INSTRUCTION MANUAL

Serial Number _____

7A15 AMPLIFIER

Tektronix, Inc. ● P. O. Box 500 ● Beaverton, Oregon 97005 ● Phone 644-0161 ● Cables: Tektronix

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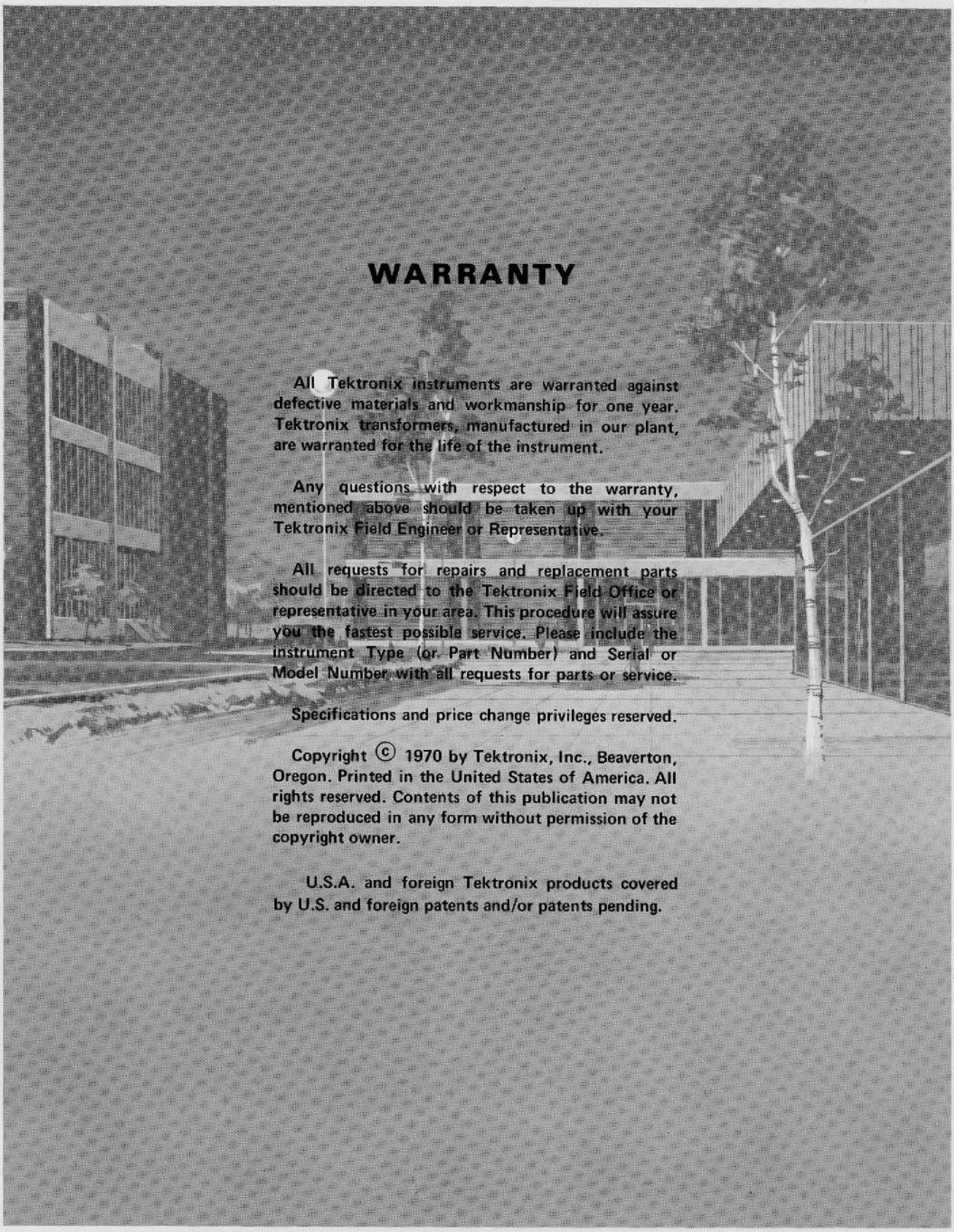

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All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our plant, are warranted for the life of the instrument.

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

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 (or Part Number) and Serial or Model Number with all requests for parts or service.

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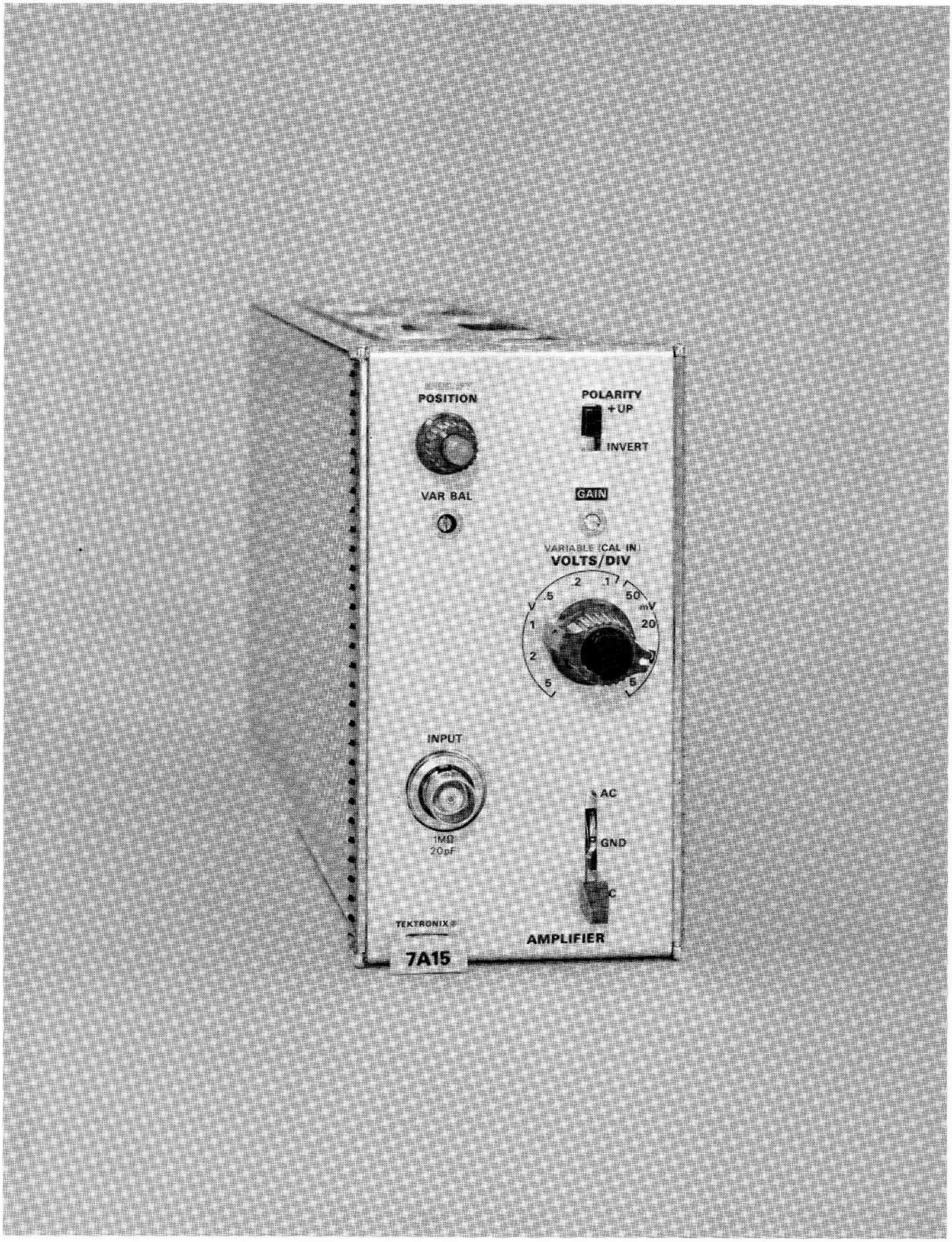
Abbreviations and symbols used in this manual are based on or taken directly from IEEE Standard 260 "Standard Symbols for Units", MIL-STD-12B and other standards of the electronics industry. Change information, if any, is located at the rear of this manual.


POSITION
POLARITY
+UP
INVERT
VAR BAL
GAIN
VARIABLE CAL IN
VOLTS/DIV
.2
.1
.5
50
mV
V
1
20
2
5
5
INPUT
1MΩ
20pF
AC
GND
C
TEKTRONIX
7A15
AMPLIFIER

SECTION 1
SPECIFICATION

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

The 7A15 vertical amplifier plug-in unit is designed for use with Tektronix 7000-series Oscilloscopes. The 7A15 is a wideband general purpose amplifier, with the upper frequency limit determined mainly by the oscilloscope in which it is used. For example, the 7A15 used with the 7504 oscilloscope will have a System Bandwidth of 60 megahertz; and when used with the 7704 oscilloscope, the system bandwidth will be 75 megahertz. A POLARITY switch provides a means of inverting the display. The 7A15 can be operated in any plug-in compartment of the 7000-series oscilloscopes.

This instrument will meet the electrical characteristics listed in Table 1-1 following complete calibration as given in Section 5. The performance check procedure given in Section 5 provides a convenient method of checking instrument performance without making internal adjustments.

The following electrical characteristics are valid over the stated environmental range for instruments calibrated at an ambient temperature of +20°C to +30°C, and after a five minute warmup unless otherwise noted.

TABLE 1-1

ELECTRICAL CHARACTERISTICS

Characteristic	Performance
Deflection Factor	
Calibrated Range	5 mV/div to 5 V/div; 10 steps in a 1, 2, 5 sequence.
Gain Ratio Accuracy	Within 2% of GAIN adjusted at 10 mV/div.
Uncalibrated (Variable)	Continuously variable between calibrated steps; extends deflection factor to at least 12.5 V/div.
GAIN	Permits adjustment of deflection factor for all 7000-series oscilloscopes.

TABLE 1-1 (cont)

Characteristic	Performance	
Frequency Response System Dependent	7500-series Oscilloscope	7700-series Oscilloscope
Upper Bandwidth (DC Coupled)	60 MHz	75 MHz
Lower Bandwidth (AC Coupled) Without Probe	2 hertz or less	
With P6053 Probe	0.2 hertz or less	
Maximum Input Voltage	500 V (DC + Peak AC). AC component 1 kHz or less.	
Input R and C		
Resistance	1 megohm within 2%	
Capacitance	20 picofarads within 1.5 picofarad	
R and C Product	Within 1% over all deflection factor settings	
Maximum Input Gate Current	0.5 nanoampere or less, 0°C to +35°C.	
	2 nanoampere or less, +35°C to +50°C.	
Displayed Noise (Tangentially Measured)	0.06 division or less at 5 mV/div measured in 7700-series oscilloscope.	
DC Drift		
Drift With Time (Ambient Temperature and Line Voltage Constant)		
Short Term	250 microvolts/minute (P-P) or 0.05 division (whichever is greater) in any one minute, after one hour warmup.	

TABLE 1-1 (cont)

Characteristic	Performance
Long Term	250 microvolts/hour (P-P) or 0.05 division (whichever is greater) in any one hour, after one hour warmup.
Drift With Ambient Temperature (Line Voltage Constant	100 microvolt/degree centigrade or less.

TABLE 1-2

ENVIRONMENTAL CHARACTERISTICS

Refer to the Specification for the associated oscilloscope.

TABLE 1-3

PHYSICAL

Fits all 7000-series plug-in compartments.

SECTION 2
OPERATING INSTRUCTIONS

Change information, if any, affecting this section will be found at the rear of this manual.

General

The 7A15 vertical plug-in units operates with a Tektronix 7000-series oscilloscope and a 7B__ series time-base unit to form a complete oscilloscope system. To effectively use the 7A15, the operation and capabilities of the instrument should be known. This section describes the operation of the front-panel controls, gives first-time operation and general operating information, and lists some measurement techniques using the amplifier.

Installation

The 7A15 is designed to operate in a vertical plug-in compartment of Tektronix 7000-series oscilloscopes. For X-Y operation, the 7A15 may also be installed in a horizontal plug-in compartment (refer to the Oscilloscope Instruction Manual for information on X-Y operation). To install the 7A15 into a plug-in compartment, push it in until it is seated flush against the front panel of the oscilloscope. To remove, pull the release latch to disengage the 7A15 from the oscilloscope. Continue to pull the release latch to remove the unit from the oscilloscope.

FRONT PANEL CONTROLS

All controls required for operation of the 7A15 are located on the front panel of the unit. A brief description of the function or operation of the front panel controls follows. More detailed information is given under General Operating Information.

VOLTS/DIV	Selects calibrated vertical deflection factor from 5 mV/div to 5 V/div in a 1, 2, 5 sequence.
VARIABLE (VOLTS/DIV)	Provides uncalibrated variable deflection factors. Extends the highest deflection factor to at least 12.5 V/div. Push knob in and release to activate; the knob moves outward from the VOLTS/DIV control when activated.
POSITION	Controls vertical position of oscilloscope display.
IDENTIFY	When pressed, deflects trace upward for identification and changes CRT readout to the word "IDENTIFY".
POLARITY	
+UP	A positive-going signal at the INPUT produces a positive deflection on the CRT.
INVERT	Inverts display. A negative-going signal at the INPUT produces a positive deflection on the CRT.
COUPLING	
AC	Capacitively couples the input signal to the vertical amplifier.
GND	Disconnects the input signal from the amplifier and grounds the amplifier input. Allows the input coupling capacitor to be charged to the DC voltage applied to the INPUT connector.
DC	The signal is directly coupled to the amplifier.
GAIN Adjustment	Screwdriver adjustment permits calibration of deflection factor.
VAR BAL Adjustment	Screwdriver adjustment permits balancing of the amplifier for minimum trace shift while rotating the VARIABLE control.
INPUT Connector	BNC connector for applying external signals.

FIRST-TIME OPERATION

General

When shipped from the factory, the 7A15 has been calibrated to meet the specifications listed in Section 1 and is ready to be used with an indicator oscilloscope.

The following steps demonstrate the basic operation of the controls of the 7A15. It is recommended that this procedure be followed completely for familiarization with the instrument. Operation of the oscilloscope and time-base unit is described in the instruction manual for these units.

Setup Information

1. Insert the 7A15 into a vertical plug-in compartment of a 7000-series oscilloscope.

2. Insert a 7B__series time-base unit into a horizontal plug-in compartment.

3. Set the controls as follows:

7A15 (Left Vert compartment)

POSITION	Midrange
POLARITY	+UP
VOLTS/DIV	10 mV
COUPLING	DC
VARIABLE	CAL IN

7B51 (B Horiz compartment)

Level/Slope	Centered on positive slope
Triggering	
Mode	P-P Auto
Coupling	AC
Source	Int
Time/Div	1 ms
Variable (Time/Div)	Cal In
Magnifier	X1
B Delay Mode	Independent
Position	Midrange

7504 (Indicator Oscilloscope)

Vertical Mode	Left
Horizontal Mode	B
B Intensity	CCW
Calibrator	1 kHz, 40 mV
B Trigger Source	Left Vert

4. Connect the oscilloscope to a power source which meets the voltage and frequency requirements of the oscilloscope power supply.

5. Turn the oscilloscope power on and allow about 5 minutes warmup.

6. Advance the B Intensity until a free-running trace is observed. Adjust the Position controls to center the trace on the CRT.

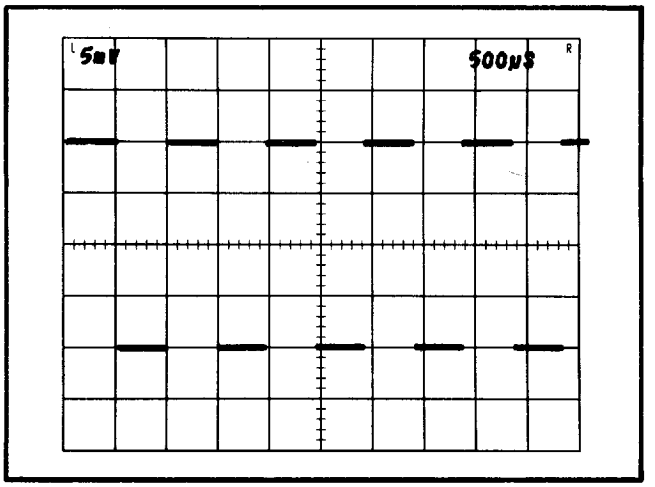


Fig. 2-1. Oscilloscope display when checking amplifier Gain.

7. Connect the Calibrator output to the 7A15 INPUT connector.

8. Check the CRT display for four divisions of vertical deflection (see Fig. 2-1). If necessary, adjust the front panel GAIN for four divisions of vertical deflection.

9. Press the IDENTIFY button and check that the display moves upward about 0.3 divisions. Also check that the readout information on the CRT is replaced by the word "IDENTIFY".

10. Press and release the VARIABLE control to its outward position. Turn the VARIABLE control fully counterclockwise, and check for 1.6 divisions or less display amplitude. Press the VARIABLE control to the CAL IN position.

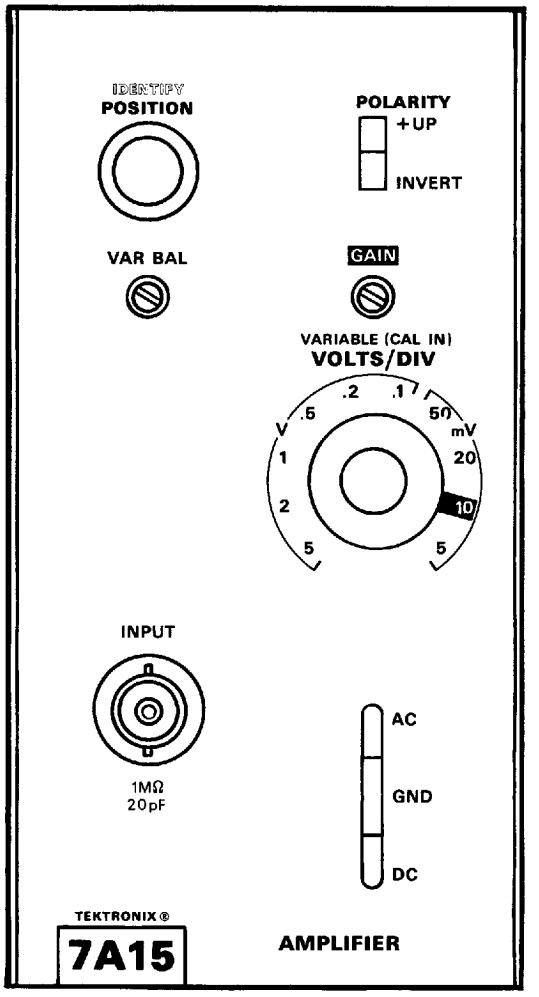
11. Change the VOLTS/DIV to 0.1 V, Calibrator Volts to 0.4 V and the Triggering Source to Ext. Connect the Calibrator output through a "T" connector to the time base Ext Trig In and the 7A15 INPUT connector. Set the POLARITY switch to INVERT to display the opposite polarity of the square wave.

This completes the basic operating procedure for the 7A15. Instrument operations not explained here or operations which need further explanation are discussed under General Operating Information.

CONTROL SETUP CHART

Figure 2-2 shows the front panel of the 7A15. This chart can be reproduced and used as a front panel record for special measurements, applications or procedures, or it may be used as a training aid for familiarization with this instrument.

7A15 TEST SET-UP CHART



NOTES:

Fig. 2-2. 7A15 control setup chart.

GENERAL OPERATING INFORMATION

Signal Connection

In general, probes offer the most convenient means of connecting a signal to the input of the 7A15. Tektronix probes are shielded to prevent pickup of electrostatic interference. A 10X attenuator probe offers a high input impedance and allows the circuit under test to operate very close to normal operating conditions. However, a 10X probe also attenuates the input signal ten times.

In high-frequency applications requiring maximum overall bandwidth, use a coaxial cable terminated at both ends in the characteristic impedance of the cable. To maintain the high-frequency characteristics of the applied signal, use high-quality low-loss cable. Resistive coaxial attenuators can be used to minimize reflections if the applied signal has suitable amplitude.

High-level low-frequency signals can be connected directly to the 7A15 INPUT connector with short unshielded leads using a BNC to Banana Jack Adapter. This method works best for signals below about one kilohertz and deflection factors above one volt/division. When this method is used, establish a common ground between the 7A15 and the equipment under test (common ground provided by line cords is usually inadequate). Attempt to position the leads away from any source of interference to avoid errors in the display. If interference is excessive with unshielded leads, use a coaxial cable or a probe.

Input Coupling

The AC-GND-DC lever switch allows a choice of input coupling. The type of display desired determines the mode of input coupling used. The DC position can be used for most applications. However, if the DC component of the signal is much larger than the AC component, the AC position will probably provide a better display. DC coupling should be used to display AC signals below about 2 hertz and square waves containing low-frequency components, as they will be attenuated in the AC position.

In the AC position, the DC component is blocked by a capacitor in the input circuit. The low-frequency response in the AC position is about 2 hertz (−3 dB point). Therefore, some low-frequency attenuation can be expected near this frequency limit. Distortion will also appear in square waves which have low-frequency components.

The GND position provides a ground reference at the amplifier input. The signal applied to the INPUT connector is presented with a one megohm load, while the amplifier input is grounded. This eliminates the need to externally ground the INPUT to establish a DC ground reference.

The GND position is also used to pre-charge the coupling capacitor to the average level of the signal applied to the INPUT connector. The pre-charge network allows the input coupling capacitor to charge to the DC source voltage level when the COUPLING switch is set to GND.

The procedure for using this feature is as follows:

1. Before connecting the signal containing a DC component to the 7A15 INPUT, set the COUPLING switch to GND. Then connect the signal to the INPUT connector.

2. Allow about two seconds for the coupling capacitor to charge.

3. Reset the COUPLING switch to AC. The trace (display) will remain on the screen and the AC component of the signal can be measured in the normal manner.

Deflection Factor

The amount of vertical deflection produced by a signal is determined by the signal amplitude, the attenuation factor of the probe (if any), the setting of the VOLTS/DIV switch and the setting of the VARIABLE control (if control is in the outward position). The calibrated deflection factors indicated by the VOLTS/DIV switch apply only when the VARIABLE control is in the inward (CAL IN) position.

The VARIABLE control provides uncalibrated vertical deflection between the calibrated settings of the VOLTS/DIV switch, and extends the maximum deflection factor to at least 12.5 volts/division.

The GAIN control, a front-panel screwdriver adjustment, sets the gain of the 7A15 in the 10 mV/div position of the VOLTS/DIV switch. The gain calibration of the unit should be checked for accuracy prior to making critical measurements, using either the oscilloscope calibrator output or a standard amplitude calibrator. If adjustment is necessary, the GAIN should be adjusted with the VOLTS/DIV switch set to 10 mV.

Variable Balance

To check and/or adjust the VAR BAL, proceed as follows:

1. Set the COUPLING to GND and adjust the time-base controls for a free-running trace.

2. Press and release the VARIABLE control to its outward position.

3. While rotating the VARIABLE control throughout its range, adjust the VAR BAL (a front panel screwdriver adjustment) for minimum trace shift (0.5 div or less shift as VARIABLE control is turned from fully clockwise to fully counterclockwise).

Signal Polarity

The POLARITY switch provides a means of inverting the display. With the POLARITY set to +UP, a positive-going voltage at the INPUT produces an upward deflection of the CRT display. With POLARITY set to INVERT, a positive-going voltage at the INPUT will produce a downward deflection of the CRT display. If a symmetrical waveform such as the calibrator square-wave is to be observed, the time-base must be triggered externally to observe the polarity inversion. This is due to the time-base unit triggering on the indicated slope of the displayed waveform when it is triggered internally.

