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OSCILLOSCOPE SET, CT536

GENERAL AND TECHNICAL INFORMATION AND SCALE OF SERVICING SPARES

BY COMMAND OF THE DEFENCE COUNCIL

Ministry of Defence

FOR USE IN THE ROYAL AIR FORCE

(Prepared by the Ministry of Technology)

FOR OFFICIAL USE ONLY

A.L.2. July 68

INSTRUCTION MANUAL

Serial Number ____________

TYPE 647
MOD 165K
OSCILLOSCOPE

Tektronix, Inc.

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Tektronix International A.G.

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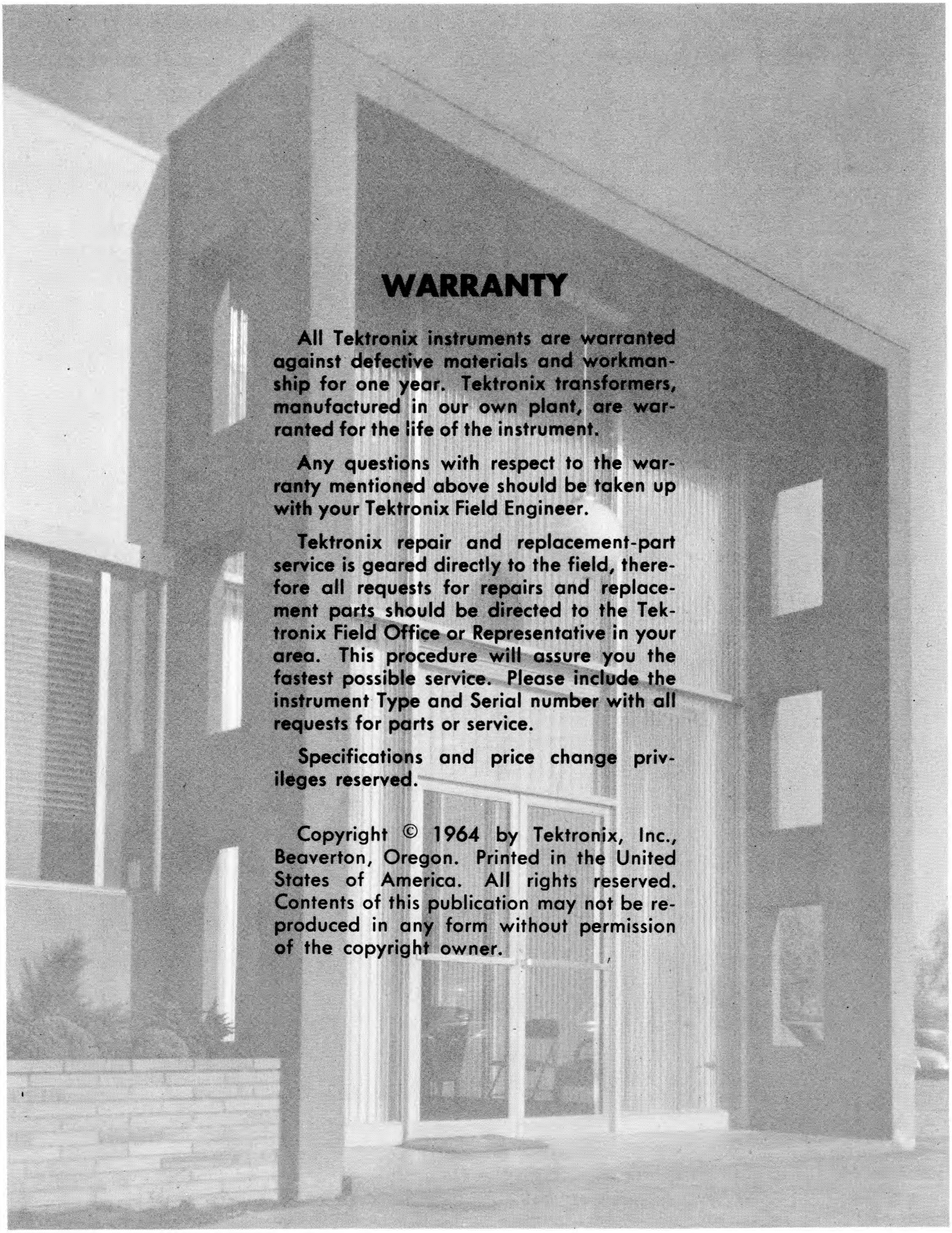


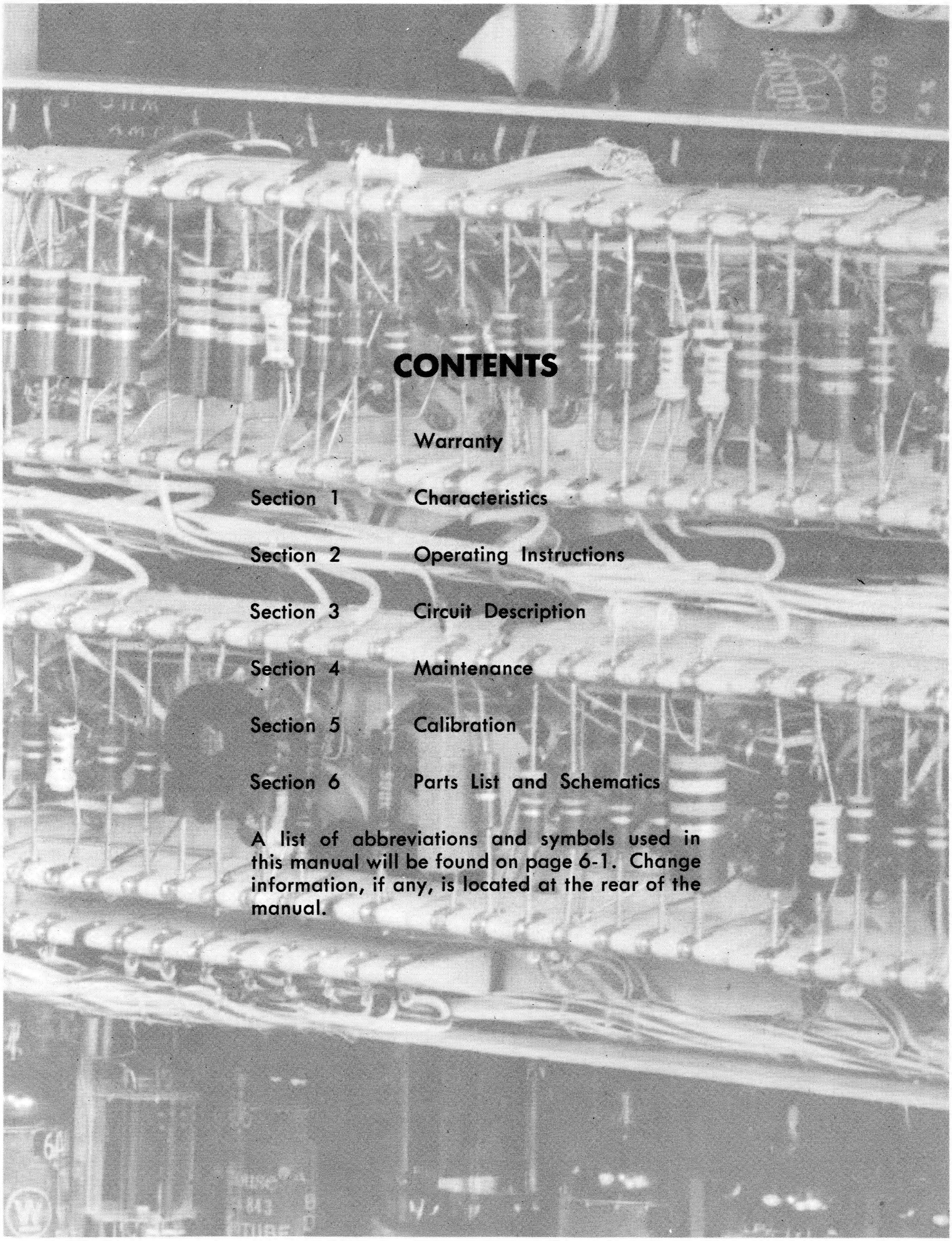
WARRANTY

All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our own plant, are warranted for the life of the instrument.

Any questions with respect to the warranty mentioned above should be taken up with your Tektronix Field Engineer.

Tektronix repair and replacement-part service is geared directly to the field, therefore all requests for repairs and replacement parts should be directed to the Tektronix Field Office or Representative in your area. This procedure will assure you the fastest possible service. Please include the instrument Type and Serial number with all requests for parts or service.

Specifications and price change privileges reserved.



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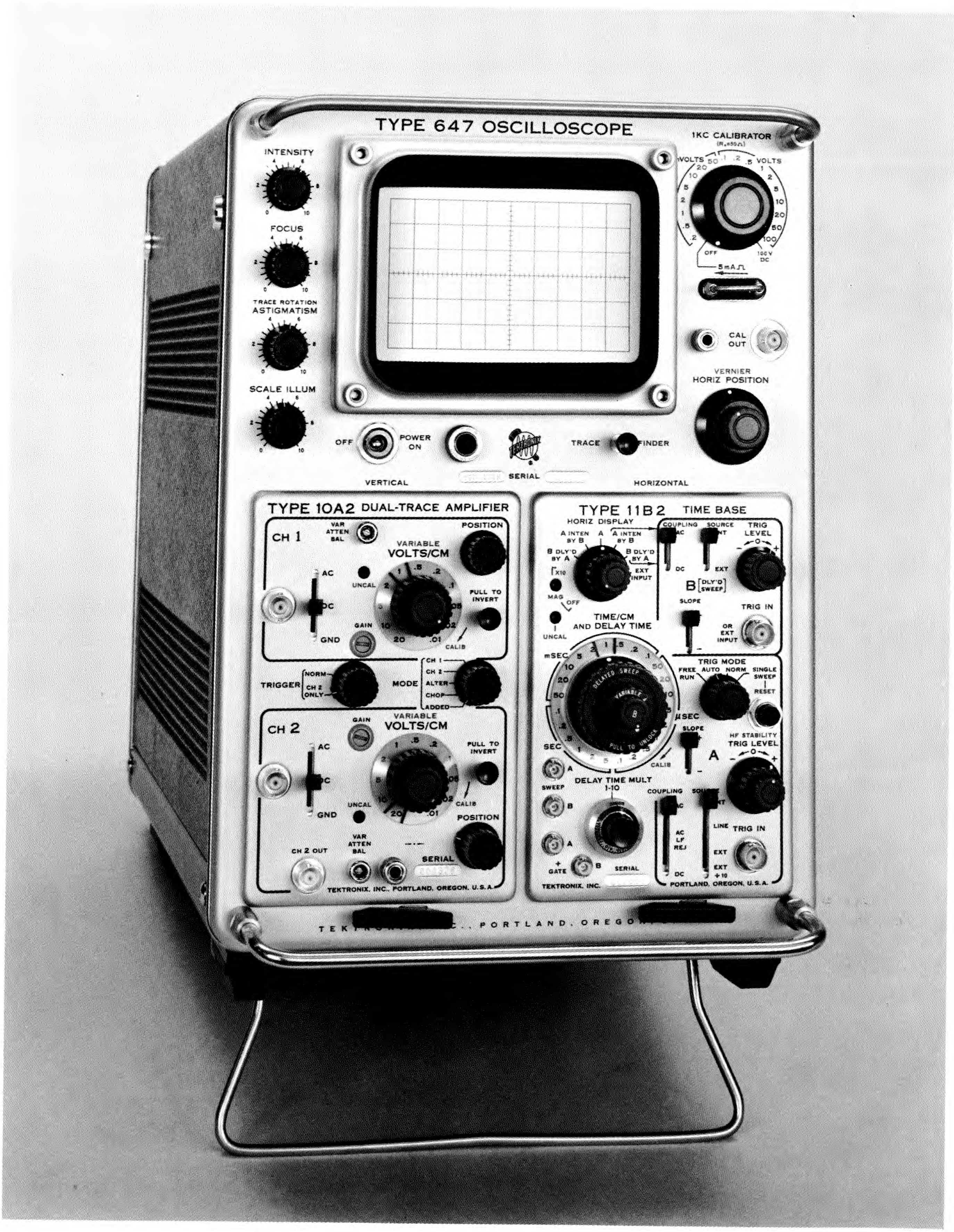
A list of abbreviations and symbols used in this manual will be found on page 6-1. Change information, if any, is located at the rear of the manual.


TYPE 647 OSCILLOSCOPE
INTENSITY
FOCUS
TRACE ROTATION
ASTIGMATISM
SCALE ILLUM
1KC CALIBRATOR
VOLTS
CAL OUT
VERNIER
HORIZ POSITION
OFF
POWER ON
TRACE FINDER
SERIAL
VERTICAL
HORIZONTAL
TYPE 10A2 DUAL-TRACE AMPLIFIER
CH 1
VAR ATTEN BAL
POSITION
VARIABLE
VOLTS/CM
AC
DC
GND
UNCAL
GAIN
PULL TO INVERT
CALIB
TRIGGER
NORM
CH 2 ONLY
MODE
CH 1
CH 2
ALTER
CHOP
ADDED
CH 2
CH 2 OUT
TEKTRONIX, INC., PORTLAND, OREGON, U.S.A.
TYPE 11B2 TIME BASE
HORIZ DISPLAY
COUPLING
SOURCE
TRIG LEVEL
SLOPE
TRIG IN
TIME/CM AND DELAY TIME
TRIG MODE
FREE RUN
AUTO
NORM
SINGLE SWEEP
RESET
HF STABILITY
DELAY TIME MULT
SWEEP
GATE
LINE
EXT
TEKTRONIX, INC.
PORTLAND, OREGON, U.S.A.

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PREFACE

The reference number of this publication was altered from AP 4837AG to AP 117K-0104-1 in Nov 67 and to AP 117K-0104-13D in July 68. No general revision of page captions has been undertaken, but the code appears in the place of the earlier AP reference on new or amended leaves issued subsequent to that date.

OSCILLOSCOPE SET CT536 6625-99-952-2040

comprising of the following main items and accessories.

ITEM	PART NO	NSN	NO. OFF
CASE, OSCILLOSCOPE (containing)	CN 36196	6625-99-952-2209	1
Oscilloscope	TYPE 647	6625-99-952-2196	1
Amplifier, Trigger Pulse	TYPE 10A2	6625-99-952-2194	1
Time Base Unit	TYPE 11B2	6625-99-952-2193	1
► Cable Assembly, Power Electrical	161-0024-03	6625-00-060-9051	1
Filter, Polarized Light	378-0540-08	5895-00-477-7836	1 ◄
Instruction Manual	- -	- -	1
CASE, OSCILLOSCOPE ACCESSORIES (containing)	CN 36209	6625-99-952-2208	1
Prod, Test	010-0130-00	6625-00-078-5219	2
► Lead, Test	175-0125-00	6625-01-016-8693	2 ◄
Lead, Electrical	175-0124-00	5995-00-978-8538	2
Lead, Test	175-0263-00	6625-00-771-5495	2
Tip, Test Prod	013-0071-00	6625-00-798-1515	2
Probe, Holder	352-0068-00	6625-00-980-9301	2
Tip, Test Prod	013-0052-00	6625-00-788-6815	2
Centre Pin	214-0325-00	6625-00-788-6811	2
Clip, Electrical	344-0046-00	5940-00-983-8310	4
Tip, Test Prod	206-0060-00	6625-00-983-6437	2
Tip, Test Prod	206-0105-00	6625-00-964-9327	2
Tip, Test Prod	134-0013-00	6625-00-830-5719	2
Tip, Test Prod	206-0015-00	6625-00-798-1508	2
Cable Assembly Radio Freq	012-0076-00	6625-00-916-8025	1
Adaptor BNC to BSM Adaptor	103-0036-00	5825-99-196-8722	1
Adaptor Connector	103-0033-00	5935-00-665-6544	1

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PRELIMINARIES

PART 1

TYPE 647 OSCILLOSCOPE

SECTION 1
CHARACTERISTICS

General Information

The Tektronix Type 647 is a general purpose, high-performance oscilloscope designed to operate under severe environmental conditions. The oscilloscope requires a Tektronix 10-Series vertical plug-in unit in the left-hand compartment and a Tektronix 11-Series horizontal plug-in unit in the right-hand compartment.

The electrical characteristics listed below are those of the Type 647, independent of the plug-in units. The environmental characteristics apply to the Type 647 and its plug-in units as a system.

NOTE

Range I and Range II, referred to in certain parts of this section, are the ambient air temperature ranges that apply for a particular characteristic. These ranges are—Range I: 0° C to +40° C, Range II: −30° C to +65° C.

Vertical Amplifier (Range I)

Sensitivity

300 mv/cm, ±1%, through 186 Ω push-pull.

Risetime

5.5 nsec, ±7%.

Bandwidth

Dc to −3 db at 64 mc, ±7%.

Display Linearity

A 2 cm centered signal will not change amplitude over ±1 mm when offset to top or bottom of graticule.

Trace Finder

Compresses display to bring it within graticule area. Used to determine nature of improper deflection signal. Push-button also actuates trace-finder switch in Horizontal Amplifier. See Section 2.

Horizontal Amplifier

Sensitivity

347 μa/cm per side, ±1%, push-pull.

Maximum Calibrated Deflection Rate

10 nsec/cm.

Bandwidth

Dc to −3 db at 3 mc, or higher.

Trace Finder

See "Trace Finder" in Vertical Amplifier characteristics.

Single-Sweep Reset

Connection between J101 on the rear panel and the 11-Series plug-in unit interconnecting socket provides for external reset of the single-sweep circuit in certain plug-in units. See J101 under "Rear Panel Connectors" in Section 2.

Cathode-Ray Tube

Type

T6470-31-1.

Phosphor

Type 31 normally supplied.

Accelerating Potential

14 kv.

Graticule Area

6 x 10 cm.

Graticule Markings

Internally marked in 6 vertical and 10 horizontal 1-cm spaces. 2-mm divisions marked on the vertical and horizontal centerlines. No parallax.

Graticule Illumination

Variable edge-lighting produces white (no filters) or red (with filters) graticule markings.

Unblanking

Bias-type, dc-coupled from 11-Series plug-in unit.

Crt Grid Z-Axis Modulation

Dc-coupled from rear-panel CRT GRID binding post. Input resistance about 22 kΩ. Bandwidth for small signals is dc to −3 db at 10 mc, or higher. Typically, ±2 volts peak will produce a visible change in display brightness.

Crt Cathode Z-Axis Modulation

Ac-coupled from rear-panel CRT CATHODE binding post. Input time constant is about 330 μsec (0.015 μf and 22 kΩ). Typically, a ±3-volt, fast-rise pulse will produce a visible change in display brightness.

Multi-Trace Chop Blanking

Crt circuitry permits multi-trace plug-in units, operating in chopped mode, to momentarily blank the display while switching between input channels.

Trace Rotation Control

Permits alignment of the trace with the graticule lines.

1-Kc Calibrator

Output Voltage Range

Square waves, 0.2 mv to 100 v peak-to-peak and 100 vdc.

Output Voltage Accuracy

(Load resistance 10 megΩ or higher)

0.1 and 100 VOLTS		All Other Voltages	
Range I	Range II	Range I	Range II
±1%	±1.5%	±2%	±3%

Output Resistance

0.2 mVOLTS to 0.1 VOLTS:	50 Ω, ±0.25%
0.2 VOLTS:	50 Ω, ±1%
0.5 to 100 VOLTS:	Varies with switch setting; about 4 kΩ maximum.

Current Through Loop

Square wave at 5 ma peak-to-peak, ±1.5%.

Frequency

1000 cps, ±0.1% (Range II).

Duty Factor

0.5, ±0.1% (Range II).

POWER REQUIREMENTS

Voltage Ranges

95 to 122 vac	190 to 244 vac
100 to 130 vac	200 to 260 vac
106 to 137 vac	212 to 296 vac

When shipped, instrument is wired for voltage range indicated on rear panel. Voltage range can be changed; see diagram attached to power transformer and fuse data provided in Section 4.

Line Voltage Distortion

For proper power supply operation at the lower line voltage limit, the line-voltage sine wave distortion must not exceed 1%.

Line Frequency

50 to 400 cps, ±10%.

Power Consumption

About 185 watts (with Type 10A2 and Type 11B2 plug-in units and 117-volt line).

Power Output Connector J101

Provides power from the regulated supplies of the Type 647 for operating external devices. Also provides an input connection for an external signal to reset the single-sweep circuit in certain 11-Series plug-in units. See Section 2.

ENVIRONMENTAL CHARACTERISTICS

Operating

Temperature

—30°C to +65°C continuous when the instrument is not tipped more than 20° in any direction from level position. Other positions require a decrease in maximum temperature. If operating at —30°C, allow 30 minutes for stabilization.

If simultaneously operated at maximum altitude and maximum line voltage in a particular operating voltage range, maximum operating temperature must be limited to +55°C. A self-resetting thermal cutout disrupts instrument power if internal temperature becomes excessive.

Altitude

15,000 feet, maximum.

Vibration

0.025 inch peak-to-peak, 10-55-10 cps (4 G's) for 15 minutes on each axis in one-minute sweeps.

Non-Operating

Temperature

—55°C to +75°C.

Altitude

50,000 feet, maximum.

Humidity

Meets Mil-Std-202B, method 106A through five cycles (120 hours), freezing and vibration excluded.

Shock

20 G's, one-half sine, for 11 milliseconds. Two shocks each direction along each of the three major axes (total of 12 shocks).

Vibration

Same as under "Operating".

Transit

Meets National Safe Transit type of test when factory packaged: Vibration for one hour at slightly greater than 1 G. 30-inch drops on corners, edges, and flat surfaces.

MECHANICAL CHARACTERISTICS

Construction

Front panel is photo-etched, anodized aluminum. Chassis is aluminum-alloy.

Dimensions

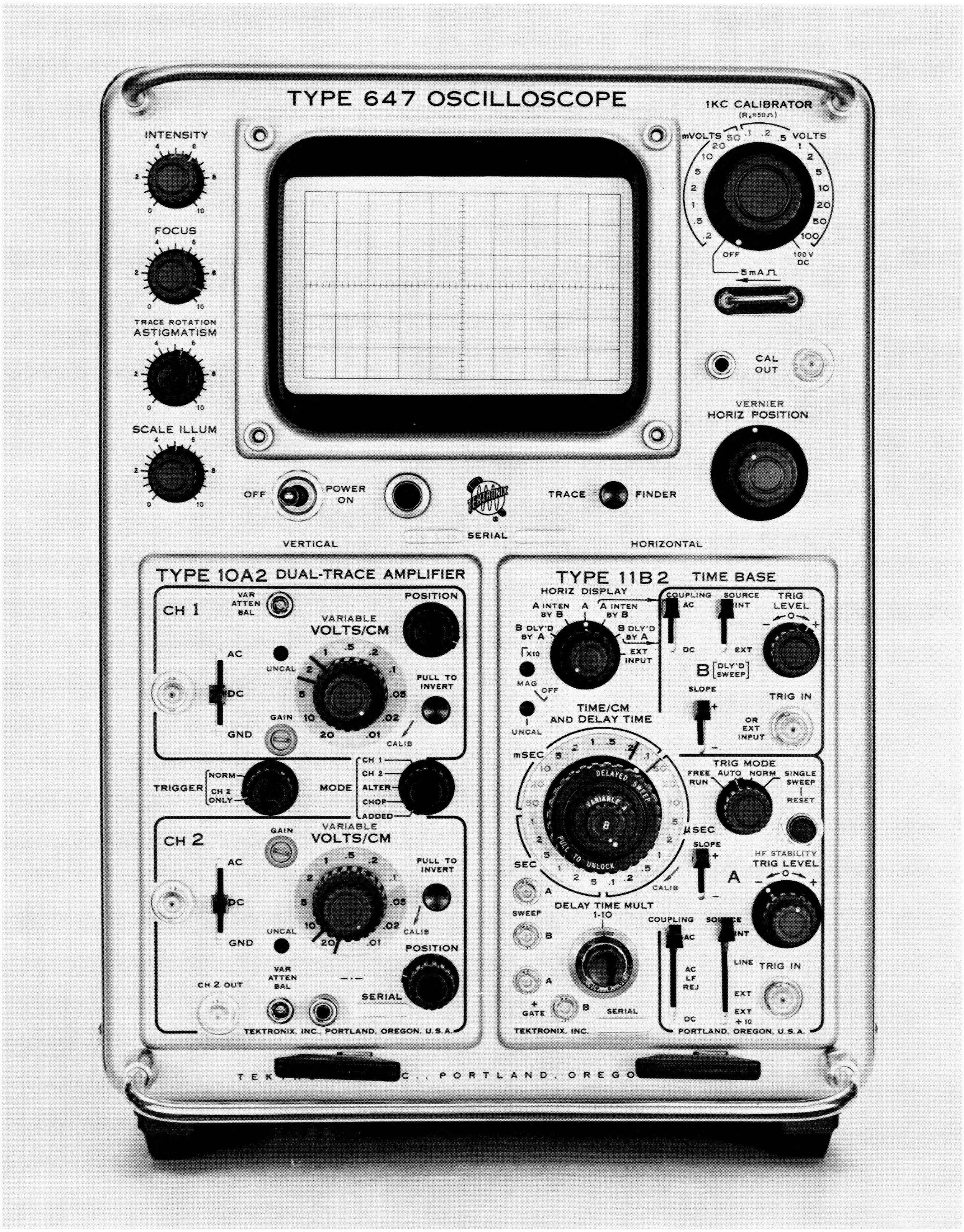
14.5 inches high.
10 inches wide.
23 inches deep.

Weight

40.5 pounds, net.

ACCESSORIES INCLUDED

	Tektronix Part No.
2—Instruction Manuals	
1—Polarized Filter	378-540
1—3-Conductor Power Cord	161-013
1—3-Wire to 2-Wire Adapter	103-013
1—BNC to Binding Post Adapter	103-033
1—20-Inch 50 Ω Coaxial Cable with BNC Connectors	012-076


TYPE 647 OSCILLOSCOPE
INTENSITY
FOCUS
TRACE ROTATION
ASTIGMATISM
SCALE ILLUM
1KC CALIBRATOR
mVOLTS
VOLTS
OFF
100 V DC
5mA
CAL OUT
VERNIER
HORIZ POSITION
OFF
POWER ON
TRACE
FINDER
VERTICAL
SERIAL
HORIZONTAL
TYPE 10A2 DUAL-TRACE AMPLIFIER
CH 1
VAR ATTEN BAL
POSITION
VARIABLE
VOLTS/CM
AC
DC
GND
UNCAL
GAIN
PULL TO INVERT
CALIB
TRIGGER
NORM
CH 2 ONLY
MODE
CH 1
CH 2
ALTER
CHOP
ADDED
CH 2
CH 2 OUT
SERIAL
TEKTRONIX, INC., PORTLAND, OREGON, U.S.A.
TYPE 11B2 TIME BASE
HORIZ DISPLAY
A INTEN BY B
A
A INTEN BY B
B DLY'D BY A
B DLY'D BY A
EXT INPUT
X10
MAG
OFF
UNCAL
COUPLING
AC
DC
SOURCE
INT
EXT
TRIG LEVEL
B DLY'D SWEEP
SLOPE
TRIG IN
OR EXT INPUT
TIME/CM AND DELAY TIME
mSEC
μSEC
SEC
DELAYED SWEEP
VARIABLE A
PULL TO UNLOCK
CALIB
TRIG MODE
FREE RUN
AUTO
NORM
SINGLE SWEEP
RESET
HF STABILITY
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TEKTRONIX, INC.
PORTLAND, OREGON, U.S.A.

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SECTION 2
OPERATING INSTRUCTIONS

Introduction

The Type 647, when combined with a 10-Series and an 11-Series plug-in unit, is a complete oscilloscope system. The 10-Series plug-in unit can be operated only in the left compartment and the 11-Series in the right.

This section of the manual describes the function of each control and connector on the Type 647, as well as general operating information.

Operating Temperature

The Type 647 Oscilloscope can be stored where the ambient air temperature is between —55°C and +75°C, and operated where the ambient air temperature is between —30°C and +65°C. After storage at temperatures beyond the operating limits, be certain to allow the chassis temperature to come within the operating limits before power is applied.

Proper cooling of the Type 647 depends on convection. It is important to choose a location for operation where the required air flow, particularly to the bottom and rear of the instrument, is not restricted. Moreover, if operated when the ambient temperature is near +65°C, the instrument must not be tilted more than 20° in any direction from the level position.

When the instrument is operated both at maximum altitude and maximum line voltage in a particular operating voltage range, limit the maximum operating temperature to +55°C.

FIRST-TIME OPERATION

The following describes one way to properly set the FOCUS, ASTIGMATISM, and TRACE ROTATION controls.

1. Install the plug-in units.
2. Set the Type 647 INTENSITY control fully counterclockwise and apply power to the instrument. Allow several minutes for warmup.
3. Set the controls on the plug-in units and the Type 647 INTENSITY control for a free-running, vertically-centered trace of moderate intensity.
4. Set the controls on the 11-Series plug-in unit for a 100 μsec/cm sweep rate.
5. Set the controls on the 10-Series plug-in unit for a vertical sensitivity of 0.05 volt/cm.
6. Set the 1KC CALIBRATOR switch to .2 VOLTS and attach a cable from the CAL OUT connector to the vertical input.
7. Set the controls on the 11-Series plug-in unit for a triggered display.
8. With the FOCUS and ASTIGMATISM controls set at midrange, set the INTENSITY control so that part of the vertical portion of the trace can be seen.
9. Set the ASTIGMATISM control so that the horizontal and vertical portions of the display are **equally** focused, but not necessarily **well** focused.
10. Set the FOCUS control so that the vertical portion of of the trace is as thin as possible.
11. Repeat steps 9 and 10 for best results. Make the final settings with the INTENSITY control set for the desired display brightness.

NOTE

To check for proper setting of the ASTIGMATISM control, slowly turn the FOCUS control back and forth through its optimum setting. If the ASTIGMATISM control is properly set, the horizontal and vertical portions of the trace will individually come into sharpest focus at the same position of the FOCUS control. This setting of the ASTIGMATISM control should be correct for any type of display. However, it may be necessary to reset the FOCUS control slightly if a large change is made in the INTENSITY control setting.

12. Disconnect the input signal and obtain a free-running, vertically-centered trace.
13. If necessary, set the TRACE ROTATION control (a screwdriver adjustment concentric with the ASTIGMATISM control) so that the trace is parallel with the graticule lines.

FUNCTION OF CONTROLS

INTENSITY	Permits control of display brightness. Lowest useable brightness is generally best for precise measurements since trace thickness decreases as intensity decreases.
FOCUS	Adjusted in conjunction with the ASTIGMATISM control to obtain sharp display definition. See "First-Time Operation" (at left) for a recommended adjustment method.
ASTIGMATISM	Adjusted so that the vertical and horizontal portions of a display are individually brought into sharpest focus at the same position of the FOCUS control.
TRACE ROTATION	A screwdriver adjustment concentric with the ASTIGMATISM control. Permits the operator to offset any trace tilt introduced by the earth magnetic field.

SCALE ILLUM	Permits brightness of the graticule markings to be varied.
1 KC CALIBRATOR	Permits selection of the accurate peak-to-peak square-wave voltage available at the CAL OUT connector. 100-volts dc and 5-ma square wave (through the current loop) also provided. Square-wave frequency is an accurate 1 kc. (See the discussion under "1 KC CALIBRATOR" in this section.)
HORIZ POSITION and VERNIER	Used to move the display horizontally. These controls are electrically part of whichever 11-Series plug-in unit is installed in the Type 647.
TRACE FINDER	When excessive deflection or improper centering result in loss of display, push the TRACE FINDER button so that the display is compressed within the graticule area. Center the display with the positioning controls and establish a vertical deflection amplitude of about 4 cm or less. Release the TRACE FINDER button. The display should then be restored.
OFF—POWER ON	Line switch for oscilloscope. Pilot lamp brightness can be varied by turning the bezel on the lamp housing.

1-KC CALIBRATOR

The following characteristics of the 1-Kc Calibrator provide a convenient means of verifying the accuracy of an oscilloscope system:

1. Accurate peak-to-peak and dc voltage output.
2. Accurate 5 ma peak-to-peak closed-loop current signal.
3. Accurate frequency.
4. Square-wave output signal.

Voltage

The 1-Kc Calibrator provides peak-to-peak voltages from 200 μvolts to 100 volts into high-resistance loads. With switch settings of .2 VOLTS and below, the output source resistance is 50 Ω as indicated by the voltages printed in red on the panel of the Type 647. The voltage across a 50 Ω termination will then be accurate at one-half the value indicated by the switch setting, provided the termination resistance is an accurate 50 Ω.

The +100-volt dc output of the calibrator has many uses, limited only by its current capability. The load resistance should be as high as possible (the output voltage will drop to 99 volts at about 35 kΩ).

Current

The current loop, located above the CAL OUT connector, provides a 5-ma peak-to-peak square wave which can be used for calibrating and checking current-probe systems such as the P6016/131. This current signal is obtained by clipping the probe through the loop and by setting the 1 KC CALIBRATOR switch to the first position clockwise from OFF.

The arrow on the front panel above the current loop indicates conventional current: + to —.

Frequency

The 1 Kc Calibrator is crystal controlled so that the frequency is accurate at 1 kc and the duty factor is stable at 0.5. Thus, the calibrator signal can be used as a time reference for checking or calibrating the basic sweep rate adjustments of 11-Series plug-in units such as the Type 11B2.

Wave Shape

The calibrator square-wave output signal can be used as a reference wave shape when checking or adjusting the compensation elements in passive, high-resistance, voltage probes. Since the flat-top characteristic of the square wave is known, the probe compensation is adjusted so that the signal delivered by the probe produces a flat-topped square-wave display.

REAR-PANEL CONNECTORS

J101

Ten-contact connector J101 on the rear panel of the Type 647 provides power from the regulated low-voltage supplies for operating external devices and the signal input connection for external single sweep reset of certain 11-Series plug-in units such as the Type 11B2. Mating connectors for J101 are available from Tektronix by part number 131-300.

J101 Contact	Voltage	'Maximum Current*
A	—75 v	50 ma
B	—15 v	20 ma
C	ground	
D	+15 v	200 ma
E	+100 v	20 ma
F	Single sweep reset input.	
G	nc	
H	nc	
J	nc	
K	nc	

*When the Type 10A2 and 11B2 plug-in units are used.

Fig. 2-1 illustrates two ways to provide an external single-sweep reset pulse suitable for the Type 11B2 plug-in unit.

CRT CATHODE

The ac-coupled CRT CATHODE input connector permits intensity (Z-axis) modulation of the crt display. The input time-constant is about 330 μsec (0.015 μfd and 22 kΩ) which corresponds to a low-frequency response at the crt cathode of —3 db at about 500 cps.

Display intensity increases during negative-going changes in the modulating signal and decreases during positive-going changes. Generally, at least 5-volts peak signal amplitude is required for visible display modulation, depending on the intensity level of the unmodulated display.

CRT GRID

The CRT GRID connector permits gating or modulating the intensity of the crt display through the wide-band, dc-coupled Z-Axis Amplifier in the Type 647. Since the amplifier inverts the signal, negative voltages increase display intensity and positive voltages decrease intensity. The voltage magnitude required for visible modulation depends on the intensity level of the unmodulated display; typically, a 2-volt signal will produce a visible change in the brightness.

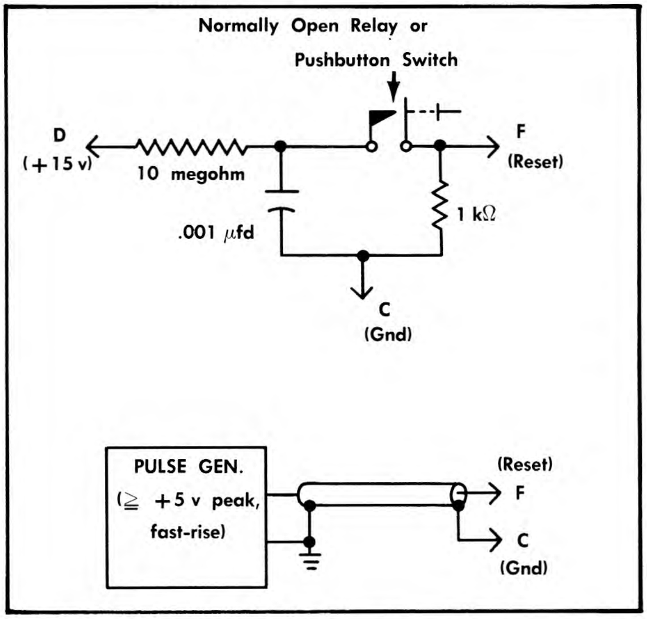


Fig. 2-1. Two means of providing an external single sweep reset pulse.

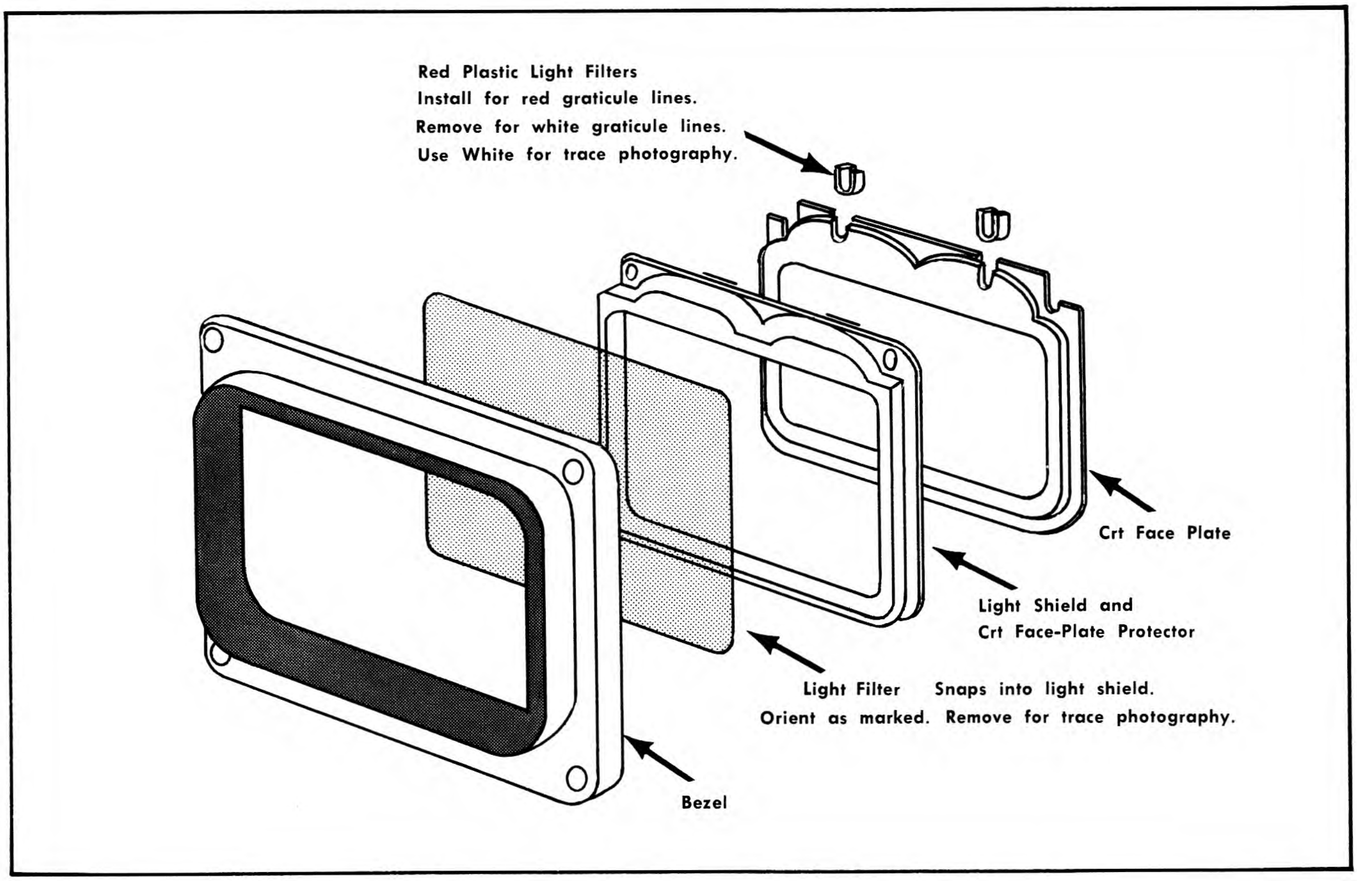


Fig. 2-2. Crt face-plate assembly.

SECTION 3
CIRCUIT DESCRIPTION

Introduction

This section of the manual contains descriptions of each circuit in the Type 647 Oscilloscope. Block diagrams are included in each description to show the major stages of the circuit and the signal flow.

A complete block diagram, showing the relationship between major circuits in the Type 647, is located in Section 6. Complete schematics for each circuit are also located in Section 6.

VERTICAL AMPLIFIER

The Type 647 Vertical Amplifier block diagram is shown in Fig. 3-1. It is a dc-coupled push-pull voltage amplifier having a maximum gain of about 42. A delay line is provided so that the rising portion of a fast-rise event which internally triggers a sweep will be displayed on the crt. RC networks in the emitter circuits provide the high-frequency peaking required to obtain broadband operation.

If the display is driven out of the graticule area by an excessive deflection signal, the TRACE FINDER button may be pressed to actuate switches in the vertical and horizontal amplifiers. The vertical deflection signal is compressed within the limits of the graticule so that the direction of the display loss can easily be determined.

The 186 Ω delay line delays the vertical signal for about 140 nanoseconds. The Phase and Amplitude Equalizers compensate for distortion introduced by the delay line.

The VERT GAIN control R414 delivers the required portion of the vertical deflection signal to Q423 and Q433. These emitter followers drive Q444 and Q454 which form a paraphase amplifier with R445, R447, R457, and R448 as the basic common-emitter elements. The series-parallel RC components in the common-emitter circuit maintain the stage gain at high frequencies. DAMPING control R456D is set to obtain critical damping of the compensation network. VERT CENT control R441 is set to balance the amplifier.

When the TRACE FINDER button is pressed, the dynamic range of the Q444-Q454 stage is decreased. This limits the vertical deflection to less than ±3 centimeters.

The Q444-Q454 collectors drive parallel, push-pull amplifiers Q464A-Q474A and Q464B-Q474B. The common-emitter circuits of these amplifiers are compensated for high frequencies in much the same manner as the previous stage.

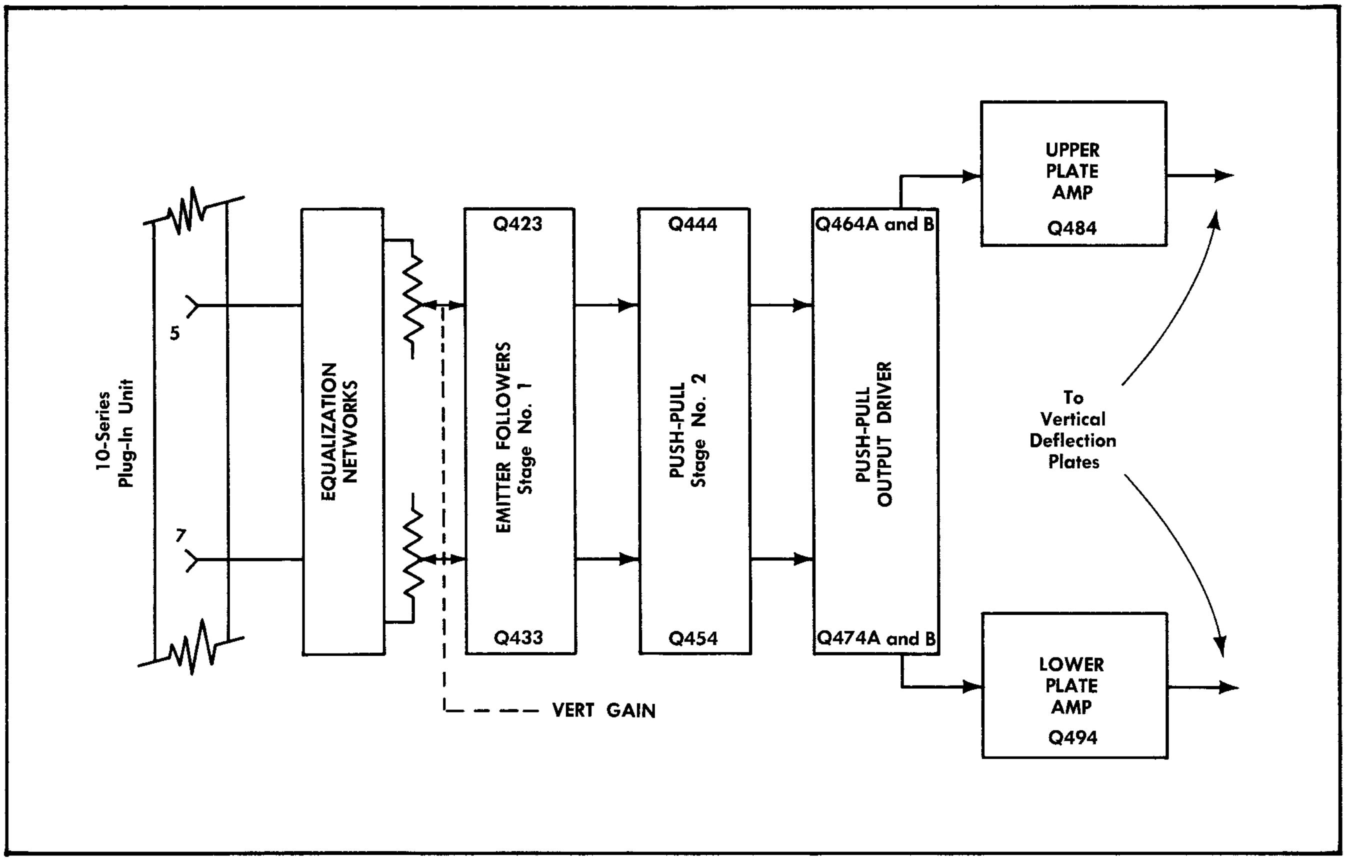


Fig. 3-1. Vertical Amplifier block diagram.

The collectors of the parallel, push-pull amplifiers provide current drive to the emitters of output amplifiers Q484 and Q494. Feedback to the bases of Q484 and Q494 permits the output voltage swing to be shared by the driver stage.

HORIZONTAL AMPLIFIER

The Type 647 Horizontal Amplifier block diagram is shown in Fig. 3-2. The dc-coupled amplifier consists of two independent current-driven operational amplifiers. A 1-ma change in input current will produce about 22-volts change in the output voltage with the HORIZ GAIN control set to midrange. The feedback circuit in each operational amplifier is compensated for best high-frequency response.

If the display is driven off the graticule by an excessive deflection signal, the TRACE FINDER button may be pressed to actuate switches in the horizontal and vertical amplifiers. When the switch in the horizontal amplifier is actuated, one of the operational amplifiers is disabled so that the overall sensitivity decreases by two-to-one. The clipping levels of the remaining operational amplifier will compress the horizontal deflection within the limits of the graticule.

Current-driven operational amplifiers, such as those used in the Type 647, have a low input impedance due to the negative feedback. Any change in the input current results in a nearly equal change in the feedback current. Since the open-loop sensitivity of the operational amplifier is very high, a minute difference between the input and feedback currents is sufficient to control a large voltage swing at the output.

The feedback impedance value determines the magnitude of the output voltage swing according to Ohm's law as follows:

$$\frac{\Delta V_{output}}{Z_{feedback}} = \Delta I_{feedback} \approx \Delta I_{input}$$

D361, D371, D362, and D363 limit the dynamic input current range to about 5.5 ma per side; a range adequate to provide horizontal deflection to about 2.5 cm beyond the edges of the graticule. D360 shunts excess signal current when D361 and D362 are off due to excess deflection to the left of the graticule.

The voltage at the junction of Zener diode D397 and R396 is about +120 volts. Clamp diode D395, connected to this voltage, prevents the output of the Q373-Q374 amplifier from going higher than +120 volts. Diode D396 serves the same purpose for the Q393-Q394 amplifier.

When the TRACE FINDER button is pushed, a known current is supplied to the Q393-Q394 amplifier which sets the output voltage at +55 to +75 volts. This is approximately the same voltage as would be produced by a "zero deflection" input signal. With one of the two dynamic deflection signals eliminated, the observed deflection is reduced two-to-one and the dynamic range of the Q373-Q374 amplifier, working alone, is insufficient to deflect the beam beyond the graticule limits.

HORIZ CENT is set so that the spot will be centered in the graticule when a "zero deflection" current signal is applied to the Horizontal Amplifier.

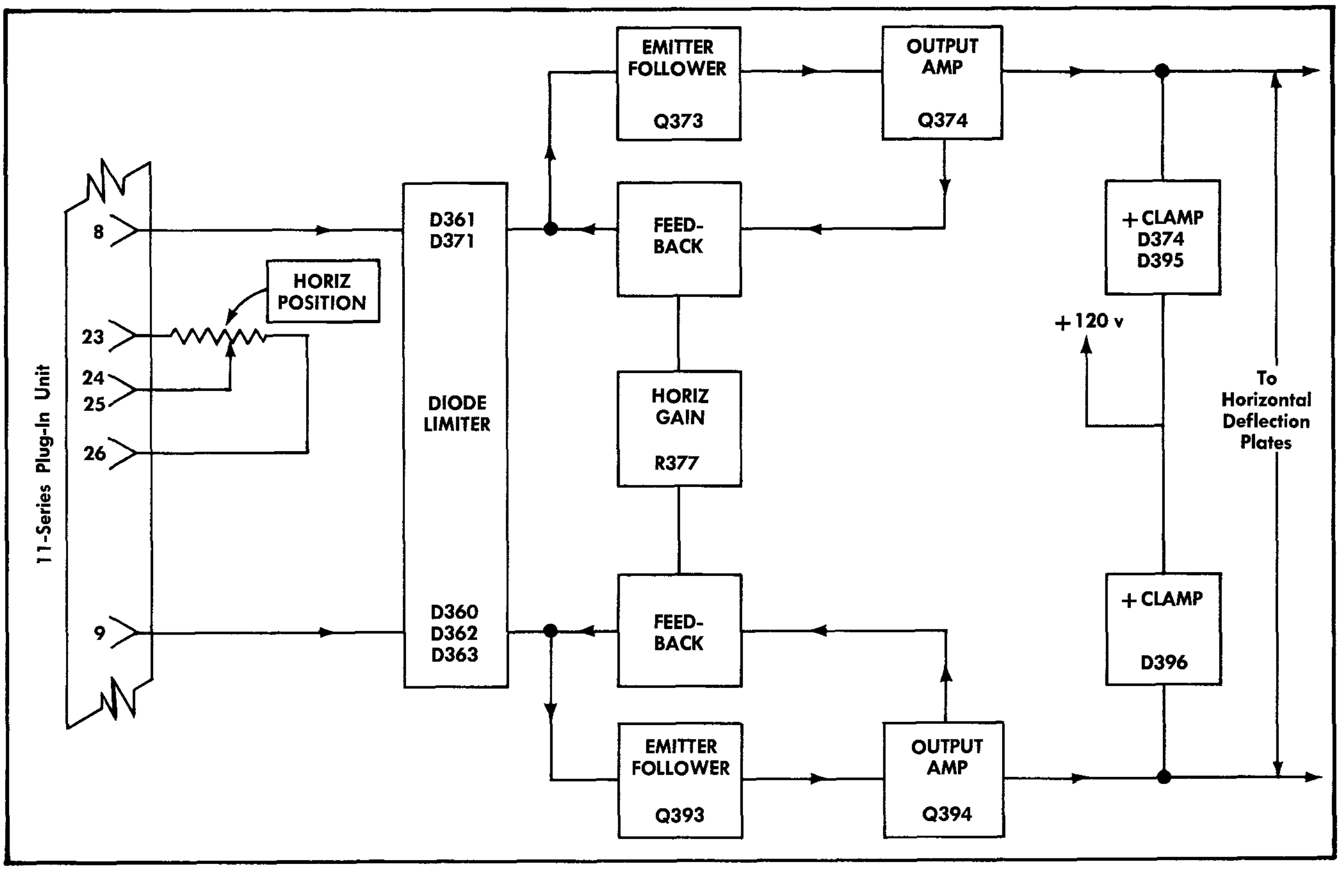


Fig. 3-2. Horizontal Amplifier block diagram.

Variable capacitors C377 and C378 and C379 are set to provide the best amplifier linearity and correct response at high sweep rates.

LOW-VOLTAGE POWER SUPPLY

The Type 647 Low-Voltage Power Supply consists of two positive and two negative interdependent accurately-regulated supplies and one positive unregulated supply. See Fig. 3-3. The most negative supply, —75 volts, is regulated by reference to a Zener diode, while the remaining regulated supplies are referenced to the —75-volt supply. The supplies are also dependent on one another since the error amplifier in each supply is powered by at least one of the other supplies.

The basic operating principle of the supplies is illustrated in Fig. 3-4. A variable resistance, in series with the load across an unregulated dc source, is varied as required so the supplied current will produce the proper voltage across the load. Control of the series resistance element, a transistor, is provided by the error amplifier which constantly compares the voltage across the load to a reference voltage. The error amplifier must detect a constant relationship between the output and reference voltages and will adjust the series resistance value as required to maintain that relationship.

With a line voltage near the center of the instrument operating range, the voltage across C612 in the —75-volt supply is about 105 volts dc. Of this voltage, 75 volts is across the load and the remainder is across the series combination of R613, R637, and Q637.

Since the Q637 emitter current is also the load current, its magnitude determines the output voltage across the load. The output voltage is sampled by divider R630-R631-R632-R634 and sets the Q614B base voltage. If the voltage across the load begins to change, the Q614B base voltage will change. The Q614A collector current will then change due to common-emitter coupling between Q614A and Q614B. The variation in Q614A collector current is amplified by Q623-Q633 and changes the Q637 current, restoring the voltage across the load to the proper value.

This negative feedback causes voltage comparator Q614A-Q614B to seek a condition of equal base voltages. The Q614A base voltage is fixed at about —9 volts by Zener diode D609. Thus, the voltage comparator forces the supply to provide an output voltage which, when divided by R630-R631-R632-R634, will also be —9 volts at the Q614B base.

It is important to note that the voltage comparator will have equal base voltages with any setting of —75 VOLTS adjustment R631 even though the output voltage may not be exactly —75 volts. To obtain a —75-volt output, R631 is set so that the resistive division ratio equals the ratio of 9 volts to the desired output voltage.

The high gain of the error amplifier at dc gives the supply a high degree of dc stability.

One difference between the —75-volt supply and the three remaining regulated supplies is in the way the voltage comparators are connected. For example, in the +100-volt supply, divider R730-R731-R732 is connected between the —75-volt reference and the +100-volt output. Since the

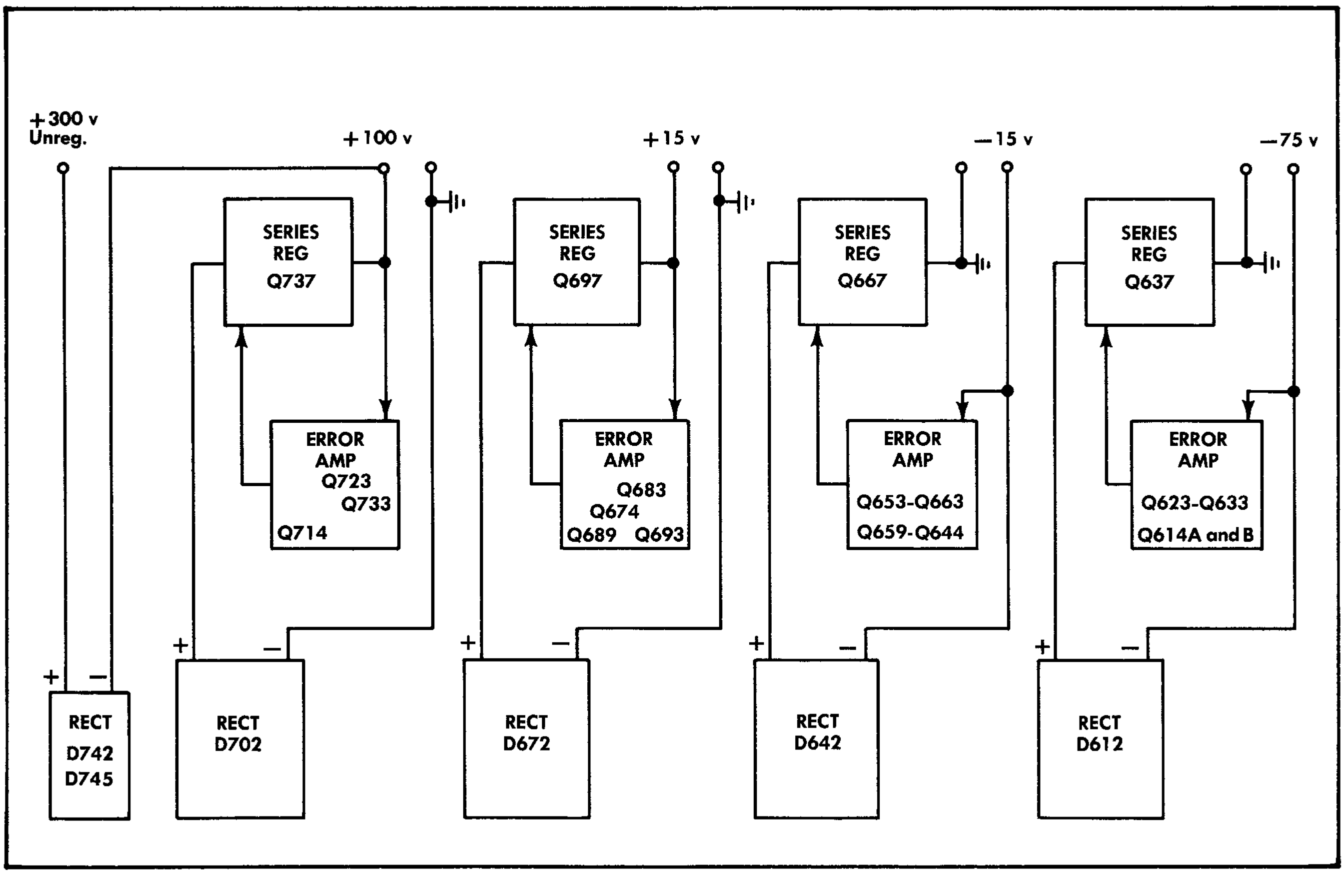


Fig. 3-3. Low-Voltage Power Supply block diagram.

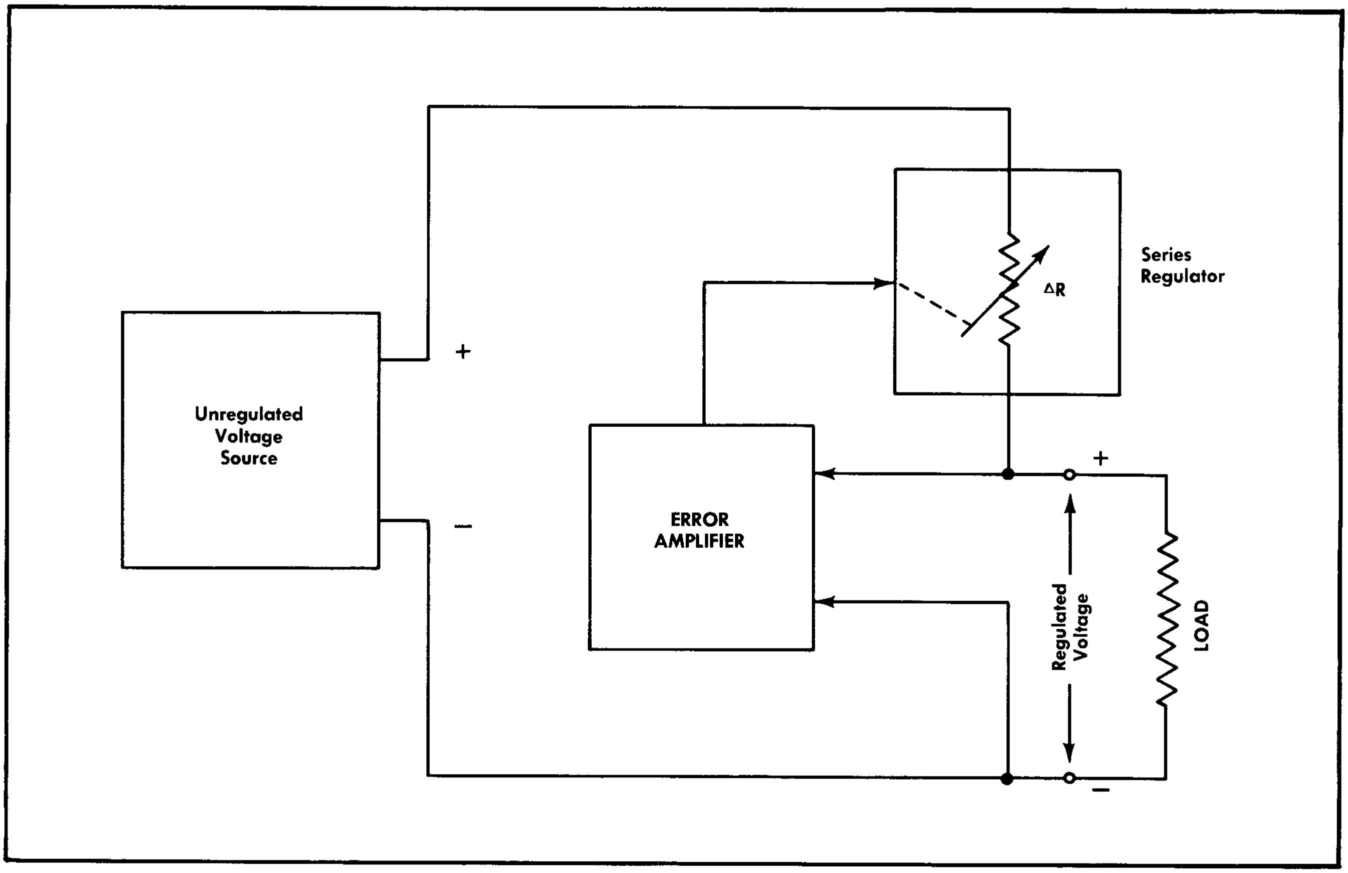


Fig. 3-4. Series regulated supply principle.

emitter of Q714 is connected to ground, any change in the +100-volt output will change the Q714 base current. This same form of voltage comparator is used in the +15-volt supply.

In the —15-volt supply, two connections are interchanged from those in the two positive voltage supplies. The emitter of Q667 is connected to ground and the emitter of Q644 is connected to the supply output. However, the operation is the same as in the +15- and +100-volt supplies; any change in the —15-volt output will produce a change in the Q644 emitter current.

CRT CIRCUIT

The Crt Circuit consists of a cathode-ray tube, its regulated high-voltage power supply, and a Z-axis (intensity) modulation amplifier. See Fig. 3-5. The crt requires operating voltages of +11.8 kv (post accelerator), —2.2 kv (cathode), —2.25 kv variable (control grid), and several lesser variable and fixed voltages for control of focus, astigmatism, geometry, etc.

The high-voltage power supply contains a controlled-amplitude oscillator which drives a step-up transformer. Rectifiers in the transformer secondaries provide the three high voltages for the crt. Negative feedback from the —2.2-kv supply through a voltage comparator regulates the oscillator output amplitude so that the —2.2 kv remains constant with variations in load. To protect the oscillator transistor from excessive dissipation, a protection circuit turns off the oscillator for about 4 seconds if the —2.2-kv supply is overloaded.

The correct ratio between the crt cathode supply voltage and the control-grid and post-accelerator supply is established by the turns ratio of the high-voltage transformer and by the CRT GRID BIAS calibration control which has the effect of a variable volts per turn ratio.

The Z-axis (intensity modulation) amplifier permits changing the crt control grid bias so that the display brightness can be controlled. The amplifier output is connected to the positive end of the floating high-voltage crt control-grid supply, and can vary the grid over a range of about 90 volts. The current input signal for the dc-coupled amplifier is obtained from the INTENSITY control, either or both plug-in units, and/or an external source through the CRT GRID connector on the rear of the instrument. Sensitivity of the wide-band, negative feedback amplifier is about 30 v/ma.

High-Voltage Power Supply

Q820 and the T820 primaries form an Armstrong oscillator. Q804 is a shunt regulator of the Q820 base drive. If Q804 conducts heavily, the base current and therefore the collector current of Q820 decrease. This decreases the ampere-turns ratio in the T820 primary, which results in a decrease in the dc high voltages developed in its secondaries. Conversely, if the Q804 conduction decreases, the magnitude of the dc high voltages will increase.

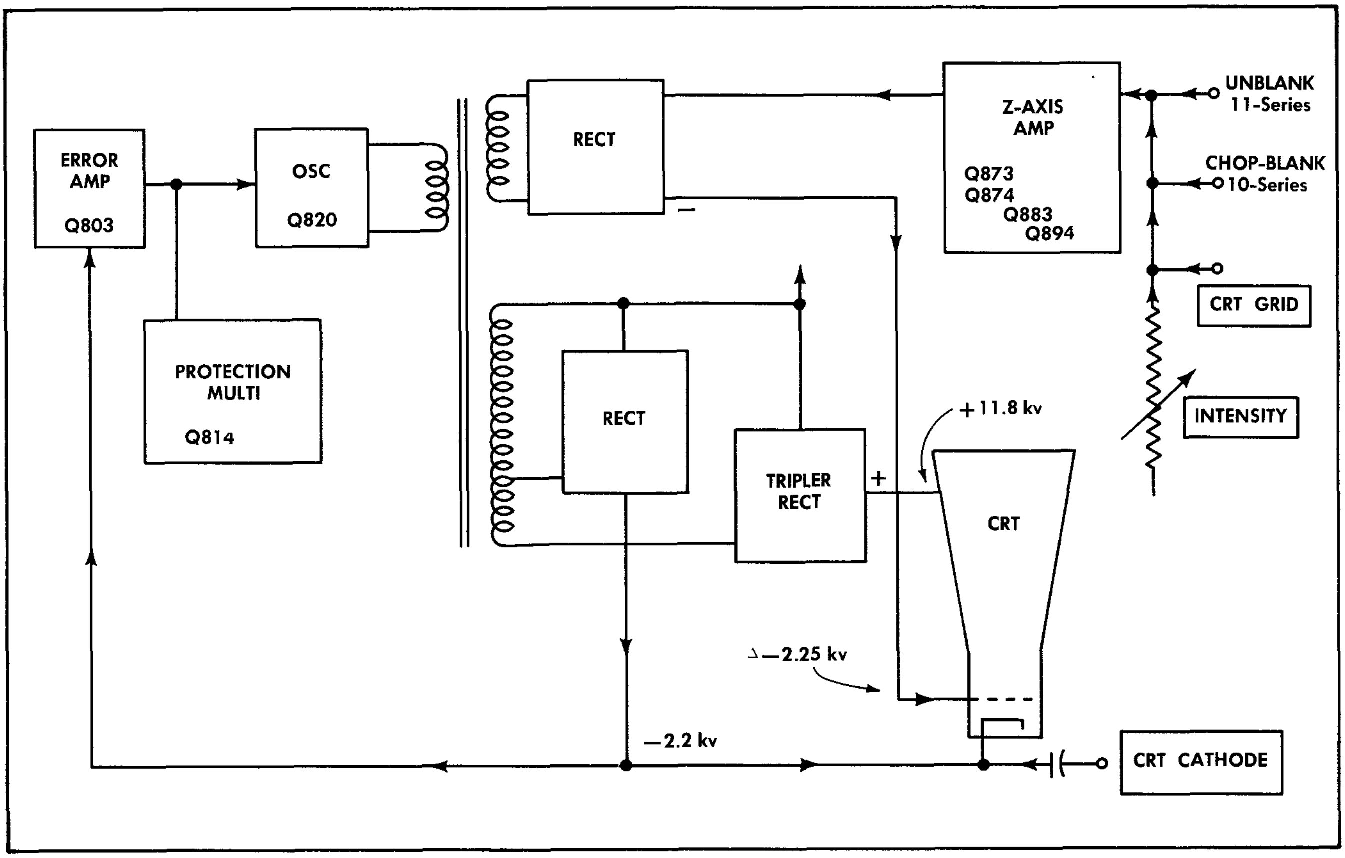


Fig. 3-5. Crt Circuit block diagram.

The conduction level of Q804 is controlled by error amplifier Q803A-Q803B which monitors the output of the —2.2-kv crt cathode supply and compares it with the +100-volt supply. When HIGH VOLTAGE control R801 is set so that the output high voltage is —2.2 kv, there is a 110 μampere current through resistors R802A-R802F. Any change in the crt cathode voltage will change the R802A-R802F current. An amplified current change at oscillator Q820 will cause a change in the oscillator output amplitude, restoring the high voltage to the proper value.

The Q814A-Q814B multivibrator protects oscillator Q820 from damage by attempting to correct for certain abnormal loads, such as accidental shorting of the high voltage during maintenance. In attempting to correct for overloads, the dissipation rating of transistor Q820 could be exceeded.

Under normal conditions, Q814A is saturated and Q814B is off. The low Q814A collector voltage holds off diode D811 and transistor Q814B. With Q814B off, capacitor C818 is charged to about 29 volts.

If the —2.2-kv supply goes out of regulation with a decrease in output voltage, the voltage at the junction of R810 and D815 will become more negative. This turns on diodes D815 and D816, diverting R817 current from the base of Q814A. The Q814A collector voltage then rises, turning on Q814B.

When Q814B turns on, its collector drops and the charge on C818 turns off D817 and Q814A. This positive feedback drives Q814B into saturation. When Q814A turns off, diode D811 turns on, clamping the Q804 base at a level which turns off oscillator Q820. Diodes D815 and D816 prevent the D811 turn-on from turning on Q814A.

When Q814B turns on, C818 begins to discharge through R817. The charge will have decreased sufficiently in about 4 seconds to turn on Q814A. Positive feedback (via the Q814B collector and C818) will drive Q814A into saturation and turn off Q814B and D811.

When D811 turns off, Q804 turns on oscillator Q820. Since no high voltage was produced while the oscillator was off, the error amplifier causes Q820 to immediately produce a very high-amplitude output. If the cause of the original overload has been removed, the crt cathode voltage will rapidly increase to —2.2 kv. The error amplifier will then decrease the Q820 output amplitude to the normal level before the temperature of transistor Q820 has risen enough to cause damage.

The protection circuit will not respond to this momentarily large error signal at the Q804 base. When Q814B turns off, C818 must be recharged. A major portion of the required charge current is supplied by Q814A base current. Thus, Q814A will be unaffected by the Q803B collector current level for about 250 milliseconds while the C818 charge is being restored. Then, if the high-voltage overload still exists, the Q803B error signal will again actuate the protection circuit.

Since only the —2.2-kv supply is regulated directly, the correct crt control-grid and post-accelerator supply voltages

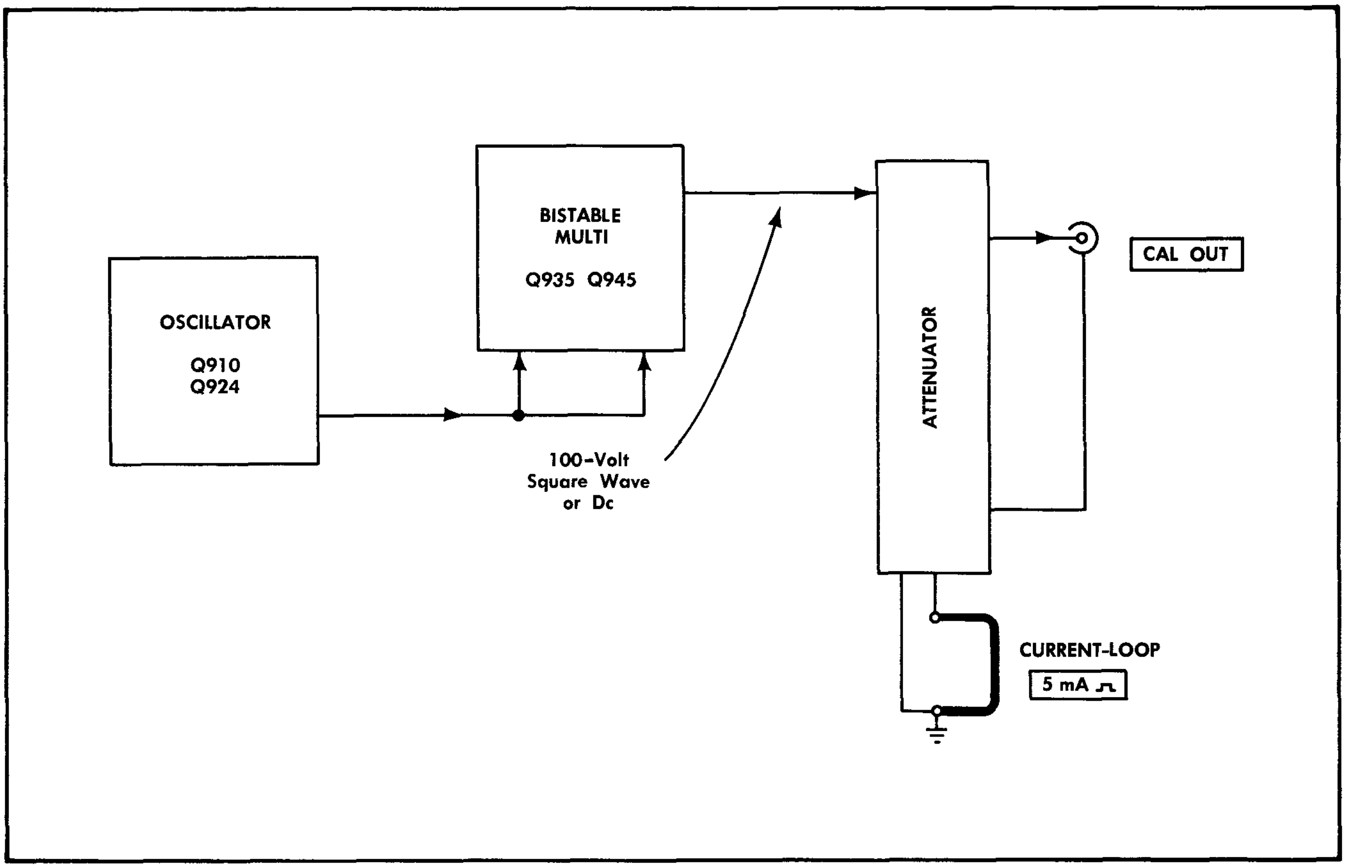


Fig. 3-6. 1-Kc Calibrator block diagram.

are established by the turns ratio of transformer T820 and by the setting of CRT GRID BIAS R832. The high-voltage oscillator will produce whatever amplitude is required to maintain the correct voltage at the negative end of C832, regardless of the voltage value at the positive end of C832. For example, if the R832 setting is changed from zero to +100 volts, the high-voltage oscillator amplitude must increase to produce an additional 100 volts across C832. The increased oscillator amplitude will also increase the voltage across C822 in the crt control-grid supply. But since the voltage at the positive-end of C822 does not vary with the setting of CRT GRID BIAS R832, the full variation appears at the crt control grid. The setting of R832 has only a slight affect on the post-accelerator supply (voltage-tripler) voltage.

Z-Axis Amplifier

The voltage at the positive end of C827 in the crt control-grid supply can be varied with no affect on the voltage across the capacitor. By varying the voltage at the positive end of C827, the crt bias and therefore the display brightness can be varied. The multiple-input Z-axis modulation amplifier provides the means for varying this bias.

Q894 provides current drive to an operational amplifier consisting of Q883 and Q874. The operational amplifier drives emitter follower Q873 which sets the voltage at the positive-end of the control grid high-voltage bias supply.

Four sources can vary the Q894 emitter current:

1. The INTENSITY control.
2. The unblanking signal from the 11-Series plug-in unit.
3. The chopped-mode blanking pulse from the 10-Series plug-in unit.
4. An external source connected to the rear-panel CRT GRID binding post.

Since the operational amplifier negative feedback via R878 makes the Q883 base a low-impedance point, the Q894 collector and Q883 base voltages are essentially constant. When any of the four current sources increases the Q894 current, the D886 current will increase causing a decrease in the Q883 and Q874 currents. The Q874 collector voltage will then rise to a level where, according to Ohm's Law:

$$\Delta V_{Q874\ collector} = R_{R878} \times \Delta I_{D886}$$

Thus ΔI_{R878} essentially equals ΔI_{D886}. (ΔI_{R878} is less than ΔI_{D886} by an amount equal to ΔI_{D886} divided by the operational amplifier open-loop gain. Since this gain is quite high, the difference is slight.) The Q874 collector voltage is applied to emitter follower Q873 which sets the crt control-grid voltage.

Capacitors C878, C877, and C879 provide control over the high-frequency response of the amplifier. During a rapid positive-going change at the emitter of Q873, C874 turns off diode D874 and boot-straps R874 to a more positive voltage, enabling the Q873 base current to rise rapidly. During a rapid negative-going change at the collector of Q874, Q873 may momentarily turn off and diode D873 will turn on to pull down the Q873 emitter voltage.

Diode D884 will clamp the Q894 collector at about +2 volts if an excessive input signal drives Q894 near turnoff. Diodes D870 and D871 protect the amplifier from the high voltage across C827 in the event that the crt control grid is shorted to chassis.

Trace rotation coil L861 provides the means for rotating the display to align the trace with the internal graticule.

1-KC CALIBRATOR

As shown in Fig. 3-6, the calibrator consists of a crystal-controlled 4-kc oscillator driving a bistable multivibrator which has clamped output levels of zero and +100 volts. These clamp levels provide a precise 100-volt peak-to-peak square wave which may be selected for output or divided to one of 17 lower amplitudes by a precision attenuator. 100-volts dc and a 5-ma square-wave output through a current loop are also available.

The clipped output of crystal-stabilized oscillator Q910-Q924 is applied to the bistable mulitivibrator through capacitors C924 and C925. Assume that Q935 has just switched off and Q945 has just switched on. When Q935 turned off, the positive-going change at its collector turned on diode D933. C924 then charges through R933 and places a substantial reverse bias on D932.

When Q945 turned on, the negative-going change at its collector turned off D943. C925 then began to discharge through R942. The discharge period is such that the negative-going portion of the first oscillator cycle following Q945 turn-on does not turn on D942. But after skipping one cycle, the C925 charge is depleted and D942 turns on during the fast, negative-going change in the second oscillator cycle. This diverts current from the Q945 base, causing the multivibrator to switch states.

Since only every other cycle of the oscillator signal causes the multivibrator to switch states, the frequency division factor is 4, instead of the usual 2.

When Q945 is on, its collector voltage is about —14 volts which turns off D948, since the attenuator series resistors are returned to chassis. When Q945 is off, D944 is off and R947 turns on both D947 and D948. The voltage across the series combination of D947 and R946 will essentially equal the voltage across D948. Thus, the voltage at the junction of D948 and R948B will switch between an accurate +100 volts, established by the 100-volt supply, and zero volts.

The attenuator accurately divides the basic 100-volt square wave to lower amplitudes and provides an accurate 50 Ω output resistance with a switch setting of .2 VOLTS and below. If the 50 Ω output is terminated in 50 Ω, the peak voltage across the termination will be one-half that indicated by the switch setting.

100-volts dc is available for use as a reference when the —15-volt supply is disconnected from the Q935 and Q945 emitters by the switch.

When the attenuator switch is set to the 5-ma square-wave position, an accurate 5 ma through the current loop is switched on and off. The accuracy of this current is established by the accurate 20-kΩ series resistance of attenuator resistors R948B through R948K.

SECTION 4
MAINTENANCE

PREVENTIVE MAINTENANCE

Cleaning the Interior

Internal cleaning should precede calibration since the cleaning process could alter the setting of certain calibration controls.

One way to clean the interior is by vacuum and/or low-pressure compressed air (high-velocity air could damage certain components). Hardened dirt may be removed with a soft paint brush, cotton-tipped swab, or cloth dampened with a water and mild detergent solution. Pay special attention to high-voltage circuits where conductive dust can cause arcing.

The contacts on the plug-in interconnecting jacks and plugs should be lightly lubricated with an oil of the type used on rotary-switch contacts. To extend the life of the contacts, clean and relubricate if the oil becomes contaminated with abrasive dust.

The plug-in unit frame-rod contact springs (located just inside the upper corners of the plug-in unit compartments) should be lubricated with a grease of the type used on rotary-switch detents (e.g. Beacon No. 325).

Visual Inspection

The instrument should be inspected occasionally for such defects as poor connections, broken or damaged ceramic terminal strips, improperly seated tubes or transistors, and heat-damaged parts. The remedy for most visible defects is obvious. But overheating is usually a symptom of other unseen defects and unless the cause is determined before parts are replaced, the damage may be repeated.

Tube and Transistor Checks

Periodic preventive maintenance checks on the tubes and transistors used in the instrument are not recommended. The circuits within the instrument generally provide the most satisfactory means of checking tube or transistor performance. Performance of the circuits is thoroughly checked during recalibration so that substandard tubes and transistors will usually be detected at that time.

Recalibration

To insure accurate measurements, the instrument calibration should be checked after each 500 hours of operation or every six months if used intermittently. Complete calibration instructions are contained in Section 5 of this manual.

The calibration procedure can be helpful in isolating major troubles in the instrument. Moreover, minor troubles not apparent during regular operation may be revealed and corrected during calibration.

Cleaning the Exterior

Loose dust may be removed with a cloth and a dry paint brush. Water and mild detergents such as Kelite or Spray White may be used. Abrasive cleansers should not be used. The graticule and crt face-plate may be cleaned with a soft, lint-free cloth dampened with denatured alcohol.

COMPONENT REPLACEMENT

General Information

Certain parts in the instrument are best replaced if definite procedures are followed as outlined in the following paragraphs.

Many electrical components are mounted in a particular way to reduce or control stray capacitance and inductance. When selecting replacement parts, it is important to remember that the physical size and shape of a component may affect its performance at high frequencies. After repair, portions of the instrument may require recalibration; see Section 5.

Standard Parts

Many components in the instrument are standard electronic parts available locally. However, all parts can be obtained through your Tektronix Field Engineer or Field Office. Before purchasing or ordering, consult the parts list to determine the value, tolerance, and rating required.

Special Parts

Some parts are manufactured or selected by Tektronix to satisfy particular requirements, or are manufactured for Tektronix to our specifications. These and most mechanical parts should be ordered directly from your Tektronix Field Engineer or Field Office. See "Parts Ordering Information" and "Special Notes and Symbols" on the first page of Section 6.

Soldering

Special silver-bearing solder is used to establish a bond to the ceramic terminal strips in Tektronix instruments. This bond may be broken by repeated use (especially if ordinary tin-lead solder is used) or by excessive heating. We recommend solder containing about 3% silver. A small supply of this solder is provided on a spool mounted inside the instrument. Additional silver-bearing solder is usually available locally or may be purchased in one-pound rolls through your Tekrtonix Field Engineer or Field Office. Order by part number 251-514.

Soldering To Ceramic Strips:

1. Use a wedge-shaped soldering-iron tip about 1/8-inch wide. This will allow you to apply heat directly to the solder in the terminal without touching the ceramic, thereby reducing the amount of heat required.
2. Maintain a clean, properly tinned tip.
3. Use a hot iron for a short time. A 50- to 75-watt iron with good heat storage and transfer properties is adequate.
4. Avoid putting pressure on the strip with the soldering iron or other tools. Excessive pressure may cause the strip to crack or chip.

Ceramic Terminal Strips

Fig. 4-1 shows an assembled ceramic terminal strip. Replacement strips with studs attached are supplied under a single part number and spacers under another number. The original spacers may be reused if undamaged.

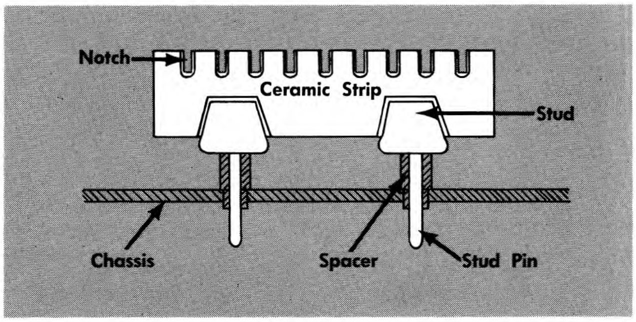


Fig. 4-1. Ceramic strip assembly.

Usually, a strip can be pried out of the chassis or pulled out with a pair of pliers. In some cases, you may choose to use a hammer and punch to drive out the studs from the opposite side of the chassis.

When the damaged strip has been removed, place new or used (but undamaged) spacers in the chassis holes. Then carefully force the studs of the new strip into the spacers until they are completely seated. If necessary, use a soft-faced mallet, tapping lightly directly over the stud area of the strip.

Switch Replacement

Individual wafers normally are not replaced in switch assemblies. Replacement switches may be ordered from Tektronix either unwired or with the associated wires and components attached. See parts list, Section 6.

When soldering leads to a switch, do not let solder flow around and beyond the terminal rivet as this may destroy the contact spring tension.

Tubes and Transistors

Tubes and transistors should not be replaced unless actually defective. When a defect is suspected, it is suggested that circuit conditions be checked first to be certain that a replacement tube or transistor will not be immediately destroyed. In some cases, these checks will also show whether or not the tube or transistor is at fault.

When circuit conditions are known to be safe, install a tube or transistor of the same type that is known to be good and check for proper operation. If the original tube or transistor proves acceptable, return it to its original socket to avoid unnecessary recalibration.

Cathode-Ray Tube and Shield

The following procedure outlines the removal and replacement of the crt. Supplementary steps for removal and replacement of the crt shield are included. Replacement of certain components on the adjacent chassis is easier with the shield removed.

WARNING

Use care when handling a crt. Avoid striking it on any object that might cause it to crack and implode. Flying glass from an imploding crt can cause serious injury. Safety glasses or a plastic face mask are recommended.

To Remove the Crt:

1. Remove the four bezel nuts and the bezel.
2. Slip off the face-plate shield.
3. Remove the high-voltage anode connector.
4. Remove the four deflection-plate leads. Be careful not to bend the crt connector pins.
5. Open the rear radiator door and remove the crt base socket.
6. Loosen the base clamp screw.
7. Start the crt forward by pressing on the crt base center pin.
8. Remove the crt.

To Replace the Crt:

1. Insert the crt.
2. All four edges of the flange around the crt face-plate should touch the front panel of the instrument, but must not be forced. Instead, the crt base clamp should be repositioned so that all four edges of the flange contact the front panel at the same time when the crt is inserted. The crt base clamp is held in place by two allen-head machine screws which are accessible from the rear of the instrument through holes in the power-supply chassis. Loosen the screws and reposition the clamp as required. When the physical alignment of the crt is correct, tighten the machine screws and proceed with the next step. Do not tighten the clamp to the crt base at this time.

3. Replace the base socket, deflection plate leads, and anode lead.
4. Clean the crt face-plate and face-plate shield, and then mount the face-plate shield and the bezel. Tighten the four bezel nuts.
5. Push lightly on the crt base socket to be certain that the crt is as far forward as it will go and then tighten the base clamp.

To Remove and Replace the Crt Shield:

1. With the crt removed, take out the four screws holding the front end of the shield and the two screws holding the rear.
2. Remove the grommet from the anode connector opening.
3. Slide the shield out so that the Trace Rotation Coil leads are accessible. Unsolder the leads, noting the polarity for reinstallation. The shield can now be separated from the instrument.
4. To reinstall the shield, reverse the above procedure.

CORRECTIVE MAINTENANCE

Troubleshooting Aids

This manual and the instrument contain many features intended to speed and simplify maintenance.

The schematics in Section 6 provide a circuit reference number for each electrical component as well as important operating voltages, signals, and conditions for their measurement. The range of circuit reference numbers associated with a particular schematic appear on that schematic. The block diagram provides an overall picture of instrument operation.

Most of the wire in the instrument is color striped to aid in circuit tracing. All regulated low-voltage power supply leads are coded as follows:

1. The basic wire color indicates voltage polarity: tan for negative, white for positive.
2. The stripe colors indicate supply voltage according to the standard EIA color code. Stripes are read in order of decreasing width.

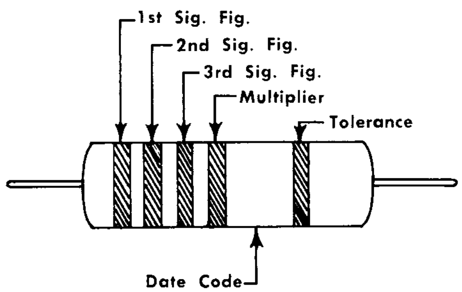


Fig. 4-2. Standard EIA color code for metal film resistors.

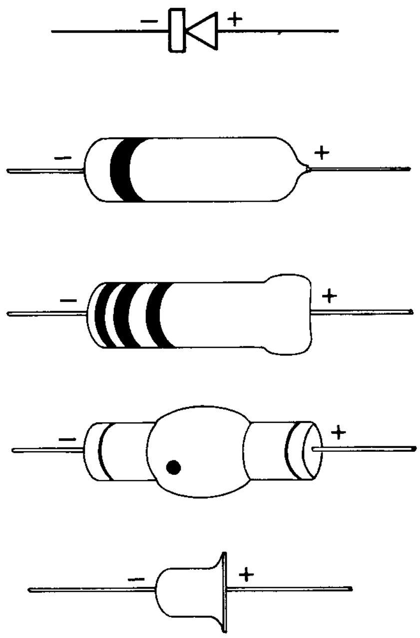


Fig. 4-3. Diode polarities.

For example, the —75-volt supply leads are tan wire (negative) bearing stripes of violet (seven), green (five), black (no zero).

The instrument contains a number of stable metal-film resistors identified by their gray background color and color coding. If a resistor has three significant figures and a multiplier, it will be EIA color coded. If it has four significant figures and a multiplier, the value will be printed on the resistor. For example, a 333 k resistor will be color coded, but a 333.5 k resistor will have its value printed on the resistor body. The color coding sequence is shown in Table 4-1 and Fig. 4-2.

TABLE 4-1
Color Code Sequence

Color	1st Sig. Fig.	2nd Sig. Fig.	3rd Sig. Fig.	Multiplier	(±) % Tolerance
Black	0	0	0	1	—
Brown	1	1	1	10	1
Red	2	2	2	100	2
Orange	3	3	3	1,000	—
Yellow	4	4	4	10,000	—
Green	5	5	5	100,000	0.50
Blue	6	6	6	1,000,000	0.25
Violet	7	7	7	10,000,000	0.10
Gray	8	8	8	100,000,000	0.05
White	9	9	9	1,000,000,000	—
Gold				0.1	5
Silver				0.01	—
No Color					10

Switch wafers shown on the schematics are coded to indicate the physical positions of the wafers on a rotary switch. The number portion of the code refers to the wafer position as counted from the front- or driven-end of the switch shaft. Letters F and R indicate whether the front or rear of the wafer is used to perform the particular switching function.

Important test points are marked (e.g. TP374) on the schematics and on the instrument chassis. Pictures on a fold-out page following the schematics show the general locations of these test points.

Fig. 4-3 identifies the polarity of the various diode types used in the instrument.

The following chart lists the proper current ratings for fuses in the Type 647.

Fuse	117-Volt Range	234-Volt Range
F601	3 amp slow-blow	1.5 amp slow-blow
F602	4 amp slow-blow	
F613	0.5 amp fast-blow	
F703	0.75 amp fast-blow	
F743	0.75 amp fast-blow	
F820	2 amp fast-blow	

SECTION 5
CALIBRATION

Introduction

This section of the manual contains a complete calibration procedure for the Type 647 Oscilloscope. The instrument will not require frequent recalibration, but occasional adjustments will be necessary as components age or are replaced.

Calibration is a valuable part of preventive maintenance since many types of minor troubles may be discovered and corrected before they become serious enough to disable the instrument. Major troubles are often more easily isolated to a particular section of the instrument by attempting calibration.

Equipment Required

1. Tektronix Type 10/11M1 Test Unit.

2. Tektronix 11-series time base plug-in unit.

3. Autotransformer such as Variac or Powerstat. Required characteristics: Output voltage range covering the full line-voltage range of the Type 647. Volt-ampere rating of at least 500.

4. Ac voltmeter, calibrated in rms, for minitoring the autotransformer output. Required characteristics: 2% accuracy over the full line-voltage range of the Type 647.

5. Dc voltmeter such as the Fluke Model 803 or the Electro Instruments Model Eitronic 880. Required Characteristics: Input resistance at least 1 megohm. Accuracy at least ±0.05% of reading between 100 millivolts and 100 volts.

6. Oscilloscope such as the Tektronix Type 540- or 550-series with a Type D Plug-In and a Type L Plug-In. Required characteristics: Type D Plug-In—Maximum calibrated sensitivity of at least 5 mvolts/div. Type L Plug-In—Bandpass of at least 20 mc.

7. Dc voltmeter. Required characteristics: Range to at least 2.5 kv full scale. Input resistance of at least 20 kΩ/v. Accurate within 2% at 2.2 kv and within 10% at 300 volts.

8. Time-mark generator such as the Tektronix Type 180A. Required characteristics: Marker intervals of 1 millisecond and 20 nanoseconds (50-mc sine wave). Accuracy of at least ±0.01%.

9. Constant-Amplitude Signal Generator, Tektronix Type 190A or 190B. Signal Generator used must provide a 200-millivolt signal variable in frequency from 500 kc to 50 mc. The signal amplitude must remain constant (200 mv) over the entire frequency range.

10. TU-5 Pulser complete kit, Tektronix Part No. 015-043, contains the following items*:

Qty.	Description	Part Number
1	TU-5 Pulser (alone) with BNC plug-and-jack connector fittings.	015-038
1	50-ohm termination with BNC plug-and-jack connector fittings.	011-049
1	50-ohm 10:1 T attenuator, ½ w, with BNC plug-and-jack connector fittings.	010-314
1	Connector adapter with UHF-plug and BNC-jack connector fittings.	103-015
1	50-ohm (nominal impedance) coaxial cable, 42" long, with a BNC connector on each end.	102-057

11. Tektronix 50 Ω 5XT attenuator: part number 011-060.

12. Miscellaneous

1—Insulated screwdriver: part number 003-001.

1—Adapter, BNC to alligator clips: part number 013-076.

***If desired, any of the following items can be ordered separately through your local Tektronix Field Engineering Office. When ordering, give complete description and part number.**

PRELIMINARY PROCEDURE

1. Remove the covers from the Type 647.

2. Disengage the captive screws which hold the heat-sink door closed.

3. Install the Type 10/11M1 plug-in unit in the horizontal compartment of the Type 647.

4. Connect the Type 647 and the ac voltmeter to the powerline autotransformer output.

5. Connect the autotransformer to the appropriate line-voltage source and set for an output near the center of the line-voltage range for which the Type 647 is wired.

6. Set the controls on the Type 647 and Type 10/11M1 as listed in Table 5-1.

TABLE 5-1

Type 647	
INTENSITY	Counterclockwise
FOCUS	Midrange
ASTIG	Midrange
SCALE ILLUM	Counterclockwise
1 KC CALIBRATOR	OFF
HORIZ POSITION	Midrange
Type 10/11M1	
Horiz Cal	5
Load	Zero
Source (voltage)	—75 v
(function)	Gnd
Pulse Rate	OFF

7. Turn on the instrument power and allow several minutes for warmup.

NOTE

Pictures on a fold-out page preceding the schematics show the location of each calibration control and each of the numbered test points listed in the schematics.

CHECK AND ADJUSTMENT PROCEDURE

Low-Voltage Power Supplies

1. Adjust Voltage; Check Ripple and Regulation

NOTE

The following ripple checks can produce erroneous indications unless ground-loop hum is minimized. To minimize hum the Type 647 and the ripple-monitoring test oscilloscope should be powered from the same convenience outlet.

