INSTRUCTION MANUAL

Serial Number ______

TYPE 86 PLUG-IN

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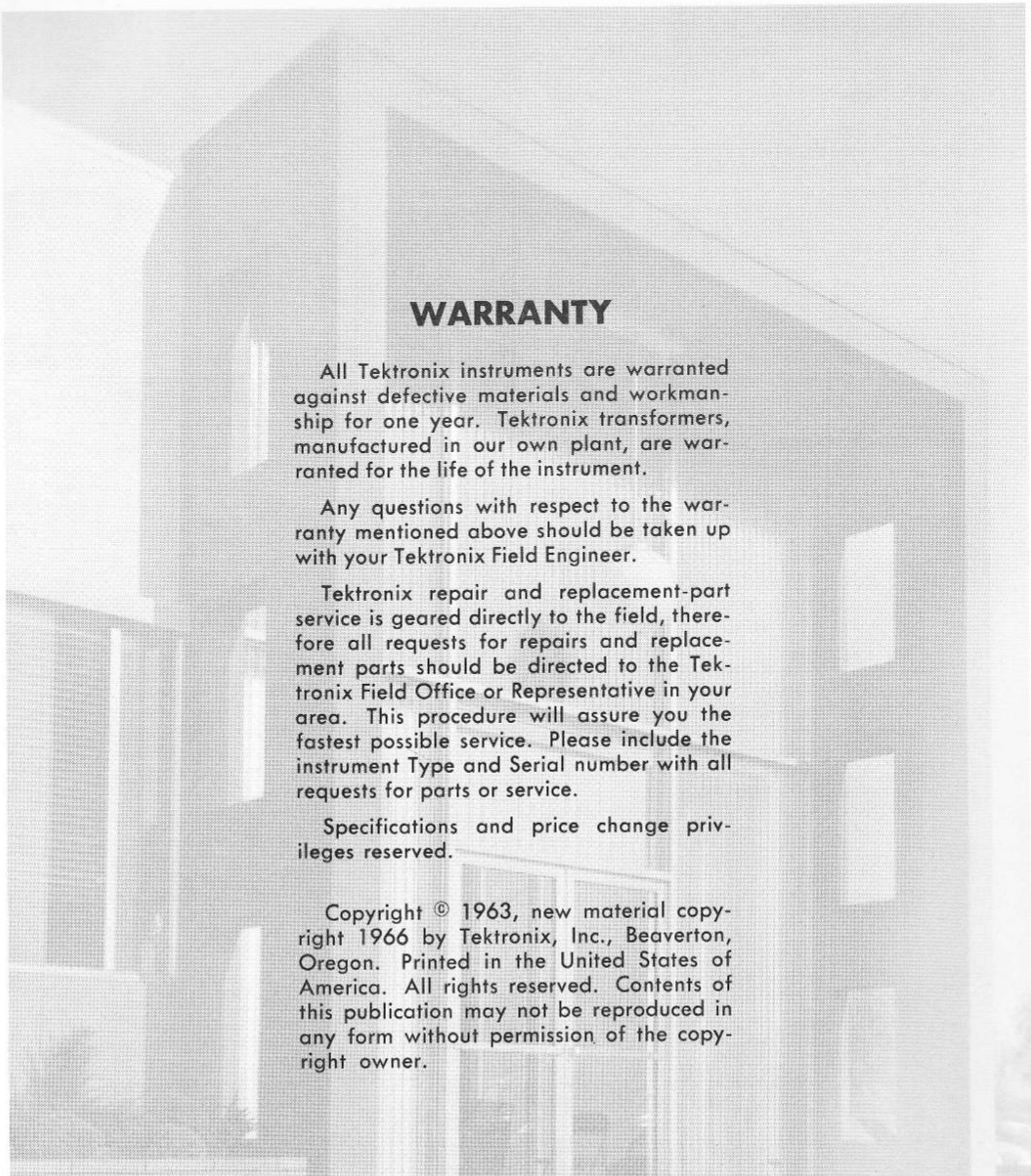

WARRANTY

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

Abbreviations and symbols used in this manual are based on, or taken directly from, IEEE Standard 260 "Standard Symbols for Units", MIL-STD-12B and other standards of the electronics industry. Change information, if any, is located at the rear of this manual.

Fig. 1-1. Type 86 Plug-In Unit.

SECTION 1
CHARACTERISTICS

General Information

The Type 86 Plug-In Unit extends the versatility of the Type 580-Series Oscilloscopes by providing fixed deflection factors from 0.01 volts/cm to 50[1] volts/cm. The Type 86 is a fast-rise, high-gain, plug-in unit with a basic deflection factor of 100 mV/cm. A built-in ×10 amplifier extends the basic deflection factor to 10 mV/cm.

A P6008 passive 10× attenuator probe supplied with the Type 86 increases the input resistance from 1 megohm to 10 megohms and decreases the input capacitance from 15 pF to about 7.5 pF. Below serial number 3000 the Type 86 had an input capacitance of 12 pF without a probe and 7 pF with a P6008 Probe connected. The probe reduces loading on the circuit under test and provides a convenient means of coupling the signal from the device under test.

Table 1-1 summarizes the risetime and bandwidth (DC to approximately 3-dB-down points) on the Type 86.

TABLE 1-1

System	Risetime	Bandwidth (DC to typical 3 dB down point)
580-Series Oscillosocpe using the Type 84 Plug-In Test Unit.	Equal to or less than 4.2 ns.	
580-Series Oscilloscope and Type 82; ×1 Gain.	Equal to or less than 4.4 ns.	DC to 80 MHz (Also see Fig. 1-2)
580-Series Oscilloscope and Type 82; ×10 Gain.	Equal to or less than 4.7 ns.	DC to 75 MHz
580-Series Oscilloscope and Type 82 (×1 Gain) with P6008 Probe.	Equal to or less than 5.3 ns.	DC to 66 MHz
580-Series Oscilloscope and Type 82 (×10 Gain) with P6008 Probe.	Equal to or less than 5.5 ns.	DC to 63 MHz

The transient response and gain of the vertical amplifier has been standardized in the Type 581 Oscilloscopes SN 950 and up, Type 585 Oscilloscopes SN 2585 and up and all 580A-Series oscilloscopes. (There are some exceptions to these SN ranges since some earlier SN oscilloscopes have been modified out of sequence. Your Tektronix Field Engineer has a list of those which have been modified.)

[1]20 volts/cm on instruments serial numbered below 1000.

[2]Typically 3-dB down; never to exceed 3.5-dB down at any of the frequencies listed in the column.

To bring an earlier serial-numbered oscilloscope up to date for optimum transient response with the Type 86, contact your Tektronix Field Engineer for information concerning modification kit number 040-0275-00.

Calibrated Deflection Factor

Basic Deflection Factor (×1 Gain): Nine calibrated steps are provided—0.1, 0.2, 0.5, 1, 2, 5, 10, 20 and 50[3] volts per centimeter. Continuously variable by about a 2-to-1 ratio (uncalibrated) between steps and up to approximately 100[4] volts/cm.

Extended Deflection Factor (×10 Gain): A ×10 amplifier may be switched in to give deflection factors of: 0.01, 0.02, 0.05, 0.1, 0.2, 0.5, 1, 2, and 5[3] volts per centimeter. Also continuously variable by about a 2-to-1 ratio (uncalibrated) between steps and up to approximately 10[4] volts/cm.

Calibration Accuracy

A front-panel ×1 and an internal ×1 adjustment is provided for setting proper gain of the Type 86 Plug-In Unit. When properly set, the vertical display will be within 3% of the panel reading for all switch positions except the 0.1 or 0.01 V/cm position. This position can be set for no error by means of the gain adjustments.

Input Impedance

1 megohm ±1% paralleled by approximately 15 pF[5].

Input Coupling

AC or DC coupling. With AC coupling low-frequency response is about 2 Hz (3-db) directly, or 0.2 Hz when using the P6008 Probe. Below SN 1997 the ac-coupled low frequency response was 15 Hz directly, or 1.5 Hz when using a P6008 Probe.

Maximum Allowable Input Voltage Rating

600 volts combined DC and peak AC or 600 volts AC peak to peak (not 1200 volts peak to peak).

Mechanical

Construction: Aluminum-alloy chassis.

Finish: Anodized panel.

Accessories Supplied with the Type 86

See the standard accessory list in this manual for accessories supplied with this instrument. For optional accessories, see the current Tektronix, Inc. catalog.

[3]Delete 50 V/cm and 5 mV/cm for instruments with serial numbers below 1000.

[4]Should read 40 volts/cm and 4 volts/cm, respectively, for instruments with serial numbers below 1000.

[5]Should read 1 megohm ±1% paralleled by approximately 12 pF, for instruments with serial numbers below 1000.

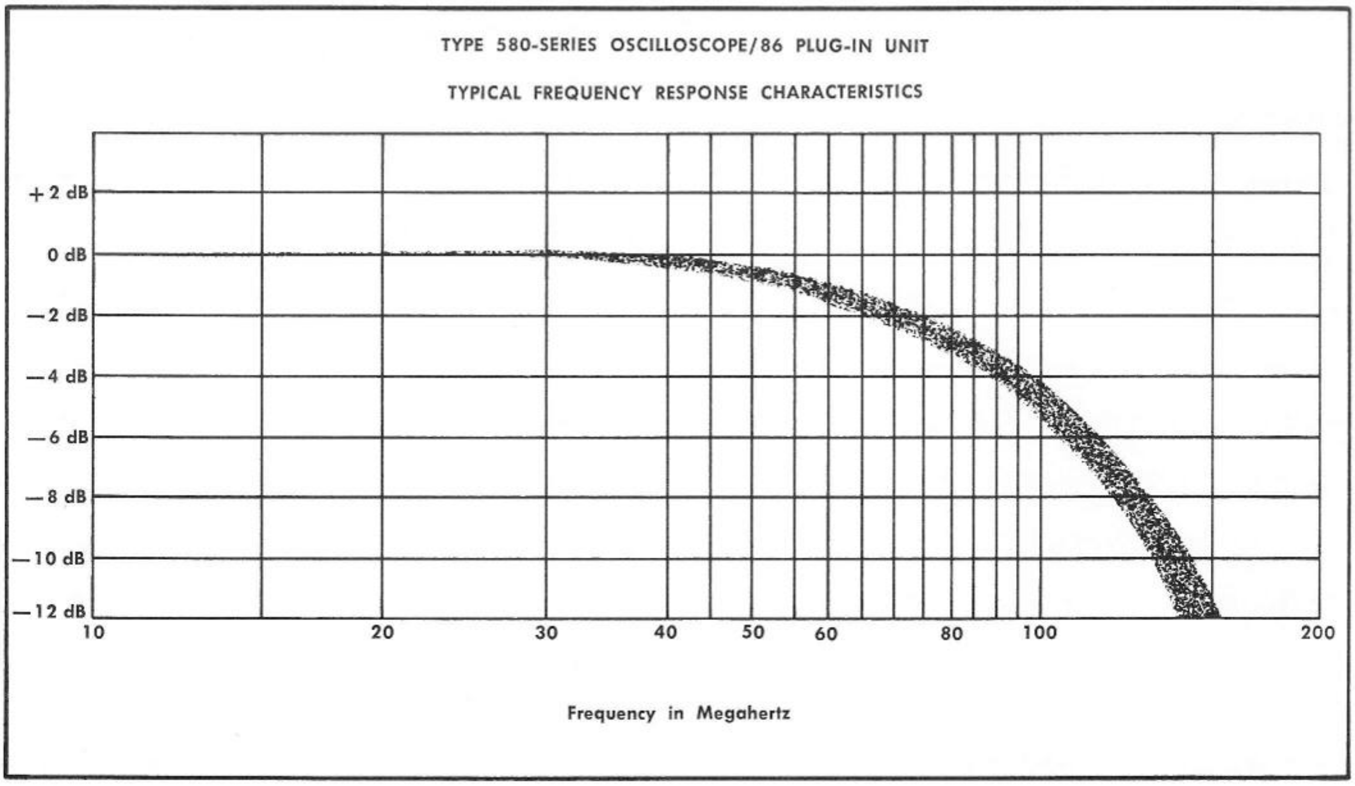

Fig. 1-2. Typical X1-gain frequency response characteristic curve of the Type 86 when used with a Type 580-Series oscilloscope. A 25-ohm resistive source (50-ohm cable terminated in 50 ohms) was used to drive the Type 86.

SECTION 2

OPERATING INSTRUCTIONS

FUNCTION OF CONTROLS AND CONNECTORS

INPUT	Signal input connector for the plug-in unit.
AC-GND-DC[1]	Three-position switch providing either AC or DC coupling into the plug-in unit. The GND position grounds the Type 86 input while disconnecting the signal, thus providing a convenient zero volt reference.
VOLTS/CM	Nine-position switch to select the calibrated vertical-deflection factors.
×1 GAIN ADJ	Screwdriver-adjustment to permit the gain of the output amplifier to be accurately set. Adjusted to make the basic deflection factor accurate at .1 VOLTS/CM.
VARIABLE VOLTS/CM	Control to provide continuously variable uncalibrated attenuation up to about a 2-to-1 ratio between the calibrated deflection factors and up to approximately 100[2] V/cm using ×1 gain or up to approximately 10[2] V/cm using ×10 gain. In the CAL position, deflection factor is as indicated by the settings of the GAIN and VOLTS/CM switches.
VERTICAL POSITION	Control for vertically shifting the position of the trace.
×10 POSITION RANGE	Screwdriver adjustment that sets the trace to coincide with the ×1 electrical center trace position when the GAIN switch is set to ×10 and VERTICAL POSITION control is centered. (Always perform this adjustment after first adjusting the ×1 POSITION RANGE control.)
×1 POSITION RANGE	Screwdriver adjustment to set the trace to coincide with the Type 86 distributed-amplifier electrical center.
GAIN	Two-position switch to select either ×1 or ×10 gain. When switch is in the ×1 position, read the black scale of the VOLTS/CM switch. When the switch is in the 10× position, read the red scale of the VOLTS/CM switch.
Securing Rod	Holds the Type 86 securely in the oscilloscope plug-in compartment. (Located at bottom center on the front panel.)

General Operation

Apply the signal to be displayed to the INPUT connector on the front panel of the Type 86. For best results, there are some precautions to observe when making the connection.

[1]This is a lever switch in instruments SN 2000-up; a rotary switch with AC-DC-GND sequence, concentric with the INPUT connector in instruments SN 101-1999.

[2]Should read 40 V/cm and 4 V/cm, respectively, for instruments with serial numbers below 1000.

(1). It is often possible to make signal connections to the Type 86 with short-length unshielded test leads[3]. This is particularly true for high-level, low-frequency signals. When such leads are used, you must also use a ground connnection between the Type 86 or oscilloscope chassis ground and the chassis of the equipment under test. Position the leads away from any stray electric or magnetic field source to avoid obtaining erroneous displays.

(2). In many low-frequency applications, however, unshielded leads are unsatisfactory for making signal connections because of unwanted parasitic oscillations and unavoidable pickup resulting from radiating fields. In such cases, use shielded (coaxial) cables. Be sure that the ground conductors of the cables are connected to the chassis of both the oscilloscope and the signal source.

NOTE

Unwanted oscillations may occur when using the Type 86 at its minimum deflection factor (V/CM switches at .1 or .01 position). See subsequent information for causes and cures.

(3). The use of coaxial cables or shielded leads may also cause oscillations, particularly if the cable length is ¼ wavelength or some multiple within the bandwidth of the Type 86. Oscillations result from the fact that an external inductance of high Q, shunted by the input capacitance of the Type 86, is a resonant circuit. This circuit can be activated by the feedback through the interelctrode capacitance of the input tube. Since the Type 86/580-Series oscilloscope combination is a wide bandwidth system, unwanted oscillations that occur within the response of the system will be amplified and displayed on the CRT.

(4). Since any form of external inductance can constitute the inductive portion of the LC circuit, connecting the device under test (or generator) directly to the Type 86 connector may not always solve the oscillation problem. Oscillations can still occur if a lead length or an inductor in the device has sufficient Q to again make the input circuit active.

(5). To prevent such unwanted oscillations, methods must be devised to lower the Q of the inductance. In the case of applications where unshielded leads are used, the Q can be lowered by wrapping each lead several times around a ferrite toroid core or by adding attenuation through the use of the other VOLTS/CM switch positions. A third method is to connect a resistor of about 100 to 1000 ohms in series with the lead where it connects to the input connector of the Type 86. A fourth method is to use the P6008 Probe.

(6). Oscillations that arise from using coaxial (shielded) leads can be eliminated in a manner similar to that described for unshielded leads. That is, add a suitable value resistor in series with the center conductor of the cable near the

[3]For ease in connecting test leads to the INPUT of the Type 86, adapters such as a BNC-to-UHF connector adapter (mates with Type 86 INPUT and accepts a banana plug, Tektronix Part Number 103-0032-00) or a single binding post fitted with a BNC plug (Tektronix Part Number 103-0033-00) are available. Order these items through your local Tektronix Field Office.

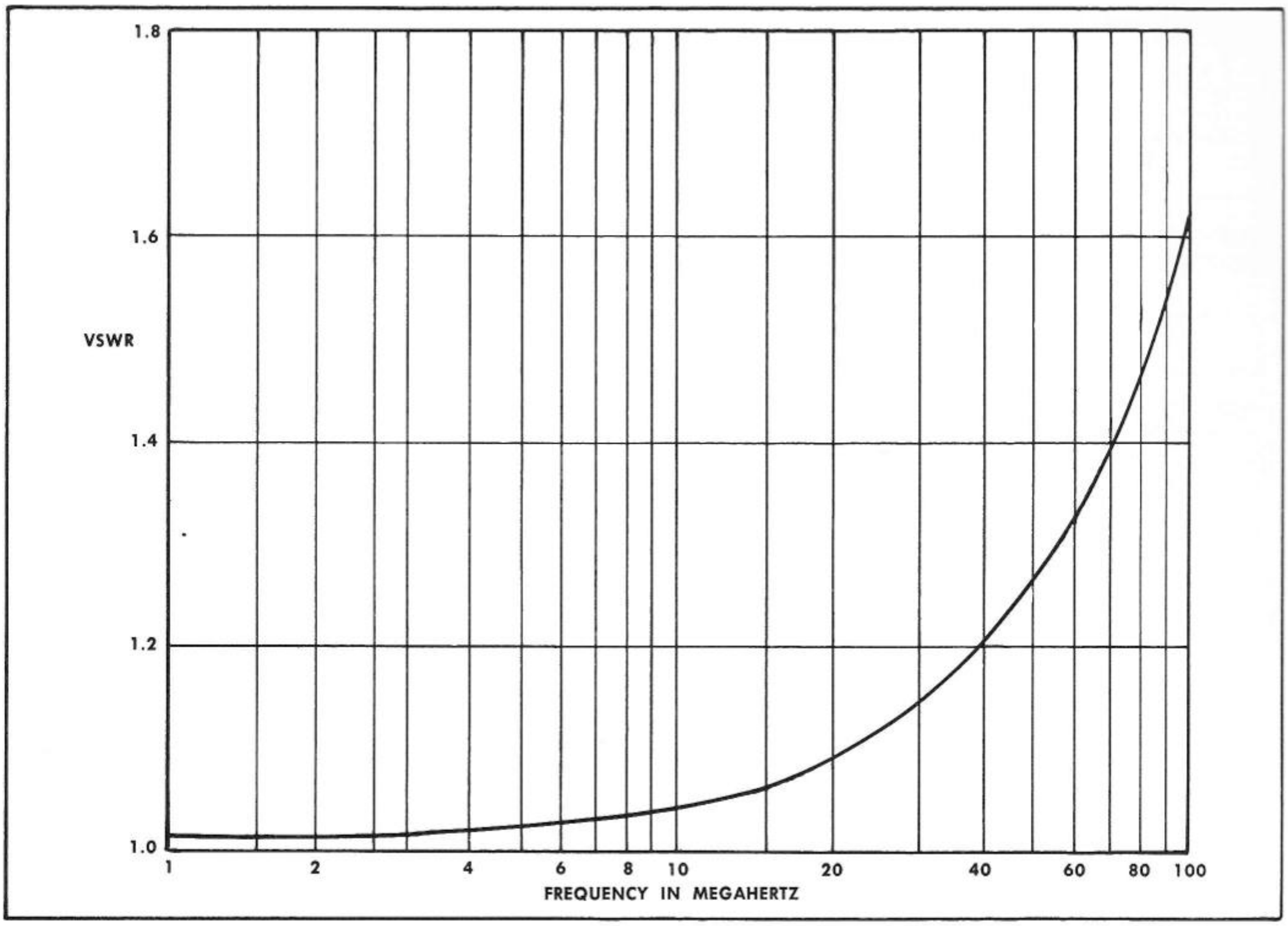

Fig. 2-1. Typical VSWR versus frequency curve measured at the Type 86 input connector. The signal source was terminated into 50 ohms at the connector.

input to the Type 86, use some other setting of the VOLTS/CM switch, or use the P6008 Probe.

(7). In high-frequency applications, it will be necessary to terminate the coaxial cable with a resistor or an attenuator presenting a resistance equal to the characteristic impedance of the cable. This will not only prevent the resonance effects but also prevent ringing (high-frequency damped oscillations).

(8). It becomes more necessary to terminate the cable properly as the length of the cable increases. The termination is generally placed at the oscilloscope end of the cable, although many sources require an additional termination at the source end of the cable as well.

(9). If you are working with 50-ohm systems, you may need to use the VSWR versus frequency curve shown in Fig. 2-1. The curve was obtained using a signal source which was terminated into 50 ohms at the input of the Type 86. The termination which was used is a type that has BNC connectors on each end (Tektronix part number 011-0049-00). If a 50-ohm 10:1 attenuator (Tektronix part number 011-0059-00) is connected between the signal source and the termination, the VSWR will be the same as the VSWR of the 10:1 attenuator.

(10). Applies only to units below SN 3000. In fast-rise pulse applications where a step function with a risetime of 10 nanoseconds or less is applied to the Type 86, clean reproduction of the step function can be obtained (limited only by the risetime of the system) for all except the three highest positions of the VOLTS/CM switches. The three highest positions are: 5 (.5), 10 (1) and 20 (2). In these positions, aberrations occur on the rising portion and leading corner of the waveform.

(11). Applies only to units below SN 1000. If the fast-rise step function of 10 nanoseconds or less is applied through a P6008 Probe to the input of the Type 86, the aberrations will still occur because the probe is capable of coupling the signal to the Type 86 with very little increase in risetime. If it is important to take full advantage of the faster risetime and transient response of the Type 86/580-Series oscilloscope combination, use the lower positions of the VOLTS/CM switches and external attenuation. For example, Tektronix BNC 50-ohm attenuators provide proper external attenuation without sacrificing transient response when used with 50-ohm systems.

(12). As nearly as possible, simulate actual operating conditions in the equipment under test. For example, the equipment should work into a load impedance equal to that which it will see in actual use.

(13). Consider the loading effect on the equipment under test due to the input circuit of the Type 86. The input circuit can be represented by a resistance of 1 megohm (±1%) shunted by a capacitance of approximately 15 picofarads from DC to about 2 MHz. (At frequencies above 2 MHz, the impedance gradually decreases.) If a few feet of unterminated shielded cable is used for coupling the signal to the input circuit of the Type 86, the capacitance added by the cable might be as much as 80 picofarads. Where such resistive and capacitive loads adversely affect operation of the signal source, you might want to use the P6008 Probe in the manner described next.

Use of Probes

The P6008 Probe furnished with the Type 86, lessens both capacitive and resistive circuit loading and at the same time, reduces sensitivity 10 times. The 10× attenuation introduced by the probe extends the calibrated vertical deflection factor of the Type 86 to 500[4] volts per centimeter. Though this means that higher amplitude signals can be displayed on the crt within the graticule area, do not apply signals to the probe that will exceed the maximum voltage rating of the probe.

(Refer to the P6008 Probe Instruction Manual for the voltage derating curves.)

In general, do not exceed the 600-volt combined DC and peak AC rating of the probe or of the Type 86. If the Type 86 AC-GND-DC switch is set to AC, consider that the probe will not attenuate the DC component of the signal because AC coupling is used. Therefore the full DC voltage applied to the probe will also be applied across the input coupling capacitor of the Type 86. If the DC voltage rating of the probe is exceeded, the DC input voltage rating of the Type 86 will also be exceeded.

To assure the accuracy of the pulse and high-frequency measurements, first check the probe compensation by using the subsequent procedure. Then, when using the probe to make amplitude measurements, be sure to multiply the observed amplitude by 10.

To compensate the P6008 Probe, proceed as follows:

1. Set the Amplitude Calibrator switch on the oscilloscope for an output of suitable amplitude.

2. Hold the probe body and loosen the locking sleeve several turns.

3. Touch the probe tip to the Cal. Out connector on the oscilloscope.

4. Adjust the oscilloscope controls to display several cycles of the waveform.

5. Hold the probe base and rotate the probe body to obtain an undistorted presentation of the square waves.

6. Hold the probe body and carefully hand tighten the locking sleeve.

[4]**Should read 200 volts/cm for instruments with serial numbers below 1000.**

If the probe changes adjustment while you are tightening the locking sleeve, continue to tighten the sleeve, as usual, until it is hand tight. Then, as a fine adjustment, hold the locking sleeve and probe body with one hand. With the other hand turn the probe base carefully in a direction that produces the correct display.

If you use a square-wave source other than the oscilloscope calibrator for compensating the probe, do not use a repetition rate higher than 5 kHz. At higher repetition rates, the waveform amplitude appears to change as the probe is compensated, and you will not be able to compensate the probe properly. If the probe remains improperly compensated, frequency response of the system will not be flat and your measurements will be inaccurate.

In some high-frequency applications or pulse work, the 7.5-pF input capacitance loading of the P6008 Probe may become an important factor to consider in your measurements. In such situations, you may prefer probe resistive loading to capacitive loading since parallel resistive loading can be calculated more easily than capacitive loading. As a solution to the problem, use a P6034 (10×) or P6035 (100×) Probe. These probes have an input capacitance of 0.6 pF (within a tolerance of ±0.1 pF).

To determine which probe to use, refer to Fig. 2-2. The graph shows the typical input capacitive reactance and resistance versus frequency curves of the P6034 and P6035 Probes as compared to the P6008. For further information concerning the characteristics of the P6034 and P6035 Probes, refer to the Tektronix catalog. If you decide to use either or both of these probes, the discussion that follows describes how they can be properly used with the Type 86.

Use of either the P6034 or the P6035 Probe means that the cable end of the probe must be terminated into 50 ohms for proper transient response. In addition, since the maximum DC voltage rating of the probe is low (compared to the P6008), external AC coupling can be used to block the DC component (up to 500 volts) of a signal without affecting the response of the probe at high frequencies. External AC coupling is accomplished by inserting a GR Type 874-K coupling capacitor between the cable connector end of the probe and any external resistance paths to ground such as an attenuator and termination (see Fig. 2-3). An external capacitor has to be used because the plug-in .01 μF coupling capacitor is not in series with the dc path through the probe resistor and these external resistances to ground.

At low frequencies the approximate 3-dB down point of the P6034 and P6035 Probes, when connected to a 50-ohm source and when used with the GR 874-K coupling capacitor, is 70 kHz for the P6034 Probe and 7 kHz for the P6035 Probe.

The probe cable is small in diameter for flexibility and is made short to minimize pulse distortion due to cable losses. If the probe cable is too short for your applications, you can increase its length by adding good quality 50-ohm cable such as RG-86/U or RG58. Add the cable, (fitted with GR Type 874 50-ohm connectors) between the coupling capacitor and the other series connected 50-ohm components (see Fig. 2-3). Be sure to consider the effect that long cable might have on pulse waveforms. However, select a length long enough to move the reflection on the waveform out of the area of interest (see Fig. 2-4).

