INSTRUCTION MANUAL

MODIFICATION INSERT

TYPE 575
MOD 122C

This insert has been written to supplement the Instruction Manual furnished with this modified instrument. The information given in this insert will supersede that given in the manual.

TYPE 575

MOD 122C

Tektronix, Inc.
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TYPE 575

MOD 122C

The instrument for which this manual was prepared has been modified to provide the following additional voltage ranges:

A 0-400 volt range to check transistors with up to 400 volts on the collector.
A 0-1.5 kv range to check the peak inverse voltage of diodes.

OPERATING INSTRUCTIONS

Several front-panel changes have been made on this modified instrument. Three positions have been added to the HORIZONTAL COLLECTOR VOLTS switch to provide 50, 100 or 200 VOLTS/DIV. Also, a 0-400 volt position has been added to the COLLECTOR SWEEP PEAK VOLTS RANGE switch to check transistors with up to 400 volts on the collector. The PEAK VOLTS control has been changed to read PERCENT OF PEAK VOLTS RANGE.

A third position has been added to the POLARITY switch. This position provides 0-1.5 kv, variable by means of the PERCENT OF PEAK VOLTS RANGE control, for checking diodes. To check diodes using this position, set the PEAK VOLTS RANGE switch to 0-20. Connect the diode to be checked between the collector binding post and ground and push the PRESS TO CHECK button. The primary of the high voltage transformer, T703, is then energized providing the amount of voltage to the diode as selected by the PERCENT OF PEAK VOLTS control. When using this control setting and the 0-400 volt position of the COLLECTOR SWEEP PEAK VOLTS RANGE switch, observe the current limits stamped on the front panel.

CALIBRATION

This modified instrument is calibrated as outlined in the Type 575 Instruction Manual with the addition of the following steps in place of step 12. There is a minimum of interaction between these adjustments if the procedure is carried out in the sequence given here. Therefore, it should not be necessary to repeat any of the steps if each adjustment is made carefully.

12a. Adjust C706A and R733

Set the Type 575 controls as follows:

VERTICAL CURRENT OR VOLTAGE PER DIVISION	.01 COLLECTOR mA
HORIZONTAL VOLTS/DIV	20 COLLECTOR VOLTS
PEAK VOLTS RANGE	0-200
POLARITY	—
PERCENT OF PEAK VOLTS RANGE	80
TRANSISTOR A - TRANSISTOR B	TRANSISTOR B

Place the instrument on an aluminum plate to simulate a bottom panel. Place a hole in the plate to adjust R733 and ground the instrument to the plate. Adjust C706A and R733 for minimum trace separation.

12b. Adjust C706B

Set the PEAK VOLTS RANGE switch to 0-400. Adjust C706B for minimum trace separation.

12c. Adjust C706C

Set the POLARITY switch to + and adjust C706C for minimum trace separation.

12d. Adjust C706D

Set the PEAK VOLTS RANGE switch to 0-200 and adjust C706D for minimum trace separation.

12e. Adjust C318

Set the PEAK VOLTS RANGE switch to 0-400 and set the HORIZONTAL VOLTS/DIV switch to 50 COLLECTOR VOLTS. Adjust C318 (located at the rear of the HORIZONTAL VOLTS/DIV switch) for minimum trace separation.

12f. Adjust C706E

Set the PEAK VOLTS RANGE to 0-20 and the POLARITY switch to ±1.5 kv. Push the PRESS TO CHECK button and adjust the PERCENT

OF PEAK VOLTS RANGE so that the complete horizontal trace may be seen on the screen. Then, hold the button depressed while adjusting C706E for minimum trace separation.

C735 has been removed by this modification.

PARTS LIST

The following part changes have been made in this modified instrument. These changes are also shown schematically in this insert. When ordering replacement parts, give a description of the part and specify instrument type, serial number and MOD number.

CAPACITORS

C318	Add	4.5-25 pf	Cer	Var	281-010
C706	Delete				
C706A	Add	3-12 pf	Cer	Var	281-007
C706B	Add	4.5-25 pf	Cer	Var	281-010
C706C	Add	4.5-25 pf	Cer	Var	281-010
C706D	Add	4.5-25 pf	Cer	Var	281-010
C706E	Add	4.5-25 pf	Cer	Var	281-010
C730	Delete				
C734	Change to	.002 μf	mica		283-529
C735	Delete				

DIODES

GR707	Germanium Rectifier (Added to Collector Supply)	106-060

RESISTORS

R250A,B	Add	1.8m	1/2w	Prec	1%	309-020
R258A,B	Add	1.8m	1/2w	Prec	1%	309-020
R319	Add	433k	1/2w	Prec	1%	309-001
R729A-D	Add	470k	2w	Comp	10%	306-474
R730A-D	Change to	2.5m	1/2w	Prec	1%	309-025
R732	Change to	300k	1/2w	Prec	1%	309-125
R733	Add	1 m	Var	Minipot		311-126

SWITCHES

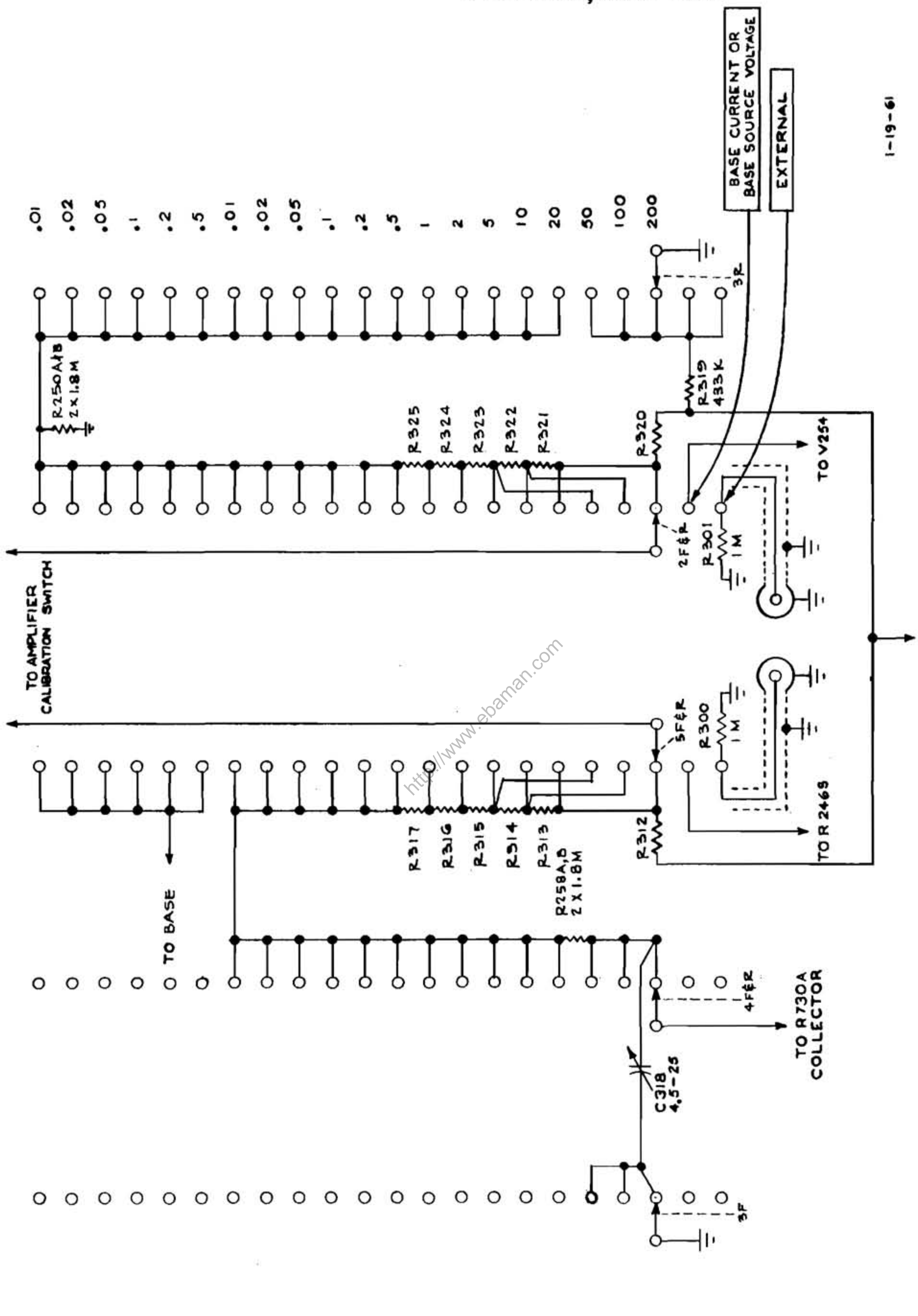
SW305	Change to	HORIZ. VOLTS/DIV	262-633
SW700	Add	PRESS TO CHECK, pushbutton	260-017
SW706	Change to	PEAK VOLTS RANGE	260-403
SW708	Change to	Collector POLARITY	260-404

TRANSFORMERS

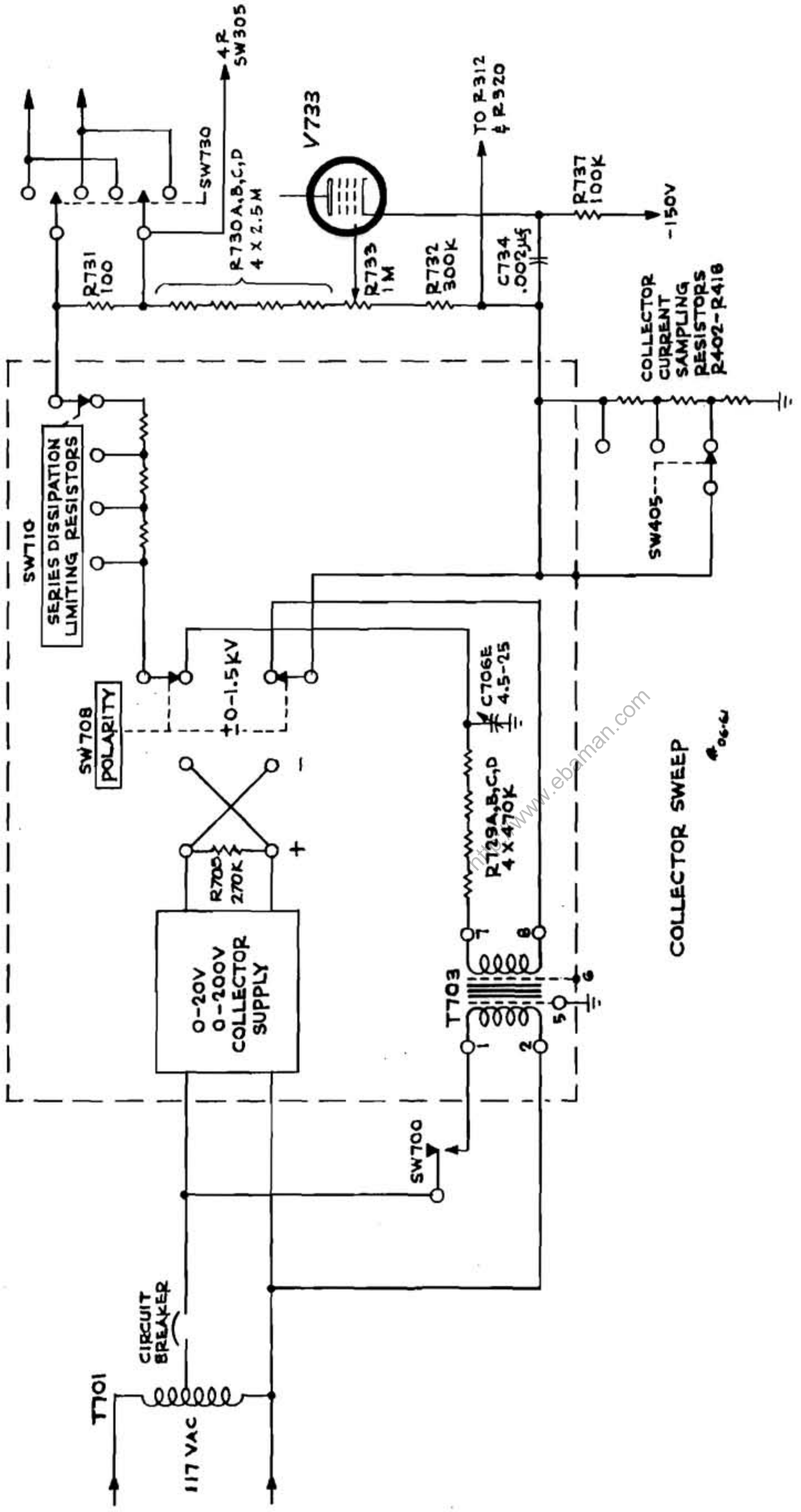
T703	Add	High-Voltage Diode Check	120-0226-00

MECHANICAL

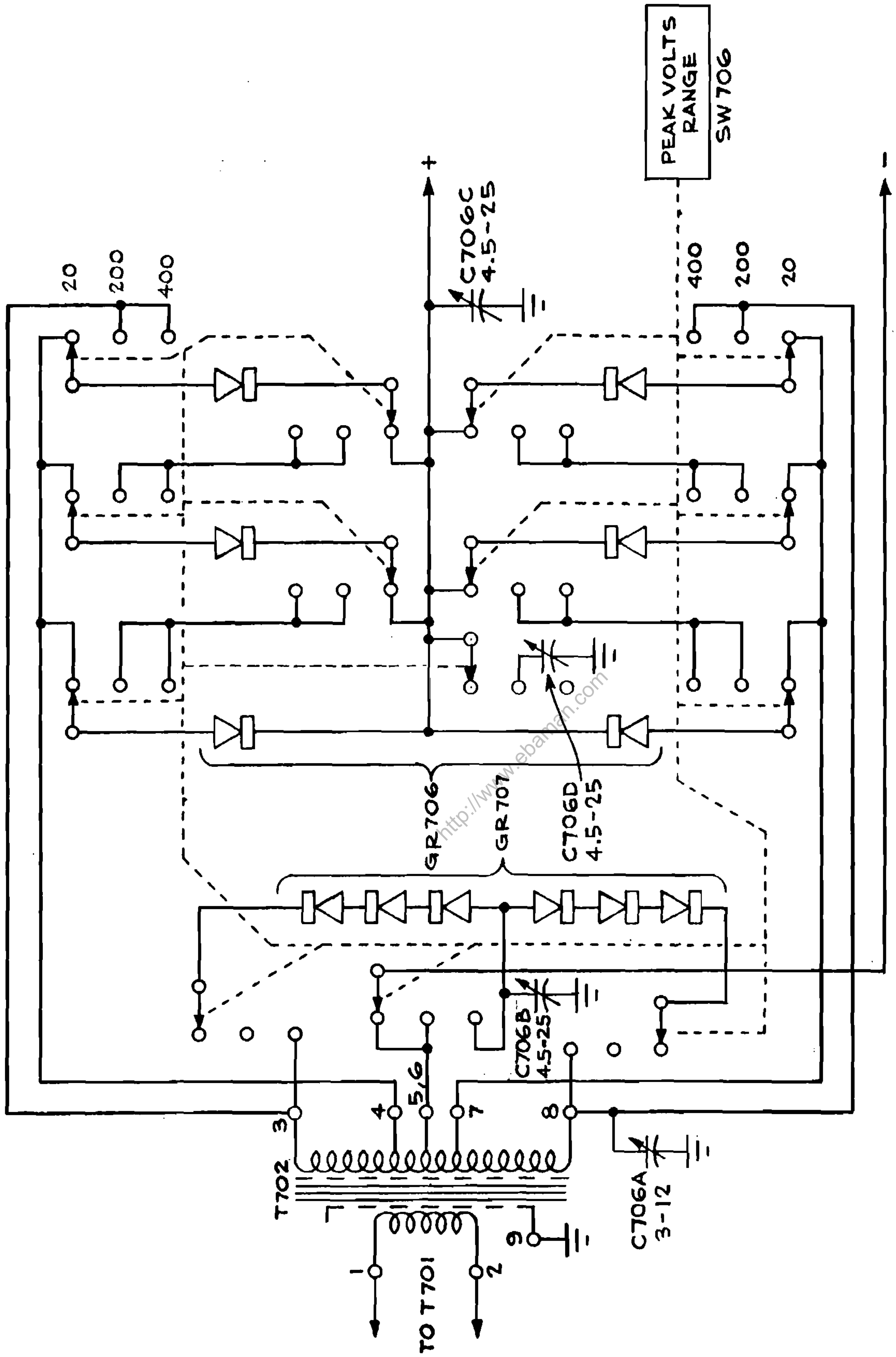
BRACKET, Transformer Support	Add	1	406-0743-00
BOARD, Etched Circuit	Add	1	388-0523-00
PANEL, Front	Change to		333-0690-02
SHIELD, Collector Sweep	Add	1	337-0476-00



TYPE 575 TRANSISTOR-CURVE TRACER HORIZONTAL AMPLIFIER SWITCHING



COLLECTOR SWEEP



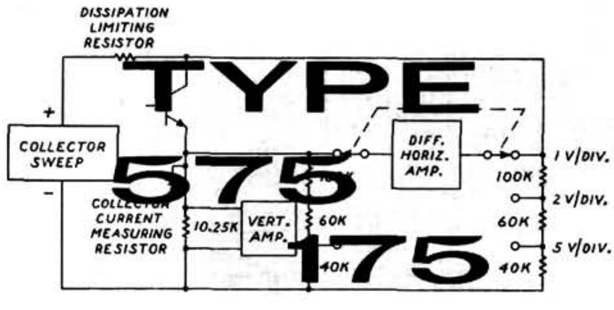
COLLECTOR SUPPLY MOD. 122C

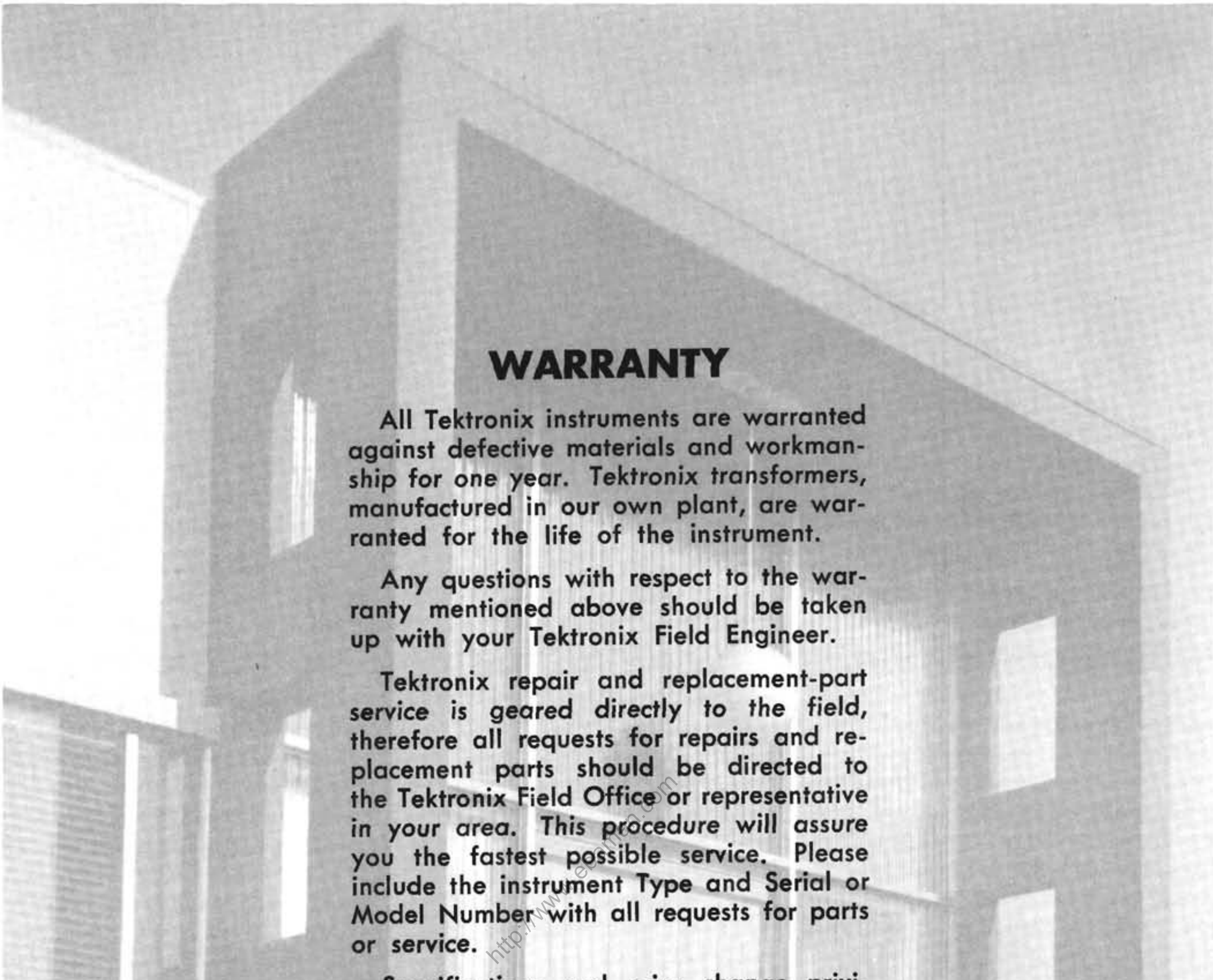
G.A.B. 06.08.61

TYPE 575 TRANSISTOR-CURVE TRACER

INSTRUCTION
MANUAL

TYPE 575 175





WARRANTY

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

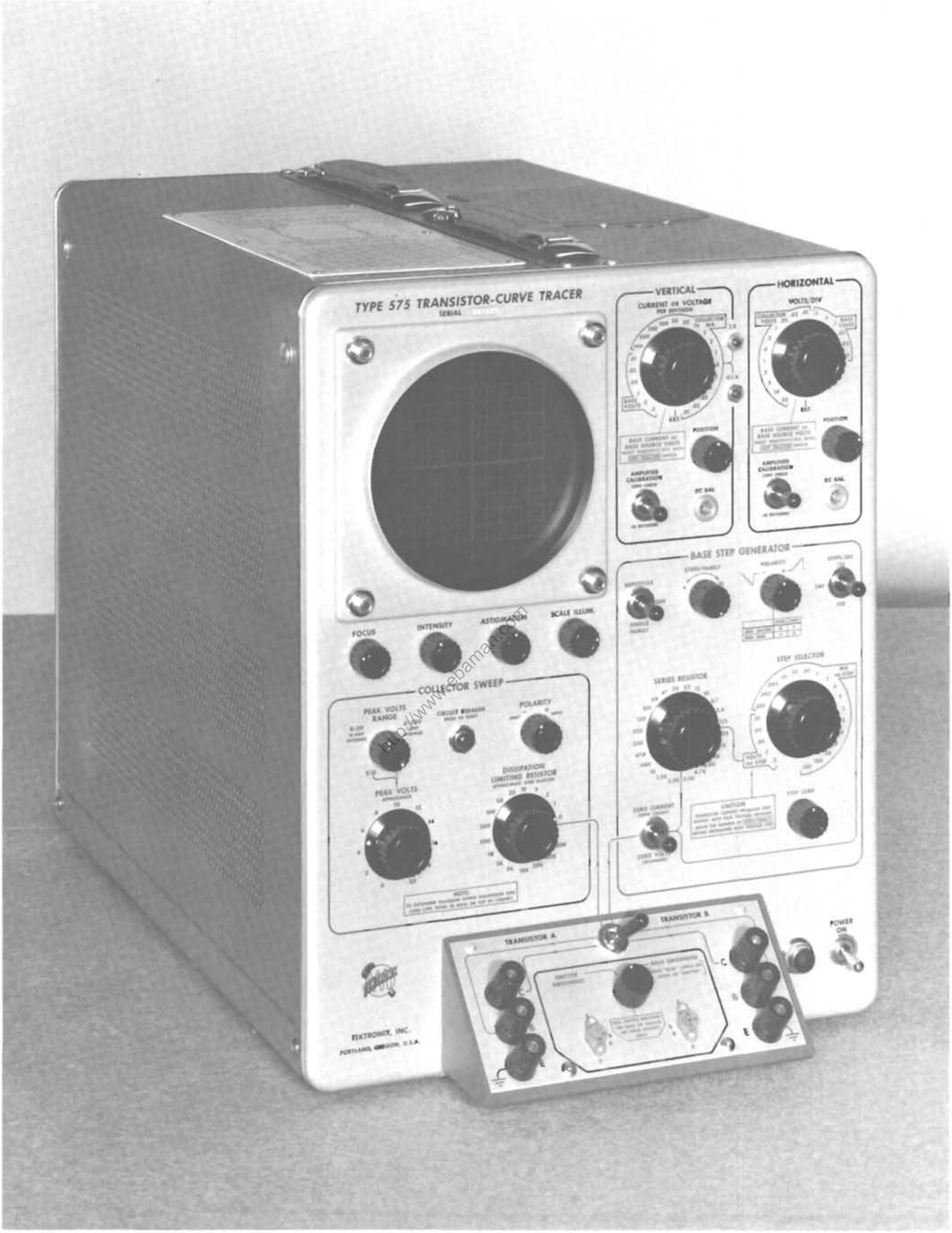
Any questions with respect to the warranty mentioned above should be taken up with your Tektronix Field Engineer.

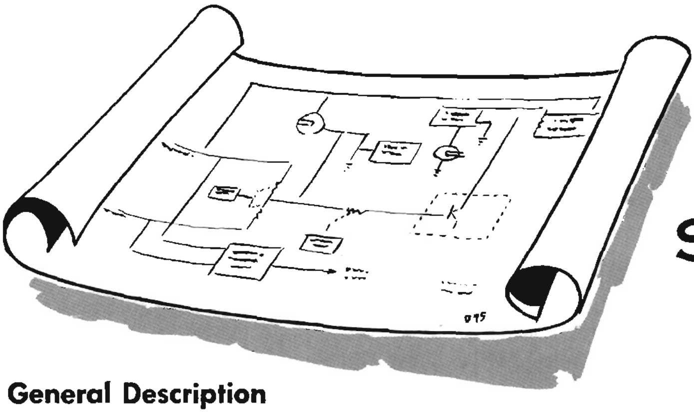
Tektronix repair and replacement-part service is geared directly to the field, therefore all requests for repairs and replacement parts should be directed to the Tektronix Field Office or representative in your area. This procedure will assure you the fastest possible service. Please include the instrument Type and Serial or Model Number with all requests for parts or service.

Specifications and price change privileges reserved.

CONTENTS

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


TYPE 575 TRANSISTOR-CURVE TRACER
VERTICAL
HORIZONTAL
VOLTS/DIV
POSITION
DC BAL.
BASE STEP GENERATOR
POLARITY
FOCUS
INTENSITY
SCALE ILLUM.
COLLECTOR SWEEP
PEAK VOLTS RANGE
PEAK VOLTS
CIRCUIT BREAKER
DISSIPATION LIMITING RESISTOR
SERIES RESISTOR
STEP SELECTOR
STEP ZERO
CAUTION
ZERO CURRENT
ZERO VOLTS
TRANSISTOR A
TRANSISTOR B
POWER ON
TEKTRONIX, INC.



SECTION 1

SPECIFICATIONS

General Description

The Type 575 Transistor Curve Tracer displays the dynamic characteristic curves of both junction and point-contact transistors on the screen of a 5-inch cathode-ray tube. Several different transistor characteristic curves may be displayed, including the collector family in the common-base and common-emitter configuration. Regulated current or voltage steps are applied to the input of the transistor under test. A rectified sine wave of controllable amplitude is used for the collector sweep. The family of characteristic curves is accurately plotted as either a repetitive or single-family display.

Tolerances and accuracies as stated in Specifications section and the Recalibration Procedure of this manual apply only to Type 575 instruments above serial number 8030.

OPERATING SPECIFICATIONS

Collector Sweep

0 to 200 volts peak —10% +20% with 1-ampere current curves.

0 to 20 volts peak —10% +20% with 20-ampere current curves.

Base Step Generator

Generates 4 to 12 current or voltage steps per family of curves at 120 or 240 steps per second (2 or 4 times power-line frequency) for either repetitive or single-family displays.

17 current-step ranges from 1 μa/step to 200 ma/step ±3%.

5 voltage-step ranges from 0.01 volt/step to .2 volt/step ±3%, with output impedance adjustable from 1 ohm to 22 thousand ohms ±10%, plus 0.1 ohm (wiring and switch contact resistance).

Vertical Display

Plots collector current from 0.01 ma/div. to 1000 ma./div. ±3% in 16 calibrated steps. Pushbuttons provide multiplying each current step by 2 or dividing by 10, increasing the current range from 0.001 ma./div. to 2000 ma./div. ±3%.

Plots base voltage from 0.01 volt/div. to 0.5 volt/div. ±3% in 6 calibrated steps.

Plots base current or base source volts with sensitivity read from step selector switch ±3%.

Horizontal Display

Plots collector voltage from 0.01 volt/div. to 20 volts/div. ±3% in 11 calibrated steps.

Plots base voltage from 0.01 volt/div. to 0.5 volt/div. ±3% in 6 calibrated steps.

Plots base current or base source volts with sensitivity read from step collector switch ±3%.

Other Features

Comparison switch permits rapid manual switching between two transistors for comparison tests.

Regulated power supplies and negative-feedback amplifiers assure the accuracy of the calibration and the stability of the display.

Cathode-ray tube is a Tektronix T52P. Accelerating potential is approximately 4 kv. P1 phosphor is supplied unless another phosphor is requested. P2, P7, or P11 phosphors are available at no extra charge.

Differential inputs to both vertical and horizontal amplifiers are available at the rear of the instrument, or at the Type 175 adaptor socket on instruments after S/N 3659. The sensitivity of each channel is .1 volt/div. and the bandpass is approximately 300 kc. The rejection of a common-mode signal is better than 100:1 with a peak-to-peak signal of 10 volts or less.

Mechanical Characteristics

Ventilation—Filtered- forced-air circulation maintains safe operating temperature.

Construction—Aluminum-alloy chassis and three-piece cabinet.

Finish—Photoetched, anodized front panel, with blue vinyl finished cabinet.

Dimensions—24" long, 13" wide, 16¾' 'high.

Weight—Approximately 70 lbs.

Power Requirements—117-volt or 234-volt nominal line voltage at 50 to 60 cycles; 410 watts maximum at 117 volts, 60 cycles, including 200 watts maximum to device in test fixture. Correct operation over regulation ranges given in Table 1-1 when connected for low-line, mid-line or high-line operation as shown in Fig. 1-1.*

Input Power Connections

The Type 575 may be operated from either a 117-volt or a 234-volt nominal line-voltage source. For 117-volt operation, the two main primary windings of the power transformer (T601) are connected in parallel; for 234-volt operation the main primary windings are connected in series.

TABLE 1-1

Regulating Ranges

Transformer Wiring	Regulating Ranges*	
	117-Volt Line	234-Volt Line
Low-Line Connection	96 to 115 volts (107 volts nominal)	192 to 230 volts (214 volts nominal)
Mid-Line Connection	105 to 125 volts (117 volts nominal)	210 to 250 volts (234 volts nominal)
High-Line Connection	114 to 136 volts (127 volts nominal)	227 to 272 volts (254 volts nominal)

***Specifications for operation on low line and high line do not apply for instruments with Serial Numbers 100 through 9168.**

In addition to the nominal 117-volt and 234-volt operation, two supplementary primary windings are provided to increase or decrease the transformer voltage output for use with an input power source that is lower or higher than nominal. See Fig. 1-1 for the proper connections. (These supplementary windings are not present in instruments SN 100-9168).

234-Volt Unbalanced-Line Connections

Special transformer connections are required for T701, the PEAK VOLTS transformer, if the Type 575 is to be operated from a 234-volt line that has one input line at approximately ground potential. This configuration is called unbalanced line, as distinguished from the usual balanced line used in the United States in which a virtual ground potential exists near the center-tap connections of the power transformer primary windings.

For 234-volt unbalanced-line operation, the live side of the power input is connected to fuse F601 and ground-potential side of the input is connected to terminal 1 of T601. The leads to T701 are connected between terminals 1 and 3 of T601 so that T701 is not at an elevated voltage, and the fan connections are moved to terminal 2 of T601 and the input side of thermal cutout TK601 to balance the load on the transformer primary.

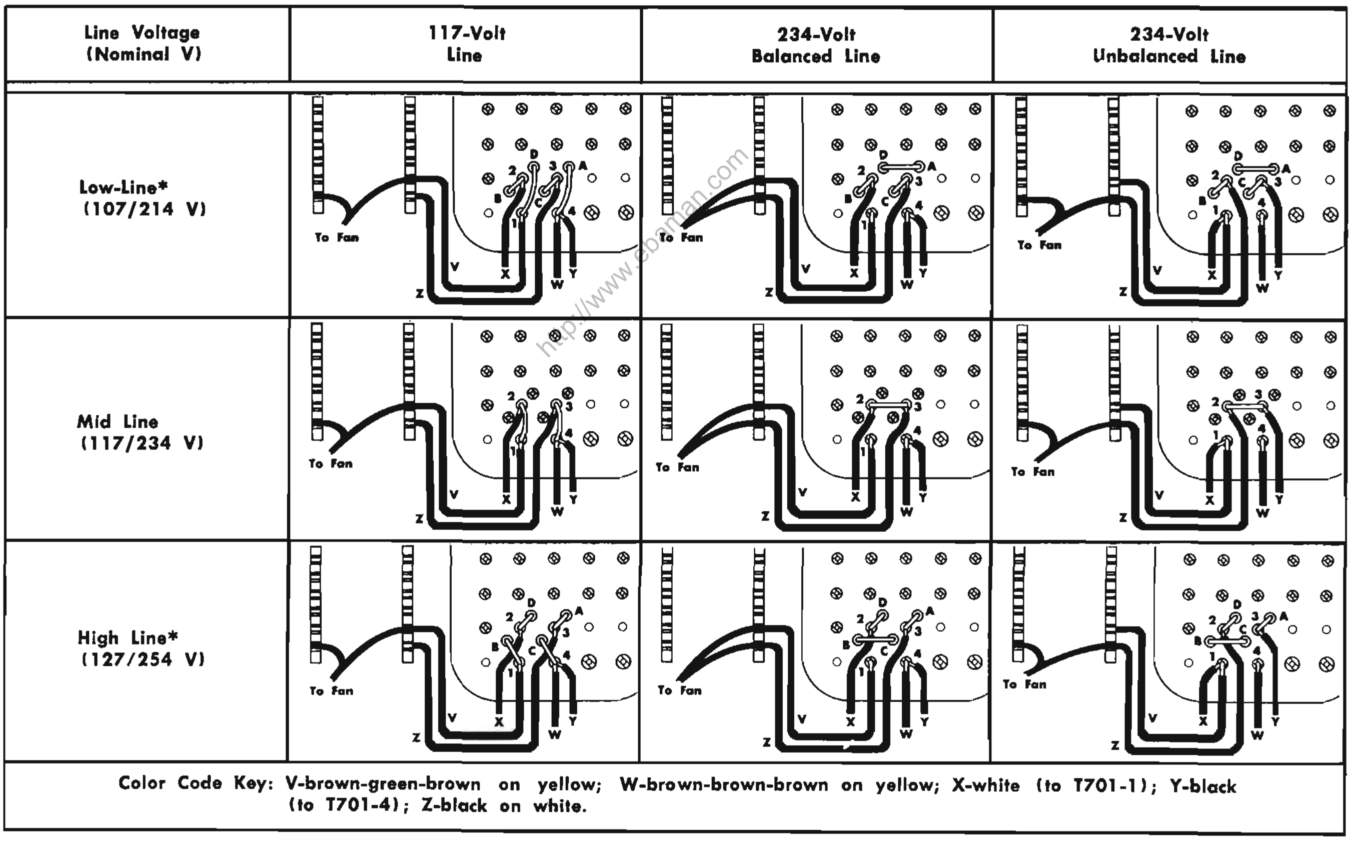
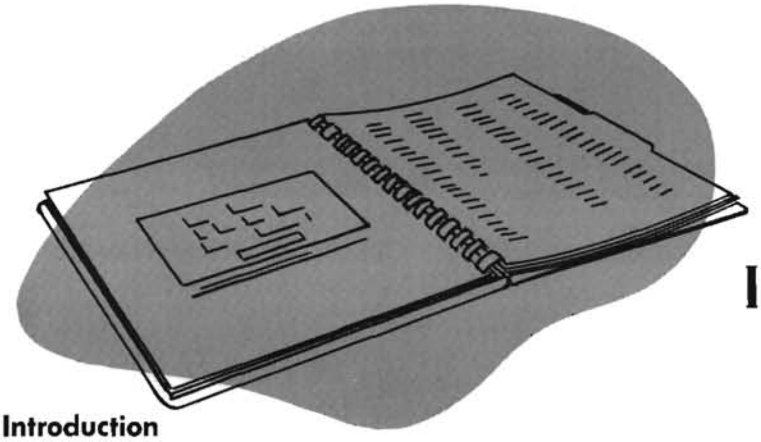


Fig. 1-1. Transformer and Fan Wiring. *Low line and high line connections not applicable to instruments SN 100-9168.



SECTION 2

OPERATING INSTRUCTIONS

Introduction

The Type 575 is an extremely versatile instrument that can be used to make several tests on a transistor. Its full utility can only be realized, however, when the operator understands the function of each of the front-panel controls.

The front-panel layout, shown in Fig. 2-1, is quite simple and logical, and can be divided into five main blocks. These blocks contain the controls for the Vertical Amplifier, the Horizontal Amplifier, the Collector Sweep, the Base (or Emitter) Step Generator and Amplifier, and the Transistor Test Panel. The location of each section, as a functional part of the instrument, is shown in Fig. 2-2.

Notice the front panel is in two colors...red and blue. Those parts of the panel etched in red refer to the Collector voltages and currents, and those parts etched in blue refer to the Base voltages and currents. However, when testing a transistor in the common-base configuration, the emitter is stepped with voltage or current; in this case, the blue printing on the front panel refers to the Emitter rather than the Base.

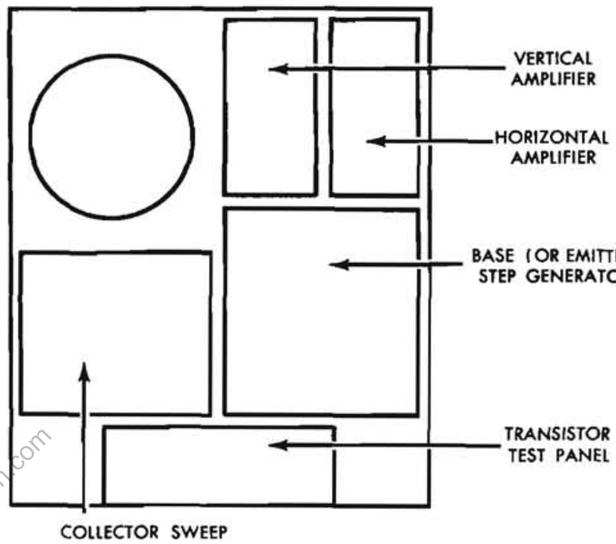


Fig. 2-1. Type 575 front-panel layout. Each section corresponds to a block in the block diagram.

Vertical Block

The Vertical block contains a 24-position Vertical Selector switch which selects the type of signal, and in some cases

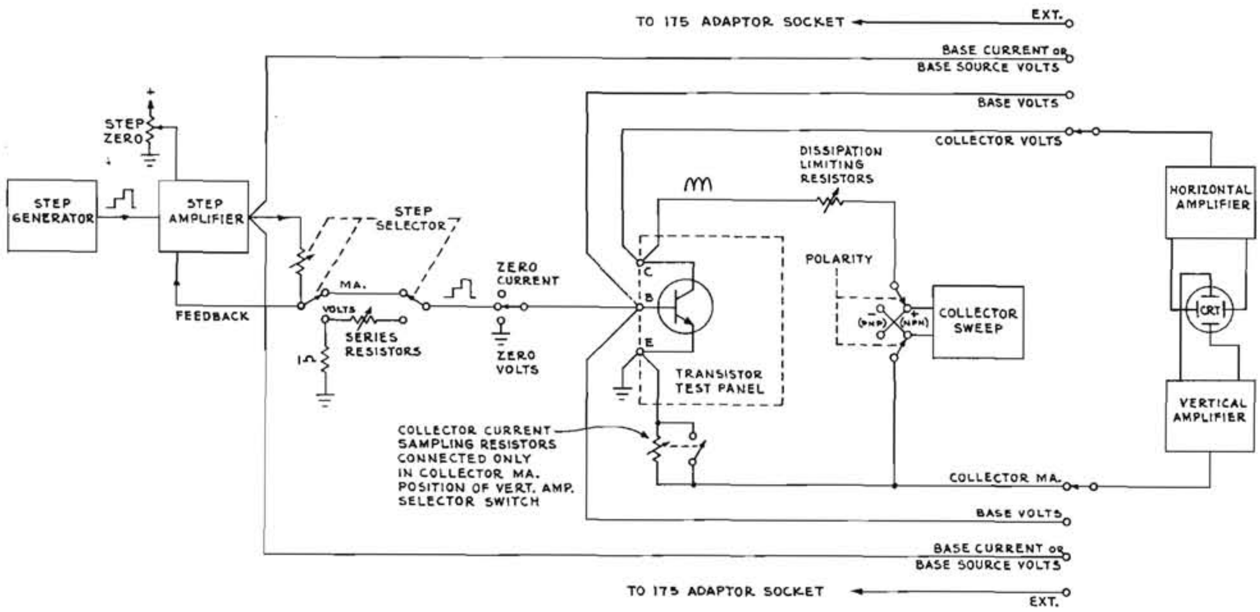


Fig. 2-2. Type 575 functional block diagram.

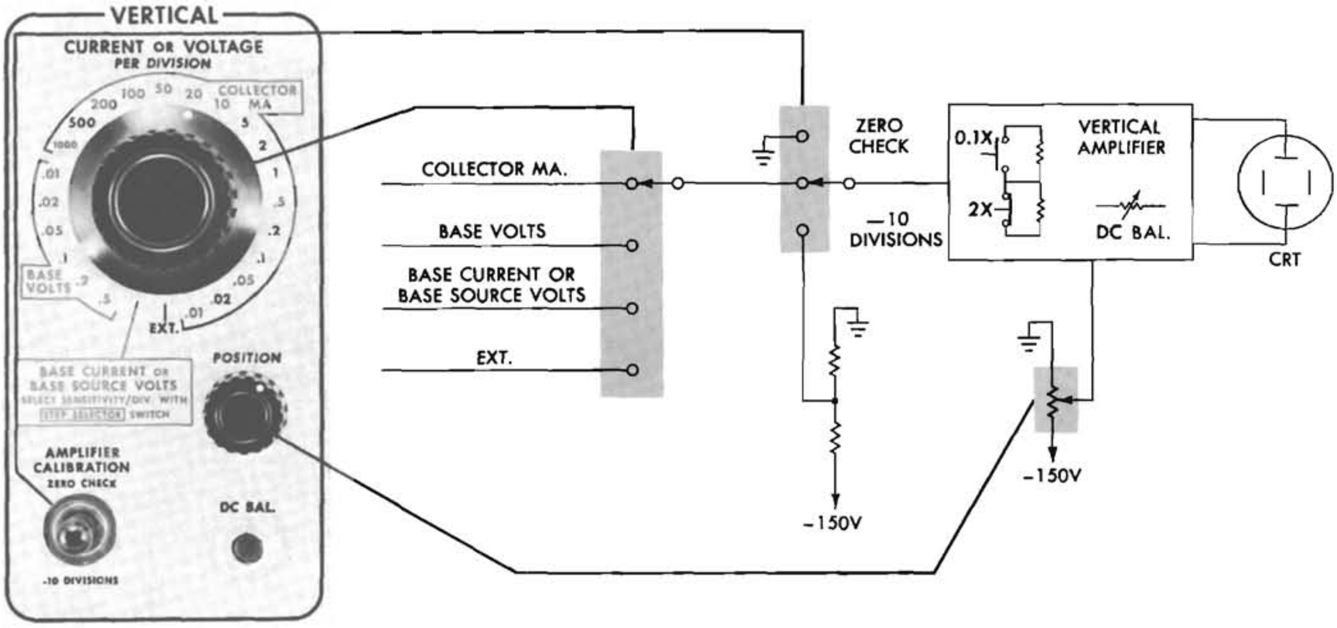


Fig. 2-3. Function of front-panel vertical-block controls.

the amplitude of the signal, fed to the Vertical Amplifier. When the switch is in any of the COLLECTOR MA positions, the collector current of the transistor appears as the Y axis signal, provided the transistor is being tested in the common-emitter (EMITTER-GROUNDED) configuration. The 2X and the 0.1X pushbutton switches provide increased current measurement ranges by multiplying each current step by 2 or dividing by 10.

When testing a transistor in the common-base (BASE GROUNDED) configuration, all of the Base-indicated nomenclature should be read as EMITTER, as explained in the note on the Transistor Test Panel.

When the Vertical Selector switch is in the BASE CURRENT OR BASE SOURCE VOLTS position, either the base current or the base source-voltage is monitored as the Y signal depending on the setting of the STEP SELECTOR switch in the Step Generator section. (In the common-base configuration, this would be either the emitter current or the emitter source-voltage).

In the EXT. position of the Vertical Selector switch, the Y signal must be obtained from an external test point, rather than from the Transistor Test Panel. Two external-input connectors are provided on the rear panel of the instrument, one for normal polarity and one for inverted polarity signals. Or, if preferred, both connectors may be employed for differential input. For instruments with S/N 3660 and up these connections are obtainable through the Type 175 adaptor socket.

The POSITION control is just what the name implies; it positions the trace or display vertically on the crt. The DC BAL. control is adjusted to maintain a state of dc balance between both sides of the Vertical Amplifier. This prevents the display from shifting vertically as the input sensitivity of the amplifier is changed in either the COLLECTOR MA or BASE VOLTS (or EMITTER VOLTS) range.

The AMPLIFIER CALIBRATION switch is used to check the gain setting (calibration) of the Vertical Amplifier. In the ZERO CHECK position both grids of the Input Amplifier are grounded to establish a zero reference on the crt. In the —10 DIVISIONS position, one grid is connected through a divider to a —150-volt supply. If the Amplifier is in proper calibration, the trace will be deflected exactly ten divisions below the zero reference.

Horizontal Block

The controls in the Horizontal block are similar to those in the Vertical block. A 19-position Horizontal Selector switch selects the type of signal, and in some cases the amplitude of the signal fed to the Horizontal Amplifier. When in any of the COLLECTOR VOLTS positions, the voltage applied to the collector of the transistor is the X-axis signal. When in any of the BASE VOLTS positions, the voltage applied to the base of the transistor is the X signal. In the BASE CURRENT OR BASE SOURCE VOLTS position, either the base current or the base source-voltage, depending on the setting of the STEP SELECTOR switch in the Step Generator block, is monitored as the X signal. As explained in conjunction with the Vertical block, the BASE-indicated nomenclature is used when testing transistors in the common-emitter configuration. When the common-base configuration is used, the word 'BASE' on the front-panel should be read as 'EMITTER'.

When the Horizontal Selector switch is in the EXT. position, the function is exactly the same as that explained for the Vertical Selector switch. In addition, the function of the POSITION, DC BAL. and AMPLIFIER CALIBRATION switches is exactly the same as that explained for the Vertical block.

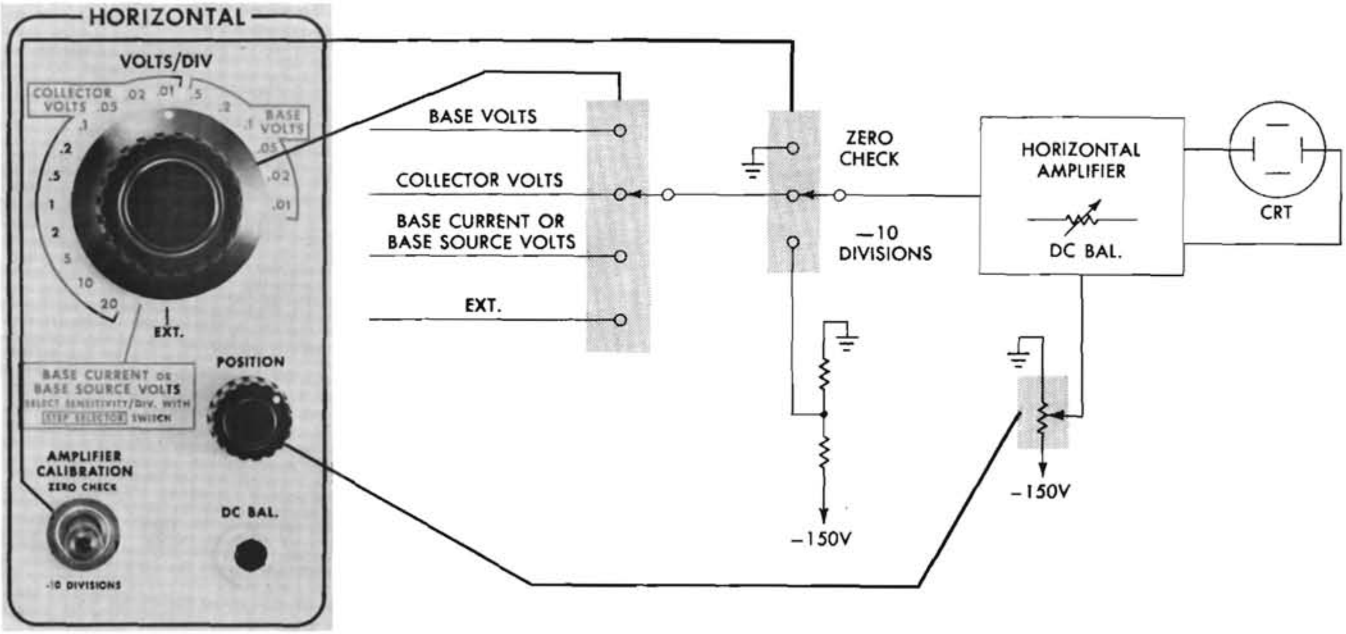


Fig. 2-4. Function of front-panel horizontal-block controls.

Collector Sweep Block

The PEAK VOLTS RANGE switch selects one of two peak voltage ranges for sweeping the collector of the transistor. In the 0-20 position, the peak voltage can be varied between zero and 20 volts by means of the PEAK VOLTS control; in the 0-200 position, the voltage is variable between zero and 200 volts. The POLARITY switch determines whether positive-going or negative-going sweeps are applied to the collector. The DISSIPATION LIMITING RESISTOR switch connects one of the indicated resistance values in series with the collector to limit the collector dissipation and thereby protect the transistor from excessive power dissipation. The value of resistance selected also becomes part of the transistor load, as explained under "Transistor Load Resistance" on the top-panel chart.

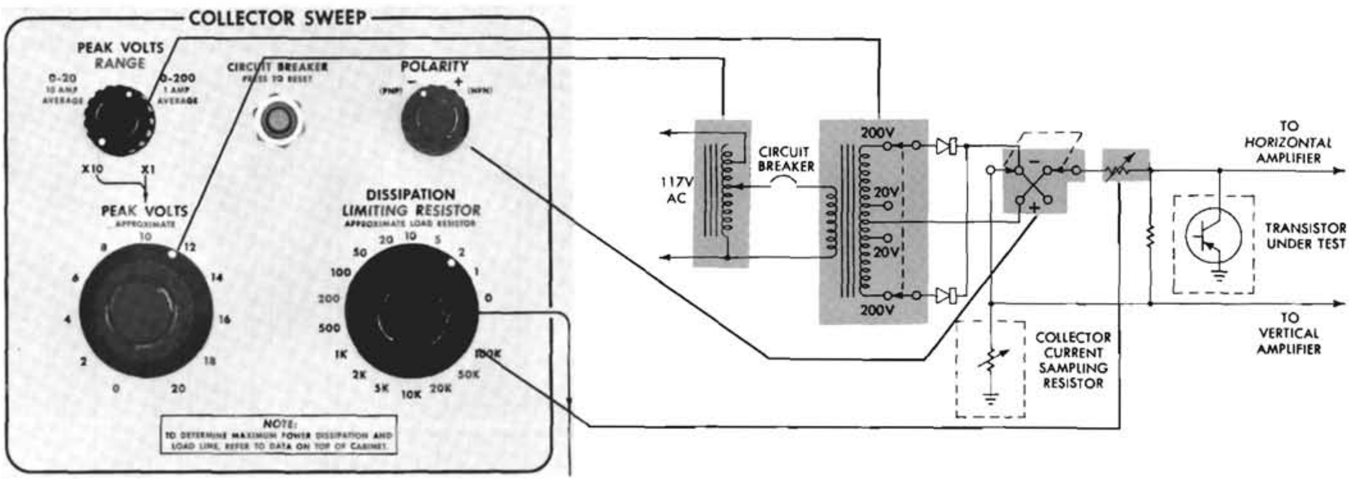


Fig. 2-5. Function of collector-sweep controls.

Step Generator Block

The Step Generator block contains a STEP SELECTOR switch which determines the type (current or voltage) and the amplitude of the steps applied to the base or the emitter of the transistor. The SERIES RESISTOR switch connects the selected value of resistance in series with the Step Generator when voltage steps are used. The value of resistance selected may be used to simulate the driving impedance of the circuit into which the transistor may be used. (In the 1Ω position of the SERIES RESISTOR switch, no resistance is added to the circuit; in this case the driving impedance is the 1-ohm internal impedance of the Step Generator.)

A POLARITY switch provides for stepping the input in either the positive or negative direction. The number of steps per family is adjustable from 4 to 12 (actually from 5 to 13 counting the zero step) by means of the STEPS/FAMILY control. With the STEPS/SEC switch, either 120 or 240 steps per second can be selected. In the upper 120 position, the current or voltage steps occur when the collector voltage is zero; in the lower 120 position of the switch, the steps occur when the collector voltage is maximum. In the 240 position, the steps occur both at zero and at maximum (of the collector voltage); this accounts for the double repetition rate in this position.

A switch is provided on the Step Generator block for selecting either a REPETITIVE or a SINGLE FAMILY display. The REPETITIVE position provides a continuous display for testing a transistor at or below its rated values. The SINGLE FAMILY position will provide a single display each time the spring-loaded switch is depressed. The low duty cycle, in this position of the switch, will permit the operator to test a transistor beyond its ratings without damage.

Another switch is provided for grounding the transistor input for a ZERO VOLTAGE check, or for opening the transistor input for a ZERO CURRENT check. The STEP ZERO control adjusts the starting point of the current or voltage steps.

Transistor Test Panel

The Transistor Test Panel has provisions for two transistors at the same time. The two sockets accept low-power transistors with short leads. The binding posts, located on either side of the small sockets, accept two types of plug-in adapters; one type of adapter is for power transistors with rigid leads, the other type is for transistors with long, flexible leads. For transistors that will not fit either type of adapter, direct connections with test leads may be made to the binding posts. For power transistors that fall into the latter category, it may be advisable to devise a heat sink to protect the transistor.

By means of a comparison switch, either transistor (TRANSISTOR A or TRANSISTOR B) can be connected into the test circuit. A Configuration switch reverses the base and emitter connections *for the transistor sockets only.* In the EMITTER GROUNDED position, the transistor is tested in the common-emitter configuration and the front-panel labels are read directly. In the BASE GROUNDED position, the transistor is tested in the common-base configuration and the BASE labels on the front panel are read as EMITTER.

If it is desired to test a transistor in the common-base configuration, when using the binding posts (with or without the adapters), the base lead must be plugged into the grounded connector marked E and the emitter lead must be plugged into the connector marked B.

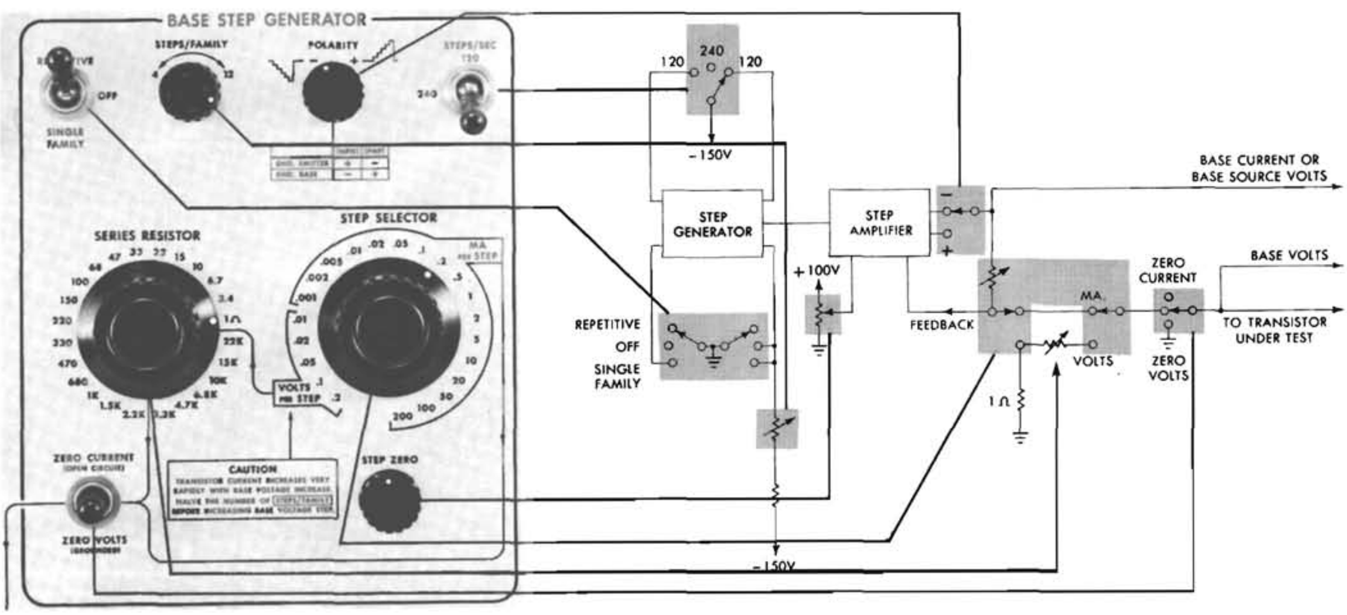


Fig. 2-6. Function of base-step generator controls.

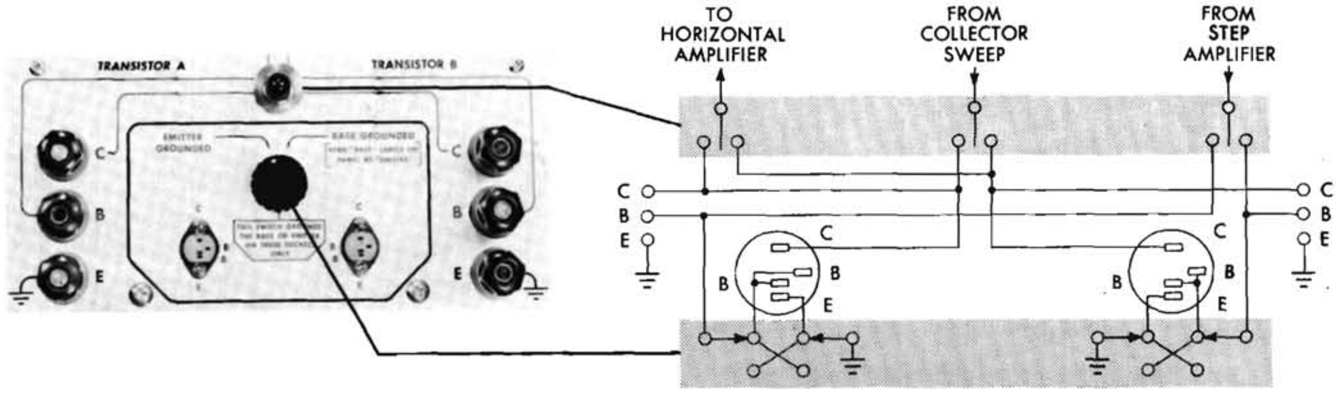


Fig. 2-7. Function of test-panel controls.