Proper power supply operation at the lower line-voltage limit requires that the line-voltage sine wave contains less than 1% distortion.

a. Connect the dc voltmeter between TP632 in the —75-volt supply and ground. Connect the ground lead to the power supply chassis as near as possible to the test point. Adjust —75 VOLTS R631 for a meter reading of —75 volts.

CAUTION

Do not reset the —75 v control unless the power supply voltages are actually out of tolerance (see Table 5-2) or you are planning to perform a complete calibration of the instrument.

b. Connect a coaxial cable from the Output connector on the Type 10/11M1 to the input connector on the plug-in of the test oscilloscope. Set the test oscilloscope controls to trigger and display automatically a line-frequency waveform with an amplitude of 5 mvolts or less. The waveform must be dc-coupled into the vertical amplifier of the test oscilloscope.

c. With the Source function switch on the Type 10/11M1 set at Gnd, position the trace on the test oscilloscope to a convenient reference point. With the test oscilloscope and plug-in set as in step (b), each 5 mvolts of deflection away from the reference point will indicate 0.1% of error in the supply voltage. The allowable error in each supply can be found in Table 5-2

d. Set the Source function switch on the Type 10/11M1 to Dc Error and reset R631 (—75 VOLTS) for no deflection of the trace on the test oscilloscopes as the Source function switch is moved between the Gnd and Dc Error positions.

e. Set the 10/11M1 Source function switch to Dc Error and the Load switch to Full. Check that the trace deflection does not equal more than 0.1% providing the supply was adjusted in step (d). Set the Load switch to Zero and the Source function switch to Ripple.

f. With the power-line autotransformer set for a line-voltage near the center of the Type 647 operating range (indicated on a metal tag on the rear panel), check that the ripple is within the limits given in Table 5-2.

g. Set the power-line autotransformer for the lower line-voltage limit (design-center voltage less 10%) of the Type 647 and the 10/11M1 Load switch to Full. Check that the ripple is within the limit given in Table 5-2.

h. Set the power-line autotransformer for the upper line-voltage limit (design-center +10%) of the Type 647 and the 10/11M1 Load switch to Zero. Check that the ripple is within the limits given in Table 5-2 in each of the four regulated supplies.

i. Reset the power-line autotransformer for a line voltage near the center of the Type 647 operating range Disconnect the voltmeter and reset the Type 10/11M1 controls to the positions listed in Table 5-1 except for the Source voltage switch.

j. Repeat steps (a) through (i) for each remaining supply in the order listed in Table 5-2. Be sure to adjust the supplies in the order listed and then recheck all supply voltages. It may be necessary to adjust the supplies a second time.

After the regulation checks have been made on the —15-volt supply, the test oscilloscope may be disconnected from the Type 10/11M1 plug-in. The +300-volt supply is checked using the dc voltmeter at TP742. The ripple is checked at TP742 by connecting a probe between the test point and the test oscilloscope.

Crt Circuit

1. Adjust HIGH VOLTAGE R801

a. Connect the high-voltage dc voltmeter between the chassis and the HV TEST POINT TP833.

b. Adjust R801 for an exact 2.2 kv meter indication.

TABLE 5-2

Supply Voltage	Test Point	Tolerance at Midrange Line Voltage	Maximum Ripple (mv p-p)	Voltage Control
—75 v	TP632	±0.3%	2	—75 VOLTS R631
+100 v	TP737	±0.5%	2	+100 VOLTS R731
+15 v	TP697	±0.5%	1.5	+15 VOLTS R691
—15 v	TP644	±0.5%	1.5	—15 VOLTS R661
+300 v	TP742	±10%	10 v	Unregulated

2. Check High-Voltage Regulation

a. Set the power-line autotransformer for the lower-limit operating voltage of the Type 647.

b. With the crt beam positioned off-screen, slowly turn the INTENSITY control from stop to stop several times and check that the high voltage remains constant.

NOTE

Few high-voltage meters will resolve the slight voltage change (less than 10 volts) that normally occurs. Hence, unless a high-resolution meter is used, no change in the high voltage should be detected.

c. Reset the power-line autotransformer for a voltage near the center of the Type 647 operating range.

d. Reset the INTENSITY control counterclockwise and disconnect the voltmeter.

3. Adjust CRT GRID BIAS R832

a. set:

CRT GRID BIAS R832	Counterclockwise
POSITION (Type 10/11M1)	Midrange

b. Set the INTENSITY control so the knob-pointer indicates 8.5.

c. Turn CRT GRID BIAS clockwise to obtain a dim spot.

d. Reset the INTENSITY control to 0.

4. Adjust TRACE ROTATION (front panel)

a. Remove the Type 10/11M1 from the horizontal compartment and install a 10-series plug-in in the vertical compartment and an 11-series plug-in in the horizontal compartment.

b. Set the 11-series plug-in for a free-running sweep with a rate of 1 msec.

c. Set the INTENSITY control for a trace of moderate brightness.

d. Center the trace vertically and horizontally.

e. Set the FOCUS control for minimum trace thickness.

f. Adjust TRACE ROTATION (front panel) so that the trace is parallel with the horizontal graticule lines.

5. Adjust GEOMETRY R863

a. Set:

1 KC CALIBRATOR	2 VOLTS
Input coupling (10-series)	Ac
Time/cm (11-series)	1 msec
Trigger mode (11-series)	Automatic
Source (11-series)	Internal

b. Connect a coaxial cable between the CAL OUT connector and the vertical input connector.

c. Set the volts/cm switch (10-series) to .2 and turn the variable control counterclockwise to obtain a 6-cm display amplitude.

d. Set the 11-series trigger level control, if used, for a triggered display.

e. Set the FOCUS and ASTIG controls for a well defined display.

f. Adjust GEOM R863 so that the row of pulse tops and the row of pulse bottoms form straight lines.

g. Increase the intensity to observe the vertical lines of the display.

h. Adjust R865 (Y AXIS ALIGN) so that the vertical lines of the pulses are perpendicular to the horizontal graticule lines.

i. Set the INTENSITY control counterclockwise and remove the signal connection.

6. Adjust Z-Axis Amplifier High-Frequency Response C879

a. Set:

Time/cm (11-series)	.5 μsec
Trigger mode (11-series)	Free running

b. Set the INTENSITY control for a dim trace.

c. Horizontally position the trace so the left end is near the center of the graticule.

d. Slowly turn C879 and note the action of the adjustment. A small segment (about 1-millimeter long) at the left end of the trace should vary in brightness.

e. Adjust C879 so the brightness of the trace segment most nearly matches that of the remainder of the trace.

f. Set the INTENSITY control to 4 and the time/cm control of the 11-series plug-in to .1 μsec.

g. Connect a 10X probe from the test oscilloscope (with 20 mc plug-in installed) to TP873 and observe a pulse about 35 volts high with a dc level of about +10 volts. Set the sweep rate of the test oscilloscope to 1 msec/cm.

h. Rotate the INTENSITY control from 0 to 8.5 and observe a pulse which varies from zero volts amplitude with a dc level of +10 volts to an amplitude of about +55 volts with a dc level of +40 volts.

i. Set the INTENSITY control to obtain a pulse with a 30-volt amplitude at TP873.

j. Check the risetime of the pulse in step (i); it should be less than 50 nsec. The overshoot on the pulse should be less than 3%.

k. Turn the INTENSITY control fully clockwise. Set the trigger mode control of the 11-series plug-in to single sweep, and position the spot off the crt.

l. Connect the output of a Type 190B to the CRT GRID connector.

m. Adjust the Type 190B controls to obtain a 4-volt 50-kc signal at TP873.

n. Adjust the test oscilloscope so that the 4-volt 50-kc signal is ac coupled into the test oscilloscope and will produce a 4-division display.

o. Increase the Type 190B output frequency to 10 MC and check the display of the test oscilloscope for a signal amplitude of at least 2.8 divisions.

p. Disconnect the Type 190B and test oscilloscope.

q. Set the INTENSITY control for normal trace brightness.

7. Check Alternate Sweep and Chopped Blanking

a. Do not do this check unless your 10-series plug-in has alternate and/or chopped provisions.

b. Set:

Mode (10-series)	Alternate
Time/cm (11-series)	.5 μsec
Trigger mode (11-series)	Free running

c. Check for dual trace in all sweep rates.

d. Set the mode switch (10-series) to chopped, the time/cm switch (11-series) to 5 μsec, and the trigger mode switch (11-series) to normal.

e. Adjust the trigger level control (11-series) to obtain a stable display and check for no vertical lines being visible at normal intensity.

1-Kc Calibrator

1. Check Voltage Accuracy

a. Turn off the instrument power and remove transistor Q945.

b. Restore instrument power.

c. Connect the precision dc voltmeter to the CAL OUT connector with a coaxial cable.

d. Set the 1 KC CALIBRATOR switch to 100 VOLTS or 100 VDC and check that the output dc voltage is between 99 and 101 volts.

NOTE

The accuracy of the 1 Kc Calibrator 100-volt output is dircetly determined by the accuracy of the +100-volt power supply.

e. Check the output voltage at each switch setting listed in Table 5-3.

TABLE 5-3

1 KC CALIBRATOR	Tolerance
50 VOLTS	49—51 v
20 VOLTS	19.6—20.4 v
10 VOLTS	9.8—10.2 v
5 VOLTS	4.9—5.1 v
2 VOLTS	1.96—2.04 v
1 VOLT	0.98—1.02 v
.5 VOLT	0.49—0.51 v
.2 VOLT	0.196—0.204 v
.1 VOLT	0.099—0.101 v

NOTE

Due to the type of attenuator used in the 1 Kc Calibrator, the remaining voltages need not be checked.

f. Turn off the instrument power and install transistor Q945.

g. Restore instrument power.

2. Check Frequency Accuracy

a. Set:

1 KC CALIBRATOR (647)	1 VOLTS
Volts/cm (10-series)	2
Mode (10-series)	To display one channel only
Time/cm (11-series)	1 msec
Trigger mode (11-series)	Normal
Trigger level (11-series)	0
Coupling (11-series)	Ac low-frequency reject
Source (11-series)	External

b. There should not be a trace on the crt. Connect a coaxial cable between the CAL OUT and the trigger input (11-series) connectors. There should now be a trace on the crt.

c. Apply 1-millisecond and 1-second markers from the Type 180A to the vertical input. Set the trigger level control on the 11-series plug-in for the most stable display.

d. Check the frequency accuracy by checking the drift of the 1-millisecond markers across the crt for a period of 10 seconds, using the 1-second markers to count the 10-second time period. There should be no more than 5 cm of drift in the 10-second time period.

e. Remove the signal connections.

Horizontal Amplifier

1. Adjust HORIZ CENT R364

a. Remove the 10- and 11-series plug-ins from the Type 647 and install the Type 10/11M1 in the horizontal compartment.

b. Set Type 10/11M1:

Horiz Cal	5
Load	Zero
Pulse Rate	Off
Position	Midrange

c. Set the INTENSITY, FOCUS, and ASTIG controls for a fine and dim spot.

d. Adjust R364 HORIZ CENT to position the spot on the center vertical graticule line.

2. Adjust HORIZ GAIN R377

a. Set the Type 10/11M1 Horiz Cal to 1 and adjust R377 HORIZ GAIN to place the spot on the first centimeter line.

Set the Horiz Cal to 9 and check that the spot is on the ninth centimeter line; if it is not adjust the HORIZ GAIN until the spot is on the first and ninth centimeter graticule lines as the Type 10/11M1 Horiz Cal control is switched between 1 and 9.

b. Recheck the HORIZ CENT to insure that the spot is still on the center vertical graticule line when the Type 10/11M1 Horiz Cal control is set to 5.

3. Adjust C378, C377, and C397

a. Remove the Type 10/11M1 from the Type 647 and install an 11-series plug-in in the horizontal compartment and a 10-series plug-in in the vertical compartment.

b. Set:

Input coupling (10-series)	Ac
Volts/cm (10-series)	2
Time/cm (11-series)	.2 μsec
Trigger mode (11-series)	Normal
Source (11-series)	Internal

c. From the Type 180A, apply a 50 MC sine-wave signal to the vertical input connector of the 10-series plug-in and adjust the trigger level control of the 11-series plug-in for a stable display.

d. Set the HORIZ POSITION so that the display is centered. Turn the 11-series plug-in magnifier so that a sweep rate of 20 nsec/cm is achieved.

e. Push the TRACE FINDER and adjust C397 for best linearity.

f. Release the TRACE FINDER and set the sweep rate to 10 nsec.

g. Set the HORIZ POSITION control to position the first five centimeters of sweep to the left of the first centimeter graticule line.

h. Adjust C377 so that the 1 cycle/2 cm display has a peak lined up with the first and ninth centimeter graticule lines. The peaks between the first and ninth graticule lines should be within ± 2 mm of their respective graticule lines.

i. Repeat steps (d), (e), (f), (g), and (h) to obtain optimum linearity and timing.

j. Remove input signal.

Vertical Amplifier

1. Adjust VERT CENT R441

a. Remove the 10-series plug-in from the vertical compartment and install the Type 10/11M1 into that compartment.

b. Set:

Vertical (Type 10/11M1)	Time Mark
Pulse Rate (Type 10/11M1)	Off
Position (Type 10/11M1)	Midrange
Magnifier (11-series)	Off
Trigger mode (11-series)	Normal
Trigger level (11-series)	0
Source (11-series)	External
Display (11-series)	Time base

c. Adjust R441 VERT CENT to position the spot on the center horizontal graticule line.

2. Adjust VERT GAIN R414

a. Set the Type 10/11M1 Vertical to +3 cm Dc Calibrate and adjust R414 VERT GAIN to place the spot on the top graticule line. Set the Vertical to —3 cm Dc Calibrate and check that the spot is on the bottom graticule line; if it is not adjust the VERT GAIN until the spot is on the top and bottom graticule lines as the Type 10/ 11M1 Vertical control is switched between +3 cm and —3 cm Dc Calibrate positions.

b. Recheck the VERT CENT to insure the spot is still on the center horizontal graticule line when the Type 10/11M1 Vertical control is set to Time Mark.

3. Adjust Vertical-System High-Frequency Response

a. Set:

Vertical (Type 10/11M1)	+ Pulse Polarity
Pulse Rate (Type 10/11M1)	One of the middle ranges
Amplitude (Type 10/11M1)	To obtain a 4-cm high pulse.
Position (Type 10/11M1)	To position top of pulse 2 cm above horizontal centerline.
Trigger mode (11-series)	Automatic
Slope (11-series)	+
Coupling (11-series)	Ac low-frequency reject
Source (11-series)	Internal

b. Adjust the trigger level for a stable display.

c. Adjust sweep rate of 11-series plug-in to obtain enough magnification to see the effect of the adjustment being made.

d. Adjust the high-frequency compensation:

1. Adjust R456D DAMPING to produce ringing on the front corner of the pulse, and then turn the control back until the ringing just disappears.

2. Adjust C484 and then C467 to make the front 10-50 nsec region of pulse top as straight and level as possible.

3. Adjust C456D to make the front pulse corner appear square with less than ½ m of overshoot, rolloff, or ringing.

e. Repeat the adjustments in step (d) until the best possible response is obtained. It may be necessary to slightly readjust R456D DAMPING to obtain minimum aberrations in the top of the waveform.

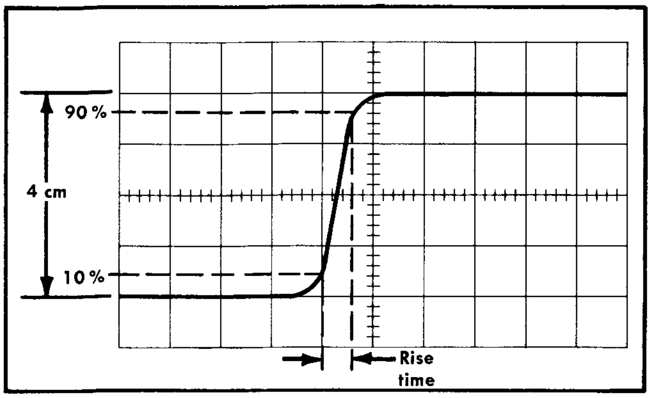


Fig. 5-1. Measuring positive going pulse risetime.

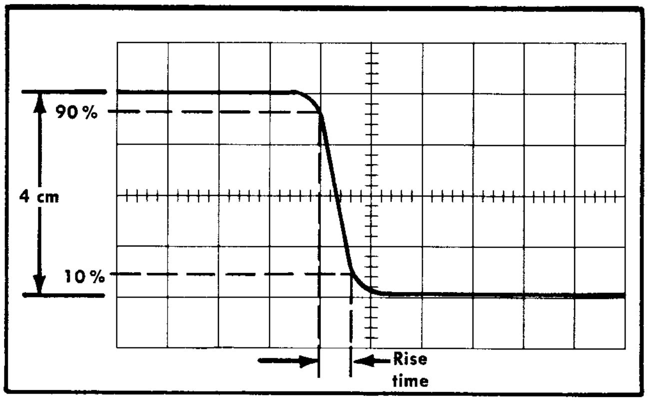


Fig. 5-2. Measuring negative going pulse risetime.

f. Set the 11-series plug-in for a sweep rate of 10 nsec/cm.

g. Check the risetime of the display (see Fig. 5-1); it should measure 6 nsec or less, from the 10% point to the 90% point.

4. Check Vertical-System Negative Response

a. Set:

Vertical (Type 10/11M1)	— Pulse Polarity
Amplitude (Type 10/11M1)	To obtain a 4 cm high pulse.
Position (Type 10/11M1)	To position bottom of pulse 2 cm below horizontal center-line.
Slope (11-series)	—

b. Check for the same response as seen in steps (d) and (e).

c. If necessary readjust R456D, C484, C467, and C456D slightly to obtain the same pulse shape in the negative polarity as in plus polarity.

d. Set the 11-series plug-in for a sweep rate of 10 nsec/cm.

e. Check the negative risetime of the display (see Fig. 5-2); it should measure 6 nsec or less, from the 10% point to the 90% point.

5. Check Step Response Variation and Amplitude and Dynamic range (±9 cm)

a. Set:

Vertical (Type 10/11M1)	— Pulse Polarity
Amplitude (Type 10/11M1)	To obtain a 6 cm high pulse.
Position (Type 10/11M1)	To position bottom of pulse on bottom graticule line.
Slope (11-series)	+

b. Vary the Type 10/11M1 Amplitude control and check for step reponse variations.

c. Set the Amplitude control as in step (a).

d. Check for less than 2 mm of overshoot on the bottom of the waveform.

e. Position the bottom of the pulse to the top graticule line. The rolloff at the front bottom corner should be less than 2 mm.

f. Set:

Vertical (Type 10/11M1)	+ Pulse Polarity
Position (Type 10/11M1)	To position top of pulse to top graticule line.

g. Do steps (b) and (c) for the + pulse.

h. Check for less than 2 mm of overshoot on the top of the waveform.

i. Position the top of the pulse to the bottom graticule line. The rolloff of the top corner should be less than 2 mm.

j. Position the top of the pulse 1 cm above the centerline and then adjust the pulse amplitude to obtain a 2 cm high pulse.

k. Position the pulse to the top and bottom areas of the graticule and note the compression or expansion of the display. The total compression and expansion must be less than ½ mm.

6. Check Delay Line Aberrations and Termination

a. Set:

Vertical (Type 10/11M1)	+ Pulse Polarity
Amplitude (Type 10/11M1)	To obtain a 4 cm high pulse.
Position (Type 10/11M1)	To center pulse on crt.
Slope (11-series)	—

b. Check the aberrations on the bottom of the waveform. They should not exceed ½ mm in height.

c. Remove the Type 10/11M1 and install a 10-series plug-in in the vertical compartment.

d. Set:

Position (10-series)	Midrange
Volts/cm (10-series)	.01
Input coupling (10-series)	Dc
Time/cm (11-series)	0.1 μsec
Magnifier (11-series)	Off
Trigger Mode (11-series)	Normal
Slope (11-series)	+
Coupling (11-series)	Ac low-frequency reject
Source (11-series)	Internal

e. Connect a Type TU-5 Pulser to the test oscilloscope 1 KC Cal Out connector with a 50-ohm coax cable and set the test oscilloscope Calibrator to 100 VOLTS. DO NOT use the Type 647 1 KC CALIBRATOR. It will not run the Type TU-5.

f. Connect the Type TU-5 to the vertical input connector of the 10-series plug-in through a 5XT attenuator and a 50-ohm termination.

g. Adjust the Type TU-5 until it generates a fast-rise pulse on the crt of the Type 647.

h. Adjust the trigger level control to obtain a stable display.

i. Check the top of the waveform for overshoot, rolloff or ringing. Any that appears should be less than 0.025 X waveform amplitude, above the top of the waveform.

j. With the variable on the 10-series plug-in, adjust the waveform so that it is 4 cm high.

k. Position the 4-cm high waveform to the center of the crt.

l. Set the sweep rate of the 11-series plug-in to 10 nsec/cm.

m. Measure the risetime of the waveform. It should be less than 7 nsec from the 10% point to the 90% point.

n. Remove the Type TU-5 and set:

Volts/cm (10-series)	.01
Variable (10-series)	Calibrated
Time/cm (11-series)	1 msec
Magnifier (11-series)	Off

o. Apply a 50-kc signal from a Type 190B through a 50-ohm coax cable and a 50-ohm termination to the vertical input connector of the 10-series plug-in.

p. Adjust the amplitude of the Type 190B signal to obtain a 4-cm high signal.

q. Increase the output frequency of the Type 190B to 50 MC and check for at least a 2.8 cm signal still remaining on the crt of the Type 647.

Miscellaneous Checks

1. Check External Crt Cathode Input

a. Remove ground strap between CRT CATHODE and GND.

b. Connect a jumper between the CRT CATHODE and CAL OUT connectors.

c. Set:

Magnifier (11-series)	Off
Time/cm (11-series)	1 msec
Trigger Mode (11-series)	Free running

d. Set the 1 KC CALIBRATOR to 5 VOLTS and check for intensity modulation.

e. Remove jumper and reconnect the ground strap between the CRT CATHODE and GND connectors.

2. Check External Crt Grid Input

a. Set:

Magnifier (11-series)	Off
Time/cm (11-series)	1 msec
Trigger mode (11-series)	Free running

b. Set the 1 KC CALIBRATOR to 5 VOLTS and connect a jumper from the CAL OUT connector to the CRT GRID connector.

c. Check for intensity modulation.

d. Remove the jumper.

3. Check J101 For Voltages and External Single Sweep Reset

a. Check for proper voltage at pins A through E. See Table 5-4.

b. Set the 1 KC CALIBRATOR to 5 VOLTS and connect a coax cable between the CAL OUT connector and the vertical input connector on the 10-series plug-in.

c. Set:

Volts/cm (10-series)	2
Trigger Mode (11-series)	Normal
Trigger level (11-series)	For a stable display
Trigger level (11-series)	Internal

d. After obtaining a stable display set the trigger mode switch on the 11-series plug-in to single sweep.

e. Remove the coax cable or set the input coupling (10-series) to ground and push the reset button on the 11-series plug-in.

f. Check that the ready neon lights and remains stable.

g. Reconnect the coax cable or reset the input coupling (10-series) to ac and note that one sweep occurs and that the ready light extinguishes.

h. Remove all connections.

TABLE 5-4

A	—75 v
B	—15 v
C	ground
D	+15 v
E	+100 v

SECTION 6
PARTS LIST and DIAGRAMS

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix Field Office.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number including any suffix, instrument type, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix Field Office will contact you concerning any change in part number.

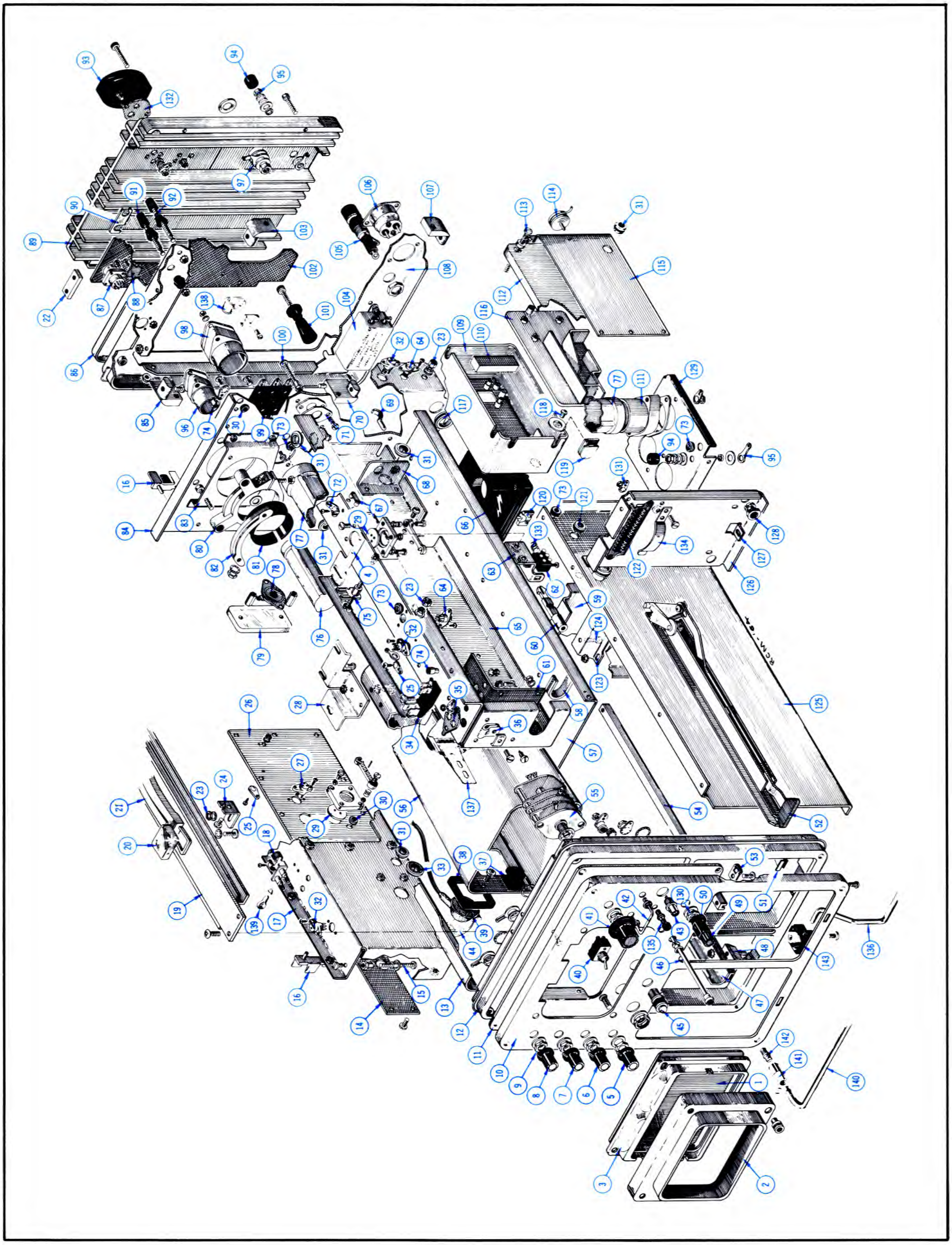
ABBREVIATIONS AND SYMBOLS

a or amp	amperes
BHS	binding head steel
C	carbon
cer	ceramic
cm	centimeter
comp	composition
cps	cycles per second
crt	cathode-ray tube
CSK	counter sunk
dia	diameter
div	division
EMC	electrolytic, metal cased
EMT	electroyltic, metal tubular
ext	external
f	farad
F & I	focus and intensity
FHS	flat head steel
Fil HS	fillister head steel
g. or G	giga, or 10^9
Ge	germanium
GMV	guaranteed minimum value
h	henry
hex	hexagonal
HHS	hex head steel
HSS	hex socket steel
HV	high voltage
ID	inside diameter
incd	incandescent
int	internal
k or K	kilohms or kilo (10^3)
kc	kilocycle
m	milli, or 10^{-3}
mc	megacycle
mm	millimeter
meg or M	megohms or mega (10^6)
met.	metal
μ	micro, or 10^{-6}
n	nano, or 10^{-9}
Ω	ohm
OD	outside diameter
OHS	oval head steel
p	pico, or 10^{-12}
PHS	pan head steel
piv	peak inverse voltage
plstc	plastic
PMC	paper, metal cased
poly	polystyrene
Prec	precision
PT	paper tubular
PTM	paper or plastic, tubular, molded
RHS	round head steel
rms	root mean square
sec	second
Si	silicon
S/N	serial number
t or T	tera, or 10^{12}
TD	toroid
THS	truss head steel
tub.	tubular
v or V	volt
Var	variable
w	watt
w/	with
w/o	without
WW	wire-wound

SPECIAL NOTES AND SYMBOLS

X000	Part first added at this serial number.
000X	Part removed after this serial number.
*000-000	Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, or reworked or checked components.
Use 000-000	Part number indicated is direct replacement.
	Internal screwdriver adjustment.
	Front-panel adjustment or connector.

EXPLODED VIEW



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EXPLODED VIEW

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	Q T Y.	DESCRIPTION
1	337-573			1	SHIELD, implosion
2	200-556			1	COVER, graticule and trim assembly
	- - - - -			-	Mounting Hardware: (not included)
	210-571			4	NUT, graticule cover
3	426-223			1	FRAME, implosion shield
4	A-S332			1	BRACKET, resistor mounting board
5	366-220			1	KNOB, small charcoal, SCALE ILLUM
	- - - - -			-	Includes:
	213-020			1	SCREW, set, 6-32 x $^1/_8$ inch HHS
6	366-254			1	KNOB, small charcoal, ASTIGMATISM
	- - - - -			-	Includes:
	213-020			1	SCREW, set, 6-32 x $^1/_8$ inch HHS
7	366-220			1	KNOB, small charcoal, FOCUS
	- - - - -			-	Includes:
	213-020			1	SCREW, set, 6-32 x $^1/_8$ inch HHS
8	366-220			1	KNOB, small charcoal, INTENSITY
	- - - - -			-	Includes:
	213-020			1	SCREW, set, 6-32 x $^1/_8$ inch HHS
9	- - - - -			-	Mounting Hardware For Each Pot:
	210-590			1	NUT, hex, $^1/_8$-32 x $^7/_{16}$ inch
	210-840			1	WASHER, .390 ID x $^9/_{16}$ inch OD
	210-013			1	LOCKWASHER, internal, $^3/_8$ x $^1/_{16}$ inch
	210-207			1	LUG, solder, $^3/_8$ inch
10	C-S315			1	PANEL, front
	- - - - -			-	Mounting Hardware: (not included)
	213-088			2	SCREW, thread forming, 4-40 x $^1/_4$ inch PHS phillips
11	387-775			1	PLATE, front subpanel
	- - - - -			-	Mounting Hardware: (not included)
	213-123			10	SCREW, tap tite, 6-32 x $^3/_8$ inch FHS phillips
12	D-S155			1	FRAME, front
	- - - - -			-	Includes:
	354-057			1	RING, ornamental
13	122-112			1	ANGLE, frame, top right
	122-113			1	ANGLE, frame, top left
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-538			4	SCREW, 6-32 x $^5/_{16}$ inch FHS phillips
	210-457			2	NUT, keps, 6-32 x $^5/_{16}$ inch
14	337-576			1	SHIELD, focus and intensity, calibration
	- - - - -			-	Mounting Hardware: (not included)
	211-007			4	SCREW, 4-40 x $^3/_{16}$ inch BHS
15	- - - - -			-	Mounting Hardware For Resistor
	211-553			1	SCREW, 6-32 x 1$^1/_2$ inch RHS phillips
	210-601			1	EYELET
	210-478			1	NUT, hex, 5-10 watt resistor
	211-507			1	SCREW, 6-32 x $^5/_{16}$ inch BHS
16	352-066			5	HOLDER, ceramic capacitor
	- - - - -			-	Mounting Hardware For Each: (not included)
	361-007			2	SPACER, nylon, .063 inch
17	441-485			1	CHASSIS, calibrator/focus and intensity
	- - - - -			-	Mounting Hardware: (not included)
	211-504			6	SCREW, 6-32 x $^1/_4$ inch BHS
	212-004			3	SCREW, 8-32 x $^5/_{16}$ inch BHS
	210-458			3	NUT, keps, 8-32 x $^{11}/_{32}$ inch
	210-457			1	NUT, keps, 6-32 x $^5/_{16}$ inch
18	136-153			1	SOCKET, crystal
	- - - - -			-	Mounting Hardware: (not included)
	213-055			2	SCREW, thread cutting, 2-32 x $^3/_{16}$ inch PHS phillips

EXPLODED VIEW *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
19	381-218			1	BAR, top support with handle
	- - - - -			-	Includes:
20	344-098			2	CLIP
	212-507			2	SCREW, 10-32 x 3/8 inch BHS
21	367-037			1	HANDLE
	- - - - -			-	Mounting Hardware: (not included)
	212-039			4	SCREW, 8-32 x 3/8 inch THS phillips
22	381-073			1	BAR, retaining
23	- - - - -			-	Mounting Hardware For Miniature Pots:
	210-583			16	NUT, hex, 1/4-32 x 5/16 inch
	210-046			12	LOCKWASHER, internal, .400 OD x .261 inch ID
	210-940			9	WASHER, 1/4 ID x 3/8 inch OD
	210-223			3	LUG, solder, 1/4 inch
	210-598			5	NUT, hex, miniature pot locking
24	406-929			1	BRACKET, pot
	- - - - -			-	Mounting Hardware: (not included)
	211-507			1	SCREW, 6-32 x 5/16 inch BHS
	210-006			1	LOCKWASHER, internal, #6
	210-407			1	NUT, hex, 6-32 x 1/4 inch
25	210-201			20	LUG, solder, SE4
	- - - - -			-	Mounting Hardware For Each: (not included)
	213-044			1	SCREW, thread cutting, 5-32 x 3/16 inch PHS phillips
26	B-S275			1	PLATE, vertical amplifier
	- - - - -			-	Mounting Hardware: (not included)
	211-504			10	SCREW, 6-32 x 1/4 inch BHS
27	136-161			8	SOCKET, 3 pin transistor
	- - - - -			-	Mounting Hardware For Each: (not included)
	213-113			2	SCREW, thread cutting, 2-56 x 5/16 inch RHS phillips
28	407-028			1	BRACKET, CRT shield
	- - - - -			-	Mounting Hardware: (not included)
	211-507			4	SCREW, 6-32 x 5/16 inch BHS
	210-457			4	NUT, keps, 6-32 x 5/16 inch
29	214-317			5	HEAT SINK, insulator disc
	- - - - -			-	Mounting Hardware For Each: (not included)
	352-062			1	HOLDER, transistor heat sink
	343-097			1	CLAMP
	211-008			2	SCREW, 4-40 x 1/4 inch BHS
	211-012			2	SCREW, 4-40 x 3/8 inch BHS
	210-406			4	NUT, hex, 4-40 x 3/16 inch
	210-599			2	NUT, sleeve
	214-368			1	SPRING, transistor heat sink holder
	210-627			1	RIVET
30	348-002			5	GROMMET, 1/4 inch
31	348-005			3	GROMMET, 1/2 inch
32	136-095			24	SOCKET, 4 pin transistor
	- - - - -			-	Mounting Hardware For Each: (not included)
	213-113			2	SCREW, thread cuting, 2-56 x 5/16 inch RHS phillips
33	348-012			1	GROMMET, 5/8 inch
34	352-031			1	HOLDER, fuse, single
	- - - - -			-	Mounting Hardware: (not included)
	211-511			1	SCREW, 6-32 x 1/2 inch BHS
	210-006			1	LOCKWASHER, internal, #6
	210-407			1	NUT, hex, 6-32 x 1/4 inch
35	- - - - -			-	Mounting Hardware For Transistor:
	387-345			1	PLATE, insulator
	211-511			2	SCREW, 6-32 x 1/2 inch BHS
	210-935			2	WASHER, fiber, .140 ID x .375 inch OD
	210-202			1	LUG, solder, SE6
	210-006			1	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch

EXPLODED VIEW *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
36	343-001			1	CLAMP, cable, 1/8 inch
	- - - - -			-	Mounting Hardware: (not included)
	211-511			1	SCREW, 6-32 x 1/2 inch BHS
	210-863			1	WASHER, "D" type
	210-006			1	LOCKWASHER, internal, #6
	210-407			1	NUT, hex, 6-32 x 1/4 inch
37	352-063			2	HOLDER, graticule light
	- - - - -			-	Mounting Hardware For Each: (not included)
	213-123			1	SCREW, tap tite, 6-32 x 3/8 inch FHS phillips
38	348-049			1	GROMMET, CRT shield
39	131-301			1	CONNECTOR, anode with lead
40	260-515			1	SWITCH, toggle, POWER
	- - - - -			-	Mounting Hardware: (not included)
	210-473			1	NUT, switch, 12 sided
	210-902			1	WASHER, .470 ID x 21/32 inch OD
	354-055			1	RING, locking, switch
	210-414			1	NUT, hex, 15/32-32 x 9/16 inch
41	366-117			1	KNOB, large charcoal, 1 KC CALIBRATOR
	- - - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HHS
42	214-335			1	BOLT, current loop
	- - - - -			-	Mounting Hardware: (not included)
	361-059			1	SPACER, current loop
	210-593			2	NUT, hex, current loop, 5-40 x 1/4 inch
	210-849			2	WASHER, fiber, #4
	210-201			2	LUG, solder, SE4
	210-442			2	NUT, hex, 3-48 x 3/16 inch
43	131-274			1	CONNECTOR, chassis mount, 1 contact, BNC
	- - - - -			-	Mounting Hardware:
	NO NUMBER			1	NUT, hex, BNC connector
	210-241			1	LUG, ground
44	A-S333			1	CLAMP, CRT anode
45	136-160			1	SOCKET, indicator light
	- - - - -			-	Mounting Hardware:
	210-414			1	NUT, hex, 15/32-32 x 9/16 inch
	210-241			1	LUG, ground
46	384-293			1	ROD, extension, switch, with molded knob
47	122-118			2	ANGLE, bottom rail
	- - - - -			-	Mounting Hardware For Each: (not included)
	212-039			4	SCREW, 8-32 x 3/8 inch Truss HS phillips
	210-458			2	NUT, keps, 8-32 x 11/32 inch
48	348-052			4	FOOT, molded gray
	- - - - -			-	Mounting Hardware For Each: (not included)
	212-071			2	SCREW, 8-32 x 1 inch Fil HS
	210-458			2	NUT, keps, 8-32 x 11/32 inch
49	366-031			1	KNOB, small red, VERNIER
	- - - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HHS
50	366-142			1	KNOB, charcoal, HORIZ POSITION
	- - - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HHS
51	214-384			2	SPRING, latch bar

EXPLODED VIEW *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
52	214-396			2	LATCH, plug-in, assembly
	- - - - -			-	Each Consisting Of:
	351-069			1	GUIDE, rail, bottom, plug-in
	351-071			1	GUIDE, latch release bar, delrin
	214-372			1	LATCH, delrin
	214-374			1	SPRING, latch
	210-694			1	RIVET, latch hinge
	358-230			1	BUSHING, latch hinge
	366-258			1	KNOB, nylon with release bar
	214-369			1	PIN, latch
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-522			1	SCREW, 6-32 x $^5/_8$ inch FHS phillips
	211-507			1	SCREW, 6-32 x $^5/_{16}$ inch BHS
53	214-459			4	SPRING, plug-in ground
	- - - - -			-	Mounting Hardware For Each: (not included)
	212-023			1	SCREW, 8-32 x $^3/_8$ inch BHS
	210-458			1	NUT, keps, 8-32 x $^{11}/_{32}$ inch
54	351-060			2	GUIDE, rail, top, plug-in
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-507			1	SCREW, 6-32 x $^5/_{16}$ inch BHS
	211-531			1	SCREW, 6-32 x $^3/_8$ inch Fil HS
	210-457			1	NUT, keps, 6-32 x $^5/_{16}$ inch
	214-376			1	SPRING, plug-in rail (not shown)
55	262-569			1	SWITCH, wired, CALIBRATOR
	- - - - -			-	Includes:
	260-536			1	SWITCH, unwired, CALIBRATOR
	- - - - -			-	Mounting Hardware: (not included)
	210-413			1	NUT, hex, $^3/_8$-32 x $^1/_2$ inch
	210-840			1	WASHER, .390 ID x $^9/_{16}$ inch OD
	210-013			1	LOCKWASHER, internal, $^3/_8$ x $^{11}/_{16}$ inch
56	337-572			1	SHIELD, CRT
	- - - - -			-	Mounting Hardware: (not included)
	211-590			4	SCREW, 6-32 x $^1/_4$ inch BHB
	211-589			2	SCREW, 6-32 x $^5/_{16}$ inch BHB
57	387-771			1	PLATE, plug-in roof
	- - - - -			-	Mounting Hardware: (not included)
	211-541			2	SCREW, 6-32 x $^1/_4$ inch FHS phillips
	210-457			2	NUT, keps, 6-32 x $^5/_{16}$ inch
	212-004			9	SCREW, 8-32 x $^5/_{16}$ inch BHS
58	358-166			1	BUSHING, black plastic
59	387-773			1	PLATE, plug-in housing, left
	- - - - -			-	Mounting Hardware: (not included)
	212-004			3	SCREW, 8-32 x $^5/_{16}$ inch BHS
	212-039			1	SCREW, 8-32 x $^3/_8$ inch Truss HS phillips
	210-458			3	NUT, keps, 8-32 x $^{11}/_{32}$ inch
60	384-291			1	ROD, push switch
61	387-816			1	PLATE, heat sink
	- - - - -			-	Mounting Hardware: (not included)
	211-507			3	SCREW, 6-32 x $^5/_{16}$ inch BHS
	210-006			3	LOCKWASHER, internal, #6
	210-407			3	NUT, hex, 6-32 x $^1/_4$ inch
62	260-516			2	SWITCH, push, TRACE FINDER
	- - - - -			-	Mounting Hardware: (not included)
	211-100			2	SCREW, 2-56 x $^3/_4$ inch RHS
	210-001			2	LOCKASHER, internal, #2
	210-405			2	NUT, hex, 2-56 x $^3/_{16}$ inch
63	406-905			1	BRACKET, push switch
	- - - - -			-	Mounting Hardware: (not included)
	211-504			2	SCREW, 6-32 x $^1/_4$ inch BHS
64	136-078			2	SOCKET, 8 pin transistor
	- - - - -			-	Mounting Hardware For Each: (not included)
	213-055			2	SCREW, thread cutting, 2-56 x $^3/_{16}$ inch PHS phillips

EXPLODED VIEW *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
65	D-S154			1	CHASSIS, horizontal
	- - - - -			-	Mounting Hardware: (not included)
	211-504			6	SCREW, 6-32 x 1/4 inch BHS
	212-070			3	SCREW, 8-32 x 5/16 inch FHS phillips
	212-004			2	SCREW, 8-32 x 5/16 inch BHS
	210-458			5	NUT, keps, 8-32 x 11/32 inch
66	119-029			1	DELAY LINE ASSEMBLY
	- - - - -			-	Includes:
	380-049			1	HOUSING, delay line
	200-482			1	COVER, delay line housing
	131-271			1	CONNECTOR, right hand
	131-272			1	CONNECTOR, left hand
	131-157			2	CONNECTOR, terminal stand-off
	131-158			2	CONNECTOR, terminal fed-thru
	211-517			1	SCREW, 6-32 x 1 inch BHS
	211-513			4	SCREW, 6-32 x 5/8 inch BHS
	211-011			2	SCREW, 4-40 x 5/16 inch BHS
	210-004			2	LOCKWASHER, internal, #4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
	210-407			5	NUT, hex, 6-32 x 1/4 inch
	- - - - -			-	Mounting Hardware: (not included)
	210-457			1	NUT, keps, 6-32 x 5/16 inch
67	214-153			1	FASTENER, snap, double pronged
68	406-930			1	BRACKET, transistor
	- - - - -			-	Mounting Hardware: (not included)
	211-504			2	SCREW, 6-32 x 1/4 inch BHS
69	343-089			12	CLAMP, cable, delrin
70	214-365			1	HINGE, bottom
	- - - - -			-	Mounting Hardware: (not included)
	212-010			1	SCREW, 8-32 x 5/8 inch BHS
	212-033			1	SCREW, 8-32 x 3/4 inch BHS
	210-458			2	NUT, keps, 8-32 x 11/32 inch
71	- - - - -			-	Mounting Hardware For Transistor:
	352-069			1	HOLDER, transistor mounting
	387-867			1	PLATE, mica, transistor
	211-510			2	SCREW, 6-32 x 3/8 inch BHS
	210-967			2	WASHER, teflon insulator
	210-803			2	WASHER, 6L x 3/8 inch
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
72	210-204			3	LUG, solder DE6
	- - - - -			-	Mounting Hardware For Each: (not included)
	213-004			1	SCREW, thread cutting, 5-32 x 3/16 inch PHS phillips
73	348-003			6	GROMMET, 5/16 inch
74	348-031			5	GROMMET, poly snap-in
75	406-301			1	BRACKET, resistor mounting
	- - - - -			-	Mounting Hardware: (not included)
	211-513			1	SCREW, 6-32 x 5/8 inch BHS
	210-006			1	LOCKWASHER, internal, #6
	210-407			1	NUT, hex, 6-32 x 1/4 inch
76	200-255			1	COVER, capacitor, small
77	200-259			4	COVER, capacitor, large
78	260-551			1	SWITCH, thermal cutout
	- - - - -			-	Mounting Hardware: (not included)
	213-044			2	SCREW, thread cutting, 5-32 x 3/16 inch PHS phillips
79	387-870			1	PLATE, thermal cutout cover
	- - - - -			-	Mounting Hardware: (not included)
	385-080			2	ROD, hex
	211-504			2	SCREW, 6-32 x 1/4 inch BHS

EXPLODED VIEW *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
80	354-215			1	RING, CRT clamping, assembly
	- - - - -			-	Consisting Of:
	354-211			1	RING, clamping
	211-585			1	SCREW, 6-32 x 1 inch RHS phillips
	220-419			1	NUT, square, 6-32 x 5/16 inch
81	124-160			1	STRIP, liner, CRT clamp
82	214-207			1	NUT, adjusting, securing
	- - - - -			-	Mounting Hardware: (not included)
	211-576			2	SCREW, 6-32 x 7/8 inch socket head
	210-949			2	WASHER, 9/64 ID x 1/2 inch OD
83	406-904			1	BRACKET, rear CRT support
	- - - - -			-	Mounting Hardware: (not included)
	211-504			4	SCREW, 6-32 x 1/4 inch BHS
84	441-484			1	CHASSIS, power
	- - - - -			-	Mounting Hardware: (not included)
	211-504			6	SCREW, 6-32 x 1/4 inch BHS
	212-004			1	SCREW, 8-32 x 5/16 inch BHS
	210-458			1	NUT, keps, 8-32 x 11/32 inch
85	214-366			1	HINGE, top
	- - - - -			-	Mounting Hardware: (not included)
	212-010			1	SCREW, 8-32 x 5/8 inch BHS
	212-033			1	SCREW, 8-32 x 3/4 inch BHS
	210-458			1	NUT, keps, 8-32 x 11/32 inch
86	387-768			1	PLATE, rear overlay
87	131-299			1	CONNECTOR, chassis mount, 10 pin
	- - - - -			-	Mounting Hardware: (not included)
	211-071			4	SCREW, 4-40 x 3/8 inch PHS phillips
	210-586			4	NUT, keps, 4-40 x 1/4 inch
88	334-882			1	TAG, voltage rating
	- - - - -			-	Mounting Hardware: (not included)
	213-088			2	SCREW, thread forming, 4-40 x 1/4 inch PHS phillips
89	214-362			1	HEAT SINK
	- - - - -			-	Mounting Hardware: (not included)
	213-128			2	SCREW, captive, 6-32 x .875 inch
	354-233			2	RING, retaining
90	346-027			1	STRAP, ground
91	129-066			2	POST, binding, 5 way
	- - - - -			-	Mounting Hardware For Each: (not incuded)
	358-213			1	BUSHING, nylon
	210-457			1	NUT, keps, 6-32 x 5/16 inch
92	129-066			1	POST, binding, 5 way
	- - - - -			-	Mounting Hardware: (not included)
	210-457			1	NUT, keps, 6-32 x 5/16 inch
93	200-500			4	COVER, transistor
	- - - - -			-	Mounting Hardware For Each: (not incuded)
	211-093			2	SCREW, 4-40 x 3/4 inch Allen HS
	210-004			2	LOCKWASHER, internal, #4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
94	200-548			10	COVER, nut
95	- - - - -			-	Mounting Hardware For Each Diode:
	220-411			1	NUT, hex, 10-32 x 3/8 inch
	210-010			1	LOCKWASHER, internal, #10
	210-805			1	WASHER, 10s x 7/16 inch
	210-910			1	WASHER, insulator, teflon, 5/16 OD x 3/16 inch ID
	210-909			2	WASHER, mica, .625 OD x .196 inch ID
	210-224			1	LUG, solder, #10
96	- - - - -			-	Mounting Hardware For Small Capacitor:
	386-252			1	PLATE, fiber flange
	432-047			1	BASE, small capacitor
	211-514			2	SCREW, 6-32 x 3/4 inch BHS
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch

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EXPLODED VIEW *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
97	214-344			2	HARDWARE, transistor mounting package
98	- - - - -			-	Mounting Hardware For Each Large Capacitor:
	386-254			1	PLATE, fiber flange
	432-048			1	BASE, large capacitor
	211-514			2	SCREW, 6-32 x 3/4 inch BHS
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
99	352-073			1	HOLDER, fuse, 3 pole
	- - - - -			-	Mounting Hardware: (not included)
	211-559			2	SCREW, 6-32 x 3/8 inch FHS phillips
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
100	- - - - -			-	Mounting Hardware For Resistor:
	211-544			1	SCREW, 6-32 x 3/4 inch Truss HS phillips
	210-478			1	NUT, hex, 5-10 watt resistor
	211-507			1	SCREW, 6-32 x 5/16 inch BHS
101	348-053			4	FOOT, body and cord holder
	348-054			4	FOOT, cap
	- - - - -			-	Mounting Hardware For Each: (not incuded)
	213-125			1	SCREW, 10-32 x 1 1/2 inch socket head cap
102	387-806			1	PLATE, back, heat sink
	- - - - -			-	Mounting Hardware: (not included)
	211-504			4	SCREW, 6-32 x 1/4 inch BHS
103	105-046			1	STOP, top
	- - - - -			-	Mounting Hardware: (not included)
	212-010			1	SCREW, 8-32 x 5/8 inch BHS
	212-033			1	SCREW, 8-32 x 3/4 inch BHS
	210-458			2	NUT, keps, 8-32 x 11/32 inch
104	119-028			1	FILTER, line
	- - - - -			-	Mounting Hardware: (not included)
	212-039			2	SCREW, 8-32 x 3/8 inch THS phillips
	210-008			2	LOCKWASHER, internal, #8
	210-409			2	NUT, hex, 8-32 x 5/16 inch
105	352-002			2	HOLDER, fuse, assembly
	- - - - -			-	Each Consisting Of:
	352-010			1	HOLDER, fuse
	200-582			1	CAP, fuse
	210-873			1	WASHER, rubber, 1/2 ID x 11/16 inch OD
	NO NUMBER			1	NUT, fuse holder
106	131-150			1	CONNECTOR, motor base
	- - - - -			-	Consisting Of:
	129-041			1	POST, ground, 4-40 thread one end
	200-185			1	COVER, 3 wire motor base
	205-014			1	SHELL, mounting
	210-003			2	LOCKWASHER, external, #4
	210-551			2	NUT, hex, 4-40 x 1/4 inch
	211-015			1	SCREW, 4-40 x 1/2 inch RHS
	214-078			2	PIN, connecting
	377-041			1	INSERT, black urea
	- - - - -			-	Mounting Hardware: (not included)
	213-104			2	SCREW, 6-32 x 3/8 inch THS phillips

EXPLODED VIEW *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
107	105-048			1	STOP, bottom
	- - - - -			-	Mounting Hardware: (not included)
	212-010			1	SCREW, 8-32 x 5/8 inch BHS
	212-033			1	SCREW, 8-32 x 3/4 inch BHS
	210-458			2	NUT, keps, 8-32 x 11/32 inch
108	387-769			1	PLATE, rear subpanel
	- - - - -			-	Includes:
	354-057			1	RING, ornamental
109	380-048			1	HOUSING, high voltage
	- - - - -			-	Mounting Hardware: (not included)
	211-504			3	SCREW, 6-32 x 1/4 inch BHS
110	381-225			1	BAR, heat sink, high voltage box
111	- - - - -			-	Mounting Hardware For Large Capacitor:
	386-254			1	PLATE, fiber flange
	432-048			1	BASE, large capacitor
	211-588			2	SCREW, 6-32 x 3/4 inch Hex HS
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
112	200-475			1	COVER, high voltage
	- - - - -			-	Mounting Hardware: (not included)
	211-521			2	SCREW, 6-32 x 1 1/2 inch RHS
113	- - - - -			-	Mounting Hardware For High Voltage Transformer:
	211-521			2	SCREW, 6-32 x 1 1/2 inch RHS
	358-228			2	BUSHING, insulator, recessed
	358-231			4	BUSHING, rubber, transformer
114	214-210			1	SPOOL, solder assembly
	- - - - -			-	Mounting Hardware: (not included)
	361-007			1	SPACER, nylon, .063 inch
115	337-583			1	SHIELD, high voltage box
	- - - - -			-	Mounting Hardware: (not included)
	211-007			2	SCREW, 4-40 x 3/16 inch BHS
	213-035			3	SCREW, thread cutting, 4-40 x 1/4 inch PHS phillips
116	D-S153			1	BOARD, high voltage
	- - - - -			-	Mounting Hardware: (not included)
	211-504			1	SCREW, 6-32 x 1/4 inch BHS
117	348-006			3	GROMMET, 3/4 inch
118	- - - - -			-	Mounting Hardware For High Voltage Capacitor:
	211-587			1	SCREW, 6-32 x 7/32 inch Hex HS
	210-966			1	WASHER, silicon rubber
	210-261			2	LUG, solder, high voltage

EXPLODED VIEW *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
119	166-320			1	SLEEVE, high voltage anode lead
	166-319			2	SLEEVE, high voltage
120	124-119			1	STRIP, ceramic, 7/16 inch x 2 notches
	- - - - -			-	Includes:
	355-046			1	STUD, nylon
	- - - - -			-	Mounting Hardware: (not included)
	361-007			1	SPACER, nylon, .063 inch
121	348-004			1	GROMMET 3/8 inch
122	131-097			2	CONNECTOR, chassis mount, 32 pin
	- - - - -			-	Mounting Hardware For Each: (not incuded)
	211-014			2	SCREW, 4-40 x 1/2 inch BHS
	166-029			2	TUBE, spacer
	210-004			2	LOCKWASHER, internal, #4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
123	387-807			1	PLATE, transformer support
	- - - - -			-	Mounting Hardware: (not included)
	212-004			2	SCREW, 8-32 x 5/16 inch BHS
	212-045			2	SCREW, 8-32 x 1/2 inch THS phillips
	385-172			2	ROD, support spacer
	210-458			4	NUT, keps, 8-32 x 11/32 inch
124	- - - - -			-	Mounting Hardware For Transformer:
	212-079			2	SCREW, 8-32 x 1/2 inch Allen HS
	212-565			4	SCREW, 10-32 x 4 1/2 inch Hex HS (not shown)
	210-812			4	WASHER, fiber, #10
	210-010			4	LOCKWASHER, internal, #10
	210-564			4	NUT, hex, 10-32 x 3/8 inch
125	387-770			1	PLATE, frame, center, vertical
	- - - - -			-	Mounting Hardware: (not included)
	211-583			4	SCREW, 6-32 x 1 inch Fil HS
	210-592			4	NUT, rod, 6-32 x 5/16 inch
	212-004			2	SCREW, 8-32 x 5/16 inch BHS
	211-538			1	SCREW, 6-32 x 5/16 inch FHS phillips
	210-457			1	NUT, keps, 6-32 x 5/16 inch
126	387-774			1	PLATE, plug-in housing right
	- - - - -			-	Mounting Hardware: (not included)
	212-004			3	SCREW, 8-32 x 5/16 inch BHS
	212-039			1	SCREW, 8-32 x 3/8 inch Truss HS phillips
	210-458			3	NUT, keps, 8-32 x 11/32 inch
127	406-947			2	BRACKET, guide rail
	- - - - -			-	Mounting Hardware For Each: (not included)
	210-004			2	LOCKWASHER, internal, #4
	210-406			2	NUT, hex, 4-40 x 3/16 inch

EXPLODED VIEW *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
128	358-224			4	BUSHING, pin
129	441-482			1	CHASSIS, capacitor
	- - - - -			-	Mounting Hardware: (not included)
	212-004			6	SCREW, 8-32 x 5/16 inch BHS
	210-458			4	NUT, keps, 8-32 x 11/32 inch
130	- - - - -			-	Mounting Hardware For Pot:
	210-413			1	NUT, hex, 3/8-32 inch x 1/2 inch
	210-840			1	WASHER, .390 ID x 9/16 inch OD
	210-013			1	LOCKWASHER, internal, 3/8 x 11/16 inch
131	210-202			4	LUG, solder, SE6
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-504			1	SCREW, 6-32 x 1/4 inch BHS
	210-407			1	NUT, hex, 6-32 x 1/4 inch
132	- - - - -			-	Mounting Hardware For Each Transistor:
	387-345			1	PLATE, insulator
	211-511			2	SCREW, 6-32 x 1/2 inch BHS
	210-935			2	WASHER, fiber, .140 ID x .375 inch OD
	210-803			2	WASHER, 6L x 3/8 inch
	210-006			1	LOCKWASHER, internal, #6
	210-202			1	LUG, solder, SE6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
133	214-333			1	PINCHER, push switch rod
134	214-373			2	SPRING, plug-in release
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-504			2	SCREW, 6-32 x 1/4 inch BHS
135	129-053			1	POST, ground, assembly
	- - - - -			-	Consisting Of:
	355-507			1	STEM, adapter
	200-103			1	CAP
	- - - - -			-	Mounting Hardware: (not included)
	210-455			1	NUT, hex, 1/4-28 x 3/8 inch
	210-046			1	LOCKWASHER, internal, .400 OD x .261 inch ID
136	348-057			1	FOOT, flip stand bail
	. . . . . .				Mounting Hardware: (not included)
	214-408			2	NUT, cam, locking
137	343-110			1	CLAMP, CRT coil form
138	343-013			1	CLAMP, cable, 3/8 inch
	. . . . . .				Mounting Hardware: (not included)
	211-510			1	SCREW, 6-32 x 3/8 inch BHS
	210-863			1	WASHER, "D" type
139	129-069			6	POST, capacitor tie off
	. . . . . .				Mounting Hardware For Each: (not included)
	361-008			1	SPACER, nylon, .188 inch

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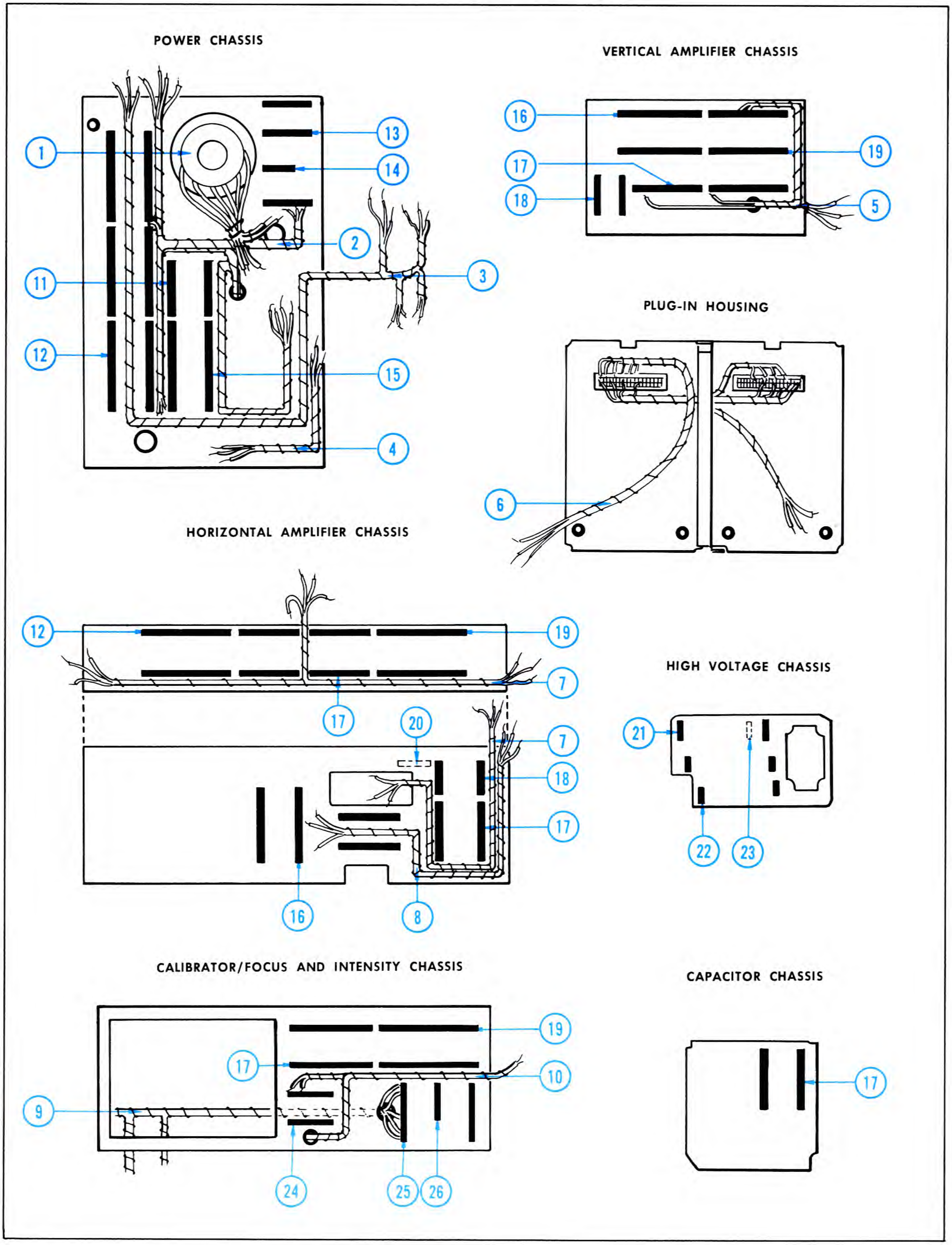
EXPLODED VIEW *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
140	B-S281			2	HANDLE, knob protector rail
	......				Mounting Hardware For Each: (not included)
141	B-S276			2	COUPLING, knob protector handle
142	A-S331			2	STUD, knob protector handle
	354-219			2	RING, retaining
143	391-057			1	BLOCK, flip stand pivot, left
	391-058			1	BLOCK, flip stand pivot, right

CERAMIC STRIPS AND CABLE HARNESS



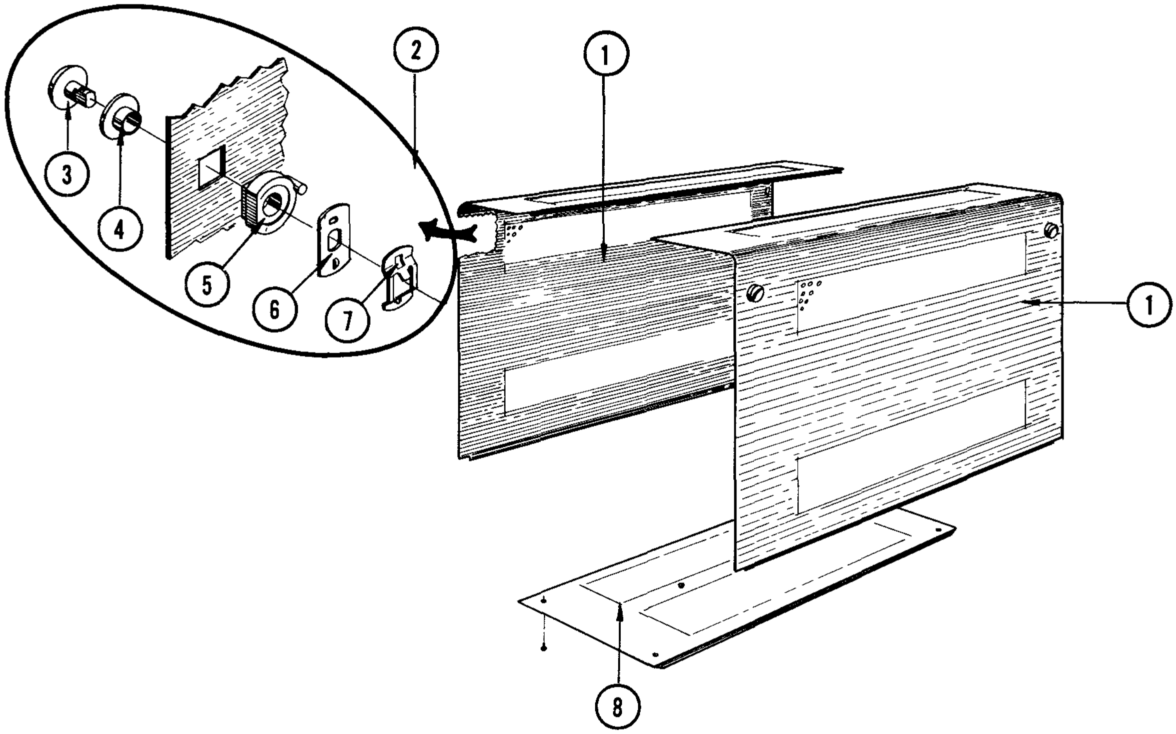
CABLE HARNESS AND CERAMIC STRIP DETAIL

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	179-752			1	CABLE HARNESS, CRT socket
	- - - - -			-	Includes:
	136-162			1	SOCKET, CRT assembly
	- - - - -			-	Includes:
	136-117			1	SOCKET, CRT
	387-393			1	PLATE, back, CRT socket
	213-086			2	SCREW, thread cutting, 2-32 x 7/16 inch PHS phillips
	131-178			11	CONNECTOR, cable end, CRT socket
2	179-747			1	CABLE HARNESS, power
3	179-798			1	CABLE HARNESS, heat sink
4	179-802			1	CABLE HARNESS, 110 volt
5	179-751			1	CABLE HARNESS, vertical amplifier
6	179-748			1	CABLE HARNESS, connector
7	179-753			1	CABLE HARNESS, high voltage
8	179-754			1	CABLE HARNESS, unblanking
9	179-749			1	CABLE HARNESS, focus and intensity
10	179-750			1	CABLE HARNESS, calibrator
11	124-148			2	STRIP, ceramic, 7/16 inch x 9 notches
	- - - - -			-	Each Includes:
	355-046			2	STUD, nylon
	- - - - -			-	Mounting Hardware For Each: (not included)
	361-009			2	SPACER, nylon, .313 inch
12	124-145			8	STRIP, ceramic, 7/16 inch x 20 notches
	- - - - -			-	Each Includes:
	355-046			2	STUD, nylon
	- - - - -			-	Mounting Hardware For Each: (not included)
	361-008			2	SPACER, nylon, .188 inch
13	124-147			3	STRIP, ceramic, 7/16 x 13 notches
	- - - - -			-	Each Includes:
	355-046			2	STUD, nylon
	- - - - -			-	Mounting Hardware For Each: (not included)
	361-009			2	SPACER, nylon, .313 inch
14	124-149			1	STRIP, ceramic, 7/16 inch x 7 notches
	- - - - -			-	Includes:
	355-046			2	STUD, nylon
	- - - - -			-	Mounting Hardware: (not included)
	361-009			2	SPACER, nylon, .313 inch
15	124-145			2	STRIP, ceramic, 7/16 inch x 20 notches
	- - - - -			-	Each Includes:
	355-046			2	STUD, nylon
	- - - - -			-	Mounting Hardware For Each: (not included)
	361-009			2	SPACER, nylon, .313 inch
16	124-146			4	STRIP, ceramic, 7/16 inch x 16 notches
	- - - - -			-	Each Includes:
	355-046			2	STUD, nylon
	- - - - -			-	Mounting Hardware For Each: (not included)
	361-007			2	SPACER, nylon, .063 inch
17	124-147			13	STRIP, ceramic, 7/16 inch x 13 notches
	- - - - -			-	Each Includes:
	355-046			2	STUD, nylon
	- - - - -			-	Mounting Hardware For Each: (not included)
	361-007			2	SPACER, nylon, .063 inch
18	124-148			4	STRIP, ceramic, 7/16 inch x 9 notches
	- - - - -			-	Each Includes:
	355-046			2	STUD, nylon
	- - - - -			-	Mounting Hardware For Each: (not included)
	361-007			2	SPACER, nylon, .063 inch
19	124-145			7	STRIP, ceramic, 7/16 inch x 20 notches
	- - - - -			-	Each Includes:
	355-046			2	STUD, nylon
	- - - - -			-	Mounting Hardware For Each: (not included)
	361-007			2	SPACER, nylon, .063 inch

CABLE HARNESS AND CERAMIC STRIP DETAIL *(Cont'd)*

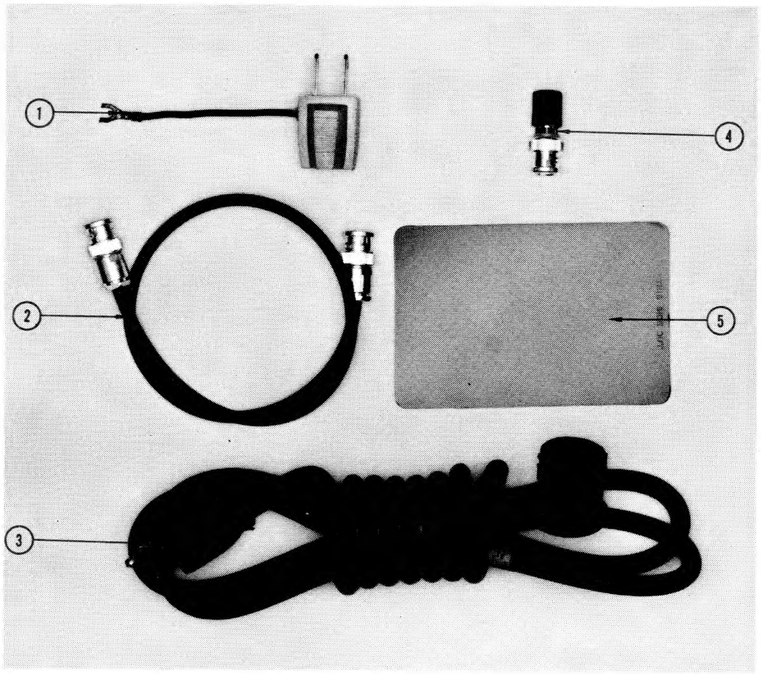
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
20	124-092			1	STRIP, ceramic, 7/16 inch x 3 notches
	- - - - -			-	Includes:
	355-046			2	STUD, nylon
	- - - - -			-	Mounting Hardware: (not included)
	361-007			2	SPACER, nylon, .063 inch
21	124-164			2	STRIP, ceramic, 4 notches
22	124-163			4	STRIP, ceramic, 2 notches
23	124-162			1	STRIP, ceramic, 7/16 inch x 4 notches
	- - - - -			-	Includes:
	355-046			1	STUD, nylon
	- - - - -			-	Mounting Hardware: (not included)
	361-007			1	SPACER, nylon, .063 inch
24	124-149			2	STRIP, ceramic, 7/16 inch x 7 notches
	- - - - -			-	Each Includes:
	355-046			2	STUD, nylon
	- - - - -			-	Mounting Hardware For Each: (not included)
	361-007			2	SPACER, nylon, .063 inch
25	124-147			2	STRIP, ceramic, 7/16 inch x 13 notches
	- - - - -			-	Each Includes:
	355-046			2	STUD, nylon
	- - - - -			-	Mounting Hardware For Each: (not included)
	361-008			2	SPACER, nylon, .188 inch
26	124-149			1	STRIP, ceramic, 7/16 inch x 7 notches
	- - - - -			-	Includes:
	355-046			2	STUD, nylon
	- - - - -			-	Mounting Hardware: (not included)
	361-008			2	SPACER, nylon, .188 inch

CABINET



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	Q T Y.	DESCRIPTION
1	387-772			2	PLATE, cabinet side
	- - - - -			-	Each Includes:
2	214-361			2	LATCH, quarter turn, assembly
	- - - - -			-	Each Consisting Of:
3	214-400			1	PIN, securing, index
4	358-218			1	BUSHING, latch bearing
5	387-871			1	PLATE, latch index
6	387-804			1	PLATE, latch locking
7	214-359			1	SPRING, latch
8	387-797			1	PLATE, bottom
	- - - - -			-	Mounting Hardware: (not included)
	212-075			4	SCREW, 8-32 x 1/4 inch Truss HS phillips
	211-542			2	SCREW, 6-32 x 5/16 inch Truss HS phillips

ACCESSORIES



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
4 1	~~103-013~~ 103-0036-00			1	ADAPTER, power cord, 3 wire to 2 wire
2	012-076			1	CABLE, 50 Ω BNC both ends
4 3	~~161-022~~ 161-0024-01			1	CORD, power, right angle
4	103-033			1	ADAPTER, BNC to binding post
5	378-540			1	FILTER, polarized light

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ELECTRICAL PARTS

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description	S/N Range

Bulbs

Ckt. No.	Tektronix Part No.	Description	
B604	150-029	Incandescent G.E. 349	
B605	150-029	Incandescent G.E. 349	SCALE ILLUM
B606	150-029	Incandescent G.E. 349	POWER ON
B852	150-030	Neon NE-2V	
B853	150-030	Neon NE-2V	
B854	150-030	Neon NE-2V	

Capacitors

Tolerance of all electroytic capacitors as follows (with exceptions):

Tolerance of all electrolytic capactors as follows (with exceptions):

3V — 50V = —10%, +250%
51V — 350V = —10%, +100%
351V — 450V = —10%, +50%

C365	283-068	.01 μf	Cer		500 v	
C366	283-068	.01 μf	Cer		500 v	
C377	281-095	.2-1.5 pf	Teflon	Var		
C378	281-077	1.3-5.4 pf	Air	Var		
C397	281-095	.2-1.5 pf	Teflon	Var		
C398	285-572	.1 μf	PTM		200 v	
C404A	281-503	8 pf	Cer		500 v	±0.5 pf
C404B	281-503	8 pf	Cer		500 v	±0.5 pf
C404C	283-557	200 pf	Mica		500 v	10%
C406A	281-503	8 pf	Cer		500 v	±0.5 pf
C406B	281-503	8 pf	Cer		500 v	±0.5 pf
C406C	283-557	200 pf	Mica		500 v	10%
C417	283-079	.01 μf	Cer		250 v	
C443	283-081	.1 μf	Cer		25 v	
C445	281-592	4.7 pf	Cer			±0.5 pf
C456B	281-603	39 pf	Cer		500 v	5%
C456D	281-081	1.8-13 pf	Air	Var		
C456E	281-602	68 pf	Cer		500 v	5%
C456F	281-602	68 pf	Cer		500 v	5%
C464	281-603	39 pf	Cer		500 v	5%
C465	281-576	11 pf	Cer		500 v	5%
C466	281-586	25 pf	Cer		500 v	5%
C467	281-079	1.5-9.1 pf	Air	Var		

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description			
C469	283-081	.1 μf	Cer		25 v
C474	281-603	39 pf	Cer		500 v
C475	281-576	11 pf	Cer		500 v
C476	281-603	39 pf	Cer		500 v
C483	283-079	.01 μf	Cer		250 v
C484	281-076	1.2-3.5 pf	Air	Var	
C601 } †					
C602 } †					
C603 } †					
C609	290-171	100 μf	EMT		12 v
C610	285-644	.033 μf	PTM		600 v
C611	285-572	.1 μf	PTM		200 v
AL4 C612 290-0169-01	~~290-169~~	400 μf	EMC		250 v
C615	285-623	.47 μf	PTM		100 v
C622	285-569	.01 μf	PTM		200 v
C631	290-198	17 μf	EMT		150 v
AL4 C642 290-0186-01	~~290-186~~	3900 μf	EMC		30 v
C660	283-078	.001 μf	Cer		500 v
C661	290-162	22 μf	EMT		35 v
C663	285-598	.01 μf	PTM		100 v
AL4 C672 290-0186-01	~~290-186~~	3900 μf	EMC		30 v
C690	283-078	.001 μf	Cer		500 v
C691	290-162	22 μf	EMT		35 v
C692	283-078	.001 μf	Cer		500 v
C694	283-081	.1 μf	Cer		25 v
C701	285-644	.033 μf	PTM		600 v
AL4 C702 290-0169-01	~~290-169~~	400 μf	EMC		250 v
C714	285-622	.1 μf	PTM		100 v
C731	290-198	17 μf	EMT		150 v
C739	281-524	150 pf	Cer		500 v
C741	285-644	.033 μf	PTM		600 v
AL 4, C740	285-0644-00	0.033uF	PTM		600v
C742	290-202	170 μf	EMC		250 v
C743	290-171	100 μf	EMT		12 v
C744	285-598	.01 μf	PTM		100 v
C745	285-587	.1 μf	PTM		600 v
C802	283-010	.05 μf	Cer		50 v
C803	283-010	.05 μf	Cer		50 v
C811	283-081	.1 μf	Cer		25 v
C815	285-598	.01 μf	PTM		100 v
C818	290-189	33 μf	EMT		35 v
C820	290-117	50 μf	EMT		50 v
C821	285-623	.47 μf	PTM		100 v
C822	283-042	.015 μf	Cer		3000 v
C827	283-042	.015 μf	Cer		3000 v
C831	285-572	.1 μf	PTM		200 v
C832	283-042	.015 μf	Cer		3000 v
C833	283-044	.001 μf	Cer		3000 v

†Furnished as a unit with *119-028 (Line Filter).

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
C835	281-556	500 pf	Cer		10,000 v		
C836	281-556	500 pf	Cer		10,000 v		
C837	281-556	500 pf	Cer		10,000 v		
C838	283-096	500 pf	Cer		20,000 v		
C844	283-042	.015 μf	Cer		3000 v		
C845	283-042	.015 μf	Cer		3000 v		
C846	283-042	.015 μf	Cer		3000 v		
C851	285-572	.1 μf	PTM		200 v		
C854	283-042	.015 μf	Cer		3000 v		
C863	283-079	.01 μf	Cer		250 v		
C864	285-572	.1 μf	PTM		200 v		
C870	283-079	.01 μf	Cer		250 v		
C874	281-543	270 pf	Cer		500 v	10%	
C877	281-534	3.3 pf	Cer			±.25 pf	
C878	281-500	2.2 pf	Cer		500 v	±0.5 pf	
C879	281-005	1.5-7 pf	Cer	Var			
C882	285-569	.01 μf	PTM		200 v		
C891	283-080	.022 μf	Cer		25 v		
C902	285-627	.0033 μf	PTM		100 v	5%	
C903	285-626	.0015 μf	PTM		100 v		
C914	285-622	.1 μf	PTM		100 v		
C916	290-026	5 μf	EMT		25 v		
C923	283-081	.1 μf	Cer		25 v		
C924	285-627	.0033 μf	PTM		100 v	5%	
C925	285-627	.0033 μf	PTM		100 v	5%	
C926	290-026	5 μf	EMT		25 v		
C935	281-519	47 pf	Cer		500 v	10%	
C936	283-081	.1 μf	Cer		25 v		
C937	283-081	.1 μf	Cer		25 v		
C945	281-504	10 pf	Cer		500 v	10%	
C946	285-572	.1 μf	PTM		200 v		
C948A	281-534	3.3 pf	Cer			±.25 pf	
C948K	281-525	470 pf	Cer		500 v		
C948Z	281-523	100 pf	Cer		350 v		

Diodes

Ckt. No.	Tektronix Part No.	Description		
D360	152-141	Silicon	1N3605	
D361	152-141	Silicon	1N3605	
D362	152-141	Silicon	1N3605	
D363	152-141	Silicon	1N3605	
D371	152-141	Silicon	1N3605	
D374	152-126	Zener	1N3024A	15 v
D395	*152-061	Silicon	Tek Spec	
D396	*152-061	Silicon	Tek Spec	
AL4. D397 Alternative 152-0291-00	152-060	Zener	1M20Z10	20 v
D609	152-124	Zener	1N938A	9 v
D611	*152-061	Silicon	Tek Spec	
D612A,B,C,D,	152-066	Silicon	1N3194	
D636	152-096	Zener	1N2997B	51 v

Diodes *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description
D642A,B,C,D	152-113	Silicon 40108
D669	152-141	Silicon 1N3605
D672A,B,C,D	152-113	Silicon 1N3605
D699	152-141	Silicon RCA40108
D702	152-066	Silicon 1N3194
A-4 D714 Alternative 152-0295-00	152-135	Zener 1N3042A 82 v
D716	152-134	Zener 1N3044A 100 v
D736	152-133	Zener 1N3001B 68 v
D737	152-066	Silicon 1N3194
D739	152-141	Silicon 1N3605
D742	152-066	Silicon 1N3194
D743	152-066	Silicon 1N3194
D745	152-066	Silicon 1N3194
A-4 D804 Alternative 152-0281-00	152-119	Zener 1N969A 22 v
D811	152-141	Silicon 1N3605
D815	152-141	Silicon 1N3605
D816	152-141	Silicon 1N3605
D817	152-141	Silicon 1N3605
A-4 D820 152-0290-00	~~152-104~~	Zener 1N3016A 6.8 v
D870	152-002	Silicon 1N1329
D871	152-002	Silicon 1N1329
D872	*152-061	Silicon Tek Spec
D873	152-141	Silicon 1N3605
D874	*152-061	Silicon Tek Spec
D884	152-141	Silicon 1N3605
D886	152-141	Silicon 1N3605
D891	152-141	Silicon 1N3605
D932	152-141	Silicon 1N3605
D933	152-141	Silicon 1N3605
D942	152-141	Silicon 1N3605
D943	152-141	Silicon 1N3605
D944	*152-061	Silicon Tek Spec
D947	*152-061	Silicon Tek Spec
D948	152-141	Silicon 1N3605

Fuses

Ckt. No.	Tektronix Part No.	Description
F601	159-005	3 Amp 3AG Slo-Blo
F602	159-027	4 Amp 3AG Slo-Blo
F613	159-025	.5 Amp 3AG Fast-Blo
F703	159-042	.75 Amp 3AG Fast-Blo
F743	159-042	.75 Amp 3AG Fast-Blo
F820	159-021	2 Amp 3AG Fast-Blo

Inductors

Ckt. No.	Tektronix Part No.	Description		S/N Range
L394	108-254	600 μh		
LR400	*108-278	.3 μh	(wound on a 3.3 Ω, 5% resistor)	
LR401	*108-278	.3 μh	(wound on a 3.3 Ω, 5% resistor)	
L403	*119-029	Delay Line Assembly		
L404	*108-220	.15 μh		
L405	*108-277	.07 μh		
L406	*108-220	.15 μh		
L407	*108-088	3.2 μh		
L414	*108-182	.3 μh		
L443	*108-088	3.2 μh		
L469	*108-260	.1 μh		
L479	*108-260	.1 μh		
L487	276-532	Core, Shield Bead		
L497	276-532	Core, Shield Bead		
L861	*108-279	Beam Rotator (X-Axis)		
L865	*108-295	Beam Rotator (Y-Axis)		X450-up

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

R350A }	311-401	1 k	2 w	Var		HORIZ POSITION
R350B }		5 k	2 w	Var		VERNIER
R360	324-317	19.6 k	1 w		Prec	1%
R361	323-302	13.7 k	½ w		Prec	1%
R362	323-347	40.2 k	½ w		Prec	1%
R363	323-338	32.4 k	½ w		Prec	1%
R364	311-400	2 x 500		Var		HORIZ CENT
R365	302-274	270 k	½ w			
R366	302-274	270 k	½ w			
R367	301-153	15 k	½ w			5%
R370	323-352	45.3 k	½ w		Prec	1%
R371	323-237	2.87 k	½ w		Prec	1%
R373	301-222	2.2 k	½ w			5%
R374	308-178	15 k	8 w	WW		5%
R376	324-296	11.8 k	1 w		Prec	1%
R377	311-326	10 k		Var		HORIZ GAIN
R378	321-251	4.02 k	⅛ w		Prec	1%
R379	321-251	4.02 k	⅛ w		Prec	1%
R390	324-289	10 k	1 w		Prec	1%
R391	323-237	2.87 k	½ w		Prec	1%
R393	301-822	8.2 k	½ w			5%
R394	*310-615	8.8 k	10 w	WW		1%
R396	324-296	11.8 k	1 w		Prec	1%
R397	302-104	100 k	½ w			
R398	301-270	27 Ω	½ w			
R404	321-047	30.1 Ω	⅛ w		Prec	1%
R406	321-047	30.1 Ω	⅛ w		Prec	1%

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description			
R407	315-751	750 Ω	¼ w		
R410	321-121	178 Ω	⅛ w		Prec
R411	321-121	178 Ω	⅛ w		Prec
R414A,B	311-379	2 x 200 Ω		Var	WW
R416	322-171	590 Ω	¼ w		Prec
R417	322-187	866 Ω	¼ w		Prec
R421	315-151	150 Ω	¼ w		
R423	315-391	390 Ω	¼ w		
R425	315-221	220 Ω	¼ w		
R433	315-391	390 Ω	¼ w		
R441	311-389	2 x 10 k		Var	
R442	315-472	4.7 k	¼ w		
R444	323-105	121 Ω	½ w		Prec
R445	322-093	90.9 Ω	¼ w		Prec
R447	323-607	600 Ω	½ w		Prec
R448	303-121	120 Ω	1 w		
R452	315-472	4.7 k	¼ w		
R454	323-105	121 Ω	½ w		Prec
R456B	315-680	68 Ω	¼ w		
R456D	311-095	500 Ω		Var	
R456E	321-195	1.05 k	⅛ w		Prec
R456F	315-822	8.2 k	¼ w		
R457	323-607	600 Ω	½ w		Prec
R458	301-472	4.7 k	½ w		
R465	321-097	100 Ω	⅛ w		Prec
R466	315-151	150 Ω	¼ w		
R467	*310-610	970 Ω	2 w	Mica Plate	
R468	*310-610	970 Ω	2 w	Mica Plate	
R469	301-100	10 Ω	½ w		
R475	321-097	100 Ω	⅛ w		Prec
R476	315-151	150 Ω	¼ w		
R477	*310-610	970 Ω	2 w	Mica Plate	
R478	*310-610	970 Ω	2 w	Mica Plate	
R480	323-245	3.48 k	½ w		Prec
R481	*310-609	4 k	2 w	Mica Plate	
R482	323-207	1.4 k	½ w		Prec
R483	301-100	10 Ω	½ w		
R484A R484B	~~*310-616~~ 310-0608-00 / 310-0608-00	1400 Ω	20 w	Mica Plate	Center Tapped
R490	323-245	3.48 k	½ w		Prec
R491	*310-609	4 k	2 w	Mica Plate	
R492	323-207	1.4 k	½ w		Prec
R601	**302-105**	**1 meg**	**½ w**		
R604	311-377	25 Ω	12.5 w	Var	
R607	304-333	33 k	1 w		
R609	324-284	8.87 k	1 w		Prec
R610	304-333	33 k	1 w		
R611	316-101	100 Ω	¼ w		

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R612	323-368	66.5 k	½ w		Prec	1%	
R613	307-009	4.7 Ω	1 w				
R614	323-418	221 k	½ w		Prec	1%	
R615	302-102	1 k	½ w				
R622	302-331	330 Ω	½ w				
R623	302-333	33 k	½ w				
R630	308-254	1.37 k	½ w		WW	1%	
R631	311-421	1 k		Var	WW	—75 VOLTS	
R632	308-259	10.7 k	1 w		WW	1%	
R633	302-333	33 k	½ w				
R634	322-147	332 Ω	¼ w		Prec	1%	
R636	304-470	47 Ω	1 w				
R637	308-123	20 Ω	5 w		WW	5%	
R642	302-103	10 k	½ w				
R644	316-224	220 k	¼ w				
R649	*308-087	.5 Ω	1 w		WW	1%	
R653	316-683	68 k	¼ w				
R660	308-257	5.11 k	½ w		WW	1%	
R661	311-378	250 Ω		Var	WW	—15 VOLTS	
R662	308-263	15.4 k	½ w		WW	1%	
R663	306-271	270 Ω	2 w				
R664	302-223	22 k	½ w				
R669	323-391	115 k	½ w		Prec	1%	
R672	302-103	10 k	½ w				
R674	316-184	180 k	¼ w				
R679	308-244	.3 Ω	2 w		WW		
R683	302-223	22 k	½ w				
R690	308-255	3.65 k	½ w		WW	1%	
R691	311-378	250 Ω		Var	WW	+15 VOLTS	
R692	308-261	15 k	1 w		WW	1%	
R693	302-273	27 k	½ w				
R694	316-101	100 Ω	¼ w				
R699	323-385	100 k	½ w		Prec	1%	
R702	304-473	47 k	1 w				
R703	308-179	5 Ω	5 w		WW	5%	
R714	302-103	10 k	½ w				
R716	316-224	220 k	¼ w				
R719	302-473	47 k	½ w				
R723	302-333	33 k	½ w				
R730	308-264	21.5 k	1 w		WW		
R731	311-380	500 Ω		Var	WW	+100 VOLTS	
R732	308-260	13.3 k	1 w		WW		
R733	302-333	33 k	½ w				
R736	use 308-223	35 Ω	3 w		WW	5%	
R737	308-279	20 Ω	5 w		WW		
R739	323-387	105 k	½ w		Prec	1%	

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description			
R742	304-104	100 k	1 w		
R744	302-560	56 Ω	½ w		
R744	302-121	120 Ω	½ w		
R745	302-270	27 Ω	½ w		
R800	323-498	1.5 meg	½ w		Prec
R801	311-408	20 k		Var	WW
R802A	324-531	3.32 meg	1 w		Prec
R802B	324-531	3.32 meg	1 w		Prec
R802C	324-531	3.32 meg	1 w		Prec
R802D	324-531	3.32 meg	1 w		Prec
R802E	324-531	3.32 meg	1 w		Prec
R802F	324-531	3.32 meg	1 w		Prec
R803	323-476	887 k	½ w		Prec
R804	316-103	10 k	¼ w		
R805	316-123	12 k	¼ w		
R806	316-222	2.2 k	¼ w		
R807	316-335	3.3 meg	¼ w		
R808	304-223	22 k	1 w		
R809	316-101	100 Ω	¼ w		
R810	316-563	56 k	¼ w		
R811	315-132	1.3 k	¼ w		
R812	315-432	4.3 k	¼ w		
R814	316-103	10 k	¼ w		
R815	316-105	1 meg	¼ w		
A64 R817 301-0564-00	~~301-561~~	~~560 Ω~~ 560K.	½ w		
R818	301-222	2.2 k	½ w		
R819	316-101	100 Ω	¼ w		
R820	306-151	150 Ω	2 w		
R821	316-563	56 k	¼ w		
R824	316-183	18 k	¼ w		
R825	316-105	1 meg	¼ w		
R826	306-106	10 meg	2 w		
R827	306-106	10 meg	2 w		
R828	306-106	10 meg	2 w		
R829	306-106	10 meg	2 w		
R831	302-102	1 k	½ w		
R832	311-329	50 k		Var	
R833	302-103	10 k	½ w		
R834	302-103	10 k	½ w		
R838	302-105	1 meg	½ w		
R840	306-395	3.9 meg	2 w		
R841	306-395	3.9 meg	2 w		
R842	306-395	3.9 meg	2 w		
R843	306-395	3.9 meg	2 w		
R844	311-121	5 meg		Var	
R845	302-275	2.7 meg	½ w		
R850	316-473	47 k	¼ w		
R851	316-563	56 k	¼ w		

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R852	302-101	100 Ω	½ w				
R853	301-223	22 k	½ w			5%	
R854	302-105	1 meg	½ w				
R855	302-101	100 Ω	½ w				
R856	302-104	100 k	½ w				
R861†	311-412	2 x 1 k		Var	WW	TRACE ROTATION	
R863	311-110	100 k		Var		GEOMETRY	
R864†	311-412	100 k		Var	WW	ASTIGMATISM	
R865	311-458	5 k		Var	WW	5%	X450-up
R870	316-101	100 Ω	¼ w				
R871	316-102	1 k	¼ w				
R873	306-333	33 k	2 w				
R874	305-622	6.2 k	2 w			5%	
R875	308-178	15 k	8 w		WW	5%	
R876	316-470	47 Ω	¼ w				
R878	323-335	30.1 k	½ w		Prec	1%	
R882	315-202	2 k	¼ w			5%	
R884	316-332	3.3 k	¼ w				
R885	321-379	86.6 k	⅛ w		Prec	1%	
R886	324-317	19.6 k	1 w		Prec	1%	
R891	316-682	6.8 k	¼ w				
R892	316-470	47 Ω	¼ w				
R893	316-470	47 Ω	¼ w				
R894	301-223	22 k	½ w			5%	
R895	322-229	2.37 k	¼ w		Prec	1%	
R896	321-253	4.22 k	⅛ w		Prec	1%	
R897	311-011	5 k		Var		INTENSITY	
R902	316-183	18 k	¼ w				
R903	316-183	18 k	¼ w				
R904	316-332	3.3 k	¼ w				
R911	316-103	10 k	¼ w				
R914	316-222	2.2 k	¼ w				
R916	316-472	4.7 k	¼ w				
R921	316-103	10 k	¼ w				
R923	316-470	47 Ω	¼ w				
R924	315-222	2.2 k	¼ w			5%	
R926	315-272	2.7 k	¼ w			5%	
R931	316-683	68 k	¼ w				
R932	323-483	1.05 meg	½ w		Prec	1%	
R933	316-103	10 k	¼ w				
R934	316-152	1.5 k	¼ w				
R935	316-392	3.9 k	¼ w				
R937	302-100	10 Ω	½ w				
R941	316-683	68 k	¼ w				
R942	323-483	1.05 meg	½ w		Prec	1%	
R943	316-103	10 k	¼ w				

†R861 and R864 furnished as a unit.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description		
R944	316-152	1.5 k	¼ w	
R945	316-392	3.9 k	¼ w	
R946	302-100	10 Ω	½ w	
R947	308-025	20 k	10 w	WW
R948B	323-289	10 k	½ w	Prec
R948C	323-635	6.667 k	½ w	Prec
R948D	323-634	1.789 k	½ w	Prec
R948E	323-633	801 Ω	½ w	Prec
R948F	323-632	452 Ω	½ w	Prec
R948G	323-631	146.1 Ω	½ w	Prec
R948H	323-630	72.4 Ω	½ w	Prec
R948J	323-629	43.1 Ω	½ w	Prec
R948K	323-628	28.6 Ω	½ w	Prec
R948L	323-627	21.4 Ω		Prec
R948X	323-636	50 k	½ w	Prec
R948Y	323-638	50 k	½ w	Prec
R948Z	323-637	50 Ω	½ w	Prec
R949	*308-090	¼ Ω	1 w	WW

Switches

	Unwired	Wired		
SW360	260-516		Push Button	TRACE FINDER
SW458	260-516		Push Button	TRACE FINDER
SW601	260-515		Toggle	POWER ON
SW948	260-536	*262-569	Rotary	1 KC CALIBRATOR

Thermal Cutout

TK601	260-551	Thermal Cutout 187°

Transformers

AL4 T600† 050-0503-00	*~~119-028~~	Line Filter
T601	*120-331	L.V. Power
T601	*120-339	L.V. Power
T820	*120-332	H.V. Power

Transistors

Q373	*151-133	Selected from 2N3251
Q374	*151-124	Selected from TA1938
AL4 Q393 151-0133-00	*~~152-133~~	Selected from 2N3251
Q394	*151-124	Selected from TA1938

† Furnished as a unit with C601, C602 and C603.