Display Identification

When the 7A15 IDENTIFY button is pressed, the CRT display representing the output of the 7A15 is deflected upward about 0.3 division for identification. This feature is particularly useful in oscilloscopes having multi-trace displays.

When using an oscilloscope system equipped with the readout feature, information such as polarity, deflection factor, etc., is displayed on the CRT. When the IDENTIFY button is pressed, the readout information pertaining to the 7A15 is replaced by the word "IDENTIFY" to aid in locating the 7A15 readout when more than one vertical unit is used.

BASIC APPLICATIONS

The following information describes the procedure and techniques for making basic measurements with the amplifier. These applications are not described in detail since each application must be adapted to the requirements of the individual measurement. Familiarity with the 7A15 will permit these basic techniques to be applied to a wide variety of uses.

Peak-to-Peak Voltage Measurement—AC

To make a peak-to-peak voltage measurement, use the following procedure:

1. With the COUPLING set to GND, connect the signal to the INPUT connector.

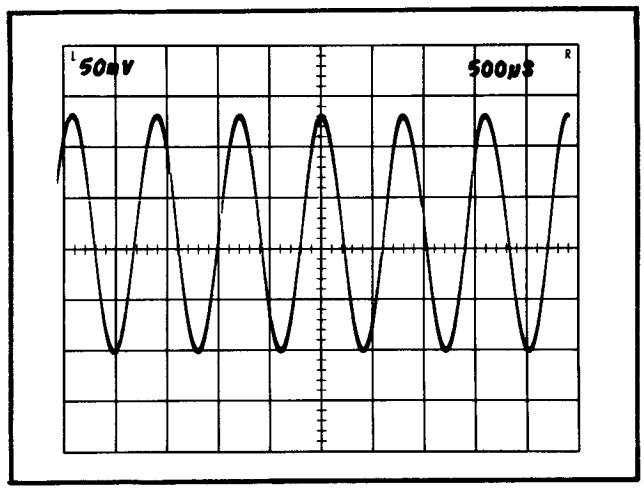


Fig. 2-3. Oscilloscope display when making P-P voltage measurements.

2. Reset the COUPLING to AC, adjust the time-base triggering controls for a stable display and set the Time/Div to display several cycles of the waveform.

3. Set the VOLTS/DIV switch to display about five vertical divisions of the waveform. Check that the VARIABLE control is in the CAL IN (pushed in) position.

4. With the POSITION control, position the display so the lower portion of the waveform coincides with one of the graticule lines below the center horizontal reference line, and the top of the waveform is in the viewing area. Move the display with the horizontal Position control so one of the upper peaks is aligned with the center vertical reference line (see Fig. 2-3).

5. Measure the vertical deflection from peak to peak (divisions).

NOTE

This technique may also be used to make measurements between two points on the waveform, rather than peak to peak.

6. Multiply the distance (in divisions) measured in step 5 by the VOLTS/DIV switch settings. Include the attenuation factor of the probe being used.

Example: Assume a peak-to-peak vertical deflection of 4.6 divisons using a 10X attenuator probe and a VOLTS/DIV setting of 0.5 V.

Volts (peak-to-peak) =

vertical deflection (divisions) X VOLTS/DIV switch setting X probe attenuation factor

Substituting the given values:

Volts (peak-to-peak) = 4.6 X 0.5 X 10

The peak-to-peak voltage is 23 volts.

Instantaneous Voltage Measurement—DC

To measure the DC level at a given point on a waveform, use the following procedure:

1. Set the COUPLING to GND and position the trace to the bottom line of the graticule (or other selected reference line). If the voltage to be measured is negative with respect to ground, position the trace to the top line of the graticule. Do not move the vertical POSITION control after this reference has been established.

NOTE

To measure a voltage level with respect to a voltage other than ground, make the following changes to step 1: Set the COUPLING to DC and apply the reference voltage to the INPUT connector, then position the trace to the reference line.

2. Connect the signal to the INPUT connector.

3. Set the COUPLING to DC (the ground reference can be checked at any time by setting the COUPLING to GND).

4. Set the VOLTS/DIV switch to display about five vertical divisions of the waveform. Check that the VARIABLE control is in the CAL IN position. Adjust the time-base triggering controls for a stable display.

5. Measure the vertical distance in divisions between the reference line and the point on the waveform at which the DC level is to be measured. For example, in Fig. 2-4 the measurement is made between the reference line and point A.

6. Establish the polarity of the signal. If the waveform is above the reference line, the voltage is positive; below the reference line, negative.

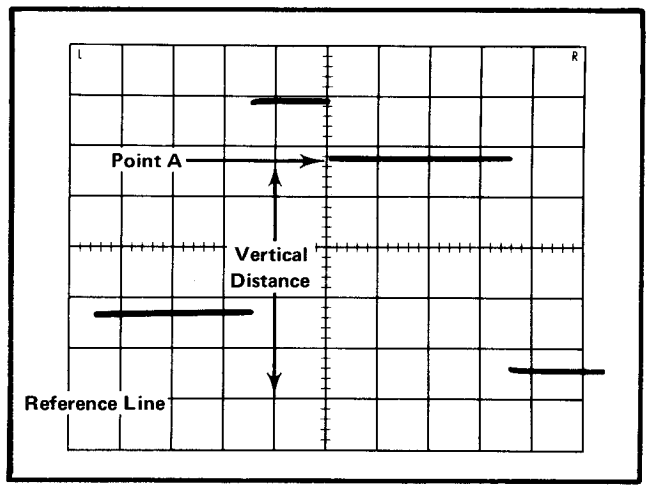


Fig. 2-4. Oscilloscope display when measuring instantaneous DC level.

7. Multiply the distance measured in step 5 by the VOLTS/DIV switch setting. Include the attenuation factor of the probe, if any. Example: Assume that the vertical distance measured is 4.8 divisions, the waveform is above the reference line, using a 10X attenuator probe and a VOLTS/DIV switch setting of 0.5 V.

Using the formula:

Instantaneous Voltage =

vertical distance (divisions) X Polarity X VOLTS/DIV Switch setting X probe attenuation factor

Substituting the given values:

Instantaneous Voltage = 4.8 X +1 X 0.5 V X 10

The instantaneous voltage is +24 volts.

Voltage Comparison Measurements

In some applications, it may be necessary to establish a set of deflection factors other than those indicated by the VOLTS/DIV switch. This is useful for comparing signals to a reference signal amplitude. To establish a new set of deflection factors based upon a specific reference amplitude, proceed as follows:

1. Apply a reference signal of known amplitude to the INPUT connector. Using the VOLTS/DIV switch and the VARIABLE control, adjust the display for an exact number of divisions. Do not move the VARIABLE control after obtaining the desired deflection.

2. Divide the amplitude of the reference signal (volts) by the product of the deflection (divisions) from step 1 and the VOLTS/DIV switch setting. This is the Deflection Conversion Factor.

$$\text{Deflection Conversion Factor} = \frac{\text{reference signal amplitude (volts)}}{\text{deflection (divisions) X VOLTS/DIV setting}}$$

3. To determine the amplitude of a signal compared to a reference, disconnect the reference signal and apply the signal to be compared to the 7A15 INPUT connector.

4. Set the VOLTS/DIV switch to a setting that provides sufficient deflection to make the measurement (do not readjust the VARIABLE control).

5. To establish an Adjusted Deflection Factor at any setting of the VOLTS/DIV switch, multiply the VOLTS/DIV switch setting by the Deflection Conversion Factor established in step 2.

$$\text{Adjusted Deflection Factor} = \text{VOLTS/DIV switch setting} \times \text{Deflection Conversion Factor}$$

This Adjusted Deflection Factor is correct if the VARIABLE control has not been moved from the position set in step 1.

6. Measure the vertical deflection in divisions and determine the amplitude by the following formula:

$$\text{Signal Amplitude} = \text{Adjusted Deflection Factor} \times \text{deflection (divisions)}$$

Example: Assume a reference signal amplitude of 30 volts, a VOLTS/DIV switch setting of 5 V and a vertical deflection of four divisions. Substituting these values in the Deflection Conversion Factor formula (step 2):

$$\text{Deflection Conversion Factor} = \frac{30 \text{ volts}}{4 \text{ (div)} \times 5 \text{ V}} = 1.5$$

Then with a VOLTS/DIV switch setting of 2 V, the Adjusted Deflection Factor (step 5) is:

Adjusted Deflection Factor = 2 V X 1.5 = 3 volts/division

To determine the amplitude of an applied signal which produces a vertical deflection of five divisions, use the Signal Amplitude formula (step 6):

Signal Amplitude = 3 V X 5 (div) = 15 volts

NOTES

SECTION 3
CIRCUIT DESCRIPTION

Change information, if any, affecting this section will be found at the rear of this manual.

Introduction

This section of the manual contains a description of the circuitry used in the 7A15 amplifier. The description begins with a discussion of the instrument using the block diagram shown in the diagrams section. Then each circuit is described in detail using the block diagram to show interconnections between the circuits and relationship of the front panel controls to the individual stages.

Complete schematics of each circuit are given in the Diagrams section. Refer to these diagrams throughout the following circuit description for electrical values and relationship.

BLOCK DIAGRAM DESCRIPTION

The following discussion is provided to aid in understanding the overall concept of the 7A15 before the individual circuits are discussed in detail. Each block on the Block Diagram, (in the Diagrams section) represents an individual circuit within the instrument. The number on each block refers to the diagram on which the complete circuit is found.

The signal to be displayed on the CRT is applied to the INPUT connector, through the input coupling circuit to the VOLTS/DIV switch. The VOLTS/DIV switch provides the appropriate input attenuation and applies the signal to the Input Amplifier (Q103A-Q103B-Q110-Q210-Q112-Q212). The gain setting, variable gain, and variable balance adjustments are contained in this stage. The input signal is changed from single-ended to differential by this stage and applied to the polarity selection stage. The Polarity Selection stage (Q130-Q230-Q140-Q240) provides signal polarity inversion when the front panel POLARITY switch is set to INVERT.

The Output Amplifier stage (Q160-Q260-Q170-Q270) provides vertical positioning of the CRT display and impedance matching between the 7A15 and the oscilloscope vertical input. The Trigger Pickoff circuit, Q180-Q280-Q185-Q285, takes the signal from the emitters of Q170-Q270 and amplifies it to provide + and − trigger signals for the time base unit.

In addition to the functions of the amplifier just explained, the 7A15 also provides readout logic for the indicator oscilloscope. Logic is supplied which identifies the display Polarity and the deflection factor, whether calibrated or uncalibrated. When the IDENTIFY button is pressed, the readout is erased and the word IDENTIFY appears. At the same time, the bottom of R274 is grounded to deflect the trace upward approximately 0.25 division.

DETAILED CIRCUIT DESCRIPTION

Input Coupling

Input signals applied to the INPUT connector can be AC-coupled, DC-coupled, or internally disconnected. With the coupling switch set to AC, the signal path is through C1-R1-COUPLING switch-C3-R3 and through the VOLTS/DIV switch to the input amplifier. In this position, C1 prevents the DC component of the signal from passing to the amplifier. With the COUPLING switch set to DC, the signal path is through C3-R3 and the VOLTS/DIV switch to the amplifier input. With the COUPLING switch set to GND, the input signal is AC-coupled through C1-R1-R2 to ground to provide a constant load for the signal source. At the same time, the amplifier input is grounded to provide a 0 volts reference level. Resistor R2 allows C1 to be precharged in the GND position so the trace will remain on screen when the AC button is pressed with a high DC level applied.

Input Attenuator

The effective overall deflection factor of the 7A15 is determined by the VOLTS/DIV switch attenuators. The basic deflection factor of the 7A15 is 5 mV per division of deflection. To increase this basic deflection factor to the values indicated on the front panel, precision attenuators are switched into the input circuit. The input attenuators form frequency-compensated voltage dividers. For DC and low-frequency signals, they are primarily resistance dividers, and the voltage attenuation is determined by the resistance ratio in the circuit. The reactance of the capacitors in the circuit is so high at low frequencies that their effect is negligible. However, at higher frequencies, the reactance of the capacitors decreases and the attenuator becomes primarily a capacitance voltage divider.

In addition to providing constant attenuation at all frequencies within the bandwidth of the system, the input

attenuators are designed to maintain the same input RC characteristics for each setting of the VOLTS/DIV switch. The attenuators contain adjustable shunt capacitors to provide input capacitance.

Input Amplifier

The signal from the input attenuator is connected to the Input Amplifier through R109-R100-R101-C101. These resistors are part of the attenuation network at all VOLTS/DIV switch positions. Resistor R101 limits the overdrive gate current of input FET Q103A. C101-CR102-C102 provide an input protection circuit to protect Q103A from large negative voltage swings. Protection from large positive voltage swings is provided by Q110, which effectively clamps the source of input FET Q103A to the +15 volt supply.

The input signal is coupled through source follower Q103A and emitter follower Q110 to the base of Q112, one-half of the input paraphase amplifier. The other half of the paraphase amplifier, Q212, is a grounded-base configuration. The reference voltage level at the base of Q212 is set by the VAR BAL control, a front panel adjust. The paraphase amplifier converts the single-ended input into a differential output. The gain of the amplifier is set in this stage by front panel GAIN control R121 with the variable control set to the CAL IN position. With the VARIABLE control in the outward (uncalibrated) position and turned fully counterclockwise to minimum resistance, the gain of the amplifier is reduced by a factor of at least 2.5. This extends the maximum uncalibrated deflection factor to at least 12.5 volts/division. Damping resistors R114 and R214 in the collector circuits of Q112 and Q212 respectively, serve to damp out any ringing or oscillations. C114-R115 and C214-R215 are thermal compensation networks.

Polarity Selection Stage

The Polarity Selection Stage made up of Q130-Q230-Q140-Q240 provides a means of inverting the input signal. With the POLARITY switch set to +UP, Q130 and Q230 are biased on and the signal is passed straight through to the output amplifier. With the POLARITY switch set to INVERT, Q130 and Q230 are biased off and Q140-Q240 are turned on to provide signal inversion. C131-R131 and C231-R231 are thermal compensation networks.

Output Amplifier

The Output Amplifier is composed of Q160-Q260-Q170-Q270 and their associated circuitry. The vertical POSITION control is located in the input to this stage. Thermistor RT151 and varactors CR154-CR254 provide proper compensation for transient response with changes of temperature. Thermal compensation for Q160 and Q260 is provided by R161-C161 and R261-C261 respectively. R171-C171 and R271-C271 provide thermal compensation for Q170 and Q270 respectively. C253-C175-R175 are high-frequency peaking adjustments for calibration of the 7A15.

Trigger Pickoff Stage

The Trigger Pickoff stage consists of Q180-Q280-Q185-Q285 and their associated circuitry. Emitter followers Q180 and Q280 provide isolation between the trigger output circuit and the signal output circuit to prevent loading of the signal output amplifier. R186-C186 and R284-C284 provide thermal compensation for Q185 and Q285 respectively. The trigger output amplitude is approximately the same as the signal output amplitude.

Readout Block

An analog coding system is used in the 7A15 to convey information from the plug-in to the oscilloscope readout section. Each symbol used by the 7A15 requires two currents to define it. This readout information is encoded on two output lines, interface connectors A37 and B37, by the resistors between output lines and interface connectors A30, A32, A33, B29, B32 and B33.

Refer to Schematic Diagram 3 in the Diagrams section to find the resistors associated with a particular setting of the VOLTS/DIV switch.

The probe connected to the INPUT connector forms a voltage divider with R75 to the −15 volt power supply. The amount of probe resistance will determine the bias applied to the base of Q80. For example, with a 10X attenuator probe such as the P6053 Probe connected to the INPUT connector, the bias applied to the base of Q80 will allow 100 microamperes of collector current to flow. When the time slot pulse from the oscilloscope interrogates interface connector B33, this 100 microamperes of current is added to the current corresponding to the setting of the VOLTS/DIV switch to increase the deflection factor (in the displayed readout) by a factor of 10. Refer to the appropriate oscilloscope Instruction Manual for more information on the Readout System.

The oscilloscope displayed readout will give the correct deflection factor from the probe tip (using the recommended attenuator probes), whereas the VOLTS/DIV knob on the plug-in will display only the plug-in deflection factor.

The trace IDENTIFY button, when pressed, does two things:

1. It grounds the junction of R75-R274 (bottom end of R274) to deflect the trace upward about 0.25 division.

2. The base of Q80, which is connected to the junction of R75-R274, is also grounded. This turns Q80 on hard, and the displayed readout is replaced by the word IDENTIFY.

These two actions aid in identifying the 7A15 trace when multiple traces are displayed on the CRT. When the IDENTIFY button is released, the readout is restored to its previous display.

NOTES

SECTION 4
MAINTENANCE

Change information, if any, affecting this section will be found at the rear of this manual.

Introduction

This section of the manual contains maintenance information for use in preventive maintenance, corrective maintenance and troubleshooting of the 7A15.

PREVENTIVE MAINTENANCE

General

Preventive maintenance consists of cleaning, visual inspection, lubrication, etc. Preventive maintenance performed on a regular basis may prevent instrument breakdown, and will improve reliability of this instrument. The severity of the environment to which the 7A15 is subjected determines the frequency of maintenance. A convenient time to perform preventive maintenance is preceding recalibration of the instrument.

Cleaning

The 7A15 should be cleaned as often as operating conditions require. Accumulation of dirt in the instrument can cause overheating and component breakdown. Dirt on the components acts as an insulating blanket and prevents effective heat dissipation. It may also provide an electrical conduction path.

CAUTION

Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. Do not apply any solvent containing ketones, esters or halogenated hydrocarbons. To clean, use only water soluble detergents, ethyl, methyl or isopropyl alcohol.

The covers of the oscilloscope minimize the amount of dust which reaches the interior of the 7A15. Operation of the system without the oscilloscope covers in place necessitates more frequent cleaning. When the 7A15 is not in use, it should be stored in a protected location, such as a dust-tight cabinet.

Exterior. Loose dust accumulated on the outside of the 7A15 can be removed with a soft cloth or small paint brush. The paint brush is particularly useful for dislodging dirt on and around the front-panel controls. Dirt which remains can be removed with a soft cloth dampened in a mild detergent and water soluton. Abrasive cleaners should not be used.

Interior. Dust in the interior of the instrument should be removed occasionally due to its electrical conductivity under high-humidity conditions. The best way to clean the interior is to blow off the accumulated dust with dry, low-velocity air. Remove any dirt which remains with a soft paint brush or a cloth dampened with a mild detergent and water solution. A cotton-tipped applicator is useful for cleaning in narrow spaces.

Visual Inspection

The 7A15 should be inspected occasionally for such defects as broken connections, broken or damaged circuit boards, improperly seated transistors and heat-damaged parts.

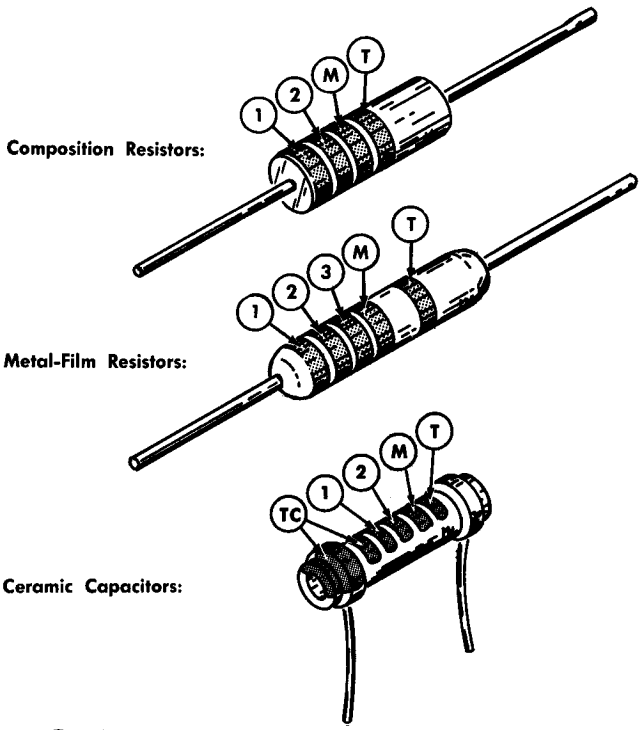
The corrective procedure for most visible defects is obvious. However, particular care must be taken if heat-damaged components are found. Overheating usually indicates other trouble in the instrument; therefore, it is important that the cause of overheating be corrected to prevent a recurrence of the damage.

Semiconductor checks

Periodic checks of the semiconductors in the 7A15 are not recommended. The best check of a semiconductor's performance is its actual operation in the instrument. More details on checking semiconductor operation are given under Troubleshooting.

Recalibration

To ensure accurate measurements, check the calibration of this instrument after each 1000 hours of operation, or every six months if used infrequently. In addition, replacement of components may necessitate recalibration of the affected circuits. Complete calibration instructions are given in Section 5.



Resistor and Capacitor Color Code

Color	Significant Figures	Multiplier Resistors	Multiplier Capacitors	Tolerance Resistors	Tolerance Capacitors
Silver	---	10^{-2}	---	±10%	---
Gold	---	10^{-1}	---	±5%	---
Black	0	1	1	---	±20% or 2 pF*
Brown	1	10	10	±1%	±1% or 0.1 pF*
Red	2	10^2	10^2	±2%	±2%
Orange	3	10^3	10^3	±3%	±3%
Yellow	4	10^4	10^4	±4%	+100% −0%
Green	5	10^5	10^5	±0.5%	±5% or 0.5 pF*
Blue	6	10^6	10^6	---	---
Violet	7	---	---	---	---
Gray	8	---	10^{-2}	---	+80% −20% or 0.25 pF*
White	9	---	10^{-1}	---	±10% or 1 pF*
(none)	---	---	---	±20%	±10% or 1 pF*

*For capacitance of 10 pF or less.

(1) (2) and (3) —1st, 2nd and 3rd significant figures;
(M) —multiplier; (T) —tolerance;
(TC) —temperature coefficient.

NOTE: (T) and/or (TC) color code for capacitors depends upon manufacturer and capacitor type. May not be present in some cases.

Fig. 4-1. Color code for resistors and ceramic capacitors.

The Performance Check/Calibration procedure can also be helpful in localizing certain troubles in the instrument. In some cases, minor troubles may be revealed and/or corrected by calibration.

TROUBLESHOOTING

Introduction

The following information is provided to facilitate troubleshooting of the 7A15. Information contained in other sections of this manual should be used along with the following information to aid in locating the defective component. An understanding of the circuit operation is very helpful in locating troubles. See the Circuit Description section for complete information.

Troubleshooting Aids

Diagrams. Circuit diagrams are given on foldout pages in the Diagrams Section. The component number and electrical value of each component in this instrument are shown on the diagrams. Important voltages and waveforms are also shown on the diagrams.

Resistor Color Code. In addition to the brown composition resistors, some metal-film resistors are used in this instrument. The resistance values of composition resistors and metal-film resistors are color-coded on the components some metal-film resistors may have the value printed on the body) with EIA color code. The color code is read starting with the stripe nearest the end of the resistor. Composition resistors have four stripes which consist of two significant figures, a multiplier and a tolerance value (see Fig. 4-1). Metal-film resistors have five stripes consisting of three significant figures, a multiplier and a tolerance value.

Capacitor Marking. The capacitance value of a common disc capacitor or small electrolytic is marked in microfarads on the side of the component body. The white ceramic capacitors used in the 7A15 are color coded in picofarads using a modified EIA code (see Fig. 4-1).

