Ser. No. 640

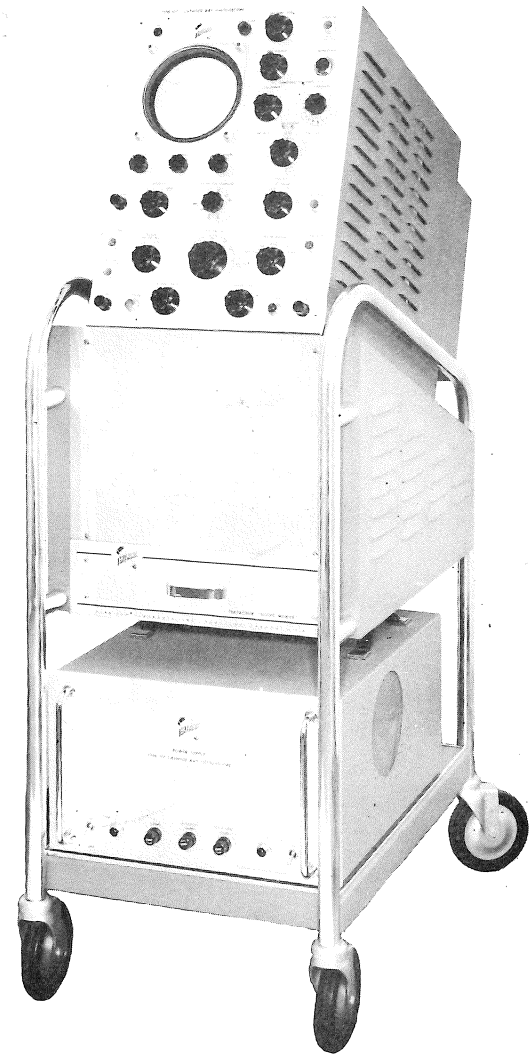
TEKTRONIX

TYPE 517

CATHODE-RAY OSCILLOSCOPE

INSTRUCTION MANUAL

CAUTION
SEE SECT. I P. I
SECT. II P. I



TEKTRONIX Inc.

Manufacturers of Cathode-Ray and Video Test Instruments

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SECTION I

General Description

The TEKTRONIX Type 517 Oscilloscope is a wide-band high-voltage cathode-ray oscilloscope designed primarily for observing and for photographically recording waveforms having extremely short rise times.

The use of a 24-kv accelerating potential on a metallized cathode-ray tube permits photographic recording of single sweeps at the maximum writing-rate permitted by the vertical amplifier and sweep circuits. Distributed vertical amplifiers provide a rise-time of 7 millimicroseconds and a sensitivity of .1 v/cm. Both amplitude and time calibrations are provided. Sufficient time delay is incorporated in the vertical amplifier to permit viewing the leading edge of the waveform which triggers the sweep.

The Type 517 consists of two units, indicator and power supply, mounted on a Scope-Mobile, thus making a convenient mobile unit. If desired, the units may be lifted off the Scope-Mobile for bench use.

Characteristics

Vertical Amplifier System

Type

Five stages of distributed amplification; 4th and 5th stages are push-pull.

Transient Response

Rise time between 10 per cent and 90 per cent amplitude points is 7 millimicroseconds (.007 microseconds). Response is free of ringing and overshoot.

Sensitivity

The maximum vertical amplifier sensitivity with a 5XP cathode-ray tube* operated at 24-kv accelerating potential is .1 v/cm without a probe. With a cathode follower probe, the maximum sensitivity is .2 v/cm.

Attenuator

A continuous control with a range of attenuation from 1X to 2X is provided in the vertical amplifier. Three screw-on attenuators are provided for use in conjunction with the cathode follower probe. A step attenuator with a characteristic impedance of 170 ohms is also provided.

Input Impedance

Input impedance direct is 170 ohms resistive. Impedance looking into probe is a 12-megohm resistor paralleled by a 5 $\mu\mu$fd capacitance. Higher impedance values can be had depending upon capacitive attenuator used ahead of probe.

Signal Delay

Delay line of RG63U coaxial cable contributes 65 mμsec delay. This, plus the inherent delay of the distributed vertical amplifier stages, makes an approximate total signal delay of 120 mμsec. This signal delay permits the sweep to be triggered and under way before the signal is applied to the vertical deflection plates.

Position Control

With 24-kv accelerating potential, the vertical positioning control moves the trace $\pm$2 cm from the center line.

Amplitude Calibrator

Pulse generator output of about 25 kc available on the front panel, with six ranges from .15 to 50 v peak full scale. Accuracy is within 4 per cent of full scale.

Sweep Circuit

Type

Triggered, hard-tube bootstrap sweep circuit with inverter to produce balanced deflection.

Rates

An eleven-position switch selects 10, 20, 50, 100, 200, or 500 MILLIμSEC PER CM, and 1, 2, 5, 10, or 20 MICRO SEC PER CM, with a maximum displacement error of 2 per cent for 8-cm sweep length.

Duty Cycle Limitation

The duty cycle of the sweep system should not be greater than about 20 per cent to avoid exceeding the dissipation limits of some of the sweep circuit components.

*With a nominal tube vertical deflection sensitivity of 38 v/cm.

The following table shows the maximum permissible repetition rate for each of the available sweep times per centimeter.

Sweep Time	Maximum Repetition Rate
20 μsec/cm	1.5 kc
10 μsec/cm	3. kc
5 μsec/cm	6. kc
2 μsec/cm	10. kc
1 μsec/cm	20. kc
500 mμsec/cm	50. kc
200 mμsec/cm	50. kc
100 mμsec/cm	50. kc
50 mμsec/cm	50. kc
20 mμsec/cm	50. kc
10 mμsec/cm	80. kc

Sweep Starting Time

Approximately 90 mμsec for the average instrument. A total signal delay of approximately 120 mμsec permits the sweep to be triggered and underway before the signal is applied to the vertical deflection plates.

Triggering

A trigger amplifier in conjunction with a selector switch permits the sweep circuit to be triggered from:
(a) an external source of either polarity
(b) internal trigger rate generator
(c) the observed signal

The trigger amplifier is connected ahead of a signal delay cable which permits complete observation of the signal at the highest sweep speed. Any signal giving 0.3 cm deflection, or an external 0.3 v peak signal, will trigger the sweep.

Horizontal Position Control

With 24-kv accelerating potential, the horizontal position control moves the trace approximately 5 cm.

Horizontal Position Vernier

In addition to the normal horizontal positioning control, a vernier control calibrated in millimeters provides accurate measurements over a range of 1 cm for use in measuring rise time, etc.

Trigger Rate Generator

Trigger selector switch permits sweep to be triggered from rate generator which also provides external pulses with following characteristics:

Polarity .... positive
Length ....0.4 μsec
Rise time ....0.15 μsec
Output level 60 v with 200 ohms internal impedance
20 v with 50 ohms internal impedance
Repetition rate......15-15,000 cps variable in three ranges within 5 per cent of full scale.

Gate Out

Twenty-five volt positive pulse with duration approximately equal to time of the sweep, and rise time 0.03 μsec, from a cathode-follower source-impedance of 200 ohms.

Power Supplies

Cathode-Ray Tube Accelerating Voltage

An oil-sealed supply of the a-f oscillator type provides 24 kv (+20 kv and —4 kv) for the normal accelerating potentials. A front-panel selector switch gives an alternate choice of 12 kv (+10 kv and —2 kv) which doubles the CRT horizontal and vertical sensitivity. The —4 kv supply is regulated to compensate for load changes and line voltage changes.

Low Voltage Supply

A separate power unit provides all dc voltages of 750 volts and less for the indicator unit. All heater voltages in the indicator unit are regulated by a saturable reactor to compensate for line voltage changes.

Power Requirements

1250 watts at 117 volts. Voltage range 105-125 or 210-250, 60 cycle single phase ac. Three primary circuit fuses are provided for protection against sustained over-load conditions.

Cathode-Ray Tube

A metallized type 5XP cathode-ray tube with P11 phosphor is furnished with the Type 517 unless a P1 or P2 phosphor is specified as the optional choice.

Construction

Contained in two separate units of convenient size, normally mounted on a TEKTRONIX Type 500 Scope-Mobile. Cabinets and chassis are made of electrically-welded aluminum alloy. Photo-etched panels are employed.

Dimensions

Indicator unit: 12½″ wide, 18½″ high, 25½″ deep.
Power unit: 16″ wide, 10″ high, 18″ deep.

Weight

Indicator unit .... 76 lbs.
Power unit .... 72 lbs.
Type 500 Scope-Mobile.................... 42 lbs.

SECTION II

Operating Instructions

The TEKTRONIX Type 517 Oscilloscope may be operated at any normal indoor location or in the open if it is protected from moisture. If the instrument has been exposed to dampness, it should be left in a warm room until it is thoroughly dry before it is placed in operation.

Ventilation

Both units require forced air cooling so that care must be exercised to avoid obstructing the air intakes to the circulating fans.

> WARNING: The Type 517 should not be operated unless the fans are running. The interior will reach dangerous temperatures in five to ten minutes of such operation.

Placing the Type 517 in Operation for the First Time

To place the Type 517 in operation for the first time, the following procedure is suggested:

1. Set the panel controls as follows:

POWER SUPPLY AC	OFF
POWER SUPPLY DC	ON
VERT. POSITION	center
HORIZONTAL POSITIONING, FULL RANGE	center
FOCUS	center
INTENSITY	full counterclockwise
TRIGGER RATE GENERATOR	50
TRIGGER RATE GEN. MULT.	100
SWEEP TIME/CM.	500 MILLIμSEC PER CM
TRIGGER SELECTOR	RATE GEN.
SWEEP STABILITY	full counterclockwise
TRIGGER AMPL.	full counterclockwise

2. Install the interunit power cable and the line-voltage cable. The source of power must be capable of supplying 12 amperes 105 to 125 volts at 60 cycles.

3. The AC POWER switch may now be turned ON.

4. Allow about 30 seconds for the tube heaters to come up to operating temperature.

5. Advance the INTENSITY control almost full clockwise until a spot appears near left center of the screen, then return counterclockwise until the spot just disappears.

> CAUTION: Do not allow this spot to be excessively bright or allow it to remain long in one position as the screen will be damaged in a few seconds.

6. Advance the SWEEP STABILITY control clockwise until a horizontal sweep appears across the screen, then return counterclockwise until the sweep just disappears.

7. Advance the TRIGGER AMPL. control until the sweep just reappears. The sweep is now being triggered by the TRIGGER RATE GENERATOR at a repetition rate of 5000 cycles.

8. Return the INTENSITY control counterclockwise to reduce the beam intensity.

9. Observe a sample signal. RATE GEN. OUTPUT A, after about 50 db of attenuation, will provide a satisfactory signal of the correct amplitude. Turn the TRIGGER SELECTOR switch to +SIG.

10. Adjust the INTENSITY, FOCUS, and ASTIGMATISM controls until a sharp trace with adequate intensity is obtained. These controls are somewhat interdependent and will require slight repeated readjustment to obtain the best trace.

11. Readjust the SWEEP STABILITY and TRIGGER AMPL. controls to obtain a stable trace.

> CAUTION: Check whether the sweep is being triggered or is running self excited, by returning the TRIGGER AMPL. control counterclockwise. The trace should disappear. Because of limitations of duty cycle on some of the components, the sweep generator should not be allowed to run in a self excited condition for extended periods.

12. Adjust the signal amplitude by means of the VERT. AMP. ATTEN. control, or with external attenuators until the vertical deflection amplitude does not exceed 2 centimeters above or below center corresponding to an input of

about 0.2 volts, and adjust the VERT. POSITION and HORIZONTAL POSITION controls for a satisfactory position of the trace.

The instrument should now be ready for application of external signals.

170 OHM Attenuator

This attenuator can be used externally when it is desired to observed signal voltages higher than about 0.2 volts, peak to peak. Both input and output impedances are 170 ohms to match the scope input, and the attenuation calibration is accurate only at this impedance level. Attenuation values up to 64 db, in one-db steps, can be selected.

Cathode-Follower Probe

The probe power plug must be plugged into the PROBE POWER receptacle near the SIGNAL INPUT connector, and the male UHF coaxial fitting must be plugged into the SIGNAL INPUT panel coaxial connector. Three screw-on attenuators are provided.

The screw-on attenuators, used with the cathode follower probe, provide attenuation at high impedance.

Signal Amplitude Calibration

Calibrating voltage is supplied by means of a 25-kilocycle ten-per-cent duty-cycle square-wave generator to the CAL. OUTPUT panel connector. The generator impedance for each CAL. RANGE setting is shown on the front panel. The calibration is accurate on open circuit at the generator and will be affected by the external load to which it is connected. The frequency of the calibrator circuit is not intended to be synchronized with that of the observed wave. Instead, the sweep should be tripped by the TRIGGER RATE GENERATOR and the CAL. OUTPUT should be substituted for the source of the signal being measured. The indication is a pair of horizontal lines displayed across the face of the CRT. The output voltage is capacitor coupled to the deflection plates so that the positions of both the base and the top of the wave vary as the amplitude controls are adjusted. Calibrations are in peak-to-peak volts, and the calibrating wave must therefore be positioned properly when a measurement is made.

Time Calibration

Calibrations for the sweep circuit are in time per centimeter of horizontal deflection, which, with the one-centimeter horizontal graduations of the graticule and the calibrated 1-CENTIMETER HORIZONTAL POSITIONING control, permits measurement of the time dimensions of the displayed pulse to be made to a fraction of a centimeter by interpolation.

Trigger Rate Generator

Calibrations of the trigger rate generator are in cycles per second times a multiplier. To select a desired trigger rate, set the CYCLES/SEC dial to the significant figures, and the TRIGGER RATE GEN. MULT. dial to multiply by 1, 10, or 100 times. Any frequency between 15 cycles and 15 kilocycles can be selected accurately within about 5 per cent.

Use of Type 517 as a Synchroscope

Two output connectors from the trigger rate generator are available on the front panel. To use the Type 517 as a synchroscope output from one of these output connectors can trigger the function to be observed, and the other output can be delayed and applied to the TRIGGER INPUT connector through an external delay circuit to start the horizontal sweep. No variable delay is incorporated in the trigger circuit.

+ Gate

This output is approximately 40 volts at 270 ohms.

Direct Connection to Vertical Deflection Plates

An access hole on the left side of the indicator unit case near the top permits direct connection to the vertical deflection plates. First, remove the clip leads running from the vertical amplifier output stage and replace them with a pair of small wire leads. The leads can be held in place by grooves in the supporting plexiglass plate so as to have low capacitance to each other and to the case.

Scale Illumination

The intensity of the graticule illumination can be adjusted, by means of a variable resistor in series with the graticule light, to suit the conditions of room lighting and trace intensity, and to permit the graticule lines to be photographed.

Functions of Front-Panel Controls and Connectors

6.3V 1A	Phone-tip jack connection from main heater bus. Useful for checking heater-bus voltage regulation. (Do not measure heater voltage on a rectifier type of voltmeter.)
SCALE ILLUM.	Variable resistor controlling brightness of lamps illuminating plastic graticule over face of cathode-ray tube.
VERT. AMPL. ATTEN.	Potentiometer varying grid bias on first and second vertical amplifier stages, permitting a two to one range of gain adjustment.
SIGNAL INPUT	UHF connector to grid line of first stage of distributed vertical amplifier.
VERT. POSITION	Twin differentially-connected potentiometer controlling average potential of cathode-ray tube vertical deflection plates, and thereby adjusting vertical position of trace.
PROBE POWER	Connector providing heater and plate voltage for cathode-follower probe power.
HORIZONTAL POSITIONING, FULL RANGE	Twin differentially-connected potentiometer controlling average potential of cathode-ray tube horizontal deflection plates and thereby adjusting horizontal position of sweep.
HORIZONTAL POSITIONING, 1 CENTIMETER	Twin differentially-connected potentiometer performing same function as above, but limited to one centimeter of positioning, and fitted with a dial calibrated in tenths of a centimeter.
FOCUS	Potentiometer controlling the voltage applied to the focusing anode (No. 1) of the cathode-ray tube for focusing the trace.
INTENSITY	Potentiometer controlling dc grid voltage of the cathode-ray tube and thereby the brightness of the trace.
ASTIGMATISM	Potentiometer controlling the grid bias of cathode-follower V134B to provide adjustable low-impedance source of voltage for anode No. 2 of cathode-ray tube. Proper setting of the voltage of this anode with respect to the deflection plates, permits the spot to be focused sharply in both dimensions simultaneously.
CAL. VOLTAGE	Potentiometer providing a continuously variable voltage to the CAL. RANGE step attenuator. CAL. VOLTAGE dial is calibrated with scales of 0 to 5 and 0 to 15, corresponding to CAL. RANGE full-scale amplitudes.
+ GATE	Binding post connected to positive multivibrator tube via cathode follower V124 to make available externally a positive pulse of the same duration as the sweep.
SENSITIVITY	Two-position switch to select either 24-kv or 12-kv accelerating voltage, and to select appropriate corresponding cathode-ray tube bias and unblanking voltages.
TRIGGER RATE GENERATOR (CYCLES/SEC.)	Variable timing resistor for phantastron trigger-frequency generator.
CAL. RANGE	A six-position step attenuator constructed to give six full-scale amplitudes of the calibrating pulse, 0.15, 0.5, 1.5, 5, 15, and 50 volts.
CAL. OUTPUT	UHF connector to arm of CAL. VOLTAGE potentiometer.
RATE GEN. OUTPUT A	UHF connector from cathode follower V130 providing 50-ohm output from trigger-rate generator.
RATE GEN. OUTPUT B	UHF connector from cathode follower V129 providing approximately 200-ohm output from trigger-rate generator.
TRIGGER RATE GEN. MULT.	Switch for selecting timing capacitors for phantastron trigger-frequency generator.

SWEEP TIME/CM	Gang switch controlling sweep duration and sweep rate. Selects appropriate multivibrator pulse length, and sweep generator charging resistor and capacitor.
TRIGGER SELECTOR	Switch selecting source and polarity of sweep-triggering voltage.
TRIGGER INPUT	UHF connector to —EXT. +EXT. positions of TRIGGER SELECTOR switch, for connection to external trigger sources.
DC POWER	Neon pilot light across negative 250-volt supply in indicator unit.
SWEEP STABILITY	Potentiometer controlling grid bias of negative multivibrator tube. Determines optimum point of triggering.
TRIGGER AMPL.	Potentiometer controlling grid bias on trigger-amplifier second distributed stage and thereby determining amplitude of trigger signal applied to succeeding stage.
HEATERS	Pilot light on indicator unit connected to heater bus.
GND	Two binding posts electrically connected to the front panel.

External Power Supply

AC POWER	ON-OFF switch on power supply unit for controlling ac line voltage to unit, pilot light indicates switch ON position.
DC POWER	ON-OFF switch on power supply unit controlling ac line voltage to primary of plate-supply transformer, pilot light indicates switch ON position.
DC SUPPLIES	6 amp thermal lag fuse.
REGULATED HEATERS	5 amp thermal lag fuse.
POWER SUPPLY HEATERS	3 amp thermal lag fuse.

SECTION III

Circuit Description

TEKTRONIX Type 517 Oscilloscope

Sweep

A linear, triggered sweep is available with eleven fixed, accurately timed sweeps ranging from 0.01 microseconds per centimeter to 20 microseconds per centimeter when a 24-kilovolt accelerating potential is used. When the 12-kilovolt accelerating potential is used, each of these SWEEP TIME/CM figures is halved.

The basic waveform is generated by a pentode clamp with a cathode-follower bootstrap linearity corrector. Push-pull deflection is accomplished at output level by addition of a plate-output unity-gain phase-inverter stage. Figure 1 is a block diagram of the sweep system.

Trigger Phase Changer

A trigger selector switch selects the source of trigger signal and V101 reverses the phase, if necessary, to provide the trigger amplifier with the required negative signal.

Distributed Trigger Amplifier

A broad-band trigger amplifier, capable of passing a steep-wave-front pulse, is used in order to reduce to a minimum the delay between the start of the trigger pulse and the start of the sweep. This amplifier consists of two distributed stages of three 6AK5 pentodes each, V102 to V107. The grids of the second stage, V105 to V107, are driven in the positive direction and the negative-pulse output amplitude of this stage is adjustable by means of the TRIGGER AMPL. control which sets the grid bias level.

Trigger Limiter

The trigger limiter stage operates with zero bias. The negative pulse from the trigger amplifier drives this tube to plate-current cutoff. Choice of the proper value of quiescent plate-current and use of shunt-compensated plate-load resistance of low value results in a very steep positive pulse limited in amplitude to about 10 volts. Thus limited, this pulse does not drive the grid of V109 into the grid-current conducting region.

Trigger Switch Tube

The resulting negative pulse at the plate of V109, coupled through coupling diode V110 to the plate of minus multivibrator tube V111, triggers the sweep.

Trigger-Coupling Diode

The trigger-coupling diode serves to disconnect the plate of trigger-switch tube, V109, from the plate of negative multivibrator tube, V111, when the plate voltage of V111 drops below that of V109.

Multivibrator

V111 and V119 operate as a plate-to-grid coupled monostable multivibrator for the purpose of converting a triggering pulse into a pulse of controllable duration, suitable for operating the sweep generator and unblank-circuits. The SWEEP STABILITY control, by varying the bias on the grid of V111, determines the optimum point of triggering. If there is insufficient bias, the multivibrator will begin to operate self excited at a duty cycle such that the allowable dissipation of the cathode followers may be exceeded. Care should be taken, therefore, not to leave this control at a setting which results in self-excited operation for extended periods.

Sweep Generator Clamp Circuit

In the quiescent state, the parallel clamp tubes, V112 and V113, conduct heavily. The negative pulse from the plate of V111 to their grids interrupts the flow of plate current very rapidly, and the plate voltage then begins to rise at a rate determined by the charging rate of the charging capacitor C129. The charging rate is determined by the values of capacitance and resistance in the charging circuits, both of which are selected by the SWEEP TIME/CM selector switch, S103, for the various sweep times. The series inductor in the grid circuit of the clamp tubes provides a 10-millimicrosecond delay to enable the unblanking circuit to reach full voltage before the sweep voltage starts.

Bootstrap Cathode Follower

The voltage rise across the charging capacitor in the foregoing circuit would be exponential if no provision were made to keep the charging current from varying during the sweep. The charging current is kept more nearly constant by the bootstrap action of V115 and V116, and sweep cathode follower, V117, which tends to keep the voltage constant across the charging resistor for the duration of the sweep.

Decoupling Diode

A decoupling diode, V114, a 6X4 in series with the plus 475-volt supply to the clamp tubes, offers low resistance to the passage of the quiescent-state current to the clamp tubes, but disconnects the positive end of the charging resistor from the 475-volt supply when bootstrap action raises the cathode of V114 above 4.5 volts.

Plus-Sweep Cathode Follower

V117, a cathode follower, provides the positive sweep voltage to the cathode-ray tube, as well as to the grids of the bootstrap tubes and to the sweep-inverter stage.

Sweep-Inverter

A unit-gain amplifier is used as a phase inverter to provide the negative portion of the sweep voltage. This stage consists of V118, a 6AG7, with gain maintained near unity by use of frequency-compensated feed-back.

Bias and Screen Adjust

V137, a 12AU7, provides a low-impedance bias voltage and screen voltage for the sweep inverter stage, V118.

DC Restorer

V133, a 6AL5 dual diode, removes the accumulated charge from the sweep-coupling capacitors, permitting the sweep to start at the same position on the cathode-ray tube regardless of the repetition rate of the sweep.

Unblanking Amplifier

During the waiting periods between sweeps, the bias on the cathode-ray tube is such that the beam current is completely cut off. As soon as a trigger pulse appears and the sweep starts, a positive pulse of approximately 100 volts is required on the cathode-ray tube grid to turn the beam back on. This pulse must have a very fast rise time and a very flat top to insure fast unblanking and uniform image brightness. Both conditions are accomplished by means of the unblanking amplifier, V120 and V121, two 6AG7's in parallel, and associated output cathode follower, V123. For the 10 MILLIμSEC PER CM setting, an inductance ringing circuit is inserted at the grid of the unblanking tube to provide a sufficiently sharp unblanking pulse. This circuit consists of a 300-microhenry inductance from the grids of the unblanking amplifier tubes to ground through a 100-ohm resistor. The negative pulse of the multivibrator starts the circuit ringing in the negative direction. One-half cycle of the oscillation is a satisfactory period of unblanking. Grid current damps out further oscillation during the positive half cycle since the unblanking amplifier tubes operate at zero bias.

Unblanking Cathode Follower Output

V123 provides low-impedance output for the unblanking amplifier.

Plus Gate Cathode Follower

V124 is a 6J6 cathode follower whose grid is coupled to the plate of the positive multivibrator tube V110. The output of the cathode follower connected to a front-panel binding post provides a positive 50v gating pulse of the same duration as the sweep.

Unblanking Amplifier Screen Supply

V122 is a cathode follower supplying the screen voltage to the unblanking amplifiers. The use of this circuit permits the unblanking voltage to be reduced to half when the cathode-ray tube is operated at a 12-kv accelerating potential. The grid voltage of V122 is controlled by the SENSITIVITY switch.

Trigger Rate Generator

An internal trigger generator provides positive pulses to two front-panel connectors labeled RATE GEN. OUTPUT A, and RATE GEN. OUTPUT B. OUTPUT A provides 20 volts at 50 ohms and OUTPUT B provides 60 volts at 200 ohms. The purpose of these circuits is to make available, externally, trigger pulses of accurate repetition rate to permit use of the Type 517 as a synchroscope.

The frequency of the trigger circuit is determined by a self-excited screen-coupled phantastron, V126, a 6BH6. A cathode follower, V127A, one-half of a 12AU7, provides a low-impedance path for recharging the phantastron charging capacitors. The other half of this tube, V127B, provides a coupling means from the phantastron to the blocking oscillator, V128, a 12AU7. One half of V125, a 12AU7, is a cathode follower providing a low-impedance bias source for the other half which serves as a plate-catching diode for phantastron V126. The output pulse is formed by the blocking oscillator, V128, and is coupled to the RATE GEN. OUTPUT A and the TRIGGER SELECTOR switch via cathode follower V130, a 12AU7, and to RATE GEN. OUTPUT B via cathode follower V129, a 12AU7.

Vertical Amplifier

The vertical deflection system consists of five stages of distributed amplification in cascade with a phase inverter preceding the fourth stage. The first three single-ended stages provide drive to a coaxial signal-delay cable and to the sweep trigger amplifier. Following the signal-delay cable, the phase inverter provides push-pull drive for the remaining two push-pull distributed stages. Figure 6 a simplified schematic of the vertical deflection system. The first two stages employ 6AK5 tubes with bias voltage adjustable to provide a gain control of two to one. The remaining stages employ type 6CB6 tubes. As shown on the simplified schematic of Figure 6, a parallel R-C network is inserted between the second-stage plate line and the third-stage grid line. This network deemphasizes the low frequencies to compensate for high-frequency losses in the amplifier system. An R-L network with a time constant of about 0.05 microseconds in the reverse termination of the first stage plate line and a similar correcting network of about 0.3 microseconds time constant in the reverse termination of the second stage plate line compensate for a time-constant effect resulting from a time variation of the electrolytic by-pass capacitors in the amplifier system. The latter network may have either capacitive or inductive reactive elements depending upon the need.

Vertical Amplifier DC Supply Distribution

Figure 9 is a simplified diagram showing dc distribution to the plates and screens of the various stages of the vertical amplifier and current consumption and normal ripple voltage at each of the four voltage levels.