Transistors *(Cont'd)*

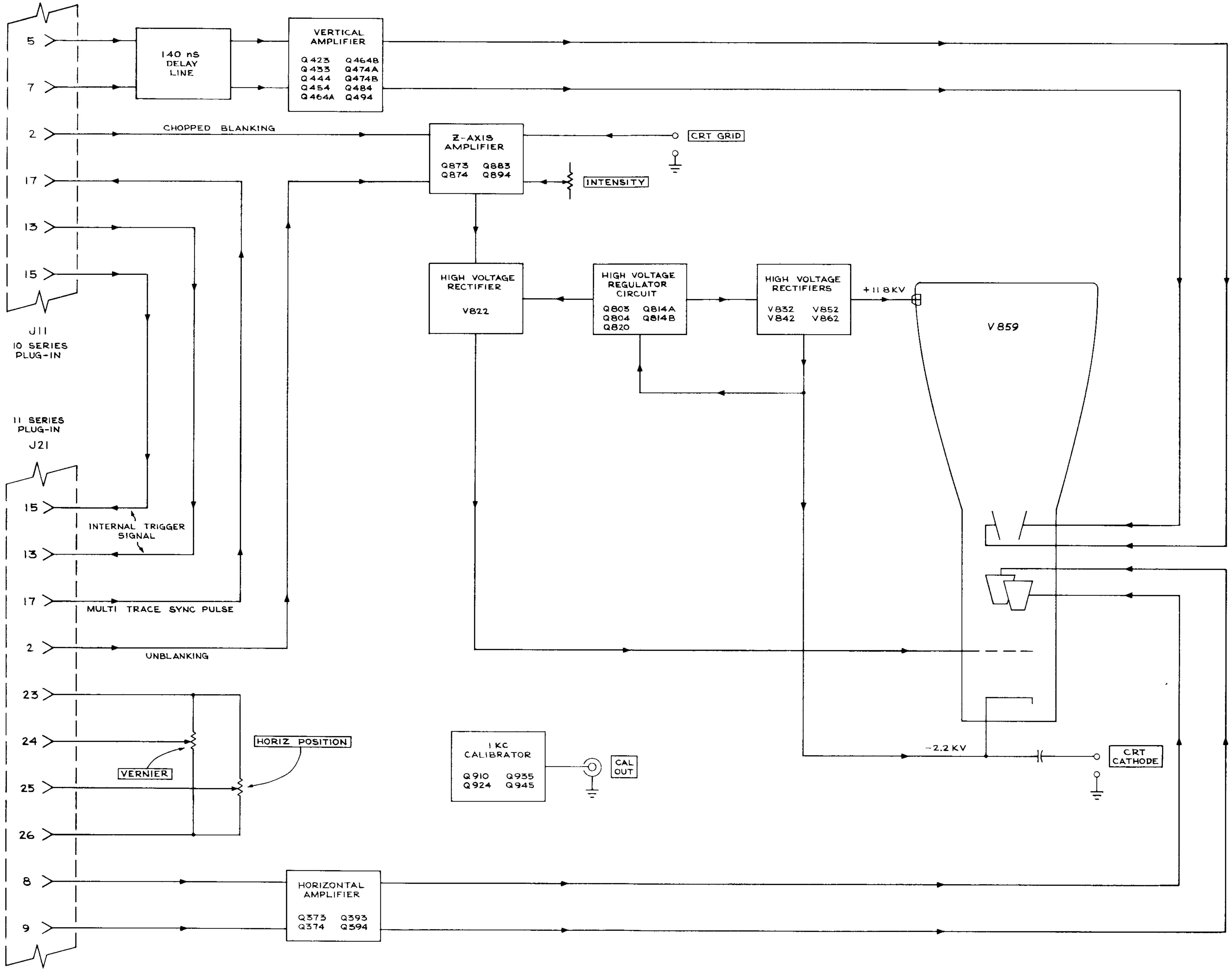
Ckt. No.	Tektronix Part No.	Description
Q423	*151-127	Selected from 2N2369
Q433	*151-127	Selected from 2N2369
Q444	*151-127	Selected from 2N2369
Q454	*151-127	Selected from 2N2369
Q464A	*151-127	Selected from 2N2369
Q464B	*151-127	Selected from 2N2369
Q474A	*151-127	Selected from 2N2369
Q474B	*151-127	Selected from 2N2369
Q484 } Q494 }	*153-524	Matched pair
Q614	*151-104	Replaceable by 2N2913
Q623	*151-096	Selected from 2N1893
Q633	*151-096	Selected from 2N1893
Q637	151-113	2N1488
Q644	*151-126	Replaceable by 2N2484
Q653	*151-103	Replaceable by 2N2219
Q659	*151-103	Replaceable by 2N2219
Q663	*151-103	Replaceable by 2N2219
Q667	151-112	2N1489
Q674	*151-126	Replaceable by 2N2484
Q683	*151-103	Replaceable by 2N2219
Q689	*151-103	Replaceable by 2N2219
Q693	151-125	2N1701
AL4 Q697 151-0140-00	~~151-110~~	152-04 Westinghouse
Q714	*151-126	Replaceable by 2N2484
Q723	*151-103	Replaceable by 2N2219
Q733	*151-103	Replaceable by 2N2219
AL4 Q737 151-0209-00	~~151-111~~	151-07 Westinghouse
Q803	*151-104	Replaceable by 2N2913
Q804	*151-103	Replaceable by 2N2219
Q814A	*151-103	Replaceable by 2N2219
Q814B	*151-103	Replaceable by 2N2219
Q820	151-112	2N1489
Q873	*151-124	Selected from TA1938
Q874	*151-124	Selected from TA1938
Q883	*151-108	Replaceable by 2N2501
Q894	*151-108	Replaceable by 2N2501
Q910	*151-126	Replaceable by 2N2484
Q924	*151-103	Replaceable by 2N2219
Q935	*151-103	Replaceable by 2N2219
Q945	*151-124	Selected from TA1938

Electron Tubes

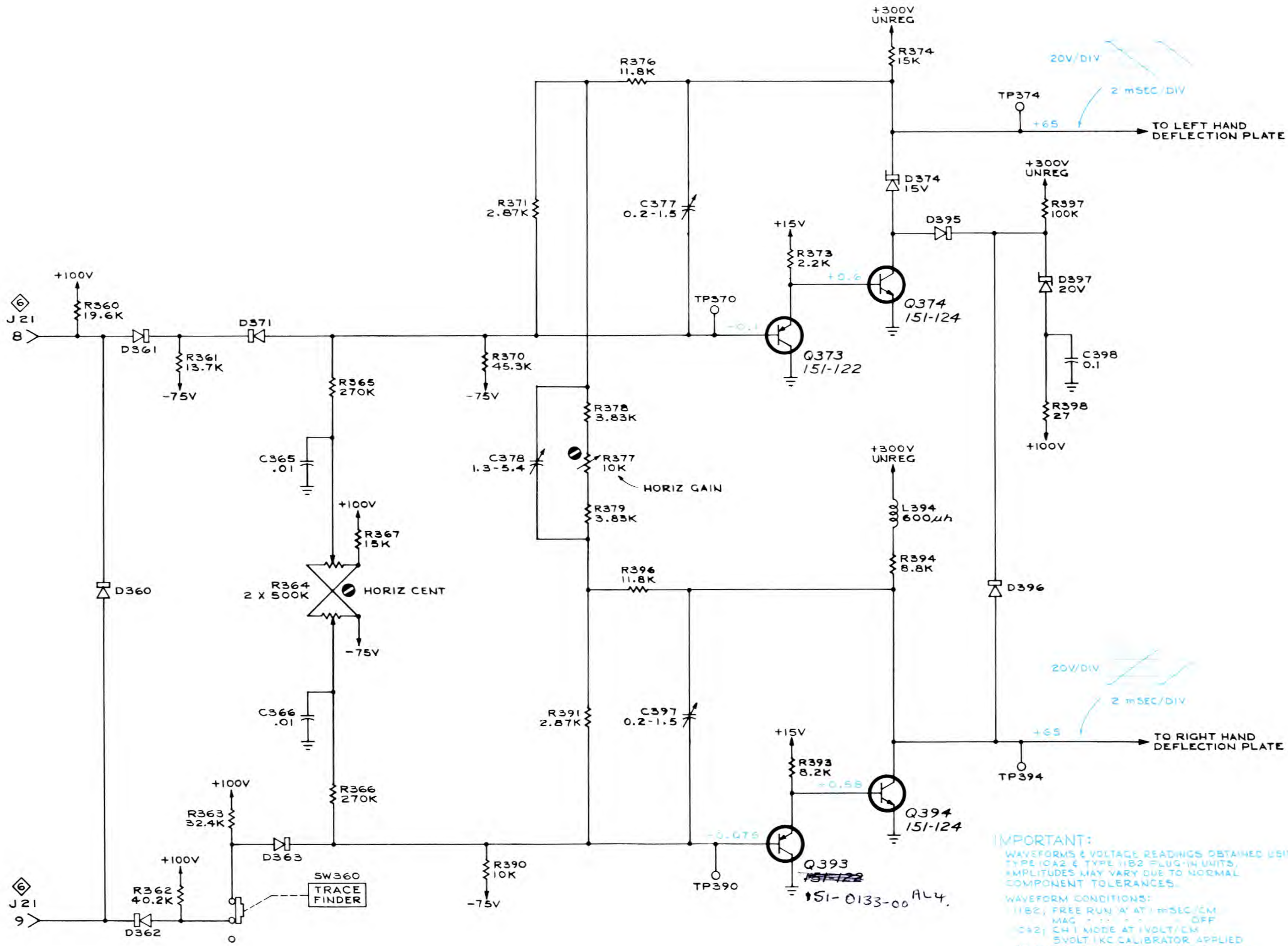
Ckt. No.	Tektronix Part No.	Description	S/N Range
V822	154-051	5642	
V832	154-051	5642	
V842	154-051	5642	
V852	154-051	5642	
V859	*154-424	CRT T6470-31-1 Standard Phosphor	100-449
V859	*154-448	CRT T6470-31-1	450-up
V862	154-051	5642	

Crystal

Y900	158-015	4 KC	



BLOCK DIAGRAM



IMPORTANT:

WAVEFORMS & VOLTAGE READINGS OBTAINED USING TYPE 10A2 & TYPE 11B2 PLUG-IN UNITS. AMPLITUDES MAY VARY DUE TO NORMAL COMPONENT TOLERANCES.

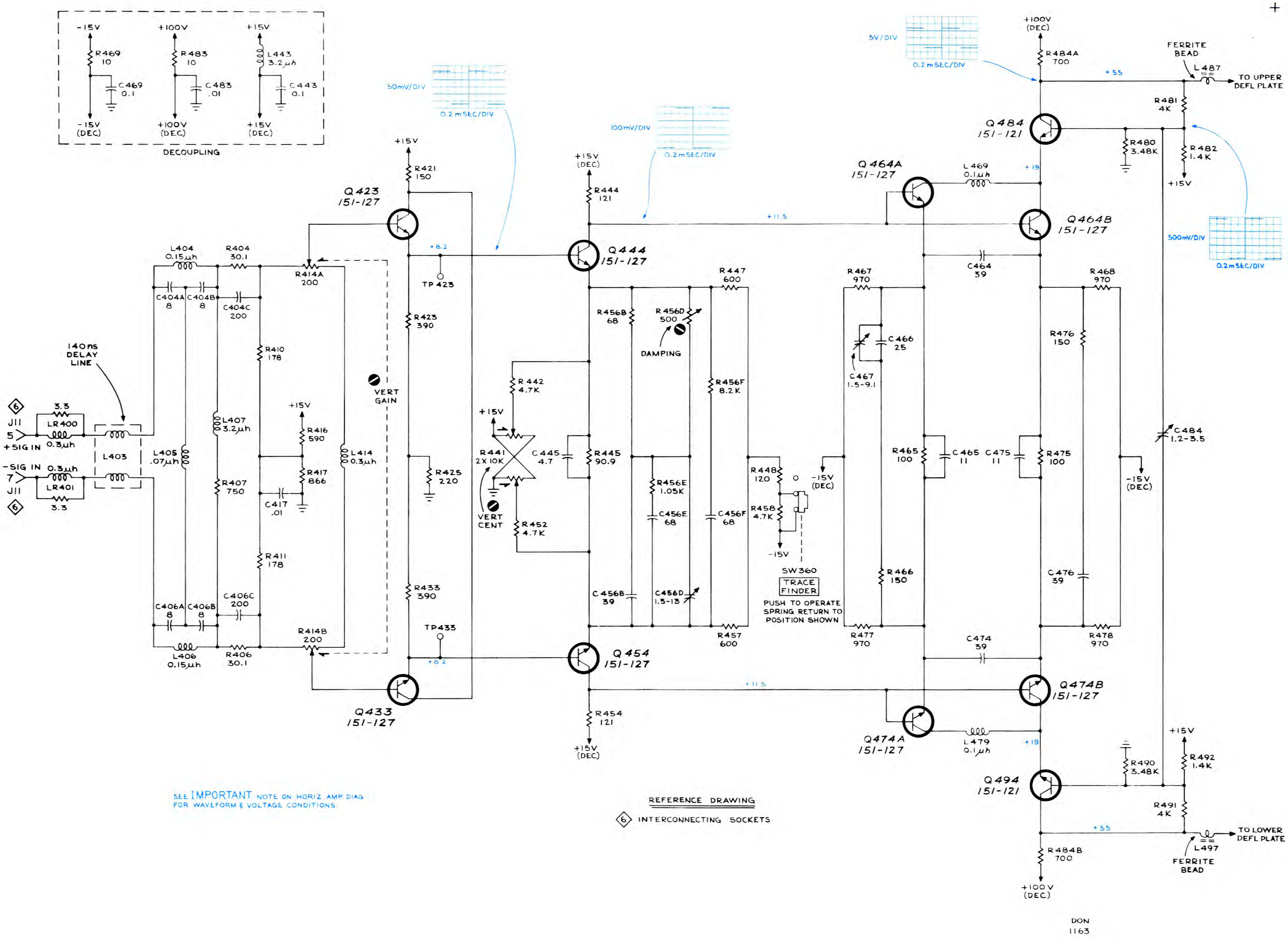
WAVEFORM CONDITIONS:
11B2; FREE RUN 'A' AT 1 mSEC/CM
MAG " " " " OFF
10A2; CH 1 MODE AT 1VOLT/CM
5VOLT 1KC CALIBRATOR APPLIED
ACTUAL PHOTOGRAPHS OF WAVEFORMS ARE SHOWN.

VOLTAGE CONDITIONS
11B2 SET FOR EXT INPUT
NO SIGNAL APPLIED TO EITHER PLUG-IN
SPOT CENTERED
READINGS ARE MEASURED IN VOLTS WITH 20KΩ/VOLT METER.

REFERENCE DRAWING:
(6) INTERCONNECTING SOCKETS

MRH
664

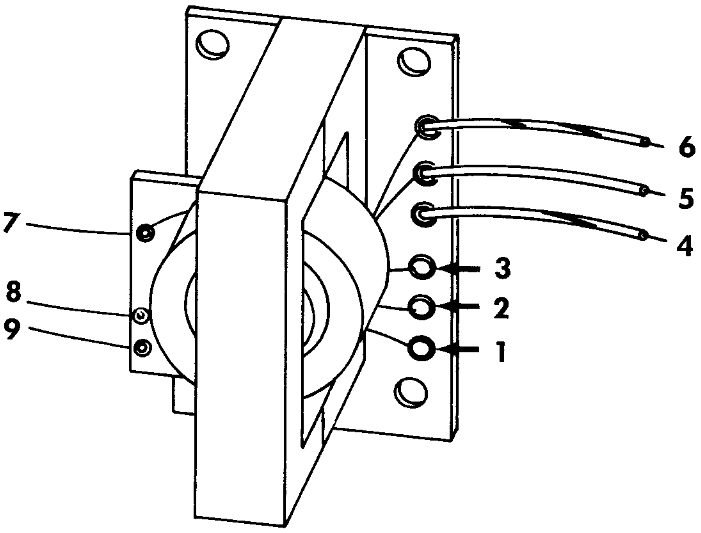
TYPE 647-MOD 165K OSCILLOSCOPE B HORIZONTAL AMPLIFIER (2)



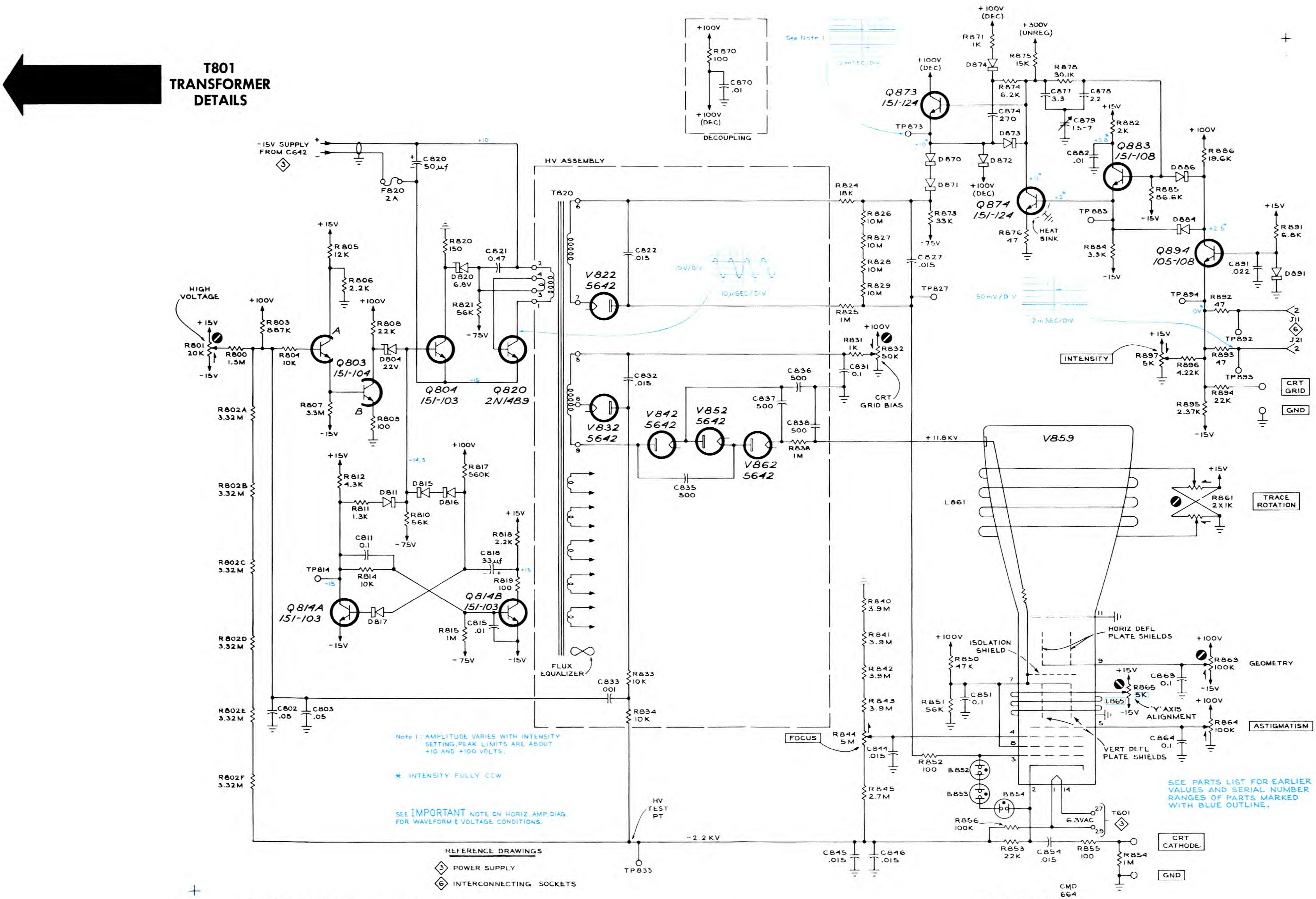
TYPE 647-MOD 165K OSCILLOSCOPE

A

VERTICAL AMPLIFIER



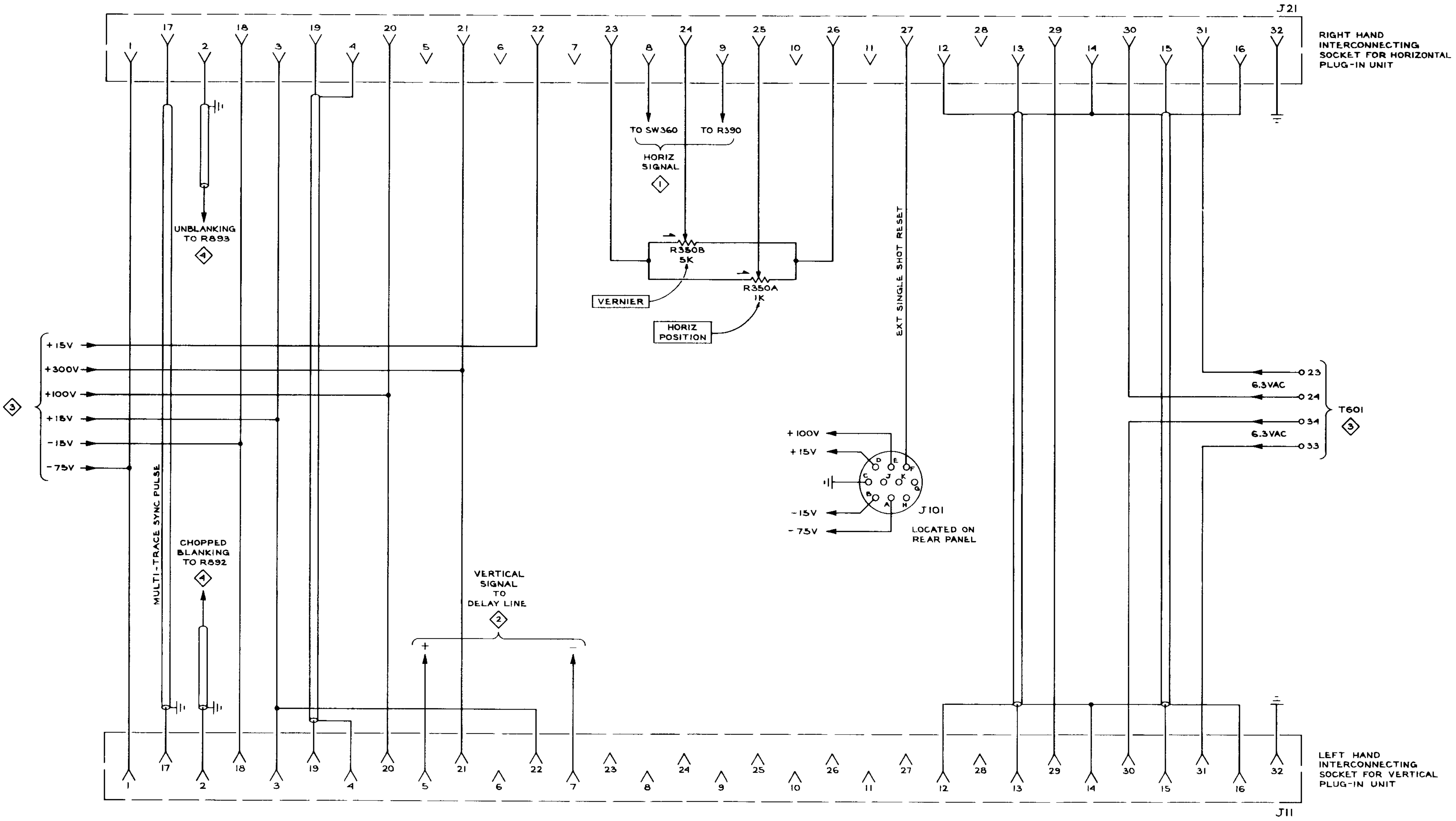
T801 TRANSFORMER DETAILS



TYPE 647-MOD 165K OSCILLOSCOPE

CRT CIRCUIT

B



REFERENCE DRAWINGS

- ⟨1⟩ HORIZONTAL AMPLIFIER
- ⟨2⟩ VERTICAL AMPLIFIER
- ⟨3⟩ POWER SUPPLY
- ⟨4⟩ CRT CIRCUIT

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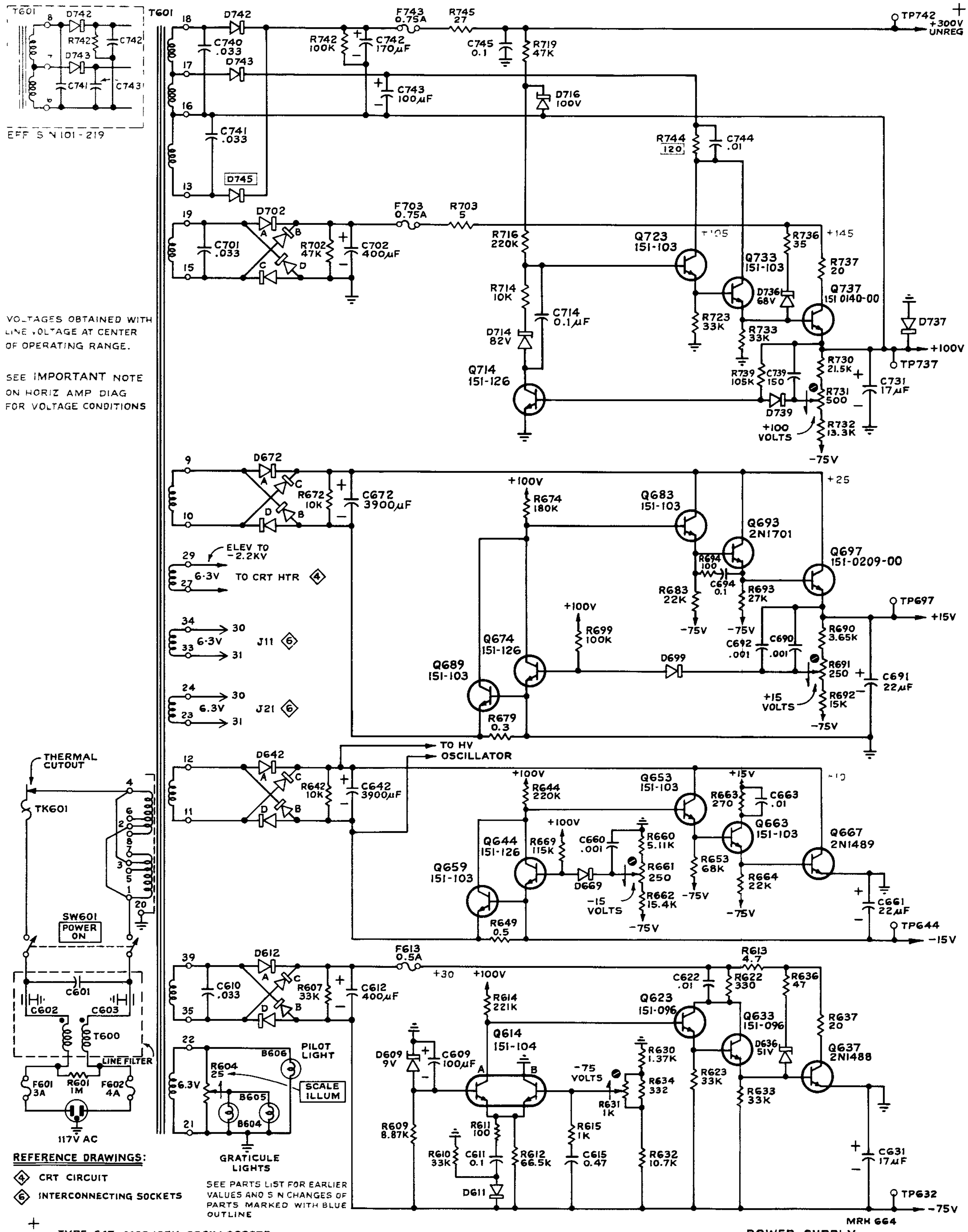
TYPE 647-MOD 165K OSCILLOSCOPE

A

INTERCONNECTING SOCKETS



TYPE 647-MOD 165K OSCILLOSCOPE

POWER SUPPLY

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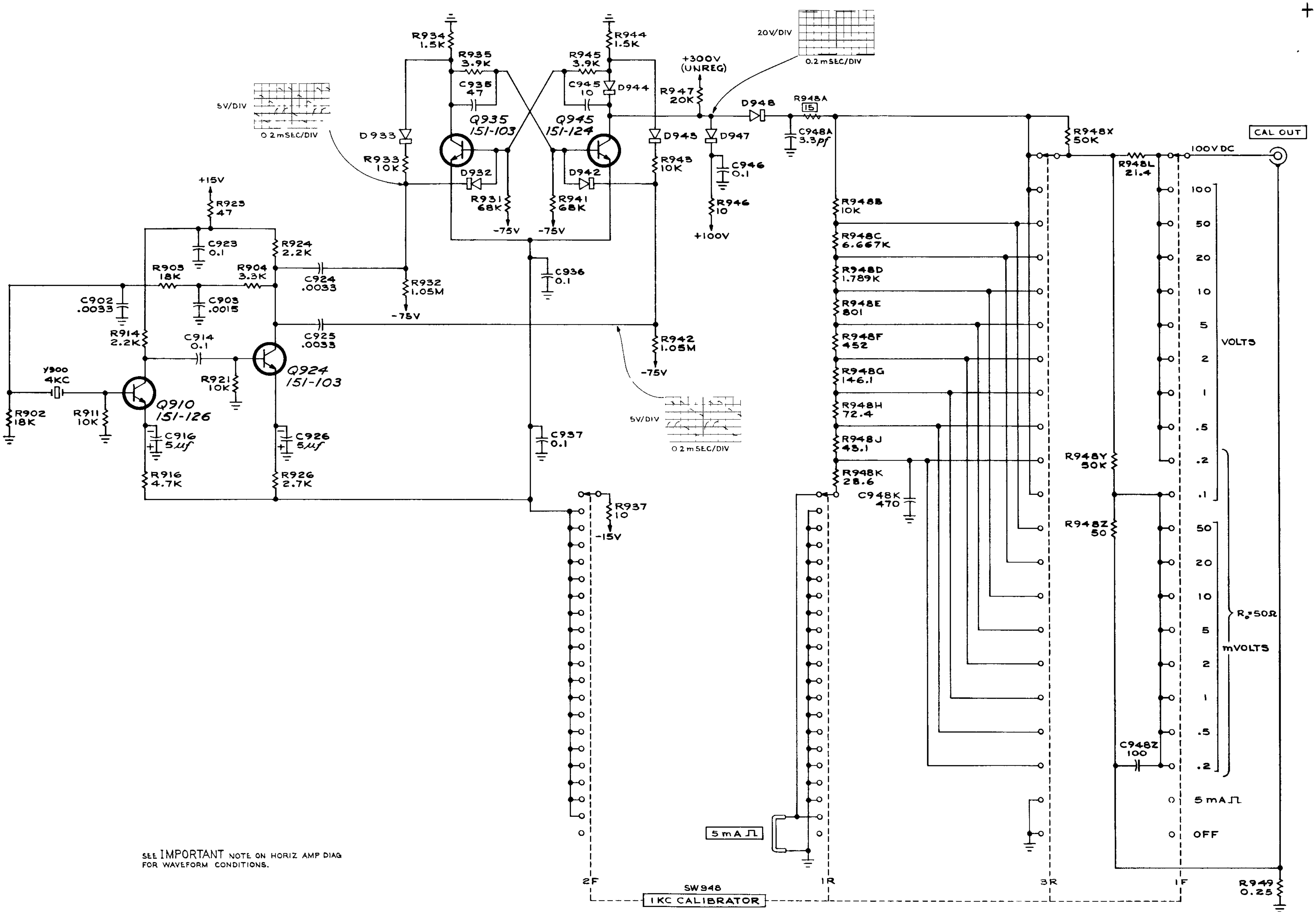

SEE IMPORTANT NOTE ON HORIZ AMP DIAG FOR WAVEFORM CONDITIONS.

SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED WITH BLUE OUTLINE

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PART 2

TYPE 10A2 DUAL-TRACE AMPLIFIER

INSTRUCTION MANUAL

Serial Number ____________

TYPE 10A2 MOD 165K DUAL-TRACE AMPLIFIER

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

070-451

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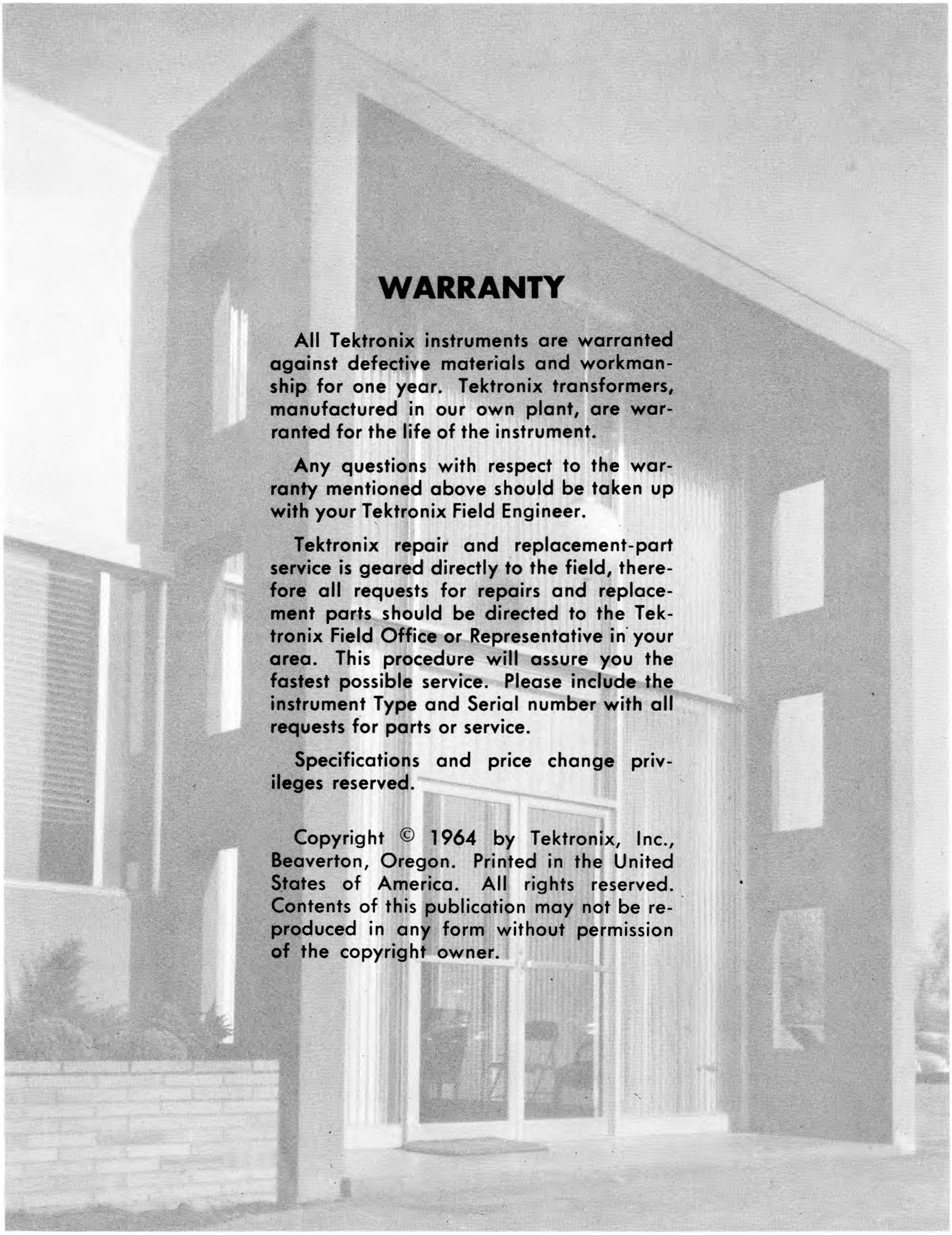


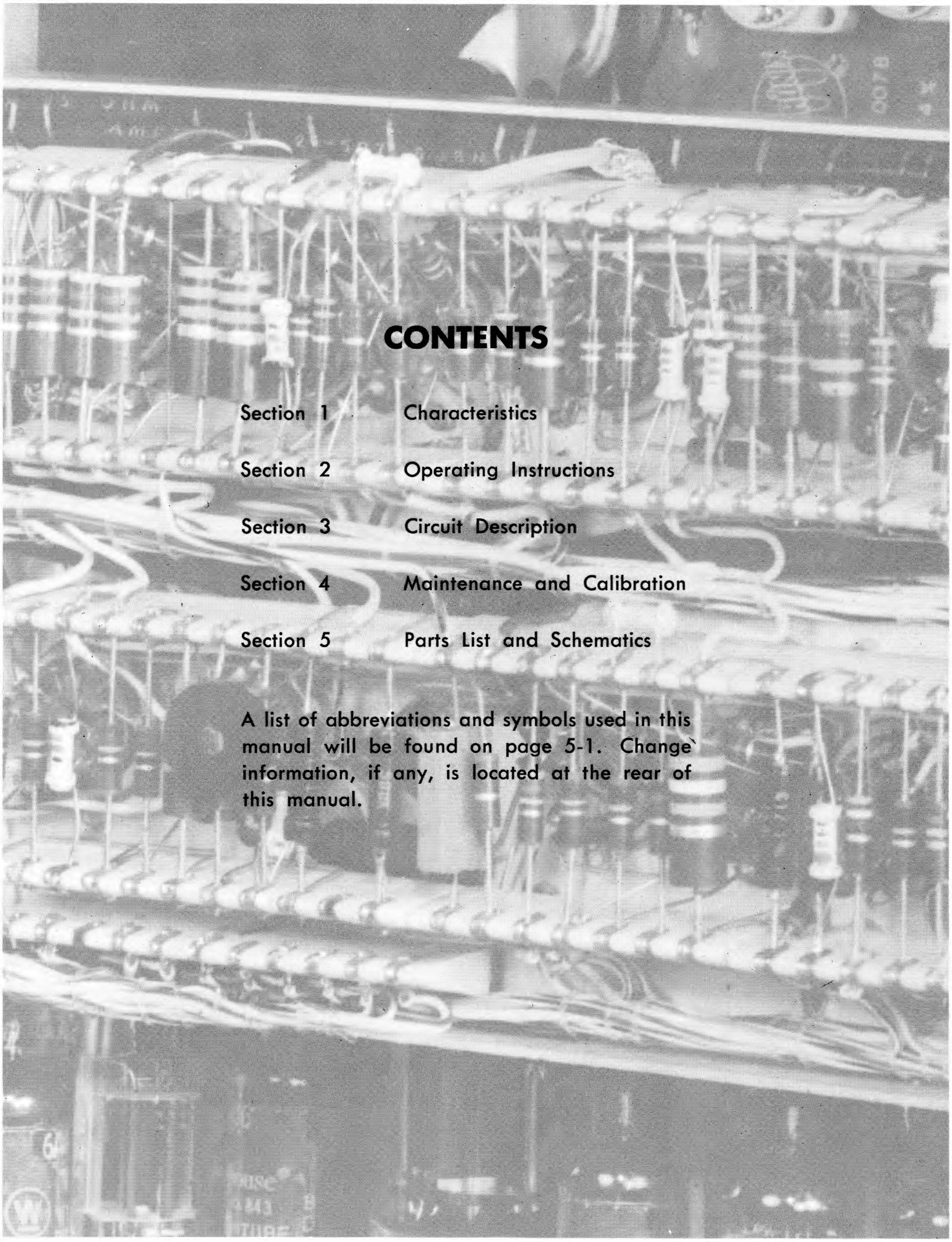
WARRANTY

All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our own plant, are warranted for the life of the instrument.

Any questions with respect to the warranty mentioned above should be taken up with your Tektronix Field Engineer.

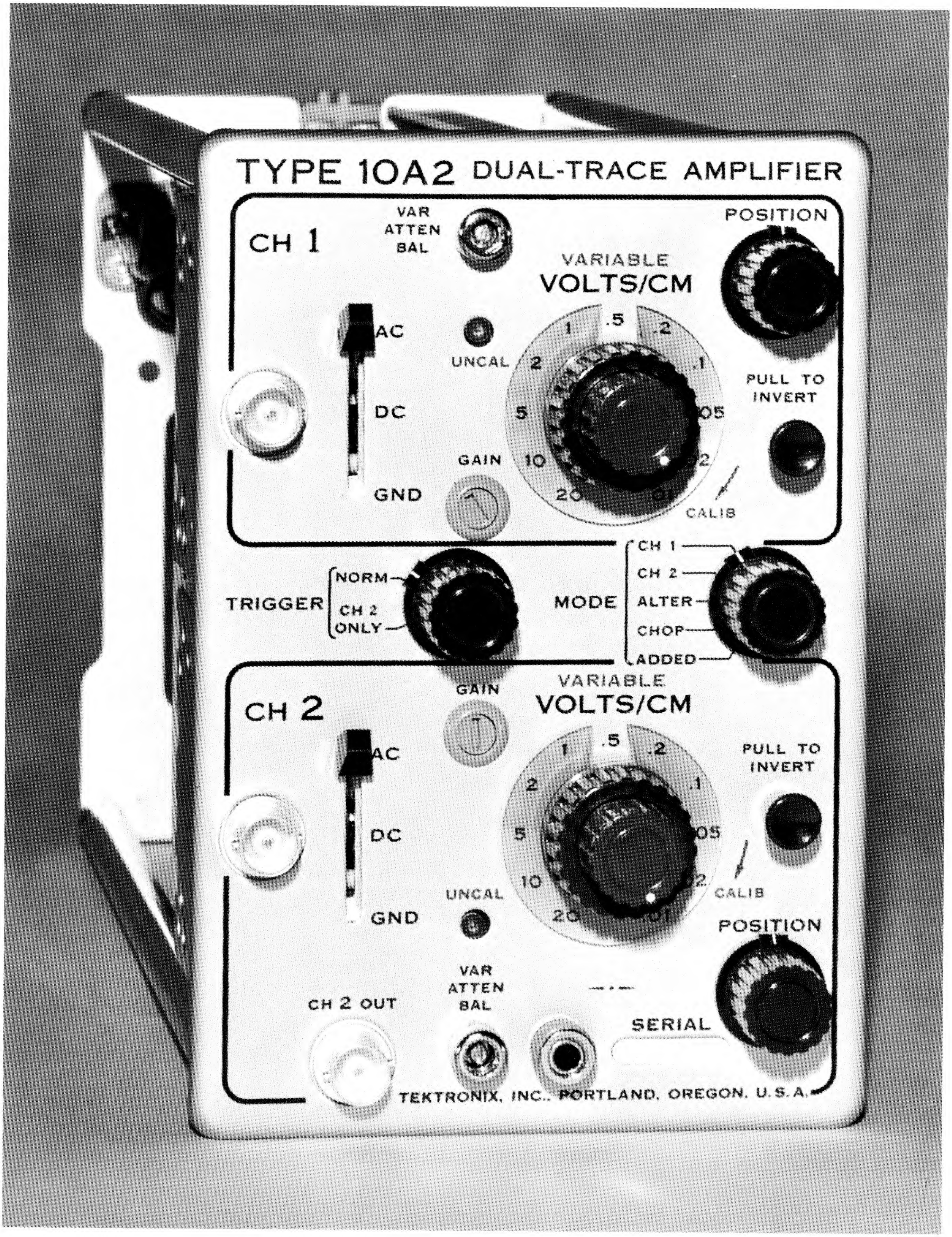
Tektronix repair and replacement-part service is geared directly to the field, therefore all requests for repairs and replacement parts should be directed to the Tektronix Field Office or Representative in your area. This procedure will assure you the fastest possible service. Please include the instrument Type and Serial number with all requests for parts or service.

Specifications and price change privileges reserved.



CONTENTS

A list of abbreviations and symbols used in this manual will be found on page 5-1. Change information, if any, is located at the rear of this manual.



TYPE 10A2 DUAL-TRACE AMPLIFIER
CH 1
VAR ATTEN BAL
POSITION
VARIABLE
VOLTS/CM
AC
DC
GND
UNCAL
GAIN
PULL TO INVERT
CALIB
TRIGGER
NORM
CH 2 ONLY
MODE
CH 1
CH 2
ALTER
CHOP
ADDED
CH 2
GAIN
VARIABLE
VOLTS/CM
AC
DC
GND
PULL TO INVERT
CALIB
UNCAL
POSITION
CH 2 OUT
VAR ATTEN BAL
SERIAL
TEKTRONIX, INC., PORTLAND, OREGON, U.S.A.

SECTION 1
CHARACTERISTICS

General Information

The Type 10A2 Dual-Trace Amplifier plug-in unit is part of a wide-band oscilloscope system designed for severe environmental operation and storage. It contains two identical vertical preamplifiers that can be used singly or combined for a variety of measurements. The Type 10A2 operates in the Type 647 Oscilloscope.

ELECTRICAL

The following electrical characteristics are divided into general operating characteristics and environmental specifications. All data applies to the Type 10A2 as operated in a Type 647 Oscilloscope.

Deflection Factors

Each channel has eleven calibrated steps from 10 mv/cm to 20 volts/cm in a 1, 2, 5 sequence. A variable control with at least a 2.5:1 uncalibrated range extends the maximum deflection factor to 50 volts/cm.

Calibration Accuracy

Adjustable to 0% at 10 mv/cm at the front panel.

Attenuation Accuracy

±2% from −30°C through +65°C.

Risetime (0°C to +40°C)

Typically 6.4 nsec, never longer than 7 nsec, 10% to 90%, for all positions of VOLTS/CM switch. (50 Ω signal source impedance with 50 Ω termination at the Type 10A2 input.)

Frequency Response (0°C to 40°C)

Dc to 50 mc minimum. Ac Coupled: 2 cps to 50 mc minimum.

Input Impedance

1 megohm paralleled by 20 pf.

Maximum Input Voltage

600 volts combined dc and ac peak.

Operating Modes

Channel 1 only, normal or inverted.

Channel 2 only, normal or inverted.

Alternate between channels.

Chopped between channels at 1-mc rate.

Added algebraically.

Channel Isolation

At least 80 db up to 20 mc (input circuits).

Algebraic Addition Common-Mode Signal

Maximum of 50 X the VOLTS/CM switch setting (limited to 600 volts at 20 volts/cm) for linear display operation.

Algebraic Subtraction Common-Mode Rejection Ratio

At least 20:1 for common-mode signals up to 10 cm from dc to 25 mc.

Trace Drift

At 25°C ambient temperature: Typically 2 mm/hr after 15-minute warmup.

Internal Triggering Information

Internal triggering information to the time-base plug-in unit can be selected from the common output amplifier or from the Channel 2 input signal only. Signal to the time base allows reliable internal triggering to a frequency beyond 50 mc.

Channel 2 Output Signal

Front-panel BNC connector labeled CH 2 OUT provides a dc-coupled signal from Channel 2. Output level centered at ground. Output signal: 100 mv/cm related to crt display. Output impedance: 100 Ω.

ENVIRONMENTAL

TABLE 1-1

Characteristic	0°C to +40°C	−30°C to +65°C
Ac Gain Stability		
Display Signal	±1.5%	±3%
CH 2 OUT Signal	±1%	±2%
3-db Bandwidth		
Display Signal	50 mc, minimum	40 mc, minimum
CH 2 OUT into 50 Ω	20 mc, minimum	20 mc, minimum
Chopped Mode Frequency, 1 Mc	±10%	±15%
Dc Trace Displacement	1 cm/20°C	<1 cm/20°C

Storage

The Type 10A2 Dual-Trace Amplifier can be stored alone, or in the Type 647 Oscilloscope at any temperature between —65°C and +75°C. After storage at either extreme, the instrument must be allowed sufficient time for all components to return to the operating ambient temperature range of —30°C to +65°C.

MECHANICAL

Construction

Aluminum-alloy chassis with chrome-plated brass side rails.

Finish

Photo-etched, anodized aluminum panel.

Dimensions

6¼ inches high, 4¼ inches wide, 14¼ inches deep.

Weight

5 pounds net.

Accessories

2—Instruction Manuals—Tektronix Part No. 070-376.

SECTION 2

OPERATING INSTRUCTIONS

FUNCTION OF FRONT PANEL CONTROLS

AC-DC-GND	In the DC position, both the ac and dc components of input signals are displayed. In the AC position, a capacitor blocks dc components of the signal. The low-frequency limit (3-db point) of the AC position is about 2 cps (0.2 cps when a 10 meg Ω 10X probe is used). In the GND position, the Type 10A2 input circuit is grounded (it does not ground the signal).
VOLTS/CM	An 11-position switch that sets the vertical deflection factor of the Type 10A2. All positions are calibrated when the red VARIABLE knob is in the switch detent at the CALIB position. Range is from 0.01 to 20 volts/cm.
VARIABLE VOLTS/CM	Red knob concentric with the VOLTS/CM switch provides continuously variable reduction in amplifier gain (uncalibrated) to at least 2.5 to 1. For example, if the VOLTS/CM switch is in the 1 position, the VARIABLE control will vary the sensitivity between the deflection factors of 1 volt/cm and about 2.5 volts/cm. When used in conjunction with the oscilloscope calibrator voltage, this control permits setting any specific deflection factor within the range of the instrument.
UNCAL	A neon lamp that lights when the VARIABLE control is turned away from its CALIB position.
POSITION	Varies the vertical position of the trace.
PULL TO INVERT	A two-position switch that presents the signal in normal or inverted polarity.
MODE	A five-position switch that sets the mode of operation. The positions are as follows: CH 1: Connects the internal circuits to operate Channel 1 only. The signal in Channel 2 is still applied to the CH 2 OUT connector. CH 2: Connects the internal circuits to operate Channel 2 only. ALTER: Sets the amplifier channels to display on alternate sweeps. For example, the first sweep would be the Channel 1 signal; the second sweep the Channel 2 signal. The flicker between channels will depend on the sweep rate. CHOP: Electronic switching changes the display between channels at a 1-mc rate. Each display segment lasts for about 0.5 μsec. ADDED: The algebraic sum of the Channel 1 and Channel 2 signals will be displayed with the MODE switch in this position. To measure the algebraic difference between signals, use one PULL TO INVERT knob.
TRIGGER	A two-position switch that selects the trigger signal to the time-base plug-in unit trigger circuits. Either Channel 2 or the signal driving the crt vertical deflection plates can be selected.
GAIN	A screwdriver adjustment that permits the gain of the channel to be correctly set.
VAR ATTEN BAL	A screwdriver adjustment that balances the amplifier so that with no signal applied there is no vertical shift of the trace as the VARIABLE VOLTS/CM control is turned.

FIRST-TIME OPERATION

The Type 10A2 should be inserted into the left-hand (Y-axis) opening of the Type 647 Oscilloscope. A time-base plug-in unit such as the Type 11B2 should be inserted in the right-hand (X-axis) opening.

The following procedure will help you become familiar with the Type 10A2 operation:

1. Set the front-panel controls as follows:

AC-DC-GND	DC (both channels)
VOLTS/CM	.01 (both channels)
VARIABLE	CALIB (both channels)
POSITION	Midrange (both channels)
MODE	CH 1
PULL TO INVERT	Pushed in (both channels)
TRIGGER	NORM

2. Apply a 20-mv signal from the oscilloscope calibrator to both Type 10A2 input connectors. Adjust the time-base controls for a stable display. Use ac low-frequency reject internal-trigger coupling. The display will be a rectangular waveform 2 divisions in amplitude. With the Channel 1 POSITION control, move the display above the graticule centerline.

3. Turn the MODE switch to CH 2. A similar two-division waveform will be displayed. With the Channel 2 POSITION control, move the display below the graticule centerline.

4. Set the MODE switch to ALTER. If necessary, adjust the time-base triggering for a stable display. Both signals should be displayed. The switching rate will depend on the sweep rate.

5. Set the MODE switch to CHOP, and the TRIGGER switch to CH 2 ONLY. If necessary, adjust the time-base triggering for a stable display. Two separate traces should appear.

6. Set the MODE switch to ADDED. There should be one display 4 divisions in amplitude. This is the addition of the Channel 1 and 2 waveforms (2 divisions each). Notice that either POSITION control can move the trace vertically.

7. Pull the Channel 1 PULL TO INVERT switch. Free run the time base. The display should be a straight line, indicating the algebraic difference between the two signals. Since the signal amplitudes are equal, the difference is zero.

Variable Attenuator Balance and Gain Adjustment

Before the Type 10A2 is used for accurate measurements, the VAR ATTEN BAL and GAIN controls (front-panel screwdriver adjustments) for each channel should be checked and adjusted as necessary. The GAIN should also be checked each time the Type 10A2 is moved from one Type 647 Oscilloscope to another.

If the variable dc balance of a channel is not properly set, the position of a no-signal trace will shift vertically as the VARIABLE VOLTS/CM control of that channel is turned.

Adjust the VAR ATTEN BAL control as follows:

1. Set both AC-DC-GND switches to GND.

2. Set the MODE switch to CH 1 and position a free-running sweep to the center of the crt.

3. Adjust the Channel 1 VAR ATTEN BAL control to a point where there is no trace shift as the VARIABLE VOLTS/CM control is turned throughout its range.

4. Repeat the preceding steps for Channel 2.

Set the GAIN control as follows:

1. Set the TRIGGER switch to NORM.

2. Set the Channel 1 AC-DC-GND switch to DC and the MODE switch to CH 1.

3. Set the Channel 1 VOLTS/CM switch to .01 (or other required position) and the VARIABLE control to CALIB.

4. Set the time-base plug-in unit for a free-running 0.1 msec/cm sweep.

5. Apply 50 mv (or other required value) from the oscilloscope calibrator to the Channel 1 input connector.

6. There should be 5 cm of display; if not, adjust the GAIN control.

7. Repeat the preceding steps for Channel 2 GAIN adjustment.

General Operation

Either of the two preamplifier channels can be used independently by setting the MODE switch to CH 1 or CH 2 and connecting the signal to be observed to the appropriate input. Table 2-1 lists several input systems suitable to the Type 10A2 input. Fig. 2-1 shows a block diagram of the input when using Method 7 of Table 2-1.

TABLE 2-1

Signal Coupling Methods

Method	Advantages	Limitations	Accessories Required	Source Loading. See Fig. 2-2 & 2-3, Input R_p & C_p Curves.	Precautions
1. Open test leads.	Simplicity.	Limited frequency response. Subject to stray pickup.	BNC to Banana Jack adapter (103-033). Two test leads.	1 meg Ω & 20 pf at input, plus test leads.	Stray pickup.
2. Unterminated coax cable.	Full sensitivity.	Limited frequency response. High capacitance of cable.	Coax cable with BNC connector(s).	1 meg Ω & 20 pf plus cable capacitance.	High capacitive loading.

TABLE 2-1 *(cont'd)*

Method	Advantages	Limitations	Accessories Required	Source Loading. See Fig. 2-2 & 2-3, Input R_p & C_p Curves.	Precautions
3. Terminated coax cable. Termination at 10A2 input.	Full sensitivity. Total 10A2/647 bandwidth. Relatively flat-response resistive loading. Long cable with uniform response.	Presents R_o (typically 50 Ω) loading at end of coax. May need blocking capacitor to prevent dc loading or damage to termination.	Coax cable with BNC connector(s). R_o termination at 10A2 input. (BNC 50 Ω Termination 011-049).	R_o plus 20 pf at 10A2 end of coax can cause reflections.	Reflection from 20 pf at input. Dc and ac loading on test point. Power limit of termination.
4. Same as 3, with coax attenuator at termination.	Less reflection from 20 pf at termination.	Sensitivity is reduced (increased deflection factor).	BNC coaxial attenuators.	R_o only.	Dc and ac loading on test point. Power limit of attenuator.
5. Tap into terminated coax system. (BNC Tee: UG-274/U at 10-A2 input.)	Permits signal to go to normal load. Dc or ac coupling without coaxial attenuators.	20-pf load at tap point.	BNC Tee and BNC connectors on signal cables.	1 meg Ω & 20 pf at tap point.	Reflections from 20 pf input.
6. 10X, 10 meg Ω probe. 100X, 9.1 meg Ω probe. 1000X, 100 meg Ω probe.	Reduced resistive and capacitive loading; nearly full bandwidth of 10A2/647.	X0.1 sensitivity. X0.01 sensitivity. X0.001 sensitivity.	P6006, P6008, P6003: 10X (P-6005 is 100X, P6015 is 1000X).	P6006: ≈7 pf, 9 meg Ω. P6008: ≈7 pf, 10 meg Ω. P6003: 12 pf, 10 meg Ω. P6005: 26 pf, 9.1 meg Ω. P6015: 3 pf, 100 meg Ω.	Check probe frequency compensation. Use square wave frequency less than 5 kc, preferably 1 kc.
7. 500 Ω and 5 kΩ probes. (Must be terminated in 50 Ω at 10A2 input.)	Reduced capacitive loading to about 0.7 pf. Bandwidth that of 10A2/647.	Resistive loading. X0.1 or X0.01 sensitivity. May need blocking capacitor to prevent dc loading or damage to termination. Limited low-frequency response when ac coupled. See Fig. 2-1.	P6043: 10X. P6035: 100X. Items in Fig. 2-1.	P6034: 500 Ω, 0.7 pf. P6035: 5 k Ω, 0.6 pf. See R_p & C_p curves in Fig. 2-2.	Dc and ac loading. Voltage rating of probe.
8. Current transformer. Terminated in 50 Ω at 10-A2. Bandwidth that of 10A2/647.	Current transformer can be permanent part of test circuit. Less than 2.2 pf to test circuit chassis. Measure signal currents in transistor circuits: CT-1—20 amps pk. CT-2—100 amps pk.	RMS current rating: CT-1—0.5 amp. CT-2—2.5 amps. Sensitivity: CT-1—5 mv/ma. CT-2—1 mv/ma.	CT-1: Coax. adapter and BNC termination. CT-2: Nothing extra (perhaps additional coax. cable for either transformer).	CT-1: Insertion; 1 Ω paralleled by about 5 μh. Up to 1.5 pf. CT-2: Insertion; 0.04 Ω paralleled by about 5 μh. Up to 2.2 pf.	Not a quick-connect device. CT-1: low-frequency limit about 75 kc. CT-2: low-frequency limits about 1.2 kc, and is 1/5th as sensitive as the CT-1.

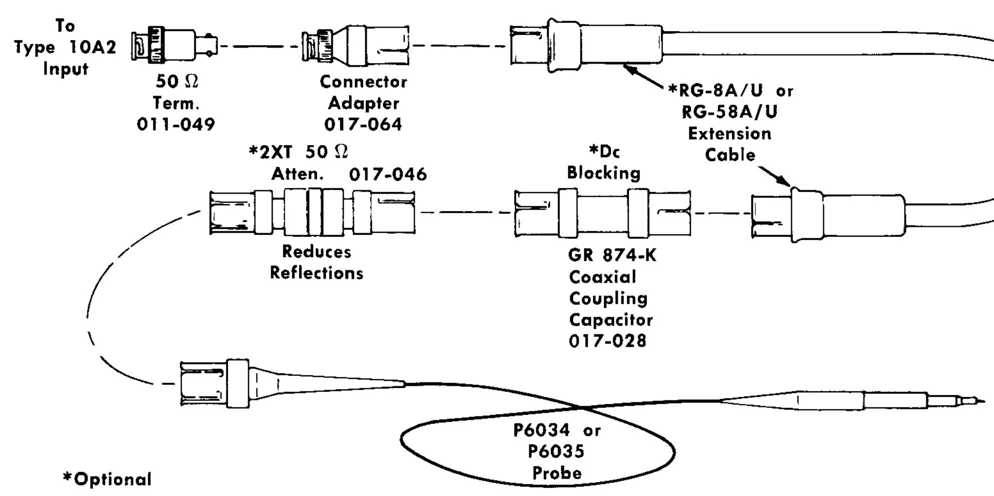


Fig. 2-1. Recommended component sequence when using the P6034 or P6035 Probe.

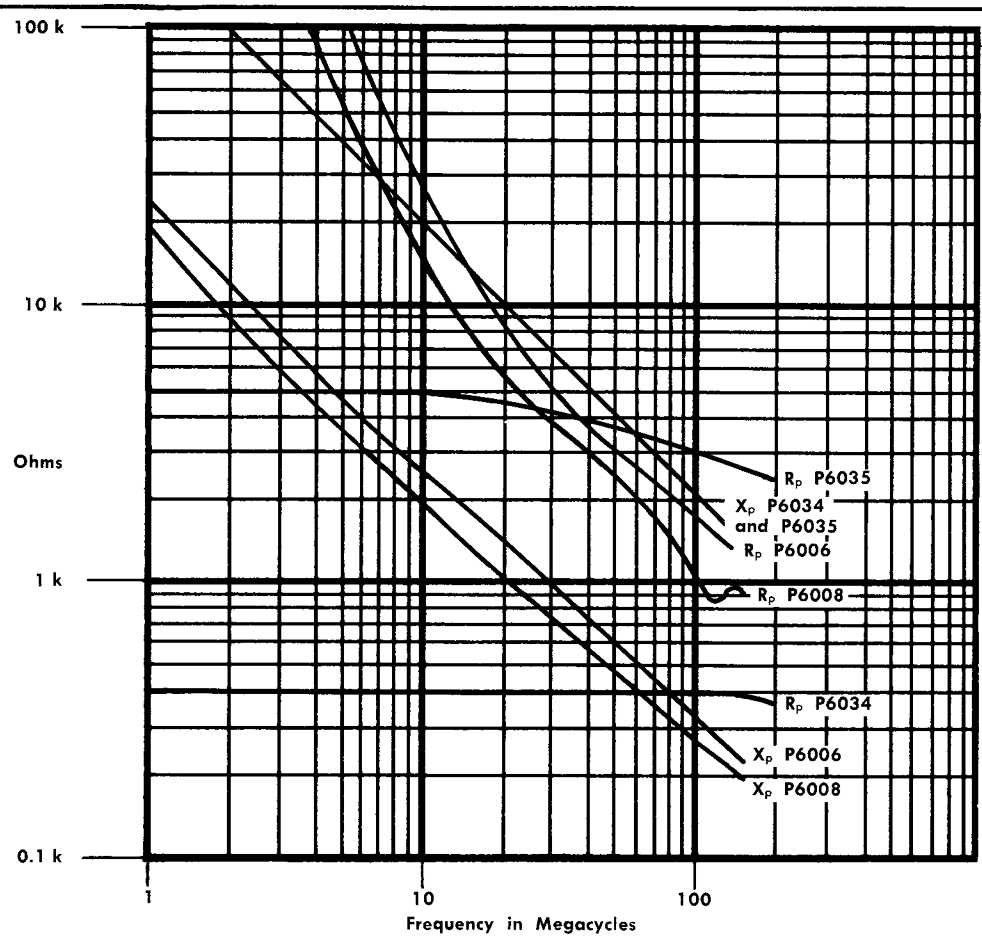


Fig. 2-2. Nominal input resistance (R_p), and capacitive reactance (X_p), of several attenuator probes when properly compensated and used with a Type 10A2.

SECTION 3
CIRCUIT DESCRIPTION

General Information

The Type 10A2 Dual-Trace Amplifier is a wide-band vertical plug-in unit for the Type 647 Oscilloscope.

The VOLTS/CM attenuators permit large signal amplitudes to be reduced before being amplified. Drift and noise characteristics are the same for all positions of the VOLTS/CM switch since the amplifier gain is not changed when switching between various deflection factors.

The Input Amplifiers raise the signal level before positioning is added. The Input Amplifier essentially changes the input voltage signal to an internal current signal. Thus, the positioning is by current offset of the Input Amplifier output. The PULL TO INVERT switch is between the Input Amplifier and the POSITION control to permit inverting the display without inverting the POSITION control action.

The Channel 2 Input Amplifier sends an isolated signal to the Channel 2 Trigger Amplifier. The Channel 2 Trigger Amplifier sends the Channel 2 signal to both the Trigger Amplifier (for internal triggering) and to the front-panel CH 2 OUT connector.

The Switching Circuit accepts one channel at a time or both channels together for use by the Output Amplifier. The MODE switch sets the Switching Circuit operating conditions.

The Output Amplifier sends an isolated output signal to the Trigger Amplifier for internal triggering.

The Trigger Amplifier receives information from either the Channel 2 Trigger Amplifier or the Output Amplifier through the TRIGGER switch. Thus, the time-base plug-in unit can be triggered either from the (composite) vertical information, or from Channel 2 information only.

Input Circuit

The Type 10A2 input connectors are the BNC type. The input signals pass through frequency-compensated voltage dividers, except at 0.01 volt/cm. All deflection factors present 1 megΩ paralleled by 20 pf to the input circuit (see Fig. 2-2 and Fig. 2-3). Each position of the VOLTS/CM switch (see Attenuators schematic) is individually adjustable for input capacitance and frequency compensation. This system permits the full bandpass of the instrument to be used at all deflection factors.

Each attenuator is made up of two or three resistors in series and two capacitors in series, forming a frequency-compensated attenuator. An additional small shunt input capacitor permits adjusting each attenuator to exhibit a 20 pf input.

Channel 1 Input Amplifier

Input tube V133 is a cathode follower that drives the Input Amplifier. The plate voltage for V133 comes from cascaded emitter followers Q123 and Q133. By adjusting the plate voltage of V133, its cathode voltage is set to the correct value of about +1.2 volts. Any grid current of V133 is offset by a small negative voltage set by R117, the CH 1 GRID CURRENT ZERO internal control.

The cathode voltage of V133 is adjusted to be equal to the voltage at the junction of R135-R136. The GAIN (R138) and VARIABLE (R144) resistors have no dc current through them. Thus, either control can be turned without shifting the crt display vertically. The base current of Q154 (that would otherwise apply current to the VARIABLE control) is canceled by R140, the Q154 BASE CURRENT internal control.

By proper adjustment of the plate voltage and grid current of V133 and the base current of Q154, the GAIN and VARIABLE controls pass no dc current when the input signal is zero.

Q154 is one-half of a paraphase amplifier stage (with fixed emitter degeneration) that drives a second push-pull amplifier stage (Q174-Q184). The CH 1 GAIN RANGE control in the emitter circuit of Q174-Q184 permits adjusting the total Input Amplifier gain so the front-panel GAIN control has its proper range of adjustment.

The dc balance of the two amplifier stages is set at the base of Q164 by CH 1 INV BAL control R160. R160 is adjusted during calibration, using the PULL TO INVERT switch to check the amplifier balance.

The dc level of the push-pull output leads of the Input Amplifier is set by varying the supply voltage to Q154-Q164 with the CH 1 COM MODE CURRENT control R150.

First-order temperature compensation of Q174-Q184 is by D157 in the base ground-return lead. The change in voltage across D157 with temperature is almost equal to and is opposite the change across the base-emitter diodes of Q174-Q184.

Protection for Common Base stage Q304-Q314 from overdrive is by D192-D193. Should the signal to one of the common-base amplifiers be great enough to reverse bias its emitter-base junction, one of the diodes will conduct. Conduction of D192 or D193 prevents the reverse biasing, and assures a rapid amplifier recovery after overload.

Signal Tracing vs Current Gain

Correct analysis of the Input Amplifier requires consideration of both current gain and voltage gain. To show the true conditions, Table 3-1 lists voltage and current signals in one-half the Input Amplifier.

TABLE 3-1

Approximate Voltage and Current Gains of One-Half the Input Amplifier

Test Point	Approximate Impedance	Mv/Cm	Ma/Cm	Gain: A = Voltage, G = Current
Q154 Base	2600 Ω	5.7	0.0022	(Q154 and Q174 $\beta \approx$ 40 each)
Q154 Collector	114 Ω	10	0.088	
Q174 Base	2400 Ω	10	0.0042	Q154B to Q174B: A = 1.75, G = 1.95
Q174 Collector	95 Ω	16	0.168	Q154B to Q174C: A = 2.8, G = 76.4

Q174 collector drives common-base amplifier Q304 through R190 and R192 (PULL TO INVERT switch pushed in). About a 1 mv/cm signal can be measured at the emitter of Q304 even though it is being driven at 0.168 ma/cm.

Fig. 3-1 shows the dc current and voltage conditions of the switching diodes, except for the ADDED mode of operation. Fig. 3-1 and the Channel 1 Input Amplifier schematic shows that measuring the dc level or signal voltage at the collector of Q174 does not indicate that Channel 1 is being displayed.

Common-Base Stage of Switching Circuit

The "pentode-like" characteristics of the collectors of Q304-Q314, and their common-base circuit, permit their collector voltages to be changed without affecting the Input Amplifier. Switching multivibrator Q345-Q355 diverts the collector current of the common-base stage of the channel not being displayed. Fig. 3-1 shows that the common base stage current is independent of operating mode.

Added mode of operation combines the output of both input amplifiers. (See Fig 3-2.) This requires 12 ma in each base lead from the Q413-Q423 input circuit. R318 and R338 are placed in parallel with the current supply to common-base stages R411-R317 on one side and R421-R337 on the other. The dc current through resistors normally used for single-channel operation remains the same. The switching multivibrator is set so it does not supply current to either channel common-base stage.

Output Amplifier

The voltage level at the base of Q413-Q423 (+6.6 volts) is set by the emitter return voltage of Q434-Q444. The base-emitter diode drop of each transistor is about 0.7 volt which elevates the 5.1 volts at the emitters of Q434-Q444 to 6.6 volts at the bases of Q413-Q423.

Q413 and Q423 are emitter followers with shunt feedback for stabilized current gain. Their emitters are isolated so they are not in push-pull. Q434-Q444 emitters are also isolated, but feedback to their bases makes them part of push-pull output pair Q454-Q464. The static current of the Output Amplifier three transistor pairs, and thus the common-mode dc output voltage, is set at the bases of Q413-Q423 by MAIN AMP CURRENT control R336.

Feedback resistors R450 and R460 set the current gain of output transistors Q434-Q444 and Q454-Q464 to a low value so the multi-stage current gain will be virtually independent of transistor beta throughout the required temperature and frequency ranges.

Table 3-2 shows the voltage gain and current gain data for the Output Amplifier.

TABLE 3-2

Approximate Voltage and Current Gains of One-Half the Output Amplifier

Test Point	Approximate Impedance	Mv/Cm	Ma/Cm	Gain: A = Voltage, G = Current
Q413 Stage Input		≈3	0.132	
Q434 Stage Input	5 Ω	≈1.6	0.317	Q413 stage input to Q434 stage input: A≈ 0.53, G=2.4
Q434 Collector	154 Ω	≈48	0.312	
Q454 Base	1.7 kΩ	≈48	0.028	(Z and Ma/Cm only theoretical.)
Q454 Collector	46 Ω	75	1.62	Q434 stage input to Q454C: A=48, G=5.3.
Type 647 Input	93 Ω	75	0.81	

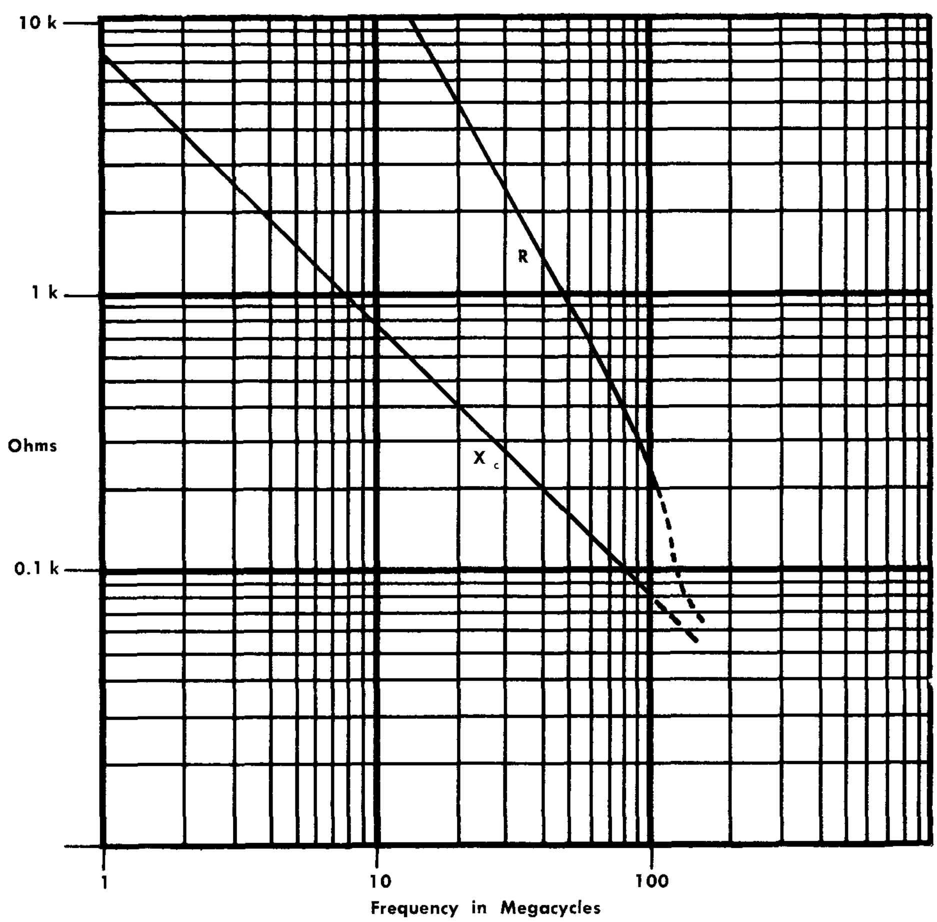


Fig. 2-3. Type 10A2 nominal input resistance and capacitive reactance vs frequency at any position of the VOLTS/CM switch.

Input Coupling

To display both the ac and dc components of an applied signal, set the appropriate AC-DC-GND switch to DC; to display only the ac component of a signal, set the switch to AC. In the AC position of the switch, the dc component of the signal is blocked by a capacitor in the input circuit. The low-frequency ac —3-db point is about 2 cps when the source impedance is low. Therefore, some low-frequency distortion of signals with components near this frequency can be expected when using the AC position. When using a 10X 10 megΩ probe, the low-frequency response is about 0.2 cps in the AC position.

Deflection Factor

The amount of vertical deflection produced by a signal is determined by the signal amplitude, the attenuation factor (if any) of a probe, the setting of the VOLTS/CM switch, and the setting of the VARIABLE VOLTS/CM control. Calibrated deflection factors indicated by the VOLTS/CM switch apply only when the VARIABLE control is set fully clockwise to the CALIB position.

The range of the VARIABLE VOLTS/CM control is at least 2.5:1 to provide variable (uncalibrated) vertical deflection factors between calibrated settings of the VOLTS/CM switch.

The VARIABLE VOLTS/CM control extends the vertical deflection factor of the Type 10A2 to above 50 volts/cm.

Dual Trace Operation

The choice of alternate or chopped mode of operation can be made from the following discussions and Table 2-2.

Displaying Two Non-Repetitive Signals. The chop mode of operation allows good resolutions of non-repetitive signals to be obtained using sweep rates as fast as 10 μsec/cm. The 10 μsec/cm sweep rate is probably the fastest sweep rate you will want to use and still get good resolution. Thus, non-repetitive signals up to 0.1 msec duration will produce a useful display with about 100 segments making up each trace.

To obtain useful displays when observing fast non-repetitive signals with the faster sweep rates, use one-channel operation.

Displaying Two Repetitive Signals. When displaying two repetitive signals using the alternate mode of operation, use sweep rates of 0.5 msec/cm or faster. When viewing a repetitive display from signals 250 cps or higher, alternate mode of operation produces an uninterrupted display (the

TABLE 2-2

Dual-Trace Internal Triggering

Signals	MODE Switch	TRIGGER Switch	Time-Base Triggering
1. Two of same or harmonically related frequency, 250 cps and above. (Lower frequency into Channel 2.)	ALTER	CH 2 ONLY	AC
2. Two of same or harmonically related frequency, anywhere within full bandwidth.*	CHOP	CH 2 ONLY	AC, DC, or AC LF REJ
3. Two of dissimilar (not harmonically related) frequency, 1 kc and above	ALTER	NORM	AC LF REJ only
4. Two one-shot signals. First signal to Channel 2. Sweep rate limited to 10 μsec/cm, max.	CHOP	CH 2 ONLY	AC, DC, or AC LF REJ

* Occasionally the signals will be harmonically related to the chopping rate, then at sweep rates above 10 μsec/cm the chop segments may be too obvious.

alternate-mode switching cycle is sufficiently fast to produce an apparently steady display). If slower sweep rates are used for viewing signals 250 cps or lower, the alternate-mode switching cycle becomes more apparent and you may prefer to use chopped mode of operation.

Voltage Measurements

To measure the voltage between two points on a signal (such as peak-to-peak ac volts), measure the vertical distance in graticule divisions between the two points and multiply by the setting of the VOLTS/CM switch and the attenuation factor, if any, of a probe. Be certain that the VARIABLE VOLTS/CM control is in the CALIB position.

For example, assume you use a 10X probe with the VOLTS/CM switch set to .02, and your display has a vertical deflection of 4 cm. In this case, 4 divisions X 0.02 volt/div = 0.08 volt. This voltage times the probe attenuation factor of 10 shows a true peak-to-peak voltage of 0.8 volt.

To measure the dc level at a given point on a waveform, proceed as follows:

1. Set the VOLTS/CM switch so that the expected voltage (at the input connector) is not more than six times the setting. Be sure the VARIABLE VOLTS/CM control is in the CALIB position.
2. Set the time-base controls so that the sweep free runs.
3. Set the AC-DC-GND switch to GND, and use the POSITION control to align the trace with one of the graticule lines. This line is a ground (or zero) reference. The position selected for this reference line depends on the polarity and amplitude of the signal to be measured. Do not move the POSITION control once the reference line has been established.
4. Set the AC-DC-GND switch to DC.
5. Apply the signal to the input connector and set the time-base triggering controls for a stable display.
6. Measure the vertical distance, in major graticule divisions, from the ground (zero) reference line to the point on the waveform that you wish to measure.
7. Multiply this distance by the setting of the VOLTS/CM switch and any probe attenuation factor. This is the instantaneous dc level of the point measured.

Check the zero reference line at any time by setting the AC-DC-GND switch to GND. It is not necessary to disconnect the signal probe from the Type 10A2. To use a reference other than zero, set the AC-DC-GND switch to DC and touch the signal probe to the reference voltage; then use the POSITION control to align the trace with a reference graticule line.

Voltage Comparison Measurements

In some applications, a set of vertical deflection factors other than those set by the VOLTS/CM switch need to be used. This is convenient for measuring signals that are multiples of fractional voltages between VOLTS/CM switch positions. To establish a set of deflection factors based on some specific voltage, use the following procedure:

1. Apply the new voltage reference signal to either Type 10A2 input connector. Set the VOLTS/CM switch and the VARIABLE control so that the display covers an exact number of graticule divisions. Do not move the VARIABLE control.
2. Divide the amplitude of the reference signal (in volts) by the product of the deflection established in step 1 (in centimeters) and the setting of the VOLTS/CM switch. The result is the deflection Conversion Factor.

   Conversion Factor =

$$\frac{\text{Amplitude of reference signal (in volts)}}{\text{Amount of deflection X VOLTS/CM switch setting}}$$

3. To calculate the true deflection factor at any position of the VOLTS/CM switch, multiply the switch setting by the deflection Conversion Factor:

   True Deflection Factor =
   VOLTS/CM switch setting X Conversion Factor

This new set of deflection factor values applies to this channel only, and only if the VARIABLE control is not moved.

Accurate Dc Millivolt Measurements

Operation of the Type 10A2 at 0.01 mv/cm may be quite common when working with 50-ohm coaxial systems near the upper frequency limit of the Type 647 system. Measurement accuracy requires careful attention to both the VAR ATTEN BAL adjustment and the input-stage grid current. The VAR ATTEN BAL adjustment must be made first as described under "First-Time Operation" in this section.

To check the input-stage grid current, warm up the Type 10A2 at least 10 minutes. Check grid current as follows:

1. Set the MODE switch to the channel in use.
2. Adjust the VAR ATTEN BAL control.
3. Set the VOLTS/CM switch to .01, VARIABLE to CALIB, and input selector to GND.
4. Center a free-running sweep. Switch input selector to DC and watch for a trace shift. If the trace shifts, you may wish to touch-up the internal GRID CURRENT ZERO adjustment in the affected channel. See Section 4, "Dc Adjustments", step 10.

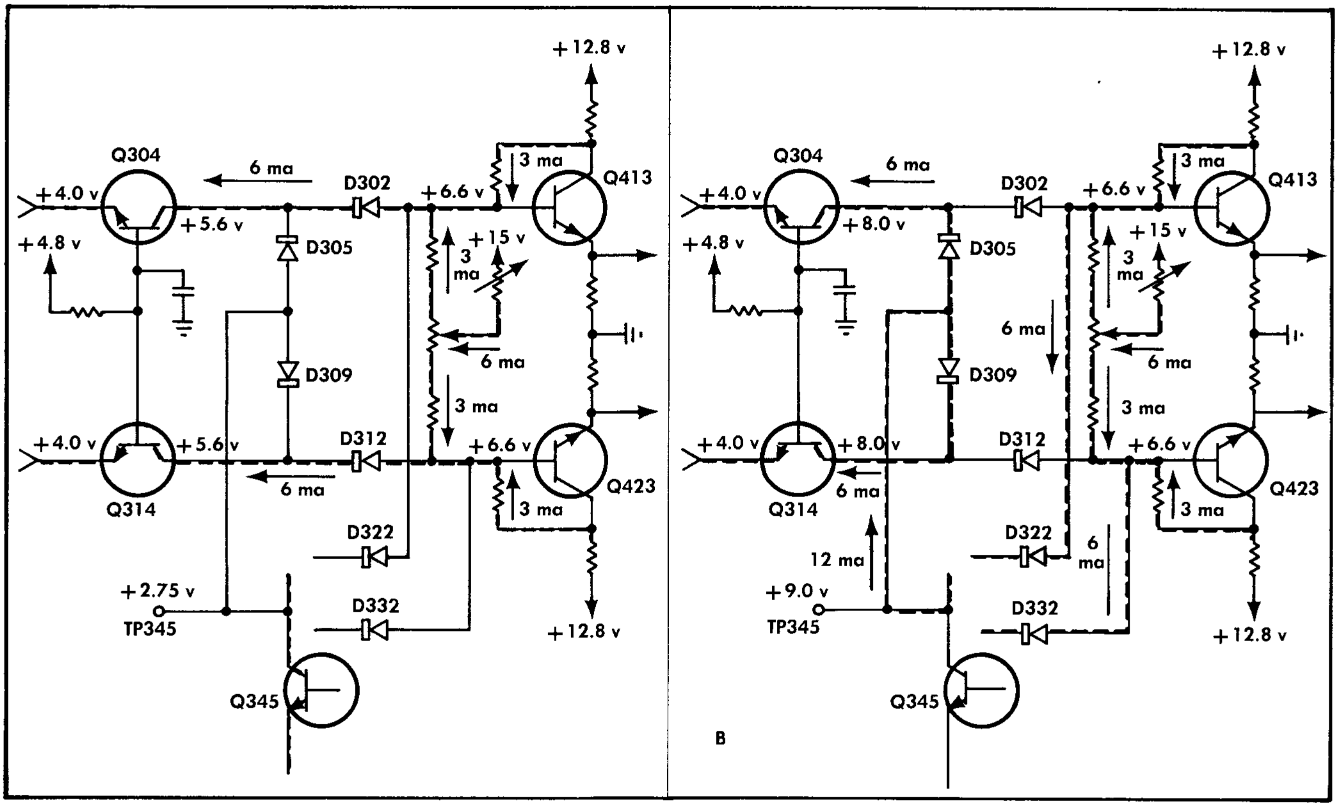


Fig. 3-1. Dc current flow and voltage levels at switching diodes for a centered trace. A: Channel 1 displayed. B: Channel 2 displayed.

Channel 2 Input Amplifier

The Channel 2 Input Amplifier is identical with that of Channel 1, except for the trigger takeoff point in the emitter circuit of Q274-Q284. The emitter-circuit resistors are different than in Channel 1 to keep the emitter degeneration the same while providing the trigger takeoff as if from an emitter follower. The Channel 2 trigger signal goes first to the base terminals of Q504-Q514, then to the TRIGGER switch.

Trigger Amplifiers

The Channel 2 Trigger Amplifier and the Trigger Amplifier are similar with low input impedance and high current output. Each has a stabilizing feedback loop that keeps the stage current gain virtually independent of transistor parameter changes throughout the required temperature and frequency ranges.

Signal voltage and current data for both amplifiers is in Table 3-3. The information is based upon the TRIGGER switch being at CH 2 ONLY.

Dual-Trace Switching Multivibrator

The dual-trace multivibrator transistors Q345-Q355 conduct current only when the MODE switch is at either CHOP or ALTER. In the Chopped mode, the emitter leads are connected to the —15-volt supply through R345-R355 and the primary of T371. The multivibrator free runs and the blanking amplifier delivers an output signal. In the Alternate mode, the multivibrator emitter leads are connected to the —15-volt supply through D348-D358 and R364-Q364. The multivibrator is then bistable and the blanking amplifier is inoperative.

TABLE 3-3

Approximate Voltage and Current Gain of One-Half the Trigger Amplifiers

Test Point	Mv/Cm	Ma/Cm	Gain: A = Voltage, G = Current
Q504 Stage Input	0.8	0.042	
Q523 Base	19		
Q523 Emitter	17	1.0	Q504 stage input to Q523E: A ≈ 22, G = 24
Q554 Stage Input	≈1.5	0.10	
Q574 Base	50		
Q574 Collector	100	1.13	Q554 stage input to Q574C: A ≈ 70, G = 11

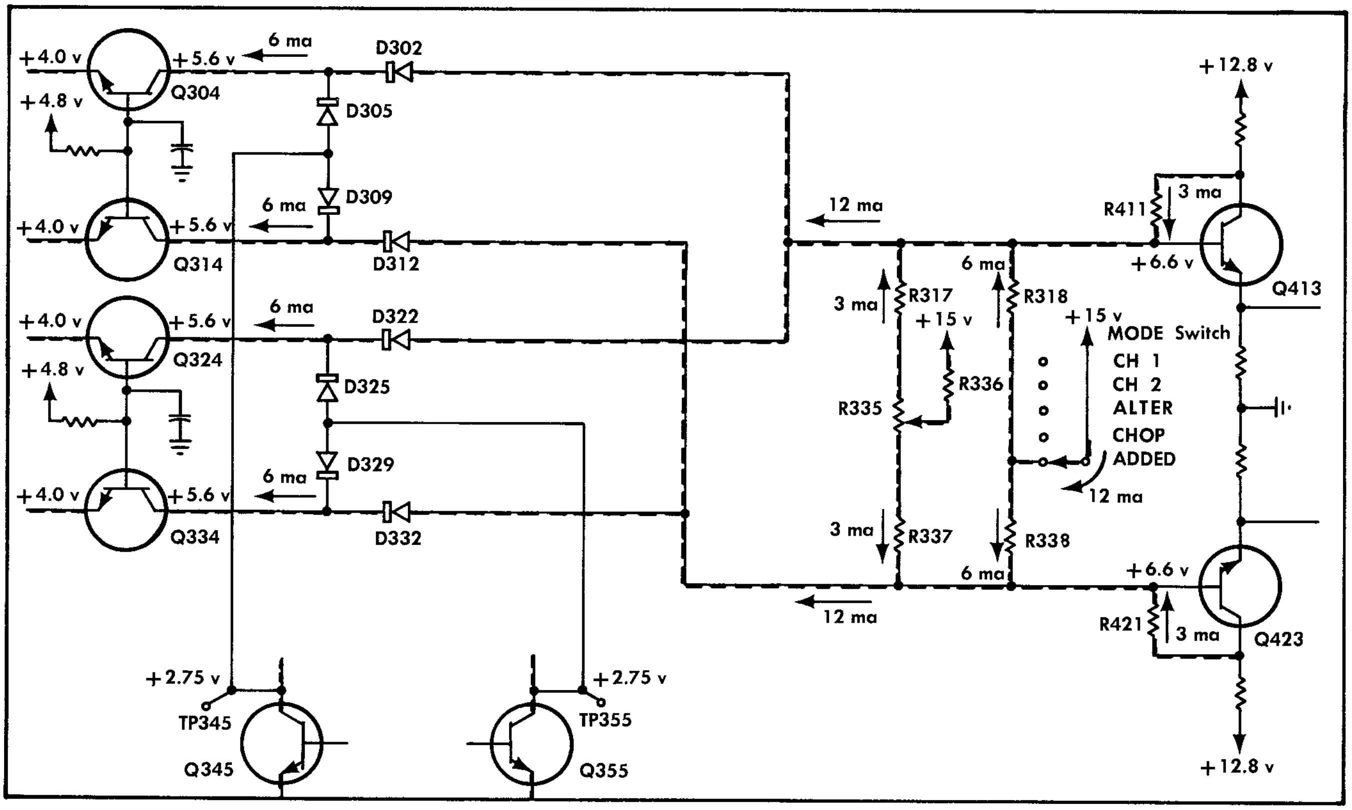


Fig. 3-2. Dc current flow and voltage levels for Added mode operation.

The voltages at the multivibrator test points are listed for all modes of operation in Table 3-4. The emitter voltages listed in Table 3-4 do not indicate transistor conduction for the Ch 1, Ch 2 or Added modes, but rather are a measure of the base voltage set by the base divider resistors.

TABLE 3-4

Switching Multivibrator Conditions

Test Point	MODE				
	CH 1	CH 2	ALTER	CHOP	ADDED
TP345	+2.8*	+8.8	+6.5	+6.5	+2.8
TP355	+8.8	+2.8	+6.5	+6.5	+2.8
Q345 Emitter	+2.0	+2.0	+0.9	+1.8	+2.0
Q355 Emitter	+2.0	+2.0	+0.9	+1.8	+2.0

* Meter: 20,000 Ω/volt.

Chopped-Mode Operation

The multivibrator is a non-saturating form with the switching time-constant network connected between emitters. The capacitors in the base circuits are for coupling only.

Chopped-mode multivibrator waveforms are shown in Fig. 3-3. They show that the emitter of conducting Q345 (Q345E) rests at 2.5 volts until the emitter voltage of Q355 (Q355E) falls to −1.6 volts at the flip point. As the flip action begins, Q345 cuts off; its collector goes positive (TP345) taking the base and emitter of Q355 positive. As the emitter of Q355 rises, it takes the emitter of Q345 to +4.3 volts via C348, assuring that Q345 goes deep into cutoff. Then the RC fall of C348-R345 takes the Q345 emitter negative (the slope from +4.3 to −1.6 volts). As soon as the Q345 emitter drops below its base voltage, the multivibrator flips back to the first condition.

NOTE

Fig. 3-3 through Fig. 3-8 were taken with a Tektronix C-12 Camera, a Type 535A Oscilloscope with Type CA Dual-Trace Plug-In Unit, and two 10X, 10 megΩ probes. The oscilloscope was externally triggered from TP345 and the plug-in unit operated in the Alternate mode.

Crt Blanking

The Type 647 crt is blanked during the brief Chopped-mode switching time of the Type 10A2. The blanking pulse is generated by Q374, Q383, and Q390.

Q374 is energized by the MODE switch and turns on briefly each time the Q345-Q355 multivibrator switches. As the multivibrator flips, the positive pulse from the multivibrator emitters is coupled through T371, in phase, to the base of Q374. Q374 turns on to saturation and its collector falls to about −12 volts (see Fig. 3-4). The signal to the base of Q383 is greatly attenuated by R374 and R375 in series to ground. As the voltage across T371 collapses, Q374 is turned off and held off by the stored charge on C371 until the next multivibrator pulse turns it on.

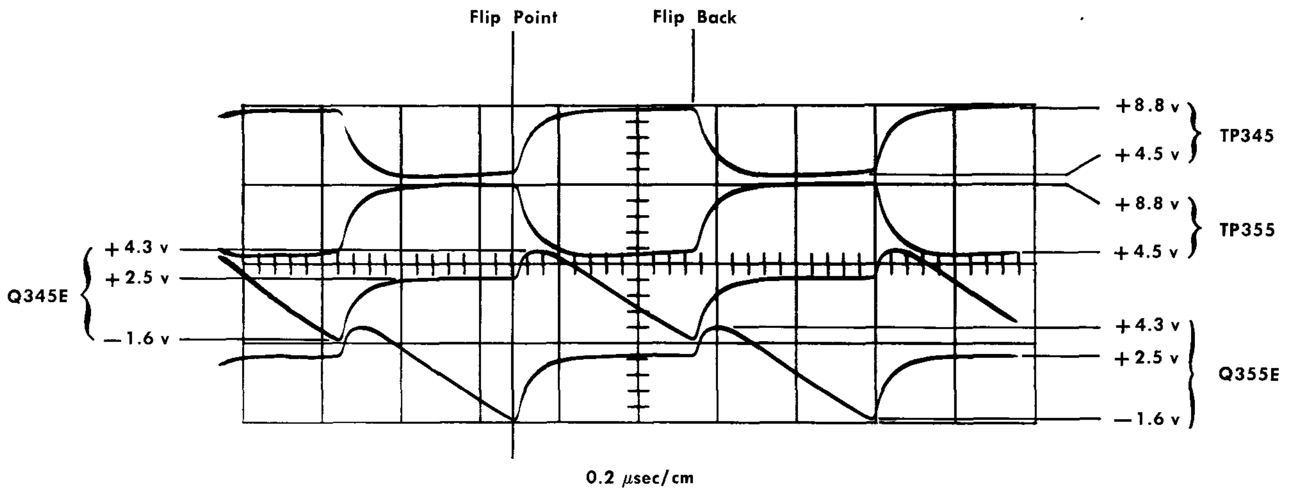


Fig. 3-3. Chopped mode signals of Q345 and Q355. Type 543A Oscilloscope with Type CA Dual-Trace Plug-in Unit.

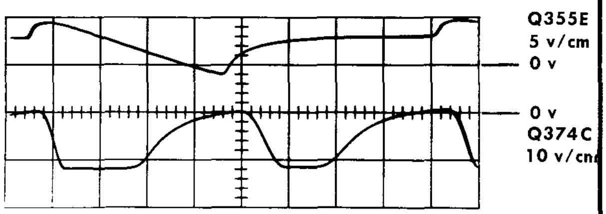


Fig. 3-4. Chopped-mode blanking circuit input voltages.

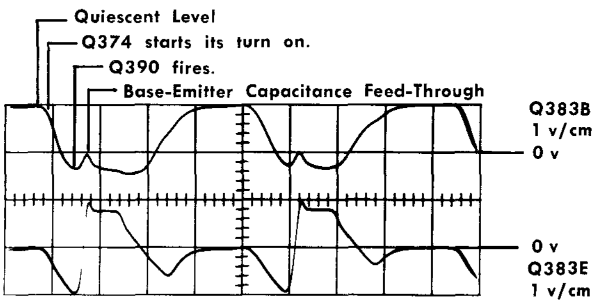


Fig. 3-5. Chopped-mode Q383 voltages. Q383E waveform explained in Fig. 3-6.

The base voltage of Q383 rests at about 0.7 volt when Q374 is off. The emitter of Q383 is at about zero volts (see Fig. 3-5). C387 is at zero volts keeping Q390 at cutoff.

