

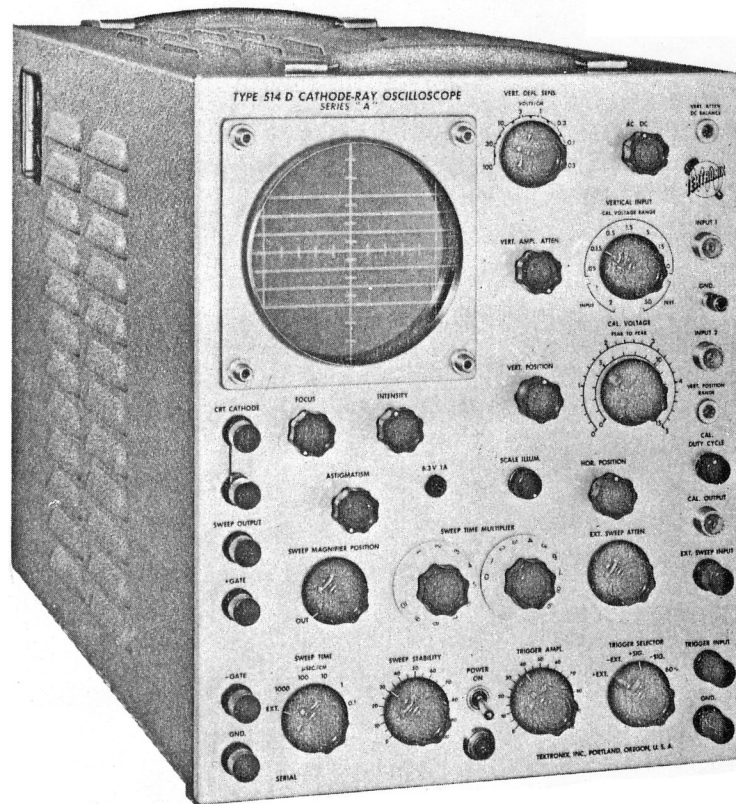
INSTRUCTION MANUAL
CATHODE-RAY OSCILLOSCOPE **TYPE** **514**

TEKTRONIX

**TYPE 514 D
SERIES A**

CATHODE-RAY OSCILLOSCOPE

INSTRUCTION MANUAL



Manufacturers of Cathode-Ray and Video Test Instruments

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SECTION I

General Description

The Tektronix Type 514D Cathode Ray Oscilloscope is a self-contained general purpose precision instrument, designed specifically to incorporate the advantages of direct coupling, excellent transient response and high gain into a medium priced oscilloscope. These features are obtained efficiently by means of the distributed amplifier technique, making possible a compact portable instrument of wide utility.

Accurately calibrated timing controls, a seven range square wave amplitude calibrator, complete dc supply regulation and liberal use of precision components, permit quantitative waveform analysis without necessity of auxiliary equipment.

The Type 514 Oscilloscope is identical to the Type 514D except for the omission of the Signal Delay Network.

Characteristics

Sweep Circuit

Hard tube type. Either triggered, recurrent or single sweeps as desired. Push-pull linear amplifier.

Sweep Time (Speed)

Continuously variable from .01 sec. per cm to .1 microsecond per cm. Calibration accurate to within $\pm 5\%$.

Trigger Requirements

Internal—Observed signal deflection on CRT. of 5 mm. or greater.

External .15 to 15 volt (Peak). Sine wave or pulse of either polarity. Pulse as short as .05 microsecond will trigger satisfactorily. A key connected between TRIGGER INPUT and GND. is suitable for triggering single sweeps.

Sweep Lag

CRT is unblanked and sweep is operating linearly in less than .1 microsecond after receipt of an infinitely sharp trigger pulse.

Sweep Magnification

Any desired 20% of the sweep can be spread over the entire trace except when a sweep time of less than .5 microsecond per cm is used.

External Sweep Input

Dc coupled via 100 k potentiometer and sweep amplifier. Maximum deflection sensitivity 1.5 V per cm dc or peak to peak ac. Band width, dc to 800 kc (3 db down at 800 kc).

Vertical Amplifier

4 stage. 3rd and 4th stage direct coupled push-pull. Distributed output (4th) stage.

Signal Input

Dual (alternate) coaxial connectors.

Vertical-Deflection Sensitivity, ac

Continuously variable from .03 v/cm to 100 v/cm, peak to peak.

Vertical-Deflection Sensitivity, dc

Continuously variable from .3 v/cm to 100 v/cm, peak to peak.

Input Impedance

1 megohm shunted by 40 μmf . With probe, 10 megohm shunted by 13 μmf . (10X attenuation).

Vertical-Amplifier Frequency Response

Dc to 10 mc at sensitivity of .3 v/cm or lower; 2 cps to 10 mc at sensitivity of .03 v/cm to 3 v/cm.

Vertical-Amplifier Transient Response

Rise time (10% - 90%) .04 μsec .

Maximum Input Signal

600 volts peak.

Signal-Delay Network (Type 514D only)

Provides .25- μsec signal delay. Permits observation of the waveform which triggers sweep.

Calibrating Voltage

Square wave. Seven ranges .05 volts to 50 volts full scale. Accuracy, within 2% of full scale.

Waveforms Available Externally

6.3 V, 1 amp at line frequency.
Sweep sawtooth, 30 volts peak.
Positive and negative gates, 40 V peak, same duration as sweep. Square wave calibrating voltage.

Cathode-Ray Tube

Type 5CPA, P1, P7, or P11 screens optional.

Connection to CRT Cathode

Via 0.1 μ capacitor. RC=.012 sec.

Accelerating voltage on cathode-ray tube, 3 kv regulated.

Power Requirements. 105-125 volts, or 210-250 volts, 50-60 cycles, 360 watts. (See Section IV)

Weight. 60 pounds.

Dimensions. 15½" high, 12½" wide, 21½" deep.

Finish. Panel, photo-etched aluminum with black letters. Cabinet, gray wrinkle.

Functions of Controls and Connections

A brief explanation of the function of each control and connection is given below. For a more detailed explanation, consult Section III, Circuit Description.

INPUT 1	Signal input to the vertical amplifier. UHF connector permits use of the Type A510 binding post adapter or the Type P510A R-C probe.	AC-DC	Switch to provide optional direct or capacitive coupling of the vertical amplifier. Only capacitive coupling is available for .03 V to .3 V sensitivity.
INPUT 2	Alternate signal input to the vertical amplifier.	CAL. DUTY CYCLE	Potentiometer in grid-return circuit of multivibrator generating calibrator squarewave. Permits variation of duty cycle between 2% and 98%
VERTICAL INPUT	Eleven position switch for selecting either INPUT 1 or INPUT 2, any one of seven squarewave calibration ranges, or either of two square-wave test ranges.	CAL. VOLTAGE	Calibrated potentiometer used in conjunction with CAL. RANGE and TEST settings of the VERTICAL INPUT selector to provide continuously variable amplitude control of the squarewave calibrator.
VERT. DEFL. SENS.	Combined 4-section rc attenuator and input channel selector, which, in conjunction with the VERT. AMPL. ATTEN. provides continuously variable control of vertical-deflection sensitivity over the range of .03 V to 100 V peak to peak per cm.	CAL. OUTPUT	Binding post connection to the arm of the CAL. VOLTAGE potentiometer. Useful as calibrated test signal.
VERT. AMPL. ATTEN.	Potentiometer in 500-ohm cathode-follower circuit to permit 3-to-1 variation in vertical-amplifier gain.	VERT. POSITION	Potentiometer controlling grid bias of one side of cathode-coupled push-pull 3rd stage. Resultant changes in the operating points of the 3rd stage tubes are direct coupled to the output stage, thus shifting the image vertically.
VERT. ATTEN. DC BALANCE	Variable resistor to -140-volt bus to supply bucking current in VERT. AMPL. ATTEN. potentiometer. When properly adjusted no dc current flows in this control and no vertical positioning occurs when the VERT. AMPL. ATTEN. control is varied.	VERT. POSITION RANGE	Screwdriver-control potentiometer setting control-grid bias of grounded-grid half of phase inverter. Permits the VERT. POSITION control to be centered.
		HOR. POSITION	Potentiometer controlling grid bias of one sweep-amplifier tube and thereby the horizontal position of the CRT image.
		TRIGGER INPUT	Binding post connecting external trigger sources to +EXT. and -EXT. position of TRIGGER SELECTOR switch.
		SWEEP STABILITY	Potentiometer controlling bias on grid of V104 in the multivibrator circuit. This bias determines whether the sweep will operate recurrently or must be triggered.



TRIGGER SELECTOR	Switch determining source and polarity of trigger voltage.	SWEEP OUTPUT	Binding post connected to sweep generator via cathode follower.
TRIGGER AMPL.	Potentiometer controlling the bias applied to the trigger-amplifier tube (V102) and thereby determining the amplitude of trigger signals applied to the multivibrator.	+ GATE	Binding post for connection to the cathode of the gate phase splitter (V107), which furnishes a 40-volt peak positive pulse of the same duration as the sweep.
SWEEP TIME	Switch selecting appropriate capacitors for the multivibrator and sweep-generator circuits. These timing capacitors, in conjunction with the SWEEP TIME MULTIPLIER, control the sweep time per cm. When set to EXT. the sweep amplifier is connected to EXT. SWEEP INPUT binding post in place of the linear sweep generator.	- GATE	Binding post for connection via 0.1- μ f capacitor to the plate of (V107), which furnishes a 40-volt negative pulse of the same duration as the sweep.
SWEEP TIME MULTIPLIER	Variable timing resistors in the multivibrator and sweep-generator circuits, consisting of calibrated dual ten-range step and continuously variable controls, which, in conjunction with the SWEEP TIME switch, determine sweep time per cm.	CRT CATHODE	Binding post permitting connection of external modulating signals to the cathode of the cathode ray tube via a 0.1- μ f capacitor. RC=.012 sec.
EXT. SWEEP INPUT	Binding post connecting to sweep amplifier via EXT. SWEEP ATTEN. when SWEEP TIME cm. When set to EXT. the sweep switch is in EXT. position. (100 k input impedance).	6.3 V., 1 A.	Connection to 6.3-volt line-frequency heater supply. May be used for low-current applications.
EXT. SWEEP ATTEN.	Potentiometer controlling the fraction of the voltage applied to EXT. SWEEP INPUT binding post which will reach the grids of the sweep amplifiers when the SWEEP RANGE switch is set in the EXT. position.	INTENSITY	Potentiometer controlling the average grid voltage of the CRT and thereby the brightness of the image.
SWEEP MAGNIFIER POSITION	Potentiometer controlling bias voltage applied to grid of sweep magnifier (V111) and thereby determining portion of sweep to be magnified. When turned to OUT sweep magnifier is disconnected from the circuit.	FOCUS	Potentiometer controlling the voltage applied to the focus anode of the CRT and thereby the sharpness of the image.
		ASTIGMATISM	Potentiometer varying potential on Anodes No. 1 and 3 with respect to the deflection plates. Correct adjustment of this control makes possible a sharp focus of the image in both directions simultaneously.
		SCALE ILLUM.	Variable resistor controlling brightness of the lamps which illuminate the plastic graticule over the face of the cathode ray tube.
		POWER	On-off switch in the ac line voltage supply to the oscilloscope.
		GND.	Connection to frame of oscilloscope.

SECTION II

Operating Instructions

The Type 514D may be operated in any normal indoor location, or in the open if protected from moisture. If the instrument has been exposed to dampness, it should be left in a warm room until thoroughly dry before being placed in operation.

To prevent excessive interior temperature, it is important to allow adequate ventilation for the oscilloscope. At least one inch clearance should be provided at the sides, back and top of the case.

If the Type 514D is used continuously for the same application, and only one setting of the controls is required, it is advisable to periodically check the instrument at all control settings to be sure it is in normal operating condition. For example, if only direct connection to the vertical deflection plates of the CRT is used, a defect in the vertical amplifier might not become evident. Operation of the controls also helps to prevent accumulation of dirt and tarnish on their contacts.

Although the components are well supported and the adjustments very stable in setting to allow for portable operation, the Type 514D should not be subjected to excessive vibration or rough handling.

To place the Type 514D in operation for the first time, the following procedure is suggested:

1. Connect to a source of 50-60-cycle, 105-125-volt power, (or 210-250 volts if T1 primary connections are changed as shown in Section IV of this manual).

2. Set controls as indicated below:

VERTICAL

INPUT.....50 V CAL. RANGE position
VERT. DEFL. SENS.....10-30 v/cm
VERT. AMPL. ATTEN.....Clockwise
AC DCAC
CAL. VOLTAGE0
TRIGGER SELECTOR+SIG.
TRIGGER AMPLITUDE..Counter clockwise
SWEEP STABILITYCounter clockwise
SWEEP TIME100 μ sec/cm
SWEEP TIME MULTIPLIER.....5.0

3. Turn POWER switch to ON and wait about 60 seconds.

4. Set INTENSITY control at about $\frac{2}{3}$ clockwise rotation.

5. Adjust VERT. POSITION, HOR. POSITION, ASTIGMATISM and FOCUS until a sharply focussed spot is obtained at the left center of the screen.

CAUTION—DO NOT ALLOW THIS SPOT TO BE EXCESSIVELY BRIGHT OR REMAIN FOR LONG IN ONE POSITION.

6. Advance the SWEEP STABILITY control until a sweep appears, then turn it back just under this point.

7. Set the CAL. VOLTAGE control to 3 (30 volt) and a vertical line about 3 cm high should appear.

8. Advance the TRIGGER AMPL. control until a stable image of a squarewave appears.

The oscilloscope is now displaying the squarewave calibrating voltage. To observe other waveforms, connect them to either INPUT 1 or INPUT 2 and set the VERTICAL INPUT selector accordingly. Adjust the VERT. DEFL. SENS. and VERT. AMPL. ATTEN. for desired vertical deflection, and select appropriate sweep time by means of the SWEEP TIME and SWEEP TIME MULTIPLIER controls.

CRT Circuit Adjustments

The Type 514D uses a Type 5CPA cathode ray tube. This tube has a five inch screen and utilizes electrostatic focus and deflection. Short (P11), medium (P1), and long (P7) persistence screens are optional. A post-accelerating electrode (intensifier) is used to provide increased brightness. The total accelerating potential of about 3000 volts gives a sharp bright image visible in normal room light.

The edge lighted plastic graticule, scribed in centimeter graduations, is used in conjunction with the calibrated sweep and vertical deflection controls to obtain accurate measurements of time and amplitude. Intensity of the lines may be varied by means of the SCALE ILLUM. control to compensate for variations in trace intensity and ambient room light. A filter of proper color to provide maximum trace contrast is located under the graticule. If a CRT with a different type screen is installed, the corresponding filter may be obtained from the factory.

Two separate controls, FOCUS and ASTIGMATISM, permit good focus to be obtained on both horizontal and vertical lines simultaneously. These controls are interdependent in setting, and also vary

slightly at different levels of intensity. In general, it is desirable to use the minimum INTENSITY setting required for adequate observation of the trace. This will vary with ambient light conditions, writing rate, repetition rate, etc.

Horizontal Deflection Adjustments

The sweep circuit of the Type 514D differs from the gas-tube type frequently employed in portable oscilloscopes. It is more flexible and capable of synchronizing with higher frequencies than such sweep circuits. Fundamental frequencies as high as 10 mc can be easily observed. By a single adjustment, the sweep can be made to run recurrently or triggered as desired.

A recurrent sawtooth sweep generated by a gas tube or similar device, receives its synchronization at the end of the sweep. The sync impulse causes the beam to return to the left side of the tube where it immediately starts another sweep. Thus the sweep time must be a multiple of the signal period.

In a triggered sweep circuit, each sweep is started independently of the preceding sweep by a trigger or synchronizing impulse. When no trigger is being received, the beam remains at the left side of the trace. When the trigger arrives, the beam goes linearly to the right for a time, in this case determined by the multivibrator pulse length. At the end of its sweep, it returns to the left side again to await another trigger. It is this variable waiting period which makes the synchronization easier since the sweep time is independent of the signal period. The triggered sweep makes it possible to view pulses such as used in radar and television where the length of the pulse is very short compared to the space between pulses. This requires a fast sweep with a long waiting period. Waiting periods of 2000 times the sweep length are frequently used.

ADJUSTMENT OF SWEEP STABILITY

The SWEEP STABILITY control varies the multivibrator bias and therefore determines whether the sweep will oscillate recurrently or wait for a trigger impulse. Correct functioning for triggered operation is therefore obtained when the control is set just under the point where oscillation takes place. Remove the trigger source, turn the TRIGGER AMPL. control counterclockwise, advance the SWEEP STABILITY knob until a sweep appears, and then decrease it until it just disappears.