External Power Supply

All voltages of 750 and less are provided by an external power supply. Distribution of the voltages, and the nominal load current at each voltage are as follows:

Negative 250 volts, regulated (50 ma)

a. bias voltages
b. negative positioning voltage
c. voltage reference supply for other voltage regulators

Positive 150 Volts, regulated (550 ma)

a. plate voltage for distributed trigger amplifier
b. plate and screen voltage for all vertical amplifiers except plates of output stage

Positive 180 Volts, unregulated (250 ma)

plate voltage only for vertical output amplifier

Positive 225 Volts, regulated (450 ma)

a. trigger phase changer
b. trigger limiter and switch tube
c. unblanking amplifier
d. positive multivibrator
e. negative multivibrator and clamp tube, screens only
f. calibrator circuit voltages
g. trigger rate generator voltage
h. filament oscillator tube for CRT high-voltage supply
i. positive vertical positioning voltage
j. probe voltage supply via a cathode follower
k. plate voltages for plus gate tube

Positive 365 Volts, unregulated (100 ma)

plate and screen supply for CRT high-voltage-supply oscillator

Positive 475 Volts, regulated (150 ma)

a. plate voltage for minus multivibrator
b. plate voltage for clamp tubes via 6x4 decoupling diode
c. plate voltage for unblanking cathode follower
d. screen voltage for sweep inverter via cathode follower
e. positive vertical positioning voltage

Positive 750 Volts, regulated (50 ma)

a. plate voltage for positive sweep output cathode follower
b. plate voltage for bootstrap cathode follower
c. plate voltage for sweep inverter tube

Filament Voltage Regulator

Heater voltages of all tubes located in the indicator unit are regulated by automatically controlling the primary voltage of the filament transformer, T901, located in the indicator unit. The transformer primary voltage is controlled at a nominal 80 volts by a variable-reactance saturable reactor, located in the external power supply unit, connected in series with the line-voltage source and the transformer primary. Reactance of the saturable reactor is controlled by varying the direct current through an auxiliary winding in accordance with line-voltage variations. These variations of ac line voltage are converted into the required variations of direct current by means of an emission-sensitive diode whose filament is supplied from the regulated transformer, T901. In the schematic, Figure 13, V419, a Sorenson Type 2AS-15, is the emission-sensitive diode. The plate resistance of this tube varies rapidly with filament voltage, and in the opposite sense, so that the directly-connected grid of V420, a 6AU5, drops in voltage, when, for example, the filament voltage increases. This results in a reduction of current through the auxiliary winding of the saturable reactor, which is a part of the plate load of V420. The resulting increase in reactance of the saturable reactor reduces the ac voltage available to the transformer primary and tends to maintain the diode filament voltage at a constant level. Capacitor C417, between grid and plate of V420, is a feedback circuit which compensates for the 120-cycle voltage at the plate of V419 resulting from 120-cycle modulation of filament temperature of V419. It should be noted that filament-winding terminals 5 and 6 on T901 are at minus 250 volts dc. This is necessary because the dc coupled plate of V419 is at approximately ground potential and its directly-heated filament is therefore depressed to provide the required cathode-to-plate potential difference.

Negative 250-Volt Regulated Supply

This supply voltage is regulated by comparing the voltage of V418, a type 5651 gas diode, to that of a voltage divider connected across the regulated output, through comparator tube V417, a 6AU6. The difference voltage is amplified in V417, and applied to the grid of V416, a 6AU5 series regulator tube in the positive lead. V415 is a type 6X4 connected as a full-wave rectifier.

Positive 150-Volt Regulated Supply

This supply voltage is regulated by comparing to ground, the voltage of a point near ground potential on a voltage divider connected between the positive 150-volt bus and regulated negative 250 volts, through comparator tube V422, a 12AX7. The difference voltage is further amplified in V414, a 6AU6, and applied to the grids of series regulator tubes, V412, V413, and V421, three 6AS7's in parallel. The additional gain provided by V422 is necessary to reduce the output ripple voltage to a satisfactorily low level. Four ten-plate selenium rectifiers are used in a bridge circuit. A tap, taken off ahead of the series regulator tubes, supplies a nominal 180 volts at 250 ma, unregulated, from the same rectifier.

Positive 225-Volt Regulated Supply

This supply voltage is regulated by comparing to ground potential, a point near ground potential on a voltage divider connected between the positive 225-volt bus and regulated negative 250 volts, through comparator tube V411, a 6AU6. The difference voltage is amplified in this tube, whose plate is directly connected to the grids of V409 and V410, two 6AS7 series regulator tubes in parallel. Four ten-plate selenium rectifiers are used in a bridge circuit. An unregulated tap at plus 330 volts is taken off ahead of the regulator to supply dc saturation current for the saturable reactor in the filament voltage regulator.

Positive 365-Volt Unregulated Supply

This unregulated supply uses V407 and V408, two 6X4's in parallel, in a full-wave rectifier circuit with capacitor input. The ac voltage for this supply is obtained from taps on the transformer that supplies ac for the positive 475-volt regulated supply.

Positive 475-Volt Regulated Supply

This supply is regulated by comparing to ground potential, a point near ground potential on a voltage divider connected between the 475-volt bus and regulated negative 250 volts through comparator tube V406, a 6AU6. The difference voltage is amplified in V406 whose plate is directly connected to the grids of V405, two halves of a 6AS7 series regulator tube in parallel. V404, a 5R4GY rectifier, is connected in a full-wave circuit. The ac voltage for this supply is obtained from the outside taps of the same transformer that supplies the 365-volt unregulated supply. R476, 7.5k shunting the regulator tube increases the available current.

Positive 750-Volt Regulated Supply

This supply is regulated by comparing to the previously-described 475-volt supply, the voltage near 475 volts of a voltage divider connected between the 750-volt bus and ground, through comparator tube V403, a 6AU6. The difference voltage is amplified in V403, and applied to the grid of V402, a triode-connected 6AU5 series-regulator tube. V401, a 6X4 rectifier, is connected in a full-wave circuit. The unregulated output of this portion of the circuit is approximately 425 volts, which, added to the unregulated 580-volt portion of the 475-volt supply, results in a potential of approximately 900 volts to ground at the plate of V402.

> NOTE: The capacitor between the regulated bus and the grid of the reference tube in each of these supplies is for the purpose of increasing the ac gain of the regulator circuit loop.

AC and DC Power Distribution

Figure 17 is a diagram showing the inter-chassis wiring and the test panel at which currents at the various voltage levels can be measured.

Cathode-Ray Tube Circuit

The schematic diagram of the cathode-ray tube intensity, astigmatism, and focus circuits is shown in Figure 16. The NE2 neon glow lamps across the INTENSITY control potentiometer and Max. Intensity Adj. variable resistor maintain the INTENSITY potentiometer terminal voltage constant regardless of cathode-ray tube cathode current, thereby stabilizing the intensity adjustment. Two of the four neon glow lamps are shorted out by the SENSITIVITY switch when it is turned to the 12-kv position. This reduces the maximum cathode-ray tube bias available by a factor of two at the lower accelerating voltage. The purpose of the Max. Intensity Adj. variable resistor is to adjust the minimum grid bias setting available by the INTENSITY control to a safe value thus preventing damage to the cathode-ray tube screen in case the INTENSITY control is advanced too far. The ASTIGMATISM control potentiometer controls the grid bias of cathode follower V135B to provide an adjustable low-impedance source of voltage for anode No. 2 of the cathode-ray tube.

Type 420 High Voltage Power Supply

All the accelerating potentials for the cathode-ray tube are provided by a high-voltage supply employing an audio oscillator operating at a frequency of approximately 1.8 kilocycles. Four type 1X2 high-voltage rectifier tubes in a voltage quadrupling circuit provide positive 20 kilovolts. Voltage divider resistors provide 13.3 kilovolts and 6.6 kilovolts positive. A single 1X2 in a half-wave rectifier circuit provides negative 4 kilovolts. The high-voltage rectifiers, capacitors, resistors, and transformers are all oil-immersed. Figure 15 is a schematic of the supply.

High-Voltage Oscillator and Regulator

The high-voltage oscillator plate voltage is regulated to maintain a constant negative 4 kilovolts of rectified output so that deflection sensitivity of the cathode-ray tube will not be affected by line-voltage or load changes.

Figure 14 is a block diagram of the high-voltage oscillator and regulator system. A tap on the negative 4-kilovolt portion of the power supply is compared to a regulated negative 250-volt source through V302A, one section of a 12AU7. The other section of this tube, V302B, amplifies the difference voltage and applies it to the grids of the series regulator tubes, V301 and V307 in parallel, which control the plate voltage of oscillator V303, a 6AU5.

V305, a 6C4, provided with an R-C network in its grid circuit, depresses the grids of the series regulator tubes, V301 and V306 when power is first applied, and then slowly allows the grids to assume their normal regulating voltage depending on the time constant of the R-C network. This circuit delays application of full accelerating voltage to the cathode-ray tube, thus preventing "flare" when the instrument is turned on with the INTENSITY control at normal setting.

Filament-Voltage Oscillator

Filament voltage for the five 1X2 high-voltage rectifiers, is supplied by means of a separate oscillator circuit with V304, a 6AQ5.

Calibrator

The signal-amplitude calibrating unit consists of a self-excited unsymmetrical multivibrator operating at a frequency of about 25 kilocycles. The positive pulse, about 3 microseconds long, is clipped in diode V135A at a level determined by the setting of the grid voltage of cathode follower V135B on the Cal. Adjust potentiometer. The negative portion of the pulse is clamped at ground potential by a 1N34 crystal diode. A potentiometer labeled CAL. VOLTAGE in the cathode circuit of cathode follower V132 provides a continuously-variable pulse amplitude to cathode follower V131. A six-position step attenuator in the cathode circuit of V131, labeled CAL. RANGE provides six voltage range steps.

170-OHM Attenuator (Type B170-V)

This device consists of a series of resistor pi pads which can be selected by means of frequency-compensated toggle switches. The nominal impedance of the box is 170Ω to match the impedance of the scope input and of the probe cable.

The inductors between switches compensate for switch capacitance to approximately 150 mc. Additional rise time, contributed by use of the attenuator to the overall step response of the Type 517, is of the order of 0.3 mμsec.

Input and output connectors are chassis-mounted female UHF coaxial fittings.

Cathode-Follower Probe

The Type P-170-CF Probe provides high-impedance input to the Type 517. The circuit diagram is shown in Figure 19. The probe consists of a type 5718 miniature triode enclosed in a brass housing, connected to the Type 517 by means of a 40-inch flexible cable. Cathode output from the cathode follower is fed through 170Ω coaxial cable to the 170Ω input of the Type 517. The cathode resistor for the cathode follower consists of the 170Ω grid-line termination of the distributed preamplifier. The cable is also provided with a four-prong power plug which plugs into a socket near the 170Ω coaxial input of the Type 517 to provide 120 volts dc at 9.5 milliamps and 6.3 volts ac at 150 milliamps, for plate and heater power for the type 5718 tube.

Three screw-on capacitive attenuators, I, II, and III, each adjustable over a ten-to-one range by means of a screwdriver adjustment in the nose of the attenuator, make available the following voltage sensitivities and attenuation ranges:

	Voltage Sensitivity	Attenuation
170Ω input	.1 to .2 volts/cm	0
Probe alone	.2 to .4 volts/cm	2:1
Attenuator I	.4 to 8.0 volts/cm	2:1 to 20:1
Attenuator II	4.0 to 80 volts/cm	20:1 to 200:1
Attenuator III	40.0 to 800 volts/cm	200:1 to 2000:1

The input admittance of the probe alone consists of a capacitance of 5μμf shunted by a 12 megohm, ½ watt Allen Bradley resistor. The minimum input capacitance of the attenuators is of the order of 1μμf.

Input capacitance of the capacitive attenuators when attached to the probe are shown in the following table. The sensitivities listed are for a full-right setting of the VERT. AMPL. ATTEN. control of the Type 517. The capacitance values were measured using actual production attenuators, but capacitance of individual attenuators may depart somewhat from the values listed.

Attenuator Number	Attenuator Sensitivity Setting	Input Capacitance
I	0.4 v/cm	5.0 μμf
	4.0	1.2
II	4.0	5.0
	40	1.2
III	40	3.0
	400	1.1

Intermediate settings of attenuators between the settings listed will result in intermediate values of input capacitance.

SECTION IV

Maintenance and Adjustment

Maintenance

Care must be taken to assure free ventilation of both units inasmuch as some of the components are operated at dissipation levels such that excessive temperatures will result without adequate air circulation.

To assure free passage of air units should be placed so that the air intakes are not blocked by other apparatus or furniture, and the filters should be kept clean.

Washable Lumaloy Air Filters are used at the air intake ports of both units. The following filter cleaning instructions are given by the filter manufacturer:

"To Clean:

(1) If grease or dirt load is light, remove filter from installation and flush dirt or grease out of filter with a stream of hot water or steam.

(2) If load is too heavy for treatment in (1) above, prepare mild soap or detergent solution (see paragraph below on use of caustics) in pan or sink deep enough to cover filter when laid flat. Agitate filter up and down in this solution until grease or dirt is loosened and carried off filter.

(3) Rinse filter and let dry.

(4) Dip or spray filter with fresh Filter Coat, or other approved adhesive. Filter Coat is available from the local representative of RESEARCH PRODUCTS CORP. in the one-pint Handi-Koter with spray attachment or one-gallon and five-gallon containers.

In most cases hot water, steam, or hot water and mild soap solution (Ivory, Dreft, Vel, etc.) is all that is needed to restore the dirt or grease laden filter to its original sparkling lustre. However, where extreme conditions are encountered with higher-than-average dirt or grease loads or where maintenance of the filters has been neglected, allowing an accumulation of hard grease or caked dirt, more comprehensive cleaning steps may be taken.

CAUTION: IN CASES OF THIS KIND, USE OF CAUSTICS WITHOUT RECOMMENDED INHIBITORS ADDED IS DAMAGING TO THE FILTER.

(For information on correct procedure, write the Research Products Corporation stating name of cleaning agent and concentration.) Certain nationally known and nationally distributed cleaners are approved for use in dish-washers, cleaning tanks or filter service company equipment. Following is a partial alphabetical list of cleaners already tested and approved by Research Products Corporation:

CLEANER	*MAKER*
Calgonite	*Calgon, Inc.*
K O L	*DuBois Company*
Oakite Composition No. 63	*Oakite Products, Inc.*
Pan Dandy	*Economics Lab., Inc.*
Super Soilax	*Economics Lab., Inc.*
Wyandotte Kecgo	*Wyandotte Chem. Corp.*

Non-inclusion of any other cleaners is not intended to indicate their being unacceptable. For specific information on other products, write the Research Products Corporation, Madison 10, Wisconsin."

Analyzing Trouble

Tube Replacement

A good percentage of the troubles that occur are likely to be found in the tubes and it is therefore advisable to check tubes before extensive tests are made on other components. Tube checks can be made by substitution in many cases. Tube failures may result in failure of other components or may be caused by failure of other components so that it is advisable to examine all components associated with an offending tube.

Selected tubes are used in several positions in the Type 517 as follows:

6AK5-V501 thru V512, distributed preamplifier
-V102 thru V107, distributed preamplifier
6CB6-V501 thru V519, distributed preamplifier
-V521 thru V523, distributed preamplifier
-V520.......... trigger pick off
6BH6-V126, trigger rate generator phantastron
6J6 -V101 ....trigger selector
NE-2 - Neon Glow Lamps, CRT bias

6AK5: Selected for normal or better Gm and for low microphonics for all tube positions.

6CB6: Selected for low grid current, and for normal plate current. Above-normal grid current loads the grid lines of the distributed amplifier and disturbs the line impedance. Tubes which exhibit plate current above or below normal are potentially unstable.

6BH6: The trigger rate generator phantastron, V126, must have suppressor grid characteristics within close limits. A good percentage of these tubes are satisfactory however.

6J6: The trigger selector phase changer 6J6, V101, requires equal sections so that both positive and negative pulses will receive equal amplification within about 20 per cent.

NE-2: The type NE-2 neon glow lamps determine the bias on the CRT. The bias must be reduced to half when the SENSITIVITY switch is turned from NORMAL (24 KV) to X2 (12 KV) position. For NORMAL (24 KV) operation, four lamps are used and for X2 (12 KV) operation, two are used so that each should have similar voltage-current characteristic.

CAUTION: VOLTAGES HIGH ENOUGH TO BE DANGEROUS ARE PRESENT AT SEVERAL PLACES IN THIS INSTRUMENT, AND INASMUCH AS MAINTENANCE MUST BE PERFORMED WITH THE POWER CIRCUITS ENERGIZED, THE UTMOST CAUTION SHOULD BE OBSERVED. BOTH THE 750-VOLT AND 475-VOLT LEADS ARE POTENTIALLY MORE DANGEROUS THAN HIGHER-VOLTAGE 4-KV AND 20-KV LEADS. THE 750-VOLT AND 475-VOLT SUPPLIES HAVE MUCH LOWER INTERNAL IMPEDANCE. USE ONLY INSULATED TOOLS. STAND ON DRY FLOOR AND DO NOT LEAN WITH THE BARE ARMS ON THE METAL FRAMEWORK OF THE INSTRUMENT. IF POSSIBLE, KEEP ONE HAND IN YOUR POCKET.

Removal of the Case

To remove the case, place the oscilloscope face downward on a padded flat surface, remove the two screws in the bottom, and lift off the case. The power supply case may be removed in a similar manner.

Fuses

Three fuses, located on the front panel of the power supply, provide over-current protection. These are labeled as follows for protection as shown:

DC SUPPLIES, 6-amp, thermal lag, in primary of dc supply high voltage transformer, T401.

REGULATED HEATERS, 5-amp, thermal lag, in primary circuit of heater transformer, T901, supplying heaters of all tubes in indicator unit. Transformer is located on underside of indicator unit.

POWER SUPPLY HEATERS, 3-amp, thermal lag, in primary of filament transformer, T402, supplying heater and filament voltage to all tubes located in power supply unit.

If the 6-ampere fuse blows, the first step in locating the trouble should be to determine whether the trouble is in the power unit or the indicator unit. This can be determined by disconnecting the inter-unit power cable. If a new 6-ampere fuse blows with the cable disconnected, the trouble is in the power unit, and the usual types of checks for capacitor failure and the tube shorts should be made until the trouble is isolated.

If the 6-ampere fuse does not blow except when the inter-unit cable is connected, however, the trouble is likely to be found in the indicator units. In this case, first measure the resistance to ground at each dc voltage jack to determine if any are below 9000 ohms. If no low resistance circuits are found to exist, it is possible there is a type of tube short which occurs only when both heater and plate voltage are applied. Reconnect inter-unit cable and set the control as follows:

SENSITIVITY ....Normal (24 KV)
SWEEP TIME/CM......10 or 20 Milli μSec
VERT. AMPL. ATTEN...Full clockwise
TRIGGER AMPL. ....Full clockwise
SWEEP STABILITY....Full counterclockwise

After these control settings have been made voltages and currents to the various units can be measured at a jack panel on the underside of the indicator unit. Adjacent to each of the jacks is shown the normal voltage and currents that should be found with the controls set as shown. The voltage at the negative 250-volt jack and positive 225-volt jack should be accurate within one per cent. Other regulated voltages should be within three per cent of those listed below. Unregulated voltages will follow line voltage, but should be within 10 per cent of those listed below at 117-volts line voltage.

Currents at the test jacks should be within 10 per cent of the following, with the exception of the plus

350-volt unregulated current which may be as low as 65 ma in some instruments.

Normal Test Jack Voltages and Currents

—250 V	Regulated	50 MA
+150 V	Regulated	550 MA
+180 V	Unregulated	250 MA
+225 V	Regulated	450 Ma
+350 V	Unregulated	100 MA
+475 V	Regulated	150 MA
+750 V	Regulated	50 MA

If currents at the test jacks are abnormal, determine what terminal boards are involved by reference to the Power Distribution Diagram, Figure 17. By lifting individual leads from the board, the offending circuit can be located.

Because of the delay in the thermal-lag fuses used, it is usually possible to make quick over-current readings by using a high ammeter range and momentarily flipping the DC POWER switch on and back off again. When an offending circuit is isolated, look for charred or discolored resistors in associated circuits, particularly the distributed amplifier line terminations.

In case of faulty operation not involving fuse failure, a similar but more leisurely procedure for locating over-current circuits can be followed.

If voltages at the test jacks are appreciably off in value, look for troubles in the power supply.

If all voltages are off in value, look for trouble in the negative 250-volt supply, which all other regulated supplies are compared to. If all voltages are low, V415 may be low in emission, or V418 may not be conducting and the minus 250-volt jack should indicate —250 volts or less. If all voltages are high, V418 may be shorted and the minus 250-volt jack should indicate about minus 350 volts.

If individual voltages are off, check the voltage at the plate of the series regulator tube involved for evidence of low cathode emission. Check resistance and voltage at grid of reference tube for evidence of failure in voltage divider.

CAUTION: TO MEASURE HEATER VOLTAGE, USE AN RMS VOLTMETER, NOT A RECTIFIER TYPE OF METER.

Heater voltage low to about 5 volts as measured at the 6.3V 1A pin jack on the indicator unit, indicates filament failure of V419, loss of emission, open circuit at V420, or open circuit on plus 350-volt lead to saturable reactor.

Heater voltage above 6.3V indicates a possible short in V420.

Sweep

If a spot can be made to appear at left center by following the procedure shown in Section II, OPERATING INSTRUCTIONS, but no sweep occurs, advance the SWEEP STABILITY control full clockwise. If a sweep occurs with this control adjustment, the difficulty may be in the trigger circuit. Turn the TRIGGER SELECTOR switch to RATE GEN. and advance the TRIGGER AMPL. control full clockwise. If no sweep occurs, observe the output at one of the RATE GEN. OUTPUT connectors on another oscilloscope such as TEKTRONIX Type 511, 512, or 514. There should be approximately 20 volts peak to peak at RATE GEN. OUTPUT A or 60 volts at RATE GEN. OUTPUT B connectors. If adequate output is available, look for low gain in the trigger amplifier.

The gain may be checked by coupling the RATE GEN. OUTPUT A or B, through a voltage divider to give about 0.1 volt peak to peak, into the trigger amplifier circuit via the TRIGGER INPUT UHF connector. Place the trigger selector switch in the plus external position. Make sure the voltage at this point is approximately 0.1 volts, and turn the TRIGGER AMPL. control full clockwise. Then with a suitable oscilloscope, such as TEKTRONIX Type 511, 513, or 514, check the gain in the various trigger amplifier stages, which should be as follows: V101, the trigger phase changer, should be approximately 0.7; between 4 and 6 for the first distributed trigger amplifier stage consisting of V102 or V104, inclusive; and between 4 and 6 for the second distributed trigger stage, V105 to V107. Output of this stage, which is negative and goes to the grid of V108, a 6AG7, which acts as a limiting amplifier. This tube should have a gain of approximately 4, making a total gain of trigger input to plate output at V108 of 80 to 100. Gain less than 80 times indicates low Gm tubes, especially 6AK5's. As an aid in checking trouble in the trigger amplifier circuit, the following point-to-point voltages are listed. These are typical voltages, made on a production model. Variations of 10% to 15% may be expected. Measurements were made with a 20,000-Ω-per volt voltmeter and with the trigger ampitude control in the full clockwise position with no signal fed into the system. For a quick first test, check the screen voltages of the 6AK5's, V102, V103, and V104. High screen voltage is an indication of low output. Normal screen voltage is around 80 volts.

V101, cathode voltage	+1.6 volts
V101, plate voltage	+150 volts each
V102, V103, and V104, plate voltage	+100 volts
V102, V103, and V104, screen voltage	Approx. 90 volts

V105, V106, and V107, plate voltage	95 volts
V105, V106, and V107, screen voltage	145 volts
V108, plate voltage	Approx. 200 volts
(This depends on the positive 225 volt source. In any event, the drop across the plate load of V108, R126, should be approximately 8 volts at 30 milliamps.)	
V108, screen voltage	Approx. 100 volts
V109, plate voltage	+205 volts
V109, cathode voltage	+8.5 volts
V109, screen voltage	Approx. 200 volts

Cathode-Ray-Tube Power Supply

In case of failure of the 20-kv power supply, determine first whether the oscillators supplying ac input voltage to the high-voltage supply and filament supply transformers are functioning satisfactorily. This can be determined by measuring the dc grid voltages of the two tubes using a 20,000 Ω-per volt meter. The voltage at the grid, pin 1, of V303, a 6AU5, should be about 27 volts. The voltage at the grid, pin 7, of V304, a 6AQ5, should be about 19.5 volts. Or alternatively, the ac voltages may be observed on another oscilloscope such as TEKTRONIX Type 511, 512, or 514.

If by these means it is determined that failure has not occurred in the oscillator circuit, it is recommended that the Type 420 power supply unit be shipped to the factory for repair. The factory will ship a replacement power unit, shipping charges prepaid, by air if desired, immediately upon receipt of notification of failure. The factory will accept a collect telegram for this purpose, and no charge will be made for the replacement unit if the defective unit is returned to the factory within reasonable time.

Vertical Amplifier

The overall gain of the vertical amplifier can be checked by using a calibrated pulse from the CAL. OUTPUT terminal. With the VERT. AMPL. ATTEN. turned full clockwise and the SENSITIVITY switch set to NORMAL (24 KV), 0.1 volts input should give approximately one centimeter of vertical deflection.

If the gain is appreciably low, first check voltages and currents at the test jack board on the underside of the indicator unit and check the power supply if indicated. Low gain of one or more 6AK5 is possible cause of low gain and it is recommended that the twelve 6AK5's, V501 to V512, be checked or replaced with tubes known to be good.

Individual stage gains can be checked by means of a second oscilloscope such as TEKTRONIX 511, 512, or 514 to observe the pulse amplitude at the input and output of each stage. The proper gain for each stage is indicated on the simplified schematic diagram of the vertical amplifier system, Figure 6. Gain about twice normal may indicate an open line termination, either the direct termination or the reverse termination. Signal saturating at low signal levels may indicate leaky .005-μf grid-coupling capacitors or shorted 150-μf cathode bypass capacitors. By biasing off individual tubes or by measuring voltages, the offending capacitor can be isolated.

If, after the preliminary tests have been made for amplifier gain and for satisfactory operation of components, aberration of the pulse shape is suspected, the recommended test procedure will require a pulse generator with a very short rise time, at the most, 3 millimicroseconds. The pulse duration should be 5 microseconds or more, and the repetition rate should be above 60 cycles. Both positive and negative pulses are needed for the procedure, and the pulse must be produced across 170 Ω at a variable level up to about 0.3 volts peak to peak. If an attenuator is required to adjust the pulse level to the required amplitude, do not use the 170-Ω step attenuator supplied with the oscilloscope.

Connect the pulser to the Type 517 SIGNAL INPUT connector and observe the displayed pulse at various levels of both polarities, and at various sweep times per centimeter. If the observed trace shows aberration of the pulse, or a difference in gain for positive and negative pulses, it is recommended that the following steps first be read and understood, and that the indicated tuning procedures then be followed:

Display on the screen a positive pulse with 1-cm amplitude and repeat, using a negative pulse.

1. If aberration of the front corner of the pulse occurs within the first 50 millimicroseconds of the rise, consisting of either of rounding, or of overshoot or spiking, correction can probably be made by tuning the trimmer capacitors on the plate line of the output distributed amplifiers, C713A to L and C714A to L. An upward deflection of the trace results from positive grid drive on the half of the output amplifier nearest the front panel, V713 to V724. Tuning the trimmers of this half of the amplifier, C714A to L therefore compensates for aberration occurring during upward deflection of the trace.

   A downward deflection of the trace is the result of positive grid drive on the half of the amplifier farthest from the panel, V701 to

V712. Tuning the trimmers of this half of the amplifier, C713A to L therefore compensates for aberration occurring during a downward deflection of the trace.

2. A much longer aberration having the shape of an RC charge or discharge curve of duration 100 to 500 millimicroseconds results from the variation with voltage and time of the impedance characteristics of the 150-μf cathode bypass capacitors throughout the amplifier, and the 8-μf capacitors to ground at the plate-line terminations. Compensation for these sources of aberration is produced by means of two RL networks in the reverse-termination networks of the first two stages of the preamplifier, R503, L509 and R515B, L510. Sense of the compensation contribution can be determined by shorting out the inductance. Amplitude of the compensation depends on the value of R and the duration, or time constant, depends on the value of L. In a few instruments, it has been found necessary to supplant one of the RL networks with a parallel RC network of 10 to 20 Ω and 0.01 to 0.02 μf.

3. A small sharp notch or spike occuring 30 to 35 mμseconds following the rise may result from feedback between plate and grid line of the output stage near the reverse terminations, especially following retuning. These aberrations can be corrected by means of C735 and C736 located at the output-stage plate-line reverse terminations, Figure 8. With a positive pulse displayed, adjust C736 at the plate line nearest the front panel. With a negative pulse displayed, adjust C735 at the plate line farthest from the panel, and repeat the procedure once or twice for the best adjustment.

4. Under normal operating conditions, a small wrinkle of about ½ mm peak-to-peak amplitude occurs on the trace about 100 millimicroseconds after the start of the sweep. Except for this wrinkle, a properly tuned amplifier will have no ringing or overshoot greater than 0.3 or 0.4 mm, peak to peak.

5. The tuning capacitors of the vertical amplifier are preset at the factory to the following approximate adjustment, in terms of the depth the inner concentric cyclinder is engaged into the outer cylinder.

First stage:	1/16 inch
Second stage:	1/8 inch
Third stage:	3/16 inch
Inverter:	3/16 inch
Driver stage:	3/32 inch
Output stage:	Adjusted by observation for best response characteristics.

6. The following list of delay times may be useful in adjusting the amplifier and in determining the effects of unmatched terminations.

First and second preamplifier stages and driver, each 8 mμsec, total	24 mμsec
Inverter stage	4 mμsec
Third stage	11 mμsec
Output stage	16 mμsec
Delay line	65 mμsec
Total overall amplifier delay	120 mμsec
Sweep-starting time, internal triggering	90 mμsec
Sweep-starting time, external triggering	60 mμsec

Noise and hum occurring elsewhere than in the vertical amplifier or in the sweep circuits can be observed by shorting the deflection plates and determining whether the noise voltage still persists on the trace.