Setting Up The Front-Panel Controls

In displaying transistor curves on the Type 575 we are concerned with two considerations. . . properly displaying the curves we wish to interpret, and protecting the transistor under test from damage.

If we know quite a bit about the transistor. . . that is, if we know such factors as the collector dissipation rating, collector current and emitter current ratings, collector-to-base and collector-to-emitter voltage ratings. . . then we can set up the front-panel of the instrument without danger of damaging the transistor. However, if all we know is whether the transistor is an NPN or a PNP, more care must be exercised when setting up the front-panel controls.

The General Procedure that follows is an outline of the steps involved in setting up the front-panel controls to obtain a collector family of curves. Following the General Procedure is a step by step procedure for setting up the controls for a transistor of unknown characteristics, to obtain a collector family, and then a procedure for obtaining a collector family for a transistor of known characteristics.

General Procedure

Indicator Unit

1. The INTENSITY control is turned to mid-scale; this will prevent damage to the crt phosphor when the power is turned on.
2. The POWER switch is turned ON, so that the instrument can be warming up while it is being set up for use.

Test Panel

3. The Configuration switch is set to the EMITTER GROUNDED position (if a common-emitter configuration is desired).
4. The Comparison switch (TRANSISTOR A-TRANSISTOR B) is set to the center position; this prevents the application of any voltage or current to the transistor socket.

Collector Sweep Block

5. The POLARITY switch is set to the proper polarity for an NPN or a PNP transistor.
6. The DISSIPATION LIMITING RESISTOR switch is set to the proper value to prevent excessive collector dissipation.
7. The PEAK VOLTS RANGE and the PEAK VOLTS switches are set for the proper amplitude of collector sweep voltage.

Base Step Generator Block

8. The Display switch is set to REPETITIVE so that we may view a continuous display.
9. The STEPS/FAMILY control is adjusted for the number of curves we wish to display.
10. The POLARITY switch is set to — if the transistor under test is a PNP (since we are in the grounded-emitter configuration), or to + if an NPN transistor (again in the grounded-emitter configuration).
11. The STEPS/SEC. switch is set for the desired step rate of the Base Step Generator (either 120 or 240 steps/second).
12. The STEP SELECTOR is set for the current per step or voltage per step that we wish to apply to the base.

12.(a) If voltage steps are applied to the base of the transistor under test, the proper value of SERIES RESISTOR must be switched into the circuit to limit the base current.

Conclusion

13. The VERTICAL sensitivity for the collector current is set by adjusting the COLLECTOR MA/DIVISION switch.
14. The HORIZONTAL sensitivity for the collector voltage is set by adjusting the COLLECTOR VOLTS/DIV. switch.
15. The transistor to be tested is placed in the socket or binding post (either A or B) and the Comparison switch set to either TRANSISTOR A or TRANSISTOR B (depending on which socket or binding post is used). This connects the transistor into the test circuit.
16. The INTENSITY, FOCUS and ASTIGMATISM controls are adjusted for a display of suitable brightness and clarity.
17. The calibration of the horizontal and vertical amplifiers is checked.
18. The display is properly positioned for interpretation.

Testing a Transistor of Unknown Characteristics

To obtain a collector family for a transistor of unknown characteristics, the following control settings will afford maximum protection. We are assuming that the type of transistor is known (NPN or PNP), and that it is to be tested in the grounded-emitter configuration.

Test Panel

Configuration Switch	EMITTER GROUNDED
Comparison Switch	Centered

Collector Sweep Block

PEAK RANGE VOLTS	0-20
PEAK VOLTS	0
POLARITY	Set according to type of transistor being tested.
DISSIPATING LIMITING RESISTOR	100 K

Base Step Generator Block

Display Switch	REPETITIVE
STEPS/FAMILY	4 (full left)
POLARITY	Set according to type of transistor being tested.
STEPS/SEC.	Any setting
STEP SELECTOR	.001 MA per STEP, or .01 VOLTS per STEP
SERIES RESISTOR	22 K

SERIES RESISTOR switch is not connected in the circuit when STEP SELECTOR switch is in MA per STEP range.

Indicator Unit

VERTICAL COLLECTOR MA	.01
HORIZONTAL COLLECTOR VOLTS	.01

Place the transistor to be tested in either the socket or binding post on the left side of the Test Panel, and place the Comparison switch in the TRANSISTOR A position. Adjust the INTENSITY and POSITION controls for a crt indication near the upper right corner of the graticule for PNP or lower left corner for NPN. At this time each of the controls mentioned in the front-panel set-up can be adjust, one position at a time, until a suitable display is obtained on the crt. As soon as an indication of a collector family of curves becomes apparent on the crt, it will probably be necessary to reposition the display to properly interpret the values of voltage and current.

Testing a Transistor of Known Characteristics

To demonstrate the front-panel set-up for a transistor of known characteristics, we have selected a 2N407 PNP transistor. Note: The test transistors furnished with your instrument are a similar type.

Test Panel

Comparison Switch	Centered
Configuration Switch	EMITTER GROUNDED

2. Collector Sweep Block

The PEAK VOLTS RANGE and the PEAK VOLTS controls are set for the peak voltage with which we wish to sweep the collector. If we wish this to be 10 volts, the controls are set as follows:

PEAK VOLTS RANGE	0-20
PEAK VOLTS	10
POLARITY	PNP—

The value of the DISSIPATION LIMITING RESISTOR depends on the maximum collector disspation and the collector sweep voltage. The transistor manual states that the maximum collector disspation, for 25° C ambient temperature, is 150 mw. Consulting the RESISTOR SELECTION GRAPH on the instrument, the proper value of resistance, for a collector dissipation of 150 mw and a peak collector voltage of 10 volts, is 200 ohms.

Therefore:

DISSIPATION LIMITING RESISTOR	200

The remainder of the controls are set for the conditions under which we wish to test the transistor.

Base Step Generator Block

Display Switch	REPETITIVE
STEPS/FAMILY	4
POLARITY	—
STEPS/SEC.	240
STEPS SELECTOR	.02 MA per STEP

Indicator Unit

VERTICAL COLLECTOR MA	.5
HORIZONTAL COLLECTOR VOLTS	1

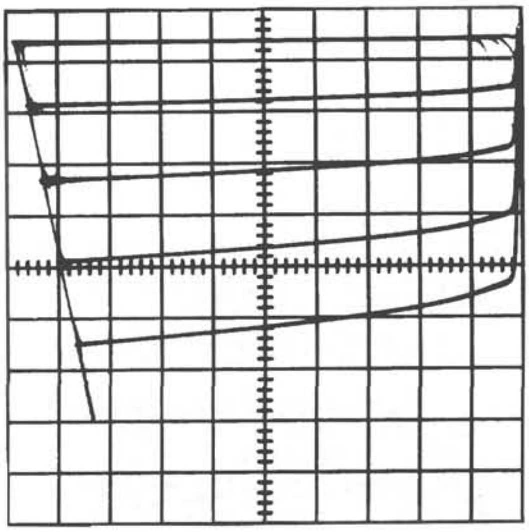


Fig. 2-8. Collector family of curves for a Type 2N407 transistor.

Insert a test transistor into the socket on the left side of the Test Panel, and place the Comparison Switch in the TRANsistor A position. Adjust the INTENSITY, FOCUS and ASTIGMATISM controls for a display of suitable brightness and clarity. The display should then be similar to the collector family shown in Fig. 2-8.

How To Check The Calibration of The Display

Before quantative information is taken from the display, a check should be made to see that the calibration of the vertical and horizontal scales is correct. The stability of the amplifiers is such that the instrument will remain in calibration over long periods of time if there are no component failures. The display must also be properly positioned.

NOTE: When you check the calibration of this instrument, calibrate it, or take information from the display, be sure your eye is at the same level as the line at which you are looking in order to avoid errors due to parallax.

Hold the VERTICAL AMPLIFIER CALIBRATION switch in the ZERO CHECK position and set the horizontal line even with the top line of the 10-division graticule. Next, hold this switch in the —10 DIVISIONS position. The horizontal line should be within 1½ minor divisions of the bottom line of the graticule if the calibration is within tolerance.

Now hold the HORIZONTAL AMPLIFIER CALIBRATION switch in the ZERO CHECK position and set the vertical line even with the extreme right vertical line of the graticule. Next, hold this switch in the —10 DIVISIONS position. The vertical line should move to within 1½ minor divisions of the extreme left vertical line of the graticule.

Since current steps are being fed into the base of the transistor under test, it is sometimes desirable to adjust the STEP ZERO control (BASE STEP GENERATOR) to a point where the first horizontal trace occurs when the base current is zero. To do this, it is necessary to have an open-circuit or zero base-current reference line. Hold the ZERO CURRENT-ZERO VOLTS switch in the ZERO CURRENT position and note precisely where the horizontal trace intersects the vertical center line of the graticule. Now release the ZERO CURRENT switch and adjust the STEP ZERO control so that the top line of the display intersects the vertical center line of the graticule at the same place.

Applying Voltage Steps to the Transistor Input

The control settings used in this display are the same as for the previous display except for the following:

SERIES RESISTOR	1 ohm
STEP SELECTOR	.02 VOLTS PER STEP
VERTICAL COLLECTOR MA	.05 MA PER DIVISION

If a complete and accurate display is desired, the display should be properly positioned by the method outlined in the next two paragraphs.

Hold the amplifier calibration switch (VERTICAL BLOCK) in the ZERO CHECK position and move the trace to the top line of the rectangular graticule. This operation sets the zero collector-current reference. Now depress the ZERO CURRENT-ZERO VOLTS switch (BASE STEP GENERATOR) in order to ground the transistor base. The vertical displacement of the horizontal trace from the zero-current reference indicates the collector current at zero bias with a calibration of .05 ma. per major division.

The STEP ZERO control (BASE STEP GENERATOR) must now be set so that the uppermost curve (zero bias) in the family of curves coincides with the position of the single curve just displayed. The family of curves now on the crt screen is that of collector current versus collector voltage with 20-millivolt steps applied to the transistor base.

Special precautions should be taken when voltage steps are fed to the input of the transistor under test. Since the input resistance of a transistor is quite nonlinear over its operating range, it is important that the number of voltage steps used does not cause excessive base current to flow. There are two controls which influence the maximum base current for a selected value of voltage-step amplitude. One is the STEPS/FAMILY control, which should be set to 4 for an initial test set-up. The other is the SERIES RESISTOR switch, which allows you to insert a protective current-limiting resistor in the transistor input lead. Excessive series resistance will seriously alter the characteristic curves displayed, therefore its effect should be taken into consideration before interpreting curves where voltage steps are being fed into the transistor input.

The SERIES RESISTOR may also be used to simulate driving impedances. When series resistance is used, it may not be possible to make the top curve of the display coincide with the zero-bias curve.

Characteristics of the Base Step Generator

The largest current steps the base generator can supply are 200 ma. each. Since up to 12 steps are available, the maximum current this supply will deliver is therefore 2.4 amperes. Because of necessary restrictions on the size of the power source for the internal transistors used to deliver the current steps, the input characteristics of the power transistor under test must be such that the base to emitter voltage does not exceed 5 volts when the base current is 2.4 amperes.

The minimum source resistance of the step generator in the VOLTS/STEP range of the STEP SELECTOR switch is one ohm (SERIES RESISTOR set at 1 ohm). This is a constant minimum source resistance irrespective of the size of the voltage steps. The source resistance increases as resistance is switched in series by the SERIES RESISTOR switch.

When power transistors are driven into the high base-current region, their input resistance is often low enough to cause the input steps to become non-uniform in size. Under these conditions, it is best to check the uniformity of the voltage steps by displaying the base voltage on either the vertical or horizontal axis. A quick check of generator loading may be made by changing the setting of the SERIES RESISTOR switch from 1 ohm to 3.4 ohms while collector characteristics are being displayed. A radical shift in the position of the trace displaying the highest collector current would indicate a low input resistance and the possiblity of non-uniform voltage input steps in the 1 ohm position.

Functions of Controls and Switches

All descriptions given below presume that the transistor under test is in the grounded-emitter configuration and that the power-line frequency is 60 CPS.

Collector Sweep Block

PEAK VOLTS RANGE. Selects appropriate power source to give collector sweep voltage and current range indicated. Operates in conjunction with PEAK VOLTS control.

PEAK VOLTS APPROXIMATE. Variable autotransformer in the primary of the collector sweep transformer. Operates in conjunction with PEAK VOLTS RANGE.

CIRCUIT BREAKER. Protects the collector sweep circuit from excessive overload currents.

POLARITY. Selects the polarity of the collector sweep to be applied to the transistor under test.

DISSIPATION LIMITING RESISTOR. Selects a protective series resistor for the collector circuit of the transistor under test. This resistance may be used as the collector load resistor to simulate operating conditions of the transistor under test. Refer to chart on top panel.

Base Step Generator Block

REPETITIVE-OFF-SINGLE-FAMILY. In the REPETITIVE position, the Base Step Generator produces stair-step waveforms. A characteristic curve is plotted during each horizontal portion of the stair-step waveform. In the OFF position, the BASE STEP GENERATOR is disabled. The SINGLE FAMILY position is a spring-return position which permits the generation of one stair-step waveform each time the switch handle is depressed.

STEPS/FAMILY. Determines the number of steps in each family of curves.

POLARITY. Selects the polarity of the stair-step waveform to be applied to the transistor under test.

STEPS/SEC. Selects the steps-per-second rate of the Base Step Generator as well as determining whether the steps occur at the beginning or at the end of each curve.

SERIES RESISTOR. This switch functions only when the STEP SELECTOR switch is in the VOLTS PER STEP position. It permits the simulation of the source impedance of the circuit in which the transistor under test is to be used. The SERIES RESISTOR may also be used as a protective device to limit the current that might otherwise be inadvertently applied to the transistor base.

STEP SELECTOR. Selects the magnitude of either voltage or current-per-step to be applied to the transistor under test.

STEP ZERO. The STEP ZERO control permits adjustment of the Step Generator to start on the zero-current or zero-volts curve of the display.

ZERO CURRENT—ZERO VOLTS. In the ZERO CURRENT position, the connection to the base of the transistor under test is broken. The curve displayed shows the open-base characteristic of the transistor. In the ZERO VOLTS position, the base is grounded to permit examination of the zero-bias characteristics.

Vertical Block

CURRENT OR VOLTAGE PER DIVISION. COLLECTOR MA. Selects the collector-current of the transistor under test for the vertical display. Different switch positions within this range change the calibration of the vertical display by changing the value of an internal current-sampling resistance.

2X. Pushbutton switch multiplies each current step by 2.

0.1X. Pushbutton switch divides each current step by 10.

BASE VOLTS. Selects the base voltage of the transistor under test for the vertical display. The sensitivity is determined by the resistance of an attenuator in the vertical amplifier.

BASE CURRENT OR BASE SOURCE VOLTS. Base current is displayed vertically when the STEP SELECTOR switch (BASE STEP GENERATOR) is in the MA PER STEP range. The calibration of the vertical display is that indicated by the STEP SELECTOR switch except that it is also in milliamperes per major division as well as milliamperes per step.

The base-source voltage is displayed vertically when the STEP SELECTOR switch is in the VOLTS PER STEP range. The display is that of the voltage steps which are occuring ahead of the SERIES RESISTOR. The calibration is indicated by the STEP SELECTOR switch except that it is also in volts per major division as well as volts per step.

EXT. This switch position permits the vertical dc amplifier to be driven by an external signal applied through connectors on the back panel of the instrument, or on instruments after S/N 3659 through the pins of the Type 175 adaptor socket. The external signal may be either single-ended or push-pull.

POSITION. This control permits the display to be moved vertically over the entire face of the crt without introducing distortion into the display.

AMPLIFIER CALIBRATION. A three-position switch with two spring-return positions used to check the ZERO position and the calibration of the vertical amplifier.

DC BAL. This control is adjusted to permit changing of the amplifier sensitivity without changing the position of the display.

Horizontal Block

VOLTS/DIV. BASE VOLTS. Selects the base voltage of the transistor under test for the horizontal display. The sensitivity is determined by the resistance of an attenuator.

COLLECTOR VOLTS. Selects the voltage on the collector of the transistor under test for the horizontal display. The various switch positions in this range either change the gain of the horizontal amplifier or introduce attenuation of the collector voltage signal applied to the input of the horizontal amplifier.

BASE CURRENT OR BASE SOURCE VOLTS. The description of this switch position is the same as that given in the VERTICAL BLOCK under the same heading, except that the display is horizontal instead of vertical.

EXT. The description of this switch position is the same as that given in the VERTICAL BLOCK under the same heading, except that the display is horizontal instead of vertical.

POSITION. This control permits the display to be moved horizontally over the entire face of the CRT without introducing distortion into the display.

AMPLIFIER CALIBRATION. A three-position switch with two spring-return positions used to check the ZERO position and the calibration of the horizontal amplifier.

DC BAL. This control adjusts the tube-current balance in the direct-coupled horizontal amplifier to permit changing of the amplifier sensitivity without changing the position of the display.

Test Panel

TRANSISTOR A, TRANSISTOR B. A three-position switch which, in either outside position, connects the two binding posts and the transistor socket indicated to the appropriate circuitry within the instrument. In the center (off) position, it disconnects all power from the transistor, sockets and binding posts.

EMITTER GROUNDED, BASE GROUNDED. A reversing switch in the base and emitter leads of the transistor sockets. It permits small transistors to be rapidly switched between the grounded-emitter and grounded-base configurations. This switch does not reverse binding post connections.

Interpreting Type 575 Curves

The following displays are devoted to some typical transistor displays and their meaning. While no attempt is made to explain transistor terminology and parameters, it is hoped that these diagrams and curves will help the operator to arrive at the desired answer in less time, and perhaps better understand the operation of the instrument in so doing.

The transistor used in most of the following tests is the 2N407 PNP junction transistor. The curves are not necessarily typical of the average 2N407 as a number of different transistors were used in order to best demonstrate certain characteristics. Other curves shown include those for the point contact transistor, Zener diode, gaseous voltage-regulator tube NE2, tetrode transistor, photodiode and phototransistor.

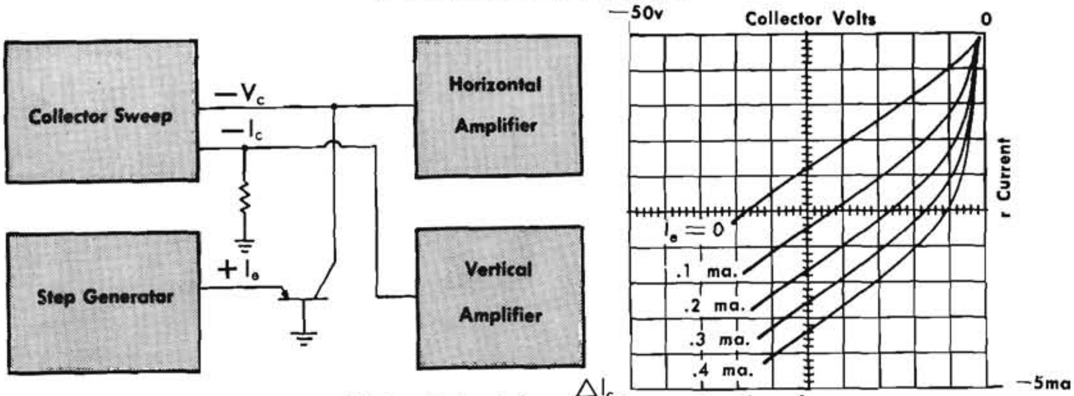
An attempt has been made to portray all of the voltages and currents that appear in transistor specifications; i.e., V_{ce}, V_{be}, V_{cb}, BV_{ce}, BV_{ceo}, I_{co}, I_{cbo}, I_{eo}, etc. Also, since some manufacturers employ the hybrid h parameters while others use the r parameters (as in low-frequency equivalent T circuit), measurements of both types have been included.

Note: The measurements obtained on the Type 575 are valid for low-frequency operation only; other equipment is required for high-frequency testing.

The effects of temperature on transistor operation are very important; this can be noted in the top two curves on page 2-7. The temperature effects can be portrayed with the aid of a thermocouple or heat box, or by means of an oil bath and heating element.

Collector Family

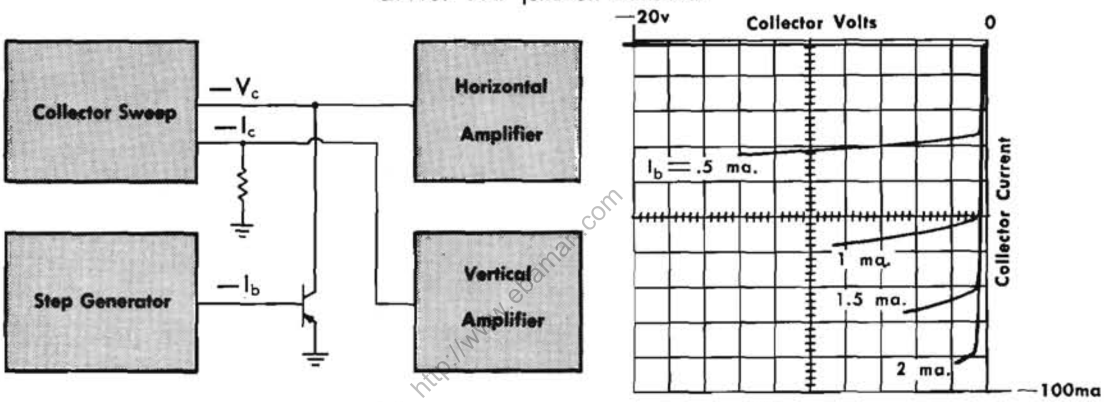
X-Bell point-contact transistor



Note: Alpha $(\alpha) = \frac{\Delta I_c}{\Delta I_e}$ is greater than 1.

Collector Family

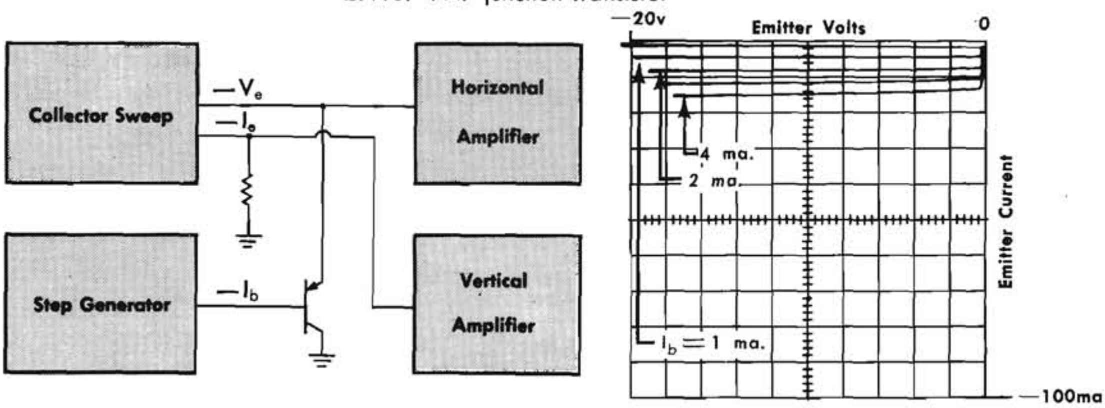
2N407 PNP junction transistor



Beta $(\beta) = \frac{\Delta I_c}{\Delta I_b} = h_{fe}, h_{FE}$. $r_{22e} = r_e + r_c = \frac{\Delta V_c}{\Delta I_c}$

Inverted Collector Family

2N407 PNP junction transistor



Reverse current transfer ratio $= h_{fc}, h_{FC}$.

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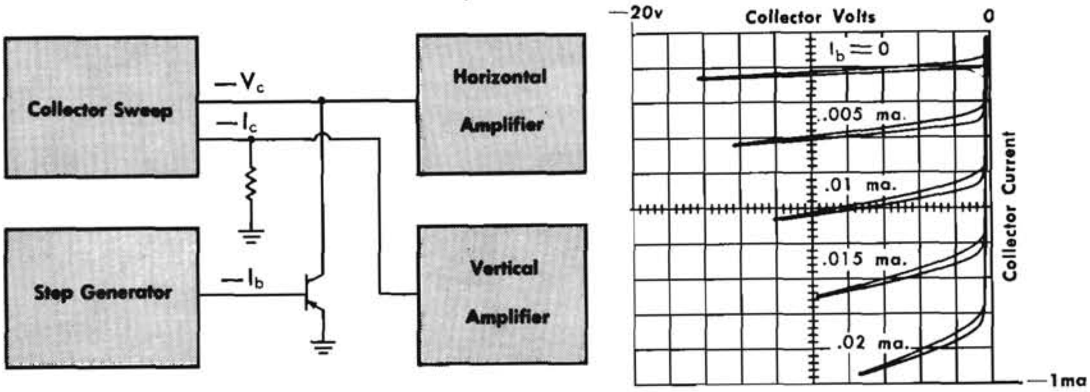
Collector Family . . . Effect of collector to base capacity

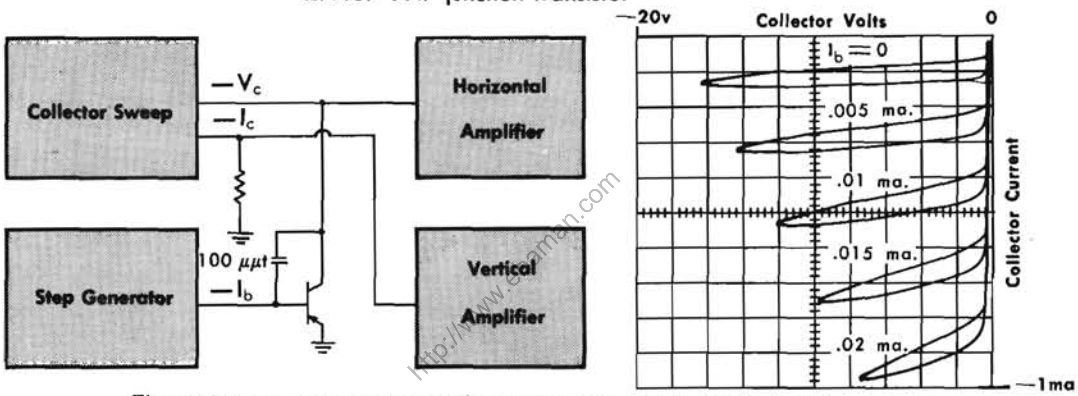
2N407 PNP junction transistor



This effect is most noticeable with high collector voltage and low collector current.

Collector Family . . . External capacity added

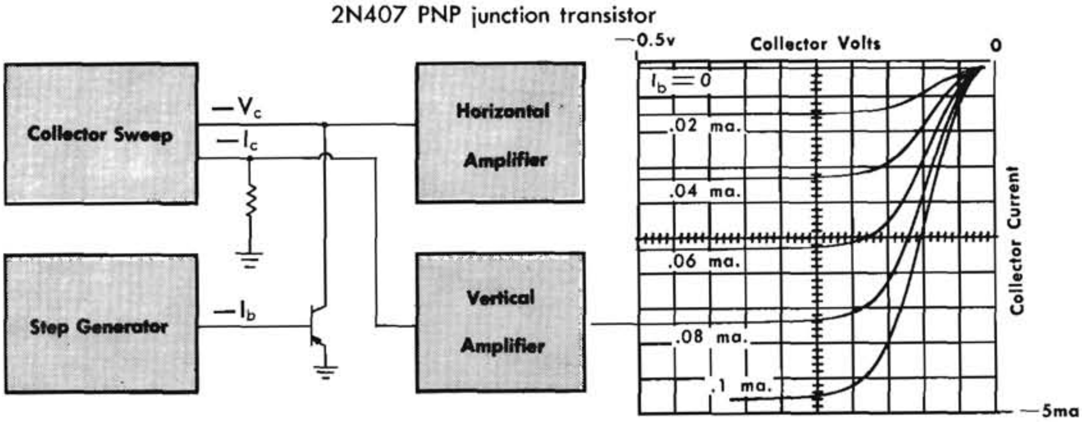
2N407 PNP junction transistor



The added capacity increases the modulation of the base current;
this effect is amplified by the transistor.

Collector Family . . . Saturation region

2N407 PNP junction transistor

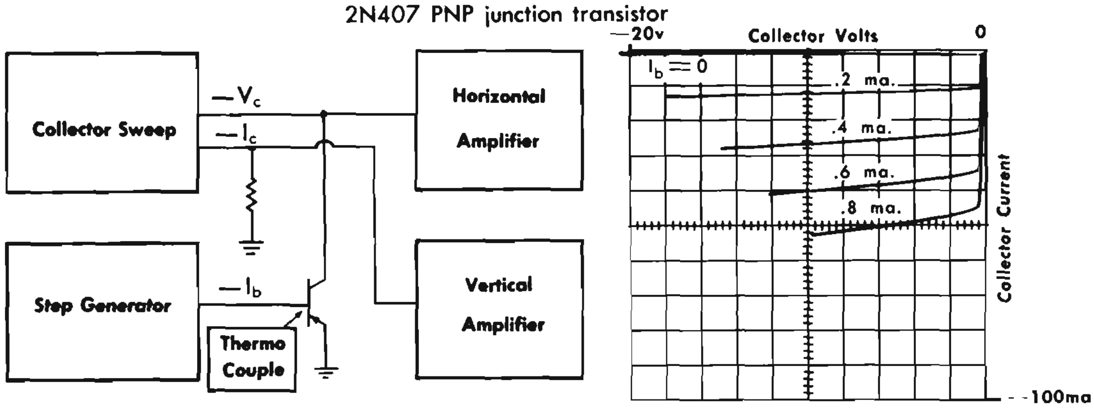


Saturation voltage V_{CE} (SAT), at specified I_b and I_c.

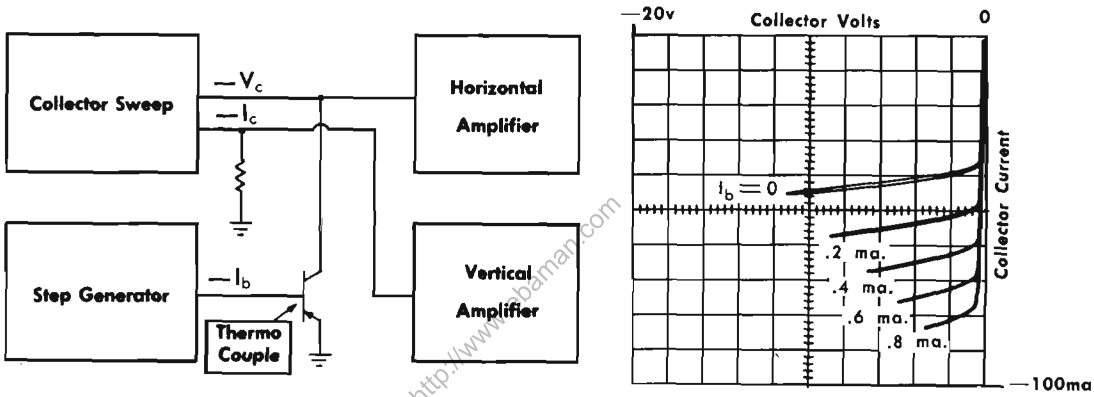
Saturation resistance R_{SC} = slope of I_c-V_c curve at specified I_c.

Collector Family . . . Room temperature (75° F.)

2N407 PNP junction transistor

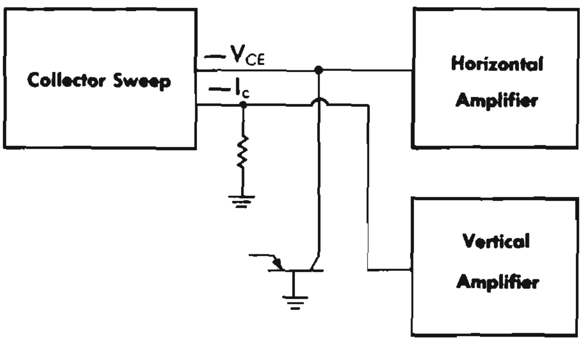


Above transistor at temperature of 150° F.



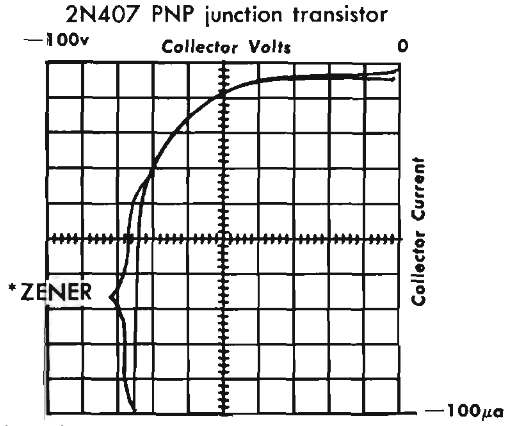
Note increase in leakage current and Beta.

Breakdown Voltage, collector to base (emitter open) BV_{CBO}



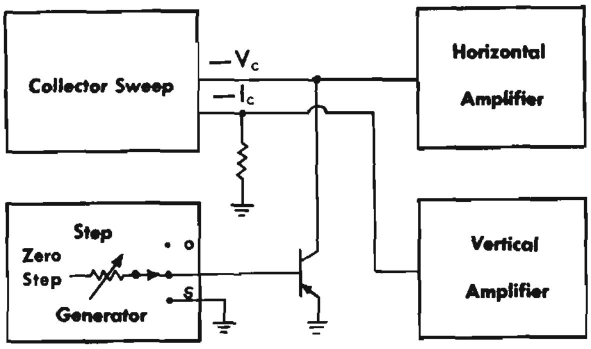
Collector Cutoff Current I_{CO}, I_{CBO}

2N407 PNP junction transistor

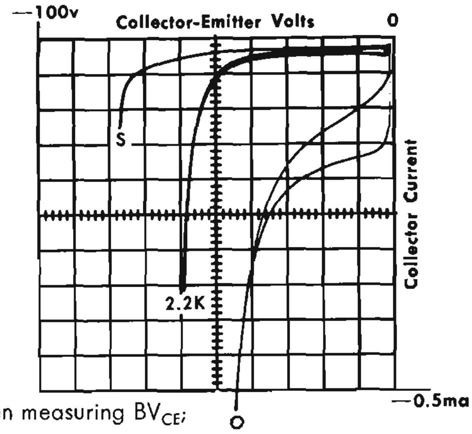


For BV_{CBO} the I_c should be specified; For I_{CBO} the voltage should be specified. Note the Zener region.*

Breakdown Voltage, collector to emitter
BV_{CE}, BV_{CEO}, BV_{CER}, BV_{CES}

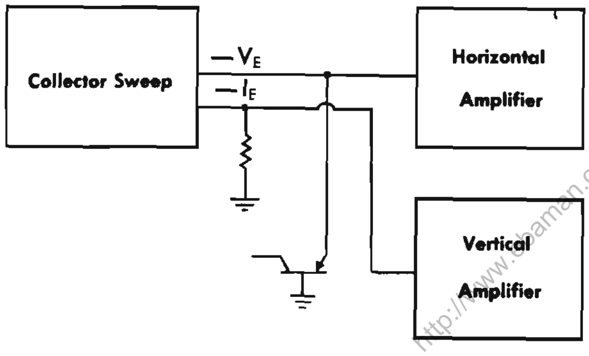


Collector Current I_{CE}, I_{CEO}, I_{CES}
2N407 PNP junction transistor

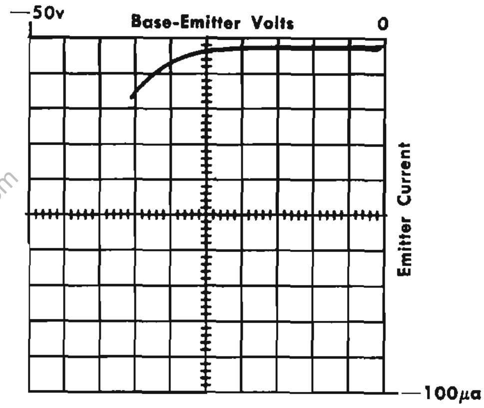


The current should be specified when measuring BV_{CE};
the resistance should be specified when measuring BV_{CER}.

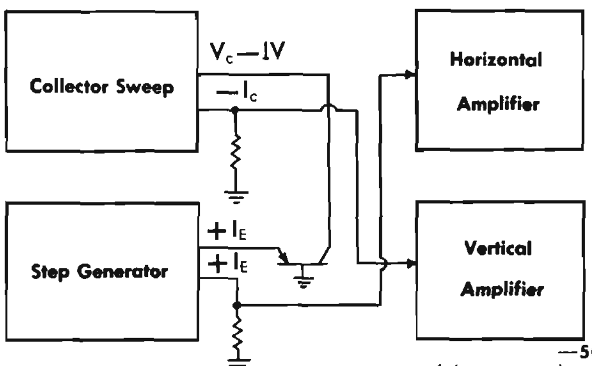
Breakdown Voltage, base to emitter
(collector open) BV_{BEO}

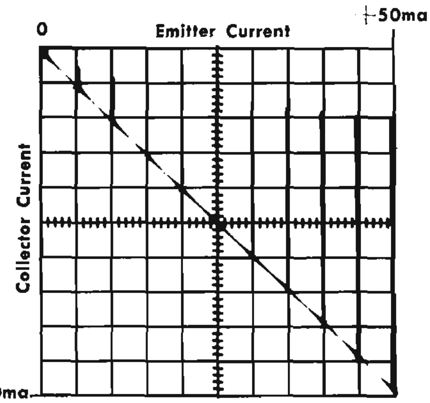


Emitter Current I_{EO}, I_{EBO}.



Alpha Curve, α, h_{21b}, h_{fb}, h_{FB}
2N407 PNP junction transistor



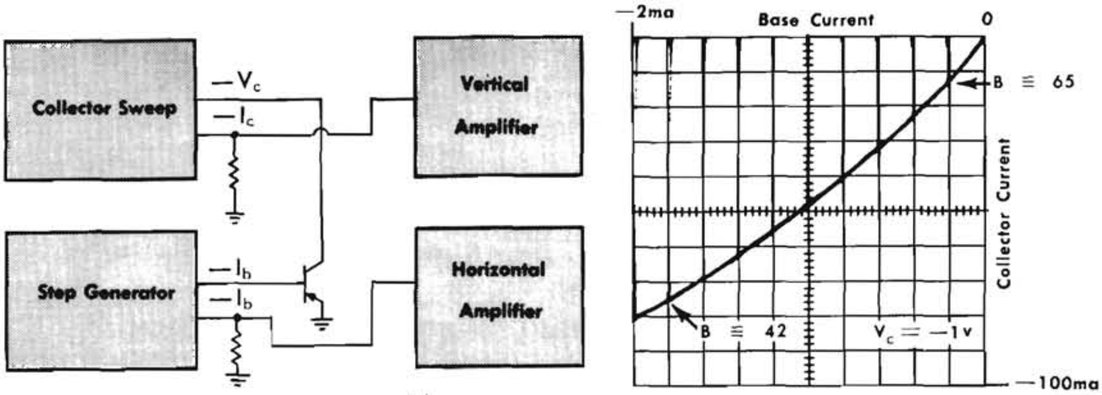


$$h_{fb} = \frac{\Delta I_c}{\Delta I_e};\ h_{FB} = \frac{I_C}{I_E}$$

$\alpha \cong .98$

Forward Current Transfer Ratio, Beta, β, h_{21e}, h_{fe}, h_{FE}

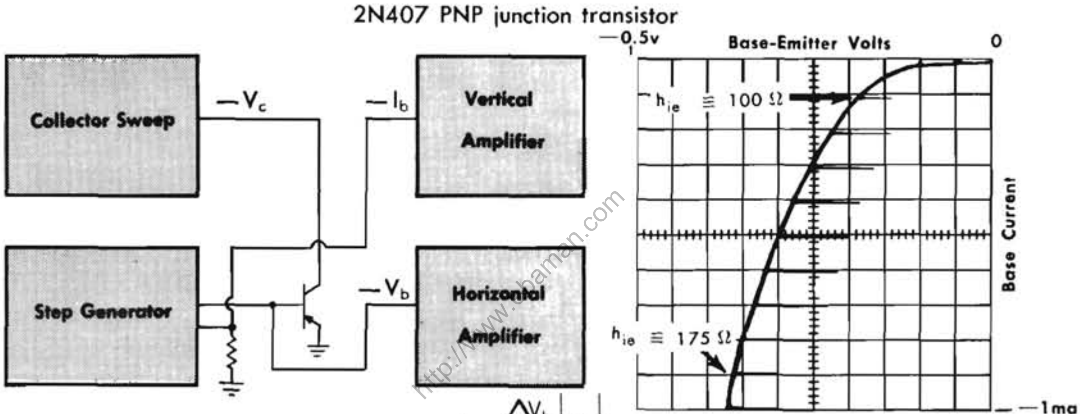
2N407 PNP junction transistor



Note Beta, $h_{fe} = \frac{\Delta I_c}{\Delta I_b}$, decreases at higher currents.

Input Impedance, h_{11e}, h_{ie}

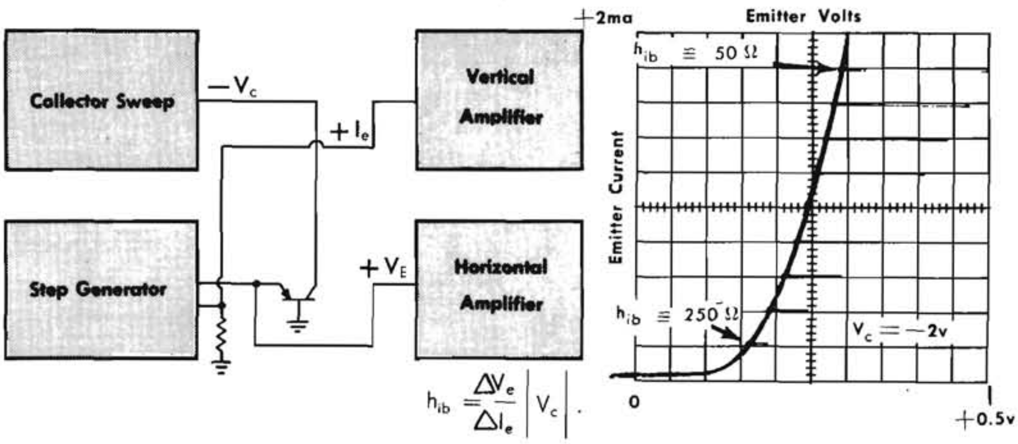
2N407 PNP junction transistor



$$h_{ie} = \frac{\Delta V_b}{\Delta I_b} \Big| V_c \Big| .$$

Input Impedance, h_{11b}, h_{ib}

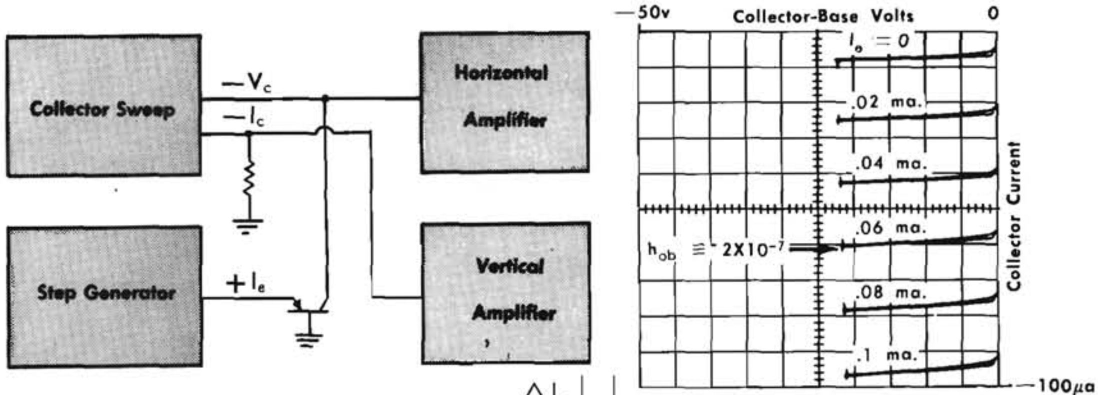
2N407 PNP junction transistor



$$h_{ib} = \frac{\Delta V_e}{\Delta I_e} \Big| V_c \Big| .$$

Output Admittance, h_{22b}, h_{ob}

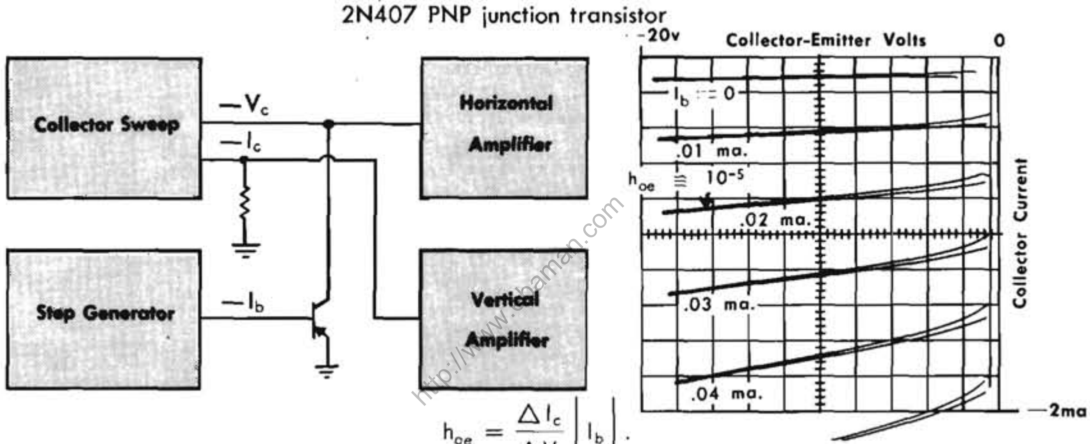
2N407 PNP junction transistor



$$h_{ob} = \frac{\Delta I_c}{\Delta V_c}\bigg| I_e \bigg| .$$

Output Admittance, h_{22e}, h_{oe}

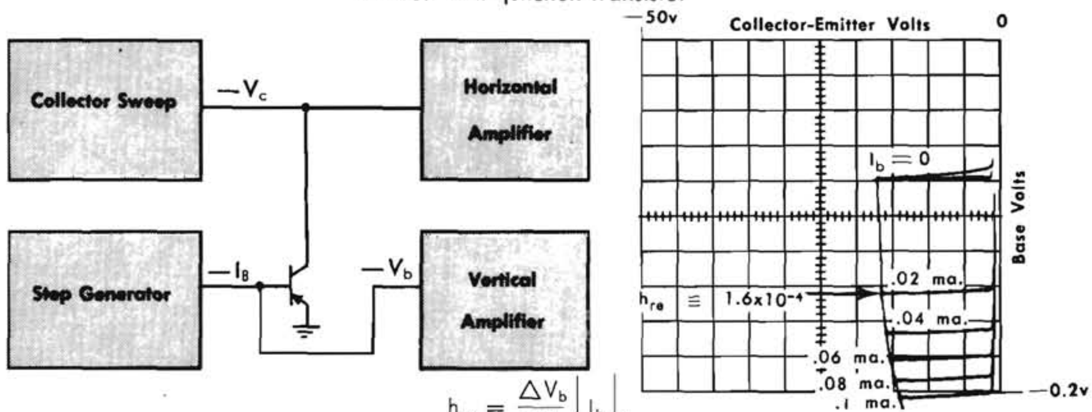
2N407 PNP junction transistor



$$h_{oe} = \frac{\Delta I_c}{\Delta V_c}\bigg| I_b \bigg| .$$

Voltage Feedback Ratio, h_{12e}, h_{re}

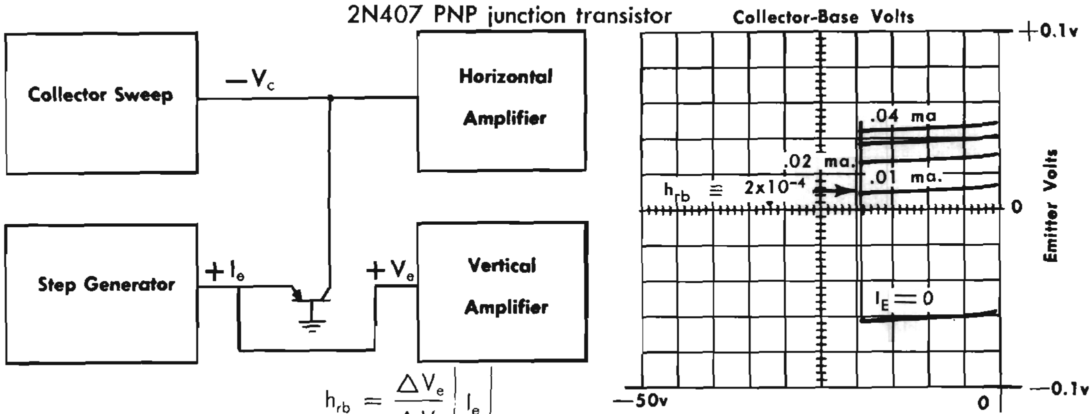
2N407 PNP junction transistor



$$h_{re} = \frac{\Delta V_b}{\Delta V_c}\bigg| I_b \bigg| .$$

Voltage Feedback Ratio, h_{12b}, h_{rb}

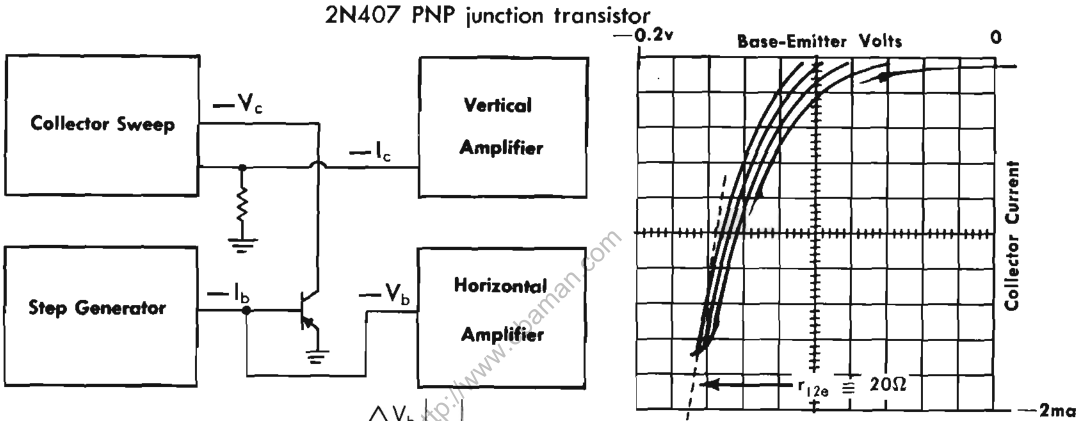
2N407 PNP junction transistor



$$h_{rb} = \frac{\Delta V_e}{\Delta V_c}\Big|_{I_e}$$

Reverse Transfer Resistance, r_{12e}

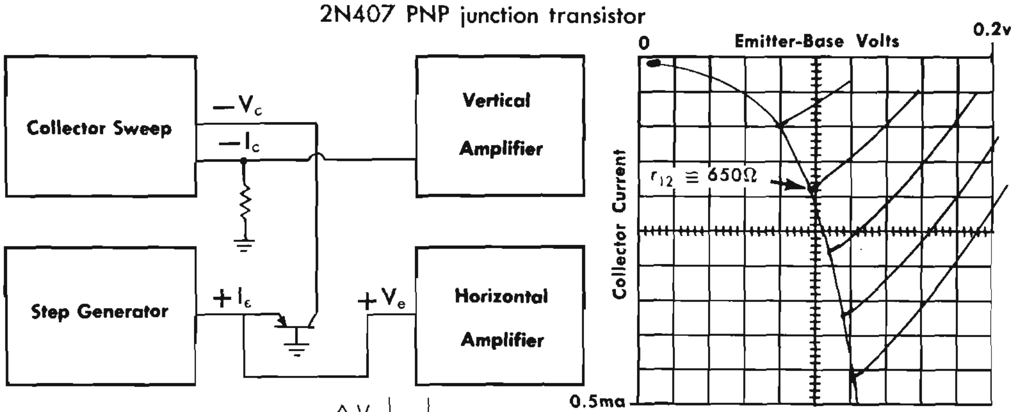
2N407 PNP junction transistor



$$r_{12e} = \frac{\Delta V_b}{\Delta I_c}\Big|_{I_b} = r_e. \text{ Slope } = r_{12e}.$$

Reverse Transfer Resistance, r_{12b}

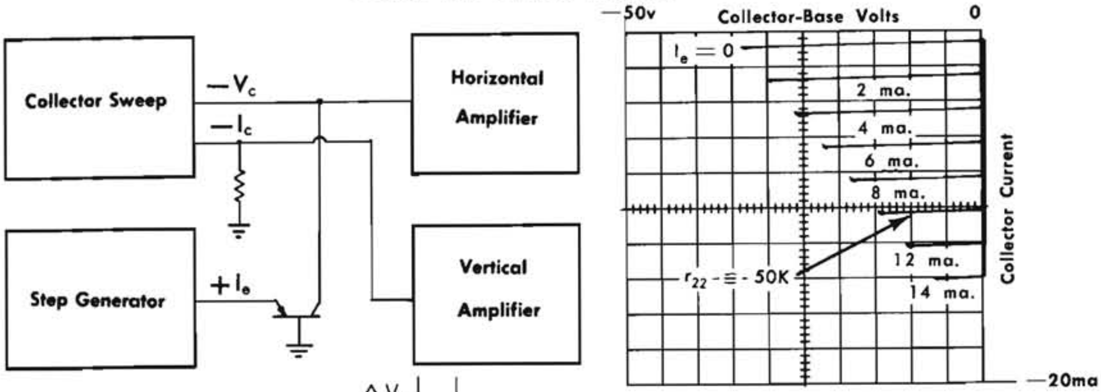
2N407 PNP junction transistor



$$r_{12b} = \frac{\Delta V_e}{\Delta I_c}\Big|_{I_e} = r_b. \text{ Slope } = r_{12}.$$

Output Resistance (input open-circuited to ac).

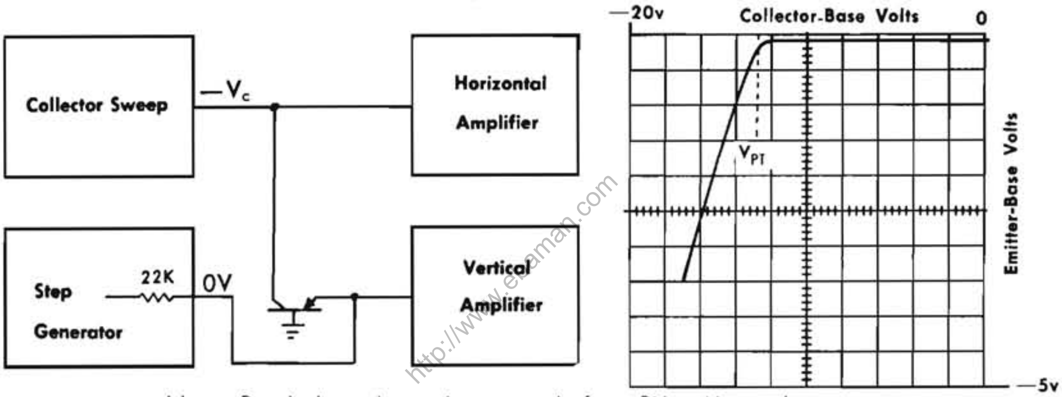
2N407 PNP junction transistor



$$r_{22} = \frac{\Delta V_c}{\Delta I_c}\Bigg| I_e \Bigg| = r_b + r_c. \quad \text{Slope} = r_{22}.$$

Punch-Through Voltage (V_{PT}) and Floating Potential.

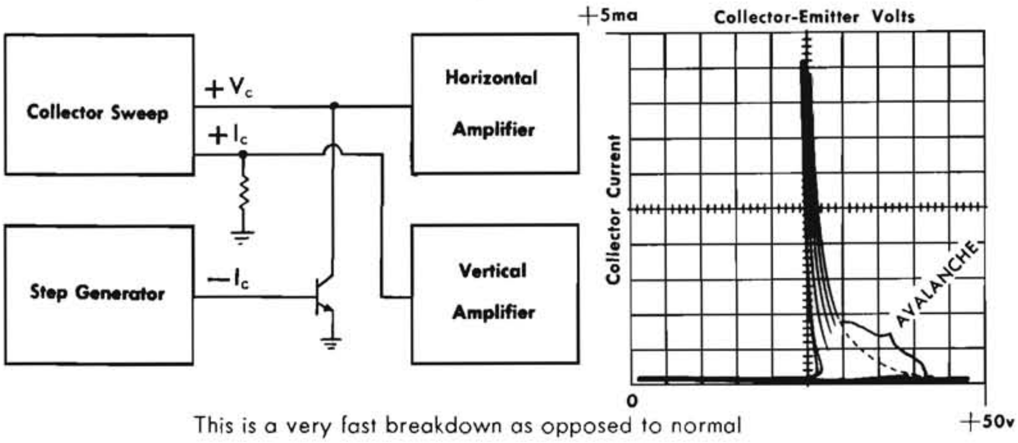
X-Philco surface-barrier transistor.



Note: Punch-through rarely occurs before BV_{CE}. V_{EB} is the floating potential

Back-Biased NPN in Avalanche Mode

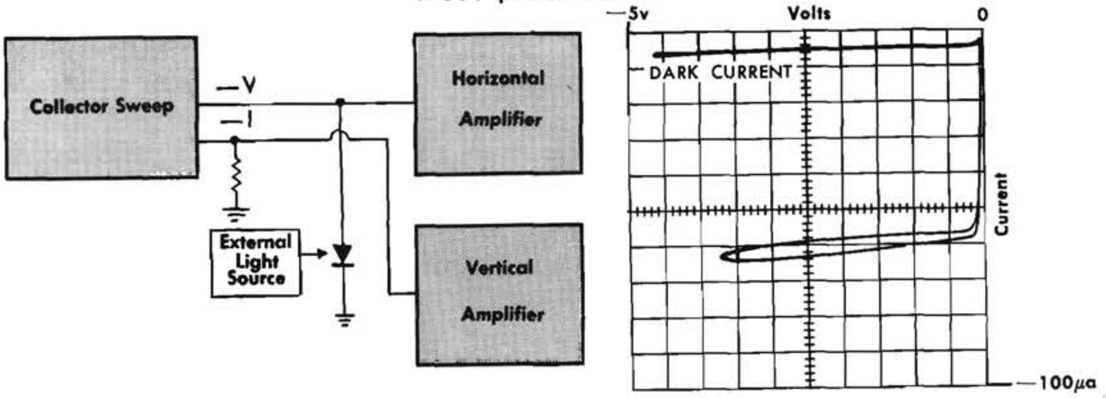
2N212 NPN junction transistor



This is a very fast breakdown as opposed to normal Zener breakdown.