NOTE—When using the internal (+SIG. or -SIG.) trigger impulses to view fundamental frequencies above about 2 mc, it will be necessary to progressively advance the SWEEP STABILITY control somewhat above the normal operating point to secure a stable pattern.

FUNCTION OF TRIGGER SELECTOR

This control selects the trigger impulses to be used from three sources, the line frequency, (60 ~), the vertical amplifier (+SIG. and -SIG.), or the TRIGGER INPUT binding post. Two positions are available for both the SIG. and EXT. sources. When using those marked (+), the sweep starts at the rising portion of the trigger impulse. The (-) positions start the sweep on the falling portion. For satisfactory operation in the EXT. positions, a trigger of from .15 to 15 volts peak to peak should be provided. Larger triggers should be reduced by an external attenuator.

ADJUSTMENT OF TRIGGER AMPLITUDE

The TRIGGER AMPL. control adjusts the bias in the trigger amplifier and therefore the amplitude of the impulse which reaches the multivibrator. After the SWEEP STABILITY is set as described previously, and the TRIGGER SELECTOR switch set to the correct position, advance the TRIGGER AMPL. control until a stable image is obtained. When the trigger source is a slowly changing wave such as a sine wave or sawtooth, adjustment of the TRIGGER AMPL. setting will change the phase of the signal relative to the start of the sweep.

In general, it is desirable to use the minimum TRIGGER AMPL. setting required to insure a stable image.

If poor synchronizing is experienced when the Type 514D is used to observe repetitive signals containing erratic peak voltages, such as produced by vibrating contacts, it may be possible to form a stabilized trigger signal by the use of auxiliary limiting and differentiating circuits. The TRIGGER SELECTOR switch should then be set to the proper EXT. polarity, and connection made to the TRIGGER INPUT.

ADJUSTMENT OF SWEEP TIME

The combination of SWEEP TIME and SWEEP TIME MULTIPLIER controls allows the operator to vary the sweep time so that the marked portion of the graticule (10 cm) is covered in any time from 0.1 second to 1 microsecond. The approximate num-



ber of microseconds for a horizontal deflection of 1 cm can be determined easily by multiplying the SWEEP TIME setting by the sum of the SWEEP TIME MULTIPLIER dial readings. Multiply this figure by ten to determine the time required to sweep the marked portion of the graticule which is calibrated in cm.

The SWEEP TIME MULTIPLIER consists of a 10-step control and a continuously variable control, with the step-control dial numbers serving as indices for the hand-calibrated variable dial. These dial readings are added to determine the multiplying number. Since 100 dial divisions are provided for each 10:1 SWEEP TIME range, accurate indication and resetting is made possible.

The overall accuracy of the sweep time calibration is dependent on several factors, including linearity of the sweep amplifier and the cathode-ray tube, but the actual time for a 10-cm sweep will be within 5 per cent of the indicated time at any setting of the controls. Somewhat greater accuracy may be expected over the range of 0.2 microseconds to 5000 microseconds per cm. Provision has been made to compensate for variations caused by different tubes, etc., by screw-driver adjustments inside the case. Procedure for these adjustments will be found in Section IV.

RECURRENT SWEEP

In case it is desirable to have a sweep without using any sort of trigger, advance the SWEEP STABILITY control until a stable sweep is obtained. This sweep is the conventional sawtooth variety used in most oscilloscopes.

SINGLE SWEEP

The triggered sweep circuit used in the Type 514D provides for single sweep operation. The beam is blanked out until the trigger simultaneously turns it on and starts the sweep. For single-sweep operation, a mechanical contact or hand key can be connected between the TRIGGER INPUT binding post and ground. If repeated sweeps occur due to intermittent or bouncing contact, a capacitor of 0.1 μf to 1 μf should be connected across the contact. This capacitor is charged through 22 megohms and the long time constant prevents an immediate recurrence of the sweep. Use minimum dependable TRIGGER AMPL. setting.

SWEEP MAGNIFIER

Frequently it is desirable to examine a portion of the waveshape under observation in greater detail for

instance the rate of fall of the end of a fairly long pulse. In the Type 514, the sweep magnifier circuit makes it possible to expand any desired 20 per cent of the sweep to cover the entire tube face. When the SWEEP MAGNIFIER POSITION control is moved from the OUT position, the sweep is delayed for a variable time and then goes at about 5 times its normal rate. Turn the SWEEP MAGNIFIER POSITION to OUT. Adjust the sweep-time controls so that the portion of the wave to be magnified is at the right side of the tube. Turn the SWEEP MAGNIFIER POSITION knob clockwise until the desired signal moves in from the right to the center of the tube face. The magnified sweep is not linear over its entire trace, so it is desirable to use only the center 6 cm if possible.

NOTE—A sweep of 10 cm per microsecond is about the limit of the sweep amplifier, so care must be taken that the magnified sweep does not exceed this value.

EXT. SWEEP INPUT

Provision has been made for the connection of external sweep generators to the Type 514D. This might be a sine wave oscillator for frequency comparison, the sweep obtained from a frequency-sweep signal generator, an auxiliary slow-sweep generator, etc. The EXT. SWEEP INPUT binding post is connected to the horizontal-deflection plates via the EXT. SWEEP ATTEN. and a one-stage push-pull amplifier. The entire system is dc coupled to permit the use of very slow sweeps. With the EXT. SWEEP ATTEN. fully clockwise, the deflection sensitivity is approximately 1.5 volts per cm dc or peak to peak ac.

SWEEP OUTPUT

The SWEEP OUTPUT binding post makes available the waveshape appearing on the plate of the sweep-generator tube. A cathode follower is used to isolate the sweep generator from whatever is connected to the SWEEP OUTPUT post. The amplitude is approximately 30 volts peak to peak.

GATE OUTPUTS

A phase splitter is used to provide positive and negative squarewaves of the same duration as the sweep. The +GATE is taken from the cathode and is dc coupled, thus providing an accurately square-topped pulse even at the longest sweep times. The -GATE is taken from the plate via a 0.05- μf capacitor to remove the dc component.

Vertical Deflection Adjustments

SIGNAL INPUT CONNECTION

Dual inputs, provided by two UHF connectors, INPUT 1 and INPUT 2, are used in conjunction with the VERTICAL INPUT selector to permit observing either of two separate signal sources without changing connections. This feature allows convenient display of change in waveform or amplitude between the input and output of a circuit, study of time and amplitude relationships, or observation of other phenomena involving comparison of two different signals.

Normally, signal input connection is accomplished by attaching one of the Type A510 Binding Post Adapters, which are supplied with the oscilloscope, to either INPUT 1 or INPUT 2, and using a standard test lead. When reduced loading on the circuit under observation or exclusion of spurious pickup from stray fields is desired, the Type P510 Input Probe should be used.

CAUTION—THE PEAK POTENTIAL APPLIED TO THE PROBE SHOULD NOT EXCEED 600 VOLTS. LARGER SIGNALS SHOULD BE ATTENUATED.

Since the probe introduces an attenuation of 10X, it will be advantageous to employ a common shielded lead (no attenuation) to prevent pickup of stray fields when dealing with very low level signals, if the additional circuit loading is permissible. A ground lead to the equipment under observation should be provided, and often an earth ground is desirable.

In case the dual-input connection is desired, connection is made to both INPUT 1 and INPUT 2. Either input may be presented to the vertical amplifier by setting the VERTICAL INPUT selector to the corresponding position. Other functions of the VERTICAL INPUT selector are described under "Calibration"

VERTICAL AMPLIFIER

The use of the direct coupled amplifier makes it possible to display both the ac component of a waveform and the dc level at which it occurs. For example, it is possible to observe when zero bias or grid cut-off occurs, how close to the cathode a plate swings and other characteristics of circuits. Another advantage of the direct-coupled amplifier is the ability to utilize the entire undistorted swing in either direction. Thus, 4 cm of undistorted deflection is available for pulse display, without recourse to a deflection-polarity switch

or similar device. To observe positive pulses, set the VERT. POSITION control so that the undeflected (zero-signal) trace coincides with the -2-cm graticule line. For negative pulses, use a +2-cm setting.

The sensitivity with direct coupling is limited to 0.3 volt per cm. This is adequate for work in circuits involving vacuum tubes, since signals too small for observation at this sensitivity are also small in comparison with the dc voltages on the tube elements, and thus can be observed without regard to the dc component. Additional gain, achieved by means of a capacitively-coupled two-stage preamplifier, provides a maximum sensitivity of 0.03 volts per cm.

CONTROL OF DEFLECTION SENSITIVITY

Continuously variable deflection sensitivity, permitting display of a wide range of signal amplitudes, is achieved by the VERT. DEFL. SENS. control and the VERT. AMPL. ATTEN. The VERT. DEFL. SENS. control performs the dual function of inserting or removing the two-stage preamplifier and selecting frequency-compensated attenuators. Seven steps (two per decade) are provided. The VERT. AMPL. ATTEN. varies the sensitivity over a 3-to-1 range, filling in between steps of the VERT. DEFL. SENS. control. It is located in a low-impedance cathode follower circuit to minimize high-frequency discrimination. The overall range of both controls is 0.03 volts per cm to 100 volts per cm.

SELECTION OF COUPLING

It is sometimes unnecessary or undesirable to display the dc level of a waveform. For example, in measuring the ripple on a dc supply, the sensitivity required to present the ripple voltage would usually cause the dc component to exceed the range of the vertical-position control. The AC-DC selector permits optional capacitive coupling in the range of 0.3 volts per cm to 100 volts per cm. Capacitive coupling only is available in the range of 0.03 volts per cm to 0.3 volts per cm.

SIGNAL DELAY

Approximately 0.1 microsecond is required, after receipt of a sharp trigger impulse, for the sweep to become linear and to unblank the cathode ray tube. In the Type 514D, a 24-section network inserts a signal delay of $\frac{1}{4}$ microsecond, so that the sweep is well underway before the initiating waveform appears on the CRT.



DIRECT CONNECTION TO DEFLECTION PLATES

To allow direct connection to be made to the deflection plates with low capacitance, banana jacks are provided on a panel accessible through an opening in left side of the case. By removing the jumpers the internal circuits may be disconnected. The terminal marked Y2 is the top plate and the one marked X2 is the right plate. Deflection sensitivity is approximately 27 volts, dc, per cm on the vertical plates and 32 volts per cm on the horizontal.

If direct connection to only one set of deflection plates is desired, it is important to maintain the correct average potential to prevent defocussing of the CRT spot. The average potential of the vertical deflection plates (measured from the chassis) is approximately 150 volts, and this same value should be maintained on the horizontal plates when they are used for direct connection.

Adjustment of the average potential of the horizontal deflection plates from 0 to +150 volts is provided for by means of screwdriver controls marked

ADJUST X1 and X2 located at the rear of the Type 514D. After making a direct connection of the vertical-deflection plates, the average potential of the horizontal plates should be adjusted to correspond. See Section IV.

CAUTION—BE SURE TO READJUST WHEN NORMAL INTERNAL DEFLECTION-PLATE CONNECTIONS ARE RESTORED.

When it is not necessary to maintain dc levels, external connection may be accomplished by replacing the jumper plugs with 1-megohm resistors and inserting blocking capacitors in series with the signal source. This method has the advantage of retaining the functions of the oscilloscope position controls. The vertical-amplifier sensitivity controls should be set at minimum to prevent introduction of spurious signals via the amplifier. When balanced input is not desired, the unused deflection plate should be bypassed to ground.

Circuit Description

BLOCK DIAGRAM

The block diagram of the Type 514 Cathode-Ray Oscilloscope shows the major units of the instrument and some pertinent waveforms at various points in the circuit. The upper half of the diagram shows the sweep circuit. In the upper left-hand corner of this diagram, the trigger selector switch is shown in the position to receive external triggers. The function of the trigger inverter is to furnish a positive-going pulse to the trigger amplifier, regardless of the polarity of the incoming trigger. The trigger amplifier amplifies the trigger waveform and presents a negative-going pulse to the coupling diode. With the sweep multivibrator in the quiescent, or untriggered state, the coupling diode will pass a negative-going pulse to trip the multivibrator. After the multivibrator is triggered the circuit condition is such that the coupling diode will no longer pass the trigger pulse. This allows the sweep to complete one cycle of operation and return to the initial state without interference from trigger pulses which occur during this interval. The positive-going waveform from the sweep multivibrator is amplified by the gate-output amplifier and is present at the front panel as both positive and negative gate. The negative-going waveform has two functions. A portion of the waveform is amplified by the unblanking amplifier and is coupled as a positive gate to the CRT control grid during the sweep cycle. The second use of the negative-going waveform is to gate the sweep generator. The output of the sweep generator is present at the front panel through the sweep-output cathode follower. The sweep waveform from the sweep generator is applied to the sweep amplifier either directly or by way of the sweep magnifier. The sweep magnifier causes the sweep to move about 5 times faster, thereby spreading the observed signal over a greater portion of the CRT screen. The sweep and sweep-magnifier dc restorers are clamping devices that cause the sweep to start at the same voltage each time and prevent horizontal jitter of the observed signal. The sweep amplifier provides push-pull amplification necessary to drive the horizontal-deflection plates of the CRT. The dc-level adjusters allow the average output voltage of the sweep amplifier to be

adjusted to equal the average output voltage of the vertical amplifier.

The astigmatism-voltage regulator provides the proper voltage for anode two of the CRT so the focus will remain sharp over the whole CRT screen.

The vertical amplifier channel, shown in the lower portion of the block diagram, consists essentially of a preamplifier, delay line, and output amplifier, with appropriate switching. The incoming signal is first applied to the input attenuator, which is a frequency-compensated rc network. The signal then is amplified by the preamplifier or is shunted around the preamplifier depending on the amount of amplification needed. This switching in and out of the preamplifier is accomplished as one of the functions of the VERT. DEFL. SENS. switch. The signal then passes through two cathode followers, through the delay network, through a delay-network-output cathode follower, and to the cathode-coupled drivers, whose plate voltages are regulated. The signal then is further amplified by the distributed output amplifiers, which drive the vertical-deflection plates of the cathode-ray tube.

An internal squarewave calibrating waveform is provided. The waveform is generated by a multivibrator, and shaped by a limiter and output cathode follower. This calibrating squarewave is applied to the vertical amplifier in the CAL VOLTAGE RANGE positions of the VERTICAL INPUT switch.

The power supply is electronically regulated so that the output voltages will remain constant for a fluctuating input line voltage or for changes in output current requirements.

TRIGGER SELECTOR

The trigger-selector switch operating in conjunction with V101 selects the source of trigger signal and reverses its polarity if necessary so a positive signal will be applied to the grid of V102. With the TRIG. SEL. switch in the -EXT, +SIG, or 60 ~ position, signals are taken from the plate of V101 and are therefore reversed in polarity thus providing a positive signal to the grid of V102. With the TRIG. SEL. SWITCH in the +EXT -SIG position, signals are taken from the cathode of V101 and are not changed in polarity.

TRIGGER AMPLIFIER

V102 is a variable-gain amplifier for the positive signal received from V101. The TRIG. AMPL. (front panel control) potentiometer varies the bias for V102 and thus determines the gain of the stage.

TRIGGER COUPLING DIODE

The negative trigger signal from the plate of V102 is applied to the plate of negative-going multivibrator, V104, by means of coupling diode V103. A negative trigger signal is transmitted through diode V103 driving the plate of V103 and thereby the plate of V104 negative. Any later trigger pulses will not interfere with the operation of the multivibrator since the plate of V103 is negative with respect to its cathode. Thus the trigger amplifier and multivibrator remain disconnected until the completion of the cycle when the multivibrator plate again goes positive and is ready to be triggered.

MULTIVIBRATOR

A multivibrator is provided to convert the various shapes of trigger waveforms into a gate waveform of controllable duration, suitable to gate the sweep generator and to provide an unblanking pulse. The multivibrator consists of the negative-going section, V104, and the positive-going section, V105. With the SWEEP STABILITY (front panel control) control properly adjusted, the grid of V104 is held below cutoff. V105 is fully conducting because its grid is near cathode potential. The circuit remains in this condition until a trigger signal is received. The grid of V105 is driven negative by the negative trigger signal, through the timing capacitor C106, C107.1, C107.5, C108.1, or C109.1. The plate voltage of V105 therefore rises, carrying with it the grid of V104, causing V104 to conduct more and V105 grid is driven negative. This regeneration action continues until V104 is fully conducting and V105 is cut off. This condition exists until the timing capacitor discharges far enough to raise the grid of V105 into the plate-current conducting region. Plate voltage of V105 then drops, carrying the grid of V104 with it until V104 is again cut off and the quiescent state is resumed. This condition continues until another negative pulse is received.

