INSTRUCTION MANUAL

NOTICE

This oscilloscope has been improved over instruments manufactured before Serial No.2585. The improvements are within the Vertical Amplifier system and are required by the user of plug-in units with type numbers above Type 80. The improvements can be put into any instrument before Serial No. 2585 by ordering Tektronix Field Modification No. 040-275. See your local Tektronix Field Engineer for details and availability.

TYPE

585

OSCILLOSCOPE

Tektronix, Inc.

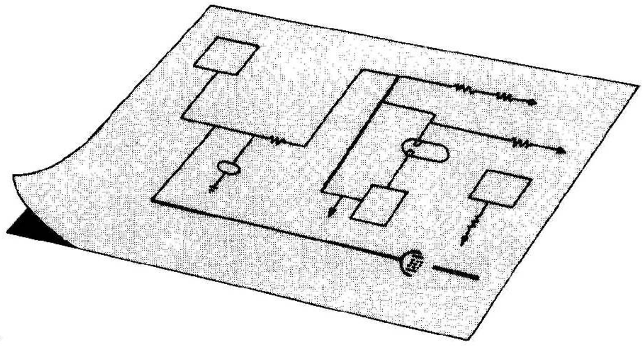
S.W. Millikan Way ● P. O. Box 500 ● Beaverton, Oregon ● Phone MI 4-0161 ● Cables: Tektronix

Tektronix International A.G.

Terrassenweg 1A ● Zug, Switzerland ● PH. 042-49192 ● Cable: Tekintag, Zug Switzerland ● Telex 53.574

070-171


TYPE 585 OSCILLOSCOPE
SERIAL
TIME BASE A
STABILITY
TRIGGERING LEVEL
TRIGGER SLOPE
PRESET
PRESET ADJUST
TRIGGERING SOURCE
LINE
INT.
DC
EXT.
AC
TRIGGER INPUT
HORIZONTAL DISPLAY
READY
RESET
'A' DEL'D BY 'B'
'A' SINGLE SWEEP
'B' INTENSIFIED BY 'A'
HORIZ. INPUT
X 10
EXT.
X 1
5X MAGNIFIER
ON
OFF
VARIABLE 10-1
VARIABLE TIME/CM
MILLI SEC
SEC
µSEC
UNCALIBRATED
CALIBRATED
TIME BASE B
TIME/CM OR DELAY TIME
LENGTH
4 CM
10 CM
DELAY-TIME MULTIPLIER 1-10
DEL'D TRIG.
+GATE B
+GATE A
SAWTOOTH A
FOCUS
INTENSITY
ASTIGMATISM
SCALE ILLUM.
TYPE 80 VERTICAL PLUG-IN UNIT
SERIAL
VERTICAL POSITION
TEKTRONIX
PROBE
POSITION RANGE ADJUST
TEKTRONIX, INC.
PORTLAND, OREGON, U.S.A.
HORIZONTAL POSITION
VERNIER
AMPLITUDE CALIBRATOR
PEAK-TO-PEAK
MILLI VOLTS
VOLTS
OFF
CAL. OUT
POWER ON
TEKTRONIX, INC., PORTLAND, OREGON, U.S.A.



SECTION 1

CHARACTERISTICS

General

The Tektronix Type 585 Oscilloscope is a wide range, general purpose laboratory instrument which provides accurate measurements in the dc to approximately 95 megacycle range. Plug-in amplifiers are used in the vertical deflection system, permitting the instrument to be used in many specialized applications. Any of the Tektronix Eighty Series Plug-In Units can be used with the oscilloscope to satisfy many types of wide-band uses. Use of the Type 81 Plug-In Adapter permits use of any of the Tektronix letter series plug-ins for applications involving, among others, dual trace operation, low level signals, differential signals, pulse sampling, and transistor risetime checking. High calibrated sweep rates allow full use of the rise-time capabilities of the instrument.

Special circuits incorporated in the Type 585 Oscilloscope allow accurate, continuously variable delay in the presentation of a sweep from 1 microsecond to 10 seconds after the receipt of a triggering impulse. The delayed sweep feature permits highly magnified displays of a small portion of an undelayed sweep; accurate measurements of waveform time jitter; precise time measurements, as well as many other uses.

VERTICAL DEFLECTION SYSTEM

Characteristics for the vertical deflection system of the Type 585 Oscilloscope depend upon the plug-in unit and probe used with the instrument. The following characteristics are given for the Type 585 when used with a Type 80 Plug-In Unit and a Type P80 Probe.

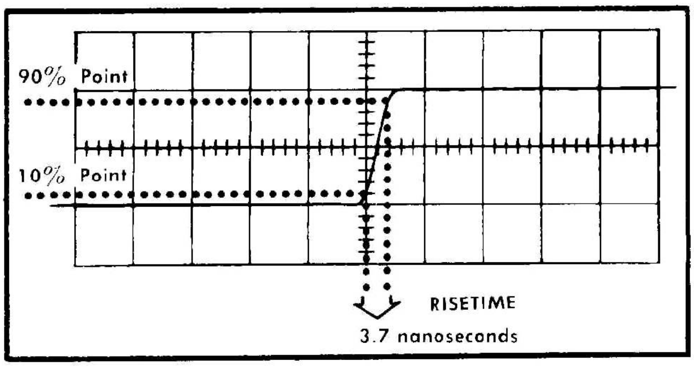


Fig. 1-1. Vertical risetime of the Type 585 Oscilloscope and Type 80 Plug-In combination.

Bandpass [1]	DC to approximately 95 megacycles
Risetime [2]	Better than 3.9 nsec, 10% to 90%, nominally 3.7 nsec.
Verical Deflection Factor	0.1 volts per centimeter.
Input Characteristics	A function of the individual plug-in or probe used.

[1] **Bandpass measured using a Type 80/P80 Probe.**

[2] **Risetime measured using a Type 84.**

HORIZONTAL DEFLECTION SYSTEM

Sweep Rates

Time Base A

0.05 microseconds (50 nsec) to 2 seconds per centimeter in 24 accurately calibrated steps. An uncalibrated control permits sweep rates to be varied continuously between 50 nsec and approximately 5 seconds per centimeter. Calibrated sweep rates are typically within 2% and in all cases within 3%, of the indicated rate.

Time Base B

2 microseconds to 1 second per centimeter in 18 accurately calibrated steps. All sweep rates are typically within 1%, with the .2, .5, and 1 second per centimeter ranges within 3% of the indicated rates.

Magnifier

Provides a 5 times horizontal expansion of the center 2-centimeter portion of the oscilloscope display. It extends the fastest Time Base A sweep rate to 10 nsec per centimeter with a typical 1% linearity.

Triggering Modes

Time Base A and B

External, Internal, and Line. Triggering SLOPE and LEVEL are adjustable.

Triggering Signal Requirements

Time Base A

Internal—a signal producing 4 mm of vertical deflection from 15 cps to 10 mc.

a signal producing 1.5 cm of vertical deflection from 10 to 30 mc.

a signal producing 2.5 cm of vertical deflection from 30 to 50 mc.

a signal producing 4.0 cm of vertical deflection from 50 to 100 mc.

NOTE

See page 2-9 for operating instructions to synchronize the A sweep with signals of less than 4.0 cm amplitude from 50 mc through 150 mc.

External—a signal of 0.2 volts to 30 volts peak-to-peak. (The A sweep will trigger on larger signals, but the TRIGGERING LEVEL control operates only over a —15 volt to +15 volt range.)

Time Base B

Internal—4 mm of crt display through 500 kc, increasing to 2 cm crt display at 4 megacycles.

External—AC or DC: a signal of ±0.4 volts through 500 kc, increasing to 1 volt at 1 mc, and 2.5 volts at 2 mc.

External-Horizontal Signal Input

Deflection Factor—approximately 0.2 to 15 volts per centimeter, continuously variable.

Frequency Response—depends on the amount of deflection. The product of frequency response and deflection in centimeters is approximately 4.8 megacycle centimeters.

Input Characteristics—1 megohm paralleled by approximately 50 pf.

Delayed Sweep

Sweep delay continuously variable from 1 microsecond to 10 seconds. Actual delay steps within 1% of indicated delay from 2 μsec/cm to 0.1 sec/cm; 0.2 sec/cm to 1 sec/cm typically within 1% but never more than 3%. Incremental delay accuracy is within 0.2%.

Jitter—not more than 1 part in 20,000.

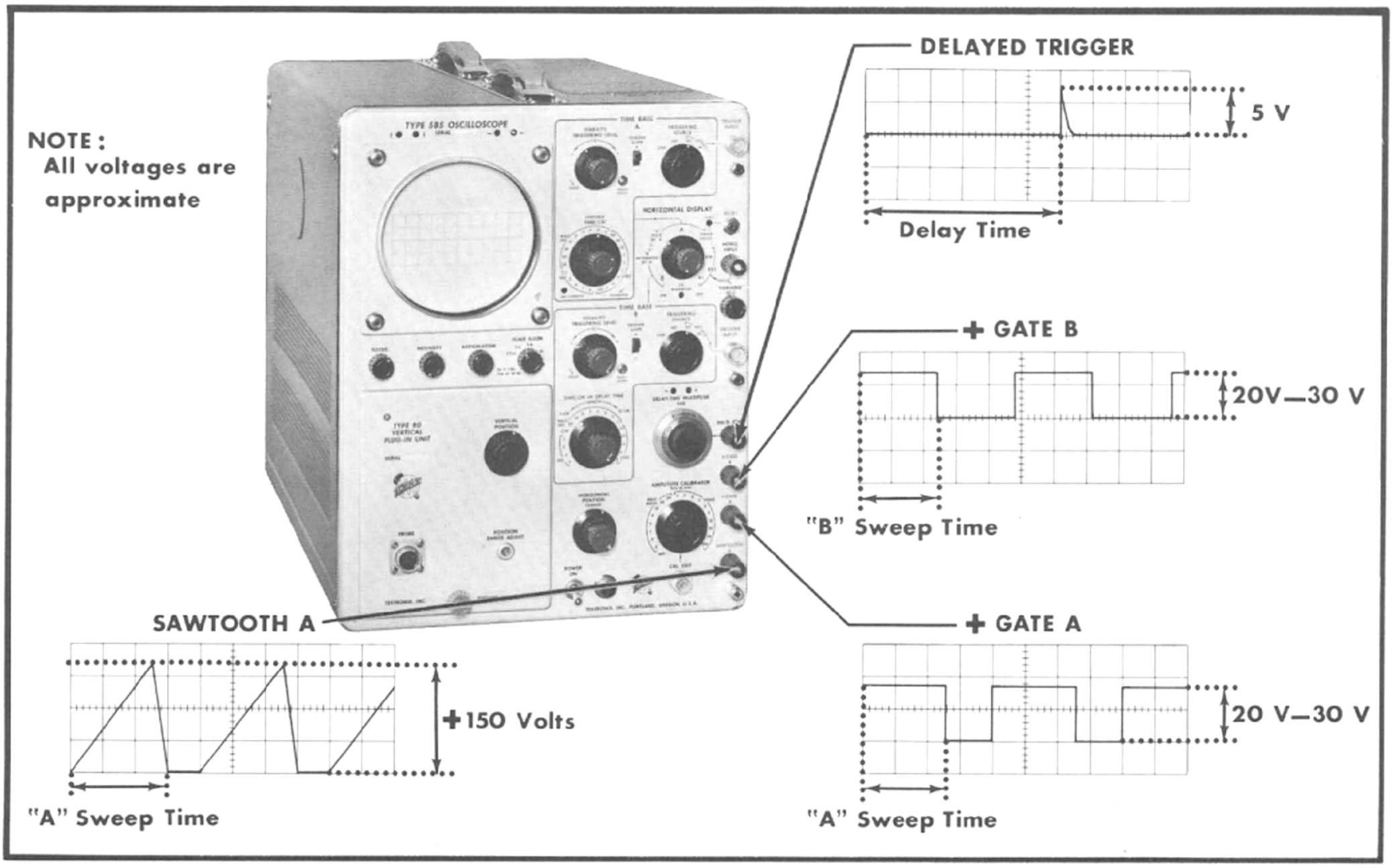


Fig. 1-2. Output waveforms available at the oscilloscope front panel.

OTHER CHARACTERISTICS

Cathode-Ray Tube

Type—T581P31; P1, P2, P7, and P11 phosphors optional. Other phosphors available on special order.

Unblanking—DC coupled.

Accelerating potential—10,000 volts.

Deflection system—electrostatic. Beam deflected vertically by 6 pairs of distributed deflection plates. Beam deflected horizontally by 1 pair of deflection plates.

Usable viewing area—4 centimeters by 10 centimeters.

Vertical Deflection Factor—4.6 to 5.6 volts per centimeter.
Horizontal Deflection Factor—18 to 21 volts per centimeter.

Graticule

Illumination—variable edge lighting.

Markings—marked in 4 vertical and 10 horizontal 1-centimeter divisions with 2-millimeter markings on the center-lines.

Amplitude Calibrator

Waveform—square-waves at approximately 1 kc.

Output voltage—0.2 millivolts peak-to-peak to 100 volts peak-to-peak in 18 steps.

Accuracy—peak-to-peak amplitude of square-waves within 3% of indicated voltage.

Output Loading—33 k load will reduce 100 volts output 2%. 500 k load will reduce 50 volt output 2%. 100 k load will effect voltages 1 volt or below.

Power Supplies

Electronically regulated for stable operation with widely varying line voltages and loads.

Line voltage requirements—105 to 125 volts, or 210 to 250 volts.

Power—approximately 630 watts.

Line frequency—50 to 60 cycles.

Output Waveforms Available

Positive Gate A—approximately 30 volts peak-to-peak with same duration as A sweep. Approximately 200 ohms output impedance.

Positive Gate B—approximately 30 volts peak-to-peak with same duration as B sweep. Approximately 300 ohms output impedance.

Delayed Trigger pulse—approximately 5 volts in amplitude, occuring at end of the delay period.

Sawtooth A—sweep A sawtooth waveform, approximately 150 volts peak-to-peak. Maximum allowable load, 18 k.

MECHANICAL SPECIFICATIONS

Ventilation

Forced filtered air. Thermal relay interrupts instrument power in the event of overheating. Will operate satisfactorily up to approximately 120° F ambient air temperature.

Construction

Aluminum-alloy chassis and three-piece cabinet.

Photo-etched anodized panel, blue vinyl covered textured aluminum.

Dimensions—see Figure 1-3.

Weight—74 pounds.

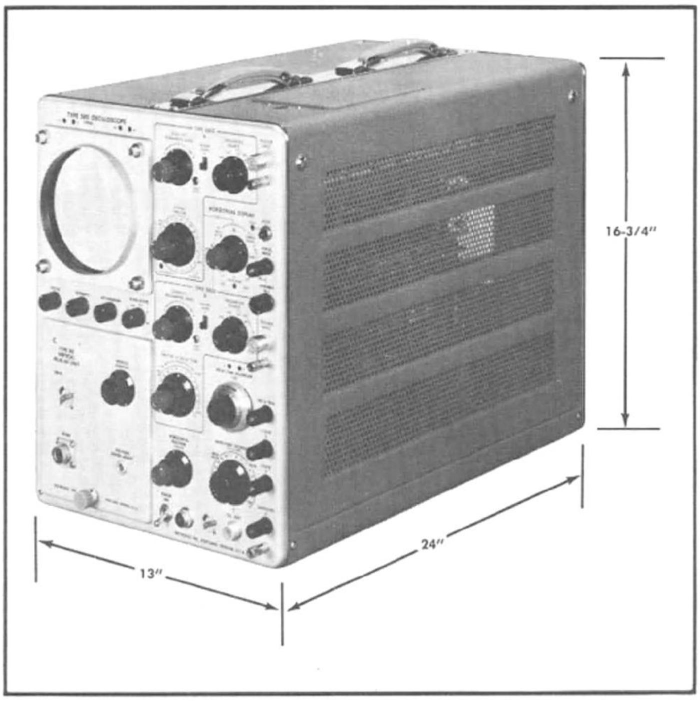


Fig. 1-3. Type 585 Oscilloscope dimensions.

Accessories Included:

2 Binding-post adapters (013-004)
1 Test lead (012-031)
1 Green Filter (378-514)
1 Power cord (161-010)
1 Adapter, 3 wire to 2 wire (103-013)
2 Instruction Manuals

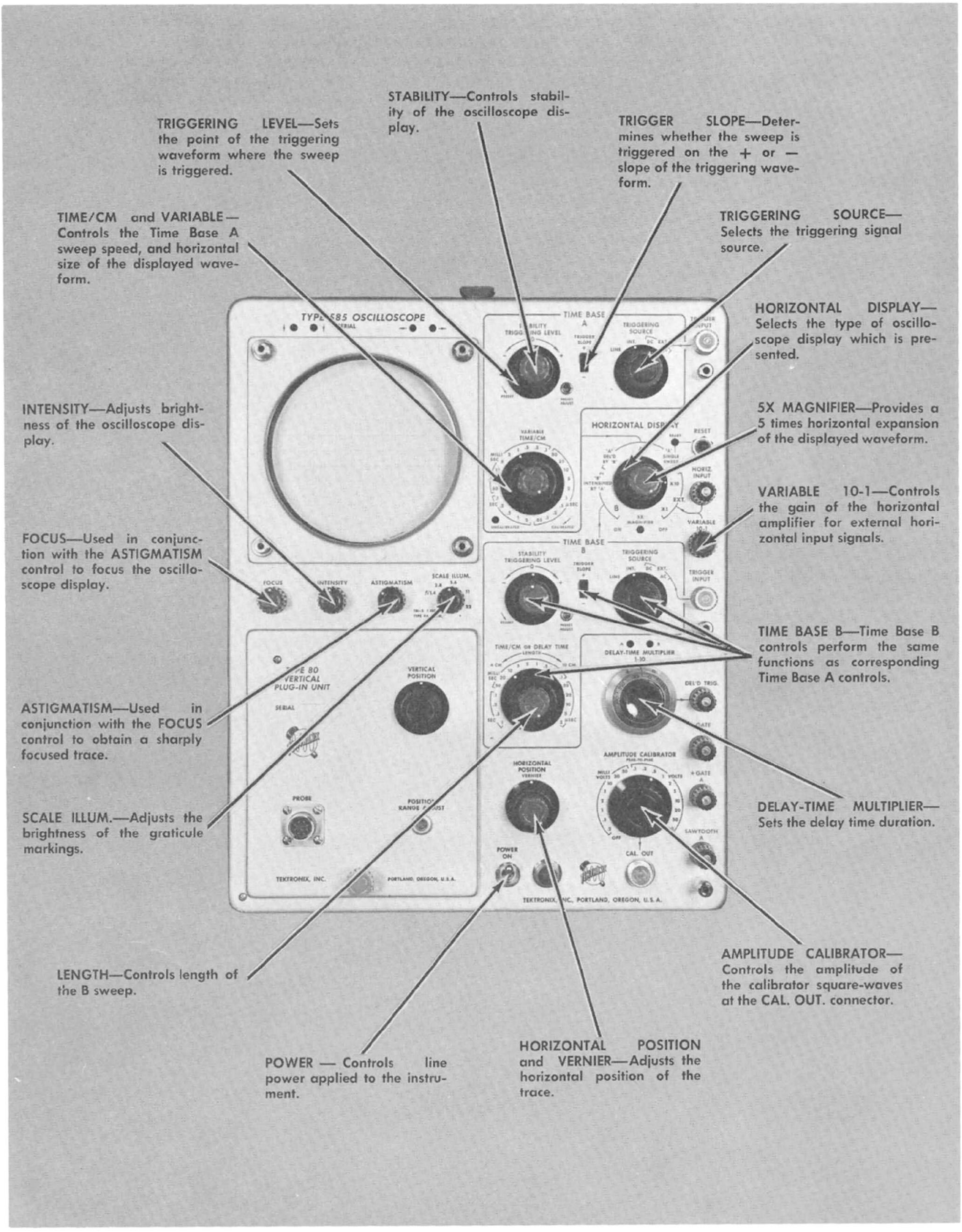
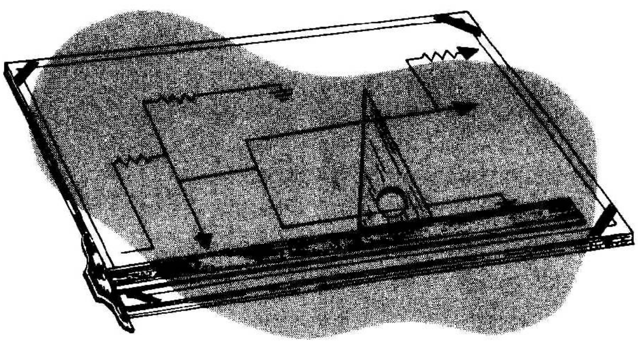


Fig. 2-14. Functions of the front panel controls.



SECTION 4

CIRCUIT DESCRIPTION

General

This portion of the Instruction Manual presents a detailed discussion of the Type 585 Oscilloscope's circuit operation. This discussion is keyed to various block diagrams inserted with the text and to detailed circuit diagrams contained at the back of this manual. It is assumed a Type 80 Plug-In Unit and P80 Probe are used.

Instrument Operation

The simplified block diagram of Figure 4-1 illustrates the interrelation of the various circuits composing the Type 585 Oscilloscope. The input signal to the oscilloscope is connected through the probe to the input connector of the plug-in unit. The output signal from the plug-in unit is then applied to the vertical amplifier of the oscilloscope. The output of the vertical amplifier system is used to drive the vertical deflection plates of the crt.

A Trigger Pickoff circuit in the Vertical Amplifier applies a sample of the input waveform to the two Time-Base Trigger circuits. This waveform sample can then be used to trigger a sweep by a Time-Base Generator. In addition, an external waveform or a line frequency waveform can be used to trigger a sweep.

Signals of widely varying shapes and amplitudes are applied to the Time-Base Trigger circuits. The Trigger Regenerators in turn produce constant amplitude output pulses which are used to start a Time-Base Generator at the proper instant of time. This insures a stable display of the input waveform.

The output pulses from two Trigger circuits may be applied to their respective Time-Base Generators to initiate an output sweep waveform. The selected sawtooth waveform is then amplified by the Horizontal Amplifier and applied to the horizontal deflection plates of the crt.

When an external sweep waveform is used, the waveform is connected through the HORIZ. INPUT connector to the External Horizontal Amplifier. The output signal of the External Horizontal Amplifier is then amplified by the Horizontal Amplifier and applied to the crt horizontal deflection plates to produce the desired horizontal deflection.

Sawtooth waveforms from the two time base generators are available to be applied to the delay pickoff circuit. This circuit utilizes one sawtooth waveform at a time to generate a delayed trigger pulse after an adjustable delay time. This delayed triggering pulse is available at the front panel DEL'D TRIG. connector. When the sawtooth waveform from the Time Base B sweep generator is used to produce the delayed trigger, the delayed trigger may be used to trigger the Time Base A Sweep Generator circuit. The delayed trigger is then used to initiate a delayed sweep by Time Base A.

The Amplitude Calibrator produces a square wave output waveform which can be used to check the deflection factor of the vertical deflection system. The Amplitude Calibrator voltage is also used to compensate attenuator probes.

There are six regulated low voltage power supplies used in the Type 585 Oscilloscope. These power supplies provide the operating voltages for all circuits except the cathode-ray tube. Operating voltages for the crt are provided by a separate high voltage power supply contained in the crt circuit. In addition to the high voltage power supply, the crt circuit contains the controls and circuitry which affect the crt display.

VERTICAL DEFLECTION SYSTEM

General

The Type 585 vertical deflection system can be driven by any of the 80 Series plug-in units, or by the Type 81 Plug-In Adapter with any Tektronix letter series plug-in unit.

