CATHODE-RAY OSCILLOSCOPE
TYPE 545

INSTRUCTION MANUAL

LIVINGSTON LABORATORIES
LIMITED
RETCAR STREET · LONDON · N·19
ARCHWAY 6351

MANUFACTURERS OF CATHODE-RAY AND VIDEO TEST INSTRUMENTS

Sunset Highway and Barnes Road • P. O. Box 831 • Portland 7, Oregon, U. S. A.
Phone: CYpress 2-2611 • Cables: Tektronix

TYPE 545 SERIAL NUMBER

NOTE : Pages 4-3 tp 4-7 were missing from the original manual

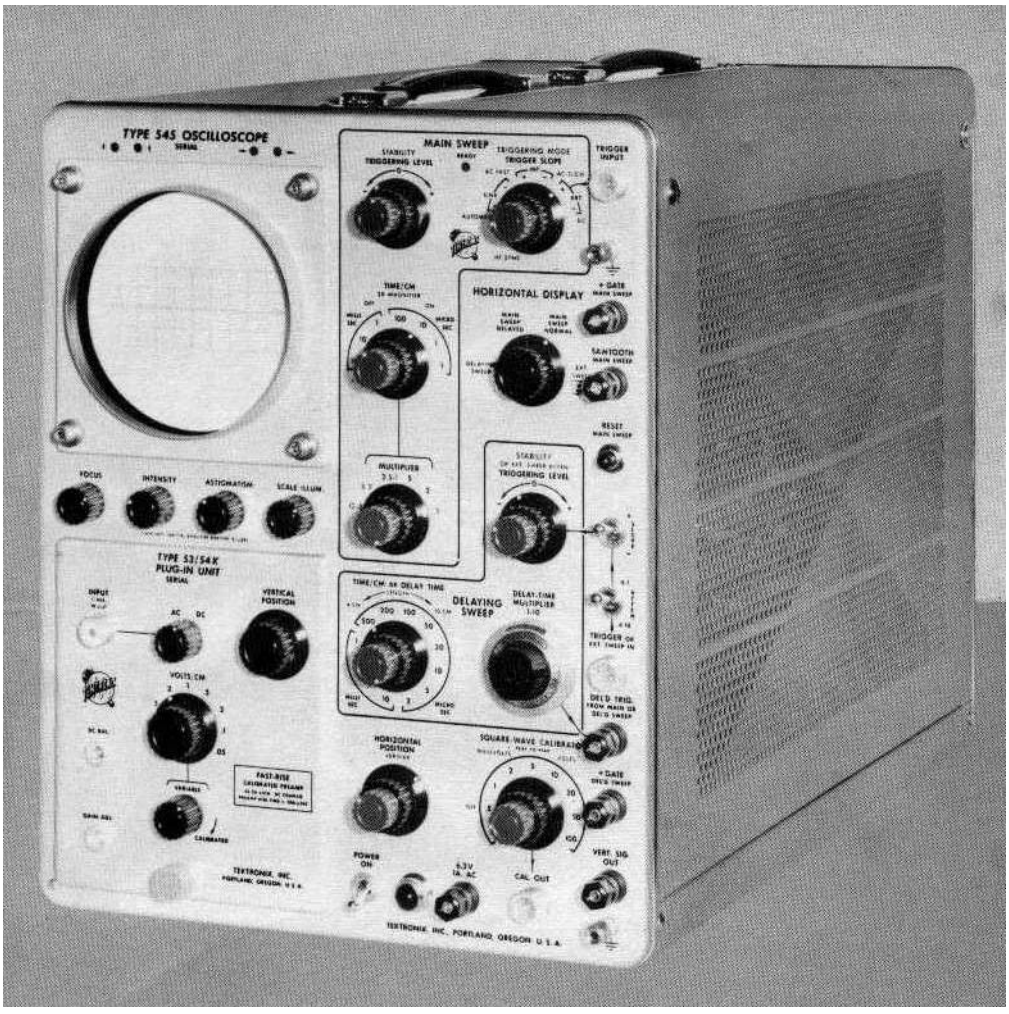

TYPE 545 OSCILLOSCOPE
MAIN SWEEP
HORIZONTAL DISPLAY
DELAYING SWEEP
TYPE 53/54K PLUG-IN UNIT
TEKTRONIX, INC. PORTLAND, OREGON U.S.A.

TABLE OF CONTENTS

SPECIFICATIONS

OPERATING INSTRUCTIONS

CIRCUIT DESCRIPTION

MAINTENANCE

SPECIFICATIONS

The Type 545 is a high-speed laboratory oscilloscope. Its fast rise time coupled with wide sweep-speed range and 10-kilovolt accelerating voltage opens the way to faster, easier analyses of fast-rising waveforms. Additional adaptability is provided by plug-in preamplifiers which extend its use to almost all laboratory-oscilloscope applications. Accurately calibrated sweep speeds and vertical-deflection sensitivity permit quantitative time and amplitude measurements to be made. Accurately-delayed triggered sweeps make possible the selection and detailed observation of minute portions of voltage waves.

Vertical-Deflection System

Output Amplifier

DC Coupled

Rise time — .01 μsec.

Delay Line

Balanced Network

Signal Delay — .2 μsec.

Linear Deflection — 4 cm.

With 53/54K Plug-In Unit (in 545)

Deflection Factor — .05 v/cm, ac or dc.

Rise Time — 12 millimicroseconds.

Frequency Response — DC to 30 mc.

2 cps to 30 mc, ac. Down 3 db ± ½ db at 30 mc, 6 db at approximately 41 mc.

Step Attenuator

Nine positions, calibrated, from .05 v/cm to 20 v/cm, accurate within 3% when set on any one step.

Maximum Allowable Combined DC and Peak AC Voltage Input — 600 v.

Input Impedance — 1 megohm, 20 μμf.
With P410 probe — 10 megohms, 8 μμf.

Horizontal-Deflection System

Calibrated Sweeps

Twenty-four calibrated speeds from .1 μsec/cm to 5 sec/cm.

Accuracy — 3 per cent.

Continuously variable, uncalibrated, between ranges and to 12 sec/cm.

Calibrated Sweep Delay

Delay Time — 1 μsec to .1 sec, continuously variable.

Time Jitter — Less than 1 part in 20,000, untriggered; jitter free when triggered.

Range Accuracy — 2 per cent.
Incremental accuracy .2 per cent of full scale.

Magnifier

Magnification — 5 times to left and right of center. Extends fastest sweep speed to .02 μsec/cm.

Unblanking — DC coupled

Trigger Requirements

Internal — 2 mm of deflection.

External — .2 volts to 100 volts.

Frequency Range — dc to 30 mc.

Horizontal Input

Deflection Factor
Continuously variable, .2 v/cm to 20 v/cm.

Frequency Response
DC to 240 kc.

Other Characteristics

Cathode-Ray Tube

Type T54P2
P1, P7, and P11 phosphors optional.

Accelerating Potential — 10,000 volts.

Deflection Factor, Direct Connection
Vertical — 7 v/cm.
Horizontal — 30 v/cm.

Voltage Calibrator

Eighteen fixed voltages from .2 millivolts to 100 volts.

Accuracy — 3 per cent.

Waveform — square wave at about 1 kc.

Trigger-Rate Source — 10 cps to 40 kc, continuously variable, using free running delaying sweep as generator.

Output Waveforms Available

Positive gate of same duration as main sweep, 20 volts.

Positive gate of same duration as delaying sweep, 20 volts.

Main-sweep sawtooth waveform, 150 volts.

Delayed trigger pulse from main or delaying sweep, 5 volts.

A sample of the vertical signal with a limited passband, 20 cps to 4.5 mc.

Heater voltage, 6.3 v ac, 1 amp.

Beam Position Indicators

Indicator lights show direction of beam when it is off the screen.

Mechanical Specifications

Power Supply

Electronically regulated

Power Requirements — 105 to 125, or 210 to 250 v, 50-60 cycles, 545 watts with Type 53K/54K unit.

Ventilation — Filtered, forced air ventilation.

Finish — Photo-etched, anodized panel, blue wrinkle cabinet.

Dimensions — 24" long, 13" wide, 16¾" high.

Weight — 65 pounds.

Accessories Include:

2 — P410 probes

2 — Binding post adaptors

1 — Test lead

1 — Light filter

1 — Instruction manual

OPERATING INSTRUCTIONS

PRELIMINARY INSTRUCTIONS

Cooling

The Type 545 Oscilloscope is cooled by filtered, forced-air ventilation. The instrument must therefore be placed so the air intake is not blocked, and the filter must be clean enough to permit adequate air circulation. If the interior temperature does rise too high for some reason, a thermal cutout switch will disconnect the power and keep it disconnected until the temperature drops to a safe value.

Time-Delay DC Power Relay

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

Cathode-Ray-Tube Controls

The Tektronix Type T54 cathode-ray tube in this instrument has a total accelerating voltage of 10,000 volts. The spot intensity with this amount of acceleration can be bright enough to damage the screen in a short time if the spot is left in one place. Be careful not to leave a fixed bright spot or slow sweep on the screen. Turn the **INTENSITY** control counterclockwise so that the spot is dim whenever you leave the instrument unattended.

Illuminated Graticule

The adjustable graticule lighting control labeled **SCALE ILLUM**, can be adjusted to suit the lighting conditions of the room. The colored filter supplied is colored to provide the maximum trace contrast for the P2 phosphor in the presence of room light. The colored filter should be mounted next to the crt so it does not block the light from the graticule lines.

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

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

Probes

Do not use the P510A Probe with an wide-band or fast-rise plug-in unit. This probe tends to ring at about 50 megacycles and the wide passband of the Type 541 Oscilloscope allows any ringing which may occur to be presented on the screen.

The Type P410 Probe, furnished with the oscilloscope, is free from ringing. This probe or any other P400-series Probe should be used with the wide-band or fast-rise plug-in units.

FUNCTIONS OF CONTROLS AND CONNECTORS

HORIZONTAL DISPLAY — Four-position switch arranges sweep circuits for four kinds of display: **MAIN SWEEP NORMAL, DELAYING SWEEP, MAIN SWEEP DELAYED** and **EXT. SWEEP.**

Main Sweep

TRIGGERING MODE (red knob) — Five-position switch arranges trigger circuits for four kinds of triggering: **AUTOMATIC, AC FAST, AC SLOW,** and **DC,** and for synchronized sweeps, **HF SYNC.**

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

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

STABILITY (red knob)	Adjustment of multivibrator bias in region for recurrent or triggered operation.
TRIGGERING LEVEL	Potentiometer determines part of triggering waveform where sweep triggers.
TIME/CM	Eight-position switch selects timing capacitors to determine sweep speeds, and determine duration of trigger holdoff period.
MULTIPLIER	Six-position switch. Three positions place precision charging resistors in series with timing capacitors to determine sweep speeds in conjunction with selected timing capacitor. Three positions, marked in red, place adjustable charging voltages in series with timing capacitors for continuous control of sweep speeds.
5X MAGNIFIER (red knob)	Two-position switch removes or inserts feedback in sweep amplifier to change sweep speeds by a factor of five.
+GATE	Connector supplying 20-volt positive pulse via cathode follower synchronized with main sweep, duration same as sweep.
SAWTOOTH	Connector supplying 150-volt positive-going sawtooth via cathode follower synchronized with main sweep.

Delaying Sweep

STABILITY (red knob)	Adjustment of multivibrator bias in region for recurrent or triggered sweeps.
TRIGGERING LEVEL	Potentiometer determines part of triggering waveform where sweep triggers.
TIME/CM	Twelve-position switch selects twelve fixed sweep speeds.
LENGTH (red knob)	Sweep-length control permits delaying sweep to be reverted immediately after delayed main sweep is triggered to increase possible duty cycle. Normally will be left at 10 cm.
DELAY-TIME MULTIPLIER	Ten-turn helical resistor adjusts pickoff voltage on sawtooth-voltage comparator to determine timing of delayed trigger.
RESET MAIN SWEEP	Pushbutton arms main-sweep triggering circuit to accept trigger for **MAIN SWEEP DELAYED** circuit.
DEL'D TRIGGER	Connector from cathode follower supplies delayed trigger from main sweep or from delaying sweep.
+GATE	Connector via cathode follower supplies 20-volt positive pulse synchronized with delaying sweep.
SLOPE +, —	Toggle switch selects inverted or in-phase output from trigger inverter for triggering sweep-gating multivibrator, or selects polarity for external sweeps.
ATTEN, X1, X10	Toggle switch inserts or bypasses 10-to-1 compensated attenuator in delaying-sweep trigger-input circuit, or external sweep circuit.
EXT SWEEP	Continuously adjustable gain control for horizontal amplifier. Switched out of circuit for internal sweeps.

EXTERNAL SWEEP IN	Front-panel connector to horizontal amplifier through **HORIZONTAL DISPLAY** switch. Magnifier must be switched to **ON** for undistorted 10-cm deflection.
HORIZONTAL POSITION	Positions trace along horizontal axis.
VERNIER (red knob)	Fine adjustments of horizontal positioning, with 5 times the resolution of the coarse adjustment.

Other Output Waveforms

SQUARE-WAVE CALIBRATOR (red knob)	Three-position switch turns on calibrator plate voltage and switches in or out 1000-to-1 voltage divider to give either volts or millivolts output.
(black knob)	Nine-position switch selects nine taps on precision voltage divider in calibrator circuit. Provides accurate peak-to-peak voltages of .2, .5, 1, 2, 5, 10, 20, 50, and 100 volts in **VOLTS** position, or millivolts in the **MILLIVOLTS** position of the red concentric control knob.
VERT. SIG. OUT	Connector via cathode follower supplies a sample of the vertical-deflection signal.
CAL OUT	UHF coax front-panel connector from the calibrator.

Auxiliary Controls

POWER	On-off switch in primary of power transformer and ventilating-fan lead.
FOCUS	Adjustable voltage for the cathode-ray tube focusing grid.
INTENSITY	Bias adjustment to cathode-ray tube control grid.
ASTIGMATISM	Adjustable voltage for the astigmatism grid of the cathode-ray tube.
SCALE ILLUM	Adjustable series resistor controls voltage across graticule lights.

Beam-position indicators, unlabeled, marked with arrows. The arrow nearest the illuminated indicator shows which way the beam is off the screen if it cannot be seen.

Rear of Cabinet

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

FIRST-TIME OPERATION

Control Settings

First get a trace on the screen with the main sweep by the simplest method, and then proceed with the presentation you want after you get an idea of the functions of the controls. To get a simple trace on the screen, insert a preamplifier, for example the 53K/54K, and proceed as follows:

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

INTENSITY	Counterclockwise (CCW)
FOCUS	Center
ASTIGMATISM	Center
POWER	**ON**

Main Sweep

TRIGGERING LEVEL	CCW
STABILITY (red knob)	CW
TRIGGER SLOPE	+INT
TRIGGERING MODE (red)	**AUTOMATIC**
TIME/CM	**100 MICROSEC**
MULTIPLIER	**2**
HORIZONTAL DISPLAY	**MAIN SWEEP NORMAL**

Delaying Sweep

TRIGGERING LEVEL	Center
STABILITY	CCW
HORIZONTAL POSITION	Center
SQUARE-WAVE CALIBRATOR	**5**
VOLTS, MILLIVOLTS, OFF	**VOLTS**

Connect a lead between the **CAL OUT** terminal and the **INPUT** terminal of the 53K/54K unit. Set the controls of the 53K/54K unit as follows:

INPUT SELECTOR	**INPUT A, AC**
VOLTS/CM	**2**
VARIABLE (red)	Clockwise
VERTICAL POSITION	Center

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

Triggering Modes

1. **Automatic**

   The triggering method just described is the **AUTOMATIC** mode of triggering. This is about the simplest mode of triggering. It is useful for general-purpose viewing, and will operate satisfactorily for a wide variety of trigger signals whose repetition rates are between sixty cycles and about two megacycles.

2. **AC Slow**

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

   Now turn the **TRIGGER SLOPE** switch to the **—INT** position, and readjust the **TRIGGERING LEVEL** to obtain a stable trace again. Notice now that the trace

starts on the down-going portion of the trace and that the position of the start can again be changed somewhat with the **LEVEL** control.

3. **DC Triggering**

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

4. **AC Fast**

In the **AC FAST** position of the **TRIGGERING MODE** switch, the circuit is quite similar to that in the **AC SLOW** position, and you will notice no difference when displaying the calibrator waveform. The only difference is that an rc filter is inserted in the circuit, making it insensitive to low frequencies, and allowing it to recover quickly from dc level changes. This is the position to use when there is hum present. This is also the best position to use with the alternate sweep feature of the 53/54C unit if you use INTernal triggering with signals having frequency components above 10 kc.

5. **HF Sync**

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

TRIGGERING INSTRUCTIONS

General

The Type 545 triggering system is very flexible and stable. However, if you are not familiar with the **TRIGGERING LEVEL** control used on this instrument, you will need to distinguish between its operation and that of the trigger amplitude control used on some other Tektronix oscilloscopes.

Triggering Level

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

Trigger Slope

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

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

Triggering Mode

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

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

The **AUTOMATIC** and the **HF SYNC** switch positions both arrange synchronizing circuits, rather than strictly triggering circuits. The **AUTOMATIC** circuit provides a free-running multivibrator having a normal repetition rate of about 50 cycles. This locks in, and runs synchronously with, recurrent triggering waveforms from

60 cycles to about 2 megacycles. The synchronized multivibrator then triggers the sweep-gating multivibrator.

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

Stability

The **STABILITY** control adjusts bias level on the sweep-gating multivibrator near the level at which it will free-run. Three principal settings of the **STABILITY** control are used; the first setting is with the control advanced to the right, just past the point where the sweep-gating multivibrator free-runs; second, retarded to the left about 5 or 10 degrees from the point where the free-running ceases; and third, retarded all the way to the left, to make the multivibrator inoperative.

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

For all triggered operations, the **STABILITY** control should be retarded to the left from the free-run point 5 to 10 degrees. Note that in the **AUTOMATIC** mode the **STABILITY** control is replaced by an internal control which is preset for optimum triggering.

SWEEP OPERATION

The four positions of the **HORIZONTAL DISPLAY SELECTOR** arrange for the horizontal deflection of the beam by the main sweep, the delaying sweep, the main sweep delayed, or by an external sweep signal.

Main Sweep Normal

For the **MAIN SWEEP NORMAL** position of the **HORIZONTAL DISPLAY SELECTOR** only the main-sweep is displayed. Triggering can be produced from the displayed signal internally, or external trigger signals can be connected to the upper **TRIGGER INPUT** connector.

Delaying Sweep

In the **DELAYING SWEEP** position, the sawtooth that is normally used to delay the main sweep is connected to the horizontal amplifier to provide the sweep. This delaying sweep can only be triggered by applying a trigger to the **TRIGGER** connector near the delaying sweep controls. This trigger signal can be obtained from an external source or a test lead can be connected from the **TRIGGER** connector to the **VERT. SIG. OUT** connector to trigger the delaying sweep on the vertical signal. The **SLOPE, +, —,** switch selects the desired slope and the **ATTEN X10** toggle switch provides attenuation if desired. Other triggering adjustments operate the same as for the main sweep.

Main Sweep Delayed

Display the waveform you want to observe with the delaying sweep. Set the **DELAY-TIME MULTIPLIER** control to **2** or **3**, and set the main-sweep **TIME/CM** several times faster than the delaying sweep time. Switch to **MAIN SWEEP DELAYED** and adjust the main sweep triggering circuits until the main sweep runs recurrently, and switch back again to the delaying sweep. When the main sweep operates it brightens the trace while it runs.

The brightening helps determine what part of the waveform displayed by the delaying sweep will be displayed by the delayed sweep. Increasing the main-sweep speed narrows the brightened portion, and increasing the **DELAY-TIME MULTIPLIER** control clockwise moves the brightened portion to the right. If desirable, adjust the delaying-sweep **LENGTH** control until the delaying sawtooth stops just after it passes the brightened portion of the trace. This causes the delaying sawtooth to revert after the main-sweep sawtooth reverts, and also increases the possible duty cycle of the main sweep.

Triggered Delayed Sweeps

Now if you back the **STABILITY** control to the left a little more the delay trigger signal will not trigger the main sweep, but will arm it for trigger signals connected into the main-sweep trigger input circuit, and permit you to display delayed signals without jitter, even if the signal itself does jitter. The **HF SYNC** triggering mode is not suitable for this operation.

Single Sweeps (Reset Main-Sweep Control)

The **RESET** button provides a means of obtaining a single sweep. Depending on the setting of the main-sweep **STABILITY** control, this sweep can occur immediately when the button is depressed or the sweep will wait until it is triggered, at which time only one sweep will occur.

Turn the delaying-sweep **STABILITY** control counterclockwise and leave the other controls

as set for main-sweep-delayed operation. Depress the **RESET** button. If the main-sweep **STABILITY** control is set to the position where it requires no trigger, there will be a single trace. If it is backed off to the position where it requires a trigger the **READY** indicator will light, indicating that the trigger circuit is armed and waiting for a trigger. Upon the occurance of a trigger, there will be a single sweep and the ready light will go out.

External Sweep

Switch the **HORIZONTAL DISPLAY** control to **EXT SWEEP** and turn the **5X MAGNIFIER** to **ON**. Connect the source of external horizontal signal to the **EXT SWEEP IN** connector. The signal can then be attenuated by the **10X** attenuator and inverted by the **SLOPE** switch, or continuously adjusted by the **EXT SWEEP ATTEN** control. There should be no dc component to the external sweep signal. If there is, the continuous gain adjustment will also position the trace horizontally, and may move the signal out of range of the **HORIZONTAL POSITION** control.

Because this amplifier was designed for optimum performance with a sawtooth, its performance with sine waves is limited. This sine-wave limitation can best be defined by an amplitude-frequency product, which can be exceeded only at the expense of considerable distortion. The amplitude-frequency product is 2.4 centimeter-megacycles. Thus a full 10 centimeters of deflection can be used at 240 kc, and a 2.4-mc sine wave can be viewed if the amplitude is one centimeter peak to peak or less. The amplifier frequency response to a sine wave is down less than 30% at 800 kc when the amplitude is within this limitation.

Main-Sweep Time/CM and Multiplier

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

Magnifier

This control inserts or removes a feedback network in the sweep amplifier that changes the gain five times. The linearity of the amplifier is somewhat better when the feedback circuit is included. The center one fifth of the trace is expanded to fill the graticule when the magnifier is switched on. When you use the sweep magnifier to realize the fastest sweep time, .02 microseconds per centimeter, the linearity is reduced from three per cent to about five per cent.

Delaying-Sweep Time/cm

The delaying-sweep **TIME/CM** control provides twelve fixed sweep speeds. The **LENGTH** control provides a means of adjusting the sweep length from four to ten centimeters. If it is desired to measure the time between two points on the trace, this time can normally be read directly from the graticule. However, if slightly greater accuracy is required, you can use the **DELAY TIME MULTIPLIER** dial. Set the main sweep to run several times faster than the delaying sweep and advance the main-sweep **STABILITY** control so it is triggered by the delaying sweep. When start of the brightened portion of the delaying sweep trace corresponds with the point you wish to measure, the **DELAY TIME** and **DELAY TIME MULTIPLIER** dials will read the time from the start of the trace to the point you wish to measure.

The accuracy of any particular range can be maximized by adjusting the DELAY START and DELAY STOP controls on that range as explained in the maintenance section of this manual.

AUXILIARY FUNCTIONS

Square-Wave Calibrator

Accuracy of the open-circuit voltage of the calibrator is within 3 per cent of the indicated voltage . However, since the output impedance at the **CAL. OUT** terminal varies with the setting of the voltage selector switch, you must be careful that the load impedance you connect it to does not change the output voltage. The output impedance varies between about 100 ohms over the millivolt range to about 5000 ohms at the 50-volt tap. Except at the 100-volt tap, the output voltage depends on the division ratio of a voltage divider. Any appreciable change in impedance of the shunt leg of the divider will therefore reduce the output approximately in proportion to the reduction of impedance. The 1-megohm input impedance of the Type 545 will cause no appreciable change in voltage at any setting of the selector switch. At the 100-volt tap, the output impedance is that of the cathode follower, about 250 ohms.

