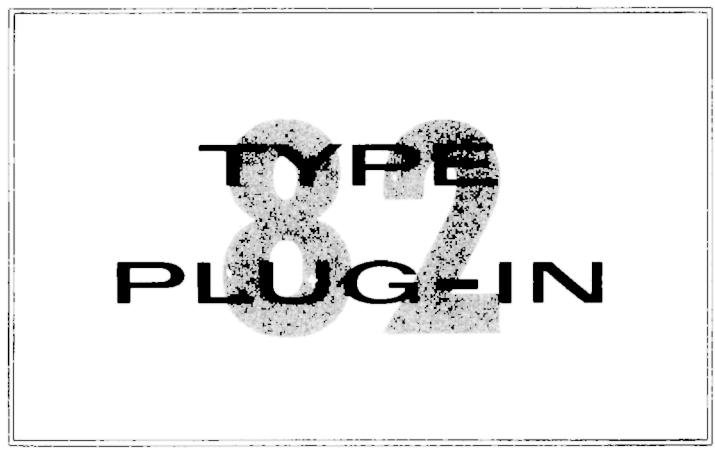


INSTRUCTION MANUAL



Tektronix, Inc.

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WARRANTY

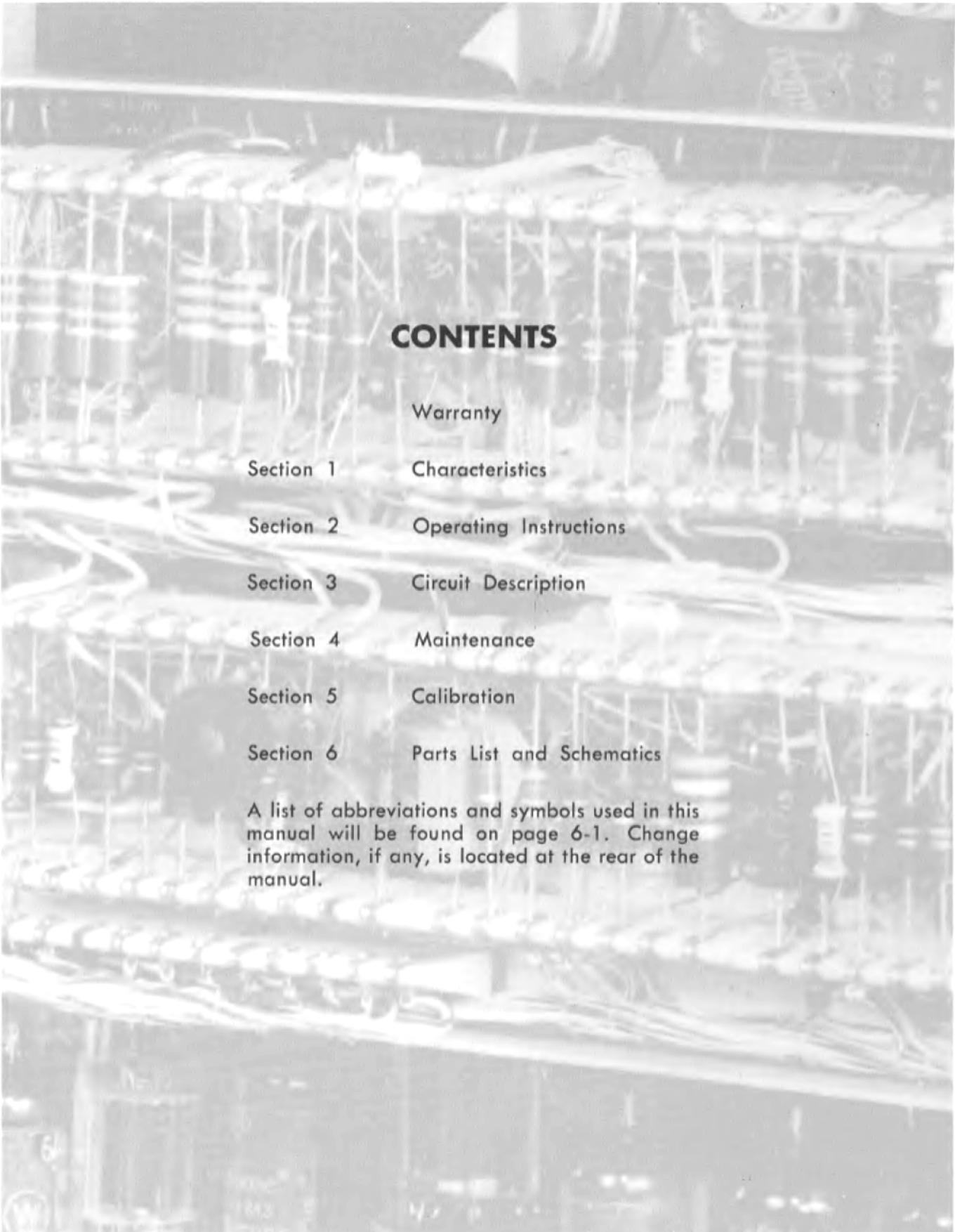
All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our own plant, are warranted for the life of the instrument.

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.

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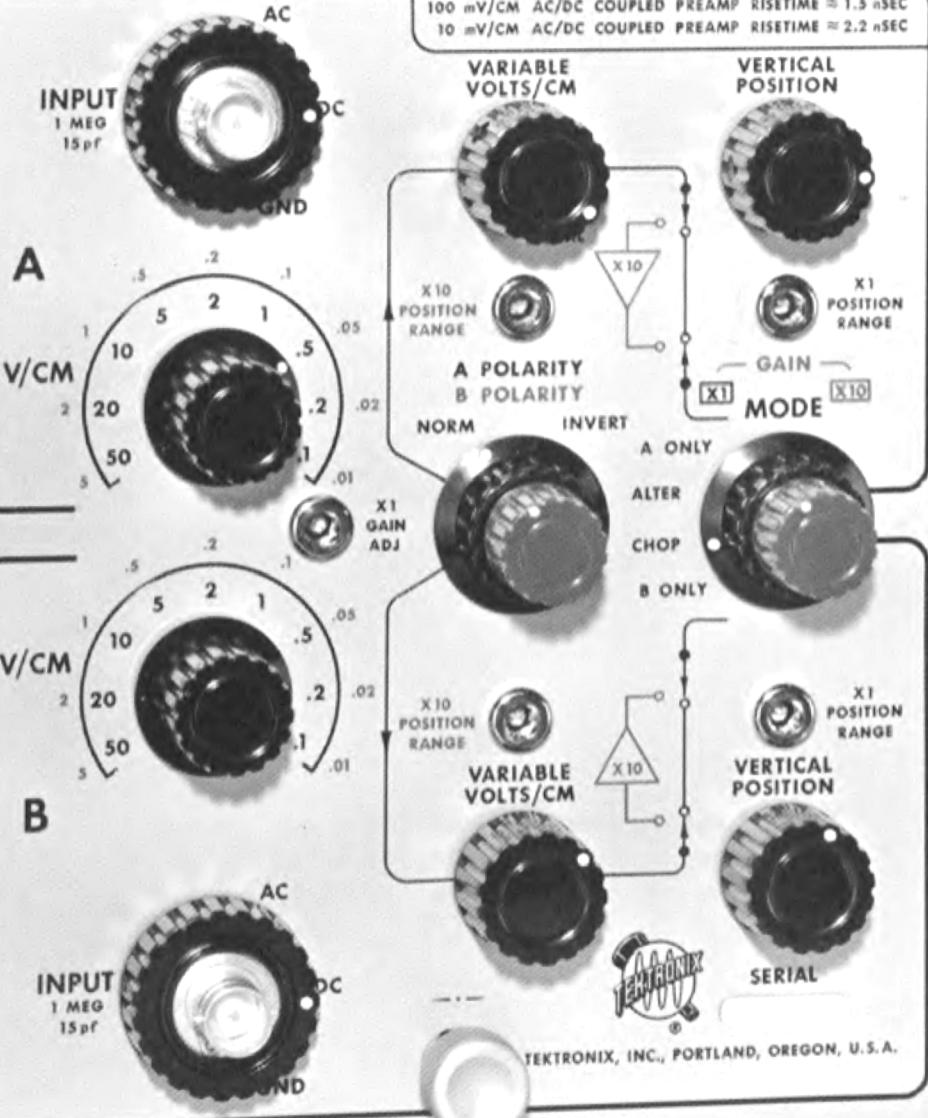
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A list of abbreviations and symbols used in this manual will be found on page 6-1. Change information, if any, is located at the rear of the manual.

TYPE 82 DUAL-TRACE PLUG-IN UNIT

100 mV/cm AC/DC COUPLED PREAMP RISETIME ≈ 1.5 nSEC
10 mV/cm AC/DC COUPLED PREAMP RISETIME ≈ 2.2 nSEC



SECTION 1

CHARACTERISTICS

General Information

The Type 82 Dual-Trace Plug-in Unit extends the versatility of the Type 580-Series Oscilloscopes by providing dual-trace operation. The Type 82 contains two identical fast-rise, high-gain, calibrated preamplifier channels. Each channel has a basic deflection factor of 100 mv/cm. Two integral X10 amplifiers extend the basic deflection factor to 10 mv/cm. Separate coupling, attenuation, variable gain, and vertical position controls are provided for each channel.

The channels can be electronically switched either by the oscilloscope sweep or at a free-running rate of approximately 100 kc or 1 mc, depending on the setting of an internal switch. Electronic switching enables the applied signals to be observed together. The signal applied to either channel can be inverted to compare signals 180° out of phase.

Two P6008 passive X10 attenuator probes, supplied with the Type 82, increase the input resistance from 1 megohm to 10 megohms and decrease the input capacitance from 15 pf to about 7.5 pf. Below serial number 3000 the Type 82 had an input capacitance of 12 pf. without a probe and 7 pf with a P6008 probe connected. The probes reduce loading of the circuit under test and provide a convenient means of coupling the signals from the device under test to the unit.

Table 1-1 summarizes the system risetimes and bandwidths.

NOTE

Where reference is made to a 580-series, 581 or 585 oscilloscope, the same information will apply to the equivalent 580A series oscilloscope.

TABLE 1-1

Instrument or System	Nominal Risetime	Bandwidth (dc to typical* 3 db down point)
Type 580-Series Oscilloscope using the Type 84 Plug-in Test Unit.	3.7 nsec; always less than 3.9 nsec.	
Type 580-Series Oscilloscope and Type 82; X1 Gain.	4.0 nsec; always less than 4.2 nsec.	dc to 85 mc (Also, see Fig. 1-1)
Type 580-Series Oscilloscope and Type 82; X10 Gain.	4.3 nsec; always less than 4.5 nsec.	dc to 80 mc
Type 580-Series Oscilloscope and Type 82 (X1 Gain) with Type P6008 Probe.	5.0 nsec; always less than 5.2 nsec.	dc to 70 mc
Type 580-Series Oscilloscope and Type 82 (X10 Gain) with Type P6008 Probe.	5.3 nsec; always less than 5.5 nsec.	dc to 66 mc

*Typically 3db down; never exceeds 3.5 db down at any of the frequencies listed in the column.

The transient response of the vertical amplifier has been standardized in Type 581 Oscilloscopes S/N 950 and up, and Type 585 Oscilloscopes S/N 2585 and up. (There are some exceptions to these S/N ranges since some earlier S/N oscilloscopes have been modified out of sequence. Your Tektronix Field Engineer has a complete list of those which have been modified.) The transient response of the vertical amplifier in all Type 581A, 585A and RM585A has been standardized.

To bring an earlier serial-numbered 580 series oscilloscope up to date for optimum performance with the Type 82, contact your Tektronix Field Engineer for information concerning modification kit number 040-275.

Calibrated Deflection Factor

Basic Deflection Factor (X1 Gain): Nine calibrated steps are provided for each channel—0.1, 0.2, 0.5, 1, 2, 5, 10, 20, and 50 volts per centimeter. Variable to about a 2-to-1 ratio (uncalibrated) between steps and up to approximately 100 volts cm. Below serial number 3000 there were eight calibrated steps provided for each channel—0.1, 0.2, 0.5, 1, 2, 5, 10, and 20 volts per centimeter. Variable to about a 2-to-1 ratio (uncalibrated) between steps and up to approximately 40 volts cm.

Extended Deflection Factor (X10 Gain): X10 amplifiers that switch into both channels simultaneously extend the deflection factor of each channel to 0.01, 0.02, 0.05, 0.1, 0.2, 0.5, 1, 2, and 5 volts per centimeter. Also variable to about a 2-to-1 ratio (uncalibrated) between steps and up to approximately 10 volts cm.

Calibration Accuracy

Front-panel X1 and internal X10 adjustments are provided for setting the gain of each channel. When accurately set, the vertical deflection factor 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 to 0% error by the gain adjustments.

Input Impedance

1 megohm $\pm 1\%$ paralleled by approximately 15 pf. SN 101-2999: 1 megohm $\pm 1\%$ paralleled by approximately 12 pf.

Input Coupling

Choice of ac or dc coupling. With ac coupling, the low-frequency response is approximately 15 cps (3-db) directly, or 1.5 cps using the P6008 Probe.

Characteristics — Type 82

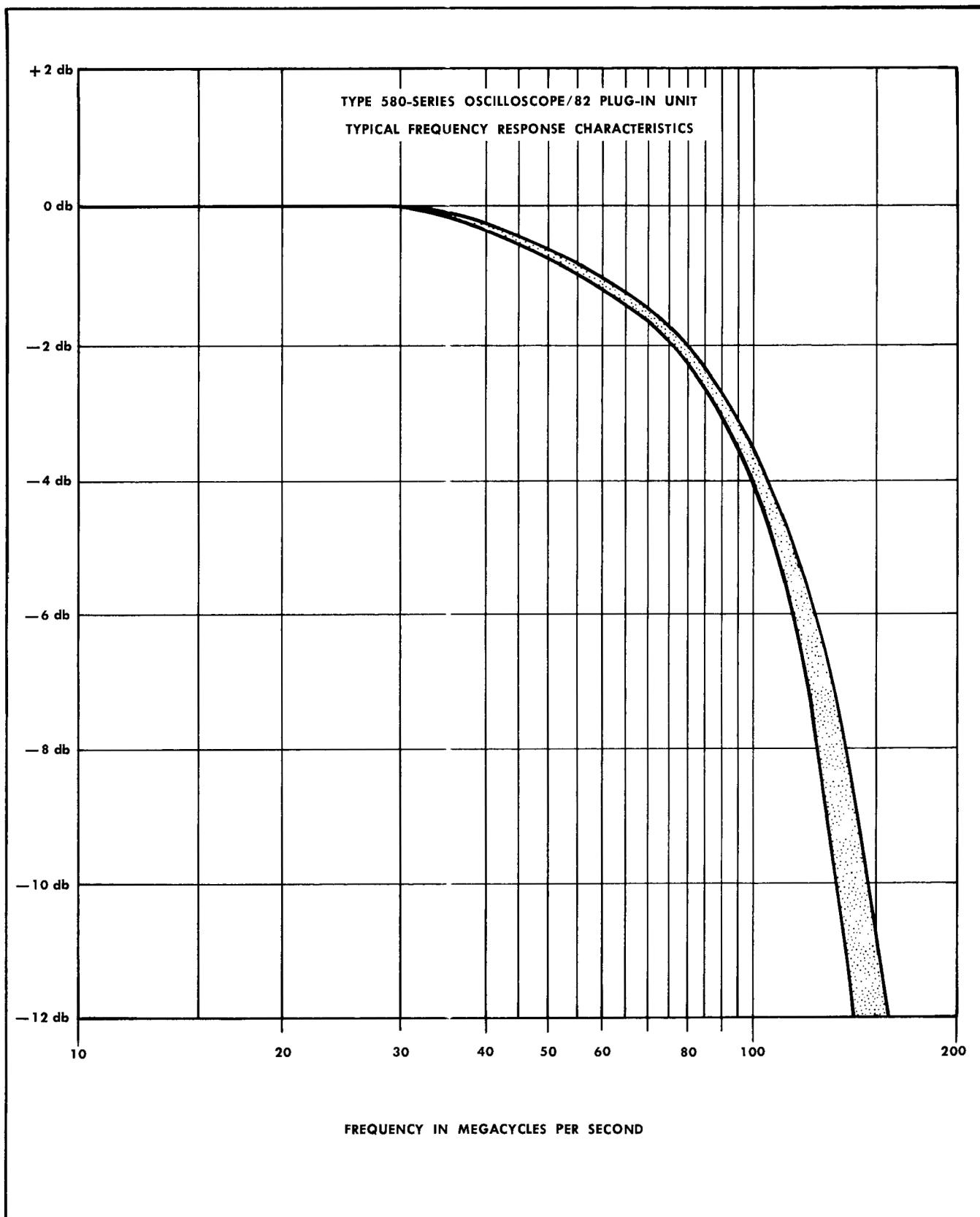


Fig. 1-1. Typical X1-gain frequency response characteristic curve of the Type 82 when used in conjunction with the Type 580-Series oscilloscope. A 25-ohm resistive source (50-ohm cable terminated in 50 ohms) was used to drive the Type 82.

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).

Operating Modes

Channel A only.

Channel B only.

Chopped: Free-running electronic switching between channels at approximately a 100-kc or 1-mc rate, depending upon the setting of an internal switch. Time duration of each chopped trace segment is approximately 5 μ sec at the 100-kc rate and approximately 0.5 μ sec at the 1-mc rate.

Alternate: Triggered electronic switching between channels at the end of each sweep, during the retrace interval.

Polarity Inversion

Polarity can be inverted on either channel for comparison of signals 180° out of phase.

Mechanical

Construction: Aluminum-alloy chassis.

Finish: Photo-etched anodized panel.

Net weight: 4 lbs. 12 oz.

Accessories Supplied With the Type 82

Qty.	Tektronix Part Number	Description
2	010-129	Type P6008 10X attenuation passive probes (for probe characteristics, etc., refer to the probe instruction manual)
2	070-349	Type 82 Instruction Manuals

NOTE

Other accessories available for use with the Type 82 can be found in the Tektronix catalog.

SECTION 2

OPERATING INSTRUCTIONS

FUNCTIONS OF CONTROLS AND CONNECTORS

INPUT A, INPUT B	Signal input connector for channel A or channel B.	at one of two preselected chopping rates, or to allow channel B to be used independently.
AC-DC-GND	Three-position switch to provide either ac or dc coupling into the amplifiers, or grounding of Input Attenuators.	Securing Rod Holds the Type 82 securely in the oscilloscope plug-in compartment. (Located at bottom center on the front panel.)
V/CM	Nine-position switch used to select the calibrated vertical-deflection factors.	CHOP RATE (see Fig. 2-1) Two-position slide switch provides the following chopped-mode switching-rate choices: 100 kc or 1 mc.
X1 GAIN ADJ.	Screwdriver-adjustable potentiometer to permit the gain of the common output amplifier to be accurately set. Adjusted to make the basic deflection factor of channel A accurate at .1 V/CM.	
VARIABLE VOLTS/CM	Potentiometer to provide variable uncalibrated attenuation up to about a 2-to-1 ratio between the calibrated deflection factors and up to approximately 100 v/cm using X1 gain or up to approximately 10 v/cm using X10 gain.	
VERTICAL POSITION	Potentiometer to provide for shifting the position of the trace vertically.	
X10 POSITION RANGE	Screwdriver-adjustable potentiometer to set the trace to coincide with the horizontal (X-axis) center-line when the GAIN switch is set to X10 and VERTICAL POSITION control is centered. (Always perform this adjustment after adjusting the X1 POSITION RANGE control first.)	AC-DC-GND DC V/CM .1 VARIABLE VOLTS/CM CAL. A POLARITY NORM. B POLARITY NORM. VERTICAL POSITION Centered GAIN X1 MODE A ONLY
X1 POSITION RANGE	Screwdriver-adjustable potentiometer to set the trace to coincide with the Type 82 distributed-amplifier center.	
A POLARITY* (Black Knob)	Two-position switch to provide operational in-phase (NORM.) or out-of-phase (INV.) output for channel A.	
B POLARITY* (Red Knob)	Two-position switch to provide operational in-phase (NORM.) or out-of-phase (INV.) output for channel B.	
GAIN (Red Knob)	Two-position switch to select either X1 or X10 gain for both channels simultaneously. When switch is in the black X1 position, read the black scale of the V/CM switches. When the switch is in the blue X10 position, read the blue scale of the V/CM switches.	
MODE (Black Knob)	Four-position switch to allow channel A to be used independently, to synchronize the switching with the oscilloscope's sweep, to provide for switching the two channels	

*In NORM. position, trace moves up if positive voltages are applied or if corresponding VERTICAL POSITION control is turned clockwise; trace moves down if negative voltages are applied or if VERTICAL POSITION control is turned counterclockwise. In INV. position, trace movement is opposite to that described for the NORM. position.

First Time Operation

To get acquainted with the Type 82 for the first time, the following operating procedure is suggested:

1. Set the internal CHOP RATE slide switch (see Fig. 2-1) to the 100 KC position.
2. Insert the Type 82 into a Type 580-Series Oscilloscope, tighten the Securing Rod, and turn the power on.
3. Allow about 2 to 3 minutes warm-up time and free run the oscilloscope sweep at 1 millisec/cm.
4. Set the Type 82 front-panel controls (both channels) as follows:

AC-DC-GND	DC
V/CM	.1
VARIABLE VOLTS/CM	CAL.
A POLARITY	NORM.
B POLARITY	NORM.
VERTICAL POSITION	Centered
GAIN	X1
MODE	A ONLY

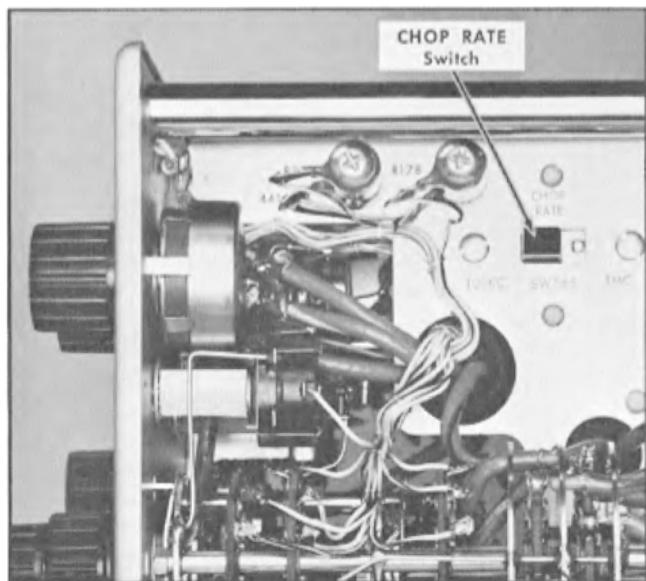


Fig. 2-1. Right side front portion view of the Type 82 showing the location of the CHOP RATE switch.

Operating Instructions—Type 82

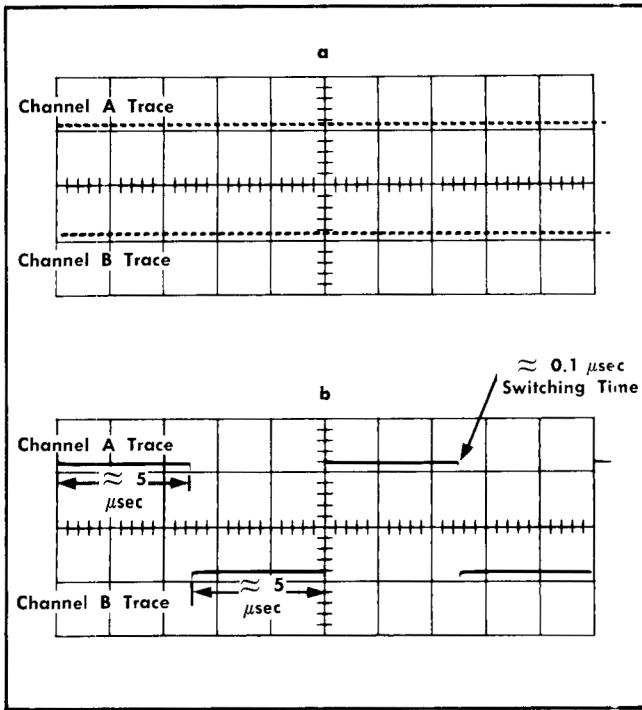


Fig. 2-2. 100-kc chopping-rate waveforms. (a) Oscilloscope sweep rate is 50 μ sec/cm, and (b) the sweep rate is 2 μ sec/cm.

5. Position the trace about one centimeter above the graticule centerline with the channel A VERTICAL POSITION control.
6. Place the MODE switch to B ONLY and position the trace about one centimeter below the graticule center with the channel B VERTICAL POSITION control.
7. Place the MODE switch to CHOP. Two traces will appear on the crt screen. Notice that the channel A VERTICAL POSITION control moves the upper trace and the channel B VERTICAL POSITION control moves the lower trace.
8. Increase the sweep rate to 50 μ sec/cm. Set the oscilloscope Stability control to Preset and adjust the Triggering Level control to obtain a stable display. Notice that each trace is composed of many short-duration bits or segments (see Fig. 2-2a). The free-running oscillator in the Type 82 switches the two channels at approximately a 100-kc rate so that each channel is "on" for about 5 μ sec and then is turned off while the other channel is "on" for an equal time. To see the switching action between channels as shown in Fig. 2-2b, increase the sweep rate to 2 μ sec/cm. Adjust the oscilloscope Stability and Triggering Level controls to obtain a stable display.
9. Now turn the MODE switch to the ALTER. position. Rotate the oscilloscope Stability control fully clockwise to free run the sweep. There are still two traces on the crt screen but the traces are no longer chopped into small bits. For each sweep cycle one channel is displayed and the other is turned off. The time-base generator in the oscilloscope switches the channels at the end of each sweep cycle, during the retrace interval. To see the alternate traces at a slower rate decrease the sweep rate to 0.1 sec/cm.

GENERAL OPERATION

Either of the two identical preamplifier channels can be used independently by setting the MODE switch to A ONLY or B ONLY and connecting the signal to be observed to the appropriate input. The following remarks apply to both channels.

The signal to be displayed is applied to the appropriate input connector on the front panel of the Type 82. For best results, here are some precautions you should observe when making the connections.

(1). It is often possible to make signal connections to the Type 82 with short-length unshielded test leads*. This is particularly true for high-level, low-frequency signals. When such leads are used, you must also use a ground connection between the Type 82 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 82 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 $1/4$ wavelength or some multiple within the bandwidth of the Type 82. Oscillations result from the fact that an external inductance of high Q, shunted by the input capacitance of the Type 82, is a resonant circuit. This circuit can be activated by the feedback through the interelectrode capacitance of the input tube. Since the Type 82/Type 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 82 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 V/CM switch positions. A third method is to con-

*For ease in connecting test leads to the unit, adapters such as a BNC-to-UHF connector adapter (plugs into BNC jack on the Type 82 and accepts a banana plug, Tektronix Part No. 103-032) or a single binding post fitted with a BNC Plug (Tektronix Part No. 103-033) are available. These items can be ordered through your Tektronix Field Office.

nect a resistor of about 100 to 1000 ohms in series with the lead where it connects to the input connector of the Type 82. 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 input to the Type 82, use some other setting of the V/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 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. 2-3. The curve was obtained using a signal source which was terminated into 50 ohms at the input of the Type 82. The termination which was used is a type that has BNC connectors on

each end (Tektronix part number 011-049). If a 50-ohm 10:1 T attenuator (Tektronix part number 010-314) 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 application where a step function with a risetime of 10 nanoseconds or less is applied to the Type 82, 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 V/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 3000. If the fast-rise step function of 10 nanoseconds or less is applied through a Type P6008 Probe to the input of the Type 82, the aberrations will still occur because the probe is capable of coupling the signal to the Type 82 with very little loss in risetime. If it is important to take full advantage of the faster risetime and transient response of the Type 82/Type 580-Series oscilloscope combination, use the lower positions of the V/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.

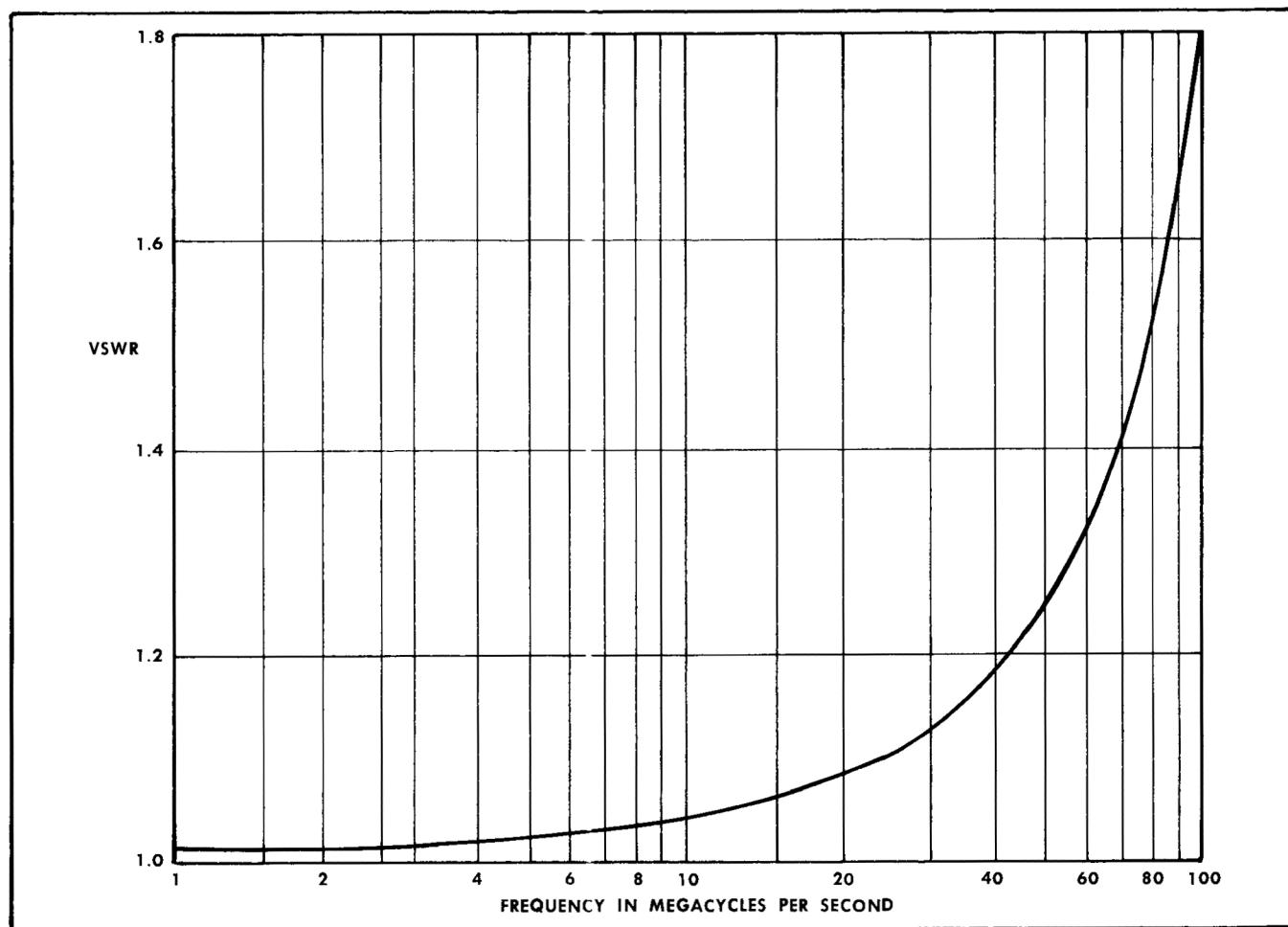


Fig. 2-3. Typical vswr versus frequency curve measured at the Type 82 input connector. The signal source was terminated into 50 ohms at the connector.

Operating Instructions—Type 82

(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 82. The input circuit can be represented by a resistance of 1 megohm ($\pm 1\%$) shunted by a capacitance of approximately 15 picofarads from dc to about 2 mc. (At frequencies above 2 mc, 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 82, 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 Probes, furnished with the Type 82, lessen both capacitive and resistive circuit loading and, at the same time, reduce sensitivity 10 times. The 10X attenuation introduced by each probe extends the calibrated vertical deflection factor of the Type 82 to 500 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 82. If the Type 82 AC-DC-GND 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 82. If the dc voltage rating of the probe is exceeded, the dc input voltage rating of the Type 82 will also be exceeded.

To assure the accuracy of 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.

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 kc. 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 at some frequency can be calculated more easily than the effect caused by capacitive loading. As a solution to the problem, use a P6034 or a P6035 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. 2-5. 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,

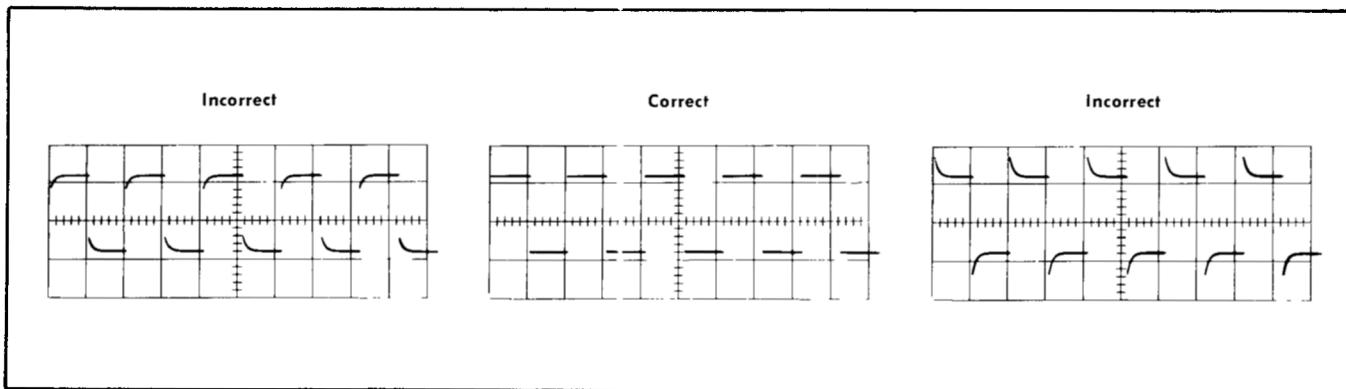
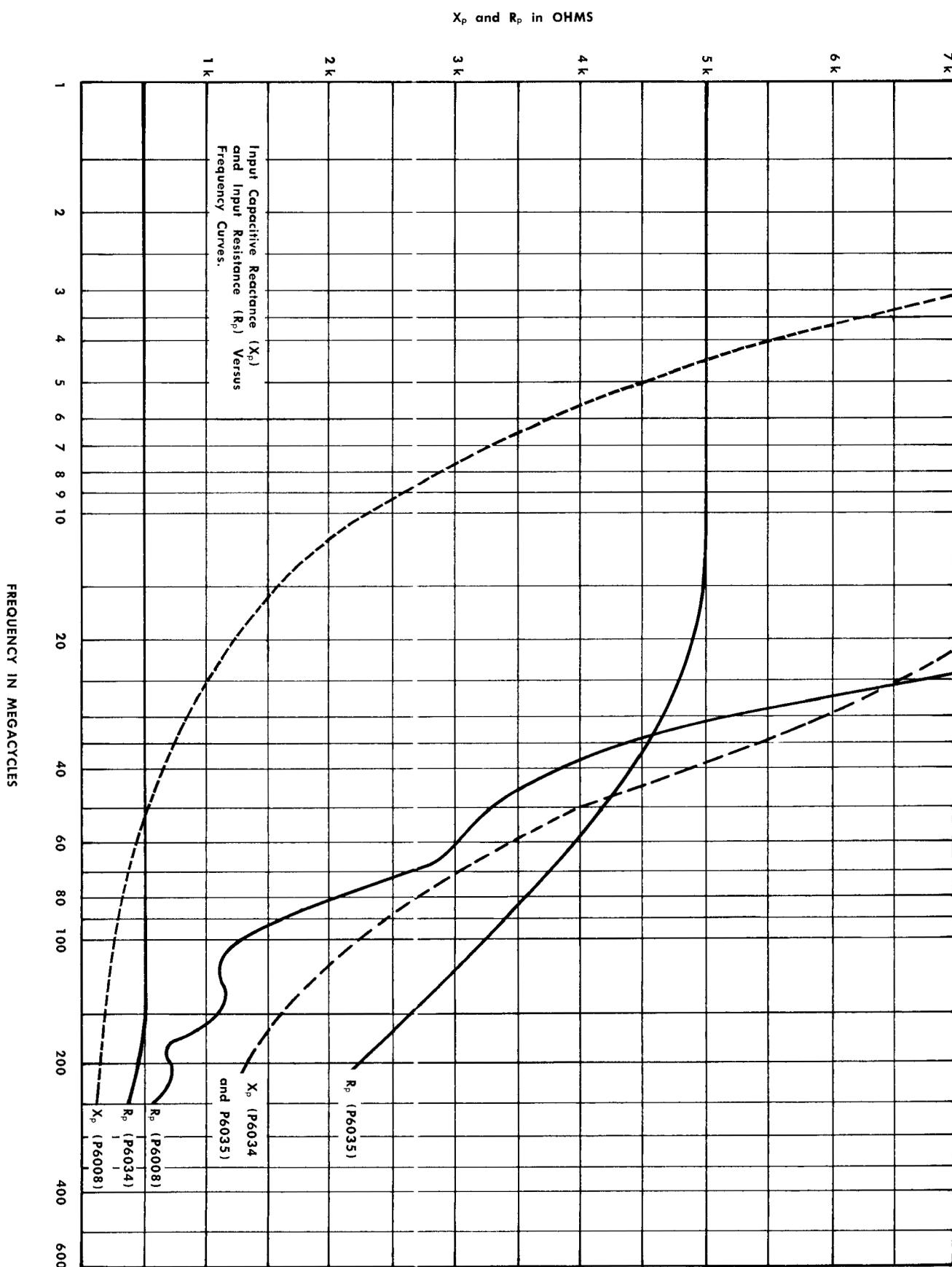


Fig. 2-4. The P6008 Probe is adjusted to obtain an undistorted presentation of the calibrator square wave.

Fig. 2-5. Typical X_p and R_p versus Frequency curves for the Types P6008, P6034 and P6035 probes.

Operating Instructions—Type 82

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 82.

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 frequency response. In addition, since 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 maximum) of a signal without affecting the response of the probe at the 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. 2-6). An external capacitor has to be used because the coupling capacitor in either channel of the Type 82 is not in series with the dc path through the probe resistor and these external resistances to ground.

At the low frequencies the approximate 3-db down point of the P6034 and P6035 probes, when connected to a 50-ohm source and when used in conjunction with the 874-k coupling capacitor, is 70 kc for the P6034 Probe and 7 kc 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 is too short to use for your application, you can extend its overall length by adding good quality 50-ohm cable such as RG-58A/U. To add the cable, simply connect a length of the cable, (fitted with GR Type 874 50-ohm connectors) between the coupling capacitor and the other series-connected 50-ohm components (see Fig. 2-6). Select a length of cable that will move the reflection on the waveform out of the area of interest (see Fig. 2-7).

The reflection, which appears as an 8% dip in the waveform, originates from the input circuit of the Type 82. It is

caused by the input capacitance of the Type 82 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 alternate method of controlling the reflection, a 50-ohm GR 2X T attenuator can be connected between the added cable and the termination (see Fig. 2-6.) The attenuator decreases the amplitude of the dip by a factor of four. The probe attenuation, however, will be increased by a factor of two. Although the probe attenuation factor is doubled, voltage rating of the probe is still the same. Therefore, avoid the tendency to apply larger signals to the probe to obtain a higher amplitude waveform on the crt. The excessive signal amplitude or dc voltage (if applied) may exceed the $\frac{1}{2}$ watt power rating of the probe resistor and damage it.

To avoid having too much bulk extending out from the front-panel connector of the Type 82 if all components are used as described, insert a short length of high quality 50-ohm extension cable between the 50-ohm GR 2X T attenuator and the GR-to-BNC adapter.