Input signals to the oscilloscope are applied directly to the Type P80 Probe, when using a Type 80 Plug-In Unit, or either to a probe or directly into a 1 megohm input of the Type 82 Dual-Trace Plug-In Unit. The output of a plug-in unit is then applied through the interconnecting plug to the Delay-Line Driver stage of the oscilloscope Vertical Amplifier. The signal traverses the Delay-Line Driver stage and is returned to the plug-in for termination. The plug-in units provide positioning voltages permitting the trace to be positioned vertically on the crt.

The input resistance and capacitance of each plug-in unit (or probe) input connector is discussed in the manual for the unit in use. In all cases, consider the oscilloscope input as a potential load on the signal source, the degree depending upon the signal source impedance, the plug-in input characteristics, and the frequency being measured.

Delay-Line Driver

The Delay-Line Driver Stage is a balanced distributed amplifier consisting of seven push-pull triode sections. Use

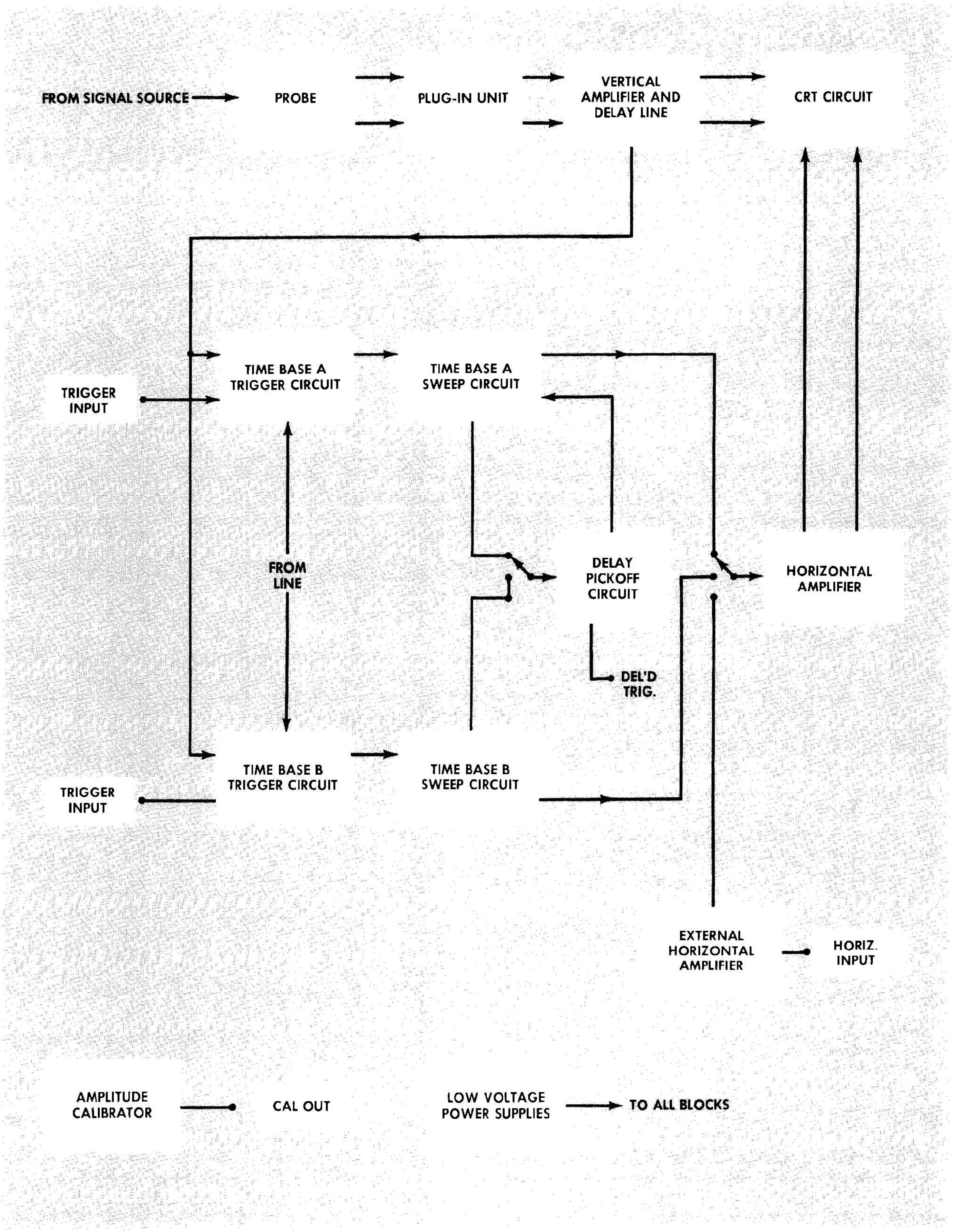


Fig. 4-1. Type 585 Oscilloscope simplified block diagram.

of the distributed amplifier principle permits amplification of frequencies much higher than conventional amplifier systems; dc coupling allows amplification of signals down to dc. All triode sections are neutralized to prevent spurious oscillations. Gain of the overall vertical amplifier is set in the Delay-Line Driver Stage cathode lead by means of the VERT. GAIN ADJ. control, R1015.

Stabilization of the Delay-Line Driver Stage

Overall distributed amplifier stabilization involves many details normally disregarded in lower bandpass systems. The Type 585 vertical distributed amplifier has been stabilized by several special methods.

As the push-pull signals enter the grid lines of the Delay-Line Driver stage they pass through a toroidal pulse transformer, T1014. T1014 serves to open the common-mode grid oscillation path to aid in the stabilization of the amplifier. (The "common-mode oscillatory path" applies to the characteristic of distributed amplifiers that they sometimes oscillate with all grids in phase, and all plates of the opposite phase.) Another toroid, T1046, located in the plate lines at V1044, also aids in stabilizing the amplifier to prevent common-mode oscillation.

Additional stabilization is provided by capacitive neutralization of each section, with the fourth section adjustable to allow for minor differences in tube and stray capacitances.

The signal velocity of propagation is identical in the grid and plate lines of the Delay-Line Driver stage. Since the amplifier is paraphase, the cathodes must exhibit a similar velocity of propagation. This is provided by placing small ferrite beads around one of the leads of each cathode coupling capacitor.

Finally, the shield between triode halves of each 6DJ8 has a 150-ohm resistor to ground to reduce the shield Q and increase the isolation between plates at high frequencies.

Plate Line Termination

The Delay-Line Driver Stage plate line is a 186-ohm balanced line terminated at each end. In instruments below Serial No. 2585, the termination resistors are not adjustable.

The reverse termination resistors, R1008-R1011 and R1009-R1012, are above the required 93-ohms each (186-ohms in series). The amplifier tubes' parallel plate resistance brings the value down to 93-ohms each, 186-ohm total.

In Instruments after Serial No. 2585, the reverse termination has been improved permitting more accurate adjustment of the termination and minimizing reflections to an optimum amount.

The fact that the reverse termination is adjustable and quite closely matches the line impedance, makes it unnecessary to make the termination at the other end of the plate line adjustable.

The Delay Line Driver plate line sends its output signal through the fixed delay line, through the Output Amplifier grid lines, and is terminated at the far end of the Output Amplifier grid line. Current and Voltage supplied to the Delay Line Driver stage is supplied at the far end of the Output Amplifier grid line and is carried to the tubes V1014 through V1074 via the fixed delay line.

DC Shift Compensation

A common fault of most high current dc coupled amplifiers is temporary instability following a sudden current change called DC Shift. This has been compensated in the Type 585 Oscilloscope. The DC Shift compensation network is located next to the plate load resistors at the input end of the Delay-Line Driver stage. R1004, C1004 and R1005 make up the compensating time constant to effectively cancel the DC Shift effect. The DC Shift compensation is not adjustable.

Trigger Pickoff

At the output of the Delay-Line Driver stage a push-pull tetrode amplifier receives signals for the triggering circuit. Tubes V1084 and V1094, amplify and invert the vertical signal and drive two cathode followers that drive both Time-Base Trigger circuits and the vertical Beam Position Indicator Amplifiers. The Trigger Pickoff circuit is a wide bandpass amplifier capable of sending frequencies to the Time-Base A Trigger circuit that are considerably above the vertical amplifier 3 db point. Two 1000 ohm resistors, R1086 and R1096, isolate the stray capacitance loading of the leads to the Time Base B chassis from the Time Base A leads.

Delay Line

The push-pull output of the Delay-Line Driver stage is applied through a 186-ohm balanced delay line to the Output stage. The delay line is a specially braided line which delays application of the vertical signal to the deflection plates until the crt has been unblanked and the horizontal sweep started. This delay allows the leading edge of fast rising pulses to be displayed as much as 60 nseconds after the sweep is started. The delay line does not require adjustment because of the nature of its construction.

Vertical Amplifier Output Stage

The Output stage is a distributed amplifier consisting of five triode sections driven by the signal from the delay line. This stage is similar to the Delay-Line Driver stage with all triodes neutralized to prevent oscillations. The major difference is that each stage has an adjustable compensating capacitor between opposing plates permitting the transient response to be adjusted. Toroidal pulse transformers (1) at the input to the grid line and (2) in the output leads to the grids of the output pentode amplifier, open the common mode oscillatory circuits aiding stabilization. The output of the distributed amplifier is applied to a push-pull power output stage which supplies the necessary power to drive the vertical deflection plates of the cathode-ray tube.

In instruments before Serial No. 2585 the Output Stage plate line reverse termination was fixed. After Serial No. 2585 it has been made adjustable. Step 45A of the Calibration Procedure details the proper adjustment procedure. This change, with the Delay Line Driver changes is avail-

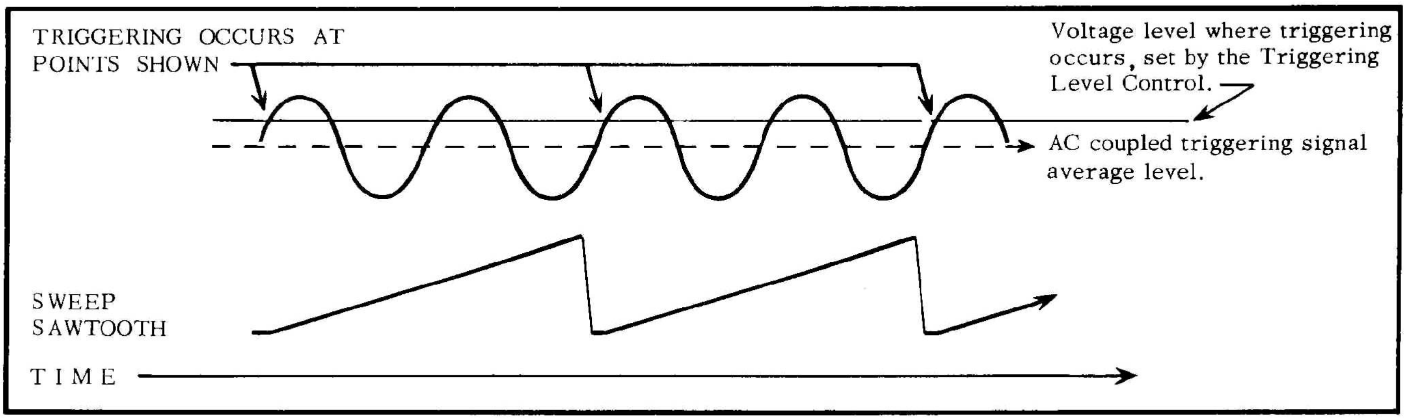


Fig. 4-2. Operation of the trigger circuit. As the triggering signal voltage exceeds the predetermined triggering level, a sweep begins.

able for instruments before Serial No. 2585 as Tektronix Field Modification No. 040-275, and is required in order for proper operation of Plug-In Units with numbers above Type 81. See your local Tektronix Field Engineer for details and availability.

Cathode-Ray Tube

Six pairs of distributed vertical deflection plates are used in the cathode-ray tube. This arrangement of distributed plates permits the necessary crt sensitivity while at the same time reducing objectionable effects of capacitance between the plates. The deflection plate lines are constructed so that the velocity of the deflection waveform through the line is essentially the same as the velocity of the electrons passing through the plates.

TIME-BASE A TRIGGER CIRCUIT

General

Triggering signals from the line, TRIGGER INPUT connector, and Trigger Pickoff circuit of the vertical amplifier can be individually connected to the input of the Time-Base A Trigger circuit. The triggering signal selected by the TRIGGERING SOURCE switch is then connected to the control grids of the Trigger Difference Amplifier stage V24 and V34.

The Trigger Difference Amplifier is supplied push-pull signals from the internal Trigger Pickoff circuit, but single-ended signals from the LINE or EXT. sources.

Instruments with a Vacuum Tube Trigger Regenerator

The Trigger Difference Amplifier is used to control the operation of the Trigger Regenerator multivibrator. The TRIGGERING LEVEL control establishes the operating point of the Trigger Difference Amplifier by determining the dc voltage applied to one grid of the amplifier. By controlling the operating point of the difference amplifier with the TRIGGERING LEVEL control it is possible to determine at which voltage level of the triggering waveform, triggering occurs.

The amplifier triggering pulses from the difference amplifier are applied through a cathode follower to the input of the trigger multivibrator circuit. The trigger multivibrator is a monostable Schmitt Trigger Circuit which switches when the output of the difference amplifier reaches a certain level. When the multivibrator switches, an output pulse is applied from the multivibrator to the sweep circuit. This pulse is relatively constant in amplitude regardless of the amplitude of the original triggering signal. After application of the pulse to the sweep circuit, the multivibrator resets to await the next triggering signal.

Instruments with a Tunnel Diode Trigger Regenerator

The Trigger Difference Amplifier stage is used to control the operation of the tunnel diode Trigger Regenerator circuit. The TRIGGERING LEVEL control establishes the operating point of the Trigger Difference Amplifier by determining the dc voltage applied to one of its grids. By controlling the operating point of the Trigger Difference Amplifier with the TRIGGERING LEVEL control it is possible to determine at which voltage level of the triggering waveform, triggering occurs. (See Figure 4-2).

Trigger Difference Amplifier

The Trigger Difference Amplifier is essentially a current control of the tunnel diode Trigger Regenerator circuit. As the plate current of V34 increases with positive going grid signals, the tunnel diode will switch.

Trigger Regenerator

The tunnel diode Trigger Regenerator output is an almost rectangular waveform of approximately 0.45 volt peak-to-peak. It is dc coupled to the base of the Trigger Amplifier Q44 where it is inverted and amplified. The amplified

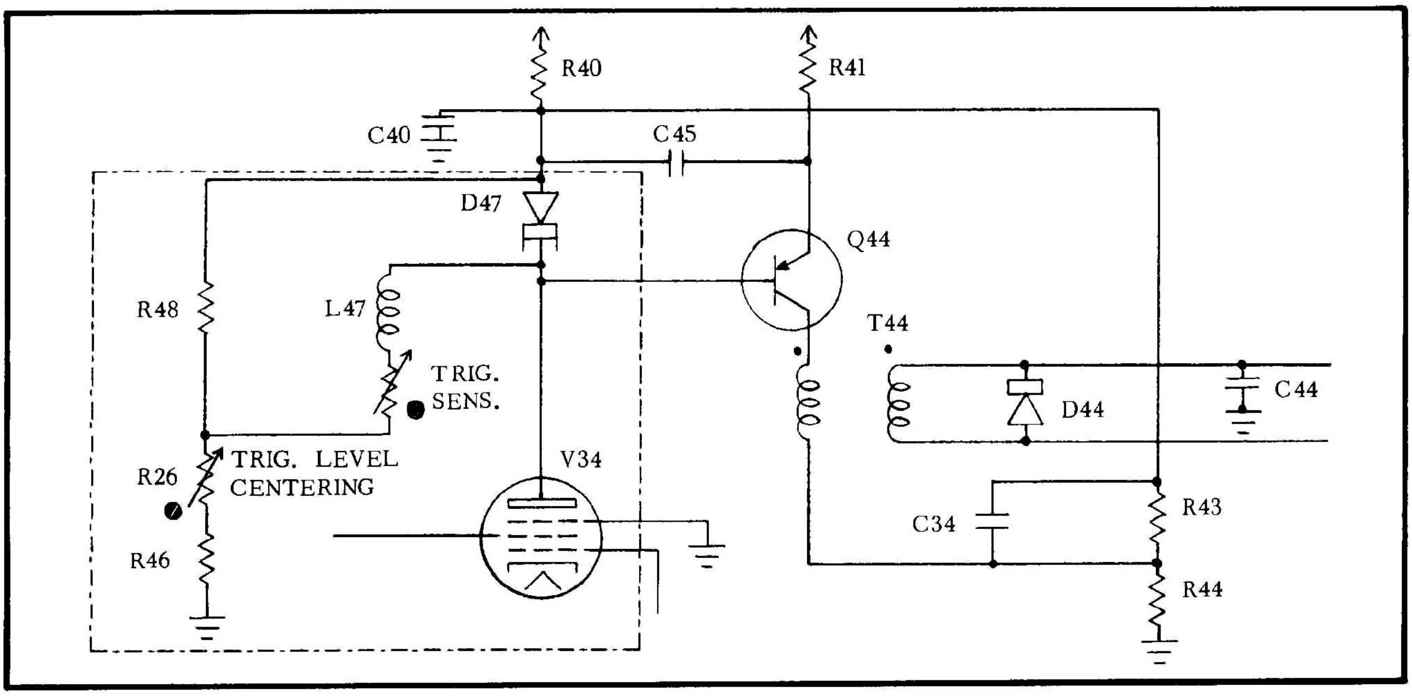


Fig. 4-3. Tunnel diode Trigger Regenerator diagram.

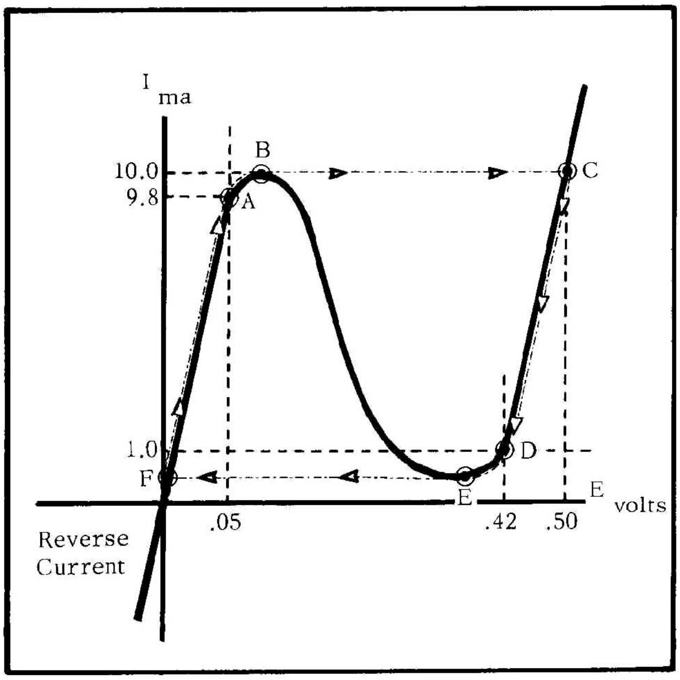


Fig. 4-4. Tunnel Diode, D47, characteristics.

signal from Q44 is coupled to the Sweep-Gating Multivibrator by the small toroidal pulse transformer T44. T44 inverts and differentiates the tunnel diode waveform such that negative triggering pulses of about 7 volts are applied to the Sweep-Gating Multivibrator. (See Figure 4-6). Diode D44 reduces the positive voltage excursion of T44 output voltage from 7 volts to about 4 volts, sufficient to prevent triggering jitter. Capacitor C44 assures a low impedance path to ground for the triggering pulse on the low side of T44 secondary.

Tunnel Diode Operation

The theory of operation of tunnel diodes is beyond the scope of this manual. Theory concerning the curves and data presented may be obtained from appropriate reference material.*

The tunnel diode Trigger Regenerator diagram is shown in Fig. 4-3.

The tunnel diode D47 dynamic characteristics are presented in Figure 4-4. You may also wish to refer to the Time-Base A Trigger diagram during the following discussion.

The tunnel diode static operating point is represented by point A of Figure 4-4 and is established when the TRIGGERING LEVEL control is at 0. (The grid voltages of V24 and V34 are both at ground potential). With the Trigger Difference Amplifier balanced, the plate current of V34 is about 3.8 ma. According to Figure 4-4 the tunnel diode resting current will then be 9.8 ma with the additional current flowing through L47, R47, R26 and R46.

If the plate current of V34 is increased to 4.0 ma by either the application of a signal to the Trigger Difference Amplifier, or by rotation of the TRIGGERING LEVEL control, the tunnel diode current can be increased to point B of Figure 4-4 where it will switch at a very rapid rate to point C. It is the high impedance to high frequencies of L47 that permits the tunnel diode to switch to point C rather than to some lower current portion of the curve between points C and D. As current through L47 slowly changes, the current of the tunnel diode slowly drops to point D. The rate at which the tunnel diode current drops to point D is controlled by the L/R time constant of L47 and the circuit resistance in parallel with it. The actual time taken for the tunnel diode current to reach point D is about 0.5 μsecond.

* General Electric Tunnel Diode Manual

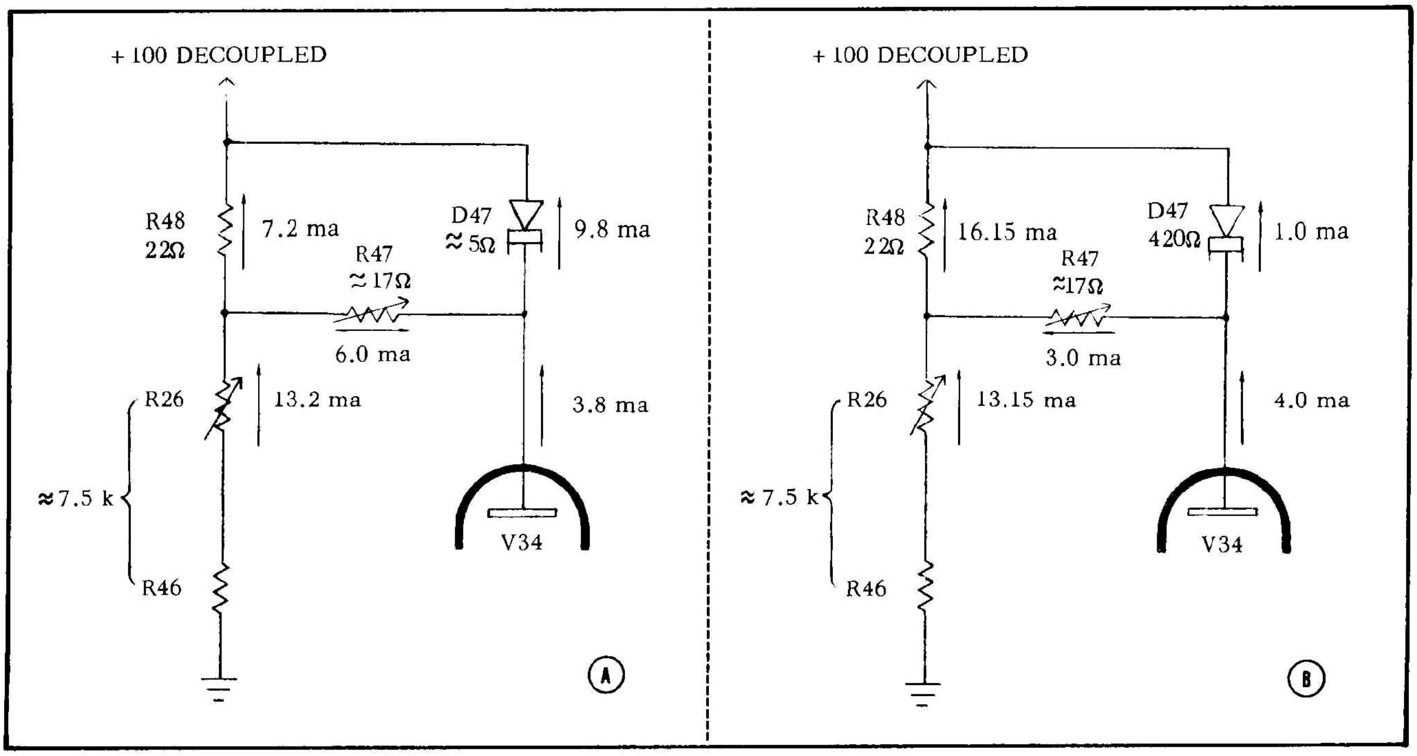


Fig. 4-5. Basic Tunnel Diode Static Currents. (A.) D47 conditions as at point A of Figure 4-4. (B.) D47 conditions as at point D of Figure 4-4.