The rising portion of the calibrator waveform follows an rc charge curve with a time constant such that it requires about 1 microsecond to reach 90 per cent of the peak. Millivolt settings provide a slightly better rise time of about 0.7 microseconds to the 90 per cent point. Reactive loads will affect these times.

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

Trigger Rate Generator

The delaying-sweep generator can be used as a trigger-rate generator by advancing the **STABILITY** control to the free-run position and using the **+ GATE** from the delaying sweep as the trigger output. The trigger rate can be varied from 10 cps to 40 kc by the delaying-sweep **TIME/CM** and **LENGTH** controls.

Trace-Brightness Modulation

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

Direct Connection to Deflection Plates

A plastic plate is attached to the neck of the crt for your convenience in mounting hardware for direct connections to the deflection plates. This plate is accessible when the left side panel is removed. Holes can be drilled in this plate for wire guides or for mounting coaxial connectors. The two pins on the left-hand side of the crt neck are the vertical deflection plates.

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

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

Vertical Signal Out

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

FUNCTIONAL BLOCK DIAGRAM

General

The functional block diagram shows the functional relationships of the basic elements of the sweep system. A four-position switch in the center of the diagram, labeled **HORIZONTAL DISPLAY**, sets up the circuits for the four kinds of sweep operation. The four positions of the switch are labeled **MAIN SWEEP NORMAL, MAIN SWEEP DELAYED, DELAYING SWEEP,** and **EXT. SWEEP.**

Horizontal Display Selector

When the **HORIZONTAL DISPLAY** switch is in the **MAIN SWEEP NORMAL** position, the triggered main sweep circuit shown in the upper half of the diagram, moves the cathode-ray spot across the screen in the normal manner.

When the switch is in the **DELAYING SWEEP** position, the triggered delaying sweep circuit, shown in the lower half of the diagram, moves the cathode-ray spot across the screen in the same manner as the main sweep.

When the switch is in the **MAIN SWEEP DELAYED** position both the main sweep circuit and the delaying sweep circuits run. The delaying sweep starts first and starts the main sweep later. There are two modes of operation in which the main sweep is delayed.

Delayed Sweeps

In one mode the delaying sweep receives the external trigger signal while the main sweep receives its trigger signal later from the delaying sweep, and the main sweep then moves the cathode-ray beam across the screen. The trigger signal for the main sweep in this mode is derived from the delaying sweep at the instant the delaying-sweep sawtooth reaches a level determined by the adjustment of the delay-pick-off circuit.

In the second mode of delayed-sweep operation, both the main sweep and the delaying sweep run, as in the first mode, but in this mode the main sweep is triggered by a selected external trigger signal. All trigger signals except the desired one are locked out until a signal from the delaying sweep opens the trigger circuit into the main sweep. Then the next external trigger signal that comes along will trigger the main sweep. The circuit into the main sweep is completed when the gating circuit is opened by the delay-pickoff signal. The delay-pickoff signal originates when the delaying-sweep sawtooth reaches the level determined by the adjustment of the delay-pickoff circuit.

Trace Brightening

The cathode-ray beam is kept turned off when a sweep is not moving the beam across the screen. When a sweep is in process the beam is turned on by an unblanking signal that lasts only as long as the sweep and then turns the beam back off after the sweep is completed. If both sweeps are running, each produces its own unblanking signal and both unblanking signals help to turn on the beam. The main-sweep unblanking pulse makes a brighter trace than the delaying-sweep pulse.

The difference in brightness for the two pulses is useful for finding out where to set the delay-pickoff circuit to display the part of a signal you want to examine. To make use of this characteristic, display the signal with the delaying-sweep and adjust the delay-pickoff circuit so that the brightening that occurs brightens the place on the trace you want to examine. Then adjust the speed of the main sweep so that the brightening covers the amount of trace you want to examine, and display the signal with the main sweep delayed. The part of the trace you have brightened will then be clear across the screen.

External Sweeps

When the **HORIZONTAL DISPLAY** switch is in the **EXT. SWEEP** position, any signal connected to the **TRIGGER** binding post will move the cathode-ray spot back and forth across the screen. There is a continuous unblanking signal with this switch setting so that the spot is visible all the time. The arrangement is useful for displaying Lissajous figures and for similar applications not requiring a linear sweep.

SIMPLIFIED SWEEP DIAGRAMS

Main-Sweep Simplified Diagram

The trigger signal is normally coupled to the multivibrator by way of the main-sweep trigger amplifier. The trigger signal trips the multivibrator, which sends a negative gate through the disconnect diodes to two points on the sweep generator. The sweep generator makes a positive-going sawtooth that is amplified and used to sweep the beam across the cathode-ray tube.

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

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

When used in delayed-trigger operation, the stability tube is combined with a second tube to form a bistable gate generator which can either trigger the multivibrator or place it near the point of triggering during its second stable state. The bistable gate generator is triggered by the delayed trigger to the second stable state where it remains until the main sweep reverts it and itself at the same time.

With low settings of the **STABILITY** control, during this period, the multivibrator will respond to trigger signals from the main-sweep trigger amplifier, but will not respond during the previous period when it is in the first stable state. Triggering of the main sweep is therefore held off until the delay trigger arrives and arms the main sweep.

With higher settings of the **STABILITY** control, the multivibrator will be triggered during the transition to the second stable state at the time of the delay-trigger signal. No trigger signal would normally be connected through the main-sweep trigger amplifier for this type of operation.

Delaying Sweep Simplified Diagram

The delaying-sweep circuit is similar to the main-sweep circuit. The trigger signal to the multivibrator control grid is coupled through the stability cathode follower. The sweep-length cathode follower operates in parallel with the stability tube, and is cut off until the sawtooth reaches the grid voltage of the stability tube. The sweep-length control determines the amplitude and dc level of the sawtooth voltage at the grid of the sweep-length tube. This control is

the red knob concentric with the **TIME/CM** switch, labeled **LENGTH** in red on the front panel.

Delay-Pickoff Simplified Diagram

The delay pickoff generates a trigger when the delaying-sweep sawtooth reaches a prescribed level, determined by the **DELAY TIME** control setting. The delay comparator has the pentode section conducting until the sawtooth raises the triode grid above the pentode grid. The positive plate pulse, generated when the pentode cuts off, triggers the delay-trigger shaper. The **DELAY TIME** control can adjust the bias of the comparator over the same range as the delay sawtooth.

CIRCUIT DESCRIPTION

BLOCK DIAGRAM

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

Vertical Amplifier

Plug-In Preamplifiers

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

Main-Unit Amplifier

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

Delay Line

The balanced, 50-section delay line adds .2 microseconds of delay to the signal so the sweep circuits will have time to get the cathode-ray spot unblanked and sweeping before the signal reaches the vertical deflection plates.

Trigger Cathode Followers

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

Main Sweep

Trigger Phase Inverter

This stage provides either in-phase or inverted output so as to provide negative-going output for either negative-going or positive-going input signals.

Trigger Shaper

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

Multivibrator

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

Stability and Delayed-Trigger CF

When the main-sweep-normal function is in operation this circuit adjusts the dc level of the input grid of the gating multivibrator. When the delayed-trigger function is in operation the circuit sets the dc level and also amplifies the delayed trigger to trigger the multivibrator or sets a dc pedestal that places the multivibrator input grid within range of the main-sweep trigger signals.

Sweep Generator

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

Trigger Holdoff

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

Sweep Amplifier

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

Delaying Sweep

The delaying sweep has essentially the same circuit elements as the main sweep. The phase

inverter selects in-phase or inverted signals by means of a toggle switch. The trigger-shaper stage makes sharp pulses that trigger the multivibrator. The multivibrator turns on the sweep generator and is reverted by the sweep generator through a holdoff circuit.

Unblanking

Each multivibrator generates a positive unblanking pulse at the same time that it turns on the sweep generator. The main-sweep pulse is several volts higher than the delaying-sweep pulse and therefore brightens the trace more than the delaying sweep pulse. The pulses are transmitted to the crt grid by separate cathode followers with the same cathode resistor.

External Sweep Amplifier

The external-sweep amplifier uses the same tubes as the delayed-sweep trigger-inverter stage. One position of the **HORIZONTAL DISPLAY SWITCH** arranges the circuits so the amplified signal is connected to the sweep-output amplifier. A ten-to-one fixed attenuator and a continuous control of amplifier gain provide 100-to-1 adjustment of horizontal-deflection sensitivity.

Calibrator

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

VERTICAL DEFLECTION SYSTEM

General

The vertical amplifier of the Type 545 Oscilloscope has separate preamplifier units that can be plugged into the main unit. These units provide a variety of passbands and sensitivities and allow for future developments in preamplifiers.

The plug-in units develop balanced push-pull output which is maintained push pull throughout the remainder of the amplifier. The units contain sensitivity adjustments and positioning controls.

Signal connections to the vertical amplifier in the main unit are made by means of terminals in a mating multiple-contact plug and socket. Power connections from the main unit are made through other connectors on the same plug-and-socket assembly.

Type 53/54K Preamplifier

The Type 53/54K preamp is capable of utilizing the full 30-mc pass band of the main-unit amplifier. It includes an input attenuator and a vertical positioning control. Power for all circuits as well as the tube heaters is obtained from the main-unit regulated dc supplies.

Main-Unit Input Stage

Signal input from the preamp is connected through terminals 1 and 3 to the grids of input amplifiers V1052B and V1040B. The cathodes of these two tubes are connected together through the degenerative network, R1026, R1027 and R1028. R1027 labeled GAIN ADJ. is variable to allow the amplifier gain to be varied over a small range. L1022 and L1041 provide series peaking and L1021 and L1042 provide shunt peaking for the stage. Triodes V1050A and V1052A provide the low impedance necessary for driving the distributed-amplifier grid line.

Beam-Position Indicators

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

Trigger Pickoff

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

DC-Shift Compensation

DC-shift compensation is accomplished in two ways and corrects for two different time constants. The series combination of R1080 and C1045B on plate line L1080, and R1084 and C1050B on plate line L1083, lowers the termination resistance of these lines to all but the very low frequencies. They provide a time constant which corrects for the initial dc shift in the amplifier. The second time constant is corrected by R1045 and C1045A and R1050 and C1050A. These rc networks have a negligible loading

effect on the distributed-amplifier plate lines, but provide low-frequency positive feedback to the input-amplifier plates. This feedback corrects for the longer-time-constant dc shift. R1059, labeled DC SHIFT COMP. permits the amount of compensation to be adjusted to accommodate tube differences.

Distributed Amplifier

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

Termination Network

Unless the plate lines are terminated at the reverse end with a resistance equal to their characteristic impedance, signals traveling the reverse direction down the line will be reflected and appear in the output. Since resistors are not available, in a suitable power rating, which appear resistive over the wide pass band of the Type 545, an adjustable terminating network is used. The coils, L1070 and L1071, are wound with resistance wire and have a total resistance of 595 ohms. Each section has a characteristic impedance which is approximately equal to the impedance of the plate lines less the series dc resistance between it and the plate lines.

Calibrator

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

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

MAIN-SWEEP CIRCUITS

Trigger Amplifier

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

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

Triggering Mode Switch

The **TRIGGERING MODE** switch, SW5, has five positions marked in red in the upper right-hand corner of the instrument panel: **DC, AC SLOW, AC FAST, AUTOMATIC,** and **HF SYNC**. This switch arranges the circuits of the trigger-amplifier and trigger-shaping stages to accomodate the five types of triggering.

DC, AC Slow and AC Fast

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

component of the triggering signal and allow fast recovery of the trigger circuits in the presence of dc level changes.

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

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

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

Automatic

In the **AUTOMATIC** position of the TRIGtode section of trigger-shaper V20, drives the grid **GERING MODE** switch, the plate of the penof the triode section just as it does in the **AC SLOW** position. But in addition, it also drives its own grid through R30, a high resistance of several megohms.

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

When pentode plate current flows, the pentode plate drops, forcing the triode grid down, and thus the right-hand end of R30 is forced down. The left-hand end of R30 and the pentode grid immediately begin to drop exponentially toward pentode cutoff. When the pentode grid reaches cutoff again it has completed one cycle of the approximately 50-cycle sawtooth. The range of pentode grid voltage between pentode cutoff and triode cutoff is about six volts for the **AUTOMATIC** circuit. This is increased from about ¼ volt for the **DC** and **AC SLOW** circuit connections by addition of R32 to the plate load of the pentode.

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

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

HF Sync

When the **TRIGGERING MODE** switch is in the **HF SYNC** position, the trigger-amplifier

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

Multivibrator

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

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

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

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

Stability Cathode Follower

The **STABILITY** control, R43, adjusts the grid voltage of cathode follower V43A, which in turn determines the quiescent grid voltage of positive multivibrator V58A at about —40 volts, just above the threshold of triggering. Holdoff cathode follower V54A, and delay trigger cathode follower V37B, are normally cut off and do not contribute to the quiescent level of V58A grid.

Sweep Generator

The sweep generator is a Miller integrator circuit. The circuit includes the Miller tube V90, timing capacitor C99, timing resistor R99, cathode follower V85 and disconnect diodes V80A and V80B. In the quiescent state between sweeps, the plates of diodes V80A and V80B rest at —3.2 volts. Very little current flows through V80A to the grid circuit of V90, and V90 grid therefore rests at about —3.3 volts. More current flows through V80B so that its cathode is at about —5 volts. The timing capacitor C99, which is connected between these two points, therefore has only about 1.7 volts of charge.

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

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

The gain of the Miller tube as a class-A amplifier is so high that the plate signal coupled back through charging capacitor C99 keeps the grid voltage constant within a fraction of a volt. Meanwhile, C99 is charging with current flowing through R99 from the —150-volt bus. Since the grid of V90 remains constant within a small fraction of a volt, the current through R99 remains constant, and C99 thus charges at a constant

rate. As C99 charges, the voltage of the upper end therefore rises linearly. Any departure from a linear rise of the cathode of cathode-follower coupled V85 will result in a change in grid voltage in the direction that will produce a change in plate voltage the right amount to correct the departure difference. The capacitor C96 helps to maintain a linear voltage rise at the faster sweeps.

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

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

Sweep Length

The positive step from multivibrator V70 occurs when a positive step is delivered to the grid of multivibrator V58A. The sawtooth to the multivibrator is delivered through cathode followers V40A and V55B from a tap on the cathode-load resistor of coupling cathode follower V85. This tap is adjustable by means of potentiometer R88, labeled SWEEP LENGTH on the chassis, a screwdriver adjustment. When the voltage of this tap is properly set the sawtooth will terminate when the spot has passed the right-hand limit of the graticule. C54 on the grid of V54A retards the return of V58A grid to the quiescent level after the passage of the positive pulse. This holds off any trigger signals from retriggering the multivibrator until all other capacitances in the circuit have had time to reach their quiescent voltage levels. Proper sizes of capacitor C54 are switched with the **TIME/CM** switch so that more recovery time is permitted for the slower sweeps and the least necessary recovery time is allowed for the faster sweeps.

Sync Amplifier

Synchronizing pulses for plug-in units under development are supplied by V78. When the negative multivibrator, V70, generates its positive plate step, it also generates a sharp differentiated positive trigger voltage at its screen, because of L72 and damping resistor R72 which connect the screen to +100 volts. The positive screen trigger pulse is coupled to the grid of V78 through C78. Grid bias of about —7 volts is set by divider R78, R79, between ground and —150 volts. Plate voltage and cathode return circuits are completed in the plug-in unit.

DELAYING-SWEEP CIRCUITS

Horizontal-Display Switch

The **HORIZONTAL DISPLAY** switch has seven sections that select the source of signal to the sweep amplifier and unblanking circuits, and connect the delayed trigger to the main-sweep circuits.

In the **MAIN SWEEP NORMAL** position, this switch connects the main-sweep generator to the sweep amplifier, grounds the grid of the delaying-sweep unblanking cathode follower and supplies main-sweep sawtooth to the delay pickoff.

In the **DELAYING SWEEP** position the switch connects the delaying-sweep generator to the sweep amplifier and to the delay-pickoff comparator circuit, V195B, and connects the delaying-sweep gate to the unblanking mixer. Both the main- and the delaying-sweep unblanking signals unblank the cathode-ray tube.

In the **MAIN SWEEP DELAYED** position of the switch the delaying-sweep is disconnected from the sweep amplifier, its unblanking mixer grid is grounded, the main-sweep generator is connected to the sweep amplifier and unblanking mixer, and the main-sweep trigger input is connected to the delay pickoff.

In the **EXT. SWEEP** position the switch rearranges the delaying-sweep trigger shaper into a cathode follower and connects its output to the sweep-amplifier input. It also biases off the delay-trigger circuit and the delaying-sweep multivibrator, and supplies a positive dc bias to the unblanking circuit to hold the cathode-ray tube unblanked.

Delayed-Trigger Amplifier

The delayed-trigger from the delay-pickoff circuit, described in a later paragraph, is amplified in V37A, and applied to the grid of delayed-trigger cathode follower V37B through compensated voltage-divider C50, R50, R51. The cathode voltage of V37B is determined by current through R53 which is returned to —150 volts.

Current through R53 can be contributed by cathode current through any of three cathode followers, V43A, the stability tube; V54A, the holdoff tube; or V37B, the delayed-trigger tube,

depending on the position of the **HORIZONTAL DISPLAY** switch, the setting of the **STABILITY** control, and the stage of the trigger-and-sweep sequence.

With the **MAIN SWEEP NORMAL** position the plates of V37A and V43A are disconnected and screen current furnishes the cathode current of V43A. With the switch in the **MAIN SWEEP DELAYED** and the **DELAYING SWEEP** positions plate voltage is connected both to V37A and V43A. The plate of V43A is connected to the grid of V37B through compensated voltage divider C50, R50, R51, in such a way that V43A and V37B become a bistable multivibrator.

In the quiescent state V37B conducts and holds the common-cathode voltage so high V43A is cut off. A positive pulse at the grid of V37A will therefore become a negative pulse at its plate. The negative pulse drives the grid of V37B down below cutoff, and the multivibrator assumes the second stable state in which V43A conducts and V37B is cut off. The cathode level in this state can be set by means of the bias voltage determined by the setting of the **STABILITY** control.

By setting the cathode level past the threshold of triggering for the sweep-gating multivibrator, a sweep will not be triggered, but the grid will be placed close enough to triggering that a negative trigger pulse from the main-sweep trigger circuit will trigger a sweep.

Two methods of delayed triggering are thus available. The first method in which the delayed trigger actually triggers the sweep is the ordinary system. The second method permits the sweep to be triggered actually from the delayed pulse you want to observe. The delayed trigger opens up the normal trigger channel that has been closed up to that time so as to hold off undesired triggers.

Delay Pickoff

The delay pickoff circuit is a sawtooth comparator circuit arranged to produce a positive output voltage at the time of pickoff. Before the pickoff time, V195B is cut off. Its cathode is tied to the cathode of V195A which is conducting and therefore determining the common-cathode voltage.

The common-cathode voltage is adjustable by means of R209, a 10-turn helical resistor, labeled **DELAY-TIME MULTIPLIER** on the front panel. V228A is a constant-current pentode supplying cathode current to the comparators from the —150-volt supply. This arrangement permits the cathode of V195A to follow its grid over a wide range with very little variation of cathode voltage.

Plate current through R205 therefore also remains very nearly constant while V195A is conducting, no matter at what voltage the grid is set by the **DELAY-TIME MULTIPLIER** control, R209. This is important because the plate voltage of V195A is required to hold the grid voltage of the shaper stage, V216A, near the level for triggering.

The positive-going delaying-sweep sawtooth raises the grid of non-conducting V195B toward its cathode voltage. When the grid rises past the cathode voltage set by the **DELAY-TIME MULTIPLIER** control, V195B conducts and V195A cuts off.

Delayed-Trigger Shaper

When V195A cuts off, because of conduction in V195B, its plate rises carrying the grid of trigger shaper V216A positive past its transition point. The trigger-shaper stage is regenerative so as to produce a fast transition, and the resulting positive step at the plate of V216B is differentiated through C228 and used to arm or to trigger the main-sweep circuits. The sharp differentiated pulse is transmitted to the succeeding circuits through cathode follower V228B.

Two internal screwdriver controls accessible from the right side through holes in the cabinet permit you to adjust the delay time more accurately if necessary so you can read centimeters of delay within a fraction of one per cent directly from the micrometer dial of the 10-turn **DELAY-TIME MULTIPLIER** control. R208 adjusts the total dc voltage across R209 so that each of the ten turns of this resistor positions the point of delay pickoff one centimeter of horizontal beam displacement. R195 sets the dc level of the delay sawtooth accurately so that the zero setting of the **DELAY-TIME MULTIPLIER** control corresponds to the start of the delaying sawtooth.

Reset Button

The main-sweep circuits can be adjusted to perform a single sweep when triggered and then be unresponsive to any further triggers. This circuitry is set up when the **HORIZONTAL DISPLAY** switch is in the **MAIN SWEEP DELAYED** position, and the delaying sweep is deactivated by turning the delaying-sweep **STABILITY** control counterclockwise.

The main-sweep multivibrator **STABILITY** control is set at the level where it would normally be for main-sweep-triggered operation, and the desired trigger-signal source is connected to the main-sweep triggering circuits.

With the **MAIN SWEEP DELAYED** setting of the switch, V43A and V37B form a bistable multivibrator when the main-sweep **STABILITY** control is adjusted as described in the

previous paragraph. In the stable state that exists after completion of one sweep and before the **RESET** button is pressed, V37B is conducting and thereby determining the voltage level of the common-cathode circuits. This level is high enough to hold off V58A from triggering. The **RESET** control, SW235, shown on the delay-pickoff diagram, applies a negative pulse to V37B and turns it off, thereby switching multivibrator V43A, V37B, to its second stable state with V43A controlling the common cathode level. This level is lower and it places the grid of V58A within the region where it will trigger, if the **STABILITY** control has been properly set, and the next trigger signal will initiate a sweep. At the end of the sweep, holdoff cathode-follower V54A raises the common-cathode level up momentarily, thereby switching V37B on and V43A off again, and the circuit returns to its first stable state.

Ready Light

The ready light, B42, shows whether V43A is conducting. When V43A conducts it pulls down the grid of V43B and thereby raises the plate high enough to light the neon glow lamp.

When the ready light is glowing a single negative pulse at the main-sweep multivibrator grid, V58A, will trigger a single sweep and the circuit will thereafter be disarmed for subsequent triggers.

SWEEP AMPLIFIER

Amplifier

Input to the amplifier is selected by one of the positions of the **HORIZONTAL DISPLAY** switch, SW200. A cathode follower, V240B, feeds the selected signal to a second cathode follower, V240A, which in turn feeds a common-cathode, grounded-grid phase inverter, V265A and V272A. Gain of the phase-inverter stage can be adjusted by adjusting R266 and R270, labeled SWP. CAL. and MAG. GAIN on the chassis, which determine the degree of coupling between the two cathodes. Output from the phase-inverter stage is applied to the horizontal-deflection plates of the cathode-ray tube through cathode followers, V265B and V272B.

Magnifier

A degenerative circuit path through R259, R254 and R253, between the negative-going cathode follower, V265B, and the —150-volt bus, accurately determines the gain of the amplifier. This degenerative path can be disconnected by means of SW254A, labeled **5X MAGNIFIER, ON** and **OFF**, in red on the front panel. When the network is removed, the gain of the amplifier is increased by a factor of five for the magnified sweep. R266 and R270 between cathodes of the phase-inverter stage V265A and V272A are also switched by the **5X MAGNIFIER** switch, to permit the gains to be individually adjusted so as to keep the ratio of gains exactly five times for the two positions while permitting the spot speeds to be accomodated to the graticule. An internal screwdriver adjustment, R262, labeled SWEEP/MAG REGIS, adjusts the bias of the degeneration cathode follower so that it is the same for both switch positions. This permits the magnified and normal sweep traces to be kept in accurate register, so that the center portion of the normal sweep will be centered when magnified.