Adjustment

1. Power Supply Unit

—250 VOLTS: Connect voltmeter to test jack panel on underside of indicator unit. Adjust R463B labeled ADJ. —250 as accurately as possible.

+150 VOLTS: No adjustment provided. Set at factory within 1 per cent. Appreciable departure from this value may degrade amplifier performance. Adjustment, if required, must be accomplished by replacing or bridging resistors.

+225 VOLTS: No adjustment provided. If off more than 3 per cent, replace or bridge resistors.

+475 VOLTS: No adjustment. If off more than 3 per cent, replace or bridge resistors.

+750 VOLTS: No adjustment. If off more than 3 per cent, replace or bridge resistors.

NOTE: Many portable voltmeters are in error as much as three per cent.

2. Cathode-Ray Tube Voltage Supply:

—4 KV: Turn INTENSITY control full counterclockwise. Connect 20,000-Ω-per-volt voltmeter to junctions of the .05-μfd capacitor and INTENSITY control R839. Turn SENSITIVITY switch to NORMAL (24 KV). Adjust R310A labeled 4 KV ADJ. located on the high voltage oscillator chassis at upper right rear of the indicator unit.

—2 KV: Repeat above procedure with SENSITIVITY switch in X2 (12 KV) position and adjust R311A labeled 2KV ADJ. on high voltage oscillator chassis.

3. Cathode-Ray Tube Intensity:

Maximum intensity is adjusted by means of R838 labeled MAXIMUM INTENSITY ADJ accessible from the left rear center of the indicator unit. With SWEEP STABILITY and TRIGGER AMPL controls full counter clockwise and the INTENSITY control full clockwise, adjust R838 until a spot just appears on the screen.

4. Cathode-Ray Tube Unblanking:

Set SENSITIVITY switch in NORMAL (24 KV) position and SWEEP TIME/CM switch at the 10 MICRO SEC. PER CM. position. Connect a 20,000-Ω-per-volt voltmeter across R173, plate load resistor for V120A and V120B, located on the left bottom center of the indicator unit. Adjust R175A labeled UNBLANK, accessible from the left bottom center of the indicator unit, for 100 volts across R173. The UNBLANK adjustment controls the screen voltage of V120 and V121 to adjust their plate current.

5. Trigger Rate Generator:

Connect the RATE GEN. OUTPUT A or B on the front panel to the vertical input of a second oscilloscope such as TEKTRONIX Type 511, 512, or 514. Connect a calibrated oscillator to the horizontal input of the second oscilloscope so as to produce lissajou patterns. Set TRIGGER RATE GEN. MULT. to X10 position and CYCLES PER SECOND dial to 150, and apply 1500-cycle voltage to the horizontal sweep. Adjust R806B labeled H. F. TRIG. RATE, to obtain one-to-one lissajou patterns. Turn CYCLES/SEC. dial to 15. Set oscillator at 150 cycles, and adjust R801B, accessible from left bottom of indicator unit labeled TRIG. RATE L. F. for one-to-one lissajou patterns. Return to 1500 cycles and recheck H. F. TRIG. RATE adjustment because there is some interaction. Set TRIGGER RATE GEN. MULT. to X100 position and check against 15-kc audio oscillator frequency. Adjust C801B mounted on the RATE GEN. MULT. switch, accessible from the front bottom of indicator for one-to-one pattern. There is no adjustment provided for the X1 TRIGGER RATE GEN. MULT. range.

6. Sweep Timing:

Before attempting to retime the sweep circuits, be sure the accelerating potentials are correct by the procedure suggested under paragraph 2, Cathode-Ray Tube Voltage Supply. Heaters should be on for a half hour and plate voltage should be on for five minutes before any adjustments are made.

A suitable timing wave can be obtained from a TEKTRONIX Type 180 Time Marker Generator. This generator provides both crystal controlled pip and sine-wave output and synchronized trigger pulses at submultiples of the output frequency so that stationary timing-wave patterns can be displayed on the Type 517.

To use the Type 180 Time Marker Generator for this purpose, connect the SIGNAL INPUT of the Type 517 to the 50MC output of the Type 180. Connect the TRIGGER output of the Type 180 to the TRIGGER INPUT of the Type 517. Set the TRIGGER RATE SELECTOR switch of the Type 180 to 1 KC.

To time the sweep, observe the output of the Type 180 on the Type 517 screen. One cycle of the 50-mc wave should occupy two centimeters at the 10 MILLIμSEC PER CM setting. For this setting only, adjust the timing by adjusting the drive on the negative sweep amplifier, V118, by means of C136, a 5-20 μμf ceramic trimmer located on the left face of the sweep output board, accessible from left center of the indicator unit. Do not change this setting when adjusting subsequent sweep times.

To time the 20 MILLIμSEC PER CM position, determine the multivibrator pulse length as above, and adjust it to 0.4 microseconds by means of C128J, a 5-20 μμf ceramic trimmer located next to C128K. Adjust C129J until one cycle of the 50-mc wave occupies one centimeter.

Except for the three longest TIME PER CM settings, subsequent adjustment are made in the same manner by adjusting the corresponding trimmer capacitors, C129J to C129D, and counting cycles or pips displayed of the Type 180 Time Market Generator. The Type 180 provides sine waves of 50 mc, 10 mc and 5 mc, and pips spaced between 1 μsecond and 1 second. Cycles per centimeter = SWEEP TIME PER CM $\times$ oscillator frequency.

A shocked oscillator can also be used for a timing-wave source. The oscillator should operate at the frequencies mentioned. To use such an oscillator for time measurements, connect the oscillator to the Type 517 SIGNAL INPUT, gate the oscillator and trigger the Type 517 sweep with the same pulse at a safe repetition rate. Then observe the stationary pattern displayed in the same manner as previously described.

A less satisfactory measurement can be made, if no better means are at hand, by observing a single trace of the output of a signal generator or similar oscillator capable of developing a tenth of a volt or so across the 170-ohm input impedance of the Type 517. A mercury switch breaking a 1.5-volt battery source will provide a satisfactory triggering means. At the fastest sweep speeds a mercury switch will probably be necessary to avoid multiple triggering caused by contact jitter found in most other kinds of contacts. The room should be darkened or the viewing hood should be used, with rather high spot intensity, or the trace can be recorded photographically. Since each trace will be of a random section of the oscillator output wave a stationary pattern cannot be obtained, and such information as can be must be obtained from single traces.

7. Low-Frequency Compensation:

The screwdriver adjust potentiometer, R160A, is adjusted at the factory for the best balance between fast and slow sweep times. It should be necessary to readjust R160A only in the event of major changes in circuit components.

8. Horizontal Positioning:

Set the SENSITIVITY switch to NORMAL (24 KV) and SWEEP STABILITY and TRIGGER AMPL. full counterclockwise. Advance the INTENSITY control clockwise and adjust FOCUS to get a fine spot not bright enough to damage the screen. With the HORIZONTAL POSITIONING, 1 CENTIMETER control, at 0, position the spot with the FULL RANGE control near the screen center at one of the graticule lines. Advance the 1 CENTIMETER control to 10. The spot should move to the next graticule line. If it does not, adjust R188, a 500-k resistor labeled HOR. POS. VERN. ADJ. located near the 1 CENTIMETER control, accessible from the right front of the indicator unit.

9. Pulse Calibrator:

This check should be made by comparing the voltage from the CAL. OUTPUT terminal with that of a calibrated square wave generator such as TEKTRONIX Type 104A, or by measuring the calibrator pulse on a TEKTRONIX Type 512 or 514 oscilloscope.

First determine that the zero adjustment is correct. If it is not, set the control to zero output, loosen the set screw and position the dial properly. Then set the CAL. RANGE switch to 50 and the CAL. VOLTAGE scale to 5. Adjust R907A, a 100-k resistor, labeled CAL. ADJ., located on the lower right side of the indicator unit.

Instructions for 230-volt Operation
of TEKTRONIX Type 517 Cathode-Ray Oscilloscope

Unless we are instructed otherwise we ship the Type 517 Oscilloscope connected for operation at 105 to 125 volts, 50 to 60 cycles ac. However, provisions are made for easy conversion to operation at 210 to 250 volts, 50 to 60 cycles. In instruments with serial numbers 200 and higher, three transformers, T401, T402, and T901, and one series reactor, L402, are provided with split input windings which are normally connected in parallel for 115-volt operation, but which can easily be connected in series for 230-volt operation. Each of these split windings terminates in a nest of four terminal lugs arranged in a square on a bakelite terminal board, and numbered 1, 2, 3 and 4 in clockwise rotation.

Terminals numbered 1 and 3 are connected to one winding and terminals numbered 2 and 4 are connected to the second winding. The ac input leads are connected to terminals 1 and 4 whether for 115-volt or for 230-volt operation, so that these leads do not need to be moved when conversion is made from one to the other operating input-voltage level.

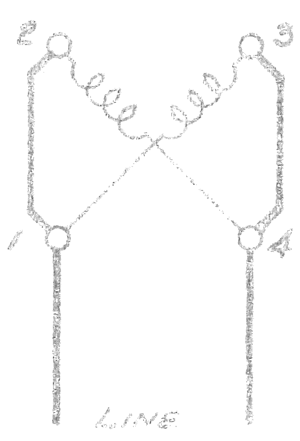
When wired for 115-volt operation, terminals 1 and 2 are joined by a bare bus wire, and terminals 3 and 4 are similarly joined. To convert to 230-volt operation, remove the bare bus wires between these terminals and substitute a single connecting wire between terminals 2 and 3.

Transformer T901 terminal board is located on the underside of the indicator unit, readily accessible at the right rear when the indicator unit is turned upside down. The remaining three terminal boards are located on the underside of the external power-supply unit. When the power-supply unit is turned upside down L402 is on the right front of the chassis, T401 is located at the left rear and T402 at the right rear.

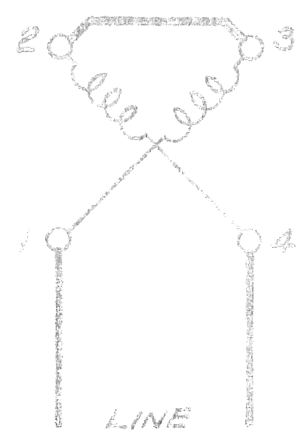
Fuses should be changed to accommodate the reduction of input current by a factor of two for 230-volt operation. The 6-amp DC SUPPLIES fuse should be replaced by one with 3-amp rating, the 5-amp REGULATED HEATERS fuse by a 2.5-amp fuse, and the 3-amp POWER SUPPLY HEATERS fuse with a 1.5-amp one.

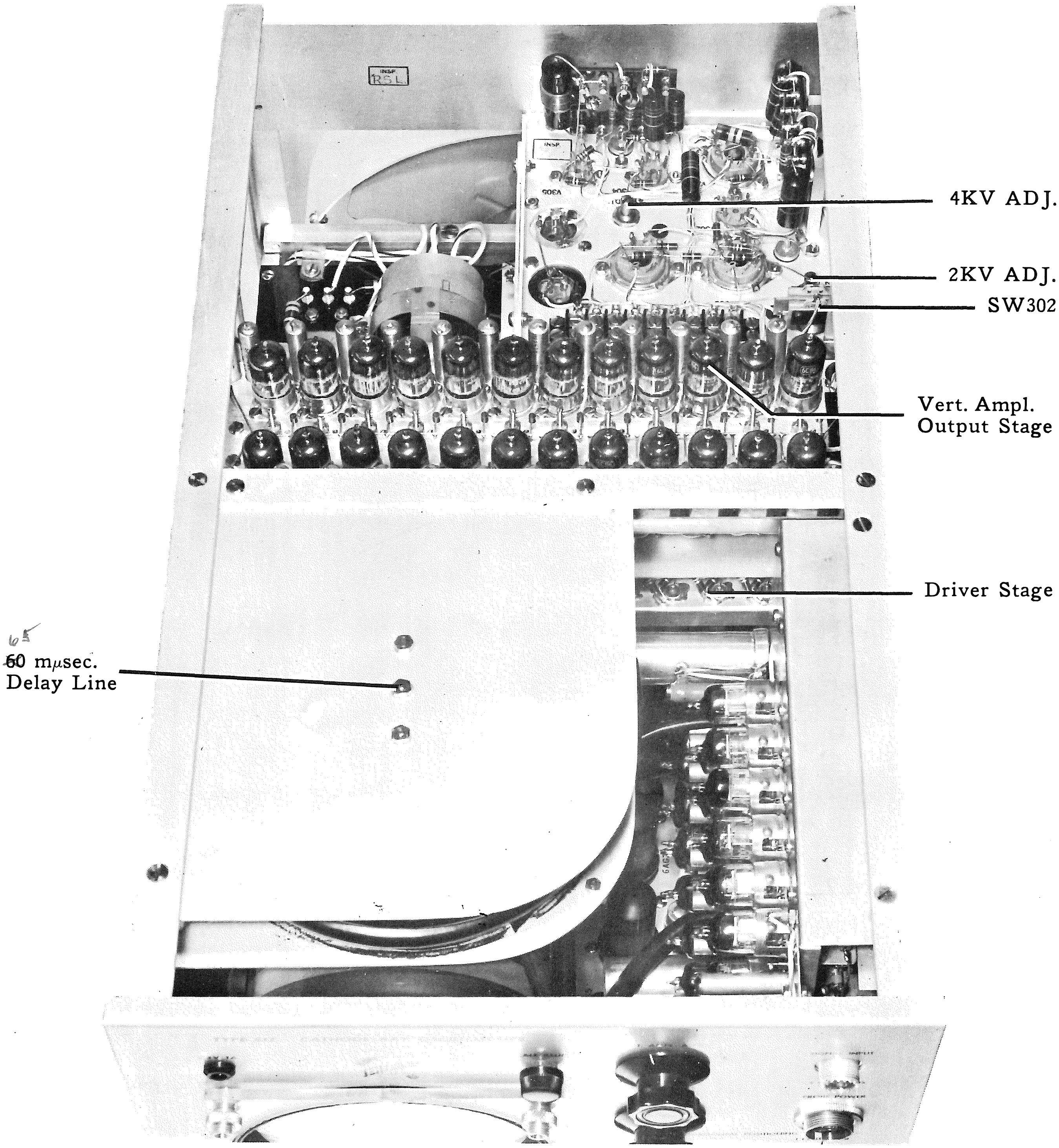
The diagrams show connections of the split-winding terminals.

115-volt connection

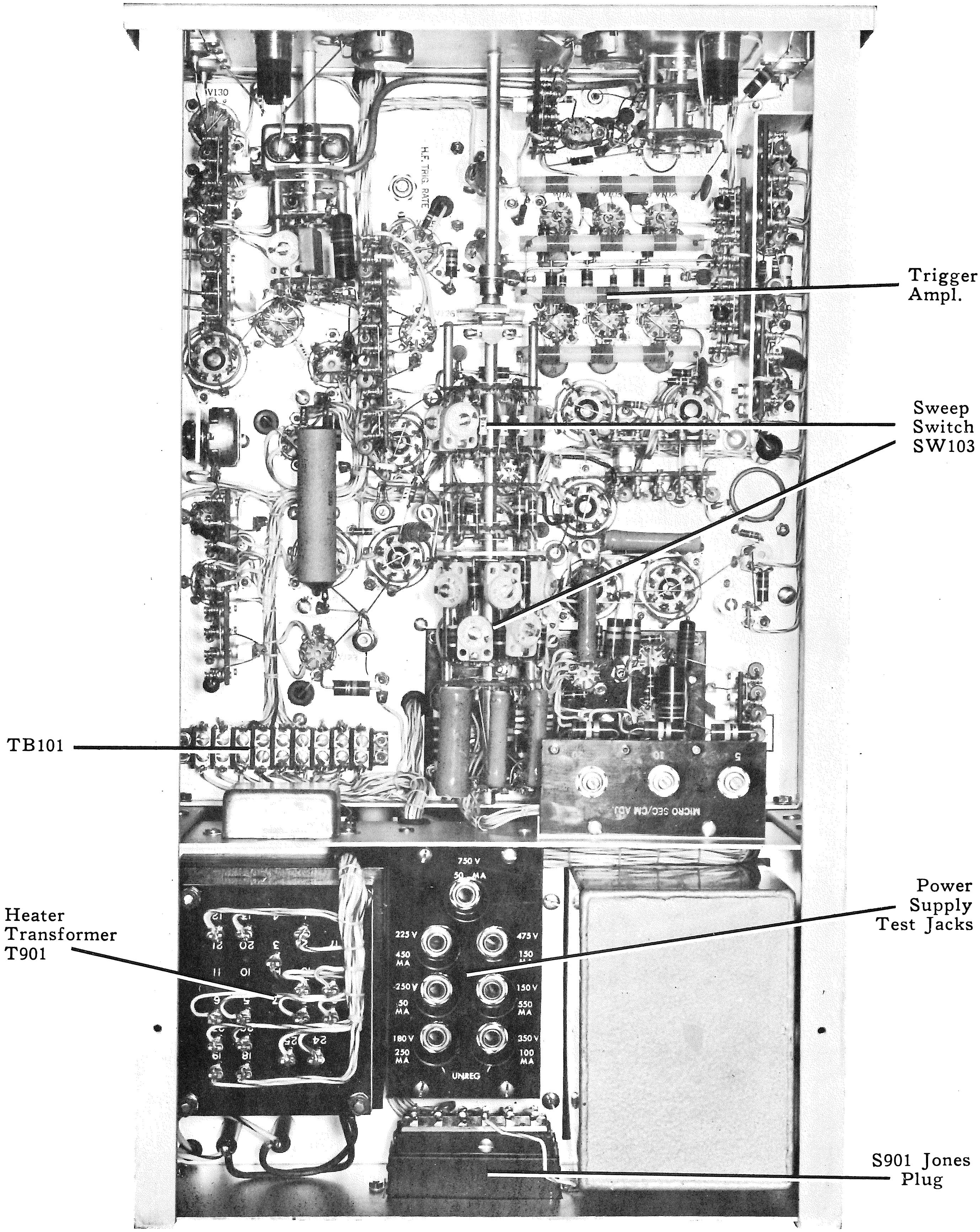


230-volt connection

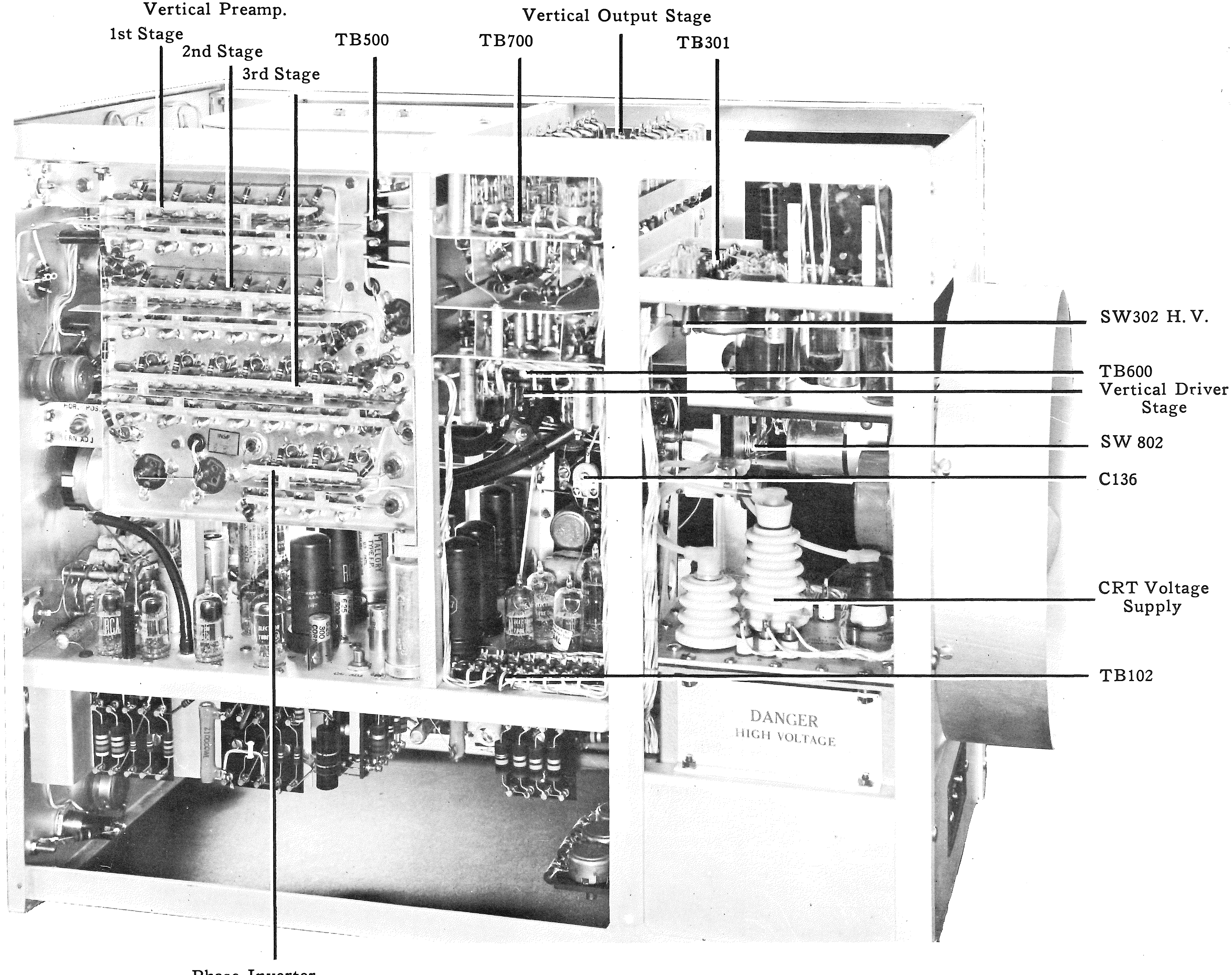




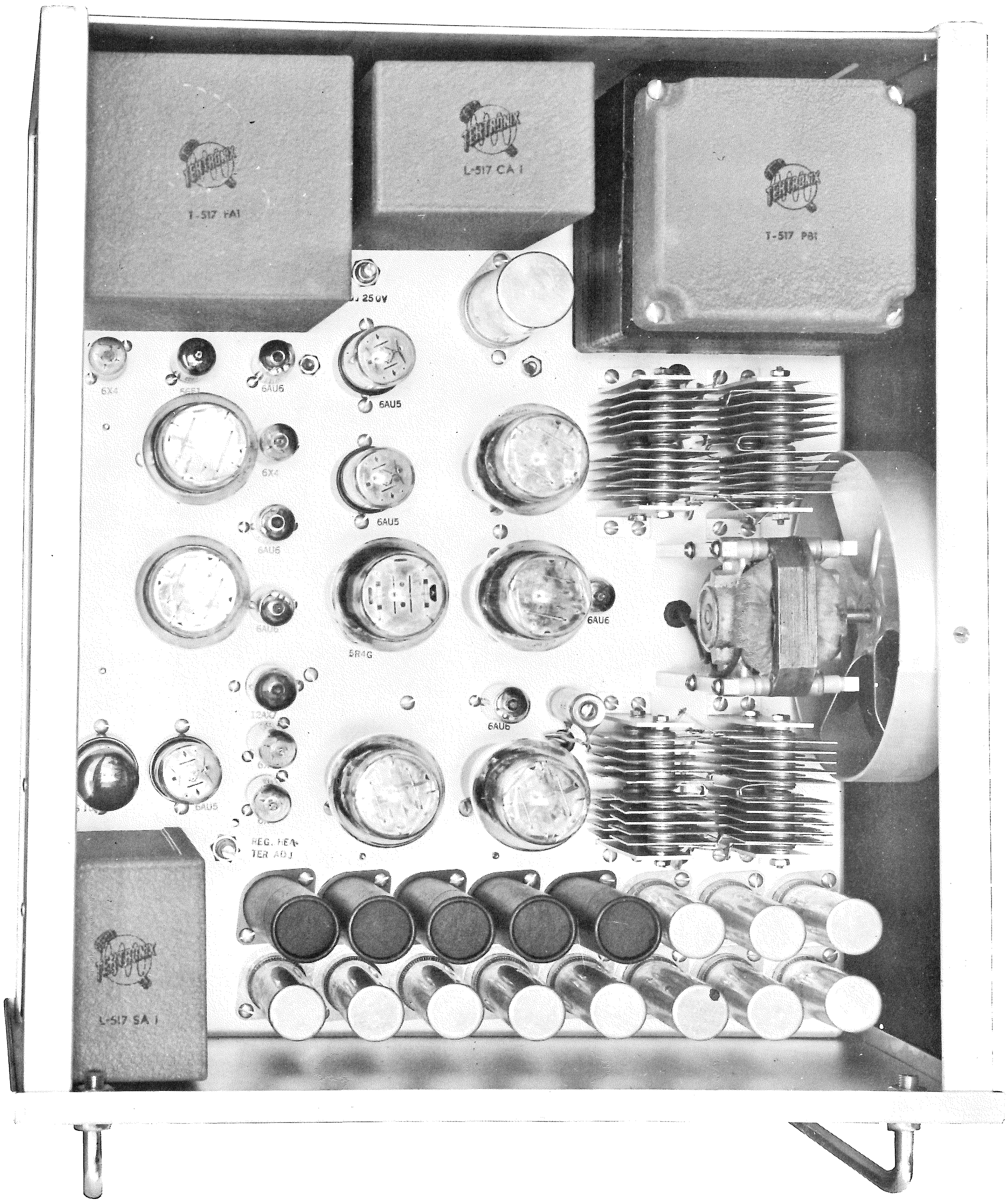
Type 517 Indicator, Top View



Type 517 Indicator Bottom View



Type 517 Indicator Unit, Right Hand Side



Type 517 External Power Supply, Top View

IMPORTANT

Include INSTRUMENT TYPE and SERIAL NUMBER in all correspondence regarding any Tektronix instrument. The serial number stamped in the instruction manual must match the instrument serial number if parts are to be ordered from the manual. Observance of the above precautions will assure your receipt of the correct replacement parts with a minimum of delay.

Ser. No.
640

WARRANTY

This instrument is guaranteed to the original user to be free from defects in material and workmanship for a period of one year from date of purchase. Our responsibility under this warranty is limited to the repair or replacement of the instrument, or any part thereof, failure of which is not due to abuse.

For service under this warranty, promptly advise the factory of all details pertinent to the failure. Replacement parts will be shipped, via air transportation upon request, prepaid to any point within the continental United States or Canada. Should it be more convenient to ship the entire instrument, transportation prepaid, to the factory, it will be serviced as required, at no charge and returned via surface transportation.

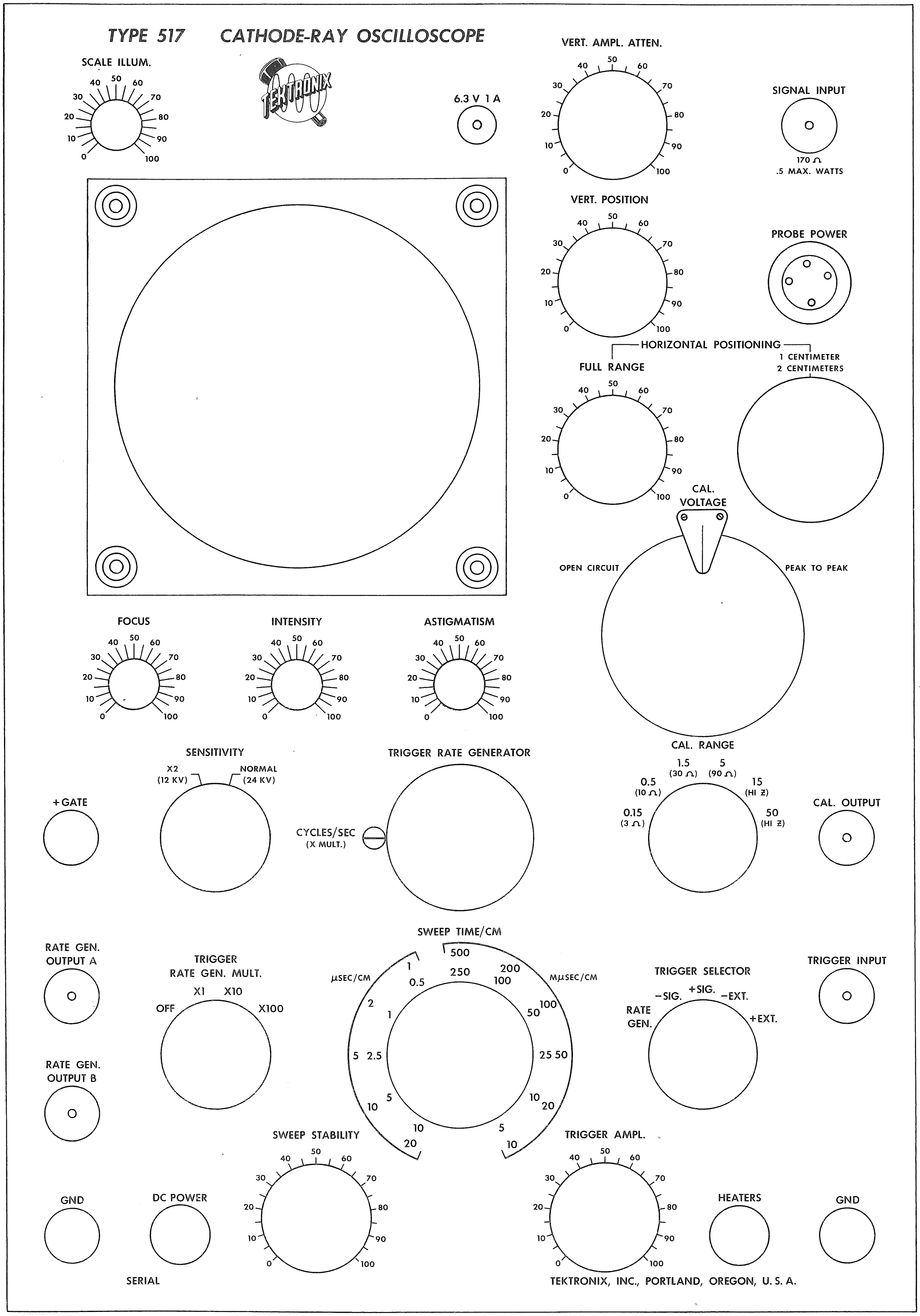
Replacement parts ordered after termination of warranty will be billed at current net prices and shipped via air prepaid to any point within the continental United States or Canada.

