

# INSTRUCTION MANUAL

**TYPE 191**  
**CONSTANT**  
**AMPLITUDE**  
**SIGNAL**  
**GENERATOR**

*Tektronix, Inc.*

S.W. Millikan Way ● P. O. Box 500 ● Beaverton, Oregon 97005 ● Phone 644-0161 ● Cables: Tektronix

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166



## WARRANTY

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

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

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## CONTENTS

Section 1	Characteristics
Section 2	Operating Instructions
Section 3	Circuit Description
Section 4	Maintenance
Section 5	Performance Check
Section 6	Calibration
	Parts Ordering Information
	Abbreviations and Symbols
Section 7	Electrical Parts List
	Mechanical Parts List Information
Section 8	Mechanical Parts List
Section 9	Diagrams
	Mechanical Parts List Illustrations
	Accessories

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



Fig. 1-1. Type 191 Constant Amplitude Signal Generator.

Type 191

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# SECTION 1 CHARACTERISTICS

## General

The Tektronix Type 191 Constant-Amplitude Signal Generator produces sine waves whose amplitude remains constant as the frequency is varied, provided the load limitations of the instrument are not exceeded. Front-panel controls indicate the peak-to-peak voltage of these sine waves at the input to a 50 ohm load.

This instrument is useful for making frequency-response measurements of broadband devices operating in the frequency range from 350 kilohertz to 100 megahertz.

The following characteristics apply over an ambient temperature range of 0° C to +50° C. Warm-up time for the given accuracies is 5 minutes at 25° C ±5° C.

## MECHANICAL CHARACTERISTICS

Characteristic	Information
Construction	Aluminum-alloy chassis, panel and cabinet. Glass laminated circuit boards.
Finish	Anodized panel, blue vinyl-coated cabinet.
Overall Dimensions (measured at maximum points)	6½ inches high, 9 inches wide, 15⅝ inches long.

## STANDARD ACCESSORIES

Standard accessories supplied with this instrument will be found on the last pullout page at the rear of this manual. For optional accessories, see the Tektronix, Inc. catalog.

## TYPE 191 OUTPUT

Characteristic	Performance Requirement	Supplemental Information
Frequency Accuracy	Within ±2% of the selected frequency when the output is terminated with 50 ohms. When the output is not terminated with 50 ohms the accuracy is still ±2% except on the 0.5-5 V range where the accuracy is ±5%.	The frequency accuracy of the 50 kHz reference frequency is 50 kHz ±2%. The tolerance takes into account the effect that the Frequency (dial) setting will have on the frequency accuracy.
Amplitude Accuracy at 50 kHz into a 50 ohm ±1% load	The 0.5-5V range is within ±3% of the indicated amplitude, the 50-500 mV range is within ±4% of the indicated amplitude, and the 5-50 mV range is within ±5% of the indicated amplitude.	The open circuit unterminated output will be twice the amplitude of the terminated output (marked on the front panel), but the output tolerances will remain the same as those stated for the terminated output.
Harmonic Content		Typically less than 5%.
Amplitude Regulation into 50 ohms at OUTPUT connector, or through 5 ns (40 inches) or less of RG-8A/U coaxial cable.	When a Type 191, properly terminated in 50 ohms, is set for any output amplitude between 5 mV and 5.5 V, the amplitude at any frequency will vary less than ±3% from the actual amplitude value at 50 kHz, except for an output between 5 mV and 55 mV and a frequency between 42 MHz and 100 MHz where the amplitude variation will be less than +3% and -5%.	The use of RG-8A/U coaxial cable is important for good amplitude regulation at high frequencies. A 40 inch length of RG-58A/U coaxial cable, for example, can introduce a 1.5% amplitude loss at 100 MHz.

## POWER REQUIREMENTS

Line Voltage Regulation	Power supplies must regulate when the line Voltage is within ±10% of the appropriate transformer center value.	
Line Voltage Center Values	105 VAC, 115 VAC, 125 VAC, 210 VAC, 230 VAC, and 250 VAC.	Center values obtained by using appropriate transformer taps.
Line Voltage Fuses	Type 3AG, 0.4 amp slow-blow for 115 V operation. Type 3AG, 0.2 amp slow-blow for 230 V operation.	
Line Frequency Operating Range	50 to 400 Hz.	
Input Power Consumption		Approximately 25 watts.



# SECTION 2 OPERATING INSTRUCTIONS

## General

To effectively use the Type 191 Constant Amplitude Signal Generator, the operation and capabilities of the instrument must be known. This section describes the operation of the front- and rear-panel controls and connectors, and gives first time operating information.

## Voltage and Fuse Considerations

When the Type 191 is shipped from the factory, it is wired so it may be operated on either 115- or 230-volt nominal line voltages. Switching between the ranges is accomplished by the Line Voltage Switch (SW105) located on the rear-panel of the instrument. Fig. 2-1 shows the Line Voltage Switch (SW105) location.

Other nominal line voltages are available by rewiring the Line Voltage Switch connectors to the transformer. Table 2-1 lists the other nominal line voltages available, their operating ranges and the Line Voltage Switch transformer connections for these line voltages. Table 2-1 also lists the correct fuse size for each nominal voltage.

**TABLE 2-1**

Line Voltage Switch Nominal Line Voltages	Nominal Voltage Operating Range	Fuse Size	Line Voltage Switch Transformer Connections
115	103.5 to 126.5	0.4 A	Factory wired to terminals 2 and 7
230	207 to 253	0.2 A	
105	94.5 to 115.5	0.4 A	Move terminal 2 wire to terminal 3 and terminal 7 wire to terminal 6
210	189 to 231	0.2 A	
125	112.5 to 137.5	0.4 A	Move terminal 2 wire to terminal 1 and terminal 7 wire to terminal 8
250	225 to 275	0.2 A	

## Cooling Considerations

Adequate clearance must be provided on all sides of the instrument to allow heat to be dissipated. The clearance provided by the feet at the bottom should be maintained. If possible, allow about two inches of clearance on the sides and top. Do not block or restrict the air flow holes in the cabinet.

## CONTROLS AND CONNECTOR

A brief description of the function or operation of the front and rear panel controls and the front panel connector follows (see Fig. 2-1 and 2-2).



Fig. 2-1. Location of Line Voltage Switch (SW105) on rear panel.

- Frequency (dial)      Selects the desired output frequency from the frequency band selected by the FREQUENCY RANGE switch.
- FREQUENCY RANGE      Selects the desired frequency band from which the specific frequency can be obtained.
- AMPLITUDE      Works in conjunction with the AMPLITUDE RANGE switch to determine the calibrated peak-to-peak amplitude of the output signal, when the output is terminated with 50 ohms. The open circuit (unterminated) output peak-to-peak amplitude of the signal will be twice the indicated amplitude.
- VARIABLE (AMPLITUDE)      Increases the output amplitude approximately up to the next fixed output amplitude of the AMPLITUDE switch, thus providing a continuous variation of output amplitude between the fixed amplitudes selected with the AMPLITUDE switch.
- AMPLITUDE RANGE (PEAK TO PEAK INTO 50 Ω)      Determines the signal amplitude (voltage) range from which the AMPLITUDE switch and VARIABLE control will select the final signal amplitude. Front-panel markings indicate amplitudes when the Type 191 output is properly terminated in 50 ohms. If the output is not terminated, the actual signal output amplitudes will be two times the markings.
- OUTPUT (R<sub>o</sub> = 50 Ω)      Signal output coaxial connector. Output resistance is 50 ohms for all control settings.



Fig. 2-2. Type 191 front-panel.

- |                                    |  |
|------------------------------------|--|
| <b>POWER</b>                       | Applies power to the instrument.   |
| <b>Power Light</b>                 | Indicates that <b>POWER</b> switch is on and the instrument is connected to a line source.   |
| <b>Line Voltage Switch (SW105)</b> | SW105 is factory wired to select either 115- or 230-volt nominal line voltages. The power transformer may be wired so that SW105 will select other than those line voltages. |

**NOTE**

The position of the Frequency (dial) setting is unimportant for the 50 kHz frequency range since it will cause not more than a  $\pm 1\%$  change in the output frequency.

**FIRST-TIME OPERATION**

The following steps will demonstrate the use of the controls and connector of the Type 191. It is recommended that this procedure be followed completely for familiarization with the instrument.

1. Set the front- and rear-panel controls as follows:

- |                           |             |
|---------------------------|-------------|
| <b>FREQUENCY RANGE</b>    | 50 kHz ONLY |
| <b>AMPLITUDE</b>          | 20          |
| <b>VARIABLE Amplitude</b> | CAL         |
| <b>AMPLITUDE RANGE</b>    | 5-50 mV     |
| <b>POWER</b>              | On          |

2. Connect the Type 191 to a power source that meets the voltage and frequency requirements of the instrument.

3. Connect one end of the supplied 5 ns coaxial cable to the **OUTPUT** connector on the Type 191. To the other end of the coaxial cable, connect the supplied 50  $\Omega$  termination.

4. Connect the 50  $\Omega$  termination to the vertical input connector of the oscilloscope.

5. Apply power to the oscilloscope and allow sufficient time for warm up.

6. Set the oscilloscope controls as follows:

- |                 |            |
|-----------------|------------|
| <b>Vertical</b> |            |
| Position        | Midrange   |
| Norm/invert     | Norm       |
| Variable        | Calibrated |

Volts/Div	0.005
Input Selector	AC
Mode Switch	To Channel being used
Time Base	
Triggering Level	Set to obtain a stable display
Triggering Mode	Triggered
Slope	+
Coupling	AC
Source	Internal Normal
Time/Div	2 $\mu$ Sec
Horizontal	
Horizontal Display	To time base being used
Position	Midrange

Positions of remaining controls are not important.

7. Adjust the Triggering Level control on the oscilloscope to obtain a stable display.

8. Change the Type 191 FREQUENCY RANGE switch to 35-75.

9. It may be necessary to readjust the oscilloscope Triggering Level control to obtain a stable display.

10. Rotate the Frequency control and note that the signal amplitude remains constant while the frequency of the signal changes. Remember that the signal amplitude will vary if the signal frequency is beyond the 30% down point of the oscilloscope.

11. Rotate the VARIABLE (Amplitude) control clockwise and note that the signal amplitude will increase from 20 mV to 25 mV.

12. Return the VARIABLE (Amplitude) control to its CAL position.

13. Change the oscilloscope Volts/Div switch to 0.05 and the Type 191 AMPLITUDE RANGE switch to 50-500 mV. The display amplitude of the signal has increased 10 times although no change in amplitude is noticeable since the oscilloscope input attenuation was increased 10 times also.

14. Rotate the VARIABLE (Amplitude) control clockwise and note that the signal amplitude increases from 200 mV to 250 mV.

15. Return the VARIABLE (Amplitude) control to its CAL position.

16. Change the AMPLITUDE switch to 15 and observe that the signal amplitude has decreased to 150 mV.

17. This ends the basic operation procedure for the Type 191.

(about 40 inches) of RG-8A/U coaxial cable (017-0502-00) and a 50 ohm termination (017-0083-00) are supplied with the instrument to provide an optimum environment for amplitude regulation. Shorter lengths of coaxial cable can also be used. The terminated coaxial cable should be connected directly to the equipment being tested. Any additional length of coaxial cable, T-connectors or wire between the 50 ohm termination and the equipment being tested will produce some variation in the output amplitude.

A smaller diameter, more flexible output coaxial cable (such as RG-58A/U) can be used with the Type 191, but some amplitude loss will occur at higher frequencies. For example, operating into a 50 ohm load at 100 MHz, a 5 nanosecond length of RG-58A/U coaxial cable will produce about a one percent amplitude loss as compared to the same length of RG-8A/U coaxial cable.

When the Type 191 is operating into an impedance much larger than 50 ohms (essentially open-circuit operation) up to twice the maximum terminated output amplitude can be obtained. Under this condition, the actual output amplitude will be 2 times the indicated amplitude on the front panel. The maximum open-circuit amplitude is 11 volts peak to peak. Open circuit amplitude regulation is not specified but is adequate for many uses, since the Type 191 50 ohm output impedance provides a reverse termination for the output coaxial cable. The reverse termination tends to keep the coaxial cable output amplitude constant even though standing waves exist in the coaxial cable. Note that a 5 nanosecond coaxial cable is a quarter-wavelength at 50 MHz and therefore when unterminated presents a short circuit to the Type 191. Therefore, the largest difference between terminated and unterminated operation will be found on the 42-100 MHz range.

### General Equivalent Circuit

The Type 191 closely approximates a constant voltage

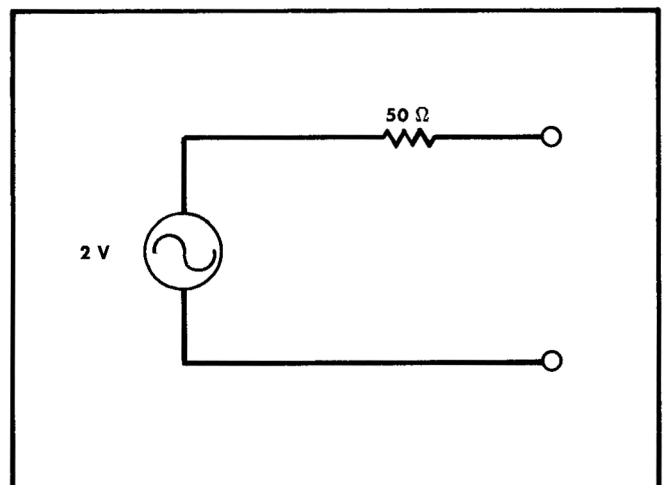


Fig. 2-3. Equivalent circuit of the Type 191 at the OUTPUT connector. In the figure V represents the generator output amplitude selected with the front-panel controls.

## APPLICATION NOTES

### Connection to other Equipment

Output amplitude regulation is specified with the Type 191 operating into a 50 ohm load. A 5 nanosecond length



**Operating Instructions—Type 191**

sine-wave generator in series with a 50 ohm resistor, as shown in Fig. 2-3.  $V$  is the peak-to-peak amplitude selected on the front panel. A voltage  $V$  will be delivered to a 50 ohm load and a voltage  $2V$  to an open circuit. The addition of an unterminated 50 ohm coaxial cable does not change this circuit representation.

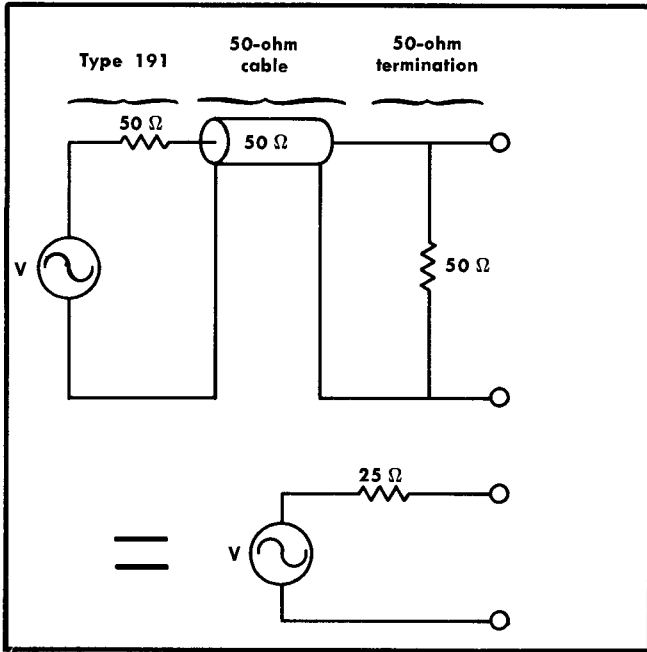


Fig. 2-4. Equivalent circuit of a Type 191, a 50 ohm cable, and a 50 ohm termination. In the figure  $V$  represents the generator output amplitude selected with the front-panel controls.

When a 50 ohm coaxial cable and termination are connected to the Type 191, the equivalent circuit becomes that shown in Fig. 2-4, a constant voltage generator in series with a 25 ohm resistor.

These equivalent circuits are useful in estimating the amplitude changes caused by reactive load impedances. For example, Fig. 2-5 shows the circuit for purely capacitive loading and the corresponding equation for the output amplitude.

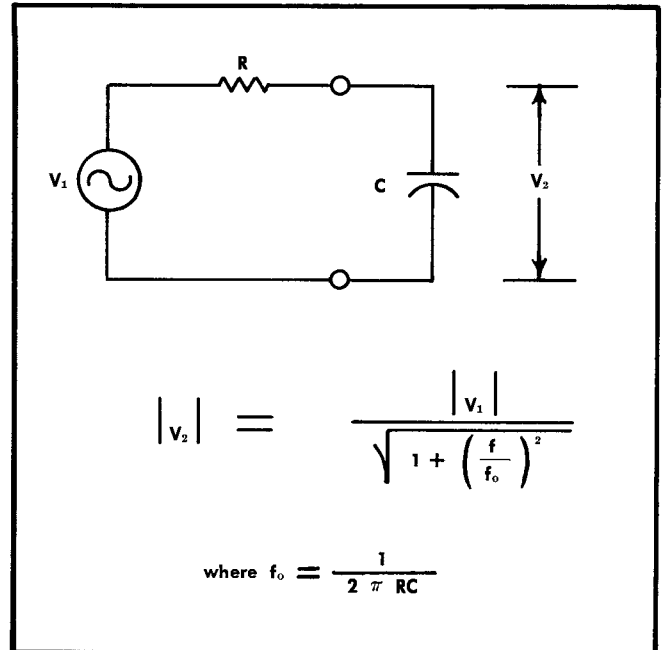


Fig. 2-5. Equivalent circuit for purely capacitive loading.

# SECTION 3

## CIRCUIT DESCRIPTION

### Introduction

This section of the manual contains an electrical description of each circuit in the Type 191. A block diagram of the instrument is located in the Diagrams section of this manual. The block diagram shows the relationships between the circuits of the instrument.

Schematic diagrams are also located in the Diagrams section. These diagrams should be referred to for electrical values and relationships of components.

### BLOCK DIAGRAM

#### Oscillator

The Oscillator output signal is supplied to both the Peak To Peak Detector and the 50  $\Omega$  Wideband Attenuator. The frequency of the Oscillator is controlled by the FREQUENCY RANGE switch and the Frequency dial. The output signal amplitude of the Oscillator is controlled by the DC voltage applied to the plate of the Oscillator tube V10 via the Series Regulator tube. This DC voltage is controlled by the AMPLITUDE switch and the VARIABLE control settings and by the comparison process occurring in the Peak To Peak Detector.

#### 50 $\Omega$ Wideband Attenuator

The 50  $\Omega$  Wideband Attenuator takes the normal 1 to 11 volt signal supplied from the Oscillator and, depending upon the AMPLITUDE RANGE switch setting, either supplies the signal through 50 ohms to the OUTPUT connector (.5-5V), attenuates the signal 10 $\times$  (50-500 mV), or attenuates the signal 100 $\times$  (5-50 mV).

The output resistance of the Type 191 is 50 ohms in all positions of the AMPLITUDE RANGE switch.

#### Comparison Voltage

The DC voltage from the Comparison Voltage circuit applied to the Peak To Peak Detector determines the Oscillator output signal amplitude applied to the 50  $\Omega$  Wideband Attenuator.

#### Peak To Peak Detector

The output of the Oscillator and the Comparison Voltage are compared in the Peak To Peak Detector and any necessary correction voltage to correct the output signal amplitude is sent to the Feedback DC Amplifier.

#### Feedback DC Amplifier

This amplifier receives the correction voltage from the Peak To Peak Detector and then supplies the amplified correction voltage to the grid of V94, the Series Regulator Tube.

#### Series Regulator

The correction voltage from the Feedback DC Amplifier varies the grid potential of V94, which causes the Series Regulator tube to adjust the amount of plate voltage available to the Oscillator tube.

#### Unregulated Power Supply

The Unregulated Power Supply makes available about +450 volts of DC voltage to the plate of the Series Regulator tube, V94.

### DETAILED CIRCUIT DESCRIPTION

#### Oscillator

Oscillator tube V10 is connected as a grounded cathode Class C Colpitts Oscillator. Plate current is supplied to the grid end of switched inductors through R90, R99, R98, L98 and Zener diode D98. L98 and resistors R98, R99 and R90 isolate the Oscillator from the low output impedance of the Series Regulator, thereby increasing the Q of the Oscillator circuit. Zener diode D98 provides a voltage drop to furnish Q94 with sufficient collector voltage when the Oscillator output amplitude is minimum.

Feedback to the grid of V10 to maintain oscillations is provided from the grid end of the switched inductors through C8 and R8.

The tuning capacitor (Frequency dial) for the Oscillator is composed of C10A, B, C and D. Sections C10A, B and C of the tuning capacitor are electrically connected in parallel in the grid circuit while only section C10D of the tuning capacitor is connected to the plate circuit. This permits the ratio of plate to grid AC voltage to be 3 to 1.

The switched inductors which provide the various frequency ranges have adjustable powdered iron slugs and individual trimmer capacitors. These adjustments permit the frequency span of each range to be accommodated to the precalibrated dial. The selection of inductor is determined by the FREQUENCY RANGE switch, SW10.

The switched inductor for the 50 kHz ONLY range also has an adjustable powdered iron slug. Large fixed capacitors are connected in parallel with C10 to reduce the necessary inductance for 50 kHz operation. The large capacitors result in a negligible frequency difference (less than  $\pm 1\%$ ) from 50 kHz at any setting on the frequency dial.

The ferrite beads L11 and L12 mounted on the leads of T10 minimize high frequency currents induced when the oscillator is operating in the 42 MHz to 100 MHz range.

The individually switched output coils, inductively coupled to the oscillator coils, provide oscillator signal to the output networks. The inductor and capacitor in each of the output networks except for the 42 to 100 MHz range output coil, constitute low pass filter which partially removes the higher frequency harmonics from the output oscillator signal. The

## Circuit Description—Type 191

resistor in each of the output networks except for the 42 to 100 MHz range reduces the Q of the resonant circuit which is formed by the components of the output network. Low Q is necessary for minimum disturbance of the Oscillator. The resistor and capacitor on the 42 to 100 MHz range constitute a low pass filter. The inductor reduces the amount of capacitance presented to the Oscillator circuit when the Type 191 OUTPUT connector is unterminated.

Toroid L64 located on the coaxial cable from the output point to the sampling point, reduces the amount of stray radio frequency current flowing in the shield of the coaxial cable.

### 50 $\Omega$ Wideband Attenuator

The Oscillator signal at the sampling point goes two ways. One path is through R40 to the 50  $\Omega$  Wideband Attenuator. The 50 ohm output impedance of the Oscillator is set by R40. This is true because the steady state impedance of the sampling point approaches zero ohms.

In all positions of the AMPLITUDE RANGE switch, both the input and output impedances of the 50  $\Omega$  Wideband Attenuator are 50 ohms. This is accomplished by the impedance of R40 and the 50 ohm T section attenuators. Each of the T section attenuators is stacked, i.e., the .5-5 V range has no signal attenuation ahead of the OUTPUT connector, while the 50-500 mV range has 10 times signal attenuation and the 5-50 mV range has 100 times signal attenuation.

The AMPLITUDE RANGE switch positions are labeled to indicate the output signal amplitude range, when the Type 191 OUTPUT connector is properly terminated into 50 ohms.

Toroid L49, located on the coaxial cable from the output of the 50  $\Omega$  Wideband Attenuator to the OUTPUT connector, reduces the amount of stray radio frequency current flowing in the shield of the coaxial cable.

### Comparison Voltage

The Comparison Voltage circuit is a Kelvin-Varley divider. The voltage picked off from the divider, which is determined by the AMPLITUDE switch position, is applied across the VARIABLE control R58. The output voltage from R58 is fed to point C of the circuit board (Peak To Peak Detector circuit).

To obtain, for example, a 5 volt peak-to-peak Oscillator signal at the sampling point the output voltage from the Comparison Voltage circuit must be  $-5$  volts.

TRACKING (R55) and AMPL CAL (R51) controls adjust the divider so the Oscillator output amplitude will agree with the front panel labeling. The AMPLITUDE switch and VARIABLE control labels indicate, in conjunction with the AMPLITUDE RANGE switch, the output signal amplitude when the Type 191 OUTPUT connector is properly terminated into 50 ohms.

### Peak To Peak Detector

The function of the Peak to Peak Detector is to provide a DC voltage to the Feedback DC Amplifier which represents the difference between the DC comparison voltage and the

actual peak-to-peak voltage (Oscillator output amplitude) at the sampling point. The output of the detector under steady conditions is a DC voltage established at the junction of R71 and the base of Q74.

For a first analysis of the Peak To Peak Detector operation, diodes D60 and D67 will be assumed to be ideal; that is, when conducting they have zero voltage drop across them. Now, assume that the comparison voltage is  $-10$  volts. The peak-to-peak voltage will also be 10 volts because of the action of the Feedback DC Amplifier and Series Regulator. When the output sine wave is at its most negative point,  $-5$  volts, the junction of D60 and D67 will be at  $-10$  volts. When the Oscillator output sine wave is at its most positive point,  $+5$  volts, the junction of D60 and D67 will be at zero volts. The detector output under these conditions will therefore be zero volts, since C66 and C67 will charge to the most positive voltage appearing on the anode of D67. In other words, C63 and C64 pass the sine wave at full amplitude to the junction of D60 and D67, but displace it negatively by a DC voltage equal to one-half the Oscillator output peak-to-peak amplitude. The waveform at the junction of D60 and D67 varies, therefore, from  $-10$  volts to zero volts. Since the detector output must supply a direct current of about  $10 \mu\text{A}$  whose source is the charge stored in C63 and C64, these capacitors must receive periodic charging currents. During the time D67 is conducting (at the positive Oscillator output sine wave peak), the charge passes from C63 and C64 to C66 and C67. This charge removal from C63 and C64 is replaced at the negative Oscillator sine wave peak when D60 conducts momentarily. The charge gained by C63 and C64 at each negative peak is exactly equal to the charge lost at each positive peak. If for any reason the Oscillator output amplitude changes, a corresponding change in the detector output will provide an error signal to the Feedback DC Amplifier which will act to restore the amplitude to its correct value.

If the comparison voltage is changed, the feedback circuit will act to make the Oscillator output amplitude change the same amount.

When D60 and D67 are real instead of ideal diodes, with forward voltages of about 0.6 volts each, the actual detector output voltage is  $-1.2$  volts instead of zero volts for the description given above. The differential amplifier consisting of Q74 and Q84 is arranged to accept this voltage by having the base of Q84 offset about  $-1.2$  volts by means of D80, D81 and R80.

C60, C64, and C67 are disc capacitors with low inductance connections to readily pass high frequency current pulses. C61, C63, and C66 are larger capacitors to provide more charge storage at lower frequencies. Ferrite beads L61, L63, and L66 provide damping for the capacitors on which they are mounted. R60-C60 and R67-C67 are low-pass filter networks and R64 is a damping resistor. Toroid L70 minimizes stray radio frequency current in the coaxial cable shield.