Gated CF Current Booster

Cathode current for cathode follower V265B which drives the negative-going, left-hand plate of the crt, is determined by the plate current of pentode V282. The pentode is used because its plate current remains nearly constant over a large range of plate voltage, so that the cathode-follower current is kept nearly constant even though its cathode voltage drops through a range of about 150 volts. For the fastest sweeps, the maximum permissible continuous current through these tubes is too small to discharge the capacitance of the crt deflection plate and its associated wiring at the required rate. To increase the current through these tubes to the required value, a positive, flat-topped pulse is applied to the grid of the pentode during the period of the sweep. The positive pulse is derived by differentiating the positive-going sawtooth, through an rc network. Its amplitude is thus proportional to sweep speed. For the fastest sweep, the tube current is several times normal, but at the reduced duty cycle of the sweep, is well within the average dissipation limit of the tubes.

Beam-Position Indicators

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

Positioning

Horizontal positioning of the trace is adjustable through cathode follower V246B which sets the dc grid voltage of input cathode follower

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

External Sweep Amplifier

When the **HORIZONTAL DISPLAY** switch, SW200, is in the **EXT. SWEEP** position, the **EXT. SWEEP** connector connects to an auxiliary amplifier which uses the tubes and circuits of delaying-sweep phase inverters.

External-sweep signals are applied either to the grid of V113A or V113B, depending on the setting of **SLOPE** switch, SW113. For in-phase amplification the **SLOPE** switch should be switched to —, and the signal will be connected to V113A.

The signal applied to V113A grid is cathode coupled to V120A, which, with V120B, is a cathode-coupled, grounded-grid amplifier. Gain of this amplifier can be adjusted by varying R122 which determines the amount of cathode coupling. The two cathodes must be at the same dc voltage, or variation of R122 will change the dc level. R114 labeled EXT. AMPL. DC BAL. on the chassis can be adjusted so that the cathodes of V120A and V120B are at the same voltage.

Plate output from V120B is connected to the sweep amplifier through cathode follower V130A in the **EXT. SWEEP** position of the **HORIZONTAL DISPLAY** switch.

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

POWER SUPPLY

Transformer

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

Rectifiers

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

Regulation, —150-Volt Supply

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

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

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

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

+100-Volt Supply

The comparator tube in the +100-volt supply, V742, compares its grounded cathode to the tapped-down voltage of divider, R750, R751 connected between the —150-volt bus as a reference voltage and the +100-volt bus to be regulated. The tapped-down point is a volt or so below

ground. The screen of V742 receives a sample of the ripple signal through R744 to provide an out-phasing signal that reduces the output ripple at the +100-volt bus. High-frequency gain of the feedback loop is increased by C750, and C751A reduces the high-frequency output impedance.

+225-Volt Supply

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

+350-Volt Supply

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

+500-Volt Supply

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

Time-Delay Relay

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

High-Voltage Supply

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

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

High-Voltage Regulator

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

If, for example, the high voltage should become too high, it would make the grid of the comparator tube more negative with respect to its cathode. When the grid drops, the plate rises, thereby raising the grid of V810B. When its grid rises its plate drops, thereby dropping the screen voltage of the oscillator tube, and reducing the amplitude of oscillation. The reduction of primary voltage of T801 reduces the high voltage, thereby correcting the original departure. C814 at V810A grid reduces noise and hum.

Unblanking

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

CRT Geometry Adjust

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

MAINTENANCE

Replacement of Components

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

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

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

Parts-Ordering Information

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

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

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

Soldering Precaution

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

Color Coding

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

Air Filter

The Type 545 Oscilloscope is cooled by filtered, forced air. If the filter gets too dirty it will restrict the flow of cooling air and may cause the instrument to overheat. The filter should be inspected every three or four months and cleaned or replaced if necessary.

Two types of air filters can be used with your Tektronix equipment. A washable air filter constructed of aluminum wool coated with an adhesive is usually supplied with your instrument. A disposable glass-wool filter is available through your local Tektronix field office or direct from the factory. If you are replacing an aluminum-type filter with the disposable glass-wool type, it is best to order No. 378-009, which includes two back-up screens that help to prevent damage to the filter. For future replacements of the glass-wool filter only, order No. 378-012.

To clean the aluminum filter, run hot water through it from the side that was inside. Or slosh it around in hot soapy water and rinse it in clear water. Then dry it thoroughly and coat it with new adhesive. When new, the filter is coated with "Filter Coat", a product of the Research Products Corporation. Pint cans are available under the name "Handi-Koter" from some air-conditioner suppliers. Other adhesive materials are no doubt satisfactory.

Fan Motor

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

Trouble Shooting

If the instrument fails to operate at all, including the fan and the pilot light, check the source of power and determine that the power cord plug is firmly in place. Then check the fuse at the back of the instrument near the power receptacle. If the instrument has been operating but has just stopped, it may have overheated and tripped the thermal cutout. The thermal

cutout will reset itself when the instrument cools down enough. Possible causes of overheating are fan stoppage, restriction of air circulation or high room temperature. Be sure the air filter is clean.

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

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

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

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

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

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

Tube failure will often show up in the voltage readings of the power supply. So another early step to take when you look for troubles is to check voltages and currents from the regulated power supplies. The voltages can be checked from the top or right side of the instrument on a ceramic terminal strip near the rear of the instrument. The voltages are marked on the chassis. The —150-volt terminal should read within one per cent of 150 volts. The remainder of the voltages should be within about five per cent of their indicated voltages. Keep in mind that these are quite close tolerances, especially the 150-volt tolerance. Very few portable voltmeters have comparable accuracy, so be sure that any small discrepancy you may find is not due to voltmeter error.

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

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

Vertical-Amplifier Adjustments

1. Gain Adjustment

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

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

a. Remove any vertical signal or triggering signal.

b. Set the controls as follows:

HORIZONTAL DISPLAY
DELAYING SWEEP

Delaying-Sweep **STABILITY**
CCW

Main-Sweep **STABILITY**
CW

MULTI BAL, R64
CW

(located about half way back on top chassis)

c. Connect a voltmeter from ground to pin 8 of V37, located just behind the **TRIGGERING MODE** switch.

d. Note the voltmeter reading — it should be about —40 volts.

e. Back the main-sweep **STABILITY** control all the way counterclockwise then advance it clockwise while watching the voltmeter until the reading is 10 volts more negative than the reading obtained in step d (about —50 volts).

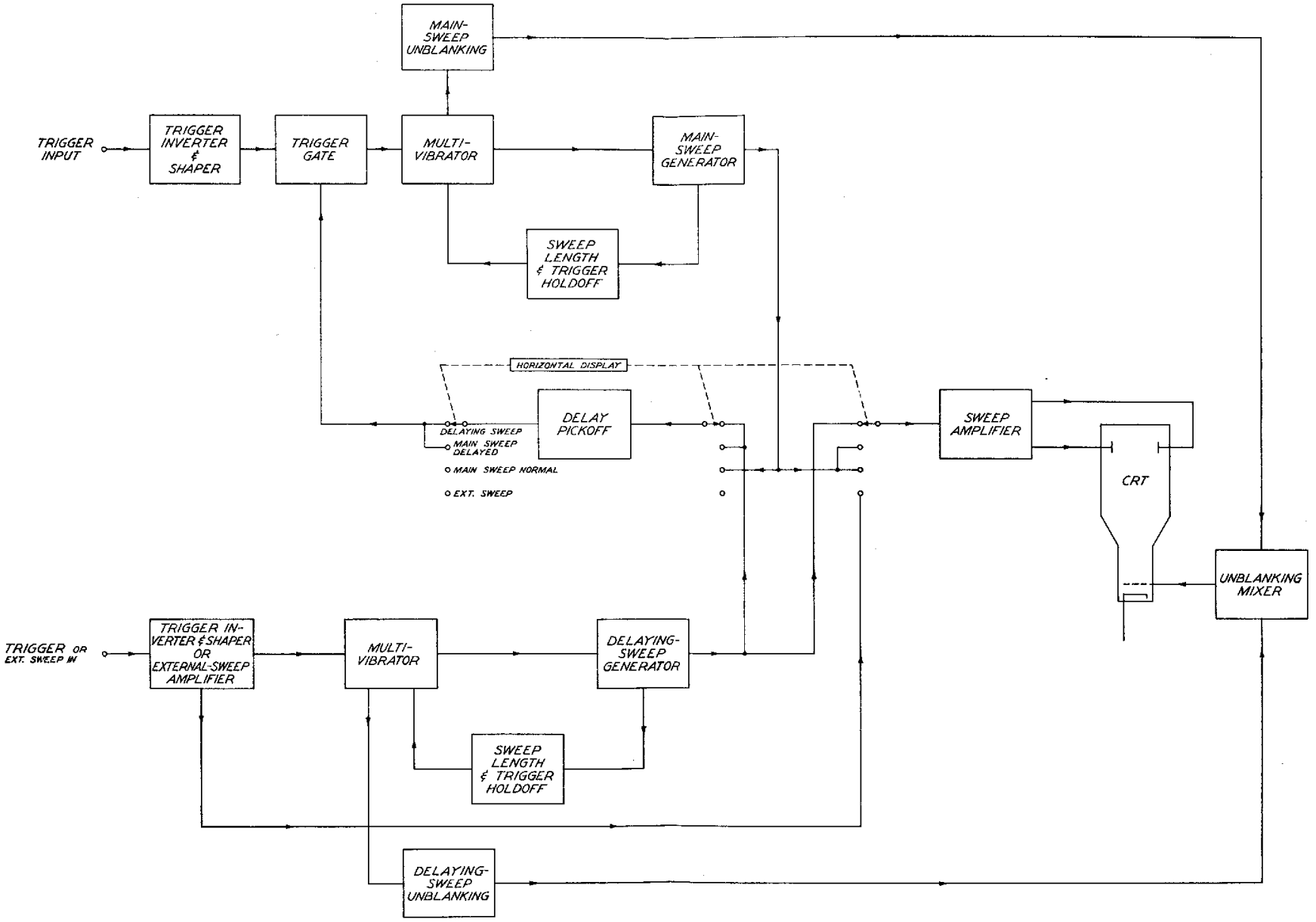
f. Slowly turn the MULTI BAL control, R64, counterclockwise until the voltmeter reading drops suddenly to a lower reading. This provides a holdoff voltage of 10 volts.

External Sweep DC Balance

Turn the **HORIZONTAL DISPLAY** switch to **EXT. SWEEP** and the **5X MAGNIFIER** to **ON.** Position the spot onto the screen and turn the **EXT. SWEEP ATTEN.** back and forth. If the spot moves horizontally as the **EXT. SWEEP ATTEN.** control is turned, adjust the EXT. SWEEP AMPL. DC BAL. control until the spot remains stationary. The EXT. SWEEP AMPL. DC BAL. control is located at the front of the vertically-mounted chassis at the right side of the instrument.

Calibrator Adjustment

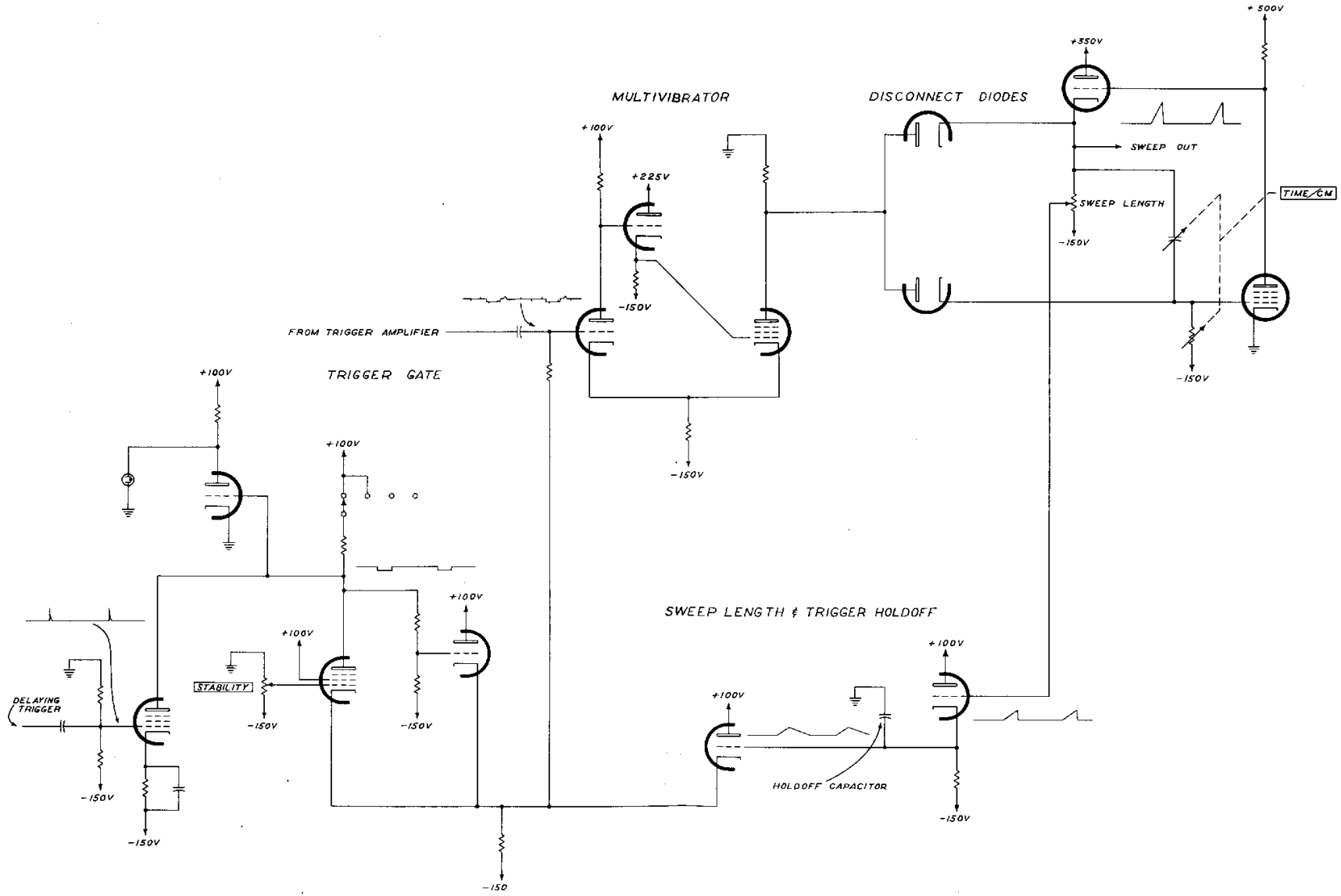
When the **CALIBRATOR** switch is turned to **OFF** the calibrator cathode follower, V246A, remains conducting at the current required to develop 100 volts across the voltage divider. To check the calibrator, turn the instrument on its side, and measure the cathode voltage at V246 cathode. This voltage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



SWEEP-CIRCUIT FUNCTIONAL BLOCK DIAGRAM

8-2-54 RF

SWEEP GENERATOR

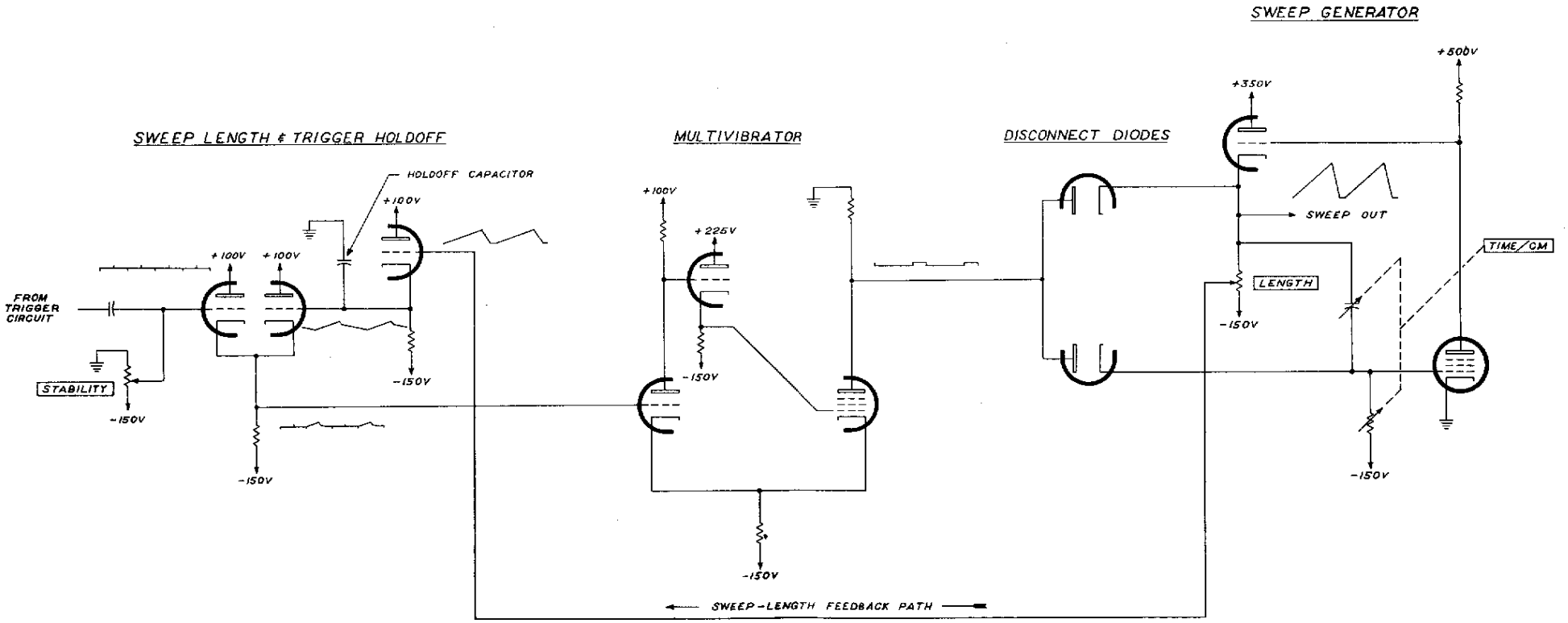


TYPE 545 OSCILLOSCOPE

A

SIMPLIFIED DIAGRAM
MAIN SWEEP

3-18-54
KF

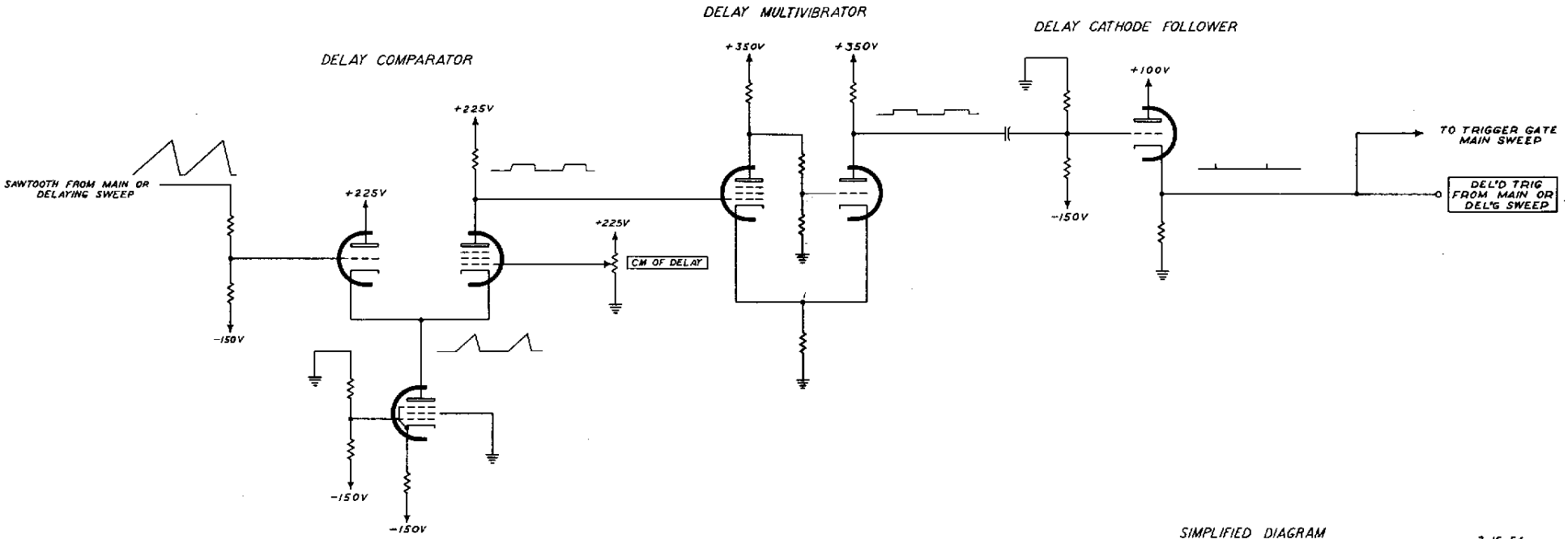


TYPE 545 OSCILLOSCOPE

A

SIMPLIFIED DIAGRAM
DELAYING-SWEEP GENERATOR

3-15-54
RF

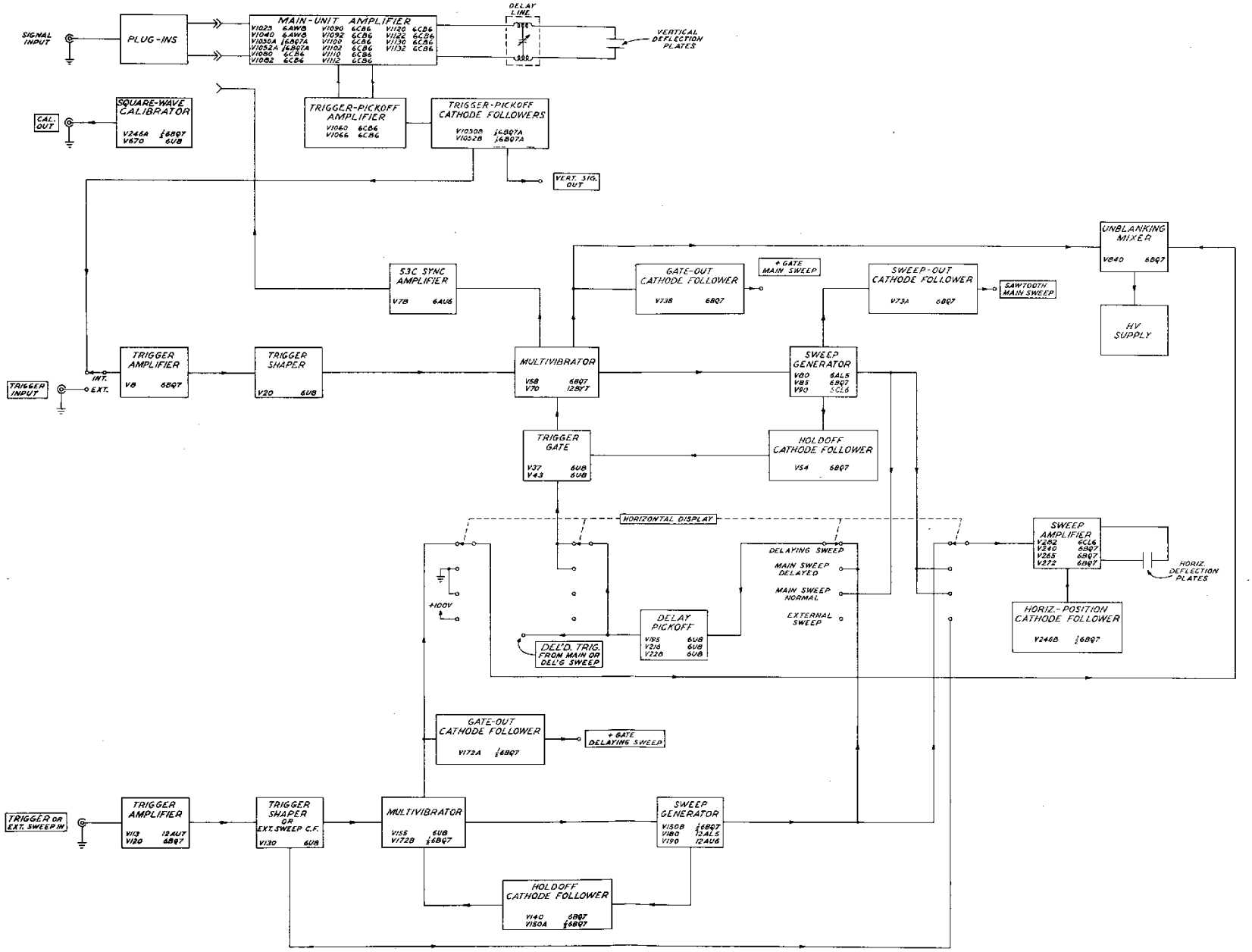


TYPE 545 OSCILLOSCOPE

A

SIMPLIFIED DIAGRAM
DELAY PICKOFF

3-15-54
KF



TYPE 545 OSCILLOSCOPE

A1

BLOCK DIAGRAM

10-5-56 KF

ABBREVIATIONS

Cer.	ceramic	m	milli or 10^{-3}
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	Poly.	polystyrene
f	farad	Prec.	precision
GMV	guaranteed minimum value	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