This reflection which appears as an 8% dip in the waveform, originates from the input circuit of the Type 86. It is

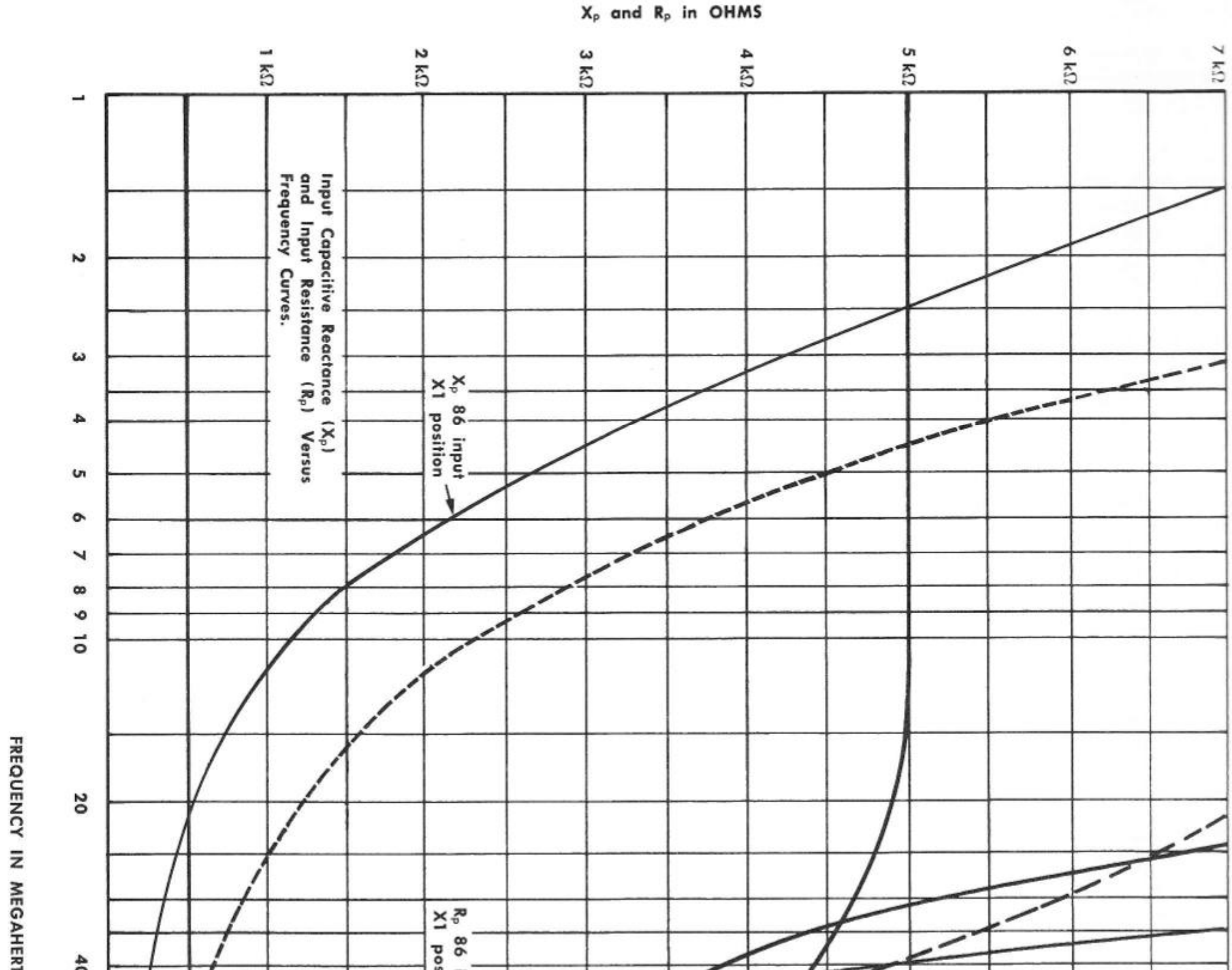

Fig. 2-2. Typical X_p and R_p versus frequency curves for P6008, P6034, and P6035 Probes.

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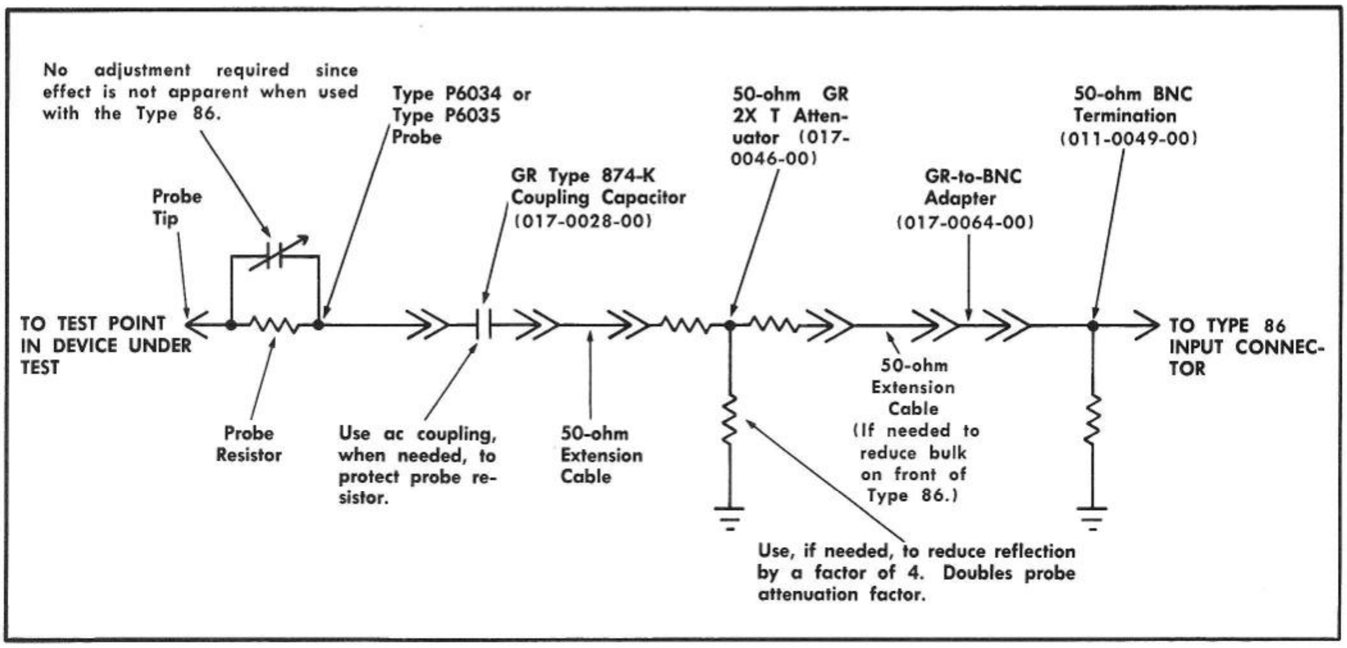


Fig. 2-3. Use of the P6034 or P6035 Probe with the Type 86.

caused by the input capacitance of the Type 86 connected in shunt with the termination. The reflection travels down the cable and reflects back when it reaches the resistor in the probe body. The down and back time of the reflection is equal to twice the delay time of the cable between the termination and the resistor in the probe. The reflection will appear behind the leading edge of the pulse delayed by this amount of time.

As an alternative method of controlling the reflection, a 50-ohm GR 2× T attenuator can be connected between the added cable and the termination (see Fig. 2-3). The attenuator decreases the amplitude of the dip by a factor of four. The probe attenuation will be increased by a factor of two. Although the probe attenuation factor is doubled, voltage rating of the probe is unchanged; therefore, avoid the tendency to apply larger signals to the probe. The excessive signal amplitude of DC voltage (if applied) may exceed the ½-watt power rating of the probe resistor.

To avoid too much bulk extending out from the front-panel connector of the Type 86, if all components are used as described, insert a short length of high quality 50-ohm cable between the 50-ohm GR 2× T attenuator and the GR-to-BNC adapter.

Input Coupling

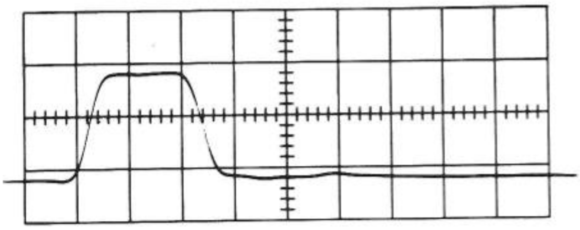
To display both the AC and DC components of an applied signal, set the AC-GND-DC switch to DC; to display only the AC compenent of a signal, set the switch to AC. In the AC position of the switch, the DC component of the signal is blocked by a capacitor in the input circuit. The Lower —3 dB frequency limit of the system with AC coupling is about 2 Hz for units SN 1977 and up. (Below SN 1997 the lower frequency level was 15 Hz). Therefore, some low-frequency distortion of signals with components below this frequency can be expected when using the AC position. By using the P6008 Probe in conjunction with the Type 86, the low frequency response is lowered to about 1.5 Hz in the AC position.

Deflection Factor

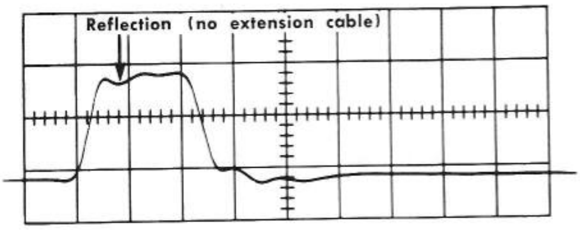
The amount of vertical deflection produced by a signal is determined by the signal amplitude, the attenuation factor (if any) of the probe, the setting of the VOLTS/CM switch, and the setting of the VARIABLE VOLTS/CM control. Calibrated deflection factors indicated by the settings of the VOLTS/CM switch apply only when the VARIABLE VOLTS/CM control is set to the CAL position. Errors in display measurements can result if the setting of this control is unintentionally moved away from the CAL position.

The range of the VARIABLE VOLTS/CM control is about 2 to 1 to provide variable (uncalibrated) vertical-deflection factors between calibrated settings of the VOLTS/CM switch. Since the maximum attenuation ratio of the VARIABLE VOLTS/CM control is approximately 2 to 1, the control does not completely cover the range between the 2-5 steps of the VOLTS/CM switch. For example, if the VOLTS/CM switch is set to .2 and the GAIN switch is set to ×1, the range of the VARIABLE VOLTS/CM control will be from 0.2 to about 0.4 volt per centimeter. However, the control provides full coverage between the 1-2 steps of the VOLTS/CM switch. For example, if the VOLTS/CM switch is set .1 and the GAIN switch is set to ×1, the range of the VARIABLE VOLTS/CM control will be from 0.1 to about 0.2 volt per centimeter.

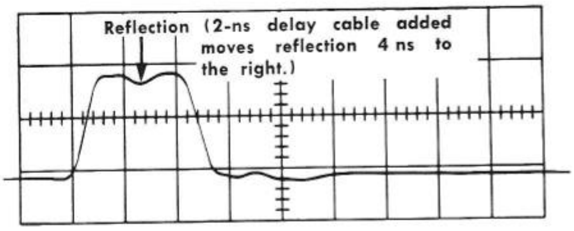
The VARIABLE VOLTS/CM control extends the basic vertical deflection factor of the Type 86 to a maximum of about 100 volts per centimeter when the GAIN switch is set to ×1 and the V/CM switch is set to 50. If the GAIN switch is set to ×10 and the V/CM switch is set to 5, the vertical



(a) System: Type 110/50 Ω Term/P6008/86/585.



(b) System: Type 110/50 Ω Term/P6034/50 Ω Term/86/585.



(c) System: Type 110/50 Ω Term/P6034/2-ns delay (extension) cable/50 Ω Term/86/585.

Fig. 2-4. Waveforms obtained when a pulse from the Type 110 is applied to each of the above series-connected systems. Applied pulse duration is 22 ns and risetime is 0.25 ns; Type 86/585 vertical deflection factor: 2 volts/cm, sweep rate: 10 ns/cm.

deflection factor can be extended from 5 to a maximum of about 10 volts per centimeter by means of the VARIABLE VOLTS/CM control.

APPLICATIONS

In general, applications such as those described in the Type 581A or 585A Instruction Manual, Section 3, also apply when using the Type 86 Plug-In Unit. Since the Type 86 has more than one calibrated sensitivity, substitute the VOLTS/CM switch setting for 0.1 VOLTS/CM in the appropriate formula given in the Applications section of the Type 581A or 585A manual. In addition, since the P6008 Probe has a fixed attenuation factor of 10, substitute 10 for Attenuation Factor of Head when you are using the P6008 Probe.

As an example, the formula for measuring the peak-to-peak AC component of a waveform is as follows:
(10) (VOLTS/CM Switch Setting) × (Vertical Deflection in cm) = Volts, peak to peak.

FRONT-PANEL ADJUSTMENTS

The following procedures describe how to adjust the front-panel screwdriver-adjustable controls. The adjustments are easy to make and no special test equipment is required.

X1 Gain Adjustment

The ×1 gain of the Type 86 should be checked periodically to assure correct vertical deflection, particularly when the Type 86 is used for the first time or when the unit is transferred from one oscilloscope to another. To check or set the gain, proceed as follows:

1. Set the Type 86 front-panel controls to these settings:

AC-GND-DC	DC
VOLTS/CM	.1
VARIABLE VOLTS/CM	CAL.
VERTICAL POSITION	Centered
GAIN	×1

2. Set the oscilloscope sweep rate and triggering controls for a 0.1-ms/cm free-running sweep.

3. Apply a 0.2-volt peak-to-peak calibrator signal from the oscilloscope to INPUT connector. (Use a short test lead through a suitable connector adapter.)

4. Check for a deflection of exactly two centimeters. If the deflection is not proper, set the ×1 GAIN ADJ for a deflection of exactly two centimeters. Use the VERTICAL POSITION control to align the display with horizontal graticule lines.

X1 POSITION RANGE and X10 POSITION RANGE Adjustments

The following procedure describes a method for adjusting the ×1 POSITION RANGE control to properly position the trace to the Type 86 distributed-amplifier electrical center (or DC-balance point) under no-signal conditions. When adjusted properly, trace shift is minimized as the VARIABLE VOLTS/CM control is rotated. When both the ×1 and ×10 POSITION RANGE adjustments are correctly adjusted, a balance positioning range above and below the graticule center is maintained. To make adjustments, proceed as follows:

1. Set the front-panel controls the same as outlined in steps 1 and 2 in the ×1 Gain Adjustment procedure except that the VERTICAL POSITION control must be set so the white dot is at 0° or 12 o'clock position. (This is the electrical center of the control as set at the factory.) Do not apply a signal to the Type 86.

2. As a preliminary setting, adjust the ×1 POSITION RANGE control to the point where there is no trace shift on the screen as the VARIABLE VOLTS/CM control is rotated.

3. For the final setting, place the gain switch to the ×10 position and readjust the ×1 POSITION RANGE control for

minimum trace shift as the VARIABLE VOLTS/CM control is rotated.

NOTE

When performing step 3, leave the VERTICAL POSITION control at 0° and use the X10 POSITION RANGE Control to keep the trace on the CRT while adjusting the X1 POSITION control.

4. Adjust ×10 POSITION RANGE control to position the trace to the graticule X-axis centerline.

IMPORTANT

After adjusting the X1 POSITION RANGE and X10 POSITION RANGE controls properly, trace shift is minimum and DC balance is correct as long as the VERTICAL POSITION control remains at 0°. If the VERTICAL POSITION control is moved away from 0°, as it will during normal operation, DC imbalance and an increased amount of trace shift will occur when operating the VARIABLE VOLTS/CM control.

SECTION 3
CIRCUIT DESCRIPTION

AMPLIFIERS

Introduction

The Type 86 consists of an input amplifier, a $\times 10$ amplifier, and an output amplifier. Throughout the discussion, you should refer to the block and circuit diagrams located near the back of the manual.

NOTE

Voltages and currents given in the circuit description are approximate.

Input Coupling

The signal to be displayed is applied to the Input Cathode Follower (V133) by way of the AC-GND-DC switch SW101 and the VOLTS/CM switch SW111. In the DC position of the AC-GND-DC switch, input coupling capacitor C101 is bypassed and the input is DC coupled. In the AC position, the input signal passes through C101 and the DC component is blocked. Capacitor C101 limits the low-frequency response to about 2 Hz at the 3 dB down point in units SN 1997 and up. (Below SN 1997 the low-frequency response was 15 Hz). The ground position provides a handy zero-volts reference without having to disconnect the signal lead from the oscilloscope. The signal is disconnected from the oscilloscope by the switch in this position.

Input Attenuation

The VOLTS/CM switch is a 9-position rotary switch that selects the various attenuator sections. The basic deflection factor of the Type 86 is 0.1 volt/cm.

When the VOLTS/CM switch is in the 0.1 position, the signal is coupled directly (without attenuation) to the Input Cathode Follower (V133). For the other settings of the VOLTS/CM switch, the attenuation networks are individually switched into the circuit so that the input voltage of V133 is always 0.1 volt for each centimeter of CRT deflection. This amount of deflection is correct when the VARIABLE VOLTS/CM control (R180) is set to the CAL position.

The attenuators are frequency-compensated RC voltage dividers. For low-frequency signals they are resistive dividers, and the attenuation factor can be expressed in a general manner as follows:

$$\text{Attenuation Factor} = \frac{\text{total divider resistances (includes R117)}}{\text{grounded-leg resistances (includes R117)}}$$

Using the 50X attenuator as a specific example (see Fig. 3-1), the formula is:

$$\text{Factor Attenuation} = \frac{(R111C)\ (R117) + (R111C)\ (R111E) + (R111E)\ (R117)}{(R111E)\ (R117)} = 50$$

At low frequencies the dividers are resistive because the impedance of the capacitors is high and their effect in the circuit is negligible. As the frequency of the input signal increases, however, the impedance of the capacitors decreases and their effect in the circuit becomes more pronounced.

For high-frequency signals the impedance of the capacitors is low, in comparison to the resistance of the circuit, and the attenuators become capacitive voltage dividers. For these frequencies, the attenuation factor is similar to the resistance case, except that the capacitive reactances are the dominant factors. A variable capacitor in each attenuator, such as C111C in the 50X attenuator (see Fig. 3-1), provides a method for adjusting the capacitance inverse ratios equal to the resistance ratios.

The variable capacitor across each attenuator, such as C111B in the 50X attenuator (see Fig. 3-1) provides a means of adjusting the input capacitance of the attenuator to a standard value of about 15 picofarads by using a 15-pF Input Time Constant Standardizer. A similar method is provided to standardize the input capacitance when the VOLTS/CM switch is in the .1 or straight-thru position. In addition to providing the same input capacitance, the resistance values in the attenuators are chosen to provide an input resistance of 1 megohm for each setting of the VOLTS/CM switch. Thus, when the P6008 Probe is connected to the Input connector, the probe will work into the same RC time constant regardless of the setting of the VOLTS/CM switch.

A few attenuator dividers contain spiking networks to aid in preserving the risetime of the system when these attenuators are switched into the circuit.

Input Cathode Follower

The Input CF (Cathode Follower) stage (V133) employs a nuvistor, which is a sub-miniature triode. This stage presents a high-impedance, low-capacitance load at the input connector and isolates the input from the succeeding stages.

A protective network consisting of C126 and R126 in the grid circuit limits the grid current to about 1 mA if up to 600 VDC overload is applied to the input.

The Input CF stage draws about 8 mA at 96 cathode-to-plate volts, and has a gain of about 0.9. The load consists of R137 and the base impedance of Q164 which is about 3 kΩ. The cathode of V133 is long-tailed; that is, cathode resistor R137 returns to a voltage which is well below the grid level. Long-tailing the cathode improves the gain stability of the stage. At the junction of R135 and R136, the cathode resistor is held at —25 volts by Zener diode D136. This diode provides a means of obtaining the desired operating potential from the —150-volt power supply.

GRID CURRENT ZERO adjustment (R121) applies to DC voltage to the junction of R117 and R118. When this control is set properly, the voltage developed across R118 offsets any grid-current-developed voltage across R117. The offset voltage minimizes any display shift due to the grid-current-developed voltage assuring accurate DC measurements.

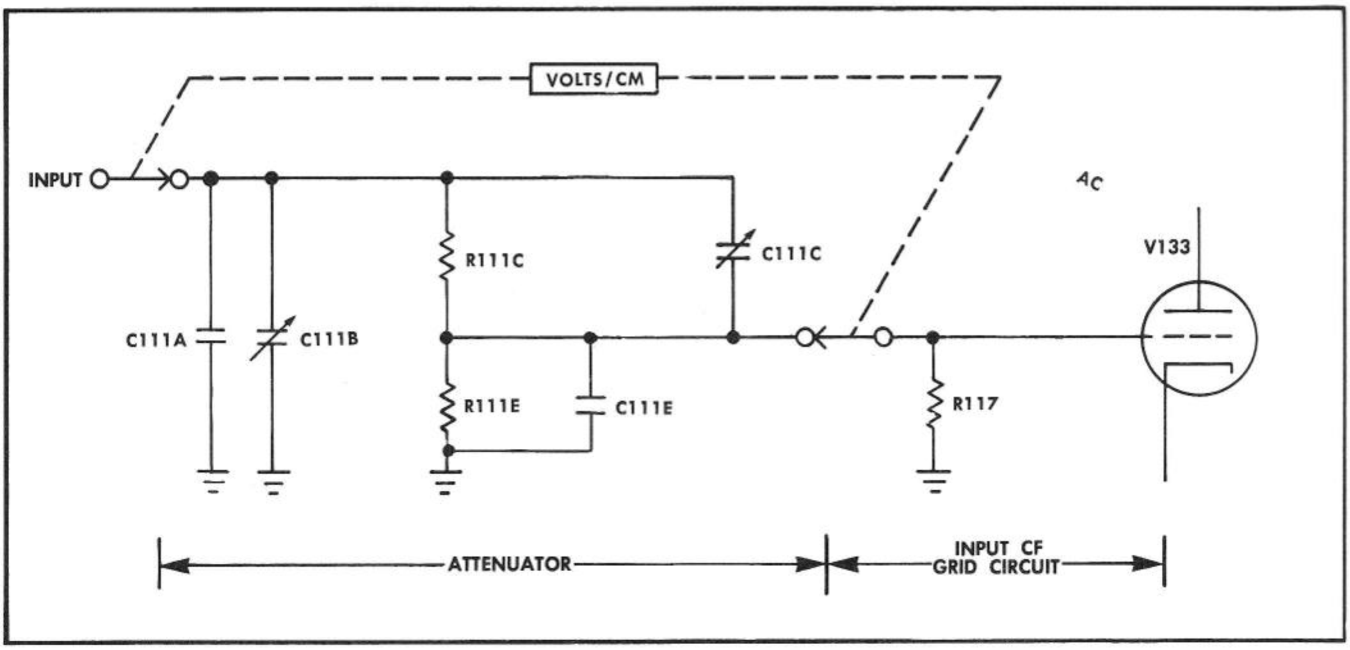


Fig. 3-1. Simplified circuit diagram showing the most important components involved when calculating attenuation factor.

Diodes D138 and D139, normally reverse biased, protect Input Amplifier transistors Q164 and Q174 from cathode-follower overloads. In addition, the diodes protect the transistors in case the nuvistor filament fails or the nuvistor is withdrawn from its socket during operation.

Diode D134, connected to the junction of R132 and R133, is a protection diode which is normally forward biased. During normal operation the diode clamps the junction at +100 volts. In the event that the grid is suddenly driven too far positive, the diode unclamps (reverse biases). R133 drops the plate voltage of V133 to protect the tube against excessive plate dissipation and cathode current.

Input Amplifier

The signal from Input CF (V133) is applied to the base of Q164 of the Input Amplifier stage. This stage consists of transistors Q164 and Q174 with associated circuitry. Both transistors are connected as an emitter-coupled paraphase amplifier. In addition to converting the single-ended signal to push-pull, this stage drives the 93-ohm coaxial lines which constitute a 186-ohm balanced line, terminated at each end.

The single-ended to push-pull gain of this stage is about one. This is determined by the ratio of collector impedance to the emitter impedance.

Transistor Q174 operates as a grounded-base device and is current fed from R167. The operating point of transistors Q164 and Q174 is set by the emitter resistors consisting of R169, R178, and R179 to —150 volts. These resistors set the operating point of each transistor at about 12 mA, V_{ce} at 3 volts.

VARIABLE VOLTS/CM Control

The VARIABLE VOLTS/CM ganged control (R180) (see Fig. 3-2) is a balanced, bridged-T, constant-impedance (as a function of rotation) attenuator. To assure linearity of operation of the Input Cathode Follower and Input Amplifier stages over the full range of the control, maximum attenuation is limited to about 2.

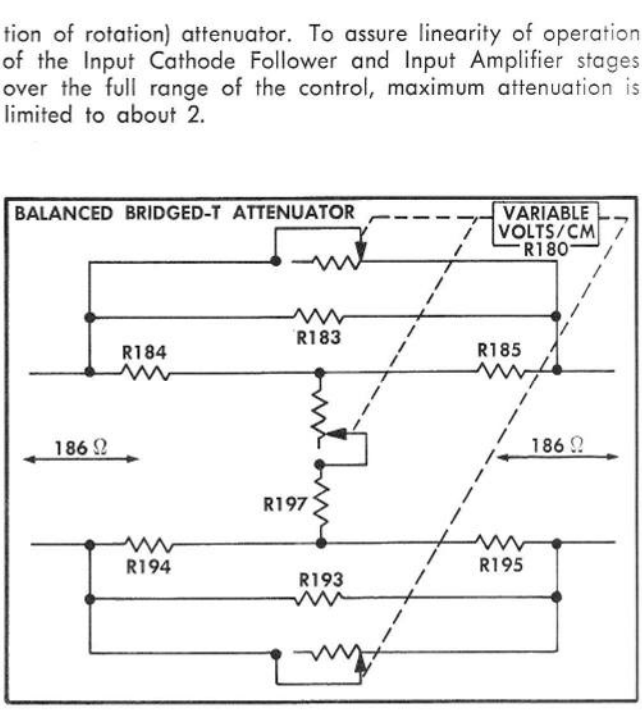


Fig. 3-2. VARIABLE VOLTS/CM control (R180) shown in the CAL. (calibrated) position.

Positioning Emitter Follower

The positioning EF (Emitter Follower, Q153) provides low impedance positioning drive for controlling the position of the trace vertically on the screen. The positioning network consists of all components shown in the base circuit of Q153.

Positioning drive applied to the network is obtained from the +12.6 volt regulated heater supply. A filter consisting of C555, R555, C556 and R556, bypasses any ripple that might appear on the +12.6-volt supply line. Thus, the filter prevents ripple from feeding into the signal channels via the positioning system.

The ×1 POSITION RANGE control (R143) sets the range of the VERTICAL POSITION control (R140) so R140 can swing symmetrically about the +1.9-volt average bias of V133. The voltage swing is approximately ±0.7 volt at the base of Q147 which corresponds to about ±9 (or a total of 18 cm) centimeters positioning range on the screen. When GAIN switch (SW390) is placed to the ×10 position, divider resistors R148 and R149 decrease the VERTICAL POSITION control voltage swing by a factor of 10.

Gain Switch

The GAIN switch (SW390) selects the push-pull signal path. When the GAIN switch is set to the ×1 position, the path for each channel is straight through the switch and 93-ohm coax to the Output Amplifier. When the GAIN switch is set to the ×10 position, the path is through the ×10 Amplifier to the Output Amplifier. Signal-delay or propagation time is 4.5 nanoseconds greater for the ×10 gain path than for ×1 gain path.

X10 Amplifier

The ×10 Amplifier has three stages. Each stage is push-pull to minimize DC drift. The collector-to-emitter impedance ratios for the first two stages produce a gain of about 3.15 each. The last stage has a gain of about one. Input and output DC level of the ×10 Amplifier is approximately +7.2 volts.