TYPE 517 CATHODE-RAY OSCILLOSCOPE

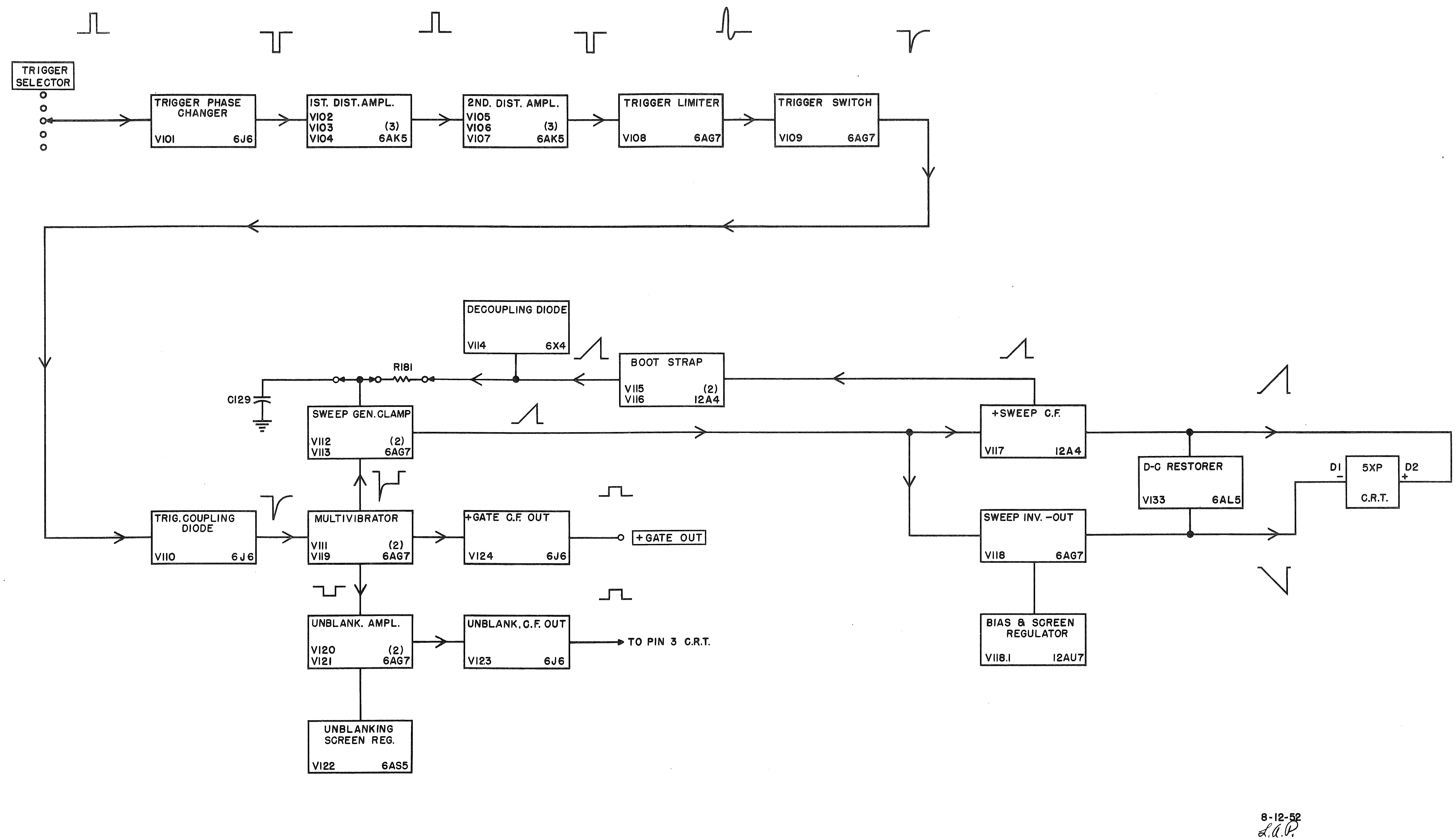
INSTRUCTION MANUAL

SECTION VI

DIAGRAMS



517 FRONT PANEL



TYPE 517 CATHODE RAY OSCILLOSCOPE

TRIGGER AND SWEEP AMPLIFIER BLOCK DIAGRAM

Section VI Fig. 1

PARTS LIST

ABBREVIATIONS

Cer. - Ceramic	μ - Micro or x 10^{-6}
Comp. - Composition	Ω - Ohm
Dep. Carb. - Deposited Carbon	PBT - Paper, Bath Tub
EMC - Electrolytic, Metal Cased	PMC - Paper, Metal Cased
f - Farads	Poly - Polystrene
GMV - Guaranteed Minimum Value	Prec. - Precision
h - Henries	PTM - Paper, Tubular Molded
k - Kilo or x 10^3	Var. - Variable

WW - Wire Wound

CAPACITORS

C101	.001 μf	Cer.	Fixed	500 WVDC	GMV
C102	20 μf	EMC	Fixed	450 WVDC	-20%+50% (1/2 of 2 x 20)
C103	.001 μf	Cer.	Fixed	500 WVDC	GMV
C104	.005 μf	Cer.	Fixed	500 WVDC	GMV
C105	.01 μf	PTM	Fixed	400 WVDC	20%
C106A	.01 μf	Cer.	Fixed	500 WVDC	GMV
C106B	.01 μf	Cer.	Fixed	500 WVDC	GMV
C106C	.01 μf	Cer.	Fixed	500 WVDC	GMV
C107A	.001 μf	Cer.	Fixed	500 WVDC	GMV
C107B	.001 μf	Cer.	Fixed	500 WVDC	GMV
C107C	.001 μf	Cer.	Fixed	500 WVDC	GMV
C108A	.01 μf	Cer.	Fixed	500 WVDC	GMV
C108B	.01 μf	Cer.	Fixed	500 WVDC	GMV
C108C	.01 μf	Cer.	Fixed	500 WVDC	GMV
C109	.01 μf	Cer.	Fixed	500 WVDC	GMV
C110	.01 μf	PTM	Fixed	400 WVDC	20%
C111	20 μf	EMC	Fixed	450 WVDC	-20%+50% (1/2 of 2 x 20)
C112	20 μf	EMC	Fixed	450 WVDC	-20%+50% (1/2 of 2 x 20)
C113	20 μf	EMC	Fixed	450 WVDC	-20%+50% (1/2 of 2 x 20)
C114	.01 μf	Cer.	Fixed	500 WVDC	GMV
C115	6.25 μf	EMC	Fixed	300 WVDC	-20%+50%
C116	.001 μf	Cer.	Fixed	500 WVDC	GMV
C117	220 $\mu\mu$f	Mica	Fixed	500 WVDC	20%
C118	6.25 μf	EMC	Fixed	300 WVDC	-20%+50%
C119	6.25 μf	EMC	Fixed	300 WVDC	-20%+50%

INDUCTORS

L101	First distributed stage trigger amplifier, grid inductor
L102	First distributed stage trigger amplifier, plate inductor
L103	Second distributed stage trigger amplifier, grid inductor
L104	Second distributed stage trigger amplifier, plate inductor
L105	12 μh Fixed

RESISTORS

R101	100 Ω	1/2 watt	Fixed	Comp.	10%
R102	470 k	1/2 watt	Fixed	Comp.	10%
R103	47 Ω	1/2 watt	Fixed	Comp.	10%
R104	220 Ω	1/2 watt	Fixed	Comp.	10%
R105	3.9 k	2 watt	Fixed	Comp.	10%
R106	270 Ω	1/2 watt	Fixed	Comp.	10%
R107	100 Ω	1/2 watt	Fixed	Comp.	10%
R108	470 k	1/2 watt	Fixed	Comp.	10%
R109	10 Ω	1/2 watt	Fixed	Comp.	10%
R110	10 Ω	1/2 watt	Fixed	Comp.	10%
R111A	27 k	1 watt	Fixed	Comp.	10%
R111B	27 k	1 watt	Fixed	Comp.	10%
R111C	27 k	1 watt	Fixed	Comp.	10%
R112	560 Ω	1/2 watt	Fixed	Comp.	10%
R113	560 Ω	1 watt	Fixed	Comp.	10%
R114	10 Ω	1/2 watt	Fixed	Comp.	10%
R115A	15 k	1 watt	Fixed	Comp.	10%
R115B	15 k	1 watt	Fixed	Comp.	10%
R115C	15 k	1 watt	Fixed	Comp.	10%
R116A	820 k	1/2 watt	Fixed	Comp.	10%
R116B	820 k	1/2 watt	Fixed	Comp.	10%
R116C	820 k	1/2 watt	Fixed	Comp.	10%
R117	560 Ω	1 watt	Fixed	Comp.	10%
R118	10 Ω	1/2 watt	Fixed	Comp.	10%
R119	560 Ω	1 watt	Fixed	Comp.	10%
R120	10 Ω	1/2 watt	Fixed	Comp.	10%
R121	220 Ω	1 watt	Fixed	Comp.	10%
R122	470 Ω	1 watt	Fixed	Comp.	10%
R123	470 Ω	2 watt	Fixed	Comp.	10%
R124	47 Ω	1/2 watt	Fixed	Comp.	10%
R125	470 k	1/2 watt	Fixed	Comp.	10%
R126	270 Ω	2 watt	Fixed	Comp.	10%
R127	15 k	2 watt	Fixed	Comp.	10%
R128	390 k	1/2 watt	Fixed	Comp.	10%
R129	2.7 k	1/2 watt	Fixed	Comp.	10%
R130	10 k	2 watt	Fixed	Comp.	10%
R131	220 Ω	2 watt	Fixed	Comp.	10%
R132A	6.8 k	1/2 watt	Fixed	Comp.	10%
R132B	100 k	2 watt	Var.	Comp.	20%
R132C	820 k	1/2 watt	Fixed	Comp.	10%
R190	27 k	1 watt	Fixed	Comp.	10%

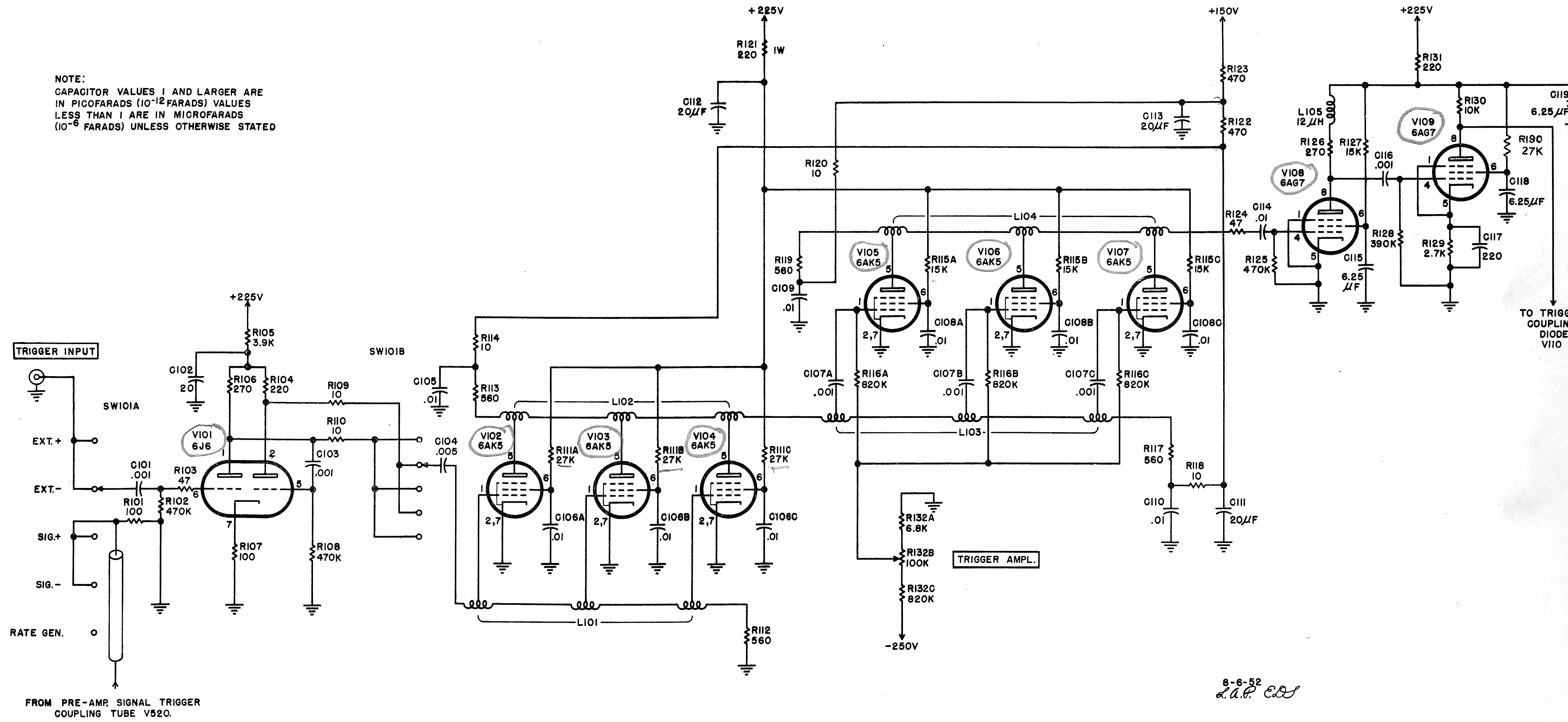
SWITCHES

SW101	Trigger selector

VACUUM TUBE COMPLEMENT

V101	6J6	Trigger phase changer
V102	6AK5	Trigger distributed amplifier
V103	6AK5	Trigger distributed amplifier
V104	6AK5	Trigger distributed amplifier
V105	6AK5	Trigger distributed amplifier
V106	6AK5	Trigger distributed amplifier
V107	6AK5	Trigger distributed amplifier
V108	6AG7	Trigger limiter
V109	6AG7	Trigger switch

NOTE:
CAPACITOR VALUES 1 AND LARGER ARE IN PICOFARADS (10^{-12} FARADS) VALUES LESS THAN 1 ARE IN MICROFARADS (10^{-6} FARADS) UNLESS OTHERWISE STATED



TRIGGER AMPLIFIER

TYPE 517 CATHODE RAY OSCILLOSCOPE TRIGGER AMPLIFIER

Section VI Fig. 2

Type 517 Fig. 3

PARTS LIST

ABBREVIATIONS

Cer. - Ceramic
Comp. - Composition
Dep. Carb. - Deposited Carbon
EMC - Electrolytic, Metal Cased
f - Farads
GMV - Guaranteed Minimum Value
h - Henries
k - Kilo or x 10^3
μ - Micro or x 10^{-6}
Ω - Ohm
PBT - Paper, Bath Tub
PMC - Paper, Metal Cased
Poly - Polystrene
Prec. - Precision
PTM - Paper, Tubular Molded
Var. - Variable
WW - Wire Wound

CAPACITORS

C120	6.25 μf	EMC	Fixed	300 WVDC	-20%+50%
C121	100 μμf	Mica	Fixed	500 WVDC	20%
C122	6.25 μf	EMC	Fixed	300 WVDC	-20%+50%
C123	47 μμf	Cer.	Fixed	500 WVDC	20%
C124	20 μf	EMC	Fixed	450 WVDC	-20%+50% (1/2 of 2 x 20)
C125	47 μμf	Cer.	Fixed	500 WVDC	20%
C126	6.25 μf	EMC	Fixed	300 WVDC	-20%+50%
C127	47 μμf	Cer.	Fixed	500 WVDC	20%
C128A	4000 μμf	Mica	Fixed	500 WVDC	5%
C128B	2000 μμf	Mica	Fixed	500 WVDC	5%
C128C	1000 μμf	Mica	Fixed	500 WVDC	5%
C128D	500 μμf	Mica	Fixed	500 WVDC	5%
C128E	250 μμf	Mica	Fixed	500 WVDC	5%
C128F	100 μμf	Mica	Fixed	500 WVDC	5%
C128G	47 μμf	Cer.	Fixed	500 WVDC	5%
C128H	27 μμf	Cer.	Fixed	500 WVDC	5%
C128I	12 μμf	Cer.	Fixed	500 WVDC	5%
C128J	5-20 μμf	Cer.	Var.	500 WVDC	
C128K	3-12 μμf	Cer.	Var.	500 WVDC	
C129A	750 μμf	Mica	Fixed	500 WVDC	5%
C129B	355 μμf	Mica	Fixed	500 WVDC	5%
C129C	170 μμf	Mica	Fixed	500 WVDC	5%
C129D	7-45 μμf	Cer.	Var.	500 WVDC	
C129E	7-45 μμf	Cer.	Var.	500 WVDC	
C129F	7-45 μμf	Cer.	Var.	500 WVDC	
C129G	7-45 μμf	Cer.	Var.	500 WVDC	
C129H	7-45 μμf	Cer.	Var.	500 WVDC	
C129I	7-45 μμf	Cer.	Var.	500 WVDC	
C129J	7-45 μμf	Cer.	Var.	500 WVDC	
C130	15 μf	EMC	Fixed	450 WVDC	-20%+50% (1/2 of 2 x 15)
C131	1 μf	PBT	Fixed	600 WVDC	20%
C132	.022 μf	PTM	Fixed	600 WVDC	20%
C133	.022 μf	PTM	Fixed	600 WVDC	20%
C134	.001 μf	PTM	Fixed	1000 WVDC	20%
C135	.01 μf	Cer.	Fixed	500 WVDC	GMV
C136	5-20 μμf	Cer.	Var.	500 WVDC	
C137	7 μμf	Cer.	Fixed	500 WVDC	±.25 μμfd
C138	.01 μf	Cer.	Fixed	500 WVDC	GMV
C139	.01 μf	Cer.	Fixed	500 WVDC	GMV
C140	.01 μf	Cer.	Fixed	500 WVDC	GMV
C141A	.01 μf	Cer.	Fixed	500 WVDC	GMV
C141B	.01 μf	Cer.	Fixed	500 WVDC	GMV
C142	.001 μf	Cer.	Fixed	500 WVDC	GMV
C143	Unassigned				
C144	Unassigned				
C145	.01 μf	Cer.	Fixed	500 WVDC	GMV
C146	0.5 μf	PBT	Fixed	1000 WVDC	20%

INDUCTORS

L106	7 μh	Fixed
L107	~~20-30 μh~~	~~Var.~~ 22 μh Fixed
L108	2.5 mh	Fixed
L109	270 μh	Fixed
L110	6.5-13 μh	Var.
L181P	2.5 mh	Fixed

RESISTORS

R133	27 Ω	1/2 watt	Fixed	Comp.	10%
R134	150 k	1/2 watt	Fixed	Comp.	10%
R135A	180 k	1/2 watt	Fixed	Comp.	10%
R135B	100 k	2 watt	Var.	Comp.	20%
R135C	120 k	1/2 watt	Fixed	Comp.	10%
R136	5.6 k	2 watt	Fixed	Comp.	10%
R137	120 k	1 watt	Fixed	Comp.	10%
R138	15 k	10 watt	Fixed	WW	10%
R139	15 k	10 watt	Fixed	WW	10%
R140	100 k	1 watt	Fixed	Comp.	10%
R141	47 Ω	1/2 watt	Fixed	Comp.	10%
R142	1.5 k	5 watt	Fixed	WW	10%
R143	6.8 k	2 watt	Fixed	Comp.	10%
R144	470 k	1/2 watt	Fixed	Comp.	10%
R145	820 k	1/2 watt	Fixed	Comp.	10%
R146	10 k	2 watt	Fixed	Comp.	10%
R147	150 Ω	1 watt	Fixed	Comp.	10%
R148A	1.5 k	25 watt	Fixed	WW	10%
R148B	1.5 k	25 watt	Fixed	WW	10%
R149	47 Ω	1/2 watt	Fixed	Comp.	10%
R150	15 k	10 watt	Fixed	WW	10%
R151	47 Ω	1/2 watt	Fixed	Comp.	10%
R152	22 Ω	1/2 watt	Fixed	Comp.	10%
R153	15 k	10 watt	Fixed	WW	10%
R154	47 Ω	1/2 watt	Fixed	Comp.	10%
R155	56 Ω	1/2 watt	Fixed	Comp.	10%
R156	47 Ω	1/2 watt	Fixed	Comp.	10%
R157	56 Ω	1/2 watt	Fixed	Comp.	10%
R158	15 k	10 watt	Fixed	WW	10%
R159	Unassigned				
R160A	500 k	2 watt	Var.	Comp.	20% L. F. Comp
R160B	100 k	1/2 watt	Fixed	Comp.	10%
R161	470 k	1/2 watt	Fixed	Comp.	5% Selected*
R162	470 Ω	1/2 watt	Fixed	Comp.	10%
R163	10 k	10 watt	Fixed	WW	5%
R164	490 k	1/2 watt	Fixed	Prec.	1%
R165	3.3 Meg.	1/2 watt	Fixed	Comp.	10%
R166	3.3 Meg.	1/2 watt	Fixed	Comp.	10%
R167	68 k	1/2 watt	Fixed	Prec.	1%
R169	120 k	1/2 watt	Fixed	Comp.	10%
R171	370 k	1/2 watt	Fixed	Prec.	1%
R172	150 k	1/2 watt	Fixed	Comp.	10%
R173	1 k	25 watt	Fixed	WW (non-inductive)	5%
R174	47 Ω	1/2 watt	Fixed	Comp.	10%
R175A	2 Meg.	2 watt	Var.	Comp.	20%
R175B	3.3 Meg.	1/2 watt	Fixed	Comp.	10%
R176	22 k	1/2 watt	Fixed	Comp.	10%
R177	15 k	2 watt	Fixed	Comp.	10%
R178	Unassigned				
R179A	1.2 ~~1~~ Meg.	1/2 watt	Fixed	Comp.	10%
R179B-D	Unassigned				
R179E	820 k	1/2 watt	Fixed	Comp.	10%
R179F	220 k	1/2 watt	Fixed	Comp.	10%
R179G	82 k	1 watt	Fixed	Comp.	10%
R179H	Unassigned				

RESISTORS (Cont.)

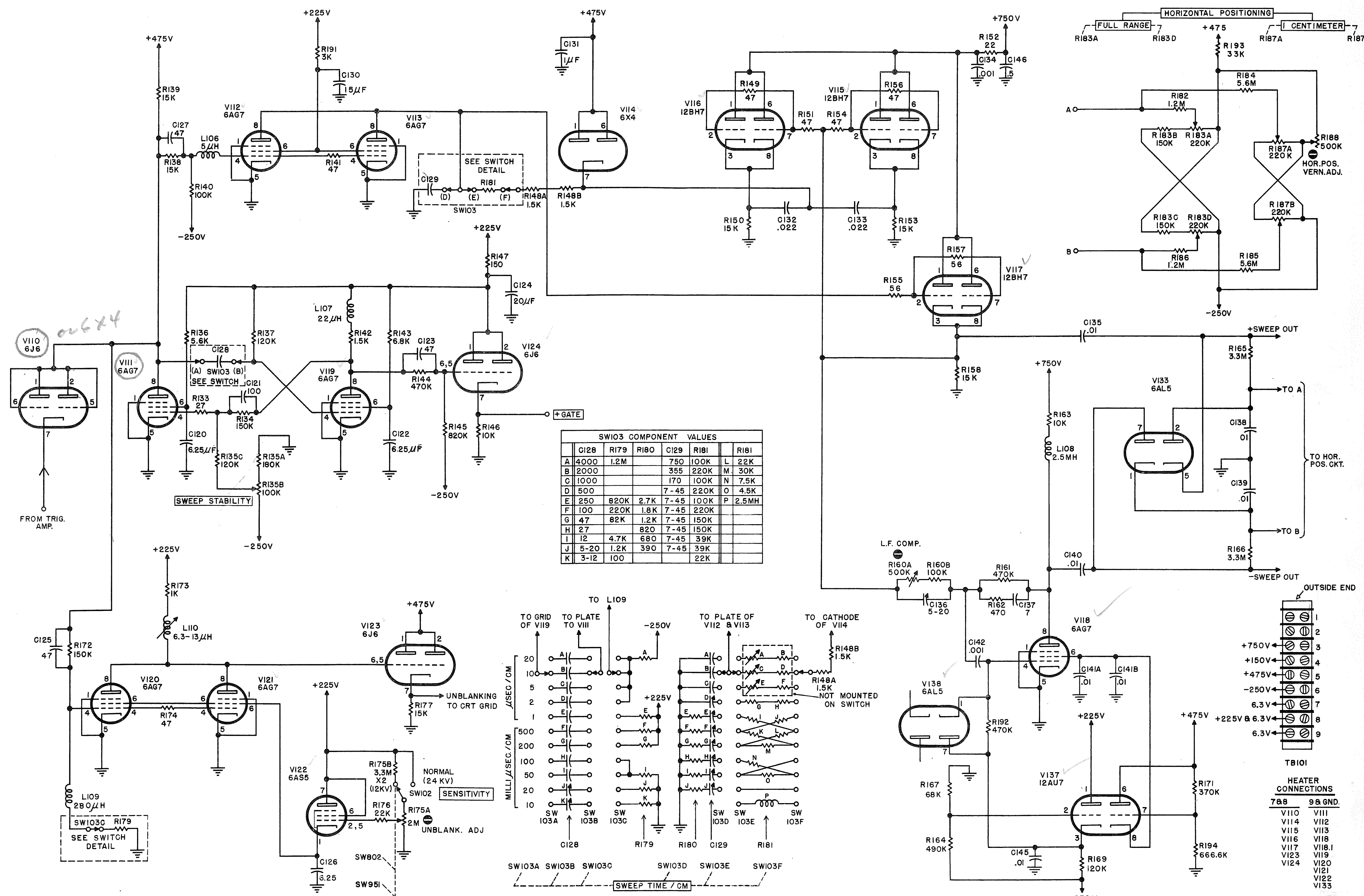
R179I	4.7 k	1/2 watt	Fixed	Comp.	10%
R179J	1.2 k	1/2 watt	Fixed	Comp.	10%
R179K	100 Ω	1/2 watt	Fixed	Comp.	10%
R180A-D	Unassigned				
R180E	2.7 k	1 watt	Fixed	Comp.	10%
R180F	1.8 k	1 watt	Fixed	Comp.	10%
R180G	1.2 k	1 watt	Fixed	Comp.	10%
R180H	820 Ω	1 watt	Fixed	Comp.	10%
R180I	680 Ω	1 watt	Fixed	Comp.	10%
R180J	390 Ω	1 watt	Fixed	Comp.	10%
R181A	100 k	2 watt	Var.	Comp.	20%
R181B	220 k	2 watt	Fixed	Comp.	10%
R181C	100 k	2 watt	Var.	Comp.	20%
R181D	220 k	2 watt	Fixed	Comp.	10%
R181E	100 k	2 watt	Var.	Comp.	20%
R181F	220 k	2 watt	Fixed	Comp.	10%
R181G	150 k	2 watt	Fixed	Comp.	10%
R181H	150 k	2 watt	Fixed	Comp.	10%
R181I	39 k	2 watt	Fixed	Comp.	10%
R181J	39 k	2 watt	Fixed	Comp.	10%
R181K	22 k	2 watt	Fixed	Comp.	10%
R181L	22 k	2 watt	Fixed	Comp.	10%
R181M	30 k	10 watt	Fixed	WW	10%
R181N	7.5 k	10 watt	Fixed	WW	10%
R181O	4.5 k	20 watt	Fixed	WW	10%
R181P	2.5 mh		Fixed		See also Inductors
R182	1.2 Meg.	1/2 watt	Fixed	Comp.	10%
R183A, D	220 k	2 watt	Var. Dual	Comp.	20%
R183B	150 k	1/2 watt	Fixed	Comp.	10%
R183C	150 k	1/2 watt	Fixed	Comp.	10%
R183D	See R183A				
R184	5.6 Meg	1/2 watt	Fixed	Comp.	10%
R185	5.6 Meg.	1/2 watt	Fixed	Comp.	10%
R186	1.2 Meg.	1/2 watt	Fixed	Comp.	10%
R187A, B	220 k	2 watt	Var. Dual	Comp.	20%
R188	500 k	2 watt	Var.	Comp.	20%
R189	Unassigned				
R191	3 k	10 watt	Fixed	WW	10%
R192	470 k	1/2 watt	Fixed	Comp.	10%
R193	33 k	2 watt	Fixed	Comp.	10%
R194	666.6 k	1/2 watt	Fixed	Prec.	1%