MAIN-SWEEP TRIGGER

Capacitors

						Order Parts by Number
C1	4.7 μμf	Cer.	Fixed	500 v	±1 μμf	281501
C3	.001 μf	PT	Fixed	600 v	20%	285501
C4	100 μμf	Cer.	Fixed	350 v	20%	281523
C7	.001 μf	Cer.	Fixed	500 v	GMV	283000
C9	47 μμf	Cer.	Fixed	500 v	20%	281518
C17	.001 μf	Cer.	Fixed	500 v	GMV	283000
C20	.01 μf	PT	Fixed	400 v	20%	285510
C28	.005 μf	Cer.	Fixed	500 v	GMV	283001
C34	22 μμf	Cer.	Fixed	500 v	20%	281510

Resistors

R1	1 meg	½ w	Fixed	Comp.	5%		301105
R2	390 k	½ w	Fixed	Comp.	5%		301394
R3	50 k	2 w	Var.	Comp.	20%	Int. Trig. DC Level Adj.	311023
R4	100 k	½ w	Fixed	Comp.	10%		302104
R5	1 meg	½ w	Fixed	Comp.	10%		302105
R6	100 k	½ w	Fixed	Comp.	10%		302104
R7	470 k	½ w	Fixed	Comp.	10%		302474
R8	47 Ω	½ w	Fixed	Comp.	10%		302470
R9	4.7 k	1 w	Fixed	Comp.	10%		304472
R10	4.7 k	1 w	Fixed	Comp.	10%		304472
R11	47 Ω	½ w	Fixed	Comp.	10%		302470
R12	33 k	2 w	Fixed	Comp.	10%		306333
R13	39 k	2 w	Fixed	Comp.	10%		306393
R14	100 k	½ w	Var.	Comp.	20%	TRIGGERING LEVEL, conc. with R43	311030*
R15	22 k	½ w	Fixed	Comp.	10%		302223
R16	470 k	½ w	Fixed	Comp.	10%		302474
R17	470 k	½ w	Fixed	Comp.	10%		302474
R19	56 k	½ w	Fixed	Comp.	10%		302563
R20	47 k	½ w	Fixed	Comp.	10%		302473
R21	47 k	½ w	Fixed	Comp.	10%		302473
R22	47 Ω	½ w	Fixed	Comp.	10%		302470
R23	1 k	½ w	Fixed	Comp.	10%		302102
R24	2.7 k	½ w	Fixed	Comp.	10%		302272
R27	22 k	2 w	Fixed	Comp.	10%		306223
R28	500 Ω	2 w	Var.	Comp.	20%	Trigger Sensitivity	311005
R29	22 k	2 w	Fixed	Comp.	10%		306223
R30	2.7 meg	½ w	Fixed	Comp.	10%		302275
R32	820 Ω	½ w	Fixed	Comp.	10%		302821
R33	47 Ω	½ w	Fixed	Comp.	10%		302470
R34	100 k	½ w	Fixed	Comp.	10%		302104

* Furnished as unit with R43, STABILITY.

Resistors (continued)

								Order Parts by Number
R35	100 k	½ w	Fixed	Comp.	10%			302104
R36	100 k	2 w	Var.	Comp.	20%	Triggering Level Centering		311026

Switches

					not wired	wired
SW1*	2 wafer	6 position	rotary	TRIGGER SLOPE	260099	262080
SW5*	3 wafer	5 position	rotary	TRIGGERING MODE		

Vacuum Tubes

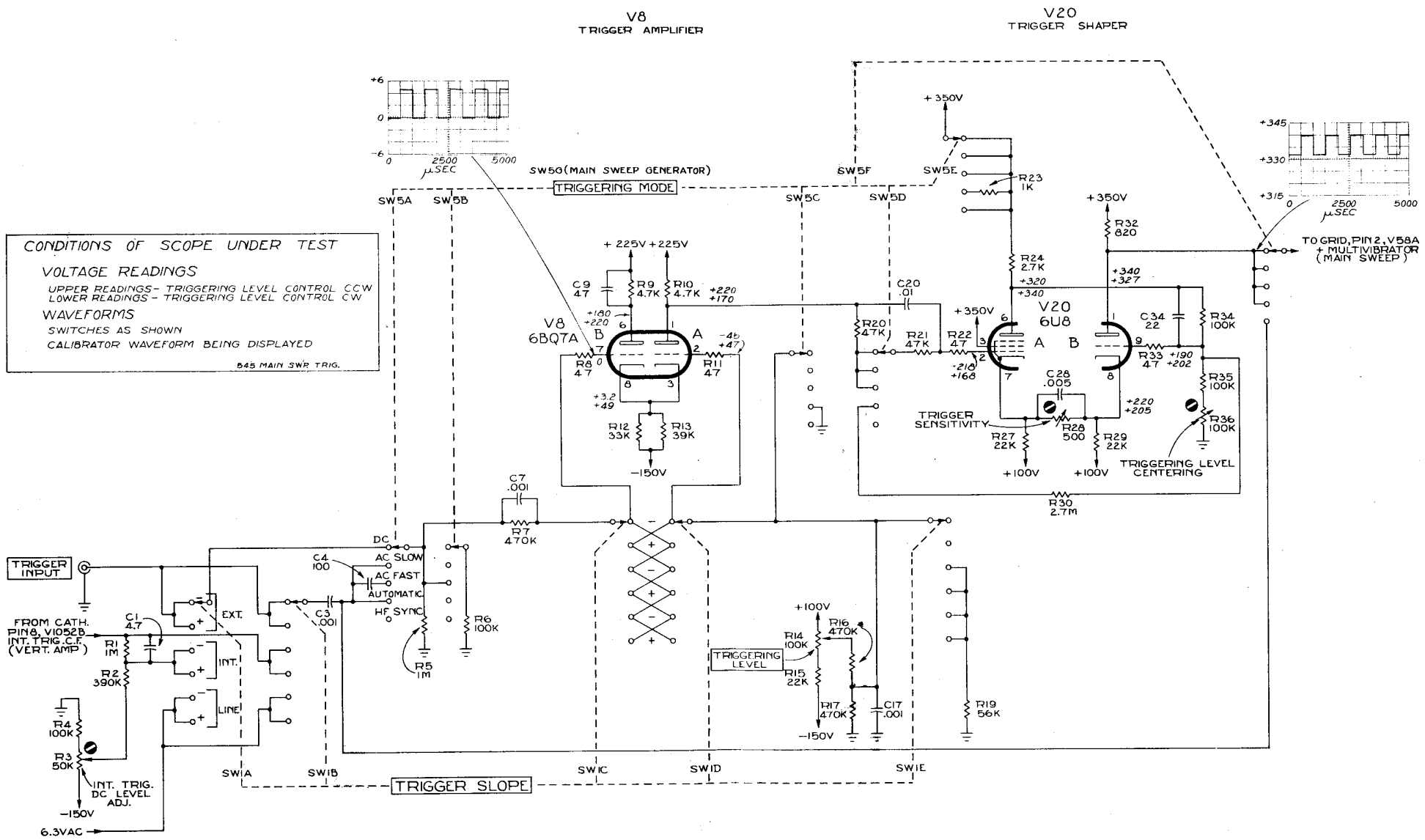
V8	6BQ7A	Trigger Amplifier	154028
V20	6U8	Trigger Shaper	154033

*** SW1 and SW5 shafts are concentric. Furnished as a unit.**

NOTE

Unless otherwise specified, all of the voltage readings were taken with a dc vacuum-tube voltmeter having an input resistance of 11 megohms. The waveforms shown were reproduced from actual photographs. There will be considerable variation between instruments because of normal manufacturing tolerances and vacuum-tube characteristics. Therefore, the significance of any discrepancies observed should be determined by referring to the circuit diagram.

All readings are in volts unless otherwise specified. Where two voltage readings are given, they represent the voltage as read by a voltmeter under two sets of conditions, and, as such, do not indicate the peak-to-peak excursion of voltage at the point.



TYPE 545 OSCILLOSCOPE

C

MAIN SWEEP TRIGGER

ABBREVIATIONS

Cer.	ceramic	m	milli or 10^{-3}
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	Poly.	polystyrene
f	farad	Prec.	precision
GMV	guaranteed minimum value	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

MAIN SWEEP GENERATOR

Bulbs

			Order Parts by Number
B42	65–75 v ignition	1/25 w	150014
B95	55 v	1/25 w	150009
B96	65 v	1/25 w	150011

Capacitors

C37	.001 μf	Cer.	Fixed	500 v	GMV		283000
C40	.005 μf	Cer.	Fixed	500 v	GMV		283001
C41	.005 μf	Cer.	Fixed	500 v	GMV		283001
C45	.001 μf	Cer.	Fixed	500 v	GMV		283000
C50	8 μμf	Cer.	Fixed	500 v	±0.5 μμf		281503
C58	27 μμf	Cer.	Fixed	500 v	20%		281513
C65	12 μμf	Cer.	Fixed	500 v	10%		281506
C71	82 μμf	Cer.	Fixed	500 v	10%		281528
C72	.005 μf	Cer.	Fixed	500 v	GMV		283001
C73	12 μμf	Cer.	Fixed	500 v	10%		281506
C76	.005 μf	Cer.	Fixed	500 v	GMV		283001
C78	.005 μf	Cer.	Fixed	500 v	GMV		283001
C81	.001 μf	Cer.	Fixed	500 v	GMV		283000
C95	.001 μf	Cer.	Fixed	500 v	GMV		283000
C96	82 μμf	Cer.	Fixed	500 v	10%		281528

Inductors

L61	88 μh	Fixed	108022
LR72	#40 wire, 450 turns, on 3.3 k 1 w resistor		108058

Resistors

R37	470 k	½ w	Fixed	Comp.	10%		302474
R38	1 meg	½ w	Fixed	Comp.	10%		302105
R39	100 Ω	½ w	Fixed	Comp.	10%		302101
R40	220 k	½ w	Fixed	Comp.	10%		302224
R41	10 k	½ w	Fixed	Comp.	10%		302103
R42	470 k	½ w	Fixed	Comp.	10%		302474
R43	100 k	½ w	Var.	Comp.	20%	**STABILITY**, conc. with R14	311030**
R44	100 k	½ w	Fixed	Comp.	5%		301104
R45	200 k	½ w	Fixed	Comp.	5%		301204
R46	100 Ω	½ w	Fixed	Comp.	10%		302101
R47	470 k	½ w	Fixed	Comp.	5%		301474
R48	47 k	1 w	Fixed	Comp.	10%		304473
R49	100 k	2 w	Var.	Comp.	20%	Preset Stability	311026
R50	95 k	½ w	Fixed	Prec.	1%		309044
R51	220 k	½ w	Fixed	Prec.	1%		309052

** Furnished as a unit with R14, **TRIGGERING LEVEL.**

Resistors (continued)

						Order Parts by Number
R52	100 Ω	½ w	Fixed	Comp.	10%	302101
R53	22 k	2 w	Fixed	Comp.	10%	306223
R54	100 Ω	½ w	Fixed	Comp.	10%	302101
R57	4.7 meg	½ w	Fixed	Comp.	10%	302475
R58	1 k	½ w	Fixed	Comp.	10%	302102
R59	47 Ω	½ w	Fixed	Comp.	10%	302470
R60	2.7 k	1 w	Fixed	Comp.	Selected*	312569
R61	3.3 k	1 w	Fixed	Comp.	Selected*	
R62	56 k	1 w	Fixed	Comp.	5%	303563
R63	47 Ω	½ w	Fixed	Comp.	10%	302470
R64	2.5 k	1/10 w	Var.	Comp.	20% Multi Bal	311010
R65	39 k	1 w	Fixed	Comp.	Selected**	312570
R66	33 k	1 w	Fixed	Comp.	Selected**	
R67	100 Ω	½ w	Fixed	Comp.	10%	302101
R68	8 k	5 w	Fixed	WW	5%	308053
R69	1 k	½ w	Fixed	Comp.	10%	302102
R70	47 k	½ w	Fixed	Comp.	10%	302473
R71	270 Ω	½ w	Fixed	Comp.	10%	302271
R72	47 Ω	½ w	Fixed	Comp.	10%	302470
R73	47 k	½ w	Fixed	Comp.	10%	302473
R74	100 k	½ w	Fixed	Comp.	10%	302104
R75	100 Ω	½ w	Fixed	Comp.	10%	302101
R76	47 Ω	½ w	Fixed	Comp.	10%	302470
R77	4.7 k	1 w	Fixed	Comp.	10%	304472
R78	47 k	½ w	Fixed	Comp.	10%	302473
R79	1 meg	½ w	Fixed	Comp.	10%	302105
R80	10 k	½ w	Fixed	Comp.	10%	302103
R81	100 k	½ w	Fixed	Comp.	10%	302104
R82	1 meg	½ w	Fixed	Comp.	10%	302105
R83	1.8 meg	½ w	Fixed	Comp.	10%	302185
R84	100 k	1 w	Fixed	Comp.	10%	304104
R85	47 Ω	½ w	Fixed	Comp.	10%	302470
R86	470 Ω	½ w	Fixed	Comp.	10%	302471
R87	8 k	5 w	Fixed	WW	5%	308053
R88	2 k	2 w	Var.	Comp.	20% Sweep Length	311008
R89	4 k	5 w	Fixed	WW	5%	308051
R90	47 Ω	½ w	Fixed	Comp.	10%	302470
R91	22 k	2 w	Fixed	Comp.	10%	306223
R92	22 k	2 w	Fixed	Comp.	10%	306223
R93	22 k	2 w	Fixed	Comp.	10%	306223
R95	47 k	½ w	Fixed	Comp.	10%	302473
R96	1.5 meg	½ w	Fixed	Comp.	10%	302155

Switches

SW200	See parts list, Delaying Sweep Trigger

* R60 and R61 selected to total 6 k ±2½%. Furnished as a unit.

** Selected with ratio 39/33 ±2½%. Furnished as a unit.

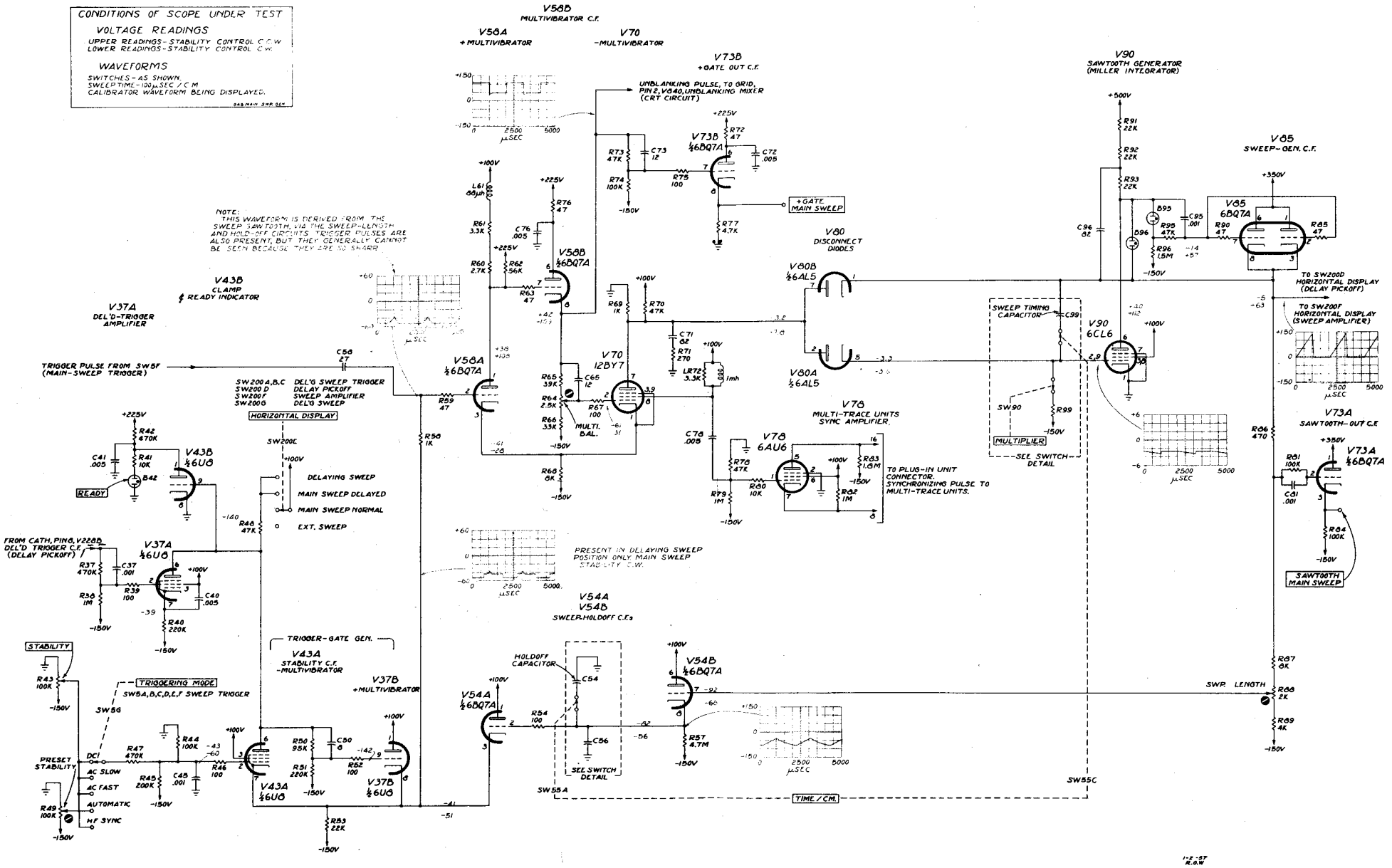
Vacuum Tubes

			Order Parts by Number
V37A	½ 6U8	Delayed Trigger Amplifier	154033
V37B	½ 6U8	+ Multivibrator, Trigger Gate Generator	
V43A	½ 6U8	— Multivibrator, Trigger Gate Generator	154033
V43B	½ 6U8	Clamp and Ready Indicator	
V54	6BQ7A	Sweep Holdoff Cathode Followers	154028
V58A	½ 6BQ7A	+ Multivibrator	154028
V58B	½ 6BQ7A	Multivibrator Cathode Follower	
V70	**12BY7**	— Multivibrator	**154047**
V73A	½ 6BQ7A	Sawtooth-out Cathode Follower	154028
V73B	½ 6BQ7A	+ Gate-out Cathode Follower	
V78	**6AU6**	Multi-Trace Units Sync Amplifier	**154022**
V80	6AL5	Disconnect Diodes	154016
V85	6BQ7A	Sweep-generator Cathode Follower	154028
V90	6CL6	Miller Integrator	154031

NOTE

Unless otherwise specified, all of the voltage readings were taken with a dc vacuum-tube voltmeter having an input resistance of 11 megohms. The waveforms shown were reproduced from actual photographs. There will be considerable variation between instruments because of normal manufacturing tolerances and vacuum-tube characteristics. Therefore, the significance of any discrepancies observed should be determined by referring to the circuit diagram.

All readings are in volts unless otherwise specified. Where two voltage readings are given, they represent the voltage as read by a voltmeter under two sets of conditions, and, as such, do not indicate the peak-to-peak excursion of voltage at the point.


CONDITIONS OF SCOPE UNDER TEST
VOLTAGE READINGS
UPPER READINGS - STABILITY CONTROL C.C.W.
LOWER READINGS - STABILITY CONTROL C.W.
WAVEFORMS
SWITCHES - AS SHOWN.
SWEEP TIME - 100 μSEC / C.M.
CALIBRATOR WAVEFORM BEING DISPLAYED.
V58B MULTIVIBRATOR C.F.
V58A + MULTIVIBRATOR
V70 - MULTIVIBRATOR
V73B + GATE OUT C.F.
UNBLANKING PULSE, TO GRID, PIN 2, V640, UNBLANKING MIXER (CRT CIRCUIT)
+GATE MAIN SWEEP
V90 SAWTOOTH GENERATOR (MILLER INTEGRATOR)
V85 SWEEP-GEN. C.F.
V80 DISCONNECT DIODES
V43B CLAMP & READY INDICATOR
V37A DEL'D-TRIGGER AMPLIFIER
TRIGGER PULSE FROM SW5F (MAIN-SWEEP TRIGGER)
SW200A,B,C SW200D SW200F SW200G
DEL'G SWEEP TRIGGER DELAY PICKOFF SWEEP AMPLIFIER DEL'G SWEEP
HORIZONTAL DISPLAY
DELAYING SWEEP
MAIN SWEEP DELAYED
MAIN SWEEP NORMAL
EXT. SWEEP
V78 MULTI-TRACE UNITS SYNC AMPLIFIER.
TO PLUG-IN UNIT CONNECTOR. SYNCHRONIZING PULSE TO MULTI-TRACE UNITS.
SWEEP TIMING CAPACITOR
SEE SWITCH DETAIL
MULTIPLIER
TO SW200D HORIZONTAL DISPLAY (DELAY PICKOFF)
TO SW200F HORIZONTAL DISPLAY (SWEEP AMPLIFIER)
V73A SAWTOOTH-OUT C.F.
SAWTOOTH MAIN SWEEP
FROM CATH, PIN 8, V220B DEL'D TRIGGER C.F. (DELAY PICKOFF)
V37A
TRIGGER-GATE GEN.
V43A STABILITY C.F. -MULTIVIBRATOR
V37B +MULTIVIBRATOR
STABILITY
TRIGGERING MODE
SW5A,B,C,D,E,F SWEEP TRIGGER
SW5G
PRESET STABILITY
AC SLOW
AC FAST
AUTOMATIC
HF SYNC
PRESENT IN DELAYING SWEEP POSITION ONLY MAIN SWEEP STABILITY C.W.
V54A V54B SWEEP-HOLDOFF C.F.s
HOLDOFF CAPACITOR
SEE SWITCH DETAIL
SW55A
SW55C
TIME/CM.
SWP. LENGTH
NOTE: THIS WAVEFORM IS DERIVED FROM THE SWEEP SAWTOOTH, VIA THE SWEEP-LENGTH AND HOLD-OFF CIRCUITS. TRIGGER PULSES ARE ALSO PRESENT, BUT THEY GENERALLY CANNOT BE SEEN BECAUSE THEY ARE SO SHARP.

