MODEL 587A

DIODE CURVE TRACER

OPERATION MANUAL

KIKUSUI ELECTRONICS CORP.

1. INTRODUCTION

The Model 587A Diode curve Tracer is an equipment to visualize the foward and reverse voltage vs. current characteristics of various semiconductor diodes on the screen of cathode-ray tube. 11 voltage ranges and 19 current ranges covering from 0.1 volt/div. to 200 volts/div and from 0.001 mA/div to 1000 mA/div enable to trace the characteristics of practically all types of semiconductor diodes. Other features include illuminated scale, easy internal calibration, various self-protecting provisions, and regulated power supply. These features combined, this equipment can perform the test accurately, quickly, and continuously.

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2. SPECIFICATIONS

Power Requirement	_____ volts, 50 to 60 Hz. approx. 100 VA (approx. 220 VA when voltage range is Set at 200 volts peak and current at 1 amp. peak using a resistor as a load.)
Dimensions (Maximum)	310W x 420H x 451D mm (314W x 445H x 578D mm)
Weight	Approx. 30 kgs.
Accessories	Short Bar 1 Dissipation Limiting Resistor selection Chart 1 Operation Manual 1
Cathode-Ray Tube	5UP1-F Accelerating potential 1300 volts. 10 div x 10 div, 8mm/div, illuminated in white or red.
Power Circuit	Electronically regulated except for tube heater circuit.
Internal Test Voltage Supply	Power Line frequency, rectified wave, positive only. 3 range as follows:
Range 1	Full-wave, from 0 to 20 volts peak, 10 amp max.
Range 2	Full-wave, from 0 to 200 volts peak, 1 amp max.
Range 3	Half-wave, from 0 to 2000 volts peak, 0.1 amp max.
Overcurrent Cutoff Relay	Sensitivity is coupled with sensitivity of current axis (vertical axis) amplifier. To operate between 12 and 15 divs.

Overload Fuse — Provided on the panel

External Test Voltage — Terminals for external test voltage are provided on the panel.

Dissipation Limiting Resistors

19 position. 0/1/2/5/10 ..... 200K/500K ohms

Power Rating — 1/2/5 ..... 5K/10K ohms 80 or 100-watt rating
20K/50K ..... 500K ohms 2000-volt rating

Tolerance — ±10%

External Dissipation Limiting Resistors

Connecting terminals are provided on the panel.

Voltage Axis (Horizontal Axis)

11 ranges. 0.1/0.2/0.5 ..... 100/200 volts/div
Accuracy ±3%

Current Axis (Vertical Axis)

19 ranges. 0.001/0.002 ..... 500/1000 mA/div
Accuracy ±3%

Calibration Voltage — Voltage Axis 1 volt p-p square-wave
Current Axis 0.5 volt p-p square-wave

Shunt Capacitance Compensation

To compensate up to 70 pF in test voltage range from 0 to 20 volts.

3. FUNCTIONS OF CONTROLS AND TERMINALS

In order to better acquainted with functions of controls and terminals, block diagram of this equipment appearing in last pages of this manual will be also helpful.

3.1 Test Voltage Supply

TEST CIRCUIT FUSE A fuse for internal test voltage supply. Usually, 1-amp fast-blow type fuse is used.

ON TEST A neon lamp indicator. When internal test voltage supply is operating, this lamp is turned on. When overcurrent cutoff relay has operated, this lamp is turned off, and keeps off condition till TEST VOLTS knob is set in RESET position.

TEST VOLTS RANGE This is a range switch for internal test voltage supply. Figures indicate voltage range and maximum allowable current both in peak values. Wavefrom of test voltage is rectified full-wave at power line frequency in ranges 0 - 20 V and 0 - 200 V; and is rectified half-wave in range 0 - 2000 V. When CHARACTERISTICS knob is placed in FORWARD position, only 0 - 20 V range is available and other ranges are cutoff.

TEST VOLTS

This knob is continuously vary the test voltage within the range set by TEST VOLTS RANGE. When this knob is turned clockwise, a hazardous voltage may be appearing at sample connecting terminals.
Therefore, the operator should be accustomed to place this knob RESET position as soon as test is finished.

Figures around the knob indicate approximate voltages. Actual voltage at no load may be approximately 20% higher than indicated so as to allow voltage drop when load is connected.