### Feedback DC Amplifier

The current output of the Peak To Peak Detector determines a voltage at the base of Q74. The voltage at the base of Q74 is compared to the voltage at the base of Q84, the other half of a differential amplifier. The voltage at the



base of Q84 is determined by the combined junction voltages of D80 and D81 and by the current through R80 and R81. The difference in voltage between the two inputs to the differential amplifier determines the voltage presented at the base of emitter follower Q93. From the emitter follower Q93 the signal is fed to the base of common emitter amplifier Q94. The output voltage of Q94 is then fed to the grid of V94, part of the Series Regulator circuit.

A differential amplifier is used as part of the Feedback DC Amplifier so temperature compensated DC voltage amplification can be obtained without inversion. The inversion in the Feedback Amplifier is due to the common emitter amplifier stage. The overall gain of the Feedback DC Amplifier is about 100,000.

Any temperature or DC offset voltage variations in the voltage at the base of Q74 caused by the Peak To Peak Detector or sampling diodes D60 and D67, is compensated for in the Feedback DC Amplifier by diodes D80 and D81, located in the base circuit of Q84. Diodes D80 and D81 introduce a temperature dependent voltage on the base of Q84 which approximately matches the temperature dependent voltage on the base of Q74 caused by the sampling diodes D60 and D67. D80 and D81 also provide an offset voltage to match the detector output.

R72 and C72 decrease the AC voltage gain of the Feedback DC Amplifier to prevent oscillation.

R70 and C71 comprise a low pass filter to bypass radio frequency voltage components to ground at the amplifier input.

### Series Regulator

The output voltage of the Feedback DC Amplifier is fed to the control grids of Series Regulator tube V94 where it controls the conduction of V94. By varying the grid voltage of V94 (connected as a cathode follower), the amount of plate voltage available to the Oscillator tube V10 can be controlled, thereby controlling the output signal amplitude of the Oscillator.

During the initial warm-up time of V94 after the instrument has been turned on, D94 prevents a high positive voltage from appearing on the grid with respect to the cathode. If such a large electric field were repeatedly applied to a cold cathode, cathode damage would eventually occur. R97 prevents a charge being stored on the cathodes of V94 after the instrument has been turned off.

R95 and R96 prevent parasitic oscillation in V94.

### Power Supply

**Primary.** Power is applied to the instrument through P101. Line filter C101-C102 reduces the effect on the power line of signals generated in the instrument. SW105, as

connected at the factory, permits the instrument to be easily converted from 115 volts to 230 volts by connecting the two transformer primaries in parallel for 115 volt operation or by connecting the two transformer primaries in series for 230 volt operation.

**+6.2 and -11 Volt Supply.** Output from transformer T101 is rectified by diodes D112A and D112B resulting in about 40 volts being applied across the parallel network of C113 and R117-D117-D118-R115. Output from the same winding of T101 is also rectified by D112C and D112D resulting in about 40 volts being applied across the parallel network of C115 and R115-R118. The output from diodes D112A and D112B supplies Zener diode D117 with current. Zener diode D11 in conjunction with D118, R115 and R118 then establishes a voltage of +6.2 volts at the junction of D117 and R117.

D118 is connected in series with D117 to provide a temperature compensation for the +6.2 volt supply.

R115 and R118 provide compensation for any change in line voltage that might cause a current change in D117 and D118. This current change through the dynamic resistance of D117 and D118 (about 15 ohms total) will produce a voltage change across the two diodes. R115 and R118 introduce a voltage of opposite polarity to the cathode of D118 which offsets the change across D117 and D118. This compensation is established so the characteristic of the +6.2 volt supply acting together with the operational amplifier in the -11 volt supply produces minimum change in the -11 volt output as the line voltage varies.

The +6.2 volts is supplied to the input of an operational amplifier stage consisting of Q123 and Q127. The operational amplifier stage has a gain of about -1.8, which is adjustable. The input resistor of the operational amplifier is R120 and the feedback resistance is made up of R121 and R122 in series. The connection of the two transistors of the operational amplifier stage provides temperature compensation for the emitter-base voltages.

The +6.2 volts which is supplied to the operational amplifier stage is inverted and amplified to obtain the -11 volts. The -11 VOLTS control R122 adjusts the gain of the operational amplifier and therefore the output voltage. The stable -11 volts is then used as the reference supply for the signal amplitude.

**+450 Volt Supply.** Output from transformer T101 is rectified by D132A, B, C and D and applied across C132A and B for an unregulated output voltage of +450 volts. R140 and R135 are bleeder resistors for the supply; R140 discharges the filter capacitor when the POWER switch has been turned off. If, however, the instrument has had the line power removed but the Power switch remains on, then R135 discharges the filter capacitor, but at a slower rate.

R137 and R138 elevate the heater of V94 to approximately 180 volts to minimize heater-to-cathode leakage.

# SECTION 4

## MAINTENANCE

### Introduction

This section of the manual contains maintenance information for use in preventive maintenance, corrective maintenance or troubleshooting of the Type 191.

### PREVENTIVE MAINTENANCE

#### General

Preventive maintenance consists of cleaning, visual inspection, lubrication, etc. Preventive maintenance performed on a regular basis will help prevent instrument failure and will improve reliability of this instrument. The severity of the environment to which the Type 191 is subjected will determine the frequency of maintenance.

#### Cleaning

The Type 191 should be cleaned as often as operating conditions require. Accumulation of dirt in the instrument can cause overheating and component breakdown. Dirt on components acts as an insulating blanket and prevents efficient heat dissipation. It also provides an electrical conduction path.

The cover provides protection against dust in the interior of the instrument. Operation without the cover in place will mean more frequent cleaning is required.

#### CAUTION

**Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. Some chemicals to avoid are benzene, toluene, xylene, acetone or similar solvents.**

**Exterior.** Loose dust accumulated on the outside of the Type 191 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 solution of water and detergent. 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 or for cleaning ceramic terminal strips and circuit board.

#### Lubrication

The reliability of potentiometers, rotary switches and other moving parts can be increased if they are kept properly lubricated. Use a cleaning-type lubricant (such as Tektronix Part No. 006-0218-00) on shaft bushings and switch

contacts. Lubricate switch detents with a heavier grease (such as Tektronix Part No. 006-0219-00). Potentiometers should be lubricated with a lubricant which will not affect electrical characteristics (such as Tektronix Part No. 006-0220-00). Do not over lubricate. A lubrication kit containing the necessary lubricants and instructions is available from Tektronix. Order Tektronix Part No. 003-0342-00.

#### Visual Inspection

The Type 191 should be inspected occasionally for such defects as broken connections, broken or damaged ceramic strips, improperly seated transistors or tubes, damaged circuit board and heat-damaged parts.

The remedy for most visible defects is obvious; however, care must be taken if heat-damaged parts are located. Overheating is usually only a symptom of trouble. For this reason, it is essential to determine the actual cause of overheating before the heat-damaged part is replaced; otherwise, the damage may be repeated.

#### Transistor and Tube Checks

Periodic checks of the transistors and tubes in the Type 191 are not recommended. The best check of transistor or tube performance is its actual operation in the instrument. More details on checking transistor and tube operation is given under Troubleshooting.

#### Recalibration

To assure accurate measurements, check the calibration of this instrument after each 500 hours of operation or every six months if used infrequently. Complete instructions are given in the Calibration section.

The calibration procedure can also be helpful in localizing certain troubles in the instrument. In some cases minor troubles, not apparent during normal use, may be revealed and/or corrected by recalibration.

### CORRECTIVE MAINTENANCE

#### General

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

#### Obtaining Replacement Parts

**Standard Parts.** All electrical and mechanical part replacements of the Type 191 can be obtained through your local Tektronix Field Office or representative. However, many of the standard electronic components can be obtained locally in less time than is required to order them from Tektronix, Inc. Before purchasing or ordering replacement parts, consult the Parts List for value, tolerance and rating.

NOTE

When selecting replacement parts, it is important to remember that the physical size and shape of a component may affect its performance at high frequencies. 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 Type 191. These parts are manufactured or selected by Tektronix, Inc. to meet specific performance requirements, or are manufactured for 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 Tektronix Field Office or representative.

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

1. Instrument Type.
2. A description of the part (if electrical, include circuit number).
3. Tektronix Part Number.
4. Instrument Serial Number.

## Soldering Techniques

WARNING

Disconnect the instrument from the power source before soldering.

**Circuit Board.** Use ordinary 60/40 solder and a 35- to 40-watt pencil type soldering iron on the circuit board. The tip of the iron should be clean and properly tinned for best heat transfer to the solder joint. A higher wattage soldering iron may separate the circuit from the base material.

The following technique should be used to replace a component on a circuit board. Most components can be replaced without removing the board from the instrument.

1. Grip the component lead with long-nose pliers. Touch the soldering iron to the lead at the solder connection. Do not lay the iron directly on the board.
2. When the solder begins to melt, pull the lead out gently. This should leave a clean hole in the board. If not, the hole can be cleaned by reheating the solder and placing a sharp object such as a toothpick or pointed tool into the hole to clean it out.
3. Bend the leads of the new component to fit the holes in the board. If the component is replaced while the board is mounted in the instrument, cut the leads so they will just protrude through the board. Insert the leads into the holes until the component is firmly seated against the board. If it does not seat properly, heat the solder and gently press the component into place.

4. Apply the iron and a small amount of solder to the connection to make a firm solder joint. To protect heat-sensitive components, hold the lead between the component body and the solder joint with a pair of long-nose pliers or other heat sink.

5. Clip the excess lead that protrudes through the board.

6. Clean the area around the soldered connection with a flux-remover solvent, being careful not to remove information printed on the board.

**Ceramic Terminal Strips.** Solder used on the ceramic terminal strips should contain about 3% silver. Ordinary tin-lead solder can be used occasionally without damage to the ceramic terminal strips. Use a 40- to 75-watt soldering iron with a 1/8 inch wide chisel-shaped tip. If ordinary solder is used repeatedly or if excessive heat is applied, the solder-to-ceramic bond may be broken.

A small roll of 3% silver solder is mounted on the main chassis. Additional silver solder should be available locally or it can be purchased directly from Tektronix; order by Tektronix Part No. 251-0514-00.

Observe the following precautions when soldering ceramic terminal strips:

1. Use a hot iron for a short time. Apply only enough heat to make the solder flow freely.
2. Maintain a clean, properly tinned tip.
3. Avoid putting pressure on the ceramic terminal strip.
4. Do not attempt to fill the terminal-strip notch with solder; use only enough solder to cover the wires adequately.
5. Clean the flux from the terminal strip with a flux-remover solvent.

**Metal Terminals.** When soldering metal terminals (e.g., switch terminals, potentiometers, etc.) ordinary 60/40 solder can be used. The soldering iron should have a 40- to 75-watt rating with a 1/8 inch wide chisel-shaped tip.

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-remover solvent.

## Component Replacement

WARNING

Disconnect the instrument from the power source before replacing components.

**Removing Covers.** The cover is held in place by a slotted thumb screw located on the front-panel of the instru-



ment. To remove the cover, loosen the slotted thumb screw and slide the cover off of the instrument.

**Ceramic Terminal Strip Replacement.** A complete ceramic terminal strip assembly is shown in Fig. 4-1. Replacement strips (including studs) and spacers are supplied under separate part numbers. The old spacers may be re-used if they are not damaged.

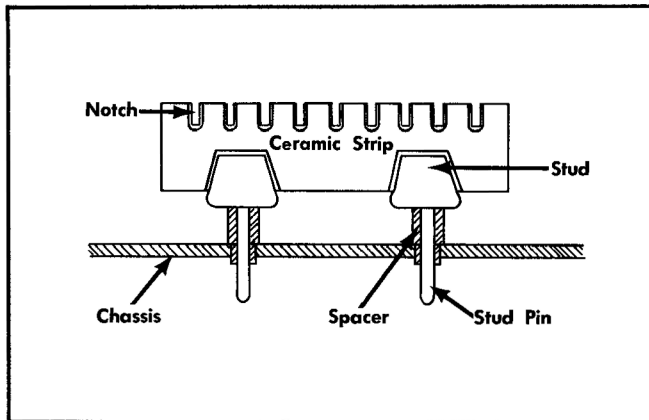


Fig. 4-1. Ceramic terminal strip assembly.

To replace a ceramic terminal strip, first unsolder all connections. Then, the damaged strip can be pried or pulled loose from the chassis. If the spacers come out with the strip, remove them from the stud pins to be used for installation of the new strip.

After the damaged strip has been removed, place the undamaged spacers in the chassis holes. Then, carefully press the studs into the spacers until completely seated. If necessary, use a soft mallet and tap lightly directly over the stud area of the strip.

**Circuit Board Replacement.** If the circuit board is damaged and cannot be repaired, the entire assembly including all soldered-on components should be replaced. The part number given in the Mechanical Parts list is for the completely-wired board.

Procedure for replacing circuit board follows:

**Removal.** All except three connections to the circuit board are push on connections. The remaining connections are soldered.

Most of the components mounted on the circuit board can be replaced without removing the board from the instrument. Observe soldering precautions given under Soldering Techniques in this section. However, if the board must be moved to gain access to other areas of the instrument, only the mounting screws need be removed and the three solder connections unsoldered. The interconnecting wires will allow the board to be moved out of the way or turned over.

Use the following procedure to remove a board:

1. Disconnect all pin connectors and the coaxial connector, all of which come through holes in the board.

2. Unsolder the ground wire which connects T14 to the board.

3. Remove all screws holding the board to the chassis.

4. Unsolder the two ground wires and the resistor connecting the board to the AMPLITUDE RANGE switch.

5. The board may now be lifted and removed for maintenance or access to areas beneath the board.

6. To replace the board, reverse the order of removal.

**Transistor and Tube Replacement.** Transistors and tubes should not be replaced unless actually defective. If removed during routine maintenance, return them to their original sockets. Unnecessary replacement of transistors or tubes may affect the calibration of this instrument. When transistors or tubes are replaced, check the operation of that part of the circuit which may be affected.

Replacement transistors or tubes should be of the original type or a direct replacement.

To replace V10:

1. Slide the tube shield away from the tube socket base as far as possible.

2. Remove the tube from the tube socket.

3. Slide the tube back into the tube shield.

4. Remove the tube and tube shield from the Type 191 as a unit.

5. Remove the tube from the tube shield.

6. Install the replacement tube into the tube shield.

7. Place the tube and tube shield into the instrument aligning it for insertion into the tube socket.

8. Slide the tube part way out of the shield.

9. Seat the tube into the tube socket.

10. Slide the tube shield onto the tube socket base.

**Fuse Replacement.** The line fuse is located on the rear panel. Table 2-1 in this manual gives the fuse value for the different line voltages.

**Rotary Switches.** Individual wafers or mechanical parts of rotary switches are normally not replaced. If a switch is defective, replace the entire assembly. Replacement switches can be ordered either wired or unwired; refer to the Electrical Parts List for the applicable part numbers.

When replacing a switch, it is recommended that the leads and switch terminals be tagged with corresponding identification tags as the leads are disconnected. Then, use the old switch as a guide for installing the new one. An alternative method would be to draw a sketch of the switch layout and record the wire color at each terminal.

## TROUBLESHOOTING

### Introduction

The following information is provided to facilitate troubleshooting of the Type 191. Information contained in other sections of this manual should be used along with the following information to aid in locating the defective component.

**Troubleshooting Aids**

**Diagrams.** Circuit diagrams are given on foldout pages in Section 9. The circuit 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.

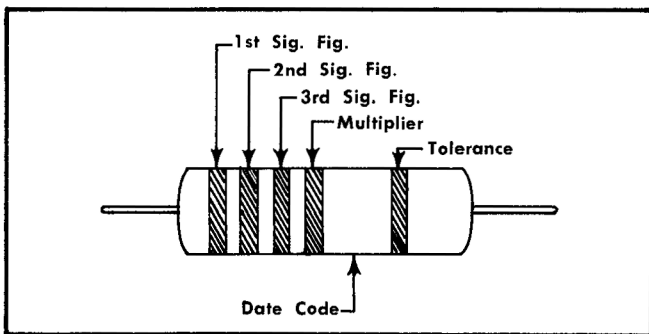
**Component Numbering.** The circuit number of each electrical part is shown on the circuit diagram. Each main circuit is assigned a series of circuit numbers. Table 4-1 lists the main circuits in the Type 191 and the series of circuit numbers assigned to each. For example, using Table 4-1, a resistor numbered R120 is identified as being located in the Power Supply.

**TABLE 4-1**

Circuit Numbers on Diagrams	Circuit
1-99	Signal Generator
100-199	Power Supply

**Switch Wafer Identification.** Switch wafers shown on the diagrams are coded to indicate the position of the wafer in the complete switch assembly. The numbered portion of the code refers to the wafer number counting from the front, or mounting end of the switch, toward the rear. The letters F and R indicate whether the front or rear of the wafer performs the particular switching function. For example, a wafer designated 2R indicates that the rear of the second wafer is used for this particular switching function.

**Circuit Boards.** Fig. 4-3 shows the circuit board used in the Type 191. Each electrical component on the board is identified by its circuit number. The circuit board is also outlined on the diagram with a blue line. This picture along with the diagram will aid in locating the components mounted on the circuit board.



**Fig. 4-2. Color-coding of metal-film resistors.**

**Wiring Color-Code.** All insulated wire used in the Type 191 is color-coded according to the EIA standard color-code (as used for resistors) to facilitate circuit tracing. The widest color stripe identifies the first color of the code. Power-supply voltages can be identified by three color stripes and the following background color-code; white, positive voltage; tan, negative voltage. Table 4-2 shows the wiring color-code for the power-supply voltages used in the Type 191. The remainder of the wiring in the Type

191 is color-coded with two or less stripes or has a solid background with no stripes. The color-coding helps to trace a wire from one point in the instrument to another.

**TABLE 4-2**

Supply	Back-ground Color	1st Stripe	2nd Stripe	3rd Stripe
-11 volt	Tan	Brown	Brown	Black
+6.2 volt	White	Blue	Red	Black
+450 volt	White	Yellow	Green	Brown

**Resistor Color-Code.** A number of precision metal-film resistors are used in this instrument. These resistors can be identified by their gray body color. If a metal-film resistor has a value indicated by three significant figures and a multiplier, it will be color-coded to the EIA standard resistor color-code. If it has a value indicated by four significant figures and a multiplier, the value will be printed on the body of the resistor. For example, a 333 kΩ resistor will be color-coded, but a 333.5 kΩ resistor will have its value printed on the resistor body. The color-code sequence is shown in Fig. 4-2.

Composition resistors are color-coded according to the EIA standard resistor color-code.

**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 assure 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 in this section.

**1. Check Associated Equipment.** Before proceeding with troubleshooting of the Type 191, check that the equipment used with the Type 191 is operating correctly. Check that the signal is properly connected and that the interconnecting cable is not defective. Also, check the power source.

**2. Check Control Settings.** Incorrect control settings can indicate a trouble that does not exist. For example, incorrect setting of the VARIABLE control appears as an uncalibrated signal amplitude; incorrect setting of the Frequency dial appears as a misadjusted Oscillator circuit, etc. If there is any question about the correct function or operation of any control, see the Operating Instructions section of this manual.

**3. Check Instrument Calibration.** Check the calibration of the instrument, or the affected circuit if the trouble exists in one circuit. The indicated trouble may only be a result of misadjustment or may be corrected by calibration. Complete instructions are given in the Calibration section of this manual. Individual calibration steps can be performed out of sequence. However, if the circuit affects the calibration of other circuits in the instrument, a more complete calibration will be necessary. General Information in the Calibration section describes how calibration steps which interact are noted.

**4. Isolate Trouble to a Circuit.** To isolate a trouble to a circuit, note the trouble symptom. The symptom often identifies the circuit in which the trouble is located. For example, incorrect frequency indicates that the Oscillator circuit is probably at fault. Methods of checking the circuits are given in steps 5 through 7.

Incorrect operation of all circuits often indicates trouble in the Power Supply. Check first for correct voltage at each of the individual supplies. However, a defective component elsewhere in the instrument can appear as a power supply trouble and may also affect the operation of other circuits.

Table 4-3 lists the typical values of the power supplies in the Type 191. If a power supply voltage is within the listed value, the supply can be assumed to be working correctly. If outside the value, the supply may be operating incorrectly. Use the procedure given in the Calibration section to adjust the  $-11$  volt power supply.

TABLE 4-3

Power Supply	Typical Value
$-11$ volt	$\pm 0.2$ V <sup>1</sup>
$+6.2$ volt	$\pm 0.4$ V
$+450$ volt	Unregulated

<sup>1</sup>Adjusted for correct output signal amplitude.

After the defective circuit has been located, proceed with steps 5 through 7 to locate the defective component(s). If the trouble has not been isolated to a circuit using the procedure described here, check voltage and waveforms as explained in step 6 to locate the defective circuit.

**5. Visual Check.** Visually check the circuit in which the trouble is located. Many troubles can be located by visual indications such as unsoldered connections, broken wires, damaged circuit boards or damaged components.

**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 diagram page for conditions under which voltages and waveforms are taken.

A. Voltages. Voltage measurements should be taken with a 20,000 ohms/volt DC voltmeter. Accuracy of the voltmeter should be within 3% on all ranges. Be sure that

the test prods are well insulated to prevent accidental shorting of components.

B. Waveforms. Use a test oscilloscope which has the following minimum specifications:

Bandwidth: DC to at least 40 MHz.

Deflection factor: 0.05 volts/division minimum.

Input impedance: Approximately 10 megohms paralleled by about 10 pF when using a  $10\times$  probe.

**7. Check Individual Components.** The following procedures describe methods of checking individual components in the Type 191. Components which are soldered in place can be checked most easily by disconnecting one end. This eliminates incorrect measurements due to the effects of surrounding circuitry.

A. Transistors and Tubes. The best check of transistor or tube operation is actual performance under operating conditions. If a transistor or tube is suspected of being defective, it can best 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 or tube might also be damaged. If substitute transistors or tubes are not available, a dynamic tester may be used (such as Tektronix Type 570 or 575). Static-type testers are not recommended, however, since they do not check operation under simulated operating conditions.

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 about 1.5 volts, the resistance should be very high in one direction and very low when the 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. Resistors normally do not need to be replaced unless the measured value varies widely from the specified value.

D. Inductors. Check for open inductors by checking continuity with an ohmmeter.

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



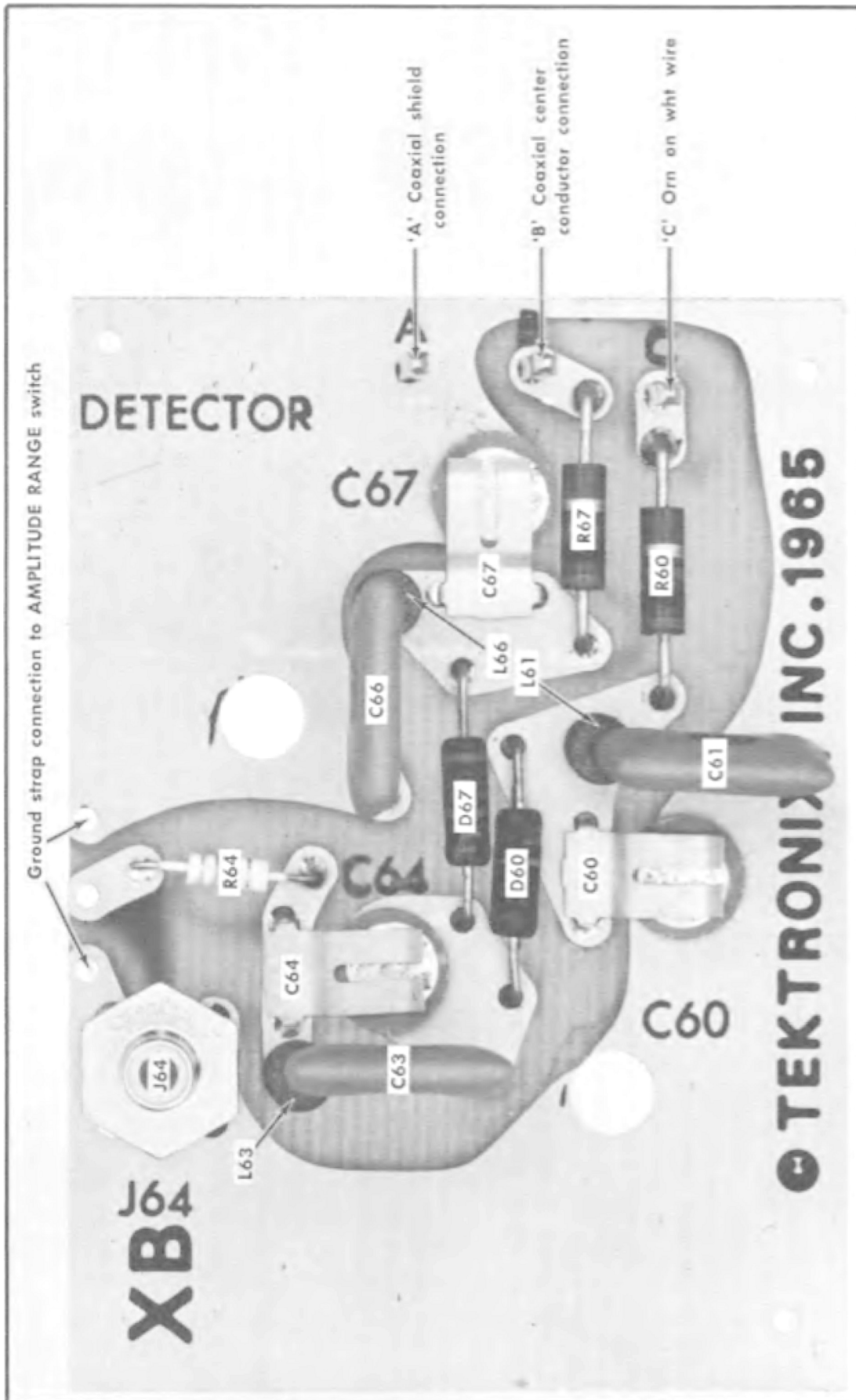


Fig. 4-3. Peak to peak detector board wiring.

# SECTION 5

## PERFORMANCE CHECK

### Introduction

This performance check procedure is provided to check the operation of the Type 191. This procedure may be used for incoming inspection, instrument familiarization, reliability testing, calibration verification, etc.

Failure to meet characteristics given in the procedure indicates that the instrument requires internal checks and/or adjustments. See the Calibration section of the Instruction Manual.

### EQUIPMENT REQUIRED

#### General

The following equipment, or its equivalent, is required for a complete performance check of the Type 191. Specifications given are the minimum necessary to accurately check the performance of this instrument. All test equipment is assumed to be correctly calibrated and operating within the original specifications. If equipment is substituted, it must meet or exceed the specifications of the recommended equipment.

#### Special Test Equipment

For the quickest and most accurate calibration, special calibration fixtures are used where necessary. All calibration fixtures listed under Equipment Required can be obtained from Tektronix, Inc. Order by part number through your local Tektronix Field Office or representative.

1. Real-time test oscilloscope. Bandwidth, DC to 10 MHz; minimum deflection factor, 0.005 volts/division. Tektronix Type 547 Oscilloscope with Type 1A1 plug-in unit or equivalent.