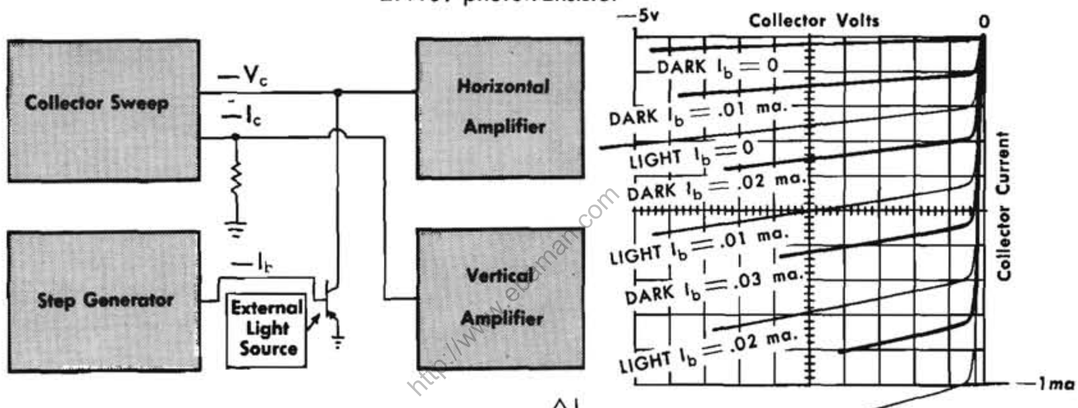
Photodiode, with and without light

TI-800 photodiode



Phototransistor, with and without light

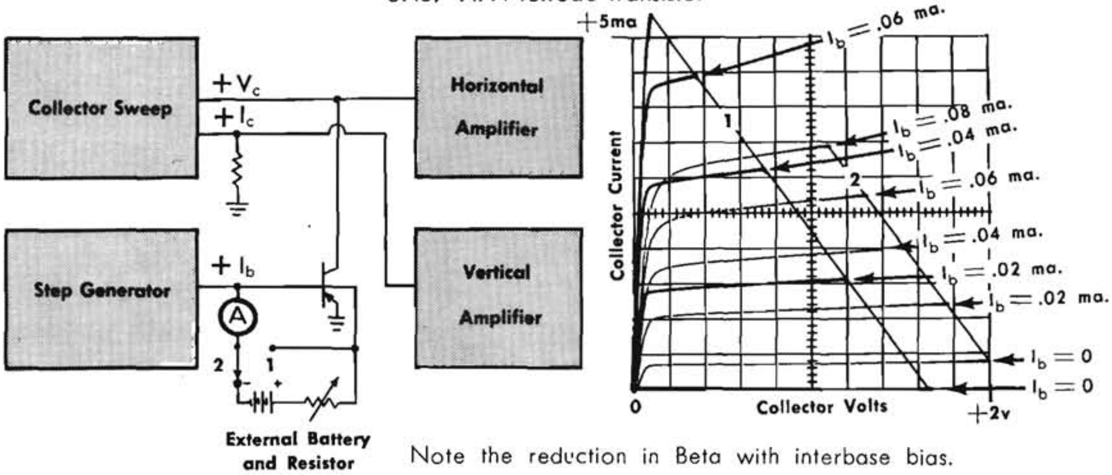
2N469 phototransistor



$$h_{fe} = \frac{\Delta I_c}{\Delta I_b}, r_{22}$$

Tetrode NPN: Effect of Interbase Bias

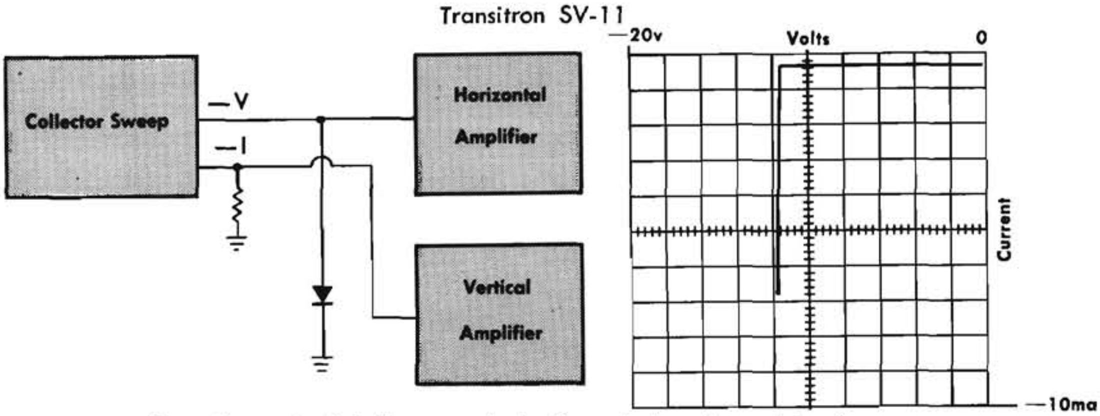
3N37 NPN tetrode transistor



Note the reduction in Beta with interbase bias.

Zener or Reference Diode, Reverse Biased

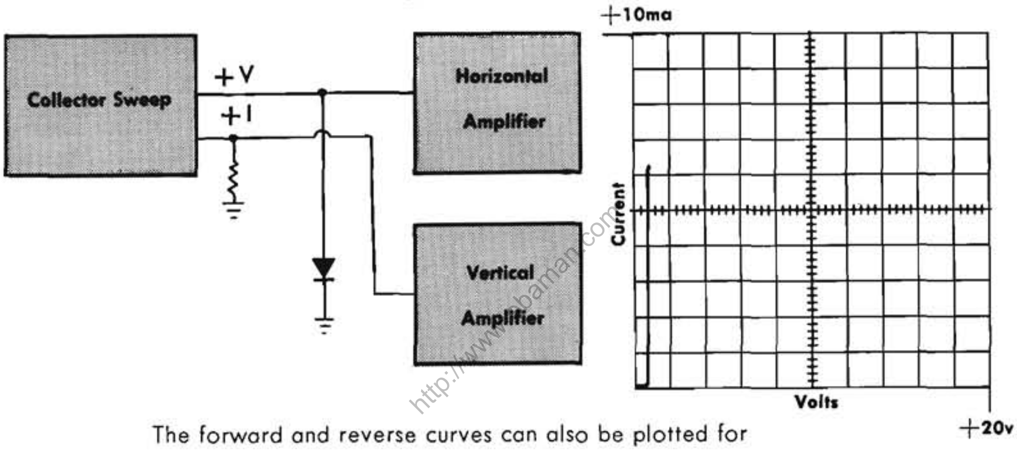
Transitron SV-11



Operating potential (Zener region), Dynamic impedance (slope)

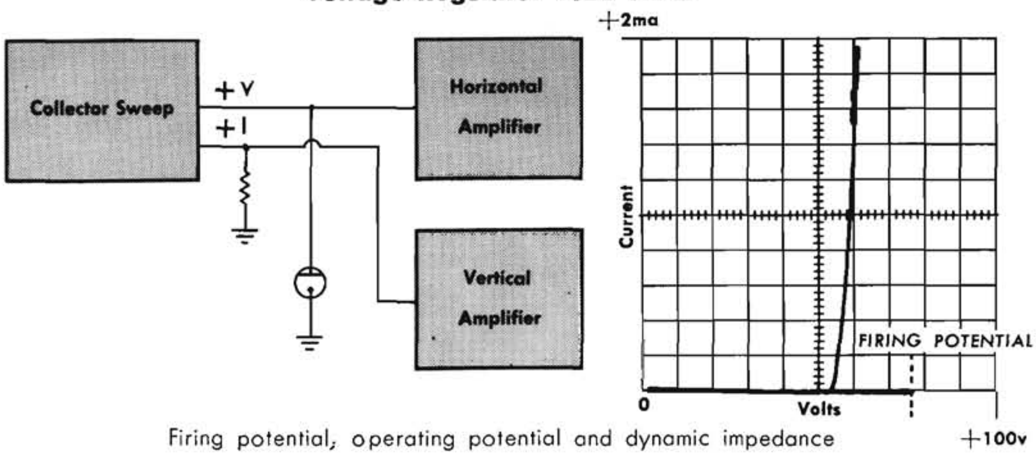
Zener or Reference Diode, Forward Biased

Transitron SV-11

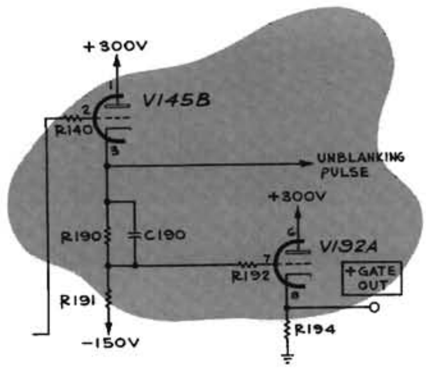


The forward and reverse curves can also be plotted for semiconductor diodes and metallic rectifiers.

Voltage Regulator Tube NE-2



Firing potential, operating potential and dynamic impedance



SECTION 3

CIRCUIT DESCRIPTION

Block Diagram

The Block Diagram shows the relationship of the Collector Sweep, the Step Generator, the Step Amplifier, and the CRT Deflection Amplifiers to the transistor under test. The Step Generator is driven by the 60-cycle line voltage and the waveform from the Step Amplifier is applied to the input of the transistor under test. The Collector Sweep Generator supplies the full-wave rectified pulses that are applied to the collector of the transistor. Notice that the pulsations occur at twice the line frequency. The crt deflection amplifiers are shown connected for a display of the transistor I_c - V_c characteristic curves.

The three possible time relationships between waveforms of the Collector Sweep and the Step Generator are shown in Fig. 3-1. In waveform (b), each voltage step begins at a time when the Collector Sweep voltage is zero. In waveform (c), each step begins at a time when the Collector Sweep voltage is at its maximum value. In waveform (d), steps begin both at times when the Collector Sweep voltage is at its maximum value and when it is at its minimum value.

Collector Sweep

The Collector Sweep circuit rectifies the 60-cycle line voltage (full-wave circuit) to produce 120 sweeps per second for the collector of the transistor under test.

The primary voltage of T702 is variable from 0 to 140 volts rms by the variable autotransformer T701 (PEAK VOLTS control). The secondary of T702 provides output voltages up to 20 volts and 200 volts, peak, depending on the setting of the PEAK VOLTS control and the PEAK VOLTS RANGE switch SW706. The collector-supply primary is protected by a circuit breaker, set to trip within 30 seconds at 1.2 ampere rms current but to hold on a rms current of 1 ampere. The turns ratio of the transformer for the 20-v range is such that a maximum peak current of 15 amperes is available with 1 ampere rms in the primary. Because the current pulses for transistors are not sinusoidal nor of constant amplitude, and their duty cycle is dependent upon the characteristics of the device being tested, it is difficult to say what maximum collector-current curves can be plotted. Generally, a family of collector-current curves can be plotted to 20 amperes or more

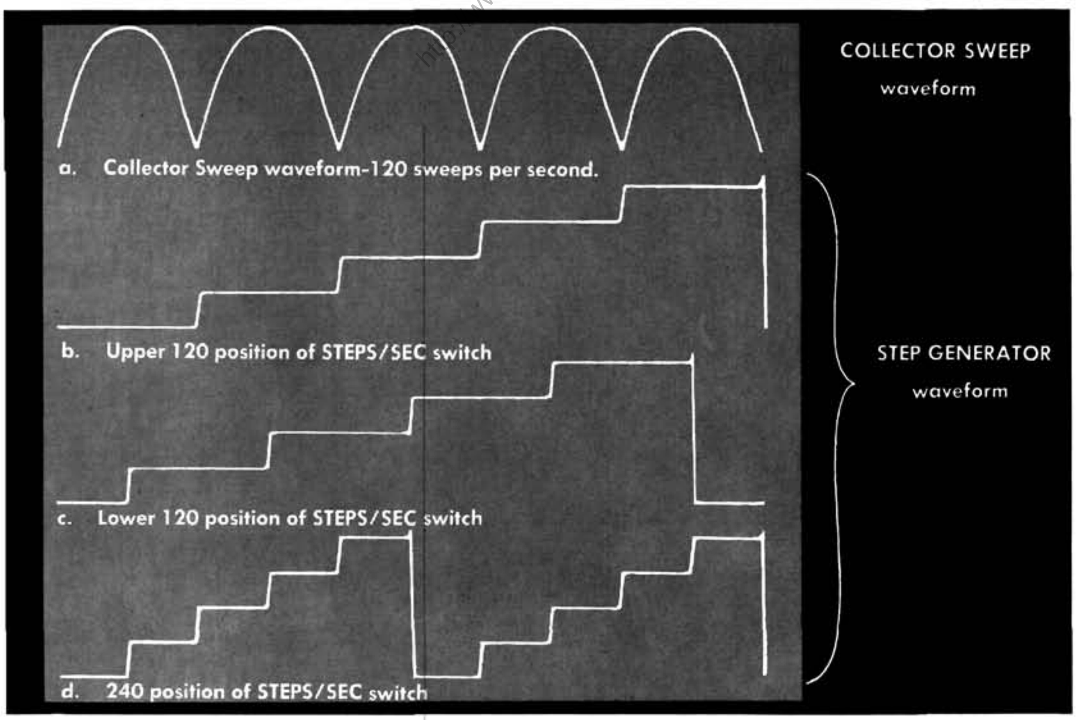


Fig. 3-1. The time relationship between waveforms of the Collector Sweep circuit and the Step Generator.

when the transistors have a beta of 8 or greater. When checking diodes, you will notice that the waveform of current pulses is such that a curve of approximately 15 amperes maximum is drawn.

By means of the PEAK VOLTS RANGE switch, each set of rectifier diodes is connected in parallel for the 0-20 volt range, or in series for the 0-200 volt range. The polarity of the output sweeps is determined by the POLARITY switch SW708. The DISSIPATION LIMITING RESISTOR switch SW710 connects the desired value of resistance in series with the collector to protect the transistor.

To compensate for the stray-circuit-capacitance charging current through the Current Sampling Resistor, a sample of the collector sweep voltage is applied through the cathode-follower V733 to the top of the Current Sampling Resistor. Capacitors C706 and C735 are used to balance the circuit capacitances.

Step Generator

The circuit diagram of the Step Generator may be considered in two sections: the pulse-generator section (left side) which develops rectangular pulses from the sine-wave input, and the staircase-generator section which uses these pulses to develop a staircase waveform. V171 is the "heart" of the Step Generator and its operation will be described first.

Staircase Generator

The staircase waveform is generated by increasing the charge on a capacitor by equal steps and then discharging the capacitor after the desired number of steps has been generated. A simplified example is shown in Fig. 3-2. When the switch is closed the voltage will rise at the normal RC charging rate as in curve A. If the switch is closed in a series of short, equal intervals, a staircase waveform like that of waveform B is produced. It is a very poor staircase waveform because the steps become progressively smaller as the voltage across the capacitor increases. To achieve a series of equal-amplitude steps, the capacitor charging current, and hence the voltage across the resistor, must be kept constant.

The diagram of Fig. 3-3 shows a method of achieving this end. It is called the Miller integrator. With the switch in position 1, the plate of the pentode is at +100 volts, the quiescent output voltage, and the charge on C177 is 101.5 volts.

When the switch is moved to position 3, C177 charges through R1 and the grid of V171 tends to become more negative. But since a negative signal on the control grid reduces the plate current, the plate voltage increases, raising the voltage at the top of C177. The coupling of this positive change at the top of C177 to the control grid almost completely cancels the negative-going tendency of the control grid. Since the dc gain of the pentode stage is very high, the plate-voltage change is always very large compared to the voltage change that occurs on the grid.

When the switch is moved to position 1, the charging process stops and the tube returns to its initial condition, discharging C177 to 101.5 volts.

Waveform A of Fig. 3-3 is the output waveform which results from moving the switch from position 2 to position 3 at a regular rate. Note that this staircase waveform has steps which are of equal amplitude, since C177 is charged at the same rate whenever the switch is in position 3. Waveform B is the corresponding grid waveform.

The circuit of Figure 3-4 is a modification of the one in Fig. 3-3, the only changes being the addition of a cathode follower between the plate of the pentode and the top of C177 and an additional switch position which permits the coupling of negative-going pulses to the bottom of C177.

With the switch in position 1, the plate of the pentode is again at +100 volts; however, the output terminal (top of C177) will be about ground potential.

With the switch in position 4, and with no input pulses fed into diodes V172A and V172B, the output voltage is constant since the electrical path through C177 is incomplete. When

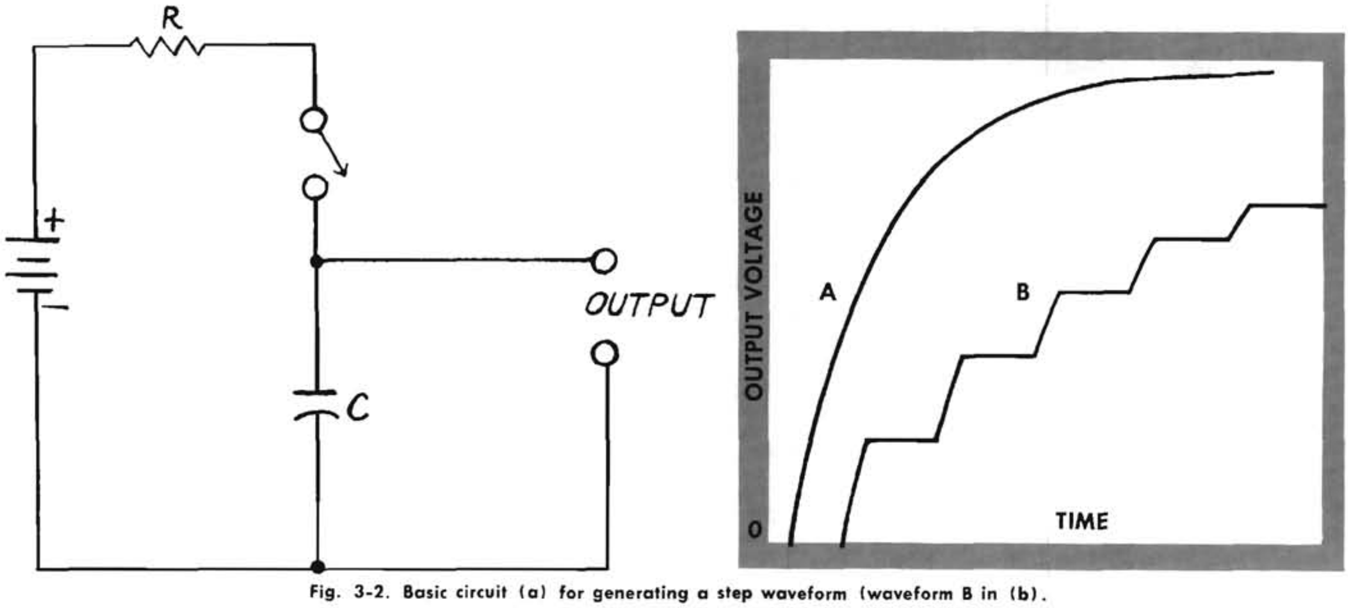


Fig. 3-2. Basic circuit (a) for generating a step waveform (waveform B in (b).

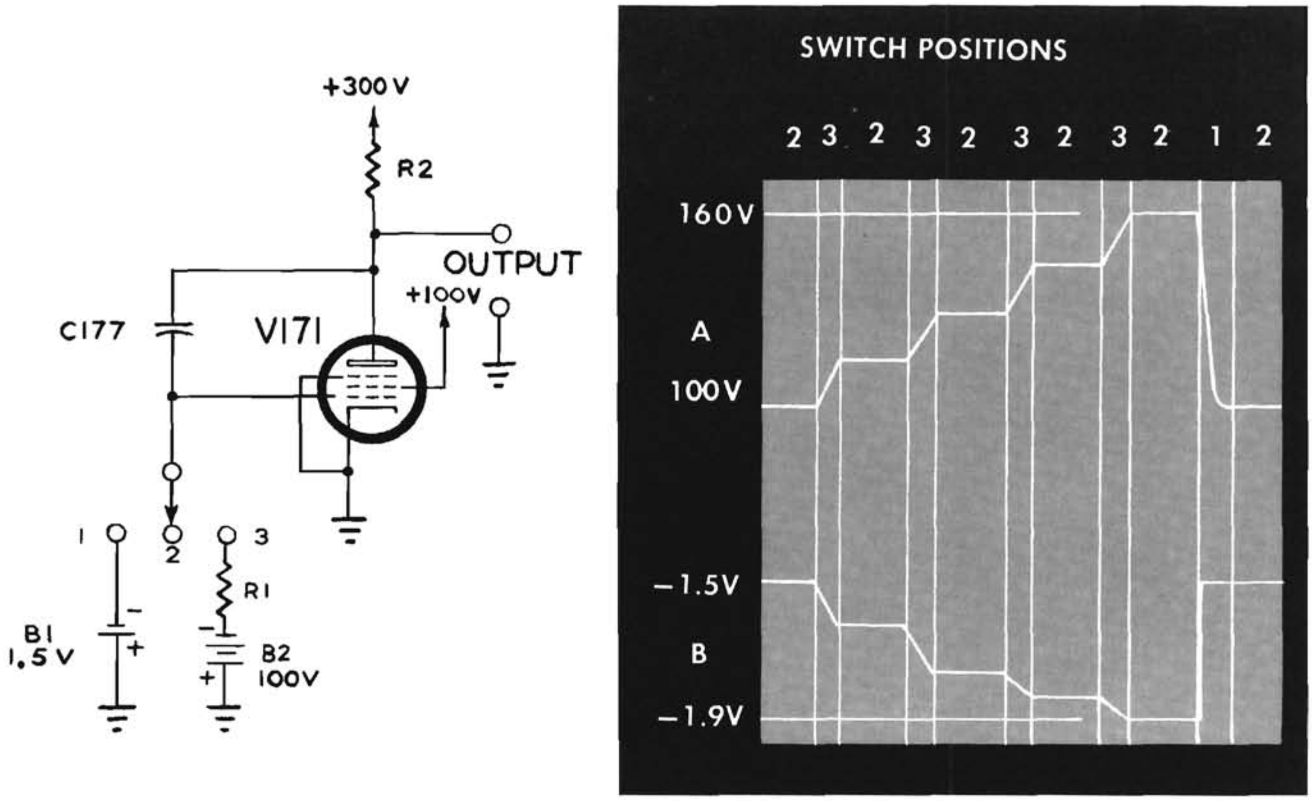


Fig. 3-3. The basic Miller Integrator circuit and the resulting plate and grid waveforms for linear step operation.

a negative pulse is fed to the cathode of V172A, C142 transfers a quantity of its charge to C177. As the negative input pulse returns to its base level, V172A stops conducting. V172B, however, begins to conduct heavily to restore the charge on C142.

Because the Miller integrator keeps the voltage at the bottom of C177 nearly constant, the same quantity of charge is transferred to C177 with each pulse. The voltage steps occuring at the output are equal, because the voltage across a capacitor is directly proportional to its charge.

The changing charge on C142 is an important part of the generation of steps. On waveform C, point "a" (between negative pulses) shows the left end of C142 to be +150 volts. Waveform B shows that at the same time, the junction of diodes V172A and V172B is near ground. The charge on C142, then, must be about 150 volts. As a negative pulse begins, the left end of C142 is driven negatively toward +50 volts. As the right end of C142 tries to follow, V172A provides a current path for C177 and its charge is increased as shown on waveform A. Since the capacity of C177 is about 7 times as large as that of C142, the increase in voltage across C177, 15 volts is equal to 1/7 of the decrease in voltage across C142. Because the Miller integrator keeps the bottom of C177 at a constant voltage, the 15-volt step occurs at the output and not at the grid of V171.

Repetitive Triggering

The circuit of Fig. 3-5 is used to show the operation of the Schmitt Trigger and the Hold-Off Cathode Follower. Their action provides a repetitive display, since they cause C177 to be discharged and then permit the formation of steps to proceed again in the same manner as described previously.

For our purposes, we think of the Schmitt Trigger as a voltage-activated switch. In its operation, the entire current through R156 in the cathode circuit is shifted from one section of V155 to the other. When one side of V155 conducts the other side is cut off.

Typical conditions for conduction are as follows: when the grid voltage of V155A is above —42 volts, V155A conducts; when the grid voltage of V155A is below —58 volts, V155B conducts. When the grid voltage of V155A is within the range from —42 to —58 volts, either tube section may conduct, but not both sections. The output of the trigger circuit is at the plate of V155B. The voltage at this plate switches between zero (V155B cut off) and a negative voltage (V155B conducting).

When V155B is conducting, the diodes V152A and V152B are cut off because their plate voltages are more negative than their cathodes. This condition permits the staircase generator to generate a stairstep waveform as described previously. As the output stairstep waveform rises, the cathode voltage of V143B follows. When the cathode voltage (and the grid voltage of V155A) reaches —42 volts, the Schmitt trigger will switch to its other stable state; that is, V155A will be conducting and V155B will be cutoff.

When V155B is not conducting, its plate voltage will be at ground potential, permitting diodes V152A and V152B to conduct. As V152B conducts, the grid of V171 is clamped at ground potential causing the plate voltage to fall rapidly.

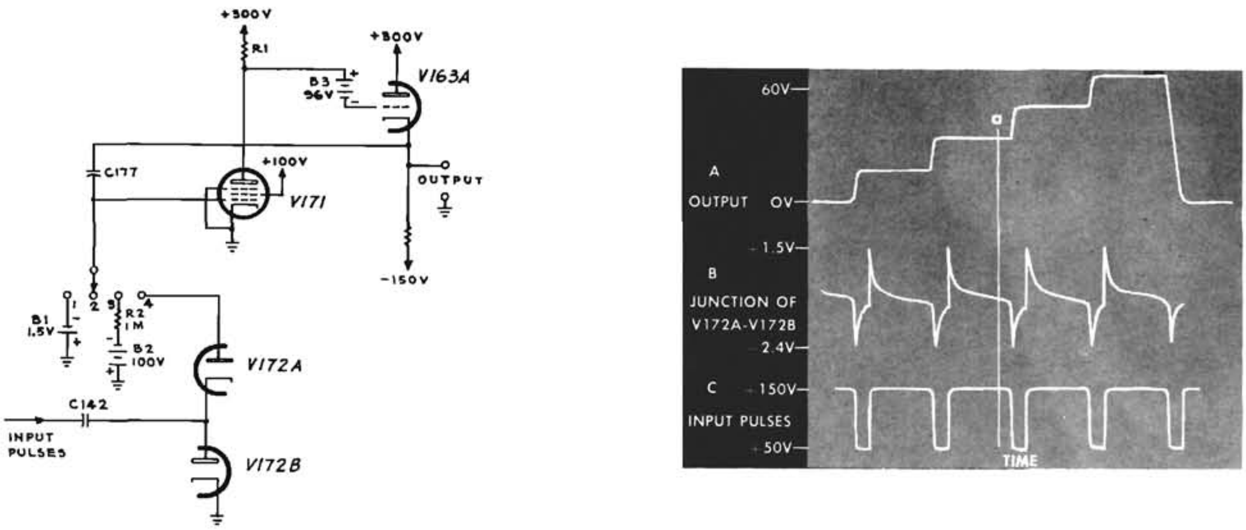


Fig. 3-4. Modification of Fig. 3-3.

As the plate voltage of V171 falls, the cathode voltage of V163A also falls, discharging C177. The cathode of V163A is prevented from going below ground potential by conduction of V152A. Because the Miller tube grid is clamped at ground potential by V152B, its plate voltage will quickly reach an equilibrium condition.

As the cathode voltage of V163A falls, so do the voltages at the cathode of V143B and the grid of V155A. If they go more negative than —58 volts, V155A will be cutoff, V155B will conduct, V152B will no longer clamp the grid of the Miller tube, and the stepping process will be resumed.

Note that the cathode circuit of V143B consists of a resistor shunted by a capacitor. If V143B is driven below cutoff, the rate of fall of the cathode voltage will be limited by the discharge rate of C186 through R186. This time-delay circuit affects only relatively fast negative-going signals; positive-going signals are not delayed. C180 emphasizes rapid changes in the output signal at the grid of V143B, and tends to compensate for the loading effect of C186 in the positive direction.

The time delay in the negative direction is necessary to allow C177 to be discharged to the point where the output voltage of the Step Amplifier has fallen to the base level before the Schmitt trigger reverts and permits the stepping process to be resumed.

Single-Family Triggering

On the circuit diagram of the Step Generator, notice the section of switch SW145 which is shown near C143B. In the OFF position of SW145, a voltage divider formed by R184 and R186 fixes the grid voltage of V155A to keep it in conduction. As a result, V155B is cutoff, disabling the Staircase Generator.

The display of a single family of curves requires that the Schmitt trigger change to its other conduction state long enough for the desired number of steps to be generated, then revert to the OFF position condition. To start the generation of one stairstep waveform, the top of C146 is grounded by depressing SW145 to the SINGLE FAMILY position. This drops the grid of V155A about 50 volts, causing the trigger circuit to change to its other state (V155B conducting).

When V155B conducts, V171 is no longer clamped and the staircase generator is ready to generate a series of voltage steps. When the desired number of steps has been generated, V143B acts in the usual way to bring V155A into conduction again.

Pulse Generator

The circuit diagram of the step Generator shows the split-load phase inverters, V104A and V124A, driven by sine waves at the power-line frequency. The single angle between these signals is adjusted to 90 degrees by the RC networks R102/C102 and R122/C122. The resulting waveforms, A and B, are shown in Fig. 3-6; the voltages are approximate. The output of each phase inverter is rectified to produce a pulsating dc waveform (C) (D) at a frequency of 120 cps. The rectified outputs of the phase inverters are fed into two pentodes (V104B and V124B) having a common plate-

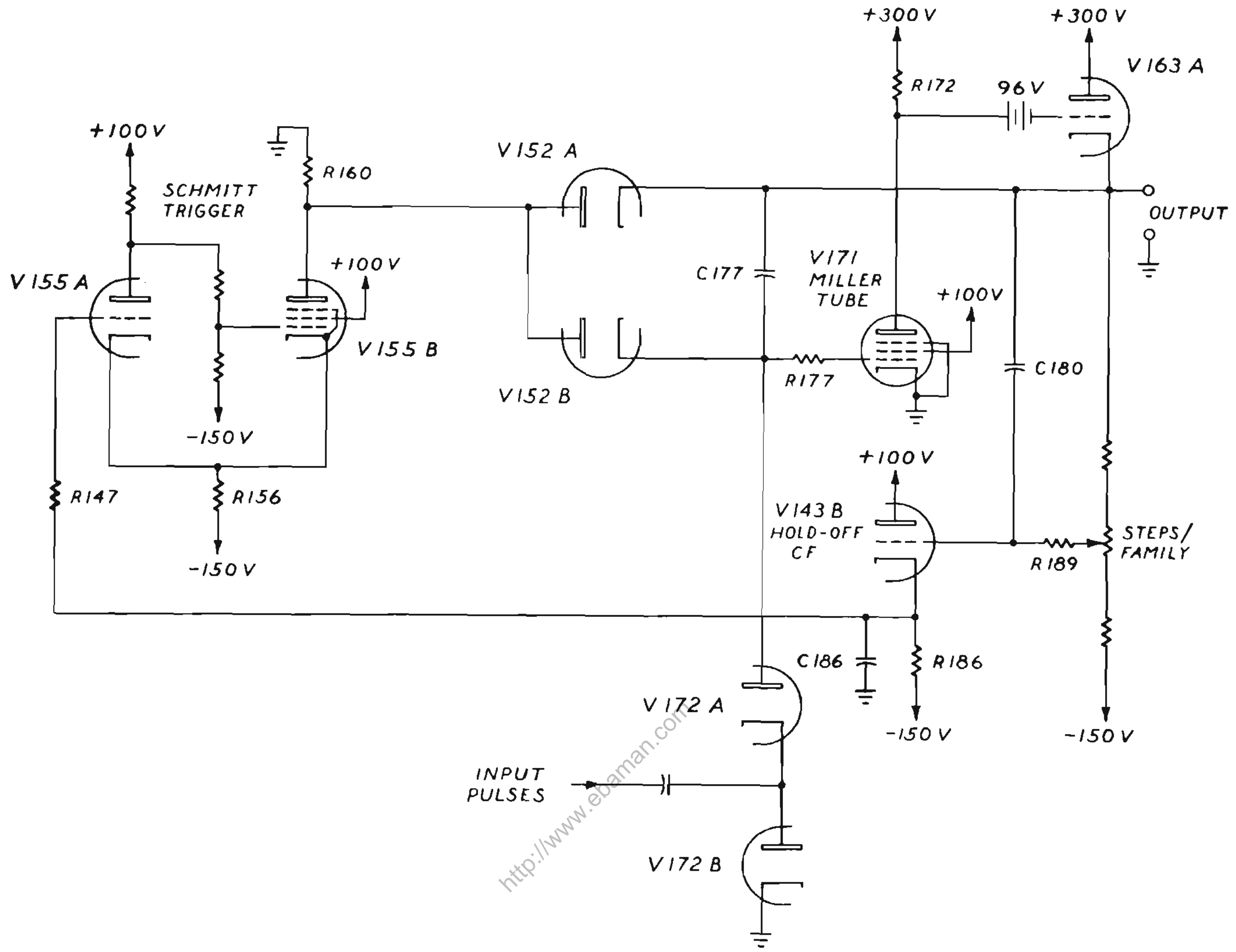


Fig. 3-5. The complete stairstep generator.

load resistor. The voltage at the common plate swings between the plate-supply voltage and ground because the voltage at the input grids drive the tubes from below cutoff to saturation. The frequency of these pulses is 240 per second (or 4 times power-line frequency). The first negative-going pulse is extra wide because the pulse generator is disabled by the clamping action of V163B during the time V155B is cut off. A cathode follower (V143A) provides a low-impedance output.

The upper limit of the pulses appearing at the cathode of V143A, determined by the setting of the VOLTS/STEP ADJ, is 150 volts. The lower limit, determined by R142/R143 is 50 volts.

Each negative-going pulse applied to the left side of C142 causes C142 to partially discharge into C177. C142 recharges through diode V172B as the input pulse returns to 150 volts. The voltage across C177 increases 15 volts with each transfer of charge. The action of the Miller integrating circuit causes this voltage increase to appear at the top of C177. The voltage at the bottom of C177 remains almost constant.

Between pulses, C177 has no discharge path and the voltage at the output of the Step Generator remains constant.

After the trigger has reverted to its initial state (V155B conducting), V163B and V152B no longer conduct and another staircase waveform is generated in response to the pulses applied to the left of C142.

Fig. 3-7 illustrates the sequence of events occuring in the generation of a staircase waveform. Voltages shown are approximate.

Step Amplifier

The voltage gain of the Step Amplifier is less than one, but the current gain is several thousand. The functions of the Step Amplifier are as follows:

1. It permits selection of the size of the output steps (current or voltage).

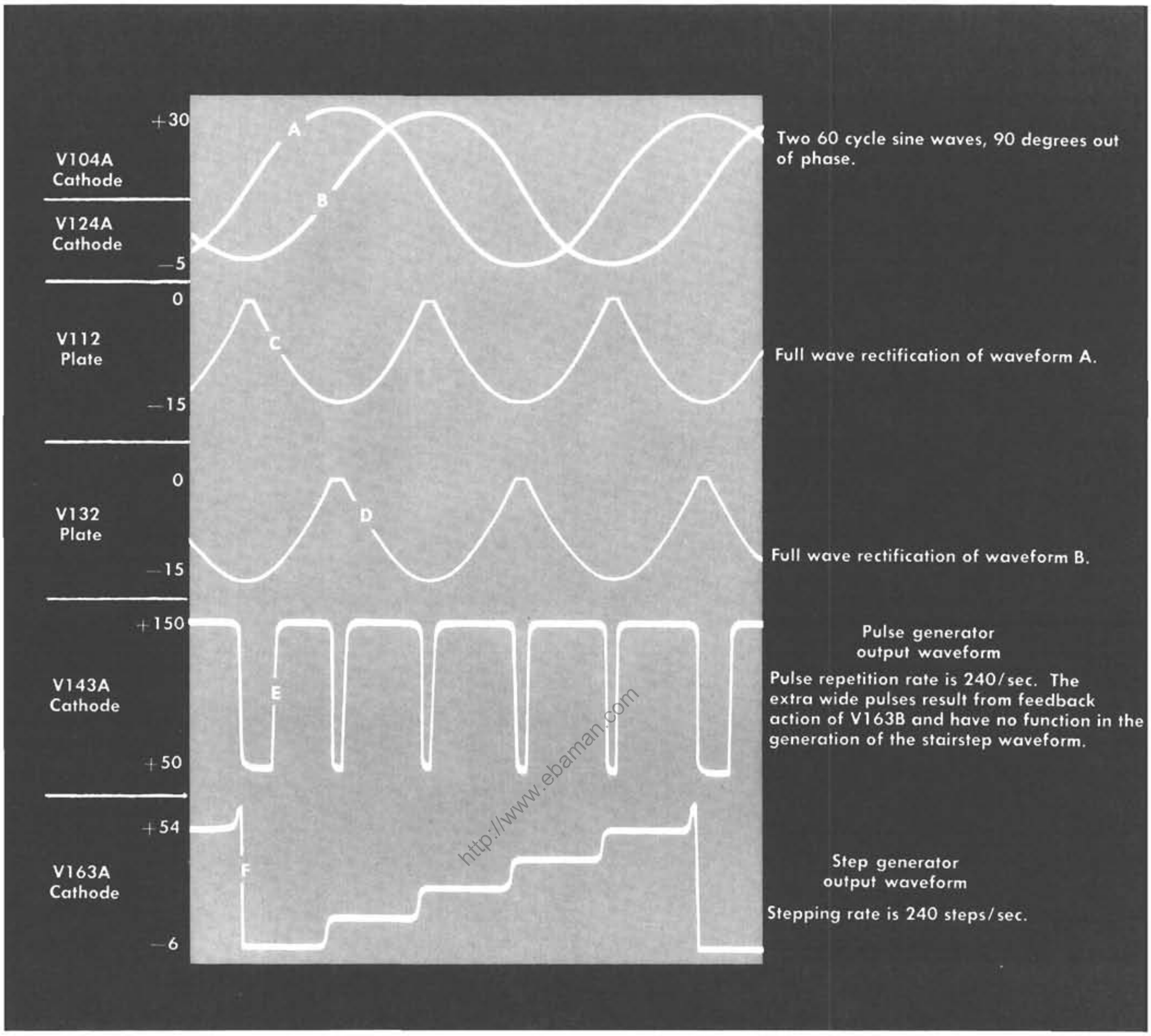


Fig. 3-6. Time relationships between the Step Generator output waveform at key points in the pulse generator section.

2. It regulates the size of the output steps (within limits) to the value chosen by means of the STEP SELECTOR switch.

3. It provides either a positive-going or a negative-going output waveform.

Figure 3-8 illustrates the role of the Step Amplifier in providing either *voltage* or *current* steps to the input of PNP transistor.

The two positions shown on SW246, the STEP SELECTOR switch, correspond to the volts-per-step and ma-per-step ranges.

The Step Amplifier consists of three functional units; a current-regulated power supply, a power-transistor output stage, and an amplifier with a voltage gain of about one.

Output Stage

A transistorized power output stage is used to deliver the output current of the Step Amplifier because of the relatively large regulated currents which must sometimes be applied to the input of the transistor under test. Since the Step Amplifier must furnish high current of either polarity, a floating power supply is used in the output stage.

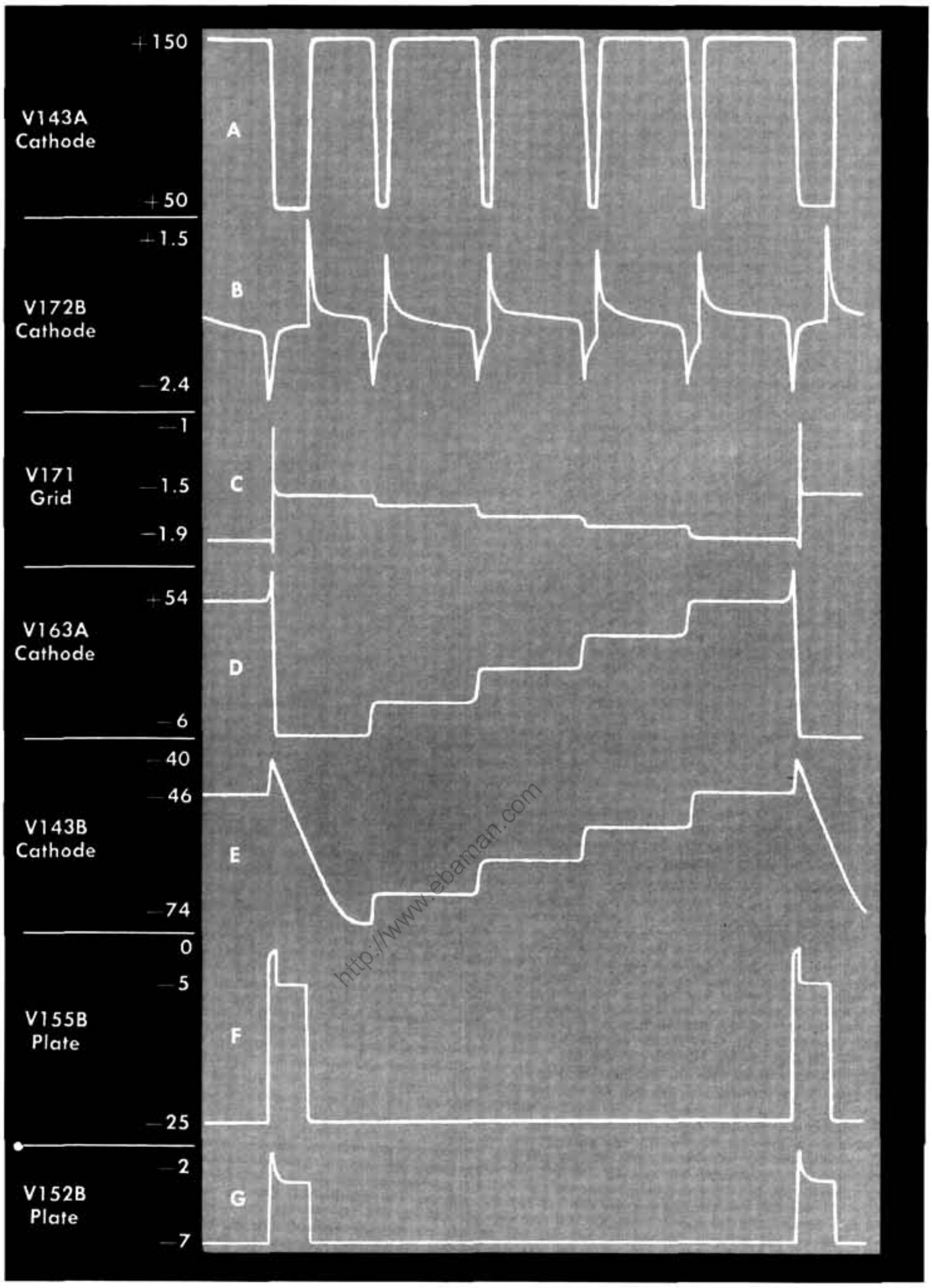


Fig. 3-7. Time relationships between the Step Generator output waveforms (D) and waveforms at key points in the step generator section.

Fig. 3-9 (a) is a diagram of a transistor operating as an emitter follower. Fig. 3-9 (b) is the vacuum-tube equivalent of the same circuit. Note that in both cases the output signal is *in phase with* the input signal. The average value of the output voltage may be set to zero by proper biasing of the input.

Fig. 3-10 shows how an *out-of-phase* signal centered around ground can be obtained with the same general configuration. Note that only the ground point has been moved. The transistor is no longer operating as an emitter follower, but as an ordinary voltage amplifier. The 100-ohm resistor is now the collector load resistor.

The approximate positive and negative limits of the no-load output voltage of Fig. 3-10 can be determined by considering the transistor as a switch which is either opened or closed. When the switch is closed (emitter and collector shorted), the output voltage must be +15 volts. When the

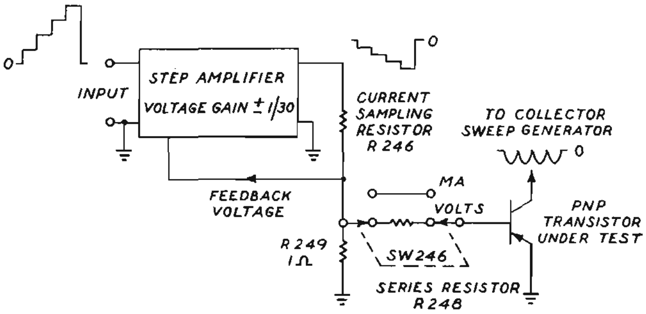


Fig. 3-8. The Step Amplifier furnishes either current or voltage steps to the input of the transistor under test.

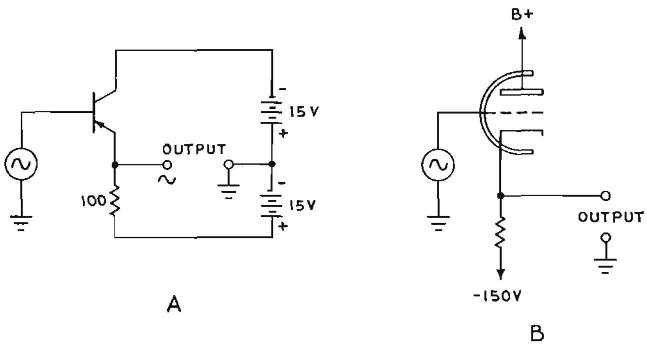


Fig. 3-9. The emitter-follower (a) operates the same as the cathode-follower (b).

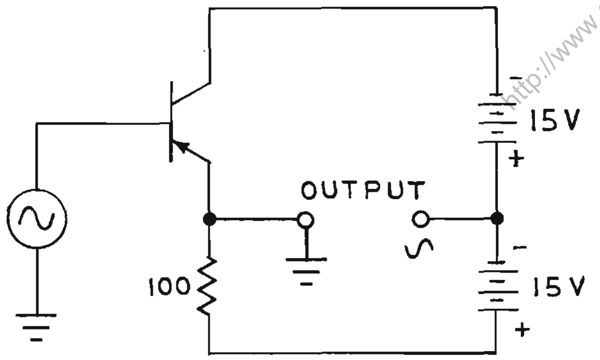


Fig. 3-10. By switching the output connections, the emitter-follower of Fig. 3-9 (a) becomes a collector-loaded amplifier.

switch is open (no current through the collector), the no-load output voltage must be —15 volts.

The circuits of Fig. 3-9 (a) and Fig. 3-10 have maximum-current limitations which are different. The circuit of Fig. 3-9 (a) can supply much more current in the *negative* direction, (making the ungrounded end of the load resistance negative) than it can supply in the positive direction (through the 100-ohm resistor).

By the same method, it can be shown that the circuit of Fig. 3-10 can supply much more current in the *positive* direction than in the negative direction.

Since the path of the higher current through the load in both circuits was always through the upper battery, the upper battery must be able to deliver more current than that which is required of the lower one.

The drawing of Fig. 3-11 shows the electron-current flow through the circuit components as the Step Generator drives a load resistance in the negative direction. The lower battery supplies only the current which flows through the 100-ohm resistor. The upper battery must supply current to the load as well.

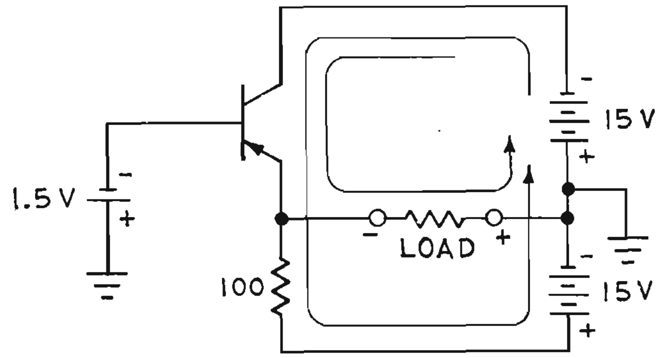


Fig. 3-11. Electron flow through the transistor V253 circuit when negative-going steps are required.

Figure 3-12 is a simplified diagram of the output circuit of the Step Amplifier. Note that the load resistance across the output circuit is always the current-sampling resistor in series with either a 1-ohm resistor (voltage steps) or the input of the transistor under test (current steps). The feedback paths go directly to vacuum-tube grids and do not load the output circuit.

The maximum current the Step Amplifier will deliver to an external load is 2.4 amperes of either polarity (ma-per-

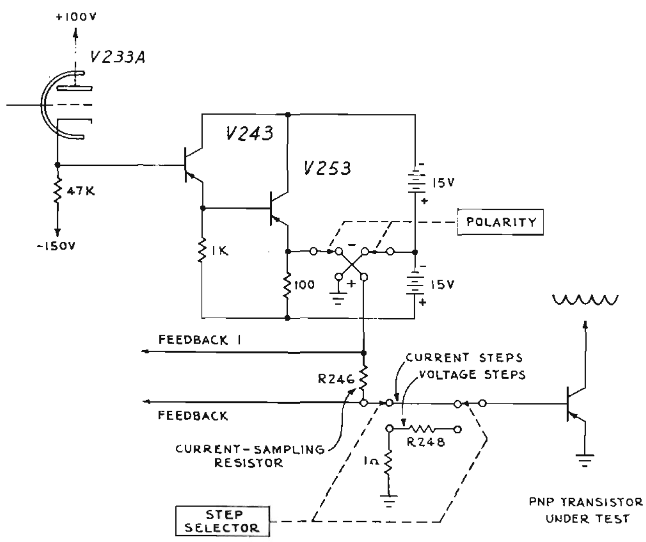


Fig. 3-12. Simplified diagram of the output circuit of the Step Amplifier.

step positions of the STEP SELECTOR switch). However, the characteristics of the external load must be such that the voltage drop across the external load resistance is no more than 5 volts when the current through it is 2.4 amperes. At lower currents, however, the 5-volt figure may be exceeded.

The simplified diagrams of Fig. 3-13 and 3-14 show the operation of the entire Step Amplifier when delivering current steps to the input of the transistor under test. Current regulation is accomplished by maintaining a constant voltage drop across R246 for each step of the input voltage from the Step Generator. That is, each time the input voltage is stepped 15 volts, the voltage drop across R246 should change 1/30 of 15 volts, or 0.5 volt, and remain at the new voltage for the duration of the step. This will provide steps of constant current proportional to the input voltage steps.

It would be a simple matter to maintain a constant voltage across R246, proportional to the input steps, if the voltage at the lower end of R246, (that is, the voltage at the input to the resistor under test) were constant. In other words, if we fix the voltage at the lower end of R246 at some potential, say ground, the voltage across R246 would remain constant for the duration of each of the input steps, and would change only when the input voltage steps from one level to the next.

However, the lower end of R246 is connected to the input of the transistor under test and not to a fixed reference. When the collector sweep voltage is applied to the collector of the transistor the voltage at the input of the transistor will change and the voltage at the lower end of R246 will change. In order to maintain a constant voltage, the voltage at the upper end of R246 must change the same amount and in the same direction as the voltage at the lower end. To accomplish this action the +1 Amplifier and the feedback loops couple any voltage change at the lower end of R246 to the difference amplifier V214-V224 which in turn, through the cathode-follower V233A and the output amplifier V243- V253, produces the same voltage change at the top of R246. Fig. 3-13 shows the circuit configuration when the POLARITY switch is set for a negative output. The operation of the circuit will be explained in two parts; first, to show how the voltage at the top of R246 changes in proportion to the input steps, and second, to show how the voltage at the top of R246 changes as a result of any voltage change at the bottom of R246.

Assume the input voltage changes from 0 to +15 volts (1 step). This tends to make the voltage at the grid of V214 go in the positive direction, and the plate voltage to go in the negative direction. The voltage at both the grid and cathode of the cathode-follower V233A goes in the negative direction, following the plate of V214. Q243 is an emitter-follower, so its emitter goes in the negative direction carrying with it the base of Q253. Since Q253 is also connected as an emitter-follower, for negative-polarity operation, its emitter and hence the voltage at the top of R246 goes in the negative direction.

A positive step at the input will therefore produce a negative step at the top of R246. This negative step also appears at the lower end of R203, since this point is connected to the top of R246. This means that as the top of R202 goes positive the lower end of R203 goes negative. The amplifier and feedback network therefore acts as a "teeter-totter" circuit that pivots about the junction of R202-R203; the grid of V214 is at virtual ground, or zero, potential.

Since the top of R203 is at ground potential, the change in voltage across R246, due to an input step, is equal to the change in voltage across R203. R202 and R203 make up a

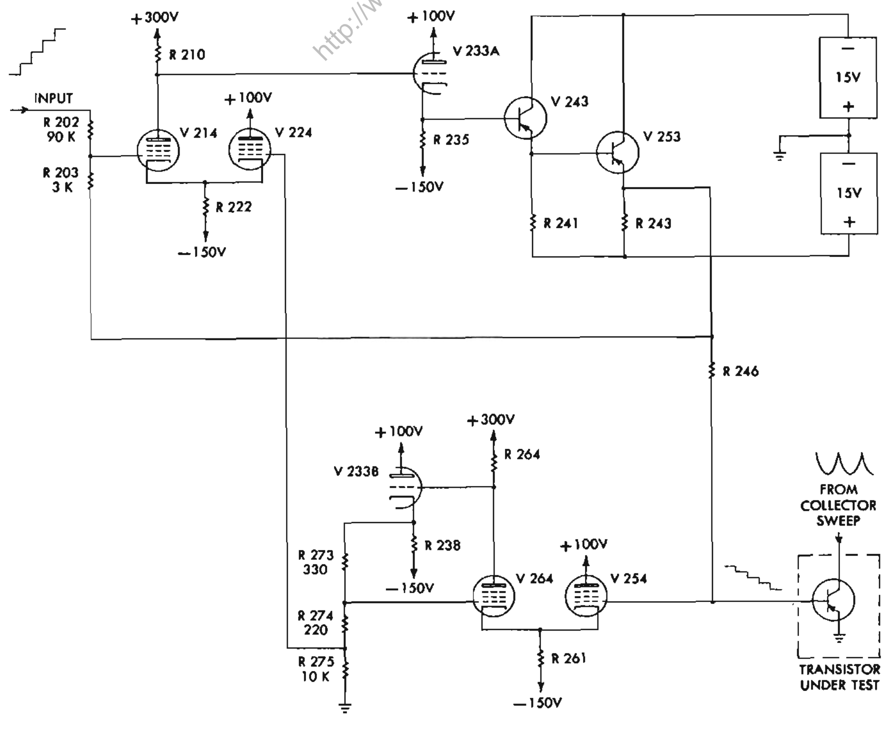


Fig. 3-13. Simplified diagram of the Step Amplifier for negative-going current steps.

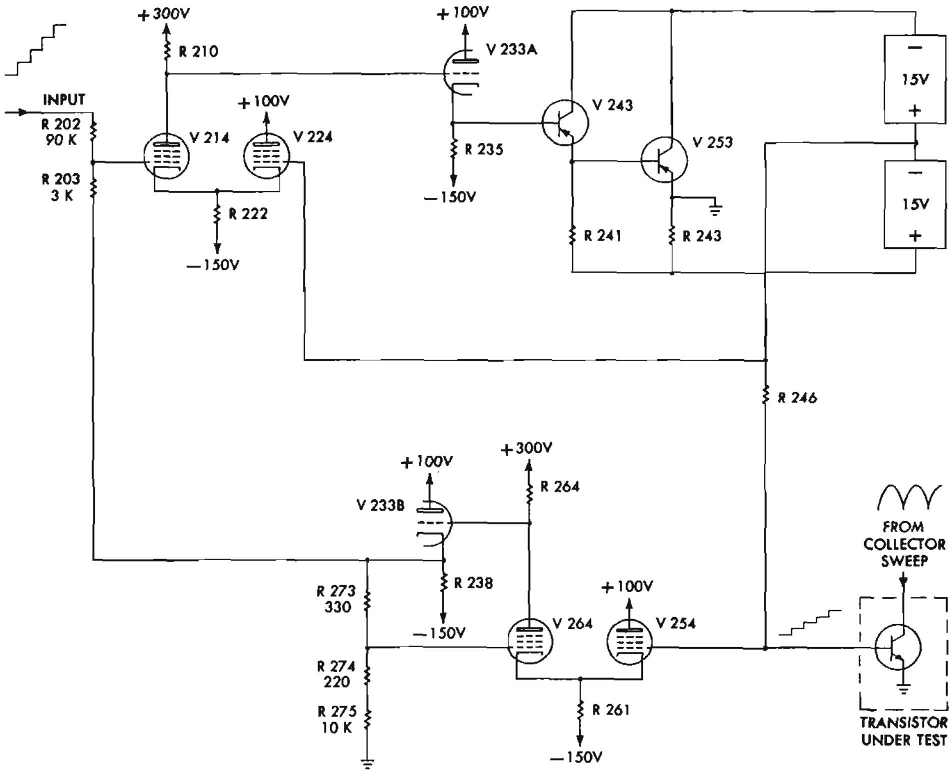


Fig. 3-14. Simplified diagram of the Step Amplifier for positive-going current steps.

30 to 1 divider; a 15-volt step in the positive direction at the top of R202 will therefore produce a 0.5-volt step in the negative direction across R246.

If the voltage at the lower end of R246 changes, the voltage at the top of R246 must change the same amount and in the same direction. This will insure that the voltage drop across R246 is proportional only to the input step voltage.

The +1 Amplifier is a feedback amplifier whose gain is just slightly greater than unity. The input impedance of this circuit is very high, so that it does not load the input of the transistor under test.

Let us assume that the voltage at the lower end of R246, and hence at the grid of V254, goes in the positive direction. This will cause the cathodes of V254 and V264 to go in the positive direction. The voltage at the plate of V264 will then go up carrying with it the voltage at the grid and cathode of V233B. Because the gain of the circuit is slightly greater than unity the change in voltage at the cathode of V233B will be slightly greater than that at the lower end of R246, but will be of the same polarity.

The output of V233B is applied to a divider consisting of R273, R274 and R275. One tap on the divider couples almost all of the output voltage back to the grid of V264. This causes the grid of V264 to move in the same direction as its cathode, and hence reduces the gain of the stage to just slightly greater than unity. The gain of the +1 Amplifier is therefore relatively independent of tube characteristics and is determined almost entirely by the ratio of R273 to R274 + R275.

The resistance values in the divider are chosen so that the change in voltage at the top of R275 is the same as that at the grid of V254 (the lower end of R246). This positive-going voltage at the top of R275 is then applied to the grid of V224, and the cathodes of V224 and V214 go in the positive direction. This causes the voltage at the plate of V214 to go up, and since there is no polarity shift in V233A or the emitter-followers, the voltage at the top of R246 will go up. Thus, the voltage at the top of R246 follows any voltage change that may occur at its lower terminal. This prevents any change in the voltage at the input of the transistor under test from affecting the current through R246, and provides for steps of constant current into the input of the transistor.