SWITCHES

SW102	Sensitivity (unblanking level)
SW103	Sweep time per centimeter

VACUUM TUBE COMPLEMENT

V110	6J6	Trigger coupling diode
V111	6AG7	Sweep minus multivibrator
V112	6AG7	Sweep generator clamp
V113	6AG7	Sweep generator clamp
V114	6X4	Sweep decoupling diode
V115	12BH7	Sweep boot strap
V116	12BH7	Sweep boot strap
V117	12BH7	Positive sweep cathode follower
V118	6AG7	Sweep inverter and negative sweep out
V119	6AG7	Sweep positive multivibrator
V120	6AG7	Unblanking amplifier
V121	6AG7	Unblanking amplifier
V122	6AS5	Unblanking screen regulator
V123	6J6	Unblanking cathode follower
V124	6J6	Positive gate cathode follower
V133	6AL5	Sweep dc restorer
V137A	1/2 12AU7	Inverter bias
V137B	1/2 12AU7	Negative sweep out
V138	6AL5	Clamp diode



SW103 COMPONENT VALUES							
	C128	R179	R180	C129	R181		R181
A	4000	1.2M		750	100K	L	22K
B	2000			355	220K	M	30K
C	1000			170	100K	N	7.5K
D	500			7-45	220K	O	4.5K
E	250	820K	2.7K	7-45	100K	P	2.5MH
F	100	220K	1.8K	7-45	220K		
G	47	82K	1.2K	7-45	150K		
H	27		820	7-45	150K		
I	12	4.7K	680	7-45	39K		
J	5-20	1.2K	390	7-45	39K		
K	3-12	100			22K		

SWEEP CIRCUIT

TYPE 517 CATHODE-RAY OSCILLOSCOPE SWEEP CIRCUIT

Section VI Fig. 3

SWEEP CIRCUIT

PARTS LIST

ABBREVIATIONS

Cer. - Ceramic	μ - Micro or x 10^{-6}
Comp. - Composition	Ω - Ohm
Dep. Carb. - Deposited Carbon	PBT - Paper, Bath Tub
EMC - Electrolytic, Metal Cased	PMC - Paper, Metal Cased
f - Farads	Poly - Polystrene
GMV - Guaranteed Minimum Value	Prec. - Precision
h - Henries	PTM - Paper, Tubular Molded
k - Kilo or x 10^3	Var. - Variable

WW - Wire Wound

CAPACITORS

C801A	7-45 $\mu\mu$f	Cer.	Var.	500 WVDC	
C801B	200 $\mu\mu$f	Mica	Fixed	500 WVDC	~~20%~~ 5%
C802	.0022 μf	Mica	Fixed	500 WVDC	10% selected*
C803	.022 μf	PTM	Fixed	400 WVDC	10% selected*
C804	0.1 μf	PBT	Fixed	600 WVDC	20% (1/3 of 3 x .1 μf)
C805	12 $\mu\mu$f	Cer.	Fixed	500 WVDC	20%
C806	22 ~~47~~ $\mu\mu$f	Cer.	Fixed	500 WVDC	20%
C807	22 $\mu\mu$f	Cer.	Fixed	500 WVDC	20%
C808	0.1 μf	PBT	Fixed	600 WVDC	20% (1/3 of 3 x .1 μf)
C809	6.25 μf	EMC	Fixed	300 WVDC	-20%+50%
C810	0.1 μf	PBT	Fixed	600 WVDC	20% (1/3 of 3 x .1 μf)
C811	Unassigned				
C812	Unassigned				

* Pair with ratio within 1 per cent of .022/.0022

RESISTORS

R801A	100 k	2 watt	Var.	Comp.	20%
R801B	20 k	2 watt	Var.	Comp.	20%
R802	680 k	1/2 watt	Fixed	Comp.	10%
R803	82 Ω	1/2 watt	Fixed	Comp.	10%
R804	100 Ω	1/2 watt	Fixed	Comp.	10%
R805	47 k	1 watt	Fixed	Comp.	10%
R806A	100 k	1/2 watt	Fixed	Comp.	10%
R806B	500 k	2 watt	Var.	Comp.	20%
R806C	220 k	1/2 watt	Fixed	Comp.	10%
R807	47 k	1 watt	Fixed	Comp.	10%
R808	180 k	1 watt	Fixed	Comp.	10%
R809	27 k	1 watt	Fixed	Comp.	10%
R810	470 k	1/2 watt	Fixed	Comp.	~~10%~~ -10 +0%
R811	1.2 Meg	1/2 watt	Fixed	Comp.	10%
R812	22 k	2 watt	Fixed	Comp.	10%
R813	10 k	1/2 watt	Fixed	Comp.	10%
R814	100 k	1/2 watt	Fixed	Comp.	10%
R815	100 k	1/2 watt	Fixed	Comp.	10%
R816	10 k	2 watt	Fixed	Comp.	10%
R817	4.7 k	1 watt	Fixed	Comp.	10%
R818	33 k	1/2 watt	Fixed	Comp.	10%
R819	220 k	1/2 watt	Fixed	Comp.	10%
R820	68 Ω	1/2 watt	Fixed	Comp.	10%
R821	470 Ω	1/2 watt	Fixed	Comp.	10%
R822	10 Ω	1/2 watt	Fixed	Comp.	10%
R823	10 k	2 watt	Fixed	Comp.	10%
R824	Unassigned				

SWITCHES

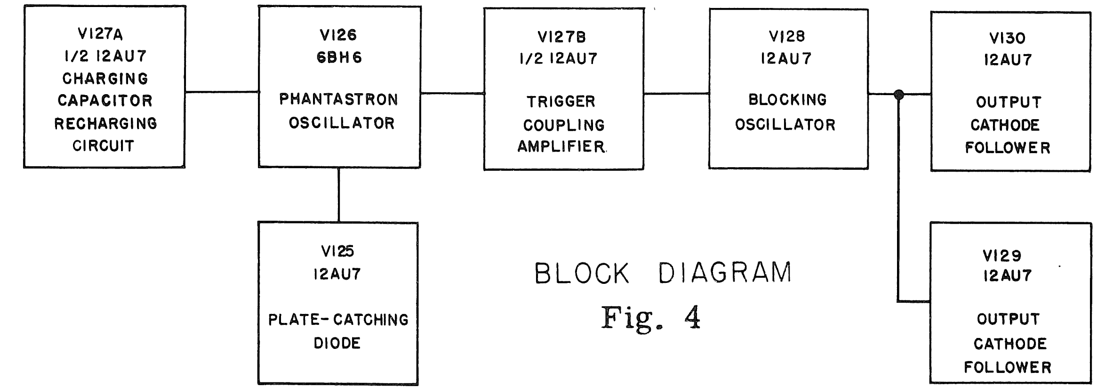
SW801 Trigger rate

TRANSFORMERS

T801 Blocking oscillator 3 windings, turns ration 1:1:1

VACUUM TUBE COMPLEMENT

V125	12AU7	Plate catching diode
V126	6BH6	Phantastron oscillator
V127A,B	12AU7	1/2 Capacitor recharging cathode follower 1/2 Trigger coupling amplifier
V128	12AU7	Blocking oscillator
V129	12AU7	Trigger output cathode follower
V130	12AU7	Trigger output cathode follower



BLOCK DIAGRAM
Fig. 4

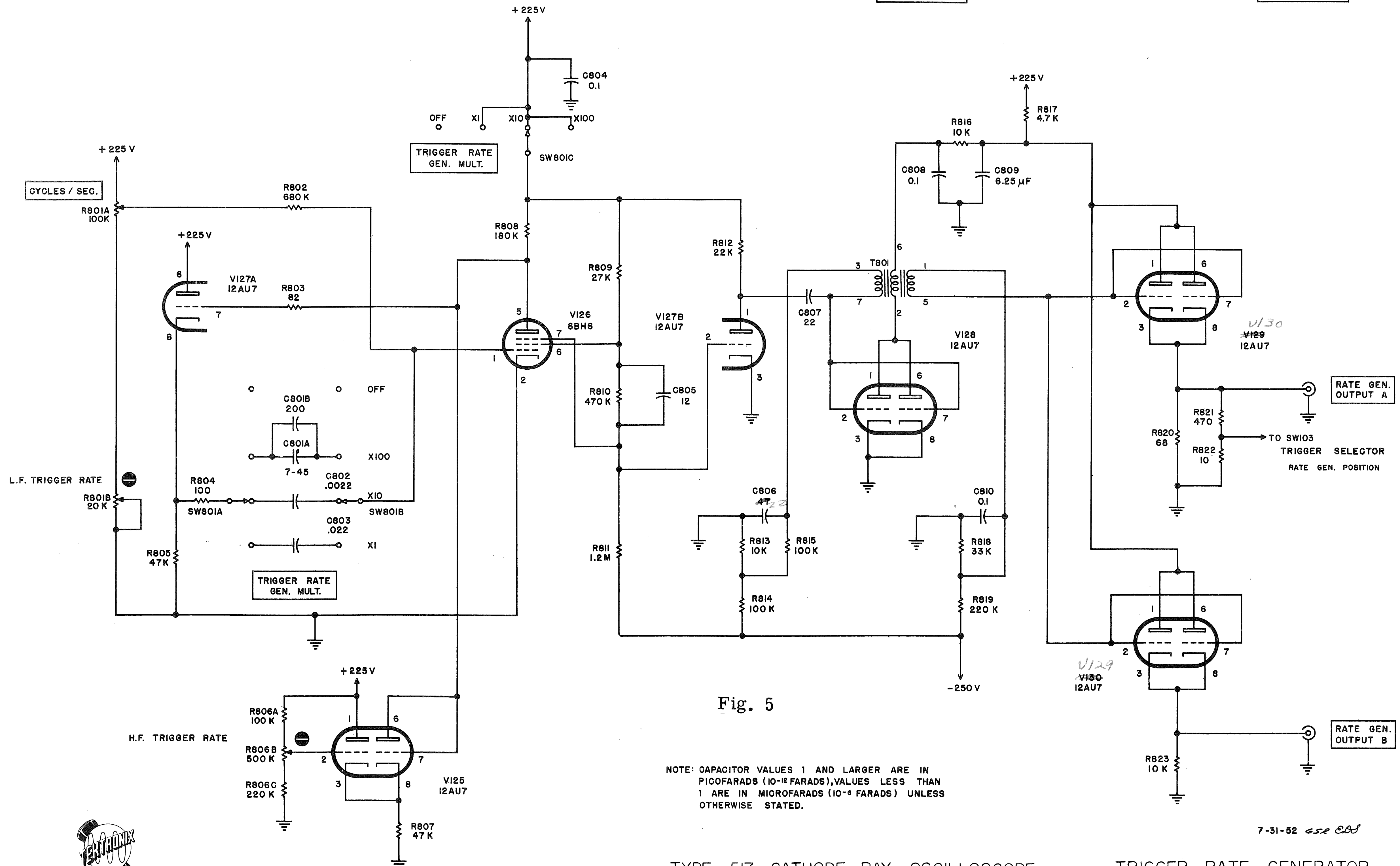


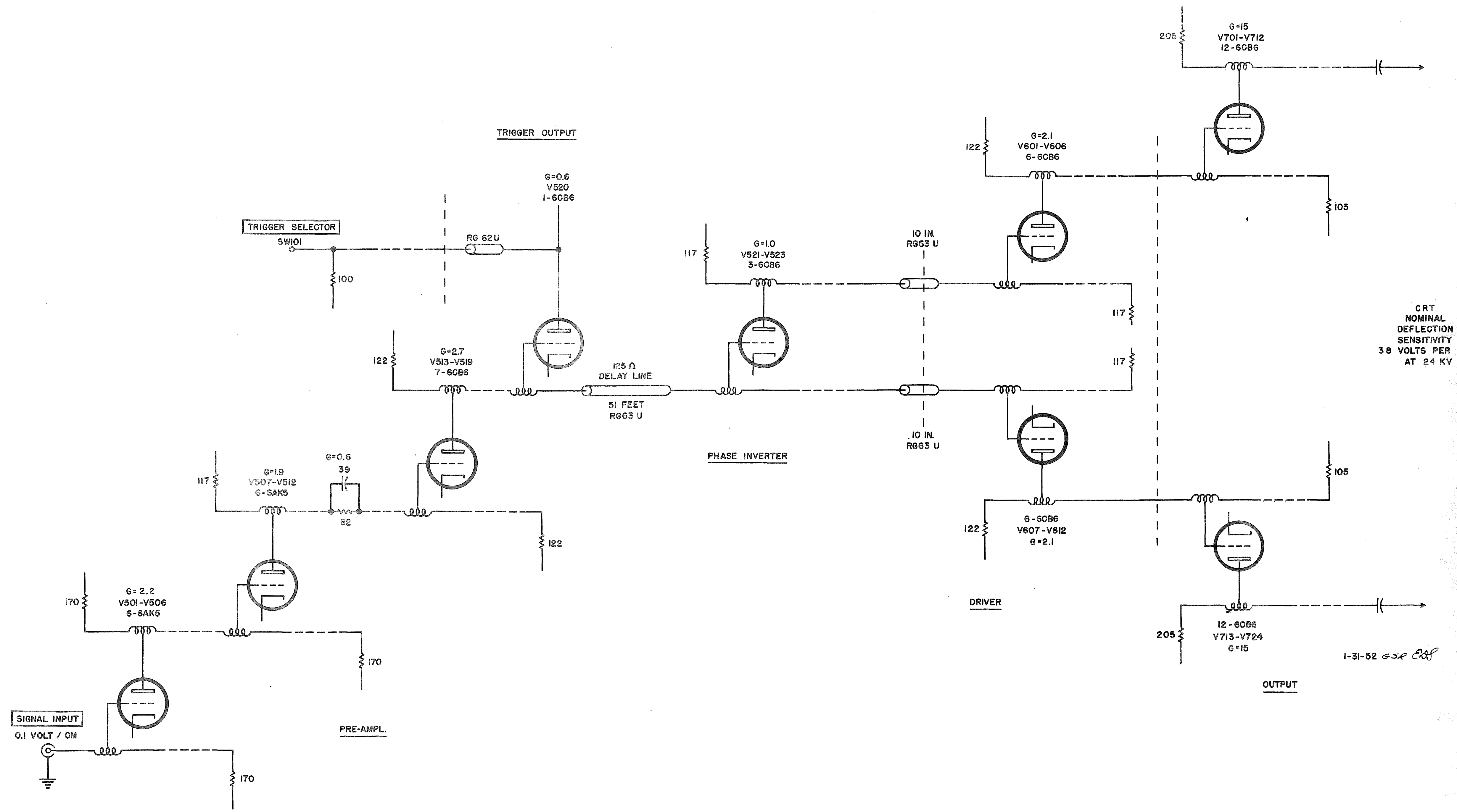
Fig. 5

NOTE: CAPACITOR VALUES 1 AND LARGER ARE IN PICOFARADS (10^{-12} FARADS), VALUES LESS THAN 1 ARE IN MICROFARADS (10^{-6} FARADS) UNLESS OTHERWISE STATED.

7-31-52 GSR EBS

TYPE 517 CATHODE-RAY OSCILLOSCOPE

TRIGGER RATE GENERATOR



VERTICAL AMPLIFIER
Simplified Schematic

TYPE 517 CATHODE-RAY OSCILLOSCOPE

SIMPLIFIED SCHEMATIC VERTICAL AMPLIFIER

Section VI Fig. 6

Type 517 Fig. 7

PARTS LIST

ABBREVIATIONS

Cer. - Ceramic
Comp. - Composition
Dep. Carb. - Deposited Carbon
EMC - Electrolytic, Metal Cased
f - Farads
GMV - Guaranteed Minimum Value
h - Henries
k - Kilo or x 10^3
μ - Micro or x 10^{-6}
Ω - Ohm
PBT - Paper, Bath Tub
PMC - Paper, Metal Cased
Poly - Polystrene
Prec. - Precision
PTM - Paper, Tubular Molded
Var. - Variable
WW - Wire Wound

CAPACITORS

C501A	.005 μf	Cer.	Fixed	500 WVDC	GMV
C501B	.005 μf	Cer.	Fixed	500 WVDC	GMV
C501C	.005 μf	Cer.	Fixed	500 WVDC	GMV
C501D	.005 μf	Cer.	Fixed	500 WVDC	GMV
C501E	.005 μf	Cer.	Fixed	500 WVDC	GMV
C501F	.005 μf	Cer.	Fixed	500 WVDC	GMV
C502A	.5-5 $\mu\mu$f	Poly	Var.	500 WVDC	
C502B	.5-5 $\mu\mu$f	Poly	Var.	500 WVDC	
C502C	.5-5 $\mu\mu$f	Poly	Var.	500 WVDC	
C502D	.5-5 $\mu\mu$f	Poly	Var.	500 WVDC	
C502E	.5-5 $\mu\mu$f	Poly	Var.	500 WVDC	
C502F	.5-5 $\mu\mu$f	Poly	Var.	500 WVDC	
C503A	.001 μf	Cer.	Fixed	500 WVDC	GMV
C503B	.001 μf	Cer.	Fixed	500 WVDC	GMV
C503C	.001 μf	Cer.	Fixed	500 WVDC	GMV
C503D	.001 μf	Cer.	Fixed	500 WVDC	GMV
C503E	.001 μf	Cer.	Fixed	500 WVDC	GMV
C503F	.001 μf	Cer.	Fixed	500 WVDC	GMV
C504	Unassigned				
C505A	.005 μf	Cer.	Fixed	500 WVDC	GMV
C505B	.005 μf	Cer.	Fixed	500 WVDC	GMV
C505C	.005 μf	Cer.	Fixed	500 WVDC	GMV
C505D	.005 μf	Cer.	Fixed	500 WVDC	GMV
C505E	.005 μf	Cer.	Fixed	500 WVDC	GMV
C505F	.005 μf	Cer.	Fixed	500 WVDC	GMV
C506A	1-8 $\mu\mu$f	Poly	Var.	500 WVDC	GMV
C506B	1-8 $\mu\mu$f	Poly	Var.	500 WVDC	GMV
C506C	1-8 $\mu\mu$f	Poly	Var.	500 WVDC	GMV
C506D	1-8 $\mu\mu$f	Poly	Var.	500 WVDC	GMV
C506E	1-8 $\mu\mu$f	Poly	Var.	500 WVDC	GMV
C506F	1-8 $\mu\mu$f	Poly	Var.	500 WVDC	GMV
C507A	.001 μf	Cer.	Fixed	500 WVDC	GMV
C507B	.001 μf	Cer.	Fixed	500 WVDC	GMV
C507C	.001 μf	Cer.	Fixed	500 WVDC	GMV
C507D	.001 μf	Cer.	Fixed	500 WVDC	GMV
C507E	.001 μf	Cer.	Fixed	500 WVDC	GMV
C507F	.001 μf	Cer.	Fixed	500 WVDC	GMV
C508	8 μf	EMC	Fixed	150 WVDC	
C509	150 μf	EMC	Fixed	150 WVDC	-20%+50%
C510	150 μf	EMC	Fixed	150 WVDC	-20%+50%
C511	150 μf	EMC	Fixed	150 WVDC	-20%+50%
C512	39 $\mu\mu$f	Cer.	Fixed	500 WVDC	20%
C513	Unassigned				
C514A	.005 μf	Cer.	Fixed	500 WVDC	GMV
C514B	.005 μf	Cer.	Fixed	500 WVDC	GMV
C514C	.005 μf	Cer.	Fixed	500 WVDC	GMV
C514D	.005 μf	Cer.	Fixed	500 WVDC	GMV
C514E	.005 μf	Cer.	Fixed	500 WVDC	GMV
C514F	.005 μf	Cer.	Fixed	500 WVDC	GMV
C514G	.005 μf	Cer.	Fixed	500 WVDC	GMV
C515A	50 μf	EMC	Fixed	3 WVDC	
C515B	50 μf	EMC	Fixed	3 WVDC	
C515C	50 μf	EMC	Fixed	3 WVDC	
C515D	50 μf	EMC	Fixed	3 WVDC	
C515E	50 μf	EMC	Fixed	3 WVDC	
C515F	50 μf	EMC	Fixed	3 WVDC	
C515G	50 μf	EMC	Fixed	3 WVDC	
C516A	.001 μf	Cer.	Fixed	500 WVDC	GMV
C516B	.001 μf	Cer.	Fixed	500 WVDC	GMV
C516C	.001 μf	Cer.	Fixed	500 WVDC	GMV
C516D	.001 μf	Cer.	Fixed	500 WVDC	GMV
C516E	.001 μf	Cer.	Fixed	500 WVDC	GMV
C516F	.001 μf	Cer.	Fixed	500 WVDC	GMV
C516G	.001 μf	Cer.	Fixed	500 WVDC	GMV
C517	Unassigned				
C518	8 μf	EMC	Fixed	150 WVDC	
C519	.005 μf	Cer.	Fixed	500 WVDC	GMV
C520	50 μf	EMC	Fixed	3 WVDC	
C521	.001 μf	Cer.	Fixed	500 WVDC	GMV
C522	.005 μf	Cer.	Fixed	500 WVDC	GMV
C523A	.005 μf	Cer.	Fixed	500 WVDC	GMV
C523B	.005 μf	Cer.	Fixed	500 WVDC	GMV
C523C	.005 μf	Cer.	Fixed	500 WVDC	GMV
C524A	50 μf	EMC	Fixed	3 WVDC	
C524B	50 μf	EMC	Fixed	3 WVDC	
C524C	50 μf	EMC	Fixed	3 WVDC	
C525A	.001 μf	Cer.	Fixed	500 WVDC	GMV
C525B	.001 μf	Cer.	Fixed	500 WVDC	GMV
C525C	.001 μf	Cer.	Fixed	500 WVDC	GMV
C526A	.5-5 $\mu\mu$f	Poly	Var.	500 WVDC	
C526B	.5-5 $\mu\mu$f	Poly	Var.	500 WVDC	
C526C	.5-5 $\mu\mu$f	Poly	Var.	500 WVDC	
C526D	.5-5 $\mu\mu$f	Poly	Var.	500 WVDC	
C526E	.5-5 $\mu\mu$f	Poly	Var.	500 WVDC	
C526F	.5-5 $\mu\mu$f	Poly	Var.	500 WVDC	
C526G	.5-5 $\mu\mu$f	Poly	Var.	500 WVDC	
C527A	.5-5 $\mu\mu$f	Poly	Var.	500 WVDC	
C527B	.5-5 $\mu\mu$f	Poly	Var.	500 WVDC	
C527C	.5-5 $\mu\mu$f	Poly	Var.	500 WVDC	
C528	8μf	EMC	Fixed	150 WVDC	
C529	8 μf	EMC	Fixed	150 WVDC	
C530	8 μf	EMC	Fixed	150 WVDC	
C531	275 μf	EMC	Fixed	6 WVDC	-20%+50%
C532	8 μf	EMC	Fixed	150 WVDC	

INDUCTORS

L501	First stage vertical amplifier, grid inductor
L502	First stage vertical amplifier, plate inductor
L503	Second stage vertical amplifier, grid inductor
L504	Second stage vertical amplifier, plate inductor
L505	Third stage vertical amplifier, grid inductor
L506	Third stage vertical amplifier, plate inductor
L507	Inverter stage vertical amplifier, grid inductor
L508	Inverter stage vertical amplifier, plate inductor
L509	0.79-1.5 μh Var.
L510	2.8-6 μh Var.