2. Sampling test oscilloscope. Bandwidth, equivalent to DC to 1000 MHz; minimum deflection factor, 5 millivolts/division. Tektronix Type 661 Oscilloscope with a Type 4S3 vertical plug-in and a Type 5T3 timing plug-in.

3. Standard amplitude calibrator. Amplitude accuracy, within  $\pm 0.25\%$ ; signal amplitude, 0.01 volts to 2 volts; output frequency, 1 kHz. Tektronix calibration fixture 067-0502-00 or equivalent.

4. Time-mark generator. Marker outputs of 1  $\mu$ s, 5  $\mu$ s, and 10  $\mu$ s; sine wave outputs of 20 ns and 50 ns; accuracy, 0.001%. Tektronix Type 184 or equivalent.

5. Variable autotransformer. Must be capable of supplying at least 25 watts to the Type 191 over a voltage range of 94 to 138 volts (188 to 276 volts for 230-volt nominal line). If autotransformer does not have an AC voltmeter to indicate output voltage, monitor output with an AC voltmeter (rms) with range of at least 138 (or 276) volts. For example, General Radio W10MT3W Metered Variac Autotransformer.

6. Two 50 ohm voltage pickoff units. Tektronix VP-1 and VP-2 or their equivalents.

7. Termination. Impedance 50 ohm; accuracy,  $\pm 1\%$ ; connectors, BNC jack to GR. Tektronix Part No. 017-0083-00.

8.  $10\times$  sampling probe. Tektronix P6034 or equivalent.

9.  $1\times$  probe. Tektronix P6028 or equivalent.

10. Cable. 5 ns RG-8A/U cable with GR connectors. Tektronix Part No. 017-0502-00.

11. Two cables. Impedance 50 ohm; type RG-58A/U; length, 42 inches, connectors BNC. Tektronix Part No. 012-0057-00.

12. Earphone. Impedance 600 ohm or higher.

### PERFORMANCE CHECK PROCEDURE

#### General

In the following procedure, test equipment connections or control settings should not be changed except as noted. If only a partial check is desired, refer to the preceding step(s) for setup information.

The following procedure uses the equipment listed under Equipment Required. If substitute equipment is used, control settings or setup must be altered to meet the requirements of the equipment used.

#### Preliminary Procedure

1. Connect the autotransformer to a suitable power source.
2. Connect a power cord from the Type 191 to the autotransformer output.
3. Set the autotransformer to 115 (or 230) volts.
4. Set the Type 191 POWER switch to ON. Allow at least 5 minutes warm up for checking the instrument to the given accuracies.

#### Control Settings

POWER	ON
AMPLITUDE RANGE	.5-5 V
AMPLITUDE	5
VARIABLE (Amplitude)	CAL
FREQUENCY RANGE	50 kHz ONLY
Frequency (dial)	Set to .5 mark of .35—.75 scale
115 V/230 V (rear panel)	Set for correct line voltage

#### 1. Check Amplitude Switch

a. Requirement—The output signal amplitude should be within  $\pm 3\%$  (.5-5 V range is used) of the front panel indicated output.

b. Connect a 1 volt square wave signal from the standard amplitude calibrator through a 50 ohm coaxial cable to the vertical input of the test oscilloscope.

## Performance Check—Type 191

- c. Set the test oscilloscope controls as follows:
- |                         |           |
|-------------------------|-----------|
| Vertical Input Coupling | AC        |
| Volts/Div               | .2        |
| Trigger Mode            | Automatic |
| Trigger Slope           | +         |
| Trigger Source          | Internal  |
| Time/Div                | 1 ms      |
- d. Adjust the vertical gain of the test oscilloscope to obtain exactly five divisions of vertical display.
- e. Disconnect the standard amplitude calibrator from the test oscilloscope.
- f. Connect the OUTPUT connector on the Type 191 through a 5 ns length of RG-8A/U coaxial cable and a 50 ohm GR to BNC termination to the vertical input connector on the test oscilloscope.
- g. Set the Time/Div switch on the test oscilloscope to 20  $\mu$ s.
- h. Check—For a test oscilloscope display whose amplitude is 2.5 divisions (0.5 volt)  $\pm 3\%$ .
- i. Set the Type 191 AMPLITUDE switch to 10.
- j. Check for a test oscilloscope display whose amplitude is 5 divisions (1 volt)  $\pm 3\%$ .
- k. Disconnect the Type 191.
- l. Connect a 2 volt square-wave signal from the standard amplitude calibrator through a 50 ohm coaxial cable to the vertical input of the test oscilloscope.
- m. Set the Volts/Div control of the test oscilloscope to 0.5.
- n. Adjust the vertical gain of the test oscilloscope to obtain exactly four divisions of vertical display.
- o. Disconnect the standard amplitude calibrator from the test oscilloscope.
- p. Connect the OUTPUT connector on the Type 191 through a 5 ns length of RG-8A/U coaxial cable and a GR to BNC 50 ohm termination to the vertical input connector on the test oscilloscope.
- q. Set the Type 191 AMPLITUDE switch to 15.
- r. Check for a test oscilloscope display whose amplitude is 3 divisions (1.5 volts)  $\pm 3\%$ .
- s. Set the Type 191 AMPLITUDE switch to 20.
- t. Check for a test oscilloscope display whose amplitude is 4 divisions (2 volts)  $\pm 3\%$ .
- u. Set the Type 191 AMPLITUDE switch to 25.
- v. Check for a test oscilloscope display whose amplitude is 5 divisions (2.5 volts)  $\pm 3\%$ .
- w. Disconnect the Type 191.
- x. Connect a 5 volt square-wave signal from the standard amplitude calibrator through a 50 ohm coaxial cable to the vertical input of the test oscilloscope.
- y. Set the Volts/Div control of the test oscilloscope to 1.
- z. Adjust the vertical gain of the test oscilloscope to obtain exactly five divisions of vertical display.
- aa. Disconnect the standard amplitude calibrator from the test oscilloscope.
- ab. Connect the OUTPUT connector on the Type 191 through a 5 ns length of RG-8A/U coaxial cable and a GR to BNC 50 ohm termination to the vertical input connector on the test oscilloscope.
- ac. Set the Type 191 AMPLITUDE switch to 30.
- ad. Check for a test oscilloscope display whose amplitude is 3 divisions (3 volts)  $\pm 3\%$ .
- ae. Set the Type 191 AMPLITUDE switch to 35.
- af. Check for a test oscilloscope display whose amplitude is 3.5 divisions (3.5 volts)  $\pm 3\%$ .
- ag. Set the Type 191 AMPLITUDE switch to 40.
- ah. Check for a test oscilloscope display whose amplitude is 4 divisions (4 volts)  $\pm 3\%$ .
- ai. Set the Type 191 AMPLITUDE switch to 45.
- aj. Check for a test oscilloscope display whose amplitude is 4.5 divisions (4.5 volts)  $\pm 3\%$ .
- ak. Set the Type 191 AMPLITUDE switch to 50.
- al. Check for a test oscilloscope display whose amplitude is 5 divisions (5 volts)  $\pm 3\%$ .

## 2. Check Amplitude Variable Control

- a. Requirement—Must increase the amplitude of the output signal from its indicated value to that of the next higher control setting. When the AMPLITUDE switch is set to 50, the VARIABLE control must increase output amplitude to approximately 10% above calibrated value. The signal should smoothly increase in amplitude as the VARIABLE (Amplitude) control is rotated clockwise.
- b. Again check for a test oscilloscope display of 5 divisions.
- c. Slowly rotate the VARIABLE (Amplitude) control clockwise from its CAL position.
- d. Check for a smooth increase in output signal amplitude and for a test oscilloscope display of about 5.5 divisions when the VARIABLE (Amplitude) control is fully clockwise.
- e. Return the VARIABLE (Amplitude) control to its CAL position.
- f. Disconnect the Type 191 from the test oscilloscope.

## 3. Check Amplitude Range Switch

- a. Requirement—Output signals for the 0.5-5 V range must be within  $\pm 3\%$  of the indicated amplitude. Output signals for the 50-500 mV range must be within  $\pm 4\%$  of the indicated amplitude. Output signals for the 5-50 mV range must be within  $\pm 5\%$  of the indicated amplitude.



- b. Connect a 5 volt square-wave signal from the standard amplitude calibrator through a 50 ohm coaxial cable to the vertical input of the test oscilloscope.
- c. Set the test oscilloscope Volts/Div control to 1 volt.
- d. Adjust the vertical gain of the test oscilloscope to obtain exactly five divisions of vertical display.
- e. Disconnect the standard amplitude calibrator from the test oscilloscope.
- f. Connect the OUTPUT connector on the Type 191 through a 5 ns length of RG-8A/U coaxial cable and a GR to BNC 50 ohm termination to the vertical input connector on the test oscilloscope.
- g. Check for a test oscilloscope display whose amplitude is 5 divisions (5 volts)  $\pm 3\%$ .
- h. Disconnect the Type 191 from the test oscilloscope.
- i. Connect a 0.5 volt square-wave signal from the standard amplitude calibrator through a 50 ohm coaxial cable to the vertical input of the test oscilloscope.
- j. Set the test oscilloscope Volts/Div control to 0.1 volt.
- k. Adjust the vertical gain of the test oscilloscope to obtain exactly five divisions of vertical display.
- l. Disconnect the standard amplitude calibrator from the test oscilloscope.
- m. Connect the OUTPUT connector on the Type 191 through a 5 ns length of RG-8A/U coaxial cable, and a GR to BNC 50 ohm termination to the vertical input connector on the test oscilloscope.
- n. Set the Type 191 AMPLITUDE RANGE switch to 50-500 mV.
- o. Check for a test oscilloscope display whose amplitude is 5 divisions  $\pm 4\%$ .
- p. Disconnect the Type 191 from the test oscilloscope.
- q. Connect a 0.05 volt square-wave signal from the standard amplitude calibrator to the vertical input of the test oscilloscope.
- r. Set the test oscilloscope Volts/Div control to 0.01 volt.
- s. Adjust the vertical gain of the test oscilloscope to obtain exactly five divisions of vertical display.
- t. Disconnect the standard amplitude calibrator from the test oscilloscope.
- u. Connect the OUTPUT connector on the Type 191 through a 5 ns length of RG-8A/U coaxial cable and a GR to BNC 50 ohm termination to the vertical input connector on the test oscilloscope.
- v. Set the Type 191 AMPLITUDE RANGE switch to 5-500 mV.
- w. Check for a test oscilloscope display whose amplitude is 5 divisions  $\pm 5\%$ .
- x. Disconnect the Type 191 from the test oscilloscope.

**4. Check Frequency Ranges' Linearity and Accuracy**

- a. Requirement—Output signal frequency should be within 2% of the indicated frequency for all signal amplitudes when the Type 191 is properly terminated into 50 ohms.

- b. Connect the OUTPUT connector on the Type 191 through a 5 ns length of RG-8A/U coaxial cable and a GR to BNC 50 ohm termination to the Channel 1 vertical input connector on the test oscilloscope.

- c. Connect a 20 ns signal from the Time-Mark Generator Marker Output connector through a 50 ohm coaxial cable to the Channel 2 vertical input connector on the test oscilloscope.

- d. It is necessary to set only the following test oscilloscope controls:

Channels 1 and 2  
 Vertical Input Coupling AC  
 Volts/Div .05  
 Vertical Channel Mode Add

- e. Set the Type 191 AMPLITUDE RANGE switch to 50-500 mV.

- f. Connect the signal lead from the earphone to the Vert Sig Out connector of the test oscilloscope.

- g. Connect the shield lead from the earphone to a ground connector on the test oscilloscope.

- h. Using Table 5-1 as a guide, set up the Type 191 and the time-mark generator controls as described for each frequency setting of the Type 191.

- i. Check for a zero beat frequency close to the frequency points indicated in Table 5-1. The zero beat frequency is the null point where no tone can be heard between two audible tones.

TABLE 5-1

Type 191		Time-Mark Generator
Frequency (dial)	FREQUENCY RANGE Switch	Time Markers or Sine Waves
50 MHz	42-100	20 ns
60 MHz	42-100	20 ns
80 MHz	42-100	50 ns
100 MHz	42-100	20 ns
20 MHz	18-42	50 ns
30 MHz	18-42	50 ns
40 MHz	18-42	50 ns
8 MHz	8-18	1 $\mu$ s
13 MHz	8-18	1 $\mu$ s
18 MHz	8-18	1 $\mu$ s
4 MHz	3.6-8	1 $\mu$ s
6 MHz	3.6-8	1 $\mu$ s
8 MHz	3.6-8	1 $\mu$ s
1.6 MHz	1.6-3.6	5 $\mu$ s
2.6 MHz	1.6-3.6	5 $\mu$ s
3.6 MHz	1.6-3.6	5 $\mu$ s
.75 MHz	.75-1.6	10 $\mu$ s
1.1 MHz	.75-1.6	10 $\mu$ s
1.6 MHz	.75-1.6	5 $\mu$ s
.35 MHz	.35-.75	10 $\mu$ s
.5 MHz	.35-.75	10 $\mu$ s
.75 MHz	.35-.75	10 $\mu$ s
.5 MHz	50 kHz ONLY	10 $\mu$ s

## Performance Check—Type 191

j. Disconnect Type 191, Time-Mark Generator and the earphones from the test oscilloscope.

### 5. Check Output Amplitude Regulation

a. Requirement—See Table 5-2.

b. Set the Type 191 AMPLITUDE switch to 5 and the AMPLITUDE RANGE switch to .5-5 V.

c. To the OUTPUT connector of the Type 191, connect a VP-1 voltage pickoff unit, a 5 ns length of RG-8A/U coaxial cable, a VP-2 voltage pickoff unit, and a 50 ohm BNC to GR termination.

d. Connect a 1× probe (furnished with the Type 4S3 vertical plug-in) from the vertical probe input connector to the appropriate connection of the VP-2 voltage pickoff unit.

e. Connect a 10× sampling probe from the external trigger input connector of the test oscilloscope to the appropriate connection on the VP-1 voltage pickoff unit.

f. Set the test oscilloscope controls as follows:

Vertical Plug-In	
Millivolts/Div	100
Vertical Position	Midrange
DC Offset	Midrange
Display	Normal
Smoothing	Refer to part g of this step
Low Noise-Fast Rise time	Low Noise
Vertical Mode	Channel A
Horizontal Plug-In	
Samples/Div	100
Time Position	Midrange
Equivalent Time/Div	10 ns
Trig Level	Midrange
Stability	Midrange
Trigger Source	External
Trigger Slope	+
External Trigger Mode	50 Ω AC
Sweep Mode	Normal
Oscilloscope	
Horizontal Display	×1
Horizontal Position	Midrange

g. Adjust the smoothing control for a loop gain of one; see procedure in Type 4S3 Instruction Manual. The equivalent time/division and the stability control will need to be changed during the procedure to obtain a readable display.

h. Set the autotransformer for an output voltage 10% below the nominal line voltage.

**TABLE 5-2**

Frequency Range	Output Amplitude Limits (Peak to Peak)	<sup>1</sup> Maximum Amplitude Variation
.35 MHz to 42 MHz	5 mV to 5.5 V	±3%
42 MHz to 100 MHz	50 mV to 5.5 V	±3%
42 MHz to 100 MHz	5 mV to 55 mV	+3% and -5%

<sup>1</sup>Amplitude variation is referenced to actual amplitude at 50 kHz.

i. Adjust the vertical plug-in Variable control to obtain a test oscilloscope vertical display of 7.8 divisions.

j. Change the FREQUENCY RANGE switch to .35-.75 and rotate the Frequency (dial) from one extreme to the other. Repeat this procedure until the complete frequency range from .35 MHz to 100 MHz has been checked.

k. Check—That as Step j is accomplished the Type 191 output amplitude does not vary more than the amount shown in Table 5-2 and that the waveform has minimum distortion.

l. Change the Type 191 AMPLITUDE RANGE switch to 50-500 mV and the FREQUENCY RANGE switch to 50 kHz ONLY.

m. Set the Type 191 AMPLITUDE switch to 50 and rotate the VARIABLE (Amplitude) fully clockwise.

n. Adjust the vertical plug-in Variable control to obtain a test oscilloscope vertical display of 7.8 divisions.

o. Change the FREQUENCY RANGE switch to .35-.75 and rotate the Frequency (dial) from one extreme to the other. Repeat this procedure until the complete frequency range from .35 MHz to 100 MHz has been checked.

p. Check—That as part o is accomplished, the Type 191 output amplitude does not vary more than the amount shown in Table 5-2.

q. Change the Type 191 AMPLITUDE RANGE switch to 5-50 mV, and the FREQUENCY RANGE switch to 50 kHz ONLY.

r. Set the test oscilloscope millivolts/division control to 10.

s. Adjust the vertical plug-in Variable control to obtain a test oscilloscope vertical display of 7.8 divisions.

t. Change the FREQUENCY RANGE switch to .35-.75 and rotate the Frequency (dial) from one extreme to the other. Repeat this procedure until the complete frequency range from .35 MHz to 100 MHz has been checked.

u. Check—That as part t is accomplished the Type 191 output amplitude does not vary more than the amount shown in Table 5-2.

v. Rotate the VARIABLE (Amplitude) control to its CAL position.

w. If desired, other Type 191 output amplitudes may be checked. However, the three output levels which have been checked will provide adequate assurance that the output amplitude regulation is within the proper tolerance.

This completes the performance check of the Type 191. Disconnect all test equipment. If the instrument has met all performance requirements given in this procedure, it is correctly calibrated and within the specified tolerances.

# SECTION 6

## CALIBRATION

### Introduction

The Type 191 Constant Amplitude Signal Generator is a stable instrument which will provide many hours of trouble-free operation. However, to insure measurement accuracy, it is suggested that you recalibrate the instrument after each 500 hours of operation, or every six months if used intermittently. It will also be necessary to recalibrate certain sections of the instrument when tubes, transistors or other components that affect the calibration accuracy of the instrument are replaced.

This calibration procedure can be used either for complete calibration of the Type 191 to return it to original performance, or as an operational check of instrument performance. Completion of every step in this procedure returns the Type 191 to original factory performance standards. If it is desired to merely touch up the calibration, perform only those steps entitled Adjust.

### NOTE

The Adjust steps provide a check of instrument performance before the adjustment is made. To prevent the need for recalibration of other circuits when performing a partial calibration, readjust only if the listed tolerance is not met.

### General Information

Any needed maintenance should be performed before proceeding with calibration. Troubles which become apparent during calibration should be corrected using the techniques given in the Maintenance section of the Instruction Manual.

This procedure is arranged in a sequence which allows this instrument to be calibrated with the least interaction of adjustments and reconnection of equipment. If desired, the steps may be performed out of sequence or a step may be done individually. However, some adjustments affect the calibration of other circuits within the instrument. In this case, it will be necessary to check the operation of other parts of the instrument. When a step interacts with others, the steps which need to be checked will be noted.

The location of test points and adjustments is shown in each step. Waveforms which are helpful in determining the correct adjustment or operation are also shown.

### EQUIPMENT REQUIRED

(see Figs. 6-1 and 6-2)

### General

The following equipment or its equivalent is required for complete calibration of the Type 191. Specifications given are the minimum necessary for accurate calibration of this instrument. All test equipment is assumed to be correctly calibrated and operating within the original speci-

fications. If equipment is substituted, it must meet or exceed the specifications of the recommended equipment.

### Special Test Equipment

For the quickest and most accurate calibration, special calibration fixtures are used where necessary. All calibration fixtures listed under Equipment Required can be obtained from Tektronix, Inc. Order by part number through your local Tektronix Field Office or representative.

1. DC voltmeter. Minimum sensitivity, 20,000 ohms/volt; accuracy, checked to within 1% at 6.2 and 11 volts, and checked to within 3% at 450 volts. For example, Simpson Model 262.

2. Real-time test oscilloscope. Bandpass, DC to 10 MHz; minimum deflection factor, 0.005 volts/division. Tektronix Type 547 Oscilloscope with Type 1A1 plug-in unit or equivalent.

3. Sampling test oscilloscope. Bandwidth, equivalent to DC to 1000 MHz; minimum deflection factor, 5 millivolts/division. Tektronix Type 661 Oscilloscope with a Type 4S3 vertical plug-in and a Type 5T3 timing plug-in.

4. Standard amplitude calibrator. Amplitude accuracy, within  $\pm 0.25\%$ ; signal amplitude, 0.01 volts to 2 volts; output frequency, 1 kHz. Tektronix calibration fixture 067-0502-00 or equivalent.

5. Time-mark generator. Marker output of 1  $\mu s$ , 5  $\mu s$  and 10  $\mu s$ ; sine wave outputs of 20 ns and 50 ns; accuracy, 0.001%. Tektronix Type 184 or equivalent.

6. Variable autotransformer. Must be capable of supplying at least 25 watts to the Type 191 over a voltage range of 94 to 138 volts (188 to 276 volts for 230-volt nominal line). If autotransformer does not have an AC voltmeter to indicate output voltage, monitor output with an AC voltmeter (rms) with range of at least 138 (or 276) volts. For example, General Radio W10MT3W Metered Variac Autotransformer.

7. Precision DC voltmeter. Accuracy, within  $\pm 0.05\%$ ; meter resolution, 50  $\mu V$ ; range, 11 volts. For example, Fluke Model 801B.

8. 50 ohm voltage pickoff unit. Tektronix VP-2 or equivalent.

9. Termination. Impedance 50 ohms; accuracy,  $\pm 1\%$ ; connectors, BNC jack to GR. Tektronix Part No. 017-0083-00.

10. 100 $\times$  sampling probe. Tektronix P6035 or equivalent.

11. 1 $\times$  probe. Tektronix P6028 or equivalent.

12. Cable. 5 ns RG-8A/U cable with GR connectors. Tektronix Part No. 017-0502-00.

13. Two cables. Impedance 50 ohms; type RG-58A/U; length, 42 inches, connectors, BNC. Tektronix Part No. 012-0057-00.





Fig. 6-1. Recommended calibration equipment. Items 1 through 12.

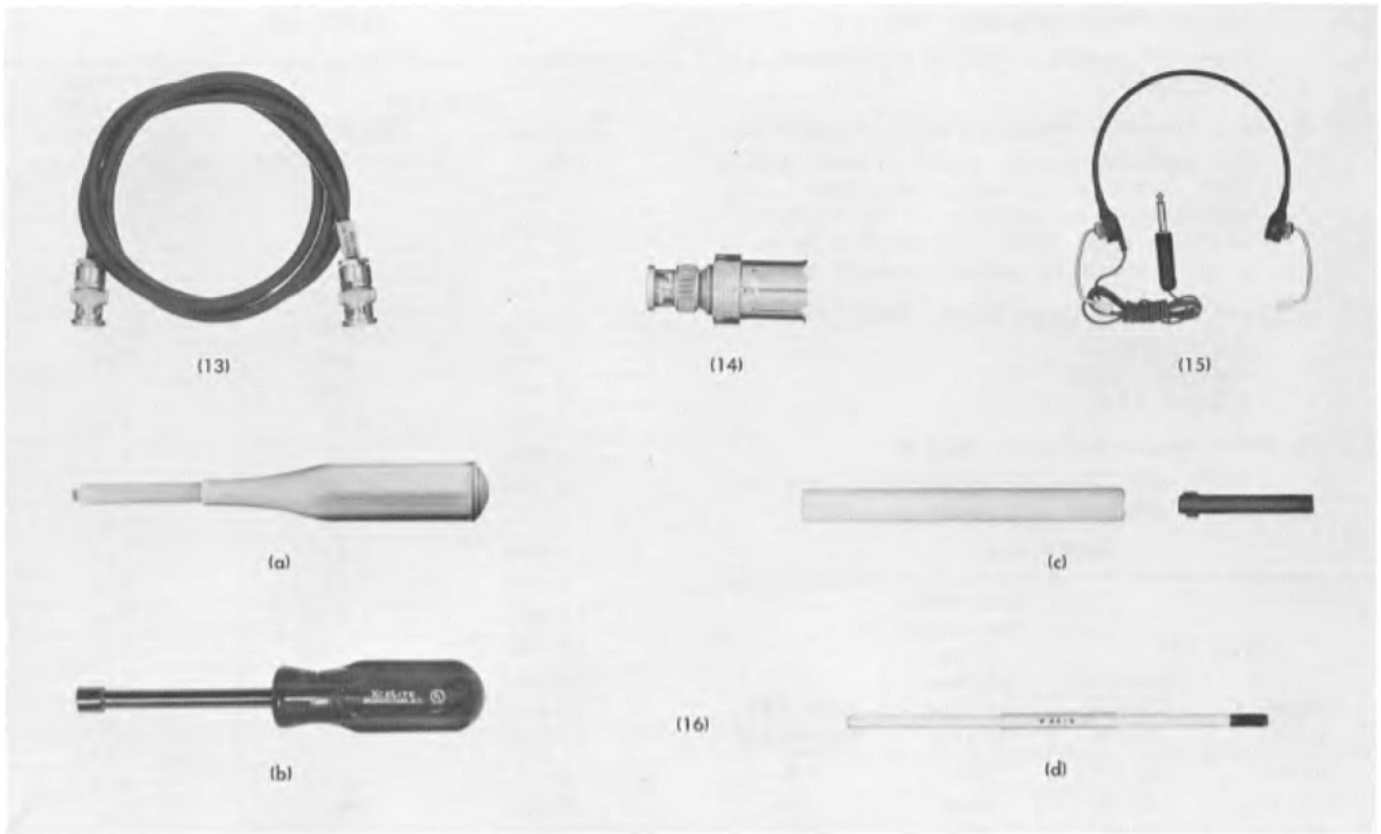


Fig. 6-2. Recommended calibration equipment. Items 12 through 16.

14. Adapter. Connectors, BNC plug to GR. Tektronix Part No. 017-0064-00.

15. Earphone. Impedance 600 ohms or higher.

16. Adjustment tools.

complete Calibration Procedure, the following short form list may serve as an index. Characteristics are those listed in the Calibration Procedure of the Instruction Manual.

Type 191, Serial No. \_\_\_\_\_

Calibration Date \_\_\_\_\_

Description	Tektronix Part No.
a. Insulated screwdriver 1½ inch shaft, non-metallic	003-0000-00
b. Nutdriver with ¼ inch socket, overall length 6 inches	003-0132-00
c. Tuning tool: Handle	003-0307-00
Insert, for 5/64 inch ID hex cores	003-0310-00
d. Tuning Tool: Rod, 7 inches long with recessed metal screwdrive tips	003-0003-00

- 1. Adjust -11 Volt Power Supply, Page 6-6.  
Adjust to -11 volts.
- 2. Check +6.2 Volt Power Supply. Page 6-6.  
Check for +6.2 volts.
- 3. Check +450 Volt Unregulated Power Supply. Page 6-7.  
Check for about +450 volts.
- 4. Check -11 Volt and +6.2 Volt Power Supply Ripple. Page 6-8.  
About 4 mV of ripple allowable on each power supply voltage.
- 5. Adjust -11 Volt Power Supply. Page 6-9.  
Adjust for exactly 10 volts of unterminated sine wave output.
- 6. Adjust Amplitude Tracking. Page 6-11.  
Adjust for 1 volt ±5 mV across the VARIABLE (Amplitude) control.