Diode Color Code. The cathode end of each glass-encased diode is indicated by a stripe, a series of stripes or a dot. For most silicon or germanium diodes with a series of stripes, the color code also indicates the type of diode or identifies the Tektronix Part Number, using the resistor color code system (e.g., a diode color coded blue or pink-

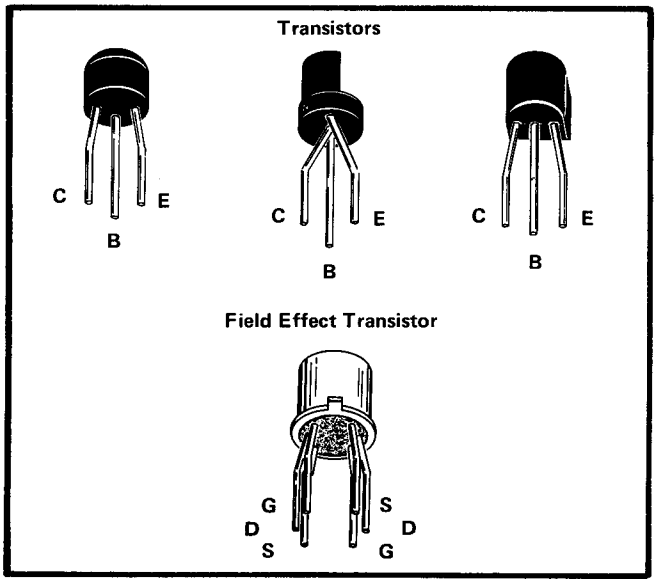


Fig. 4-2. Electrode configurations for semiconductors used in this instrument.

brown-gray-green indicates Tektronix Part Number 152-0185-00). The cathode and anode ends of a metal-encased diode can be identified by the diode symbol marked on the body.

Semiconductor Lead Configuration. Fig. 4-2 shows the lead configuration of the semiconductors used in this instrument. The view is as seen from the bottom of the semiconductor.

Multi-Connector Holders. The multi-connector holder is keyed with two triangles, one on the holder and one on the circuit board. When a connection is made perpendicular to a circuit board surface, the orientation of the triangle and the slot numbers on the connector holder is determined by the direction of the nomenclature marking (see Fig. 4-3).

Main Amplifier Board. Fig. 4-4 shows the locations of the components on the circuit board associated with this instrument.

Troubleshooting Equipment

The following equipment is useful for troubleshooting the 7A15:

1. Transistor Tester

Description: Tektronix Type 576 Transistor-Curve Tracer or equivalent.

Purpose: To test the semiconductors used in this instrument.

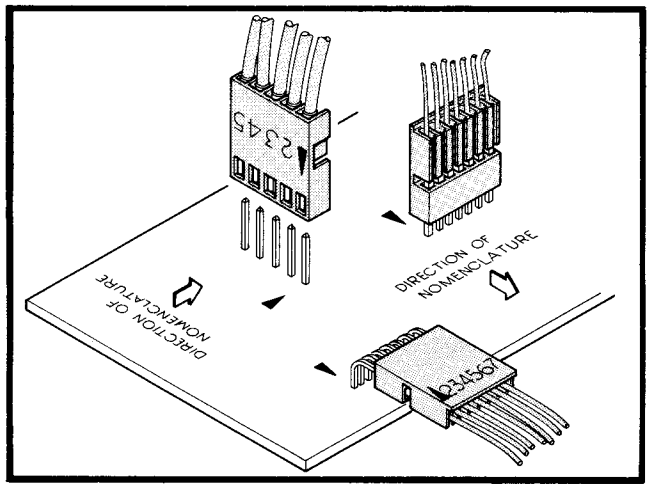


Fig. 4-3. Multi-connector holder orientation.

2. Volt-Ohmmeter

Description: 20,000 ohms/volt; 0-50 volts DC; accuracy within 3%. Test probes must be well insulated.

Purpose: To measure voltages and resistances.

3. Test Oscilloscope

Description: DC to 85 megahertz frequency response; 5 millivolts to 5 volts per division sensitivity. Use a 10X probe.

Purpose: To check waveforms in the instrument.

4. Plug-In Extender

Description: Calibration Fixture, Tektronix Part Number 067-0589-00.

Purpose: Permits operation of the unit outside the plug-in compartment for better accessibility during troubleshooting.

Troubleshooting Techniques

This troubleshooting procedure is arranged in an order which checks the simple trouble possibilities before proceeding with extensive troubleshooting. The first few checks ensure proper connection, operation and calibration. If the trouble is not located by these checks, the remaining steps aid in locating the defective component. When the defective component is located, it should be replaced following the replacement procedures given under Corrective Maintenance.

1. Check Control Settings. Incorrect control settings can indicate a trouble that does not exist. If there is any question about the correct function or operation of any control, refer to the Operating Instructions Section.

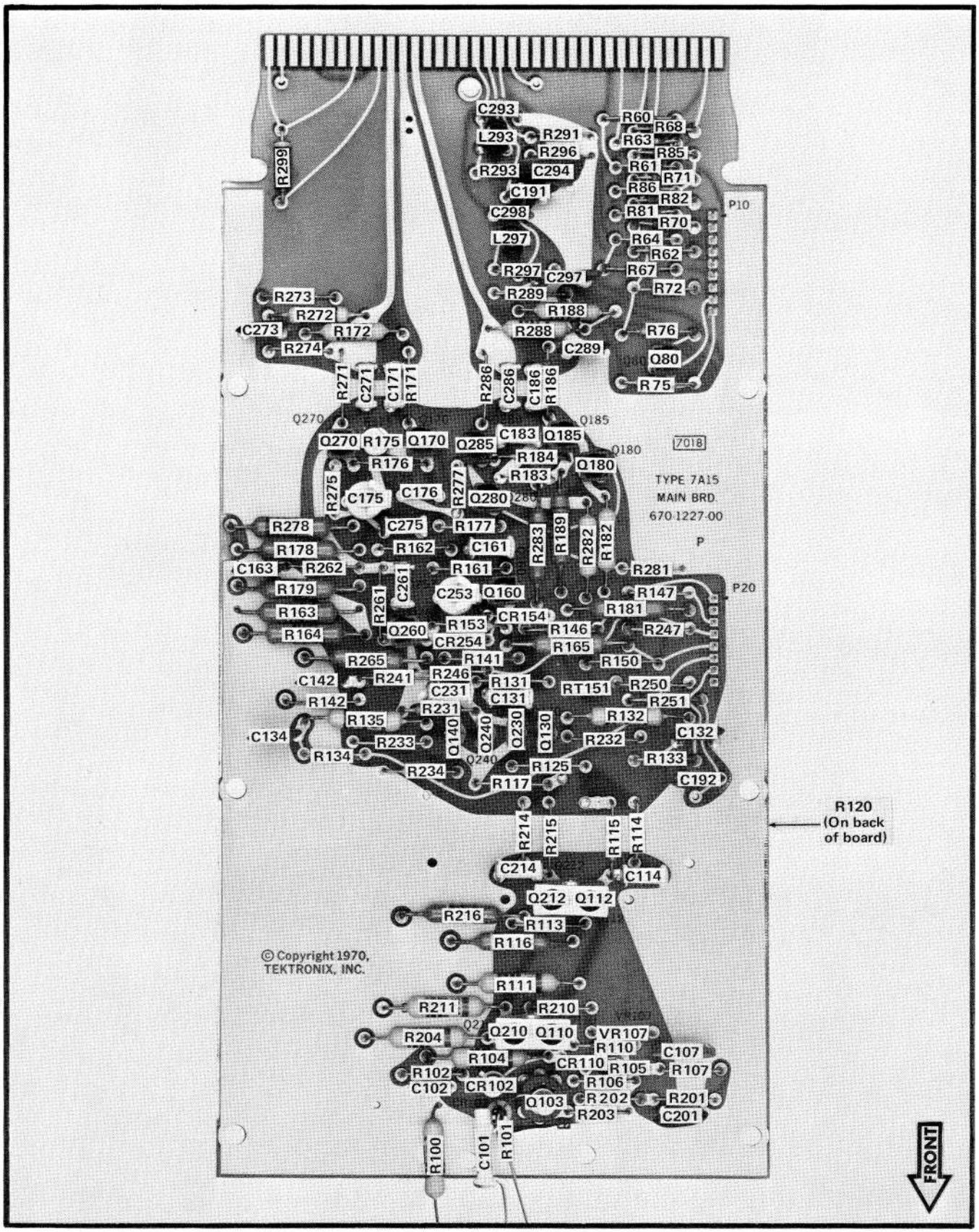


Fig. 4-4. Main Amplifier board showing location of components.

2. Check Associated Equipment. Before proceeding with troubleshooting of the 7A15, check that the equipment used with this instrument is operating correctly. Check that the signal is properly connected and that the probe cable is not defective. The oscilloscope and time-base plug-in unit can be checked for proper operation by substituting another vertical plug-in unit known to be operating properly (preferably another 7A15). If the trouble persists after substitution, the oscilloscope and/or time-base is defective.

3. Check Instrument Calibration. Check the calibration of this instrument, or the affected circuit if the trouble exists in one circuit. The apparent trouble may only be a result of misadjustment or may be corrected by calibration. Complete instructions are given in the Calibration Section.

4. Visual Check. Visually check that portion of the instrument in which the trouble is located. Many troubles can be located by visual indications such as broken wires, unsoldered connections, damaged components, etc.

5. Isolate Trouble To A Circuit. To isolate a trouble to a circuit, note the trouble symptoms. The symptom often indicates the circuit in which a trouble is located. When trouble symptoms appear in more than one circuit, check all affected circuits by taking voltage and waveform readings.

6. Check Voltages and Waveforms. Often the defective component can be located by checking for the correct voltage or waveform in the circuit. Typical voltages and waveforms are given on the diagrams.

NOTE

Voltages and waveforms given on the diagrams are not absolute and may vary slightly between instruments. To obtain operating conditions similar to those used to take these readings, see the first diagrams page.

7. Check Individual Components. The following procedures describe methods of checking individual components in the 7A15. Components which are soldered in place are best checked by disconnecting one end. This isolates the measurement from the effects of surrounding circuitry.

A. SEMICONDUCTORS

CAUTION

Power switch must be turned off before removing or replacing semiconductors.

The best check of transistor operation is actual performance under operating conditions. If a transistor is suspected of being defective, it can be checked by substituting a new component or one which has been checked previously. However, be sure that circuit conditions are not such that a replacement transistor might also be damaged. If substitute transistors are not available, use a dynamic tester such as the Tektronix Type 576.

B. DIODES

A diode can be checked for an open or shorted condition by measuring the resistance between terminals. With an ohmmeter scale having an internal source of between 800 millivolts and 3 volts, the resistance should be very high in one direction and very low when the meter leads are reversed.

CAUTION

Do not use an ohmmeter scale that has a high internal current. High currents may damage the diode.

C. RESISTORS

Resistors can be checked with an ohmmeter. Check the Electrical Parts List for the tolerance of the resistors used in this instrument.

D. CAPACITORS

A leaky or shorted capacitor can be detected by checking the resistance with an ohmmeter on the highest scale. Do not exceed the voltage rating of the capacitor. The resistance reading should be high after the initial charge of the capacitor. An open capacitor can be detected using a capacitance meter, or by checking whether the capacitor passes AC signals.

8. Repair and Readjust the Circuit. If any defective parts are located, follow the replacement procedures given in this section. Be sure to check the performance of any circuit that has been repaired or that has had any electrical components replaced.

CORRECTIVE MAINTENANCE

General

Corrective maintenance consists of component replacement and instrument repair. Special techniques required to replace components in this instrument are given here.

Obtaining Replacement Parts

Standard Parts. All electrical and mechanical part replacements for the 7A15 can be obtained through your local Tektronix Field Office or representative. However, many of the electronic components can be obtained locally in less time than is required to order them from Tektronix, Inc. Before purchasing or ordering replacement parts, check the parts list for value, tolerance, rating and description.

NOTE

When selecting replacement parts, it is important to remember that the physical size and shape of a component may affect the performance of the instrument, particularly at high frequencies. All replacement parts should be direct replacements unless it is known that a different component will not adversely affect instrument performance.

Special Parts. In addition to the standard electronic components, some special parts are used in the 7A15. These parts are manufactured or selected by Tektronix, Inc. in accordance with our specifications. These special parts are indicated in the parts list by an asterisk preceding the part number. Most of the mechanical parts used in this instrument have been manufactured by Tektronix, Inc. Order all special parts directly from your local Tektronix Field Office or representative.

Ordering Parts. When ordering replacement parts from Tektronix, Inc., include the following information:

1. Instrument Type.

2. Instrument Serial Number.

3. A description of the part (if electrical, include circuit number).

4. Tektronix Part Number.

Soldering Techniques

WARNING

Disconnect the instrument from the power source before soldering.

Circuit Board. The components mounted on the circuit board in the amplifier can be replaced using normal circuit board soldering techniques. Keep the following points in mind when soldering on the circuit board:

1. Use a pencil-type soldering iron with a power rating of between 15 and 50 watts.

2. Apply heat form the soldering iron to the junction between the component and the circuit board.

3. Heat-shunt the lead to the component by means of a pair of long-nosed pliers.

4. Avoid excessive heating of the junction with the circuit board, as this could separate the circuit board wiring from the laminate.

5. Use electronic grade 60-40 tin-lead solder.

6. Clip off any excess lead length extending beyond the circuit board. Clean off any residual flux with a flux-removing solvent. Be careful that the solvent does not remove any printing from the circuit board.

Metal Terminals. When soldering metal terminals (potentiometers, etc.), use 60-40 tin-lead solder and a 15 to 50 watt soldering iron. Observe the following precautions when soldering metal terminals:

1. Apply only enough heat to make the solder flow freely.

2. Apply only enough solder to form a solid connection. Excess solder may impair the function of the part.

3. If a wire extends beyond the solder joint, clip off the excess.

4. Clean the flux from the solder joint with a flux-removing solvent.

Component Replacement

WARNING

Disconnect the equipment from the power source before replacing components.

Semiconductor Replacement. Transistors should not be replaced unless actually defective. If removed from their sockets during routine maintenance, return them to their original sockets. Unnecessary replacement of transistors may affect the calibration of this instrument. When transistors are replaced, check the performance of that part of the instrument which may be affected.

Replacement semiconductors should be of the original type or a direct replacement. Fig. 4-2 shows the lead configuration of the semiconductors used in this instrument. If the replacement semiconductor is not of the original type, check the manufacturer's basing diagram for proper basing.

Circuit Board Replacement. If the circuit board is damaged beyond repair, either the entire assembly (including all soldered-on components), or the board only, can be replaced. Part numbers are given in the Mechanical Parts List for either wired or unwired board.

Use the following procedure to remove the amplifier circuit board:

1. Unsolder the two leads from the Uncal switch (ganged with the Variable potentiometer) and the ground lead from the Volts/Div switch to the circuit board.

2. Disconnect the two multi-pin connectors from the component side of the circuit board.

3. Unsolder the capacitor and two resistors from the attenuator output.

4. Remove the two bolts holding the circuit board to the attenuator shield.

5. Remove the six screws (three at the top and three at the bottom) which secure the circuit board to the positioning blocks on the top and bottom frame.

6. Loosen the set screw on the collar of the Variable potentiometer with a 0.050 hex-key wrench.

7. Remove the four screws (two at the top and two at the bottom) from the rear end of the unit and slide the circuit board out.

8. Unsolder and remove the Gain potentiometer and the ganged Variable potentiometer-Uncal switch. Note the position of each wire and resistor before unsoldering.

9. Replace the circuit board by reversing the above procedure. When replacing the multi-pin connectors, match the triangle on the connector to the triangle on the circuit board.

Volts/Div Switch and Attenuator Replacement. The Volts/Div switch, Attenuator, BNC Input connector and input Coupling switch can be removed as a unit; however, replacement of the Coupling switch or the BNC connector does not require removal of the Volts/Div switch and attenuator. Use the following procedure to replace the Volts/Div switch and attenuator:

1. Perform steps 1, 2, 3, 4 and 6 of Circuit Board Replacement procedure.

2. Rotate the VOLTS/DIV switch and POSITION control fully clockwise.

3. Pull off the IDENTIFY and COUPLING switch knobs. Remove the knobs from the VARIABLE control, VOLTS/DIV switch and POSITION control with a 1/16 inch hex-key wrench. Remove the nut and washer from the VOLTS/DIV switch with a 7/16 inch wrench.

4. Remove the front panel by prying out at the top and bottom with a screwdriver blade.

5. Remove the four screws securing the front sub-panel to the top and bottom frame, and slide the front of the unit out.

6. Remove the two screws (one to the left of the COUPLING switch and one to the left of the VOLTS/DIV switch) securing the attenuator assembly to the front sub-panel.

7. Note the color code position of the wires to the last two wafers of the Volts/Div switch. Unsolder the wires and remove the unit.

8. To replace any individual component in the unit, remove the attenuator covers for access to the components.

9. Reverse the above procedure to replace.

Position Potentiometer and Identify Switch Replacement. To replace the Position potentiometer, use the following procedure:

1. Remove the front panel by performing steps 2, 3 and 4 of Volts/Div and Attenuator Replacement procedure.

2. Note the color code and position of the connecting wires. Unsolder all wires to the Position potentiometer and Identify switch.

3. With a 5/16-inch wrench, remove the nut securing the Position potentiometer to the front sub-panel. Remove the unit.

4. Reverse the above procedure to replace.

Var Bal Potentiometer Replacement. To replace the Var Bal potentiometer, use the following procedure:

1. Remove the front panel by performing steps 2, 3 and 4 of Volts/Div and Attenuator Replacement procedure.

2. Note the color code and position of the three connecting wires. Unsolder the wires.

3. Remove the nut securing the Var Bal potentiometer to the front sub-panel, and remove the unit.

4. Reverse the above procedure to replace.

Polarity Switch Replacement. To replace the Polarity switch, use the following procedure:

1. Remove the front panel by performing steps 2, 3 and 4 of Volts/Div and Attenuator Replacement procedure.

2. Note the color code and position of the connecting wires. Unsolder the wires.

3. Remove the two phillips-head screws which secure the Polarity switch to the front sub-panel, and remove the switch.

4. Reverse the above procedure to replace.

Circuit Board Pin Replacement. To replace a pin which is mounted on a circuit board, first disconnect any pin connectors. Then, unsolder the damaged pin and pull it out of the circuit board. Observe the precautions given under Soldering Techniques to prevent damage to the circuit board. Ream out the hole in the circuit board with a 0.031 inch drill. Remove the ferrule from the new interconnecting pin and press the new pin into the hole in the circuit board. Position the pin in the same manner as the old pin. Solder the pin on both sides of the circuit board. If the old pin was bent at an angle to mate with a connector, bend the new pin to match the associated pins.

NOTE

A pin replacement kit including necessary tools, instructions and replacement pins is available from Tektronix, Inc. Order Part No. 040-0542-00.

End-Lead Pin Connectors. The pin connectors used to connect the wires to the interconnecting pins are clamped to the ends of the associated leads. To replace damaged end-lead pin connectors, remove the old pin connector from the end of the lead and clamp the replacement connector to the lead.

Some of the pin connectors are grouped together and mounted in a plastic holder. These connectors are referred to as multi-pin connectors, and are removed and re-installed as a unit. To provide correct orientation of this multi-pin connector when it is replaced, an arrow is stamped on the circuit board and a matching arrow is molded into the plastic housing of the multi-pin connector. Align these arrows when replacing the multi-pin connector. If individual end-lead pin connectors are removed from the plastic holder, note the color of the wire for replacement.

Instrument Repackaging

If the 7A15 is to be shipped for long distances by commercial means of transportation, it is recommended that the instrument be repackaged in the original manner for maximum protection. Refer to the repackaging illustration in the back of the manual for details. The original carton can be saved and used for this purpose, or new shipping cartons can be obtained from Tektronix, Inc. Contact your local Tektronix Field Office or representative for information or assistance.

NOTE

The plug-ins should not be shipped installed in an oscilloscope. The oscilloscope packaging material is not designed to protect the plug-ins.

SECTION 5
PERFORMANCE CHECK/CALIBRATION

Change information, if any, affecting this section will be found at the rear of this manual.

Introduction

To assure instrument accuracy, check the calibration of the 7A15 every 1000 hours of operation, or every six months if used infrequently. Before complete calibration, thoroughly clean and inspect this instrument as outlined in the Maintenance section.

As an aid to the calibration of the instrument, a Short-Form Procedure is given prior to the complete procedure. To facilitate instrument calibration for the experienced calibrator, the Short-Form Procedure lists the calibration adjustments necessary for each step and the applicable tolerances. This procedure also includes the step number and title as listed in the complete Performance Check/Calibration Procedure, and the page number on which each step begins. Therefore, the Short-Form Procedure can be used as an index to locate a step in the complete procedure. The Short-Form Procedure also provides spaces to record performance data or to check off steps as they are completed. This procedure can be reproduced and used as a permanent record of instrument calibration.

The complete Performance Check/Calibration Procedure can be used to check instrument performance without removing the covers or making internal adjustments by performing all portions except the ADJUST part of a step. Front-panel screwdriver adjustments are adjusted as part of the performance check procedure. A note titled PERFORMANCE CHECK ONLY gives instructions applicable only to the performance check procedure and lists the next applicable step for the performance check procedure.

Completion of each step in the complete Performance Check/Calibration Procedure insures that this instrument meets the electrical specifications given in Section 1. Where possible, instrument performance is checked before an adjustment is made. For best overall performance when performing a complete calibration procedure, make each adjustment to the exact setting even if the CHECK is within the allowable tolerance.

NOTE

Limits, tolerances and waveforms in this procedure are given as calibration guides and should not be interpreted as instrument specifications except as specified in Section 1. All waveforms shown in this procedure were taken with a Tektronix Oscilloscope Camera System.

A partial calibration is often desirable after replacing components, or to touch up the adjustment of a portion of the instrument between major recalibrations. To check or adjust only part of the instrument, set the controls as given under Preliminary Control Settings and start with the nearest test equipment set-up picture preceding the desired portion. Any control settings that differ from the preliminary settings are listed under the heading Partial Procedure following the equipment required picture. To prevent unnecessary recalibration of other parts of the instrument, readjust only if the tolerance given in the CHECK part of the step is not met. If readjustment is necessary, also check the calibration of any steps listed under INTERACTION.

TEST EQUIPMENT REQUIRED

General

The following test equipment and accessories, or equivalent are required for complete calibration of the 7A15. Specifications given are the minimum necessary for accurate calibration. Some of the recommended equipment may have specifications that exceed those given. All test equipment is assumed to be correctly calibrated and operating within the given specifications. If equipment is substituted, it must meet or exceed the specifications of the recommended equipment.

Special Tektronix calibration fixtures are used in this procedure only where they facilitate calibration. These special calibration fixtures are available from Tektronix, Inc. Order by part number through your local Tektronix Field Office or representative.

Test Equipment

1. 7000-series Indicator Oscilloscope. Tektronix 7704.

2. 7B70-series Time Base. Tektronix 7B70 used for this procedure.

3. Square-wave generator. Frequency, 1 kilohertz to 100 kilohertz; risetime, 12 nanoseconds or less from high-amplitude output and one nonosecond or less from fast-rise output (into 50 ohms); output amplitude, about 12 volts into 50 ohms from hi-amplitude output and 50-500 millivolts from fast-rise output into 50 ohms. Tektronix Type 106 Square-Wave Generator recommended.

4. Constant amplitude sine-wave generator. Frequency, 50 kilohertz to about 85 megahertz; reference frequency, 50 kilohertz; output amplitude, variable from 5 millivolts to 5 volts into 50 ohms; amplitude accuracy, within 3% of 50 kilohertz reference as frequency is varied throughout range. Tektronix Type 191 Constant Amplitude Signal Generator recommended.

5. Standard amplitude calibrator. Amplitude accuracy, within 0.25%; signal amplitude, 5 millivolts to 50 volts; output signal 1 kilohertz square wave and DC voltage. Tektronix calibration fixture 067-0502-00 recommended.