The plate of V104 produces a negative waveform, and the plate of V105 produces a positive waveform. The positive multivibrator waveform is used to provide the gate waveforms. The negative multivibrator waveform is used to gate the sweep generator and to control the unblanking pulse.

The duration of the multivibrator pulse depends upon the length of time V105 is cut off, which in turn depends upon the rc time constant of the timing capacitors and the timing resistors (R121 plus R124 plus R150B) and is substantially independent of the shape or amplitude of the trigger pulse. Variation of pulse

duration is provided by selection of timing capacitors on the SWEEP TIME switch, SW 102, and the variation of timing resistors, R124 and R150B. R124 is a step switch calibrated in units of one, and R150B is continuously variable and calibrated in tenths. The time constants selected provide a multivibrator-pulse duration about 20 per cent longer than the time required for the spot to traverse the cathode-ray screen at any sweep speed.

UNBLANKING WAVEFORM

The negative multivibrator waveform used for unblanking is obtained at the grid of V105 rather than at the plate of V104 to reduce the loading effect on the plate of V104, so as to improve rise time. The negative waveform is applied to one grid of V106, amplified and inverted, and applied to the other grid. The waveform at this point is positive in polarity so the unblanking pulse is obtained from the cathode of V106 and applied to the control grid of the cathode-ray tube to unblank the tube while the spot is moving across the screen.

GATE CIRCUITS

The positive multivibrator waveform is applied through a frequency-compensated voltage divider to one grid of V107. The -GATE terminal is connected to the plate of this section and the +GATE terminal is connected to the cathode. Since the cathode and plate resistors of this section of V107 are of equal value, the amplitude of both gate signals are of equal amplitude.

SWEEP GENERATOR

The sweep generator, V109, is held in a highly conducting state during the period between sweeps by the voltage divider R118.1, R118.2, R139, and R140. The plate voltage of V109 is low and the selected timing capacitors C117 through C122, have very little charge on them. The sharp negative-pulse from the plate of V104 cuts off V109 allowing the timing capacitors to charge through R153, R151, and R150A toward the voltage of cathode-follower voltage regulator V110. R151 is a step switch calibrated in units of one. It is changed simultaneously with R124 in the multivibrator circuit. R150A is continuously variable and calibrated in tenths, and it is changed simultaneously with R150B. Accuracy of the sweep speed is maintained by charging the timing capacitor from a constant-voltage, low-impedance source. Linearity of the sweep sawtooth waveform is improved by using



only the first 10 per cent or less of the charging voltage. When the multivibrator returns to its quiescent state, the positive pulse that occurs at the plate of V104 raises the grid of V109 positive, the plate of V109 drops nearly to ground, and the timing capacitor discharges ready to receive the next gate from the multivibrator. The sweep waveform is applied to one grid of V108, and the waveform for the front panel SWEEP OUTPUT connector is obtained from the cathode of this section. V112 is a dc restorer which starts the sweep at the same dc level each sweep.

SWEEP MAGNIFIER

The sweep magnifier, V111, delays the start of the sweep for an adjustable period of time and then causes the sweep to be speeded five times its normal sweep speed. Delay is accomplished by setting the bias voltage on R171, labeled SWEEP MAGNIFIER POSITION, to the proper level so that conduction does not begin until the desired percentage of the sawtooth sweep voltage has been completed. The normal sweep waveform is applied to one grid of V111. The cathode follows this grid. The bias voltage is applied to the other grid, so that this half of the tube conducts only when the cathode potential has risen near grid potential of the other half. The gain of this half of the tube amplifies or magnifies the sweep waveform amplitude five times. The bias voltage variation available by adjustment of R171 is sufficient to permit the magnified sweep to be started at any part of normal sweep. The second half of V108 is a cathode follower which supplies the signal to the sweep amplifier.

SWEEP AMPLIFIER

Since the amplitude of the sweep waveform at the plate of the sweep generator is not large enough to drive the horizontal deflection plates, further amplification is needed. The signal from the sweep generator is impressed on the grid of V113, a cathode coupled amplifier which inverts phase and operates in push-pull in conjunction with V114. Degeneration is introduced in the cathode circuit to improve linearity. Capacitor C130.1 improves band width so that the fastest sweeps will be amplified with good linearity. The horizontal deflection plates must operate near the same dc potential as the vertical deflection plates to avoid defocusing as the spot moves across the screen. V115 and V116 are level-setting tubes which provide an adjustable dc voltage level within this range for the horizontal plates. Adjustment for this

dc level is provided by screwdriver adjustments R193.1 and R194.1.

The dc level-setting tubes permit the current through dropping resistors R187 and R188 to be varied while maintaining high plate resistance so that their shunting effect across the deflection plates is negligible. Plate current is varied by means of the potentiometers in the cathode circuit which varies the grid-to-cathode voltage. The plate resistance is kept high by means of the neon lamps between cathode and screen which maintains that voltage constant.

Vertical Deflecting System

VERTICAL INPUT

The VERTICAL INPUT switch, SW2, in its first two positions selects either of two coaxial front panel connectors labeled INPUT 1 and INPUT 2, and connects them to the vertical amplifier system. In the next seven positions, SW2 selects a calibrating square-wave voltage between 0.05 and 50 volts, peak to peak, and connects it to the vertical amplifier system. In the last two positions, labeled TEST 5, and TEST 50, SW2 connects either 5 volts or 50 volts of the calibrating square wave to the CAL OUTPUT front-panel connector, and at the same time connects INPUT 1 front-panel connector to the vertical amplifier system. With this adjustment, the probe cable can be connected to INPUT 1, and the probe can then be touched to the CAL OUTPUT connector to obtain two accurate ranges for adjusting the probe compensating capacitance.

CALIBRATOR

The calibrating-voltage generator is a multivibrator, consisting of V501A and V502B operating with their cathodes at -140 volts and their plates near ground during cutoff. The grids are returned to ground potential through R505, a potentiometer so connected that the resistance to ground from one grid is increased while the resistance to ground from the other grid is decreased. When the arm of potentiometer R505 is near the grid of V502B, for example, the time constant of the circuit through which C535 discharges after V501A begins conducting is short compared to the discharge time constant of C536 when the multivibrator switches over and V502B conducts. The conduction period of V502B is thus longer than the conduction period of V501A with this setting of R505.

V502A is an amplifier whose grid is dc coupled to V502B grid, and whose cathode is also returned to -140 volts. Its plate voltage during cutoff is determined by voltage divider R520 and adjustable R517, connected between +225 volts and ground.

During the conduction period, V502A plate drops below ground and during cutoff it rises to the divider voltage. The cathode of cathode-follower V501B, whose grid is dc connected to V502A plate, therefore executes a squarewave change in voltage between ground and approximately the divider voltage, as the multivibrator oscillates. The cathode resistor is tapped to give the prescribed voltage ranges at the CAL OUTPUT terminal. R517, labeled CAL VOLTAGE ADJ, permits the squarewave amplitude to be adjusted so that the CAL VOLTAGE dial reads accurately, directly in volts, peak to peak.

VERTICAL SENSITIVITY

A seven-position switch labeled VERT. DEFL. SENS., SW3, arranges the input circuits to the vertical deflection system for seven fixed sensitivities. In the first two positions of SW3, the positions of highest sensitivity, 0.03 volts per cm, and 0.1 volts per cm, a preamplifier with a gain of ten is connected into the circuit. The preamplifier consists of two capacitively coupled stages.

Shunt and series peaking inductors are used, and cathode-follower V2B reduces the effects of capacitance loading caused by the switch. R28, a screwdriver adjustable resistor in the grid circuit of V2A, can be adjusted to correct the preamplifier low-frequency response. The preamplifier extends the system risetime slightly.

In the third position of SW3, the input is connected directly to the vertical deflection system with no attenuation. In all other switch positions except the first and third, resistor-capacitor frequency-compensated voltage-divider attenuators are selected to provide the five additional fixed sensitivities. When the probe is used, an additional ten times attenuation results. The probe resistor forms the series arm of a voltage divider, the shunt arm of which is the input network of each of the switch positions.

V4A is a cathode follower whose output is fed to two tubes: V5A, an internal-trigger-signal amplifier and V4B, another cathode follower whose cathode resistor is the terminating resistor in the 0.25-microsecond delay network. R40.1, labeled VERT. AMPL. ATTN. is the variable gain control. R42, a front-panel potentiometer, labeled VERT ATTN DC BALANCE, adjusts the dc voltage at the junction of

R40.1 and R41.2 so that it is at the same potential as the cathode of V4A. When this adjustment is correctly made, no dc shift of the trace will occur with change in the VERT. AMPL. ATTN. control.

The delayed output from the delay line feeds another cathode follower V6, which drives four pentodes, V7, V9, V8, and V10 in a push-pull-parallel cathode-coupled driver amplifier.

V18 is a cathode-follower amplifier whose voltage gain is accurately one-half. Its cathode resistor, R52, is also the common-cathode coupling impedance for the phase-inversion stage. By maintaining the common-cathode signal voltage at one-half of the grid voltage of the grid-excited half of the phase-inverter, rather than depending on the division of cathode current between halves of the phase inverter, non-linearity which is introduced by relative variation of transconductance with signal voltage between the two halves is substantially reduced.

Vertical positioning is accomplished by adjusting the dc voltage of R46 labeled VERT. POSITION, which sets the dc level of the grid of the delay-line input cathode follower, V4B. Since the amplifier is dc coupled a change in dc level at this point appears as a dc change in voltage between deflection plates.

DISTRIBUTED AMPLIFIERS

The grid lines of the distributed amplifiers are fed at a midsection to avoid adding reactance to the plate load of the drivers. The lines are terminated at each end in 910 ohms. The grid lines are direct coupled to the plates of the drivers and the plate voltage is obtained from a cathode-follower voltage regulator V17. The cathodes of the distributed amplifiers are set at a potential determined by the drop across the filaments of V1, V4, and V6 which serve as the cathode resistor of the distributed amplifier tubes. This places dc voltage on these filaments to reduce hum from these tubes. The grids of the distributed amplifier tubes, V11 to V16, are fed successively by the signal as it travels down the grid lines. The amplified signal appearing at each plate moves in both directions, and the portion of the signal moving in the forward direction is reinforced at each tube, so that the total gain is the sum of the individual tube gains. The available voltage at the cathode-ray tube vertical-deflection plates is doubled by omitting terminating resistors at the forward end of the plate line. The reactances of the deflection plates of the cathode-ray tube are compensated by L5 and L6. The portion of the signal going in the reverse direction is dissipated in the plate terminations R59 and R60.



POWER SUPPLY

The negative 140-volt supply is stabilized by an OD3 gas regulator tube supplied with a nominal 300 volts from the plate of V211, which rectifies the 60-cycle ac current from terminals 23 and 24 of transformer T201.

The positive 225-volt supply receives rectified current from terminals 23 and 25 of T201 through full-wave rectifiers V204, V205, and V206, which are in parallel. This rectified voltage is regulated by comparing the voltage of a type 5651, gas regulator tube, to the voltage of divider R229, R230, R231, connected between the positive 225-volt bus and ground. The error voltage is amplified by V208, a voltage-comparator tube, and is further amplified by V209 and applied to the grids of the series-regulator tube, V210, with such polarity as to compensate the error in the positive 225-volt bus. R219.1 and R219.2 increase the current capacity of the regulated portion of the supply.

The positive 450-volt supply receives rectified current from terminals 20 and 22 of T201 through full-wave rectifier V201. Its voltage is added to the unregulated voltage of the positive 225-volt supply. The rectified voltage is regulated by comparing the regulated positive 225-volt supply to the voltage of a voltage divider, R216, R217, connected between +450 volts and ground. The error voltage is amplified by V203 and applied to the grid of V202, the series-regulator tube.

HIGH VOLTAGE POWER SUPPLY

The dc accelerating voltage for the cathode-ray tube is supplied by a high-frequency oscillator and rectifier circuit. V215 is used in a Hartley oscillator circuit in which the primary of T801 is used as the tuned circuit. T801 is a transformer supplying the necessary voltage to the rectifier, V805, and V806. The positive 1500 volts is used as the intensifier ring voltage and the negative 1500 volts is applied to the cathode of the cathode-ray tube. The rectified voltage is regulated by comparing a portion of the negative voltage to minus 140 volts in V214A. The error voltage is amplified by V214A and V214B and applied to the series-regulator tube, V213, which controls the screen voltage of the oscillator, V215.

CATHODE-RAY TUBE CIRCUITS UNBLANKING

A second high-voltage winding is wound bifilar with

the previously described high-voltage secondary on T801 to provide biasing voltage for the unblanking circuit. This winding is tightly coupled to the winding of the regulated supply and its output voltage therefore follows the regulated portion quite closely.

The unblanking squarewave from the sweep circuit is applied to the low-voltage positive end of the biasing-voltage supply. The high-voltage negative end of the supply is connected to the control grid, pin 3, of the cathode-ray tube through potentiometer R814, a front-panel control labeled INTENSITY.

The whole power supply is therefore raised and lowered in accordance with the waveform of the unblanking voltage. The maximum risetime of the transformer winding is somewhat restricted because of its capacitance to ground. C815 and R815, a high-pass network connected to the control grid, is therefore provided to permit the leading edge of the unblanking wave to be transmitted directly to the grid to improve the risetime.

FOCUS

Potentiometer R826, labeled FOCUS on the front panel, is a part of a voltage divider connected between ground and -1500 volts to permit the focusing grid voltage to be varied over the required range near -1500 volts to focus the spot.

ASTIGMATISM

Pin 9 of the cathode-ray tube connects to the astigmatism-control grid. Voltage for this grid is obtained from cathode-follower voltage regulator V107A connected in series with the +450-volt supply. Grid voltage for V107A is obtained from a front-panel control potentiometer, R164, labelled ASTIGMATISM, a part of a voltage divider between +450 volts and -140 volts.

EXTERNAL CATHODE CONNECTION

A front-panel binding post labeled CRT CATHODE is connected to the cathode through a capacitor, C829, to remove the high-voltage dc from the binding post. R829 prevents the accumulation of high voltage which might otherwise build up through dielectric leakage.

SECTION IV

Maintenance and Adjustment

Maintenance

Care must be taken to assure free ventilation of the unit 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 placed by other apparatus or furniture, and the filters should be kept clean.

A washable Lumaloy Air Filter is used at the air intake port of the unit. 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 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 loosed 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 local representative of RESEARCH PRODUCTS CORP. in the one-pint Handi-Koter with spray attachment or one-gallon and five-gallon containers.

REPLACEMENT OF COMPONENTS

Most of the components used in the construction of TEKTRONIX instruments are standard parts obtainable from any well-stocked parts distributor. Some of the components carrying 1% and 2% tolerances may not be so readily obtainable but may be purchased from the manufacturer at these tolerances. The remainder of the low-tolerance components are standard 10%- and 20%-tolerance parts that are checked at the factory for proper value or performance. Replacement parts are available on order from the factory at current net prices but in the case of standard parts it is probably more economical of time to purchase them locally.

It is not feasible to attempt to check out low-tolerance parts or matched pairs without a reasonably large stock to choose from as the rejection percentage is quite high in most cases.

A TEKTRONIX instruction manual will usually contain hand-made changes of diagrams, parts lists, and text, appropriate only to the instrument it was prepared for. There are good reasons why this is true.

First, TEKTRONIX engineers are continually working to improve TEKTRONIX instruments. When the improved circuitry is developed or when better components become available, they are put into TEKTRONIX instruments as soon as possible. As a result of constant improvement TEKTRONIX instruments are always built as good as we can build them, but the changes caused by these improvements must frequently be entered by hand into the manual.

Second, when TEKTRONIX instruments go through our exhaustive test procedure, TEKTRONIX technicians adjust them individually to obtain optimum operation. This kind of hand tailoring occasionally requires substitution of components differing from the nominal values printed in the manual.

Third, because of procurement difficulties, equivalent but different parts are sometimes used. Usually such parts are directly interchangeable with those originally specified. No alternate parts have been used which have adversely affected the instrument, and you were able to receive your instrument much earlier than you might have otherwise.

To assure that you will receive the correct replacement parts with the minimum of delay it is therefore important that you include the instrument serial number with your order, along with the instrument type and part numbers, of course. And as a further precaution, get ordering information from the instruction manual whose serial number agrees with the instrument.

Equivalent parts, supplied by the factory when the exact replacement parts ordered are not available, will be accompanied by an explanation and will be directly interchangeable in most cases.

REMOVAL OF THE CASE

Set the oscilloscope face downward on a padded flat surface, remove the two screws in the bottom, then lift off the case.