Input Coupling

To display both the ac and dc components of an applied signal, set the appropriate AC-DC-GND switch to DC; to display only the ac component of a signal, set the switch to AC. In the AC position of the switch, the dc component of the signal is blocked by a capacitor in the input circuit. The lower frequency limit at -3db for the system is about 15 cps when the INPUT switch is set to AC. Therefore, some low-

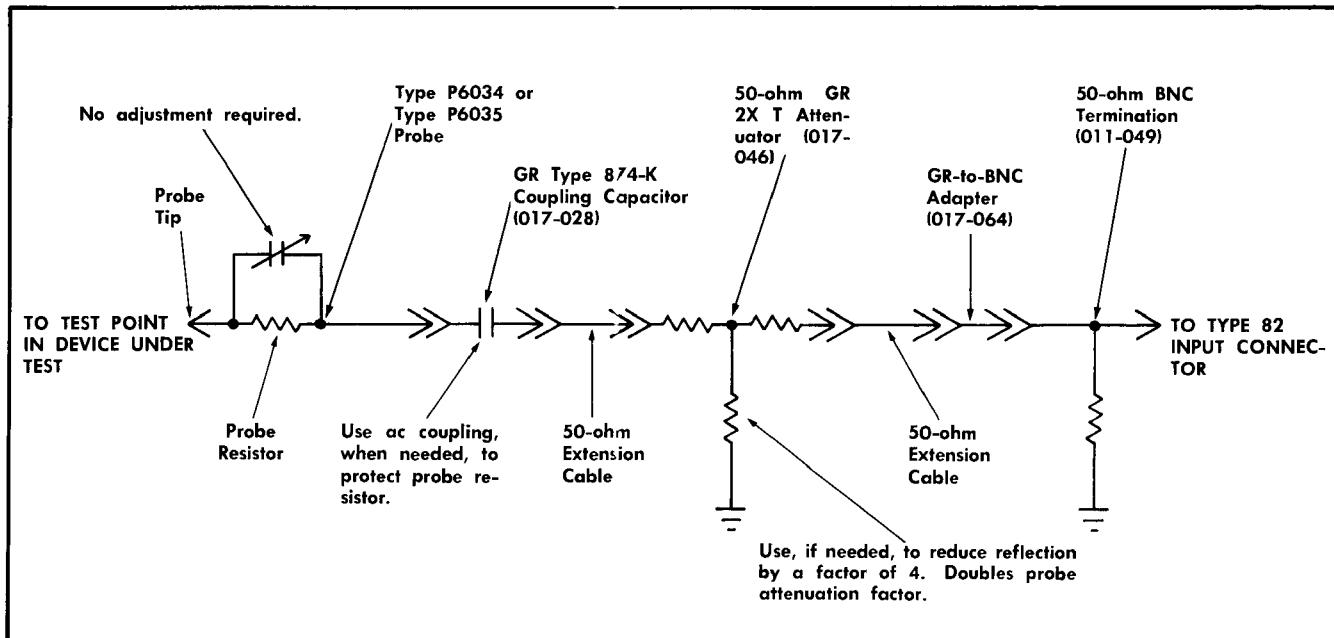


Fig. 2-6. Use of the Type P6034 or the Type P6035 Probe with the Type 82.

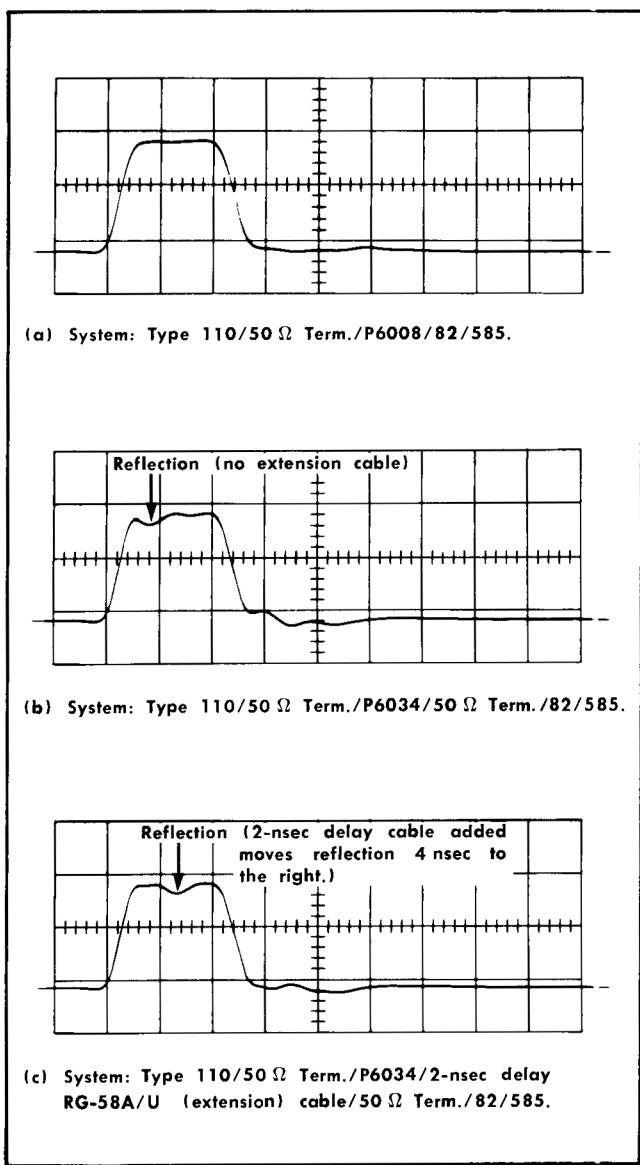


Fig. 2-7. Waveforms obtained when a pulse from the Type 110 is applied to each of the above series-connected systems. Applied pulse duration is 22 nsec and risetime is 0.25 nsec; Type 82/585 vertical deflection factor: 2 volts/cm, sweep rate: 10 nsec/cm.

frequency distortion of signals with components below this frequency can be expected when using the AC position. For example, low-frequency distortion can be seen when displaying the 1-kc calibrator waveform. By using the P6008 probe in conjunction with the Type 82, you can extend the low-frequency response to about .5 cps in the AC position.

Deflection Factor

The amount of vertical deflection produced by a signal is determined by the signal amplitude, the attenuation factor (if any) of the probe, setting of the V/CM switch, and the setting of the VARIABLE VOLTS/CM control. Calibrated deflection factors indicated by the settings of the V/CM switch

apply only when the VARIABLE VOLTS/CM control is set fully clockwise to the CAL. position. Errors in display measurements may result if the setting of this control is unintentionally moved away from its CAL. position.

The range of the VARIABLE VOLTS/CM control is approximately 2 to 1 to provide variable (uncalibrated) vertical-deflection factors between calibrated settings of the V/CM switch. Since the maximum attenuation ratio of the VARIABLE VOLTS/CM control is approximately 2 to 1, the control does not provide continuously variable (uncalibrated) vertical deflection factors between the 2-5 steps of the V/CM switch. For example, if the V/CM switch is set to .2 and the GAIN switch is set to X1, the range of the VARIABLE VOLTS/CM control will be from 0.2 to about 0.4 volt per centimeter. However, the control does provide nearly full coverage between the 1-2 steps of the V/CM switch. For example, if the V/CM switch is set to .1 and the GAIN switch is set to X1, 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 82 to a maximum of about 100 volts per centimeter when the GAIN switch is set to X1 and the V/CM switch is set to 50. If the GAIN switch is set to X10 and the V/CM switch is set to 5, the vertical deflection factor can be extended from 5 to a maximum of about 10 volts per centimeter by means of the VARIABLE VOLTS/CM control.

Output Polarity

At times you may want to invert the displayed waveform, particularly when using the dual-trace feature of the Type 82. The A POLARITY and B POLARITY switches have two positions. In the NORM. position the displayed waveform will have the same polarity as the input signal. In the INVERT. position the displayed waveform will be inverted; that is a positive-going pulse will be displayed as a negative-going pulse. In addition, the INVERT. position inverts the effect of the VERTICAL POSITION control.

Mode Switch

The MODE switch has four positions: A ONLY, ALTER., CHOP., and B ONLY. To display a single signal (single-trace operation) with the Type 82, apply the signal either to the A INPUT or the B INPUT connector and set the MODE switch to the corresponding position—A ONLY or B ONLY.

To display a single signal independently when the same signal or two different signals are applied to the input connectors, simply select the signal to be displayed by setting the MODE switch to the appropriate position. That is, A ONLY to display the channel A input signal; B ONLY to display the channel B input signal.

To display two signals simultaneously (dual-trace operation), connect a signal to each input connector and set the MODE switch to the ALTER. or CHOP. position. In general,

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use the CHOP. position (chopped-mode operation) with low sweep rates and the ALTER. position (alternate-mode operation) with the higher sweep rates.

Chopping rate, signal repetition rate and your preference are the main factors that determine the specific mode of dual-trace operation and sweep rate to use. For an operational guide concerning these factors, use the information that follows.

CHOP RATE Switch

When the MODE switch is set to the CHOP. position, the internal CHOP RATE switch permits you to select one of two chopping rates: 100 kc or 1 mc. The 1-mc rate is most useful for observing short-duration non-repetitive pulses with maximum resolution (the greatest number of segments that make up the traces). The 100-kc rate is most useful for observing long-duration non-repetitive pulses and low-repetition-rate signals with best trace clarity. Non-repetitive pulses or signals, as termed in this manual, refers to signals which are single-shot or randomly occurring.

Differences in trace clarity, when comparing the two chopping rates, are noticeable because the duty cycles for the two rates are different. At the 100-kc rate the display-time to switching-time ratio is greater than at the 1-mc rate, therefore the traces appear clearer. However, resolution at the slower chopping rate is 1/10 that of the higher rate. Therefore, in some cases you may prefer to use the 1-mc rate for greater resolution and in other cases you may prefer to use the 100-kc rate for greater trace clarity.

As a further comparison between the two chopping rates, the 1-mc rate has approximately a 20% loss of display time—0.1 μ sec switching time out of a trace display time of 0.5 μ sec; the 100-kc rate has approximately 2% loss of display time—0.1 μ sec switching time out of a display time of 5 μ sec.

(1) Displaying Non-Repetitive Signals

If you use the 100-kc chopping rate to display non-repetitive signals, good resolution can be obtained with sweep rates as high as 0.1 millisecond/cm. At a 0.1 millisecond/cm sweep rate, non-repetitive signals up to 1 millisecond duration will have good resolution, with about 100 segments or pieces making up a complete trace for each channel. If a lower (slower) sweep rate is used, more segments make up the traces and resolution increases. Conversely, resolution decreases if a higher sweep rate than 0.1 millisecond/cm is used. To display non-repetitive signals when using a higher sweep rate, use single-trace operation.

If you use the 1-mc chopping rate to display non-repetitive signals, good resolution can be obtained using sweep rates as fast as 10 μ sec/cm. This is 10 times higher than the fastest sweep-rate limit suggested for use with the 100-kc chopping rate. The 10- μ sec/cm sweep rate is probably the fastest sweep rate you will want to use with the 1-mc chopping rate and still get good resolution. This means that non-repetitive signals up to 0.1 millisecond duration will produce a useful display with about 100 segments making up each trace.

As described for the 100-kc rate, resolution increases if the sweep rate is decreased, and decreases if the sweep rate is increased. To obtain useful displays when observing

fast non-repetitive signals with the faster sweep rates, use single-trace operation.

(2) Displaying Repetitive Signals

When displaying repetitive signals, the most likely sweep-rate dividing point between the use of chopped-mode operation with the higher sweeps is 0.5 millisecond/cm. With this or a higher sweep rate, and when viewing repetitive signals 250 cps or higher, alternate mode of operation produces an uninterrupted display. That is, the alternate-mode switching cycle is sufficiently fast to produce an apparently steady display. If lower sweep rates are used for viewing signals 250 cps or lower, the alternate-mode switching cycle becomes more apparent and you may prefer to use 100- μ sec chopped-mode of operation to obtain steady, clear displays.

Dual-Trace Triggering

Dual-trace triggering is divided into this order; (1) External triggering using chopped or alternate modes of operation, (2) internal triggering using the chopped mode, and (3) internal triggering using the alternate mode.

(1) External Triggering Using Chopped or Alternate Modes

For dual-trace operation, it is usually best to trigger the time base with an external triggering signal which bears a fixed time relationship to the applied signals. With an external triggering signal a stable display is more easily obtained and the true time or phase relationship between input signals can be determined.

In low-frequency applications one of the signals applied directly to the Type 82 may normally be used as an external triggering signal by applying this same signal directly to the oscilloscope Trigger Input connector. Useful, stable displays can be obtained in this manner without excessively loading down the signal source. However, in high-frequency applications direct leads may result in loading down the signal source and cause erroneous display. It will then be necessary to use the P6008 Probe to apply the signal to the Type 82 and to employ minimum-loading methods of deriving the external trigger. As an example of a minimum-loading method, connect the cable end of another P6008 Probe to the Trigger Input connector and connect the probe tip to the signal source. As another example—if you are using a generator to drive a device under test and the generator has a trigger-output connector, use the trigger from the generator to externally trigger the oscilloscope.

(2) Internal Triggering Using Chopped Mode

During dual-trace chopped-mode operation when repetitive signals are applied to the Type 82, a stable display is difficult to obtain using internal triggering. The internal trigger is a composite signal consisting of the applied signals superimposed on, but not synchronized with, the chopping-rate signal. Since the composite trigger consists of unsynchronized signals, internal triggering may occur first on the applied signals and then on the chopping-rate signal, resulting in an unstable, jittery display.

A stable display can sometimes be obtained by carefully setting the oscilloscope Triggering Level control to a point

where best triggering on the applied signals is obtained, as evidenced by obtaining a display having the least jitter or instability. However, if you are unable to obtain a stable display, use external triggering.

(3) Internal Triggering Using Alternate Mode

If the time or phase relationship between signals is not related, use internal triggering during alternate-mode operation. Internal triggering is convenient since no external device is required for mixing the triggers.

In alternate mode of operation the signals applied to the Type 82 internally trigger the time base which, in turn, switches the channels at the end of each sweep cycle during retrace intervals. Therefore, it is important to set the oscilloscope triggering controls to a point where the time base can trigger on the signal applied to each channel. That is, the applied signals must be large enough to produce 2 millimeters or more of vertical deflection to fulfill the internal triggering signal requirements for the oscilloscope.

If one signal displayed has a smaller amplitude than the other, then the triggering controls must be set for reliable triggering on the smaller-amplitude signal or on the dc positioning levels in order to repeat the alternate-mode switching cycle automatically. The dc positioning levels produce a square-wave trigger which is part of the composite internal trigger. The square waveshape is formed each time the channels are switched during the retrace interval. The upper and lower levels of the square wave are determined by the difference in dc positioning levels of the displays as they are positioned apart vertically.

Since the square-wave amplitude is determined by the dc positioning levels, the VERTICAL POSITION controls will change the amplitude of the square wave as the controls are varied. If the displays are vertically positioned further apart the square-wave amplitude is larger than if the displays are moved closer together. Since ac coupling is used in the oscilloscope internal trigger circuitry, the amplitude of the square wave will be a governing factor in the recovery time of the trigger circuits.

In general, trigger recovery time is faster, and stable triggering on repetitive signals is easier to obtain if the displays are positioned closer together. If trigger recovery time decreases, the sweep repetition rate increases, and you will get a brighter display. The INT AC LF REJ position of the TRIGGERING SOURCE switch on the Type 580A-series oscilloscopes has an inherently faster recovery time.

When applying a signal to one channel only during alternate mode of operation, stable internal triggering is possible as long as there is a difference in dc positioning levels. A careful setting of the Triggering Level Control is required and the Trigger Slope switch should be set to a position that results in best triggering. If the trace at the no-signal channel is superimposed on the applied signal display of the other channel, unstable or no triggering will result because of insufficient trigger signal amplitude.

APPLICATIONS

In general, applications such as those described in the Type 581 or 585 Instruction Manual, Section 3, also apply when using the Type 82 Dual-Trace Plug-in Unit. Since the

Type 82 has more than one calibrated sensitivity, substitute the V/CM Switch Setting for 0.1 Volts/Cm in the appropriate formulae given in the Applications section of the Type 581 or 585 manual. In addition, since the P6008 Probe has a fixed attenuation factor of 10, substitute 10 for the 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:

$$(10) (V/CM \text{ Switch Setting}) (\text{Vertical Deflection}) = \text{Volts, peak-to-peak}$$

In making time and phase measurements the dual-trace feature enables both waveforms to be displayed together. Thus, measurements and comparisons between two waveforms can be made accurately. The basic time and phase applications shown in the Type 581, 585, 581A, 585A, or RM585A Instruction Manual can be easily adapted to dual-trace operation.

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 X1 gain of the Type 82 should be checked periodically to assure correct vertical deflection factors, particularly when the Type 82 is used for the first time or when the unit is transferred from one oscilloscope to another. To check or set the gain, a suggested procedure using channel A is as follows:

1. Set the Type 82 front-panel controls for channel A to these settings:

AC-DC-GND	DC
V/CM	.1
VARIABLE VOLTS/CM	CAL.
A POLARITY	NORM.
VERTICAL POSITION	Centered
GAIN	X1
MODE	A ONLY

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

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

4. Set the X1 GAIN ADJ. for a deflection of exactly two centimeters. Use the VERTICAL POSITION control to align the display with the center two horizontal graticule lines.

Channel A X1 POSITION RANGE and X10 POSITION RANGE Adjustments

The following procedure describes a method for adjusting the channel A X1 POSITION RANGE control to properly position the trace to the Type 82 distributed-amplifier electrical center (or dc-balance point) under no-signal conditions. When adjusted properly, trace shift is minimized as the

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VARIABLE VOLTS/CM control is rotated or if the A POLARITY/B POLARITY switches are operated at this trace position. When both the channel A X1 and X10 POSITION RANGE adjustments are correctly adjusted, a balanced positioning range above and below the graticule center is maintained. To make the adjustments, proceed as follows:

1. Set the front-panel controls the same as outlined in steps 1 and 2 in the X1 GAIN Adjustments procedure except that the A 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 any signal to the Type 82.
2. As a preliminary setting, adjust the channel A X1 POSITION RANGE control to the point where there is no trace shift on the screen as the channel A VARIABLE VOLTS/CM control is rotated.
3. For the final setting, place the GAIN switch to the X10 position and readjust the A X1 POSITION RANGE control for minimum trace shift as the channel A VARIABLE VOLTS/CM control is rotated.

NOTE

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

4. Adjust the channel A X10 POSITION RANGE control to position the trace to the graticule X-axis centerline.

IMPORTANT

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

Channel B X1 POSITION RANGE and X10 POSITION RANGE Adjustments

The purpose of these adjustments is the same as those for Channel A.

1. To make the adjustments set the Type 82 front-panel controls for channel B to these settings.

AC-DC-GND	DC
V/CM	.1
VARIABLE VOLTS/CM	CAL.
B POLARITY	NORM.
VERTICAL POSITION	0°
GAIN	X1
MODE	B ONLY

2. Set the oscilloscope sweep rate and triggering controls for a 0.1-millisecond/cm free-running sweep.
3. As a preliminary setting, adjust the channel B X1 POSITION RANGE control to the point where there is no trace shift on the screen as the channel B VARIABLE VOLTS/CM control is rotated.
4. For a final setting, set the GAIN switch to the X10 position and readjust the B X1 POSITION RANGE control for minimum trace shift as the channel B VARIABLE VOLTS/CM control is rotated.

NOTE

In step 4 of this procedure, leave the B VERTICAL POSITION control at 0° and use the channel B X10 POSITION RANGE control to keep the trace on the crt while adjusting the channel B X1 POSITION control.

5. Adjust the channel B X10 POSITION RANGE control to position the trace to the graticule centerline.

IMPORTANT

After adjusting the channel B X1 POSITION RANGE and X10 POSITION RANGE controls properly, trace shift is minimum and dc balance is correct while the channel B VERTICAL POSITION control remains at 0°. If the VERTICAL POSITION control is moved away from 0°, as it will be during normal operation, greater trace shift due to dc imbalance will occur when operating the channel B VARIABLE VOLTS/CM control and/or B POLARITY switch.

SECTION 3

CIRCUIT DESCRIPTION

AMPLIFIERS

Introduction

The Type 82 consists of two similar input amplifiers, two identical X10 amplifiers, and a common output amplifier. Since the input and X10 amplifiers are virtually identical, the following description of channel A applies equally well to the other channel. Any circuit differences between the two channels are pointed out in the description. 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 Input Cathode Follower V133 by way of the AC-DC-GND switch SW101 and the V/CM switch SW111. In the DC position of the AC-DC-GND switch, input coupling capacitor C101 is bypassed so 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 15 cps at -3db. The GND position grounds the Input Attenuator, but not the Input connector.

Input Attenuation

The V/CM switch is a 9-position rotary switch that selects the various attenuator sections. The basic deflection factor of the Type 82 is 0.1 volt/cm.

When the V/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 V/CM switch, the attenuation networks are individually switched into the circuit so that the input voltage at 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 X1.

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:

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

Using the X50 attenuator as a specific example (see Fig. 3-1), the formula is:

$$\frac{\text{Attenuation}}{\text{Factor}} =$$

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

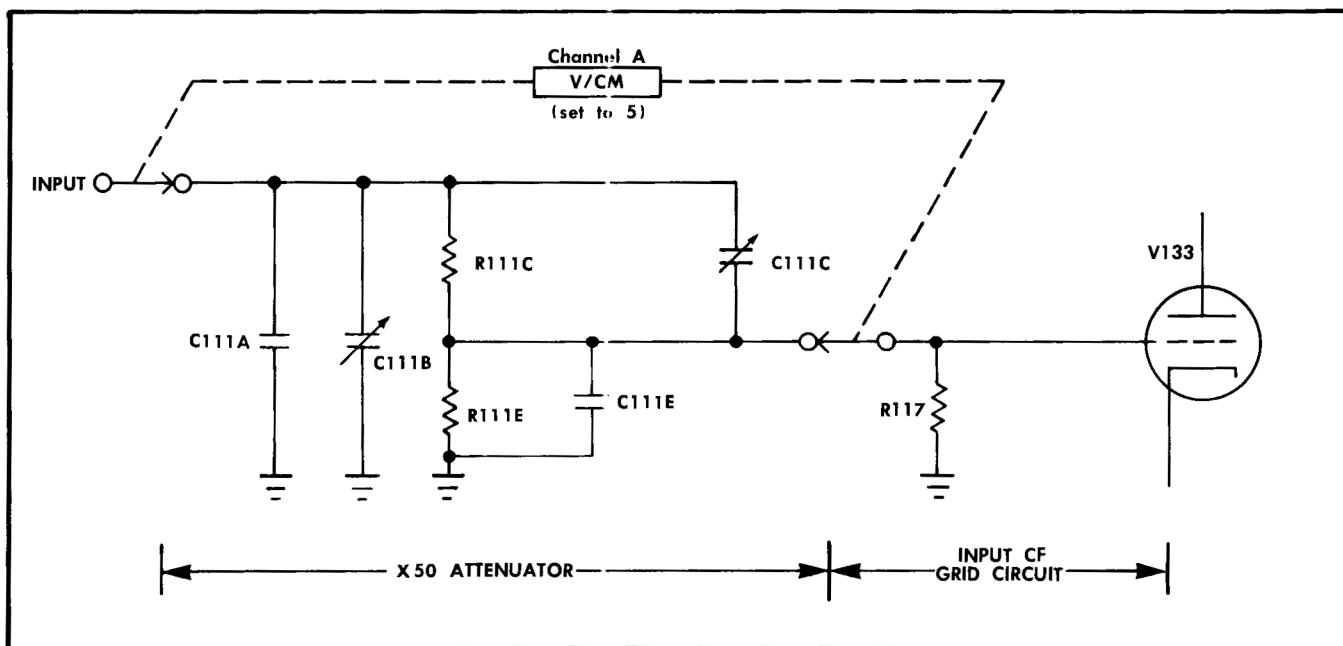


Fig. 3-1. Simplified circuit diagram showing the most important components involved when calculating the X50 attenuation factor.

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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 C111 in the X50 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 X50 attenuator (see Fig. 3-1) provides a means of adjusting the input capacitance of the attenuator to a "standard" value of about 15 picofards by using a 15-pf Input Time Constant Standardizer. A similar method is provided to standardize the input capacitance when the V/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 V/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 V/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 k. 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 R137 and R237, the cathode resistor is Zenered at -25 volts by D236. This diode provides a means of obtaining the desired operating potential from the -150-volt power supply.

Channel A GRID CURRENT ZERO adjustment R121 applies a 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.

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.

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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 base of the Input Amplifier stage Q164. 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 emitter impedance. SN101-2999 Channel B emitter impedance is variable by means of GAIN BAL. control R277 to permit setting the gain of channel B to equal the gain of channel A. SN 3000-up Channel A emitter impedance is variable by means of the GAIN BAL Control R177 to permit setting the gain of Channel A to equal the gain of Channel B.

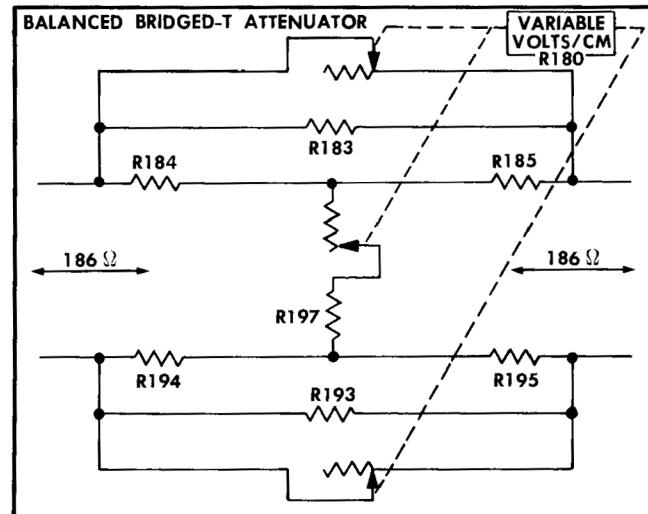


Fig. 3-2. VARIABLE VOLTS/CM Control R180 shown in the CAL. (calibrated) position.

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) connected 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, attenuation is limited to about 2.

Polarity Switch

The channel A POLARITY switch SW199 is a nominal 93-ohm impedance switch which is concentric with the channel B section. Connections to the switch are made through 93-ohm coax to maintain the 186-ohm balanced line existing between the Input Amplifier stage and the interconnecting plug. When the switch is set to the NORM. position, the push-pull signal passes directly to the following stage. When the switch is set to the INVERT. position, the switch reverses the signal-cable paths to the following push-pull stage.

Positioning Emitter Follower

The Positioning EF (Emitter Follower) Q153 provides low-impedance positioning drive to Q174 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 X1 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 X10 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 for both channels simultaneously. When the GAIN switch is set to the X1 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 X10 position, the path for each channel is through the X10 Amplifier to the Output Amplifier. Signal-delay or propagation time is 4.5 nanoseconds greater for the X10 gain path than for X1 gain path, but this delay does not affect the time relationship

between channels since one channel always has the same signal delay as the other channel.

X10 Amplifier

The X10 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 X10 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 provide the means for obtaining optimum transient response through the amplifier. In the first stage (Q314 and Q324) emitter circuit, two networks correct for time constants arising within the X10 Amplifier. The first network consists of R318 and adjustable capacitor C318. The second network consists of adjustable capacitor C328 and fixed resistor R328.

In the first stage the X10 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 X10, the VERTICAL POSITION control is centered, and the X1 POSITION RANGE control is properly adjusted.

The channel A X10 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 X10 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

R381 is a fixed resistor whose value is selected to obtain optimum square-wave response from the transistors used in the X10 Amplifier. When the proper value is chosen, low-frequency aberrations are minimized. To provide for additional compensation for variations in transistor characteristics, network C377/R377 was added in Plug-in units S/N 380-up and R392 was added in Plug-in units S/N 3610-up. C377 and R392 are adjustable to vary the time constant of the networks to obtain optimum square-wave response.

Diode Gate

A diode matrix, consisting of diodes D501, D502, D503 and D504, forms the diode gate. The gate when turned "on" by the Switching Multivibrator Q565 and Q575, the push-pull signal passes to the grid line of the distributed Output Amplifier. The drive point for the channel A diode gate is the collector of Q575 and the drive for channel B gate is the collector of Q565.

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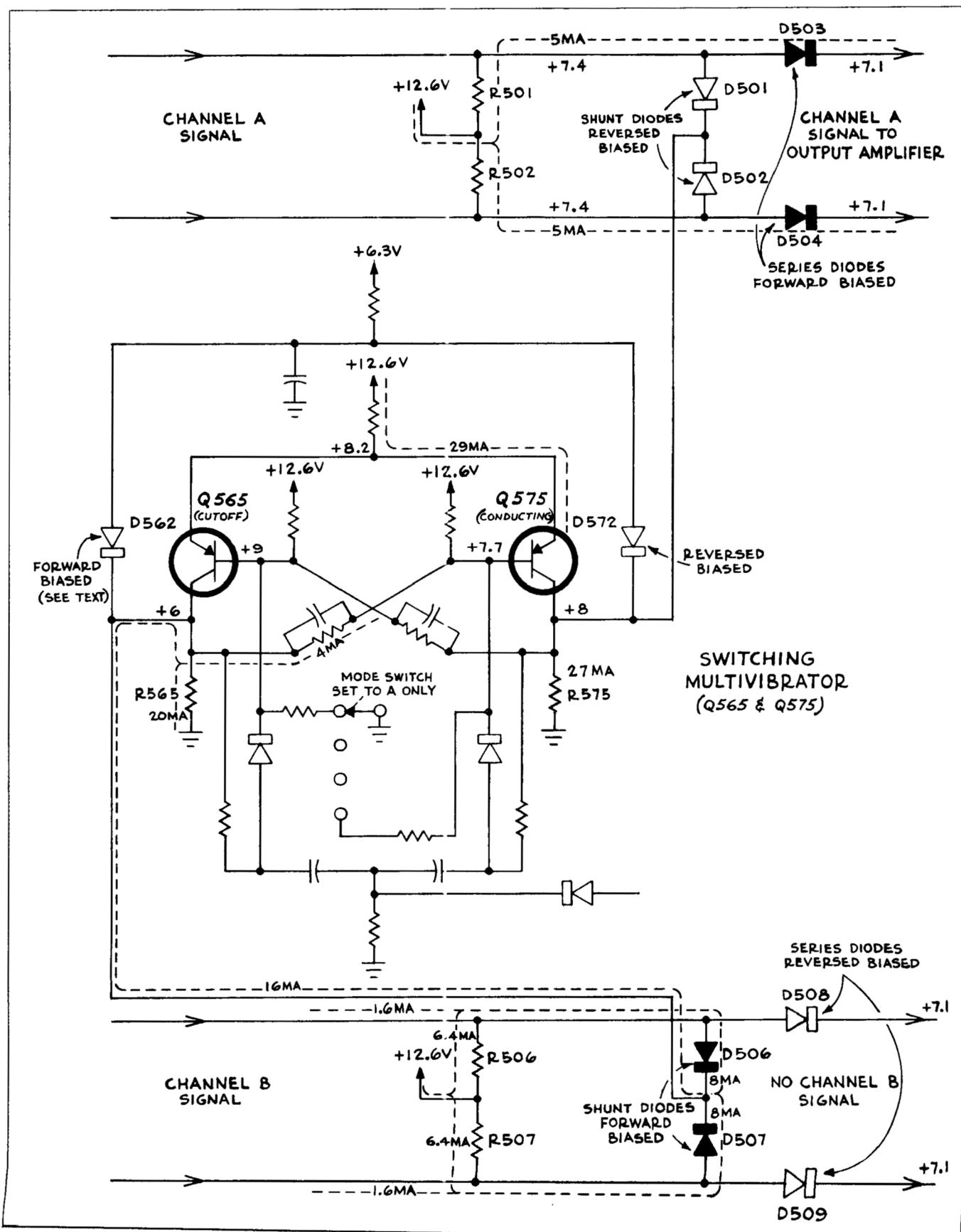


Fig. 3-3. Simplified diagram of the Switching Multivibrator and Diode Gates. Diode-Gate currents and voltages are shown for the A ONLY position of the MODE switch.

When the MODE switch is placed to the A ONLY position, the collector of Q575 is at +8 volts and collector of Q565 is at +6 volts (see Fig. 3-3). The +8 volts reverse biases shunt diodes D501 and D502 in the channel A gate. Series diodes D503 and D504 are then forward biased and they feed the channel A signal to the Output Amplifier. The current for diodes D503 and D504 is 10 ma through R516. The current then divides equally—5 ma flows through each of the grid lines in the Output Amplifier, through the series diodes and through R501 and R502.

The current through the channel B Diode Gate is 20 ma through R565, 16 ma through shunt diodes D506 and D507, and 12.8 ma through R506 and R507. Fig. 3-3 shows how the current paths divide through the channel B diodes. "Clamp-diode" D562 conducts if the collector of Q565 drops below 6 volts and during the time interval that the multivibrator switches to the A ONLY state. Divider R564 and R573 sets the base level of Q575.

When the MODE switch is set to B ONLY, the Switching Multivibrator reverses states and flips the +8-volt point to +6 volts and the +6-volt point to +8 volts. The Switching Multivibrator drives through the channel A shunt diodes against the line impedance to provide enough diode reverse current for rapid turn-off of diodes D503 and D504. Simultaneously, the Switching Multivibrator reverse biases the channel B shunt diodes and the signal passes through series diodes D508 and D509 to the Output Amplifier.

During dual-trace operation when the Mode switch is set to either the ALTER. or CHOP position, the total transition time in switching from one channel to the other is about 100 nanoseconds. The keep-alive current for the channel A Diode Gate is supplied by resistors R501 and R502.

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 Type 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 at +7 volts and +50 volts respectively.

The cathodes all return to ground through the X1 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 D554 regulates the plate line voltage against any current changes resulting from adjusting the X1 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. The junction of this termination is connected to ground through R516 which is also the current path for the diode gate current. Capacitor C516 is the ac ground for the R513/R514 termination.

SN 3000-Up

Two time-constant networks are incorporated at the input to the grid line of the Output Amplifier. One network is C510, R510, C511 and R511; the other is R512 and C512. These networks aid in offsetting any time constants remaining in the Type 82 circuitry.

SN 101-2999

Two time-constant networks are incorporated at the input to the grid line of the Output Amplifier. One network is C510 and R510; the other is R511 and C511. These networks aid in offsetting any time constants remaining in the Type 82 circuitry.

All the coaxial systems used in the Type 82 are doubly terminated to minimize reflection.

SWITCHING CIRCUIT

Selection of the input channel whose output is to be applied to the Output Amplifier is accomplished by means of the Switching Circuit.

The Switching Circuit consists of the following three stages in the order described: Switching Multivibrator, Q565 and Q575; Blocking Oscillator, Q590; B. O. (Blocking Oscillator) Bias EF, Q583. These stages operate in any of four modes as determined by the setting of MODE switch SW590. These modes are A ONLY, ALTER., CHOP., and B ONLY. Since A ONLY and B ONLY modes of operation are basically the same, they are described together.

Switching Multivibrator

The Switching Multivibrator Q565 and Q575 is a bistable circuit that switches channels A and B in the Type 82. When Q575 conducts, the channel A signal or trace is displayed. When Q565 conducts, the channel B signal or trace is displayed. The setting of the MODE switch determines whether the Switching Multivibrator rests in one of its stable states or is base triggered by the Blocking Oscillator.

(1) **A Only, B Only.** Assume that the MODE switch is set to A ONLY. In this position the switch end of R567 connects to ground and becomes part of a divider circuit with R563, R574 and R575. This divider reverse biases Q565 so that Q565 cuts off. As Q565 cuts off, D562 is forward biased, Q575 conducts, and D572 is reverse biased. "Clamp-diode" D562 keeps the collector of Q565 from falling lower than +6 volts. The collector of Q565, tied to divider resistors R564 and R573, sets the bias of Q575 so the collector of Q575 rests at +8 volts. The +8 volts reverse biases the Channel A gate diodes D501 and D502 (as shown in Fig. 3-3).

Series diodes D503 and D504 in the Channel A Diode Gate are then forward biased and they permit the Channel A signal to pass through them to the grid line of the Output Amplifier. The +6 volts at the collector of Q565 forward biases D506 and D507 in the Channel B Diode Gate. Series diodes D508 and D509 in the Channel B Diode Gate become reverse biased and block the Channel B signals from getting to the grid line of the Output Amplifier.

Circuit Description—Type 82

When the MODE switch is set to the B ONLY position, just the opposite occurs. The switch end of R567 is disconnected and the switch end of R577 is grounded to complete the divider circuit that reverse biases Q575 and turns on Q565. As Q565 conducts, diodes D508 and D509 are then forward biased and they pass the Channel B signal to the grid line of the Output Amplifier. The Channel A Diode Gate blocks the Channel A signals from reaching the grid line.

(2) Alternate Mode. When the MODE switch is placed to the ALTER. position, the crt displays the signal in one channel for one sweep of the beam, and the signal in the other channel for the next sweep of the beam. In this mode of operation, the Blocking Oscillator triggers the Switching Multivibrator into each state at the end of each sweep, during retrace intervals. The action is accomplished in the following manner:

At the end of each sweep of the time base, a positive and negative sharply-differentiated synchronizing pulse is applied through pin 7 of the interconnecting plug to diode D585. The diode conducts during the positive-going portion of the pulse and is reverse biased during the negative-going portion. The positive-going portion is inverted by T580 and applied to Q583. From the emitter of Q583 the pulse is applied to the base of Q590. Blocking Oscillator Q590, operating in a triggered mode, inverts and reshapes the pulse. The pulse at the collector of Q590 is positive going and is applied through diode D579 to network R579 and C579, and to capacitors C566 and C576. The network stretches the pulse, giving the Switching Multivibrator time to switch completely into its other stable state.

The trigger pulse is coupled through capacitors C566 and C576 to diodes D566 and D576. One diode conducts and applies the pulse to the base of Q565 or Q575. If we assume that Q575 is conducting and Q565 is cut off, a positive pulse will not reach the base of Q565. However, D576 conducts and the positive pulse is applied to the base of Q575, driving this transistor into cut off and causing the Switching Multivibrator to change states.

(3) Chopped Mode In the CHOP. position of the MODE switch, the Blocking Oscillator free runs at 200 kc or 2 mc, depending on the setting of the CHOP RATE switch SW585. The free-running Blocking Oscillator supplies the trigger pulses to the Switching Multivibrator to make it switch states in the same manner as described for alternate mode of operation. Thus, in chopped-mode operation the multivibrator switches states at a 200-kc or 2-mc rate, but the chopping rate per channel will be one-half the multivibrator rate.

Blocking Oscillator

During A Only or B Only mode, the Blocking Oscillator stage is inoperative. During alternate mode, this stage is triggered and supplies regenerated trigger pulses to the Switching Multivibrator at the end of each sweep cycle. During chopped mode, the Blocking Oscillator free runs at either a 200-kc or 2-mc rate, depending on the setting of the CHOP RATE switch SW585. In addition to supplying trigger pulses to the Switching Multivibrator in chopped mode, the Blocking Oscillator supplies chopped-mode blanking pulses through pin 8 of the interconnecting plug to the oscilloscope.

(1) A Only, B Only. When the MODE switch is placed to the A ONLY or B ONLY position, the switch end of R599 is connected to -150 volts. The opposite end of R599 connects to diode D585 and to the 50-ohm coax. The coax goes to pin 7 of the interconnecting plug, through a 1-k resistor in the oscilloscope time-base generator, and then to ground. This network forms a divider which reverse biases D585 and prevents the alternate-trace sync pulse from driving transistor Q583. Transistor Q583 emitter voltage sets the base-emitter bias of Q590. In A ONLY or B ONLY mode of operation Q583 biases Q590 into cut off so that the Blocking Oscillator stage is inactive and will not free run. Thus, no triggers are generated or supplied to the Switching Multivibrator stage.

(2) Alternate Mode When the MODE switch is set to the ALTER. position, the switch end of R599 is open. This permits the differentiated alternate-trace sync pulse, arriving at pin 7 of the interconnecting plug, to be applied to D585. In this mode of operation D585 is slightly reverse biased and conducts only during the positive-going portion of the sync pulse.

The positive-going pulse is inverted and stepped up by T580. The base winding of T580 applies the pulse to Q583. The negative pulse, produced at the emitter of Q583, is applied to the base of Q590. In this (alternate) mode of operation the emitter of Q583 sets Q590 almost into conduction so the Blocking Oscillator operates in a triggered mode.

With the negative pulse applied to the base of Q590, transistor Q590 is driven into saturation due to the blocking oscillator action of the stage. A positive-going pulse is generated at the collector of Q590 to drive the Switching Multivibrator stage through diode D579.

The blocking oscillator action occurs in the following manner. As Q590 conducts when the pulse is applied to its base, current flows in the collector winding of T590. The current produces a varying magnetic flux that induces a voltage of opposite (negative) polarity at the base of Q590. The negative induced voltage supplies the regenerative feedback to drive Q590 into saturation. As Q590 saturates, collector current momentarily becomes constant, no feedback voltage is induced and T590 field collapses. Then, the base-emitter bias takes over until the next sync pulse triggers the Blocking Oscillator to repeat the cycle.