6. Pulse generator. Risetime, 0.25 nanosecond; amplitude 0 to 50 volts into 50 ohms; polarity, + or – selectable. Tektronix Type 109 Pulse Generator recommended.

7. Delay Line. Characteristic impedance, 50 ohms; delay, 60 nanoseconds. Tektronix Type 113 Delay Cable recommended.

8. Low-Frequency Constant Amplitude Sine-Wave Generator. Frequency range, 2 hertz to over 10 kilohertz; amplitude, 0.5 volt to 5 volts; amplitude accuracy, constant within 3% of 1 kilohertz reference as output frequency changes. For example, General Radio Model 1310-A Oscillator.

9. Non-loading DC Voltmeter. Accuracy, within 1%; range, 0 to greater than 15 volts. For example, Fairchild Model 7050 Digital Multimeter.

Accessories

10. RC Normalizer. Time constant, 1 megohm X 20 picofarad; connectors, BNC. Tektronix Calibration Fixture 067-0538-00.

11. Termination, feedthrough. Impedance, 50 ohms; connectors, BNC. Tektronix Part No. 011-0049-01.

12. Adapter, GR to BNC female. Tektronix Part No. 017-0063-00.

13. Cable. Impedance, 50 ohms; length, 42 inches; connectors, BNC. Tektronix Part No. 012-0057-01.

14. Cable. Impedance, 50 ohms; connectors, GR; electrical length, 5 nanoseconds. Tektronix Part No. 017-0512-00.

15. Termination, endline, Impedance, 50 ohms; connector, GR. Tektronix Part No. 017-0081-00.

16. Attenuator (three). Impedance, 50 ohms; attenuation, 10X; connectors, BNC. Tektronix Part No. 011-0059-01.

17. Attenuator. Impedance, 50 ohms; attenuation, 5X; connectors, BNC. Tektronix Part No. 011-0060-01.

18. Attenuator. Impedance, 50 ohms; attenuation, 2X; connectors, BNC. Tektronix Part No. 011-0069-01.

19. Alignment Tool Kit. Tektronix Part No. 003-0007-00.

SHORT-FORM PROCEDURE AND INDEX

7A15 Serial No. _____

Calibration Date _____

Calibrated By _____

1. Check Gain Range Page 5-4

Requirement: At least +8% to –8% from calibrated setting.

Performance: Correct _____; Incorrect _____.

2. Check/Adjust GAIN (R121) Page 5-5

Requirement: With VOLTS/DIV set to 10 mV and a 50 mV square-wave signal applied, the vertical deflection can be set to exactly five divisions.

Performance: Correct _____; Incorrect _____.

3. Check/Adjust VAR BAL (R200) Page 5-5

Requirement: 0.5 division or less trace shift as the VARIABLE VOLTS/DIV is rotated throughout its range.

Performance: Correct _____; Incorrect _____.

4. Check VARIABLE Range Page 5-5

Requirement: Continuously variable between calibrated steps of the VOLTS/DIV switch.

Performance: Correct _____; Incorrect _____.

5. Check +UP to INVERT Shift Page 5-5

Requirement: One division or less trace shift when switching POLARITY from + UP to INVERT.

Performance: Correct _____; Incorrect _____.

6. Check POSITION Range Page 5-5

Requirement: At least +10 divisions to −10 divisions from graticule center.

Performance: Correct _____; Incorrect _____.

7. Check Deflection Accuracy Page 5-6

Requirement: Vertical deflection accurate within 2% of gain set at 10 mV/div for all VOLTS/DIV switch settings.

Performance: Correct _____; Incorrect _____.

8. Adjust Input Capacitance (C6) Page 5-6

Requirement: Optimum square-wave response.

Performance: Correct _____; Incorrect _____.

9. Adjust Attenuator Shunt Compensation (C10, C20, C30, C41, C51) Page 5-6

Requirement: Optimum flat top (minimum tilt).

Performance: Correct _____; Incorrect _____.

10. Adjust Attenuator Series Compensation (C13, C23, C33, C43, C53) Page 5-7

Requirement: Optimum square corner.

Performance: Correct _____; Incorrect _____.

11. Adjust High Frequency Compensation (R175, C175, C253) Page 5-7

Requirement: Optimum 100 kilohertz square-wave response at 5 millivolts/division. Risetime not to exceed 4.5 nanoseconds and aberrations not to exceed 5% peak to peak.

Performance: Correct _____; Incorrect _____.

12. Check Step Response Page 5-8

Requirement: Optimum pulse response, risetime 4.5 nanoseconds or less and aberrations not to exceed the following:

5 mV to 5 V	+4%, −4%; total not to exceed 5% peak to peak.

Performance: Correct _____; Incorrect _____.

13. Check Amplifier Upper Bandwidth Page 5-8

Requirement: Not more than −3 dB at 78 megahertz.

Performance: −3 dB point, _____ megahertz.

14. Check Amplifier Lower Bandwidth Page 5-9

Requirement: Not more than −3 dB at 2 hertz.

Performance: −3 dB point, _____ hertz.

15. Check Input Gate Current Page 5-9

Requirement: 0.1 division or less trace shift when switching from GND to DC.

Performance: Correct _____; Incorrect _____.

16. Check Displayed Noise (Tangentially Measured) Page 5-9

Requirement: 0.05 division or less at 5 mV/div measured in a 7700-series oscilloscope.

Performance: Correct _____; Incorrect _____.

17. Check Trigger DC Level With Respect to Signal DC Level Page 5-10

Requirement: Trigger DC level within 50 millivolts of Signal DC level.

Performance: Correct _____; Incorrect _____.

18. Check IDENTIFY Operation Page 5-10

Requirement: Trace moves upward about 0.25 divisions when IDENTIFY button is pressed.

Performance: Correct _____; Incorrect _____.

PERFORMANCE CHECK/CALIBRATION PROCEDURE

General

The following procedure is arranged so the 7A15 can be calibrated with the least interaction of adjustments and reconnection of equipment. A picture is given of the test equipment required for each group of steps to aid in identification of the necessary equipment. The control settings and test equipment setup throughout this procedure continue from the preceding step(s) unless noted otherwise. The control settings can be checked at any "test equipment required" picture by setting the controls as given at the start of the procedure under the heading Preliminary Control Settings. Then make any changes listed following the test equipment required picture, under the heading Partial Procedure (also applies to partial calibration procedure).

NOTE

Control titles which are printed on the front panel of the 7A15 are capitalized in this procedure (e.g., POSITION). Internal adjustments and associated equipment controls are initially capitalized only (e.g., oscilloscope Vertical Mode).

The following procedure uses the equipment listed under Test Equipment Required. If other equipment is substituted, control settings or calibration setup may need to be altered to meet the requirements of the equipment used. Detailed operating instructions for the test equipment are not given in this procedure. Refer to the instruction manual for the test equipment if more information is required.

NOTE

This instrument should be calibrated at an ambient temperature of +20°C to +30°C for best overall accuracy. The performance of this instrument can be checked at any temperature within the 0°C to +50°C range. If the temperature is outside the given range, see Section 1 for the applicable tolerances.

Preliminary Procedure for Complete Calibration

1. Remove the oscilloscope left side cover.

2. Insert the 7A15 in the oscilloscope Right Vertical compartment.

3. Insert the time base in the oscilloscope A Horizontal compartment.

4. Connect the oscilloscope to a suitable power source.

5. Turn the oscilloscope power switch to On and allow 20 minutes warmup before proceeding with calibration of the 7A15.

6. Set the controls as given under Preliminary Control Settings.

Preliminary Control Settings

7A15

POSITION	Midrange
POLARITY	+UP
VOLTS/DIV	10 mV
VARIABLE (VOLTS/DIV)	CAL IN
AC-GND-DC	DC

7B70

Level/Slope	Centered on Positive Slope
Triggering	
Mode	P-P Auto
Coupling	AC
Source	Int
Magnifier	X1
Time/Div	.5 ms
Variable (Time/Div)	Cal In
Display Mode	Time Base

7704

Vertical Mode	Right
Horizontal Mode	A
A Trigger Source	Right Vert
Calibrator	
Rate	1 kHz
Volts	40 mV
A Intensity	Optimum

1. Check Gain Range

a. Test equipment required for steps 1 through 10 is shown in Fig. 5-1.

b. Connect a 50 millivolt squarewave from the standard amplitude calibrator to the 7A15 INPUT connector.

c. Adjust the front-panel GAIN for a five division display.

d. CHECK—Turn the GAIN control fully clockwise and check for a displayed amplitude of 5.4 divisions or more.

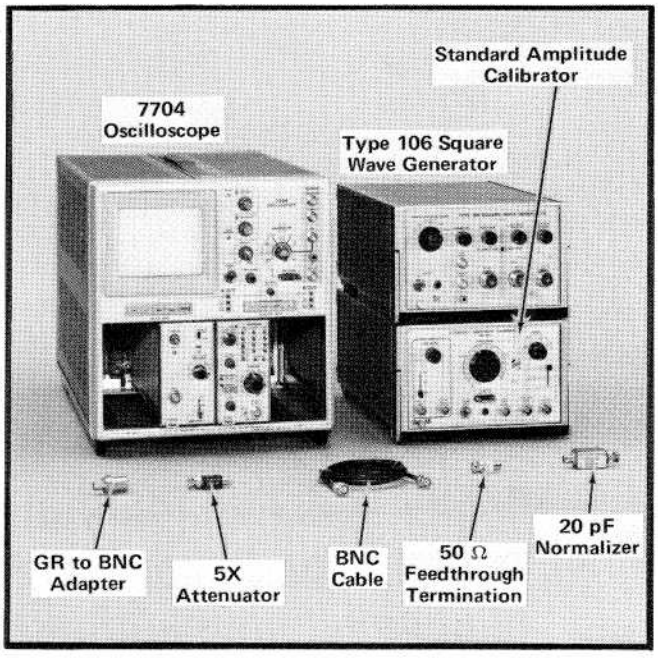


Fig. 5-1. Test equipment required for steps 1 through 10.

Turn the GAIN control fully counterclockwise and check for a displayed amplitude of 4.6 divisions or less. Return GAIN control to midrange.

2. Check/Adjust GAIN ◐

a. CHECK—With the 50 millivolt square wave signal connected as above, check for exactly five divisions of displayed amplitude.

NOTE

PERFORMANCE CHECK ONLY. This adjustment may be performed as part of the performance check.

b. ADJUST—R121, front-panel GAIN, for exactly five divisions of displayed amplitude.

3. Check/Adjust VAR BAL ◐

a. Set the COUPLING switch to GND and the VARIABLE control to the outward (press and release) position. Position the trace to the center horizontal reference line with the POSITION control.

b. CHECK—Rotate the VARIABLE control throughout its range and check for a 0.5 division or less of trace shift.

NOTE

PERFORMANCE CHECK ONLY. This adjustment may be performed as part of the performance check.

c. ADJUST—R200, front-panel VAR BAL, for minimum trace shift as the VARIABLE control is rotated throughout its range.

d. Press the VARIABLE control to the CAL IN position and set the COUPLING to DC.

4. Check VARIABLE Range

a. With the GAIN adjusted for exactly five divisions, press and release the VARIABLE control to its outward position.

b. CHECK—Turn the VARIABLE control fully counterclockwise and check for two divisions or less of displayed amplitude.

c. Return the VARIABLE control to the CAL IN position.

5. Check + UP to INVERT SHIFT

a. Set the COUPLING switch to GND.

b. CHECK—For trace shift of one division or less when switching POLARITY from + UP to INVERT.

c. Return the POLARITY switch to +UP.

6. Check POSITION Range

a. Set the COUPLING switch to GND and position the trace to the center horizontal reference line.

b. Set the standard amplitude calibrator to 0.1 volt.

c. CHECK—Set the COUPLING switch to DC. Turn the POSITION control counterclockwise and check that the top of the square wave can be positioned to graticule center or below. Reposition the bottom of the square wave to graticule center and set the POLARITY switch to INVERT. Turn the POSITION control clockwise and check that the bottom of the square wave can be positioned to graticule center or above.

d. Return the POLARITY switch to +UP and POSITION to midrange.

7. Check Deflection Accuracy

a. CHECK—Using the VOLTS/DIV switch and standard amplitude calibrator settings given in Table 5-1, check vertical deflection within 2% for each position of the VOLTS/DIV switch.

TABLE 5-1

Vertical Deflection Accuracy

VOLTS/DIV Switch Setting	Standard Amplitude Calibrator Output	Vertical Deflection in Divisions	Maximum Error for ±2% Accuracy (divisions)
5 mV	20 mV	4	±0.08
10 mV	50 mV	5	Set in Step 2
20 mV	0.1 V	5	±0.1
50 mV	0.2 V	4	±0.08
.1 V	0.5 V	5	±0.1
.2 V	1 V	5	±0.1
.5 V	2 V	4	±0.08
1 V	5 V	5	±0.1
2 V	10 V	5	±0.1
5 V	20 V	4	±0.08

b. Disconnect the standard amplitude calibrator signal.

8. Adjust Input Capacitance ◐

a. Connect a 10 kHz square wave from the Type 106 Hi-Amplitude output through a GR to BNC adapter, coaxial cable, 5 X attenuator, 50 ohm feedthrough termination and 20 pF RC Normalizer to the 7A15 INPUT connector.

b. Set the VOLTS/DIV to 5 mV and adjust the Type 106 Amplitude control for a five-division display.

c. ADJUST—C6 for best flat top (minimum tilt) on the displayed waveform (see Fig. 5-2).

9. Adjust Attenuator Shunt Compensation ◐

a. With a test equipment connected as above, set the VOLTS/DIV to 10 mV.

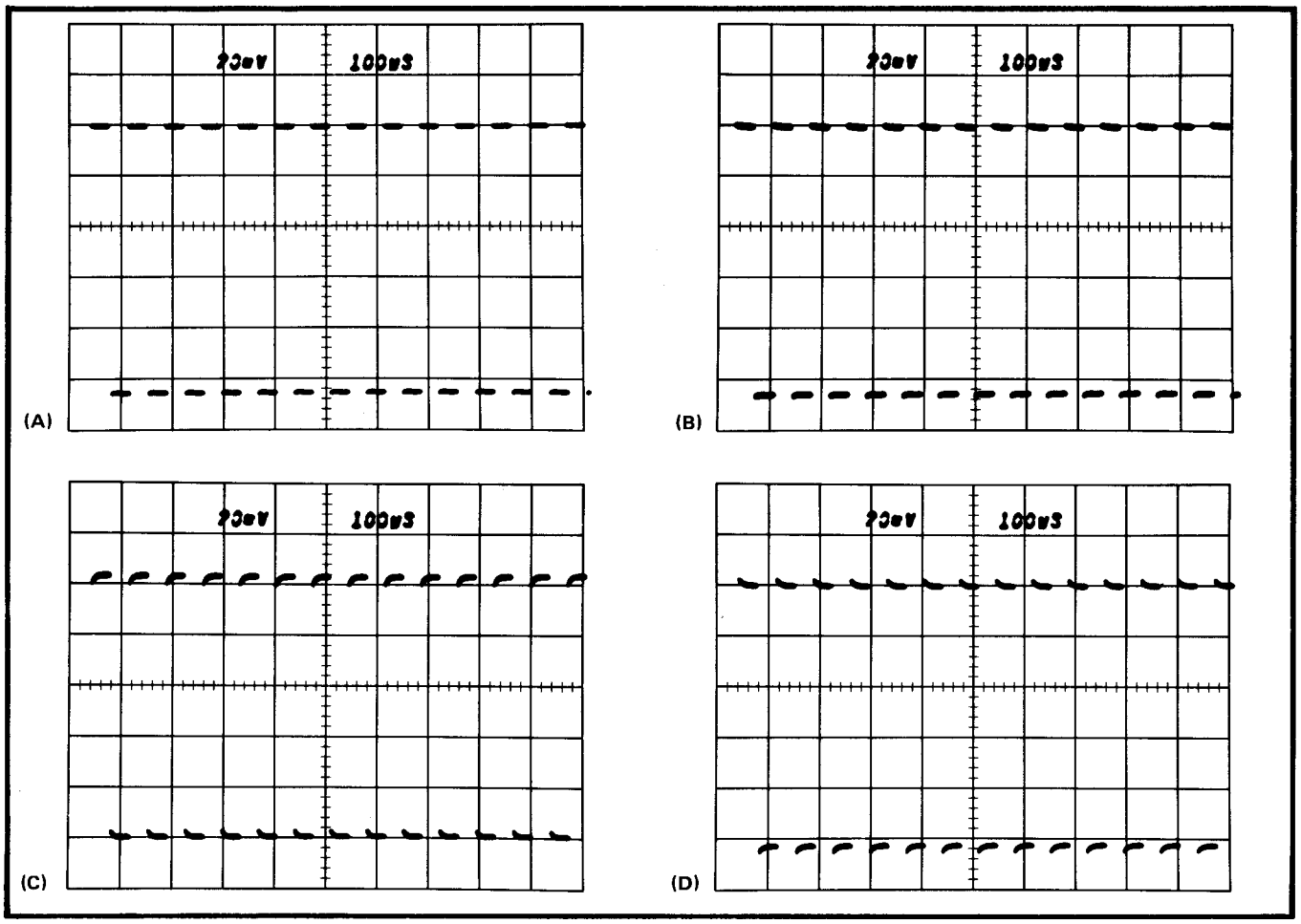


Fig. 5-2. CRT display showing (A) correct compensation, (B) tilt, (C) undercompensated front corner and (D) overcompensated front corner.

b. ADJUST—Using Table 5-2 as a guide, adjust attenuator compensation for best flat top (see Fig. 5-2). Maintain a five-division display (remove the 5X attenuator when necessary) except that in the 2 V and 5 V positions, the maximum display amplitude will be less than five divisions.

TABLE 5-2

Attenuator Shunt Compensation

VOLTS/DIV Setting	Adjust for Optimum Flat Top
10 mV	C10
20 mV	C20
50 mV	C30
0.1 V	Check
0.2 V	Check
0.5 V	C41
1 V	Check
2 V	Check
5 V	C51

10. Adjust Attenuator Series Compensation ◐

a. Remove the 20 pF RC Normalizer.

b. ADJUST—Using Table 5-3 as a guide, adjust attenuator series compensation for optimum square corner (see Fig. 5-2). Maintain a five-division display (about three divisions in the 5 V position) for all positions of the VOLTS/DIV switch.

TABLE 5-3

Attenuator Series Compensation

VOLTS/DIV Setting	Adjust for Optimum Square Corner
10 mV	C13
20 mV	C23
50 mV	C33
0.1 V	Check
0.2 V	Check
0.5 V	C43
1 V	Check
2 V	Check
5 V	C53

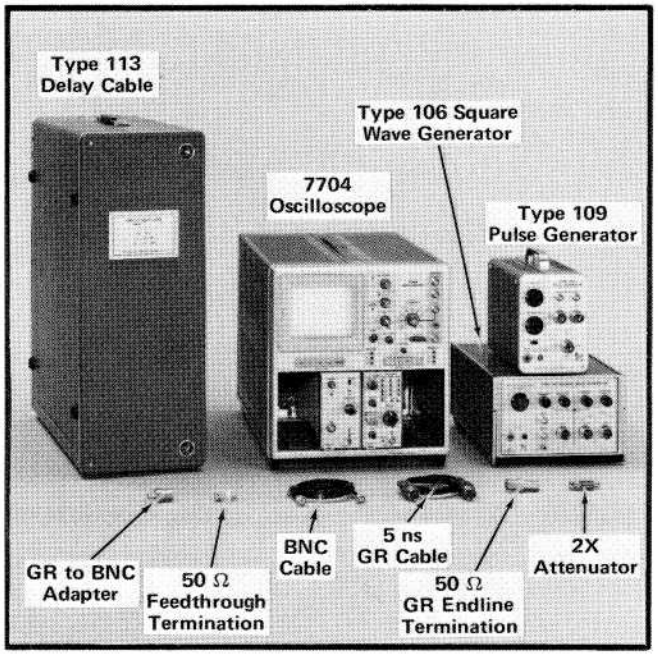


Fig. 5-3. Test equipment required for steps 11 and 12.

PARTIAL PROCEDURE

If beginning a partial procedure with this step, set the controls as given under Preliminary Control Settings except as follows:

VOLTS/DIV	5 mV
Time/Div	0.02 μs

11. Adjust High Frequency Compensation ◐

a. Test equipment required for steps 11 and 12 is shown in Fig. 5-3.

b. Connect the Type 106 fast-rise + Output through a GR to BNC adapter, BNC cable, and 50 ohm feedthrough termination to the 7A15 INPUT connector.

c. Set the Type 106 Repetition Rate Range to 100 kHz, Multiplier to X1, Hi Amplitude-Fast Rise switch to Fast Rise and adjust the + Transition Amplitude for a five division display.

d. ADJUST—In order given for minimum aberrations and minimum risetime. Since these adjustments interact, readjust until optimum square-wave response is obtained (see Fig. 5-4). Use either X1 or X10 Magnifier on the timebase as required to best view the effect of each adjustment.

Location of the adjustments are shown in Fig. 5-5.

Adjustment	Most Noticeable Effect
R175	First 20 ns level
C175	First 10 ns level
C253	Front corner; 3-5 ns level

12. Check Step Response

a. Connect a 5 ns GR cable between the Type 113 Delay Cable and the Type 109 Chg. Line 1; connect a 50 ohm termination to Chg. Line 2. Connect the Type 109 Output through a GR to BNC adapter, BNC 50 ohm cable, 2X attenuator and 50 ohm feedthrough termination to the 7A15 INPUT connector.

b. Use the Type 109 Voltage Range and Amplitude controls to maintain about five divisions of display amplitude for all checks. Risetime is measured between the 10% and 90% amplitude points on the leading edge of the pulse.

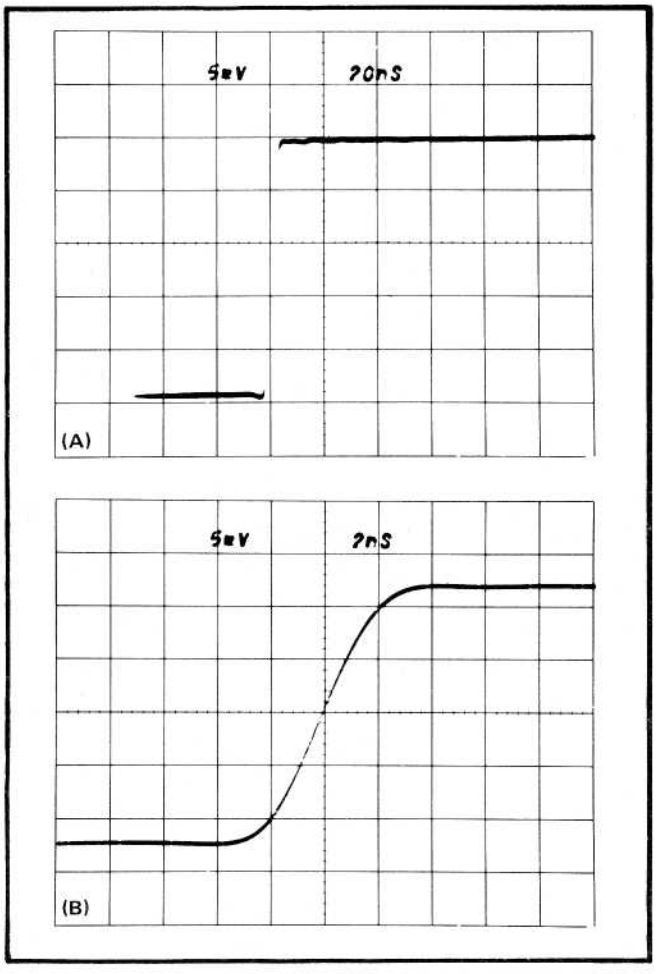


Fig. 5-4. CRT display showing (A) aberrations and (B) risetime measurement.