If the plate current of V34 is maintained at 4.0 ma the tunnel diode current will remain at point D. Either by the rotation of the TRIGGERING LEVEL control or by a signal, the tunnel diode current can be reduced to point E where it will switch rapidly to point F. Again L47 has a voltage impressed across it such that its L/R time constant will soon permit the tunnel diode current to return to point A. The time from point F to point A is about 0.3 μsecond.

From the above description you can see that the tunnel diode has two possible stable states, point A at about 5 Ω resistance, and point D at about 420 Ω resistance. It is the slow change in current of the shunt system around the tunnel diode, controlled by L47, that prevents the tunnel diode Trigger Regenerator system from triggering the Sweep-Gating Multivibrator circuit at too high a rate. If the rate of the negative trigger pulses sent to the Sweep-Gating Multivibrator exceed about 1.3 megacycles, unstable triggering can result.

Two partial diagrams show the current paths for both tunnel diode static conditions. Figure 4-5a shows approximate current values for static condition A of Figure 4-4, and Figure 4-5b shows approximate current values for static condition D of Figure 4-4. In both cases L47 is not included because its dc resistance is insignificant for this purpose.

Trigger Amplifier Q44

The base of the transistor Trigger Amplifier Q44 is dc coupled from the cathode of D47 while the emitter is ac coupled from the anode of D47. Since the emitter of Q44 is returned to its positive supply voltage through a large degenerative resistor (long-tailed), the collector current will increase at the time D47 switches, but will return to its original value as soon as C45 charges. The collector current of Q44 will drop to its original value even if D47 remains at its D state indefinitely. As soon as D47 switches from E to A, the collector current of Q44 will decrease until C45 again changes its charge, and Q44 will then stay at its original static current value as long as D47 remains at point A. The collector current pulses of Q44 are never longer than about 0.3 μsecond.

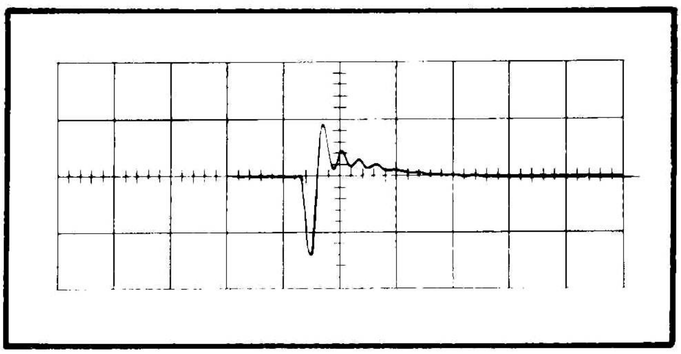


Fig. 4-6. Output pulse of T44. 5 volts per cm. .1 μsec per cm.

TIME-BASE B TRIGGER CIRCUIT

General

Triggering signals from the line, TRIGGER INPUT connector, and Trigger Pickoff circuit of the vertical amplifier

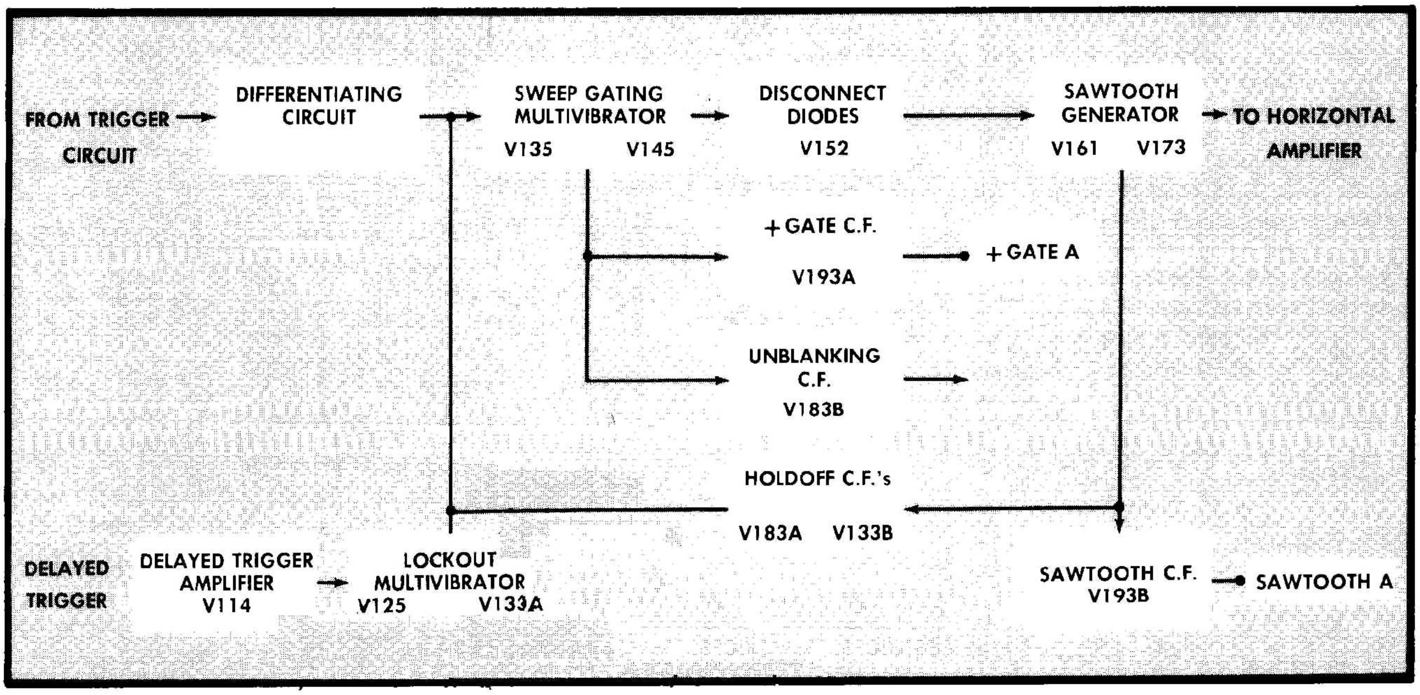


Fig. 4-7. Time Base Generator A block Diagram.

can be individually connected to the input of the Time-Base B Trigger circuit. The operation of the Trigger Amplifier and Trigger Regenerator is essentially identical with other Tektronix delaying sweep oscilloscopes.

An amplified triggering signal from the Trigger Amplifier, V74A and V74B, is applied to the Trigger Regenerator multivibrator. The Trigger Regenerator is a monostable Schmitt circuit which switches when the output of the trigger difference amplifier reaches a certain level. When the multivibrator switches, a negative output pulse is applied to the 'B' Sweep Gating multivibrator to initiate a sweep. The pulse is relatively constant in amplitude regardless of the original triggering signal amplitude. After application of the pulse to the sweep circuit, the trigger regenerator resets to await the next triggering signal.

The TRIG. LEVEL CENTER control, R78, permits an adjustment of the output voltage level of the Trigger Amplifier. This assures that the Trigger Amplifier output signal will lie in the center of the Trigger Regenerator input hysteresis voltage range when the Trigger Amplifier grids are both zero volts to ground.

TIME-BASE GENERATOR A

General

The Time-Base Generator A block diagram of Figure 4-7, and the Time-Base Generator A diagram at the back of this manual should be used during the following discussion.

The output pulses from the A Trigger Regenerator system previously discussed are applied to the grid of V135A, the input triode of the Sweep-Gating Multivibrator V135A, V135B and V145. The Sweep-Gating Multivibrator is a Schmitt Gating circuit acting as an electronic switch for the Time-Base Generator circuit. When the negative triggering pulse is received, the Sweep-Gating Multivibrator switches, cutting off the Disconnect Diodes V152A and B and allowing the Miller-Runup sweep generator circuit to operate. A positive going square wave output of the Sweep-Gating Multivibrator is taken from the cathode of V135B and is connected through the Unblanking Cathode Follower V183B to the crt to unblank the tube. The unblanking signal is employed only in the INTERNAL SWEEP and SINGLE SWEEP positions of the HORIZONTAL DISPLAY switch. Another positive going square wave output of the Sweep-Gating Multivibrator is connected through the +Gate Output Cathode Follower V193A to the +GATE OUT connector on the front panel.

The sawtooth voltage used by the Horizontal Amplifier to move the crt electron beam across the face of the crt is also available at the front panel at the SAWTOOTH A terminal. Cathode follower V193B isolates the internal sawtooth voltage circuit from external loading. Maximum external load of 18K is permissible.

For persons experienced with Tektronix time-base generator systems, the Type 585 Time-Base Generators are nearly identical with those found in any of the 530 or 540 series instruments. The major difference is that the Type 585 Time Base A Miller Runup circuit fastest rate of rise has been increased by a factor of 2. This requires doubling the static current of V161 and slightly altering the associated circuitry.

Sweep-Gating Multivibrator

The Sweep-Gating Multivibrator operates as a bistable circuit. In the quiescent state V135A is conducting and its plate is down at about +35 volts. This cuts off V145 through cathode follower V135B and the divider R141-R143, by taking the grid of V145 about 12 volts below its cathode which rests at about −60 volts. With V145 cutoff, its plate is held at about −3 volts with respect to ground by conduction of Disconnect Diodes V152A and B through R147 and R148. The greater amount of diode current of about 5 ma flows through V152A with smaller amounts of current flowing through V152B. Conduction of the lower diode V152B through the Timing Resistor R160 then clamps the control grid of the Miller tube V161 at about −2.9 volts. Conduction through diode V152A places the Time-Base Generator output voltage at about −10 volts.

Miller Runup Circuit

The quiescent state of the Miller Runup circuit, including V161 and V173, is determined by a dc network between plate and grid of V161. This network consists of the neon glow tube B167, the Runup C.F. V173, the Disconnect Diodes V152A and B, and R151. The purpose of this network is to establish the voltage at the plate of V161 at a value such that it will operate linearly during its runup period. The quiescent plate voltage is about +31 volts.

Sweep Generation

If the STABILITY and TRIGGERING LEVEL controls are adjusted for triggered operation, a negative trigger pulse drives the grid of V135A below cutoff (below about −70 volts) forcing the Sweep-Gating Multivibrator into its other state in which V145 is the conducting tube. Diode D134 and R133 hold the plate of V135A solidly at +100 volts preventing triggered pulses from being amplified, coupled to the crt unblanking waveform, and intensity modulating the display. As V145 conducts, its plate drops to about −7.5 volts, cutting off the Disconnect Diodes V152A and B. Any spiking that may occur during this transition is attenuated by the network C150-R150. Since R151 is in series with the transition of the plate of V145 and diode V152A, C151 is used as a speed-up capacitance to assure V152A being cut off at the same time V152B is cut off.

With the Disconnect Diodes cut off, the grid of the Miller Runup tube V161 and the cathodes of the Runup C.F. V173 are free to seek their own voltages. Current through the Timing Resistor R160 then starts V161 control grid toward −150 volts. The plate voltage of V161 begins to rise by an amount equal to the drop in grid voltage times the gain of the stage, carrying with it the grid and cathodes of V173. This raises the voltage at the top of Timing Capacitor C160, which in turn pulls up on the grid of V161 and prevents it from dropping more than about a volt during about a 150 volt rise of the plate.

The Timing Capacitor charging current is then equal to the current through the Timing Resistor. Since the voltage at the grid of the Miller Runup tube remains essentially constant, the voltage drop across the Timing Resistor also remains essentially constant. This provides a constant source of current for charging the Timing Capacitor C160. By this action C160 charges linearly, and the voltage at the cathodes of V173 rises linearly. Any departure from a linear rise in voltage at this point will produce a change in voltage at the grid of the Miller Runup tube in a direction to correct for the error.

Timing Switch

The linear rise in voltage at the cathode of V173 is used as the sweep time-base. Timing Capacitor C160 and Timing Resistor R160 are selected by the TIME/CM switch SW160. R160 determines the current that charges C160. By means of the TIME/CM switch both the size of the capacitor being charged and the charging current can be selected to cover a wide range of sawtooth slopes (sweep rates). For high sweep rates bootstrap capacitor C165 helps supply current to charge the stray capacitance at the plate of the Miller Runup tube. This permits the plate voltage to rise linearly at the required rate.

If uncalibrated sweep rates are desired, the VARIABLE TIME/CM (red knob) control may be turned away from the CALIBRATED position. This control, R160Y, varies the sweep rate over a $2\frac{1}{2}$ to one range. Switch 160B is ganged with the VARIABLE control in such a way that the UNCALIBRATED light comes on when the control is turned away from the CALIBRATED position.

Sweep Length

The sweep rate, the rate at which the spot moves across the face of the crt, is determined by the timing circuit C160 and R160. The length of the sweep, the distance the spot moves across the face of the crt, however, is determined by the setting of the SWP. LENGTH control R176. The sweep sawtooth voltage increases the voltage at the grid and cathode of V183A and at the grid and cathode of V133B. As the voltage at the cathode of V133B rises, the voltage at the grid of V135A will rise. When the voltage at this point is sufficient to bring V135A out of cutoff (about −50 volts), the Sweep-Gating Multivibrator circuit will revert to its original state with V135A conducting and V145 cut off. The voltage at the plate of V145 rises, carrying with it the voltage at the diode plates of V152A and B. The diodes then conduct and provide a discharge path for C160 through R151, R147 and R148, and through the resistance of the cathode circuit of V173. The plate voltage of the Miller Runup tube now falls linearly under feedback conditions essentially the same as when it generated the sweep portion of the waveform except for a reversal of direction. The resistance through which C160 discharges is much less than that of the Timing Resistor through which it charged. The capacitor current for this period will therefore be much larger than during the sweep portion, and the plate of the Miller Runup tube will return rapidly to its quiescent voltage. This produces the retrace portion of the sweep sawtooth during which time the crt beam returns rapidly to its starting point. The unblanking voltage drops turning off the crt beam current during retrace.

Holdoff

The Holdoff circuit prevents the Time-Base Generator from being triggered during the retrace interval. That is, the Holdoff circuit allows a finite time for the Time-Base circuits to reach a steady-state condition after the completion of a sweep.

During the trace portion of the sweep sawtooth, the Holdoff Capacitor C180 charges through V183A, as a result of the rise in voltage at the cathode of V183A. At the same time the grid of V135A is being pulled up by V133B, until V135A comes out of cutoff and starts conducting, initiating the retrace. At the start of the retrace interval C180 starts discharging through the Holdoff Resistor R181. The time constant of this circuit is long enough, however, so that during the retrace interval (and for a short period of time after the completion of the retrace) C180 holds the grid of V135A high enough so that it cannot be triggered. However, when C180 discharges to the point where V133B is cut off, it loses control over the grid of V135A which returns to the level established by the STABILITY control somewhere between about —58 and —70 volts. The holdoff time required is determined by the size of the Timing Capacitor. For this reason the TIME/CM switch changes the time constant of the Holdoff circuit simultaneously with the change of Timing Capacitors. (In the μSEC positions of the TIME/CM switch R181 is shunted by either R180A or R180B, shown on the Timing Switch diagram.)

Stability Control

The operational mode of the Time-Base Generator is determined by the setting of the STABILITY control R110. By means of this control the sweep can be turned off, free run, or adjusted for triggered operation. The STABILITY control, through cathode follower V125, regulates the grid level of V135A. (V133A is inoperative during A SWEEP operation.)

For triggered operation, the STABILITY control is adjusted so that the grid of V135A is at about —64 volts, just negative enough to prevent the Sweep-Gating Multivibrator from free running. Adjusted in this manner a sweep can only be produced when an incoming negative trigger pulse drives the grid of V135A below cutoff, about —66 volts.

Moving the arm of the STABILITY control toward ground, (ccw rotation), but not so far as to actuate the PRESET switch, will raise the grid level of V135A to about —58 volts and prevent the Sweep-Gating Multivibrator from being triggered. This action turns off the sweep. Moving the arm toward —150 volts (cw) drops the grid of V135A to the point where the discharge of the Holdoff Capacitor C180 can switch the multivibrator. Adjusted in this manner, the Sweep-Gating Multivibrator will free-run and produce a recurrent sweep.

When the STABILITY control is turned full ccw to the PRESET position, R110 is switched out of the circuit and R111 is switched in. This control, a front-panel screwdriver adjustment labeled PRESET ADJUST, provides a fixed dc voltage for the grid of V135A. When properly adjusted, PRESET operation can be used for most triggering applications. When triggering may be difficult, however, the manual STABILITY control R110 should be used.

Lockout Multivibrator Modes of Operation

The Lockout Multivibrator is placed into operation by only three positions of the seven position HORIZONTAL DISPLAY switch. These modes of operation are: 1. 'A' SINGLE SWEEP, 2. 'A' DEL'D BY 'B', and 3. 'B' INTENSIFIED BY 'A'. The detailed operation of the Lockout multivibrator is explained for the 'A' SINGLE SWEEP mode, with the other two modes presented as variations of the first.

1. 'A' Single Sweep

When the HORIZONTAL DISPLAY switch is in the 'A' SINGLE SWEEP position, plate voltage is applied to V133A which then operates in conjunction with V125 as a bistable Lockout Multivibrator.

In the first stable state that exists after the completion of a sweep, V125 is cut off and V133A is conducting. In this state, the divider between the plate of V125 and the grid of V133A sets the common bus cathode voltage of the Lockout Multivibrator and consequently the grid voltage of V135A. The Lockout Level control R125 is adjusted to set the grid of V135A a little less negative than —55 volts so that the Sweep-Gating Multivibrator cannot be triggered; this "locks out" the sweep.

The front panel push-button labeled RESET permits the Lockout Multivibrator to switch, unlocking the sweep generator for a single sweep. Depressing the RESET button applies a positive voltage pulse to the grid of V114. V114 inverts and amplifies the pulse and applies it to the grid of V133A placing V125 in conduction. The STABILITY control again has control of the grid of V135A, and should a negative trigger pulse come from the triggering circuitry, a sweep can occur. The RESET switch functions as follows: when open, C103 is charged to about —20 volts. The drop across R104 is essentially zero volts. As the RESET button is depressed, grounding the switch side of C103, the opposite side rises to about +8 volts. The plate of V114 drops about —17 volts from ground (clamped there by D122), cutting off V135A and resetting the Lockout Multivibrator until a single sweep occurs.

Depending on the adjustment of the STABILITY control, a sweep can now be produced in one of two ways. If the STABILITY control is turned clockwise, the grid of V135A can be pulled down below about —70 volts causing the Sweep-Gating Multivibrator to switch to its other state and initiate a sweep. If the STABILITY control is adjusted for triggered operation, the sweep will be initiated by the first negative trigger pulse to arrive at the grid of V135A via T44.

As the sweep begins, the rising sawtooth voltage pulls up the cathode of V133B by the holdoff action previously described. As the cathodes of the Lockout Multivibrator follow the cathode of V133B up, V125 cuts off and V133A conducts; immediately raising the common cathode bus potential from about —64 to about —53 volts. As the sawtooth voltage continues to rise, the cathode of V133B catches the cathode of V133A and carries the common cathode bus voltage up to about —48 volts causing V135A to conduct to revert the Sweep-Gating Multivibrator, and terminate the sweep. (See Figure 4-8).

As the Holdoff Capacitor C180 discharges, the cathodes of the Lockout Multivibrator start to fall. The grid level of V133A is such that this tube comes out of cutoff first, holding the common cathode bus at the locked out voltage level of about —53 volts. As V133A conducts, its plate drops, extinguishing the READY light. A new sweep cannot be initiated until the RESET button is again depressed.

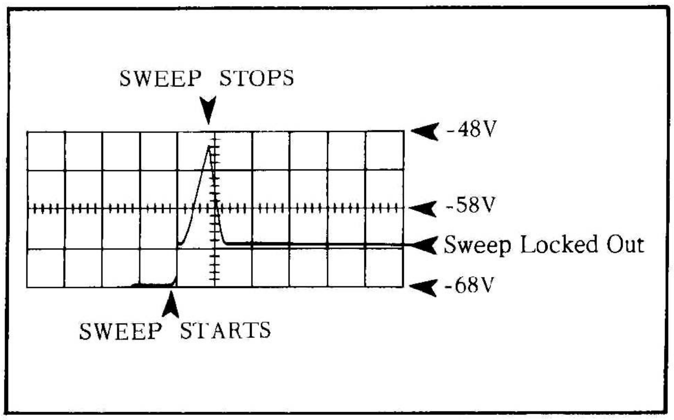


Fig. 4-8. Single-Sweep Waveform.

2. 'A' DEL'D BY 'B'

When the HORIZONTAL DISPLAY switch is placed in the 'A' DEL'D BY 'B' position, the Lockout Multivibrator, V125 and V133A, serves the same function as when the HORIZONTAL DISPLAY switch is at 'A' SINGLE SWEEP. However, instead of the Lockout Multivibrator receiving the unlocking pulse from the front panel RESET button, it receives the pulse from the Delay Pickoff circuitry. A positive pulse of about 5 to 7 volts is delivered to the grid of V144 from the Delay Pickoff circuit each time that Time-Base B generates a sweep.

With the HORIZONTAL DISPLAY switch in the 'A' DEL'D BY B' position, the Time-Base A sweep generator system will be permitted to operate only during a sweep of the Time-Base B sweep generator. The permission to operate occurs at a time determined by the Time Base B TIME/CM or DELAY TIME control multiplied by the setting of the DELAY-TIME MULTIPLIER control. The actual operation is determined by the STABILITY control, whether it is in a triggerable or free-run state.

The crt display is that of the Time Base A sweep generator.

3."'B' INTENSIFIED BY 'A'

When the HORIZONTAL DISPLAY switch is placed in the 'B' INTENSIFIED BY 'A' position, the operation of the Lockout Multivibrator is identical with operation as in 'A' DEL'D BY 'B'. However, the Horizontal Amplifier receives a different signal.

The crt presentation is that of the Time-Base B sweep generator. If the Time-Base A sweep generator is caused to generate a sweep, the sawtooth voltage is not seen on the crt. Time-Base A presents only its crt unblanking signal to the crt circuit to intensify the portion of the display where the delayed action of Time-Base A occurs. (See Fig. 4-9).

Unblanking

The Sweep Gating Multivibrator provides a positive gate pulse coincident with each sweep to unblank the cathode ray tube. The output of the Unblanking Cathode Follower V183B rests at about +55 volts during periods of no sweep, and rises to about +105 volts to gate on the crt beam during a sweep. The unblanking waveform goes directly to the HORIZONTAL DISPLAY switch, and is connected to the crt circuit in all positions except Time-Base B.

+GATE A

The Sweep Gating Multivibrator positive gate waveform used by the Unblanking C.F. is also used by the front panel terminal +GATE A. The control grid of V193A rests at about —20 volts during periods of no sweep, and rises to about +20 volts during a sweep. The output waveform therefore operates between ground and about +20 to +30 volts.

TIME-BASE GENERATOR B

Time-Base Generator B is very similar to Time-Base Generator A except its maximum sweep rate is not as fast and it does not have the delayed sweep and single sweep circuitry.

