CATHODE-RAY OSCILLOSCOPE
TYPE 524AD

INSTRUCTION MANUAL

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

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TYPE 524AD SERIAL NUMBER ________


TYPE 524AD CATHODE-RAY OSCILLOSCOPE
SERIAL
VERTICAL AMPLIFIER AND CALIBRATOR
VOLTS/CM
INPUT SELECTOR
INPUT 1
INPUT 2
CAL.
CAL. VOLTAGE RANGE
VARIABLE ATTEN.
VARIABLE ATTEN. BAL.
CAL. VOLTAGE
PEAK TO PEAK
CAL. DUTY CYCLE
CAL. OUTPUT
SCALE ILLUM
FOCUS
INTENSITY
ASTIGMATISM
TIME MARKER
GND
EXT MARKER
PHASE
AMPLITUDE
VERTICAL POSITION
HORIZONTAL POSITION
PROBE POWER
TEKTRONIX
SWEEP GENERATOR
MAG POS
MAGNIFIER
GATE
μSEC/CM MULTIPLIER
SWEEP DELAY
0-25 MILLISECONDS
SWEEP OUTPUT
FIELD SHIFT
EXTERNAL SWEEP INPUT
TIME
STABILITY
OR
EXT. SWEEP ATTEN.
POWER ON
TRIGGER
AMPLITUDE
OR
INT. 60~ SWEEP PHASE
SELECTOR
UNDELAYED SWEEP
DELAYED SWEEP
EXTERNAL TRIGGER INPUT
TEKTRONIX, INC. PORTLAND, OREGON, U.S.A.

GENERAL DESCRIPTION

General

The Tektronix Type 524AD is a portable, self-contained cathode-ray oscilloscope specifically designed for maintenance and adjustment of television transmitters and studio equipment.

With this oscilloscope, any portion of the television picture can be observed, from complete frames to small portions of individual lines. Any one of the 525 lines in the picture can be selected and observed in detail. Internally-generated time markers facilitate sync-pulse timing. The wide-band vertical amplifier is provided with a network that can be switched in to limit the high-frequency response to that recommended by the IRE Standards Committee for standardized pulse-level measurements. A second switch position adds high-frequency compensation to make flat frequency response to 5 mc, within one per cent, but at the sacrifice of best transient response.

The vertical amplifier has a bandwidth to 10 megacycles, a dc sensitivity to 0.15 volts per centimeter, and an ac sensitivity increased by a 10X ac-coupled preamplifier to 0.015 volts per centimeter. A built-in variable-duty-cycle calibrator aids in pulse-level measurements.

The sweep system provides calibrated sweeps as fast as 0.1 microsecond per centimeter, includes a 3X and 10X magnifier, a television composite-video-signal sync separator, and a variable delayed sweep. The unblanking pulse is dc coupled.

Characteristics

Sweep Circuit

Hard-tube type, triggered or recurrent operation as desired.

Sweep-Time Range

Continuously variable, 0.1 microsecond per centimeter to 0.01 second per centimeter.

Trigger Requirements

TV composite video signal between 0.5 volt and 15 volt peak, or pulses 0.15 to 15 volts peak to peak.

Sweep Magnification

Magnifier expands the trace to right and left of center, either 3X or 10X. Magnified sweep speed limited to 0.1 microsecond per centimeter.

External Sweep Input

External sweep voltage can be coupled in via 100-k potentiometer through dc-coupled sweep amplifier, with magnification, if desired. Horizontal positioning included.

Sine-Wave, 60-Cycle Phased Sweep

This sine-wave sweep is adjustable in amplitude and the phase can be varied through 150 degrees. Applied via the sweep amplifier. Includes sweep-magnifier and horizontal-positioning circuits.

Time Markers

Five time intervals are provided of 1 μsec, 0.1 μsec, 0.05 μsec, 0.318 μsec and 1.59 μsec. (200 markers and 40 markers per television line.)

DC Unblanking

The dc-coupled unblanking pulse permits the slowest sweeps to be used with uniform spot intensity throughout the sweep.

Vertical Amplifier

Four dc-coupled stages provide sensitivities from 0.15 volts per centimeter. Output stage is a three-section push-pull distributed amplifier. An ac-coupled 10X preamplifier can be switched in for highest sensitivity, giving a sensitivity of 0.015 volts per centimeter.

AC Vertical-Deflection Sensitivity

Continuously variable from 0.015 volts per centimeter to 50 volts per centimeter, peak to peak.

DC Vertical-Deflection Sensitivity

Continuously variable from 0.15 volts per centimeter to 50 volts per centimeter, peak to peak.

Vertical-Amplifier Frequency Response

DC to 10 megacycles at a maximum sensitivity of 0.15 volts per centimeter. Two cycles to 10 megacycles with the ac-coupled preamplifier for sensitivity increased to 0.015 volts per centimeter.

Over-compensation of high frequencies can be selected with a switch to provide flat frequency response, within 1 per cent, to 5 mc, but with some overshoot on transient response.

Vertical-Amplifier Transient Response

Rise time 0.04 microseconds between response points 10 per cent and 90 per cent of the final value.

Vertical-Amplifier Input Impedance

One megohm shunted by 45 $\mu\mu$f capacitance.

Probe Input Impedance

Ten megohms shunted by 15 $\mu\mu$f; 10X attenuation.

Signal-Delay Network

A delay network supplies an additional 0.25 microsecond of delay to the vertical-amplifier system to permit the triggering waveform to be displayed. Total signal delay is 0.34 microseconds.

Calibrator

A variable-duty-cycle square wave is provided. Seven full-scale ranges between 0.05 volts and 50 volts, continuously variable, can be read directly from the dial settings with an accuracy within three per cent of full scale. The duty cycle is variable between 1 per cent and 99 per cent. Frequency varies with duty cycle.

Cathode-Ray Tube

A type 5ABP1 cathode-ray tube is supplied with the Type 524AD unless a P7 or a P11 is specified as the optional choice.

Cathode-Ray Tube Accelerating Voltage

Four kilovolts. (+2.5 and —1.5 kv.)

Construction

Welded aluminum alloy, with photo-etched panel and blue wrinkle case.

Dimensions

25″ long, 13″ wide, 16¾″ high.

Weight

61 pounds.

Power Requirements

105 to 125 volts or 210 to 250 volts ac, 50 to 60 cycles. 500 watts at 117 or 234 volts.

Front-Panel Controls and Connectors

Vertical Amplifier

VOLTS/CM	Seven-position gang switch. Selects attenuators or preamplifier at the input to the vertical amplifier to select vertical-deflection sensitivity.
INPUT SELECTOR	Six-position switch connects **INPUT 1, INPUT 2,** or the calibrator output to the vertical amplifier, and inserts or removes a capacitor for ac or dc coupling.
INPUT 1, INPUT 2	Coaxial connectors to the vertical-amplifier system via the **INPUT SELECTOR** switch.
GND	Binding post connected to the instrument case.
VARIABLE ATTEN.	Variable resistor between cathodes of the cathode-coupled variable-gain stage. Varying this resistor varies the coupling between stages and varies the overall stage gain.
CAL. VOLTAGE RANGE	Eight-position switch selects attenuators providing seven calibrator voltage ranges, and turns the calibrator off.
VARIABLE ATTEN. BAL.	Adjusts grid bias of vertical variable-gain stage. When the two cathodes of this cathode-coupled stage are at equal voltage, no vertical positioning occurs when the **VARIABLE ATTEN.** control is adjusted.
CAL. DUTY CYCLE	Variable resistor adjusting time constants of calibrator multivibrator. Time constant of one-half of multivibrator is lengthened while time constant of other is shortened. Permits duty cycle to be varied between one per cent and 99 per cent limits.
CAL. VOLTAGE	Calibrated potentiometer across the **CAL VOLTAGE RANGE** step-attenuator output. Gives continuously variable voltage within the step range.
CAL. OUTPUT	Coaxial connector from arm of **CAL VOLTAGE** potentiometer. Provides the same voltage as is applied to vertical amplifier input.
PROBE POWER	Connector to provide plate and filament power for a cathode-follower probe.

CRT Controls

SCALE ILLUMINATION	Potentiometer in the graticule light circuit to vary brightness of scale illumination.
FOCUS	Potentiometer varying the voltage of the focusing anode of the cathode-ray tube.
INTENSITY	Potentiometer adjusting the control-grid bias on cathode-ray tube to adjust spot intensity.
ASTIGMATISM	Potentiometer adjusting the grid bias of a cathode-follower voltage regulator supplying astigmatism-grid voltage on cathode-ray tube.
VERTICAL POSITION	Potentiometer setting the grid voltage of one-half of the phase-inverter amplifier stage. Since the amplifier is dc coupled, variation of the dc level at this stage varies the average dc voltage between the vertical-deflection plates.

HORIZONTAL POSITION — Potentiometer setting bias of first sweep-amplifier V218A. Since sweep amplifier is dc coupled, change in dc level at this point affects average voltage between horizontal-deflection plates.

Time Marker

EXT MARKER (CRT CATH) — Front-panel connector connected through the **EXT** position of the time marker switch and through a .015-μf capacitor to the cathode-ray tube cathode.

Time Marker Switch — Six-position gang switch selects circuit constants for time-mark time intervals and connects marker to cathode-ray tube cathode circuit in five of the six switch positions. In sixth position switch turns off time-marker generator and connects cathode-ray tube cathode to external binding post.

PHASE — Control to delay the start of the markers up to 1.5 μsec.

AMPLITUDE — Variable resistor setting bias of clipper amplifier and thereby setting amplitude of marker pips.

Sweep Generator

+GATE — Front-panel binding post to cathode of gate-output amplifier. Peak voltage about 30 volts dc coupled to binding post.

−GATE — Front-panel binding post to plate of gate-output amplifier through 0.047-μf capacitor. Peak voltage about 30 volts.

MAG. POS. — Screwdriver front-panel control adjusts bias of phase-inverter sweep-amplifier stage to permit adjustment fo magnified-sweep position so that the magnified sweep centers at the center of the screen.

μSEC/CM MULTIPLIER — Ganged variable resistors in timing-capacitor charging circuit and multivibrator-timing circuit. Units dial controls ten-position gang switch increasing resistance by equal increments in both timing-capacitor circuit and multivibrator-timing circuit. Tenths dial controls dual variable resistors in series with step resistors. Dial is calibrated in conjunction with variable resistors. Sum of units-dial reading and tenths-dial reading gives sweep-time multiplying factor.

SWEEP DELAY — Three-turn potentiometer setting grid bias of voltage-comparator tube. Determines point on triggered sawtooth at which delayed trigger voltage is generated. Triggered sawtooth has maximum repetition rate of 30 per second. Permits triggering sweep on any line of television field.

SWEEP OUTPUT — Front-panel connector from cathode-follower amplifier provides a positive-going sawtooth voltage simultaneously with the sweep. Fixed peak voltage of about 40 volts, dc coupled to binding post.

FIELD SHIFT — Extends duration of one delay-timing sawtooth so that an extra vertical sync pulse is missed, and sawtooth thereafter synchronizes with alternate field.

EXTERNAL SWEEP INPUT — External front-panel connection to the sweep amplifier, dc coupled to amplifier through **EXT SWEEP ATTEN** potentiometer.

TIME — Seven-position ganged switch. Selects five sizes of timing capacitors in sweep circuit and corresponding five sizes of capacitors in multivibrator timing circuit. In remaining two positons, connects **EXTERNAL SWEEP INPUT** connector or internally-developed 60-cycle sine wave to sweep amplifier, and biases gating multivibrator off to unblank cathode-ray tube.

STABILITY (EXT. SWEEP ATTEN.) — Ganged dual potentiometer. Adjusts bias on gating multivibrator in region of bias for recurrent operation. Second potentiometer provides amplitude adjustment for external sweeps.

Trigger

AMPLITUDE (INT 60∿ SWEEP PHASE) — Potentiometer setting bias on trigger-amplifier tube to adjust gain and operating point. Ganged with variable resistor in 60-cycle phasing circuit which varies phase of sine-wave sweep when **SWEEP TIME** switch is in **INTERNAL 60∿ SWEEP** position.

SELECTOR — Ten-position switch selects various sources of trigger voltage and arranges trigger-amplifier output circuit to maintain positive trigger output for either polarity of input pulse. In the **UNDELAYED SWEEP** positions, output of the trigger-phase changer is applied to sweep circuit directly. In the **DELAYED SWEEP** positions marked in red on the panel, input triggers pass through a sync separator and are arranged to trigger a sawtooth generator which produces a second trigger delayed by an adjustable time after the first trigger.

EXTERNAL TRIGGER INPUT — Coaxial connector to **EXT** position of trigger **SELECTOR** switch.

POWER — Toggle switch in primary circuit of power transformer.

Preliminary Instructions

Cooling

The Type 524AD Oscilloscope is cooled by filtered, forced-air ventilation. The instrument must therefore be placed so the air intake is not blocked, and the filter must be clean enough to permit adequate air circulation. If the interior temperature does rise too high for some reason, a thermal cutout switch will disconnect the power and keep it disconnected until the temperature drops back to a safe value.

Keep the instrument dry. If is it exposed to excessive dampness, let it dry thoroughly before operating it.

Cathode-Ray Tube Controls

The Type 5ABP cathode-ray tube used in this instrument has a total deflection potential of about 4000 volts. With this amount of acceleration, the spot can be bright enough to damage the screen if it is left long in one place. Be careful to turn the **INTENSITY** control to the left so that the spot is dim whenever you leave the instrument unattended.

Individual **FOCUS, ASTIGMATISM,** and **INTENSITY** controls are available on the front panel. These controls are slightly interdependent, and may require readjustment for different **INTENSITY** control settings.

Illuminated Graticule

The adjustable graticule lighting control labeled **SCALE ILLUM.**, can be adjusted to suit the lighting conditions of the room. The colored filter supplied is colored to provide the maximum trace contrast for the P1 phosphor in the presence of room light.

The graticule is accurately scribed in centimeters, and the sweep times and vertical-deflection factors are given in units per centimeter. To find volts from the amplitude of deflection, therefore, multiply centimeters of deflection from the graticule reading by the volts per centimeter indicated by the vertical-amplifier dial settings. Similarly, to find time, multiply centimeters along the time axis of the graticule by the sweep time per centimeter indicated by the sweep-dial settings.

The graticule can be mounted in either of two positions, rotated 180 degrees from each other. In one position, the graticule illumination is colored red, and in the other position it is white. The red contrasts well with the green filter. The white is more satisfactory photographically.

First Time Operation

To place the Type 524AD in operation for the first time, the following procedure is suggested:

1. Connect to a source of 50-60 cycle, 105-125 v power (or 210-250 v if T401 primary connections have been changed according to the directions shown in the Adjustment Section of this manual).

2. Set controls as indicated below.

INPUT SELECTOR	CAL., AC
VOLTS/CM	15-50
VARIABLE ATTEN.	Clockwise
CAL. VOLTAGE RANGE	50
CAL. DUTY CYCLE	Mid range
CAL. VOLTAGE	0
SELECTOR	+SIG, UNDELAYED SWEEP
AMPLITUDE	Counterclockwise
STABILITY	Counterclockwise
TIME	100 μsec/cm
TIME MULTIPLIER	5.0
MAGNIFIER	OFF
TIME MARKER	EXT

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

4. Set **INTENSITY** control at about ½ clockwise rotation.

5. Adjust **VERTICAL POSITION, HORIZONTAL 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 until the sweep just disappears.

7. Set the **CAL. VOLTAGE** control to 5 (50 v).

8. Advance the trigger **AMPLITUDE** control to obtain a stable trace of a square wave (about 3⅓ cm vertical deflection).

The oscilloscope is now displaying the square-wave calibrating voltage. To observe other waveforms, connect to either **INPUT 1** or **INPUT 2** and set the **INPUT SELECTOR** accordingly. Adjust the **VOLTS/CM** and **VARIABLE ATTEN** for the desired amount of vertical deflection, and then select the appropriate sweep time by means of the sweep **TIME** and **µSEC/CM MULTIPLIER** controls.

Sweep Operation

General

The sweep circuit of the Type 524AD is very flexible and is capable of synchronizing at high frequencies. Fundamental frequencies as high as 10 mc can be observed easily. By adjusting the sweep **STABILITY** control, the sweep can be made to run recurrently or triggered as desired.

Adjustment of Sweep Stability

The sweep **STABILITY** control varies the multivibrator bias and therefore determines whether the sweep will operate recurrently or wait for a trigger impulse. Correct functioning for triggered operation is therefore obtained when the **STABILITY** control is set just under the point where oscillation takes place. The procedure is to remove the trigger source by turning the trigger **AMPLITUDE** control counterclockwise, advance the **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 signals at fundamental frequencies of about 2 mc or higher, it will be necessary to advance the **STABILITY** control somewhat above the normal operating point to secure a stable pattern.
>
> The **µSEC/CM MULTIPLIER** dials also may have some effect upon the critical bias for triggered operation of the multivibrator. The **STABILITY** control may need to be readjusted when the **MULTIPLIER** dials are changed.

Function of Trigger Selector

This control selects the trigger impulses to be used from three sources: the line frequency (60∿), the vertical amplifier (**+SIG.** or **—SIG.**) and the **EXTERNAL TRIGGER INPUT** coax connector. The trigger **SELECTOR** switch is divided into two sectors of rotation. One sector, marked in black, provides positions for all types of trigger signals without the delayed-trigger circuit. The other sector provides the same positions as the first sector, but includes the delayed trigger circuits. When using those marked (+), the sweep starts during the rising portion of the trigger impluse. When using the positions marked (—), the sweeps start during the falling protion. For satisfactory operation in the **EXT** positions, trigger amplitudes between .5 volts and 15 volts peak should be provided. Larger trigger voltages should be attenuated externally.

Adjustment of Trigger Amplitude

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

In general, it is desirable to use the minimum **AMPLITUDE** setting required to insure a stable trace.

If poor synchronizing is experienced when the Type 524AD is used to observe repetitive signals containing erratic peak voltages, such as are 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 should be made to the **EXTERNAL TRIGGER INPUT** connector.

Adjustment of Sweep Time

The combination of sweep **TIME** and **µSEC/CM 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 .1 sec to 1 microsec. The approximate number of microseconds for a horizontal deflection of 1 cm can be determined easily by multiplying the **TIME** setting by the sum of the **MULTIPLIER** dial readings. Multiply this figure by ten to determine the time required to sweep the entire 10-cm portion of the graticule which is calibrated in centimeters.

The **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-to-1 **TIME** range, accurate indication and precise resetting are 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 five per cent of the indicated time at any setting of the controls. Compensation for variations caused by different tubes, etc., can be made by means of screwdriver adjustments inside the case. Procedure for these adjustments will be found in the Maintenance section.

Recurrent Sweep

In case it is desirable to have a sweep without using any sort of trigger, retard the trigger **AMPLITUDE** control and advance the sweep **STABILITY** control until a stable repetitive sweep is obtained.

Single Sweep

The triggered sweep circuit used in the Type 524AD inherently 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 **EXTERNAL TRIGGER INPUT** connector and ground, with the trigger **SELECTOR** switch at **—EXT.** If multiple sweeps occur because of intermittent or bouncing contact, a capacitor of .1 μf to 1 μf should be connected across the contact. This capacitor will charge toward about 10 volts through 1 megohm and the long time constant will prevent an immediate recurrence of the sweep. Use minimum dependable trigger **AMPLITUDE** setting.

Sweep Delay

The **SWEEP DELAY** control will produce triggers no faster than 30 times per second. This control adjusts the amount of delay between receipt of the trigger and the start of the sweep. The delay circuit operates only when the trigger **SELECTOR** switch is in the **DELAYED SWEEP** sector. The panel markings give an approximate indication of the delay.

When a composite television signal enters the sweep-delay circuitry a sync separator extracts the 60-cycle field-sync pulse. The sweep delay, operating 30 times per second, accepts every other vertical-sync pulse and starts the sweep from zero milliseconds to 25 milliseconds after the accepted sync pulse. This amount of delay allows the sweep to display any of the lines in one field.

Field Shift

When the **FIELD SHIFT** button is depressed, the other 60-cycle vertical-sync pulse is accepted by the sweep delay circuitry, allowing display of the other interlaced field.

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 a fairly long pulse. In the 524AD, the sweep magnifier makes it possible to expand any desired 33.3 per cent or 10 per cent of the sweep to cover the entire tube face. The operating procedure is as follows: Turn the sweep **MAGNIFIER** to **OFF**. Adjust the sweep-time and horizontal-positioning controls so that the portion of the wave to be magnified is at the center of the tube. Then move the **MAGNIFIER** control to either **3X** or **10X** and the portion of the wave in the center of the tube will be magnified linearly in both directions. The accuracy of sweep magnification will be within five per cent for sweep speeds to **1.0 μSEC/CM.** The accuracy will decrease for sweep speeds in excess of this amount.

If the portion of the wave to be magnified moves from the center of the screen when the **MAGNIFIER** is turned to one of the two positions for magnification, the **MAG. POS.** adjustment should be reset. (See Maintenance section.)

> **NOTE:** A sweep of 10 cm per microsecond is about the limit of the sweep amplifier. Some non-linearity will result if the sweep exceeds this value.

External Sweep Input

In the full-counterclockwise position of the sweep **TIME** switch a binding post labeled **EXT SWEEP INPUT** is connected to the sweep-amplifier input. This connection can be used, for example, for a sine-wave oscillator for frequency-comparison measurements, for an auxiliary slow-sweep generator, etc. The connection to the sweep amplifier is made through a potentimeter ganged with the sweep **STABILITY** control, for adjustment of the amplitude of the external sweep. The magnifier circuits and the horizontal-positioning control operate on sweep voltages applied at this connector. At maximum sensitivity with the **MAGNIFIER** at **10X** and the **SWEEP ATTEN.** control full clockwise, the deflection factor is about .25 volts per centimeter, peak to peak.

INT 60∿ SWEEP

This circuit is provided in the second most counterclockwise position of the sweep **TIME** switch. The principal use of this circuit is to facilitate the determination of bandpass characteristics of filters, amplifiers, etc., in conjunction with swept-frequency signal generators which can be swept at a 60-cycle rate. A 60-cycle sine-wave sweep is provided whose phase can be varied over a 150-degree range by means of a ganged control on the trigger **AMPLITUDE** control knob, and whose amplitude can be varied by means of the ganged control on the sweep **STABILITY** control knob. The signal is applied to the sweep amplifier so that the magnifier and positioning circuits function in the conventional manner.

Vertical Amplifier

The risetime of the Type 524AD is designed so that at the fastest sweep time of one-tenth microsecond per centimeter at the fastest risetime that the vertical amplifier is capable of, the rise will take place in a little less than half a centimeter of horizontal distance, and the trace of a sine wave near the upper-frequency limit at 10 megacycles will appear as one cycle per centimeter of horizontal distance.

The use of dc coupling in the vertical amplifier makes it possible to display both the dc and ac components of a signal simultaneously. The ability to include the dc component makes it possible to observe, for example, when zero bias or grid cutoff occurs, or how close to the cathode voltage the plate voltage of a tube can drop, and such similar characteristics.

VARIABLE ATTEN BAL, FRONT-PANEL CONTROL

After a warm-up period of several minutes, it should be possible to rotate the **VARIABLE ATTEN.** control back and forth to different positions without a change in the vertical position of the no-signal trace. If such a change should occur, the **VARIABLE ATTEN. BAL.** control should be readjusted while the **VARIABLE ATTEN.** control is being rotated back and forth until no such change in vertical position occurs.

SIGNAL DELAY

The sweep circuit requires approximately a tenth microsecond of time to get underway and to get the crt beam unblanked after receipt of a trigger signal. A total signal delay of 0.34 microsecond occurs in the vertical amplifier, including a quarter-microsecond delay in a signal delay line. When the triggering waveform has a very sharp rise, therefore, approximately a quarter-microsecond of sweep shows on the screen before the waveform appears. However, when the triggering waveform begins with a slower rise, an appreciable portion of the wave may pass before an adequate trigger voltage can develop. In practice it has been found that the additional quarter-microsecond of delay provided is about the optimum to permit the display of the start of a slower-rising waveform.