The collapsing field during Q590 turn off results in a collector voltage back-swing which is limited in amplitude by diode D590. When D590 conducts during the backswing interval, the energy in T590 is dissipated in R590. Thus D590 and R590 prevent voltage breakdown of Q590 by limiting the potential reached between collector and emitter. The pulse produced by the Blocking Oscillator has a short duration—about 100 nanoseconds.

The decoupling network in the emitter circuit of Q590 consists of C596, R596 and C597. This network is a filter which keeps the Blocking Oscillator pulses from getting into the +12.6-volt supply.

The dots above the individual T580 and T590 windings, as shown on the schematic diagram, are phasing dots. They show that there is no phase reversal if pulse polarities are compared at the dot end of the windings. However, there is a phase reversal when comparing the signal at the dot end of one winding with the signal at the no-dot end of the adjacent winding. For example, the signal voltage at the dot end of the T590 winding that connects to the collector of

Q590 is positive going while the induced voltage at the no-dot end of the T590 winding connected to the base of Q590 is negative going.

(3) Chopped Mode When the MODE switch is set to the CHOP. position, the switch end of R599 connects to -150 volts and D585 reverse biases. Diode D585 blocks the alternate-trace sync pulses from driving the base of Q583 during this mode of operation. The emitter level of Q583 is proper to forward bias Q590. As Q590 conducts, the current produces a varying magnetic flux that induces a negative voltage at the base of Q590 for regenerative feedback. The negative voltage is positive at the dot end of Q590 base winding of T590. The positive voltage causes D586 to conduct and quickly charge C580.

The blocking oscillator action for the remainder of the cycle is similar to triggered operation (alternate mode) except that Q590 goes into conduction after its base level decays to a point that will allow Q590 to be forward biased again. The decay time and hence the repetition rate is mostly determined by the RC time constant of C580, R584 and R585 when the CHOP RATE switch is set to 100 kc; at a setting of 1 MC the repetition rate is mostly determined by the RC time constant of C580 and R584. Capacitor C593 in the emitter circuit of Q590 provides for fast turn on of the Blocking Oscillator and also helps to determine pulse length.

The chopped-mode blanking pulse is derived from the third winding of T590. The MODE switch grounds one end of the winding through R591 and the pulse is taken from the other end. The pulse is then fed through the 93-ohm coax, through pin 8 of the interconnecting plug, and out of the Type 82 into the oscilloscope.

B. O. Bias EF Q583

Transistor Q583 and its associated circuitry controls the operating modes of the Blocking Oscillator.

(1) A Only, B Only. The base-emitter bias for Q583 is determined by the divider consisting of R580 and R581. When the MODE switch is set to the A ONLY or B ONLY position, the R580-R581 divider connects between the +100-volt and +12.6-volt supplies. The divider forward biases D581, thus applying the divider voltage to the base of Q583.

As Q583 conducts, the emitter follower action of Q583 applies about +15 volts to the base of Q590. The result is that the base-emitter junction of Q590 is reverse biased to the point where Q590 cannot conduct and the Blocking Oscillator does not generate any triggers.

(2) Alternate Mode When the MODE switch is set to the ALTER. position, the switch end of the R580-R581 divider connects to the +51-volt supply. When the ALT. SYNC. SENS. control R581 is properly adjusted, the divider continues to forward bias D581 but causes transistor Q583 to conduct slightly less current than it did for single-trace (A Only, B Only) mode of operation.

With a correct setting of R581, Q583 emitter level sets the base level of Q590 so that the base-emitter junction of Q590 is biased almost into conduction. Under these conditions Q590 operates in a triggered mode for the alternate trace sync pulse.

As explained earlier, the alternate trace sync pulses are applied to the base of Q583 by means of T580. The pulses are negative going at the emitter of Q583 and they are applied to the base of Q590 to trigger the Blocking Oscillator.

The ALT. SYNC. SENS. control R581 is adjusted to obtain reliable alternate-mode of operation when the CHOP RATE switch is set to either 1 MC or 100 kc. R581 has enough range to make the Blocking Oscillator inoperative at the counterclockwise end of the control's rotation or to make the Blocking Oscillator free run at the clockwise end. Proper setting of the control is near midrange between the two extremes.

(3) Chopped Mode—100 kc When the MODE switch is set to CHOP., the switch end of R580 connects to ground. With the CHOP RATE switch set to 100 kc, the switch end of R582 is grounded and D581 reverse biases. Q583 emitter level forward biases the Q590 base-emitter junction, causing the Blocking Oscillator to free run at a 200-kc rate.

As mentioned earlier, diode D586 couples the induced voltage in the Q590-base winding of T590 to C580 so that C580 charges. C580 discharges through R584 and R585 to determine the time between pulses. Diode D580 limits the backswing of pulse in the windings of T580.

(4) Chopped Mode—1 mc When the CHOP RATE switch is set to 1 MC, the switch end of R582 is disconnected from ground and R584-R585 divider is grounded at its junction. Diode D581 remains reverse biased, which is the same condition as for 100-kc chopped-mode operation. Other operating conditions are the same for the B.O. Bias E.F. stage except that the 2-mc free-running rate of the Blocking Oscillator is determined by the C580 discharge rate through R584 only.

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 repair, or needs recalibration. Visual defects may include loose or broken connections, frayed coax-shield 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 82 is a stable plug-in unit that will provide many hours of trouble-free operation. However, to insure the reliability of measurements, check the 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 procedure for calibrating the unit and checking its operation is given in the Calibration section of this manual.

COMPONENT REPLACEMENT

General Information

Useful information concerning the replacement of important parts in the Type 82 is given in this portion of the manual. Because of the nature of the unit, replacement of certain parts such as the V/CM switches, variable capacitors, nuvistors, transistors or tubes, will require that you recalibrate the unit to insure proper operation. Refer to the Calibration section of this manual for the complete procedure.

Switches

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

If any of the rotary switches (excluding the AC-DC-GND switch) are defective, single wafers on these switches are not normally replaced. If a wafer is defective, the entire switch should be replaced. The V/CM and GAIN MODE switches may be ordered from the factory either unwired or wired, as desired. Refer to the 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:

1. Unsolder the output of the attenuator from the grid at the junction of C126, R126 and R117. Unsolder connections to AC-DC-GND switch.
2. Use a thin 1" open end wrench to loosen and remove the nut from the AC-DC-GND switch.
3. Loosen the $\frac{1}{16}$ " hex set screw in the VOLTS/CM knob and remove the knob.
4. Remove the $\frac{1}{2}$ " nut from the shaft on the front panel that holds the attenuator unit casting.
5. Remove screws holding the back of the etched circuit board in place
6. Fold the complete unit back on the etched circuit board leads.
7. Unsolder and unscrew the etched circuit board from the attenuator chassis at the front of the unit. Do not overheat and damage etched circuit board.
8. Remove the attenuator unit by removing the gear on the shaft of the attenuator. Leave the etched circuit board in Type 82 chassis.
9. 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 Etched 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 etched circuit board.
- c. Remove the etched circuit board.

Maintenance—Type 82

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

(3) Removing the GAIN-MODE switch.

The GAIN-MODE switch combination can be removed by disconnecting its coax leads where they connect on the A POLARITY-B POLARITY-NORM.-INV. switch and other terminals. (Use a replacement wired switch as a guide if one is available.) Then remove the GAIN and MODE switch knobs. Loosen and remove the nut which holds the switch combination to the front panel. Remove the 6-32 x $\frac{5}{16}$ BHS screw which holds the rear switch bracket. Remove the switch.

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 terminal strip with a soldering iron. Occasional use of ordinary tin-lead solder will not break the bond if excessive heat is not applied.

If you frequently perform work on Tektronix instruments, it is advisable that you have a stock of solder containing about 3% silver. This type of solder is used quite 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 part number 251-514.

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 solder in the terminals and reduces the amount of heat required. It is important to use as little heat as possible while producing a full-flow joint. Fig. 4-1 shows the correct shape for the tip of the soldering iron. Be sure to file smooth the surfaces of the tip before tinning. This prevents solder from building up on rough spots where it will quickly oxidize.

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. Prepare the tip of the iron as shown in Fig. 4-1. Tin only the wedge portion of the tip with solder containing 3% silver.
3. Apply one corner of the soldering iron tip to the notch where you intend to unsolder the lead (see Fig. 4-2).

NOTE

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

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

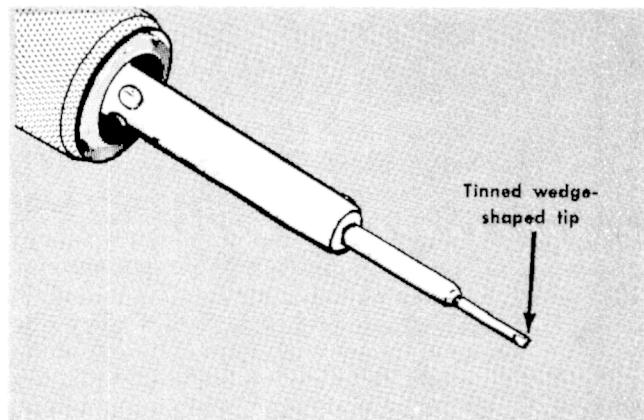


Fig. 4-1. Soldering iron tip properly shaped and tinned.

6. 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 as shown in Fig. 4-3.

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 $\frac{1}{8}$ " so that it will go through small spaces between wiring. Prepare the soldering iron as outlined previously and apply the iron to the part to be soldered as shown in Fig. 4-2. Allow the joint to heat sufficiently to permit the solder to flow freely and to form a slight fillet around the wire as shown in Fig. 4-3.

Due to the high-frequency requirements of the Type 82, many of the 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 the leads of the removed component.

If, after soldering the lead, it extends beyond the solder joint, clip the excess as close to the solder joint as possible. In clipping ends of wires remove all clippings that fall in the chassis.

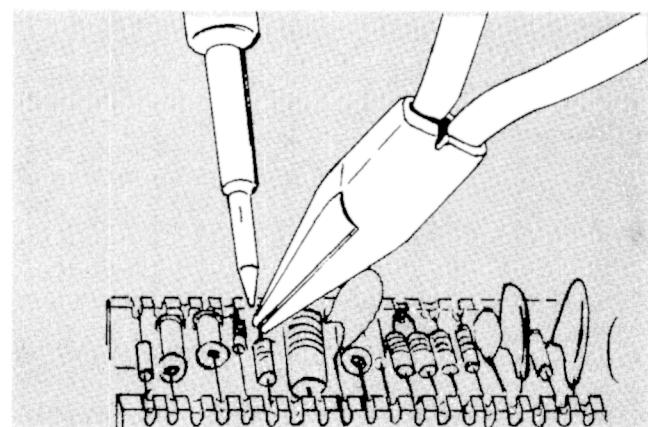


Fig. 4-2. Correct method of applying heat when unsoldering or soldering leads to a ceramic strip.

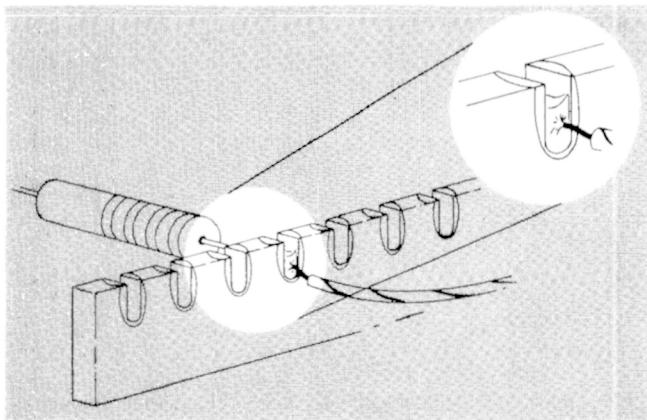


Fig. 4-3. A slight fillet of solder is formed around the wire when heat is applied correctly.

To hold down leads from components which are not adversely affected by heat during the soldering process, use a short length of wooden dowel with ends shaped as shown in Fig. 4-4. 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. 4-5) makes a convenient tool for this purpose.

In soldering leads or coax braids to ground use a 50-60-watt iron with a tip having a shank diameter of about $\frac{1}{4}$ ". The higher-wattage iron and heavier tip will assure that the joint receives adequate heat to form a good solder joint.

Replacing 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 alternate 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 can be reused as long as they hold the strip assembly securely.

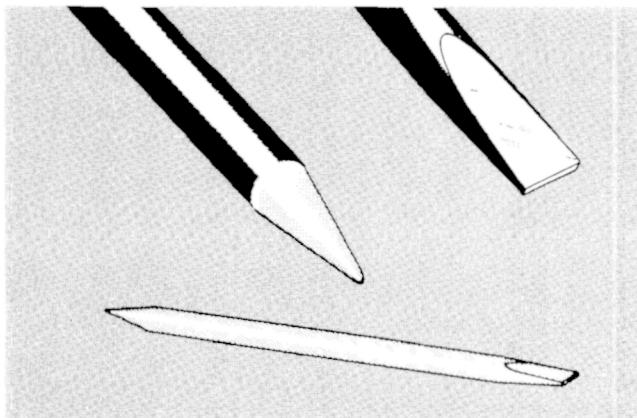


Fig. 4-4. A soldering aid constructed from a $\frac{1}{4}$ -inch dowel.

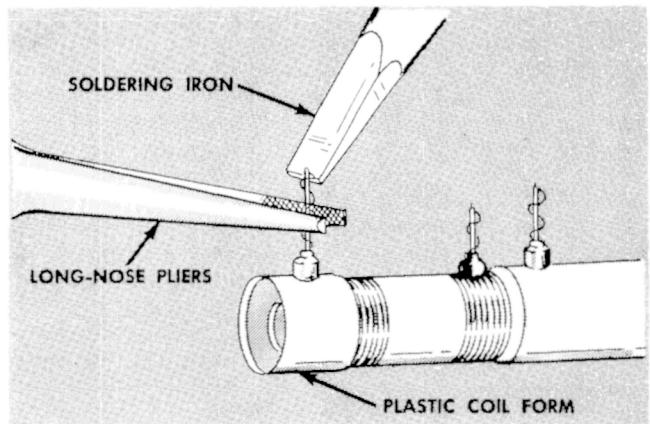


Fig. 4-5. Soldering to a terminal mounted in plastic. Note the use of the long-nose pliers between the iron and coil form to absorb the heat.

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. 4-6 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

Replacements for all parts used in constructing the Type 82 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 than required to obtain them from the factory. Before purchasing a part, be sure to consult the Parts List of this

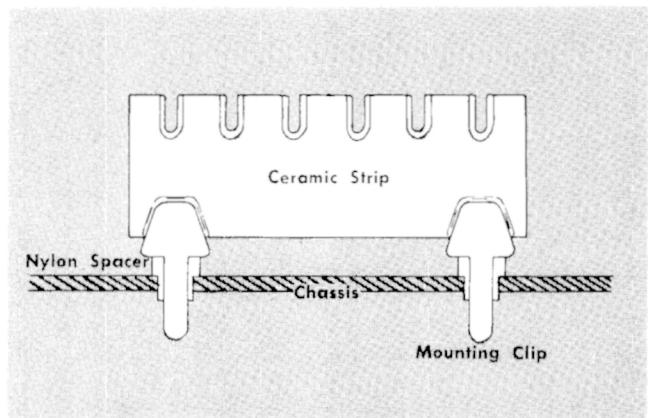


Fig. 4-6. Installation of a ceramic strip.

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manual to determine the tolerance and rating required. The Parts 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 that a trouble develops, use the information in this portion of the Instruction Manual to more efficiently troubleshoot the Type 82. The information starts with preliminary checks to make and then advances to detailed circuit troubleshooting.

Front-Panel Controls

Before troubleshooting, double-check the front-panel controls and CHOP RATE switch for proper settings. Also, check the front-panel screwdriver-adjustable controls 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 and the CHOP RATE switch are set properly and you determine that a trouble definitely exists, check whether the trouble is in the oscilloscope or the Type 82.

Oscilloscope or Type 82

When following a troubleshooting procedure, it is assumed that the oscilloscope used with the Type 82 is operating normally. Since this is not always the case, check the operation of the oscilloscope before attempting to troubleshoot the Type 82.

Troubles occurring in the oscilloscope can usually be detected by substituting another plug-in unit for the Type 82. Preferably, another Type 82, a Type 84*, or a Type CA** Plug-In Unit that is working normally should be used if one is available. Then you can readily isolate a dual-trace trouble such as loss of alternate-mode sync pulses, for example, to either the oscilloscope or the Type 82. If one of the foregoing units is not available, then dual-trace troubles will have to be isolated using a test oscilloscope for signal tracing the Type 82 and possibly the oscilloscope used with the Type 82.

*Type 84 Load-Pulser Plug-In Test Unit.

**A Type 81 Adapter required to operate the Type CA in a Type 580-Series Oscilloscope.

Type 82 Operational Check

If the Type 82 is definitely at fault and not the associated oscilloscope, a good procedure to follow is to make a careful operational check of the Type 82. By noting the effect that each front-panel control (including the CHOP RATE switch) has on the symptom, you can sometimes isolate a trouble to either a defective control or circuits that are likely to contain the trouble. The normal or abnormal operation of each control should indicate to you the checks to make.

As an additional aid to troubleshooting, the step-by-step method of checking and adjusting the Type 82 as given in the Calibration procedure (Section 5) of this manual is a good way to check the operational standards of your own 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 including a list of suggested test equipment for servicing the Type 82. 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, voltages, and waveforms. Conditions under which the voltages and waveforms were taken are summarized and placed on the diagrams. Certain 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 82 is shown on the circuit diagrams. The following is a list of the circuit numbers associated with each diagram.

Circuit Numbering Range	Circuit Diagram
100 to 199	Attenuators (Channel A) Input Amplifiers (Channel A)
200 to 299	Attenuators (Channel B) Input Amplifiers (Channel B)
300 to 399	X10 Amplifiers (Channel A)
400 to 499	X10 Amplifiers (Channel B)
500 to 599	Switching Circuit and Output Amplifier

Test Points

Numbered test points aid in troubleshooting and calibrating the Type 82. They simplify reference to particular locations in the circuitry. Each test point is indicated by a bracketed number with an arrow pointing to its location in the circuit. 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, excluding the Attenuators diagram.

Since both channels are similar, the letter "A" after the test point number indicates that it applies to channel A and the letter "B" indicates that the number applies to channel B. Physical locations of the test points on the Type 82 chassis are shown in Fig. 4-7. The test-point numbers in the illustrations are grouped in pairs corresponding to related points in the circuitry, such as points opposite to each other in the push-pull amplifier stages of each channel.

Coding of Switch Wafers

Switch wafers shown on the circuit diagrams are coded to indicate the physical location of the wafer on the switches. The number portion of the code refers to the wafer number on the switch assembly. Wafers are numbered from the first wafer located behind the detent section of the switch to the last wafer. The letters F and R indicate whether the front or the rear of the wafer is used to perform the particular switching function. For example 2R of the V/CM switch is the second wafer when counting back from the detent section, and R is the rear side of the wafer.

Cable Color Coding

All wiring in the Type 82 is color coded to facilitate 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 black

Test Equipment

When preparing to circuit troubleshoot the Type 82, you may find useful some of the minimum equipment described here. This list summarizes 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 82.

(2) VOM

Description: 20,000 Ω /vdc, 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%.

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

(3) Dc Volt-Milliammeter

Description: Ranges 0 to 50 volts; zero to 2 ma.

Purpose: Used for determining currents delivered by the VOM (item 2) and to measure the internal source voltages if the VOM (item 2) is going to be used for checking transistors and diodes.

(4) Test Oscilloscope

- a. Low-Bandwidth Test Oscilloscope (with a 10X probe). Description: Bandwidth, dc to 300 kc or better. Calibrated vertical deflection factors down to 5 mv/cm without a 10X probe (with a 10X probe, 50 mv/cm). Input resistance, 1 megohm without a 10X probe and 10 megohms with a 10X probe.

Purpose: For low-frequency signal-tracing and checking dc levels in the amplifier stages. Can be used to signal-trace the Switching Circuits if bandwidth limitation is considered.

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

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

Purpose: Signal trace the Switching Circuits. If the deflection factor for this wide-band test oscilloscope is as low as 5 mv/cm, use it in place of item 4a.

(5) Flexible Plug-In Cable Extension

Description: 30" long, Tektronix Part No. 012-038.

Purpose: Permits operating the Type 82 out of the oscilloscope plug-in compartment so that all sides of the Type 82 are accessible for servicing.

(6) Adapter (Use either a or b)

- a. BNC Plug and UHF Jack Connector Fittings
Description: Tektronix Part No. 103-032.

Purpose: Accepts interconnecting lead with a banana plug.

- b. Single Binding Post
Description: Fitted with a BNC plug. Tektronix Part No. 103-033.

Purpose: Accepts interconnecting lead with a banana plug.

(7) 18" Interconnecting Leads (two required)

Description: Combination banana-plug and jack connectors on each end. Tektronix Part No. 012-031.

Purpose: Use in low-frequency signal-tracing setup to apply the calibrator signal to the Type 82 and test oscilloscope Ext. Trig. input connector.

(8) 30" Interconnecting Lead

Description: Banana plug on one end, alligator clip on other. Tektronix Part No. 012-014.

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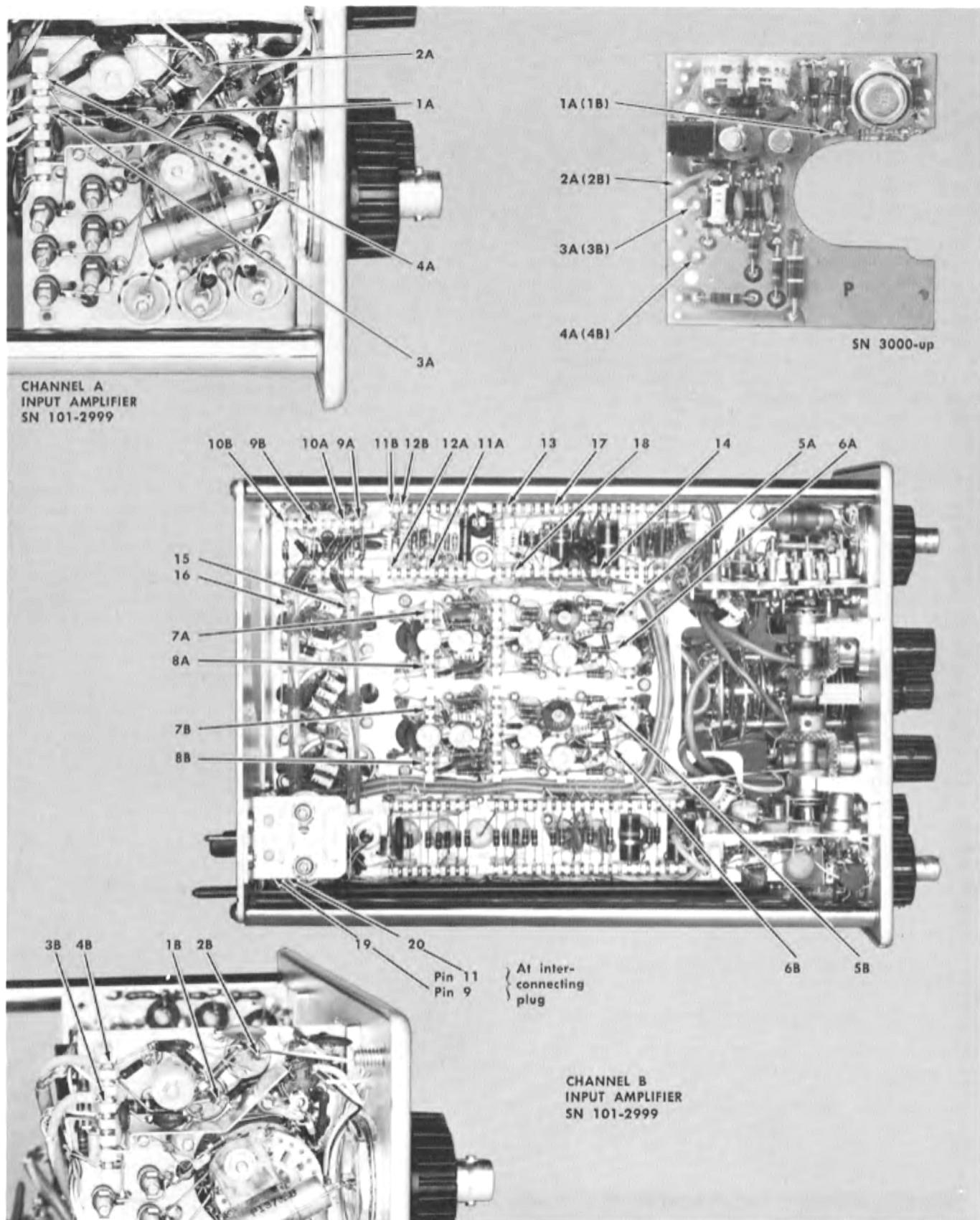


Fig. 4-7. Location of the test points.

Purpose: Use in low-frequency signal-tracing setup to ground the Type 82 and test oscilloscope together.

(9) **Miscellaneous:** Replacement tubes, transistors, and diodes.

Tube Checks

Periodic tube checks on the tubes used in the Type 82 are not recommended. Tube testers in many cases indicate a tube to be defective when that tube is operating quite satisfactorily in a circuit, and fail to indicate tube defects which affect the performance of the circuits. The ultimate criterion of the useability of a tube is whether or not the tube works 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 opening, shorting or developing excessive leakage. 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 resistances using proper ohmmeter ranges that will not exceed the transistor ratings, or by using the substitution method. Voltage and resistance checks can be made using the following information.

(1) In-Circuit Voltage Checks

To check transistors using a voltmeter, measure the emitter-to-base and emitter-to-collector voltages as shown in Fig. 4-8. 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.

CAUTION

Do not remove transistor Q583 from its socket while the Type 82 is operating. If Q583 is removed, Q590 in the Blocking Oscillator stage can be damaged by excessive power dissipation.

TABLE 4-1A
Checking the Emitter-To-Base Voltage

Emitter-to-base Voltage	Action
Normal*	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. Then, if necessary, substitute the transistor.

*See schematic to determine proper voltage drop and polarity.

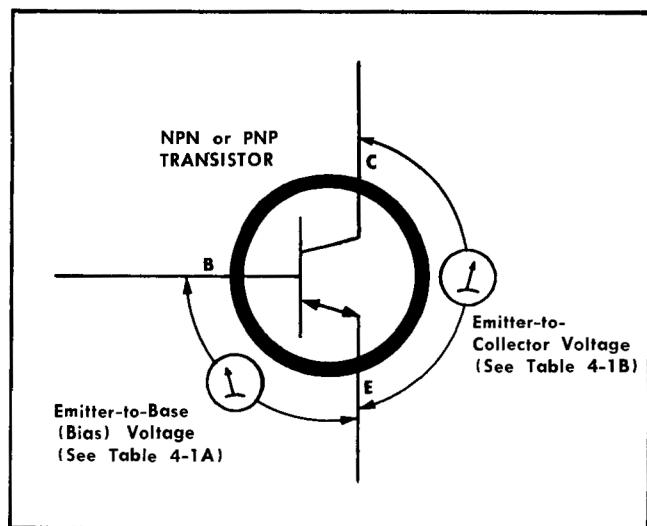


Fig. 4-8. In-circuit voltage checks of NPN or PNP transistors.

TABLE 4-1B
Checking The Emitter-to-Collector Voltage

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

*See schematic diagram to determine proper voltage drop.

**Q590 is an exception. It could be open. Check by substitution.

(2) Resistance Measurements

To check a transistor using an ohmmeter, know your ohmmeter ranges, the currents they deliver, and the internal battery voltage(s). 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 range where the current is limited to less than 2 ma and the internal voltage is usually 1½ volts. You can quickly check the current and voltage by inserting a multimeter between the ohmmeter leads and measuring the current and voltage for the range you intend to use.

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

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TABLE 4-2
Transistor Resistance Checks

Ohmmeter Connections*	Resistance Readings That Can Be Expected Using the RX1k Range
Emitter-Collector	High readings both ways (about 60k to around 500k)
Emitter-Base	High reading one way (about 200k or more). Low reading the other way (about 400 Ω to 2.5 k).
Base-Collector	High reading one way (about 500 k or more). Low reading the other way (about 400 Ω to 2.5 k).

*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 whether the transistor is good or not, substitute the transistor in the Type 82; but first be certain the circuit voltages applied to the transistor are correct before making the substitution.

Diode Checks

Diode defects are similar to transistor defects when they open or short. 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 (except D580, D586 and D590) can be made quite easily by using a voltmeter to find out if the diode is functioning properly in the circuit. Use Table 4-3 to determine whether a particular diode should be forward biased or not, then measure the drop across it. By noting the difference between voltages on each side of the diode as given on the schematic diagrams, you can determine whether the drop is normal or not. Refer to Fig. 4-9 if you need to locate any of the Switching-Circuit or gate diodes quickly. The other diodes are not shown because they are easier to find.

If you are in doubt whether a diode is defective or not, for an additional check, unsolder one end and check the forward-to-back resistance. Use this method for checking D580, D586 and D590 because voltage checks are not as conclusive. If the ohmmeter check is inconclusive and you suspect that the diode is defective, replace the diode.

Interconnecting-Plug Resistance Checks

Table 4-4 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 82 if such a trouble occurs.

The resistance measurements are not absolute and vary considerably since semiconductors are used in the Type 82 circuitry. In addition, the readings can vary as much as 50% due to the type of ohmmeter you are using, even if you use the same ranges. Therefore, space is provided in the table so you can log your own measurements for future reference.

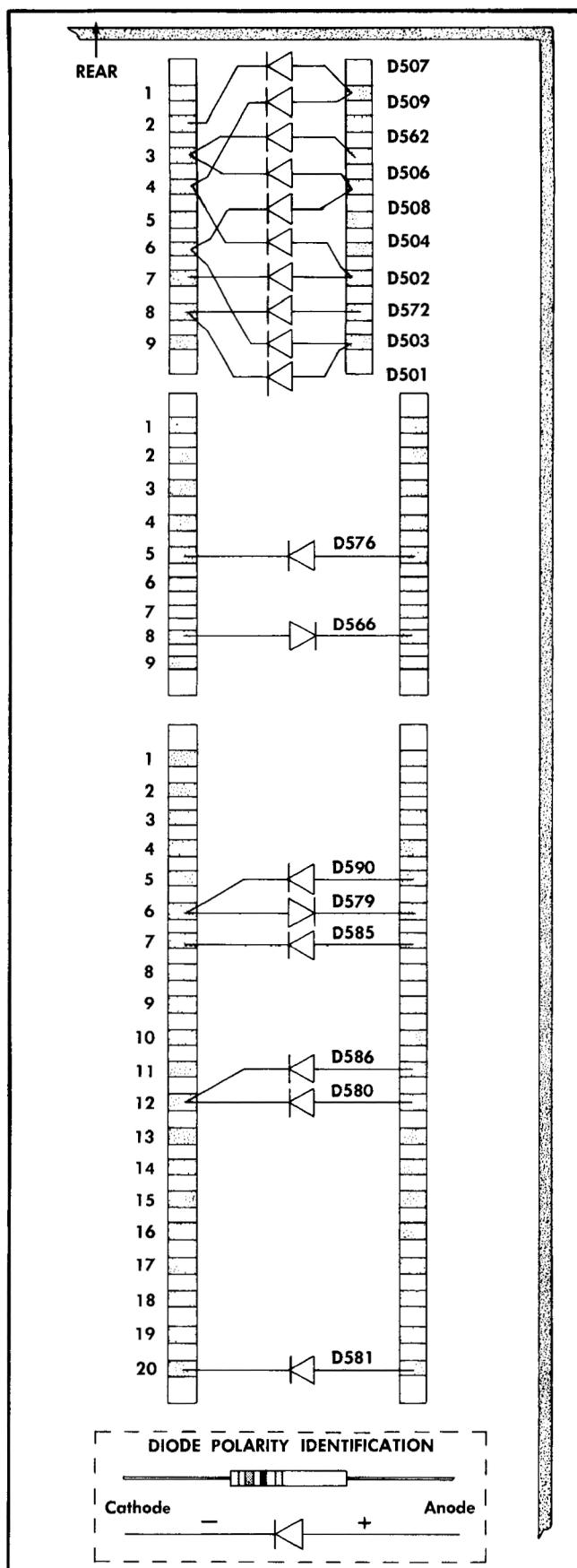


Fig. 4-9. Location of the diodes used in the Switching Circuit and diode gates.

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
Diode Bias Conditions

Diode	MODE Switch Setting			
	A ONLY	B ONLY	ALTER.	CHOP.
D134	Forward	Forward	Forward	Forward
D138	Reverse	Reverse	Reverse	Reverse
D139	Reverse	Reverse	Reverse	Reverse
D234	Forward	Forward	Forward	Forward
D238	Reverse	Reverse	Reverse	Reverse
D239	Reverse	Reverse	Reverse	Reverse
D501	Reverse	Forward		
D502	Reverse	Forward		
D503	Forward	Reverse	See footnote 1.	See footnote 1.
D504	Forward	Reverse		
D562	Forward	Reverse		
D572	Reverse	Forward		
D566	Reverse	Reverse	See footnote 2.	See footnote 2.
D576	Reverse	Reverse		
D579	Unbiased	Unbiased	See footnote 3.	See footnote 3.
D580	Unbiased	Unbiased	Unbiased	Unbiased
D581	Forward	Forward	Forward	Reverse
D585	Reverse	Reverse	Slightly reverse biased. See footnote 4.	Reverse
D586	Reverse	Reverse	Reverse	100 kc-Reverse 1 mc-Forward
D590	Unbiased	Unbiased	See footnote 5.	See footnote 5.
D506	Forward	Reverse		
D507	Forward	Reverse		
D508	Reverse	Forward	See footnote 1.	See footnote 1.
D509	Reverse	Forward		

1. Same as A ONLY bias conditions when channel A is electronically switched "on"; same as B ONLY conditions when channel B is switched "on".

2. Reverse biased. Conducts only during duration of positive-going trigger pulses.

3. Unbiased. Conducts when triggers from Blocking Oscillator stage are applied.

4. Conducts only when the positive-going portion of the alternate trace sync pulse is applied to the diode.

5. Unbiased. Conducts only during the negative-going backswing as T590 field collapses.

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TABLE 4-4
Typical Resistances at Interconnecting Plug

Pin No.	MODE Switch Setting	Type of Meter: VOM*		Type of Meter: Mfg: Model No.: Type 82 Ser. No.:	
		Resistance Readings**	Ohms Range Used	Resistance Readings**	Ohms Range Used
1	A ONLY or B ONLY	2.8k, 6.2k	RX1K		
	ALTER.	2.8k, 7k			
	CHOP.	2.8k, 6.2k			
2	A ONLY or B ONLY	3.1k, 5.6k	RX1K		
	ALTER.	3.1k, 5.6k			
	CHOP.	3.7k, 20k			
3	A ONLY or B ONLY	38k, 13k	RX10K		
	ALTER.	38k, 13k			
	CHOP.	38k, 28k			
4		Infinite (No connection)			
5					
6					
12					
13					
7***	A ONLY or B ONLY	50k, 700 Ω	RX1K		
	ALTER.	Over 500k, 700 Ω			
	CHOP.	50k, 700 Ω			
8	A ONLY or B ONLY	Infinite	RX100		
	ALTER.	Infinite			
	CHOP.	100 Ω			
9 11	A ONLY or B ONLY	2.5k, 6.7k	RX1K		
	ALTER.	2.5k, 5.8k			
	CHOP.	2.6k, 20k			
10	Any	0 Ω (connected to ground)			
14 16	Any	Infinite			
15	Any	3 Ω	RX1		

*VOM used for these measurements is a 20,000 Ω /vdc meter with a center-scale reading of 4.5k on the RX1K range. For the RX1K range, mid-scale deflection current is 160 μ A; at full scale it is 320 μ A. On the higher ranges current never exceeds 520 μ A for full-scale deflection. For ranges RX1K and lower a 1 1/2-volt internal battery is used; on RX10K and RX100K ranges, a 30-volt battery is used.

**Reverse the ohmmeter leads to get both readings.

***For this measurement use the ranges shown in the table. Do not use the lower range since excessive forward current can damage diode D585. Do not use higher ranges if an internal battery of 22 volts or more is used.

Symptoms

The symptoms that are listed in Table 4-5 are those that could happen if certain troubles occur. Since a diode could cause deceiving troubles if one breaks down many of the symptoms are based on what could happen if a diode shorts or opens. Since it is impossible to list every kind of

symptom that could happen, those that are included here provide a basis for finding the cause of the trouble.

Table 4-5 does not include those troubles that are caused by improperly adjusted front-panel controls. Refer to the Operating Instructions (Section 2) if you are in doubt about the proper control settings.

To use Table 4-5, 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 are 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.

As an aid in circuit troubleshooting an area, in some cases the third column directs you to Part I or II. Part I contains information for troubleshooting the Amplifier stages and Part II contains information for troubleshooting the Switching Circuits.

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

TABLE 4-5
Trouble Isolation Procedure

Symptoms	Checks To Make	
	Possible Causes	Area at Fault
1. No trace, either channel. GAIN switch set to either position.	Defective Output Amplifier tube (V524, V534, or V544). Check these nominal supply voltages in the Type 82: +225v, +100v, +51v, +12.6v, +6.3v, -25v and -150v. 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 D236.	Check for dc imbalance in the Output Amplifier. Refer to Part 1A.
2. No channel A trace. GAIN switch set to either position.	Check for an open series-diode: D503 or D504. Check that Switching Multivibrator Q565 and Q575 switches states properly (Q575 should conduct to turn "on" channel A when MODE switch is set to A ONLY). If one of the above components or stages is abnormal, make repair to obtain normal operation. If the above checks are normal, check for defective V133, Q153, Q164 or Q174.	Check for dc imbalance from input circuit of channel A Input Amplifier to input circuit of Output Amplifier. Refer to Part 1A.
3. No channel B trace. GAIN switch set to either position.	Check for an open series-diode: D508 or D509. Check that Switching Multivibrator Q565 and Q575 switches states properly (Q565 should conduct to turn "on" channel B when MODE switch is set to B ONLY). If one of the above components or stages is abnormal, make repair to obtain normal operation. If the above checks are normal, check for defective V233, Q253, Q264 or Q274.	Check for dc imbalance from input circuit of channel B Input Amplifier to input circuit of Output Amplifier. Refer to Part 1A.
4. No trace for one channel. GAIN switch set to X10.	Check the transistors in the X10 Amplifier of the channel at fault.	Check for dc imbalance in the inoperative X10 Amplifier channel. Refer to Part 1A.
5. Switching transients* that correspond to the normal chopping rate (100 kc or 1 mc) appear on channel A trace with MODE switch set to A ONLY and on channel B trace when switch is set to B ONLY.	Check for open D581.	Check for trouble in the Switching Circuits. Refer to Part II.

TABLE 4-5
Trouble Isolation Procedure

Symptoms	Checks To Make	
	Possible Causes	Area at Fault
6. No dual-trace switching; get only one trace. If MODE switch is set to CHOP., switching transients* appear on the trace. As one of the VERTICAL POSITION controls is rotated, amplitude of transients appears to change.	Check D566 or D576 for short or open.	Check for trouble in the Switching Circuits. Refer to Part II.
7. No alternate-mode switching; get only one trace. Other modes are normal.	Check for shorted D580 or open D585. Check for trouble between pin 7 of the inter-connecting plug and D585. Check ALTER. SYNC SENS. adjustment.	Check Blocking Oscillator Q590 and B.O. Bias EF Q583 stages. Refer to Part II.
8. Alternate mode operates at one of the chopping rates (depending on setting of CHOP RATE switch).	Check ALTER. SYNC. SENS. adjustment.	Check B.O. Bias EF Q583 stage. Refer to Part II.
9. No alternate-mode switching; get only one trace. In chopped-mode operation, get improper chopped-rate switching. With CHOP RATE Switch set to 100 kc, the rate is about 118 kc; with switch set to 1 MC, the rate is about 720 Kc.	Check for shorted D586.	Check for trouble in the Blocking Oscillator Q590 or B.O. Bias EF Q583 stages. Refer to Part II.
10. Improper chopped-mode operation. Chopping occurs at a rate of about 70 kc if CHOP RATE switch is set to 100 kc, and about 830 kc if switch is set to 1 MC.	Check for open D580 or shorted D585. (D585 shorted causes a very slight decrease in chopping rate.)	Check for trouble in the Blocking Oscillator Q590 or B.O. Bias EF Q583 stages. Refer to Part II.
11. Improper chopped-mode operation. Abnormally high-amplitude switching transients** on the traces when they are superimposed.	Check for an open shunt diode in the diode gate: D501, D506, D502 or D507.	Check for trouble in the diode gate.
12. Improper chopped-mode operation. Trace segments in affected channel are not flat but are distorted and tilted. Distortion exceeds $\frac{1}{2}$ mm in amplitude.	Check for a shorted shunt diode in the diode gate of the channel affected. For example, D501 or D502 in channel A; D506 or D507 in Channel B.	Check for trouble in the diode gate.
13. Improper chopped-mode operation. Channels do not switch alternately. One channel is turned on twice as long as the other channel.	Check for shorted D581.	Check for trouble in the Blocking Oscillator Q590 or B.O. Bias EF Q583 stages. Refer to Part II.
14. No chopped-mode operation when CHOP RATE switch is set to 1 MC. Get only one trace. Inadequate Positioning range. Other modes of operation appear normal except for abnormal positioning-range symptom.	Check for a shorted series diode in the diode gate of either channel: D503, D504, D508 or D509.	Check for trouble in the diode gate.
15. No chopped-mode operation when CHOP RATE switch is set to either position. Get only one trace.	Check for open D586.	Check for trouble in the Blocking Oscillator Q590 or B.O. Bias EF Q583 stages. Refer to Part II.
16. Low gain, both channels. Gain switch set to X1***.	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 Part IB.