The Sweep Gating Multivibrator, V235A, V235B and V245, performs the same function as in Time-Base A. The Disconnect Diodes require less pull-down current of V245, therefore the pentode serves adequately.

Time-Base Generator B has a closer tolerance linearity specification of 0.1% deviation from a true sawtooth output waveform each 10% of its total change. This then requires higher gain of the Miller Integrator (V261) than in Time-Base A. The increased gain is accomplished by using a higher plate load resistor for V261. The grid of the Miller Tube does not move more than about 0.4 volt during a sweep. Thus the voltage gain of the Miller Integrator is about 400.

The output sawtooth voltage of Time-Base Generator B goes directly to the HORIZONTAL DISPLAY switch. The Delay Pickoff circuit receives the 'B' sawtooth in all positions except Time-Base A, and 'A' SINGLE SWEEP. The Horizontal Amplifier receives the sawtooth in Time-Base B and 'B' INTENSIFIED BY 'A' positions.

The Unblanking C.F. V293A output is connected directly to the HORIZONTAL DISPLAY switch. The signal is coupled to the crt circuit in the Time-Base B and 'B' INTENSIFIED BY 'A' positions. The signal rests at about +40 volts during periods of no sweep, and rises to about +90 volts to gate the crt beam on during a sweep. Note that the Time-Base B unblanking pulse amplitude is about 15 volts lower in amplitude than the unblanking pulse of Time-Base A. This difference permits the Time-Base A unblanking pulse to brighten a part of the trace that indicates 'B' INTENSIFIED BY 'A'.

Alternate-Trace Sync A

Synchronizing pulses for alternate-trace plug-in preamplifiers are supplied via D142 and the differentiating network C154-R154. Both positive and negative sharply differentiated output pulses are applied from C154-R154 to the plug-in unit. Only the positive pulses are used by the plug-in unit alternate-trace switching circuitry.

The quiescent voltage at the junction of D142 and C154 is approximately —3 volts. The quiescent voltage on the other side of D142 is about —3.1 volts. As the Sweep-Gating Multivibrator switches and V145 plate drops to about —7.5 volts, D142 conducts. The plug-in side of C154 then drops about —2 volts (less than the —4.5 volts possible due to additional circuit capacitance loading the output of C154). The charge on C154 rapidly stabilizes at —7.5 volts, and remains there until the Sweep-Gating Multivibrator terminates the sweep. At this time, the plate of V145 rises very rapidly momentarily cutting D142 off. Cutting off D142 disconnects the capacitance of the dual trace switching circuitry at the time that any loading capacitance would slow the action of Disconnect Diodes V152A and B. The positive pulse from C154-R154 switches the alternate-trace plug-in unit from one trace to the next trace. (See the instruction manual for the alternate-trace plug-in unit in use.)

Alternate-Trace Sync B

Synchronizing pulses for alternate-trace plug-in preamplifiers are supplied from the screen grid circuit of V245. As the plate current of V245 increases or decreases, the screen voltage as developed across L249 decreases or increases accordingly. Only the positive pulse is used by the alternate-trace plug-in unit.

At the end of each Time-Base B sweep, a positive pulse of about 15 volts is developed across R254 and sent directly to the HORIZONTAL DISPLAY switch. The pulse from Time-Base B is presented to the plug-in interconnecting plug only when the HORIZONTAL DISPLAY switch is in the Time-Base B or 'B' INTENSIFIED BY 'A' positions.

HORIZONTAL AMPLIFIER

General

The input to the Horizontal Amplifier is selected from waveforms applied from either Time-Base Generator A, Time-Base Generator B or the External Horizontal Amplifier.

The dc-coupled Horizontal Amplifier consists of the Input Cathode-Follower (CF) stage followed by the Driver CF stage that drives the paraphase Output Amplifier. The Output Amplifier then drives separate Output CF's that drive the crt horizontal deflection plates. The CF Capacitance Driver tube in the cathode circuit of the left-hand deflection plate Output CF pulls the cathode of the Output CF rapidly down during a sweep. The gain of the Output Amplifier is controlled by negative feedback applied from the left Output CF to a frequency compensated network between the Input CF and the Driver CF. The negative feedback is modified for 5X sweep magnification.

Input Circuit

The positive-going sawtooth voltages produced by the Time-Base Generator circuits are coupled through a frequency-compensated voltage divider to the grid of the Input CF V343A. The input divider has a 1.5 to 1 attenuation ratio. The small time-constant network C340-R340 improves the start of the waveform at the fastest sweep rates. The two positioning controls, HORIZONTAL POSITION R333 and VERNIER R338, affect the beam position by altering the dc level at the grid of V343A. The VERNIER position control can move the spot about 2 centimeters while the HORIZONTAL POSITION control can move the spot from about the center of the crt screen to well off the left edge. These limits apply when the HORIZONTAL DISPLAY switch is in the INTERNAL SWEEP position. Because of their low resistance, an adjustment of the positioning controls does not alter the attenuation of the divider network.

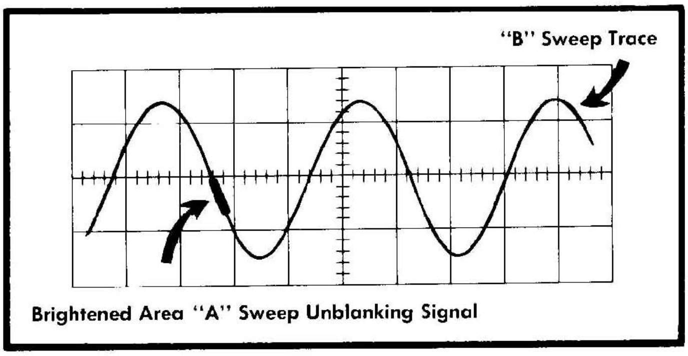


Fig. 4-9. 'B' INTENSIFIED BY 'A' operation.

Driver Cathode Follower

Signals from the cathode of V343A pass either through the input portion of the feedback circuit or straight into the grid of the Driver CF V343B. The Driver CF eliminates possible loading of the feedback network by the grid of V364A during high positive sawtooth voltages. The low output impedance of the Driver CF drives the grid of V364A assuring no distortion of the linear sawtooth sweep voltage.

With the 5X MAGNIFIER switch SW347B in the OFF position, the grid of the Driver CF V343B receives the positive going sawtooth voltage from the center of feedback divider network R348, R349, R355 and R356. The amplitude of the sawtooth voltage as it leaves the cathode of V343A is reduced by a factor of five by the negative going sawtooth voltage applied at the top of R355. With the 5X MAGNIFIER switch SW347B in the ON position, or with the HORIZONTAL DISPLAY switch in either external horizontal input position, R348 and R349 are switched out of the circuit, and the total signal voltage from the cathode of V343A is applied to the grid of the Driver CF. Part of the feedback circuit remains connected between the left deflection plate Output CF cathode and the grid of the Driver CF, but essentially no feedback action occurs due to the low impedance of the Input CF cathode.

The NORM/MAG. REGIS. control, R358, is used to eliminate any voltage drop across R348 and R349 (5X MAGNIFIER OFF) when the crt beam is at the center of the screen. It has no appreciable effect with the 5X MAGNIFIER ON. Thus when the two centimeters of display at the center of the screen are to be magnified, the display will be expanded symmetrically about the center of the crt when the 5X MAGNIFIER switch is turned ON.

A MAGNIFIER neon glow lamp is located on the front panel immediately below the HORIZONTAL DISPLAY switch; circuitry for the lamp is shown with the 5X MAGNIFIER switching detail of the Horizontal Amplifier diagram.

Output Stage

The Output Amplifier stage V364A-V384A is a paraphase amplifier with output from both plates. Cathode followers V364B-V384B provide high-impedance, low-capaitance loads which help to maintain the gain of the stage constant over the sweep range of the instrument. The Output CF's also provide the necessary low-impedance output to drive the capacitance of the horizontal deflection plates. Bootstrap capacitors C364 and C384 improve the response at the fastest sweep rates by supplying additional current from the Output CF stage to charge and discharge the stray capacitance in the plate circuit of the Output Amplifier.

Capacitance Driver

At the fastest sweep rates the current through the left-hand deflection plate Output CF tube is too small to discharge the stray capacitance in the cathode circuit at the required rate. Additional current to discharge the stray capacitance is provided by the gated pentode V398 connected in the cathode circuit of V364B. This permits the cathode of V364B to run down at the required rate. A similar current boost is not required for V384B since this tube is the positive-sawtooth cathode follower and the cathode runs down during the retrace when speed and linearity are not important.

Because the plate current of a pentode is fairly constant over a large range of plate voltage, the current through V398 will remain nearly constant even though its plate falls about 150 volts due to the negative sweep sawtooth waveform.

The additional current required for fastest sweep rates is obtained by applying a positive flat-topped pulse to the grid of pentode V398 during the period of the sweep. The pulse is derived by differentiating the positive-going sawtooth from the cathode of V384B with C390 and R390. The pulse amplitude is proportional to the slope of the sawtooth, and thus proportional to the sweep rate. The pulse first becomes noticeable when the sawtooth voltage at the cathode of V384B exceeds the rate of about 1.6 volts/μsecond.

External Horizontal Amplifier

The External Horizontal Amplifier is a cathode coupled circuit providing the necessary gain to drive the horizontal amplifier from external signals. An input attenuator and a gain control provide horizontal deflection factors between approximately 0.2 and 15 volts per centimeter.

A front-panel binding post labeled HORIZ. INPUT couples externally-derived signals to the Horizontal Amplifier circuit when the HORIZONTAL DISPLAY switch is in either of the EXT. positions. A preamplifier stage, V314 amplifies the external signals before applying them to the input attenuator of the Horizontal Amplifier. The position of the HORIZONTAL DISPLAY switch determines whether the signal is directly coupled to the grid circuit of V314A, or whether a 10:1 frequency-compensated attenuator is connected in the signal path. In either case the input resistance is 1 megohm paralleled by approximately 47 picofarads.

The External Horizontal Preamplifier V314 is a cathode-coupled amplifier. V314A is a cathode-follower and V314B is a grounded-grid amplifier stage. The VARIABLE 10-1 control provides a means for adjusting the gain over a 10 to 1 range. The Ext. Horiz. DC. Bal. control R317 adjusts the dc level of V314B grid so that its cathode is at the same voltage as the cathode of V314A under no signal conditions. With the cathodes at the same voltage there is no current through the variable attenuator control R314. By this arrangement an adjustment of the VARIABLE 10-1 gain control does not change the dc level at the plate of V314B and therefore does not affect the positioning of the crt beam.

Delay Pickoff Circuit

General

A sawtooth waveform from either Time Base Generator is applied to the input of the delay pickoff comparator cir-

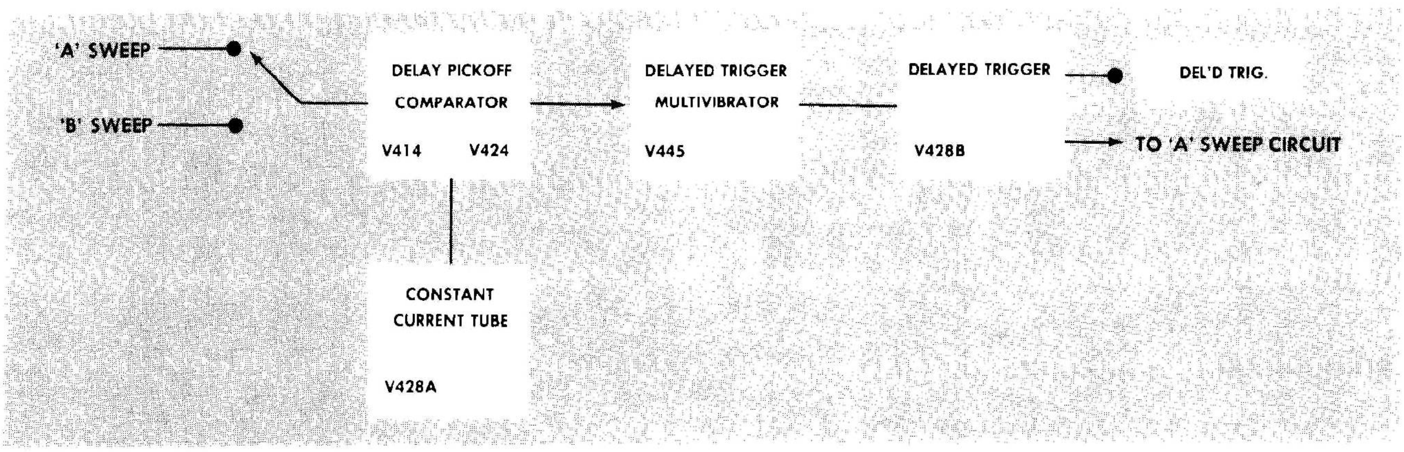


Fig. 4-10. Delay Pickoff Circuit block diagram.

cuit. (See Fig. 4-11.) This circuit is a difference amplifier which compares the voltage level of the input sawtooth against a fixed voltage obtained from the DELAY TIME MULTIPLIER control. When the voltage level of the input sawtooth waveform reaches a certain level, as determined by the setting of the DELAY TIME MULTIPLIER, the output of the comparator circuit triggers the Delayed Trigger Multivibrator. The Delayed Trigger Multivibrator then initiates the delayed trigger which is applied through a differentiating circuit to the delayed trigger cathode follower. Outputs from the delayed trigger cathode follower are applied to the DEL'D TRIG. connector on the front panel and to the HORIZONTAL DISPLAY switch. Delayed trigger pulses are connected to the 'A' sweep circuit when the HORIZONTAL DISPLAY switch is in the positions 'B' INTENSIFIED BY 'A', and 'A' DEL'D BY 'B'.

Difference Amplifier

The Difference Amplifier V414 and V424 receives the sweep sawtooth from the Time Base indicated by the neon lamps directly above the DELAY-TIME MULTIPLIER dial.

The Difference Amplifier permits a time selection of any rate sawtooth voltage. (The accuracy decreases above 2 μsec/cm). The time selection is based upon the position of the DELAY-TIME MULTIPLIER dial, setting the voltage at the grid of V424. Thus a voltage comparison becomes a time selection because the sawtooth voltage is changing at a definite rate. Assume that the sawtooth input to the comparator difference amplifier was moving at a rate of 15 volts per millisecond (TIME/CM = 1 MILLISEC/CM). Then if the DELAY-TIME MULTIPLIER dial was set to 2.0 (2.0 is equal to 30 volts of a 150 volt sawtooth) the delay pickoff would generate a delayed trigger 2 milliseconds after the sawtooth started.

To permit the Difference Amplifier to have the dynamic range of 150 volt grid signals it is necessary to establish a constant cathode current. A second reason for a very constant cathode current is that the Difference Amplifier output voltage must always go between the same limits regardless of which portion of the sawtooth is amplified.

Constant Current Tube

The normal long-tailed cathode resistor found in many Tektronix amplifier circuits provides a relatively constant current for a tube with limited grid voltage swing. Thus the constant current system of the Difference Amplifier must be improved since the grid signals have a 150 volt amplitude. Triode V428A grid rests at —100 volts and its cathode is then long-tailed to the —150 volt supply. R428 assures that the cathode current of V428A will remain essentially at 5 milliamps. Thus the plate can move over a wide voltage range without appreciable current change in the system. The triode plate resistance changes as the plate-to-cathode voltage changes, thus assuring a constant-current cathode circuit for the Difference Amplifier.

Delayed Trigger Multivibrator

The Delayed Trigger Multivibrator receives a dc coupled signal from the Difference Amplifier. With the sawtooth at a voltage below the time-selection point, the grid voltage of V445A rests at about +190 volts. Shortly after the sawtooth has passed the time-selection point, the grid rests at the +225 volt supply. It is within this 30 volt range that the 4 volt hysterisis limits of the Delayed Trigger Multivibrator exist. The multivibrator flips as the input voltage rises to about +210 volts. V445B is held in conduction during the quiescent state of the Delayed Trigger Multivibrator. As the grid of V445A is carried positive, causing it to conduct, the plate of V445B rises sharply from about +330 volts to +350 volts. The output square wave is then differentiated by C454 and the combined resistance of R454 and R455.

Delayed Trigger C.F.

The grid of V428B rests at —4.5 volts, holding the tube at cut-off. As the output of the Delayed Trigger Multivibrator switches positive, the differentiated pulse takes V428B out of cut-off, and delivers about a 5 to 7 volt pulse to the DEL'D TRIG terminal and the HORIZONTAL DISPLAY switch.

A waveform ladder diagram is presented in Figure 4-11 showing the sequence of operation throughout one complete sawtooth.

LOW-VOLTAGE POWER SUPPLIES

General

The low-voltage power supplies produce all operating voltages for the oscilloscope with the exception of parts of the crt circuit. These power supplies produce regulated voltages of —150, +100, +225, +350, and +500 volts and two unregulated outputs of +180 and +340 volts. In addition a separate transistorized power supply provides regulated +12.6 volts for filaments of tubes in either the P80 Probe, or in the Type 81 Plug-In Adapter, and other 80 series plug-in units.

Each of the power supplies operates in a similar manner. A sensing circuit compares a sample of the output voltage against a fixed reference voltage. Any error in the output voltage produces an error signal which is amplified and applied to the series regulator tube(s), causing the series regulators to compensate for the error and return the voltage to normal.

Reference voltage for the —150-volt supply is obtained from a gas filled voltage regulator tube. Reference voltages for the other regulated power supplies, except the filament supply, are obtained from the output of the —150-volt supply. Consequently, operation of the regulated power supplies is dependent on operation of the —150-volt supply. The output voltages of all the regulated power supplies can be changed slightly by adjusting the output of the —150-volt supply.

Power Transformer

Plate and filament power for the tubes in the Type 585 is furnished by a single power transformer, T601. The primary has two equal windings which may be connected in parallel for 117-volt operation, or in series for 234-volt

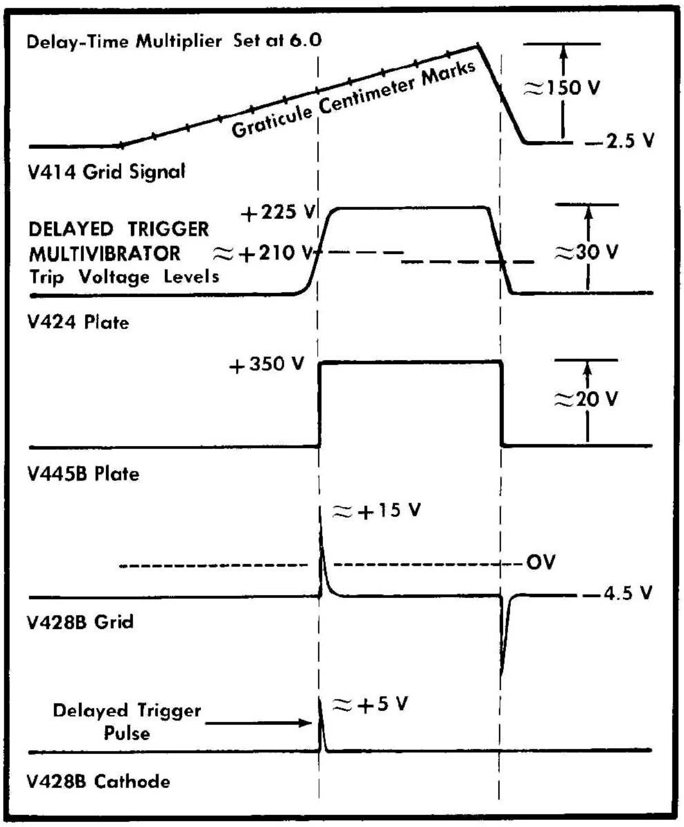


Fig. 4-11. Waveform ladder diagram of the Delay-Time Multiplier circuit operation.

operation. The power supply will maintain regulation over line voltage ranges of 105 to 125 volts, or 210 to 250 volts, rms, 50-60 cycles, when the line voltage has less than about 3 to 5% distortion of the waveform peaks. All Type 585 power transformers, after serial number 310 are provided with two 6% Boost-Buck windings to permit primary turns adjustment to suit slightly different line voltages from those just mentioned. Refer to Figures 2-1 and 2-2 for additional details.

−150-Volt Supply

Reference voltage for the −150-volt supply is furnished by a gas diode voltage-reference tube V609. This tube, which has a constant voltage drop, establishes a fixed potential of about −87 volts at the grid of V624A, one-half of a difference amplifier. The grid voltage for the other half of the difference amplifier, V624B, is obtained from a divider consisting of R615, R616, and R617. The −150 ADJ. control R616 determines the percentage of total output voltage that appears at the grid of V624B and thus determines the total voltage across the divider. This control is adjusted so that the output voltage is −150 volts, ±2%.

If line-voltage or load fluctuations tend to change the output voltage, an error signal is produced between the two grids of the difference amplifier. The error signal is amplified in V624B and V634 and applied to the grids of the series tubes V627, V637 and V647. The resulting change in voltage at the plates of the series tubes corrects the −150-volt bus back to its original value. Capacitors C617 and C628 improve the ac gain of the feedback loop to increase the rate of response of the regulator circuit to sudden changes in output voltage and to reduce ripple.

A small amount of unregulated bus ripple is coupled to the screen of V634 through R637. The phase of the amplified ripple voltage at the plate of V634 is such as to cancel most of the ripple on the −150-volt bus.

+100-Volt Supply

Reference for the +100-volt supply is a voltage located at a point near ground potential obtained from a divider R650-R651. V664 essentially compares the reference voltage to ground. Any voltage change at the +100-volt output is amplified and inverted in polarity by V664 and applied to the grid of series regulator V677A correcting the output voltage. Capacitor C650 improves the ac gain of this circuit and helps to eliminate ripple.

A small sample of the unregulated bus ripple appears at the screen of V664 through R667. This produces a ripple component at the grid of series regulator V677A that is opposite in polarity to the ripple at the plate. This tends to cancel the ripple at the cathode and hence on the +100-volt bus. This same circuit also improves the regulation in the presence of line-voltage variations.

+225-Volt Supply

The +225-volt supply source is the secondary windings between terminals 5 and 7 and terminals 10 and 14 of T601, part of a two-voltage supply. Diodes D702 A and B serve as full-wave rectifiers for the +225-volt supply, with their center lead connected to the +180-volt unregulated supply. Voltage from the full-wave rectifier system is added to the +180-volt unregulated lead to provide sufficient voltage for the +325-volt unregulated lead and the +225-volt regulated supply.

Reference for the +225-volt supply is a voltage located at a point near ground obtained from the divider R680-R681. V684A essentially compares the reference voltage to ground. Any voltage changes at the +225-volt output produces an error voltage between the grids of the difference amplifier V684. The error signal is amplified in both V684 and V694, and coupled to the grids of series regulators V677B and V737A. The voltage change at the cathode of V677B and V737A, due to the regulator action, is opposite in polarity to the original error signal keeping the output voltage constant. The unregulated output of about +325 volts is used by the oscillator of the crt high-voltage supply. It is unnecessary to regulate this voltage as the crt supply has its own regulator circuit.

+350-Volt Supply

The +350-volt supply source is at the common connection between Diodes D732 A and B. These diodes are part of a full-wave bridge rectifier system.

The negative lead of the +350-volt rectifiers is connected to the +180-volt unregulated bus of the +100-volt power supply. Thus both the +225-volt and +350-volt regulated supplies are elevated on the +180-volt unregulated bus.

Good engineering practice does not permit using a semiconductor two diode full-wave rectifier system because line voltage transients can exceed the peak inverse voltage rating of the diodes. Thus an advantage of the two voltage system, as used with the +225-volt and +350-volt regulated supplies, is that capacitor C730 protects all diodes from high peak inverse voltage transients.

