscope is cooled by filtered, forced-air ventilation. The instrument must therefore be placed so the air intake is not blocked, and the filter must be clean enough to permit adequate air circulation. If the interior temperature does rise too high for some reason, a thermal cutout switch will disconnect the power and keep it disconnected until the temperature drops to a safe value.

Time-Delay DC Power Relay

A time-delay relay delays application of the rectified dc to the circuits long enough for all heaters to reach operating temperature. The time delay is approximately 25 seconds. If you switch the ac power off, even briefly, the time-delay relay will delay reapplication of the dc.

Cathode-Ray Tube Controls

The Tektronix cathode-ray tube in this instrument has a total accelerating voltage of 10,000 volts. The spot intensity with this amount of acceleration can be bright enough to damage the screen in a short time if the spot is left in one place. Be careful not to leave a fixed bright spot or slow sweep on the screen. Turn the INTENSITY control counterclockwise so that

the spot is dim whenever you leave the instrument unattended.

The separate FOCUS, ASTIGMATISM and INTENSITY controls are somewhat interdependent, and may require readjustment for different INTENSITY control settings.

Illuminated Graticule

The adjustable graticule lighting control labeled SCALE ILLUM., can be adjusted to suit the lighting conditions of the room. The colored filter supplied is colored to provide the maximum trace contrast for the P2 phosphor in the presence of room light.

The graticule is accurately scribed in centimeters and fifths of centimeters. These scale markings and the calibrated fixed vertical-deflection sensitivities and sweep times, can be used to convert deflections in centimeters into volts and seconds. Vertical sensitivities are calibrated in volts per centimeter, and horizontal sweep-times are calibrated in seconds per centimeter, which, if multiplied by centimeters of deflection, give volts and seconds.

The graticule can be mounted in either of two positions rotated 180 degrees from each other. In one position, the graticule illumination is colored red, and in the other position in white. The white will reproduce well photographically.

FIRST-TIME OPERATION

First get a trace on the screen by the simplest method, and then proceed with the presentation you want after you get an idea of the functions of the controls. To get a simple trace on the screen, insert a preamplifier, and proceed as follows:

Turn the POWER switch to OFF. Connect the power cord to a source of 117-volt, 60-cycle power. Then set the front-panel controls as follows:

INTENSITY
Counterclockwise (CCW)

FOCUS
Center

ASTIGMATISM
Center

POWER
ON

TRIGGERING LEVEL
CCW

STABILITY (red knob)
PRESET or CCW

TRIGGER SLOPE
+ INT



TRIGGERING MODE (red)	AUTOMATIC or AC AUTO	Connect a lead between the CAL. OUT terminal and the INPUT terminal of the unit. Set the controls of the plug-in as follows:
TIME/CM	100 MICRO SEC	AC--DC AC
MULTIPLIER	2	VOLTS/CM 2
HORIZONTAL DISPLAY	INTERNAL SWEEP	VARIABLE Clockwise
HORIZONTAL POSITION	Center	VERTICAL POSITION Center
SQUARE-WAVE CALIBRATOR	5	
VOLTS, MILLIVOLTS, OFF VOLTS		

When the POWER switch has been turned on for about one minute, turn the INTENSITY control clockwise until you can see a trace on the screen. With the calibrator waveform displayed, you can set the FOCUS, INTENSITY, and ASTIGMATISM controls for a sharp line, and position the trace near the screen center with the HORIZONTAL POSITION and VERTICAL POSITION controls.

TRIGGERING MODES

Automatic

You are now displaying the calibrator waveform, whose repetition rate is about one kilocycle, and whose amplitude is five volts, peak-to-peak, with the AUTOMATIC mode of triggering. This is about the simplest mode of triggering. It is useful for general purpose viewing, and will operate satisfactorily for a wide variety of trigger signals whose repetition rates are between sixty cycles and about two megacycles.

AC Slow

When you have a good, well-focused trace of the calibrating waveform by the AUTOMATIC mode of triggering, try the other four TRIGGERING MODE switch positions. Turn the switch to the AC SLOW position. Advance the TRIGGERING LEVEL control clockwise until you get a stable trace again. There may be a considerable range of the LEVEL control over which you can get a stable trace, and the start of the trace will move up and down the edge of the square wave within this range. Notice that the trace starts on the upgoing part of the calibrator square wave.

Now turn the TRIGGER SLOPE switch to the -INT position, and readjust the TRIGGERING LEVEL to obtain a stable trace again. Notice now that the trace starts on the down-going portion of the trace and that the position of the

start can again be changed somewhat with the LEVEL control.

DC Triggering

Now turn the TRIGGERING MODE switch to DC. Adjust the LEVEL control for stable triggering, and then position the trace with the VERTICAL positioning control. You will notice that triggering occurs at a vertical level on the screen selected by the LEVEL control and that the triggering point changes relative to the waveform as the waveform is positioned vertically. This effect will be more noticeable if you look at a low-frequency sine wave.

This triggering position is most useful for low-frequency signals. It is not suitable for applications where the dc level is changing such as when a Dual-Trace Unit is being used.

AC Fast

In the AC FAST position of the TRIGGERING MODE switch, the circuit is quite similar to that in the AC SLOW position, and you will notice no difference when displaying the calibrator waveform. The only difference is that an rc filter is inserted in the circuit, making it insensitive to low frequencies, and allowing it to recover quickly from dc level changes. This is the position to use when there is hum present. This is also the best position to use with the



alternate sweep feature of the 53/54C unit if you use INTERNAL triggering with signals having frequency components above 10 kc.

HF Sync

The HF SYNC position of the TRIGGERING

MODE switch is primarily for signals having a repetition rate in excess of ten megacycles. In this position the sweep will trigger poorly, if at all, on the calibrator waveform. To trigger on a high-frequency signal, simply advance the STABILITY control until a stable trace is obtained. The LEVEL control is not used in this position.

TRIGGERING INSTRUCTIONS

Triggering Level

The TRIGGERING LEVEL control selects the point on the triggering waveform at which triggering will occur. To trigger on small signals this control must be set near 0, or near the dc level with dc triggering. The levels are indicated on the panel as positive to the right and negative to the left. Negative positions of the LEVEL control cause triggering to occur during negative levels of the triggering waveform and positive positions cause triggering during positive levels. This control is not used in the AUTOMATIC and HF SYNC positions of the TRIGGERING MODE switch.

Trigger Slope

The + positions of the TRIGGER SLOPE switch (black knob) cause triggering to occur during the rising portion of the triggering waveform. The level may be either negative or positive. The - positions cause triggering to occur during the falling portion of the waveform. Thus for slow rising waveforms such as sine waves, the triggering point can be caused to occur at almost any point in the waveform.

An additional function of the TRIGGER SLOPE switch selects the source of trigger signals. For each of the available signal sources, the switch provides a choice of positive or negative slope.

Triggering Mode

The TRIGGERING MODE switch arranges the circuits to provide the kind of triggering you need. This is the red knob and the positions it selects are labeled in red on the panel.

Slowly changing waveforms work best on the AC SLOW and DC positions. In the AC SLOW position a capacitor removes the dc component of the triggering waveform and makes triggering on the vertical signal independent of trace posi-

tion. This position is suitable for signals from twenty cycles up to about five or ten megacycles. The DC position is the same except that it responds to dc as well. In the AC FAST position, the circuit includes an rc filter, useful for preventing 60-cycle, or other low-frequency components, from triggering the sweep when both high- and low-frequency components are present in the triggering waveform. The low-frequency limit is about two kilocycles. In these three positions, if the STABILITY control is properly set, the sweep will not run unless triggered by a signal.

The AUTOMATIC and HF SYNC switch positions both arrange synchronizing circuits rather than strictly triggering circuits. The AUTOMATIC circuit provides a free-running multivibrator with a normal repetition rate of about 50 cycles, which locks in and runs synchronously with recurrent triggering waveforms from 60 cycles to about 2 megacycles. The synchronized multivibrator then triggers the sweep-gating multivibrator.

The HF SYNC switch setting arranges a circuit which connects the triggering source directly to the sweep-gating multivibrator so that it can synchronize with the triggering waveform. The sweep-gating multivibrator must be free-running for this type of operation. It free-runs at advanced settings of the STABILITY control. It will synchronize with signals whose frequencies are as high as 30 megacycles, at a sweep-repetition rate up to 200 kilocycles.

Stability

The STABILITY control adjusts bias level on the sweep-gating multivibrator near the level at which it will free-run. Three principal settings of the STABILITY control are used; the first setting is with the control advanced to the right, just past the point where the sweep-gating multivibrator free-runs; second, retarded to the left



about 5 or 10 degrees from the point where free-running ceases; and third, retarded all the way left, to make the multivibrator inoperative.

For synchronized operation of the sweep-gating multivibrator, as used in the HF SYNC position, set the STABILITY control to the advanced position so that the sweep just free-runs, and keep it to the right of this point while adjusting

its position to synchronize the sweep.

For all triggered modes of operation, except AUTOMATIC, the STABILITY control should be retarded 5 to 10 degrees to the left of the free-run point. In the AUTOMATIC mode and when the STABILITY control is turned to the PRESET position, the STABILITY control is replaced by an internal control which has been preset to give reliable triggering for most applications.

SWEEP OPERATION

Time/Cm and Multiplier

These controls determine the speed of the horizontal trace. The time per centimeter of horizontal deflection is equal to the product of the MULTIPLIER setting and the TIME/CM setting. Times per centimeter from .1 microsecond to 1 second in steps of 10 can be selected with the TIME/CM switch, and accurate, fixed multipliers of 1, 2, and 5 times can be selected with the MULTIPLIER switch. The sweep times so selected can be depended on within three per cent of their indicated value. The variable sweep time positions can be checked at the limits of the 2.5-to-1 times, and 5-to-2 times positions against the accurate fixed multipliers to improve their accuracy.

Magnifier

This control inserts or removes a feedback network in the sweep amplifier that changes the gain five times. The linearity of the amplifier is somewhat better when the feedback circuit is included. The center one fifth of the trace is extended to fill the graticule when the magnifier is switched on. When you use the sweep magnifier to realize the fastest sweep time, .02 microseconds per centimeter, the linearity is reduced from three per cent to about five per cent. With a constant repetition rate of triggering you will need to increase the INTENSITY control settings as you decrease the TIME/CM control settings because of the reduced duty cycle.

External Sweep

In the X10 and X1 positions of the HORIZONTAL DISPLAY switch, the EXTERNAL SWEEP IN binding post is connected to the horizontal amplifier. In both of these positions you must switch the 5X MAGNIFIER switch to ON to keep the input amplifier within its linear range. It will be necessary to advance the INTENSITY control because the unblanking pulse is not present if the sweep is not running.

The variable EXTERNAL SWEEP ATTENUATOR, 10-1 can be used in conjunction with the X10 and X1 positions of the HORIZONTAL DISPLAY switch to obtain continuous coverage of the 100-1 attenuation range. Because the amplifier is dc-coupled, a large dc component in the signal being viewed may position the trace off the screen and make it impossible to center the display with the HORIZONTAL POSITION control.

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.

calibrator is within 3 per cent of the indicated voltage. However, since the output impedance at the CAL. OUT terminal varies with the setting

AUXILIARY FUNCTIONS

Square-Wave Calibrator

Accuracy of the open-circuit voltage of the



of the voltage-selector switch, you must be careful that the load impedance you connect it to does not change the output voltage. The output impedance varies between about 100 ohms over the millivolt range to about 500 ohms at the 50-volt tap. Except at the 100-volt tap, the output voltage depends on the division ratio of a voltage divider. Any appreciable change in impedance of the shunt leg of the divider will therefore reduce the output approximately in proportion to the reduction of impedance. The 1-megohm input impedance of the oscilloscope will cause no appreciable change in voltage at any setting of the selector switch. At the 100-volt tap, the out impedance is that of the cathode follower, about 250 ohms.

The rising portion of the calibrator waveform follows an rc curve with a time constant such that it requires about 1 microsecond to reach 90 per cent of peak. Millivolt settings provide a slightly better risetime of about 0.7 microseconds, and the worst case is the 50-volt setting with about 1.5 microseconds to the 90 per cent point. Reactive loads will affect these times.

The frequency of the calibrator multivibrator is nominally 1000 cycles, but may vary 30 per cent either way. Do not use it for more than a rough check of sweep-timing accuracy.

Trace-Brightness Modulation

To couple time markers into the cathode circuit for brightness modulation, disconnect the ground strap at the rear of the instrument and connect the source of modulating voltage to the CRT CATHODE post. A peak-to-peak voltage of about 50 volts is required to turn the beam on and off. Input impedance is 8 k to 15 k, depending on the INTENSITY control setting. The circuit is ac-coupled through a high-voltage capacitor, discharge time constant about 15 milliseconds.

Direct Connection to Deflection Plates

A plastic plate and mounting bracket are

available from the factory for making direct connections to the crt vertical-deflection plates. The mounting bracket is designed to clamp around the neck of the crt shield, adjacent to the deflection-plate connections. When mounted correctly, the plate will be accessible through the crt deflection-plate access hole in the left side-panel. The bracket and plate may be ordered with or without the necessary parts for vertical-positioning voltages. Specify part number 013-008 for the unwired unit, or part number 013-007 for the wired unit. Holes can be drilled in the plastic plate for mounting coaxial or other connectors. The two pins on the left-hand side of the crt neck are the vertical-deflection plates.

To avoid distortion, the average dc potential on the vertical-deflection plates should be 300 volts. If you use a different voltage, the distortion can be minimized by adjusting the GEOM. ADJ. control at the rear of the sweep chassis.

Unless dc coupling is required, connect coupling capacitors in series with the leads to the deflection plates and connect one-megohm resistors from the deflection plates to the leads from the vertical amplifier. With this connection the plates are maintained at the proper operating potential, and positioning control is retained for the front-panel VERTICAL POSITION control.

Vertical Signal Out

The signal applied to the vertical amplifier is available at the front-panel VERT. SIG. OUT binding post. A signal which will cause one centimeter of deflection will produce a signal of about two volts, peak-to-peak, at the binding post. The signal is applied to the binding post at a relatively low impedance from a cathode follower. The passband is dependent on the external load. With a one megohm resistor shunted by a 50 μ uf capacitor as a load, it extends from about 20 cycles to 4.5 megacycles at the 3 db points. Without the capacitive load the high-frequency 3-db point is extended to about 6 megacycles.

SIMPLIFIED SWEEP DIAGRAMS

The trigger signal is normally coupled to the multivibrator by way of the trigger amplifier. The trigger signal trips the multivibrator, which sends a negative gate through the disconnect diodes to two points on the sweep generator.

The sweep generator makes a positive-going sawtooth that is amplified and used to sweep the beam across the cathode-ray tube.

The speed of the sawtooth depends on the



capacitance of the timing capacitor and the resistance of the charging resistor. The height of the sawtooth depends on the setting of the sweep length adjustment. A portion of the sawtooth voltage is coupled back to the multivibrator control grid via the sweep-length and holdoff tubes, where it reverts the multivibrator and turns the sawtooth generator off.

Quiescent bias on the multivibrator is determined by the dc level of the stability cathode follower, which depends on the STABILITY control setting. The purpose of this control is to set the multivibrator bias near enough to triggering that the input trigger will trigger it. If the bias is lowered still further, the multivibrator

will trigger itself again as soon as it is reverted, and will run recurrently.

Although the STABILITY control is mounted concentrically with the TRIGGERING LEVEL control, it works only on the sweep generator, and is not involved in the triggering circuits. The purpose of the STABILITY control is to place the grid of the normally-conducting left-hand multivibrator near enough to cutoff that the negative trigger signal from the regenerative trigger shaper can drive the tube to cutoff. The control therefore requires only one adjustment to make the multivibrator responsive to that size of trigger. The multivibrator turns the sweep generator on when it is triggered.



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-hold-off 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 fol-

lower 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 trans-

former 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.



SECTION 4 MAINTENANCE

GENERAL INFORMATION

Replacement of Components

Tektronix will supply replacement components at current net prices. However, since most of the components are standard electronic and radio parts we suggest you get them from your local dealer if you can. Be sure to consult your instruction manual first to see what tolerances are required.

We specially select some of the components, whose values must fall within prescribed limits, by sorting through our regular stocks. The components so selected will have standard RETMA color-code marks showing the values and tolerances of the stock they were selected from, but they will not in general be replaceable from dealers stocks.

Such selected parts, as well as the parts we manufacture at Tektronix, are identified in the parts lists either by notes or by our own stock numbers. Order these parts from the Tektronix factory in Portland, Oregon.

Parts-Ordering Information

You will find a serial number on the frontispiece of this manual. This is the serial number of the instrument the manual was prepared for. Be sure the manual number matches the number of the instrument when you order parts.

A Tektronix instruction manual usually contains hand-made changes to diagrams and parts lists, and sometimes text. These changes are in general only appropriate to the instrument the manual was prepared for, the instrument whose serial number appears on the manual frontispiece. The hand-made changes show changes to the instrument that have been made after the printing of the manual.

We make some of the instrument changes during the factory test procedure. Our technicians hand-tailor the circuits, if it seems appropriate, to provide the widest possible latitude of operation. Other changes are made to include the latest circuit improvements as they are developed in our engineering department, or when

improved components become available. In any event, the changes are to your benefit. We have tried to give you the best instrument we can.

Soldering Precaution

The solder used on the ceramic terminals in this instrument must contain a small percentage of silver. If for any reason you resolder, be sure the solder you use contains silver. Silver-bearing solder is used in printed-circuit techniques, and is therefore available from all solder manufacturers. Repeated use of ordinary tin-lead solder will dissolve the fused bond of silver that makes the solder adhere to the porcelain, especially if the soldering iron is quite hot.

Color Coding

We use color-coded wires in this instrument to help you identify the various circuits. The ac power leads are yellow and coded 1-1-0 (brown-brown-brown) following the RETMA resistor color code. The +350-volt bus is white and coded 3-5-0 (orange-green-brown, beginning with the widest stripe). The -150-volt bus is black and coded 1-5-0. The heater leads are coded 6-1, 6-2, etc., not to indicate that the voltages are different but to differentiate between the leads. All signal leads have a single stripe. A few wire colors are indicated by small, lower-case letters on the diagrams.

Air Filter

The Oscilloscope is cooled by filtered, forced air. If the filter gets too dirty it will restrict the flow of cooling air and may cause the instrument to overheat. The filter should be inspected every three or four months and cleaned or replaced if necessary.

Two types of air filters can be used with your Tektronix equipment. A washable air filter constructed of aluminum wool coated with an adhesive is usually supplied with your instrument. A disposable glass-wool filter is available through your local Tektronix field office or direct from the factory. If you are replacing an aluminum-type filter with the disposable glass-wool type, it is best to order No. 387-009, which includes two back-up screens that help to prevent



damage to the filter. For future replacements of the glass-wool only, order No. 378-012.

To clean the aluminum filter, run hot water through it from the side that was inside, or slosh it around in hot soapy water and rinse it in clean water. Then dry it thoroughly and coat it with new adhesive. When new, the filter is coated with "Filter Coat", a product of the Research Products Corporation. Pint cans are

available under the name "Handi-Koter" from some air-conditioner suppliers. Other adhesive materials are no doubt satisfactory.

Fan Motor

The fan motor bearings will require oiling every few months or every thousand hours of operation. Use a good grade of light machine oil, and apply only a drop or two.

TROUBLE SHOOTING

If the instrument fails to operate at all, including the fan and the pilot light, check the source of power and determine that the power-cord plug is firmly in place. Then check the fuse at the back of the instrument near the power receptacle. If the instrument has been operating but has just stopped, it may have overheated and tripped the thermal cutout. The thermal cutout will reset itself when the instrument cools down enough. Possible causes of overheating are fan stoppage, restriction of air circulation or high room temperature. Be sure the air filter is clean.

If the fan and pilot light operate but there is no spot visible, there is a possibility that the spot is positioned off the screen for some reason. Check whether the beam-position-indicator lights are operating and if the positioning controls produce any effect. Advance the INTENSITY control and see if there is some unfocused glow on the screen to indicate the presence of beam current. If there is an indication that there is a beam positioned off the screen, look for a dc component in one of the input signals.

This is a complex electronic instrument. There is no simple way of locating troubles. An understanding of the functions of the circuits is the best help. With an understanding of the circuits, you will be able to make a good guess at the general source of troubles from their symptoms. Be doubly sure that the difficulty you are having is not caused by some misadjustment of the front-panel controls. If not, you will need to take the panels off for further checks.

Each side panel and the bottom panel are individually removable when service becomes necessary. To remove a side panel, release the fasteners near the front and back and swing the top of the panel out until the bottom hinge releases. To remove the bottom panel release the four fasteners and lift the panel off.

To replace the panels, reverse the process above. Each fastener is designed so that the first one-quarter turn engages an ear on the fastener with the oscilloscope frame. Further turning of the screw locks the ear in place.

Warning: When you have the panels off the instrument, be careful of high voltages. The lower-voltage buses are potentially more dangerous than the crt accelerating voltage because of the higher current capabilities and rather large filter capacitors in these supplies. When you reach into the instrument while it is turned on, do not hold the metal frame with the other hand. If possible stand on an insulating floor and use insulated tools.

Troubles are usually caused by tube failure, and you can frequently correct them by finding the bad tube and replacing it with a good one. However, sometimes a tube burns up resistors or overstresses capacitors when it fails, and in these cases you will also have to find the bad components. Sometimes you can find them by visual inspection. One way to find bad tubes is to try replacing suspected tubes with good ones. If possible, replace all suspected tubes at one time, and if the trouble is helped, return the old ones, one at a time, until the offending one is discovered.

Tube failure will often show up in the voltage readings of the power supply. So another early step to take when you look for troubles is to check voltages and currents from the regulated power supplies. The voltages can be checked from the top or right side of the instrument on a ceramic terminal strip near the rear of the instrument. The voltages are marked on the chassis. The -150-volt terminal should read within one per cent of 150 volts. The remainder of the voltages should be within about five per cent of their indicated voltages. Keep in mind that these are quite close tolerances, especially



the 150-volt tolerance. Very few portable voltmeters have comparable accuracy, so be sure that any small discrepancy you may find is not due to voltmeter error.

All four positive voltage supplies refer to -150 volts for their control. If this voltage is off, all other voltages will also be off. Be especially sure of your -150-volt measurement before you draw any conclusions from either voltage measurements. The -150-volt supply can be adjusted by means of a screwdriver control marked -150 ADJ. on the right near the bottom of the instrument. The remaining supplies cannot be adjusted, and any large discrepancy you find in them will probably be caused by tube deterioration, or by unusual loads in the rest of

the instrument.

Total current from each supply can be measured roughly by measuring the voltage drop across the protective resistors, R732, R740, R756, R780 and R790. Current indication is 200 ma per volt on R732 and R780; 100 ma per volt on all the others. The resistors are conveniently mounted on the under side of the instrument. R790 in the 500-volt supply is nearest the front panel, and the others follow in order of their voltage. These resistors are located on the unregulated side of the supplies, and their voltage-to-ground will depend on line voltage. Toward the back of the instrument from each resistor is a bare bus across the terminal strip. These have the regulated voltages on them.

RECALIBRATION PROCEDURE

Vertical Amplifier, Type 531

Before changing any adjustments in the vertical amplifier check whether the tubes have deteriorated. You can make a satisfactory check by determining the approximate gain of each stage and how nearly balanced the two halves of each push-pull stage are. First check the balance of each stage. This can be done by connecting together the plates of the two halves of each stage, or the cathodes for cathode followers, and finding how far the trace is deflected from its position with the deflection plates shorted together.

Check Balance

First, short the vertical-deflection plates together, and note where the trace lies. Then position the trace with the VERTICAL POSITION control to the same spot with the short removed, and short together pins 2 and 7 of V606, the output cathode followers in S/N101 through 7600, or pins 2 of V554 and V564, the output amplifiers in S/N7601 and up. The spot should not move more than .75 cm.

Repeat the procedure with V570 and V580 in S/N101 through 7600, shorting pins 2 together. In S/N7601 and up, short together pins 2 of V533A and V543A. In either case, replace or interchange the tubes if there is more than two centimeters unbalance. In S/N101 through 7600, repeat with V508 and V509, connecting together pins 2. In S/N7601 and up, short together pins 2 of V504 and V524. Replace tubes if unbalance is more than 3 cm.

CHECK GAIN

First check the high voltage at the left end of the ceramic terminal near the crt socket. Adjust to -1350 volts if necessary with the H.V. ADJ control at the right side of the instrument near the rear.

Connect a EP53A Gain Set Adapter between the output of the plug-in and the plug-in connector. Connect .2 millivolts from the square-wave calibrator to the gain set adapter and adjust the GAIN ADJ. control in the center of the vertical amplifier chassis for 2 cm deflection. Remove the Gain Set Adapter after adjusting the vertical amplifier gain.

DC Shift Compensation

In Type 531, S/N101 through 7600, set the sweep speed at a slow speed, say 1 millisecond per centimeter and set the vertical sensitivity to .5 VOLTS/CM DC. Connect the negative terminal of a 1-1/2 volt or 2-volt battery to the oscilloscope ground and touch a lead from the positive terminal to the vertical input. Look for an overshoot or rounding at the start of the step of voltage with a time constant in the neighborhood of 1 or 2 seconds. If necessary, adjust R596, labeled DC SHIFT COMP, accessible from the left of the instrument near the center of the left side so the spot comes immediately to the final level without overshooting.

The DC SHIFT COMP adjustment is not found in instruments above S/N7600, since compensation is accomplished by fixed circuit components.



In instruments S/N101 through 7600, high-frequency compensation is adjustable by means of inductors L570 and L580 in the plate loads of V570 and V580. In instruments S/N7601 and up, high-frequency compensation adjustment is by means of inductors L506 and L523 in the plate loads of V504 and V524, and by means of inductors L553 and L563 in the plate loads of V554 and V564. Other peaking inductors in the circuit have fixed values that produce a response characteristic that can be accurately compensated by the four variable inductors to take care of variations in vacuum tubes.

The adjustment of these inductors can best be made with square waves whose risetime is faster than the response time of the Type 531 which is about .035 microseconds with the Type 53/54A Preamp in place. The Type 104 or Type 105 is used in factory alignment. The waveform of the built-in calibrator of the oscilloscope has fast enough rise for some adjustments but not for high-frequency compensation.

Insert a wide-band plug-in preamplifier, for example the Type 53/54A. Connect the Tektronix Type 105 Square-Wave Generator to either one of the 53/54A inputs and set the frequency to 400 kc. Set the 53/54A to .05 VOLTS/CM and the TIME/CM switch of the oscilloscope to 1 MICROSEC/CM. Obtain a stable, triggered trace of the square wave.

Examine the square wave display on the crt. If one portion seems to be worse than the remainder examine the coils in the vertical amplifier visually. If one coil is set to a physical position quite different than the other coil try changing its position while watching the square wave display.

The delay-line affects only the first half microsecond of the square wave. If the first part of the square wave shows slight wrinkles try touching the metal blade of the alignment tool to various trimmers until the trimmer which affects the wrinkle is seen. Only a slight adjustment of the trimmer should be necessary to remove the wrinkle. If more than one bump is seen in the first part of the square wave adjust the trimmers in turn, taking care to make only a slight readjustment each time, until the wrinkles are reduced. The trimmers are all more or less interacting so that the technique of adjustment requires considerable practice.

When the slight wrinkles have been removed

from the delay-line you may find that the leading edge of the square wave has a slightly rounded appearance. Adjustment of the compensating coils in the vertical amplifier should prove helpful in correcting this. When the front corner of the waveform is correct you may find that the two compensating coils in the plate circuit of the output amplifiers are set to physically different positions.

The coils at the termination of the delay-line, next to the crt, affect the termination of the line. The action of these coils will appear half-way across the top of the square wave. Normally, a slight termination bump will be evident at this point. The two coils at the termination of the line should be adjusted to bring this bump to a minimum.

In general, if you seriously suspect delay-line trouble we recommend that you get in touch with your nearest representative, or the factory at Portland, Oregon for more detailed instruction, or help.

Vertical-Amplifier Adjustments Type 541

1. Gain Adjustment

The main unit sensitivity is standardized at 0.1 volt per centimeter so that the calibrated gain controls of all plug-in units will be correct. Since this sensitivity is affected by the crt accelerating voltage, first check the voltage at the left end of the ceramic terminal strip near the crt socket. Adjust to -1350 volts if necessary with the H.V. ADJ. control at the right side of the instrument near the rear.

Now connect a voltmeter between pins 1 and 3 on the interconnecting plug. Position the trace two centimeters above and below center with the VERTICAL POSITION control and adjust the main amplifier GAIN ADJ. control, R1027, until there is a total voltage change of .4 volts.

As an alternate method a plug-in unit can be used that is known to have the correct gain. Apply a signal from the oscilloscope square-wave calibrator and adjust the main amplifier GAIN ADJ. control to obtain the correct sensitivity.

2. DC Shift Compensation

The DC SHIFT COMP. control compensates



for a relatively slow drift in the vertical amplifier when a dc voltage is applied. To make this adjustment, free run the sweep at about 2 seconds per centimeter. Intermittently apply the probe to the +100 bus, or other regulated dc supply, and set the vertical sensitivity to obtain about 3 cm deflection. Look for an overshoot or rounding at the start of the step with a time constant of one or two seconds. If necessary, adjust the DC SHIFT COMP. control until the spot comes immediately to the final level without overshooting.

3. Distributed Amplifier and Delay Line

The adjustments of the trimmers in the distributed amplifier and delay line should be quite stable. Minor adjustments may be required as tubes are changed, however.