CONNECTION TO DEFLECTION PLATES

Banana jacks are provided to permit connections to be made directly to the deflection plates with low stray capacitances. These jacks are located at the left rear, accessible through an opening in the back of the case. The terminal marked Y2 is the top plate and the terminal marked X2 is the right-hand plate. Deflection factors are approximately 25 volts per cm dc at the horizontal-plate jacks, and 15 volts per cm at the vertical-plate jacks.

A switch on the access panel makes connections to the vertical-deflection plates in four ways labeled **IRE, NORMAL, FLAT** and **EXT.**: **IRE** for bandwidth reduced to comply with **IRE** minimum standards, **NORMAL** for a normal 10-mc response with optimum transient response, **FLAT** for high-frequency compensation to 5 mc, flat within one per cent, but with some overshoot, and **EXT.** for external connection to the deflection plates by means of connectors on the access panel. In the **EXT.** position, the external signal is applied to the deflection plates through blocking capacitors with one-megohm resistors to the vertical amplifier. The one-megohm resistors retain the function of the vertical position control.

If direct connection to the horizontal plates is desired, it is important to maintain the correct average potential to prevent defocusing of the beam. The average potential of the vertical-deflection plates (measured from the chassis) is approximately 160 volts and this same value should be maintained on the horizontal plates when they are dc coupled. When dc coupling to the horizontal plates is not necessary, external connection may be accomplished by replacing the jumper plugs with 1-megohm resistors and inserting blocking capacitors in series with the horizontal-signal source. The **HORIZONTAL POSITION** control will then function for positioning the external signal. The **TIME** switch should be turned to **EXT SWEEP**, to prevent internal-sweep signals from coupling through the 1-megohm resistors. When balanced input is not desired, the unused deflection plate should be bypassed to ground.

Miscellaneous

Sweep Output

The **SWEEP OUTPUT** binding post makes available the sawtooth waveshape appearing at the plate of the sweep-generator tube. A cathode follower isolates the sweep generator from the effects of the external loads connected to the binding post. The sawtooth amplitude is approximately 30 volts, peak to peak.

Gate Output

A thirty-volt peak-to-peak squarewave of either polarity is available at the binding posts marked **+GATE** and **—GATE**. The **—GATE** signal is taken from the plate of the gate-output amplifier through a 0.05-μf capacitor to remove the dc component. The **+GATE** signal is dc coupled from the cathode of the gate-output amplifier and provides a good flat-topped squarewave at the slowest sweep speeds.

Time Markers

Time markers are inserted as beam intensification pips on the cathode-ray tube at intervals of 1 μsec, 0.1 μsec, and 0.05 μsec, or pips spaced 40 or 200 per television line. The marker **PHASE** control delays the start of the markers up to 1.5 microseconds, allowing the markers to be phased along the sweep. The **AMPLITUDE** control varies the brightness of the marker pip. This should be kept as low as possible for minimum sweep distortion and trace defocusing. In the **EXT.** position of the marker switch, the crt cathode is capacitively coupled to the front-panel binding post labeled **EXT. MARKER.**

The first marker pip may be slightly out of position, but all subsequent pips will be well within the 2-per-cent timing accuracy.

Special Television Instructions

IRE Response

The full bandwidth of the Type 524AD will generally be desired for all engineering measurements or maintenance of television circuits or equipment. However, for monitoring the signal level of an existing facility it has been found that restricted high-frequency response is desirable, with bandwidth as low as is consistent with satisfactory readings of signal levels.

The **IRE**-response position of the VERTICAL AMPLIFIER switch on the crt access panel has been provided to limit the high-frequency response for signal-level measurements, as recommended by the IRE Standards Committee.

The **FLAT**-response position of the switch provides flat-frequency response to 5 mc, within 1 per cent, but with attendant overshoot for fast pulses.

Sweep Delay

The 524AD sweep-delay system contains a sync-separator circuit which adapts the system particularly to television signals but limits its usefulness for other applications. Jitter-free sweep delay is obtained with television signals by establishing a coarse time delay from a vertical-sync pulse and then actually triggering the sweep from a selected horizontal-sync pulse. Thus, by operating the **FIELD SHIFT** button in conjunction with the **SWEEP DELAY** control and selecting the appropriate sweep speed, any particular horizontal-sync pulse, line, or lines can be observed.

Hood

When using sweep delay the sweep is triggered 30 times per second. With a sweep speed of 0.1 microsecond per centimeter (1 microsecond for 10 cm) the beam is on the screen only 30 microseconds of each second or 0.00003 of the time. The resulting display is correspondingly dim and should be viewed through the viewing hood when the ambient light is objectionably bright.

Time Marker

Time markers are useful for accurately measuring and adjusting the timing of the horizontal sync and blanking pulses generated in the sync generator. They are normally not required for adjusting the vertical pulse group.

Individual horizontal-sync pulses may be observed with sweep delay and with the viewing hood, the best technique being to start the sweep on a selected sync pulse and to choose a sweep length which allows the next pulse to be inspected with time markers and sweep magnification.

A much brighter picture will be obtained if the sweep is triggered directly by the horizontal sync pulses without sweep delay. Trigger from **+SIG** or **—SIG** and advance the trigger **AMPLITUDE** control until a stable, clear display is obtained. Sweep speed should be about 6 to 10 microsec/cm. This display requires much lower marker amplitude than for the first method, giving better marker accuracy. A high marker amplitude may change the crt cathode potential sufficiently to affect the horizontal- and vertical-deflection sensitivities during the time of each marker pip, thus displacing the pips from their proper positions on the screen.

The .005H time marker will be found very useful in adjusting and measuring horizontal-sync pulse timing, since the F.C.C. standards give time measurements in terms of H. H is the time between horizontal sync pulses, approximately 63.5 microseconds. The .005 H marker is set to 3.15 megacycles, 200 times 15.75 kc, thus producing markers each .5 per cent of H. Similarly the 0.025 H marker is set to 630 kilocycles.

Radio-Frequency Interference

In some transmitter locations rf interference to the video trace may be experienced from rf pickup into the station video equipment itself or directly into the oscilloscope input. This type of difficulty can be reduced by use of completely shielded connections, short signal leads, and husky, short ground straps. When using the probe, be sure at all times to maintain the shortest possible ground connection directly to the probe body.

Probe Adjustment

Proper operation of the sweep delay depends somewhat upon correct adjustment of the probe and vertical-amplifier attenuators. Adjustment of the probe can be checked by observing the calibrator **VOLTS/CM** waveform through the probe with the switch at 0.15 volts/cm to 0.5 volts/cm. Further instructions for tuning the attenuators are contained in the Maintenance section.

Line Indicating Video

In the event it is found necessary to observe a particular horizontal line or other detail with the 524AD Oscilloscope, a spare picture monitor may be connected to the LINE-INDICATING VIDEO output jack at the rear of the cabinet to determine that the oscilloscope is displaying the desired portion of the picture. The picture appearing on the monitor will be brightened during the time of the 524AD sweep gate. The bandwidth of the line-indicating video circuit is somewhat restricted but is adequate for this purpose.

The line-indicating video technique can be used to determine the range and resolution of a television system which is transmitting a monoscope test-chart signal. Grey-scale information from the test chart will be displayed by the 524AD as signal-voltage level, while the line-indicating video system depicts the portion of the test chart being scanned. Test-chart bandwidth wedges provide squarewave test signals whose frequency is determined by the portion of the wedges being scanned.

CIRCUIT DESCRIPTION

Sweep Block Diagram Description

The trigger **SELECTOR** switch selects the source and polarity of input trigger voltage and determines whether delayed triggering is provided.

The trigger phase inverter provides the required positive input to the trigger amplifier or the sync separator for either polarity of input trigger voltage.

The sync separator extracts the synchronizing pulses from the television composite signal.

The sweep-delay circuit provides a means of delaying the initiation of a sweep by an adjustable amount of time after receipt of the vertical sync pulse.

The **FIELD SHIFT** switch changes synchronization of the sweep to either field of a television frame.

The trigger amplifier raises the level of the trigger signal for triggering the multivibrator.

The multivibrator provides a basic square-wave signal used in several circuits: The clamp-tube sweep generator, unblanking, external gate, time-marker circuit, and the video monitor line indicator.

The clamp and dc restorer provide a linear sawtooth voltage of constant dc starting level which is applied through a cathode follower to the sweep amplifier. The sweep sawtooth voltage is also available at a front-panel connector through a cathode-follower impedance converter.

The unblanking circuit applies a positive square wave to the cathode-ray tube to turn on the beam during the period of the sweep.

The floating power supply is added in series with the output of the unblanking amplifier to provide the unblanking pulse at high-voltage negative bias to the cathode-ray tube control grid.

The external-gate circuit provides both positive and negative square-wave pulses at front-panel connectors which are synchronized with the sweep.

The magnifier circuit includes the horizontal-positioning control. A switch selects a multiplication of the sweep speed by a factor of ten, three, or one. The trace is magnified both to right and to left of screen center.

The sweep output amplifier provides phase inversion and amplified push-pull sawtooth sweep voltage at the horizontal-deflection plates, D1 and D2, of the cathode-ray tube.

Vertical Amplifier Block Diagram

The **INPUT SELECTOR** switch connects the vertical-amplifier system to either of two front-panel connectors or to an internal calibrator circuit.

A vertical-deflection-sensitivity switch selects a preamplifier for the two most sensitive positions and selects various attenuators for the positions of less sensitivity.

The preamplifier provides a gain of ten times for the two most sensitive positions of the **VOLTS/CM** switch. In the second position the overall gain is reduced by means of an input attenuator.

A cathode follower reduces the effects of changing input capacitance with gain in the variable-gain cathode-coupled amplifier.

Gain of this amplifier is adjusted by switching cathode-coupling resistors. Plate output from the grounded-grid half feeds vertical signal through the delay network. Plate output from the input half supplies vertical signal to the triggering circuit through the trigger-selector switch.

The **VARIABLE ATTEN. BAL.** control adjusts the cathode-follower grid voltage which sets the dc level of the cathode-coupled stages so that adjustment of the **VARIABLE ATTEN.** control will not affect the vertical position of the trace.

The delay network provides a signal delay of ¼ microsecond which is long enough to permit the sweep to be triggered by the observed signal and well under way before the signal itself is applied to the deflection plates.

Single-ended output from the delay network is converted to balanced push-pull output by a cathode-coupled phase-inverter stage, which also includes the vertical-positioning control.

The current regulator provides an adjustment for the operating point of the push-pull amplifier.

Cathode-follower drivers drive the push-pull distributed-amplifier output stage which in turn drives the vertical deflection plates.

The IRE-NORMAL-FLAT-EXT switch located on the access panel on the left rear panel provides four circuit connections for the vertical deflection plates of the cathode-ray tube: 1 — for normal, 10-mc bandwidth, 2 — for bandwidth reduced to comply with the IRE minimum standards, 3 — for high-frequency compensation to 5 mc, but with slight overshoot, and 4 — for external connection to the deflection plates by means of connectors located on the access panel.

Auxiliary Circuit Block Diagram

The time-mark generator provides accurately spaced time markers by intensity modulating the cathode-ray beam with shaped pulses from inductance-capacitance oscillators.

The calibrator oscillator produces square waves of adjustable duty cycle with peak-to-peak amplitude set by calibrated controls.

The line-indicating video circuit provides a video signal output on which is superimposed a positive gate synchronized with the oscilloscope sweep, to apply to the television video monitor for the purpose of indicating, by a bright line on the monitor raster, the line of the composite video signal being displayed on the Type 524AD Oscilloscope.

The internal 60-cycle phased-sweep circuit provides a 6.3-volt 60-cycle ac voltage adjustable approximately 150 degrees in phase.

Detailed Circuit Description

Trigger Selector

The trigger-selector switch, SW201 is a three-section, ten-position front-panel control. This control selects the source of trigger signal, arranges the circuits to accommodate either negative or positive trigger signals, and includes or removes a delayed-trigger circuit. The switch is divided into two sectors of rotation. One sector provides positions for all the types of trigger signals without the delay-trigger circuit. The other sector provides the same positions as the first sector but includes the delayed-trigger circuits.

In the undelayed-trigger sector positions, marked in black on the front panel, either the in-phase or inverted output of the trigger-inverter stage feeds directly to the trigger amplifier.

In the **DELAYED SWEEP** sector positions, marked in red on the front panel, either the in-phase or inverted output of the trigger-inverter stage is applied through the trigger-delay circuits to the trigger amplifier.

Trigger Circuits

V201A is the trigger-inverter amplifier. A positive trigger signal is obtained regardless of trigger input polarity by selecting either inverted signal from the plate or in-phase signal from the cathode of V201A.

Internal 60-cycle triggering is provided in both delayed and undelayed positions of the **SELECTOR** switch. In the undelayed position, 6.3-volt, 60-cycle ac is applied to the grid of the trigger-inverter tube V201A, and cathode output is applied directly to trigger amplifier V207 on the sweep chassis. In the delayed position the 60-cycle voltage taken from the cathode of V201A is applied to the television sync-separator circuits to trigger the phantastron, V204. The sync-separator circuits will also accept a 60-cycle signal. V202 is over-driven so that a flat-topped waveform is applied through V203B, V203A, and C210 to the grid of V204. The negative square wave at the grid of V204 triggers the phantastron rundown action. In the quiescent state the grid of V205B is held above the grid of V205A, so that the B section conducts while the A section is cut off. When the plate of V204 starts its phantastron rundown action, it carries the grid of V205B with it. When the grid of the B section of V205 has dropped down near the grid voltage of the A section, current transfers from the B to the A section and a positive step is generated at the B-section plate. The voltage of the A-section grid is determined by R230, labeled **SWEEP DELAY** on the front panel, which can be adjusted to cause current transfer at any point on the sawtooth. Internal 60-cycle triggering is not sufficiently stable to use for observing a line of a television composite video signal. For observing a single line of a television signal, triggering should be accomplished by means of the sync pulses of the composite video signal.

Sync Separator

The sync-separator circuits separate the sync portion of the composite video signal for the purpose of triggering the sweep delay. Diode-connected V201B establishes a bias level at the grid of V202B through R212 such that the sync pulses of the composite video signal are kept well within the amplifying region of V202 regardless of the signal amplitude. V202 is a pulse amplifier whose in-phase output is applied to the grid of the sync-separator tube V203B. The grid of V203B is returned to +120 volts through R215 and limited by grid current to a voltage near cathode, which is at ground potential. The positive peaks of the pulses are effectively clamped to ground potential. The video portion of the composite signal is therefore below cutoff of V203B because the sync pulses have an amplitude of several volts at this point.

Between pulses the plate of V203B rests at +120 volts. During the period that a sync pulse is present at V203B grid, the plate drops several volts. The vertical sync pulses are transmitted through R217, V203A and C210 to the grid of V204, the phantastron, while the horizontal pulses are not transmitted through R217 to the cathode of V203A because of C208, but are differentiated by C209 and R218, and applied to the grid of V205B. The vertical pulses arriving at the phantastron grid are formed into a negative-going waveform of several volts to trigger the rundown action.

Phantastron Sawtooth Generator

In the quiescent state just before the operation of the phantastron, the control grid of the phantastron is held at approximately ground potential by grid current flowing in R220 and R221 which connect to +120 volts, and the suppressor is held below plate-current cutoff by screen current flowing in voltage divider, R223, R222, R224, which is connected between +225 and —150 volts. When the negative pulse through V203A arrives at the grid of V204, the grid is driven toward screen-current cutoff.

As the grid approaches screen-current cutoff, screen current is rapidly reduced and the screen rises, carrying the suppressor with it through C211 to a voltage high enough to allow plate current to flow. When plate current begins to flow, the plate begins to drop from its zero-plate-current voltage of +120 volts and the phantastron rundown action commences.

The grid of V204 is connected to a positive voltage source through R220 and R221 which total several megohms, so that in the quiescent state before the phantastron is tripped, current flowing in these resistors prevents the grid voltage from rising more than a fraction of a volt positive. One end of timing capacitor C210 is connected to the plate of V204 which with no plate current flowing, rests at approximately +115 volts. The timing capacitor C210, is therefore initially charged to about 115 volts.

When the rundown is initiated and plate current begins to flow, the plate voltage drops momentarily, a few volts, carrying the grid down with it the same amount through C210, which is still charged to 115 volts. C210 begins to discharge into +120 volts through R220 and R221. The discharge current through R220 and R221 determines the voltage of the grid of V204, which in turn determines the plate voltage, because during the rundown phase of operation the phantastron tube acts as a class A linear amplifier in which the plate voltage varies inversely but linearily with grid voltage. A given grid voltage therefore exactly determines a corresponding plate voltage.

The charge voltage remaining on C210 must always be slightly larger than the plate voltage because the grid end must be slightly below ground but above plate-current cutoff, to remain within the linear region. If, for example, the voltage across C210 were momentarily to become too small, the grid voltage would rise and the plate voltage would therefore drop, thus restoring the grid end to its proper potential so as to maintain the discharge current constant.

Since the voltage drop from the discharge current from C210, flowing through R220 and R221, determines the grid voltage of the phantastron, a change in voltage drop across these resistors, resulting from a change in discharge current from C210, will therefore cause a change in grid voltage in the correct direction to oppose the change in voltage drop. For example, if C210 were simply to discharge through a resistor, the discharge current would fall off exponentially with time. The falling off of discharge current would result in a decreasing drop in R220 and R221 and cause the grid of V204 to rise. V204 plate would then fall, dropping the control-grid end of C210 the requisite amount to increase the discharge current and thus tend to maintain it at a constant value. With a constant discharge current flowing from C210 the voltage across this capacitor will fall off linearly, and since the righthand end of this capacitor remains near ground voltage, the plate of V204 also falls linearly.

When C210 is nearly discharged and the plate V204 nears cathode potential, the cathode current, which has been flowing largely through the plate, suddenly transfers to the screen, the screen voltage drops, carrying the suppressor with it, and thereby completely cuts off plate current from V204.

When plate current is cut off the plate immediately returns toward +120 volts as fast as C210 can charge, carrying the grid with it through C210, until grid current through R220 and R221 prevents it from going farther positive, and the original quiescent state is resumed with the phantastron ready to accept another negative triggering voltage.

V205 is the comparator tube which generates a trigger pulse when the sawtooth reaches a prescribed percentage of its final value. During the quiescent state of phantastron V204, the grid of comparator tube V205B is held at approximately 115 volts through resistor R218, and the cathode of the comparator tube rests at a point just above the grid. The grid of the second half of the comparator, V205A, is set at a bias determined by the setting of R230, labeled **SWEEP DELAY** on the front panel, at any point between ground and +120 volts.

When the phantastron rundown action begins, the sawtooth voltage of the phantastron plate carries the grid of V205B down. V205B cathode closely follows the grid as it drops until it approaches the grid voltage of the A section, at which time cathode current transfers from the B section to the A section.

The differentiated horizontal sync pulses arriving at the B-section grid of V205 through C209 are of greater amplitude than the drop in sawtooth voltage resulting from the phantastron rundown action during the time between horizontal sync pulses. The time of transfer of cathode current from the B section to the A section of the comparator tube is therefore always coincident with a horizontal sync pulse, and a single line of the video picture can thus be displayed without jitter.

Field Shift

The rundown time of the phantastron trigger-delay circuit is made approximately half again as long as the time between vertical sync pulses so that the maximum frequency of operation is somewhat less than the 60-cycle repetition rate of the pulses. This arrangement assures that the sweep will be triggered only by alternate vertical sync pulses, and one of the interlaced fields can therefore be observed repetitively to the exclusion of the other interlaced field. When the composite video signal is first applied to the trigger circuit the delayed trigger will synchronize with one of the fields and stay synchronized with this same field unless the rundown time is momentarily changed. The **FIELD SHIFT** circuit performs this change by extending the time of one rundown by approximately the interval between vertical sync pulses. A momentary pushbutton switch, normally closed, is labeled **FIELD SHIFT** on the front panel. In the closed position of this switch, the junction between R225 and C212 is grounded and C212 is therefore charged to about 110 volts. When the switch is opened, the negative end of C212 is connected to +225 volts through R225, which reverses the direction of charge and leaves it charged to about 100 volts in the opposite direction. Then, when the button is released, the junction of R225 and C212 is grounded again and the current through R220 is reversed so that the grid of the phantastron is momentarily depressed to the extent that the plate voltage actually rises for a short period before continuing its rundown. As the reverse voltage of C212 decreases, the phantastron grid rises and when equilibrium is reestablished with C212 again charged to 110 volts as before, the rundown action of the phantastron resumes. The time of delay caused by the temporary runup is approximately equal to the time between vertical sync pulses, so that two pulses are skipped instead of one, and the rundown is thereafter synchronized with the alternate interlaced fields.

Sweep Circuit

Trigger output from the trigger delay circuits or from the undelayed circuits is applied to trigger amplifier V207 by means of the C section of the trigger **SELECTOR** switch SW201. The bias of V207 is adjustable by means of the front-panel control, R242, labeled trigger **AMPLITUDE,** a part of a voltage divider with R243, connected between —150 volts and ground. Negative plate output of V207 is coupled through disconnect diode V208 and multivibrator coupling capacitor C221 through C225 to the grid of positive-going multivibrator V210. In the quiescent state, V210 is conducting and its plate is down. When the negative pulse from V208 arrives at V210 grid, plate current is cut off and V210 plate rises toward +225 volts carrying the grid of negative-going multivibrator V209 up. V209 plate then drops, carrying the grid of V210 down still farther. Diode V208 disconnects the trigger circuit from the plate of V209 as soon as this plate drops below the plate of trigger amplifier V207. The grid of V210 is returned to +225 volts through R251 and through **μSEC/CM MULTIPLIER** resistor R290 and R291, and starts immediately to go positive but is controlled in its rise by the charging rate of the sweep **TIME** capacitor. (C225 in the diagram as drawn.) When this capacitor has charged so that the grid of V210 just gets into the region of plate-current conduction, V210 plate drops and the resulting negative step is coupled to the grid of V209 through C226 which causes the plate to rise, and, through C225, further raises V210 grid, and the original stable quiescent state is rapidly resumed with V210 conducting. The length of the period of cutoff depends on the size of the capacitor selected by SW202A and B, and the size of R290 and R291.

During the period of conduction of V209, the negative-going multivibrator, the grid voltage of V213 is held below plate-current cutoff. V213 is the sweep-clamp tube whose grid is normally held at about ground potential by voltage divider R264, R263, R240 and R241 connected between —150 volts and +225 volts. With this grid near ground, the tube conducts heavily so that the plate is held near ground. When the negative gate from V209 depresses the grid of V213 below plate-current cutoff, the plate is free to rise toward +450 volts at a rate determined by the charging rate of the timing capacitor, C231 to C235, charging toward +450 volts through R292 and R293 and R294. The negative gate to the grid of V213 is chosen to be appreciably longer than the time required for the beam to sweep across the cathode-ray tube screen, but short compared to the time constant of the timing capacitor and resistor, so that the final voltage to which the timing capacitor charges is only about ten per cent of the +450 volts, and the portion of the charge curve during which the beam is on the screen is only five per cent of this voltage. The first six to ten per cent of the charge curve of a capacitor is very nearly linear.

At the termination of the negative gate at the grid of clamp tube V213, the grid returns positive, clamp-tube plate current again flows and brings the plate down near ground potential, at the same time charging the timing capacitor, and the sweep circuit is restored to its original quiescent state ready for another trigger voltage to arrive at the multivibrator.

The sweep **STABILITY** control adjusts the bias of the normally-cutoff negative-going multivibrator, V209. If the bias is set near enough to ground potential, plate current will commence to flow, tripping the multivibrator and initiating a sweep. When the multivibrator resets at the termination of one sweep it will immediately retrip and the circuit will free run. A bias level just below the free-run level is normally used when it is desired to trigger the sweep from the trigger-amplifier signal.