CAUTION—VOLTAGES HIGH ENOUGH TO BE DANGEROUS ARE PRESENT IN THIS INSTRUMENT. SINCE MUCH MAINTENANCE MUST NECESSARILY BE PERFORMED

WITH THE CASE REMOVED, GREAT CARE SHOULD BE TAKEN. USE ONLY INSULATED TOOLS, STAND ON A DRY FLOOR, AND IF POSSIBLE KEEP ONE HAND IN YOUR POCKET.

SWEEP

POWER SUPPLY

Operation on 210-250 Volt Line

The power transformer of the Type 514 is wound with two 115 volt primaries. When the instrument leaves the factory, the primaries are ordinarily connected in parallel for 105-125 volt operation. If operation from 210-250 volt lines is desired, remove the jumpers connecting 1 to 2 and 3 to 4, and connect terminals 2 and 3 together. With the line still connected to terminals 1 and 4, the instrument is ready for 210-250 volt operation.

CAUTION: Use only silver-bearing solder on the ceramic terminal strips and for tinning the soldering iron, if it becomes necessary to resolder.

The slots in the ceramic terminals are filled with solder containing 3 per cent of silver which is bonded to a film of pure silver fused with the porcelain glaze. Ordinary tin-lead solder absorbs the silver from the fused film to the extent that a bond can no longer be formed between the solder and the porcelain after only a few resoldering operations.

Silver-bearing solder is used in printed and etched-circuit techniques and is therefore readily available from all principal solder manufacturers. A length of three-per cent silver solder included with the instrument will be found mounted on the back plate.

Adjustment

Output Voltages

The output of the +450-volt supply is dependent on the output of +225-volt supply. In order for the instrument to perform properly, it is necessary that the 225-volt supply be within 5 volts of that value. This should be checked with an accurate voltmeter and corrected if necessary by adjustment of potentiometer R230 on the sweep and power supply chassis marked ADJ to 225 V. This check should always be made if the 5651 tube V207 is changed.

DC Output Level

To obtain proper CRT focus, the average potentials of the horizontal- and vertical-deflection plates must be approximately equal. Because of direct coupling, the potential of the vertical-deflection plates is determined by the vertical amplifier. A dc-level control circuit at the sweep-amplifier output provides a means for setting the average horizontal-plate potential to the same value as the vertical plates as follows:

With the HOR. POSITION control fully clockwise and the CRT spot centered vertically (no horizontal or vertical deflection), connect a jumper wire from Y1 to Y2. Then connect a jumper wire from Y1 to X1 and adjust R193.1 marked X2. ADJUST until the spot is centered horizontally. Move the jumper wire from X1 to X2 and adjust R194.1 marked XI ADJUST until the spot is again centered horizontally. Repeat the adjustments if necessary until the spot falls within 1 cm of the graticule center.

Sweep Time Calibration

If the cathode-ray Tube is replaced, or if the sweep amplifier tubes V13 and V14 change their characteristics, the indicated sweep time may be in error. This may be corrected by adjustment of the potentiometer on the chassis marked SWEEP TIME ADJ. (R149), for all ranges except the 0.1 to 1 MICROSECOND PER CM range, which is corrected by varying C118 located on the rear section of the SWEEP TIME switch.

These adjustments may be made with the aid of an accurately calibrated oscillator. A commonly available instrument suitable for this purpose is the Army frequency meter BC221, or the Navy equivalent, Type LM. If this type instrument is used, set the frequency at 200 kc and connect it to the Type 514D SIGNAL INPUT. With the SWEEP TIME MULTIPLIER at 1.0 and the SWEEP TIME at 1.0 MICROSECOND PER CM, adjust R149 until 2 cycles coincide with 10 cm. Change the frequency meter setting to 2 mc, set the SWEEP TIME MULTIPLIER at 2.0, the SWEEP TIME at 0.1 MICROSECOND PER CM and adjust C118 until 4 cycles occupy 10 cm.

NOTE—Use the minimum TRIGGER AMPL. setting consistent with a stable pattern.

CALIBRATOR

Calibrator Voltage Check

The calibrator voltage can be checked without re-



moving the instrument case. Set the VERTICAL INPUT switch to TEST 50, CAL VOLTAGE dial accurately to 5, CAL DUTY CYCLE full clockwise. Measure the output voltage between the CAL OUTPUT terminal and ground on a 20,000-ohm-per-volt meter shunted with a capacitance of 0.1 μ f or higher. The meter should be accurate within one per cent at 50 volts. The voltage reading should be 50 volts. If readjustment is necessary adjust R517 labeled CAL VOLTAGE ADJ, located on the lower right side of the chassis near the panel.

VERTICAL AMPLIFIER

NOTE—A warm-up period of approximately fifteen minutes to stabilize tube characteristics should precede adjustment of the vertical amplifier. **CAUTION:** Do not permit the CRT image to exceed the ruled portion of the graticule during adjustment.

Vertical Position Range

The range of the VERT POSITION control can be adjusted by means of R47, marked VERT POS RANGE. With the VERT POSITION control centered (index mark vertical) adjust the VERT POS RANGE control until the CRT trace is centered vertically.

Cathode Follower Balance

R42, labeled VERT ATTEN DC BALANCE, located on the right side of the oscilloscope should be adjusted so that varying the setting of the VERT AMPL ATTEN does not shift the vertical position of the trace. If considerable adjustment is required, it may be desirable to recheck the range of the VERT POSITION control.

Preamplifier L-F Response

Since the low-frequency compensating capacitors C7A and C11A are electrolytics, the L F ADJ screwdriver control may require occasional readjustment to accommodate their capacitance changes due to aging. This readjustment should be made while displaying a low-frequency squarewave on the oscilloscope. Adjust for minimum tilt on the wave top. The compensation includes the effects of the high-pass characteristics of coupling capacitor C5 and the shunt resistance load of the input circuits past the capacitor. If the compensation is made correctly for a signal connected through the 10-to-1 probe, therefore, it will under compensate for a signal connected directly to the input terminal because the high-pass characteris-

tic of C5 and associated circuits will have a lower frequency of cutoff with the added 9-megohm series resistor of the probe. When the instrument leaves the factory it is compensated correctly with the signal connected to the input through the 10-to-1 probe.

Input Attenuator and Probe

The various attenuators in the Type 514D are of the rc type in which the resistor divider ratio is equal to the capacitor divider ratio and therefore the voltage division is constant from dc to well above the frequency limit of the Type 514D. Adjustment of these attenuators is made by observation of their squarewave response. The self-contained calibrator in the Type 514D is a suitable squarewave source, and thus a check of the attenuators is available by the turn of a switch. A vertical deflection of 2 to 3 cm is recommended. When the variable capacitors in the attenuators are properly adjusted, a squarewave will be correctly reproduced by the oscilloscope. If the capacitive divider has a lower attenuation ratio than the resistive divider, a spike appears on the corner of the leading edge. If the capacitive divider has a higher attenuation, the corner of the leading edge is rounded.

The following adjustment procedure is recommended:

1. Lay a sheet of metal on the top of the instrument to simulate the presence of the case.
2. Apply a CAL VOLTAGE of 1.5 volts by setting the VERTICAL INPUT switch in the 1.5 VOLT CAL RANGE position and the CAL VOLTAGE control in the maximum clockwise position. Set the VERT DEFL SENS switch at the 1 to 3 VOLTS PER CM position; the VERT AMPL ATTEN control at maximum clockwise position; the sweep time at 200 MICROSECONDS PER CM. Adjust C20 on the right side of the VERT DEFL SENS switch.
3. Move the VERT DEFL SENS switch to the 3 to 10 VOLTS PER CM position and the VERTICAL INPUT switch to 5 volts CAL RANGE position. Adjust C22 on the left side of the VERT DEFL SENS switch.
4. Move the VERT DEFL SENS switch to the 10 to 30 VOLTS PER CM position, and the VERTICAL INPUT switch to the 15-volt CAL RANGE position. Adjust C25 on the right side of the VERT DEFL SENS switch.
5. Move the VERT DEFL SENS switch to the 30 to 100 VOLTS PER CM position, and the VERTICAL INPUT switch to the 50-volt CAL RANGE position. Adjust C28 on the right side of the VERT DEFL SENS switch.

6. Attach input probe to INPUT 1. Remove the insulated alligator clip and plug the probe into the CAL OUTPUT connector. Move the VERTICAL INPUT switch to the 5-volt TEST position. Set the sweep time to 600 MICROSECONDS PER CM. Move the VERT DEFL SENS switch to the 0.3 to 1 VOLT position. Adjust the probe compensating capacitor.

7. Move the CAL VOLTAGE control to 1 volt. Move the VERT DEFL SENS switch to 0.03 to 0.1 VOLT PER CM position. Adjust C6 mounted on the chassis on the right side of the VERT DEFL SENS switch.

8. Move the VERT DEFL SENS switch to the 0.1 to 0.3 VOLTS PER CM position. Set the VERTICAL INPUT switch to the 0.5-volt CAL RANGE position and the CAL VOLTAGE control for 0.25 volts. Change the sweep time to 200 MICROSECONDS PER CM. Adjust C20A on the left side of the VERT DEFL SENS switch.

NOTE—The probe is not in the circuit in step No. 8, but should be left connected as it is used in the following steps.

9. Move the VERTICAL INPUT switch to the 5-volt TEST position, change the sweep time to 600 MICROSECONDS PER CM, and adjust C19A mounted on the chassis on the left side of the VERT DEFL SENS switch.

10. Move the VERT DEFL SENS switch to the 1 to 3 VOLTS PER CM position. Set the VERTICAL INPUT switch at the 50-volt TEST position and the CAL VOLTAGE control for 20 volts. Adjust C19 mounted on the chassis on the right side of the VERT DEFL SENS switch.

11. Move the VERT DEFL SENS switch to the 3 to 10 VOLTS PER CM position and set the CAL VOLTAGE control for 50 volts. Adjust C21 located on the left side of the VERT DEFL SENS switch.

12. Move the VERT DEFL SENS switch to the 10 to 30 VOLTS PER CM position and adjust C24 located on the left side of the VERT DEFL SENS switch.

13. Move the VERT DEFL SENS switch to the 30 to 100 VOLTS PER CM position and adjust C27 located on top of the VERT DEFL SENS switch.

NOTE—Greater accuracy in the adjustment of C24 and C27 may be obtained by providing increased signal input and therefore greater vertical deflection. A convenient method is to substitute a 1-megohm variable resistor shunted by a 50- μ f capacitor for the

probe. With the VERT DEFL SENS switch in the 0.3 to 1 VOLT PER CM position, adjust the variable resistor until the square-wave is properly reproduced. Then proceed with the adjustment of C24 and C27, as directed in steps 12 and 13.

High-Frequency Compensation

The following describes the procedure for high-frequency compensation in the Type 514D. Although they are not extremely critical settings, these adjustments do require considerable care to obtain optimum results. Since they are very stable, readjustment should not be attempted without first eliminating other possible sources of waveform distortion including defective vacuum tubes and a deficient signal source.

NOTE—Before proceeding with hf compensation, it is desirable to check the 1-megacycle waveform of the squarewave generator which is to be used, by connecting it directly to Y1 at the CRT access panel. **CAUTION:** Leads between the terminated cable and the Type 514D access panel must be very short to prevent ringing.

Terminating resistors at BOTH ends of the generator output cable are recommended.

Output (Distributed) Amplifier

The final vertical-amplifier stage of the Type 514D is a three-section distributed amplifier operated in push-pull. Adjustable series-compensating inductors couple the amplifier to the CRT vertical-deflection plates. An accurate impedance match between sections of the lines must be maintained to prevent reflections and attendant waveform distortion of high-frequency signal components. The impedances of the line sections are made adjustable by means of twelve trimmer capacitors. They are factory adjusted for optimum transient response, rather than flattest frequency response. This adjustment provides a gradually falling high-frequency characteristic, with useful amplification well beyond the specified 10-mc 3-db-down point. Adjustment is made while observing a 1-mc square wave having a rise time of .03 microsecond or less. This test signal should have squarest possible corners and a minimum of overshoot so that the oscilloscope compensation adjustments are not inadvertently used to correct for these deficiencies. The Tektronix Type 104A and Type 105 Square Wave Generators provide a suitable signal.

Maintain a CRT image of 2 to 3 cm by proper adjustment of the generator signal amplitude and the VERT



DEFL SENS control, and keep the image centered vertically. The factory procedure which gives the flattest frequency response consistent with satisfactory transient response is as follows:

1. In the Type 514D (but not in the Type 514) the delay network must be disconnected before any adjustments are made on the output amplifier. This is done as follows:

Disconnect wire from V4 pin 8 to the delay Network.

Disconnect wire from V6 pin 2 to the delay Network.

Connect a jumper wire from V4 pin 8 to V6 pin 2.

Connect a 600 ohm resistor from this jumper to the chassis.

2. Lay a piece of metal $4\frac{1}{4}$ " by 12" on the top of the instrument between trimmers C48A to C49F to simulate the presence of the case.

NOTE—If only a slight adjustment is necessary, steps 3, 4, and 5 may be omitted.

3. Effectively short out the signal of one side of the push-pull amplifier by bypassing the signal with a capacitor ($0.1 \mu\text{f}$ may be used) from Y2 to ground. Y2 is available at the side access panel. Set C48A to C49F at 50-per cent capacitance.

4. Apply a 1-mc squarewave to INPUT 1 or INPUT 2. Set the sweep time at .2 MICROSECOND PER CM. Set the VERT AMPL ATTEN control maximum clockwise. Adjust C48A to C48F and L6 for the smallest ripple or irregularity of the horizontal portion and squarest corner of the squarewave.

NOTE—The position of a capacitor along the transmission line determines which portion of the squarewave will be affected by its adjustment.

5. Remove the bypass capacitor from Y2 to ground and connect it from Y1 to ground. Proceed as in step 4 except adjust C49A to C49F and L5.

6. Remove the bypass capacitor from Y1 to ground and slightly readjust C48A to C49F, L5 and L6 as necessary for best waveform.

7. Apply a 100-kc squarewave and using a sweep time of 4.0 MICROSECONDS PER CM, observe the squareness of the leading corner of the squarewave. If necessary, readjust C48A to C49F, L5, and L6, using a 1-mc squarewave as in step 6, until the best compromise between squareness of corners and flatness of the level portion is obtained.

Delay Network

The delay network is a 24-section artificial transmission line providing a signal delay of $\frac{1}{4}$ microsecond. An accurate impedance match between sections must be maintained to prevent reflections. Each section is adjustable by means of a variable capacitor (C501 to C524). The effects of these adjustments are distributed over the first $\frac{1}{2}$ microsecond of the signal.

CAUTION—ADJUSTMENT OF THE DELAY NETWORK SHOULD NOT BE ATTEMPTED WITHOUT FIRST VERIFYING NORMAL TRANSIENT RESPONSE OF THE OUTPUT AMPLIFIER, AS EXPLAINED UNDER OUTPUT (DISTRIBUTED) AMPLIFIER ADJUSTMENT. OTHERWISE THE DELAY-NETWORK ADJUSTMENTS MAY BE SET TO COMPENSATE FOR DEFICIENCIES IN THE OUTPUT STAGE.

The recommended (factory) method of adjustment follows:

1. Lay a sheet of metal on the top of the instrument over the output (distributed) amplifier to simulate the presence of the case.

2. Apply a 100-kc squarewave to INPUT 1 or INPUT 2. Set the VERT AMPL ATTEN maximum clockwise, and the sweep time at 1 microsecond per cm.

3. Adjust C501 to C524 for the smallest ripple or irregularity on the first $\frac{1}{2}$ microsecond of the squarewave. The position of a capacitor along the delay network determines which portion of the squarewave will be affected by its adjustment. Adding a small additional capacitance to the exposed, hot, terminal of a capacitor (such as by touching it with a screwdriver) will indicate the position of that capacitor's effect, thus simplifying adjustment.

4. Change the sweep line to 4.0 MICROSECONDS PER CM and observe the squareness of the leading corner. If the corner (first $\frac{1}{2}$ microsecond) is higher in amplitude than the remainder of the squarewave, repeat step 3 but set all the capacitors at higher capacitance. If lower, repeat using lower capacitance settings. If a square corner cannot thus be obtained, an incorrect delay-network terminating resistor, R501, is indicated. Incorrect resistance may be caused by a short in V6 or V4. To check R501, turn off the Type 514D and allow the tubes to cool. Then measure R501

with an accurate bridge. If outside the range of 570 to 590 ohms, replace with a composition resistor selected to be within these limits.

Preamplifier H-F Response

The Type 514D preamplifier employs shunt compensation to improve the high-frequency characteristics. It is factory adjusted for best transient response rather than greatest bandwidth. This can be accom-

plished while observing the response to a 1-mc square-wave having a rise time of .03 microsecond or less. The Tektronix Type 104A or Type 105 Square Wave Generators provide a suitable signal.