These adjustments are best made with a pulser which has a risetime of 5 millimicroseconds or better and is free of overshoot. The Tektronix Type 105 Square-Wave Generator can be used but care must be exercised to avoid overcompensation because of its slower risetime.

Connect the pulser to the INPUT connector of the 53/54K unit and observe the pulse with about three centimeters deflection. Use a sweep speed of about .1 microsecond per centimeter to observe wrinkles, and about 1 microsecond per centimeter to observe the level or slope of the pulse. If there is considerable rounding of the leading edge or many wrinkles, be sure that the tubes are not at fault before making any adjustments.

The waveform, starting at the leading edge and extending for about .4 microseconds along the pulse, is affected by the trimmers beginning at the crt deflection plates and extending back through the termination network. The location of any trimmer causing a wrinkle can be determined by touching the tuning tool to the trimmers until the resulting wrinkle coincides with the wrinkle in question. It can then be removed by a slight adjustment of the trimmer. If several trimmers need adjustment, switch the sweep speed to 1 microsecond per centimeter periodically to check the level of the section being adjusted. The coils, L1254 and L1255 in S/N 101 through 6474, and L1354 and L1355 in S/N 6475 and up, affect only the leading edge of the pulse.

Crt-Tube Geometry Adjust

The second-anode voltage required for best linearity at the extremes of deflection may vary somewhat between tubes. Apply a 60-cycle sine wave to the vertical amplifier and free-run the sweep so there is a solid raster 10 cm wide and 6 cm high in Type 531, 4 cm high in Type 541, on the face of the CRT. Adjust R861, a screwdriver control labeled GEOM ADJ, so that the top, bottom and sides of the rectangular raster are as straight as possible.

Trigger-Circuit Adjustments

The screwdriver adjustable controls referred to in the following discussion are located at the top and to the front of the instrument and are accessible when the right side panel is removed.

1. Triggering Level Centering

This control sets the level of the trigger shaper stage so that no readjustment of the TRIGGERING LEVEL control is required as the TRIGGER SLOPE switch is changed from + to - slope.

- a. Set the TRIGGERING MODE switch to AC SLOW and the TRIGGER SLOPE switch to +INT.
- b. Display the calibrator waveform with 2 to 4 mm amplitude.
- c. Turn the TRIGGER SLOPE switch back and forth from +INT to -INT. Simultaneously adjust the TRIGGERING LEVEL CENTERING control and the TRIGGERING LEVEL control until no change of either control is required as the SLOPE switch is changed from +INT to -INT.

2. Internal Trigger DC Level

This control sets the triggering level in the DC position of the TRIGGERING MODE switch. It is set so the sweep will trigger near 0 on the TRIGGERING LEVEL control when the trace is centered vertically.

- a. Display the calibrator waveform with 1 cm amplitude and the trace centered.
- b. Turn the TRIGGERING MODE to DC.
- c. Turn the TRIGGERING LEVEL control to 0.



- d. Adjust the INT. TRIG. DC LEVEL ADJ. control so the sweep will trigger on either + or -INT without readjustment of the TRIGGERING LEVEL control.

3. Trigger Sensitivity

This control adjusts the sensitivity of the trigger shaper stage. If the sweep triggers erratically or on the wrong slope it may indicate that this adjustment is incorrect.

- a. Remove the vertical signal.
- b. Turn the TRIGGER SLOPE switch to +LINE.
- c. Set the sweep controls to 100 μ sec/cm and trigger from the line.
- d. Turn the TRIG. SENS. control clockwise until the trace brightens abruptly. This indicates that the trigger circuit is oscillating. Now back the control off about 4 or 5 degrees.

4. Preset Stability

This control sets the trigger shaper circuit to the optimum point for triggering in the AUTOMATIC mode and when the STABILITY control is turned to the PRESET position.

- a. Use no vertical INPUT signal.
- b. Set the TIME/CM switch to 100 MICRO-SEC and the TRIGGERING MODE switch to AUTOMATIC.
- c. Turn the PRESET STABILITY control R49 full right. Then back it off until the trace dims. Continue turning left until trace disappears.
- d. Adjust the PRESET STABILITY control to the center of the range between the points where the trace dims and where the trace disappears.

Sweep-Circuit Adjustments

The sweep circuits are quite stable and should not require frequent readjustments. The need for readjustment can be determined quickly by checking the time-base calibration with an accurate time-mark generator. Often only a single adjustment need be made.

We check our sweep timing with a Tektronix Type 180 or 181 Time-Mark Generator. However, you can use any other frequency generator accurate to one per cent or better. Because the small amount of non-linearity present in the sweep is concentrated in the first and last centimeters, we adjust the timing over the center 8 centimeters of the display. In this way the errors are minimized and the accuracy over the center portion can approach a value limited principally by the spot size.

The following procedure is based on that used in our test department. This sequence should be followed.

1. C240 Adjustment

This adjustment provides high-frequency compensation for a voltage divider in the sweep amplifier.

- a. Connect the calibrator signal to both the EXT. SWEEP INPUT and the TRIGGER INPUT.

Trigger Controls---AC SLOW, +EXT
VOLTS/CM--10
TIME/CM--500 MICROSEC/CM
HORIZONTAL DISPLAY--EXT. SWEEP
MAGNIFIER--ON

- c. Connect the SAWTOOTH OUT to the vertical input.
- d. Obtain a stable vertical sweep with the STABILITY and TRIGGERING LEVEL controls.
- e. Adjust C240, located on the top of the sweep chassis to the right of V240, for a square-topped signal with no overshoot.

2. Swp. Cal. Adjustment

The SWP. CAL. control adjusts the gain of the sweep amplifier to calibrate the low- and medium-speed sweeps.

- a. Set the TIME/CM controls at 1 MILLISEC/CM.
- b. Display 1-millisecond markers from a time-mark generator.
- c. Adjust the SWP CAL. control, located in the



top row of controls, so the markers correspond with the graticule.

3. Sweep Length Adjustment

The SWP. LENGTH control sets the sweep length so it fills the graticule without hitting the sides of the crt with attendant electron scattering.

- a. Free run the sweep.
- b. Set the SWP LENGTH control, located in the row of controls, so the sweep is about 10-1/2 centimeters long.

4. Mag. Gain Adjustment

The MAG. GAIN control adjusts the gain of the sweep amplifier when the MAGNIFIER is turned on.

- a. Set the TIME/CM controls at 1 MILLISEC/CM.
- b. Display 100-microsecond markers.
- c. Turn the MAGNIFIER switch to ON.
- d. Adjust the MAG. GAIN control, located in the row of controls, so every second marker corresponds with a graticule line.

5. Swp./Mag. Regis.

The SWP./MAG. REGIS. control adjusts the voltage on the feedback attenuator so the magnifier expands the trace both ways from the screen center.

- a. Back the STABILITY control off to stop the sweep.
- b. Turn up the INTENSITY control so the spot is visible.
- c. Turn the MAGNIFIER on and center the spot behind the center graticule line with the HORIZONTAL POSITION control.
- d. Turn the MAGNIFIER off and adjust the SWP./MAG. REGIS. control, located in the row of controls, so that the spot is still centered.

6. 10 Microsec/cm Adjustment

A trimmer across the timing capacitor adjusts the sweep speed in this range.

- a. Display 10-microsecond markers with the sweep set at 10-MICROSEC/CM.
- b. Adjust C99F, the trimmer nearest the panel on the right of the TIME/CM switch so the markers correspond with the graticule.

7. 1 Microsec/cm Adjustment

A trimmer across the timing capacitor adjusts the sweep speed in this range.

- a. Display 1-microsecond markers with the sweep set at 1 MICROSEC/CM.
- b. Adjust C99H, the trimmer toward the rear of the TIME/CM switch, so the markers correspond with the graticule.

8. .1 Microsec/cm Adjustment

A trimmer serves as an adjustable timing capacitor in this range.

- a. Display 1-microsecond markers with the sweep speed set at .5 MICROSEC/CM.
- b. Adjust C99J so the markers correspond with every other graticule line.

9. .1 Microsec/cm Linearity Adjustment

Two capacitors are adjusted for best linearity at this speed.

- a. Display 10-mc sine wave with the sweep set at .1 MICROSEC/CM.
- b. Adjust C254, located at the top rear of the sweep chassis, for correct timing of the last half of the sweep.
- c. Adjust C267, located between the last two controls at the left of the chassis for linearity and correct timing of the start of the trace.
- d. Repeat steps b. and c. until interaction is overcome.



10. .02 Microsec/cm Adjustment

This adjustment provides high-speed compensation for the sweep so that the sweep speed is correct when the trace is centered. For best results this adjustment requires the use of a Tektronix Type 180 Time-Mark Generator as described in the following procedure. However, an alternate procedure is also given requiring only an accurate frequency generator.

- a. Connect the 50-mc output of the Type 180 to the vertical input.
- b. Trigger the sweep externally with the 100 kc trigger from the Type 180.
- c. Set the sweep speed to .1 MICROSEC/CM.
- d. Obtain a stable display with the trace centered and turn the MAGNIFIER to ON.
- e. Preset C278 and C286 to minimum capacitance (lettering toward mounting holes).
- f. Without changing the horizontal positioning more than one centimeter, turn C278 and C286 in equal increments to increase the sweep speed until the waveform is aligned with the graticule.
- g. Recheck the .1 Microsec/cm Linearity Adjustment (Paragraph 9). There is some interaction between these two adjustments.

Alternate Procedure

- a. If you don't have a Type 180, connect a 10-mc sine wave from an accurate (at least 1%) frequency generator to the vertical input.
- b. Obtain a stable trace with full-screen vertical deflection.
- c. Set the sweep speed to .1 MICROSEC/CM and turn the MAGNIFIER to ON. Do not

change the horizontal position more than two centimeters.

- d. Starting with both capacitors, C278 and C286, at minimum capacitance, (lettering toward mounting holes) turn them in equal increments to increase the sweep speed until one cycle fills five centimeters. For best accuracy observe the waveform at the center line where the slope is the greatest. Recheck the .1 Microsec/cm Linearity Adjustment (Paragraph 9).

External Sweep DC Balance

Turn the HORIZONTAL DISPLAY switch to EXT. SWEEP ATTEN., X10 and turn the 5X MAGNIFIER to ON. Position the spot on the screen and turn the EXTERNAL SWEEP ATTENUATOR back and forth. If the spot moves horizontally as the EXTERNAL SWEEP ATTENUATOR control is turned, adjust the EXT. SWP. AMPL. DC BAL. control until the spot remains stationary. The EXT. SWP. AMPL. DC BAL. control is located at the top front of the instrument accessible from the top.

Calibrator Adjustment

When the CALIBRATOR switch is turned to OFF the calibrator cathode follower, V246A, remains conducting at the current required to develop 100 volts across the voltage divider. To check the calibrator, turn the instrument on its side, and measure the cathode voltage at V246 cathode. This voltage appears at the pin jack labeled CAL. TEST POINT on the side of the chassis to the rear of the CALIBRATOR switch. If necessary, adjust R679, a screwdriver control labeled CAL. ADJ., accessible at the underside of the bottom chassis near the CALIBRATOR switch, so the cathode voltage measures 100 volts. Be sure of the accuracy of your test meters. Test meters are likely to be less accurate than the calibrator, which should be within about one per cent at this point.



SECTION 5

PARTS LIST

BULBS

Ckt. No.	Instr.	S/N Range	S/N Range	Description	Part No.
NE95	531	101-5000	55 v	1/25 w	*150-009
	541	101-6841	55 v	1/25 w	*150-009
B95	531	5001 - up	50-75 v	1/25 w	150-002
	541	6842 - up	50-75 v	1/25 w	150-002
NE96	531	101-5000	65 v	1/25 w	*150-011
	541	101-6841	65 v	1/25 w	*150-011
B96	531	5001 - up	50-75 v	1/25 w	150-002
	541	6842 - up	50-75 v	1/25 w	150-002
NE287	531	101-6710	55-70 v	1/25 w	Use 150-002
	541	101-6841	55-70 v	1/25 w	Use 150-002
B 287	531	6711 - up	50-75 v	1/25 w	150-002
	541	6842 - up	50-75 v	1/25 w	150-002
NE292	531	101-8543	75 v	1/25 w	*150-014
	541	101-6474	75 v	1/25 w	*150-014
B 292	531	8544 - up	50-75 v	1/25 w	150-002
	541	6475 - up	50-75 v	1/25 w	150-002
NE293	531	101-8543	75 v	1/25 w	*150-014
	541	101-6474	75 v	1/25 w	*150-014
B 293	531	8544 - up	50-75 v	1/25 w	150-002
	541	6475 - up	50-75 v	1/25 w	150-002
B700	531 only		#47	Incandescent	150-001
B701	531 only		#47	Incandescent	150-001
B702	531 only		#47	Incandescent	150-001
B734	541 only		#47	Incandescent	150-001
B735	541 only		#47	Incandescent	150-001
B736	541 only		#47	Incandescent	150-001

CAPACITORS

C1	4.7 μ f	Cer.	Fixed 500 v	+ or - 1 μ f	281-501
C3	.001 μ f	PT	Fixed 600 v	20%	285-501



C4			100 μmf	Cer.	Fixed	350 v	20%	281-523
C7			.001 μf	Cer.	Fixed	500 v	GMV	283-000
C9			47 μmf	Cer.	Fixed	500 v	20%	281-518
C17			.001 μf	Cer.	Fixed	500 v	GMV	283-000
C20			.01 μf	PT	Fixed	400 v	20%	285-510
C22	531	X8544 - up	.01 μf	Cer.	Fixed	500 v	GMV	283-002
	RM31	X310 - up	.01 μf	Cer.	Fixed	500 v	GMV	283-002
	541	6502 - up	.01 μf	Cer.	Fixed	500 v	GMV	283-002
C28			.005 μf	Cer.	Fixed	500 v	GMV	283-001
C34			22 μmf	Cer.	Fixed	500 v	20%	281-510
C41			.001 μf	Cer.	Fixed	500 v	GMV	283-000
C54A			.22 μf	PT	Fixed	400 v	20%	285-533
C54B			.022 μf	PT	Fixed	400 v	20%	285-515
C54C			.0022 μf	PT	Fixed	400 v	20%	285-543
C54D			220 μmf	Mica	Fixed	500 v	10%	283-536
C56			39 μmf	Cer.	Fixed	500 v	10%	281-516
C58			27 μmf	Cer.	Fixed	500 v	10%	281-513
C65			12 μmf	Cer.	Fixed	500 v	10%	281-506
C71			82 μmf	Cer.	Fixed	500 v	10%	281-528
C72	531	X5115 - up	.005 μf	Cer.	Fixed	500 v	GMV	283-001
	541	X5063 - up	.005 μf	Cer.	Fixed	500 v	GMV	283-001
C73			12 μmf	Cer.	Fixed	500 v	10%	281-506
C76	531	X1020 - up	.005 μf	Cer.	Fixed	500 v	GMV	283-001
	541	101 - up	.005 μf	Cer.	Fixed	500 v	GMV	283-001
C78			.005 μf	Cer.	Fixed	500 v	GMV	283-001
C81			.001 μf	Cer.	Fixed	500 v	GMV	283-000
C95			.001 μf	Cer.	Fixed	500 v	GMV	283-000
C96	531	X220 - up	82 μmf	Cer.	Fixed	500 v	10%	281-528
	541	101 - up	82 μmf	Cer.	Fixed	500 v	10%	281-528



C99A	1.0 μ f)	Special Timing Series				
C99B	.1 μ f)	Manufactured by Tektronix.				*291-007
C99C	.01 μ f)	Order replacements from factory				

C99D .001 μ f

C99D, a timing capacitor can be ordered separately. When ordering, note the color band painted on the end of the capacitor. If the capacitor has a white color band, order 290-008A. If the capacitor has a black color band, order 291-008B.

C99E		82 μ f	Mica	Fixed	500 v	5%	283-534
C99F		4.5-25 μ f	Cer.	Var.	500 v	20%	281-010
C99G		82 μ f	Mica	Fixed	500 v	5%	283-534
C99H		4.5-25 μ f	Cer.	Var.	500 v	20%	281-010
C99J		3-12 μ f	Cer.	Var.	500 v	20%	281-007
C101		8-50 μ f	Cer.	Var.	500 v		281-022
C102		220 μ f	Mica	Fixed	500 v	5%	283-513
C240	531	101-8906	3-12 μ f	Cer.	Var.	500 v	281-007
		8907 - up	4.5-25 μ f	Cer.	Var.	500 v	281-010
	RM31	X352 - up	4.5-25 μ f	Cer.	Var.	500 v	281-010
	541	101-7636	3-12 μ f	Cer.	Var.	500 v	281-007
		7637 - up	4.5-25 μ f	Cer.	Var.	500 v	281-010
	RM41	101-177	3-12 μ f	Cer.	Var.	500 v	Use 281-010
		178 - up	4.5-25 μ f	Cer.	Var.	500 v	281-010
C241		4.7 μ f	Cer.	Fixed	500 v	+or-1 μ f	281-501
C245	531	X8544 - up	.68 μ f	Cer.	Fixed	500 v +or-20%	281-537
	RM31	X310 - up	.68 μ f	Cer.	Fixed	500 v +or-20%	281-537
	541	X7484 - up	.68 μ f	Cer.	Fixed	500 v +or-20%	281-537
	RM41	X168 - up	.68 μ f	Cer.	Fixed	500 v +or-20%	281-537
C249	531	101-8543X	.01 μ f	PTM	Fixed	400 v 20%	285-510
	541	101-7483X	.01 μ f	PTM	Fixed	400 v 20%	285-510
C254	531	101-141	1.5-7 μ f	Cer.	Var.	500 v	281-005
		142-306	.5-5 μ f	Tub.	Var.	500 v	281-002
		307 - up	3-12 μ f	Cer.	Var.	500 v +or-1/2 μ f	281-007
	541	101 - up	3-12 μ f	Cer.	Var.	500 v +or-1/2 μ f	281-007
C258	531	X307 - up	1.5 μ f	Cer.	Fixed	500 v +or-1/2 μ f	281-526
	541	X101 - up	1.5 μ f	Cer.	Fixed	500 v +or-1/2 μ f	281-526
C266	531 only	101-306X	47 μ f	Cer.	Fixed	500 v 20%	281-518
C267	531	101-306	8-50 μ f	Mica	Var.	500 v	281-022
		307 - up	9-180 μ f	Mica	Var.	500 v	281-023
	541	101 - up	9-180 μ f	Mica	Var.	500 v	281-023
C273			6.25 μ f	EMC	Fixed	300 v -20+50%	290-000



C278	531	X307 - up	3-12 $\mu\mu\text{f}$	Cer.	Var.	500 v		281-009
	541	101 - up	3-12 $\mu\mu\text{f}$	Cer.	Var.	500 v		281-009
C282			.047 μf	PT	Fixed	400 v	20%	285-519
C284			4.7 $\mu\mu\text{f}$	Cer.	Fixed	500 v	+ or -1 $\mu\mu\text{f}$	281-501
C286	531	X307 - up	3-12 $\mu\mu\text{f}$	Cer.	Var.	500 v		281-009
	541	101 - up	3-12 $\mu\mu\text{f}$	Cer.	Var.	500 v		281-009
C292	531	X8544 - up	.005 μf	Cer.	Fixed	500 v		283-001
	541	X7484 - up	.005 μf	Cer.	Fixed	500 v		283-001
	RM41	X168 - up	.005 μf	Cer.	Fixed	500 v		283-001
C603	531 only	X7601 - up	2x40 μf	EMC	Fixed	250 v		*290-040
C605A)	40 μf					
C605B	531 only	X7601 - up) 20 μf	EMC	Fixed	475 v		*290-063
C605C)	10 μf					
C650	531 only	X593-7600X	2x1000 μf	EMC	Fixed	150 v	-20+50%	*290-051
C672			330 $\mu\mu\text{f}$	Mica	Fixed	500 v	10%	283-518
C673			330 $\mu\mu\text{f}$	Mica	Fixed	500 v	10%	283-518
C682			27 $\mu\mu\text{f}$	Cer.	Fixed	500 v	20%	281-513
C695			.001 μf	Cer.	Fixed	500 v	GMV	283-000
C700			.02 μf	Cer.	Fixed	150 v	GMV	283-004
C707			.01 μf	PT	Fixed	400 v	20%	285-510
C711			.01 μf	PT	Fixed	400 v	20%	285-510
C715			2x40 μf	EMC	Fixed	250 v	-20+50%	*290-040
C717			.01 μf	PT	Fixed	400 v	20%	285-510
C720	531	X5377 - up	.01 μf	Cer.	Fixed	500 v	GMV	283-002
	541	X5213 - up	.01 μf	Cer.	Fixed	500 v	GMV	283-002
C732			125 μf	EMC	Fixed	350 v	-20+50%	*290-044
C740			150 μf	EMC	Fixed	250 v	-20+50%	*290-048
C741			150 μf	EMC	Fixed	250 v	-20+50%	*290-048
C750			.01 μf	PT	Fixed	400 v	20%	285-510
C751A,B,C			3x10 μf	EMC	Fixed	450 v	-20+50%	*290-033
C756			125 μf	EMC	Fixed	450 v	-20+50%	*290-045
C763			.01 μf	PT	Fixed	400 v	20%	285-510



C770			.01 μ f	PT	Fixed 400 v	20%	285-510
C780			125 μ f	EMC	Fixed 350 v	-20+ 50%	*290-044
C787			.01 μ f	PT	Fixed 400 v	20%	285-510
C790A,B			2x40 μ f	EMC	Fixed 450 v	-20+ 50%	*290-042
C797			.01 μ f	PT	Fixed 400 v	20%	285-510
C800			.047 μ f	PT	Fixed 400 v	20%	285-519
C803			.001 μ f	PT	Fixed 600 v	20%	285-501
C805			.01 μ f	PT	Fixed 400 v	20%	285-510
C806			.001 μ f	PT	Fixed 600 v	20%	285-501
C807			2x20 μ f	EMC	Fixed 450 v	-20+ 50%	*290-037
C814			.0068 μ f	PT	Fixed 3000 v	20%	285-508
C815			.01 μ f	Cer.	Fixed 500 v	GMV	283-002
C820			.0068 μ f	PT	Fixed 3000 v	20%	285-508
C821			.0068 μ f	PT	Fixed 5000 v	20%	285-509
C822			.00047 μ f	PT	Fixed 10000 v	20%	285-500
C823			.00047 μ f	PT	Fixed 10000 v	20%	285-500
C830			.0068 μ f	PT	Fixed 3000 v	20%	285-508
C832			.015 μ f	PT	Fixed 3000 v	20%	285-513
C834			.015 μ f	PT	Fixed 3000 v	20%	285-513
C841	531	X1020 - up	.005 μ f	Cer.	Fixed 500 v	GMV	283-001
	541	101 - up	.005 μ f	Cer.	Fixed 500 v	GMV	283-001
C855			.015 μ f	PT	Fixed 3000 v	20%	285-513
C857			.015 μ f	PT	Fixed 3000 v	20%	285-513

FUSES

F701			6 amp	3AG	Fast-Blo, 60 cycle, 117 v		159-013
			3 amp	3AG	Fast-Blo, 60 cycle, 234 v		159-015
			3 amp	3AG	Slo-Blo, 50 cycle, 234 v		159-005
			6.25 amp	3AG	Slo-Blo, 50 cycle, 117 v		159-011

INDUCTORS

L61			88 μ h	Fixed			*108-022
LR72			1 Mh, #40 wire, on 3.3 k, 1 w resistor				*108-058



RECTIFIERS

SR650	531 only	X593-7600X	4-500 ma plates per leg		*106-016
SR732			5-250 ma plates per leg		*106-012
SR740			5-500 ma plates per leg		*106-013
SR756	531	101-7600	4-250 ma plates per leg		*106-014
		7601 - up	4-500 ma plates per leg		*106-019
	541	101 - up	4-500 ma plates per leg		*106-019
SR780			4-250 ma plates per leg	Use	*106-014
SR790			5-125 ma plates per leg		*106-015

RELAYS

K700			45 sec., thermal time-delay		148-002
K701	531	101-1280	4P2T	6 volt (order Mod Kit, K531-1104)	*040-085
		1281 - up	4P2T	6 volt	148-004
	541	101 - up	4P2T	6 volt	148-004

RESISTORS

R1			1 meg	1/2 w	Fixed Comp.	5%	301-105
R2			390 k	1/2 w	Fixed Comp.	5%	301-394
R3			50 k	2 w	Var. Comp.	20%	311-023
R4			100 k	1/2 w	Fixed Comp.	10%	302-104
R5			1 meg	1/2 w	Fixed Comp.	10%	302-105
R6			100 k	1/2 w	Fixed Comp.	10%	302-104
R7			470 k	1/2 w	Fixed Comp.	10%	302-474
R8			47 Ω	1/2 w	Fixed Comp.	10%	302-470
R9			4.7 k	1 w	Fixed Comp.	10%	304-472
R10			4.7 k	1 w	Fixed Comp.	10%	304-472
R11			47 Ω	1/2 w	Fixed Comp.	10%	302-470
R12			33 k	2 w	Fixed Comp.	10%	306-333
R13			39 k	2 w	Fixed Comp.	10%	306-393



R14	531	101-6710	100 k	1/2 w	Var.	Comp.	20%	311-030*
		6711 - up	100 k	1/2 w	Var.	Comp.	20%	311-096**
	541	101-5942	100 k	1/2 w	Var.	Comp.	20%	311-030*
		5943 - up	100 k	1/2 w	Var.	Comp.	20%	311-096**
*Concentric with R43.								
**Furnished as a unit with R43 and SW43.								
R15			22 k	1/2 w	Fixed	Comp.	10%	302-223
R16			470 k	1/2 w	Fixed	Comp.	10%	302-474
R17			470 k	1/2 w	Fixed	Comp.	10%	302-474
R19			56 k	1/2 w	Fixed	Comp.	10%	302-563
R20			47 k	1/2 w	Fixed	Comp.	10%	302-473
R21			47 k	1/2 w	Fixed	Comp.	10%	302-473
R22			47 Ω	1/2 w	Fixed	Comp.	10%	302-470
R23	531	101-8543	1 k	1/2 w	Fixed	Comp.	10%	302-102
		8544 - up	680 Ω	1/2 w	Fixed	Comp.	10%	302-681
	RM31	101-167	1 k	1/2 w	Fixed	Comp.	10%	302-102
		168 - up	680 Ω	1/2 w	Fixed	Comp.	10%	302-681
	541	101-7483	1 k	1/2 w	Fixed	Comp.	10%	302-102
		7484 - up	680 Ω	1/2 w	Fixed	Comp.	10%	302-681
R24	531	101-8543	2.7 k	1/2 w	Fixed	Comp.	10%	302-272
		8544 - up	1.5 k	1/2 w	Fixed	Comp.	10%	302-152
	RM31	101-167	2.7 k	1/2 w	Fixed	Comp.	10%	302-272
		168 - up	1.5 k	1/2 w	Fixed	Comp.	10%	302-152
	541	101-7483	2.7 k	1/2 w	Fixed	Comp.	10%	302-272
		7484 - up	1.5 k	1/2 w	Fixed	Comp.	10%	302-152
R27			22 k	2 w	Fixed	Comp.	10%	306-223
R28			500 Ω	2 w	Var.	Comp.	20%	311-005
R29			22 k	2 w	Fixed	Comp.	10%	306-223
R30			2.7 meg	1/2 w	Fixed	Comp.	10%	302-275
R32			1.5 k	1/2 w	Fixed	Comp.	10%	302-152
R33			47 Ω	1/2 w	Fixed	Comp.	10%	302-470
R34			100 k	1/2 w	Fixed	Comp.	10%	302-104
R35			100 k	1/2 w	Fixed	Comp.	10%	302-104
R36			100 k	2 w	Var.	Comp.	20%	311-026
R38	531	101-238	470 k	1/2 w	Fixed	Comp.		Use 301-474
		239 - up	470 k	1/2 w	Fixed	Comp.	5%	301-474
	541	101 - up	470 k	1/2 w	Fixed	Comp.	5%	301-474



R40			100 k	1/2 w	Fixed Comp.	5%	301-104
R41			200 k	1/2 w	Fixed Comp.	5%	301-204
R42			22 k	2 w	Fixed Comp.	10%	306-223
R43	531	101-6710 †	100 k	2 w	Var. Comp.	20%	311-030
		6711 - up ††	100 k	1/2 w	Var. Comp.	20%	311-096
	541	101-5942 †	100 k	2 w	Var. Comp.	20%	311-030
		5943 - up ††	100 k	1/2 w	Var. Comp.	20%	311-096
		†Concentric with R14.					
		††Concentric with R14 and SW43. Furnished as a unit.					
R46			100 Ω	1/2 w	Fixed Comp.	10%	302-101
R49	531	X6020 - up	100 k	2 w	Var. Comp.	20%	311-026
	541	X5415 - up	100 k	2 w	Var. Comp.	20%	311-026
R54			100 Ω	1/2 w	Fixed Comp.	10%	302-101
R55A			4.7 meg	1/2 w	Fixed Comp.	10%	302-475
R55B			470 k	1/2 w	Fixed Comp.	10%	302-474
R57			4.7 meg	1/2 w	Fixed Comp.	10%	302-475
R58			1 k	1/2 w	Fixed Comp.	10%	302-102
R59			47 Ω	1/2 w	Fixed Comp.	10%	302-470
R60			2.7 k	1 w	Fixed Comp.	Selected)	*312-569
R61			3.3 k	1 w	Fixed Comp.	Selected)	
		R60 and R61 are selected to total 6 k, +or-2 1/2%. Furnished as a unit.					
R62			56 k	1 w	Fixed Comp.	5%	303-563
R63			47 Ω	1/2 w	Fixed Comp.	10%	302-470
R65			39 k	1 w	Fixed Comp.	Selected)	312-570
R66			33 k	1 w	Fixed Comp.	Selected)	
		R65 and R66 selected with ratio 39/33, +or-2 1/2%. Furnished as a unit.					
R67			100 Ω	1/2 w	Fixed Comp.	10%	302-101
R68			8 k	5 w	Fixed WW	5%	308-053
R69			1 k	1/2 w	Fixed Comp.	10%	302-102
R70			47 k	1/2 w	Fixed Comp.	10%	302-473
R71			270 Ω	1/2 w	Fixed Comp.	10%	302-271