Under no-signal conditions, the first stage operates at about 3 volts V_{ce} and 9 mA: the second stage operates at about 2.5 volts V_{ce} and 8.5 mA. In each of these two stages the emitter load resistance and base potential determine the operating point. The last stage operates at about 3 volts V_{ce} and 11 mA.

All three stages contain high-frequency peaking adjustments in their emitter circuits. These are C316, C356, and C387. Additional adjustments and networks in the emitter circuits of each stage provide the means for obtaining optimum transient response through the amplifier.

In the first stage the ×10 POSITION RANGE control (R336) injects DC balance correction into the emitters. The control is adjusted to vertically position the trace to coincide with the graticule centerline when the GAIN switch is set to ×10, the VERTICAL POSITION control is centered and the ×1 POSITION RANGE control is properly adjusted.

The ×10 GAIN control (R356) in the emitter of the second stage (Q344 and Q354) is an internal adjustment. This control provides a means of setting the gain of the ×10 Amplifier to exactly 10 times.

The output stage (Q374 and Q384) acts as a line-driver stage. Each half drives a parallel-connected collector load consisting of the 91-ohm collector resistance and the 93-ohm output load.

NOTE

C381, C391, R381 and R391 installed in instruments from serial number 101 to 1060 are fixed components whose value is selected to obtain optimum square-wave response from the transistors used in the X10 Amplifier. When the proper values are chosen, low-frequency aberrations are minimized.

To provide for additional compensation for variations in transistor characteristics, network C377/R377 was added. C377 and R377 (SN 1060-1349) are adjustable to vary the time constant of the network to obtain optimum square-wave response.

Output Amplifier

The Output Amplifier consisting of V524, V534, and V544 with its associated circuitry is a three-section distributed amplifier. It is similar to the distributed amplifier section used in the 580-Series oscilloscope. All triode sections are neutralized to minimize grid capacitance. Capacitors C528 and C538 bypass the cathodes from one to the other. The grid and plate lines are 186 ohms push-pull and are +7 volts and +50 volts respectively.

The cathodes all return to ground through the ×1 GAIN ADJ R549 and R550 (if used). These components set the current through the tubes and consequently the G_m. Resistor R550 may be removed in some units to provide sufficient gain-adjust range for R549. Zener diode D554 regulates the plate line voltage against any current changes resulting from adjusting the ×1 GAIN ADJ.

The output of the plate line drives the oscilloscope grid line through pins 9 and 11 of the interconnecting plug. The termination for the grid line is R551 and R552 connected to pins 14 and 16 at the interconnecting plug. Capacitor C552 is the AC ground point for the termination junction. The termination for the grid line of the Output Amplifier is R513 and R514. Capacitor C516 is the AC ground for the R513/R514 termination.

Two time-constant networks are in the input circuitry of the grid line of the Output Amplifier. One network is C509-C510-R510; the other is R511 and C511. These networks aid in offsetting any time constant remaining in the Type 86 circuitry.

All the coaxial systems used in the Type 86 are double terminated to minimize reflection.

SECTION 4
MAINTENANCE

PREVENTIVE MAINTENANCE

Visual Inspection

Many potential or existing troubles can be detected by a visual inspection of the unit. For this reason, a complete visual check should be performed periodically or every time the unit is inoperative, needs repairs, or needs recalibration. Visual defects include loose or broken connections, frayed coaxial-shield wires that could cause a short, damaged connectors, improperly seated tubes or transistors, scorched or burned parts, and broken terminal strips.

The remedy for these troubles is readily apparent except in the case of heat-damaged parts. Damage to parts due to heat is often the result of other less apparent troubles in the unit. It is essential that the cause of overheating be determined and corrected before replacing the damaged parts.

Recalibration

The Type 86 is a stable plug-in unit that will provide many hours of trouble-free operation. However, to insure the reliability of measurements, check calibration of the unit after each 500-hour period of operation (or every six months if the unit is used intermittently). A complete step-by-step calibration procedure and operation check appears in the Calibration section of this manual.

COMPONENT REPLACEMENT

General Information

Useful information concerning the replacement of important parts in the Type 86 is given in this portion of the manual. Due to the nature of the unit, replacement of certain parts such as the VOLTS/CM switch, variable capacitors, nuvistors, transistors or tubes, will require recalibration of the unit to insure proper operation. Refer to the Calibration section of this manual.

Switches

If the AC-GND-DC switch is defective, replace the switch. Use normal care in unsoldering and disconnecting the leads.

If any of the rotary switches are defective, single wafers on these switches are not normally replaced. If a wafer is defective, the entire switch should be replaced. The VOLTS/CM and GAIN switches may be ordered from the factory either unwired or wired, as desired. Refer to the Electrical Parts List to find the unwired and wired switch part numbers. Since the unwired switches require great care for proper wiring, you may prefer to replace a defective switch with a wired one.

NOTE

When soldering leads to a terminal on a rotary-type switch, do not let solder flow around and beyond the rivet on the terminal. Otherwise the spring tension of the switch contact can be destroyed.

(1) Removing the Attenuator Unit

The attenuator unit contains the VOLTS/CM switch wafers and attenuator chassis. It can be replaced with a wired unit ordered through your field representative. To remove the attenuator unit, proceed as follows:

a. Unsolder the output of the attenuator from the grid at the junction of C126, R126 and R117. Unsolder connection to the INPUT connector. (SN 101-1999, unsolder connections to AC-DC-GND switch.)

b. Remove the AC-GND-DC switch knob and use a ½-inch open end wrench to loosen and remove the nut from the INPUT connector. (SN 101-1999, use a thin 1-inch open end wrench to loosen and remove the nut from the AC-DC-GND switch.)

c. Loosen the $^{1}/_{16}$-inch hex set screw in the VOLTS/CM knob and remove the knob.

d. Remove the ½-inch nut from the shaft on the front panel that holds the attenuator unit casting.

e. Remove screws holding the back of the circuit board in place.

f. Fold the complete unit back on the circuit board leads.

g. Unsolder the circuit board from the attenuator chassis at the front of the unit. Do not overheat and damage circuit board.

h. Remove the attenuator unit by removing the gear on the shaft of the attenuator. Leave the circuit board in Type 86 chassis.

i. To replace the unit, reverse the order of the preceding steps.

NOTE

The gears which drive the VOLTS/CM switch do not need lubrication.

(2) Removing the Circuit Board

A replacement wired etched circuit board can be ordered through your field representative. To remove the etched circuit board, proceed as follows:

a. Remove the attenuator unit as described in Removing the Attenuator Unit.

b. Unsolder all leads on the back of the etched circuit board. Keep the leads in order so they can be replaced in the identical holes in the new circuit board.

c. Remove the circuit board.

d. Install the complete unit by reversing this procedure as well as that of Removing the Attenuator Unit.

Soldering Precautions

In the production of Tektronix instruments, a special silver-bearing solder is used to establish a bond to the ceramic terminal strips. This bond can be broken by repeated use of ordinary tin-lead solder, or by excessive heating of the junction with a soldering iron. Occasional use of ordinary tin-lead solder will not break the bond if normal heat is applied.

If you frequently perform work on Tektronix instruments, it is advisable to have a stock of solder containing about 3% silver. This type of solder is used often in printed circuitry and is generally available locally. It may also be purchased directly from Tektronix in one pound rolls. To order the solder specify Tektronix Part Number 251-0514-00.

Because of the shape of the terminals of the ceramic terminal strips, you may prefer to use a wedge-shaped tip on your soldering iron. Such a tip allows you to apply heat directly to the junction and reduces the overall heating effect. It is important to use as little heat as possible while producing a full-flow joint.

When removing or replacing components mounted on the ceramic strips, the procedure can be summed up as follows:

1. Use a soldering iron having a rating of about 40 to 60 watts.

2. Apply one corner of the soldering iron tip to the notch where you intend to unsolder the lead.

NOTE

If the tip of the iron is placed partly in the notch, do not twist the iron as this might chip or break the ceramic strip.

3. Apply only enough heat to melt the solder and remove the lead. If long-nose pliers are used to grip the lead to be removed, use the very tip of the pliers to keep from drawing away too much heat.

4. When resoldering the lead, apply enough heat to make the solder flow freely.

5. Do not attempt to fill the notch on the strip with solder; instead, apply sufficient solder to cover the wire adequately and to form a slight fillet on the wire.

In soldering leads to metal terminals (examples: interconnecting plug, pins on a tube or transistor socket) a similar technique should be employed. Use a soldering iron tip having a shank diameter of 1/8-inch so that it will go through small spaces between wiring. Allow the joint to heat sufficiently to permit the solder to flow freely and to form a smooth, slight fillet around the wire. Due to the high-frequency requirements of the Type 86, many components are soldered in place with very short leads. This is necessary to reduce lead inductance. When these components are replaced, the leads should be clipped to match to the leads of the components that were removed. After clipping wires be sure to remove all clippings that fall in the chassis.

In soldering to terminal pins mounted in plastic rods or in soldering leads from thermal-sensitive components, such as semiconductors and ceramic capacitors, it is necessary to use some form of heat sink. A pair of long-nose pliers (see Fig. 4-1) makes a convenient tool for this purpose.

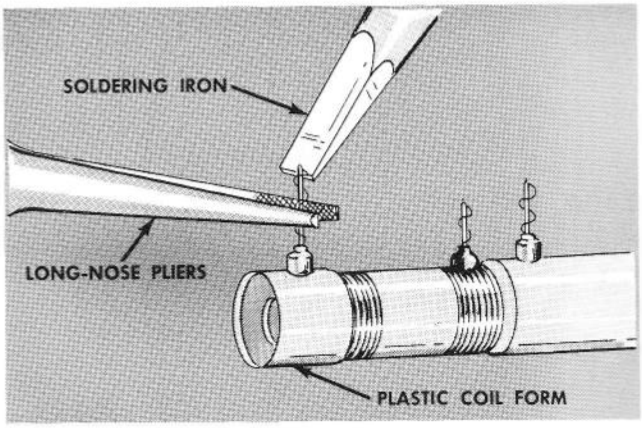


Fig. 4-1. Soldering to a terminal mounted in the plastic. Note the use of the long-nose pliers between the iron and the coil form to absorb the heat.

In soldering leads or coaxial braids to ground use a 50-to-60-watt iron with a tip having a shank diameter of about 1/4-inch. The higher wattage iron and heavier tip will assure that the joint receives adequate heat to make a good solder joint.

Removing Ceramic Terminal Strips

To remove a ceramic terminal strip, unsolder all components and connections, then pry the strip with yokes attached, out of the chassis. An alternative method is to use diagonal cutters to cut off one side of each yoke to free the strip but try not to damage the spacer. After removing the strip, the remainder of each yoke can be easily extracted from the chassis with a pair of pliers. The yokes need not be salvaged since new ones are furnished with the new strips. If spacers are not damaged, they may be re-used as long as they hold the strip assembly securely.

To install a new strip, place the spacers in the chassis holes, insert the yoke through the spacers, and press down on top of the strip above the yokes. Use a plastic or hard rubber mallet, if necessary, to seat the yokes firmly. Be sure to tap lightly directly above the yokes and drive them down in equal increments to keep from placing too great a strain on the strip. Fig. 4-2 illustrates the way the parts fit together. If desired, the extending portion of the yoke pins can be cut off to within about an eighth of an inch of the lower end of the spacers.

Observe all soldering precautions described earlier when soldering leads to the strip.

OBTAINING REPLACEMENT PARTS

Standard Parts

Tektronix stocks replacements for all parts used in the Type 86. All parts can be purchased directly from Tektronix at current net prices. Many of the components, however, are standard electronic parts that can usually be purchased locally in less time. Before purchasing a part, be sure to consult the Parts List of this manual to determine the tol-

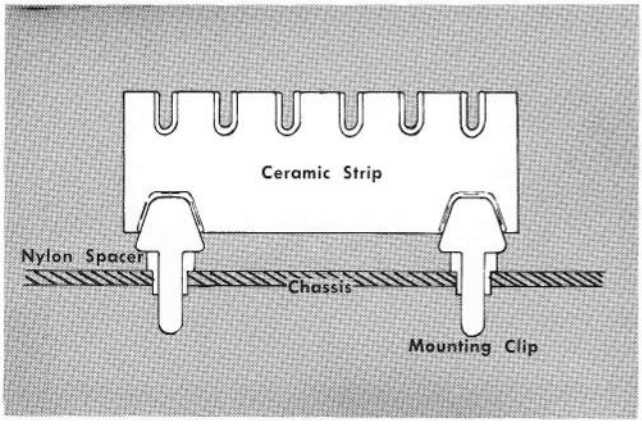


Fig. 4-2. Installation of a ceramic strip.

erance and rating required. The Part List gives the values, tolerances, ratings and Tektronix part numbers for all components used in the unit.

Special Parts

In addition to the standard electronic components mentioned in the previous paragraph, special parts are also used. These parts are manufactured or selected by Tektronix to satisfy particular requirements, or are manufactured especially for Tektronix by other companies. These parts and most mechanical parts should be ordered directly from Tektronix since they are normally difficult or impossible to obtain from other sources. All parts can be obtained through your local Tektronix Field Engineering Office.

TROUBLESHOOTING

Introduction

In the event a trouble develops, use the information in this portion of the Instruction Manual to more efficiently troubleshoot the Type 86. The information starts with preliminary checks to make and then advances to detailed circuit troubleshooting.

PRELIMINARY TROUBLESHOOTING

Front-Panel Controls

Before troubleshooting, double-check the front-panel controls for proper settings. Also, check the front-panel screwdriver adjustments to determine if their settings are proper. This is important since symptoms caused by incorrect control settings are not described in this section of the manual.

If you are in doubt as to the proper settings of the controls or their function, refer to the Operating Instructions section. If the front-panel controls are properly set and you find that a trouble definitely exists, first check to determine whether the trouble is in the oscilloscope or the Type 86.

When following a troubleshooting procedure, it is assumed that the oscilloscope used with the Type 86 is operating normally. Since this is not always the case, check the operation of the oscilloscope before attempting to troubleshoot the Type 86.

Troubles occurring in the oscilloscope can usually be detected by substituting another plug-in unit for the Type 86. Preferably, another Type 86 or Type 82, a Type 84[1] or a Type CA[2] Plug-In Unit that is working normally should be used if one is available.

Type 86 Operational Check

If the Type 86 is definitely at fault and not the associated oscilloscope, a good procedure to follow is to make a careful operation check of the Type 86. By noting the effect that each front-panel control has on the symptom, you can sometimes isolate a trouble to either a defective control or probable circuits that contain the trouble. The normal or abnormal operation of the control may indicate the possible checks to make.

Table 4-4 at the end of this section lists many symptoms of troubles that could happen. It is possible that the symptom noticed in the Type 86 is the same as one of those listed in the table. In such a case, a table can be very useful since it also lists the possible causes of the trouble and the area within the Type 86 that is probably at fault.

As an additional aid to troubleshooting, the step-by-step method of checking and adjusting the Type 86 as given in the Calibration Procedure (Section 5) of this manual is a good way to check the operational standards of your unit. Any deficiency that shows up while performing the steps may indicate the area at fault and the possible causes.

CIRCUIT-TROUBLESHOOTING INFORMATION

This portion of the manual contains circuit-troubleshooting information which includes a list of recommended test equipment for servicing the Type 86. The information is subdivided into clearly titled topics so you can quickly choose the most useful information.

Diagrams

Block and circuit diagrams are contained in the pullout pages near the back cover of this manual. The circuit diagrams contain component circuit numbers and voltages. Conditions under which the voltages were taken are shown on the diagrams. Test points are also shown. This and other information is described in the subsequent paragraphs.

Circuit Numbers

The circuit number or reference designation of each electronic component in the Type 86 is shown on the circuit diagrams. The following is a list of the circuit numbers associated with each diagram.

[1]Type 84 is a Plug-In Test Unit.

[2]Type 81 Adapter is required to operate the Type CA in a 580-Series oscilloscope.

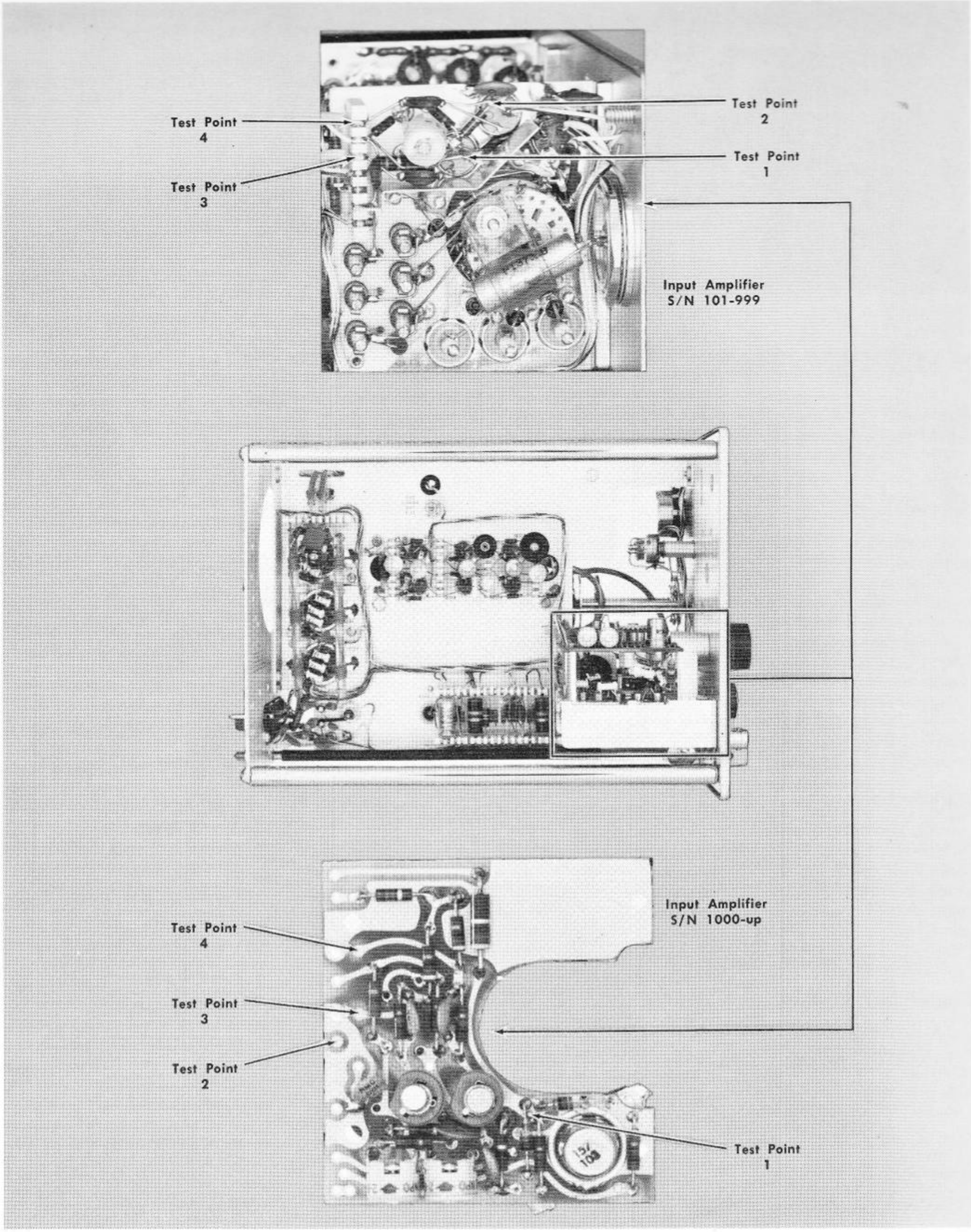


Fig. 4-3. Location of Input Amplifier test points.

Circuit Numbering Range	Circuit Diagram
100 to 199	Attenuators and Input Amplifier
300 to 399	×10 Amplifier
500 to 599	Output Amplifier

In general, circuit numbers increase from left to right across each diagram.

Test Points

Numbered test points aid in troubleshooting and calibrating the Type 86. They simplify reference to particular locations in the circuitry. Each test point in the diagrams is indicated by a bracketed number adjacent to its location. The test points are numbered consecutively starting with the Input Amplifiers diagram. The numbers increase from left to right across the following pages of circuit diagrams.

Physical locations of the test points on the Type 86 chassis are shown in Fig. 4-4.

Coding of Switch Wafers

Switch wafers shown on the circuit diagrams are coded to indicate the actual mechanical position of the wafers on switches. The number portion of the code refers to the wafer number on the switch assembly. Wafers are numbered from the first wafer to the last wafer. The letters F and R indicate front or rear of the wafer (with respect to the front or top of the instrument). For example, 2R of the VOLTS/CM switch is the second wafer when counting back from the front panel or top of the instrument and R is the rear side of the wafer.

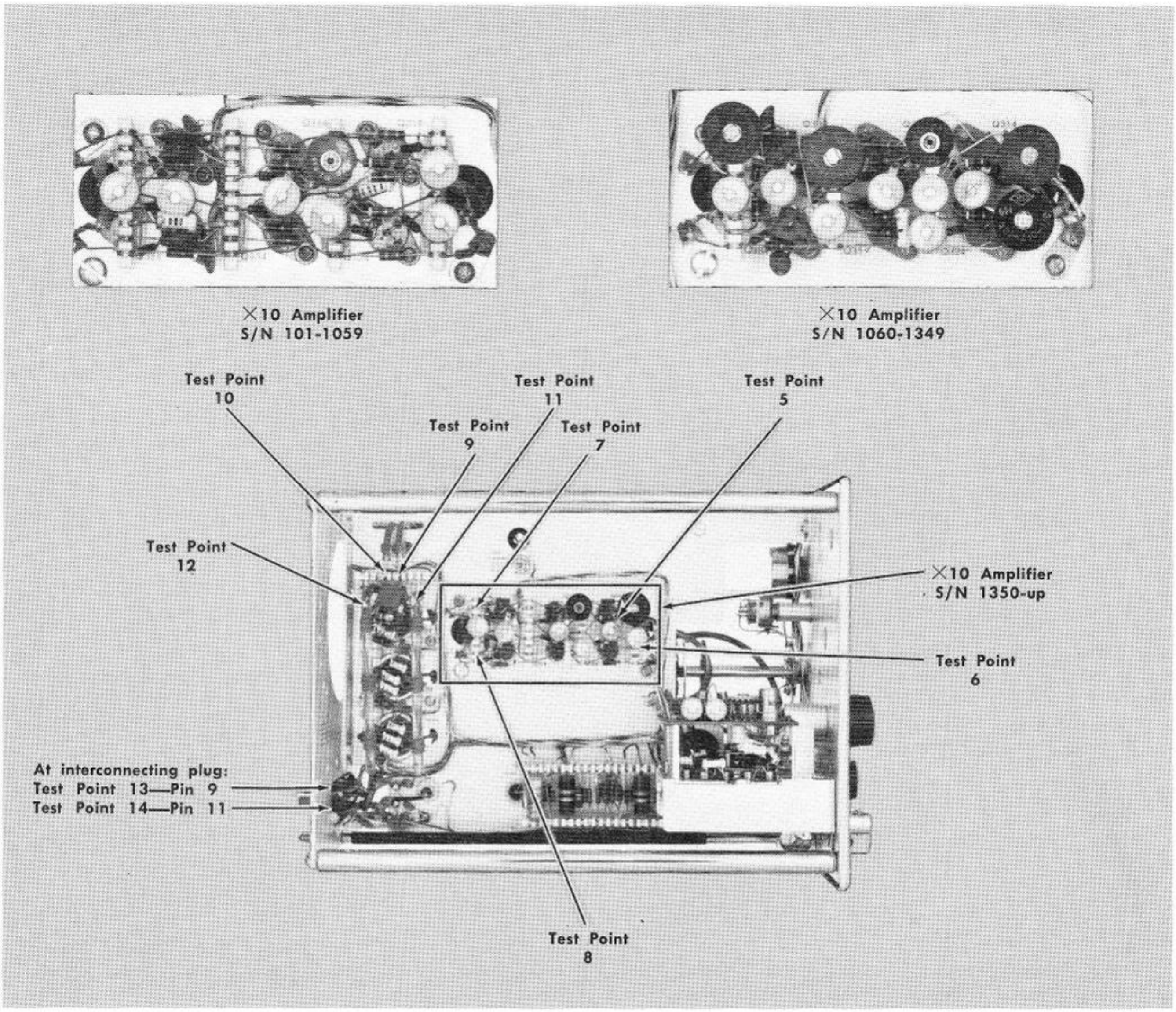


Fig. 4-4. Location of ×10 Amplifier and Output Amplifier test points.

Cable Color Coding

All wiring in the Type 86 is color coded to help in circuit tracing The power-supply wires are identified by the following code; the widest stripe identifies the first color in the code.

Supply Voltage	Cable Color Code
+225 V	Red-red-brown on white
+100 V	Brown-black-brown on white
+12.6 V	Brown-red-black on white
+6.3 V	Blue-orange on white
−150 V	Brown-green-brown on tan

Test Equipment

When preparing to circuit troubleshoot the Type 86, you may find useful some of the minimum equipment described here. This list contains the servicing equipment and other servicing aids mentioned in this portion of the Maintenance Section.

(1) Transistor Tester

Description: Tektronix Type 575 Transistor-Curve Tracer.

Purpose: Test transistors and diodes used in the Type 86.

(2) VOM

Description: 20,000 Ω/V DC, calibrated for an accuracy of 1% or better at these voltage readings: +225 V, +100 V, and −150 V. Accuracy for other voltage readings, within ±3%. Be sure the test prods are well insulated (except for the very tip) to prevent accidental shorts when reaching a test point. If you use the VOM as an ohmmeter to measure resistances when the semiconductors are in the circuit, know and use ranges (usually RX1k and higher) that deliver current less than 2 mA at full deflection.

Purpose: Precision and general-purpose use. Can also be used to check transistors and diodes if used with care. Not recommended as a substitute for a good transistor and diode tester.

(3) Test Oscilloscope

a. Low-Bandwidth Test Oscilloscope (with a 10× probe).

Description: Bandwidth, DC to 300 kHz or better. Calibrated vertical deflection factors down to 5 mV/cm without a 10× probe (with a 10× probe, 50 mV/cm). Input resistance, 1 megohm without a 10× probe and 10 megohms with a 10× probe.

Purpose: For low-frequency signal-tracing and checking DC levels in the amplifier stages.

b. Wide-Bandwidth Test Oscilloscope (with a 10× probe).

Description: Bandwidth, DC to 5 MHz or better. Calibrated vertical deflection factors down to 0.1 volt/cm without a 10× probe (1 volt/cm with a 10× probe).

Purpose: High-frequency signal tracing for high-frequency distortion problems. Otherwise not needed. If the deflection factor for this wideband test oscilloscope is as low as 5 mV/cm, it may be used in place of item 3a.

(4) Flexible Plug-In Cable Extension

Description: 30-inches long, Tektronix Part No. 012-0038-00.

Purpose: Permits operating the Type 86 out of the oscilloscope plug-in compartment for better accessibility.

(5) BNC Cable assembly (Tektronix Part Number 012-0057-00)

Purpose: Use in low frequency signal-tracing setup to apply the calibrator signal to the Type 86 and test oscilloscope Ext. Trig input connector.

(6) 30-inch Interconnecting Lead

Description: Banana plug on one end, alligator clip on other. Tektronix Part No. 012-0014-00.

Purpose: Use in low-frequency signal tracing setup to ground the Type 86 and test oscilloscope together.

Tube Checks

Periodic tube checks on the tubes (including the nuvistor) used in the Type 86 are not recommended. Tube testers in many cases indicate a tube to be defective when that tube is operating quite satisfactorily in a circuit, or fail to indicate tube defects that affect the performance of the circuits. The ultimate criterion of the usability of a tube is whether or not the tubes work properly in the circuit. If it does not, then it should be replaced. If it is working correctly, it should not be replaced. Unnecessary replacement of tubes is not only expensive but may also result in needless recalibration of the unit.