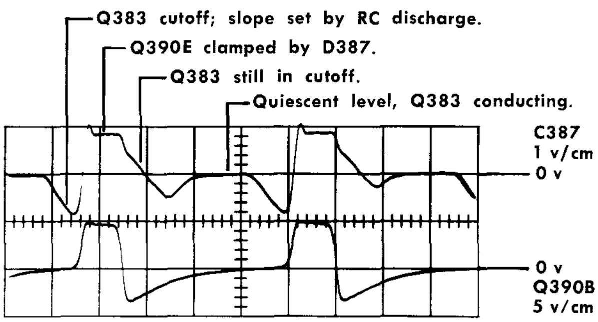


Fig. 3-6. Chopped-mode blanking circuit voltages of Q383 and Q390.

As Q374 saturates, Q383 is cut off and its emitter starts to fall at a rate set by C387 and the current through R387 and R384. As soon as C387 reaches about —0.7 volt, Q390 conducts and regenerates in blocking oscillator action. The base winding of T390 takes the base of Q390 from ground to about +4 volts (see Fig. 3-6) and sends about 100 mv of signal through D392 to the Type 647. The pulse lasts about 0.08 μsec.

Alternate-Mode Operation

When the MODE switch is at ALTER, Q364 is energized and Q345-Q355 emitters are connected to the —15-volt supply through D348-D358, and R364. The multivibrator emitter impedance is such that a trigger is required before it will switch. The trigger arrives from terminal 17 of P11 and the Type 647. The signal at terminal 17 rests at about +5 volts, and goes rapidly to ground at the end of each sweep (see Fig. 3-7).

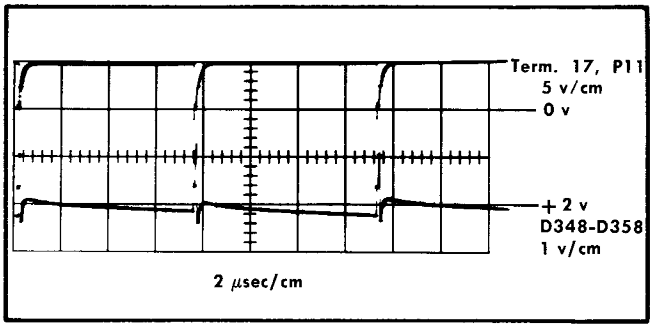


Fig. 3-7. Alternate mode. Type 11B2 Time Base free running at 0.2 μsec/cm.

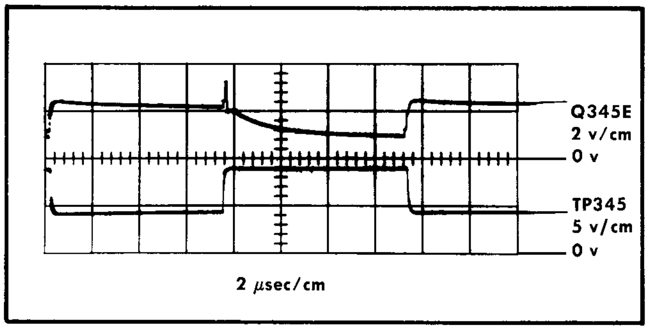


Fig. 3-8. Alternate mode. Type 11B2 Time Base free running at 0.2 μsec/cm.

The alternate trigger-amplifier base voltage is about —10.9 volts, (the decoupled —15-volt supply is about —11.6 volts) and the collector voltage is about —11.5 volts; Q364 is saturated. The junction of D348-D358 and R364 rests at +1 volt.

The negative trigger arriving at the base of Q364 momentarily turns Q364 off (see Fig. 3-7). The conducting multivibrator transistor turns off and as Q364 turns back on, the stored charge on C348 causes the opposite multivibrator transistor to turn on. Thus, the Time Base negative trigger at the end of successive sweeps switches the display first from Channel 1 to Channel 2 and back.

The relationship between the Alternate-mode triggers to the bistable multivibrator and the voltages that control the channel diode switches is shown in Fig. 3-8.

Voltage-Source Transistors

Two voltage-setting emitter followers provide special supply voltages within the Type 10A2. They are: Q483, diagrammed with the Switching Circuit and Output Amplifier schematics, and Q593, diagrammed with the Trigger Amplifier schematic. Each transistor provides two low-current voltage sources for special use. The voltage value is set by two precision resistors in the base lead. Q483 supplies +5.1 and +4.8 volts, and Q593 supplies —3.45 and —4.2 volts.

SECTION 4
MAINTENANCE AND CALIBRATION

Introduction

Maintenance of the Type 10A2 is similar to that of the oscilloscope and is therefore described in the oscilloscope instruction manual.

The Type 10A2 is a stable instrument which will provide many hours of trouble-free operation. However, to insure measurement accuracy, it is suggested that you recalibrate the instrument after each 500 hours of operation, or every six months if used intermittently. It will also be necessary to recalibrate certain sections of the instrument when tubes, transistors, or other components are replaced.

This section of the manual contains a complete recalibration procedure for the Type 10A2. The steps should be performed in the order they appear.

NOTE

The performance standards described in this section of your manual are provided strictly as guides to calibration of your instrument and should not be construed as advertised performance specifications. However, if your instrument performs within the guide tolerances given in the calibration procedure, it will also perform as listed in Section 1 of this manual.

Recommended Test Equipment

1. Oscilloscope such as the Tektronix Type 647. This procedure assumes that the oscilloscope has been calibrated independently. If this is not the case, refer to the oscilloscope instruction manual for information about calibrating the Type 10A2 and the oscilloscope as a system.

2. Tektronix 11-Series time-base plug-in unit such as the Type 11B2. This plug-in unit must be calibrated.

3. Plug-in unit extension (optional). Tektronix part number 012-080 (30-inch flexible) or Tektronix part number 013-077 (12-inch rigid).

4. Dc voltmeter.

5. (2 ea) 50 Ω coaxial cables about 20-inches long and fitted with BNC connectors.

6. Tektronix BNC 50 Ω termination unit. Tektronix part number 011-049.

7. Square-wave generator such as the Tektronix Type 105. Required characteristics: Output frequency of 2.5 kc. Output impedance of 600 Ω or less. Output amplitude of about 100 volts peak-to-peak when unterminated. Risetime of 1 microsecond or less when unterminated.

8. UHF male to BNC female coaxial adapter. UG-273/U.

9. Tektronix BNC 50 Ω X10 coaxial attenuator: Tektronix part number 010-314.

10. Tektronix BNC 20 pf input time-constant standardizer. Tektronix part number 011-066.

11. Pulse generator such as the Tektronix Type 109. Required characteristics: Risetime no longer than 2 nanoseconds. Amplitude about 50 millivolts across a 50 Ω termination. Repetition rate of at least 275 pulses per second.

12. Charge-line for the pulse generator, Tektronix Type 113 delay cable preferred. Electrical length should be at least 30 nanoseconds.

13. RG-58A/U coaxial cable equipped with GR Type 874 connectors and having an electrical length of 2 nanoseconds (about 1-foot long) or less. Tektronix part number 017-505. For use with Tektronix Type 113 delay cable.

14. (2 ea.) Tektronix GR Type 874, 50 Ω X10, coaxial attenuator. Tektronix part number 017-044.

15. RG-8A/U coaxial cable equipped with GR Type 874 connectors and having an electrical length of 10 nanoseconds or less.

16. GR Type 874 to BNC jack coaxial adapter: GR part number 874-QBPA.

PRELIMINARY PROCEDURE

1. Remove the left side cover from the Type 647.
2. Install the Type 10A2 in the left-hand compartment of the Type 647 and an 11-Series plug-in unit such as the Type 11B2 in the right-hand compartment. A plug-in unit extension will be helpful for troubleshooting, but should not be used when making final adjustments.
3. Set the Type 10A2 front-panel controls as follows:

CH 1 and CH 2.

VAR ATTEN BAL	180° from fully clockwise
GAIN	180° from fully clockwise
POSITION	Centered
PULL TO INVERT	Pushed in
VOLTS/CM	.01
VARIABLE	Fully counterclockwise
AC-DC-GND	GND
MODE	CH 1
TRIGGER	CH 2 ONLY

4. Set the Type 647 INTENSITY control fully counterclockwise. Turn on the instrument power and allow several minutes for warmup.
5. Set the 11-Series plug-in unit controls for a free-running, non-magnified sweep at about 0.5 msec/cm.
6. Set the Type 647 INTENSITY control to obtain a trace. If no trace is obtained, use the CH 1 INV BAL R160 adjustment as a position control to obtain the trace.

NOTE

Photographs on a foldout page following the schematics in the back of this manual show the location of each calibration adjustment and test point.

CHECK AND ADJUSTMENT PROCEDURE

Dc Adjustments

NOTE

Steps 1 through 10 apply to both Channel 1 and Channel 2. Complete these steps for Channel 1 first, disregarding the information in parenthesis. Then repeat the steps for Channel 2, substituting the information in parenthesis for the Channel 1 information. Both POSITION controls must be set to midrange and their setting must not be changed until instructed in the procedure.

1. ATTEN BAL RANGE Preliminary Adjustment (S/N 100-359 only)

a. Set the dc voltmeter for at least +1.5 volts full scale and connect it to the V133 (V233) cathode bus shown in Fig. 4-1.

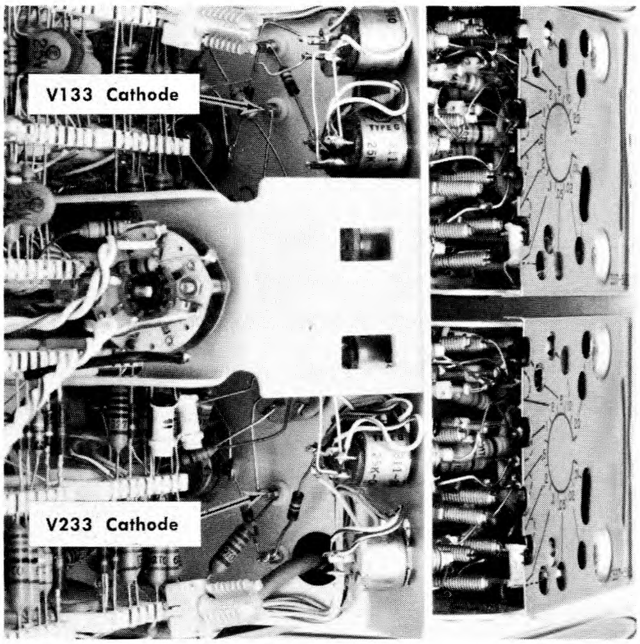


Fig. 4-1. Voltmeter connection points.

b. Adjust ATTEN BAL RANGE R122 (R222) for a meter indication of about +1.2 volts.

c. Disconnect the meter.

2. INV BAL Preliminary Adjustment

a. Adjust INV BAL R160 (R260) to position the trace to the center of the graticule.

3. COM MODE CURRENT Preliminary Adjustment

a. Set the dc voltmeter for at least +10 volts full scale and connect it to TP345 (TP355).

b. Set the MODE switch to CH2 (CH1).

c. Adjust COM MODE CURRENT R150 (R250) for a meter indication of +9 volts.

d. Disconnect the meter and set the MODE switch to CH 1 (CH 2).

4. ATTEN BAL RANGE Final Adjustment (S/N 100-359 only)

a. Note the present position of the trace on the graticule.

b. Turn the CH 1 (CH 2) VARIABLE VOLTS/CM control fully clockwise and note the distance the trace has moved from its previous position.

c. Adjust ATTEN BAL RANGE R122 (R222) to position the trace beyond its previous position by one-half the distance noted in step (b). If necessary, adjust INV BAL R160 (R260) to keep the trace within the graticule area.

d. Turn the CH 1 (CH 2) VARIABLE VOLTS/CM control fully counterclockwise and repeat steps (a) through (c) until no further improvement can be made. Disregard any trace movement which may occur between the clockwise and counterclockwise limits of the VARIABLE VOLTS/CM control.

5. BASE CURRENT Preliminary Adjustment

a. If the trace position with the VARIABLE VOLTS/CM control near midrange differs more than 1 mm from that with the control set at either limit, set the control for the greatest deviation and note the deviation distance. Otherwise go on to step 6.

b. Adjust BASE CURRENT R140 (R240) so that the trace is beyond the position obtained with the VARIABLE VOLTS/CM control set to either limit by about four times the deviation noted in step (a). If necessary, adjust INV BAL R160 (R260) to keep the trace within the graticule area.

6. INV BAL Second Adjustment

a. Notice the present trace position.

b. Pull out the PULL TO INVERT knob.

c. Adjust INV BAL R160 (R260) to return the trace one-half the distance to its previous position.

d. Push in the PULL TO INVERT knob.

e. Repeat steps (a) through (d), if necessary, so that the trace positions differ by less than 2 mm with the PULL TO INVERT knob in or out.

7. VAR ATTEN BAL Adjustment

a. Adjust the front-panel CH 1 (CH 2) VAR ATTEN BAL control so that the trace position is the same with the VARIABLE VOLTS/CM control set fully clockwise as with it set fully counterclockwise.

8. BASE CURRENT Final Adjustment

a. Adjust BASE CURRENT R140 (R240) so that the trace does not move as the VARIABLE VOLTS/CM control is turned throughout its range.

9. INV BAL Final Adjustment

a. Adjust INV BAL R160 (R260) so that the trace position is the same within 2 mm with the PULL TO INVERT knob either pulled out or pushed in.

10. GRID CURRENT ZERO Adjustment

a. Use the CH 1 (CH 2) POSITION control to move the trace to the center of the graticule.

b. Adjust GRID CURRENT ZERO R117 (R217) so that the trace position is the same with the CH 1 (CH 2) AC-DC-GND switch set to DC as with it set to GND.

11. Channel 2 Adjustments

a. Set the MODE switch to CH 2 and repeat steps 1 through 10 for Channel 2.

12. COM MODE CURRENT and MAIN AMP CURRENT Final Adjustments

a. Connect the dc voltmeter to TP453.

b. With the MODE switch set to CH 2, adjust CH 2 COM MODE CURRENT R250 for a 0-volt indication on the meter.

c. Set the MODE switch to ADDED.

d. Adjust CH 1 COM MODE CURRENT R150 for a 0-volt indication on the meter.

e. Set the MODE switch to CH 1.

f. Adjust MAIN AMP CURRENT R336 for a 0-volt indication on the meter.

g. Set the MODE switch to CH 2.

h. Adjust CH 2 COM MODE CURRENT R250 for a 0-volt indication on the meter.

i. Check that the meter indicates 0, ±50 millivolts, with the MODE switch set to CH 1, CH 2, or ADDED. If not, repeat steps (a) through (h).

j. Disconnect the voltmeter.

13. MAIN AMP DIFF BAL Adjustment

a. Set the MODE switch to CH 2.

b. Set the CH 2 POSITION control to align the trace with the graticule centerline.

c. Set the MODE switch to ADDED.

d. Set the CH 1 POSITION control to align the trace with the graticule centerline.

e. Set the MODE switch to CH 1.

f. Adjust MAIN AMP DIFF BAL R335 to align the trace with the graticule centerline.

g. Set the MODE switch to CH 2.

h. Set the CH 2 POSITION control to align the trace with the graticule centerline.

i. Check that the trace remains within 1 minor graticule division (2 mm) of the graticule centerline when the MODE switch is set to either CH 1 or ADDED. If not, repeat steps (a) through (i).

14. NORM TRIG DC BAL Adjustment

a. Set the Type 647 1KC CALIBRATOR switch to .2 VOLTS.

b. Attach a coaxial cable between the Type 647 CAL OUT and the Type 10A2 CH 1 input connectors.

c. Set the MODE switch to CH 1, the TRIGGER switch to NORM, the CH 1 VOLTS/CM switch to .1, the VARIABLE VOLTS/CM controls (both) fully clockwise, the CH 1 AC-DC-GND switch to AC, and the CH 1 POSITION control to center the free-running square-wave display.

d. Set the 11-Series plug-in unit controls for internal, dc-coupled automatic triggering with the triggering level control set to zero. A triggered display may or may not be obtained.

e. Adjust NORM TRIG DC BAL R546 to obtain a triggered display. Then refine the adjustment so that R546 is centered in the range where the triggered display is obtained with the 1KC CALIBRATOR switch setting reduced to 20 mVOLTS.

f. Disconnect the input signal and restore the free-running sweeps.

15. CH 2 OUT DC LEVEL Adjustment

a. Set both AC-DC-GND switches to GND.

b. Connect a coaxial cable between the CH 2 OUT connector and the CH 1 input connector.

c. Set the CH 1 POSITION control to align the trace with the graticule centerline.

d. Set the CH 1 AC-DC-GND switch to DC.

e. Adjust CH 2 OUT DC LEVEL R530 to align the trace with the graticule centerline.

f. Remove the coaxial cable.

Gain Adjustments

1. GAIN RANGE Adjustment

a. Set the CH 1 and CH 2 VOLTS/CM switches to .01, VARIABLE controls to CALIB, AC-DC-GND switches to AC, and PULL TO INVERT knobs pushed in. Set the MODE switch to CH 1.

b. Set the Type 647 1KC CALIBRATOR switch to 50 mVOLTS.

c. Connect a coaxial cable between the CAL OUT connector and the CH 1 input. You should obtain two free-running sweeps separated by about 5 cm.

d. Adjust GAIN RANGE R176 (R276) so that the separation between the traces is exactly 5 cm.

e. Set MODE switch to CH 2 and repeat steps 1c and 1d for Channel 2.

Attenuator Checks

NOTE

The 1-Kc Calibrator in the Type 647 is used to check the division accuracy of the attenuators in the Type 10A2. Both the calibrator voltage accuracy and the attenuator accuracy are rated at ±2% between 0°C and +40°C. Although unlikely, this could permit an error of ±4% in an attenuator to appear as an acceptable ±2% error. For example, if the calibrator voltage is 2% high and the attenuator output is 4% low, the display amplitude would be only 2% low. To avoid such errors, it is suggested that you determine the actual output voltages of the calibrator within about 0.1%. The Type 647 calibration procedure describes how to check the calibrator voltage accuracy on a dc basis by using a precision dc voltmeter. Record and use the calibration voltage values.

1. Fixed Attenuators Check (CH 2)

a. Set the CH 1 and CH 2 VOLTS/CM switches at .02.

b. Connect the coaxial cable to the CH 2 input.

c. Check that the correct display amplitude is obtained (±2%) at each setting of the VOLTS/CM switch (.02 through 20).

2. Variable Attenuator Check (CH 2)

a. With the VOLTS/CM switch set to 20 and the 1KC CALIBRATOR switch set to 100 VOLTS (square wave), turn the VARIABLE VOLTS/CM control fully counterclockwise and check that the display amplitude is 2 cm or less.

b. Check that the UNCAL lamp is lit.

c. Reset the VARIABLE control to CALIB and check that the UNCAL lamp is not lit.

3. Channel 1 Attenuators

a. Set the MODE switch to CH 1.

b. Set the 1KC CALIBRATOR switch to .1 VOLTS and move the coaxial cable to the CH 1 input.

c. Repeat steps 1c and 2 for Channel 1.

d. Remove the coaxial cable.

Attenuator Compensation and Input Time-Constant Adjustments

NOTE

The numbers on the attenuator cover plates correspond to the VOLTS/CM switch positions. The solid line leading from a number points to the attenuator compensation capacitor for that switch setting. The dashed line is an extension of the solid line and points to the input time-constant standardization capacitor. The single capacitor associated with the .01 VOLTS/CM switch setting is for input time-constant adjustment since no attenuator is used.

1. Attenuator Compensation

a. Set the CH 1 and CH 2 VOLTS/CM switches to .02 and the AC-DC-GND switches to DC.

b. Connect the square-wave generator to the CH 1 input as shown in Fig. 4-2.

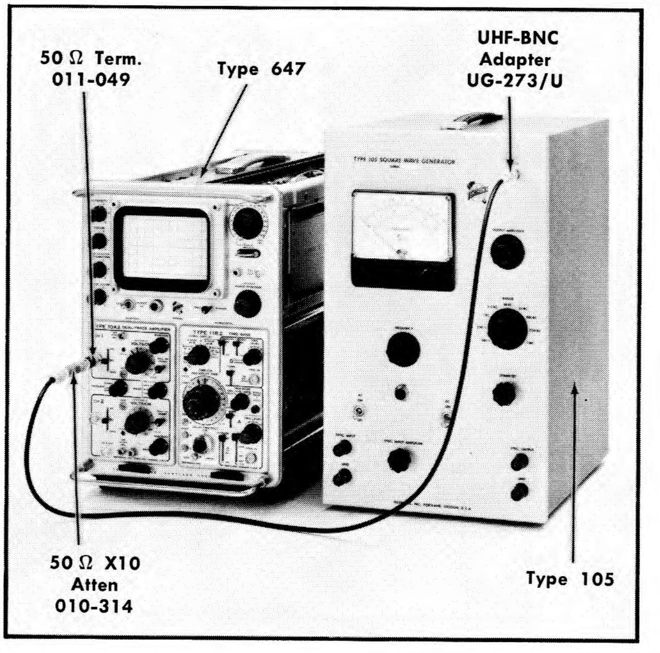


Fig. 4-2. Attenuator compensation setup.

c. With a sweep rate of 0.2 msec/cm, obtain a triggered display of 2.5-kc square waves.

d. Set the generator amplitude control for a display amplitude of about 5 cm.

e. Adjust the .02 VOLTS/CM compensation capacitor (solid line on cover plate) to make the top left corner of the display nearly square.

f. Repeat steps (d) and (e) for each position of the VOLTS/CM switch (.05 through 20).

NOTE

If a Tektronix Type 105 Square-Wave Generator is used, proper amplitude range will be obtained by first removing the X10 attenuator after making the .05 VOLTS/CM adjustment; then remove the 50Ω termination after making the 1 VOLTS/CM adjustment.

g. Set the MODE switch to CH 2 and repeat step 1 (above) for Channel 2.

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h. Disconnect the square-wave generator.

2. Input Time-Constant Standardization

a. Set the Type 647 1KC CALIBRATOR switch to .1 VOLTS and both Type 10A2 VOLTS/CM switches to .01.

b. Connect the input time-constant standardizer as shown in Fig. 4-3.

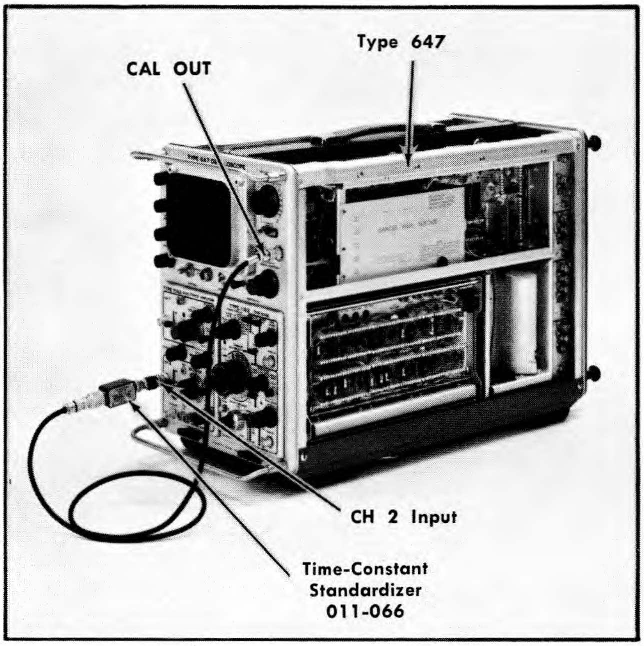


Fig. 4-3. Input time-constant standardization setup.

c. Using a 0.5 msec/cm sweep rate, obtain a triggered display of the square-wave signal. The display amplitude should be about 5 cm.

d. Adjust the .01 VOLTS/CM input time-constant standardizing capacitor to make the top of the displayed square wave as flat and level as possible. Judge the correctness of the adjustment with the alignment tool removed.

e. Set the VOLTS/CM switch to .02.

f. Set the 1KC CALIBRATOR switch to .2 VOLTS.

g. Adjust each input time-constant standardizing capacitor for the remaining settings of the VOLTS/CM switch (.02 through 20). Change the setting of the 1KC CALIBRATOR switch as required to provide either a 4- or 5-cm display amplitude at each setting of the VOLTS/CM switch.

h. Set the MODE switch to CH 1 and repeat step 2 (above) for Channel 1.

i. Remove the cable and standardizer.

High-Frequency Response Adjustments

1. Set the Type 10A2 controls as follows:

CH 1 and CH 2

VOLTS/CM	.01
VARIABLE	CALIB
POSITION	Midrange
AC-DC-GND	DC
TRIGGER	NORM
MODE	CH 1

2. Connect the pulse generator to the Type 10A2 CH 1 input as shown in Fig. 4-4.
3. Set the pulse generator controls for positive-going pulses of about 50-mv amplitude.
4. Set the time-base plug-in unit controls for a 20 nsec/cm sweep rate (0.2 μsec/cm, 10X magnifier) and internally triggered sweeps with + slope and ac coupling.

NOTE

It may be necessary to darken the room and set the INTENSITY control more clockwise to view the display. A viewing hood may also be helpful. The display should be a positive pulse of about 5-cm amplitude.

5. Adjust C169 and C176 (C269 and C276) in the CH 1 (CH 2) Input Amplifier for the squarest pulse corner.
6. Adjust L465 for the squarest pulse corner.
7. Set the MODE switch to CH 2 and move the signal connection to the CH 2 input.
8. Repeat step 5 for Channel 2.

Vertical-System Risetime

1. Use the same setup and display as described under "High-Frequency Response Adjustments."
2. Set the pulse generator so that the displayed pulse amplitude is 5 cm.
3. Set the time-base plug-in unit sweep rate to 10 nsec/cm (0.01 μsec/cm, 10X magnifier).
4. Check thaf the 10% to 90% risetime is 7 nsec or less.
5. Check the other channel risetime in the same manner.
6. Disconnect the pulse generator.

Functional Checks

1. Chop Mode

a. Set the time-base plug-in unit controls for a free-running sweep at 0.5 μsec/cm (non-magnified).

b. Set the Type 10A2 MODE switch to CHOP. With the CH 1 and CH 2 POSITION controls properly adjusted, you should obtain two traces.

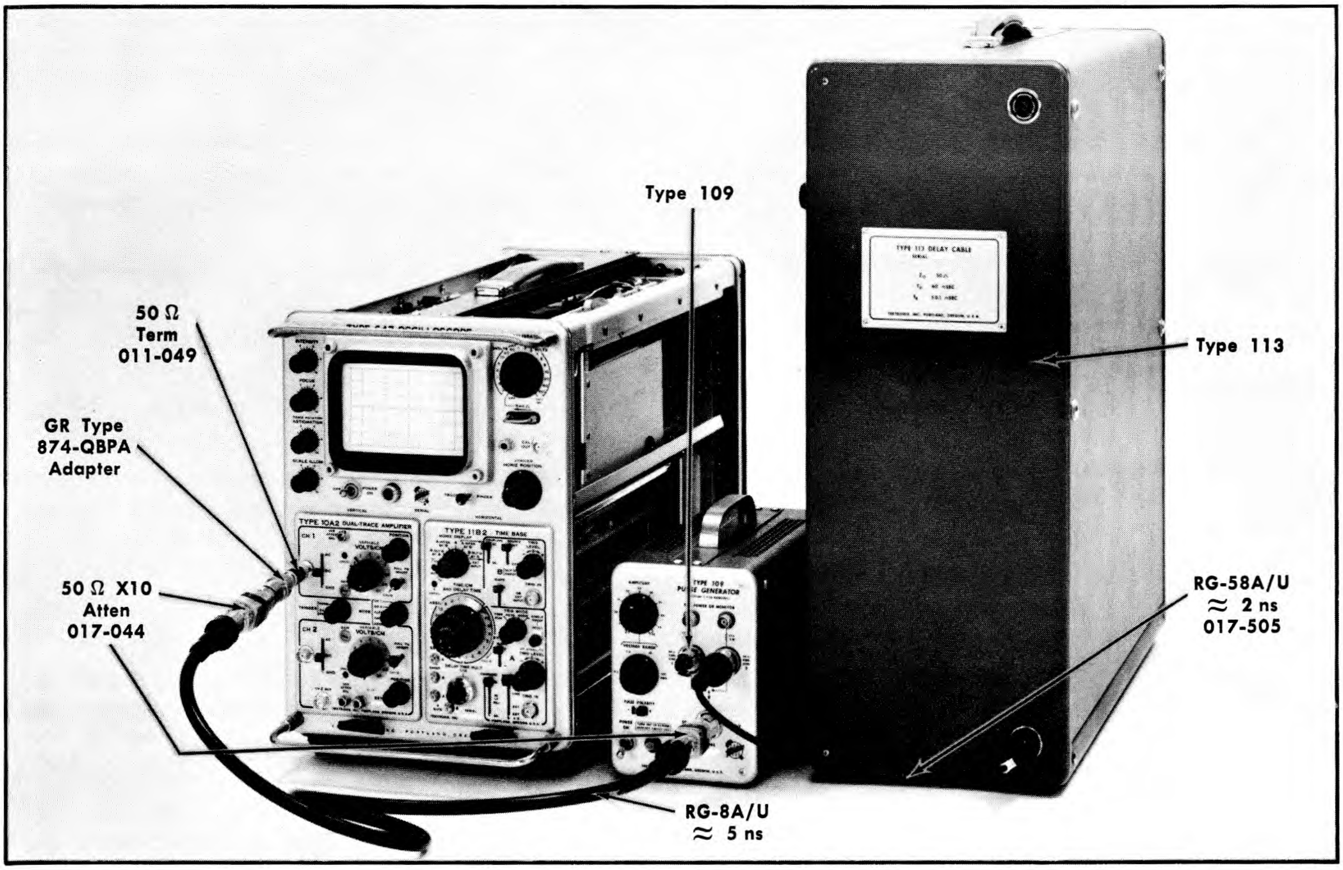


Fig. 4-4. High-frequency compensation adjustments setup.

2. Chop Blanking

a. Position one trace near the top of the graticule and one near the bottom

b. Set the time-base plug-in unit controls for triggered sweeps. You should obtain what appears to be a square-wave display. However, the rising and falling portions of the display should not be visible except when the intensity of the top and bottom portions is unnecessarily high.

3. Alternate Mode

a. Set the time-base plug-in unit controls for free-running sweeps at 20 msec/cm.

b. Set the Type 10A2 MODE switch to ALTER. The traces should now be displayed alternately.

4. Channel 2 Output Signal Amplitude

a. Set the CH 1 VOLTS/CM switch to .1, CH 2 VOLTS/CM switch to .01, and the MODE switch to CH 1.

b. Set the Type 647 1KC CALIBRATOR switch to 20 mVOLTS.

c. Connect a coaxial lead between the CAL OUT and the CH 2 input connectors.

d. Connect a coaxial lead between the CH 2 OUT and the CH 1 input connectors.

e. Set the time-base plug-in unit controls for internally triggered sweeps at 0.5 msec/cm. You should obtain a square-wave display between 2 and 3 cm in amplitude.

SECTION 5
PARTS LIST AND SCHEMATICS

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix Field Office.

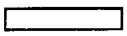
Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number including any suffix, instrument type, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix Field Office will contact you concerning any change in part number.

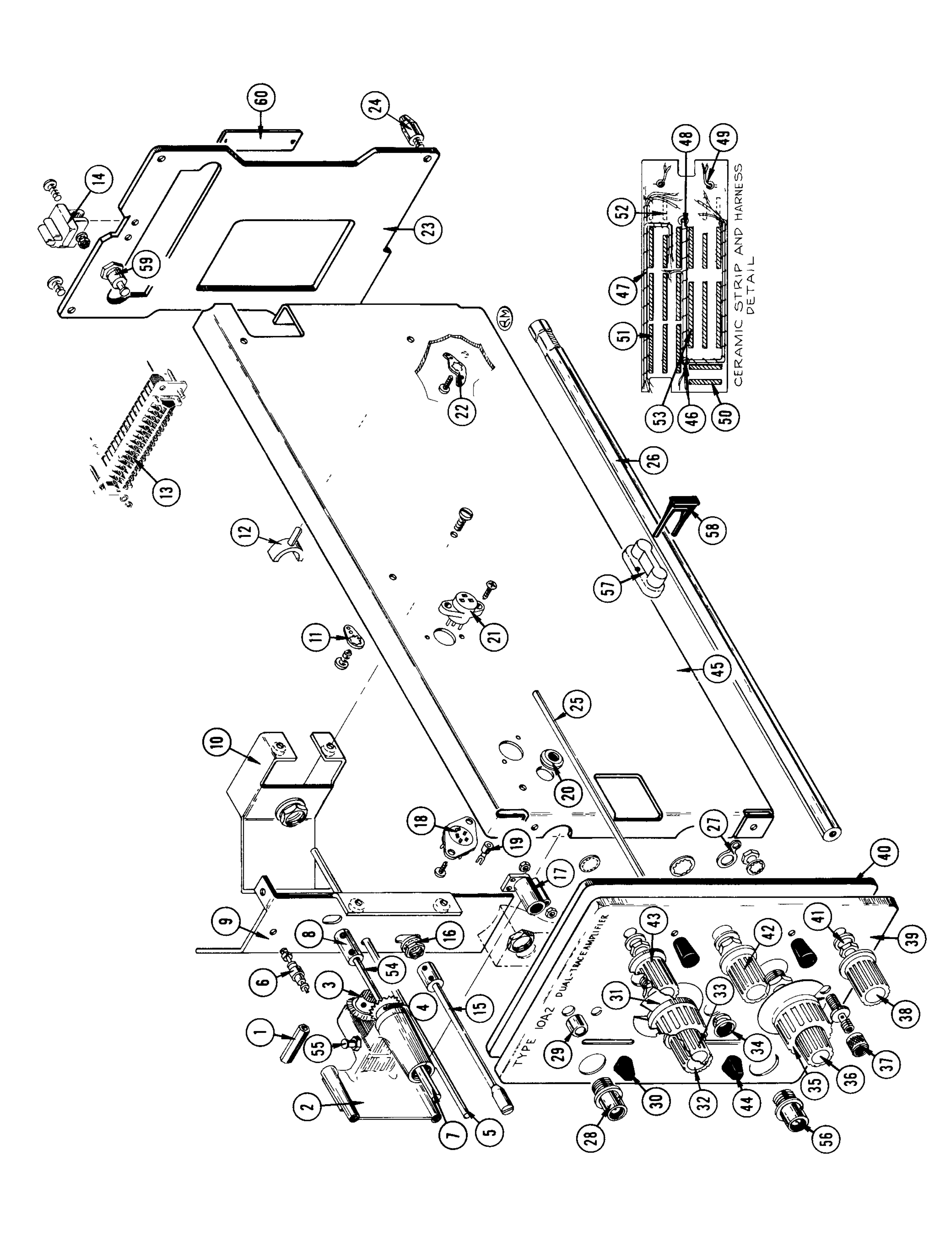
ABBREVIATIONS AND SYMBOLS

a or amp	amperes
BHS	binding head steel
C	carbon
cer	ceramic
cm	centimeter
comp	composition
cps	cycles per second
crt	cathode-ray tube
CSK	counter sunk
dia	diameter
div	division
EMC	electrolytic, metal cased
EMT	electroyltic, metal tubular
ext	external
f	farad
F & I	focus and intensity
FHS	flat head steel
Fil HS	fillister head steel
g or G	giga, or 10^9
Ge	germanium
GMV	guaranteed minimum value
h	henry
hex	hexagonal
HHS	hex head steel
HSS	hex socket steel
HV	high voltage
ID	inside diameter
incd	incandescent
int	internal
k or K	kilohms or kilo (10^3)
kc	kilocycle
m	milli, or 10^{-3}
mc	megacycle
mm	millimeter
meg or M	megohms or mega (10^6)
met.	metal
μ	micro, or 10^{-6}
n	nano, or 10^{-9}
Ω	ohm
OD	outside diameter
OHS	oval head steel
p	pico, or 10^{-12}
PHS	pan head steel
piv	peak inverse voltage
plstc	plastic
PMC	paper, metal cased
poly	polystyrene
Prec	precision
PT	paper tubular
PTM	paper or plastic, tubular, molded
RHS	round head steel
rms	root mean square
sec	second
Si	silicon
S/N	serial number
t or T	tera, or 10^{12}
TD	toroid
THS	truss head steel
tub.	tubular
v or V	volt
Var	variable
w	watt
w/	with
w/o	without
WW	wire-wound

SPECIAL NOTES AND SYMBOLS

X000	Part first added at this serial number.
000X	Part removed after this serial number.
*000-000	Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, or reworked or checked components.
Use 000-000	Part number indicated is direct replacement.
	Internal screwdriver adjustment.
	Front-panel adjustment or connector.

EXPLODED VIEW



EXPLODED VIEW

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	361-056			4	SPACER
	337-582			2	SHIELD, attenuator
	......			.	Mounting Hardware For Each: (not included)
	211-504			2	SCREW, 6-32 x 1/4 inch BHS
2	214-348			2	CASTING, attenuator
	......			.	Mounting Hardware For Each: (not included)
	211-538			2	SCREW, 6-32 x 5/16 inch FHS phillips
	358-029			1	BUSHING, panel
3	214-350			2	GEAR, miter
	......			.	Each includes.
	213-020			2	SCREW, set, 6-32 x 1/8 inch HSS allen head
4	214-272			2	GEAR, miter
	......			.	Each Includes:
	213-020			2	SCREW, set, 6-32 x 1/8 inch HSS allen head
	210-839			2	WASHER, 1/4 ID x 7/16 inch OD; rippled
5	384-273			1	ROD, extension
6	131-183			4	CONNECTOR, feed thru
	358-136			4	BUSHING, teflon
7	384-276			2	ROD, extension
8	376-030			2	COUPLING
	......			.	Each Includes:
	213-048			2	SCREW, set, 4-40 x 1/8 inch HSS allen head
9	406-916			1	BRACKET, pot
	......			.	Mounting Hardware: (not included)
	211-504			4	SCREW, 6-32 x 1/4 inch BHS
10	B-S284			1	BRACKET, switch
	......			.	Mounting Hardware: (not included)
	211-504			2	SCREW, 6-32 x 1/4 inch BHS
11	210-201			1	LUG, solder, SE 4
	......			.	Mounting Hardware For Each: (not included)
	213-044			1	SCREW, thread cutting, 5-32 x 3/16 inch PHS phillips
12	426-121			2	MOUNT, toroid
	361-007			2	SPACER, nylon
13	131-096			1	CONNECTOR, chassis mount, 32 pin
	......			.	Mounting Hardware: (not included)
	210-201			2	LUG, solder, SE 4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
	211-008			2	SCREW, 4-40 x 1/4 inch BHS
14	351-063			2	GUIDE, shoe
	......			.	Mounting Hardware For Each: (not included)
	210-004			2	LOCKWASHER, int. #4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
	211-013			2	SCREW, 4-40 x 3/8 inch BHS
15	384-272			2	ROD, extension
	376-029			2	COUPLING
	......			.	Each Includes:
	213-048			2	SCREW, set, 4-40 x 1/8 inch HSS allen head
16	......			.	Pot Mounting Hardware
	210-583			1	NUT, hex, 1/4-32 x 1/16 inch
	210-940			1	WASHER, 1/4 ID x 3/8 inch OD
17	352-067			2	HOLDER, neon
	......			.	Mounting Hardware For Each: (not included)
	210-406			2	NUT, hex, 4-40 x 3/16 inch
	211-031			1	SCREW, 4-40 x 1 inch FHS
	378-541			2	FILTER, lens
18	136-101			2	SOCKET, 5 pin tube
	......			.	Mounting Hardware For Each: (not included)
	213-055			2	SCREW, thread forming, 2-56 x 3/16 inch PHS phillips
19	131-235			2	CONNECTOR, terminal
	358-136			2	BUSHING, teflon
20	348-003			14	GROMMET, rubber 5/16 inch

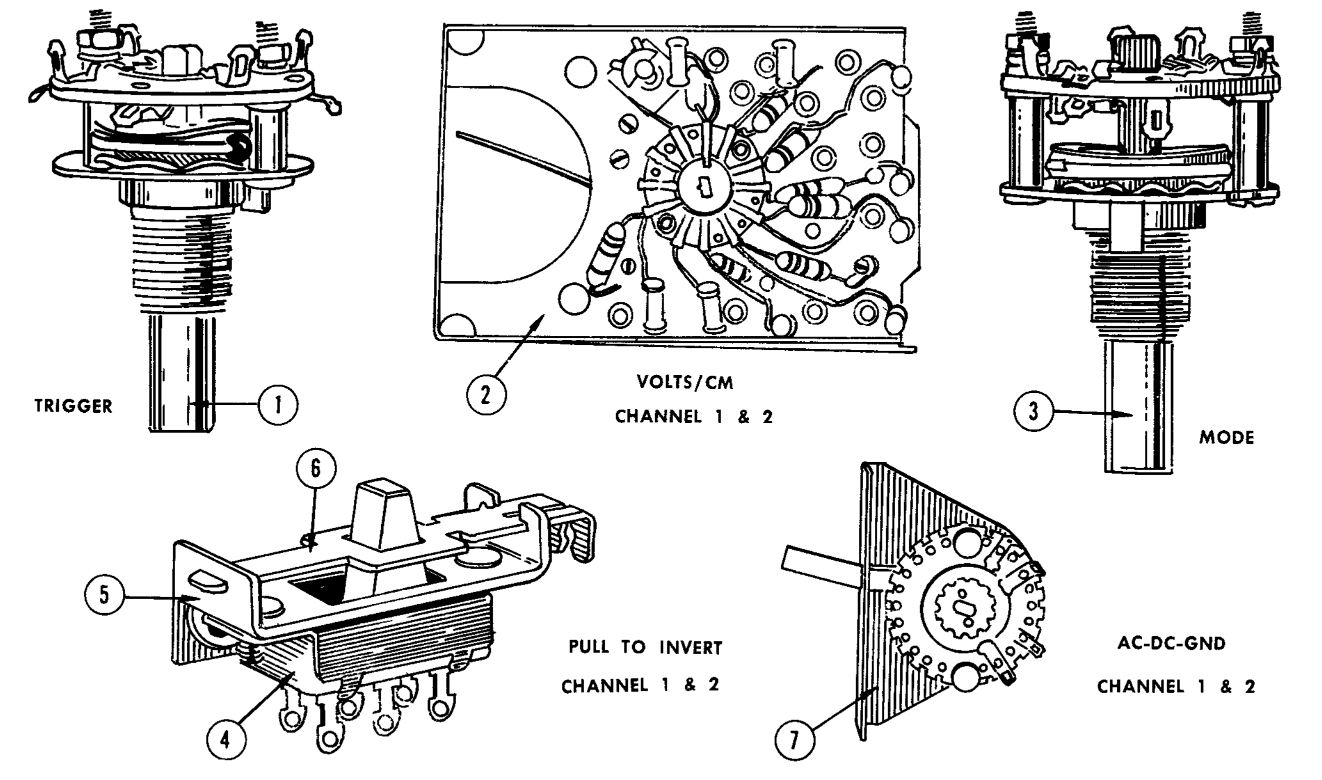
EXPLODED VIEW *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
21	136-161			38	SOCKET, 3 pin transistor
	......			.	Mounting Hardware For Each: (not included)
	213-113			2	SCREW, thread cutting, 2-32 x 5/16 inch RHS phillips
22	210-204			3	LUG, solder, DE 6
	......			.	Mounting Hardware For Each: (not included)
	213-044			1	SCREW, thread cutting, 5-32 x 3/16 inch
23	387-777			1	PLATE, rear
24	214-370			2	PIN, locating
25	384-275			2	ROD, slide switch with molded knob
26	384-615			4	ROD, spacer
	......			.	Mounting Hardware For Each: (not included)
	212-044			1	SCREW, 8-32 x 1/2 inch RHS phillips
27	210-223			3	LUG, solder, 1/4 inch
28	131-106			1	CONNECTOR, chassis mount
	......			.	Mounting Hardware For Each:
	210-012			1	LOCKWASHER, int. 3/8 x 1/2 inch
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
29	358-075			2	BUSHING, pot
AL4 30	~~366-215~~	366-0125-01.		1	KNOB, lever, AC-DC-GND, charcoal
31	366-230			1	KNOB, VOLTS/CM, large charcoal
	......			.	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS allen head
32	366-225			1	KNOB, trigger, charcoal
	......			.	Includes:
	213-020			1	SCREW, set, 6-32 x 1/8 inch HSS allen head
33	366-081			1	KNOB, VARIABLE, small red
	......			.	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS allen head
34	358-216			2	BUSHING, front panel
35	366-230			1	KNOB, VOLTS/CM, large charcoal
	......			.	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS allen head
36	366-081			1	KNOB, VARIABLE, small red
	......			.	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS allen head
37	129-035			1	POST, ground assembly
	......			.	Includes:
	200-103			1	CAP
	210-046			1	LOCKWASHER, Int., .400 OD x .261 inch ID
	210-455			1	NUT, hex, 1/4-28 x 3/8 inch
	355-507			1	STEM, adaptor
38	366-225			1	KNOB, POSITION, charcoal
	......			.	Includes:
	213-020			1	SCREW, set, 6-32 x 1/8 inch HSS allen head
39	333-751			1	PANEL, front
40	387-784			1	PLATE, front subpanel
41	......			.	Pot Mounting Hardware
	210-583			1	NUT, hex, 1/4-32 x 5/16 inch
	210-940			1	WASHER, 1/4 ID x 3/8 inch OD
42	366-220			1	KNOB, MODE, charcoal
	......			.	Includes:
	213-020			1	SCREW, set, 6-32 x 1/8 inch HSS allen head
43	366-225			1	KNOB, POSITION, charcoal
	......			.	Includes:
	213-020			1	SCREW, set, 6-32 x 1/8 inch HSS allen head
AL4 44	~~366-215~~	366-0215-	01	1	KNOB, lever, AC-DC-GND, charcoal
45	441-491			1	CHASSIS
	......			.	Mounting Hardware: (not included)
	210-457			2	NUT, keps, 6-32 x 5/16 inch
	211-507			4	SCREW, 6-32 x 5/16 inch BHS
	211-538			4	SCREW, 6-32 x 5/16 inch FHS phillips

EXPLODED VIEW *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
46	179-759			1	CABLE, harness, Channel 2
47	179-758			1	CABLE, harness, Channel 1
48	179-760			1	CABLE, harness, MODE switch
49	179-797			2	CABLE, harness, input
50	124-147			6	STRIP, ceramic, 7/16 inch x 13 notches
	......			.	Mounting Hardware: (not included)
	361-009			12	SPACER, nylon
51	124-146			6	STRIP, ceramic, 7/16 inch x 16 notches
	......			.	Mounting Hardware: (not included)
	361-009			12	SPACER, nylon
52	124-148			6	STRIP, ceramic, 7/16 inch x 9 notches
	......			.	Mounting Hardware: (not included)
	361-009			12	SPACER, nylon
53	124-145			3	STRIP, ceramic, 7/16 inch x 20 notches
	......			.	Mounting Hardware: (not included)
	361-009			6	SPACER, nylon
54	384-281			2	ROD, shaft
55	129-070			2	POST, tie
56	131-342			2	CONNECTOR, BNC
57	200-497			5	COVER, transistor
	......				Mounting Hardware: (not included)
58	352-071			5	HOLDER, transistor cover
59	129-007	X159		1	POST, connector, insulated
	......				Mounting Hardware: (not included)
	210-006			1	LOCKWASHER, int. #6
	210-407			1	NUT, hex, 6-32 x 1/4
60	A-S204			1	TAG, identification
	......				Mounting Hardware: (not included)
	213-035			4	SCREW, thread cutting, 4-40 x 1/4 PHS, phillips

SWITCHES



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	260-523			1	SWITCH TRIGGER, unwired
	......			.	Mounting Hardware: (not included)
	210-012			1	LOCKWASHER, internal $\frac{3}{8}$ x $\frac{1}{2}$ inch
	210-413			1	NUT, hex, $\frac{3}{8}$-32 x $\frac{1}{2}$ inch
	210-840			1	WASHER, flat
2	262-566			2	SWITCH VOLTS/CM, wired Channel 1 and 2
	......			.	Each Includes:
	260-522			1	SWITCH VOLTS/CM, wired Channel 1 and 2
	......			.	Mounting Hardware For Each: (not included)
	211-008			1	SCREW, 4-40 x $\frac{1}{4}$ inch BHS
3	260-524			1	SWITCH MODE, unwired
	......			.	Mounting Hardware: (not included)
	210-012			1	LOCKWASHER, internal $\frac{3}{8}$ x $\frac{1}{2}$ inch
	210-413			1	NUT, hex, $\frac{3}{8}$-32 x $\frac{1}{2}$ inch
	210-840			1	WASHER, flat
4	260-447			2	SWITCH slide PULL TO INVERT, unwired Channel 1 and 2
	......			.	Mounting Hardwaie For Each: (not included)
	210-406			2	NUT, hex, 4-40 x $\frac{3}{16}$ inch
5	406-917			2	BRACKET, slide switch
	......			.	Mounting Hardware For Each: (not included)
	211-504			2	SCREW, 6-32 x $\frac{1}{4}$ inch BHS
6	406-918			2	BRACKET, slide switch actuator
7	260-492			2	SWITCH lever AC-DC-GND, Channel 1 and 2
	......			.	Mounting Hardware For Each: (not included)
	210-004			2	LOCKWASHER, internal #4
	210-406			2	NUT, hex, 4-40 x $\frac{3}{16}$ inch

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ELECTRICAL PARTS

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description	S/N Range

Bulbs

Ckt. No.	Tektronix Part No.	Description		S/N Range
B119	150-030	Neon NE 2V		
B144	150-027	Neon NE 23	UNCAL	
B219	150-030	Neon NE 2V		
B244	150-027	Neon NE 23	UNCAL	

Capacitors

Tolerance ±20% unless otherwise indicated.

Tolerance of all electrolytic capacitors as follows (with exceptions):

3V — 50V = —10%, +250%

51V — 350V = —10%, +100%

351V — 450V = —10%, +50%

Ckt. No.	Tektronix Part No.	Description					S/N Range
C101	*285-634	.1 μf	MT		600 v		
C102	281-558	18 pf	Cer		500 v		
C103	281-064	.2-1.5 pf	Tub	Var			
C104A	Use 281-547	2.7 pf	Cer		500 v	10%	
C104B	281-064	.2-1.5 pf	Tub	Var			
C104C	281-081	1.8-13 pf	Air	Var	800 v		
C104D	281-592	4.7 pf	Cer			±.5 pf	
C105A	281-572	6.8 pf	Cer		500 v	10%	
C105B	281-027	.7-3 pf	Tub	Var			
C105C	281-027	.7-3 pf	Tub	Var			
C106A	281-572	6.8 pf	Cer		500 v	10%	
C106B	281-027	.7-3 pf	Tub	Var			
C106C	281-027	.7-3 pf	Tub	Var			
C107A	281-572	6.8 pf	Cer		500 v	10%	
C107B	281-027	.7-3 pf	Tub	Var			
C107C	281-027	.7-3 pf	Tub	Var			
C107E	281-512	27 pf	Cer		500 v	10%	
C108A	281-503	8 pf	Cer		500 v	±.5 pf	
C108B	281-027	.7-3 pf	Tub	Var			
C108C	281-027	.7-3 pf	Tub	Var			
C108E	281-519	47 pf	Cer		500 v	10%	
C109A	281-503	8 pf	Cer		500 v	±.5 pf	
C109B	281-027	.7-3 pf	Tub	Var			
C109C, C109E	281-071	.2-1.5 pf/100 pf	Mica	Var		10%	
C110A	281-503	8 pf	Cer		500 v	±.5 pf	
C110B	281-027	.7-3 pf	Tub	Var			
C110C, C110E	281-069	.2-1.5 pf/200 pf	Mica	Var		10%	

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
C111A	281-503	8 pf	Cer		500 v	±.5 pf	
C111B	281-027	.7-3 pf	Tub	Var			
C111C } C111E }	281-072	.2-1.5 pf/500 pf	Mica	Var		10%	
C112A	281-503	8 pf	Cer		500 v	±.5 pf	
C112B	281-027	.7-3 pf	Tub	Var			
C112C } C112E }	281-073	.2-1.5 pf/1000 pf	Mica	Var		10%	
C113A	281-503	8 pf	Cer		500 v	±.5 pf	
C113B	281-027	.7-3 pf	Tub	Var			
C113C } C113E }	281-074	.2-1.5 pf/2000 pf	Mica	Var		10%	
C118	281-614	.0068 pf	Cer		500 v		
C123	283-079	.01 μf	Cer		250 v		
C130	285-622	.1 μf	PTM		100 v		
C131	283-079	.01 μf	Cer		250 v		
C132	281-519	47 pf	Cer		500 v	10%	
C134	283-081	.1 μf	Cer		25 v		
C159	281-577	14 pf	Cer		500 v	5%	
C169	281-081	1.8-13 pf	Air	Var	800 v		
C176	281-081	1.8-13 pf	Air	Var	800 v		
C192	281-504	10 pf	Cer		500 v	10%	
C193	281-504	10 pf	Cer		500 v	10%	
C199	290-183	1 μf	EMT		20 v	10%	
C201	*285-634	.1 μf	MT		600 v		
C202	281-558	18 pf	Cer		500 v		
C203	281-064	.2-1.5 pf	Tub	Var			
C204A	Use 281-547	2.7 pf	Cer		500 v	10%	
C204B	281-064	.2-1.5 pf	Tub	Var			
C204C	281-081	1.8-13 pf	Air	Var	800 v		
C204D	281-592	4.7 pf	Cer			±.5 pf	
C205A	281-572	6.8 pf	Cer		500 v	10%	
C205B	281-027	.7-3 pf	Tub	Var			
C205C	281-027	.7-3 pf	Tub	Var			
C206A	281-572	6.8 pf	Cer		500 v	10%	
C206B	281-027	.7-3 pf	Tub	Var			
C206C	281-027	.7-3 pf	Tub	Var			
C207A	281-572	6.8 pf	Cer		500 v	10%	
C207B	281-027	.7-3 pf	Tub	Var			
C207C	281-027	.7-3 pf	Tub	Var			
C207E	281-512	27 pf	Cer		500 v	10%	
C208A	281-503	8 pf	Cer		500 v	±.5 pf	
C208B	281-027	.7-3 pf	Tub	Var			
C208C	281-027	.7-3 pf	Tub	Var			
C208E	281-519	47 pf	Cer		500 v	10%	
C209A	281-503	8 pf	Cer		500 v	±.5 pf	
C209B	281-027	.7-3 pf	Tub	Var			

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
C209C, C209E	281-071	.2-1.5 pf/100 pf	Mica	Var		10%	
C210A	281-503	8 pf	Cer		500 v	±.5 pf	
C210B	281-027	.7-3 pf	Tub	Var			
C210C, C210E	281-069	.2-1.5 pf/200 pf	Mica	Var		10%	
C211A	281-503	8 pf	Cer		500 v	±.5 pf	
C211B	281-027	.7-3 pf	Tub	Var			
C211C, C211E	281-072	.2-1.5 pf/500 pf	Mica	Var		10%	
C212A	281-503	8 pf	Cer		500 v	±.5 pf	
C212B	281-027	.7-3 pf	Tub	Var			
C212C, C212E	281-073	.2-1.5 pf/1000 pf	Mica	Var		10%	
C213A	281-503	8 pf	Cer		500 v	±.5 pf	
C213B	281-027	.7-3 pf	Tub	Var			
C213C, C213E	281-074	.2-1.5 pf/2000 pf	Mica	Var		10%	
C218	281-614	.0068 µf	Cer		500 v		
C223	283-079	.01 µf	Cer		250 v		
C230	285-622	.1 µf	PTM		100 v		
C231	283-079	.01 µf	Cer		250 v		
C232	281-519	47 pf	Cer		500 v	10%	
C234	283-081	.1 µf	Cer		25 v		
C259	281-577	14 pf	Cer		500 v	5%	
C269	281-081	1.8-13 pf	Air	Var	800 v		
C271	281-519	47 pf	Cer		500 v	10%	
C276	281-081	1.8-13 pf	Air	Var	800 v		
C281	281-519	47 pf	Cer		500 v	10%	
C292	281-504	10 pf	Cer		500 v	10%	
C293	281-504	10 pf	Cer		500 v	10%	
C299	290-183	1 µf	EMT		20 v	10%	
C314	283-078	.001 µf	Cer		500 v		
C334	283-078	.001 µf	Cer		500 v		
C343	283-084	270 µf	Cer		1000 v	5%	
C344	283-080	.022 µf	Cer		25 v		
C348	283-088	.0011 µf	Cer		500 v	5%	
C353	283-084	270 pf	Cer		1000 v	5%	
C354	283-080	.022 µf	Cer		25 v		
C366	283-084	270 pf	Cer		1000 v	5%	
C367	283-095	56 pf	Cer		200 v	10%	
C371	283-080	.022 µf	Cer		25 v		
C382	283-080	.022 µf	Cer		25 v		
C387	283-084	270 pf	Cer		1000 v	5%	
C390	283-080	.022 µf	Cer		25 v		
C452	283-081	.1 µf	Cer		25 v		
C462	281-578	18 pf	Cer		500 v	5%	
C483	283-080	.022 µf	Cer		25 v		
C497	283-080	.022 µf	Cer		25 v		
C498	283-080	.022 µf	Cer		25 v		
C550	281-519	47 pf	Cer		500 v	10%	
C560	281-519	47 pf	Cer		500 v	10%	

Diodes

Ckt. No.	Tektronix Part No.	Description
D125	152-061	Silicon 6061
D133	*152-075	Tek Spec
D157	Use 152-141	Silicon 1N3605
D192	*152-075	Tek Spec
D193	*152-075	Tek Spec
D225	152-061	Silicon 6061
D233	*152-075	Tek Spec
D257	Use 152-141	Silicon 1N3605
D292	*152-075	Tek Spec
D293	*152-075	Tek Spec
D302	152-065	Silicon HD5000
D305	152-065	Silicon HD5000
D309	152-065	Silicon HD5000
D312	152-065	Silicon HD5000
D322	152-065	Silicon HD5000
D325	152-065	Silicon HD5000
D329	152-065	Silicon HD5000
D332	152-065	Silicon HD5000
D348	*152-075	Tek Spec
D358	*152-075	Tek Spec
D369	*152-075	Tek Spec
D387	152-141	Silicon 1N3605
D391	*152-075	Tek Spec
D392	152-065	Silicon HD5000

Inductors

L343	276-507	Core, Ferramic Suppressor	
L353	276-507	Core, Ferramic Suppressor	
L390	108-226	100 μh	
L392	*108-146	5 μh	
L434	*108-260	.1 μh	
L444	*108-260	.1 μh	
L465	*114-160	.1-.12 μh	Var
L504	*108-211	.5 μh	
L514	*108-211	.5 μh	
L527	*108-260	.1 μh	
L554	*108-112	.3 μh	
L564	*108-112	.3 μh	
L577	*108-220	.15 μh	

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

R102	315-470	47 Ω	1/4 w	
R104C	322-610	500 k	1/4 w	Prec
AL4 R104E 322-0481-01	~~322-481~~	1 meg	1/4 w	Prec
R105C	323-620	800 k	1/2 w	Prec
R105E	321-618	250 k	1/8 w	Prec

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R106C	323-611	900 k	½ w		Prec	1%	
R106E	321-617	111 k	⅛ w		Prec	1%	
A4 R107C 323-0612-01	~~323-612~~	950 k	½ w		Prec	1%	
R107E	321-616	52.6 k	⅛ w		Prec	1%	
R108C	323-621	980 k	½ w		Prec	1%	
R108E	321-615	20.4 k	⅛ w		Prec	1%	
R109C	323-614	990 k	½ w		Prec	1%	
R109D	315-470	47 Ω	¼ w			5%	
R109E	321-614	10.1 k	⅛ w		Prec	1%	
R110C	322-625	995 k	¼ w		Prec	1%	
R110D	315-620	62 Ω	¼ w			5%	
R110E	321-613	5.03 k	⅛ w		Prec	1%	
R111C	322-628	998 k	¼ w		Prec	1%	
R111D	315-220	22 Ω	¼ w			5%	
R111E	321-222	2 k	⅛ w		Prec	1%	
R112C	322-629	999 k	¼ w		Prec	1%	
R112D	315-331	33 Ω	¼ w			5%	
R112E	321-193	1 k	⅛ w		Prec	1%	
R113C	323-481	1 meg	½ w		Prec	1%	
R113D	315-300	30 Ω	¼ w			5%	
AL4 R113E 321-0612-01	~~321-612~~	500 Ω	⅛ w		Prec	1%	
R114	323-481	1 meg	½ w		Prec	1%	
R115	316-101	100 Ω	¼ w				
R116	316-104	100 k	¼ w				
R117	311-390	25 k		Var		CH 1 GRID CURRENT ZERO	
R118	301-105	1 meg	½ w			5%	
R119	316-100	10 Ω	¼ w				
R120	311-328	1 k		Var		VAR ATTEN BAL	100-359
R120	311-387	5 k		Var		VAR ATTEN BAL	360-up
R121	321-209	1.47 k	⅛ w		Prec	1%	
R122	311-387	5 k		Var		CH 1 ATTEN BAL RANGE	100-359X
R123	323-305	14.7 k	½ w		Prec	1%	
R125	303-153	15 k	1 w			5%	
R129	315-153	15 k	¼ w			5%	
R130	308-077	1 k	3 w		WW		
R132	315-151	150 Ω	¼ w			5%	
R133	322-225	2.15 k	¼ w		Prec	1%	
R134	315-510	51 Ω	¼ w			5%	
R135	321-251	4.02 k	⅛ w		Prec	1%	
R136	321-153	383 Ω	⅛ w		Prec	1%	
R138	311-169	100 Ω		Var		GAIN	
R140	311-390	25 k		Var		BASE CURRENT	
R142	321-325	23.7 k	⅛ w		Prec	1%	
R143	315-823	82 k	¼ w			5%	
R144†	311-385	250 Ω	½ w	Var		VARIABLE	
R148	322-215	1.69 k	¼ w		Prec	1%	

† Furnished as a unit with SW144.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R149	321-117	162 Ω	1/8 w		Prec	1%	
R150	311-258	100 Ω		Var		CH 1 COM MODE CURRENT	
R151	322-097	100 Ω	1/4 w		Prec	1%	
R154	322-161	464 Ω	1/4 w		Prec	1%	
R157	321-129	215 Ω	1/8 w		Prec	1%	
R158	322-211	1.54 k	1/4 w		Prec	1%	
R159	321-097	100 Ω	1/8 w		Prec	1%	
R160	311-390	25 k		Var		CH 1 GRID CURRENT ZERO	
R161	321-297	12.1 k	1/8 w		Prec	1%	
R163	321-103	115 Ω	1/8 w		Prec	1%	
R164	322-161	464 Ω	1/4 w		Prec	1%	
R165	322-202	1.24 k	1/4 w		Prec	1%	
R167	321-129	215 Ω	1/8 w		Prec	1%	
R168	322-211	1.54 k	1/4 w		Prec	1%	
R169	321-080	66.5 Ω	1/8 w		Prec	1%	
R170	321-257	4.64 k	1/8 w		Prec	1%	
R171	321-121	178 Ω	1/8 w		Prec	1%	
R174	321-081	68.1 Ω	1/8 w		Prec	1%	
R176	311-258	100 Ω		Var		CH 1 GAIN RANGE	
R178	321-223	2.05 k	1/8 w		Prec	1%	
R180	321-257	4.64 k	1/8 w		Prec	1%	
R181	321-121	178 Ω	1/8 w		Prec	1%	
R184	321-081	68.1 Ω	1/8 w		Prec	1%	
R188	321-223	2.05 k	1/8 w		Prec	1%	
R190	321-073	56.2 Ω	1/8 w		Prec	1%	
R191	321-073	56.2 Ω	1/8 w		Prec	1%	
R192	321-069	51.1 Ω	1/8 w		Prec	1%	
R193	321-069	51.1 Ω	1/8 w		Prec	1%	
R195	315-103	10 k	1/4 w			5%	
R196	311-389	2 x 10 k		Var		POSITION	
R197	315-103	10 k	1/4 w			5%	
R199	315-510	51 Ω	1/4 w			5%	
R202	315-470	47 Ω	1/4 w			5%	
R204C	322-610	500 k	1/4 w		Prec	1%	
AL4 R204E 322-0481-01	~~322-481~~	1 meg	1/4 w		Prec	1%	
R205C	323-620	800 k	1/2 w		Prec	1%	
R205E	321-618	250 k	1/8 w		Prec	1%	
R206C	323-611	900 k	1/2 w		Prec	1%	
R206E	321-617	111 k	1/8 w		Prec	1%	
AL4 ~~R207C~~ 323-0612-01 R207C	~~323-612~~	950 k	1/2 w		Prec	1%	
R207E	321-616	52.6 k	1/8 w		Prec	1%	
R208C	323-621	980 k	1/2 w		Prec	1%	
R208E	321-615	20.4 k	1/8 w		Prec	1%	
R209C	323-614	990 k	1/2 w		Prec	1%	
R209D	315-470	47 Ω	1/4 w			5%	

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R209E	321-614	10.1 k	1/8 w		Prec	1%	
R210C	322-625	995 k	1/4 w		Prec	1%	
R210D	315-620	62 Ω	1/4 w			5%	
R210E	321-613	5.03 k	1/8 w		Prec	1%	
R211C	322-628	998 k	1/4 w		Prec	1%	
R211D	315-220	22 Ω	1/4 w			5%	
R211E	321-222	2 k	1/8 w		Prec	1%	
R212C	322-629	999 k	1/4 w		Prec	1%	
R212D	315-331	33 Ω	1/4 w			5%	
R212E	321-193	1 k	1/8 w		Prec	1%	
R213C	323-481	1 meg	1/2 w		Prec	1%	
R213D	315-300	30 Ω	1/4 w			5%	
A-4h R213E 321-0612-01	~~321-612~~	500 Ω	1/8 w		Prec	1%	
R214	323-481	1 meg	1/2 w		Prec	1%	
R215	316-101	100 Ω	1/4 w				
R216	316-104	100 k	1/4 w				
R217	311-390	25 k		Var		CH 2 GRID CURRENT ZERO	
R218	301-105	1 meg	1/2 w			5%	
R219	316-100	10 Ω	1/4 w				
R220	311-328	1 k		Var		VAR ATTEN BAL	100-359
	311-387	5 k		Var		VAR ATTEN BAL	360-up
R221	321-209	1.47 k	1/8 w		Prec	1%	
R222	311-387	5 k		Var		CH 2 ATTEN BAL RANGE	100-359X
R223	323-305	14.7 k	1/2 w		Prec	1%	
R225	303-153	15 k	1 w			5%	
R229	315-153	15 k	1/4 w			5%	
R230	308-077	1 k	3 w		WW		
R232	315-151	150 Ω	1/4 w			5%	
R233	322-225	2.15 k	1/4 w		Prec	1%	
R234	315-510	51 Ω	1/4 w			5%	
R235	321-251	4.02 k	1/8 w		Prec	1%	
R236	321-153	383 Ω	1/8 w		Prec	1%	
R238	311-169	100 Ω		Var		GAIN	
R240	311-390	25 k		Var		BASE CURRENT	
R242	321-325	23.7 k	1/8 w		Prec	1%	
R243	315-823	82 k	1/4 w			5%	
R244†	311-385	250 k	1/2 w	Var		VARIABLE	
R248	322-215	1.69 k	1/4 w		Prec	1%	
R249	321-117	162 Ω	1/8 w		Prec	1%	
R250	311-258	100 Ω		Var		CH 2 COM MODE CURRENT	
R251	322-097	100 Ω	1/4 w		Prec	1%	
R254	322-161	464 Ω	1/4 w		Prec	1%	
R257	321-129	215 Ω	1/8 w		Prec	1%	
R258	322-211	1.54 k	1/4 w		Prec	1%	
R259	321-097	100 Ω	1/8 w		Prec	1%	
R260	311-390	25 k		Var		CH 2 INV BAL	

† Furnished as a unit with SW244.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R261	321-297	12.1 k	1/8 w		Prec	1%	
R263	321-103	115 Ω	1/8 w		Prec	1%	
R264	322-161	464 Ω	1/4 w		Prec	1%	
R265	322-202	1.24 k	1/4 w		Prec	1%	
R267	321-129	215 Ω	1/8 w		Prec	1%	
R268	322-211	1.54 k	1/4 w		Prec	1%	
R269	321-080	66.5 Ω	1/8 w		Prec	1%	
R270	322-197	1.1 k	1/4 w		Prec	1%	
R271	321-085	75 Ω	1/8 w		Prec	1%	
R272	321-097	100 Ω	1/8 w		Prec	1%	
R273	323-163	487 Ω	1/2 w		Prec	1%	
R274	321-081	68.1 Ω	1/8 w		Prec	1%	
R276	311-258	100 Ω		Var		CH 2 GAIN RANGE	
R278	321-223	2.05 k	1/8 w		Prec	1%	
R280	322-197	1.1 k	1/4 w		Prec	1%	
R281	321-085	75 Ω	1/8 w		Prec	1%	
R282	321-097	100 Ω	1/8 w		Prec	1%	
R283	323-163	487 Ω	1/2 w		Prec	1%	
R284	321-081	68.1 Ω	1/8 w		Prec	1%	
R286	315-120	12 Ω	1/4 w			5%	
R288	321-223	2.05 k	1/8 w		Prec	1%	
R290	321-073	56.2 Ω	1/8 w		Prec	1%	
R291	321-073	56.2 Ω	1/8 w		Prec	1%	
R292	321-069	51.1 Ω	1/8 w		Prec	1%	
R293	321-069	51.1 Ω	1/8 w		Prec	1%	
R295	315-103	10 k	1/4 w			5%	
R296	311-389	2 x 10 k		Var		POSITION	
R297	315-103	10 k	1/4 w			5%	
R299	315-510	51 Ω	1/4 w			5%	
R314	315-270	27 Ω	1/4 w			5%	
R317	321-193	1 k	1/8 w		Prec	1%	101-459
R317	321-204	1.3 k	1/8 w		Prec	1%	460-up
R318	321-201	1.21 k	1/8 w		Prec	1%	
R334	315-270	27 Ω	1/4 w			5%	
R335	311-328	1 k		Var		MAIN AMP DIFF BAL	
R336	311-328	1 k	1/8 w	Var		MAIN AMP CURRENT	
R337	321-193	1 k	1/8 w		Prec	1%	101-459
R337	321-204	1.3 k	1/8 w		Prec	1%	460-up
R338	321-201	1.21 k	1/8 w		Prec	1%	
R341	315-101	100 Ω	1/4 w			5%	
R342	315-332	3.3 k	1/4 w			5%	
R343	323-125	196 Ω	1/2 w		Prec	1%	
AL4, R344 323-0213-00	~~321-213~~	1.62 k	1/8 w		Prec	1%	
AL4 R345 323-0213-00	~~322-181~~	750 Ω	1/4 w		Prec	1%	
R347	321-249	3.83 k	1/8 w		Prec	1%	
R351	315-101	100 Ω	1/4 w			5%	
R352	315-332	3.3 k	1/4 w			5%	

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Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description				S/N Range
R353	323-125	196 Ω	½ w	Prec	1%	
R354	321-213	1.62 k	⅛ w	Prec	1%	
R355	322-181	750 Ω	¼ w	Prec	1%	
R357	321-249	3.83 k	⅛ w	Prec	1%	
R364	323-153	383 Ω	½ w	Prec	1%	
R365	Use 315-153	15 k	¼ w		5%	
R367	315-152	1.5 k	¼ w		5%	
R369	315-682	6.8 k	¼ w		5%	
R371	315-224	220 k	¼ w		5%	
R373	321-289	10 k	⅛ w	Prec	1%	
R374	315-332	3.3 k	¼ w		5%	
R375	321-161	464 Ω	⅛ w	Prec	1%	
R382	315-152	1.5 k	¼ w		5%	
R384	322-221	1.96 k	¼ w	Prec	1%	
R387	315-330	30 Ω	¼ w		5%	
R389	321-069	51.1 Ω	⅛ w	Prec	1%	
R390	315-221	220 Ω	¼ w		5%	
R391	315-221	220 Ω	¼ w		5%	
R392	315-222	2.2 k	¼ w		5%	
R411	321-161	464 Ω	⅛ w	Prec	1%	
R412	321-080	66.5 Ω	⅛ w	Prec	1%	
R413	321-145	316 Ω	⅛ w	Prec	1%	
R415	321-157	422 Ω	⅛ w	Prec	1%	
R421	321-161	464 Ω	⅛ w	Prec	1%	
R423	321-145	316 Ω	⅛ w	Prec	1%	
R425	321-157	422 Ω	⅛ w	Prec	1%	
R432	322-133	237 Ω	¼ w	Prec	1%	
R434	321-115	154 Ω	⅛ w	Prec	1%	
R444	321-115	154 Ω	⅛ w	Prec	1%	
R450	321-109	133 Ω	⅛ w	Prec	1%	
R452	322-085	75 Ω	¼ w	Prec	1%	
R453	321-629	5.11 k	⅛ w	Prec	½%	
R454	322-094	93.1 Ω	¼ w	Prec	1%	
R455	321-630	6.81 k	⅛ w	Prec	½%	
R456	322-173	619 Ω	¼ w	Prec	1%	
R457	323-137	261 Ω	½ w	Prec	1%	
R458	323-137	261 Ω	½ w	Prec	1%	
R459	322-043	27.4 Ω	¼ w	Prec	1%	
R460	321-109	133 Ω	¼ w	Prec	1%	
R462	315-242	2.4 k	¼ w		5%	
R464	322-094	93.1 Ω	¼ w	Prec	1%	
R465	321-080	66.5 Ω	⅛ w	Prec	1%	
R466	322-173	619 Ω	¼ w	Prec	1%	
R467	323-137	261 Ω	½ w	Prec	1%	
R468	323-137	261 Ω	½ w	Prec	1%	
R481	322-193	1 k	¼ w	Prec	1%	

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Ra
R482	321-173	619 Ω	⅛ w		Prec	1%	
R483	301-151	150 Ω	½ w			5%	
R485	315-100	10 Ω	¼ w			5%	
R487	315-151	150 Ω	¼ w			5%	
R494	*310-606	67 Ω	4 w	Mica		1%	
R496	*310-606	67 Ω	4 w	Mica		1%	
R497	322-073	56.2 Ω	¼ w		Prec	1%	
R498	322-085	75 Ω	¼ w		Prec	1%	
ALH R504 323-0125-00	~~321-125~~	196 Ω	⅛ w		Prec	1%	
ALH R514 323-0125-00	~~321-125~~	196 Ω	⅛ w		Prec	1%	
R525	321-161	464 Ω	⅛ w		Prec	1%	
R526	321-058	39.2 Ω	⅛ w		Prec	1%	
R527	321-053	34.8 Ω	⅛ w		Prec	1%	
R529	323-170	576 Ω	½ w		Prec	1%	
R530	311-390	25 k		Var		CH 2 OUT DC LEVEL	
R531	315-392	3.9 k	¼ w			5%	
R532	323-181	750 Ω	½ w		Prec	1%	
R533	321-103	115 Ω	⅛ w		Prec	1%	
R535	321-161	464 Ω	⅛ w		Prec	1%	
R536	321-058	39.2 Ω	⅛ w		Prec	1%	
R539	323-170	576 Ω	½ w		Prec	1%	
R541	315-820	82 Ω	¼ w			5%	
R543	315-820	82 Ω	¼ w			5%	
R545	321-289	10 k	⅛ w		Prec	1%	
R546	311-390	25 k		Var		NORM TRIG DC BAL	
R548	321-105	121 Ω	⅛ w		Prec	1%	
R550	321-065	46.4 Ω	⅛ w		Prec	1%	
R551	321-297	12.1 k	⅛ w		Prec	1%	
R554	321-127	205 Ω	⅛ w		Prec	1%	
R560	321-065	46.4 Ω	⅛ w		Prec	1%	
R561	321-297	12.1 k	⅛ w		Prec	1%	
R564	321-127	205 Ω	⅛ w		Prec	1%	
ALH R574'	323-181	~~780 Ω~~ 750 ohms	½ w		Prec	1%	
R576	323-173	619 Ω	½ w		Prec	1%	
R577	321-073	56.2 Ω	⅛ w		Prec	1%	
R579	321-145	316 Ω	⅛ w		Prec	1%	
R584	323-181	750 Ω	½ w		Prec	1%	
R586	323-173	619 Ω	½ w		Prec	1%	
R589	321-145	316 Ω	⅛ w		Prec	1%	
R591	321-169	562 Ω	⅛ w		Prec	1%	
R592	321-230	2.43 k	⅛ w		Prec	1%	
R595	315-270	27 Ω	¼ w			5%	
R597	303-221	220 Ω	1 w			5%	

Switches

Ckt. No.	Tektronix Part No. Unwired	Tektronix Part No. Wired	Description		S/N Range
SW101	260-492		Lever	AC/DC Ground	
SW110	260-522	*262-566	Rotary	VOLTS/CM	
SW144†	311-385				
SW190	260-447		Slide	PULL TO INVERT	
SW201	260-492		Lever	AC/DC Ground	
SW210	260-522	*262-566	Rotary	VOLTS/CM	
SW244††	311-385				
SW290	260-447		Slide	PULL TO INVERT	
SW350	260-524		Rotary	MODE	
SW540	260-523		Rotary	TRIGGER	

Transformers

T371	*120-273	Toroid, Bifilar 5T-10T
T390	*120-273	Toroid, Bifilar 5T-10T

Transistors

Q123	*151-103	Replaceable by 2N2219
Q133	*151-103	Replaceable by 2N2219
Q154	*151-109	Selected from 2N918
Q164	*151-109	Selected from 2N918
Q174	*151-109	Selected from 2N918
Q184	*151-109	Selected from 2N918
Q223	*151-103	Replaceable by 2N2219
Q233	*151-103	Replaceable by 2N2219
Q254	*151-109	Selected from 2N918
Q264	*151-109	Selected from 2N918
Q274	*151-109	Selected from 2N918
Q284	*151-109	Selected from 2N918
Q304	*151-109	Selected from 2N918
Q314	*151-109	Selected from 2N918
Q324	*151-109	Selected from 2N918
Q334	*151-109	Selected from 2N918
Q345	*151-103	Replaceable by 2N2219
Q355	*151-103	Replaceable by 2N2219
Q364	Use *151-108	Replaceable by 2N2501
Q374	*151-103	Replaceable by 2N2219
Q383	*151-103	Replaceable by 2N2219
Q390	*151-108	Replaceable by 2N2501
Q413	*151-120	Selected from 2N2475
Q423	*151-120	Selected from 2N2475
Q434	*151-109	Selected from 2N918

† Furnished as a unit with R144.

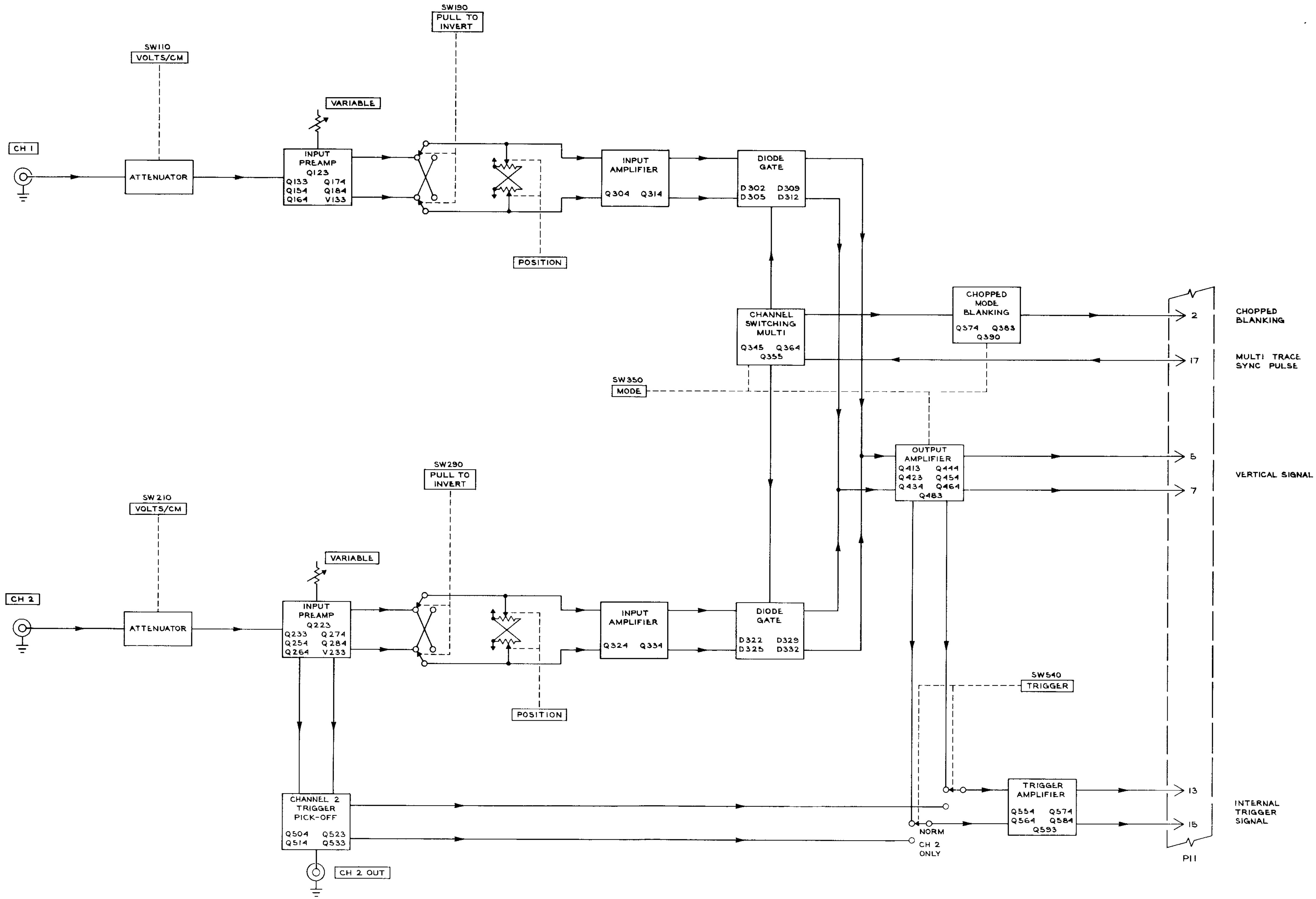
†† Furnished as a unit with R244.

Transistors *(Cont'd)*

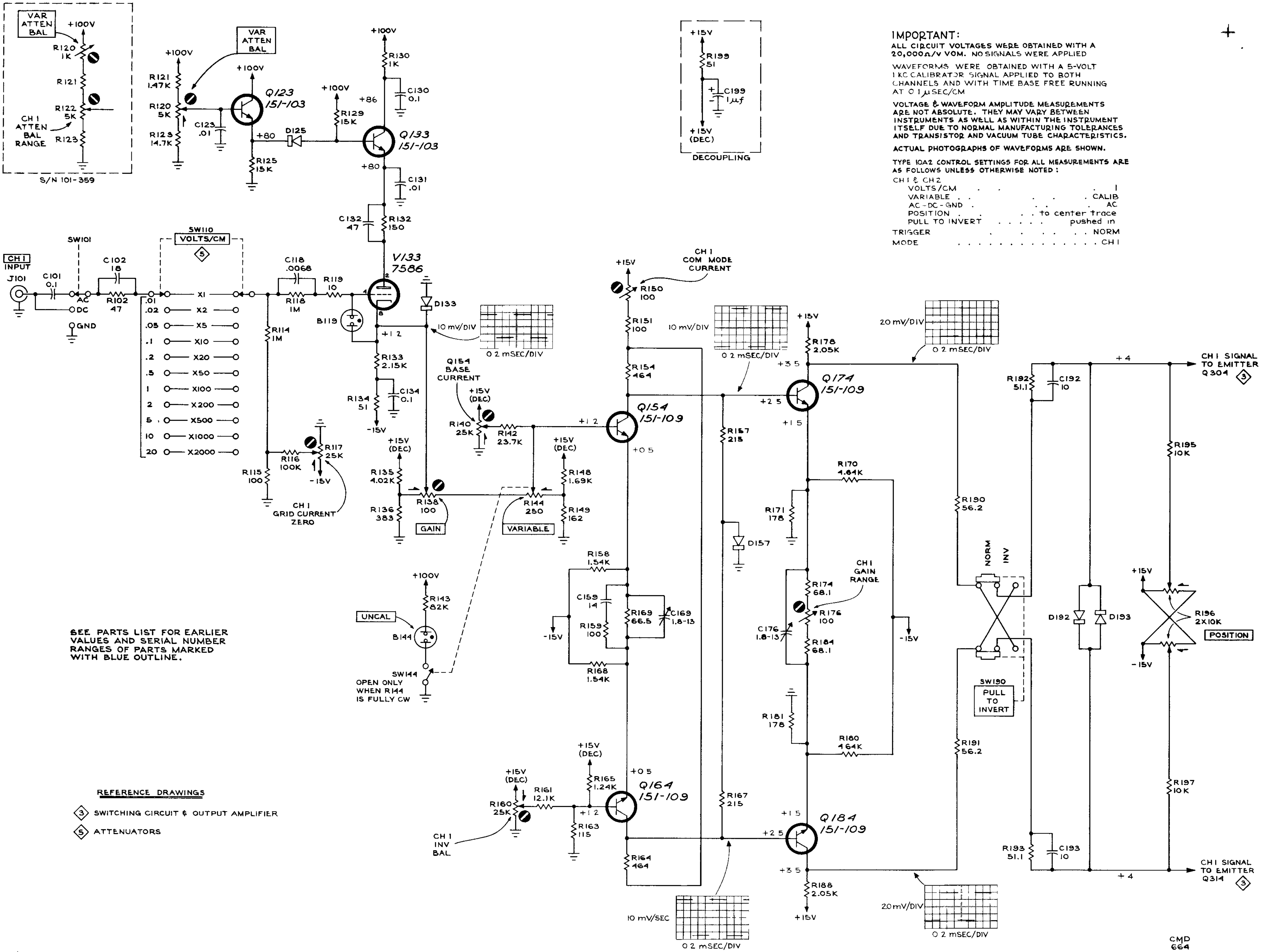
Ckt. No.	Tektronix Part No.	Description	S/N Range
Q444	*151-109	Selected from 2N918	
Q454	*151-120	Selected from 2N2475	
Q464	*151-120	Selected from 2N2475	
Q483	*151-103	Replaceable by 2N2219	
Q504	*151-120	Selected from 2N2475	
Q514	*151-120	Selected from 2N2475	
Q523	*151-120	Selected from 2N2475	
Q533	*151-120	Selected from 2N2475	
Q554	*151-120	Selected from 2N2475	
Q564	*151-120	Selected from 2N2475	
Q574	*151-120	Selected from 2N2475	
Q584	*151-120	Selected from 2N2475	
Q593	*151-103	Replaceable by 2N2219	

Electron Tubes

V133	*157-080	7586	
V233	*157-080	7586	


SW110
VOLTS/CM
CH 1
ATTENUATOR
VARIABLE
INPUT PREAMP Q123 Q133 Q174 Q154 Q184 Q164 V133
SW190
PULL TO INVERT
POSITION
INPUT AMPLIFIER Q304 Q314
DIODE GATE D302 D309 D305 D312
CHANNEL SWITCHING MULTI Q345 Q364 Q355
CHOPPED MODE BLANKING Q374 Q383 Q390
SW350
MODE
OUTPUT AMPLIFIER Q413 Q444 Q423 Q454 Q434 Q464 Q483
2
CHOPPED BLANKING
17
MULTI TRACE SYNC PULSE
5
7
VERTICAL SIGNAL
SW210
VOLTS/CM
CH 2
ATTENUATOR
VARIABLE
INPUT PREAMP Q223 Q233 Q274 Q254 Q284 Q264 V233
SW290
PULL TO INVERT
POSITION
INPUT AMPLIFIER Q324 Q334
DIODE GATE D322 D329 D325 D332
SW540
TRIGGER
CHANNEL 2 TRIGGER PICK-OFF Q504 Q523 Q514 Q533
CH 2 OUT
NORM
CH 2 ONLY
TRIGGER AMPLIFIER Q554 Q574 Q564 Q584 Q593
13
15
INTERNAL TRIGGER SIGNAL
P11

CMD
1163



IMPORTANT:

ALL CIRCUIT VOLTAGES WERE OBTAINED WITH A 20,000Ω/V VOM. NO SIGNALS WERE APPLIED

WAVEFORMS WERE OBTAINED WITH A 5-VOLT 1 KC CALIBRATOR SIGNAL APPLIED TO BOTH CHANNELS AND WITH TIME BASE FREE RUNNING AT 0.1 µSEC/CM

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.