At RESET position, overcurrent cut0ff relay is reset. (This function will be further explained in later section)

EXT↔ INT

When internal test voltage supply is used, this switch is turned to INT position. When any external test voltage supply is used, this switch is turned to EXT position.

EXT SUPPLY

These are input terminals to connect external test voltage supply. In connection, care should be paid to connect with right polarity. When not used, these terminals are short circuited using short bar.

3.2 Dissipation limiting resistance

In following explanation, we now assume that internal test voltage supply is used unless specifically noted otherwise.

DISSIPATION LIMITING RESISTORS	This is a switch to select dissipation limiting resistors provided in the equipment to protect sample diode under test, and at the same time, to protect test voltage supply circuit. Using Selection Chart appearing in the last section of this manual, an appropriate value is selected.
EXT ⟷ INT	When internal dissipation limiting resistors are used, this switch is turned to INT position. When other resistor is to be connected externally, this switch is turned to EXT position.
EXT RESISTOR	External dissipation limiting resistor is connected to these terminals. When such resistor is used, EXT⟷INT switch is turned to EXT position.

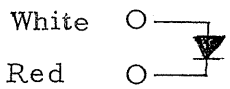
In following explanation, we now assume that internal test voltage supply and internal dissipation limiting resistors are used unless specifically noted otherwise.

3.3 Sample Connecting Terminals

CHARACTERISTICS — A switch to select the characteristics to be observed. In REVERSE position, sample can be tested in any range set by TEST VOLTS RANGE. In FORWARD position, sample can be tested only 0 - 20 V range of TEST VOLTS RANGE.

REVERSE FORWARD — These are lamps to indicate the characteristics being measured. These also serve as pilot lamp to indicate power being applied.

SAMPLE — A switch to allow comparative test on two diode samples. In lefthand position, sample diode connected to lefthand terminals is tested, and in righthand position, righthand sample is tested. Center position is OFF.



Two pairs of three terminals each. Sample is connected with polarity as indicated. GND terminal is connected to the panel. Note - In reverse characteristics measurement, a high voltage may be appearing at red terminal.

CAPACITY BALANCE

In test of high-voltage low-current diode, a trace on the screen may be looped due to shunt capacitance across sample diode. Turning this knob, such capacitance can be compensated.

3.4 Vertical and Horizontal Amplifiers

VERTICAL mA/DIV — A switch to select sensitivity of vertical (current axis) amplifier. Figures indicate milliamps per division. (one division is equal to 8 mm)

HORIZONTAL V/DIV — A switch to select sensitivity of horizontal (voltage axis) amplifier. Figures indicate volts per division (one division is equal to 8 mm).

10 DIV CALIBRATION — These are self-return toggle switches and screw driver adjustments for calibration of voltage and current axis. Pushing a switch downward, a line with high brilliance points on both ends appears on the screen. Then, the length of the line is adjusted to 10 division length on the screw driver adjustment. As switch is released, it automatically returns to measurement position.

3.5 Cathode-Ray Tube

INTENSITY — This is to control the intensity of the trace. As this knob is turned clockwise, the intensity increases.

FOCUS — This is to control the focus for the best sharpness of the trace. The best focus is usually obtained around center position.

ASTIGMATISM — In conjunction with FOCUS control, this knob is adjusted to obtain the best sharpness on any point of the trace. When setting of INTENSITY knob is changed, it usually requires to readjust these FOCUS and ASTIGMATISM knobs.

ILLUMINATION — This is to control the illumination on the scale. Turning clockwise, intensity increases. By mounting the scale sheet upside down, the color can be changed from white to red.

POSITION — These are to adjust the position of trace on the screen. Knob with marking ↕ is to adjust the position vertically and knob with marking ↔ is to adjust horizontally.

POWER — This is a toggle switch to turn the power on or off.

4. OPERATION

4.1 Overcurrent Cutoff Relay

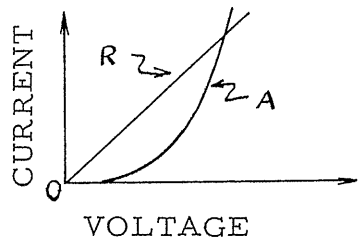
Overcurrent cutoff relay operates irrespectively to the voltage range of TEST VOLTS RANGE but in relation to the position of spot on the screen, and cuts the primary circuit of the test voltage supply off when characteristic curve appears in excess to the upper end of the scale by 2 or 3 divisions. As this relay operates, ON TEST lamp is turned off.