Transistor Checks

Transistor defects usually take the form of the transistor either opening or shorting. To check a transistor for these and other defects, use a transistor-curve display instrument such as the Tektronix Type 575. However, if a good transistor checker is not readily available, a defective transistor can be found by signal-tracing, by making in-circuit voltage checks, by measuring the transistor forward-to-back resis-

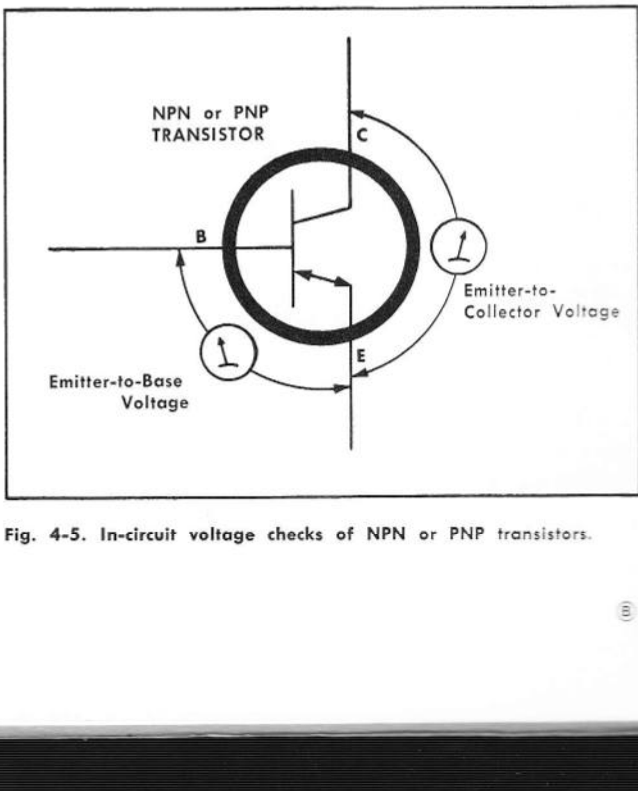


Fig. 4-5. In-circuit voltage checks of NPN or PNP transistors.

tance using proper ohmmeter ranges, or by substitution. Voltage and resistance checks can be made using the following information.

(1) In-Circuit Voltage Checks

To check transistors using a voltmeter, measure the junction bias and the emitter-to-collector drop as shown in Fig. 4-5. Use Tables 4-1A and 4-1B to determine the condition of the transistor.

When substituting transistors as suggested in the tables, first be sure that the voltages and loads on the transistor are normal before making the substitution. If a transistor is substituted without first checking out the circuit, the new transistor may immediately be damaged by some defect in the circuit.

TABLE 4-1A

Checking Emitter-To-Base Voltage

Emitter-to-Base Voltage	Action
Normal[3]	Go to Table 4-1B
If junction is forward biased and voltage is several tenths of a volt too high.	Transistor is possibly defective. Substitute. If substitution does not correct trouble, check associated circuit.
Voltage and/or polarity incorrect.	Check associated circuit first and correct the trouble. Then if necessary, substitute the transistor.

TABLE 4-1B

Checking the Emitter-to-Collector Voltage

Emitter-to-Collector Voltage	Condition of Transistor	Action
Normal[3]	Good	None
Too low	Possibly shorted	Replace transistor
Too high	Possibly open	Check associated circuit. Substitute transistor.

[3]See schematic to determine proper voltage drop and polarity.

(2) Resistance Measurements

To check a transistor using an ohmmeter, know your ommeter ranges and the currents they deliver. If your ohmmeter does not have sufficient resistance in series with its internal voltage source, excessive current will flow through the transistor under test. Excessive current and/or high internal source voltage may permanently damage the transistor.

NOTE

As a general rule, use the RX1K ranges where the current is limited to less than 2 mA. You can quickly check the current by inserting a multimeter between the ohmmeter leads and then noting the current for each range you intend to use.

When you know the ohmmeter will not harm the transistor, then measure the resistance with the ohmmeter connected both ways as given in Table 4-2.

TABLE 4-2

Transistor Resistance Checks

Ohmmeter Connections[4]	Resistance Readings That Can Be Expected Using the RX1K Range
Emitter-Collector	High readings both ways (about 60 kΩ to around 500 kΩ).
Emitter-Base	High reading one way (about 200 kΩ or more). Low reading the other way (about 400 Ω to 2.5 kΩ).
Base-Collector	High reading one way (about 500 kΩ or more). Low reading the other way (about 400 Ω to 2.5 kΩ).

[4]Test prods from the ohmmeter are first connected one way to the transistor leads, and then the test prods are reversed (connected the other way). Thus, the effects of the polarity reversal of the voltage applied from the ohmmeter to the transistor can be observed.

If there is doubt about the transistor being good, substitute the transistor in the Type 86; but first be certain the voltages on the transistor are correct before making the substitution.

Diode Checks

Diode defects are similar to transistor defects as they usually open or short when defective. Therefore, checks similar to that described for transistors can be applied to diodes.

NOTE

If you use an ohmmeter, observe the same precautions as described for checking transistors.

In-circuit checks of diodes can be made quickly by using a voltmeter to find out if the diode is functioning properly in the circuit. D134 should have a forward bias and D138 and D139 should have a reverse bias. By noting the difference betwen voltages on each side of the diode as given on the schematic diagrams, you can determine whether or not the drop is normal.

If in doubt whether or not a diode is defective, or for an additional check, unsolder one end and check its forward-to-back-resistance ratio. If the forward and back resistance ratio shows defective, replace the diode.

Interconnecting-Plug Resistance Checks

Table 4-3 lists the typical resistances measured between the interconnecting-plug pins and ground. These readings are particularly useful for locating a possible short circuit or low-resistance path in the Type 86 if such a trouble occurs.

The resistance measurements are not absolute and vary considerably. In addition, the reading can vary as much as 50% due to the type of ohmmeter you are using, even if you use the same ranges.

Significant differences between ohmmeter types are: (1) the amount of internal voltage they use, (2) the currents they require to make the meter needle deflect full scale for each range, and (3) the scale readings on the meter itself. If ohmmeters did not differ so much in these respects, the resistance measurements as given in the table would be more typical.

TABLE 4-3

Typical Resistances to Ground at Interconnecting Plug

Pin No.	Resistance	Pin No.	Resistance
1	5.5 kΩ, 11 kΩ[5]	9	2.7 kΩ, open[5]
2	4 kΩ, open[5]	10	0 Ω
3	250 kΩ[6]	11	2.7 kΩ, open[5]
4	open	12	open
5	open	13	open
6	open	14	2.7 kΩ, open[5]
7	open	15	3 Ω
8	open	16	2.7 kΩ, open[5]

[5]Reverse ohmmeter leads to get both readings.

[6]This reading is across an electrolytic capacitor and, hence, will vary widely.

Troubleshooting Chart

The troubleshooting Chart, Table 4-4, lists a variety of symptoms, with possible causes and certain checks to make. If there is an apparent trouble in your Type 86, find the symptom in the table that most nearly describes the trouble in your plug-in unit. Then perform the checks prescribed in the table. As a further aid, some of the columns direct you to Troubleshooting Tips, following Table 4-4. Troubleshooting Tips furnishes background information for troubleshooting a particular circuit if the trouble is not found by use of Table 4-4.

To use Table 4-4, proceed as follows:

(1) Find the symptom in the first column.

(2) Check the possible causes of trouble as listed in the second column.

(3) If one of the listed causes is the trouble, make the repair.

(4) If none of the causes is the trouble, go to the third column. This column indicates which area is most likely at fault. The names of these areas are the same as those on the block and circuit diagrams.

In all cases, by using the troubleshooting information in conjunction with the information provided on the schematics and in other portions of the manual, guesswork and parts substitution can be reduced to a minimum.

TABLE 4-4

Trouble Isolation Procedure

	Checks To Make	
Symptoms	Possible Causes	Area at Fault
1. No trace, GAIN switch set to either position.	Defective Output Amplifier tube (V524, V534, or V544). Check these nominal supply voltages in the Type 86: +225 V, +100 V, +51 V, +12.6 V, +6.3 V, —25 V and —150 V. If any of these voltages are incorrect, find the trouble before going to third column. Some possible causes are: Open filament in one of the tubes. Defective interconnecting plug. Defective D136 If the above checks are normal, check for defective V133, Q153, Q164, or Q174. If one of the above components or stages is abnormal, make repair to obtain normal operation.	Check for DC imbalance in the Output Amplifier. Refer to Troubleshooting Tips, part A. Check for DC imbalance from input circuit of Input Amplifier to input circuit of Output Amplifier. Refer to Troubleshooting Tips, part A.
2. No trace, GAIN switch set to ×10.	Check transistors in the ×10 Amplifier.	Check for DC imbalance in the ×10 Amplifier. Refer to Troubleshooting Tips, part A.
3. Low gain, GAIN switch set to ×1.	Check for defective tubes: V524, V534, V544. Check for leaky capacitors: C525, C526, C535, C536, C539, C545, C546 or C549.	Check for trouble in the Output Amplifier stage. Refer to Troubleshooting Tips, part B.
4. Deflection factor decreased by a factor of five. Rotation of the VERTICAL POSITION control affects the deflection factor. GAIN switch set to ×1[7].	Check for an open circuit between the VARIABLE VOLTS/CM control and preceding stage.	Check for trouble in the Input Amplifier. Refer to Troubleshooting Tips, part B.

TABLE 4-4 *(Cont'd)*

Trouble Isolation Procedure

	Checks to Make	
Symptoms	Possible Causes	Area at Fault
5. Low gain for all positions of the VOLTS/CM switch. GAIN switch set to ×1[7].	Check V133, Q164, or Q174	Check for trouble in the Input Amplifier. Refer to Troubleshooting Tips, part B.
6. Low gain in only one position of the VOLTS/CM switch. GAIN switch set to ×1[7].	Check for trouble in the attenuator or the VOLTS/CM switch contacts for that switch position.	Check VOLTS/CM switch.
7. No DC coupling of the signal.	Defective AC-GND-DC switch	Check AC-GND-DC switch connections.
8. Trace shifts position vertically when the INPUT connector center conductor is grounded.	Check the adjustment of GRID CURRENT ZERO control.	Check for defective V133. Check for other possible troubles in the Input Cathode Follower stage (V133).
9. Low gain when GAIN switch is set to ×10.	Check ×10 Gain adjustment. Check the transistors in the ×10 Amplifier.	Check for trouble in the ×10 Amplifier Refer to Troubleshooting Tips, part B.
10. No waveform display, but trace can be obtained.	Shorted capacitor: C539, C549 or C554 Check for shorted D554. Check for open R554 Check for no +12.6-volt supply voltage.	Isolate trouble by signal tracing. Refer to Troubleshooting Tips, part B.
11. No waveform display, GAIN switch set to ×1.	Open circuit between INPUT connector and junction of R117 and R126. **SN 101-999.** Check for shorted C117 or C127.	Check for trouble in the input circuit of the Input Cathode Follower stage (V133). Refer to Troubleshooting Tips part B.
12. No waveform display, GAIN switch set to ×10.	Coaxial cable shorted to ground at either the input or output of the ×10 Amplifier.	Check for trouble in the ×10 Amplifier. and the connections leading to or from the ×10 Amplifier. Refer to Troubleshooting Tips, part B.
13. Square-wave distortion. Spike or overshoot on fast-rise (13 ns or faster) square waves. Repetition rate: 500 kHz. For 1% overshoot, 1 RC decay time constant is 15 ns; for 10% overshoot, 1 RC decay time constant is 150 ns.	Substitute V524, V534 and V544 (these tubes could develop cathode interface trouble and other defects; replace with new tubes). Check adjustment of C524.	Check for trouble in the Output Amplifier. Refer to Troubleshooting Tips, part C.
14. Square-wave distortion or poor frequency response, GAIN switch set to ×1.		Check for trouble in the Input Amplifier. Refer to Troubleshooting Tips, Part C.
15. Square-wave distortion or poor frequency response, GAIN switch set to ×10.	Substitute transistors in the X10 Amplifier. Check high-frequency adjustments.	Check for trouble in the ×10 Amplifier circuitry. Refer to Troubleshooting Tips part C.
16. Microphonics. Set GAIN switch to ×10; lightly tap on the front panel of the Type 86. Microphonics of the ringing type should not exceed 1 centimeter.	Check nuvistor V133.	Input CF stage at fault.

[7]**Any change in ×1 gain also causes the same gain-change symptom when GAIN switch is set to ×10.**

TROUBLESHOOTING TIPS

A. Isolating DC Imbalance

To make free-running traces appear within the usable viewing area of the CRT screen, the DC output voltage at test points 13 and 14 must be essentially equal—that is within a fraction of a volt (see Fig. 4-6). As little as 0.2-volt difference between these two points may position the beam above or below the range of visibility.

The DC output voltages depend on the DC balance of the Output Amplifier and all the preceding amplifier stages. Since the amplifier stages are DC coupled, a condition anywhere between input and output that unbalances the output voltage more than 0.2 volt can cause the trace to deflect out of the viewing area. Voltage-difference limits for proper

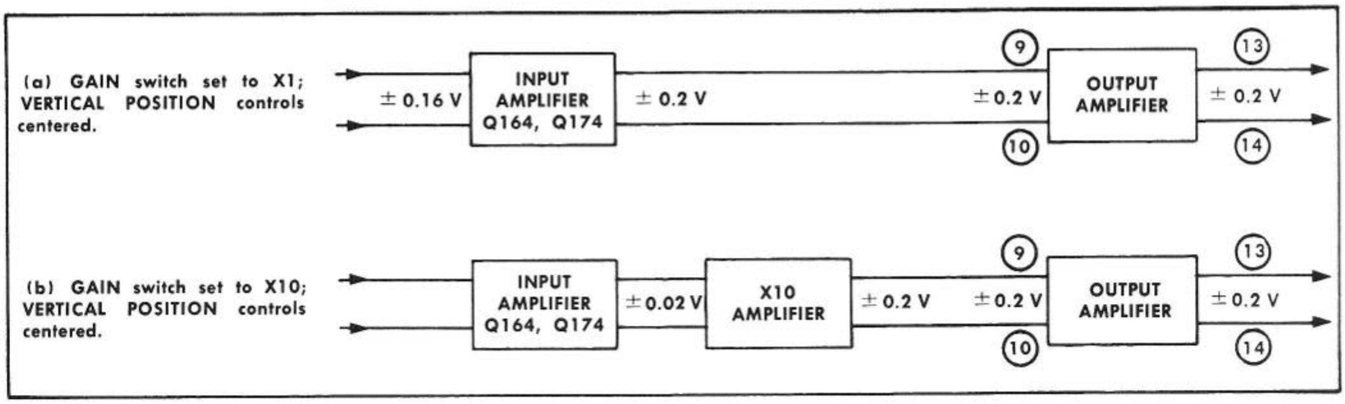


Fig. 4-6. Voltage-difference limits that should not be exceeded to obtain proper DC balance for positioning the trace on the CRT.

DC balance under two sets of conditions are shown in Figs. 4-6a and 4-6b. These conditions are: (a) when the GAIN switch is set to ×1 as shown in Fig. 4-6a, and (b) when the GAIN switch is set to ×10 as shown in Fig. 4-6b. Use these voltage limits as a guide when you are isolating a DC imbalance trouble.

The procedure for isolating the cause of dc imbalance is accomplished by first determining which area is most likely at fault. The area can be determined by using Table 4-4. Once the area is determined, the voltmeter can be used to verify your conclusions and to isolate the imbalance within an area (such as the Input Amplifiers, for example). In addition, the voltmeter is a good indicator of the amount of imbalance between any two corresponding points in a push-pull stage.

As an example of this method, assume that you determine the imbalance is in the Output Amplifier. Proceed as follows:

1. Connect the voltmeter between test points 11 and 12.

2. Set the GAIN switch to ×1.

3. Rotate the VERTICAL POSITION control to obtain zero reading on the voltmeter. If zero volts cannot be obtained, the DC imbalance is probably in the grid line of the Output Amplifier. Make careful resistance checks in this part of the circuitry to find the cause. Check for open R510, R511 R513, or R514; check for open supply resistors. If zero voltage reading is obtained, then proceed to make detailed voltage and resistance checks in the plate circuits of V524, V534 and V544.

B. Low-Frequency Signal Tracing

Use this signal-tracing information for checking amplitude, polarity, and DC level of the calibrator signal at various test points in the Type 86 Amplifier circuitry. The technique used here is limited to low frequency because a plug-in cable extension is used to operate the Type 86 out of the oscilloscope plug-in compartment. Using the cable extension makes all sides of the Type 86 easily accessible for detailed signal tracing and troubleshooting.

After you have succeeded in getting the Type 86 working properly at the lower frequencies, then it is easy to go directly to the Calibration procedure to check square-wave response or to completely recalibrate the unit.

IMPORTANT

The amplitude and DC level shown adjacent to the waveform drawings in Figs. 4-7 and 4-8 are intended to be used as a guide and are not absolute. They may vary due to gain-adjustment settings, normal manufacturing tolerances, and characteristics of Zener diodes, transistors and tubes. In addition, the power-supply voltages applied to the Type 86 vary between oscilloscopes within their tolerances. For example, the +12.6-volt supply can vary as much as ±5%.

To signal trace the amplifier stages in the Type 86, proceed as follows:

1. Set the front-panel controls as follows:

AC-GND-DC	DC
VOLTS/CM	1[8] or 10[9]
VARIABLE VOLTS/CM	CAL.
VERTICAL POSITION	Centered[10]
GAIN	×1[8] or ×10[9]

2. Connect a 30-inch plug-in cable extension between the Type 86 and the 580-Series oscilloscope.

3. Apply a 2-volt peak-to-peak calibrator signal from the 580-Series oscilloscope to the INPUT connector of the Type 86. Also, apply the calibrator signal to External Trigger input connector on the test oscilloscope. (Use items 5 or 6 in the Test Equipment list for this purpose.)

4. Connect a third lead between the test oscilloscope ground terminal and the Type 86 ground.

5. Set the test oscilloscope input coupling switch to AC.

---

[8]**Set the VOLTS/CM switch to 1 and the GAIN switch to ×1 when checking ×1 gain of the Type 86.**

[9]**Set the VOLTS/CM to 10 and the GAIN switch to ×10 when signal tracing through the ×10 Amplifiers.**

[10]**The trace was positioned at vertical-system electrical center when obtaining the waveform data. Thus, balanced DC-voltage readings are obtained at test points 13 and 14.**

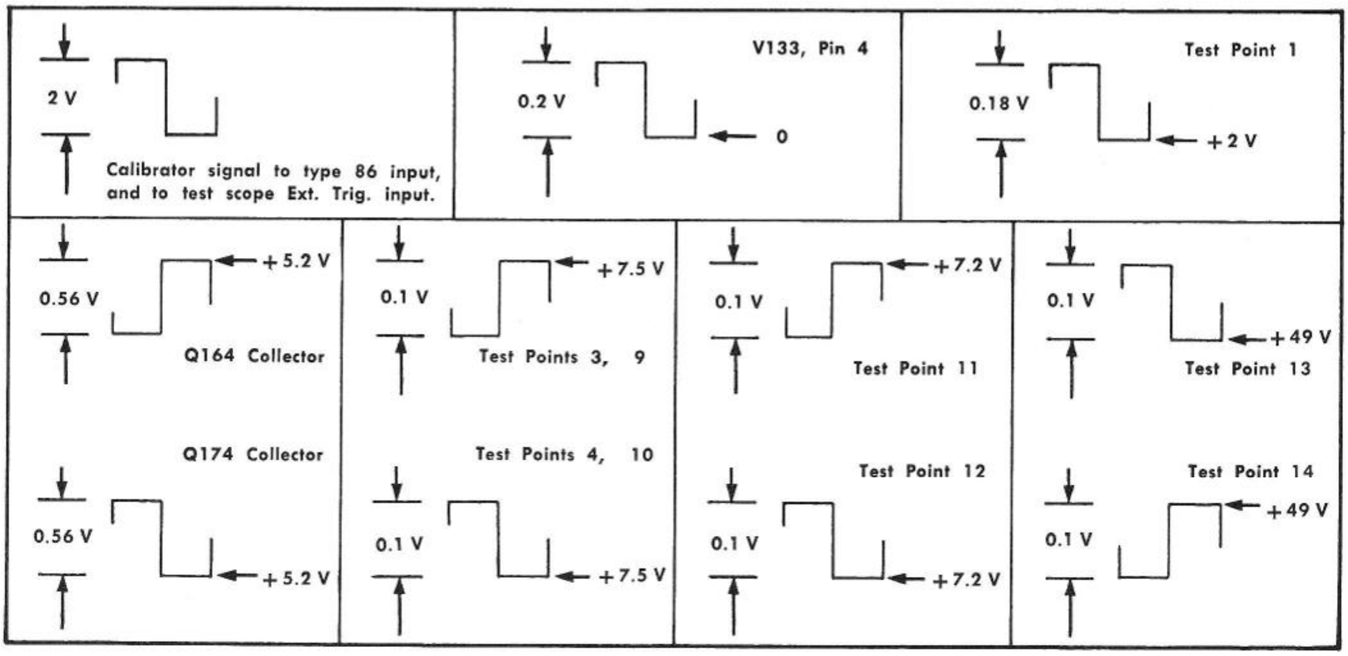


Fig. 4-7. Checking ×1 voltage gain. Set the GAIN switch to ×1 and the VOLTS/CM switch to 1.

6. Touch the tip of the probe to the Cal Out connector on the 580-Series oscilloscope. Set the front-panel controls on the test oscilloscope to display one or two cycles of the calibrator waveform. (Use a sweep rate of 0.1 ms/cm or 0.2 ms/cm). Be sure to set the test oscilloscope triggering controls for external triggering and to display the first ½-cycle of the waveform as positive going. The displayed waveform will then correspond to the input waveform polarity as shown in Figs. 4-7 and 4-8. Disconnect the probe.

7. Touch the probe tip to the desired test point in the Type 86 circuitry. Set the test oscilloscope Volts/Cm switch to obtain a suitable amplitude display.

8. Check amplitude and phase of the waveform. Disconnect the probe.

9. Set the test oscilloscope input coupling switch to DC. Preset the test oscilloscope Volts/Cm switch such that the expected DC voltage to be measured in step 10 will keep the trace within the graticule-marking area. Ground the probe tip to the Type 86 chassis and position the trace to establish a zero reference point.

10. Touch the probe tip to the same test point you used in step 7 of this procedure. Measure the DC level from the reference point established in step 9 to the same DC-level point as indicated on the waveform drawing. Disconnect the probe.

11. Continue on to the next test point and repeat steps 7 through 10 until you reach a test point where an abnormal indication is obtained. Then proceed with detailed troubleshooting checks to find the cause of the trouble. Such checks usually consist of transistor or tube substitution, and voltage and resistance checks.

If you have replaced a defective solder-in type of component and substituted tubes or transistors, return the good tubes or transistors to their original sockets. Such a procedure, if followed, results in less recalibration of the Type 86 upon completion of the servicing.

C. Checking Square-Wave Response

In general, the best way to isolate square-wave distortion troubles is to go to the Calibration section of this manual after you have checked the symptoms given in Table 4-4. The distortion symbols listed in the table show how to localize the trouble and the probable causes. The Calibration section describes the proper setup needed to check square-wave response and how to make the compensation adjustments properly. If you perform steps 14 through 16 of the Calibration procedure, they will furnish an orderly approach for isolating a poor transient-response type of trouble.

Besides the usual causes of distortion given in Table 4-4, other causes can be found only by careful, detailed voltage and resistance checks. If a component is suspected as a possible cause, substitution may prove the best method for finding out.

CALIBRATION ADJUSTMENTS FOLLOWING REPAIR

When servicing the Type 86, a repair or an adjustment to one circuit may affect the operation of another circuit. The following table shows the minimum calibration checks that you should make following a repair or adjustment. The areas listed in the first column correspond to the names given to the major circuits on the block and circuit diagrams.

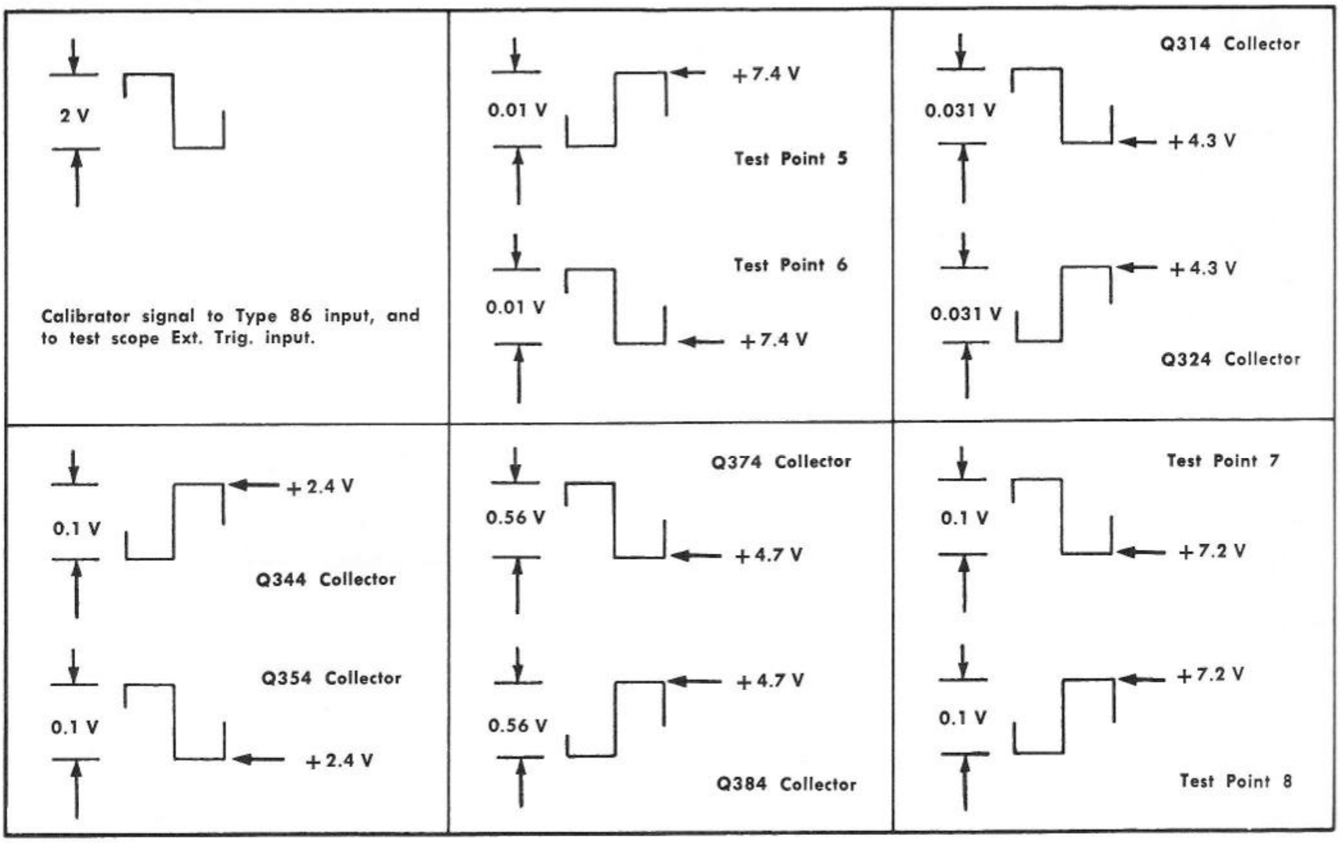


Fig. 4-8. Checking ×10 voltage gain. Set GAIN switch to ×10 and VOLTS/CM switch to 10.