TABLE 4-5
Trouble Isolation Procedure

Symptoms	Checks To Make	
	Possible Causes	Area at Fault
17. Low gain in channel A, deflection factor is decreased by a factor of about three. Gain switch set to X1***. Limited positioning range of the trace. Obtain only Channel B trace when MODE switch is set to ALTER. or CHOP.	Check for shorted D572.	Check for trouble in the Switching Multivibrator Q565-Q575 stage.
18. Low gain in channel B, deflection factor is decreased by a factor of about three. Gain switch set to X1***. Limited positioning range of the trace. Obtain only Channel A trace when MODE switch is set ALTER. or CHOP.	Check for shorted D562.	Check for trouble in the Switching Multivibrator Q565-Q575 stage.
19. Low gain, one channel. Deflection factor decreased by a factor of five. Rotation of the VERTICAL POSITION control affects the deflection factor. GAIN switch set to X1***.	Check for an open circuit between the VARIABLE VOLTS/CM control and preceding stage of the channel at fault.	Check for trouble in the Input Amplifier of the channel at fault. Refer to Part 1B.
20. Low gain in one channel for all positions of the V/CM switch. GAIN switch set to X1***.	SN 101-2999 Check V133, Q164, or Q174 if Channel A is at fault. Check V233, Q264, or Q274 and the B GAIN BAL. adjustment if Channel B is at fault. SN 3000-Up Check V133, Q164, or Q174 and the A GAIN BAL. adjustment if Channel A is at fault. Check V233, Q264, or Q274 if Channel B is at fault.	Check for trouble in the Input Amplifier of the channel at fault. Refer to Part 1B.
21. Low gain in one channel for only one position of the V/CM switch. GAIN switch set to X1***.	Check for trouble in the attenuator or the V/CM switch contacts for that switch position.	Check V/CM switch in the channel at fault.
22. No dc coupling of the signal.	Defective AC-DC-GND switch for that channel.	Check AC-DC-GND switch connections.
23. Trace shifts position vertically when the INPUT connector center conductor is grounded.	Check the adjustment of A GRID CURRENT ZERO control if Channel A is at fault; check B GRID CURRENT ZERO control if Channel B is at fault.	Check for defective nuvistor. Check for other possible troubles in the Input Cathode Follower stage V133 or V233, depending on channel at fault.
24. Low gain in one channel when GAIN switch is set to X10.	Check A X10 GAIN adjustment in the channel at fault. Check the transistors in the channel at fault.	Check for trouble in the X10 Amplifier of the channel at fault. Refer to Part 1B.
25. No waveform display using either channel 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 Part 1B.
26. No waveform display when using one of the channels. GAIN switch set to X1.	Open circuit between INPUT connector and junction of R117 and R126 if Channel A is at fault; between INPUT connector and R217 and R226 if Channel B is at fault. SN 101-2999 For Channel A: check for shorted C117 or C127. For Channel B: check for shorted C217 or C227.	Check for trouble in the input circuit of the Input Cathode Follower stage V133 or V233, depending on channel at fault. Refer to Part 1B.
27. No waveform display when using one of the channels. GAIN switch set to X10.	Coax cable shorted to ground at either the input or output of the X10 Amplifier at fault.	Check for trouble in connections leading to or from the X10 Amplifier of the channel at fault. Check for trouble in the X10 Amplifier of the channel at fault. Refer to Part 1B.

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TABLE 4-5
Trouble Isolation Procedure

Symptoms	Checks To Make	
	Possible Causes	Area at Fault
28. Square-wave distortion. Spike or overshoot on fast-rise (13 nsec or faster) squarewaves. Repetition rate: 500 kc. For 1% overshoot, 1 RC decay time constant is 15 nsec; for 10% overshoot, 1 RC decay time constant is 150 nsec.	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 Part 1C.
29. Square-wave distortion or poor frequency response in one channel but not in the other. GAIN switch set to X1.		Check for trouble in the Input Amplifier of the channel at fault. Refer to Part 1C.
30. Square-wave distortion or poor frequency response in one channel but not in the other. GAIN switch set to X10.	Substitute transistors in the X10 Amplifier of the channel at fault. Check high-frequency adjustments in that channel.	Check for trouble in the X10 Amplifier circuitry of the channel at fault. Refer to Part 1C.
31. Microphonics in either channel. Set GAIN switch to X10 and MODE switch to ALTER. Tap lightly on the front panel of the Type 82. Microphonics of the ringing type should not exceed 1 centimeter.	Check the nuvistor in the channel which is microphonic.	Input CF stage of channel at fault.

*Switching transients result from an abnormal condition where the Blocking Oscillator free runs in the A ONLY or B ONLY MODE switch settings and its triggers superimpose on the trace.

**These switching transients are caused by feed-thru from the Switching Multivibrator as it switches states when triggered by the Blocking Oscillator.

***Any change in X1 gain also causes the same gain-change symptom when GAIN switch is set to X10.

Part I—Troubleshooting the Amplifiers

A. Isolating DC Imbalance

To make free-running traces appear within the useable viewing area of the crt screen, the dc output voltage at test points 19 and 20 must be essentially equal—that is, within a fraction of a volt (see Fig. 4-10). 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 in each channel. 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 dc balance under two sets of conditions are shown in Figs. 4-10a and 4-10b. These conditions are: (a) when the GAIN switch is set to X1 as shown in Fig. 4-10a, and (b) when the GAIN switch is set to X10 as shown in Fig. 4-10b. 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 4-5.

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 Channel A Input Amplifier, 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 15 and 16.
2. Set the GAIN switch to X1 and the MODE switch to A ONLY.
3. Rotate the Channel A 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. To verify this, set the MODE switch to B ONLY and try to obtain a zero reading by rotating the Channel B VERTICAL POSITION control. If zero volts cannot be obtained and the amount of imbalance remains unchanged, then the trouble is in the grid line.

Make careful resistance checks in this part of the circuitry to find the cause. Check for open R510, R511, R512, R513 or

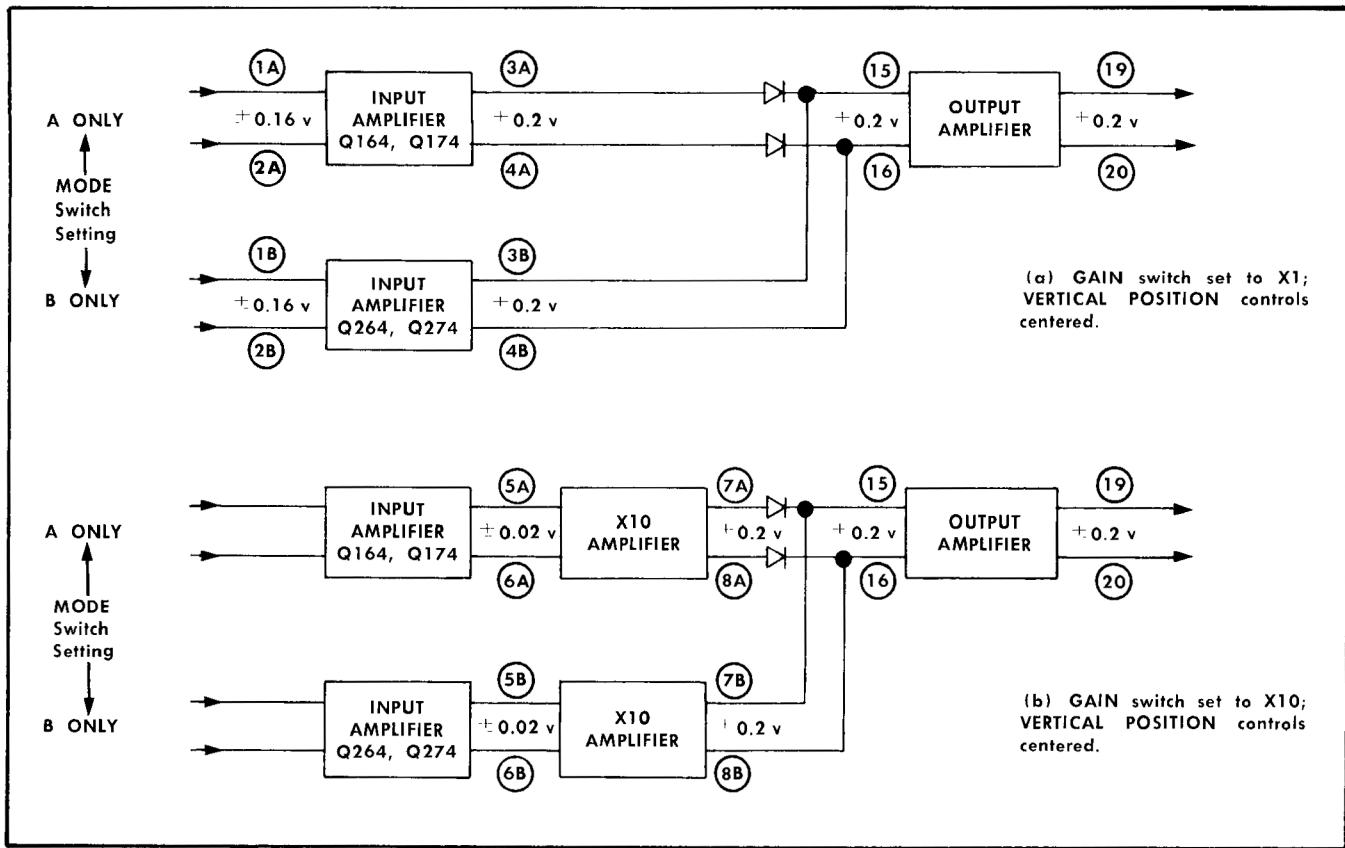


Fig. 4-10. Voltage-difference limits that should not be exceeded to obtain proper dc balance for positioning the trace on the crt.

R514; check for open supply resistors or open switching diodes (D503, D504, D508 or D509).

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 82 amplifier circuitry. The technique used here is limited to the low frequencies because a plug-in cable extension is used to operate the Type 82 out of the oscilloscope plug-in compartment. Using the cable extension makes all sides of the Type 82 easily accessible for detailed signal tracing and troubleshooting.

After you have succeeded in getting the Type 82 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. 4-11 and 4-12 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 Zeners, transistors and tubes. In addition, the power-supply voltages applied to the Type 82 vary between oscilloscopes within

their tolerances. For example, the +12.6-volt supply can vary as much as $\pm 5\%$.

To signal trace the amplifier stages in the Type 82, proceed as follows:

1. Set the front-panel controls for both channels as follows:

AC-DC-GND	DC
V/CM	1* or 10**
VARIABLE VOLTS/CM	CAL.
VERTICAL POSITION	Centered†
A POLARITY	NORM.
B POLARITY	NORM.
GAIN	X1* or X10**
MODE††	A ONLY or B ONLY

*Set the V/CM switch to 1 and the GAIN switch to X1 when checking X1 gain of the Type 82.

**Set the V/CM to 10 and the GAIN switch to X10 when signal tracing through the X10 Amplifiers.

†The trace was positioned at "vertical-system electrical center" when obtaining the waveform data. Thus, balance dc-voltage readings are obtained at test points 19 and 20.

††Set the MODE switch to A ONLY when signal tracing in the channel A amplifier stages and the Output Amplifier; set the MODE switch to B ONLY when signal tracing in channel B.

Maintenance—Type 82

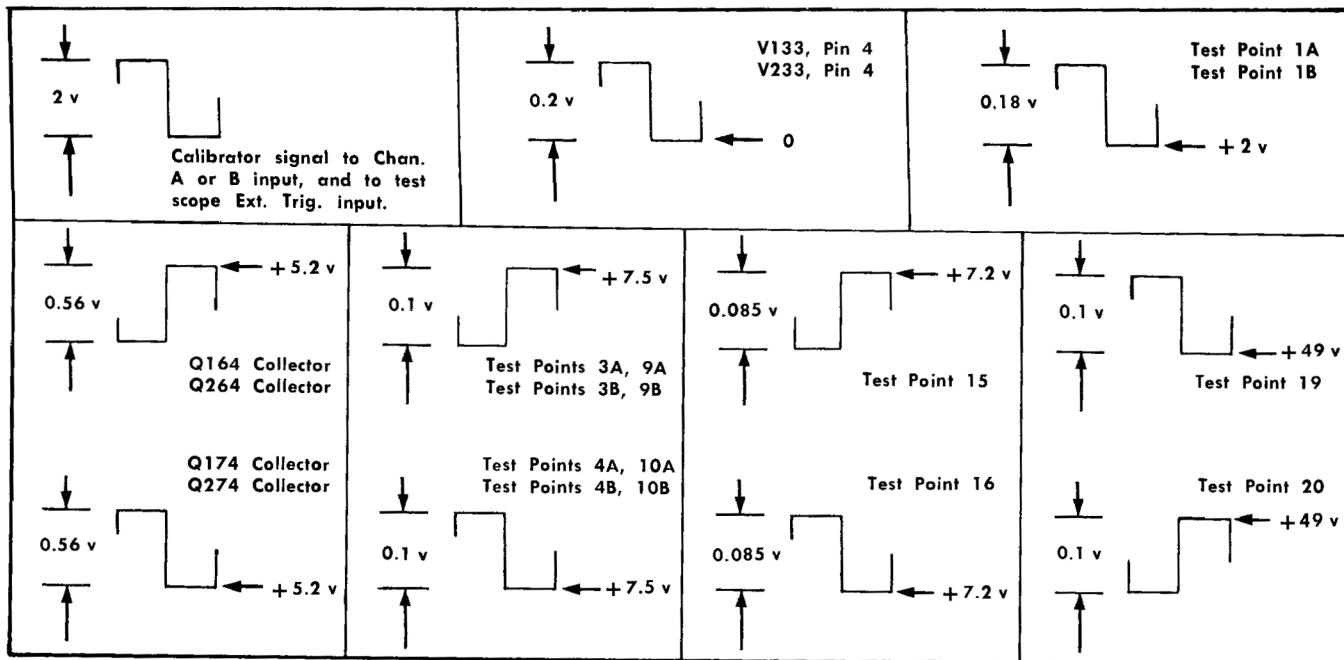


Fig. 4-11. Checking X1 voltage gain. Set GAIN switch to X1 and V/CM switch to 1.

2. Connect a 30" plug-in cable extension between the Type 82 and the Type 580-Series Oscilloscope.
3. Apply a 2-volt peak-to-peak calibrator signal from the Type 580-Series Oscilloscope to the appropriate INPUT connector of the Type 82. Also, apply the calibrator signal to the External Trigger input connector on the test oscilloscope. (Use items 6 and 7 in the Test Equipment list for this purpose.)
4. Connect a third lead (item 8) between the test oscilloscope ground terminal and the Type 82 ground.
5. Set the test oscilloscope input coupling switch to AC.
6. Touch the tip of the probe to the CAL. OUT connector on the Type 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 millisecond/cm or 0.2 millisecond/cm.) Be sure to set the test oscilloscope triggering controls for external triggering and to display the first $\frac{1}{2}$ -cycle of the waveform as positive-going. The displayed waveform will then correspond to the input waveform polarity as shown in Fig. 4-11 and 4-12. Disconnect the probe.
7. Touch the probe tip to the desired test point in the Type 82 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 82 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 soldered-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 82 upon completion of the servicing.

C. Checking Square-Wave Response

In general, the best way to isolate square-wave distortion trouble is to go to the Calibration section of this manual after you have checked the symptoms given in Table 4-5. The distortion symptoms 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 24 through 29 in the procedure, they will furnish you an orderly approach for isolating a poor transient-response type of trouble.

Besides the usual causes of distortion given in Table 4-5, 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.

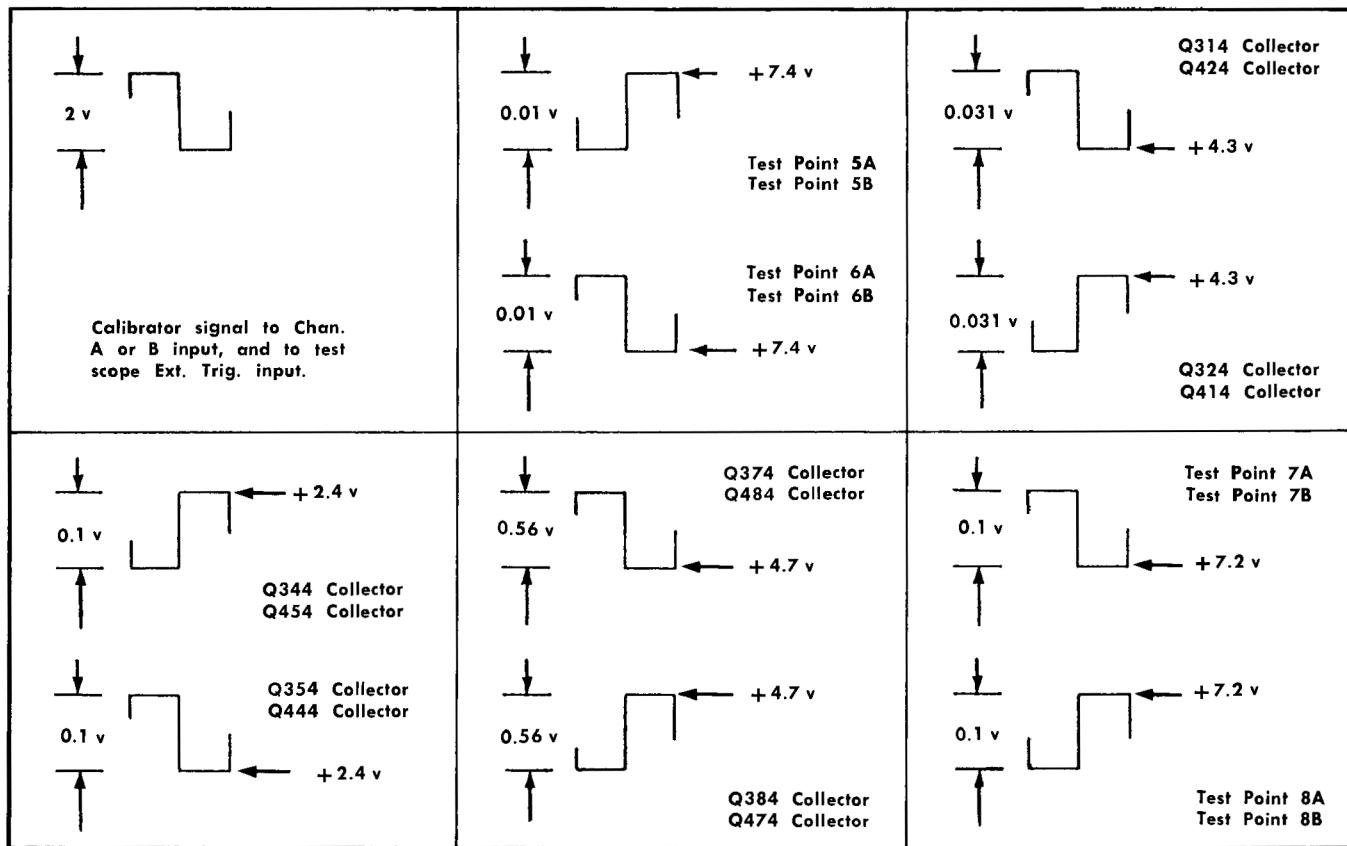


Fig. 4-12. Checking X10 voltage gain. Set GAIN switch to X10 and V/CM switch to 10.

Part II—Troubleshooting

Switching Circuits

A. Signal Tracing

The technique for signal tracing the Switching Circuits is similar to the technique described for low-frequency signal tracing. That is the technique of checking the amplitude and dc level of the signal at the various test points. A wide-band test oscilloscope should be used for signal tracing as described in the Test Equipment list (item 4b).

Waveforms at the various important test points are shown on the Switching Circuit diagram. The MODE and CHOP RATE switch settings (where needed), amplitude, dc levels, and sweep rate are indicated near each waveform for each reference.

B. Voltage Table

As an aid to making detailed voltage checks in the Blocking Oscillator Q590 and B.O. Bias EF Q583 stages Table 4-6 is provided. This table gives typical voltage measurements obtained when the MODE switch is set to ALTER. and CHOP. If the voltages are affected by the setting of the CHOP RATE switch, then the voltages for each setting of the switch are given.

Voltages obtained when the MODE switch is set to A ONLY are indicated on the circuit diagram. If the MODE switch is set to B ONLY, the channel B voltages will be the same as those given for the A ONLY position.

TABLE 4-6
Q583 and Q590 Voltage Measurements*

Location	Mode Switch Setting ALTER.	CHOP RATE CHOP.	Switch Setting
R580-R581 Junction	+13.2	+11.1	100 KC
	+13.3	+11.9	1 MC
Q583 Base	+13.0	+12.7	100 KC
	+13.0	+12.6	1 MC
Q583 Emitter	+12.9	+12.6	100 KC
Q590 Base	+12.9	+12.8	1 MC
Q583 Collector	+19.5	+19.5	100 KC
	+19.5	+19.7	1 MC
Q590 Emitter	+12.5	+12.4	100 KC
	+12.5	+11.0	1 MC
Test Point 17	-0.08	-3.1	100 KC or 1 MC
Test Point 18	0	0	100 KC or 1 MC

*Free run the oscilloscope time-base at 1 μ sec/cm.

ADJUSTMENTS FOLLOWING REPAIR

Calibration checks to Make

When servicing the Type 82, a repair or an adjustment may affect the operation of another circuit. The following table shows the minimum calibration checks you may have to 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.

Maintenance—Type 82

TABLE 4-7

Repair made in this area	Calibration Steps to be Checked																												
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Channel A Attenuators													X													X			
Channel B Attenuators													X												X				
Channel A Input Ampl.	X	X								X	X	S	S	X				S	S	X					X				
Channel B Input Ampl.		X	X							X	S	S		X			S	S		X			X			X			
Channel A X10 Ampl.																X				X									X
Channel B X10 Ampl.															X					X				X				X	
Output Amplifier			X	X				X	X	X				X	X					X	X			X			X		
Switching Circuits					X	X	X																						

"X" in any boxed area denotes calibration step to be checked.

"S" in a boxed area denotes operation check of a specific component. For example, step 12 is "Check VARIABLE VOLTS/-CM Control (Both Channels)". 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 82 is provided in this section of the manual. The steps are arranged in 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, this procedure should be used 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 25. The remaining steps check and aid in restoring the Type 82 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 4-7, 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 82.

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

- (2) Square-wave generator, Tektronix Type 105 or equivalent. Required specifications: 13-nsec or less risetime; output frequency of approximately 2.5 kc; output amplitude variable from 10 to 100 volts across an internal 600-ohm load.
- (3) TU-5 Pulser complete kit, Tektronix Part No. 015-043, contains the following items*:

Qty.	Description	Part Number
1	TU-5 Pulser (alone) with BNC plug-and-jack connector fittings.	015-038
1	50-ohm termination with BNC plug-and-jack connector fittings.	011-049
1	50-ohm 10:1 T attenuator, $\frac{1}{2}$ w, with BNC plug-and-jack connector fittings.	010-314
1	Connector adapter with UHF-plug and BNC-jack connector fittings.	103-015
1	50-ohm (nominal impedance) coaxial cable, 42" long, with a BNC connector on each end.	012-057

*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 (015-038) characteristics:

Input Voltage Required—+100-volt (from ground) square wave capable of supplying 10 ma. The Type 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. 013-075.

Output Voltage—200 millivolts or more into 50 ohms.

Output Pulse Risetime—1.5 nsec or less into a 50-ohm resistive load such as the 50-ohm termination (011-049).

- (4) Dc voltmeter. Sensitivity of at least $5000 \Omega/v$.
- (5) SN 3000-Up. 15-pf Input Time Constant standardizer, 2X attenuation, with BNC-plug and UHF-jack connector fittings, Tektronix Part No. 011-073.
- (5) SN 101-2999. 12-pf Input Time Constant Standardizer, 2X attenuation, with BNC-plug and UHF-jack connector fittings, Tektronix Part No. 011-051.
- (6) Plug-In Extension, $6\frac{1}{2}$ " long, Tektronix Part No. 013-055.
- (7) Connector Adapter, with UHF-plug and BNC-jack connector fittings, fits UHF-jack and BNC-plug connectors, Tektronix Part No. 103-015.

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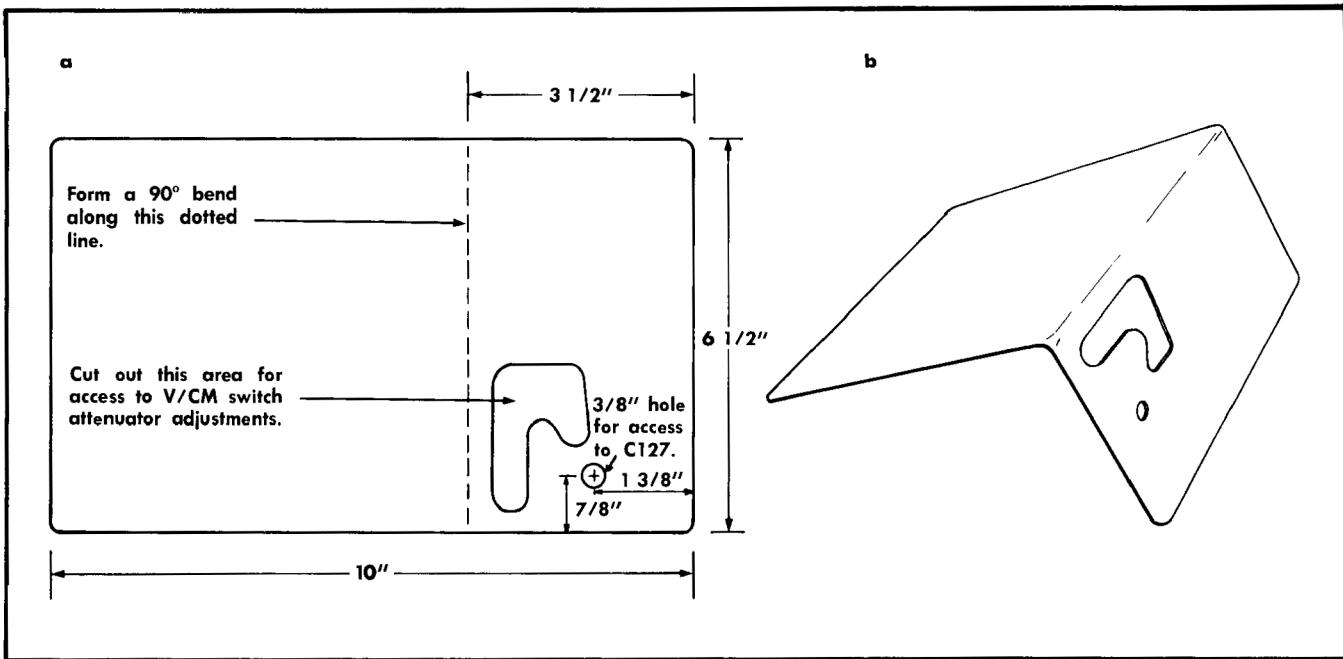


Fig. 5-1. Constructing the tuning shield. (a) shows layout and (b) shows completed shield.

- (8) Connector Adapter, with BNC-plug and UHF-jack connector fittings, fits BNC-jack and UHF-plug connectors, will accept a banana plug, Tektronix Part No. 103-032.
- (9) Tuning shield (applies only to instruments below SN 3000). This is an optional item to construct to decrease calibration time if there are several units to calibrate. The shield is used when performing step 25 in the calibration procedure. Suggested layout for constructing the shield is shown in Fig. 5-1. (If you are calibrating a single unit, the first portion of step 25 can be performed without using the shield. Then the last portion of the step can be performed as described in the procedure.)
- (10) 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 the screwdriver-adjust potentiometers.

1— $1\frac{1}{16}$ -inch allen wrench, for the VERTICAL POSITION knob setscrews.

1—Alignment tool, consisting of a handle (Part No. 003-307) a gray nylon insert with a wire pin (part no. 003-308) and a nylon insert with a metal screwdriver tip (Part No. 003-334).

PRELIMINARY PROCEDURE

Remove the left side panel from the Type 580-Series Oscilloscope. Lay the oscilloscope on its right side and re-

move the bottom cover. Leave the oscilloscope on its right side.

Connect a 6 1/2-inch plug-in extension to the Type 82. Install the Type 82 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 warmup 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 RM585A)

Trigger Slope	+
---------------	---

Stability	Fully clockwise
-----------	-----------------

Time/Cm	1 Millisec
---------	------------

Variable (Time/Cm)	Calibrated
--------------------	------------

5X Magnifier	Off
--------------	-----

Preset the Type 82 front-panel controls (both channels) and CHOP RATE switch as follows:

AC-DC-GND	DC
-----------	----

V/CM	.1
------	----

VARIABLE VOLTS/CM	CAL.
-------------------	------

VERTICAL POSITION	Centered*
-------------------	-----------

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

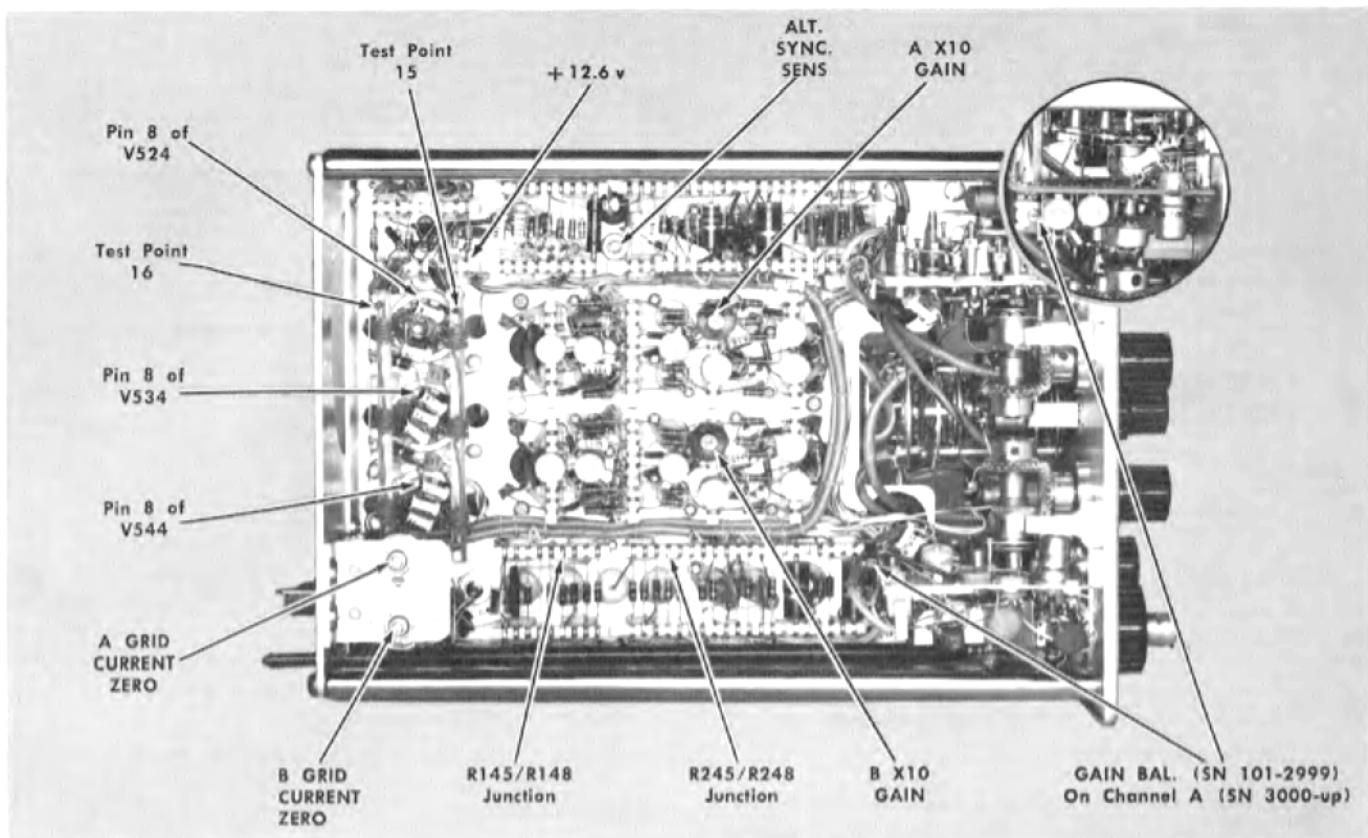


Fig. 5-2. Left rear portion of the Type 82 showing locations of various test points and internal adjustments.

X1 GAIN ADJ.	Fully clockwise
A POLARITY	NORM.
B POLARITY	NORM.
GAIN	X1
MODE	A ONLY
CHOP RATE	100 KC

CALIBRATION PROCEDURE

1. Channel A VERTICAL POSITION Control Electrical Center

This step places the channel A VERTICAL POSITION Control at its electrical center as one of the first steps in dc balancing the Type 82. To perform the step proceed as follows.

Connect a voltmeter between the center terminal of the Channel A VERTICAL POSITION control and the junction of R145 and R148. See Fig. 5-2 for location of the junction. Rotate the Channel A VERTICAL POSITION control to obtain a zero reading on the meter. At zero volts if the white dot on the A VERTICAL POSITION knob is not exactly at 0° position, loosen the setscrew and reposition the knob. Recheck that the voltmeter reads zero when the white dot is at 0° .

NOTE

Leave the A VERTICAL POSITION control at 0° until you complete step 3.

2. Channel B VERTICAL POSITION Control Electrical Center

The purpose of this step is similar to that described for Channel A, step 1.

Connect the voltmeter between the center terminal of Channel B VERTICAL POSITION control and the junction of

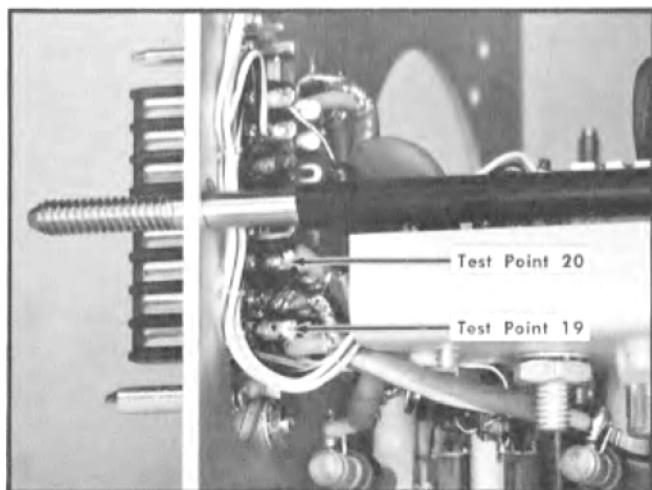


Fig. 5-3. Bottom rear portion of the Type 82 showing locations of test points used in steps 3 and 4.

Calibration—Type 82

R245 and R248. See Fig. 5-2 for location of the junction. Rotate Channel B VERTICAL POSITION control to obtain a zero reading on the voltmeter. If the white dot on the knob is not at 0° loosen the setscrew and reposition the knob. Recheck that the voltmeter reads zero when the white dot is at 0° .

NOTE

Leave the B VERTICAL POSITION control at 0° until you complete step 4.

3. Channel A X1 POSITION RANGE Coarse Adjustment

Touch the voltmeter probe tips to test points 19 and 20 (see Fig. 5-3). Adjust the channel A X1 POSITION RANGE control until the voltmeter reads zero. Disconnect the voltmeter.

Note the position of the trace as a reference for use in steps 4 and 9. This reference is the oscilloscope vertical-amplifier electrical center.

4. Channel B X1 POSITION RANGE Coarse Adjustment

Set the MODE switch to B ONLY. Adjust the channel B X1 POSITION RANGE control to position the trace to coincide with the oscilloscope vertical-amplifier electrical center.

5. ALT. SYNC. SENS. Adjustment

Set the front-panel controls of the oscilloscope you are using as follows:

Types 581 or 581A

Time/Cm $10 \mu\text{Sec}$

Types 585, 585A and RM585A

Horizontal Display	B
B Stability	Fully clockwise
B Trigger Slope	+
B Triggering Source	Int (Type 585) Int AC (Type 585-A and RM585A)
B Time/Cm or Delay Time	$10 \mu\text{Sec}$
B Length	Fully clockwise

Set the Type 82 MODE switch to ALTER, and the CHOP RATE switch to 1 MC. Adjust the ALT. SYNC. SENS. control to a point midway in the region where stable alternate-mode operation is obtained. (This is a point midway between where one trace is obtained and where the two traces are chopped; i. e. the Blocking Oscillator is free running.)

Use the VERTICAL POSITION controls to position the traces about 1.5 centimeters apart near the center of the crt so the effect of the adjustment can be observed.

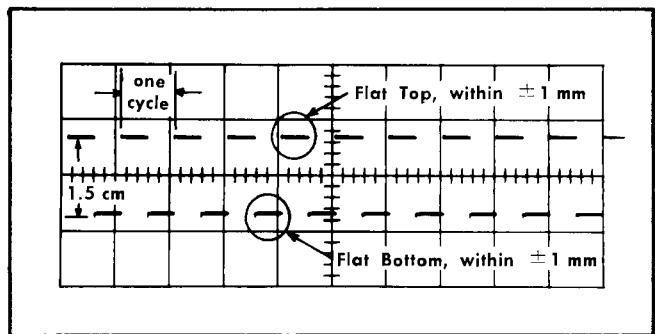


Fig. 5-4. Typical 100-kc chopping-rate waveform. Sweep rate is $10 \mu\text{sec}/\text{cm}$.

6. Check Chopped-Mode Operation at 100 KC

Place the Type 82 switch to CHOP, and the CHOP RATE switch to 100 KC. (If you are using a Type 585, 585A or RM585A Oscilloscope, the Time Base A controls will be used for the remainder of the calibration procedure. Set the oscilloscope Horizontal Display switch to A and the A TIME/Cm switch to $10 \mu\text{Sec}$.)

Set the oscilloscope Stability control to Preset and adjust the Triggering Level control to obtain a stable display of the chopped waveform.

Observe that the waveform is flat on the top and bottom when the waveform amplitude is 1.5 centimeters peak-to-peak. Use the VERTICAL POSITION controls to control the amplitude of the display (see Fig. 5-4). Tilting of the flat portion of the waveform should not exceed 1 millimeter.

Check the waveform chopping rate. The chopping rate should be within $\pm 20\%$ of 100 kc; i.e. the time duration for any one cycle should be between $8.3 \mu\text{sec}$ and $12.5 \mu\text{sec}$.

7. Check Chopped-Mode Operation at 1 MC

Set the oscilloscope Time/Cm switch to $1 \mu\text{Sec}$. Place the CHOP RATE switch to 1 MC. Adjust the oscilloscope Triggering Level control to obtain a stable display. Check the waveform for flat top and bottom (see Fig. 5-5). Tilt of the flat portion of the waveform should not exceed 1mm with a waveform amplitude of 1.5 centimeters. The chop-

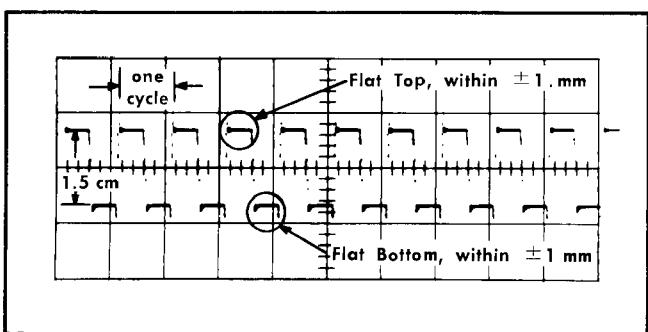


Fig. 5-5. Typical 1-mc chopping-rate waveform. Sweep rate is $1 \mu\text{sec}/\text{cm}$.

ping rate should be within 20% of 1 mc; i.e., the time duration for any one cycle should be between 0.83 μ sec and 1.25 μ sec.