Therefore, when TEST VOLTS RANGE switch is placed in 0 - 200 V or 0 - 2000 V position, damage of sample diode can be eliminated by setting VERTICAL mA/DIV at higher sensitivity position than 100 mA/div or 10 mA/div.

4.2 Current Rating of TEST CIRCUIT

Capacity of internal test voltage supply has been designed assuming a resistive load. When a resistor is connected instead of diode, rated maximum current of 1.5 amps may flow in the test voltage supply. However, semiconductor diode usually exhibit the characteristics as shown in the figure. When only diodes are connected, therefore, 1-amp or less rated fuse is used to protect test voltage supply circuit.

R - Characteristics of Resistance
A - Typical Characteristics of Semiconductor Diode



4.3 Adjustment of Controls During Measurement

During measurement, following control knobs should not be adjusted

CHARACTERISTICS	Knob
TEST VOLTS RANGE	Knob
TEST VOLTS EXT ↔ INT	Toggle Switch
DISSIPATION LIMITING RESISTOR	Knob
DISSIPATION LIMITING RESISTOR EXT ↔ INT	Toggle Switch
SAMPLE	Toggle Switch
VERTICAL mA/DIV	Knob
TEST CIRCUIT FUSE	Fuse Holder

However, when test current is less than 1 ampere peak, and controls are turned toward less current positions, these controls may be turned. In turning CHARACTERISTICS and TEST VOLTS RANGE, however, TEST VOLTS should be placed in zero volt position.

4.4 Spot on the Screen

A spot on the screen will be stable within 5 minutes after power is applied. If it fluctuates after 5 minites of warm-up due to fluctuation in power line voltage or any other reason, it is necessary to adjust POSITION knobs at each time.

The spot should not be kept on a stationary point of the screen for appreciable length of time with high briliance because discoloration or burning of the screen may result. In such case, spot should be dimmed turning INTENSITY control or faded turning FOCUS knob.

Owing to residual voltage of sliding transformer, if it is unable to obtain a sharp spot even when TEST VOLTS knob is set at zero volt position, TEST VOLTS switch is turned to EXT position.

4.5 Inclination of Vertical or Horizontal Line on the Screen

Vertical or horizontal line on the screen might in some cases incline from right vertical or horizontal plane in relation to the place in which this equipment is installed. In such case, opening lefthand side board, cathode-ray tube is rotated at its base so as to compensate such inclination. In this case, 10 DIV CALIBRATION can be used to trace vertical or horizontal line on the screen.

4.6 Waveform of Internal Test Voltage Supply

Internal test voltage supply feeds sweep voltage with a waveform of rectified full-wave at power line frequency in ranges 0 - 20 V and 0 - 200 V. The waveform at these ranges can be changed to rectified half-wave by disconnecting SR5 and SR1 and 2 (or SR6 and SR3 and 4). If this is done, the spot remains at zero point on the screen for half cycle period, and the brilliance of zero point increases.

If the waveform is changed to rectified half-wave, the power consumed in dissipation limiting resistors becomes one-half, and rating of fuse in TEST CIRCUIT FUSE should be halved.

4.7 Maximum Ratings for External Connections

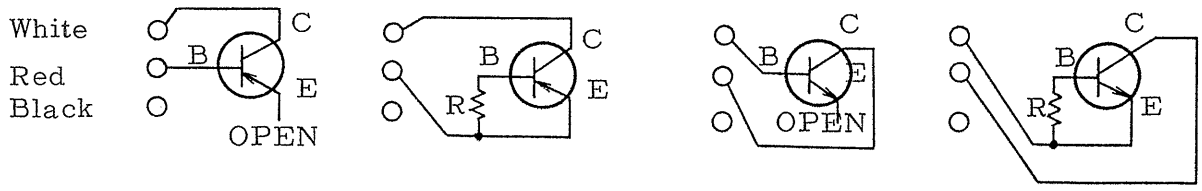
When TEST VOLTS EXT ⇔ INT switch is turned to EXT position, or DISSIPATION LIMITING RESISTOR EXT ⇔ INT switch is turned to EXT position, voltage and current at EXT terminals are not to exceed 2000 volts peak and 10 amperes peak, respectively.