### CALIBRATION RECORD AND INDEX

This Abridged Calibration Procedure is provided to aid in checking the operation of the Type 191. It may be used as a calibration guide by the experienced calibrator, or it may be used as a calibration record. Since the step numbers and titles used here correspond to those used in the

## Calibration—Type 191

- 7. Adjust Amplitude Calibration. Page 6-12.  
Adjust for exactly 1 volt of unterminated sine wave output.
- 8. Check Amplitude Variable Control. Page 6-12.  
Full clockwise rotation should increase AMPLITUDE switch setting output amplitude to the next fixed output amplitude of the AMPLITUDE switch, or if the AMPLITUDE switch is set to 50 it will increase the output amplitude by 10%.
- 9. Check Amplitude Range Switch. Page 6-13.  
.5-5 V  $\pm$ 3%  
50-500 mV  $\pm$ 4%  
5-50 mV  $\pm$ 5%
- 10. Adjust Frequency Ranges. Page 6-15.  
Adjust each frequency range for a zero beat at the indicated frequencies.

**TABLE 6-1**

Type 191		Time-Mark Generator Time Markers or Sine Waves	Type 191 Adjustment
Frequency (dial)	Frequency RANGE switch		
50 MHz	42-100	20 ns	T38
100 MHz	42-100	20 ns	C38
20 MHz	18-42	50 ns	T34
40 MHz	18-42	50 ns	C34
8 MHz	8-18	1 $\mu$ s	T30
18 MHz	8-18	1 $\mu$ s	C30
4 MHz	3.6-8	1 $\mu$ s	T26
8 MHz	3.6-8	1 $\mu$ s	C26
1.6 MHz	1.6-3.6	5 $\mu$ s	T22
3.6 MHz	1.6-3.6	5 $\mu$ s	C22
.75 MHz	.75-1.6	10 $\mu$ s	T18
1.6 MHz	.75-1.6	5 $\mu$ s	C18
.35 MHz	.35-.75	10 $\mu$ s	T14
.75 MHz	.35-.75	10 $\mu$ s	C14
.5 MHz	50 kHz ONLY	5 $\mu$ s	T10

- 11. Check Frequency Ranges Accuracy. Page 6-16.  
Check each frequency range for a zero beat at the indicated frequencies.

**TABLE 6-2**

Type 191		Time-Mark Generator Time Markers or Sine Waves
Frequency (dial)	FREQUENCY RANGE switch	
50 MHz	42-100	20 ns
60 MHz	42-100	20 ns
80 MHz	42-100	50 ns
100 MHz	42-100	20 ns
20 MHz	18-42	50 ns
30 MHz	18-42	50 ns
40 MHz	18-42	50 ns
8 MHz	8-18	1 $\mu$ s
13 MHz	8-18	1 $\mu$ s
18 MHz	8-18	1 $\mu$ s
4 MHz	3.6-8	1 $\mu$ s
6 MHz	3.6-8	1 $\mu$ s
8 MHz	3.6-8	1 $\mu$ s
1.6 MHz	1.6-3.6	5 $\mu$ s
2.6 MHz	1.6-3.6	5 $\mu$ s
3.6 MHz	1.6-3.6	5 $\mu$ s
.75 MHz	.75-1.6	10 $\mu$ s
1.1 MHz	.75-1.6	10 $\mu$ s
1.6 MHz	.75-1.6	5 $\mu$ s
.35 MHz	.35-.75	10 $\mu$ s
.5 MHz	.35-.75	10 $\mu$ s
.75 MHz	.35-.75	10 $\mu$ s

**TABLE 6-3**

Frequency Range	Output Amplitude Limits (peak to peak)	<sup>1</sup> Maximum Amplitude Variation
.35 MHz to 42 MHz	5 mV to 5.5 V	$\pm$ 3%
42 MHz to 100 MHz	50 mV to 5.5 V	$\pm$ 3%
42 MHz to 100 MHz	5 mV to 55 mV	+3% and -5%

<sup>1</sup>Amplitude variation is referenced to actual amplitude at 50 kHz.

- 12. Check Output Amplitude Regulation. Page 6-17.  
Check the output signal amplitude for the required tolerance over the indicated frequency range.



## General

In the following calibration procedure, a test equipment setup is shown for each major setup change. Complete control settings are listed below the picture. If only a partial calibration is performed, start with the nearest setup preceding the desired portion.

### NOTE

**When performing a complete recalibration, best performance will be provided if each adjustment is made to the exact setting, even if the Check is within the allowable tolerance.**

The following procedure uses the equipment listed under Equipment Required. If substitute equipment is used, control settings or setup must be altered to meet the requirements of the equipment used.

## Preliminary Procedure

1. Remove the Type 191 from its case to allow access to all internal adjustments and test points.

2. Rotate the Frequency (dial) clockwise until the plates of capacitor C10 just become fully meshed. Check that the Frequency (dial) now indicates a frequency of 42 MHz (on the 42-100 MHz scale); if it does not, loosen the two screws holding the Frequency (dial) mechanism to the shaft of capacitor C10, then rotate the Frequency (dial) so it indicates a frequency of 42 MHz (on the 42-100 MHz scale) and retighten the two screws.

3. Connect the autotransformer (if used) to a suitable power source.

4. Connect a power cord from the Type 191 to the autotransformer output (or directly to the power source).

5. Set the autotransformer to 115 (or 230) volts.

6. Set the Type 191 POWER switch to ON. Allow at least 5 minutes warm up for checking the instrument to the given accuracies.

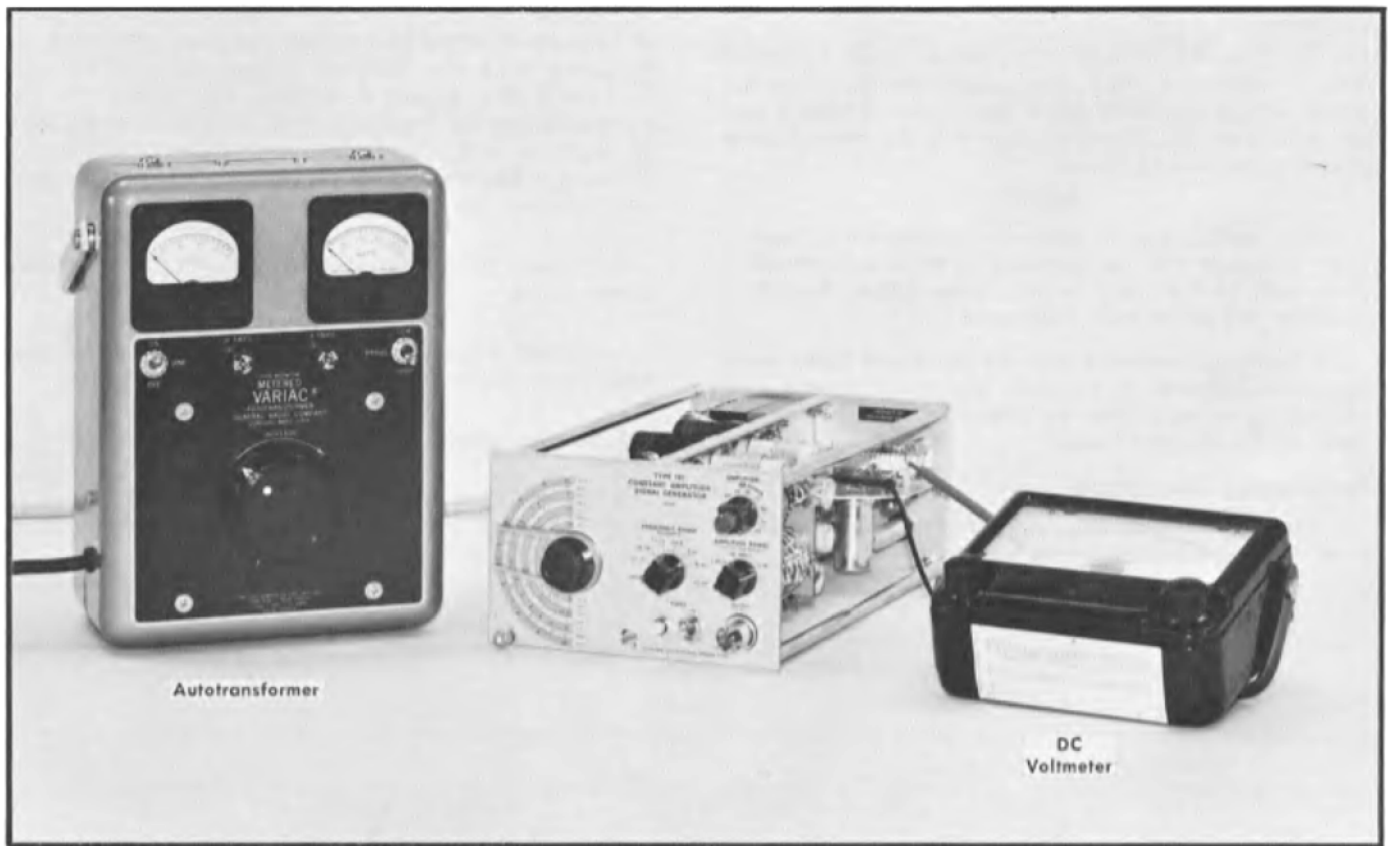


Fig. 6-3. Test equipment setup for steps 1 through 3.

**Control Settings**

POWER	ON
AMPLITUDE RANGE	.5-5 V
AMPLITUDE	50
VARIABLE (Amplitude)	CAL
FREQUENCY RANGE	50 kHz ONLY
Frequency (dial)	Set to .5 mark of .35-.75 scale
115 V/230 V (rear panel)	Set for correct line voltage.

**1. Adjust -11-Volt Power Supply** ❶

- a. Test equipment setup is shown in Fig. 6-3.
- d. Connect the negative lead of the DC voltmeter to the junction of R122, R123 and C128; see Fig. 6-4.
- c. Connect the positive DC voltmeter lead to ground.
- d. Check—For about a -11 volt reading on the DC voltmeter.

e. Adjust -11 VOLTS control, R122 (see Fig. 6-4) until about a -11 volt reading is obtained on the DC voltmeter.

f. Set the autotransformer output voltage 10% above the nominal line voltage and check that the DC voltmeter still reads about -11 volts.

g. Set the autotransformer output voltage 10% below the nominal line voltage and check that the DC voltmeter still reads about -11 volts.

h. Interaction—May affect all circuits.

i. Disconnect the DC voltmeter and return the autotransformer output voltage to nominal line voltage.

**2. Check +6.2-Volt Power Supply**

- a. Test equipment setup is shown in Fig. 6-3.
- b. Connect the positive lead of the DC voltmeter to the junction of D117 and C127; see Fig. 6-4.
- c. Connect the negative lead of the DC voltmeter to ground.
- d. Check—For a DC voltmeter reading of about 6.2 volts.

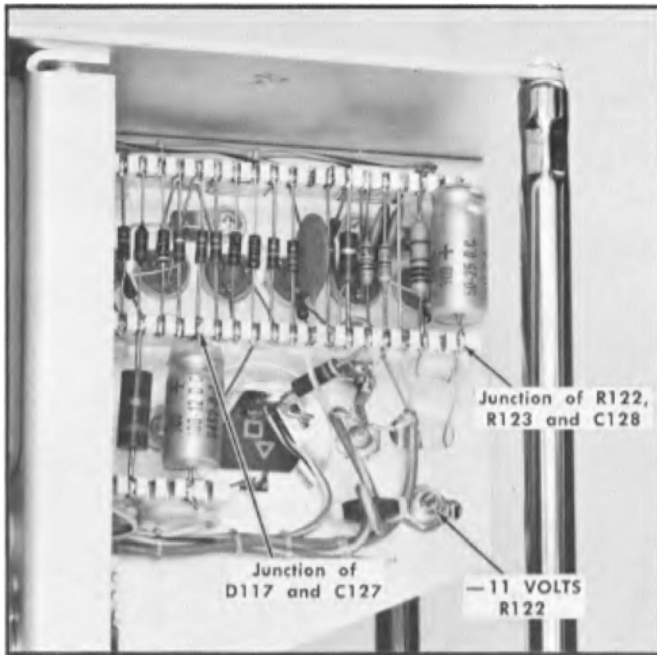


Fig. 6-4. Location of R122, R123 and C128 junction, -11 VOLTS R122 control, and the junction of D117 and C127.

e. Interaction—May affect operation of Feedback DC Amplifier and -11-Volt Power Supply.

f. Disconnect DC voltmeter.

### 3. Check +450-Volt Unregulated Power Supply

a. Test equipment setup is shown in Fig. 6-3.

b. Connect the positive lead of the DC voltmeter to the

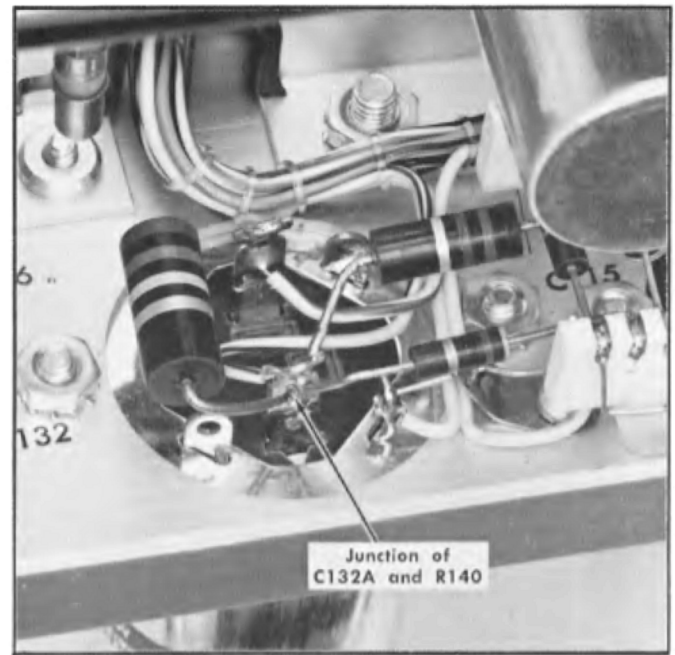


Fig. 6-5. Location of C132A and R140 junction.

junction of C132A and R140; see Fig. 6-5.

c. Connect the negative DC voltmeter lead to ground.

d. Check—For a DC voltmeter reading between 435 volts and 450 volts.

e. Interaction—May affect operation of Oscillator circuit.

f. Disconnect DC voltmeter.



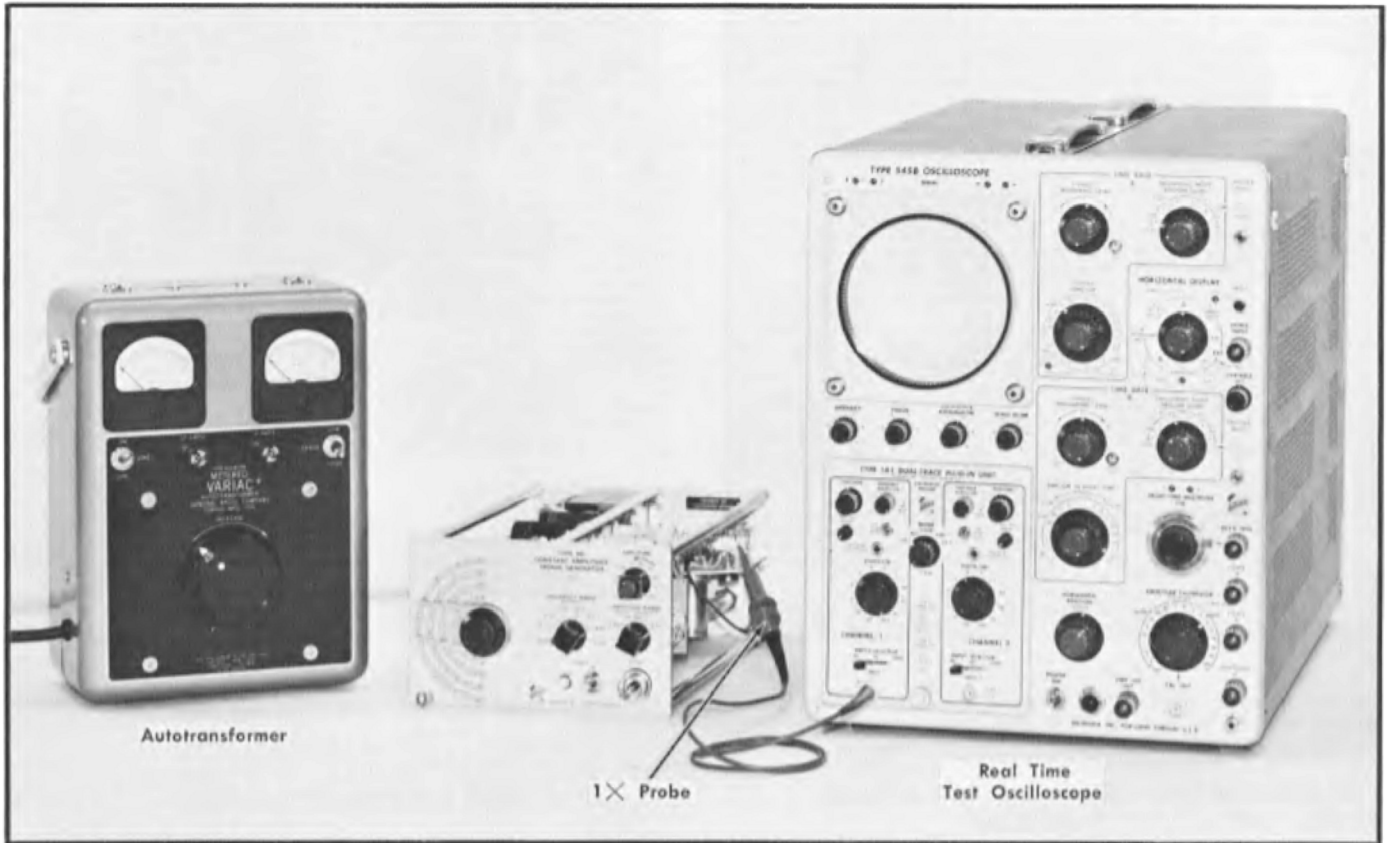


Fig. 6-6. Test equipment setup for step 4.

**Control Settings**

POWER	ON
AMPLITUDE RANGE	.5-5 V
AMPLITUDE	50
VARIABLE (Amplitude)	CAL
FREQUENCY RANGE	50 kHz ONLY
Frequency (dial)	Set to .5 mark of .35-.75 scale
115 V/230 V (rear panel)	Set for correct line voltage

**4. Check -11-Volt and +6.2-Volt Power Supply Ripple**

- a. Test equipment setup is shown in Fig. 6-6.
- b. Connect a 1X probe from the test oscilloscope to the junction of R122, R123 and C128; see Fig. 6-4.
- c. Set the test oscilloscope controls as follows:
 

Vertical Input Coupling	AC
Volts/Div	.005
Trigger Mode	Automatic
Trigger Slope	+
Trigger Source	Line
Time/Div	5 ms

- d. Check—For about 4 mV of ripple.
- e. Set the autotransformer output voltage 10% above the nominal line voltage.
- f. Check—For about 4 mV of ripple.
- g. Set the autotransformer output voltage 10% below the nominal line voltage.
- h. Check—For about 4 mV of ripple.
- i. Return the autotransformer output voltage to the nominal line voltage.
- j. Change the 1X probe connection to the junction of D117 and C127; see Fig. 6-4.
- k. Check—For about 4 mV of ripple.
- l. Set the autotransformer output voltage 10% above the nominal line voltage.
- m. Check—For about 4 mV of ripple.
- n. Set the autotransformer output voltage 10% below the nominal line voltage.
- o. Check for about 4 mV of ripple.
- p. Disconnect the 1X probe and return the autotransformer output voltage to the nominal line voltage.

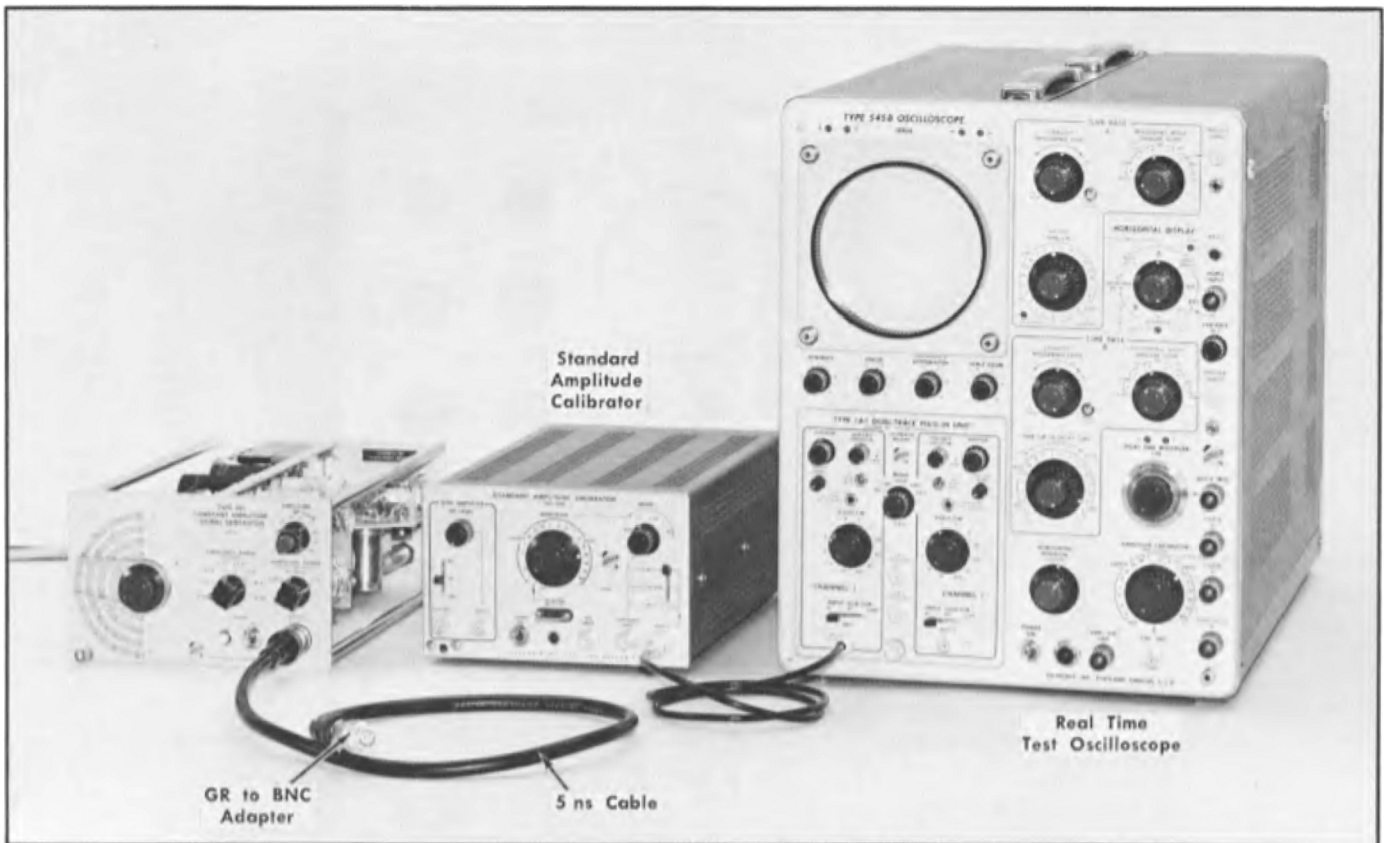


Fig. 6-7. Test equipment setup for step 5.

**Control Settings**

POWER	ON
AMPLITUDE RANGE	.5-5 V
AMPLITUDE	50
VARIABLE (AMPLITUDE)	CAL
FREQUENCY RANGE	50 kHz ONLY
Frequency (dial)	Set to .5 mark of .35-.75 scale
115 V/230 V (rear panel)	Set for correct line voltage

Trigger Mode	Automatic
Trigger Slope	+
Trigger Source	Internal
Time/Div	1 ms

**5. Adjust —11-Volt Power Supply**



- a. Test equipment setup is shown in Fig. 6-7.
- b. Connect a 10 volt square-wave signal from the standard amplitude calibrator to the vertical input of the test oscilloscope.
- c. Set the test oscilloscope controls as follows:
 

Vertical Input Coupling	AC
Volts/Div	2

- d. Adjust the vertical gain of the test oscilloscope to obtain exactly five divisions of vertical display.
- e. Disconnect the standard amplitude calibrator from the test oscilloscope.
- f. Connect the OUTPUT connector on the Type 191 through a 5 ns length of RG-8A/U coaxial cable and a GR to BNC adapter to the vertical input connector on the test oscilloscope; see Fig. 6-8.
- g. Set the Time/Div switch on the test oscilloscope to 0.2 ms.
- h. Check—For a test oscilloscope display whose amplitude is exactly 5 divisions (10 volts).
- i. Adjust the —11 VOLTS control (see Fig. 6-4) to obtain a test oscilloscope display of exactly 5 divisions.
- j. Interaction—Interacts with steps 6 and 7.
- k. Disconnect the Type 191 from the test oscilloscope.

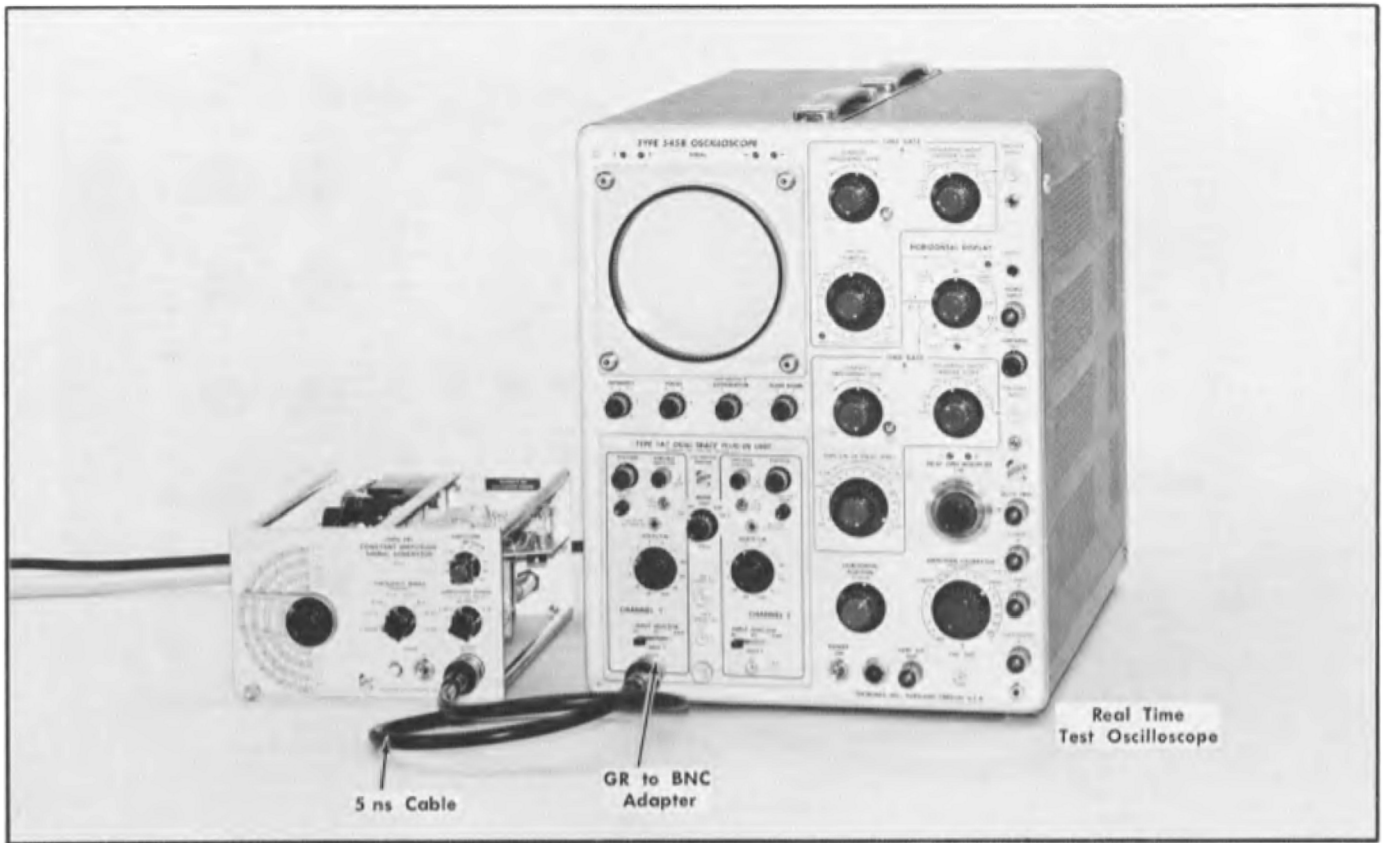


Fig. 6-8. Type 191 connection to real time test oscilloscope.