Set the VERT DEFL SENS at either the .03 to .1 or .1 to .3 VOLT PER CM positions, the VERT AMPL ATTEN fully clockwise, and the sweep time at .2 MICROSECOND PER CM. Adjust L1 and L2 for the squarest corner of the leading edge.



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.



WARRANTY

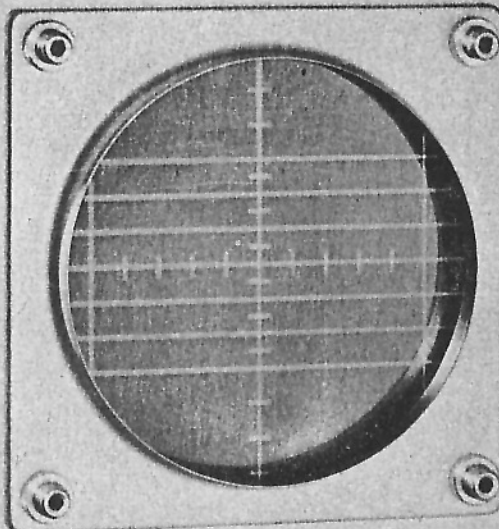
This instrument is guaranteed to the original user to be free from defects in material and workmanship for a period of one year from date of purchase. Our responsibility under this warranty is limited to the repair or replacement of the instrument, or any part thereof, failure of which is not due to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

All price revision and design modification privileges reserved.

TYPE 514 D CATHODE-RAY OSCILLOSCOPE
SERIES "A"



VERT. DEFL. SENS.
VOLTS/CM

10 0.3
30 0.1
100 0.03

AC DC

VERT. ATTEN.
DC BALANCE

VERTICAL INPUT
CAL VOLTAGE RANGE

0.5 1.5 5
0.15 15
0.05 50

INPUT 2

CAL VOLTAGE
PEAK TO PEAK

0 1 2 3 4 5

VERT. POSITION

INPUT 1

GND.

INPUT 2

VERT POSITION RANGE

CRT CATHODE

FOCUS

INTENSITY

ASTIGMATISM

6.3 V 1A

SCALE ILLUM.

HOR. POSITION

CAL DUTY CYCLE

SWEEP OUTPUT

+GATE

SWEEP MAGNIFIER POSITION

OUT

SWEEP TIME MULTIPLIER

SWEEP TIME MULTIPLIER

EXT. SWEEP ATTEN.

CAL OUTPUT

EXT. SWEEP INPUT

-GATE

GND.

SWEEP TIME
μSEC./CM

1000 100 10 0.1

EXT.

SWEEP STABILITY

POWER ON

TRIGGER AMPL.

TRIGGER SELECTOR

-EXT. +SIG. -SIG.

+EXT. 60 Hz

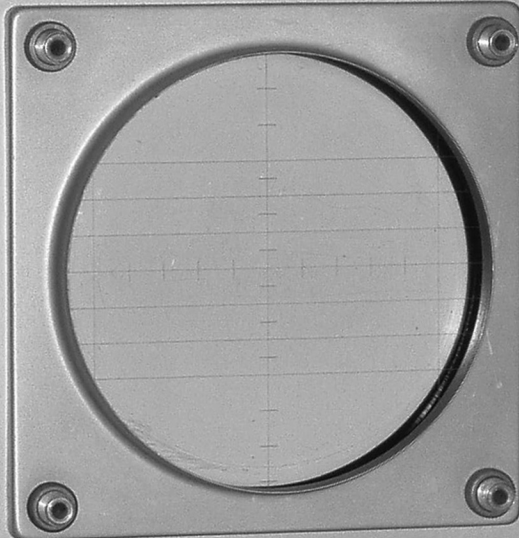
TRIGGER INPUT

GND.

SERIAL

TEKTRONIX, INC. PORTLAND, OREGON, U. S. A.

TYPE 514AD CATHODE-RAY OSCILLOSCOPE
SERIAL 8193



VERT. DEFL. SENS. VOLTS/CM
10 3 1 0.3 0.1 0.03

AC DC

VERT. AMPL. ATTN.

VERTICAL INPUT CAL. VOLTAGE RANGE
0.5 1.5 5 15 50 100
INPUT 1 2 50 TEST

CAL. VOLTAGE PEAK TO PEAK
2 3 4 5 10 15 20

VERT. POSITION

SCALE ILLUM.

HOR. POSITION

EXT. SWEEP ATTN.

TRIGGER AMPL.
30 40 50 60 70 80 90 100

TRIGGER SELECTOR
-EXT. +SIG. -SIG. +EXT. 60~

VERT. ATTEN. DC BALANCE

INPUT 1

GND

INPUT 2

VERT. POSITION RANGE

CAL. DUTY CYCLE

CAL. OUTPUT

EXT. SWEEP INPUT

TRIGGER INPUT

GND

CRT CATHODE

FOCUS

INTENSITY

ASTIGMATISM

6.3 V 1A

SWEEP OUTPUT

SWEEP MAGNIFIER POSITION

+GATE

OUT

SWEEP TIME μ SEC/CM
1000 100 10 1 0.1

EXT.

SWEEP STABILITY
30 40 50 60 70 80 90 100

POWER ON

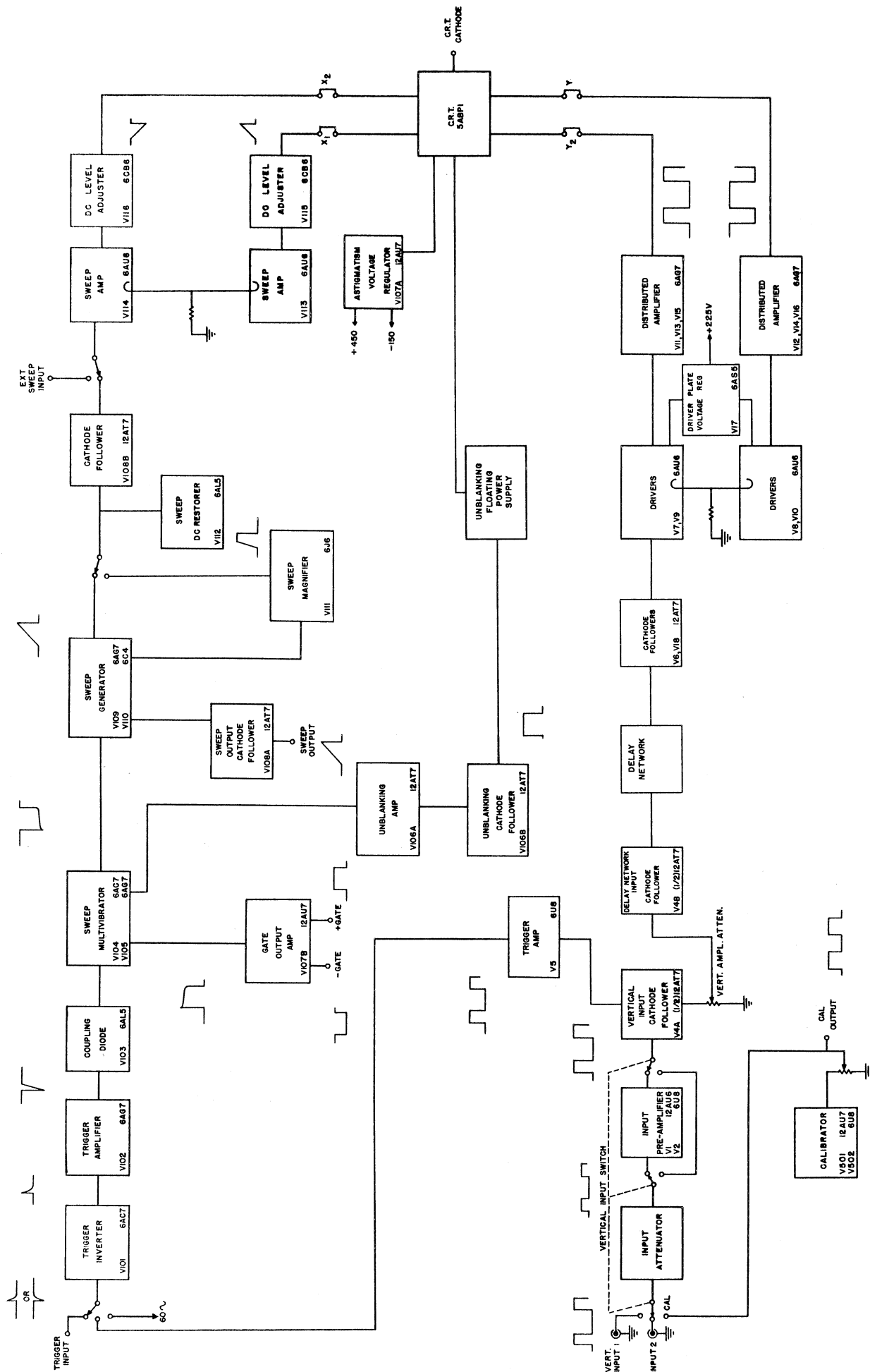
SWEEP TIME MULTIPLIER
1 2 3 4 5 6 8 10

SWEEP TIME MULTIPLIER
1 2 3 4 5 6 8 10

-GATE

GND

TEKTRONIX, INC., PORTLAND, OREGON, U. S. A.



3-18-65
44P-25

TYPE 514 SERIES A CATHODE RAY OSCILLOSCOPE

BLOCK DIAGRAM

ABBREVIATIONS

Cer	ceramic	m	milli or 10^{-3}
Comp	composition	Ω	ohm
EMC	electrolytic, metal cased	PMC	paper, metal cased
f	farad	Poly	polystyrene
GMV	guaranteed minimum value	Prec	precision
h	henry	PT	paper tubular
k	kilo or 10^3	v	working volts dc
meg	mega or 10^6	Var	variable
μ	micro or 10^{-6}	w	watt
$\mu\mu$	micromicro or 10^{-12}	WW	wire wound

SWEEP CIRCUITS

CAPACITORS

C101	.01 μ f	PT	Fixed	400 v	20%
C102A,B	2x20 μ f	EMC	Fixed	450 v	-20% +50%
C103	.01 μ f	PT	Fixed	400 v	20%
C104	.01 μ f	PT	Fixed	400 v	20%
C105A,B	2x20 μ f	EMC	Fixed	450 v	-20% +50%
C106	22 $\mu\mu$ f	Cer	Fixed	500 v	-0% +20%
C107.1	150 $\mu\mu$ f	Mica	Fixed	500 v	-3% +20%
C107.5	.0015 μ f	PT	Fixed	400 v	-2% +20%
C108.1	.015 μ f	PT	Fixed	400 v	-2% +20%
C109.1	.15 μ f	PT	Fixed	400 v	-2% +20%
C110	47 $\mu\mu$ f	Cer	Fixed	500 v	20%
C112	47 $\mu\mu$ f	Cer	Fixed	500 v	20%
C114	.01 μ f	PT	Fixed	600 v	20%
C115	8 $\mu\mu$ f	Cer	Fixed	500 v	20%
C116	.047 μ f	PT	Fixed	400 v	20%

C117	39 μ f	Cer	Fixed	500 v	10%
C118	7-45 μ f	Cer	Var.	500 v	
C119	.001 μ f	PT	Fixed	600 v	Selected
C120	.01 μ f	PT	Fixed	400 v	Selected
C121	.1 μ f	PT	Fixed	400 v	Selected
C122	1 μ f	PMC	Fixed	600 v	Selected
C124	1 μ f	PT	Fixed	400 v	20%
C125	12 μ f	Cer	Fixed	500 v	10%
C127	.01 μ f	Cer	Fixed	500 v	GMV
C128	.22 μ f	PT	Fixed	400 v	20%
C130.1	250 μ f	Mica	Fixed	500 v	20%
C131	.005 μ f	Mica	Fixed	400 v	GMV
C132	3-12 μ f	Cer	Var	500 v	
C133	.005 μ f	Mica	Fixed	500 v	GMV
C136	.01 μ f	PT	Fixed	400 v	20%

INDUCTORS

L101	7 μ h	Fixed	CF712
L103	88 μ h	Fixed	CF883
L104	21 μ h	Fixed	CF213

RESISTORS

R101	22 meg	$\frac{1}{2}$ w	Fixed	Comp	10%
R102	1 meg	$\frac{1}{2}$ w	Fixed	Comp	10%
R103	470 k	$\frac{1}{2}$ w	Fixed	Comp	10%
R104	4.7 k	2 w	Fixed	Comp	10%

R105.1	560 Ω	$\frac{1}{2}$ w	Fixed	Comp	10%	
R106	47 Ω	$\frac{1}{2}$ w	Fixed	Comp	10%	
R107	330 Ω	$\frac{1}{2}$ w	Fixed	Comp	10%	
R108.1	120 Ω	$\frac{1}{2}$ w	Fixed	Comp	10%	
R109	500 k	$\frac{1}{2}$ w	Var	Comp	20%	TRIGGER AMPL.
R110	1.5 meg	$\frac{1}{2}$ w	Fixed	Comp	10%	
R111	470 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R112	47 Ω	$\frac{1}{2}$ w	Fixed	Comp	10%	
R113	10 k	2 w	Fixed	Comp	10%	
R113.1	470 Ω	$\frac{1}{2}$ w	Fixed	Comp	10%	
R113.2	390 Ω	$\frac{1}{2}$ w	Fixed	Comp	10%	
R114	1 k	1 w	Fixed	Comp	10%	
R115	10 k	1 w	Fixed	Comp	10%	
R116	10 k	1 w	Fixed	Comp	10%	
R117	15 k	1 w	Fixed	Comp	10%	
R118.1	4.7 k	2 w	Fixed	Comp	10%	
R118.2	4.7 k	2 w	Fixed	Comp	10%	
R119	47 Ω	$\frac{1}{2}$ w	Fixed	Comp	10%	
R120	100 k	$\frac{1}{2}$ w	Var	Comp	20%	SWEEP STABILITY
R121	220 k	1 w	Fixed	Comp	10%	
R122	100 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R123	220 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R124A to I	220 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R125	47 Ω	$\frac{1}{2}$ w	Fixed	Comp	10%	

R126	3.3 meg	$\frac{1}{2}$ w	Fixed	Comp	10%	
R134	47 Ω	$\frac{1}{2}$ w	Fixed	Comp	10%	
R135	47 Ω	$\frac{1}{2}$ w	Fixed	Comp	10%	
R137	100 Ω	$\frac{1}{2}$ w	Fixed	Comp	10%	
R138.1	2.7 k	2 w	Fixed	Comp	10%	
R138.2	2.2 k	2 w	Fixed	Comp	10%	
R139	120 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R140	100 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R141	47 Ω	$\frac{1}{2}$ w	Fixed	Comp	10%	
R142	47 k	1 w	Fixed	Comp	10%	
R143	10 k	2 w	Fixed	Comp	10%	
R144	10 k	2 w	Fixed	Comp	10%	
R145	4.7 k	1 w	Fixed	Comp	10%	
R146	470 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R147	470 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R148	270 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R149	500 k	$\frac{1}{2}$ w	Var	Comp	20%	SWEEP SPEED ADJ.
R150	1 meg	$\frac{1}{2}$ w	Fixed	Comp	10%	
R150A,B*	2x220 k	2 w	Var	Comp	20%	SWEEP TIME MULT.
R151A to I	200 k	$\frac{1}{2}$ w	Fixed	Prec	1%	
R152.1	22 meg	$\frac{1}{2}$ w	Fixed	Comp	10%	
R152.2	22 meg	$\frac{1}{2}$ w	Fixed	Comp	10%	
R153	200 k	2 w	Fixed	Prec	1%	
R158	100 Ω	$\frac{1}{2}$ w	Fixed	Comp	10%	

*R150A,B supplied complete with hand calibrated dial.