The sawtooth voltage from the clamp-tube sweep generator is capacitively coupled to the grid of cathode follower V215B, whose cathode is returned to —150 volts. V214 is a clamp which sets the grid of V215B at ground potential before each sweep. Output from the cathode of cathode follower V215B supplies sawtooth voltage to the sweep output and magnifier section, and to V215A, a second cathode follower which provides a sawtooth voltage to a front-panel connector labeled **SWEEP OUTPUT**.

The unblanking waveform is gated by the multivibrator. The grid of V212A is connected to the grid of positive-going multivibrator V210 so that it is driven negative below plate-current cutoff during the same period that V210 is cut off. The rise time of the plate of V212A is speeded by L202. Cathode follower V212B removes the loading effects on V212A of the remainder of the unblanking circuit.

External gate signals of both polarities are available at the front panel through connectors labeled **+GATE** and **—GATE**. Both are derived from V211B whose grid is coupled to the plate of positive-going multivibrator V210. Between sweeps the grid of V211B is held below cutoff by means of voltage divider R254, R255 connected between the plate of V210 and —150 volts. C229 speeds the rise time of the grid of V211B. The **+GATE** pulse output has a peak value in the vicinity of 30 volts and a rise time of about 0.2 microseconds. The output impedance is approximately 300 ohms coupled from the cathode. The negative pulse from the plate of V211B is capacitively coupled to the **—GATE** at an impedance level of about 10,000 ohms. The wave shape of this output is therefore more susceptible to external circuit effects.

V211A is a cathode-follower voltage regulator whose grid voltage is set by means of R268, a voltage divider labeled **ASTIGMATISM** on the front panel, connected between +450 volts and —150 volts, used to set the voltage of pin 9, the second anode of the cathode-ray tube, for astigmatism control.

Magnifier and Sweep Output Amplifier

V218A is an amplifier. Its output is applied to the grid of V221 through cathode follower V219B. Feedback between the grid circuit of V221 and the grid of V218A is provided through V217 by way of frequency-compensated resistor networks, R310 A to C. The amount of feedback is determined by the voltage division of the feedback-loop voltage divider, R301, R310. SW301, labeled **MAGNIFIER**, selects the series arm of the voltage divider, R310, so that voltage division in the ratio 1, 3, or 10 is accomplished to produce net gain at the grid of V221 in these ratios. With the switch in either the 3X or 10X magnified positions, the grid of V218A is driven to grid current in the positive direction. V217 eliminates the effects of this grid current from the feedback system. V217B is a cathode follower whose cathode is connected to the cathode of diode-connected V217A. The anode of this diode is connected to the grid of V218A and to +225 volts through R305. By this arrangement, the plate of the diode closely follows the cathode, which follows the grid of V217B, until grid current starts to flow in V218A. When this occurs, grid current through R305 holds the diode plate at this voltage level while the cathode is free to rise past.

Horizontal positioning is provided by adjustable R303, a three-turn helical potentiometer, which determines the negative voltage return point of the grid circuit of V217 and V221. C304 on the lower end of R303 bypasses voltages induced in the long lead from the front-panel control to the sweep chassis.

V218B is a cathode-follower voltage regulator supplying the screen of V218A.

Push-pull output is obtained by means of common-cathode coupling between V221 and V220. Plate output is applied to the cathode-ray-tube deflection plates through cathode followers V222A and V222B, and through two NE2 neon tubes in series. The neon tubes provide a dc drop of about 150 volts below the dc level of the cathode-follower cathodes to place the quiescent-state deflection-plate potential near +160 v. R352 and R357 limit current which might otherwise be excessive in the case of accidental grounding of the deflection plates. C307 and C308 provide high-requency bypassing for these resistors.

Screwdriver adjustable R325, labeled SWEEP AMP CURRENT ADJ on the chassis adjusts the size of the common-cathode resistor to set the quiescent-state current level.

Screwdriver adjustable R328, labeled **MAG. POS.** on the front panel, adjusts the grid of V220 about the level of the grid of V221 to provide horizontal positioning of the magnified sweep so that the magnified sweep will center at the same point as the unmagnified sweep.

A feedback loop between the plate and grid of V220, R335, R330, stabilizes the gain of the amplifier. R330 is a screwdriver adjustable resistor labeled L.F. SWEEP TIME ADJ. on the chassis, by means of which the amount of feedback can be adjusted to accommodate the horizontal sentitivity of the cathode-ray tube to the front-panel sweep-time calibrations. A screwdriver adjustable capacitor, C305A, labeled H.F. SWEEP TIME on the chassis, and paralleled by C305B, provides compensation for the grid-to-plate capacitance of V220.

R353 and R356, which present high impedance to the sweep-signal voltage while supplying operating current for the NE2 neon tubes, form the positive end of a voltage divider which provides adjustable focusing potential for the cathode-ray tube. The voltage at this junction is about —400 volts.

Time-Marker Generator

The time marks are generated by means of V602 in a Colpitts oscillator clrcuit with the screen used for the anode at +120 volts, and the plate used for electron-coupled output. Switched inductors and capacitors provide the five timing intervals. V625 is a dc-coupled multivibrator with the triode section conducting in the quiescent state. The positive-gate waveform causes the pentode grid to rise at a rate determined by the time constants in the grid circuit until the pentode section begins to conduct and the triode section is cut off. The **PHASE** control determines the voltage level at which this occurs and thus the time at which the markers begin. D630 is cut off in the quiescent state and does not begin to conduct until the plate of V625A has begun its fall. This helps to improve the gating waveform.

During the quiescent period, V601A remains conducting and the resulting low cathode impedance loads the grid circuit of V602, preventing oscillation. The negative gate drives V601A well below cutoff and cathode current ceases. Magnetic energy in the oscillator coil changes to oscillating energy, maintained by V602 and limited in amplitude by grid current in this tube. Only short-duration current pulses reach the plate. These pulses are peaked in L605 and applied to V601B as negative pips through C609. The grid of V601B is held positive between pulses limited by grid current through R607, so that positive pulses appear at V601B plate. These in turn are shaped by L606 and applied to the grid of V603 where they are again amplified and shaped. The gain of V603 is adjustable by means of variable resistor R610, labeled **AMPLITUDE** on the front panel. Marker pips are applied to the cathode-ray tube cathode to cause brightening of the trace. External marker signals can be applied to the cathode-ray tube through a front panel connector labeled **EXT MARKER** with the time-marker control set to **EXT.** The grounding link must be opened when external connections are made to the cathode, but must be replaced and left connected at other times.

Calibrator

The **CAL. VOLTAGE RANGE** switch applies dc power to the multivibrator and selects the desired tap on the calibrator voltage divider. The plates of multivibrator sections V41A and V41B are grounded through their plate-load resistors and the cathodes are connected to —150 volts. The grids are returned to ground (positive with respect to cathode) through R125 and variable potentiometer R127, labeled **CAL. DUTY CYCLE** on the front panel. The time constant of the grid-to-plate coupling-capacitor charging circuits can be varied by adjusting the position of the potentiometer arm to add resistance to one grid while subtracting resistance from the other. The length of the time constant determines the time the grid is kept below grid-current conduction during its cutoff period.

V42A is an amplifier whose grid is held below plate-current cutoff during the same period as V41B. During this period V42A plate rests at the voltage determined by voltage divider R128, R129, R131 and adjustable R130 connected between ground and +225 volts.

During the conduction period of V41B the plate of V42A drops below cutoff of V42B. The cathode of V42B therefore operates between ground and approximately the divider voltage. The cathode resistor in cathode follower V42B is tapped to provide various voltage ranges, selectable by means of the D section of the **CAL. VOLTAGE RANGE** switch, SW40. An adjustable potentiometer, R136, labeled **CAL. VOLTAGE** on the front panel, provides a calibrated, continuously-adjustable squarewave output to the **CAL. OUTPUT** front-panel connector.

Vertical Amplifier

The **INPUT SELECTOR** switch, SW2, connects either **INPUT 1, INPUT 2** or the calibrator to the vertical amplifier, and inserts or removes a capacitor from the input circuit to provide either ac or dc coupling.

The **VOLTS/CM** switch, SW3, connects the signal selected by the **INPUT SELECTOR** switch to the vertical-amplifier system through a preamplifier for the two most sensitive positions, and through resistor-capacitor attenuators for the positions giving less sensitivity. In the first, full-clockwise position, a sensitivity of .015 to .05 volts per centimeter is obtained with a preamplifier which has a gain of ten. In the second position, a sensitivity of .05 to .15 volts per centimeter is obtained by inserting a 10/3 resistance-capacitance attenuator in the input circuit of the preamplifier. The third position of the switch connects the input directly to the vertical amplifier, and subsequent positions insert attenuators with increasingly large attenuation. An ac-dc switch permits a capacitor to be inserted in the input circuit in the event a dc component is undesirable.

Preamplifier

The preamplifier consists of two pentode amplifiers with a cathode follower between stages and a second cathode-follower output stage feeding the B section of the **VOLTS/CM** switch, SW3. The use of the cathode follower between stages and into the switch circuit minimizes the effect on the preamplifier of the change of capacitance with switch position.

Vertical Amplifier Attenuator

The vertical-amplifier input stage is also a cathode follower which supplies the variable attenuator stage through series-peaking coil L4.

The variable-attenuator stage is a cathode-coupled long-tail pair of pentodes, with a separate cathode resistor for each, and with coupling between cathodes provided by means of a variable resistor, R35, labeled **VARIABLE ATTEN.** R34 in the plate circuit of the input tube, V12, of this pair provides the internal trigger source. V11B, a cathode-follower voltage regulator supplying grid bias voltage for the grounded grid is for the purpose of adjusting the no-signal cathode voltage of V13 to the no-signal voltage of the cathode of V12, so that adjustment of the **VARIABLE ATTEN.** control will not affect the dc level and position of the trace. A screwdriver front-panel control labeled **VARIABLE ATTEN. BAL.** permits this adjustment to be made. Plate and screen voltage supply is provided by means of V14, a cathode-follower voltage regulator. Plate voltage to V13 is fed through the delay-network termination resistor, and the delay network.

Delay Network

The delay network provides ¼ microseconds of delay to the vertical-deflection signal which is time enough to permit the sweep-sawtooth voltage to be well under way before the vertical-deflection signal is displayed on the cathode-ray tube when the sweep is triggered by the signal being displayed.

The delay network consists of 24 M-derived low-pass sections. The M of these sections is 1.27 which produces the minimum phase dispersion with frequency for the best transmission of pulses without phase distortion. Regulated +105 volts from cathode-follower voltage regulator V14 is supplied to the plate of V13 through the delay network and its terminating resistor, R501. The shunt capacitors of the network sections are adjustable to compensate for slight variations in the manufactured components. Cutoff frequency of the sections is about 3.5 times the upper frequency limit of the balance of the amplifier to minimize any distortion of the pulse response caused by the network.

Phase Inverter, Vertical Positioning

Output from the delay network is applied to V21, the input stage of a cathode-coupled phase inverter. The **VERTICAL POSITION** adjustment is provided by means of R59 which adjusts the grid bias on V22. Positioning results from the difference in dc level between the two halves of the phase inverter. Since the amplifier is dc coupled, a dc change at this level appears also at the deflection plates. Push-pull output from the phase inverter drives the push-pull distributed amplifier through cathode followers, V23B and V24B.

Current Adjust Circuit

Bias level of the cathode followers is set to control the dc operating level of the distributed amplifier, by V23A and V24A which, in turn, receive bias from screwdriver-adjustable voltage divider R66, labeled CURRENT ADJ. The ac impedance of V23A and V24A is kept very high by use of large unbypassed cathode-resistors R68 and R74, while the plate current can be varied easily through a sufficient range to effect the required bias range.

Distributed Output Amplifier

The push-pull distributed amplifier has three tubes in each half. L9 and L11 are the grid and plate delay lines. The signal from the cathode follower V23B is fed down the grid line terminated in R85. As the signal passes each grid, it is amplified and appears at the plate of each tube. At each plate the amplified grid-line signal is applied to the plate line whereupon it travels down the plate line at the same speed as the signal in the grid line, and is therefore reinforced each time it passes a plate. For example, a positive pulse traveling down grid line L9 from the cathode of V23B passes the grid of V31 and passes on toward V33. The negative pulse voltage at the grid of V31 is amplified and appears at the plate of V31 as a negative pulse. The negative pulse on the plate line L11 starts to travel to right and to left along the line, and the portion going to the right approaches the plate tap of V33. The lines are constructed so that the time of propagation of the pulse along the grid line between V31 and V33 is the same as the time of propagation of the amplified pulse along the plate line between V31 and V33 so that at the moment the grid pulse, amplified in

V33, appears at the plate of V33, the plate pulse from V31 also appears at the plate of V33. Since the two plate-line signals are in phase, they add at this point and the result is a pulse twice as high leaving the plate of V33 toward the right. Similarly, as this pulse passes the plate of V35, the grid-line pulse passes the grid of V35, is amplified and added to the plate-line pulse from V31 and V33, so that the pulse is now three times as large as the first pulse out of V31.

The plate pulse at the plate of each tube is also propagated in the left-hand direction as well as in the right-hand direction in the plate line. The portion going to the left is dissipated in R79 which is equal to the characteristic impedance of the plate line so that there is no reflection. The opposite side of the distributed output stage, with V32, V34 and V36, functions in the same manner.

Access Panel Switch

Output from the distributed amplifier is applied through compensating inductors L13 and L14 to switch SW5, labeled IRE-NORM-FLAT-EXT. This switch, located on the access panel at the left rear of the instrument, applies the vertical-deflection signal to the vertical-deflection plates, D3 and D4. In the NORM position the amplifier output is applied to the deflection plates directly. In the IRE position, C56 is shunted across the deflection plates to slow down the amplifier rise time and reduce the bandwidth so that the response conforms with the IRE bandwidth standard for pulse-measurement. In a third position labeled FLAT, the switch adds series-peaking inductance at the deflection plates to provide over-compensation, so the frequency response will be flat to 5 mc. In a fourth position, labeled EXT, the deflection plates are available at the access panel through C47 and C48 with the positioning control retained through R93 and R94.

Elevated Heaters

Hum otherwise present in the low-level stages resulting from heater-to-cathode current is reduced by operation of the heaters at a dc bias of +37.5 volts obtained from the output-stage cathode. R95 and R96 balance the ac voltage to ground to further reduce hum pickup.

Internal-Trigger and Monitor-Video Pickoff

V15A is an amplifier whose grid is supplied with a portion of the vertical signal from a load resistor, R34, in the plate circuit of V12. Cathode output is connected to the internal-trigger positions of the trigger **SELECTOR** switch.

Plate output is applied to the grid of cathode-follower V15B, where it is combined linearly with a portion of the +gate signal coupled in from the sweep circuit via R261 (sweep circuit).

Line-Indicating Video to Monitor

The combined video and gate signal is taken from the cathode of V15B and connected to a UHF coaxial connector at the rear of the instrument, labeled LINE INDICATING VIDEO (TO MONITOR). This circuit is provided so that the television video monitor can indicate on the video-monitor raster which lines of the video field are displayed on the Type 524AD Oscilloscope. The indication on the monitor consists of a horizontal strip brighter than the rest of the picture.

Power Supply

Power supply transformer T401 provides heater voltage and high-voltage ac to the rectifiers which furnish direct current for all parts of the instrument except the cathode-ray tube. This is a 60-cycle transformer with two primary windings to permit use of either 117-volt or 234-volt ac input. A thermal cutout protects the instrument from damage of overheating.

Regulated —150-volt Supply

Reference voltage for the negative 150-volt supply is a type 5651 voltage regulator tube. Regulation of this supply is accomplished by comparing the 87-volt drop across the regulator tube to the voltage of a tap near 87 volts on voltage divider R405, R406, R407. The difference voltage is amplified in V402 and applied to the grid of V403, a series-regulator tube. R408 connected between ground and the unregulated part of the supply increases the current available at the regulated negative 150-volt bus. C404 between grid and ground of comparator tube V402 increases the ac gain of the feedback loop to improve the ac regulation and reduce the ripple. A center-tapped winding to two full-wave rectifiers provides the direct current to the regulator.

Regulated +225-volt Supply

The regulated +225-volt supply consists of a difference amplifier, V407, an amplifier, V408, and a series tube, V409. A change in the output voltage of the regulated supply will cause the voltage at the junction of the sampling resistors, R429 and R430, to change. This voltage change is amplified by V407 and V408. The phase of this amplified voltage change is such when it is fed into the series tube, V409, the current through the series tube is changed in the direction needed to keep the output voltage of the regulated supply constant. Resistors R424 and R425 form a voltage divider which is necessary to place the proper operating voltage on the grid of V408. C423 and C424 improve the regulation of the supply against rapid changes in load and also help to reduce the output ripple.

Regulated +120-volt Supply

The +120-volt supply drops the voltage of the regulated +225-volt bus through series-regulator tube V412. The voltage is determined by comparing to ground in comparator tube V411 the voltage near ground on voltage divider R410, R411 connected between —150 volts and the regulated 120-volt bus. C410 reduces ripple by improving the ac gain of the feedback loop.

Regulated +450-volt Supply

The +450-volt supply drops the voltage of the unregulated +600-volt supply through series-regulator tube V415. Regulation is accomplished by comparing to regulated +225 volts, in comparator tube V414, the voltage near +225 volts on voltage-divider R445, R446 connected between ground and the regulated +450-volt bus. The error voltage is amplified in V414 and applied to the grid of series-regulator tube V415. R447 reduces the current through V415. C441 increases ac gain through the regulator loop to reduce ripple.

High-Voltage Supply

The primary of the high-voltage power transformer, T802, is the inductor of a Hartley type of oscillator operating at about 60 kilocycles, with C803 as the tank capacitor and V803 as the oscillator vacuum tube. The secondary contains three filament windings and two high-voltage windings. The two high-voltage windings are wound bifilar to keep the ac voltage between windings as small as possible. The winding connected to V806 is raised to about 200 volts positive by the unblanking circuitry.

The other bifilar winding is therefore also biased to +225 volts at its ac grounded end to reduce the dc voltage between windings. This winding is tapped. The full ac voltage is rectified by V805 at about +2500 volts for the post-deflection acceleration voltage. The ac from the tap is rectified in V804 at about —1500 volts for the cathode supply voltage. The —1500-volt supply is regulated by comparing to regulated —150 volts, the voltage near —150 volts on a voltage divider R806, R807, R808 and R809, connected between —1500 volts and +225 volts, in comparator tube V802A. The difference voltage is amplified in V802A and applied to the grid of V802B, a shunt-regulator tube controlling screen voltage to the oscillator tube, V803, so as to correct the oscillator output level. R807, labeled Adj to —1500, a screwdriver control located on the sweep chassis, adjusts the voltage divider in the comparator circuit.

Unblanking

The positive unblanking pulse from V212B on the sweep chassis is applied to the crt control grid through the second high-voltage power supply, whose rectifier tube is V806. The whole power supply therefore follows the unblanking waveform. The unblanking pulse is therefore dc coupled to the crt control grid so as to provide a stable unblanking voltage even for very slow sweeps. C701 improves the rise time for faster sweeps. R705, a front-panel control labeled **INTENSITY**, adjusts the dc level of the unblanking voltage to control the intensity of the trace.

Focus

R708, a potentiometer front-panel control labeled **FOCUS**, is a portion of a voltage divider between the negative 1500-volt supply and a point on the sweep chassis at negative 400 volts. This control permits the voltage of grid number 4 of the crt to be varied for focusing the trace.

Astigmatism

The astigmatism control is R268, a front-panel-control potentiometer labeled **ASTIGMATISM**, in the grid circuit of V211A, a cathode-follower, voltage regulator located on the sweep chassis, which controls the voltage at pin 9, anode number 2, of the cathode-ray tube.

Replacement of Components

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

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

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

Parts-Ordering Information

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

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

We make some of the instrument changes during the factory test procedure. Our technicians hand-tailor the circuits, if it seems appropriate, to provide the widest possible latitude of operation. Other changes are made to include the latest circuit improvements as they are developed in our engineering department, or when improved components become available. In any event, the changes are to your benefit. We have tried to give you the best instrument we can.

Soldering Precaution

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

Removing the Cabinet

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

CAUTION — Voltages high enough to be dangerous are present in this instrument. Since 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.

Power Supply

Operation on 210-250 Volt Line

The power transformer of the Type 524AD 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. Then connect terminals 2 and 3 together. Move the fan lead from the switch side of the thermal cutout to the terminal-1 side. With the line still connected to terminals 1 and 4, the instrument is ready for 210-250-volt operation.

The fuse supplied when the Type 524AD is wired for 105-125-volt operation is a 6.25-amp 250-volt fast blow. For proper protection on 210-250-volt operation this fuse should be changed to a 3-amp 250-volt fast blow.

Locating Troubles

An early step to take in locating troubles is to determine if the various plate-supply voltages are correct. Convenient measuring points are accessible on the under side of the chassis. If there is no voltage, check the fuse at the rear of the case and the thermo-disk cutout near the transformer. The disk opens at 130° F. and closes at 100° F., approximately. For 120-volt operation the fan continues to run when the cutout opens. Since all the regulated voltages are referred to negative 150 volts, start with this one. Use an accurate dc voltmeter and measure the voltage between pin 7 of V401 and ground. This voltage should be within one per cent of 150 volts.

Then check +120 volts at pin 1 of V412.
+225 volts at pin 6 of V412.
+450 volts at pin 1 of V415.

These voltages should be within 3 per cent of their nominal values.

Then check +330 volts at pin 5 of V409.
+600 volts at pin 9 of V415.

These voltages are unregulated and will vary with line voltage but should be within ten or fifteen per cent of their nominal values.

Since most troubles with the equipment will result from tube deterioration or failure, first determine whether any departure from these voltages is caused by bad tubes. Look for evidence of overheating of components associated with a tube found to be defective. It is usually advisable to replace tubes before making adjustments. The circuits of the Type 524AD oscilloscope are designed and adjusted to operate properly with the correct plate voltages and should not be sensitive to minor changes of components values or tube characteristics. The usual cause of deteriorated performance, therefore, will be tube or component failure and not misadjustment. However, after replacement of tubes or components, readjustment may be necessary.

Adjustment

Since the instrument is adjusted to operate correctly when the power-supply voltages are set accurately to their nominal values, before making other adjustments these voltages should be checked and if necessary, readjusted.

—150-volt Adjustment

This control is located at right rear of the power supply, accessible from the underside. Measure between ground and pin 7 of V401 with an accurate voltmeter (within 1 per cent) and set accurately to 150 volts.

Set Current Adjust Control

Connect positive voltmeter lead to top of R87, 200-ohm 20-watt wire wound, adjacent to V23 on vertical amplifier chassis, and negative meter lead to chassis. Adjust R66 to get exactly 37.5 volts. This is cathode voltage on the output tubes.

Check for 120 Volts, 225 Volts, and 450 Volts

Check for 120 volts between pin 1 of V412 and ground. Check for 225 volts between pin 6 of V412 and ground. Check for 450 volts between pin 1 of V415 and ground. These voltages should be within 3 per cent.

Adjust —1500 Volts

Connect negative meter lead at crt filament jacks, positive lead to chassis, and set R807 labeled ADJ to —1500 v, located on left side of sweep chassis, for exactly 1500 volts, use 20,000 ohm-per-volt meter. Check oscillator screen voltage between pin 6 on V803 located on high-voltage supply on left side, and ground. Should be between 150 and 170 volts at normal intensity.

Check Ripple and Regulation

Using a second oscilloscope, check ripple at —150 volts. Should be 40 millivolts or less. Check ripple at 225 volts, should be 20 millivolts or less. Check ripple at 120 volts, should be 10 millivolts or less. Check ripple at 450 volts, should be 50 millivolts or less.

Set Sweep Amp. Current

Position spot on crt at center of screen and set **INTENSITY** to normal. Now set the voltage on the sweep-amplifier deflection plates at 150 to 155 volts by adjusting R325 labeled SWEEP AMP. CURRENT ADJ. Measure voltage between X plates and ground. Should be same as Y plates.

Check Unblanking Pulse

Set sweep time at **500 μSEC/CM, TRIGGER SELECTOR** at **60∿ UNDELAYED,** and advance the **STABILITY** control until sweep runs recurrently. Connect a second scope probe to the unblanking post, located by V213, on the sweep deck. The amplitude of the unblanking pulse should be 50 volts or more.