TYPE 10A2 CONTROL SETTINGS FOR ALL MEASUREMENTS ARE AS FOLLOWS UNLESS OTHERWISE NOTED:

CH 1 & CH 2
- VOLTS/CM . . . 1
- VARIABLE . . . CALIB
- AC-DC-GND . . . AC
- POSITION . . . to center trace
- PULL TO INVERT . . . pushed in

TRIGGER . . . NORM
MODE . . . CH 1

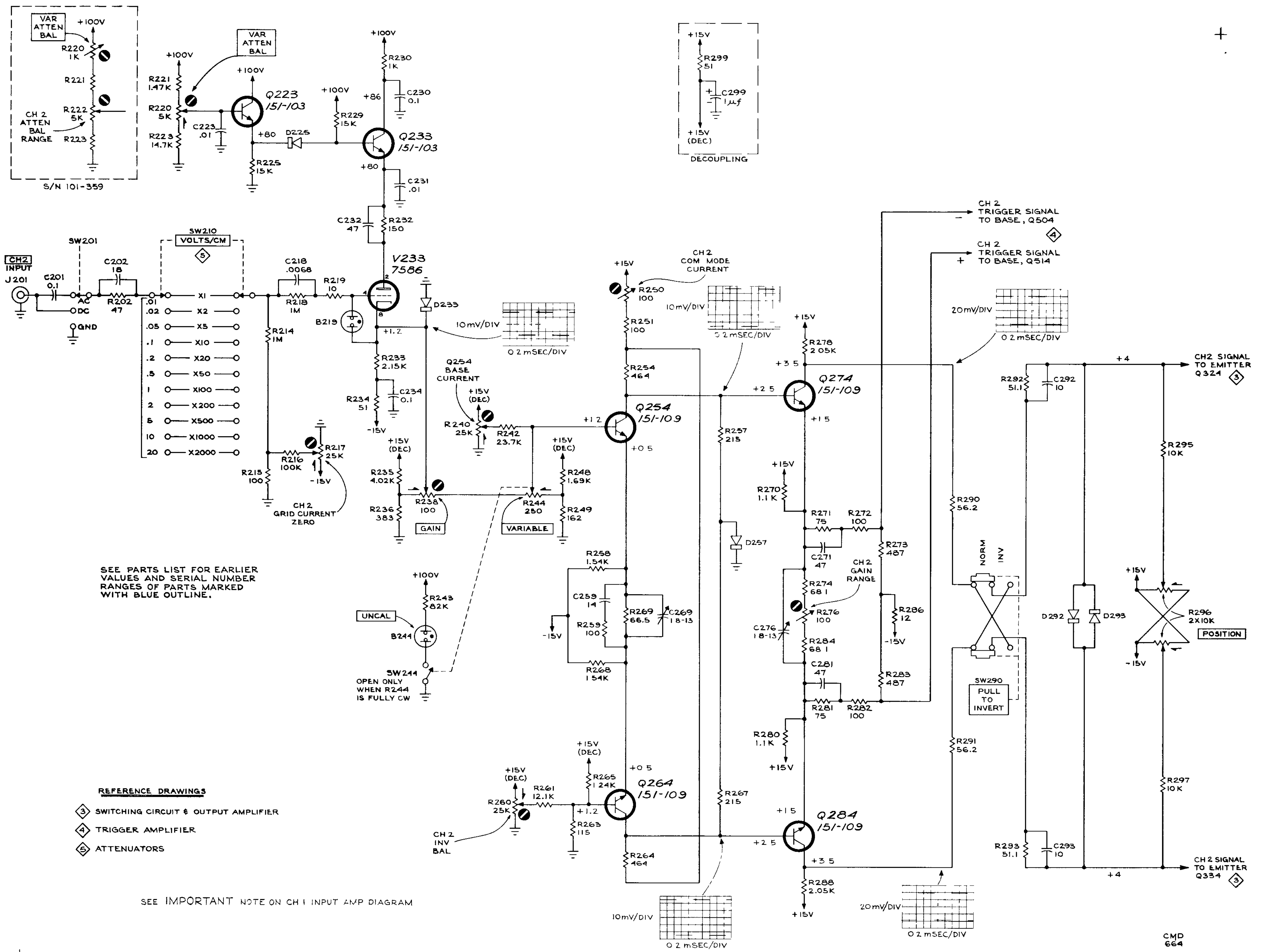
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

REFERENCE DRAWINGS

3 SWITCHING CIRCUIT & OUTPUT AMPLIFIER

5 ATTENUATORS

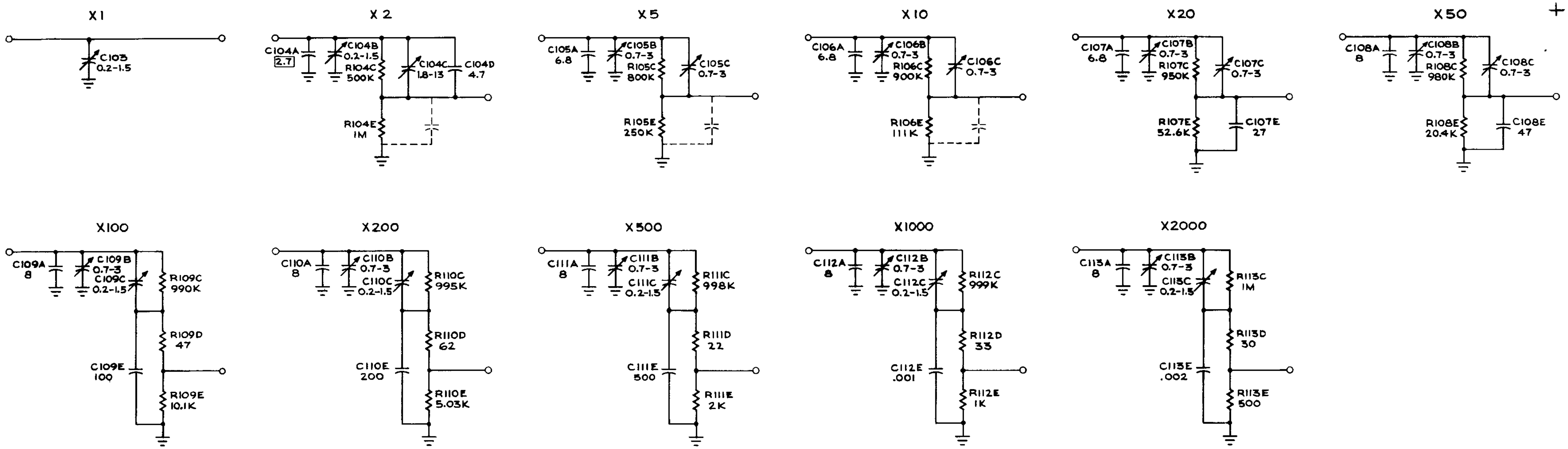
CMD 664



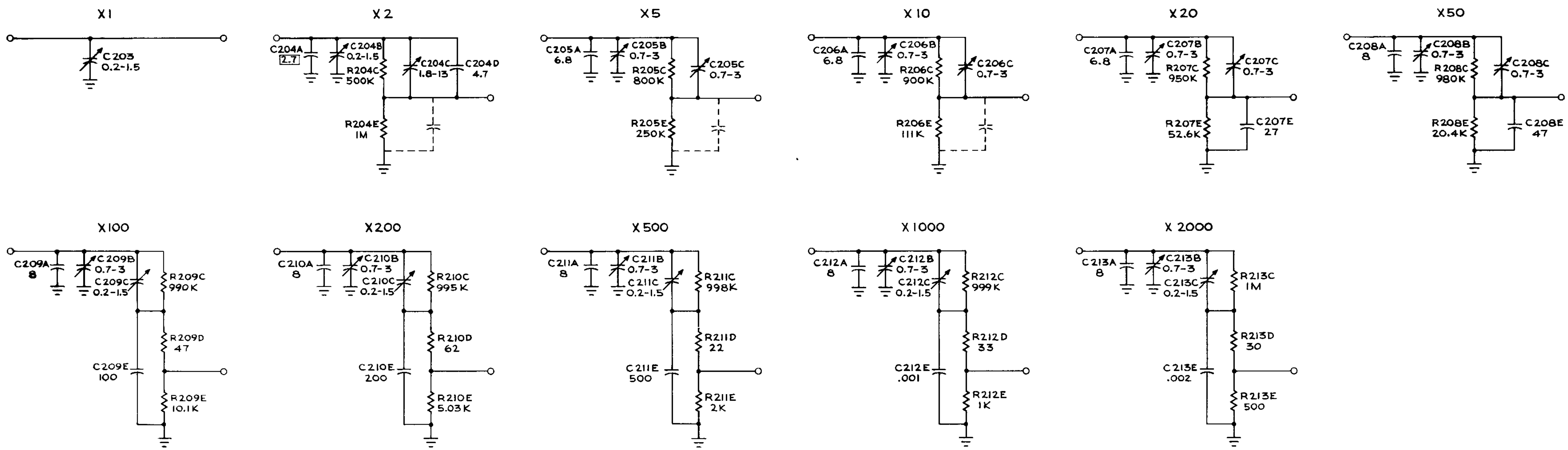
TYPE 10A2 - MOD 165K PLUG-IN

B

CHANNEL 2 INPUT AMPLIFIER



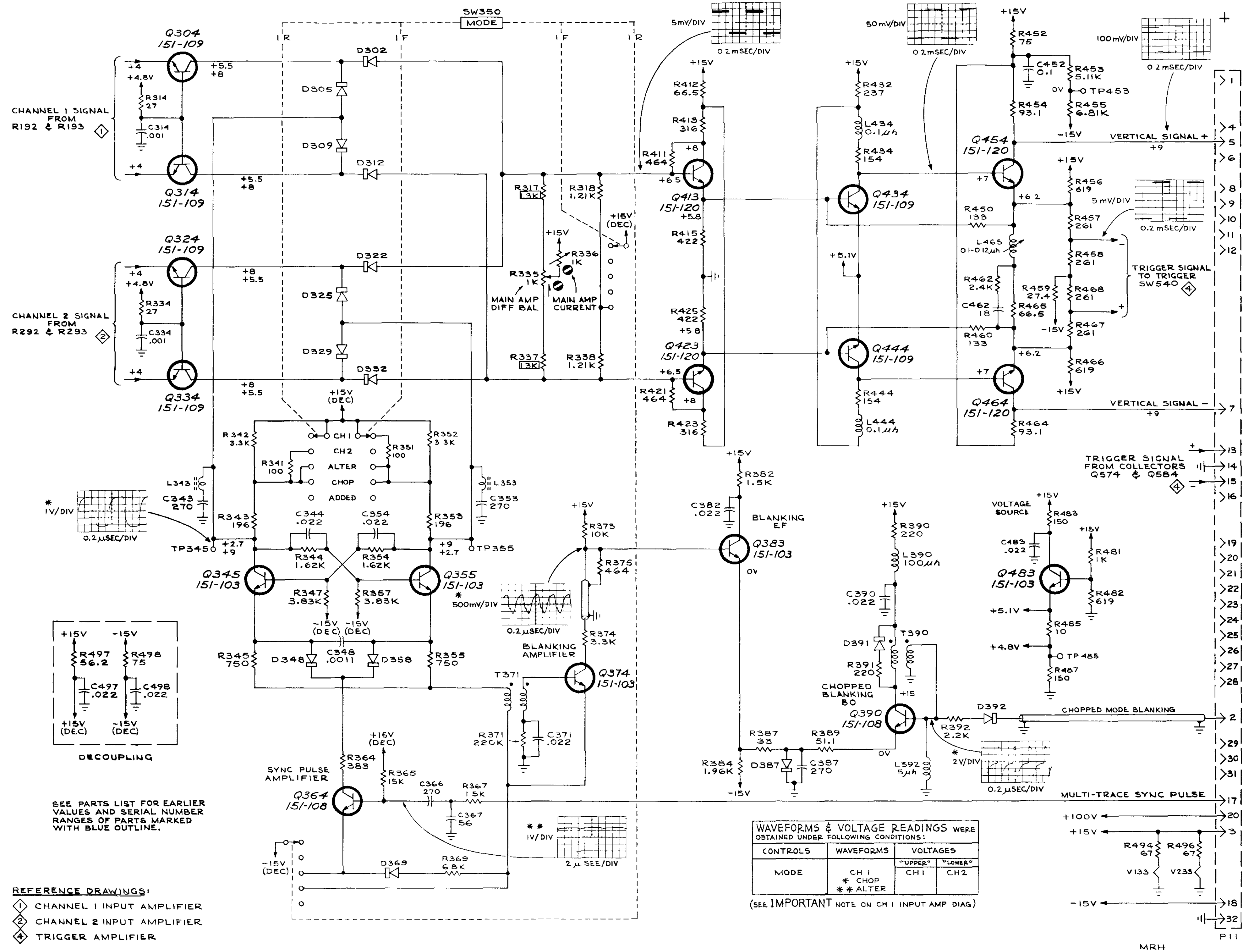
CHANNEL 1



SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

CHANNEL 2

DON
664



WAVEFORMS & VOLTAGE READINGS WERE OBTAINED UNDER FOLLOWING CONDITIONS:			
CONTROLS	WAVEFORMS	VOLTAGES	
		"UPPER"	"LOWER"
MODE	CH 1 * CHOP ** ALTER	CH 1	CH 2

(SEE IMPORTANT NOTE ON CH 1 INPUT AMP DIAG)

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

REFERENCE DRAWINGS:

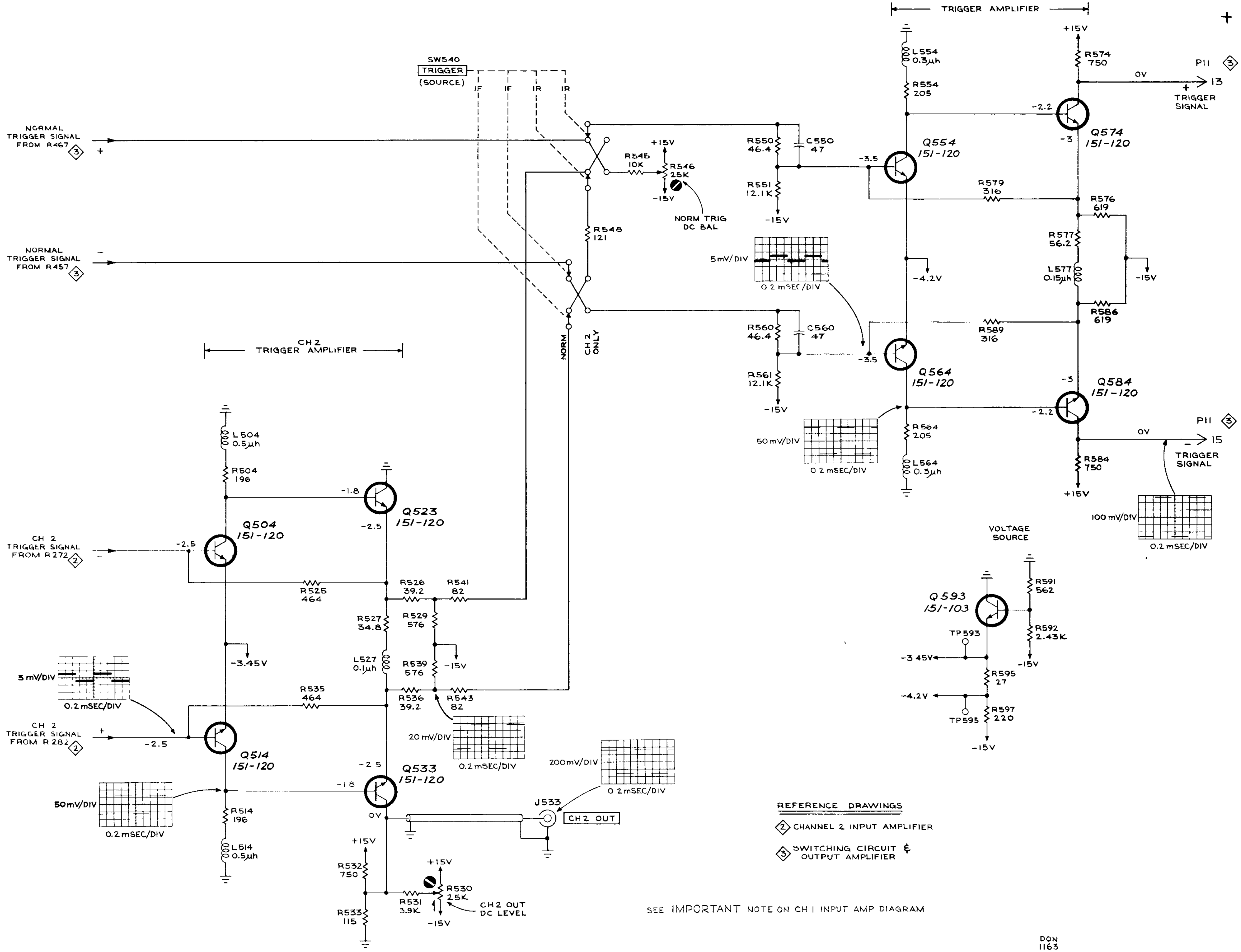
1. CHANNEL 1 INPUT AMPLIFIER
2. CHANNEL 2 INPUT AMPLIFIER
4. TRIGGER AMPLIFIER

MRH
664

TYPE 10A2-MOD 165K PLUG-IN

B

SWITCHING CIRCUIT & OUTPUT AMPLIFIER



TRIGGER AMPLIFIER
SW540 TRIGGER (SOURCE)
IF IF IR IR
NORMAL TRIGGER SIGNAL FROM R467 3 +
NORMAL TRIGGER SIGNAL FROM R457 3 −
R545 10K
R546 25K
+15V
−15V
NORM TRIG DC BAL
R548 121
NORM
CH 2 ONLY
R550 46.4
C550 47
R551 12.1K
R560 46.4
C560 47
R561 12.1K
L554 0.3µh
R554 205
Q554 151-120
Q564 151-120
Q574 151-120
Q584 151-120
R574 750
R579 316
R576 619
R577 56.2
L577 0.15µh
R586 619
R589 316
R564 205
L564 0.3µh
R584 750
−4.2V
−3.5
−2.2
−3
0V
P11 3 13
+ TRIGGER SIGNAL
P11 3 15
− TRIGGER SIGNAL
5mV/DIV
0.2 mSEC/DIV
50 mV/DIV
100 mV/DIV
CH 2 TRIGGER AMPLIFIER
L504 0.5µh
R504 196
Q504 151-120
Q523 151-120
Q514 151-120
Q533 151-120
CH 2 TRIGGER SIGNAL FROM R272 2 −
CH 2 TRIGGER SIGNAL FROM R282 2 +
−2.5
−1.8
R525 464
R526 39.2
R541 82
R527 34.8
R529 576
L527 0.1µh
R539 576
−3.45V
R535 464
R536 39.2
R543 82
20 mV/DIV
200mV/DIV
R514 196
L514 0.5µh
J533
CH2 OUT
R532 750
R533 115
R531 3.9K
R530 2.5K
CH2 OUT DC LEVEL
VOLTAGE SOURCE
Q593 151-103
R591 562
R592 2.43K
TP593
TP595
−3.45V
R595 27
R597 220
REFERENCE DRAWINGS
2 CHANNEL 2 INPUT AMPLIFIER
3 SWITCHING CIRCUIT & OUTPUT AMPLIFIER
SEE IMPORTANT NOTE ON CH 1 INPUT AMP DIAGRAM
DON 1163

PART 3

TYPE 11B2 TIME BASE

INSTRUCTION MANUAL

Serial Number ____________

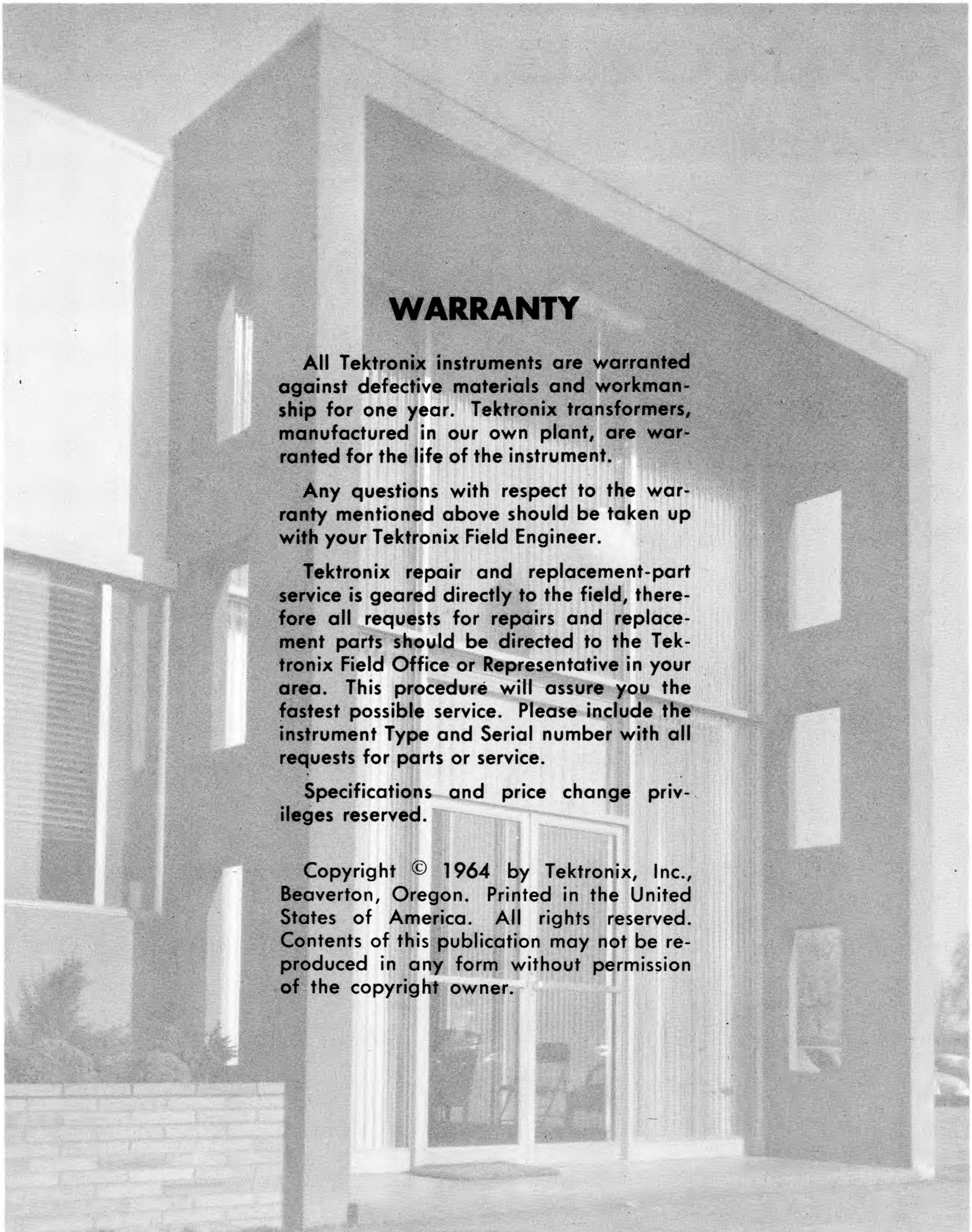
TYPE 11B2
MOD 165K
TIME BASE

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 53.57

76

070-452



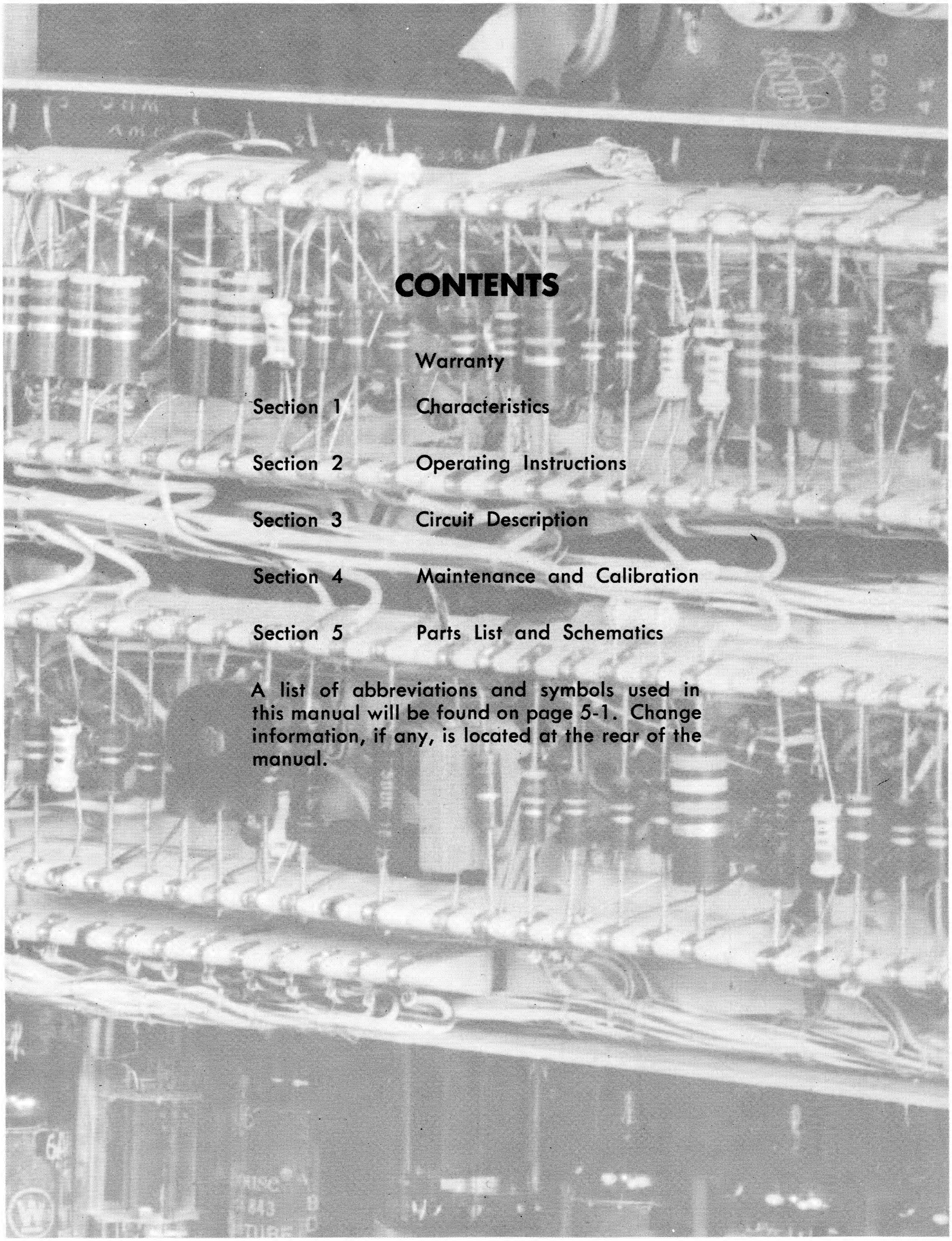
WARRANTY

All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our own plant, are warranted for the life of the instrument.

Any questions with respect to the warranty mentioned above should be taken up with your Tektronix Field Engineer.

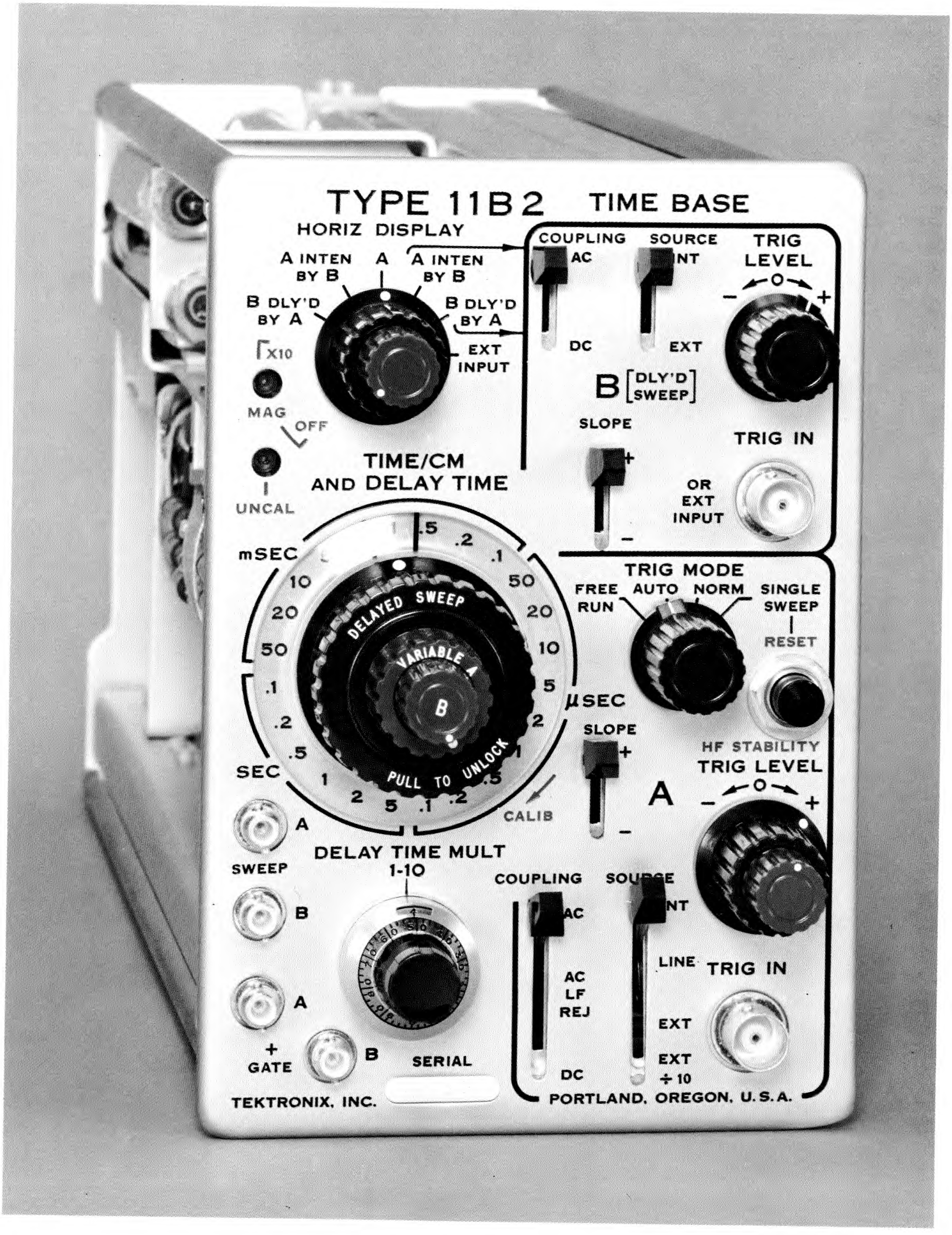
Tektronix repair and replacement-part service is geared directly to the field, therefore all requests for repairs and replacement parts should be directed to the Tektronix Field Office or Representative in your area. This procedure will assure you the fastest possible service. Please include the instrument Type and Serial number with all requests for parts or service.

Specifications and price change privileges reserved.



CONTENTS

A list of abbreviations and symbols used in this manual will be found on page 5-1. Change information, if any, is located at the rear of the manual.



TYPE 11B2 TIME BASE
HORIZ DISPLAY
A INTEN BY B
A
A INTEN BY B
B DLY'D BY A
B DLY'D BY A
EXT INPUT
X10
MAG
OFF
UNCAL
COUPLING
AC
DC
SOURCE
INT
EXT
TRIG LEVEL
B [DLY'D SWEEP]
SLOPE
TRIG IN
OR EXT INPUT
TIME/CM AND DELAY TIME
mSEC
μSEC
SEC
DELAYED SWEEP
VARIABLE
PULL TO UNLOCK
CALIB
TRIG MODE
FREE RUN
AUTO
NORM
SINGLE SWEEP
RESET
HF STABILITY
TRIG LEVEL
A
SWEEP
B
DELAY TIME MULT 1-10
COUPLING
AC
AC LF REJ
DC
SOURCE
INT
LINE
EXT
EXT ÷ 10
TRIG IN
+ GATE
SERIAL
TEKTRONIX, INC.
PORTLAND, OREGON, U.S.A.

SECTION 1
CHARACTERISTICS

General Information

The Type 11B2 Time Base plug-in unit is part of a wide-band oscilloscope system designed for operation and storage under severe environmental conditions. The Type 11B2 operates in the right-hand compartment of a Tektronix Type 647 Oscilloscope. The environmental characteristics of the Type 11B2 and Type 647 are the same and are described in Section 1 of the Type 647 instruction manual.

Special circuits incorporated in the Type 11B2 permit an accurate, continuously variable delay of up to 50 seconds in the presentation of a sweep after the receipt of a triggering impulse. This delayed-sweep feature permits highly magnified displays of a small portion of an undelayed sweep, accurate measurement of signal time-jitter, and precise time measurements, as well as many other uses.

The following characteristics apply only when the Type 11B2 is operated in a calibrated oscilloscope such as the Tektronix Type 647.

NOTE

Range I and Range II, mentioned in various parts of of this section, refer to the ambient air temperaature ranges that apply for a particular characteristic. Range I is from 0°C to +40°C; Range II from −30°C to +65°C.

HORIZONTAL DEFLECTION

Sources

Sweep Generator A

Sweep Generator B—Delayed, or delayed and triggered

External sources

A Sweep and Delay Generator

24 calibrated steps provide sweep rates from 5 sec to 0.1 μsec/cm. An uncalibrated control provides continuously variable sweep rates between 0.1 μsec/cm and about 12 sec/cm. The sweep magnifier (MAG at X10) extends the fastest calibrated sweep rate to 10 nsec/cm (nanosecond$=10^{-9}$ second). Panel lamps light when the magnifier is on and when the sweep rates are uncalibrated. When used as a delay generator, Sweep Generator A provides 21 over-lapping, calibrated delay-time ranges from 50 sec to 1 μsec. The three fastest A sweep ranges are not normally used for delay generation.

Accuracy

See Table 1-1.

TABLE 1-1

A TIME/CM and DELAY TIME	Displayed Sweep Rate		[1] Delay	
	Range I	Range II	Range I	Range II
5 SEC — .1 SEC	±3%	+4% −6%	±2.5%	+3% −6%
50 mSEC — .1 μSEC	±1.5%	±2.5%		
50 mSEC — 1 μSEC			±1%	±2%
Added when MAG is set to ×10 up to 50 nsec/cm	±1%	±1.5%		
Added when MAG is set to ×10: 20 nsec/cm and 10 nsec/cm	±2%	±2.5%		

[1] See Section 2, "Non-Triggered Delay Sweep", for additional details.

B Sweep

24 calibrated steps provide delayed sweep rates from 5 sec to 0.1 μsec/cm. An uncalibrated control provides continuously variable sweep rates between 0.1 μsec/cm and about 12 sec/cm. The sweep magnifier (MAG at X10) extends the fastest sweep rate to 10 nsec/cm. Panel lamps light when the magnifier is on and when the sweep rates are uncalibrated.

Accuracy

See Table 1-2

TABLE 1-2

B TIME/CM	Displayed Sweep Rate	
	Range I	Range II
5 SEC — .1 SEC	±3%	+2% −5%
50 mSEC — .1 μSEC	±1.5%	±2%
Added when MAG switch is set to ×10 up to 50 nsec.	±1%	±1.5%
Added when MAG is set to ×10: 20 nsec/cm and 10 nsec/cm	±2%	±2.5%

External Horizontal Input (to B TRIG OR EXT INPUT connector)

Sensitivity — About 1 volt/cm with MAG switch set to OFF. About 0.1 volt/cm with MAG switch set to X10. A lamp on the front panel next to the MAG switch lights when the X10 position is used.

[2] Bandwidth — Dc to at least 3 mc (—3-db point) with B COUPLING switch set to DC. About 16 cps to at least 3 mc (—3-db points) with B COUPLING switch set to AC.

Input R and C — About 1 megohm paralleled by about 30 pf.

[2] Referenced to 6 cm, centered deflection, at 50 kc.

TRIGGERING

A Sweep

Facilities

SOURCE — Internal, Line, External, and External ÷ 10.

COUPLING — Ac, Ac Low-Frequency Reject, and Dc.

SLOPE — + or —.

TRIG MODE — Free Run, Automatic, Normal, and Single Sweep.

TRIG LEVEL — See Table 1-6.

HF STABILITY — For jitter reduction at high frequencies.

Internal Triggering Sensitivity (with Type 10A2 plug-in unit)

See Table 1-3.

TABLE 1-3

Frequency	Peak-To-Peak Crt Deflection (Range I)	
	Typ.	Min.
To 50 kc	1 mm	2 mm
[3] To 50 mc		10 mm

External Triggering Sensitivity

See Table 1-4.

TABLE 1-4

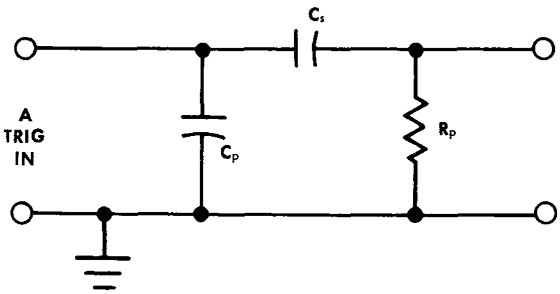
Frequency	Peak-To-Peak Voltage (Range I)	
	Typ.	Min.
To 50 kc	75 mv	125 mv
[3] To 50 mc	150 mv	250 mv

[3] HF STABILITY control used to minimize jitter above 5 or 10 mc.

A TRIG IN Connector Input Characteristics

See Table 1-5.

TABLE 1-5



SOURCE	COUPLING	C_p (pf)	C_s	R_p (megΩ)	Max Input Voltage (Peak)
EXT	DC	≈25	shorted	≈1	±75 v
	AC	≈25	≈0.01 μf	≈1	±500 v
	AC LF REJ	≈25	≈100 pf	≈0.091	±500 v
EXT ÷ 10	DC	≈5	shorted	≈10.1	±500 v
	AC	≈5	≈0.01 μf	≈10.1	±500 v
	AC LF REJ	≈5	≈100 pf	≈9.2	±500 v

A TRIG LEVEL Control Voltage Range (external triggering)
See Table 1-6.

NOTE

The voltage range of the TRIG LEVEL control indicates the maximum external peak voltage that will permit triggering at any amplitude point on the signal. Signals with greater amplitudes can be used and will provide triggering, but the range of trigger-point selection is still limited to the TRIG LEVEL control voltage range.

TABLE 1-6

SOURCE	COUPLING	Voltage Range	
		Typ.	Min.
EXT	AC, DC, or AC LF REJ	±6.5 v	±5 v
EXT ÷ 10	AC or DC	±65 v	±50 v
	AC LF REJ		±500 v

Automatic Triggering

The A sweep triggering characteristics stated previously also apply for automatic triggering except that the triggering signal frequency must be higher than about 20 cps.

A Single Sweep

Permits only one triggered sweep following each reset pulse. Reset pulse can be supplied internally or externally (see Section 2, "Normal Sweep Operation"). External pulse amplitude must be at least 5 volts peak; risetime must be 10 μsec or less.

B Sweep (triggered after delay)

Facilities

SOURCE	Internal and External.
COUPLING	Ac and Dc.
SLOPE	+ or —.
TRIG LEVEL	See "B TRIG LEVEL Control Voltage Range".

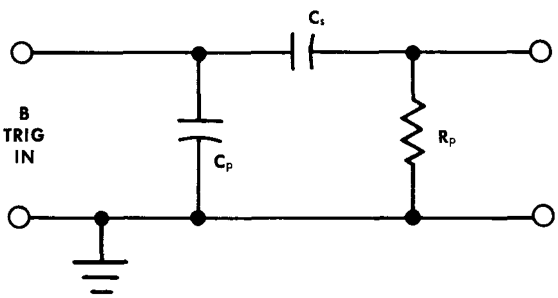
Triggering Sensitivity

Same as for A Sweep.

B TRIG IN Connector Input R and C

See Table 1-7.

TABLE 1-7



COUPLING	C_p (pf)	C_s	R_p (MΩ)	Max. Input Voltage (Peak)
DC	≈30	shorted	≈1	500 v
AC	≈30	≈0.01 μf	≈1	500 v

B TRIG LEVEL Control Voltage Range (external triggering)

Typically ±13 volts, ±10 volts minimum (see NOTE under "A TRIG LEVEL Control Voltage Range").

OUTPUT SIGNALS

+GATE (A and B)

Output Voltage	About +15.2 volts peak into a high resistance load.
Output Resistance	About 1600 ohms.
Output Current	About 9 ma into zero ohms.

SWEEP (A and B)

Output Voltage	About +10 volts peak into a high resistance load.
Output Resistance	About 750 ohms.
Output Current	About 13 ma peak into zero ohms.

MECHANICAL CHARACTERISTICS

Construction

Aluminum-alloy chassis with chrome-plated brass side rails.

Front panel is photo-etched, anodized aluminum.

Dimensions (approx.)

6¼ inches high.

4¼ inches high.

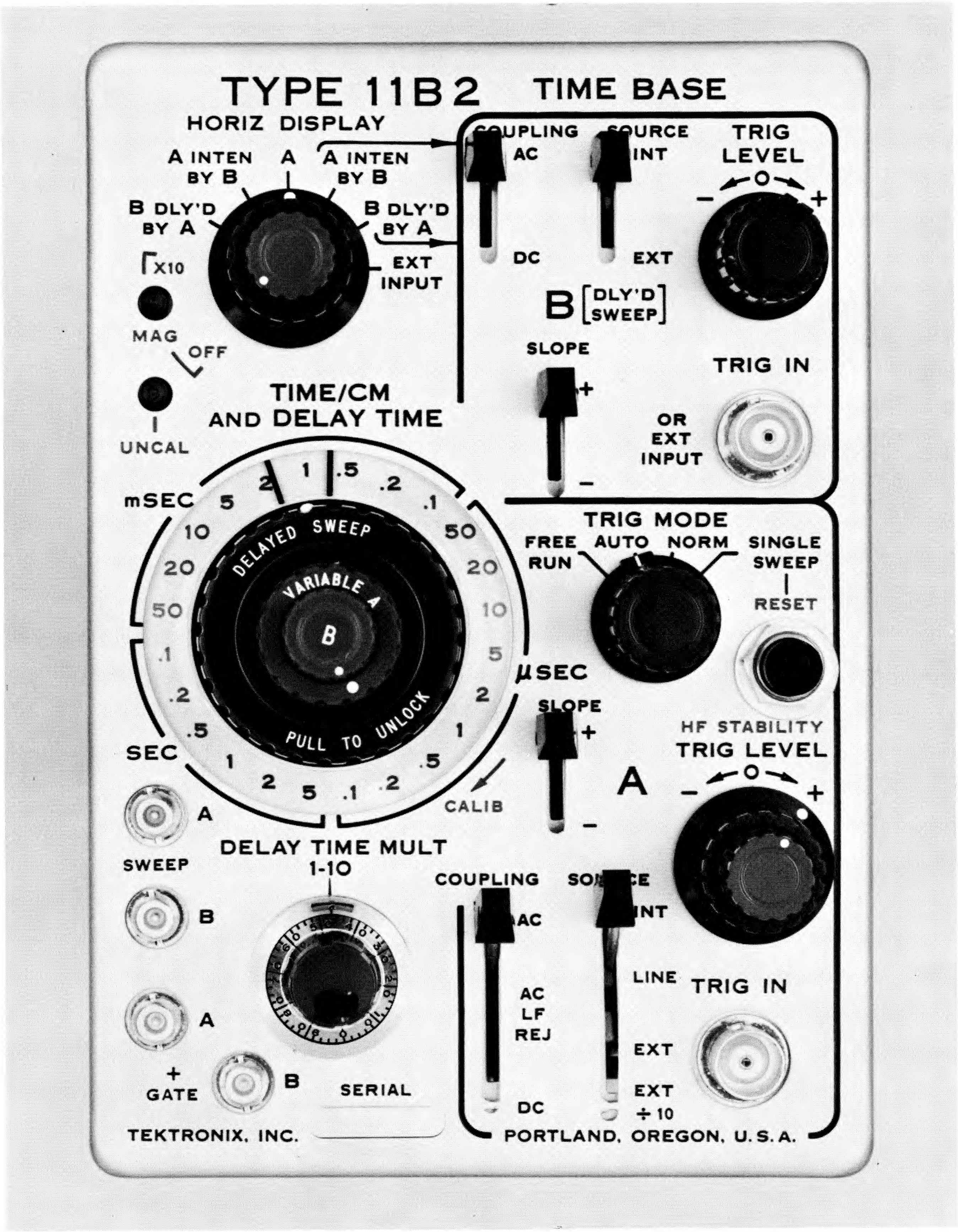
14¾ inches deep (overall).

Weight

About 6.5 pounds, net.

Accessories Included

	Tektronix Part No.
1—BSM to BNC coaxial adapter	103-036
2—Instruction Manuals	


TYPE 11B2 TIME BASE
HORIZ DISPLAY
A INTEN BY B
A
A INTEN BY B
B DLY'D BY A
B DLY'D BY A
EXT INPUT
X10
MAG
OFF
UNCAL
TIME/CM AND DELAY TIME
mSEC
SEC
μSEC
DELAYED SWEEP
VARIABLE A
B
PULL TO UNLOCK
CALIB
DELAY TIME MULT 1-10
SWEEP
A
B
A
+ GATE
B
SERIAL
TEKTRONIX, INC.
COUPLING
AC
DC
SOURCE
INT
EXT
TRIG LEVEL
B DLY'D SWEEP
SLOPE
TRIG IN
OR EXT INPUT
TRIG MODE
FREE RUN
AUTO
NORM
SINGLE SWEEP
RESET
HF STABILITY
TRIG LEVEL
A
COUPLING
AC
AC LF REJ
DC
INT
LINE
EXT
EXT ÷ 10
TRIG IN
PORTLAND, OREGON, U.S.A.

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SECTION 2

OPERATING INSTRUCTIONS

FIRST-TIME OPERATION

The following control and switch settings for the Type 11B2 can be used for a wide range of measurement applications with maximum convenience for the operator. The operating conditions established by these settings also provide a starting point for the operator who is learning to use the instrument.

HORIZ DISPLAY	A
TRIG MODE	AUTO
A COUPLING	AC
A SOURCE	INT
VARIABLE A (TIME/CM)	CALIB (fully clockwise)
MAG	OFF

The Type 11B2 now provides the time base for a wide range of measurements with vertical deflection signals above about 20 cps. In many cases, only the A TIME/CM switch and A TRIG LEVEL control may require setting for a particular measurement.

The appropriate A TIME/CM switch setting depends on the frequency of the applied signal and the type of measurement. For example, to observe about 2 cycles of the oscilloscope 1-Kc Calibrator signal, set the A TIME/CM switch to .2 mSEC.

In order to obtain a triggered display of the vertical deflection signal with the control settings mentioned, three conditions must be met:

1. The frequency of the vertical deflection signal must be about 20 cps or greater (below 20 cps, TRIG MODE switch must be set to NORM).

2. The vertical deflection amplitude must be at least one-half centimeter.

3. The A TRIG LEVEL control must be properly adjusted.

If the first two conditions are met, a stable display can be obtained with the A TRIG LEVEL control set near zero. When the observed deflection amplitude is a fraction of a centimeter, the range of adjustment is relatively narrow, but broadens with increased vertical deflection.

CONTROL AND SWITCH FUNCTIONS

NOTE

A more complete description of the controls and switches is included at the rear of this section.

TRIGGER A

TRIG MODE — Triggering mode. Selects the manner in which each Time Base A sweep will be initiated:

- FREE RUN — Provides recurrent sweeps; the completion of one sweep causes the next sweep to begin.
- AUTO — Automatic. Permits each sweep to be triggered when the triggering signal repetition rate is about 20 cps or greater. For lower repetition rates or in the absence of a triggering signal, the sweeps are recurrent, as in the FREE RUN position.
- NORM — Normal. Each sweep will be triggered by the signal from the Trigger Generator.
- SINGLE SWEEP and RESET — Often used when displays of nonrepetitive signals are photographed. When the RESET lamp is lit, the time base is ready to produce one triggered sweep. When the one sweep is complete, the RESET lamp will not be lit and the time base will no longer be triggerable. Before the cycle can repeat, the RESET button must be pushed or a reset pulse must be applied to pin F of J101 on the rear of the oscilloscope (pin C is ground).

SOURCE — Selects the source of the triggering signal:

- INT — Internal. Obtains the sweep triggering signal from the vertical plug-in unit.
- LINE — Obtains the sweep triggering signal from a low-voltage winding on the oscilloscope power transformer.
- EXT and EXT ÷ 10 — External and external divided-by-ten. Permits external signals applied to the TRIG IN connector to be used for sweep triggering. High amplitude triggering signals can be attenuated by using the EXT ÷ 10 position.

COUPLING — Permits acceptance or rejection of some triggering signal characteristics:

- AC — Rejects dc and attenuates very low-frequency ac triggering signals.
- AC LF REJ — Ac low-frequency reject. Rejects dc and ac triggering signals below about 1000 cps.
- DC — Accepts ac and dc triggering signals.

SLOPE (+ or —) — Determines whether sweep triggering will occur during the positive-going (+) or negative-going (—) portion of the triggering signal.

TRIG LEVEL — Triggering level. Selects the amplitude point on the triggering signal where sweep triggering will occur.

HF STABILITY — High-frequency stability. Used if necessary with triggering signals above about 5-10 mc to obtain best display stability. Has no effect at lower triggering signal frequencies.

TIME BASE A

TIME/CM AND DELAY TIME — Provides 24 calibrated display sweep rates and 24 calibrated ranges of time delay for delayed sweep operation. The number bracketed by the two black lines on the clear plastic knob flange is the sweep time per centimeter and the delay time range. To change the sweep rate and delay range, the concentric A flange and B knob must first be interlocked by positioning the dot on the B knob between the two black lines on the flange.

VARIABLE A — Provides continuously variable uncalibrated sweep rates and delay ranges between about 0.4 and 1.0 times that indicated by the TIME/CM AND DELAY TIME switch. Whenever VARIABLE A is not set to CALIB, the UNCAL lamp will light.

DELAY TIME MULT — Delay time multiplier. A continuously variable control that accurately multiplies the delay time indicated by the DELAY TIME switch to a maximum of ten times.

HORIZONTAL DISPLAY

HORIZ DISPLAY

B DLY'D BY A — B sweep delayed by A sweep (to the left of A on the panel). The oscilloscope horizontal deflection is provided by Time Base B. The beginning of B sweep is delayed from the beginning of A sweep by a time equal to the product of the A DELAY TIME switch and DELAY TIME MULT dial settings.

A INTEN BY B — A sweep display intensified by B sweep (to the left of A on the panel). The oscilloscope horizontal deflection is provided by Time Base A. A portion of the display has greater brightness than the remainder. The intensified zone provides a visual check on the relative duration and time-position of the delayed B sweep with respect to A sweep.

A — The oscilloscope horizontal deflection is provided by Time Base A. Delayed sweep is inoperative.

A INTEN BY B and B DLY'D BY A — A sweep display intensified by B sweep and B sweep delayed by A sweep. Same as previously described for A INTEN BY B and B DLY'D BY A. Addition of the arrows indicates that the B [DLY'D SWEEP] triggering controls and switches must be used. Instead of B sweep beginning at the end of the selected delay period, Time Base B becomes triggerable. B sweep must be triggered after the delay period, but before the end of A sweep.

EXT INPUT — External input. External signals applied to the B TRIG IN OR EXT INPUT connector provide horizontal deflection if the B SOURCE switch is set to EXT. The B COUPLING switch provides either ac or dc signal coupling.

MAG — Magnifier. In the X10 position, the one-centimeter segment at the center of an unmagnified crt display is horizontally expanded to full graticule width. Any other one-centimeter segment of the original unmagnified display may then be observed in magnified form by turning the oscilloscope HORIZ POSITION control. The lamp below the X10 designation on the instrument panel lights whenever the magnifier is on.

TRIGGER B (DLY'D SWEEP)

NOTE

For trigger purpose, the SOURCE, COUPLING, and SLOPE switches, and the TRIG LEVEL control operate only when the HORIZ DISPLAY switch is set to either of the delayed sweep positions which have arrows pointing to the trigger B block. The SOURCE and COUPLING switches have additional functions when the HORIZ DISPLAY switch is set to EXT INPUT.

SOURCE — Permits the B sweep triggering signal to be obtained from the vertical plug-in unit (INT) or from the TRIG IN connector (EXT). When external horizontal deflection signals are used, the SOURCE switch must be set to EXT.

COUPLING — Permits acceptance or rejection of some triggering signal or external horizontal deflection signal characteristics:

AC — Rejects dc and attenuates very low-frequency signals.

DC — Accepts ac and dc signals.

SLOPE (+ or —) — Determines whether B sweep triggering will occur during the positive-going (+) or negative-going (—) portion of the triggering signal.

TRIG LEVEL — Triggering level. Selects the amplitude point on the triggering signal where B sweep triggering will occur.

TIME BASE B (DLY'D SWEEP)

TIME/CM — Provides 24 calibrated delayed-sweep rates. To set the delayed-sweep rate without changing delaying (A) sweep, pull outward on the DELAYED SWEEP knob. Turn the knob at least one position clockwise before allowing it to move inward. DELAYED SWEEP can now be changed independently as long as it is not set to the same position as delaying sweep.

B (variable) — Provides continuously variable uncalibrated B sweep rates between about 0.4 and 1.0 times the rate indicated by the TIME/CM switch. Whenever B is not set to CALIB, the UNCAL lamp will light.

NORMAL SWEEP OPERATION

General Information

The control and switch settings listed previously under "First-Time Operation" establish the basic conditions necessary for most measurements.

The following paragraphs describe in detail each control and switch used in normal sweep operation.

Sweep Triggering

In most cases, it is desirable for a repetitive signal to produce a stationary display on the crt so the waveform can be examined in detail. As a necessary condition for this type of display, the start of each sweep must bear a definite fixed-time relationship to the events in the input signal. This can be accomplished by using the displayed signal or another related signal to start (trigger) each single or repetitive sweep.

The following controls provide complete control over the means of triggering the A sweep.

TRIG MODE

FREE RUN. Free-running operation produces continuously repetitive sweeps, independent of any triggering signal. These sweeps provide a reference trace, as does the AUTO position. This method of operation is useful in applications where a device under test requires a trigger or input signal. The front-panel +GATE A or SWEEP A output signal may be used to operate the device under test. The resulting signals displayed on the crt will then be synchronized with the sweep.

AUTO. Automatic triggering is frequently used for ease of operation and because of the reference trace produced in the absence of a triggering signal. It can be used to observe a large variety of signals with ease, requiring little or no resetting of the triggering controls.

Automatic triggering is useful for obtaining stable displays of signals above about 20 cps. In AUTO, the normal condition is for the time base to free run. If a triggering signal is received, the free-running condition is interrupted, but this first event in the signal does not trigger a sweep. If the first signal event is followed by a second event within about 80 milliseconds, a triggered sweep is initiated, and if not, the free-running sweep resumes.

Since the dormant period is limited to about 80 milliseconds, signals having frequencies below about 20 cps cannot produce a triggered sweep in the AUTO mode. For such signals, the NORM mode must be used.

NORM. In the NORM or normal mode, the usual condition is for the time base to be dormant. Each sweep is initiated by the triggering signal.

SINGLE SWEEP. Single sweep is often used when photographing nonrepetitive waveforms and in other applications where the vertical input signal continually varies in amplitude, shape, or time interval. A continuous display of such signals would appear as a jumbled mixture of many different waveforms and would yield little or no useful information.

The Type 11B2 permits you to obtain a single sweep presentation and eliminate all subsequent sweeps so information is clearly recorded without confusion resulting from multiple traces.

When the TRIG MODE switch is set to SINGLE SWEEP, time base A becomes inoperative. The time base can be "reset" to the triggerable condition by pressing the RESET button or by applying a fast-rise positive-going pulse of about 5-volts amplitude to pin F of J101 on the rear panel of the oscilloscope (pin C is ground). If there is sufficient delay before triggering, the RESET lamp will light to show that time base A is ready to be triggered. When the time base has been triggered and one sweep completed, the time base again becomes inoperative and the lamp will be extinguished.

SOURCE

INT. It is usually convenient to obtain the sweep triggering signal internally (INT) from the vertical deflection system.

LINE. If the displayed signal frequency is related to the power-line frequency, the line source can be used. This source is particularly useful when the displayed signal will not allow stable internal triggering.

EXT. External triggering is often used when signal tracing in amplifiers, phase-shift networks, and wave-shaping circuits. The signal from a single point in the circuit can be connected to the TRIG IN connector through a signal probe or a cable. With this signal triggering the sweep, it is possible to observe the shaping, amplification, and time relationship of a signal at various points in the circuit without resetting the triggering controls.

EXT ÷ 10. The only difference between external (EXT) and external divided-by-10 (EXT ÷ 10) is that the latter attenuates the external triggering signal. Attenuation of high-amplitude external triggering signals is desirable to broaden the TRIG LEVEL control range. (The division factor is X100 when ac low-frequency reject coupling is used.)

COUPLING

The trigger A COUPLING switch permits you to accept or reject certain properties of triggering signals. Three means of coupling are provided:

DC. Dc coupling allows the trigger circuits to receive signals of all frequencies and dc levels.

AC. Ac coupling rejects the dc component of triggering signals and attenuates ac signals below about 20 cps.

AC LF REJ. Ac low-frequency reject coupling rejects the dc component of triggering signals and rejects ac signals below about 1000 cps.

In general, ac coupling is used. It will be necessary to dc couple for very low-frequency triggering signals. If line-frequency hum is mixed with the desired high-frequency triggering signal, best results may be obtained using ac low-frequency reject coupling.

Ac low-frequency reject coupling should also be used when triggering internally from multi-trace plug-in units operated in the alternate-trace mode (unless the "trigger from a single channel only" feature of the plug-in is used). For additional information, see the multi-trace vertical plug-in unit instruction manual.

SLOPE

Sweeps can be triggered during either the rising or falling portion of the triggering signal. When the display consists of several cycles of the input signal, either setting of the SLOPE switch may be used. However, if you wish to display less than one full cycle of the input signal, the SLOPE switch permits you to start the sweep on the desired slope; either rising (+ slope) or falling (— slope).

TRIG LEVEL

The TRIG LEVEL control determines the instantaneous voltage on the triggering signal at which the sweep is triggered. (This instantaneous voltage can include a dc component if the COUPLING switch is set to DC.) With the SLOPE switch at +, adjustment of the TRIG LEVEL control makes it possible to trigger the sweep consistently at virtually any point on the positive slope of the triggering signal. Likewise, with the SLOPE switch at —, adjustment of the TRIG LEVEL control makes it possible to trigger the sweep consistently at virtually any point on the negative slope of the triggering signal.

HF STABILITY

The HF STABILITY control is used only when the triggering signal frequency is above 5 or 10 megacycles, and then only if the triggered sweep display tends to jitter horizontally. In such cases the control may be set for minimum jitter. At lower frequencies the setting of the HF STABILITY control is not important.

Sweep Rates

Time Base A has 24 calibrated sweep rates ranging from 0.1 microsecond per centimeter to 5 seconds per centimeter. Calibrated sweep rates are obtained only when the VARIABLE A control is snapped in the fully clockwise position. The VARIABLE A control and MAG switch, used in conjunction with the TIME/CM switch, permit the sweep rate to be varied continuously between 10 nanoseconds and about 12 seconds per centimeter. (The MAG switch is discussed under "Sweep Magnification".) All sweep rates obtained with the VARIABLE A control in any but the fully clockwise position are uncalibrated. Uncalibrated sweep rates are indicated when the UNCAL lamp is lit. However, this lamp will also light when the B variable control is not set to CALIB.

The sweep-rate value being used appears between the two black lines on the clear plastic flange of the TIME/CM knob. If the DELAYED SWEEP knob is pulled outward, it will disengage from the clear plastic flange. This permits changing the sweep rate of the delayed sweep without a change in the delay time generated by the delaying sweep. Hence, at times you may find that turning the knob will not change the A sweep rate. If this occurs, turn the knob until the indicator dot is between the black lines on the flange. The knob and the flange will then lock together and the A sweep rate can be changed.

Sweep Magnification

Any signal displayed on the oscilloscope can be expanded horizontally 10 times by setting the MAG switch to X10. This switch has the same effect whether the horizontal deflection is produced by one of the time bases in the Type 11B2 or by an external signal passing through the amplifier in the Type 11B2. The lamp next to the X10 panel marking lights whenever the magnifier is turned to X10.

When internal sweeps are used, the magnifier increases the observed sweep rate by 10 times the TIME/CM switch setting. The true sweep rate is then found by multiplying the setting of the TIME/CM switch by 0.1.

The 1-centimeter portion at the horizontal center of the graticule of an unmagnified display is expanded and remains centered in the full 10-centimeter width of the graticule when the magnifier is turned on. Any other 1-centimeter portion of the original unmagnified display can then be observed in magnified form by using the HORIZ POSITION control to position that portion on the crt.

NON-TRIGGERED DELAYED SWEEP

Introduction

The following procedures describe various measurements and other operations that can be performed by using delayed sweep.

First, set the controls and switches as listed in Table 2-1. Then, set the oscilloscope HORIZ POSITION control so the trace begins precisely at the left edge of the graticule. Notice the position of the intensified segment in the trace.

Now set the A DELAY TIME switch to .2 SEC and B TIME/CM switch to 20 mSEC. The intensified segment should be at the same position as with the previous sweep rates.

Connect the SWEEP B output on the Type 11B2 to the vertical plug-in unit input. Notice that the B sweep sawtooth and the intensified segment in the trace start and end at the same time. This display shows that B produces one sweep during each A sweep. The B trigger switches and B TRIG LEVEL control have no effect on the operation.

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The A sweep rate is 0.2 second per centimeter and the intensified segment begins 5 centimeters after the beginning of the trace. Hence, the B sweep starts one second after the A sweep (0.2 second per centimeter times 5 centimeters).

The number of centimeters between the beginning of the trace and the beginning of the intensified segment is established by the setting of the DELAY TIME MULT dial. Therefore, with any dial setting, the time difference between the beginning of the A and B sweeps is the product of the A DELAY TIME switch and the DELAY TIME MULT dial settings.

TABLE 2-1

Set the applicable front-panel controls as follows:

Type 11B2

A TRIG MODE	AUTO
A SOURCE	INT
A COUPLING	AC
A SLOPE	+
A TRIG LEVEL	0
A DELAY TIME	1 mSEC
B TIME/CM	.1 mSEC
VARIABLE A (and B)	CALIB
HORIZ DISPLAY	A INTEN BY B non-triggered (to the left of A on the panel)
MAG	OFF
DELAY TIME MULT	5.00

Oscilloscope

1KC CALIBRATOR	10 VOLTS
HORIZ POSITION	Centered
INTENSITY	So both intensity levels in the trace are easily seen

Vertical Unit

VOLTS/CM	5
VARIABLE	CALIB
AC-DC-GND	DC
MODE	CH 1
POSITION	Trace centered
TRIGGER	NORM
PULL TO INVERT	Pushed in

The following procedures describe five common applications of the delayed-sweep feature. The applications include time measurements which are more accurate than those obtained directly from the crt display, and other operations that can only be performed on oscilloscopes having a delayed-sweep feature.

Demonstration 1

Demonstration 1 describes how to measure the time between two pulses; the first of which triggers Time Base A.

Set the Type 11B2 controls as listed in Table 2-1 except as follows:

A DELAY TIME	.1 mSEC
B TIME/CM	1 μSEC

Apply the oscilloscope 1-Kc Calibrator signal to the vertical input. If necessary, adjust the A TRIG LEVEL control to obtain a stable display. The display should consist of about one cycle of the square-wave signal.

Set the DELAY TIME MULT dial so the falling portion of the square wave is intensified. Set the HORIZ DISPLAY switch to B DLY'D BY A non-triggered (to the left of A on the panel). The display should now be a horizontally expanded version of the signal observed in the intensified segment of the previous display.

Set the DELAY TIME MULT dial so the trace starts at about the 50% amplitude level of the falling portion of the square wave. Multiply the DELAY TIME MULT dial reading (e.g. 5.03) by the A DELAY TIME switch setting. The product is the time duration of the square-wave positive-going half cycle.

Accuracy. Determined by the combination of ***ALL*** the following factors:

1. The basic accuracy of time measurements made by using the Time Base A Generator is as stated in Section 1 of this manual. In measurements made directly from the crt, the accuracy figure is the percentage of the total time represented within the 10-centimeter graticule (percent of full scale). However, when the measurement is made by using the sweep-delay feature, the accuracy is a percentage of the time being measured.

2. The effect of sweep-delay system linearity on measurement accuracy depends on the DELAY TIME MULT dial setting used. Inaccuracy due to non-linearity is generally negligible when dial settings above 2.0 or 2.5 are used. It is usually possible to avoid lower dial settings by setting the DELAY TIME switch for the shortest calibrated interval that will provide adequate delay range.

3. The triggering point can affect measurement accuracy, since the triggering signal does not rise instantaneously. For example, if the first portion of a pulse rise triggers the sweep, most of the pulse risetime will be included in the measurement. This is of little concern in measurements such as Demonstration 1 where the risetime is small in relation to the measured time. As the risetime, in relation to the measured time increases, it becomes more important that the triggering point be known. One way to establish a known triggering point is to set the TRIG LEVEL control at one end of the range in which a stable-triggered A intensified by B display is obtained. Most of the signal risetime will be included in the measurement when:

a. The A trigger SLOPE switch is set to + and TRIG LEVEL control is set to the — end of the triggering range (positive-going signals).

b. The A trigger SLOPE switch is set to — and TRIG LEVEL control is set to the + end of the triggering range (negative-going signals).

4. The A Trigger Generator, Time Base A Generator, and Time Base B Generator circuits typically require a net total of about 30 to 40 nanoseconds to respond to the signal event which triggers A. This small inherent delay need not be considered unless it is a significant percentage of the time being measured. When necessary, add the net circuit delay time to the measured time.

The method described in Demonstration 1 will provide a time measurement accuracy within 1.5% of reading. Accuracy will be greatest when:

a. DELAY TIME MULT dial settings above 2.0 or 2.5 are used.

b. The event triggering A has a fast risetime.

c. DELAY TIME switch settings of 1 μsec/cm or slower are used.

Demonstration 2

Demonstration 2 describes how to measure the time between two pulses, neither of which triggers A.

Set the Type 11B2 controls as listed in Table 2-1 except as follows:

A DELAY TIME .2 mSEC

Apply the oscilloscope 1-Kc Calibrator signal to the vertical input. If necessary, adjust the A TRIG LEVEL control to obtain a stable display. The display should consist of about two cycles of the square-wave signal. Set the DELAY TIME MULT dial so the square-wave rise located near the center of the display is intensified.

Set the HORIZ DISPLAY switch to B DLY'D BY A non-triggered (to the left of A on the panel). The display should now be a horizontally expanded version of the intensified segment observed in the previous display.

Set the DELAY TIME MULT dial so the 50% amplitude level of the square-wave rise intersects the vertical line at the center of the graticule. Note the exact DELAY TIME MULT dial setting (e.g. 5.04). Turn the DELAY TIME MULT dial clockwise until the 50% amplitude level of the square-wave fall intersects the same vertical graticule line used with the previous dial setting. Again note the exact DELAY TIME MULT dial setting.

Subtract the first dial setting from the second. The product of this difference and the A DELAY TIME switch setting equals the time duration of the square-wave positive-going half cycle (between the 50% amplitude points). In this case, the time duration should be between 0.494 and 0.506 millisecond.

Accuracy. Determined by the combination of ***ALL*** the following factors:

1. The basic accuracy of the A delay time as described in Demonstration 1.

2. The error that the sweep delay system linearity adds to the measurement depends on the numerical difference between the two dial settings used. The error decreases as the numerical difference increases. The time error in this type of measurement is less than 0.15% of the full-scale delay (±0.15% of ten times the A DELAY TIME switch setting). However, this applies only when the DELAY TIME MULT dial settings are separated by at least one full dial turn.

NOTE

When the separation between dial settings is one full dial turn or less, the desired time measurement can often be made more accurately by direct reading from a magnified crt display. See Demonstration 3.

3. The accuracy of time measurements made according to Demonstration 2 is independent of the inherent circuit delays and of the triggering point (discussed in Demonstration 1), provided the A TRIG LEVEL control setting is the same for each of the two dial readings.

The method described in Demonstration 2 provides time measurement accuracy within 1.5% of reading. Accuracy will be greatest when:

a. The numerical difference between the two DELAY TIME MULT dial settings is greatest.

b. DELAY TIME switch settings of 1 μsec/cm or slower are used.

Demonstration 3

Demonstration 3 describes how to accurately magnify any event within a series of events by factors of two to several thousand.

Complex signals often consist of a number of individual events of different amplitudes. Since the trigger circuits of the Type 11B2 are sensitive to signal amplitude, a stable display will normally be obtained only when the sweep is triggered by the event having the greatest amplitude. The B DLY'D BY A non-triggered mode (to the left of A on the HORIZ DISPLAY switch) permits the start of a sweep to be delayed for a selected time after the signal event having the greatest amplitude. Any event within the series of events may then be displayed in magnified form as follows:

Set the Type 11B2 controls as listed in Table 2-1. Apply the oscilloscope 1-Kc Calibrator signal to the vertical input. If necessary, adjust the A TRIG LEVEL control to obtain a stable display. The display should consist of several cycles of the square-wave signal. Set the DELAY TIME MULT dial to intensify one of the positive-going pulses.

Set the HORIZ DISPLAY switch to B DLY'D BY A non-triggered (to the left of A on the panel). The display now contains the same signal information as the intensified trace segment in the previous display, but horizontally expanded (magnified) ten times.

Increase the B sweep rate to 1 microsecond per centimeter. Set the DELAY TIME MULT dial to position a square-wave rise on the crt. The display now provides X1000 magnification over that previously observed with the HORIZ DISPLAY switch in A INTEN BY B.

Slowly turn the DELAY TIME MULT dial. Note that any portion of the square-wave display can be brought into view in magnified form.

The DELAY TIME MULT dial indication corresponds to the number of centimeters between the beginning of the A INTEN BY B trace and the beginning of the intensified trace segment (e.g. 7.00 = 7 centimeters).

The B DLY'D BY A display will probably exhibit some horizontal jitter. The time jitter contributed by the delay system is less than 5 X 10^{-4} times the A DELAY TIME switch setting. Since the sweep rate of the delayed sweep is now 1 microsecond per centimeter, the jitter due to the delay system is less than one-half centimeter.

Accuracy. Depends solely on the displayed B sweep-rate accuracy as listed in Section 1 of this manual.

Demonstration 4

Ordinarily, the signal to be displayed is also used to trigger the oscilloscope. In some instances, it may be desirable to reverse this situation. The sweep-related output pulses, available at the front panel of the Type 11B2 can be used as the input or triggering signal for external devices. The output signal of the external device will then produce a stable display while the oscilloscope sweep free runs.

Set the Type 11B2 controls as listed in Table 2-1 except as follows:

A SOURCE	EXT
DELAY TIME MULT	1.00

Connect the Type 11B2 + GATE B output to the vertical input. The display should consist of a positive-going pulse about 1-centimeter wide. This pulse is available from the Type 11B2 during each A sweep. In a practical application, the pulse would not be applied to the vertical input but to some external device to be tested. The pulse would serve as the trigger pulse or input signal for the external device and the output of the device would be displayed on the oscilloscope. Since the pulse has a known time relationship to each A sweep, the output of the device would provide a stable display on the oscilloscope, as though the oscilloscope were triggered in the normal manner.

Demonstration 5

The Type 11B2 + GATE B output signal can provide a pulse with a variable up rate and duty factor.

Set the Type 11B2 controls as follows:

HORIZ DISPLAY	A INTEN BY B non-triggered (to the left of A on the panel)
DELAY TIME MULT	About 0.30
TRIG MODE	FREE RUN

The pulse signal is available at the + GATE B connector. Monitor the signal on another oscilloscope and establish the desired pulse repetition rate by setting the A DELAY TIME switch and VARIABLE A control. Establish the desired duty factor by setting the B TIME/CM switch and variable B control.

The maximum pulse-repetition frequency that can be obtained in this manner is about 130 kc. Maximum duty factor is about 0.9, decreasing to about 0.15 with faster sweep rates.

TRIGGERED DELAYED SWEEP

Complex signals often contain a number of individual events of different amplitudes. Since the trigger circuits in the Type 11B2 are sensitive to signal amplitude, a stable display will normally be obtained only when the sweep is triggered by the event having the greatest amplitude.

The B DLY'D BY A triggered position (to the right of A on the HORIZ DISPLAY switch) provides a means of triggering the sweep by events other than those having the greatest amplitude. The following instructions demonstrate that Time Base B can be triggered by virtually any event within a series of events.

Set the Type 11B2 controls as listed in Table 2-1 except as follows:

B COUPLING	AC
B SOURCE	INT
B SLOPE	+
B TRIG LEVEL	0

Connect the oscilloscope CAL OUT signal to the vertical input. If necessary, adjust the A TRIG LEVEL control to obtain a stable square-wave display.

Turn the DELAY TIME MULT dial about 2 turns in either direction. Notice that the brightened segment in the display moves smoothly across the crt.

Set the DELAY TIME MULT dial so the brightened segment begins about the middle of a pulse top. Set the HORIZ DISPLAY switch to B DLY'D BY A non-triggered (to the left of A) and notice that this display also begins in the middle of a pulse top. Now, set the HORIZ DISPLAY switch to A INTEN BY B triggered (to the right of A). Notice that the brightened segment in the display has shifted to the next pulse on the right. (If the brightened segment is not present, or is unstable, readjust the B TRIG LEVEL control.) Turn the DELAY TIME MULT dial several full turns. The brightened segment in the display should jump from one pulse to the next. Set the HORIZ DISPLAY switch to B DLY'D BY A triggered (to the right of A) and notice that the display now begins within the rising portion of the pulse. With the present display, turning the DELAY TIME MULT dial will cause no change in the display, since all of the 1-Kc Calibrator pulses are the same shape. However, if the input signal consists of a repeating series of dissimilar pulses, turning the dial will provide a triggered display of each pulse in the series (provided the B TRIG LEVEL control is set for triggering on the smallest pulse).

The display is produced in the following manner:

Time Base B produces one sweep during each A sweep. B sweep will begin at some time after the start of A sweep. This time is the total of the A DELAY TIME switch setting multiplied by the DELAY TIME MULT dial setting, plus the time between the end of this delay interval and the next event in the signal which can trigger B.

B sweep occurs only if B is triggered before A sweep ends. If A sweep ends while B sweep is in progress, B sweep will also terminate. If this occurs, a B delayed by A display will not be the full width of the graticule.

EXTERNAL HORIZONTAL DEFLECTION

For special applications, you can produce horizontal deflection with an externally derived signal. This permits you to use the oscilloscope system to plot one function against another (e.g. Lissajous figures). However, the system is not intended for qualitative phase-angle measurements.

To use an external signal for horizontal deflection, connect the signal to the B TRIG IN OR EXT INPUT connector. Set the HORIZ DISPLAY switch to EXT INPUT and the B SOURCE switch to EXT. The signal can be either ac or dc coupled to the deflection amplifier by setting the B COUPLING switch. The MAG switch can be turned to X10 to increase the horizontal deflection by a factor of 10.

SECTION 3

CIRCUIT DESCRIPTION

General Information

This portion of the instruction manual presents a detailed discussion of the Type 11B2 circuitry. This discussion refers to various block diagrams inserted in the text and to the schematics in Section 5.

A block diagram of the Type 11B2 is also provided in Section 5. The relationship of the circuits in each block to those in other portions of the system is discussed in the detailed description of that block.

TRIGGER GENERATOR

For best triggering stability, the time-base generators require trigger pulses that are representative of the triggering-signal frequency, but with greater wave-shape consistency than the signals generally encountered. The Trigger Generator converts the triggering signal into a pulse having a consistently fast risetime while retaining the characteristic repetition frequency of the triggering signal. The converted pulse is then used to trigger the time-base sweep.

Sections A and B of the Trigger Generator operate similarly for sweep triggering; but section B has an alternative function. The input cathode follower in section B is used as an isolation stage when external horizontal deflection signals are used.

The block diagram, Fig. 3-1, shows the basic elements of the Trigger Generator.

The A triggering signal can be selected from three sources: internal, line, or external. External (EXT) triggering signals are connected to the A TRIG IN connector and high-amplitude external signals can be attenuated by setting the A SOURCE switch to EXT ÷ 10. This forms an input divider consisting of R29 and R30A. If the COUPLING switch is set to AC LF REJ, about 100 times attenuation is obtained because R30B parallels R30A.

The line-source signal comes from a divider connected to a low-voltage winding of the oscilloscope power transformer.

The internal-source signal comes from the vertical deflection plug-in unit to the Type 11B2 Internal Trigger Preamp. The Preamp consists of a push-pull driven, single-ended output, paraphase amplifier driving a complementary emitter follower.

The samples of the vertical deflection signal applied to the bases of Q14A and B are of opposite polarity. If, for example, the signal increases the Q14A current, it will decrease the Q14B current. Due to the common-emitter coupling, a current increase through Q14A will compound the current reduction in Q14B. INT TRIG DC LEVEL (R7) is adjusted during calibration so the "no signal" dc voltage delivered to the SOURCE switch will be zero volts when the trace is vertically positioned near the center of the graticule.

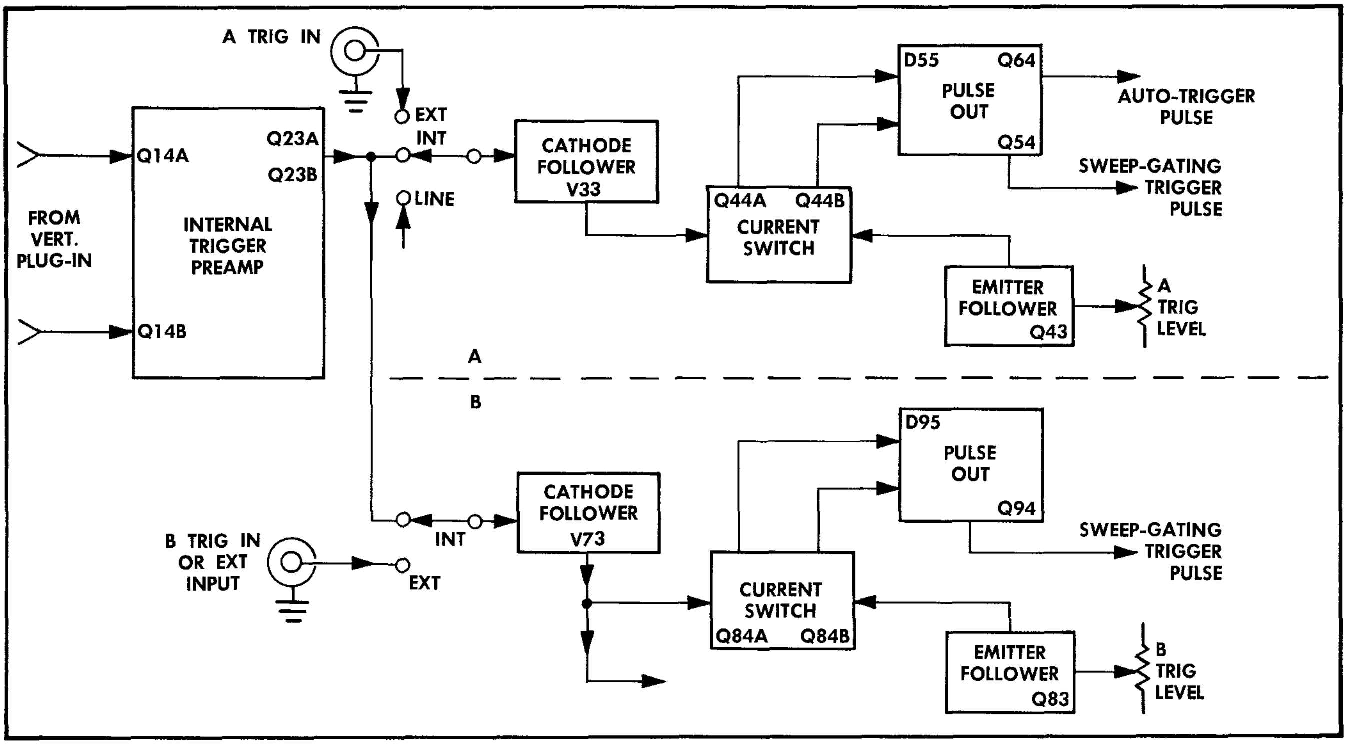

Fig. 3-1. Trigger generator block diagram.

The amplified triggering signal from the paraphase amplifier is applied to the base of Q23A, and in slightly attenuated form, to the base of Q23B. The combined function of Q23A and Q23B is that of an emitter follower, but this special configuration overcomes a common limitation of conventional emitter followers by providing equally fast response for both positive- and negative-going portions of a signal. The output signal is available to both the A and B SOURCE switches.

In the AC position of the COUPLING switch, C30A and R30A provide a coupling time contant such that dc and very low-frequency ac signals are rejected. In the AC LF REJ position, the coupling time constant is decreased so the ac rejection includes somewhat higher frequencies. This rejection is primarily intended to prevent triggering on the dc-level switching information encountered in alternate-trace operation of vertical plug-in units. The signal from the A COUPLING switch is applied to the grid of cathode follower V33. R30C, D30, and D31 protect V33 from triggering signals with excessive amplitude.

The triggering signal from the cathode follower is applied to the base of Q44A. D33 protects Q44A by limiting negative voltage excursions to about —16 volts.

Q44A and Q44B form a sensitive current switch. If the instantaneous triggering signal voltage at the base of Q44A is more positive than the voltage established at the base of Q44B by the TRIG LEVEL control, Q44A will conduct. Unless the base voltages are very nearly equal, the two transistors cannot conduct at the same time due to the common-emitter coupling. Hence, as the positive-going portion of the triggering signal drives the base of Q44A from negative to positive, with respect to the base of Q44B, the current through R44 switches from Q44B to Q44A.

When the SLOPE switch is set to +, Q44A collector current must pass through D45A. The current then divides with the greatest portion passing through tunnel diode D55. This current puts the tunnel diode in its high state (see Fig. 3-2).

When Q44A is off, the tunnel diode is in its low state. With the SLOPE switch set to —, the Q44B collector current controls the tunnel diode. Hence, with the SLOPE switch set to +, the tunnel diode will switch to its high state when Q44A comes into conduction, and with the SLOPE switch to — the tunnel diode will switch to its high state when Q44B comes into conduction.

As is characteristic of a tunnel diode, the transition from the low-voltage state to the high-voltage state occurs very rapidly, no matter how slowly the current increases. Therefore, this switching action of the tunnel diode provides the base of Q54 with a fast-rise, negative-going pulse.

When the tunnel diode suddenly drives the Q54 base negative, Q54 is driven into heavy conduction. While the Q54 steady-state current passes through the high resistance of R53, the very fast-rise base pulse enables Q54 to pass considerable current through C53 and the series combination of C63, Q64, and R61. Due to the short time constants in the Q54 emitter circuit, the Q54 current rapidly decreases to the steady-state level, even though the tunnel diode may remain in the high state. Thus, fast-rise positive-going pulses are developed simultaneously at the collectors of Q54 and Q64.

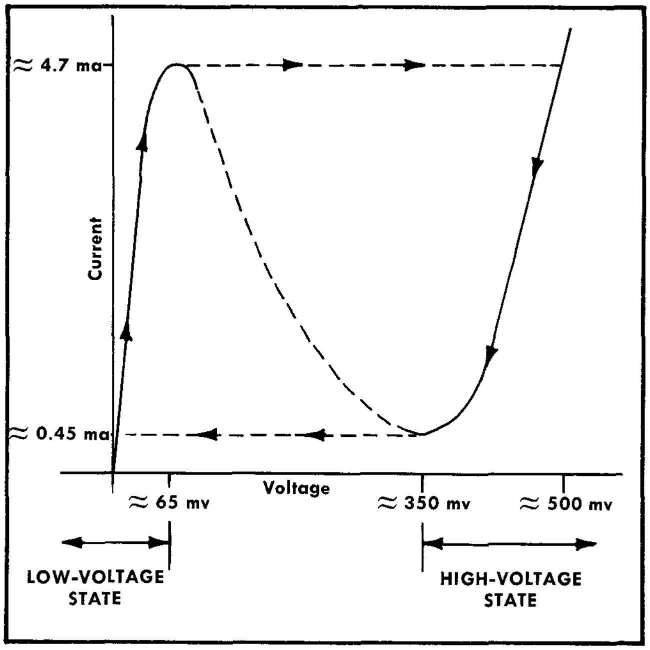

Fig. 3-2. Tunnel diode characteristics.

When the triggering signal resets the tunnel diode to its low state, Q54 turns off, but rapidly recovers to the steady-state conduction level. The output pulses produced at reset have no effect on Sweep Generator A.

The operation of section B of the Trigger Generator is similar to section A until the signal reaches the cathode circuit of V73. When the HORIZ DISPLAY switch is set to B DLY'D BY A non-triggered, A INTEN BY B non-triggered, or A, the —15-volt source at the ends of R75D and R75F, and the cathode potential of V73, back bias D73 and D74. Hence, no signal passes this point. Current is diverted through R75A to maintain the proper current value through V73. When the HORIZ DISPLAY switch is set to EXT INPUT, D73 remains back biased, but D74 conducts and an external horizontal deflection signal will be passed to the Horizontal Preamp. The network consisting of R73, D75, R75E, and R76, offsets a zero-referenced signal to about +7 volts. This is approximately the voltage at the 50% amplitude point on the A and B sawtooth sweep signals. Thus, if the operator centers the A or B sweep display and then sets the HORIZ DISPLAY switch to EXT INPUT, a display produced by a zero-referenced horizontal deflection signal will also be centered.

With the HORIZ DISPLAY switch set to A INTEN BY B triggered or B DLY'D BY A triggered, D74 is back biased while D73 passes the triggering signal to the base of Q84A.

The remainder of section B is identical to section A, with two exceptions. B Sweep Generator has no automatic triggering circuit; thus section B of the Trigger Generator has no automatic trigger pulse output amplifier. Also, the B TRIG LEVEL control is connected differently. When an external triggering signal is used for section B, the B triggering-level voltage range is about twice that obtained in section A when the A SOURCE switch is set to EXT.

SWEEP GENERATOR A

Sweep Generator A produces four simultaneous output signals (see Fig 3-3.)

1. A positive-going sawtooth that is applied to the Delay Pickoff section of Sweep Generator B, and which can be applied to the Horizontal Preamp by proper setting of the HORIZ DISPLAY switch. The positive-going sawtooth is also available for external use at the SWEEP A front-panel connector.

2. A negative-going crt unblanking pulse having the same duration as the sweep sawtooth rise. Coupled to the oscilloscope Crt Circuit when the Type 11B2 HORIZ DISPLAY switch is set to A or A INTEN BY B (triggered and non-triggered).

3. A positive-going pulse (+ GATE A) having the same duration as the sweep sawtooth rise. Coupled to a front-panel connector for external use.

4. A negative-going multi-trace sync pulse occurring at the end of the sweep sawtooth rise. Coupled to the vertical plug-in unit interconnecting socket. Causes a multi-trace plug-in unit, operating in the alternate mode, to switch channels.

In most applications, each cycle of events is started by a trigger pulse from the Trigger Generator. However, it is also possible to free run Sweep Generator A; that is, the end of one cycle will cause the next cycle to begin. The desired operation is selected by setting the TRIG MODE switch. The four operating modes provided by the TRIG MODE switch are described in Section 2 of this manual.

The block diagram, Fig. 3-3, shows the basic elements of Sweep Generator A.

The Sweep-Gating Multi is an electronic switch that drives the Gate Amplifier to turn the Disconnect Diode on and off. When the Disconnect Diode is switched off, the Miller Runup Integrator begins to produce a sawtooth signal. A sample of the sawtooth is fed back to the Gate Enable Multi to reset the Sweep-Gating Multi as the sawtooth reaches a certain amplitude. As the Sweep-Gating Multi resets, the Disconnect Diode is switched on, and the Miller Runup resets to form the retrace or falling portion of the sawtooth. Following a short stabilization period, Sweep Generator A is ready to repeat the sequence.

The TRIG MODE switch provides four ways to switch the Sweep-Gating Multi so that the sweep will begin. In NORM, the multi is switched by a pulse from the Trigger Generator. In SINGLE SWEEP, two pulses are required to start ***EACH*** sweep. First, a pulse from the Reset Amplifier (originating at the RESET pushbutton or from an external device through pin F of J101 on the rear panel of the oscilloscope) resets the Gate-Enable Multi. Then, after reset, the Sweep-Gating Multi can be switched by a pulse from the Trigger Generator. FREE RUN results in recurrent sweeps that are independent of any triggering signal. The retrace portion of one sawtooth switches the multi to begin the next sawtooth.

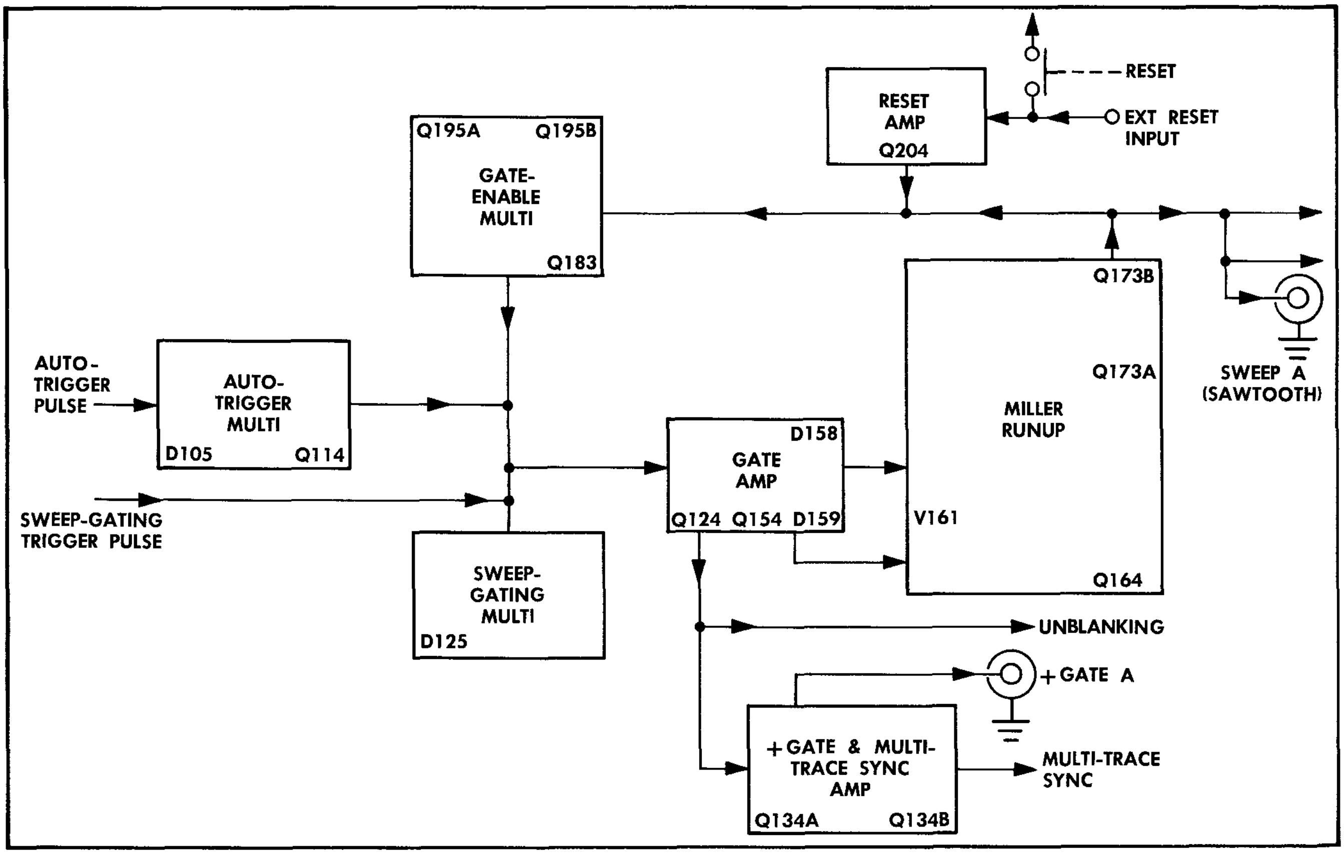

Fig. 3-3. Sweep Generator A block diagram.

AUTO is a combination of NORM and FREE RUN. If there are no trigger pulses coming from the Trigger Generator, the Auto-Trigger Multi holds the Sweep-Gating Multi in the "free run" condition. When a pulse comes from the Trigger Generator, the Auto-Trigger Multi switches the Sweep-Gating Multi to the "normal" condition, but this first trigger pulse does not start a sweep. If the first trigger pulse is followed by a second within about 80 milliseconds, the Sweep-Gating Multi will switch and a sweep will begin. If trigger pulses continue to arrive every 80 milliseconds or less, the Auto-Trigger Multi will remain in the normal condition and each sweep will be a triggered sweep. Whenever the period between trigger pulses exceeds 80 milliseconds, the Auto-Trigger Multi will revert to the free-run condition until the next trigger pulse arrives.

The following description refers to the Sweep Generator A schematic in the back of this manual. The first portion of the description pertains to operation with the TRIG MODE switch set to NORM.

Quiescent Conditions

In the quiescent state; that is, when the sweep generator is triggerable but no sweep is being generated, the circuit conditions are as follows:

Q195B is conducting and Q195A is cut off. Q195B establishes current through the parallel arrangement of D125, D118, and D121. Tunnel diode D125 is in the low-voltage state (see Fig. 3-2) so that Q124 is off. With Q124 off, the series combination of R124 and R127 is effectively in parallel with R154. Q154 conducts at a level which forward biases Disconnect Diode D159 and diode D158.

The conduction of Q154 through R127 and R124 produces about +6.5 volts at the Q124 collector. This voltage is divided to about zero volts at the unblanking signal output (see Interconnecting Plug schematic). Q134 conducts heavily, but its collector and the + GATE A connector output are clamped at about —0.6 volt by diode D133. Q134B is cut off and the voltage on the multi-trace sync-pulse bus is about +5 volts.

With Disconnect Diode D159 conducting, the grid of V161 is clamped at about zero volts. D158 clamps the sawtooth output bus at about +2.4 volts to provide a stable, repeatable sawtooth starting voltage. This starting voltage can be set during calibration by adjusting DELAY START (R150). The arm of the control is connected to the equivalent point in Sweep Generator B so both will have the same sawtooth starting voltage and will therefore produce sweeps that start at the same point on the crt. The starting voltage is variable over a small range to permit calibration of the DELAY TIME MULT dial.

V161, Q164, and Q173A form a Miller Runup Integrator. The tube and transistors are clamped at moderate conduction levels by D158 and D159. The Q173B emitter voltage is about +1.8 volts, forward biasing D180 and D181. Q183 conducts heavily and reverse biases D183. Q195B is held on by the divider consisting of R184, R185, R199, R193, and R194 paralleled by D193 and Q183.

With the TRIG MODE switch set to NORM, Q114 has no collector supply and the Auto-Trigger Multi is disabled.

Cycle of Operation

A sweep-gating trigger pulse will turn on D120 and turn off D121. The Q195B current does not decrease when D121 cuts off, but is transferred instead to tunnel diode D125, rapidly switching it to its high-voltage state (see Fig. 3-2).

When the tunnel diode switches, Q124 turns on. The negative voltage step at the collector of Q124 provides the oscilloscope crt unblanking signal. Q134A cuts off, forming the rise of the +GATE A connector output signal. Q134B remains cut off.

The negative-going voltage step at the collector of Q124 is applied to the emitter of Q154, turning the transistor off. Thus, Disconnect Diode D159 is rapidly switched off.

When the Disconnect Diode turns off, the current through timing resistor R_t does not cease, but instead begins to charge timing capacitor C_t. As the timing capacitor charges, the grid of V161 goes negative. But the inverted and greatly amplified change at the emitter of Q173A is fed back to the timing capacitor and opposes the grid voltage change. (The positive-going change also turns off D158.) This action persists throughout the sawtooth period and limits the total grid voltage change to less than 0.02 volt. Since the voltage drop across the timing resistor is held nearly constant, the current through the resistor is essentially a fixed value. This fixed current flows into the timing capacitor, producing a linearly increasing voltage (sawtooth) across the capacitor. D159 is a special diode that exhibits very low leakage under reverse-bias conditions. This characteristic prevents the diode from effectively altering the timing resistance value.

The rate of the sawtooth rise is a function of the RC time constant of the timing resistor and capacitor, and of the voltage magnitude at the negative end of the timing resistor. Increasing the voltage across the timing resistor increases the current into the timing capacitor and therefore increases the sawtooth rate of rise. The voltage across the timing resistor can be varied over about a 9-volt range by adjusting A SWP CAL (R160W) shown on the Timing Switches schematic. R160W is adjusted during calibration to establish the correct absolute rate of sawtooth rise and affects all A sweep rates equally.

The VARIABLE A front-panel control operates in much the same manner as A SWP CAL, but permits a wider variation in sweep rate. This control permits the operator to obtain uncalibrated sweep rates as much as two and one-half times slower than the calibrated rates obtained with the control set fully clockwise.

The sawtooth signal at the emitter of Q173A is available to the Horizontal Preamp through the HORIZ DISPLAY switch, and is applied to the Delay Pickoff circuit and the base of Q173B. The rising voltage at the emitter of Q173B supplies the front-panel A SWEEP connector output signal and charges holdoff capacitor C_{ho} through D180 and D181. As the holdoff capacitor charges, the base and emitter of Q183 go more positive. D183 will become forward biased and the positive-going change at the emitter of Q183 will drive the base of Q195B more positive. As the positive-going Q195B base voltage equals and then surpasses the Q195A base voltage, the R195 current switches regeneratively from Q195B to Q195A.

When Q195B turns off, tunnel diode D125 reverts to its low-voltage state. The time duration of the sweep-gating trigger pulse, which started the cycle of operation, will always be considerably less than the time duration of the sweep. However, once the sweep-gating pulse switches the tunnel diode to its high-voltage state, additional trigger pulses can have no further affect on the operation. The tunnel diode will revert to its low state only when Q195B turns off.

As the tunnel diode reverts to its low state, Q124 turns off. The Q124 collector voltage rises, blanking the oscilloscope crt. Q134A turns on, forming the falling portion of the + GATE A connector output signal and driving Q134B into conduction. C136 quickly discharges and Q134B turns off. Thus, the multi-trace sync pulse is negative-going and has a very short duration.

The positive-going voltage step at the collector of Q124 turns on Q154, forward biasing Disconnect Diode D159. Since the timing capacitor still holds the charge developed during the sweep, D158 remains back-biased. The timing capacitor begins to discharge through D159, Q154, and the series-parallel combination of R154, R124, and R127. D158 will not conduct until the charge is nearly depleted.

The removal of the timing capacitor charge forms the retrace or falling portion of the output sawtooth. As the Q173B emitter voltage falls, D180 becomes back biased. During the sawtooth rise, hold-off capacitor C_{ho} charged through D180, but must now discharge through the high resistance of R180 and R181. Thus, timing capacitor C_t will have discharged, restoring the Miller Runup circuit to the quiescent condition before the Q183 base voltage reaches the quiescent level. This time lag can be varied slightly by adjusting the front-panel HF STABILITY control. The need for this variable time lag is discussed in a later paragraph.

As the hold-off capacitor discharges, the Q183 emitter voltage falls. However, this falling voltage does not immediately cause the R195 current to switch to Q195B. The voltage drop across R193 and R194, produced by the conduction of Q195A, is divided by R199, R185, and R184 and holds off Q195B. When the Q183 emitter voltage becomes low enough to forward bias D193, the added current through R193, R199, R185, and R184, pulls down the Q195B base voltage and switches the R195 current to Q195B. The entire sweep generator is then restored to the quiescent condition described previously.

HF STABILITY control (R181) permits the operator to vary slightly the time between the completion of a sweep and the instant when the sweep generator again becomes triggerable. As Q195B turns on after a sawtooth retrace, a very short but sometimes significant amount of time is required for the current through tunnel diode D125 to reach the quiescent level. This recovery time is significant only under the following conditions:

1. When the A sweep rate is faster than about 0.2 microsecond per centimeter.

2. When the triggering frequency is above about 5 megacycles.

3. When the relationship between the sweep rate and triggering frequency is such that the sweep-gating trigger pulse tends to trigger each new sweep while the tunnel-diode current is approaching the quiescent level.

A display obtained under these conditions may jitter horizontally. The operator can minimize and often eliminate the jitter by resetting the HF STABILITY control. This will either advance or delay the Q195B turn-on time so D125 can stabilize at the quiescent level in an interval between sweep-gating trigger pulses.

FREE RUN Mode. Differs from the NORM mode as follows:

When TRIG MODE is set to FREE RUN, R117 is connected to +15 volts and D118 is reverse biased. The Q195B current that was carried by D118 in NORM operation is now carried by tunnel diode D125. As Q195B turns on following a sawtooth retrace, D125 will switch to its high-voltage state without waiting for a sweep-gating trigger pulse. (Moreover, trigger pulses will have no effect on the overall operation.) Thus, the completion of one sweep causes the next to begin.

AUTO Mode. The basic operation of the Auto-Trigger Multi was described previously in the Sweep Generator A block diagram discussion. The conduction state of the Auto-Trigger Multi determines whether diode D118 will be forward biased or reverse biased. When forward biased, Sweep Generator A operates exactly as described for the NORM mode. When D118 is reverse biased, Sweep Generator A operates as described for the FREE RUN mode.

When C102 has received no trigger pulse for more than 80 milliseconds, tunnel diode D105 will be in its high-voltage state (see Fig. 3-2) and Q114 will be turned off. D114 conducts through R116, reverse biasing D118, and Sweep Generator A free runs. The current paths, static current magnitude, and voltages with the circuit in this condition are shown in Fig. 3-4.

The first portion of the following discussion describes the sequence of events caused by a single auto-trigger pulse. The only effect of such a pulse would be an interruption of the free-running A sweeps. The latter portion of the discussion describes how triggered sweeps are produced by triggering signals occurring more often than every 80 milliseconds.

When a current pulse is applied to C102, D102 conducts by diverting current from tunnel diode D105. The tunnel diode rapidly switches to its low-voltage state, driving Q114 into saturation. The Q114 collector drops to about —14 volts, reverse biasing D114, and D118 turns on. (It is probable that D118 will turn on while a "free-run initiated" A sweep is in progress. If this occurs, Sweep Generator A will complete the sweep and can become triggerable at the end of the usual sweep hold-off period.)