R159	470 Ω	$\frac{1}{2}$ w	Fixed	Comp	10%	
R160	10 k	1 w	Fixed	Comp	10%	
R161	10 k	1 w	Fixed	Comp	10%	
R162	4.7 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R163	330 k	1 w	Fixed	Comp	10%	
R163.1	180 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R164	500 k	1 w	Var	Comp	20%	ASTIGMATISM
R165	10 k	1 w	Fixed	Comp	10%	
R166.1	10 meg	$\frac{1}{2}$ w	Fixed	Comp	10%	
R166.2	22 meg	$\frac{1}{2}$ w	Fixed	Comp	10%	
R167	1 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R168	22 k	2 w	Fixed	Comp	10%	
R169	15 k	2 w	Fixed	Comp	10%	
R170	680 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R171	100 k	$\frac{1}{2}$ w	Var	Comp	20%	MAGNIFIER POSITION
R172	8.2 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R173.1	700 k	$\frac{1}{2}$ w	Fixed	Prec	1%	
R173.2	600 k	$\frac{1}{2}$ w	Fixed	Prec	1%	
R174	100 k	2 w	Var	Comp	20%	EXT. SWEEP ATTEN.
R175	10 k	10 w	Fixed	WW	5%	
R176	180 ohm	$\frac{1}{2}$ w	Fixed	Comp	10%	
R176.1	100 Ω	$\frac{1}{2}$ w	Fixed	Comp	10%	
R176.2	47 k	1 w	Fixed	Comp	10%	
R177	4.7 k	1 w	Fixed	Comp	10%	

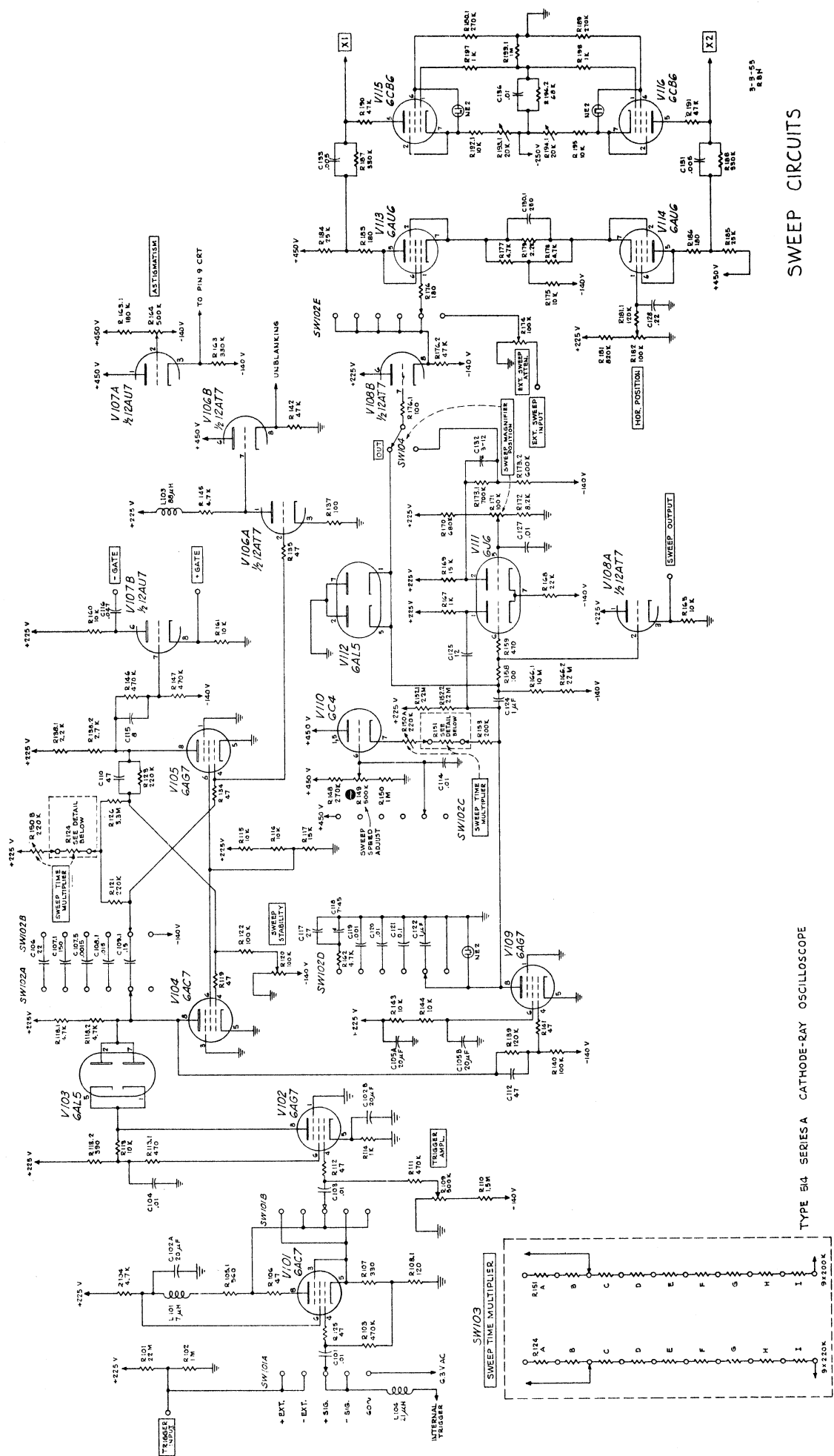
R178	4.7 k	1 w	Fixed	Comp	10%	
R179	2.2 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R180.1	270 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R181	820 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R181.1	120 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R182	100 k	$\frac{1}{2}$ w	Var	Comp	20%	HOR. POSITION
R183	180 Ω	$\frac{1}{2}$ w	Fixed	Comp	10%	
R184	25 k	10 w	Fixed	WW	5%	
R185	25 k	10 w	Fixed	WW	5%	
R186	180 Ω	$\frac{1}{2}$ w	Fixed	Comp	10%	
R187	330 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R188	330 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R189	270 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R190	47 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R191	47 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R192.1	10 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R193.1	20 k	2 w	Var	WW	10%	
R194.1	20 k	2 w	Var	WW	10%	
R195	10 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R196.2	68 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R197	1 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R198	1 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R199.1	1 meg	$\frac{1}{2}$ w	Fixed	Comp	10%	

SWITCHES

SW101	2 wafer	5 position	Rotary	TRIGGER SELECTOR
SW102A,B,C	3 wafer	6 position	Rotary	SWEEP TIME (front)
SW102D,E	2 wafer	6 position	Rotary	SWEEP TIME (rear)
SW103	2 wafer	10 position	Rotary	SWEEP TIME
SW104	Double Pole	Single Throw	Toggle	SWEEP MAGNIFIER

VACUUM TUBES

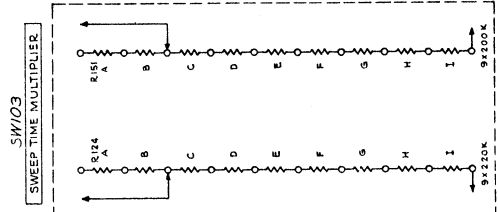
V101	6AC7	Trigger Inverter
V102	6AG7	Trigger Amplifier
V103	6AL5	Coupling Diode
V104	6AC7	Sweep Multivibrator
V105	6AG7	Sweep Multivibrator
V106A	12AT7	Unblanking Amplifier
V106B	12AT7	Unblanking Cathode Follower
V107A	12AU7	Astigmatism Potential Cathode Follower
V107B	12AU7	Gate Output Inverter
V108A	12AT7	Sweep Output Cathode Follower
V108B	12AT7	Sweep Magnifier DC Restorer
V109	6AG7	Sweep Generator
V110	6C4	Sweep Charging Potential Cathode Follower
V111	6J6	Sweep Magnifier
V112	6AL5	Sweep DC Restorer
V113	6AU6	Sweep Amplifier
V114	6AU6	Sweep Amplifier
V115	6CB6	DC Level Control
V116	6CB6	DC Level Control



SWEEP CIRCUITS

TYPE 614 SERIES A CATHODE-RAY OSCILLOSCOPE

9-2-55
R. B. P.



SWEEP TIME MULTIPLIER

PARTS LIST

ABBREVIATIONS

Cer.	Ceramic	m	milli or 10^{-3}
Comp.	Composition	Ω	ohm
EMC	Electrolytic, Metal Cased	PMC	Paper, Metal Cased
f	farad	Poly.	Polystyrene
GMV	Guaranteed Minimum Value	Prec.	Precision
h	henry	PT	Paper Tubular
k	kilo or 10^3	v	working volts dc
meg	mega or 10^6	Var.	Variable
μ	micro or 10^{-6}	w	watt
$\mu\mu$	micromicro or 10^{-12}	WW	Wire Wound

VERTICAL ATTENUATOR SWITCH

CAPACITORS

C5	.1 μ f	PT	Fixed	600 v	20%
C12	.001 μ f	Cer.	Fixed	400 v	GMV

RESISTORS

R2	47 Ω	1/2 w	Fixed	Comp.	10%
R3	47 Ω	1/2 w	Fixed	Comp.	10%

PREAMP AND ATTENUATOR

CAPACITORS

C6	1.5-7 $\mu\mu$ f	Cer.	Var.	500 v	
C7A	1/2 2x20 μ f	EMC	Fixed	450 v	-20%+50%
C7B	1/2 2x20 μ f	EMC	Fixed	450 v	-20%+50%
C8	275 μ f	EMC	Fixed	6 v	-20%+50%
C9	.01 μ f	PT	Fixed	400 v	20%
C10	.047 μ f	PT	Fixed	400 v	20%
C11A	1/2 2x20 μ f	EMC	Fixed	450 v	-20%+50%
C11B	1/2 2x20 μ f	EMC	Fixed	450 v	-20%+50%
C13	.1 μ f	PT	Fixed	400 v	20%
C19	3-12 $\mu\mu$ f	Cer.	Var.	500 v	
C19A	3-12 $\mu\mu$ f	Cer.	Var.	500 v	
C20	3-12 $\mu\mu$ f	Cer.	Var.	500 v	
C20A	3-12 $\mu\mu$ f	Cer.	Var.	500 v	
C21	3-12 $\mu\mu$ f	Cer.	Var.	500 v	
C22	1.5-7 $\mu\mu$ f	Cer.	Var.	500 v	
C23	27 $\mu\mu$ f	Cer.	Fixed	500 v	10%
C24	3-12 $\mu\mu$ f	Cer.	Var.	500 v	
C25	1.5-7 $\mu\mu$ f	Cer.	Var.	500 v	
C26	100 $\mu\mu$ f	Mica	Fixed	400 v	10%
C27	3-12 $\mu\mu$ f	Cer.	Var.	500 v	
C28	1.5-7 $\mu\mu$ f	Cer.	Var.	500 v	
C29	330 $\mu\mu$ f	Mica	Fixed	400 v	10%

INDUCTORS

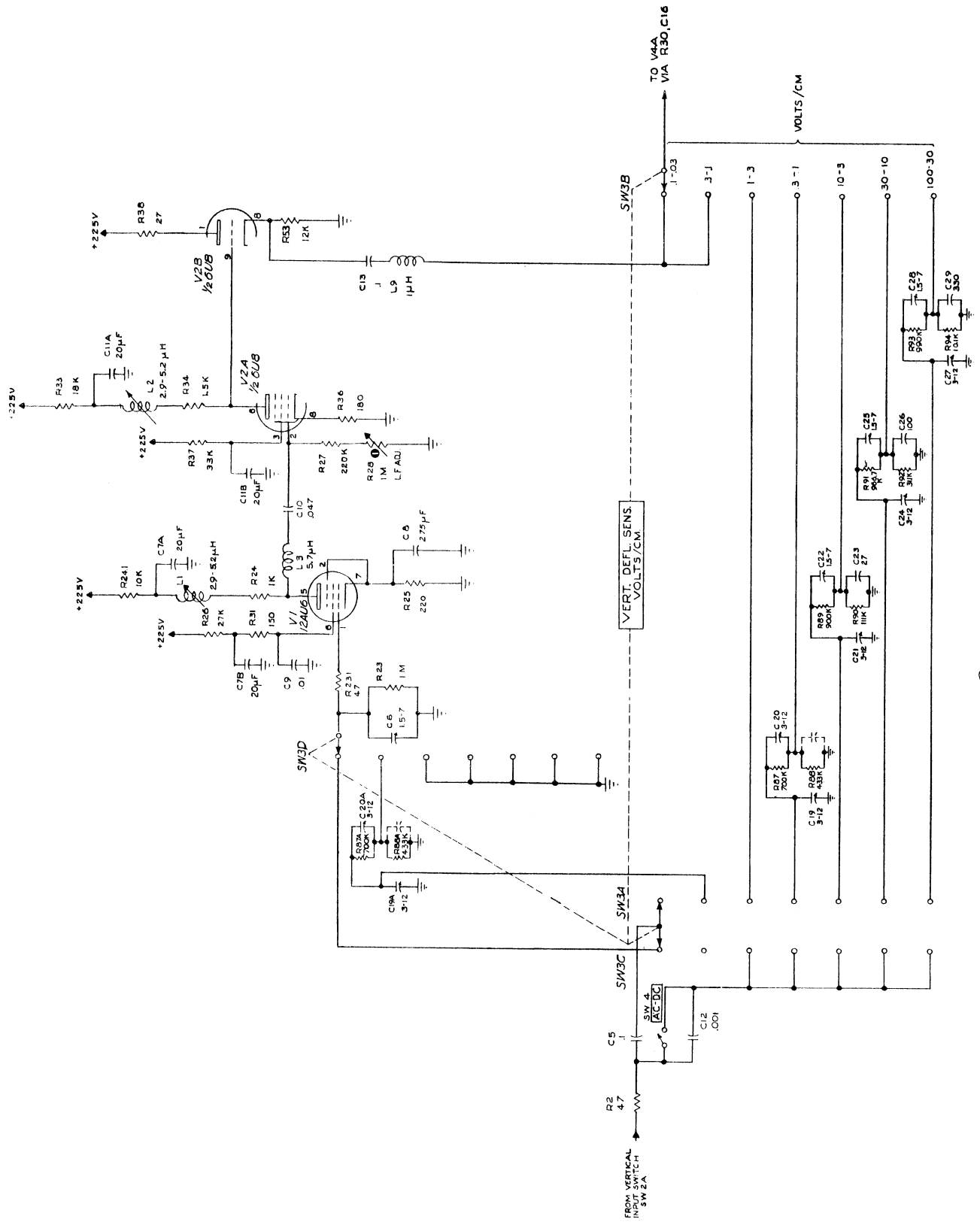
L1	2.9-5.2 μ h	Var.	CV292
L2	2.9-5.2 μ h	Var.	CV292
L3	5.7 μ h	Fixed	CF572
L9	1 μ h	Fixed	CF102

RESISTORS

R23	1 meg	1/2 w	Fixed	Prec.	1%
R23.1	47 Ω	1/2 w	Fixed	Comp.	10%
R24	1 k	1/2 w	Fixed	Comp.	10%
R24.1	10 k	2 w	Fixed	Comp.	10%
R25	220 Ω	1/2 w	Fixed	Comp.	10%
R26	27 k	1 w	Fixed	Comp.	10%
R27	220 k	1/2 w	Fixed	Comp.	10%
R28	1 meg	2 w	Var.	Comp.	20% L. F. ADJ.
R31	150 Ω	1/2 w	Fixed	Comp.	10%
R33	18 k	2 w	Fixed	Comp.	10%
R34	1.5 k	1/2 w	Fixed	Comp.	10%
R36	180 Ω	1/2 w	Fixed	Comp.	10%
R37	33 k	1 w	Fixed	Comp.	10%
R38	27 Ω	1/2 w	Fixed	Comp.	10%
R53	12 k	2 w	Fixed	Comp.	10%
R87	700 k	1/2 w	Fixed	Prec.	1%
R87A	700 k	1/2 w	Fixed	Prec.	1%
R88	433 k	1/2 w	Fixed	Prec.	1%
R88A	433 k	1/2 w	Fixed	Prec.	1%
R89	900 k	1/2 w	Fixed	Prec.	1%
R90	111 k	1/2 w	Fixed	Prec.	1%
R91	966.7 k	1/2 w	Fixed	Prec.	1%
R92	31.1 k	1/2 w	Fixed	Prec.	1%
R93	990 k	1/2 w	Fixed	Prec.	1%
R94	10.1 k	1/2 w	Fixed	Prec.	1%

VACUUM TUBE COMPLEMENT

V1	12AU6	Input Preamplifier
V2A	1/2 6U8	Second-stage Preamplifier
V2B	1/2 6U8	Output Cathode Follower



TYPE 514 CATHODE-RAY OSCILLOSCOPE ATTENUATOR SWITCH AND PREAMPLIFIER

TYPE 514 CATHODE-RAY OSCILLOSCOPE

PARTS LIST

ABBREVIATIONS

Cer.	Ceramic	m	milli or 10^{-3}
Comp.	Composition	Ω	ohm
EMC	Electrolytic, Metal Cased	PMC	Paper, Metal Cased
f	farad	Poly.	Polystyrene
GMV	Guaranteed Minimum Value	Prec.	Precision
h	henry	PT	Paper Tubular
k	kilo or 10^3	v	working volts dc
meg	mega or 10^6	Var.	Variable
μ	micro or 10^{-6}	w	watt
$\mu\mu$	micromicro or 10^{-12}	WW	Wire Wound