TABLE 4-5

Calibration Steps To Be Checked After Repairs

Repair Made In This Arae	Calibration Steps to be Checked															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Attenuators								S								
Input Amplifier	X	X			X	S	S		X		S		X			
×10 Amplifier										X			X			X
Output Amplifier		X	X	X	X				X				X			

An X in any boxed area denotes a calibration step to be checked. Refer to the calibration section to find the calibration steps.

S in a boxed area denotes an operational check of a specific component, for example, step 6 is Check VARIABLE VOLTS/CM control. Perform the step to check out the replaced component.

SECTION 5
CALIBRATION

INTRODUCTION

A complete procedure for checking the operational standards and calibration of the Type 86 is provided in this section of the manual. The steps are arranged in a logical sequence to avoid unnecessary repetition.

NOTE

Calibration steps may be performed out of sequence, or a single step may be performed individually. However, it may be necessary to refer to the preceding step(s) and/or preliminary procedure for additional setup information, such as the proper front-panel control settings, test equipment used, and lead or cable connections.

These step-by-step instructions furnish an orderly approach for isolation of minor operational deficiencies that may not be apparent during normal usage. Consequently, use this procedure in conjunction with any maintenance and troubleshooting system to locate such deficiencies. Obscure symptoms, if any, occurring during low-frequency operation usually show up when performing steps 1 through 13. The remaining steps check and aid in restoring the Type 86 to optimum transient response.

If a minor malfunction becomes apparent at some point in the procedure, it is not usually necessary to locate its cause immediately before continuing to the next step. Additional symptoms revealed by performing further steps may sometimes simplify the task of locating the trouble. Once the trouble is located, make the necessary repair. Then repeat any calibration steps affected by the repair, before going on (see Table 4-5, Maintenance section).

Test equipment used in a particular step should be left connected at the end of that step unless instructions state otherwise. Similarly, controls not mentioned are assumed to be in the positions they were in at the conclusion of the preceding step(s).

EQUIPMENT REQUIRED

The following equipment is required to perform a complete calibration of the Type 86.

1. Tektronix Type 581A or 585A Oscilloscope. Must be calibrated. In addition, the transient response of the vertical amplifier must be standardized for optimum performance with 80-Series plug-in units. (Type 581 Oscilloscopes, SN 950 and up, and Type 585 Oscilloscopes SN 2585 and up have been standardized.) There are some exceptions to the SN ranges since some earlier SN oscilloscopes were modified out of sequence. Your Tektronix Field Engineer has a complete list of the modified instruments. All 580A-Series oscilloscopes have the transient response of the vertical amplifier standardized.

2. Square-wave generator, Tektronix Type 105 or equivalent. Required specifications: 13-ns or less risetime; output frequency of approximately 2.5 kHz; output amplitude variable from 10 to 100 volts across an internal 600-ohm load.

3. TU-5 Pulser complete kit, Tektronix Part No. 015-0043-00, contains the following items[1]:

Qty.	Description	Tektronix Part No.
1	TU-5 Pulser (alone) with BNC plug and jack connector fittings.	015-0038-00
1	50-ohm termination with BNC plug and jack connector fittings.	011-0049-00
1	50-ohm 10:1 T attenuator, ½ W, with BNC plug and jack connector fittings.	010-0314-00
1	Connector adapter with UHF plug and BNC jack connector fittings.	103-0015-00
1	50 ohm (nominal impedance) coaxial cable, 42 inches long, with a BNC connector on each end.	012-0057-00

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

TU-5 Pulser (015-0038-00) characteristics:

Input Voltage Required — +100-volt (from ground) square wave capable of supplying 10 mA. The 580-Series oscilloscope Amplitude Calibrator fulfills this requirement. The Type 105 Square-Wave Generator, item 2, can be used to drive the TU-5 Pulser in place of the oscilloscope calibrator if a special adapter is used. Use of the Type 105 will provide a brighter display due to its higher repetition-rate capabilities. To order the adapter, give this description: TU-5/105 Adapter, Tektronix Part No. 013-0075-00.

Output Voltage—200 millivolts or more into 50 ohms.

Output Pulse Risetime—1.5 ns or less into a 50-ohm resistive load such as the 50-ohm termination (011-0049-00).

4. Standard Amplitude Calibrator, Tektronix Part No. 067-0502-00. An oscilloscope Amplitude Calibrator may be substituted for the Standard Amplitude Calibrator. However the accuracy of the Standard Amplitude Calibrator is within ¼%, whereas the accuracy of an oscilloscope Amplitude Calibrator is 3%.

5. DC voltmeter, sensitivity of at least 5000 Ω/V.

6. SN 1000-Up. 15-pF Input Time Constant standardizer, with BNC connector fittings, Tektronix Part No. 011-0073-00.

SN 101-999. 12-pF Input Time Constant Standardizer, with BNC connector fittings, Tektronix Part No. 011-0065-00.

7. 50-ohm 10× attenuator, Tektronix Part No. 011-0059-00.

8. Plug-In Extension, 6½ inches long, Tektronix Part No. 013-0055-00.

9. (Optional) Connector Adapter, with UHF plug and BNC jack connector fittings, fits UHF jack and BNC plug connectors, Tektronix Part No. 103-0015-00.

10. (Optional) Connector Adapter, with BNC plug and UHF jack connector fittings, fits BNC jack and UHF plug, will accept a banana plug, Tektronix Part No. 103-0032-00.

11. Miscellaneous

1—3-inch jumper lead with small insulated alligator clips on each end.

1—Short jumper lead with 4-inch insulated test prods connected to each end.

1—Screwdriver, for screwdriver-adjust potentiometers.

1—$1/16$-inch hexagonal wrench, for the VERTICAL POSITION knob setscrews.

1—Alignment tool, consisting of a handle (Tektronix Part No. 003-0307-00), a gray nylon insert with a wire pin (Tektronix Part No. 003-0308-00) and a nylon insert with a metal screwdriver tip (Tektronix Part No. 003-0334-00).

PRELIMINARY PROCEDURE

Remove the left side panel from the 580-Series oscilloscope. Lay the oscilloscope on its right side and remove the bottom cover. Leave the oscilloscope on its right side.

Connect a $6^1/_2$-inch plug-in extension to the Type 86. Install the Type 86 with the extension in the oscilloscope vertical plug-in compartment. Connect the power cord of the oscilloscope to the operating voltage for which the oscilloscope is wired. Turn on the oscilloscope and allow 15 minutes for warm up and stabilization. Preset the oscilloscope front-panel controls as follows:

Horizontal Display	Internal Sweep (Type 581 and 581A) A (Type 585, 585A and RM585A)
Triggering Source	Int (Type 581 and 585) Int AC (Type 581A, 585A and RM 585A)
Triggering Slope	+
Stability	Fully clockwise
Time/Cm	1 Millisec
Variable (Time/cm)	Calibrated
5× Magnifier	Off

Preset the Type 86 front-panel controls as follows:

AC-GND-DC	DC
VOLTS/CM	.1
VARIABLE VOLTS/CM	CAL
VERTICAL POSITION	Centered[2]
×1 GAIN ADJ	Fully clockwise
GAIN	×1

[2]White dot on knob at 12:00 o'clock (0°) position.

CALIBRATION PROCEDURE

1. VERTICAL POSITION Control Electrical Center

This step places the VERTICAL POSITION control at its electrical center as one of the primary steps in setting the DC balance of the Type 86. To perform the step proceed as follows:

Connect a voltmeter between the center terminal of the VERTICAL POSITION control and the junction of R145 and R148. See Fig. 5-1 for location of the junction. Rotate the VERTICAL POSITION control to obtain a zero reading on the voltmeter. At zero volts, if the white dot on the VERTICAL POSITION knob is not exactly at the 12 o'clock position, loosen the setscrew and reposition the knob. Recheck to be sure that the voltmeter will read zero when the white dot is at the 12 o'clock position.

NOTE

Do not move the VERTICAL POSITION control from 12 o'clock until you complete step 2.

2. X1 POSITION RANGE—Coarse Adjustment

Touch the voltmeter probe tips to test points 13 and 14 (see Fig. 5-1). Adjust the ×1 POSITION RANGE control until the voltmeter reads zero. Disconnect the voltmeter.

Note the position of the trace for use as a reference in step 4. This reference is the oscilloscope vertical-amplifier electrical center.

3. Check Output Amplifier Bias

Connect a short (3-inch) jumper clip lead between test points 11 and 12 (see Fig. 5-1). Check grid bias by connecting the negative lead of the voltmeter between test point 12 and the positive lead to each of the following test points (see Fig. 5-1 for location).

(a) Pin 8 (cathode) of V524.

(b) Pin 8 (cathode) of V534.

(c) Pin 8 (cathode) of V544.

The grid bias at each of the foregoing test points must be —0.3 volt or greater. If bias is less than —0.3 volt, cause of the trouble can be the tube or its cathode resistor at the point where the low bias voltage was measured. Disconnect the voltmeter.

4. Check Output Amplifier DC Balance

Rotate the oscilloscope Stability control fully clockwise to free run the time base. Note the position of the trace. If the trace is within 0.8 centimeter of the oscilloscope vertical-amplifier electrical center as noted in step 2, go on to step 5. If the position of the trace is further away than 0.8 centimeter, replace V524 with a new tube. After allowing sufficient warm-up time for the new tube, check the position of the trace. If the trace is still out of range, put the original tube back in its socket and replace the next tube in the Output Amplifier until each tube has been checked by the replacement method.

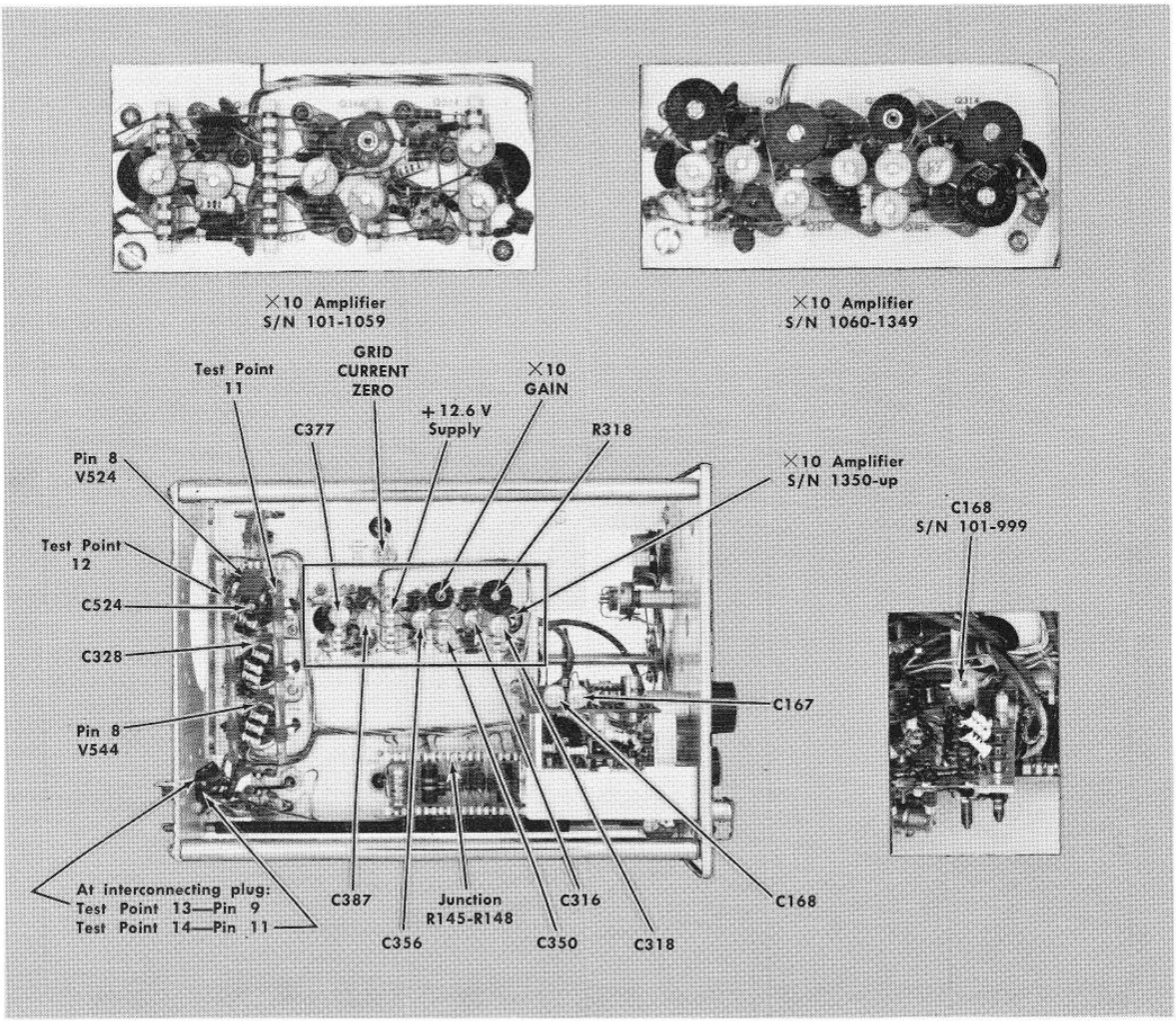


Fig. 5-1. Location of test points and calibration adjustments.

In some cases the imbalance can be cumulative; that is, each tube contributes slight imbalance in the same direction and the imbalances add. This effect can be checked on an individual tube basis by applying +12.6 volts (see Fig. 5-1) with a short jumper to pin 8 of each tube in the Output Amplifier. At the same time notice the direction of the trace shift. (The +12.6 volts cuts off the tube and effectively removes it from the circuit.)

To offset cumulative imbalance, replace a tube with one that makes the trace shift in the opposite direction. After obtaining proper DC balance, check the bias for the new tubes that were installed by repeating step 3.

After completing this step, note the position of the trace for use in step 13. This is the Type 86 distributed-amplifier electrical center.

Remove the 3-inch jumper clip lead.

5. X1 Gain ADJ

Set the oscilloscope Time/Cm switch to .5 ms.

Set the Standard Amplitude Calibrator Mode switch to Square Wave lever switch up and the Amplitude switch to .2 Volts. Turn the Power switch on and allow fifteen minutes for the instrument to warm up before proceeding.

Using a coaxial cable, connect the calibrator Output connector of the Standard Amplitude Calibrator to the Type 86 INPUT connector. Set the Stability control to Preset and adjust the Triggering Level control to obtain a stable display. Use the VERTICAL POSITION control to position the waveform to the center of the CRT. Rotate the ×1 GAIN ADJ control to obtain exactly two centimeters of vertical deflection.

6. Check VARIABLE VOLTS/CM Control

Rotate the VARIABLE VOLTS/CM control and check for smooth electrical and mechanical operation. Check that the control has an attenuation range of approximately 2 to 1 while observing the Calibrator waveform. Then return the control to its CAL position.

7. Check AC-GND-DC Switch

Place the AC-GND-DC switch to the AC position. The calibrator waveform should shift downward about one centimeter to its average voltage level. The shifting of the waveform indicates that the switch and the input coupling capacitor function properly. Set AC-GND-DC switch to GND position. Waveform should disappear. After making the checks, set the AC-GND-DC switch to DC.

8. Check VOLTS/CM Switch Accuracy

This step checks the calibrated deflection factors of the Type 86. While making this check, be sure the VARIABLE VOLTS/CM control is set fully clockwise to the CAL position. Then proceed as follows:

Use the VERTICAL POSITION control to align the waveform with the graticule lines so the amplitude measurement can be made easily. Check for proper vertical deflection at each position of the VOLTS/CM switch. Amplitude tolerance for each attenuator VOLTS/CM switch setting should be within ±3¼%. (VOLTS/CM switch attenuator tolerance is ±3%. The tolerance of the Standard Amplitude Calibrator is ±¼%).

TABLE 5-1

VOLTS/CM Switch Attenuation Check

VOLTS/CM Switch Setting	Standard Amplitude Calibrator	Vertical Deflection in cm
.1	.2 volt	2
.2	.5 volt	2.5
.5	1 volt	2
1	2 volts	2
2	5 volts	2.5
5	10 volts	2
10	20 volts	2
20	50 volts	2.5
50[3]	100 volts	2

[3]Found in plug-ins SN 1000-up.

After completing this, set the Standard Amplitude Calibrator Amplitude switch to Off and remove the interconnecting lead and adapter.

9. X1 POSITION RANGE—Fine Adjustment

Rotate the oscilloscope Stability control fully clockwise. Set the Type 86 front-panel controls as follows:

VOLTS/CM	2
VERTICAL POSITION	Centered 12 o'clock
GAIN	×10

If the trace moved off the screen, adjust the ×10 POSITION RANGE control to position the trace onto the screen. Then adjust the ×1 POSITION RANGE control for minimum trace shift while rotating the VARIABLE VOLTS/CM control. Keep the trace on the CRT by adjusting the ×10 POSITION RANGE control.

After adjusting for minimum trace shift, set the VARIABLE VOLTS/CM control fully clockwise to the CAL position.

10. X10 GAIN Adjustment

Using a 50-ohm coaxial cable, apply a 20-millivolt signal from the Standard Amplitude Calibrator to the INPUT connector. Set the VOLTS/CM switch to .01. Adjust the oscilloscope Stability and Triggering Level controls to obtain a stable display. Position the calibrator waveform to the center of the crt with the ×10 POSITION RANGE control. Adjust ×10 GAIN control (see Fig. 5-1) so the waveform is exactly two centimeters in amplitude. Disconnect the calibrator signal.

11. Check for Microphonics

This step checks for excessive ringing-type microphonics in the nuvistor with the gain switch to ×10.

To make the check, rotate the Stability control fully clockwise to free run the sweep. Ground the Input Connector, or if the Type 86 has a serial number of 1000 or higher, the GND position on the AC-GND-DC switch may be used. After grounding the input, tap lightly on the front panel of the Type 86. Watch for microphonics on the CRT screen. Sustained microphonics should be less than one centimeter in amplitude.

[4]12. GRID CURRENT ZERO Adjustment

Using a small screwdriver, short the center conductor of the INPUT BNC connector to its outer conductor (ground). If the trace shifts vertically, note the position of the trace and continue with this step. However, if there is no trace shift, unground the connector and go to the next step.

To cancel trace shift due to V133 grid current, first unground the INPUT connector. Then adjust the GRID CURRENT ZERO control (see Fig. 5-1) to position the trace to the point noted at the beginning of this step.

To check on the accuracy of your adjustment, intermittently short the INPUT connector to ground. If there is trace shift, carefully readjust the GRID CURRENT ZERO control until there is no trace shift.

If the trace shift cannot be eliminated by means of the GRID CURRENT ZERO control, replace V133. If V133 is replaced, repeat steps 5, 9, 11 and this step before going to the next step.

NOTE

Allow at least 10 minutes warm-up time for the replaced tube to stabilize before repeating step 12.

[4]On instruments SN 1000-up, ground the input connector by setting AC-GND-DC to GND. Where the input does not have to be grounded, return the switch to DC.

13. X10 POSITION RANGE Adjustments

First, repeat step 9 to make sure the ×1 POSITION RANGE control is still properly adjusted. Slight readjustment of this control may be necessary due to normal circuit drift. Be certain the VERTICAL POSITION control is set to 0°. (For an exact 0° setting, use the voltmeter to obtain a reading of zero volts as described in step 1.)

Adjust the ×10 POSITION RANGE control to position the trace to coincide with the center horizontal graticule line.

Set the GAIN switch to ×1. Trace shift should not be greater than ±1 centimeter from the Type 86 distributed-amplifier electrical center.

14. Input-Capacitance Standardization and Attenuator Compensation

This step is a combination procedure that provides a method of adjusting the input capacitance so the input time constant is the same for each position of the VOLTS/CM switch. In addition, this procedure provides a method for compensating the attenuators so the ac attenuation is equal to dc attenuation.

Turn on the Type 105 Square-Wave Generator, or equivalent. Set the generator for an output frequency of 2.5 kHz and its output amplitude to minimum. Connect a 50-ohm coaxial cable to the Output connector of the Type 105. Connect the other end of the cable through a 10:1 attenuator and a 15-pF[5] input time constant standardizer to the INPUT connector of the Type 86 (see Fig. 5-2).

Increase the output amplitude of the generator to produce a vertical deflection of about 3 centimeters on the CRT. (Make sure that the VOLTS/CM switch is set to .1.) Set the

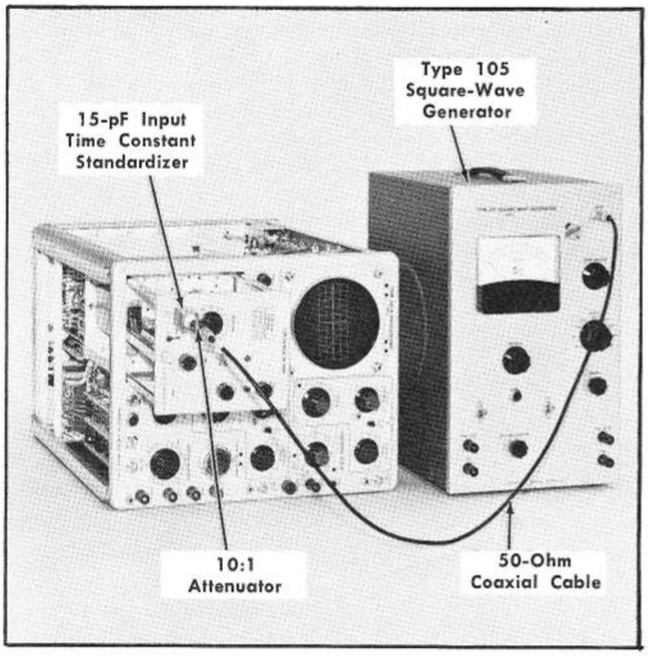


Fig. 5-2. The manner in which the Type 105 Square-Wave Generator should be connected to the Type 86 to perform the first part of Step 14.

[5]Should read 12-pF for instruments with serial numbers below 1000.

oscilloscope Stability control to Preset and adjust the Triggering Level control to obtain a stable display. Adjust the generator Symmetry control to obtain a symmetrical waveform. Use the VERTICAL POSITION control during this and succeeding steps whenever it is necessary to position the waveform to the center of the CRT screen for best viewing.

Table 5-2 lists the settings of the VOLTS/cm switch and the adjustment to make for each setting. The adjustments are divided into two columns according to their purpose and their effect on the waveform.

TABLE 5-2 (SN 1000-up)

V/CM Switch Setting	Instant Time Constant Standardization[6]	Attenuator Compensation[7]
.1	C106	None
.2	C107B	C107C
.5[8]	C108B	C108C
1	C109B	C109C
2	C110B	C110C
5	C111B	C111C
10	C112B	C112C
20	C113B	C113C
50[9]	C114B	C114C

TABLE 5-2 (SN 101–999)

V/CM Switch Setting	Instant Time Constant Standardization[6]	Attenuator Compensation[7]
.1	C127	None
.2	C103B	C103C
.5[8]	C105B	C105C
1	C107B	C107C
2	C109B	C109C
5	C111B	C111C
10	C113B	C113C
20	C115B	C115C

[6] **Use a 0.5-ms/cm sweep rate and adjust for optimum flat top.**

[7] **Use a 0.1-ms/cm sweep rate and adjust for optimum leading corner (minimum fast rolloff or spike).**

[8] **Remove the 10:1 attenuator for the rest of the step.**

[9] **Maximum amplitude of the display is about 2 cm.**

Fig. 5-3 shows the location of the adjustments including the VOLTS/CM switch setting used for each set of adjustments. Fig. 5-4 shows the effect on the waveform when any of the input-capacitance standardization adjustments are varied. As an example, C106 (C127) was misadjusted to obtain the waveforms used in the illustration.

Figs. 5-5a, c and d show the combined effect obtained when both the input-capacitance and the attenuator compensation adjustments are varied; for example, C109B and C109C respectively. Fig. 5-5b shows how the fast rolloff on the waveform in Fig. 5-5a was corrected by adjusting C109C. In Figs. 5-5c and d, C109B was misadjusted to make the flat tops of the waveforms slope downward while C109C

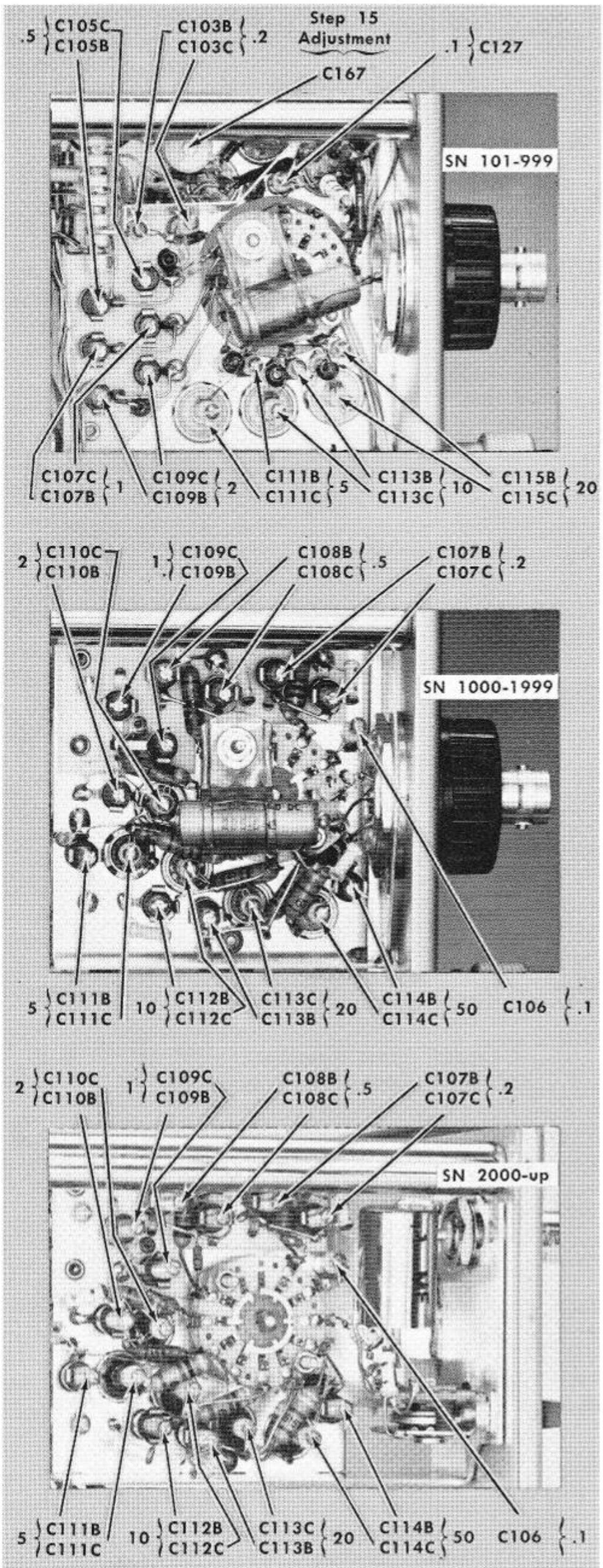


Fig. 5-3. Locations of attenuator adjustments described in Step 14.

was misadjusted to cause a fast rolloff (Fig. 5-5c) and a spike (Fig. 5-5d). Fig. 5-5e shows the proper waveform obtained when C109C is adjusted for no fast rolloff or spike.

To make the waveform shown in Figs. 5-5b and e have a flat top, the sweep rate should be set to 0.5 ms/cm and C109B, for this example, is then adjusted to obtain a waveform similar to that shown in Fig. 5-4c.

Maintain about 3 centimeters of vertical deflection by adjusting the generator Output Amplitude control each time the VOLTS/CM switch is moved from one position to the next. In the .5 position of the VOLTS/CM switch, it will be necesary to remove the 10:1 attenuator to obtain more signal to drive the Type 86. To prevent a shock hazard, turn the generator DC ON-OFF switch to OFF before removing the attenuator. Then, place the switch to ON and continue with the adjustments.