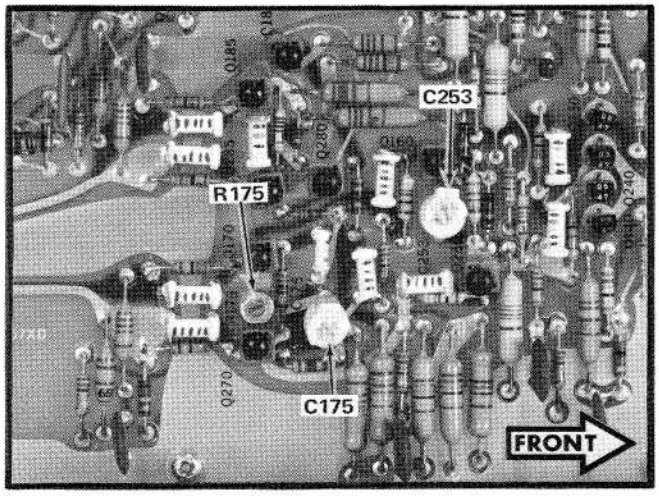


Fig. 5-5. Main amplifier board showing location of high-frequency compensation adjustments.

Aberrations in the form of overshoot, ringing and tilt are expressed as a percentage of pulse amplitude. The pulse amplitude reference level is the average level in the 40 ns to 50 ns period after the step.

c. CHECK–Using Table 5-4 as a guide, check all positions of the VOLTS/DIV switch for risetime and aberrations.

TABLE 5-4

RISETIME AND ABERRATION CHECK

VOLTS/DIV Switch Setting	Type 109 Pulse Amplitude	Risetime	Aberrations
5 mV to 5 V	5 div	4.5 ns	+4%, –4%; total not to exceed 5% P-P

13. Check Amplifier Upper Bandwidth

a. Test equipment required for steps 13 through 18 is shown in Fig. 5-6.

b. Connect the Type 191 Constant Amplitude Signal Generator output through a GR to BNC adapter, BNC cable and 50 ohm feedthrough termination to the 7A15 INPUT connector. Set the Type 191 frequency to 50 kHz and Amplitude Range to 5-50 mV.

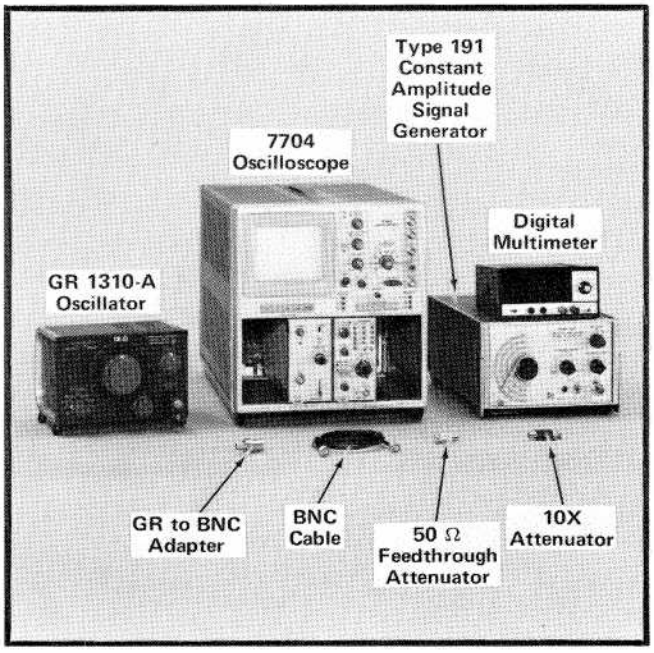


Fig. 5-6. Test equipment required for steps 13 through 17.

c. Set the VOLTS/DIV to 5 mV and adjust the Type 191 Amplitude for a six-division display.

d. CHECK—Increase the generator frequency until the display decreases to 4.2 divisions. Check that the generator frequency is at least 78 megahertz.

e. Disconnect the Type 191 signal generator.

14. Check Amplifier Lower Bandwidth

a. Set the COUPLING switch to AC. Connect the output of the GR 1310-A Low-Frequency Generator through a BNC cable, 10X attenuator, and 50 ohm feedthrough termination to the 7A15 INPUT connector. Set the Time/Div to 50 μs.

b. Set the generator frequency to 10 kHz and adjust the amplitude for a six-division display.

c. CHECK—Decrease the generator frequency until the display decreases to 4.2 divisions. Check that the generator frequency is 2 hertz or less.

d. Disconnect the GR1310-A signal generator.

15. Check Input Gate Current

a. Set the COUPLING switch to GND and position the trace to the center horizontal reference line with the POSITION control.

b. CHECK—For 0.1 division or less trace shift when switching the COUPLING switch from GND to DC.

16. Check Displayed Noise (Tangentially Measured)

a. Set the COUPLING switch to DC and free-run the time-base. Connect the Type 106 Hi Amplitude output through a GR to BNC adapter, BNC cable, three 10X attenuators and 50 ohm feedthrough termination to the 7A15 INPUT connector.

b. Set the Type 106 frequency to 1 kHz and increase the amplitude until two free-running traces are observed (see Fig. 5-7A), then decrease the amplitude until the two traces just merge (dark band between the two traces just disappears; see Fig. 5-7B).

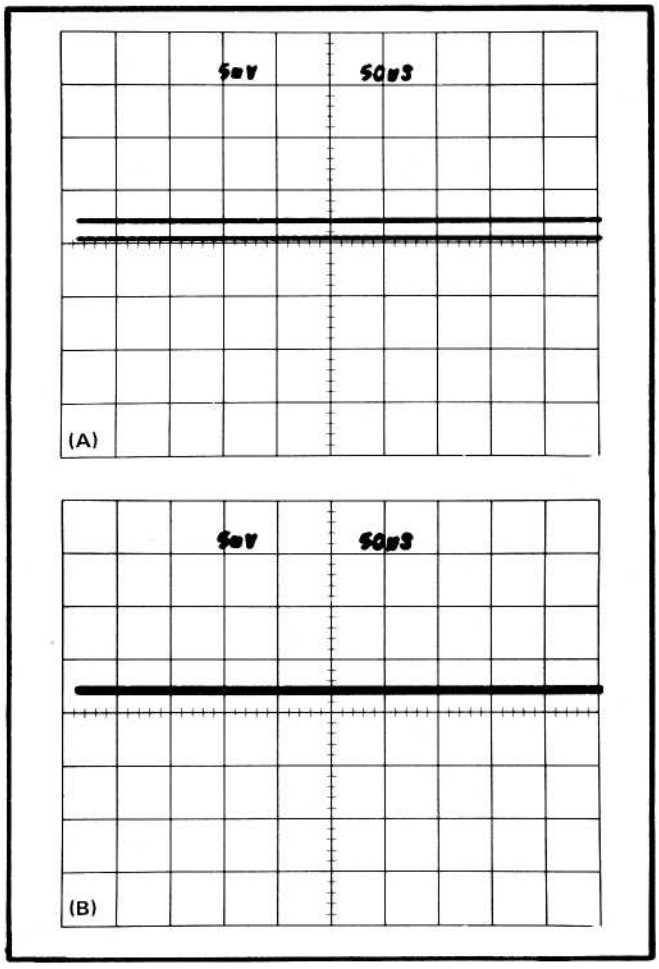


Fig. 5-7. CRT display showing (A) two free-running traces and (B) the two traces being merged when checking amplifier noise.

c. Set the VOLTS/DIV to 50 mV and remove two 10X attenuators.

d. CHECK—Set the time-base controls for a stable display and check that the square-wave amplitude is 0.5 division or less. Noise is the square-wave value divided by 100 (two 10X attenuators were removed).

EXAMPLE:

Tangentially Measured Noise =

$$\frac{\text{Square Wave Amplitude}}{100} = \frac{25\text{ mV}}{100} = 0.25\text{ mV}$$

This is equal to 0.05 division at 5 mV/div.

e. Disconnect the Type 106 Square Wave Generator.

17. Check Trigger DC Level With Respect to Signal DC Level

a. Set the VOLTS/DIV to 5 mV and the COUPLING switch to GND.

b. Position the trace to the center horizontal reference line with the POSITION control.

c. Connect the digital voltmeter between B11 and A11 (top of R171 and bottom of R271; see Fig. 5-8). Adjust the POSITION control for a voltage null (zero volts). Do not move any controls after the voltage null is set.

d. Change the voltmeter leads to B13 and A13 (top of R186 and bottom of R284; see Fig. 5-8).

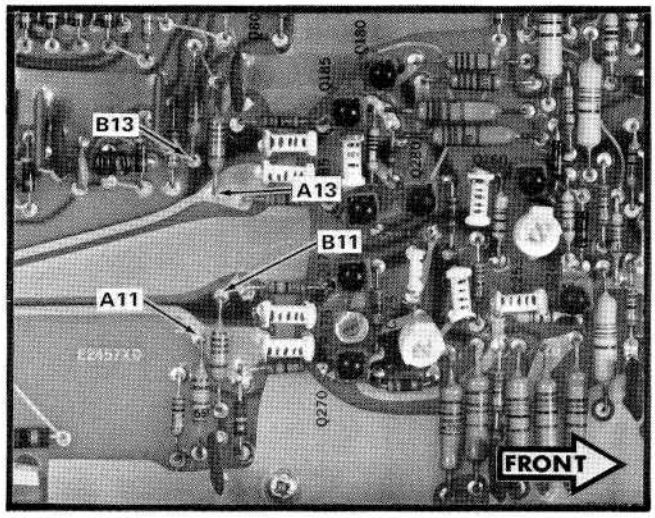


Fig. 5-8. Location of voltage check points for step 17.

e. CHECK—For a voltmeter reading not to exceed 50 millivolts.

18. CHECK IDENTIFY Operation

a. Position the trace to the center horizontal reference line with the POSITION control.

b. CHECK—Press the IDENTIFY button and check that the trace moves upward about 0.25 division.

This completes the calibration of the 7A15. Disconnect all test equipment, replace the oscilloscope side cover and the 7A15 side covers. If the instrument has been completely calibrated to the tolerances given in this procedure, it will perform to the limits given in the Specification Section.

PARTS LIST ABBREVIATIONS

BHB	binding head brass
BHS	binding head steel
cap.	capacitor
cer	ceramic
comp	composition
conn	connector
CRT	cathode-ray tube
csk	countersunk
DE	double end
dia	diameter
div	division
elect.	electrolytic
EMC	electrolytic, metal cased
EMT	electrolytic, metal tubular
ext	external
F & I	focus and intensity
FHB	flat head brass
FHS	flat head steel
Fil HB	fillister head brass
Fil HS	fillister head steel
h	height or high
hex.	hexagonal
HHB	hex head brass
HHS	hex head steel
HSB	hex socket brass
HSS	hex socket steel
ID	inside diameter
inc	incandescent
int	internal
lg	length or long
met.	metal
mtg hdw	mounting hardware
OD	outside diameter
OHB	oval head brass
OHS	oval head steel
P/O	part of
PHB	pan head brass
PHS	pan head steel
plstc	plastic
PMC	paper, metal cased
poly	polystyrene
prec	precision
PT	paper, tubular
PTM	paper or plastic, tubular, molded
RHB	round head brass
RHS	round head steel
SE	single end
SN or S/N	serial number
S or SW	switch
TC	temperature compensated
THB	truss head brass
thk	thick
THS	truss head steel
tub.	tubular
var	variable
w	wide or width
WW	wire-wound

INDEX OF ELECTRICAL PARTS LIST

SECTION 6
ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
				CHASSIS		
				Capacitors		
Tolerance ±20% unless otherwise indicated.						
C1	*285-0697-03			0.1 μF	Plastic	600 V	10%
C2	283-0004-00			0.02 μF	Cer	150 V	
C3	281-0672-00			11.4 pF	Cer	500 V	1%
C4	281-0538-00			1 pF	Cer	500 V	
C5	281-0538-00			1 pF	Cer	500 V	
C6	281-0064-00			0.25-1.5 pF, Var	Plastic		
C7	281-0547-00			2.7 pF	Cer	500 V	10%
C10	281-0064-00			0.25-1.5 pF, Var	Plastic		
C12	281-0572-00			6.8 pF	Cer	500 V	±0.5 pF
C13	281-0043-00			0.7-3 pF, Var	Tub.		
C20	281-0064-00			0.25-1.5 pF, Var	Plastic		
C22	281-0659-00			4.3 pF	Cer	500 V	±0.25 pF
C23	281-0043-00			0.7-3 pF, Var	Tub.		
C24	281-0504-00			10 pF	Cer	500 V	10%
C30	281-0043-00			0.7-3 pF, Var	Tub.		
C32	281-0544-00			5.6 pF	Cer	500 V	10%
C33, C34	281-0119-00			50 pF/0.25-1.5 pF	Mica		10%
C40	281-0547-00			2.7 pF	Cer	500 V	10%
C41	281-0043-00			0.7-3 pF, Var	Tub.		
C42	281-0659-00			4.3 pF	Cer	500 V	±0.25 pF
C43, C44	281-0086-00			500 pF/0.25-1.5 pF	Mica		10%
C50	281-0544-00			5.6 pF	Cer	500 V	10%
C51	281-0043-00			0.7-3 pF, Var	Tub.		
C53, C54	281-0108-00			1000 pF/0.25-1.5 pF	Mica		10%
				Connector			
J1	131-0679-00			Receptacle, electrical, BNC			

CHASSIS (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Inductors			
L1	*108-0440-00			8 μH			
LR13	*108-0270-00			0.25 μH (wound on a 62-Ω, 1/8 W, 5% resistor)			
LR23	*108-0614-00			0.25 μH (wound on a 56-Ω, 1/8 W, 5% resistor)			
LR33	*108-0257-00			0.1 μH (wound on a 27-Ω, 1/8 W, 5% resistor)			
LR43	*108-0613-00			0.14 μH (wound on a 20-Ω, 1/8 W, 5% resistor)			
				Resistors			
Resistors are fixed, composition, ±10% unless otherwise indicated.							
R1	317-0082-00			8.2 Ω	1/8 W		5%
R2	317-0105-00			1 MΩ	1/8 W		5%
R3	321-0064-00			45.3 Ω	1/8 W	Prec	1%
R9	317-0270-00			27 Ω	1/8 W		5%
R10	317-0150-00			15 Ω	1/8 W		5%
R12	322-0610-01			500 kΩ	1/4 W	Prec	1/2%
R14	322-0481-01			1 MΩ	1/4 W	Prec	1/2%
R20	317-0620-00			62 Ω	1/8 W		5%
R22	322-0469-01			750 kΩ	1/4 W	Prec	1/2%
R24	321-0628-01			333 kΩ	1/8 W	Prec	1/2%
R30	317-0560-00			56 Ω	1/8W		5%
R32	322-0621-01			900 kΩ	1/4 W	Prec	1/2%
R34	321-1389-01			11 kΩ	1/8 W	Prec	1/2%
R40	317-0390-00			39 Ω	1/8 W		5%
R42	322-0624-01			990 kΩ	1/4 W	Prec	1/2%
R44	321-1289-01			10.1 kΩ	1/8 W	Prec	1/2%
R50	317-0430-00			43 Ω	1/8 W		5%
R52	322-0629-01			999 kΩ	1/4 W	Prec	1/2%
R54	321-0193-01			1 kΩ	1/8 W	Prec	1/2%
R57	317-0430-00			43 Ω	1/8 W		5%
R109	317-0750-00			75 Ω	1/8 W		5%
R145[1]	311-0652-00	B010100	B029999	2 x 5 kΩ, Var			
R145[1]	311-0652-01	B030000		2 x 5 kΩ, Var			
R200	311-0310-00			5 kΩ, Var			

[1]Furnished as a unit with S2.

CHASSIS (cont)

Ckt. No.		Part No. Tektronix	Serial/Model No. Eff	Disc	Description		
			Switches				
	Wired or Unwired						
S1		260-1168-00			Lever		
S2[2]		311-0652-00	B010100	B029999			
S2[2]		311-0652-01	B030000				
S10	Wired	*262-0903-00			Rotary	VOLTS/DIV	
S10		260-1151-00			Rotary	VOLTS/DIV	
S133		260-0816-00			Slide		

MAIN Circuit Board Assembly

*670-1227-00	Complete Board	

Capacitors

Tolerance ±20% unless otherwise indicated.

C101	281-0614-00	6800 pF	Cer	500 V	+80%—20%
C102	283-0177-00	1 μF	Cer	25 V	+80%—20%
C107	283-0010-00	0.05 μF	Cer	50 V	
C114	281-0623-00	650 pF	Cer	500 V	5%
C124	281-0656-00	22 pF	Cer	200 V	5%
C131	281-0630-00	390 pF	Cer	500 V	5%
C132	283-0004-00	0.02 μF	Cer	150 V	
C134	283-0004-00	0.02 μF	Cer	150 V	
C142	283-0004-00	0.02 μF	Cer	150 V	
C161	281-0623-00	650 pF	Cer	500 V	5%
C163	283-0004-00	0.02 μF	Cer	150 V	
C171	281-0623-00	650 pF	Cer	500 V	5%
C175	281-0166-00	1.9-15.7 pF, Var	Air	250 V	
C176	281-0645-00	8.2 pF	Cer	500 V	±0.25 pF
C183	281-0542-00	18 pF	Cer	500 V	10%
C186	281-0623-00	650 pF	Cer	500 V	5%
C191	283-0004-00	0.02 μF	Cer	150 V	
C192	283-0004-00	0.02 μF	Cer	150 V	
C201	283-0004-00	0.02 μF	Cer	150 V	
C214	281-0623-00	650 pF	Cer	500 V	5%
C231	281-0630-00	390 pF	Cer	500 V	5%
C253	281-0153-00	1.7-11 pF, Var	Air	250 V	
C261	281-0623-00	650 pF	Cer	500 V	5%
C271	281-0623-00	650 pF	Cer	500 V	5%
C273	283-0004-00	0.02 μF	Cer	150 V	
C275	281-0540-00	51 pF	Cer	500 V	5%

[2]Furnished as a unit with R145.

MAIN Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Capacitors (cont)			
C286	281-0623-00			650 pF	Cer	500 V	5%
C289	283-0004-00			0.02 μF	Cer	150 V	
C293	283-0000-00			0.001 μF	Cer	500 V	
C294	283-0010-00			0.05 μF	Cer	50 V	
C297	283-0010-00			0.05 μF	Cer	50 V	
C298	283-0000-00			0.001 μF	Cer	500 V	
				Semiconductor Device, Diodes			
CR102	*152-0367-00			Silicon	Tek Spec		
VR107	152-0306-00			Zener	1N960B 400 mW, 9.1 V, 5%		
CR110	*152-0185-00			Silicon	Replaceable by 1N4152		
CR154	*152-0269-00			Silicon	Volt. var cap. Tek Spec		
CR254	*152-0269-00			Silicon	Volt. var cap. Tek Spec		
				Inductors			
L293	*120-0382-00			Toroid, 14 turns, single			
L297	*120-0382-00			Toroid, 14 turns, single			
				Transistors			
Q80	151-0254-00			Silicon	NPN	TO-92 2N5308	
Q103A, B	151-1031-00			Silicon	FET	TO-18 N channel, dual	
Q110[3]	*153-0547-00			Silicon	NPN	Replaceable by MPS 918	
Q112[4]	*153-0547-00			Silicon	NPN	Replaceable by MPS 918	
Q130[5]	*153-0547-00			Silicon	NPN	Replaceable by MPS 918	
Q140[6]	*153-0547-00			Silicon	NPN	Replaceable by MPS 918	
Q160	*151-0325-00			Silicon	PNP	TO-106 Selected from 2N4258	
Q170	*151-0325-00			Silicon	PNP	TO-106 Selected from 2N4258	
Q180	151-0221-00			Silicon	PNP	TO-18 2N4258	
Q185	151-0221-00			Silicon	PNP	TO-18 2N4258	
Q210[7]	*153-0547-00			Silicon	NPN	Replaceable by MPS 918	
Q212[8]	*153-0547-00			Silicon	NPN	Replaceable by MPS 918	
Q230[9]	*153-0547-00			Silicon	NPN	Replaceable by MPS 918	
Q240[10]	*153-0547-00			Silicon	NPN	Replaceable by MPS 918	
Q260	*151-0325-00			Silicon	PNP	TO-106 Selected from 2N4258	

[3]**Furnished as a matched pair with Q210.**
[4]**Furnished as a matched pair with Q212.**
[5]**Furnished as a matched pair with Q230.**
[6]**Furnished as a matched pair with Q240.**
[7]**Furnished as a matched pair with Q110.**
[8]**Furnished as a matched pair with Q112.**
[9]**Furnished as a matched pair with Q130.**
[10]**Furnished as a matched pair with Q140.**

MAIN Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
		Transistors (cont)		
Q270	*151-0325-00		Silicon	PNP TO-106 Selected from 2N4258
Q280	151-0221-00		Silicon	PNP TO-18 2N4258
Q285	151-0221-00		Silicon	PNP TO-18 2N4258

Resistors

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

R60	321-0344-00	37.4 kΩ	1/8 W	Prec	1%
R61	315-0753-00	75 kΩ	1/4 W		5%
R62	315-0154-00	150 kΩ	1/4 W		5%
R63	315-0513-00	51 kΩ	1/4 W		5%
R64	315-0154-00	150 kΩ	1/4 W		5%
R67	321-0344-00	37.4 kΩ	1/8 W	Prec	1%
R68	315-0753-00	75 kΩ	1/4 W		5%
R70	315-0154-00	150 kΩ	1/4 W		5%
R71	315-0753-00	75 kΩ	1/4 W		5%
R72	315-0753-00	75 kΩ	1/4 W		5%
R75	321-0223-00	2.05 kΩ	1/8 W	Prec	1%
R76	321-0299-00	12.7 kΩ	1/8 W	Prec	1%
R81	315-0133-00	13 kΩ	1/4 W		5%
R82	315-0154-00	150 kΩ	1/4 W		5%
R85	315-0154-00	150 kΩ	1/4 W		5%
R86	315-0154-00	150 kΩ	1/4 W		5%
R100	323-0481-03	1 MΩ	1/2 W	Prec	1/4%
R101	315-0105-00	1 MΩ	1/4 W		5%
R102	315-0682-00	6.8 kΩ	1/4 W		5%
R104	323-0289-00	10 kΩ	1/2 W	Prec	1%
R105	315-0201-00	200 Ω	1/4 W		5%
R106	315-0681-00	680 Ω	1/4 W		5%
R107	315-0100-00	10 Ω	1/4 W		5%
R110	315-0150-00	15 Ω	1/4 W		5%
R111	323-0289-00	10 kΩ	1/2 W	Prec	1%
R113	321-0064-00	45.3 Ω	1/8 W	Prec	1%
R114	315-0390-00	39 Ω	1/4 W		5%
R115	321-0175-00	649 Ω	1/8 W	Prec	1%
R116	323-0287-00	9.53 kΩ	1/2 W	Prec	1%
R117	321-0039-00	24.9 Ω	1/8 W	Prec	1%
R120	321-0088-00	80.6 Ω	1/8 W	Prec	1%
R121	311-0632-00	2 kΩ, Var			
R122	321-0088-00	80.6 Ω	1/8 W	Prec	1%
R123[11]	311-1075-01	2.5 kΩ, Var			
R124	321-0038-00	24.3 Ω	1/8 W	Prec	1%

[11]Furnished as a unit with S123.