If voltage steps are desired, R249 (not shown on Fig. 3-13) is connected between R246 and ground. The current steps through R246 and R249 then produce voltage steps across R249 which are coupled through the series resistor R248 (not shown) to the input of the transistor under test.

When negative steps are required, the voltage steps at the top of R246 must be reversed in polarity from those at the input (positive-going steps are always applied to the input of the Step Amplifier). The 180-degree shift in signal polarity is accomplished in V214, since this stage is a plate-loaded amplifier. And, since V233A is a cathode-follower and the transistors are connected as emitter-followers, the polarity shift in V214 satisfies the circuit requirements.

When positive-going steps are required at the top of R246, however, the output of V214 must be reversed in polarity. This is accomplished by reversing the output and ground terminals in the Q253 circuit. Q253 is connected in the common emitter configuration, as shown in Fig. 3-14, and the load resistor R243 is connected into the collecter circuit. With this configuration V253 is a collector-loaded amplifier and will produce a 180-degree shift in the signal polarity. This will put voltage steps at the top of R246 in phase with input steps (positive-going steps).

To compensate for the additional shift in signal polarity, the grids of the difference amplifier V214-V224 must be switched insofar as the feedback loops are concerned. That is, the grid of V224 is now connected to the top of R246 and the grid of V214 is connected through R203 to the divider at the output of the +1 Amplifier. Notice, in Fig. 3-14, that the grid circuit of V214 is connected to the top of the divider at the output of the +1 Amplifier, while in Fig. 3-13 the grid circuit of V224 is connected to a tap on the divider.

Since the gain of the +1 Amplifier is just slightly greater than 1, the voltage at the cathode of V233B is slightly greater than that at the grid of V254. The voltage applied to the difference amplifier from the +1 Amplifier must be equal to the amount of correction needed to keep the voltage across R246 constant. The resistance values in the divider at the output of the +1 Amplifier are such that the voltage drop across R275 is the same as the voltage at the grid of V254. This satisfies the requirements of the circuit, in Fig. 3-13, where the feedback is applied directly to the grid of V224. In Fig. 3-14, the feedback is applied to the grid of V214 through R203, and, since there is a voltage drop across R203, the voltage at the output of the +1 Amplifier must exceed the required feedback voltage by an amount equal to this drop. For positive-polarity signals, therefore, the voltage at the output of the +1 Amplifier must exceed the voltage at the grid of V254 by an amount equal to the drop across R203.

CRT Deflection Amplifiers

The diagram of the Vertical and Horizontal Amplifiers include a simplified diagram of most of the switching related to these amplifiers. The purpose of the simplified diagram is to help you understand the relationships between the Vertical and Horizontal Amplifiers and other parts of this instrument. Accordingly, this discussion will include switching information.

The circuits of the Vertical and Horizontal Amplifiers are quite similar. Both consist of three difference amplifiers in cascade. A difference amplifier, or cathode-coupled phase inverter, rejects any signal applied to both input grids, responding only to a voltage difference between the input grids. The gain of the difference amplifiers in the Type 575 is stabilized by negative-feedback paths from the plates of the output amplifier to the opposite cathodes of the input stage.

The ranges of the VERTICAL and HORIZONTAL switches are shown in capital letters. Only a few of the positions in the COLLECTOR MA, BASE VOLTS, and COLLECTOR VOLTS ranges are shown. In the following paragraphs, the signal paths to the Vertical and Horizontal Amplifiers will be traced for each range of the corresponding switch.

Collector MA Display

Collector current is displayed on the vertical axis only. The collector current is proportional to the voltage drop across a current-sampling resistance. This voltage is fed directly to the control grid of V454, the other input to the vertical amplifier being grounded. One volt must be developed across the current-sampling resistance to cause a full-scale vertical deflection of ten major divisions. In all switch positions within the COLLECTOR MA range, the Vertical Amplifier works at a reduced constant gain. This reduced gain, one-tenth of maximum, is accomplished by inserting a resistance of about 10K ohms, R447 in parallel with R432B, between the cathodes of the input stage. R432B is located on the detailed switching diagram.

Base Volts

In the BASE VOLTS position of the VERTICAL switch, the control grid of V454 is grounded and a signal from the base of the transistor under test is fed to the control grid of V444. The sensitivity of the Vertical Amplifier is varied by changing the resistance between the cathodes of V454 and V444.

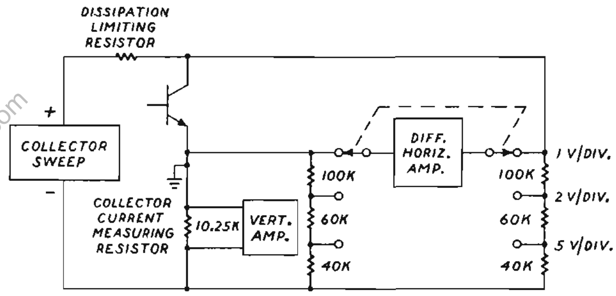


Fig. 3-15. With this configuration an accurate display of collector current (Vert. Amp.) and collector voltage (Horiz. Amp.) is obtained.

Collector Volts Display

The diagram of Fig. 3-15 shows the method used to solve the problem of presenting an accurate display of both collector current and collector voltage at the same time. Discussion of this diagram does not necessarily apply to corresponding parts of the Type 575. Note that two attenuators are used and that the horizontal display of collector voltage is obtained by using the common-mode rejection feature of the Horizontal Amplifier. As shown in Fig. 3-15, the Horizontal Amplifier amplifies only the voltage difference existing between its input grids.

Also note that the true current-sampling resistance is made up of the 10.25-K resistor and the attenuator in parallel with it.

Low-Voltage Power Supply

Plate and filament power for the Type 575 is furnished by a single power transformer T601. The primary windings may be connected in parallel for 105- to 125-volt operation, or in series for 210- to 250-volt operation.

The three regulated supplies furnish voltages of —150-volts, +100 volts and +300 volts. The +300-volt supply also has an unregulated output of about +400 volts for the oscillator tube in the high-voltage supply for the crt.

Reference voltage for the —150-volt, full-wave power supply is established by a voltage-regulator tube V649. This tube, which has a constant voltage drop of about 85 volts, is connected between the —150-volt bus and the grid circuit of V644A, one-half of a difference amplifier. The grid potential for the other half of the difference amplifier, V644B, is obtained from a divider consisting of R662, R664 and R666. The —150-V ADJ, R664, determines the percentage of total voltage appearing at the grid of V644B and thus determines the total voltage across the divider. When this control is properly set, the output voltage is exactly —150-volts.

The operation of the circuit can be explained by assuming the output voltage tends to change. For example, assume the loading on the supply tends to make the output voltage go more negative. The voltage at the grid of V644A will go negative the same amount as the output, since the voltage across the voltage-regulator tube is always constant. The voltage at the grid of V644B will go negative only a proportionate amount, however, since this grid obtains its voltage from the divider, an error voltage will then exist between the two grids of the difference amplifier, which will be in a direction to make less current go through the left side and more current through the right side.

The voltage at both the plate of V644B and the grid of V657 will then go in the negative direction, which will cause the voltage at the plate of V657 to go in the positive direction. The change in voltage at the plate of V657, which will be in a direction to compensate for the change in the output voltage, is coupled through the rectifier to the output and forces the output voltage back to its established value of —150 volts.

C644 and C655 improve the ac response of the feedback loop, thereby increasing the response of the circuit to sudden changes in output voltage.

The +100-volt supply uses silicon rectifiers in a full-wave bridge circuit. Reference voltage for this supply is obtained from the regulated —150-volt supply. The voltage divider R636-R638 establishes a voltage of essentially zero at the grid of V624. (The actual voltage at this grid is equal to the bias required by the tube). If the loading should tend to change the output voltage, an error signal will exist at the grid of V624. The error signal will be amplified and inverted in polarity, and will appear at the grids of the parallel cathode-followers V627A and V627B. The cathodes will follow the grids and will force the output voltage back to its established value of +100 volts. C630 improves the response of this circuit to sudden changes in output voltage.

A small sample of the unregulated bus ripple will appear at the screen grid of V624 through R624. The ripple signal appearing at the screen (which acts as an injector grid) will produce a ripple component at the grids of V627 which will be opposite in polarity to the ripple appearing at the plates of V627. This tends to cancel the ripple at the cathodes, thereby reducing the ripple on the 100-volt bus. The same circuit also improves the regulation of the supply in the presence of line-voltage variations.

The operation of the regulator circuit in the +300-volt supply is the same as that in the +100-volt supply.

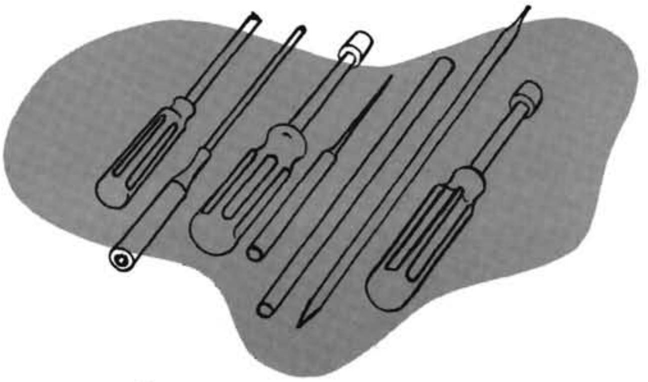
CRT Circuit

A 30-kc Hartley oscillator circuit furnishes energy for the two half-wave power supplies that provide accelerating potentials for the crt. The main components of the oscillator circuit are V810 and the primary of T801 tuned by C809.

V812 supplies about +2400 volts for the post-deflection accelerating helix. V822 supplies about —1850 volts to a divider to provide the grid and cathode potentials. The other end of the divider is connected to the regulated +300-volt bus. The —1700 V ADJ control R816 determines the total resistance in the divider and hence the total voltage across the divider. When this control is properly set, the voltage at the test point will be exactly —1700 volts.

The accelerating potentials are kept constant by regulating the supplies by comparing a sample of the negative high voltage to the regulated —150-volt supply. This sample of the negative high voltage is obtained from a tap on the divider (the junction of R816 and R818) and is applied to the grid of an amplifier V804A. The cathode of this tube is connected to the —150-volt regulated supply. If the negative supply tends to drift, an error signal appears at the grid of V804A. The error signal is amplified by V804A and V804B, and produces a change in the screen voltage at the oscillator tube. This varies the amplitude of the oscillator output in a direction to compensate for the change in output voltage.

The positive high-voltage supply is regulated indirectly, as the output of both supplies is proportional to the oscillator output.



SECTION 4

MAINTENANCE

PREVENTIVE MAINTENANCE

Air Filter

The Type 575 Transistor-Curve Tracer is cooled by air drawn into the instrument through a washable filter constructed of adhesive-coated aluminum wool. If this filter is allowed to become dirty, it will restrict the flow of air and may cause the instrument to overheat. You should inspect, and clean if necessary, the filter every three months. If the filter is damaged, you should replace it as soon as possible to prevent dust being drawn into the instrument.

To remove the loose dirt in the filter, rap the filter gently on a hard surface. Then wash the filter briskly with hot soapy water. After rinsing and drying thoroughly, coat the filter with "Handi-Koter" or "Filtercoat", products of the Research Products Corporation. These products are generally available from air-conditioner suppliers.

Fan Motor

To protect the fan motor bearings, they should be lubricated every three or four months with a few drops of light machine oil.

Visual Inspection

You should visually inspect the entire instrument every few months for possible circuit defects. These defects may include loose or broken connections, damaged binding posts, improperly seated tubes, scorched or burned parts, or broken terminal strips as well as many others. For most of these troubles, the remedy is apparent, but particular care must be taken when scorched or burned components are detected. Burned parts are often the result of other, less apparent, defects in the circuit. Therefore, it is essential that you determine the cause of overheating before replacing damaged parts in order to prevent damage to the new components.

Recalibration

The Type 575 is a stable instrument, and will provide many hours of trouble-free operation. To insure the reliability of measurements made with the Type 575 however, we suggest that you recalibrate the instrument after each 500 hours of operation (or every six months if used intermittently). A complete step-by-step procedure for recalibrating the instrument is presented in the Recalibration section of this manual.

REMOVAL AND REPLACEMENT OF PARTS

The procedures required for replacement of most parts in the Type 575 are obvious. Detailed instructions for their removal are therefore not required. Other parts, however, can best be removed if a definite procedure is followed. Instructions for the removal of some of these parts are contained in the following paragraphs. Because of the nature of the instrument, replacement of certain parts will require that you recalibrate portions of the instrument in order to insure proper operation. Refer to the Recalibration section of this manual.

Removal of Panels

The panels of the Type 575 are held in place by small screwhead fasteners. To remove the side panels, use a screwdriver to rotate the fasteners approximately two turns counterclockwise; then pull the upper portion of the panels outward from the carrying handles. To remove the bottom panel, lay the instrument on its side, rotate the fasteners two turns

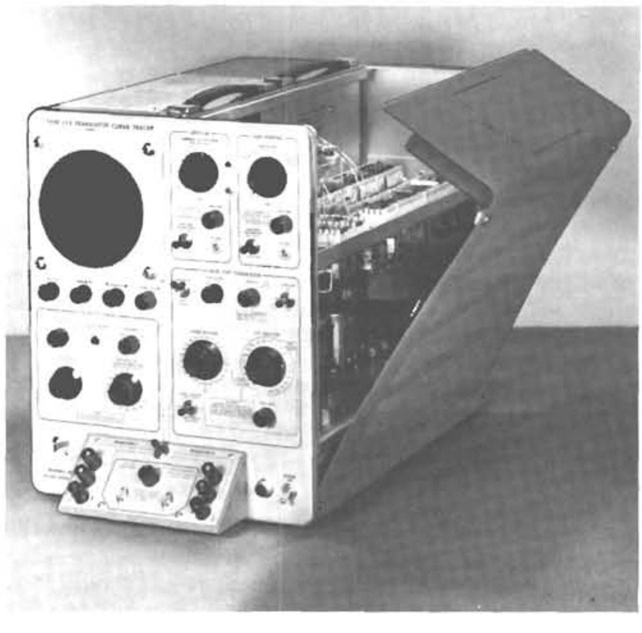


Fig. 4-1. Removal of the instrument side panels.

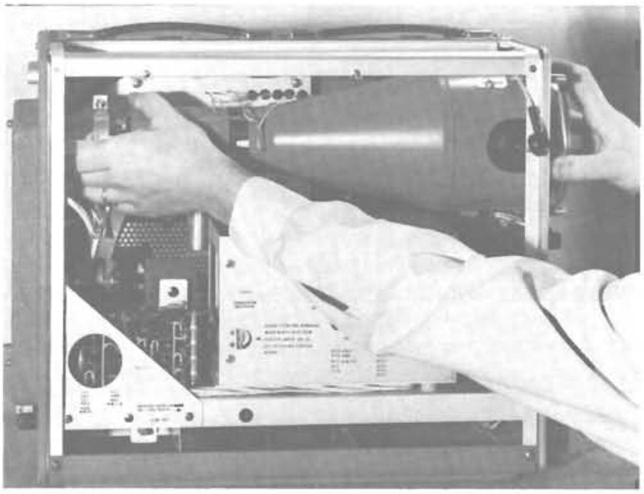


Fig. 4-2. The method used to remove or replace the cathode-ray tube.

counterclockwise, and pull off the panel. In order to prevent damage to the finish of the side panels, you should remove them before laying the instrument on its side. The bottom panel should then be removed last. Panels are replaced by reversing the order of their removal.

Replacement of Cathode-Ray Tube

To remove the cathode-ray tube, first disconnect the tube socket and all leads connected to the neck of the tube. Loosen the tube clamp at the base of the crt and remove the graticule cover. Pull the crt straight out through the front panel. When the new crt is in place, the leads may be properly connected to the neck of the tube by following the color code information provided on the tube shield. After replacement of a crt, it will be necessary for you to recalibrate the instrument.

Replacement of Switches

Methods for removal of defective switches are, for the most part, obvious and only a normal amount of care is required. Single wafers are normally not replaced on the switches used in the Type 575 and if one wafer is defective, the entire switch should be replaced. Switches may be ordered from Tektronix either wired or unwired as desired.

Tube Replacement

Care should be taken both in preventive and corrective maintenance that tubes are not replaced unless they are actually causing a definite circuit malfunction. Many times during routine maintenance it will be necessary for you to remove tubes from their sockets. It is important that these tubes be returned to the same sockets unless they are actually defective. Needless replacement or switching of tubes will many times cause unnecessary recalibration of the instrument. If tubes do require replacement, it is recommended that they be replaced by previously checked high-quality tubes.

Soldering Precautions

In the production of Tektronix instruments, a special silver-bearing solder is used to establish a bond to the ceramic terminal strips. This bond may be broken by repeated use of ordinary tin-lead solder, or by the application of too much heat. However, occasional use of ordinary solder will not break the bond if too much heat is not applied.

It is advisable that you have a stock of solder containing about 3% silver if you frequently perform work on Tektronix instruments. This type of solder is used quite often in printed circuitry and should be readily available. It may also be purchased directly from Tektronix in one-pound rolls (order by part number 251-514).

Because of the shape of the terminals on the ceramic terminal strips, you may wish to use a wedge-shaped tip on your soldering iron. A tip such as this allows you to apply heat directly to the solder in the terminals and reduces the amount of heat required. It is important to use as little heat as is possible.

REPLACEMENT PARTS

Standard Parts

Replacements for all parts used in the Type 575 Transistor-Curve Tracer can be purchased directly from Tektronix at current net prices. However, since most of the components are standard electronic parts, they can generally be obtained locally in less time than is required to obtain them from the factory. Before ordering or purchasing parts, be sure to consult the parts list to determine the tolerance required. The parts list gives the values, tolerances, and Tektronix part numbers of all components used in the instrument.

Special Parts

In addition to the standard parts used in the instrument, special parts are used also. These parts are manufactured or specially selected by Tektronix, or are made especially for Tektronix by other manufacturers. Special parts and most mechanical parts should be ordered directly from Tektronix since they will normally be difficult or impossible to obtain from other sources. Special parts may be obtained either from the factory or from the local Tektronix Field Engineering Office.

Since the production of your instrument, some of the Tektronix manufactured components may have been superseded by improved components. The part numbers of these new components will not be listed in your manual. Your Tektronix Field Engineering Office has a knowledge of these changes and may call you if a change in your purchase order is necessary.

Replacement information sometimes accompanies the improved component to aid in its installation.

Parts Ordering Information

You will find a serial number on the frontispiece of this manual. This is the serial number of the instrument for which this manual was prepared. Be sure that the number on the manual matches the serial number of the instrument when ordering parts from this manual.

Each part in this instrument has been assigned a 6-digit Tektronix part number. This number, together with a description of the part, will be found in the parts list. When ordering parts, be sure to include both the description of the part and the part number. For example, a certain resistor would be ordered as follows: R160A, 100 k, ½ w, Fixed, Precision, 1%, part number 309-045, for Type 575 Transistor-Curve Tracer, serial number ______. When parts are ordered in this manner, we are able to fill your orders promptly, and delays that might result from transposed numbers in the part number are avoided.

NOTE

Always include the instrument TYPE and SERIAL NUMBER in any correspondence concerning this instrument.

TROUBLESHOOTING

General Information

This section is included to provide you with information about the Type 575 Transistor-Curve Tracer that will enable you to more efficiently troubleshoot the instrument in the event of equipment failure. During troubleshooting work, you should correlate information contained in this section with information obtained from other sections of this manual. We have not attempted to give detailed step-by-step procedures for finding the cause of specific troubles, but rather have attempted to outline a general troubleshooting guide. This guide provides a means for determining the probable defective circuit or part from the symptoms observed rather than from detailed voltage or resistance measurements.

Although the 575 is a complex instrument, it can conveniently be thought of as consisting of a number of interrelated basic circuits as shown in the block diagram contained in the diagram section of the manual. Each of these circuits performs a specific part of the overall circuit operation required to display transistor characteristic curves on the face of the crt. If any one of these circuits should fail, a definite symptom of this failure will be apparent. By investigating the possible causes of this symptom by means of systemized circuit checks, it is possible to determine which circuit or circuits are at fault. After determining which circuit is defective, additional checks will allow you to isolate the trouble to a particular part.

Separate schematic diagrams of each circuit are contained in the rear portion of this manual together with a block diagram which provides an overall picture of instrument operation. The reference designation of each electronic component of the instrument is shown on the circuit diagrams as well as important voltages and waveforms. These voltages and waveforms may be used during troubleshooting work to isolate the cause of the trouble. The following chart lists the reference designations associated with each circuit.

100 series .... Step Generator
200 series .... Step Amplifier
300 series .... Horizontal Amplifier
400 series .... Vertical Amplifier
600 series .... Low Voltage Power Supply
700 series .... Collector Sweep Circuit
800 series .... CRT Circuit

Switch wafers shown on the schematic diagrams are coded to indicate the position of the wafer on the actual switches. The number portion of the code refers to the wafer numbers on the switch assembly, wafers being numbered from the front of the switch to the rear, and the letters F and R indicate whether the front or the rear of the wafer is used to perform the particular switching function. Photographic details of these switches are also shown on the same foldout page as the corresponding circuit diagram. These photographs are provided as parts location guides.

All wiring used in the 575 is color coded to facilitate circuit tracing. In addition, primary power, filament, and regulated power-supply output leads are distinguished by specific color codes. All regulated power-supply output leads follow the standard RETMA code. The —150 volt bus wire is coded brown-green-brown; the +300 volt bus is coded orange-black-brown; and the +100 volt bus is coded brown-black-brown. The widest stripe identifies the first color of the code.

Circuit Isolation

Before proceeding with detailed troubleshooting of the instrument, make sure that an apparent trouble is actually due to a malfunction within the instrument and not due to improper control settings. Instructions for the operation of the insrument are contained in the Operating Instructions section of this manual. If, after reviewing the Operating Instructions, you determine that control settings are not at fault, you should next check the calibration of the instrument according to the procedure contained in the Recalibration section of the manual.

A calibration check will not only allow you to correct any troubles due to improper calibration, but will also enable you to isolate the defective circuit should an actual trouble exist. If a trouble exists in the instrument, you will reach an adjustment or check while going through the recalibration procedure where you obtain an abnormal indication. From the adjustment or check where the trouble first appears and from the indications obtained, you will be able to determine which circuit is defective and also in many cases which portion of the defective circuit is at fault.

When you have determined which circuit is defective, you can then refer to the Circuit Troubleshooting information that follows where procedures are given for troubleshooting the individual circuits. If you recognize immediately which circuit is at fault when a trouble appears, you can proceed directly to the Circuit Troubleshooting information without using the recalibration procedure to isolate the defective circuit. In such cases, however, you must be certain that the trouble cannot be corrected by recalibration before using the Circuit Troubleshooting information.

For any type of trouble the power supplies should be checked as one of the first steps in the troubleshooting procedure. Correct operation of every circuit in the instrument depends on proper output voltages from the regulated power supplies. Due to the circuit configuration employed in the Type 575, it is possible for an incorrect power supply voltage to affect one circuit more than the others. When all but one circuit is operating properly, there is a tendency to overlook the power supply as a source of the trouble and to concentrate on the circuit where the trouble apparently exists. In cases of this type, valuable time can be saved by checking the power supplies first. The power supplies may be checked using Step 1 of the recalibration procedure.

WARNING

Be careful of power supply voltages. Under certain conditions, they can be dangerous to human life. Outputs of the Low Voltage power supply are particularly dangerous due to their high current capabilities. When working on the instrument with the power on, you should work with only one hand at a time, being careful that the other hand does not touch the metal frame to the instrument. If possible stand on an insulated surface and use insulated tools and probes.

Circuit Troubleshooting

This portion of the Troubleshooting Procedure contains information for locating a defective stage within a given circuit. Once the stage at fault is known, the component(s) causing the trouble can be located by tube and component substitution, voltage and resistance measurements, or by short and continuity checks.

Tube failure is the most prevalent cause of circuit failure. For this reason, the first step in troubleshooting any circuit is to check for defective tubes, preferably by direct substitution. Do not depend on tube testers to adequately indicate the suitability of a tube for use in the instrument. The crierion for usability of a tube is whether or not it works satisfactorily in the instrument. Be sure to return any tubes found to be good to their original sockets. If this procedure is followed, less recalibration of the instrument will be required upon completion of the servicing.

If the replacement of a defective tube does not correct the trouble, then check that components which are associated with the tube have not been damaged. Shorted tubes will often overload plate-load and cathode resistors. These components can usually be checked by a visual inspection of the circuit. If no damaged components are apparent, however, it will be necessary to make measurements or other checks within the circuit to locate the trouble.

Troubleshooting The Low-Voltage Power Supply

Proper operation of every circuit in the Type 575 depends on proper operation of the Low-Voltage Power Supply. The regulated voltages must be within their specified tolerances for the instrument to remain within calibration.

For no output voltage

If the pilot lamps and the fan do not operate when the power switch is turned on, check the power switch, the line fuse, and the line voltage. If your instrument is wired for 234-volt operation, also check the thermal cutout switch. (In an instrument wired for 117-volt operation, the fan will run even though the thermal cutout switch may be open). If the fuse is not blown and the line voltage is correct, check the primary windings of the power transformer.

If the pilot lamp and the fan operate correctly, the primary circuit of the power transformer may be assumed to be operating normally. The trouble then lies somewhere in the secondary circuits.

When only one of the outputs of the Low-Voltage Power Supply is zero, the trouble is probably due to a defective rectifier, series regulator, or power transformer secondary winding. To determine which circuit element is defective, measure the secondary voltage of the transformer and the voltage at the output of the rectifier. The cause of the trouble can be determined by the voltage readings obtained.

For failure of a power supply to regulate at the proper voltage

If any one or all of the supplies fail to regulate at the proper voltages, first check the line voltage. The supplies are designed to regulate between 105 and 125 volts (or 210 and 250 volts) with the design center at 117 volts (or 234 volts), rms. Improper line voltage may cause abnormal operation of one or all of the power supplies.

The +100- and +300-volt power supplies are dependent upon the —150-volt power supply for regulation, and consequently a change in the regulation point of all the supplies is indicative of a defective —150-volt supply. If the output voltage of the —150-volt power supply is off only a small amount, it may be possible to readjust the —150 ADJ control for the proper voltage. In any event it will be necessary to recalibrate the instrument when the trouble is corrected and the output voltages are again normal.

In case a single power supply should fail to regulate at the proper voltage check the following:

1. Line voltage
2. Transformer secondary voltage
3. Output voltage of the rectifier
4. Tubes
5. Loading

Important power supply voltages are marked on the power supply schematic diagram. These voltages may be used to perform checks on the power supply operation. One cause of improper regulation by a power supply is incorrect loading. To check power supply loading, shut off the power and check the resistance of the power supply output bus to ground. The —150-volt bus should measure approximately 6 kilohms, the +100-volt bus approximately 90 ohms, and the +300-volt bus approximately 17 kilohms.

If none of the preceding checks determine the cause of the trouble, the improper regulation is probably due to a change in value of one or more of the resistors or capacitors composing the voltage divider networks. The resistance networks in the grid circuits of V604, V624, and V644 are particularly critical since they determine the output voltage of their respective power supplies. Use resistance checks to isolate the defective part or parts.

The following information may be used as a quick index to troubleshooting the Low-Voltage Power Supply.

If the output voltage is high with excessive ripple, check:

1. For high line voltage.
2. The amplifier tubes (V604, V624, and V644).
3. For insufficient loading.

If the output voltage is high with normal ripple, check:

1. For proper resistance values in the dividers (R613 and R617; R636 and R638; and R662, R664, and R666).

If the output voltage is low with excessive ripple, check:

1. For low line voltage.
2. The series regulator tube (V607, V627, or V657).
3. For excessive loading.
4. Open or leaky filter capacitors.
5. Rectifiers (V602, SR620, or V642).

If the output voltage is low with normal ripple, check:

1. The resistance values in the dividers.
2. The capacitors shunting the dividers.

If the output voltage is normal with excessive ripple, check:

1. Filter capacitors at the output of the rectifiers and at the output of the power supplies.
2. AC bypass capacitors in the grid circuits of the regulator amplifiers.
3. Regulator amplifier screen grid circuits.

Troubleshooting the CRT Circuit

If no high voltage is available from either the positive or the negative high voltage power supplies, the trouble is probably due either to a defective oscillator stage (V810) or high voltage transformer (T801). The oscillator can quickly be checked by placing a neon bulb in the field of the high voltage transformer, T801. If the bulb glows, the oscillator is operating and the trouble is probably located in the secondary windings of T801. It is unlikely that both rectifier tubes (V812 and V822) would simultaneously be defective but the possibility should not be ignored.

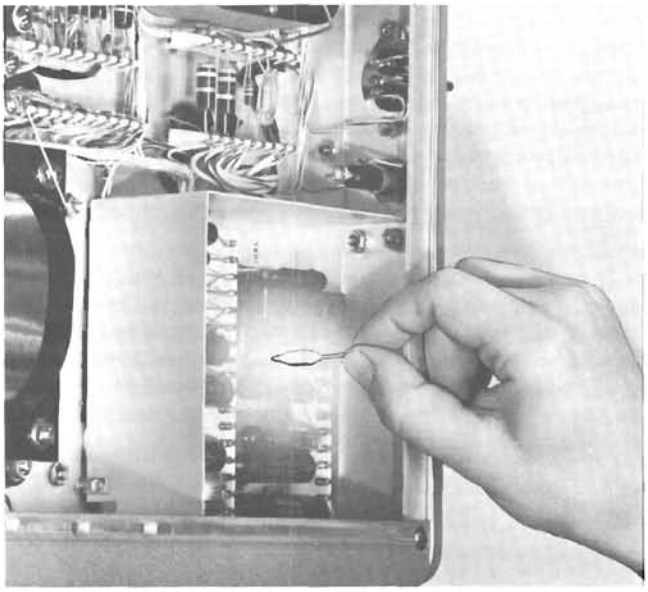


Fig. 4-3. Checking operation of the high voltage oscillator by the placement of a neon bulb in the field of the high voltage transformer.

If the neon bulb does not glow in the transformer field, the oscillator is not operating. In such a case the oscillator tube, V810 and the regulator tube, V804 should be checked by substitution. If this does not correct the trouble, check all components of the oscillator circuit including the high voltage transformer.

If unregulated voltage is obtained from both high voltage power supplies, (a lack of regulation is indicated if the display changes size and becomes defocused as the intensity setting is changed or as the line voltage is varied between 105 and 125 volts) the regulator tube, V804 and the oscillator tube, V810 should be checked by replacement. The voltage divider containing the INTENSITY and FOCUS controls can also cause a lack of regulation if one or more of the resistors is defective. However, if the voltage divider is at fault, the trouble will also result in a badly defocused and distorted display or no display at all, thereby giving a more direct indication of this type of trouble.

If both high voltage power supplies are operating correctly and the FOCUS and INTENSITY voltage divider is normal, the trouble can only be the cathode-ray tube or the ASTIGMATISM and GEOM ADJ controls. The ASTIGMATISM and GEOM ADJ controls can easily be checked by voltage readings. If the entire circuit checks out properly and the trouble still exists, replace the cathode-ray tube.

Troubleshooting the Horizontal Amplifier

Troubles occuring in the horizontal amplifier can generally be classified as either amplifier unbalance or as abnormal gain. These two troubles wil be discussed separately in the following paragraphs.

Amplifier unbalance is indicated if one or more of the following conditions exist: if the beam is deflected off the face of the crt, if the POSITION control does not have sufficient range to move the beam completely across the face of the crt, or if the trace shifts horizontally as the VOLTS/DIV switch is rotated. When the unbalance is slight, as in the case where the trace shifts horizontally as the VOLTS/DIV switch is rotated, it can usually be corrected by readjusting the DC BAL control. When the unbalance is more pronounced, however, it will be necessary to determine which stage is producing the unbalance and to make the necessary repairs.

If the unbalance occurs in all positions of the VOLTS/DIV switch one of the amplifier stages is probably at fault. To determine which stage is producing the unbalance, a short jumper can be used. If the beam is deflected off the face of the crt due to an unbalanced amplifier, the beam should return to the face of the crt when the jumper is placed between the horizontal deflection plates at the neck of the tube. The stage causing the unbalance can then be found by jumpering successively between corresponding points on opposite sides of the horizontal amplifier. As you short between the points, in turn, you should see the beam return to the screen as each connection is made. When you reach a point where the spot does not return to the screen, the stage immediately following that point is at fault, unless the feedback networks from the plates of the output stage to the cathodes of the input stage are defective. The unbalance will usually be caused by a defective tube or resistor.

Abnormal gain troubles will generally be either insufficient gain or no output. The gain of the amplifier in each position of the VOLTS/DIV switch can be checked by means of the calibration voltage applied to the amplifier by the AMPLIFIER CALIBRATION switch. Using this switch you should obtain 10 divisions of horizontal deflection regardless of which position the VOLTS/DIV switch is in. If, when using the calibration voltage, abnormal gain occurs only in certain positions of the VOLTS DIV switch, the resistors switched between the cathodes of V344 and V354 in these positions should be checked.

It is possible that the operation of the amplifier will appear normal using the calibration voltage but abnormal when the amplifier is used in displaying transistor curves. In such a case one or more of the attenuator resistors are probably defective.

If the gain is abnormal in all positions of the VOLTS/DIV switch when using the calibration voltage, at least one of the amplifier stages is defective. If the gain is only slightly abnormal, the amplifier may be recalibrated for the correct gain using the procedure given in the Recalibration section. If the error in gain is more pronounced or if there is no output, you should check the tubes first. Then check for components which will affect the gain of both sides of the amplifier without unbalancing the amplifier, such as common cathode resistors.

Troubleshooting the Vertical Amplifier

Troubles which may occur in the vertical amplifier are much the same as those which occur in the horizontal amplifier since the two amplifiers are virtually identical. Therefore the same general troubleshooting techniques may be applied to the vertical amplifier as were described for the horizontal amplifier. There is one difference between the two amplifiers however, that is worthy of note. That is the location of the collector sweep current sampling resistors in the vertical amplifier. The current sampling resistors must conduct the entire collector current of the transistor under test. Consequently, if one of the resistors is open no collector current will flow when the CURRENT OR VOLTAGE PER DIVISION switch is in any position where the open resistor is part of the series string composing the current sampling resistor.

Since some of the current sampling resistors have a very small value of resistance and must remain within close tolerances, it is impossible to check some of these resistors without a precision ohmmeter. If you find it necessary to check the value of one of these resistors, it will be necessary for you to use a resistance bridge or other suitable device.

Troubleshooting the Step Generator

For purposes of troubleshooting, the step generator can be divided into two parts. One portion (pulse generator, of the circuit generates a continuous train of positive pulses which are applied to the other half of the circuit. The second portion (stairstep generator) of the circuit then utilizes these pulses to generate the output stairstep voltage waveform. When a trouble occurs in the step generator, the trouble can many times be isolated to either the pulse generator or to the stairstep portions of the step generator by checking the output waveform with the STEPS/SEC switch in the 240 position.

Troubles which affect either the number of steps per second or the amplitude of the steps will generally be located in the pulse generator section. Troubles which affect the number of steps per family or cause a variation in the amplitude of the steps will generally be located in the stairstep generator section. If no output at all results, the trouble may be in either the pulse generator or the stairstep generator.

A trouble can be isolated to either the pulse generator or stairstep generator portions of the step generator by means of the following check. Place the STEPS/SEC switch in the 240 position, remove tube V163, and connect the input of a test oscilloscope to pin 3 of V143A. On the test oscilloscope you should observe a train of positive pulses of approximately 115 volts peak amplitude occuring at a 240 cycle rate. If this indication is normal, the trouble is located in the stairstep generator section of the step generator. However, if this indication is abnormal, either in amplitude or in repetition rate, the trouble is located in the pulse generator portion of the step generator. Tube V163 should be replaced as soon as this check is complete. Troubleshooting techniques for the pulse generator and stairstep generator sections of the step generator are discussed separately in the following paragraphs.

Pulse Generator

The best way to troubleshoot the pulse generator is to trace the signal flow through the circuit using a test oscilloscope. Checking the outputs of the full wave rectifier circuits is a good place to start. The waveforms at the output of the rectifier circuits (V112 and V123) are given on the schematic diagram of the step generator. If the outputs of either or both full wave rectifier circuits are abnormal, it will be necessary for you to trace the signal back toward the secondary of transformer T601 in order to determine the exact cause of the trouble. If the outputs of the rectifiers are normal, you should then check the waveform at the plates of the pulse shaper tubes, V104B and V124B. This should be done after disabling the pulse gating circuit by removing tube V163. The pulses at the plates of V104B and V124B should occur at either a 120 or 240 cycle rate depending upon the position of the STEPS/SEC switch. If the waveform is normal check V143A and its cathode circuit. Replace V163 at the completion of this check.

Stairstep Generator

If a trouble in the stairstep generator section results in no output from the step generator, a clue to the cause of the trouble can be obained by measuring the plate voltage of the integrator tube, V171. Usually when no output is obtained from the step generator, the voltage at the plate of V171 is either approximately 35 volts or more than 250 volts. These conditions are discussed separately in the following paragraphs.

If the voltage at the plate of the integrator tube, V171 is approximately 35 volts, the tube is not being allowed to perform its normal step-up action. This may result from defective coupling diodes (V172A or V172B), improper operation of the Schmitt trigger circuit (V155A and V155B), or an open resistor in the cathode circuit of V143B.

The coupling diodes may be checked by removing tube V163 and observing the waveform at the control grid of V171. Under these conditions the waveform should be a series of sharp negative spikes approximately 6 volts in amplitude. The coupling diodes are operating correctly if the spikes are present. If the spikes disappear when V163 is replaced in its socket, the Schmitt trigger circuit is not in the condition which allows the integrator circuit to perform its step-up action (V155A cutoff and V155B conducting). If R186, in the cathode circuit of V143B is not open, the trouble probably is V155B or its associated circuitry.

If the plate voltage of the integrator tube is more than 250 volts with the STEPS/FAMILY control fully clockwise, the tube is cut off. If this is the case, rotate the STEPS/FAMILY control fully counterclockwise and momentarily ground the control grid of V171. If the voltage at the plate of V171 drops and remains at a lower level, the trouble is that the disconnect diodes (V142A and V142B) are not conducting to reset the integrator tube. Tube V152 is probably at fault in such a case.

If the voltage at the plate of V171 does not decrease and remain lower after the control grid is momentarily grounded, but instead remains at about 275 volts, the integrator tube is not being reset. Since practically any stage in the stairstep generator can produce this condition it is necessary to make additional checks to determine the exact cause of the trouble. It is necessary to check each stage individually by means of voltage checks at important points in the circuit. The integrator stage should be checked first however.

With approximately 275 volts at the plate of V171, the cathode of V163A should be at about 215 volts. If this voltage is incorrect, check V163A and its grid and cathode circuits. If the voltage at the cathode of V163A is correct, the stage is probably operating correctly and you should then check the voltage at the cathode of V143B with the STEPS/FAMILY control fully clockwise. The voltage should be approximately —40 volts. If the voltage is not correct, check V143B and the cathode circuit of V163A. If the voltage at the cathode of V143B is correct, the stage is probably operating normally and you should then check V155A and its grid and cathode circuits for troubles which may not allow the tube to conduct. If V155A is conducting, (this can be determined by measuring the plate voltage of V155A...if the tube is conducting, this voltage should be less than 50 volts) the trouble then must be V163B or its associated circuitry.

If it is impossible to obtain the correct number of steps in each stairstep waveform, the trouble will probably be located in the cathode circuit of V163A. If the cathode circuit of V163A is normal, you must then check the resistors in the plate circuit of V155A and the grid circuit of V155B.

Adjusting The Step Amplifier

A trouble occuring in any stage in the step amplifier can produce virtually the same symptoms as a trouble occuring in any other stage. For this reason, it is probably best to troubleshoot the circuit by checking each stage individually. This may be done if the following procedure is used.

The +1 Amplifier (V254, V264, and V233B) should be checked first. This can be done by placing the POLARITY switch in the — position and grounding the control grid of V254 by placing a jumper from the junction of R251 and R246 to ground. Under these conditions, the cathode voltage of V233B should be zero. (It may be necessary to adjust the ±ADJ control to obtain this voltage.) If the cathode voltage of V233B is correct, the +1 Amplifier circuit is probably operating normally. You should, however check resistor R238 in the cathode circuit of V233B before proceeding to the next circuit check.

NOTE

You should leave the grid of V254 grounded during the circuit checks made on the remainder of the step amplifier.

If the cathode voltage of V233B is other than zero volts when the grid of V254 is grounded, the +1 Amplifier is defective. The trouble can be isolated either to cathode follower V233B or to the difference amplifier (V254 and V264) by measuring the voltages at the control grid of V264 and V233B. The voltage at the grid of V264 should be approximately the same as the voltage at the cathode of V233B if the cathode circuit of V233B is normal. If the grid voltage of V233B is approximately zero, but the cathode voltage is not, V233B should be replaced. If the grid voltage of V233B is not approximately zero, the difference amplifier stage is defective. In the latter case, it will be necessary to make additional voltage and resistance checks to determine the exact cause of the trouble.

With the POLARITY switch in the — position, the grid of V224 is maintained at ground potential by the +1 Amplifier. This causes the step amplifier to function as a voltage-regulated power supply with the stairstep voltage waveform from the step generator serving as the reference voltage. Under

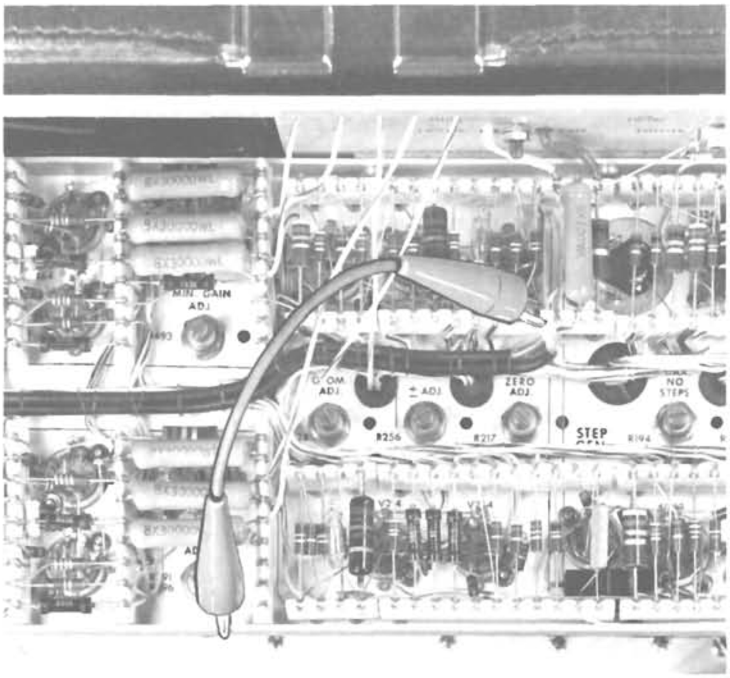


Fig. 4-4. Grounding the junction of resistors R251 and R246 to check operation of the Step Amplifier Circuit.

these conditions, if the circuit is operating correctly the voltage across R246 should increase from zero by .5 volts per step regardless of the position of the STEP SELECTOR switch. This means that with 12 steps in a family, the last step should bring this total voltage drop across R246 to 6 volts. This voltage can be observed on a test oscilloscope connected to the ungrounded side of R246. If the circuit operates properly in all but one or two positions of the STEP SELECTOR switch, you should check the resistors peculiar to these positions.

If you place the BASE STEP GENERATOR switch in the OFF position, no output should be obtained from the amplifier and the voltage measured at the ungrounded side of R246 should be zero. (It may be necessary to adjust the STEP ZERO and ZERO ADJ controls to obtain zero voltage). Also, adjustment of either the STEP ZERO or ZERO ADJ controls should change the voltage slightly across R246 if the circuit is working properly.

If you obtain an abnormal voltage across R246 under these conditions, you can locate the defective stage by using the STEP ZERO control to generate a signal voltage. The change in voltage produced by the STEP ZERO control can then be traced through the remainder of the circuit. When the circuit is operating normally, the voltage change at each point in the circuit is in the order of one volt as the STEP ZERO control is rotated between its limits. When the circuit is not operating properly, the voltage change will be much greater, however, making it relatively easy to trace the voltage shift through the circuit. When a point in the circuit is reached where the voltage does not change as the STEP ZERO control is rotated, this will locate the defective stage.

If adjustment of the STEP ZERO control produces more than approximately a one-volt change in the voltage across R246, resistor R203 should be checked. A large voltage change at the output of the circuit when the STEP ZERO control is rotated is indicative that the feedback circuit is not operating.

If the entire circuit appears to operate correctly except that the top of the stairstep waveform at the output is flattened off so that one or more of the steps is eliminated, the rectifiers for both power supplies in the step amplifier must be checked. With a stairstep waveform of 12 steps, a maximum of 2.4 amperes must be supplied by the power supply. If the power supply is unable to supply the required current, the last steps of each waveform will simply be eliminated and the upper portion of the waveform will be flattened off.

If the circuit appears to be operating correctly except that the voltage steps across R246 are more or less than the .5 volts which is normal, resistors R202 and R203 must be checked. The ratio of these two resistors controls the amplitude of the output steps from the step amplifier.

Troubleshooting the Collector Sweep Circuit

If a trouble occurs in the collector sweep circuit, it will generally result in either current flow through the current measuring resistor under no load conditions, insufficient output voltage, or insufficient output current. If both insufficient output voltage and current occur simultaneously the trouble is probably a defective rectifier.

A small amount of current flow through the current measuring resistor with no load on the output of the circuit is generally due to failure of V733 or to a misadjustment of C706 or C735. See Fig. 4-5. The circuitry of V733 is designed to eliminate current flow through the current measuring resistor resulting from current flowing in the output capacitance of the collector sweep circuit. Consequently, if V733 should fail, current flows through the current measuring

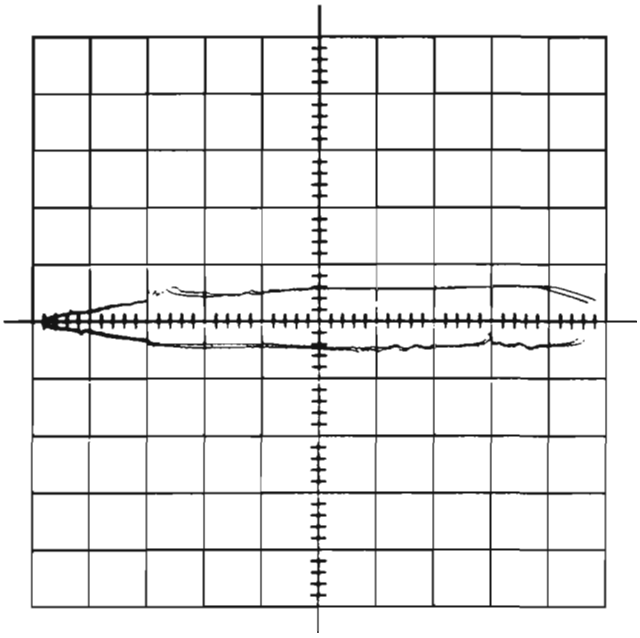


Fig. 4-5. The waveform resulting from a failure of V733.

This waveform shows collector current displayed vertically and collector voltage displayed horizontally. The CURRENT OR VOLTAGE PER DIVISION switch is in the .01 COLLECTOR MA position, the VOLTS/DIV switch is in the 20 COLLECTOR VOLTS position, and the PEAK VOLTS control is set for 200 volts output.

resistor and produces a small amount of vertical deflection on the face of the crt. This trouble is most evident when the PEAK VOLTS control is set for 200 volts and the CURRENT OR VOLTS PER DIVISION switch is set in the .01 COLLECTOR MA position.

The cause of insufficient or no output voltage may be determined by checking the voltages and waveforms at various points throughout the circuit using the information contained on the schematic diagram. Since this is an unregulated circuit, the line voltage should be checked first. Voltage checks at the output of the rectifiers should be made with a load on the output of the collector sweep circuit. A satisfactory load can be obtained by placing the DISSIPATION LIMITING RESISTOR switch in the 100 position and grounding terminal C on the Transistor Mounting Plate. The load then can be switched in and out as desired through use of the transistor selector switch.

CAUTION

When the dissipation resistors are used as a load for the collector sweep circuit, the peak collector sweep voltage should not be adjusted higher than 70 volts to prevent damage to the dissipation resistors.

It is best to perform the necessary voltage and waveform checks on the collector sweep circuit with the PEAK VOLTS RANGE switch in the 0-200 position. In this position the entire secondary winding of transformer T702 is utilized and the rectifiers are switched into a series connection. This makes it easier to detect troubles resulting from a defective secondary winding on T702 or from a defective rectifier.

If the circuit is unable to supply the specified currents, one or more of the rectifiers is probably at fault. However, if no current can be obtained from the circuit the trouble then is probably an open current measuring resistor. These resistors are shown on the schematic diagram of the Horizontal Amplifier.

SECTION 5
RECALIBRATION PROCEDURE

NOTE

Tolerances and accuracies as stated in Specifications section and the Recalibration Procedure of this manual apply only to Type 575 instruments above serial number 8030.

INTRODUCTION

The following equipment is required for the complete calibration of your instrument.

1. A voltmeter which measures dc voltage in the range from 100 to 1700 volts with an accuracy of 3%.
2. Dc voltmenter such as the Fluke Model 803 or the Electro Instruments Model Eitronic 880. Required characteristics: Input resistance at least 1 megohm. Accuracy at least ±1% of reading between 0.1 volt and 5 volts.
3. A variable-voltage transformer capable of supplying 6.5 amperes at 105 to 125 volts, rms.
4. An oscilloscope capable of displaying a low-frequency waveform with an amplitude of about 10 mv, peak-to-peak.
5. A resistance bridge capable of measuring resistances from 1 ohm to 500 kilohms. The resistance bridge accuracy must be capable of insuring that the resistor is within 1% of its proper value.
6. A small, non-metallic screwdriver.

NOTE

Steps 5 and 6 should be performed in the sequence given. Other steps may be performed in any sequence.

Unless otherwise stated, all adjustments are to be made at design center line voltage (117 v).

1. Checking the Step Selector Switch

Connect the resistance bridge between the wire running from the STEP SELECTOR switch to the POLARITY switch and the wire running from the front wafer to the middle wafer on top of the STEP SELECTOR switch. Read resistance values as shown in Table 5-1, and record percentage error at each position of the STEP SELECTOR switch.

2. Checking the Series Resistor Switch

Set the STEP SELECTOR switch to .01 VOLTS/STEP and Transistor Selector Switch to TRANSISTOR A. Connect the resistance bridge between binding posts B and E on the left side of the test panel. Compare each resistance value on the SERIES RESISTOR switch with the resistance reading of the resistance bridge (±10%). There is approximately 0.1 Ω resistance in series with the SERIES RESISTOR switch which may make the lower resistance readings appear slightly high. The 0.1 Ω of resistance is made up of wiring and switch contact resistance.

3. Checking the Dissipation Limiting Resistor Switch

Connect the resistance bridge between binding post C on the left side of the test panel and the white-brown-red wire on top of the Collector Sweep POLARITY switch. Set the Collector Sweep POLARITY switch between detents. Measure the resistance in each position at the DISSIPATION LIMITING RESISTOR switch. Each measured resistance should agree with the value indicated (±5%).

TABLE 5-1

STEP SELECTOR (MA PER STEP)	Resistance ±1%
.001	500 k
.002	250 k
.005	100 k
.01	50 k
.02	25 k
.05	10 k
.1	5 k
.2	2.5 k
.5	1 k
1	500 Ω
2	250 Ω
5	100 Ω
10	50 Ω
20	25 Ω
50	10 Ω
100	5 Ω
200	2.5 Ω

4. Power Supply

All voltage test points are brought out to pin jacks on the sides of the lower deck.

a. Turn the instrument on and allow a ten minute warm-up period. After the ten minute warm-up period, switch the Horizontal AMPLIFIER CALIBRATION switch to —10 DIVISIONS and connect the precision voltmeter between pin 1 of V344 and ground. Set Horizontal VOLTS/DIV switch to 0.1 BASE VOLTS. Adjust the —150 V ADJ control for a voltmeter reading of exactly —1 V. Measure the voltage with the BASE VOLTS switch set to the other positions indicated in Table 5-2, and record the voltage errors. These errors will be taken into account when calibrating the vertical and horizontal amplifiers.

TABLE 5-2

Measure between ground and junction of:	Correct reading in volts
R303 and R304	—2
R304 and R305	—1
R305 and R306	—0.5
R306 and R307	—0.2
R307 and R308	—0.1

NOTE

To avoid damage to the precision voltmeter, keep the AMPLIFIER CALIBRATION switch in the —10 DIVISIONS position as long as the voltmeter is connected to pin 1 of V344.

The accuracy of the entire instrument is no better than the accuracy with which this adjustment is made. Check voltage at —150 V TEST PT for —150 volts ±3%. Use the voltmeter to check regulation and an oscilloscope to check for ripple on this supply as the line voltage is changed through the range from 105-125 volts. Normal ripple is 10 millivolts, peak-to-peak.

b. In the same manner, check regulation and ripple of the +100-volt and +300-volt supplies. The output voltage of both supplies should be within 3% of the nominal value. The ripple on the +100-volt supply is normally 10 millivolts, peak-to-peak. The ripple on the +300-volt supply is normally 25 millivolts, peak-to-peak.

c. Set the output of the high-voltage supply to —1700 volts with the —1700 ADJ control. The control and jack are located on the left side of the lower deck. Defocus the crt beam and turn the INTENSITY control fully clockwise. Change the power line voltage from 105 volts to 125 volts and check the —1700-volt supply for constant output voltage. Then turn the INTENSITY control fully ccw and again check for constant output voltage as the line voltage is changed from 105 to 125 volts. Now reset the line voltage to the design center voltage (117 v).

5. DC Balance

When the DC BAL control is properly set, the trace on the crt will not shift appreciably as the corresponding Vertical or Horizontal control is moved through the BASE VOLTS range. (AMPLIFIER CALIBRATION in ZERO CHECK position.)

a. Horizontal Amplifier

Set controls as follows:

BASE STEP GENERATOR	OFF
Horizontal	.5 BASE VOLTS
INTENSITY	Usable level

Hold the AMPLIFIER CALIBRATION switch in the ZERO CHECK position as you make the following adjustments.

Move the spot to the center of the graticule with the two positioning controls. Switch the Horizontal control to .01 BASE VOLTS and move the spot back to the center of the graticule with the DC BAL control. If the spot cannot be moved to the center, it will be necessary to match the input tube (V344, V354) by trial and error. Normally, the spot can be positioned off either side of the CRT screen with the DC BAL control.

Readjust the DC BAL control until the spot does not shift appreciably as the Horizontal control is moved between .5 and .01 BASE VOLTS.

b. Vertical Amplifier

The procedure for adjusting the vertical DC BAL control is the same as that used for adjusting the horizontal DC BAL control.

6. Differential Balance

When the differential balance control is properly adjusted, equal signals applied to both grids will not appear between the plates of the input tubes and therefore will not be amplified by succeeding stages.

Set controls as follows:

Vertical	EXT.
Horizontal	EXT.
PEAK VOLTS RANGE	0-20
PEAK VOLTS	5
Transistor Selector Switch	TRANSISTOR A

Connect all four external inputs together (rear panel). On instruments above S/N 3659 pins E, F, H, and J, of the Type 175 adapter socket must be tied together for this adjustment. Run a wire from the external inputs to the binding post marked "C" on the left side of the test panel. Position the trace on the central area of the graticule. On instruments below serial number 2765 the DIFF BAL controls are the miniature potentiometers mounted on ceramic terminal strips below the Vertical and Horizontal selector switches. Instruments above serial number 2764 have the DIFF BAL controls mounted on a small bracket just behind the front panel on the right side of the instrument. Adjust the DIFF BAL controls so that only a spot remains on the face of the CRT.

Slowly turn the PEAK VOLTS control from 5 to 0 and watch the spot. If it changes into a line which is longer than four spot diameters as you rotate the PEAK VOLTS control, it will be necessary to select input tubes which have more similar characteristics. When you change input tubes, repeat the DC BAL procedure before attempting to adjust the differential balance. After a satisfactory differential balance has been attained, repeat the DC BAL procedure. Remove your test leads.

7. CRT Alignment

Set controls as follows:

PEAK VOLTS RANGE	0-20
Vertical	1 COLLECTOR MA
Horizontal	.5 COLLECTOR VOLTS

Adjust the PEAK VOLTS and Horizontal POSITION controls for a horizontal trace of about 10 major divisions. Center the trace with the Vertical POSITION control. The trace and the graticule line should coincide.

CRT Adjustment S/N 101-1620

If the trace and graticule line do not coincide over the length of the graticule, loosen the crt base clamp and rotate the tube with the alignment ring. When the trace and the graticule line are in coincidence, push the tube forward so that it rests snugly against the graticule. Then tighten the crt base clamp. Recheck the alignment after tightening the clamp to be sure it didn't move while the clamp was being tightened.

CRT Adjustment S/N 1620-up

Loosen the clamp at the base of the crt and push the crt against the graticule, then tighten the clamp. Now with the red knob, near the bottom of the clamp, rotate the crt until the trace runs parallel to the horizontal lines of the graticule.

8. Vertical Gain

The controls to be adjusted in this step set the gain of the Vertical Amplifier to a value which results in a trace deflection of 10 divisions when the appropriate internal calibrating voltage is fed into the input grids (AMPLIFIER CALIBRATION switch).

a. Switch the Base Step Generator off and set the STEP SELECTOR to .01 VOLTS PER STEP. Set the Vertical switch to 1000 COLLECTOR MA. Hold the vertical AMPLIFIER CALIBRATION switch in the ZERO CHECK position and move the spot or trace directly behind the fifth line above the center of the graticule. Now press down the AMPLIFIER CALIBRATION switch lever to the —10 DIVISIONS position. If the vertical MIN GAIN ADJ control is properly set, the trace will move to the fifth line below the center of the graticule, plus or minus the recorded error of the —1 volt measurement at the junction or R304 and R305, which was recorded in step 4.

If the adjustment is not properly set, alternately adjust the Vertical POSITION control and the vertical MIN GAIN ADJ control until exactly 10 divisions of deflection, plus or minus the error of —1 volt measurement taken in step 4, is obtained as the AMPLIFIER CALIBRATION switch is changed from the ZERO CHECK to the —10 DIVISIONS position.

b. Now set the Vertical switch to .01 BASE VOLTS and adjust the MAX GAIN ADJ control for 10 divisions of deflection in the manner described in part (a) of this step considering the error at the —0.1 volt measurement instead of the —1 volt measurement which was taken in step 4.

The MAX GAIN ADJ control is a miniature potentiometer mounted on the Horizontal switch. Since there is interaction between the MAX GAIN ADJ and the MIN GAIN ADJ controls, it is now necessary to recheck the calibration in the 1000 COLLECTOR MA position and recalibrate in both the 1000 COLLECTOR MA and .01 BASE VOLTS positions if necessary. Then check the calibration in the other positions of the Horizontal switch in the same manner.