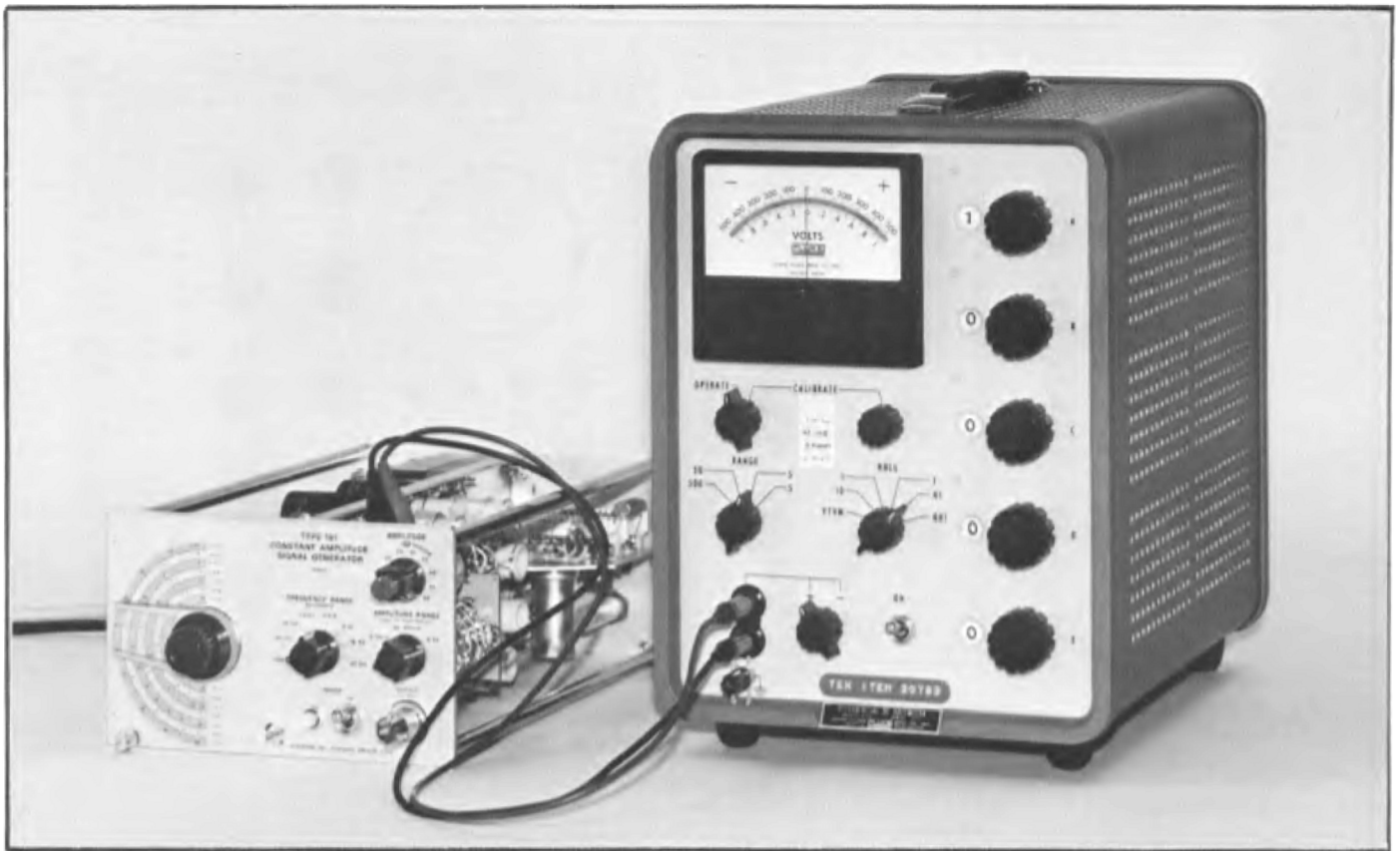


Fig. 6-9. Test equipment setup for step 6.

### Control Settings

POWER	ON
AMPLITUDE RANGE	.5-5 V
AMPLITUDE	50
VARIABLE (Amplitude)	CAL
FREQUENCY RANGE	50 kHz ONLY
Frequency (dial)	Set to .5 mark of .35-.75 scale
115 V/230 V (rear panel)	Set for correct line voltage

### 6. Adjust Amplitude Tracking



- a. Test equipment setup is shown in Fig. 6-9.
- b. Connect the negative lead of a precision DC voltmeter to the -11 volt end of R53L; see Fig. 6-10.
- c. Connect the positive lead of the precision DC voltmeter to the junction of R53J and R53K; see Fig. 6-10.
- d. Check—For a voltage of 1 volt  $\pm$ 5 mV.
- e. Adjust TRACKING control, R55 (see Fig. 6-12) to obtain a voltage 1 volt  $\pm$ 5 mV.

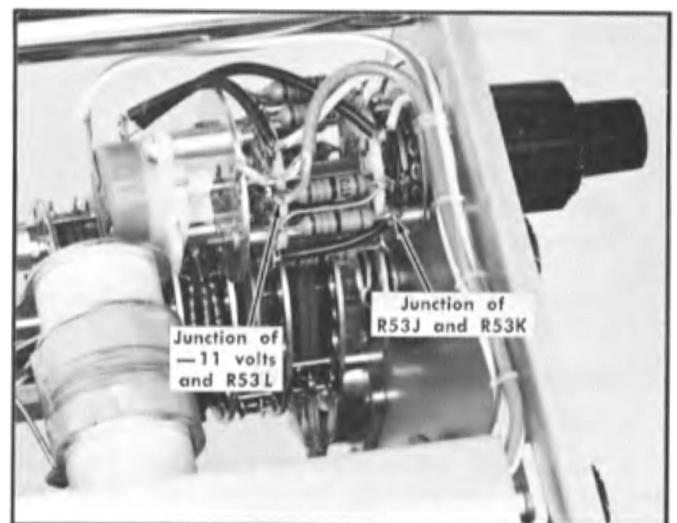


Fig. 6-10. Location of -11 volt end of R53L and the junction of R53J and R53K.

- f. Interaction—Interacts with steps 5 and 7.
- g. Disconnect the precision DC voltmeter.

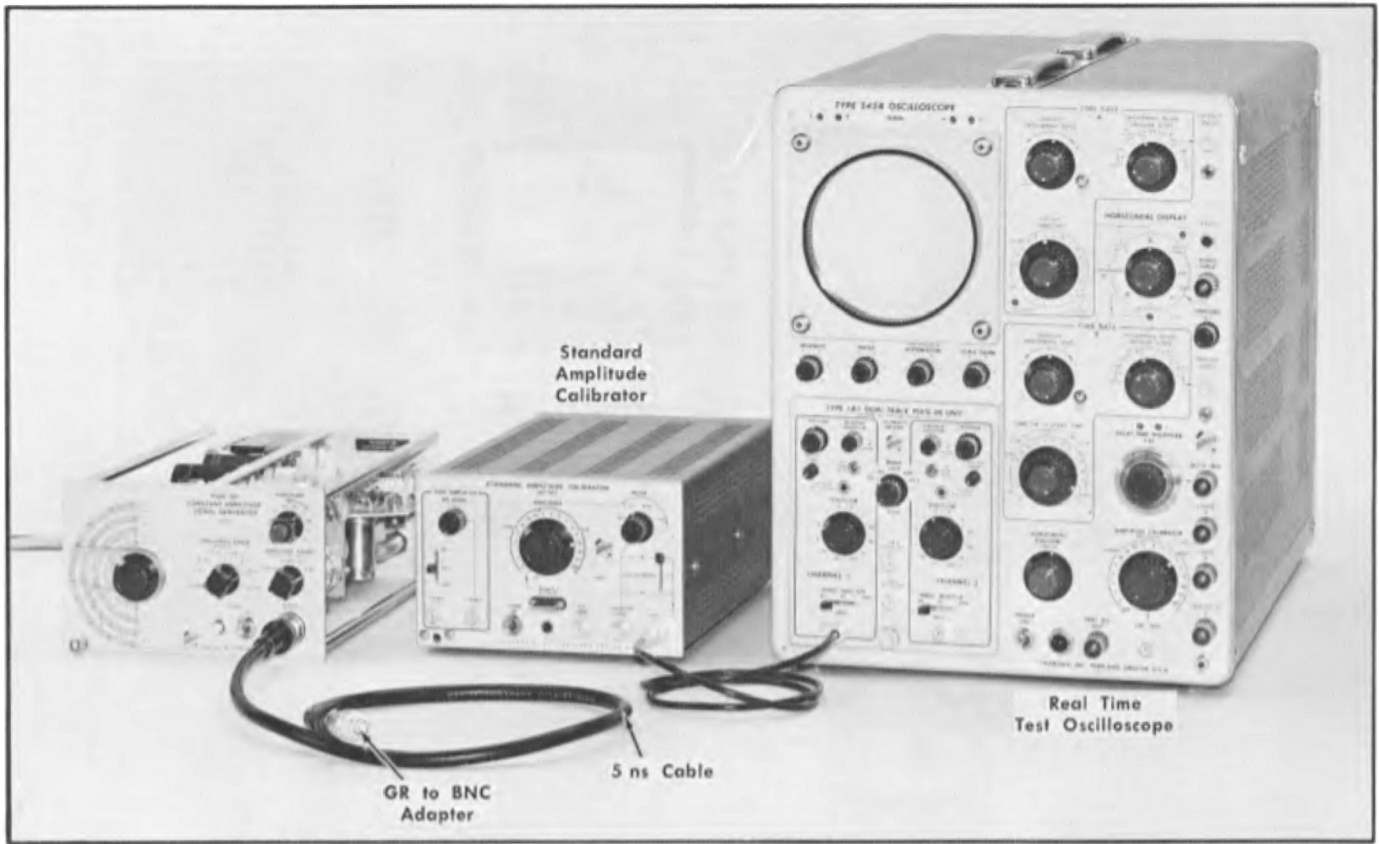


Fig. 6-11. Test equipment setup for steps 7 and 9.

**Control Settings**

POWER	ON
AMPLITUDE RANGE	.5-5 V
AMPLITUDE VARIABLE (Amplitude)	5
FREQUENCY RANGE	CAL
Frequency (dial)	50 kHz ONLY
115 V/230 V (rear panel)	Set to .5 mark of .35-.75 scale
	Set for correct line voltage

**7. Adjust Amplitude Calibration**



- a. Test equipment setup is shown in Fig. 6-11.
- b. Connect a 1 volt square-wave signal from the standard amplitude calibrator to the vertical input of the test oscilloscope.
- c. Set the test oscilloscope controls as follows:
 

Vertical Input Coupling	AC
Volts/Div	.2
Trigger Mode	Automatic
Trigger Slope	+
Trigger Source	Internal
Time/Div	1 ms

- d. Adjust the vertical gain of the test oscilloscope to obtain exactly five divisions of vertical display.
- e. Disconnect the standard amplitude calibrator from the test oscilloscope.
- f. Connect the OUTPUT connector on the Type 191 through a 5 ns length of RG-8A/U coaxial cable, and a GR to BNC adapter to the vertical input connector on the test oscilloscope; see Fig. 6-8.
- g. Set the Time/Div switch on the test oscilloscope to 0.2 ms.
- h. Check—For a test oscilloscope display whose amplitude is exactly 5 divisions (1 volt).
- i. Adjust the AMPL CAL control (see Fig. 6-12) to obtain a test oscilloscope display of exactly 5 divisions.
- j. Interaction—Interacts with steps 5 and 6.

**8. Check Amplitude Variable Control**

- a. Test equipment setup is given in step 7.
- b. Set the Type 191 AMPLITUDE switch to 50.
- c. Set the test oscilloscope Volts/Div control to 2 volts.
- d. Check—For a test oscilloscope display amplitude of about 5 divisions.



Fig. 6-12. Location of TRACKING and AMPL CAL controls.

e. Slowly rotate the VARIABLE (Amplitude) control clockwise and check for a smoothly increasing signal display on the test oscilloscope.

f. Check—For a test oscilloscope display amplitude of about 5.5 divisions with the Type 191 VARIABLE (Amplitude) control fully clockwise.

g. Rotate the Type 191 VARIABLE (Amplitude) control to its CAL position.

h. Disconnect the Type 191 from the test oscilloscope.

## 9. Check Amplitude Range Switch

a. Test equipment setup is shown in Fig. 6-11.

b. Connect a 5 volt square-wave signal from the standard amplitude calibrator to the vertical input of the test oscilloscope.

c. Set the test oscilloscope Volts/Div control to 1 volt.

d. Adjust the vertical gain of the test oscilloscope to obtain exactly five divisions of vertical display.

e. Disconnect the standard amplitude calibrator from the test oscilloscope.

f. Connect the OUTPUT connector on the Type 191 through a 5 ns length of RG-8A/U coaxial cable, and a GR to BNC 50 ohm termination to the vertical input connector on the test oscilloscope; see Fig. 6-13.

g. Check—For a test oscilloscope display whose amplitude is 5 divisions (5 volts)  $\pm 3\%$ .

h. Disconnect the Type 191 from the test oscilloscope.

i. Connect a 0.5 volt square-wave signal from the standard amplitude calibrator to the vertical input of the test oscilloscope.

j. Set the test oscilloscope Volts/Div control to 0.1 volt.

k. Adjust the vertical gain of the test oscilloscope to obtain exactly five divisions of vertical display.

l. Disconnect the standard amplitude calibrator from the test oscilloscope.

m. Connect the OUTPUT connector on the Type 191 through a 5 ns length of RG-8A/U coaxial cable, and a GR to BNC 50 ohm termination to the vertical input connector on the test oscilloscope; see Fig. 6-13.

n. Set the Type 191 AMPLITUDE RANGE switch to 50-500 mV.

o. Check—For a test oscilloscope display whose amplitude is 5 divisions  $\pm 4\%$ .

p. Disconnect the Type 191 from the test oscilloscope.

q. Connect a 0.05 volt square-wave signal from the standard amplitude calibrator to the vertical input of the test oscilloscope.

r. Set the test oscilloscope Volts/Div control to 0.01 volt.

s. Adjust the vertical gain of the test oscilloscope to obtain exactly five divisions of vertical display.

t. Disconnect the standard amplitude calibrator from the test oscilloscope.

u. Connect the OUTPUT connector on the Type 191 through a 5 ns length of RG-8A/U coaxial cable, and a GR to BNC 50 ohm termination to the vertical input connector on the test oscilloscope; see Fig. 6-13.

v. Set the Type 191 AMPLITUDE RANGE switch to 5-50 mV.

w. Check—For a test oscilloscope display whose amplitude is 5 divisions  $\pm 5\%$ .

x. Disconnect the Type 191 from the test oscilloscope.



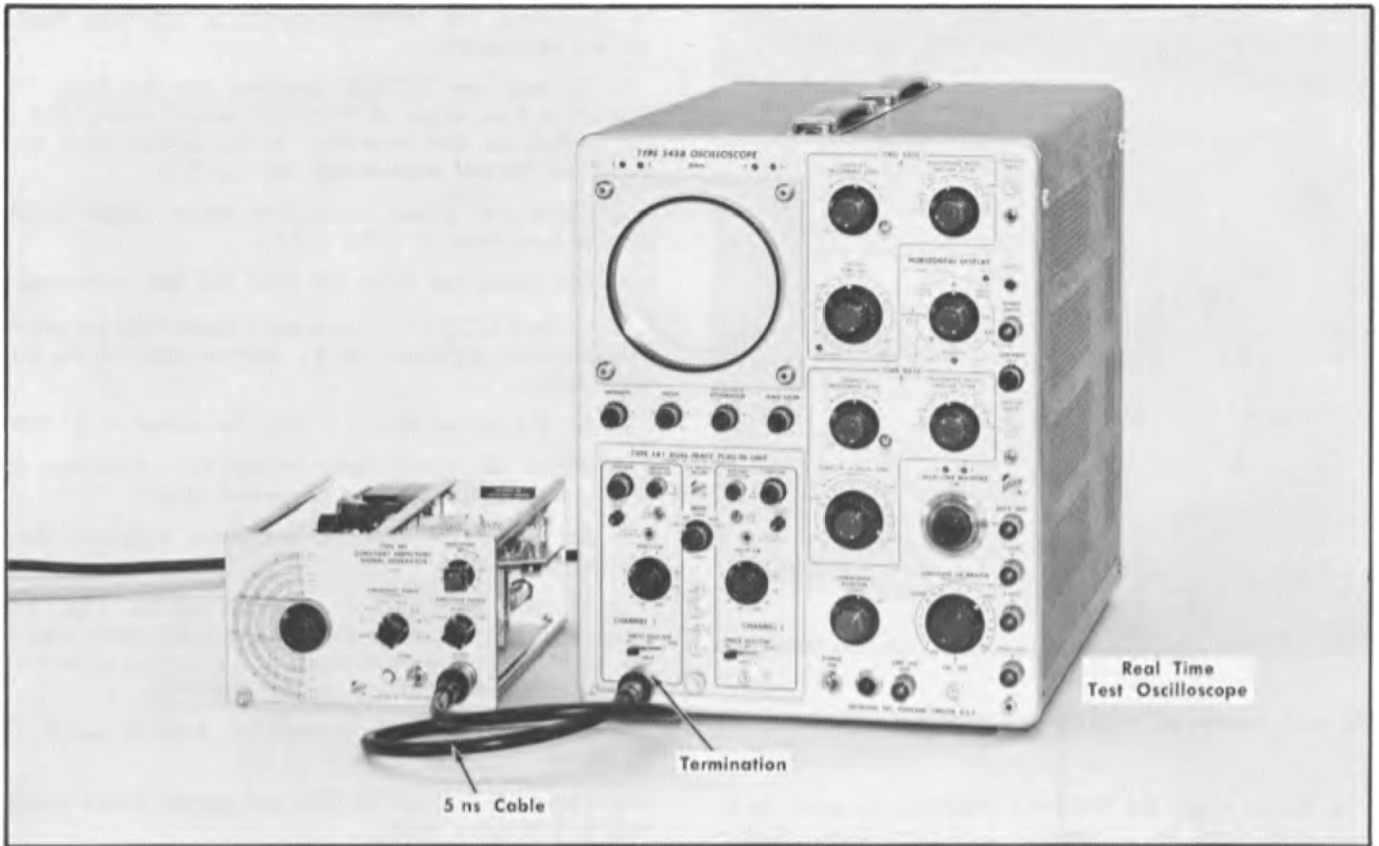


Fig. 6-13. Type 191 connection to real time test oscilloscope.

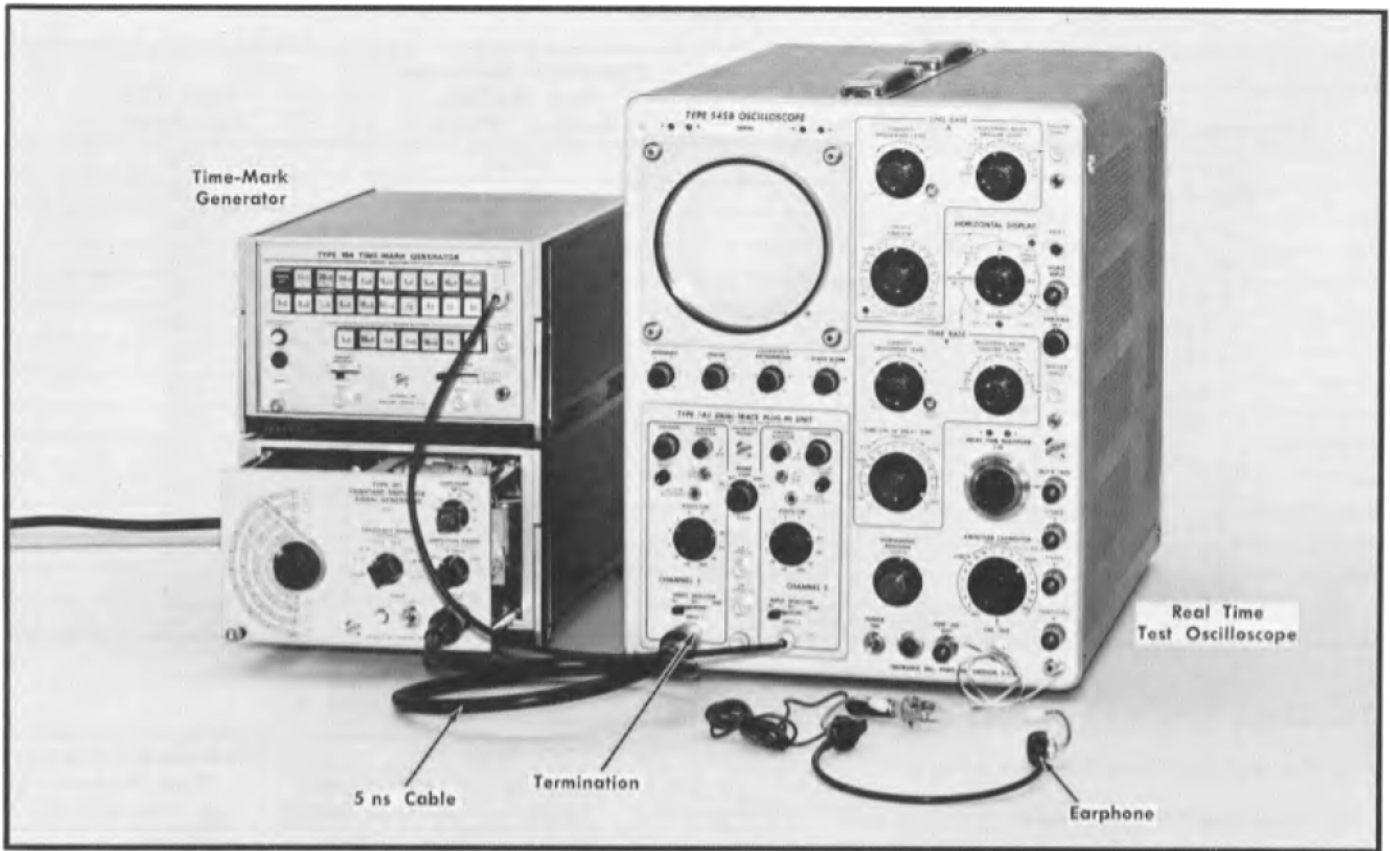


Fig. 6-14. Test equipment setup for steps 10 and 11.

### Control Settings

POWER	ON
AMPLITUDE RANGE	50-500 mV
AMPLITUDE	50
VARIABLE (Amplitude)	CAL
FREQUENCY RANGE	42-100 MHz
Frequency (dial)	Set to 50
115 V/230 V (rear panel)	Set for correct line voltage

### 10. Adjust Frequency Ranges



- a. Test equipment setup is shown in Fig. 6-14.
- b. Loosen the lock nut on each oscillator coil.
- c. Connect the OUTPUT connector on the Type 191 through a 5 ns length of RG-8A/U coaxial cable, and a GR to BNC 50 ohm termination to the channel 1 vertical input connector on the test oscilloscope.
- d. Connect a 20 ns signal from the Time-Mark Generator Marker Output connector through a 50 ohm coaxial cable to the channel 2 vertical input connector on the test oscilloscope.

e. It is necessary to set only the following test oscilloscope controls:

Channels 1 and 2	
Vertical Input Coupling	AC
Volts/Div	.05
Vertical Channel Mode	Add

- f. Connect the signal lead from the earphone to the Vert Sig Out connector of the test oscilloscope.
- g. Connect the shield lead from the earphone to a ground connector on the test oscilloscope.
- h. Using Table 6-1 as a guide, set up the Type 191 and the time-mark generator controls as described for each end of each frequency setting of the Type 191.
- i. Check—For a zero beat frequency at the frequency points indicated in Table 6-1. The zero beat frequency is the point where no tone is audible between two audible tones.
- j. Adjust the oscillator coil (for the low end of each frequency range) or the trimmer capacitor (for the upper end of each frequency range) for a zero beat frequency.
- k. Interaction—Trimmer capacitor and oscillator coil adjustments for each frequency range interact with each other.

TABLE 6-1

Type 191		Time-Mark Generator Time Markers or Sine Waves	Type 191 Adjustment
Frequency (dial)	Frequency RANGE Switch		
50 MHz	42-100	20 ns	T38
100 MHz	42-100	20 ns	C38
20 MHz	18-42	50 ns	T34
40 MHz	18-42	50 ns	C34
8 MHz	8-18	1 $\mu$ s	T30
18 MHz	8-18	1 $\mu$ s	C30
4 MHz	3.6-8	1 $\mu$ s	T26
8 MHz	3.6-8	1 $\mu$ s	C26
1.6 MHz	1.6-3.6	5 $\mu$ s	T22
3.6 MHz	1.6-3.6	5 $\mu$ s	C22
.75 MHz	.75-1.6	10 $\mu$ s	T18
1.6 MHz	.75-1.6	5 $\mu$ s	C18
.35 MHz	.35-.75	10 $\mu$ s	T14
.75 MHz	.35-.75	10 $\mu$ s	C14
.5 MHz	50 kHz ONLY	5 $\mu$ s	T10

11. Check Frequency Ranges Accuracy

- a. Test equipment setup is shown in Fig. 6-14.
- b. Install Type 191 into its case.
- c. Connect the OUTPUT connector on the Type 191 through a 5 ns length of RG-8A/U coaxial cable and a GR to BNC 50 ohm termination to the channel 1 vertical input connector on the test oscilloscope.
- d. Connect a 20 ns signal from the Time-Mark Generator Marker Output connector through a 50 ohm coaxial cable to the channel 2 vertical input connector on the test oscilloscope.
- e. It is necessary to set only the following test oscilloscope controls:
 

Channels 1 and 2	
Vertical Input Coupling	AC
Volts/Div	.05
Vertical Channel Mode	Add
- f. Connect the signal lead from the earphone to the Vert Sig Out connector of the test oscilloscope.
- g. Connect the shield lead from the earphone to a ground connector on the test oscilloscope.
- h. Using Table 6-2 as a guide, set up the Type 191 and the time-mark generator controls as described for each frequency setting of the Type 191.
- i. Check—For a zero beat frequency close to the frequency points indicated in Table 6-2.