8. Check Output Amplifier Bias

Set the Type 82 MODE switch to A ONLY. Connect a short (3") jumper clip lead between test points 15 and 16 (see Fig. 5-2). Check grid bias by connecting the voltmeter between test point 16 and each of the following test points (see Fig. 5-2 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 the 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.

9. 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, go on to step 10. If the position of the trace is farther away than 0.8 centimeter, replace V524. After allowing sufficient warmup 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 replaced.

In some cases the imbalance can be cumulative; that is each tube contributes slight imbalance in the same direction so they add up. This effect can be checked on an individual tube basis by applying +12.6 volts (see Fig. 5-2) 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 will cut off the tube and effectively remove 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 bias for the new tubes that were installed by repeating step 8.

After completing this step, remember the position of the trace for use in steps 22 and 23. This is the Type 82 distributed-amplifier electrical center. Remove the 3-inch jumper clip lead.

10. X1 GAIN ADJ. (SN 3000-up)

Set the oscilloscope Time/Cm switch to .5 Millisec and the Amplitude Calibrator switch to .2 Volts. Set the MODE Switch of the Type 82 to B ONLY.

Using a connector adapter (part No. 103-015) and a coaxial cable (Part No. 012-057) to make the connections to the Channel B INPUT connector. Set the Stability control to Preset and adjust the Triggering level control to obtain a stable display. Use the Channel B VERTICAL POSITION control to position the waveform to the center of the crt. Rotate the X1 GAIN ADJ. control to obtain exactly two

centimeters of vertical deflection. (Amplitude tolerance of the oscilloscope calibrator waveform is $\pm 3\%$. Therefore the vertical deflection factor will be within $\pm 3\%$.)

10. X1 GAIN ADJ. (SN 2999)

Set the oscilloscope Time/Cm switch to .5 Millisec and the Amplitude Calibrator switch to .2 Volts.

Using a connector adapter (part No. 103-015) and a coaxial cable (Part No. 012-057) to make the connections to the Channel A INPUT connector. Set the Stability control to Preset and adjust the Triggering Level control to obtain a stable display. Use the Channel A VERTICAL POSITION control to position the waveform to the center of the crt. Rotate the X1 GAIN ADJ. control to obtain exactly two centimeters of vertical deflection. (Amplitude tolerance of the oscilloscope calibrator waveform is $\pm 3\%$. Therefore the vertical deflection factor will be within $\pm 3\%$.)

11. GAIN BAL. Adjustment (SN 3000-up)

Remove the calibrator signal from the Channel B INPUT connector and apply the signal to the Channel A INPUT connector. Set the MODE switch to A ONLY. Use the Channel A VERTICAL POSITION control to position the waveform to the center of the crt. Adjust the GAIN BAL. control (see Fig. 5-2) to obtain exactly two centimeters of vertical deflection. (Calibrated gain accuracy will be no better than $\pm 3\%$ due to the $\pm 3\%$ accuracy of the Amplitude Calibrator.)

Return the MODE Switch to B ONLY.

11. GAIN BAL. Adjustment (SN 2999)

Remove the calibrator signal from the Channel A INPUT connector and apply the signal to the Channel B INPUT connector. Set the MODE switch to B ONLY. Use the Channel B VERTICAL POSITION control to position the waveform to the center of the crt. Adjust the GAIN BAL. control (see Fig. 5-2) to obtain exactly two centimeters of vertical deflection. (Calibrated gain accuracy will be no better than $\pm 3\%$ due to the $\pm 3\%$ accuracy of the Amplitude Calibrator.)

12. Check VARIABLE VOLTS/CM Control (Both Channels)

Rotate the Channel B 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 (typical ratio is 1.9 to 1). Then return the control to its CAL position.

Apply the calibrator signal to Channel A INPUT connector and place the MODE switch to A ONLY. Check the Channel A VARIABLE VOLTS/CM control for proper attenuation range (typically 1.9 to 1). Check for smooth electrical and mechanical operation. Then return the control to its CAL position.

Calibration—Type 82

13. Check AC-DC-GND Switch (Both Channels)

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

Apply the calibrator signal to Channel B. Set the MODE switch to B ONLY and Channel B AC-DC-GND switch to AC. Observe that the waveform shifts downward about one centimeter. Switch AC-DC-GND switch to GND position. The waveform should disappear. Return the Channel B AC-DC-GND switch to its DC position.

14. Check V/CM Switch Attenuation Ratios (Both Channels)

This step checks the calibrated deflection factors of the Type 82 for both channels. While making the check, be sure the VARIABLE VOLTS/CM controls are set fully clockwise to their CAL positions. Then proceed as follows:

Use the Channel B VERTICAL POSITION control to align the waveform with the horizontal graticule lines so the amplitude measurement can be made easily. Check for proper vertical deflection at each position of the Channel B V/CM switch. Use Table 5-1 as a convenient guide. Amplitude tolerance for each attenuator V/CM switch setting should be within $\pm 6\%$. (V/CM switch attenuator and oscilloscope-calibrator tolerance are each $\pm 3\%$). The tolerance of the precision calibrator used at the factory to check the Type 82 attenuators is $\pm 1/4\%$.

TABLE 5-1

V/CM Switch Attenuation Check

V/CM Switch Setting	Amplitude Calibrator Output	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*	100 Volts	2

* Found in plug-ins SN 3000-up.

After completing the check for Channel B, set the Amplitude Calibrator switch to .2 Volt and apply the signal to Channel A. Set the MODE switch to A ONLY and repeat this step to check the vertical deflection at each position of the Channel A V/CM switch.

After completing the check for Channel A, set the Amplitude Calibrator switch to Off.

15. Channel A X1 POSITION RANGE Fine Adjustment

Rotate the oscilloscope Stability control fully clockwise. Set the Type 82 front-panel controls as follows:

V/CM (Chan. A)	2
VERTICAL POSITION (Chan. A)	Centered (0°)
GAIN	X10

If the trace moved off the screen, adjust the Channel A X10 POSITION RANGE control to position the trace onto the screen. Then adjust the Channel A X1 POSITION RANGE control for minimum trace shift while rotating the Channel A VARIABLE VOLTS/CM control. Keep the trace on the crt by adjusting the Channel A X10 POSITION RANGE control.

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

16. Channel B X1 POSITION RANGE Fine Adjustment

Set the Type 82 front-panel controls to these settings:

V/CM (Chan. B)	2
VERTICAL POSITION (Chan. B)	Centered (0°)
MODE	B ONLY

If the trace moved off the screen, adjust the Channel B X10 POSITION RANGE control to position the trace onto the screen. Then adjust the Channel B X1 POSITION RANGE control for minimum trace shift while rotating the Channel B VARIABLE VOLTS/CM control. Keep the trace on the crt by adjusting the Channel B X10 POSITION RANGE control.

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

17. Channel B X10 GAIN Adjustment

Disconnect the coaxial cable from the Channel A INPUT connector and connect the cable to Channel B INPUT connector. Set the oscilloscope Amplitude Calibrator switch to 20 millivolts. Set the Type 82 Channel B V/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 B X10 POSITION RANGE control. Adjust Channel B X10 GAIN control (see Fig. 5-2) so the waveform is exactly two centimeters in amplitude.

18. Channel A X10 GAIN Adjustment

Apply the 20-millivolt calibrator signal to Channel A INPUT connector. Set Channel A V/CM switch to .01 and the MODE switch to A ONLY. Position the waveform to the center of the crt with the A X10 POSITION RANGE control.

Adjust Channel A X10 GAIN control (see Fig. 5-2) so the waveform is exactly two centimeters in amplitude. Disconnect the cable and the adapter.

19. Check for Microphonics (Both Channels)

This step checks for excessive ringing-type microphonics in the nuvistors with the GAIN switch set to X10.

To make the check rotate the Stability control fully clockwise to free run the sweep. Ground the Input Connector, or if the Type 82 has a serial number of 3000 or higher, the GND position on the AC-DC-GND switch may be used. After grounding the input tap lightly on the front panel of the Type 82. Watch for microphonics on the crt screen. Sustained microphonics should be less than one centimeter in amplitude.

Set the MODE switch to B ONLY and check for microphonics as described in the previous paragraph.

20. * Channel B GRID CURRENT ZERO Adjustment

Using a small screwdriver, short the center conductor of the Channel B 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 V233 grid current, first unground the Channel B INPUT connector. Then, adjust the B GRID CURRENT ZERO control (see Fig. 5-2) 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 Channel B INPUT connector to ground. If there is trace shift, carefully readjust the B GRID CURRENT ZERO control until there is no trace shift.

If the trace shift cannot be eliminated by means of the B GRID CURRENT ZERO control, replace V233. If V233 is replaced, repeat steps 11, 16, 19 and this step before going to the next step.

NOTE

Allow at least 10 minutes warmup time for the replaced tube to stabilize before repeating step 20.

21. * Channel A GRID CURRENT ZERO Adjustment

Set the MODE switch to A ONLY. Then, using a small screwdriver, ground the Channel A INPUT connector. If the trace shifts vertically, note the position of the trace and continue with this step. If there is no trace shift, unground the connector and proceed to the next step.

To cancel trace shift due to V133 grid current, first unground the Channel A INPUT center conductor. Then, adjust the A GRID CURRENT ZERO control (see Fig. 5-2) to position the trace to the point noted at the beginning of this step.

* On instruments SN 3000-up, ground the input connector by setting AC-DC-GND to GND. Where the input does not have to be grounded, return the switch to DC.

Check on the accuracy of your adjustment by intermittently shorting the Channel A INPUT connector to ground. If there is trace shift, carefully readjust the A GRID CURRENT ZERO control for no trace shift.

If the trace shift cannot be eliminated by adjusting the A GRID CURRENT ZERO control, replace V133. If V133 is replaced, repeat steps 10, 11, 15, 19 and this step before going to the next step.

22. Channel A X10 POSITION RANGE Adjustment

First repeat step 15 to make sure the Channel A X1 POSITION RANGE control is still in proper adjustment. Slight readjustment of this control may be necessary due to normal circuit drift. Be certain the Channel A 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 Channel A X10 POSITION RANGE control to position the trace to coincide with the center horizontal graticule line. Set Channel A POLARITY switch to INVERT. The trace should not shift more than ± 1 centimeter from the center graticule line.

Set the GAIN switch to X1 and the A POLARITY switch to NORM. Trace shift should not be greater than ± 1 centimeter from the Type 82 distributed-amplifier electrical center.

23. Channel B X10 POSITION RANGE Adjustment

First, set the GAIN switch to X10 and the MODE switch to B ONLY. Repeat step 16 to make sure Channel B X1 POSITION RANGE control is still in proper adjustment. Be certain that the B VERTICAL POSITION control is set to exactly 0°. (For an exact 0° setting, use the voltmeter to obtain a reading of zero volts as described in step 2.)

Adjust Channel B X10 POSITION RANGE control to make the trace coincide with the center horizontal graticule line. Set the Channel B POLARITY switch to INVERT. and check the amount of trace shift. The trace should not shift more than ± 1 centimeter from the center horizontal graticule line.

Set the GAIN switch to X1 and the B POLARITY switch to NORM. The trace should not shift more than ± 1 centimeter from the Type 82 distributed-amplifier electrical center.

24. Channel B Input Time Constant Standardization and Attenuator Compensation

This step is a combination procedure which describes a method of adjusting the input capacitance of each channel so the input time constant is the same for each position of the V/CM switch. This permits a P6008 probe, when compensated using one setting of the V/CM switch, to be used

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for all settings of either V/CM switch without readjustment. In addition this procedure describes a method for compensating the attenuators so that the ac attenuation is equal to the dc attenuation.

Turn on the Type 105 Square-Wave Generator, or equivalent. Set the generator for an output frequency of 2.5 kc and its output amplitude to minimum. Connect an adapter (Part No. 103-015) to the Output connector of the Type 105. Connect a coaxial cable (Part No. 012-057) to the adapter. To the other end of the cable, connect a 10:1 attenuator (Part No. 010-314), another adapter (Part No. 103-015), and a 15-pf input time constant standardizer [item 5]—in that order—to the Channel B INPUT connector. Fig. 5-6 shows the complete setup.

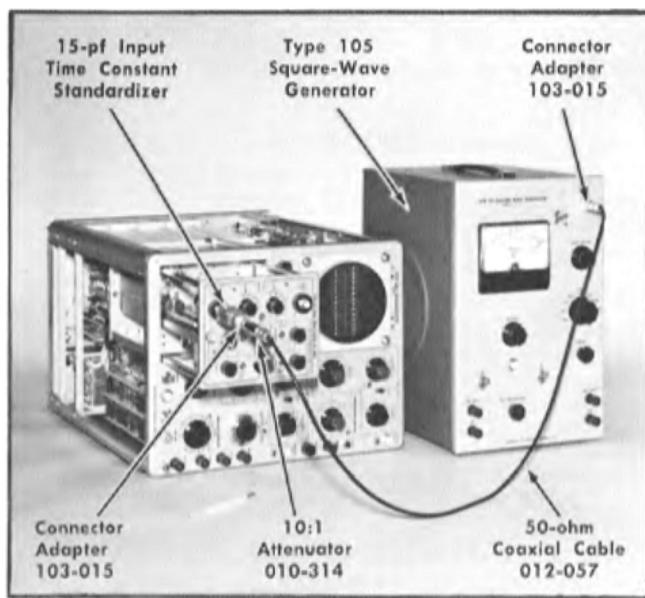


Fig. 5-6. The manner in which the Type 105 Square-Wave Generator should be connected to the Type 82 to perform the first part of step 24.

Increase the output amplitude of the generator to produce a vertical deflection of about 3 centimeters on the crt. Set the 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 display. Use the B 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 Channel B V/CM switch and the adjustments to make for each setting. The adjustments are divided into two columns according to their purpose and their effect on the waveform.

Fig. 5-7 shows the locations of the adjustments including the V/CM switch setting used for each set of adjustments. Fig. 5-8 shows the effect on the waveform when any of the input-capacitance adjustments are varied. As an example, C206 was misadjusted to obtain the waveforms used in the Fig. 5-8a and b waveform illustrations.

TABLE 5-2 (SN 3000-up)

Channel B V/CM Switch Setting	Input Time Constant Standardization*	Attenuator Compensation**
.1	C206	None
.2	C207B	C207C
.5†	C208B	C208C
1	C209B	C209C
2	C210B	C210C
5	C211B	C211C
10	C212B	C212C
20††	C213B	C213C
50†††	C214B	C214C

TABLE 5-2 (SN 101-2999)

Channel B V/CM Switch Setting	Input Time Constant Standardization*	Attenuator Compensation**
.1	C227	None
.2	C203B	C203C
.5†	C205B	C205C
1	C207B	C207C
2	C209B	C209C
5	C211B	C211C
10	C213B	C213C
20††	C215B	C215C

*Use a 0.5-millisecl/cm sweep rate and adjust for optimum flat top.

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

†Remove the 10:1 attenuator for the rest of the step.

††Maximum amplitude of the display is about 2.5 cm since 100 volts is approximately the maximum output obtained from the Type 105 and the standardizer attenuates the signal 2X.

†††Maximum amplitude of the display is about 1 cm.

Fig. 5-9a, c and d show the combined effect obtained when both the input capacitance and the attenuator compensation adjustments are varied; for example, C209B and C209C respectively. Fig. 5-9b shows how the fast rolloff (see Fig. 5-9a) was corrected by adjusting C209C. For Figs. 5-9c and d, C209B was misadjusted to make the flat tops of the waveform slope downward while C209C was misadjusted to cause a fast rolloff (see Fig. 5-9c) and a spike (see Fig. 5-9d). Fig. 5-9e shows the waveform obtained when C209C was adjusted for no fast rolloff or spike.

Finally, to make the waveforms shown in Figs. 5-9b and e display a flat top, the sweep rate should be set to 0.5 millisecl/cm and then C209B, for this example, should be adjusted to obtain a waveform similar to that shown in Fig. 5-8c.

When making the adjustments, maintain 3 centimeters of vertical deflection by adjusting the generator Output Amplitude control each time the V/CM switch is moved from one

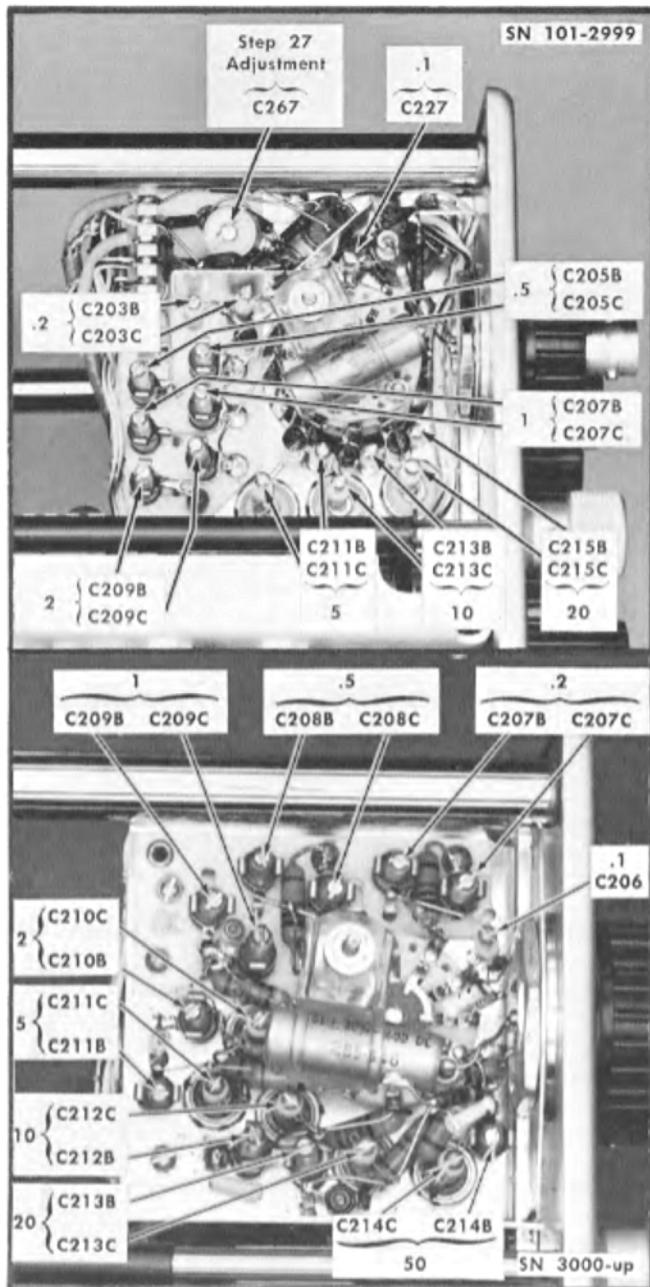


Fig. 5-7. Locations of Channel B internal adjustments described in steps 24 and 27.

position to the next. In the .5 V/CM switch position it will be necessary to remove the 10:1 attenuator to obtain more signal to drive the Type 82 for the rest of the step.

To prevent a shock hazard, turn the generator DC ON-OFF switch to OFF (or set the generator Output Amplitude control for minimum output) before removing the attenuator. Then turn the switch ON. If the waveform amplitude is too high after removing the attenuator and if the generator Output Amplitude control is set to minimum, use the Type 82 Channel B VARIABLE VOLTS/CM control to decrease the

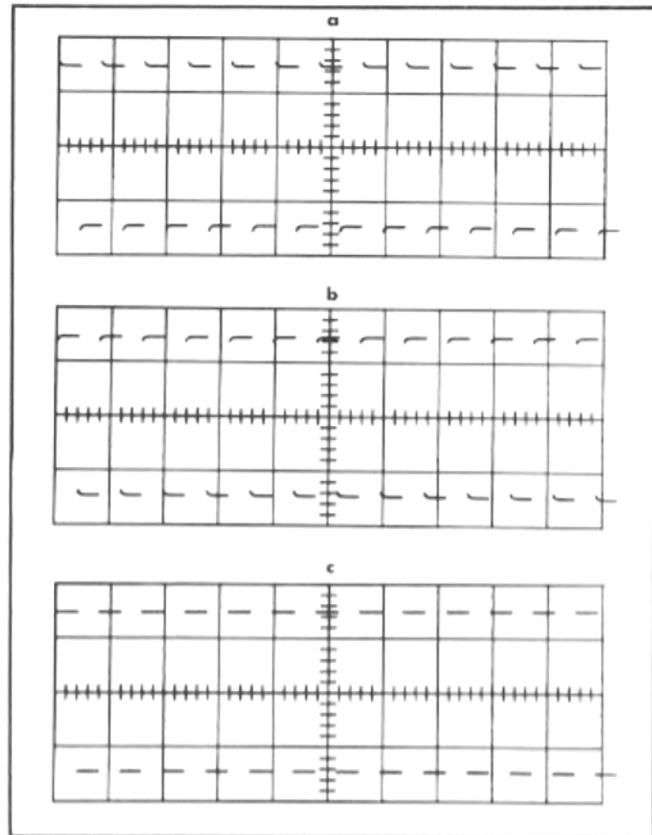


Fig. 5-8. Standardizing the input time constant; for example, when adjusting C227. (a) and (b) show the effect on the waveform when C227 is improperly adjusted; (c) is the desired result obtained when C227 is properly adjusted. Square-wave repetition rate: 2.5 kc; sweep rate: 0.5 millisecl/cm.

amplitude. After completing the .5 V/CM attenuator adjustments, set the VARIABLE VOLTS/CM control to CAL. and continue with the adjustments that remain.

25. Channel A Input Time Constant Standardization and Attenuator Compensation

This step is similar to step 24. Therefore, use the information given in step 24 when performing this step. To make the adjustments, set the Type 82 MODE switch to A ONLY. Use the same setup as that shown in Fig. 5-6 except the signal must be applied to Channel A INPUT connector. (SN 101-2999, If you have constructed a metal shield, item 9, install the shield over the protruding part of the Type 82 so the access holes are positioned over the Channel A input-capacitance and attenuator adjustments.)

Table 5-3 lists the settings of the Channel A V/CM switch and the adjustments to make for each setting.

Fig. 5-10 shows the locations of the adjustments including the V/CM switch setting that is used for each set of adjustments. The effects the adjustments have on the waveforms are the same as those shown in Figs. 5-8 and 5-9. Make the adjustments through the metal shield if it was installed in the beginning of this step.

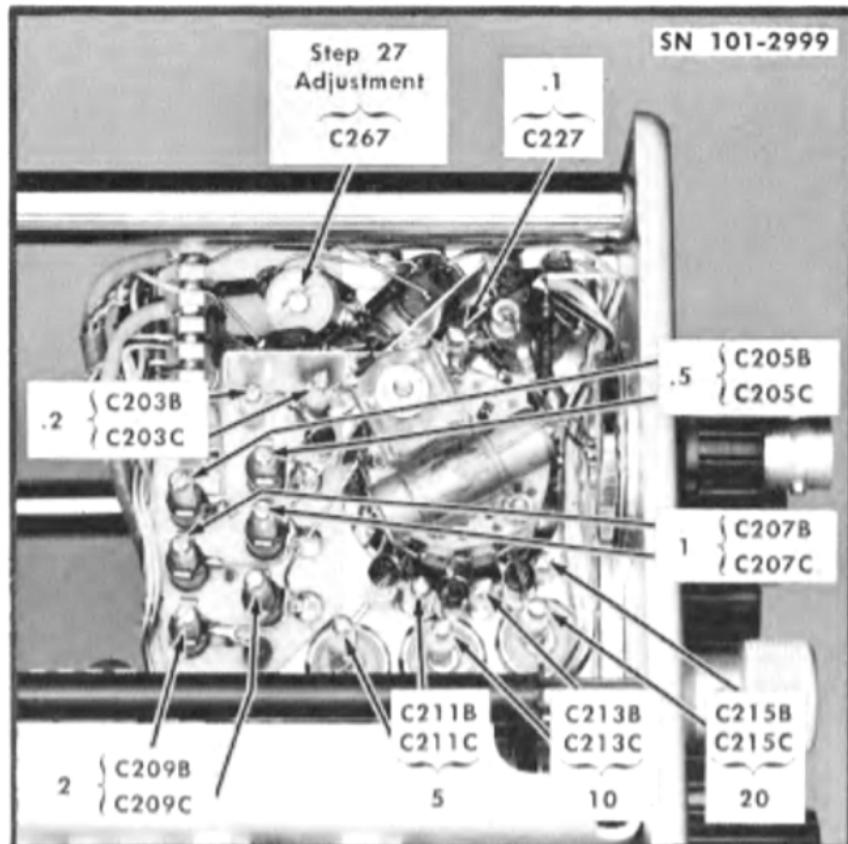


Fig. 5-7. Locations of Channel B internal adjustments described in steps 24 and 27

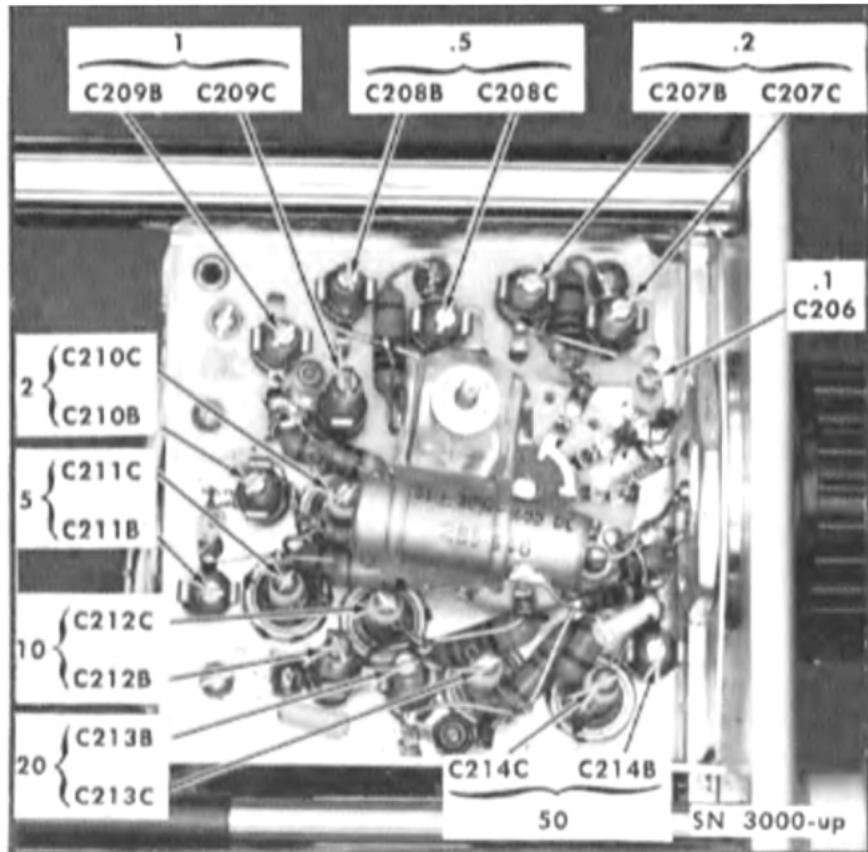


Fig. 5-7. Locations of Channel B internal adjustments described in steps 24 and 27.

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After completing this step, remove the 6½-inch plug-in extension and the metal shield. Plug the Type 82 directly into the oscilloscope plug-in compartment. Install the bottom and left side panels on the oscilloscope. Repeat steps 24 and 25 to check the accuracy of your adjustments.

TABLE 5-3 (SN 3000-up)

Channel A V/CM Switch Setting	Input Time Constant Standardization*	Attenuator Compensation**
.1	C106	None
.2	C107B	C107C
.5†	C108B	C108C
1	C109B	C109C
2	C110B	C110C
5	C111B	C111C
10	C112B	C112C
20††	C113B	C113C
50†††	C114B	C114C

TABLE 5-3 (SN 101-2999)

Channel A V/CM Switch Setting	Input Time Constant Standardization*	Attenuator Compensation**
.1	C127	None
.2	C103B	C103C
.5†	C105B	C105C
1	C107B	C107C
2	C109B	C109C
5	C111B	C111C
10	C113B	C113C
20††	C115B	C115C

*Use a 0.5-millisecond/cm sweep rate and adjust for optimum flat top.

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

†Remove the 10:1 attenuator for the rest of the step.

††Maximum amplitude of the display is about 2.5 cm since 100 volts is approximately the maximum output obtained from the Type 105.

†††Maximum amplitude of the display is about 1 cm.

"Touch-up" any of the adjustments that are affected by the change in environment. (For access to the adjustments, the plug-in extension and shield, if used, will have to be used again. As an alternate method, the Type 82 can be unplugged with the oscilloscope on. Turn the adjustment slightly, and then replug the Type 82 into the oscilloscope to check the results. Repeat this method until the adjustment is correct.)

Disconnect the 15-pf Input Time Constant Standardizer and turn off the Type 105 Square-Wave Generator or equivalent.

26. Channel A X1 High Frequency Compensation

Remove the bottom and left side panels from the oscilloscope. Connect a 50-ohm coaxial cable to the calibrator

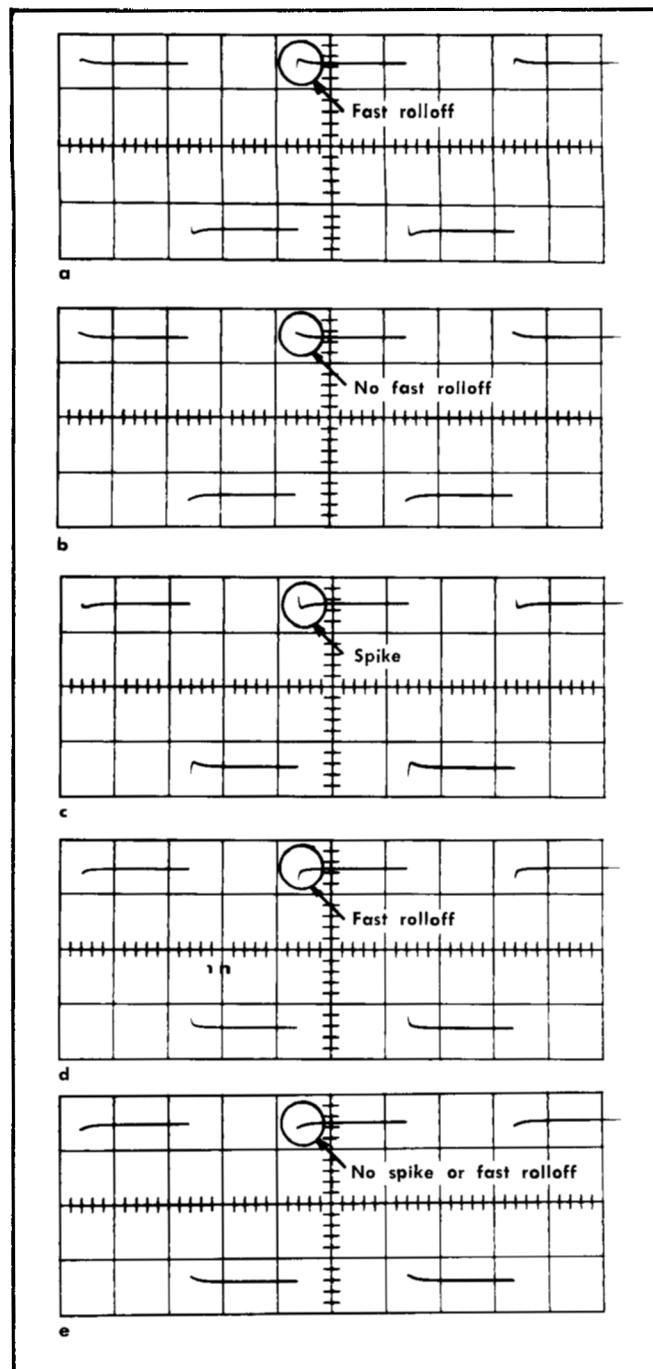


Fig. 5-9. Effect of the input-capacitance and attenuator adjustments on the waveform when both are misadjusted as in (a), (c) and (d). Waveforms (b) and (e) show desired result obtained when the attenuator adjustment is set for no fast rolloff or spike (see text). Square-wave repetition rate: 2.5 kc; sweep rate: 0.1 millisecond/cm.

output connector and to a TU-5 Pulser. Connect a 50-ohm termination between the output connector of the TU-5 Pulser and the INPUT A connector of the Type 82. Fig. 5-11 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 μ sec.

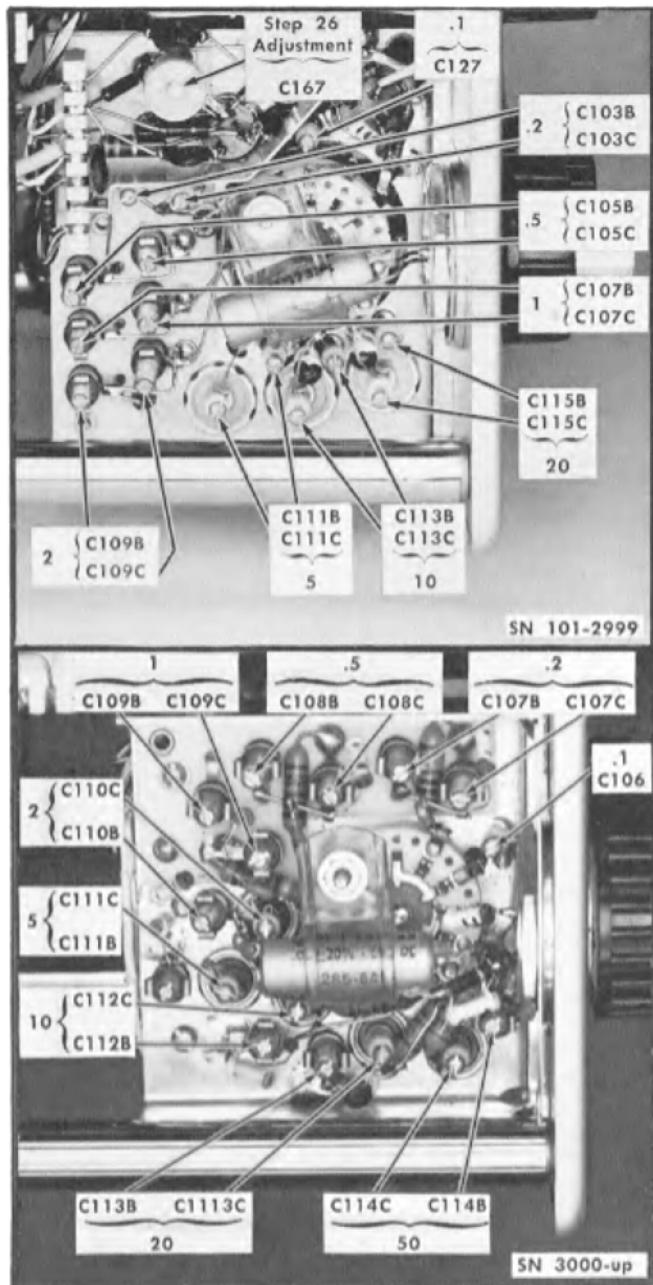


Fig. 5-10. Top left corner of the Type 82 showing locations of Channel A internal adjustments described in steps 25 and 26.

Set the Type 82 Channel A V/CM to the .1 position. Rotate the pulser knob slowly clockwise from a fully counter-clockwise position until the tunnel diode triggers and produces a step waveform display on the crt. Amplitude of the waveform should be 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 leading flat-top portion of the waveform will roll off excessively and this is undesirable.)

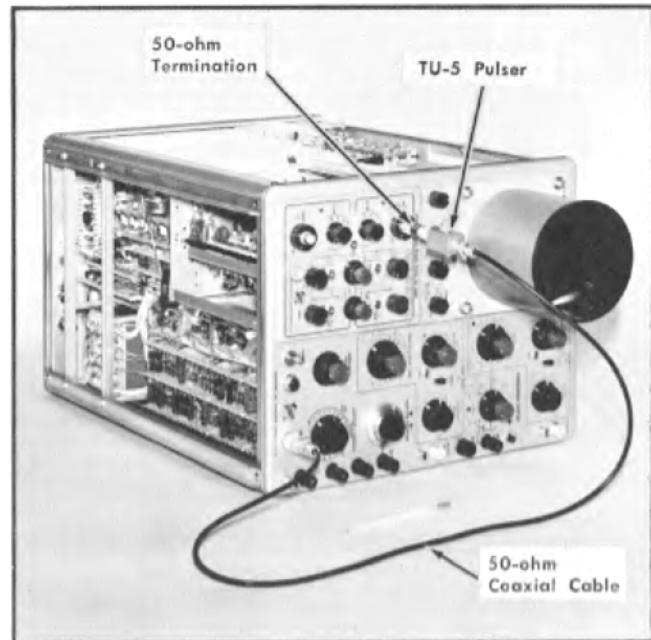


Fig. 5-11. Setup used for high-frequency compensation adjustments.

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 appropriate Type 82 VERTICAL POSITION control to position the waveform for best viewing.

Examine the waveform display produced by the system when using the same sweep rates as those shown in the illustrations of Fig. 5-12. If the leading corner distortion of the waveform exceeds ± 2 trace widths in amplitude, adjust C167, C168 and C524 [see Figs. 5-10 and 5-13] for optimum square corner. The portion of the front leading corner affected by each adjustment is pointed out in Table 5-4.

TABLE 5-4 (SN 101-2999)

Adjustment	Approx. Time Duration (as measured from the leading corner)
C167	3 nsec
C168	20 nsec
C524	15 nsec

TABLE 5-4 (SN 3000-up)

Adjustment	Approx. Time Duration (as measured from the leading corner)
C167	3 nsec
C168	12 nsec
C524	20 nsec

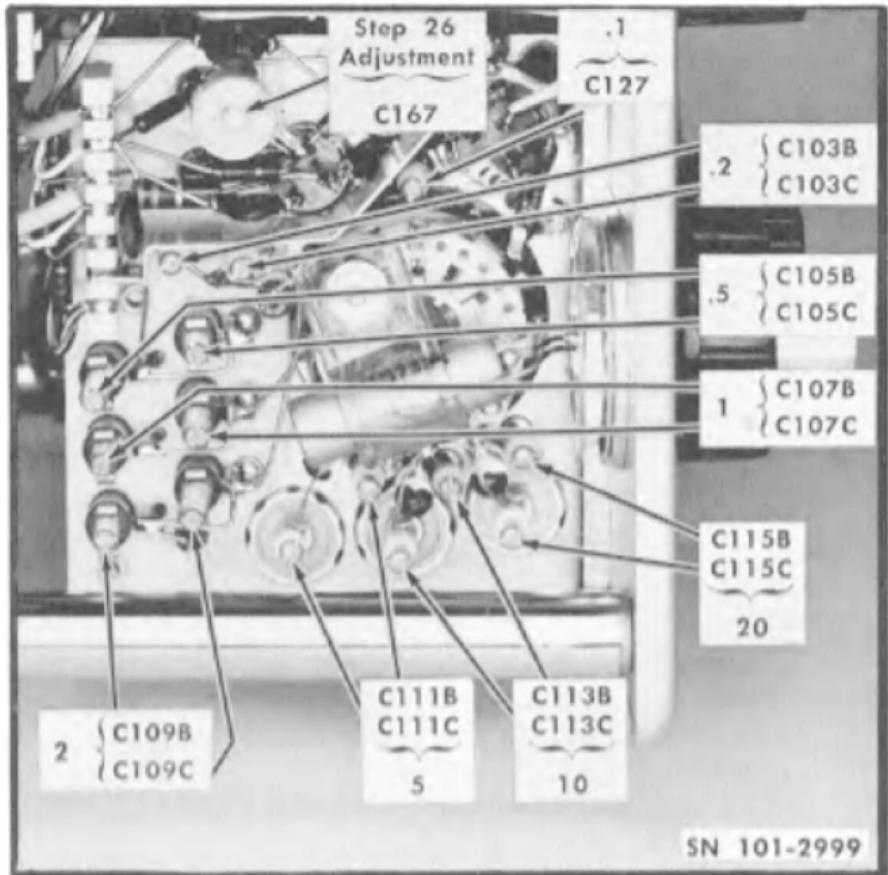


Fig. 5-10. Top left corner of the Type 82 showing locations of Channel A internal adjustments described in steps 25 and 26.