9. Horizontal Gain

The controls to be adjusted in this step set the gain of the Horizontal Amplifier to a value which results in a trace deflection of 10 divisions when the appropriate internal calibrating voltage is fed into the input grids (AMPLIFIER CALIBRATION switch).

a. Set the Horizontal switch to .5 BASE VOLTS. Hold the horizontal AMPLIFIER CALIBRATION switch in the ZERO CHECK position and position the spot directly behind the right-hand edge of the graticule. Now press down the AMPLIFIER CALIBRATION switch to the —10 DIVISIONS position. If the horizontal MIN GAIN ADJ control is properly set, the spot will move directly behind the left edge of the graticule. If not, aternately adjust the horizontal MIN GAIN ADJ and the Horizontal POSITION control until the deflection is exactly 10 divisions.

b. Now set the Horizontal switch to .01 BASE VOLTS and adjust the MAX GAIN ADJ control for 10 divisions of deflection in the same way as described in part (a) of this step, considering the recorded error of the —0.1 volt measurement in step 4. The MAX GAIN ADJ control is a miniature potentiometer mounted on the Horizontal switch. Since there is interaction between the MAX GAIN ADJ and the MIN GAIN ADJ controls, it is now necessary to recheck the calibration of the .5 BASE VOLTS range and recalibrate both the .5 and .01 BASE VOLTS positions if necessary. Then check the calibration in the other positions of the Horizontal switch by the same method.

10. Phase A, Phase B, and Geometry

The PHASE A and PHASE B controls adjust the time relationship between the Collector Sweep and the Step Generator so that switching between steps occurs at a time when the collector sweep voltage is either at a maximum, at a minimum, or both.

The GEOM ADJ control is used to adjust the voltage on one of the crt elements to give the best trace linearity. Set controls as follows:

Veritcal	.1 COLLECTOR MA
Horizontal	BASE CURRENT OR BASE SOURCE VOLTS
Base Step Generator	REPETITIVE
STEP SELECTOR	.01 VOLTS/STEP
STEPS/SEC	120 lower
Collector Sweep POLARITY	Minus
PEAK VOLTS RANGE	0-20
PEAK VOLTS	10
DISSIPATION LIMITING RESISTOR	10 k
Transistor Selector Switch	TRANSISTOR B
Base Step Generator POLARITY	+

Short binding posts C and E on the TRANSISTOR B side of the test panel. Position the display so that the tops and bottoms of the vertical lines are within the graticule area. Adjust the Phase B control for a display like that of Fig. 5-1.

Now set the STEPS/SEC switch to the upper 120 position and adjust the STEPS/FAMILY control for a stable display.

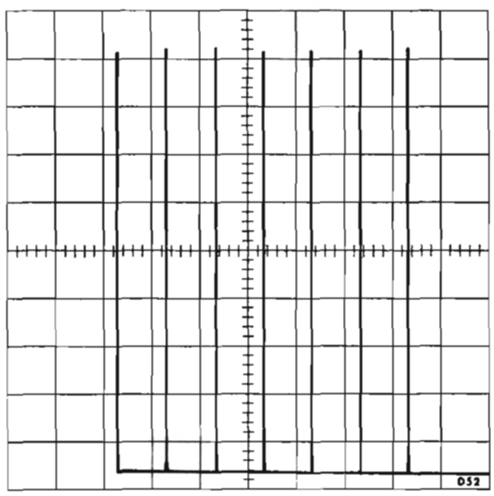


Fig. 5-1. Typical display resulting from proper adjustment of the Phase B control.

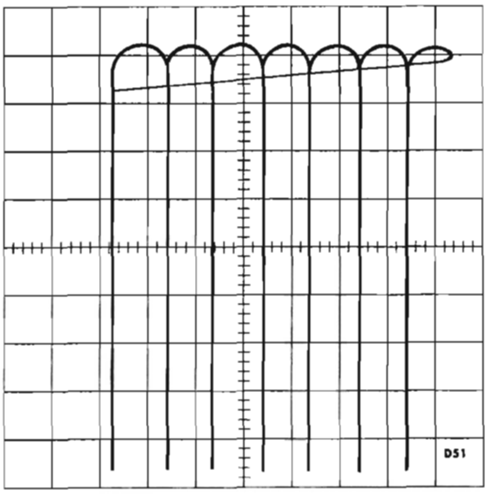


Fig. 5-2. Typical display resulting from the proper adjustment of the Phase A control.

Adjust the Phase A control for a display similar to that of Fig. 5-2. Return STEPS/SEC control to 240.

Move the Vertical control to .05 COLLECTOR MA and position the resulting display so that only the vertical lines of the trace are visible. Adjust the STEPS/FAMILY control so that there is one vertical section of the trace for each vertical line of the graticule. Adjust the GEOM ADJ control for minimum curvature of the vertical lines which are within the area enclosed by the graticule.

11. Zero Adj, ± Adj, and Volts/Step Adj

The ZERO ADJ control sets the voltage at the base of the stairstep waveform to a value which is the same in both positions of the Base Step Generator POLARITY switch.

The ±ADJ control is used to set the voltage at the base of the output stairstep waveform to zero.

The VOLTS/STEP ADJ control is used to set the amplitude of the voltage steps occurring across the current determining resistor of the Step Amplifier (R246).

Set:

STEP ZERO	Midrange

Position the display so the last trace to the right is in the center of the graticule. When the Base Step Generator POLARITY switch is changed to the plus position, the centered trace should not move. If it does, set the ZERO ADJ control for a symmetrical display around this trace as the Base Step Generator POLARITY switch is changed from one position to the other.

Now hold the horizontal AMPLIFIER CALIBRATION switch in the ZERO CHECK position and move the trace to a point directly behind the center vertical graticule line. Then release the switch and move the same trace behind the center vertical line with the ±ADJ control.

The STEP ZERO front-panel control should move the display approximately one-half of a major division each side of the centerline.

Position the display toward the center of the graticule and turn the STEPS/FAMILY control fully clockwise. With the POLARITY switch set in the minus position, set the VOLTS/STEP ADJ for one trace per major division. Remove shorting strap.

12. Adjusting the Collector Sweep Balance

The Collector Sweep Balance capacitors are used to cancel the effects of stray capacitance in the Collector Sweep wiring so that no current flows through the collector current sampling resistors when the Collector Sweep is not loaded.

Set the controls as follows:

Vertical	.01 COLLECTOR MA
Horizontal	20 COLLECTOR VOLTS
PEAK VOLTS RANGE	0-200
PEAK VOLTS	Fully clockwise
Collector Sweep POLARITY	Minus
Transistor Selector Switch	TRANSISTOR B

Use a non-metallic screwdriver to make the following adjustments. Press 0.1X button and adjust C735 (behind POWER switch) for minimum trace separation. Switch Collector Sweep POLARITY to plus, press 0.1X button and adjust C706 (collector sweep power-supply chassis) for minimum trace separation.

13. Min. No. Steps and Max. No. Steps

These controls determine the upper and lower limits of the STEPS/FAMILY control.

Vertical	1 COLLECTOR MA
Horizontal	.01 BASE VOLTS
Base Step Generator	REPETITIVE
STEP SELECTOR	.01 VOLTS/STEP

Turn the STEPS/FAMILY control fully counterclockwise and adjust MIN. NO. STEPS for 5 dots. Next, turn the STEPS/FAMILY control fully clockwise and adjust MAX. NO. STEPS for 13 dots. There is some interaction between these controls, so it may be necessary to repeat both adjustments.

14. Check the Step Selector Switch and set the +Step Adj (SN 4270-up)

Set controls as follows:

Vertical	1000 COLLECTOR MA
Horizontal	.01 BASE VOLTS
STEP SELECTOR	.01 VOLTS/STEP
Base Step Generator	REPETITIVE
PEAK VOLTS	0
Base Step Generator POLARITY	—

Check for one dot per division ±2% and note percentage of error. Change POLARITY to + and adjust +STEP ADJ for exactly the same display as was seen when the POLARITY switch was in the minus position.

15. Checking Vertical Collector ma/div Switch

Set controls as follows:

Horizontal	20 COLLECTOR VOLTS
Vertical	.01 MA/STEP
STEP SELECTOR	.01 MA/STEP
Base Step Generator	REPETITIVE
PEAK VOLTS	0
DISSIPATION LIMITING RESISTOR	0
Base Step Generator POLARITY	+

Short binding posts C and B on right side of test panel together and switch Transistor Selector Switch to TRANSISTOR B.

Note a display of one dot per division ±1% minus the percent of error recorded in step 1 (Table 5-1) for the .01 MA PER STEP position of the STEP SELECTOR switch. Do this procedure for each of the corresponding positions of the CURRENT OR VOLTAGE PER DIVISION section of the Vertical switch and the MA PER STEP section of the STEP SELECTOR switch. The 500 and 1000 COLLECTOR MA positions of the Vertical switch should be checked with the STEP SELECTOR at 50 and 100 MA PER STEP respectively, and with the 0.1X button depressed.

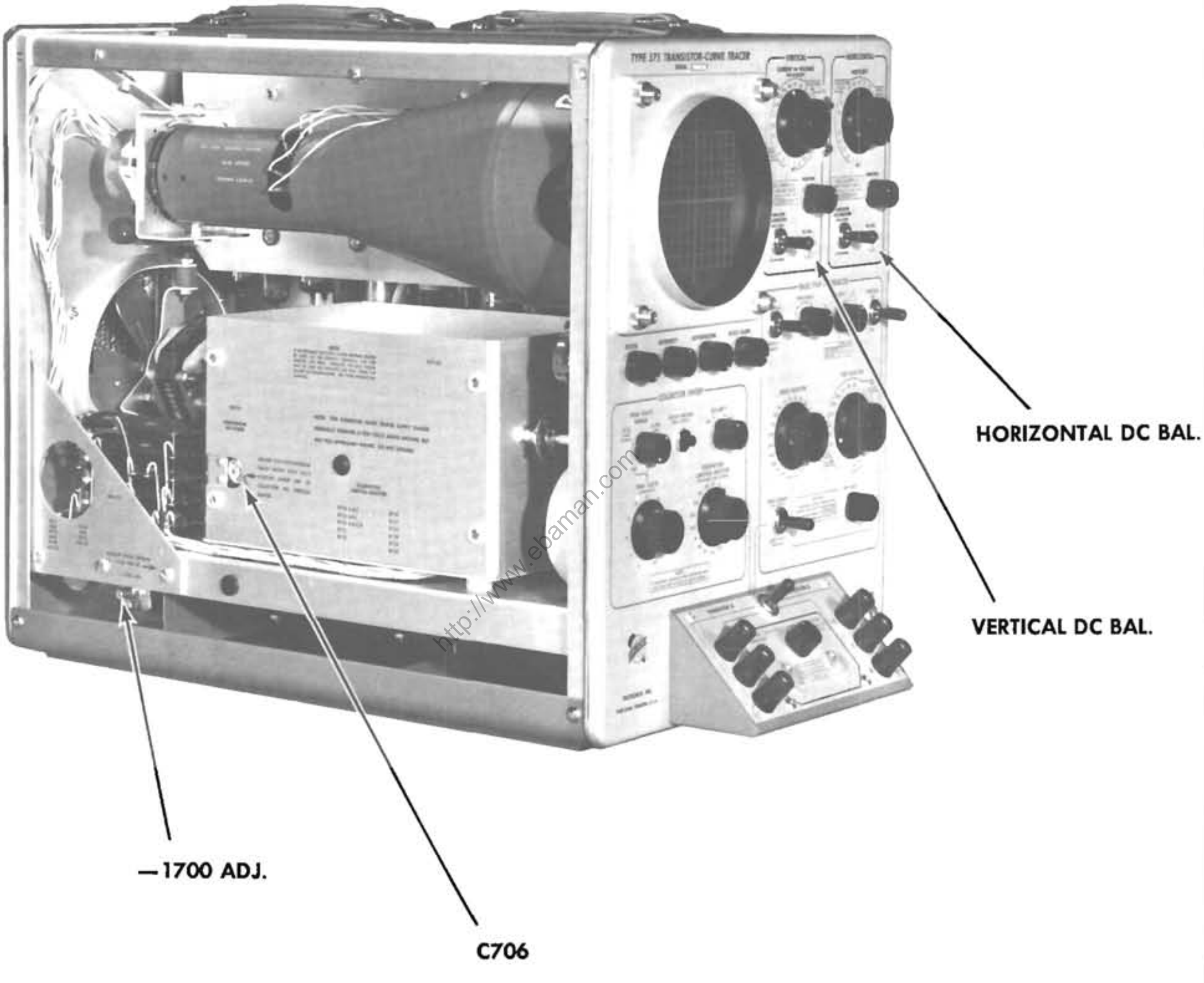


Fig. 5-3 Left Side View

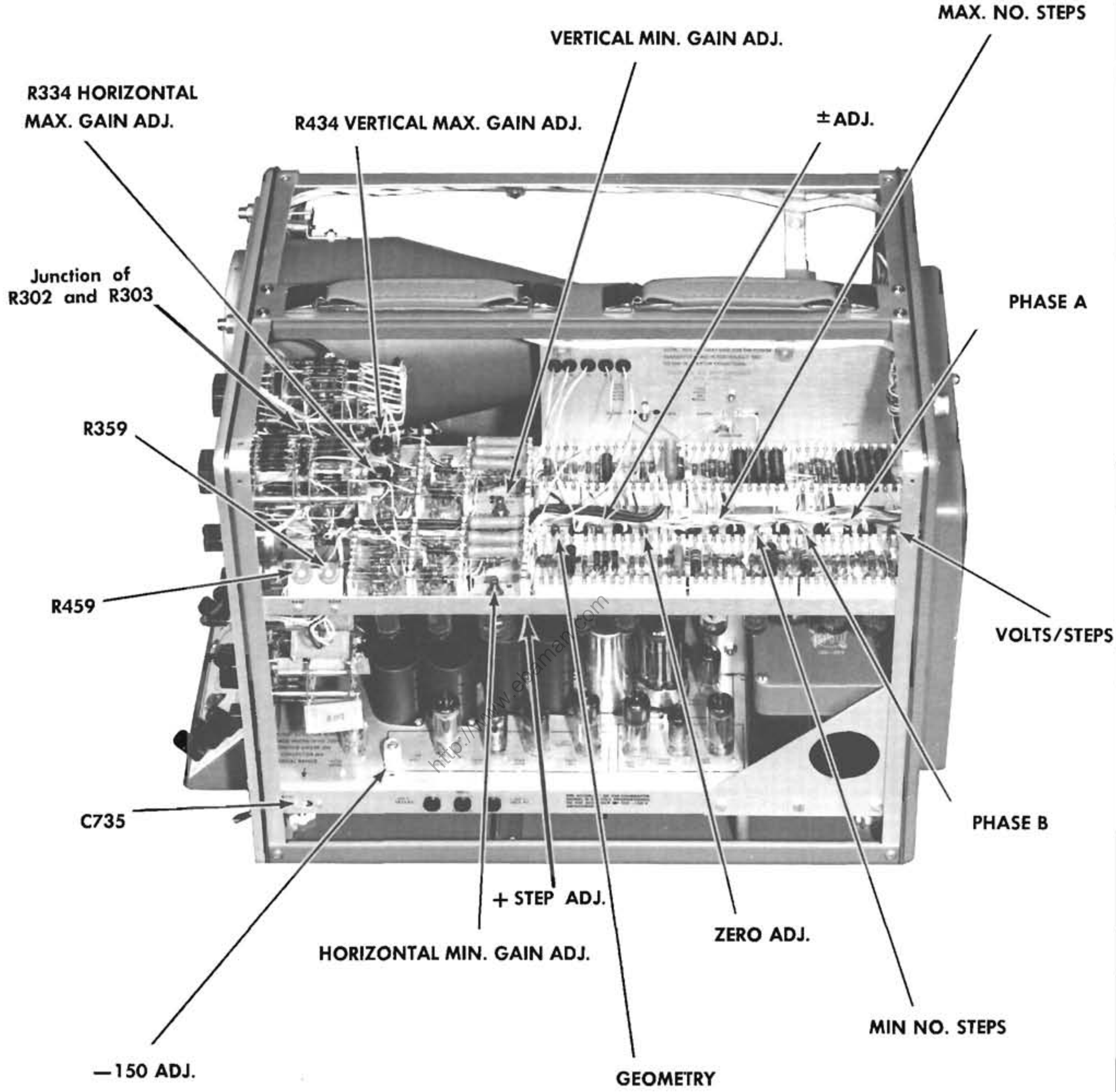
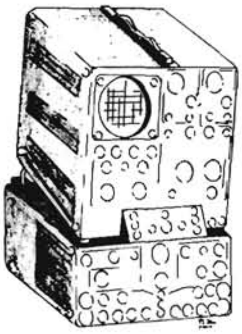


Fig. 5-4 Right Side View



SECTION 6

TYPE 175

GENERAL DESCRIPTION

The Type 175 Transistor-Curve Tracer High-Current Adapter enables the Type 575 Transistor-Curve Tracer to plot and display the characteristic curves of high-power transistors. Basically the Type 175 High Current Adapter contains a Collecter Sweep circuit and a Step Amplifier which are used in place of those in the Type 575. These circuits are capable of handling peak collector curents om more than 200 amperes and base currents up to 12 amperes. The Type 175 also contains the necessary voltage-dropping and current-sampling resistors for translating these high currents and voltages into deflection voltages suitable for display on the Type 575 crt.

The Step Generator and the Horizontal and Vertical Amplifiers in the Type 575 perform the same functions when the Type 175 is used with the Type 575 as when the Type 575 is used by itself.

ACCESSORIES

2 Instruction Manual
2 Black output leads, 012-014
2 Red output leads, 012-015
1 Interconnecting cable, 012-042
2 Red test cable, 012-043
2 Black test cable, 012-044
1 575 Adapter cable, 012-045
2 Blue test leads, 012-056
1 3 to 2-Wire adapters, 103-013
1 3-conductor power cord, 9 ft., 15 amp, 161-0030-00
1 3-conductor power cord, 20", 161-014

INSTALLATION INSTRUCTIONS

If your Type 575 Transistor-Curve Tracer has not been modified for use with the Type 175 High-Current Adapter, it will be necessary for you to do so before the two can be operated together. The following instructions tell you how to make this modification and how to mount the Type 575 on top of the Type 175 to make a convenient operating unit.

Modification

Drill five holes in the upper left corner (facing the instrument from the rear) of the rear panel according to the dimensions shown in Fig. 6-1. Mount the Type 175 interconnecting plug and harness in the holes and connect the wires as shown in Fig. 6-2 and Fig. 6-3.

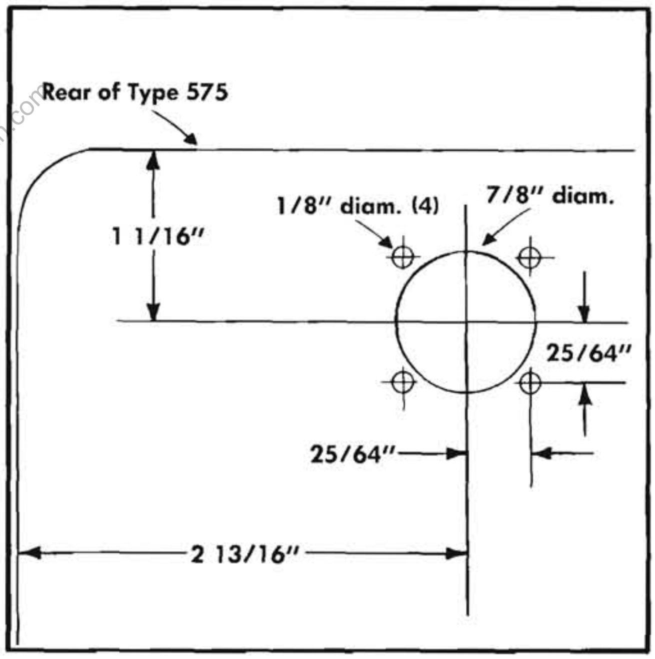


Fig. 6-1. Location and dimensions of holes for mounting interconnecting plug in Type 575.

Mounting

Remove the two cabinet bolts from the bottom front of the instrument and replace them with the two hinge bolts provided in the modification kit (see Fig. 6-4). If necessary, enlarge the holes in the Type 575 with a 3/16-inch drill. Set the Type 575 on top of the Type 175 so that the hinge bolts fall into the sockets in the front mounting feet on the Type

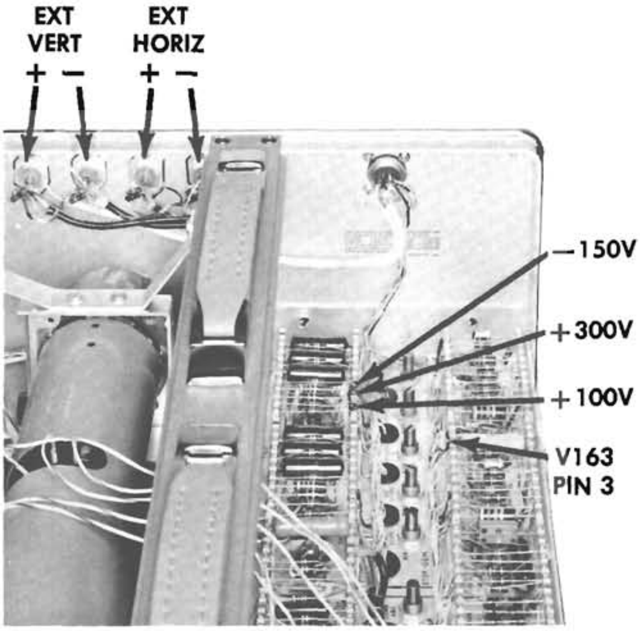


Fig. 6-2. Wiring connections to interconnecting plug in Type 575 (schematic).

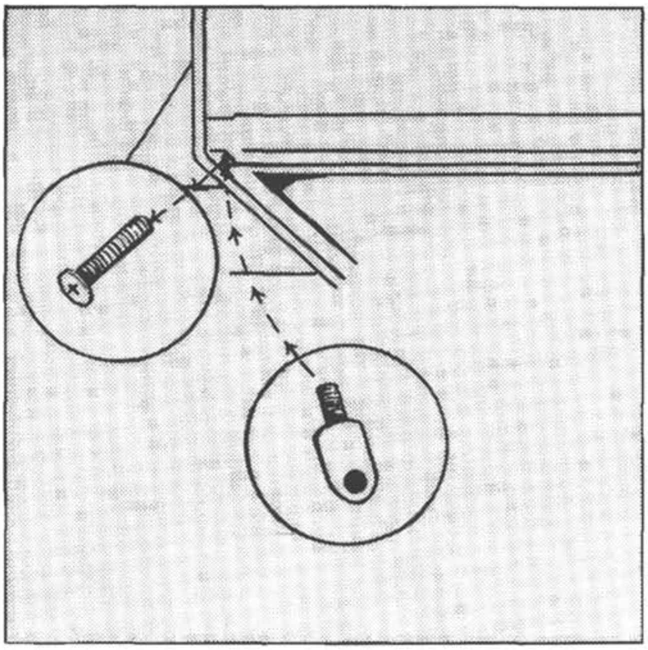


Fig. 6-4. Replacing cabinet bolts with hinge bolts in Type 575.

175. *Insert the two 10-32 x 1¼" bolts through the holes in* the mounting feet and the hinge bolts to hold the Type 575 securely in place. Note that the rear of the Type 575 can be raised for more convenient viewing. (See Fig. 6-5).

OPERATING INSTRUCTIONS

Operation of the Type 175 High-Current Adapter with the Type 575 Transistor-Curve Tracer is essentially the same as operation of the Type 575 by itself. The only major difference *is that the transistor connections are made at the* Type 175 instead of the Type 575 and the front-panel controls of the Type 175 take the place of some of the front-panel controls of the Type 575.

The following instructions deal only with those parts of the operating procedure which are unique to combined operation; it is assumed that the operator is already familiar with the operation of the Type 575 by itself.

To operate the two instruments together, the interconnecting cable must be connected and the VERTICAL CURRENT

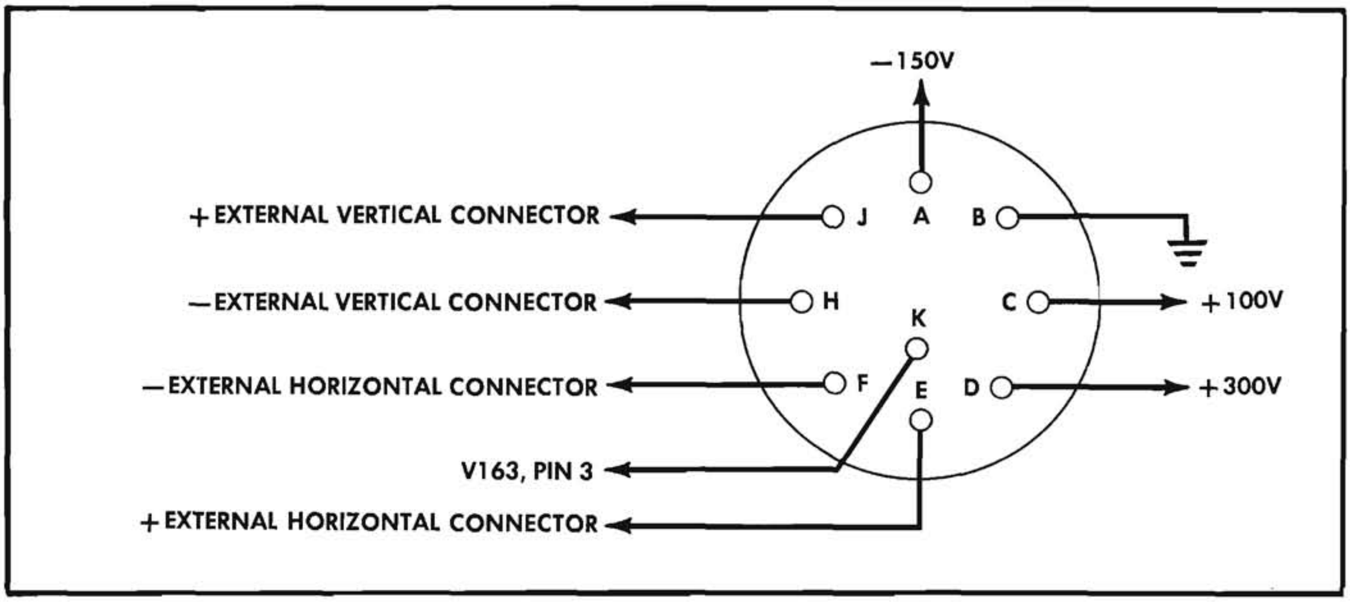


Fig. 6-3. Wiring connections to interconnecting plug in Type 575

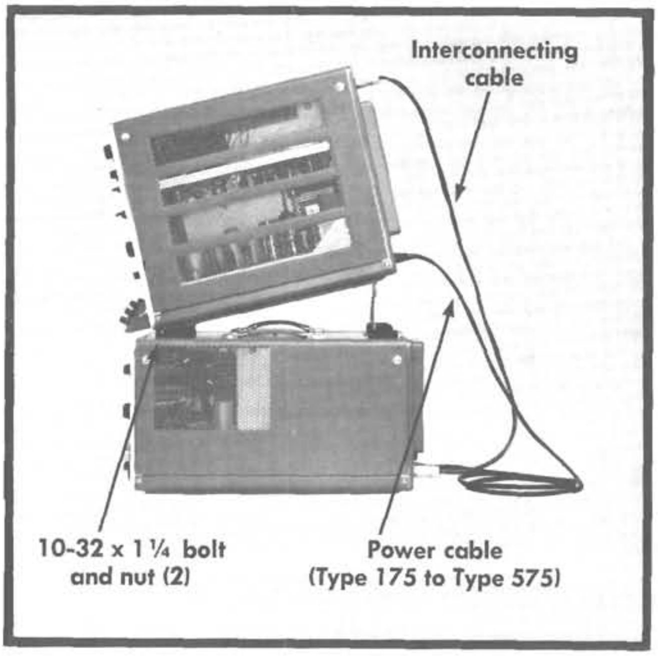


Fig. 6-5. Type 575 tilt-mounted on Type 175.

OR VOLTAGE PER DIVISION and the HORIZONTAL VOLTS/DIV. switches on the Type 575 must be set to EXT. For convenience, power to the Type 575 can be obtained from the POWER TO TYPE 575 connector on the rear of the Type 175. In this case, power to both instruments will be controlled by the Type 175 POWER ON switch. However, if it is intended that the Type 575 will be used frequently without the Type 175, it may be connected independently to its own power source, if desired. It is not recommended to have power applied to the Type 175 when the Type 575 is turned off.

A discussion of the front-panel controls of the Type 175 and their relationship to the front-panel controls of the Type 575 follows. With the VERTICAL CURRENT OR VOLTAGE PER DIVISION and HORIZONTAL VOLTS/DIV. switches on the Type 575 set to EXT., all other controls on the Type 575 whose functions are duplicated by controls on the Type 175 have no effect on the operation of the instruments.

VERTICAL DISPLAY Switch

The VERTICAL DISPLAY switch on the Type 175 takes the place of the VERTICAL CURRENT OR VOLTAGE PER DIVISION switch on the Type 575, except that there is no provisions for displaying base volts vertically on the Type 175. The VERTICAL DISPLAY switch selects the amplitude of the signal fed to the Vertical Amplifier of the Type 575. This signal is proportional to the collector current flowing through the transistor under test.

The POSITION control, AMPLIFIER CALIBRATION switch, and DC. BAL. adjustment in the VERTICAL block of the Type 575 perform exactly the same functions as they do without the Type 175.

COLLECTOR SWEEP Block

All of the controls in the COLLECTOR SWEEP block of the Type 175 perform the same functions, except for range of operation, as the corresponding controls on the Type 575. On the Type 175, there is no DISSIPATION LIMITING RESISTOR switch; the 300-ohm resistor inserted in series with the collector of the transistor in one of the PEAK VOLTS RANGE switch positions is the only dissipation limiting resistor available in the Type 175. If you wish to insert additional external dissipation limiting resistors, connect them in series with the collector of the transistor under test. With these additional resistors inserted in the circuit, it will be necessary to use test leads connected to the V_{ce} EXT. INPUT terminals, as described in the discussion of the Transistor Test Panel, for accurate presentation of collector-to-emitter voltages.

BASE STEP GENERATOR Block

All of the controls in the BASE STEP GENERATOR block of the Type 175 perform the same functions, except for range of operation, as the corresponding controls on the Type 575. The Display Selector switch (REPETITIVE-SINGLE FAMILY), the STEP/FAMILY control, and the STEPS/SEC. switch on the Type 575 perform the same functions as they do without the Type 175.

Transistor Test Panel

The Transistor Test Panel of the Type 175 is basically the same as that of the Type 575. Special connectors and cables are provided for high-current applications and for elimination of measurement errors due to voltage drops in high-current-carrying leads.

As with the Type 575 panel, the collector, base, and emitter connections are made to the binding posts C, B and E, respectively. If a peak collector current of more than about 25 amperes is expected, connect the collector and emitter to the large C and E terminals on the Type 175 through the high-current test cables provided.

With long leads to the collector and emitter of high-current transistors, or with dissipation limiting resistors inserted in series with a transistor, the voltage drop in the leads themselves may be enough to introduce a significant error into the voltage across the transistor as seen by the oscilloscope. This problem can be eliminated by connecting test leads from the collector and emitter of the transistor under test to the red and black V_{ce} EXT. INPUT terminals, respectively. These test leads are essentially non-current-carrying and provide a more accurate indication to the Horizontal Amplifier of the voltage at the transistor itself.

Also, the voltage drop in a high-current-carrying emitter lead can cause some loss in the base-drive voltage at the transistor, thereby making each base step less than that indicated by the setting of the STEP SELECTOR switch. (This applies only when the STEP SELECTOR is in one of the VOLTS/STEP positions.) For this reason, when high-current transistors are being tested with voltage steps at the base, you should remove the strap between the two REMOTE VOLTAGE-DRIVE GROUND REFERENCE binding posts and connect a lead from the ungrounded post to the emitter lead of the transistor itself.

CIRCUIT DESCRIPTION

Block Diagram

Fig. 6-6 shows a simplified circuit diagram of the Type 175 connected to the Type 575 for plotting collector current versus collector-to-emitter voltage of an NPN transistor. Most of the switching has been omitted from this diagram.

Overall operation of the unit is as follows: The step output from the Type 575 Step Generator is applied through pin K of the interconnecting plug to the Step Amplifier in the Type 175. The Type 175 Step Amplifier applies the steps to the base of the transistor under test while the Type 175 Collector Sweep circuit sweeps the collector voltage from zero to a peak voltage determined by the setting of the Type 175 controls. The time relationship between the collector sweeps and the base steps is the same as in the Type 575 alone. The number of steps per family and the number of steps per second are determined by the setting of the Type 575 controls. Polarity of the steps is determined by the Type 175.

The voltage drop across R415 is proportional to the current through it. This voltage is applied through pins H and J of the interconnecting plug to the Vertical Amplifier of the Type 575. The voltage difference between the switch arms of R315 and R316 is proportional to the collector-to-emitter voltage across the transistor. This voltage is applied through pins E and F of the interconnecting plug to the Horizontal Amplifier of the Type 575. (Both the VERTICAL CURRENT OR VOLTAGE PER DIVISION and the HORIZONTAL VOLTS/DIV. switches of the Type 575 are in the EXT. position for operation with the Type 175 Adaptor.

Collector Sweep

The Collector Sweep circuit in the Type 175 is essentially the same as that in the Type 575 except for current and voltage capabilities. Full-wave rectification of the 60-cycle line voltage produces 120 sweeps per second from 0 to 20 or 0 to 100 volts peak. These sweeps may be applied as either positive-going or negative-going voltages to the collector of either of two transistors under test by means of switch-actuated relays.

The Collector Sweep circuit is capable of supplying peak currents of over 200 amperes through the transistor under test at the 0-to-20 volt range of the PEAK VOLTS RANGE switch and over 40 amperes in the 0-to-100 volt range. The circuit breaker in the primary circuit of T702 is nominally rated at 8 amperes rms, but is capable of carrying considerably higher currents for short periods of time. The primary voltage of T702 is variable between zero and line voltage by means of the PERCENT OF PEAK VOLTS RANGE control. This provides a maximum average input power rating of about 1 kilowatt. Again, peak power can surpass this average by several times for short periods.

In one of the 0-100 positions of the PEAK VOLTS RANGE switch, a 300-ohm resistor (R720) is inserted in series with the output of T702 as a dissipation limiting resistor. Additional limiting resistors may be added externally, if desired (see Operating Instructions, "Collector Sweep Block".)

The internal resistance of the Collector Sweep circuit, exclusive of the current-sampling resistor (R415) and R720, is 0.03 ohm when the PEAK VOLTS RANGE switch is in the 0-20 position, and 0.5 ohm when the PEAK VOLTS RANGE switch is in the 0-100 position. Because of this low internal impedance, it is possible, in the more sensitive positions of the VERTICAL DISPLAY switch and with the C and E terminals shorted or nearly shorted, to dissipate enough power within the Type 175 to cause damage to the components. For this reason, the VERTICAL DISPLAY switch should always be in such a position that the maximum collector-current signal does not exceed a maximum amplitude of about five screen diameters.

A counterpart for V733 in the Type 575 is not required in the Type 175 because currents due to stray capacitance in the Type 175 are negligible compared to the high currents being measured.

Step Amplifier

The Step Amplifier in the Type 175 is virtually the same as that of the Type 575. The only significant differences are the use of 20-volt floating power supplies in place of 15-volt power supplies and the use of four parallel-connected transistors in the output stage. (The output of the 20-volt supplies is actually about 25 volts at nominal line voltage.) The Type 175 is capable of supplying a maximum base current of 12 amperes whereas the Type 575 supplies a maximum base current of only about 2.4 amperes.

The 20-volt supplies for the Step Amplifier are shown on the Power Supply schematic diagram. Diode-connected transistors are used in the negative supply to handle the additional current which must flow through that supply.

R244R and R244S reduce the transients which appear at the base of the transistor under test whenever the STEP SELECTOR switch is moved from one position to the next. They are shorted out except when the switch is between positions.

MAINTENANCE

General maintenance information, such as filter cleaning, parts replacement and ordering, and general troubleshooting instructions is the same for the Type 175 as for the Type 575. Therefore, the following information is concerned only with specific troubleshooting procedures for the Type 175 Step Amplifier and Collector Sweep circuit and the associated switches.

Troubleshooting the Step Amplifier

Troubleshooting the Step Amplifier of the Type 175 can be accomplished by the same procedures as for the Type 575 (note, however, that in some cases corresponding parts

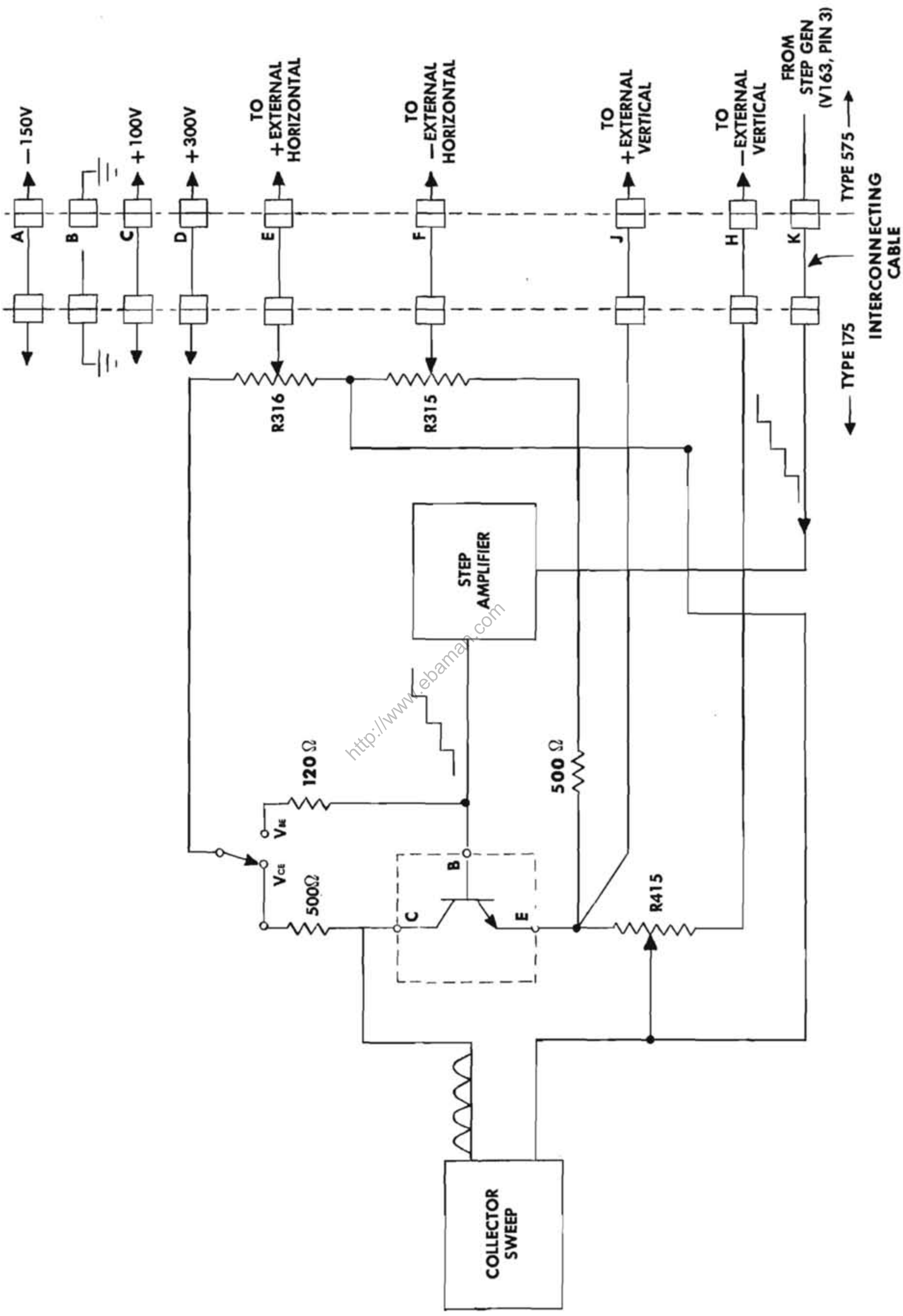


Fig. 6-6. Simplified circuit diagram of Type 175 Transistor-Curve Tracer High-Current Adapter.

are numbered differently). As with the Type 575, the voltage drop across the current-sampling resistor (R244 in the Type 175, R246 in the Type 575 should increase from zero by 0.5 volt steps regardless of the position of the STEP SELECTOR switch. The maximum current which must be supplied by the Step Amplifier power supplies in the Type 175 is 12 amperes as compared to 2.4 amperes in the Type 575. Note also that the Type 175 Step Amplifier has a VOLTS/STEP ADJ. adjustment at its input, the setting of which can affect the amplitude of the signal throughout the circuit.

Troubleshooting the Collector Sweep Circuit

The cause of insufficient or no output voltage from the Collector Sweep circuit can be isolated by continuity checks through the circuit. Verification of sufficient output can be made by measurements described later in the procedure for checking the resistors of the VERTICAL DISPLAY switch.

Checking Switch Resistance

The following procedures tell you how to check the resistors in the HORIZONTAL DISPLAY, STEP SELECTOR VERTICAL DISPLAY, *and* SERIES RESISTANCE *switches of the Type* 175 for proper values. Since the Type 575 and the Type 175 are essentially self-checking, this can be done by measurements observed on the screen of the Type 575. In each measurement, the faulty resistor can be determined by comparing the position of the switch in which a faulty indication is obtained with the appropriate schematic diagram. To perform the measurements, you will need five precision (1%) resistors of the following values and ratings: 100 ohms, 2 watts; 2 ohms, 50 watts; 0.05 ohms, 50 watts; 0.005 ohms, 100 watts; and 10 ohms, 20 watts. These resistors will be referred to by their resistance values only. The set of four resistors containing the five values listed may be ordered from Tektronix, Inc. The Tektronix part number for the set is 015-0042-00.

Throughout the procedures, the Type 175 and Type 575 should be connected together for combined operation, as described under Operating Instructions, and turned on, unless otherwise noted. For a complete checkout of all switches, the procedures should be performed in the order presented. If you merely wish to check the operation of one of the switches, you may check it separately as long as you realize that, in these procedures, an off-value resistor in the HORIZONTAL DISPLAY switch can make any of the other switches (except the SERIES RESISTANCES switch) appear faulty.

HORIZONTAL DISPLAY *and* STEP SELECTOR Switches.

To check the resistors associated with the HORIZONTAL DISPLAY and STEP SELECTOR switches, proceed as follows:

1. Connect the resistor designated in the first column of Table 1 between the E and B binding posts to the TRANSISTOR A side of the Transistor Test Panel of the Type 175.

2. Set the STEP SELECTOR and HORIZONTAL DISPLAY switches to the positions shown in the second and third columns of the table.

3. Set the Transistor Selector switch to TRANSISTOR A and the STEPS/FAMILY control (on the Type 575) fully clockwise. The display on the Type 575 screen should contain the number of dots per division shown in the fourth column of the table.

4. Continue in like manner down the table, inserting the proper resistor and setting the controls as designated, and check for the proper number fo dots per division in the display for each measurement. (Remove the resistor for the last five measurements on the table.)

If an incorrect display first occurs in the second, fourth, sixth, of eighth measurement of the table, the trouble is in

TABLE I

Resistor (between E and B posts)	STEP SELECTOR switch	HORIZONTAL DISPLAY switch (BASE V_{be})	Dots per division
100 Ω	1 MA/STEP	.1	1
100 Ω	1 MA/STEP	.2	2
100 Ω	2 MA/STEP	.2	1
100 Ω	2 MA/STEP	.5	5 dots per 2 divisions
100 Ω	5 MA/STEP	.5	1
100 Ω	5 MA/STEP	1	2
10 Ω	10 MA/STEP	1	1
10 Ω	10 MA/STEP	2	2
10 Ω	20 MA/STEP	2	1
10 Ω	50 MA/STEP	.1	1
2 Ω	100 MA/STEP	.2	1
2 Ω	200 MA/STEP	.5	5 dots per 4 divisions
2 Ω	500 MA/STEP	1	1
2 Ω	1000 MA/STEP	1	1 dot per 2 divisions
open	.02 VOLTS/STEP	.1	5
open	.05 VOLTS/STEP	.1	2
open	.1 VOLTS/STEP	.1	1
open	.2 VOLTS/STEP	.2	1
open	.5 VOLTS/STEP	.5	1

the corresponding position of the HORIZONTAL DISPLAY switch. An incorrect display in any of the other measurements indicates that the trouble is in the corresponding position of the STEP SELECTOR switch. A small consistent error at all positions of both switches indicates a need for adjustment of the internal VOLTS/STEP ADJ. adjustment (see Calibration). If the dots are consistently farther apart in the VOLTS/STEP positions of the STEP SELECTOR switch than in the MA/STEP positions, this indicates that R246 has increased in value or the wiring resistance of the circuit has increased. Conversely, if the dots are consistently closer together in the VOLTS/STEP position of the STEP SELECTOR switch than in the MA/STEP positions, this indicates that R246 has decreased in value or has become shorted.

HORIZONTAL DISPLAY Switch (COLLECTOR V_{ce} Positions) After you have verified the accuracy of all the BASE V_{be} positions of the HORIZONTAL DISPLAY switch, proceed as follows to check the resistors associated with the COLLECTOR V_{ce} positions of the switch:

1. Set the Transistor Selector switch to TRANSISTOR A, the PEAK VOLTS RANGE switch to 0-20, and the PERCENT OF PEAK VOLTS RANGE control to 0.

2. Set the HORIZONTAL DISPLAY switch to 2 COLLECTOR V_{ce}.

3. Rotate the PERCENT OF PEAK VOLTS RANGE control clockwise until you obtain exactly 10 divisions of horizontal deflection on the screen.

4. Set the HORIZONTAL DISPLAY switch to 5 COLLECTOR V_{ce}. There should be four divisions ($\pm 2\%$) of horizontal deflection on the screen.

5. Return the PERCENT OF PEAK VOLTS RANGE control to 0.

6. Set the PEAK VOLTS RANGE switch to 0-100 and the PERCENT OF PEAKS VOLTS RANGE control for exactly 10 divisions of horizontal deflection.

7. Set the HORIZONTAL DISPLAY switch to 10 COLLECTOR V_{ce}. There should be five divisions ($\pm 2\%$) of horizontal deflection on the screen.

(The remaining COLLECTOR V_{ce} positions of the HORIZONTAL DISPLAY switch use the same resistors as the BASE V_{ce} positions which were checked previously.)

VERTICAL DISPLAY Switch. In checking the resistance in the VERTICAL DISPLAY switch, the output of the Collector Sweep circuit is applied across an externally connected resistor at each setting of the VERTICAL DISPLAY switch. The voltage across the resistor is displayed as horizontal deflection and the current through the resistor is displayed as vertical deflection. The slope of the line displayed, as the Collector Sweep output sweeps between zero and a selected maximum voltage, should indicate the value of the external resistance. Any deviation from the proper slope indicates an off-value current sampling resistor (assuming that the resistances in the HORIZONTAL DISPLAY switch as measured previously are all correct).

To check the resistances in the VERTICAL DISPLAY switch, proceed as follows:

1. Set the PERCENT OF PEAK VOLTS RANGE control to 0.

2. Set the COLLECTOR SWEEP POLARITY switch on the Type 175 to +.

3. Connect the resistor designated in Column A of Table II between the large C and E terminals on the TRANSISTOR A side of the transistor Test Panel of the Type 175 using the high-current test cables.

4. Connect test leads from the ends of the resistor to the V_{ce} EXT. INPUT binding posts on the same side of the Transistor Test Panel.

5. Set the Transistor Selector switch to TRANSISTOR A.

6. Set the PEAK VOLTS RANGE, VERTICAL DISPLAY, and HORIZONTAL DISPLAY switches on the Type 175 to the positions designated in columns B, C, and D of Table II.

7. Adjust the POSITION controls on the Type 575 to position the spot to the lower left corner of the graticule.

8. Rotate the PERCENT OF PEAK VOLTS RANGE control clockwise until you obtain the horizontal deflection specified in column E of the table. The slope of the line (Δ vertical deflection divided by Δ horizontal deflection) should be within 2% of that specified in column F.

NOTE

In the first measurement, you may not be able to obtain the full 10 divisions of horizontal deflection before the circuit breaker actuates. However, if the slope of the displayed lines is correct, the measurement may be considered to be within tolerance. If the circuit breaker does actuate, return the PERCENT OF PEAK VOLTS RANGE control to 0 and wait one minute for the heating element in the breaker to cool before resetting it.

9. Return the PERCENT OF PEAK VOLTS RANGE control to 0 after each measurement.

10. Continue in like manner down the table, inserting the proper resistor and setting the controls as designated, and check for adequate deflection and proper slope on the Type 575 screen. If any of the slopes are not correct, or if adequate horizontal deflection cannot be obtained, make a note of it (whether the slope is greater or less than specified) and go on to the next measurement.

If the slope is correct for the first few measurements in Table II, but is incorrect for the remaining measurements, this indicates that one of the current-sampling resistors has changed in value. It will generally be the resistor associated with the VERTICAL DISPLAY switch position at which the incorrect slope first occurred as you progressed down the table. If the slope is greater than specified, the resistor has increased in value; if the slope is less than specified, the resistor has decreased in value.

Insufficient horizontal deflection in the fifth and/or seventh measurements of the table (1 and 2 positions of the VERTICAL DISPLAY switch, respectively) indicates that the internal resistance of the Collector Sweep circuit itself has increased beyond its proper value. In this case, check T702 and the associated rectifier diodes as described in the paragraph on Troubleshooting the Collector Sweep Circuit.

TABLE II

A	B	C	D	Trace should cross at these intersections E	F
Test Resistor (015-0042-00)	PEAK VOLTS RANGE	Vertical Display	Horizontal Display V_{ce}	Horizontal Div From Left Edge Graticule Line	Vertical Div From Bottom Graticule Line
.005 Ω	0-20	20	.1	10 div	10 div
.005 Ω	0-20	10	.1	5 div	10 div
.05 Ω	0-20	5	.2	10 div	8 div
.05 Ω	0-20	2	.1	10 div	10 div
.05 Ω	0-20	1	.1	5 div	10 div
2 Ω	0-20	.5	1	10 div	10 div
10 Ω	0-100	.2	2	10 div	10 div
10 Ω	0-20	.1	1	10 div	10 div
10 Ω	0-20	.05	.5	10 div	10 div
10 Ω	0-20	.02	.2	10 div	10 div
10 Ω	0-20	.01	.1	10 div	10 div
10 Ω	0-20	.005	.1	5 div	10 div

SERIES RESISTANCE switch. To check the resistance in the SERIES RESISTANCE switch, proceed as follows:

1. Turn the Type 175 off.
2. Set the Transistor Selector switch to TRANSISTOR A.
3. Set the STEP SELECTOR switch to .02 VOLTS/STEP.
4. Measure the resistance between the E and B binding posts of the TRANSISTOR A side of the Transistor Test Panel at each setting of the SERIES RESISTANCE switch. In each case, the resistance should be within 5% of that indicated by the setting of the switch.

CALIBRATION

There are only four internal adjustments in the Type 175 High-Current Adapter: the ZERO ADJ., the ±ADJ., and the VOLTS/STEP ADJ. (See Fig. 6-7). They all perform the same functions as the corresponding adjustments in the Type 575. They should be adjusted only after the Type 575 has been properly calibrated.

To properly set the internal adjustments of the Type 175, proceed as follows:

1. Set the front-panel controls as follows:

HORIZONTAL DISPLAY (Type 175)	.1 V_{be}
Display Switch (Type 575)	REPETITIVE
POLARITY (Type 175 Base Step Generator)	—
STEP SELECTOR (Type 175)	.1 VOLTS PER STEP
STEP ZERO (Type 175)	midrange
Transistor Selector switch	TRANSISTOR B

2. Position the display so the last dot to the right is in the center of the graticule.

3. Set the ZERO ADJ. adjustment in the Type 175 so that this dot does not move as the Type 175 Base Step Generator POLARITY switch is switched from one position to the other. (The other dots will shift from one side to the other as the POLARITY is switched.) Leave the POLARITY switch in the — position when you are finished with this step.

4. Hold the HORIZONTAL AMPLIFIER CALIBRATION switch in the ZERO CHECK position, and position the dot directly behind the center vertical graticule line.

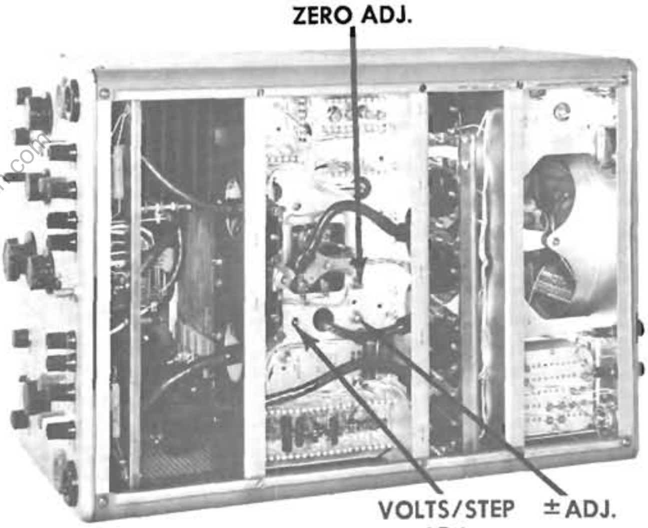


Fig. 6-7. Bottom of Type 175, showing internal adjustments.

5. Release the switch and set the ± ADJ. adjustments so that the last dot to the right is directly behind the center vertical graticule line.

6. Set the STEP SELECTOR switch to .5 VOLTS PER STEP and repeat steps 2 through 5 until both the ZERO ADJ. and the ± ADJ. are properly set.

7. Set the STEP SELECTOR switch to .1 VOLTS PER STEP and turn the STEPS/FAMILY control on the Type 575 fully clockwise.

8. Position the display of dots so that it extends across the graticule.

9. Set the VOLTS/STEP adjustment on the Type 175 for one dot per major graticule division. This adjustment must be done in the minus position of the POLARITY switch.

10. Adjusting +Step Adj. (SN 240 and up)

Set the controls as follows:

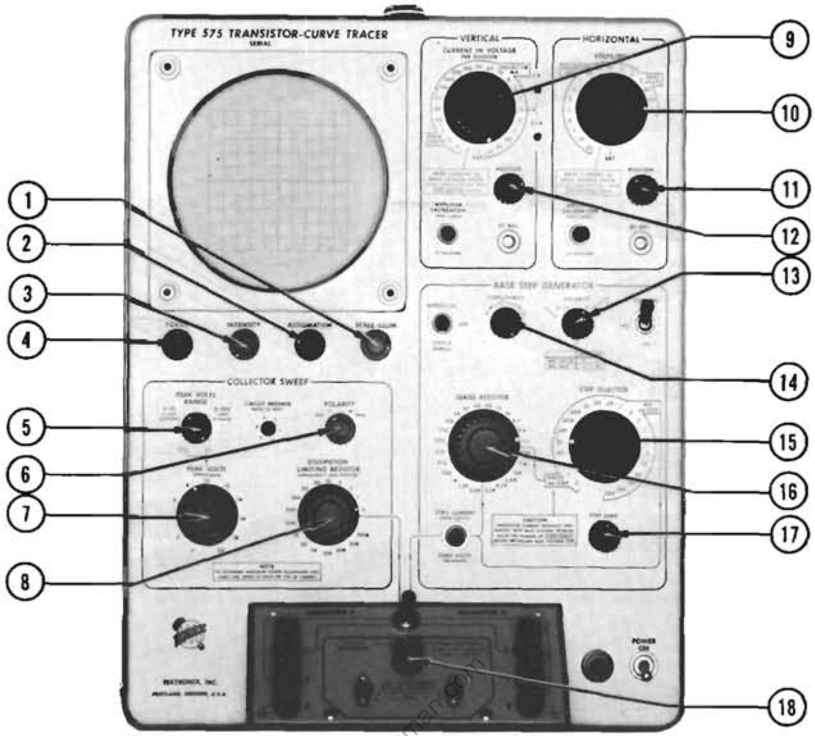
HORIZONTAL	0.1 BASE VOLTS
VERTICAL	100 COLLECTOR MA
STEP SELECTOR	1 MA/STEP
POLARITY	MINUS

Connect a 1 K precision resistor between terminals B and E on the right side of the test panel and move the lever switch to the TRANSISTOR B position. There should now be a display of approximately one dot per ten major divisions. Check the distance between the dots and turn POLARITY switch to the plus position. With the +Step Adj., move *the dots so that the same spacing as the minus position is* obtained.

With the +Step Adj. it will be possible to maintain the same amount of voltage per step in both the plus and minus positions of the POLARITY switch. The standardizing is measured in the 1 MA/STEP position of the STEP SELECTOR with a 1 K resistor from the Step Amplifier to ground.