As Q114 goes into saturation, the greater portion of its collector current passes through R114 and begins to discharge C114. The voltage across C114 decreases and D113 begins to conduct, decreasing the current through R112. The R106 current no longer carried by R112 is diverted to tunnel diode D105, switching it to its high-voltage state. (By this time, the auto-trigger pulse current through D102 will have subsided.) Q114 turns off, but C114 must recharge for the Q114 collector voltage to rise. Hence, D114 remains off and D118 remains on.

As Q114 turns off, C114 begins to charge through R114 and R116 in parallel with R113. When the voltage at the junction of C114 and R114 reaches about —7 volts, D113 turns off and C114 continues to charge through R114 and R116.

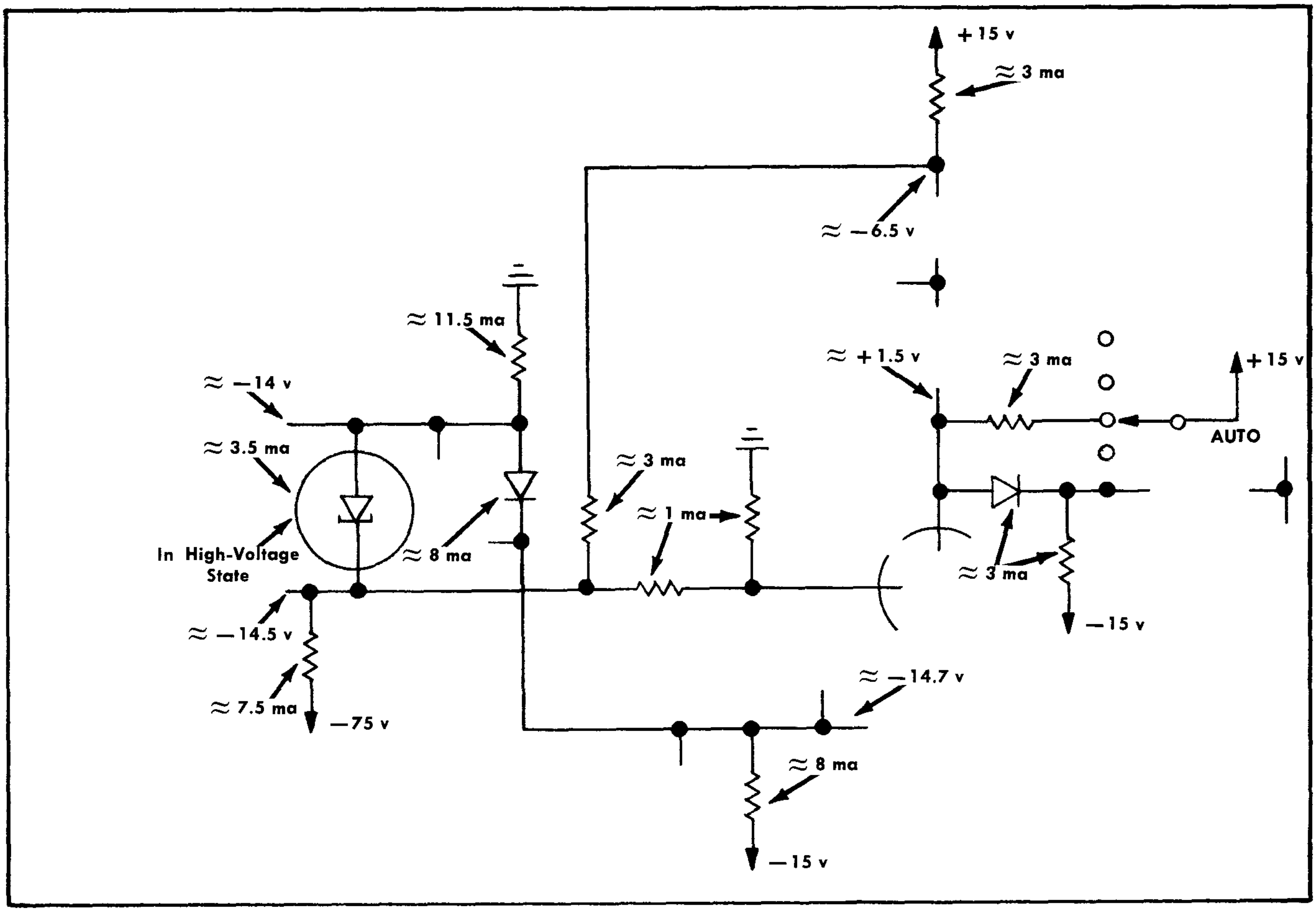

Fig. 3-4. Auto Trigger Multi static conditions.

D114 will turn on when the Q114 collector reaches about zero volts. D118 will then turn off and Sweep Generator A is returned to the free-running condition.

As stated previously, the Auto-Trigger Multi probably will turn on diode D118 while a free-run initiated A sweep is in progress. Hence, Sweep Generator A cannot become triggerable until the end of the hold-off period for this sweep. But from then on, every A sweep will be a triggered sweep if the repetition rate of the auto-trigger and sweep-gating trigger pulses is greater than about 20 pulses per second.

If an auto-trigger pulse arrives at C102 after tunnel diode D105 has reset to its high state, but before C114 has completely recharged, D105 will again switch to its low state. Q114 will turn on and discharge the partially recharged C114 as discussed previously. Additional auto-trigger pulses that may arrive while the tunnel diode is in its low state will have no significant effect on the circuit. But pulses that arrive while the tunnel diode is in its high state will switch the diode back to its low state if the D113 current has decreased sufficiently. Thus, auto-trigger pulses with a repetition rate greater than about 20 pulses per second will repeatedly switch the multi, preventing C114 from charging enough to turn on D114. With D114 turned off continuously, Sweep Generator A will operate exactly as it does in the NORM mode. The negative-going pulse following each positive-going auto-trigger pulse has no effect on the Auto-Trigger Multi except that it discharges C102 through D103.

SINGLE SWEEP Mode. As described previously in the NORM mode discussion, the retrace portion of a sawtooth normally allows discharging hold-off capacitor $C_{h\text{-}o}$ to pull down the Q183 base to near zero volts. D193 would then conduct and turn on Q195B. However, in the SINGLE SWEEP mode, R182 is connected to +15 volts, forming a divider with R180 and R181. This divider stops the hold-off capacitor discharge at about +4.5 volts. Thus, the Q183 emitter does not drop far enough to cause D193 to conduct, and Q195B does not turn on. D180 becomes reverse biased, but D181 in series with the divider remains on.

Since Q195B does not turn on following a sweep, Sweep Generator A becomes locked in an inoperative state. With Q195A on, Q184 is held off and RESET lamp B186 is not lit, indicating the inoperative state of the generator.

The generator can be reset to the operative state either by pressing the RESET button or by applying a positive-going pulse to pin F of J101 on the rear panel of the oscilloscope.

In SINGLE SWEEP mode, Q204 is normally off. The RESET button is connected to a divider consisting of R189A and R189B. When the RESET button is pressed, neon lamp

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B200 fires, supplying a fast-rise turn-on pulse to Q204. The negative-going pulse at the collector of Q204 is applied to the base of Q183. (At this time, D181 serves its only purpose; it is reverse biased by the pulse so that the hold-off capacitor will not pass the pulse to ground.) The pulse pulls down the Q183 emitter and turns on D193. Q195B and Q184 turn on and RESET lamp B186 lights to indicate that the generator is ready to be triggered. At the end of one conventionally-triggered sweep, the generator will again become inoperative.

An externally applied reset pulse can turn on Q204. The pulse must have a reasonably fast rise for adequate energy to pass through C204.

SWEEP GENERATOR B

Sweep Generator B produces the same output signals as Sweep Generator A, except for a multi-trace sync pulse.

The principle difference between Sweep Generators A and B is that Sweep Generator B can produce no more than one sawtooth for each A sawtooth and only while the A sawtooth is in progress. The A sawtooth signal, applied to Sweep Generator B through the Delay Pickoff circuit, controls this operation.

B sweep cannot begin until the A sawtooth has reached an amplitude (which represents a certain amount of time from the beginning of the A sweep) selected by setting the DELAY TIME MULT dial. If non-triggered delayed sweep is used, B sweep will begin at the selected A sawtooth amplitude. But if triggered delayed sweep is used, B sweep will begin *AFTER* the A sweep sawtooth reaches the selected amplitude when a B sweep-gating trigger pulse is applied. However, if a sweep-gating trigger pulse has not been applied to Sweep Generator B before the end of A sweep, B will not produce a sawtooth. Regardless of whether triggered or non-triggered delayed sweep is used, if B sweep is in progress when A sweep ends, the retrace portion of the A sawtooth will cause Sweep Generator B to reset to the quiescent condition.

The block diagram in Fig. 3-5 shows the basic elements of Sweep Generator B.

The Sweep Generator A sawtooth output is permanently connected to the base of Q214A. When Sweep Generator A is in the quiescent condition, the conditions in Sweep Generator B are as follows:

DELAY TIME MULT can be set so the Q214B base voltage will equal the instantaneous A sawtooth voltage at any point along the sawtooth (except for the sawtooth portion which produces approximately the first 3 millimeters of deflection and the portion which produces deflection beyond 10 centimeters). Hence, Q214A will be off and Q214B will be on.

When Q214A is off, the voltage at its collector and therefore at the base of Q219 will be about +17 volts. Since the emitter of Q219 is clamped at about +15.6 volts, Q219 is off. With Q219 off, Q295A and B have no current source and are also off. When Q295B is off, tunnel diode D225 is in its low-voltage state and cannot be switched to its high-voltage state by a sweep-gating trigger pulse. Thus, the remainder of Sweep Generator B is in a quiescent condition similar to that described previously for Sweep Generator A.

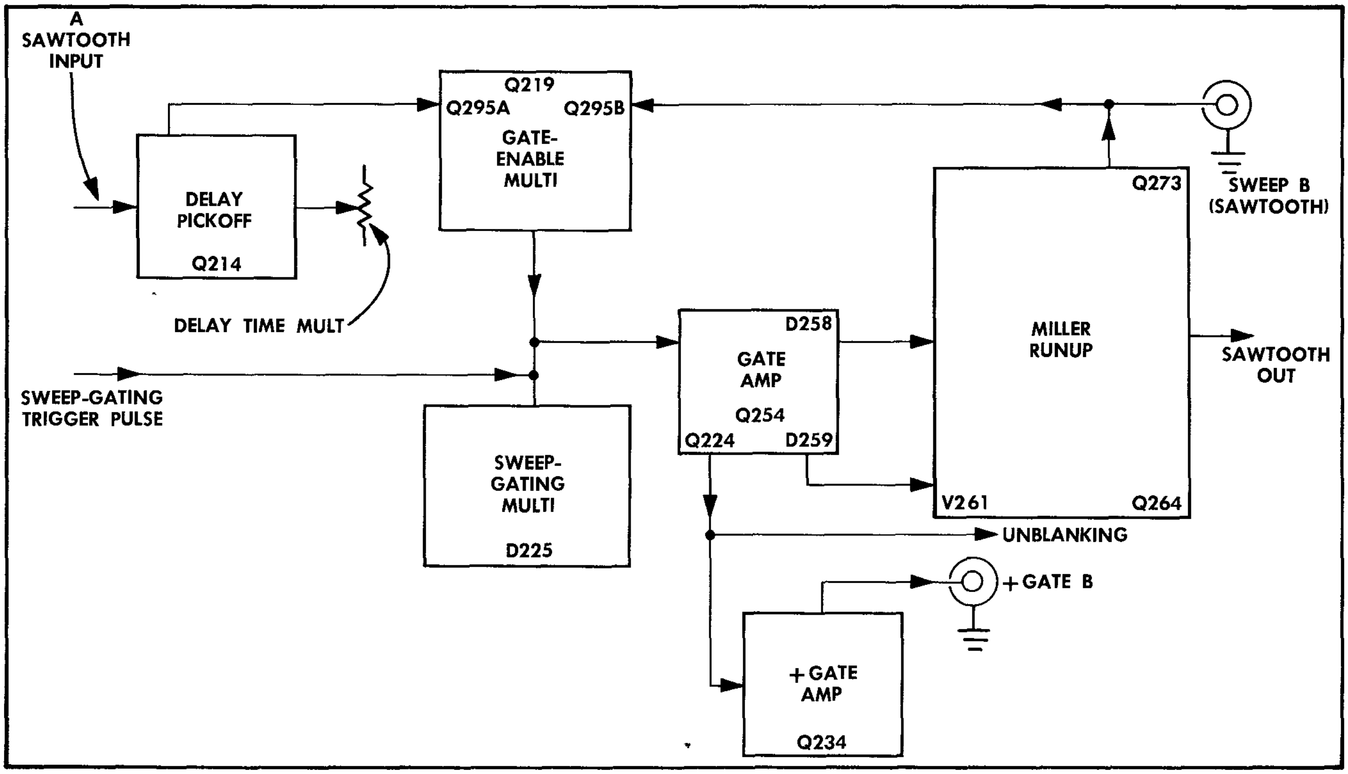


Fig. 3-5. Sweep Generator B block diagram.

At the beginning of an A sawtooth, the base of Q214A will be less positive than the base of Q214B. But at a selected point along the sawtooth rise, this situation will reverse and the R215 current will switch from Q214B to Q214A. The voltage at the collector of Q214A and the base of Q219 will drop, turning on Q219. Because of its large emitter resistor, Q219 becomes a stable source of about 6 ma for the transistors connected to its collector.

The Q295B base voltage is less positive than that of Q295A; therefore, Q295B turns on and holds off Q295A by common-emitter coupling. Depending on the setting of the HORIZ DISPLAY switch, one of three things can now happen:

1. If set to A, R296C will conduct nearly all of the Q295B collector current. The current change through tunnel diode D225 wil be insignificant and Sweep Generator B will remain inoperative and insenstive to sweep-gating trigger pulses.

2. If set to A INTEN BY B triggered or B DLY'D BY A triggered, tunnel diode D225 will be in its low-voltage state, but conducting enough of the Q295B collector current so a sweep-gating trigger pulse will switch it to its high-voltage state.

3. If set to A INTEN BY B non-triggered, B DLY'D BY A non-triggered, or EXT INPUT, R296A will carry very little of the Q295B collector current, and tunnel diode D225 will switch to its high state immediately when Q295B turns on.

The remainder of Sweep Generator B is nearly identical to portions of Sweep Generator A; thus, the Sweep Generator A circuit description applies also to Sweep Generator B.

The B unblanking signal can be one of two amplitudes depending on the setting of the HORIZ DISPLAY switch (see the Interconnecting Plug schematic). When either B DLY'D BY A position is used, the display brightness will be about the same as obtained using the A position. When either A INTEN BY B position is used, the B unblanking signal will brighten the A trace for the duration of the B sweep.

As the B sawtooth rises, D273 (connected to the emitter of Q273) becomes forward biased and the Q295B base voltage begins to rise. As the Q295B base voltage surpasses the Q295A base voltage, the Q219 collector current switches to Q295A. Tunnel diode D225 reverts to its low-voltage state and Sweep Generator B resets as described for Sweep Generator A. (Sweep Generator B needs no hold-off capacitor since it cannot produce another sweep during the present A sweep.) The coupling between the collector of Q295A and the base of Q295B prevents the sawtooth retrace from turning on Q295B.

During the A sawtooth retrace, the R215 current will switch from Q214A to Q214B. The Q214A collector voltage will rise, turning off Q219. Thus, both sweep generators are returned to their quiescent conditions described previously.

If the A sweep retrace occurs while B sweep is in progress, Q219, rather than the B sawtooth rise, will turn off Q295B. If this occurs, tunnel diode D225 will revert to its low state and the B sweep retrace will begin before the sawtooth has reached its usual amplitude.

HORIZONTAL PREAMP

The Horizontal Preamp input signal can come from Sweep Generator A, Sweep Generator B, or from an external source, depending on the HORIZ DISPLAY switch setting. The push-pull output of the preamp connects to the input of the oscilloscope horizontal amplifier through pins 8 and 9 of the interconnecting plug. The operator can increase the preamp gain ten times by setting the MAG switch to X10.

The block diagram in Fig. 3-6 shows the basic subcircuits of the Horizontal Preamp. Q343 provides a signal-voltage offset and a constant source impedance to Q344. Q313 couples the horizontal positioning voltage to Q324 and provides a low source impedance. Q324 and Q344 form a paraphase amplifier.

Refer to the Horizontal Preamp schematic in the back of this manual. This description assumes that the Horizontal Preamp input signal is the Sweep Generator A sawtooth.

The sawtooth swings symmetrically around approximately +7 volts dc. Zener diodes D340 and D341 negatively offset the signal by about 18 volts. Zener diode D343 establishes a fixed voltage across R342 so that D340 and D341 are provided with a stable holding-current. Thus, the signal at the base of Q344 swings symmetrically around approximately —11 volts dc, with peak voltages of about —6 and —16 volts.

The oscilloscope HORIZ POSITION controls provide the means for varying the Q324 base voltage between about —4 and —18 volts; a range which exceeds the peak voltages of the signal at the base of Q344.

Transistors Q344 and Q324 operate as a paraphase amplifier with degenerative emitter coupling. The resistance between the emitters and the —75-volt supply is quite high. Because of this high resistance, the total current through the two transistors is nearly constant and the input signal only reapportions the current. For example, an increase in current through Q344 would be offset by a nearly equal decrease in current through Q324. MAG REGIS (R339) is set during calibration to balance the output currents when Q344 and Q324 have equal emitter voltages.

The effective resistance between the base of Q344 and the stable voltage at the base of Q324 (via the degenerative emitter circuit) is much lower than the resistance to the —75-volt supply. Thus, Q344 can be considered as an emitter follower with the base circuit of Q324 acting as the signal ground point. The input signal voltage divides proportionally between the internal emitter resistance of Q344, the degenerative emitter coupling network, and the internal emitter resistance of Q324.

Since the internal emitter resistances of Q344 and Q324 are essentially equal, the two transistors receive base-emitter drive signals of essentially equal magnitude, but opposite phase. The ratio of the degenerative emitter-coupling resistance to the internal emitter resistances determines the magnitude of the base-emitter drive signals and therefore determines the magnitude of collector current swing of both Q344 and Q324. The resistance between the emitters is about 2.5 kΩ when the MAG switch is set to OFF and about 250 Ω when set to X10. These resistances are

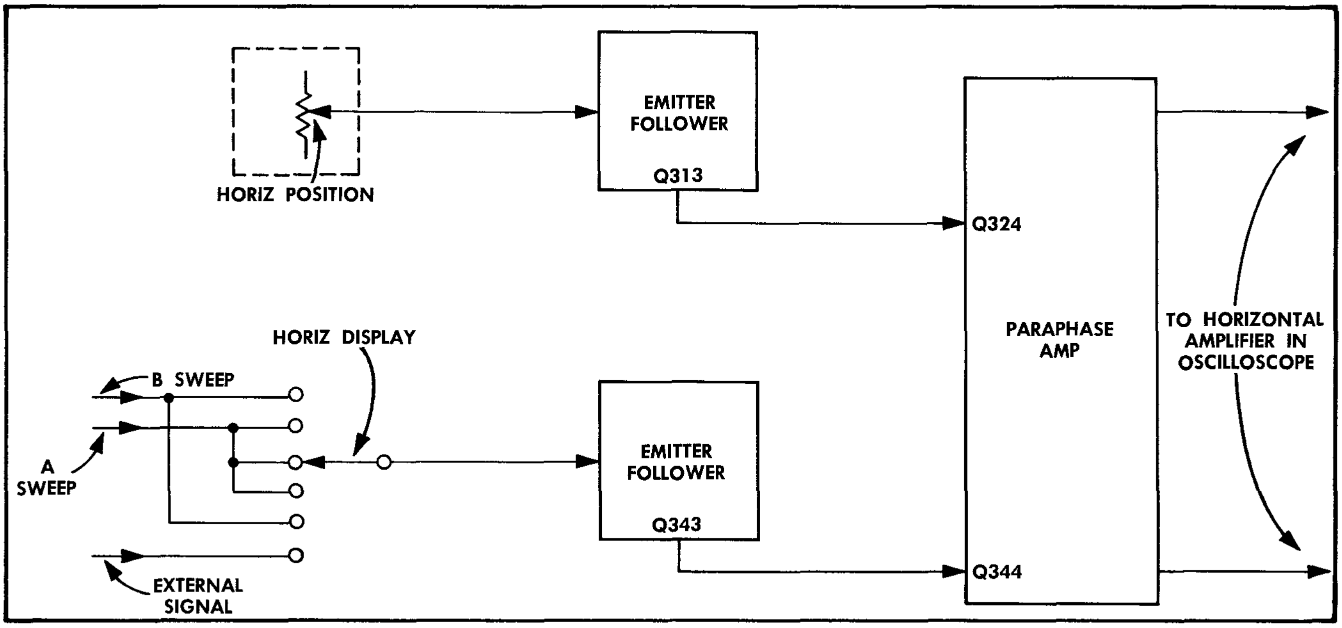


Fig. 3-6. Horizontal Preamp block diagram.

set during calibration to provide two precise current gain-factors which differ by a factor of ten-to-one.

The collectors of Q344 and Q324 are near ground potential and connected to the low-impedance input of the oscilloscope horizontal amplifier. Because of this low input impedance, the Horizontal Preamp of the Type 11B2 provides a current output at an essentially fixed voltage.

SECTION 4
MAINTENANCE AND CALIBRATION

Introduction

Maintenance of the Type 11B2 is similar to that of the oscilloscope and is therefore described in the oscilloscope instruction manual.

The Type 11B2 is a stable instrument which will provide many hours of trouble-free operation. However, to insure measurement accuracy, it is suggested that you recalibrate the instrument after each 500 hours of operation, or every six months if used intermittently. It will also be necessary to recalibrate certain sections of the instrument when tubes, transistors, or other components are replaced.

This section of the manual contains two procedures: a calibration and verification procedure and an abridged adjustment procedure. In the calibration and verification procedure, the title of each numbered step begins either with "Adjust" or "Check", thereby identifying the step function as calibration or verification. To further identify the calibration steps, an asterisk (*) precedes the step number. The steps are identified in this manner because any or all ***groups*** of numbered "Checks" can be skipped without disrupting the continuity of the procedure. However, adjustments must be completed in the order given and none should be skipped. Remember that you can be certain of proper overall operation only when all steps in the procedure have been completed.

The abridged adjustment procedure contains only the information necessary to adjust all seven internal calibration potentiometers without any test equipment. The only items required are an oscilloscope in which to install the Type 11B2, a vertical plug-in unit for the oscilloscope, an adjustment tool, and a 15-inch coaxial cable fitted with BNC connectors. The oscilloscope crystal-controlled 1-Kc Calibrator provides the required accurate time reference.

Adjustment of the four variable timing capacitors which control the accuracy of the six fastest sweep rates of each sweep generator is not described in this procedure since a timing standard other than the oscilloscope 1-Kc Calibrator would be required.

The abridged adjustment procedure, complete with a list of initial control settings and other necessary information is located at the end of this section. Extra copies of the abridged procedure may be obtained from your Tektronix Field Engineer.

NOTE

The performance standards described in this section of your manual are provided strictly as guides to calibration of your instrument and should **not** be construed as advertised performance specifications. However, if your instrument performs within the guide tolerances given in the calibration procedure, it will also perform as listed in the Characteristics section of this manual.

CALIBRATION AND VERIFICATION

Equipment Required

1. Oscilloscope such as the Tektronix Type 647. This procedure assumes that the oscilloscope has been calibrated independently. If this is not the case, refer to the oscilloscope instruction manual for information about calibrating the Type 11B2 and the oscilloscope as a system.

2. Tektronix 10-Series vertical plug-in unit such as the Type 10A2. This unit need not be calibrated, but must operate in all respects.

3. Constant-amplitude sine-wave generator such as the Tektronix Type 190A or 190B. Required characteristics: (a) output frequencies of 50 kc, 3 mc, and 50 mc, (b) output voltage adjustable from about 0.3 volt to 4.0 volts peak-to-peak when terminated in 50 Ω, and (c) provisions for maintaining constant amplitude (manually or automatically) with a change in frequency.

4. Tektronix 50 Ω BNC termination, part no. 011-049.

5. UHF-BNC adapter, for connecting Type 190A or 190B to the BNC termination (UG-255/U).

6. Tektronix P6006 or P6008 Probe.

7. Time-mark generator such as the Tektronix Type 180A. Markers required at 1 and 5 seconds; 100, 10, and 1 milliseconds; 100, 50, 10, 5 and 1 microseconds; 5, 10, and 50-mc sine wave. All outputs should have a time accuracy of at least 0.01%.

8. Coaxial cables, fittings, and adjustment tools as required.

Preliminary Instructions

1. Remove the access panel from the right-hand side of the oscilloscope.

2. Set the controls and switches as follows:

Oscilloscope

INTENSITY	Low brightness
1KC CALIBRATOR	1 VOLTS

Type 11B2

HORIZ DISPLAY	EXT INPUT
MAG	OFF
B COUPLING	AC
B SOURCE	INT
B SLOPE	+
B TRIG LEVEL	0
A and B TIME/CM	5 mSEC
VARIABLE A	CALIB
B (variable)	CALIB

TRIG MODE	FREE RUN
A SLOPE	+
A COUPLING	DC
A SOURCE	INT
A TRIG LEVEL	0
DELAY TIME MULT	0.30

Vertical Plug-In Unit

NOTE

If a multi-trace plug-in unit is used, use channel 1.

MODE	CH 1
VOLTS/CM	.5
VARIABLE	CALIB
AC-DC-GND	DC
PULL TO INVERT	Pushed in
POSITION	Spot centered
TRIGGER	NORM

3. Apply power to the instruments and allow several minutes for warmup before beginning calibration.

NOTE

Photographs on a foldout page following the schematics in the back of this manual show the location of each calibration adjustment control and test point.

Procedure

*1. Adjust INT TRIG DC LEVEL (R7)

a. Remove the vertical plug-in unit.

b. Move B COUPLING switch back and forth between AC and DC, and adjust INT TRIG DC LEVEL (R7) so the spot on the crt remains stationary.

c. Reset B COUPLING switch to AC and reinstall the vertical plug-in unit.

2. Check A Free-Run Mode

a. Set HORIZ DISPLAY switch to A.

b. With TRIG MODE switch set to FREE RUN, check for a trace on crt.

3. Check A Normal Mode

a. Set TRIG MODE switch to NORM, and check for no trace on the the crt.

b. Set:

A SOURCE switch to LINE
A COUPLING switch to AC

c. Connect a X10 probe between the vertical input and a source of a power-line frequency sine-wave signal (such as pin 30, ≈ 6.3 volts ac, of the horizontal interconnecting plug in the oscilloscope).

d. Check that a triggered display can be obtained by adjusting the A TRIG LEVEL control. Note whether the display begins within the rising or falling portion of the sine wave.

e. Set A SLOPE switch to — and repeat step (d). The display should begin within the opposite portion of the sine wave (rise or fall) from that noted in step (d).

f. Disconnect the probe.

4. Check A Single-Sweep Mode

a. Set:

A TRIG LEVEL control to 0
A SLOPE switch to +
A and B TIME/CM switch to 50 mSEC
TRIG MODE switch to SINGLE SWEEP

b. Set A SOURCE switch to EXT and check that the RESET lamp is not lit and that there is no trace on the crt.

c. Push the RESET button.

d. Check that the RESET lamp is lit.

e. While watching the crt, set A SOURCE switch to LINE. Sweep Generator A should produce only one sweep on the crt and the RESET lamp should extinguish.

f. Set A SOURCE switch to EXT.

g. Set the oscilloscope 1KC CALIBRATOR to 5 VOLTS.

h. Momentarily connect the calibrator output to pin F of J101 on the rear panel of the oscilloscope.

i. Repeat steps (d) and (e).

5. Check A Automatic Mode

a. Set:

A SOURCE switch to EXT
A and B TIME/CM switch to 10 μSEC
TRIG MODE switch to AUTO

b. Connect the constant-amplitude sine-wave generator to the A TRIG IN connector. Terminate the generator with a Tektronix 50 Ω BNC termination unit (part no. 011-049), using a UHF to BNC adapter (part no. 103-032).

c. Set the generator for a 125-millivolt peak-to-peak output at 50 kc. (When a Tektronix Type 190A or 190B is used, a 125-millivolt peak-to-peak output across the termination is obtained when the attenuator is set to 0.5 volt and the meter indicates 5 volts on the 10-volt scale.)

d. Connect a Tektronix P6006 or P6008 Probe between the vertical input and the terminal on the rear of the A TRIG IN connector or the bottom of the 9.1-megohm resistor on the A SOURCE switch. Connect the probe-body ground lead to the Type 11B2 chassis.

e. Set the vertical plug-in VOLTS/CM switch to .01.

f. Check that a stable sine-wave display can be obtained by setting the A TRIG LEVEL control with the A SLOPE switch set to either + or —.

g. Repeat step (f) with A COUPLING switch set to AC LF REJ and then to DC.

h. Change the generator frequency to 50 mc and output amplitude to 250 millivolts peak-to-peak. (With a Tektronix Type 190A or 190B, set the attenuator to 0.5 volt and use a meter indication of 10 volts.)

NOTE

The input amplitude may be vertified with a sampling oscilloscope system by using a probe such as the Tektronix P6034. This probe should be connected in parallel with the probe used in step (d) and should be left connected through step (j).

i. Set:
   A and B TIME/CM switch to .1 μSEC
   MAG switch to X10
   A COUPLING switch to AC

j. Repeat step (f). It may be necessary to use the HF STABILITY control to obtain a stable display.

k. Disconnect the probe and move the generator connection to the vertical input.

l. Set:
   A SOURCE switch to INT
   MAG switch to OFF
   A and B TIME/CM switch to 20 μSEC
   VOLTS/CM switch (vertical plug-in) to 2

m. Set the generator to 50 kc and reduce the output amplitude for 2 mm of deflection. Check that the A TRIG LEVEL control will stabilize the display.

n. Set:
   A and B TIME/CM switch to .1 μSEC
   MAG switch to X10
   VOLTS/CM switch (vertical plug-in) to .5

o. Set the generator frequency to 50 mc and change the output amplitude as required for 10 mm of deflection. Check that the A TRIG LEVEL control will stabilize the display. (It may be necessary to use the HF STABILITY control.)

p. Disconnect the generator.

q. Set:
   A SOURCE switch to EXT ÷ 10
   A and B TIME/CM switch to 1 mSEC
   MAG switch to OFF
   VOLTS/CM switch (vertical plug-in) to 2
   1KC CALIBRATOR switch (oscilloscope) to 5 VOLTS

r. Connect the oscilloscope calibrator output to the A TRIG IN connector and to the vertical input.

s. Check that a stable display can be obtained by setting the A TRIG LEVEL control.

t. Remove the signal connections.

6. Check B External Triggering Sensitivity

a. Set:
   A SOURCE switch to INT
   B SOURCE switch to EXT
   A TIME/CM switch to 50 μSEC
   B TIME/CM switch to 10 μSEC
   HORIZ DISPLAY switch to A INTEN BY B (triggered)
   VOLTS/CM switch (vertical plug-in) to .01

b. Connect the sine-wave generator to the B TRIG IN connector, see step 5b.

c. Connect a Tektronix P6006 or P6008 Probe between the vertical input and the solder connection on the rear of the B TRIG IN connector. Connect the probe-body ground lead to the Type 11B2 chassis. Do not use a plug-in extension between the Type 11B2 and the oscilloscope.

d. Set the generator for a 50-kc output at 125 millivolts peak-to-peak as described in step 5c.

e. Set A TRIG LEVEL control for a stable display.

f. Check that a stable intensified zone can be obtained near the left end of the display by setting the B TRIG LEVEL control.

g. Set B SLOPE switch to — and repeat step (f).

h. Set:
   A TIME/CM switch to .5 μSEC
   B TIME/CM switch to .1 μSEC
   MAG switch to X10

i. Change the generator frequency to 50 mc and output amplitude to 250 millivolts peak-to-peak. (With a Type 190A or 190B, set the attenuator to 0.5 volt and use a meter indication of 10 volts.)

j. Set A TRIG LEVEL and HF STABILITY controls as required for a stable display.

k. Set HORIZ DISPLAY switch to B DLY'D BY A (triggered).

l. Check that a stable display can be obtained by setting the B TRIG LEVEL control.

m. Set:
   B SLOPE switch to +
   B COUPLING switch to DC

n. Repeat step (l).

o. Disconnect the probe.

7. Check B Internal Triggering Sensitivity

a. Set:
   B SOURCE switch to INT
   B COUPLING switch to AC
   HORIZ DISPLAY switch to A INTEN BY B (triggered)
   MAG switch to OFF
   A TIME/CM switch to 50 μSEC
   B TIME/CM switch to 10 μSEC
   VOLTS/CM switch (vertical plug-in) to 1

b. Move the generator connection to the vertical input.

c. Change the genrator frequency to 50 kc and reduce the output amplitude for 2 mm of deflection.

d. Set A TRIG LEVEL control for a stable display.

e. Check that a stable intensified zone can be obtained near the left end of the display by setting the B TRIG LEVEL control.

f. Set:
   A and B TIME/CM switch to .1 μSEC
   MAG switch to X10
   VOLTS/CM switch (vertical plug-in) to .2

g. Change the generator frequency to 50 mc and set the output amplitude for 10 mm of vertical deflection.

h. Set A TRIG LEVEL and HF STABILITY controls for a stable display.

i. Set HORIZ DISPLAY switch to B DLY'D BY A (triggered).

j. Check that a stable display can be obtained by setting the B TRIG LEVEL control.

k. Disconnect the input signal.

l. Reset:
   MAG switch to OFF
   A SLOPE switch to +

8. Adjust DELAY START (R150) and A SWP CAL (R160W)

a. Set:
   TRIG MODE switch to AUTO
   A COUPLING switch to AC
   A TIME/CM switch to 1 mSEC
   B TIME/CM switch to 2 μSEC
   DELAY TIME MULT dial to 1.00
   HORIZ DISPLAY switch to A INTEN BY B (non-triggered)
   VOLTS/CM switch (vertical plug-in) to 2
   INTENSITY control for normal brightness

b. Apply 1-millisecond markers to the vertical input.

c. Set A TRIG LEVEL control for a triggered display.

d. Set INTENSITY control so the small brightened spot near the left end of the trace is easily seen.

e. Adjust DELAY START (R150) so the peak of the 1st marker (not counting the marker at the left end of the trace) is intensified.

f. Set DELAY TIME MULT dial to 9.00.

g. Adjust A SWP CAL (R160W) so the peak of the 9th marker (not counting the marker at the left end of the trace) is intensified.

h. If necessary, repeat steps (e) and (g) until the effects of adjustment interaction are minimized.

i. Set:
   HORIZ DISPLAY switch to B DLY'D BY A (non-triggered)
   DELAY TIME MULT dial to 1.00
   B TIME/CM switch to 10 μSEC

j. Adjust DELAY START (R150) so the trace begins near the base of the leading edge of the time marker displayed on the crt.

k. Set DELAY TIME MULT dial to 9.00.

l. Adjust A SWP CAL (R160W) so the trace begins near the base of the leading edge of the time marker displayed on the crt.

m. Repeat steps (i) through (l) until there is no further improvement.

9. Check Delay Linearity

a. Using the same setup as in step 8, turn DELAY TIME MULT dial clockwise to about (2.00) until the marker peak is at the left end of the trace.

b. Check that DELAY TIME MULT dial indicates (2.00), ±0.015.

c. Repeat steps (a) and (b) for each major digit on the DELAY TIME MULT dial: 3.00 through 8.00 The tolerance at each setting is ±0.015.

10. Check Delay-Time Jitter

a. Set B TIME/CM switch to 1 μSEC.

b. With 1-millisecond time markers applied to the vertical input, set DELAY TIME MULT dial near 9.00 to position the rise of a marker near the center of the graticule.

c. Check that the marker jitters horizontally 0.5 centimeter or less.

d. Repeat steps (b) and (c) with DELAY TIME MULT dial set near 1.00.

*11. Adjust NORM GAIN (R331)

a. Set HORIZ DISPLAY switch to A.

b. Adjust NORM GAIN (R331) for 1 marker/cm. Refine this adjustment so the 1st and 9th markers are aligned with the 1st and 9th major graticule lines. (The marker at the beginning of the trace and the line at the extreme left edge of the graticule are each counted as 0.)

*12. Adjust MAG GAIN (R334)

a. Set MAG switch to X10. Check that the MAG lamp on the front panel of the Type 11B2 is lit.

b. Apply 100-microsecond markers to the vertical input.

c. If necessary, set A TRIG LEVEL control for a stable display.

d. Adjust MAG GAIN (R334) for 1 marker/cm. Refine this adjustment so markers are exactly aligned with the 1st and 9th major graticule lines.

*13. Adjust MAG REGIS (R339)

a. Apply 5-millisecond time markers to the vertical input.

b. With MAG switch to X10, set HORIZ POSITION control so that the peak of the marker nearest the center of the expanded trace is at the exact center of the graticule.

c. Set MAG switch to OFF.

d. Adjust MAG REGIS (R339) so the peak of the center time marker is again positioned to the exact center of the graticule.

e. If necessary, repeat steps (b) through (d) until there is no further improvement.

f. Reset MAG switch to OFF.

14. Check A Sweep Length: 10.5—11.0 cm

a. Apply 1-millisecond markers to the vertical input.

b. Set HORIZ POSITION control so the 1st marker is aligned with the 0 graticule line. (This will put 1 centimeter of the trace outside the left edge of the graticule.)

c. Check that the right-hand end of the trace is within the last one-half centimeter of the graticule.

15. Check VARIABLE A Range and UNCAL Lamp

a. Apply 10-millisecond markers to the vertical input.

b. Set HORIZ POSITION control so the 0 marker is aligned with the 0 graticule line.

c. Slowly turn VARIABLE A control counterclockwise. The distance between markers should decrease smoothly. With VARIABLE A control fully counterclockwise, there should be 4 centimeters or less between markers.

d. Check that the UNCAL lamp is lit.

e. Reset VARIABLE A control to CALIB.

16. Check A Delay-Time Ranges: 10 μSEC—5 SEC

a. Set:

A TIME/CM switch to (10 μSEC)
B TIME/CM switch to (.5 μSEC)
HORIZ DISPLAY switch to A INTEN BY B (non-triggered)
TRIG MODE switch to NORM

b. Apply (10-microsecond) markers to the vertical input.

c. Set A TRIG LEVEL control for a triggered display.

d. Check for (1) marker/cm and that markers can be simultaneously aligned with the 1st and 9th graticule lines. (With a 10-microsecond/cm sweep rate, the tolerance for exact marker alignment at the 9th line, when a marker is aligned with the 1st line, is ±1.2 mm.)

e. Set INTENSITY control so both brightness levels in the display are easily seen.

f. Set DELAY TIME MULT dial so the 1st marker is intensified.

g. Set HORIZ DISPLAY switch to B DLY'D BY A (non-triggered).

h. Set DELAY TIME MULT dial so the trace begins during the marker rise. Record the exact DELAY TIME MULT dial indication.

i. Set DELAY TIME MULT dial near 9.00 so the trace again begins during the marker rise. Record the exact DELAY TIME MULT dial indication.

j. Subtract the first dial indication from the second. The difference should be 8.00 (±0.08 when the A sweep rate is 10 microseconds/cm).

k. Repeat steps (a) through (j) for each A sweep rate listed in Table 4-1.

TABLE 4-1

Step A		Step B	Step D		Step J
A TIME/ CM	B TIME/ CM	Time Marker	Markers Per Cm	Tol. (mm)	DELAY TIME MULT Tol.
10 μSEC	.5 μSEC	10 μsec	1	±1.2	±0 08
20 μSEC	.5 μSEC	10 μsec	2	±1 2	±0 08
50 μSEC	2 μSEC	50 μsec	1	±1.2	±0.08
1 mSEC	5 μSEC	100 μsec	1	±1.2	±0 08
1 mSEC	50 μSEC	1 msec	1	±1 2	±0 08
10 mSEC	5 mSEC	10 msec	1	±1.2	±0.08
.1 SEC	5 mSEC	100 msec	1	±2.4	±0 20
1 SEC	50 mSEC	1 sec	1	±2.4	±0 20
2 SEC	50 mSEC	1 sec	2	±2 4	±0.20
5 SEC	2 SEC	5 sec	1	±2 4	±0.20

l. Reset TRIG MODE switch to AUTO.

***17. Adjust A Sweep Rates and Delay Time: 5 μSEC-.1 μSEC**

a. Set:

A TIME/CM switch to 1 μSEC
B TIME/CM switch to .1 μSEC
HORIZ DISPLAY switch to A INTEN BY B (non-triggered)

b. Apply 1-microsecond markers to the vertical input.

c. Set A TRIG LEVEL control for a triggered display.

d. Adjust C160C for 1 marker/cm.

e. Check the adjustment of C160C by using steps 16e through 16j.

f. If step 16j indicates an error greater than ±0.08 on the DELAY TIME MULT dial, readjust C160C.

g. Repeat steps 16f through 16j until the dial indicates an error less than ±0.08. Be certain that the requirement of step 17d is retained.

h. Set:

A and B TIME/CM switch to .5 μSEC
HORIZ DISPLAY switch to A

i. Horizontally position the marker that is about 2 centimeters from the beginning of the trace to the line that is 1 centimeter from the left edge of the graticule.

j. Adjust C160A for 1 marker/2 cm. Refine the adjustment so markers can be exactly aligned with the 1st and 9th graticule lines.

k. Set A and B TIME/CM switch to .2 μSEC.

l. Apply 5-mc markers (sine waves) to the vertical input and obtain a triggered display.

m. Check for 1 marker/cm and that the 1st and 9th markers can be simultaneously aligned with the 1st and 9th graticule lines. With this sweep rate, the tolerance for exact marker alignment at the 9th centimeter line, when a marker is aligned with the 1st centimeter line, is ±1.2 mm.

n. Set A and B TIME/CM switch to .1 μSEC.

o. Apply 10-mc markers (sine waves) to the vertical input and obtain a triggered display.

p. Repeat step (m).

18. Check 10-Nanosecond/Cm Sweep Rate (.1 μsec/cm with MAG switch to X10)

a. Set MAG switch to X10.

b. Apply 50-mc markers (sine waves) to the vertical input.

c. Set A TRIG LEVEL and HF STABILITY controls for a stable, triggered display.

d. Check for 1 marker/2 cm and that markers can be simultaneously aligned with the 1st and 9th graticule lines. The tolerance for exact marker alignment at the 9th line, when a marker is aligned with the 1st line, is ±2.8 mm.

NOTE

The accuracy of the 10 nanosecond/cm sweep rate depends, to a large degree, on the high-frequency response of the main horizontal amplifier in the oscilloscope.

e. Reset MAG switch to OFF.

***19. Adjust B SWP CAL (R260W)**

a. Set:
HORIZ DISPLAY switch to B DLY'D BY A (non-triggered)
A TIME/CM switch to 2 mSEC
B TIME/CM switch to 1 mSEC
DELAY TIME MULT dial to 0.30

b. Apply 1-millisecond markers to the vertical input.

c. Set A TRIG LEVEL control for a stable display.

d. Set HORIZ POSITION control so the marker nearest the left end of the trace is aligned with the 1st graticule line.

e. Adjust B SWP CAL (R260W) for 1 marker/cm. Refine the adjustment so markers can be simultaneously aligned with the 1st and 9th graticule lines.

20. Check B Sweep Length: 10.2—10.7 Cm

a. Set DELAY TIME MULT dial near 0.50 so the trace begins at a marker peak.

b. With a stable display of 1-millisecond markers, set HORIZ POSITION control so the 1st marker is one and one-half minor divisions to the right of the 0 graticule line.

c. Check that the right-hand end of the trace is within the last one-half centimeter of the graticule.

d. Horizontally center the display.

21. Check B (Variable) Control Range and UNCAL Lamp

a. Set B TIME/CM switch to .1 mSEC.

b. With a stable display of 1-millisecond markers, slowly turn B (variable) control counterclockwise. The distance between markers should decrease smoothly. With B (variable) control fully counterclockwise, there should be 4 centimeters or less between markers.

c. Check that the UNCAL lamp is lit.

d. Reset B (variable) control to CALIB.

22. Check B Sweep Rates: 10 μSEC—5 SEC

a. set:
VARIABLE A control to midrange
A and B TIME/CM switch to (10 μSEC)
TRIG MODE switch to NORM
DELAY TIME MULT dial to 0.30

b. Apply (10-microsecond) markers to the vertical input.

c. Set A TRIG LEVEL control for a stable display.

d. Check for (1) marker/cm and that markers can be simultaneously aligned with the 1st and 9th graticule lines. (With a 10 microsecond/cm sweep rate, the tolerance for exact marker alignment at the 9th line, when a marker is aligned with the 1st line, is ±1.2 mm)

e. Repeat steps (a) through (d) for each B sweep rate listed in Table 4-2.

TABLE 4-2

Step A	Step B	Step D	
A and B TIME/CM	Time Marker	Markers Per Cm	Tol. (mm)
10 μSEC	10 μsec	1	±1.2
20 μSEC	10 μsec	2	±1.2
50 μSEC	50 μsec	1	±1.2
.1 mSEC	100 μsec	1	±1.2
1 mSEC	1 msec	1	±1.2
10 mSEC	10 msec	1	±1.2
.1 SEC	100 msec	1	±2.4
1 SEC	1 sec	1	±2.4
2 SEC	1 sec	2	±2.4
5 SEC	5 sec	1	±2.4

f. Reset TRIG MODE switch to AUTO.

***23. Adjust B Sweep Rates: 5 μSEC—.1 μSEC**

a. Set:
VARIABLE A control to midrange
A and B TIME/CM switch to 1 μSEC

b. Apply 1-microsecond markers to the vertical input.

c. Set A TRIG LEVEL control for a stable display.

d. Adjust C260C for 1 marker/cm. Refine this adjustment so that markers can be simultaneously aligned with the 1st and 9th graticule lines.

e. Set A and B TIME/CM switch to .5 μSEC.

f. Adjust C260A for 1 marker/2cm. Refine this adjustment so that markers can be simultaneously aligned with the 1st and 9th graticule lines.

24. Check B Sweep Rates: .2 μSEC and .1 μSEC

a. Set A and B TIME/CM switch to .2 μSEC.

b. Apply 5-mc markers (sine waves) to the vertical input.

c. If necessary, set A TRIG LEVEL and HF STABILITY controls for a stable display.

d. Check for 1 marker/cm and that the 1st and 9th markers can be simultaneously aligned with the 1st and 9th graticule lines. The tolerance for exact marker alignment at the 9th line, when a marker is aligned with the 1st line, is ±1.2 mm.

e. Set A and B TIME/CM switch to .1 μSEC.

f. Apply 10-mc markers (sine waves) to the vertical input.

g. Repeat steps (c) and (d).

h. Reset VARIABLE A control to CALIB.

i. Disconnect the input signal.

25. Check External Horizontal Deflection Sensitivity

a. Set:

A and B TIME/CM switch to 1 mSEC
INTENSITY control to 0
HORIZ DISPLAY switch to EXT INPUT
B COUPLING switch to DC
B SOURCE switch to EXT
1KC CALIBRATOR switch to 5 VOLTS

b. Connect oscilloscope calibrator output to B TRIG IN OR EXT INPUT connector.

c. Set INTENSITY control to obtain a display. The display should consist of two spots or short horizontal lines.

d. Check that the peak-to-peak horizontal deflection is between 4.5 and 5.5 centimeters.

e. Set 1KC CALIBRATOR switch to .5 VOLTS.

f. Horizontally center the display.

g. Set MAG switch to X10.

h. Repeat step (d).

i. Disconnect the input signal.

26. Check External Horizontal Frequency Response

a. Set MAG switch to OFF.

b. Connect the constant-amplitude sine-wave generator to B TRIG IN OR EXT INPUT connector. Terminate the generator with a Tektronix 50 Ω termination (part no. 011-049), using a UHF to BNC adapter (part no. 103-032).

c. Set the generator frequency to 50 kc and output amplitude to produce 4 centimeters peak-to-peak horizontal deflection.

d. Without changing the output amplitude, increase the generator frequency to 3 mc.

e. Check that the peak-to-peak horizontal deflection is at least 2.8 centimeters.

f. Disconnect the generator.

g. Reset:

HORIZ DISPLAY switch to A
MAG switch to OFF
INTENSITY control for normal trace

27. (Optional) Check Alternate-Trace Vertical Operation

a. Set TRIG MODE switch to FREE RUN.

b. Set the vertical plug-in unit (e.g. Type 10A2) switches for alternate-trace operation.

c. Check that the appropriate number of traces are obtained.

28. Check +GATE and SWEEP Connector Output Signals

a. Set:

TRIG MODE switch to FREE RUN
A TIME/CM switch to .5 μSEC
B TIME/CM switch to .2 μSEC
DELAY TIME MULT dial to 0.30
HORIZ DISPLAY switch to A INTEN BY B (non-triggered)
VOLTS/CM switch (vertical plug-in) to 5

b. If the sensitivity of the vertical plug-in unit is known to be correct, use it to check for the following output voltages. Otherwise, use a separate oscilloscope.

+ GATE A ≈ 15 v
+ GATE B ≈ 15 v
SWEEP A ≈ 10 v
SWEEP B ≈ 10 v

Abridged Adjustment Procedure

Introduction

This procedure contains only the information necessary to adjust the seven internal calibration potentiometers without test equipment. The time-accuracy of these adjustments is derived from the oscilloscope crystal-controlled 1-Kc Calibrator. Adjustment of the four variable timing capacitors which establish the accuracy of the six fastest sweep rates of each sweep generator is not described here because a timing standard other than the 1-Kc Calibrator would be required.

Preliminary Instructions

1. Remove the access panel from the right-hand side of the oscilloscope.

2. Set the controls and switches as follows:

Oscilloscope

INTENSITY	Low brightness
1 KC CALIBRATOR	1 VOLTS

Type 11B2

HORIZ DISPLAY	EXT INPUT
MAG	OFF
B SOURCE	INT
A TIME/CM	1 mSEC
VARIABLE A	CALIB
B TIME/CM	1 μSEC
(variable) B	CALIB
TRIG MODE	AUTO
A SLOPE	+
A COUPLING	AC
A SOURCE	INT
DELAY TIME MULT	1.00

Vertical Plug-In Unit

VOLTS/CM	.5
VARIABLE	CALIB
AC-DC-GND	AC
POSITION	Spot centered
MODE	CH 1
TRIGGER	NORM
PULL TO INVERT	Pushed in

3. Apply power to the instrument and allow several minutes for warmup.

Procedure

1. Adjust INT TRIG DC LEVEL (R7)

a. Remove the vertical plug-in unit

b. Move B COUPLING switch back and forth between AC and DC, and adjust INT TRIG DC LEVEL (R7) so the spot on the crt remains stationary.

c. Reset B COUPLING switch to AC and reinstall the vertical plug-in unit.

2. Adjust DELAY START (R150) and A SWP CAL (R160W)

a. Set:

HORIZ DISPLAY switch to A INTEN BY B (non-triggered)

INTENSITY control for normal brightness

b. Connect the oscilloscope 1-Kc Calibrator signal to the vertical input.

c. Set A TRIG LEVEL control for a triggered display.

d. Set INTENSITY control so the small brightened spot near the left end of the trace is easily seen.

e. Adjust DELAY START (R150) so the rise of the 1st pulse (not counting the pulse at the extreme left end of the trace) is intensified.

f. Set DELAY TIME MULT dial to 9.00.

g. Adjust A SWP CAL (R160W) so the rise of the 9th pulse (not counting the pulse at the extreme left end of the trace) is intensified.

h. If necessary, repeat steps (e) and (g) until the effects of adjustment interaction are minimized.

i. Set:

HORIZ DISPLAY switch to B DLY'D BY A (non-triggered)

DELAY TIME MULT dial to 1.00

B TIME/CM switch to 10 μSEC

j. Adjust DELAY START (R150) so the pulse rise is at the left end of the trace.

k. Set DELAY TIME MULT dial to 9.00.

l. Adjust A SWP CAL (R160W) so the pulse rise is at the left end of the trace.

m. Repeat steps (i) through (l) until no further improvement can be made.

3. Adjust NORM GAIN (R331)

a. Set HORIZ DISPLAY switch to A.

b. Adjust NORM GAIN (R331) for 1 pulse/cm. Refine this adjustment so the rise of the 1st and 9th pulses are aligned with the 1st and 9th graticule lines. (The pulse rise at the beginning of the trace and the line at the extreme left edge of the graticule are each counted as number 0.)

4. Adjust MAG GAIN (R334)

a. Set:

A and B TIME/CM switch to 10 mSEC

MAG switch to X10

b. Adjust MAG GAIN (R334) for 1 pulse/cm. Refine this adjustment so pulse rise can be exactly aligned with the 1st and 9th graticule lines.

5. Adjust MAG REGIS (R339)

a. Set A and B TIME/CM switch to .1 mSEC.

b. With MAG switch set to X10, set HORIZ POSITION control so that the pulse fall near the center of the expanded trace is at the exact center of the graticule.

c. Set MAG switch to OFF.

d. Adjust MAG REGIS (R339) so the peak of the 0 pulse is again positioned to the exact center of the graticule.

e. If necessary, repeat steps (b) through (d) until no further improvement can be made.

f. Reset MAG switch to OFF.

6. Adjust B SWP CAL (R260W)

a. Set:

HORIZ DISPLAY switch to B DLY'D BY A (non-triggered)
A TIME/CM switch to 2 mSEC
B TIME/CM switch to 1 mSEC
DELAY TIME MULT dial to 0.30

b. Set HORIZ POSITION control so the pulse rise nearest the left end of the trace is aligned with the 1st graticule line.

c. Adjust B SWP CAL (R260W) for 1 pulse/cm. Refine the adjustment so pulse rises can be simultaneously aligned with the 1st and 9th graticule lines.

SECTION 5
PARTS LIST and DIAGRAMS

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix Field Office.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number including any suffix, instrument type, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix Field Office will contact you concerning any change in part number.

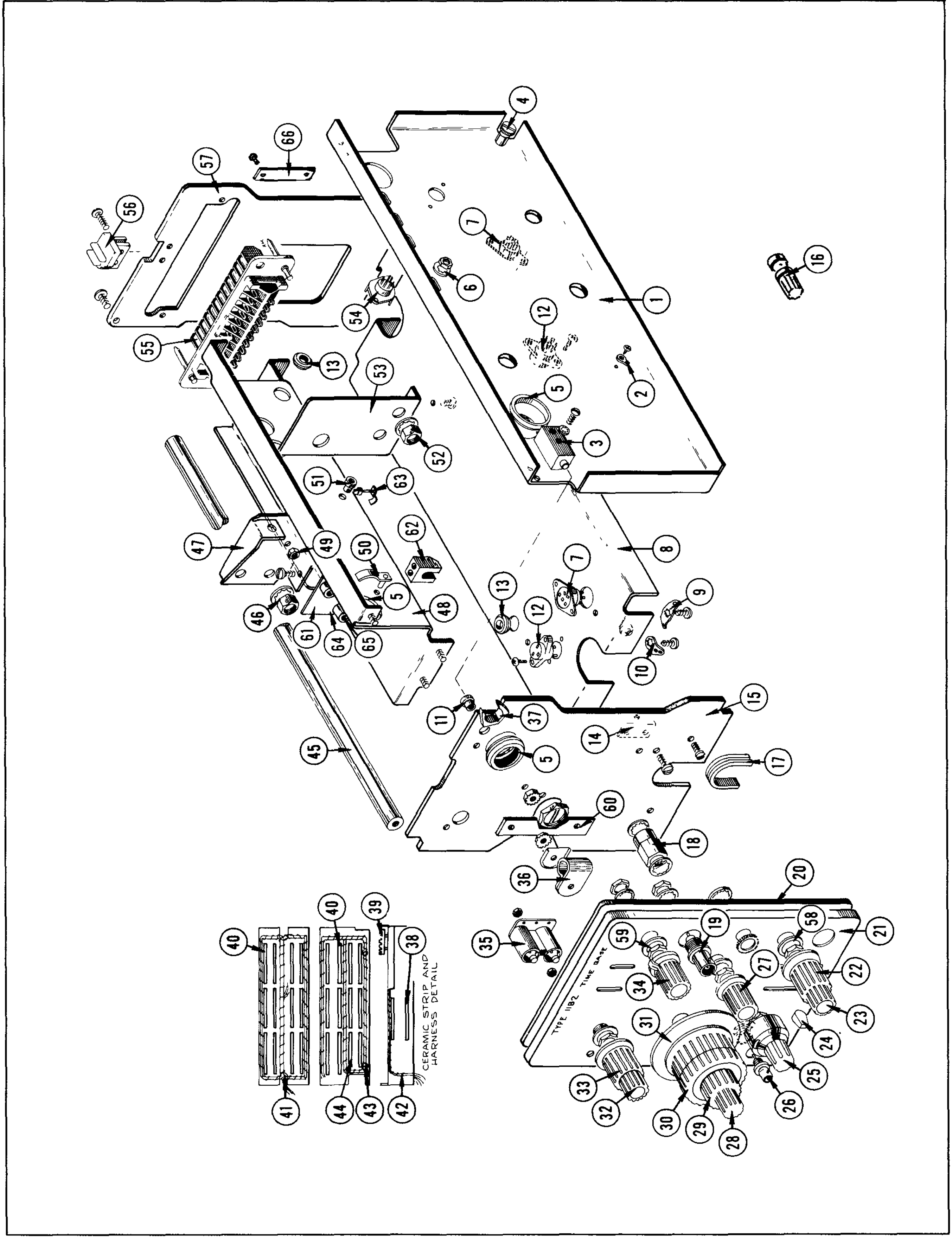
ABBREVIATIONS AND SYMBOLS

a or amp	amperes
BHS	binding head steel
C	carbon
cer	ceramic
cm	centimeter
comp	composition
cps	cycles per second
crt	cathode-ray tube
CSK	counter sunk
dia	diameter
div	division
EMC	electrolytic, metal cased
EMT	electroyltic, metal tubular
ext	external
f	farad
F & I	focus and intensity
FHS	flat head steel
Fil HS	fillister head steel
g or G	giga, or 10^9
Ge	germanium
GMV	guaranteed minimum value
h	henry
hex	hexagonal
HHS	hex head steel
HSS	hex socket steel
HV	high voltage
ID	inside diameter
incd	incandescent
int	internal
k or K	kilohms or kilo (10^3)
kc	kilocycle
m	milli, or 10^{-3}
mc	megacycle
mm	millimeter
meg or M	megohms or mega (10^6)
met.	metal
μ	micro, or 10^{-6}
n	nano, or 10^{-9}
Ω	ohm
OD	outside diameter
OHS	oval head steel
p	pico, or 10^{-12}
PHS	pan head steel
piv	peak inverse voltage
plstc	plastic
PMC	paper, metal cased
poly	polystyrene
Prec	precision
PT	paper tubular
PTM	paper or plastic, tubular, molded
RHS	round head steel
rms	root mean square
sec	second
Si	silicon
S/N	serial number
t or T	tera, or 10^{12}
TD	toroid
THS	truss head steel
tub.	tubular
v or V	volt
Var	variable
w	watt
w/	with
w/o	without
WW	wire-wound

SPECIAL NOTES AND SYMBOLS

X000	Part first added at this serial number.
000X	Part removed after this serial number.
*000-000	Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, or reworked or checked components.
Use 000-000	Part number indicated is direct replacement.
	Internal screwdriver adjustment.
	Front-panel adjustment or connector.

EXPLODED VIEW



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EXPLODED VIEW

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	441-486			1	CHASSIS, B time base
2	210-259			11	LUG, solder #2
	213-113			11	SCREW, thread forming, 2-32 x $^{5}/_{16}$ inch RHS, phillips
3	214-340			2	PIN, hinge
	......			.	Mounting Hardware For Each: (not included)
	211-016			2	SCREW, 4-40 x $^{5}/_{8}$ inch RHS
	210-004			2	LOCKWASHER, steel, internal #4
4	214-329			2	FASTENER, retractable screw, assembly
5	348-050			5	GROMMET, nylon
AL4. 6	352-0068-00			.	Pot Mounting Hardware For Each:
	210-583			1	NUT, hex, brass, $^{1}/_{4}$-32 x $^{5}/_{16}$ inch
	210-940			1	WASHER, steel
7	136-101			4	SOCKET, 5 pin
AL4. 7a	214-0325-00 Pin Centre (Part of item 7)			.	Mounting Hardware For Each: (not included)
	213-055			2	SCREW, thread forming, 2-56 x $^{3}/_{16}$ inch PHS
8	441-488			1	CHASSIS, A time base
	......			.	Mounting Hardware For Each: (not included)
	211-504			4	SCREW, 6-32 x $^{1}/_{4}$ inch BHS
9	210-204			2	LUG, solder, DE6
	213-044			2	SCREW, thread cutting, 5-32 x $^{3}/_{16}$ inch PHS
10	210-201			23	LUG, solder, SE4
	213-044			23	SCREW, thread cutting, 5-32 x $^{3}/_{16}$ inch PHS
11	358-210			2	BUSHING, nylon
12	136-161			35	SOCKET, transistor
	......			.	Mounting Hardware For Each: (not included)
	213-113			2	SCREW, thread forming, 2-32 x $^{5}/_{16}$ inch RHS, phillips
13	348-003			2	GROMMET, rubber, $^{5}/_{16}$ inch
14	406-908			2	BRACKET, chassis latch
	......			.	Mounting Hardware For Each: (not included)
	211-504			2	SCREW, 6-32 x $^{1}/_{4}$ inch BHS
15	B-S283			1	PLATE, bulkhead, alum
16	103-036			1	ADAPTER, connector, BSM to BNC (Accessory)
17	358-215			3	BUSHING, black plastic
18	......			.	Switch Mounting Hardware
	210-494			1	NUT, hex, alum, $^{3}/_{8}$-32 x $^{1}/_{2}$ x $^{11}/_{16}$ inch
	210-012			1	LOCKWASHER, steel, pot, internal, $^{3}/_{8}$ x $^{1}/_{2}$ inch
	210-013			1	LOCKWASHER, steel, internal, $^{3}/_{8}$ x $^{11}/_{16}$ inch
19	131-106			2	CONNECTOR, chassis mount, BNC, 1 contact
	......			.	Each Includes:
	210-413			1	NUT, hex, brass, $^{3}/_{8}$-32 x $^{1}/_{2}$ inch
	210-012			1	LOCKWASHER, steel, pot, internal, $^{3}/_{8}$ x $^{1}/_{2}$ inch
20	387-778			1	PLATE, subpanel, front
21	333-750			1	PANEL, front
22	366-249			1	KNOB, TRIG LEVEL, charcoal
	......			.	Includes:
	213-004			1	SCREW, set, 6-32 x $^{3}/_{16}$ inch HSS
23	366-255			1	KNOB, HF STABILITY, red
	......			.	Includes:
	213-020			1	SCREW, set, 6-32 x $^{1}/_{8}$ inch HSS
AL4. 24	~~366-215~~ 336-0215-00			6	KNOB, lever switch
25	331-096			1	DIAL, with charcoal knob
	......			.	Includes:
	213-022			1	SCREW, set, 4-40 x $^{3}/_{16}$ inch HSS
26	131-282			4	CONNECTOR, bulkhead receptacle
	......			.	Mounting Hardware For Each: (not included)
	210-583			1	NUT, hex, brass, $^{1}/_{4}$-32 x $^{3}/_{16}$ inch
	210-046			1	LOCKWASHER, steel
	210-223			1	LUG, solder, $^{1}/_{4}$ inch
27	366-220			1	KNOB, TRIG MODE, charcoal
	......			.	Includes:
	213-020			1	SCREW, set, 6-32 x $^{1}/_{8}$ inch HSS

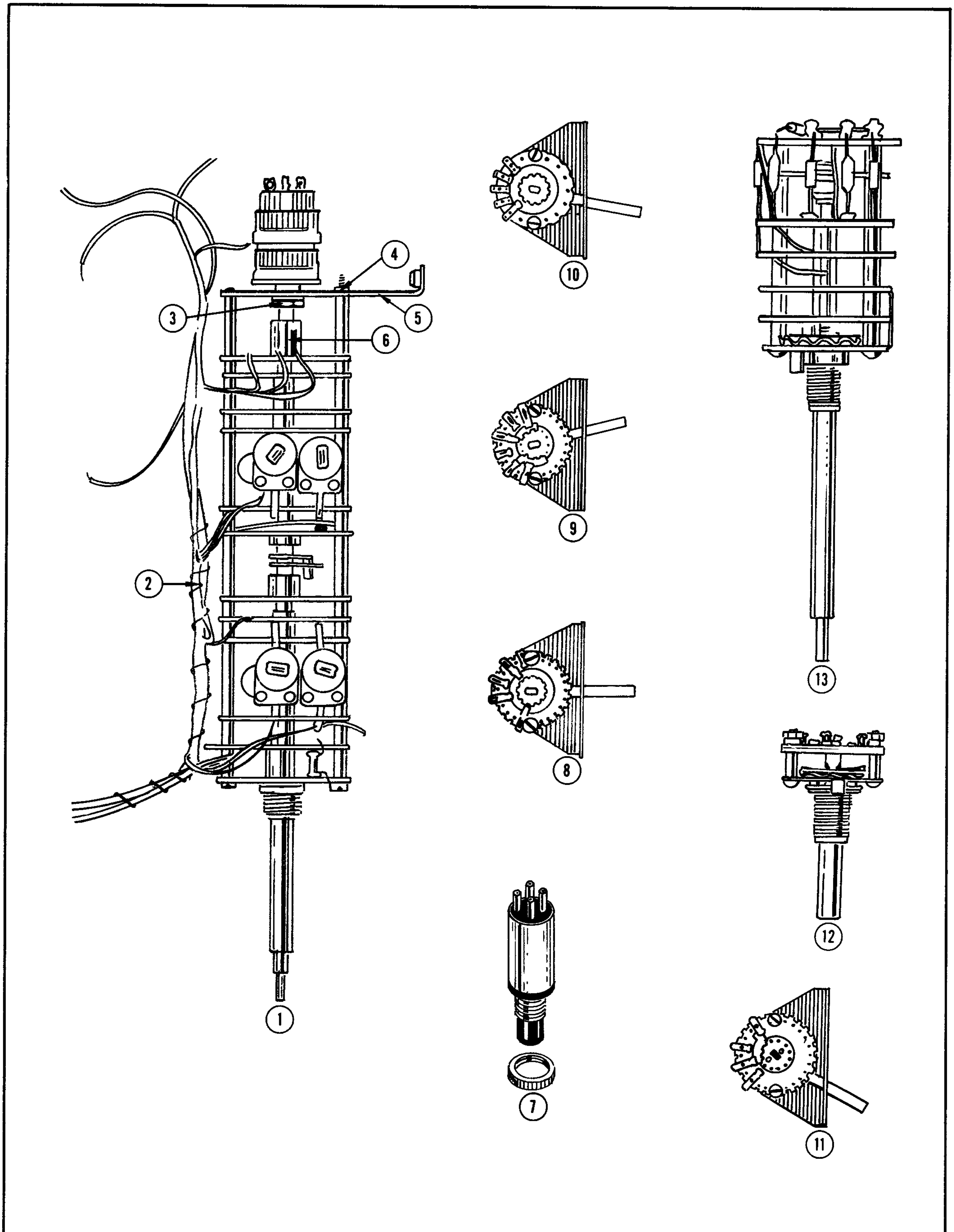
EXPLODED VIEW *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
28	366-232			1	KNOB, variable B, red
	......			.	Includes:
	213-020			1	SCREW, set, 6-32 x 1/8 inch HSS
29	366-222			1	KNOB, VARIABLE A, red
	......			.	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
30	366-194			1	KNOB, TIME/CM AND DELAY TIME, charcoal
	......			.	Includes:
	213-022			2	SCREW, set, 4-40 x 3/16 inch HSS
31	331-092			1	KNOB, dial window
32	366-140			1	KNOB, MAG, red
	......			.	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
33	366-250			1	KNOB, HORIZ DISPLAY, charcoal
	......			.	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
34	366-220			1	KNOB, TRIG LEVEL, charcoal
	......			.	Includes:
	213-020			1	SCREW, set, 6-32 x 1/8 inch HSS
35	352-064			1	HOLDER, double neon
	......			.	Mounting Hardware: (not included)
	211-031			1	SCREW, 4-40 x 1 inch FHS
	210-406			2	NUT, hex, brass, 4-40 x 3/16 inch
36	343-004			2	CLAMP, cable, 5/16 inch plastic
	......			.	Mounting Hardware For Each: (not included)
	210-863			1	WASHER, steel, "D" type #10
	210-458			1	NUT, steel, 8-32 x 11/32 inch
37	343-093			4	CLAMP, plug-in rod
	......			.	Mounting Hardware For Each: (not included)
	211-094			1	SCREW, 4-40 x 1/2 inch PHS
38	124-145			2	STRIP, ceramic, 20 notches, 3 x 7/16 inch
	......			.	Mounting Hardware For Each: (not included)
	361-009			2	SPACER, nylon
39	124-149			2	STRIP, ceramic, 7 notches, 1 5/32 x 7/16 inch
	......			.	Mounting Hardware For Each: (not included)
	361-007			2	SPACER, nylon
40	124-145			22	STRIP, ceramic, 20 notches, 3 x 7/16 inch
	......			.	Mounting Hardware For Each: (not included)
	361-007			2	SPACER, nylon
41	179-755			1	CABLE, harness, A chassis
42	179-820			1	CABLE, harness, horizontal amplifier
43	179-756			1	CABLE, harness, B chassis
44	124-146			2	STRIP, ceramic, 16 notches, 2 7/16 x 7/16 inch
	......			.	Mounting Hardware For Each: (not included)
	361-007			2	SPACER, nylon
45	384-615			4	ROD, spacer, hex tubing, 12 1/4 inch long
	......			.	Mounting Hardware For Each: (not included)
	212-044			2	SCREW, 8-32 x 1/2 inch
	214-370			2	PIN, locating, 15/16 inch long, with 8-32 thread
46	......			.	Capacitor Mounting Hardware
	210-524			1	NUT, hex, steel, 5/16-23 x 1/2 x 3/16 inch
	210-018			1	LOCKWASHER, steel, 5/16 inch
47	406-906			1	BRACKET, capacitor mounting
	......			.	Mounting Hardware: (not included)
	211-504			2	SCREW, 6-32 x 1/4 inch BHS

EXPLODED VIEW *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
48	D-S152			1	CHASSIS, horizontal amplifier
	......			.	Mounting Hardware: (not included)
	211-504			3	SCREW, 6-32 x $^{1}/_{4}$ inch BHS
	210-457			3	NUT, steel, 6-32 x $^{5}/_{16}$ inch
49	......			.	Capacitor Mounting Hardware
	210-457			4	NUT, steel, 6-32 x $^{5}/_{16}$ inch
50	343-089			2	CLAMP, cable, size "D", delrin snap
51	348-031			1	GROMMET, polypropylene, snap-in, $^{1}/_{4}$ inch
52	......			.	Capacitor Mounting Hardware
	210-524			1	NUT, hex, steel, $^{5}/_{16}$-24 x $^{1}/_{2}$ x $^{3}/_{16}$ inch
	210-018			1	LOCKWASHER, steel, $^{5}/_{16}$ inch
53	406-907			1	BRACKET, time/cm switch, alum
54	136-078			1	SOCKET, No. 704 BC, subminiature
	......			.	Mounting Hardware: (not included)
	213-055			2	SCREW, thread forming, 2-56 x $^{3}/_{16}$ inch PHS
55	131-096			1	CONNECTOR, chassis mount, 32 contact
	......			.	Mounting Hardware: (not included)
	211-008			2	SCREW, 4-40 x $^{1}/_{4}$ inch BHS
	210-201			2	LUG, solder, SE4
	210-406			2	NUT, hex, brass, 4-40 x $^{3}/_{16}$ inch
56	351-063			2	GUIDE, shoe, white delrin
	......			.	Mounting Hardware For Each: (not included)
	211-013			2	SCREW, 4-40 x $^{3}/_{8}$ inch RHS
	210-004			2	LOCKWASHER, steel, internal #4
	210-406			2	NUT, hex, brass, 4-40 x $^{3}/_{16}$ inch
57	387-777			1	PLATE, rear, alum
58	......			.	Pot Mounting Hardware:
	210-012			1	LOCKWASHER, steel, pot, internal, $^{3}/_{8}$ x $^{1}/_{2}$ inch
	210-840			1	WASHER, steel
	210-413			1	NUT, hex, brass, $^{3}/_{8}$-32 x $^{1}/_{2}$ inch
59	......			.	Pot Mouting Hardware:
	210-012			1	LOCKWASHER, steel, pot, internal, $^{3}/_{8}$ x $^{1}/_{2}$ inch
	210-978			1	WASHER, $^{3}/_{8}$ ID x $^{1}/_{2}$ inch OD
	210-590			1	NUT, hex, $^{3}/_{8}$-32 x $^{7}/_{16}$
60	A-S336			1	BRACKET, switch mounting
	......			.	Mounting Hardware: (not included)
	210-457			1	NUT, keps, 6-32 x $^{5}/_{16}$ inch
	211-507			1	SCREW, 6-32 x $^{5}/_{16}$ inch
61	A-S335			1	BRACKET, switch mounting
	......			.	Mounting Hardware: (not included)
	211-008			2	SCREW, 4-40 x $^{1}/_{4}$ inch BHS
62	A-S334			1	CLAMP, switch
	......			.	Mounting Hardware: (not included)
	211-007			2	SCREW, 4-40 x $^{3}/_{16}$ inch BHS
63	343-088			3	CLAMP, cable, delrin
	......			.	Mounting Hardware For Each: (not included)
	361-007			1	SPACER, nylon
64	348-002			1	GROMMET, rubber, $^{1}/_{4}$ inch (not shown)
65	385-109			2	ROD, nylon, $^{5}/_{16}$ x $^{5}/_{16}$ inch
	......			.	Mounting Hardware For Each: (not included)
	211-010			1	SCREW, 4-40 x $^{1}/_{4}$ inch RHS
66	A-S204			1	TAG, Identification
	......			.	Mounting Hardware: (not included)
	213-035			2	SCREW, thread cutting, 4-40 x $^{1}/_{4}$ inch PHS phillips

SWITCHES



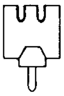
SWITCHES

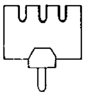
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	262-567			1	SWITCH, TIME/CM, wired
	......			.	Includes:
	260-543			1	SWITCH, TIME/CM, unwired
2	179-757			1	CABLE, harness
3	210-413			2	NUT, hex, brass, 3/8-32 x 1/2 inch
	210-012			1	LOCKWASHER, steel, pot, internal, 3/8 x 1/2 inch
4	210-407			2	NUT, hex, brass, 6-32 x 1/4 inch
	210-006			2	LOCKWASHER, steel, internal #6
5	406-907			1	BRACKET, alum
6	376-032			1	COUPLING, switch shaft
	......			.	Includes:
	213-004			2	SCREW, set, 6-32 x 3/16 inch HSS
	......			.	Switch Mounting Hardware: (not included)
	210-579			2	NUT, mounting, switch, 5/8-24 x 3/4 inch
	210-049			1	LOCKWASHER, steel, internal, 5/8 inch ID
	211-504			2	SCREW, 6-32 x 1/4 inch BHS
7	260-518			1	SWITCH, push, RESET SPST with red indicator light
					Mounting Hardware: (not included)
	210-012			1	LOCKWASHER, steel, pot, internal, 3/8 x 1/2 inch
	210-978			1	WASHER, 3/8 ID x 1/2 inch OD
	210-590			1	NUT, hex, 3/8-32 x 7/16 inch
8	260-519			1	SWITCH, lever, COUPLING A
	......			.	Mounting Hardware: (not included)
	210-406			2	NUT, hex, brass, 4-40 x 3/16 inch
	210-004			2	LOCKWASHER, steel, internal #4
9	260-640			1	SWITCH, lever, SOURCE B
	......			.	Mounting Hardware: (not included)
	210-406			2	NUT, hex, brass, 4-40 x 3/16 inch
	210-004			2	LOCKWASHER, steel, internal #4
10	260-546			1	SWITCH, lever, SOURCE A
	......			.	Mounting Hardware: (not included)
	210-406			2	NUT, hex, brass, 4-40 x 3/16 inch
	210-004			2	LOCKWASHER, steel, internal #4
11	260-472			3	SWITCH, lever, SLOPE A, SLOPE B, COUPLING B
	......			.	Mounting Hardware For Each: (not included)
	210-406			2	NUT, hex, brass, 4-40 x 3/16 inch
	210-004			2	LOCKWASHER, steel, internal #4
12	260-545			1	SWITCH, TRIG MODE
	......			.	Mounting Hardware: (not included)
	358-029			1	BUSHING, brass, hex, 3/8-32 x 13/32 inch
	210-013			1	LOCKWASHER, steel, internal, 3/8 x 11/16 inch
	210-494			1	NUT, hex, alum, 3/8-32 x 1/2 x 11/16 inch
	210-012			1	LOCKWASHER, steel, pot, internal, 3/8 x 1/2 inch
13	262-568			1	SWITCH, HORIZ DISPLAY, wired
	260-544			1	SWITCH, HORIZ DISPLAY, unwired
	......			.	Mounting Hardware: (not included)
	358-029			1	BUSHING, brass, hex, 3/8-32 x 13/32 inch
	210-413			2	NUT, hex, brass, 3/8-32 x 1/2 inch
	210-840			2	WASHER, steel
	210-012			1	LOCKWASHER, steel, pot, internal, 3/8 x 1/2 inch

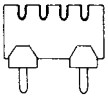
CERAMIC STRIPS AND MOUNTINGS

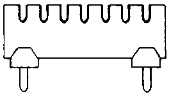
3/4 inch

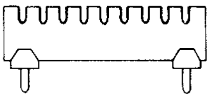

1 notch 124-100

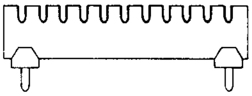

2 notch 124-086


3 notch 124-087


4 notch 124-088

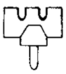

7 notch 124-089

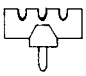

9 notch 124-090

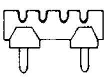

11 notch 124-091

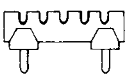
7/16 inch

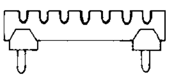

1 notch 124-118

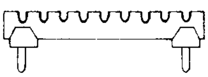

2 notch 124-119

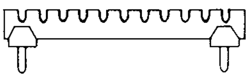

3 notch 124-092


4 notch 124-120

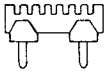

5 notch 124-093

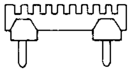

7 notch 124-094

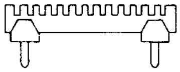

9 notch 124-095

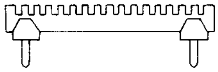

11 notch 124-106

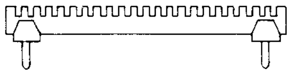
7/16 inch SMALL NOTCH —Short Stud


7 notch 124-149

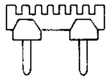

9 notch 124-148

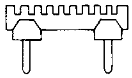

13 notch 124-147

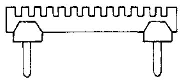

16 notch 124-146

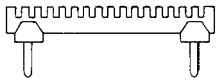

20 notch 124-145

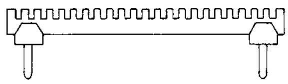
7/16 inch SMALL NOTCH —Tall Stud


7 notch 124-158


9 notch 124-157

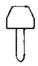

13 notch 124-156


16 notch 124-155


20 notch 124-154

MOUNTINGS


Stud, nylon, short..355-046


Stud, nylon, tall .. 355-082


Spacer, $^{11}/_{32}$ inch..361-039


Spacer, $^{3}/_{8}$ inch .. 361-009


Spacer, $^{1}/_{4}$ inch...361-008


Spacer, $^{5}/_{32}$ inch...361-007

Ceramic strips include studs, but spacers must be ordered separately by part no.

Ⓐ

ELECTRICAL PARTS

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description				S/N Range

Bulbs

Ckt. No.	Tektronix Part No.	Description	S/N Range
B160X	150-030	Neon, NE-2V	
B186†	260-518	Neon, NE-2V	RESET
B200	150-030	Neon, NE-2V	
B330	150-030	Neon, NE-2V	

Capacitors

Tolerance ±20% unless otherwise indicated.

Tolerance of all electrolytic capacitors as follows (with exceptions):

3 V — 50 V = −10%, +250%
51 V — 350 V = −10%, +100%
351 V — 450 V = −10%, +50%

Ckt. No.	Tektronix Part No.	Description				S/N Range
C12	283-080	.022 μf	Cer	25 v		
C14	283-080	.022 μf	Cer	25 v		
C15	281-516	39 pf	Cer	500 v	10%	
C21	281-518	47 pf	Cer	500 v		
C23	283-078	.001 μf	Cer	500 v		
C25	283-080	.022 μf	Cer	25 v		
C26	283-080	.022 μf	Cer	25 v		
C27	281-542	18 pf	Cer	500 v	10%	
C29	281-557	1.8 pf	Cer	500 v		
C30A	283-068	.01 μf	Cer	500 v		
C30B	281-523	100 pf	Cer	350 v		
C30C	281-525	470 pf	Cer	500 v		
C32	283-079	.01 μf	Cer	250 v		
C43	283-080	.022 μf	Cer	25 v		
C44C	283-078	.001 μf	Cer	500 v		
C44D	283-078	.001 μf	Cer	500 v		
C46	283-080	.022 μf	Cer	25 v		
C53	281-603	39 pf	Cer	500 v	5%	
C54	281-525	470 pf	Cer	500 v		
C63	281-549	68 pf	Cer	500 v	10%	
C70A	283-068	.01 μf	Cer	500 v		
C70C	281-525	470 pf	Cer	500 v		
C72	283-079	.01 μf	Cer	250 v		
C75A	283-078	.001 μf	Cer	500 v		
C76	283-079	.01 μf	Cer	250 v		
C83	283-080	.022 μf	Cer	25 v		
C84C	283-078	.001 μf	Cer	500 v		
C84D	283-078	.001 μf	Cer	500 v		
C86	283-080	.022 μf	Cer	25 v		
C93	281-603	39 pf	Cer	500 v	5%	

†Furnished as a unit with SW201.

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
C94	281-525	470 pf	Cer		500 v		
C102	281-543	270 pf	Cer		500 v	10%	
C104	283-078	.001 μf	Cer		500 v		
C109	283-080	.022 μf	Cer		25 v		
C114	290-189	33 μf	EMT		35 v		
C122	281-525	470 pf	Cer		500 v		
C127	281-542	18 pf	Cer		500 v	10%	
C130	281-518	47 pf	Cer		500 v		
C132	283-081	.1 μf	Cer		25 v		
C136	281-516	39 pf	Cer		500 v	10%	
C153	290-139	180 μf	EMT		6 v		
C156	281-523	100 pf	Cer		350 v		
C160A	281-010	4.5-25 pf	Cer	Var			
C160B	283-097	84 pf	Cer		1000 v	2%	
C160C	281-010	4.5-25 pf	Cer	Var			
C160D	283-097	84 pf	Cer		1000 v	2%	
C160F }		.001 μf }					
C160G }		.01 μf }					
C160H }	*295-082	.1 μf }	Timing Series				
C160J }		1 μf }					
C160K }		10 μf }					
C160R	281-525	470 pf	Cer		500 v		
C162	283-079	.01 μf	Cer		250 v		
C165	281-577	14 pf	Cer		500 v	5%	
C169	283-078	.001 μf	Cer		500 v		
C170	290-135	15 μf	EMT		20 v		
C171	283-079	.01 μf	Cer		250 v		
C180D	281-525	470 pf	Cer		500 v		
C180F	281-536	.001 μf	Cer		500 v	10%	
C180G	285-598	.01 μf	PTM		100 v	5%	
C180H	290-188	.1 μf	EMT		20 v	10%	
C180J	290-183	1 μf	EMT		20 v	10%	
C180K	290-167	10 μf	EMT		15 v		
C186	285-629	.047 μf	PTM		100 v		
C191	283-080	.022 μf	Cer		25 v		
C198	281-549	68 pf	Cer		500 v	10%	
C199	281-523	100 pf	Cer		350 v		
C200	285-622	.1 μf	PTM		100 v		
C201	281-543	270 pf	Cer		500 v	10%	
C202	281-524	150 pf	Cer		500 v		
C203	281-525	470 pf	Cer		500 v		
C204	281-543	270 pf	Cer		500 v	10%	
C207	283-078	.001 μf	Cer		500 v		
C210	290-137	100 μf	EMT		30 v		
C213	283-080	.022 μf	Cer		25 v		
C222	281-525	470 pf	Cer		500 v		

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
C227	281-542	18 pf	Cer		500 v	10%	
C230	281-518	47 pf	Cer		500 v		
C232	283-081	.1 μf	Cer		25 v		
C253	283-080	.022 μf	Cer		25 v		
C256	281-523	100 pf	Cer		350 v		
C260A	281-010	4.5-25 pf	Cer	Var			
C260B	283-097	84 pf	Cer		1000 v	2%	
C260C	281-010	4.5-25 pf	Cer	Var			
C260D	283-097	84 pf	Cer		1000 v	2%	
C260F	*295-082	.001 μf	Timing Series				
C260G		.01 μf					
C260H		.1 μf					
C260J		1 μf					
C260K		10 μf					
C260R	281-525	470 pf	Cer		500 v		
C262	283-079	.01 μf	Cer		250 v		
C265	281-577	14 pf	Cer		500 v	5%	
C270	283-081	.1 μf	Cer		25 v		
C271	283-081	.1 μf	Cer		25 v		
C291	283-080	.022 μf	Cer		25 v		
C310	283-081	.1 μf	Cer		25 v		
C320	283-080	.022 μf	Cer		25 v		
C340	283-080	.022 μf	Cer		25 v		
C409	283-079	.01 μf	Cer		250 v		
C410	283-080	.022 μf	Cer		25 v		
C411	283-080	.022 μf	Cer		25 v		
C414	283-079	.01 μf	Cer		250 v		

Diodes

Ckt. No.	Tektronix Part No.	Description
D30	152-045	Silicon 6045
D31	152-045	Silicon 6045
D33	152-141	Silicon 1N3605
D44A	152-141	Silicon 1N3605
D44B	152-141	Silicon 1N3605
D44C	152-075	Germanium 6075
D44D	152-075	Germanium 6075
D45A	152-141	Silicon 1N3605
D45B	152-141	Silicon 1N3605
D55	152-125	Tunnel STD 704 4.7 ma
D56	Use *152-153	Silicon, Replaceable by 1N4244
D57	*152-153	Silicon, Replaceable by 1N4244
D70	152-045	Silicon 6045
D71	152-045	Silicon 6045
D73	152-141	Silicon 1N3605
D74	152-141	Silicon 1N3605

Diodes *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description
D75	152-139	Zener 1N751 5.1 v
D84A	152-141	Silicon 1N3605
D84B	152-141	Silicon 1N3605
D84C	152-075	Germanium 6075
D84D	152-075	Germanium 6075
D85A	152-141	Silicon 1N3605
D85B	152-141	Silicon 1N3605
D95	152-125	Tunnel STD 704 4.7 ma
D96	Use *152-153	Silicon, Replaceable by 1N4244
D102	Use *152-153	Silicon, Replaceable by 1N4244
D103	Use *152-153	Silicon, Replaceable by 1N4244
D104	152-141	Silicon 1N3605
D105	152-125	Tunnel STD 704 4.7 ma
D113	152-141	Silicon 1N3605
D114	152-141	Silicon 1N3605
D118	152-141	Silicon 1N3605
D120	Use *152-153	Silicon, Replaceable by 1N4244
D121	Use *152-153	Silicon, Replaceable by 1N4244
D125	152-125	Tunnel STD 704 4.7 ma
D133	152-141	Silicon 1N3605
D155	152-141	Silicon 1N3605
D158	152-141	Silicon 1N3605
Alternative D159	152-0249-00 Use *152-161	Ga-As diffused w/axial leads
D163	152-141	Silicon 1N3605
D180	152-141	Silicon 1N3605
D181	152-141	Silicon 1N3605
D183	152-141	Silicon 1N3605
D193	152-141	Silicon 1N3605
D200	152-141	Silicon 1N3605
D214A,B	*152-151	Diode Assembly
D219	152-141	Silicon 1N3605
D220	Use *152-153	Silicon, Replaceable by 1N4244
D221	Use *152-153	Silicon, Replaceable by 1N4244
D225	152-125	Tunnel STD 704 4.7 ma
D233	152-141	Silicon 1N3605
D255	152-141	Silicon 1N3605
D258	Alternative 152-141	Silicon 1N3605
Alt D259	152-0249-00 Use *152-161	Ga-As diffused w/axial leads
D263	152-141	Silicon 1N3605
D273	152-141	Silicon 1N3605
D293	152-141	Silicon 1N3605
D321	152-141	Silicon 1N3605
D340	152-123	Zener 1N935A 9.1 v
D341	152-123	Zener 1N935A 9.1 v
D343	152-034	Zener 1N753 6.2 v

Diodes *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description	S/N Range
D346	152-141	Silicon 1N3605	
D407	152-123	Zener 1N935A 9.1 v	

Inductors

Ckt. No.	Tektronix Part No.	Description	S/N Range
L14	Use 276-507	Core, Ferramic Suppressor	
L43A	Use 276-507	Core, Ferramic Suppressor	
L43B	Use 276-507	Core, Ferramic Suppressor	
L45	*108-112	.3 μh	
A24 L46 108-0107-01	*~~108-170~~	.5 μh	
L83A	Use 276-507	Core, Ferramic Suppressor	
L83B	Use 276-507	Core, Ferramic Suppressor	
L85	*108-112	.3 μh	
A24 L86 108-0170-01	*108-170	.5 μh	
L125	*108-147	2.2 μh	
L225	*108-147	2.2 μh	
L320	Use 276-507	Core, Ferramic Suppressor	

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Value	Wattage	Type	Prec	Tolerance / Description
R7	311-326	10 k		Var		INT TRIG DC LEVEL
R9	316-392	3.9 k	¼ w			
R10	315-101	100 Ω	¼ w			5%
R11	315-101	100 Ω	¼ w			5%
R12	316-330	33 Ω	¼ w			
R13	323-161	464 Ω	½ w		Prec	1%
R14	302-391	390 Ω	½ w			
R15	321-101	110 Ω	⅛ w		Prec	1%
R16	323-191	953 Ω	½ w		Prec	1%
R17	323-191	953 Ω	½ w		Prec	1%
R19	316-100	10 Ω	¼ w			
R20	303-153	15 k	1 w			5%
R21	321-225	2.15 k	⅛ w		Prec	1%
R22	323-313	17.8 k	½ w			1%
R23	315-751	750 Ω	¼ w		Prec	5%
R24	316-472	4.7 k	¼ w			
R25	316-472	4.7 k	¼ w			
R26	316-471	470 Ω	¼ w			
R27	316-470	47 Ω	¼ w			
R28	302-100	10 Ω	½ w			

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description				S/N Range
R29	301-915	9.1 meg	½ w		5%	
R30A	301-105	1 meg	½ w		5%	
R30B	316-104	100 k	¼ w			
R30C	302-105	1 meg	½ w			
R30D	316-470	47 Ω	¼ w			
R31	316-470	47 Ω	¼ w			
R32	316-471	470 Ω	¼ w			
R33	305-912	9.1 k	2 w		5%	
R40	315-102	1 k	¼ w		5%	
R41†	311-272	5 k		Var	A TRIG LEVEL	
R42A	315-822	8.2 k	¼ w		5%	
R42B	315-821	820 Ω	¼ w		5%	
R43	316-683	68 k	¼ w			
R44	305-682	6.8 k	2 w		5%	
R45	315-750	75 Ω	¼ w		5%	
R46	316-470	47 Ω	¼ w			
R47	316-100	10 Ω	¼ w			
R53	323-321	21.5 k	½ w	Prec	1%	
R54	315-222	2.2 k	¼ w		5%	
R55	321-245	3.48 k	⅛ w	Prec	1%	
R61	316-101	100 Ω	¼ w			
R63	301-223	22 k	½ w		5%	
R64	315-242	2.4 k	¼ w		5%	
R70A	302-100	10 Ω	½ w			
R70B	301-105	1 meg	½ w		5%	
R70C	302-105	1 meg	½ w			
R70D	316-470	47 Ω	¼ w			
R71	316-470	47 Ω	¼ w			
R72	316-471	470 Ω	¼ w			
R73	305-512	5.1 k	2 w		5%	
R75A	302-472	4.7 k	½ w			
R75C	302-472	4.7 k	½ w			
R75D	316-104	100 k	¼ w			
R75E	301-362	3.6 k	½ w		5%	
R75F	316-104	100 k	¼ w			
R76	303-103	10 k	1 w		5%	
R80	315 621	620 Ω	¼ w		5%	
R81††	311-272	5 k		Var	B TRIG LEVEL	
R82A	315-273	27 k	¼ w		5%	
R82B	315-332	3.3 k	¼ w		5%	
R82C	315-332	3.3 k	¼ w		5%	
R83	316-683	68 k	¼ w			
R84	305-682	6.8 k	2 w		5%	
R85	315-750	75 Ω	¼ w		5%	

†Furnished as a unit with R81.
††Furnished as a unit with R41.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R86	316-470	47 Ω	¼ w				
R87	316-100	10 Ω	¼ w				
R93	323-321	21.5 k	½ w		Prec	1%	
R94	315-222	2.2 k	¼ w			5%	
R95	321-245	3.48 k	⅛ w		Prec	1%	
R104	316-471	470 Ω	¼ w				
R105	301-112	1.1 k	½ w			5%	
R106	323-281	8.25 k	½ w		Prec	1%	
R109	316-330	33 Ω	¼ w				
R110	321-105	121 Ω	⅛ w		Prec	1%	
R111	321-303	14 k	⅛ w		Prec	1%	
R112	321-229	2.37 k	⅛ w		Prec	1%	
R113	321-271	6.49 k	⅛ w		Prec	1%	
R114	315-471	470 Ω	¼ w			5%	
R116	Use 321-245	3.48 k	⅛ w		Prec	1%	
R117	316-392	3.9 k	¼ w				
R118	321-258	4.75 k	⅛ w		Prec	1%	
R120	321-258	4.75 k	⅛ w		Prec	1%	
R122	315-101	100 Ω	¼ w			5%	
R123	321-243	3.32 k	⅛ w		Prec	1%	
R124	301-112	1.1 k	½ w			5%	
R125	316-331	330 Ω	¼ w				
R127	315-112	1.1 k	¼ w			5%	
R130	321-250	3.92 k	⅛ w		Prec	1%	
R131	322-341	34.8 k	¼ w		Prec	1%	
R132	316-101	100 Ω	¼ w				
R133	315-162	1.6 k	¼ w			5%	
R134	323-171	590 Ω	½ w		Prec	1%	
ALY R135	321-173	~~6.9 Ω~~ 619 ohms	⅛ w		Prec	1%	
R136	316-472	4.7 k	¼ w				
R138	315-122	1.2 k	¼ w			5%	
R139	315-621	620 Ω	¼ w			5%	
R150	311-405	10 k		Var		DELAY START	
R151	315-472	4.7 k	¼ w			5%	
R152	323-184	806 Ω	½ w			1%	
R153	321-131	226 Ω	⅛ w		Prec	1%	
R154	315-392	3.9 k	¼ w			5%	
R155	315-512	5.1 k	¼ w			5%	
R156	316-101	100 Ω	¼ w				
R158	316-101	100 Ω	¼ w				
R160A	323-654	75 k	½ w		Prec	½%	
R160B	323-654	75 k	½ w		Prec	½%	
R160C	315-392	3.9 k	¼ w			5%	
R160D	323-653	221 k	½ w		Prec	¼%	
R160E	323-657	750 k	½ w		Prec	.1%	

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description			
R160F	323-655	750 k	½ w		Prec
R160G	323-655	750 k	½ w		Prec
R160H	323-656	1.5 meg	½ w		Prec
R160J	309-440	3.74 meg	½ w		Prec
R160K	309-441	7.50 meg	½ w		Prec
R160L	309-442	22.6 meg	½ w		Prec
R160R	316-470	47 Ω	¼ w		
R160T	316-182	1.8 k	¼ w		
R160V† 311-0402-01	~~311-402~~	20 k		Var	
R160W	311-404	1 k		Var	WW
R160X	316-184	180 k	¼ w		
R160Y	316-223	22 k	¼ w		
R161	316-470	47 Ω	¼ w		
R162	316-221	220 Ω	¼ w		
R163	315-471	470 Ω	¼ w		
R164	323-315	18.7 k	½ w		Prec
R165	316-220	22 Ω	¼ w		
R168	304-223	22 k	1 w		
R170	316-100	10 Ω	¼ w		
R171	316-470	47 Ω	¼ w		
R172	316-220	22 Ω	¼ w		
R173	316-220	22 Ω	¼ w		
R174	301-183	18 k	½ w		
R176	316-470	47 Ω	¼ w		
R177	316-471	470 Ω	¼ w		
R178	315-751	750 Ω	¼ w		
R179	315-333	33 k	¼ w		
R180	315-124	120 k	¼ w		
R181	311-117	5 k		Var	
R182	316-153	15 k	¼ w		
R183	302-393	39 k	½ w		
R184	322-357	51.1 k	¼ w		Prec
R185	321-225	2.15 k	⅛ w		Prec
R186	316-225	2.2 meg	¼ w		
R187	316-473	47 k	¼ w		
R188	316-473	47 k	¼ w		
R189A	316-564	560 k	¼ w		
R189B	316-333	33 k	¼ w		
R190	321-207	1.4 k	⅛ w		Prec
R191	321-257	4.64 k	⅛ w		Prec
R193	321-171	590 Ω	⅛ w		Prec
R194	321-189	909 Ω	⅛ w		Prec
R195	324-305	14.7 k	1 w		Prec
R196	315-113	11 k	¼ w		
R197	316-221	220 Ω	¼ w		

†Furnished as a unit with SW160V.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R198	316-101	100 Ω	¼ w				
R199	321-225	2.15 k	⅛ w		Prec	1%	
R200	316-104	100 k	¼ w				
R201	316-473	47 k	¼ w				
R202	316-472	4.7 k	¼ w				
R203	316-104	100 k	¼ w				
R204	316-102	1 k	¼ w				
R207	316-103	10 k	¼ w				
R208	316-104	100 k	¼ w				
R210	Use 322-130	221 Ω	¼ w		Prec	1%	
R211	311-386	2 k		Var	WW	DELAY TIME MULT 1-10	
R212	323-639	1.1 k	½ w		Prec	½%	
R213	322-124	191 Ω	¼ w		Prec	1%	
R214	301-625	6.2 meg	½ w			5%	
R215	323-333	28.7 k	½ w		Prec	1%	
R217	316-473	47 k	¼ w				
R218	316-102	1 k	¼ w				
R219	323-302	13.7 k	½ w		Prec	1%	
R220	321-258	4.75 k	⅛ w		Prec	1%	
R222	315-101	100 Ω	¼ w			5%	
R223	321-243	3.32 k	⅛ w		Prec	1%	
R224	301-112	1.1 k	½ w			5%	
R225	316-331	330 Ω	¼ w				
R227	315-112	1.1 k	¼ w			5%	
R230	321-250	3.92 k	⅛ w		Prec	1%	
R231	322-341	34.8 k	¼ w		Prec	1%	
R232	316-101	100 Ω	¼ w				
R233	315-162	1.6 k	¼ w			5%	
R234	323-171	590 Ω	½ w		Prec	1%	
R235	321-173	619 Ω	⅛ w		Prec	1%	
R251	315-682	6.8 k	¼ w			5%	
R252	321-201	1.21 k	⅛ w		Prec	1%	
R253	321-143	301 Ω	⅛ w		Prec	1%	
R254	315-392	3.9 k	¼ w			5%	
R255	315-512	5.1 k	¼ w			5%	
R256	316-101	100 Ω	¼ w				
R258	316-101	100 Ω	¼ w				
R259	316-220	22 Ω	¼ w				
R260A	323-654	75 k	½ w		Prec	½%	
R260B	323-654	75 k	½ w		Prec	½%	
R260C	315-392	3.9 k	¼ w			5%	
R260D	323-653	221 k	½ w		Prec	¼%	
R260E	323-657	750 k	½ w		Prec	.1%	
R260F	323-655	750 k	½ w		Prec	½%	
R260G	323-655	750 k	½ w		Prec	½%	

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description			
R260H	323-656	1.5 meg	½ w		Prec
R260J	309-440	3.74 meg	½ w		Prec
R260K	309-441	7.50 meg	½ w		Prec
R260L	309-442	22.6 meg	½ w		Prec
R260R	316-470	47 Ω	¼ w		
R260T	316-182	1.8 k	¼ w		
R260V†	~~311-402~~ 311-0402-07	20 k		Var	
R260W	311-328	1 k		Var	
R260Y	316-223	22 k	¼ w		
R261	316-470	47 Ω	¼ w		
R262	316-221	220 Ω	¼ w		
R263	315-471	470 Ω	¼ w		
R264	323-315	18.7 k	½ w		Prec
R265	316-220	22 Ω	¼ w		
R268	305-752	7.5 k	2 w		
R270	316-101	100 Ω	¼ w		
R271	316-100	10 Ω	¼ w		
R274	315-751	750 Ω	¼ w		
R275	315-333	33 k	¼ w		
R290	321-207	1.4 k	⅛ w		Prec
R291	321-257	4.64 k	⅛ w		Prec
R293	315-123	12 k	¼ w		
R294	321-261	5.11 k	⅛ w		Prec
R296A	315-113	11 k	¼ w		
R296C	316-222	2.2 k	¼ w		
R296E	321-245	3.48 k	⅛ w		Prec
R297	322-349	42.2 k	¼ w		Prec
R298	321-257	4.64 k	⅛ w		Prec
R307	Use 316-333	33 k	¼ w		
R308	321-193	1 k	⅛ w		Prec
R310	323-321	21.5 k	½ w		Prec
R311	316-183	18 k	¼ w		
R313	302-223	22 k	½ w		
R321 316-0104-00	Use 316-184	~~[illegible]~~ k 100K	¼ w		
R323	321-291	10.5 k	⅛ w		Prec
R324	Use 323-324	20.5 k	½ w		Prec
R330	316-104	100 k	¼ w		
R331	311-095	500 Ω		Var	
R332	321-231	2.49 k	⅛ w		Prec
R333	321-097	100 Ω	⅛ w		Prec
R334	311-169	100 Ω	½ w	Var	
R335	322-133	237 Ω	¼ w		Prec
R337	324-289	10 k	1 w		Prec

†Furnished as a unit with SW260V.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Rang
R338	324-289	10 k	1 w		Prec	1%	
R339	311-328	1 k		Var		MAG REGIS	
R340	Use 322-357	51.1 k	¼ w		Prec	1%	
R341	316-471	470 Ω	¼ w				
R342	Use 321-247	3.65 k	⅛ w		Prec	1%	
R343	304-822	8.2 k	1 w				
R344	Use 323-324	20.5 k	½ w		Prec	1%	
R345	321-291	10.5 k	⅛ w		Prec	1%	
R346 316-0104-00	Use 316-184	~~180 k~~ 100k	¼ w				
R407	305-202	2 k	2 w			5%	
R409	307-103	2.7 Ω	¼ w			5%	
R410	303-200	20 Ω	1 w			5%	
R411	303-200	20 Ω	1 w			5%	
R414	307-103	2.7 Ω	¼ w			5%	
R420	321-239	3.01 k	⅛ w		Prec	1%	
R421	315-181	180 Ω	¼ w			5%	
R422	321-273	6.81 k	⅛ w		Prec	1%	
R423	316-273	27 k	¼ w				
R426	315-183	18 k	¼ w			5%	
R427	315-393	39 k	¼ w			5%	
R428	321-237	2.87 k	⅛ w		Prec	1%	
R429	321-271	6.49 k	⅛ w		Prec	1%	

Switches

Ckt. No.	Unwired	Wired	Description		S/N Range
SW30A	260-564		Lever	SOURCE	
SW30B	260-519		Lever	COUPLING	
SW30C	260-472		Lever	SLOPE	
SW70A	Use *050-211		Lever	SOURCE	100-45
SW70A	260-640		Lever	SOURCE	460-u
SW70B	260-472		Lever	COUPLING	
SW70C	260-472		Lever	SLOPE	
SW116	260-545		Rotary	TRIG MODE	
SW160A,B	~~260-543~~	*262-567	Rotary	TIME/CM	
SW160V†	~~311-402~~ 311-0402-01				
SW201††	260-518		Push	RESET	
SW260V†††	311-402				
SW300A, SW300B	260-544	*262-568	Rotary	HORIZ DISPLAY MAG	

Transistors

Ckt. No.	Part No.	Description
Q14A	*151-108	Replaceable by 2N2501
Q14B	*151-108	Replaceable by 2N2501
Q23A	*151-108	Replaceable by 2N2501
Q23B 151-0133-00	*~~151-122~~	Selected from FT1746
Q43	*151-087	Replaceable by 2N1131

†Furnished as a unit with R160V.