Reference for the +350-volt supply is a voltage located at a point near ground obtained from the divider R710-R711. V724 essentially compares the reference voltage to ground. The operation of the regulated circuit is the same as that described for the +100-volt supply.

+500-Volt Supply

Rectified voltage from terminals 20 and 21 of T601 is added to the regulated +350-volt supply to furnish power for the +500-volt regulator. Reference for the +500-volt supply is a voltage located at a point near +350 volts obtained from the divider R740-R741. V754 essentially compares this voltage to the +350-volt supply. The regulator action of this circuit is the same as that described for the +100-volt supply.

+12.6-Volt Supply

A transistorized +12.6-volt dc regulator supplies voltage for use within plug-in units of the Type 585 Oscilloscope.

Rectified voltage from terminals 33 and 34 of T601 is used both by the Time Delay Relay K600 with K601, and by the +12.6-volt Regulator.

Reference voltage for the +12.6-volt supply is at the center point of four resistors in series-parallel between the +100-volt supply and ground, R781 A and B, and R782-R783. The reference voltage is applied directly to the base of amplifier Q774 where it is essentially compared to the +12.6-volt bus. Emitter follower Q793 provides current gain to correction signals amplified by Q774, controlling the Collector-to-Emitter resistance of Q797 to maintain the proper voltage of the +12.6-volt supply lead.

The +12.6-Volt Supply voltage tolerance is not as rigid as the other regulated supplies, and its output may go as high as +13.25 volts under small load conditions.

In order for the +12.6-volt supply to warm up tube heaters before the Time-Delay Relay closes, a special turn-on voltage is applied to the base of Q774 via R780 from the +180-volt unregulated supply.

To protect the power transistors in the event Q774 is removed from its socket, diode D792 will clamp the base of Q793 to the +20-volt unregulated supply. Otherwise the base of Q793 would rise toward the +180-volt unregulated bus and damage both itself and Q797.

Time-Delay

A Time-Delay relay K600, in conjunction with relay K601, delays the application of power supply voltages to the oscilloscope tubes for about 15 to 45 seconds. This delay allows the tubes to warm up before operating potentials are applied.

CRT CIRCUIT

Cathode-Ray Tube Control Circuits

The INTENSITY control R826 varies the voltage at the grid of the crt to control the beam current. The FOCUS control R856 varies the voltage at the focusing anode to focus the trace. The ASTIGMATISM control R864 varies the voltage at the astigmatism anode to adjust principally the spot vertical dimension. The GEOM. ADJ. R861 varies the field the beam encounters as it passes from the vertical plates to the horizontal plates to control the linearity at the extremes of deflection. The VERT. SHIELD VOLTS ADJ. control R860 permits minor changes of crt deflection sensitivities and linearity.

High-Voltage Supply

A 60-kc modified Hartley oscillator furnishes power for the three power supplies that provide accelerating potentials for the crt. The main components in the oscillator circuit are the pentode V800 and the primary of T801 tuned by C808.

A half-wave rectifier V862 provides —1350 volts for the crt cathode. V862 supply is the reference supply, and is the only one of the three that is firmly regulated. A half-wave voltage tripler circuit, V832, V842 and V852, provides +8650 volts for the post deflection accelerator anode. The two supplies provide a total accelerating voltage of 10,000 volts. Both supplies are referenced to the +100-volt regulated supply through the decoupling filter R801-C801.

A floating half-wave rectifier V822 furnishes bias voltage of —1450 volts for the crt grid. This floating grid supply, independent of the cathode supply, allows dc-coupled unblanking to the crt grid. All three supplies employ capacitor-input filters.

Reference for the —1350-volt cathode supply is a voltage near —150 volts obtained from a tap on the divider network R840 through R844. The resistance ratio of the divider is determined by the setting of R840 labeled HV. ADJ. The reference voltage is essentially compared to —150 volts by V814B. When R840 is properly adjusted, the voltage at the HV ADJ. Test Point will be —1350 volts.

If variations in load change the voltage on the —1350-volt bus, an error signal will exist between the grid and cathode of V814B. The error signal will be amplified by V814B and V814A; the plate of V814A varies the screen voltage of the oscillator tube V800, thereby controlling its output.

The +8650-volt supply and the negative bias supply are regulated indirectly, as the output voltage of all three supplies is proportional to the output of the oscillator circuit.

Unblanking

As mentioned previously, dc-coupled unblanking is accomplished by employing separate power supplies for the grid and cathode of the crt. Unblanking pulses from the Time-Base Generators control the crt grid through cathode followers V183B, V293A and the floating grid supply. (V183B is diagrammed with the Time-Base Generator A and V293A is diagrammed with the Time-Base Generator B).

At the fastest sweep rates the stray capacitance of the floating crt grid supply makes it difficult for the crt grid to rise fast enough to unblank the crt in the required time. An isolation network composed of R827, R828 and C828, C829 isolates that capacitive loading. By this arrangement the fast leading edge of the unblanking pulse is coupled through C828 and C829 to the grid of the crt. For short duration unblanking pulses, at the fastest sweep rates, the power supply itself is not appreciably affected.

Longer unblanking pulses at slow sweep rates, charge the stray capacitance in the circuit through R827. This pulls up the floating supply and holds the crt grid at the unblanked potential for the duration of the unblanking pulse.

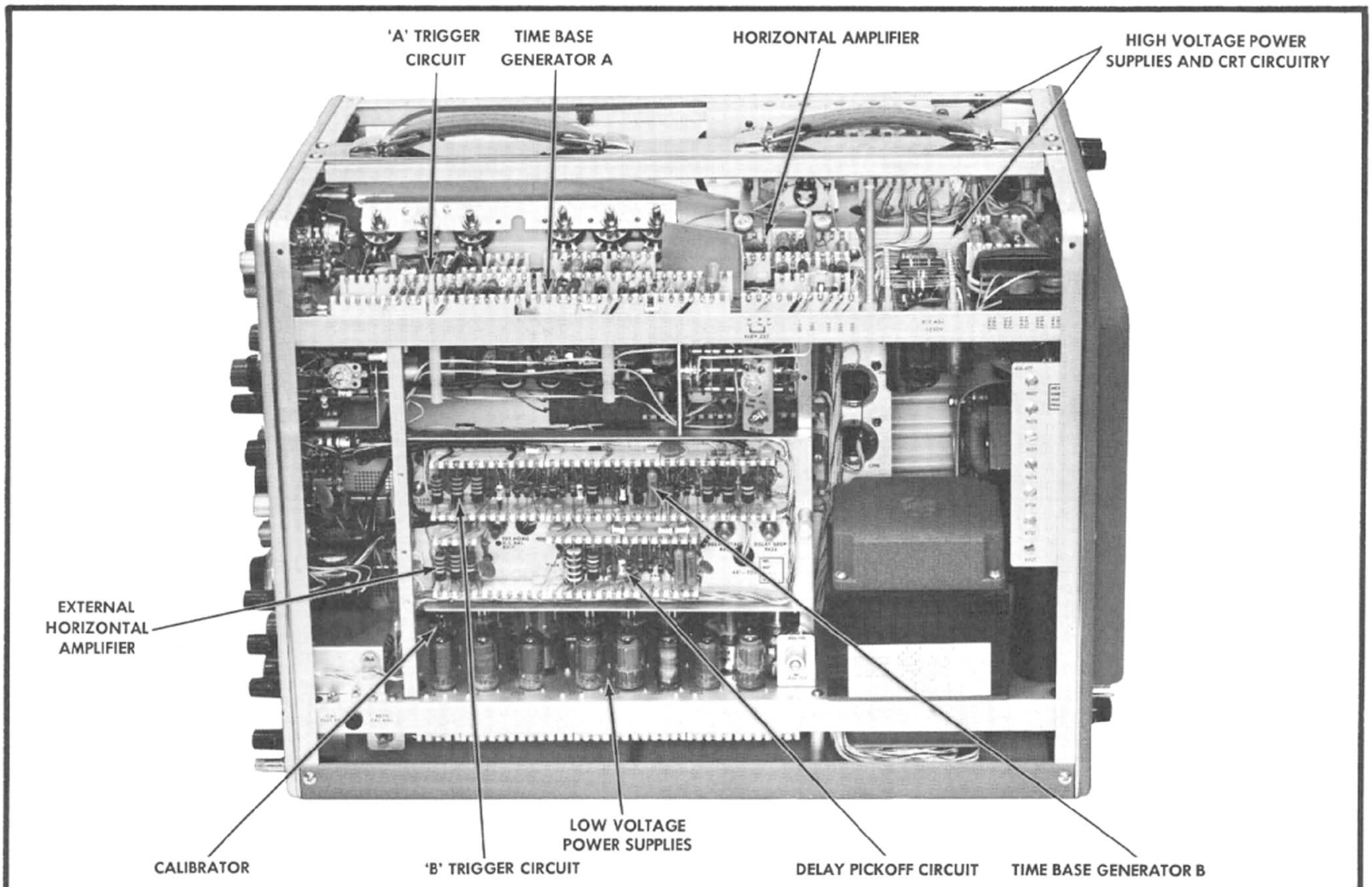
Amplitude Calibrator

The AMPLITUDE CALIBRATOR is a square-wave generator producing an output at approximately 1 kc which is available at the front panel CAL. OUT connector. Multivibrator, V875 and V885A, is connected to switch the cathode follower, V885B, between cutoff and conduction.

During the negative portion of the multivibrator output waveform the grid of V885B is driven well below cutoff and its cathode rests at ground potential. During the positive portion of the waveform V875 is cut off and its plate rests slightly below +100 volts. The voltage at the plate of V875 and grid of V885B when V875 is cut off, is determined by the setting of the CAL. ADJ. control R879.

Cathode-follower V885B has a precision, tapped divider for its cathode resistor. When the CAL. ADJ. control is properly adjusted, the cathode of V885B is at +100 volts when V875 is cut off. By means of the tapped divider R885 through R893 and a second 1000 to 1 divider R896-R897, output voltage steps are available from 0.2 millivolts to 100 volts. C885, connected between the cathode of V885B and ground, corrects the output waveforms for a slight overshoot.

A 0.25 ohm resistor located between the CAL. OUT coax connector and ground is approximately equal to the resistance of the braid of a 42 inch long RG-58A/U coax cable. Its purpose is to cancel any coax braid ground current effects on calibrator voltage accuracy that may exist when the Type 585 AMPLITUDE CALIBRATOR is employed as a signal source between the oscilloscope and some other instrument chassis. The ground currents in this case are usually developed in the ac power line third wire grounding system when the Type 585 and the other instrument chassis are supplied from different convenience outlets.



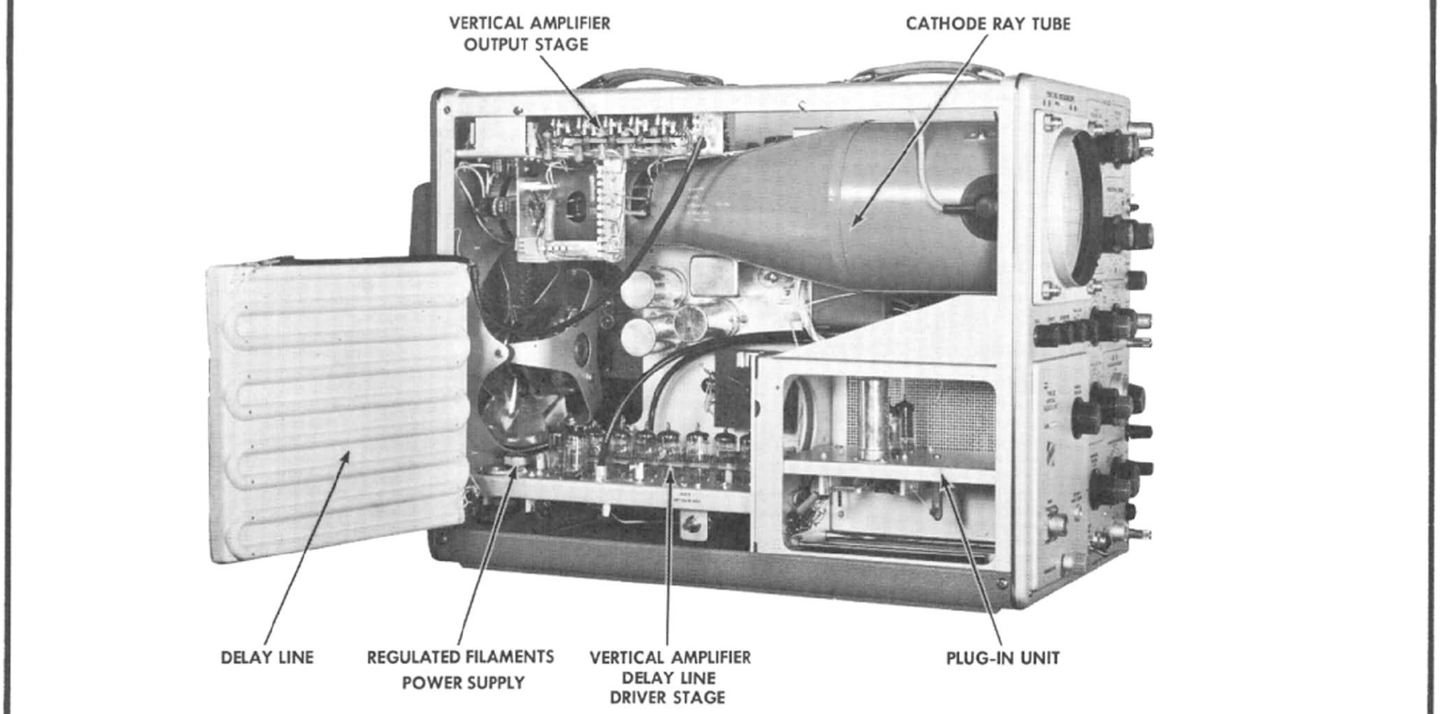


Fig. 5-9. Physical location of circuits which compose the Type 585 Oscilloscope.

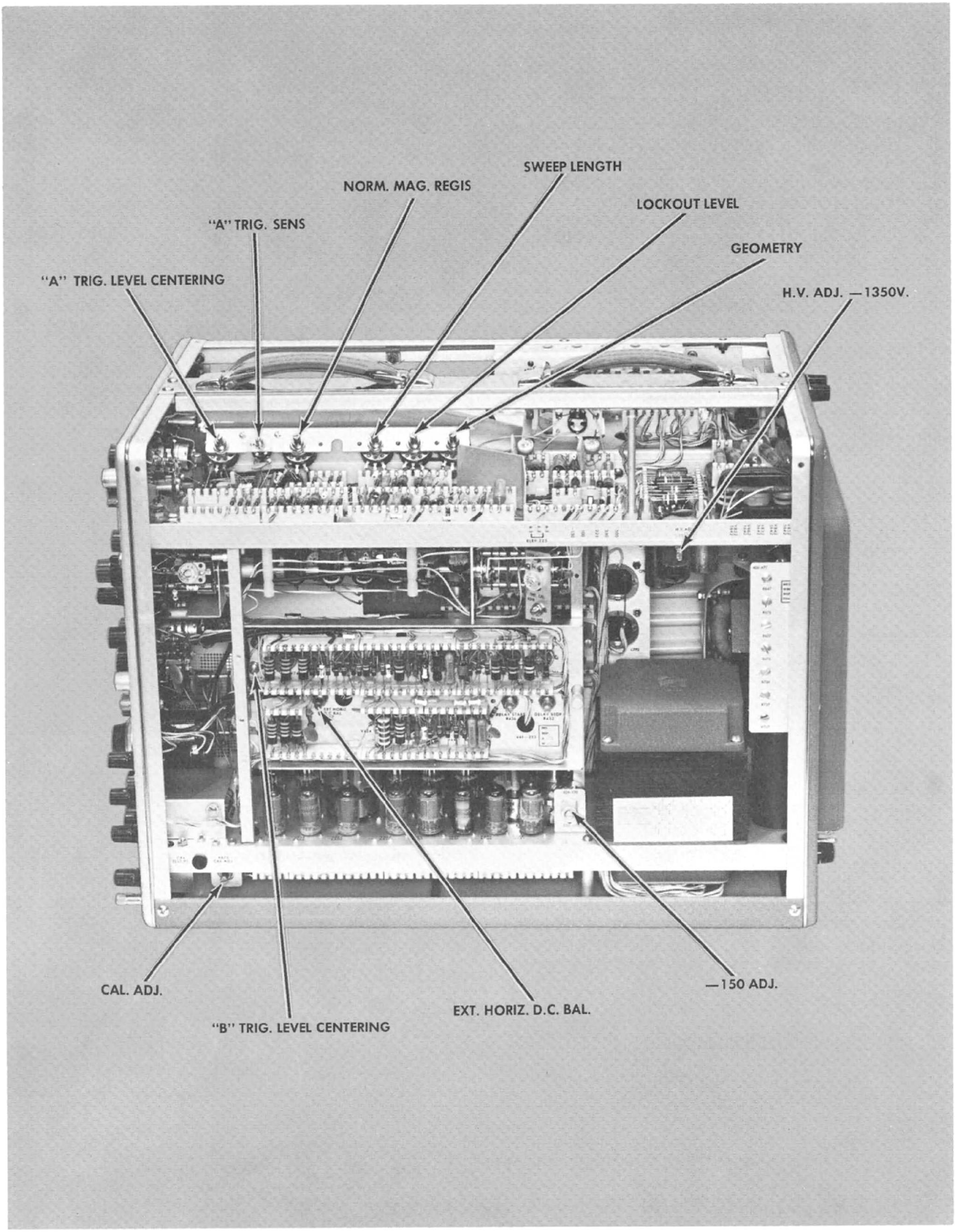


Fig. 6-17. Right side view of the oscilloscope showing the location of the 'B' TRIG. LEVEL CENTERING adjustments and test points.

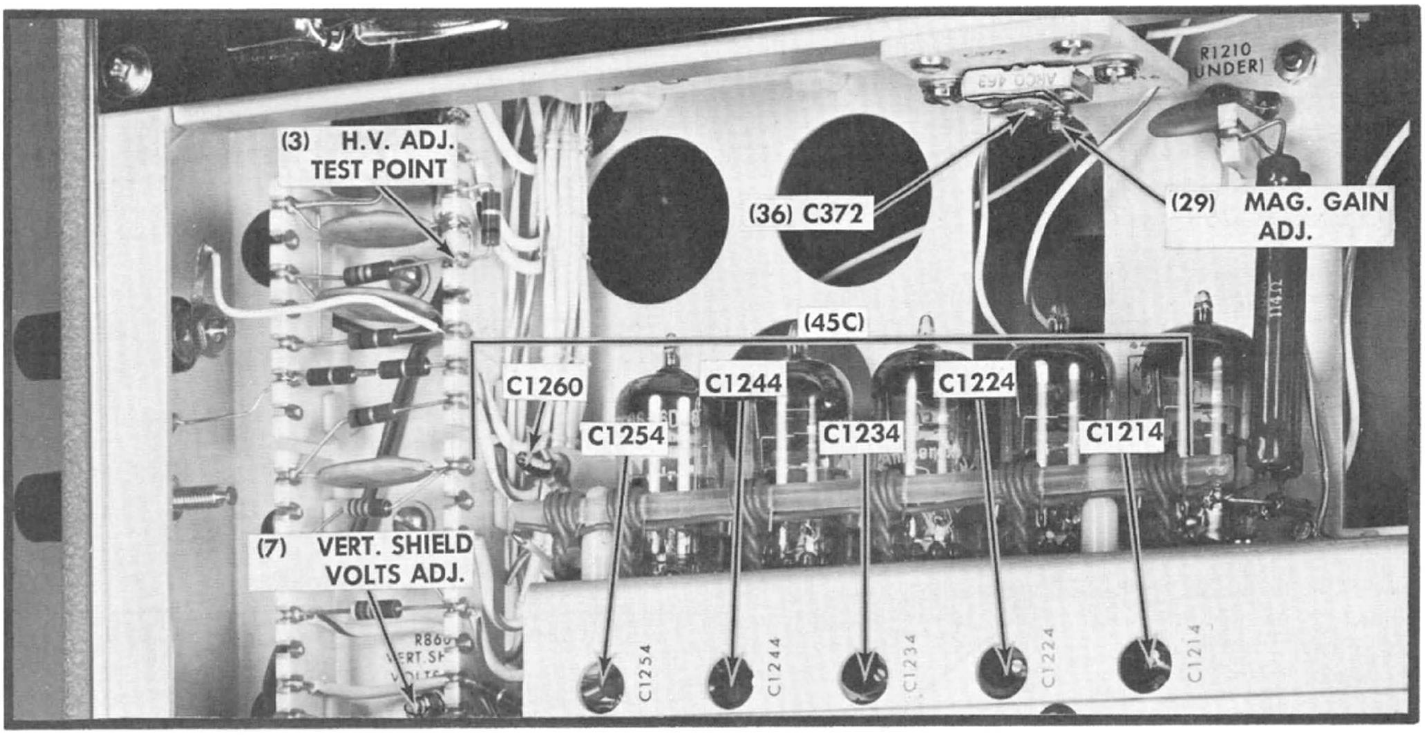


Fig. 6-18. Top view of the oscilloscope showing the location of internal adjustments. Before Serial No. 2585.