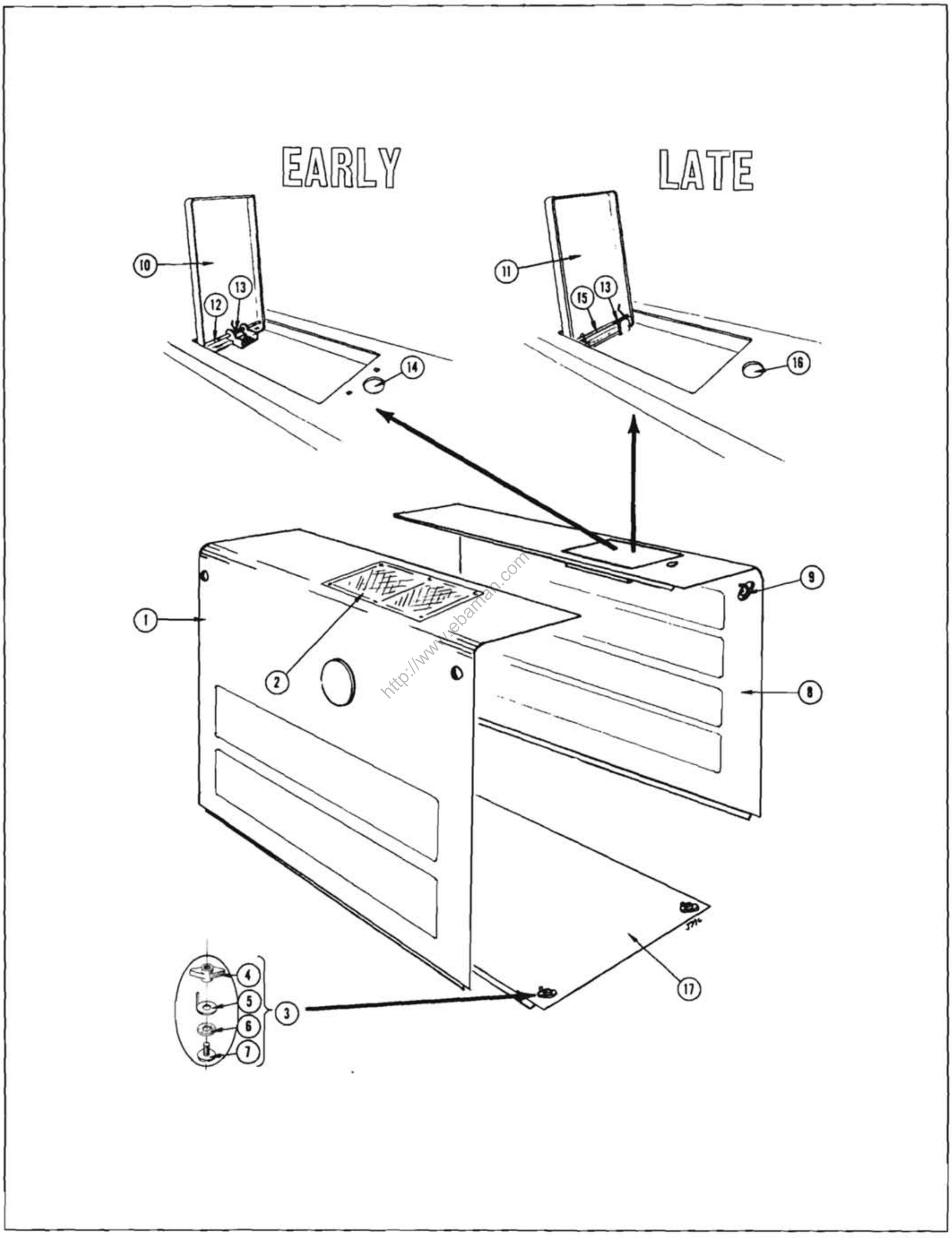
SECTION 7
MECHANICAL PARTS LIST

KNOBS



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
1	366-0033-00			1	SCALE ILLUM., black
2	366-0033-00			1	ASTIGMATISM, black
3	366-0033-00			1	INTENSITY, black
4	366-0033-00			1	FOCUS, black
5	366-0033-00	101	788	1	PEAK VOLTS RANGE, black
	366-0069-00	789		1	PEAK VOLTS RANGE, black
6	366-0033-00			1	POLARITY, black
7	366-0042-00			1	PEAK VOLTS, black
8	366-0042-00			1	DISSIPATION LIMIT RES., black
9	366-0060-00			1	VERTICAL VOLTS/DIV., black
10	366-0060-00			1	HORIZONTAL VOLTS/DIV., black
11	366-0033-00			1	HORIZONTAL POSITION, black
12	366-0033-00			1	VERTICAL POSITION, black
13	366-0033-00			1	BASE STEP GENERATOR, POLARITY, black
14	366-0033-00			1	BASE STEP GENERATOR, STEPS/FAMILY, black
15	366-0060-00			1	STEP SELECTOR, black
16	366-0060-00			1	SERIES RESISTOR, black
17	366-0033-00			1	STEP ZERO, black
18	366-0033-00			1	EMITTER AND BASE GROUND, black

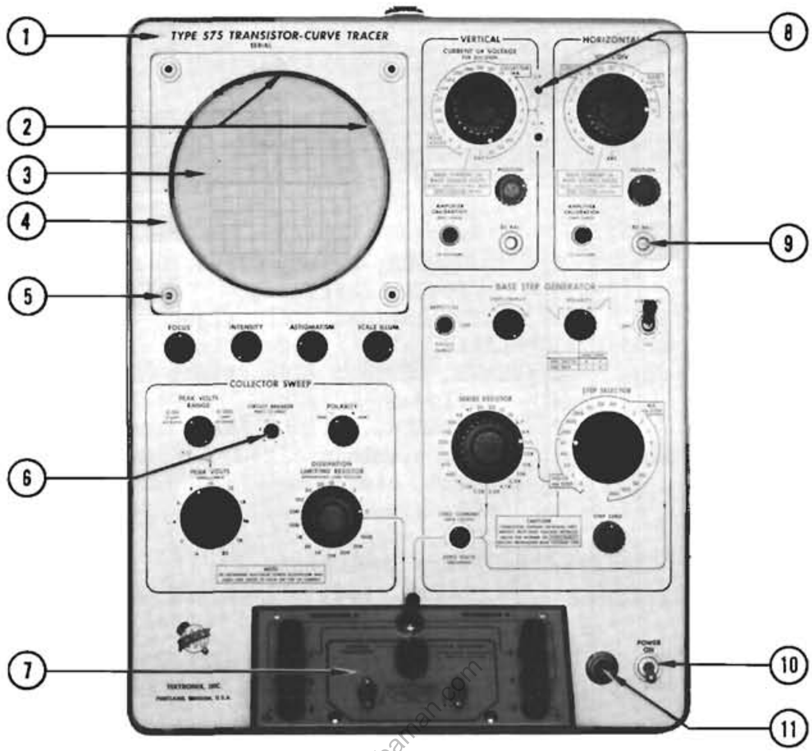
CABINET



CABINET (cont)

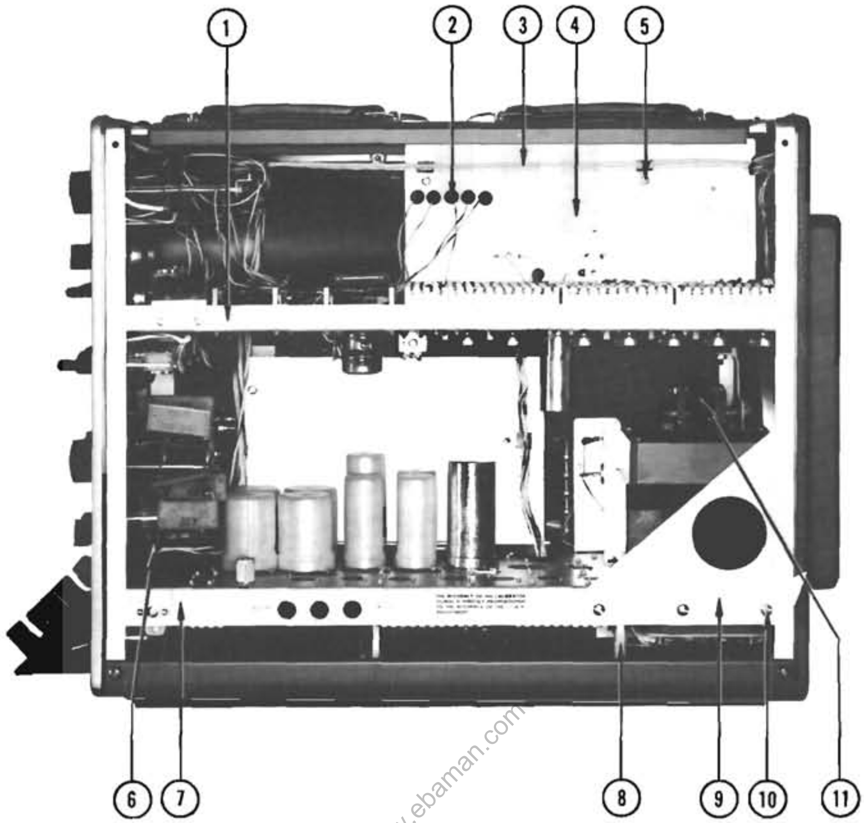
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	386-0706-00	101	530	1	PLATE, cabinet, left side
	386-0773-00	531	2265	1	PLATE, cabinet side, left
	387-0091-00	2266		1	PLATE, cabinet side, left
	- - - - - -			-	includes:
2	334-0641-00	101	226	1	TAG, resistor selection chart
	334-0659-00	227		1	TAG, resistor selection chart
3	214-0057-00			2	FASTENER, cabinet latch assembly
	- - - - - -			-	each consisting of:
4	210-0480-00			1	NUT, latch, nylon
5	105-0007-00			1	STOP
6	210-0847-00			1	WASHER, nylon, 0.164 ID x 0.500 inch OD
7	213-0033-00			1	SCREW, fastening
8	386-0677-00	101	530	1	PLATE, cabinet side, right
	386-0783-00	530	2265	1	PLATE, cabinet side, right
	387-0087-00	2266		1	PLATE, cabinet side, right
	- - - - - -			-	includes:
9	214-0057-00			2	FASTENER, cabinet latch assembly
10	200-0118-00	101	2265	1	CAP, aluminum
11	200-0216-00	2266		1	COVER, aluminum
12	384-0538-00			1	ROD, hinge
	166-0126-00			2	TUBE, spacing
	- - - - - -			-	each includes:
	213-0048-00			1	SCREW, set, 4-40 x 1/8 inch, HSS
13	214-0061-00			1	SPRING, instruction manual box
14	214-0058-00			1	FASTENER, tray
	- - - - - -			-	mounting hardware: (not included w/fastener alone)
	211-0008-00			1	SCREW, 4-40 x 1/4 inch, BHS
	210-0004-00			1	LOCKWASHER, internal, #4
	210-0406-00			1	NUT, hex., 4-40 x 3/16 inch
	406-0312-00			1	BRACKET, box fastener
	- - - - - -			-	mounting hardware: (not included w/bracket alone)
	211-0008-00			2	SCREW, 4-40 x 1/4 inch, BHS
	210-0004-00			2	LOCKWASHER, internal, #4
	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
15	384-0538-00			1	ROD, hinge
	354-0165-00			1	RING, retaining
16	214-0234-00			1	SPRING, clip
	- - - - - -			-	mounting hardware: (not included w/spring alone)
	211-0007-00			1	SCREW, 4-40 x 3/16 inch, BHS
	210-0004-00			1	LOCKWASHER, internal, #4
	210-0406-00			1	NUT, hex., 4-40 x 3/16 inch
17	386-0620-00	101	2265	1	PLATE, cabinet bottom
	387-0089-00	2266		1	PLATE, cabinet bottom
	- - - - - -			-	Includes:
	214-0057-00			4	FASTENER, cabinet latch assembly

FRONT



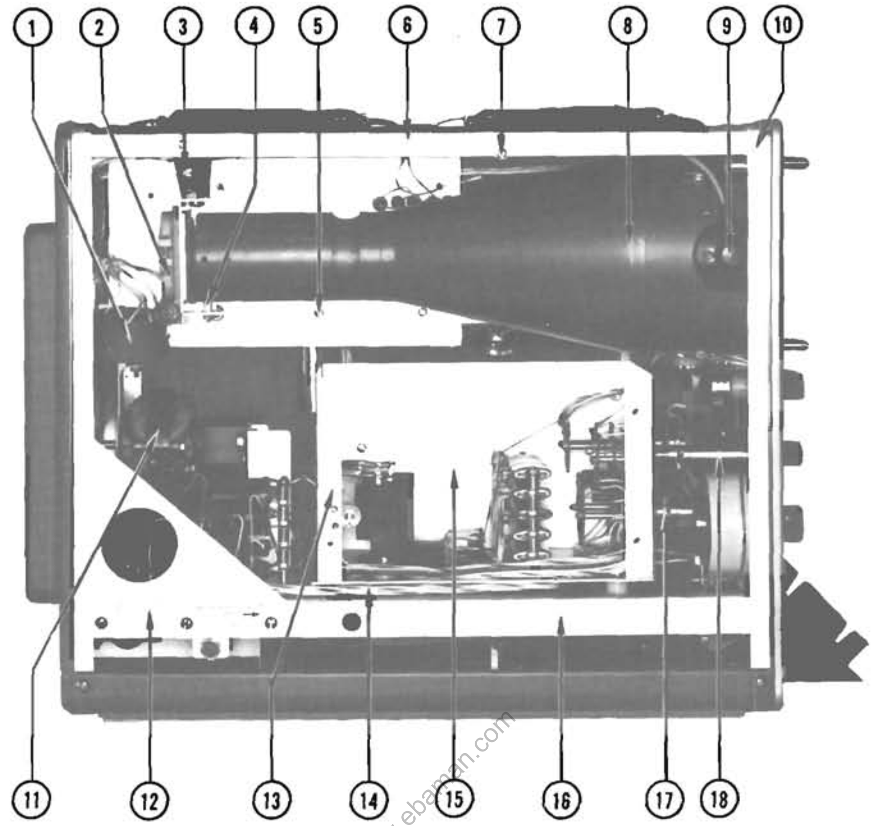
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
1	333-0329-00	101	860	1	PANEL, front
	333-0527-00	861	13089	1	PANEL, front
	333-0527-02	13090		1	PANEL, front
2	406-0239-00			2	BRACKET, 3/4 x 2-1/4 x 5/8 inch, CRT spring
3	378-0514-00			1	FILTER, light, plexi, 5 inch green
	337-0187-00			1	SHIELD, 5 inch graticule light, acrylic
4	200-0382-00			1	COVER, graticule
5	210-0424-00			4	NUT, knurled, 3/8-24 x 9/16 x 3/16 inch
	210-0816-00			4	WASHER, rubber
	355-0043-00			4	STUD, alum. graticule
6	210-0505-00			1	NUT, 3/8-27 x 1/2 inch
	210-0840-00			13	WASHER, steel
7	Pg. 7-18				Transistor Socket Base
8	210-0465-00			2	NUT, 1/4-32 x 3/8 x 3/32 inch
9	358-0010-00			2	BUSHING, alum. 3/8-32 x 9/16 inch
	210-0013-00			7	LOCKWASHER, internal, 3/8 x 11/16 inch
10	210-0473-00			6	NUT, 15/32-32 x 5/64 inch, 12 sided
	210-0414-00			6	NUT, 15/32-32 x 9/16 inch
	354-0055-00			1	RING, locking switch, 23/32 x 15/32 inch
	210-0902-00			6	WASHER, steel, flat
11	136-0025-00			1	SOCKET, light, jewel
	378-0518-00	101	21359	1	JEWEL, light, pilot, red
	378-0513-00	12360		1	JEWEL, light, pilot, green

RIGHT SIDE



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
1	Pg 7-13				Step Generator Amplifier
2	348-0020-00			5	GROMMET, rubber, 1/4 inch
3	179-0176-00	101	3659	1	CABLE HARNESS, external input
	179-0534-00	3660		1	CABLE HARNESS, assembly of adapter socket and external input
4	386-0652-00			1	PLATE, aluminum 6 x 10 1/4 inch, transistor heat sink
5	343-0004-00			2	CLAMP, cable, plastic, 5/16 inch
	211-0510-00				SCREW, 6-32 x 3/8 inch, BHS
	210-0803-00				WASHER, 6L x 3/8 inch
	210-0457-00				NUT, 6-32 x 5/16 inch
6	179-0180-00			1	CABLE HARNESS, voltage sampling cable
7	Pg. 7-17				Power
8	385-0112-00			1	ROD, aluminum 3/8 x 2-15/16 inch
9	406-0295-00			1	BRACKET, aluminum right filter housing stiffener
10	212-0002-00				SCREW, 8-32 x 1/4 inch, BHS
11	Pg. 7-22				Fan Assembly

LEFT SIDE

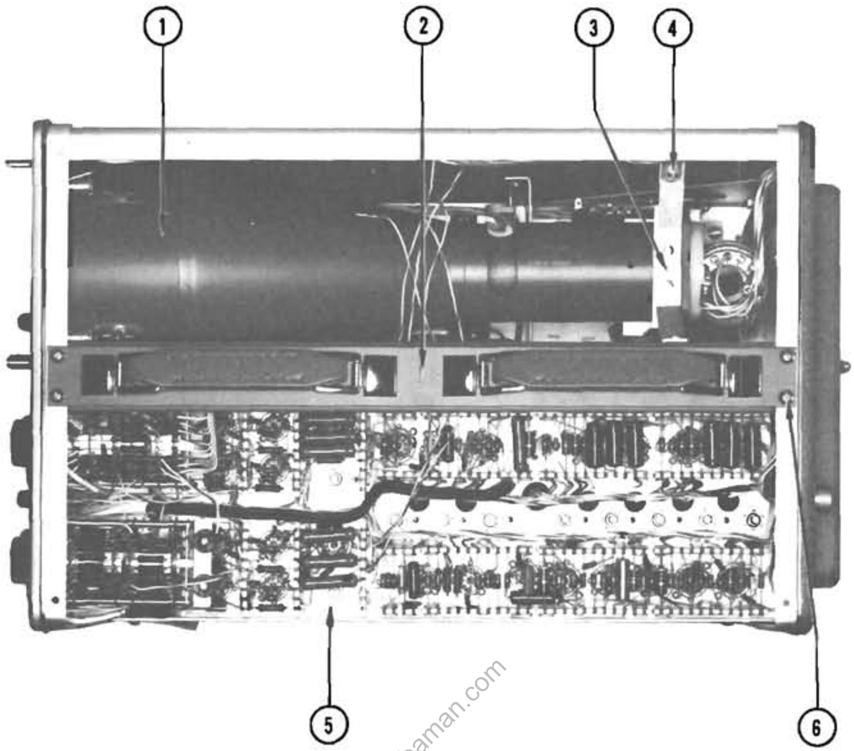


REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
1	136-0019-00			1	SOCKET, STM14
	211-0017-00			2	SCREW, 4-40 x 3/4 inch, RHS
	210-0586-00			2	NUT, keps, 4-40 x 1/4 inch
	179-0171-00			1	CABLE HARNESS, Focus and Intensity
2	Pg. 7-21				CRT Support Bracket
3	406-0514-00			1	BRACKET, alum. 5/8 x 7-3/16 inch, CRT Shield Mtg.
4	166-0031-00	101	9199	1	TUBE, spacer, 1/4 inch
	166-0030-00	9200		1	TUBE, spacer, 3/16 inch
	210-0803-00				WASHER, 6L x 3/8 inch
	210-0457-00				NUT, 6-32 x 5/16 inch
5	210-0859-00			4	WASHER, bakelite #8 shouldered
	211-0511-00				SCREW, 6-32 x 1/2 inch, BHS
	210-0803-00				WASHER, 6L x 3/8 inch
	124-0082-00			1	STRIP, bakelight, 1/16 x 3/4 x 9-1/4 inch, heat sink
6	122-0036-00			1	ANGLE, frame, top left, 18-3/8 inches
7	343-0013-00			2	CLAMP, cable, plastic, 3/8 inch
	211-0510-00				SCREW, 6-32 x 3/8 inch, BHS
8	Pg. 7-19				CRT Shield

LEFT SIDE *(cont)*

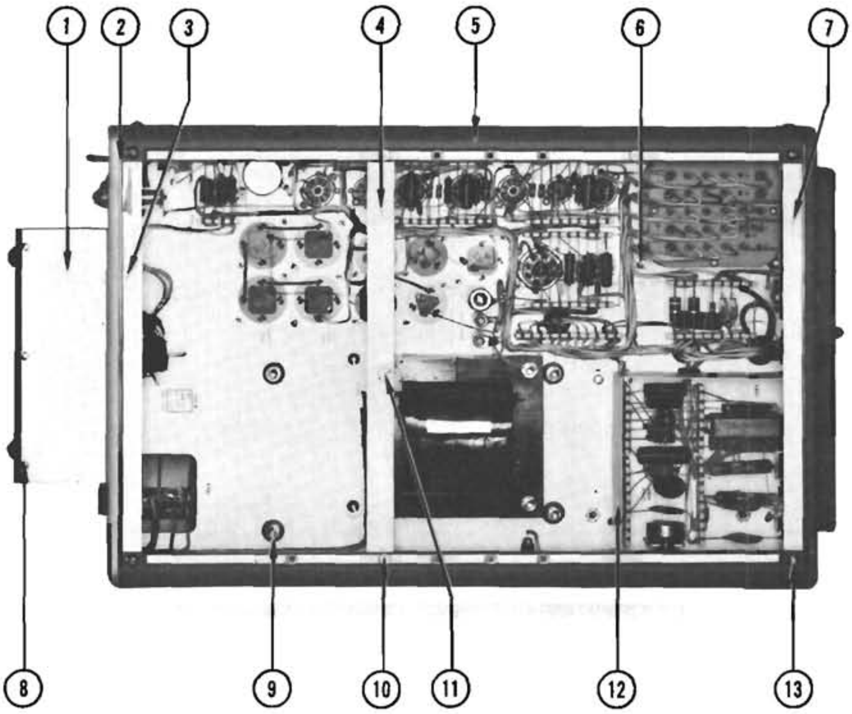
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
9	131-0080-00	101	345	1	ASSEMBLY, anode connector and cover
	131-0086-00	346		1	ASSEMBLY, anode connector and cap
	- - - - - -			-	assembly includes:
	131-0026-00	101	345	1	CONNECTOR, anode
	131-0073-00	346		1	CONNECTOR, anode
	200-0023-00	101	345	1	COVER, anode
	200-0110-00	346		1	CAP, anode
	134-0031-00	X346		1	PLUG, CRT contact
	210-0914-00	X2389		1	WASHER, wavy
10	211-0559-00				SCREW, 6-32 x 3/8 inch, FHS 100°
11	Pg. 7-22				Fan Assembly
12	406-0302-00			1	BRACKET, alum. filter housing stiffener
13	337-0182-00			1	SHIELD, alum. 5-1/2 x 8-15/16 inch (not shown)
14	179-0173-00			1	CABLE, harness, 575 current
15	Pg. 7-15			1	Collector Sweep
16	Pg. 7-17				Power
17	376-0003-00			3	COUPLING, fiber, 2 screw
18	384-0158-00			3	ROD, extension, alum. 1/4 x 3-1/8 inch
	358-0029-00			3	BUSHING, 3/8-32 x 13/32 inch
	210-0413-00				NUT, 3/8-32 x 1/2 inch

TOP



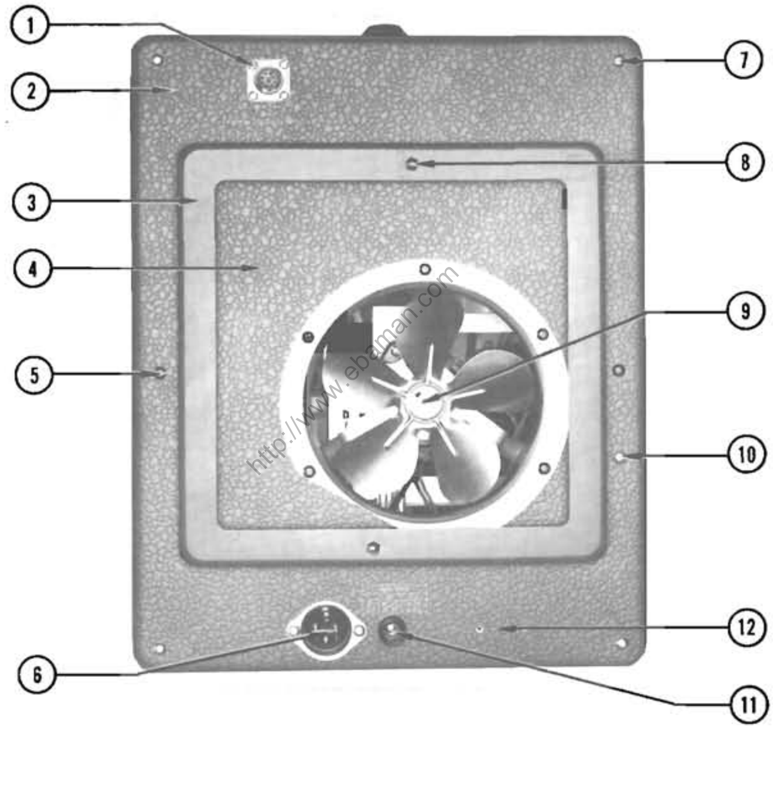
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	Q T Y.	DESCRIPTION
1	Pg. 7-19			-	CRT Shield
2	381-0082-00	101	1448	1	BAR, top support, w/handles
	381-0126-00	1449	2265	1	BAR, top support, w/handles
	381-0151-00	2266	4859	1	BAR, top support, w/handles
	381-0206-00	4860		1	BAR, top support, w/handles
	- - - - - -			-	bar includes:
	367-0001-00	101	1448	2	HANDLE, black
	367-0011-00	1449		2	HANDLE, blue
	343-0052-00	101	1448	4	CLAMP, handle
	343-0073-00	1449		4	CLAMP, handle
3	406-0514-00	X1620		1	BRACKET, alum. 5/8 x 7 3/16 inch, CRT Shield mtg.
4	343-0013-00			2	CLAMP, cable, plastic, 3/8 inch
	211-0510-00			1	SCREW, 6-32 x 3/8 inch, BHS
	210-0803-00			1	WASHER, 6L x 3/8 inch
	210-0457-00			1	NUT, 6-32 x 5/16 inch
5	Pg. 7-13			-	Step Generator Amplifier
6	212-0039-00			4	SCREW, 8-32 x 3/8 inch, THS, phillips
	381-0073-00			2	BAR, alum. 3/16 x 1/2 x 1 3/4 inch (under handle)

BOTTOM



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
1	386-0480-00			1	PLATE, alum., 2 5/16 x 7 inch jack plate
2	354-0056-00			2	RING, ornamental, 1/8 x 12 5/8 x 15 7/8 inch
3	386-0650-00			1	PLATE, sub-panel, front
4	122-0038-00			1	ANGLE, brace, 3/4 x 3/4 x 11 1/2 inch
5	122-0037-00	101	2265		ANGLE, frame, bottom, blue wrinkle
	122-0073-00	2266		2	ANGLE, frame, bottom, blue vinyl
6	212-0546-00			4	SCREW, 10-32 x 4 1/2 inch, RHS
	166-0230-00			4	TUBE, insulating
	210-0812-00			4	WASHER, fiber #10
	210-0564-00			4	NUT, 10-32 x 3/8 x 1/8 inch
	200-0372-00	X9420		1	CAP, screw protector
7	386-0649-00	101	3659		PLATE, sub-panel, rear
	387-0374-00	3660		1	PLATE, sub-panel, rear
8	211-0007-00			3	SCREW, 4-40 x 3/16 inch, BHS
9	358-0036-00			4	BUSHING, nylon
	210-0458-00				NUT, 8-32 x 11/32 inch
10	211-0522-00			3	SCREW, 6-32 x 5/8 inch FHS, 100° phillips
	210-0457-00				NUT, 6-32 x 5/16 inch
11	212-0506-00			1	SCREW, 10-32 x 3/8 inch, FHS, 100° phillips
	210-0812-00	X9631		1	WASHER, fiber, #10
	210-0813-00	X9631		1	WASHER, fiber, #10 shouldered
	384-0535-00	101	8029	1	ROD, spacing
	384-0632-00	8030		1	ROD, spacing
	212-0517-00	101	8029	4	SCREW, 10-32 x 1 3/4 inches, HHS
	212-0516-00	8030		4	SCREW, 10-32 x 2 inches, HHS
12	337-0183-00			1	SHIELD, alum. 2 1/2 x 5 3/16 x 5 1/4 inch, H.V.
13	212-0039-00			12	SCREW, 8-32 x 3/8 inch, THS, phillips
	210-0458-00				NUT, 8-32 x 11/32 inch

REAR

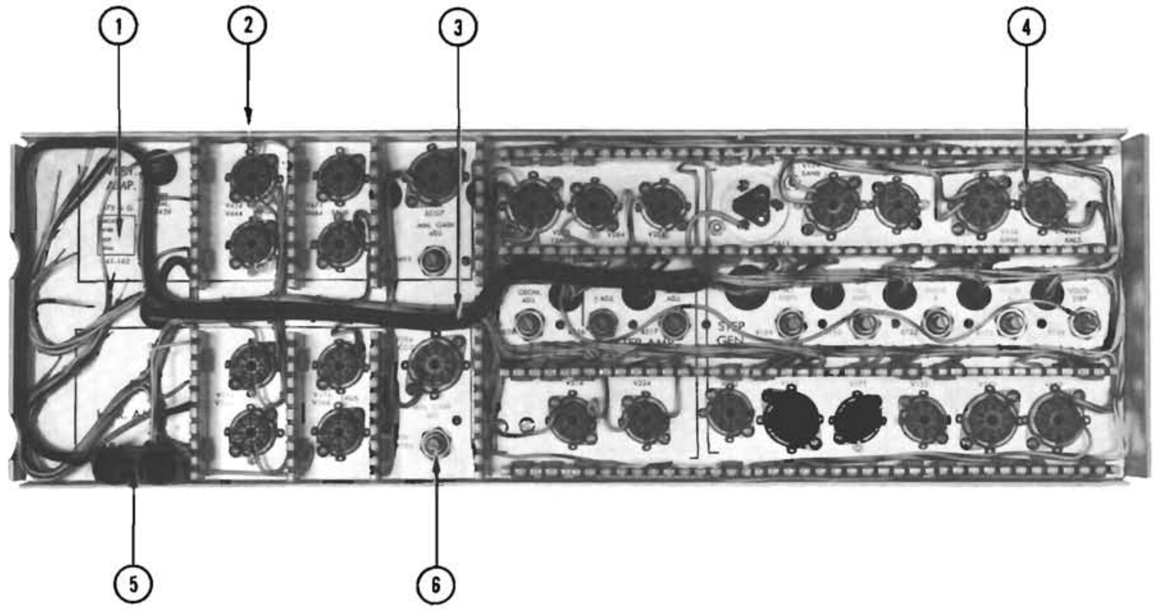


REAR (cont)

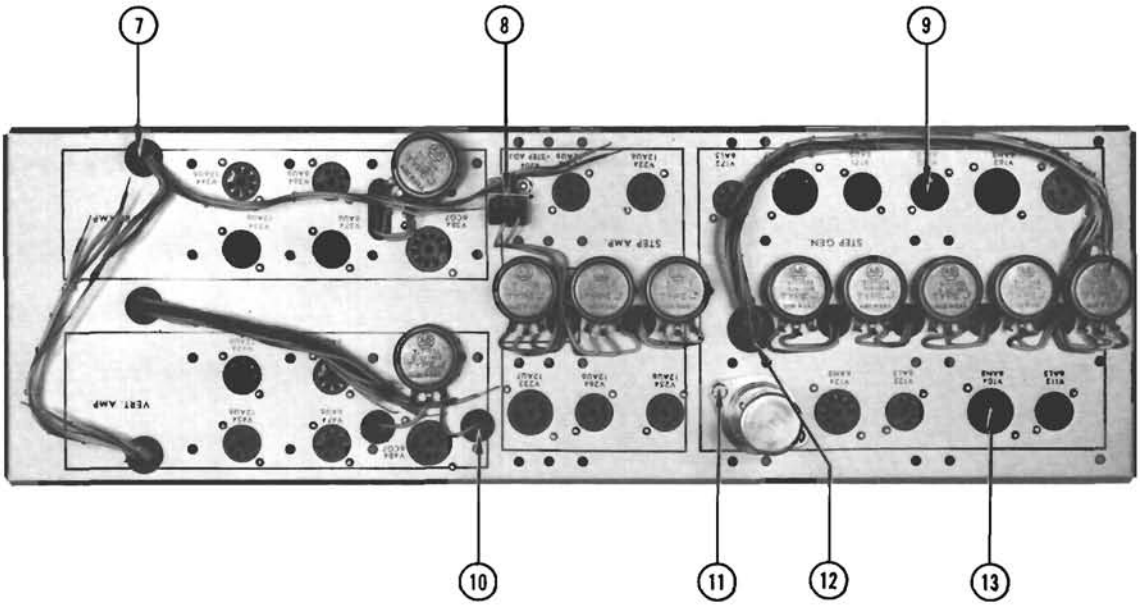
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
1	387-0207-00	X2266	2827X	1	PLATE, adapter, hole cover
	012-0045-00	X2828	3659	1	ADAPTER, socket, cable
	179-0534-00	3660		1	CABLE HARNESS, external input/adapter socket
	- - - - - -			-	mounting hardware: (not included)
	211-0011-00	101	9199	4	SCREW, 4-40 x 5/16 inch, BHS
	211-0012-00	9200		4	SCREW, 4-40 x 3/8 inch, BHS
	210-0406-00			4	NUT, hex., 4-40 x 3/16 inch
2	386-0659-00	101	2265	1	PLATE, rear overlay
	387-0092-00	2266	3659	1	PLATE, rear overlay
	387-0376-00	3600		1	PLATE, rear overlay
3	380-0008-00	101	2265	1	HOUSING, air filter, blue wrinkle
	380-0018-00	2266		1	HOUSING, air filter, blue vinyl
4	378-0011-00			1	FILTER, air, 10 x 10 x 1 inch (not shown)
5	211-0537-00			8	SCREW, 6-32 x 3/8 inch, THS, phillips
6	131-0010-00	101	610	1	CONNECTOR, chassis mount, 2 wire
	131-0102-00	611	3659	1	CONNECTOR, chassis mount, 3 wire
	131-0150-00	3660	12029	1	CONNECTOR, chassis mount, 3 wire
	131-0150-01	12030		1	CONNECTOR, chassis mount, 3 wire
7	213-0104-00			6	SCREW, 6-32 x 3/8 inch, THS, thread forming
8	212-0031-00			2	SCREW, 8-32 x 1 1/4 inch, RHS
	210-0458-00			2	NUT, 8-32 x 11/32 inch
	210-0402-00			2	NUT, cap, 8-32 x 5/16 inch
9	Pg. 7-22				Fan Assembly
10	211-0544-00			1	SCREW, 6-32 x 3/4 inch, THS, phillips
	343-0013-00			1	CLAMP, cable plastic, 3/8 inch
	210-0457-00			1	NUT, 6-32 x 5/16 inch
11	352-0002-00			1	HOLDER, fuse assembly, 3AG
	- - - - - -			-	Consisting of:
	352-0010-00			1	HOLDER, fuse, 3AG
	200-0015-00			1	CAP, fuse, 3AG
	210-0873-00			1	WASHER, rubber
	No number			1	NUT, fuse holder
12	334-0649-00			1	TAG, voltage rating, 117V (not shown)
	213-0088-00			2	SCREW, thread forming, 1/4 inch, PHS

STEP GENERATOR AMPLIFIER

TOP



BOTTOM

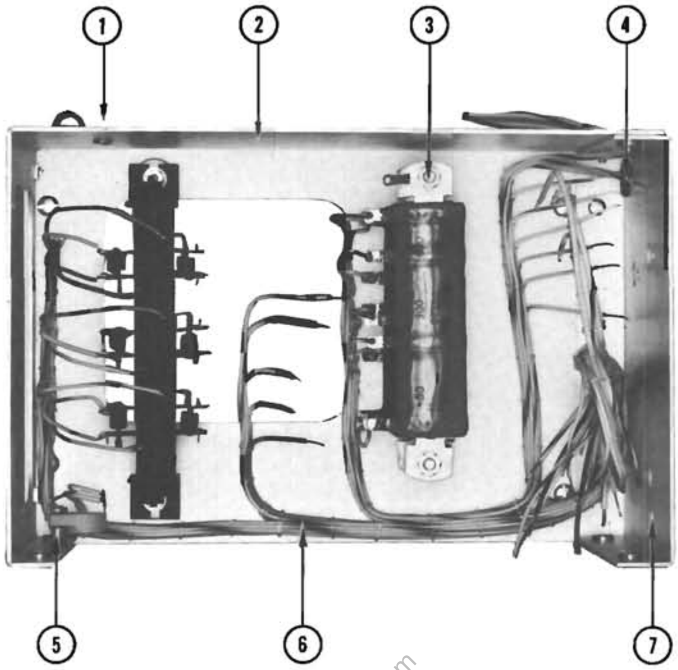


STEP GENERATOR AMPLIFIER (cont)

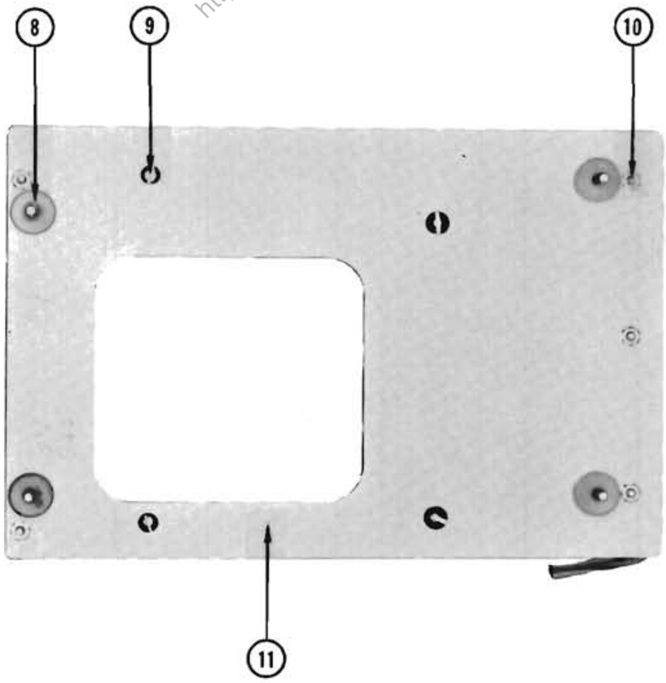
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
1	441-0162-00			1	CHASSIS, Step generator amplifier
2	343-0042-00			1	CLAMP, cable, plastic, 5/16 inch (half)
	211-0507-00			1	SCREW, 6-32 x 5/16 inch, BHS
3	179-0169-00	101	4269		CABLE HARNESS, step generator
	179-0620-00	4270		1	CABLE HARNESS, step generator
4	213-0044-00			50	SCREW, thread cutting, 5/32 x 3/16 inch, Pan HS
5	406-0619-00	X2765		1	BRACKET, mini pot, 1 1/2 x 1 13/64 inch
	211-0008-00			2	SCREW, 4-40 x 1/4 inch, BHS
6	210-0413-00			10	NUT, 3/8-32 x 1/2 inch
	210-0840-00			10	WASHER, steel, 9/16 inch
7	348-0005-00			3	GROMMET, rubber, 1/2 inch
8	406-0576-00	X4270		1	BRACKET, mini pot, 3/4 x 5/8 x 3/8 inch
	211-0504-00			2	SCREW, 6/32 x 1/4 inch, BHS
	210-0006-00			4	LOCKWASHER, int. #6
	210-0407-00			4	NUT, 6-32 x 1/4 inch
9	136-0008-00			17	SOCKET, STM7G
10	348-0004-00			8	GROMMET, rubber, 3/8 inch
11	211-0534-00			2	SCREW, 6-32 x 5/16 inch, PHS, w/lockwasher
12	348-0012-00			1	GROMMET, rubber, 5/8 inch
13	136-0015-00			8	SOCKET, STM9G

COLLECTOR SWEEP

TOP



BOTTOM



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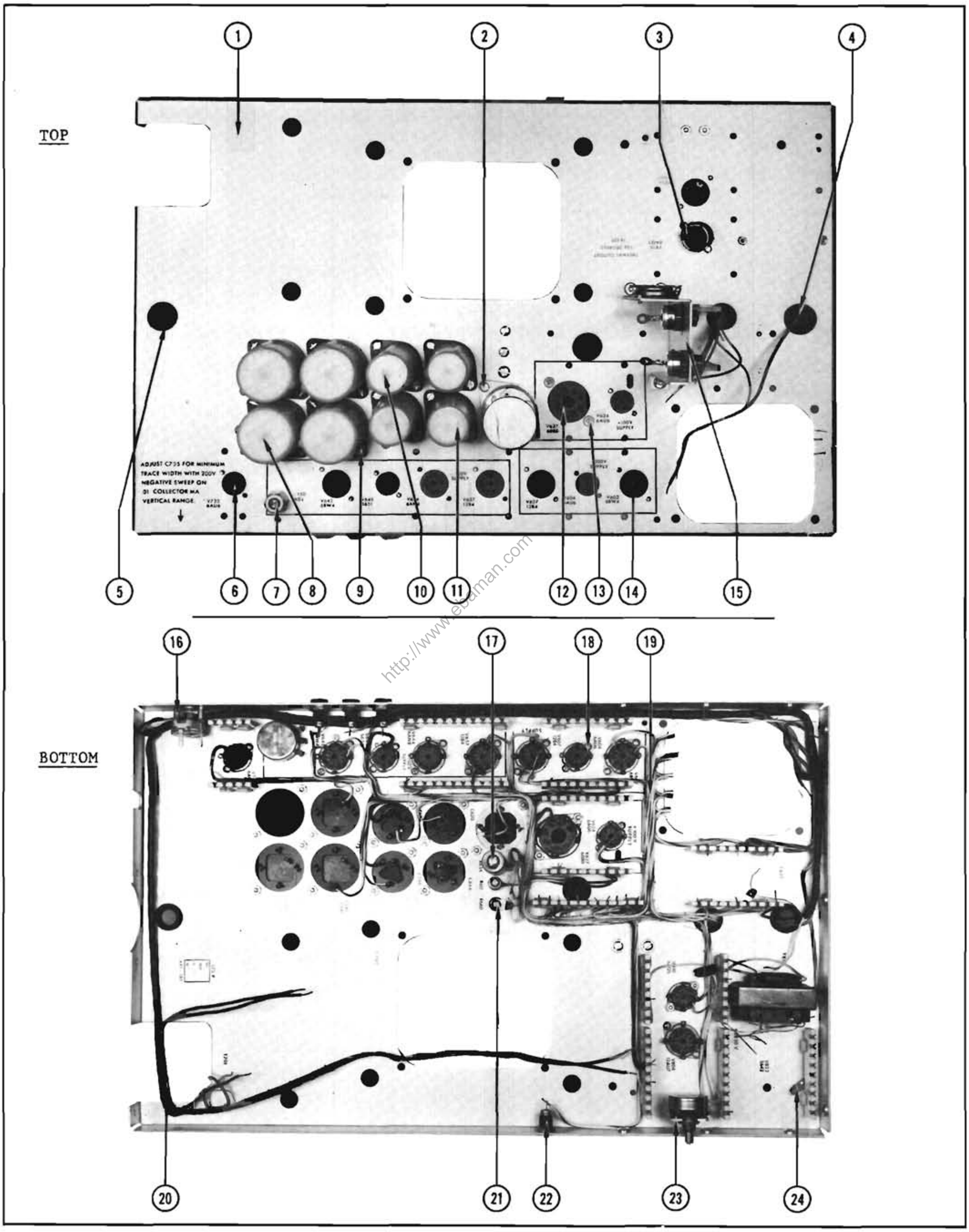
COLLECTOR SWEEP (cont)

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
1	343-0042-00			1	CLAMP, cable, plastic, 5/16 inch (half)
	211-0510-00			1	SCREW, 6/32 x 3/8 inch BHS
	210-0006-00			8	LOCKWASHER, int. # 6
	210-0803-00			5	WASHER, steel, 6L x 3/8 inch
	210-0407-00			8	NUT, 6-32 x 1/4 inch
2	337-0180-00	101	358	1	SHIELD, sweep collector
	337-0189-00	359		1	SHIELD, sweep collector
3	212-0511-00			2	SCREW, 10-32 x 3 inch, RHS
	210-0206-00			1	LUG, solder, SE10 long
	210-0010-00			1	LOCKWASHER, int. # 10
	210-0410-00			2	NUT, 10-32 x 5/16 inch
4	348-0004-00			1	GROMMET, rubber, 3/8 inch
5	166-0025-00			2	TUBE, spacer, alum. 3/16 x 1/4 inch
	211-0016-00			2	SCREW, 4-40 x 5/8 inch, RHS
	210-0906-00	101	9628X	4	WASHER, red, fiber
	210-0406-00			2	NUT, 4-40 x 3/16 inch
6	179-0170-00	101	508	1	CABLE HARNESS, collector power
	179-0172-00	101	508	1	CABLE HARNESS, dissipation switch
	179-0240-00	509		1	CABLE HARNESS, collector power/dissipation switch
7	386-0651-00	101	358	1	PLATE, sweep collector
	386-0656-00	359		1	PLATE, sweep collector
8	212-0020-00			4	SCREW, 8-32 x 1 inch BHS
	385-0101-00			6	ROD, nylon, 5/8 x 3/8 inch
9	211-0514-00			2	SCREW, 6-32 x 3/4 inch, BHS
10	211-0507-00			5	SCREW, 6-32 x 5/16 inch, BHS
11	441-0160-00	101	358	1	CHASSIS, sweep collector
	441-0193-00	359		1	CHASSIS, sweep collector

POWER


TOP
ADJUST C735 FOR MINIMUM TRACE WIDTH WITH 200V NEGATIVE SWEEP ON .01 COLLECTOR MA VERTICAL RANGE.
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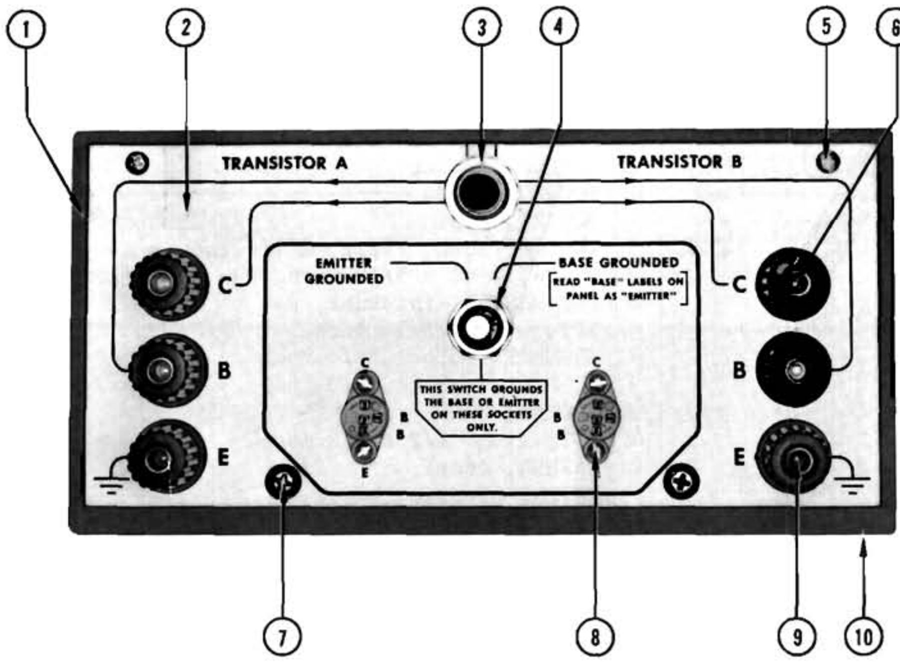
POWER (cont)

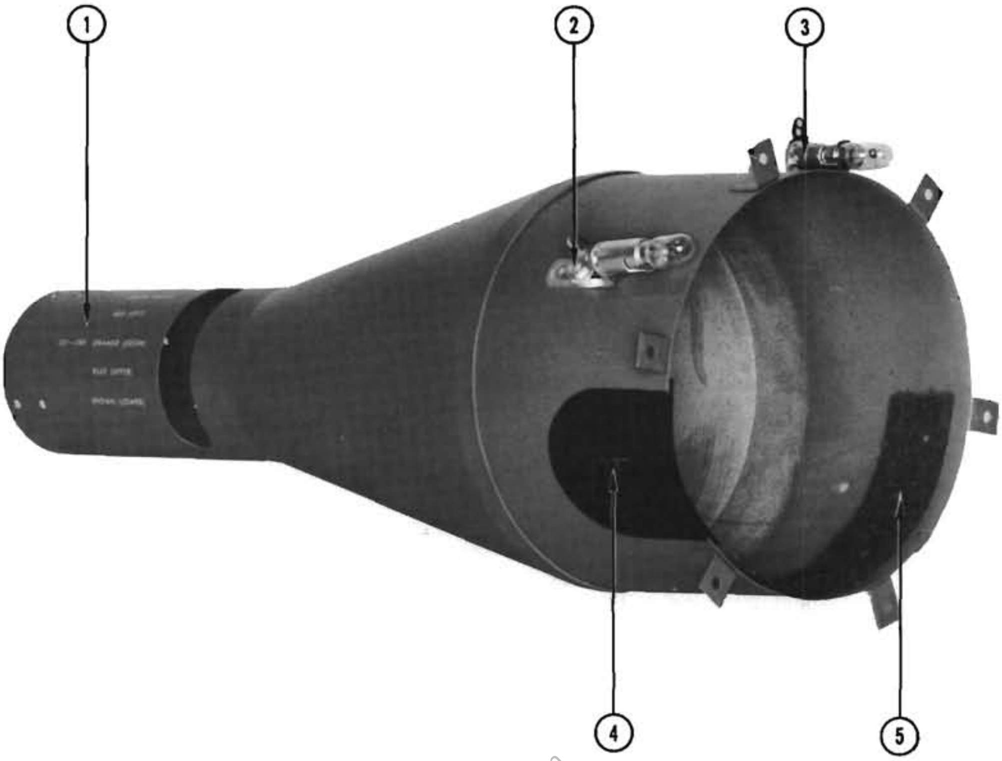
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
1	441-0161-00	101	8989	1	CHASSIS, power
	441-0627-00	8990		1	CHASSIS, power
2	211-0534-00			10	SCREW, 6/32 x 5/16 inch, PHS, w/lockwasher
	210-0006-00			22	LOCKWASHER, internal, #6
	210-0407-00			22	NUT, 6-32 x 1/4 inch
3	337-0004-00	101	7409X	1	SHIELD, socket
	136-0008-00	101	7409	1	SOCKET, STM7G
	136-0010-00	7410		1	SOCKET, 7 pin
	337-0128-00	101	7409X	1	SHIELD, tube, 7 pin, 2 1/4 inches H1
	211-0033-00			2	SCREW, 4-40 x 5/16 inch, Pan HS, w/lockwasher
	210-0004-00			6	LOCKWASHER, internal, #4
	210-0406-00			4	NUT, 4-40 x 3/16 inch
4	348-0006-00			1	GROMMET, rubber, 3/4 inch
5	348-0012-00			3	GROMMET, rubber, 5/8 inch
6	136-0008-00			5	SOCKET, STM7G
7	210-0444-00			1	NUT, alum. 1/2 x 5/8 inch
	210-0840-00			6	WASHER, steel
8	200-0360-00				COVER, plastic, black
	200-0260-00			4	COVER, plastic, clear
9	211-0543-00			8	SCREW, 6-32 x 5/16 inch, RHS
10	200-0358-00				COVER, plastic, black
	200-0255-00			1	COVER, plastic, clear
11	200-0357-00				COVER, plastic, black
	200-0257-00			3	COVER, plastic, clear
12	136-0011-00			1	SOCKET, STM8, ground
13	211-0538-00			2	SCREW, 6-32 x 5/16 inch, FHS 100°
14	136-0015-00			6	SOCKET, STM9G
15	406-0299-00	101	4929	2	BRACKET, rectifier, 1/8 x 1-1/8 x 3 1/2 inch
	406-0815-00	4930		1	BRACKET, rectifier, silicon mtg.
16	166-0031-00	101	723	2	TUBE, spacer
	166-0026-00	724		2	TUBE, spacer
17	212-0037-00			1	SCREW, 8-32 x 1 3/4 inch, FHS, Fil HS
	210-0809-00			1	WASHER, brass, centering
	210-0462-00			1	NUT, alum. 8-32 x 1/2 x 23/64 inch
	212-0004-00			1	SCREW, 8-32 x 5/16 inch, BHS
18	213-0044-00			22	SCREW, thread cutting, 5-32 x 3/16 inch, pan HS
19	179-0168-00			1	CABLE HARNESS, low voltage power
20	179-0175-00			1	CABLE HARNESS, 110 V (power on)
21	211-0553-00			2	SCREW, 6-32 x 1 1/2 inch RHS, phillips
	210-0601-00			2	EYELET, brass
	210-0478-00			2	NUT, alum., 6-32 x 5/16 inch resistor mounting
	211-0507-00				SCREW, 6-32 x 5/16 inch, RHS
	210-0202-00				LUG, solder, SE6
22	136-0037-00			4	SOCKET, tip jack, 3/8-32 x 1/2 inch black nylon
	210-0413-00			5	NUT, 3/8-32 x 1/2 inch
	210-0840-00			6	WASHER, steel
23	406-0023-00			1	BRACKET, alum. 1 x 1-21/32 x 1/2 inch
24	210-0202-00			2	LUG, solder, SE6

TRANSISTOR SOCKET BASE



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
1	432-0019-00	101	2265	1	BASE, alum. mounting
	432-0030-00	2266		1	BASE alum. mounting
2	333-0386-00			1	PANEL, front, jack plate
3	- - - - - -			-	SEE SWITCH VIEW
4	210-0413-00			1	NUT 3/8-32 x 1/2 inch
	210-0840-00			1	WASHER, steel, 9/16 inch O.D.
5	213-0035-00			2	SCREW, 4-40 x 1/4 inch PHS, thread cutting
6	129-0036-00			4	POST, binding, 5 way stem and cap
	358-0036-00			4	BUSHING, nylon for 5 way
	210-0206-00	101	9299X	6	LUG, solder, SE10 long
	210-0410-00	101	9299	6	NUT, 10-32 x 5/16 inch
	220-0410-00	9300		6	NUT, keps, 10-32 x 3/8 inch
7	211-0537-00			2	SCREW, 6-32 x 3/8 inch truss HS, phillips
	210-0457-00			2	NUT 6-32 x 5/16 inch keps
8	136-0050-00	101	2699	2	SOCKET, 4 pin transistor
	136-0095-00	2700		2	SOCKET, 4 pin, transistor
	211-0062-00			4	SCREW 2-56 x 5/16 inch RHS
	210-0405-00			4	NUT, 2-56 x 3/16 inch brass
	210-0001-00			4	LOCKWASHER, internal #2
9	129-0040-00			2	POST, binding, 5 way
10	386-0670-00			1	PLATE, alum. 13/16 x 6 7/8 inch test spacing

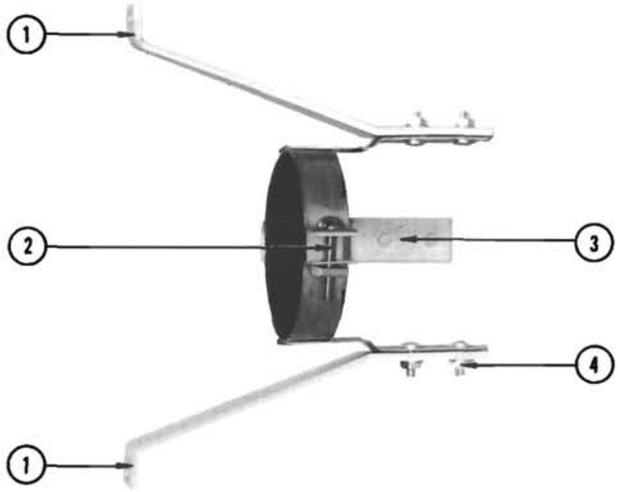
CRT SHIELD



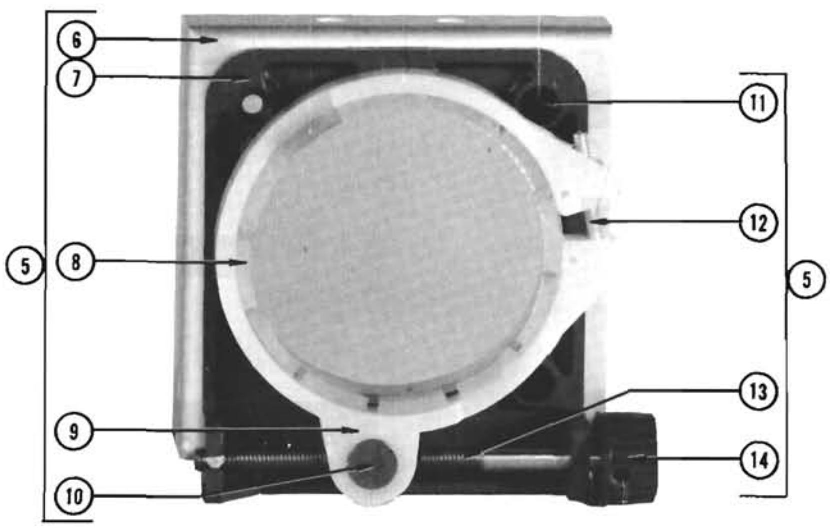
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	337-0088-00			1	SHIELD, CRT
2	211-0534-00			2	SCREW, 6-32 x 5/16 inch, PHS, w/lockwasher
	210-0803-00			2	WASHER, 6L x 3/8 inch
	210-0457-00			2	NUT, 6-32 x 5/16 inch, keps
3	136-0001-00			2	SOCKET, graticule lamp
4	200-0112-00	X346		1	ASSEMBLY, anode plate and cover
	- - - - - -			-	assembly includes:
	386-0647-00			1	PLATE, anoda
	200-0111-00			1	COVER, anode
5	124-0068-00			1	STRIP, felt, 1/8 x 1 x 5-3/4 inch, gray

CRT SUPPORT BRACKET-ROTATOR

s/n 101-1619



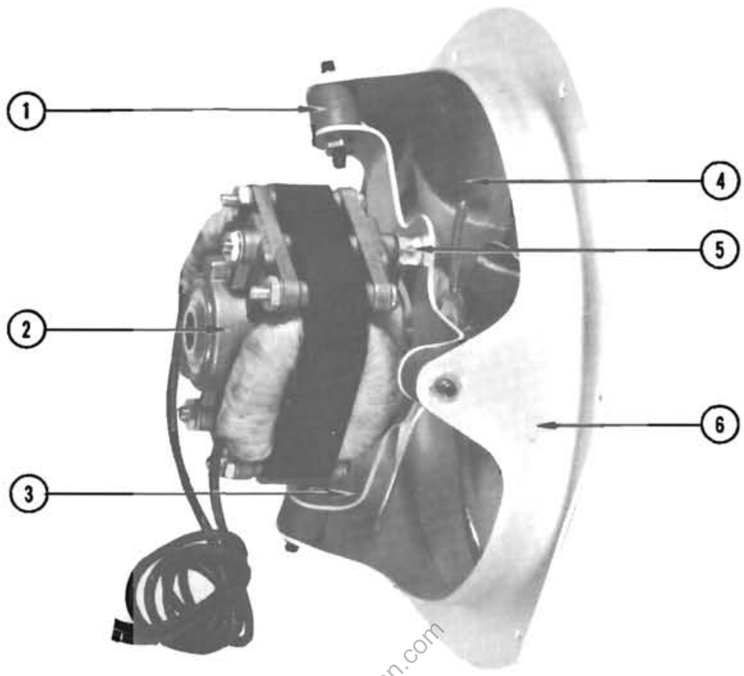
s/n 1620-up



CRT SUPPORT BRACKET-ROTATOR (cont)

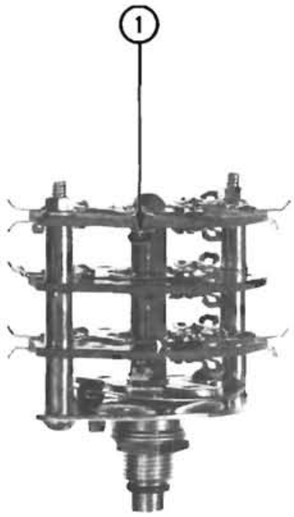
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
1	406-0280-00	101	1619	2	BRACKET, alum. 1/2 x 4 9/16 inch
2	212-0548-00	101	1619	1	SCREW, 10-32 x 7/8 inch, RHS
	210-0501-00	101	1619	1	NUT, 10-32 sq.
3	343-0027-00	101	1619	1	CLAMP, steel, CRT
4	211-0510-00	101	1619	4	SCREW, 6-32 x 3/8 inch, BHS
	210-0803-00	101	1619	4	WASHER, 6Lx 3/8 inch
	210-0006-00	101	1619	4	LOCKWASHER, int. #6
	210-0407-00	101	1619	4	NUT, 6-32 x 1/4 inch
5	640-0437-00	1620		1	KIT ASSEMBLY, CRT shield support
	- - - - - -			-	consisting of:
6	406-0368-00	1620		1	BRACKET, alum. 3 1/4 x 3 1/32 x 3/4 inch
7	432-0022-00	1620		1	BASE, alum. 3 3/4 x 3 3/16 x 9/16 inch CRT rotator
8	354-0078-00	1620	4928	1	RING, securing
	354-0178-00	4929		1	RING, securing
9	354-0103-00	1620		1	RING, clamping, assembly of 254-0998-00 or 210-0502-00
10	210-0502-00	1620		1	NUT, 10-32 thread, CRT rotator
11	211-0561-00	1620		2	SCREW, 6-32 x 3/8 inch hex soc. FH cap
	210-0503-00	1620		1	NUT, alum. 21/32 x 2-1/2 inch CRT rotator securing
12	211-0560-00	1620		1	SCREW, 6-32 x 1 inch RHS
	210-0407-00	1620		1	NUT, 6-32 x 1/4 inch
13	355-0049-00	1620		1	STUD, steel, 3/16 x 3 1/4 inch 10-32 thread
14	366-0032-00	1620		1	KNOB, small red

FAN ASSEMBLY

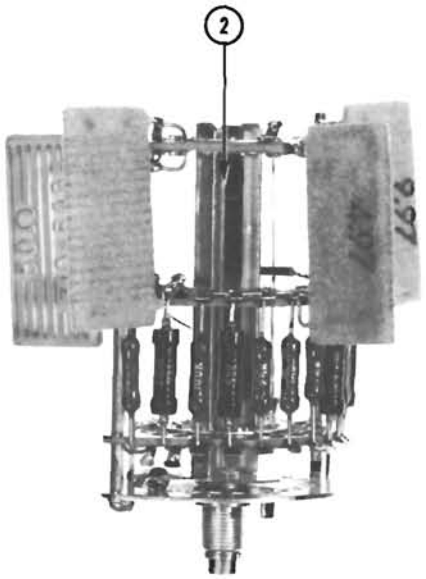


REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
1	348-0008-00			3	SHOCKMOUNT, rubber, 1/2 x 1/2 inch round
	210-0008-00			6	LOCKWASHER, internal #8
	210-0409-00			6	NUT, 8-32 x 5/16 inch
2	147-0001-00			1	MOTOR, 1500 RPM, 115 V, 1/4 inch diameter
3	426-0046-00			1	MOUNT, fan motor, 5-1/2 inch
4	369-0001-00			1	FAN, aluminum 5-1/2 inch blade, clock rotation
5	355-0044-00			2	STUD, steel, 10-32 x 2-7/16 inch, 2 inches under shoulder
	210-0010-00			6	LOCKWASHER, internal #10
	210-0410-00			4	NUT, 10-32 x 5/16 inch
6	354-0051-00			1	RING, fan, aluminum 5-3/4 inch ID

SWITCHES



Coll. Peak Volts Range

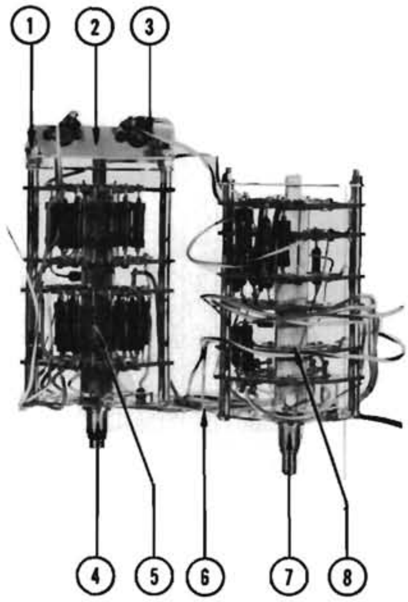


Base Step Selector

Coll. Sweep Polarity

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	260-0180-00	101	10349	1	SWITCH, unwired--PEAK VOLTS RANGE
	260-0180-01	10350		1	SWITCH, unwired--PEAK VOLTS RANGE
	210-0840-00			1	WASHER, steel, 9/16 inch OD
	210-0413-00			1	NUT, 3/8-32 x 1/2 inch
2	262-0135-00			1	SWITCH, wired--BASE STEP SELECTOR
	- - - - - -			-	switch includes:
	260-0182-00	101	10289	1	SWITCH, unwired--BASE STEP SELECTOR
	260-0182-01	10290		1	SWITCH, unwired--BASE STEP SELECTOR
	210-0012-00	101	11079	1	LOCKWASHER, internal, 3/8 x 1/2 inch
	210-0013-00	11080		1	LOCKWASHER, internal, 3/8 x 11/16 inch
	210-0840-00			1	WASHER, steel, 9/16 inch OD
	210-0413-00			1	NUT, 3/8-32 x 1/2 inch
3	260-0179-00	101	10349	1	SWITCH, unwired--COLLECTOR SWEEP POLARITY
	260-0179-01	10350		1	SWITCH, unwired--COLLECTOR SWEEP POLARITY
	210-0840-00			1	WASHER, steel, 9/16 inch OD
	210-0413-00			1	NUT, 3/8-32 x 1/2 inch

SWITCHES (cont)



Horiz. Volts/Div.   Vert. Volts/Div. or Currents/Div.