TABLE 6-2

Type 191		Time-Mark Generator Time Markers or Sine Waves
Frequency (dial)	FREQUENCY RANGE Switch	
50 MHz	42-100	20 ns
60 MHz	42-100	20 ns
80 MHz	42-100	50 ns
100 MHz	42-100	20 ns
20 MHz	18-42	50 ns
30 MHz	18-42	50 ns
40 MHz	18-42	50 ns
8 MHz	8-18	1 $\mu$ s
13 MHz	8-18	1 $\mu$ s
18 MHz	8-18	1 $\mu$ s
4 MHz	3.6-8	1 $\mu$ s
6 MHz	3.6-8	1 $\mu$ s
8 MHz	3.6-8	1 $\mu$ s
1.6 MHz	1.6-3.6	5 $\mu$ s
2.6 MHz	1.6-3.6	5 $\mu$ s
3.6 MHz	1.6-3.6	5 $\mu$ s
.75 MHz	.75-1.6	10 $\mu$ s
1.1 MHz	.75-1.6	5 $\mu$ s
1.6 MHz	.75-1.6	5 $\mu$ s
.35 MHz	.35-.75	10 $\mu$ s
.5 MHz	.35-.75	10 $\mu$ s
.75 MHz	.35-.75	10 $\mu$ s

- j. Disconnect the Type 191, Time-Mark Generator and the earphones from the test oscilloscope.
- k. Remove the Type 191 from its case.



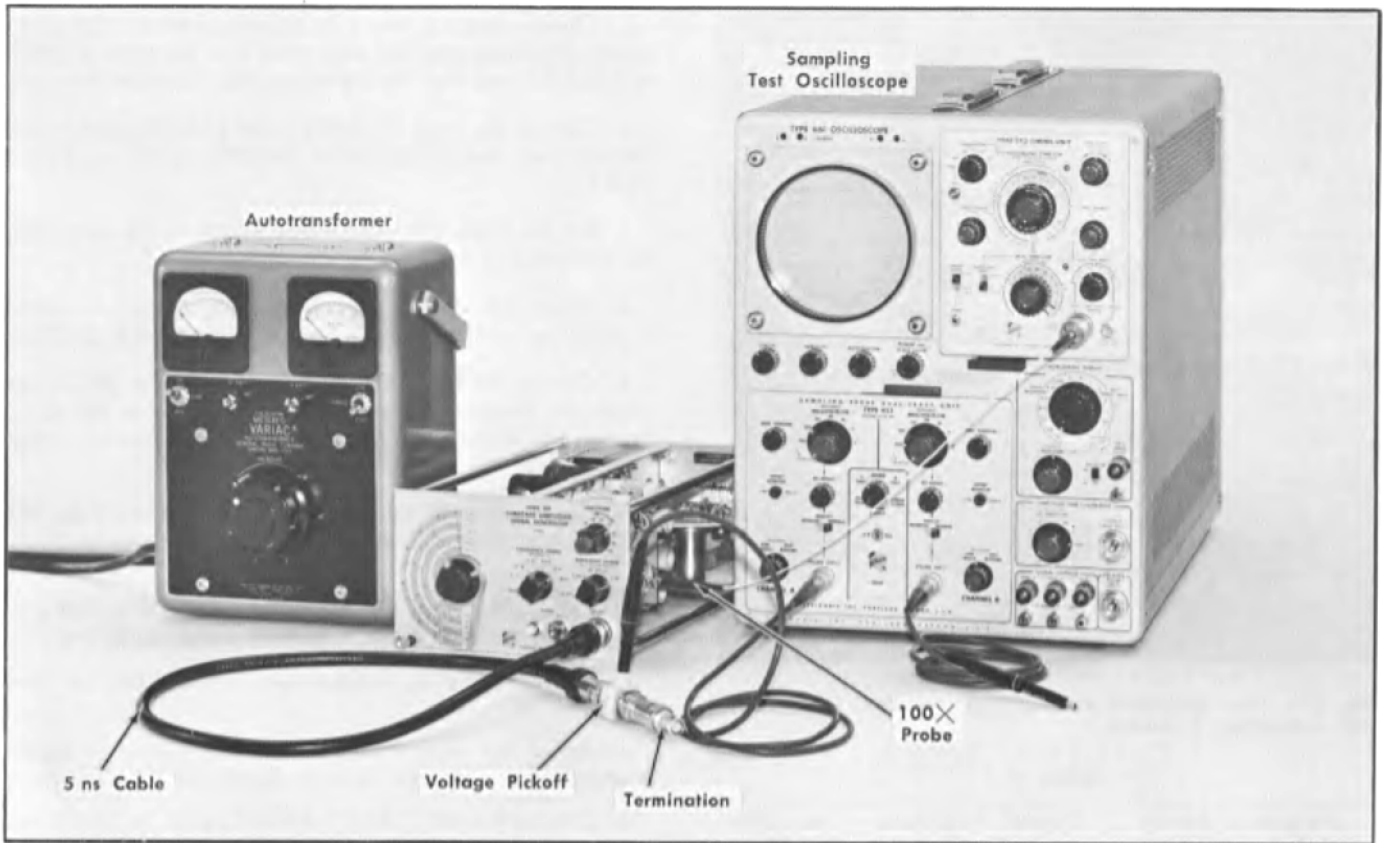


Fig. 6-15. Test equipment setup for step 12.

**Control Settings**

POWER	ON
AMPLITUDE RANGE	.5-5 V
AMPLITUDE	5
VARIABLE (Amplitude)	CAL
FREQUENCY RANGE	50 kHz ONLY
Frequency (dial)	As is
115 V/230 V (rear panel)	Set for correct line voltage

**12. Check Output Amplitude Regulation**

- a. Test equipment setup is shown in Fig. 6-15.
- b. Connect a 100× sampling probe from external trigger input connector of the sampling oscilloscope to the FREQUENCY RANGE switch end of the coaxial cable which runs from the switch to the sampling point. See Fig. 6-16.
- c. To the OUTPUT connector of the Type 191, connect a 5 ns length of RG-8A/U coaxial cable, a voltage pickoff unit, and a 50 ohm BNC to GR termination.
- d. Connect a 1× probe (furnished with the Type 4S3 vertical plug-in) from the vertical probe input connector to the appropriate connection on the voltage pickoff unit.
- e. Set the sampling oscilloscope controls as follows:

Vertical Plug-In	
Millivolts/Div	100
Vertical Position	Midrange
DC Offset	Midrange
Display	Normal
Smoothing	Refer to part f of this step
Low Noise-Fast Risetime	Low Noise
Vertical Mode	Channel A
Horizontal Plug-In	
Samples/Div	100
Time Position	Midrange
Equivalent Time/Div	10 ns
Trig Level	Midrange
Stability	Midrange
Trigger Source	External
Trigger Slope	+
External Trigger Mode	50 Ω AC
Sweep Mode	Normal
Oscilloscope	
Horizontal Display	×1
Horizontal Position	Midrange

- f. Adjust the smoothing control for a loop gain of one; see procedure in Type 4S3 Instruction Manual. The equivalent time/division and the stability control will need to be changed during the procedure to obtain a readable display.

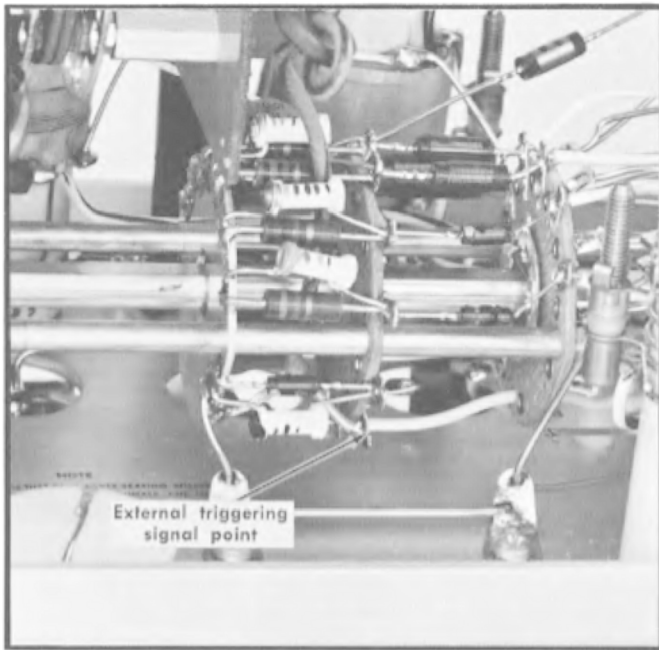


Fig. 6-16. Point from which external triggering signal for sampling test oscilloscope is derived.

TABLE 6-3

Frequency Range	Output Amplitude Limits (peak to peak)	<sup>1</sup> Maximum Amplitude Variation
.35 MHz to 42 MHz	5 mV to 5.5 V	±3%
42 MHz to 100 MHz	50 mV to 5.5 V	±3%
42 MHz to 100 MHz	5 mV to 55 mV	+3% and -5%

<sup>1</sup>Amplitude variation is referenced to actual amplitude at 50 kHz.

- g. Set the autotransformer for an output voltage 10% below the nominal line voltage.
- h. Adjust the vertical plug-in Variable control to obtain a sampling oscilloscope vertical display of 7.8 divisions.
- i. Change the FREQUENCY RANGE switch to .35-.75 and rotate the Frequency (dial) from one extreme to the other. Repeat this procedure until the complete frequency range from .35 MHz to 100 MHz has been checked.

- j. Check—That as part i is accomplished the Type 191 output amplitude does not vary more than the amount shown in Table 6-3 and that the waveform has minimum distortion.

- k. Change the Type 191 AMPLITUDE RANGE switch to 50-500 mV and the FREQUENCY RANGE switch to 50 kHz ONLY.

- l. Set the Type 191 AMPLITUDE switch to 50 and rotate the VARIABLE (Amplitude) fully clockwise.

- m. Adjust the vertical plug-in Variable control to obtain a sampling oscilloscope vertical display of 7.8 divisions.

- n. Change the FREQUENCY RANGE switch to .35-.75 and rotate the Frequency (dial) from one extreme to the other. Repeat this procedure until the complete frequency range from .35 MHz to 100 MHz has been checked.

- o. Check—That as part n is accomplished the Type 191 output amplitude does not vary more than the amount shown in Table 6-3.

- p. Change the Type 191 AMPLITUDE RANGE switch to 5-50 mV, and the FREQUENCY RANGE switch to 50 kHz.

- q. Set the sampling oscilloscope millivolts/division control to 10.

- r. Adjust the vertical plug-in Variable control to obtain a sampling oscilloscope vertical display of 7.8 divisions.

- s. Change the FREQUENCY RANGE switch to .35-.75 and rotate the Frequency (dial) from one extreme to the other. Repeat this procedure until the complete frequency range from .35 MHz to 100 MHz has been checked.

- t. Check—That as part s is accomplished the Type 191 output amplitude does not vary more than the amount shown in Table 6-3.

- u. Rotate the VARIABLE (Amplitude) control to its CAL position.

- v. If desired other Type 191 output amplitudes may be checked. However the three output levels which have been checked will provide adequate assurance that the output amplitude regulation is within the proper tolerance.

This completes the calibration of the Type 191. Disconnect all test equipment and slide the instrument into its case. If the instrument has been completely calibrated to the tolerances given in this procedure, it will perform to the limits given in the Characteristics section of the Instruction Manual.

## ABBREVIATIONS AND SYMBOLS

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



## PARTS ORDERING INFORMATION

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

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

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

## SPECIAL NOTES AND SYMBOLS

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



# SECTION 7

## ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description	S/N Range			
<b>Bulb</b>						
B109	150-0052-00	Incandescent, 10 V, 40 mA	Pilot Light			
<b>Capacitors</b>						
Tolerance $\pm 20\%$ unless otherwise indicated.						
C8	281-0623-00	650 pF	Cer		500 V	5%
C10A,B,C,D	Use 281-0054-01	4 x 15-150 pF	Air	Var		
C11	285-0552-00	0.018 $\mu$ F	PTM		600 V	
C12	285-0591-00	0.0047 $\mu$ F	PTM		600 V	5%
C13	283-0024-00	0.1 $\mu$ F	Cer		30 V	
C14	281-0027-00	0.7-3 pF	Tub.	Var		
C15	285-0699-00	0.0047 $\mu$ F	PTM		100 V	10%
C18	281-0027-00	0.7-3 pF	Tub.	Var		
C19	283-0028-00	0.0022 $\mu$ F	Cer		50 V	
C22	281-0027-00	0.7-3 pF	Tub.	Var		
C23	283-0078-00	0.001 $\mu$ F	Cer		500 V	
C26	281-0027-00	0.7-3 pF	Tub.	Var		
C27	281-0551-00	390 pF	Cer		500 V	10%
C30	281-0027-00	0.7-3 pF	Tub.	Var		
C31	281-0524-00	150 pF	Cer		500 V	
C34	281-0027-00	0.7-3 pF	Tub.	Var		
C35	281-0549-00	68 pF	Cer		500 V	10%
C38	281-0101-00	1.5-9.1 pF	Air	Var		
C38	281-0102-00	1.7-11 pF	Air	Var		
C39	281-0504-00	10 pF	Cer		500 V	10%
C60	283-0025-00	0.005 $\mu$ F	Cer		500 V	5%
C61	283-0026-00	0.2 $\mu$ F	Cer		25 V	
C63	283-0026-00	0.2 $\mu$ F	Cer		25 V	
C64	283-0025-00	0.005 $\mu$ F	Cer		500 V	5%
C66	283-0026-00	0.2 $\mu$ F	Cer		25 V	
C67	283-0025-00	0.005 $\mu$ F	Cer		500 V	5%
C71	283-0081-00	0.1 $\mu$ F	Cer		25 V	+80% -20%
C72	283-0078-00	0.001 $\mu$ F	Cer		500 V	
C97	283-0002-00	0.01 $\mu$ F	Cer		500 V	
C97	283-0000-00	0.001 $\mu$ F	Cer		500 V	
C101	283-0078-00	0.001 $\mu$ F	Cer		500 V	
C102	283-0078-00	0.001 $\mu$ F	Cer		500 V	

100-1019  
1020-up

100-744  
745-up

**Electrical Parts List—Type 191**

**Capacitors (Cont'd)**

Ckt. No.	Tektronix Part No.	Description			S/N Range
C109	283-0051-00	0.0033 $\mu$ F	Cer	100 V	5%
C113	290-0278-00	550 $\mu$ F	EMC	50 V	
C115	290-0278-00	550 $\mu$ F	EMC	50 V	
C121	283-0002-00	0.01 $\mu$ F	Cer	500 V	
C125	283-0002-00	0.01 $\mu$ F	Cer	500 V	+75%—10%
C127	290-0171-00	100 $\mu$ F	EMT	12 V	
C128	290-0209-00	50 $\mu$ F	EMT	25 V	
C132 A,B	290-0262-00	2 x 40 $\mu$ F	EMC	500 V	

**Diodes**

D60	*152-0205-00	GaAs	Glass diffused	
D67	*152-0205-00	GaAs	Glass diffused	
D80	*152-0185-00	Silicon	Replaceable by 1N3605	
D81	*152-0185-00	Silicon	Replaceable by 1N3605	
D94	*152-0185-00	Silicon	Replaceable by 1N3605	
D98	152-0067-00	Zener	1M25Z10	1 W, 25 V, 10%
D112 A,B C,D (4)	*152-0107-00	Silicon	Replaceable by 1N647	
D117	152-0166-00	Zener	1N753A	0.4 W, 6.2 V, 5%
D118	*152-0107-00	Silicon	Replaceable by 1N647	
D132 A,B C,D (4)	152-0208-00	Silicon	1N3195	

**Fuses**

F101	159-0031-00	0.4 A, 3AG, Slo-Blo, 115 V
F101	159-0044-00	0.2 A, 3AG, Slo-Blo, 230 V

**Connector**

J64	131-0391-00	Coaxial, 50 $\Omega$ male
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**Inductors**

L11	276-0507-00	Core, Ferramic Suppressor
L12	276-0507-00	Core, Ferramic Suppressor
L13	*108-0109-00	60 $\mu$ H
L15	*108-0129-00	18 $\mu$ H
L19	*108-0146-00	5 $\mu$ H

**Inductors (Cont'd)**

Ckt. No.	Tektronix Part No.	Description	S/N Range
L23	*108-0103-00	2.5 $\mu$ H	
L27	*108-0056-00	1.2 $\mu$ H	
L31	*108-0262-00	0.6 $\mu$ H	
L35	*108-0260-00	0.1 $\mu$ H	
L39	*108-0262-00	0.6 $\mu$ H	
L49	276-0525-00	Core, Ferrite	
L61	276-0528-00	Core, Ferramic Suppressor	
L63	276-0528-00	Core, Ferramic Suppressor	
L64	276-0525-00	Core, Ferrite	
L66	276-0528-00	Core, Ferramic Suppressor	
L70	276-0525-00	Core, Ferrite	
L98	*108-0008-00	6.3 mH	

**Plug**

P101	*131-0102-00	3 wire, male
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**Transistors**

Q74	*151-0155-00	Silicon	Replaceable by 2N2925
Q84	*151-0155-00	Silicon	Replaceable by 2N2925
Q93	*151-0153-00	Silicon	Replaceable by 2N2923
Q94	151-0150-00	Silicon	2N3440
Q123	*151-0153-00	Silicon	Replaceable by 2N2923
Q127	Use *151-0087-00	Silicon	Replaceable by 2N1131

**Resistors**

Resistors are fixed, composition,  $\pm 10\%$  unless otherwise indicated.

R8	302-0563-00	56 k $\Omega$	$\frac{1}{2}$ W	
R13	301-0750-00	75 $\Omega$	$\frac{1}{2}$ W	5%
R15	301-0101-00	100 $\Omega$	$\frac{1}{2}$ W	5%
R19	301-0121-00	120 $\Omega$	$\frac{1}{2}$ W	5%
R23	301-0151-00	150 $\Omega$	$\frac{1}{2}$ W	5%
R27	301-0181-00	180 $\Omega$	$\frac{1}{2}$ W	5%
R31	301-0221-00	220 $\Omega$	$\frac{1}{2}$ W	5%
R35	301-0271-00	270 $\Omega$	$\frac{1}{2}$ W	5%
R39	315-0270-00	27 $\Omega$	$\frac{1}{4}$ W	5%
R40	323-0637-00	50 $\Omega$	$\frac{1}{2}$ W	Prec $\frac{1}{4}\%$
R41	318-0092-00	40.9 $\Omega$	$\frac{1}{8}$ W	Prec $\frac{1}{2}\%$
R42A	318-0093-00	20.2 $\Omega$	$\frac{1}{8}$ W	Prec $\frac{1}{2}\%$
R42B	318-0093-00	20.2 $\Omega$	$\frac{1}{8}$ W	Prec $\frac{1}{2}\%$

Electrical Parts List—Type 191

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.		Description		S/N Range
R43	318-0092-00	40.9 Ω	1/8 W	Prec	1/2 %
R44	318-0092-00	40.9 Ω	1/8 W	Prec	1/2 %
R45A	318-0093-00	20.2 Ω	1/8 W	Prec	1/2 %
R45B	318-0093-00	20.2 Ω	1/8 W	Prec	1/2 %
R46	318-0092-00	40.9 Ω	1/8 W	Prec	1/2 %
R47	318-0092-00	40.9 Ω	1/8 W	Prec	1/2 %
R48A	318-0093-00	20.2 Ω	1/8 W	Prec	1/2 %
R48B	318-0093-00	20.2 Ω	1/8 W	Prec	1/2 %
R49	318-0092-00	40.9 Ω	1/8 W	Prec	1/2 %
R51	311-0344-00	100 Ω		Var	
R52	321-0129-00	215 Ω	1/8 W	Prec	1 %
R53A	322-0649-00	266 Ω	1/4 W	Prec	1/2 %
R53B	322-0649-00	266 Ω	1/4 W	Prec	1/2 %
R53C	322-0649-00	266 Ω	1/4 W	Prec	1/2 %
R53D	322-0649-00	266 Ω	1/4 W	Prec	1/2 %
R53E	322-0649-00	266 Ω	1/4 W	Prec	1/2 %
R53F	322-0649-00	266 Ω	1/4 W	Prec	1/2 %
R53G	322-0649-00	266 Ω	1/4 W	Prec	1/2 %
R53H	322-0649-00	266 Ω	1/4 W	Prec	1/2 %
R53J	322-0649-00	266 Ω	1/4 W	Prec	1/2 %
R53K	322-0649-00	266 Ω	1/4 W	Prec	1/2 %
R53L	322-0649-00	266 Ω	1/4 W	Prec	1/2 %
R55	311-0404-00	1 kΩ		Var	
R56	321-0174-00	634 Ω	1/8 W	Prec	1 %
R58 <sup>1</sup>	*311-0586-00	1 kΩ		Var	
R60	316-0101-00	100 Ω	1/4 W		
R64	317-0220-00	22 Ω	1/10 W		5%
R67	316-0101-00	100 Ω	1/4 W		
R70	316-0101-00	100 Ω	1/4 W		
R71	302-0125-00	1.2 MΩ	1/2 W		
R72	316-0102-00	1 kΩ	1/4 W		
R75	315-0203-00	20 kΩ	1/4 W		5%
R76	315-0681-00	680 Ω	1/4 W		5%
R80	315-0821-00	820 Ω	1/4 W		5%
R81	315-0103-00	10 kΩ	1/4 W		5%
R83	315-0203-00	20 kΩ	1/4 W		5%
R84	315-0123-00	12 kΩ	1/4 W		5%
R90	306-0102-00	1 kΩ	2 W		
R92	316-0272-00	2.7 kΩ	2 W		
R93	315-0203-00	20 kΩ	1/4 W		5%
R94	304-0474-00	470 kΩ	1 W		
R95	302-0270-00	27 Ω	1/2 W		
R96	302-0270-00	27 Ω	1/2 W		
R97	302-0474-00	470 kΩ	1/2 W		

<sup>1</sup>Furnished as a unit with SW53.



Resistors (Cont'd)

Ckt. No.	Tektronix Part No.	Description		S/N Range	
R98	306-0102-00	1 kΩ	2 W		
R99	306-0102-00	1 kΩ	2 W		
R109	302-0151-00	150 Ω	1/2 W		
R111	316-0100-00	10 Ω	1/4 W		
R112	316-0100-00	10 Ω	1/4 W		
R115	315-0680-00	68 Ω	1/4 W		5% 100-1059
R115	315-0820-00	82 Ω	1/4 W		5% 1060-1353
R115	315-0910-00	91 Ω	1/4 W	Selected (nominal value)	1354-up
R117	301-0432-00	4.3 kΩ	1/2 W		
R118	303-0272-00	2.7 kΩ	1 W		5%
R120	321-0239-00	3.01 kΩ	1/8 W	Prec	1%
R121	321-0258-00	4.75 kΩ	1/8 W	Prec	1%
R122	311-0404-00	1 kΩ		Var	
R123	323-0222-00	2 kΩ	1/2 W		Prec 1%
R125	316-0223-00	22 kΩ	1/4 W		
R131	302-0100-00	10 Ω	1/2 W		
R132	304-0271-00	270 Ω	1 W		
R135	306-0184-00	180 kΩ	2 W		
R137	302-0394-00	390 kΩ	1/2 W		
R138	302-0274-00	270 kΩ	1/2 W		
R140	304-0472-00	4.7 kΩ	1 W		

Switches

	Unwired	Wired		
SW10	260-0768-00	*262-0744-00	Rotary	FREQUENCY RANGE
SW40	260-0769-00	*262-0743-00	Rotary	AMPLITUDE RANGE
SW53 <sup>2</sup>	260-0770-00	*262-0745-00	Rotary	AMPLITUDE
SW101	260-0014-00		Toggle	POWER
SW105	260-0675-00		Slide	115 V - 230 V

Transformers

T10	*114-0204-00	2.3-4 mH	Var	core 276-0508-00
T14	*114-0203-00	1.5-2.5 mH	Var	core 276-0508-00
T18	*114-0060-00	0.4-7.6 mH	Var	core 276-0508-00
T22	*114-0061-00	70-99 μH	Var	core 276-0508-00
T26	*114-0062-00	9-16 μH	Var	core 276-0508-00
T30	*114-0063-00	1.8-3 μH	Var	core 276-0508-00
T34	*114-0202-00	0.28-0.4 μH	Var	core 276-0508-00
T38	Use *114-0201-01	80-100 nH	Var	core 276-0506-00
T101	*120-0424-00	LV Power		

Electron Tubes

V10	154-0340-00	7119
V94	154-0340-00	7119

<sup>2</sup>Furnished as a unit with R58.