4.8 Measurement of I_{CBO}, I_{CEO}, or I_{CER} of Transistors

This equipment can also be used to trace $V_{CB} - I_{CBO}$ and $V_{CE} - I_{CEO}$ characteristics of both PNP and NPN transistors.

CHARACTERISTICS switch is turned to REVERSE position, and same procedure as measurement of diodes is followed. Connections to terminals are made as showen below.

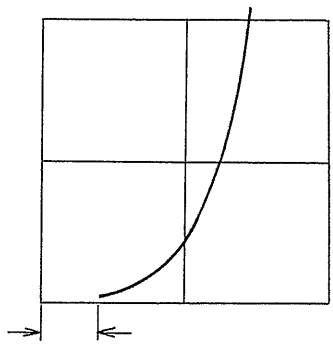
	PNP Transistors		NPN Transistors	
	I_{CBO}	I_{CER}, I_{CEO} (R ∞)	I_{CBO}	I_{CER}, I_{CEO} (R ∞)
White	C	C	C	C
Red	B	B	B	B
Black	E	E	E	E
	OPEN	R	OPEN	R



4.9 Vanish of Trace Arouned Zero Point

In measurement at low test voltage, according to increase in test voltage by TEST VOLTS control, trace around zero point vanishes as shown in the figure, and causes an illusion as if zero point has shifted rightward.

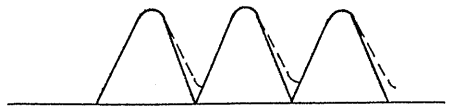
This vanish results from deformation of sweep voltage due to shunt capacitance developing in parallel to sample diode. (see figure)
This vanish therefore should not be regarded as the shift of zero point.



Trace may vanish in this area

In measurement at high voltage with high dissipation limiting resistor, trace around zero point may be darkened or faded because of high speed trace around zero point.

Sweep voltage deforms like dotted line due to parallel capacitance



4.10 Selection of Dissipation Limiting Resistors

A chart attached to the last of this manual is to show the relation among value of dissipation limiting resistor, peak test voltage, power dissipated in sample diode, and peak current when sample is short circuited.

Example 1: -- How many ohms of dissipation limiting resistor should be selected to test a diode at 2 volts peak and limiting its dissipation within 1 watt?

Answer: -- Cross point of 2 volts on Peak Test Voltage (horizontal) axis, and 1 watt on Peak Sample Power (vertical axis) is obtained. Then, it is read that dissipation limiting resistor of more than 1-ohm is satisfactory.

Example 2: -- Then, how many ohms when peak voltage of 1000 volts and dissipation of 100 mW.

Answer: -- Similarly to Example 1, it is read that dissipation limiting resistor of more than 2.5 megohms is satisfactory. However, such resistance is not provided in this equipment, therefore, it is necessary to prepare a resistor separately. Supposing short circuit of sample diode, such resistor should be rated at least 2 times of peak dissipation, i.e., 200 mW, and capable to withstand 1000 volts.

4.11 Limitation of Short Circuit Current

In order to avoid the internal test voltage supply damaged due to short circuit of sample, DISSIPATION LIMITING RESISTOR knob is usually set in following positions:

In range 0 - 20 V	More than 2 ohms
0 - 200 V	More than 200 ohms
0 - 2000 V	More than 2 Kiloohms

When it is required to measure with lower limiting resistance than noted above, a voltage which corresponds to lower current than peak maximum is obtained in the chart, and test is made below such voltage.

Example 3: -- When dissipation limiting resistor of 100 ohms is selected, how many volts of test voltage is allowed?