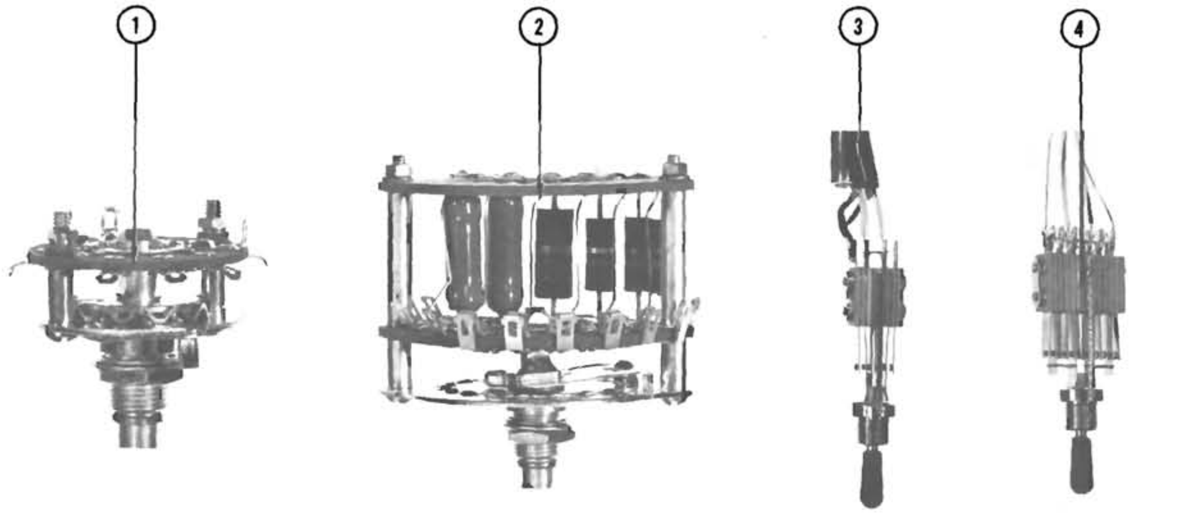
Series Resistor

Base Grounded-Emitter Grounded

SWITCHES (cont)

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	Q T Y.	DESCRIPTION
1	210-0407-00	822		2	NUT, 6-32 x 1/4 inch
	210-0006-00	822		2	LOCKWASHER, internal, #6
2	406-0330-00	822		1	BRACKET, aluminum, 1/2 x 2-1/4 x 1/2 inch minipot
3	210-0438-00	822		4	NUT, brass, 1-72 x 5/32 inch w/pot
4	210-0012-00	101	11079	1	LOCKWASHER, internal, 3/8 x 1/2 inch
	210-0013-00	11080		1	LOCKWASHER, internal, 3/8 x 11/16 inch
	210-0840-00			1	WASHER, steel, 9/16 inch OD (not shown)
	210-0413-00			1	NUT, 3/8 x 1/2 inch (not shown)
5	262-0137-00	101	821	1	SWITCH, wired--HORIZONTAL VOLTS/DIV.
	262-0195-00	822	3659	1	SWITCH, wired--HORIZONTAL VOLTS/DIV.
	262-0416-00	3660	6054	1	SWITCH, wired--HORIZONTAL VOLTS/DIV.
	262-0494-00	6055		1	SWITCH, wired--HORIZONTAL VOLTS/DIV.
	- - - - - -			-	switch includes:
	260-0184-00	101	10306	1	SWITCH, unwired--HORIZONTAL VOLTS/DIV.
	260-0184-01	10307		1	SWITCH, unwired--HORIZONTAL VOLTS/DIV.
6	179-0174-00			1	CABLE, harness, 575 Calibrator Switch
7	210-0012-00	101	11079	1	LOCKWASHER, internal, 3/8 x 1/2 inch
	210-0013-00	11080		1	LOCKWASHER, internal, 3/8 x 11/16 inch
	210-0840-00			1	WASHER, steel, 9/16 inch (not shown)
	210-0413-00			1	NUT, 3/8-32 x 1/2 inch (not shown)
8	262-0138-00	101	821	1	SWITCH, wired--VERTICAL VOLTS/DIV. or CURRENT/DIV.
	262-0189-00	822	860	1	SWITCH, wired--VERTICAL VOLTS/DIV. or CURRENT/DIV.
	262-0202-00	861	3659	1	SWITCH, wired--VERTICAL VOLTS/DIV. or CURRENT/DIV.
	262-0417-00	3660		1	SWITCH, wired--VERTICAL VOLTS/DIV. or CURRENT/DIV.
	- - - - - -			-	switch includes:
	260-0185-00	101	821	1	SWITCH, unwired--VERTICAL VOLTS/DIV. or CURRENT/DIV.
	260-0243-00	822	10349	1	SWITCH, unwired--VERTICAL VOLTS/DIV. or CURRENT/DIV.
	260-0243-01	10350		1	SWITCH, unwired--VERTICAL VOLTS/DIV. or CURRENT/DIV.
9	262-0136-00	101	8029	1	SWITCH, wired--SERIES RESISTOR
	262-0673-00	8030		1	SWITCH, wired--SERIES RESISTOR
	- - - - - -			-	switch includes:
	260-0183-00	101	10349	1	SWITCH, unwired--SERIES RESISTOR
	260-0183-01	10350		1	SWITCH, unwired--SERIES RESISTOR
10	260-0189-00	101	10099	1	SWITCH, unwired--BASE GROUNDED-EMITTER GROUNDED
	260-0189-01	10100		1	SWITCH, unwired--BASE GROUNDED-EMITTER GROUNDED
11	210-0012-00	101	9539	1	LOCKWASHER, internal, 3/8 x 1/2 inch
	210-0013-00	9540		1	LOCKWASHER, internal, 3/8 x 11/16 inch
	210-0840-00			1	WASHER, steel, 9/16 inch OD (not shown)
	210-0413-00			1	NUT, 3/8 x 1/2 inch (not shown)
12	210-0013-00			1	LOCKWASHER, pot, internal, 3/8 x 11/16 inch
	210-0840-00			1	WASHER, steel, 9/16 inch OD
	210-0413-00			1	NUT, 3/8-32 x 1/2 inch

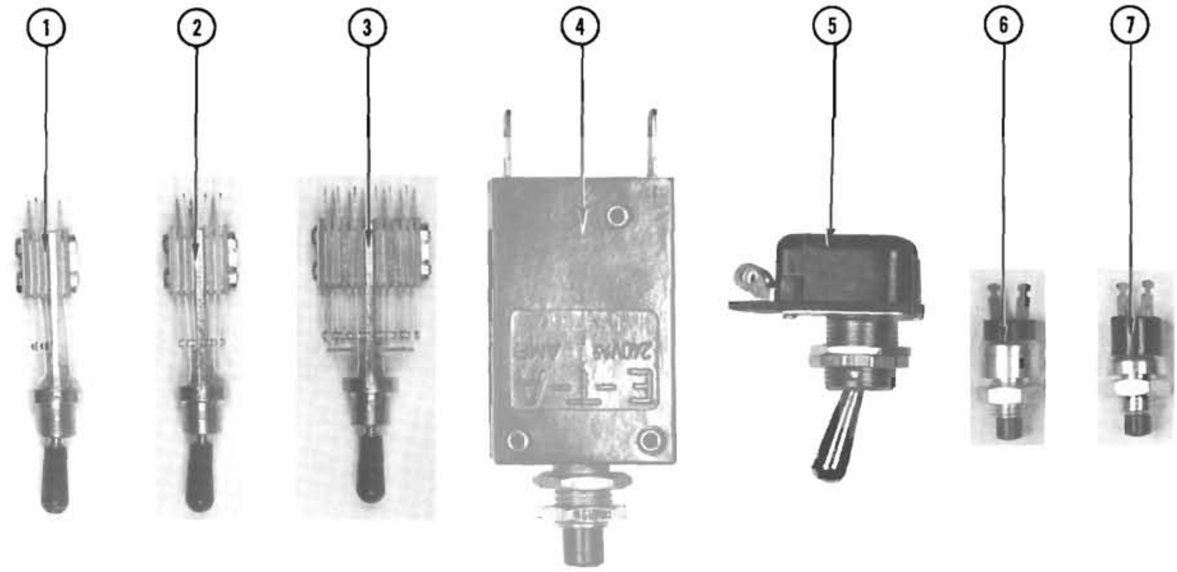
SWITCHES (cont)



Step. Gen. Polarity | Dissipation Limiting | Zero Current-Zero Volts | Vertical Amp. Cal.

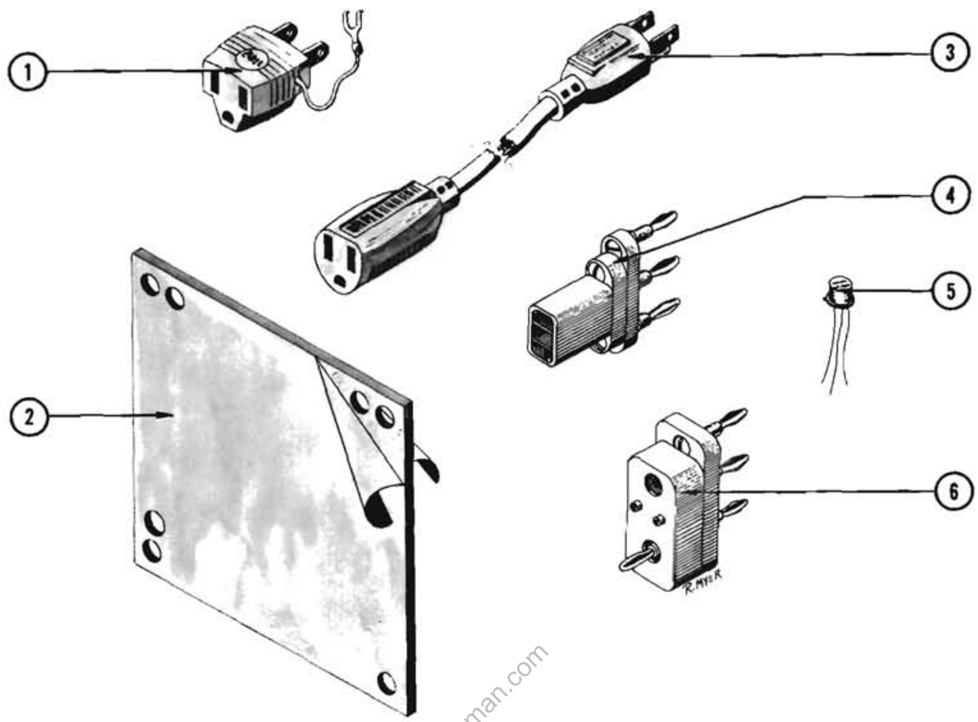
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	Q T Y.	DESCRIPTION
1	260-0178-00	101	1088	1	SWITCH, unwired--BASE STEP GEN. POLARITY
	260-0258-00	1089	10349	1	SWITCH, unwired--BASE STEP GEN. POLARITY
	260-0258-01	10350		1	SWITCH, unwired--BASE STEP GEN. POLARITY
	210-0013-00			1	LOCKWASHER, pot, internal, 3/8 x 11/16 inch (not shown)
	210-0840-00			1	WASHER, steel, 9/16 inch OD
	210-0413-00			1	NUT, 3/8-32 x 1/2 inch
2	262-0134-00			1	SWITCH, wired--DISSIPATION LIMITING RESISTOR
	- - - - - -			-	switch includes:
	260-0181-00	101	10219	1	SWITCH, unwired--DISSIPATION LIMITING RESISTOR
	260-0181-01	10220		1	SWITCH, unwired--DISSIPATION LIMITING RESISTOR
	210-0840-00			1	WASHER, steel, 9/16 inch OD
	210-0413-00			1	NUT, 3/8-32 x 1/2 inch
3	262-0164-00			1	SWITCH, Zero Current-Zero Volts, wired
	260-0196-00	101	11509	1	SWITCH, Zero Current-Zero Volts, unwired
	260-0196-01	11510		1	SWITCH, Zero Current-Zero Volts, unwired
	210-0902-00			1	WASHER, steel, 21/32 inch OD (not shown)
	210-0414-00			1	NUT, 15/32-32 x 9/16 inch (not shown)
	210-0473-00			1	NUT, switch, 15/32-32 x 5/64 inch, 12 sided (not shown)
4	262-0165-00			2	SWITCH, Vertical Amplifier Cal., wired
	260-0198-00			-	SWITCH, Vertical Amplifier Cal., unwired
	210-0902-00			2	WASHER, steel, 213/2 inch OD (not shown)
	210-0414-00			2	NUT, 15/32-32 x 9/16 inch (not shown)
	210-0473-00			2	NUT, switch, 15/32-32 x 5/64 inch, 21 sided (not shown)

SWITCHES (cont)



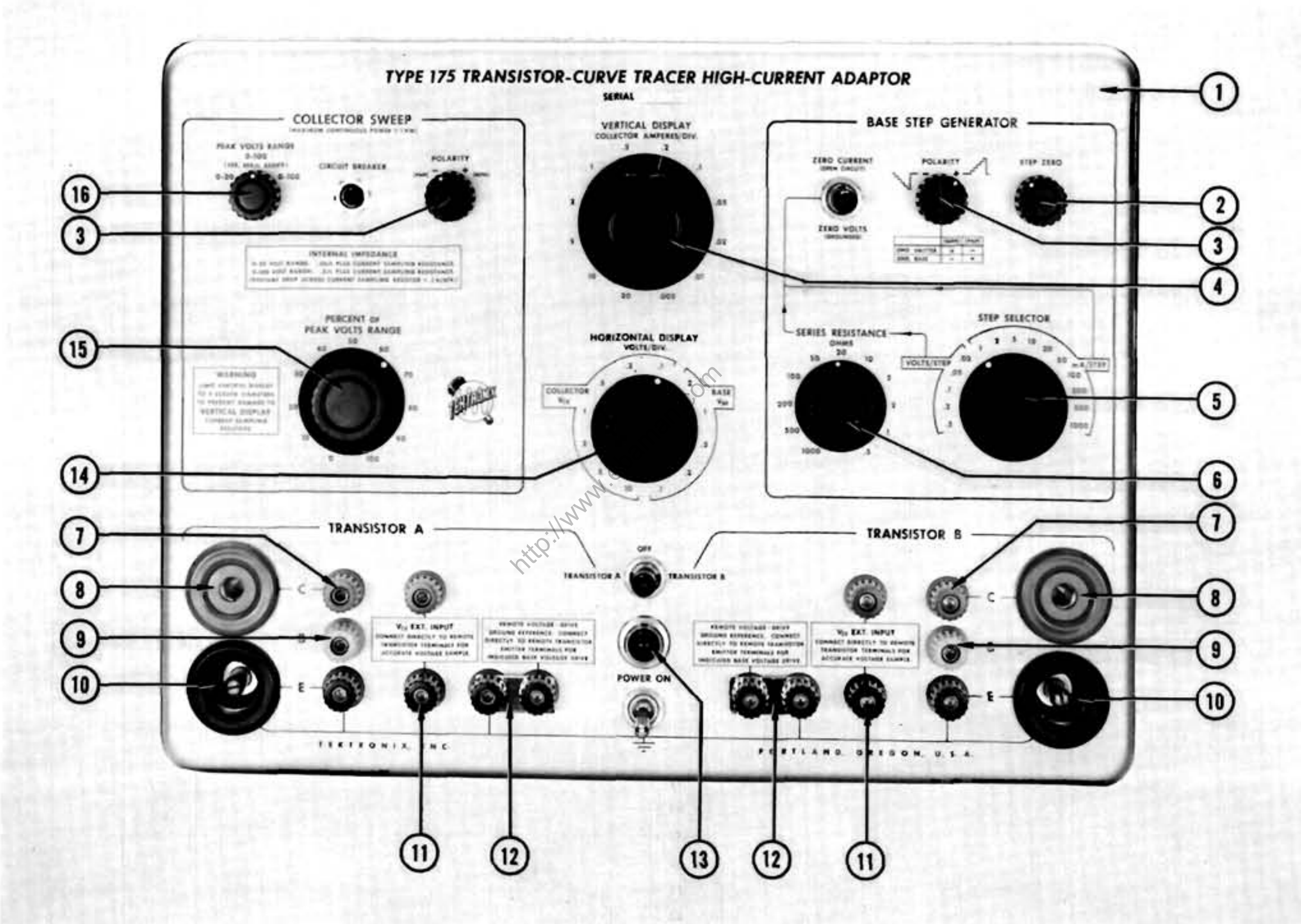
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	Q T Y.	DESCRIPTION
1	260-0195-00	101	11489	1	SWITCH, lever, DPDT, 1-locking position, unwired
	260-0195-01	11490		1	SWITCH, lever, DPDT, 1-locking position, unwired
	210-0902-00			1	WASHER, steel, 21/32 inch OD (not shown)
	210-0414-00			1	NUT, 15/32-32 x 9/16 inch (not shown)
	210-0473-00			1	NUT, switch, 15/32-32 x 5/64 inch, 12 sided (not shown)
2	260-0190-00	101	11869	1	SWITCH, lever, SPDT, locking switch, unwired
	260-0190-02	11870		1	SWITCH, lever, SPDT, locking switch, unwired
	210-0902-00			1	WASHER, steel, 21/32 inch OD (not shown)
	210-0414-00			1	NUT, 15/32-32 x 9/16 inch (not shown)
	210-0473-00			1	NUT, switch, 15/32-32 x 5/64 inch, 12 sided (not shown)
3	260-0197-00	101	5909	1	SWITCH, lever
	260-0463-00	5910		1	SWITCH, lever
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0902-00	101	5909	1	WASHER, steel, 21/32 inch OD (not shown)
	210-0414-00	101	5909	1	NUT, 15/32-32 x 9/16 inch (not shown)
	210-0473-00	101	5909	1	NUT, switch, 15/32-32 x 5/64 inch, 12 sided (not shown)
	210-0845-00	5910		1	WASHER, steel, 1/2 inch ID x 5/8 inch OD
	361-0048-00	5910		1	SPACER, switch
4	260-0249-00	X861		1	SWITCH, circuit breaker, 0.8 amp. unwired
	210-0013-00			1	LOCKWASHER, pot, internal 3/8 x 11/16 inch (not shown)
	210-0902-00			1	WASHER, steel, 21/32 inch OD (not shown)
	210-0473-00			2	NUT, switch, 15/32-32 x 5/64 inch, 12 sided
5	260-0134-00			1	SWITCH, toggle, 1 pole, 1 thro, unwired
	210-0902-00			1	WASHER, steel, 21/32 inch OD (not shown)
	210-0414-00			1	NUT, 15/32-32 x 9/16 inch
	210-0473-00			1	NUT, switch, 15/32-32 x 5/64 inch, 12 sided
6	260-0248-00	X861		1	SWITCH, pushbutton, SPST, red closed, unwired
	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
	210-0940-00			1	WASHER, 1/4 ID x 3/8 inch OD
7	260-0247-00	X861		1	SWITCH, pushbutton, SPST, red open, unwired
	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
	210-0940-00			1	WASHER, 1/4 ID x 3/8 inch OD

STANDARD ACCESSORIES



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	Q T Y.	DESCRIPTION
1	103-0013-00	X611		1	ADAPTER, power cord, 3 to 2 wire
2	378-0514-00	101	9709	1	FILTER, light, plexiglas, 5 inch, green w/cam hole
	378-0567-00	9710		1	FILTER, light, smoke gray
3	161-0004-00	101	610	1	CORD, power, 16 gauge, 8 feet, 2 wire
	161-0010-00	611	11789	1	CORD, power, 16 gauge, 8 feet, 3 wire
	161-0010-03	11790		1	CORD, power, 16 gauge, 8 feet, 3 wire
4	013-0010-00	101	6749	2	ADAPTER, transistor (for transistors w/wire leads)
	013-0069-00	6750		2	ADAPTER, transistor (for transistors w/wire leads)
5	151-0039-00			2	TRANSISTOR, 2N1381
6	013-0012-00	X434	6749	2	ADAPTER, transistor (for transistors w/2-pin basis)
	013-0070-00	6750		2	ADAPTER, transistor (for transistors w/2-pin basis)
--	070-0255-01			2	MANUAL, instrument (not shown)
	062-1009-00			1	BOOKLET, semiconducter device measurements

FRONT


TYPE 175 TRANSISTOR-CURVE TRACER HIGH-CURRENT ADAPTOR
COLLECTOR SWEEP
VERTICAL DISPLAY
BASE STEP GENERATOR
HORIZONTAL DISPLAY
SERIES RESISTANCE
STEP SELECTOR
TRANSISTOR A
TRANSISTOR B
POWER ON
1
2
3
4
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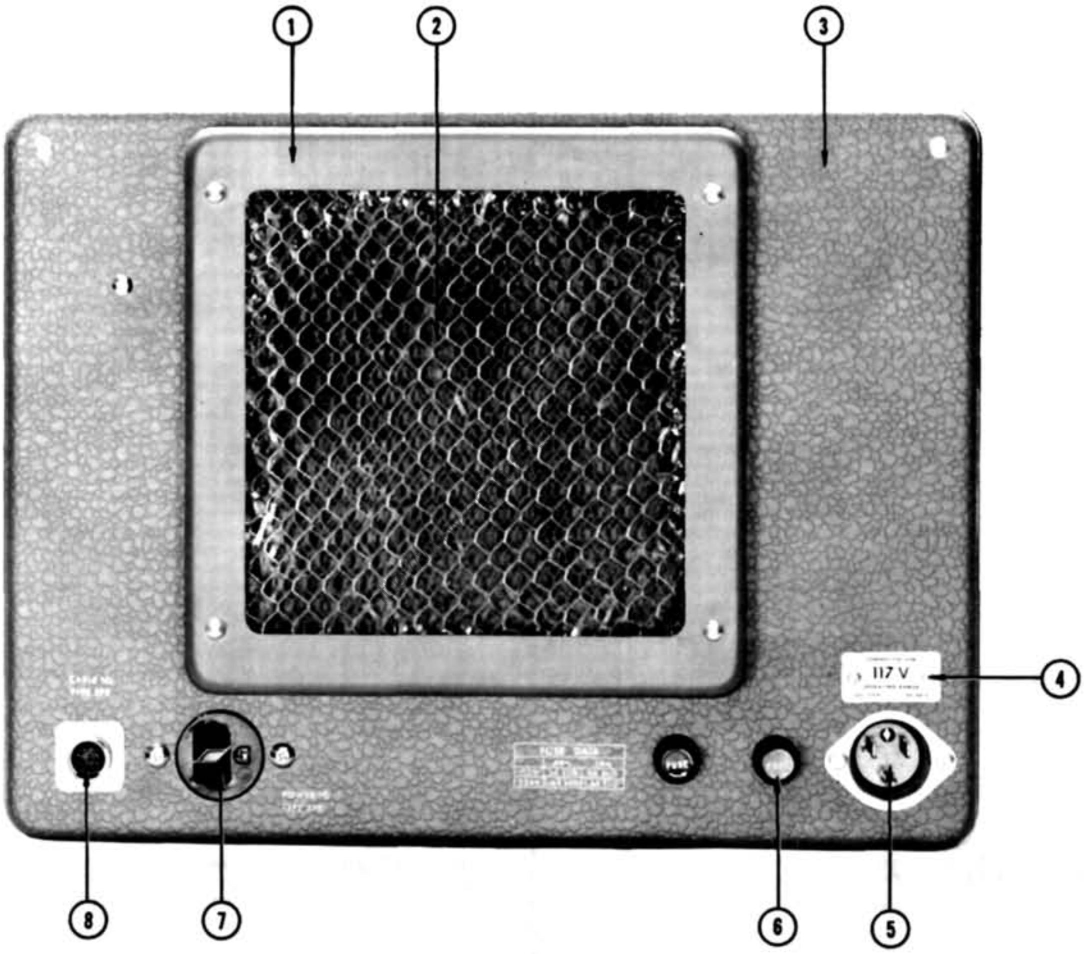
FRONT (cont)

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION 1 2 3 4 5
1	333-0597-00			1	PANEL, front
	387-0273-00			1	PLATE, front subpanel
	- - - - - -			-	Includes:
	354-0069-00			1	RING, ornamental
2	366-0044-00			1	KNOB, STEP ZERO, small black
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
	- - - - - -			-	Mounting Hardware For Pot:
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
	210-0840-00			1	WASHER, 0.390 ID x 9/16 inch OD
	210-0013-00			1	LOCKWASHER, internal, 3/8 x 11/16 inch
3	366-0044-00			2	KNOB, POLARITY, small black
	- - - - - -			-	Each Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
4	366-0120-00			1	KNOB, VERTICAL DISPLAY, large black
	- - - - - -			-	Includes:
	213-0007-00			2	SCREW, set, 10-32 x 1/4 inch HSS
5	366-0060-00			1	KNOB, STEP SELECTOR, large black
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
6	366-0042-00			1	KNOB, SERIES RESISTANCE, large black
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
7	129-0055-00			4	POST, binding, red
	- - - - - -			-	Mounting Hardware For Each: (not included)
	210-0445-00			2	NUT, hex., 10-32 x 3/8 inch
	210-0010-00			1	LOCKWASHER, internal, #10
	210-0206-00			1	LUG, solder, SE10
8	136-0083-00			2	SOCKET, receptacle, red
	210-0217-00			2	LUG, solder, 5/16 inch
9	129-0054-00			2	POST, binding, blue
	- - - - - -			-	Mounting Hardware For Each: (not included)
	210-0445-00			2	NUT, hex., 10-32 x 3/8 inch
	210-0010-00			1	LOCKWASHER, internal, #10
	210-0206-00			1	LUG, solder, SE10
10	136-0084-00			2	SOCKET, receptacle, black
	210-0217-00			4	LUG, solder, 5/16 inch
11	129-0036-00			8	POST, binding, assembly
	- - - - - -			-	Mounting Hardware For Each: (not included)
	358-0036-00			1	BUSHING, nylon
	210-0445-00			2	NUT, hex., 10-32 x 3/8 inch
	210-0010-00			1	LOCKWASHER, internal, #10
	210-0206-00			1	LUG, solder, SE10
12	386-0427-00			2	PLATE, ground
13	136-0027-00			1	SOCKET, light, with green jewel and mounting hardware
14	366-0060-00			1	KNOB, HORIZONTAL DISPLAY, large black
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
15	366-0111-00			1	KNOB, PERCENT OF PEAK VOLTS RANGE
	- - - - - -			-	Includes:
	213-0004-00			2	SCREW, set, 6-32 x 3/16 inch HSS
16	366-0044-00			1	KNOB, PEAK VOLTS RANGE, small black
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS

REAR



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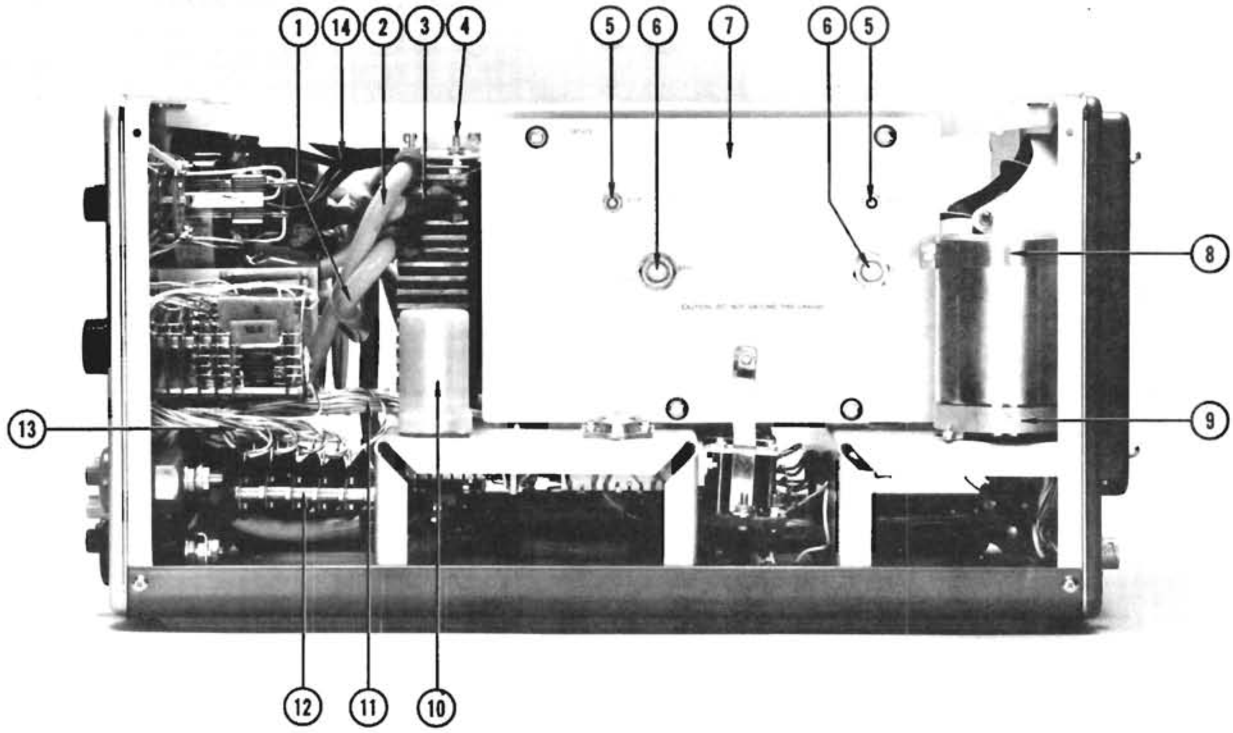
REAR (cont)

FIG. & INDEX NO.	TEKTRONIX PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION 1 2 3 4 5
1	380-0023-00			1	HOUSING, air filter
	- - - - - -			-	Mounting Hardware: (not included)
	212-0031-00			4	SCREW, 8-32 x 1 1/4 inches, RHS
	210-0458-00			4	NUT, keps, 8-32 x 11/32 inch
	210-0402-00			4	NUT, cap, hex., 8-32 x 5/16 inch
2	378-0021-00	101	339	1	FILTER, air
	378-0022-00	340		1	FILTER, air, foam
	378-0762-00	340		1	SCREEN, filter
3	387-0281-00			1	PLATE, rear overlay
	- - - - - -			-	Mounting Hardware: (not included)
	213-0041-00			2	SCREW, thread cutting, 6-32 x 3/8 inch, THS
	387-0276-00			1	PLATE, rear sub-panel
	- - - - - -			-	Includes:
	354-0069-00			1	RING, ornamental
4	334-0649-00			1	TAG, voltage rating
	- - - - - -			-	Mounting Hardware: (not included)
	213-0088-00			2	SCREW, thread cutting, 4-40 x 1/4 inch, PHS
5	131-0150-00	101	749	1	CONNECTOR, chassis mount, motor base
	131-0150-01	750	794	1	CONNECTOR, chassis mount, motor base
	131-0572-00	795		1	CONNECTOR, chassis mount, motor base
	- - - - - -			-	connector includes:
	129-0041-00	101	749	1	POST, ground
	129-0041-01	750	794	1	POST, ground
	200-0185-00	101	749	1	COVER
	200-0185-01	750	794	1	COVER
	204-0335-00	795		1	BODY-CONTACT ASSEMBLY
	205-0014-00			1	SHELL, mounting
	210-0003-00	101	749X	2	LOCKWASHER, external, #4
	210-0551-00	101	749X	2	NUT, hex., 4-40 x 1/4 inch
	211-0015-00	101	749	1	SCREW, 4-40 x 1/2 inch, RHS
	213-0088-00	750	794	1	SCREW, thread forming, 4-40 x 1/4 inch, PHS
	213-0146-00	795		1	SCREW, thread forming, #6 x 0.313 inch, PHS
	214-0078-00			2	PIN, connecting
	211-0132-00	X750	794	1	SCREW, sems, 4-40 x 1/2 inch, RHS
	211-0534-00	795	959	1	SCREW, sems, 6-32 x 5/16 inch, PHS
	211-0614-00	960		1	SCREW, sems, 6-32 x 1/4 inch, PHS
	377-0041-00	101	749	1	INSERT, black
	377-0051-00	750	794	1	INSERT, black
	214-1016-00	795		1	INSULATOR, connector
6	352-0002-00			2	HOLDER, fuse, assembly
	- - - - - -			-	Each Consisting Of:
	352-0010-00			1	HOLDER, fuse
	200-0015-00			1	CAP, fuse
	210-0873-00			1	WASHER, rubber, 1/2 ID x 11/16 inch OD
	NO NUMBER			1	NUT, fuse holder
7	136-0036-00			1	SOCKET, grounding, type, 125 V
	- - - - - -			-	Mounting Hardware: (not included)
	212-0039-00			2	SCREW, 8-32 x 3/8 inch, THS
8	136-0077-00			1	SOCKET, chassis mount, 9 pin
	- - - - - -			-	Mounting Hardware: (not included)
	211-0012-00			4	SCREW, 4-40 x 3/8 inch, BHS
	210-0004-00			4	LOCKWASHER, internal, #4
	210-0406-00			4	NUT, hex., 4-40 x 3/16 inch

RIGHT SIDE

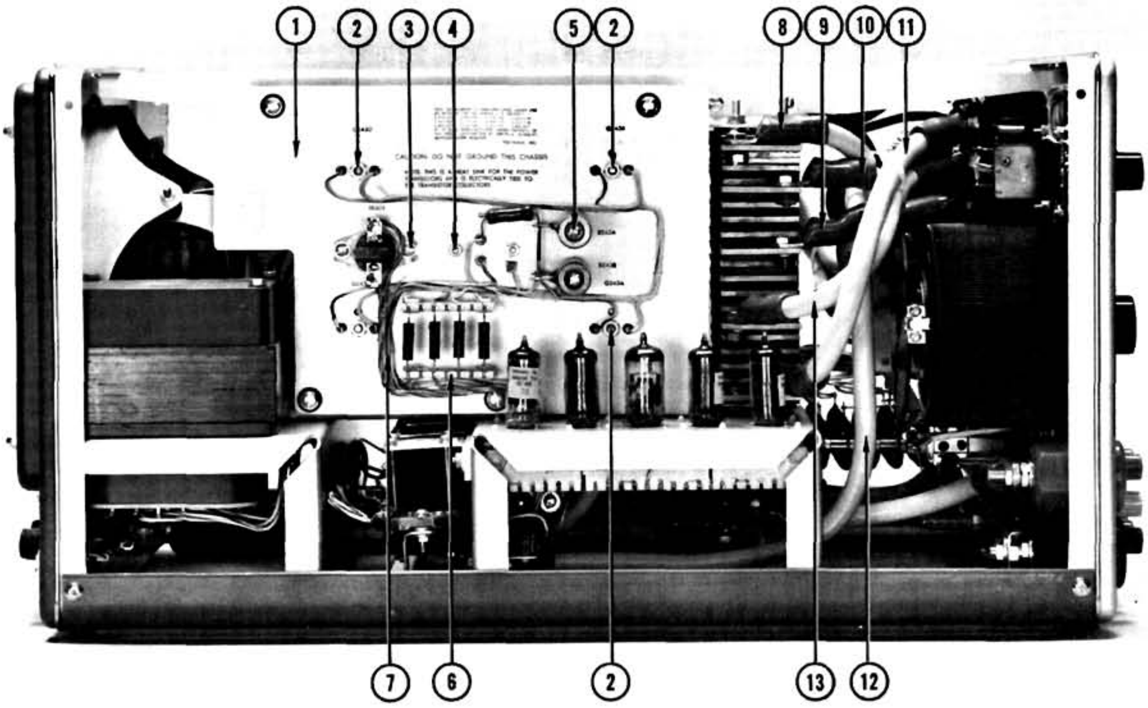


REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	Q T Y.	DESCRIPTION
1	175-0136-00			1	CABLE, power strap, 11 inches
	- - - - - -			-	Includes:
	200-0326-00			2	COVER, lug insulating
	- - - - - -			-	Mounting Hardware: (not included)
	213-0090-00			1	SCREW, 10-32 x 1/2 inch HHS
	210-0010-00			3	LOCKWASHER, internal, #10
	210-0445-00			1	NUT, hex., 10-32 x 3/8 inch
	213-0001-00			1	SCREW, cap, 1/4-20 x 1/2 inch HHS
	210-0016-00			1	LOCKWASHER, split, spring, 1/4 inch
	210-0411-00			1	NUT, hex., 1/4-20 x 7/16 inch
2	175-0137-00			1	CABLE, power strap, 12 inches
	- - - - - -			-	Includes:
	200-0326-00			2	COVER, lug insulating
	- - - - - -			-	Mounting Hardware: (not included)
	213-0090-00			1	SCREW, 10-32 x 1/2 inch HHS
	210-0206-00			1	LUG, solder, SE10
	210-0805-00			1	WASHER, 10S x 7/16 inch
	210-0010-00			1	LOCKWASHER, internal, #10
	210-0445-00			1	NUT, hex., 10-32 x 3/8 inch
	213-0001-00			1	SCREW, cap, 1/4-20 x 1/2 inch HHS
	210-0016-00			1	LOCKWASHER, split, spring, 1/4 inch
	210-0411-00			1	NUT, hex., 1/4-20 x 7/16 inch

RIGHT SIDE (cont)

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
3	175-0133-00			1	CABLE, power strap, 8 inches
	- - - - - -			-	Includes:
	200-0326-00			2	COVER, lug insulator
	- - - - - -			-	Mounting Hardware: (not included)
	213-0090-00			1	SCREW, 10-32 x 1/2 inch, HHS
	210-0010-00			1	LOCKWASHER, internal, #10
	210-0445-00			1	NUT, hex, 10-32 x 3/8 inch
	213-0001-00			1	SCREW, cap, 1/4-20 x 1/2 inch, HHS
	210-0016-00			1	LOCKWASHER, split, spring, 1/4 inch
	210-0411-00			1	NUT, hex, 1/4-20 x 7/16 inch
4	- - - - - -			-	Mounting Hardware For Resistor:
	387-0287-00			4	PLATE, terminal, washer
	355-0065-00			4	STUD, 10-32 x 7 inches
	210-0445-00			16	NUT, hex, 10-32 x 3/8 inch
	210-0805-00			8	WASHER, 10S x 7/16 inch
	210-0010-00			12	LOCKWASHER, internal, #10
5	- - - - - -			-	Mounting Hardware For Each Diode:
	210-0455-00			1	NUT, hex, 1/4-28 x 3/8 inch
	210-0011-00			1	LOCKWASHER, internal, 1/4 inch
6	- - - - - -			-	Mounting Hardware Included With Diode:
7	387-0275-00			1	PLATE, diode mounting
	- - - - - -			-	Mounting Hardware: (not included)
	212-0033-00			4	SCREW, 8-32 x 3/4 inch, BHS
	210-0804-00			4	WASHER, 8S x 3/8 inch
	210-0900-00			8	WASHER, bakelite, .129 x 1/2 inch
8	343-0067-00			1	CLAMP, capacitor
	- - - - - -			-	Mounting Hardware: (not included)
	211-0537-00			1	SCREW, 6-32 x 3/8 inch, THS phillips
	211-0514-00			1	SCREW, 6-32 x 3/4 inch, BHS
	210-0803-00			1	WASHER, 6L x 3/8 inch
	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch
9	343-0066-00			1	CLAMP, capacitor
	- - - - - -			-	Mounting Hardware: (not included)
	211-0510-00			2	SCREW, 6-32 x 3/8 inch, BHS
	211-0514-00			1	SCREW, 6-32 x 3/4 inch, BHS
	210-0802-00			2	WASHER, 6S x 5/16 inch
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex, 6-32 x 1/4 inch
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
10	200-0293-00			1	COVER, capacitor
11	179-0484-00			1	CABLE HARNESS, subpanel
12	- - - - - -			-	Mounting Hardware Included With Resistor:
	212-0524-00			2	SCREW, 10-32 x 3/4 inch, HHS
	166-0084-00	101	488	10	TUBE, spacing
	166-0093-00	489		8	TUBE, spacing
	- - - - - -			-	mounting hardware not included w/resistor:
	210-0410-00	101	488	4	NUT, hex, 10-32 x 5/16 inch
	220-0410-00	489		2	NUT, keps, 10-32 x 3/8 inch
13	179-0482-00			1	CABLE HARNESS, step selector
14	179-0480-00			1	CABLE HARNESS, current resistor
	- - - - - -			-	Mounting Hardware: (not included)
	213-0090-00			5	SCREW, 10-32 x 1/2 inch, HHS
	210-0010-00			14	LOCKWASHER, internal, #10
	210-0206-00			1	LUG, solder, SE10
	210-0445-00			5	NUT, hex, 10-32 x 3/8 inch
	213-0089-00			1	SCREW, 10-32 x 3/8 inch, HHS

LEFT SIDE



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	387-0274-00			1	PLATE, transistor mounting
	- - - - - -			-	Mounting Hardware: (not included)
	212-0010-00			4	SCREW, 8-32 x 5/8 inch BHS
	210-0804-00			4	WASHER, 8S x 3/8 inch
	210-0900-00			8	WASHER, bakelite, 0.129 x 1/2 inch
2	- - - - - -			-	Mounting Hardware For Each Transistor:
	210-0410-00			1	NUT, hex., 10-32 x 5/16 inch
	210-0010-00			1	LOCKWASHER, internal, #10
3	260-0246-00			1	SWITCH, thermal cut-out
	- - - - - -			-	Mounting Hardware: (not included)
	211-0507-00			2	SCREW, 6-32 x 5/16 inch BHS
	210-0803-00			2	WASHER, 6L x 3/8 inch
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
4	- - - - - -			-	Mounting Hardware For Transistor:
	211-0510-00			2	SCREW, 6-32 x 3/8 inch BHS
	210-0006-00			1	LOCKWASHER, internal, #6
	210-0202-00			1	LUG, solder, SE6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
5	- - - - - -			-	Mounting Hardware For Each Resistor:
	212-0037-00			1	SCREW, 8-32 x 1 3/4 inch Fil HS
	210-0008-00			1	LOCKWASHER, internal, #8
	210-0809-00			1	WASHER, resistor centering
	210-0462-00			1	NUT, hex., 25 w/resistor
	212-0004-00			1	SCREW, 8-32 x 5/16 inch BHS
6	124-0089-00			2	STRIP, ceramic, 3/4 inch x 7 notches
	- - - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			2	SPACER, nylon, 0.313 inch
7	179-0478-00			1	CABLE HARNESS, transistor mounting plate

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LEFT SIDE (cont)

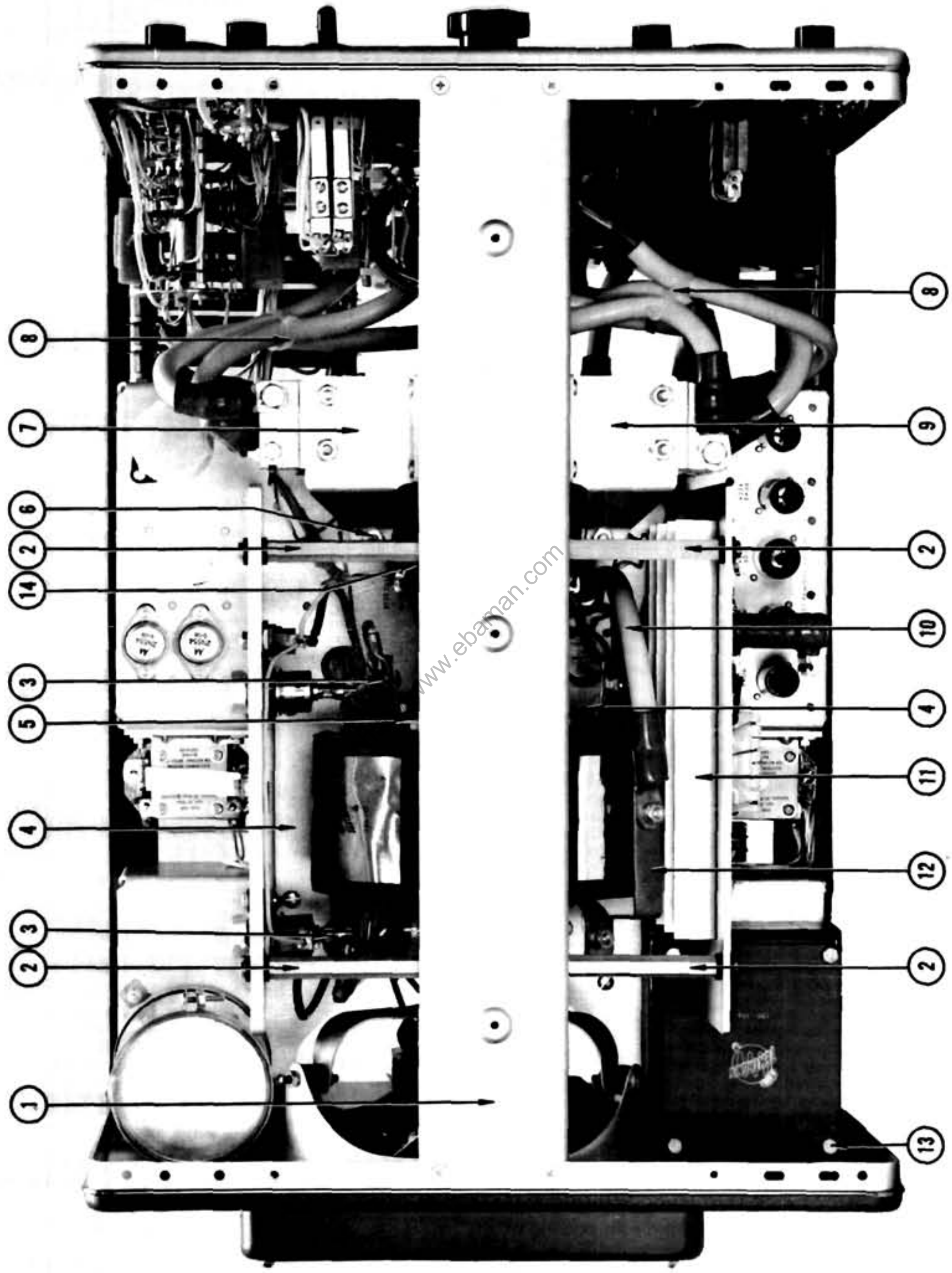
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
8	175-0134-00			1	CABLE, power strap, 9 inches
	- - - - - -			-	Includes:
	200-0326-00			2	COVER, lug insulating
	- - - - - -			-	Mounting Hardware: (not included)
	213-0090-00			1	SCREW, 10-32 x 1/2 inch HHS
	210-0010-00			3	LOCKWASHER, internal, #10
	210-0445-00			1	NUT, hex, 10-32 x 3/8 inch
	213-0001-00			1	SCREW, cap, 1/4-20 x 1/2 inch HHS
	210-0016-00			1	LOCKWASHER, split, spring, 1/4 inch
	210-0411-00			1	NUT, hex, 1/4-20 x 7/16 inch
9	175-0129-00			1	CABLE, power strap, 5 inches
	- - - - - -			-	Includes:
	200-0326-00			2	COVER, lug insulating
	- - - - - -			-	Mounting Hardware: (not included)
	213-0090-00			1	SCREW, 10-32 x 1/2 inch HHS
	210-0010-00			3	LOCKWASHER, internal, #10
	210-0445-00			1	NUT, hex, 10-32 x 3/8 inch
	213-0001-00			1	SCREW, cap, 1/4-20 x 1/2 inch HHS
	210-0016-00			1	LOCKWASHER, split, spring, 1/4 inch
	210-0411-00			1	NUT, hex, 1/4-20 x 7/16 inch
10	175-0132-00			1	CABLE, power strap, 7 inches
	- - - - - -			-	Includes:
	200-0326-00			2	COVER, lug insulating
	- - - - - -			-	Mounting Hardware: (not included)
	213-0090-00			1	SCREW, 10-32 x 1/2 inch HHS
	210-0010-00			3	LOCKWASHER, internal, #10
	210-0445-00			1	NUT, hex, 10-32 x 3/8 inch
	213-0001-00			1	SCREW, cap, 1/4-20 x 1/2 inch HHS
	210-0016-00			1	LOCKWASHER, split, spring, 1/4 inch
	210-0411-00			1	NUT, hex, 1/4-20 x 7/16 inch
11	175-0135-00			1	CABLE, power strap, 10 inches
	- - - - - -			-	Includes:
	200-0326-00			2	COVER, lug insulating
	- - - - - -			-	Mounting Hardware: (not included)
	213-0090-00			1	SCREW, 10-32 x 1/2 inch HHS
	210-0010-00			3	LOCKWASHER, internal, #10
	210-0445-00			1	NUT, hex, 10-32 x 3/8 inch
	213-0001-00			1	SCREW, cap, 1/4-20 x 1/2 inch HHS
	210-0016-00			1	LOCKWASHER, split, spring, 1/4 inch
	210-0411-00			1	NUT, hex, 1/4-20 x 7/16 inch
	346-0024-00	X890		1	STRAP, cable tie (not shown)

LEFT SIDE (cont)

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
12	175-0139-00			1	CABLE, power strap, 18 inches
	- - - - - -			-	Includes:
	200-0326-00			2	COVER, lug insulating
	- - - - - -			-	Mounting Hardware: (not included)
	213-0090-00			1	SCREW, 10-32 x 1/2 inch HHS
	210-0010-00			2	LOCKWASHER, internal #10
	210-0206-00			1	LUG, solder, SE6
	210-0445-00			1	NUT, hex, 10-32 x 3/8 inch
	213-0001-00			1	SCREW, cap, 1/4-20 x 1/2 inch HHS
	210-0016-00			1	LOCKWASHER, split, spring, 1/4 inch
	210-0411-00			1	NUT, hex, 1/4-20 x 7/16 inch
13	175-0133-00	101	609	1	CABLE, power strap, 8 inches
	175-0134-00	610		1	CABLE, power strap, 9 inches
	- - - - - -			-	Includes:
	200-0326-00			2	COVER, lug insulating
	- - - - - -			-	Mounting Hardware: (not included)
	213-0090-00			1	SCREW, 10-32 x 1/2 inch HHS
	210-0010-00			3	LOCKWASHER, internal, #10
	210-0445-00			1	NUT, hex, 10-32 x 3/8 inch
	213-0001-00			1	SCREW, cap, 1/4-20 x 1/2 inch HHS
	210-0016-00			1	LOCKWASHER, split, spring, 1/4 inch
	210-0411-00			1	NUT, hex, 1/4-20 x 7/16 inch

Ⓐ

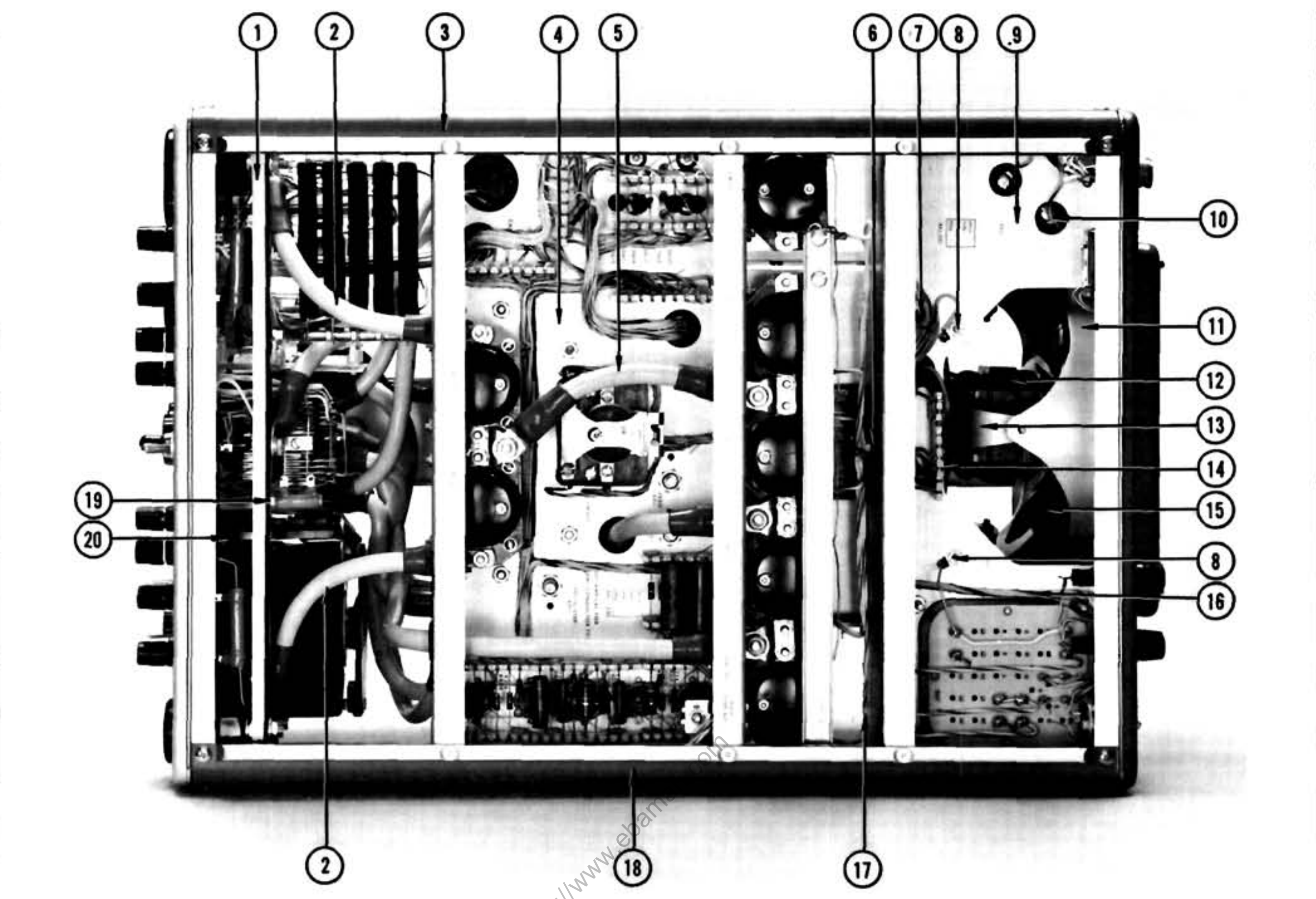
TOP



TOP (cont)