R72	531	101-5114	3.3 k	1 w	Fixed Comp.	10%	304-332
		5115 - up	47 Ω	1/2 w	Fixed Comp.	10%	302-470
	541	X5063 - up	47 Ω	1/2 w	Fixed Comp.	10%	302-470
R73			47 k	1/2 w	Fixed Comp.	10%	302-473
R74			100 k	1/2 w	Fixed Comp.	10%	302-104
R75			100 Ω	1/2 w	Fixed Comp.	10%	302-101
R76	531	X1020 - up	47 Ω	1/2 w	Fixed Comp.	10%	302-470
	541	101 - up	47 Ω	1/2 w	Fixed Comp.	10%	302-470
R77			4.7 k	1 w	Fixed Comp.	10%	304-472
R78	531	101-7747	47 k	1/2 w	Fixed Comp.		Use 301-363
		7748 - up	36 k	1/2 w	Fixed Comp.	5%	301-363
	RM31	101-121	47 k	1/2 w	Fixed Comp.		Use 301-363
		122 - up	36 k	1/2 w	Fixed Comp.	5%	301-363
	541	101-6591	47 k	1/2 w	Fixed Comp.		Use 301-363
		6592 - up	36 k	1/2 w	Fixed Comp.	5%	301-363
R79			1 meg	1/2 w	Fixed Comp.	10%	302-105
R80			10 k	1/2 w	Fixed Comp.	10%	302-103
R81			100 k	1/2 w	Fixed Comp.	10%	302-104
R82			1 meg	1/2 w	Fixed Comp.	10%	302-105
R83			1.8 meg	1/2 w	Fixed Comp.	10%	302-185
R84			100 k	1 w	Fixed Comp.	10%	304-104
R85			47 Ω	1/2 w	Fixed Comp.	10%	302-470
R86			470 Ω	1/2 w	Fixed Comp.	10%	302-471
R87			8 k	5 w	Fixed WW	5%	308-053
R88			2 k	2 w	Var. Comp.	20%	311-008
R89			4 k	5 w	Fixed WW	5%	308-051
R90			47 Ω	1/2 w	Fixed Comp.	10%	302-470
R91			22 k	2 w	Fixed Comp.	10%	306-223
R92			22 k	2 w	Fixed Comp.	10%	306-223
R93			22 k	2 w	Fixed Comp.	10%	306-223
R95			47 k	1/2 w	Fixed Comp.	10%	302-473
R96			1.5 meg	1/2 w	Fixed Comp.	10%	302-155



R97	531	101-2977X	100 Ω	1/2 w	Fixed	Comp.	10%	302-101
	541	101-649X	100 Ω	1/2 w	Fixed	Comp.	10%	302-101
R99A			30 meg	2 w	Fixed	Prec.	1%	310-505
R99B			10 meg	1 w	Fixed	Prec.	1%	310-107
R99C			10 meg	1 w	Fixed	Prec.	1%	310-107
R99D			3 meg	1/2 w	Fixed	Prec.	1%	309-026
R99E			1 meg	1/2 w	Fixed	Prec.	1%	309-014
R99F			1 meg	1/2 w	Fixed	Prec.	1%	309-014
R99G			300 k	1/2 w	Fixed	Prec.	1%	309-125
R99H			100 k	1/2 w	Fixed	Prec.	1%	309-045
R99J			100 k	1/2 w	Fixed	Prec.	1%	309-045
R99K	531	101-3574	10 k	1/2 w	Fixed	Comp.	10%	302-103
		3575 - up	6.8 k	1 w	Fixed	Comp.	10%	304-682
	541	101-865	10 k	1/2 w	Fixed	Comp.	10%	302-103
		866 - up	6.8 k	1 w	Fixed	Comp.	10%	304-682
R99L	531	101-3574	20 k	2 w	Var.	Comp.	20%	311-018
		3575 - up	15 k	2 w	Var.	Comp.	20%	311-045
	541	101-865	20 k	2 w	Var.	Comp.	20%	311-018
		866 - up	15 k	2 w	Var.	Comp.	20%	311-045
R99M	531	101-6710X	Selected for individual instrument.					
	541	101 - up	Selected for individual instrument.					
R100	531	X7900 - up	47 Ω	1/2 w	Fixed	Comp.	10%	302-470
	RM31	X160 - up	47 Ω	1/2 w	Fixed	Comp.	10%	302-470
	541	X6729 - up	47 Ω	1/2 w	Fixed	Comp.	10%	302-470
	RM41	X134 - up	47 Ω	1/2 w	Fixed	Comp.	10%	302-470
R101			900 k	1/2 w	Fixed	Prec.	1%	309-111
R102			111 k	1/2 w	Fixed	Prec.	1%	309-046
R105			1 meg	1/2 w	Fixed	Comp.	10%	302-105
R110			47 k	1 w	Fixed	Comp.	10%	304-473
R111			50 k	2 w	Var.	Comp.	20%	311-023
R112	531	101-7012	47 k	1 w	Fixed	Comp.	10%	304-473
		7013 - up	33 k	1 w	Fixed	Comp.	10%	304-333
	541	101-6196	47 k	1 w	Fixed	Comp.	10%	304-473
		6197 - up	33 k	1 w	Fixed	Comp.	10%	304-333
R115			100 Ω	1/2 w	Fixed	Comp.	10%	302-101



R116			47 k	1 w	Fixed	Comp.	10%	304-473
R117	531	101-8788	15 k	2 w	Var.	Comp.		Use 311-112
		8789 - up	15 k	2 w	Var.	Comp.	20%	311-112
	RM31	X335 - up	15 k	2 w	Var.	Comp.	20%	311-112
	541	101-7576	15 k	2 w	Var.	Comp.		Use 311-112
		7577 - up	15 k	2 w	Var.	Comp.	20%	311-112
	RM41	101-167	15 k	2 w	Var.	Comp.		Use 311-112
		168 - up	15 k	2 w	Var.	Comp.	20%	311-112
R118			47 k	1 w	Fixed	Comp.	10%	304-473
R119			100 Ω	1/2 w	Fixed	Comp.	10%	302-101
R120			33 k	2 w	Fixed	Comp.	10%	306-333
R240	531	101-8543	1 meg	1/2 w	Fixed	Prec.	1%	309-014
		8544 - up	1.75 meg	1/2 w	Fixed	Prec.	1%	309-019
	541	101-7483	1 meg	1/2 w	Fixed	Prec.	1%	309-014
		7484 - up	1.75 meg	1/2 w	Fixed	Prec.	1%	309-019
R241	531	101-8543	1.23 meg	1/2 w	Fixed	Prec.	1%	309-016
		8544 - up	3.1 meg	1/2 w	Fixed	Prec.	1%	309-027
	541	101-7483	1.23 meg	1/2 w	Fixed	Prec.	1%	309-016
		7484 - up	3.1 meg	1/2 w	Fixed	Prec.	1%	309-027
R242			100 Ω	1/2 w	Fixed	Comp.	10%	302-101
R243			100 k	1 w	Fixed	Comp.	10%	304-104
R244	531	X1020 - up	2.2 k	1/2 w	Fixed	Comp.	10%	302-222
	541	101 - up	2.2 k	1/2 w	Fixed	Comp.	10%	302-222
R245	531	X8544 - up	22 meg	1/2 w	Fixed	Comp.	10%	302-226
	541	X7484 - up	22 meg	1/2 w	Fixed	Comp.	10%	302-226
R246	531	101-8543	470 k	1/2 w	Fixed	Comp.	10%	302-474
		8544 - up	100 k	1/2 w	Var.	Comp.	10%	311-030
	541	101-7483	470 k	1/2 w	Fixed	Comp.	10%	302-474
		7484 - up	100 k	1/2 w	Var.	Comp.	10%	311-030
From S/N8544 - up (531) and S/N7484 - up (541), R246 and R248 are concentric and furnished as a unit. From S/N101-8543 (531) and 101-7483 (541), R248 and R250 are concentric and furnished as a unit.								
R247	531	101-8543	4.7 meg	1/2 w	Fixed	Comp.	10%	302-475
		8544 - up	9 meg	1/2 w	Fixed	Prec.	2%	309-232
	541	101-7483	4.7 meg	1/2 w	Fixed	Comp.	10%	302-475
		7484 - up	9 meg	1/2 w	Fixed	Prec.	2%	309-232
R248	531	101-8543	500 k	1/2 w	Var.	Comp.	20%	311-048
		8544 - up	100 k	1/2 w	Var.	Comp.	20%	311-030
	541	101-7483	500 k	1/2 w	Var.	Comp.	20%	311-048
		7484 - up	100 k	1/2 w	Var.	Comp.	20%	311-030



R249	531	101-8543	560 k	1/2 w	Fixed	Comp.	10%	302-564
		8544 - up	33 k	1/2 w	Fixed	Comp.	10%	302-333
	541	101-7483	560 k	1/2 w	Fixed	Comp.	10%	302-564
		7484 - up	33 k	1/2 w	Fixed	Comp.	10%	302-333
R250	531	101-8543	500 k	1/2 w	Var.	Comp.	20%	311-048
		8544 - up	47 k	1/2 w	Fixed	Comp.	10%	302-473
	541	101-7483	500 k	1/2 w	Var.	Comp.	20%	311-048
		7484 - up	47 k	1/2 w	Fixed	Comp.	10%	302-473
R253	531	101-8543X	100 Ω	1/2 w	Fixed	Comp.	10%	302-101
	541	101-7483X	100 Ω	1/2 w	Fixed	Comp.	10%	302-101
R254			111 k	1/2 w	Fixed	Prec.	1%	309-046
R255			100 Ω	1/2 w	Fixed	Comp.	10%	302-101
R256			100 k	1 w	Fixed	Comp.	10%	304-104
R259			400 k	1 w	Fixed	Prec.	1%	310-094
R260			400 k	1 w	Fixed	Prec.	1%	310-094
R261			22 k	1/2 w	Fixed	Comp.	10%	302-223
R262			20 k	2 w	Var.	Comp.	20%	311-018
R265			47 Ω	1/2 w	Fixed	Comp.	10%	302-470
R266	531	101-306	5 k	2 w	Var.	Comp.	20%	311-011
		307 - up	10 k	2 w	Var.	Comp.	20%	311-016
	541	101 - up	10 k	2 w	Var.	Comp.	20%	311-016
R267			2.2 k	1 w	Fixed	Cer.	10%	304-222
R268			6 k	5 w	Fixed	WW	5%	308-052
R269			2.2 k	1 w	Fixed	Comp.	10%	304-222
R270	531	101-306	1 k	2 w	Var.	Comp.	20%	311-006
		307 - up	2 k	2 w	Var.	Comp.	20%	311-008
	541	101 - up	2 k	2 w	Var.	Comp.	20%	311-008
R272			47 Ω	1/2 w	Fixed	Comp.	10%	302-470
R273			100 Ω	1/2 w	Fixed	Comp.	10%	302-101
R278	531	101-306	25 k	5 w	Prec.	Mica Plate		*310-503
		307 - up	6-25 k	5 w	Prec.	Mica Plate		*310-506
	541	101 - up	6-25 k	5 w	Prec.	Mica Plate		*310-506
R279			47 Ω	1/2 w	Fixed	Comp.	10%	302-470
R282			390 Ω	1/2 w	Fixed	Comp.	10%	302-391
R283			47 Ω	1/2 w	Fixed	Comp.	10%	302-470



R284			2.2 k	1/2 w	Fixed Comp.	10%	302-222
R286	531	101-306	30 k	5 w	Prec. Mica Plate		*310-504
		307 - up	6-30 k	5 w	Prec. Mica Plate		*310-507
	541	101 - up	6-30 k	5 w	Prec. Mica Plate		*310-507
R287			100 Ω	1/2 w	Fixed Comp.	10%	302-101
R288			39 k	2 w	Fixed Comp.	10%	306-393
R289			39 k	2 w	Fixed Comp.	10%	306-393
R292			470 k	1/2 w	Fixed Comp.	10%	302-474
R293			470 k	1/2 w	Fixed Comp.	10%	302-474
R294	531	101-7600	470 k	1/2 w	Fixed Comp.	10%	302-474
		7601 - up	820 k	1/2 w	Fixed Comp.	10%	302-824
	541	101-6513	470 k	1/2 w	Fixed Comp.	10%	302-474
		6514 - up	820 k	1/2 w	Fixed Comp.	10%	302-824
R295	531	101-7600	470 k	1/2 w	Fixed Comp.	10%	302-474
		7601 - up	820 k	1/2 w	Fixed Comp.	10%	302-824
	541	101-6513	470 k	1/2 w	Fixed Comp.	10%	302-474
		6514 - up	820 k	1/2 w	Fixed Comp.	10%	302-824
R670			150 k	1/2 w	Fixed Comp.	10%	302-154
R671			1 k	1/2 w	Fixed Comp.	10%	302-102
R672	531	101-8543	3.3 meg	1/2 w	Fixed Comp.	10%	302-335
		8544 - up	3.9 meg	1/2 w	Fixed Comp.	10%	302-395
	541	101-7483	3.3 meg	1/2 w	Fixed Comp.	10%	302-335
		7484 - up	3.9 meg	1/2 w	Fixed Comp.	10%	302-395
R673			2.7 meg	1/2 w	Fixed Comp.	10%	302-275
R674			1 k	1/2 w	Fixed Comp.	10%	302-102
R675			68 k	1/2 w	Fixed Comp.	10%	302-683
R676			33 k	1 w	Fixed Comp.	10%	304-333
R679			10 k	2 w	Fixed Var.	20%	311-016
R680	531	101-8543	100 k	1/2 w	Fixed Comp.	10%	302-104
		8544 - up	68 k	1/2 w	Fixed Comp.	10%	302-683
	541	101-7483	100 k	1/2 w	Fixed Comp.	10%	302-104
		7484 - up	68 k	1/2 w	Fixed Comp.	10%	302-683
R681			1.5 meg	1/2 w	Fixed Comp.	10%	302-155
R682			100 Ω	1/2 w	Fixed Comp.	10%	302-101
R683			9.5 k	1/2 w	Fixed Prec.	1%	309-121



R684			6.375 k	1/2 w	Fixed	Prec.	1%		309-119
R685			2.1 k	1/2 w	Fixed	Prec.	1%		309-117
R686			1.025 k	1/2 w	Fixed	Prec.	1%		309-116
R687			610 Ω	1/2 w	Fixed	Prec.	1%		309-113
R688			200 Ω	1/2 w	Fixed	Prec.	1%		309-073
R689			100 Ω	1/2 w	Fixed	Prec.	1%		309-112
R690			60 Ω	1/2 w	Fixed	Prec.	1%		309-067
R691			40 Ω	1/2 w	Fixed	Prec.	1%		309-066
R694			100 k	1/2 w	Fixed	Prec.	1%		309-045
R695			100 Ω	1/2 w	Fixed	Prec.	1%		309-112
R698	531	X5001 - up	.25 Ω	1/2 w	Fixed	WW	10%		*308-090
	541	X5001 - up	.25 Ω	1/2 w	Fixed	WW	10%		*308-090
R699			100 Ω	1/2 w	Fixed	Comp.	10%		302-101
R700			15 k	1 w	Fixed	Comp.	10%		304-153
R701			15 k	1 w	Fixed	Comp.	10%		304-153
R703			68 k	1/2 w	Fixed	Comp.	10%		302-683
R704			27 k	1/2 w	Fixed	Comp.	10%		302-273
R706			2.7 meg	1/2 w	Fixed	Comp.	10%		302-275
R707			2.7 meg	1/2 w	Fixed	Comp.	10%		302-275
R708	531	X766 - up	12 Ω	1 w	Fixed	Comp.	10%		304-120
	541	101 - up	12 Ω	1 w	Fixed	Comp.	10%		304-120
R710			33 k	1/2 w	Fixed	Comp.	10%		302-333
R711			100 k	1/2 w	Fixed	Comp.	10%		302-104
R712			100 k	1/2 w	Fixed	Comp.	10%		302-104
R713	531	X1543 - up	1 k	1/2 w	Fixed	Comp.	10%		302-102
	541	X286 - up	1 k	1/2 w	Fixed	Comp.	10%		302-102
R715	531	101-2819	50 k	1/2 w	Fixed	Prec.		Use	310-086
		2820 - up	50 k	1 w	Fixed	Prec.	1%		310-086
	541	101-568	50 k	1/2 w	Fixed	Prec.		Use	310-086
		569 - up	50 k	1 w	Fixed	Prec.	1%		310-086
R716			10 k	2 w	Var.	WW	20%		311-015



R717			100 k	1/2 w	Fixed	Comp.	10%		302-104
R718	531	101-2819	68 k	1/2 w	Fixed	Prec.		Use	310-054
		2820 - up	68 k	1 w	Fixed	Prec.	1%		310-054
	541	101-568	68 k	1/2 w	Fixed	Prec.		Use	310-054
		569 - up	68 k	1 w	Fixed	Prec.	1%		310-054
R719			470 k	1/2 w	Fixed	Comp.	10%		302-474
R720	531	X5377 - up	10 Ω	1/2 w	Fixed	Comp.	10%		302-100
	541	X5213 - up	10 Ω	1/2 w	Fixed	Comp.	10%		302-100
R724	531	101-203	1.5 k	25 w	Fixed	WW		Use	308-055
		204 - up	1.5 k	10 w	Fixed	WW	5%		308-055
	541	101 - up	1.5 k	10 w	Fixed	WW	5%		308-055
R726			1 k	1/2 w	Fixed	Comp.	10%		302-102
R727			1 k	1/2 w	Fixed	Comp.	10%		302-102
R728			150 k	1/2 w	Fixed	Comp.	10%		302-154
R729			1 meg	1/2 w	Fixed	Comp.	10%		302-105
R732	531	101-364	10 Ω	2 w	Fixed	Comp.	10%		306-100
		365 - up	10 Ω /2	1 w	Fixed	Comp.	10%	(2)	304-100
	541	101 - up	10 Ω /2	1 w	Fixed	Comp.	10%	(2)	304-100
R733	531	X5001 - up	10 Ω	1 w	Fixed	Comp.	10%		304-100
	541	X5001 - up	10 Ω	1 w	Fixed	Comp.	10%		304-100
R735			100 k	1/2 w	Fixed	Comp.	10%		302-104
R736	531	101-5000	50 Ω	2 w	Var.	WW	20%		311-002
		5001 - up	50 Ω	2 w	Var.	WW	20%		311-055
	541	101-5000	50 Ω	2 w	Var.	WW	20%		311-002
		5001 - up	50 Ω	2 w	Var.	WW	20%		311-055
R740	531	101-364	10 Ω	1/2 w	Fixed	Comp.		Use	304-100
		365 - up	10 Ω	1 w	Fixed	Comp.	10%		304-100
	541	101 - up	10 Ω	1 w	Fixed	Comp.	10%		304-100
R742			47 k	1/2 w	Fixed	Comp.	10%		302-473
R743			39 k	1/2 w	Fixed	Comp.	10%		302-393
R744			680 k	1/2 w	Fixed	Comp.	10%		302-684
R747			1.5 meg	1/2 w	Fixed	Comp.	10%		302-155
R748	531	101 - up	3 k	10 w	Fixed	WW	5%		308-020
	541	101 - up	30 k	10 w	Fixed	WW	5%		308-027
R749			750 Ω	10 w	Fixed	WW	5%		308-016



R750	531	101-3394	333 k	1/2 w	Fixed Prec.		Use	310-056
		3395 - up	333 k	1 w	Fixed Prec.	1%		310-056
	541	101-743	333 k	1/2 w	Fixed Prec.		Use	310-056
		744 - up	333 k	1 w	Fixed Prec.	1%		310-056
R751	531	101-3394	490 k	1/2 w	Fixed Prec.		Use	310-057
		3395 - up	490 k	1 w	Fixed Prec.	1%		310-057
	541	101-743	490 k	1/2 w	Fixed Prec.		Use	310-057
		744 - up	490 k	1 w	Fixed Prec.	1%		310-057
R752			167 Ω	5 w	Fixed WW	5%		308-045
R756			10 Ω	2 w	Fixed Comp.	10%		306-100
R757			270 k	1/2 w	Fixed Comp.	10%		302-274
R758			56 k	1/2 w	Fixed Comp.	10%		302-563
R760			1.5 meg	1/2 w	Fixed Comp.	10%		302-155
R762	531	101-524	2 k	10 w	Fixed WW		Use	308-020
		525-1412	2.25 k	10 w	Fixed WW		Use	308-020
		1413-2819	2.25 k	20 w	Fixed WW		Use	308-020
		2820-6637	2.4 k	20 w	Fixed WW		Use	308-020
		6638 - up	3 k	10 w	Fixed WW	5%		308-020
	541	101-568	2.25 k	20 w	Fixed WW		Use	308-020
		569-5873	2.4 k	20 w	Fixed WW		Use	308-020
		5874 - up	3 k	10 w	Fixed WW	5%		308-020
R763			1.5 meg	1/2 w	Fixed Comp.	10%		302-155
R764			2.2 meg	1/2 w	Fixed Comp.	10%		302-225
R765			180 k	1/2 w	Fixed Comp.	10%		302-184
R766			82 k	1 w	Fixed Comp.	10%		304-823
R767	531	X1543 - up	1 k	1/2 w	Fixed Comp.	10%		302-102
	541	X286 - up	1 k	1/2 w	Fixed Comp.	10%		302-102
R770			2.2 meg	1/2 w	Fixed Comp.	10%		302-225
R771	531	101-3394	220 k	1/2 w	Fixed Prec.		Use	310-055
		3395 - up	220 k	1 w	Fixed Prec.	1%		310-055
	541	101-743	220 k	1/2 w	Fixed Prec.		Use	310-055
		744 - up	220 k	1 w	Fixed Prec.	1%		310-055
R772	531	101-3394	333 k	1/2 w	Fixed Prec.		Use	310-056
		3395 - up	333 k	1 w	Fixed Prec.	1%		310-056
	541	101-743	333 k	1/2 w	Fixed Prec.		Use	310-056
		744 - up	333 k	1 w	Fixed Prec.	1%		310-056
R777	531	X5001 - up	10 Ω	1 w	Fixed Comp.	10%		304-100
	541	101 - up	10 Ω	1 w	Fixed Comp.	10%		304-100
R778			82 k	2 w	Fixed Comp.	10%		306-823



R779			2.2 meg	1/2 w	Fixed	Comp.	10%		302-225
R780	531	101-5000	10 Ω/2	1 w	Fixed	Comp.	10%		304-100
		5001 - up	10 Ω	1 w	Fixed	Comp.	10%		304-100
	541	101-5000	10 Ω/2	1 w	Fixed	Comp.	10%		304-100
		5001 - up	10 Ω	1 w	Fixed	Comp.	10%		304-100
R781	531	101-7279	1.5 meg	1/2 w	Fixed	Comp.	10%		302-155
		7280 - up	1.0 meg	1/2 w	Fixed	Comp.	10%		302-105
	541	101-6474	1.5 meg	1/2 w	Fixed	Comp.	10%		302-155
		6475 - up	1.0 meg	1/2 w	Fixed	Comp.	10%		302-105
R782	531	101-7279	390 k	1/2 w	Fixed	Comp.	10%		302-394
		7280 - up	560 k	1/2 w	Fixed	Comp.	10%		302-564
	541	101-6474	390 k	1/2 w	Fixed	Comp.	10%		302-394
		6475 - up	560 k	1/2 w	Fixed	Comp.	10%		302-564
R783			47 k	1/2 w	Fixed	Comp.	10%		302-473
R784			1.5 meg	1/2 w	Fixed	Comp.	10%		302-155
R785	531	101-7279	2 k	20 w	Fixed	WW	5%		308-031
		7280 - up	2.4 k	20 w	Fixed	WW	5%		308-068
	541	101-6474	2.25 k	20 w	Fixed	WW	5%		308-064
		6475 - up	2 k	20 w	Fixed	WW	5%		308-031
R786	531	X7280 - up	2.4 k	20 w	Fixed	WW	5%		308-068
	541	X5001 - up	2.25 k	20 w	Fixed	WW	5%		308-064
R787	531	101-3394	1.84 meg	1/2 w	Fixed	Prec.		Use	308-083
		3395 - up	236 k	1 w	Fixed	WW	1%		308-083
	541	101-743	1.84 meg	1/2 w	Fixed	Prec.		Use	308-083
		744 - up	236 k	1 w	Fixed	WW	1%		308-083
R788	531	101-3394	780 k	1/2 w	Fixed	Prec.		Use	308-084
		3395 - up	100 k	1/2 w	Fixed	WW	1%		308-084
	541	101-743	780 k	1/2 w	Fixed	Prec.		Use	308-084
		744 - up	100 k	1/2 w	Fixed	Prec.	1%		308-084
Replace R787 and R788 at the same time with a new Tek. number.									
R789			11 k	1/2 w	Fixed	Comp.	10%		302-102
R790			10 Ω	1/2 w	Fixed	Comp.	10%		302-100
R791			150 k	1/2 w	Fixed	Comp.	10%		302-154
R792			120 k	1/2 w	Fixed	Comp.	10%		302-124
R793			27 k	1/2 w	Fixed	Comp.	10%		302-273
R794			1 meg	1/2 w	Fixed	Comp.	10%		302-105
R795	531	101-7600	2 k	10 w	Fixed	WW	5%		308-017
		7601 - up	4.5 k	5 w	Fixed	WW	5%		308-066
	541	101 - up	3 k	10 w	Fixed	WW	5%		308-020



R797	531	101-3394	220 k	1/2 w	Fixed	Prec.		Use	310-055
		3395 - up	220 k	1 w	Fixed	Prec.	1%	Use	310-055
	541	101-743	220 k	1/2 w	Fixed	Prec.		Use	310-055
		744 - up	220 k	1 w	Fixed	Prec.	1%		310-055
R798	531	101-3394	720 k	1/2 w	Fixed	Prec.		Use	310-059
		3395 - up	720 k	1 w	Fixed	Prec.	1%	Use	310-059
	541	101-743	720 k	1/2 w	Fixed	Prec.		Use	310-059
		744 - up	720 k	1 w	Fixed	Prec.	1%		310-059
R800			1 k	1/2 w	Fixed	Comp.	10%		302-102
R803			56 k	2 w	Fixed	Comp.	10%		306-563
R804			100 k	1/2 w	Fixed	Comp.	10%		302-104
R805			1 k	1/2 w	Fixed	Comp.	10%		302-102
R807			390 Ω	2 w	Fixed	Comp.	10%		306-391
R810			470 k	1/2 w	Fixed	Comp.	10%		302-474
R811			2 meg	2 w	Var.	Comp.	20%		311-042
R812			2.2 meg	1/2 w	Fixed	Comp.	10%		302-225
R813			4.7 meg	1/2 w	Fixed	Comp.	10%		302-475
R814			4.7 meg	1/2 w	Fixed	Comp.	10%		302-475
R815			4.7 meg	1/2 w	Fixed	Comp.	10%		302-475
R830			47 k	1/2 w	Fixed	Comp.	10%		302-473
R831			1 meg		Var.	Comp.	20%		311-041
R832			4.7 meg	2 w	Fixed	Comp.	10%		306-475
R833			4.7 meg	2 w	Fixed	Comp.	10%		306-475
R834			100 k	1/2 w	Fixed	Comp.	10%		302-104
R835			1 meg	1/2 w	Fixed	Comp.	10%		302-105
R838			100 Ω	1/2 w	Fixed	Comp.	10%		302-101
R840			68 k	2 w	Fixed	Comp.	10%		306-683
R841	531	X1020 - up	47 Ω	1/2 w	Fixed	Comp.	10%		302-470
	541	101 - up	47 Ω	1/2 w	Fixed	Comp.	10%		302-470
R850			2.2 meg	2 w	Fixed	Comp.	10%		306-225
R851			2.2 meg	2 w	Fixed	Comp.	10%		306-225
R852			2 meg		Var.	Comp.	20%		311-043



R853		1 meg	2 w	Fixed Comp.	10%	306-105	
R855		10 k	1/2 w	Fixed Comp.	10%	302-103	
R856		27 k	1/2 w	Fixed Comp.	10%	302-273	
R857		1 meg	1/2 w	Fixed Comp.	10%	302-105	
R860		50 k	2 w	Var. Comp.	20%	311-023	
R861		100 k	2 w	Var. Comp.	20%	311-026	
R863	541 only	101 - up	100 k	1/2 w	Fixed Comp.	10%	302-104
R864	541 only	101 - up	150 k	1/2 w	Fixed Comp.	10%	302-154