VERTICAL AMPLIFIER

CAPACITORS

C15	750 $\mu\mu\text{f}$	Mica	Fixed	500 v	5%
C16	.001 μf	Cer.	Fixed	500 v	GMV
C30	.22 μf	PT	Fixed	400 v	20%
C35	.001 μf	Cer.	Fixed	500 v	GMV
C36	.001 μf	Cer.	Fixed	500 v	GMV
C41	.001 μf	Cer.	Fixed	500 v	GMV
C42	.001 μf	Cer.	Fixed	500 v	GMV
C47A	1/2 2x20 μf	EMC	Fixed	450 v	-20%+50%
C47B	1/2 2x20 μf	EMC	Fixed	450 v	-20%+50%
C48A	.5-5 $\mu\mu\text{f}$	Poly	Var.	500 v	
C48B-F	1.5-7 $\mu\mu\text{f}$	Cer.	Var.	500 v	
C49A	.5-5 $\mu\mu\text{f}$	Poly	Var.	500 v	
C49B-F	1.5-7 $\mu\mu\text{f}$	Cer.	Var.	500 v	
C50	220 μf	EMC	Fixed	6 v	-20%+50%
C51	.001 μf	Cer.	Fixed	500 v	20%
C52	.005 μf	Cer.	Fixed	500 v	GMV
C53	.01 μf	PT	Fixed	400 v	20%
C54	.1 μf	PT	Fixed	400 v	20%
C56	.001 μf	Cer.	Fixed	500 v	GMV
C58	.005 μf	Cer.	Fixed	500 v	GMV
C59	.005 μf	Cer.	Fixed	500 v	GMV
C60	.01 μf	PT	Fixed	400 v	20%
C61A	20 μf	EMC	Fixed	450 v	-20%+50%
C61B	20 μf	EMC	Fixed	450 v	-20%+50%
C62	.01 μf	Cer.	Fixed	500 v	GMV

INDUCTORS

L4	1 μh	Fixed	CF102
L5	6.2-10 μh	Var.	CV622
L6	6.2-10 μh	Var.	CV622
L7	Distributed amplifier grid inductor		
L8	Distributed amplifier grid inductor		
L11	Distributed amplifier plate inductor		
L12	Distributed amplifier plate inductor		

RESISTORS

R29	1 meg	1/2 w	Fixed	Prec.	1%
R30	1 meg	1/2 w	Fixed	Comp.	10%
R30.1	47 Ω	1/2 w	Fixed	Comp.	10%
R35	27 Ω	1 w	Fixed	Comp.	10%
R39	18 k	2 w	Fixed	Comp.	10%
R40.1	2 k	2 w	Var.	WW	20%* VERT. AMP. ATTEN.
R40.2	820 Ω	1 w	Fixed	Comp.	10%*
R41.2	22 k	2 w	Fixed	Comp.	10%*
R42	20 k	2 w	Var.	Comp.	20% VERT. ATTEN. ADJ.
R43	680 Ω	1/2 w	Fixed	Comp.	10%
R44	8.2 k	2 w	Fixed	Comp.	10%
R45	10 k	1/2 w	Fixed.	Comp.	10%
R46	500 k	2 w	Var.	Comp.	20% VERT. POSITION
R47	20 k	2 w	Var.	Comp.	20% VERT. RANGE POS.ADJ..
R48	100 k	1/2 w	Fixed	Comp.	10%
R49	47 Ω	1/2 w	Fixed	Comp.	10%
R50	47 Ω	1/2 w	Fixed	Comp.	10%
R51	47 Ω	1/2 w	Fixed	Comp.	10%
R52	180 Ω	2 w	Fixed	Comp.	10%
R54	47 Ω	1/2 w	Fixed	Comp.	10%
R55	47 Ω	1/2 w	Fixed	Comp.	10%
R56.1	27 Ω	1/2 w	Fixed	Comp.	10%
R56.2	27 Ω	1/2 w	Fixed	Comp.	10%
R56.3	27 Ω	1/2 w	Fixed	Comp.	10%
R56.4	27 Ω	1/2 w	Fixed	Comp.	10%
R56.5	27 Ω	1/2 w	Fixed	Comp.	10%
R56.6	27 Ω	1/2 w	Fixed	Comp.	10%
R56.7	47 Ω	1/2 w	Fixed	Comp.	10%
R57	15 meg	1/2 w	Fixed	Comp.	10%
R59	1 k	25 w	Fixed	WW Non Ind.	5%
R60	1 k	25 w	Fixed	WW Non Ind.	5%
R63	1 meg	1/2 w	Fixed	Comp.	10%
R68	1 meg	1/2 w	Fixed	Comp.	10%
R70	1 meg	1/2 w	Fixed	Comp.	10%
R71	1 meg	1/2 w	Fixed	Comp.	10%
R73	1 meg	1/2 w	Fixed	Comp.	10%
R74	27 k	2 w	Fixed	Comp.	10%
R75	3.9 k	1/2 w	Fixed	Comp.	10%
R76	470 Ω	1/2 w	Fixed	Comp.	10%
R77	1 meg	1/2 w	Fixed	Comp.	10%
R78	33 k	1 1 w	Fixed	Comp.	10%
R79.2	333 k	1/2 w	Fixed	Prec.	1%
R80.2	111 k	1/2 w	Fixed	Prec.	1%
R82	910 Ω	1/2 w	Fixed	Comp.	1%
R82.1	910 Ω	1/2 w	Fixed	Comp.	5%
R83	910 Ω	1/2 w	Fixed	Comp.	1%
R83.1	910 Ω	1/2 w	Fixed	Comp.	5%
R84	1 meg	1/2 w	Fixed	Comp.	10%
R85	100 k	1/2 w	Fixed	Comp.	10%
R86	100 k	1/2 w	Fixed	Comp.	10%

*R41.2/R40.2 and R40.1/R40.2 selected with ratios within 2 1/2% of 220/8.2 and 20/8.2.

R95	680 Ω	1/2 w	Fixed	Comp.	10%
R96	200 Ω	10 w	Fixed	WW	5%
R97	1.5 k	5 w	Fixed	WW	5%
R98	22 k	2 w	Fixed	Comp.	10%

SWITCHES

SW2	5 wafer	11 position	Rotary	VERT. INPUT
SW3	6 wafer	7 position	Rotary	VERT. DEFL. SENS.
SW4	2 wafer	2 position	Rotary	AC DC

VACUUM TUBE COMPLEMENT

V4A	1/2 12AT7	Gain Control state input
V4B	1/2 12AT7	Gain Control stage cathode follower
V5A	1/2 6U8	Trigger Amplifier
V5B	1/2 6U8	Trigger Amplifier cathode follower
V6	12AT7	DC Balance cathode follower
V7	6AH6	Driver
V8	6AH6	Driver
V9	6AH6	Driver
V10	6AH6	Driver
V11	6AG7	Output Distributed Amplifier
V12	6AG7	Output Distributed Amplifier
V13	6AG7	Output Distributed Amplifier
V14	6AG7	Output Distributed Amplifier
V15	6AG7	Output Distributed Amplifier
V16	6AG7	Output Distributed Amplifier
V17	6AS5	Cathode Follower Voltage Regulator
V18	12AT7	Phase Inverter Compensator

DELAY LINE

CAPACITORS

C501	3-12 $\mu\mu\text{f}$	Var.	Cer.	500 v	20%
C502	3-12 $\mu\mu\text{f}$	Var.	Cer.	500 v	20%
C503	3-12 $\mu\mu\text{f}$	Var.	Cer.	500 v	20%
C504	3-12 $\mu\mu\text{f}$	Var.	Cer.	500 v	20%
C505-C524	1.5-7 $\mu\mu\text{f}$	Var.	Cer.	500 v	
C501A-C523A	12 $\mu\mu\text{f}$	Fixed	Cer.	400 v	10%
C525	2.2 $\mu\mu\text{f}$	Fixed	Cer.	500 v	25%

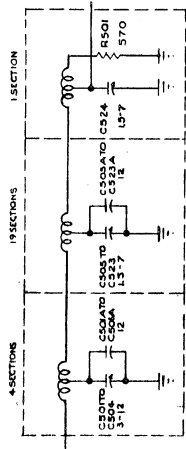
INDUCTORS

L501-2-3-4	Fixed	Delay network inductors	CF6-612
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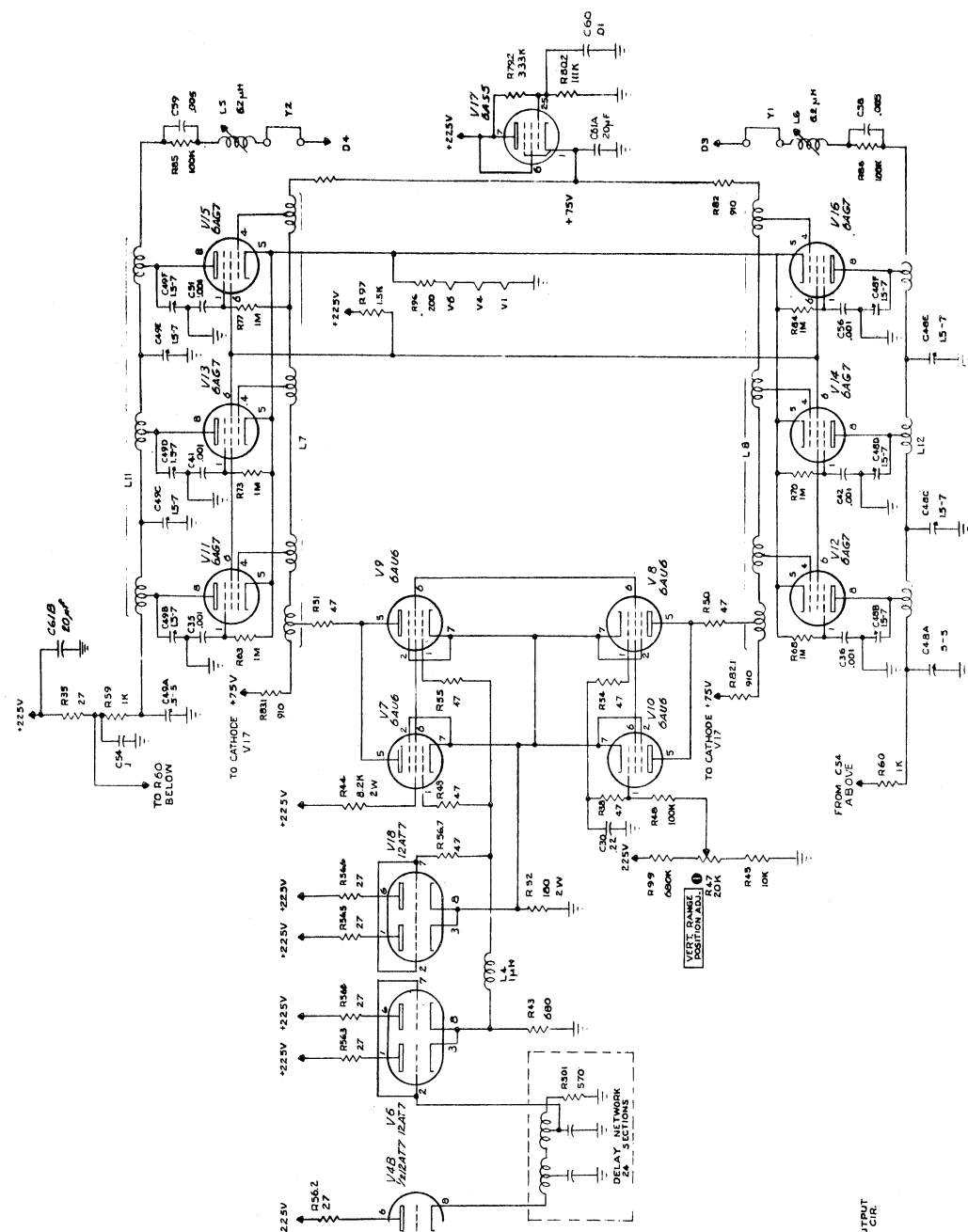
RESISTORS

R501	570 Ω	1/2 w	Fixed	Prec.	1%
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DELAY LINE DETAIL



NOTE: C533, 2.2μF, CONNECTED BETWEEN UNGROUNDED ENDS OF C503 AND C508



TYPE 514 SERIES CATHODE-RAY OSCILLOSCOPE

VERTICAL AMPLIFIER CIRCUITS

PARTS LIST

ABBREVIATIONS

Cer.	Ceramic	m	milli or 10^{-3}
Comp.	Composition	Ω	ohm
EMC	Electrolytic, Metal Cased	PMC	Paper, Metal Cased
f	farad	Poly.	Polystyrene
GMV	Guaranteed Minimum Value	Prec.	Precision
h	henry	PT	Paper Tubular
k	kilo or 10^3	v	working volts dc
meg	mega or 10^6	Var.	Variable
μ	micro or 10^{-6}	w	watt
$\mu\mu$	micromicro or 10^{-12}	WW	Wire Wound

CALIBRATOR

CAPACITORS

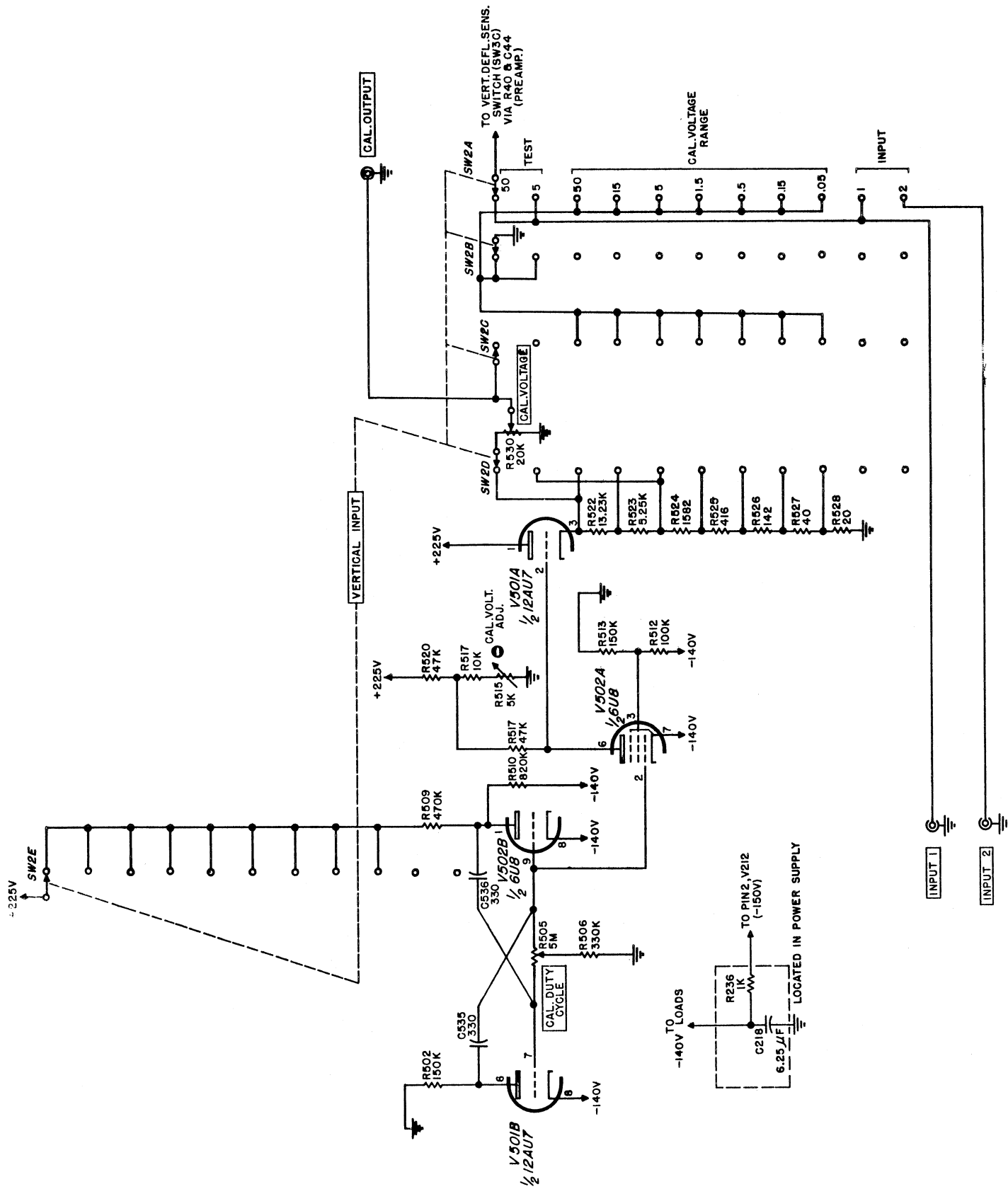
C218	6.25 μ f	EMC	Fixed	450 v	-20%+50%
C535	330 μ μ f	Mica	Fixed	500 v	20%
C536	330 μ μ f	Mica	Fixed	500 v	20%