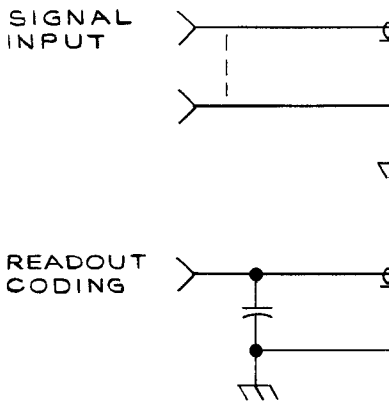
MAIN Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Description			
				Resistors (cont)			
R131	321-0172-00			604 Ω	1/8 W	Prec	1%
R132	323-0298-00			12.4 kΩ	1/2 W	Prec	1%
R133	315-0101-00			100 Ω	1/4 W		5%
R134	315-0101-00			100 Ω	1/4 W		5%
R135	323-0298-00			12.4 kΩ	1/2 W	Prec	1%
R141	321-0130-00			221 Ω	1/8 W	Prec	1%
R142	321-0032-00			21 Ω	1/8 W	Prec	1%
R146	321-0308-00			15.8 kΩ	1/8 W	Prec	1%
R147	315-0183-00			18 kΩ	1/4 W		5%
R150	321-0373-00			75 kΩ	1/8 W	Prec	1%
RT151	317-0181-00			100 kΩ	Thermal		
R153	321-0121-00			178 Ω	1/8 W	Prec	1%
R161	321-0158-00			432 Ω	1/8 W	Prec	1%
R162	321-0130-00			221 Ω	1/8 W	Prec	1%
R163	323-0131-00			226 Ω	1/2 W	Prec	1%
R164	323-0155-00			402 Ω	1/2 W	Prec	1%
R165	323-0273-00			6.81 kΩ	1/2 W	Prec	1%
R171	321-0146-00			324 Ω	1/8 W	Prec	1%
R172	322-0201-00			1.21 kΩ	1/4 W	Prec	1%
R175	311-0634-00			500 Ω, Var			
R176	321-0101-00			110 Ω	1/8 W	Prec	1%
R177	315-0331-00			330 Ω	1/4 W		5%
R178	323-0229-00			2.37 kΩ	1/2 W	Prec	1%
R179	323-0167-00			536 Ω	1/2 W	Prec	1%
R181	323-0167-00			536 Ω	1/2 W	Prec	1%
R182	322-0322-00			22.1 kΩ	1/4 W	Prec	1%
R183	317-0121-00			120 Ω	1/8 W		5%
R184	321-0097-00			100 Ω	1/8 W	Prec	1%
R186	321-0153-00			383 Ω	1/8 W	Prec	1%
R188	322-0201-00			1.21 kΩ	1/4 W	Prec	1%
R189	323-0226-00			2.21 kΩ	1/2 W	Prec	1%
R201	315-0202-00			2 kΩ	1/4 W		5%
R202	315-0223-00			22 kΩ	1/4 W		5%
R203	315-0510-00			51 Ω	1/4 W		5%
R204	323-0289-00			10 kΩ	1/2 W	Prec	1%
R210	315-0150-00			15 Ω	1/4 W		5%
R211	323-0289-00			10 kΩ	1/2 W	Prec	1%
R214	315-0390-00			39 Ω	1/4 W		5%
R215	321-0176-00			665 Ω	1/8 W	Prec	1%
R216	323-0287-00			9.53 kΩ	1/2 W	Prec	1%
R217	321-0039-00			24.9 Ω	1/8 W	Prec	1%
R231	321-0172-00			604 Ω	1/8 W	Prec	1%
R232	321-0185-00			825 Ω	1/8 W	Prec	1%
R233	321-0185-00			825 Ω	1/8 W	Prec	1%

MAIN Circuit Board Assembly (cont)

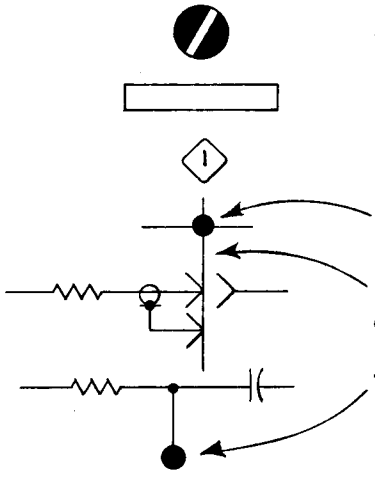
Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
			Resistors (cont)			
R234	321-0202-00		1.24 kΩ	1/8 W	Prec	1%
R241	321-0130-00		221 Ω	1/8 W	Prec	1%
R246	321-0308-00		15.8 kΩ	1/8 W	Prec	1%
R247	315-0183-00		18 kΩ	1/4 W		5%
R250	321-0417-00		215 kΩ	1/8 W	Prec	1%
R251	321-0387-00		105 kΩ	1/8 W	Prec	1%
R261	321-0158-00		432 Ω	1/8 W	Prec	1%
R262	321-0130-00		221 Ω	1/8 W	Prec	1%
R265	323-0273-00		6.81 kΩ	1/2 W	Prec	1%
R271	321-0146-00		324 Ω	1/8 W	Prec	1%
R272	322-0202-00		1.24 kΩ	1/4 W	Prec	1%
R273	321-0032-00		21 Ω	1/8 W	Prec	1%
R274	315-0513-00		51 kΩ	1/4 W		5%
R275	317-0332-00		3.3 kΩ	1/8 W		5%
R277	317-0331-00		330 Ω	1/8 W		5%
R278	323-0229-00		2.37 kΩ	1/2 W	Prec	1%
R281	315-0101-00		100 Ω	1/4 W		5%
R282	322-0322-00		22.1 kΩ	1/4 W	Prec	1%
R283	323-0226-00		2.21 kΩ	1/2 W	Prec	1%
R286	321-0153-00		383 Ω	1/8 W	Prec	1%
R288	322-0201-00		1.21 kΩ	1/4 W	Prec	1%
R289	321-0032-00		21 Ω	1/8 W	Prec	1%
R291	315-0510-00		51 Ω	1/4 W		5%
R293	315-0470-00		47 Ω	1/4 W		5%
R206	315-0510-00		51 Ω	1/4 W		5%
R297	315-0470-00		47 Ω	1/4 W		5%
R299	301-0470-00		47 Ω	1/2 W		5%
			Switch			
	Wired or Unwired					
S123[12]	311-1075-01					
			Transformer			
T100	*120-0469-00		Toroid, 3 turns, bifilar			

[12]Furnished as a unit with R123.



SECTION 7
DIAGRAMS
and
MECHANICAL PARTS ILLUSTRATIONS

The following special symbols are used on the diagrams:



Screwdriver adjustment

Front or rear-panel control or connector.

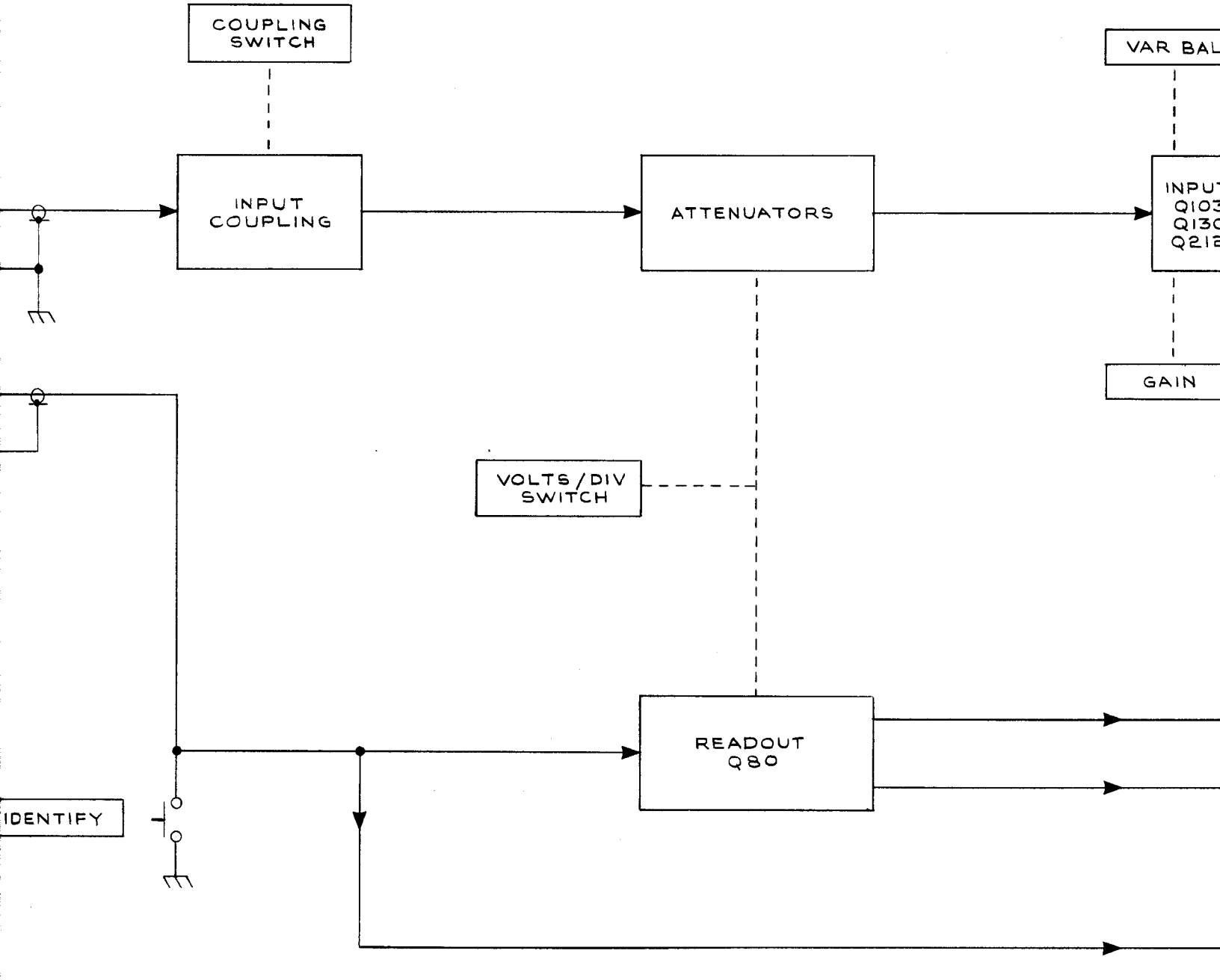
Refers to the indicated diagram.

Connection soldered to circuit board.

Blue line encloses components located on circuit board.

Test point.

IDE


COUPLING SWITCH
VAR BAL
INPUT COUPLING
ATTENUATORS
INPUT
Q103
Q130
Q212
GAIN
VOLTS/DIV SWITCH
READOUT Q80
IDENTIFY

R

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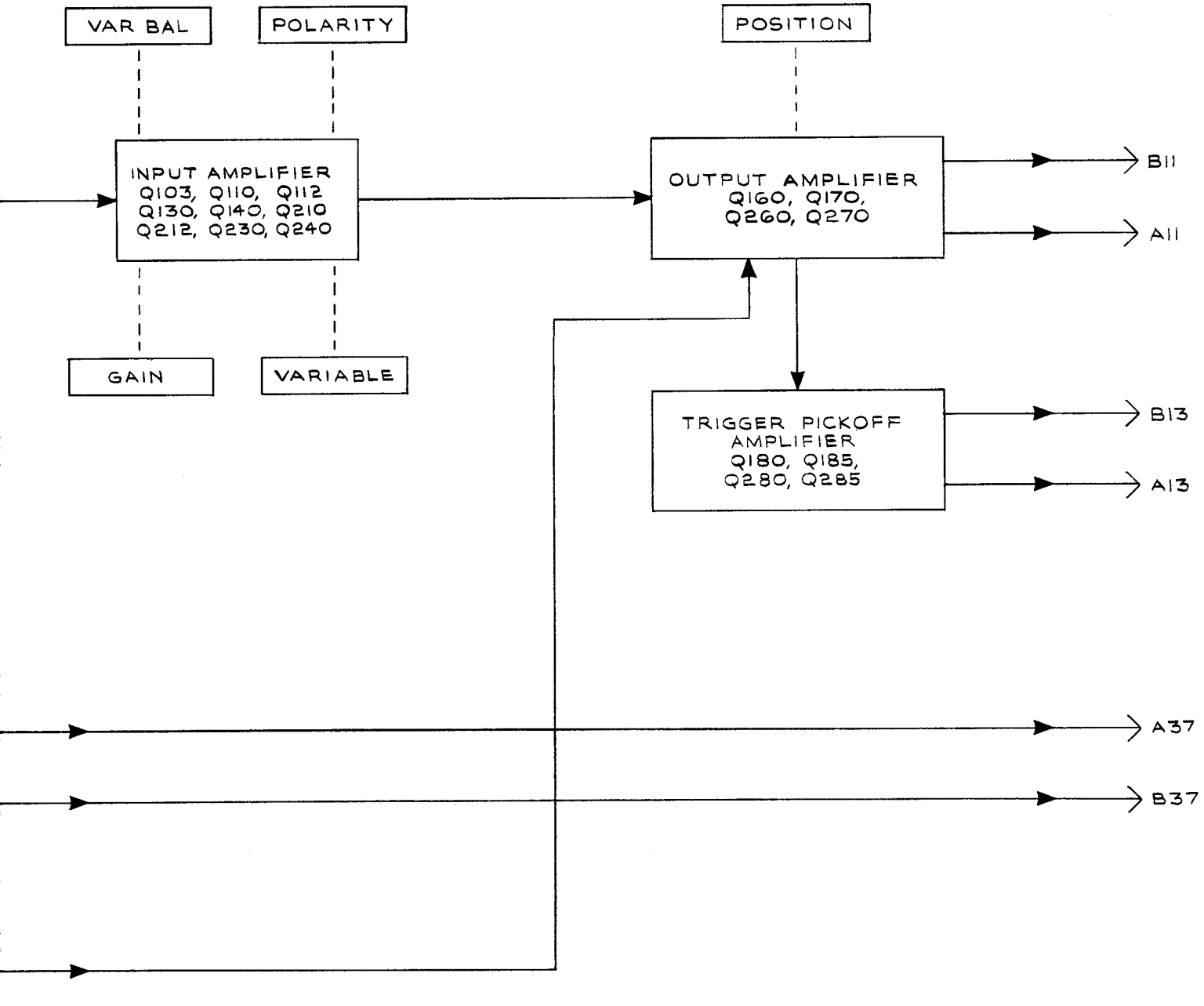


BLOCK DIAGRAM 670 EKP

VOLTAGE AND WAVEFORM TEST CONDITIONS

Typical waveforms and voltage measurements were obtained under the following conditions unless noted otherwise on the individual diagrams:

Voltmeter

Type	Non-loading digital multimeter
Input Impedance	10 megohms or greater
Range	0 to 50 volts or greater
Type used for voltages on diagrams	Fairchild Model 7050

7704 Oscilloscope

Vertical Mode	Right
Horizontal Mode	A
A Trigger Source	Right Vert
A Intensity	Optimum
Calibrator	
Volts	40 mV (20 mV)
Rate	1 kHz

7A15 (Left Vert plug-in)

VOLTS/DIV	5 mV
VARIABLE	CAL IN
COUPLING	DC
POLARITY	+UP
POSITION	Midrange
Signal Applied	20 millivolt square wave

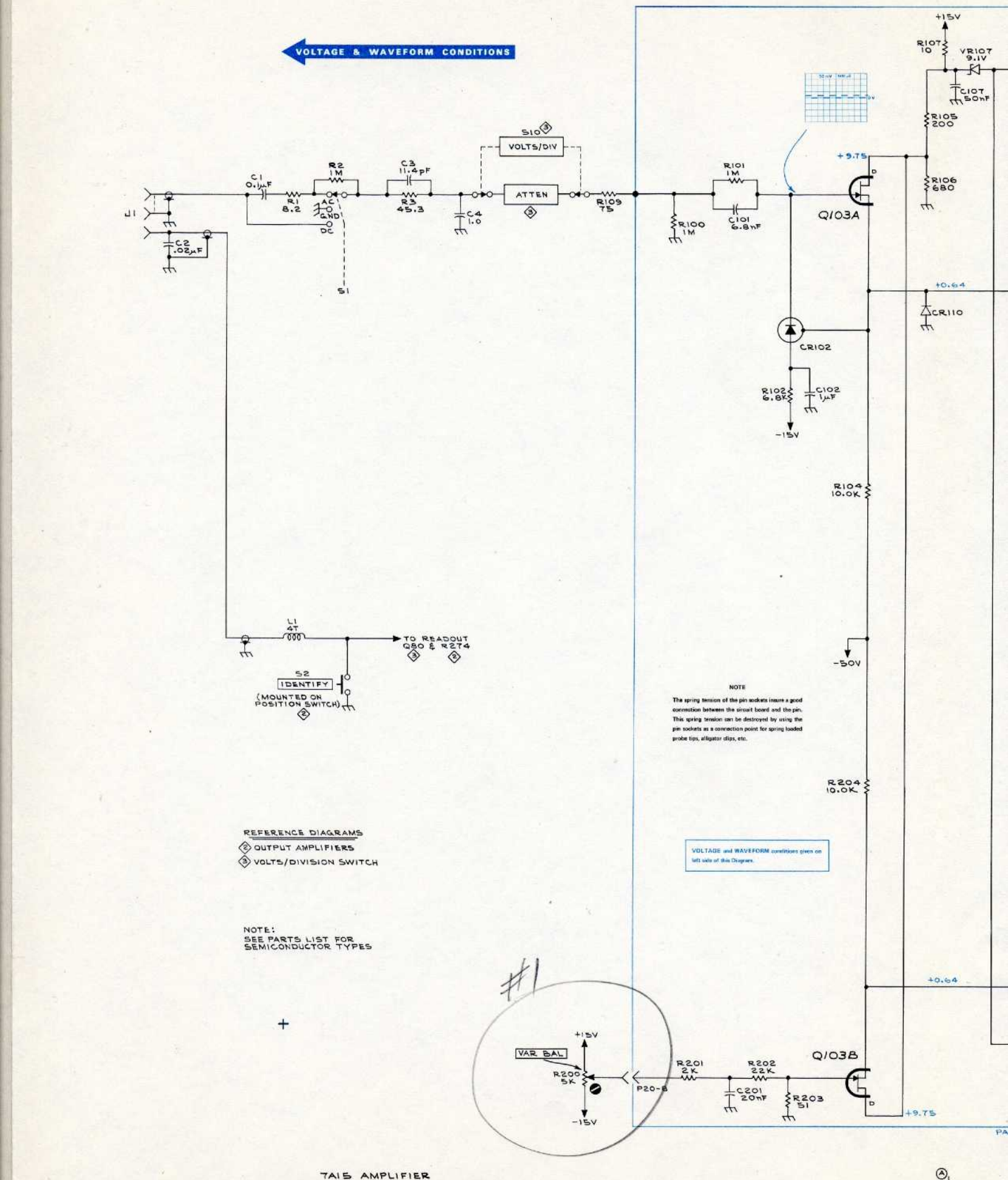
7A16 (Right Vert plug-in)

Volts/Div	As shown on waveform
Variable	Cal In
Coupling	AC
Polarity	+UP
Bandwidth	Full
Position	Midrange

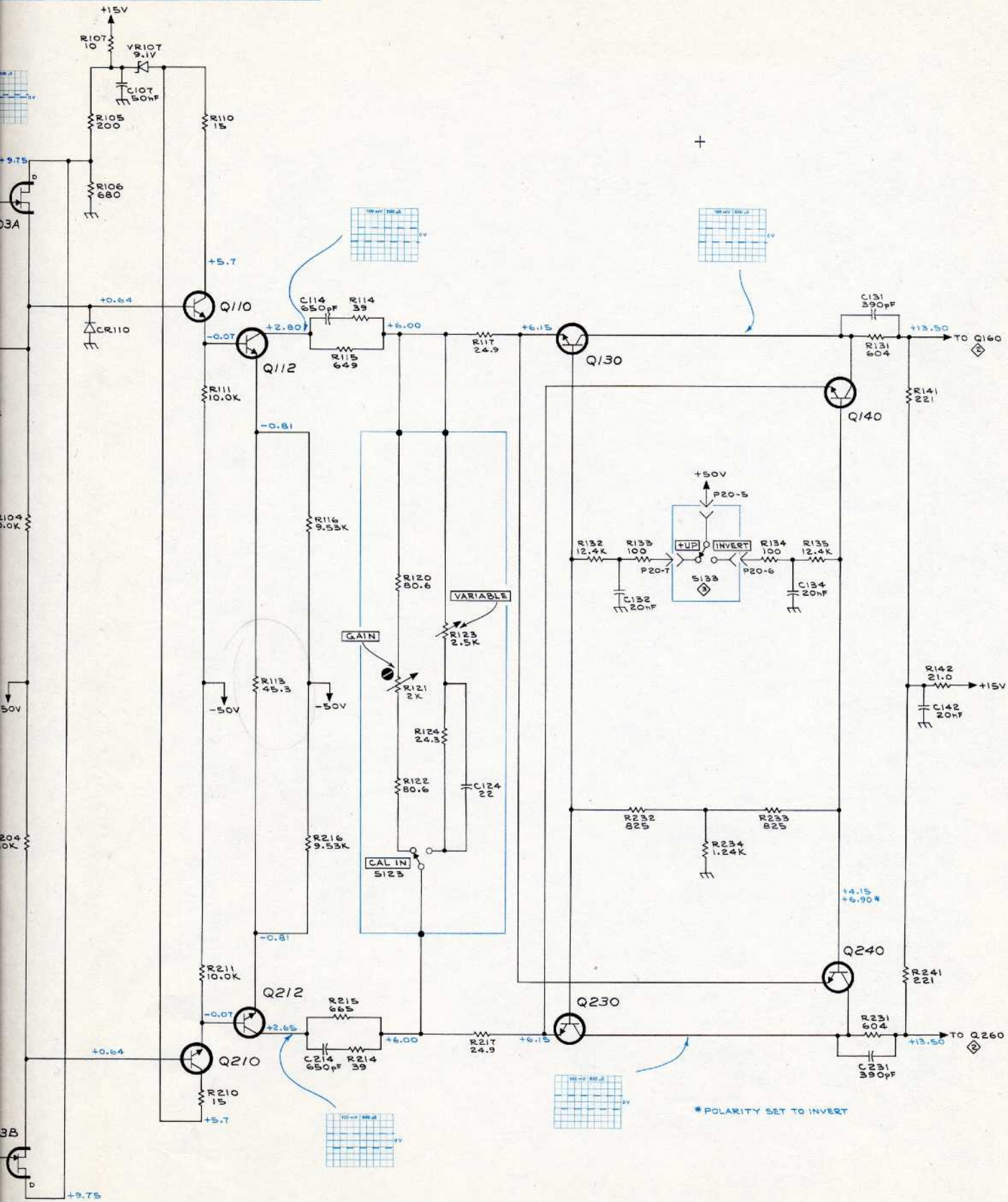
7B71 (A Horiz plug-in)

Time/Div	As shown on waveform
Variable	Cal In
Magnifier	X1
B Delay Mode	Independent
Position	Midrange
Level/Slope	Centered on positive slope
Triggering	
Mode	P-P Auto
Coupling	AC
Source	Int

All voltages given on the diagrams are in volts. Waveforms shown are actual waveform photographs taken with a Tektronix Oscilloscope Camera System and Projected Graticule. Readouts are simulated in larger than normal type. Voltages and waveforms on the diagrams (shown in blue) are not absolute and may vary between instruments because of differing component tolerances, internal calibration or front-panel control settings.