ABBREVIATIONS

Cer.	ceramic	m	milli or 10^{-3}
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	Poly.	polystyrene
f	farad	Prec.	precision
GMV	guaranteed minimum value	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

MAIN-SWEEP TIMING SWITCH

Capacitors

							Order Parts by Number
C54A	.22 μf	PT	Fixed	400 v	20%		285533
C54B	.022 μf	PT	Fixed	400 v	20%		285515
C54C	.0022 μf	PT	Fixed	400 v	20%		285543
C54D	220 μμf	Mica	Fixed	500 v	10%		283536
C56	39 μμf	Cer.	Fixed	500 v	10%		281516
C99A C99B C99C	1.0 μf .1 μf .01 μf	Special timing series manufactured by Tektronix. Order replacements from factory.					291007
C99D	.001 μf	Special			±¼%		291008
C99E	82 μμf	Mica	Fixed	500 v	5%		283534
C99F	5-20 μμf	Cer.	Var.	500 v	20%		281010
C99G	82 μμf	Mica	Fixed	500 v	5%		283534
C99H	5-20 μμf	Cer.	Var.	500 v	20%		281010
C99J	3-12 μμf	Cer.	Var.	500 v	20%		281007

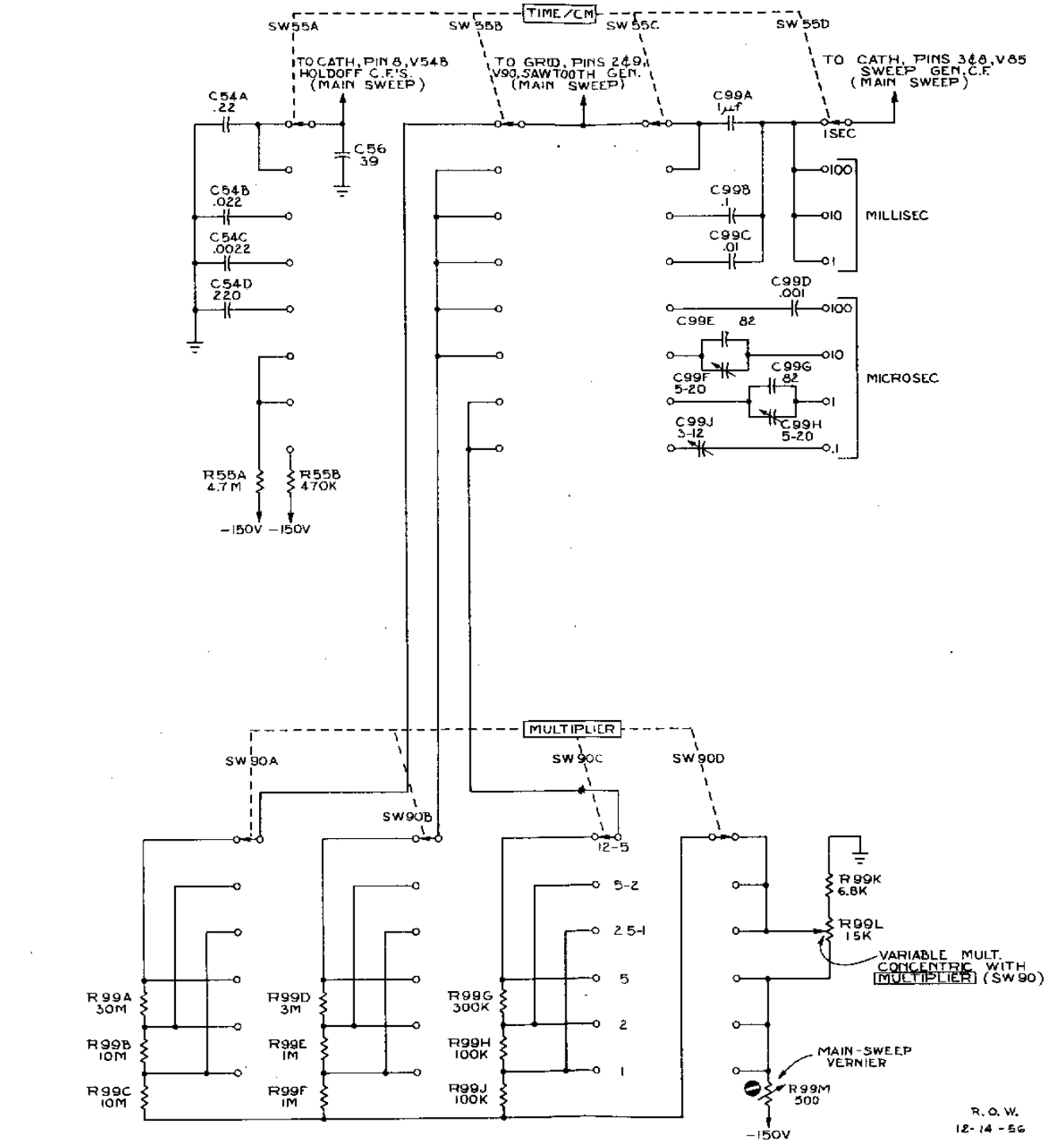
Resistors

R55A	4.7 meg	½ w	Fixed	Comp.	10%		302475
R55B	470 k	½ w	Fixed	Comp.	10%		302474
R99A	30 meg	2 w	Fixed	Prec.	1%		310505
R99B	10 meg	1 w	Fixed	Prec.	1%		310107
R99C	10 meg	1 w	Fixed	Prec.	1%		310107
R99D	3 meg	½ w	Fixed	Prec.	1%		309026
R99E	1 meg	½ w	Fixed	Prec.	1%		309014
R99F	1 meg	½ w	Fixed	Prec.	1%		309014
R99G	300 k	½ w	Fixed	Prec.	1%		309125
R99H	100 k	½ w	Fixed	Prec.	1%		309045
R99J	100 k	½ w	Fixed	Prec.	1%		309045
R99K	6.8 k	1 w	Fixed	Comp.	10%		304682
R99L	15 k	2 w	Var.	Comp.	20%		311045
R99M	500 Ω	½ w	Var.	Comp.	20%	MAIN SWEEP VERNIER	311056

Switches

					not wired	wired
SW55*	4 wafer	8 position	rotary	TIME/CM	260010	262063
SW90	4 wafer	6 position	rotary	MULTIPLIER	260011	262064

*SW55 and SW254, 5X MAGNIFIER, shafts are concentric. Furnished as a unit.



TYPE 545 OSCILLOSCOPE

MAIN - SWEEP TIMING SWITCH

ABBREVIATIONS

Cer.	ceramic	m	milli or 10^{-3}
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	Poly.	polystyrene
f	farad	Prec.	precision
GMV	guaranteed minimum value	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

DELAYING-SWEEP TRIGGER

Capacitors

							Order Parts by Number
C100	5-25 μμf	Cer.	Var.	500 v			281011
C101	5-25 μμf	Cer.	Var.	500 v			281011
C102	100 μμf	Cer.	Fixed	500 v	10%		281530
C108	.001 μf	Cer.	Fixed	500 v	GMV		283000
C110	5-25 μμf	Cer.	Var.	500 v			281011
C132	22 μμf	Cer.	Fixed	500 v	20%		281510

Resistors

R101	900 k	½ w	Fixed	Prec.	1%		309111
R102	111 k	½ w	Fixed	Prec.	1%		309046
R105	100 k	½ w	Var.	Comp.	20%	TRIGGERING LEVEL, conc. with R122 and R140	311046*
R106	22 k	½ w	Fixed	Comp.	10%		302223
R107	1 meg	½ w	Fixed	Comp.	10%		302105
R108	100 k	½ w	Fixed	Comp.	10%		302104
R109	47 Ω	½ w	Fixed	Comp.	10%		302470
R110	1 meg	½ w	Fixed	Prec.	1%		309014
R113	47 k	1 w	Fixed	Comp.	10%		304473
R114	50 k	2 w	Var.	Comp.	20%	Ext. Sweep Ampl. DC Bal.	311023
R115	47 k	1 w	Fixed	Comp.	10%		304473
R120	100 Ω	½ w	Fixed	Comp.	10%		302101
R121	47 k	1 w	Fixed	Comp.	10%		304473
R122	15 k	½ w	Fixed	Comp.	20%	EXT. SWEEP ATTEN., ganged with R140	311046*
R123	47 k	1 w	Fixed	Comp.	10%		304473
R124	33 k	2 w	Fixed	Comp.	10%		306333
R130	100 Ω	½ w	Fixed	Comp.	10%		302101
R131	3.3 k	½ w	Fixed	Comp.	10%		302332
R132	100 k	½ w	Fixed	Comp.	10%		302104
R133	270 k	½ w	Fixed	Comp.	10%		302274
R134	100 Ω	½ w	Fixed	Comp.	10%		302101
R135	33 k	2 w	Fixed	Comp.	10%		306333
R136	2.2 k	½ w	Fixed	Comp.	10%		302222

* R105, R122 and R140 furnished as a unit.

Switches

					Order Parts by Number	
					not wired	wired
SW100	double pole	double throw	toggle	ATTEN	260014	—
SW113	double pole	double throw	toggle	SLOPE	260014	—
SW200	4 wafer	4 position	rotary	HORIZONTAL DISPLAY	260007	262061

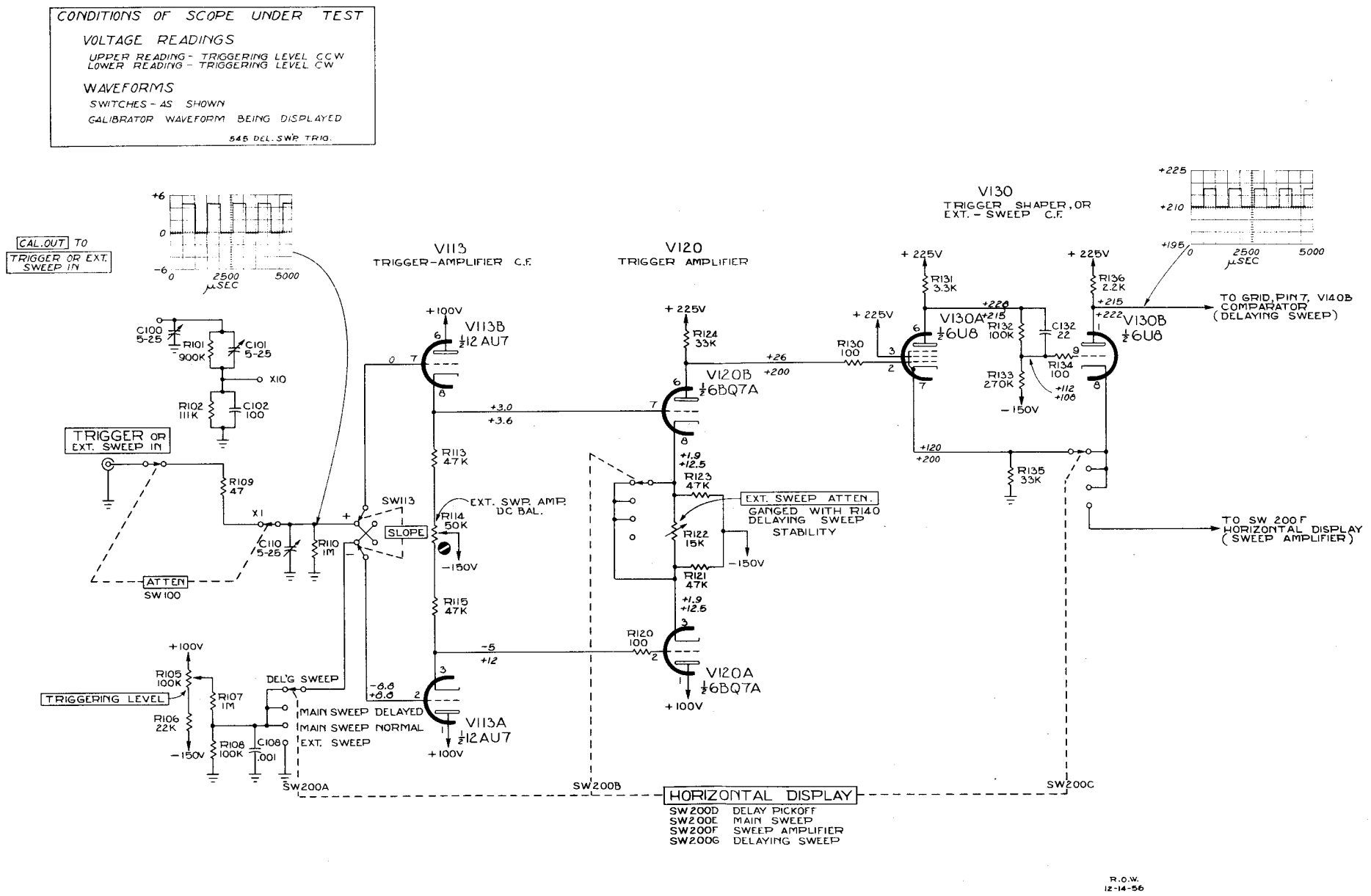
Vacuum Tubes

V113	12AU7	Trigger Amplifier Cathode Follower	154041
V120	6BQ7A	Trigger Amplifier	154028
V130	6U8	Trigger Shaper Ext. Sweep Cathode Follower	154033

NOTE

Unless otherwise specified, all of the voltage readings were taken with a dc vacuum-tube voltmeter having an input resistance of 11 megohms. The waveforms shown were reproduced from actual photographs. There will be considerable variation between instruments because of normal manufacturing tolerances and vacuum-tube characteristics. Therefore, the significance of any discrepancies observed should be determined by referring to the circuit diagram.

All readings are in volts unless otherwise specified. Where two voltage readings are given, they represent the voltage as read by a voltmeter under two sets of conditions, and, as such, do not indicate the peak-to-peak excursion of voltage at the point.


CONDITIONS OF SCOPE UNDER TEST
VOLTAGE READINGS
UPPER READING - TRIGGERING LEVEL CCW
LOWER READING - TRIGGERING LEVEL CW
WAVEFORMS
SWITCHES - AS SHOWN
CALIBRATOR WAVEFORM BEING DISPLAYED
545 DEL. SWP. TRIG.
CAL. OUT TO TRIGGER OR EXT. SWEEP IN
V113 TRIGGER-AMPLIFIER C.F.
V120 TRIGGER AMPLIFIER
V130 TRIGGER SHAPER, OR EXT. - SWEEP C.F.
V113B ½12AU7
V113A ½12AU7
V120B ½6BQ7A
V120A ½6BQ7A
V130A ½6U8
V130B ½6U8
TRIGGER OR EXT. SWEEP IN
ATTEN SW100
SLOPE
SW113
EXT. SWP. AMP DC BAL.
EXT. SWEEP ATTEN. GANGED WITH R140 DELAYING SWEEP STABILITY
TRIGGERING LEVEL
DEL'G SWEEP
MAIN SWEEP DELAYED
MAIN SWEEP NORMAL
EXT. SWEEP
TO GRID, PIN 7, V140B COMPARATOR (DELAYING SWEEP)
TO SW 200F HORIZONTAL DISPLAY (SWEEP AMPLIFIER)
HORIZONTAL DISPLAY
SW200D DELAY PICKOFF
SW200E MAIN SWEEP
SW200F SWEEP AMPLIFIER
SW200G DELAYING SWEEP
SW200A
SW200B
SW200C
R.O.W. 12-14-56

ABBREVIATIONS

Cer.	ceramic	m	milli or 10^{-3}
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	Poly.	polystyrene
f	farad	Prec.	precision
GMV	guaranteed minimum value	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

DELAYING SWEEP GENERATOR

Bulbs

			Order Parts by Number
B180	65 v	1/25 w	150011
B187	55 v	1/25 w	150009

Capacitors

							Order Parts by Number
C146	47 μμf	Cer.	Fixed	500 v	20%		281518
C158	12 μμf	Cer.	Fixed	500 v	10%		281506
C170	39 μμf	Cer.	Fixed	500 v	10%		281516
C172	12 μμf	Cer.	Fixed	500 v	10%		281506
C187	.001 μf	Cer.	Fixed	500 v	GMV		283000

Resistors

							Order Parts by Number
R140	100 k	½ w	Var.	Comp.	20%	STABILITY, ganged with R122	311046*
R141	100 k	½ w	Fixed	Comp.	10%		302104
R142	27 k	½ w	Fixed	Comp.	10%		302273
R143	47 k	½ w	Fixed	Comp.	10%		302473
R146	100 Ω	½ w	Fixed	Comp.	10%		302101
R147	22 k	1 w	Fixed	Comp.	10%		304223
R148	100 Ω	½ w	Fixed	Comp.	10%		302101
R150	1 meg	½ w	Fixed	Comp.	10%		302105
R151	1 k	½ w	Fixed	Comp.	10%		302102
R155	100 Ω	½ w	Fixed	Comp.	10%		302101
R156	10 k	1 w	Fixed	Comp.	5%		303103
R157	100 Ω	½ w	Fixed	Comp.	10%		302101
R158	39 k	1 w	Fixed	Comp.	5%		303393
R159	33 k	1 w	Fixed	Comp.	5%		303333
R160	15 k	2 w	Fixed	Comp.	5%		305153
R163	100 Ω	½ w	Fixed	Comp.	10%		302101
R164	2.2 k	½ w	Fixed	Comp.	10%		302222
R165	47 k	½ w	Fixed	Comp.	10%		302473
R170	2.7 k	½ w	Fixed	Comp.	10%		302272
R172	47 k	½ w	Fixed	Comp.	10%		302473
R173	100 k	½ w	Fixed	Comp.	10%		302104
R174	100 Ω	½ w	Fixed	Comp.	10%		302101
R177	10 k	½ w	Fixed	Comp.	10%		302103
R180	15 k	2 w	Fixed	Comp.	10%		306153
R181A	10 k	2 w	Var.	Comp.	20%	LENGTH	311016
R181B**		½ w	Fixed	Comp.	10%		
R182A	12 k	2 w	Fixed	Comp.	10%		306123
R182B**		½ w	Fixed	Comp.	10%		
R185	100 Ω	½ w	Fixed	Comp.	10%		302101
R186	220 k	2 w	Fixed	Comp.	10%		306224

* R140, R105, and R122 furnished as a unit.
Selected to adjust the range of the **DELAYING SWEEP LENGTH control.

Resistors (Continued)

						Order Parts by Number
R187	100 k	½ w	Fixed	Comp.	10%	302104
R188	1.5 meg	½ w	Fixed	Comp.	10%	302155

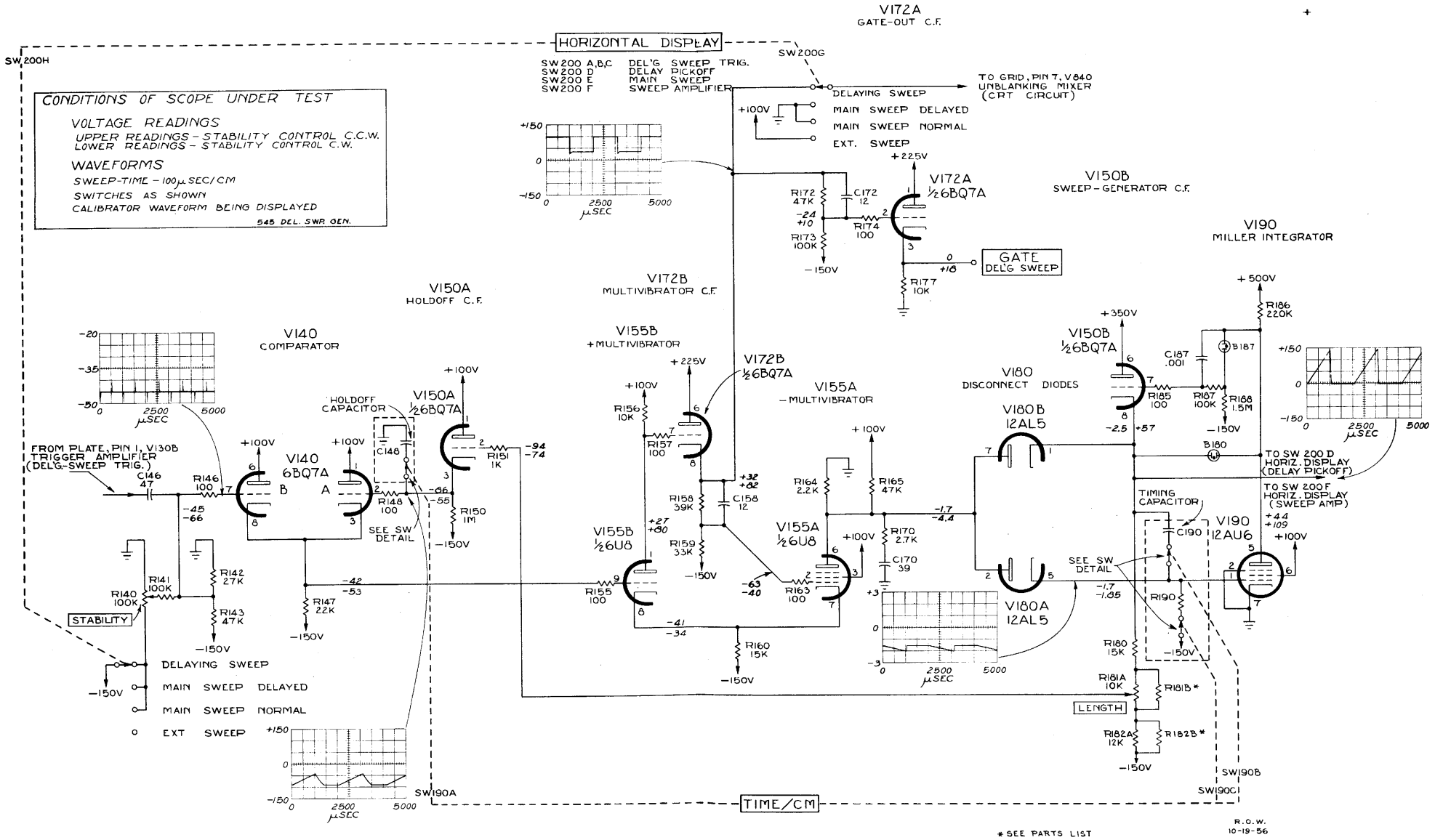
Vacuum Tubes

V140	6BQ7A	Comparator	154028
V150A	½ 6BQ7A	Holdoff Cathode Follower	154028
V150B	½ 6BQ7A	Sweep-Generator Cathode Follower	
V155A	½ 6U8	— Multivibrator	154033
V155B	½ 6U8	+ Multivibrator	
V172A	½ 6BQ7A	Gate-Out Cathode Follower	154028
V172B	½ 6BQ7A	Multivibrator Cathode Follower	
V180	12AL5	Disconnect Diodes	154038
V190	12AU6	Miller Integrator	154040

NOTE

Unless otherwise specified, all of the voltage readings were taken with a dc vacuum-tube voltmeter having an input resistance of 11 megohms. The waveforms shown were reproduced from actual photographs. There will be considerable variation between instruments because of normal manufacturing tolerances and vacuum-tube characteristics. Therefore, the significance of any discrepancies observed should be determined by referring to the circuit diagram.

All readings are in volts unless otherwise specified. Where two voltage readings are given, they represent the voltage as read by a voltmeter under two sets of conditions, and, as such, do not indicate the peak-to-peak excursion of voltage at the point.