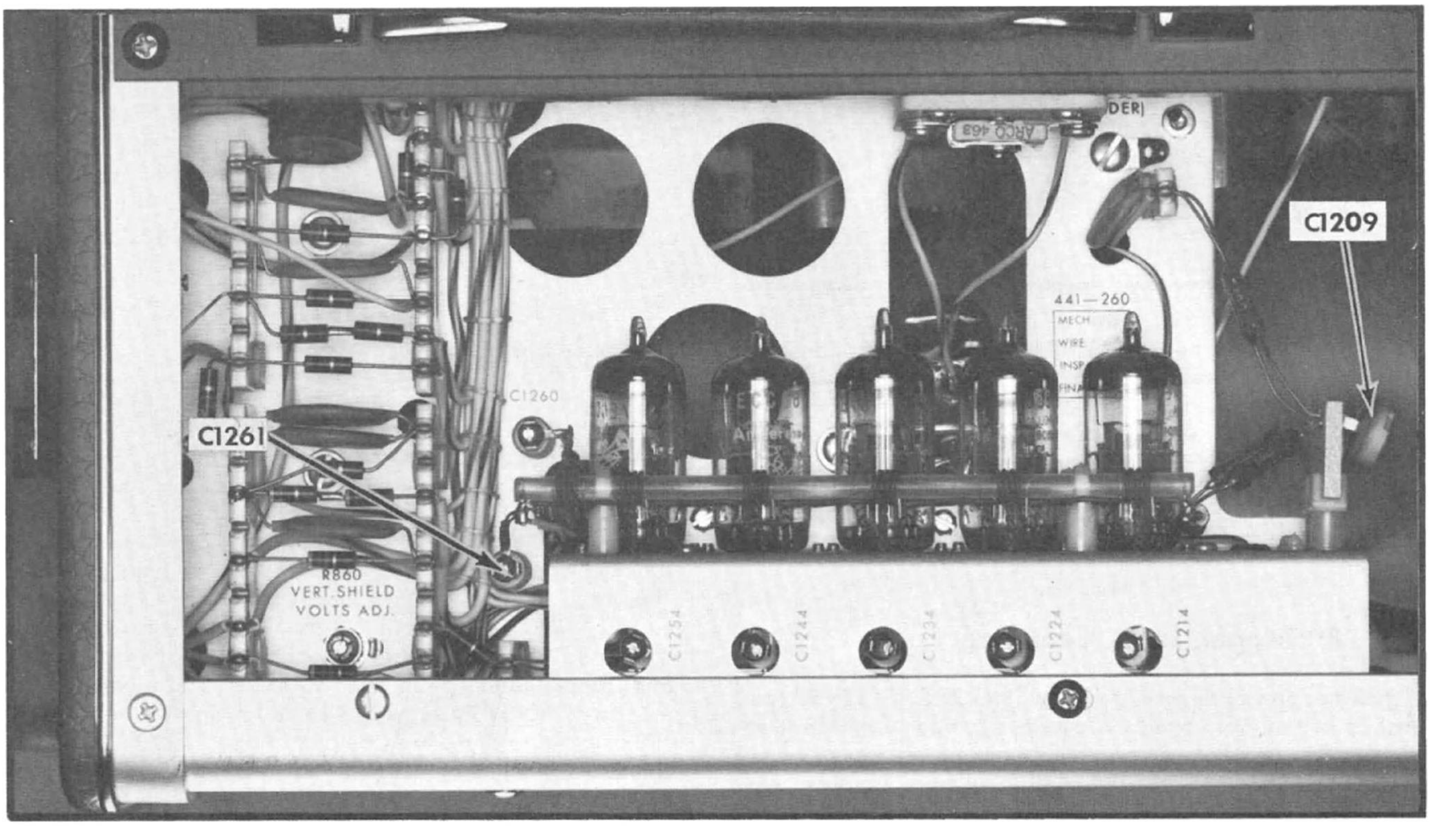
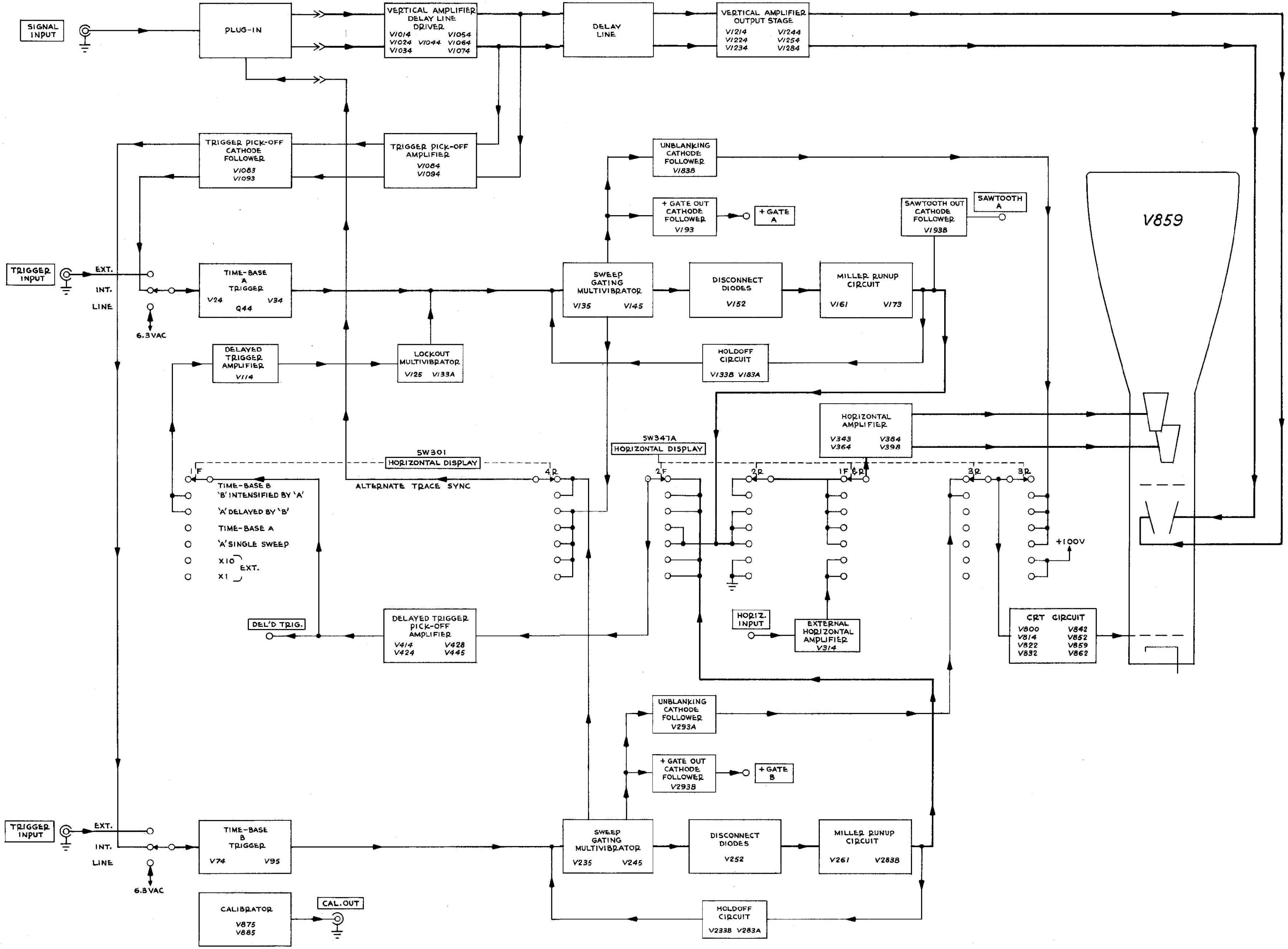


Fig. 6-19. Top view of the oscilloscope showing the location of internal adjustments. After Serial No. 2585.



4-27-62

TYPE 585 OSCILLOSCOPE

AA

BLOCK DIAGRAM

IMPORTANT:
ALL CIRCUIT VOLTAGES WERE OBTAINED WITH A 20,000Ω/V VOM. ALL READINGS ARE IN VOLTS.

VOLTAGE & WAVEFORM AMPLITUDE MEASUREMENTS ARE NOT ABSOLUTE. THEY MAY VARY BETWEEN INSTRUMENTS AS WELL AS WITHIN THE INSTRUMENT ITSELF DUE TO NORMAL MANUFACTURING TOLERANCES AND TRANSISTOR AND VACUUM TUBE CHARACTERISTICS.

ACTUAL PHOTOGRAPHS OF WAVEFORMS ARE SHOWN.

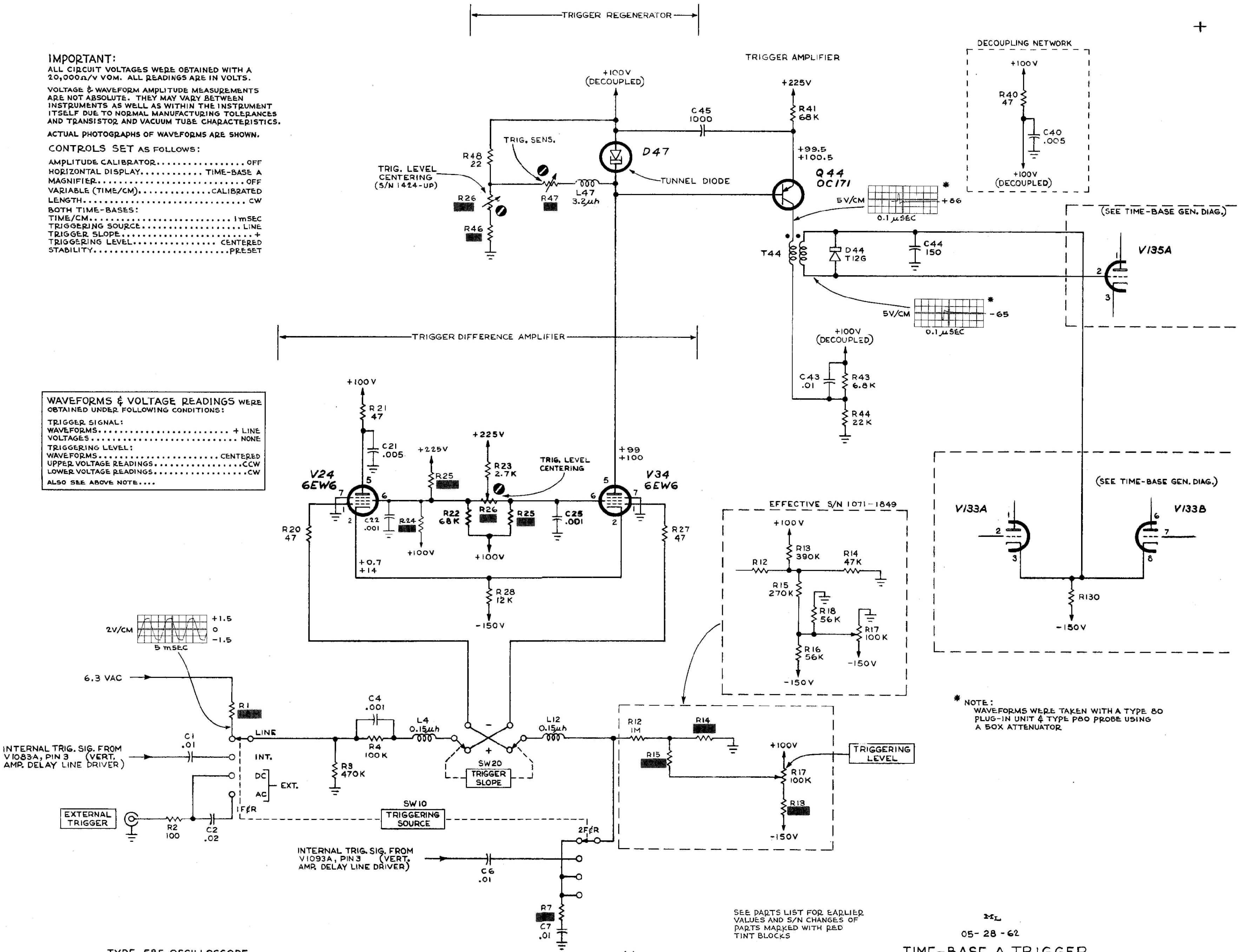
CONTROLS SET AS FOLLOWS:

AMPLITUDE CALIBRATOR	OFF
HORIZONTAL DISPLAY	TIME-BASE A
MAGNIFIER	OFF
VARIABLE (TIME/CM)	CALIBRATED
LENGTH	CW
BOTH TIME-BASES:	
TIME/CM	1 mSEC
TRIGGERING SOURCE	LINE
TRIGGER SLOPE	+
TRIGGERING LEVEL	CENTERED
STABILITY	PRESET

WAVEFORMS & VOLTAGE READINGS WERE OBTAINED UNDER FOLLOWING CONDITIONS:

TRIGGER SIGNAL:	
WAVEFORMS	+ LINE
VOLTAGES	NONE
TRIGGERING LEVEL:	
WAVEFORMS	CENTERED
UPPER VOLTAGE READINGS	CCW
LOWER VOLTAGE READINGS	CW

ALSO SEE ABOVE NOTE....



* NOTE: WAVEFORMS WERE TAKEN WITH A TYPE 80 PLUG-IN UNIT & TYPE P80 PROBE USING A 50X ATTENUATOR

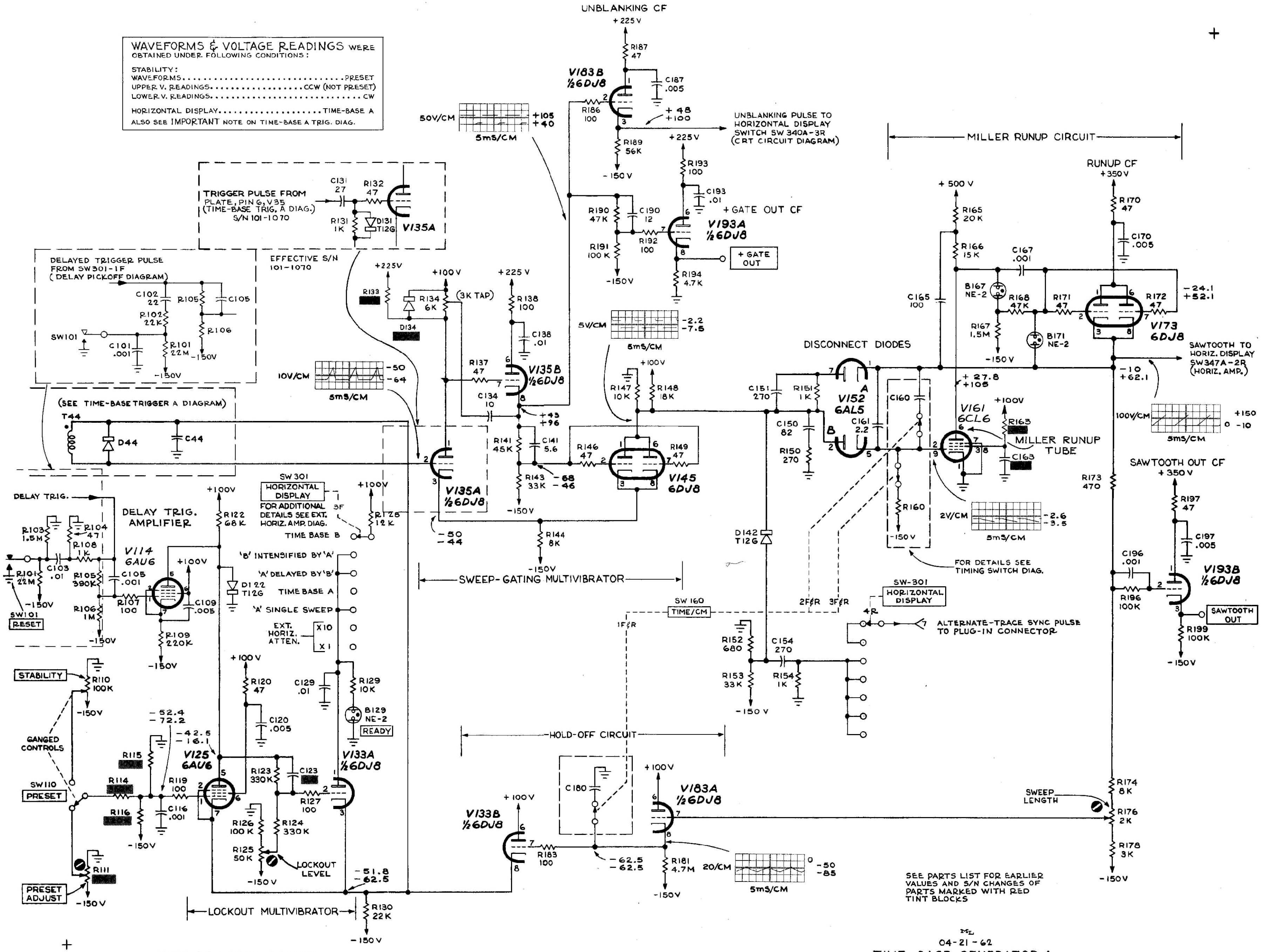
SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED WITH RED TINT BLOCKS