SWITCHES

				Unwired	Wired
SW1 and 5	531	101-8543	Trig. Slope and Mode	Use 260-099	262-080
		8544 - up	Trig. Slope and Mode	260-099	262-183
	541	101-7483	Trig. Slope and Mode	260-099	262-080
		7484 - up	Trig. Slope and Mode	260-099	262-183
	RM41	101-166	Trig. Slope and Mode	260-099	262-080
		167 - up	Trig. Slope and Mode	260-099	262-183
SW1 and SW5 shafts are concentric. Furnished as a unit.					
SW43	531	X6711 - up	Furnished with R14 and R43		311-096
	541	X5493 - up			
SW55			4 wafer, 8 position, rotary, TIME/CM	260-010	262-063
SW90			4 wafer, 6 position, rotary, MULTIPLIER	260-011	262-064
SW110			3 wafer, 3 position, rotary, HORIZ. DISPLAY	260-012	262-066
SW254			1 wafer, 2 position, rotary, 5X MAG.	260-010	262-063
SW55 and SW254 shafts are concentric. Furnished as a unit.					
SW670	531	101-7000	Volts, Millivolts, Off) Use		262-132
SW680		101-7000	Sq. Wave Calibrator)		
SW670	541	101-6186	Volts, Millivolts, Off) Use		262-132
SW680		101-6186	Sq. Wave Calibrator)		
SW670	531	7001 - up	Volts, Millivolts, Off) Use	260-177	262-132
SW680		7001 - up	Sq. Wave Calibrator)		
SW670	541	6187 - up	Volts, Millivolts, Off) Use	260-177	262-132
SW680		6187 - up	Sq. Wave Calibrator)		
Note: SW670 and SW680 shafts are concentric. Furnished as a unit.					
SW701			Toggle, 1 pole, 1 throw, POWER ON	260-134	

THERMAL CUT-OUT

TK701		Type SE11, 128 degrees Fahrenheit	260-070
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TRANSFORMERS

T700	531	101-6418	50-60 cycle, 117 v and 234 v	Power	*120-037
		6419 - up	50-60 cycle, 110 v, 117 v, 124 v, 220 v, 234 v, 248 v,		*120-086
541		101-5822	Plate and Heater Supply	Power	*120-037
		5823 - up	Plate and Heater Supply,	Power, EXPORT	*120-086
T801			CRT Supply		*120-036

VACUUM TUBES

V8	531	101-8543	6BQ7A	Trigger Amplifier	154-028
		8544 - up	6DJ8	Trigger Amplifier	154-187
541		101-7483	6BQ7A	Trigger Amplifier	154-028
		7484 - up	6DJ8	Trigger Amplifier	154-187
V20	531	101-8543	6U8	Trigger Shaper	154-033
		8544 - up	6DJ8	Trigger Shaper	154-187
541		101-7483	6U8	Trigger Shaper	154-033
		7484 - up	6DJ8	Trigger Shaper	154-187
V40	531	101-8543	6BQ7A	Stability C.F. and Swp.-Holdoff C.F.	154-028
		8544 - up	6DJ8	Stability C.F. and Swp.-Holdoff C.F.	154-187
541		101-7483	6BQ7A	Stability C.F. and Swp.-Holdoff C.F.	154-028
		7484 - up	6DJ8	Stability C.F. and Swp.-Holdoff C.F.	154-187
V55	531	101-8543	6BQ7A	Unblanking C.F. and Swp.-Holdoff C.F.	154-028
		8544 - up	6DJ8	Unblanking C.F. and Swp.-Holdoff C.F.	154-187
541		101-7483	6BQ7A	Unblanking C.F. and Swp.-Holdoff C.F.	154-028
		7484 - up	6DJ8	Unblanking C.F. and Swp.-Holdoff C.F.	154-187
V58	531	101-8543	6BQ7A	+ Multivibrator and Multi. C.F.	154-028
		8544 - up	6DJ8	+ Multivibrator and Multi. C.F.	154-187
541		101-7483	6BQ7A	+ Multivibrator and Multi. C.F.	154-028
		7484 - up	6DJ8	+ Multivibrator and Multi. C.F.	154-187
V70			12BY7	-Multivibrator	154-047
V73	531	101-8543	6BQ7A	Sawtooth Out C.F. and + Gate Out C.F.	154-028
		8544 - up	6DJ8	Sawtooth Out C.F. and + Gate Out C.F.	154-187
541		101-7483	6BQ7A	Sawtooth Out C.F. and + Gate Out C.F.	154-028
		7484 - up	6DJ8	Sawtooth Out C.F. and + Gate Out C.F.	154-187
V78			6AU6	Sync. Amplifier for Multi-Trace Units	154-022
V80			6AL5	Disconnect Diodes	154-016
V85	531	101-8543	6BQ7A	Sweep Generator C.F.	154-028
		8544 - up	6DJ8	Sweep Generator C.F.	154-187
541		101-7483	6BQ7A	Sweep Generator C.F.	154-028
		7484 - up	6DJ8	Sweep Generator C.F.	154-187
V90			6CL6	Sweep Generator	154-031
V105			12AU7	Ext. Swp. Amp. C.F. and DC Level C.F.	154-041



V115	531	101-8543	6BQ7A	External Sweep Amplifier	154-028
		8544 - up	6DJ8	External Sweep Amplifier	154-187
	541	101-7483	6BQ7A	External Sweep Amplifier	154-028
		7484 - up	6DJ8	External Sweep Amplifier	154-187
V240	531	101-8543	6BQ7A	Driver C.F. and Input C.F.	154-028
		8544 - up	6DJ8	Driver C.F. and Input C.F.	154-187
	541	101-7483	6BQ8A	Driver C.F. and Input C.F.	154-028
		7484 - up	6DJ8	Driver C.F. and Input C.F.	154-187
V246	531	101-8543	6BQ7A	Cal. C.F. and Horiz. Pos. C.F.	154-028
		8544 - up	12AU7	Cal. C.F. and Horiz. Pos. C.F.	154-041
	541	101-7483	6BQ7A	Cal. C.F. and Horiz. Pos. C.F.	154-028
		7484 - up	12AU7	Cal. C.F. and Horiz. Pos. C.F.	154-041
V265	531	101-592	6BQ7A	Sweep Amplifier and Sweep C.F.	Use *157-022
		593-8543	6BQ7	Sweep Amplifier and Sweep C.F.	*157-022
		8544 - up	6DJ8	Sweep Amplifier and Sweep C.F.	154-187
	541	101-7483	6BQ7A	Sweep Amplifier and Sweep C.F.	154-028
		7484 - up	6DJ8	Sweep Amplifier and Sweep C.F.	154-187
V272	531	101-592	6BQ7A	+ Sweep Amplifier and + Sweep C.F.	Use *157-022
		593-8543	6BQ7	+ Sweep Amplifier and + Sweep C.F.	*157-022
		8544 - up	6DJ8	+ Sweep Amplifier and + Sweep C.F.	154-187
	541	101-7483	6BQ7A	+ Sweep Amplifier and + Sweep C.F.	154-028
		7484 - up	6DJ8	+ Sweep Amplifier and + Sweep C.F.	154-187
V282	531	101-685	12BY7	Sawtooth Corrector	154-047
		686 - up	6CL6	Gated C.F. Current Booster	154-031
	541	101 - up	6CL6	Gated C.F. Current Booster	154-031
V670	531	101-8543X	6U8	Calibrator Multivibrator	154-033
	541	101-7483X	6U8	Calibrator Multivibrator	154-033
V670	531	X8544 - up	6AU6	Calibrator Multivibrator	154-022
	541	X7484 - up	6AU6	Calibrator Multivibrator	154-022
V700			6AU6	-150 v DC Amplifier	154-022
V710			5651	Voltage Reference	154-052
V712			12AX7	-150 v Comparator	154-043
V725			12B4	-150 v Series Regulator	154-044
V726			12B4	-150 v Series Regulator	154-044
V727			12B4	-150 v Series Regulator	154-044
V742			6AU6	+100 v Comparator	154-022
V748			6080	+225 v and +100 v Series Regulator	154-056
V757			6AU6	+225 v DC Amplifier	154-022
V765			12AX7	+225 v Comparator	154-043



V782		6AU6	+350 v Comparator	154-022	
V784		6080	+350 v Series Regulator	154-056	
V791		6AU6	+500 v Comparator	154-022	
V794		12B4	+500 v Series Regulator	154-044	
V803		6AU5	Oscillator	154-021	
V810		12AU7	DC Comparator and Shunt Comparator	154-041	
V820		5642	-1350 v Rectifier	154-051	
V821		5642	+8650 v Voltage Tripler	154-051	
V822		5642	+8650 v Voltage Tripler	154-051	
V823		5642	+8650 v Voltage Tripler	154-051	
V824		5642	-1450 v Rectifier	154-051	
V859	531	101-8543	T51P2A/5BGP2	CRT	*154-081
		8544 - up	T64P16/T533P16	CRT	*154-194
	541	101 - up	T54P2/5BHP2	CRT	*154-098

531 VERTICAL AMPLIFIER

All changes made to Type 531 at S/N7601 were incorporated in RM31 at S/N101
Changes made to Type 531 at S/N8544 were made to RM31 at S/N310.

BULBS

B536	X7601 - up	Type NE-2	50-75 v	150-002
B546	X7601 - up	Type NE-2	50-75 v	150-002
NE628	101-5000	75 v, 1/25 w		Use *150-014
B628	5001 -7600X	75 v, 1/25 w		Use *150-014
NE629	101-5000	65-75 v, 1/25 w		*150-014
B629	5001-7600X	65-75 v, 1/25 w		*150-014

CAPACITORS

C500	101-592X	2.2 μf	Cer.	Fixed	500 v	+or-.5 μf	281-500
C501	101-592X	2.2 μf	Cer.	Fixed	500 v	+or-.5 μf	281-500
C503	101-7600X	.047 μf	PT	Fixed	400 v	20%	285-519
C504	X7601 - up	.005 μf	Cer.	Fixed	500 v	GMV	283-001
C505	X7601 - up	.005 μf	Cer.	Fixed	500 v	GMV	283-001



C507A,B	X7601 - up	2x10 μ f	EMC	Fixed	250 v	GMV	*290-076
C510	X2341-7600	.01 μ f	Cer.	Fixed	500 v	GMV	283-002
	7601 - up	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C513	X593-7600X	.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C515	101-7600X	150 μ f	EMC	Fixed	250 v	-20+ 50%	*290-047
C516	101-7600X	150 μ f	EMC	Fixed	250 v	-20+ 50%	*290-048
C517A	101-7600X						
		2x40 μ f	EMC	Fixed	450 v	-20+ 50%	*290-043
C517B	101-7600X						
C517	X7601 - up	.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C520	101-290	.01 μ f	PT	Fixed	400 v	Use	283-002
	291-7600X	.01 μ f	Cer.	Fixed	500 v	GMV	283-002
C532	X505-7600X	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C537	X7601 - up	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C538	X5508-7600X	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C540	X608-2675	.022 μ f	PT	Fixed	400 v	Use	285-517
	2676-7600X	.022 μ f	PT	Fixed	600 v	20%	285-517
C543	X7601 - up	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C547	X7601 - up	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C550	X7601 - up	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C556	X7601 - up	.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C560	X5969-7600X	.01 μ f	Cer.	Fixed	500 v	GMV	283-002
C566	X7601 - up	.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C571	101-7600X	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C579	101-7600X	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C582	X7601 - up	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C586	X7601 - up	1.5 μ μ f	Cer.	Fixed	500 v	+or-0.5 μ μ f	281-526
C595A	101-7600X						
		2x40 μ f	EMC	Fixed	150 v	-20+ 50%	*290-039
C595B	101-7600X						
C596	X7601 - up	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C599	X7601 - up	.022 μ f	PTM	Fixed	600 v	20%	285-517



INDUCTORS

L506	X7601 - up	21-40 μ h	Var.			*114-082
L523	X7601 - up	21-40 μ h	Var.			*114-082
L527	101-7600X	29 μ h	Fixed			*108-016
L536	X652-7600X	1.1 μ h	Fixed			*108-078
L551	X7601 - up	.75 μ h	Fixed			*108-072
L553	X7601-7915	26-45 μ h	Var.			*114-081
	7916 - up	17-48 μ h	Var.			*114-103
	RM31 101-170	26-45 μ h	Var.			*114-081
	171 - up	17-48 μ h	Var.			*114-103
L557	101-7600X	1.2 μ h	Fixed			*108-056
L560	101-7600X	1.2 μ h	Fixed			*108-056
L561	X7601 - up	.75 μ h	Fixed			*108-072
L563	X7601-7915	26-45 μ h	Var.			*114-081
	7916 - up	17-48 μ h	Var.			*114-103
	RM31 101-160	26-45 μ h	Var.			*114-081
	161 - up	17-48 μ h	Var.			*114-103
L570	101-7600X	17-30 μ h	Var.			*114-004
L580	101-7600X	17-30 μ h	Var.			*114-004
L582	X7601 - up	18 μ h, wound on 1 w, 2.2 meg res.				*108-129
L634	101-299	8.8 μ h	Fixed			*108-057
	300-364	9.3 μ h	Fixed	Use		*108-057
	365-7600X	8.8 μ h	Fixed			*108-057
L635	101-299	8.8 μ h	Fixed			*108-057
	300-364	9.3 μ h	Fixed	Use		*108-057
	365-7600X	8.8 μ h	Fixed			*108-057

For initial replacement, replace L634 and L635 at the same time.

RESISTORS

R500	101-7600X	4 k	5 w	Fixed	WW	5%	308-051
R501	101-592	20 k	8 w	Fixed	WW	5%	308-011
	593-7600X	15 k	10 w	Fixed	WW	5%	308-024
R502	101-7600	10 Ω	1/2 w	Fixed	Comp.	10%	302-100
	7601 - up	27 Ω	1/2 w	Fixed	Comp.	10%	302-270
R503	101-290	5.6 Ω	1 w	Fixed	Comp.	10%	307-002
	291-7600X	3.9 Ω	1 w	Fixed	Comp.	5%	307-004



R504	101-7600 7601 - up	10 Ω 150 k	1/2 w 1/2 w	Fixed Comp. Fixed Comp.	10% 10%	302-100 302-154
R505	X7601 - up	620 Ω	2 w	Fixed Comp.	5%	305-621
R506	X7601 - up	1.8 k	1/2 w	Fixed Mica Plate	1%	*310-533
R507	101-592X X7601 - up	10 Ω 100 k	1/2 w 1/2 w	Fixed Comp. Fixed Comp.	10% 10%	302-100 302-104
R508	101-592X	10 Ω	1/2 w	Fixed Comp.	10%	302-100
R509	101-592X	10 Ω	1/2 w	Fixed Comp.	10%	302-100
R510	101-592X X7601 - up	10 Ω 6.8 k	1/2 w 1 w	Fixed Comp. Fixed Comp.	10% 10%	302-100 304-682
R511	X593-7600X	10 k	1 w	Fixed Comp.	10%	304-103
R512	X593-7600X	39 k	1/2 w	Fixed Comp.	10%	302-393
R513	X593-7600 7601 - up	1 meg 4 k	1/2 w 5 w	Fixed Comp. Fixed WW	10% 5%	302-105 308-051
R514	X7601 - up	15 k	5 w	Fixed WW	5%	308-108
R515	101-141 142-7600X	100 Ω 100 Ω	1/2 w 1 w	Fixed Comp. Fixed Comp.	10%	Use 304-101 304-101
R516	101-141 142-7601X	100 Ω 100 Ω	1/2 w 1 w	Fixed Comp. Fixed Comp.	10%	Use 304-101 304-101
R517	101-7600 7601 - up	100 Ω 470 k	1 w 1/2 w	Fixed Comp. Fixed Comp.	10% 10%	304-101 302-474
R518	101-141 142-7601X	100 Ω 100 Ω	1/2 w 1 w	Fixed Comp. Fixed Comp.	10%	Use 304-101 304-101
R520	101-7600 7601 - up	120 k 27 Ω	1/2 w 1/2 w	Fixed Comp. Fixed Comp.	10% 10%	302-124 302-270
R521	101-7600X	150 k	1/2 w	Fixed Comp.	10%	302-154
R523	X7601 - up	1.8 k	1/2 w	Fixed Mica Plate	1%	*310-533
R524	X7601 - up	100 k	1/2 w	Fixed Comp.	10%	302-104
R526	X7601 - up	47 Ω	1/2 w	Fixed Comp.	10%	302-470
R527	101-7600X	4.7 k	1 w	Fixed Comp.	10%	304-472
R528	101-290 291-599 600-7600X	1 k 47 Ω 150 Ω	1/2 w 1/2 w 1/2 w	Fixed Comp. Fixed Comp. Fixed Comp.	10% 10% 10%	302-102 302-470 302-151



R529	101-7600 7601 - up	15 k 8.2 k	2 w 2 w	Fixed Comp. Fixed Comp.	10% 5%	306-153 305-822
R530	101-7600 7601 - up	470 Ω 8.2 k	1/2 w 2 w	Fixed Comp. Fixed Comp.	10% 10%	302-471 305-822
R531	101-7600X	18 k	1 w	Fixed Comp.	10%	304-183
R532	101-290 291-599 600-7600X	1 k 47 Ω 150 Ω	1/2 w 1/2 w 1/2 w	Fixed Comp. Fixed Comp. Fixed Comp.	10% 10% 10%	302-102 302-470 302-151
R533	X7601 - up	150 k	1/2 w	Fixed Comp.	10%	302-154
R534	X487-7600 7601 - up	47 Ω 330 k	1/2 w 1/2 w	Fixed Comp. Fixed Comp.	10% 10%	302-470 302-334
R535	X608-7600X	47 Ω	1/2 w	Fixed Comp.	10%	302-470
R536	101-7600 7601 - up	15 k 330 k	2 w 1/2 w	Fixed Comp. Fixed Comp.	10% 10%	306-153 302-334
R537	X7601 - up	1 meg	1/2 w	Fixed Comp.	10%	302-105
R538	101-7600X	47 Ω	1/2 w	Fixed Comp.	10%	302-470
R539	X608-7600 7601 - up	15 k 680 k	2 w 1/2 w	Fixed Comp. Fixed Comp.	10% 10%	306-153 302-684
R540	X608-7600X	1 meg	1/2 w	Fixed Comp.	10%	302-105
R541	X7601 - up	47 Ω	1/2 w	Fixed Comp.	10%	302-470
R546	X7601 - up	330 k	1/2 w	Fixed Comp.	10%	302-334
R547	X7601 - up	1 meg	1/2 w	Fixed Comp.	10%	302-105
R550	X7601 - up	1 k	5 w	Fixed WW	5%	308-106
R551	X7601 - up	47 Ω	1/2 w	Fixed Comp.	10%	302-470
R553	X7601 - up	1.8 k	3 w	Fixed Mica Plate	1%	*310-534
R556	101-7600 7601 - up	47 Ω 100 k	1/2 w 1/2 w	Fixed Comp. Fixed Comp.	10% 10%	302-470 302-104
R557	101-7600X	10 Ω	1/2 w	Fixed Comp.	10%	302-100
R558	101-7600 7601 - up	8.2 k 27 Ω	2 w 1/2 w	Fixed Comp. Fixed Comp.	10% 10%	306-822 302-270
R559	101-7600X	8.2 k	2 w	Fixed Comp.	10%	306-822
R560	101-7600X	10 Ω	1/2 w	Fixed Comp.	10%	302-100
R561	X7601 - up	47 Ω	1/2 w	Fixed Comp.	10%	302-470



R563	X7601 - up	1.8 k	3 w	Fixed	Prec.	1%	*310-534
R566	X7601 - up	100 k	12 w	Fixed	Comp.	10%	302-104
R568	X7601 - up	27 Ω	1/ w	Fixed	Comp.	10%	302-270
R570	101-7600 7601 - up	3 k 500 Ω	4 w 2 w	Fixed	Mica Plate Var. Comp.		*310-502 311-005
R571	101-7600X	1 meg	1/2 w	Fixed	Comp.	10%	302-105
R573	101-7600 7601 - up	4 k 2.5 k	5 w 5 w	Fixed	WW Fixed WW	5% 1%	308-051 308-103
R574	101-7600 7601 - up	100 Ω 2.5 k	2 w 5 w	Var.	Comp. Fixed WW	20% 1%	311-003 308-103
R575	101-7600X	4 k	5 w	Fixed	WW	5%	308-051
R577	101-7600 7601 - up	2.7 k 100 Ω	1 w 1/2 w	Fixed	Comp. Fixed Comp.	10% 10%	304-272 302-101
R579	101-7600X	1 meg	1/2 w	Fixed	Comp.	10%	302-105
R580	101-7600 7601 - up	3 k 100 Ω	4 w 1/2 w	Fixed	Mica Plate Fixed Comp.		*310-502 302-101
R582	X7601 - up	3 k	2 w	Fixed	Comp.	5%	305-302
R583	X7601 - up	3.6 k	1 w	Fixed	Comp.	5%	303-362
R585	X7601 - up	12 k	2 w	Fixed	Comp.	5%	305-123
R586	X7601 - up	1.6 k	1/2 w	Fixed	Comp.	5%	301-162
R587	X7601 - up	12 k	2 w	Fixed	Comp.	5%	305-123
R590	X7601 - up	47 Ω	1/2 w	Fixed	Comp.	10%	302-470
R593	X7601 - up	30 k	10 w	Fixed	WW	5%	308-027
R595	101-1900 1901-7600 7601 - up	39 k 27 k 47 Ω	1/2 w 1/2 w 1/2 w	Fixed	Comp. Fixed Comp. Fixed Comp.	5% 10% 10%	301-393 302-273 302-470
R596	101-7600 7601 - up	1 meg 47 Ω	2 w 1/2 w	Var.	Comp. Fixed Comp.	20% 10%	311-039 302-470
R597	101-1900 1901-7600X	39 k 27 k	1/2 w 1/2 w	Fixed	Comp. Fixed Comp.	5% 10%	301-393 302-273
R598	X7601 - up	22 k	2 w	Fixed	Comp.	10%	306-223
R599	X7601 - up	1 meg	1/2 w	Fixed	Comp.	10%	302-105
R603	X7601 - up	100 Ω	1/2 w	Fixed	Comp.	10%	304-101



R605	X7601 - up	100 Ω	1/2 w	Fixed Comp.	10%	302-101
R606	101-7600X	10 Ω	1/2 w	Fixed Comp.	10%	302-100
R607	101-7600	1.2 k	2 w	Fixed Comp.	10%	306-122
	7601 - up	47 Ω	1/2 w	Fixed Comp.	10%	302-470
R608	101-7600X	47 Ω	1/2 w	Fixed Comp.	10%	302-470
R609	101-7600	5.6 k	2 w	Fixed Comp.	10%	306-562
	7601 - up	100 Ω	1/2 w	Fixed Comp.	10%	302-101
R610	101-7600X	8 k	5 w	Fixed WW	5%	308-007
R612	101-7600X	8 k	5 w	Fixed WW	5%	308-007
R613	101-7600X	5.6 k	2 w	Fixed Comp.	10%	306-562
R615	101-7600X	10 Ω	1/2 w	Fixed Comp.	10%	302-100
R627	X1090-7600X	1 k	1/2 w	Fixed Comp.	10%	302-102
R628	101-7600X	100 k	1/2 w	Fixed Comp.	10%	302-104
R629	101-7600X	100 k	1/2 w	Fixed Comp.	10%	302-104
R634	101-574	820 Ω	1/2 w	Fixed Comp.		Use 301-821
	575-7600X	820 Ω	1/2 w	Fixed Comp.	5%	301-821
R635	101-574	820 Ω	1/2 w	Fixed Comp.		Use 301-821
	575-7600X	820 Ω	1/2 w	Fixed Comp.	5%	301-821
R650	X593-751	180 Ω	2 w	Fixed Comp.	10%	306-181
	752-7600X	220 Ω	2 w	Fixed Comp.	10%	306-221

VACUUM TUBES

V504	X7601 - up	12BY7A	Input Amplifier			*157-053
V508	101-592	6BQ7A	Delay Line Input, Selected and Matched			Use *157-016
	593-7600X	6CL6	Delay Line Input, Selected and Matched			*157-021
V509	101-592	6BQ7A	Delay Line Input, Selected and Matched			Use *157-016
	593-7600X	6CL6	Delay Line Input, Selected and Matched			*157-021
	Note: V508 and V509 must be replaced at the same time.					
V524	X7601 - up	12BY7A	Input Amplifier			*157-053
V527	101-7600X	6U8	Internal Trigger Amplifier			154-033
V533	X7601 - up	6BQ7A	Indicator Amp. and Driver			154-028
V535	101-7600X	6BQ7A	Int. Trigger Cathode Follower			154-028
V543	X7601 - up	6BQ7A	Indicator Amp. and Driver			154-028



V554	X7601 - up	6197	Output Amplifier	154-146
V558	101-7600X	6BQ7A	Delay Line Output C.F.	154-028
V564	X7601 - up	6197	Output Amplifier	154-146
V570	101-7600X	12BY7	Output Amplifier	154-047
V580	101-7600X	12BY7	Output Amplifier	154-047
V584	X7601 - up	6U8	Trigger Pickoff Amplifier	154-033
V593	X7601 - up	6BQ7A	Vertical Signal Out C.F.	154-028
V606	101-7600X	6BQ7A	Output C.F.	154-028

531 DELAY LINE

CAPACITORS

C900	101-7600X	1.5-7 $\mu\mu\text{f}$	Cer.	Var.	500 v	Use	*295-057
C901	101-290X	1.5 $\mu\mu\text{f}$	Cer.	Fixed	500 v	+or-0.5 $\mu\mu\text{f}$	281-526
C902-909	101-7600X	1.5-7 $\mu\mu\text{f}$	Cer.	Var.	500 v	Use	*295-057
C903-920	X7601 - up	.7-3 $\mu\mu\text{f}$	Tub.	Var.			281-027
C920-928	101-7600X	1.5-7 $\mu\mu\text{f}$	Cer.	Var.	500 v	Use	*295-057
C930-935	101-7600X	1.5-7 $\mu\mu\text{f}$	Cer.	Var.	500 v	Use	*295-057
C930-940	X7601 - up	.7-3 $\mu\mu\text{f}$	Tub.	Var.	500 v		281-027
C938	101-2655	1.5 $\mu\mu\text{f}$	Cer.	Fixed	500 v	+or-0.5 $\mu\mu\text{f}$	281-526
	2656-7600X	1 $\mu\mu\text{f}$	Cer.	Fixed	500 v	+or-0.2 $\mu\mu\text{f}$	281-538
C939	101-7600X	.001 μf	Cer.	Fixed	500 v	GMV	283-000
C940	101-2655	1.5 $\mu\mu\text{f}$	Cer.	Fixed	500 v	+or-0.5 $\mu\mu\text{f}$	281-526
	2656-7600X	1 $\mu\mu\text{f}$	Cer.	Fixed	500 v	+or-0.2 $\mu\mu\text{f}$	281-538

INDUCTORS

L900	101-573	Assembly of 108-059 and 108-064	Fixed		Use	*108-117
	574-7600X	9 section	Fixed			*108-059
L900A	X574-7600X	2.8-5.0 μh		Var.		*114-012
L901	101-573	Assembly of 108-059 and 108-064	Fixed		Use	*108-117
	574-7600X	9 section	Fixed			*108-059
L901A	X574-7600X	2.8-5.0 μh		Var.		*114-012



L905	X7601 - up	1/4 "	18 section	Fixed	*108-130
RM31	101 - up	1/4"	18 section	Fixed	*108-130
L906	X7601 - up	1/4"	18 section	Fixed	*108-130
RM31	101 - up	1/4"	18 section	Fixed	*108-130
L920	101-7600X		9 section	Fixed	*108-060
L921	101-7600X		9 section	Fixed	*108-060
L925	X7601 - up	2.5 μ h, 40 turns, #35 wire on 1/2 w, 15 meg res.			*108-103
L926	X7601 - up	2.5 μ h, 40 turns, #35 wire, on 1/2 w, 15 meg res.			*108-103
L930	101-7600X		6 section	Fixed	*108-061
L931	101-7600X		6 section	Fixed	*108-061
L935	X7601 - up		11 section	Fixed	*108-131
RM31	101 - up		11 section	Fixed	*108-131
L936	X7601 - up		11 section	Fixed	*108-131
RM31	101 - up		11 section	Fixed	*108-131
L955	X7601 - up	7.5-15 μ h		Var.	*114-083
L956	X7601 - up	7.5-15 μ h		Var.	*114-083

RESISTORS

R936	101-7600X	10 Ω	1/2 w	Fixed	Comp. 10%	302-100
R937	101-7600X	10 Ω	1/2 w	Fixed	Comp. 10%	302-100
R938	101-7600X	775 Ω	1/2 w	Fixed	Prec. 1%	309-114
R939	101-7600X	470 Ω	1 w	Fixed	Comp. 10%	304-471
R940	101-7600X	775 Ω	1/2 w	Fixed	Prec. 1%	309-114

541 VERTICAL AMPLIFIER

Changes made to Type 541 at S/N 6475 were made to RM41 at S/N 101.
 Changes made to Type 541 at S/N 6664 were made to RM41 at S/N 134.
 Changes made to Type 541 at S/N 7023 were made to RM41 at S/N 143.
 Changes made to Type 541 at S/N 7079 were made to Rm41 at S/N 150.
 Changes made to Type 541 at S/N 7484 were made to RM41 at S/N 168.