RESISTORS

R236	1 k	1/2 w	Fixed	Comp.	10%
R502	150 k	1/2 w	Fixed	Comp.	10%
R505	5 meg	2 w	Var.	Comp.	20% CAL DUTY CYCLE
R506	330 k	1/2 w	Fixed	Comp.	10%
R509	470 k	1/2 w	Fixed	Comp.	10%
R510	820 k	1/2 w	Fixed	Comp.	10%
R512	100 k	1/2 w	Fixed	Comp.	10%
R513	150 k	1/2 w	Fixed	Comp.	10%
R515	5 k	2 w	Var.	WW	20% CAL ADJ
R516	10 k	1 w	Fixed	Comp.	10%
R517	47 k	1/2 w	Fixed	Comp.	10%
R520	47 k	2 w	Fixed	Comp.	10%
R522	13.23 k	1/2 w	Fixed	Prec.	1%
R523	5.25 k	1/2 w	Fixed	Prec.	1%
R524	1582 Ω	1/2 w	Fixed	Prec.	1%
R525	416 Ω	1/2 w	Fixed	Prec.	1%
R526	142 Ω	1/2 w	Fixed	Prec.	1%
R527	40 Ω	1/2 w	Fixed	Prec.	1%
R528	20 Ω	1/2 w	Fixed	Prec.	1%
R530	20 k	3 w	Var.	WW	2% CAL VOLTAGE

VACUUM TUBE COMPLEMENT

V501A	1/2 12AU7	Calibrator Multivibrator
V501B	1/2 12AU7	Cal. Output Cathode Follower
V502A	1/2 6U8	Cal. Amplifier
V502B	1/2 6U8	Calibrator Multivibrator



ABBREVIATIONS

Cer	ceramic	m	milli or 10^{-3}
Comp	composition	Ω	ohm
EMC	electrolytic, metal cased	PMC	paper, metal cased
f	farad	Poly	polystyrene
GMV	guaranteed minimum value	Prec	precision
h	henry	PT	paper tubular
k	kilo or 10^3	v	working volts dc
meg	mega or 10^6	Var	variable
μ	micro or 10^{-6}	w	watt
$\mu\mu$	micromicro or 10^{-12}	WW	wire wound

POWER SUPPLY

CAPACITORS

C135	10 μ f	EMC	Fixed	450 v	-20% +50%
C210	2x20 μ f	EMC	Fixed	450 v	-20% +50%
C211	.01 μ f	PT	Fixed	400 v	20%
C212	3-2x20 μ f	EMC	Fixed	450 v	-20% +50%
C213	.01 μ f	PT	Fixed	400 v	20%
C214	.01 μ f	PT	Fixed	400 v	20%
C216	2x20 μ f	EMC	Fixed	450 v	-20% +50%
C217	2x20 μ f	EMC	Fixed	450 v	-20% +50%
C226	.047 μ f	PT	Fixed	400 v	20%

RESISTORS

R212	220 k	1 w	Fixed	Comp	10%
R213	470 k	$\frac{1}{2}$ w	Fixed	Comp	10%
R214	150 k	$\frac{1}{2}$ w	Fixed	Comp	10%
R215	47 k	$\frac{1}{2}$ w	Fixed	Comp	10%
R216	1 meg	$\frac{1}{2}$ w	Fixed	Comp	+3% +5%

R217	1 meg	$\frac{1}{2}$ w	Fixed	Comp	-5%	-3%
R218	470 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R219.1	1.5 k	25 w	Fixed	WW	5%	
R219.2	1.5 k	25 w	Fixed	WW	5%	
R220	82 k	1 w	Fixed	Comp	10%	
R221	22 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R222	1 meg	$\frac{1}{2}$ w	Fixed	Comp	10%	
R223	1.11 meg	$\frac{1}{2}$ w	Fixed	Prec	1%	
R224	68 k	1 w	Fixed	Comp	10%	
R225	220 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R226	220 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R227	150 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R228	470 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R229	470 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R230	100 k	$\frac{1}{2}$ w	Var	Comp	20%	ADJ. TO 225 V
R231	270 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R232	3 k	25 w	Fixed	WW	5%	
R234	470 k	1 w	Fixed	Comp	10%	
R235	10 k	1 w	Fixed	Comp	10%	
R257	50 Ω	2 w	Var	WW	20%	SCALE ILLUM.

SWITCHES

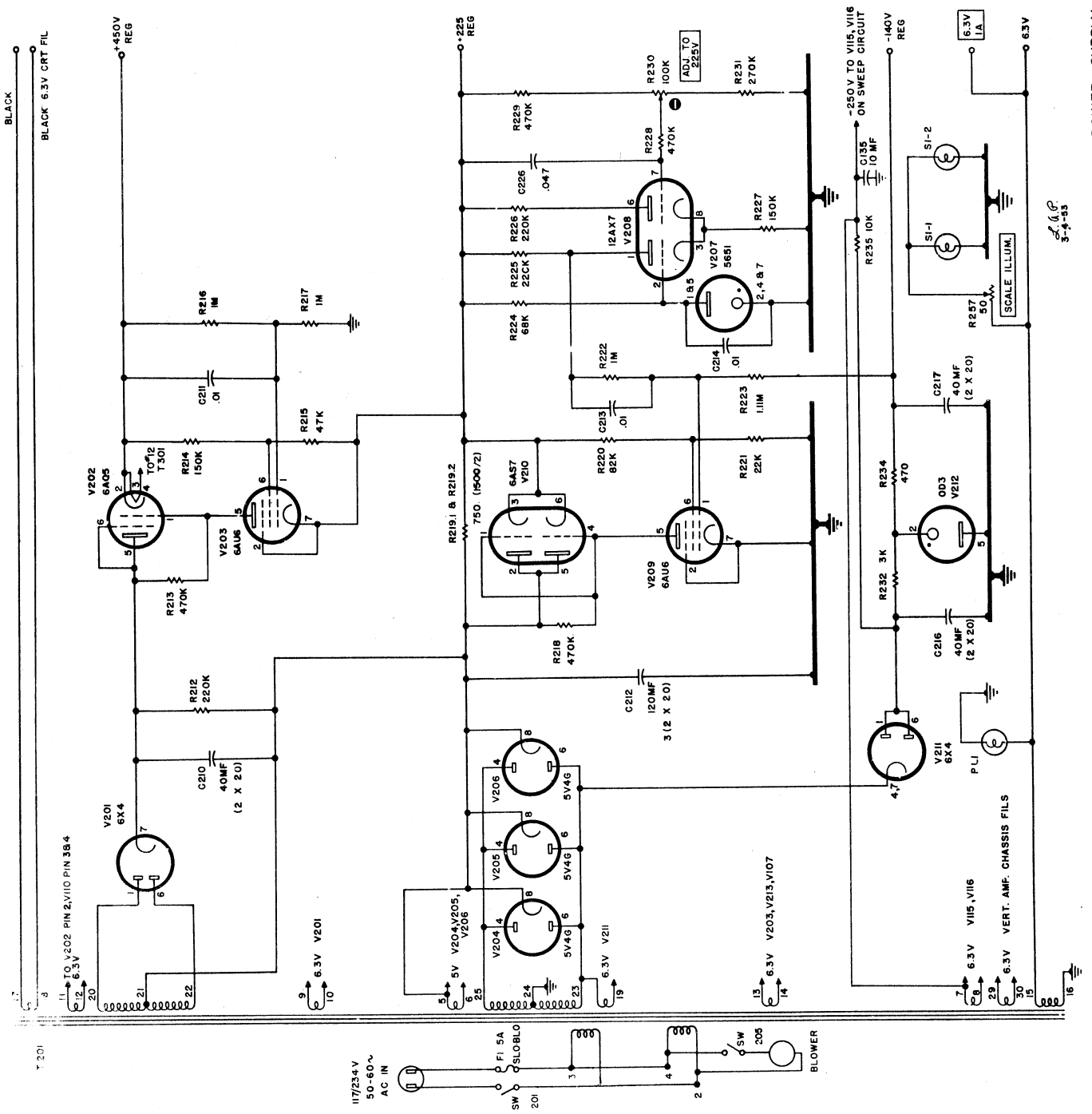
SW201	Single Pole	Single Throw	Toggle	POWER
SW205	Single Pole	Single Throw	Toggle	FAN INTERLOCK

TRANSFORMER

T101	Plate and heater	T514PB1
	Primary:	117/234 vac, 50/60 cycle
	Secondaries:	282-0-282 vac 300 ma
		282-0-282 vac 30 ma
		5 vac 6 amp
		6.3 vac 6 amp
		6.3 vac 6 amp
		6.3 vac 6 amp
		6.3 vac 1.7 amp
		6.3 vac 7 amp
		6.3 vac 6 amp
		6.3 vac 6 amp

VACUUM TUBES

V201	6X4	+450 v Rectifier
V202	6AQ5	+450 v Series Regulator
V203	6AU6	+450 v Regulator Amplifier
V204	5V4G	+225 v Rectifier
V205	5V4G	+225 v Rectifier
V206	5V4G	+225 v Rectifier
V207	5651	+225 v Voltage Reference
V208	12AX7	+225 v Regulator Comparator
V209	6AU6	+225 v Regulator Amplifier
V210	6AS7	+225 v Series Regulator
V211	6X4	-150 v Rectifier
V212	OD3	-150 v Regulator



POWER SUPPLY

TYPE 514 SERIES A CATHODE RAY OSCILLOSCOPE

3-4-33

ABERVIATIONS

Cer	ceramic	m	milli or 10^{-3}
Comp	composition	Ω	ohm
EMC	electrolytic, metal cased	PMC	paper, metal cased
f	farad	Poly	polystyrene
GMV	guaranteed minimum value	Prec	precision
h	henry	PT	paper tubular
k	kilo or 10^3	v	working volts dc
meg	mega or 10^6	Var	variable
μ	micro or 10^{-6}	w	watt
$\mu\mu$	micromicro or 10^{-12}	WW	wire wound

HV SUPPLY AND CRT CIRCUIT

CAPACITORS

C801	.1 μ f	PT	Fixed	400 v	20%
C803	.0047 μ f	PT	Fixed	400 v	20%
C806	.001 μ f	PT	Fixed	600 v	20%
C807	.001 μ f	PT	Fixed	600 v	20%
C812	.0068 μ f	PT	Fixed	3000 v	20%
C815	.015 μ f	PT	Fixed	3000 v	20%
C816	.0068 μ f	PT	Fixed	3000 v	20%
C820	.001 μ f	PT	Fixed	3000 v	20%
C822	.0068 μ f	PT	Fixed	3000 v	20%
C828	.015 μ f	PT	Fixed	3000 v	20%
C829	.1 μ f	PMC	Fixed	2000 v	20%

RESISTORS

R801	220 k	1/2 w	Fixed	Comp	10%
R802	47 Ω	1/2 w	Fixed	Comp	10%
R803	470 k	1/2 w	Fixed	Comp	10%

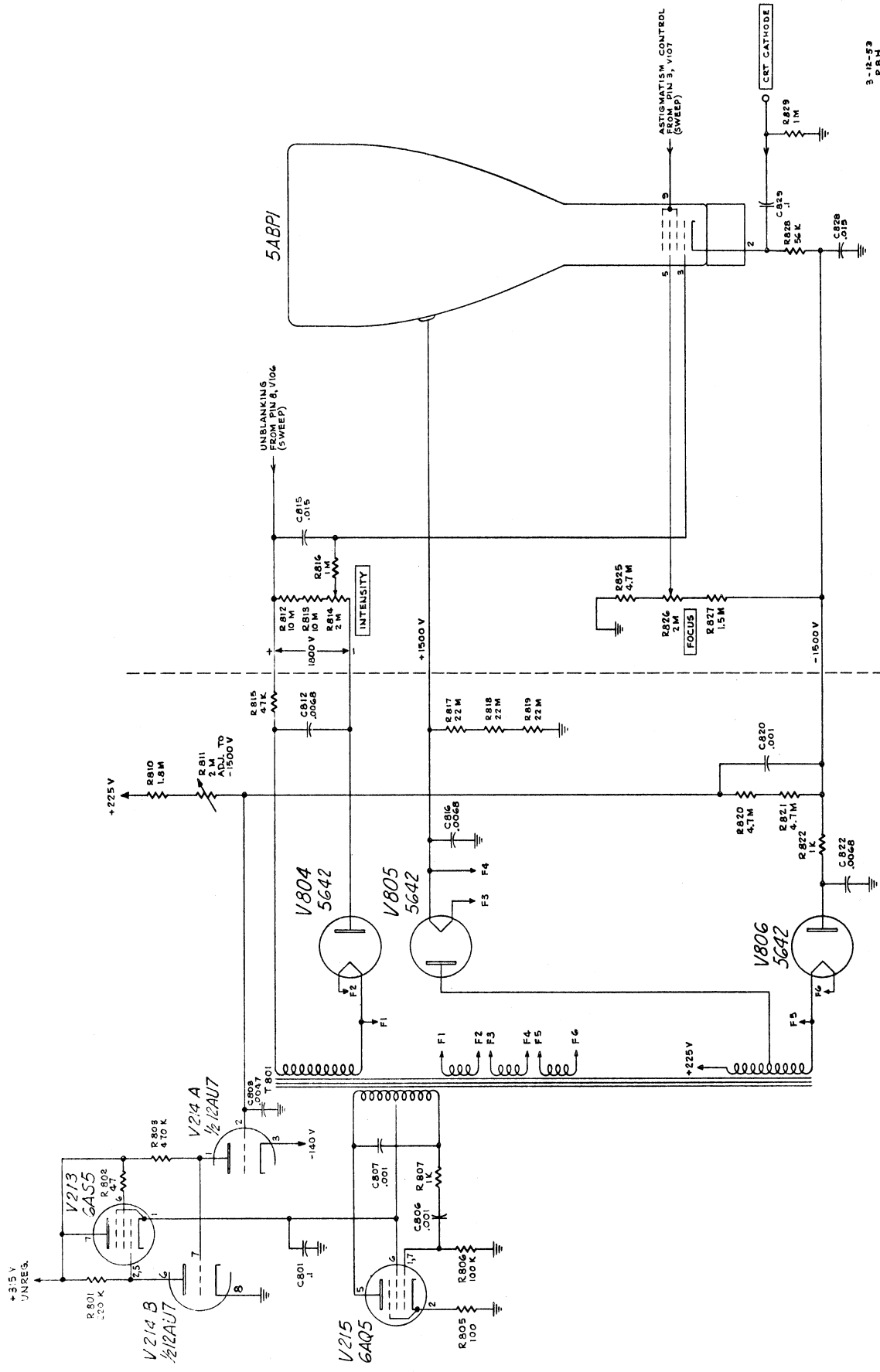
R804	Unassigned					
R805	100 Ω	$\frac{1}{2}$ w	Fixed	Comp	10%	
R806	100 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R807	1 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R810	1.8 meg	$\frac{1}{2}$ w	Fixed	Comp	10%	
R811	2 meg	2 w	Var	Comp	20%	ADJ. TO -1500V
R812	10 meg	2 w	Fixed	Comp	10%	
R813	10 meg	2 w	Fixed	Comp	10%	
R814	2 meg	2 w	Var	Comp	20%	INTENSITY
R815	47 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R816	1 meg	$\frac{1}{2}$ w	Fixed	Comp	10%	
R817	22 meg	$\frac{1}{2}$ w	Fixed	Comp	10%	
R818	22 meg	$\frac{1}{2}$ w	Fixed	Comp	10%	
R819	22 meg	$\frac{1}{2}$ w	Fixed	Comp	10%	
R820	4.7 meg	2 w	Fixed	Comp	10%	
R821	4.7 meg	2 w	Fixed	Comp	10%	
R822	1 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R825	4.7 meg	2 w	Fixed	Comp	10%	
R826	2 meg	2 w	Var	Comp	20%	FOCUS
R827	1.5 meg	$\frac{1}{2}$ w	Fixed	Comp	10%	
R828	56 k	$\frac{1}{2}$ w	Fixed	Comp	10%	
R829	1 meg	$\frac{1}{2}$ w	Fixed	Comp	10%	

TRANSFORMER

T801 HV Transformer T514-0C1

VACUUM TUBES

V213	6AS5	Series Regulator
V214	12AU7	DC Amplifier
V215	6AQ5	HV Oscillator
V804	5642	HV Rectifier
V805	5642	HV Rectifier
V806	5642	HV Rectifier



3-12-53
R 5H

H V POWER SUPPLY & CRT CIRCUITS

E 514 SERIES A CATHODE-RAY OSCILLOSCOPE