TYPE 545 OSCILLOSCOPE

C1

DELAYING-SWEEP GENERATOR

ABBREVIATIONS

Cer.	ceramic	m	milli or 10^{-3}
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	Poly.	polystyrene
f	farad	Prec.	precision
GMV	guaranteed minimum value	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

DELAYING-SWEEP TIMING SWITCH

Capacitors

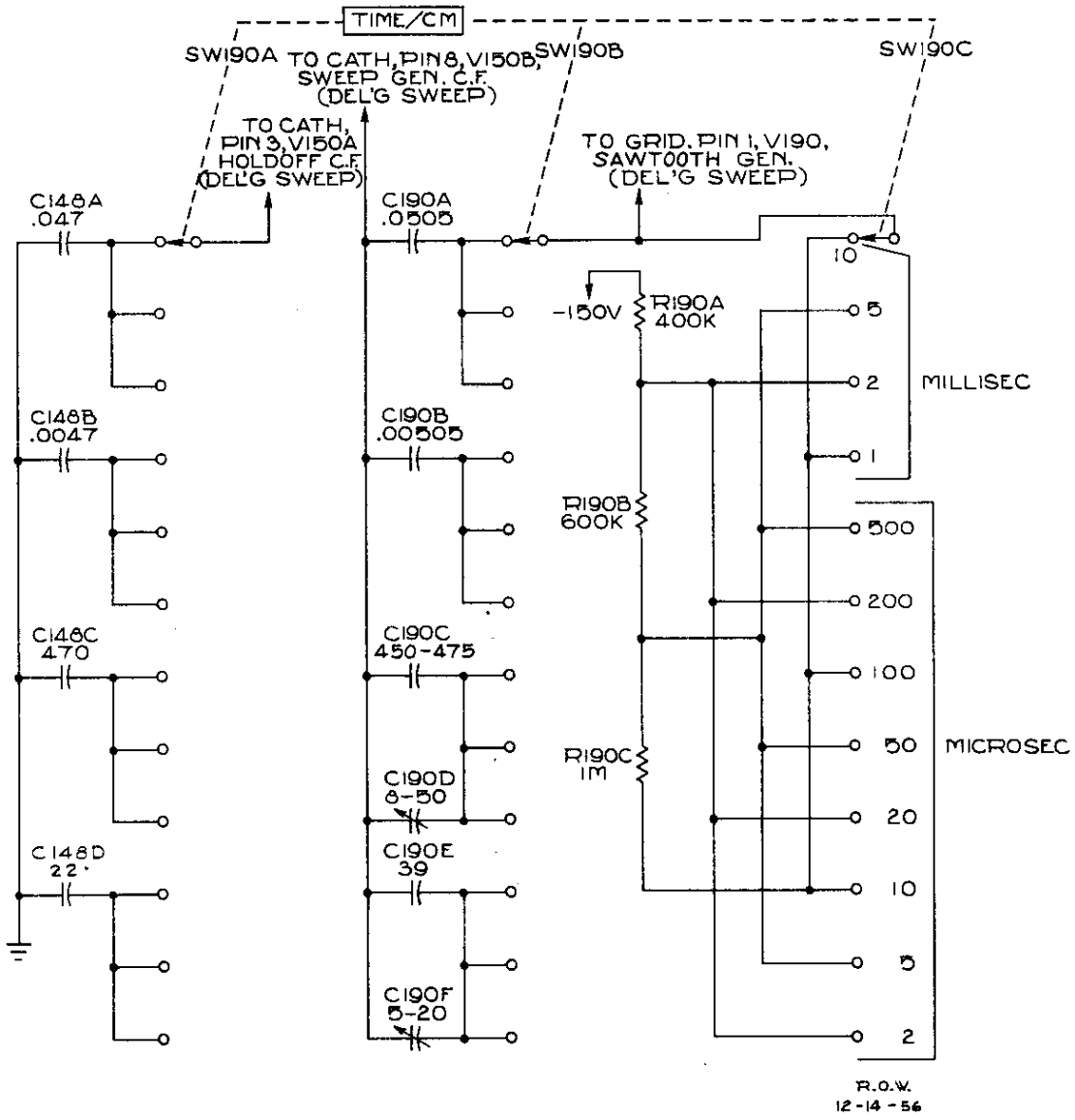
							Order Parts by Number
C148A	.047 μf	PT	Fixed	400 v	20%		285519
C148B	.0047 μf	PT	Fixed	400 v	20%		285506
C148C	470 μμf	Cer.	Fixed	500 v	20%		281525
C148D	22 μμf	Cer.	Fixed	500 v	20%		281510
C190A	.0505 μf	Special		Special timing series manufactured by Tektronix. Order replacements from factory.			291006
C190B	.00505 μf	Special					
C190C	450-475 μμf	Special					
C190D	8-50 μμf	Cer.	Var.	500 v			281013
C190E	39 μμf	Mica	Fixed	500 v	5%		283533
C190F	3-12 μμf	Cer.	Var.	500 v			281009

Resistors

							Order Parts by Number
R190A	400 k	½ w	Fixed	Prec.	1%	Checked within ¼% of ratio 4/6/10	312567
R190B	600 k	½ w	Fixed	Prec.	1%		312568
R190C	1 meg	½ w	Fixed	Prec.	1%		312571

Switches

					Order Parts by Number	
					not wired	wired
SW190	3 wafer	12 position	rotary	TIME/CM	260009	262060



TYPE 545 OSCILLOSCOPE

DELAYED - SWEEP TIMING - SWITCH

B2

ABBREVIATIONS

Cer.	ceramic	m	milli or 10^{-3}
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	Poly.	polystyrene
f	farad	Prec.	precision
GMV	guaranteed minimum value	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

DELAY PICKOFF

Capacitors

							Order Parts by Number
C197	220 μμf	Mica	Fixed	500 v	20%		283536
C209	.01 μf	Cer.	Fixed	500 v	20%		283002
C218	22 μμf	Cer.	Fixed	500 v	20%		281510
C228	47 μμf	Cer.	Fixed	500 v	20%		281518
C232	.005 μf	Cer.	Fixed	500 v	GMV		283001
C235	22 μμf	Cer.	Fixed	500 v	20%		281510
C236	.001 μf	Cer.	Fixed	500 v	GMV		283000

Resistors

R195	100 k	2 w	Var.	Comp.	20%	Delay Start Adj.	311026
R196	470 k	½ w	Fixed	Comp.	10%		302474
R197	6.8 k	½ w	Fixed	Comp.	10%		302682
R198	100 Ω	½ w	Fixed	Comp.	10%		302101
R200	100 k	½ w	Fixed	Comp.	10%		302104
R201	47 k	½ w	Fixed	Comp.	10%		302473
R202	10 k	½ w	Fixed	Comp.	10%		302103
R205	15 k	½ w	Fixed	Comp.	10%		302153
R206	100 Ω	½ w	Fixed	Comp.	10%		302101
R207	10 k	5 w	Fixed	WW	5%		308054
R208	10 k	2 w	Var.	WW	20%	Delay Stop Adj.	311015
R209	30 k	3 w	Var.	helipot	.1%	linearity—DELAY-TIME MULTIPLIER	311022
R216	100 Ω	½ w	Fixed	Comp.	10%		302101
R217	3.9 k	½ w	Fixed	Comp.	10%		302392
R218	95 k	½ w	Fixed	Prec.	1%		309044
R219	150 k	½ w	Fixed	Prec.	1%		309049
R220	100 Ω	½ w	Fixed	Comp.	10%		302101
R223	39 k	2 w	Fixed	Comp.	10%		306393
R224	5.6 k	½ w	Fixed	Comp.	10%		302562
R228	10 k	½ w	Fixed	Comp.	10%		302103
R229	270 k	½ w	Fixed	Comp.	10%		302274
R230	100 Ω	½ w	Fixed	Comp.	10%		302101
R231	1 k	½ w	Fixed	Comp.	10%		302102
R232	47 Ω	½ w	Fixed	Comp.	10%		302470
R235	22 k	½ w	Fixed	Comp.	10%		302223
R236	22 meg	½ w	Fixed	Comp.	10%		302226

Switches

SW200	See parts list, Delaying Sweep Trigger		
SW235	Push button, normally open	RESET, MAIN SWEEP	260017

Vacuum Tubes

V195	6U8	Delay Pickoff	
V216	6U8	Delay Trigger Shaper	154033
V228A	½ 6U8	Constant Current Tube	154033
V228B	½ 6U8	Delayed Trigger Cathode Follower	

NOTE

Unless otherwise specified, all of the voltage readings were taken with a dc vacuum-tube voltmeter having an input resistance of 11 megohms. The waveforms shown were reproduced from actual photographs. There will be considerable variation between instruments because of normal manufacturing tolerances and vacuum-tube characteristics. Therefore, the significance of any discrepancies observed should be determined by referring to the circuit diagram.

All readings are in volts unless otherwise specified. Where two voltage readings are given, they represent the voltage as read by a voltmeter under two sets of conditions, and, as such, do not indicate the peak-to-peak excursion of voltage at the point.

CONDITIONS OF SCOPE UNDER TEST

VOLTAGE READINGS
UPPER READINGS - STABILITY CONTROL CCW
LOWER READINGS - STABILITY CONTROL CW
CM OF DELAY - 2.00

WAVEFORMS
SWEEPTIME - 100 μSEC/CM
SWITCHES AS SHOWN
CM OF DELAY - 3.00

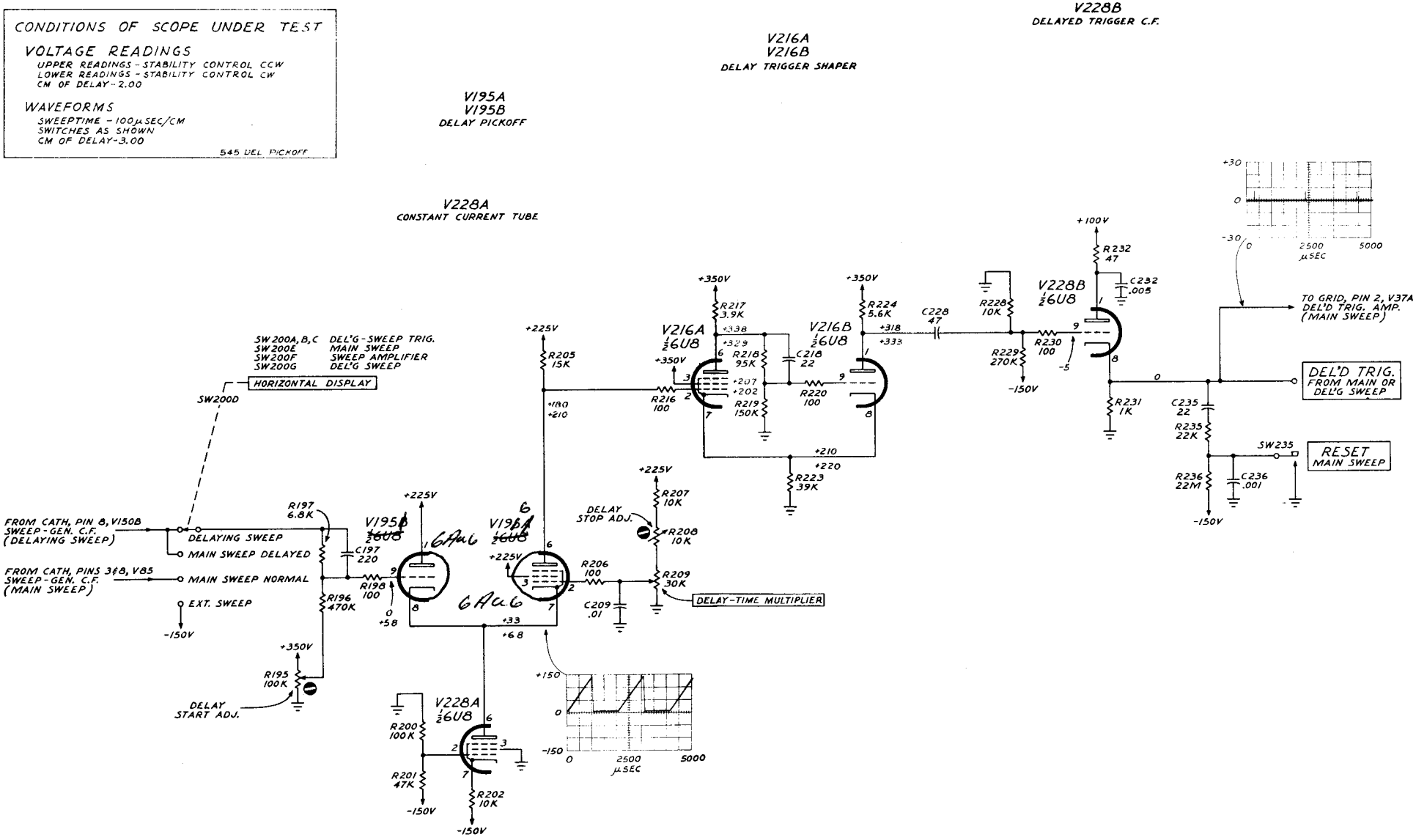
545 DEL PICKOFF

V195A
V195B
DELAY PICKOFF

V228A
CONSTANT CURRENT TUBE

V216A
V216B
DELAY TRIGGER SHAPER

V228B
DELAYED TRIGGER C.F.



TYPE 545 OSCILLOSCOPE

D

DELAY PICKOFF

12-6-56
KF

ABBREVIATIONS

Cer.	ceramic	m	milli or 10^{-3}
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	Poly.	polystyrene
f	farad	Prec.	precision
GMV	guaranteed minimum value	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

SWEEP AMPLIFIER

Bulbs

			Order Parts by Number
B287	1/25 w	55-70 v	150009
B292	1/25 w	Ignition voltage 75 v	150014
B293	1/25 w	Ignition voltage 75 v	150014

Capacitors

							Order Parts by Number
C240	3-12 μμf	Cer.	Var.	500 v			281007
C241	4.7 μμf	Cer.	Fixed	500 v	±1 μμf		281501
C249	.01 μf	PT	Fixed	400 v	20%		285510
C254	3-12 μμf	Cer.	Var.	500 v			281007
C258	1.5 μμf	Cer.	Fixed	500 v	±½ μμf		281526
C267	9-180 μμf	Mica	Var.	500 v			281023
C273	6.25 μf	EMC	Fixed	300 v	−20%+50%		290000
C278	3-12 μμf	Cer.	Var.	500 v			281009
C282	.047 μf	PT	Fixed	400 v	20%		285519
C284	4.7 μμf	Cer.	Fixed	500 v	±1 μμf		281501
C286	3-12 μμf	Cer.	Var.	500 v			281009

Resistors

							Order Parts by Number
R240	1 meg	½ w	Fixed	Prec.	1%		309014
R241	1.23 meg	½ w	Fixed	Prec.	1%		309016
R242	100 Ω	½ w	Fixed	Comp.	10%		302101
R243	100 k	1 w	Fixed	Comp.	10%		304104
R244	2.2 k	½ w	Fixed	Comp.	10%		302222
R246	470 k	½ w	Fixed	Comp.	10%		302474
R247	4.7 meg	½ w	Fixed	Comp.	10%		302475
R248	500 k	½ w	Var.	Comp.	20%	VERNIER, conc. with R250	311048
R249	560 k	½ w	Fixed	Comp.	10%		302564
R250	500 k	½ w	Var.	Comp.	20%	HORIZONTAL POS., conc. with R248	311048
R253	100 Ω	½ w	Fixed	Comp.	10%		302101
R254	111 k	½ w	Fixed	Prec.	1%		309046
R255	100 Ω	½ w	Fixed	Comp.	10%		302101
R256	100 k	1 w	Fixed	Comp.	10%		304104
R259	400 k	1 w	Fixed	Prec.	1%		310094
R260	400 k	1 w	Fixed	Prec.	1%		310094
R261	22 k	½ w	Fixed	Comp.	10%		302223
R262	20 k	2 w	Var.	Comp.	20%	Swp./Mag. Regis.	311018
R265	47 Ω	½ w	Fixed	Comp.	10%		302470
R266	10 k	2 w	Var.	Comp.	20%	Swp. Cal.	311016
R267	2.2 k	1 w	Fixed	Comp.	10%		304222
R268	6 k	5 w	Fixed	WW	5%		308052
R269	2.2 k	1 w	Fixed	Comp.	10%		304222
R270	2 k	2 w	Var.	Comp.	20%	Mag. Gain	311008
R272	47 Ω	½ w	Fixed	Comp.	10%		302470

Resistors (continued)

						Order Parts by Number
R273	100 Ω	½ w	Fixed	Comp.	10%	302101
R278	6–25 k	Special				310506
R279	47 Ω	½ w	Fixed	Comp.	10%	302470
R282	390 Ω	½ w	Fixed	Comp.	10%	302391
R283	47 Ω	½ w	Fixed	Comp.	10%	302470
R284	2.2 k	½ w	Fixed	Comp.	10%	302222
R286	6–30 k	Special				310507
R287	100 Ω	½ w	Fixed	Comp.	10%	302101
R288	39 k	2 w	Fixed	Comp.	10%	306393
R289	39 k	2 w	Fixed	Comp.	10%	306393
R292	470 k	½ w	Fixed	Comp.	10%	302474
R293	470 k	½ w	Fixed	Comp.	10%	302474
R294	470 k	½ w	Fixed	Comp.	10%	302474
R295	470 k	½ w	Fixed	Comp.	10%	302474

Switches

					not wired	wired
SW200	See Delaying Sweep Trigger					
SW254*	1 wafer	2 position	rotary	5X MAGNIFIER	260010	262063

Vacuum Tubes

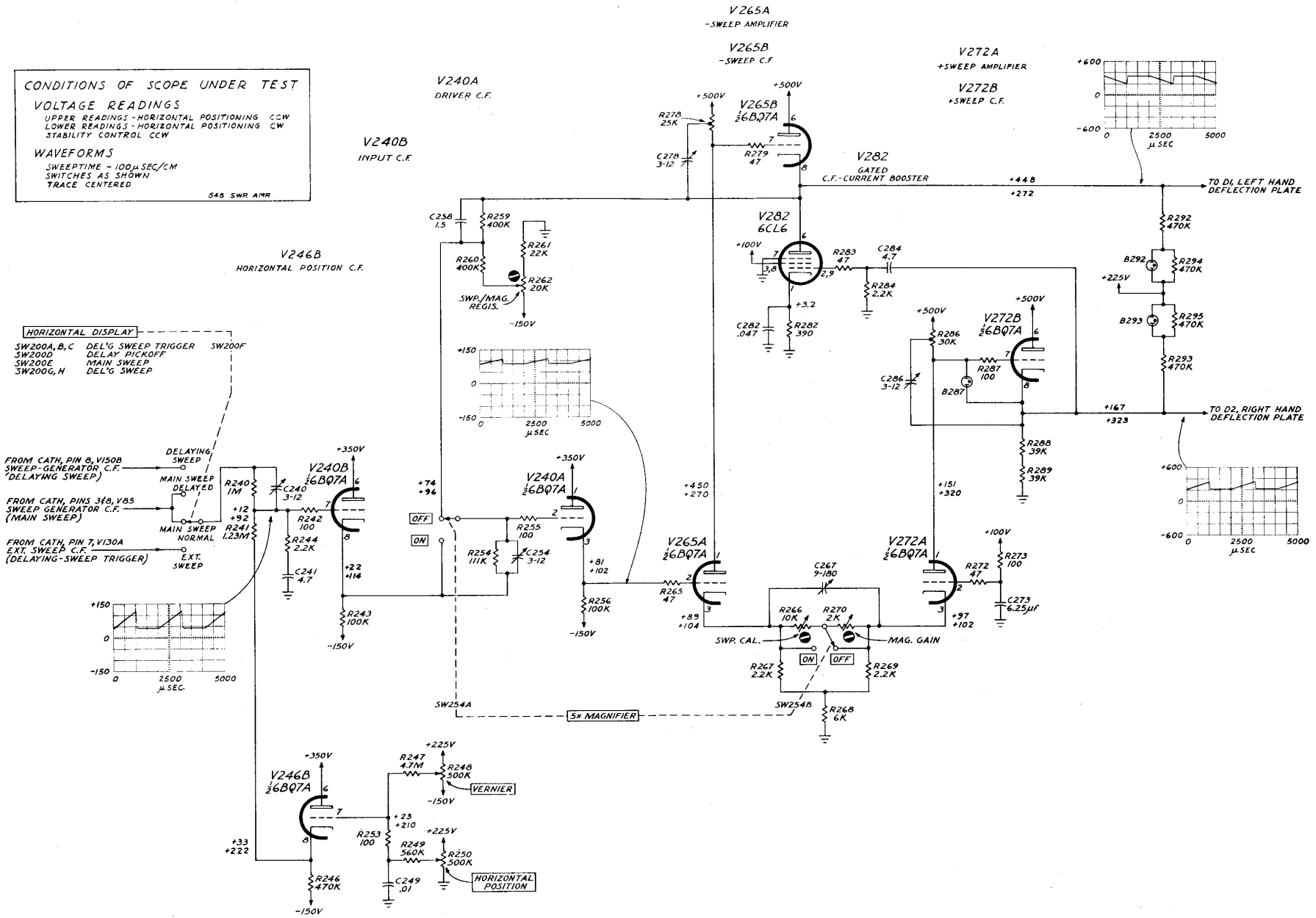
V240A	½ 6BQ7A	Driver Cathode Follower	154028
V240B	½ 6BQ7A	Input Cathode Follower	
V246B	½ 6BQ7A	Horizontal Position Cathode Follower	154028
V265A	½ 6BQ7A	— Sweep Amplifier	157022
V265B	½ 6BQ7A	— Sweep Cathode Follower	
V272A	½ 6BQ7A	+ Sweep Amplifier	157022
V272B	½ 6BQ7A	+ Sweep Cathode Follower	
V282	6CL6	Gated CF-Current Booster	154031

***SW254 and SW55 shafts are concentric. Furnished as a unit.**

NOTE

Unless otherwise specified, all of the voltage readings were taken with a dc vacuum-tube voltmeter having an input resistance of 11 megohms. The waveforms shown were reproduced from actual photographs. There will be considerable variation between instruments because of normal manufacturing tolerances and vacuum-tube characteristics. Therefore, the significance of any discrepancies observed should be determined by referring to the circuit diagram.

All readings are in volts unless otherwise specified. Where two voltage readings are given, they represent the voltage as read by a voltmeter under two sets of conditions, and, as such, do not indicate the peak-to-peak excursion of voltage at the point.