## FIGURE AND INDEX NUMBERS

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

## INDENTATION SYSTEM

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

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

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

**Mounting hardware must be purchased separately, unless otherwise specified.**

## PARTS ORDERING INFORMATION

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

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

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

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

## ABBREVIATIONS AND SYMBOLS

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

**INDEX OF MECHANICAL PARTS LIST ILLUSTRATIONS**

<b>FIG. 1</b>	<b>FRONT</b>
<b>FIG. 2</b>	<b>CHASSIS</b>
<b>FIG. 3</b>	<b>CABINET</b>
<b>FIG. 4</b>	<b>ACCESSORIES</b>

# SECTION 8

## MECHANICAL PARTS LIST

FIG. 1 FRONT AND REAR

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q † y	Description
		Eff	Disc		
1-1	333-0927-00			1	PANEL, front
-2	386-1019-00			1	PLATE, sub-panel
-3	366-0117-01			1	KNOB, charcoal—Frequency Dial
	- - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-4	331-0170-00			1	POINTER
	- - - - -			-	mounting hardware: (not included with pointer)
-5	211-0099-00			3	SCREW, 4-40 x 5/16 inch, 100° csk, FHS
	- - - - -				
-6	331-0140-00			1	DRIVE, dial, 3:1 ratio
	- - - - -			-	drive includes:
	213-0020-00			2	SCREW, set, 6-32 x 1/8 inch, HSS
	- - - - -			-	mounting hardware: (not included with drive)
-7	354-0289-00			1	RING, mounting
-8	210-0586-00			4	NUT, keps, 4-40 x 1/4 inch
	- - - - -				
-9	- - - - -			1	CAPACITOR, variable
	- - - - -			-	capacitor includes:
	344-0136-00	X264		1	CLIP, ground
	- - - - -			-	mounting hardware: (not included with capacitor)
-10	407-0222-00			1	BRACKET, angle, rear
-11	407-0221-00			1	BRACKET, angle, front
-12	212-0001-00	100	369	4	SCREW, 8-32 x 1/4 inch, PHS
	212-0084-00	370		4	SCREW, 8-32 x 5/16 inch, HHS
	210-0804-00	X370		4	WASHER, flat, 0.170 ID x 3/8 inch OD
-13	211-0507-00			4	SCREW, 6-32 x 5/16 inch, PHS
	210-0803-00			4	WASHER, flat, 0.150 ID x 3/8 inch OD
	- - - - -				
-14	366-0322-01			1	KNOB, charcoal—FREQUENCY RANGE
	- - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-15	262-0744-00			1	SWITCH, wired—FREQUENCY RANGE
	- - - - -			-	switch includes:
	260-0768-00			1	SWITCH, unwired
-16	131-0375-00			1	CONNECTOR, coaxial, 1-contact
	- - - - -			-	mounting hardware: (not included with switch)
-17	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
	210-0840-00			1	WASHER, flat, 0.390 ID x 7/16 inch OD
	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD



FIG. 1 FRONT AND REAR (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q					Description	
				†	Y	1	2	3		4
1-18	260-0014-00			1						SWITCH, toggle—POWER
	- - - - -			-						mounting hardware: (not included with switch)
	210-0414-00			1						NUT, hex., 1 <sup>5</sup> / <sub>32</sub> -32 x <sup>9</sup> / <sub>16</sub> inch
-19	354-0055-00			1						RING, locking, switch
	210-0902-00			1						WASHER, flat, 0.470 ID x 2 <sup>1</sup> / <sub>32</sub> inch OD
-20	210-0473-00			1						NUT, switch, 1 <sup>5</sup> / <sub>32</sub> -32 x 0.634 inch, 12 sided
-21	670-0224-00			1						ASSEMBLY, circuit board—DETECTOR
	- - - - -			-						assembly includes:
	388-0681-00			1						BOARD, circuit
	- - - - -			-						board includes:
-22	214-0506-00			3						PIN, connector, straight
-23	131-0391-00			1						CONNECTOR, coaxial, 1-contact
-24	352-0041-00			3						CLIP, diode
	- - - - -			-						mounting hardware: (not included with assembly)
-25	220-0449-00	100	259	2						NUT, hex., 4-40 x 1/4 x 1/2 inch long
-26	211-0116-00	100	259	2						SCREW, sems, 4-40 x <sup>5</sup> / <sub>16</sub> inch, PHB
	210-0994-00	260		2						WASHER, flat, 0.125 ID x 0.250 inch OD
	210-0004-00	260		2						LOCKWASHER, internal, #4
	210-0406-00	260		2						NUT, hex., 4-40 x <sup>3</sup> / <sub>16</sub> inch
-27	366-0189-00			1						KNOB, red—VARIABLE
	- - - - -			-						knob includes:
	213-0020-00			1						SCREW, set, 6-32 x 1/8 inch, HSS
-28	366-0322-00			1						KNOB, charcoal—AMPLITUDE
	- - - - -			-						knob includes:
	213-0004-00			1						SCREW, set, 6-32 x <sup>3</sup> / <sub>16</sub> inch, HSS
-29	262-0745-00			1						SWITCH, wired—AMPLITUDE
	- - - - -			-						switch includes:
	260-0770-00			1						SWITCH, unwired
-30	166-0026-00			2						TUBE, spacer, 0.125 ID x <sup>3</sup> / <sub>16</sub> OD x <sup>3</sup> / <sub>8</sub> inch long
-31	211-0016-00			2						SCREW, 4-40 x <sup>5</sup> / <sub>8</sub> inch, RHS
	210-0054-00			2						LOCKWASHER, split, #4
-32	- - - - -			1						RESISTOR, variable
	- - - - -			-						resistor includes:
	213-0022-00			2						SCREW, set, 4-40 x <sup>3</sup> / <sub>16</sub> inch, HSS
-33	384-0358-01			1						ROD, extension
	- - - - -			-						mounting hardware: (not included with switch)
-34	210-0413-00			1						NUT, hex., <sup>3</sup> / <sub>8</sub> -32 x 1/2 inch
	210-0840-00			1						WASHER, flat, 0.390 ID x <sup>9</sup> / <sub>16</sub> inch OD
	210-0012-00			1						LOCKWASHER, internal, <sup>3</sup> / <sub>8</sub> ID x 1/2 inch OD
-35	136-0164-00			1						SOCKET, lamp
	- - - - -			-						mounting hardware: (not included with socket)
	210-0413-00			1						NUT, hex., <sup>3</sup> / <sub>8</sub> -32 x 1/2 inch
	210-0012-00			1						LOCKWASHER, internal, <sup>3</sup> / <sub>8</sub> ID x 1/2 inch OD
	210-0978-00			1						WASHER, flat, <sup>3</sup> / <sub>8</sub> ID x 1/2 inch OD
-36	210-0590-00			1						NUT, hex., <sup>3</sup> / <sub>8</sub> -32 x <sup>7</sup> / <sub>16</sub> inch

FIG. 1 FRONT AND REAR (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q † y	Description
		Eff	Disc		
1-37	366-0322-01			1	KNOB, charcoal—AMPLITUDE RANGE
	- - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-38	262-0743-00			1	SWITCH, wired—AMPLITUDE RANGE
	- - - - -			-	switch includes:
	260-0769-00			1	SWITCH, unwired
-39	132-0121-00			1	NUT, retaining
-40	175-0376-00			1	ASSEMBLY, cable and connector
	- - - - -			-	assembly includes:
-41	166-0221-00			2	TUBE, ferrule
-42	132-0002-00			1	SLEEVE, conductor, outer
-43	132-0029-00			1	CONDUCTOR, inner
-44	132-0028-00			1	INSULATOR
-45	132-0116-00			1	TRANSITION, inner
-46	132-0007-00			1	RING, snap
-47	132-0115-00			1	TRANSITION, outer
	132-0119-00			1	DISC, plastic (not shown)
-48	166-0239-00			1	TUBE, adapter, coaxial
-49	132-0001-00			1	NUT, coupling
	- - - - -			-	mounting hardware: (not included with switch)
-50	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
-51	210-0840-00			1	WASHER, flat, 0.390 ID x 3/16 inch OD
	- - - - -				
-52	132-0040-00			1	ADAPTER, panel
	- - - - -			-	mounting hardware: (not included with adapter)
-53	211-0101-00			4	SCREW, 4-40 x 1/4 inch, 100° csk, FHS
	- - - - -				
-54	131-0102-00			1	ASSEMBLY, 3 wire connector
	- - - - -			-	assembly includes:
-55	129-0041-00			1	POST, ground
-56	200-0185-00			1	COVER, plastic
-57	211-0015-00			1	SCREW, 4-40 x 1/2 inch, RHS
-58	214-0078-00			2	PIN, connecting
-59	377-0041-00			1	INSERT, plastic
-60	386-0933-00			1	PLATE
-61	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
	210-0003-00			2	LOCKWASHER, external, #4
	- - - - -			-	mounting hardware: (not included with assembly)
	211-0542-00			2	SCREW, 6-32 x 3/16 inch, THS
-62	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch
	210-0202-00			2	LUG, solder, SE #6
	- - - - -				
-63	352-0002-00			1	ASSEMBLY, fuse holder
	- - - - -			-	assembly includes:
-64	352-0010-00			1	HOLDER, fuse
-65	210-0873-00			1	WASHER, rubber, 1/2 ID x 1 1/16 inch OD
-66	200-0582-00			1	CAP, fuse
-67	- - - - -			1	NUT, hex.

FIG. 1 FRONT AND REAR (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q					Description	
				t	y	1	2	3		4
1-68	214-0680-00			1						PIN, locating
	- - - - -			-						mounting hardware: (not included with pin)
	210-0458-00			1						NUT, keps, 8-32 x 1 1/32 inch
-69	386-1018-00			1						PLATE, rear
-70	384-0615-00			3						ROD, spacer
	- - - - -			-						mounting hardware for each: (not included with rod)
-71	212-0044-00			1						SCREW, 8-32 x 1/2 inch, RHS
-72	351-0096-00			1						GUIDE, rail
	- - - - -			-						mounting hardware: (not included with guide)
	212-0044-00			1						SCREW, 8-32 x 1/2 inch, RHS
	211-0559-00			2						SCREW, 6-32 x 3/8 inch, 100° csk, FHS
-73	214-0680-00			1						PIN, locating
-74	214-0553-00			1						SCREW, latch
-75	358-0255-00			1						BUSHING, latch
-76	213-0120-00	100	219	2						SCREW, thread forming, 2-32 x 1/4 inch, PHS
	211-0001-00	220		2						SCREW, 2-56 x 1/4 inch, RHS
	210-0405-00	X220		2						NUT, hex., 2-56 x 3/16 inch
-77	260-0675-00			1						SWITCH, slide—115 V-230 V
	- - - - -			-						mounting hardware: (not included with switch)
-78	211-0008-00			2						SCREW, 4-40 x 1/4 inch, PHS
	210-0406-00			2						NUT, hex., 4-40 x 3/16 inch

FIG. 2 CHASSIS

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Disc	Q f Y						Description
				1	2	3	4	5	
2-1	441-0663-00		1						CHASSIS, vertical
	- - - - -		-						mounting hardware: (not included with chassis)
	211-0542-00		2						SCREW, 6-32 x 5/16 inch, THS
	211-0538-00		3						SCREW, 6-32 x 5/16 inch, 100° csk, FHS
-2	441-0662-00		1						CHASSIS, power
	- - - - -		-						mounting hardware: (not included with chassis)
	211-0507-00		1						SCREW, 6-32 x 5/16 inch, PHS
	211-0542-00		2						SCREW, 6-32 x 5/16 inch, THS
-3	136-0181-00		6						SOCKET, transistor, 3-pin
-4	354-0234-00		6						RING, socket mounting
-5	210-0201-00		12						LUG, solder, SE #4
	- - - - -		-						mounting hardware for each: (not included with lug)
-6	213-0044-00		1						SCREW, thread forming, 5-32 x 3/16 inch, PHS
-7	426-0121-00		1						HOLDER, toroid
-8	361-0007-00		1						SPACER, plastic, 0.188 inch long
-9	- - - - -		1						RESISTOR, variable
	- - - - -		-						mounting hardware: (not included with resistor)
	210-0583-00		1						NUT, hex., 1/4-32 x 5/16 inch
	210-0940-00		1						WASHER, flat, 1/4 ID x 3/8 inch OD
-10	- - - - -		1						CAPACITOR
	- - - - -		-						mounting hardware: (not included with capacitor)
-11	386-0253-00		1						PLATE, metal, small
	211-0534-00		2						SCREW, sems, 6-32 x 5/16 inch, PHS
	210-0457-00		2						NUT, keps, 6-32 x 5/16 inch
-12	358-0215-00		1						BUSHING, plastic
-13	- - - - -		7						COIL
	- - - - -		-						mounting hardware for each: (not included with coil)
-14	210-0413-00		1						NUT, hex., 3/8-32 x 1/2 inch
-15	210-0840-00		1						WASHER, flat, 0.390 ID x 9/16 inch OD
-16	210-0407-00		1						NUT, hex., 6-32 x 1/4 inch
	210-0012-00		1						LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
-17	- - - - -		1						COIL
	- - - - -		-						mounting hardware: (not included with coil)
-18	211-0507-00		1						SCREW, 6-32 x 5/16 inch, PHS
-19	- - - - -		2						RESISTOR, variable
	- - - - -		-						mounting hardware for each: (not included with resistor)
-20	210-0583-00		1						NUT, hex., 1/4-32 x 5/16 inch
	210-0940-00		1						WASHER, flat, 1/4 ID x 3/8 inch OD
-21	214-0210-00		1						ASSEMBLY, solder spool
	- - - - -		-						assembly includes:
	214-0209-00		1						SPOOL, w/o solder
	- - - - -		-						mounting hardware: (not included w/assembly)
	361-0007-00		1						SPACER, plastic, 0.188 inch long
-22	343-0088-00		2						CLAMP, cable, small



FIG. 2 CHASSIS (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Disc	Q † y	1 2 3 4 5					Description
				1	2	3	4	5	
2-23	348-0031-00		2						GROMMET, plastic, 5/32 inch diameter
-24	348-0056-00		1						GROMMET, plastic, 3/8 inch diameter
-25	348-0055-00		1						GROMMET, plastic, 1/4 inch diameter
-26	- - - - -		1						TRANSFORMER
	- - - - -		-						transformer includes:
-27	212-0515-00		4						SCREW, 10-32 x 2 1/4 inch, HHS
	210-0812-00		4						WASHER, fiber, 0.190 ID x 0.380 inch OD
	- - - - -		-						mounting hardware: (not included with transformer)
-28	220-0410-00		4						NUT, keps, 10-32 x 3/8 inch
-29	136-0074-00		1						SOCKET, tube, 9-pin, w/o saddle
	- - - - -		-						mounting hardware: (not included with socket)
-30	354-0109-00		1						HOLDER, tube socket
-31	337-0005-00		1						SHIELD, tube socket
	211-0012-00		2						SCREW, 4-40 x 3/8 inch, PHS
	210-0586-00		2						NUT, keps, 4-40 x 1/4 inch
-32	337-0810-00		2						SHIELD, tube
-33	- - - - -		1						CAPACITOR
	- - - - -		-						mounting hardware: (not included with capacitor)
-34	386-0252-00		1						PLATE, fiber, small
-35	211-0534-00		2						SCREW, sems, 6-32 x 5/16 inch, PHS
	210-0457-00		2						NUT, keps, 6-32 x 5/16 inch
-36	200-0256-00		1						COVER, capacitor
-37	- - - - -		1						CAPACITOR
	- - - - -		-						mounting hardware: (not included with capacitor)
-38	386-0255-00		1						PLATE, metal, large
-39	211-0534-00		2						SCREW, sems, 6-32 x 5/16 inch, PHS
	210-0457-00		2						NUT, keps, 6-32 x 5/16 inch
-40	- - - - -		1						CAPACITOR
	- - - - -		-						mounting hardware: (not included with capacitor)
-41	214-0456-00		1						FASTENER, plastic
-42	136-0022-00		1						SOCKET, tube, 9-pin, w/shield
	- - - - -		-						mounting hardware: (not included with socket)
	213-0044-00		2						SCREW, thread forming, 5-32 x 3/16 inch, PHS
-43	179-1024-00		1						CABLE HARNESS
	- - - - -		-						cable harness includes:
	131-0371-00		3						CONNECTOR, single contact
-44	124-0149-00		1						STRIP, ceramic, 7/16 inch h, w/7 notches
	- - - - -		-						strip includes:
	355-0046-00		2						STUD, plastic
	- - - - -		-						mounting hardware: (not included with strip)
	361-0009-00		2						SPACER, plastic, 0.406 inch long
-45	124-0162-00		2						STRIP, ceramic, 7/16 inch h, w/4 notches
	- - - - -		-						each strip includes:
	355-0046-00		1						STUD, plastic
	- - - - -		-						mounting hardware for each: (not included with strip)
	361-0009-00		1						SPACER, plastic, 0.406 inch long

FIG. 2 CHASSIS (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Disc	Q † y						Description
				1	2	3	4	5	
2-46	124-0146-00		2						STRIP, ceramic, $\frac{7}{16}$ inch h, w/16 notches
	- - - - -		-						each strip includes:
	355-0046-00		2						STUD, plastic
	- - - - -		-						mounting hardware for each: (not included with strip)
	361-0009-00		2						SPACER, plastic, 0.406 inch long
-47	124-0149-00		1						STRIP, ceramic, $\frac{7}{16}$ inch h, w/7 notches
	- - - - -		-						strip includes:
	355-0046-00		2						STUD, plastic
	- - - - -		-						mounting hardware: (not included with strip)
	361-0009-00		2						SPACER, plastic, 0.406 inch long
-48	124-0145-00		2						STRIP, ceramic, $\frac{7}{16}$ inch h, w/20 notches
	- - - - -		-						each strip includes:
	355-0046-00		2						STUD, plastic
	- - - - -		-						mounting hardware for each: (not included with strip)
	361-0009-00		2						SPACER, plastic, 0.406 inch long

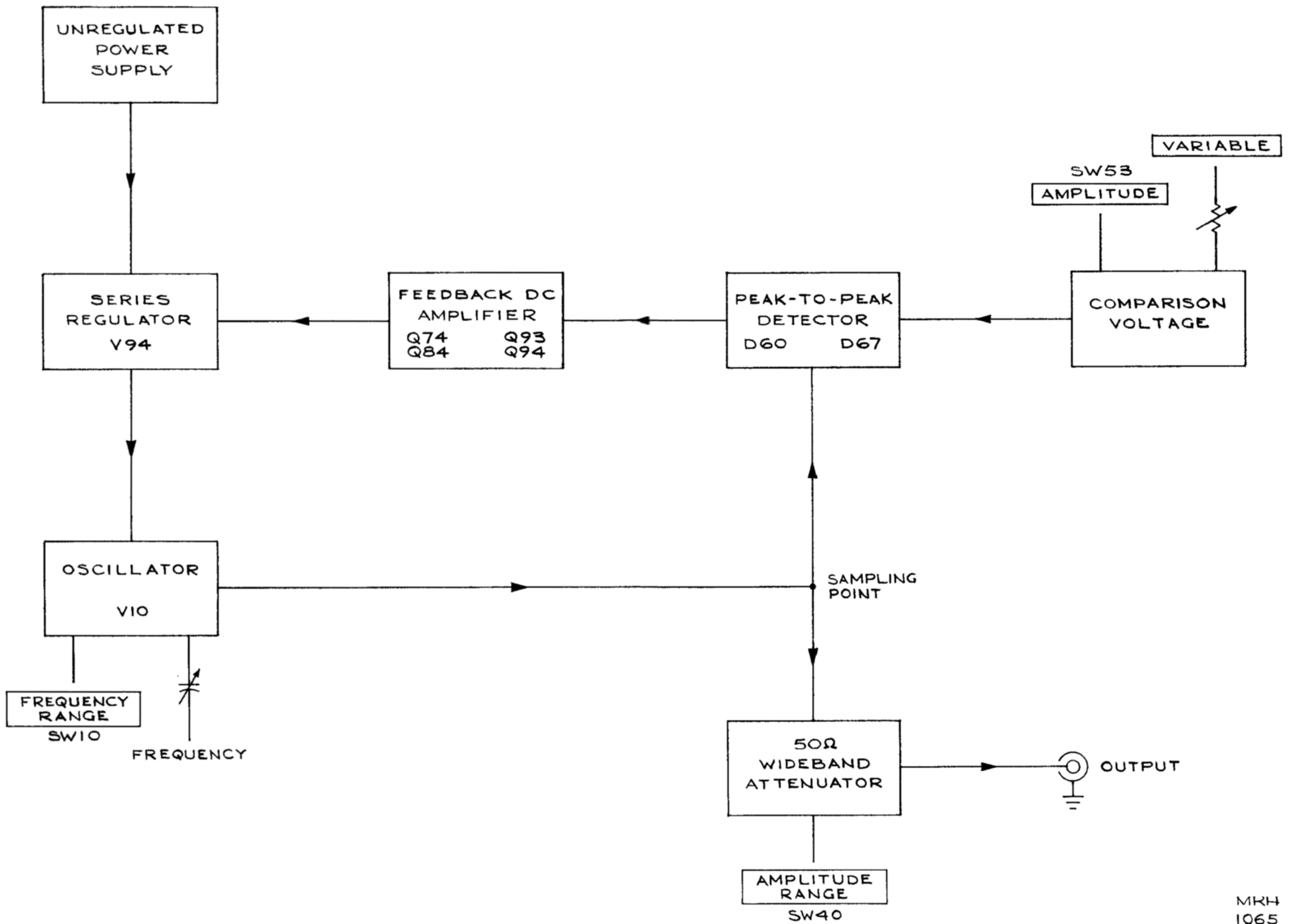
FIG. 3 CABINET

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Disc	Q					Description	
			t	Y	1	2	3		4
	437-0078-00		1						CABINET
3-1	- - - - -		-						cabinet includes:
	386-0141-00		2						PLATE, side
	- - - - -		-						mounting hardware for each: (not included w/plate alone)
	212-0002-00		2						SCREW, 8-32 x 1/4 inch, 100° csk, FHS
-2	426-0253-00		1						FRAME, front, left
-3	377-0121-00		1						INSERT, frame, left
-4	426-0252-00		1						FRAME, front, right
-5	377-0120-00		1						INSERT, frame, right
-6	426-0254-00		1						FRAME, front, bottom
	- - - - -		-						mounting hardware: (not included w/frame alone)
	212-0004-00		2						SCREW, 8-32 x 5/16 inch, PHS
	212-0002-00		2						SCREW, 8-32 x 1/4 inch, 100° csk, FHS
-7	426-0255-00		1						FRAME, front, top
	- - - - -		-						mounting hardware: (not included w/frame alone)
	212-0002-00		4						SCREW, 8-32 x 1/4 inch, 100° csk, FHS
-8	351-0093-00		1						GUIDE, left
	- - - - -		-						mounting hardware: (not included w/guide alone)
	212-0023-00		1						SCREW, 8-32 x 3/8 inch, PHS
	210-0007-00		1						LOCKWASHER, external, #8
-9	351-0092-00		1						GUIDE, right
-10	358-0293-01		1						BUSHING, plug-in securing, left
	- - - - -		-						mounting hardware: (not included w/bushing alone)
	211-0510-00		1						SCREW, 6-32 x 3/8 inch, PHS
	210-0005-00		1						LOCKWASHER, external, #6
	212-0001-00		1						SCREW, 8-32 x 1/4 inch, PHS
	210-0007-00		1						LOCKWASHER, external, #8
-11	358-0294-01		1						BUSHING, plug-in securing, right
	- - - - -		-						mounting hardware: (not included w/bushing alone)
	211-0510-00		1						SCREW, 6-32 x 3/8 inch, PHS
	210-0005-00		1						LOCKWASHER, external, #6
	212-0001-00		1						SCREW, 8-32 x 1/4 inch, PHS
	210-0007-00		1						LOCKWASHER, external, #8
-12	386-0139-00		1						PLATE, rear
-13	386-0140-00		1						PLATE, bottom
-14	386-0138-00		1						PLATE, top
-15	348-0075-00		2						FOOT, rear guard, left and right
	- - - - -		-						mounting hardware for each: (not included w/foot alone)
	212-0004-00		2						SCREW, 8-32 x 5/16 inch, PHS

FIG. 3 CABINET (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q					Description	
				t	y	1	2	3		4
3-16	348-0074-00			1						FOOT, rear, left
	- - - - -			-						mounting hardware: (not included w/foot alone)
	211-0532-00			2						SCREW, 6-32 x 3/4 inch, Fil HS
	348-0074-00			1						FOOT, front, right
	- - - - -			-						mounting hardware: (not included w/foot alone)
	211-0532-00			2						SCREW, 6-32 x 3/4 inch, Fil HS
	210-0457-00			1						NUT, keps, 6-32 x 5/16 inch
-17	378-0073-00			1						FOOT, front, left
	- - - - -			-						mounting hardware: (not included w/foot alone)
	211 0532-00			2						SCREW, 6-32 x 3/4 inch, Fil HS
	210-0457-00			1						NUT, keps, 6-32 x 5/16 inch
	348-0073-00			1						FOOT, rear, right
	- - - - -			-						mounting hardware: (not included w/foot alone)
	211-0532-00			2						SCREW, 6-32 x 3/4 inch, Fil HS
-18	377-0119-00			4						INSERT, foot
-19	348-0072-00			1						FOOT, flip-stand bail
-20	367-0052-00			1						HANDLE
	- - - - -			-						mounting hardware: not included w/handle alone)
	212-0040-00			2						SCREW, 8-32 x 3/8 inch, 100° csk, FHS
-21	367-0051-00			1						PIVOT, handle, left
-22	377-0123-00			1						PIVOT, insert, left
-23	367-0050-00			1						PIVOT, handle, right
-24	377-0122-00			1						PIVOT, insert, right
-25	214-0054-00			2						BOLT, hinge
	214-0558-00			2						WASHER, thrust, 5/16 x 1/2 inch





TYPE 191

A

MRH  
1065  
BLOCK DIAGRAM

## IMPORTANT

### VOLTAGE AND WAVEFORM CONDITIONS

Circuit voltages measured with a 20,000  $\Omega$ /volt VOM. All readings in volts. Voltages are measured with respect to chassis ground unless otherwise noted.

Waveforms shown are actual waveform photographs taken with a Tektronix Oscilloscope Camera System and Projected Graticule.

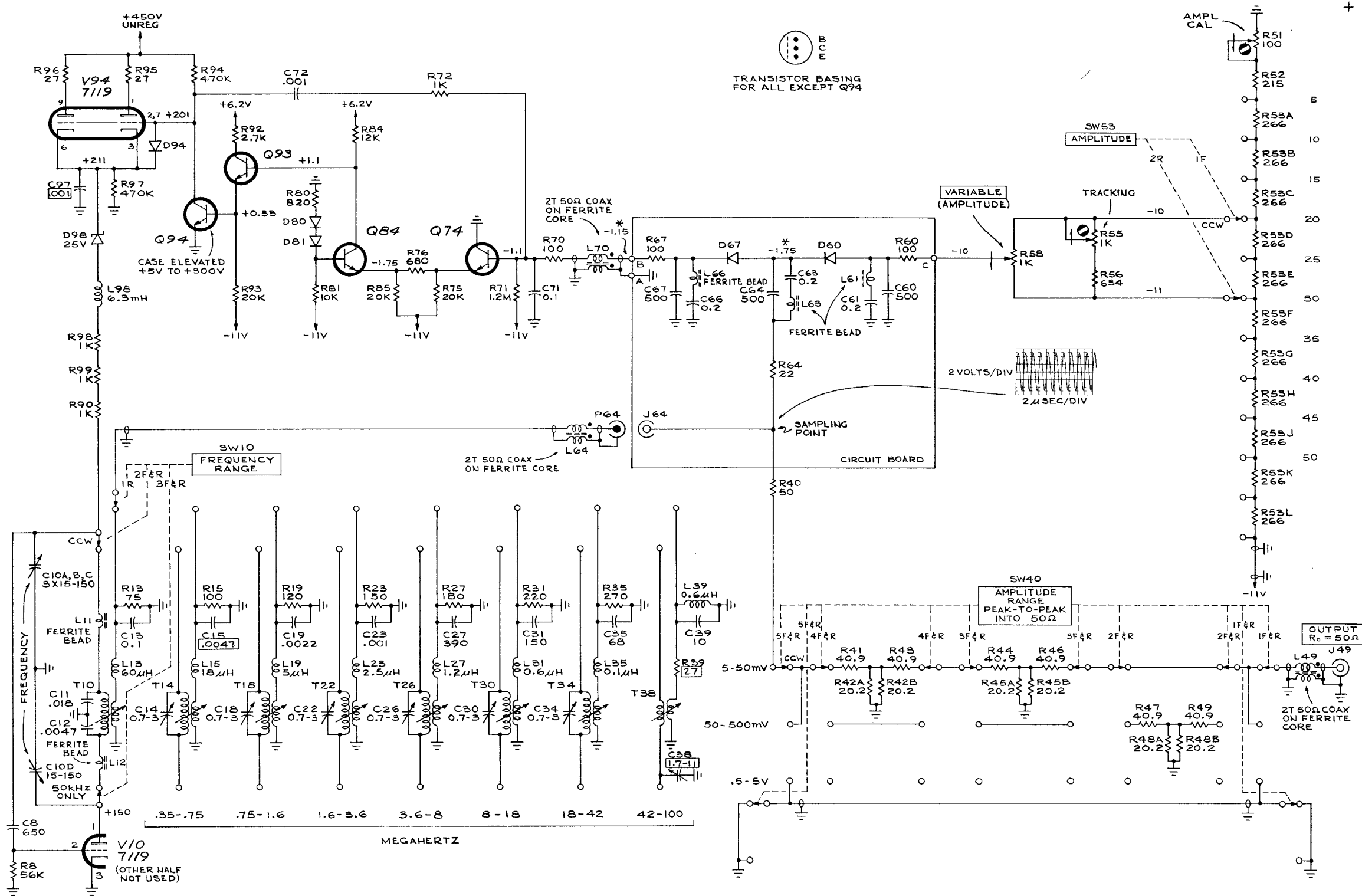
Voltages and waveform on the schematics (shown in blue) are not absolute and may vary between instruments.