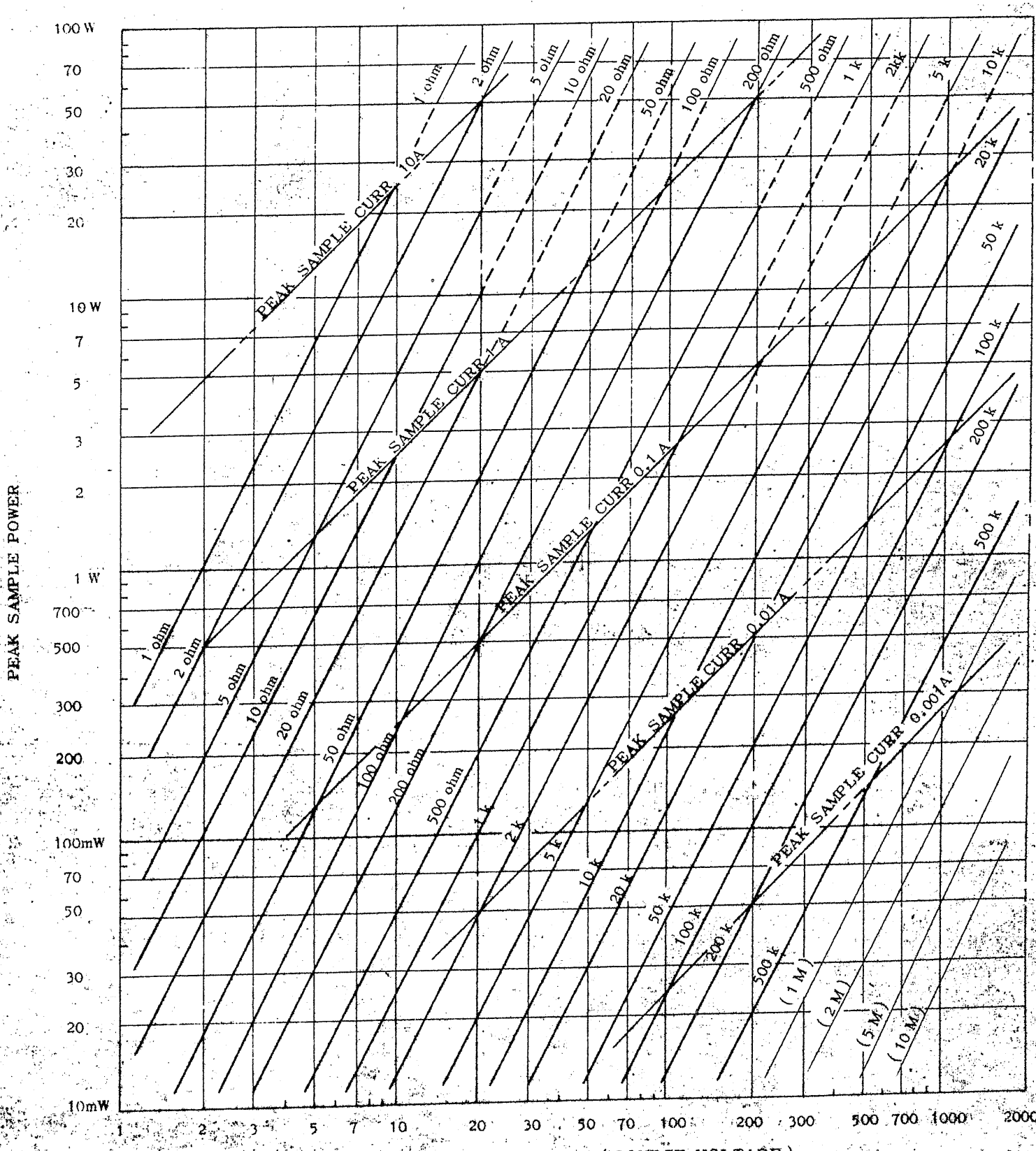
Answer: -- In range 0 - 20 V, it is perfectly safe. In ranges 0 - 200 V and 0 - 2000 V, maximum allowable peak voltages are 100 volts peak and 10 volts peak.

With internal test voltage supply, the test at a condition shown in the chart with dotted lines can not be made because current is excessing peak maximum in this area. When test is made in such condition, external test voltage supply is to be prepared.

The peak dissipation is assumed to be peak voltage (volts) by peak current (amps), and its RMS value is 1/2 of peak value in case of rectified full-wave and 1/4 of peak value in case of rectified half-wave.

DISSIPATION LIMITING RESISTOR

VOLTAGE TO CURRENT & POWER CHART



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5. MAINTENANCE

-HV ADJ

This adjustment is provided on lower chassis, and is to adjust high voltage supply for cathode-ray tube. This adjustment is adjusted so as to obtain -1100 volts at pin #3 of V9 using a vaccum tube volt-meter.