Check Sweep Output

Connect the second-scope probe to the **SWEEP OUTPUT** binding post on the front panel, and turn the trigger **AMPLITUDE** control counterclockwise. With the sweep running recurrently, a regular sawtooth should be indicated on the test scope having a peak-to-peak amplitude of 30 volts or more.

Check Positive and Negative Gate Output

Using the same setup as before, connect the second-scope probe, first to the **+GATE** and then to the **—GATE** binding posts on the front panel. The waveform of the **+GATE** should be square on top. The peak amplitude of each should be about 30 volts.

Adjust Variable Attenuator Balance Control

Position the trace to the center of the screen with the calibrator voltage off. Rotating the **VARIABLE ATTEN.** control should not change the position of the trace. If it does, the **VARIABLE ATTEN BAL.** control should be adjusted until there is no change while the **VARIABLE ATTEN.** control is rotated. Note: this control may require readjustment as the tubes age. Check for V11 grid current by switching to **DC** input, and changing the **VOLTS/CM** control throughout its range. The trace should not shift more than 2 mm.

Adjust Vertical Driver Compensation, C28, C31

Set the **VOLTS/CM** switch to the **.15-.5** position. Connect a Tektronix Type 105 Square-Wave Generator to the vertical input and adjust it for about 4 cm of vertical deflection at about 2.5 kc. Adjust C28 and C31, adjacent to V21 and V22, for best leading edge and a flat top on the square wave. These trimmers should have approximately the same capacitance when the adjustment is completed. If you don't have a Tektronix Type 105 Square-Wave Generator, the calibrator waveform can be used, although the rise time is not fast enough for best results.

Adjust Input Attenuator and Probe

The built-in attenuators are resistor voltage dividers paralleled by capacitor voltage dividers. The division of low-frequency voltage components is determined by the ratio of the resistors, while the division of high-frequency voltage components is determined by the inverse capacitance ratio. When both division ratios are equal, components of all frequencies are equally divided so that a complex wave will be accurately reproduce at the attenuated level. A square wave is an ideal complex wave for determining whether the attenuated wave is accurately reproduced.

If the attenuation ratio of the capacitor divider is lower than that of the resistor divider a spike will appear at the leading edge of the attenuated output waveform when a square wave is applied to the input of the attenuator. Conversely, if the attenuation ratio of the capacitor divider is greater than that of the resistor divider, the leading edge of the output wave will be rounded.

The probe is also a resistor-capacitor voltage divider, similar to the built-in attenuators, except that the shunt leg of the divider is formed by the input impedance of the oscilloscope.

The input impedance is one megohm paralleled by approximately 40 $\mu\mu f$, or a time constant of 40 microseconds. The input time constant must therefore be made equal for all positions of the **VOLTS/CM** switch so that the high-frequency response through the probe will be the same for all switch positions.

The following procedure is based on the use of the calibrator waveform for making the attenuator adjustments. If you have a Type 105 Square Wave Generator, its faster rise time will allow a more accurate adjustment of the series trimmers. It can be used to make all the adjustments or to recheck the series trimmers only.

To make these adjustments, lay a sheet of metal on top of the instrument to simulate the presence of the cabinet. A special aluminum shield with suitable openings for making these adjustments may be purchased from Tektronix. Connect a 10 to 1 attenuation probe to **INPUT 2.** Insert the tip of the probe into the **CAL. OUTPUT** connector. Set the **VARIABLE ATTENUATOR** clockwise, the **INPUT SELECTOR** to the **AC** position of **INPUT 2** and adjust the calibrator controls to give about 3 cm of deflection on the crt screen. Set the sweep and triggering controls to display several cycles of the square wave. Make the adjustments indicated in the following table in the order shown. Adjust in each case for the best leading edge and flattest top on the square wave.

VOLTS/CM	Adjust
.15 to .5	Probe trimmer

(Change the **INPUT SELECTOR** switch to the **AC** position of **INPUT 1.** Connect the probe to **INPUT** 1.)

VOLTS/CM	Adjust
.15 to .5	C136
.5 to 1.5	C103 & C104
1.5 to 5	C105 & C106
5 to 15	No adjustments
15 to 50	C111 & C112
.015 to .05	C1 & R10
.05 to .15	C101 & C102

In the 15-to-50 position of the **VOLTS/CM** switch the deflection caused by the maximum calibrator voltage through the 10-to-1 attenuation of the probe is only a third of a centimeter so that it is somewhat difficult to adjust C111 properly. A better adjustment can be obtained if the sweep is allowed to run unsynchronized. Reduce the trigger **AMPLITUDE** control setting and advance the **STABILITY** control until the sweep runs recurrently. The display will be two parallel lines. Adjust the **FOCUS** and **AS-**

TIGMATISM carefully and then adjust C111 so that no spikes or rounding appear above or below the lines. The presence of spikes or rounding will appear as a barely discernible blurring or deterioration of the sharpness of the trace. A magnifying glass will help.

Adjustment of C11 and C112 can both be made more accurately with more deflection than is available through the 10-to-1 attenuation of the probe. Five times more deflection can be obtained by substituting a 2-to-1 external attenuator for the 10-to-1 probe. A 2-to-1 attenuator can be made quite easily using a 1-megohm resistor shunted by a capacitance which can be adjusted in the vicinity of 40 $\mu\mu$f, for example a 7-to-45 $\mu\mu$f trimmer.

Connect this 2-to-1 attenuator between the **CAL OUTPUT** and the **INPUT 1** terminals and repeat the settings of controls as used for adjusting C106 and adjust the external attenuator trimmer for best squarewave response. Then repeat the settings of controls for adjustment of C111 and C112.

Calibrator Check

Set the **CAL. VOLTAGE RANGE** to **50, CAL. VOLTAGE** dial accurately to **5**, **CAL. DUTY CYCLE** full clockwise. Measure output voltage between the **CAL. OUTPUT** terminal and ground on a 20,000 ohm-per-volt meter shunted with a capacitance of 0.1 μf or higher. The reading should be 50 volts. The meter should be accurate within one per cent.

Trigger Sensitivity

Set **VOLTS/CM** to **5** to **15**, **VARIABLE ATTEN.** full clockwise, **CAL. VOLTAGE** to **0**, sweep time 100 μsec/cm, trigger **SELECTOR +SIG UNDELAYED**, trigger **AMPLITUDE** full counterclockwise. Advance the sweep **STABILITY** control until the sweep runs recurrently and then return it counterclockwise until the sweep stops. Advance the **AMPLITUDE** control full clockwise and then advance the **CAL. VOLTAGE** control until the sweep starts. If more than 3 millimeters of deflection is required V207 may need replacement.

Adjust Vertical Amplifier Gain

First, recheck that the cathode voltage of the output amplifier is 37.5 volts to ground at Pin 8 of V23.

Set the **VOLTS/CM** dial at **.15-.5**. Set **CAL. VOLTAGE RANGE** to **1.5**, and set the **CAL. VOLTAGE** control to **.9**. Rotate the **VARIABLE ATTEN.** control to get 6 centimeters of vertical deflection. If the control encounters the stop before 6 centimeters of deflection occurs, or if the deflection is more than 6.3 centimeters when the **VARIABLE ATTEN.** control is turned full right, loosen the appropriate collar on the shaft near the control (inside the instrument) and reset the collar on the shaft so that the control stops when the deflection is 6 centimeters.

Leave the **VOLTS/CM** dial at **.15-5**, set the **CAL. VOLTAGE RANGE** control to **5**, and leave the **CAL. VOLTAGE** control at **3**. Turn the **VARIABLE ATTEN.** knob to the left to get 6 centimeters of vertical deflection as before. If necessary to do this, readjust the appropriate collar slightly on the shaft.

Leave the **CAL. VOLTAGE** control at the setting that provides 6 centimeters of vertical deflection. Turn the **VARIABLE ATTEN.** control full right. Set the **CAL. VOLTAGE RANGE** control to **.15** and set the **VOLTS/CM** control to **.015-.05**. Adjust the PREAMP GAIN control (R16, located on the upper side of the vertical-amplifier chassis) for 6 centimeters of vertical deflection.

Check CRT Cathode Circuit

Set the time-marker control to **EXT**, the sweep **TIME** to **100 μSEC/CM**, advance the **STABILITY** control so that the sweep runs recurrently, and then reduce the intensity control setting until the sweep trace disappears. Open the **CRT CATH.** shorting link on left side of the front panel, and connect **CAL. OUTPUT** to the **CRT CATH.** terminal. Starting with zero volts, slowly advance the **CAL. VOLTAGE** control clockwise until the trace reappears. Reducing the **CAL. VOLTAGE** control counterclockwise should make the trace disappear again. This indicates that the crt cathode and associated circuits are satisfactory. Close the link.

Set the MAG. POS. Control

Turn the **HORIZONTAL POSITION** control so that the sweep starts at the center graticule line, then turn the **SWEEP MAGNIFIER** switch to **10X** position and position the start of the sweep at the center graticule line with the **HORIZONTAL POSITION** control. Now turn the **SWEEP MAGNIFIER** control to **OFF** and reposition the start of the sweep to the center line by using the **MAG. POS.** screwdriver adjustment on front panel. Repeat the above steps until there is no difference in the position of the start of the sweep in the two positions.

Sweep Circuit Adjustments

Before making any adjustments of these circuits, be sure the crt accelerating voltage is correctly set to 1500 volts. See the paragraph concerning this adjustment. Adjust the **FOCUS, INTENSITY** and **ASTIGMATISM** controls for a well defined spot.

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

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

1. Adjust R330, L. F. Sweep Time

   Display 100-microsecond markers from the time-mark generator with the sweep **TIME** control set to **100 μSEC/CM** and the **μSEC/CM MULTIPLIER** controls set at **1.0.** If necessary, adjust R330, marked L.F. ADJ. at the rear of the sweep chassis so that the markers correspond with the graticule lines.

2. Adjust C305A, H. F. Sweep Time

   Display 1-microsecond markers with the **TIME** control set to **1 μSEC/CM** and the **MULTIPLIER** controls set at **1.0.** Adjust C305A, labeled H.F. SWEEP TIME at the rear of the sweep chassis so that the markers correspond with the graticule lines.

3. .1 Microsec/cm Adjust, C231A

   Display 1-microsecond markers with the **TIME** control set to **.1 μSEC/CM** and the **MULTIPLIER** set to **10.0.** Adjust C231A, on the rear section of the **TIME** switch, accessible from the left, so that the markers correspond with the graticule lines.

4. Sweep Magnifier 10X Adjust, C301

   Turn the **MAGNIFIER** to **10X** and position the trace slightly to the right so that markers occur near the right and left sides of the graticule. Ajust C301 so that the markers are 10 cm apart.

5. Sweep Magnifier 3X Adjust, C302B

   Turn the **MAGNIFIER** to **3X** and the **MULTIPLIER** to **3.0.** Adjust C302B so that the markers are 10 cm apart.

6. C302C Adjust

   Turn the **MAGNIFIER** to **OFF** and the **MULTIPLIER** to **10.0.** Adjust C302C so the markers correspond with the graticule. If an appreciable change is made in this adjustment, recheck steps 2 through 6.

Time-Marker Adjustments

Time-marker intervals are changed by changing the inductance of the oscillator coils, L601, L602, L603, L604, and L608. These inductors are mounted near the panel just above the time-marker switch.

The frequency of the time-marker oscillators can be determined by comparison with another oscillator of known frequency, such as a BC221 frequency meter, or a calibrated signal generator. A Tektronix Type 180 or 181 Time-Mark Generator can be used to adjust L601, L602 and L603. To make the comparison, display a stable pattern of several cycles of the signal-generator output wave, and determine the positions on the trace where brightening occurs when the time marker is turned on.

For example, set the signal generator to 1 mc, and set the time marker switch for **1 μSEC.** Each cycle of the sine wave should have one bright spot on the trace. After determining with only five or ten cycles displayed that each cycle is brightened once, slow the sweep so that fifty or so cycles are displayed, and adjust the marker oscillator inductor, L603, so that the brightening occurs at the same height on each cycle displayed clear across the screen. By this means, the difference in frequency between the signal generator and the time-marker oscillator can be observed over the relatively long period of the sweep. Since the sweep and time-marker oscillator are both triggered by the signal generator, several cycles need to be observed before a change in phase can occur corresponding to a difference in frequency. If the height of the brightened part of the trace remains quite nearly constant for fifty cycles, the relative phases of the signal generator and time-marker oscillator are constant within a small part of a cycle in fifty cycles, corresponding to an equality in frequency within a small fraction of one per cent.

For the **0.1 μSEC** marker, set the oscillator to 10 mc or a submultiple of 10 mc. Adjust L602 for a horizontal bright line on the screen as for the **1 μSEC** marker.

For the **0.05 μSEC** marker, set the oscillator to 10 mc and adjust L601 for two horizontal bright lines.

For the **.005H** and **.025H** markers use an oscillator frequency of 3.15 mc or a submultiple of 3.15 mc and proceed as for the other markers.

Vertical Amplifier Adjustment

A good square wave source of voltage is required for adjustments to the vertical amplifier. The risetime must be 0.04 microseconds or faster for adjustment of the high-frequency response and the top of the wave must remain flat without appreciable slope for a good fraction of a second for low-frequency adjustments. The Tektronix Types 105 and 107 Square-Wave Generators provide an excellent waveform for the amplifier adjustments. The risetime of the calibrator waveform of the Type 524AD oscilloscope is not fast enough for these adjustments. If there are any irregularities in the test waveform the tendency will be to compensate for them by mistuning the amplifier. If there is any question about the quality of the test waveform, it should be observed on the oscilloscope connected directly to the vertical-deflection plates without the vertical amplifier.

If you are sure that the test waveform is good enough, proceed as follows to check the vertical amplifier and if necessary, readjust it.

Removal of Delay Line

First, disconnect the delay line, by unsoldering the blue-tracer lead from pin 6 of V13, the orange-tracer lead from pin 2 of V21, and the brown-tracer lead from the bakelite-post tie point at the right-hand side of the delay-line assembly. Then connect a jumper between pin 6 of V13 and pin 2 of V21, a 570-ohm resistor between pin 2 of V21 and the post-mounted tie point, and connect a 330-ohm resistor and a 40-μf capacitor in series between pin 2 of V21 and ground.

Preamp Low-Frequency Adjustment

Set the **VOLTS/CM** switch to the **.015** to **.05** position. Set the sweep **TIME** switch to **10 μSEC/CM**, and the trigger **SELECTOR** switch to **—EXT**. Advance the **STABILITY** control so that the sweep runs recurrently and displays an unsynchronized 50- to 100-cycle square wave. The trace will appear as two horizontal lines. Adjust R10, labeled L.F. ADJ. on the chassis, for the most sharply defined trace.

Distributed Amplifier, C41 and C42 Trimmers

Set the **VERT. AMP.** switch to **NORMAL.** Set the **VOLTS/CM** to **.15** to **.5** and the sweep **TIME** controls to about **4 μSEC/CM**, and obtain a stable display of the square wave. Adjust C41A and C42A through C41F and C42F in that order so as to get the squarest corner on the leading edge of the square wave. When the adjustments are completed, each pair of trimmers in like positions in the two lines should have approximately equal capacitance settings.

Driver-Stage High-Frequency Shunt-Peaking Coils, L6 and L7

With the control settings and input pulse the same as for the foregoing trimmer adjustments, adjust L6 and L7 for best leading-edge square-wave response.

Output-Stage Normal-Peaking Coils, L13 and L14

With the control settings and input pulse the same as for the foregoing trimmer adjustments, adjust L13 and L14 for best square wave response.

The shunt and series coils should be adjusted alternately for best overall response. The shunt coils, L6 and L7 have a short time constant and their effect is most noticeable on the upper left corner of the square wave. The series coils have a longer time constant and their contribution is to the start of the flat portion of the square wave. After these adjustments have been completed, check the adjustments of the distributed-amplifier trimmers and the peaking coils alternately a time or two more for the best overall response.

Over-Peaking Coils, L17 and L18

First be sure that peaking coils, L13 and L14, are properly adjusted for transient response when the VERT. AMP. switch, SW5, is at NORMAL. Then switch to the FLAT position. There will be about 10 per cent overshoot if you are observing a fast pulse with a rise time of .02 μsec or less, such as the output from a Tektronix Type 105 Square-Wave Generator.

Check the response to a sine wave at 750 kc and at 5 mc. The response should be equal within 1 per cent at the two frequencies. Keep in mind that 1 per cent is a very close tolerance for a signal generator. A swept-frequency oscillator with constant output voltage is the best type for this purpose.

With this type of signal input you will observe a slow drop, no greater than 1 per cent, in the response curve between 1 mc and 2 mc; a similar rise, no greater than 1 per cent, near 3.5 mc; slowly dropping to 1 per cent low at about 5.5 mc. Adjust L17 and L18 located on the access panel while observing the response. The adjustment is not critical.

Delay-Line Adjustment

Do not adjust the delay line without first assuring yourself that the vertical amplifier is in adjustment. See foregoing tuning procedure. Remove the 570-ohm and 330-ohm resistors and the connection between pin 6 of V13 and pin 2 of V21. Reconnect the delay line, the brown-tracer lead to pin 2 of V21 and the blue-tracer lead to pin 6 of V13. Apply a square wave voltage of about 250-kc frequency, set the sweep time to about six microseconds per centimeter. Obtain a stable trace of at least four-centimeter peak-to-peak amplitude.

First adjust C525 and L525, located on the back of the delay line, for flattest top. The effect of these adjustments appears about half a microsecond from the leading edge of the pulse. Then adjust the remaining trimmers, C524, C523, C522, etc., in this order for the flattest top while frequently switching the sweep time between **6 μSEC/CM** and **60 μSEC/CM**, to help assure that gradual slope to the top of the pulse is not resulting from the adjustments. The presence of slope is more readily discernible when the trace is shorter, but the contribution of individual trimmer adjustment is more apparent when the trace is longer. Recheck the adjustment at least once again.

While you are adjusting the delay line, you may experience difficulty in gaining the correct adjustments due to the proximity of your arm and hand. This trouble may be eliminated by shielding the delay line and associated circuits from the effects of body capacitance. A shield is available from the factory for this purpose. When ordering, specify part number 333-363.

Preamp High-Frequency Peaking

Set the **VOLTS/CM** control to the **.015** to **.05** position, **INPUT SELECTOR** switch to **AC**, sweep time to about 6 μsec/cm and apply a square wave signal to give at least four centimeters of deflection, peak to peak, at a repetition rate of about 250 kc. Obtain a stable pattern and adjust L1, L3 and L2, in this order, for best leading edge without overshoot. These inductors are located on the front part of the vertical amplifier chassis. All three should have approximately the same setting when adjustment is completed. Then check the risetime and bandwidth.

Risetime Measurement

Risetime is measured by measuring the time between points on the leading edge of a square-wave response at which the amplitude is 10 per cent and 90 per cent of the peak-to-peak value.

To make this measurement set the sweep-time controls to get .1 μsec/cm. Obtain a stable pattern 2.4 cm, peak to peak, extending 2 mm above the +1-cm graticule mark and 2 mm below the —1-cm graticule mark. Position the trace so that it intersects the vertical center graticule line and the —1-cm graticule line, and read the horizontal distance to the intersection with the +1-cm line. This distance should be less than 3 mm corresponding to a risetime of 0.03 microseconds.

Frequency Response

A check of the frequency response will help to determine whether the vertical amplifier is performing properly. To make this determination, a source of sine-wave voltage is required which will operate over the frequency range of about 5 mc to 12 mc at a constant or measurable amplitude. Display the sine wave on the oscilloscope with an unsynchronized sweep. Adjust the input level to get a ±2-cm deflection (4 cm peak to peak) with the **VOLTS/CM** control in the **.015** to **.05** position and the oscillator frequency at about 5 mc. Increase the frequency while maintaining the input voltage constant until the deflection decreases to ±1.4 cm (2.8 cm peak to peak). Determine the oscillator frequency at this point. It should be 10 mc or higher.

Switch the **VOLTS/CM** control to the **.15** to **.5** position, and then repeat the foregoing check. This bandwidth should be well over 11 mc.

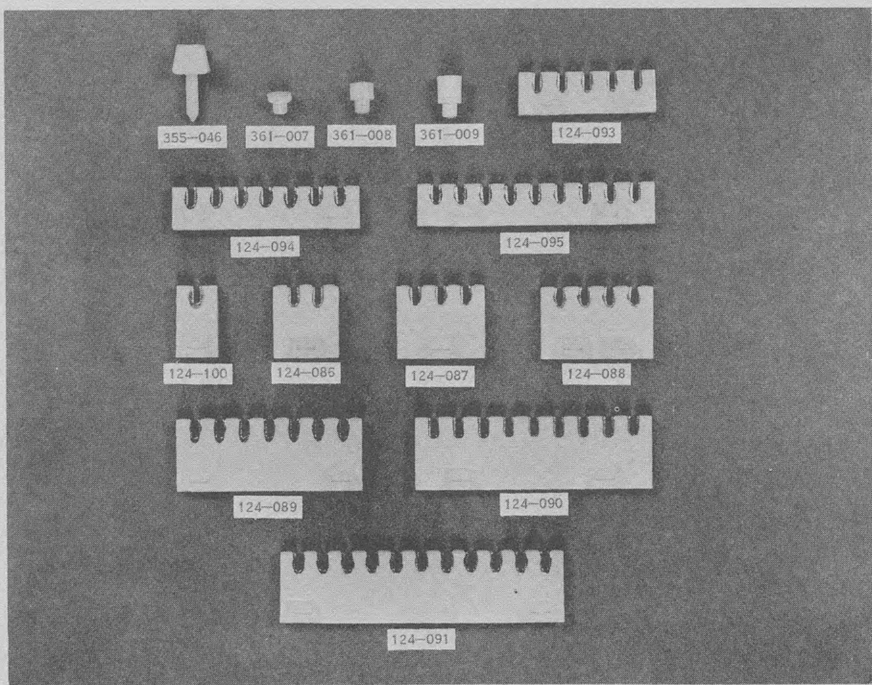
MODIFICATION NOTICE

CLIP-MOUNTED CERAMIC STRIPS

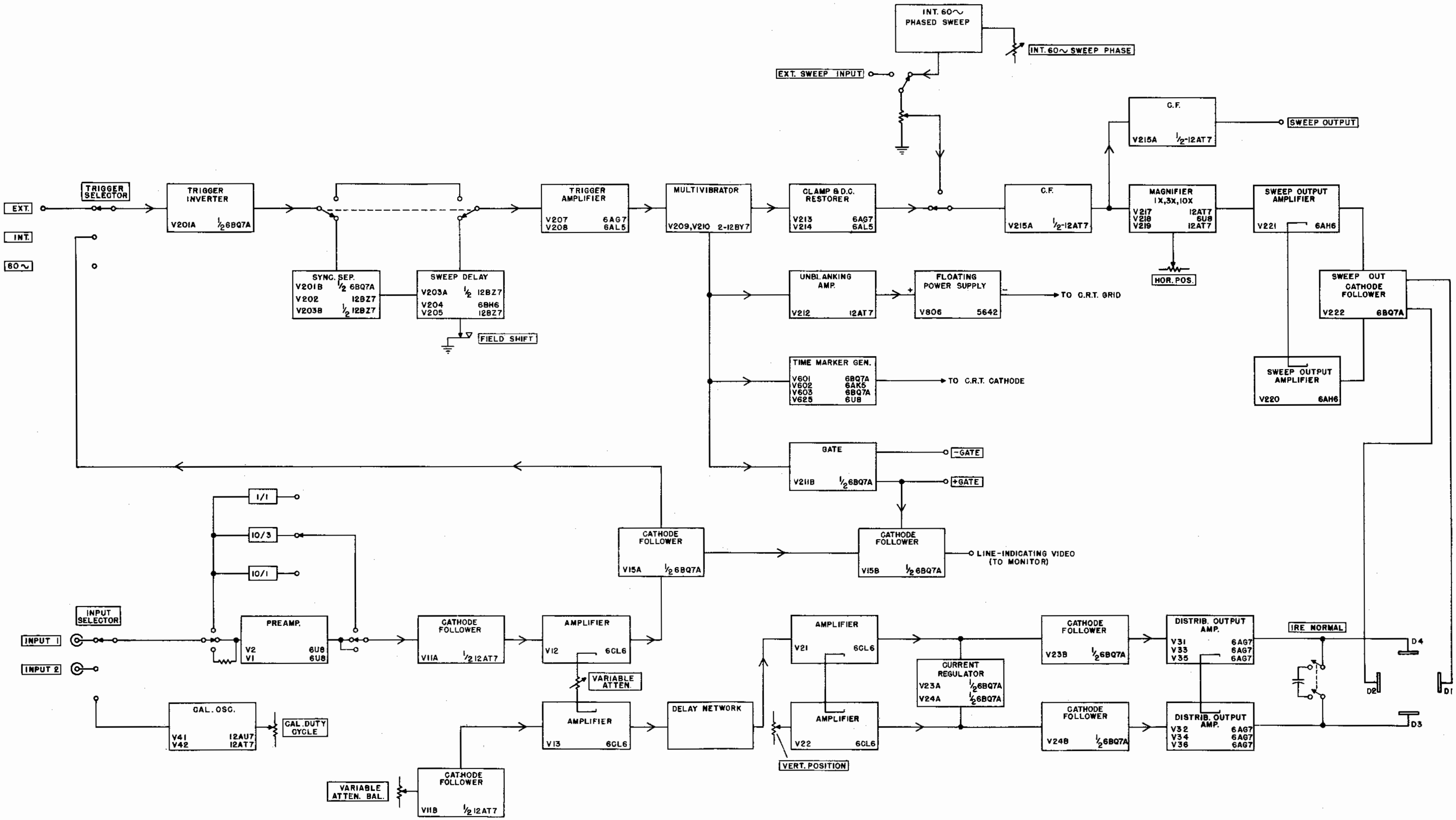
YOUR INSTRUMENT MAY BE EQUIPPED WITH CLIP—MOUNTED CERAMIC STRIPS. IF YOU FIND IT NECESSARY TO ORDER THESE STRIPS FOR REPLACEMENT, BE SURE TO CONSULT THIS SHEET. INCLUDE A DESCRIPTION OF THE PART, PART NUMBER, INSTRUMENT TYPE AND SERIAL NUMBER.