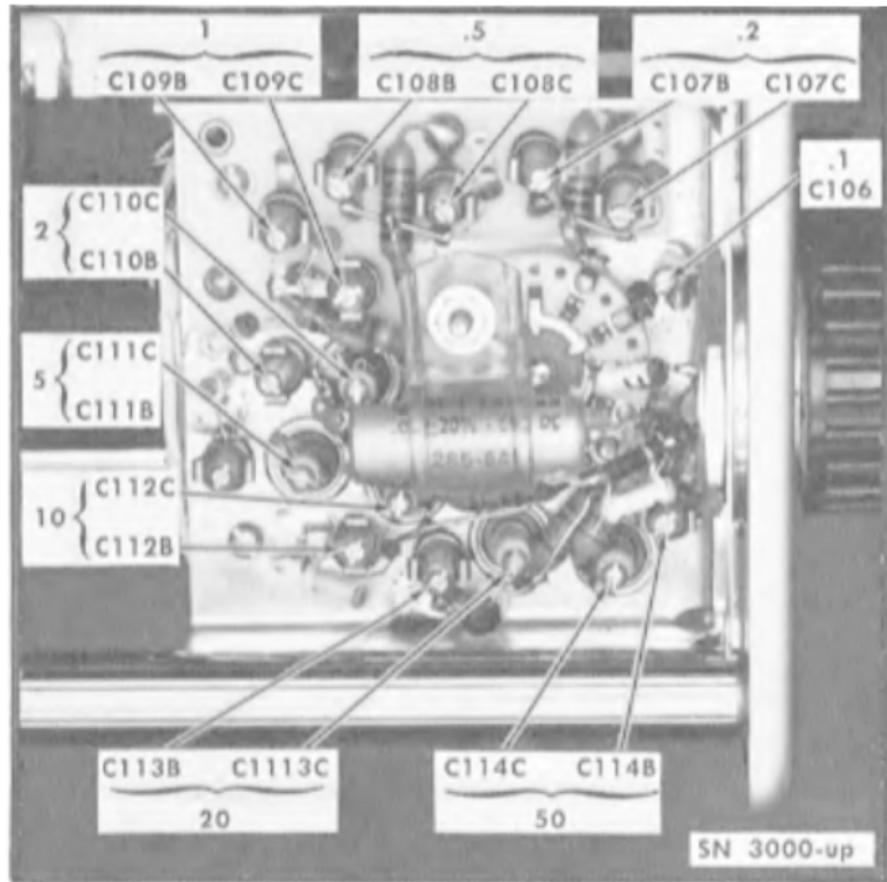


Fig. 5-10. Top left corner of the Type 82 showing locations of Channel A internal adjustments described in steps 25 and 26.

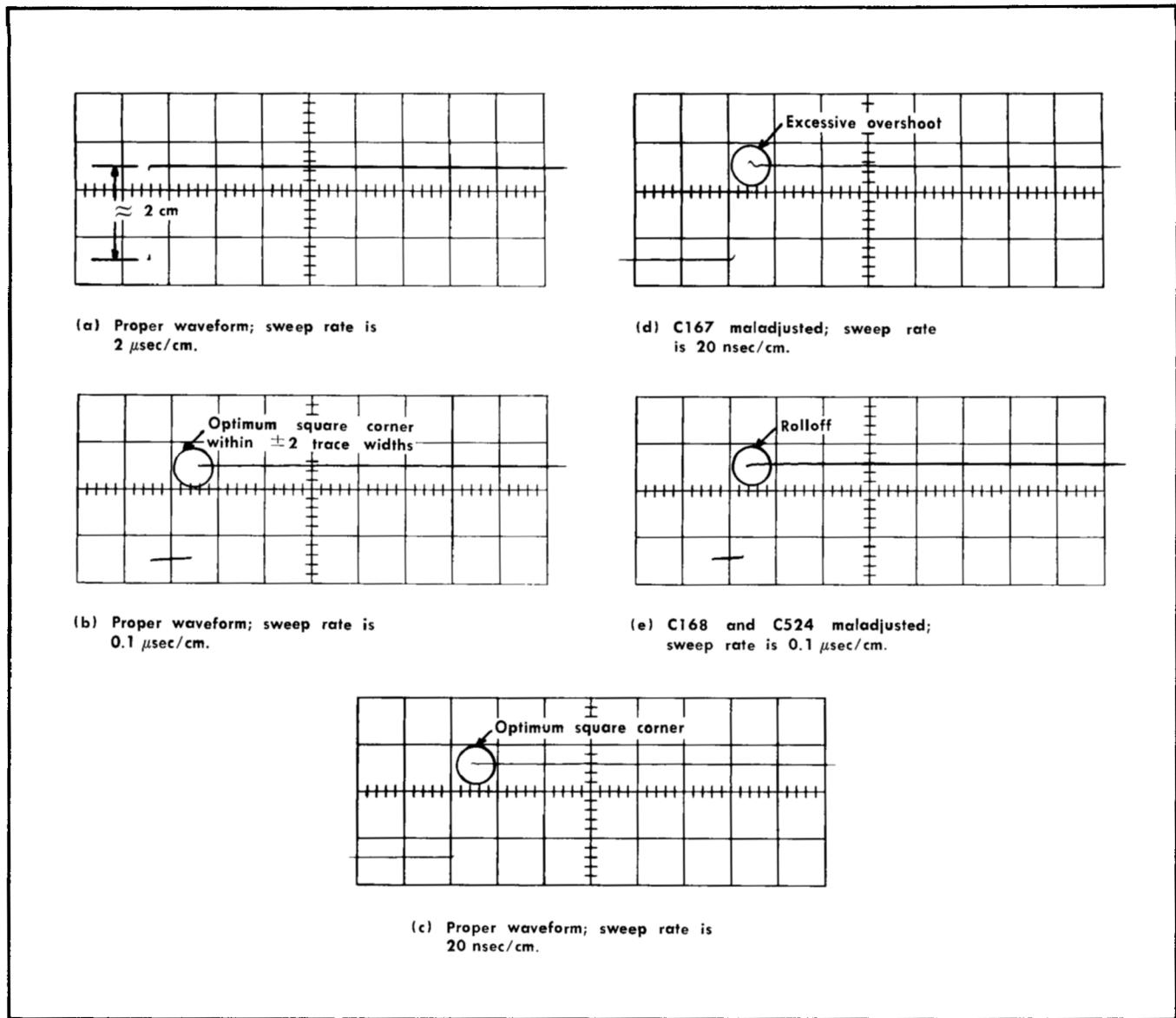


Fig. 5-12. GAIN switch set to X1. Using different sweep rates, waveforms a, b and c show typical displays obtained when C167, C168 and C524 are properly adjusted. Waveform d shows result obtained when C167 is maladjusted; C168 and C524 are both misadjusted to obtain waveform e.

NOTE

The 6½" plug-in extension can be used while adjusting C167. After making the adjustment, recheck the adjustment accuracy by observing the display without using the extension. As an alternate method, unplug the Type 82 momentarily (with the oscilloscope on) and adjust C167. Then re-insert the unit to check adjustment accuracy.

27. Channel B X1 High-Frequency Compensation

Disconnect the output end of the 50-ohm termination from the INPUT A connector and connect it to the INPUT B connector. Now that the pulses are applied to Channel B, set

the Channel B V/CM switch to .1 and the MODE switch to B ONLY.

Observe the waveform using sweep rates such as those that were used to perform the previous step. If the front corner distortion of the waveform exceeds ± 2 trace widths for the 2-centimeter high pulse, adjust C267 and C268 (see Figs. 5-7 and 5-13) for optimum square corner. These two adjustments cause the same effect on the waveform as do C167 and C168, respectively for Channel A.

28. Channel B X10 High-Frequency Compensation

Insert a 50-ohm 10:1 attenuator between the pulser output and the 50-ohm termination. Set the GAIN switch to X10.

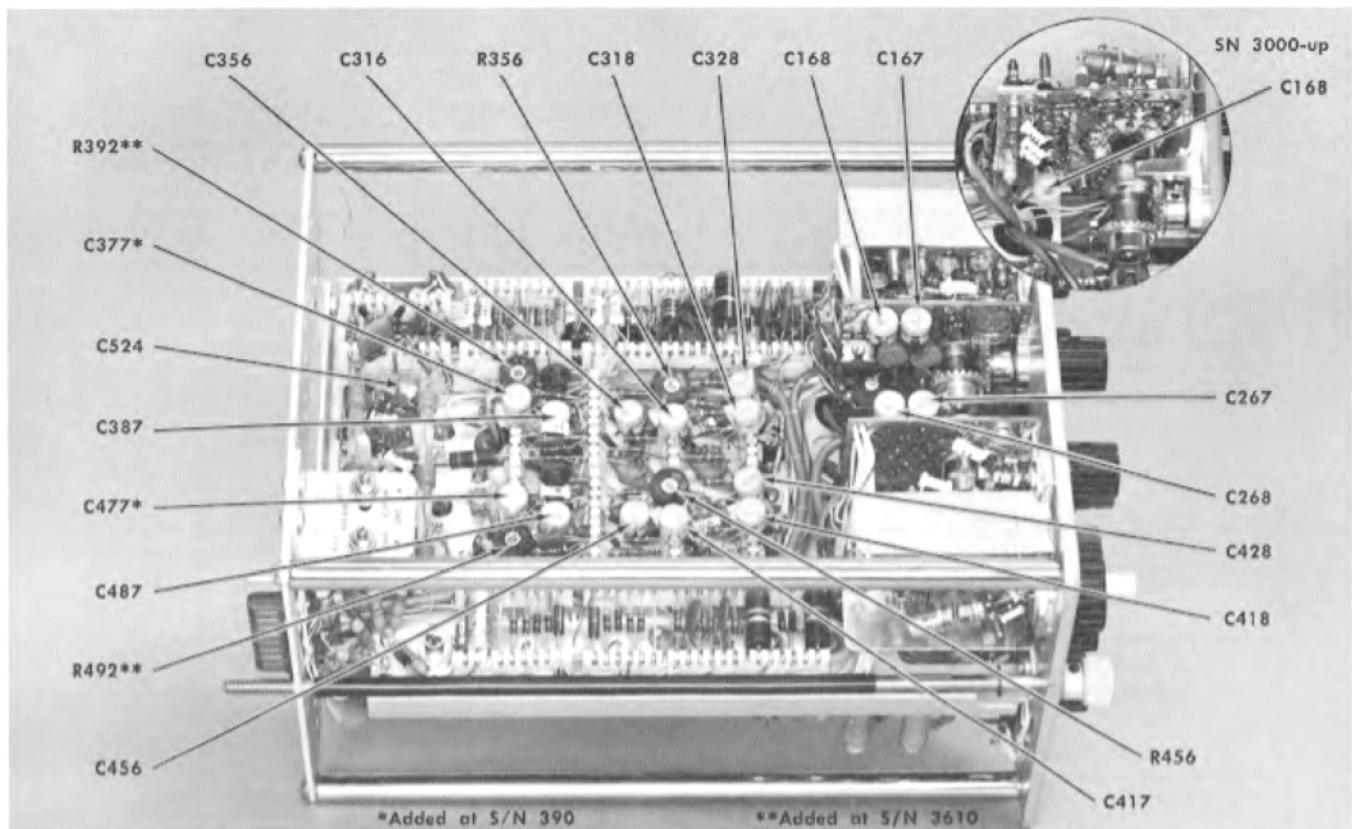


Fig. 5-13. Left side view showing locations of high-frequency adjustments.

Using the same oscilloscope sweep rates as those used to obtain the oscilloscopes shown in Fig. 5-14 a, 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-nsec-duration portion of the front corner of the waveform is not within ± 1 millimeter of being square, adjust C417, C418, C456, C477*, C487 and R492** (see Fig. 5-13) for optimum square corner and amplitude level. The portion of the waveform that each of these adjustments affects is given in Table 5-5.

TABLE 5-5

Adjustment	Approx. Time Duration (as measured from the front leading corner)
C417	4 nsec
C418	60 nsec
C428	20 nsec
C456	8 nsec
C477*	100 nsec
C487	6 nsec
R492**	Affects all 100 nsec

29. Channel A X10 High-Frequency Compensation

Disconnect the output end of the 50-ohm termination from INPUT B and connect the output to INPUT A connector. Set the MODE switch to A ONLY.

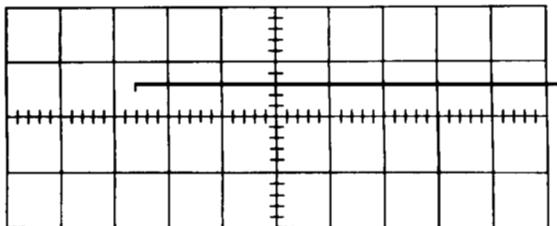
If the waveform display does not have a square corner which is within ± 1 millimeter as shown in Fig. 5-14 a, b and c (based on a waveform amplitude of 2 centimeters), adjust C316, C318, C328, C356, C377*, C387 and R392** (see Fig. 5-13) for optimum square corner and amplitude level. Use various sweep rates to examine the waveform from time to time to obtain best overall results. The Channel A high-frequency adjustments have the same effect on the waveform as the corresponding adjustments did for Channel B.

After completing this step turn off the calibrator. Disconnect the various items connected to the Type 82 and the oscilloscope.

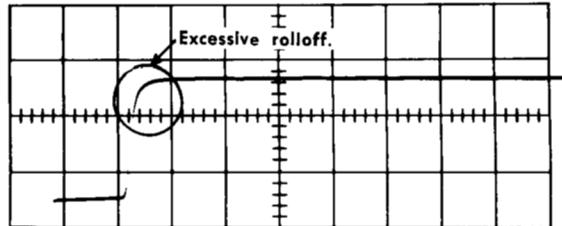
*Added in Type 82 Plug-in Units S/N 390 and up.

**Added in Type 82 Plug-In Units SN 361D-up.

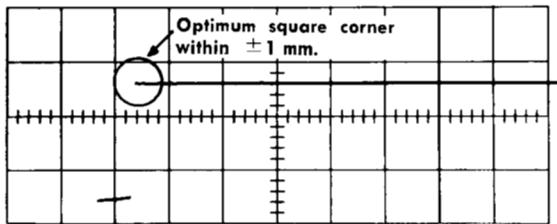
Calibration — Type 82



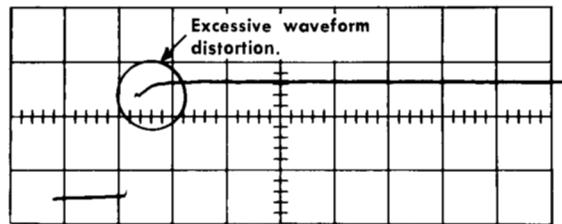
(a) Proper waveform; sweep rate is 1 μ sec/cm.



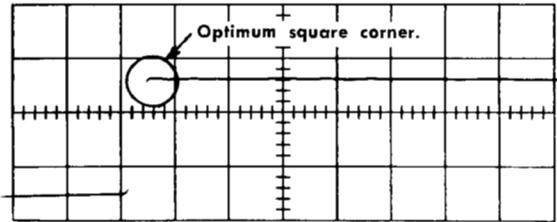
(e) C417, C456 and C487 maladjusted; sweep rate is 40 nsec/cm.



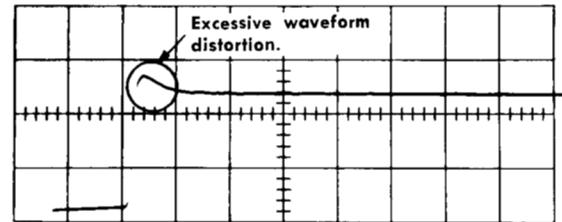
(b) Proper waveform; sweep rate is 0.1 μ sec/cm.



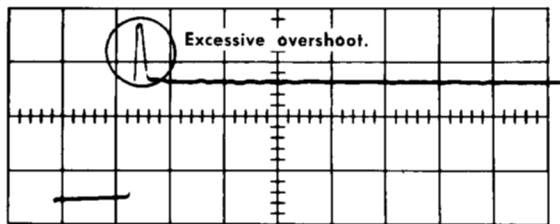
(f) C418 and C428 maladjusted; sweep rate 40 nsec/cm.



(c) Proper waveform; sweep rate is 20 nsec/cm.



(g) C418 and C428 maladjusted; sweep rate is 40 nsec/cm.



(d) C417, C456 and C487 maladjusted; sweep rate is 40 nsec/cm.

Fig. 5-14. GAIN switch set to X10. Using different sweep rates, waveforms a, b and c show typical displays obtained when the X10 amplifier is working normally and is correctly adjusted. Oscilloscopes d, e, f and g illustrate effects obtained when the adjustments are incorrectly made.

SECTION 6

PARTS LIST AND SCHEMATICS

PARTS ORDERING INFORMATION

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

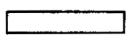
Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information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

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

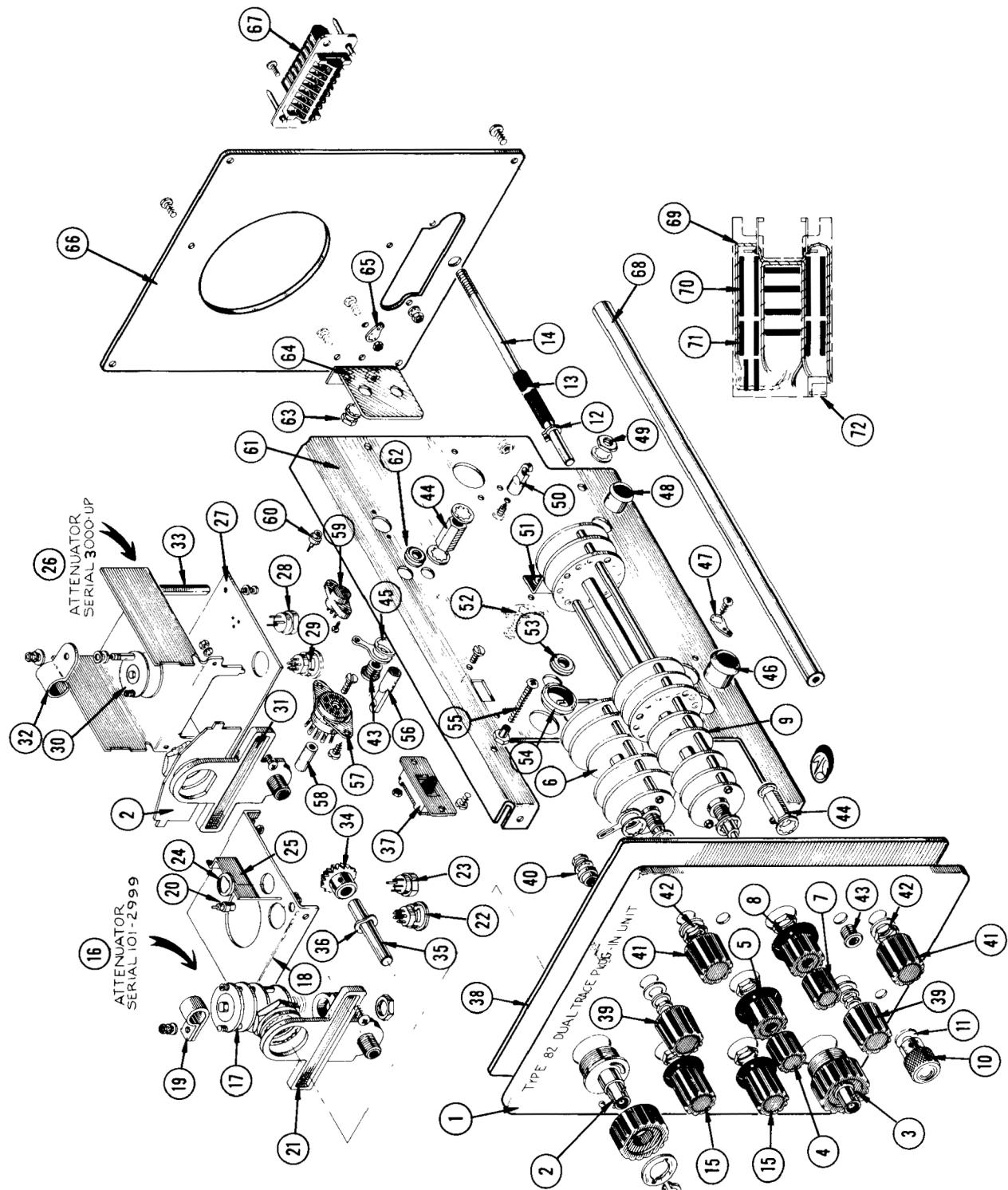
ABBREVIATIONS AND SYMBOLS

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

SPECIAL NOTES AND SYMBOLS

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

EXPLODED VIEW



EXPLODED VIEW

REF. NO.	PART NO.	SERIAL NO.		Q T Y.	DESCRIPTION
		EFF.	DISC.		
1	333-705	101	2999	1	PANEL, front
	333-784	3000		1	PANEL, front
2	260-457	101	2999	1	SWITCH, AC-DC, channel A includes:
	366-179			1	KNOB, AC-DC, black
	210-951			1	WASHER, locating
	354-179			1	RING, retaining
	Mounting Hardware: (not included)
	210-047			1	LOCKWASHER, internal, .1110 OD x .880 inch ID
	210-568			1	NUT, mounting, $\frac{7}{8}$ -32 x $1\frac{1}{8}$ inch diameter
	260-573	3000		1	SWITCH, AC-DC, channel A includes:
	366-259			1	KNOB, AC-DC, black
	210-951			1	WASHER, locating
	354-179			1	RING, retaining
	Mounting Hardware: (not included)
	210-568			1	NUT, mounting, $\frac{7}{8}$ -32 x $1\frac{1}{8}$ inch diameter
	337-601			1	SHIELD, attenuator
3	260-458	101	2999	1	SWITCH, AC-DC, channel B
			1	Includes:
	366-180			1	KNOB, AC-DC, black
	210-951			1	WASHER, locating
	354-179			1	RING, retaining
	Mounting Hardware: (not included)
	210-047			1	LOCKWASHER, internal, .1110 OD x .880 inch ID
	210-568			1	NUT, mounting, $\frac{7}{8}$ -32 x $1\frac{1}{8}$ inch diameter
	260-577	3000		1	SWITCH, AC-DC, channel B
			1	Includes:
	366-180			1	KNOB, AC-DC, black
	210-951			1	WASHER, locating
	354-179			1	RING, retaining
	Mounting Hardware: (not included)
	210-568			1	NUT, mounting, $\frac{7}{8}$ -32 x $1\frac{1}{8}$ inch diameter
	337-601			1	SHIELD, attenuator
4	366-177			1	KNOB, B POLARITY, small red
			1	Includes:
	213-004			1	SCREW, set, 6-32 x $\frac{3}{16}$ inch HSS
5	366-126			1	KNOB, A POLARITY, black
			1	Includes:
	213-004			1	SCREW, set, 6-32 x $\frac{3}{16}$ inch HSS
6	260-460			1	SWITCH, POLARITY, unwired
			1	Mounting Hardware: (not included)
	210-413			1	NUT, hex, $\frac{3}{8}$ -32 x $\frac{1}{2}$ inch
	210-012			1	LOCKWASHER, internal, $\frac{3}{8}$ x $\frac{1}{2}$ inch
7	366-177			1	KNOB, GAIN, small red
			1	Includes:
	213-004			1	SCREW, set, 6-32 x $\frac{3}{16}$ inch HSS
8	366-126			1	KNOB, MODE, black
			1	Includes:
	213-004			1	SCREW, set, 6-32 x $\frac{3}{16}$ inch HSS
9	262-502			1	SWITCH, MODE, wired
			1	Includes:
	260-459			1	SWITCH, MODE, unwired
			1	Mounting Hardware: (not included)
	210-413			1	NUT, hex, $\frac{3}{8}$ -32 x $\frac{1}{2}$ inch
	210-012			1	LOCKWASHER, internal, $\frac{3}{8}$ x $\frac{1}{2}$ inch
10	366-125			1	KNOB, plug-in securing
	Includes:
	213-004			1	SCREW, set, 6-32 x $\frac{3}{16}$ inch HSS
11	210-894			1	WASHER, polyethelene, $\frac{7}{16}$ inch OD
12	354-025			1	RING, retaining, securing
13	162-011			1	TUBING, plastic, black, #5
14	384-510			1	ROD, securing
		1FT			
			1		

Parts List — Type 82

EXPLODED VIEW

REF. NO.	PART NO.	SERIAL NO.		Q T Y.	DESCRIPTION
		EFF.	DISC.		
15	366-136			2	KNOB, V/CM, black, each includes:
	213-004			1	SCREW, set, 6-32 x $\frac{3}{16}$ inch HSS
16	610-076	101	2999	1	ATTENUATOR UNIT, channel A, wired
	610-077	101	2999	1	ATTENUATOR UNIT, channel B, wired
	Each Includes:
17	262-501			1	SWITCH, V/CM, wired
	Includes:
	260-461			1	SWITCH, unwired
	Mounting Hardware:
	210-413			1	NUT, hex, $\frac{3}{8}$ -32 x $\frac{1}{2}$ inch
18	441-447			1	CHASSIS
	Mounting Hardware:
	211-079			3	SCREW, 2-56 x $\frac{3}{16}$ inch PHS phillips
	210-001			3	LOCKWASHER, internal, #2
	210-405			3	NUT, hex, 2-56 x $\frac{3}{16}$ inch
19	343-085			1	CLAMP, capacitor mounting
	Mounting Hardware:
	210-405			1	NUT, hex, 2-56 x $\frac{3}{16}$ inch
	210-001			1	LOCKWASHER, internal, #2
	210-850			1	WASHER, #2
	210-849			1	WASHER, fiber, #4
20	131-180			1	CONNECTOR, terminal standoff
	358-135			1	BUSHING
21	426-159			1	FRAME, attenuator
22	136-134			2	SOCKET, 4 pin transistor
23	136-131			1	SOCKET, 5 pin
24	354-180			1	RING, mounting, socket
25	406-844			1	BRACKET, shielding
	124-149			1	STRIP, ceramic, $\frac{7}{16}$ inch x 7 notches (not shown)
	Includes:
	355-046			2	STUD, nylon
	Mounting Hardware:
	361-007			2	SPACER, nylon, .063 inch
26	644-005	3000		1	ATTENUATOR UNIT, channel A, wired
	644-006	3000		1	ATTENUATOR UNIT, channel B, wired
	Each Includes:
27	670-043			1	BOARD, etched, attenuator, channel A
	670-044			1	BOARD, etched, attenuator, channel B
	Each Includes:
28	136-150			2	SOCKET, 3 pin transistor
29	136-166			1	SOCKET, 5 pin
30	262-612			1	SWITCH, V/CM, wired
	Includes:
	260-575			1	SWITCH, V/CM, unwired
	Mounting Hardware:
	210-413			1	NUT, hex, $\frac{3}{8}$ -32 x $\frac{1}{2}$ inch
31	426-159			1	FRAME, attenuator
	Mounting Hardware:
	211-079			3	SCREW, 2-56 x $\frac{3}{16}$ inch PHS phillips
	210-001			3	LOCKWASHER, internal, #2
	210-405			3	NUT, hex, 2-56 x $\frac{3}{16}$ inch
32	343-085			1	CLAMP, capacitor mounting
	Mounting Hardware:
	210-405			1	NUT, hex, 2-56 x $\frac{3}{16}$ inch
	210-001			1	LOCKWASHER, internal, #2
	210-850			1	WASHER, #2
	210-849			1	WASHER, fiber, #4
33	361-066			2	SPACER, hex
	Mounting Hardware For Each:
	211-062			2	SCREW, 2-56 x $\frac{5}{16}$ inch RHS
	210-001			2	LOCKWASHER, internal, #2

EXPLODED VIEW

REF. NO.	PART NO.	SERIAL NO.		Q T Y.	DESCRIPTION
		EFF.	DISC.		
34	214-272			4	GEAR, miter Each includes: SCREW, set, 6-32 x 1/8 inch HSS
	
	213-020			2	SCREW, set, 6-32 x 1/8 inch HSS
35	384-259			2	ROD, shaft
36	210-839			2	WASHER, 1/4 ID x 7/16 inch OD, rippled
37	260-145			1	SWITCH, slide Mounting Hardware: (not included)
	SCREW, 4-40 x 1/4 inch BHS
	211-008			2	NUT, hex, 4-40 x 3/16 inch
	210-406			2	PLATE, front subpanel
38	387-648			1	KNOB, VARIABLE VOLTS/CM, black Each Includes:
39	366-045			2	SCREW, set, 6-32 x 3/16 inch HSS
	MOUNTING HARDWARE FOR EACH MINIATURE POT:
40	NUT, hex, 1/4-32 x 5/16 inch
	210-583			1	WASHER, 1/4 ID x 3/8 inch OD
	210-940			1	WASHER, fiber, 1/4 ID x 1/2 inch OD
	210-904			1	BUSHING, nylon, panel
41	366-044			2	KNOB, VERTICAL POSITION, black Each Includes:
	SCREW, set, 6-32 x 3/16 inch HSS
42	213-004			1	MOUNTING HARDWARE FOR EACH POT:
	NUT, hex, 3/8-32 x 1/2 inch
	210-413			1	WASHER, .390 ID x 9/16 inch OD
	210-840			1	LOCKWASHER, internal, 3/8 x 1/2 inch
	210-012			1	LUG, solder, 3/8 inch
	210-207			1	BUSHING, banana jack
43	358-054			5	MOUNTING HARDWARE FOR EACH MINIATURE POT:
44	NUT, hex, spacer, 1/4-32 x 5/16 inch
	210-471			1	LOCKWASHER, internal, 1/4 inch
	210-011			1	LUG, solder, 1/4 inch
45	210-223			1	RING, mounting, capacitor
46	354-068			2	LUG, solder, SE4
47	210-201			8	Mounting Hardware For Each: (not included)
	SCREW, thread cutting, 5-32 x 3/16 inch PHS phillips
48	354-176			4	RING, mounting, capacitor
49	MOUNTING HARDWARE FOR DIODE:
	210-445			1	NUT, hex, 10-32 x 3/8 inch
	210-010			1	LOCKWASHER, internal, #10
50	352-022			4	HOLDER, nylon, coil form
	Mounting Hardware For Each: (not included)
	213-035			1	SCREW, thread forming, 4-40 x 1/4 inch PHS phillips
51	406-807			1	BRACKET, switch
	Mounting Hardware: (not included)
	211-507			1	SCREW, 6-32 x 5/16 inch BHS
	210-204			1	LUG, solder, DE6
52	210-204			1	LUG, solder, DE6
	Mounting Hardware: (not included)
	213-044			1	SCREW, thread cutting, 5-32 x 3/16 inch PHS phillips
53	348-004			4	GROMMET, 3/8 inch
54	348-012			2	GROMMET, 5/8 inch
55	MOUNTING HARDWARE FOR EACH RESISTOR:
	211-544			1	SCREW, 6-32 x 3/4 inch THS phillips
	210-478			1	NUT, hex, 5-10 watt resistor
	211-507			1	SCREW, 6-32 x 5/16 inch BHS
56	352-015			4	HOLDER, nylon, coil form
	Mounting Hardware For Each: (not included)
	213-035			1	SCREW, thread forming, 4-40 x 1/4 inch PHS phillips
57	136-072			3	SOCKET, 9 pin
	Mounting Hardware For Each: (not included)
	213-044			2	SCREW, thread cutting, 5-32 x 3/16 inch PHS phillips

Parts List — Type 82

EXPLODED VIEW

REF. NO.	PART NO.	SERIAL NO.		Q T Y.	DESCRIPTION
		EFF.	DISC.		
58	352-052			1	HOLDER, trimmer capacitor
	Mounting Hardware: (not included)
	211-040			1	SCREW, 4-40 x 1/4 inch nylon BHS
59	136-095			18	SOCKET, 4 pin transistor
	Mounting Hardware For Each: (not included)
	213-113			2	SCREW, thread forming, 2-32 x 5/16 inch RHS phillips
60	131-181			5	CONNECTOR, terminal standoff
	131-183			1	CONNECTOR, terminal feed-thru
				Mounting Hardware For Each: (not included)
	358-136			1	BUSHING, nylon
61	441-434			1	CHASSIS
	Mounting Hardware: (not included)
	211-504			2	SCREW, 6-32 x 1/4 inch BHS
	211-538			2	SCREW, 6-32 x 5/16 inch FHS phillips
62	348-003			1	GROMMET, 5/16 inch
63	MOUNTING HARDWARE FOR EACH MINIATURE POT:
	210-583			1	NUT, hex, 1/4-32 x 5/16 inch
	210-046			1	LOCKWASHER, internal, .400 OD x .261 inch ID
64	406-808			1	BRACKET, pot
	Mounting Hardware: (not included)
	211-504			2	SCREW, 6-32 x 1/4 inch BHS
65	210-202			1	LUG, solder, SE6
	Mounting Hardware: (not included)
	211-504			1	SCREW, 6-32 x 1/4 inch BHS
	210-407			1	NUT, hex, 6-32 x 1/4 inch
66	387-688			1	PLATE, rear frame
67	131-017			1	CONNECTOR, chassis mount, 16 contact
	Mounting Hardware: (not included)
	211-008			2	SCREW, 4-40 x 1/4 inch BHS
	210-004			2	LOCKWASHER, internal, #4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
68	384-508			4	ROD, frame
	Mounting Hardware For Each: (not included)
	212-044			1	SCREW, 8-32 x 1/2 inch RHS phillips
69	179-642	101	2999	1	CABLE HARNESS
	179-836	3000		1	CABLE HARNESS
70	124-145			4	STRIP, ceramic, 7/16 inch x 20 notches
	Each Includes:
	355-046			2	STUD, nylon
	Mounting Hardware For Each: (not included)
	361-009			2	SPACER, nylon, .313 inch
71	124-148			14	STRIP, ceramic, 7/16 inch x 9 notches
	Each Includes:
	355-046			2	STUD, nylon
	Mounting Hardware For Each: (not included)
	361-008			2	SPACER, nylon, .188 inch
72	124-120			1	STRIP, ceramic, 7/16 inch x 4 notches
	Includes:
	355-046			2	STUD, nylon
	Mounting Hardware: (not included)
	361-009			2	SPACER, nylon, .313 inch

ACCESSORIES



REF. NO.	PART NO.	SERIAL NO.		Q T Y.	DESCRIPTION
		EFF.	DISC.		
1	010-129 010-130			2 .1	PROBE, package, P6008, BNC Each Includes: PROBE, only, P6008

ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description	S/N Range
Capacitors			
Tolerance $\pm 20\%$ unless otherwise indicated.			
Tolerance of all electrolytic capacitors are as follows (with exceptions):			
	3 V — 50 V = -10%, +250%		
	51 V — 350 V = -10%, +100%		
	351 V — 450 V = -10%, +50%		
C101	285-611	.01 μf	MT 600 v 101-2999
C101†	285-646	.01 μf	MT 600 v 3000-up
C102	281-618	4.7 pf	Cer 200 v X3000-up
C103B	281-064	.2-1.5 pf	Tub Var 101-2999X
C103C	281-064	.2-1.5 pf	Tub Var 101-2999X
C103D	use 281-601	7.5 pf	Cer 500 v $\pm .5$ pf 101-2999X
C104	281-613	10 pf	Cer 200 v X3000-up
C105B	281-027	.7-3 pf	Tub Var 101-2999X
C105C	281-027	.7-3 pf	Tub Var 101-2999X
C105E	281-534	3.3 pf	Cer $\pm .25$ pf 101-2999X
C106	281-064	.2-1.5 pf	Tub Var X3000-up
C107B	281-027	.7-3 pf	Tub Var
C107C	281-027	.7-3 pf	Tub Var 101-2999
	281-043	.7-3 pf	Tub Var 3000-up
C107D	281-616	6.8 pf	Cer 200 v X3000-up
C107E	281-503	8 pf	Cer 500 v $\pm .5$ pf 101-2999X
C108B	281-027	.7-3 pf	Tub Var X3000-up
C108C	281-043	.7-3 pf	Tub Var X3000-up
C108D	281-611	2.7 pf	Cer 200 v X3000-up
C108E	281-577	14 pf	Cer 500 v 5% X3000-up
C109A	281-538	1 pf	Cer 500 v 101-2999X
C109B	281-027	.7-3 pf	Tub Var 101-2999
	281-043	.7-3 pf	Tub Var 3000-up
C109C	281-027	.7-3 pf	Tub Var
C109D	281-611	2.7 pf	Cer 200 v X3000-up
C109E	281-504	10 pf	Cer 500 v 10% 101-2999
	281-512	27 pf	Cer 500 v 10% 3000-up
C110A	281-611	2.7 pf	Cer 200 v X3000-up
C110B	281-043	.7-3 pf	Tub Var X3000-up
C110C }	281-082	.2-1.5 pf/15 pf	Mica Var X3000-up
C111A	281-593	3.9 pf	Cer 500 v 10% 101-2999
C111A	281-615	3.9 pf	Cer 200 v 3000-up
C111B	281-064	.2-1.5 pf	Tub Var 101-2999
	281-027	.7-3 pf	Tub Var 3000-up
C111C	281-064	.2-1.5 pf	Tub Var 101-2999
C111E	283-565	50 pf	Mica 500 v 5% 101-2999

† Furnished as a unit with R102.

Parts List—Type 82

Capacitors (Cont'd)

Ckt. No.	Tektronix Part No.	Description				S/N Range
C111C }	281-083	.2-1.5 pf/50 pf	Mica	Var		3000-up
C111E }						
C111H	281-617	15 pf	Cer		200 v	X3000-up
C112A	281-615	3.9 pf	Cer		200 v	X3000-up
C112B	281-043	.7-3 pf	Tub	Var		X3000-up
C112C }	281-084	.2-1.5 pf/100 pf	Mica	Var		X3000-up
C112E }						
C113A	281-593	3.9 pf	Cer		500 v	10%
C113B	281-064	.2-1.5 pf	Tub	Var		101-2999
	281-027	.7-3 pf	Tub	Var		3000-up
C113C	281-064	.2-1.5 pf	Tub	Var		101-2999
C113E	283-566	100 pf	Mica		500 v	5%
C113C }	281-085	.2-1.5 pf/200 pf	Mica	Var		3000-up
C113E }						
C114A	281-593	3.9 pf	Cer		500 v	10%
C114B	281-027	.7-3 pf	Tub	Var		X3000-up
C114C }	281-086	.2-1.5 pf/500 pf	Mica	Var		X3000-up
C115A	281-593	3.9 pf	Cer		500 v	10%
C115B	281-064	.2-1.5 pf	Tub	Var		101-2999X
C115C	281-064	.2-1.5 pf	Tub	Var		101-2999X
C115E	283-557	200 pf	Mica		500 v	10%
C117	281-537	.68 pf	Cer		500 v	$\pm .136 \text{ pf}$
C126	281-591	.0056 μf	Cer		200 v	101-2999X
C127	281-064	.2-1.5 pf	Tub	Var		101-2999X
C131	281-575	39 pf	Cer		500 v	1%
C132	283-000	.001 μf	Cer		500 v	X3000-up
C134	283-004	.02 μf	Cer		150 v	
C135	290-110	.20 μf	EMT		150 v	
C151	283-023	.1 μf	Cer		10 v	
C153	283-023	.1 μf	Cer		10 v	101-2999
	283-080	.022 μf	Cer		25 v	3000-up
C164	283-000	.001 μf	Cer		500 v	
C166	281-544	5.6 pf	Selected	(nominal value)		X1463-2999
	281-547	2.7 pf	Cer		500 v	3000-up
C167	281-060	2-8 pf	Cer	Var		101-2999
	281-089	2-8 pf	Cer	Var		3000-up
C168	281-060	2-8 pf	Cer	Var		101-1462
	281-061	5.5-18 pf	Cer	Var		1463-2999
	281-089	2-8 pf	Cer	Var		3000-up
C174	283-000	.001 μf	Cer		500 v	
C178	283-000	.001 μf	Cer		500 v	X339-2999X
C201	285-611	.01 μf	MT		600 v	101-2999
C201†	285-646	.01 μf	MT		600 v	3000-up
C202	281-618	4.7 pf	Cer		200 v	X3000-up

† Furnished as a unit with R202.