BULBS

NE1010	101-682	Vertical Beam Position Indicator	150-014
B1010	683-6474X	Vertical Beam Position Indicator	150-002
NE1014	101-682	Vertical Beam Position Indicator	150-014
B1014	683-6474X	Vertical Beam Position Indicator	150-002



B1083	X6475 - up	Neon, Type NE-2	50-75 v	150-002
B1087	X6475 - up	Neon, Type NE-2	50-75 v	150-002

CAPACITORS

C1003	X6475 - up	2x20 μ f	EMC	Fixed	450 v		*290-036
C1005A	X6475 - up	40 μ f)					
C1005B	X6475 - up	20 μ f)	EMC	Fixed	475 v		*290-063
C1005C	X6475 - up	10 μ f)					
C1007	X6475 - up	.1 μ f	PTM	Fixed	400 v	20%	285-526
C1010	101-6474X	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C1013	X6475 - up	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C1014	101-6474X	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C1015	X6475 - up	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C1020	101-6475X	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C1029	X6475 - up	.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C1030	X6475 - up	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C1031	X6475 - up	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C1033	X6475 - up	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C1035	101-6474X	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C1039	X6475 - up	.001 μ f	Cer.	Fixed	500 v	10%	281-536
C1045A,B	101-6474X	2x75 μ f	EMC	Fixed	150 v	-20+50%	*290-053
C1049	X6475 - up	.001 μ f	Cer.	Fixed	500 v	10%	281-536
C1050A,B	101-6474X	2x75 μ f	EMC	Fixed	150 v	-20+50%	*290-053
C1051	X5001-6474X	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C1052	X5001-6474	.001 μ f	Cer.	Fixed	500 v	10%	281-536
	6475 - up	.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C1054	101-6474	.001 μ f	Cer.	Fixed	500 v	10%	281-536
	6475 - up	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C1055	101-531	.022 μ f	PT	Fixed	400 v		Use 285-517
	532-6474X	.022 μ f	PT	Fixed	400 v	20%	285-517
C1056	X6475 - up	150 μ f	Cer.	Fixed	500 v	20%	281-524
C1057	101-6474X	.001 μ f	Cer.	Fixed	500 v	GMV	283-000



C1060	101-6474X	.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C1062	101-6474 6475 - up	150 μ μ f .001 μ f	Cer. Cer.	Fixed Fixed	500 v 500 v	20% GMV	281-524 283-000
C1064	101-6474X	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C1066	101-6474X	.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C1070	101-6474X	100 μ f	Cer.	Fixed	350 v	20%	281-523
C1072	101-6474X	12 μ μ f	Cer.	Fixed	500 v	10%	281-506
C1073	101-6474X	1-8 μ μ f	Cer.	Var.	500 v		281-003
C1074	101-261 262-6474X	10 μ μ f 4.7 μ μ f	Cer. Cer.	Fixed Fixed	500 v 500 v	10% 10%	281-504 281-501
C1075	101-6474 6475 - up	1-8 μ μ f 8-50 μ μ f	Poly. Cer.	Var. Var.	500 v		281-003 281-022
C1076	101-6474X	1-8 μ μ f	Poly.	Var.	500 v		281-003
C1077	101-6474 6475 - up	1-8 μ μ f 8-50 μ μ f	Poly. Cer.	Var. Var.	500 v		281-003 281-022
C1078	X262-6474 6475 - up	2.2 μ μ f .7-3 μ μ f	Cer. Tub.	Fixed Var.	500 v	+ or -1/2 μ μ f	281-500 281-027
C1081	101-6474X	.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C1082	101-6474X	150 μ μ f	Cer.	Fixed	500 v	20%	281-524
C1083	101-6474X	.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C1084	101-6474X	.7-3 μ μ f	Tub.	Var.	500 v		281-027
C1085	X6475 - up	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C1089	X6475 - up	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C1090	101-6474X	.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C1091	101-6474X	150 μ μ f	Cer.	Fixed	500 v	20%	281-524
C1092	101-6474X	.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C1093	101-6474X	.7-3 μ μ f	Tub.	Var.	500 v		281-207
C1093A,B,C,D	X6475 - up	4x75 μ f	EMC	Fixed	150 v		*290-071
C1100	101-6474X	.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C1101	101-6474X	150 μ μ f	Cer.	Fixed	500 v	20%	281-524



C1102		.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C1103	101-6474X	.7-3 μ μ f	Tub.	Var.	500 v		281-027
C1104	X6475 - up	.7-3 μ μ f	Tub.	Var.	500 v		281-027
C1105	X6475 - up	150 μ μ f	Cer.	Fixed	500 v	20%	281-524
C1106	X6475 - up	150 μ μ f	Cer.	Fixed	500 v	20%	281-524
C1110	101-6474X	.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C1111	101-6474X	150 μ μ f	Cer.	Fixed	500 v	20%	281-524
C1112		.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C1113	101-6474X	.7-3 μ μ f	Tub.	Var.	500 v		281-027
C1120	101-6474X	.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C1121	101-6474X	150 μ μ f	Cer.	Fixed	500 v	20%	281-524
C1122		.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C1123	101-6474X	.7-3 μ μ f	Tub.	Var.	500 v		281-027
C1124	X6475 - up	.7-3 μ μ f	Tub.	Var.	500 v		281-027
C1126	X6475 - up	150 μ μ f	Cer.	Fixed	500 v	20%	281-524
C1130	101-6474X	.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C1132		.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C1133	101-6474X	.7-3 μ μ f	Tub.	Var.	500 v		281-027
C1141	101-6474X	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C1142	X6475 - up	.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C1144	X6475 - up	.7-3 μ μ f	Tub.	Var.	500 v		281-027
C1146	X6475 - up	150 μ μ f	Cer.	Fixed	500 v	20%	281-524
C1150A,B	101-6474X	2x20 μ f	EMC	Fixed	450 v	-20+ 50%	*290-036
C1151A,B	101-6474X	2x20 μ f	EMC	Fixed	450 v	-20+ 50%	*290-037
C1152	101-5000	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
	5001-6474	.1 μ f	PT	Fixed	400 v	20%	285-526
	6475 - up	.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C1153A,B	101-6474X	2x20 μ f	EMC	Fixed	450 v	-20+ 50%	*290-037
C1155	101-6474X	.005 μ f	Cer.	Fixed	500 v	GMV	283-001



C1161	101-6474X	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C1162	X6475 - up	.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C1164	X6475 - up	.7-3 μ μ f	Tub.	Var.			281-027
C1166	X6475 - up	150 μ μ f	Cer.	Fixed	500 v	20%	281-524
C1172	X6475 - up	.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C1182	X6475 - up	.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C1184	X6475 - up	.7-3 μ μ f	Tub.	Var.			281-027
C1186	X6475 - up	150 μ μ f	Cer.	Fixed	500 v	20%	281-524
C1192	X6475 - up	.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C1202	X6475 - up	.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C1204	X6475 - up	.7-3 μ μ f	Tub.	Var.			281-027
C1205	X6475 - up	150 μ μ f	Cer.	Fixed	500 v	20%	281-524
C1208	X6475 - up	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C1212	X6475 - up	.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C1220	X6475 - up	.005 μ f	Cer.	Fixed	500 v	GMV	283-001
C1223	X6475 - up	.001 μ f	Cer.	Fixed	500 v	GMV	283-000
C1228	X6475 - up	.022 μ f	PTM	Fixed	600 v	20%	285-517

INDUCTORS

L1014	X6475-7078 7079 - up	1.7-3.7 μ h 1.8-3.9 μ h		Var. Var.			*114-008 *114-112
L1021	101-168 169-6474X	.79-1.5 μ h .3-5 μ h		Var. Var.		Use	*114-037 *114-037
LR1022	101-168	2.5 μ h on 4.7 k, 1/2 w res.		Fixed		Use	*108-103
L1022	169-181 182-6208 6209-6474X	3.2 μ h 2.5 μ h 1.8-3.7 μ h		Fixed Fixed Var.		Use	*108-103 *108-103 *114-079
L1024	X6475-7078 7079 - up	1.7-3.7 μ h 1.8-3.9 μ h		Var. Var.			*114-088 *114-112
L1036	X6475-7078 7079 - up	.5-1 μ h .3-.55 μ h		Var. Var.			*114-087 *114-111
LR1041	101-168	2.5 μ h, on 4.7 k, 1/2 w res.		Fixed		Use	*108-103
L1041	169-181 182-6208 6209-6474X	3.2 μ h 2.5 μ h 1.8-3.7 μ h		Fixed Fixed Var.		Use	*108-103 *108-103 *114-079



L1042	101-168 169-6474X	.79-1.5 μ h .3-.5 μ h	Var. Var.	Use	*114-037 *114-037
L1046	X6475-7078 7079 - up	.5-1 μ h .3-.55 μ h	Var. Var.		*114-087 *114-111
L1064	X6475-6663 6664 - up	14 μ h 8.4 μ h	Fixed Fixed		*108-134 *108-157
RM41	X188 - up	8.4 μ h	Fixed		*108-157
L1067	101-6474X	12 μ h	Fixed		*108-005
L1070	101-6474X	5 section, terminating line	Fixed		*108-081
L1071	101-6474 6475-6663 6664 - up	5 section, terminating line .9-1.6 μ h .3-.5 μ h	Fixed Var. Var.		*108-081 *114-038 *114-092
L1073	X6475-6663 6664 - up	.9-1.6 μ h .3-.5 μ h	Var. Var.		*114-038 *114-092
L1080	101-6474X	Plate line, 7 section	Fixed		*108-096
L1081	101-6474X	Grid line, 7 section	Fixed		*108-080
L1082	101-6474X	Grid Line, 7 section	Fixed		*108-080
L1083	101-6474X	Plate Line, 7 section	Fixed		*108-096
L1103	X6475-6663 6664 - up	Grid Line, 7 section Grid Line, 6 section	Fixed Fixed	Use	*108-045 *108-145
L1104	X6475-6663 6664 - up	Plate Line, 6 section Plate Line, 7 section	Fixed Fixed		*108-135 *108-139
L1113	X6475-6663 6664 - up	Grid Line, 7 section Grid Line, 6 section	Fixed Fixed	Use	*108-145 *108-145
L1114	X6475-6663 6664 - up	Plate Line, 6 section Plate Line, 7 section	Fixed Fixed		*108-135 *108-139

RESISTORS

R1003	X6475 - up	100 Ω	1 w	Fixed	Comp.	10%	304-101
R1005	X6475 - up	100 Ω	1 w	Fixed	Comp.	10%	304-101
R1007	X6475 - up	47 Ω	1/2 w	Fixed	Comp.	10%	302-470
R1008	X6475 - up	47 Ω	1/2 w	Fixed	Comp.	10%	302-470
R1009	X6475 - up	100 Ω	1 w	Fixed	Comp.	10%	304-101
R1010	101-6474X	1 meg	1/2 w	Fixed	Comp.	10%	302-105



R1011	101-5393	1 meg	1/2 w	Fixed	Comp.	10%	302-105
	5394-6474	100 k	1/2 w	Fixed	Comp.	10%	302-104
	6475 - up	27 Ω	1/2 w	Fixed	Comp.	10%	302-270
R1012	101-6474X	470 k	1/2 w	Fixed	Comp.	10%	302-474
R1013	101-5393	1 meg	1/2 w	Fixed	Comp.	10%	302-105
	5394-6474	100 k	1/2 w	Fixed	Comp.	10%	302-104
	6475 - up	910 Ω	2 w	Fixed	Comp.	5%	305-911
R1014	101-6474	1 meg	1/2 w	Fixed	Comp.	10%	302-105
	6475 - up	500 Ω	1/2 w	Mica Plate		2%	*310-515
R1015	101-6474	1 k	1/2 w	Fixed	Comp.	10%	302-102
	6475 - up	150 k	1/2 w	Fixed	Comp.	10%	302-154
R1016	X6475-7022	4 k	5 w	Fixed	WW	5%	308-051
	7023 - up	3 k	5 w	Fixed	WW	5%	308-062
R1017	X6475-7022	12 k	8 w	Fixed	WW	5%	308-069
	7023 - up	10 k	8 w	Fixed	WW	5%	308-126
R1018	X6475 - up	330 Ω	1/2 w	Fixed	Comp.	10%	302-331
R1019	X6475 - up	470 k	1/2 w	Fixed	Comp.	10%	302-474
R1020	101-6285	1.2 k	2 w	Fixed	Comp.	10%	306-122
	6286-6474X	1.2 k	2 w	Fixed	Comp.	5%	305-122
R1021	101-6474	650 Ω	1/2 w	Fixed	Mica Plate		*310-513
	6475 - up	27 Ω	1/2 w	Fixed	Comp.	10%	302-270
R1022	101-6474X	100 Ω	1/2 w	Fixed	Comp.	10%	302-101
R1023	101-6474X	68 k	.1 w	Fixed	Comp.	10%	307-006
R1024	X6475 - up	500 Ω	1/2 w	Mica Plate		2%	*310-515
R1025	101-6474X	27 Ω	1/2 w	Fixed	Comp.	10%	302-270
R1026		330 Ω	1/2 w	Fixed	Comp.	10%	302-331
R1027		200 Ω	2 w	Var.	Comp.	20%	311-004
R1028	101-6474X	330 Ω	1/2 w	Fixed	Comp.	10%	302-331
R1029	X6475 - up	470 k	1/2 w	Fixed	Comp.	10%	302-474
R1030	101-6474X	4 k	5 w	Fixed	WW	5%	308-051
R1031	101-6474	15 k	10 w	Fixed	WW	5%	308-024
	6475-7022	4.7 k	1 w	Fixed	Comp.	10%	304-472
	7023 - up	2.2 k	1 w	Fixed	Comp.	10%	304-222
R1033	X6475-7078	1.5 k	5 w	Fixed	WW	5%	308-061
	7079 - up	2.5 k	5 w	Fixed	WW	5%	308-127



R1035	101-6474X	10 k	1 w	Fixed	Comp.	10%	304-103
R1036	X6475 - up	27 k	2 w	Fixed	Comp.	10%	306-273
R1039	X6475-7078 7079 - up	39 Ω	1/2 w	Fixed	Comp.	10%	302-390
		33 Ω	1/2 w	Fixed	Comp.	10%	302-330
R1040	101-6474X	27 Ω	1/2 w	Fixed	Comp.	10%	302-270
R1041	101-6474X	100 Ω	1/2 w	Fixed	Comp.	10%	302-101
R1042	101-6474X	650 Ω	1/2 w	Fixed	Mica Plate		*310-513
R1043	101-6474X	68 k	.1 w	Fixed	Comp.	10%	307-006
R1045	101-6474X	47 k	1/2 w	Fixed	Comp.	10%	302-473
R1046	101-6474 6475 - up	100 Ω	1/2 w	Fixed	Comp.	10%	302-101
		27 k	2 w	Fixed	Comp.	10%	306-273
R1047	101-6474X	100 Ω	1/2 w	Fixed	Comp.	10%	302-101
R1049	X6474-7078 7079 - up	39 Ω	1/2 w	Fixed	Comp.	10%	302-390
		33 Ω	1/2 w	Fixed	Comp.	10%	302-330
R1050	101-6474X	47 k	1/2 w	Fixed	Comp.	10%	302-473
R1051	101-6474X	2.2 k	1 w	Fixed	Comp.	10%	304-222
R1052	101-6474 6475 - up	47 Ω	1/2 w	Fixed	Comp.	10%	302-470
		470 k	1/2 w	Fixed	Comp.	10%	302-474
R1053	101-6474X	30 k	10 w	Fixed	WW	5%	308-027
R1054	101-6474 6475 - up	47 Ω	1/2 w	Fixed	Comp.	10%	302-470
		167 Ω	5 w	Fixed	WW	5%	308-104
R1055	101-6474 6475 - up	15 k	2 w	Var.	Comp.	20%	311-061
		4.5 k	5 w	Fixed	WW	5%	308-066
R1056	101-6474X	1 meg	1/2 w	Fixed	Comp.	10%	302-105
R1057	101-6474X	2.7 k	2 w	Fixed	Comp.	10%	306-272
R1059	101-6474X	250 k	2 w	Var.	Comp.	20%	311-061
R1060	101-6474X	470 k	1/2 w	Fixed	Comp.	10%	302-474
R1062	101-6474 6475 - up	4.5 k	5 w	Fixed	WW	5%	308-066
		470 k	1/2 w	Fixed	Comp.	10%	302-474
R1064	101-6474 6475-7692X	167 Ω	5 w	Fixed	WW	5%	308-045
		2 k	1 w	Fixed	Comp.	5%	303-202
R1066	101-6474X	470 k	1/2 w	Fixed	Comp.	10%	302-474



R1067	101-168 169-6474X	2.2 k 2 k	1 w 1 w	Fixed Fixed	Comp. Comp.	10% 5%	304-222 303-202
R1071	X6475-6564	600 Ω	5 w	Mica Plate)	Selected	Use	*312-587
R1073	X6475-6564	600 Ω	5 w	Mica Plate)	Pair		
R1071	X6565 - up	600 Ω	5 w	Mica Plate)	Selected	Use	*312-587
R1073	X6565 - up	600 Ω	5 w	Mica Plate)	Pair		
R1071 and R1073 are paired within 1/2% of each other.							
R1075	X6475 - up	220 Ω	1/4 w	Fixed	Comp.	10%	316-221
R1077	X6475 - up	47 Ω	1/4 w	Fixed	Comp.	10%	316-470
R1078	X6475 - up	150 Ω	1/4 w	Fixed	Comp.	10%	316-151
R1080	101-6474 6475 - up	8.2 k 150 k	1/2 w 1/2 w	Fixed Fixed	Comp. Comp.	10% 10%	302-822 302-154
R1081	101-6474 6475 - up	470 k 330 k	1/2 w 1/2 w	Fixed Fixed	Comp. Comp.	10% 10%	302-474 302-334
R1082	101-6474X	4.5 k	5 w	Fixed	WW	5%	308-066
R1083	101-6474 6475-6713 6714 - up	470 k 330 k 390 k	1/2 w 1/2 w 1/2 w	Fixed Fixed Fixed	Comp. Comp. Comp.	10% 10% 10%	302-474 302-334 302-394
R1084	101-6474 6475 - up	8.2 k 680 k	1/2 w 1/2 w	Fixed Fixed	Comp. Comp.	10% 10%	302-822 302-684
R1085	X6475 - up	1 meg	1/4 w	Fixed	Comp.	10%	316-105
R1087	X6475-6713 6714 - up	330 k 390 k	1/2 w 1/2 w	Fixed Fixed	Comp. Comp.	10% 10%	302-334 302-394
R1089	X6475 - up	1 meg	1/4 w	Fixed	Comp.	10%	316-105
R1090	101-6474 6475 - up	470 k 8.2 k	1/2 w 1/4 w	Fixed Fixed	Comp. Comp.	10% 10%	302-474 316-822
R1091	101-6474 6475 - up	4.5 k 250 k	5 w 2 w	Fixed Var.	WW Comp.	5%	308-066 311-061
R1092	101-6474 6475 - up	470 k 47 k	1/2 w 1/2 w	Fixed Fixed	Comp. Comp.	10% 10%	302-474 302-473
R1093	X6475-6542X	15 k	1/2 w	Fixed	Comp.	10%	302-153
R1094	X6475 - up	68 k	.1 w	Fixed	Comp.	10%	307-006
R1095	X6475 - up	8.2 k	1/4 w	Fixed	Comp.	10%	316-822
R1097	X6475 - up	47 k	1/2 w	Fixed	Comp.	10%	302-473
R1098	X6475-6542X	15 k	1/2 w	Fixed	Comp.	10%	302-153



R1099	X6475 - up	68 k	.1 w	Fixed	Comp.	10%	307-006
R1100	101-6474X	470 k	1/2 w	Fixed	Comp.	10%	302-474
R1101	101-6474X	4.5 k	5 w	Fixed	WW	5%	308-066
R1102		470 k	1/2 w	Fixed	Comp.	10%	302-474
R1105	X6475 - up	4.5 k	5 w	Fixed	WW	5%	308-066
R1110	101-6474X	470 k	1/2 w	Fixed	Comp.	10%	302-474
R1111	101-6474X	4.5 k	5 w	Fixed	WW	5%	308-066
R1112		470 k	1/2 w	Fixed	Comp.	10%	302-474
R1120	101-6474X	470 k	1/2 w	Fixed	Comp.	10%	302-474
R1121	101-6474X	4.5 k	5 w	Fixed	WW	5%	308-066
R1122		470 k	1/2 w	Fixed	Comp.	10%	302-474
R1125	X6475 - up	4.5 k	5 w	Fixed	WW	5%	308-066
R1130	101-6474X	470 k	1/2 w	Fixed	Comp.	10%	302-474
R1131	101-6474X	4.5 k	5 w	Fixed	WW	5%	308-066
R1132		470 k	1/2 w	Fixed	Comp.	10%	302-474
R1140	101-6474X	390 Ω	1/2 w	Fixed	Comp.	5%	301-391
R1141	101-196 in series with 197-6474X	10 k 1.8 k 12 k	5 w 1 w 8 w	Fixed Fixed Fixed	WW Comp. WW	5% 10% 5%	308-008 304-182 308-069
R1142	101-6285 6286-6474 6475 - up	1.2 k 1 k 470 k	5 w 5 w 1/2 w	Fixed Fixed Fixed	WW WW Comp.	5% 5% 10%	308-063 308-106 302-474
R1143	101-6474X	390 Ω	1 w	Fixed	WW	5%	301-391
R1145	X6475 - up	4.5 k	5 w	Fixed	WW	5%	308-066
R1150	101-6474X	100 Ω	1 w	Fixed	Comp.	10%	304-101
R1151	101-6474X	100 Ω	1 w	Fixed	Comp.	10%	304-101
R1152	101-6474 6475 - up	47 Ω 470 k	1/2 w 1/2 w	Fixed Fixed	Comp. Comp.	10% 10%	302-470 302-474
R1153	101-6474X	47 Ω	1/2 w	Fixed	Comp.	10%	302-470
R1154	101-6474X	100 Ω	1 w	Fixed	Comp.	10%	304-101
R1155	101-6474X	150 k	1/2 w	Fixed	Comp.	10%	302-154



R1162	X6475 - up	470 k	1/2 w	Fixed	Comp.	10%	302-474
R1165	X6475 - up	4.5 k	5 w	Fixed	WW	5%	308-066
R1172	X6475 - up	470 k	1/2 w	Fixed	Comp.	10%	302-474
R1182	X6475 - up	470 k	1/2 w	Fixed	Comp.	10%	302-474
R1185	X6475 - up	4.5 k	5 w	Fixed	WW	5%	308-066
R1192	X6475 - up	470 k	1/2 w	Fixed	Comp.	10%	302-474

VACUUM TUBES

V1014	X6475 - up	12BY7A	Input Amplifier	Selected			*157-053
V1024	X6475 - up	12BY7A	Input Amplifier	Selected			*157-053
V1025	101- 6474X	6AW8	Decoupling Amp. and Amp.	Selected	Use		*157-039
V1033	X6475-7078 7079 - up	6BQ7A 6DJ8	Grid Line Driver Grid Line Driver				154-028 154-187
V1040	101- 6474X	6AW8	Decoupling Amp. and Amp.	Selected	Use		*157-039
V1043	X6475-7078 7079 - up	6BQ7A 6DJ8	Grid Line Driver Grid Line Driver				154-028 154-187
V1050	101-6474X	6BQ7A	Driver C.F. and Internal Trig. C.F.				154-028
V1052	101-6474X	6BQ7A	Driver C.F. and Vert. Sig. Out. C.F.				154-028
V1054	X6475 - up	6DK6	Trigger Pickoff Amplifier				154-149
V1060	101-487 488-6474X	6CB6 6CB6	Balance Amplifier Balance Amplifier	Selected			154-030 *157-037
V1064	X6475 - up	6DK6	Trigger Pickoff Amplifier				154-149
V1066	101-487 488-6474X	6CB6 6CB6	Internal Trigger Amplifier Internal Trigger Amplifier	Selected			154-030 *157-037
V1080-1132	101-487 488-6474X	6CB6 6CB6	Output Amplifier (12 tubes) Output amplifier (12 tubes)	Selected			154-030 *157-037
V1084	X6475 - up	12AU7	Indicator Amplifier				154-041
V1104-1214	X6475 - up	6DK6	Distributed Amplifier (12 tubes)				154-149
V1223	X6475-7078 7079 - up	6BQ7A 6DJ8	Vertical Signal Out. C.F. Vertical Signal Out. C.F.				154-028 154-187



541 DELAY LINE

CAPACITORS

C1201-1250	101-6474X	.7-3 $\mu\mu\text{f}$	Tub.	Var.	500 v		281-027
C1260-1275	101-6409X	3.3 $\mu\mu\text{f}$	Cer.	Fixed	500 v	+ or -1/4 $\mu\mu\text{f}$	281-534
	6410-6474X	1.5 $\mu\mu\text{f}$	Cer.	Fixed	500 v		281-526
C1280	101-6474X	.68 $\mu\mu\text{f}$	Cer.	Fixed	500 v	20%	281-537
C1281	101-384X	.68 $\mu\mu\text{f}$	Cer.	Fixed	500 v	20%	281-537
	X6410-up	.68 $\mu\mu\text{f}$	Cer.	Fixed	500 v	20%	281-537
C1282	101-6474X	1 $\mu\mu\text{f}$	Cer.	Fixed	500 v	20%	281-538
C1301-1350	X6475 - up	.7-3 $\mu\mu\text{f}$	Tub.	Var.	500 v		281-027
C1360-1375	X6475 - up	1.5 $\mu\mu\text{f}$	Cer.	Fixed	500 v	+ or -0.25 $\mu\mu\text{f}$	281-529
C1380	X6475 - up	.68 $\mu\mu\text{f}$	Cer.	Fixed	500 v	20%	281-537
C1381	X6475 - up	.68 $\mu\mu\text{f}$	Cer.	Fixed	500 v	20%	281-537
C1382	X6475 - up	1 $\mu\mu\text{f}$	Cer.	Fixed	500 v	20%	281-538
C1384	X6538 - up	68 $\mu\mu\text{f}$	Cer.	Fixed	500 v	20%	281-537
	RM41 X105 - up	68 $\mu\mu\text{f}$	Cer.	Fixed	500 v	20%	281-537
C1385	X6538 - up	68 $\mu\mu\text{f}$	Cer.	Fixed	500 v	20%	281-537
	RM41 X105 - up	68 $\mu\mu\text{f}$	Cer.	Fixed	500 v	20%	281-537

INDUCTORS

L1204	101-6409	30 section		Fixed			*108-094
	6410-6474X	30 section		Fixed			*108-133
L1205	101-6409	30 section		Fixed			*108-094
	6410-6474X	30 section		Fixed			*108-133
L1234	101-6409	20 section		Fixed			*108-093
	6410-6474X	20 section		Fixed			*108-132
L1235	101-6409	20 section		Fixed			*108-093
	6410-6474X	20 section		Fixed			*108-132
L1254	101-6474X	0.9-1.6 μh		Var.			*114-038
L1255	101-6474X	0.9-1.6 μh		Var.			*114-038
L1304	X6475 - up	30 section		Fixed			*108-133
L1305	X6475 - up	30 section		Fixed			*108-133
L1334	X6475 - up	20 section		Fixed			*108-132