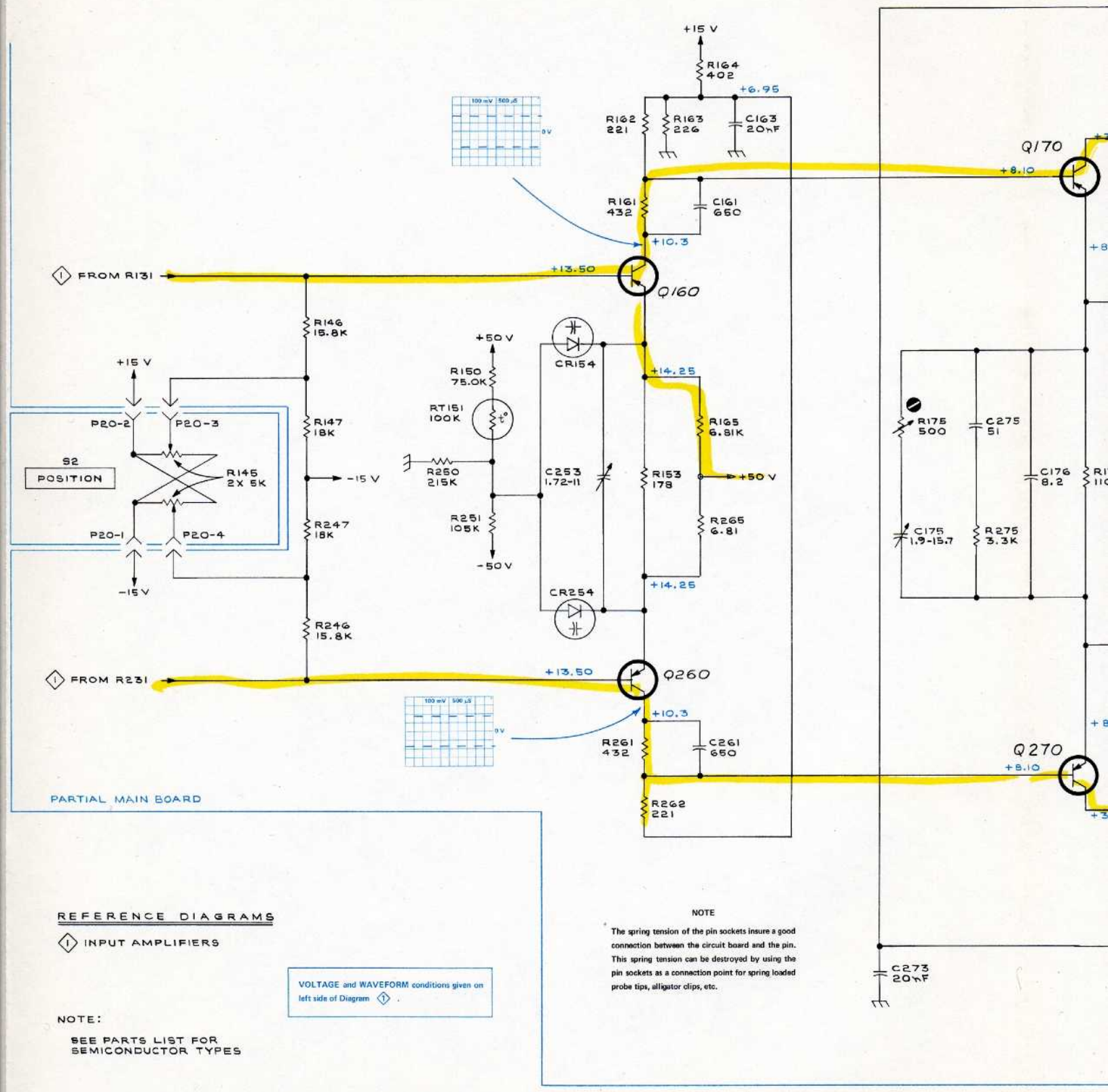
7A15 AMPLIFIER



PARTIAL MAIN BOARD

PLM 0670

INPUT AMPLIFIERS (1)



REFERENCE DIAGRAMS

(1) INPUT AMPLIFIERS

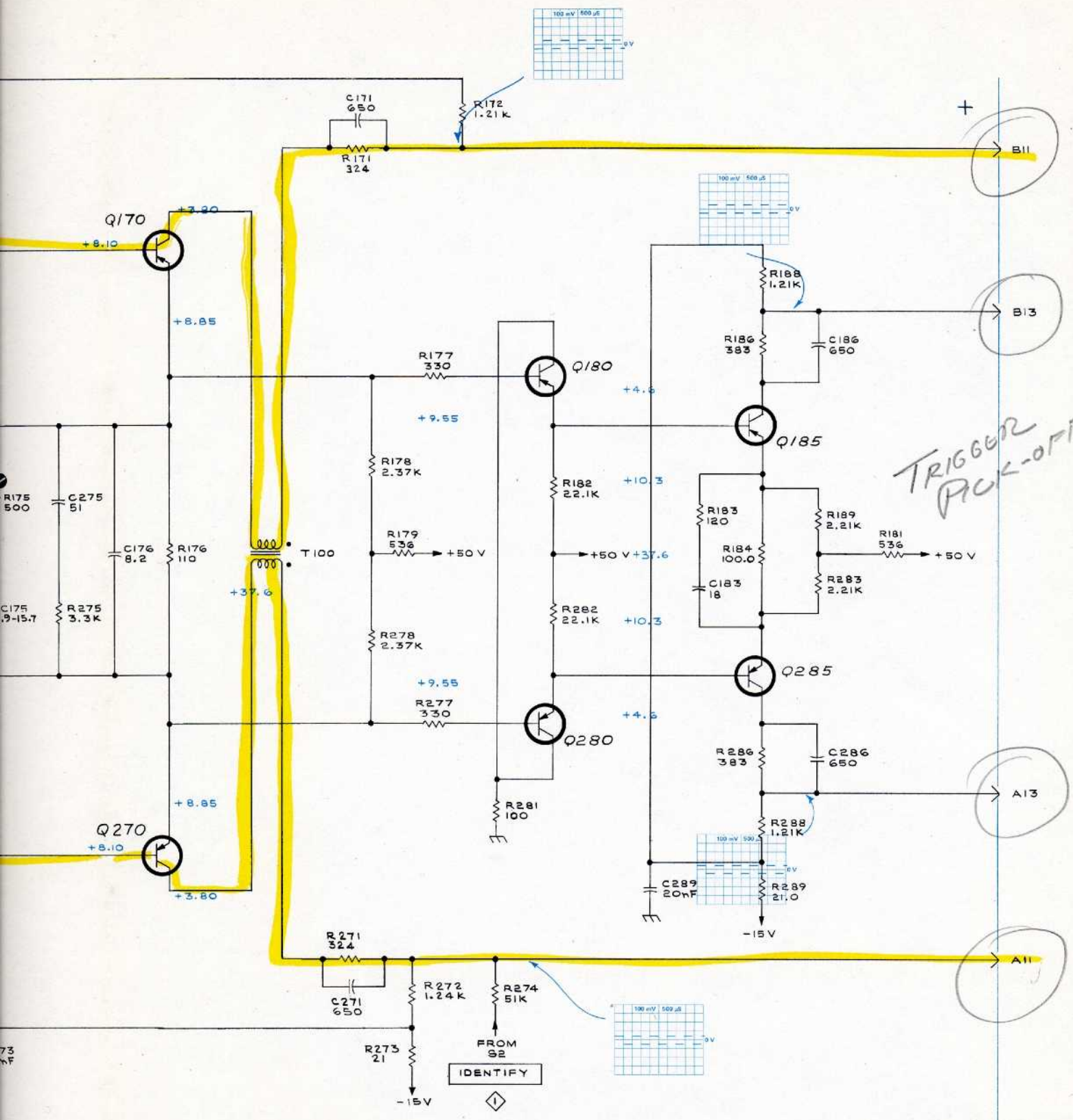
VOLTAGE and WAVEFORM conditions given on left side of Diagram (1).

NOTE:

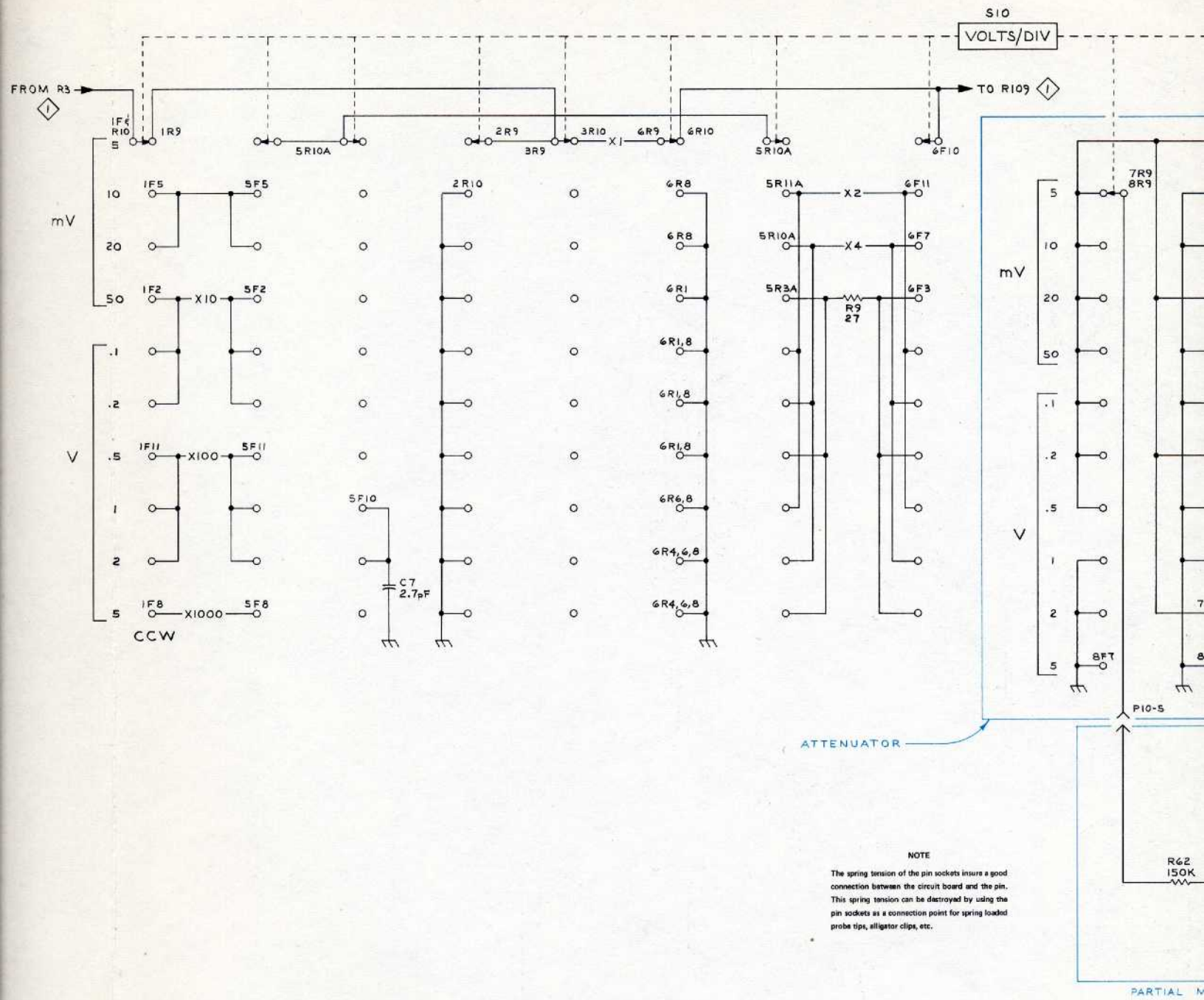
SEE PARTS LIST FOR SEMICONDUCTOR TYPES

NOTE

The spring tension of the pin sockets insure a good connection between the circuit board and the pin. This spring tension can be destroyed by using the pin sockets as a connection point for spring loaded probe tips, alligator clips, etc.

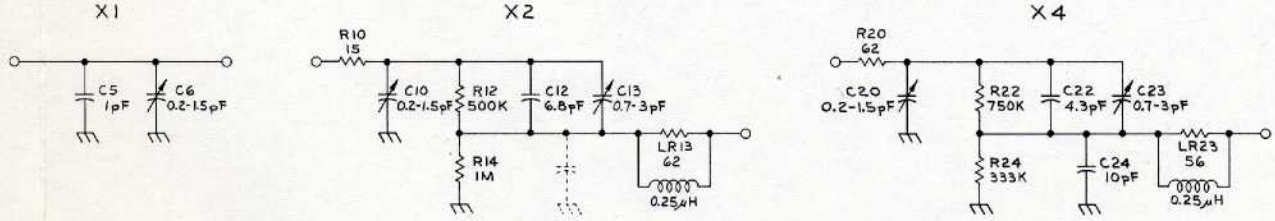


OUTPUT AMPLIFIERS ② 670 EKP



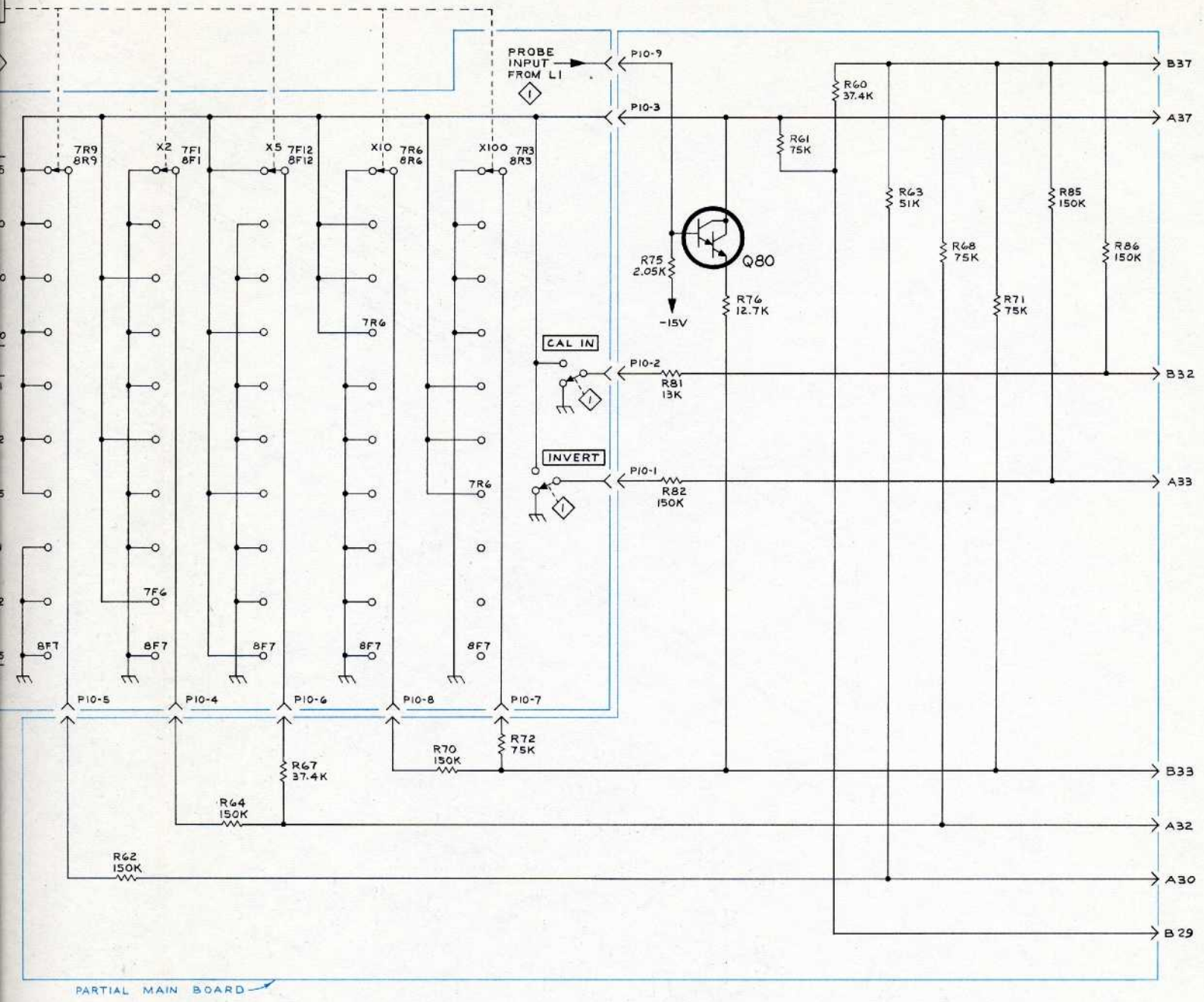
NOTE

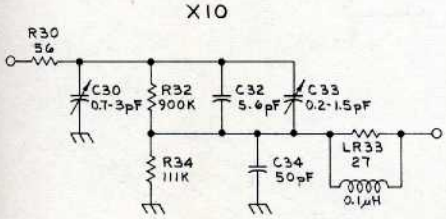
The spring tension of the pin sockets insure a good connection between the circuit board and the pin. This spring tension can be destroyed by using the pin sockets as a connection point for spring loaded probe tips, alligator clips, etc.