TYPE 545 OSCILLOSCOPE

B2

SWEEP AMPLIFIER

12-5-56
KF

ABBREVIATIONS

Cer.	ceramic	m	milli or 10^{-3}
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	Poly.	polystyrene
f	farad	Prec.	precision
GMV	guaranteed minimum value	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

VERTICAL AMPLIFIER

Bulbs

			Order Parts by Number
B1010	55-70 v		150002
B1014	55-70 v		150002

Capacitors

C1010	.005 μf	Cer.	Fixed	500 v	GMV	283001
C1014	.005 μf	Cer.	Fixed	500 v	GMV	283001
C1020	.005 μf	Cer.	Fixed	500 v	GMV	283001
C1035	.005 μf	Cer.	Fixed	500 v	GMV	283001
C1045	2x75 μf	EMC	Fixed	150 v	—20%+50%	290053
C1050	2x75 μf	EMC	Fixed	150 v	—20%+50%	290053
C1051	.005 μf	Cer.	Fixed	500 v	GMV	283001
C1052	.001 μf	Cer.	Fixed	500 v	10%	281536
C1054	.001 μf	Cer.	Fixed	500 v	10%	281536
C1055	.022 μf	PT	Fixed	600 v	20%	285517
C1057	.001 μf	Cer.	Fixed	500 v	GMV	283000
C1060	.001 μf	Cer.	Fixed	500 v	GMV	283000
C1062	150 μμf	Cer.	Fixed	500 v	20%	281524
C1064	.005 μf	Cer.	Fixed	500 v	GMV	283001
C1066	.001 μf	Cer.	Fixed	500 v	GMV	283000
C1070	100 μμf	Cer.	Fixed	350 v	20%	281523
C1072	12 μμf	Poly	Var.	500 v	10%	281506
C1073	1–8 μμf	Poly	Var.	500 v		281003
C1074	4.7 μμf	Cer.	Fixed	500 v	10%	281501
C1075	1–8 μμf	Poly	Var.	500 v		281003
C1076	1–8 μμf	Poly	Var.	500 v		281003
C1077	1–8 μμf	Poly	Var.	500 v		281003
C1078	2.2 μμf	Cer.	Fixed	500 v	±½ μμf	281500
C1081	.001 μf	Cer.	Fixed	500 v	GMV	283000
C1082	150 μμf	Cer.	Fixed	500 v	20%	281524
C1083	.001 μf	Cer.	Fixed	500 v	GMV	283000
C1084	.7–3 μμf	Tub.	Var.	500 v		281027
C1090	.001 μf	Cer.	Fixed	500 v	GMV	283000
C1091	150 μμf	Cer.	Fixed	500 v	20%	281524
C1092	.001 μf	Cer.	Fixed	500 v	GMV	283000
C1093	.7–3 μμf	Tub.	Var.	500 v		281027
C1100	.001 μf	Cer.	Fixed	500 v	GMV	283000
C1101	150 μμf	Cer.	Fixed	500 v	20%	281524
C1102	.001 μf	Cer.	Fixed	500 v	GMV	283000
C1103	.7–3 μμf	Tub.	Var.	500 v		281027

Capacitors (Continued)

						Order Parts by Number
C1110	.001 μf	Cer.	Fixed	500 v	GMV	283000
C1111	150 μμf	Cer.	Fixed	500 v	20%	281524
C1112	.001 μf	Cer.	Fixed	500 v	GMV	283000
C1113	.7–3 μμf	Tub.	Var.	500 v		281027
C1120	.001 μf	Cer.	Fixed	500 v	GMV	283000
C1121	150 μμf	Cer.	Fixed	500 v	20%	281524
C1122	.001 μf	Cer.	Fixed	500 v	GMV	283000
C1123	.7–3 μμf	Tub.	Var.	500 v		281027
C1130	.001 μf	Cer.	Fixed	500 v	GMV	283000
C1132	.001 μf	Cer.	Fixed	500 v	GMV	283000
C1133	.7–3 μμf	Tub.	Var.	500 v		281027
C1141	.005 μf	Cer.	Fixed	500 v	GMV	283001
C1150	2x20 μf	EMC	Fixed	450 v	—20%+50%	290036
C1151	2x20 μf	EMC	Fixed	450 v	—20%+50%	290037
C1152	.1 μf	PT	Fixed	400 v	20%	285526
C1153	2x20 μf	EMC	Fixed	450 v	—20%+50%	290037

Inductors

			Order Parts by Number
L1021	.3–.5 μh	Var.	114037
L1022	2.5 μh	Fixed	108103
L1041	2.5 μh	Fixed	108103
L1042	.3–.5 μh	Var.	114037
L1067	12 μh	Fixed	108005
L1070	Terminating line		108081
L1071	Terminating line		108081
L1080	Plate line		108096
L1081	Grid line		108080
L1082	Grid line		108080
L1083	Plate line		108096

Resistors

							Order Parts by Number
R1010	1 meg	½ w	Fixed	Comp.	10%		302105
R1011	100 k	½ w	Fixed	Comp.	10%		302104
R1012	470 k	½ w	Fixed	Comp.	10%		302474
R1013	100 k	½ w	Fixed	Comp.	10%		302104
R1014	1 meg	½ w	Fixed	Comp.	10%		302105
R1015	1 k	½ w	Fixed	Comp.	10%		302102
R1020	1.2 k	2 w	Fixed	Comp.	10%		306122
R1021	~~650 Ω~~	~~Special~~	500 Ω 1/2 watt fixed prec.		1% 309-0179-00		~~310513~~
R1022	100 Ω	½ w	Fixed	Comp.	10%		302101
R1023	68 k	1/10 w	Fixed	Comp.	10%		307006
R1025	27 Ω	½ w	Fixed	Comp.	10%		302270
R1026	330 Ω	½ w	Fixed	Comp.	10%		302331
R1027	200 Ω	2 w	Var.	Comp.	20%	Gain Adj.	311004
R1028	330 Ω	½ w	Fixed	Comp.	10%		302331
R1030	4 k	5 w	Fixed	WW	5%		308051
R1031	15 k	10 w	Fixed	WW	5%		308024
R1035	10 k	1 w	Fixed	Comp.	10%		304103
R1040	27 Ω	½ w	Fixed	Comp.	10%		302270
R1041	100 Ω	½ w	Fixed	Comp.	10%		302101
R1042	~~650 Ω~~	~~Special~~	500 Ω 1/2 w fixed prec		1% 309-0179-00		310513
R1043	68 k	1/10 w	Fixed	Comp.	10%		307006
R1045	47 k	½ w	Fixed	Comp.	10%		302473
R1046	100 Ω	½ w	Fixed	Comp.	10%		302101
R1047	100 Ω	½ w	Fixed	Comp.	10%		302101
R1050	47 k	½ w	Fixed	Comp.	10%		302473

Resistors (continued)

							Order Parts by Number
R1051	2.2 k	1 w	Fixed	Comp.	10%		304222
R1052	47 Ω	½ w	Fixed	Comp.	10%		302470
R1053	30 k	10 w	Fixed	WW	5%		308027
R1054	47 Ω	½ w	Fixed	Comp.	10%		302470
R1055	15 k	2 w	Fixed	Comp.	10%		306153
R1056	1 meg	½ w	Fixed	Comp.	10%		302105
R1057	2.7 k	2 w	Fixed	Comp.	10%		306272
R1059	250 k	2 w	Var.	Comp.	20%	DC Shift Comp.	311061
R1060	470 k	½ w	Fixed	Comp.	10%		302474
R1062	4.5 k	5 w	Fixed	WW	5%		308066
R1064	167 Ω	5 w	Fixed	WW	5%		308045
R1066	470 k	½ w	Fixed	Comp.	10%		302474
R1067	2 k	1 w	Fixed	Comp.	5%		303202
R1080	8.2 k	½ w	Fixed	Comp.	10%		302822
R1081	470 k	½ w	Fixed	Comp.	10%		302474
R1082	4.5 k	5 w	Fixed	WW	5%		308066
R1083	470 k	½ w	Fixed	Comp.	10%		302474
R1084	8.2 k	½ w	Fixed	Comp.	10%		302822
R1090	470 k	½ w	Fixed	Comp.	10%		302474
R1091	4.5 k	5 w	Fixed	WW	5%		308066
R1092	470 k	½ w	Fixed	Comp.	10%		302474
R1100	470 k	½ w	Fixed	Comp.	10%		302474
R1101	4.5 k	5 w	Fixed	WW	5%		308066
R1102	470 k	½ w	Fixed	Comp.	10%		302474
R1110	470 k	½ w	Fixed	Comp.	10%		302474
R1111	4.5 k	5 w	Fixed	WW	5%		308066
R1112	470 k	½ w	Fixed	Comp.	10%		302474
R1120	470 k	½ w	Fixed	Comp.	10%		302474
R1121	4.5 k	5 w	Fixed	WW	5%		308066
R1122	470 k	½ w	Fixed	Comp.	10%		302474
R1130	470 k	½ w	Fixed	Comp.	10%		302474
R1131	4.5 k	5 w	Fixed	WW	5%		308066
R1132	470 k	½ w	Fixed	Comp.	10%		302474
R1140	390 Ω	1 w	Fixed	Comp.	0 to —5%		312529
R1141	12 k	8 w	Fixed	WW	5%		308069
R1142	~~1.2 k~~	~~5 w~~	~~Fixed~~	~~WW~~	~~5%~~	8202 2 w Fixed Comp 10%	306-0821-00 312529
R1143	390 Ω	1 w	Fixed	Comp.	0 to —5%		308063
R1150	100 Ω	1 w	Fixed	Comp.	10%		304101
R1151	100 Ω	1 w	Fixed	Comp.	10%		304101
R1152	47 Ω	½ w	Fixed	Comp.	10%		302470
R1153	47 Ω	½ w	Fixed	Comp.	10%		302470
R1154	100 Ω	1 w	Fixed	Comp.	10%		304101

Vacuum Tubes

V1025A	½ 6AW8	Indicator Amplifier	157039
V1025B	½ 6AW8	Input Amplifier	
V1040A	½ 6AW8	Indicator Amplifier	157039
V1040B	½ 6AW8	Input Amplifier	
V1050A	½ 6BQ7A	Driver CF	154028
V1050B	½ 6BQ7A	Internal Trigger CF	
V1052A	½ 6BQ7A	Driver CF	154028
V1052B	½ 6BQ7A	Vert. Sig. Out CF	

		Vacuum Tubes (Continued)	Order Parts by Number
V1060	6CB6	Balance Amplifier	157037
V1066	6CB6	Internal Trigger Amplifier	157037
V1080	6CB6	Output Amplifier	157037
V1082	6CB6	Output Amplifier	157037
V1090	6CB6	Output Amplifier	157037
V1092	6CB6	Output Amplifier	157037
V1100	6CB6	Output Amplifier	157037
V1102	6CB6	Output Amplifier	157037
V1110	6CB6	Output Amplifier	157037
V1112	6CB6	Output Amplifier	157037
V1120	6CB6	Output Amplifier	157037
V1122	6CB6	Output Amplifier	157037
V1130	6CB6	Output Amplifier	157037
V1132	6CB6	Output Amplifier	157037

8136s

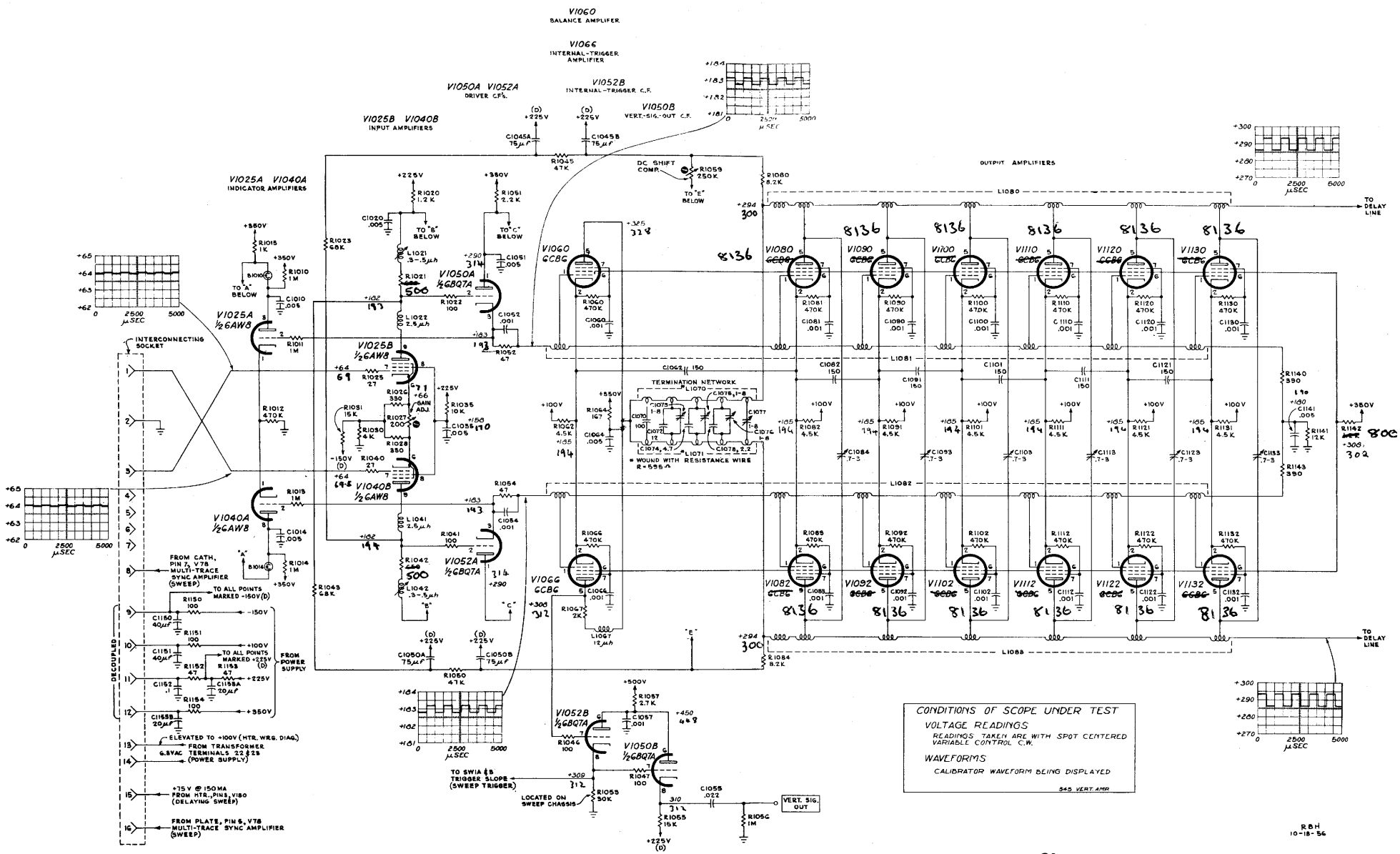
154-0367-00

or order set of 14 checked tubes 157-0082-00

NOTE

Unless otherwise specified, all of the voltage readings were taken with a dc vacuum-tube voltmeter having an input resistance of 11 megohms. The waveforms shown were reproduced from actual photographs. There will be considerable variation between instruments because of normal manufacturing tolerances and vacuum-tube characteristics. Therefore, the significance of any discrepancies observed should be determined by referring to the circuit diagram.

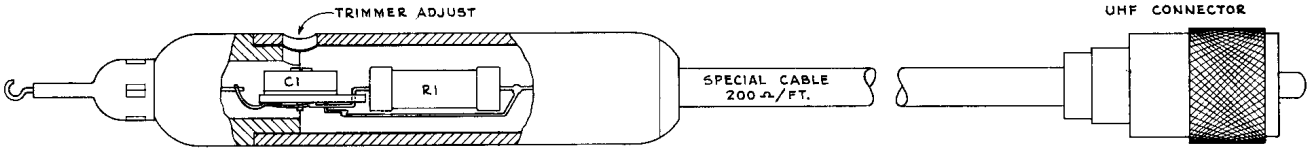
All readings are in volts unless otherwise specified. Where two voltage readings are given, they represent the voltage as read by a voltmeter under two sets of conditions, and, as such, do not indicate the peak-to-peak excursion of voltage at the point.

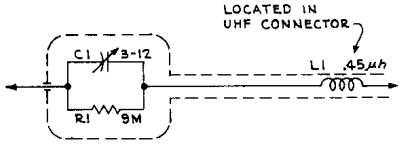


TYPE 545 OSCILLOSCOPE

C1

VERTICAL AMPLIFIER





							PART NO.
C1	3-12 μμf	Cer.	Var.				281008
R1	9 meg.	1w	Fixed	Prec.	1%		310106
L1	0.45 μh	Fixed					108098

RBH
7-31-56

A

TEKTRONIX TYPE P410 PROBE

ABBREVIATIONS

Cer.	ceramic	m	milli or 10^{-3}
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	Poly.	polystyrene
f	farad	Prec.	precision
GMV	guaranteed minimum value	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

DELAY LINE

Capacitors

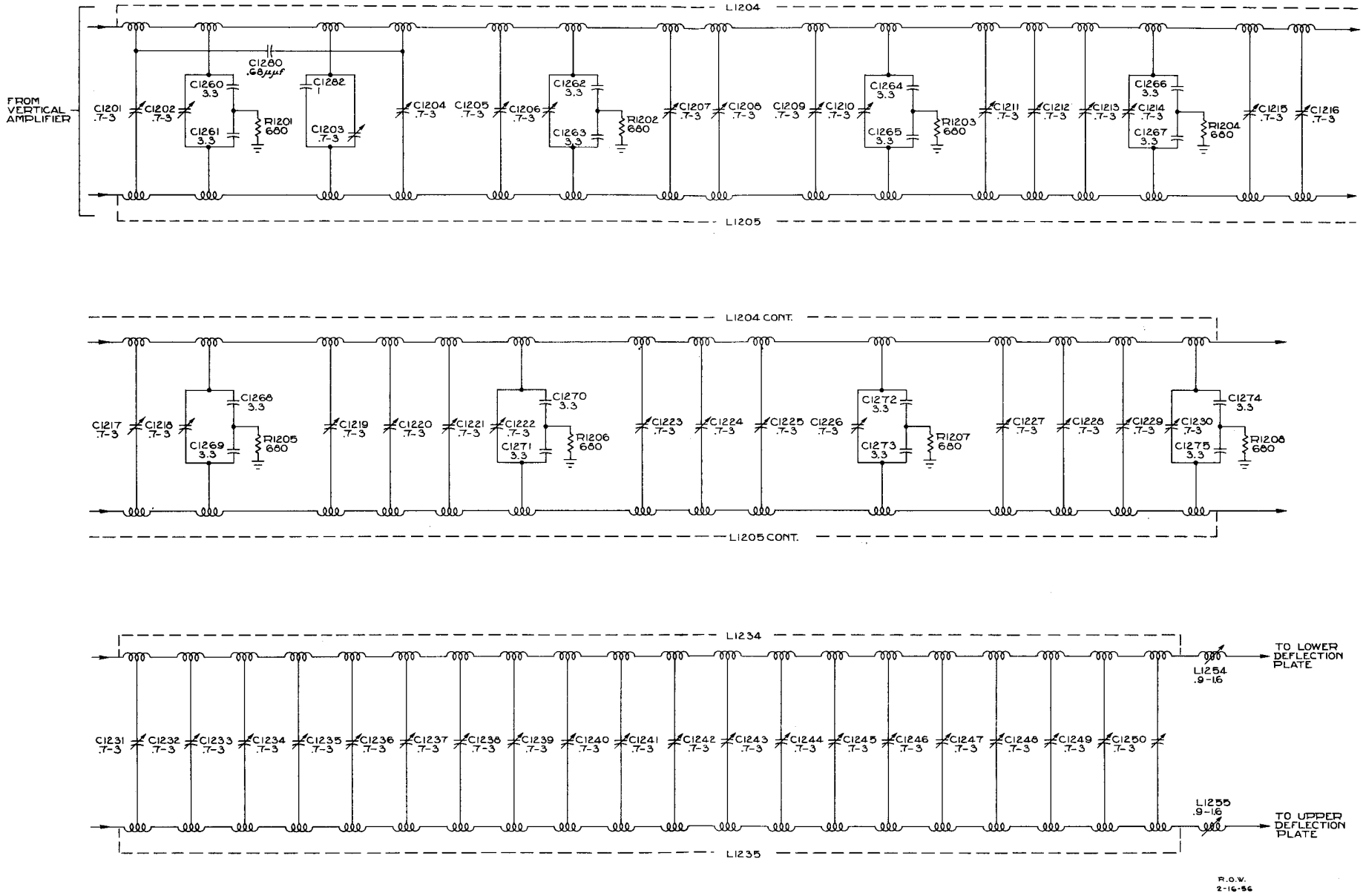
							Order Parts by Number
C1201–1250	.7–3 μμf	Tub.	Var.	500 v			281027
C1260–1275	3.3 μμf	Cer.	Fixed	500 v		±¼ μμf	281534
C1280	.68 μμf	Cer.	Fixed	500 v		20%	281537
C1282	1 μμf	Cer.	Fixed	500 v		20%	281538

Inductors

L1204	Delay Line						108094
L1205	Delay Line						108094
L1234	Delay Line						108093
L1235	Delay Line						108093
L1254	0.9–1.6 μh		Var.				114038
L1255	0.9–1.6 μh		Var.				114038

Resistors

R1201	680 Ω	½ w	Fixed	Comp.		10%	302681
R1202	680 Ω	½ w	Fixed	Comp.		10%	302681
R1203	680 Ω	½ w	Fixed	Comp.		10%	302681
R1204	680 Ω	½ w	Fixed	Comp.		10%	302681
R1205	680 Ω	½ w	Fixed	Comp.		10%	302681
R1206	680 Ω	½ w	Fixed	Comp.		10%	302681
R1207	680 Ω	½ w	Fixed	Comp.		10%	302681
R1208	680 Ω	½ w	Fixed	Comp.		10%	302681



TYPE 545 OSCILLOSCOPE

C

DELAY LINE NETWORK

ABBREVIATIONS

Cer.	ceramic	m	milli or 10^{-3}
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	Poly.	polystyrene
f	farad	Prec.	precision
GMV	guaranteed minimum value	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

CALIBRATOR

Capacitors

							Order Parts by Number
C672	330 μμf	Mica	Fixed	500 v	10%		283518
C673	330 μμf	Mica	Fixed	500 v	10%		283518
C682	27 μμf	Cer.	Fixed	500 v	20%		281513
C695	.001 μf	Cer.	Fixed	500 v	GMV		283000

Resistors

R670	150 k	½ w	Fixed	Comp.	10%		302154
R671	1 k	½ w	Fixed	Comp.	10%		302102
R672	3.3 meg	½ w	Fixed	Comp.	10%		302335
R673	2.7 meg	½ w	Fixed	Comp.	10%		302275
R674	1 k	½ w	Fixed	Comp.	10%		302102
R675	68 k	½ w	Fixed	Comp.	10%		302683
R676	33 k	1 w	Fixed	Comp.	10%		304333
R679	10 k	2 w	Var.	Comp.	20%	Cal Adj	311016
R680	100 k	½ w	Fixed	Comp.	10%		302104
R681	1.5 meg	½ w	Fixed	Comp.	10%		302155
R682	100 Ω	½ w	Fixed	Comp.	10%		302101
R683	9.5 k	½ w	Fixed	Prec.	1%		309121
R684	6.375 k	½ w	Fixed	Prec.	1%		309119
R685	2.1 k	½ w	Fixed	Prec.	1%		309117
R686	1.025 k	½ w	Fixed	Prec.	1%		309116
R687	610 Ω	½ w	Fixed	Prec.	1%		309113
R688	200 Ω	½ w	Fixed	Prec.	1%		309073
R689	100 Ω	½ w	Fixed	Prec.	1%		309112
R690	60 Ω	½ w	Fixed	Prec.	1%		30906Z
R691	40 Ω	½ w	Fixed	Prec.	1%		309066
R694	100 k	½ w	Fixed	Prec.	1%		309045
R695	100 Ω	½ w	Fixed	Prec.	1%		309112
R698	.25 Ω		Special				308090
R699	100 Ω	½ w	Fixed	Comp.	10%		302101

Switches

					not wired	wired
SW670*	1 wafer	3 position	rotary	VOLTS, MILLIVOLTS, OFF	260013	262065
SW680*	2 wafer	7 position	rotary	SQUARE WAVE CALIBRATOR		

Vacuum Tubes

V670	6U8	Calibrator Multivibrator	154033
V246A	½ 6BQ7A	Calibrator Cathode Follower	154028

* SW670 and SW680 shafts are concentric. Furnished as a unit.

NOTE

Unless otherwise specified, all of the voltage readings were taken with a dc vacuum-tube voltmeter having an input resistance of 11 megohms. The waveforms shown were reproduced from actual photographs. There will be considerable variation between instruments because of normal manufacturing tolerances and vacuum-tube characteristics. Therefore, the significance of any discrepancies observed should be determined by referring to the circuit diagram.

All readings are in volts unless otherwise specified. Where two voltage readings are given, they represent the voltage as read by a voltmeter under two sets of conditions, and, as such, do not indicate the peak-to-peak excursion of voltage at the point.