After completing this step, remove the 6½-inch plug-in extension. Plug the Type 86 directly into the oscilloscope plug-in compartment. Install the bottom and left side panels on the oscilloscope. Repeat step 14 to check the accuracy of your adjustments. Touch up any of the adjustments that are affected by the change in environment.

Disconnect the 15-pF input time constant standardizer and turn off the Type 105 Square-Wave Generator or equivalent.

15. X1 High-Frequency Compensation

Remove the bottom and left side panels from the oscilloscope. Connect a 50-ohm coaxial cable to the oscilloscope calibrator output connector. Connect the other end of the cable to the input connector of the TU-5 Pulser. Connect 50-ohm termination between the output connector of the TU-5 Pulser and the INPUT connector of the Type 86. Fig. 5-6 shows the entire setup.

Set the oscilloscope calibrator for an output of 100 volts, peak to peak. Set the oscilloscope Time/cm switch to 2 μSec. Set the Type 86 VOLTS/CM to the .1 position. Rotate the pulser knob slowly clockwise from a fully counterclockwise position until the tunnel diode triggers to produce a step waveform display on the CRT. Amplitude of the waveform is about 2 centimeters. (The pulser knob should be set only a few degrees clockwise from the triggering point to obtain a stable pulse with optimum square corner. If the knob is advanced too far, the front corner of the waveform will roll off excessively.)

NOTE

Use the oscilloscope Triggering Level control whenever it is necessary to obtain stable triggering of the time base during this and the following steps. Use the oscilloscope Horizontal Position and the Type 86 VERTICAL POSITION control to position the waveform for best viewing.

TABLE 5-3 (SN 1000-up)

Adjustment	Approximate Time Duration (as measured from the leading corner)
C167	3 ns
C168	12 ns
C524	20 ns

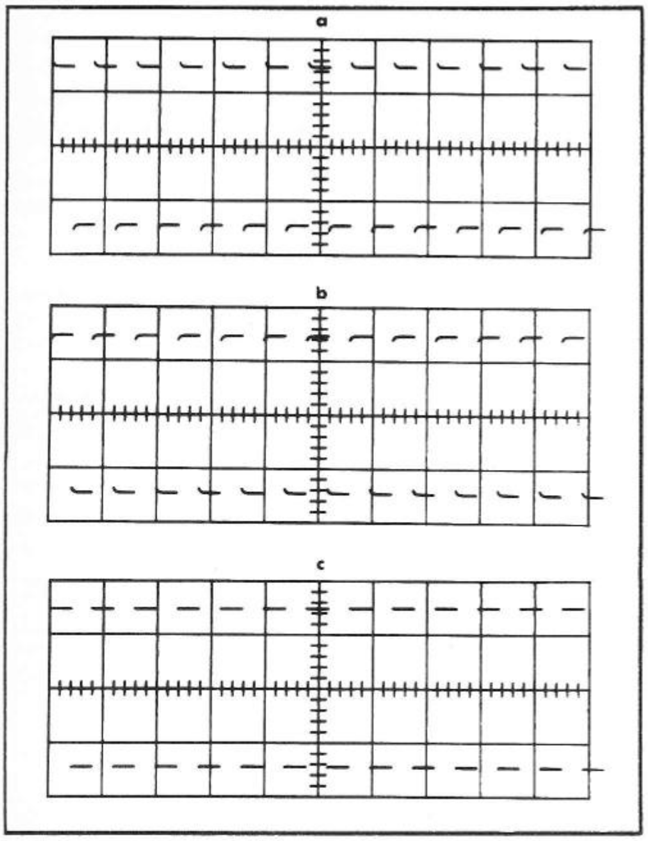


Fig. 5-4. Standardizing the input time constant; for example, when adjusting C106 (C127), (a) and (b) show the effect when C106 (C127) is improperly set; (c) is the desired appearance when C106 (C127) is set properly. Square-wave repetition rate: 2.5 kHz; sweep rate: 0.5 ms/cm.

TABLE 5-3 (SN 101–999)

Adjustment	Approximate Time Duration (as measured from the leading corner)
C167	3 ns
C168	20 ns
C524	15 ns

Examine the waveform display produced by the system when using the same sweep rates as those shown in the illustrations of Fig. 5-7. If the distortion in the leading corner of the waveform exceeds ±2 trace widths in amplitude, adjust C167, C168 and C524 (see Figs 5-1 and 5-3) for optimum square corner. The portion of the front leading corner affected by each adjustment is pointed out in Table 5-3.

16. X10 High-Frequency Compensation

SN 1350-up

Insert a 50-ohm 10:1 attenuator between the pulser output and the 50-ohm termination. Set the GAIN switch to ×10.

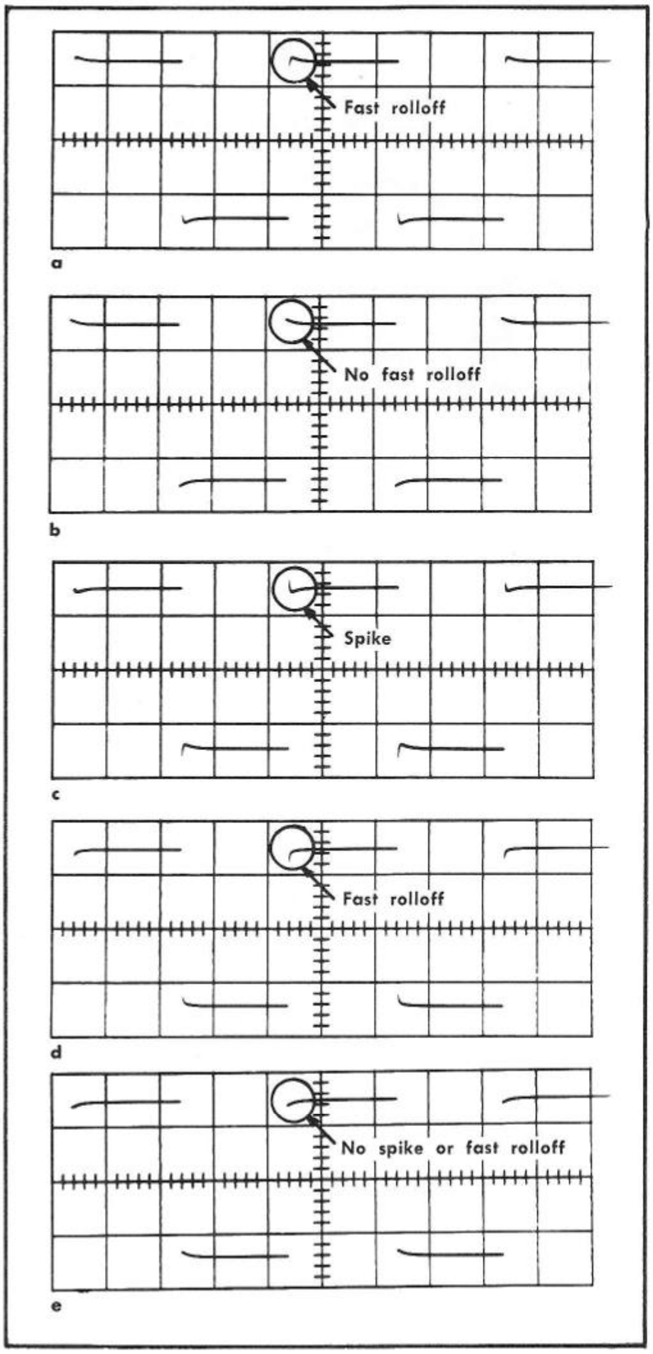


Fig. 5-5. Effect of the input capacitance and attenuator adjustments on the waveform when both are misadjusted as in (a), (c), and (d). Waveforms (b) and (e) show desired result when the attenuator adjustment is set for no fast rolloff or spike (see text). Square-wave repetition rate: 2.5 kHz; sweep rate: 0.1 ms/cm.

Using the same oscilloscope sweep rates as those used to obtain the oscillograms shown in Fig. 5-8a, b and c, examine the waveform displayed on your oscilloscope CRT. For a waveform 2 centimeters in amplitude, distortion should not exceed ±1 millimeter. If the leading 100-ns-duration portion of the front corner of the waveform is not within ±1 millimeter of being square, adjust C316, C318, C350, C356, C377, C387, and R418 (see Fig. 5-1) for optimum

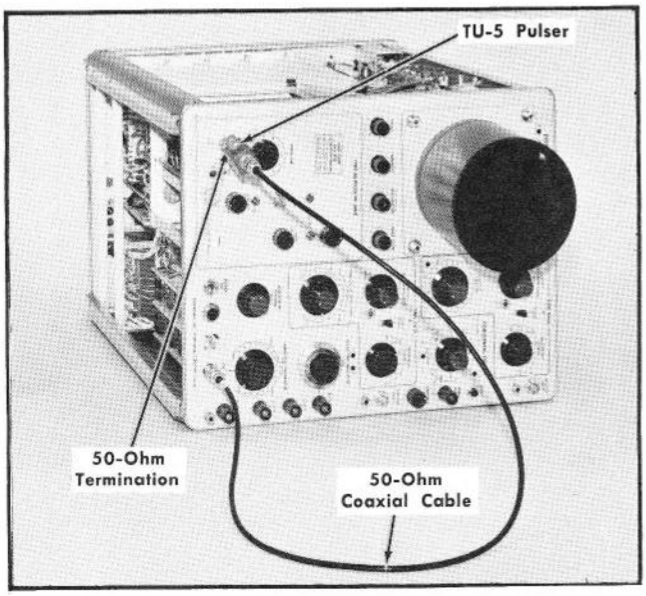


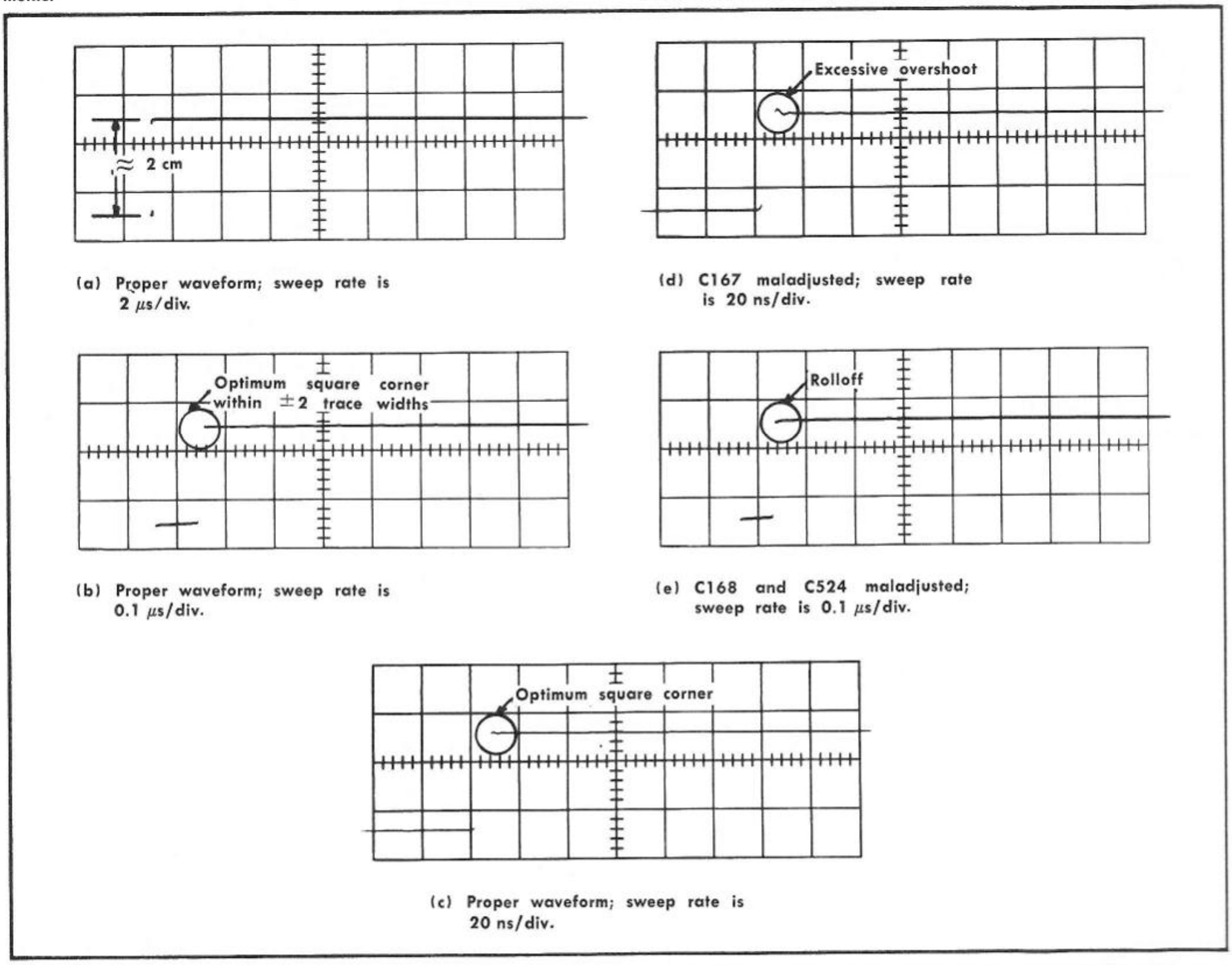
Fig. 5-6. Setup used for the high-frequency compensation adjustments.

square corner and amplitude level. The portion of the waveform that each of these adjustments affects is given in Table 5-4a.

During the following procedure, remember to use sweep rates which will be slow enough to cover the area being adjusted and a small portion more of the square wave. If at any time in the following procedure the adjustments made are not working toward the desired result, it is best to start over again by setting the adjustments to midrange.

TABLE 5-4a

Adjustment(s)	Approximate Time Duration (as measured from the front leading corner)	Adjustments made for
C350	800 ns	An optimum square corner and a level top on the square-wave.
C377	400 ns	
C318 and R318	100 ns	
C356	20 ns	
C387	6 ns	
C316	4 ns	



(a) Proper waveform; sweep rate is 2 μs/div.

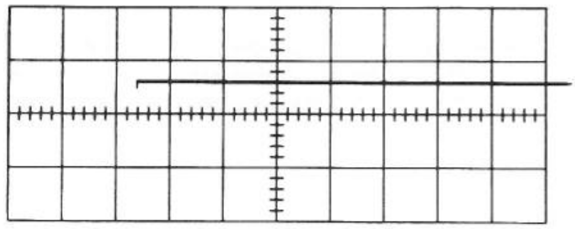
(d) C167 maladjusted; sweep rate is 20 ns/div.

(b) Proper waveform; sweep rate is 0.1 μs/div.

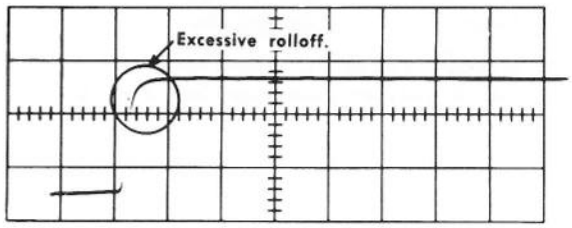
(e) C168 and C524 maladjusted; sweep rate is 0.1 μs/div.

(c) Proper waveform; sweep rate is 20 ns/div.

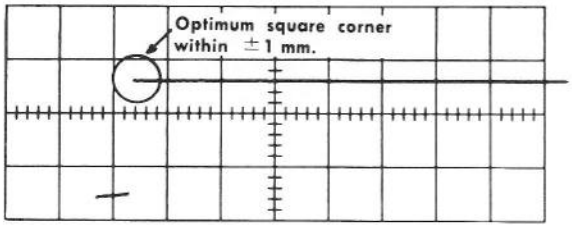
Fig. 5-7. GAIN switch set to ×1. Using different sweep rates, waveforms (a), (b), and (c) show typical displays when C167, C168, and C524 are properly adjusted. Waveform (d) shows result when C167 is misadjusted; waveform (e) shows result with both C168 and C524 misadjusted.



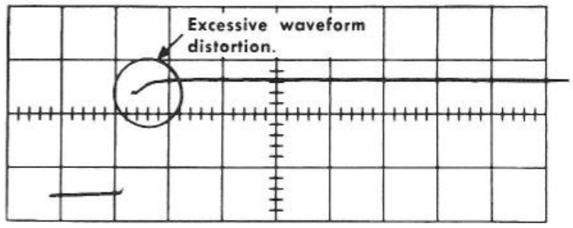
(a) Proper waveform; sweep rate is 1 μs/div.



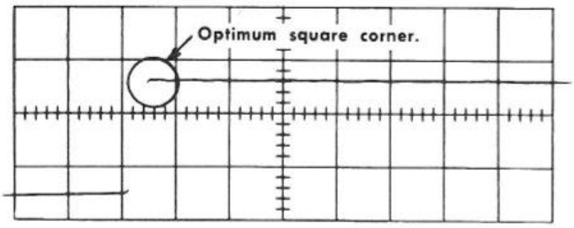
(e) C316, C356 and C387 misadjusted; sweep rate 40 ns/div.



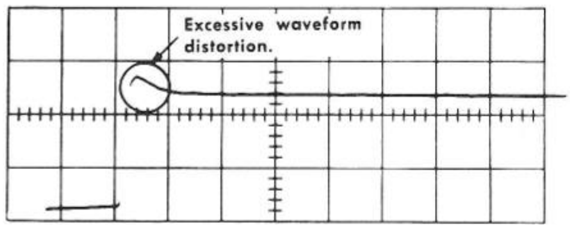
(b) Proper waveform; sweep rate is 0.1 μs/div.



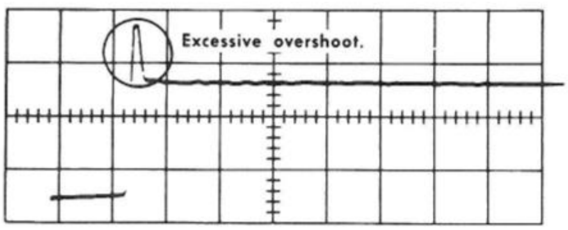
(f) C318, and C328 misadjusted; sweep rate 40 ns/div.



(c) Proper waveform; sweep rate is 20 ns/div.



(g) C318 and C328 misadjusted; sweep rate 40 ns/div.



(d) C316, C356 and C387 misadjusted; sweep rate 40 ns/div.

Fig. 5-8. GAIN switch set to ×10. Using different sweep rates, waveforms (a), (b), and (c) show typical displays when the ×10 amplifier is working normally and is correctly adjusted. Waveforms (d), (e), (f), and (g) illustrate effects when the adjustments are incorrect.

SN 1060-1349

Insert a 50-ohm 10:1 attenuator between the pulser output and the 50-ohm termination. Set the GAIN Switch to ×10.

Using the same oscilloscope sweep rates as those used to obtain the oscillograms shown in Fig. 4-8a, b and c, examine the waveform displayed on your oscilloscope CRT. For a waveform 2 centimeters in amplitude, distortion should not exceed ±1 millimeter. If the first 100-ns-duration portion of the front corner of the waveform is not within ±1 millimeter of being square, adjust C316, C318, C328, C356, C377, C383, C387, R318, R328, R377, and R383 (see Fig. 5-1) for optimum square corner and amplitude level. The portion of the waveform that each of these adjustments affects is given in Table 5-4b.

TABLE 5-4b

Adjustments (s)	Approx. Time Duration (as measured from the front leading corner	Adjustments made for
C387		Maximum spike on the front leading corner of the waveform.
C316, C356 C318, R318	10 to 50 ns depending upon transistors.	A square leading front corner on the waveform.
C383, R383		Adjusts only if front leading edge of the waveform has a long time-constant overshoot. Adjust until the waveform has a constant slope.
C377, R377	100 ns	A flat and level top on the waveform.
C328, R328	2 s	A flat and level top on the waveform.

If a component in the ×10 amplifier has been changed, then R318, R328, R377 and R383 should be set to maximum resistance before proceeding.

During the following adjustments remember to use sweep rates which will cover the area being adjusted and a small portion more of the square-wave. If at any time in the following procedure the adjustments made are not working toward the desired result, it is best to start over again by once again setting R318, R328, R377 and R383 to maximum resistance.

SN 101-1059

Insert a 50-ohm 10:1 attenuator between the pulser output and the 50-ohm termination. Set the GAIN switch to ×10.

Using the same oscilloscope sweep rates as those used to obtain the oscillograms shown in Fig. 5-8a, b, and c, examine the waveform displayed on your oscilloscope CRT. For a waveform which is 2 centimeters in amplitude, distortion should not exceed ±1 millimeter. If the first 100-ns-duration portion of the front corner of the waveform is not within ±1 millimeter of being square, adjust C316, C318, C328, C356, C377 and C387 (see Fig. 5-1) for optimum square corner and amplitude level. The portion of the waveform that each of these adjustments affects is given in Table 5-4c.

TABLE 5-4c

Adjustment	Approximate Time Duration (as measured from the front leading corner
C316	4 ns
C318	60 ns
C328	20 ns
C356	8 ns
C377	100 ns
C387	6 ns

ABBREVIATIONS AND SYMBOLS

A or amp	amperes
AC or ac	alternating current
AF	audio frequency
α	alpha—common-base current amplification factor
AM	amplitude modulation
$\approx$	approximately equal to
β	beta—common-emitter current amplification factor
BHB	binding head brass
BHS	binding head steel
BNC	baby series "N" connector
$\times$	by or times
C	carbon
C	capacitance
cap.	capacitor
cer	ceramic
cm	centimeter
comp	composition
conn	connector
$\sim$	cycle
c/s or cps	cycles per second
CRT	cathode-ray tube
csk	countersunk
Δ	increment
dB	decibel
dBm	decibel referred to one milliwatt
DC or dc	direct current
DE	double end
$^\circ$	degrees
$^\circ$C	degrees Celsius (degrees centigrade)
$^\circ$F	degrees Fahrenheit
$^\circ$K	degrees Kelvin
dia	diameter
$\div$	divide by
div	division
EHF	extremely high frequency
elect.	electrolytic
EMC	electrolytic, metal cased
EMI	electromagnetic interference (see RFI)
EMT	electrolytic, metal tubular
ε	epsilon—2.71828 or % of error
$\geq$	equal to or greater than
$\leq$	equal to or less than
ext	external
F or f	farad
F & I	focus and intensity
FHB	flat head brass
FHS	flat head steel
Fil HB	fillister head brass
Fil HS	fillister head steel
FM	frequency modulation
ft	feet or foot
G	giga or 10^9
g	acceleration due to gravity
Ge	germanium
GHz	gigahertz
GMV	guaranteed minimum value
GR	General Radio
$>$	greater than
H or h	henry
h	height or high
hex.	hexagonal
HF	high frequency
HHB	hex head brass
HHS	hex head steel
HSB	hex socket brass
HSS	hex socket steel
HV	high voltage
Hz	hertz (cycles per second)
ID	inside diameter
IF	intermediate frequency
in.	inch or inches
incd	incandescent
∞	infinity
int	internal
$\int$	integral
k	kilohms or kilo (10^3)
k Ω	kilohm
kc	kilocycle
kHz	kilohertz
L	inductance
λ	lambda—wavelength
$\gg$	large compared with
$<$	less than
LF	low frequency
lg	length or long
LV	low voltage
M	mega or 10^6
m	milli or 10^{-3}
MΩ or meg	megohm
μ	micro or 10^{-6}
mc	megacycle
met.	metal
MHz	megahertz
mm	millimeter
ms	millisecond
—	minus
mtg hdw	mounting hardware
n	nano or 10^{-9}
no. or #	number
ns	nanosecond
OD	outside diameter
OHB	oval head brass
OHS	oval head steel
Ω	omega—ohms
ω	omega—angular frequency
p	pico or 10^{-12}
/	per
%	percent
PHB	pan head brass
ϕ	phi—phase angle
π	pi—3.1416
PHS	pan head steel
$+$	plus
$\pm$	plus or minus
PIV	peak inverse voltage
plstc	plastic
PMC	paper, metal cased
poly	polystyrene
prec	precision
PT	paper, tubular
PTM	paper or plastic, tubular, molded
pwr	power
Q	figure of merit
RC	resistance capacitance
RF	radio frequency
RFI	radio frequency interference (see EMI)
RHB	round head brass
ρ	rho—resistivity
RHS	round head steel
r/min or rpm	revolutions per minute
RMS	root mean square
s or sec.	second
SE	single end
Si	silicon
SN or S/N	serial number
$\ll$	small compared with
T	tera or 10^{12}
TC	temperature compensated
TD	tunnel diode
THB	truss head brass
θ	theta—angular phase displacement
thk	thick
THS	truss head steel
tub.	tubular
UHF	ultra high frequency
V	volt
VAC	volts, alternating current
var	variable
VDC	volts, direct current
VHF	very high frequency
VSWR	voltage standing wave ratio
W	watt
w	wide or width
w/	with
w/o	without
WW	wire-wound
xmfr	transformer

PARTS ORDERING INFORMATION

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

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, instrument type or number, serial or model number, and modification number if applicable.

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

SPECIAL NOTES AND SYMBOLS

×000	Part first added at this serial number
00×	Part removed after this serial number
*000-0000-00	Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, Inc., or reworked or checked components.
Use 000-0000-00	Part number indicated is direct replacement.
◐	Screwdriver adjustment.
▭	Control, adjustment or connector.

SECTION 6
ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

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

Tolerance ±20% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Description					S/N Range
C101	285-0611-00	0.01 μF	MT		600 V		101-999
C101[1]	285-0646-00	0.01 μF	MT		600 V		1000-1996
C101	*285-0724-00	0.1 μF	MT		600 V	+5%—15%	1997-up
C102	281-0618-00	4.7 pF	Cer		200 V	±0.5 pF	X1000-up
C103B	281-0064-00	0.2-1.5 pF	Tub.	Var			101-999X
C103C	281-0064-00	0.2-1.5 pF	Tub.	Var			101-999X
C103D	Use 281-0601-00	7.5 pF	Cer		500 V	±0.5 pF	101-999X
C104	281-0613-00	10 pF	Cer		200 V		X1000-up
C105B	281-0027-00	0.7-3 pF	Tub.	Var			101-999X
C105C	281-0027-00	0.7-3 pF	Tub.	Var			101-999X
C105E	281-0534-00	3.3 pF	Cer			±0.25 pF	101-999X
C106	281-0064-00	0.2-1.5 pF	Tub.	Var			X1000-up
C107B	281-0027-00	0.7-3 pF	Tub.	Var			
C107C	281-0027-00	0.7-3 pF	Tub.	Var			101-999
C107C	281-0043-00	0.7-3 pF	Tub.	Var			1000-up
C107D	281-0616-00	6.8 pF	Cer		200 V		X1000-up
C107E	281-0503-00	8 pF	Cer		500 V	±0.5 pF	101-999X
C108B	281-0027-00	0.7-3 pF	Tub.	Var			X1000-up
C108C	281-0043-00	0.7-3 pF	Tub.	Var			X1000-up
C108D	281-0611-00	2.7 pF	Cer		200 V	±0.25 pF	X1000-up
C108E	281-0577-00	14 pF	Cer		500 V	5%	X1000-up
C109A	281-0538-00	1 pF	Cer		500 V		101-999X
C109B	281-0027-00	0.7-3 pF	Tub.	Var			101-999
C109B	281-0043-00	0.7-3 pF	Tub.	Var			1000-up
C109C	281-0027-00	0.7-3 pF	Tub.	Var			
C109D	281-0611-00	2.7 pF	Cer		200 V	±0.25 pF	X1000-up
C109E	281-0504-00	10 pF	Cer		500 V	10%	101-999
C109E	281-0512-00	27 pF	Cer		500 V	10%	1000-up
C110A	281-0611-00	2.7 pF	Cer		200 V	±0.25 pF	X1000-up
C110B	281-0043-00	0.7-3 pF	Tub.	Var			X1000-up
C110C }	281-0082-00	0.2-1.5 pF	Tub.	Var		10%	X1000-up
C110E }		15 pF	Mica				
C111A	281-0593-00	3.9 pF	Cer		500 V	10%	101-999
C111A	281-0615-00	3.9 pF	Cer		200 V		1000-up
C111B	281-0064-00	0.2-1.5 pF	Tub.	Var			101-999

[1]Furnished as a unit with R102.