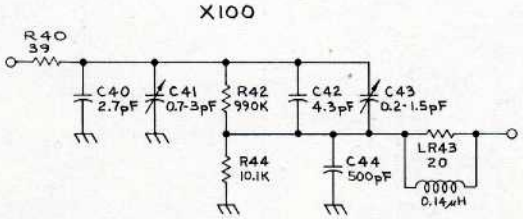


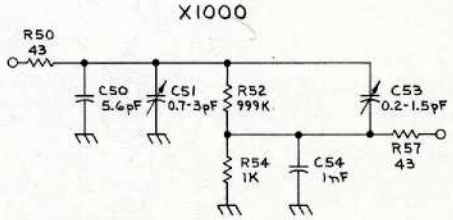
REFERENCE DIAGRAMS
◇1 INPUT AMPLIFIERS

NOTE:
SEE PARTS LIST FOR
SEMICONDUCTOR TYPES





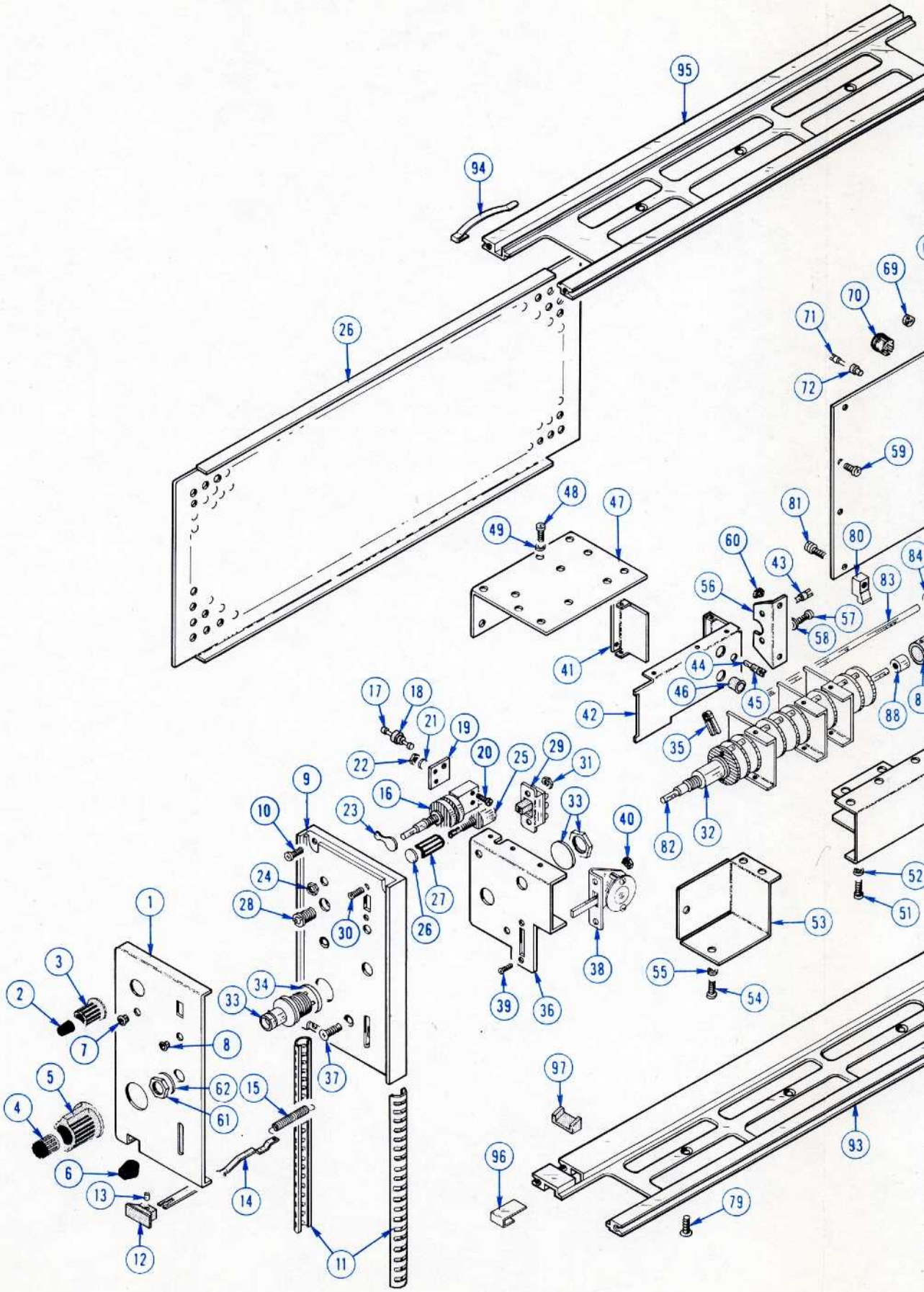




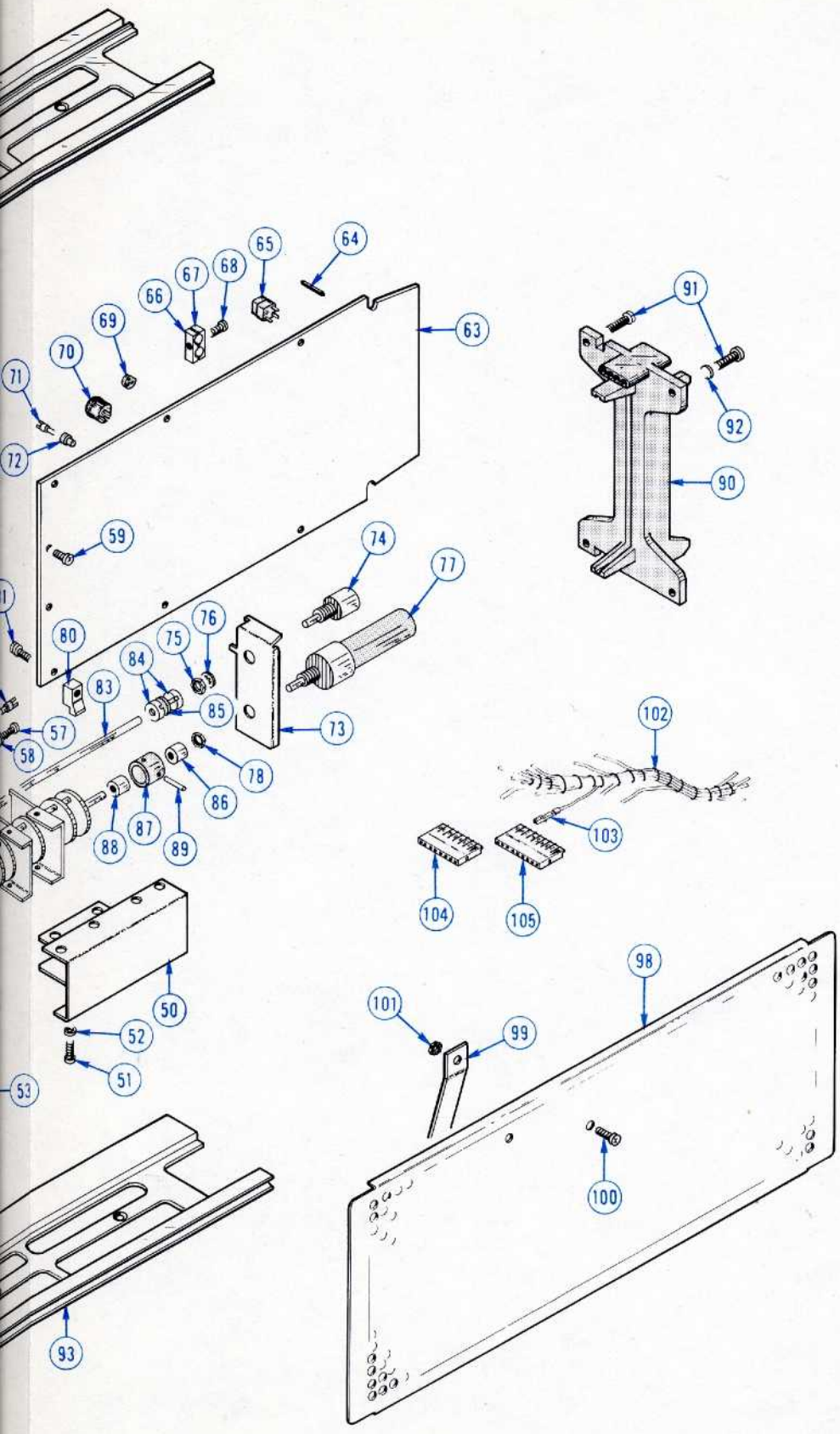
FOR
R TYPES

A1

VOLTS/DIVISION SWITCH 3 MGF 0670



7A15 AMPLIFIER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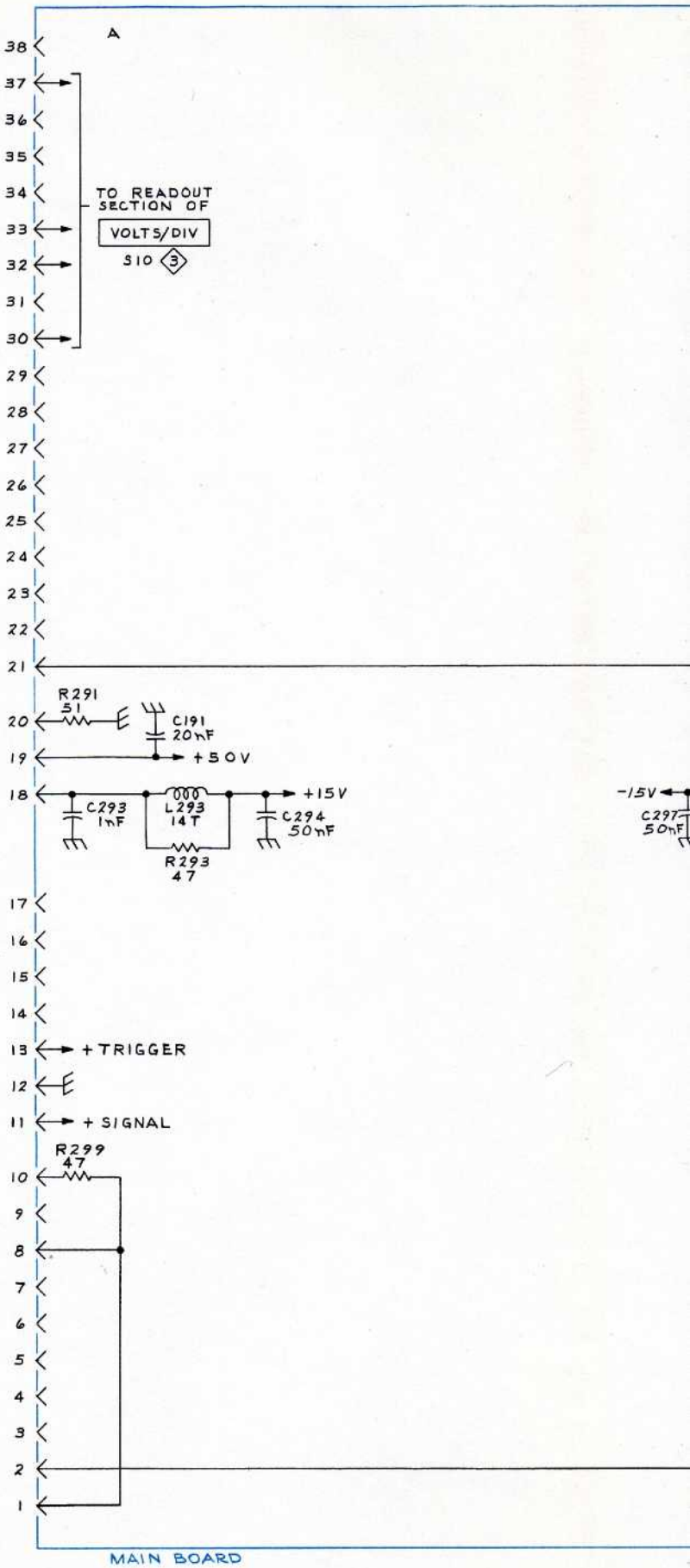
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TO READOUT SECTION OF
VOLTS/DIV
S10 3
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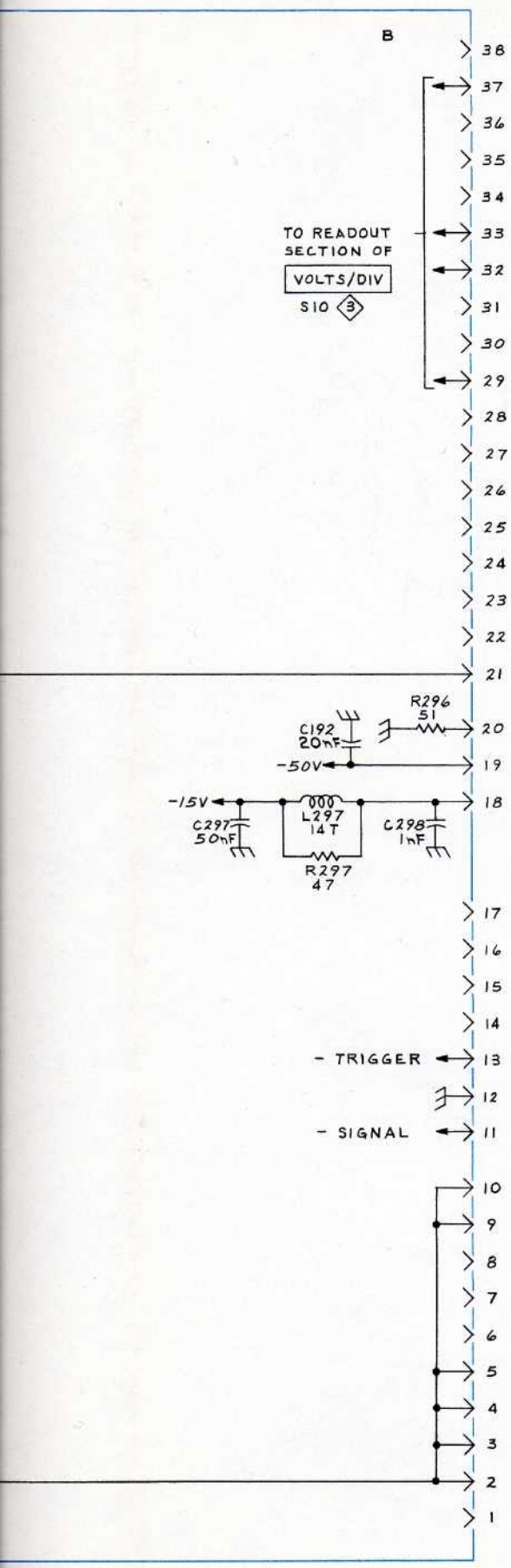
24
23
22
21
R291
51
C191
20nF
20
19
+50V
18
C293
1nF
L293
14T
+15V
C294
50nF
R293
47
-15V
C297
50nF
17
16
15
14
13
+TRIGGER
12
11
+SIGNAL
R299
47
10
9
8
7
6
5
4
3
2
1
MAIN BOARD



REFERENCE DIAGRAMS

◇3 VOLTS/DIVISION SWITCH

WLB
0670

CARTON ASSEMBLY
(Part No. 065-0125-00)

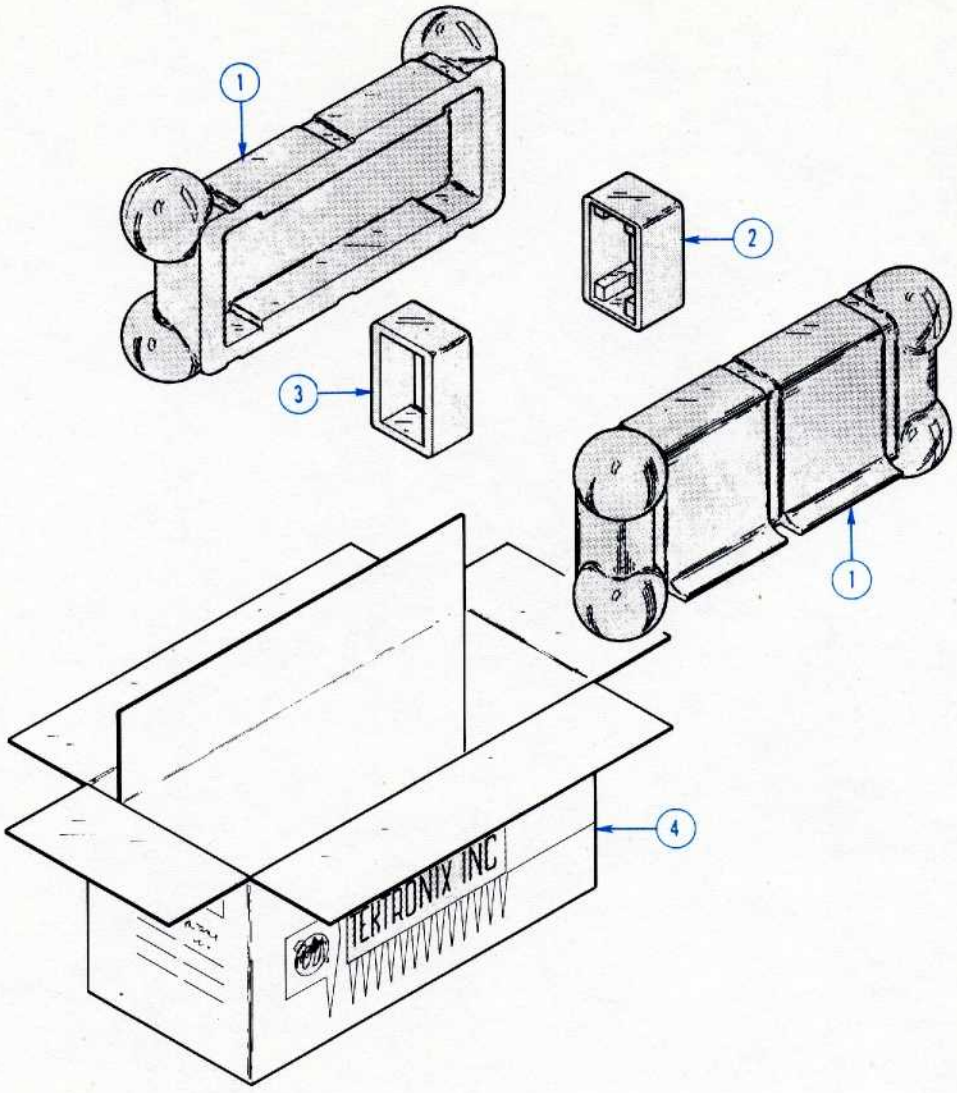


Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty 1 2 3 4 5	Description
2-	065-0125-00			1	ASSEMBLY, carton
	- - - - - -			-	assembly includes:
-1	004-0241-00			2	CASE HALF
-2	004-0242-00			1	END CAP, rear
-3	004-0243-00			1	END CAP, front
-4	004-0748-00			1	CARTON

FIGURE AND INDEX NUMBERS

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

INDENTATION SYSTEM

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

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

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

Mounting hardware must be purchased separately, unless otherwise specified.

PARTS ORDERING INFORMATION

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

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

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

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

ABBREVIATIONS AND SYMBOLS

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

INDEX OF MECHANICAL AND REPACKAGING PARTS ILLUSTRATIONS

SECTION 8
MECHANICAL PARTS LIST

FIGURE 1 EXPLODED

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5	Description
1-1	333-1321-00			1		PANEL, front
-2	366-1059-00			1		KNOB, gray—IDENTITY
-3	366-1077-00			1		KNOB, gray—POSITION
	- - - - - -			-		knob includes:
	213-0153-00			1		SETSCREW, 5-40 x 0.125 inch, HSS
-4	366-1168-00			1		KNOB, red-black—VARIABLE (CAL IN)
	- - - - - -			-		knob includes:
	213-0153-00			1		SETSCREW, 5-40 x 0.125 inch, HSS
-5	366-1057-00			1		KNOB, gray—VOLTS/DIV
	- - - - - -			-		knob includes:
	213-0153-00			2		SETSCREW, 5-40 x 0.125 inch, HSS
-6	366-0215-02			1		KNOB, gray—AC-GND-DC
-7	358-0378-00			1		BUSHING, sleeve
-8	358-0301-02			1		BUSHING, plastic, 0.188 inch ID
-9	386-1447-42			1		SUBPANEL, FRONT
	- - - - - -			-		mounting hardware: *(not included w/subpanel)*
-10	213-0192-00			4		SCREW, thread forming, 6-32 x 0.50, Fil HS
-11	348-0235-00			2		SHIELDING GASKET
-12	366-1058-15			1		KNOB, latch
	- - - - - -			-		mounting hardware: *(not included w/knob)*
-13	214-1095-00			1		PIN, spring
-14	105-0076-00			1		RELEASE BAR
-15	214-1280-00			1		SPRING, helical
-16	- - - - - -			1		RESISTOR, variable
	- - - - - -			-		resistor includes:
-17	131-0182-00			1		CONNECTOR, terminal feed thru
-18	358-0135-00			1		BUSHING, insulator, 0.15 inch long
-19	386-1853-00			1		SUPPORT, feed thru terminal
	- - - - - -			-		mounting hardware: *(not included w/support)*
-20	211-0034-00			2		SCREW, 2-56 x 0.50 inch, RHS
-21	210-0001-00			2		WASHER, lock, internal, #2
-22	210-0405-00			2		NUT, hex., 2-56 x 0.188 inch
	- - - - - -			-		mounting hardware: *(not included w/resistor)*
-23	210-0223-00			1		LUG, solder
-24	210-0583-00			1		NUT, hex., 0.25-32 x 0.312 inch

FIGURE 1 EXPLODED (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
-25	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: *(not included w/resistor)*
-26	337-1064-00			1	SHIELD, electrical, left side
-27	210-0471-00			1	NUT, hex., 0.25-32 x 0.312 x 0.594 inch long
-28	358-0409-00			1	BUSHING
-29	260-0816-00			1	SWITCH, slide—POLARITY
	- - - - - -			-	mounting hardware: *(not included w/switch)*
-30	211-0030-00			2	SCREW, 2-56 x 0.25 inch, 82° csk, FHS
-31	210-0405-00			2	NUT, hex., 2-56 x 0.188 inch
-32	262-0903-00			1	SWITCH, rotary—VOLTS/DIV, wired
	- - - - - -			-	switch includes:
	260-1151-00			1	SWITCH, rotary, unwired
-33	131-0679-00			1	CONNECTOR, receptacle, BNC, w/*hardware*
-34	361-0322-00			1	SPACER, sleeve, ground
-35	214-0599-00			4	SPRING, shaft ground
-36	337-1297-00			1	SHIELD, electrical, front
	- - - - - -			-	mounting hardware: *(not included w/shield)*
-37	211-0541-00			2	SCREW, 6-32 x 0.25 inch, 100° csk, FHS
-38	260-1168-00			1	SWITCH, lever—AC-GND-DC
	- - - - - -			-	mounting hardware: *(not included w/switch)*
-39	211-0105-00			2	SCREW, 4-40 x 0.188 inch, 100° csk, FHS
-40	210-0586-00			2	NUT, keps, 4-40 x .025 inch
-41	337-1296-00			1	SHIELD, electrical, left
-42	441-0939-00			1	CHASSIS, attenuator
-43	131-0403-00			1	CONNECTOR, feed thru
-44	131-0344-00			1	CONNECTOR, feed thru, 0.538 inch long
-45	358-0241-00			1	BUSHING, plastic
-46	358-0300-00			2	BUSHING, insulator, plastic
-47	337-1298-00			1	SHIELD, electrical, top and left
	- - - - - -			-	mounting hardware: *(not included w/shield)*
-48	213-0055-00			13	SCREW, thread forming, 2-32 x 0.188 inch, PHS
-49	210-0850-00			13	WASHER, flat, #2
-50	337-1299-00			1	SHIELD, electrical, bottom
	- - - - - -			-	mounting hardware: *(not included w/shield)*
-51	213-0055-00			7	SCREW, thread forming, 2-32 x 0.188 inch, PHS
-52	210-0850-00			7	WASHER, flat, #2

FIGURE 1 EXPLODED (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5	Description
-53	337-1300-00			1		SHIELD, electrical, rear
	- - - - - -			-		mounting hardware: *(not included w/shield)*
-54	213-0055-00			4		SCREW, thread forming, 2-32 x 0.188 inch, PHS
-55	210-0850-00			4		WASHER, flat, #2
-56	407-0777-00			1		BRACKET, component, ground
	- - - - - -			-		mounting hardware: *(not included w/bracket)*
-57	213-0055-00			2		SCREW, thread forming, 2-32 x 0.188 inch, PHS
-58	210-0850-00			2		WASHER, flat, #2
-59	211-0116-00			2		SCREW, sems, 4-40 x 312 inch, PHB
-60	210-0586-00			2		NUT, keps, 4-40 x 0.25 inch
	- - - - - -			-		mounting hardware: *(not included w/switch)*
-61	210-0590-00			1		NUT, hex., 0.375-32 x 0.438 inch
-62	210-0978-00			1		WASHER, flat, 0.375 ID x 0.50 inch OD
-63	670-1227-00			1		CIRCUIT BOARD ASSEMBLY—MAIN
	- - - - - -			-		circuit board assembly includes:
	388-1596-00			1		CIRCUIT BOARD
-64	131-0608-00			17		TERMINAL, pin, 0.365 inch long
-65	136-0220-00			13		SOCKET, transistor, 3 pin
-66	200-0945-01			2		COVER, half transistor
-67	200-0945-00			2		COVER, half transistor, threaded
-68	211-0001-00			2		SCREW, 2-56 x 0.25 inch, RHS
-69	136-0350-00			5		SOCKET, transistor, 3 pin
-70	136-0235-00			1		SOCKET, semiconductor device, 6 contact
-71	131-0235-00			1		CONNECTOR, terminal, 0.455 inch long
-72	358-0136-00			1		BUSHING, plastic
-73	407-0767-00			1		BRACKET, component mounting
-74	- - - - - -			1		RESISTOR, variable
	- - - - - -			-		mounting hardware: *(not included w/resistor)*
-75	210-0583-00			1		NUT, hex., 0.25-32 x 0.312 inch
-76	210-0046-00			1		WASHER, lock, internal, 0.261 ID x 0.40 inch OD
-77	- - - - - -			1		RESISTOR, variable
	- - - - - -			-		mounting hardware: *(not included w/resistor)*
-78	210-0583-00			1		NUT, hex., 0.25-32 x 0.312 inch
	- - - - - -			-		mounting hardware: *(not included w/circuit board assembly)*
-79	211-0105-00			6		SCREW, 4-40 x 0.188 inch, 100° csk, FHS
-80	220-0547-01			6		NUT, 0.312-32 x 0.375 x 0.282 inch long
-81	211-0116-00			6		SCREW, sems, 4-40 x 0.312 inch, PHB
-82	384-1016-00			1		SHAFT, extension, 5.18 inches long

FIGURE 1 EXPLODED (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5	Description
-83	384-1015-00			1		SHAFT, extension, 4.75 inches long
	376-0051-00			1		COUPLING, flexible
	- - - - - -			-		coupling includes:
-84	354-0251-00			2		RING, coupling
	213-0048-00			4		SETSCREW, 4-40 x 0.125 inch, HSS
-85	376-0049-00			1		COUPLING, plastic
	376-0107-00			1		COUPLING, shaft, flexible
	- - - - - -			-		coupling includes:
-86	376-0104-00			1		COUPLING SECTION, shaft, front
	213-0075-00			4		SETSCREW, 4-40 x 0.094 inch, HSS
-87	376-0105-00			1		COUPLING SECTION, shaft, center
-88	376-0106-00			1		COUPLING SECTION, shaft, rear
-89	214-0660-00			2		PIN, straight
-90	386-1402-00			1		PANEL, rear
	- - - - - -			-		mounting hardware: *(not included w/panel)*
-91	213-0192-00			4		SCREW, thread forming, 6-32 x 0.50 inch, Fil HS
-92	361-0326-00			1		SPACER, sleeve, 0.10 inch long
-93	426-0603-02			1		FRAME SECTION
-94	214-1061-00			1		SPRING, flat, sliding ground
-95	426-0602-02			1		FRAME SECTION
-96	214-1054-00			1		SPRING, flat, latch detent
-97	105-0075-00			1		BOLT, latch, plastic
-98	337-1064-02			1		SHIELD, electrical, right side
	- - - - - -			-		shield includes:
-99	214-1436-00			1		SPRING, grounding
	- - - - - -			-		mounting hardware: *(not included w/spring)*
-100	211-0005-00			1		SCREW, 4-40 x 0.125 inch, PHS
-101	210-0586-00			1		NUT, keps, 4-40 x 0.25 inch
-102	179-1540-00			1		WIRING HARNESS
	- - - - - -			-		wiring harness includes:
-103	131-0707-00			17		CONNECTOR, terminal, straight
-104	352-0166-00			1		HOLDER, terminal connector, 8 wire
-105	352-0167-00			1		HOLDER, terminal connector, 9 wire

STANDARD ACCESSORIES

	070-1044-00			2		MANUAL, instruction *(not shown)*

7A15 TENT SN B040000-up

ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTION

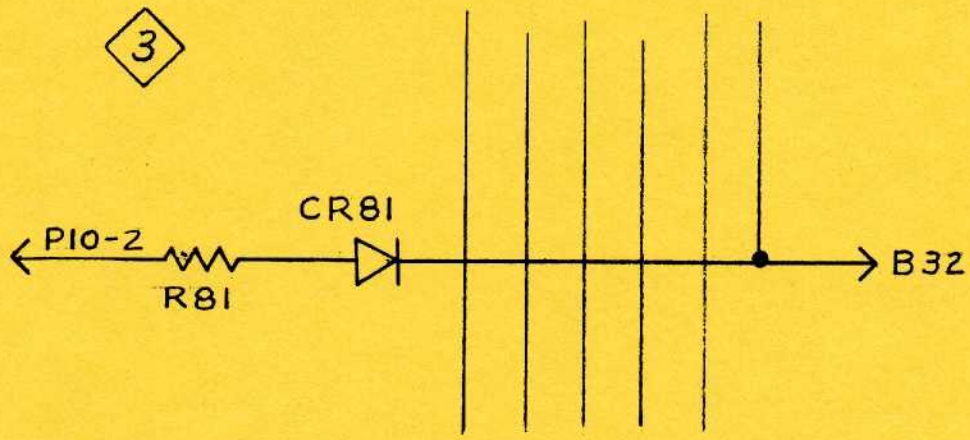
MAIN Circuit Board Assembly

CHANGE TO:

670-1227-01	Complete Board	

ADD:

CR81	152-0185-00	Silicon	Replaceable by 1N4152



PARTIAL—
VOLTS/DIVISION SWITCH

M17,382/771