V670

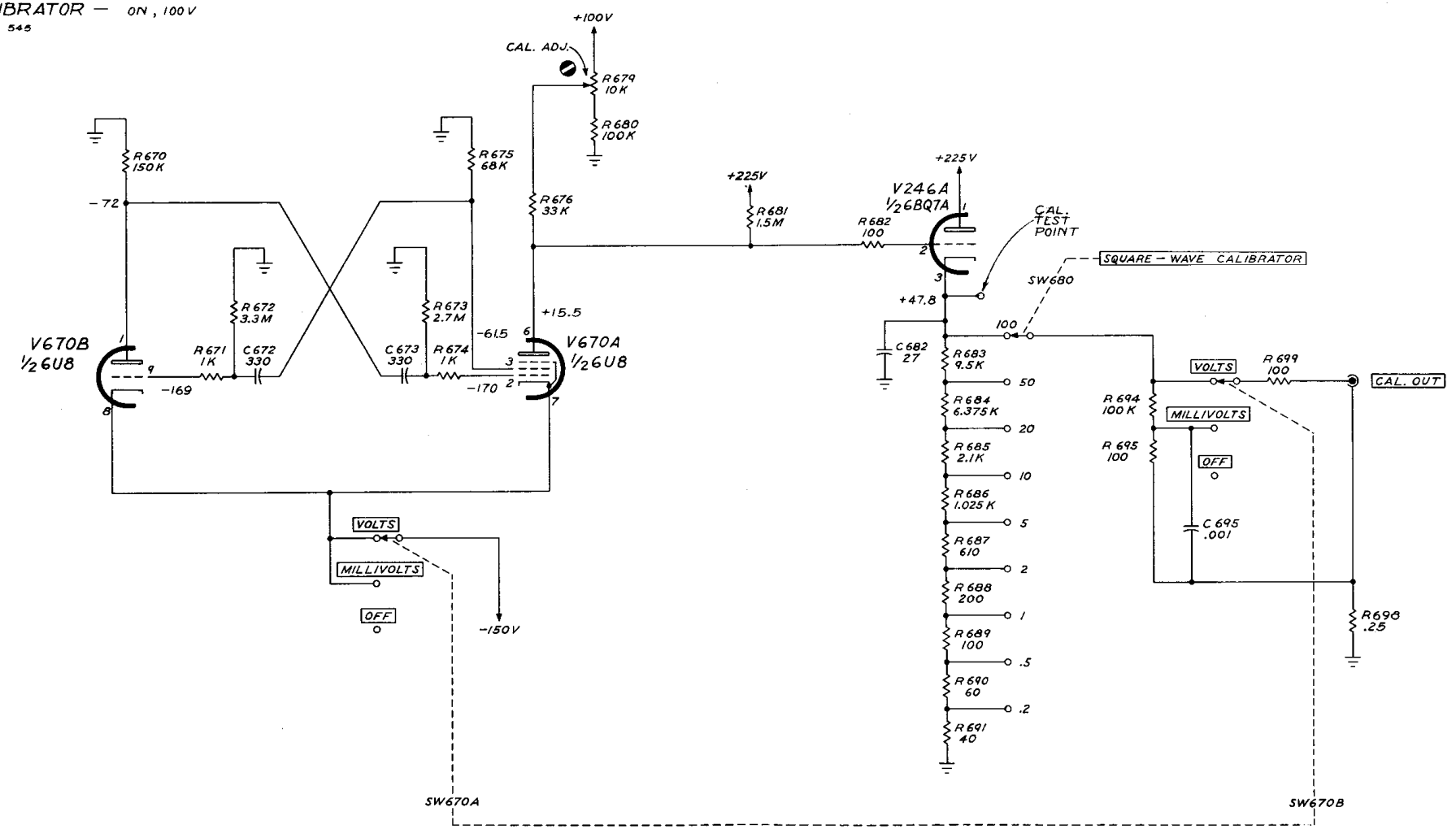
CALIBRATOR MULTIVIBRATOR

V246A

CALIBRATOR CATHODE FOLLOWER

CALIBRATOR — ON, 100V

545



ABBREVIATIONS

Cer.	ceramic	m	milli or 10^{-3}
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	Poly.	polystyrene
f	farad	Prec.	precision
GMV	guaranteed minimum value	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

POWER SUPPLY

Bulbs

		Order Parts by Number
B730	#47	150001
B731	#47	150001
B732	#47	150001

Capacitors

C191	.01 μf	PT	Fixed	400 v	20%	285510
C700	.02 μf	Cer.	Fixed	250 v	GMV	283004
C707	.01 μf	PT	Fixed	400 v	20%	285510
C711	.01 μf	PT	Fixed	400 v	20%	285510
C715	2x40 μf	EMC	Fixed	250 v	−20%+50%	290040
C717	.01 μf	PT	Fixed	400 v	20%	285510
C720	.01 μf	Cer.	Fixed	500 v	GMV	283002
C732	125 μf	EMC	Fixed	350 v	−20%+50%	290044
C740	150 μf	EMC	Fixed	250 v	−20%+50%	290048
C741	150 μf	EMC	Fixed	250 v	−20%+50%	290048
C750	.01 μf	PT	Fixed	400 v	20%	285510
C751	3x10 μf	EMC	Fixed	450 v	−20%+50%	290033
C756	125 μf	EMC	Fixed	450 v	−20%+50%	290045
C763	.01 μf	PT	Fixed	400 v	20%	285510
C770	.01 μf	PT	Fixed	400 v	20%	285510
C780	125 μf	EMC	Fixed	350 v	−20%+50%	290044
C787	.01 μf	PT	Fixed	400 v	20%	285510
C790A,B	2x40 μf	EMC	Fixed	450 v	−20%+50%	290042
C797	.01 μf	PT	Fixed	400 v	20%	285510
C1155	.005 μf	Cer.	Fixed	500 v	GMV	283001
C1161	.005 μf	Cer.	Fixed	500 v	GMV	283001

Fuses

F701	6 amp	3AG	Fast-Blo	for 117 v operation	159013
F701	3 amp	3AG	Fast-Blo	for 234 v operation	159015
F730	No. 33 copper wire, coiled				

Rectifiers

SR732	5-250 ma plates per leg	106012
SR740	5-500 ma plates per leg	106013
SR756	4-500 ma plates per leg	106019
SR780	4-250 ma plates per leg	106014
SR790	5-125 ma plates per leg	106015

Relays

K700	45-sec. Thermal Time-delay		Amperite 6NO45T	148002
K701	Relay	4P2T 6 volt		148004

Resistors

							Order Parts by Number
R700	15 k	1 w	Fixed	Comp.	10%		304153
R701	15 k	1 w	Fixed	Comp.	10%		304153
R703	68 k	½ w	Fixed	Comp.	10%		302683
R704	27 k	½ w	Fixed	Comp.	10%		302273
R706	2.7 meg	½ w	Fixed	Comp.	10%		302275
R707	2.7 meg	½ w	Fixed	Comp.	10%		302275
R708	12 Ω	1 w	Fixed	Comp.	10%		304120
R710	33 k	½ w	Fixed	Comp.	10%		302333
R711	100 k	½ w	Fixed	Comp.	10%		302104
R712	100 k	½ w	Fixed	Comp.	10%		302104
R713	1 k	½ w	Fixed	Comp.	10%		302102
R715	50 k	1 w	Fixed	Comp.	1%		310086
R716	10 k	2 w	Var.	WW	20%	—150 Adj.	311015
R717	100 k	½ w	Fixed	Comp.	10%		302104
R718	68 k	1 w	Fixed	Prec.	1%		310054
R719	470 k	½ w	Fixed	Comp.	10%		302474
R720	10 Ω	½ w	Fixed	Comp.	10%		302100
R724	1 k	25 w	Fixed	WW	5%		308037
R725	10 k	2 w	Fixed	Comp.	10%		306103
R726	1 k	½ w	Fixed	Comp.	10%		302102
R727	1 k	½ w	Fixed	Comp.	10%		302102
R728	150 k	½ w	Fixed	Comp.	10%		302154
R729	1 meg	½ w	Fixed	Comp.	10%		302105
R732	10 Ω	1 w	Fixed	Comp.	10%		304100
R733	10 Ω	1 w	Fixed	Comp.	10%		304100
R735	100 k	½ w	Fixed	Comp.	10%		302104
R736	50 Ω	2 w	Var.	WW	20%	SCALE ILLUM	311055
R740	10 Ω	1 w	Fixed	Comp.	10%		304100
R742	47 k	½ w	Fixed	Comp.	10%		302473
R743	39 k	½ w	Fixed	Comp.	10%		302393
R744	680 k	½ w	Fixed	Comp.	10%		302684
R747	1.5 meg	½ w	Fixed	Comp.	10%		302155
R748	30 k	10 w	Fixed	WW	5%		308027
R749	750 Ω	10 w	Fixed	WW	5%		308016
R750	333 k	1 w	Fixed	Prec.	1%		310056
R751	490 k	1 w	Fixed	Prec.	1%		310057
R756	10 Ω	2 w	Fixed	Comp.	10%		306100
R757	270 k	½ w	Fixed	Comp.	10%		302274
R758	56 k	½ w	Fixed	Comp.	10%		302563
R760	1.5 meg	½ w	Fixed	Comp.	10%		302155
R762	2 k	10 w	Fixed	WW	5%		308017
R763	1.5 meg	½ w	Fixed	Comp.	10%		302155
R764	2.2 meg	½ w	Fixed	Comp.	10%		302225
R765	180 k	½ w	Fixed	Comp.	10%		302184
R766	82 k	1 w	Fixed	Comp.	10%		304823
R767	1 k	½ w	Fixed	Comp.	10%		302102
R770	2.2 meg	½ w	Fixed	Comp.	10%		302225
R771	220 k	1 w	Fixed	Prec.	1%		310055
R772	333 k	1 w	Fixed	Prec.	1%		310056
R777	10 Ω	1 w	Fixed	Comp.	10%		304100
R778	82 k	2 w	Fixed	Comp.	10%		306823
R779	2.2 meg	½ w	Fixed	Comp.	10%		302225
R780	10 Ω	1 w	Fixed	Comp.	10%		304100
R781	1.5 meg	½ w	Fixed	Comp.	10%		302155
R782	390 k	½ w	Fixed	Comp.	10%		302394

Resistors (Continued)

						Order Parts by Number
R783	47 k	½ w	Fixed	Comp.	10%	302473
R784	1.5 meg	½ w	Fixed	Comp.	10%	302155
R785	2 k	20 w	Fixed	WW	5%	308031
R786	2 k	20 w	Fixed	WW	5%	308031
R787	236 k	Special				308083
R788	100 k	Special				308084
R789	1 k	½ w	Fixed	Comp.	10%	302102
R790	10 Ω	½ w	Fixed	Comp.	10%	302100
R791	150 k	½ w	Fixed	Comp.	10%	302154
R792	120 k	½ w	Fixed	Comp.	10%	302124
R793	27 k	½ w	Fixed	Comp.	10%	302273
R794	1 meg	½ w	Fixed	Comp.	10%	302105
R795	3 k	10 w	Fixed	WW	5%	308020
R797	220 k	1 w	Fixed	Prec.	1%	310055
R798	720 k	1 w	Fixed	Prec.	1%	310059
R1155	150 k	½ w	Fixed	Comp.	10%	302154

Switches

SW701	single pole	single throw	toggle	POWER ON	260134

Thermal Cut-Out

TK701	Thermal Cut-out, Type SE11, 128°F	260070

Transformers

T700	Plate and Heater Supply	T535PB1	120037

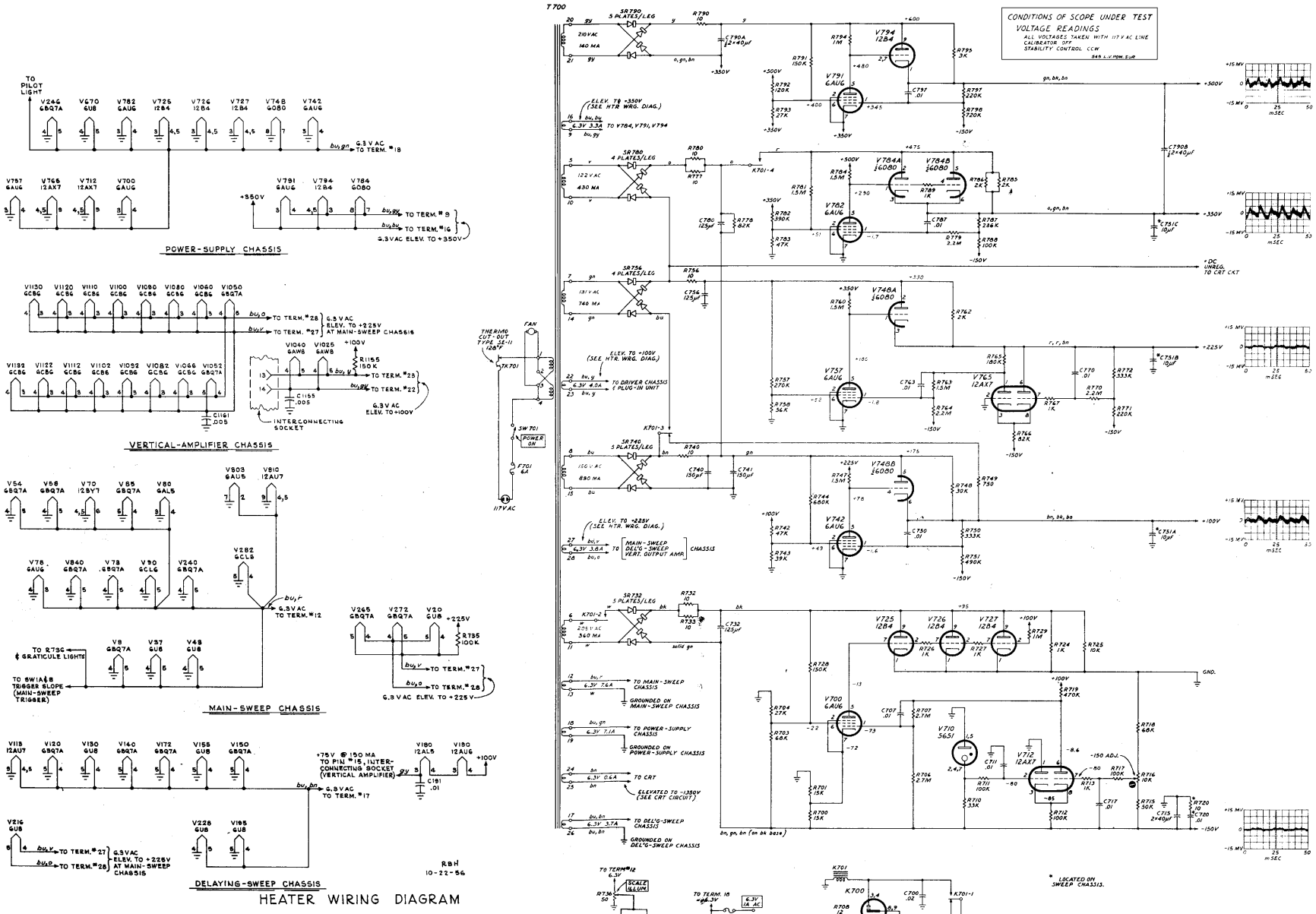
Vacuum Tubes

V700	6AU6	—150-v DC Amplifier	154022
V710	5651	Voltage Reference	154052
V712	12AX7	—150-v Comparator	154043
V725	12B4	—150-v Series Regulator	154044
V726	12B4	—150-v Series Regulator	154044
V727	12B4	—150-v Series Regulator	154044
V742	6AU6	+100-v Comparator	154022
V748A	½ 6080/6AS7GA	+225-v Series Regulator	154056
V748B	½ 6080/6AS7GA	+100-v Series Regulator	
V757	6AU6	+225-v DC Amplifier	154022
V765	12AX7	+225-v Comparator	154043
V782	6AU6	+350-v Comparator	154022
V784	6080/6AS7GA	+350-v Series Regulator	154056
V791	6AU6	+500-v Comparator	154022
V794	12B4	+500-v Series Regulator	154044

NOTE

Unless otherwise specified, all of the voltage readings were taken with a dc vacuum-tube voltmeter having an input resistance of 11 megohms. The waveforms shown were reproduced from actual photographs. There will be considerable variation between instruments because of normal manufacturing tolerances and vacuum-tube characteristics. Therefore, the significance of any discrepancies observed should be determined by referring to the circuit diagram.

All readings are in volts unless otherwise specified. Where two voltage readings are given, they represent the voltage as read by a voltmeter under two sets of conditions, and, as such, do not indicate the peak-to-peak excursion of voltage at the point.


POWER-SUPPLY CHASSIS
VERTICAL-AMPLIFIER CHASSIS
MAIN-SWEEP CHASSIS
DELAYING-SWEEP CHASSIS
HEATER WIRING DIAGRAM
RBH
10-22-56
T700
CONDITIONS OF SCOPE UNDER TEST
VOLTAGE READINGS
ALL VOLTAGES TAKEN WITH 117 V AC LINE
CALIBRATOR OFF
STABILITY CONTROL CCW
545 L.V. POW. SUP.
THERMO CUT-OUT TYPE 3E-11 125°F
FAN
TK701
3W 701
POWER ON
F701 6A
117 V AC
INTERCONNECTING SOCKET
TO PILOT LIGHT
TO DRIVER CHASSIS & PLUG-IN UNIT
TO MAIN-SWEEP CHASSIS
GROUNDED ON MAIN-SWEEP CHASSIS
TO POWER-SUPPLY CHASSIS
GROUNDED ON POWER-SUPPLY CHASSIS
TO CRT
ELEVATED TO -1350V (SEE CRT CIRCUIT)
TO DEL'G-SWEEP CHASSIS
GROUNDED ON DEL'G-SWEEP CHASSIS
+DC UNREG. TO CRT CKT
GRATICULE LIGHTS
PILOT LIGHT
* LOCATED ON SWEEP CHASSIS.

ABBREVIATIONS

Cer.	ceramic	m	milli or 10^{-3}
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	Poly.	polystyrene
f	farad	Prec.	precision
GMV	guaranteed minimum value	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

Capacitors

							Order Parts by Number
C800	.047 μf	PT	Fixed	400 v	20%		285519
C803	.001 μf	PT	Fixed	600 v	20%		285501
C805	.01 μf	PT	Fixed	400 v	20%		285510
C806	.001 μf	PT	Fixed	600 v	20%		285501
C807	2x20 μf	EMC	Fixed	450 v	20%		290037
C814	.0068 μf	PT	Fixed	3000 v	20%		285508
C815	.01 μf	Cer.	Fixed	500 v	GMV		283002
C820	.0068 μf	PT	Fixed	3000 v	20%		285508
C821	.0068 μf	PT	Fixed	5000 v	20%		285509
C822	470 μμf	PT	Fixed	10000 v	20%		285500
C823	470 μμf	PT	Fixed	10000 v	20%		285500
C830	.0068 μf	PT	Fixed	3000 v	20%		285508
C832	.015 μf	PT	Fixed	3000 v	20%		285513
C834	.015 μf	PT	Fixed	3000 v	20%		285513
C841	.005 μf	Cer.	Fixed	500 v	GMV		283001
C855	.015 μf	PT	Fixed	3000 v	20%		285513
C857	.015 μf	PT	Fixed	3000 v	20%		285513

Resistors

R800	1 k	½ w	Fixed	Comp.	10%		302102
R803	56 k	2 w	Fixed	Comp.	10%		306563
R804	100 k	½ w	Fixed	Comp.	10%		302104
R805	1 k	½ w	Fixed	Comp.	10%		302102
R807	390 Ω	2 w	Fixed	Comp.	10%		306391
R810	470 k	½ w	Fixed	Comp.	10%		302474
R811	2 meg	2 w	Var.	Comp.	20%	HV Adj	311042
R812	2.2 meg	½ w	Fixed	Comp.	10%		302225
R813	4.7 meg	½ w	Fixed	Comp.	10%		302475
R814	4.7 meg	½ w	Fixed	Comp.	10%		302475
R815	4.7 meg	½ w	Fixed	Comp.	10%		302475
R830	47 k	½ w	Fixed	Comp.	10%		302473
R831	1 meg	½ w	Var.	Comp.	20%	INTENSITY	311041
R832	4.7 meg	2 w	Fixed	Comp.	10%		306475
R833	4.7 meg	2 w	Fixed	Comp.	10%		306475
R834	100 k	½ w	Fixed	Comp.	10%		302104
R835	1 meg	½ w	Fixed	Comp.	10%		302105
R837	4.7 meg	½ w	Fixed	Comp.	10%		302475
R838	1 k	½ w	Fixed	Comp.	10%		302102
R839	100 Ω	½ w	Fixed	Comp.	10%		302101
R840	68 k	2 w	Fixed	Comp.	10%		306683
R841	47 Ω	½ w	Fixed	Comp.	10%		302470
R850	2.2 meg	2 w	Fixed	Comp.	10%		306225
R851	2.2 meg	2 w	Fixed	Comp.	10%		306225

Resistors (continued)

							Order Parts by Number
R852	2 meg	½ w	Var.	Comp.	20%	FOCUS	311043
R853	1 meg	2 w	Fixed	Comp.	10%		306105
R855	10 k	½ w	Fixed	Comp.	10%		302103
R856	27 k	½ w	Fixed	Comp.	10%		302273
R857	1 meg	½ w	Fixed	Comp.	10%		302105
R860	50 k	2 w	Var.	Comp.	20%	ASTIGMATISM	311023
R861	100 k	2 w	Var.	Comp.	20%	Geom. Adj.	311026
R863	100 k	½ w	Fixed	Comp.	10%		302104
R864	150 k	½ w	Fixed	Comp.	10%*		302154

Transformers

T801	CRT Supply	T535OA1	120036

Vacuum Tubes

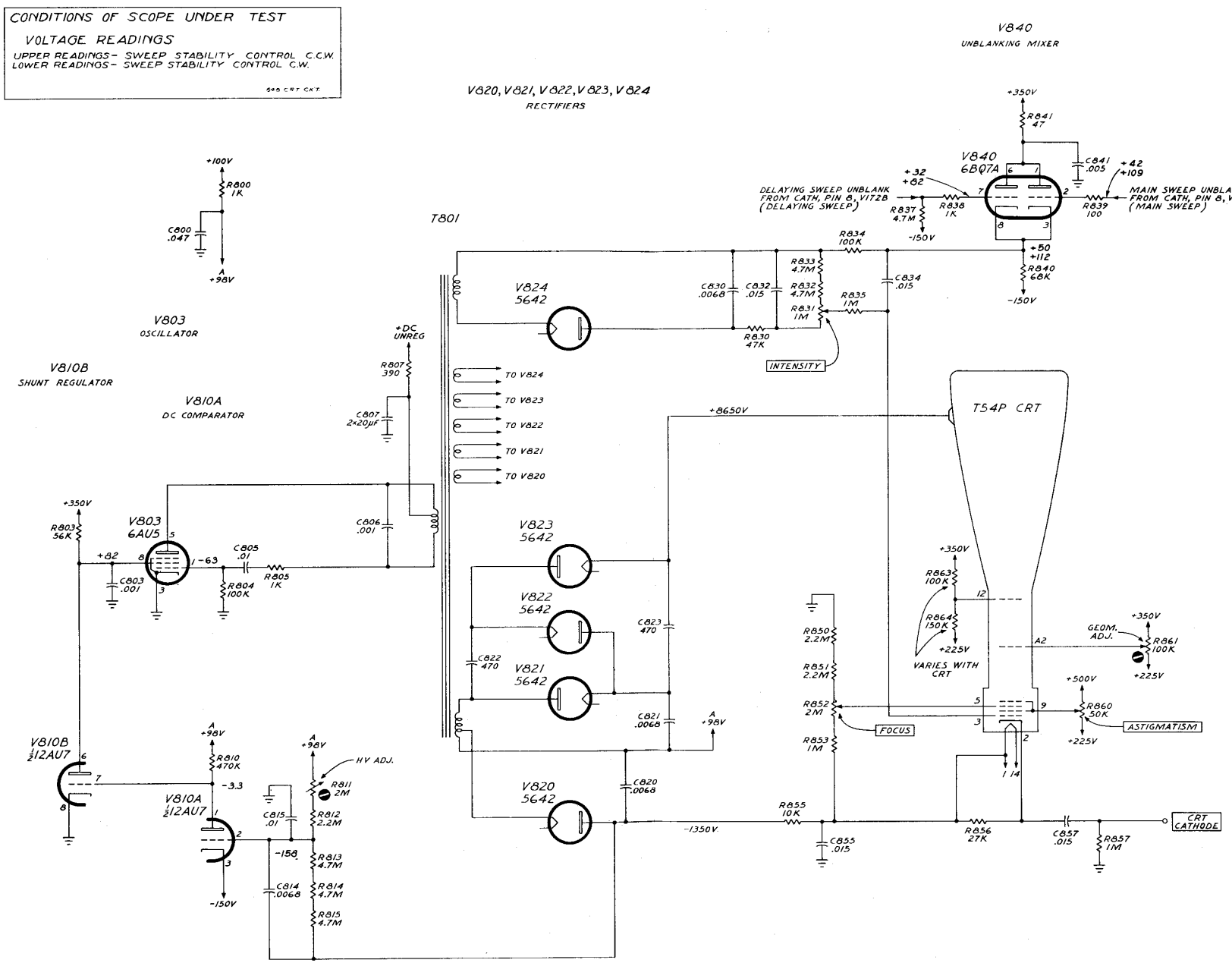
V803	6AU5	Oscillator	154021
V810A	½ 12AU7	DC Comparator	154041
V810B	½ 12AU7	Shunt Regulator	
V820	5642	—1350-v Rectifier	154051
V821	5642	+8650-v Voltage Tripler	154051
V822	5642	+8650-v Voltage Tripler	154051
V823	5642	+8650-v Voltage Tripler	154051
V824	5642	—1450-v Rectifier	154051
V840	6BQ7A	Unblanking Mixer	154028

* Nominal value, may vary between instruments.

NOTE

Unless otherwise specified, all of the voltage readings were taken with a dc vacuum-tube voltmeter having an input resistance of 11 megohms. The waveforms shown were reproduced from actual photographs. There will be considerable variation between instruments because of normal manufacturing tolerances and vacuum-tube characteristics. Therefore, the significance of any discrepancies observed should be determined by referring to the circuit diagram.

All readings are in volts unless otherwise specified. Where two voltage readings are given, they represent the voltage as read by a voltmeter under two sets of conditions, and, as such, do not indicate the peak-to-peak excursion of voltage at the point.



TYPE 545 OSCILLOSCOPE

C

CRT CIRCUIT

12-8-56
KF