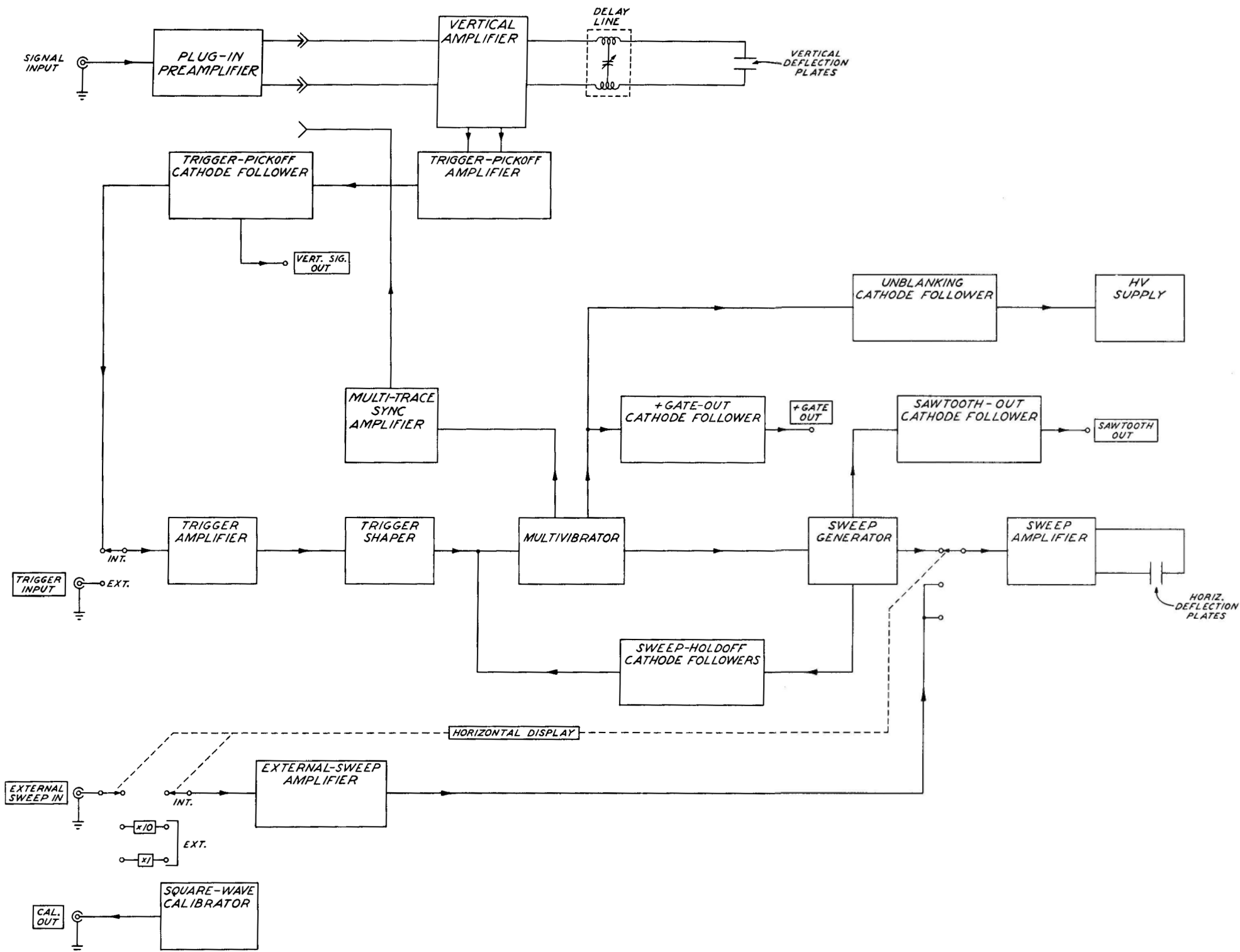


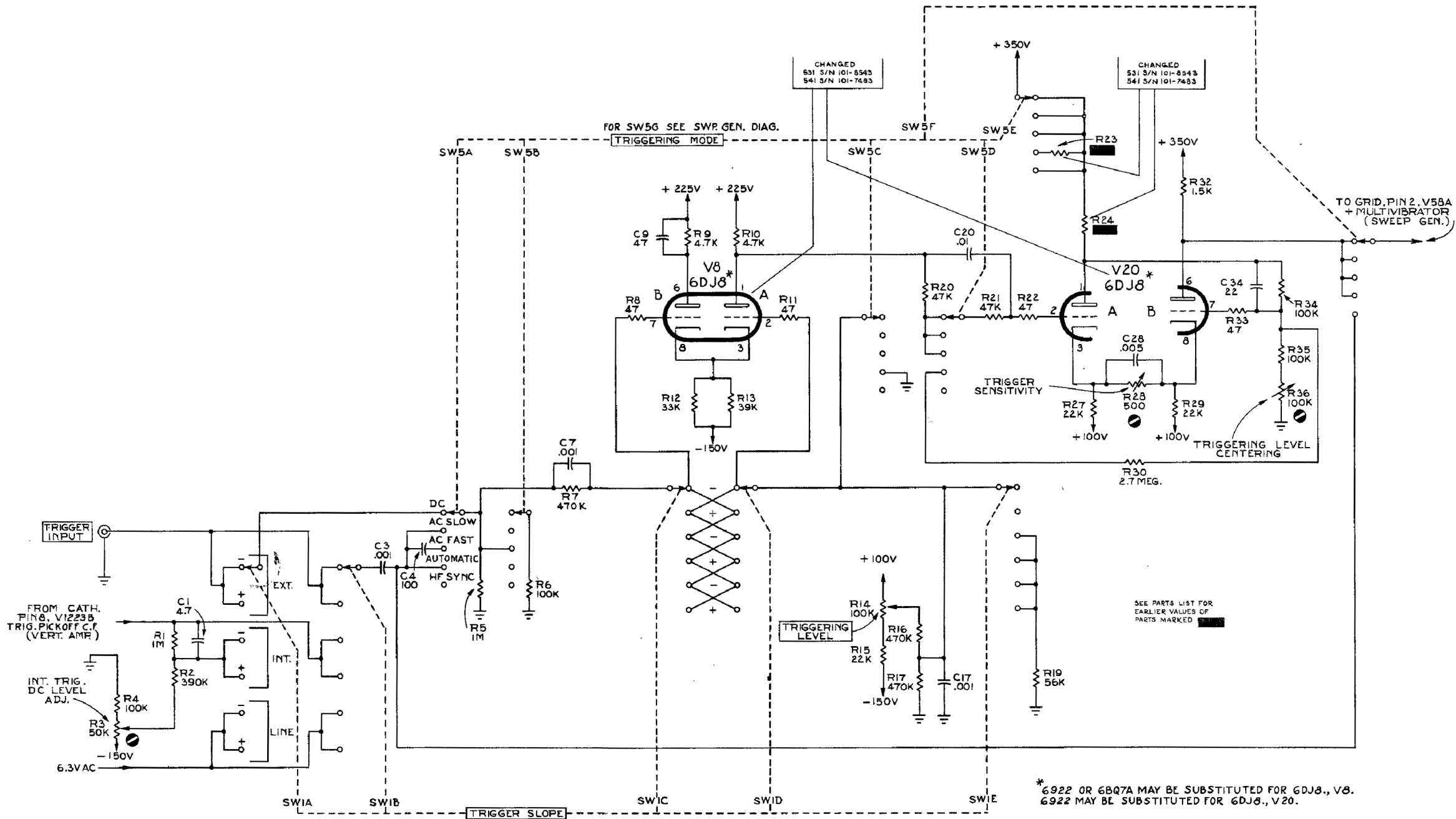
L1335	X6475 - up	20 section	Fixed	*108-132
L1354	X6475 - up	0.9-1.6 μ h	Var.	*114-038
L1355	X6475 - up	0.9-1.6 μ h	Var.	*114-038

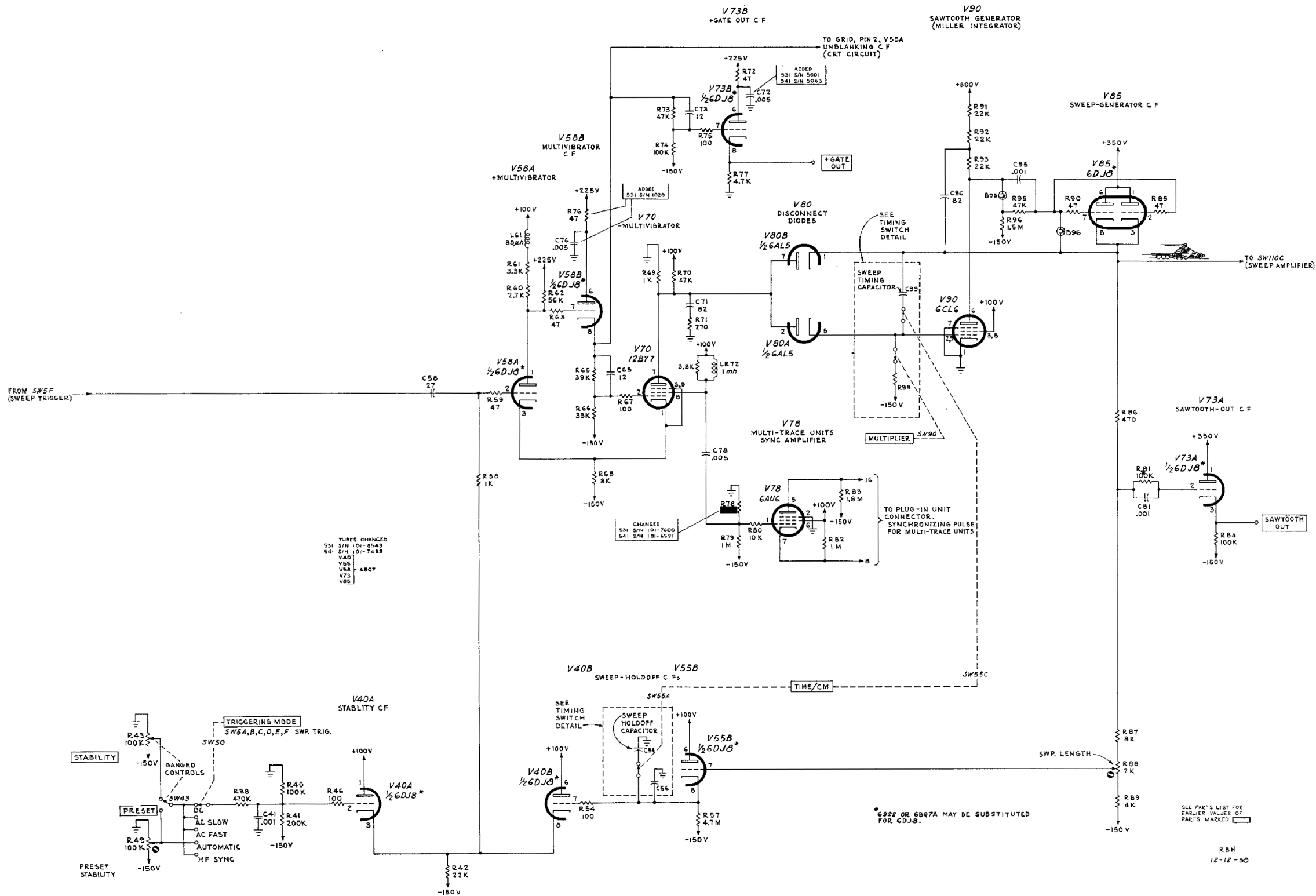
RESISTORS

R1201	101-6409	680 Ω	1/2 w	Fixed	Comp.	10%	302-681
	6410-6474X	1 k	1/2 w	Fixed	Comp.	10%	302-102
R1202	101-6409	680 Ω	1/2 w	Fixed	Comp.	10%	302-681
	6410-6474	1 k	1/2 w	Fixed	Comp.	10%	302-102
	6475 - up	470 k	1/2 w	Fixed	Comp.	10%	302-474
R1203	101-6409	680 Ω	1/2 w	Fixed	Comp.	10%	302-681
	6410-6474X	1 k	1/2 w	Fixed	Comp.	10%	302-102
R1204	101-6409	680 Ω	1/2 w	Fixed	Comp.	10%	302-681
	6410-6474X	1 k	1/2 w	Fixed	Comp.	10%	302-102
R1205	101-6409	680 Ω	1/2 w	Fixed	Comp.	10%	302-681
	6410-7474	1 k	1/2 w	Fixed	Comp.	10%	302-102
	6475 - up	4.5 k	5 w	Fixed	WW	5%	308-066
R1206	101-6409	680 Ω	1/2 w	Fixed	Comp.	10%	302-681
	6410-6474	1 k	1/2 w	Fixed	Comp.	10%	302-102
	6475 - up	360 Ω	1/2 w	Fixed	Comp.	5%	301-361
R1207	101-6409	680 Ω	1/2 w	Fixed	Comp.	10%	302-681
	6410-6474X	1 k	1/2 w	Fixed	Comp.	10%	302-102
R1208	101-6409	680 Ω	1/2 w	Fixed	Comp.	10%	302-681
	6410-6474	1 k	1/2 w	Fixed	Comp.	10%	302-102
	6475 - up	12 k	8 w	Fixed	WW	5%	308-069
R1212	X6475 - up	470 k	1/2 w	Fixed	Comp.	10%	302-474
R1216	X6475 - up	360 Ω	1/2 w	Fixed	Comp.	5%	301-361
R1218	X6475 - up	1 k	5 w	Fixed	WW	5%	308-106
R1221	X6475 - up	100 Ω	1/2 w	Fixed	Comp.	10%	302-101
R1223	X6474-7078	2.7 k	2 w	Fixed	Comp.	10%	306-272
	7079 - up	4.7 k	2 w	Fixed	Comp.	10%	306-472
R1224	X6475 - up	30 k	10 w	Fixed	WW	5%	308-027
R1226	X6475 - up	100 Ω	1/2 w	Fixed	Comp.	10%	302-101
R1227	X6475 - up	15 k	2 w	Fixed	Comp.	10%	306-153
R1228	X6475 - up	1 meg	1/2 w	Fixed	Comp.	10%	302-105
R1301-1308	X6475 - up	1 k	1/2 w	Fixed	Comp.	10%	302-102





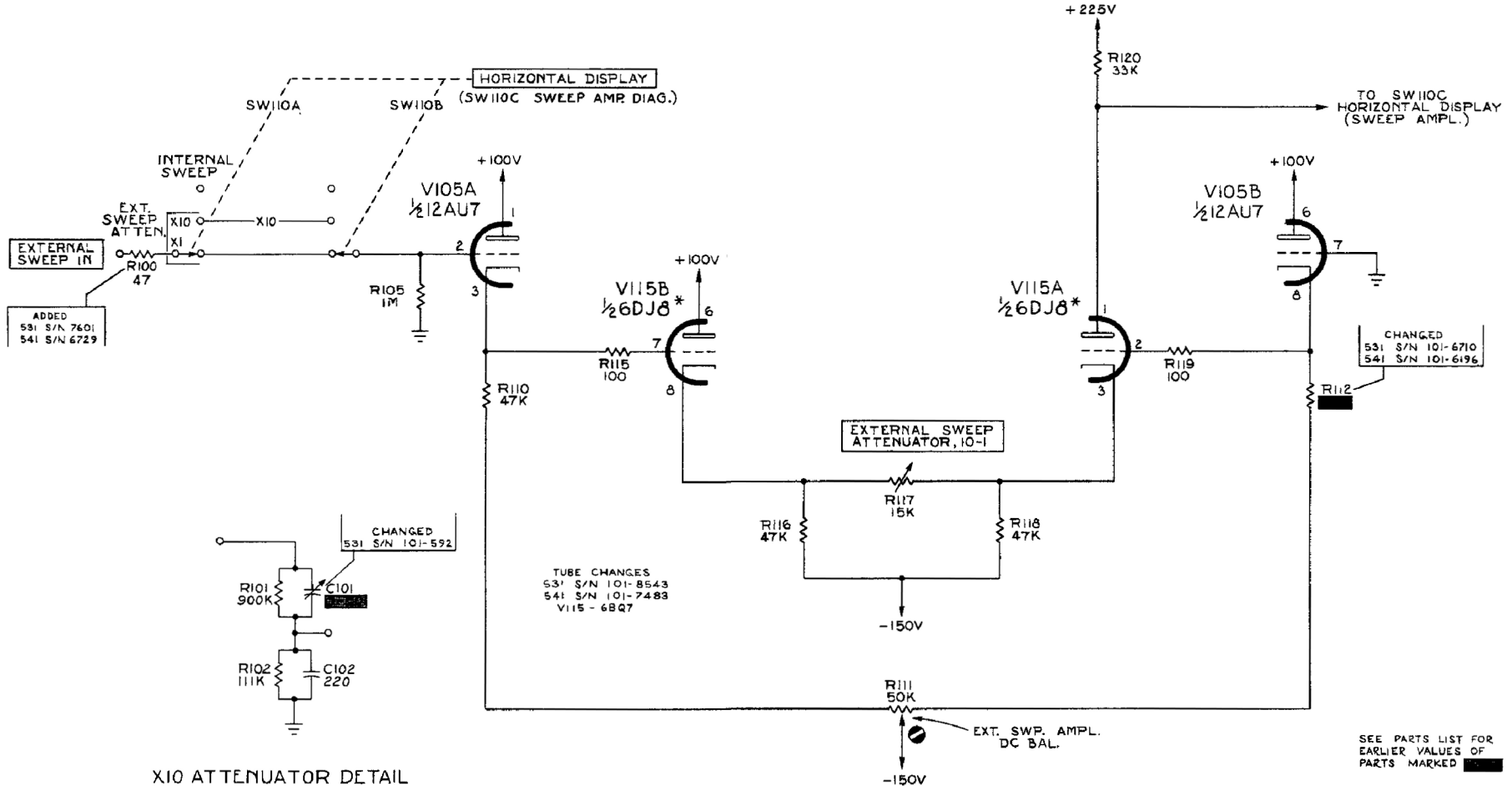




V105A
EXT.-SWEEP C.F.

V105B
DC LEVEL-SETTING C.F.

V115
EXT.-SWEEP
AMPLIFIER



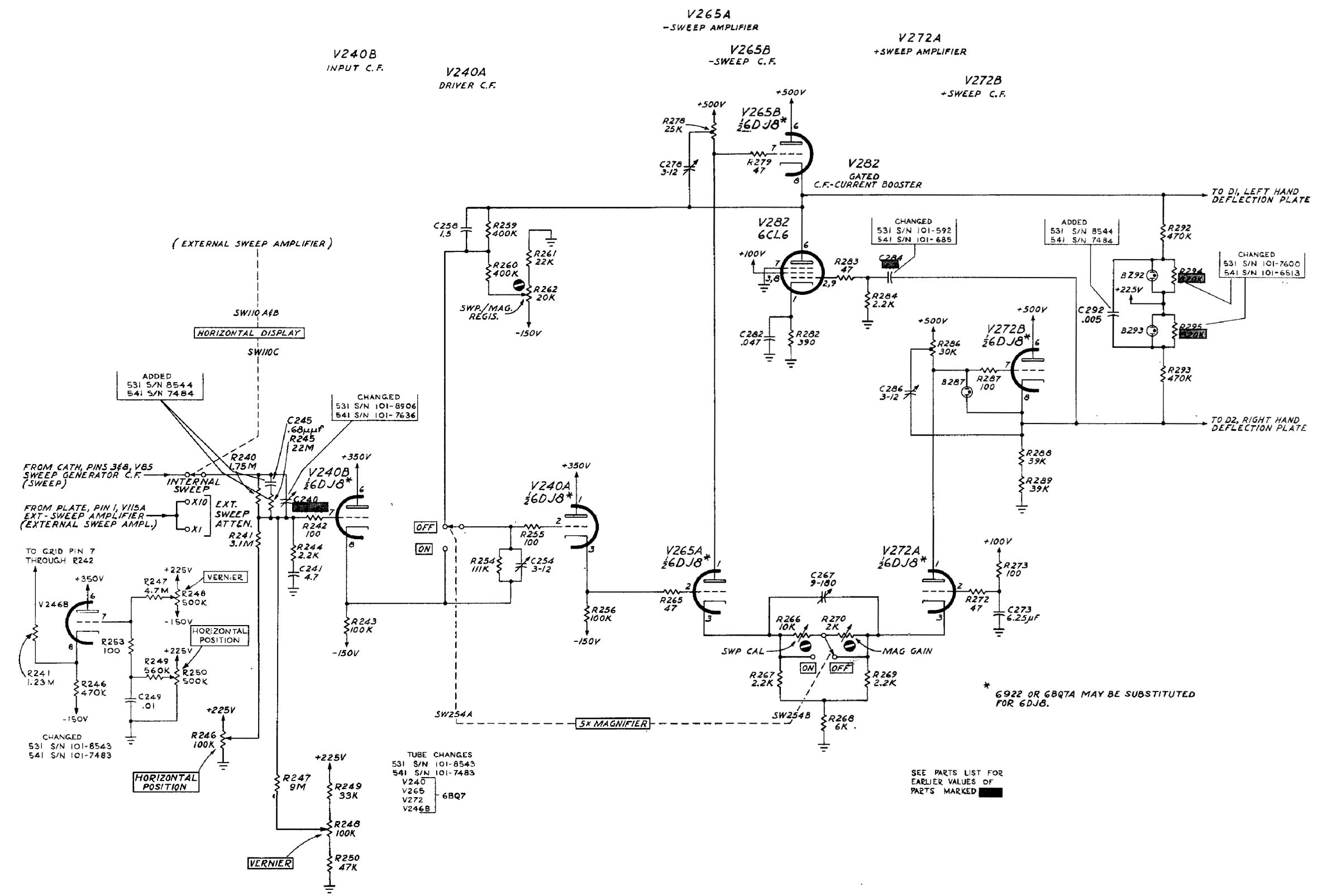
X10 ATTENUATOR DETAIL

TUBE CHANGES
531 S/N 101-8543
541 S/N 101-7483
V115 - 6BQ7

* 6922 OR 6BQ7A MAY BE SUBSTITUTED FOR 6DJ8.

SEE PARTS LIST FOR EARLIER VALUES OF PARTS MARKED [REDACTED]

R.O.W.
12-10-56



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)

HORIZONTAL DISPLAY

ADDED
531 S/N 8544
541 S/N 7484

CHANGED
531 S/N 101-8506
541 S/N 101-7636

FROM CATH. PINS 3&8, VBS
SWEEP GENERATOR C.F.
(SWEEP)

FROM PLATE, PIN 1, V115A
EXT-SWEEP AMPLIFIER
(EXTERNAL SWEEP AMPL.)

TO GRID PIN 7
THROUGH R242

VERNIER

HORIZONTAL POSITION

CHANGED
531 S/N 101-8543
541 S/N 101-7483

HORIZONTAL POSITION

VERNIER

TUBE CHANGES
531 S/N 101-8543
541 S/N 101-7483
V240
V265
V272
V246B
6BQ7

CHANGED
531 S/N 101-592
541 S/N 101-685

ADDED
531 S/N 8544
541 S/N 7484

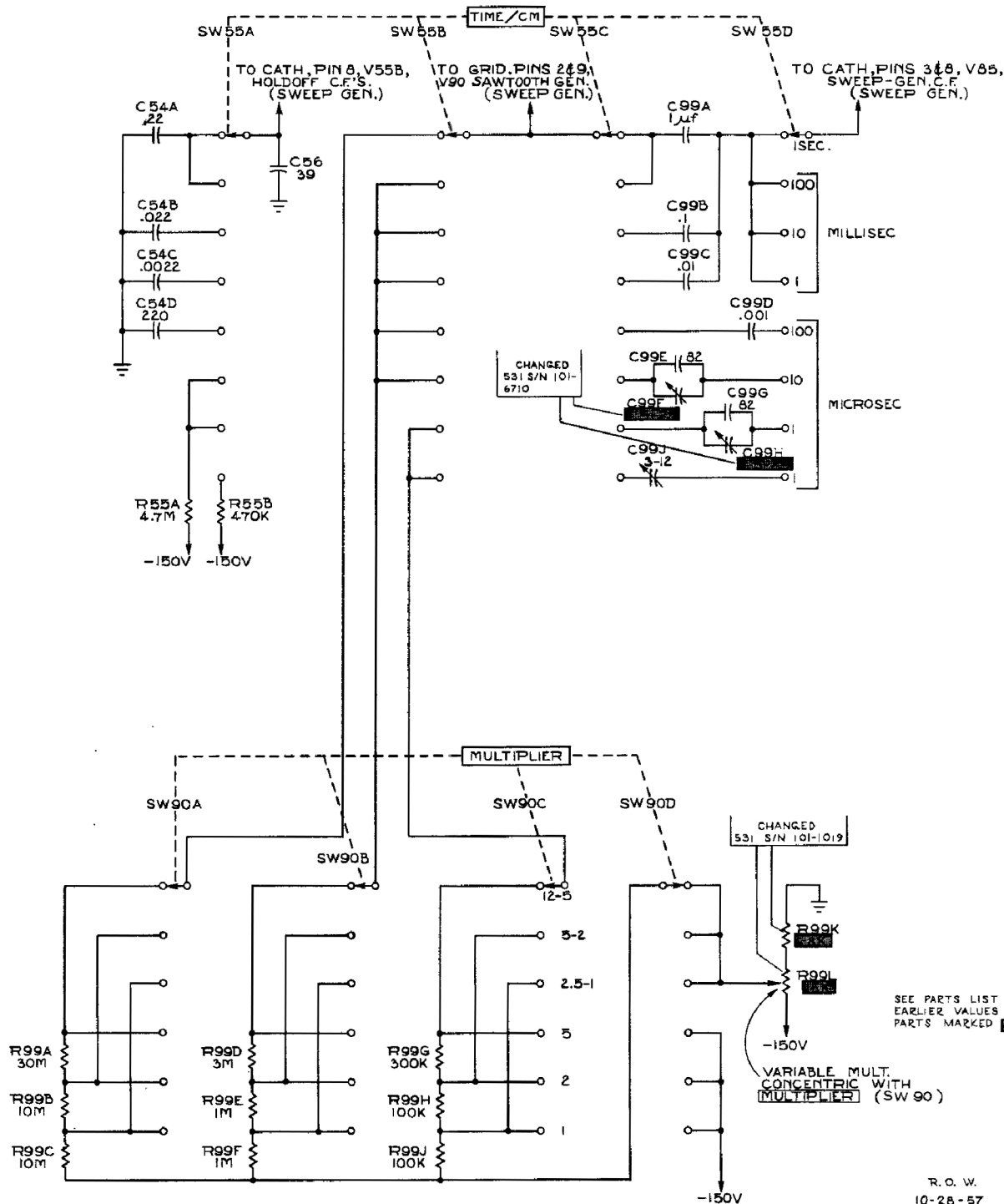
CHANGED
531 S/N 101-7600
541 S/N 101-6513

TO D1, LEFT HAND
DEFLECTION PLATE

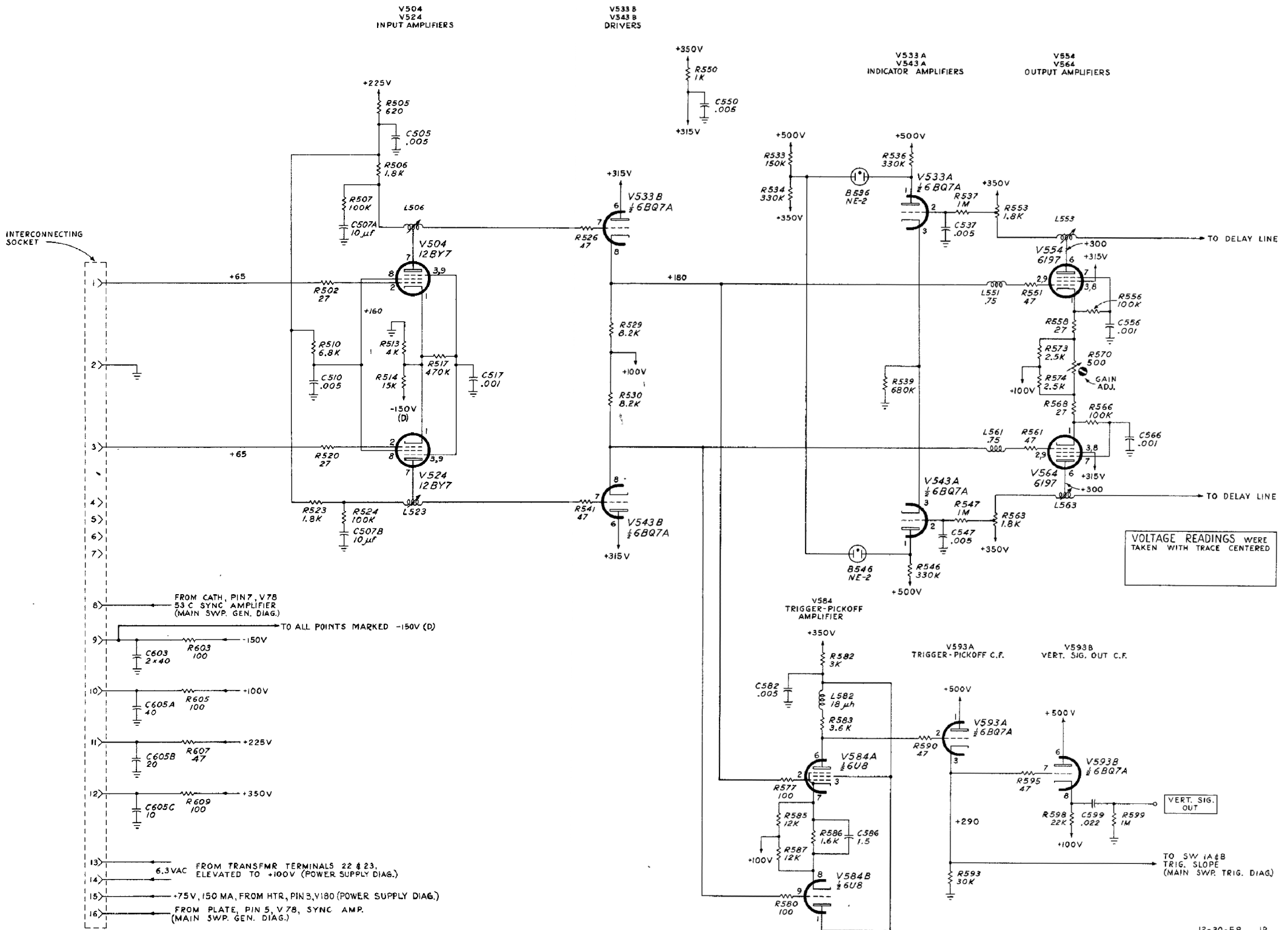
TO D2, RIGHT HAND
DEFLECTION PLATE

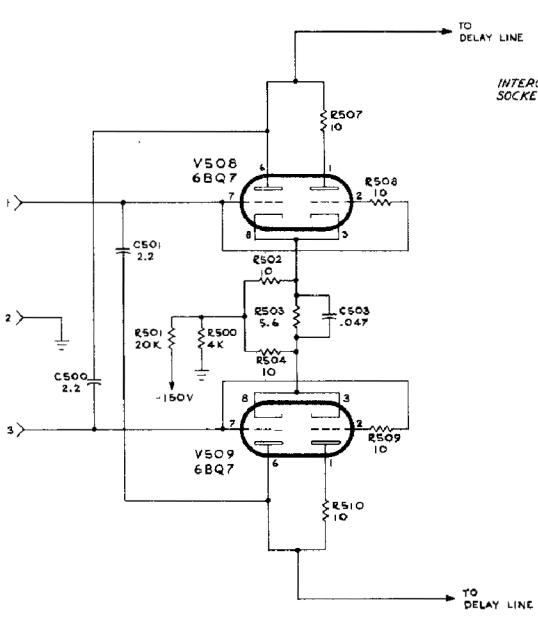
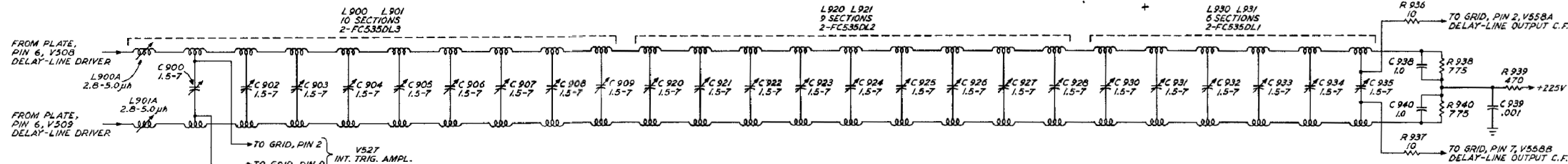
* 6922 OR 6BQ7A MAY BE SUBSTITUTED
FOR 6DJ8.