The test oscilloscope used had the following characteristics: Minimum deflection factor, 0.5 volts/division using a 10 $\times$  probe; frequency response, dc to 30 MHz; AC input coupling was used.

To indicate true time relationship between signals, the test oscilloscope was externally triggered from the sampling point.

Voltage readings and waveforms were obtained under the following conditions unless otherwise noted on the individual diagrams:

POWER	ON
OUTPUT (Connector)	Terminated with 50 ohms
AMPLITUDE RANGE	.5-5 V
AMPLITUDE	50
VARIABLE (AMPLITUDE)	CAL
FREQUENCY RANGE	50 kHz ONLY
Frequency (dial)	Set to .5 mark of .35-.75 scale
115 V/230 V (rear panel)	Set for correct line voltage

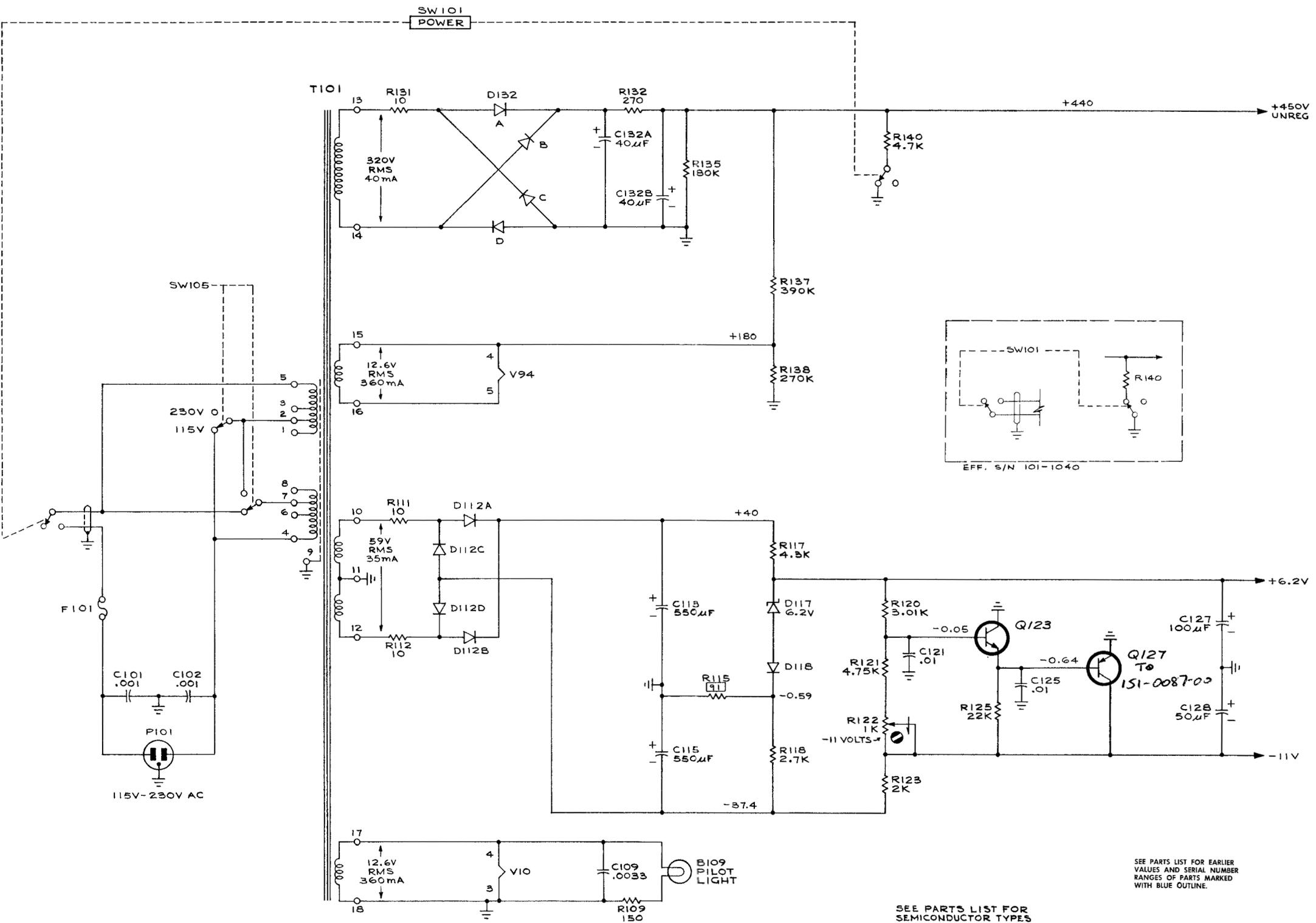


TRANSISTOR BASING FOR ALL EXCEPT Q94

\* HIGHEST PRACTICAL VOLTMETER RANGE USED

INACTIVE TANK CIRCUITS ARE SHORTED BY FREQUENCY RANGE SWITCH  
SEE PARTS LIST FOR SEMICONDUCTOR TYPES

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

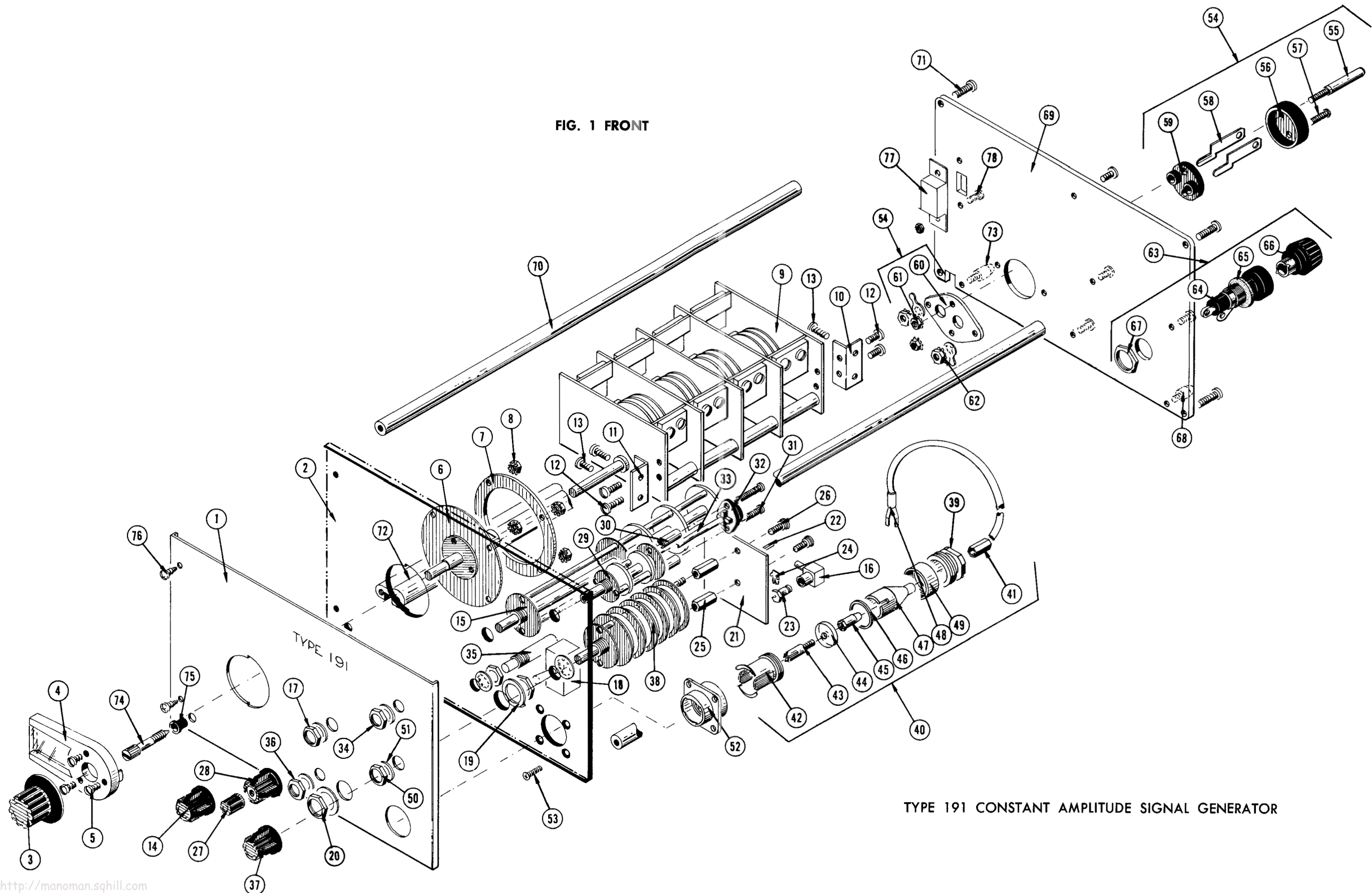


SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

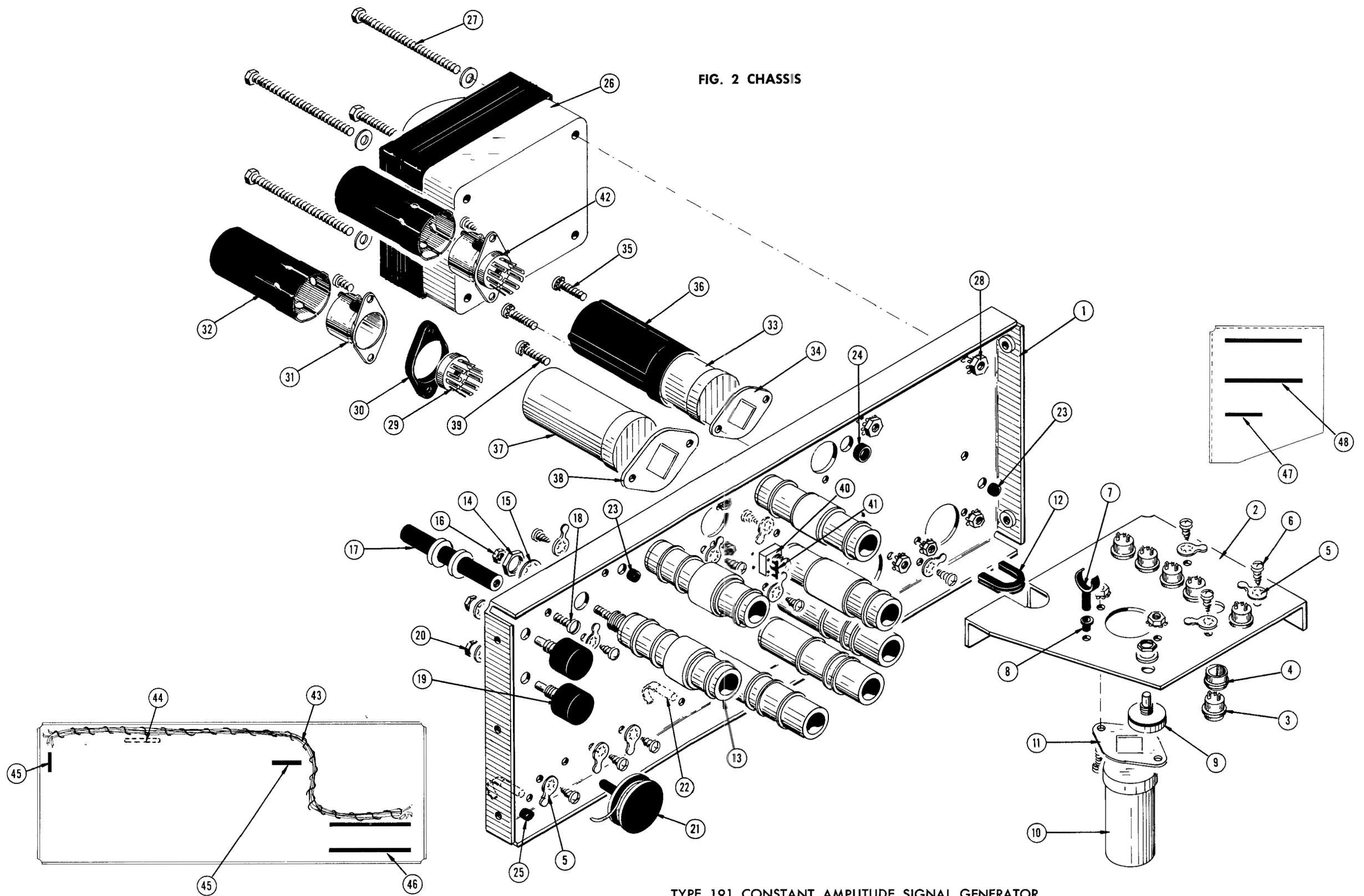


FIG. 1 FRONT



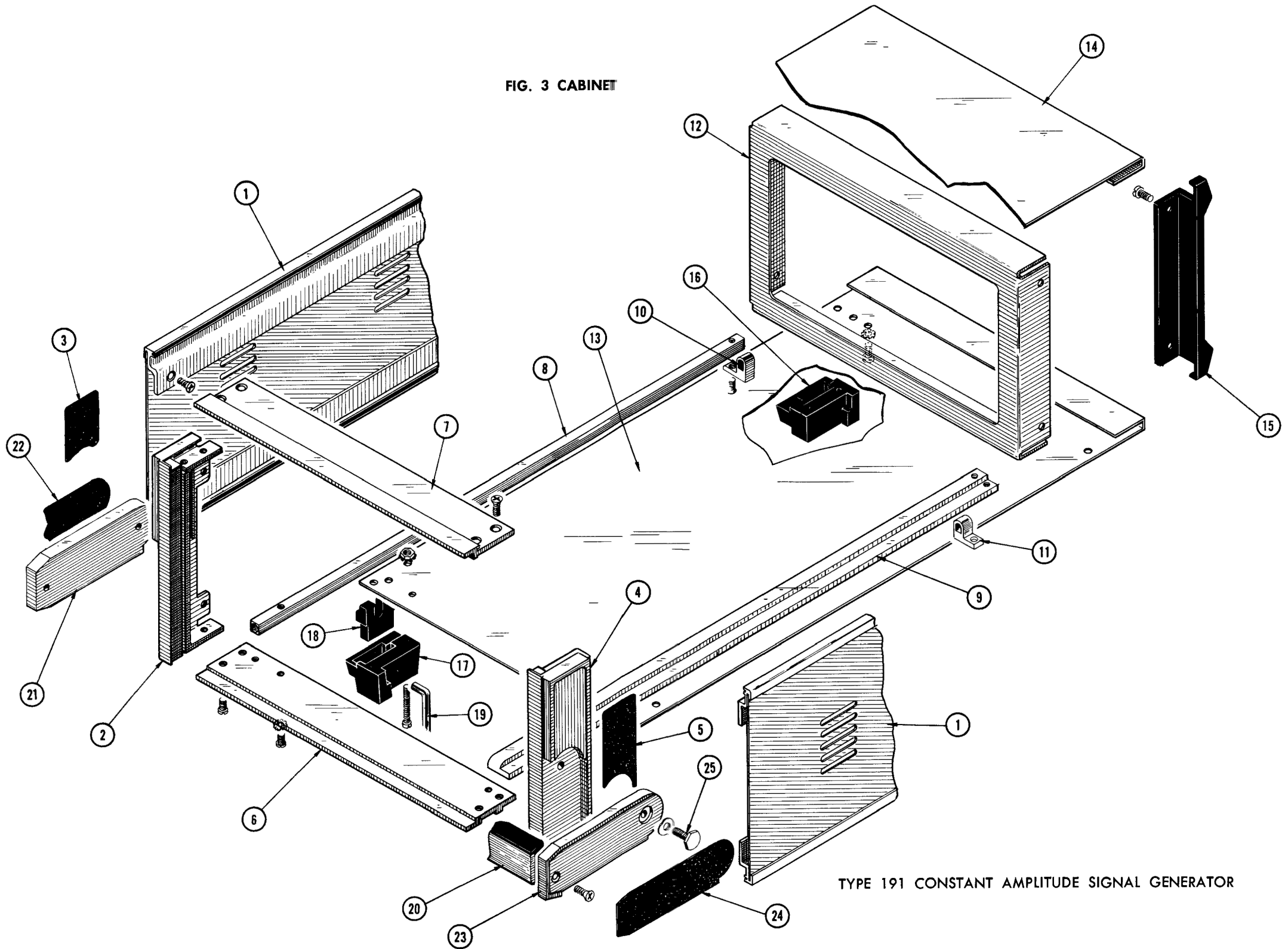
TYPE 191 CONSTANT AMPLITUDE SIGNAL GENERATOR

FIG. 2 CHASSIS



TYPE 191 CONSTANT AMPLITUDE SIGNAL GENERATOR

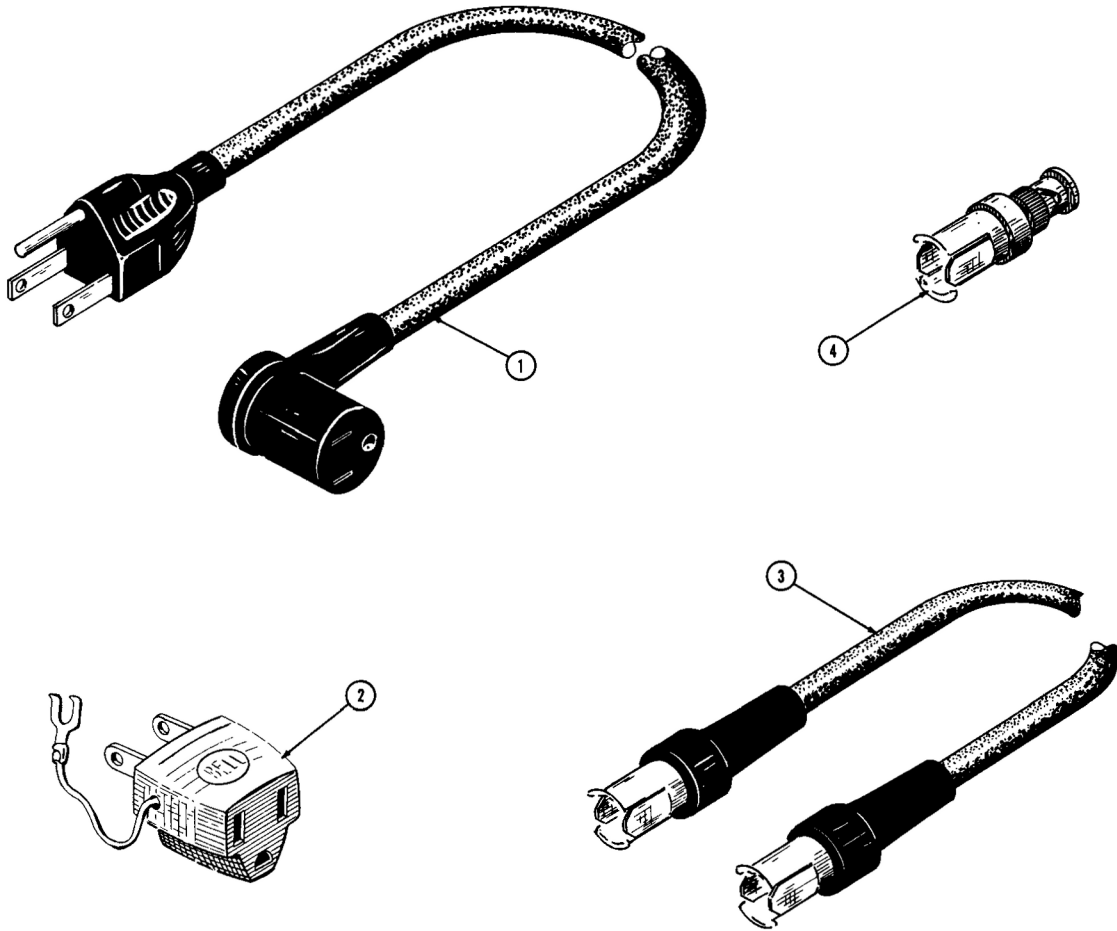
FIG. 3 CABINET



TYPE 191 CONSTANT AMPLITUDE SIGNAL GENERATOR

FIG. 4 STANDARD ACCESSORIES

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+ <sup>A</sup>

TYPE 191 CONSTANT AMPLITUDE SIGNAL GENERATOR

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Qty	Q					Description
					1	2	3	4	5	
4-1	161-0024-00	100	1349	1						CORD, power, 3-conductor, 8 feet
	161-0024-01	1350		1						CORD, power, 3-conductor, 8 feet
-2	103-0013-00			1						ADAPTER, power cord, 3 to 2 wire
-3	017-0502-00			1						CABLE, 50 ohm, 5 ns
-4	017-0083-00			1						TERMINATION, 50 ohm, GR to BNC
	070-0522-00			2						MANUAL, instruction (not shown)

ⓑ



## **MANUAL CHANGE INFORMATION**

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

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

CORRECTION NOTICE

Due to a temporary shortage of 40.9  $\Omega$ , 1/8 W, 1% resistors, a 41.2  $\Omega$ , 1/8 W, 1% resistor, selected to be within the tolerance range of the original resistor, may have been substituted for R41, R43, R44, R46, R47 and R49 in this instrument.

When ordering replacement parts, order the 40.9  $\Omega$  resistor for which information is given in the parts list.

TYPE 191

TENT SN 1660

PARTS LIST CORRECTION

CHANGE TO:

B109

150-0065-00 Incandescent, 10 V, 40 mA

M12,031/667

PARTS LIST CORRECTION

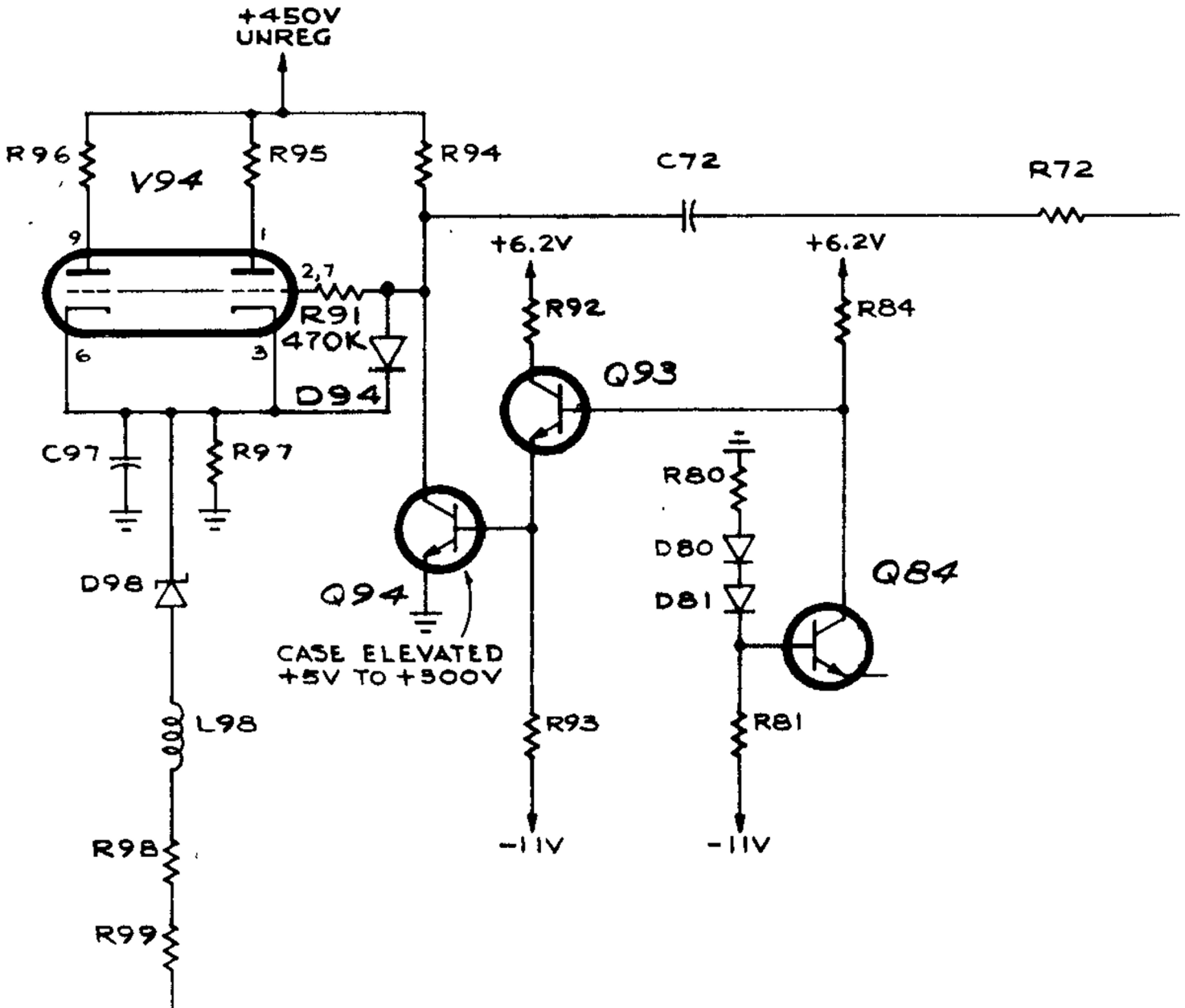
CHANGE TO:

Q94	151-0169-00	Silicom	2N3439
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ADD:

R91	302-0474-00	470 K	1/2 W	10 %
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SCHEMATIC CORRECTION



PARTIAL  
CONSTANT AMPLITUDE SIGNAL GENERATOR



TYPE 191

TENT SN 1354

PARTS LIST CORRECTION

CHANGE TO:

R115

315-0910-00

91  $\Omega$  (nominal installed value)

1/4 W

5 %

M12,422/567