Capacitors *(Cont)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
C111B	281-0027-00	0.7-3 pF	Tub.	Var			1000-up
C111C	281-0064-00	0.2-1.5 pF	Tub.	Var			101-999
C111E	283-0565-00	50 pF	Mica		500 V	5%	101-999
C111C }	281-0083-00	0.2-1.5 pF	Tub.	Var			
C111E }		50 pF	Mica			10%	1000-up
C111H	281-0617-00	15 pF	Cer		200 V		X1000-up
C112A	281-0615-00	3.9 pF	Cer		200 V		X1000-up
C112B	281-0043-00	0.7-3 pF	Tub.	Var			X1000-up
C112C }	281-0084-00	0.2-1.5 pF	Tub.	Var			
C112E }		100 pF	Mica			10%	X1000-up
C113A	281-0593-00	3.9 pF	Cer		500 V	10%	
C113B	281-0064-00	0.2-1.5 pF	Tub.	Var			101-999
C113B	281-0027-00	0.7-3 pF	Tub.	Var			1000-up
C113C	281-0064-00	0.2-1.5 pF	Tub.	Var			101-999
C113E	283-0566-00	100 pF	Mica		500 V	5%	101-999
C113C }	281-0085-00	0.2-1.5 pF	Tub.	Var			
C113E }		200 pF	Mica			10%	1000-up
C114A	281-0593-00	3.9 pF	Cer		500 V	10%	X1000-up
C114B	281-0027-00	0.7-3 pF	Tub.	Var			X1000-up
C114C }	281-0086-00	0.2-1.5 pF	Tub.	Var			X1000-up
C114E }		500 pF	Mica			10%	
C115A	281-0593-00	3.9 pF	Cer		500 V	10%	101-999X
C115B	281-0064-00	0.2-1.5 pF	Tub.	Var			101-999X
C115C	281-0064-00	0.2-1.5 pF	Tub.	Var			101-999X
C115E	283-0557-00	200 pF	Mica		500 V	10%	101-999X
C117	281-0537-00	0.68 pF	Selected		(nominal value)		
C126	281-0591-00	5600 pF	Cer		200 V		
C127	281-0064-00	0.2-1.5 pF	Tub.	Var			101-999X
C131	281-0575-00	39 pF	Cer		500 V	1%	X1000-up
C132	283-0000-00	0.001 μF	Cer		500 V		X1000-up
C134	283-0004-00	0.02 μF	Cer		150 V		101-999X
C135	290-0110-00	20 μF	EMT		150 V		
C136	290-0145-00	10 μF	EMT		50 V		
C151	Use 283-0024-00	0.1 μF	Cer		30 V		
C153	283-0023-00	0.1 μF	Cer		10 V		101-999
C153	283-0080-00	0.022 μF	Cer		25 V		1000-up
C154	283-0000-00	0.001 μF	Cer		500 V		X1640-up
C164	283-0000-00	0.001 μF	Cer		500 V		
C165[2]			Selected				X1060-up
C166	281-0547-00	2.7 pF	Cer		500 V	10%	X1000-1639X
C167	281-0060-00	2-8 pF	Cer	Var			101-999

[2]Added in Test Dept. if needed.

Capacitors *(Cont)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
C167	281-0089-00	2-8 pF	Cer	Var			1000-up
C168	281-0060-00	2-8 pF	Cer	Var			101-999
C168	281-0089-00	2-8 pF	Cer	Var			1000-up
C174	283-0000-00	0.001 μF	Cer		500 V		
C178	283-0000-00	0.001 μF	Cer		500 V		101-999X
C316	281-0061-00	5.5-18 pF	Cer	Var			101-1059
C316	281-0063-00	9-35 pF	Cer	Var			1060-1349
C316	281-0060-00	2-8 pF	Cer	Var			1350-up
C317	281-0513-00	27 pF	Cer		500 V		101-1059X
C318	281-0060-00	2-8 pF	Cer	Var			101-1059
C318	281-0061-00	5.5-18 pF	Cer	Var			1060-1349
C318	281-0060-00	2-8 pF	Cer	Var			1350-1619
C318	281-0061-00	5.5-18 pF	Cer	Var			1620-up
C328	281-0063-00	9-35 pF	Cer	Var			101-1349X
C329	281-0516-00	39 pF	Cer		500 V	10%	X1060-1349X
C350	281-0063-00	9-35 pF	Cer	Var			X1350-up
C351	281-0516-00	39 pF	Cer		500 V	10%	X1350-up
C355	281-0617-00	15 pF	Cer		200 V		X1620-1829
C355[2]			Selected				1830-up
C356	281-0063-00	9-35 pF	Cer	Var			
C374	283-0000-00	0.001 μF	Cer		500 V		101-1349
C374	281-0536-00	1000 pF	Cer		500 V	10%	1350-up
C377	281-0060-00	2-8 pF	Cer	Var			101-1059
C377	281-0063-00	9-35 pF	Cer	Var			1060-1749
C377	281-0060-00	2-8 pF	Cer	Var			1750-up
C381	283-0004-00	0.02 μF	Selected		(nominal value)		101-1059X
C382	283-0004-00	0.02 μF	Selected		(nominal value)		101-1059X
C383	281-0061-00	5.5-18 pF	Cer	Var			X1060-1349X
C384	283-0000-00	0.001 μF	Cer		500 V		101-1349
C384	281-0536-00	1000 pF	Cer		500 V	10%	1350-up
C387	281-0063-00	9-35 pF	Cer	Var			101-1059
C387	281-0060-00	2-8 pF	Cer	Var			1060-1349
C387	281-0061-00	5.5-18 pF	Cer	Var			1350-up
C389	281-0551-00	390 pF	Cer		500 V	10%	X1750-up
C391	283-0004-00	0.02 μF	Selected		(nominal value)		101-1059X
C393	281-0536-00	1000 pF	Cer		500 V	10%	101-1059X
C393	281-0523-00	100 pF	Cer		350 V	10%	X1750-up
C509	283-0003-00	0.01 μF	Selected		(nominal value)		101-1699
C509[2]							1700-up
C510	283-0004-00	0.02 μF	Selected		(nominal value)		
C511	283-0026-00	0.2 μF	Selected		(nominal value)		
C516	283-0000-00	0.001 μF	Cer		500 V		
C524	281-0027-00	0.7-3 pF	Tub.	Var			
C525	281-0557-00	1.8 pF	Cer		500 V		
C526	281-0557-00	1.8 pF	Cer		500 V		

[2]Added in Test Dept. if needed.

Capacitors *(Cont)*

Ckt. No.	Tektronix Part No.	Description			S/N Range
C528	283-0000-00	0.001 μF	Cer	500 V	
C534	281-0557-00	1.8 pF	Cer	500 V	
C535	281-0557-00	1.8 pF	Cer	500 V	
C536	281-0557-00	1.8 pF	Cer	500 V	
C538	283-0000-00	0.001 μF	Cer	500 V	
C539	281-0538-00	1 pF	Cer	500 V	
C544	281-0557-00	1.8 pF	Cer	500 V	
C545	281-0557-00	1.8 pF	Cer	500 V	
C546	281-0557-00	1.8 pF	Cer	500 V	
C549	281-0538-00	1 pF	Cer	500 V	
C552	283-0003-00	0.01 μF	Cer	150 V	
C553	283-0057-00	0.1 μF	Cer	200 V	
C554	283-0003-00	0.01 μF	Cer	150 V	
C555	290-0168-00	100 μF	EMT	6 V	101-1996
C555	*290-0194-01	10 μF	EMT	100 V	1997-up
C556	290-0168-00	100 μF	EMT	6 V	101-1996
C556	*290-0194-01	10 μF	EMT	100 V	1997-up
C557	283-0026-00	0.2 μF	Cer	25 V	

Diodes

D134	*152-0061-00	Silicon	Tek Spec		
D136	152-0067-00	Zener	1M25Z10	1 W, 25 V, 10%	
D138	152-0008-00	Germanium			
D139	152-0008-00	Germanium			
D152	152-0008-00	Germanium			X1620-up
D554	152-0096-00	Zener	1N2997B	10 W, 51 V, 5%	

Inductors

L103	*108-0258-00	0.25 μH	(wound on a 62 Ω resistor)	101-999X
L105A	*108-0248-00	0.25 μH	(wound on a 91 Ω resistor)	101-999X
L524	*108-0243-00	Plate Line		
L525	*108-0244-00	Grid Line		
L534	*108-0243-00	Plate Line		
L535	*108-0244-00	Grid Line		
LR107A	*108-0280-00	0.085 μH	(wound on a 43 Ω resistor)	X1000-up
LR108A	*108-0281-00	0.13 μH	(wound on a 36 Ω resistor)	X1000-up
LR109A	*108-0282-00	0.13 μH	(wound on a 30 Ω resistor)	X1000-up
LR110A	*108-0283-00	0.13 μH	(wound on a 43 Ω resistor)	X1000-up
LR111A	*108-0284-00	0.1 μH	(wound on a 43 Ω resistor)	X1000-up

Transistors

Ckt. No.	Tektronix Part No.	Description		S/N Range
Q153	151-0039-00	Germanium	2N1381	
Q164	*151-0086-00	Germanium	Selected from 2N955	101-1639
Q164	*151-0120-01	Silicon	Tek Spec	1640-up
Q174	*151-0086-00	Germanium	Selected from 2N955	101-1639
Q174	*151-0120-01	Silicon	Tek Spec	1640-up
Q314	*151-0088-00	Germanium	Selected from 2N700	101-1349
Q314	*151-0142-00	Silicon	Selected from 2N3546	1350-up
Q324	*151-0088-00	Germanium	Selected from 2N700	101-1349
Q324	*151-0142-00	Silicon	Selected from 2N3546	1350-up
Q344	*151-0088-00	Germanium	Selected from 2N700	101-1349
Q344	*151-0142-00	Silicon	Selected from 2N3546	1350-up
Q354	*151-0088-00	Germanium	Selected from 2N700	101-1349
Q354	*151-0142-00	Silicon	Selected from 2N3546	1350-up
Q374	*151-0086-00	Germanium	Selected from 2N955	101-1749
Q374	*151-0120-01	Silicon	Tek Spec	1750-up
Q384	151-0086-00	Germanium	Selected from 2N955	101-1749
Q384	151-0120-01	Silicon	Tek Spec	1750-up

Resistors

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

Ckt. No.	Tektronix Part No.	Description				S/N Range
R102[3]		15 Ω	¼ W			X1000-1996
R102	316-0150-00	15 Ω	¼ W			1997-up
R103A[4]		62 Ω	⅛ W		5%	101-999X
R103C	318-0109-00	500 kΩ	⅛ W	Prec	1%	101-999X
R103E	319-0031-00	1 MΩ	¼ W	Prec	1%	101-999X
R104	317-0470-00	47 Ω	⅛ W		5%	X1000-up
R105A[5]		91 Ω	⅛ W		5%	101-999X
R105C	318-0110-00	800 kΩ	⅛ W	Prec	1%	101-999X
R105E	318-0032-00	250 kΩ	⅛ W	Prec	1%	101-999X
R105F	315-0471-00	470 Ω	¼ W		5%	101-999X
R107C	318-0111-00	900 kΩ	⅛ W	Prec	1%	101-999
R107C	322-0610-00	500 kΩ	¼ W	Prec	1%	1000-up
R107E	318-0006-00	111 kΩ	⅛ W	Prec	1%	101-999
R107E	322-0481-00	1 MΩ	¼ W	Prec	1%	1000-up
R107F	315-0271-00	270 Ω	¼ W		5%	101-999X
R108C	322-0620-00	800 kΩ	¼ W	Prec	1%	X1000-up
R108E	321-0618-00	250 kΩ	⅛ W	Prec	1%	X1000-up
R109C	318-0095-00	950 kΩ	⅛ W	Prec	1%	101-999
R109C	322-0621-00	900 kΩ	¼ W	Prec	1%	1000-up
R109E	318-0007-00	52.6 kΩ	⅛ W	Prec	1%	101-999

[3]Furnished as a unit with C101.

[4]Furnished as a unit with L103A.

[5]Furnished as a unit with L105A.

Resistors *(Cont)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R109E	321-0617-00	111 kΩ	1/8 W		Prec	1%	1000-up
R109F	315-0221-00	220 Ω	1/4 W			5%	101-999X
R110C	322-0622-00	950 kΩ	1/4 W		Prec	1%	X1000-up
R110E	321-0616-00	52.6 kΩ	1/8 W		Prec	1%	X1000-up
R111C	318-0112-00	980 kΩ	1/8 W		Prec	1%	101-999
R111C	322-0630-00	980 kΩ	1/4 W		Prec	1%	1000-up
R111E	318-0033-00	20.4 kΩ	1/8 W		Prec	1%	101-999
R111E	321-0615-00	20.4 kΩ	1/8 W		Prec	1%	1000-up
R111H	317-0510-00	51 Ω	1/8 W			5%	X1000-up
R112C	322-0624-00	990 kΩ	1/4 W		Prec	1%	X1000-up
R112E	321-0614-00	10.1 kΩ	1/8 W		Prec	1%	X1000-up
R112H	317-0510-00	51 Ω	1/8 W			5%	X1000-up
R113C	318-0113-00	990 kΩ	1/8 W		Prec	1%	101-999
R113C	322-0625-00	995 kΩ	1/4 W		Prec	1%	1000-up
R113E	318-0009-00	10.1 kΩ	1/8 W		Prec	1%	101-999
R113E	321-0613-00	5.03 kΩ	1/8 W		Prec	1%	1000-up
R113H	317-0750-00	75 Ω	1/8 W			5%	X1000-up
R114A	317-0560-00	56 Ω	1/8 W			5%	X1997-up
R114C	322-0628-00	998 kΩ	1/4 W		Prec	1%	X1000-up
R114E	321-0222-00	2 kΩ	1/8 W		Prec	1%	X1000-up
R114H	317-0750-00	75 Ω	1/8 W			5%	X1000-up
R115C	318-0114-00	995 kΩ	1/8 W		Prec	1%	101-999X
R115E	318-0010-00	5.03 kΩ	1/8 W		Prec	1%	101-999X
R116	317-0180-00	18 Ω	1/8 W			5%	X1000-up
R117	319-0031-00	1 MΩ	1/4 W		Prec	1%	101-999
R117	322-0481-00	1 MΩ	1/4 W		Prec	1%	1000-up
R118	316-0101-00	100 Ω	1/4 W				101-999
R118	315-0101-00	100 Ω	1/4 W			5%	1000-up
R119	302-0124-00	120 kΩ	1/2 W				
R121	311-0154-00	50 kΩ		Var			
R123	317-0330-00	33 Ω	1/8 W			5%	101-999X
R126	317-0474-00	470 kΩ	1/8 W			5%	
R131	315-0181-00	180 Ω	1/4 W			5%	X1000-up
R132	316-0151-00	150 Ω	1/4 W				101-999X
R133	306-0123-00	12 kΩ	2 W				
R134	307-0107-00	5.6 Ω	1/4 W			5%	101-999
R134	316-0220-00	22 Ω	1/4 W				1000-up
R135	316-0470-00	47 Ω	1/4 W				
R136	306-0103-00	10 kΩ	2 W				
R137	302-0332-00	3.3 kΩ	1/2 W				101-999
R137	302-0472-00	4.7 kΩ	1/2 W				1000-up
R138	315-0751-00	750 Ω	1/4 W			5%	X1000-up
R140	311-0003-00	100 Ω		Var			101-1996
R140	311-0006-00	1 kΩ		Var			1997-up
R143	311-0324-00	50 Ω		Var			101-1996
R143	311-0483-00	500 Ω		Var			1997-up

Resistors *(Cont)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R145	316-0330-00	33 Ω	¼ W				101-1996
R145	315-0331-00	330 Ω	¼ W			5%	1997-up
R146	316-0330-00	33 Ω	¼ W				101-1996
R146	315-0331-00	330 Ω	¼ W			5%	1997-up
R148	315-0200-00	20 Ω	¼ W			5%	101-999
R148	315-0160-00	16 Ω	¼ W			5%	1000-1996
R148	315-0161-00	160 Ω	¼ W			5%	1997-up
R149	316-0331-00	330 Ω	¼ W				101-1996
R149	315-0332-00	3.3 kΩ	¼ W			5%	1997-up
R153	316-0561-00	560 Ω	¼ W				
R154	316-0123-00	12 kΩ	¼ W				X1620-up
R155	316-0152-00	1.5 kΩ	¼ W				X1620-up
R163	316-0181-00	180 Ω	¼ W				X1000-up
R164	315-0201-00	200 Ω	¼ W			5%	
R165	315-0750-00	75 Ω	¼ W			5%	101-999
R165	315-0910-00	91 Ω	¼ W			5%	1000-up
R166	315-0221-00	220 Ω	¼ W			5%	101-999
R166	316-0152-00	1.5 kΩ	¼ W				1000-1639X
R167	315-0750-00	75 Ω	¼ W			5%	101-2059
R167	315-0820-00	82 Ω	¼ W			5%	2060-up
R168	315-0102-00	1 kΩ	¼ W			5%	101-999
R168	316-0181-00	180 Ω	¼ W				1000-1639
R168	316-0102-00	1 kΩ	¼ W				1640-up
R169	315-0112-00	1.1 kΩ	¼ W			5%	
R174	315-0201-00	200 Ω	¼ W			5%	
R175	315-0750-00	75 Ω	¼ W			5%	101-999
R175	315-0910-00	91 Ω	¼ W			5%	1000-up
R178	308-0216-00	6 kΩ	5 W		WW	1%	
R179	315-0112-00	1.1 kΩ	¼ W			5%	
R180	Use *050-0289-00	Replacement Kit					101-1996
R180	*311-0570-00	200 Ω x 200 Ω x 2 kΩ		Var			1997-up
R183	315-0131-00	130 Ω	¼ W			5%	
R184	315-0820-00	82 Ω	¼ W			5%	
R185	315-0820-00	82 Ω	¼ W			5%	
R193	315-0131-00	130 Ω	¼ W			5%	
R194	315-0820-00	82 Ω	¼ W			5%	
R195	315-0820-00	82 Ω	¼ W			5%	
R197	315-0161-00	160 Ω	¼ W			5%	101-1619
R197	315-0131-00	130 Ω	¼ W			5%	1620-up
R301	315-0910-00	91 Ω	¼ W			5%	
R303	316-0471-00	470 Ω	¼ W				101-1349
R303	316-0392-00	3.9 kΩ	¼ W				1350-1619
R303	316-0822-00	8.2 kΩ	¼ W				1620-up
R305	315-0910-00	91 Ω	¼ W			5%	
R312	316-0470-00	47 Ω	¼ W				X2060-up
R314	315-0241-00	240 Ω	¼ W			5%	101-1349
R314	315-0221-00	220 Ω	¼ W			5%	1350-up

Resistors *(Cont)*

Ckt. No.	Tektronix Part No.	Description				S/N Range
R316	315-0101-00	100 Ω	¼ W		5%	101-1059
R316	315-0131-00	130 Ω	¼ W		5%	1060-1349
R316	315-0151-00	150 Ω	¼ W		5%	1350-up
R317	315-0330-00	33 Ω	¼ W		5%	101-1059X
R318	315-0202-00	2 kΩ	¼ W		5%	101-1059
R318	311-0131-00	1 kΩ		Var		1060-1349
R318	311-0010-00	2.5 kΩ		Var		1350-up
R322	316-0470-00	47 Ω	¼ W			X2060-up
R324	315-0241-00	240 Ω	¼ W		5%	101-1349
R324	315-0221-00	220 Ω	¼ W		5%	1350-up
R325	315-0121-00	120 Ω	¼ W		5%	
R328	315-0131-00	130 Ω	¼ W		5%	101-1059
R328	311-0017-00	10 kΩ		Var		1060-1349X
R330	315-0391-00	390 Ω	¼ W		5%	101-1349
R330	315-0361-00	360 Ω	¼ W		5%	1350-up
R331	315-0620-00	62 Ω	¼ W		5%	
R332	315-0620-00	62 Ω	¼ W		5%	
R333	315-0391-00	390 Ω	¼ W		5%	101-1349
R333	315-0361-00	360 Ω	¼ W		5%	1350-up
R335	315-0621-00	620 Ω	¼ W		5%	
R336	311-0091-00	1 kΩ		Var		
R337	315-0621-00	620 Ω	¼ W		5%	
R344	315-0271-00	270 Ω	¼ W		5%	101-1349
R344	315-0221-00	220 Ω	¼ W		5%	1350-up
R346	316-0101-00	100 Ω	¼ W			
R347	315-0301-00	300 Ω	¼ W		5%	
R349	315-0751-00	750 Ω	¼ W		5%	101-1349
R349	315-0681-00	680 Ω	¼ W		5%	1350-up
R350	315-0472-00	4.7 kΩ	¼ W		5%	X1350-up
R354	315-0271-00	270 Ω	¼ W		5%	101-1349
R354	315-0221-00	220 Ω	¼ W		5%	1350-up
R356	311-0249-00	1 kΩ		Var		101-1349
R356	311-0150-00	500 Ω		Var		1350-up
R359	315-0751-00	750 Ω	¼ W		5%	101-1349
R359	315-0681-00	680 Ω	¼ W		5%	1350-up
R374	315-0201-00	200 Ω	¼ W		5%	
R375	315-0910-00	91 Ω	¼ W		5%	
R376	315-0201-00	200 Ω	¼ W		5%	
R377	315-0821-00	820 Ω	¼ W		5%	101-1059
R377	311-0017-00	10 kΩ		Var		1060-1349
R377	315-0332-00	3.3 kΩ	¼ W		5%	1350-1749
R377	316-0182-00	1.8 kΩ	¼ W			1750-up
R379	315-0181-00	180 Ω	¼ W		5%	
R381	307-0108-00	6.8 Ω	Selected	(nominal value)		101-1059X
R383	311-0078-00	50 kΩ		Var		X1060-1349X
R384	315-0201-00	200 Ω	¼ W		5%	

Resistors *(Cont)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
R385	315-0910-00	91 Ω	¼ W			5%	
R387	315-0910-00	91 Ω	¼ W			5%	
R389	315-0181-00	180 Ω	¼ W			5%	
R390	316-0472-00	4.7 kΩ	¼ W				X1750-up
R391	307-0106-00	4.7 Ω	Selected	(nominal value)			101-1059X
R393	315-0113-00	11 kΩ	¼ W			5%	101-1059X
R393	316-0472-00	4.7 kΩ	¼ W				X1750-up
R510	307-0106-00	4.7 Ω	Selected	(nominal value)			101-1699
R510	307-0104-00	3.3 Ω	Selected	(nominal value)			1700-up
R511	307-0111-00	3.6 Ω	Selected	(nominal value)			101-1699
R511	307-0103-00	2.7 Ω	Selected	(nominal value)			1700-up
R513	309-0266-00	93.1 Ω	½ W		Prec	1%	101-999
R513	323-0094-00	93.1 Ω	½ W		Prec	1%	1000-up
R514	309-0266-00	93.1 Ω	½ W		Prec	1%	101-999
R514	323-0094-00	93.1 Ω	½ W		Prec	1%	1000-up
R521	309-0266-00	93.1 Ω	½ W		Prec	1%	101-999
R521	323-0094-00	93.1 Ω	½ W		Prec	1%	1000-up
R522	309-0266-00	93.1 Ω	½ W		Prec	1%	101-999
R522	323-0094-00	93.1 Ω	½ W		Prec	1%	1000-up
R524	315-0152-00	1.5 kΩ	¼ W			5%	
R527	316-0101-00	100 Ω	¼ W				
R528	302-0471-00	470 Ω	½ W				
R537	316-0101-00	100 Ω	¼ W				
R538	302-0471-00	470 Ω	½ W				
R546	316-0471-00	470 Ω	¼ W				X2060-up
R547	316-0101-00	100 Ω	¼ W				
R548	302-0471-00	470 Ω	½ W				
R549	311-0169-00	100 Ω		Var			101-2059
R549	311-0461-00	250 Ω		Var			2060-up
R550	315-0100-00	10 Ω	Selected	(nominal value)			101-2059X
R551	309-0266-00	93.1 Ω	½ W		Prec	1%	101-999
R551	323-0094-00	93.1 Ω	½ W		Prec	1%	1000-up
R552	309-0266-00	93.1 Ω	½ W		Prec	1%	101-999
R552	323-0094-00	93.1 Ω	½ W		Prec	1%	1000-up
R554	308-0107-00	1 kΩ	5 W		WW	5%	
R555	315-0470-00	47 Ω	¼ W			5%	101-999
R555	315-0910-00	91 Ω	¼ W			5%	1000-1996
R555	315-0911-00	910 Ω	¼ W			5%	1997-up
R556	315-0470-00	47 Ω	¼ W			5%	101-999
R556	301-0181-00	180 Ω	½ W			5%	1000-1996
R556	315-0182-00	1.8 kΩ	¼ W			5%	1997-up
R557	*308-0141-00	1 Ω	½ W		WW	5%	X1000-up
R558	308-0142-00	30 Ω	3 W		WW	5%	
R559	301-0121-00	120 Ω	½ W			5%	X1000-up

Switches

Ckt. No.	Tektronix Part No. Unwired	Wired	Description		S/N Range
SW101	260-0458-00		Rotary	AC-DC	101-999
SW101	260-0577-00		Rotary	AC-DC	1000-1619
SW101	*260-0714-00		Rotary	AC-DC	1620-1996
SW101	260-0621-00		Lever	AC-GND-DC	1997-up
SW111	260-0461-00	*262-0501-00	Rotary	VOLTS/CM	101-999
SW111	260-0575-00	*262-0612-00	Rotary	VOLTS/CM	1000-1996
SW111	260-0575-01	*262-0612-01	Rotary	VOLTS/CM	1997-up
SW390	260-0504-00		Rotary	GAIN	

Electron Tubes

Ckt. No.	Tektronix Part No.		Description
V133	Use *157-0103-00	7586	Checked
V524	154-0187-00	6DJ8	
V534	154-0187-00	6DJ8	
V544	154-0187-00	6DJ8	

FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations which appear on the pullout pages immediately following the Diagrams section of this instruction manual.

INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the Description column.

Assembly and/or Component
Detail Part of Assembly and/or Component
mounting hardware for Detail Part
Parts of Detail Part
mounting hardware for Parts of Detail Part
mounting hardware for Assembly and/or Component

Mounting hardware always appears in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation.

Mounting hardware must be purchased separately, unless otherwise specified.