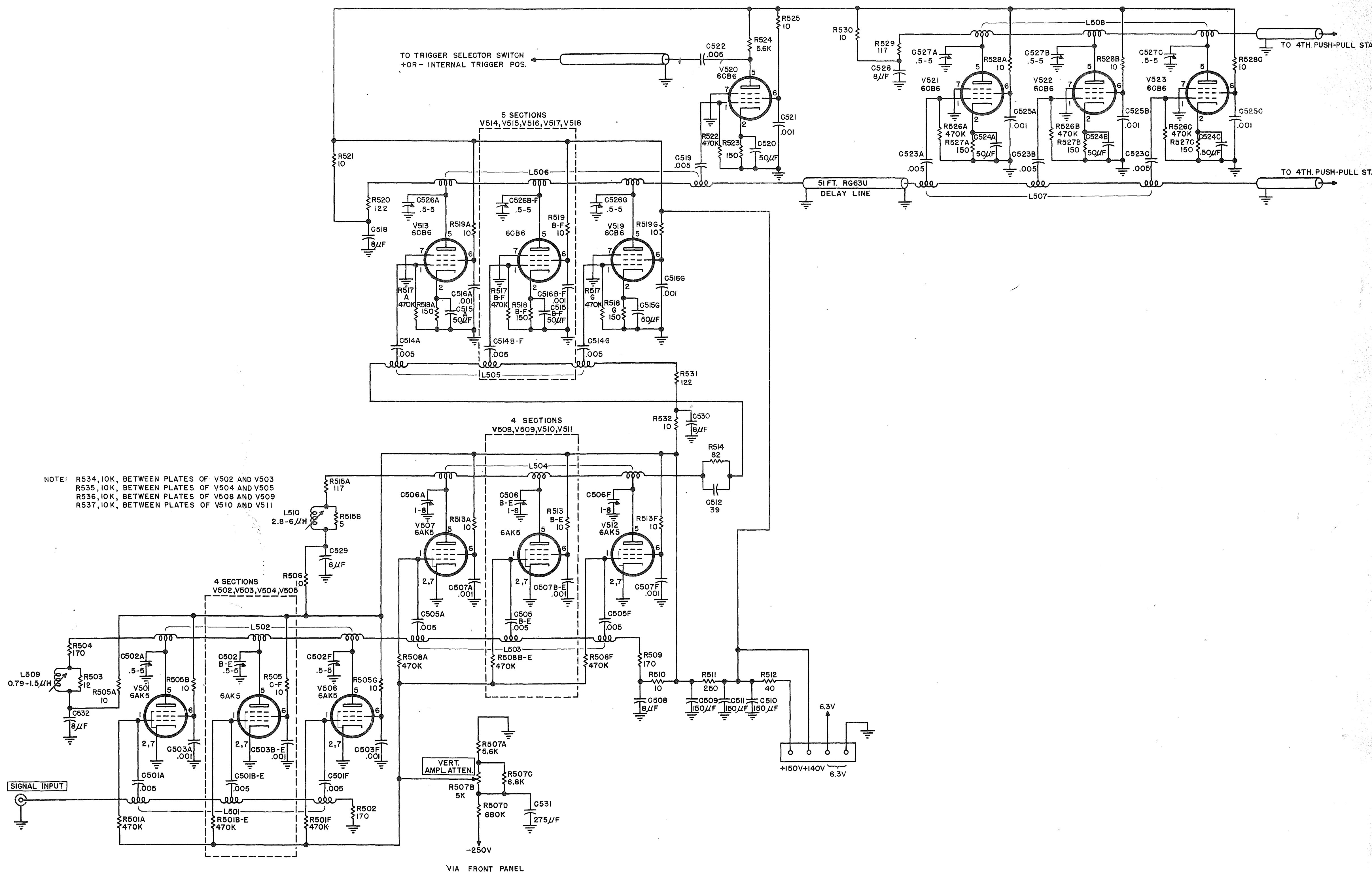
RESISTORS

R501A	470 k	1/2 watt	Fixed	Comp.	10%	
R501B	470 k	1/2 watt	Fixed	Comp.	10%	
R501C	470 k	1/2 watt	Fixed	Comp.	10%	
R501D	470 k	1/2 watt	Fixed	Comp.	10%	
R501E	470 k	1/2 watt	Fixed	Comp.	10%	
R501F	470 k	1/2 watt	Fixed	Comp.	10%	
R502	170 Ω	1/2 watt	Fixed	Comp.	1%	Selected
R503	12 Ω	1/2 watt	Fixed	Comp.		Selected***
R504	170 Ω	1/2 watt	Fixed	Comp.	1%	Selected
R505A	10 Ω	1/2 watt	Fixed	Comp.	10%	
R505B	10 Ω	1/2 watt	Fixed	Comp.	10%	
R505C	10 Ω	1/2 watt	Fixed	Comp.	10%	
R505D	10 Ω	1/2 watt	Fixed	Comp.	10%	
R505E	10 Ω	1/2 watt	Fixed	Comp.	10%	
R505F	10 Ω	1/2 watt	Fixed	Comp.	10%	
R505G	10 Ω	1/2 watt	Fixed	Comp.	10%	
R506	10 Ω	1/2 watt	Fixed	Comp.	10%	
R507A	5.6 k	1/2 watt	Fixed	Comp.	5%	Selected*
R507B	5 k	2 watt	Var.	Comp.	20%	
R507C	6.8 k	1/2 watt	Fixed	Comp.	5%	Selected*
R507D	680 k	1/2 watt	Fixed	Comp.	5%	Selected*
R508A	470 k	1/2 watt	Fixed	Comp.	10%	
R508B	470 k	1/2 watt	Fixed	Comp.	10%	
R508C	470 k	1/2 watt	Fixed	Comp.	10%	
R508D	470 k	1/2 watt	Fixed	Comp.	10%	
R508E	470 k	1/2 watt	Fixed	Comp.	10%	
R508F	470 k	1/2 watt	Fixed	Comp.	10%	
R509	170 Ω	1/2 watt	Fixed	Comp.	1%	Selected
R510	10 Ω	1/2 watt	Fixed	Comp.	10%	
R511	250 Ω	10 watt	Fixed	WW	10%	
R512	40 Ω	10 watt	Fixed	WW	10%	
R513A	10 Ω	1/2 watt	Fixed	Comp.	10%	
R513B	10 Ω	1/2 watt	Fixed	Comp.	10%	
R513C	10 Ω	1/2 watt	Fixed	Comp.	10%	
R513D	10 Ω	1/2 watt	Fixed	Comp.	10%	
R513E	10 Ω	1/2 watt	Fixed	Comp.	10%	
R513F	10 Ω	1/2 watt	Fixed	Comp.	10%	
R514	82 Ω	1/2 watt	Fixed	Comp.	10%	
R515A	117 Ω	1/2 watt	Fixed	Comp.	1%	
R515B	5 Ω	1/2 watt	Fixed	Comp.	10%	Selected**
R516	Unassigned					
R517A	470 k	1/2 watt	Fixed	Comp.	10%	
R517B	470 k	1/2 watt	Fixed	Comp.	10%	
R517C	470 k	1/2 watt	Fixed	Comp.	10%	
R517D	470 k	1/2 watt	Fixed	Comp.	10%	
R517E	470 k	1/2 watt	Fixed	Comp.	10%	
R517F	470 k	1/2 watt	Fixed	Comp.	10%	
R517G	470 k	1/2 watt	Fixed	Comp.	10%	
R518A	150 Ω	1/2 watt	Fixed	Comp.	10%	
R518B	150 Ω	1/2 watt	Fixed	Comp.	10%	
R518C	150 Ω	1/2 watt	Fixed	Comp.	10%	
R518D	150 Ω	1/2 watt	Fixed	Comp.	10%	
R518E	150 Ω	1/2 watt	Fixed	Comp.	10%	
R518F	150 Ω	1/2 watt	Fixed	Comp.	10%	
R518G	150 Ω	1/2 watt	Fixed	Comp.	10%	
R519A	10 Ω	1/2 watt	Fixed	Comp.	10%	
R519B	10 Ω	1/2 watt	Fixed	Comp.	10%	
R519C	10 Ω	1/2 watt	Fixed	Comp.	10%	
R519D	10 Ω	1/2 watt	Fixed	Comp.	10%	
R519E	10 Ω	1/2 watt	Fixed	Comp.	10%	
R519F	10 Ω	1/2 watt	Fixed	Comp.	10%	
R519G	10 Ω	1/2 watt	Fixed	Comp.	10%	
R520	122 Ω	1/2 watt	Fixed	Comp.	1%	Selected
R521	10 Ω	1/2 watt	Fixed	Comp.	10%	
R522	470 k	1/2 watt	Fixed	Comp.	10%	
R523	150 Ω	1/2 watt	Fixed	Comp.	10%	
R524	5.6 k	1 watt	Fixed	Comp.	10%	
R525	10 Ω	1/2 watt	Fixed	Comp.	10%	
R526A	470 k	1/2 watt	Fixed	Comp.	10%	
R526B	470 k	1/2 watt	Fixed	Comp.	10%	
R526C	470 k	1/2 watt	Fixed	Comp.	10%	
R527A	150 Ω	1/2 watt	Fixed	Comp.	10%	
R527B	150 Ω	1/2 watt	Fixed	Comp.	10%	
~~R527C~~	~~150 Z~~	~~1/2 watt~~	~~Fixed~~	~~Comp.~~	~~10%~~	
R527C	150 Ω	1/2 watt	Fixed	Comp.	10%	
R528A	10 Ω	1/2 watt	Fixed	Comp.	10%	
R528B	10 Ω	1/2 watt	Fixed	Comp.	10%	
R528C	10 Ω	1/2 watt	Fixed	Comp.	10%	
R529	117 Ω	1/2 watt	Fixed	Comp.	1%	Selected
R530	10 Ω	1/2 watt	Fixed	Comp.	10%	
R531	122 Ω	1/2 watt	Fixed	Comp.	1%	Selected
R532	10 Ω	1/2 watt	Fixed	Comp.	10%	
R533	Unassigned					
R534	10 k	1/2 watt	Fixed	Comp.	10%	See note on
R535	10 k	1/2 watt	Fixed	Comp.	10%	diagram
R536	10 k	1/2 watt	Fixed	Comp.	10%	
R537	10 k	1/2 watt	Fixed	Comp.	10%	

* Grouped, all minus tolerance or all plus tolerance.
** Selected for optimum amplifier performance.
*** Selected for best amplifier performance.

VACUUM TUBE COMPLEMENT

V501	6AK5	First stage vertical amplifier
V502	6AK5	First stage vertical amplifier
V503	6AK5	First stage vertical amplifier
V504	6AK5	First stage vertical amplifier
V505	6AK5	First stage vertical amplifier
V506	6AK5	First stage vertical amplifier
V507	6AK5	Second stage vertical amplifier
V508	6AK5	Second stage vertical amplifier
V509	6AK5	Second stage vertical amplifier
V510	6AK5	Second stage vertical amplifier
V511	6AK5	Second stage vertical amplifier
V512	6AK5	Second stage vertical amplifier
V513	6CB6	Third stage vertical amplifier
V514	6CB6	Third stage vertical amplifier
V515	6CB6	Third stage vertical amplifier
V516	6CB6	Third stage vertical amplifier
V517	6CB6	Third stage vertical amplifier
V518	6CB6	Third stage vertical amplifier
V519	6CB6	Third stage vertical amplifier
V520	6CB6	Trigger coupling tube
V521	6CB6	Inverter, vertical amplifier
V522	6CB6	Inverter, vertical amplifier
V523	6CB6	Inverter, vertical amplifier



TYPE 517 CATHODE-RAY OSCILLOSCOPE

VERTICAL PRE-AMPLIFIER

Section VI Fig. 7

VERTICAL PRE-AMPLIFIER

PARTS LIST

ABBREVIATIONS

Cer. - Ceramic
Comp. - Composition
Dep. Carb. - Deposited Carbon
EMC - Electrolytic, Metal Cased
f - Farads
GMV - Guaranteed Minimum Value
h - Henries
k - Kilo or x 10^3
μ - Micro or x 10^{-6}
Ω - Ohm
PBT - Paper, Bath Tub
PMC - Paper, Metal Cased
Poly - Polystrene
Prec. - Precision
PTM - Paper, Tubular Molded
Var. - Variable
WW - Wire Wound

CAPACITORS

C601A — F	.005 μf	Cer.	Fixed	500 WVDC	GMV
C602A — F	50 μf	EMC	Fixed	3 WVDC	
C603A — F	.001 μf	Cer.	Fixed	500 WVDC	GMV
C604	8 μf	EMC	Fixed	150 WVDC	
C605	8 μf	EMC	Fixed	150 WVDC	
C606A — F	.005 μf	Cer.	Fixed	500 WVDC	GMV
C607A — F	50 μf	EMC	Fixed	3 WVDC	
C608A — F	.001 μf	Cer.	Fixed	500 WVDC	GMV
C609	8 μf	EMC	Fixed	150 WVDC	
C610	8 μf	EMC	Fixed	150 WVDC	
C611A — F	.5-5 $\mu\mu$f	Poly	Var.	500 WVDC	
C612A — F	.5-5 $\mu\mu$f	Poly	Var.	500 WVDC	
C701A — L	.005 μf	Cer.	Fixed	500 WVDC	GMV
C702A — L	50 μf	EMC	Fixed	3 WVDC	
C703A — L	.001 μf	Cer.	Fixed	500 WVDC	GMV
C704	8 μf	EMC	Fixed	150 WVDC	
C705	.01 μf	Cer.	Fixed	500 WVDC	GMV
C706	6.25 μf	EMC	Fixed	300 WVDC	-20%+50%
C707A — L	.005 μf	Cer.	Fixed	500 WVDC	GMV
C708A — L	50 μf	EMC	Fixed	3 WVDC	
C709A — L	.001 μf	Cer.	Fixed	500 WVDC	GMV
C710	8 μf	EMC	Fixed	150 WVDC	
C711	.01 μf	Cer.	Fixed	500 WVDC	GMV
C712	6.25 μf	EMC	Fixed	300 WVDC	-20%+50%
C713A — L	.5-5 $\mu\mu$f	Poly	Var.	500 WVDC	
C714A — L	.5-5 $\mu\mu$f	Poly	Var.	500 WVDC	
C715-734	Unassigned				
C735	.5-5 $\mu\mu$f	Poly	Var.	500 WVDC	
C736	.5-5 $\mu\mu$f	Poly	Var.	500 WVDC	

INDUCTORS

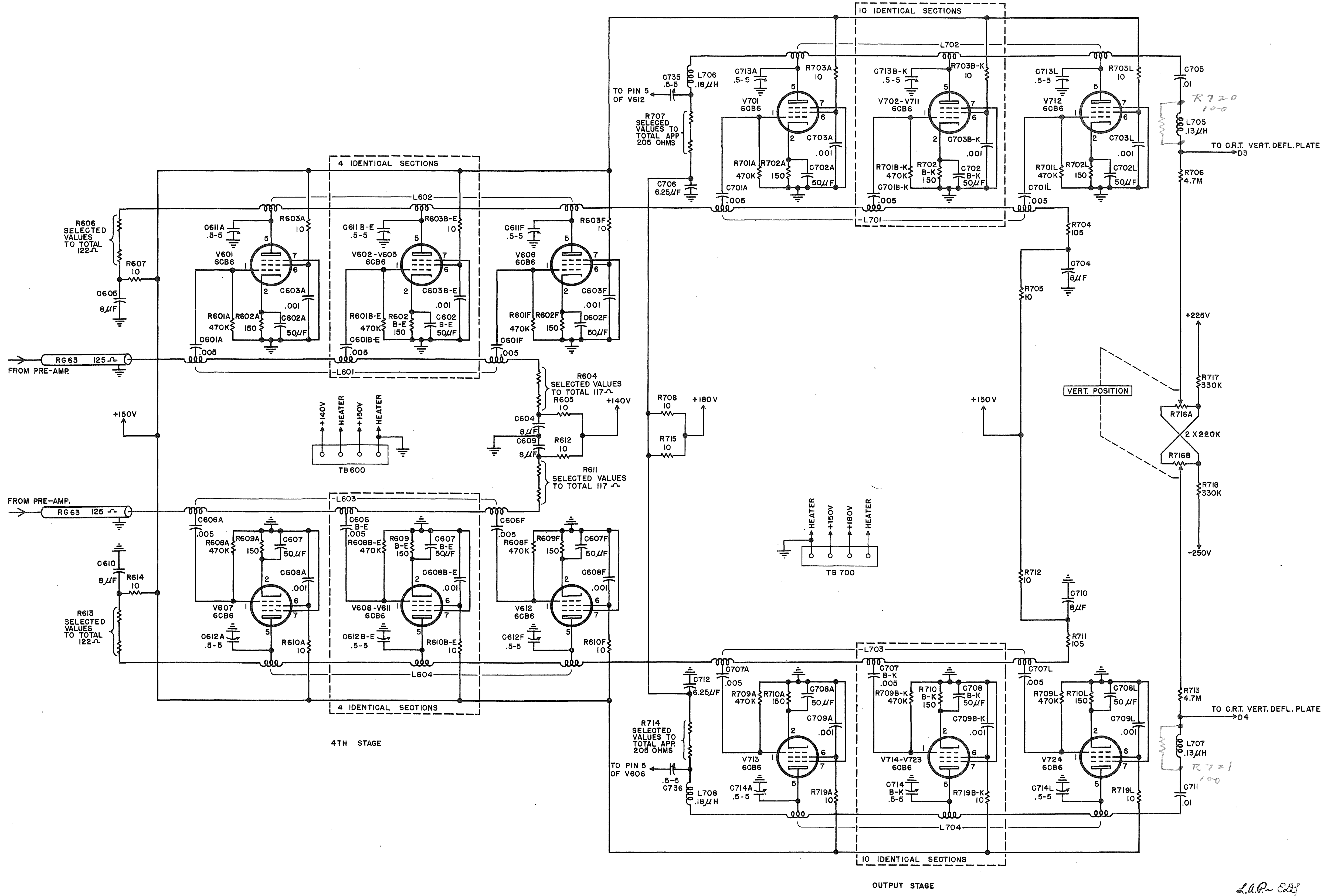
L601	Fourth stage vertical amplifier, D3 chain, grid inductor	
L602	Fourth stage vertical amplifier, D3 chain, plate inductor	
L603	Fourth stage vertical amplifier, D4 chain, grid inductor	
L604	Fourth stage vertical amplifier, D4 chain, plate inductor	
L701	Output stage vertical amplifier, D3 chain, grid inductor	
L702	Output stage vertical amplifier, D3 chain, plate inductor	
L703	Output stage vertical amplifier, D4 chain, grid inductor	
L704	Output stage vertical amplifier, D4 chain, plate inductor	
L705	.13 μh	Fixed
L706	.18 μh	Fixed
L707	.13 μh	Fixed
L708	.18 μh	Fixed

RESISTORS

R601A — F	470 k	1/2 watt	Fixed	Comp.	10%	
R602A — F	150 Ω	1/2 watt	Fixed	Comp.	10%	
R603A — F	10 Ω	1/2 watt	Fixed	Comp.	10%	
R604	117 Ω total		Fixed	Comp.	1%	Selected
R605	10 Ω	1/2 watt	Fixed	Comp.	10%	
R606	122 Ω total		Fixed	Comp.	1%	Selected
R607	10 Ω	1/2 watt	Fixed	Comp.	10%	
R608A — F	470 k	1/2 watt	Fixed	Comp.	10%	
R609A — F	150 Ω	1/2 watt	Fixed	Comp.	10%	
R610A — F	10 Ω	1/2 watt	Fixed	Comp.	10%	
R611	117 Ω total		Fixed	Comp.	1%	Selected
R612	10 Ω	1/2 watt	Fixed	Comp.	10%	
R613	122 Ω total		Fixed	Comp.	1%	Selected
R614	10 Ω	1/2 watt	Fixed	Comp.	10%	
R701A — L	470 k	1/2 watt	Fixed	Comp.	10%	
R702A — L	150 Ω	1/2 watt	Fixed	Comp.	10%	
R703A — L	10 Ω	1/2 watt	Fixed	Comp.	10%	
R704	105 Ω	1/2 watt	Fixed	Comp.	1%	Selected
R705	10 Ω	1/2 watt	Fixed	Comp.	10%	
R706	4.7 Meg	1/2 watt	Fixed	Comp.	10%	
R707	205 Ω total		Fixed	Comp.		Selected
R708	10 Ω	1/2 watt	Fixed	Comp.	10%	
R709A — L	470 k	1/2 watt	Fixed	Comp.	10%	
R710A — L	150 Ω	1/2 watt	Fixed	Comp.	10%	
R711	105 Ω	1/2 watt	Fixed	Comp.	1%	Selected
R712	10 Ω	1/2 watt	Fixed	Comp.	10%	
R713	4.7 Meg	1/2 watt	Fixed	Comp.	10%	
R714	205 Ω total		Fixed	Comp.		Selected
R715	10 Ω	1/2 watt	Fixed	Comp.	10%	
R716A, B	220 k	2 watt	Var. Dual	Comp.	20%	
R717	330 k	1/2 watt	Fixed	Comp.	10%	
R718	330 k	1/2 watt	Fixed	Comp.	10%	
R719A — L	10 Ω	1/2 watt	Fixed	Comp.	10%	
R720	100 Ω	"	"	"	"	(with L705)
R721	"	"	"	"	"	(with L707)

VACUUM TUBE COMPLEMENT

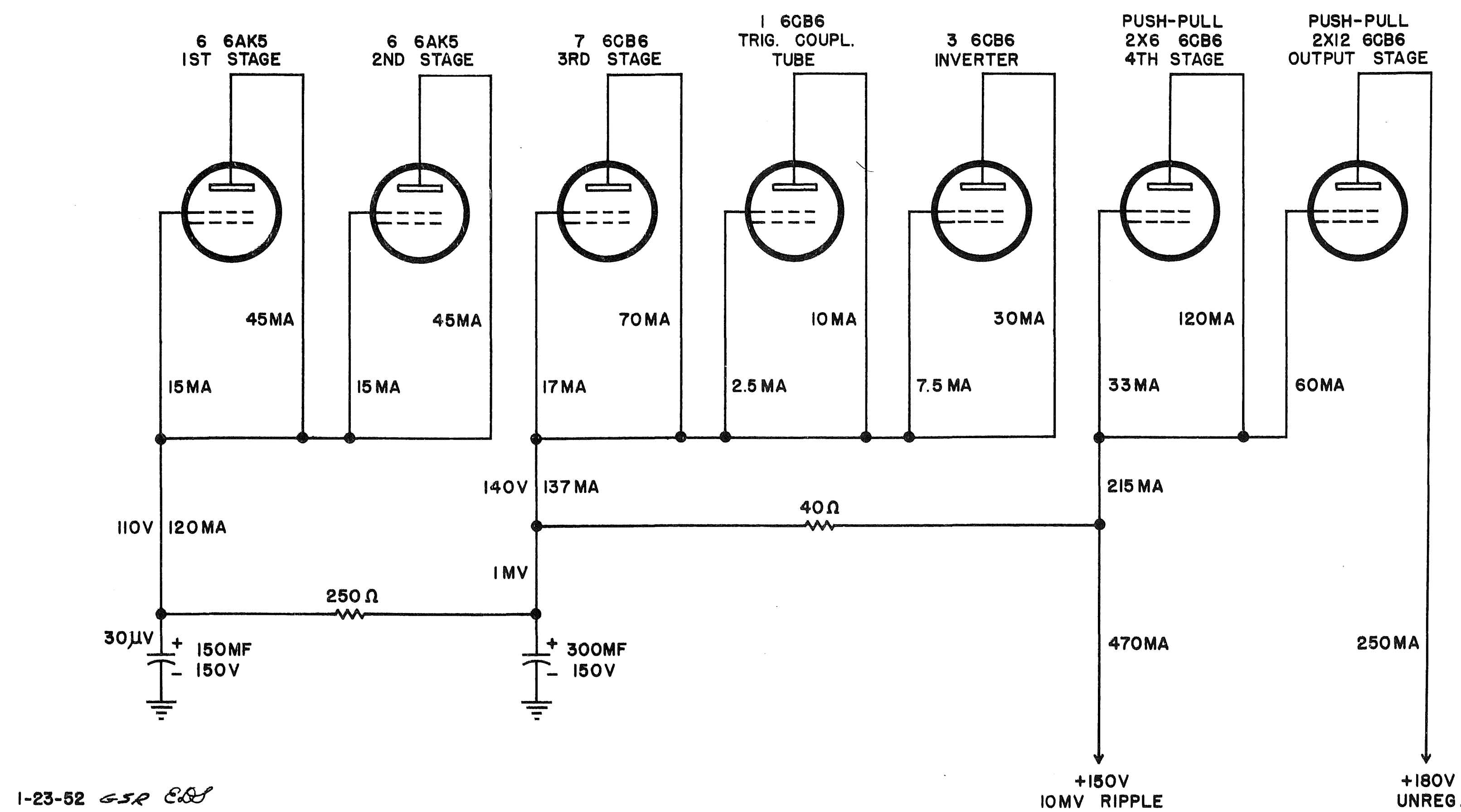
V601	6CB6	Fourth stage, vertical amplifier
V602	6CB6	Fourth stage, vertical amplifier
V603	6CB6	Fourth stage, vertical amplifier
V604	6CB6	Fourth stage, vertical amplifier
V605	6CB6	Fourth stage, vertical amplifier
V606	6CB6	Fourth stage, vertical amplifier
V607	6CB6	Fourth stage, vertical amplifier
V608	6CB6	Fourth stage, vertical amplifier
V609	6CB6	Fourth stage, vertical amplifier
V610	6CB6	Fourth stage, vertical amplifier
V611	6CB6	Fourth stage, vertical amplifier
V612	6CB6	Fourth stage, vertical amplifier
V701	6CB6	Output stage vertical amplifier
V702	6CB6	Output stage vertical amplifier
V703	6CB6	Output stage vertical amplifier
V704	6CB6	Output stage vertical amplifier
V705	6CB6	Output stage vertical amplifier
V706	6CB6	Output stage vertical amplifier
V707	6CB6	Output stage vertical amplifier
V708	6CB6	Output stage vertical amplifier
V709	6CB6	Output stage vertical amplifier
V710	6CB6	Output stage vertical amplifier
V711	6CB6	Output stage vertical amplifier
V712	6CB6	Output stage vertical amplifier
V713	6CB6	Output stage vertical amplifier
V714	6CB6	Output stage vertical amplifier
V715	6CB6	Output stage vertical amplifier
V716	6CB6	Output stage vertical amplifier
V717	6CB6	Output stage vertical amplifier
V718	6CB6	Output stage vertical amplifier
V719	6CB6	Output stage vertical amplifier
V720	6CB6	Output stage vertical amplifier
V721	6CB6	Output stage vertical amplifier
V722	6CB6	Output stage vertical amplifier
V723	6CB6	Output stage vertical amplifier
V724	6CB6	Output stage vertical amplifier



TYPE 517 CATHODE-RAY OSCILLOSCOPE

VERTICAL PUSH PULL DISTRIBUTED AMPLIFIER

Section VI Fig. 8



TYPE 517 CATHODE-RAY OSCILLOSCOPE

VERTICAL AMPLIFIER, PLATE AND SCREEN SUPPLY DISTRIBUTION

Section VI Fig. 9

VERTICAL AMPLIFIER
Plate and Screen Supply Distribution

PARTS LIST

ABBREVIATIONS

Cer. - Ceramic
Comp. - Composition
Dep. Carb. - Deposited Carbon
EMC - Electrolytic, Metal Cased
f - Farads
GMV - Guaranteed Minimum Value
h - Henries
k - Kilo or x 10^3
μ - Micro or x 10^{-6}
Ω - Ohm
PBT - Paper, Bath Tub
PMC - Paper, Metal Cased
Poly - Polystrene
Prec. - Precision
PTM - Paper, Tubular Molded
Var. - Variable
WW - Wire Wound

CAPACITORS

C901	47 μμf	Cer.	Fixed	500 WVDC	20%
C902	100 μμ	Mica	Fixed	500 WVDC	20%
C903	.01 μf	Cer.	Fixed	500 WVDC	GMV
C904	0.1 μf	PTM	Fixed	400 WVDC	20%
C905	.01 μf	PTM	Fixed	400 WVDC	20%
C906	15 μf	EMC	Fixed	450 WVDC	-20%+50% (1/2 of 2 x 15 μf)
C907	~~8~~ μf 6.25	EMC	Fixed	~~150~~ WVDC 300	

RESISTORS

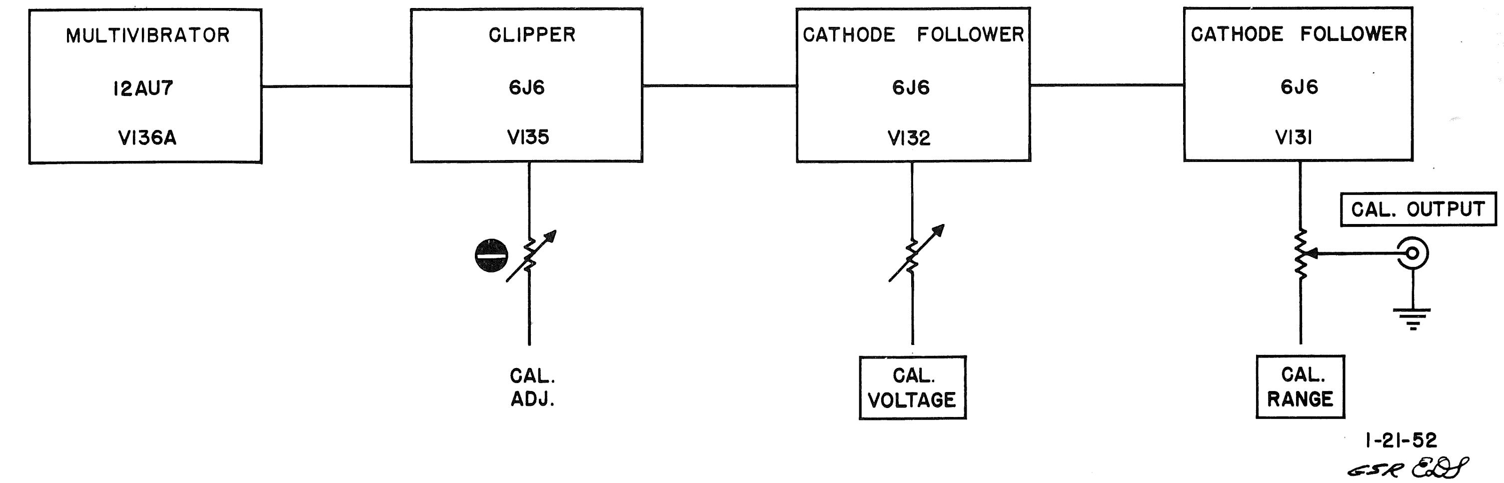
R901	10 k	1/2 watt	Fixed	Comp.	10%	
R902	150 k	1/2 watt	Fixed	Comp.	10%	
R903	150 k	1/2 watt	Fixed	Comp.	10%	
R904	10 k	10 watt	Fixed	WW	10%	
R905	10 k	1/2 watt	Fixed	Comp.	10%	
R906	27 k	1/2 watt	Fixed	Comp.	10%	
R907A	100 k	2 watt	Var.	Comp.	20%	
R907B	390 k	1/2 watt	Fixed	Comp.	10%	
R907C	82 k	1/2 watt	Fixed	Comp.	10%	
R908	470 k	1/2 watt	Fixed	Comp.	10%	
R909	47 Ω	1/2 watt	Fixed	Comp.	10%	
R910	5 k	3 watt	Var.	WW	10%	
R911	47 Ω	1/2 watt	Fixed	Comp.	10%	
R912	180 Ω	1 watt	Fixed	Comp.	10%	
R913	470 k	1/2 watt	Fixed	Comp.	10%	
R914	100 k	1/2 watt	Fixed	Comp.	10%	
R915	47 k	1 watt	Fixed	Comp.	10%	
R916	47 Ω	1/2 watt	Fixed	Comp.	10%	
R917A	700 Ω	1/2 watt	Fixed	Prec.	1%	
R917B	200 Ω	1/2 watt	Fixed	Prec.	1%	
R917C	70 Ω	1/2 watt	Fixed	Prec.	1%	
R917D	20 Ω	1/2 watt	Fixed	Prec.	1%	
R917E	7 Ω	1/2 watt	Fixed	Prec.	1%	
R917F	3 Ω	1/2 watt	Fixed	Prec.	1%	
R918	47 k/2	2 x 2 watt	Fixed	Comp.	10%	two 47 k, 2 watt resistors in parallel
R919	47 k	1/2 watt	Fixed	Comp.	10%	

SWITCHES

SW901	Calibrator range

VACUUM TUBE COMPLEMENT

V131	6J6	Calibrator cathode follower out
V132	6J6	Calibrator cathode follower
V135A, B	6J6	Calibrator clipper
V136A, B	12AU7	Calibrator multivibrator