CAL V ADJ

This is to adjust the output voltage of internal square-wave generator to operate when 10 DIV CALIBRATION switch is pushed downward. In adjusting this, TEST VOLTS is turned to zero, and both EXT INT switches of TEST VOLTS and DISSIPATION LIMITING RESISTOR are put in EXT position, and both terminals for external connections are open circuited. In addition, SAMPLE switch is placed in OFF position.

1. Adjustment of 1 Vp-p for calibration of voltage axis amplifier (horizontal): -- Placing HORIZONTAL V/DIV in 0.1 V/DIV position, an accurate DC voltage of +1 volt is applied between red and black (GND) terminals for sample connection, and CHARACTERISTICS switch is placed in REVERSE position. Then, turning SAMPLE switch, horizontal traverse length of the spot is checked. Then pushing 10 DIV CALIBRATION, 1 Vp-p is turned so that length of horizontal line becomes equal to horizontal traverse length of the spot.
   During this adjustment, VERTICAL mA/DIV switch is turned at highest sensitivity position.

2. Adjustment of 0.5 Vp-p for calibration of current axis amplifier ((vertical) : -- Placing VERTICAL mA/DIV in 0.001 mA/DIV position, an accurate DC voltage of +0.5 volt is applied, and CHARACTERISTICS switch is placed in FORWARD position. Turning SAMPLE switch, if vertical traverse length is different from the length of vertical line, R 102 or R 103 is replaced so that these resistance values are equal each other. During this adjustment, HORIZONTAL V/DIV switch is turned at highest sensitivity position.

   In these measurements, when Model 494 Square-Wave Voltage Calibrator is used instead of accurate DC source, it is unnecessary to turn SAMPLE switch.

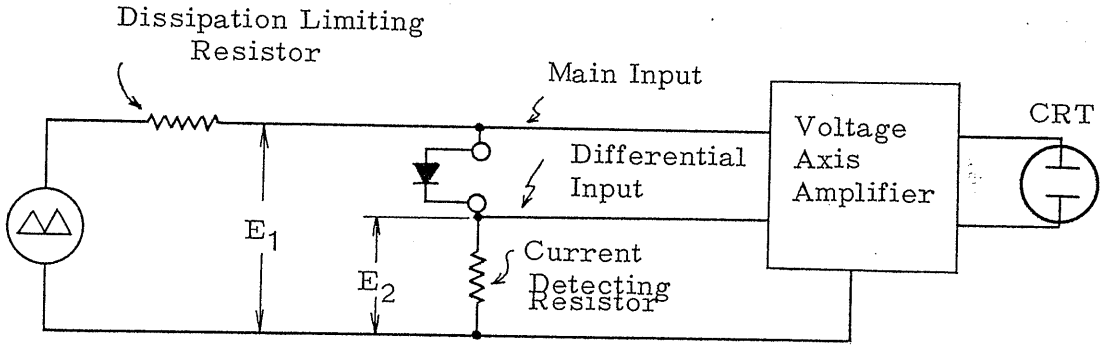
Measurement of Sensitivity of Voltage Axis (Horizontal) Amplifier

In order to obtain accurate voltage across the diode under test, voltage axis (horizontal) amplifier has a differentiating circuit to cancel voltage drop across the current detecting resistor. For this reason, in addition to the error (d1) of main input voltage (E1), the error (d2) of differential input voltage (E2) also relates to the total error, and the total error can be expressed by formula:

$$\triangle' = (E1 \cdot d1 - E2 \cdot d2)/(E1 - E2)$$

It is therefore understood that, the higher the sensitivity of current axis amplifier is, and the higher the amplitude of current is, the greater the effect of error in differentiating circuit results. Following table gives this relation.

When measuring forward characteristics



Range of HORIZONTAL V/DIV	Total Error: When both voltage and current amplitudes are 10 divs	Total Error: When current is zero
0.1 V/DIV	1.5 x dl - 0.5 x d2	dl
0.2	1.25 x dl - 0.25 x d2	dl
0.5	1.1 x dl - 0.1 x d2	dl
1	1.05 x dl - 0.05 x d2	dl
2	1.025 x dl - 0.025 x d2	dl
5	1.01 x dl - 0.01 x d2	dl
10	1.005 x dl - 0.005 x d2	dl
20	1.0025 x dl - 0.0025 x d2	dl