ML
05-28-62

TIME-BASE A TRIGGER

EFFECTIVE S/N 1071-UP

CIRCUIT NUMBERS 1 THRU 49

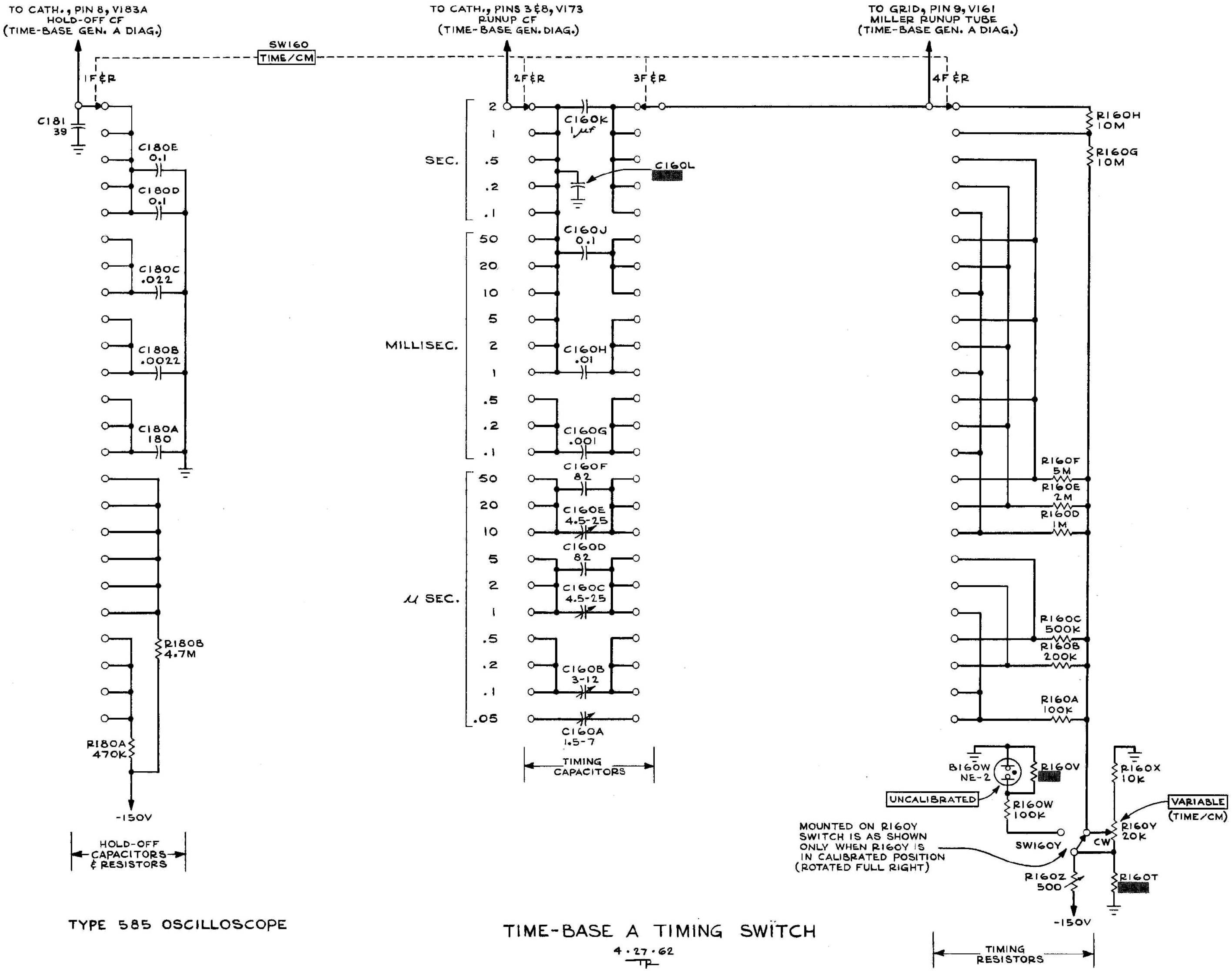


TYPE 585 OSCILLOSCOPE

04-21-62

TIME-BASE GENERATOR A

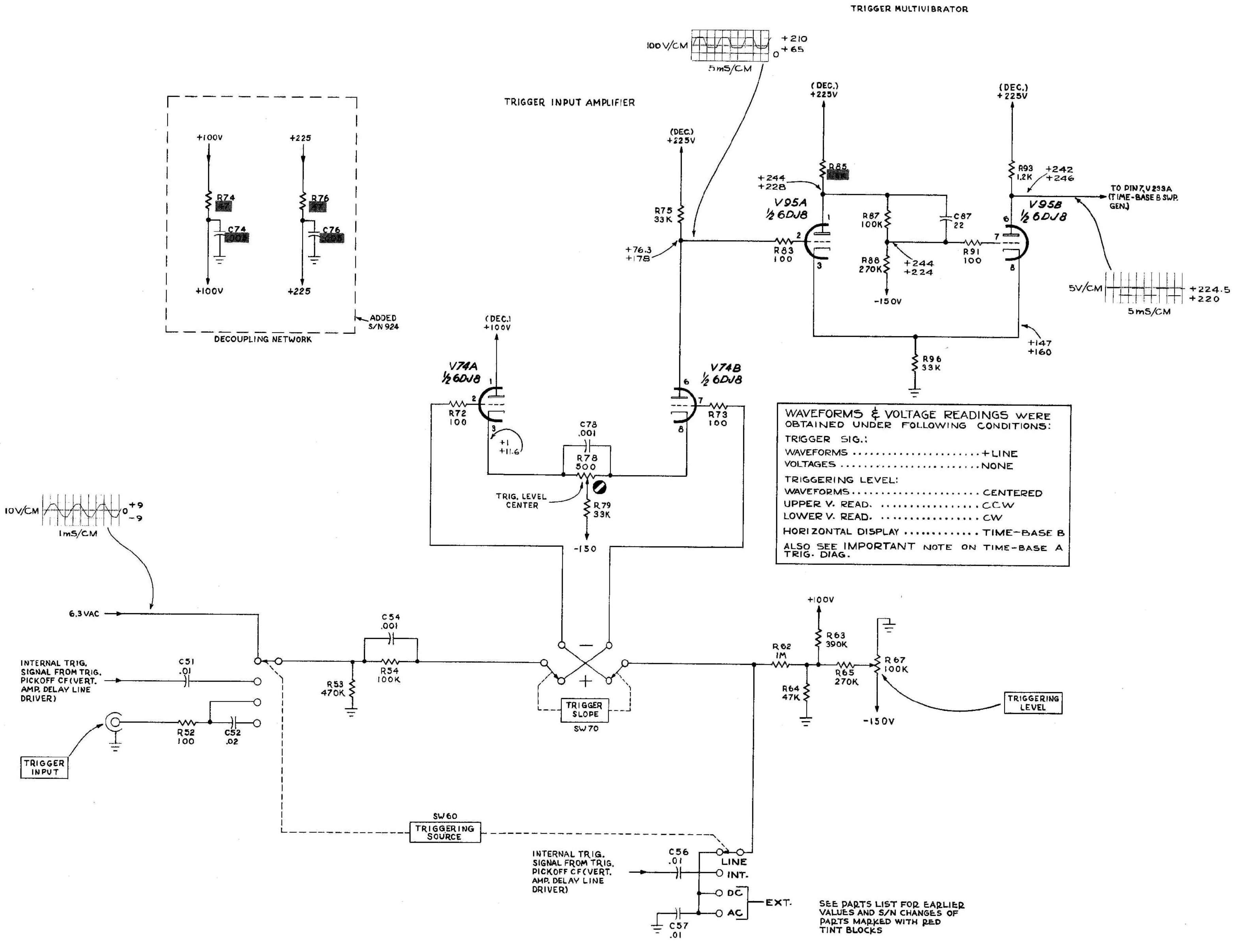
CIRCUIT NUMBERS 100 THRU 199



TYPE 585 OSCILLOSCOPE

TIME-BASE A TIMING SWITCH

4·27·62
TP



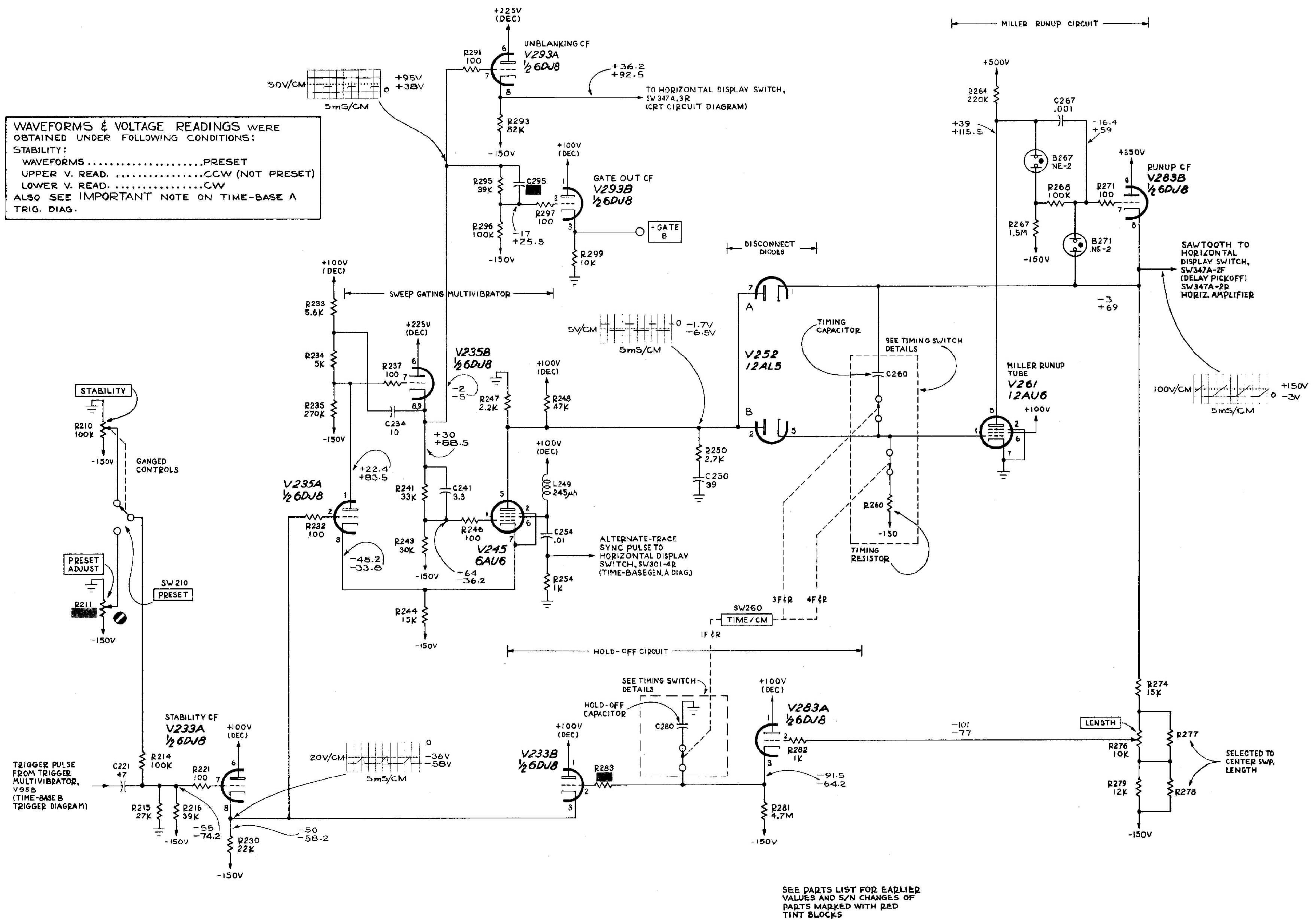
4-20-62
JN

TYPE 585 OSCILLOSCOPE

AA

TIME-BASE B TRIGGER

CIRCUIT NUMBERS 50 THRU 99



JN
4-20-62

+ TYPE 585 OSCILLOSCOPE

AA

TIME-BASE B GENERATOR

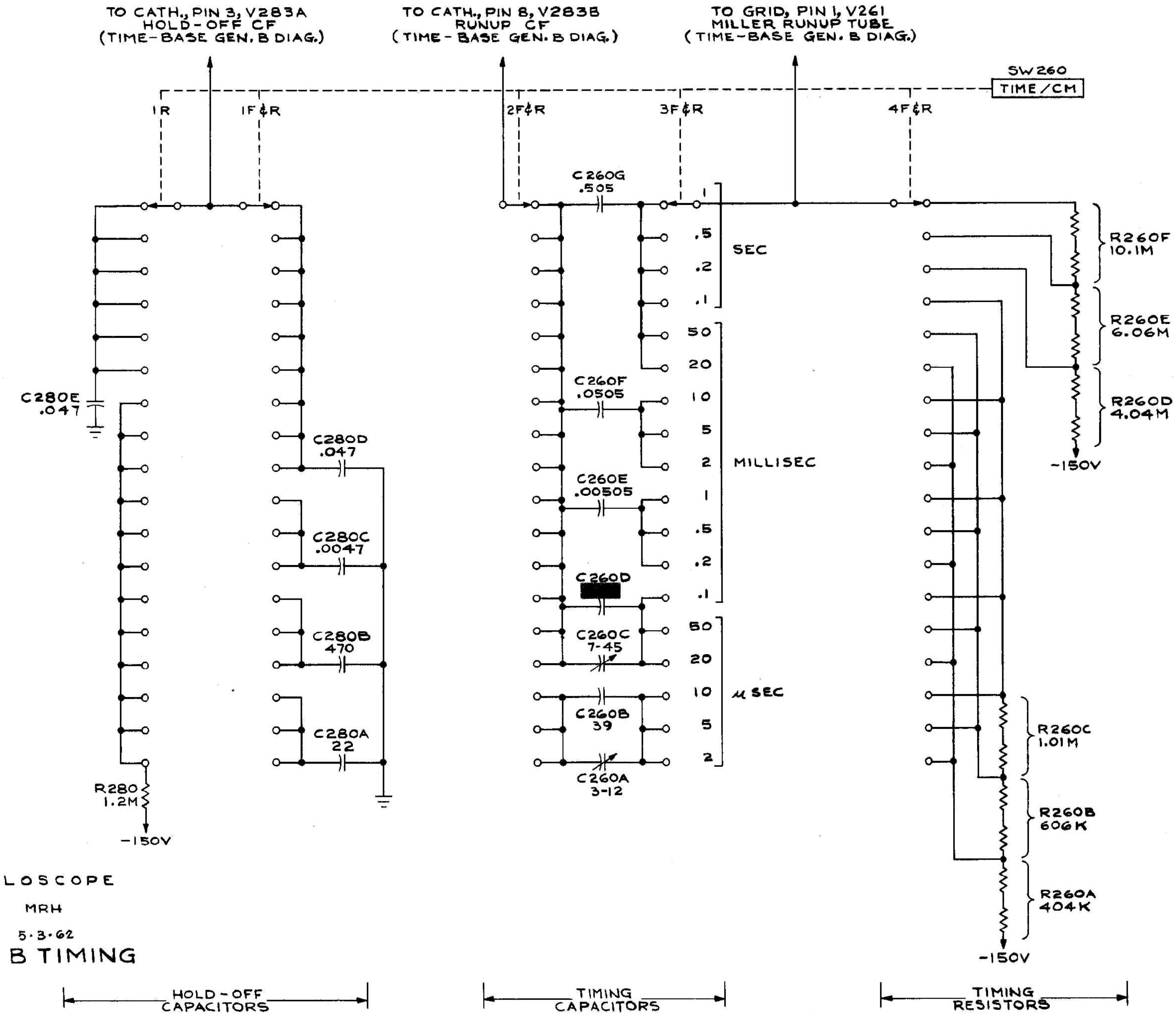
CIRCUIT NUMBERS 210 THRU 299

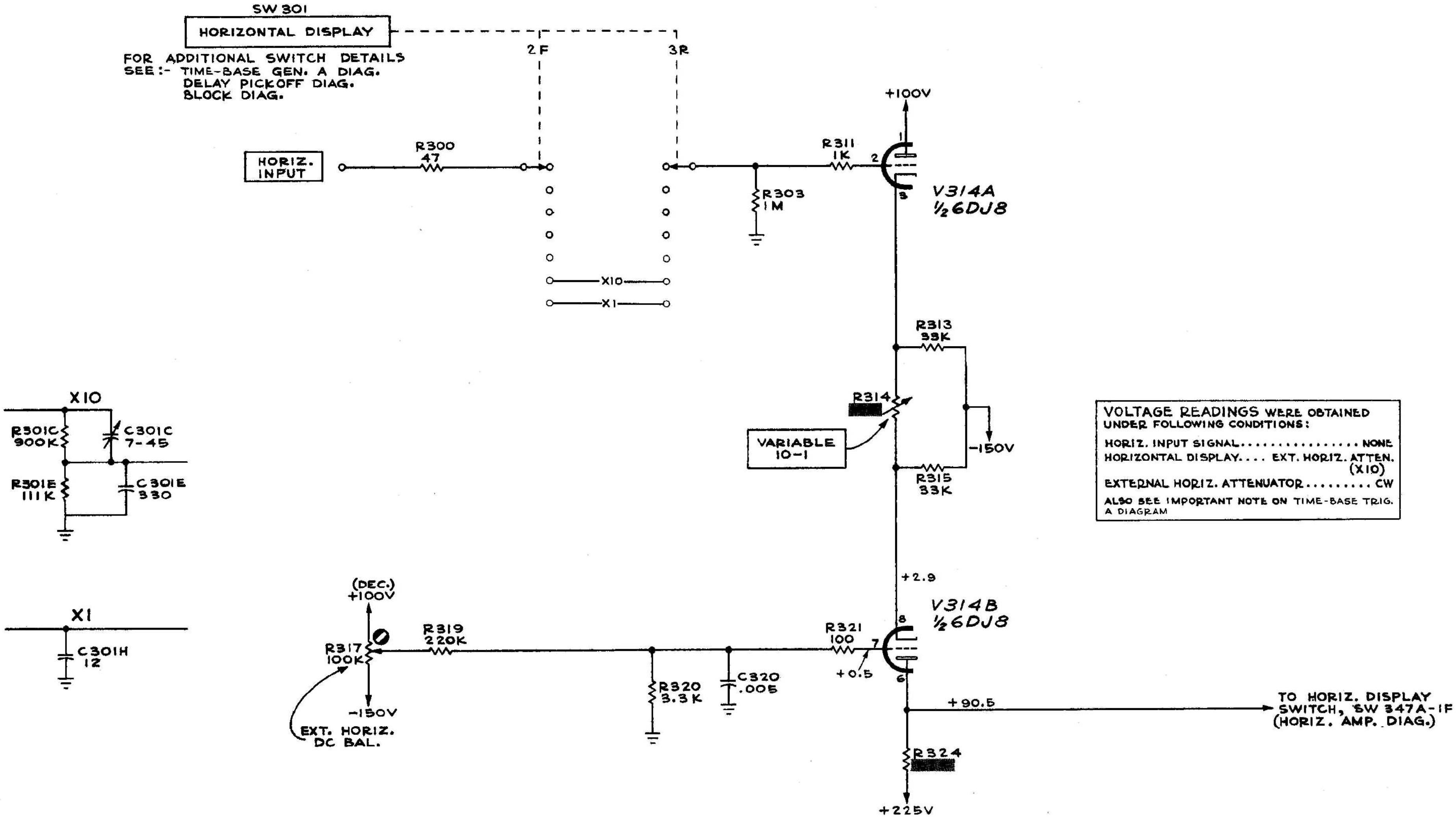
TYPE 585 OSCILLOSCOPE

MRH

5-3-62

TIME-BASE B TIMING





SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED WITH RED TINT BLOCKS

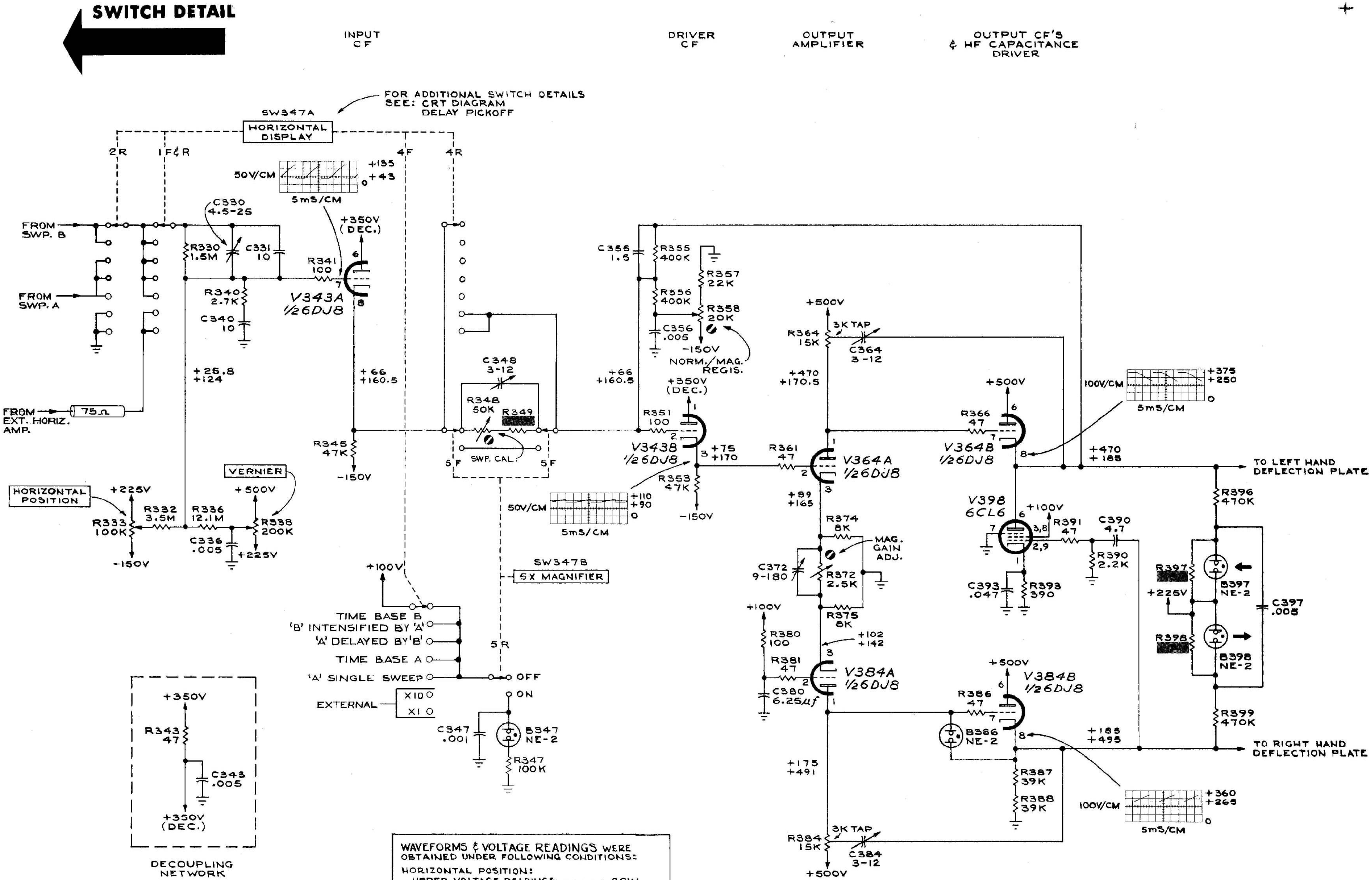
TYPE 585 OSCILLOSCOPE

EXTERNAL HORIZONTAL AMPLIFIER

CIRCUIT NUMBERS
300 THRU 325

AA

GAB
4-28-62



WAVEFORMS & VOLTAGE READINGS WERE OBTAINED UNDER FOLLOWING CONDITIONS:
HORIZONTAL POSITION:
UPPER VOLTAGE READINGS . . . . . CCW
LOWER VOLTAGE READINGS . . . . . . CW
VERNIER . . . . CW
WAVEFORMS:
HORIZONTAL DISPLAY . . . . . TIME-BASE A
ALSO SEE IMPORTANT NOTE ON TIME-BASE A TRIG. DIAG.

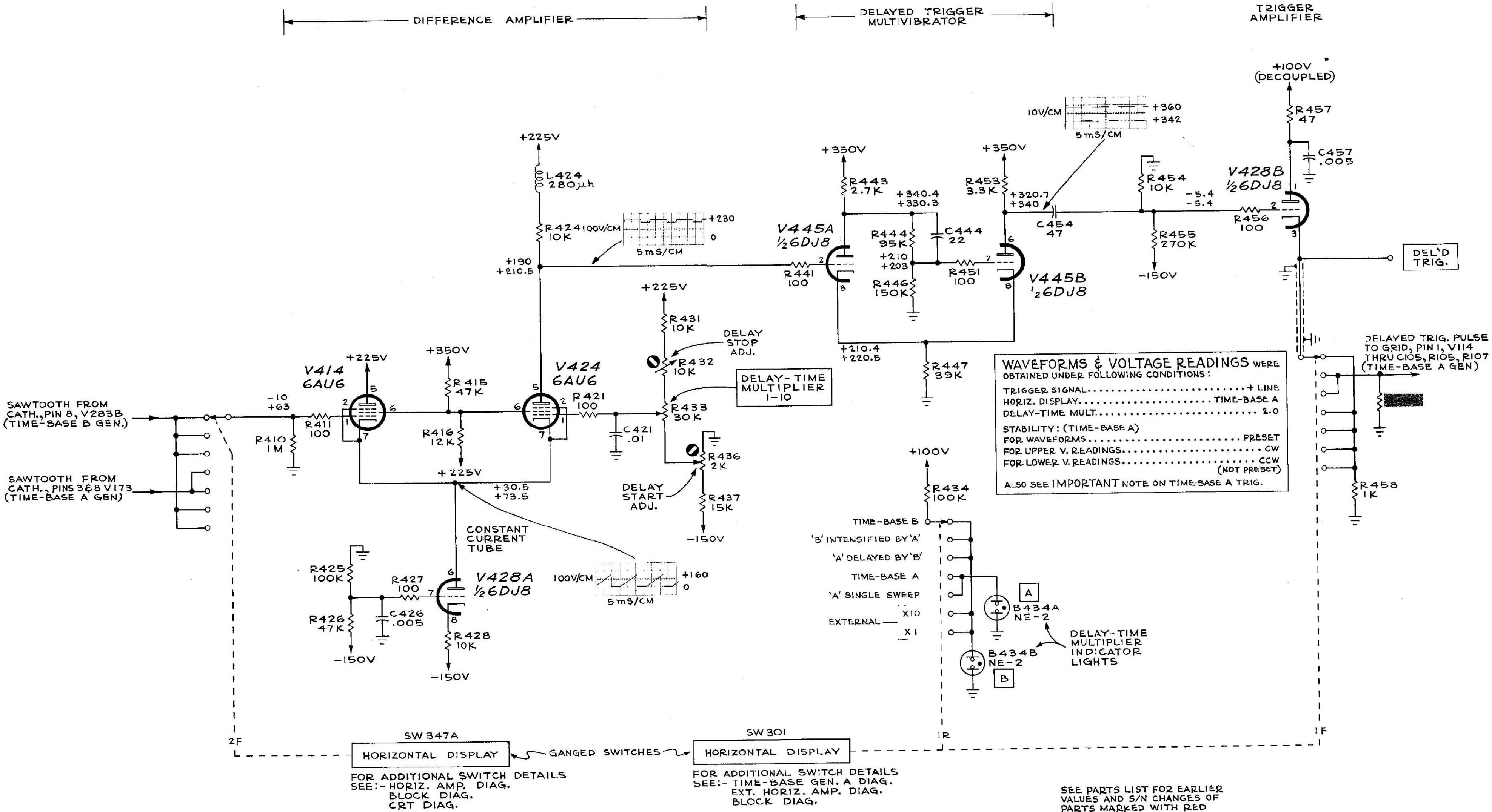
SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED WITH RED TINT BLOCKS