CERAMIC STRIP PARTS LIST

	PART NUMBER
STUD, CLIP, MOLDED NYLON	355—046
SPACER, MOLDED NYLON, 5/32" HEIGHT	361—007
SPACER, MOLDED NYLON, 1/4" HEIGHT	361—008
SPACER, MOLDED NYLON, 3/8" HEIGHT	361—009
CERAMIC STRIP, 7/16" BY 3 NOTCHES	124—092
CERAMIC STRIP, 7/16" BY 5 NOTCHES	124—093
CERAMIC STRIP, 7/16" BY 7 NOTCHES	124—094
CERAMIC STRIP, 7/16" BY 9 NOTCHES	124—095
CERAMIC STRIP, 7/16" BY 11 NOTCHES	124—106
CERAMIC STRIP, 3/4" BY 1 NOTCH	124—100
CERAMIC STRIP, 3/4" BY 2 NOTCHES	124—086
CERAMIC STRIP, 3/4" BY 3 NOTCHES	124—087
CERAMIC STRIP, 3/4" BY 4 NOTCHES	124—088
CERAMIC STRIP, 3/4" BY 7 NOTCHES	124—089
CERAMIC STRIP, 3/4" BY 9 NOTCHES	124—090
CERAMIC STRIP, 3/4" BY 11 NOTCHES	124—091



CERAMIC STRIPS AND MOUNTINGS USED IN TEKTRONIX EQUIPMENT.



BLOCK DIAGRAM
TYPE 524AD CATHODE-RAY OSCILLOSCOPE

L.A.P.
10-28-58

ABBREVIATIONS

Cer.	ceramic	m	milli or 10^{-3}
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	Poly.	polystyrene
EMT	electrolytic, metal tubular	Prec.	precision
f	farad	PT	paper tubular
h	henry	Tub.	tubular
k	kilohm or 10^3 ohms	v	working volts dc
meg	megohm or 10^6 ohms	Var.	variable
μ	micro or 10^{-6}	w	watt
μμ	micromicro or 10^{-12}	WW	wire wound

GMV guaranteed minimum value

SYNC SEPARATOR, TRIGGER DELAY, AND FIELD SHIFT

Capacitors

C202	.022 μf	PT	Fixed	400 v	20%	285515
C203	½ 2x20 μf	EMC	Fixed	450 v	—20% +50% with C411	290037
C204	47 μμf	Cer.	Fixed	500 v	20%	281518
C205	.01 μf	PT	Fixed	400 v	20%	285510
C206	.01 μf	PT	Fixed	400 v	20%	285510
C207	.01 μf	PT	Fixed	400 v	20%	285510
C208	.01 μf	PT	Fixed	400 v	20%	285510
C209	2.2 μμf	Cer.	Fixed	500 v	±0.5 μμf	281500
C210	.01 μf	PT	Fixed	400 v	20% (Selected —10 to —5%)	295016
C211	22 μμf	Cer.	Fixed	500 v	20%	281510
C212	.047 μf	PT	Fixed	400 v	20%	285519
C213	.01 μf	PT	Fixed	400 v	20%	285510
C214	22 μμf	Cer.	Fixed	500 v	20%	281510

Resistors

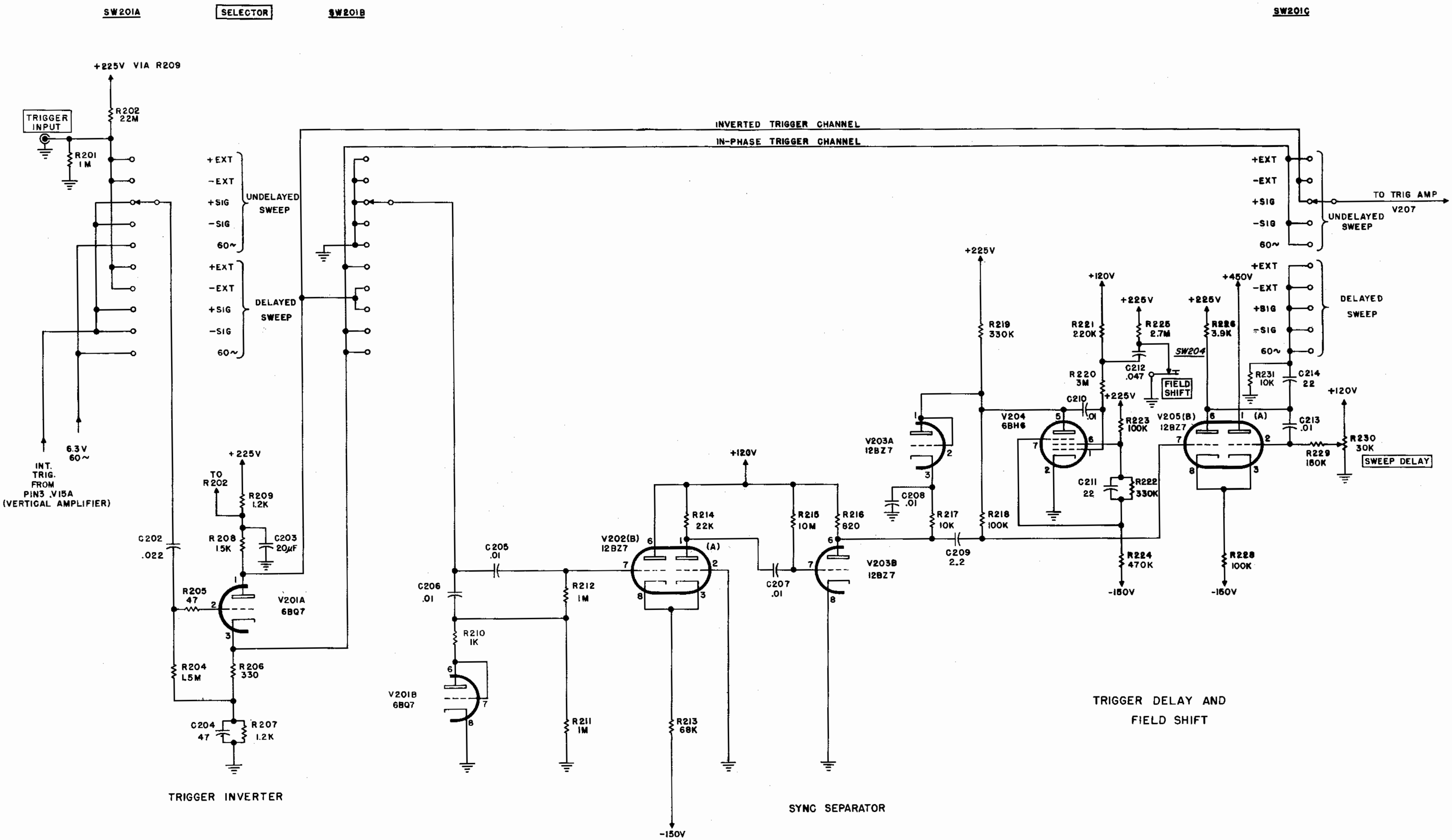
R201	1 meg	½ w	Fixed	Comp.	10%		302105
R202	22 meg	½ w	Fixed	Comp.	10%		302226
R204	1.5 meg	½ w	Fixed	Comp.	10%		302155
R205	47 Ω	½ w	Fixed	Comp.	10%		302470
R206	330 Ω	½ w	Fixed	Comp.	10%		302331
R207	1.2 k	½ w	Fixed	Comp.	10%		302122
R208	1.5 k	½ w	Fixed	Comp.	10%		302152
R209	1.2 k	½ w	Fixed	Comp.	10%		302122
R210	1 k	½ w	Fixed	Comp.	10%		302102
R211	1 meg	½ w	Fixed	Comp.	10%		302105
R212	1 meg	½ w	Fixed	Comp.	10%		302105
R213	68 k	1 w	Fixed	Comp.	10%		304683
R214	22 k	½ w	Fixed	Comp.	10%		302223
R215	10 meg	½ w	Fixed	Comp.	10%		302106
R216	820 Ω	½ w	Fixed	Comp.	10%		302821
R217	10 k	½ w	Fixed	Comp.	10%		302103
R218	100 k	½ w	Fixed	Comp.	10%		302104
R219	330 k	½ w	Fixed	Comp.	10%		302334
R220	3 meg	½ w	Fixed	Prec.	1%		309026
R221	220 k	½ w	Fixed	Comp.	10%		302224
R222	330 k	½ w	Fixed	Comp.	10%		302334
R223	100 k	1 w	Fixed	Comp.	10%		304104
R224	470 k	½ w	Fixed	Comp.	10%		302474
R225	2.7 meg	½ w	Fixed	Comp.	10%		302275
R226	3.9 k	½ w	Fixed	Comp.	10%		302392
R228	100 k	1 w	Fixed	Comp.	10%		304104
R229	150 k	½ w	Fixed	Comp.	10%		302154
R230	30 k	3 w	Var.	helipot	.5% linearity	SWEEP DELAY	311021
R231	10 k	½ w	Fixed	Comp.	10%		302103

Switches

					not wired	wired
SW201	3 wafer	10 Position	rotary	SELECTOR	260041	262079
SW204	Normally closed	2 Position	Push Button	FIELD SHIFT	260016	—

Vacuum Tubes

V201A	½ 6BQ7	Trigger Inverter	154028
V201B	½ 6BQ7	Sync Separator Bias Diode	
V202	12BZ7	Sync Amplifier	154048
V203A	½ 12BZ7	Phantastron Trigger Diode	154048
V203B	½ 12BZ7	Sync Separator	
V204	6BH6	Phantastron	154026
V205	12BZ7	Trigger Delay Comparator	154048



HOS 7-10-56

SYNC SEPARATOR,
TRIGGER DELAY, AND FIELD SHIFT

ABBREVIATIONS

Cer.	ceramic	m	milli or 10^{-3}
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	Poly.	polystyrene
EMT	electrolytic, metal tubular	Prec.	precision
f	farad	PT	paper tubular
h	henry	Tub.	tubular
k	kilohm or 10^3 ohms	v	working volts dc
meg	megohm or 10^6 ohms	Var.	variable
μ	micro or 10^{-6}	w	watt
μμ	micromicro or 10^{-12}	WW	wire wound

GMV guaranteed minimum value

MULTIVIBRATOR AND SWEEP GENERATOR

Bulbs

B270	Type NE-2 Neon Bulb	150002

Capacitors

C218	.01 μf	PT	Fixed	400 v	20%	285510
C219	.01 μf	PT	Fixed	400 v	20%	285510
C220	½ 2x20 μf	EMC	Fixed	450 v	—20% +50% (with C412)	290037
C221	22 μμf	Cer.	Fixed	500 v	20% (Selected —0 to +20%)	295002
C222	150 μμf	Mica	Fixed	500 v	10%	283508
C223	.0015 μf	PT	Fixed	400 v	—2% +20%	285504
C224	.015 μf	PT	Fixed	400 v	—2% +20%	285512
C225	.15 μf	PT	Fixed	400 v	—2% +20%	285532
C226	47 μμf	Cer.	Fixed	500 v	20%	281518
C228	47 μμf	Cer.	Fixed	500 v	20%	281518
C229	8 μμf	Cer.	Fixed	500 v	20%	281503
C230	.047 μf	PT	Fixed	400 v	20%	285519
C231A	7-45 μμf	Cer.	Var.	500 v		281012
C231B	22 μμf	Cer.	Fixed	500 v	20%	281510
C232	.001 μf	Special				291017
C235A	.01 μf	Special timing series manufactured by Tektronix. Order replacements from factory.				291002
C235B	.1 μf					
C235C	1 μf					
C236	2x20 μf	EMC	Fixed	450 v	—20% +50% (½ unused)	290037
C237	.47 μf	PTM	Fixed	400 v	20%	285562
C238	.001 μf	Cer.	Fixed	500 v	GMV	283000
C241	.047 μf	PT	Fixed	400 v	20%	285519
C242	1 μf	PMC	Fixed	400 v	20%	285542
C267	.01 μf	Cer.	Fixed	500 v	GMV	283002

Inductors

L202	100 μh	Fixed	CF104	108002

Resistors

R235	470 k	½ w	Fixed	Comp.	10%	302474
R236	47 Ω	½ w	Fixed	Comp.	10%	302470
R237	470 Ω	½ w	Fixed	Comp.	10%	302471
R238	10 k	2 w	Fixed	Comp.	10%	306103
R239	390 Ω	½ w	Fixed	Comp.	10%	302391
R240	4.7 k	2 w	Fixed	Comp.	10%	306472
R241	4.7 k	2 w	Fixed	Comp.	10%	306472
R242	500 k	2 w	Var. Dual	Comp.	20% AMPLITUDE GANGED WITH R286	311037
R243	1.5 meg	½ w	Fixed	Comp.	10%	302155
R244	1 k	½ w	Fixed	Comp.	10%	302102

Resistors (Continued)

R245	33 k	2 w	Fixed	Comp.	10%		306333
R246	47 Ω	½ w	Fixed	Comp.	10%		302470
R247	220 k	½ w	Fixed	Comp.	10%		302224
R248	100 k	½ w	Fixed	Comp.	10%		302104
R249	100 k	2 w	Var. Dual	Comp.	20%	STABILITY GANGED WITH R278	311028
R250	47 Ω	½ w	Fixed	Comp.	10%		302470
R251	220 k	1 w	Fixed	Comp.	10%		304224
R252	2.2 k	2 w	Fixed	Comp.	10%		306222
R253	2.7 k	2 w	Fixed	Comp.	10%		306272
R254	500 k	½ w	Fixed	Prec.	1%		309003
R255	500 k	½ w	Fixed	Prec.	1%		309003
R256	6.8 k	½ w	Fixed	Comp.	10%		302682
R257	4.7 k	2 w	Fixed	Comp.	10%		306472
R258	47 Ω	½ w	Fixed	Comp.	10%		302470
R260	100 k	1 w	Fixed	Comp.	10%		304104
R261	470 k	½ w	Fixed	Comp.	10%		302474
R262	10 k	1 w	Fixed	Comp.	10%		304103
R263	120 k	½ w	Fixed	Comp.	10%		302124
R264	150 k	½ w	Fixed	Comp.	10%		302154
R265	47 Ω	½ w	Fixed	Comp.	10%		302470
R266	10 k	1 w	Fixed	Comp.	10%		304103
R267	180 k	½ w	Fixed	Comp.	10%		302184
R268	500 k	2 w	Var.	Comp.	20%	ASTIGMATISM	311034
R269	330 k	1 w	Fixed	Comp.	10%		304334
R270	10 k	2 w	Fixed	Comp.	10%		306103
R271	10 k	2 w	Fixed	Comp.	10%		306103
R272	15 meg	½ w	Fixed	Comp.	10%		302156
R273	22 meg	½ w	Fixed	Comp.	10%		302226
R274	1.5 k	½ w	Fixed	Comp.	10%		302152
R276	22 meg	½ w	Fixed	Comp.	10%		302226
R277	10 meg	½ w	Fixed	Comp.	10%		302106
R278	100 k	2 w	Var. Dual	Comp.	20%	SWEEP ATTEN. GANGED WITH R249	311028
R279	100 Ω	½ w	Fixed	Comp.	10%		302101
R280	1 meg	½ w	Fixed	Comp.	10%		302105
R281	27 k	2 w	Fixed	Comp.	10%		306273
R282	10 k	1 w	Fixed	Comp.	10%		304103
R285	220 k	½ w	Fixed	Comp.	10%		302224
R286	20 k	2 w	Var. Dual	Comp.	20%	INT. 60 ~ SWEEP PHASE GANGED WITH R242	311037
R289	3.3 meg	½ w	Fixed	Comp.	10%		302335
R290A-J	220 k	½ w	Fixed	Comp.	10%		302224
R291	220 k	2 w	Var. Dual	Comp.	10%	TIME MULT.*	312103
R292A-J	200 k	½ w	Fixed	Prec.	1%		309051
R293	220 k	2 w	Var. Dual	Comp.	10%	TIME MULT.**	312103
R294	200 k	2 w	Fixed	Prec.	1%		310501

*R291 Special, combined with R293 and calibrated dial.

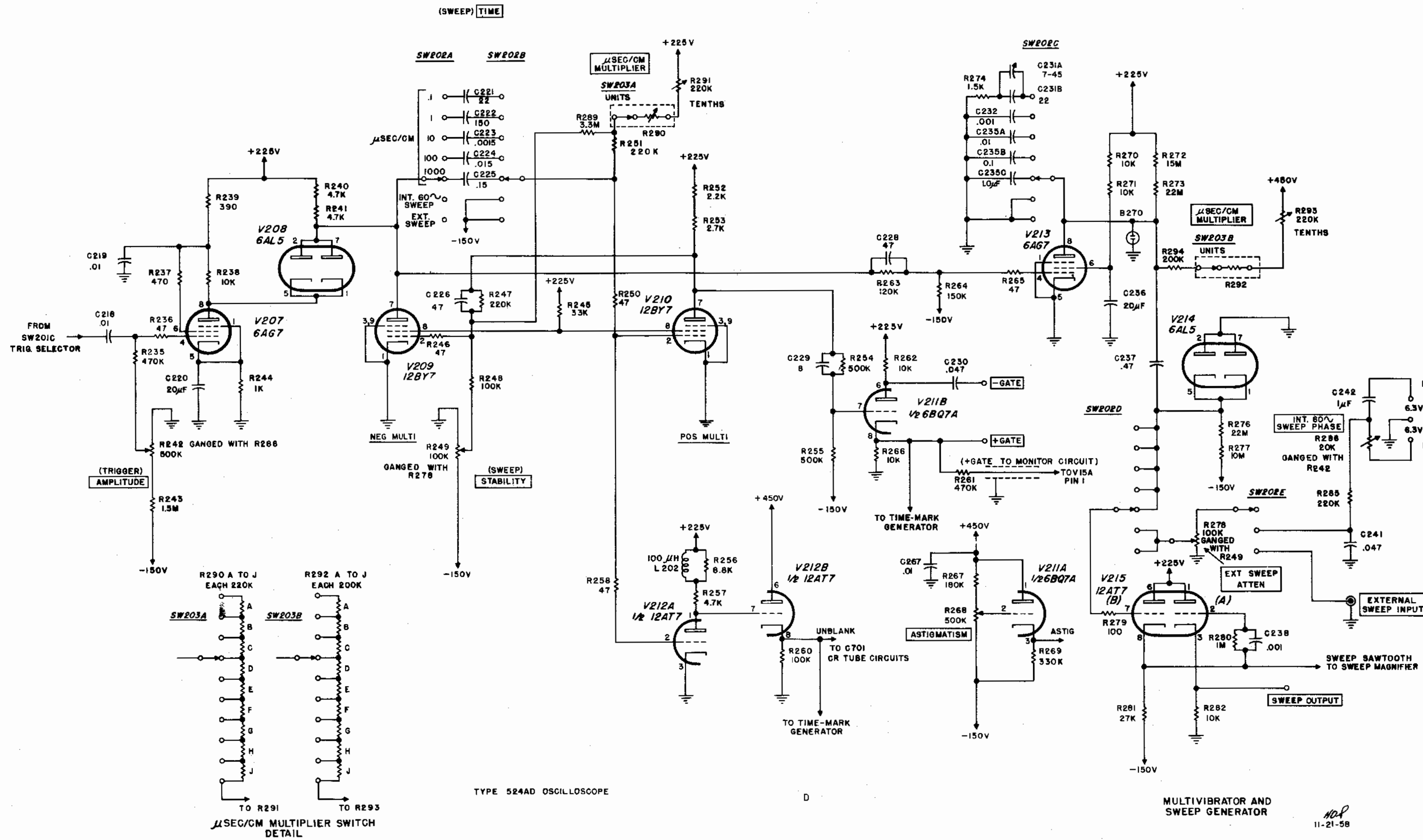
**R293 Special, combined with R291 and calibrated dial.