BLOCK DIAGRAM OF CALIBRATOR

Fig. 10

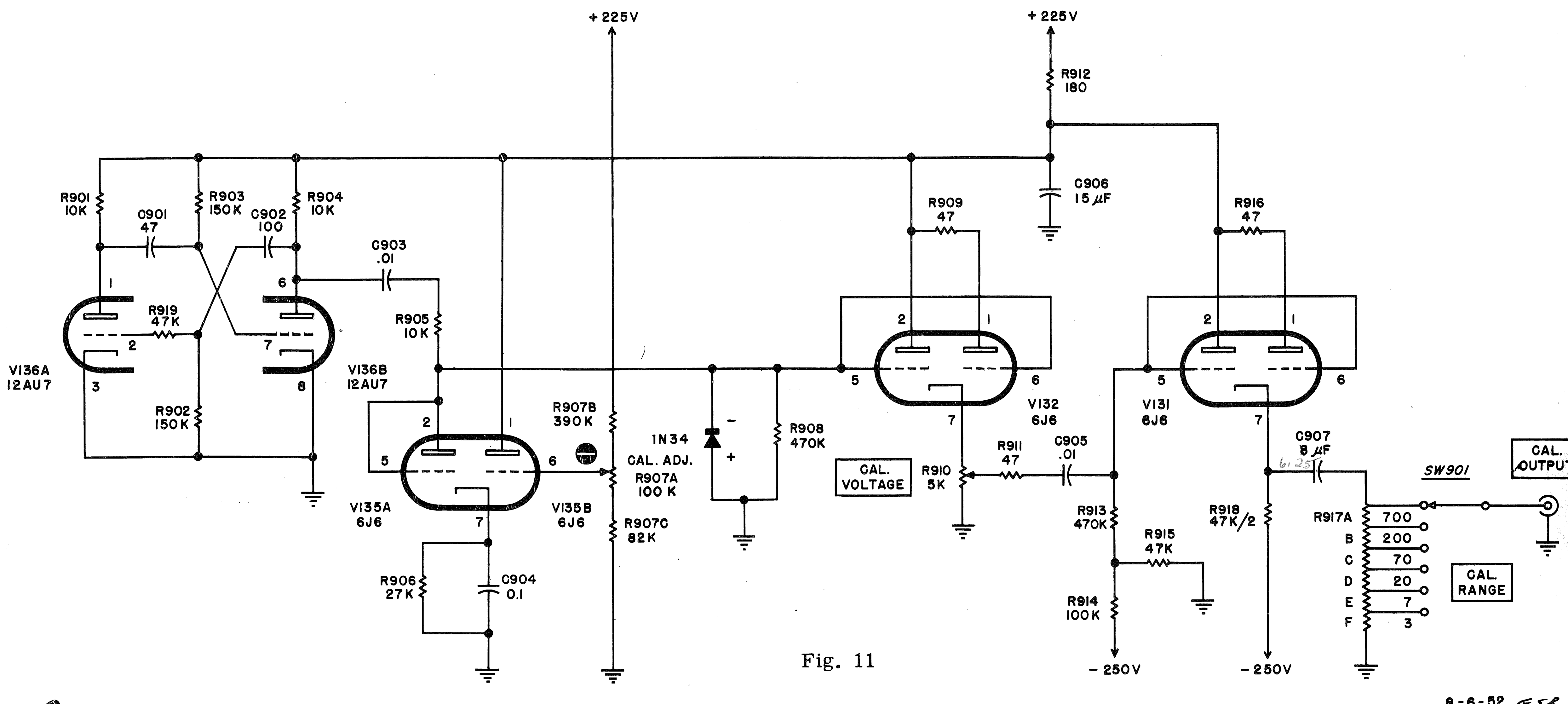


Fig. 11

TYPE 517 CATHODE-RAY OSCILLOSCOPE CALIBRATOR CIRCUIT

Section VI Fig. 10 and Fig. 11

PARTS LIST

ABBREVIATIONS

Cer. - Ceramic
Comp. - Composition
Dep. Carb. - Deposited Carbon
EMC - Electrolytic, Metal Cased
f - Farads
GMV - Guaranteed Minimum Value
h - Henries
k - Kilo or x 10^3
μ - Micro or x 10^{-6}
Ω - Ohm
PBT - Paper, Bath Tub
PMC - Paper, Metal Cased
Poly - Polystrene
Prec. - Precision
PTM - Paper, Tubular Molded
Var. - Variable
WW - Wire Wound

CAPACITORS

C401	40 μf	EMC	Fixed	450 WVDC	-20%+50% (2 x 20)
C402	.01 μf	PTM	Fixed	400 WVDC	20%
C403A	40 μf	EMC	Fixed	450 WVDC	-20%+50% (2 x 20)
C403B	40 μf	EMC	Fixed	450 WVDC	-20%+50% (2 x 20)
C403C	40 μf	EMC	Fixed	450 WVDC	-20%+50% (2 x 20)
C403D	40 μf	EMC	Fixed	450 WVDC	-20%+50% (2 x 20)
C403E	40 μf	EMC	Fixed	450 WVDC	-20%+50% (2 x 20)
C403F	40 μf	EMC	Fixed	450 WVDC	-20%+50% (2 x 20)
C404	.01 μf	PTM	Fixed	400 WVDC	20%
C405A	40 μf	EMC	Fixed	450 WVDC	-20%+50% (2 x 20)
C405B	40 μf	EMC	Fixed	450 WVDC	-20%+50% (2 x 20)
C406A	40 μf	EMC	Fixed	450 WVDC	-20%+50% (2 x 20)
C406B	40 μf	EMC	Fixed	450 WVDC	-20%+50% (2 x 20)
C406C	40 μf	EMC	Fixed	450 WVDC	-20%+50% (2 x 20)
C406D	40 μf	EMC	Fixed	450 WVDC	-20%+50% (2 x 20)
C406E	40 μf	EMC	Fixed	450 WVDC	-20%+50% (2 x 20)
C407	.01 μf	PTM	Fixed	400 WVDC	20%
C408	80 μf	EMC	Fixed	450 WVDC	-20%+50%
C409	40 μf	EMC	Fixed	450 WVDC	-20%+50% (2 x 20)
C410	.01 μf	PTM	Fixed	400 WVDC	20%
C411	.01 μf	PTM	Fixed	400 WVDC	20%
C412	.01 μf	PTM	Fixed	400 WVDC	20%
C413	20 μf	EMC	Fixed	450 WVDC	-20%+50% (1/2 of 2 x 20)
C414	20 μf	EMC	Fixed	450 WVDC	-20%+50% (1/2 of 2 x 20)
C415	.01 μf	PTM	Fixed	400 WVDC	20%
C416	.01 μf	PTM	Fixed	400 WVDC	20%
C418	.001 μf	Cer.	Fixed	500 WVDC	GMV

INDUCTORS

L401	.7h	Fixed

RESISTORS

R401	330 k	1 watt	Fixed	Comp.	10%	
R402	1 Meg	1/2 watt	Fixed	Comp.	10%	
R403	47 Ω	1/2 watt	Fixed	Comp.	10%	
R404	600 k	1/2 watt	Fixed	Prec.	1%	
R405	1 Meg	1/2 watt	Fixed	Prec.	1%	
R406	47 k	2 watt	Fixed	Comp.	10%	
R407	18 k	1 watt	Fixed	Comp.	10%	
R408	470 k	2 watt	Fixed	Comp.	10%	
R409	1 Meg	1/2 watt	Fixed	Comp.	10%	
R410	1 k	1/2 watt	Fixed	Comp.	10%	
R411	1 k	1/2 watt	Fixed	Comp.	10%	
R412	56 Ω	2 watt	Fixed	Comp.	10%	
R413	56 Ω	2 watt	Fixed	Comp.	10%	
R414	970 k	1/2 watt	Fixed	Prec.	1%	
R415	500 k	1/2 watt	Fixed	Prec.	1%	
R416	100 k	2 watt	Fixed	Comp.	10%	
R417	27 k	1 watt	Fixed	Comp.	10%	
R418	330 k	1 watt	Fixed	Comp.	10%	
R419	10/2 Ω	2 x 2 watt	Fixed	Comp.	10%	Two 10 Ω, 2 watt
R420	100 k	2 watt	Fixed	Comp.	10%	resistors in parallel
R421	1 Meg	1/2 watt	Fixed	Comp.	10%	
R422	1 k	1/2 watt	Fixed	Comp.	10%	
R423	1 k	1/2 watt	Fixed	Comp.	10%	
R424	56 Ω	2 watt	Fixed	Comp.	10%	
R425	56 Ω	2 watt	Fixed	Comp.	10%	
R426	1 k	1/2 watt	Fixed	Comp.	10%	
R427	56 Ω	2 watt	Fixed	Comp.	10%	
R428	1 k	1/2 watt	Fixed	Comp.	10%	
R429	56 Ω	2 watt	Fixed	Comp.	10%	
R430	~~600 k~~ 610K	1/2 watt	Fixed	Prec.	1%	
R431	666.6 k	1/2 watt	Fixed	Prec.	1%	
R432	39 k	2 watt	Fixed	Comp.	10%	
R433	18 k	1 watt	Fixed	Comp.	10%	
R434	100 k	1 watt	Fixed	Comp.	10%	
R435	1 Meg	1/2 watt	Fixed	Comp.	10%	
R436	1 k	1/2 watt	Fixed	Comp.	10%	
R437	1 k	1/2 watt	Fixed	Comp.	10%	
R438	1 k	1/2 watt	Fixed	Comp.	10%	
R439	56 Ω	2 watt	Fixed	Comp.	10%	
R440	56 Ω	2 watt	Fixed	Comp.	10%	
R441	1 k	1/2 watt	Fixed	Comp.	10%	
R442	56 Ω	2 watt	Fixed	Comp.	10%	
R443	56 Ω	2 watt	Fixed	Comp.	10%	
R444	2 x 470 Ω	2 x 1/2 watt	Fixed	Comp.	10%	Two 470 Ω, 1/2 wa
R445	1 k	1/2 watt	Fixed	Comp.	10%	resistors in series
R446	56 Ω	2 watt	Fixed	Comp.	10%	
R447	56 Ω	2 watt	Fixed	Comp.	10%	
R448	200 Ω	20 watt	Fixed	WW	10%	
R449	18 k	1 watt	Fixed	Comp.	10%	
R450	18 k	1 watt	Fixed	Comp.	10%	
R451	820 k	1/2 watt	Fixed	Comp.	10%	
R452	270 k	1/2 watt	Fixed	Comp.	10%	
R453	470 k	1/2 watt	Fixed	Comp.	10%	
R454	470 k	1/2 watt	Fixed	Comp.	10%	
R455	600 k	1/2 watt	Fixed	Prec.	1%	
R456	220 Ω	2 watt	Fixed	Comp.	10%	
R457	390 k	1 watt	Fixed	Comp.	10%	
R458	1 Meg	1/2 watt	Fixed	Comp.	10%	
R459	1 k	1/2 watt	Fixed	Comp.	10%	
R460	47 Ω	1/2 watt	Fixed	Comp.	10%	
R461	22 k	1 watt	Fixed	Comp.	10%	
R462	470 k	1/2 watt	Fixed	Comp.	10%	
R463A	143 k	1/2 watt	Fixed	Prec.	1%	
R463B	10 k	2 watt	Var.	WW	10%	
R463C	68 k	1/2 watt	Fixed	Prec.	1%	
R464	33 k	1 watt	Fixed	Comp.	10%	
R465	2.7 Meg	1/2 watt	Fixed	Comp.	10%	
R472	Unassigned					
R473	Unassigned					
R474	1 k	1/2 watt	Fixed	Comp.	10%	
R475	990 k	/ ~~1/2~~ watt	Fixed	Prec.	1%	
R476	7.5 k	10 watt	Fixed	WW	10%	

SWITCHES

SW401	DC power
SW402	AC power

TRANSFORMERS

T401	Ext. power supply plate	Primary:	117, 234, 50/60 cy.
		Secondary:	326-0-326, 35 ma
			562-328-0-328-562, 280 ma
			285 v, 430 ma
			309 v, 780 ma
			334-0-334, 45 ma
T402	Ext. power supply filaments and heaters	Primary:	117, 234, 50/60 cy.
		Secondary:	6.3 v, 2.8 A, 500 v insulat
			6.3 v, 1.85 A, 1200 v insul
			5 v, 2.0 A, 700 v insulation
			6.3 v, 17.4 A

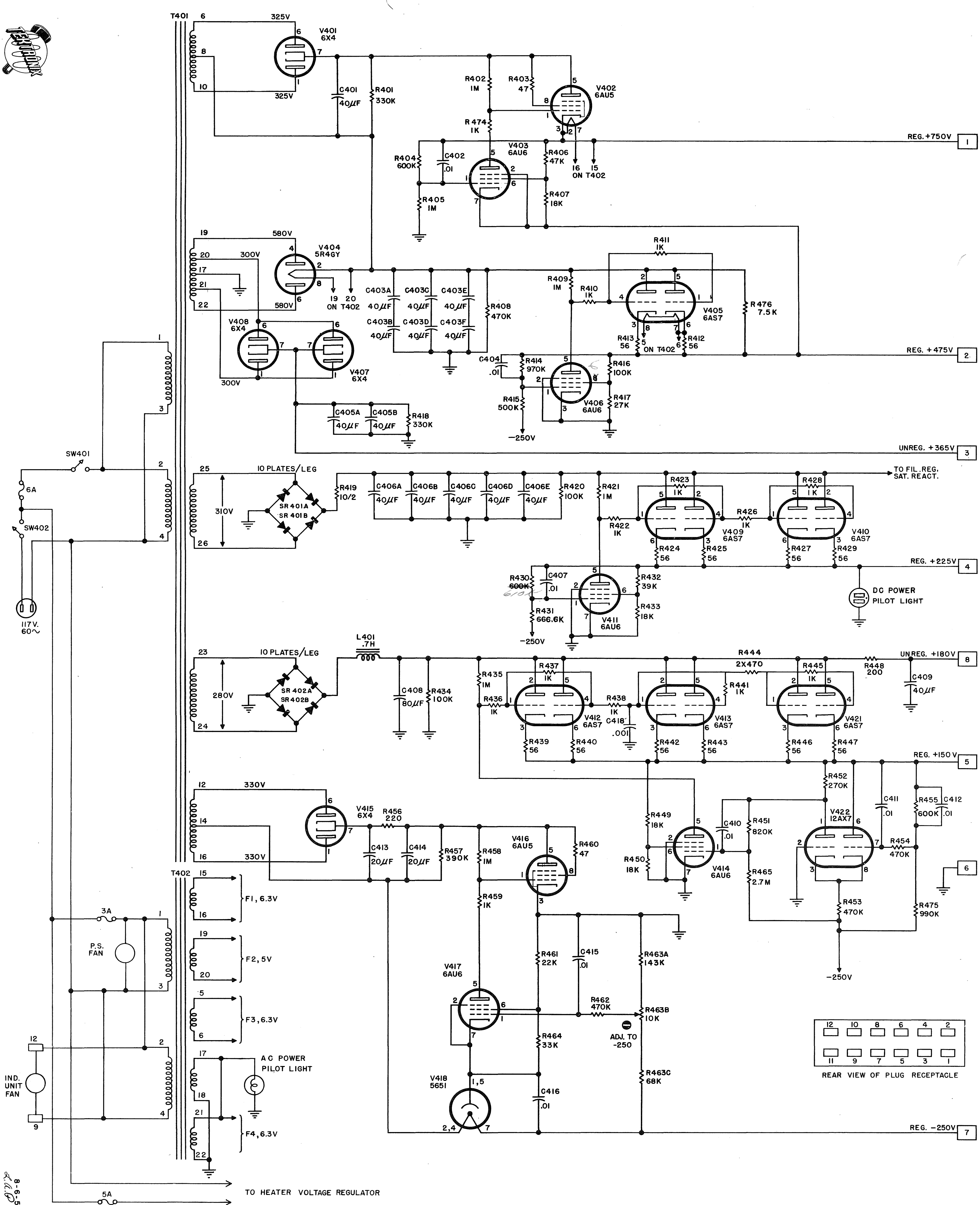
6V TS47 Brown Bead	Pilot light, external power supply, AC
NE 51	Pilot light, external power supply, DC

VACUUM TUBE COMPLEMENT

V401	6X4	Rectifier 750-V supply
V402	6AU5	Series regulator 750-V supply
V403	6AU6	DC amplifier, regulator 750-V supply
V404	5R4GY	Rectifier 475-V supply
V405	6AS7	Series regulator 475-V supply
V406	6AU6	DC amplifier, regulator 475-V supply
V407	6X4	Rectifier 365-V supply
V408	6X4	Rectifier 365-V supply
V409	6AS7	Series regulator 225-V supply
V410	6AS7	Series regulator 225-V supply
V411	6AU6	DC amplifier, regulator 225-V supply
V412	6AS7	Series regulator 150-V supply
V413	6AS7	Series regulator 150-V supply
V414	6AU6	DC amplifier, regulator 150-V supply
V415	6X4	Rectifier -250-V supply
V416	6AU5	Series regulator -250-V supply
V417	6AU6	DC amplifier, regulator -250-V supply
V418	5651	Reference -250-V regulator
V421	6AS7	Series regulator 150-V supply
V422	12AX7	DC amplifier, regulator 150-V supply

TYPE 517 CATHODE-RAY OSCILLOSCOPE EXTERNAL POWER SUPPLY

Section VI Fig. 12



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EXTERNAL POWER SUPPLY

PARTS LIST

ABBREVIATIONS

Cer. - Ceramic	μ - Micro or x 10^{-6}
Comp. - Composition	Ω - Ohm
Dep. Carb. - Deposited Carbon	PBT - Paper, Bath Tub
EMC - Electrolytic, Metal Cased	PMC - Paper, Metal Cased
f - Farads	Poly - Polystrene
GMV - Guaranteed Minimum Value	Prec. - Precision
h - Henries	PTM - Paper, Tubular Molded
k - Kilo or x 10^3	Var. - Variable

WW - Wire Wound

CAPACITORS

C417	1 μf	PBT	Fixed	600 WVDC	20%

INDUCTORS

L402	Saturable reactor

RESISTORS

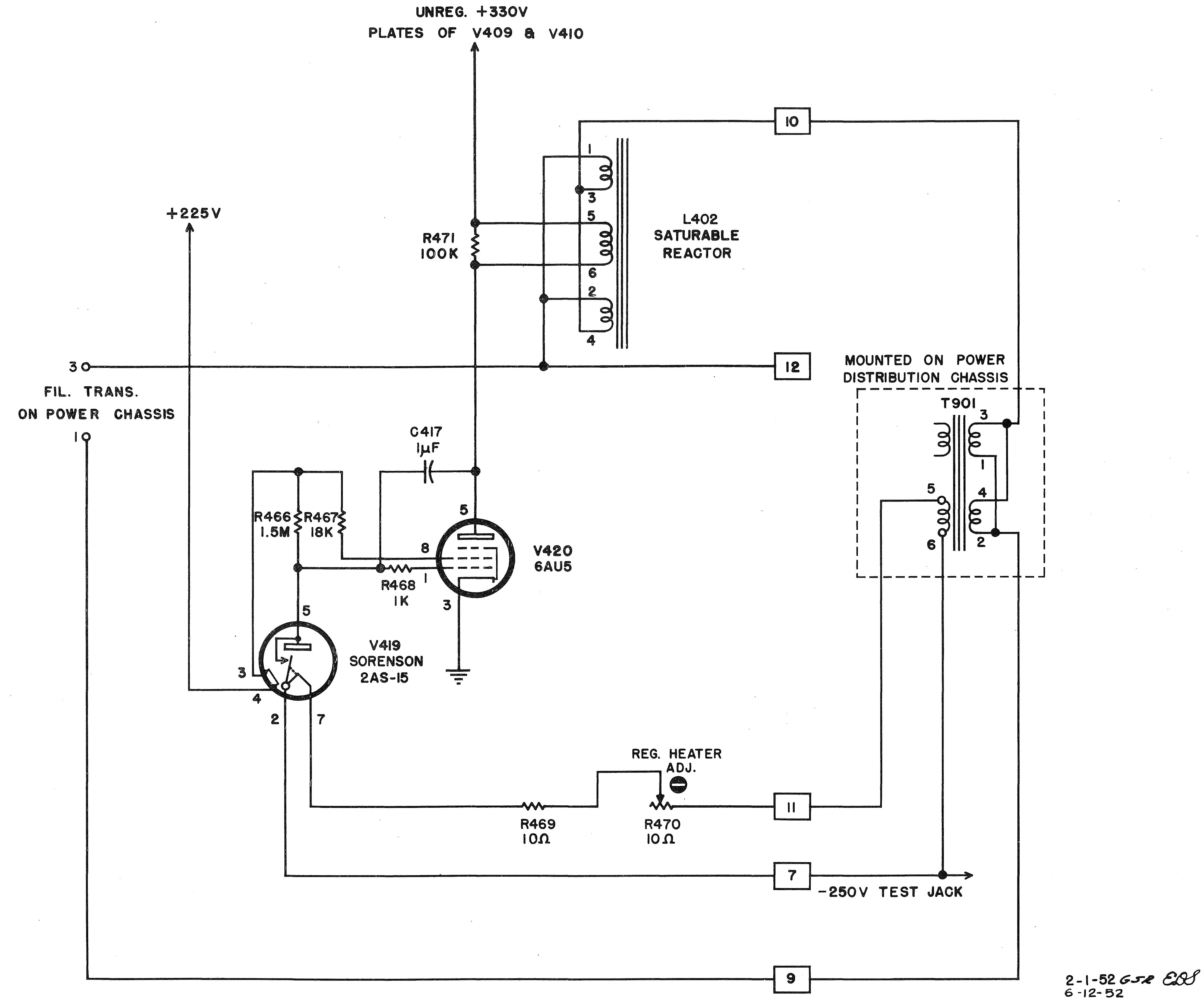
R466	1.5 Meg	1/2 watt	Fixed	Comp.	10%
R467	18 k	2 watt	Fixed	Comp.	10%
R468	1 k	1/2 watt	Fixed	Comp.	10%
R469	10 Ω	2 watt	Fixed	Comp.	10%
R470	10 Ω	2 watt	Var.	WW	10%
R471	100 k	2 watt	Fixed	Comp.	10%

TRANSFORMERS

T901	Indicator Unit Heaters	Primary:	117 v, 50/60 cy.
		Secondary:	6.3 v, 16.7 A
			6.3 v, 7.2 A
			6.3 v, 5.4 A
			6.3 v, 3.6 A
			6.3 v, 0.3 A
			6.3 v, 2.25 A, 300 v insulation
			6.3 v, 0.6 A, 5000 v insulation
			6.3 v, 2.5 A, 400 v insulation

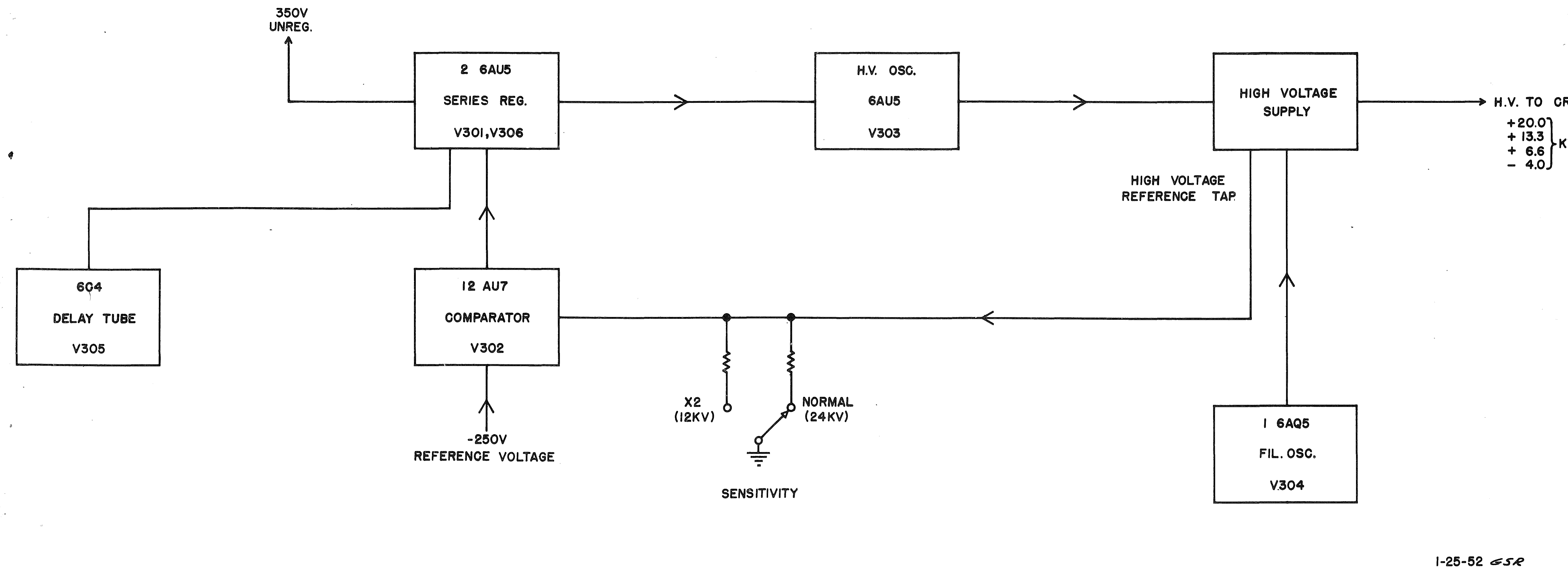
VACUUM TUBE COMPLEMENT

V419	Sorensen 2AS-15	Filament voltage sensing diode
V420	6AU5	Amplifier filament regulator



TYPE 517 HEATER VOLTAGE REGULATOR CIRCUIT

INDICATOR-UNIT HEATERS



TYPE 517 CATHODE-RAY OSCILLOSCOPE

BLOCK DIAGRAM
POWER SUPPLY OSCILLATORS
AND FILAMENT SUPPLY

Section VI Fig. 14

PARTS LIST

ABBREVIATIONS

Cer. - Ceramic	μ - Micro or x 10^{-6}
Comp. - Composition	Ω - Ohm
Dep. Carb. - Deposited Carbon	PBT - Paper, Bath Tub
EMC - Electrolytic, Metal Cased	PMC - Paper, Metal Cased
f - Farads	Poly - Polystrene
GMV - Guaranteed Minimum Value	Prec. - Precision
h - Henries	PTM - Paper, Tubular Moldea
k - Kilo or x 10^3	Var. - Variable

WW - Wire Wound

CAPACITORS

C201	.0047 μf	PTM	Fixed	6000 WVDC	20%
C202	.0047 μf	PTM	Fixed	6000 WVDC	20%
C203	.0047 μf	PTM	Fixed	6000 WVDC	20%
C204	.0047 μf	PTM	Fixed	6000 WVDC	20%
C205	.0047 μf	PTM	Fixed	6000 WVDC	20%
C206	.0047 μf	PTM	Fixed	6000 WVDC	20%
C207	.0047 μf	PTM	Fixed	6000 WVDC	20%
C208	.0047 μf	PTM	Fixed	6000 WVDC	20%
C209	.015 μf	PTM	Fixed	3000 WVDC	20%
C210	.0068 μf	PTM	Fixed	5000 WVDC	20%
C211	.0068 μf	PTM	Fixed	5000 WVDC	20%
C212	.015 μf	PTM	Fixed	3000 WVDC	20%
C213	.0047 μf	PTM	Fixed	6000 WVDC	20%
C214	.0068 μf	PTM	Fixed	3000 WVDC	20%
C215	.0068 μf	PTM	Fixed	3000 WVDC	20%
C216	.0068 μf	PTM	Fixed	3000 WVDC	20%
C217	"	"	"	5000 "	"
C301	6.25 μf	EMC	Fixed	300 WVDC	-20%+50%
C302	.1 μf	PTM	Fixed	400 WVDC	20%
C303	40 μf	EMC	Fixed	450 WVDC	-20%+50% (2 x 20)
C304	.022 μf	PTM	Fixed	400 WVDC	5%
C305	.01 μf	PTM	Fixed	400 WVDC	20%
C306	.01 μf	PTM	Fixed	400 WVDC	20%
C307	6.25 μf	EMC	Fixed	300 WVDC	-20%+50%
C308	.022 μf	PTM	Fixed	600 WVDC	5%
C309	.01 μf	PTM	Fixed	400 WVDC	20%
C310	Unassigned				
C311	.047 μf	PTM	Fixed	600 WVDC	5%
C312	6.25 μf	EMC	Fixed	300 WVDC	-20%+50%
C314	15 μf	EMC	Fixed	450 WVDC	-20%+50% (1/2 of 2 x 15)
C315	~~.22~~ .25 μf	PTM	Fixed	~~400~~ 600 WVDC	20%