††Furnished as a unit with B186.

†††Furnished as a unit with R260V.

Transistors *(Cont'd)*

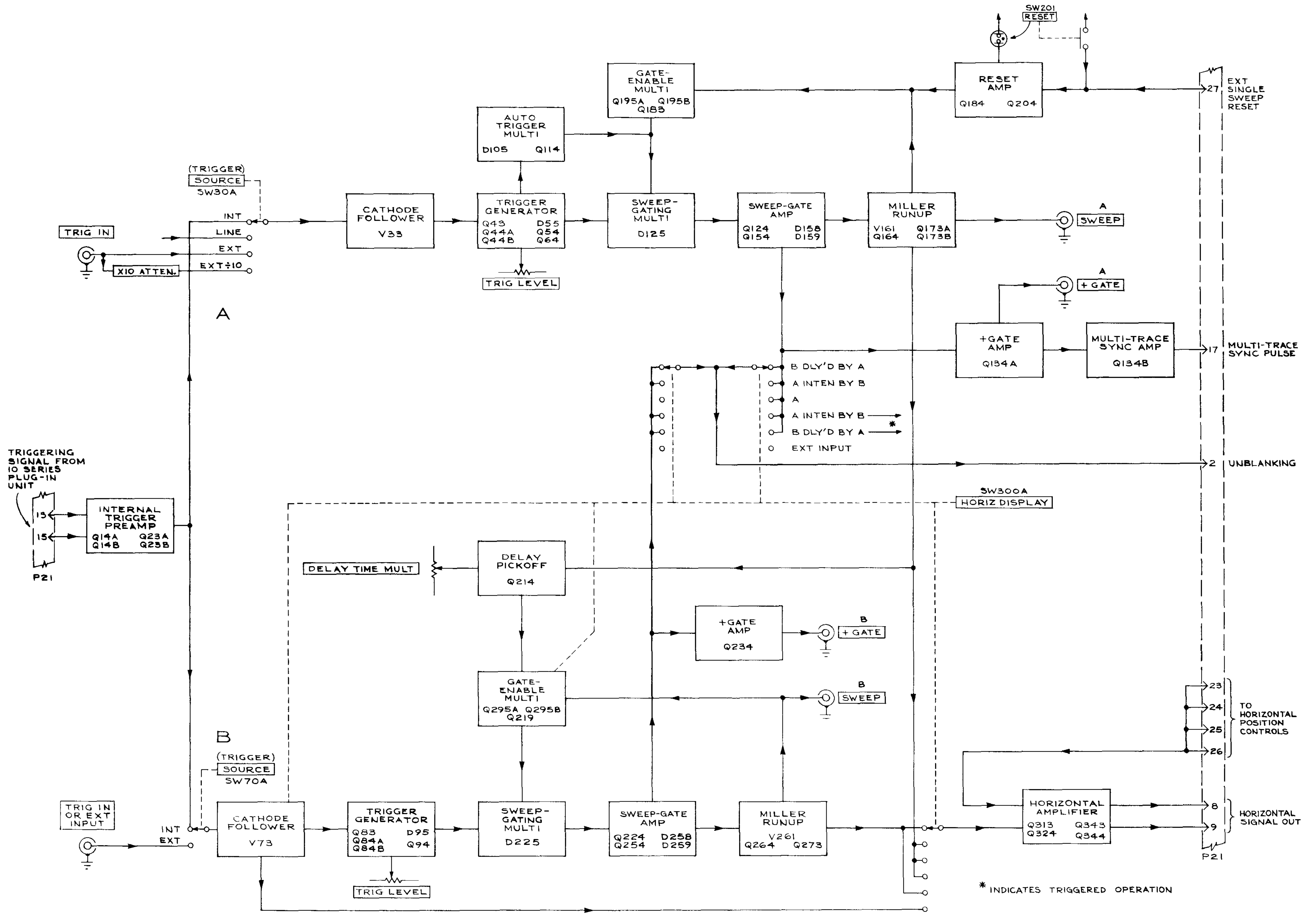
Ckt. No.	Tektronix Part No.	Description
Q44A	*151-103	Replaceable by 2N2219
Q44B	*151-103	Replaceable by 2N2219
Q54	151-131	2N964
Q64	151-107	2N967
Q83	*151-087	Selected from 2N1131
Q84A	*151-103	Replaceable by 2N2219
Q84B	*151-103	Replaceable by 2N2219
Q94	151-131	2N964
Q114	*151-103	Replaceable by 2N2219
Q124	*151-108	Replaceable by 2N2501
Q134A	*151-108	Replaceable by 2N2501
Q134B	*151-108	Replaceable by 2N2501
Q154	151-107	2N967
Q164	*151-127	Selected from 2N2369
Q173A	*151-108	Replaceable by 2N2501
Q173B	*151-103	Replaceable by 2N2219
Q183	*151-087	Selected from 2N1131
Q184	*151-096	Selected from 2N1893
AL4 Q195A	151-0133-00 *151-122	Selected from FT1746
AL4 Q195B	151-0133-00 ~~*151-122~~	Selected from FT1746
Q204	*151-103	Replaceable by 2N2219
Q214	*151-104	Replaceable by 2N2913
AL4 Q219	151-0133-00 *~~151-122~~	Selected from FT1746
Q224	*151-108	Replaceable by 2N2501
Q234	*151-108	Replaceable by 2N2501
Q254	151-107	2N967
Q264	*151-127	Selected from 2N2369
Q273	*151-103	Replaceable by 2N2219
Q295A	*151-087	Selected from 2N1131
Q295B	*151-087	Selected from 2N1131
Q313	*151-103	Replaceable by 2N2219
Q324	*151-108	Replaceable by 2N2501
Q343	*151-103	Replaceable by 2N2219
Q344	*151-108	Replaceable by 2N2501

Electron Tubes

Ckt. No.	Tektronix Part No.	Description
V33	154-306	7586
V73	154-306	7586
V161	154-306	7586
V261	154-306	7586

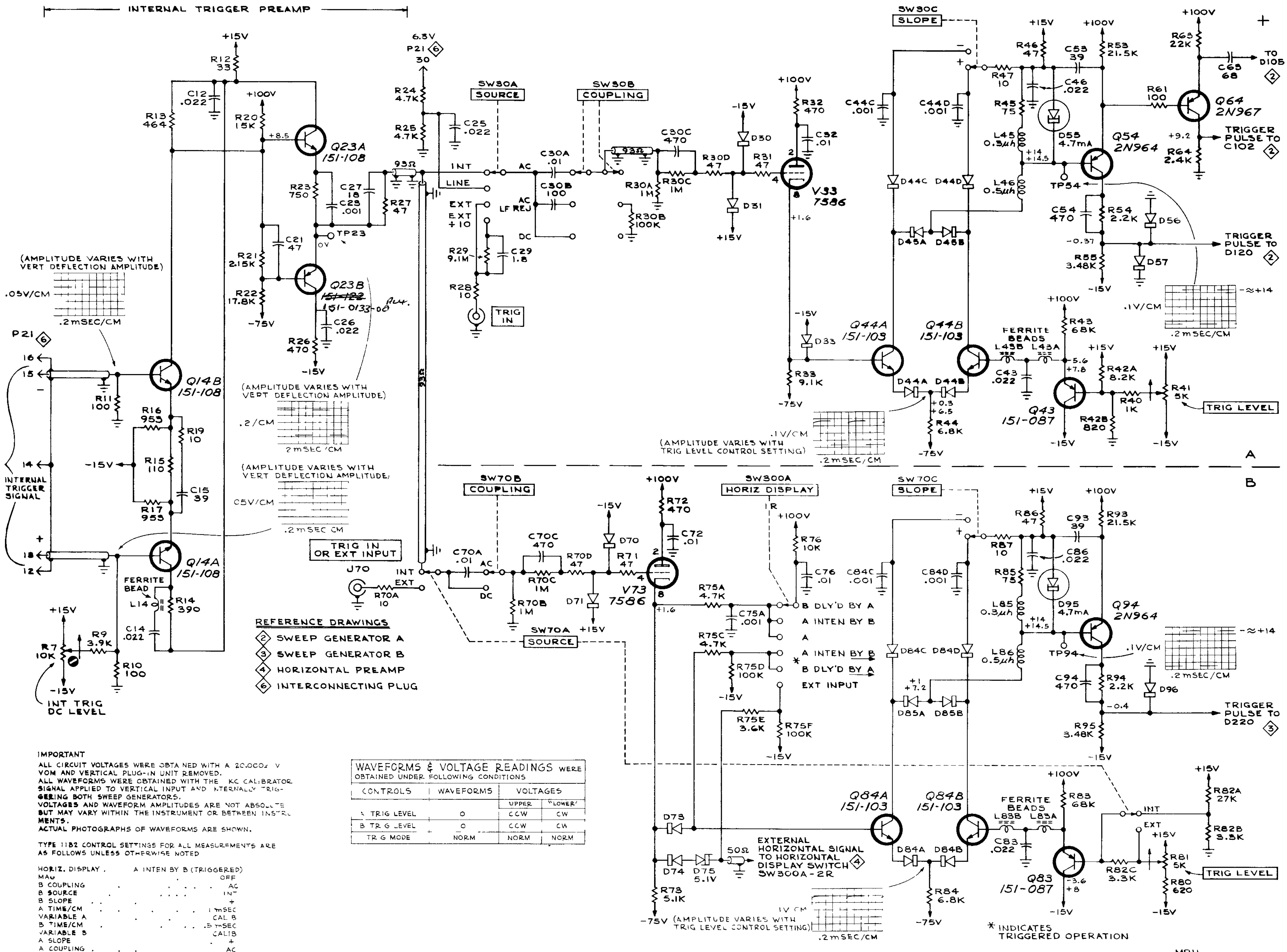
PART 4

P6088 PROBE



MRH
1163

BLOCK DIAGRAM



IMPORTANT

ALL CIRCUIT VOLTAGES WERE OBTAINED WITH A 20,000Ω/V VOM AND VERTICAL PLUG-IN UNIT REMOVED.
ALL WAVEFORMS WERE OBTAINED WITH THE KC CALIBRATOR SIGNAL APPLIED TO VERTICAL INPUT AND INTERNALLY TRIGGERING BOTH SWEEP GENERATORS.
VOLTAGES AND WAVEFORM AMPLITUDES ARE NOT ABSOLUTE BUT MAY VARY WITHIN THE INSTRUMENT OR BETWEEN INSTRUMENTS.
ACTUAL PHOTOGRAPHS OF WAVEFORMS ARE SHOWN.

TYPE 11B2 CONTROL SETTINGS FOR ALL MEASUREMENTS ARE AS FOLLOWS UNLESS OTHERWISE NOTED

HORIZ. DISPLAY	A INTEN BY B (TRIGGERED)
MAG	OFF
B COUPLING	AC
B SOURCE	INT
B SLOPE	+
A TIME/CM	1 mSEC
VARIABLE A	CAL B
B TIME/CM	.5 mSEC
VARIABLE B	CALIB
A SLOPE	+
A COUPLING	AC
A SOURCE	INT
DELAY TIME MULT	1.00

WAVEFORMS & VOLTAGE READINGS WERE OBTAINED UNDER FOLLOWING CONDITIONS

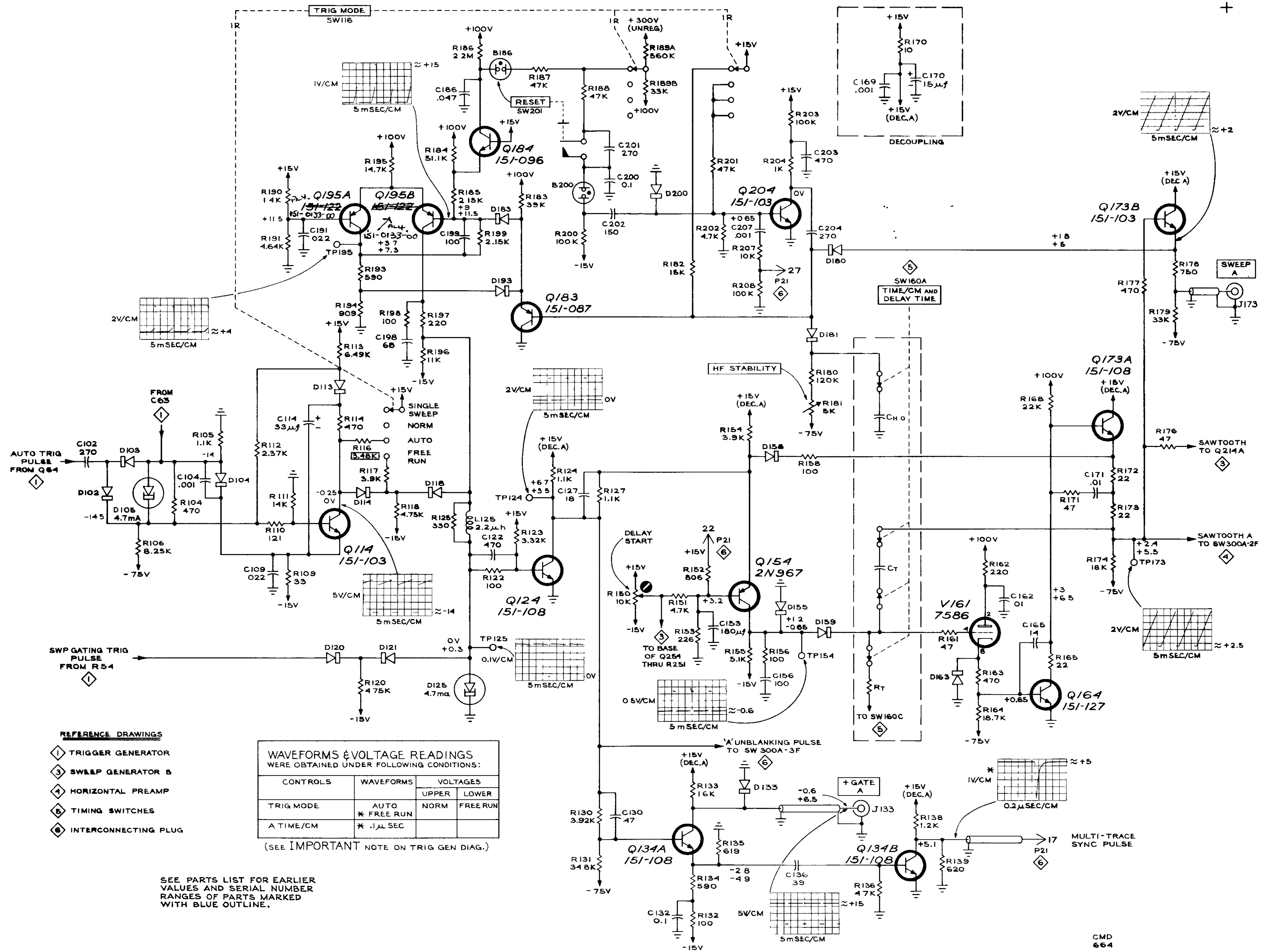
CONTROLS	WAVEFORMS	VOLTAGES	
		UPPER	"LOWER"
A TRIG LEVEL	0	CCW	CW
B TRIG LEVEL	0	CCW	CW
TRIG MODE	NORM	NORM	NORM

MRH 1163

A

TRIGGER GENERATOR

TYPE 11B2-MOD 165K PLUG-IN



REFERENCE DRAWINGS

- ① TRIGGER GENERATOR
- ③ SWEEP GENERATOR B
- ④ HORIZONTAL PREAMP
- ⑤ TIMING SWITCHES
- ⑥ INTERCONNECTING PLUG

WAVEFORMS & VOLTAGE READINGS
WERE OBTAINED UNDER FOLLOWING CONDITIONS:

CONTROLS	WAVEFORMS	VOLTAGES	
		UPPER	LOWER
TRIG MODE	AUTO * FREE RUN	NORM	FREE RUN
A TIME/CM	* .1µ SEC		

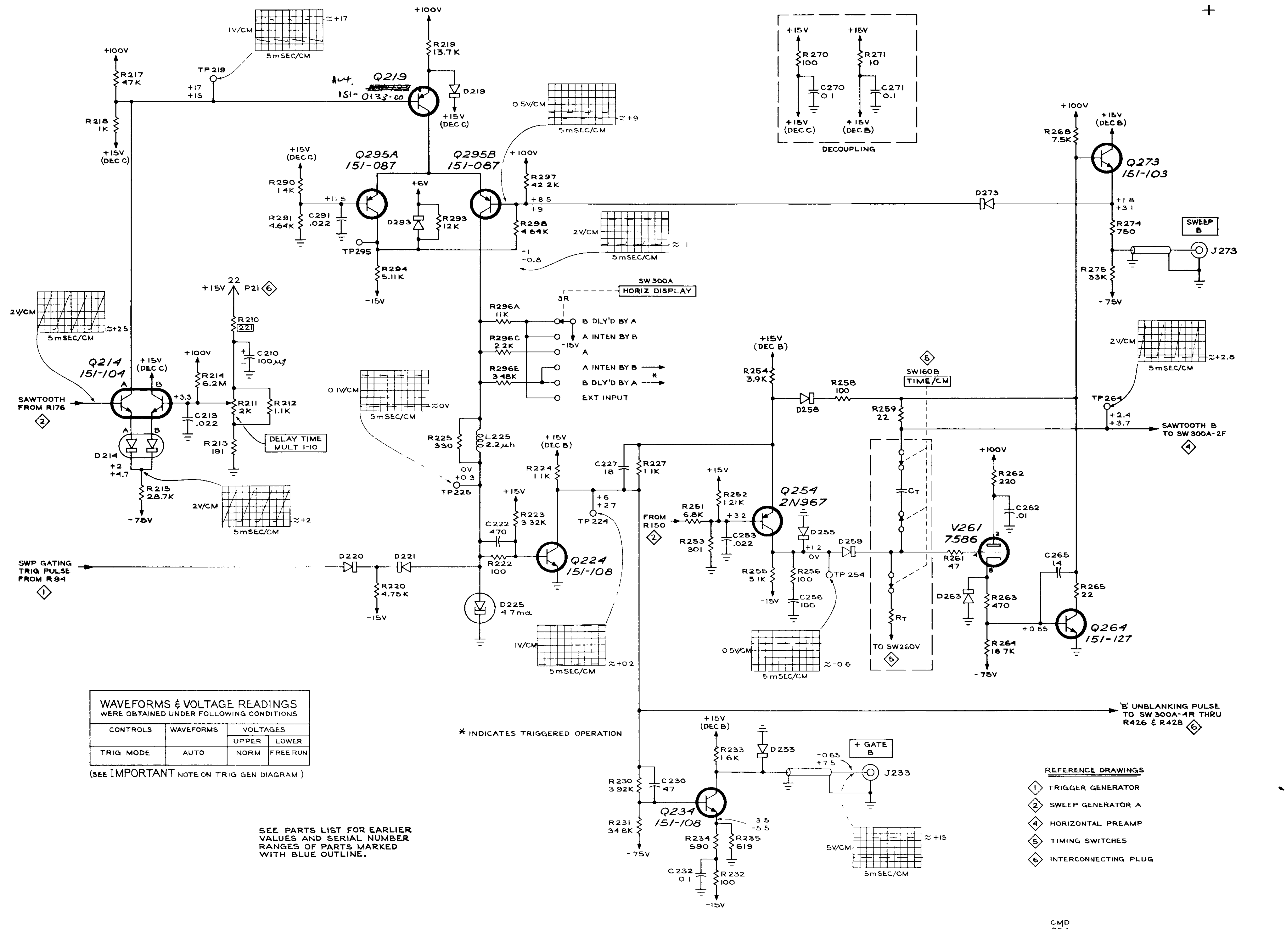
(SEE IMPORTANT NOTE ON TRIG GEN DIAG.)

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

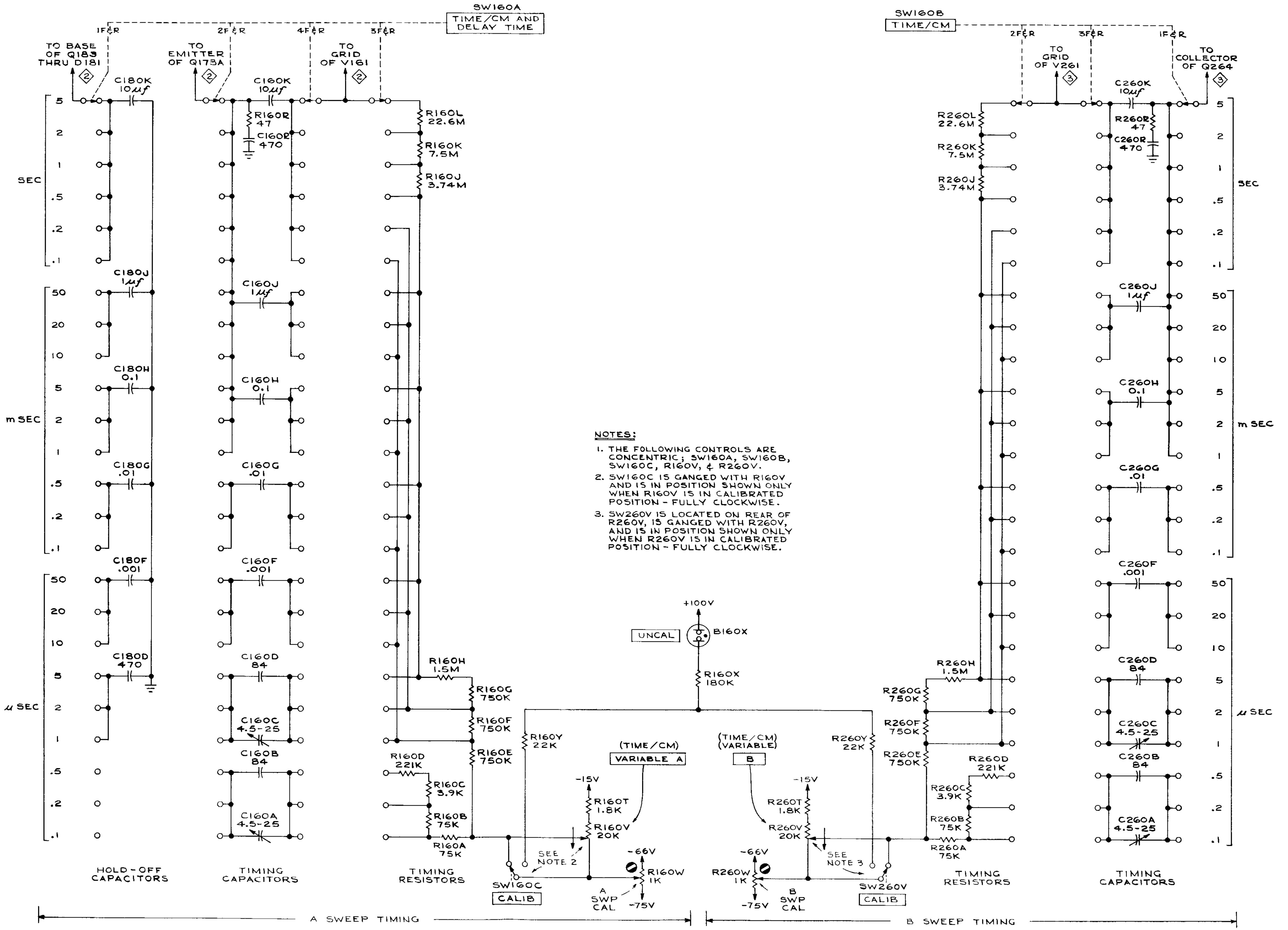
TYPE 11B2-MOD 165K PLUG-IN

B

SWEEP GENERATOR A



WAVEFORMS & VOLTAGE READINGS WERE OBTAINED UNDER FOLLOWING CONDITIONS
CONTROLS | WAVEFORMS | VOLTAGES UPPER | LOWER
TRIG MODE | AUTO | NORM | FREE RUN
(SEE IMPORTANT NOTE ON TRIG GEN DIAGRAM)
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.
* INDICATES TRIGGERED OPERATION
REFERENCE DRAWINGS
1 TRIGGER GENERATOR
2 SWEEP GENERATOR A
4 HORIZONTAL PREAMP
5 TIMING SWITCHES
6 INTERCONNECTING PLUG
DECOUPLING
SAWTOOTH FROM R176
SWP GATING TRIG PULSE FROM R94
FROM R150
SAWTOOTH B TO SW300A-2F
'B' UNBLANKING PULSE TO SW300A-4R THRU R426 & R428
SWEEP B
+ GATE B
DELAY TIME MULT 1-10
SW300A HORIZ DISPLAY
B DLY'D BY A
A INTEN BY B
A
A INTEN BY B
B DLY'D BY A
EXT INPUT
SW160B TIME/CM
TO SW260V
Q219
Q295A 151-087
Q295B 151-087
Q214 151-104
Q224 151-108
Q254 2N967
V261 7586
Q264 151-127
Q273 151-103
Q234 151-108
J273
J233
CMD 764



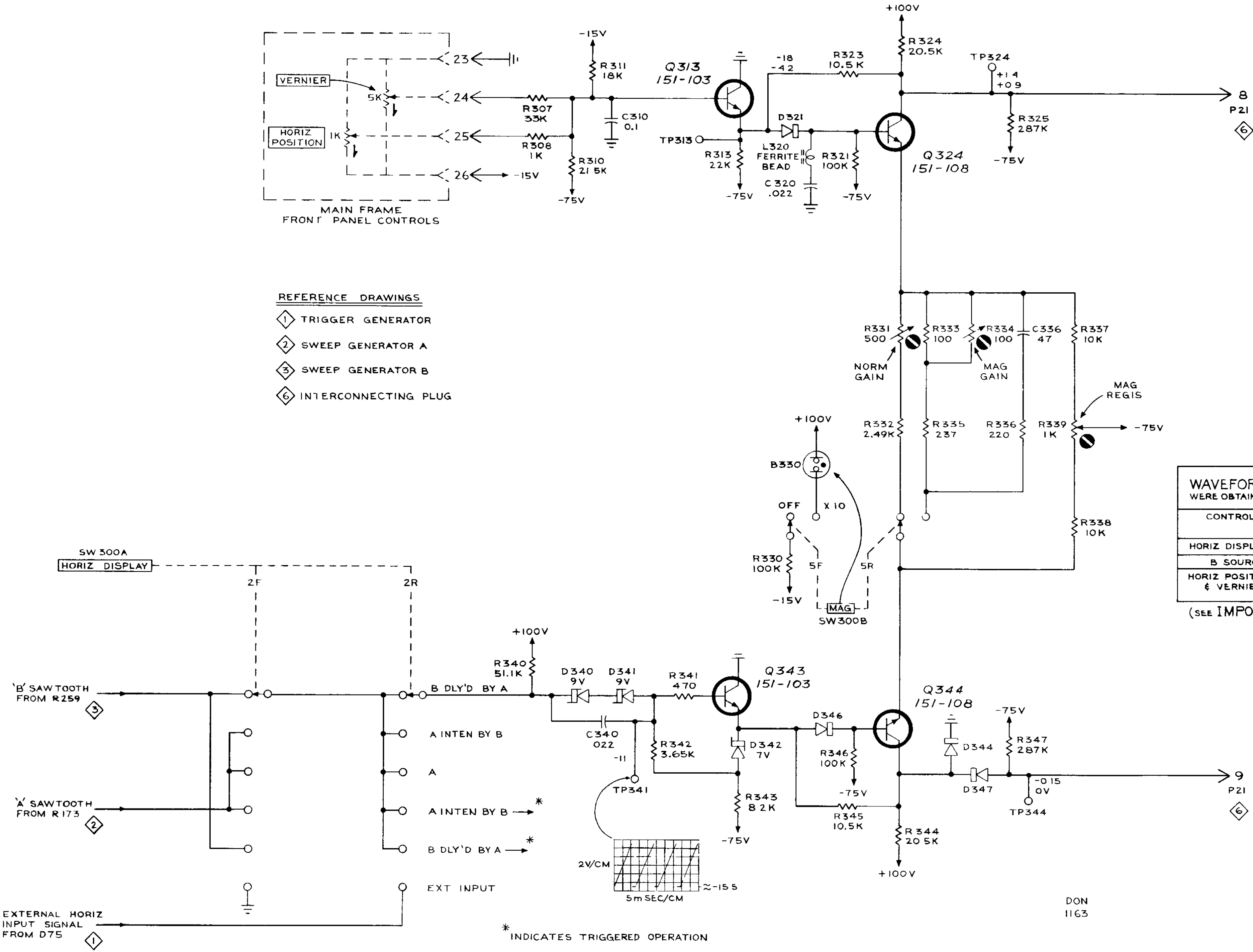
REFERENCE DRAWINGS:
- 2 SWEEP GENERATOR A
- 3 SWEEP GENERATOR B

TYPE 11B2 MOD 165K PLUG-IN

A

MRH 1163

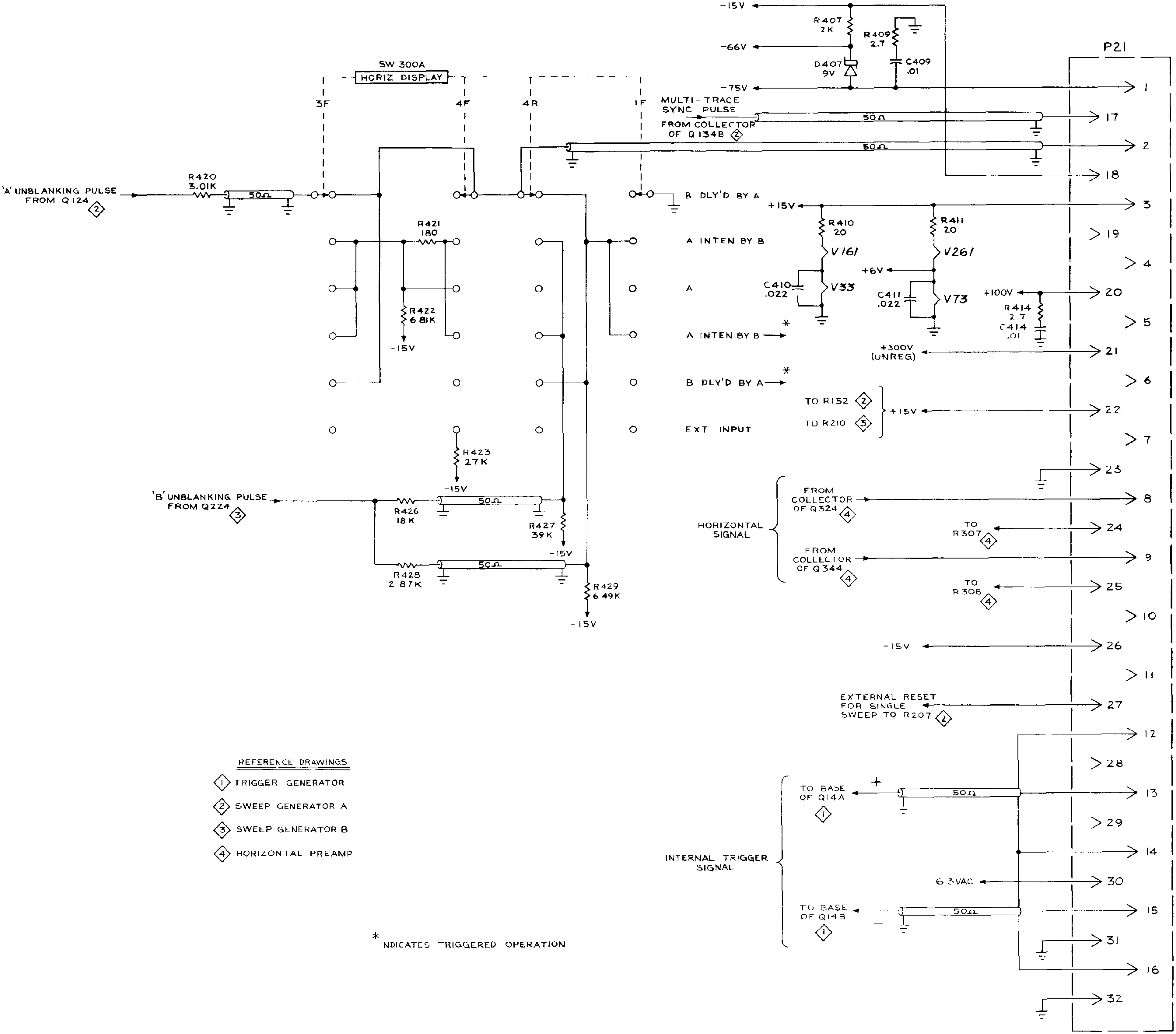
TIMING SWITCHES



WAVEFORMS & VOLTAGE READINGS
WERE OBTAINED UNDER FOLLOWING CONDITIONS

CONTROLS	WAVEFORMS	VOLTAGES UPPER	VOLTAGES LOWER
HORIZ DISPLAY	A	EXT INPUT	EXT INPUT
B SOURCE	INT	EXT	EXT
HORIZ POSITION & VERNIER	CENTERED	CW	CCW

(SEE IMPORTANT NOTE ON TRIG GEN DIAG)



TYPE 11B2-MOD 165K PLUG-IN A INTERCONNECTING PLUG

DON 1163

VOLUME 3D

SCALE OF SERVICING SPARES

FOR

10S/6625-99-9522040

OSCILLOSCOPE SET, CT536

Note:—*This Scale of Servicing Spares is based on the most up-to-date information available at the time of printing. Any aspect of the scale thought to be unsatisfactory is to be reported in accordance with A.P.*3158, *Vol.* 2 (*2nd Edn.*), *Leaflet D*.6 (*A.L.*184), *to Ministry of Defence* (*Air*), (*ADE*.25 (*RAF*)), *via Command Headquarters.*

Col 1 - Section and Reference number.

Col 2 - Nomenclature.

Col 3 - Qty off per equipment.

Col 4 - 4 months station holding to support one equipment.

Col 5 - 4 months station holding to support two equipments.

Col 6 - 4 months station holding to support three equipments.

Note 1 Quantities scaled in Cols 4, 5 and 6 are maximum station holdings.

Note 2 Items marked with an asterisk (*) in Col 4 may be demanded on a one-for-one basis by user units.

Col 7 - 6 months 3rd line test equipment repair unit holding. Items marked with an asterisk are to be demanded on a one-for-one basis (See Note 3).

Col 8 - Items marked Ø affect calibration of the equipment.

Col 9 - Circuit reference, part number or other reference.

Note 3 Where more than one circuit reference is quoted in Col 9 and the calibration symbol (Ø) appears in Col 6, circuit references that affect calibration are underlined.

1	2	3	4	5	6	7	8	9
10AC								
5340-99-580-1339	RING, RETAINING	[illegible]	[illegible]			*		PT.No. [illegible]
5305-99-952-2576	SCREW, EXTERNALLY RELIEVED BODY	-	*			*		[illegible]
10AS								
5330-99-952-2652	RUBBER STRIP	AR				*		P[illegible] [illegible]65[illegible]
10D								
6625-99-952-2193	TIME BASE UNIT	1						TYPE 1152
10S								
6625-99-952-2206	CASE SUB-ASSEMBLY, OSCILLOSCOPE	1				*		PT.No. CN 3619-
6625-99-952-2207	COVER, OSCILLOSCOPE CASE	1	*			*		PT.No. CN 3619[illegible]
6625-99-952-2208	CASE, OSCILLOSCOPE ACCESSORIES	1	*			*		PT.No. CN 36209
6625-99-952-2209	CASE, OSCILLOSCOPE	1						PT.No. CN 36196
6625-99-957-5068	MODIFICATION KIT, ELECTRONIC	1						PT.No. 65K 4/-1001

1	2	3	4	5	6	7	8	9
28F								
5330-99-942-8451	WASHER, SEAL, FLAT	4						PT.No. AGS 1186-7
105L								
6240-00-299-7035	LAMP, NEON	2	1	1	1	3		PT.No. 150-0027-00 B144, 244
6240-00-882-8487	LAMP, GLOW	8	1	2	3	8		PT.No. 150-0030-00 B119, 160X, 200, 219, 330, 852, 853, 854
6240-00-962-0525	BULB, MINIATURE	3	1	2	3	6		PT.No. 150-0029-00 B604, 605, 606
110AC								
5310-99-116-5124	NUT, LOCKING	1	*			*		PT.No. 210-0576-00
5340-99-140-5712	NUT, CAM, LOCKING	2						PT.No. 214-0408-00
5340-99-140-6045	RING RETAINING	2						PT.No. 354-0219-00
5307-99-140-7296	STUD, KNOB PROTECTOR HANDLE	2						PT.No. AS 331
6625-99-140-7298	COUPLING, KNOB PROTECTOR	2						PT.No. BS 276
110AD								
6625-00-937-9978	CONTACT ELECTRICAL	1	*			*		PT.No. 166-0282-00
6625-00-980-9301	HOLDER PROBE	1	*			*		PT.No. 352-0024-00
5825-99-196-8722	ADAPTOR	1	*			*		PT.No. 103-0036-00
110AE								
6625-00-078-5219	PROBE TEST	1	*			*		PT.No. 010-0130-00
6250-00-089-7366	LAMP HOLDER	2				*		PT.No. 352-0067-00
6625-00-788-6811	CENTRE PIN	1				*		PT.No. 214-0325-00
6625-00-790-2001	PROBE, ELECTRONIC TEST	2						PT.No. 010-0129-00
5930-00-829-3251	SWITCH, ELECTRICAL	1						PT.No. 260-0551-00

1	2	3	4	5	6	7	8	9
110AK								
5355-00-084-4331	KNOB	1	*			*		PT.No. 366-0250-00
► 5355-00-422-2330	KNOB, LEVER SWITCH	8	*			*		PT.No. 366-0215-01 ◄
5355-00-685-5580	KNOB	1						PT.No. 366-0031-00
5355-00-833-9259	KNOB	1	*			*		PT.No. 366-0117-00
5355-00-849-7445	KNOB	1	*			*		PT.No. 366-0142-00
5355-00-870-1174	KNOB	1	*			*		PT.No. 366-0254-00
5355-00-882-1194	KNOB, TRIGGER	3	*			*		PT.No. 366-0225-00
5355-00-913-5493	KNOB	1	*			*		PT.No. 366-0140-00
5355-00-918-9525	KNOB	1	*			*		PT.No. 366-0194-00
5355-00-918-9527	KNOB	1	*			*		PT.No. 331-0092-00
5355-00-918-9528	DIAL	1	*			*		PT.No. 331-0096-00
5355-00-926-5267	KNOB, VOLTS/CM	2	*			*		PT.No. 366-0230-00
5355-00-939-1232	KNOB, MODE	6	*			*		PT.No. 366-0220-00
5355-00-983-8715	KNOB, TRIGGER	2	*			*		PT.No. 366-0081-00
5355-99-140-5392	KNOB	1	*			*		PT.No. 366-0222-00
5355-99-140-5432	KNOB	2	*			*		PT.No. 366-0232-00
5355-99-140-5433	KNOB	1	*			*		PT.No. 366-0249-00
5340-99-140-5434	HANDLE	1				*		PT.No. 367-0037-00
6625-99-140-7297	HANDLE, KNOB, PROTECTOR	2						PT.No. BS 281

1	2	3	4	5	6	7	8	9
110AL								
5340-00-0[illegible]2-0589	CAP, PROTECTIVE, DUST AND MOISTURE	2				*		PT.No. 348-0050-00
5325-00-071-6256	GROMMET, PLASTICS	6				*		PT.No. 348-0031-00
5325-00-256-7752	GROMMET	1				*		PT.No. 348-0049-00
5325-00-276-4205	GROMMET	3				*		PT.No. 348-0005-00
5325-00-276-4257	GROMMET	3				*		PT.No. 348-0006-00
5325-00-447-7140	GROMMET	1				*		PT.No. 348-0012-00
5825-00-477-7833	SHIELD, IMPLOSION DMC	1				*		PT.No. 337-0573-00
5325-00-754-2165	GROMMET	22				*		PT.No. 348-0003-00
5325-00-813-6936	GROMMET	5				*		PT.No. 348-0002-00
6625-00-832-4561	SLEEVE, LOCKING	1	*			*		PT.No. 166-0285-00
5910-00-856-6458	SHIELD, CAPACITOR	4						PT.No. 200-0259 00
5325-00-866-3933	GROMMET	1				*		PT.No. 348-0004-00
5950-00-916-8080	INDUCTOR	2				*		PT.No. 276-0532-00 L487, 497
6625-99-116-5800	SHIELD, FOCUS AND INTENSITY	1				*		PT.No. 337-0576-00
[illegible]								
6625-00-168-0172	PROD TEST	1	*			*		PT.No. 202-0116-00
5826-00-612-6583	CLAMP ASSEMBLY	1						PT.No. 200-0556-00
5961-99-140-5407	COVER, TRANSISTOR	4				*		PT.No. 200-0500-00
5310-99-140-5408	COVER, NUT	10				*		PT.No. 200-0548-00

1	2	3	4	5	6	7	8	9
110AR								
5355-00-016-8665	BUSHING-SHAFT, PANEL	2				*		PT.No. 358-0216-00
3020-00-134-9321	GEAR, BEVEL	1				*		PT.No. 214-0272-00
3020-00-134-9322	GEAR, BEVEL	1				*		PT.No. 214-0350-00
6625-00-832-4555	BUSHING, INNER BASE	1	*			*		PT.No. 358-0192-00
6625-00-832-4562	BUSHING, BASE	1	*			*		PT.No. 358-0194-00
5910-00-856-6461	SHIELD, CAPACITOR	1				*		PT.No. 432-0047-00
5910-00-856-6465	SHIELD, CAPACITOR	4				*		PT.No. 432-0048-00
5975-99-116-4655	BUSHING	2				*		PT.No. 358-0210-00
6625-99-116-5756	BODY,TIP ASSEMBLY	1	*			*		PT.No. 204-0144-00
5340-99-140-5430	FOOT, BODY AND CORD HOLDER	4				*		PT.No. 348-0053-00
5340-99-140-6037	FOOT, ANTI-SLIDE	4				*		PT.No. 348-0052-00
5340-99-140-6038	FOOT, FLIP STAND	1						PT.No. 348-0057-00
5340-99-140-6074	BLOCK, FLIP STAND PIVOT LEFT	1				*		PT.No. 391-0057-00
5340-99-140-6075	BLOCK, FLIP STAND PIVOT RIGHT	1						PT.No. 391-0058-00
5325-99-140-6175	FASTENER, SCREW, RETRACTABLE	2				*		PT.No. 214-0329-00
110AS								
6625-99-116-3630	SHELL, COMPENSATOR	1	*			*		PT.No. 205-0046-00

1	2	3	4	5	6	7	8	9
110AT								
➤ 6210-00-103-6337	LENS LIGHT	3				*		PT.No. 378-0541-00
5825-00-477-7830	FILTER, POLARIZED LIGHT	1	*			*		PT.No. 378-0540-08 ◄
110B								
5970-00-104-7899	INSULATOR DISC	5				*		PT.No. 214-0317-00
5340-00-792-2001	SPACER, SLEEVE	46				*		PT.No. 361-0009-00
5340-00-816-0002	SPACER, SLEEVE	52				*		PT.No. 361-0007-00
110C								
5910-00-014-6565	CAPACITOR, FIXED, PAPER DIELECTRIC 0.0033uF ± 5%. 100V	3				*		PT.No. 285-0627-00 C902, 924, 925
5910-00-050-8329	CAPACITOR, FIXED, CERAMIC DIELECTRIC 27pF ± 10%, 500V	2				*	Ø	PT.No. 281-0512-00 C107E, 207E
6625-00-056-2474	DELAY LINE ASSEMBLY	1				*	Ø	PT.No. 119-0029-00 L403
➤ 5910-00-436-3907	CAPACITOR, FIXED, CERAMIC, DIELECTRIC 68pF, ± 10%, 500V	2				*		PT.No. 281-0549-00 C63, 198
5910-00-879-0123	CAPACITOR, FIXED, ELECTROLYTIC 50uF - 10% + 250%, 50V	1				*		PT.No. 290-0117-00 C820 ◄
5950-00-070-7591	INDUCTOR, RADIO FREQUENCY 600uH	1				*	Ø	PT.No. 180-0254-00 L394
5915-00-070-7599	SUPPRESSOR PARASITIC 0.15uH	3				*	Ø	PT.No. 108-0220-00 L404, 406, 577
5950-00-070-7600	INDUCTOR, RADIO FREQUENCY 0.07uH	1				*	Ø	PT.No. 108-0277-00 L405
5950-00-070-7601	INDUCTOR, RADIO FREQUENCY	1				*	Ø	PT.No. 108-0295-00 L865
5910-00-070-7610	SHIELD, CAPACITOR	1				*		PT.No. 200-0255-00
5910-00-071-7356	CAPACITOR, FIXED, ELECTROLYTIC 17uF - 10% + 100%, 150V	2				*		PT.No. 290-0198-00 C631, 731
5910-00-071-7359	CAPACITOR, FIXED, CERAMIC DIELECTRIC 84pF ± 2%, 1000V	4				*	Ø	PT.No. 283-0097-00 C160B,D 260B,D

1	2	3	4	5	6	7	8	9
110C								
5910-00-081-6973	CAPACITOR, FIXED, ELECTROLYTIC 100uF - 10% + 250%, 30V	1				*		PT.No. 290-0137-00 C210
6625-00-082-7547	INDUCTOR, CORE	8				*		PT.No. 276-0507-00 L14, 43A,43B, 83A,83B,320,343, 353
5950-00-083-5544	INDUCTOR, RADIO FREQUENCY 0.3uH	2				*	Ø	PT.No. 108-0278-00 LR400, 401
5950-00-085-0114	INDUCTOR, RADIO, FREQUENCY 0.3uH	1				*	Ø	PT.No. 108-0182-00 L414
5910-00-103-0282	CAPACITOR, VARIABLE 0.2-1.5/200pF ± 10%	2				*	Ø	PT.No. 281-0069-00 C110C, 210C, 110E, 210E
5910-00-103-0284	CAPACITOR, VARIABLE 0.2-1.5/2000pF ± 10%	2				*	Ø	PT.No. 281-0074-00 C113C, 213C, 113E, 213E
5910-00-103-9681	CAPACITOR, VARIABLE 0.2-1.5/100pF ± 10%	2				*	Ø	PT.No. 281-0071-00 C109C, 209C 109E, 209E
5910-00-104-7260	CAPACITOR, VARIABLE 0.2-1.5/100pF ± 10%	2				*	Ø	PT.No. 281-0073-00 C112C, 212C, 112E, 212E
5910-00-126-1619	CAPACITOR, VARIABLE 0.2-1.5/100pF ± 10%	4				*	Ø	PT.No. 281-0010-00 C160A, 160C, 260A, 260C
5910-00-226-0475	CAPACITOR, FIXED, CERAMIC DIELECTRIC 2.7pF ± 0.25pF, 500V	2				*		PT.No. 281-0547-00 C104A, 204A
► 5950-00-241-3672	INDUCTOR 0.5 uH	2				*		PT.NO. 108-0170-01 L46, 86
5910-00-436-4220	CAPACITOR, FIXED, CERAMIC DIELECTRIC 18pF ± 20%, 500V	2				*		PT.NO. 281-0558-00 C102, 202
5910-00-451-3209	CAPACITOR, FIXED, ELECTROLYTIC 22uF ± 20%, 35V	2				*		PT.NO. 290-0162-00 C661, 691 ◄
5910-00-472-6320	CAPACITOR, FIXED, CERAMIC DIELECTRIC 6.8pF ± 10%, 500V	6				*		PT.No. 281-0572-00 C105A, 106A, 107A, 205A, 206A 207A
5910-00-472-6321	CAPACITOR, FIXED, CERAMIC DIELECTRIC 4.7pF ± 0.5pF	3				*		PT.No. 281-0592-00 C104D, 204D, 445

1	2	3	4	5	6	7	8	9
110C								
5910-00-577-1315	CAPACITOR, FIXED, CERAMIC DIELECTRIC 10pF ± 10%, 500V	5				*		PT.No. 281-0504-00 C192, 193, 292, 293, 945
5910-00-682-3251	CAPACITOR, FIXED, CERAMIC DIELECTRIC 470pF ± 20%, 500V	11				*		PT.NO. 281-0525-00 C30C, 54, 70C, 94, 122, 160R, 180D, 203, 222, 260R, 948K
5910-00-682-3287	CAPACITOR, FIXED, CERAMIC DIELECTRIC 2.2pF ± 0.5pF, 500V	1				*		PT.No. 281-0500-00 C878
5950-00-683-3203	INDUCTOR, RADIO FREQUENCY 3.2uH	1				*	Ø	PT.No. 108-0088-00 L407
5910-00-683-3679	CAPACITOR, FIXED, CERAMIC DIELECTRIC 8pF ± 20%, 500V	16				*		PT.No. 281-0503-00 C108A, 109A, 110A,111A, 112A, 113A, 208A, 209A 210A, 211A, 212A 213A,404A,B, , 406A, B
5950-00-686-6829	INDUCTOR, RADIO FREQUENCY 0.3uH	4				*		PT.No. 108-0112-00 L45, L85,554, 564
5910-00-713-2011	CAPACITOR, FIXED, CERAMIC DIELECTRIC 100pF ± 20%, 350V	5				*	Ø	PT.No. 281-0523-00 C30B, 156, 199, 256, 948Z
5910-00-715-0452	CAPACITOR, FIXED, CERAMIC DIELECTRIC 18pF ± 10%, 500V	3				*		PT.No. 281-0542-00 C27, 127,227
5910-00-726-8952	CAPACITOR, FIXED CERAMIC DIELECTRIC 0.0068uF ± 20%, 500V	2				*		PT.No. 281-0614-00 C118, 218
5910-00-752-4290	CAPACITOR, FIXED, ELECTROLYTIC 10 uF - 10% + 250%, 15V	1				*		PT.No. 290-0167-00 C180K
5910-00-754-9826	CAPACITOR, FIXED, CERAMIC DIELECTRIC 1.8pF ± 20%, 500	1				*		PT.No. 281-0557-00 C29
5910-00-782-7614	CAPACITOR, FIXED, CERAMIC DIELECTRIC 0.1uF + 80% - 20%, 25V	15				*		PT.No. 283-0081-00 C132, 134 232, 234,270,271 310,443,452,469, 694,811,923,936, 937
5910-00-794-3318	CAPACITOR, FIXED, CERAMIC DIELECTRIC 39pF ± 10%, 500V	2				*		PT.No. 281-0516-00 C15, 136
5910-00-794-3408	CAPACITOR, FIXED, CERAMIC DIELECTRIC 150pF ± 20%. 500V	2				*		PT.No. 281-0524-00 C202, 739

1	2	3	4	5	6	7	8	9
110C								
5910-00-794-3710	CAPACITOR, VARIABLE 1.5pF - 7pF	1				*	Ø	PT.No. 281-0005-00 C879
5910-00-794-3888	CAPACITOR, FIXED, CERAMIC DIELECTRIC 4.7pF ± 10%, 500V	9				*	Ø	PT.No. 281-0519-00 C108E, 132, 208E, 232, 271 281, 550, 560, 935
➤ 5910-00-810-3819	CAPACITOR, FIXED, CERAMIC DIELECTRIC 0.001uF ± 10% 500V	1				*		PT.No. 281-0536-00 C180F ◄
5910-00-814-7525	CAPACITOR, FIXED, CERAMIC DIELECTRIC 0.01uF ± 20%, 500V	4				*		PT.No. 283-0068-00 C30A,70A,365, 366
5950-00-815-7309	INDUCTOR, RADIO FREQUENCY 2.2uH	2				*		PT.No. 108-0147-00 L125, 225
5910-00-833-4685	CAPACITOR, FIXED, PAPER DIELECTRIC 0.1uF ± 20%, 600V	2				*		PT.No. 285-0634-00 C101, 201
➤ 5910-00-834-4931	CAPACITOR VARIABLE 1.8pF-13pF ± 20%	7				*		PT.No. 281-0081-00 C456,104C, 204C,169,269, 276C ◄
5915-00-835-2984	SUPPRESSOR, PARASITIC 0.5uF	1				*		PT.No. 108-0146-00 L392
5910-00-839-5603	CAPACITOR, FIXED, CERAMIC DIELECTRIC 500pF ± 20%, 10,000V	3				*		PT.No. 281-0556-00 C835, 836, 837
5910-00-850-2124	CAPACITOR, FIXED, CERAMIC DIELECTRIC 1pF ± 0.1pF, 200V	1				*		PT.No. 281-0599-00 C103
5910-00-851-8654	CAPACITOR, FIXED, CERAMIC DIELECTRIC 270pF ± 10%, 500V	4				*		PT.No. 281-0543-00 C102, 201, 204
5950-00-855-3989	INDUCTOR, RADIO FREQUENCY	1				*	Ø	PT.No. 108-0279-00 L861
5950-00-865-0250	TRANSFORMER, RADIO FREQUENCY 0.1-0.12uH	1				*	Ø	PT.No. 114-0160-00 L465
5910-00-865-6900	CAPACITOR, FIXED, PAPER DIELECTRIC 0.1uF ± 20%, 200V	6				*	Ø	PT.No. 285-0572-00 C398,611,831, 851, 864, 946
5910-00-879-5921	CAPACITOR, FIXED, CERAMIC DIELECTRIC 0.05 uF ± 20%, 50V	2				*		PT.No. 283-0010-00 C802, 803

1	2	3	4	5	6	7	8	9
110C								
5910-00-879-6813	CAPACITOR, FIXED, CERAMIC DIELECTRIC 39 pF ± 5%, 500V	6				*	Ø	PT.No. 281-0603-00 C53,93,456B, 464,474,476
5950-00-882-2752	INDUCTOR, RADIO FREQUENCY 0.5uH	2				*		PT.No. 108-0211-00 L504, 515
5910-00-882-7003	CAPACITOR, FIXED, CERAMIC DIELECTRIC 0.001 uF ± 20%, 3000V	1				*		PT.No. 283-0044-00 C833
► 5910-00-889-4824	CAPACITOR, FIXED, PAPER DIELECTRIC 0.1uF ± 20%, 600V	1				*		PT.No. 285-0587-00 C745 ◄
5910-00-890-4499	CAPACITOR, FIXED, MICA DIELECTRIC 200 pF ± 10%, 500V	2				*	Ø	PT.No. 283-0557-00 C404C,406C
5910-00-890-5707	CAPACITOR, FIXED, ELECTROLYTIC 400uF - 10% + 100%, 250V	2				*		PT.No. 290-0169-01 C612, 702
5910-00-900-1102	CAPACITOR, VARIABLE 9.35 pF	1	*			1		PT.No. 281-0063-00 C104
5910-00-900-1104	CAPACITOR, FIXED, PAPER, DIELECTRIC 0.01 uF ± 5%, 100V	4				*		PT.No. 285-0598-00 C180G,663,744 815
5910-00-914-4085	CAPACITOR, FIXED, CERAMIC DIELECTRIC 500pF ± 20% 20,000V	1				*		PT.No. 283-0096-00 C838
5915-00-914-4106	SUPPRESSOR, PARASITIC 0.1 uH	5				*	Ø	PT.No. 108-0260-00 L434,444 469,479,527
5910-00-916-8011	CAPACITOR, FIXED, CERAMIC DIELECTRIC 68 pF ± 5%, 500V	2				*		PT.No. 281-0602-00 C456E,456F
5910-00-917-0559	CAPACITOR, FIXED, CERAMIC DIELECTRIC 0.0011 uF ± 5%, 500V	1				*		PT.No. 283-0088-00 C348
5910-00-919-4374	CAPACITOR, FIXED, CERAMIC DIELECTRIC 270 pF ± 5%, 1,000V	4				*		PT.No. 283-0084-00 C343,353,366 387
5910-00-924-4338	CAPACITOR, FIXED, CERAMIC DIELECTRIC 0.015 uF ± 20%, 3,000V	7				*		PT.No. 283-0042-00 C822, 827, 832,844,845,846, 854
5910-00-931-7067	CAPACITOR, FIXED, CERAMIC DIELECTRIC 0.022uF ± 80% - 20%, 25V	26				*		PT.No. 283-0080-00 C12,14,25,26, 43,46,83,86,109, 191,213,253,291, 320,340,344,354, 371,382,390,410, 411,483,497,498, 896

1	2	3	4	5	6	7	8	9
110C								
5910-00-932-9453	CAPACITOR, VARIABLE 0.2 - 1.5 pF - 20%	4				*	Ø	PT.No. 281-0064-00 C103,104B,203 204B
5910-00-937-0660	CAPACITOR, FIXED, ELECTROLYTIC 5 uF - 10% + 250%, 25V	2				*		PT.No. 290-0026-00 C916, 926
5910-00-938-4696	CAPACITOR, FIXED, CERAMIC DIELECTRIC 0.001 uF ± 20%, 500V	14				*		PT.No. 283-0078-00 C23,44C,44D, 75A 84C, 84D, 104,169,207,314, 334,660,690,692,
5910-00-947-9498	CAPACITOR, FIXED, CERAMIC DIELECTRIC	4				*	Ø	PT.No. 281-0577-00 C159,165, 259,265
► 5910-00-947-9499	CAPACITOR, FIXED, CERAMIC DIELECTRIC 18pF ± 5%, 500V	1				*	Ø	PT.NO. 281-0578-00 C462 ◄
5910-00-949-4995	CAPACITOR, FIXED, CERAMIC DIELECTRIC 11 pF ± 5%, 500V	2				*		PT.No. 281-0576-00 C465, 475
5910-00-950-3924	CAPACITOR, VARIABLE 0.7 - 3 pF ± 20%	26				*		PT.No. 281-0027-00 C105B,C, 106B,C,107B,C, 108B,C,109B,110B 111B,112B,113B, 205B, C,206B,C, 207B,C,208B,C, 209B,210B,211B, 212B,213B
5910-00-951-0668	CAPACITOR, FIXED, CERAMIC DIELECTRIC 47 pF ± 20%, 500V	3				*		PT.No. 281-0518-00 C21,130,230
5910-00-978-2441	CAPACITOR, FIXED, CERAMIC 3.3 pF - 0.25 pF	2				*		PT.No. 281-0534-00 C877,C948A
5910-99-116-5759	CAPACITOR, VARIABLE 1.2 pF - 3.5 pF ± 20%	1				*	Ø	PT.No. 281-0076-00 C484,
5910-99-116-5760	CAPACITOR, VARIABLE 1.5 pF - 9.1 pF ± 20%	1				*	Ø	PT.No. 281-0079-00 C467,
5910-99-116-5761	CAPACITOR, FIXED, CERAMIC DIELECTRIC 25 pF ± 5%, 500V	1				*		PT.No. 281-0586-00 C466
5910-99-116-5762	CAPACITOR, FIXED, ELECTROLYTIC 170 uF - 10%, + 100%, 250V	1				*		PT.No. 290-0202-00 C742
5910-99-140-5418	CAPACITOR, FIXED, ELECTROLYTIC 15 uF - 10% + 250%, 20V	1				*		PT.No. 290-0135-00 C170
5910-99-140-5419	CAPACITOR, FIXED, ELECTROLYTIC 180 uF - 10% + 250%, 6V	1				*		PT.No. 290-0139-00 C153,

1	2	3	4	5	6	7	8	9
110C								
5910-99-140-5421	CAPACITOR, FIXED, ELECTROLYTIC 100 uF - 10% + 250%, 12V	2				*		PT.No. 290-0171-00 C609,743
5910-99-140-5422	CAPACITOR, FIXED, ELECTROLYTIC 1 uF ± 10%, 35V	3				*		PT.No. 290-0183-00 C108J,199,299
5910-99-140-5423	CAPACITOR, FIXED, ELECTROLYTIC 3900 uF - 10% + 250%, 30V	2				*		PT.No. 290-0186-00 C642,672
5910-99-140-5424	CAPACITOR, FIXED, ELECTROLYTIC 0.1 uF ± 10%, 35V	1				*		PT.No. 290-0188-00 C180H
5910-99-140-5425	CAPACITOR, FIXED, ELECTROLYTIC 33 uF - 10% + 250%, 35V	2				*		PT.No. 290-0189-00 C114,818
5950-99-140-5628	INDUCTOR 100 uH	1				*		PT.No. 108-0226-00 L390
5910-99-140-5720	CAPACITOR, VARIABLE 0.2 - 1.5/500 pF ± 10%	2				*	Ø	PT.No. 281-0072-00 C111C, 211C, 111E, 211E
5910-99-140-5721	CAPACITOR, VARIABLE 1.3 pF - 5.4 pF ± 20%	1				*	Ø	PT.No. 281-0077-00 C378,
5910-99-140-5722	CAPACITOR, VARIABLE 0.2 pF - 1.5 pF ± 20%	2				*		PT.No. 281-0095-00 C377, 397
5910-99-140-5727	CAPACITOR, FIXED, CERAMIC DIELECTRIC 0.01 uF ± 20%, 250V	16				*		PT.No. 283-0079-00 C32,72,76, 123,131,162,171, 223,231,262,409, 414,417,483,863, 870
5910-99-140-5728	CAPACITOR, FIXED, CERAMIC DIELECTRIC 56 pF ± 10%, 200V	1				*		PT.No. 283-0095-00 C367
5910-99-140-5731	CAPACITOR, FIXED, PAPER DIELECTRIC 0.01 uF ± 20%, 200V	2				*		PT.No. 285-0569-00 C622, 882
5910-99-140-5732	CAPACITOR, FIXED, PAPER DIELECTRIC 0.1 uF ± 20%, 100V	5				*		PT.No. 285-0622-00 C130,200,230, 714,914
5910-99-140-5733	CAPACITOR, FIXED, PAPER DIELECTRIC 0.47 uF ± 20% 100V	2				*		PT.No. 285-0623-00 C615-821
5910-99-140-5734	CAPACITOR, FIXED, PAPER DIELECTRIC 0.0015 uF ± 20%, 100V	1				*		PT.No. 285-0626-00 C903

1	2	3	4	5	6	7	8	9
110C								
5910-99-140-5735	CAPACITOR, FIXED, PAPER DIELECTRIC 0.047 uF ± 20%, 100V	1				*		PT.No. 285-0629-00 C186
5910-99-140-5736	CAPACITOR, FIXED, PAPER DIELECTRIC 0.033 uF ± 20%, 600V	4				*		PT.No. 285-0644-00 C610, 701, 740,741
5910-99-140-5738	CAPACITOR SET matched set of 5 capacitors .001uF,0.01uF,0.1uF,1uF,10uF	2				*	Ø	PT.No. 295-0082-00 C160 F-K C260 F-K
110CV								
5961-00-018-1179	TRANSISTOR	32				5	Ø	PT.No. 151-0103-00 Q44A,B,84A, B,114,123,133, 173B,204,223,233 273,313,343, 345,355,374, 383,483,593, 653,659,663,683, 689,723,733,804, 814A,B,924,935
5961-00-018-1180	TRANSISTOR	6				2	Ø	PT.No. 151-0133-00 Q23B,195A, B,219,373,393
5961-00-045-4196	SEMICONDUCTOR, DEVICE, DIODE	57				11		PT.No. 152-0141-00 D33,44A,B, 45A,B,73/4, 84A,B,85A,B, 104,113/4,118, 133,155,157,158, 163,180/1,183, 193,200,219,233, 255,257,258,263, 273,293,321,344, 346,347,360,363, 371,387,669,699, 739,811,815/7, 873,884,886,891, 932,933,942/3, 948
5961-00-051-4719	DIODE	8				2		PT.No. 152-0113-00 D642A,B,C,D D672,A,B,C,D

1	2	3	4	5	6	7	8	9
110CV								
5961-00-051-5975	TRANSISTOR	4				2	Ø	PT.No. 151-0126-00 Q644,674,714,910
5961-00-070-7609	SEMICONDUCTOR DEVICE, DIODE	2				2		PT.No. 152-0151-00 D214A,B
5961-00-078-0628	SEMICONDUCTOR DEVICE, DIODE	1				1	Ø	PT.No. 152-0124- 00 D609,
5961-00-226-8581	TRANSISTOR	2				1		PT.No. 151-0131-00 Q54,94
5960-00-230-5321	VALVE, ELECTRONIC	5				3	Ø	PT.No. 154-0051-00 V822,832,842,852, 862
5961-00-710-2771	SEMICONDUCTOR DEVICE, DIODE	9				4	Ø	PT.No. 152-0065-00 D302,305,309,312,322,325,329,332,392
5961-00-713-7393	SEMICONDUCTOR DEVICE, DIODE	1				1	Ø	PT.No. 152-0034-00 D343,
5961-00-724-2136	TRANSISTOR	1				1		PT.No. 151-0113-00 Q637
5961-00-724-2138	TRANSISTOR	1				1		PT.No. 151-0140-00 Q697
5960-00-755-0184	VALVE, ELECTRONIC	4				3		PT.No. 154-0306-00 V33,73,161,261
5961-00-759-9393	TRANSISTOR	3				1		PT.No. 151-0096-00 Q184,623,633
➤ 5961-00-781-6825	TRANSISTOR	15				4		PT.No. 151-0108-00 Q14A,B,23A,124,134A,B,173A,224,234,324,344,364,390,883,894
5961-00-837-9286	DIODE	1				1	Ø	PT.No. 152-0135-00 D714
5961-00-849-4186	SEMICONDUCTOR DEVICE, DIODE	1				1	Ø	PT.No. 152-0291-00 ◄
5961-00-855-3997	TRANSISTOR	2				1		PT.No. 151-0112-00 Q667,820
5961-00-857-1914	SEMICONDUCTOR DEVICE, DIODE	1				1	Ø	PT.No. 152-0060-00 D397,
5961-00-865-9229	SEMICONDUCTOR DEVICE, DIODE	3				2	Ø	PT.No. 152-01233-00 D340,341,407

1	2	3	4	5	6	7	8	9
110CV								
5961-00-879-7448	TRANSISTOR	14				4		PT.No. 151-0109-00 Q154,164,174,184,254,264,274,284,304,314,324,334,434,444
5961-00-900-6703	TRANSISTOR	3				1		PT.No. 151-0107-00 Q64,154,254
5961-00-905-6871	SEMICONDUCTOR DEVICE, DIODE	9				4		PT.No. 152-0061-00 D125,225,395,396,611,872,874,944,947
5961-00-908-7598	SEMICONDUCTOR DEVICE, DIODE	14				5	Ø	PT.No. 152-0075-00 D44C,D, 84C,D,133,192,193 233,292,293,348,358,369,391
5961-00-914-3329	SEMICONDUCTOR DEVICE, DIODE	1				1	Ø	PT.No. 152-0126-00 D374
5960-00-920-7941	VALVE, ELECTRONIC	2				2	Ø	PT.No. 152-0161-00 D159,259
5960-00-920-7942	VALVE, ELECTRONIC	1				1	Ø	PT.No. 154-0448-00 V859
5960-00-920-7996	VALVE, ELECTRONIC	2				2		PT.No. 157-0080-00 V133,233
5961-00-923-9763	SEMICONDUCTOR DEVICE, DIODE	9				4		PT.No. 152-0066-00 D612A,B,C,D,702,737,742,743,745
5961-00-923-9772	SEMICONDUCTOR DEVICE, DIODE	5				3		PT.No. 152-0125-00 D55,95,105,125,225
5961-00-923-9773	SEMICONDUCTOR DEVICE, DIODE	9				4		PT.No. 152-0153-00 D56,57,96,102,103,120,121,220,221
5961-00-923-9775	TRANSISTOR	10				3	Ø	PT.No. 151-0127-00 Q164,264,423,433,444,454,464A B,474A,B

1	2	3	4	5	6	7	8	9
110CV								
5961-00-923-9776	TRANSISTOR	12				3		PT.No. 151-0120 00 Q413,423,454, 464,504,514,523, 533,554,564,574, 584
5961-00-923-9777	SEMICONDUCTOR DEVICE SET (Matched Pair)	1				1	Ø	PT.No. 153-0524-00 Q484,494
5961-00-923-9778	TRANSISTOR	3				1	Ø	PT.No. 151-0104-00 Q214,614,803
5961-00-927-2932	TRANSISTOR	5				2	Ø	PT.No. 151-0124-00 Q374,394, 873,874,945,
5961-00-965-6721	SEMICONDUCTOR DEVICE, DIODE	4				3		PT.NO. 152-0045-00 D30, 31, 70, 71
5961-00-968-0084	TRANSISTOR	5				2	Ø	PT.No. 151-0087-00 Q43,83,183 295A,B
5961-00-989-2434	SEMICONDUCTOR DEVICE, DIODE	2				2		PT.No. 152-0002-00 D870,871
5961-99-037-4910	TRANSISTOR CV 7528 Q637							
5961-99-116-5752	TRANSISTOR	1				1		PT.No. 151-0125-00 Q693
5961-99-116-5753	SEMICONDUCTOR DEVICE, DIODE	1				1		PT.No. 152-0096-00 D636
5961-99-116-5754	SEMICONDUCTOR DEVICE, DIODE	1				1		PT.No. 152-0119-00 D804
5961-99-116-5755	SEMICONDUCTOR DEVICE, DIODE	1				1		PT.No. 152-0133-00 D736
5961-99-118-3882	SEMICONDUCTOR DEVICE, DIODE	3				1	Ø	PT.NO. 152-0134-00 D716
5961-99-140-5647	TRANSISTOR	1				1		PT.No. 151-0209-00 Q737
5960-99-197-7928	SEMICONDUCTOR DEVICE, DIODE	1				1		PT.No. 152-0290-00 D820
110F								
5930-00-051-2205	SWITCH, ROTARY	3				*		PT.No. 260-0472-00 SW30C,70B,C
5930-00-833-4653	SWITCH, LEVER	2				*		PT.No. 260-0492-00 SW101,201
5930-00-833-4654	SWITCH, ROTARY	1				*		PT.No. 260-0523-00 SW540

1	2	3	4	5	6	7	8	9
110F								
5930-00-833-4655	SWITCH, ROTARY	1				*		PT.No. 260-0524-00 SW350
5930-00-920-3670	SWITCH, LEVER	1				*		PT.No. 260-0640-00 SW70A
5930-00-937-0872	SWITCH, SLIDE	2				*		PT.No. 260-0447-00 SW190,290
5930-99-116-5757	SWITCH, LEVER	1				*		PT.No. 260-0564-00 SW30A
5930-99-116-5758	SWITCH. ROTARY	2				*		PT.No. 262-0566-00 SW110,210
5930-99-140-5411	SWITCH, TOGGLE	1				*		PT.No. 260-0515-00 SW601
5930-99-140-5412	SWITCH, PUSH	2				*		PT.No. 260-0516-00 SW360,458
5930-99-140-5413	SWITCH, PUSH	1				*		PT.No. 260-0518-00 SW201,B186
5930-99-140-5414	SWITCH, LEVER	1				*		PT.No. 260-0519-00 SW30B
5930-99-140-5415	SWITCH, ROTARY	1				*		PT.No. 260-0545-00 SW116
5930-99-140-5416	SWITCH, ROTARY	1				*		PT.No. 262-0569-02 SW948
5930-99-140-5717	SWITCH, ROTARY	2				*	Ø	PT.No. 262-0567-00 SW160A,B
5930-99-140-5718	SWITCH, ROTARY	1				*		PT.No. 262-0568-00 SW300A,B
5930-99-140-5800	SWITCH	2				*		PT.No. 311-0385-00 SW144,R144, SW244,R244
5340-99-140-6110	ROD, EXTENSION SWITCH	1				*		PT.No. 384-0293-00
110H								
5920-00-082-7561	FUSE 4 amp	1	1	2	3	6		PT.No. 159-0027-00 F602
5935-00-103-1696	CONNECTOR, RECEPTACLE	1				*		PT.No. 131-0299-00

1	2	3	4	5	6	7	8	9
110H								
5935-00-109-9850	SOCKET, PLUG-IN-ELECTRICAL	5				*		PT.No. 136-0101-00
5961-00-177-6535	TERMINAL, STUD	2				*		PT.No. 136-0235-00
5940-00-179-2819	TERMINAL CONNECTOR	4				*		PT.No. 131-0183-00
5999-00-224-4375	CAP ELECTRICAL	1	*			*		PT.No. 200-0015-00
5920-00-280-4960	FUSE 2 amp	1	1	2	3	6		PT.No. 159-0021-00 F820
5340-00-469-6192	CLIP	2				*		PT.NO. 344-0098-00
5920-00-538-3494	FUSE 3 amp	1	1	2	3	6		PT.No. 159-0005-00 F601
5935-00-665-6544	ADAPTOR,CONNECTOR	1	*			*		PT.No. 103-0033-00
5940-00-686-6057	TERMINAL POST	1				*		PT.No. 129-0035-00
6625-00-788-6815	TIP, TEST PROD	1				*		PT.No. 013-0052-00
5920-00-794-4158	FUSE HOLDER	2				*		PT.No. 352-0002-00
5935-00-832-4946	PLUG, PROBE	1	*			*		PT.No. 134-0044-00
5920-00-836-0763	FUSE 0.75 amp	2	1	2	3	8		PT.NO. 159-0042-00 F703, 743
6250-00-871-7347	HOLDER,GRATICULE LIGHT	2				*		PT.No. 352-0063-00
5935-00-892-9180	PLUG, ELECTRICAL	1						PT.No. 131-0572-00
5935-00-900-1236	CONNECTOR, RECEPTACLE	5				*		PT.No. 131-0106-00
5935-00-901-9702	CONNECTOR,PLUG,ELECTRICAL	1				*		PT.No. 131-0274-00
5920-00-933-5439	FUSE 0.5 amp	1	1	2	3	6		PT.No. 159-0025-00 F613
5940-00-937-0882	TERMINAL BOARD	27				*		PT.No. 124-0145-00
5940-00-937-0883	TERMINAL BOARD	8				*		PT.No. 124-0146-00
5940-00-937-0884	TERMINAL STRIP	6				*		PT.No. 124-0147-00

1	2	3	4	5	6	7	8	9
110H								
5940-00-937-0886	TERMINAL BOARD	6				*		PT.No. 124-0148-00
5961-00-969-9096	SOCKET	24				*		PT.No. 136-0095-00
5940-00-983-8310	CLIP, ELECTRICAL	2	*			*		PT.No. 344-0046-00
5935-99-116-5751	SOCKET, TRANSISTOR	82				*		PT.No. 136-0161-00
5935-99-116-5799	SOCKET, INDICATOR LIGHT	1				*		PT.No. 136-0160-00
5940-99-140-5398	TERMINAL,POST	3				*		PT.No. 129-0066-00
5935-99-140-5399	CONNECTOR	1				*		PT.No. 131-0097-00
5935-99-140-5401	CONNECTOR, ANODE	1				*		PT.No. 131-0301-00
5935-99-140-5643	CONNECTOR	2				*		PT.No. 131-0096-00
5935-99-140-5644	SOCKET, TUBE	3				*		PT.No. 136-0078-00
5935-99-140-5645	SOCKET	1				*		PT.No. 136-0117-00
5935-99-140-5646	SOCKET, CRYSTAL	1				*		PT.No. 136-0153-00
5910-99-140-6042	HOLDER CAPACITOR	5				*		PT.No. 352-0066-00
5920-99-140-6044	HOLDER, FUSE, TRIPLE	1				*		PT.No. 352-0073-00
110 HS								
6625-00-771-5495	LEAD, TEST	1	*			*		PT.No. 175-0263-01
6625-00-850-2104	CABLE ASSEMBLY	1	*			*		PT.No. 175-0262-01
► 6625-00-060-9051	CABLE ASSEMBLY, POWER ELECTRICAL	1						PT.No. 161-0024-03 ◄

1	2	3	4	5	6	7	8	9
110HS								
6625-00-916-8025	CABLE ASSEMBLY	1	*			*		PT.No. 012-0076-00
5995-00-978-8538	LEAD, ELECTRICAL	1	*			*		PT.No. 175-0124-00
► 6625-01-016-8693	LEAD, ELECTRICAL, TEST 12in lg	1	*			*		PT.No. 175-0125-00 ◄
110K								
5950-00-014-5742	TRANSFORMER, POWER STEP-UP AND STEP-DOWN	1				*		PT.No. 120-0339-00 T601
5950-00-855-3990	TRANSFORMER, POWER, STEP-UP	1				*		PT.No. 120-0332-00 T820
5950-00-865-0260	INDUCTOR, AUDIO FREQUENCY							PT.No. 120-0273-00 T371,390
110P								
6625-99-116-6377	FILTER LINE ASSEMBLY	1				*		PT.No. 050-0503-00 T600, C601, C602, C603
110Q								
5950-00-850-2114	COIL, VARIABLE 0.15 uH to 0.25 uH	1	*			*		PT.No. 114-0153-00 L103
5950-00-850-2121	COIL, VARIABLE 0.6 uH to 1.1 uH	1	*			*		PT.No. 114-0156-00 L104
110S								
6625-00-798-1508	TIP, TEST PROD, STRAIGHT	1	*			*		PT.No. 206-0015-00
6625-00-798-1515	TIP, TEST PROD	1						PT.No. 013-0071-00
6625-00-830-5719	TIP, TEST PROD	1	*			*		PT.No. 134-0013-00
6625-00-964-9327	TIP, TEST PROD	1	*			*		PT.No. 206-0105-00
6625-00-983-6437	TIP, TEST PROD	1	*			*		PT.No. 206-0060-00
110W								
5905-00-010-5383	RESISTOR, VARIABLE 500 ohms	1				*	Ø	PT.No. 311-0380-00 R731
5905-00-063-6851	RESISTOR, FIXED, WIREWOUND 0.5 ohms ± 1%, 1W	1				*	Ø	PT.No. 308-0087-00 R649

1	2	3	4	5	6	7	8	9
110W								
5905-00-070-5852	RESISTOR, FIXED, COMPOSITION 27K ohms ± 10%, 1/2W	1				*		PT.No. 302-0273-00 R693
5905-00-070-5854	RESISTOR, FIXED, COMPOSITION 2.7M ohms ± 10%, 1/2W	1				*		PT.No. 302-0275-00 R845
5905-00-072-8055	RESISTOR, VARIABLE 5K ohms	1				*		PT.No. 311-0458-00 R865
5905-00-102-2444	RESISTOR, FIXED, COMPOSITION 47K ohms ± 10%, 1W	1				*		PT.No. 304-0473-00 R702
5905-00-102-5294	RESISTOR, FIXED, COMPOSITION 100 ohms ± 5%, 1/4W	6				*		PT.No. 315-0101-00 R10,11,122, 222,341,351
5905-00-104-8581	RESISTOR, FIXED, COMPOSITION 14.7K ohms ± 1%, 1W	1						PT.No. 324-0305-00 R195 (11B2)
5905-00-104-8582	RESISTOR FIXED, COMPOSITION 19.6K ohms ± 1%, 1W	2				*		PT.No. 324-0317-00 R360,886
5905-00-106-1317	RESISTOR, FIXED, COMPOSITION 1M ohms ± 1%, 1/4W	2				*	Ø	PT.No. 322-0481-01 R104E, 204E,
5905-00-111-8454	RESISTOR, VARIABLE 1K ohms	1				*	Ø	PT.No. 311-0404-00 R160W
5905-00-135-3973	RESISTOR, FIXED, COMPOSITION 220 ohms ± 5%, 1/4W	3				*		PT.No. 315-0221-00 R390,391,425
5905-00-171-1997	RESISTOR, FIXED, COMPOSITION 330 ohms ± 10%, 1/2W	1				*		PT.No. 302-0331-00 R622
5905-00-190-8867	RESISTOR, FIXED, COMPOSITION 5.1K ohms ± 5%, 2W	1				*		PT.No. 305-0512-00 R73
5905-00-192-3979	RESISTOR, FIXED, COMPOSITION 33K ohms 10%, 2W	1				*	Ø	PT.No. 306-0333-00 R873
5905-00-192-3982	RESISTOR, FIXED, COMPOSITION 1M ohms ± 10%, 1/2W	5				*		PT.No. 302-0105-00 R30C,70C, 601,838,854
5905-00-192-3987	RESISTOR, FIXED, COMPOSITION 100K ohms ± 10%, 1/2W	2				*	Ø	PT.No. 301-0104-00 R397,856
5905-00-196-4533	RESISTOR, FIXED, COMPOSITION Not known	2						PT.No. 302-0100-00 R837 R946
5905-00-247-2661	RESISTOR, FIXED, WIREWOUND 35 ohms ± 5%, 3W	1				*		PT.No. 308-0223-00 R736
5905-00-249-1555	RESISTOR, FIXED, WIREWOUND 0.3 ohms ± 10%, 2W	1				*		PT.No. 308-0244-00 R679
5905-00-252-1671	RESISTOR, FIXED, COMPOSITION 2.2M ohms ± 10%, 1/4W	1				*		PT.No. 316-0225-00 R186

1	2	3	4	5	6	7	8	9
110W								
5905-00-279-1749	RESISTOR, FIXED, COMPOSITION 6.2M ohms ± 5%, 1/2W	1				*		PT.No. 301-0625-00 R214
5905-00-299-2019	RESISTOR, FIXED, COMPOSITION 22K ohms ± 10%, 1W	2				*	Ø	PT.No. 304-0223-00 R168,808
5905-00-299-2031	RESISTOR, FIXED, COMPOSITION 8.2K ohms ± 10%, 1W	1				*		PT.No. 304-0822-00 R343
5905-00-405-7972	RESISTOR, FIXED, COMPOSITION 909 ohms ± 1%, 1/8W	1				*		PT.No. 321-0189-00 R194
5905-00-426-7707	RESISTOR, FIXED, COMPOSITION 2k ohms ± 1%, 1/8W	2				*		PT.No. 321-0222-00 R111E, 211E
5905-00-426-7708	RESISTOR, FIXED, COMPOSITION 2.05K ohms ± 1%, 1/8W	4				*		PT.NO. 321-0223-00 R178, 188, 278, 288
5905-00-426-7723	RESISTOR, FIXED, COMPOSITION 2.37K ohms ± 1%, 1/8W	1				*		PT.No. 321-0229-00 R112
5905-00-426-7754	RESISTOR, FIXED, COMPOSITION 3.32K ohms ± 1%, 1/8W	2				*		PT.No. 321-0243-00 R123, 223
5905-00-426-7783	RESISTOR, FIXED, COMPOSITION 3.83K ohms ± 1%, 1/8W	2				*		PT.No. 321-0249-00 R347, 357
5905-00-426-7791	RESISTOR, FIXED, COMPOSITION 5.11K ohms ± 1%, 1/8W	1				*		PT.No. 321-0261-00 R294
5905-00-434-5053	RESISTOR, FIXED, COMPOSITION 1.21K ohms ± 1%, 1/8W	3				*	Ø	PT.No. 321-0201-00 R252, 318, 338
5905-00-434-5059	RESISTOR, FIXED, COMPOSITION 1K ohms ± 1%, 1/8W	3				*		PT.No. 321-0193-00 R112E,212E, 308
5905-00-434-5068	RESISTOR, FIXED, COMPOSITION 10K ohms ± 1%, 1/8W	2				*		PT.No. 321-0289-00 R373,545
5905-00-434-5438	RESISTOR, FIXED, COMPOSITION 10 ohms ± 5%, 1/4W	1				*		PT.No. 315-0100-00 R485
5905-00-434-5439	RESISTOR, FIXED, COMPOSITION 1K ohms ± 5%, 1/4W	1				*		PT.No. 315-0102-00 R40
5905-00-434-5442	RESISTOR, FIXED, COMPOSITION 10K ohms ± 5%, 1/4W	4				*		PT.No. 315-0103-00 R195, 197, 295, 297
5905-00-436-9382	RESISTOR, FIXED, COMPOSITION 2.7K ohms ± 5%, 1/4W	1				*		PT.No. 315-0272-00 R926
5905-00-436-9764	RESISTOR, FIXED, COMPOSITION 2.4K ohms ± 5%, 1/4W	2				*		PT.No. 315-0242-00 R64, 462
5905-00-436-9789	RESISTOR, FIXED, COMPOSITION 27 ohms ± 5%, 1/4W	3				*		PT.No. 315-0270-00 R314,334,595

1	2	3	4	5	6	7	8	9
110W								
► 5905-00-437-0051	RESISTOR, FIXED, COMPOSITION 4.7K ohms ± 5%, 1/4W	3				*	Ø	PT.No. 315-0472-00 R151,442,452
5905-00-437-0272	RESISTOR, FIXED, COMPOSITION 51 ohms ± 5%, 1/4W	4				*		PT.No. 315-0510-00 R134, 199, 234, 299
5905-00-437-0833	RESISTOR, FIXED, COMPOSITION 33 ohms ± 5% 1/4W	4				*		PT.No. 315-0331-00 R112D,212D
5905-00-437-0891	RESISTOR, FIXED, COMPOSITION 47 ohms ± 5%, 1/4W	4				*		PT.No. 315-0470-00 R102,202,109D 209D
5905-00-437-0896	RESISTOR, FIXED, COMPOSITION 1K ohms ± 10%, 1/4W	3				*		PT.No. 316-0102-00 R204,218,871
5905-00-437-0908	RESISTOR, FIXED, COMPOSITION 2.2K ohms ± 10%, 1/4W	3				*		PT.No. 316-0222-00 296C,806,914
5905-00-437-0913	RESISTOR, FIXED, COMPOSITION 68 ohms ± 5%, 1/4W	1				*	Ø	PT.NO. 315-0680-00 R456B
5905-00-437-0917	RESISTOR, FIXED, COMPOSITION 750 ohms ± 5%, 1/4W	4				*	Ø	PT.No. 315-0751-00 R23, 176,274 407
5905-00-437-0942	RESISTOR, FIXED, COMPOSITION 68K ohms ± 10%, 1/4W	5				*		PT.No. 316-0683-00 R43,83,653, 931, 941
5905-00-437-1780	RESISTOR, FIXED, COMPOSITION 470 ohms ± 5%, 1/4W	3				*		PT.No. 316-0471-00 R26, 32, 72, 104, 177, 341
5905-00-437-1782	RESISTOR, FIXED, COMPOSITION 4.7K ohms ± 10%, 1/4W	7				*		PT.No. 316-0472-00 R24,25,75A, 75C,136,202,916
5905-00-445-3708	RESISTOR, FIXED, COMPOSITION 18K ohms ± 5%, 1/4W	1				*		PT.No. 315-0183-00 R426
5905-00-445-3739	RESISTOR, FIXED, COMPOSITION 2K ohms ± 5%, 1/4W	5				*		PT.No. 315-0202-00 R54, 94, 392, 882, 924
5905-00-445-3781	RESISTOR, FIXED, COMPOSITION 1.1K ohms ± 5%, 1/4 W	2				*		PT.No. 315-0112-00 R127, 227
5905-00-445-3801	RESISTOR, FIXED, COMPOSITION 12 ohms ± 5%, 1/4 W	1				*		PT.No. 315-0120-00 R286
5905-00-445-3826	RESISTOR, FIXED, COMPOSITION 12K ohms ± 5%, 1/4W	3				*		PT.No. 315-0123-00 R123, 223 293 ◄