Switches

					not wired	wired
SW201A,B,C	3-wafer	10 Position	Rotary	SELECTOR	260041	—
SW202A,B,E	2-wafer	7 Position	Rotary	TIME (front)	260050	262048
SW202C,D	2-wafer	7 Position	Rotary	TIME (rear)	260051	262049
SW203A,B	2-wafer	10 Position	Rotary	TIME MULTIPLIER	260035	262050

Vacuum Tubes

V207	6AG7	Trigger Amplifier	154012
V208	6AL5	Trigger Coupling Diode	154016
V209	12BY7	Sweep Multivibrator Negative	154047
V210	12BY7	Sweep Multivibrator Positive	154047
V211A	½ 6BQ7A	Astigmatism Cathode Follower	154028
V211B	½ 6BQ7A	Gate Output Amplifier	
V212A	½ 12AT7	Unblanking Pulse Amplifier and Inverter	154039
V212B	½ 12AT7	Unblanking Pulse Cathode Follower	
V213	6AG7	Sweep Generator Clamp	154012
V214	6AL5	Sweep DC Restorer	154016
V215A	½ 12AT7	Cathode Follower	154039
V215B	½ 12AT7	Sweep Generator Cathode Follower	



TYPE 524AD OSCILLOSCOPE

D

MULTIVIBRATOR AND SWEEP GENERATOR

11-21-58

ABBREVIATIONS

Cer.	ceramic	m	milli or 10^{-3}
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	Poly.	polystyrene
EMT	electrolytic, metal tubular	Prec.	precision
f	farad	PT	paper tubular
h	henry	Tub.	tubular
k	kilohm or 10^3 ohms	v	working volts dc
meg	megohm or 10^6 ohms	Var.	variable
μ	micro or 10^{-6}	w	watt
μμ	micromicro or 10^{-12}	WW	wire wound

GMV guaranteed minimum value

SWEEP OUTPUT AMPLIFIER AND MAGNIFIER

Bulbs

B338	Type NE-2 Neon Bulb	150002
B346	Type NE-2 Neon Bulb	150002
B351	Type NE-2 Neon Bulb	150002
B352	Type NE-2 Neon Bulb	150002
B357	Type NE-2 Neon Bulb	150002
B358	Type NE-2 Neon Bulb	150002

Capacitors

C301	7-45 μμf	Cer.	Var.	500 v		281012
C302A	2.2 μμf	Cer.	Fixed	500 v	±.5 μμf	281500
C302B	3-12 μμf	Cer.	Var.	500 v		281007
C302C	7-45 μμf	Cer.	Var.	500 v		281012
C303	22 μμf	Cer.	Fixed	500 v	20%	281510
C304	.01 μf	Cer.	Fixed	500 v	GMV	283002
C305A	7-45 μμf	Cer.	Var.	500 v		281012
C305B	12 μμf	Cer.	Fixed	500 v	10%	281505
C306	82 μμf	Cer.	Fixed	500 v	10%	281528
C307	.01 μf	PT	Fixed	400 v	20%	285510
C308	.01 μf	PT	Fixed	400 v	20%	285510

Resistors

R301	31.1 k	½ w	Fixed	Prec.	1%	309037
R302	100 k	2 w	Fixed	Comp.	10%	306104
R303	30 k	3 w	Var.	WW	5% HELIPOT, HOR. POSITION	311021
R304	22 k	2 w	Fixed	Comp.	10%	306223
R305	180 k	½ w	Fixed	Comp.	10%	302184
R306	68 k	1 w	Fixed	Comp.	10%	304683
R307	100 k	½ w	Fixed	Comp.	10%	302104
R308	330 k	½ w	Fixed	Comp.	10%	302334
R309	120 k	½ w	Fixed	Comp.	10%	302124
R310A	31.1 k	½ w	Fixed	Prec.	1%	309037
R310B	95 k	½ w	Fixed	Prec.	1%	309044
R310C	355 k	½ w	Fixed	Prec.	1%	309054
R315	360 k	½ w	Fixed	Comp.	5%	301364
R316	2.7 k	½ w	Fixed	Comp.	10%	302272
R317	22 k	2 w	Fixed	Comp.	10%	306223
R318	150 k	½ w	Fixed	Comp.	5%	301154
R319	47 Ω	½ w	Fixed	Comp.	10%	302470
R320	180 Ω	½ w	Fixed	Comp.	10%	302181
R324	10 k	10 w	Fixed	WW	5%	308023
R325	2 k	2 w	Var.	Comp.	20% SWEEP AMP CURRENT ADJ.	311008

Resistors (Continued)

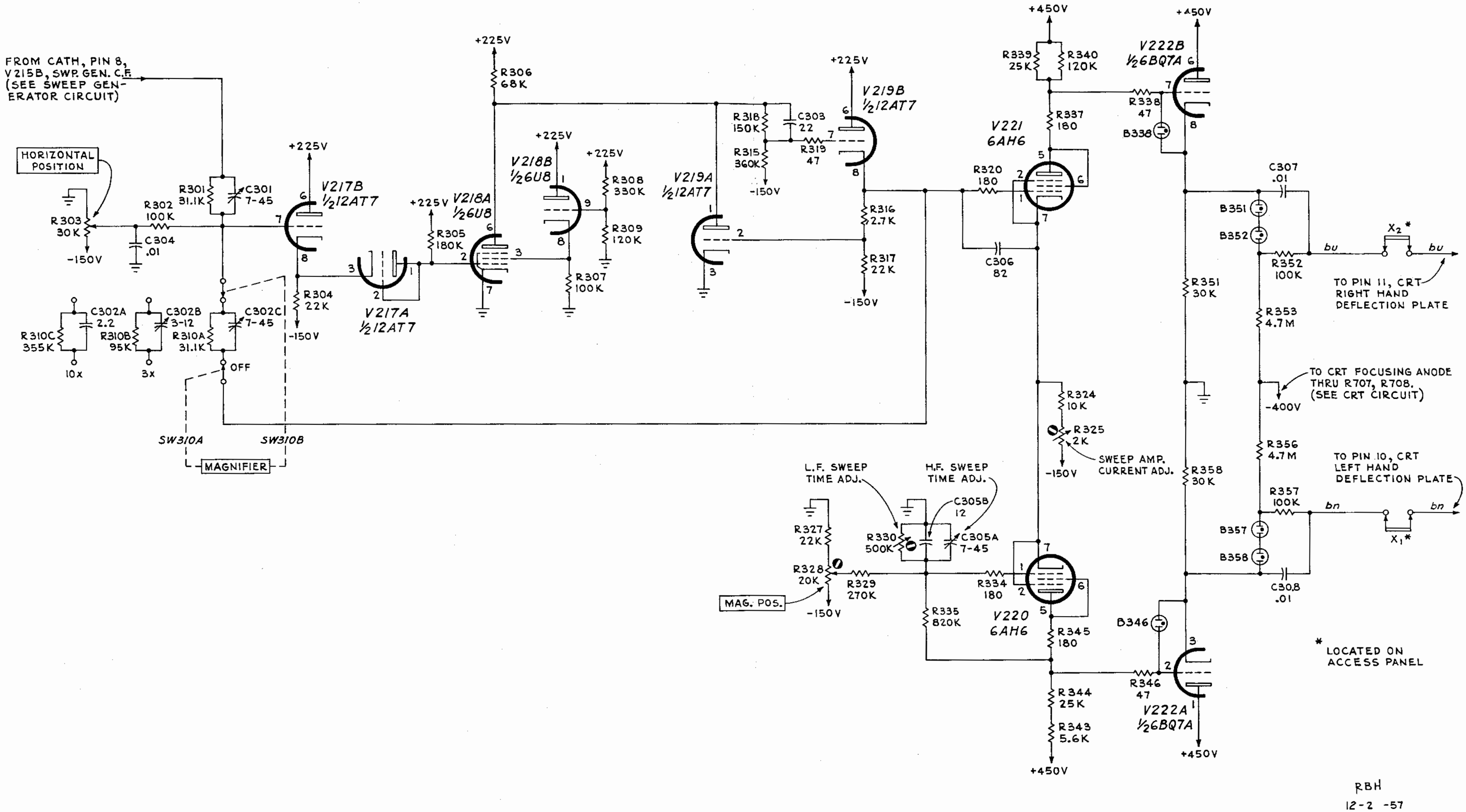
R327	22 k	1 w	Fixed	Comp.	10%		304223
R328	20 k	2 w	Var.	Comp.	20%	MAG. POS.	311018
R329	270 k	½ w	Fixed	Comp.	10%		302274
R330	500 k	2 w	Var.	Comp.	20%	L. F. SWEEP TIME ADJ.	311034
R334	180 Ω	½ w	Fixed	Comp.	10%		302181
R335	820 k	½ w	Fixed	Comp.	10%		302824
R337	180 Ω	½ w	Fixed	Comp.	10%		302181
R338	47 Ω	½ w	Fixed	Comp.	10%		302470
R339	25 k	10 w	Fixed	WW	5%		308026
R340	120 k	2 w	Fixed	Comp.	10%		306124
R343	5.6 k	2 w	Fixed	Comp.	10%		306562
R344	25 k	10 w	Fixed	WW	5%		308026
R345	180 Ω	½ w	Fixed	Comp.	10%		302181
R346	47 Ω	½ w	Fixed	Comp.	10%		302470
R351	30 k	10 w	Fixed	WW	5%		308027
R352	100 k	½ w	Fixed	Comp.	10%		302104
R353	4.7 meg	2 w	Fixed	Comp.	10%		306475
R356	4.7 meg	2 w	Fixed	Comp.	10%		306475
R357	100 k	½ w	Fixed	Comp.	10%		302104
R358	30 k	10 w	Fixed	WW	5%		308027

Switches

					not wired	wired
SW301A,B	2-wafer	3 Position	Rotary	MAGNIFIER	260027	262051

Vacuum Tubes

V217A	½ 12AT7	Magnifier Coupling Diode	154039
V217B	½ 12AT7	Magnifier Amplifier Cathode Follower	
V218A	½ 6U8	Magnifier Amplifier	154033
V218B	½ 6U8	V218A Screen Supply Cathode Follower	
V219A	½ 12AT7	Sweep Clamp	154039
V219B	½ 12AT7	Magnifier Output Cathode Follower	
V220	6AH6	Sweep Amplifier D2	154013
V221	6AH6	Sweep Amplifier D1	154013
V222A	½ 6BQ7	Sweep Output Cathode Follower D2	154028
V222B	½ 6BQ7	Sweep Output Cathode Follower D1	


FROM CATH, PIN 8, V215B, SWP. GEN. C.F. (SEE SWEEP GENERATOR CIRCUIT)
HORIZONTAL POSITION
R303 30K
-150V
R302 100K
C304 .01
R301 31.1K
C301 7-45
+225V
V217B 1/2 12AT7
R304 22K
-150V
V217A 1/2 12AT7
+225V
R305 180K
V218A 1/2 6U8
R306 68K
+225V
V218B 1/2 6U8
R308 330K
R309 120K
R307 100K
V219A 1/2 12AT7
R318 150K
C303 22
R315 360K
R319 47
-150V
V219B 1/2 12AT7
R316 2.7K
R317 22K
-150V
C302A 2.2
C302B 3-12
C302C 7-45
R310C 355K
R310B 95K
R310A 31.1K
10x
3x
OFF
SW310A
SW310B
MAGNIFIER
+450V
R339 25K
R340 120K
R337 180
V221 6AH6
R320 180
C306 82
R324 10K
R325 2K
-150V
SWEEP AMP. CURRENT ADJ.
V222B 1/2 6BQ7A
R338 47
B338
C307 .01
B351
B352
R352 100K
R351 30K
R353 4.7M
TO PIN 11, CRT RIGHT HAND DEFLECTION PLATE
TO CRT FOCUSING ANODE THRU R707, R708. (SEE CRT CIRCUIT)
-400V
R356 4.7M
R358 30K
TO PIN 10, CRT LEFT HAND DEFLECTION PLATE
R357 100K
B357
B358
C308 .01
bu
bn
X2*
X1*
L.F. SWEEP TIME ADJ.
H.F. SWEEP TIME ADJ.
C305B 12
C305A 7-45
R327 22K
R330 500K
R328 20K
R329 270K
MAG. POS.
-150V
R334 180
R335 820K
V220 6AH6
R345 180
R344 25K
R343 5.6K
+450V
B346
R346 47
V222A 1/2 6BQ7A
+450V
* LOCATED ON ACCESS PANEL
RBH
12-2 -57

ABBREVIATIONS

Cer.	ceramic	m	milli or 10^{-3}
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	Poly.	polystyrene
EMT	electrolytic, metal tubular	Prec.	precision
f	farad	PT	paper tubular
h	henry	Tub.	tubular
k	kilohm or 10^3 ohms	v	working volts dc
meg	megohm or 10^6 ohms	Var.	variable
μ	micro or 10^{-6}	w	watt
μμ	micromicro or 10^{-12}	WW	wire wound

GMV guaranteed minimum value

TIME MARK GENERATOR

Capacitors

C602A	½ 2x15 μf	EMC	Fixed	450 v	—20% +50%	290035
C602B	½ 2x15 μf	EMC	Fixed	450 v	—20% +50%	
C604	100 μμf	Mica	Fixed	500 v	10%	283505
C605	47 μμf	Cer.	Fixed	500 v	20%	281519
C606	470 μμf	Mica	Fixed	500 v	10%	283522
C607	470 μμf	Mica	Fixed	500 v	10%	283522
C608	22 μμf	Cer.	Fixed	500 v	20%	281511
C609	.01 μf	Cer.	Fixed	500 v	GMV	283002
C610	470 μμf	Cer.	Fixed	500 v	20%	281525
C611	.01 μf	Cer.	Fixed	500 v	GMV	283002
C615	220 μμf	Mica	Fixed	500 v	10%	283536
C616	750 μμf	Mica	Fixed	500 v	5%	283524
C622	4.7 μμf	Cer.	Fixed	500 v	±1 μμf	281501
C623	4.7 μμf	Cer.	Fixed	500 v	±1 μμf	281501
C630	.047 μf	PT	Fixed	400 v	20%	285519
C631	7 μμf	Cer.	Fixed	500 v	±¼ μμf	281502

Inductors

L601	2.6-4.8 μh	Var.	CV272	114011
L602	11-19 μh	Var.	CV113	114001
L603	220-330 μh	Var.	CV224	114008
L604	32-56 μh	Var.	CV323	114015
L605	4.9 μh	Fixed	CF492	108017
L606	22 μh	Fixed	CF223	108014
L607	4.9 μh	Fixed	CF492	108017
L608	320-500 μh	Var.	CV324	114016

Resistors

R602	47 Ω	½ w	Fixed	Comp.	10%	302470
R603	220 Ω	½ w	Fixed	Comp.	10%	302221
R604	220 Ω	½ w	Fixed	Comp.	10%	302221
R605	820 Ω	½ w	Fixed	Comp.	10%	302821
R606	560 Ω	½ w	Fixed	Comp.	10%	302561
R607	330 k	½ w	Fixed	Comp.	10%	302334
R608	820 Ω	½ w	Fixed	Comp.	10%	302821
R609	330 k	½ w	Fixed	Comp.	10%	302334
R610	50 k	2 w	Var.	Comp.	20% AMPLITUDE	311023
R611	10 k	½ w	Fixed	Comp.	10%	302103
R612	560 Ω	½ w	Fixed	Comp.	10%	302561
R613	1 meg	½ w	Fixed	Comp.	10%	302105
R614	27 Ω	½ w	Fixed	Comp.	10%	302270

Resistors (continued)

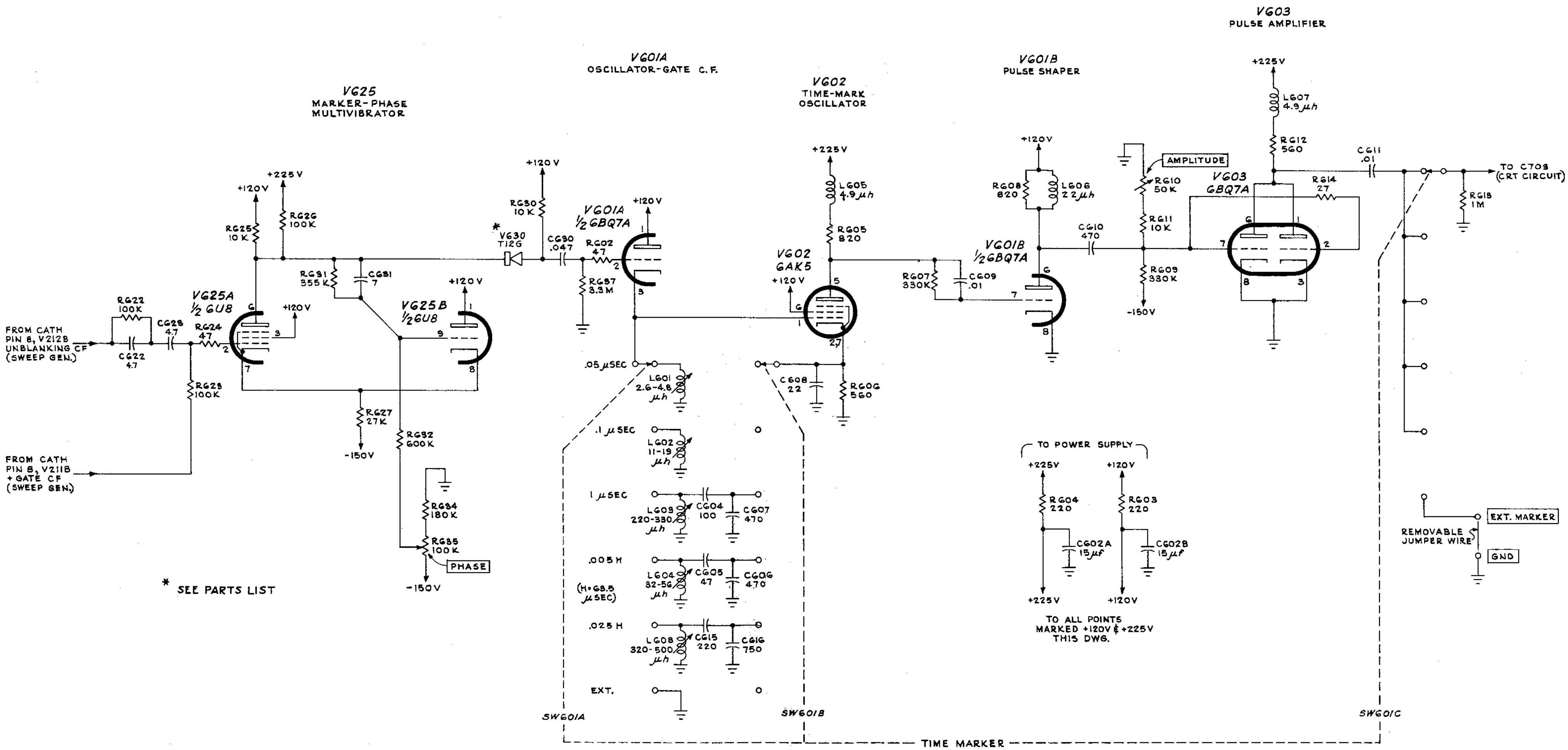
R622	100 k	½ w	Fixed	Comp.	10%	302104
R623	100 k	½ w	Fixed	Comp.	10%	302104
R624	47 Ω	½ w	Fixed	Comp.	10%	302470
R625	10 k	½ w	Fixed	Comp.	10%	302103
R626	100 k	½ w	Fixed	Comp.	10%	302104
R627	27 k	2 w	Fixed	Comp.	10%	306273
R630	10 k	½ w	Fixed	Comp.	10%	302103
R631	355 k	½ w	Fixed	Prec.	1%	309054
R632	600 k	½ w	Fixed	Prec.	1%	309004
R634	180 k	½ w	Fixed	Comp.	10%	302184
R635	100 k	2 w	Var.	Comp.	20% PHASE	311026
R637	3.3 meg	½ w	Fixed	Comp.	10%	302335

Switches

SW601A,B,C	3-wafer	6 position	Rotary	TIME MARKER	260103

Vacuum Tubes

V601A	½ 6BQ7	Time Marker Osc. Unclamping Cathode Follower	154028
V601B	½ 6BQ7	Time Marker Pulse Shaper	
V602	6AK5	Time Marker Oscillator	154014
V603	6BQ7	Time Marker Pulse Amplifier	154028
V625	6U8	Marker-Phase Multivibrator	154033
V630	T12G	Germanium Diode	152008



9-18-59

TYPE 524AD CATHODE-RAY OSCILLOSCOPE

E

TIME-MARK GENERATOR

ABBREVIATIONS

Cer.	ceramic	m	milli or 10^{-3}
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	Poly.	polystyrene
EMT	electrolytic, metal tubular	Prec.	precision
f	farad	PT	paper tubular
h	henry	Tub.	tubular
k	kilohm or 10^3 ohms	v	working volts dc
meg	megohm or 10^6 ohms	Var.	variable
µ	micro or 10^{-6}	w	watt
µµ	micromicro or 10^{-12}	WW	wire wound

GMV guaranteed minimum value

PREAMPLIFIER

Capacitors

C1	.5-5 µµf	Cer.	Var.	500 v		281001
C2	275 µf	EMC	Fixed	6 v		290020
C3	½ 2x20 µf	EMC	Fixed	450 v	—20% +50% (with C4)	290037
C4	½ 2x20 µf	EMC	Fixed	450 v	—20% +50% (with C3)	
C5	½ 2x20 µf	EMC	Fixed	450 v	—20% +50% (with C6)	290037
C6	½ 2x20 µf	EMC	Fixed	450 v	—20% +50% (with C5)	
C7	.1 µf	PT	Fixed	400 v	20%	285526
C8	.1 µf	PT	Fixed	400 v	20%	285526
C11	.047 µf	PT	Fixed	400 v	20%	285519
C13	1.5 µµf	Cer.	Fixed	500 v		281526
C101	3-12 µµf	Cer.	Var.	500 v		281007
C102	3-12 µµf	Cer.	Var.	500 v		281007
C103	3-12 µµf	Cer.	Var.	500 v		281007
C104	3-12 µµf	Cer.	Var.	500 v		281007
C105	4.5-25 µµf	Cer.	Var.	500 v		281010
C106	1.5-7 µµf	Cer.	Var.	500 v		281005
C107	27 µµf	Cer.	Fixed	500 v	10%	281512
C111	4.5-25 µµf	Cer.	Var.	500 v		281010
C112	1.5-7 µµf	Cer.	Var.	500 v		281005
C113	330 µµf	Cer.	Fixed	500 v	20% (Selected 0 to +20%)	295010
C127	.1 µf	PT	Fixed	600 v	20%	285528
C128	.001 µf	Cer.	Fixed	500 v	GMV	283000
C136	.7-3 µµf	Tub.	Var.	500 v		281027

Inductors

L1	1.3-2.2 µh	Var.	CV132	114003
L2	2.2-4.4 µh	Var.	CV222	114007
L3	.92-1.5 µh	Var.	CV921	114028

Resistors

R1	1 meg	½ w	Fixed	Prec.	1%	309014
R2	47 Ω	½ w	Fixed	Comp.	10%	302470
R3	220 Ω	½ w	Fixed	Comp.	10%	302221
R4	18 k	2 w	Fixed	Comp.	10%	306183
R5	1 k	½ w	Fixed	Comp.	5%	301102
R6	33 k	1 w	Fixed	Comp.	10%	304333
R7	27 Ω	½ w	Fixed	Comp.	10%	302270
R8	18 k	2 w	Fixed	Comp.	10%	306183
R9	330 k	½ w	Fixed	Comp.	10%	302334
R10	1 meg	2 w	Var.	Comp.	10% L. F. ADJ.	311039

Resistors (Continued)