PARTS ORDERING INFORMATION

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

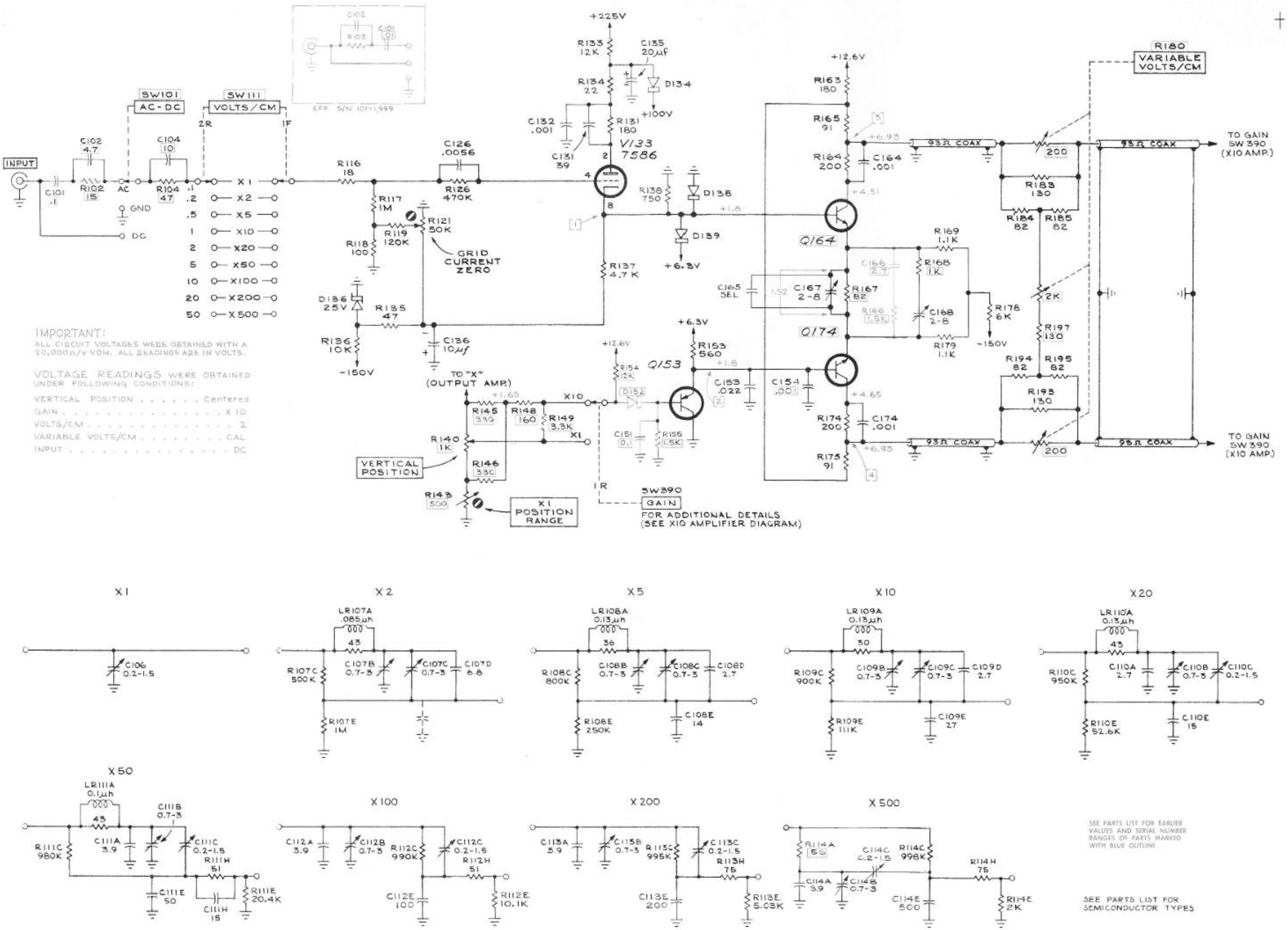
Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information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

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

Change information, if any, is located at the rear of this manual.

ABBREVIATIONS AND SYMBOLS

For an explanation of the abbreviations and symbols used in this section, please refer to the page immediately preceding the Electrical Parts List in this instruction manual.



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

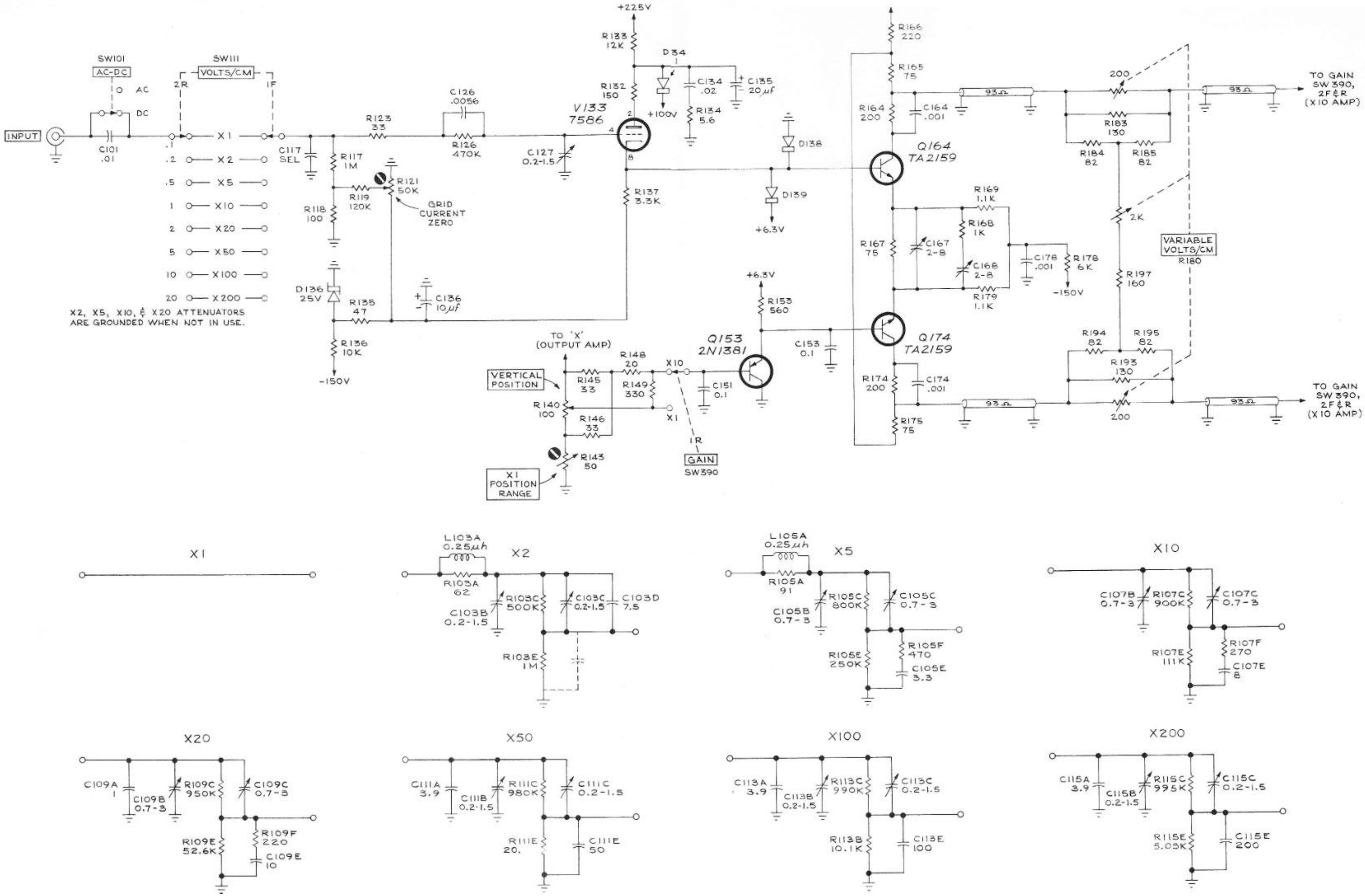
SEE PARTS LIST FOR SEMICONDUCTOR TYPES

DON
866

TYPE 86 PLUG-IN

E

INPUT AMPLIFIER
S/N 1000-UP

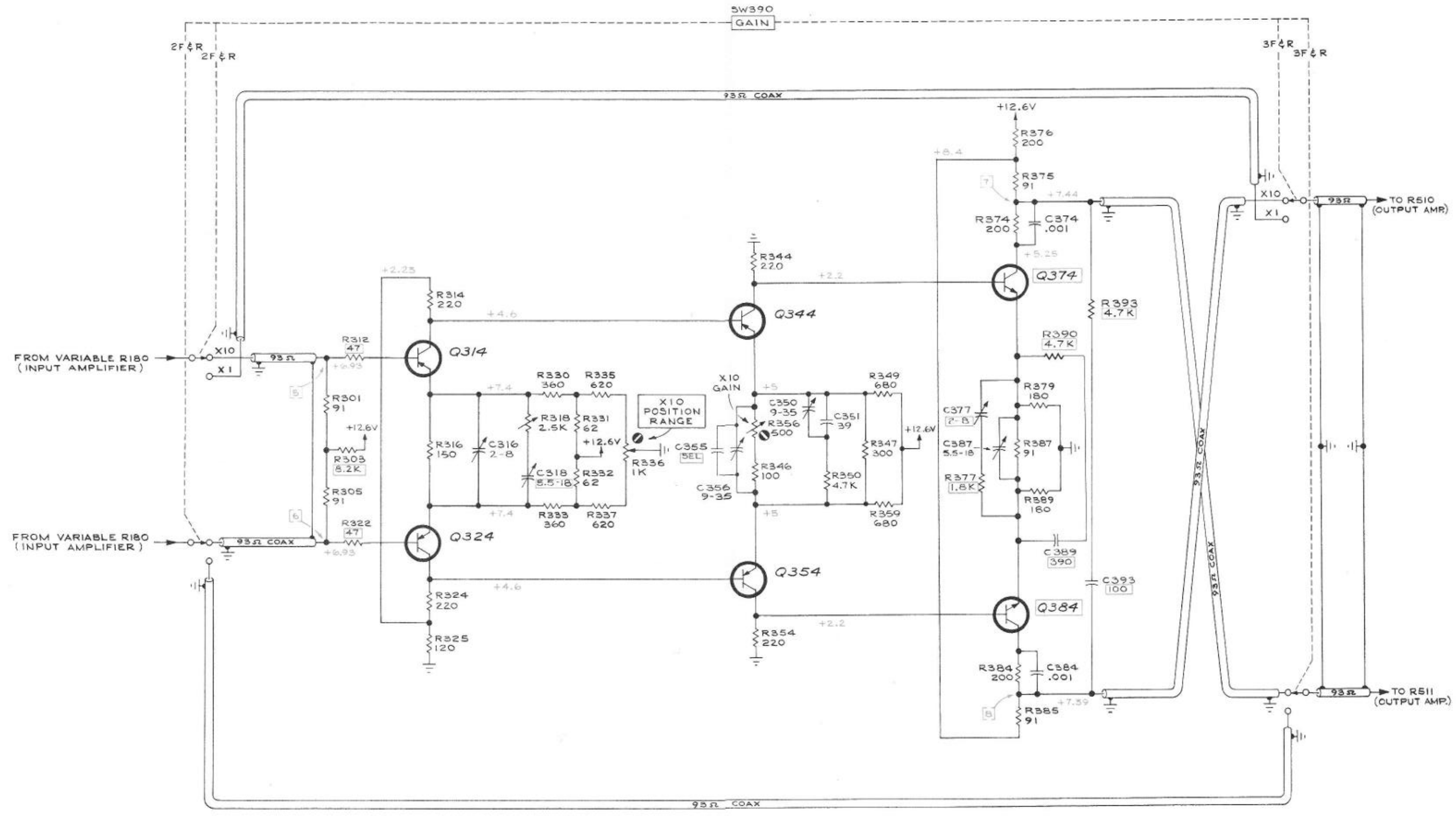


TYPE 86 PLUG-IN

A

DON
963

INPUT AMPLIFIER
S/N 101-999



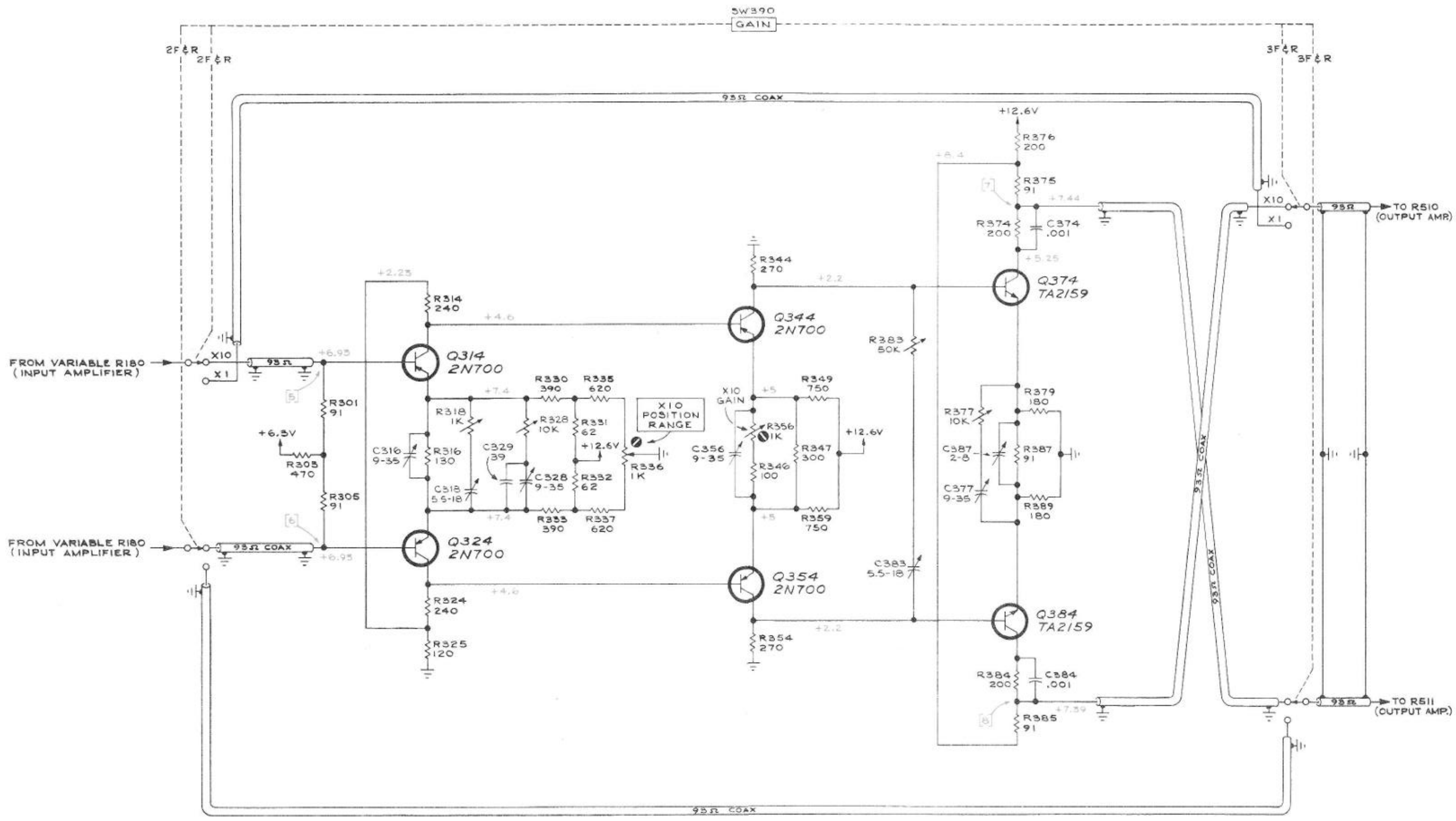
SEE PARTS LIST FOR SEMICONDUCTOR TYPES

SEE IMPORTANT NOTE ON INPUT AMPLIFIER DIAGRAM.

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

866
MRH

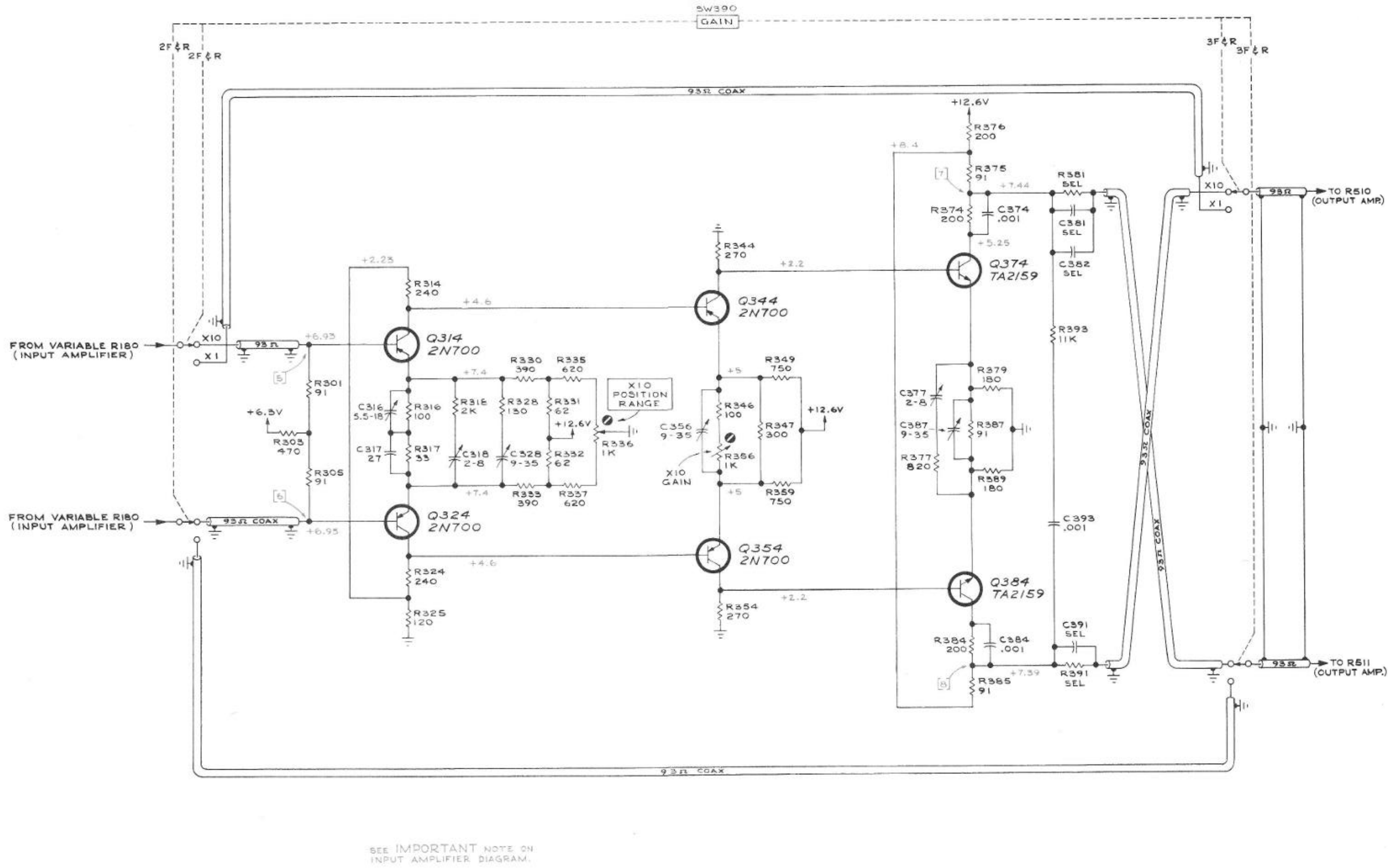
S/N 1350-UP
X10 AMPLIFIER



SEE IMPORTANT NOTE ON INPUT AMPLIFIER DIAGRAM.

MRH
1064

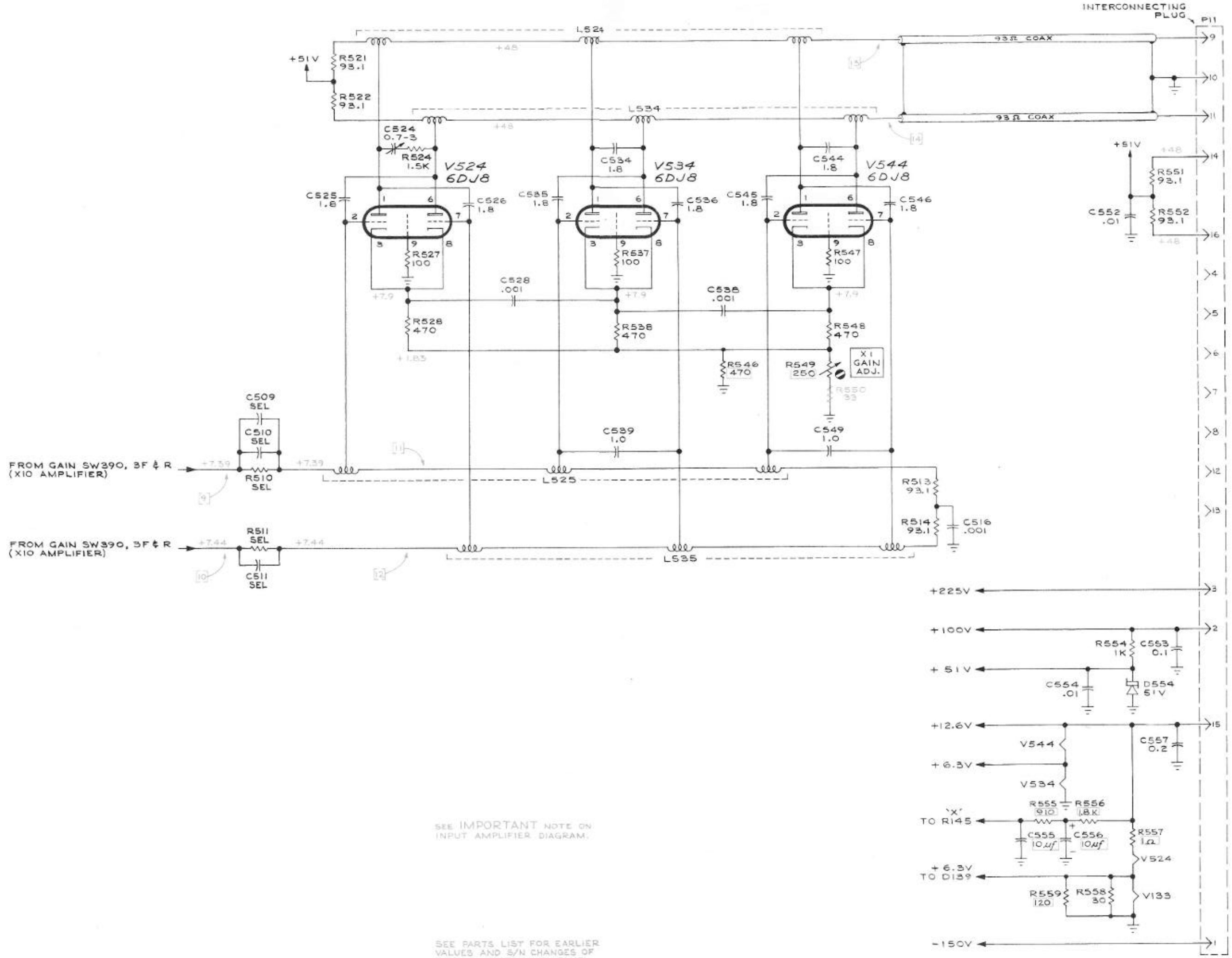
S/N 1060-1349
X10 AMPLIFIER



TYPE 86 PLUG-IN

B

MRH
1064
S/N 101-1059
X10 AMPLIFIER



SEE IMPORTANT NOTE ON INPUT AMPLIFIER DIAGRAM.

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

866
MRH

TYPE 86 PLUG-IN

c

OUTPUT AMPLIFIER

TEXT CORRECTION

Section 1 CHARACTERISTICS

Page 1-1 TABLE 1-1

REPLACE: The present TABLE 1-1 with the following TABLE 1-1.

TABLE 1-1

System	Risetime	Bandwidth (DC to typical 3 dB down point)
580-Series Oscilloscope using the Type 84 Plug-In Test Unit.	Equal to or less than 3.9 ns	
580-Series Oscilloscope and Type 86; X1 Gain.	Equal to or less than 4.4 ns.	DC to 80 MHz (Also see Fig. 1-2)
580-Series Oscilloscope and Type 86; X10 Gain.	Equal to or less than 4.7 ns.	DC to 75 MHz
580-Series Oscilloscope and Type 86 (X1 Gain) with P6008 Probe.	Equal to or less than 5.3 ns	DC to 66 MHz
580-Series Oscilloscope and Type 86 (X10 Gain) with P6008 Probe.	Equal to or less than 5.5 ns	DC to 63 MHz

Page 1-2

REPLACE: Fig. 1-2 with the following Fig. 1-2.

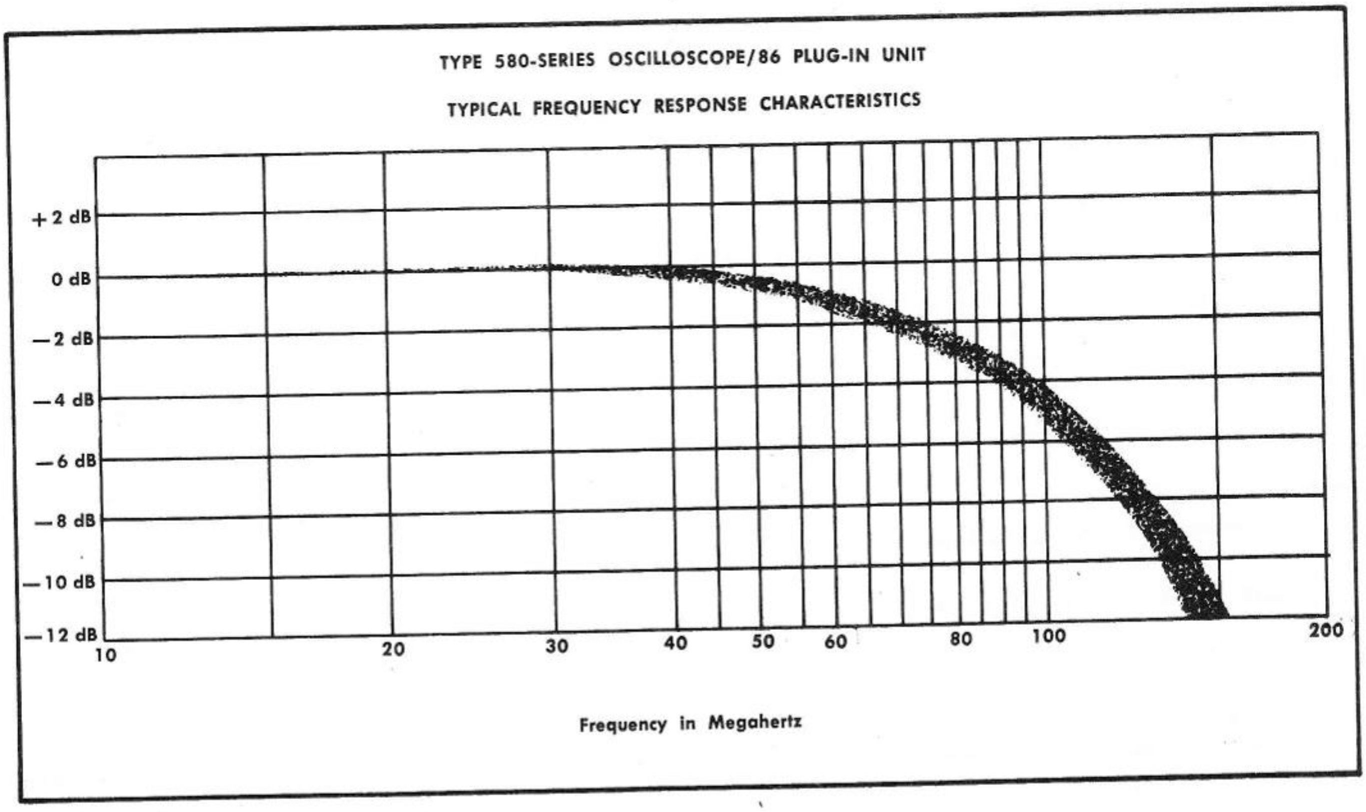


Fig. 1-2. Typical X1-gain frequency response characteristic curve of the Type 82 when used in conjunction with the Type 580-Series oscilloscope. A 25-ohm resistive source (50-ohm cable termination in 50 ohms) was used to drive the Type 82.

TYPE 86 TENT SN 2540

PARTS LIST CORRECTION

CHANGE TO:

D136	152-0022-00	1N25Z5	1 W, 25 V, ±5%

M11,191/168

TYPE 86 TENT SN 2600

SCHEMATIC CORRECTION

OUTPUT AMPLIFIER

REMOVE:

Pin connectors 12 and 13 from the Interconnecting Plug.

M13,526/468