Capacitors (Cont'd)

Ckt. No.	Tektronix Part No.	Description				S/N Range
C203B	281-064	.2-1.5 pf	Tub	Var		101-2999X
C203C	281-064	.2-1.5 pf	Tub	Var		101-2999X
C203D	use 281-601	7.5 pf	Cer		500 v	$\pm .5$ pf
C204	281-613	10 pf	Cer		200 v	X3000-up
C205B	281-027	.7-3 pf	Tub	Var		101-2999X
C205C	281-027	.7-3 pf	Tub	Var		101-2999X
C205E	281-534	3.3 pf	Cer			$\pm .25$ pf
C206	281-064	.2-1.5 pf	Tub	Var		X3000-up
C207B	281-027	.7-3 pf	Tub	Var		
C207C	281-027	.7-3 pf	Tub	Var		101-2999
	281-043	.7-3 pf	Tub	Var		3000-up
C207D	281-616	6.8 pf	Cer		200 v	X3000-up
C207E	281-503	8 pf	Cer		500 v	101-2999X
C208B	281-027	.7-3 pf	Tub	Var		X3000-up
C208C	281-043	.7-3 pf	Tub	Var		X3000-up
C208D	281-611	2.7 pf	Cer		200 v	X3000-up
C208E	281-577	14 pf	Cer		500 v	X3000-up
C209A	281-538	1 pf	Cer		500 v	101-2999X
C209B	281-027	.7-3 pf	Tub	Var		101-2999
	281-043	.7-3 pf	Tub	Var		3000-up
C209C	281-027	.7-3 pf	Tub	Var		
C209D	281-611	2.7 pf	Cer		200 v	X3000-up
C209E	281-504	10 pf	Cer		500 v	101-2999
	281-512	27 pf	Cer		500 v	3000-up
C210A	281-611	2.7 pf	Cer		200 v	X3000-up
C210B	281-043	.7-3 pf	Tub	Var		X3000-up
C210C } C210E }	281-082	.2-1.5 pf/15 pf	Mica	Var		X3000-up
C211A	281-593	3.9 pf	Cer		500 v	101-2999
	281-615	3.9 pf	Cer		200 v	3000-up
C211B	281-064	.2-1.5 pf	Tub	Var		101-2999
	281-027	.7-3 pf	Tub	Var		3000-up
C211C	281-064	.2-1.5 pf	Tub	Var		101-2999
C211E	283-565	50 pf	Mica		500 v	101-2999
C211C } C211E }	281-083	.2-1.5 pf/50 pf	Mica	Var		3000-up
C211H	281-617	15 pf	Cer		200 v	X3000-up
C212A	281-615	3.9 pf	Cer		200 v	X3000-up
C212B	281-043	.7-3 pf	Tub	Var		X3000-up
C212C } C212E }	281-084	.2-1.5 pf/100 pf	Mica	Var		X3000-up
C213A	281-593	3.9 pf	Cer		500 v	10%
C213B	281-064	.2-1.5 pf	Tub	Var		101-2999
	281-027	.7-3 pf	Tub	Var		3000-up
C213C	281-064	.2-1.5 pf	Tub	Var		101-2999
C213E	283-566	100 pf	Mica		500 v	5%
						101-2999

Parts List—Type 82

Capacitors (Cont'd)						
Ckt. No.	Tektronix Part No.	Description			S/N Range	
C213C }	281-085	.2-1.5 pf/200 pf	Mica	Var		3000-up
C213E }						
C214A	281-593	3.9 pf	Cer		500 v	X3000-up
C214B	281-027	.7-3 pf	Tub	Var		X3000-up
C214C }	281-086	.2-1.5 pf/500 pf	Mica	Var		X3000-up
C214E }						
C215A	281-593	3.9 pf	Cer		500 v	10%
						101-2999X
C215B	281-064	.2-1.5 pf	Tub	Var		101-2999X
C215C	281-064	.2-1.5 pf	Tub	Var		101-2999X
C215E	283-557	200 pf	Mica		500 v	101-2999X
C217	281-537	.68 pf	Cer		500 v	$\pm .136$ pf
C226	281-591	.0056 μ f	Cer		200 v	101-2999X
C227	281-064	.2-1.5 pf	Tub	Var		101-2999X
C231	281-575	39 pf	Cer		500 v	X3000-up
C232	283-000	.001 μ f	Cer		500 v	X3000-up
C234	283-004	.02 μ f	Cer		150 v	101-2999X
C235	290-110	20 μ f	EMT		150 v	
C236	283-012	.1 μ f	Cer		100 v	101-2999
	290-145	10 μ f	EMT		50 v	3000-up
C251	283-023	.1 μ f	Cer		10 v	
C253	283-023	.1 μ f	Cer		10 v	101-2999
	283-080	.022 μ f	Cer		25 v	3000-up
C264	283-000	.001 μ f	Cer		500 v	
C266	281-544	5.6 pf	Selected	(nominal value)		X1463-2999
	281-547	2.7 pf	Cer		500 v	3000-up
C267	281-060	2-8 pf	Cer	Var		101-2999
	281-089	2-8 pf	Cer	Var		3000-up
C268	281-060	2-8 pf	Cer	Var		101-1462
	281-061	5.5 pf	Cer	Var		1463-2999
	281-089	2-8 pf	Cer	Var		3000-up
C274	283-000	.001 μ f	Cer		500 v	
C278	283-000	.001 μ f	Cer		500 v	X339-2999X
C316	281-061	5.5-18 pf	Cer	Var		
C317	281-513	27 pf	Cer		500 v	
C318	281-060	2-8 pf	Cer	Var		
C328	281-063	9-35 pf	Cer	Var		
C356	281-063	9-35 pf	Cer	Var		
C374	283-000	.001 μ f	Cer		500 v	
C377	281-063	9-35 pf	Cer	Var		X380-up
C381	283-003	.01 μ f	Selected	(nominal value)		
C384	283-000	.001 μ f	Cer		500 v	
C387	281-063	9-35 pf	Cer	Var		
C391	283-023	.1 μ f	Selected	(nominal value)		
C393	281-524	150 pf	Cer		500 v	101-3609
C393	281-518	47 pf	Cer		500 v	3610-up
C416	281-513	27 pf	Cer		500 v	
C417	281-061	5.5-18 pf	Cer	Var		
C418	281-060	2-8 pf	Cer	Var		

Capacitors (Cont'd)

Ckt. No.	Tektronix Part No.		Description		S/N Range
C428	281-063	9.35 pf	Cer	Var	
C456	281-063	9.35 pf	Cer	Var	
C474	283-000	.001 μ f	Cer		500 v
C477	281-063	9.35 pf	Cer	Var	
C481	283-023	.1 μ f	Selected	(nominal value)	X380-up
C484	283-000	.001 μ f	Cer		500 v
C487	281-063	9.35 pf	Cer	Var	
C491	283-003	.01 μ f	Selected	(nominal value)	
C493	281-524	150 pf	Cer		500 v
C493	281-518	47 pf	Cer		500 v
C510	283-004	.02 μ f	Selected	(nominal value)	101-3609 3610-up
C511	283-026	.2 μ f	Cer		25 v
C512	283-028	.0022 μ f	Selected	(nominal value)	101-2999 3000-up
C516	283-010	.05 μ f	Selected	(nominal value)	X3000-up
C524	283-000	.001 μ f	Cer		500 v
	281-027	.7-3 pf	Tub	Var	
C525	281-557	1.8 pf	Cer		500 v
C526	281-557	1.8 pf	Cer		500 v
C528	283-000	.001 μ f	Cer		500 v
C534	281-557	1.8 pf	Cer		500 v
C535	281-557	1.8 pf	Cer		500 v
C536	281-557	1.8 pf	Cer		500 v
C538	283-000	.001 μ f	Cer		500 v
C539	281-538	1 pf	Cer		500 v
C544	281-557	1.8 pf	Cer		500 v
C545	281-557	1.8 pf	Cer		500 v
C546	281-557	1.8 pf	Cer		500 v
C549	281-538	1 pf	Cer		500 v
C552	283-003	.01 μ f	Cer		150 v
C553	283-057	.1 μ f	Cer		200 v
C554	283-003	.01 μ f	Cer		150 v
C555	290-168	100 μ f	EMT		6 v
C556	290-168	100 μ f	EMT		6 v
C558	290-168	100 μ f	EMT		6 v
C559	290-168	100 μ f	EMT		6 v
C561	283-003	.01 μ f	Cer		150 v
C564	281-513	27 pf	Cer		500 v
C566	281-525	470 pf	Cer		500 v
C574	281-513	27 pf	Cer		500 v
C576	281-525	470 pf	Cer		500 v
C579	281-524	150 pf	Cer		500 v
C580	281-580	470 pf	Cer		500 v
C593	281-536	.001 μ f	Cer		500 v
C596	283-059	1 μ f	Cer		25 v
C597	283-059	1 μ f	Cer		25 v

Parts List—Type 82

Diodes

Ckt. No.	Tektronix Part No.	Description	S/N Range
D134	152-061	Silicon 6061	
D138	152-008	Germanium T12G	
D139	152-008	Germanium T12G	
D234	152-061	Silicon 6061	
D236	152-067	Zener 25 v 1 w 10%	
D238	152-008	Germanium T12G	
D239	152-008	Germanium T12G	
D501	152-071	Germanium ED2007	
D502	152-071	Germanium ED2007	
D503	Use 152-160	Germanium ID6-022	
D504	Use 160-026	Germanium ID6-022	
D506	152-071	Germanium ED2007	
D507	152-071	Germanium ED2007	
D508	Use 152-160	Germanium ID6-022	
D509	Use 152-160	Germanium ID6-022	
D554	152-096	Zener 50 v 10 w 5%	
D562	152-075	Germanium 6075	
D566	152-075	Germanium 6075	
D572	152-075	Germanium 6075	
D576	152-075	Germanium 6075	
D579	152-075	Germanium 6075	
D580	152-075	Germanium 6075	
D581	152-075	Germanium 6075	
D585	152-075	Germanium 6075	
D586	152-075	Germanium 6075	
D590	152-075	Germanium 6075	

Inductors

L103A	*108-258	.25 μ h wound on a 62 Ω resistor	101-2999X
L105A	*108-248	.25 μ h wound on a 91 Ω resistor	101-2999X
LR107A	*108-280	.085 μ h wound on a 43 Ω resistor	X3000-up
LR108A	*108-281	.13 μ h wound on a 36 Ω resistor	X3000-up
LR109A	*108-282	.13 μ h wound on a 30 Ω resistor	X3000-up
LR110A	*108-283	.13 μ h wound on a 43 Ω resistor	X3000-up
LR111A	*108-284	.1 μ h wound on a 43 Ω resistor	X3000-up
L203A	*108-258	.25 μ h wound on a 62 Ω resistor	101-2999X
L205A	*108-248	.25 μ h wound on a 91 Ω resistor	101-2999X
LR207A	*108-280	.085 μ h wound on a 43 Ω resistor	X3000-up
LR208A	*108-281	.13 μ h wound on a 36 Ω resistor	X3000-up
LR209A	*108-282	.13 μ h wound on a 30 Ω resistor	X3000-up
LR210A	*108-283	.13 μ h wound on a 43 Ω resistor	X3000-up
LR211A	*108-284	.1 μ h wound on a 43 Ω resistor	X3000-up
L524	*108-243	Plate Line	
L525	*108-244	Grid Line	
L534	*108-243	Plate Line	
L535	*108-244	Grid Line	

Resistors

Ckt. No.	Tektronix Part No.	Description		S/N Range
Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.				
R102†	316-150	15 Ω	$\frac{1}{4}$ w	Prec 5% 1% 1% 1% 5%
R103A††	317-620	62 Ω	1/10 w	
R103C	318-109	500 k	$\frac{1}{8}$ w	
R103E	319-031	1 meg	$\frac{1}{4}$ w	
R104	317-470	47 Ω	1/10 w	
R105A†††	317-910	91 Ω	1/10 w	5% 101-2999X
R105C	318-110	800 k	$\frac{1}{8}$ w	Prec 1% 101-2999X
R105E	318-032	250 k	$\frac{1}{8}$ w	Prec 1% 101-2999X
R105F	315-471	470 Ω	$\frac{1}{4}$ w	5% 101-2999X
R107C	318-111	900 k	$\frac{1}{8}$ w	Prec 1% 101-2999
R107C	322-610	500 k	$\frac{1}{4}$ w	Prec 1% 3000-up
R107E	318-006	111 k	$\frac{1}{8}$ w	Prec 1% 101-2999
	322-481	1 meg	$\frac{1}{4}$ w	Prec 1% 3000-up
R107F	315-271	270 Ω	$\frac{1}{4}$ w	5% 101-2999X
R108C	322-620	800 k	$\frac{1}{4}$ w	Prec 1% X3000-up
R108E	321-618	250 k	$\frac{1}{8}$ w	Prec 1% X3000-up
R109C	318-095	950 k	$\frac{1}{8}$ w	Prec 1% 101-2999
	322-621	900 k	$\frac{1}{4}$ w	Prec 1% 3000-up
R109E	318-007	52.6 k	$\frac{1}{8}$ w	Prec 1% 101-2999
	321-617	111 k	$\frac{1}{8}$ w	Prec 1% 3000-up
R109F	315-221	220 Ω	$\frac{1}{4}$ w	5% 101-2999X
R110C	322-622	950 k	$\frac{1}{4}$ w	Prec 1% X3000-up
R110E	321-616	52.6 k	$\frac{1}{8}$ w	Prec 1% X3000-up
R111C	318-112	980 k	$\frac{1}{8}$ w	Prec 1% 101-2999
	322-630	980 k	$\frac{1}{4}$ w	Prec 1% 3000-up
R111E	318-033	20.4 k	$\frac{1}{8}$ w	Prec 1% 101-2999
	321-615	20.4 k	$\frac{1}{8}$ w	Prec 1% 3000-up
R111H	317-510	51 Ω	1/10 w	5% X3000-up
R112C	322-624	990 k	$\frac{1}{4}$ w	Prec 1% X3000-up
R112E	321-614	10.1 k	$\frac{1}{8}$ w	Prec 1% X3000-up
R112H	317-510	51 Ω	1/10 w	5% X3000-up
R113C	318-113	990 k	$\frac{1}{8}$ w	Prec 1% 101-2999
	322-625	995 k	$\frac{1}{4}$ w	Prec 1% 3000-up
R113E	318-009	10.1 k	$\frac{1}{8}$ w	Prec 1% 101-2999
	321-613	5.03 k	$\frac{1}{8}$ w	Prec 1% 3000-up
R113H	317-750	75 Ω	1/10 w	5% X3000-up
R114C	322-628	998 k	$\frac{1}{4}$ w	Prec 1% X3000-up
R114E	321-222	2 k	$\frac{1}{8}$ w	Prec 1% X3000-up
R114H	317-750	75 Ω	1/10 w	5% X3000-up
R115C	318-114	995 k	$\frac{1}{8}$ w	Prec 1% 101-2999X

† Furnished as a unit with C101.

†† Furnished as a unit with L103A.

††† Furnished as a unit with L105A.

Parts List—Type 82

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.	Description		S/N Range
R115E	318-010	5.03 k	1/8 w	Prec 1% 101-2999X
R116	317-180	18 Ω	1/10 w	5% X3000-up
R117	319-031	1 meg	1/4 w	Prec 1% 101-2999
	322-481	1 meg	1/4 w	Prec 1% 3000-up
R118	316-101	100 Ω	1/4 w	101-2999
R118	315-101	100 Ω	1/4 w	5% 3000-up
R119	302-274	270 k	1/2 w	101-2339
	302-124	120 k	1/2 w	2340-up
R121	311-154	50 k	Var	A GRID CURRENT ZERO
R123	317-330	33 Ω	1/10 w	5% 101-2999X
R126	317-474	470 k	1/10 w	5%
R131	315-181	180 Ω	1/4 w	5% X3000-up
R132	316-151	150Ω	1/4 w	101-2999X
R133	306-123	12 k	2 w	
R134	307-107	5.6 Ω	1/4 w	5% 101-2999
R134	316-220	22 Ω	1/4 w	3000-up
R137	302-332	3.3 k	1/2 w	101-2999
	302-472	4.7 k	1/2 w	3000-up
R138	315-751	750 Ω	1/4 w	5% X3000-up
R140	311-003	100 Ω	2 w	VERTICAL POSITION A
R142	315-910	91 Ω	1/4 w	5% 101-1529
	315-620	62 Ω	1/4 w	5% 1530-2339X
R143	311-324	50 Ω	1/2 w	Var
R145	316-330	33 Ω	1/4 w	WW X1 POSITION RANGE A
	315-270	27 Ω	1/4 w	101-1529
	315-330	33 Ω	1/4 w	5% 1530-2999
	315-910	91 Ω	1/4 w	5% 3000-up
R146	316-330	33 Ω	1/4 w	101-1529
	315-270	27 Ω	1/4 w	5% 1530-2999
	315-330	33 Ω	1/4 w	5% 3000-up
R148	315-200	20 Ω	1/4 w	5% 101-1529
	315-270	27 Ω	1/4 w	5% 1530-2999
R148	315-160	16 Ω	1/4 w	5% 3000-up
R149	316-331	330 Ω	1/4 w	
R150	316-221	220 Ω	1/4 w	X2340-2999X
R151	302-104	100 k	1/2 w	X2340-2999X
R153	316-561	560 Ω	1/4 w	
R163	315-181	180 Ω	1/4 w	5% 101-2999
	316-181	180 Ω	1/4 w	3000-up
R164	315-201	200 Ω	1/4 w	5%
R165	315-910	91 Ω	1/4 w	5%
R166	315-220	22 Ω	1/4 w	5% X1463-2339
R166	315-270	27 Ω	Selected (nominal value)	2340-2999
	316-152	1.5 k	1/4 w	3000-up
R167	315-750	75 Ω	1/4 w	5% 101-1462
	315-510	51 Ω	1/4 w	5% 1463-2999
	315-820	82 Ω	1/4 w	5% 3000-up

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.	Description		S/N	Range
R168	315-102	1 k	1/4 w	5%	101-1462
	316-471	470 Ω	1/4 w		1463-2999
	316-181	180 Ω	1/4 w		3000-up
R169	315-112	1.1 k	1/4 w	5%	
R174	315-201	200 Ω	1/4 w	5%	
R175	315-910	91 Ω	1/4 w	5%	
R176	316-121	120 Ω	1/4 w		X3000-up
R177	311-331	1 k		Var	GAIN BAL
R178	308-216	6 k	5 w	WW	1%
R179	315-112	1.1 k	1/4 w		5%
R180	311-302	200 Ω x 200 Ω x 2 k		Var	VARIABLE VOLTS/CM A
R183	315-131	130 Ω	1/4 w		5%
R184	315-820	82 Ω	1/4 w		5%
R185	315-820	82 Ω	1/4 w		5%
R193	315-131	130 Ω	1/4 w		5%
R194	315-820	82 Ω	1/4 w		5%
R195	315-820	82 Ω	1/4 w		5%
R197	315-161	160 Ω	1/4 w		5%
R202†	316-150	15 Ω	1/4 w		X3000-up
R203A††	317-620	62 Ω	1/10 w		101-2999X
R203C	318-109	500 k	1/8 w	Prec	1%
R203E	319-031	1 meg	1/4 w	Prec	1%
R204	317-470	47 Ω	1/10 w		5%
R205A†††	317-910	91 Ω	1/10 w		101-2999X
R205C	318-110	800 k	1/8 w	Prec	1%
R205E	318-032	250 k	1/8 w	Prec	1%
R205F	315-471	470 Ω	1/4 w		101-2999X
R207C	318-111	900 k	1/8 w	Prec	1%
	322-610	500 k	1/4 w	Prec	1%
R207E	318-006	111 k	1/8 w	Prec	1%
	322-481	1 meg	1/4 w	Prec	1%
R207F	315-271	270 Ω	1/4 w		101-2999X
R208C	322-620	800 k	1/4 w	Prec	1%
R208E	321-618	250 k	1/8 w	Prec	1%
R209C	318-095	950 k	1/8 w	Prec	1%
	322-621	900 k	1/4 w	Prec	1%
R209E	318-007	52.6 k	1/8 w	Prec	1%
	321-617	111 k	1/8 w	Prec	1%
R209F	315-221	220Ω	1/4 w		3000-up
R210C	322-622	950 k	1/4 w	Prec	1%
R210E	321-616	52.6 k	1/8 w	Prec	1%
R211C	318-112	980 k	1/8 w	Prec	1%
	322-630	980 k	1/4 w	Prec	1%
R211E	318-033	20.4 k	1/8 w	Prec	1%
	321-615	20.4 k	1/8 w	Prec	1%
R211H	317-510	51 Ω	1/10 w		3000-up
					X3000-up

† Furnished as a unit with C201.

†† Furnished as a unit with L203A.

††† Furnished as a unit with L205A.

Parts List—Type 82

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.	Description		S/N Range
R212C	322-624	990 k	1/4 w	Prec 1% X3000-up
R212E	321-614	10.1 k	1/8 w	Prec 1% X3000-up
R212H	317-510	51 Ω	1/10 w	5% X3000-up
R213C	318-113	990 k	1/8 w	Prec 1% 101-2999
	322-625	995 k	1/4 w	Prec 1% 3000-up
R213E	318-009	10.1 k	1/8 w	Prec 1% 101-2999
	321-613	5.03 k	1/8 w	Prec 1% 3000-up
R213H	317-750	75 Ω	1/10 w	5% X3000-up
R214C	322-628	998 k	1/4 w	Prec 1% X3000-up
R214E	321-222	2 k	1/8 w	Prec 1% X3000-up
R214H	317-750	75 Ω	1/10 w	5% X3000-up
R215C	318-114	995 k	1/8 w	Prec 1% 101-2999X
R215E	318-010	5.03 k	1/8 w	Prec 1% 101-2999X
R216	317-180	18 Ω	1/10 w	5% X3000-up
R217	319-031	1 meg	1/4 w	Prec 1% 101-2999
	322-481	1 meg	1/4 w	Prec 1% 3000-up
R218	316-101	100 Ω	1/4 w	
	315-101	100 Ω	1/4 w	5% 3000-up
R219	302-274	270 k	1/2 w	
	302-124	120 k	1/2 w	101-2339 2340-up
R221	311-154	50 k	Var	B GRID CURRENT ZERO
R223	317-330	33 Ω	1/10 w	5% 101-2999X
R226	317-474	470 k	1/10 w	5%
R231	315-181	180 Ω	1/4 w	5% X3000-up
R232	316-151	150 Ω	1/4 w	101-2999X
R233	306-123	12 k	2 w	
R234	307-107	5.6 Ω	1/4 w	5% 101-2999
	316-220	22 Ω	1/4 w	3000-up
R235	316-470	47 Ω	1/4 w	X3000-up
R236	308-217	5.5 k	5 w	WW 5% 101-2999
R237	302-332	3.3 k	1/2 w	
R237	302-472	4.7 k	1/2 w	
R238	315-751	750 Ω	1/4 w	5% X3000-up
R240	311-003	100 Ω	2 w	Var VERTICAL POSITION B
R242	315-910	91 Ω	1/4 w	5% 101-1529
	315-620	62 Ω	1/4 w	5% 1530-2339X
R243	311-324	50 Ω	1/2 w	Var WW X1 POSITION RANGE B
R245	316-330	33 Ω	1/4 w	101-1529
	315-270	27 Ω	1/4 w	5% 1530-2999
	315-330	33 Ω	1/4 w	5% 3000-up
R246	316-330	33 Ω	1/4 w	101-1529
R246	315-270	27 Ω	1/4 w	5% 1530-2999
	315-330	33 Ω	1/4 w	5% 3000-up
R248	315-200	20 Ω	1/4 w	5% 101-1529
	315-270	27 Ω	1/4 w	5% 1530-2999
	315-160	16 Ω	1/4 w	5% 3000-up

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.	Description	S/N Range
R249	316-331	330 Ω	1/4 w
R250	316-221	220 Ω	1/4 w
R251	302-104	100 k	1/4 w
R253	316-561	560 Ω	1/4 w
R262	315-681	680 Ω	Selected (Nominal Value)
R263	315-181	180 Ω	1/4 w
R263	316-181	180 Ω	1/4 w
R264	315-201	200 Ω	1/4 w
R265	315-910	91 Ω	1/4 w
R266	315-510	51 Ω	1/4 w
	316-152	1.5 k	1/4 w
R267	315-101	100 Ω	1/4 w
	315-510	51 Ω	1/4 w
	315-680	68 Ω	1/4 w
R268	315-102	1 k	1/4 w
	316-471	470 Ω	1/4 w
R268	316-181	180 Ω	1/4 w
R269	315-112	1.1 k	1/4 w
R274	315-201	200 Ω	1/4 w
R275	315-910	91 Ω	1/4 w
R276	315-121	120 Ω	1/4 w
R276	316-100	10 Ω	1/4 w
R277	311-249	1 k	Var
	311-303	200 Ω	Var
R278	308-216	6 k	5 w
R279	315-112	1.1 k	1/4 w
R280	311-302	200 Ω x 200 Ω x 2 k	Var
R283	315-131	130 Ω	1/4 w
R284	315-820	82 Ω	1/4 w
R285	315-820	82 Ω	1/4 w
R293	315-131	130 Ω	1/4 w
R294	315-820	82 Ω	1/4 w
R295	315-820	82 Ω	1/4 w
R297	315-161	160 Ω	1/4 w
R301	315-910	91 Ω	1/4 w
R303	316-471	470 Ω	1/4 w
R305	315-910	91 Ω	1/4 w
R314	315-241	240 Ω	1/4 w
R316	315-101	100 Ω	1/4 w
R317	315-330	33 Ω	1/4 w
R318	315-162	1.6 k	1/4 w
R324	315-241	240 Ω	1/4 w
R325	315-121	120 Ω	1/4 w
R328	315-121	120 Ω	1/4 w
R330	315-391	390 Ω	1/4 w
R331	315-620	62 Ω	1/4 w

Parts List—Type 82

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.	Description	S/N Range
R332	315-620	62 Ω	5%
R333	315-391	390 Ω	5%
R335	315-621	620 Ω	5%
R336	311-091	1 k	Var
R337	315-621	620 Ω	5%
X10 POSITION RANGE A			
R344	315-271	270 Ω	5%
R346	316-101	100 Ω	5%
R347	315-201	200 Ω	5%
	315-301	300 Ω	5%
R349	315-751	750 Ω	5%
R354	315-271	270 Ω	5%
R356	311-249	1 k	Var
R359	315-751	750 Ω	5%
R374	315-201	200 Ω	5%
R375	315-910	91 Ω	5%
X10 GAIN A			
R376	315-201	200 Ω	5%
R377	315-102	1 k	5%
R379	315-181	180 Ω	5%
R381	307-114	6.2 Ω	Selected (nominal value)
R384	315-201	200 Ω	5%
R385	315-910	91 Ω	5%
R387	315-910	91 Ω	5%
R389	315-181	180 Ω	5%
R391	307-114	6.2 Ω	Selected (nominal value)
R392	311-245	10 k	Var
R393	315-113	11 k	5%
	315-102	1 k	5%
X380-up			
R401	315-910	91 Ω	5%
R403	316-471	470 Ω	5%
R405	315-910	91 Ω	5%
R414	315-241	240 Ω	5%
R415	315-121	120 Ω	5%
R416	315-330	33 Ω	5%
R417	315-101	100 Ω	5%
R418	315-162	1.6 k	5%
R424	315-241	240 Ω	5%
R428	315-121	120 Ω	5%
R430	315-391	390 Ω	5%
R431	315-620	62 Ω	5%
R432	315-620	62 Ω	5%
R433	315-391	390 Ω	5%
R435	315-621	620 Ω	5%
X10 POSITION RANGE B			
R436	311-091	1 k	Var
R437	315-621	620 Ω	5%
R444	315-271	270 Ω	5%
R446	316-101	100 Ω	5%
R447	315-201	200 Ω	5%
101-440			

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.	Description		S/N Range
R447	315-301	300 Ω	$\frac{1}{4}$ w	5%
R449	315-751	750 Ω	$\frac{1}{4}$ w	5%
R454	315-271	270 Ω	$\frac{1}{4}$ w	5%
R456	311-249	1 k	$\frac{1}{4}$ w	X10 GAIN B
R459	315-751	750 Ω	$\frac{1}{4}$ w	5%
R474	315-201	200 Ω	$\frac{1}{4}$ w	5%
R475	315-910	91 Ω	$\frac{1}{4}$ w	5%
R477	315-102	1 k	$\frac{1}{4}$ w	5%
R479	315-181	180 Ω	$\frac{1}{4}$ w	5%
R481	307-114	6.2 Ω	Selected (nominal value)	X380-up
R484	315-201	200 Ω	$\frac{1}{4}$ w	5%
R485	315-910	91 Ω	$\frac{1}{4}$ w	5%
R486	315-201	200 Ω	$\frac{1}{4}$ w	5%
R487	315-910	91 Ω	$\frac{1}{4}$ w	5%
R491	307-114	6.2 Ω	Selected (nominal value)	X3610-up
R492	311-245	10 k	Var	
R493	315-113	11 k	$\frac{1}{4}$ w	5%
R493	315-102	1 k	$\frac{1}{4}$ w	5%
R501	318-049	1 k	$\frac{1}{8}$ w	Prec 1% 101-2999
	322-193	1 k	$\frac{1}{4}$ w	Prec 1% 3000-up
R502	318-049	1 k	$\frac{1}{8}$ w	Prec 1% 101-2999
	322-193	1 k	$\frac{1}{4}$ w	Prec 1% 3000-up
R506	318-049	1 k	$\frac{1}{8}$ w	Prec 1% 101-2999
	322-193	1 k	$\frac{1}{4}$ w	Prec 1% 3000-up
R507	318-049	1 k	$\frac{1}{8}$ w	Prec 1% 101-2999
	322-193	1 k	$\frac{1}{4}$ w	Prec 1% 3000-up
R510	307-114	6.2 Ω	$\frac{1}{4}$ w	5% 101-2999
R510	307-113	5.1 Ω	Selected (nominal value)	3000-up
R511	307-111	3.6 Ω	$\frac{1}{4}$ w	5% 101-2999
	307-107	5.6 Ω	Selected (nominal value)	3000-up
R512	307-114	6.2 Ω	Selected (nominal value)	X3000-up
R513	309-266	93.1 Ω	$\frac{1}{2}$ w	Prec 1% 101-2999
R513	323-094	93.1 Ω	$\frac{1}{2}$ w	Prec 1% 3000-up
R514	309-266	93.1 Ω	$\frac{1}{2}$ w	Prec 1% 101-2999
	323-094	93.1 Ω	$\frac{1}{2}$ w	Prec 1% 3000-up
R516	309-082	670 Ω	$\frac{1}{2}$ w	Prec 1% 101-2999
	323-176	665 Ω	$\frac{1}{2}$ w	Prec 1% 3000-up
R521	309-266	93.1 Ω	$\frac{1}{2}$ w	Prec 1% 101-2999
	323-094	93.1 Ω	$\frac{1}{4}$ w	Prec 1% 3000-up
R522	309-266	93.1 Ω	$\frac{1}{2}$ w	Prec 1% 101-2999
	323-094	93.1 Ω	$\frac{1}{2}$ w	Prec 1% 3000-up
R524	315-152	1.5 k	$\frac{1}{4}$ w	5% 101-1462X
R524	316-152	1.5 k	$\frac{1}{4}$ w	X3000-up
R527	316-101	100 Ω	$\frac{1}{4}$ w	
R528	302-471	470 Ω	$\frac{1}{2}$ w	
R537	316-101	100 Ω	$\frac{1}{4}$ w	
R538	302-471	470 Ω	$\frac{1}{2}$ w	
R547	316-101	100 Ω	$\frac{1}{4}$ w	

Parts List—Type 82

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.	Description		S/N Range
R548	302-471	470 Ω	1/2 w	
R549	311-169	100 Ω	1/2 w	X1 GAIN ADJ.
R550	315-330	33 Ω	Var Selected (nominal value)	
R551	309-266	93.1 Ω	1/2 w	Prec 1% 101-2999
	323-094	93.1 Ω	1/2 w	Prec 1% 3000-up
R552	309-266	93.1 Ω	1/2 w	Prec 1% 101-2999
	323-094	93.1 Ω	1/2 w	Prec 1% 3000-up
R554	308-107	1 k	5 w	WW 5%
R555	315-470	47 Ω	1/4 w	5%
	315-330	33 Ω	1/4 w	5% 101-1529
				5% 1530-2339
R555	315-470	47 Ω	1/4 w	5% 2340-2999
	315-910	91 Ω	1/4 w	5% 3000-up
R556	315-390	39 Ω	1/4 w	5% 101-1529
	315-330	33 Ω	1/4 w	5% 1530-2339
	304-151	150 Ω	1 w	5% 2340-2999
R556	301-181	180 Ω	1/2 w	5% 3000-up
R558	315-470	47 Ω	1/4 w	5% 101-1529
	315-330	33 Ω	1/4 w	5% 1530-2339
	315-470	47 Ω	1/4 w	5% 2340-2999
	315-910	91 Ω	1/4 w	5% 3000-up
R559	315-390	39 Ω	1/4 w	5% 101-1529
	315-330	33 Ω	1/4 w	5% 1530-2339
	304-151	150 Ω	1 w	2340-2999
R560	301-181	180 Ω	1/2 w	5% 3000-up
	303-510	51 Ω	1 w	5% X2340-up
R561	308-141	1 Ω	1/2 w	WW 5% X2340-up
R563	315-152	1.5 k	1/4 w	5%
R564	315-391	390 Ω	1/4 w	5%
R565	315-301	300 Ω	1/4 w	5%
R566	316-102	1 k	1/4 w	5%
R567	315-182	1.8 k	1/4 w	5%
R571	309-211	150 Ω	1/2 w	Prec 1% 101-2999
	323-114	150 Ω	1/2 w	Prec 1% 3000-up
R573	315-152	1.5 k	1/4 w	5%
R574	315-391	390 Ω	1/4 w	5%
R575	315-301	300 Ω	1/4 w	5%
R576	316-102	1 k	1/4 w	
R577	315-182	1.8 k	1/4 w	5%
R579	316-152	1.5 k	1/4 w	
R580	306-822	8.2 k	2 w	
R581	311-155	1 k	Var	ALT. SYNC SENS.
R582	315-562	5.6 k	1/4 w	5%
R584	315-562	5.6 k	1/4 w	5%
R585	315-913	91 k	1/4 w	5% 101-1389
	315-753	75 k	1/4 w	5% 1390-up

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.	Description	S/N Range
R586	315-473	47 k	1/4 w
R588	302-183	18 k	1/2 w
R589	315-182	1.8 k	1/4 w
R590	316-470	47 Ω	1/4 w
R591	316-101	100 Ω	1/4 w
R592	316-100	10 Ω	1/4 w
R593	315-820	82 Ω	1/4 w
R596	316-100	10 Ω	1/4 w
R599	304-473	47 k	1 w

Switches

	Unwired	Wired		
SW101	260-457	Rotary	AC-DC A	101-2999
	260-573	Rotary	AC-DC A	3000-up
SW111	260-461 *262-501	Rotary	VOLTS/CM A	101-2999
	260-575 *262-612	Rotary	VOLTS/CM A	3000-up
SW199	260-460	Rotary	POLARITY A	
SW201	260-458	Rotary	AC-DC B	101-2999
	260-577	Rotary	AC-DC B	3000-up
SW211	260-461 *262-501	Rotary	VOLTS/CM B	101-2999
	260-575 *262-612	Rotary	VOLTS/CM B	3000-up
SW299	260-460	Rotary	POLARITY B	
SW390	260-459 *262-502	Rotary	GAIN	
SW590			MODE	
SW585	260-145	Slide	CHOP RATE	

Transformers

T580	*120-190	Toroid 12T Trifilar
T590	*120-166	Toroid 3T Trifilar

Transistors

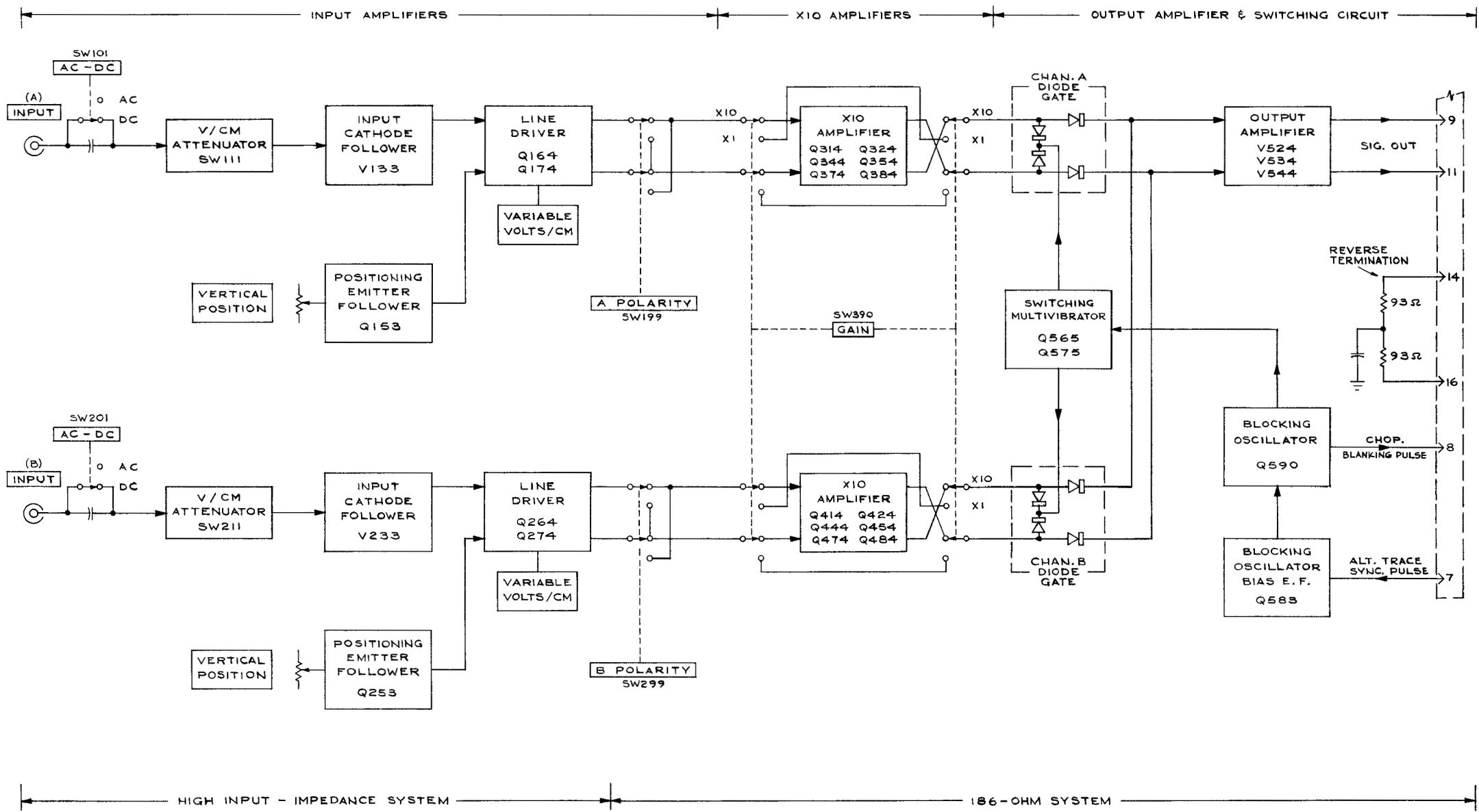
Q153	151-039	2N1381
Q164	151-086	TA2159
Q174	151-086	TA2159
Q253	151-039	2N1381
Q264	151-086	TA2159
Q274	151-086	TA2159
Q314	151-088	2N700
Q324	151-088	2N700
Q344	151-088	2N700
Q354	151-088	2N700

Parts List—Type 82**Transistors (Cont'd)**

Ckt. No.	Tektronix Part No.	Description	S/N Range
Q374	151-086	TA2159	
Q384	151-086	TA2159	
Q414	151-088	2N700	
Q424	151-088	2N700	
Q444	151-088	2N700	
Q454	151-088	2N700	
Q474	151-086	TA2159	
Q484	151-086	TA2159	
Q565	151-061	T2040	
Q575	151-061	T2040	
Q583	151-005	2N212	
Q590	151-085	2N741	101-1389
	151-083	2N964	1390-up