SEE PARTS LIST FOR
EARLIER VALUES OF
PARTS MARKED

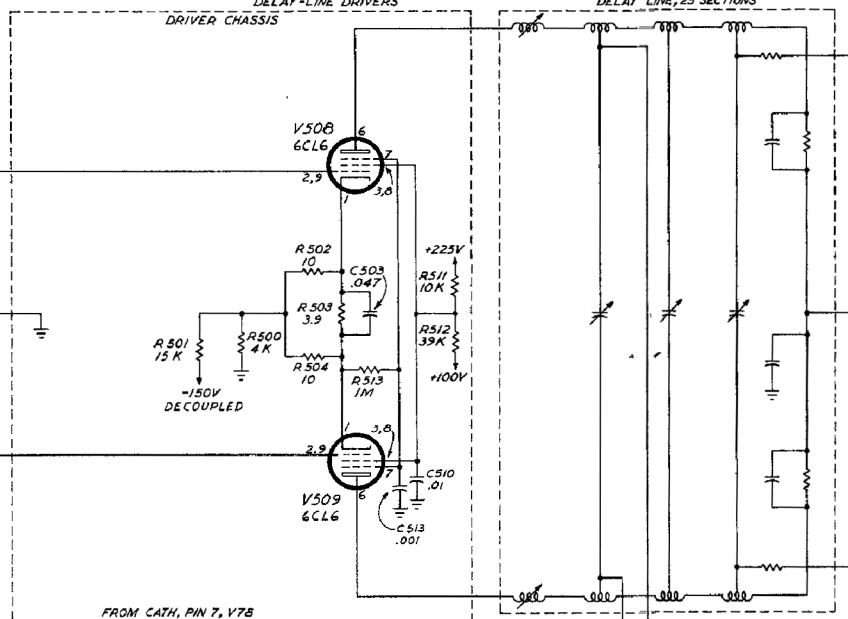


R. O. W.
10-28-57

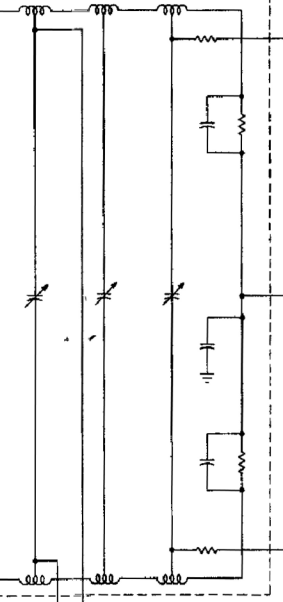




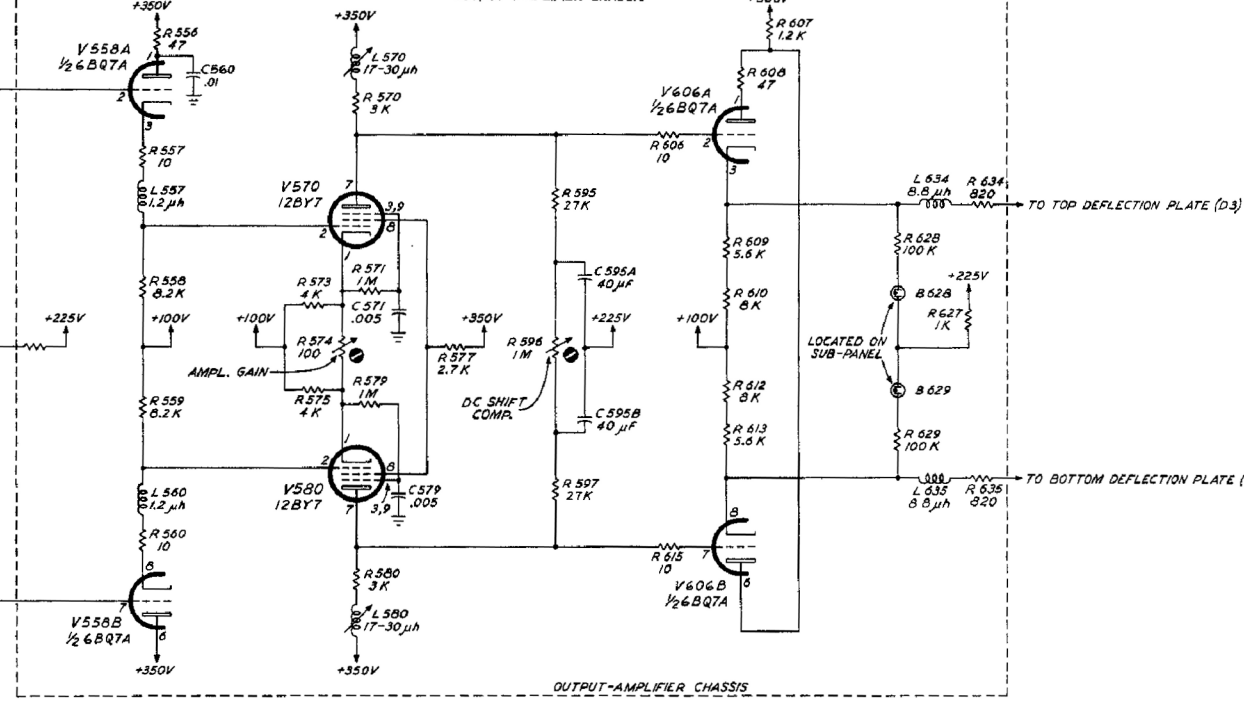
V508 V509 DELAY-LINE DRIVERS DRIVER CHASSIS



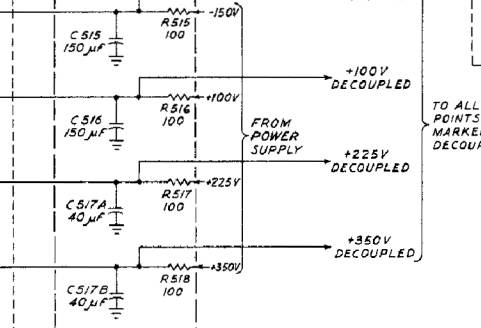
DELAY LINE, 25 SECTIONS



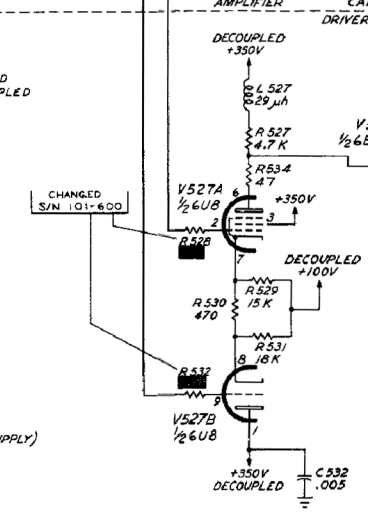
V558 V570 V606 OUTPUT-AMPLIFIER CHASSIS



FROM CATH. PIN 7, V7B 53C SYNC AMPLIFIER (SWEEP GENERATOR)



V527 V535A V535B DRIVER CHASSIS



DELAY LINE DRIVER STAGE S/N 101-592

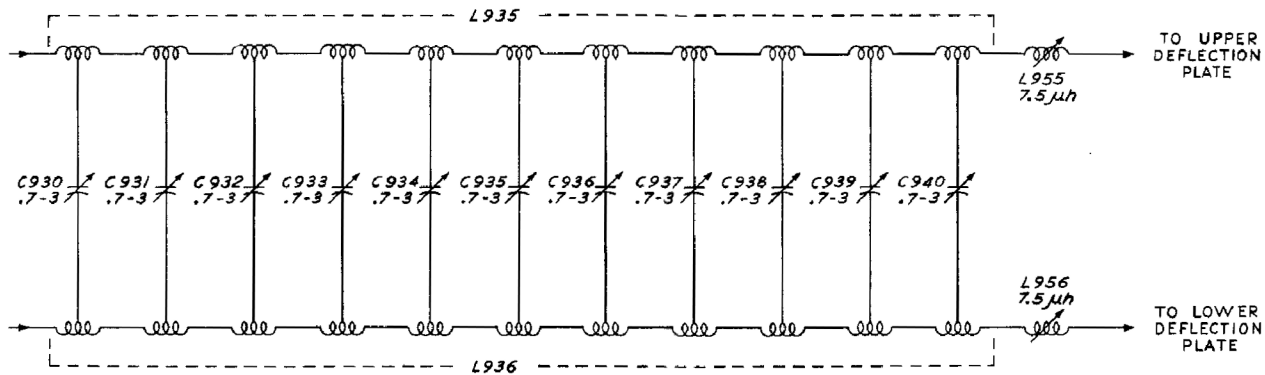
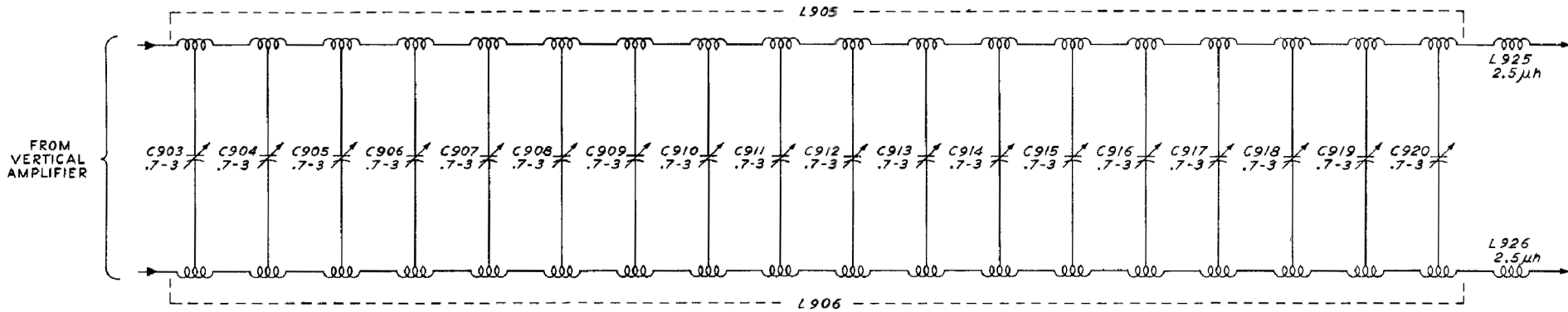
DECOUPLED VOLTAGES TO PLUG-IN PREAMP

TYPE 531 OSCILLOSCOPE S/N 101-7600

SEE PARTS LIST FOR EARLIER VALUES OF PARTS MARKED

LOCATED ON SUB-PANEL

NOTE: V558, V570, V580, & V606 HEATERS ELEVATED TO +225V V527, & V535 HEATERS ELEVATED TO +170V

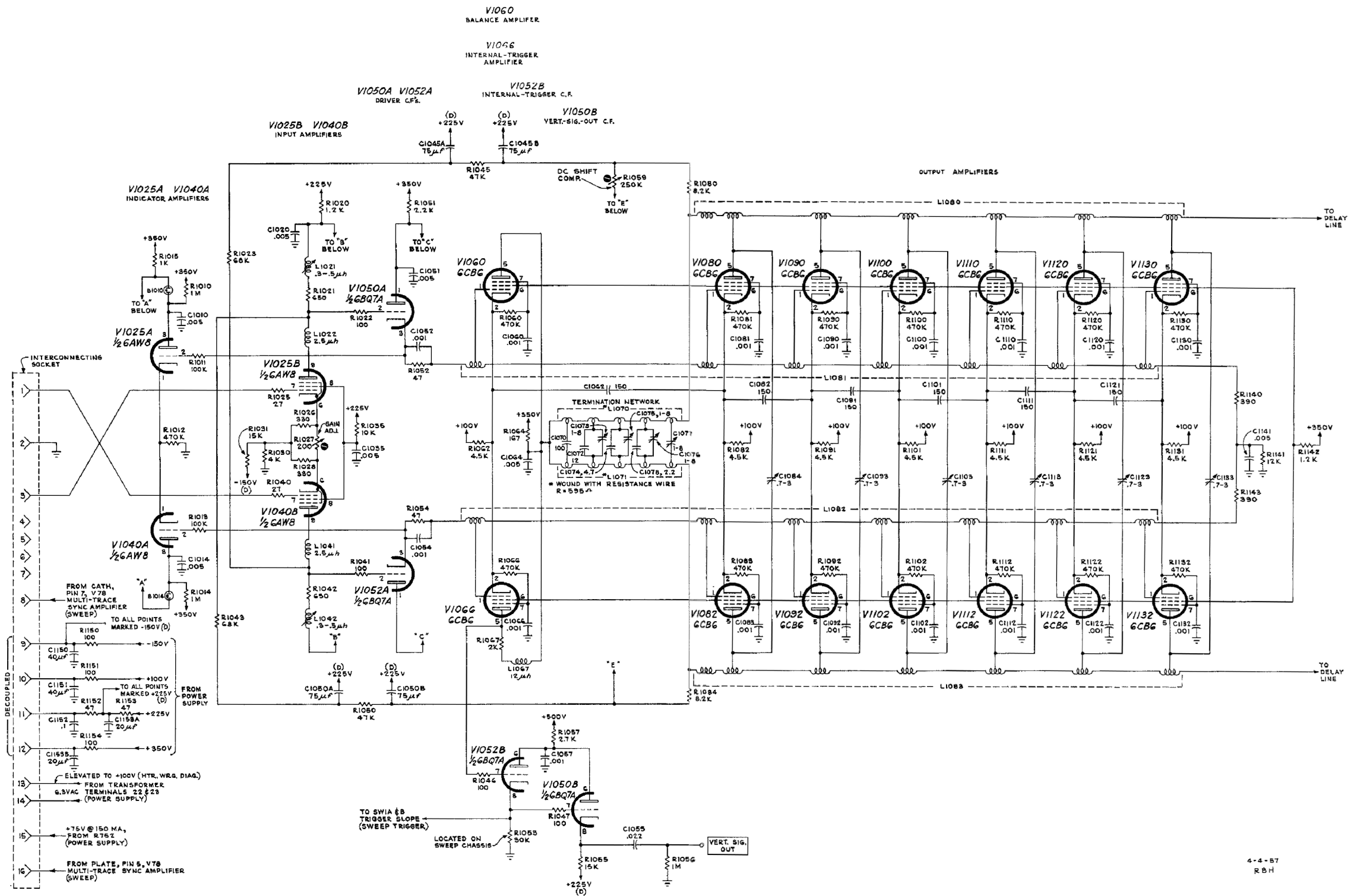


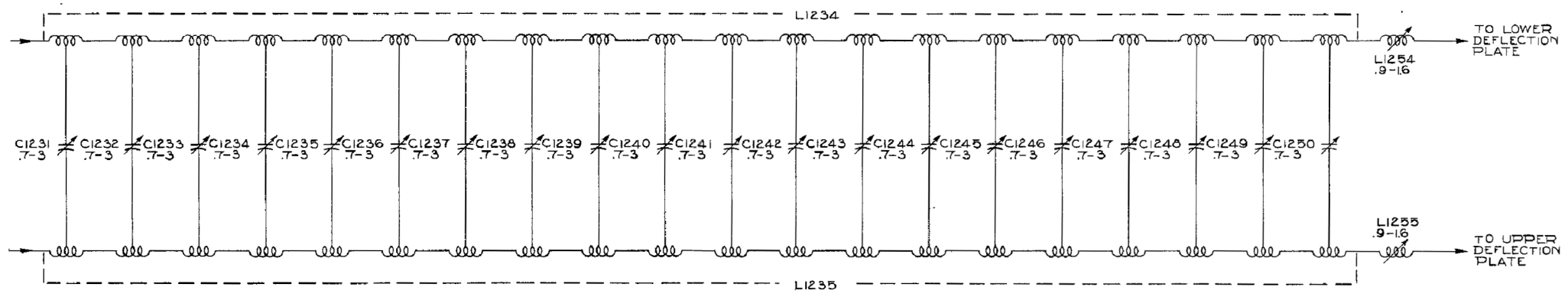
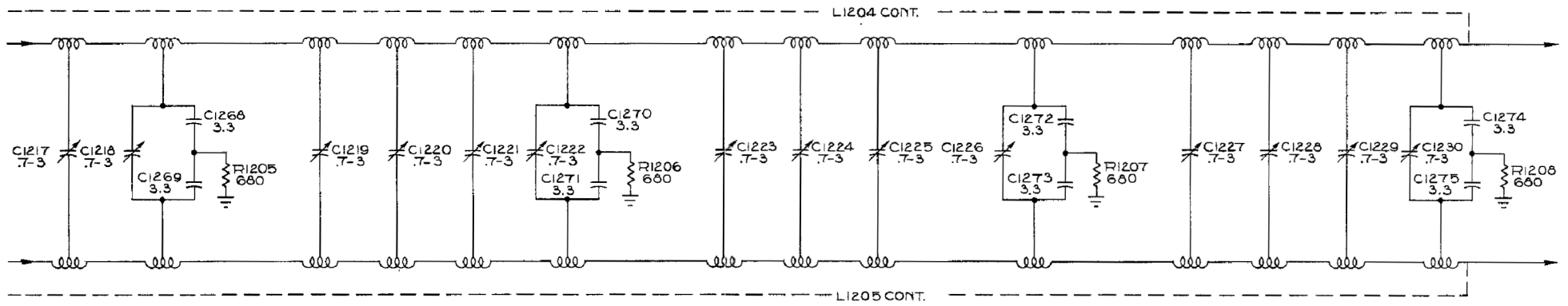
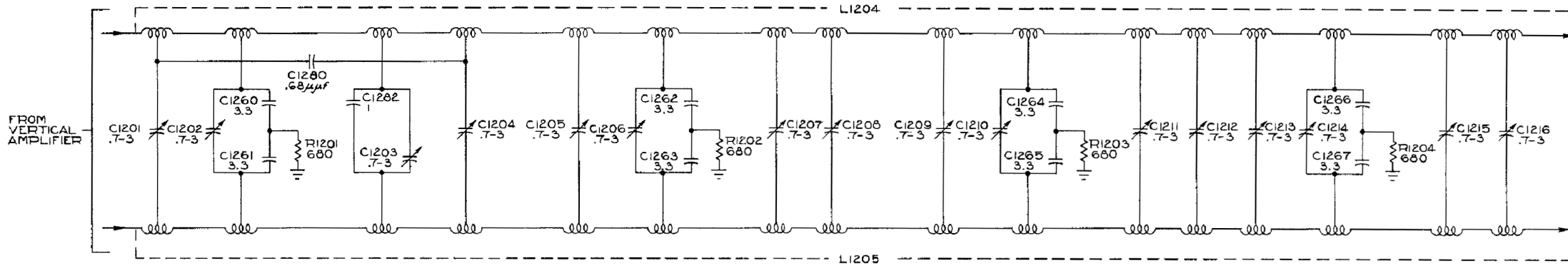
11-29-57 JR

TYPE 531 OSCILLOSCOPE

AA

DELAY LINE NETWORK

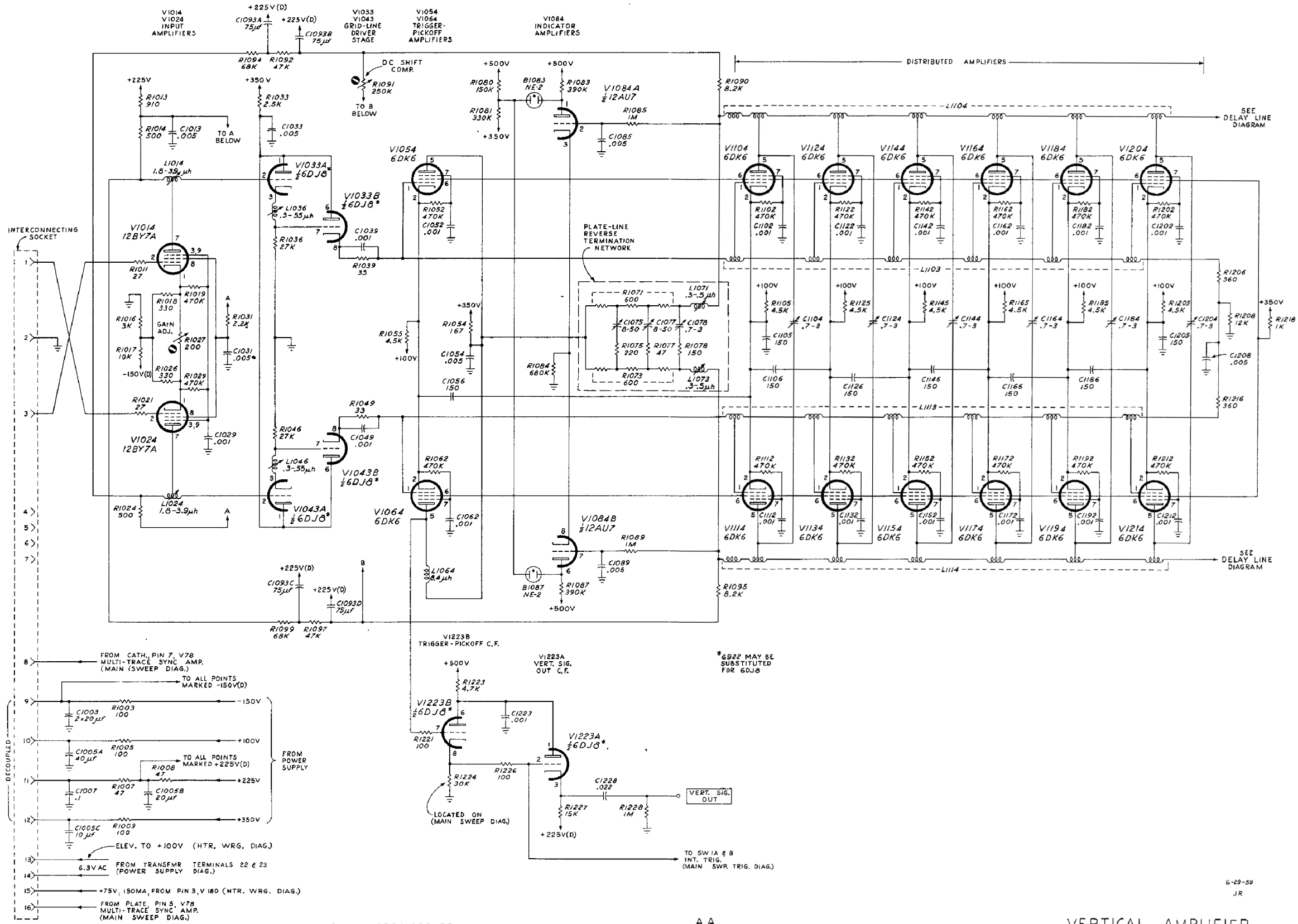




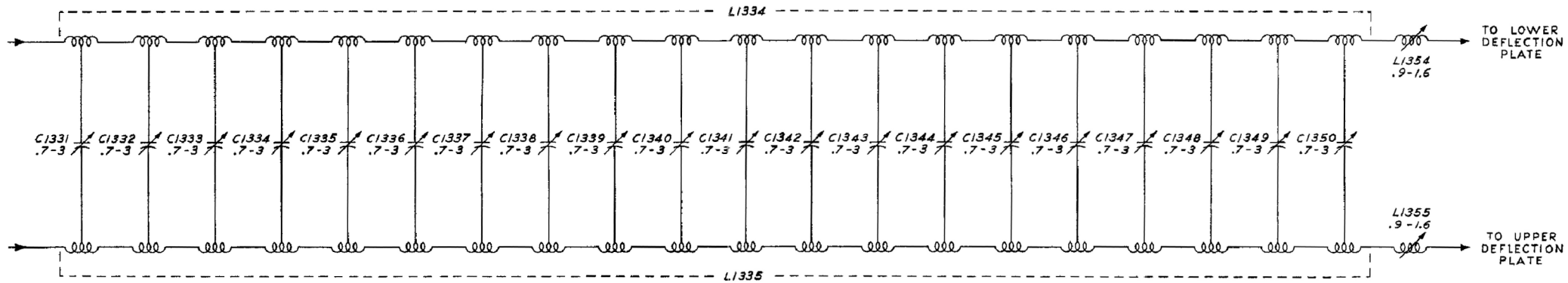
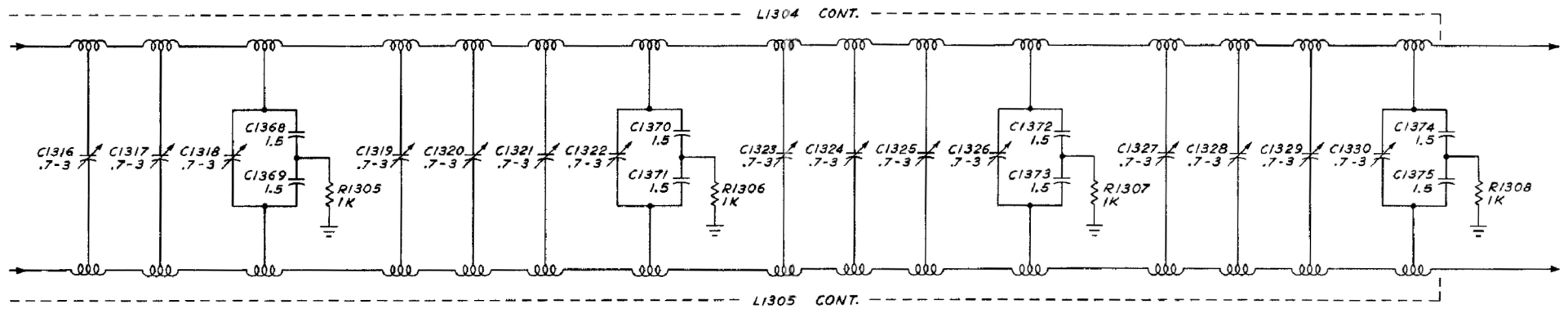
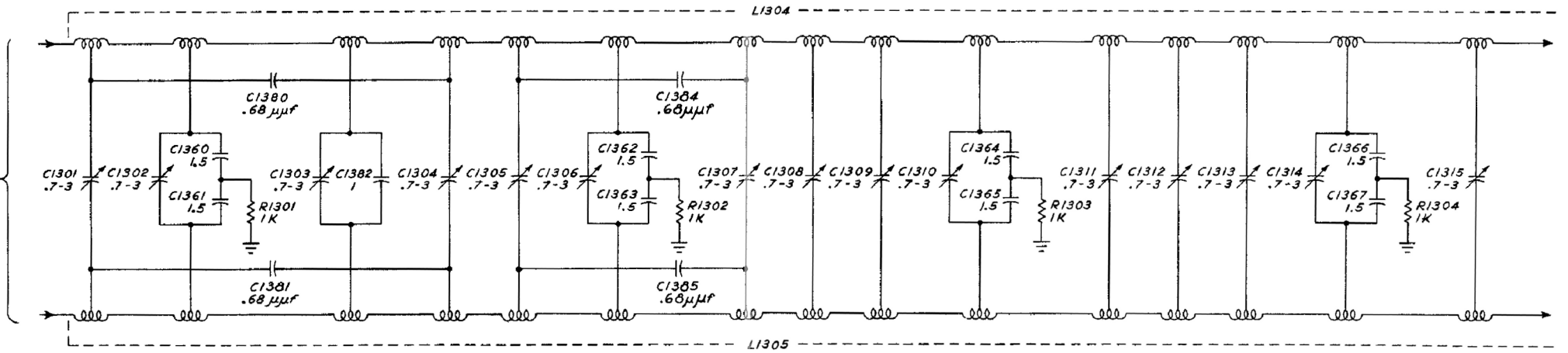
R.O.W.
2-16-56