1	2	3	4	5	6	7	8	9
110W								
➤ 5905-00-445-3831	RESISTOR, FIXED, COMPOSITION 1.5K ohms ± 5%, 1/4 W	2				*		PT.No. 315-0152-00 R367, 382
5905-00-469-2916	RESISTOR, FIXED, COMPOSITION 10 ohms ± 10%, 1/4W	7				*		PT.No. 316-0100-00 R19, 47, 87, 119,170,219,271
5905-00-472-6188	RESISTOR, FIXED, COMPOSITION 39K ohms ± 10%, 1/2W	1				*		PT.No. 302-0393-00 R183
5905-00-475-8262	RESISTOR, FIXED, COMPOSITION 4.75K ohms ± 1%, 1/8W	3				*		PT.No. 321-0258-00 R118,120,220 ◄
5905-00-476-0080	RESISTOR, VARIABLE 500 ohms	2				*	Ø	PT.No. 311-0095-00 R331, 456D
5905-00-476-0094	RESISTOR, VARIABLE 2 x 200 ohms	1				*	Ø	PT.No. 311-0379-00 R414A,B
5905-00-476-5759	RESISTOR, FIXED, COMPOSITION 1M ohms ± 1%, 1/2W	4				**	Ø	PT.No. 323-0481-00 R113C, 114, 213C,214
5905-00-476-5763	RESISTOR, FIXED, COMPOSITION 50K ohms ± 1%, 1/2W	1				*		PT.No. 323-0636-00 R948X
5905-00-476-5790	RESISTOR, FIXED, COMPOSITION 121 ohms ± 1%, 1/2W	2				*	Ø	PT.No. 323-0105-00 R444,454
➤ 5905-00-496-9488	RESISTOR, FIXED, COMPOSITION 3.3K ohms ± 5%, 1/4W	5				*		PT.No. 315-0332-00 R82B, 82C, 342, 352, 374 ◄
5905-00-497-0809	RESISTOR, VARIABLE Not known	2				*	Ø	PT.NO. 311-0402-01 SW160V, R10V, SW260V, R260V
5905-00-504-4702	RESISTOR, FIXED, COMPOSITION 82K ohms ± 5%, 1/4W	2				*		PT.No. 315-0823-00 R143, 243
5905-00-577-9598	RESISTOR, FIXED, COMPOSITION 150 ohms ± 5%, 1/4W	6				*	Ø	PT.No. 315-0151-00 R132,232 421,466,476,487
5905-00-577-9666	RESISTOR, FIXED, COMPOSITION 15K ohms ± 5%, 1/2W	3				*		PT.No. 315-0153-00 R129,229, 365
➤ 5905-00-577-9676	RESISTOR, FIXED, COMPOSITION 8.2K ohms ± 5%, 1/4W	2				*	Ø	PT.No. 315-0822-00 R42A, 456F
5905-00-581-6481	RESISTOR, FIXED, COMPOSITION 270K ohms ± 10%, 1/2W	2				*		PT.No. 302-0274-00 R365,366
5905-00-682-4099	RESISTOR, FIXED, COMPOSITION 4.3K ohms ± 5%, 1/4W	1				*		PT.No. 315-0432-00 R812 ◄

1	2	3	4	5	6	7	8	9
110W								
► 5905-00-688-3474	RESISTOR, FIXED, COMPOSITION 27 ohms ± 10%, 1/2W	1				*		PT.No. 302-0270-00 R745
5905-00-724-5713	RESISTOR, FIXED, COMPOSITION 1.3K ohms ± 1%, 1/4W	2				*		PT.NO. 321-0204-00 R317, 337 ◄
5905-00-725-9141	RESISTOR, FIXED, WIREWOUND 0.25 ohms ± 10%, 1W	1				*		PT.No. 308 0090-00 R949
5905-00-726-5340	RESISTOR, FIXED, COMPOSITION 100 ohms ± 10%, 1/4W	16				*	Ø	PT.No. 316-0101-00 R61,115,132, 156,158,198,215, 232,256,258,270, 611,694,809,819, 870
5905-00-727-3569	RESISTOR, FIXED, COMPOSITION 3.9M ohms ± 10%, 2W	4				*		PT.No. 306-0395-00 R840, 841, 842,843,
5905-00-728-3217	RESISTOR, VARIABLE 2 X 10K ohms ± 10%	3				*	Ø	PT.No. 311-0389-00 R196,296,441
5905-00-732-4188	RESISTOR, FIXED, WIRE WOUND 20K ohms ± 5%, 10W	1				*		PT.No. 308-0025-00 R947
5905-00-754-5750	RESISTOR, VARIABLE 5K ohms	1				*		PT.No. 311-0011-00 R897
5905-00-789-5945	RESISTOR, VARIABLE 2K ohms	1				*		PT.No. 311-0386-00 R211
5905-00-794-3697	RESISTOR, FIXED, COMPOSITION 47 ohms ± 10%m,1/4W	17				*		PT.No. 316-0470-00 R27,30D,31, 46,70D,71,86, 160R, 161,171, 176,260R,261,876 892,893,923
5905-00-794-3698	RESISTOR, FIXED, COMPOSITION 1M ohms ± 10%, 1/4W	2				*		PT.No. 316-0105-00 R815, 825
5905-00-801-0443	RESISTOR, FIXED, COMPOSITION 120K ohms ± 5%, 1/4W	1				*		PT.No. 315-0124-00 R180
5905-00-813-5968	RESISTOR, VARIABLE 100 ohms	3				*		PT.No. 311-0169-00 R138,238,334
5905-00-816-3350	RESISTOR, VARIABLE 5M ohms ± 20%, 0.2W	1				*		PT.No. 311-0121-00 R844
5905-00-825-9572	RESISTOR, VARIABLE 5K ohms	1				*		PT.No. 311-0117-00 R181
5905-00-839-4857	RESISTOR, FIXED, COMPOSITION 115K ohms ± 1%, 1/2W	1				*	Ø	PT.No. 323-0391-00 R669

1	2	3	4	5	6	7	8	9
110W								
5905-00-842-9545	RESISTOR, FIXED, COMPOSITION 15K ohms ± 5%, 1/2W	1				*		PT.No. 301-0153-00 R367
5905-00-850-2126	RESISTOR, VARIABLE 1K ohms	1	*			*		PT.No. 311-0249-00 R104
5905-00-851-1486	RESISTOR, VARIABLE 2 X 500K ohms	1				*	Ø	PT.No. 311-0400-00 R364
5905-00-851-2120	RESISTOR, FIXED, COMPOSITION 700 ohms ± 1%, 20W	2				*	Ø	PT.No. 310-0608-00 R484,A,B,
5905-00-851-2122	RESISTOR, FIXED, COMPOSITION 4K ohms ± 1%, 2W	2				*	Ø	PT.No. 310-0609-00 R481,491
5905-00-851-2123	RESISTOR, FIXED, COMPOSITION 970 ohms ± 1%, 2W	4				*		PT.No. 310-0610-00 R467,468,477, 478
5905-00-856-9615	RESISTOR, FIXED, COMPOSITION 20.4K ohms ± 1%, 1/8W	2				*		PT.No. 321-0615-00 R108E, 208E
5905-00-856-9636	RESISTOR, FIXED, COMPOSITION 998K ohms ± 1%, 1/4W	2				*	Ø	PT.No. 322-0628-00 R11C,211C
5905-00-863-6240	RESISTOR, FIXED, COMPOSITION 250K ohms ± 1%, 1/8W	2				*		PT.No. 321-0618-00 R105E, 205E
5905-00-863-6242	RESISTOR, FIXED, COMPOSITION 801 ohms ± 1%, 1/4W	2					Ø	PT.No. 323-0633-00 R417,R948E
5905-00-865-0275	RESISTOR, FIXED, COMPOSITION 67 ohms ± 1%, 4W	2				*		PT.No. 310-0606-00 R494,496
5905-00-873-6919	RESISTOR, FIXED, COMPOSITION 10K ohms ± 10%, 1/4W	7				*		PT.No. 316-0103-00 R207,804,814, 921,933,943
5905-00-873-6934	RESISTOR, FIXED, COMPOSITION 1M ohms ± 5%, 1/2W	4				*		PT.No. 301-0105-00 R30A,70B,118, 218
5905-00-873-6939	RESISTOR, FIXED, COMPOSITION 560K ohms ± 5%, 1/2W	1				*		PT.No. 301-0564-00 R817
5905-00-879-7815	RESISTOR, FIXED, COMPOSITION 1.4K ohms ± 1%, 1/8W	2				*		PT.No. 321-0207-00 R190,290
5905-00-887-4441	RESISTOR, VARIABLE 250 ohms	2				*	Ø	PT.No. 311-0378-00 R661,691
5905-00-887-4442	RESISTOR, VARIABLE "A" 1K ohms "B" 5K ohms, 2W	1				*		PT.No. 311-0401-00 R350A,B
5905-00-890-9372	RESISTOR, VARIABLE R861 2x1K ohms, R864 100K ohms	1				*		PT.No. 311-0412-00 R861, 864

1	2	3	4	5	6	7	8	9
110W								
5905-00-890-9377	RESISTOR, VARIABLE 10K ohms	1				*		PT.No. 311-0405-00 R150
5905-00-890-9395	RESISTOR, VARIABLE 5K ohms	1				*		PT.No. 311-0272-00 R41,81
5905-00-893-1240	RESISTOR, FIXED, COMPOSITION 52.6K ohms ± 1%, 1/8W	2				*		PT.No. 321-0616-00 R107E, 207E
5905-00-893-1242	RESISTOR, FIXED, COMPOSITION 10.1K ohms ± 1%, 1/8W	2				*		PT.No. 321-0614-00 R109E,209E
5905-00-893-1243	RESISTOR, FIXED, COMPOSITION 995K ohms ± 1%, 1/4W	2				*	Ø	PT.No. 322-0625-00 R110C, 210C
5905-00-893-1286	RESISTOR, FIXED, COMPOSITION 111K ohms ± 1%, 1/8W	2				*		PT.No. 321-0617-00 R106E, 206E
5905-00-893-1289	RESISTOR, FIXED, COMPOSITION 205 ohms ± 1%, 1/8W	2				*		PT.No. 321-0127-00 R554,564
5905-00-893-1290	RESISTOR, FIXED, COMPOSITION 100 ohms ± 1%, 1/8W	7				*	Ø	PT.No. 321-0097-00 R159,259,272, 282,333,465,475
5905-00-893-1292	RESISTOR, FIXED, COMPOSITION 46.4 ohms ± 1%, 1/8W	2				*		PT.No. 321-0065-00 R550,560
5905-00-900-1112	RESISTOR, FIXED, COMPOSITION 5.03K ohms ± 1%, 1/8W	2				*		PT.No. 321-0613-00 R110E,210E
5905-00-902-5928	RESISTOR, FIXED, COMPOSITION 110 ohms ± 1%, 1/8W	1				*	Ø	PT.No. 321-0101-00 R15
➤ 5905-00-904-4397	RESISTOR, FIXED, COMPOSITION 6.81K ohms ± 1%, 1/8W	1				*		PT.No. 321-0273-00 R422 ◄
5905-00-906-6360	RESISTOR, FIXED, COMPOSITION 100K ohms ± 1%, 1/2W	1				*	Ø	PT.No. 323-0385-00 R699
5905-00-908-5410	RESISTOR, FIXED, COMPOSITION 1K ohms ± 10%, 1/2W	2				*		PT.No. 302-0102-00 R615,831
5905-00-909-1778	RESISTOR, FIXED, COMPOSITION 750 ohms ± 1%, 1/2W	3				*		PT.No. 323-0181-00 R532,574,584
5905-00-910-0763	RESISTOR VARIABLE 100 ohms	4				*	Ø	PT.No. 311-0258-00 R150,176,250, 276
➤ 5905-00-913-7117	RESISTOR, FIXED, COMPOSITION 12.1K ohms ± 1%, 1/8W	4				*		PT.No. 321-0297-00 R161,261,551, 561 ◄

1	2	3	4	5	6	7	8	9
110W								
5905-00-916-5598	RESISTOR, FIXED, COMPOSITION 90.9 ohms ± 1%, 1/4W	1				*	Ø	PT.No. 322-0093-00 R445
5905-00-916-8019	RESISTOR, FIXED, WIRE WOUND 1K ohms + 10%, 3W	2				*		PT.No. 308-0077-00 R130,230
5905-00-917-1870	RESISTOR, VARIABLE 10K ohms	2				*	Ø	PT.No. 311-0326-00 R7, 377
5905-00-917-4147	RESISTOR, FIXED, COMPOSITION 900K ohms ± 1%, 1/2W	2				*		PT.No. 323-0611-00 R106C, 206C
5905-00-917-4148	RESISTOR, FIXED, COMPOSITION 261 ohms ± 1%, 1/2W	4				*	Ø	PT.No. 323-0137-00 R457,458,467,, 468
5905-00-917-4149	RESISTOR, FIXED, COMPOSITION 221K ohms ± 1%, 1/2W	1				*	Ø	PT.No. 323-0418-00 R614
5905-00-919-3143	RESISTOR, FIXED, WIRE WOUND 15K ohms ± 5%, 8W	2				*	Ø	PT.No. 308-0178-00 R374,875
► 5905-00-928-3233	RESISTOR, FIXED, COMPOSITION 1.5M ohms ± 1%, 1/2W	1				*		PT.No. 323-0498-00 R800 ◄
5905-00-932-7016	RESISTOR, FIXED, COMPOSITION 500K ohms ± 1%, 1/4W	2				*		PT.No. 322-0610-00 R104C, 204C
5905-00-943-9071	RESISTOR, FIXED, COMPOSITION 120 ohms ± 10%, 1/2W	1				*		PT.No. 302-0121-00 R744
5905-00-943-9072	RESISTOR, FIXED, COMPOSITION 33K ohms ± 10%, 1/2W	4				*		PT.No. 302-0333-00 R623,633,723, 733
5905-00-943-9076	RESISTOR, FIXED, COMPOSITION 47 ohms ± 10%, 1W	1				*		PT.No. 304-0470-00 R636
5905-00-974-6076	RESISTOR, FIXED, COMPOSITION 215 ohms ± 1%, 1/8W	4				*		PT.No. 321-0129-00 R157,167,257, 267,
5905-00-983-9317	RESISTOR, VARIABLE 100K ohms ± 20%, 5W	1				*		PT.No. 311-0110-00 R863
5905-99-116-2646	RESISTOR, FIXED, COMPOSITION 28.6 ohms ± 1%, 1/2W	1				*	Ø	PT.No. 323-0628-00 R948K
5905-99-116-4650	RESISTOR, FIXED, COMPOSITION 30.1 ohms ± 1%, 1/8W	2				*	Ø	PT.No. 321-0047-R404, 406
5905-99-116-4740	RESISTOR, FIXED, COMPOSITION 30 ohms ± 5%, 1/4W	2				*		PT.No. 351-0300-00 R113D, 213D
5905-99-116-4743	RESISTOR, FIXED, COMPOSITION 4.7K ohms ± 5%, 1/2W	1				*		PT.No. 301-0472-00 R458

1	2	3	4	5	6	7	8	9
110W								
5905-99-116-4744	RESISTOR, FIXED, COMPOSITION 800K ohms ± 1%, 1/2W	2				*		PT.No. 323-0620-00 R105C, 205C
5905-99-116-5370	RESISTOR, FIXED, COMPOSITION 68.1 ohms ± 1%, 1/8W	4				*		PT.No. 321-0081-00 R174,184, 274,284
5905-99-116-5763	RESISTOR, FIXED, COMPOSITION 10 ohms ± 5%, 1/2W	2				*		PT.No. 301-0100-00 R469, 483
5905-99-116-5764	RESISTOR, FIXED, COMPOSITION 150 ohms ± 5%, 1/2W	1				*		PT.No. 301-0151-00 R483/10A2
5905-99-116-5765	RESISTOR, FIXED, COMPOSITION 120 ohms ± 5%, 1W	1				*		PT.No. 303-0121-00 R448
5905-99-116-5766	RESISTOR, FIXED, COMPOSITION 150 ohms ± 10%, 2W	1				*		PT.No. 306-0151-00 R820
5905-99-116-5767	RESISTOR, FIXED, COMPOSITION 1.3K ohms ± 5%, 1/4W	1				*		PT.No. 315-0132-00 R811
5905-99-116-5768	RESISTOR, FIXED, COMPOSITION 12K ohms ± 10%, 1/4W	1				*		PT.No. 316-0123-00 R805
5905-99-116-5769	RESISTOR, FIXED, COMPOSITION 3.3M ohms ± 10%, 1/4W	1				*		PT.No. 316-0335-00 R807
5905-99-116-5770	RESISTOR, FIXED, COMPOSITION 133 ohms ± 1%, 1/8W	2				*	Ø	PT.No. 321-0109-00 R450, 460
5905-99-116-5771	RESISTOR, FIXED, COMPOSITION 422 ohms ± 1%, 1/8W	2				*		PT.No. 321-0157-00 R415, 425
5905-99-116-5772	RESISTOR, FIXED, COMPOSITION 1.05K ohms ± 1%, 1/8W	1				*	Ø	PT.No. 321-0195-00 R456E
5905-99-116-5775	RESISTOR, FIXED, COMPOSITION 5.11K ohms ± 1/2%, 1/8W	1				*	Ø	PT.No. 321-0629-00 R453
5905-99-116-5777	RESISTOR, FIXED, COMPOSITION 619 ohms ± 1%, 1/4W	2				*		PT.No. 322-0173-00 R456,466
5905-99-116-5778	RESISTOR, FIXED, COMPOSITION 750 ohms ± 1%, 1/4W	2				*		PT.No. 322-0181-00 R345,355
5905-99-116-5779	RESISTOR, FIXED, COMPOSITION 866 ohms ± 1%, 1/4W	1				*	Ø	PT.No. 322-0187-00 R417
5905-99-116-5780	RESISTOR, FIXED, COMPOSITION 1K ohms ± 1%, 1/4W	1				*		PT.No. 322-0193-00 R481
5905-99-116-5781	RESISTOR, FIXED, COMPOSITION 1.1K ohms ± 1%, 1/4W	2				*		PT.No. 322-0197-00 R270,280

1	2	3	4	5	6	7	8	9
110W								
5905-99-116-5782	RESISTOR, FIXED, COMPOSITION 1.54K ohms ± 1%, 1/4W	4				*		PT.No. 322-0211-00 R158,168,258, 268
5905-99-116-5783	RESISTOR, FIXED, COMPOSITION 2.37K ohms ± 1%, 1/4W						Ø	PT.No. 322-0229-00 R895
5905-99-116-5784	RESISTOR, FIXED, COMPOSITION 999K ohms ± 1%, 1/4W	2				*		PT.No. 322-0629-00 R112C, 212C
5905-99-116-5785	RESISTOR, FIXED, COMPOSITION 1.4K ohms ± 1%, 1/2W	2				*	Ø	PT.No. 323-0207-00 R482, R492
5905-99-116-5786	RESISTOR, FIXED, COMPOSITION 1.62K ohms ± 1%, 1/8W	2				*		PT.No. 323-0213-00 R344,354
5905-99-116-5787	RESISTOR, FIXED, COMPOSITION 3.48K ohms ± 1%, 1/2W	2				*	Ø	PT.No. 323-0245-00 R480, 490
5905-99-116-5788	RESISTOR, FIXED, COMPOSITION 887K ohms ± 1%, 1/2W	1				*	Ø	PT.No. 323-0476-00 R803
5905-99-116-5789	RESISTOR, FIXED, COMPOSITION 600 ohms ± 1%, 1/2W	2				*	Ø	PT.No. 323-0607-00 R447, 457
5905-99-116-5790	RESISTOR, FIXED, COMPOSITION 990K ohms ± 1%, 1/2W	2				*	Ø	PT.No. 323-0614-00 R109C, 209C
5905-99-116-5791	RESISTOR, FIXED, COMPOSITION 980K ohms ± 1%, 1/2W	2				*	Ø	PT.No. 323-0621-00 R108C, 208C
5905-99-116-5792	RESISTOR, FIXED, COMPOSITION 21.4 ohms ± 1%	1				*	Ø	PT.No. 323-0627-00 R948L
5905-99-116-5793	RESISTOR, FIXED, COMPOSITION 43.1 ohms ± 1%, 1/2W	1				*	Ø	PT.No. 323-0629-00 R948J
5905-99-116-5794	RESISTOR, FIXED, COMPOSITION 72.4 ohms ± 1%, 1/2W	1				*	Ø	PT.No. 323-0630-00 R948H
5905-99-116-5795	RESISTOR, FIXED, COMPOSITION 146.1 ohms ± 1%, 1/2W	1				*	Ø	PT.No. 323-0631-00 R948G
5905-99-116-5796	RESISTOR, FIXED, COMPOSITION 452 ohms ± 1%, 1/2W	1				*	Ø	PT.No. 323-0632-00 R948F
5905-99-116-5797	RESISTOR, FIXED, COMPOSITION 1.789K ohms ± 1%, 1/2W	1				*	Ø	PT.No. 323-0634-00 R948D
5905-99-116-5798	RESISTOR, FIXED, COMPOSITION 6.667K ohms ± 1%, 1/2W	1				*	Ø	PT.No. 323-0635-00 R948C
5905-99-116-5813	RESISTOR, FIXED, COMPOSITION 100 ohms ± 1%, 1/4W	2				*		PT.No. 322-0097-00 R151, 251

1	2	3	4	5	6	7	8	9
110W								
5905-99-116-5815	RESISTOR, FIXED, COMPOSITION 27.4 ohms ± 1%, 1/4W	1				*	Ø	PT.No. 322-0043-00 R459
5905-99-116-5816	RESISTOR, FIXED, COMPOSITION 178 ohms ± 1%, 1/8W	4				*	Ø	PT.No. 321-0121-00 R171, 181, 410 411
5905-99-140-4613	RESISTOR, FIXED, COMPOSITION 4.02K ohms ± 1%, 1/8W	4					Ø	PT.No. 321-0251-00 R135,235,378, 379
5905-99-140-4620	RESISTOR, FIXED, COMPOSITION 10K ohms ± 1%, 1/2W	1				*	Ø	PT.No. 323-0289-00 R948B
5905-99-140-5739	RESISTOR, FIXED, COMPOSITION 1.1K ohms ± 5%, 1/2W	3				*		PT.No. 301-0112-00 R105,124,224,
5905-99-140-5741	RESISTOR, FIXED, COMPOSITION 18K ohms ± 5%, 1/2W	1				*		PT.No. 301-0183-00 R174
5905-99-140-5742	RESISTOR, FIXED, COMPOSITION 2.2K ohms ± 5%, 1/2W	2				*		PT.No. 301-0222-00 R373, 818
5905-99-140-5743	RESISTOR, FIXED, COMPOSITION 22K ohms ± 5%, 1/2W	3				*		PT.No. 301-0223-00 R63,853,894
5905-99-140-5744	RESISTOR, FIXED, COMPOSITION 27 ohms ± 5%, 1/2W	1				*	Ø	PT.No. 301-0270 00 R398
5905-99-140-5745	RESISTOR, FIXED, COMPOSITION 3.6K ohms ± 5%, 1/2W	1				*		PT.No. 301-0362-00 R75E
5905-99-140-5747	RESISTOR, FIXED, COMPOSITION 8.2K ohms ± 5%, 1/2W	1				*		PT.No. 301-0822-00 R393
5905-99-140-5748	RESISTOR, FIXED, COMPOSITION 9.1M ohms ± 5%, 1/2W	1				*		PT.No. 301-0915-00 R29
5905-99-140-5754	RESISTOR, FIXED, COMPOSITION 390 ohms ± 10%, 1/2W	1				*		PT.No. 302-0391-00 R14
5905-99-140-5756	RESISTOR, FIXED, COMPOSITION 47K ohms ± 10%, 1/2W	1				*		PT.No. 302-0473-00 R719
5905-99-140-5757	RESISTOR, FIXED, COMPOSITION 10K ohms ± 5%, 1W	1				*		PT.No. 303-0103-00 R76
5905-99-140-5758	RESISTOR, FIXED, COMPOSITION 15K ohms ± 5%, 1W	3				*		PT.No. 303-0153-00 R20,125,225
5905-99-140-5759	RESISTOR, FIXED, COMPOSITION 20 ohms ± 5%, 1W	2				*		PT.No. 303-0200-00 R410,411
5905-99-140-5760	RESISTOR, FIXED, COMPOSITION 220 ohms ± 5%, 1W	1				*		PT.No. 303-0221-00 R597

1	2	3	4	5	6	7	8	9
110W								
5905-99-140-5763	RESISTOR, FIXED, COMPOSITION 33K ohms ± 10%, 1W	2				*		PT.No. 304-0333-00 R607,610
5905-99-140-5766	RESISTOR, FIXED, COMPOSITION 2K ohms ±5%,2W	1				*		PT.No. 305-0202-00 R407
5905-99-140-5768	RESISTOR, FIXED, COMPOSITION 6.2K ohms ± 5%, 2W	1				*		PT.No. 305-0622-00 R874
5905-99-140-5769	RESISTOR, FIXED, COMPOSITION 6.8K ohms ± 5%, 2W	2				*		PT.No. 305-0682-00 R44,84
5905-99-140-5770	RESISTOR, FIXED, COMPOSITION 7.5K ohms ± 5%, 2W	1				*		PT.No. 305-0752-00 R268
5905-99-140-5771	RESISTOR, FIXED, COMPOSITION 9.1K ohms ± 5%, 2W	1				*		PT.No. 305-0912-00 R33
5905-99-140-5772	RESISTOR, FIXED, COMPOSITION 10M ohms ± 10%, 2W	4				*		PT.No. 306-0106-00 R826,827,828, 829
5905-99-140-5773	RESISTOR, FIXED, COMPOSITION 270 ohms ± 10%, 2W	1				*		PT.No. 306-0271-00 R663
5905-99-140-5774	RESISTOR, FIXED, COMPOSITION 4.7 ohms ± 10%, 1W	1				*		PT.No. 307-0009-00 R613
5905-99-140-5775	RESISTOR, FIXED, COMPOSITION 2.7 ohms ± 5%, 1/4W	2				*		PT.No. 307-0103-00 R409,414
5905-99-140-5778	RESISTOR, FIXED, WIREWOUND 20 ohms ± 5%, 5W	1				*		PT.No. 308-0123-00 R637
5905-99-140-5780	RESISTOR, FIXED, WIREWOUND 5 ohms ± 5%, 5W	1				*		PT.No. 308-0179-00 R703
5905-99-140-5783	RESISTOR, FIXED, WIREWOUND 1.37K ohms ± 1%, 1/2W	1				*	Ø	PT.No. 308-0254-00 R630
5905-99-140-5784	RESISTOR, FIXED, WIREWOUND 3.65K ohms ± 1%, 1/2W	1				*	Ø	PT.No. 308-0255-00 R690
5905-99-140-5785	RESISTOR, FIXED, WIREWOUND 5.11K ohms ± 1%, 1/2W	1				*	Ø	PT.No. 308-0257-00 R660
5905-99-140-5786	RESISTOR, FIXED, WIREWOUND 10.7K ohms ± 1%, 1W	1				*	Ø	PT.No. 308-0259-00 R632
5905-99-140-5787	RESISTOR, FIXED, WIREWOUND 13.3K ohms ± 10%, 1W	1				*		PT.No. 308-0260-00 R732,
5905-99-140-5788	RESISTOR, FIXED, WIREWOUND 15K ohms ± 1%, 1W	1				*	Ø	PT.No. 308-0261-00 R692

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110W								
5905-99-140-5789	RESISTOR, FIXED, WIREWOUND 15.4K ohms ± 1%, 1/2W	1				*	Ø	PT.No. 308-0263-00 R662
5905-99-140-5790	RESISTOR, FIXED, WIREWOUND 21.5K ohms ± 10%, 1W	1				*		PT.No. 308-0264-00 R730
5905-99-140-5791	RESISTOR, FIXED, WIREWOUND 20 ohms ± 10%, 5W	1				*		PT.No. 308-0279-00 R737
5905-99-140-5793	RESISTOR, FIXED, COMPOSITION 3.74M ohms ± 1%, 1/2W	2				*		PT.No. 309-0440-00 R160J, 260J
5905-99-140-5794	RESISTOR, FIXED, COMPOSITION 7.5M ohms ± 1%, 1/2W	2				*		PT.No. 309-0441-00 R160K, 260K
5905-99-140-5795	RESISTOR, FIXED, COMPOSITION 22.6M ohms ± 1%, 1/2W	1				*		PT.No. 309-0442-00 R160L/260L
5905-99-140-5796	RESISTOR, FIXED, WIREWOUND 8.8K ohms ± 1%, 10W	1				*		PT.No. 310-0615-00 R394
5905-99-140-5798	RESISTOR, VARIABLE 1K	4				*		PT.No. 311-0328-, 00 R260W, 335, 336, 339
5905-99-140-5799	RESISTOR, VARIABLE 50K	1				*		PT.No. 311-0329-00 R832
5905-99-140-5802	RESISTOR, VARIABLE 25K ohms	8				*		PT.No. 311-0390-00 R117, 140, 160, 217, 240, 260, 530, 546
5905-99-140-5804	RESISTOR, VARIABLE 20K ohms	1				*		PT.No. 311-0408-00 R801
5905-99-140-5805	RESISTOR, VARIABLE 1K	1				*	Ø	PT.No. 311-0421-00 R631
5905-99-140-5813	RESISTOR, FIXED, COMPOSITION 11K ohms ± 5%, 1/4 W	2				*		PT.No. 315-0113-00 R196, 296A
5905-99-140-5819	RESISTOR, FIXED, COMPOSITION 1.6K ohms ± 5%, 1/4W	2				*		PT.No. 315-0162-00 R113, 233
5905-99-140-5821	RESISTOR, FIXED, COMPOSITION 22 ohms ± 5%, 1/4W	2				*		PT.No. 315-0220-00 R111D, 211D
5905-99-140-5824	RESISTOR, FIXED, COMPOSITION 220K ohms ± 5%, 1/4W	1				*		PT.No. 315-0224-00 R371
5905-99-140-5828	RESISTOR, FIXED, COMPOSITION 27K ohms ± 5%, 1/4W	1				*		PT.No. 315-0273-00 R82A R321

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110W								
5905-99-140-5829	RESISTOR, FIXED, COMPOSITION 30 ohms ± 5%, 1/4W	1				*		PT.No. 315-0330-00 R387
5905-99-140-5831	RESISTOR, FIXED, COMPOSITION 33K ohms ± 5%, 1/4W	2				*		PT.No. 315-0333-00 R179, 275
5905-99-140-5832	RESISTOR, FIXED, COMPOSITION 3.9K ohms ± 5%, 1/4W	5				*	Ø	PT.No. 315-0392-00 R154,160C,254 260C, 531
5905-99-140-5833	RESISTOR, FIXED, COMPOSITION 39K ohms ± 5%, 1/4W	1				*		PT.No. 315-0393-00 R427
5905-99-140-5838	RESISTOR, FIXED, COMPOSITION 5.1K ohms ± 5%, 1/4W	2				*	Ø	234, 299 PT.No. 315-0512-00 R155,255
5905-99-140-5840	RESISTOR, FIXED, COMPOSITION 62 ohms ± 5%, 1/4W	2				*		PT.No. 315-0620-00 R110D,210D
5905-99-140-5841	RESISTOR, FIXED, COMPOSITION 620 ohms ± 5%, 1/4W	2				*		PT.No. 315-0621-00 R80, 139
5905-99-140-5843	RESISTOR, FIXED, COMPOSITION 6.8K ohms ± 5%, 1/4W	2				*	Ø	PT.No. 315-0682-00 R251, 369
5905-99-140-5845	RESISTOR, FIXED, COMPOSITION 75 ohms ± 5%, 1/4W	2				*		PT.No. 315-0750-00 R45,85
5905-99-140-5847	RESISTOR, FIXED, COMPOSITION 82 ohms ± 5%, 1/4W	2				*		PT.No. 315-0820-00 R541, 543
5905-99-140-5848	RESISTOR, FIXED, COMPOSITION 820 ohms ± 5%, 1/4W	1				*		PT.No. 315-0821-00 R42B
5905-99-140-5853	RESISTOR, FIXED, COMPOSITION 100K ohms ± 10%, 1/4W	11				*	Ø	PT.No. 316-0104-00 R30B,75D,F, 116,200,203,208, 216,321,330,346
5905-99-140-5854	RESISTOR, FIXED, COMPOSITION 1.5K ohms ± 10%, 1/4W	2				*		PT.No. 316-0152-00 R934, 944
5905-99-140-5855	RESISTOR, FIXED, COMPOSITION 15K ohms ± 10%, 1/4W	1				*		PT.No. 316-0153-00 R182
5905-99-140-5856	RESISTOR, FIXED, COMPOSITION 1.8K ohms ± 10%, 1/4W	2				*		PT.No. 316-0182-00 R160T, 260T
5905-99-140-5857	RESISTOR, FIXED, COMPOSITION 18K ohms ± 10%, 1/4W	4				*		PT.No. 316-0183-00 R311, 824, 902, 903
5905-99-140-5858	RESISTOR, FIXED, COMPOSITION 180K ohms ± 10%, 1/4W	2				*		PT.No. 316-0184-00 R160X, 674
5905-99-140-5859	RESISTOR, FIXED, COMPOSITION 22 ohms ± 10%, 1/4W	5				*		PT.No. 316-0220-00 R165, 172 173,259,265

1	2	3	4	5	6	7	8	9
110W								
5905-99-140-5861	RESISTOR, FIXED, COMPOSITION 22K ohms ± 10%, 1/4W	2				*		PT.No. 316-0223-00 R160Y,260Y
5905-99-140-5862	RESISTOR, FIXED, COMPOSITION 220K ohms ± 10%, 1/4W	2				*		PT.No. 316-0224-00 R644, 716
5905-99-140-5866	RESISTOR, FIXED, COMPOSITION 330 ohms ± 10%, 1/4W	2				*		PT.No. 316-0331-00 R125, 225
5905-99-140-5867	RESISTOR, FIXED, COMPOSITION 3.3K ohms ± 10%, 1/4W	2				*		PT.No. 316-0332-00 R884, 904
5905-99-140-5869	RESISTOR, FIXED, COMPOSITION 3.9K ohms ± 10%, 1/4W	4				*	Ø	PT.No. 316-0392-00 R9,117, 935, 945
5905-99-140-5872	RESISTOR, FIXED, COMPOSITION 47K ohms ± 10%, 1/4W	5				*		PT.No. 316-0473-00 R187,188, 201, 217, 850
5905-99-140-5873	RESISTOR, FIXED, COMPOSITION 560K ohms ± 10%, 1/4W	1				*		PT.No. 316-0564-00 R189A
► 5905-99-140-5874	RESISTOR, FIXED, COMPOSITION 6.8K ohms ± 10%, 1/4 W	1				*		PT.NO. 316-0682-00 R891 ◄
5905-99-140-5880	RESISTOR, FIXED, COMPOSITION 34.8 ohms ± 1%, 1/8W	1				*	Ø	PT.No. 321-0053-00 R527
5905-99-140-5882	RESISTOR, FIXED, COMPOSITION 39.2 ohms ± 1%, 1/8W	2				*		PT.No. 321-0058-00 R526, 536
5905-99-140-5884	RESISTOR, FIXED, COMPOSITION 51.1 ohms ± 1%, 1/8W	5				*		PT.No. 321-0069-00 R192,193,292, 293,389
5905-99-140-5885	RESISTOR, FIXED, COMPOSITION 56.2 ohms ± 1%, 1/8W	5				*		PT.No. 321-0073-00 R190,191,290 291, 577
5905-99-140-5887	RESISTOR, FIXED, COMPOSITION 66.5 ohms ± 1%, 1/8W	4				*		PT.No. 321-0080-00 R169, 269, 412, 465
5905-99-140-5891	RESISTOR, FIXED, COMPOSITION 115 ohms ± 1%, 1/8W	3				*	Ø	PT.No. 321-0103-00 R163,263,533
5905-99-140-5892	RESISTOR, FIXED, COMPOSITION 121 ohms ± 1%, 1/8W	2				*	Ø	PT.No. 321-0105-00 R110, 548
5905-99-140-5895	RESISTOR, FIXED, COMPOSITION 154 ohms ± 1%, 1/8W	2				*	Ø	PT.No. 321-0015-00 R434,444
5905-99-140-5896	RESISTOR, FIXED, COMPOSITION 162 ohms ± 1%, 1/8W	2				*	Ø	PT.No. 321-0117-00 R149,249
5905-99-140-5897	RESISTOR, FIXED, COMPOSITION 226 ohms ± 1%, 1/8W	1				*	Ø	PT.No. 321-0131-00 R153

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110W								
5905-99-140-5901	RESISTOR, FIXED, COMPOSITION 301 ohms ± 1%, 1/8W	1				*	Ø	PT.No. 321-0143-00 R253
5905-99-140-5902	RESISTOR, FIXED, COMPOSITION 383 ohms ± 1%, 1/8W	2				*	Ø	PT.No. 321-0153-00 R136,236
5905-99-140-5903	RESISTOR, FIXED, COMPOSITION 464 ohms ± 1%, 1/8W	5				*	Ø	PT.No. 321-0161-00 R375,411,421 525,535
5905-99-140-5904	RESISTOR, FIXED, COMPOSITION 562 ohms ± 1%, 1/8W	1				*		PT.No. 321-0169-00 R591
5905-99-140-5905	RESISTOR, FIXED, COMPOSITION 590 ohms ± 1%, 1/8W	1				*		PT.No. 321-0171-00 R193 (11B2)
5905-99-140-5907	RESISTOR, FIXED, COMPOSITION 619 ohms ± 1%, 1/8W	3				*		PT.No. 321-0173-00 R135,235,482
5905-99-140-5912	RESISTOR, FIXED, COMPOSITION 1.47K ohms ± 1%, 1/8W	2				*		PT.No. 321-0209-00 R121, 221
5905-99-140-5914	RESISTOR, FIXED, COMPOSITION 2.15K ohms ± 1%, 1/8W	3				*		PT.No. 321-0225-00 R21,185,199
5905-99-140-5916	RESISTOR, FIXED, COMPOSITION 2.43K ohms ± 1%, 1/8W	1				*		PT.No. 321-0230-00 R592
5905-99-140-5917	RESISTOR, FIXED, COMPOSITION 2.49K ohms ± 1%, 1/8W	1				*		PT.No. 321-0231-00 R332
5905-99-140-5918	RESISTOR, FIXED, COMPOSITION 2.87K ohms ± 1%, 1/8W	1				*		PT.No. 321-0237-00 R428
5905-99-140-5922	RESISTOR, FIXED, COMPOSITION 3.48K ohms ± 1%, 1/8W	4				*		PT.No. 321-0245-00 R55,95,116, 296E
5905-99-140-5926	RESISTOR, FIXED, COMPOSITION 4.22K ohms ± 1%, 1/8W	1				*	Ø	PT.No. 321-0253-00 R896
5905-99-140-5927	RESISTOR, FIXED, COMPOSITION 4.64K ohms ± 1%, 1/8W	5				*	Ø	PT.No. 321-0257-00 R170,180,191, 291,298
5905-99-140-5930	RESISTOR, FIXED, COMPOSITION 6.49K ohms ± 1%, 1/8W	2				*		PT.No. 321-0271-00 R113,429
5905-99-140-5932	RESISTOR, FIXED, COMPOSITION 10.5K ohms ± 1%, 1/8W	2				*	Ø	PT.No. 321-0291-00 R323,345
5905-99-140-5934	RESISTOR, FIXED, COMPOSITION 14K ohms ± 1%, 1/8W	1				*		PT.No. 321-0303-00 R111
5905-99-140-5935	RESISTOR, FIXED, COMPOSITION 23.7K ohms ± 1%, 1/8W	2				*		PT.No. 321-0335-00 R142,242

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110W								
5905-99-140-5936	RESISTOR, FIXED, COMPOSITION 86.6K ohms ± 1%, 1/8W	1				*	Ø	PT.No. 321-0379-00 R885
5905-99-140-5937	RESISTOR, FIXED, COMPOSITION 500 ohms ± 1%, 1/8W	2				*		PT.No. 321-0612-00 R113E,213E
5905-99-140-5942	RESISTOR, FIXED, COMPOSITION 6.81K ohms ± ½%, 1/8W	1				*		PT.No. 321-0630-00 R455
5905-99-140-5945	RESISTOR, FIXED, COMPOSITION 56.2 ohms ± 1%, 1/4W	1				*		PT.No. 322-0073-00 R497
5905-99-140-5946	RESISTOR, FIXED, COMPOSITION 75 ohms ± 1%, 1/4W	2				*		PT.No. 322-0085-00 R452,498
5905-99-140-5947	RESISTOR, FIXED, COMPOSITION 93.1 ohms ± 1%, 1/4W	2				*	Ø	PT.No. 322-0094-00 R454, 464
5905-99-140-5948	RESISTOR, FIXED, COMPOSITION 191 ohms ± 1%, 1/4W	1				*		PT.No. 322-0124-00 R213
5905-99-140-5950	RESISTOR, FIXED, COMPOSITION 221 ohms ± 1%, 1/4W	1				*	Ø	PT.No. 322-0130-00 R210
5905-99-140-5951	RESISTOR, FIXED, COMPOSITION 237 ohms ± 1%, 1/4W	2				*	Ø	PT.No. 322-0133-00 R335,432
5905-99-140-5952	RESISTOR, FIXED, COMPOSITION 332 ohms ± 1%, 1/4W	1				*	Ø	PT.No. 322-0147-00 R634
5905-99-140-5953	RESISTOR, FIXED, COMPOSITION 464 ohms ± 1%, 1/4W	4				*	Ø	PT.No. 322-0161-00 R154,164,254,264
5905-99-140-5954	RESISTOR, FIXED, COMPOSITION 1.24K ohms ± 1%, 1/4W	2				*	Ø	PT.No. 322-0202-00 R165,265
5905-99-140-5955	RESISTOR, FIXED, COMPOSITION 1.69K ohms ± 1%, 1/4W	2				*		PT.No. 322-0215-00 R148,248
5905-99-140-5956	RESISTOR, FIXED, COMPOSITION 1.96K ohms ± 1%, 1/4W	1				*		PT.No. 322-0221-00 R384
5905-99-140-5957	RESISTOR, FIXED, COMPOSITION 2.15K ohms ± 1%, 1/4W	2				*		PT.No. 322-0225-00 R133, 233
5905-99-140-5959	RESISTOR, FIXED, COMPOSITION 34.8K ohms ± 1%, 1/4W	2				*		PT.No. 322-0341-00 R131, 231
5905-99-140-5960	RESISTOR, FIXED, COMPOSITION 42.2K ohms ± 1%, 1/4W	1				*		PT.No. 322-0349-00 R297
5905-99-140-5961	RESISTOR, FIXED, COMPOSITION 51.1K ohms ± 1%, 1/4W	2				*	Ø	PT.No. 322-0357-00 R184,340

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110W								
5905-99-140-5970	RESISTOR, FIXED, COMPOSITION 196 ohms + 1%, 1/2W	4				*		PT.No. 323-0125-00 R343,353,504, 514
5905-99-140-5974	RESISTOR, FIXED, COMPOSITION 383 ohms + 1%, 1/2W	1				*		PT.No. 323-0153-00 R364,
5905-99-140-5976	RESISTOR, FIXED, COMPOSITION 464 ohms + 1%, 1/2W	1				*		PT.No. 323-0161-00 R13
5905-99-140-5977	RESISTOR, FIXED, COMPOSITION 487 ohms + 1%, 1/2W	2				*	Ø	PT.No. 323-0163-00 R273,283
5905-99-140-5979	RESISTOR, FIXED, COMPOSITION 576 ohms + 1%, 1/2W	2				*	Ø	PT.No. 323-0170-00 R529, 539
5905-99-140-5980	RESISTOR, FIXED, COMPOSITION 590 ohms + 1%, 1/2W	2				*		PT.No. 323-0171-00 R134,234
5905-99-140-5981	RESISTOR, FIXED, COMPOSITION 619 ohms + 1%, 1/2W	2				*		PT.No. 323-0173-00 R576, 586
5905-99-140-5982	RESISTOR, FIXED, COMPOSITION 806 ohms + 1%, 1/2W	1				*	Ø	PT.No. 323-0184-00 R152
5905-99-140-5983	RESISTOR, FIXED, COMPOSITION 953 ohms + 1%, 1/2W	2				*		PT.No. 323-0191-00 R16, 17
5905-99-140-5985	RESISTOR, FIXED, COMPOSITION 2.87K ohms + 1%, 1/2W	2				*		PT.No. 323-0237-00 R371, 391
5905-99-140-5986	RESISTOR, FIXED, COMPOSITION 8.25K ohms + 1%, 1/2W	1				*		PT.No. 323-0281-00 R106,
5905-99-140-5988	RESISTOR, FIXED, COMPOSITION 13.7K ohms + 1%, 1/2W	2				*	Ø	PT.No. 323-0302-00 R219, 361
5905-99-140-5990	RESISTOR, FIXED, COMPOSITION 17.8K ohms + 1%, 1/2W	1				*	Ø	PT.No. 323-0313-00 R22
5905-99-140-5991	RESISTOR, FIXED, COMPOSITION 18.7K ohms + 1%, 1/2W	2				*		PT.No. 323-0315-00 R164, 264
5905-99-140-5992	RESISTOR, FIXED, COMPOSITION 21.5K ohms + 1%, 1/2W	3				*		PT.No. 323-0321-00 R53,93,310
5905-99-140-5993	RESISTOR, FIXED, COMPOSITION 20.5K ohms + 1%, 1/2W	2				*	Ø	PT.No. 323-0324-00 R324, 344
5905-99-140-5994	RESISTOR, FIXED, COMPOSITION 28.7K ohms + 1%, 1/2W	1				*	Ø	PT.No. 323-0333-00 R215
5905-99-140-5995	RESISTOR, FIXED, COMPOSITION 30.1K ohms + 1%, 1/2W	1				*	Ø	PT.No. 323-0335-00 R878

1	2	3	4	5	6	7	8	9
110W								
5905-99-140-5996	RESISTOR, FIXED, COMPOSITION 32.4K ohms ± 1%, 1/2W	1				*	Ø	PT.No. 323-0338-00 R363
5905-99-140-5997	RESISTOR, FIXED, COMPOSITION 40.2K ohms ± 1%, 1/2W	1				*	Ø	PT.No. 323-0347-00 R362
5905-99-140-5998	RESISTOR, FIXED, COMPOSITION 45.3K ohms ± 1%, 1/2W	1				*	Ø	PT.No. 323-0352-00 R370
5905-99-140-5999	RESISTOR, FIXED, COMPOSITION 66.5K ohms ± 1%, 1/2W	1				*	Ø	PT.No. 323-0368-00 R612
5905-99-140-6000	RESISTOR, FIXED, COMPOSITION 105K ohms ± 1%, 1/2W	1				*	Ø	PT.No. 323-0387-00 R739
5905-99-140-6002	RESISTOR, FIXED, COMPOSITION 1.05M ohms ± 1%, 1/2W	2				*	Ø	PT.No. 323-0483-00 R932,942
5905-99-140-6005	RESISTOR, FIXED, COMPOSITION 950K ohms ± 1%, 1/2W	2				*		PT.No. 323-0612-00 R107C 207C
5905-99-140-6021	RESISTOR, FIXED, COMPOSITION 1.1K ohms ± 1/2%, 1/2W	1				*		PT.No. 323-0639-00 R212
5905-99-140-6022	RESISTOR, FIXED, COMPOSITION 221K ohms ± 1/4%, 1/2W	2				*	Ø	PT.No. 323-0653-00 R160D,260D
5905-99-140-6023	RESISTOR, FIXED, COMPOSITION 75K ohms ± 1/2%, 1/2W	4				*		PT.No. 323-0654-00 R160A,160B, 260A, 260B
5905-99-140-6024	RESISTOR, FIXED, COMPOSITION 750K ohms ± 1/2%, 1/2W	4				*	Ø	PT.No. 323-0655-00 R160F,G,260F, G,
5905-99-140-6025	RESISTOR, FIXED, COMPOSITION 1.5M ohms ± 1/2%, 1/2W	2				*	Ø	PT.No. 323-0656-00 R160H, 260H
5905-99-140-6026	RESISTOR, FIXED, COMPOSITION 750K ohms ± 1%, 1/2W	2				*	Ø	PT.No. 323-0657-00 R160E, 260E
5905-99-140-6027	RESISTOR, FIXED, COMPOSITION 8.87K ohms ± 1%, 1W	1				*	Ø	PT.No. 324-0284-00 R609
5905-99-140-6028	RESISTOR, FIXED, COMPOSITION 10K ohms ± 1%, 1W	3				*	Ø	PT.No. 324-0289-00 R337,338,390
5905-99-140-6029	RESISTOR, FIXED, COMPOSITION 11.8K ohms ± 1%, 1W	2				*	Ø	PT.No. 324-0296-00 R376, 396
5905-99-140-6030	RESISTOR, FIXED, COMPOSITION 3.32M ohms ± 1%, 1W	6				*	Ø	PT.No. 324-0531-00 R802,A,B,C,D, E,F.

1	2	3	4	5	6	7	8	9
110W								
5905-99-140-9200	RESISTOR, FIXED, COMPOSITION 50K ohms ± 1%, 1/2W	1				*	Ø	PT.No. 323-0638-00 R.948Y
5905-99-140-9201	RESISTOR, FIXED, COMPOSITION 50 ohms ± 1%, 1/2W	1				*	Ø	PT.No. 323-0637-00 R.948Z
5905-99-140-9202	RESISTOR, FIXED, COMPOSITION 56K ohms ± 10%, 1/4W	3				*		PT.No. 316-0563-00 R810,821,851,
5905-99-140-9579	RESISTOR, FIXED, COMPOSITION 180 ohms ± 5%, 1/4W	1				*		PT.No. 315-0181-00 R421
➤ 5905-99-141-4688	RESISTOR, FIXED, COMPOSITION 3.65K ohms ± 1%, 1/8W	1				*	Ø	PT.No. 321-0247-00 R342,
5905-99-141-4700	RESISTOR, FIXED, COMPOSITION 3.92K ohms ± 1%, 1/8W	2				*		PT.No. 321-0250-00 R130-230
5905-99-141-4713	RESISTOR, FIXED, COMPOSITION 100K ohms ± 10%, 1W	1				*		PT.No. 304-0104-00 R742
5905-99-141-4740	RESISTOR, FIXED, COMPOSITION 3.01K ohms ± 1%, 1/8W	1				*		PT.No. 321-0239-00 R420
5905-99-141-4748	RESISTOR, FIXED, COMPOSITION 75 ohms ± 1%, 1/8W	2				*		PT.No. 321-0085-00 R271, 281
5905-99-141-4750	RESISTOR, FIXED, COMPOSITION 1.2K ohms, ± 5%, 1/4W	1				*		PT.No. 315-0122-00 R138
5905-99-141-4766	RESISTOR, FIXED, COMPOSITION 390 ohms ± 5%, 1/4W	2				*		PT.No. 315-0391-00 R423,433
5905-99-141-6337	RESISTOR, FIXED, COMPOSITION 10K ohms ± 10%, 1/2W	5				*		PT.No. 302-0103-00 R642,672 714,833,834
5905-99-141-6338	RESISTOR, FIXED, COMPOSITION 22k ohms ± 10%, 1/2W	3				*		PT.No. 302-0223-00 R313,664,683 ◄
5905-99-196-7414	RESISTOR, VARIABLE 25 ohms, 12.5W	1				*		PT.No. 311-0377-00 R604
5905-99-196-7432	RESISTOR, FIXED, COMPOSITION 33K ohms ± 10%, 1/4W	2				*		PT.No. 316-0333-00 R189B, 307
5905-99-196-7587	RESISTOR, FIXED, COMPOSITION 316 ohms ± 1%, 1/8W	4				*	Ø	PT.No. 321-0145-00 R413, 423, 579, 589
➤ 5905-99-462-2806	RESISTOR, FIXED, COMPOSITION 590 ohms ± 1%, 1/4W	1				*	Ø	PT.NO. 322-0171-00 R416 ◄
5905-99-581-2786	RESISTOR, FIXED, COMPOSITION 100 ohms ± 10%, 1/2 W	2				*		PT.NO. 302-0101-00 R852, 855

1	2	3	4	5	6	7	8	9
110X								
5955-00-103-6455	CRYSTAL UNIT, QUARTZ	1				*		PT.No. 158-0015-00 Y900
6625								
► 6625-00-056-2474	DELAY LINE ASSEMBLY	1				*		PT.No 119-0029-00

Instruction Manual

TEKTRONIX ®

P6008 PROBE

WARRANTY

All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our own plant, are warranted for the life of the instrument.

Any questions with respect to the warranty mentioned above should be taken up with your Tektronix Field Engineer.

Tektronix repair and replacement-part service is geared directly to the field, therefore all requests for repairs and replacement parts should be directed to the Tektronix Field Office or Representative in your area. This procedure will assure you the fastest possible service. Please include the instrument Type and Serial number with all requests for parts or service.

Specifications and price change privileges reserved.

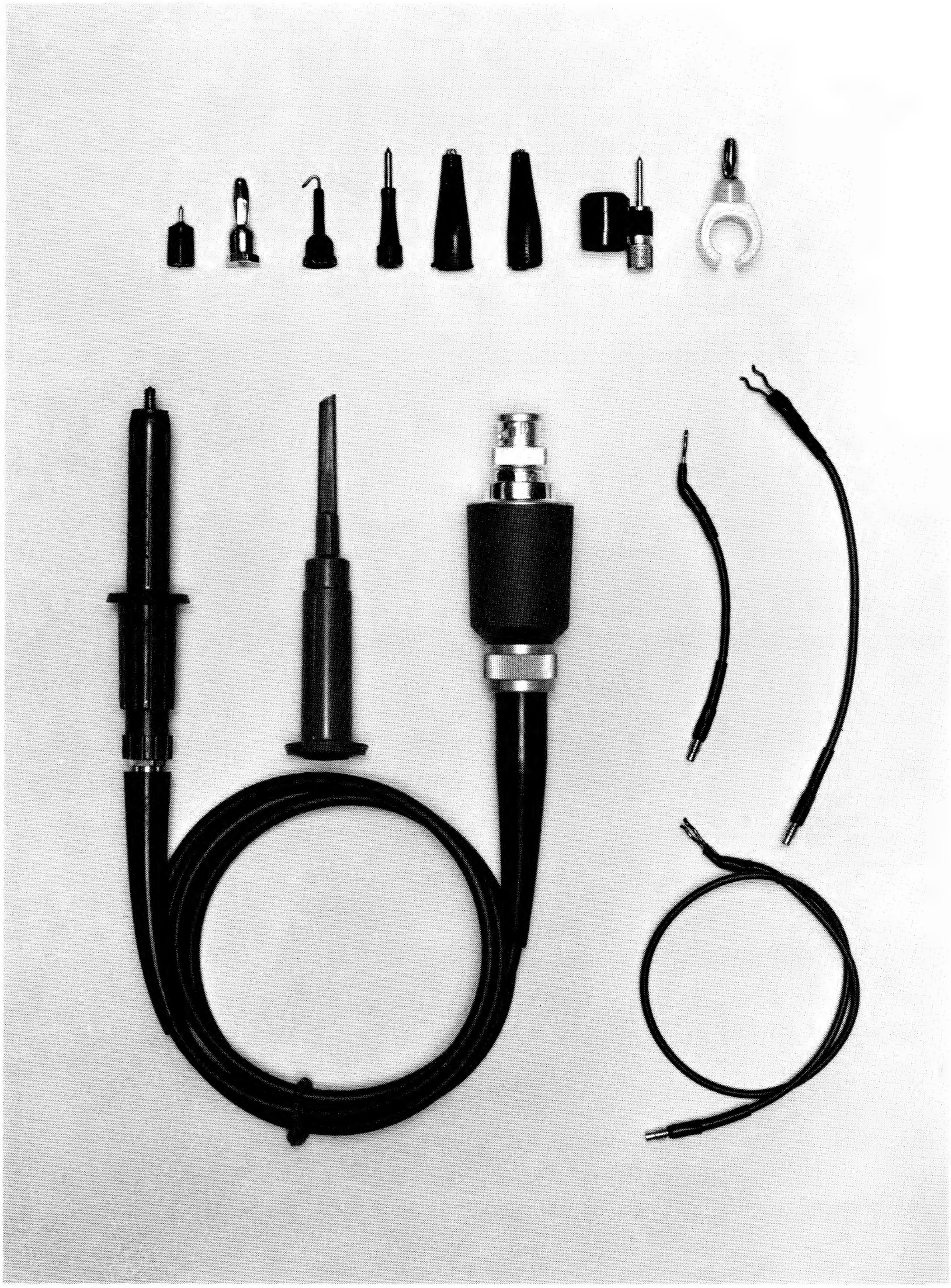

Fig. 1-1. P6008 Probe and accessories.

SECTION 1
CHARACTERISTICS

General Information

The P6008 Probe, shown at left, is a passive probe with 10X attenuation of signals. It is designed for use with Tektronix Type 82 and 86 plug-in units. The probe provides a convenient means for coupling signals to the plug-in unit with minimum loading and maximum response.

The probe consists of a probe body assembly, a 3½-ft cable, a compensating box assembly, and a BNC connector. The 9-megohm resistor in the probe body assembly has adjustable capacitive compensation which may be set to match the plug-in used. The compensating box houses a network which provides optimum transient response.

The probe is factory calibrated for use with plug-in units which have a 1-megohm input, paralleled by 15 pf. It may be used with units which have up to 20-pf input capacitance, with a corresponding decrease in frequency response.

Characteristics (when used with Type 82 or 86 plug-in unit)

Input Impedance

10 megohms paralleled by about 7 pf. Fig. 2-3 shows input impedance vs frequency up to 250 megacycles.

Attenuation

Dc attenuation is 10X, ±3%, with plug-in. Probe attenuation is ±2%.

Voltage Rating

Maximum dc or ac peak-to-peak below 20 megacycles: 600 volts. Above 20 megacycles, maximum voltage must be derated according to frequency duty factor. See the curves in Fig. 2-4.

Frequency and Transient Response.

Probe alone has a characteristic risetime of less than 3 nanoseconds, corresponding to a frequency response of dc to 116 megacycles or higher. With a Type 82 or 86 plug-in unit and 580-Series Oscilloscope, typical risetime with the GAIN switch set to X1 is 5 nanoseconds which corresponds to 70 megacycles; a X10 GAIN risetime is 5.3 nanoseconds which corresponds to 66 megacycles.

Connecting Cable

Cable is 3½-ft long with a special resistive center conductor which provides critical damping of reflections. This allows the probe to present a relatively high impedance without mismatch when viewing signals from low-impedance sources.

Environmental Capability

Probe will operate normally with temperatures to 75°C.

Plug-In Connector

BNC type; mates with connectors of Type 82 and 86 plug-in units.

Accessories Supplied with Probe

Qty.	Tektronix Part No.	Description
1	013-052	Bayonet Ground Assembly
*1	214-325	Center Pin
1	013-071	Pincer Tip
1	134-013	Banana Plug
1	175-124	5" Ground Lead
1	175-125	12" Ground Lead
1	175-263	3" Ground Lead
1	206-015	BNC Tip
1	206-060	Spring Tip
1	206-105	Hook Tip
2	344-046	Miniature Alligator Clips (screw-on type to fit the end of ground leads)
1	352-024	Probe Holder
1	070-362	Instruction Manual

Optional Accessories

013-054	BNC-to-Probe Adapter
206-061	Spring Tip (without shank)
206-054	Pinjack Tip (insulated)
206-052	Insert Tip
206-045	Pinjack Tip
206-034	Straight Tip
175-184	18" Ground Strap

*Added to probes manufactured after May 1, 1963.

NOTES

SECTION 2
OPERATING INSTRUCTIONS

General Information

The P6008 Probe allows you to connect an oscilloscope into a circuit with minimum loading and without impedance matching. Before using the probe, compensate it according to the procedure given in the following paragraphs. Always check compensation when connecting the probe to the plug-in, and recheck it before making critical measurements. Slight variations in input capacitance between different plug-ins of the same type affect compensation. Lack of compensation can cause measurement error since it affects both waveshape and magnitude of the display. The probe is therefore provided with an adjustment to match it to the plug-in used.

Compensation

To compensate the P6008 Probe, proceed as follows:

1. Set the oscilloscope calibrator for an output of suitable amplitude.

2. Hold the probe body and tip assembly and loosen the locking sleeve several turns (see Fig. 2-1).

3. Touch the probe tip to the oscilloscope calibrator output connector.

4. Set the sweep rate to display several cycles of the calibrator output signal.

5. Hold the base bushing and turn the probe body and tip assembly to obtain an undistorted presentation of the calibrator output signal.

6. Hold the probe body and tip assembly and carefully hand-tighten the locking sleeve.

If the probe changes adjustment while you are tightening the locking sleeve, continue turning the sleeve until it is just tight. Then, as a fine adjustment, hold the probe body and the locking sleeve and turn the base bushing assembly carefully in the direction that will properly compensate the probe.

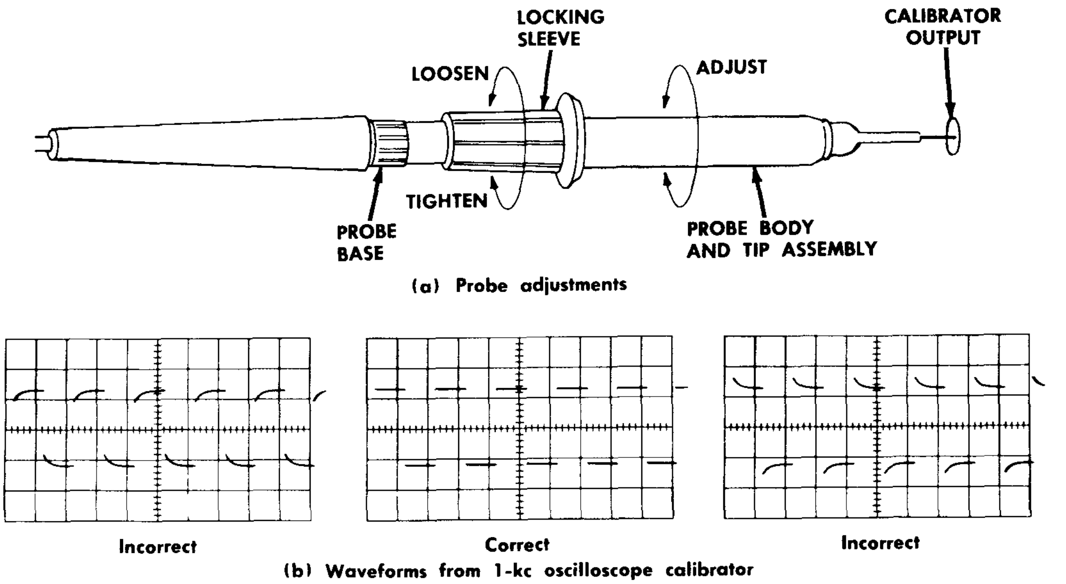

Fig. 2-1. Probe compensation.

Connecting the Probe to the Signal Source

The probe may be connected to the signal source by means of the tips, leads, and connectors supplied. Generally, you should select the tips and leads that are best suited physically. When measuring high-frequency signals, use the shortest ground connection possible. Longer ground leads may result in ringing because of the inductive reactance of the ground lead. Be careful not to short-circuit between wires, connections, etc. in the circuit under test with the probe tip. Always provide some form of ground between the probe and the circuit under test to prevent hum pickup, ringing, and other spurious signals. The 5" and 12" ground leads clip to the junction of the probe bushing assembly and the cable assembly.

The 3-inch ground lead is used with the bayonet ground assembly (see Fig. 2-2). To connect the 3-inch ground lead to the bayonet ground assembly, slip the ground assembly onto the probe body and tip assembly. Unscrew the knurled nut and clip the ground lead to the pin holder at the end of the holder opposite from the knurled nut. Be careful not to drop the pin or the spring.

Considerations

After compensating the probe, consider the following before connecting the probe and making measurements:

1. Loading—Fig. 2-3 is a graph of the probe input resistance and reactance versus frequency measured with the probe connected to the plug-in and an R-X meter connected to the probe input. X_p represents capacitive reactance, and R_p represents resistance. The input impedance of the probe may affect the operation of the circuit under test.

2. Frequency Response—The frequency response of the probe, plug-in, and oscilloscope is stated in Section 1. Although the system 3-db point is near 70 megacycles, the probe and oscilloscope are useful at higher frequencies with a corresponding decrease in gain.

3. Voltage Rating—Fig. 2-4 is a graph of the maximum voltage rating at various frequencies with various duty factors. At higher frequencies, the maximum voltage decreases because charging currents in the probe cable, which charge the input capacitance of the plug-in, increase until the cable overheats. When computing duty factor, the maximum "on" time is one second. If "on" time and "off" time are less than one second, then duty factor:

$$DF = \frac{\text{ON time}}{\text{ON time} + \text{OFF time}}$$

(CW signals have a DF of 1)

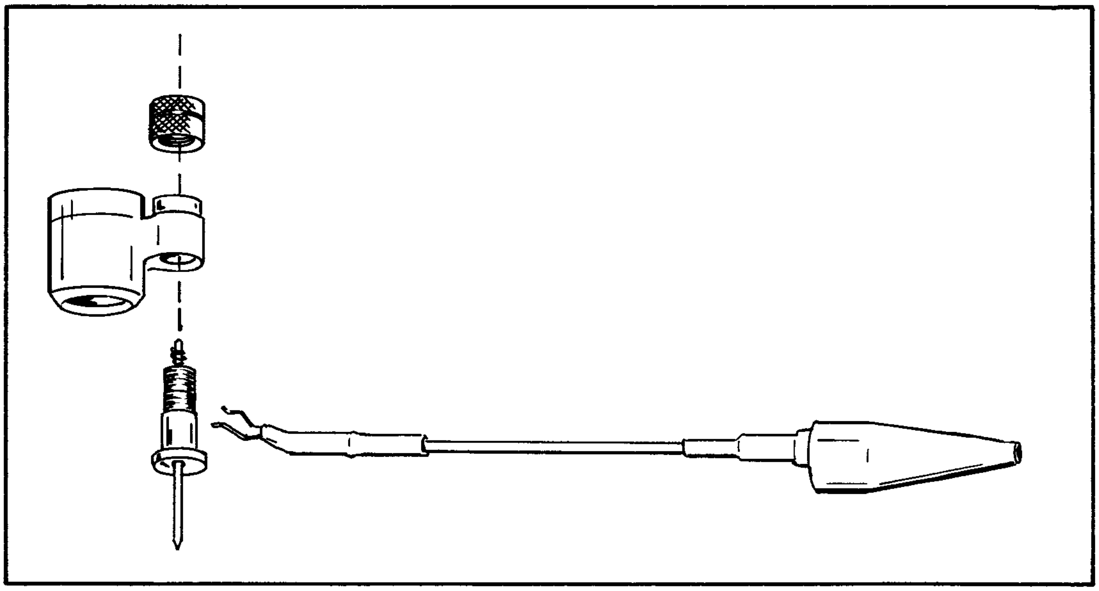

Fig. 2-2. Connecting 3-inch ground lead to bayonet ground assembly.

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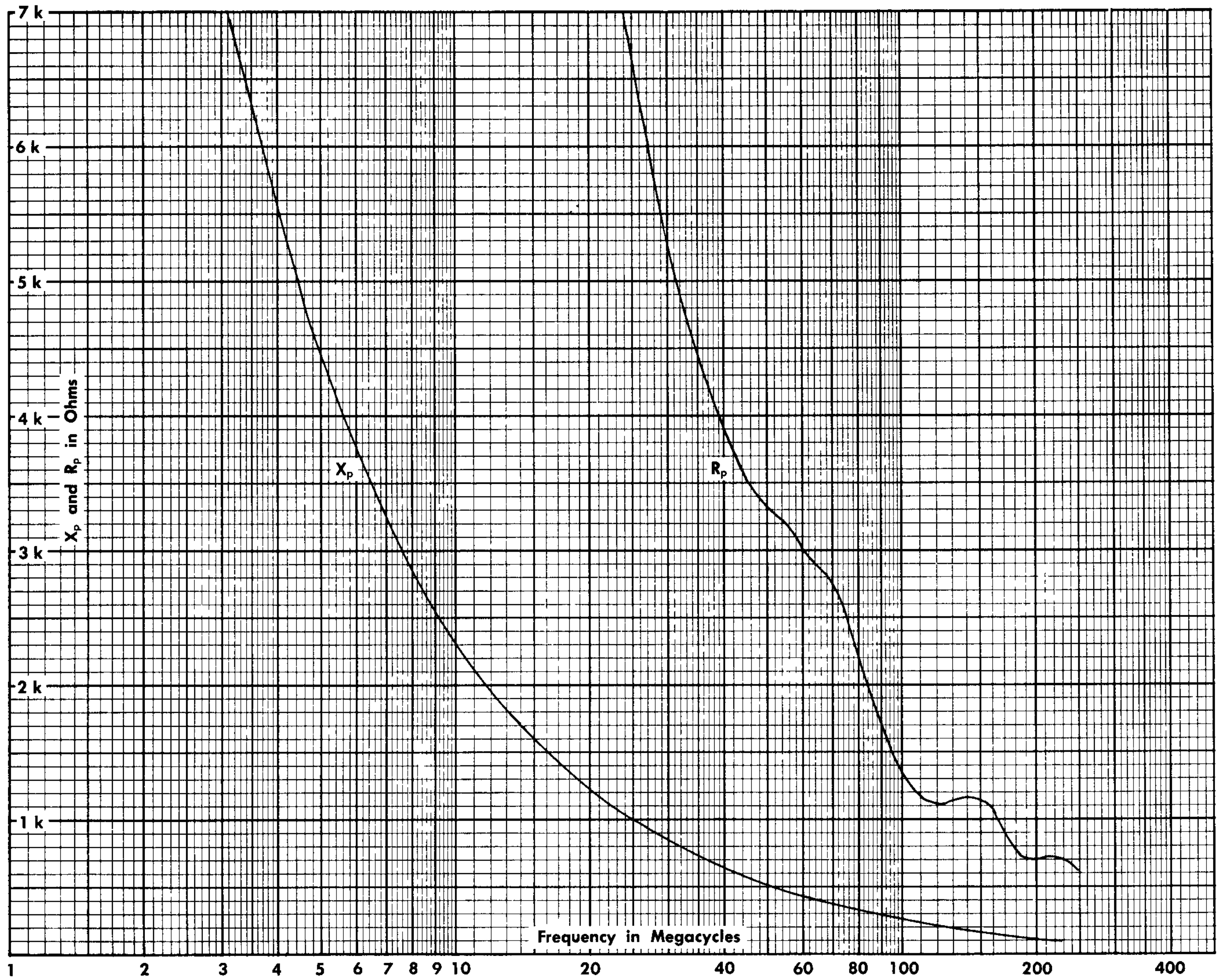


Fig. 2-3. P6008 Input Resistance and Reactance Versus Frequency.

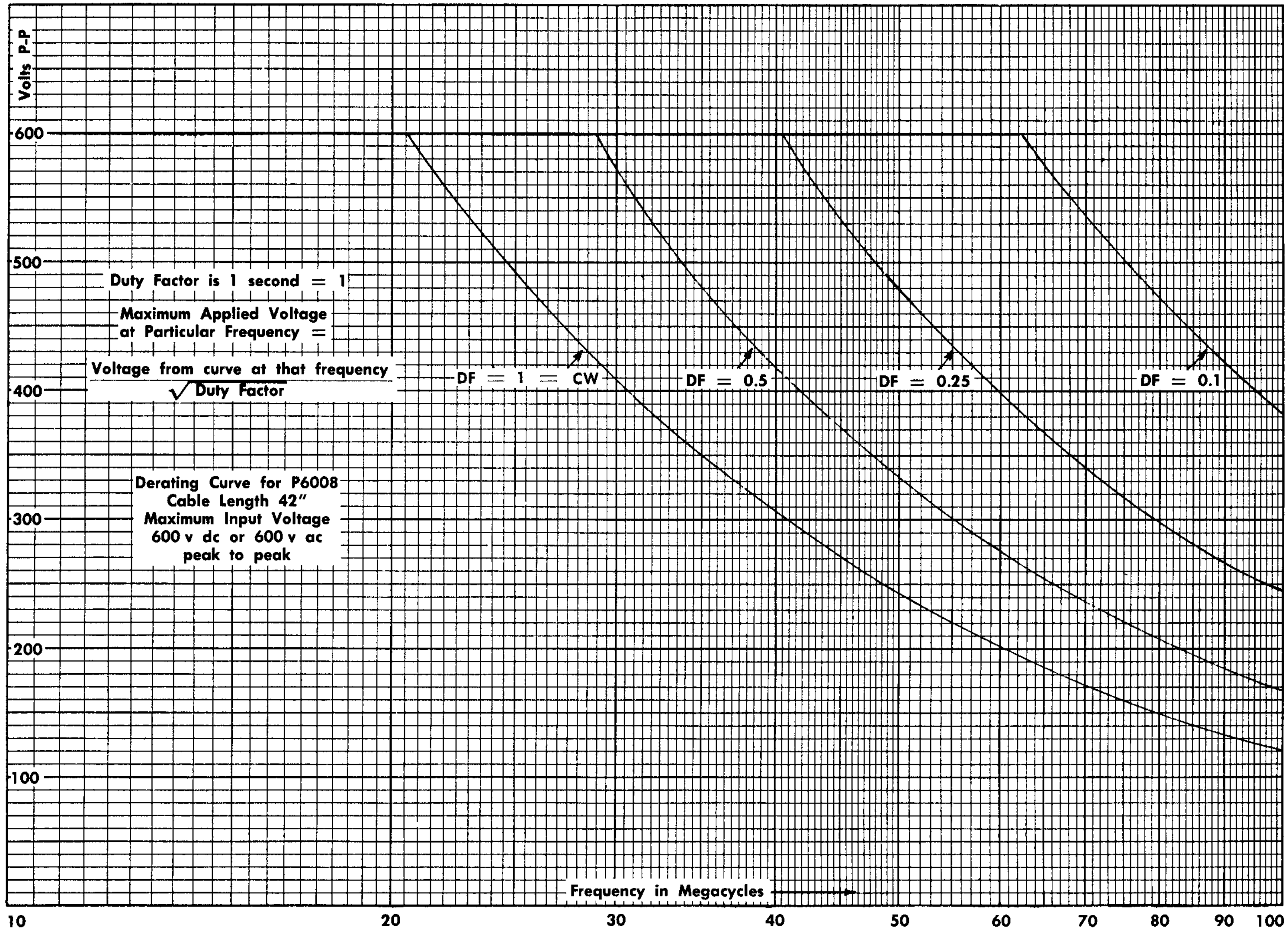


Fig. 2-4. Maximum Applied Voltage At Specific Duty Factors.

SECTION 3
CIRCUIT DESCRIPTION

The P6008 Probe is a simple voltage divider operating in conjunction with the input impedance of the plug-in unit to provide 10:1 signal division. The divider resistor is mounted in the probe body and tip assembly. A spring contact connects the resistor to the sleeve. Capacitance between the probe tip and the sleeve is varied for frequency compensation by turning the probe body and tip assembly with respect to the base bushing to move it along the base bushing assembly. Resistor location in the probe body and tip assembly is carefully controlled during manufacture; therefore, the resistor should not be replaced in the field.

The $3\frac{1}{2}$-ft cable is critically damped by a resistive center conductor which allows the probe to drive the oscilloscope plug-in input without ringing.

A compensating box at the plug-in connection maintains response at high frequencies. The circuit parameters in the compensating box are adjusted at the factory for correct response with plug-in units that have a 1-megohm input paralleled by 12 or 15 pf. When interchanging the P6008 Probe with other Type 82 or Type 86 plug-in units no retuning of the components in the compensating box is necessary, other than to ascertain that the probe is still compensated for the input capacitance of the particular plug-in.

Two ferrite cores around the cable at the compensating-box end sense ground currents in the shield braid and magnetically couple them to the center conductor, establishing common-mode signals which will not be seen by the oscilloscope.

SECTION 4 MAINTENANCE AND CALIBRATION

MAINTENANCE

The Type P6008 Probe is designed to withstand normal operation and handling and should give many hours of continuous use without failure. However, if the probe fails or breaks, replacement parts are available. See mechanical and electrical parts lists in Section 5.

Replacing Cable Assembly

If the coaxial cable between the probe and the compensating box should fail, the cable assembly is available complete with fittings and cable reliefs.

Replace the cable assembly as follows:

1. Remove the Compensating Box Cover by unscrewing the Locking Nut that holds it in place (see Fig. 4-2).

2. Unsolder the bare wire from the center terminal of the Cable Assembly (next to L104).

3. Use thin $^{7}/_{16}$- and $^{9}/_{16}$-inch end wrenches to remove the Cable Assembly from the Compensating Box.

4. Turn the Locking Sleeve to unlock the Probe Body and Tip Assembly and remove both by unscrewing from the end of the Base Bushing Assembly (see Fig. 4-1).

5. Unscrew the Sleeve from the plastic Inner Base Bushing.

6. Use thin $^{11}/_{32}$- and $^{3}/_{8}$-inch end wrenches to remove the Base Bushing Assembly from the end of the Cable Assembly.

7. Use a scribe to lift the wire from the thread groove of the Inner Base Bushing and remove the bushing.

8. Unsolder the bare wire from the center terminal of the Cable Assembly.

Install the new Cable Assembly by reversing the above procedure. After assembling the

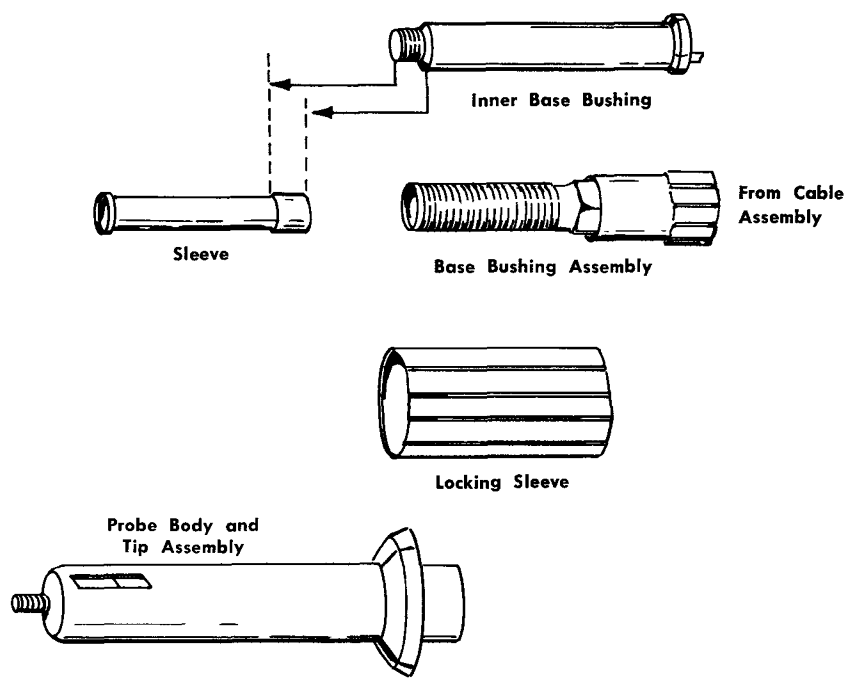


Fig. 4-1. P6008 Probe Body Assembly.

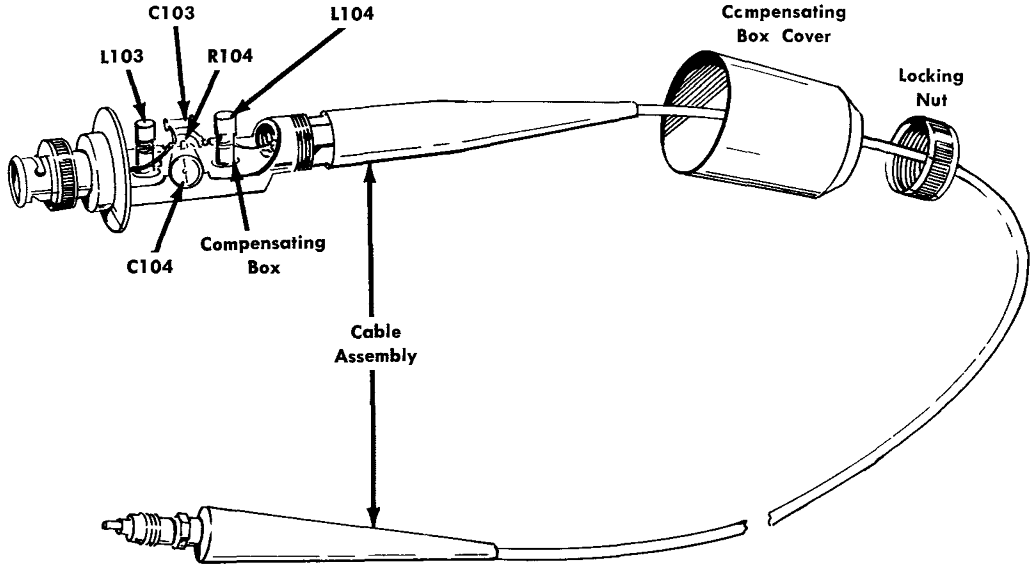


Fig. 4-2. P6008 Probe Compensating Box Assembly.

probe parts, be sure to compensate the probe for low frequencies as described in Section 2. Then compensate the probe for high frequencies according to the procedure given in this section.

Replacing Parts In the Compensating Box

To replace parts in the Compensating Box, you need only a pair of long-nose pliers and a soldering iron. Use a heat sink (tip of long-nose pliers) to protect the new components from excessive heat. If replacing a variable inductor, be careful not to strip the plastic threads. If you have a torque wrench, the proper nut pressure is from 2 to 5 inch-pounds.

Replacing the Probe Body and Tip Assembly (with 9-megohm resistor factory installed)

If the 9-megohm resistor (R100) fails, do not try to replace the resistor. Instead, replace the whole Probe Body and Tip Assembly shown in Fig. 4-1. Order from your local Tektronix Field Office.

CALIBRATION

The Compensating Box of the P6008 does not have to be recalibrated if used with other than a Type 82 or 86 plug-in. However it does not give the optimum response with plug-in units of different input capacitance. When used consistently with Type 82 or 86 plug-in units, only an occasional check of the high-frequency compensation is required.

Equipment Required

1. Type 581 or Type 585 Oscilloscope.
2. Type 82 or 86 plug-in unit.
3. 50-ohm fast-rise square-wave generator, such as the Tektronix Type 109 or Type 110. Risetime must be less than 1 nsec, 10% to 90%.
4. 50-ohm BNC-to-BNC Termination, Tektronix Part No. 011-049.
5. Probe-to-BNC Adapter, Tektronix Part No. 013-054.

6. GR Type 874-to-BNC Jack Adapter (GR Type 874-QBJ), Tektronix Part No. 017-024.

7. 20-nsec 50-ohm cable, with GR 874 fitting. Tektronix Part No. 017-504.

8. Special plastic ferrite core alignment tool.

Tektronix Part Nos. {Tool Tip—003-310. Handle—003-307.}

9. Small nonconducting screwdriver, such as Jaco No. 125 with 1½-inch shank, Tektronix Part No. 003-000.

Preliminary Procedure

Check the transient response of the plug-in and 580-Series Oscilloscope before attempting to calibrate the P6008 Probe. Use the procedures in the instruction manuals for the plug-in and oscilloscope.

Set the plug-in controls as follows:

AC - DC	DC
VOLTS/CM	.1
VARIABLE VOLTS/CM	CAL.
GAIN	X1
* MODE	A ONLY
* POLARITY	NORMAL

*** Type 82 only**

Loosen the Locking Nut on the Compensating Box and move the cover back onto the cable. Connect the P6008 Probe to the INPUT (INPUT A on Type 82) connector of the plug-in unit.

High-Frequency Compensation Procedure (Early models)

Early models of the P6008 require a different calibration procedure from later models. To ascertain which model you have, check for the presence or absence of C103, a 1-pf tubular capacitor mounted between the two coils. Early models do not have this capacitor.

1. Set the oscilloscope sweep rate for 2 msec/cm and the triggering controls for a + internal trigger. Set the amplitude calibrator for a 2-volt output.

2. Connect the probe tip to the center conductor of the oscilloscope calibrator output connector. Adjust the triggering controls for a stable display.

3. Set C104 (see probe schematic and Fig. 4-2) to maximum capacitance. Maximum capacitance of C104 is determined when the display shows a minimum spike, or some roll-off.

4. Adjust the compensating capacitor by turning the Probe Body and Tip Assembly until the square-wave display has a good flat top. Tighten the Locking Sleeve and check the flat top display.

5. Use items 3, 4, 5, 6, and 7 of Equipment Required, and connect the probe to the 50-ohm fastrise square-wave generator. Use the 20-nsec cable with the generator as the chargeline to obtain a 40-nsec pulse.

6. Adjust the oscilloscope sweep rate for 0.05 μsec/cm. Turn up the intensity and focus display. It is possible to raise the intensity past the point of being able to obtain a sharp focus. Proper adjustment of the P6008 Probe is easiest when the display is sharply focused.

7. Adjust R104 (near maximum resistance) for a level display.

8. Adjust L103 for the correct front-corner level.

9. Adjust L104 for proper level about 3 or 4 nsec after the display front corner.

10. Adjust the oscilloscope sweep rate for 0.2 μsec/cm. Both square-wave corners should be at the same level. If not, repeat steps 6, 7 and 8, and recheck.

11. Set the oscilloscope sweep rate for 0.05 μsec/cm and magnified 5X. The risetime (10% to 90%) should be 5 nsec or less.

12. Replace the Compensating Box Cover.

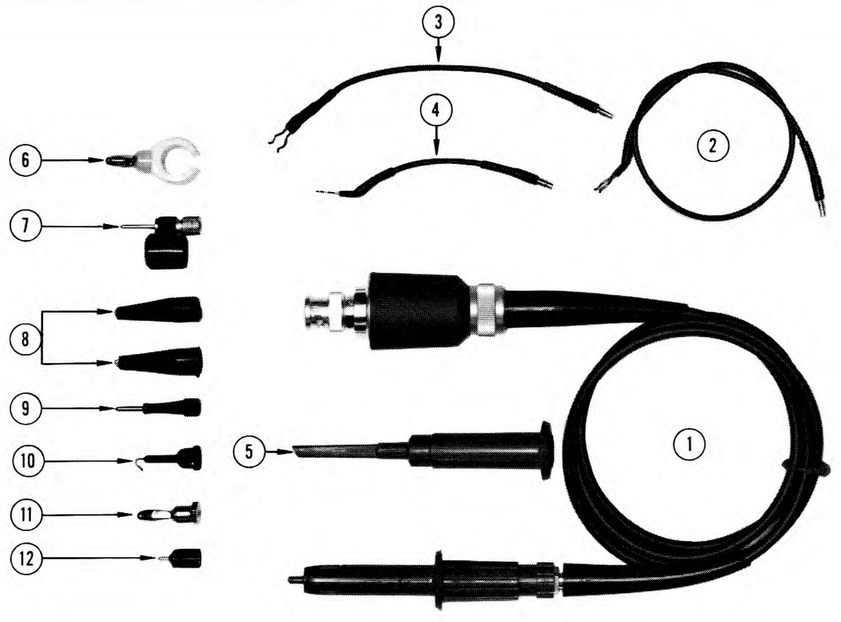
High-Frequency Compensation Procedure (Later models)

1. Set the oscilloscope sweep rate for 2 msec/cm and the triggering controls for + external trigger. Set the amplitude calibrator for a 2-volt output.

2. Connect the probe tip to the center conductor of the oscilloscope calibrator output connector. Adjust the triggering controls for a stable display.

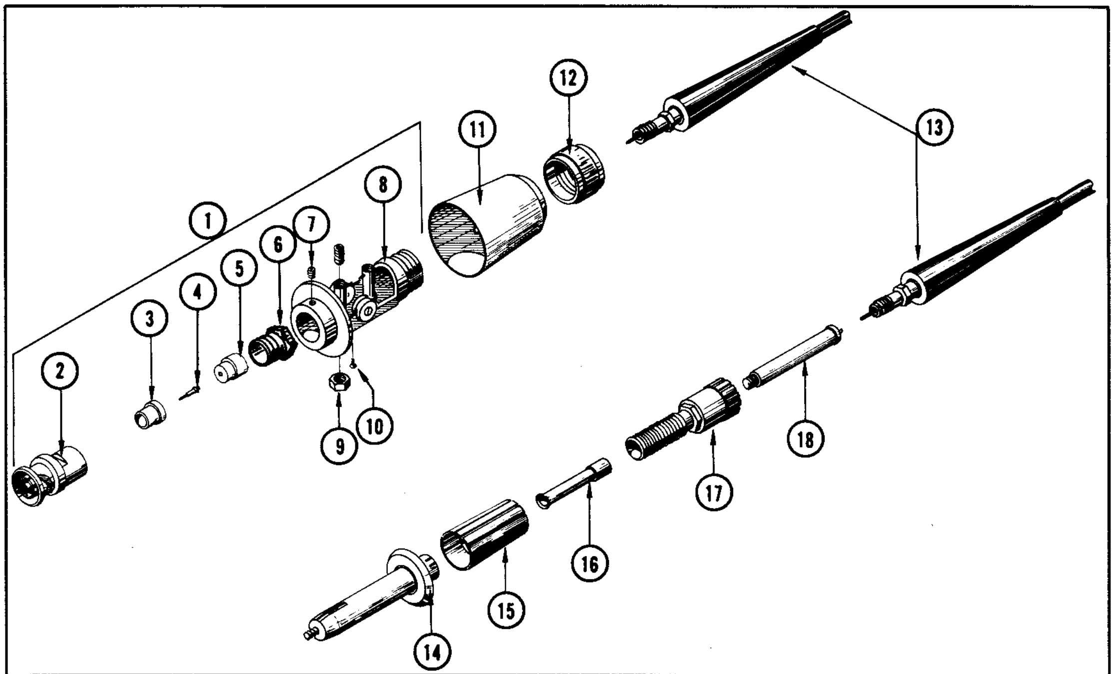
3. Set the 9-35 pf capacitor (C104) in the minimum capacitance position so that the dis-

PROBE WITH ACCESSORIES



REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
	PROBE PACKAGE				
1.-12.	010-129				PROBE (3.5 ft.) AND STANDARD ACCESSORIES
	PROBE ONLY				
1.	010-130				
	STANDARD ACCESSORIES				
2.	175-125			1	CABLE, ground lead, 12 in.
3.	175-124			1	CABLE, ground lead, 5 in.
4.	175-263			1	CABLE, ground lead, 3 in.
5.	013-071			1	PINCER TIP ASSEMBLY
6.	352-024			1	HOLDER, assembly, probe
7.	013-052			1	BAYONET, adapter for P6008
8.	344-046			2	CLIP, probe
9.	206-060			1	TIP, probe, 6-32, male
10.	206-105			1	TIP, probe, w/6-32 threads
11.	134-013			1	PLUG, banana, female, 6-32 tap
12.	206-015			1	TIP, assembly w/straight shank

REPLACEABLE PARTS



REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
	010-130				PROBE, P6008 Includes:
1.	202-116			1	BOX, Compensator assembly for P6008 (wired) Includes:
2.	134-044			1	PLUG, probe, BNC
3.	358-072			1	BUSHING, insulator
4.	214-109			1	PIN, probe contact, male
5.	166-217			1	TUBE, spacer insulator, BNC
6.	132-081			1	NUT
7.	213-020			1	SCREW, set, 6-32 x $1/8$ in. HHS
8.	204-147			1	BODY, Compensator
9.	210-577			2	NUT, hex, brass, $3/8$ x $7/32$-32 in. double chamfered
10.	213-121			1	SCREW, 0-80 x $3/32$ in. long
11.	205-046			1	SHELL, Compensator
12.	210-576			1	NUT, locking
13.	175-262			1	CABLE, assembly, 42 in. long (BNC)
14.	204-144			1	ASSEMBLY, body and tip
15.	166-285			1	SLEEVE, locking
16.	166-282			1	SLEEVE
17.	358-194			1	BUSHING, base
18.	358-192			1	BUSHING, inner base

ELECTRICAL PARTS

REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY	DESCRIPTION
	114-153			1	L103, COIL, .15-.25 μh, var.
See	114-156			1	L104, COIL, .6-1.1 μh, var.
Fig.	281-599			1	C103, CAPACITOR, 1 pf, cer, 200 v, $\pm$.1 pf.
4-2	281-063			1	C104, CAPACITOR, 9-35 pf, cer, var.
	311-249			1	R104, RESISTOR, 1 k, var.

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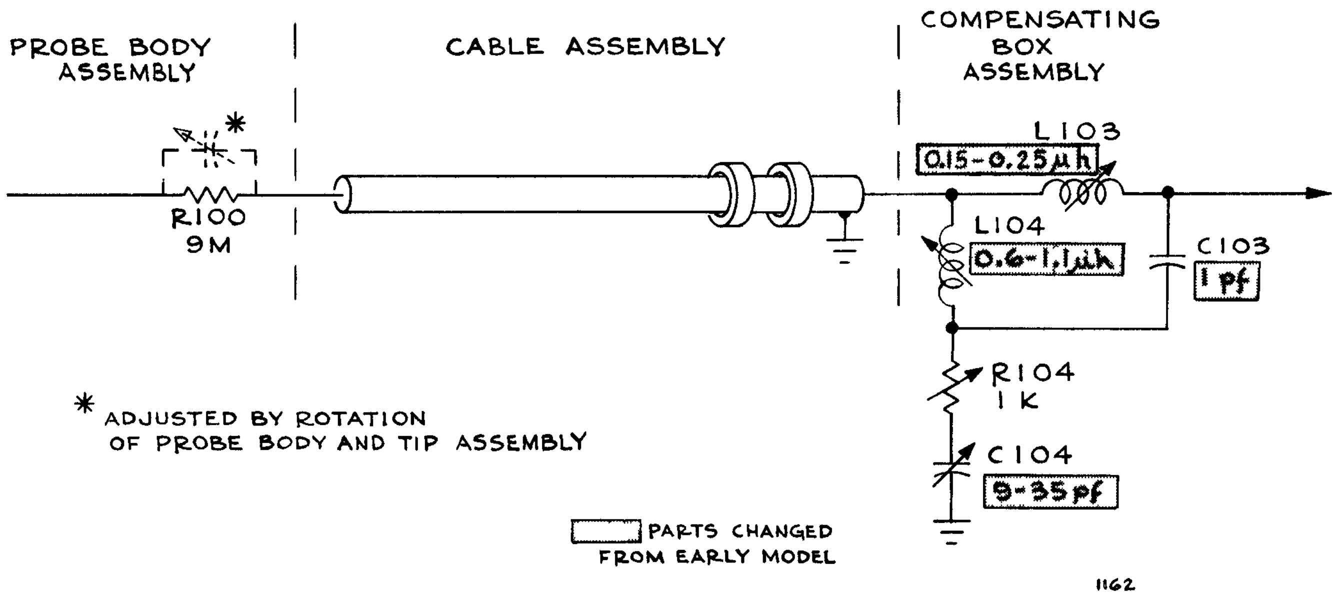
PROBE BODY ASSEMBLY
CABLE ASSEMBLY
COMPENSATING BOX ASSEMBLY
R100
9M
L103
0.15-0.25µh
L104
0.6-1.1µh
C103
1 pf
R104
1 K
C104
9-35pf
* ADJUSTED BY ROTATION OF PROBE BODY AND TIP ASSEMBLY
PARTS CHANGED FROM EARLY MODEL
1162

P6008 PROBE