Electron Tubes

V133	154-306	7586
V233	154-306	7586
V524	154-187	6DJ8
V534	154-187	6DJ8
V544	154-187	6DJ8



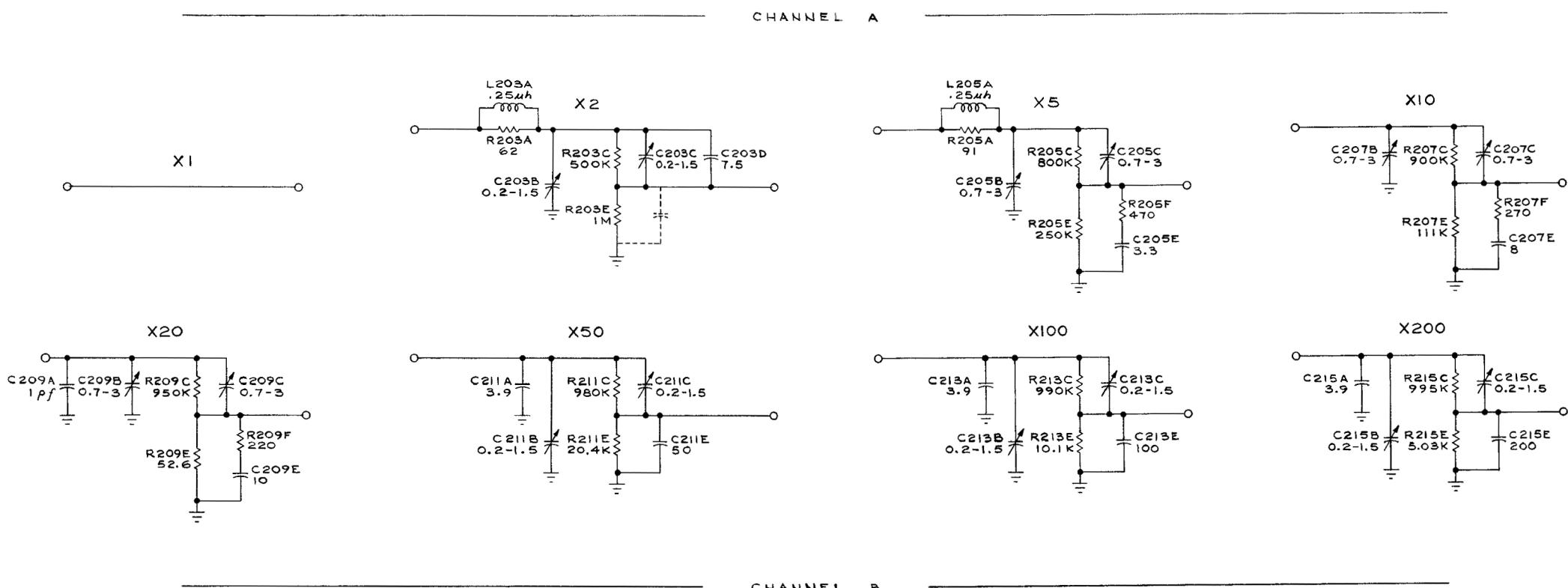
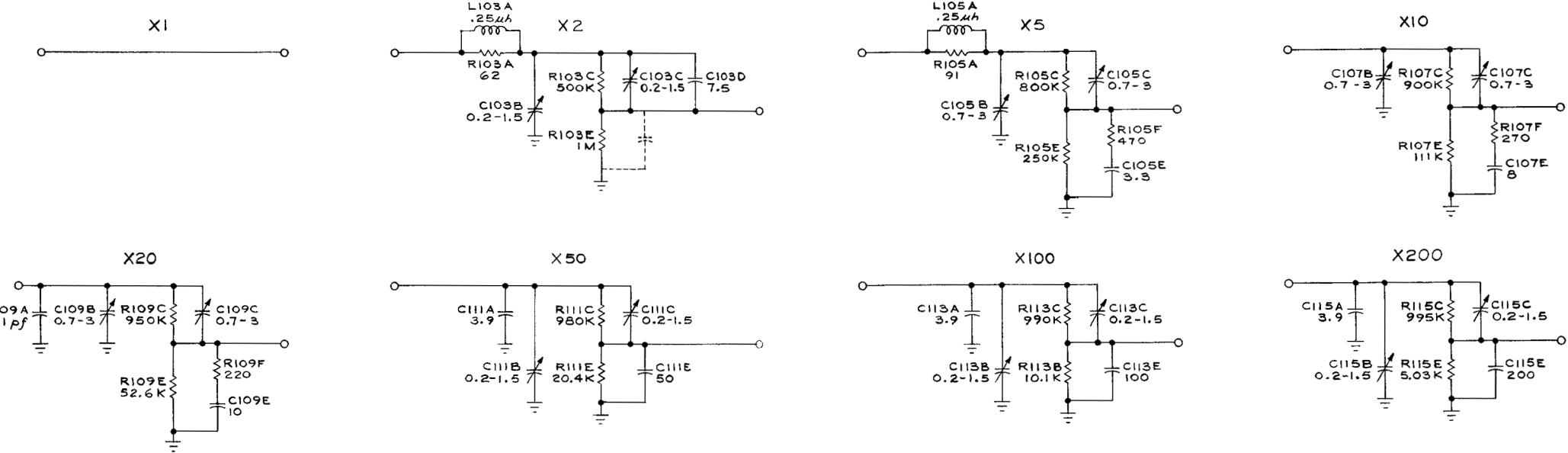
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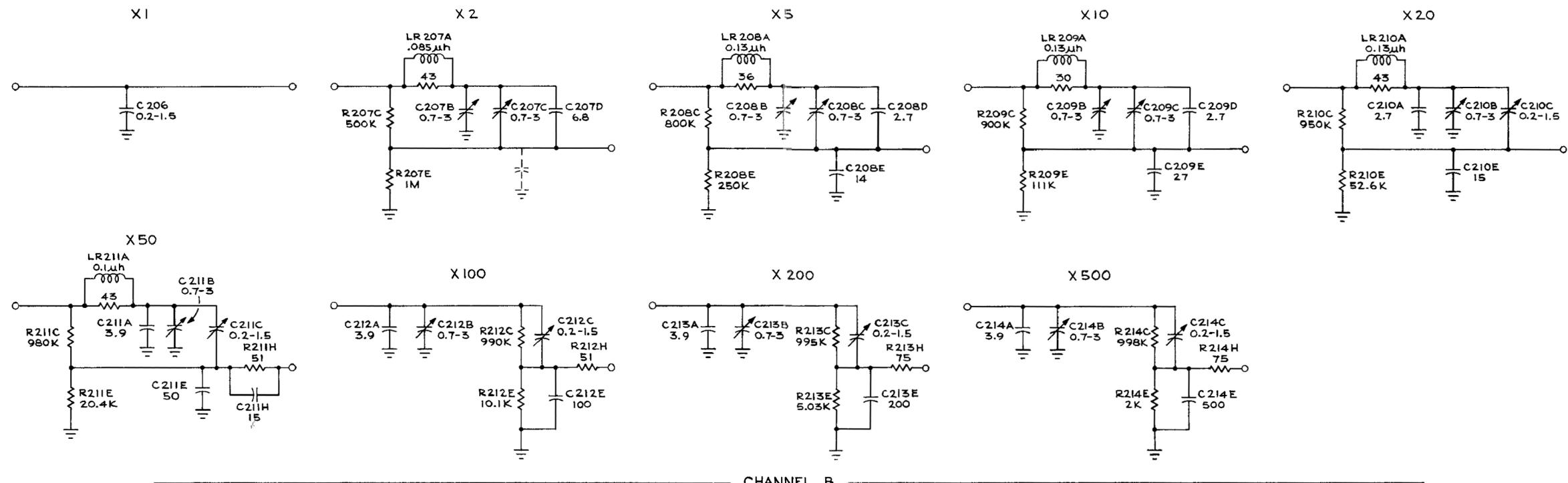
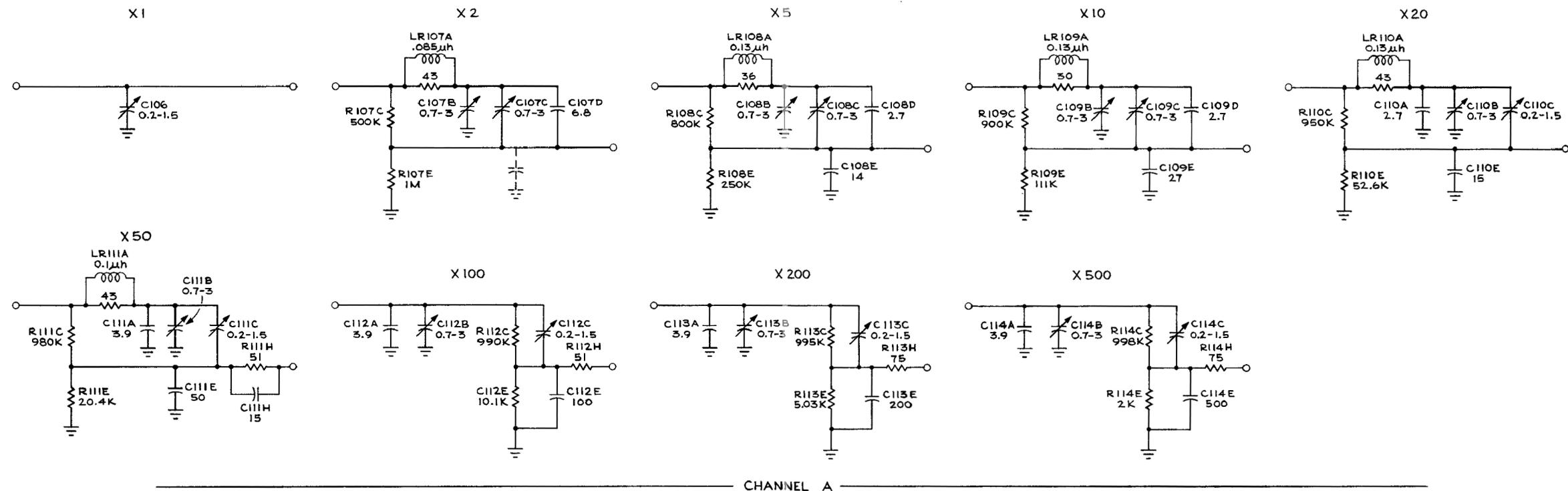
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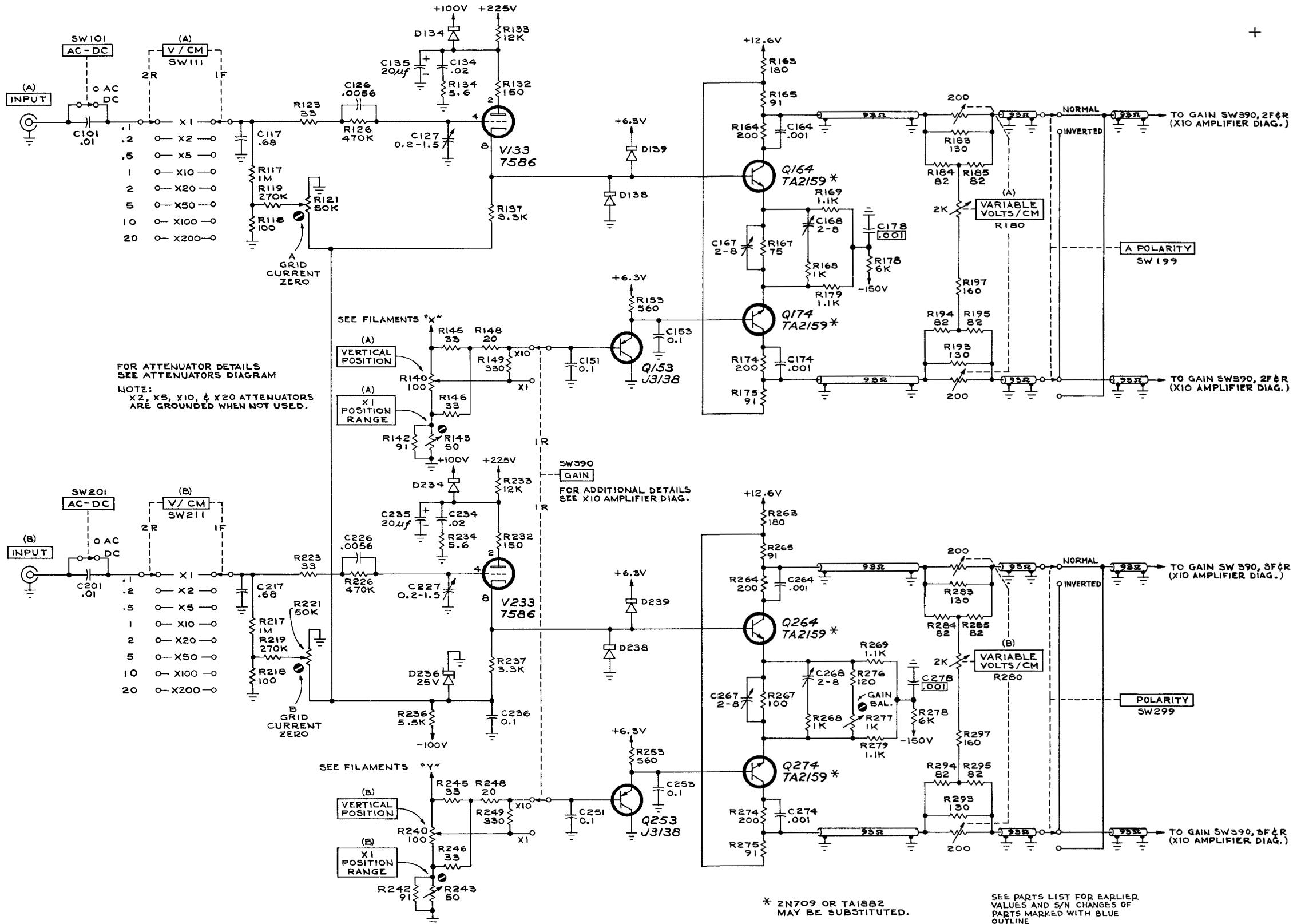
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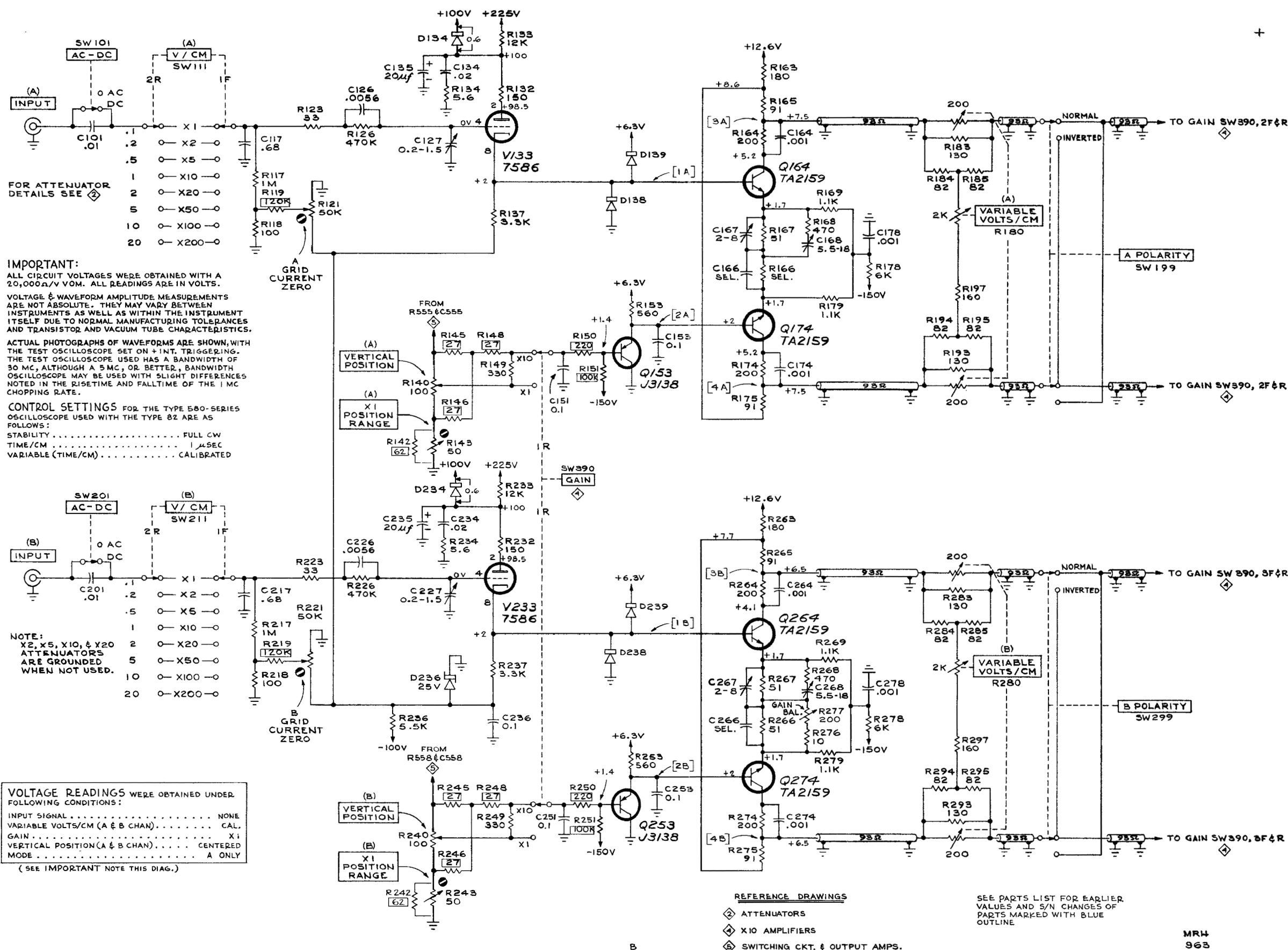
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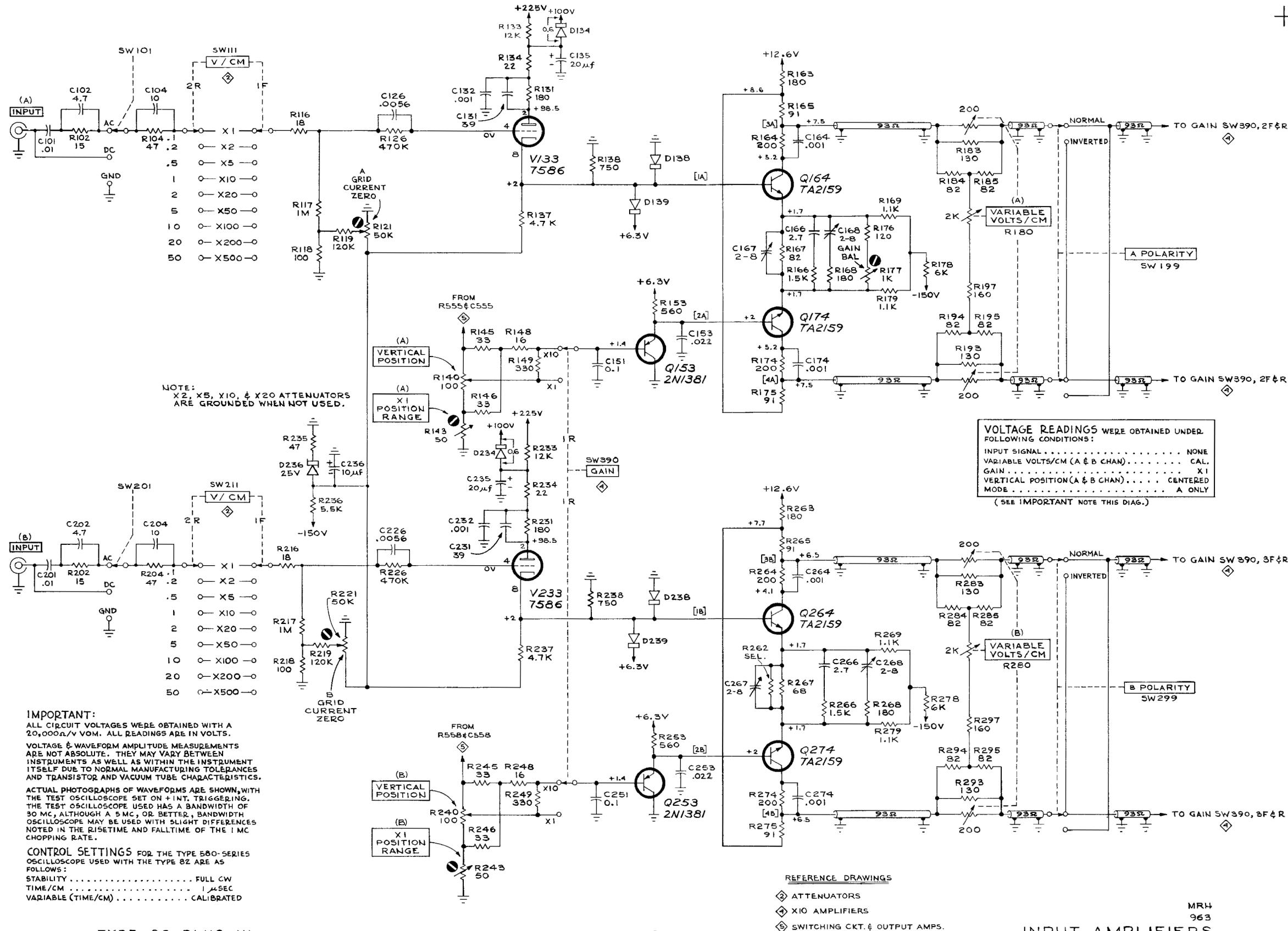
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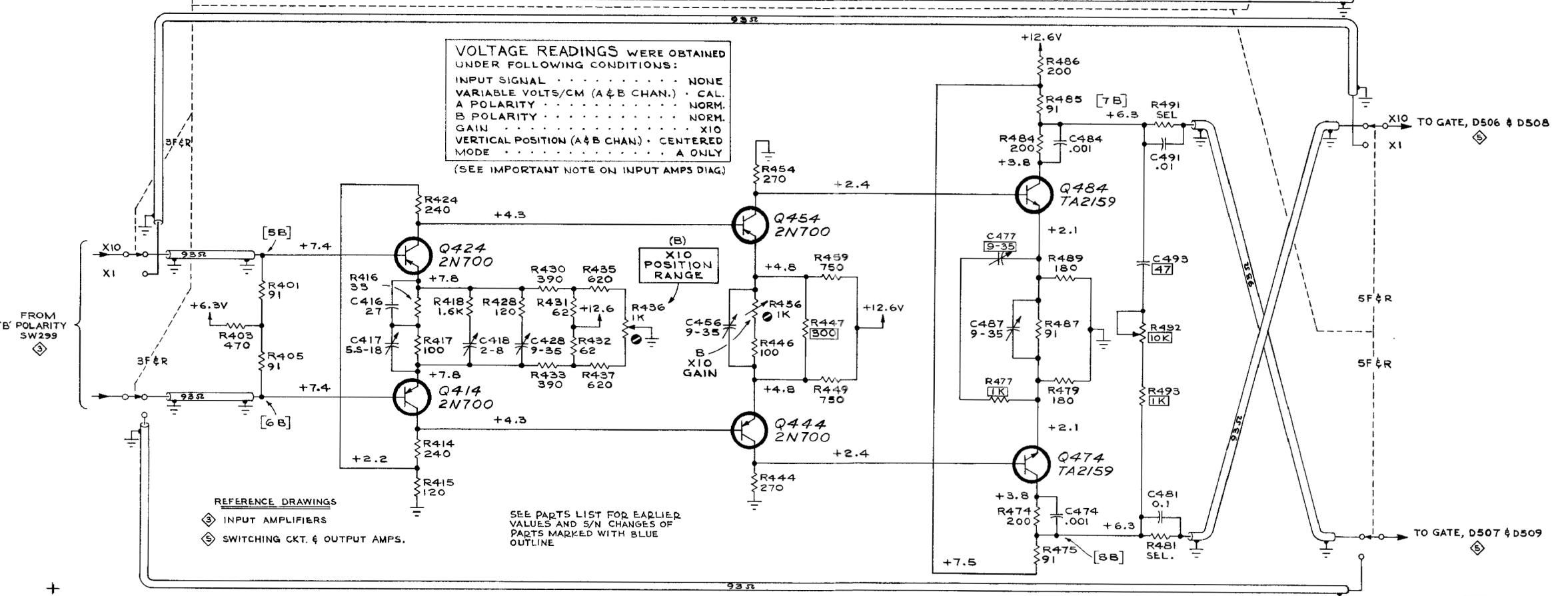
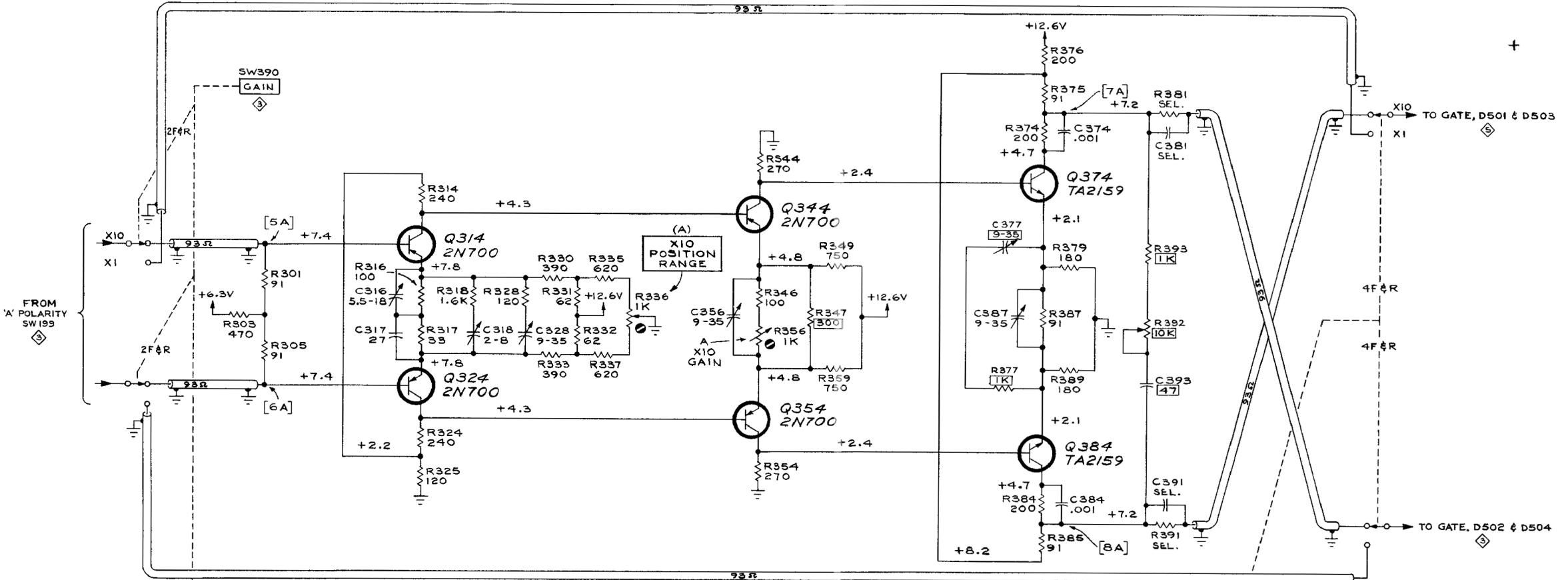


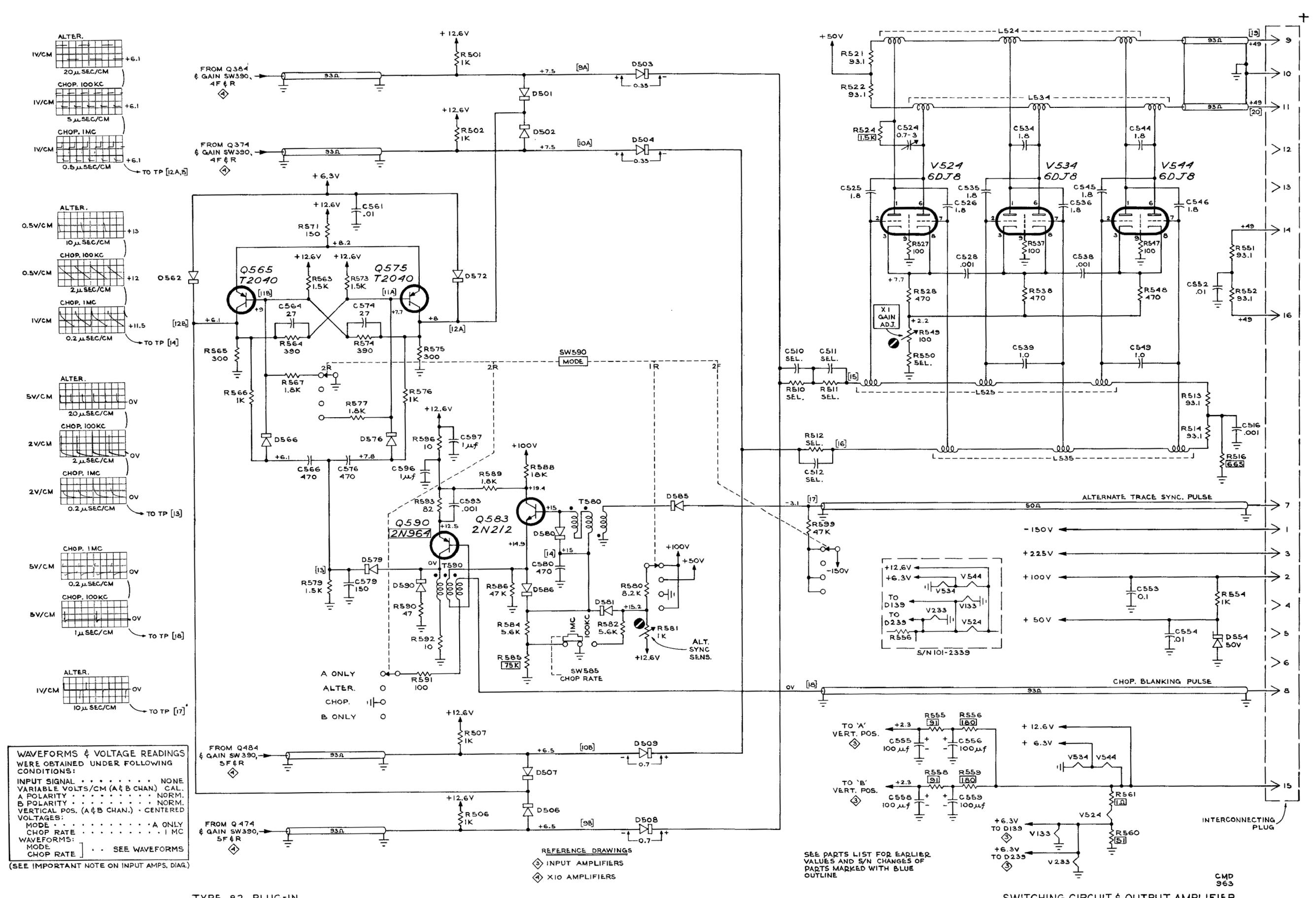












MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages. If it does not, your manual is correct as printed.

TYPE 82

PARTS LIST CORRECTIONS

REMOVE:

C317	281-513	27pf	Cer	500v
C381	283-003	.01 μ f		
C391	283-023	.1 μ f		
C393	281-524	47pf	Cer	500v
C417	281-061	5.5-18pf	Cer	Var
C481	283-023	.1 μ f		
C491	283-003	.01 μ f		
C493	281-518	47pf	Cer	500v
R317	315-330	33 Ω	1/4w	5%
R381	307-114	6.2 Ω		
R391	307-114	6.2 Ω		
R392	311-245	10k	Var	
R393	315-102	1k	1/4w	5%
R417	315-101	100 Ω	1/4w	5%
R481	307-114	6.2 Ω		
R491	307-114	6.2 Ω		
R492	311-245	10k	Var	
R493	315-102	1k	1/4w	5%

CHANGE TO

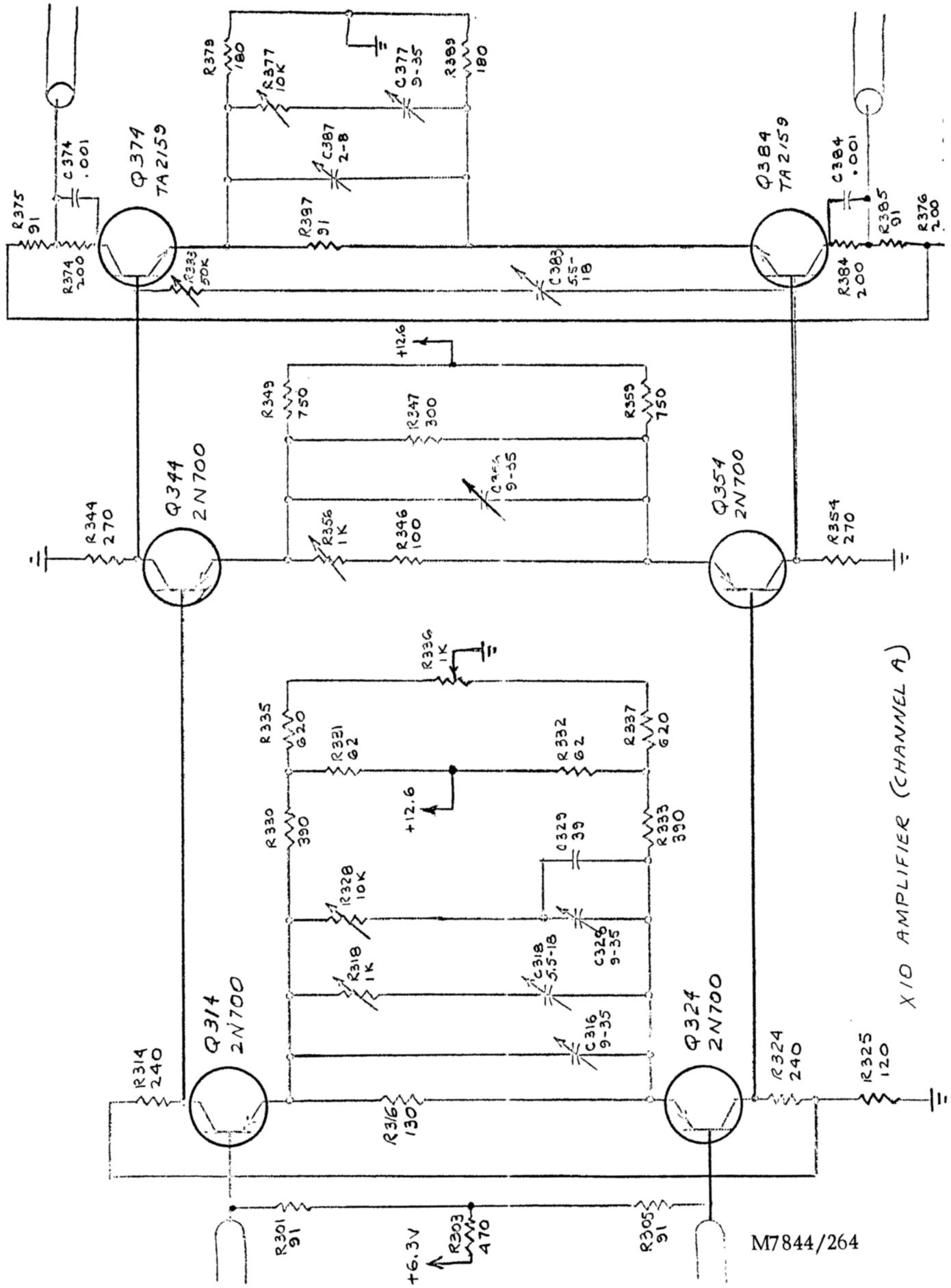
C316	281-063	9-35pf	Cer	Var
C318	281-061	5.5-18pf	Cer	Var
C387	281-060	2-8pf	Cer	Var
C416	281-063	9-35pf	Cer	Var
C418	281-061	5.5-18pf	Cer	Var
C487	281-060	2-8pf	Cer	Var
R316	315-131	130 Ω	1/4w	5%
R318	311-131	1k	Var	
R328	311-017	10k	Var	
R377	311-017	10k	Var	
R416	315-131	130 Ω	1/4w	5%
R418	311-131	1k	Var	
R428	311-017	10k	Var	
R477	311-017	10k	Var	

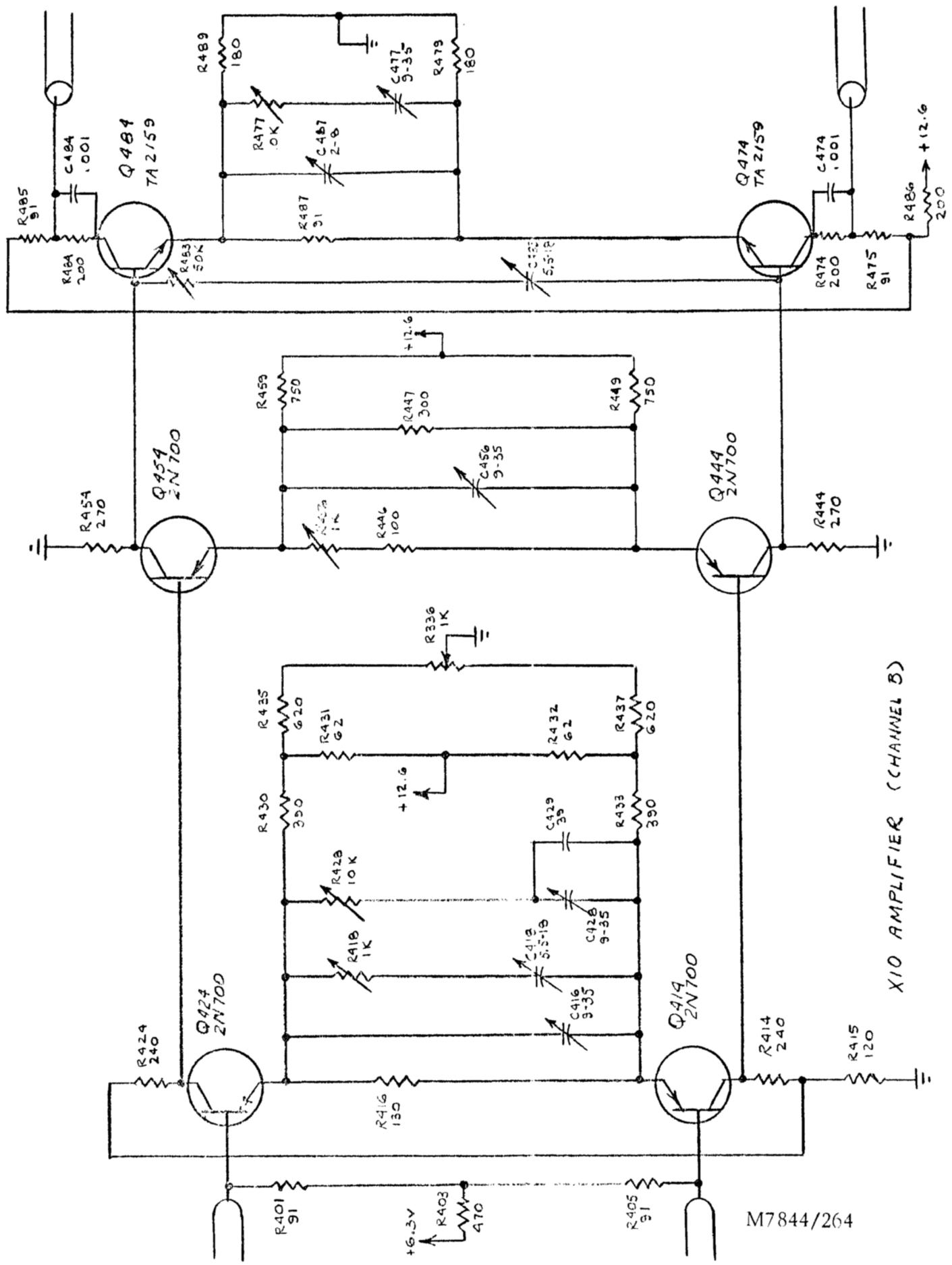
ADD:

* C165	Selected				
** C265	Selected				
C329	281-516	39pf	Cer		500v
C383	281-061	5.5-18pf	Cer	Var	
C429	281-516	39pf	Cer		500v
C483	281-061	5.5-18pf	Cer	Var	
R383	311-078	50k		Var	
R483	311-078	50k		Var	

*CONNECTED IN PARALLEL WITH C167

**CONNECTED IN PARALLEL WITH C267





X10 AMPLIFIER (CHANNEL 3)

TYPE 82 and 86
Calibration Procedure Corrections

Add to steps 26 and 27 of the Type 82, and to step 15 of the Type 86, the following:

C165 (C265) is selected to set C167 (C267) into the middle of its adjustment range.

Correct steps 28 and 29 of the Type 82, and step 16 of the Type 86 to read as below. Only the procedure for calibrating one X10 amplifier is outlined below since the A and B X10 amplifiers in the Type 82 differ only in circuit number. The circuit numbers used are those for the 82 (channelA) and the 86 X10 amplifiers.

X10 High-Frequency Compensation

Insert a 50-ohm 10:1 attenuator between the TU-5 pulser output and the 50-ohm termination. Set the GAIN switch to X10.

If a component in the X10 amplifier has been changed, then R318, R377, R383 and R328 should be set to maximum resistance before starting the procedure.

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 once again setting R318, R377, R383 and R328 to maximum resistance.

Adjustment(s)	Approx. Time Duration (as measured from the front leading corner)	Adjustment made for.
C387		Maximum spike on the front leading corner of the wave- form.
C316, C356		
C318 and R318	10 to 50 nsec depend- ing upon transistor	A square leading front corner on the waveform.

C383 and R383		Adjust only if front leading edge of the waveform has a long time-constant overshoot. Adjust until the waveform has a constant slope.
C377 and R377	100 nsec	A flat and level top on the waveform.
C328 and R328	2 μ sec	A flat and level top on the waveform.