TYPE 541 OSCILLOSCOPE

DELAY LINE NETWORK



FROM VERTICAL AMPLIFIER



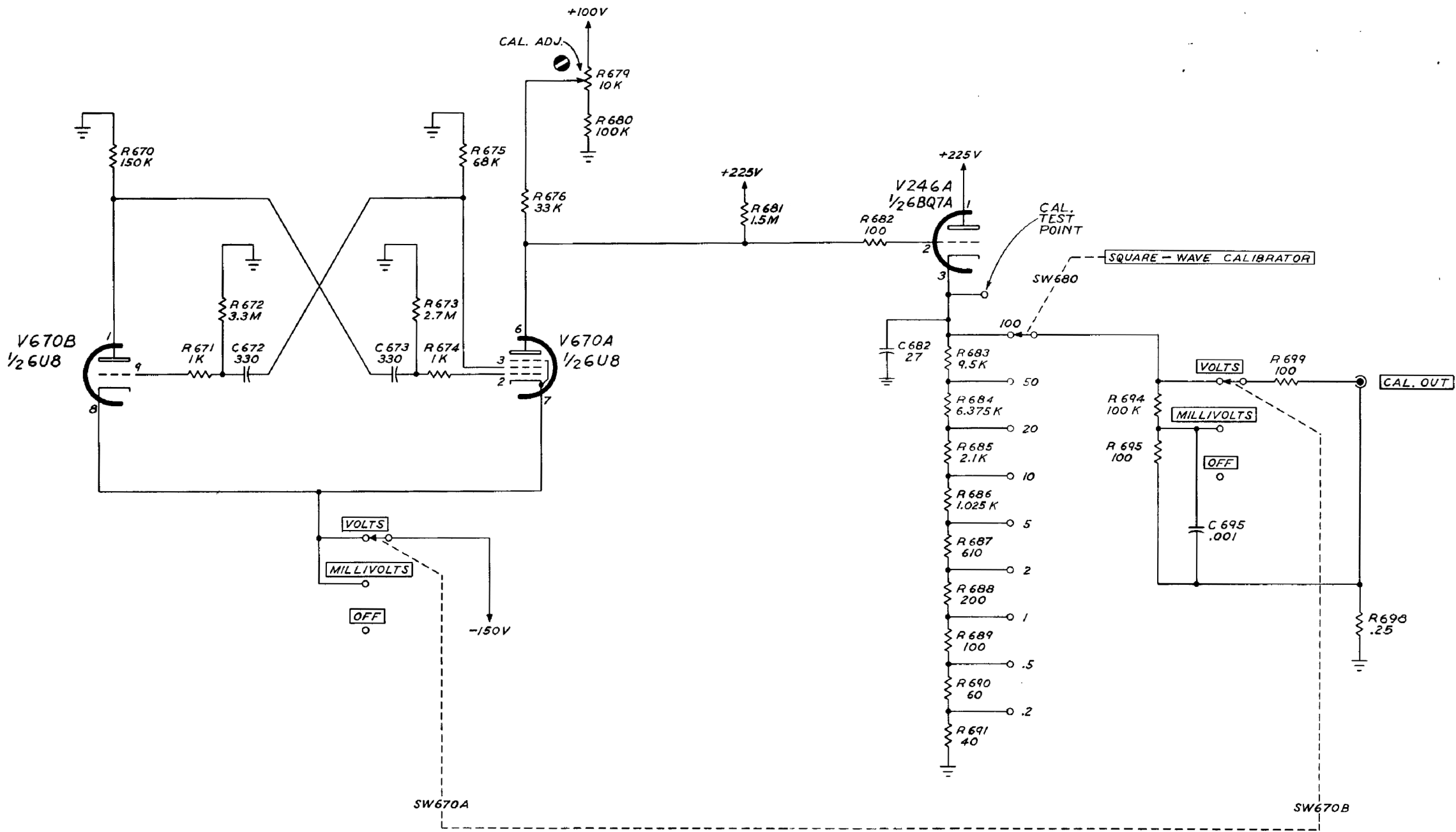
7-16-58 JR

V670

CALIBRATOR MULTIVIBRATOR

V246A

CALIBRATOR CATHODE FOLLOWER

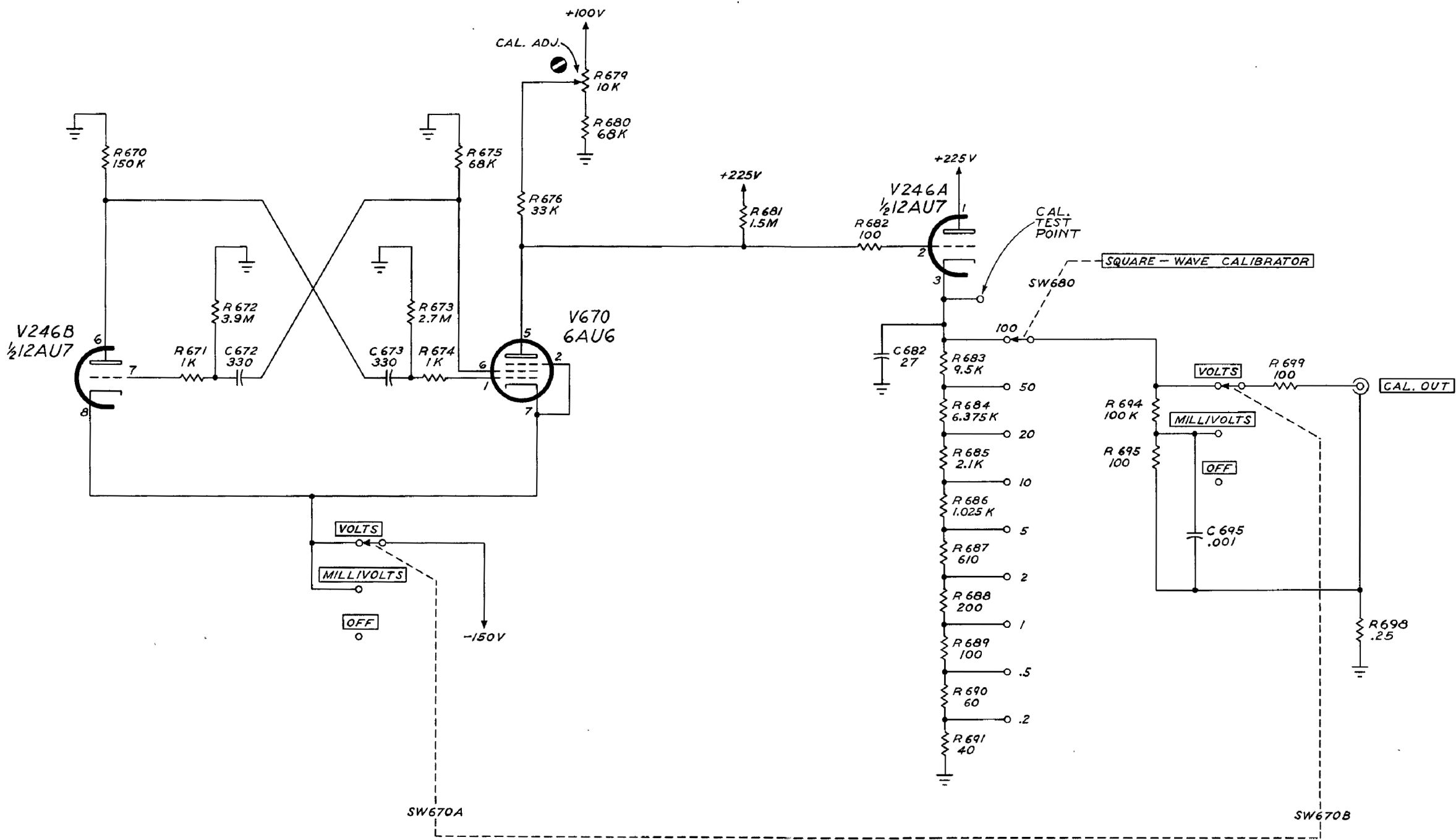


V670

CALIBRATOR MULTIVIBRATOR

V246A

CALIBRATOR CATHODE FOLLOWER



TYPE 531-541 OSCILLOSCOPE

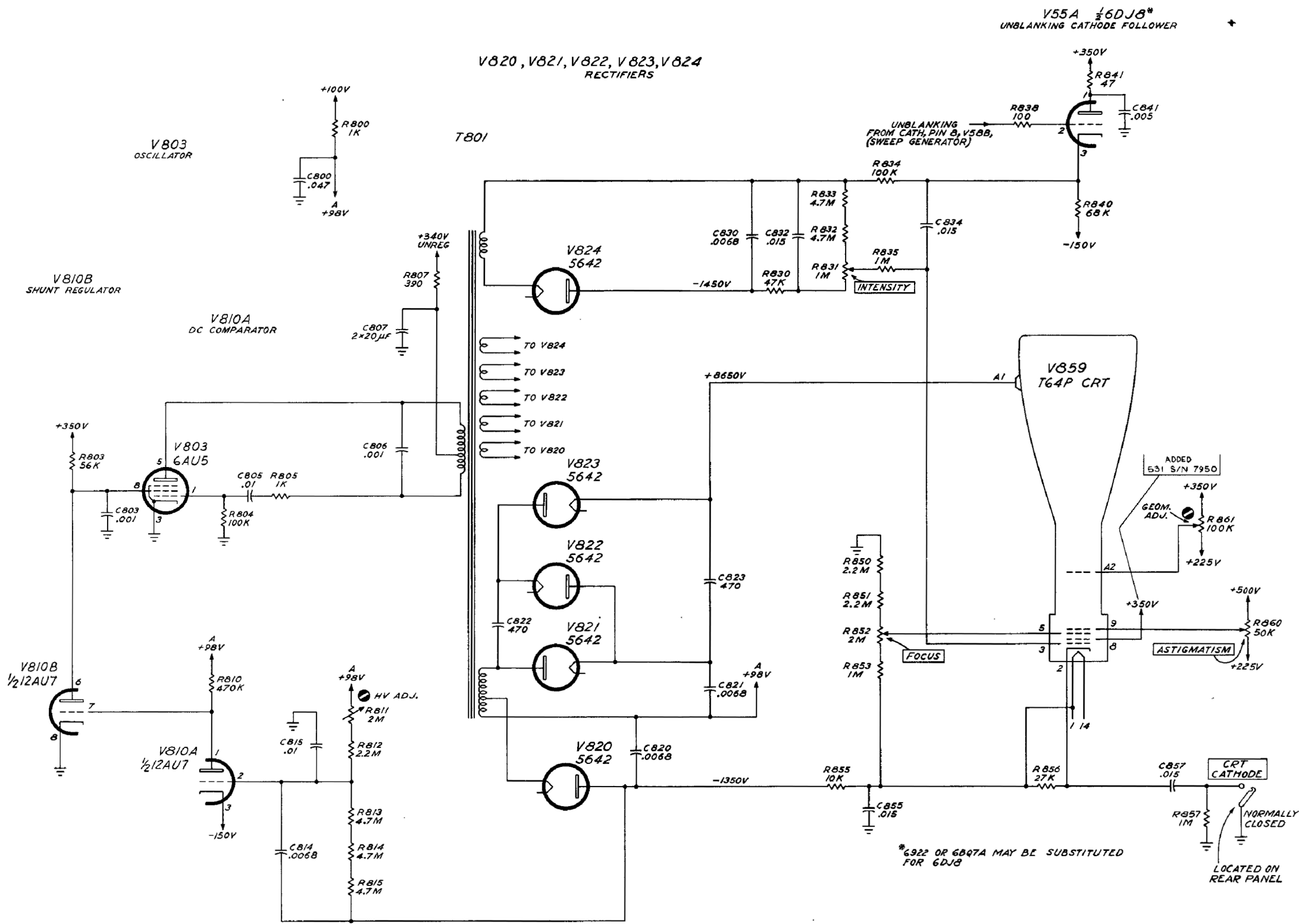
531 S/N 8545 & UP
541 S/N 7485 & UP

A A

CALIBRATOR

4-10-59
KF

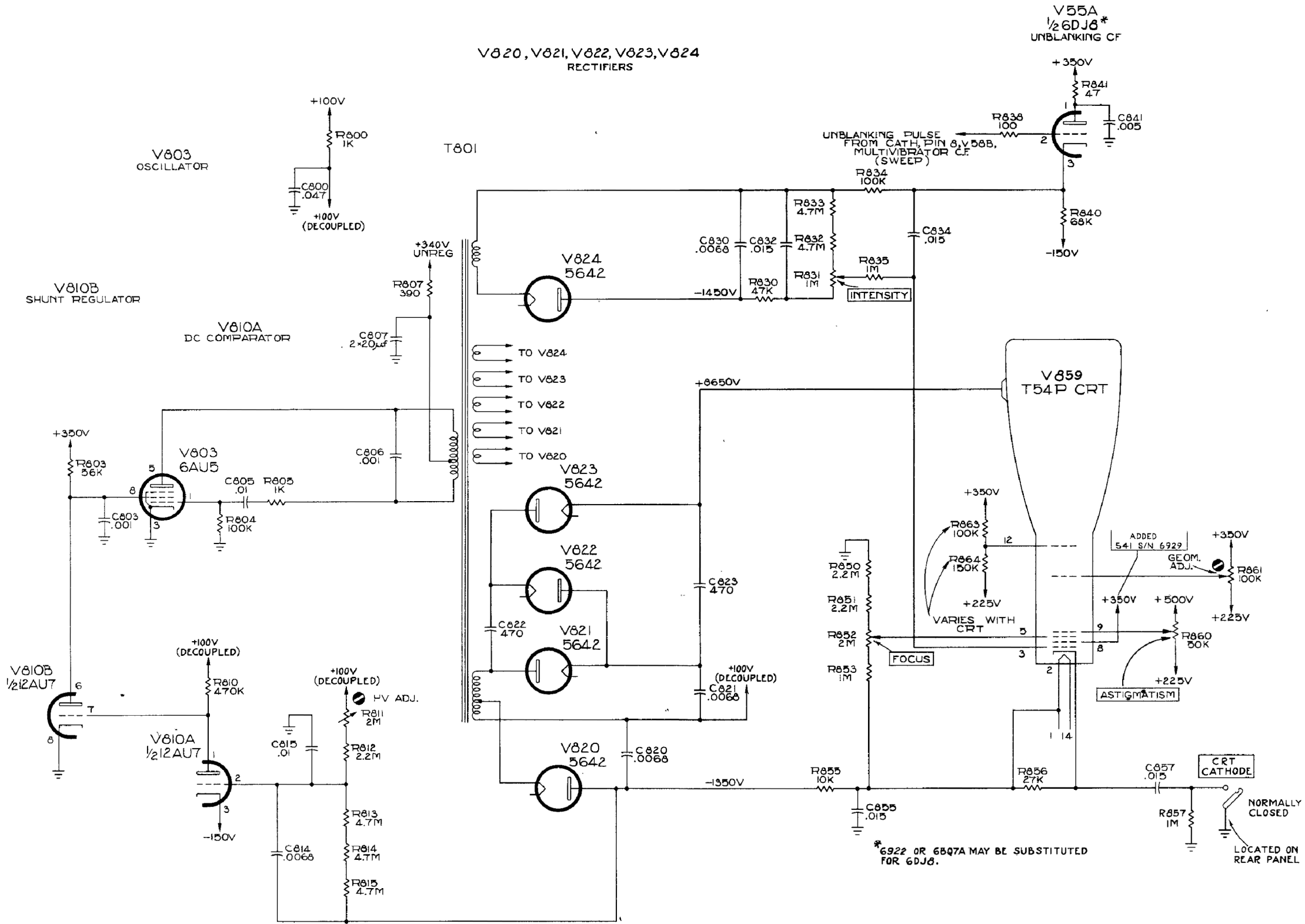
V820, V821, V822, V823, V824
RECTIFIERS



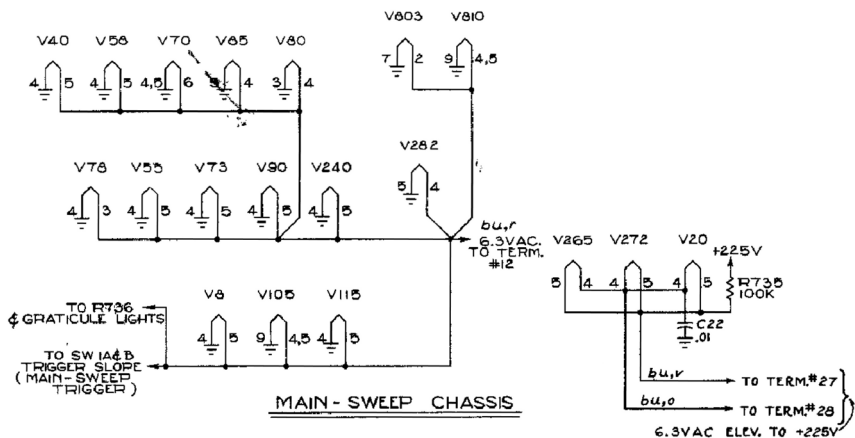
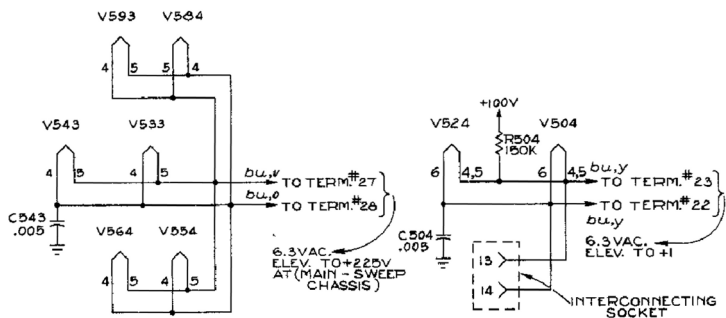
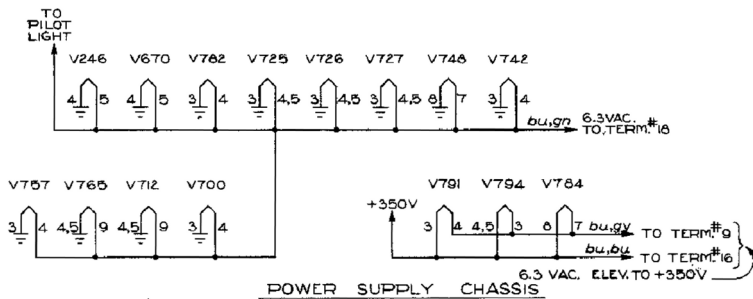
*6922 OR 6BQ7A MAY BE SUBSTITUTED FOR 6DJ8

CRT CATHODE
NORMALLY CLOSED
LOCATED ON REAR PANEL

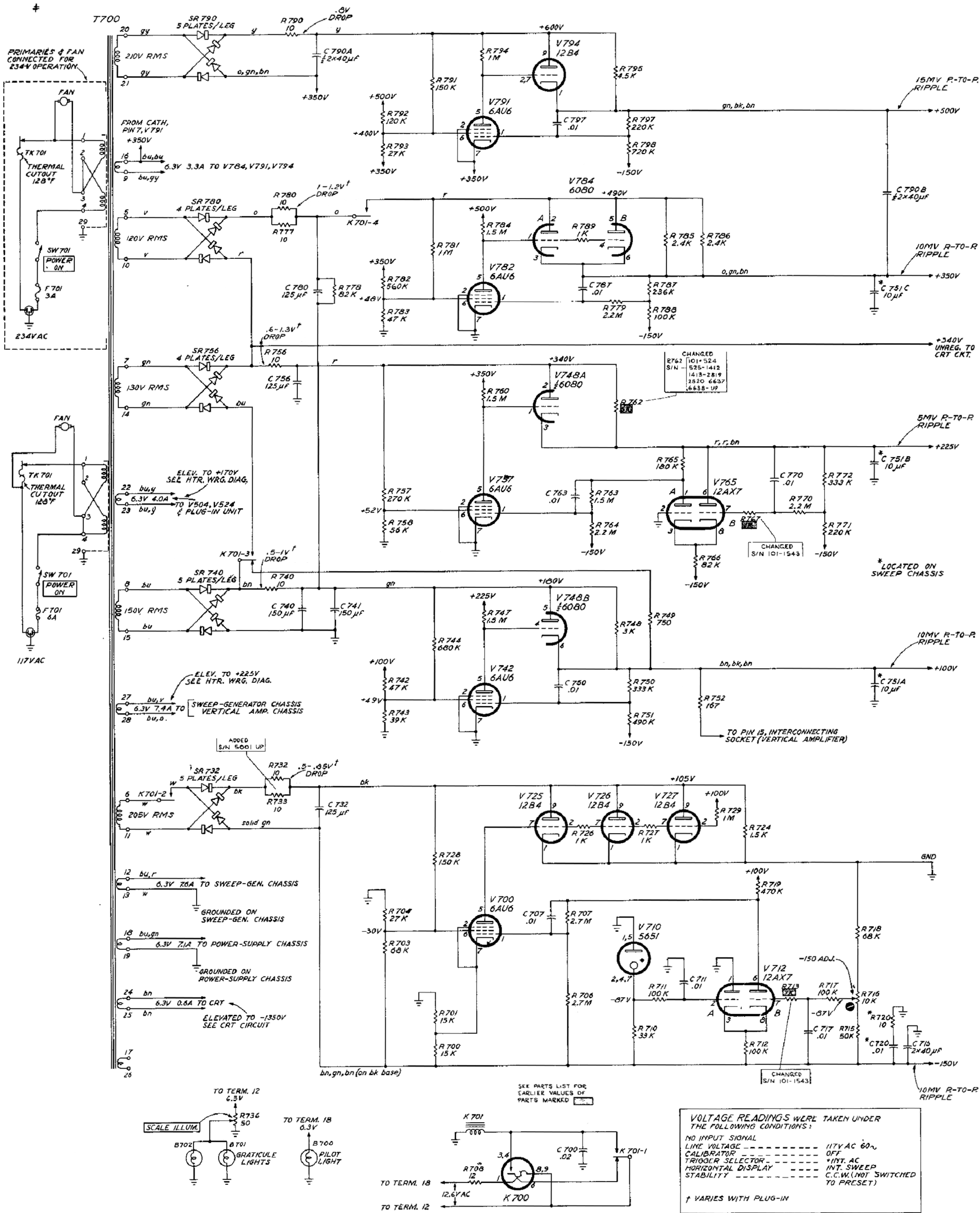
V820, V821, V822, V823, V824
RECTIFIERS

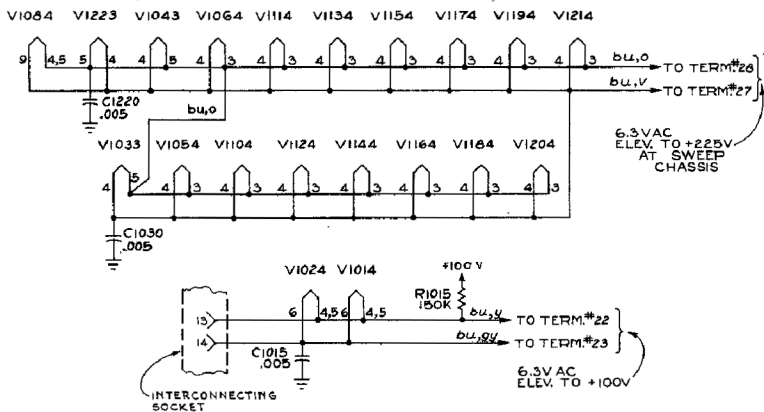
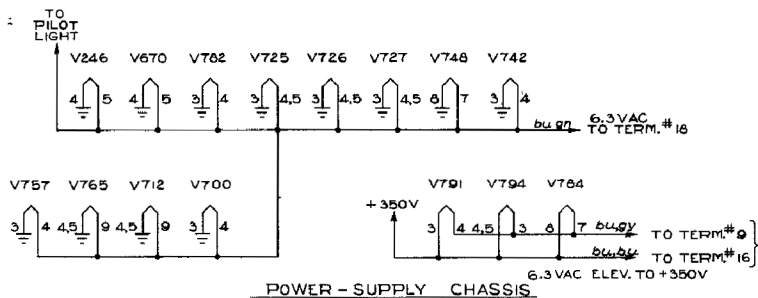


R.O.V
12-10-58

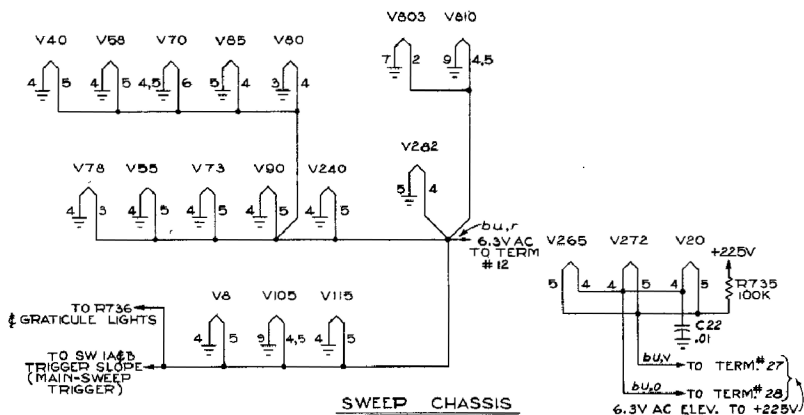


R.O.W.
12-6-66





VERTICAL AMPLIFIER CHASSIS



R. O. W.
12-10-58

PRIMARIES & FAN CONNECTED FOR 234V OPERATION

THERMAL CUTOUT TYPE SE-II 128°F

TK701

SW 701 POWER ON

F701 3A

234V AC

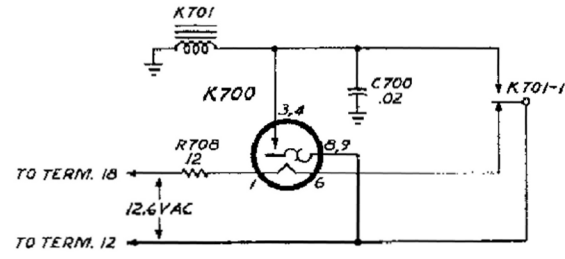
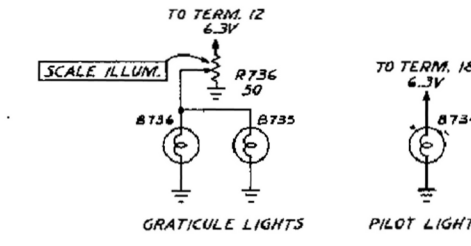
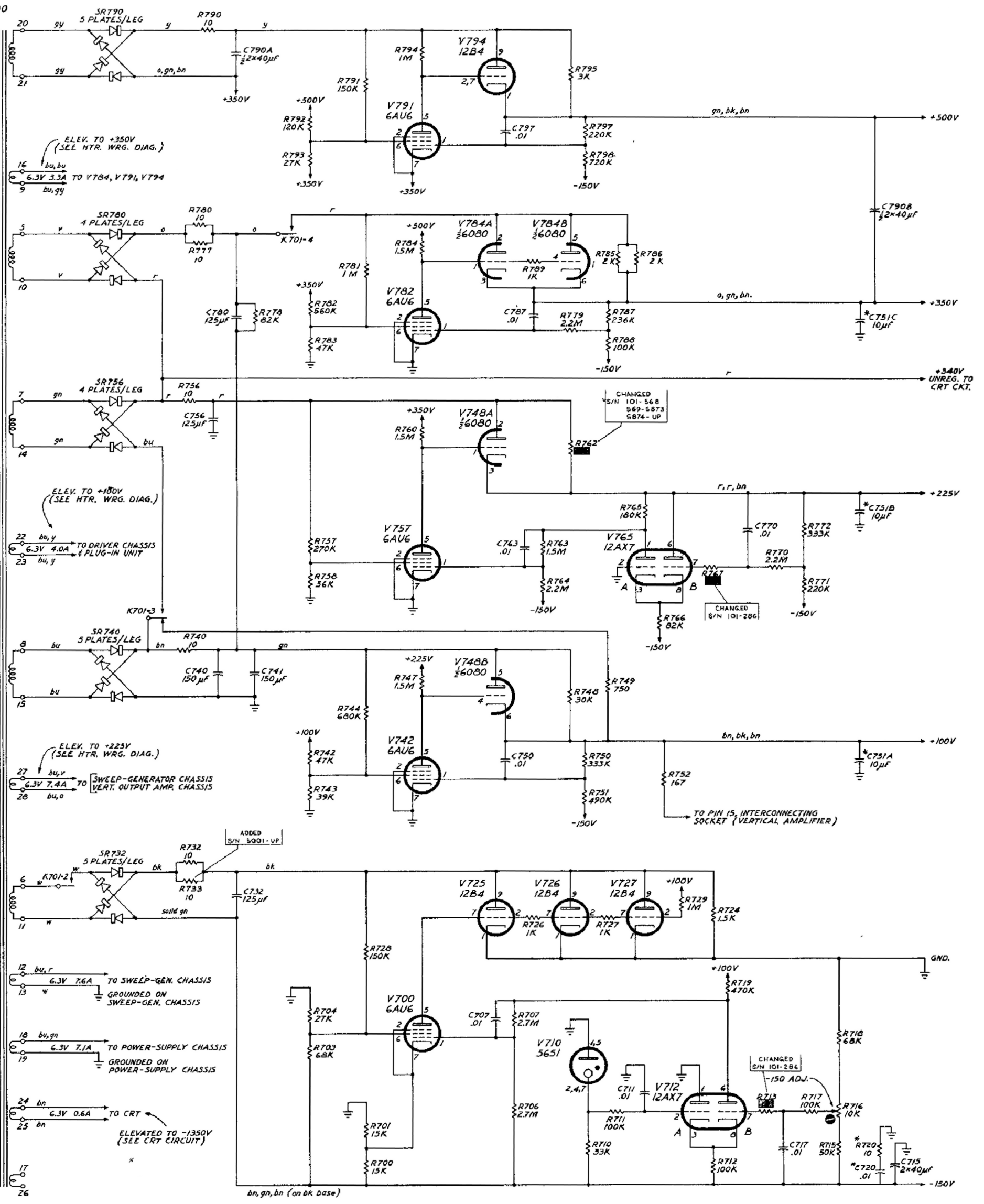
THERMAL CUTOUT TYPE SE-II 128°F

TK701

SW 701 POWER ON

F701 6A

117V AC



SEE PARTS LIST FOR EARLIER VALUES OF PARTS MARKED

*LOCATED ON SWEEP CHASSIS