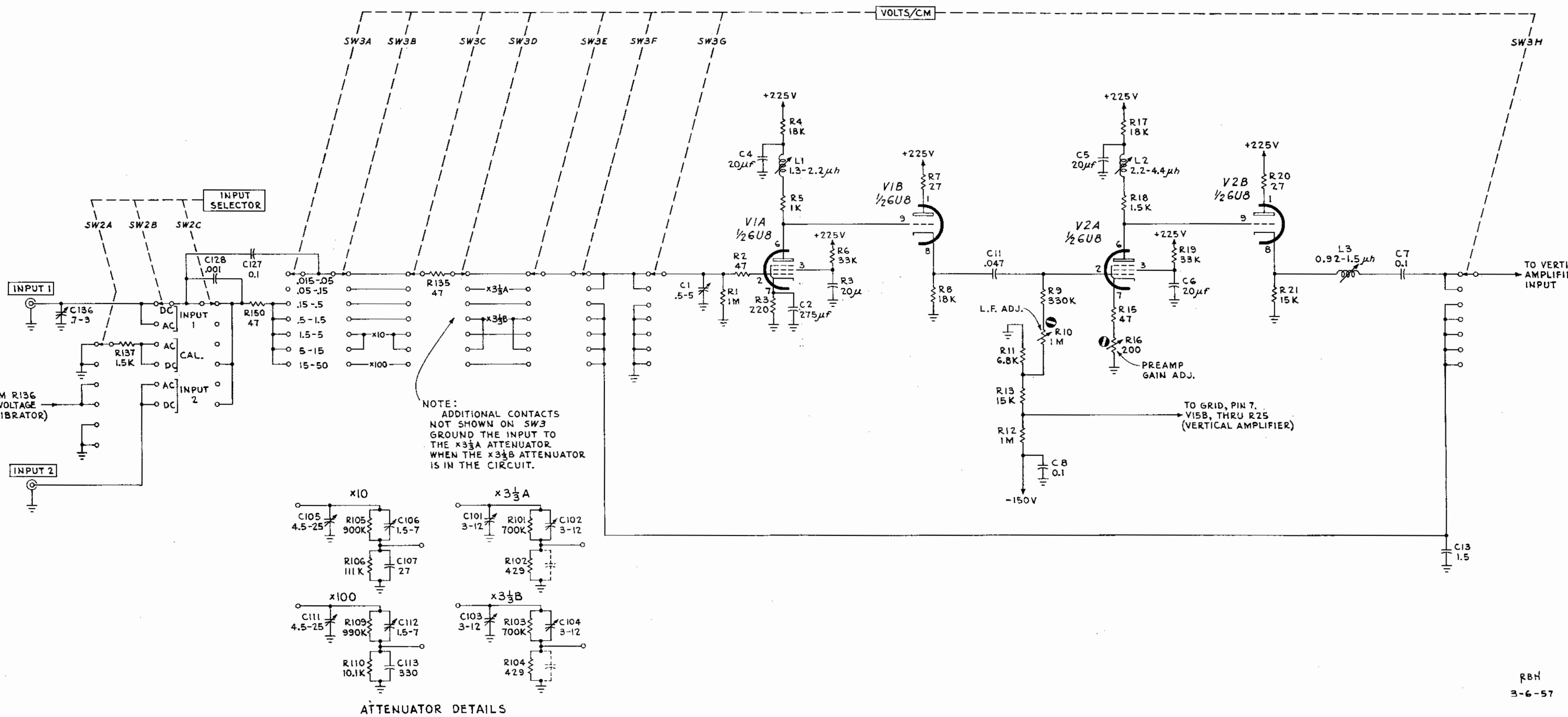
R11	6.8 k	½ w	Fixed	Comp.	10%	302682
R12	1 meg	½ w	Fixed	Comp.	10%	302105
R13	15 k	½ w	Fixed	Comp.	10%	302153
R15	47 Ω	½ w	Fixed	Comp.	10%	302470
R16	200 Ω	2 w	Var.	Comp.	20% PREAMP GAIN	311004
R17	18 k	2 w	Fixed	Comp.	10%	306183
R18	1.5 k	½ w	Fixed	Comp.	5%	301152
R19	33 k	1 w	Fixed	Comp.	10%	304333
R20	27 Ω	½ w	Fixed	Comp.	10%	302270
R21	15 k	2 w	Fixed	Comp.	10%	306153
R101	700 k	½ w	Fixed	Prec.	1%	309008
R102	429 k	½ w	Fixed	Prec.	1%	309170
R103	700 k	½ w	Fixed	Prec.	1%	309008
R104	429 k	½ w	Fixed	Prec.	1%	309170
R105	900 k	½ w	Fixed	Prec.	1%	309111
R106	111 k	½ w	Fixed	Prec.	1%	309046
R109	990 k	½ w	Fixed	Prec.	1%	309013
R110	10.1 k	½ w	Fixed	Prec.	1%	309034
R135	47 Ω	½ w	Fixed	Comp.	10%	302470
R137	1.5 k	½ w	Fixed	Comp.	10%	302152
R150	47 Ω	½ w	Fixed	Comp.	10%	302470

Switches

					not wired	wired
SW2A,B,C	2-wafer	6 position	Rotary	INPUT SELECTOR	260112	262096
SW3A,B,C,D E,F,G	6-wafer	7 position	Rotary	VOLTS/CM	260170	262131

Vacuum Tubes

V1A	½ 6U8	First Stage Preamplifier	154033
V1B	½ 6U8	Cathode Follower	
V2A	½ 6U8	Second Stage Preamplifier	154033
V2B	½ 6U8	Cathode Follower	


VOLTS/CM
SW3A SW3B SW3C SW3D SW3E SW3F SW3G SW3H
INPUT SELECTOR
SW2A SW2B SW2C
INPUT 1
INPUT 2
C136 .7-3
C128 .001
C127 0.1
R150 47
R137 1.5K
FROM R136 CAL.VOLTAGE (CALIBRATOR)
DC AC INPUT 1
AC DC CAL.
AC DC INPUT 2
.015-.05
.05-.15
.15-.5
.5-1.5
1.5-5
5-15
15-50
x10
x100
R135 47
x3⅓A
x3⅓B
NOTE: ADDITIONAL CONTACTS NOT SHOWN ON SW3 GROUND THE INPUT TO THE x3⅓A ATTENUATOR WHEN THE x3⅓B ATTENUATOR IS IN THE CIRCUIT.
C1 .5-5
R1 1M
R2 47
V1A ½6U8
+225V
R4 18K
C4 20μf
L1 1.3-2.2μh
R5 1K
R6 33K
R3 20μ
R3 220
C2 275μf
V1B ½6U8
R7 27
R8 18K
C11 .047
R9 330K
L.F. ADJ.
R10 1M
R11 6.8K
R13 15K
R12 1M
C8 0.1
-150V
TO GRID, PIN 7, V15B, THRU R25 (VERTICAL AMPLIFIER)
V2A ½6U8
R17 18K
C5 20μf
L2 2.2-4.4μh
R18 1.5K
R19 33K
C6 20μf
R15 47
R16 200
PREAMP GAIN ADJ.
V2B ½6U8
R20 27
R21 15K
L3 0.92-1.5μh
C7 0.1
TO VERTICAL AMPLIFIER INPUT
C13 1.5
C105 4.5-25
R105 900K
C106 1.5-7
R106 111K
C107 27
C111 4.5-25
R109 990K
C112 1.5-7
R110 10.1K
C113 330
C101 3-12
R101 700K
C102 3-12
R102 429
C103 3-12
R103 700K
C104 3-12
R104 429
ATTENUATOR DETAILS
RBH
3-6-57

ABBREVIATIONS

Cer.	ceramic	m	milli or 10^{-3}
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	Poly.	polystyrene
EMT	electrolytic, metal tubular	Prec.	precision
f	farad	PT	paper tubular
h	henry	Tub.	tubular
k	kilohm or 10^3 ohms	v	working volts dc
meg	megohm or 10^6 ohms	Var.	variable
μ	micro or 10^{-6}	w	watt
μμ	micromicro or 10^{-12}	WW	wire wound

GMV guaranteed minimum value

CALIBRATOR

Capacitors

C124	.01 μf	Cer.	Fixed	500 v	GMV	283002
C125	360 μμf	Mica	Fixed	500 v	5%	283519
C126	360 μμf	Mica	Fixed	500 v	5%	283519

Resistors

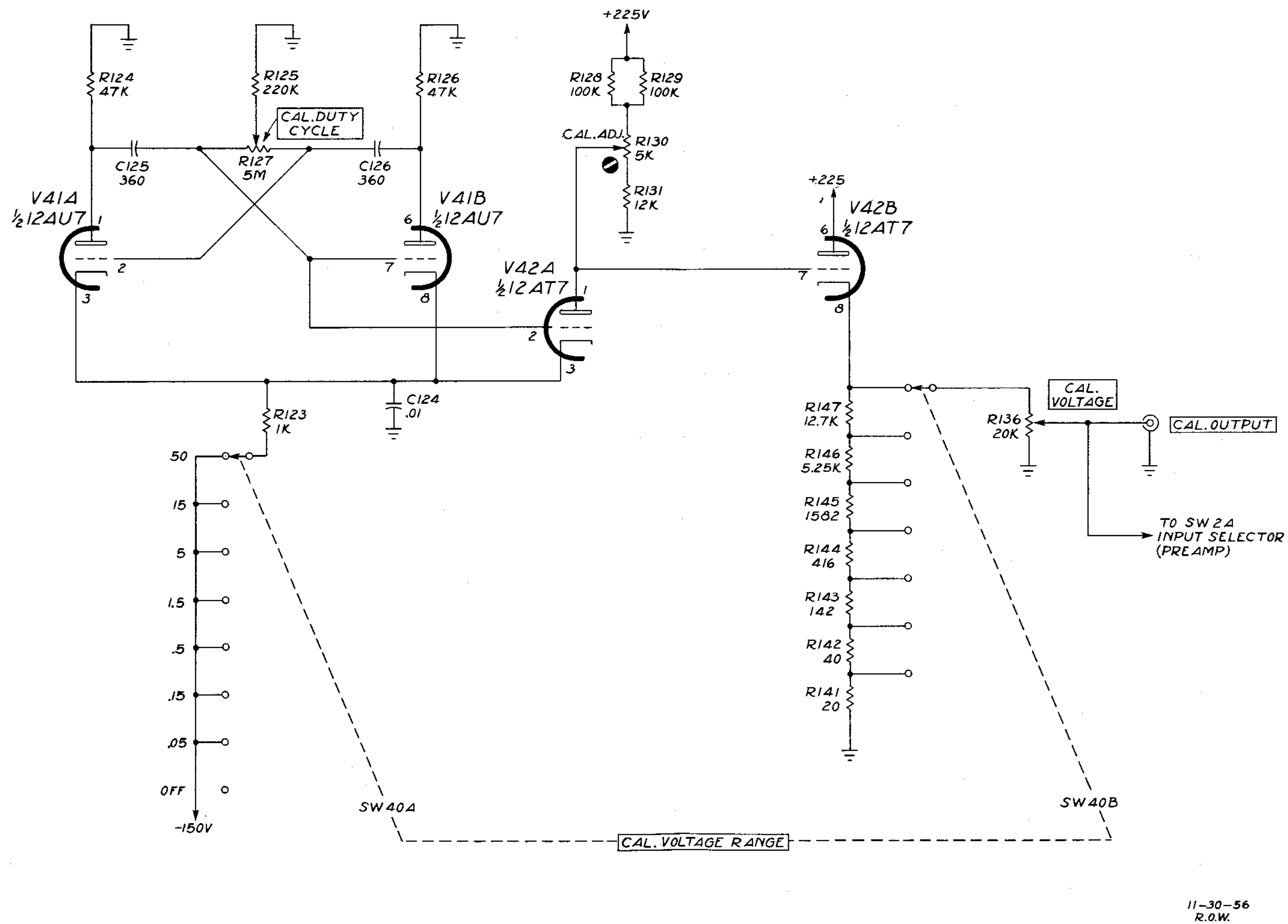
R123	1 k	½ w	Fixed	Comp.	10%	302102
R124	47 k	1 w	Fixed	Comp.	10%	304473
R125	220 k	½ w	Fixed	Comp.	10%	302224
R126	47 k	1 w	Fixed	Comp.	10%	304473
R127	5.0 meg	2 w	Var.	Comp.	20% CAL. DUTY CYCLE	311044
R128	100 k	2 w	Fixed	Comp.	10%	306104
R129	100 k	2 w	Fixed	Comp.	10%	306104
R130	5 k	2 w	Var.	WW	10% CAL. ADJ.	311012
R131	12 k	1 w	Fixed	Comp.	10%	304123
R136	20 k	3 w	Var.	WW	5% (Selected ±2%) CAL. VOLTAGE	312003
R141	20 Ω	½ w	Fixed	Prec.	1%	309064
R142	40 Ω	½ w	Fixed	Prec.	1%	309066
R143	142 Ω	½ w	Fixed	Prec.	1%	309071
R144	416 Ω	½ w	Fixed	Prec.	1%	309079
R145	1582 Ω	½ w	Fixed	Prec.	1%	309029
R146	5.25 k	½ w	Fixed	Prec.	1%	309032
R147	12.7 k	½ w	Fixed	Prec.	1%	309122

Switches

					not wired	wired
SW40	2-wafer	8 position	Rotary	CAL. VOLTAGE RANGE	260111	262095

Vacuum Tubes

V41A,B	12AU7	Calibrator Multivibrator	154041
V42A	½ 12AT7	Calibrator Amplifier	154039
V42B	½ 12AT7	Calibrator Output Cathode Follower	



TYPE 524 AD OSCILLOSCOPE

A

CALIBRATOR

ABBREVIATIONS

Cer.	ceramic	m	milli or 10^{-3}
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	Poly.	polystyrene
EMT	electrolytic, metal tubular	Prec.	precision
f	farad	PT	paper tubular
h	henry	Tub.	tubular
k	kilohm or 10^3 ohms	v	working volts dc
meg	megohm or 10^6 ohms	Var.	variable
μ	micro or 10^{-6}	w	watt
μμ	micromicro or 10^{-12}	WW	wire wound

GMV guaranteed minimum value

DELAY LINE

Bulbs

~~B77~~	~~Neon, Type NE-2~~	~~150002~~
~~B78~~	~~Neon, Type NE-2~~	~~150002~~

Capacitors

C501-C524	1.5-7 μμf	Cer.	Var.	500 v		281005
C501A	2.7 μμf	Cer.	Fixed	500 v	10%	281547
C502A	8 μμf	Cer.	Fixed	500 v	10%	281503
C503A-C506A	10 μμf	Cer.	Fixed	500 v	10%	281504
C507A-C523A	12 μμf	Cer.	Fixed	500 v	10%	281506
C525	.5-5 μμf	Poly.	Var.	500 v		281001
C526	.1 μf	PT	Fixed	400 v	20%	285526

Inductors

L501-L506	6.2 μh each 44 turns #32, on one rod	FC524DL	108048
L507-L512	6.2 μh each 44 turns #32, on one rod	FC524DL	108048
L513-L518	6.2 μh each 44 turns #32, on one rod	FC524DL	108048
L519-L523	6.2 μh each 44 turns #32, on one rod	FC524DL2	108049
L524	7 μh 46 turns #33, on end of rod with L519-L523		
L525	.79-1.5 μh Var.	CV 791	114025

Resistors

R501	570 Ω	1 w	Fixed	Prec.	1%	310091

VERTICAL AMPLIFIER

Capacitors

C10	.01 μf	Cer.	Fixed	500 v	GMV	283002
C12	.005 μf	Cer.	Fixed	500 v	GMV	283001
C15	.005 μf	Cer.	Fixed	500 v	GMV	283001
C16	.005 μf	Cer.	Fixed	500 v	GMV	283001
C18	.01 μf	PT	Fixed	400 v	20%	285510
C19	.005 μf	Cer.	Fixed	500 v	GMV	283001
C20	.005 μf	Cer.	Fixed	500 v	GMV	283001
C22	½ 2x20 μf	EMC	Fixed	450 v	—20% +50% (with C34)	290037
C25	.005 μf	Cer.	Fixed	500 v	GMV	283001
C26	.005 μf	Cer.	Fixed	500 v	GMV	283001
C27	.005 μf	Cer.	Fixed	500 v	GMV	283001
C28	9-180 μμf	Mica	Var.	500 v		281023
C31	9-180 μμf	Mica	Var.	500 v		281023
C34	½ 2x20 μf	EMC	Fixed	450 v	—20% +50% (with C22)	290037
C35	.1 μf	PT	Fixed	400 v	20%	285526
C41A	.5-5 μμf	Poly.	Var.	500 v		281001
C41BCDEF	1-8 μμf	Poly.	Var.	500 v		281003

Capacitors (Continued)

C42A	.5-5 $\mu\mu f$	Poly.	Var.	500 v		281001
C42BCDEF	1-8 $\mu\mu f$	Poly.	Var.	500 v		281003
C43	.005 μf	Cer.	Fixed	500 v	GMV	283001
C44	.005 μf	Cer.	Fixed	500 v	GMV	283001
C47	.022 μf	PT	Fixed	600 v	20%	285517
C48	.022 μf	PT	Fixed	600 v	20%	285517
C50	56 $\mu\mu f$	Mica	Fixed	500 v	10%	283503
C52	.01 μf	Cer.	Fixed	500 v	GMV	283002
C53	.01 μf	Cer.	Fixed	500 v	GMV	283002

Inductors

L4	.75 μh	Fixed	CF751	108072
L6	2.9-5.2 μh	Var.	CV292	114014
L7	2.9-5.2 μh	Var.	CV292	114014
L9	12 μh	Fixed	FC3F12	108029
L10	12 μh	Fixed	FC3F12	108029
L11	15 μh	Fixed	FC3F15	108031
L12	15 μh	Fixed	FC3F15	108031
L13	2.5-4.5 μh	Var.	CV252	114010
L14	2.5-4.5 μh	Var.	CV252	114010
L17	2.9-5.2 μh	Var.	CV292	114014
L18	2.9-5.2 μh	Var.	CV292	114014

Resistors

R23	18 k	1 w	Fixed	Comp.	10%		304183
R24	10 k	½ w	Fixed	Comp.	10%		302103
R25	1 meg	½ w	Fixed	Comp.	10%		302105
R26	1 k	½ w	Fixed	Comp.	10%		302102
R27	1 meg	½ w	Fixed	Prec.	1%		309014
R28	1 meg	½ w	Fixed	Comp.	10%		302105
R29	100 Ω	½ w	Fixed	Comp.	10%		302101
R30	500 k	½ w	Fixed	Prec.	1%		309003
R31	370 k	½ w	Fixed	Prec.	1%		309055
R32	27 Ω	½ w	Fixed	Comp.	10%		302270
R33	20 k	8 w	Fixed	WW	5%		308011
R34	2.2 k	2 w	Fixed	Comp.	10%		306222
R35	1 k	2 w	Var.	Comp.	20%	VARIABLE ATTEN.	311006
R38	10 k	5 w	Fixed	WW	5%		308008
R39	10 k	5 w	Fixed	WW	5%		308008
R42	27 Ω	½ w	Fixed	Comp.	10%		302270
R44	27 Ω	½ w	Fixed	Comp.	10%		302270
R45	20 k	8 w	Fixed	WW	5%		308011
R46	68 k	½ w	Fixed	Comp.	10%		302683
R47	1 meg	½ w	Fixed	Comp.	10%		302105
R48	10 meg	½ w	Fixed	Comp.	10%		302106
R49	20 k	2 w	Var.	Comp.	20%	VARIABLE ATTEN. BAL.	311018
R54	2.4 k	25 w	Fixed	WW	10%		308041
R55	680 Ω	2 w	Fixed	Comp.	5%		305681
R56	1 meg	½ w	Fixed	Comp.	10%		302105
R57	47 Ω	½ w	Fixed	Comp.	10%		302470
R58	10 k	½ w	Fixed	Comp.	10%		302103
R59	20 k	2 w	Var.	Comp.	20%	VERTICAL POSITION	311018
R60	270 k	½ w	Fixed	Comp.	10%		302274
R61	10 k	½ w	Fixed	Comp.	10%		302103

Resistors (Continued)

R62	680 Ω	2 w	Fixed	Comp.	5%	305681
R63	1 meg	½ w	Fixed	Comp.	10%	302105
R64	47 Ω	½ w	Fixed	Comp.	10%	302470
R65	22 k	½ w	Fixed	Comp.	10%	302223
R66	20 k	2 w	Var.	Comp.	20% CURRENT ADJ.	311018
R67	56 k	1 w	Fixed	Comp.	10%	304563
R68	120 k	½ w	Fixed	Prec.	1%	309047
R69	10 Ω	½ w	Fixed	Comp.	10%	302100
R70	10 Ω	½ w	Fixed	Comp.	10%	302100
R72	220 k	½ w	Fixed	Prec.	1%	309052
R73	27 Ω	½ w	Fixed	Comp.	10%	302270
R74	120 k	½ w	Fixed	Prec.	1%	309047
R75	27 Ω	½ w	Fixed	Comp.	10%	302270
R76	220 k	½ w	Fixed	Prec.	1%	309052
R77	470 Ω	½ w	Fixed	Comp.	5%	301471
R78	470 Ω	½ w	Fixed	Comp.	5%	301471
R79	875 Ω	25 w	Fixed	WW	Non Ind. Selected*	312548
R80	875 Ω	25 w	Fixed	WW	Non Ind. Selected*	
R81	27 Ω	1 w	Fixed	Comp.	10%	304270
R82	3 k	10 w	Fixed	WW	5%	308020
R83	20 k	8 w	Fixed	WW	5%	308011
R84	2.2 k	2 w	Fixed	Comp.	10%	306222
R85	680 Ω	½ w	Fixed	Comp.	5%	301681
R86	680 Ω	½ w	Fixed	Comp.	5%	301681
R87	200 Ω	10 w	Fixed	WW	5%	308013
R89	330 k	½ w	Fixed	Comp.	10%	302334
R90	330 k	½ w	Fixed	Comp.	10%	302334
R93	1 meg	½ w	Fixed	Comp.	10%	302105
R94	1 meg	½ w	Fixed	Comp.	10%	302105
R95	47 k	½ w	Fixed	Comp.	10%	302473
R96	82 k	½ w	Fixed	Comp.	10%	302823

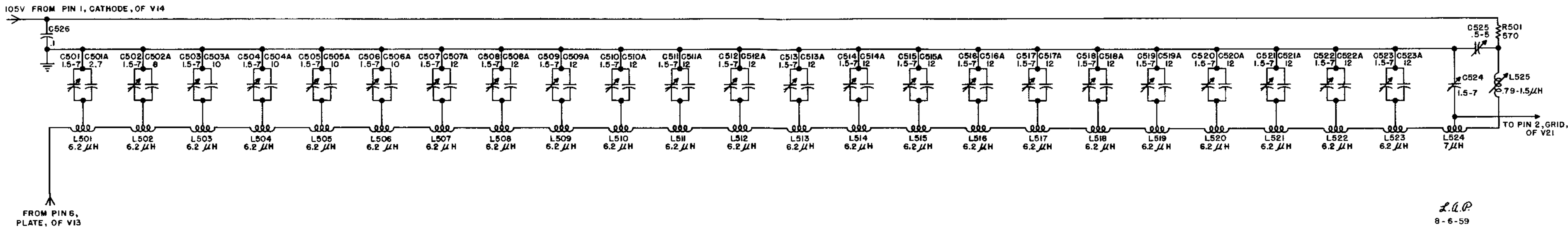
*R79 and R80 paired, equal within 1%.