MRH
4-20-62

TYPE 585 OSCILLOSCOPE

HORIZONTAL AMPLIFIER

CIRCUIT NUMBERS 330 THRU 399



SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED WITH RED TINT BLOCKS

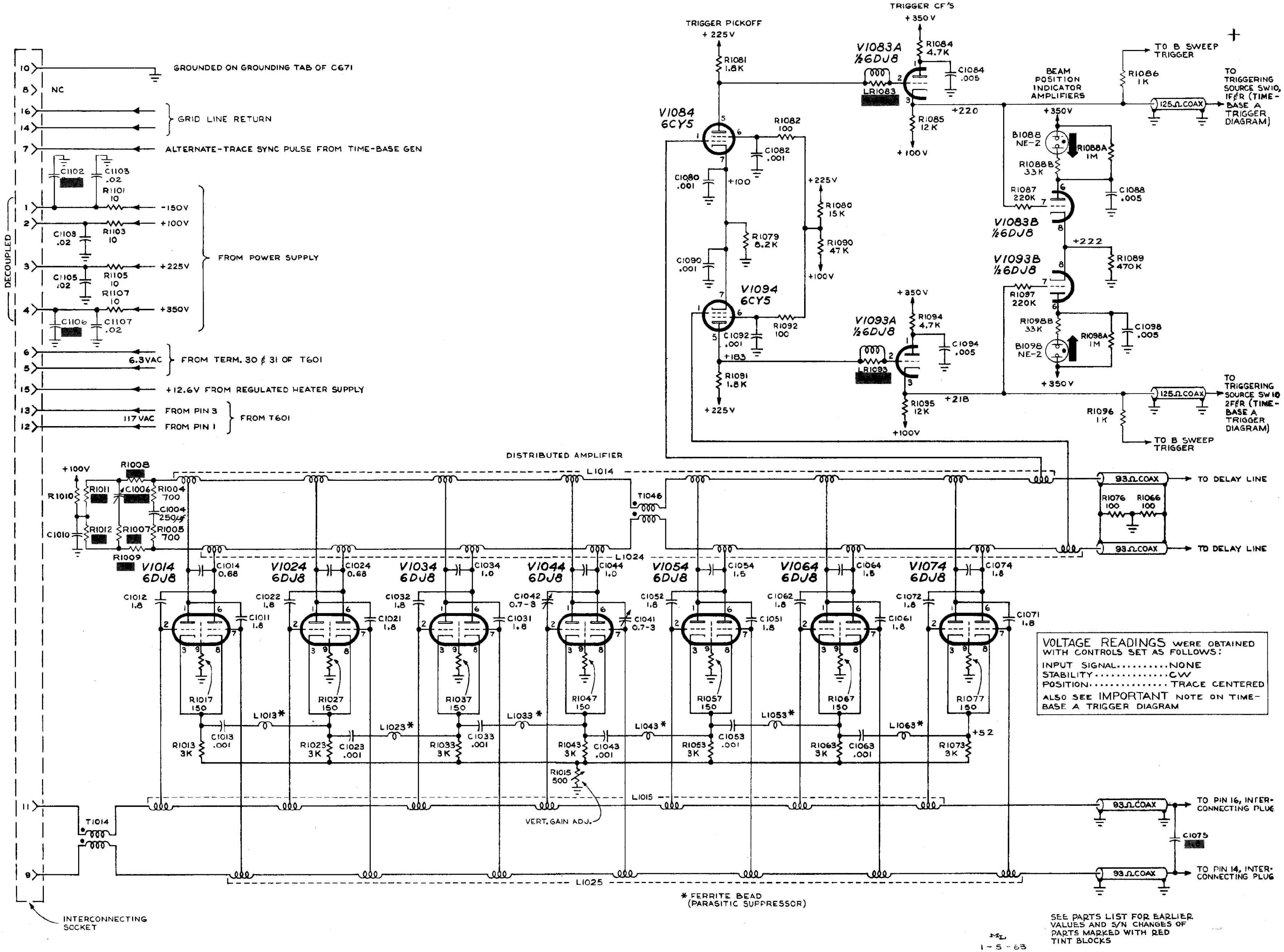
GAB
4-23-62

TYPE 585 OSCILLOSCOPE

AA,

DELAY PICKOFF

CIRCUIT NUMBERS 410 THRU 459



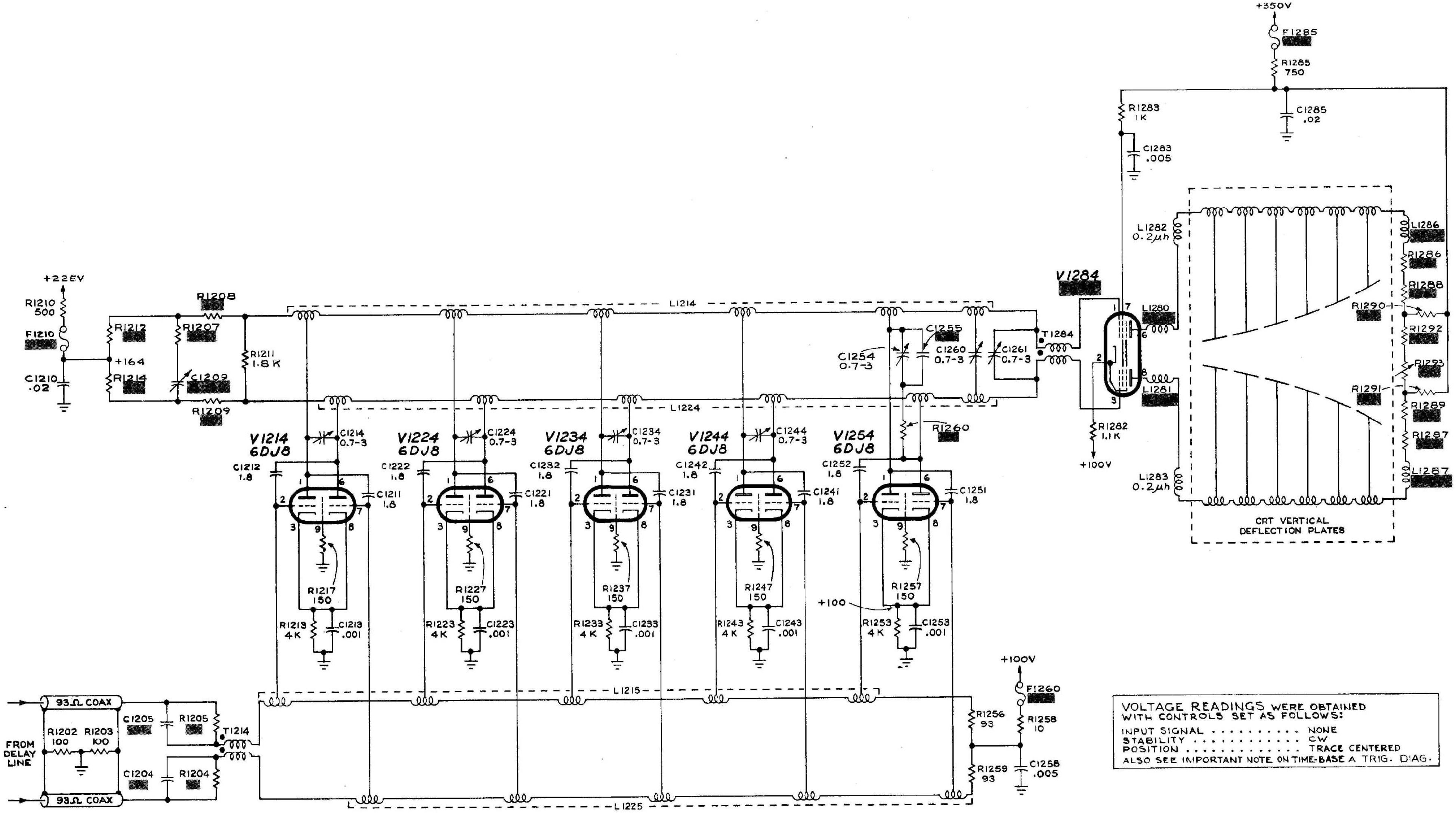
ML
1-5-63

TYPE 585 OSCILLOSCOPE

AB

VERTICAL AMPLIFIER DELAY LINE DRIVER

CIRCUIT NUMBERS 1000 THRU 1199

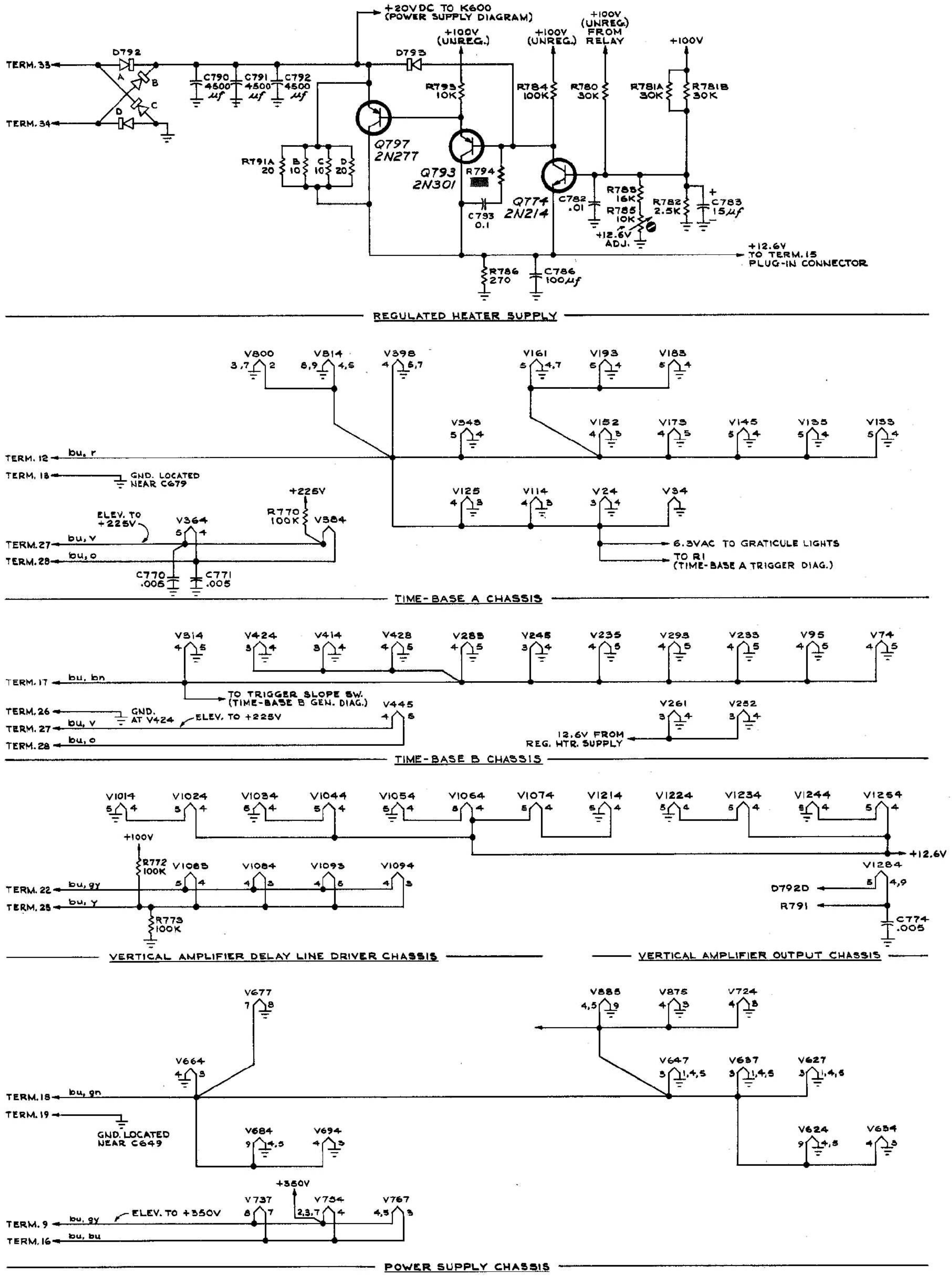


1-5-63
ML

TYPE 585 OSCILLOSCOPE

VERTICAL AMPLIFIER OUTPUT STAGE

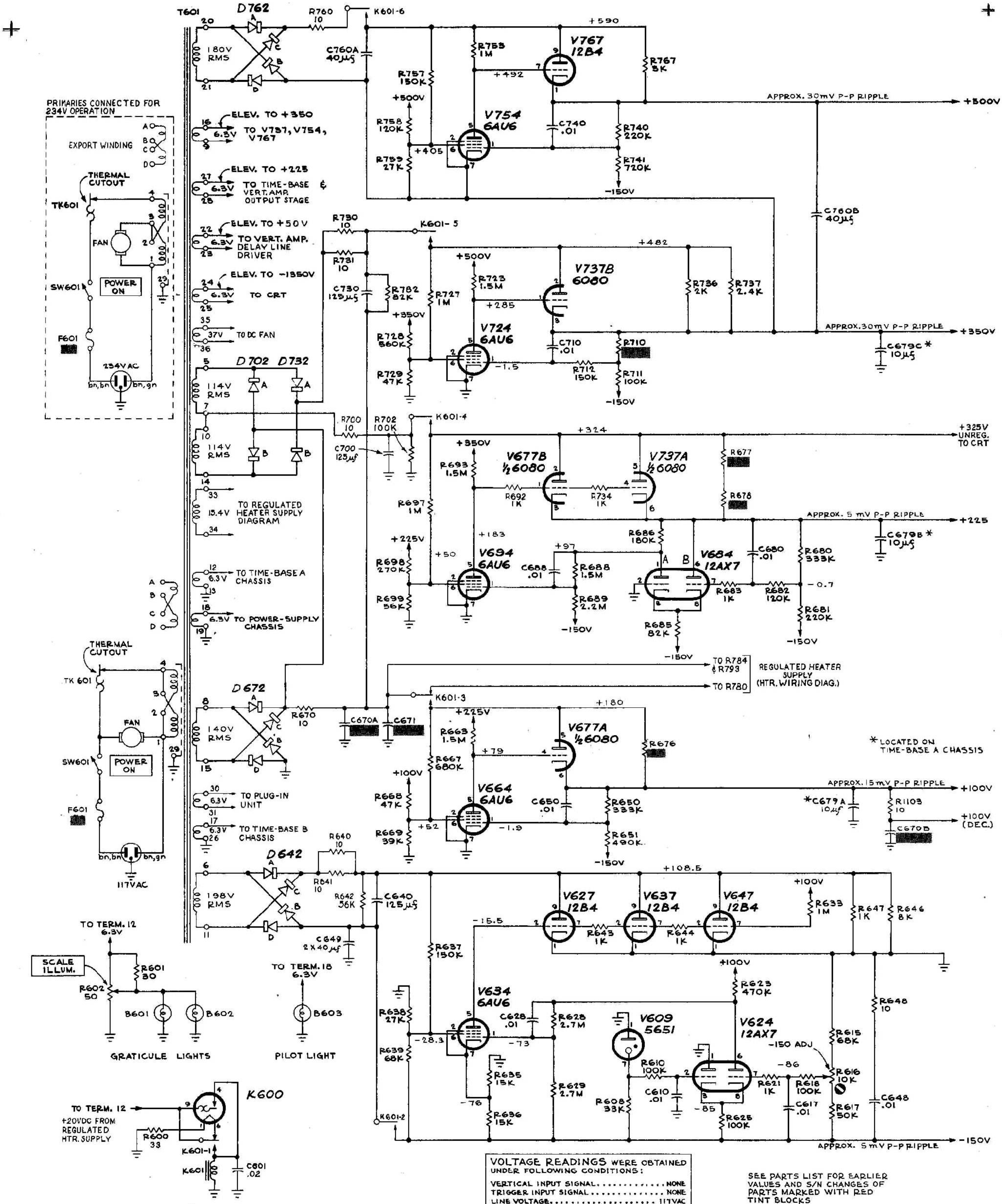
CIRCUIT NUMBERS
1200 THRU 1299



MRH
2-3-63

TYPE 585 OSCILLOSCOPE

HEATER WIRING DIAGRAM
S/N 3763-UP



VOLTAGE READINGS WERE OBTAINED UNDER FOLLOWING CONDITIONS:

VERTICAL INPUT SIGNAL	NONE
TRIGGER INPUT SIGNAL	NONE
LINE VOLTAGE	117VAC
STABILITY	CCW (NOT PRESET)

ALSO SEE IMPORTANT NOTE ON TIME-BASE TRIG. A DIAGRAM

SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED WITH RED TINT BLOCKS

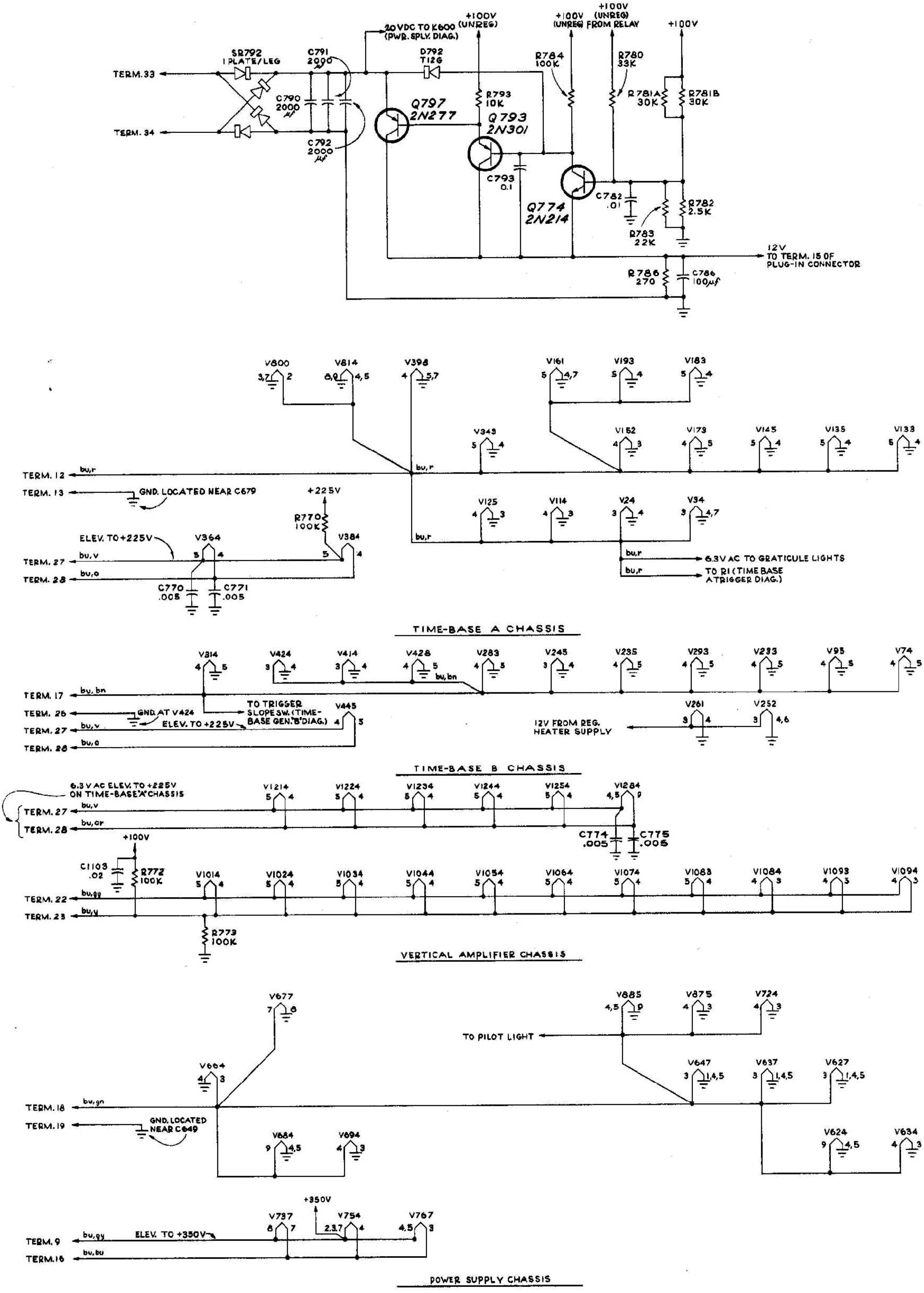
TYPE 585 OSCILLOSCOPE

AC

POWER SUPPLY

CIRCUIT NUMBERS 600 THRU 799

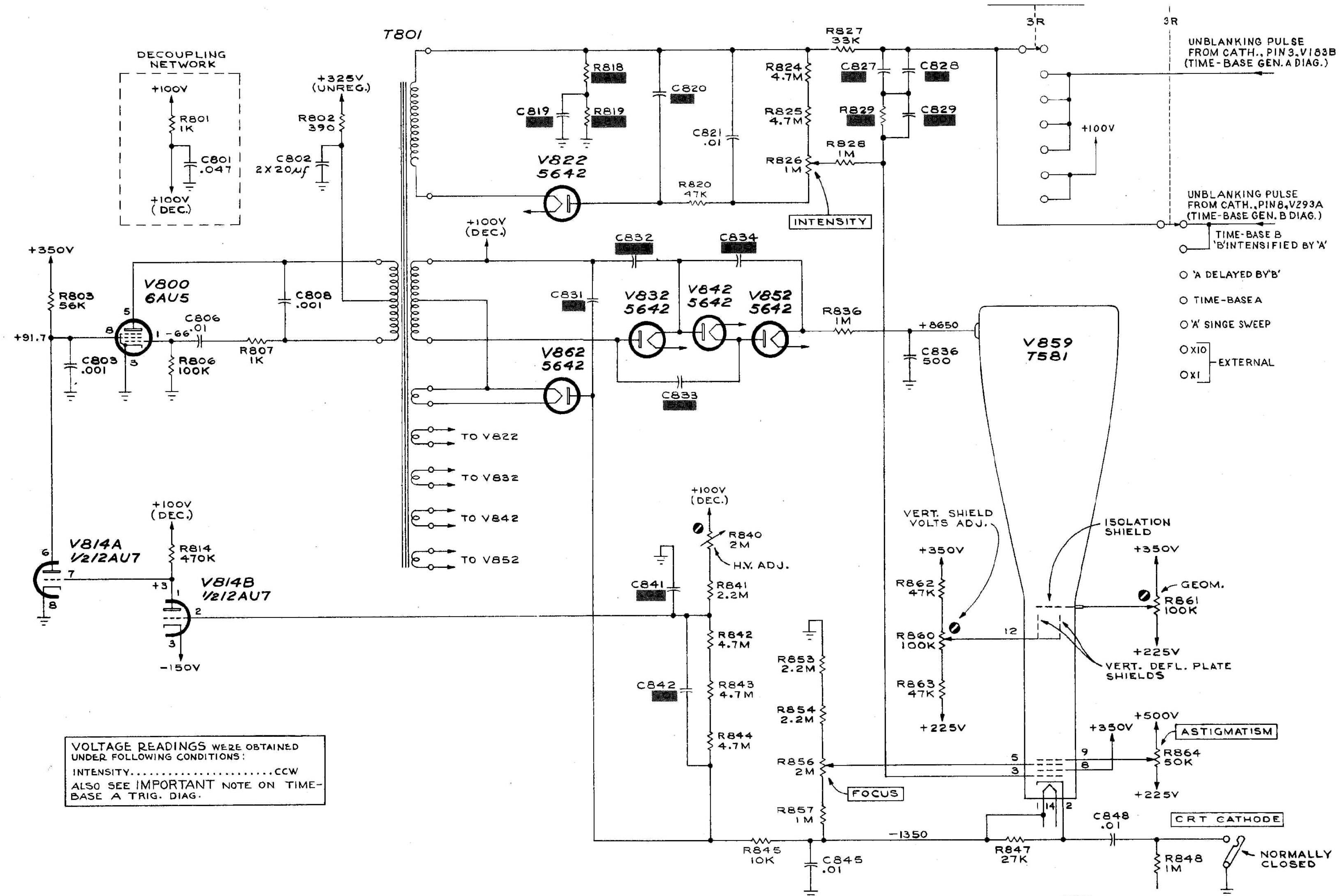
GAB 2-5-63



TYPE 585 OSCILLOSCOPE

JN
4-20-62

HEATER WIRING DIAGRAM
S/N 101-3762

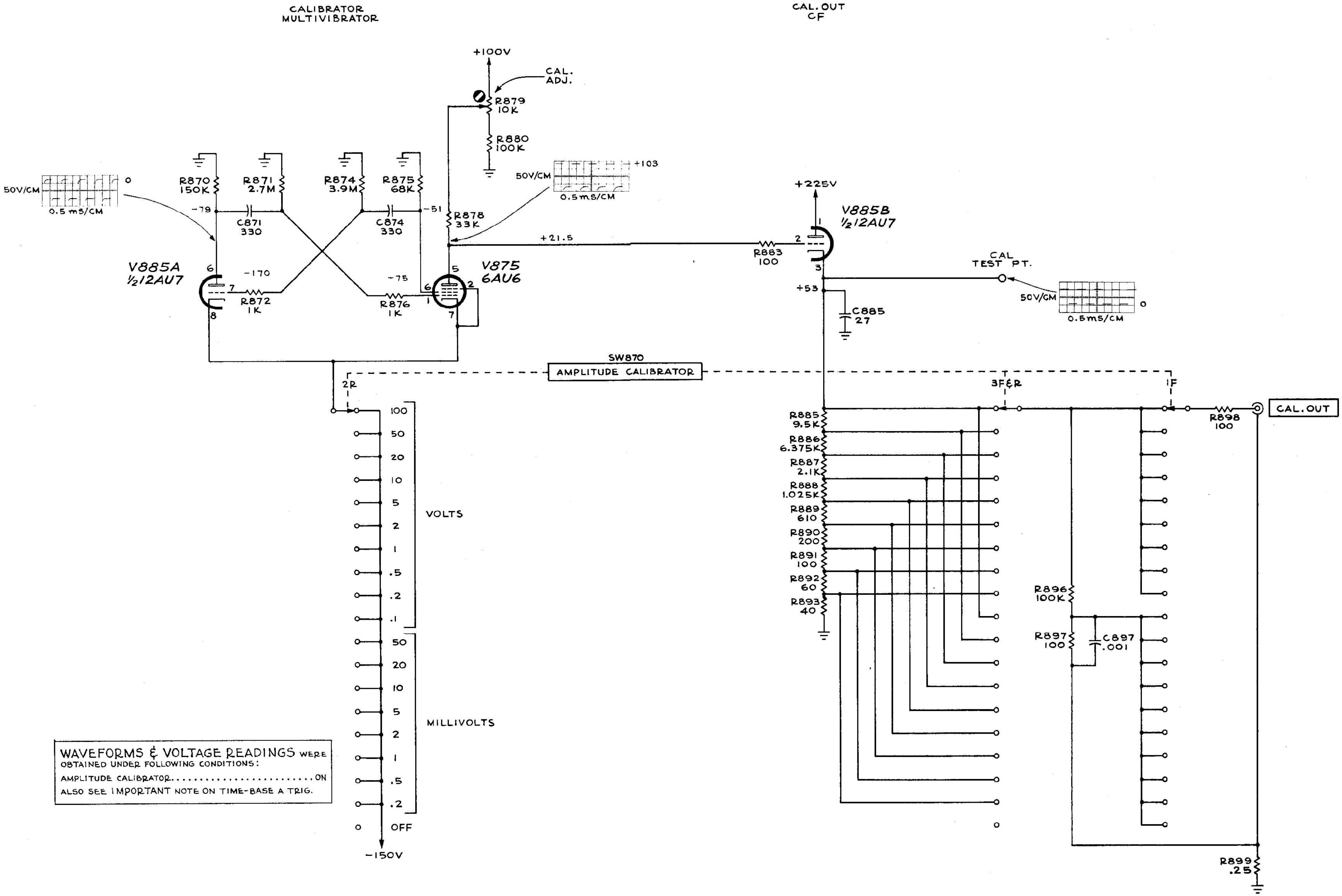


TYPE 585 OSCILLOSCOPE

MRH
4-20-62

CRT CIRCUIT

CIRCUIT NUMBERS 800 THRU 869 ALSO SW340A



WAVEFORMS & VOLTAGE READINGS WERE OBTAINED UNDER FOLLOWING CONDITIONS:
AMPLITUDE CALIBRATOR.......................ON
ALSO SEE IMPORTANT NOTE ON TIME-BASE A TRIG.

GAB

4-20-62

TYPE 585 OSCILLOSCOPE

CALIBRATOR

CIRCUIT NUMBERS 870 THRU 899

AA