RESISTORS

R201	100 Meg	2 watt	Fixed	Dep. Carb.	10%
R202	100 Meg	2 watt	Fixed	Dep. Carb.	10%
R203	30 Meg	2 watt	Fixed	Dep. Carb.	10%
R204	10 Meg	1/2 watt	Fixed	Comp.	10%
R205	10 Meg	1 watt	Fixed	Dep. Carb.	10%
R206	20 Meg	2 watt	Fixed	Dep. Carb.	10%
R207	10 Meg	1/2 watt	Fixed	Comp.	10%
R208	20 Meg	2 watt	Fixed	Dep. Carb.	10%
R209	10 Meg	1 watt	Fixed	Dep. Carb.	10%
R210	10 Meg	1/2 watt	Fixed	Comp.	10%
R211	30 Meg	2 watt	Fixed	Dep. Carb.	10%
R212	22 Meg	1/2 watt	Fixed	Comp.	10%
R213	50 Meg	2 watt	Fixed	Dep. Carb.	10%
R214	220 k	1/2 watt	Fixed	Comp.	10%
R215	1 Meg	1/2 watt	Fixed	Comp.	10%
R301	180 k	1/2 watt	Fixed	Comp.	10%
R302	1 k	1/2 watt	Fixed	Comp.	10%
R303	1 k	1/2 watt	Fixed	Comp.	10%
R304	47 Ω	1/2 watt	Fixed	Comp.	10%
R305	47 Ω	1/2 watt	Fixed	Comp.	10%
R306	47 Ω	1/2 watt	Fixed	Comp.	10%
R307	330 k	1 watt	Fixed	Comp.	10%
R308	1 k	1/2 watt	Fixed	Comp.	10%
R309	1.5 k	1/2 watt	Fixed	Comp.	10%
R310A	2 Meg	2 watt	Var.	Comp.	20%
R310B	3 Meg	1/2 watt	Fixed	Comp.	10%
R311A	5 ~~4~~ Meg	2 watt	Var.	Comp.	20%
R311B	1 2 Meg	1/2 watt	Fixed	Comp.	10%
R312	10 k	2 watt	Fixed	Comp.	10%
R313	120 k	1/2 watt	Fixed	Comp.	10%
R314	1 k	1/2 watt	Fixed	Comp.	10%
R315	470 Ω	1 watt	Fixed	Comp.	10%
R316	82 k	1/2 watt	Fixed	Comp.	10%
R317	3.3 k	1/2 watt	Fixed	Comp.	10%
R318	33 k	1/2 watt	Fixed	Comp.	10%
R319	Unassigned				
R320	220 k	1/2 watt	Fixed	Comp.	10%
R321	33 k	1/2 watt	Fixed	Comp.	10%
R322	6.8 Meg	1/2 watt	Fixed	Comp.	10%

SWITCHES

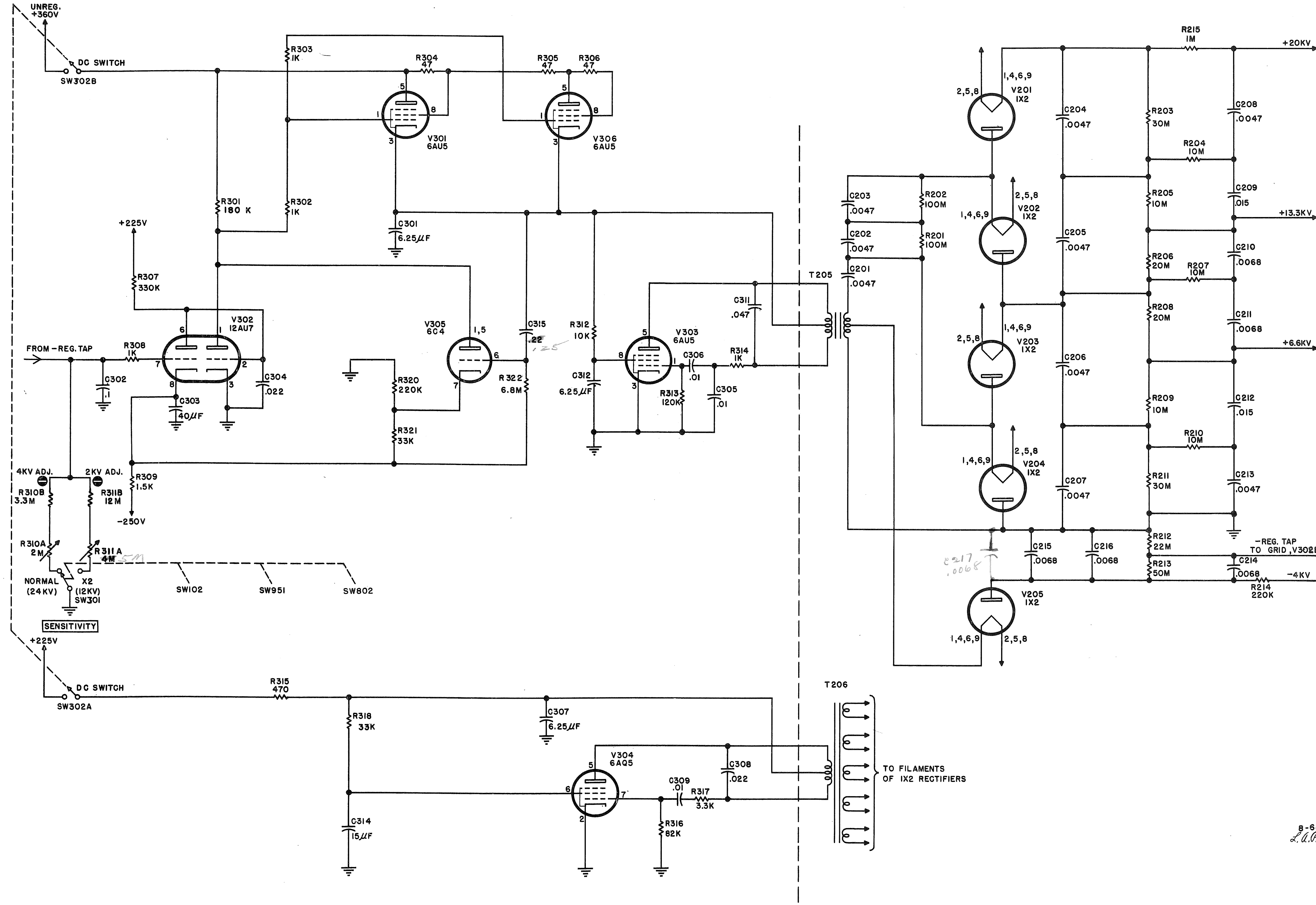
SW301	Sensitivity (H. V. oscillator reference voltage)
SW302A	DC to filament oscillator
SW302B	DC to high voltage oscillator

TRANSFORMERS

T205	CRT supply (Type 420 supply)	Primary: Secondary:	27-0-135, 2 kc 0-4000-5000 peak
T206	CRT voltage rectifier filaments (Type 420 supply)	Primary: Secondary:	22-0-115, 2 kc 1.25 v, 0.2 A, 20 kv insulation 1.25 v, 0.2 A, 15 kv insulation 1.25 v, 0.2 A, 10 kv insulation 1.25 v, 0.2 A, 5 kv insulation 1.25 v, 0.2 A, 4 kv insulation

VACUUM TUBE COMPLEMENT

V201	1X2	H. V. rectifier
V202	1X2	H. V. rectifier
V203	1X2	H. V. rectifier
V204	1X2	H. V. rectifier
V205	1X2	H. V. rectifier
V301	6AU5	Series regulator H. V. oscillator
V302	12AU7	DC amplifier, H. V. oscillator regulator
V303	6AU5	H. V. oscillator
V304	6AQ5	Filament oscillator
V305	6C4	H. V. oscillator time delay cathode follower
V306	6AU5	Series regulator H. V. oscillator



TYPE 517 CATHODE-RAY OSCILLOSCOPE

POWER SUPPLY OSCILLATORS AND FILAMENT SUPPLY

Section VI Fig. 15

PARTS LIST

ABBREVIATIONS

Cer. - Ceramic
Comp. - Composition
Dep. Carb. - Deposited Carbon
EMC - Electrolytic, Metal Cased
f - Farads
GMV - Guaranteed Minimum Value
h - Henries
k - Kilo or x 10^3
μ - Micro or x 10^{-6}
Ω - Ohm
PBT - Paper, Bath Tub
PMC - Paper, Metal Cased
Poly - Polystrene
Prec. - Precision
PTM - Paper, Tubular Molded
Var. - Variable
WW - Wire Wound

CAPACITORS

C813	Unassigned				
C814	Unassigned				
C815	.01 μf	PTM	Fixed	400WVDC	20%
C816	.01 μf	PTM	Fixed	400WVDC	20%
C817	20 μf	EMC	Fixed	450WVDC	-20%+50% (1/2 of 2 x 20 μf)
C818	.0068 μf	PTM	Fixed	5000 WVDC	20%
C819	.001 μf	PTM	Fixed	600 WVDC	20%
C820	.05 μf	PMC	Fixed	5000 WVDC	20%
C825	1000 μf	EMC	Fixed	15 WVDC	-20%to +50% (1/2 2 x 1000μf)
C826	1000 μf	EMC	Fixed	15 WVDC	-20% to +50% (1/2 2 x 1000μf)

RESISTORS

R825	150 k	1/2 watt	Fixed	Comp.	10%
R826	180 k	1/2 watt	Fixed	Comp.	10%
R827	220 k	1/2 watt	Fixed	Comp.	10%
R828	220 k	1/2 watt	Fixed	Comp.	10%
R829	.5 Meg.	2 watt	Var.	Comp.	20%
R830	330 k	1/2 watt	Fixed	Comp.	10%
R831	1 k	1/2 watt	Fixed	Comp.	10%
R832	100 k	1/2 watt	Fixed	Comp.	10%
R833	3.3 Meg.	2 watt	Fixed	Comp.	10%
R834	2.7 Meg.	2 watt	Fixed	Comp.	10%
R835	3.3 Meg	2 watt	Fixed	Comp.	10%
R836	2 Meg.	2 watt	Var.	Comp.	20%
R837	3.3 Meg.	2 watt	Fixed	Comp.	10%
R838	2 Meg.	2 watt	Var.	Comp.	20%
R839	2 Meg.	2 watt	Var.	Comp.	20%
R840	2.2 Meg.	1/2 watt	Fixed	Comp.	10%
R841	22 k	1/2 watt	Fixed	Comp.	10%
R842	Unassigned				
R845	10 Ω	1 watt	Fixed	Comp.	10%
R846	10 Ω	1 watt	Fixed	Comp.	10%

SWITCHES

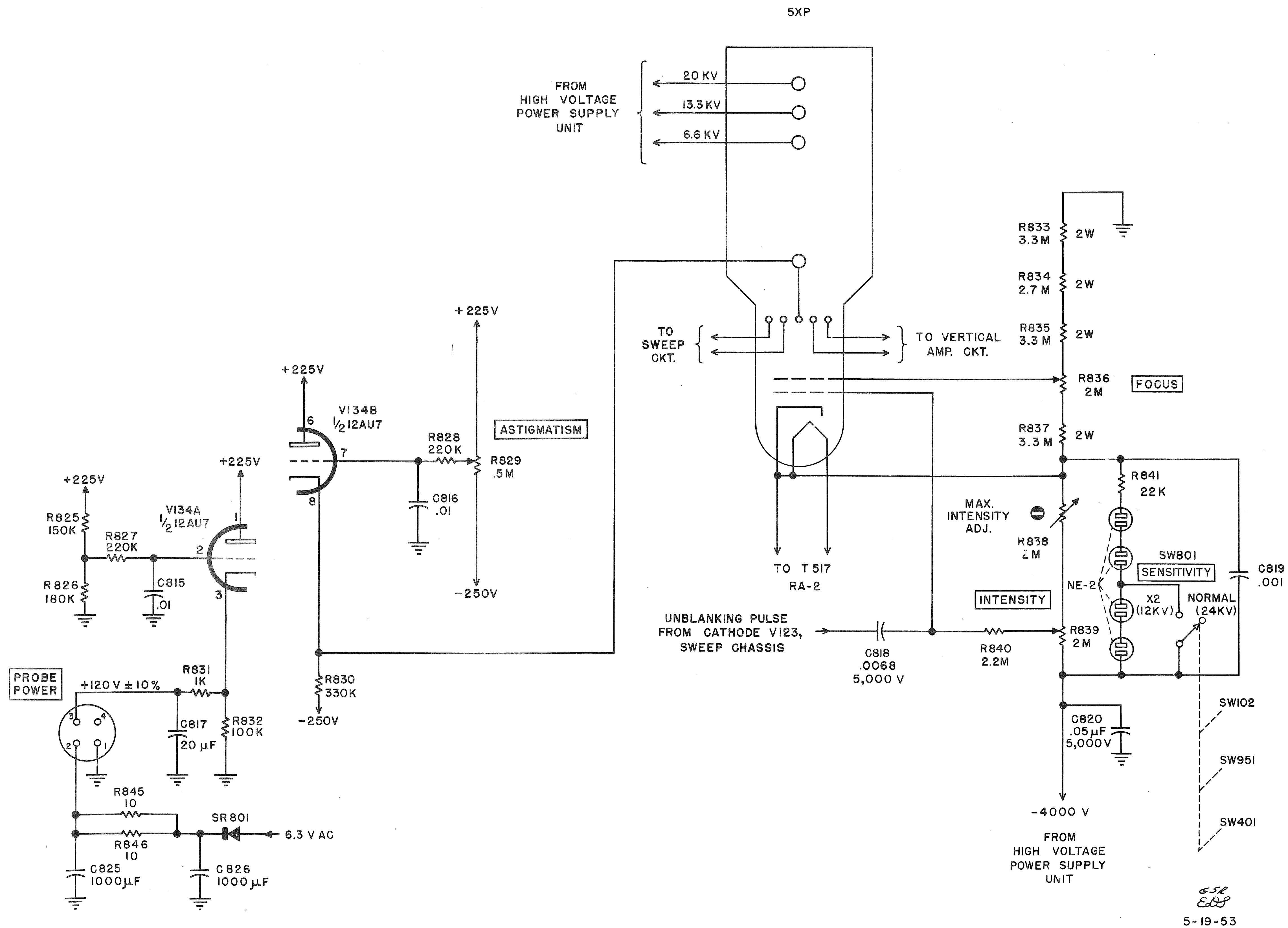
SW802 Sensitivity (CR tube bias)

VACUUM TUBE

V134A, B	12AU7	1/2 Probe power regulator 1/2 Astigmatism voltage cathode follower

MISCELLANEOUS

NE2	Neonnglow lamps	Cathode-Ray tube bias regulator
SR801	Selenium Rectifier	500 ma



TYPE 517 CATHODE-RAY OSCILLOSCOPE

CATHODE-RAY TUBE CIRCUIT

PARTS LIST

ABBREVIATIONS

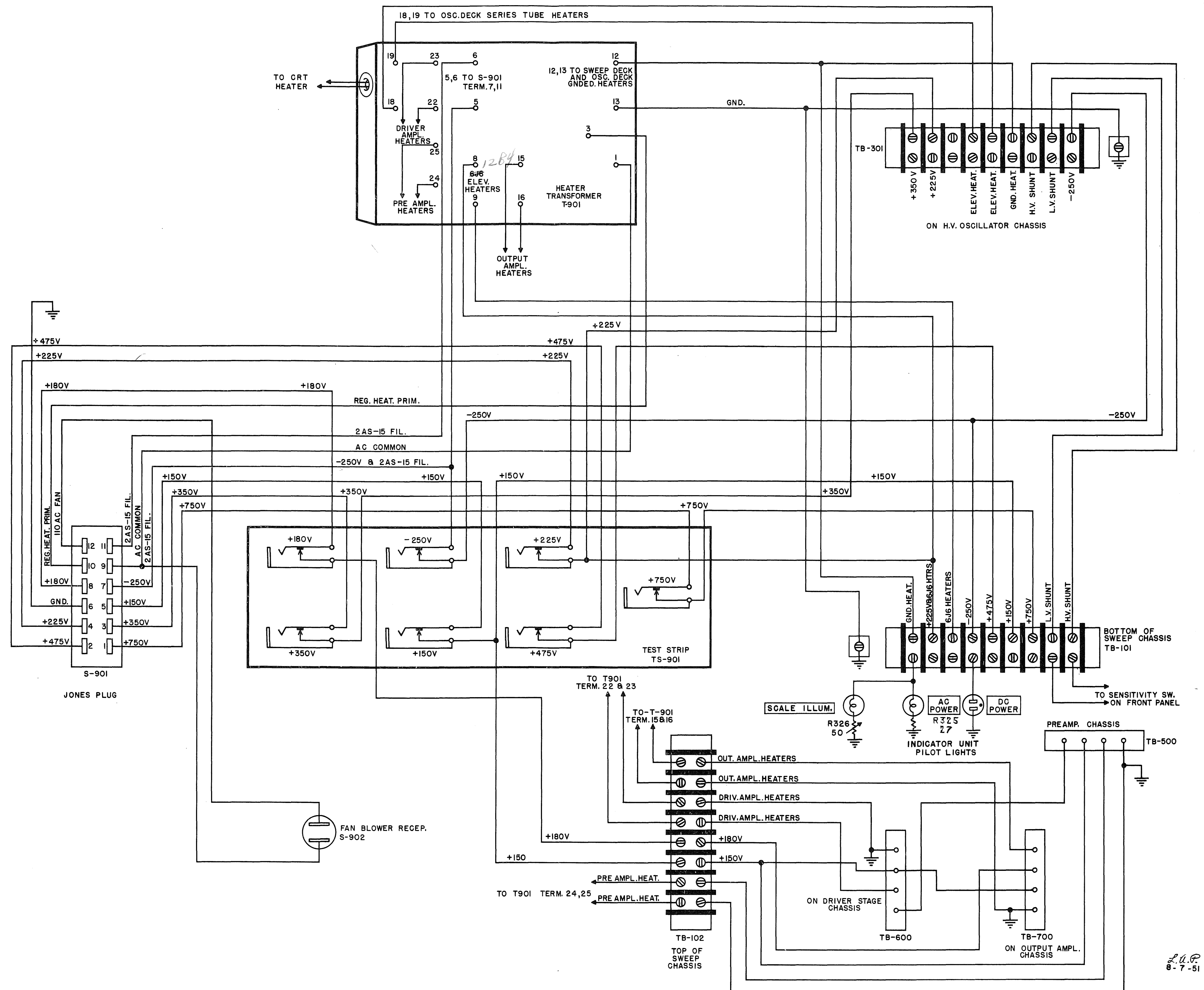
Cer. - Ceramic
Comp. - Composition
Dep. Carb. - Deposited Carbon
EMC - Electrolytic, Metal Cased
f - Farads
GMV - Guaranteed Minimum Value
h - Henries
k - Kilo or x 10^3
μ - Micro or x 10^{-6}
Ω - Ohm
PBT - Paper, Bath Tub
PMC - Paper, Metal Cased
Poly - Polystrene
Prec. - Precision
PTM - Paper, Tubular Molded
Var. - Variable
WW - Wire Wound

RESISTORS

R325	27 Ω	1/2 watt	Fixed	Comp.	10%
R326	50 Ω	2 watt	Var.	WW	20%

PILOT LIGHTS

NE 51	Pilot light, indicator unit, DC power
6V TS47 Brown Bead	Pilot light, indicator unit, heaters
6V TS47 Brown Bead	Scale illumination, two



TYPE 517 CATHODE-RAY OSCILLOSCOPE POWER DISTRIBUTION DIAGRAM

Section VI Fig. 17

PARTS LIST

ABBREVIATIONS

Cer. - Ceramic
Comp. - Composition
Dep. Carb. - Deposited Carbon
EMC - Electrolytic, Metal Cased
f - Farads
GMV - Guaranteed Minimum Value
h - Henries
k - Kilo or x 10^3
μ - Micro or x 10^{-6}
Ω - Ohm
PBT - Paper, Bath Tub
PMC - Paper, Metal Cased
Poly - Polystrene
Prec. - Precision
PTM - Paper, Tubular Molded
Var. - Variable
WW - Wire Wound

Figure 18

INDUCTORS

L995	Special
L996	Special

RESISTORS

R995A	2960 Ω	1/2 watt	Fixed	Dep. Carb.	2%
R995B	1480 Ω	1/2 watt	Fixed	Dep. Carb.	2%
R995C	995 Ω	1/2 watt	Fixed	Dep. Carb.	2%
R995D	513 Ω	1/2 watt	Fixed	Dep. Carb.	2%
R995E	285 Ω	1/2 watt	Fixed	Dep. Carb.	2%
R995F	208 Ω	1/2 watt	Fixed	Dep. Carb.	2%
R995G	208 Ω	1/2 watt	Fixed	Dep. Carb.	2%
R996A	19.6 Ω	1/2 watt	Fixed	Dep. Carb.	2%
R996B	39.5 Ω	1/2 watt	Fixed	Dep. Carb.	2%
R996C	60 Ω	1/2 watt	Fixed	Dep. Carb.	2%
R996D	127 Ω	1/2 watt	Fixed	Dep. Carb.	2%
R996E	317 Ω	1/2 watt	Fixed	Dep. Carb.	2%
R996F	840 Ω	1/2 watt	Fixed	Dep. Carb.	2%
R996G	840 Ω	1/2 watt	Fixed	Dep. Carb.	2%
R997A	2960 Ω	1/2 watt	Fixed	Dep. Carb.	2%
R997B	1480 Ω	1/2 watt	Fixed	Dep. Carb.	2%
R997C	995 Ω	1/2 watt	Fixed	Dep. Carb.	2%
R997D	513 Ω	1/2 watt	Fixed	Dep. Carb.	2%
R997E	285 Ω	1/2 watt	Fixed	Dep. Carb.	2%
R997F	208 Ω	1/2 watt	Fixed	Dep. Carb.	2%
R997G	208 Ω	1/2 watt	Fixed	Dep. Carb.	2%

SWITCHES

SW995A to G Attenuator toggle switches

Figure 19

CAPACITORS

C951	.001 μf	Cer.	Fixed	500 WVDC	GMV
C952	.01 μf	Cer.	Fixed	500 WVDC	GMV
C953	.01 μf	Cer.	Fixed	500 WVDC	GMV
C954	.04 μf	Cer.	Fixed	500 WVDC	GMV (2 x .02)
C955A	.5-5 μμf	Special	Var.		
C955B	.5-5 μμf	Special	Var.		
C955C	.5-5 μμf	Special	Var.		
C956A	Special*				
C956B	Special*				
C956C	Special*				

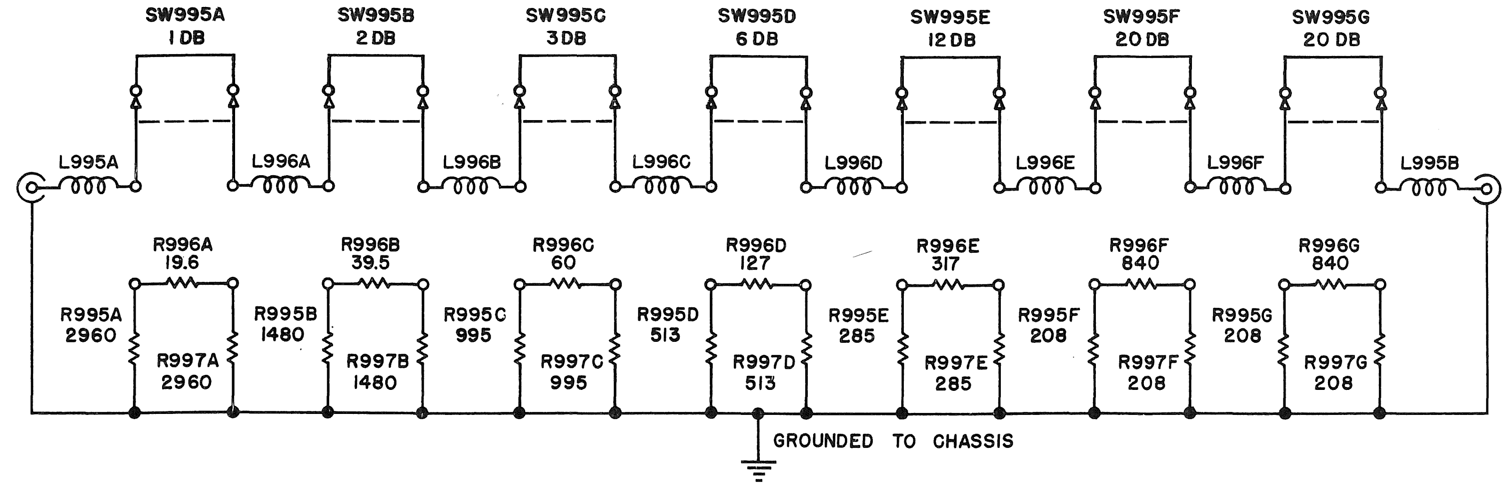
*Silvered Mica Disk. Capacitance depends on desired time constant and voltage division ratio. Limits between 2 μμf and 500 μμf, approximately.

RESISTORS

R951	100 Ω	1/4 watt	Fixed	Comp.	20%
R952	12 Meg	1/2 watt	Fixed	Comp.	10%
R953	10 Ω	1/2 watt	Fixed	Comp.	10%

VACUUM TUBE

V951	5718	Probe cathode follower



L995: 20 TURNS #28 BARE COPPER 3/32" FORM, 1/2" LONG.
L996: 15 TURNS #28 BARE COPPER 3/32" FORM, 3/8" LONG.

1-28-52 G.S.R. EDS

Fig. 18 TYPE B170-V 170 OHM ATTENUATOR

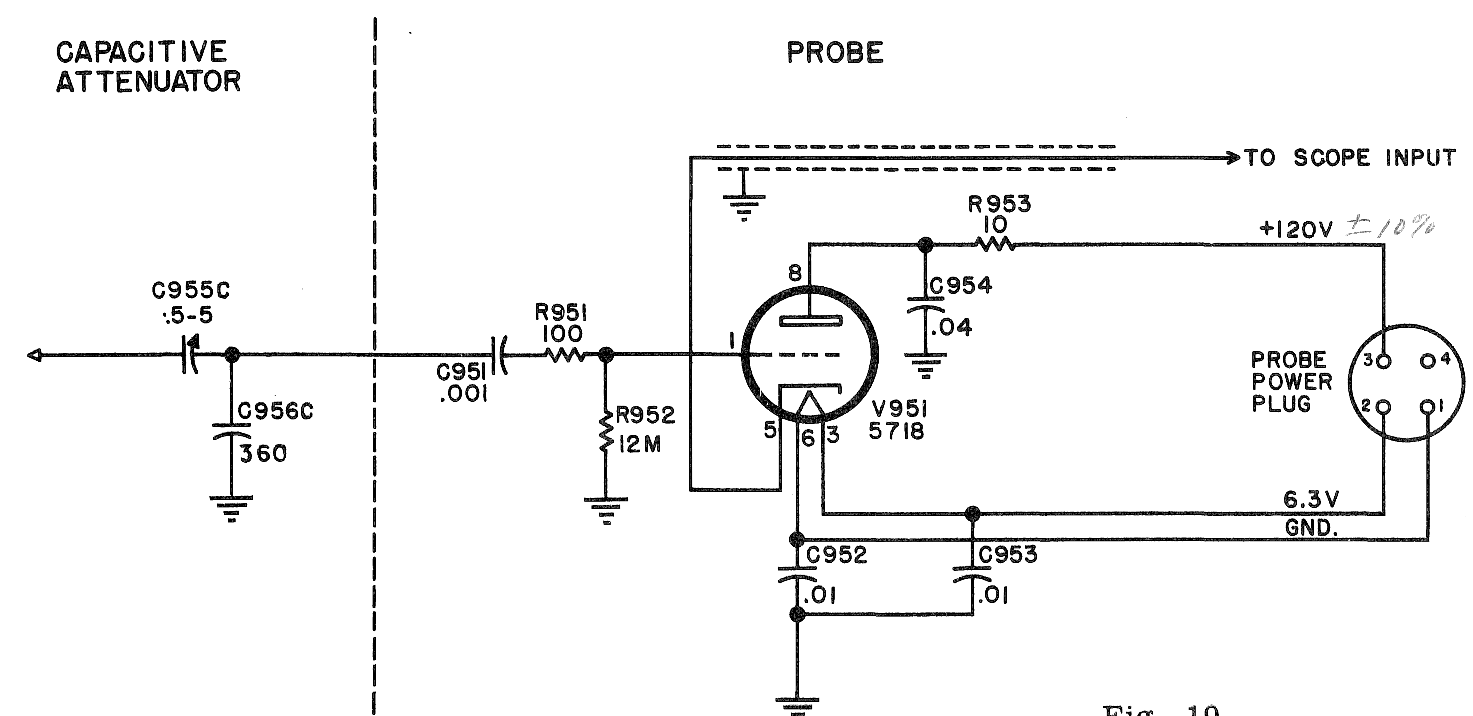


Fig. 19
ATTENUATOR & PROBE PR-170-CF

TYPE 517 CATHODE-RAY OSCILLOSCOPE

L.A.P. EDS
5-2-52