Switches

					not wired	wired
SW5	1-wafer	3 position	Rotary	IRE-NORM-FLAT-EXT (located on access panel)	260083	262128

Vacuum Tubes

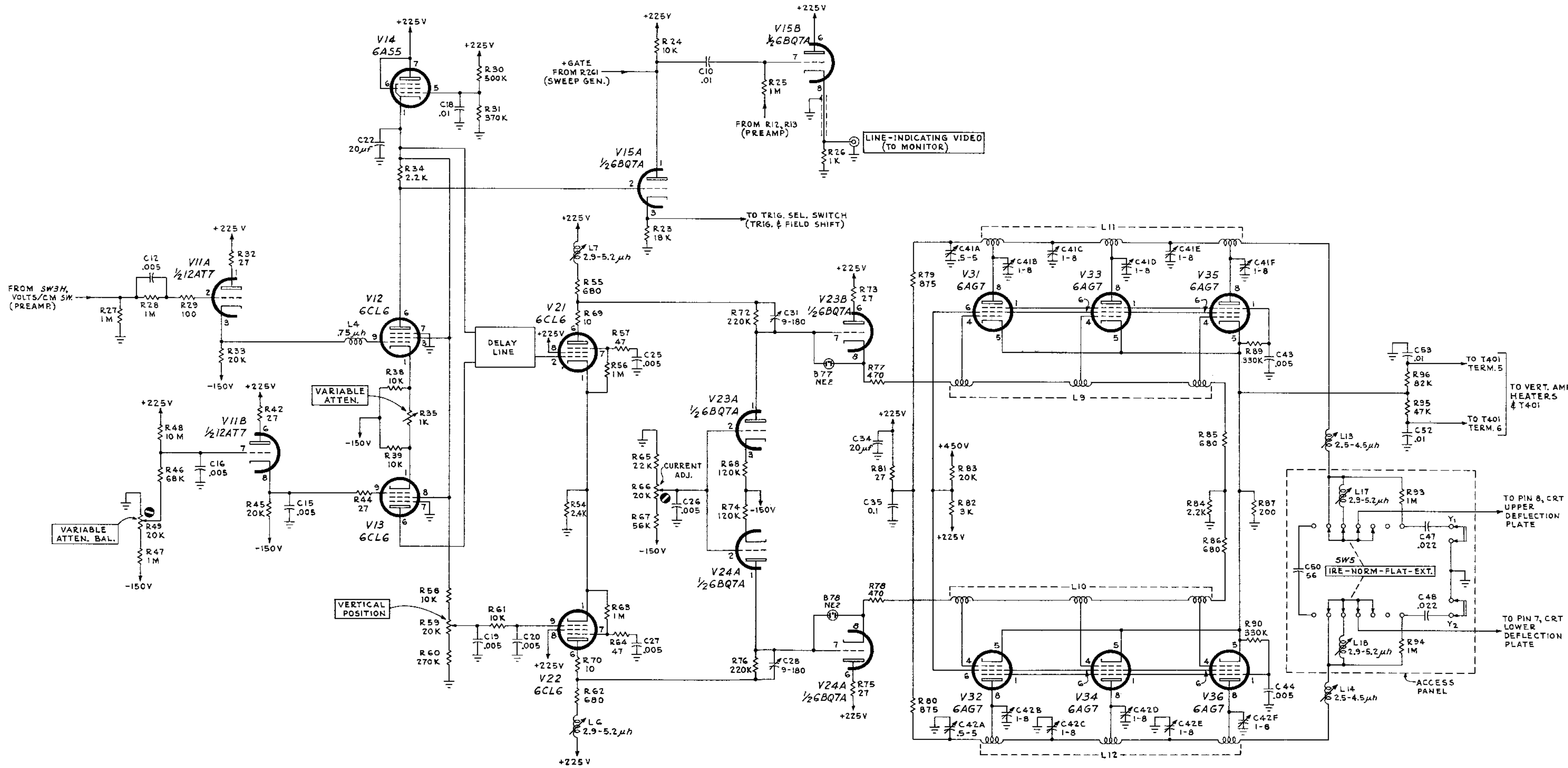
V11A	½ 12AT7	Atten. Stage Input Cathode Follower	157030
V11B	½ 12AT7	Atten. Stage Balance Cathode Follower	
V12	6CL6	Atten. Stage Input Amplifier, Int. Trigger Source	157007
V13	6CL6	Atten. Stage Output Amplifier, Delay Network Input	157007
V14	6AS5	Voltage Regulator	154018
V15A	½ 6BQ7	Internal-Trigger Amplifier	154028
V15B	½ 6BQ7	Video Monitor Out Cathode Follower	
V21	6CL6	Cathode-Coupled Phase Inverter: D4	157006
V22	6CL6	Cathode-Coupled Phase Inverter: D3	157006
V23A	½ 6BQ7	Constant Current Source: D4	157003
V23B	½ 6BQ7	Distributed Amplifier Cathode Follower: D4	
V24A	½ 6BQ7	Constant Current Source: D3	157003
V24B	½ 6BQ7	Distributed Amplifier Cathode Follower Driver: D4	
V31	6AG7	Distributed Amplifier: D4	154012
V32	6AG7	Distributed Amplifier: D3	154012
V33	6AG7	Distributed Amplifier: D4	154012
V34	6AG7	Distributed Amplifier: D3	154012
V35	6AG7	Distributed Amplifier: D4	154012
V36	6AG7	Distributed Amplifier: D3	154012



L.A.P.
8-6-59

TYPE 524 CATHODE-RAY OSCILLOSCOPE

SIGNAL DELAY NETWORK

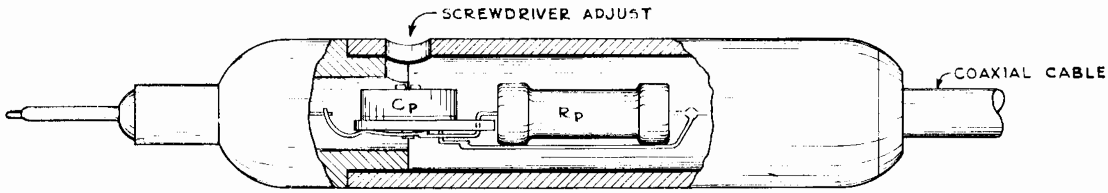


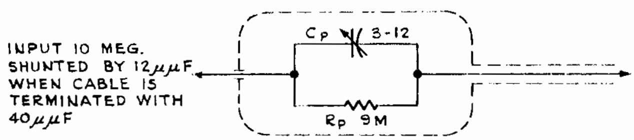
RBH
8-6-59

E

TYPE 524AD OSCILLOSCOPE

VERTICAL AMPLIFIER





Cp 3-12 µµF CER. VAR. 500V
Rp 9 MEG. 1W FIXED PREC. 1%

RBH
1-13-55

TEKTRONIX TYPE P510A PROBE

ABBREVIATIONS

Cer.	ceramic	m	milli or 10^{-3}
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	Poly.	polystyrene
EMT	electrolytic, metal tubular	Prec.	precision
f	farad	PT	paper tubular
h	henry	Tub.	tubular
k	kilohm or 10^3 ohms	v	working volts dc
meg	megohm or 10^6 ohms	Var.	variable
μ	micro or 10^{-6}	w	watt
μμ	micromicro or 10^{-12}	WW	wire wound

GMV guaranteed minimum value

LOW VOLTAGE POWER SUPPLY

Bulbs

B407	#47	150001
B408	#47	150001
B409	#47	150001

Capacitors

C49	.01 μf	Cer.	Fixed	500 v	GMV	283002
C401	½ 2x20 μf	EMC	Fixed	450 v	—20% +50% (with C402) }	290036
C402	½ 2x20 μf	EMC	Fixed	450 v	—20% +50% (with C401) }	
C403	.01 μf	PT	Fixed	400 v	20%	285510
C404	.01 μf	PT	Fixed	400 v	20%	285510
C405	.02 μf	Cer.	Fixed	900 v		283022
C410	.047 μf	PT	Fixed	400 v	20%	285519
C411	½ 2x20 μf	EMC	Fixed	450 v	—20% +50% (with C203)	290037
C412	½ 2x20 μf	EMC	Fixed	450 v	—20% +50% (with C220)	290037
C420	40 μf	EMC	Fixed	450 v	—20% +50% (2 x 20)	290037
C421	40 μf	EMC	Fixed	450 v	—20% +50% (2 x 20)	290037
C422	40 μf	EMC	Fixed	450 v	—20% +50% (2 x 20)	290037
C423	.01 μf	PT	Fixed	400 v	20%	285510
C424	.047 μf	PT	Fixed	400 v	20%	285519
C440	40 μf	EMC	Fixed	450 v	—20% +50% (2 x 20)	290036
C441	.01 μf	PT	Fixed	400 v	20%	285510
C442	.01 μf	PT	Fixed	600 v	20%	285511
C449	6.25 μf	EMC	Fixed	300 v	—20%+50%	290000
C452	6.25 μf	EMC	Fixed	300 v	—20%+50%	290000

Fuses

F1	6 amp	3AG	Fast-Blo	for 117 v operation	159013
F1	3 amp	3AG	Fast-Blo	for 234 v operation	159015

Resistors

R400	15 Ω	25 w	Fixed	WW	5%	308133
R401	33 k	½ w	Fixed	Comp.	10%	302333
R402	1.2 m	½ w	Fixed	Comp.	10%	302125
R403	82 k	½ w	Fixed	Comp.	10%	302823
R404	2.2 k	½ w	Fixed	Comp.	10%	302222
R405	220 k	½ w	Fixed	Comp.	10%	302224
R406	250 k	2 w	Var.	Comp.	20% —150 ADJ	311032
R407	330 k	½ w	Fixed	Comp.	10%	302334
R408	1.5 k	25 w	Fixed	WW	5%	308040
R409	50 Ω	2 w	Var.	WW	10% SCALE ILLUM.	311055
R410	600 k	½ w	Fixed	Prec.	1%	309004

Resistors (Continued)

R411	700 k	½ w	Fixed	Prec.	1%		309008
R412	1 meg	½ w	Fixed	Comp.	10%		302105
R416	27 Ω	½ w	Fixed	Comp.	10%		302270
R417	27 Ω	½ w	Fixed	Comp.	10%		302270
R420	470 k	½ w	Fixed	Comp.	10%		302474
R421	150 k	½ w	Fixed	Comp.	10%		302154
R422	47 k	½ w	Fixed	Comp.	10%		302473
R424	1.5 meg	½ w	Fixed	Comp.	10%		302155
R425	2.2 meg	½ w	Fixed	Comp.	10%		302225
R426	47 k	1 w	Fixed	Comp.	10%		304473
R427	180 k	½ w	Fixed	Comp.	10%		302184
R428	1.5 meg	½ w	Fixed	Comp.	10%		302155
R429	500 k	½ w	Fixed	Prec.	1%		309003
R430	333 k	½ w	Fixed	Prec.	1%		309053
R433	125 Ω	25 w	Fixed	WW	5%		308035
R434	125 Ω	25 w	Fixed	WW	5%		308035
R435	125 Ω	25 w	Fixed	WW	5%		308035
R440	220 k	1 w	Fixed	Comp.	10%		304224
R441	1 meg	½ w	Fixed	Comp.	10%		302105
R442	120 k	2 w	Fixed	Comp.	10%		306124
R443	100 k	½ w	Fixed	Comp.	10%		302104
R444	10 k	½ w	Fixed	Comp.	10%		302103
R445	500 k	½ w	Fixed	Prec.	1%		309003
R446	500 k	½ w	Fixed	Prec.	1%		309003
R447	6 k	20 w	Fixed	WW	5%		308034
R448	10 k	½ w	Fixed	Comp.	10%		302103
R449	50 Ω	2 w	Var.	WW	20%	HUM BALANCE	311055
R452	470 Ω	½ w	Fixed	Comp.	10%		302471

Switches

SW401	Single Pole	Single Throw	Toggle	POWER	260134

Vacuum Tubes

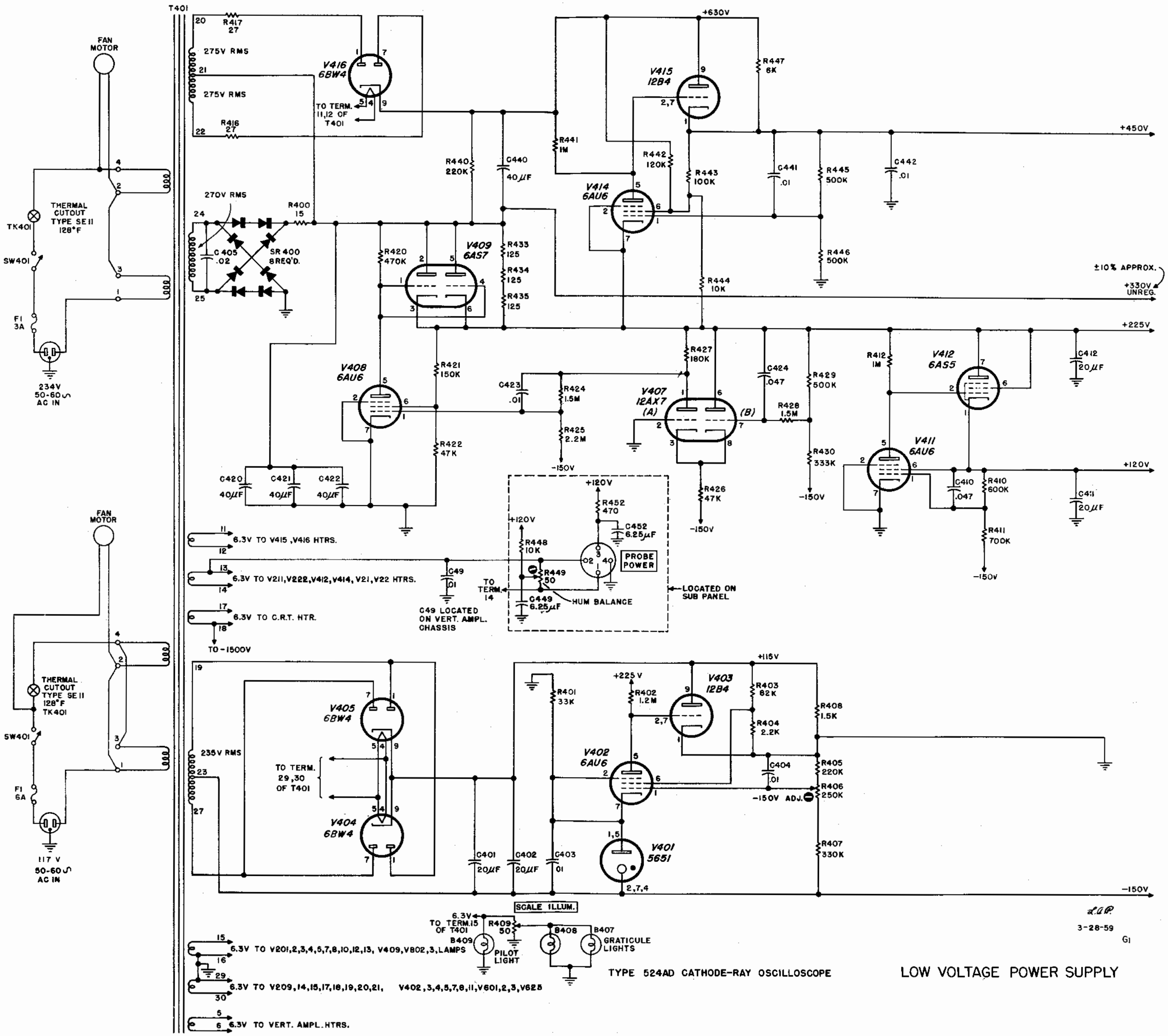
V400A-H		Silicon Diode		152011
V401	5651	Voltage Reference		154052
V402	6AU6	DC Amplifier	—150 v Supply	154022
V403	12B4	Series Regulator	—150 v Supply	154044
V404	6BW4	Rectifier	—150 v Supply	154119
V405	6BW4	Rectifier	—150 v Supply	154119
V407	12AX7	Voltage Comparator	+225 v Supply	154043
V408	6AU6	DC Amplifier	+225 v Supply	154022
V409	6AS7	Series Regulator	+225 v Supply	154020
V411	6AU6	DC Amplifier	+120 v Supply	154022
V412	6AS5	Series Regulator	+120 v Supply	154018
V414	6AU6	DC Amplifier	+450 v Supply	154022
V415	12B4	Series Regulator	+450 v Supply	154044
V416	6BW4	Rectifier	+450 v Supply	154119

Transformers

T401	**Plate and heater**	T524PA4	**120031**

Thermal Cutout

TK401	Thermal Cut-out, 133° F	260208



TYPE 524AD CATHODE-RAY OSCILLOSCOPE

LOW VOLTAGE POWER SUPPLY

ABBREVIATIONS

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

CRT CIRCUIT AND HV SUPPLY

Capacitors

C701	.015 μf	PT	Fixed	3000 v	20%	285513
C702	.015 μf	PT	Fixed	3000 v	20%	285513
C703	.015 μf	PT	Fixed	3000 v	20%	285513
C801	.001 μf	PT	Fixed	600 v	20%	285501
C802	.022 μf	PT	Fixed	400 v	20%	285515
C803	.001 μf	PT	Fixed	600 v	20%	285501
C804	.001 μf	PT	Fixed	600 v	20%	285501
C807	.0068 μf	PT	Fixed	3000 v	20%	285508
C808	.0068 μf	PT	Fixed	3000 v	20%	285508
C809	.0068 μf	PT	Fixed	3000 v	20%	285508
C810	.0068 μf	PT	Fixed	3000 v	20%	285508

Resistors

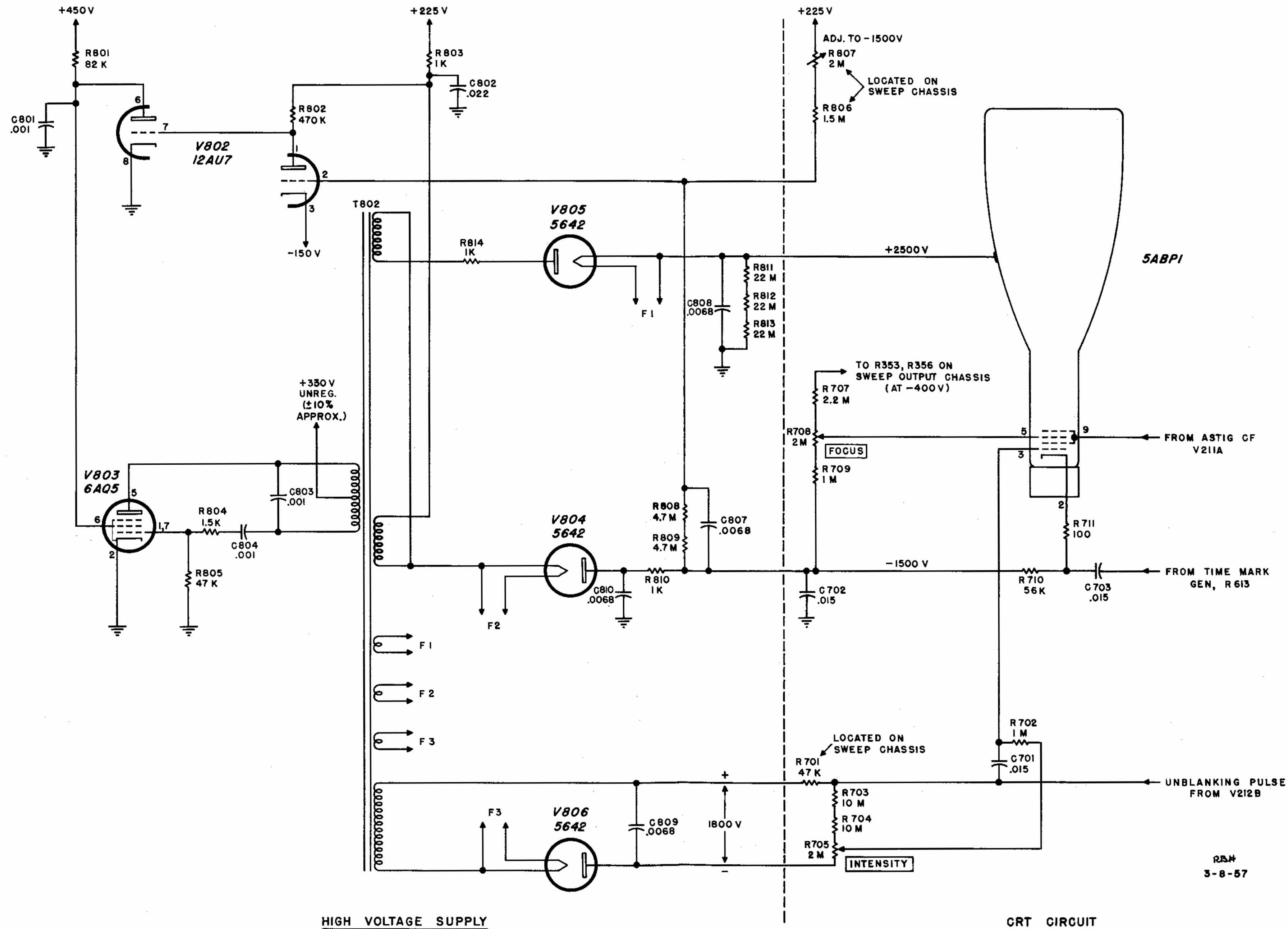
R701	47 k	½ w	Fixed	Comp.	10%		302473
R702	1.0 meg	½ w	Fixed	Comp.	10%		302105
R703	10 meg	2 w	Fixed	Comp.	10%		306106
R704	10 meg	2 w	Fixed	Comp.	10%		306106
R705	2 meg	2 w	Var.	Comp.	20%	INTENSITY	311042
R707	2.2 meg	2 w	Fixed	Comp.	10%		306225
R708	2 meg	2 w	Var.	Comp.	20%	FOCUS	311042
R709	1 meg	1 w	Fixed	Comp.	10%		304105
R710	56 k	½ w	Fixed	Comp.	10%		302563
R711	100 Ω	½ w	Fixed	Comp.	10%		302101
R801	82 k	2 w	Fixed	Comp.	10%		306823
R802	470 k	½ w	Fixed	Comp.	10%		302474
R803	1 k	½ w	Fixed	Comp.	10%		302102
R804	1.5 k	½ w	Fixed	Comp.	10%		302152
R805	47 k	½ w	Fixed	Comp.	10%		302473
R806	1.5 meg	½ w	Fixed	Comp.	10%		302155
R807	2 meg	2 w	Var.	Comp.	20%	HV ADJ.	311042
R808	4.7 meg	2 w	Fixed	Comp.	10%		306475
R809	4.7 meg	2 w	Fixed	Comp.	10%		306475
R810	1 k	½ w	Fixed	Comp.	10%		302102
R811	22 meg	½ w	Fixed	Comp.	10%		302226
R812	22 meg	½ w	Fixed	Comp.	10%		302226
R813	22 meg	½ w	Fixed	Comp.	10%		302226
R814	1 k	½ w	Fixed	Comp.	10%		302102

Transformers

T802	CRT Supply	T524OA2	120030

Vacuum Tubes

V802	12AU7	DC Amplifier HV Oscillator Supply	154041
V803	6AQ5	HV Oscillator	154017
V804	5642	—1500 v Rectifier	154051
V805	5642	+2500 v Rectifier	154051
V806	5642	—1800 v Rectifier	154051
	5ABP1	Cathode Ray Tube	154068


+450V
R801
82 K
C801
.001
V802
12AU7
+225 V
R803
1K
C802
.022
R802
470 K
-150 V
T802
R814
1K
V805
5642
F1
C808
.0068
R811
22 M
R812
22 M
R813
22 M
+2500V
+225 V
ADJ. TO -1500V
R807
2 M
LOCATED ON
SWEEP CHASSIS
R806
1.5 M
5ABP1
TO R353, R356 ON
SWEEP OUTPUT CHASSIS
(AT -400V)
R707
2.2 M
R708
2M
FOCUS
R709
1 M
FROM ASTIG CF
V211A
R711
100
-1500 V
R710
56K
C703
.015
FROM TIME MARK
GEN, R613
C702
.015
+330 V
UNREG.
(±10%
APPROX.)
V803
6AQ5
R804
1.5K
C803
.001
C804
.001
R805
47 K
R808
4.7 M
R809
4.7 M
C807
.0068
V804
5642
R810
1K
C810
.0068
F2
F1
F2
F3
F3
V806
5642
C809
.0068
1800 V
LOCATED ON
SWEEP CHASSIS
R701
47 K
R703
10 M
R704
10 M
R705
2 M
INTENSITY
R702
1 M
C701
.015
UNBLANKING PULSE
FROM V212B
RBH
3-8-57
HIGH VOLTAGE SUPPLY
CRT CIRCUIT

ABBREVIATIONS USED IN OUR PARTS LISTS

Cer.	ceramic	m	milli
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	Poly.	polystyrene
EMT	electrolytic, metal tubular	Prec.	precision
f	farad	PT	paper tubular
h	henry	Tub.	tubular
k	thousands of ohms	v	working volts dc
meg	megohms	Var.	variable
μ	micro	w	watt
$\mu\mu$	micromicro	WW	wire wound

GMV guaranteed minimum value

ABBREVIATIONS USED IN OUR CIRCUIT DIAGRAMS

Resistance values are in ohms. The symbol k stands for thousands. A resistor marked 2.7 k has a resistance of 2,700 ohms. The symbol M stands for million. For example, a resistor marked 5.6 M has a resistance of 5.6 megohms.

Unless otherwise specified on the circuit diagram, capacitance values marked with the number 1 and numbers greater than 1 are in $\mu\mu$f. For example, a capacitor marked 3.3 would have a capacitance of 3.3 micromicrofarads. Capacitance values marked with a number less than 1 are in μf. For example, a capacitor marked .47 would have a capacitance of .47 microfarads.

Inductance values marked in mh are in millihenrys. Inductance values marked in μh are in microhenrys.

Your instrument WARRANTY appears on the reverse side of this sheet.

SERIAL NO. ________

IMPORTANT

Include the INSTRUMENT TYPE and the above SERIAL NUMBER in any correspondence regarding this instrument. The above serial number must match the instrument serial number if parts are to be ordered from the manual. Your help in this will enable us to answer your questions or fill your order with the least delay possible.

WARRANTY

All Tektronix instruments are fully guaranteed against defective materials and workmanship for one year. Should replacement parts be required, whether at no charge under warranty or at established net prices, notify us promptly, including sufficient details to identify the required parts. We will ship them prepaid (via air if requested) as soon as possible, usually within 24 hours.

Tektronix transformers, manufactured in our own plant, carry an indefinite warranty.

All price revision and design modification privileges reserved.