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION 1 2 3 4 5
	381-0179-00			1	BAR, rail, top center support
	- - - - - -			-	Mounting Hardware: (not included)
	212-0040-00			4	SCREW, 8-32 x 3/8 inch FHS
2	385-0103-00			4	ROD, support
	- - - - - -			-	Mounting Hardware For Each: (not included)
	211-0507-00			1	SCREW, 6-32 x 5/16 inch BHS
3	- - - - - -			-	Mounting Hardware For Each Diode Cable:
	213-0089-00			1	SCREW, 10-32 x 3/8 inch HHS
	210-0206-00			1	LUG, solder, SE10
	210-0805-00			1	WASHER, 10S x 7/16 inch
	210-0010-00			1	LOCKWASHER, internal, #10
	210-0445-00			1	NUT, hex., 10-32 x 3/8 inch
4	406-0605-00			2	BRACKET, transformer, lower
	- - - - - -			-	Mounting Hardware For Each: (not included)
	212-0023-00			4	SCREW, 8-32 x 3/8 inch BHS
	210-0804-00			4	WASHER, 8S x 3/8 inch
	210-0458-00			4	NUT, keps, 8-32 x 11/32 inch
5	- - - - - -			-	Mounting Hardware For Transformer:
	212-0029-00			4	SCREW, 8-32 x 3 inches RHS
	210-0804-00			8	WASHER, 8S x 3/8 inch
	210-0458-00			4	NUT, keps, 8-32 x 11/32 inch
6	- - - - - -			-	Mounting Hardware Included With Resistor:
	355-0064-00			2	STUD, 10-32 x 5 1/2 inches
	406-0301-00			16	BRACKET, resistor mounting
	166-0084-00			16	TUBE, spacing
	210-0410-00			2	NUT, hex., 10-32 x 5/16 inch
	- - - - - -			-	Mounting Hardware Not Included With Resistor:
	210-0410-00			2	NUT, hex., 10-32 x 5/16 inch
	210-0805-00			4	WASHER, 10S x 7/16 inch
	210-0010-00			4	LOCKWASHER, internal, #10
	210-0445-00			4	NUT, hex., 10-32 x 3/8 inch
7	406-0660-00			1	BRACKET, resistor support, right
	- - - - - -			-	Mounting Hardware: (not included)
	212-0004-00			2	SCREW, 8-32 x 5/16 inch
8	346-0024-00			2	STRAP, cable tie, nylon
9	406-0661-00			1	BRACKET, resistor support, left
	- - - - - -			-	Mounting Hardware: (not included)
	212-0004-00			2	SCREW, 8-32 x 5/16 inch
10	175-0138-00			1	CABLE, power strap, 13 inches
	- - - - - -			-	Mounting Hardware: (not included)
	213-0089-00			1	SCREW, 10-32 x 3/8 inch HHS
	210-0805-00			1	WASHER, 10S x 7/16 inch
	210-0010-00			1	LOCKWASHER, internal, #10
	210-0445-00			1	NUT, hex., 10-32 x 3/8 inch
	213-0001-00			1	SCREW, cap, 1/4-20 x 1/2 inch HHS
	210-0016-00			1	LOCKWASHER, split, spring, 1/4 inch
	210-0411-00			1	NUT, hex., 1/4-20 x 7/16 inch
11	406-0645-00			2	BRACKET, heat sync
12	346-0018-00			1	STRAP, transformer
	- - - - - -			-	Mounting Hardware: (not included)
	213-0089-00			2	SCREW, 10-32 x 3/8 inch HHS
	210-0805-00			2	WASHER, 10S x 7/16 inch
	210-0010-00			2	LOCKWASHER, internal, #10
	210-0445-00			2	NUT, hex., 10-32 x 3/8 inch
13	- - - - - -			-	Mounting Hardware For Transformer:
	212-0543-00			4	SCREW, 10-32 x 3 3/4 inches HHS
	210-0812-00			4	WASHER, fiber, #10
	210-0010-00			4	LOCKWASHER, internal, #10
	210-0564-00			4	NUT, hex., 10-32 x 3/8 inch
14	343-0006-00			1	CLAMP, cable, 1/2 inch (not shown)

BOTTOM

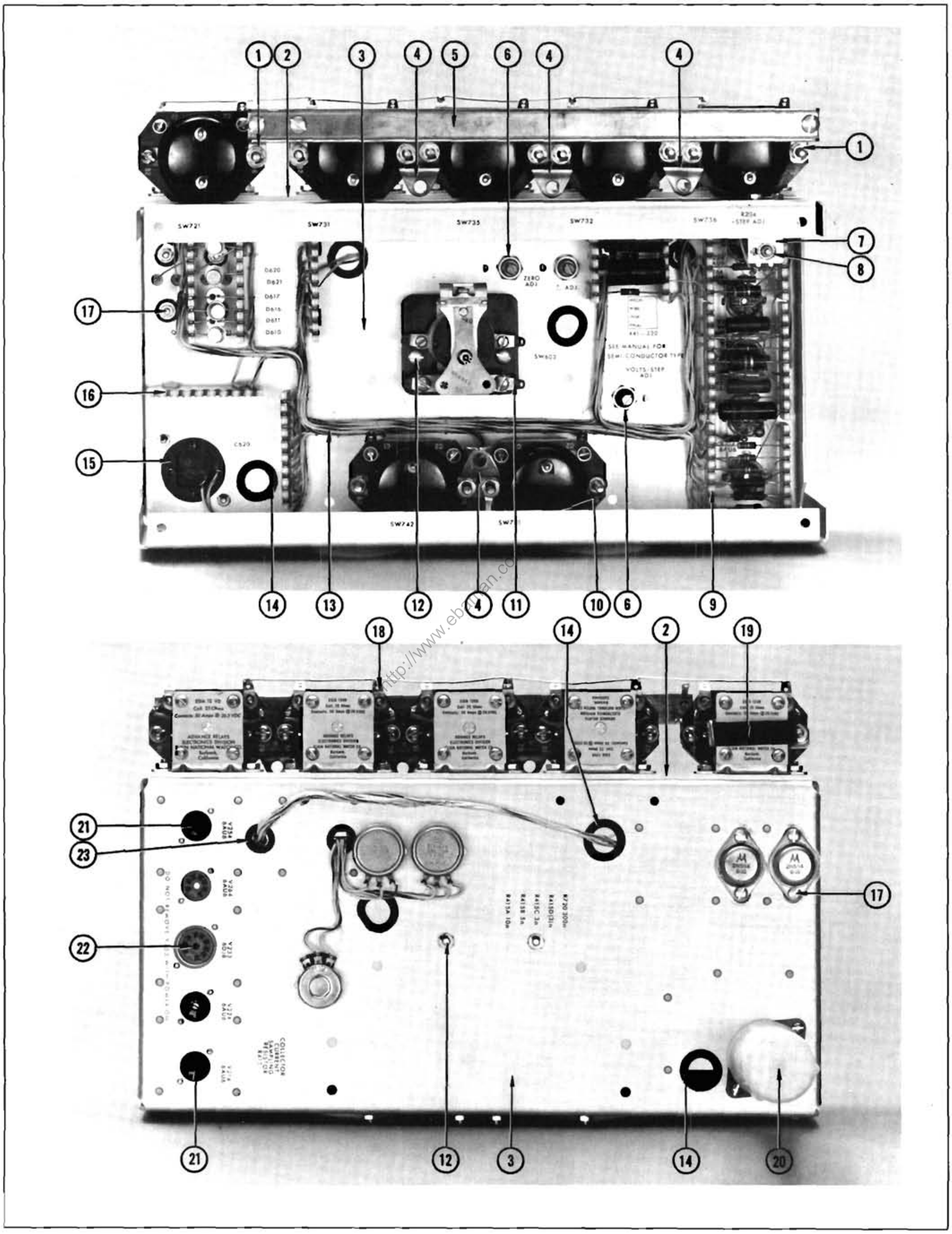


REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
1	346-0021-00			1	STRAP, emitter coupling
2	175-0131-00			2	CABLE, power strap, 6 inches
	- - - - - -			-	Each Includes:
	200-0326-00			2	COVER, lug insulating
	- - - - - -			-	Mounting Hardware For Each: (not included)
	210-0009-00			2	LOCKWASHER, external, #10
	210-0445-00			2	NUT, hex., 10-32 x 3/8 inch
3	122-0087-00			1	ANGLE, frame, bottom rail, right
	- - - - - -			-	Mounting Hardware: (not included)
	212-0039-00			4	SCREW, 8-32 x 3/8 inch THS
	210-0458-00			4	NUT, keps, 8-32 x 11/32 inch
4	- - - - - -			-	SWEEP CHASSIS - see sweep chassis view

BOTTOM (cont)

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION 1 2 3 4 5
5	175-0130-00			1	CABLE, power strap, 5 inches
	- - - - - -			-	Includes:
	200-0326-00			2	COVER, lug insulating
	- - - - - -			-	Mounting Hardware: (not included)
	213-0001-00			2	SCREW, cap, 1/4-20 x 1/2 inch HHS
	210-0016-00			2	LOCKWASHER, split, spring, 1/4 inch
	210-0411-00			2	Nut, hex., 1/4-20 x 7/16 inch
6	348-0012-00			2	GROMMET, 5/8 inch
7	348-0006-00			1	GROMMET, 3/4 inch
8	210-0205-00			2	LUG, solder, SE8
	- - - - - -			-	Mounting Hardware For Each: (not included)
	212-0001-00			1	SCREW, 8-32 x 1/4 inch BHS
	210-0409-00			1	NUT, hex., 8-32 x 5/16 inch
9	441-0331-00			1	CHASSIS, power
	- - - - - -			-	Mounting Hardware: (not included)
	212-0011-00			2	SCREW, 8-32 x 3/4 inch FHS
	212-0040-00			4	SCREW, 8-32 x 3/8 inch FHS
	210-0458-00			6	NUT, keps, 8-32 x 11/32 inch
10	210-0206-00			2	LUG, solder, SE10
	- - - - - -			-	Mounting Hardware For Each: (not included)
	212-0507-00			1	SCREW, 10-32 x 3/8 inch BHS
	210-0010-00			1	LOCKWASHER, internal, #10
11	354-0104-00			1	RING, fan
	- - - - - -			-	Mounting Hardware: (not included)
	213-0041-00			4	SCREW, thread cutting, 6-32 x 3/8 inch THS
12	147-0001-00			1	MOTOR, 34 watt, 1500 RPM, 115 volt
	- - - - - -			-	Mounting Hardware: (not included)
	355-0044-00			2	STUD, 10-32 x 2 7/16 inches
	210-0410-00			4	NUT, hex., 10-32 x 5/16 inch
	210-0010-00			6	LOCKWASHER, internal, #10
13	426-0047-00			1	MOUNT, fan motor
	- - - - - -			-	Mounting Hardware: (not included)
	348-0008-00			3	SHOCKMOUNT
	210-0409-00			6	NUT, hex., 8-32 x 5/16 inch
	210-0008-00			6	LOCKWASHER, internal, #8
14	124-0090-00			1	STRIP, ceramic, 3/4 inch x 9 notches
	- - - - - -			-	Includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	Mounting Hardware: (not included)
	361-0009-00			2	SPACER, nylon, 0.313 inch
15	369-0007-00			1	FAN
16	179-0479-00			1	CABLE HARNESS, 110 V
17	179-0481-00			1	CABLE HARNESS, power
18	122-0088-00			1	ANGLE, frame, bottom rail, left
	- - - - - -			-	Mounting Hardware: (not included)
	212-0039-00			4	SCREW, 8-32 x 3/8 inch THS
	210-0458-00			4	NUT, keps, 8-32 x 11/32 inch
19	- - - - - -			-	Mounting Hardware For Resistor:
	211-0544-00	104		1	SCREW, 6-32 x 3/4 inch THS
	210-0601-00	104		1	EYELET
	210-0478-00	104		1	NUT, hex., 5-10 w/resistor
	211-0507-00	104		1	SCREW, 6-32 x 5/16 inch BHS
20	- - - - - -			-	Mounting Hardware For Variable Transformer
	210-0411-00			4	NUT, hex., 1/4-20 x 7/16 inch
	210-0016-00			4	LOCKWASHER, split, spring, 1/4 inch

SWEEP CHASSIS



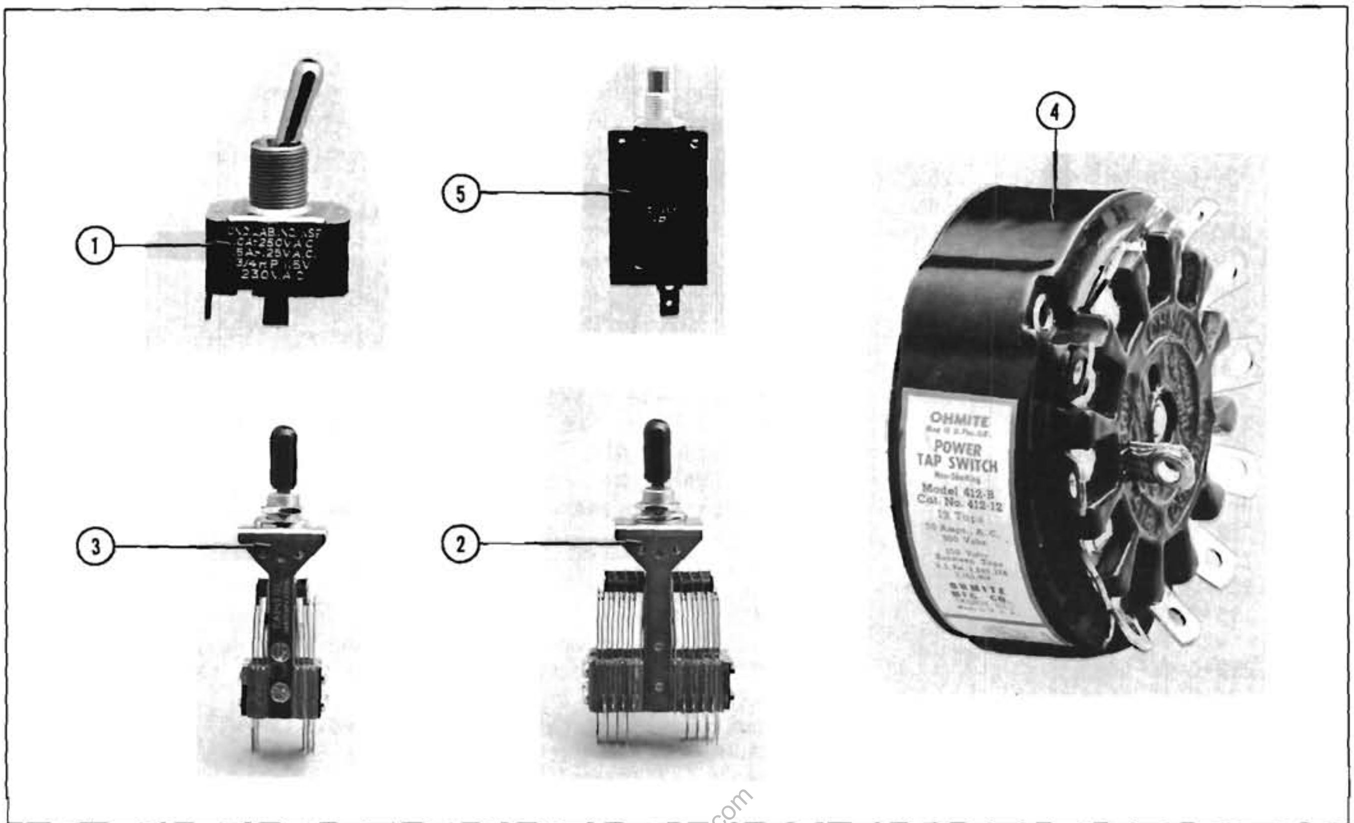
SWEEP CHASSIS (cont)

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
1	346-0016-00			3	STRAP, relay connecting
2	- - - - - -			-	Mounting Hardware For Relays:
	381-0180-00			1	BAR, spacer, relay
	212-0008-00			10	SCREW, 8-32 x 1/2 inch, BHS
	210-0008-00			10	LOCKWASHER, internal, #8
	210-0409-00			10	NUT, hex., 8-32 x 5/16 inch
3	441-0330-00	101	726	1	CHASSIS, sweep
	441-0330-01	727		1	CHASSIS, sweep
	- - - - - -			-	Mounting Hardware: (not included)
	212-0011-00			4	SCREW, 8-32 x 3/4 inch, FHS phillips
	210-0458-00			4	NUT, keps, 8-32 x 11/32 inch
4	346-0019-00			4	STRAP, cable
5	346-0020-00			1	STRAP, relay connecting
	- - - - - -			-	Mounting Hardware: (not included)
	212-0518-00			3	SCREW, 10-32 x 5/16 inch, BHS
	210-0010-00			2	LOCKWASHER, internal, #10
	210-0206-00			1	LUG, solder, SE10
	210-0410-00			3	NUT, hex., 10-32 x 5/16 inch
6	- - - - - -			-	Mounting Hardware For Each Pot:
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
	210-0840-00			1	WASHER, 0.390 ID x 9/16 inch OD
7	406-0576-00	240		1	BRACKET, miniature pot
	- - - - - -			-	Mounting Hardware: (not included)
	211-0516-00	240		2	SCREW, 6-32 x 7/8 inch, BHS
	166-0037-00	240		2	TUBE, spacer
	210-0006-00	240		2	LOCKWASHER, internal, #6
	210-0407-00	240		2	NUT, hex., 6-32 x 1/4 inch
8	- - - - - -			-	Mounting Hardware For Miniature Pot:
	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
	210-0046-00			1	LOCKWASHER, internal, 0.400 OD x 0.261 inch ID
9	124-0089-00			6	STRIP, ceramic, 3/4 inch x 7 notches
	- - - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			2	SPACER, nylon, 0.313 inch
10	- - - - - -			1	Mounting Hardware For Relays: (not shown)
	381-0181-00			1	BAR, spacer, relay
	212-0008-00			4	SCREW, 8-32 x 1/2 inch, BHS
	210-0008-00			4	LOCKWASHER, internal, #8
	210-0409-00			4	NUT, hex., 8-32 x 5/16 inch
11	210-0205-00			3	LUG, solder, SE8
12	- - - - - -			-	Mounting Hardware For Relay:
	212-0010-00			2	SCREW, 8-32 x 5/8 inch, BHS
13	179-0477-00			1	CABLE HARENSS, sweep
14	348-0006-00			4	GROMMET, 3/4 inch
15	- - - - - -			-	Mounting Hardware For Capacitor:
	386-0254-00			1	PLATE, fiber flange
	211-0543-00			2	SCREW, 6-32 x 5/16 inch, RHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
16	124-0090-00			7	STRIP, ceramic, 3/4 inch x 9 notches
	- - - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			2	SPACER, nylon, 0.313 inch

SWEEP CHASSIS (cont)

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
17	- - - - - -			-	TRANSISTOR
	- - - - - -			-	Mounting Hardware For Each: (not included)
	386-0978-00	101	726X	1	PLATE, mica insulator
	129-0049-00	101	368X	2	POST, terminal
	210-0407-00	101	726X	2	NUT, hex., 6-32 x 1/4 inch
	210-0006-00	101	726X	2	LOCKWASHER, internal, #6
	210-0900-00	101	726X	2	WASHER, bakelite, 0.129 x 1/2 inch
	210-0008-00	101	368	2	LOCKWASHER, internal, #8
	210-0409-00	101	368	2	NUT, hex., 8-32 x 5/16 inch
	210-0803-00	369	726X	2	WASHER, steel, 6L
	211-0513-00	369	726X	2	SCREW, 6-32 x 5/8 inch, BHS
	210-0202-00	101	726X	1	LUG, solder, SE6
18	210-0202-00			16	LUG, solder, SE6
19	346-0017-00			1	STRAP, relay connecting
	- - - - - -			-	Mounting Hardware: (not included)
	212-0010-00			1	SCREW, 8-32 x 5/8 inch, BHS
	210-0458-00			2	NUT, keps, 8-32 x 11/32 inch
20	200-0293-00			1	COVER, capacitor
21	136-0008-00			4	SOCKET, STM7G
	- - - - - -			-	Mounting Hardware For Each: (not included)
	213-0004-00			2	SCREW, thread cutting, 5-32 x 3/16 inch, PHS phillips
22	136-0015-00			1	SOCKET, STM9G
	- - - - - -			-	Mounting Hardware: (not included)
	213-0004-00			2	SCREW, thread cutting, 5-32 x 3/16 inch, PHS phillips
23	348-0005-00			2	GROMMET, 1/2 inch

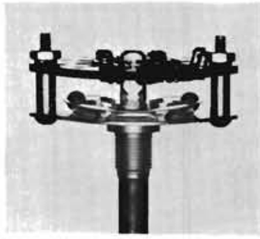
SWITCHES



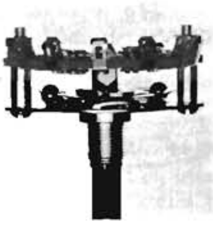
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
1	260-0199-00			1	SWITCH, toggle -- POWER
	- - - - - -			-	Mounting Hardware: (not included)
	210-0473-00			1	NUT, switch, 12 sided
	210-0902-00			1	WASHER, 0.470 ID x 21/32 inch OD
	354-0055-00			1	RING, locking, switch
	210-0414-00			1	NUT, hex, 15/32-32 x 9/16 inch
2	260-0317-00	101	402	1	SWITCH, lever -- TRANSISTOR
	260-0636-00	403		1	SWITCH, lever -- TRANSISTOR
	- - - - - -			-	Mounting Hardware: (not included)
	210-0473-00	101	402	1	NUT, switch, 12 sided
	210-0902-00	101	402	1	WASHER, 0.470 ID x 21/32 inch OD
	361-0048-00	403		1	TUBE, spacer
	210-0845-00	403		1	WASHER, steel, 1/2 ID x 5/8 inch OD
	354-0055-00			1	RING, locking, switch
3	260-0339-00			1	SWITCH, lever -- ZERO CURRENT/ZERO VOLTS
	- - - - - -			-	Mounting Hardware: (not included)
	210-0473-00	101	575X	1	NUT, switch, 12 sided
	210-0902-00			1	WASHER, 0.470 ID x 21/32 inch OD
	354-0055-00	101	575X	1	RING, locking, switch
	210-0414-00			1	NUT, hex, 15/32-32 x 9/16 inch
	361-0048-00			1	SPACER, switch
4	260-0338-00			1	SWITCH, tap -- VERTICAL DISPLAY
	- - - - - -			-	Mounting Hardware: (not included)
	212-0560-00			3	SCREW, 10-32 x 5/16 inch, FHS phillips
	210-0009-00			3	LOCKWASHER, external, #10
5	260-0337-00			1	SWITCH -- CIRCUIT BREAKER
	- - - - - -			-	Mounting Hardware: (not included)
	210-0505-00			1	NUT, hex, 3/8-27 x 1/2 inch
	210-0840-00			1	WASHER, 0.390 ID x 9/16 inch OD
	210-0013-00			1	LOCKWASHER, internal, 3/8 x 11/16 inch

SWITCHES (cont)

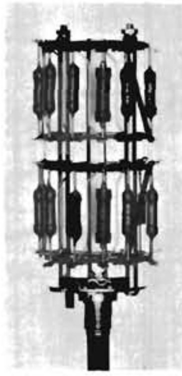
(6) BASE STEP GENERATOR POLARITY



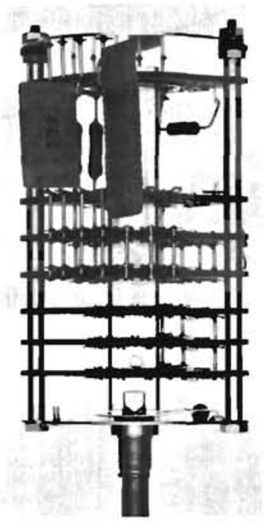
(7) COLLECTOR SWEEP POLARITY



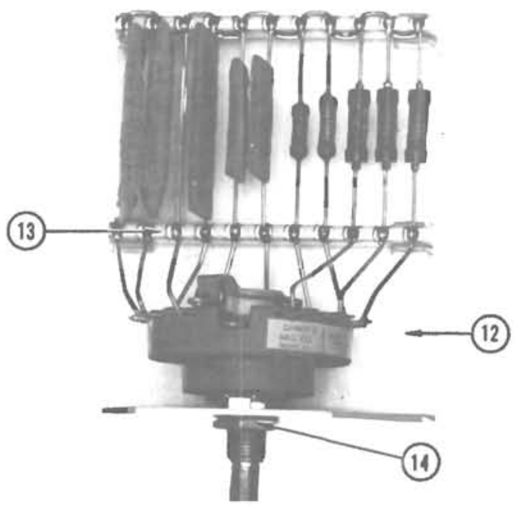
(8) PEAK VOLTS RANGE



(9) HORIZONTAL DISPLAY



(10) STEP SELECTOR

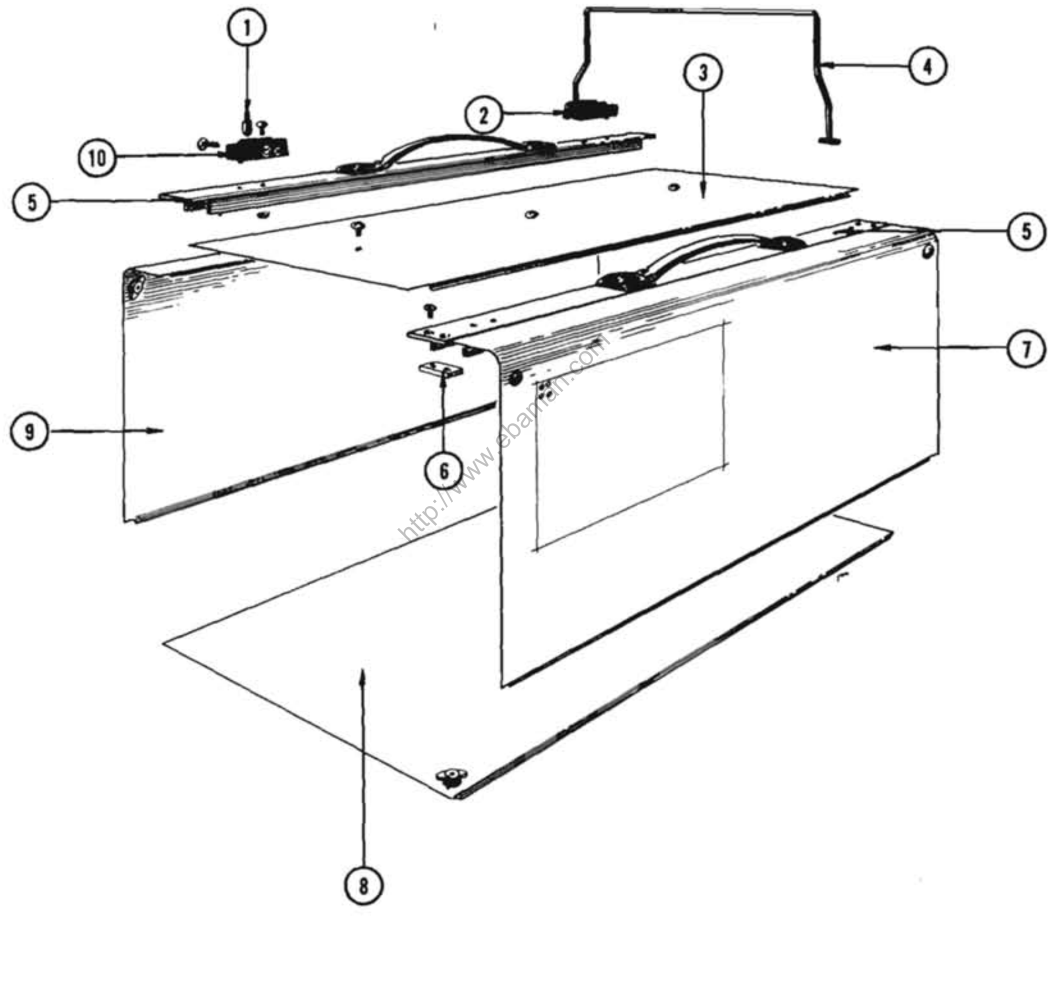


(11) SERIES RESISTANCE

SWITCHES (cont)

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION 1 2 3 4 5
6	260-0365-00			1	SWITCH, BASE STEP GENERATOR POLARITY, unwired
	- - - - - -			-	Mounting Hardware: (not included)
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
	210-0840-00			1	WASHER, 0.390 ID x 9/16 inch OD
	210-0013-00			1	LOCKWASHER, internal, 3/8 x 11/16 inch
7	260-0366-00			1	SWITCH, COLLECTOR SWEEP POLARITY, unwired
	- - - - - -			-	Mounting Hardware: (not included)
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
	210-0840-00			1	WASHER, 0.390 ID x 9/16 inch OD
	210-0013-00			1	LOCKWASHER, internal, 3/8 x 11/16 inch
8	260-0367-00			1	SWITCH, PEAK VOLTS RANGE, unwired
	- - - - - -			-	Mounting Hardware: (not included)
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
	210-0840-00			1	WASHER, 0.390 ID x 9/16 inch OD
	210-0013-00			1	LOCKWASHER, internal, 3/8 x 11/16 inch
9	262-0384-00			1	SWITCH, HORIZONTAL DISPLAY, wired
	- - - - - -			-	Includes:
	260-0364-00			1	SWITCH, unwired
	- - - - - -			-	Mounting Hardware: (not included)
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
	210-0013-00			1	LOCKWASHER, internal, 3/8 x 11/16 inch
10	262-0382-00			1	SWITCH, STEP SELECTOR, wire
	- - - - - -			-	Includes:
	260-0363-00			1	SWITCH, unwired
	387-0742-00			1	PLATE, switch
	210-0017-00			2	LOCKWASHER, #5
	210-0449-00			2	NUT, hex., 5-40 x 1/4 inch
	210-0811-00			2	WASHER, fiber, #6
	210-0823-00			2	WASHER, fiber, 1/8 ID x 1/4 inch OD
	- - - - - -			-	Mounting Hardware: (not included)
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
	210-0013-00			1	LOCKWASHER, internal, 3/8 x 11/16 inch
11	262-0383-00			1	SWITCH, SERIES RESISTANCE, wired
	- - - - - -			-	Includes:
	260-0355-00			1	SWITCH, unwired
12	406-0641-00			1	BRACKET, resistor mounting
13	124-0106-00			2	STIRP, ceramic, 7/16 inch x 11 notches
	- - - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon
	361-0007-00			4	SPACER, nylon, 0.063 inch
14	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
	- - - - - -			-	Mounting Hardware: (not included)
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
	210-0013-00			1	LOCKWASHER, internal, 3/8 x 11/16 inch

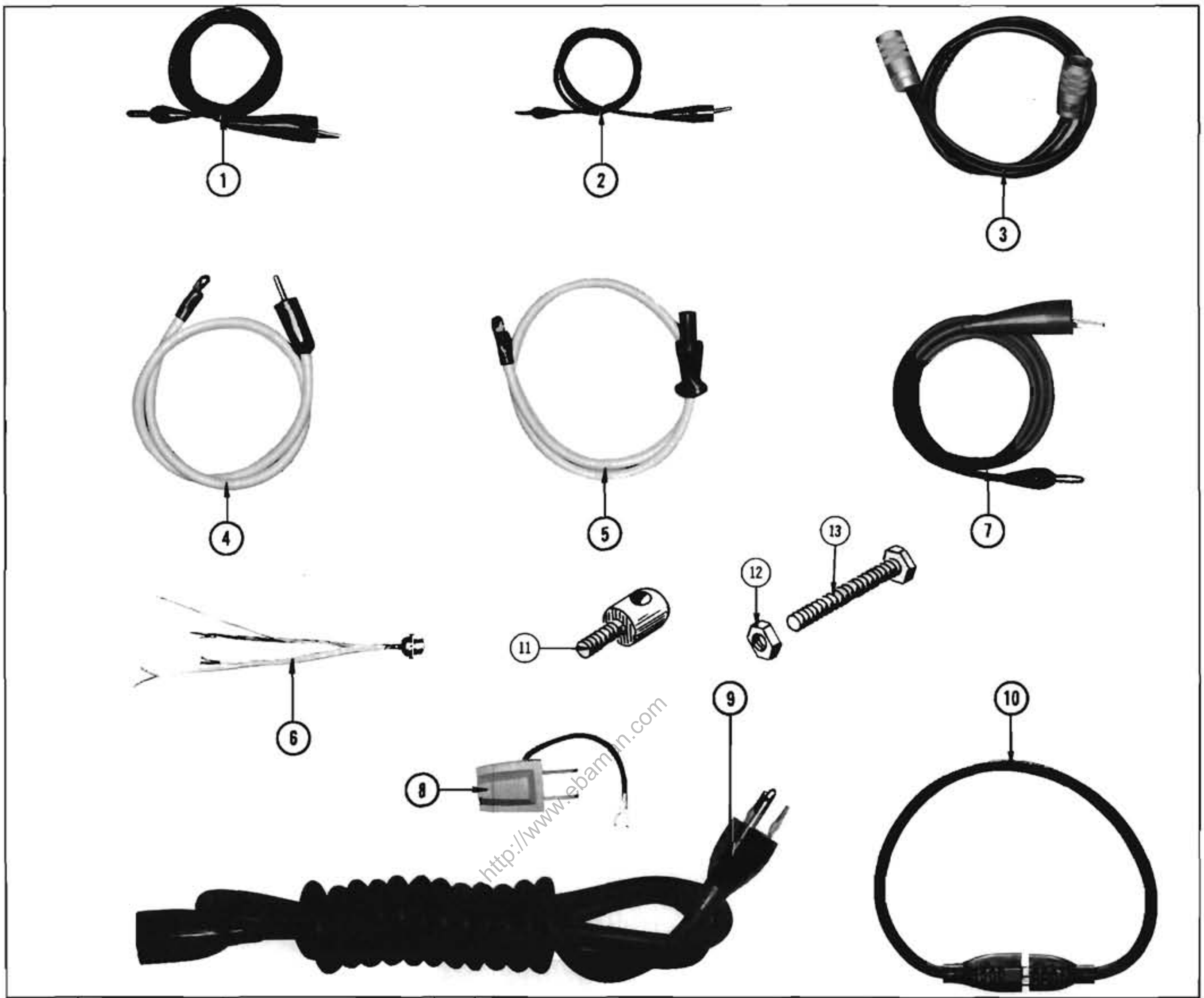
CABINET



CABINET (cont)

REF. NO.	PART NO	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION 1 2 3 4 5
1	214-0152-00			2	BOLT, hinge, 3/8 inch diameter
	- - - - - -			-	Mounting Hardware For Each: (not included)
	212-0520-00			1	SCREW, 10-32 x 1 1/4 inch Hex HS
	210-0010-00			1	LOCKWASHER, internal, #10
	210-0410-00			1	NUT, hex., 10-32 x 5/16 inch
2	348-0033-00			2	FOOT, instrument support
	- - - - - -			-	Mounting Hardware For Each: (not included)
	212-0010-00			1	SCREW, 8-32 x 5/8 inch BHS
	210-0458-00			1	NUT, keps, 8-32 x 11/32 inch
3	387-0278-00			1	PLATE, top cover
	- - - - - -			-	Mounting Hardware: (not included)
	212-0039-00			7	SCREW, 8-32 x 3/8 inch THS
4	348-0034-00			1	FOOT, flip stand support
5	381-0178-00	101	279	2	BAR, top support with handle
	381-0209-00	280		2	BAR, top support with handle
	- - - - - -			-	Mounting Hardware For Each: (not included)
6	381-0073-00			2	BAR, retaining
	212-0039-00			4	SCREW, 8-32 x 3/8 inch THS
7	387-0277-00			1	PLATE, cabinet side, right
	- - - - - -			-	Includes:
	105-0007-00			2	STOP
	210-0480-00			2	NUT, latch, nylon, cabinet fastener
	210-0847-00			2	WASHER, nylon, 0.164 ID x 0.500 inch OD
	213-0033-00			2	SCREW, fastening, 8-32 x 1/2 inch
8	387-0279-00			1	PLATE, cabinet bottom
	- - - - - -			-	Includes:
	105-0007-00			4	STOP
	210-0480-00			4	NUT, latch, nylon, cabinet fastener
	210-0847-00			4	WASHER, nylon, 0.164 ID x 0.500 inch OD
	213-0033-00			4	SCREW, fastening, 8-32 x 1/2 inch
9	387-0280-00			1	PLATE, cabinet side, left
	- - - - - -			-	Includes:
	105-0007-00			2	STOP
	210-0480-00			2	NUT, latch, nylon, cabinet fastener
	210-0847-00			2	WASHER, nylon, 0.164 ID x 0.500 inch OD
	213-0033-00			2	SCREW, fastening, 8-32 x 1/2 inch
10	348-0035-00			2	FOOT, instrument support
	- - - - - -			-	Mounting Hardware For Each: (not included)
	212-0010-00			1	SCREW, 8-32 x 5/8 inch BHS
	210-0458-00			1	NUT, keps, 8-32 x 11/32 inch

STANDARD ACCESSORIES



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
1	012-0014-00			2	LEAD, black output
2	012-0015-00			2	LEAD, red, output
3	012-0042-00			1	CABLE, interconnecting
4	012-0043-00			2	CABLE, transistor test, red
5	012-0044-00			2	CABLE, transistor test, black
6	012-0045-00			1	CABLE, 575 adapter
7	012-0056-00			2	CABLE, test lead, blue
8	103-0013-00			1	ADAPTER, 3 to 2 wire
9	161-0010-00	101	729	1	CORD, power
	161-0010-03	730	812	1	CORD, power
	161-0030-01	813		1	CORD, power
10	161-0014-00			1	CORD, power, 20 inches
	161-0014-01	730		1	CORD, power, 20 inches
11	214-0152-00			2	BOLT, hinge
12	210-0410-00			2	NUT, hex., 10-32 x 5/16 inch
13	212-0520-00			2	SCREW, 10-32 x 1/2 inch, OHS
	210-0010-00			2	LOCKWASHER, internal, #10
--	070-0255-01			2	MANUAL, instruction

PARTS LIST ABBREVIATIONS

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

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 8
ELECTRICAL PARTS LIST

Bulbs

		Tektronix Part Number
B174	Neon, NE-23	Use 150-027
B231	Neon, NE-23	Use 150-027
B266	Neon, NE-23	Use 150-027
B601	Incandescent, #47	150-001
B602	Incandescent, #47	150-001
B603	Incandescent, #47	150-001
B826	Neon, NE-23	Use 150-027
B827	Neon, NE-23	Use 150-027

Capacitors

Values fixed unless marked variable.

Tolerance ±20% unless otherwise indicated.

C102		.047 μf	PTM	400 v		285-519
C103		.001 μf	Cer.	500 v		281-536
C105		.047 μf	PTM	400 v		285-519
C108		.047 μf	PTM	400 v		285-519
C122		.047 μf	PTM	400 v		285-519
C123		.001 μf	Cer.	500 v	10%	281-536
C128		.047 μf	PTM	400 v		285-519
C130		.047 μf	PTM	400 v		285-519
C142		.0015 μf	Mica	500 v	10%	283-535
C145		.005 μf	Cer.	500 v		283-001
C146		470 μμf	Cer.	500 v		281-525
C153		12 μμf	Cer.	500 v	10%	281-505
C165		470 μμf	Cer.	500 v		281-525
C177		.01 μf	Polystyrene	300 v	5%	Use *291-038
C180		470 μμf	Cer.	500 v		281-525
C186		.022 μf	PTM	400 v		285-515
C213		.005 μf	Cer.	500 v		283-001
C232		.001 μf	PTM	600 v		285-501
C240		2000 μf	EMC	20 v		Use 290-029
C241		2000 μf	EMC	20 v		Use 290-029
C242		2000 μf	EMC	20 v		Use 290-029
C243		2000 μf	EMC	20 v		Use 290-029
C244		150 μf	EMC	150 v		Use 290-018
C267		.001 μf	PTM	600 v		285-501
C361		47 μμf	Cer.	500 v	10%	281-519
C380	X8030-up	100 pf	Cer.	350 v		281-523
C381	X8030-up	100 pf	Cer.	350 v		281-523
C391		47 μμf	Cer.	500 v		281-518
C396		47 μμf	Cer.	500 v		281-518
C461		47 μμf	Cer.	500 v	10%	281-519
C480	X8030-up	100 pf	Cer.	350 v		281-523

Capacitors *(cont)*

							Tektronix Part Number
C481	X8030-up	100 pf	Cer.		350 v		281-523
C602		2 x 20 μf	EMC		450 v		Use 290-010
C611A,B		2 x 20 μf	EMC		450 v		Use 290-010
C613		.01 μf	PTM		400 v		285-510
C620		125 μf	EMC		350 v		Use 290-016
C630		.01 μf	PTM		400 v		285-510
C641		2 x 20 μf	EMC		450 v		Use 290-010
C644	101-12259	.01 μf	PTM		400 v		285-510
C644	12260-up	.047 μf	MT		400 v		285-0519-00
C655	101-12259	.01 μf	PTM		400 v		285-510
C655	12260-up	.047 μf	MT		400 v		285-0519-00
C666		2 x 20 μf	EMC		450 v		Use 290-010
C706		4.5-25 μμf	Cer.	Var.			281-010
C730		4.7 μμf	Cer.				281-501
C734	101-195	82 μμf	Mica		500 v	5%	283-534
	196-723	120 μμf	Mica		500 v	10%	283-507
	724-up	82 μμf	Mica		500 v	5%	283-534
C735	101-723	7-45 μμf	Cer.	Var.			281-012
	724-up	20-125 μμf	Cer.	Var.			281-028
C802		.001 μf	PTM		600 v		285-501
C808		.01 μf	PTM		600 v		285-511
C809	101-10219	.001 μf	PTM		600 v		285-0501-00
C809	10220-up	.001 μf	Cer.		3000 v		283-0044-00
C811		.047 μf	PTM		600 v	10%	285-520
C812	101-2389	.0068 μf	PTM		3000 v		285-508
	2390-up	.01 μf	Cer.		2000 v		283-011
C813	101-1942	.015 μf	PTM		3000 v		285-513
	1943-up	.01 μf	Cer.		2000 v		283-011
C815	101-2389	.0068 μf	PTM		3000 v		285-508
	2390-up	.005 μf	Cer.		4000 v		283-034
C816		.022 μf	PTM		600 v		285-516
C818	101-2389	.0068 μf	PTM		3000 v		285-508
	2390-up	.01 μf	Cer.		2000 v		283-011

Diodes

D138	X12310-up	Silicon	Replaceable by 1N647	*152-0107-00
D152	X10650-10769X	Silicon Low leakage	0.25 w, 40 v	152-0246-00
D241A,B	X4930-up	Silicon	IN3209	152-088
D241C.D	X4930-10649	Silicon	IN2862	152-047
D241C,D	10650-up	Silicon	1N3194	152-0066-00
D620A,B,C,D	X4930-10649	Silicon	IN2862	152-047
D620A,B,C,D	10650-up	Silicon	1N3194	152-0066-00

Fuses

F240	X8030-up	5 Amp Fast-Blo w/pig tails	159-053
F241	X8030-up	5 Amp Fast-Blo w/pig tails	159-053
F601	101-232	4 Amp Fast-Blo	Use 159-005
F601	233-up	4 Amp Slo-Blo (117 volt operation)	Use 159-027
F601	101-3809	1.6 Amp Slo-Blo (234 volt operation)	159-003
F601	3810-up	2 Amp Slo-Blo (234 volt operation)	159-023
F702	101-860X	1 Amp Fast-Blo	159-022

Inductors

			Tektronix Part Number
L734†	X4820-up	Ferramic Suppressor	276-517
L735†	X4820-up	Ferramic Suppressor	276-517

Rectifiers

SR241	101-4929X	Selenium Rectifier Stack 8-500 ma plates	*106-043
SR620	101-4929X	Full-wave bridge, 5-250 ma plates/leg	*106-044
GR706		6 germanium rectifier cells, each cell rated at .5 amp., 300 v peak inverse	*106-034

Resistors

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

R102		20 k	2 w	Var.	WW	Phase Adj. A	Use 311-151
R103	101-536	1 meg	½ w			5%	301-105
	537-up	680 k	½ w				302-684
R105		10 k	1 w				304-103
R107		12 k	½ w				302-123
R108		47 k	1 w				304-473
R110		150 k	½ w				302-154
R111		150 k	½ w				302-154
R113		10 meg	½ w				302-106
R114	101-12259	10 meg	½ w				302-106
R114	12260-up	4.7 meg	½ w				302-0475-00
R116		27 k	½ w				302-273
R117	101-11469	10 k	½ w				302-103
R117	11470-up	27 k	½ w				302-0273-00
R122		250 k	2 w	Var.	Comp.	Phase Adj. B	311-032
R123		1 meg	½ w			5%	301-105
R125		10 k	1 w				304-103
R127		12 k	½ w				302-123
R128		47 k	1 w				304-473
R130		150 k	½ w				302-154
R131		150 k	½ w				302-154
R133		10 meg	½ w				302-106
R134	101-12259	10 meg	½ w				302-106
R134	12260-up	4.7 meg	½ w				302-0475-00
R135	X8030-12309	1 meg	½ w		Prec.	1%	323-481
R135	12310-up	1 meg	½ w			5%	301-0105-00
R136	101-8029	1 meg	½ w				302-105
R136	8030-12309X	200 k	½ w		Prec.	1%	323-414
R138	101-8029	1 meg	½ w				302-105
R138	8030-up	499 k	½ w		Prec.	1%	323-452
R139	101-8029	100 k	2 w	Var.	Comp.	Volts/Step Adj.	311-026
R139	8030-up	50 k	2 w	Var.	WW	Volts/Step Adj.	311-218
R140		1 k	½ w				302-102
R142	101-8029	47 k	½ w				302-473
R142	8030-up	46.4 k	½ w		Prec.	1%	323-0353-00
R143	101-8029	47 k	2 w				306-473
R143	8030-up	49.9 k	1 w		Prec.	1%	324-356
R145		10 meg	½ w				302-106
R146		10 k	½ w				302-103

† Two turns of number 26 wire on Ferramic Suppressor.

Resistors *(cont)*

							Tektronix Part Number
R147		10 k	½ w				302-103
R148		1 k	½ w				302-102
R150		18 k	½ w				302-183
R151		180 k	½ w				302-184
R152	X14110-up	100 meg	⅛ w			5%	317-0107-00
R153		120 k	½ w			5%	301-124
R154		100 k	½ w			5%	301-104
R156	101-633	27 k	½ w				302-273
	634-up	27 k	1 w				304-273
R158		1 k	½ w				302-102
R160		10 k	½ w				302-103
R164		47 k	½ w				302-473
R165		100 k	½ w				302-104
R167		4.7 k	½ w				302-472
R168	101-8029	100 k	½ w				302-104
R168	8030-12309	56 k	½ w				302-563
R168	12310-up	100 k	½ w				302-0104-00
R172	101-319	100 k	½ w				Use 304-104
	320-up	100 k	1 w				304-104
R173	X342-up	100 k	½ w				302-104
R174		1.5 meg	½ w				302-155
R175		1 k	½ w				302-102
R176	X342-8029	1 k	½ w				302-102
R176	8030-up	2.2 k	½ w				302-222
R177		1 k	½ w				302-102
R179		47 k	2 w				306-473
R180		33 k	½ w				302-333
R182		50 k	2 w	Var.	Comp.	Min No. Steps	311-023
R184		220 k	½ w			5%	301-224
R186		390 k	½ w			5%	301-394
R188		1 k	½ w				302-102
R189		100 k	½ w				302-104
R190		20 k	2 w	Var.	Comp.	STEPS/FAMILY	311-018
R194		50 k	2 w	Var.	Comp.	Max. No. Steps	311-023
R196		22 k	½ w				302-223
R202		90 k	½ w		Prec.	1%	309-195
R203		3 k	½ w		Prec.	1%	309-182
R204	101-4269	68 Ω	½ w				302-680
R204	4270-up	200 Ω		Var.		+STEP ADJ.	311-158
R206		600 k	½ w		Prec.	1%	309-004
R207	101-150	500 k	2 w	Var.	Comp.	STEP ZERO	Use 311-026
	151-up	100 k	2 w	Var.	Comp.		311-026
R210	101-10879	470 k	½ w				302-474
R210	10880-up	510 k	½ w			5%	301-0514-00
R213		4.7 k	½ w				302-472
R215		47 k	½ w				302-473
R216	101-579	22 k	½ w				302-223
	580-up	4.7 k	½ w				302-472
R217		20 k	2 w	Var.	Comp.	Zero Adj.	311-018
R218		47 k	½ w				302-473
R222		150 k	½ w				302-154
R224		1 k	½ w				302-102
R231		1.5 meg	½ w				302-155

Resistors *(cont)*

						Tektronix Part Number
R232		100 k	½ w			302-104
R235		47 k	1 w			304-473
R238	101-6629	47 k	½ w			302-473
R238	6630-up	47 k	1 w			304-473
R241		1 k	2 w			306-102
R243	101-14099	100 Ω	8 w	WW	5%	308-110
R243	14100-up	300 Ω	5 w	WW	1%	308-0070-00
R245	X1089-8029X	.05 Ω	5 w	WW		308-136
R246A		500 k	½ w	Prec.	1%	309-003
R246B		250 k	½ w	Prec.	1%	309-162
R246C		100 k	½ w	Prec.	1%	309-045
R246D		50 k	½ w	Prec.	1%	309-090
R246E		25 k	½ w	Prec.	1%	309-193
R246F		10 k	½ w	Prec.	1%	309-100
R246G		5 k	½ w	Prec.	1%	309-159
R246H		2.5 k	½ w	Prec.	1%	309-181
R246J		1 k	½ w	Prec.	1%	309-115
R246K		500 Ω	½ w	Prec.	1%	309-179
R246L		250 Ω	½ w	Prec.	1%	309-178
R246M		100 Ω	½ w	Prec.	1%	309-112
R246N	101-102	50 Ω	½ w	Prec.	1%	Use *310-542
	103-up	50 Ω	8 w	Prec.	1%	*310-542
R246P	101-102	25 Ω	½ w	Prec.	1%	Use *310-543
	103-up	25 Ω	8 w	Prec.	1%	*310-543
R246Q	101-102	10 Ω	½ w	Prec.	1%	Use *310-544
	103-1141	10 Ω	8 w	Prec.	1%	*310-544
	1142-1319	9.94 Ω	8 w	Mica		*310-544
	1320-up	9.97 Ω	8 w	Mica	1%	*310-544
R246R	101-102	5 Ω	3 w	Prec.	1%	Use *310-545
	103-1141	5 Ω	8 w	Prec.	1%	*310-545
	1142-1319	4.94 Ω	8 w	Mica		*310-545
	1320-up	4.97 Ω	8 w	Mica	1%	*310-545
R246S	101-1141	2.5 Ω	8 w	Mica	1%	*310-537
	1142-1319	2.44 Ω	8 w	Mica		*310-537
	1320-up	2.47 Ω	8 w	Mica	1%	*310-537
R247R	X8030-up	4.7 k	¼ w			316-472
R247S	X8030-up	2.2 k	¼ w			316-222
R247T	X8030-up	1 k	¼ w			316-102
R247U	X8030-up	470 Ω	¼ w			316-471
R247V	X8030-up	180 Ω	¼ w			316-181
R248A		22 k	½ w		5%	301-223
R248B		15 k	½ w		5%	301-153
R248C		10 k	½ w		5%	301-103
R248D		6.8 k	½ w		5%	301-682
R248E		4.7 k	½ w		5%	301-472
R248F		3.3 k	½ w		5%	301-332
R248G		2.2 k	½ w		5%	301-222
R248H		1.5 k	½ w		5%	301-152
R248J		1 k	½ w		5%	301-102
R248K		680 Ω	½ w		5%	301-681

Resistors *(cont)*

							Tektronix Part Number
R248L		470 Ω	½ w			5%	301-471
R248M		330 Ω	½ w			5%	301-331
R248N		220 Ω	½ w			5%	301-221
R248P		150 Ω	½ w			5%	301-151
R248Q		100 Ω	½ w			5%	301-101
R248R		68 Ω	½ w			5%	301-680
R248S		47 Ω	½ w			5%	301-470
R248T		33 Ω	½ w			5%	301-330
R248U		22 Ω	½ w			5%	301-220
R248V		15 Ω	½ w			5%	301-150
R248W		3.3 Ω	1 w			5%	307-015
R248X		3.3 Ω	1 w			5%	307-015
R248Y		2.4 Ω	2 w	Mica Plate		5%	*310-536
R249		1 Ω	4 w	Mica Plate		½%	*310-535
R251		1 k	½ w				302-102
R254		47 k	½ w				302-473
R255	101-579	22 k	½ w				302-223
	580-up	4.7 k	½ w				302-472
R256		20 k	2 w	Var.	Comp.	±Adj.	311-018
R257		47 k	½ w				302-473
R261		150 k	½ w				302-154
R264	101-10879	470 k	½ w				302-474
R264	10880-up	510 k	½ w			5%	301-0514-00
R266		1.5 meg	½ w				302-155
R267		100 k	½ w				302-104
R273	101-14109	330 Ω	½ w			5%	301-331
R273	14110-up	560 Ω	½ w			5%	301-0561-00
R274	101-14109X	220 Ω	½ w			5%	301-221
R275		10 k	½ w			5%	301-103
R300		1 meg	½ w				302-105
R301		1 meg	½ w				302-105
R302	101-6054	116 k	½ w		Prec.	¼%	use *050-065
R302	6055-up	116 k	½ w		Prec.	½%	309-405
R303	101-6054	2.4 k	½ w		Prec.	¼%	use *050-065
R303	6055-up	2.4 k	½ w		Prec.	½%	309-409
R304	101-6054	800 Ω	½ w		Prec.	¼%	use *050-065
R304	6055-up	800 Ω	½ w		Prec.	½%	309-408
R305	101-6054	400 Ω	½ w		Prec.	¼%	use *050-065
R305	6055-up	400 Ω	½ w		Prec.	½%	309-407
R306	101-6054	240 Ω	½ w		Prec.	¼%	use *050-065
R306	6055-up	240 Ω	½ w		Prec.	½%	309-406
R307	101-6054	80 Ω	½ w		Prec.	¼%	use *050-065
R307	6055-up	80 Ω	½ w		Prec.	½%	309-400
R308	101-6054	80 Ω	½ w		Prec.	¼%	use *050-065
R308	6055-up	80 Ω	½ w		Prec.	½%	309-400
R312		10 k	½ w		Prec.	1%	309-100
R313		10 k	½ w		Prec.	1%	309-100
R314		20 k	½ w		Prec.	1%	309-153
R315		60 k	½ w		Prec.	1%	309-041
R316		100 k	½ w		Prec.	1%	309-045
R317		200 k	½ w		Prec.	1%	309-051
R320		10 k	½ w		Prec.	1%	309-100

Resistors *(cont)*

							Tektronix Part No.
R321		10 k	½ w		Prec.	1%	309-100
R322		20 k	½ w		Prec.	1%	309-153
R323		60 k	½ w		Prec.	1%	309-041
R324		100 k	½ w		Prec.	1%	309-045
R325		200 k	½ w		Prec.	1%	309-051
R328		32.31 k	½ w		Prec.	1%	309-194
R329		11.480 k	½ w		Prec.	1%	309-192
R330		4.535 k	½ w		Prec.	1%	309-191
R331		1.063 k	½ w		Prec.	1%	309-180
R332	X148-up	2 k	½ w		Prec.	1%	309-098
R333	101-147	808 Ω	½ w		Prec.	1%	Use 309-030
	148-up	1.8 k	½ w		Prec.	1%	309-030
R334		500 Ω	.1 w	Var.	Comp.	Max. Gain Adj.	311-056
R335		560 k	½ w			5%	301-564
R337		2 x 100 k	2 w	Var.	Comp.	POSITION	311-028
R338		560 k	½ w			5%	301-564
R340		1 k	½ w				302-102
R343	101-8029	680 k	½ w			5%	301-684
R343	8030-up	470 k	½ w			5%	301-474
R344		200 k	½ w			5%	301-204
R345	101-12109	3.3 meg	½ w				302-335
R345	12110-up	8.2 meg	½ w		Selected	(nominal value)	302-0825-00
R346		300 k	½ w		Prec.	1%	309-125
R347		60 k	½ w		Prec.	1%	309-041
R348		300 k	½ w		Prec.	1%	309-125
R350		1 k	½ w				302-102
R353	101-8029	680 k	½ w			5%	301-684
R353	8030-up	470 k	½ w			5%	301-474
R354		200 k	½ w			5%	301-204
R355	101-6629	47 k	½ w				302-473
R355	6630-up	100 k	½ w				302-104
R356	101-6629	5 k	2 w	Var.	Comp.	D.C. BAL.	311-011
R356	6630-up	10 k		Var.	Comp.	D.C. BAL.	311-191
R357	101-6629	47 k	½ w				302-473
R357	6630-up	100 k	½ w				302-104
R358	101-6629	22 k	½ w				302-223
R358	6630-up	10 k	½ w				302-103
R359		200 k	.1 w	Var.	Comp.	Diff. Bal.	311-106
R360		1 k	½ w				302-102
R361		47 k	½ w				302-473
R364	101-8029	33 k	½ w				302-333
R364	8030-up	120 k	½ w				302-124
R366	101-8029	68 k	2 w				306-683
R366	8030-up	82 k	2 w				306-823
R370		1 k	½ w				302-102
R374	101-8029	33 k	½ w				302-333
R374	8030-up	120 k	½ w				302-124
R377	101-8029X	15 k	½ w				302-153
R379	X8030-up	120 k	½ w				302-124
R380	101-8029	1 k	½ w				302-102
R380	8030-up	120 k	½ w				302-124

Resistors *(cont)*

							Tektronix Part No.
R381	101-8029	1 k	½ w				302-102
R381	8030-up	120 k	½ w				302-124
R382	X8030-up	120 k	½ w				302-124
R384		30 k	8 w		WW	5%	308-105
R385		30 k	8 w		WW	5%	308-105
R387		30 k	8 w		WW	5%	308-105
R389		47 k	½ w				302-473
R390		800 k	½ w		Prec.	1%	309-110
R391		100 k	2 w	Var.		Min Gain Adj.	311-028
R393		680 k	½ w				302-684
R395		800 k	½ w		Prec.	1%	309-110
R396		100 k	2 w	Var.		Furnished with R391	
R397		47 k	½ w				302-473
R400		1 meg	½ w				302-105
R401		1 meg	½ w				302-105
R402A		.1 Ω					
R402B		.1 Ω					
R402C		.3 Ω					
R402D		.5 Ω					
R406A		1 Ω					
R406B		3 Ω					
R408A		5 Ω					
R408B		10 Ω					
R408C		30 Ω					
R408D		35 Ω					
R412A		15 Ω					
R412B		100 Ω					
R414A		300 Ω					
R414B		502 Ω					

R402 thru R414 supplied as a unit, #308-109, with lifetime warranty on exchange basis.

R416	101-232	1.01 k	1 w		Prec.	1%	310-081
	233-792	1.015 k	1 w		Prec.	½%	310-060
	793-up	1.008 k	1 w		Prec.	½%	310-062
R417	101-792	3.108 k	½ w		Prec.	½%	use 309-196
	793-up	3.053 k	½ w		Prec.	½%	309-198
R418	101-792	5.398 k	½ w		Prec.	½%	use 309-197
	793-up	5.193 k	½ w		Prec.	½%	309-199
R420	X263-793X	180 k	½ w				302-184
R421	X263-793X	120 k	½ w				302-124
R428		32.31 k	½ w		Prec.	1%	309-194
R429		11.48 k	½ w		Prec.	1%	309-192
R430		4.535 k	½ w		Prec.	1%	309-191
R431		1.063 k	½ w		Prec.	1%	309-180
R432	X148-up	2 k	½ w		Prec.	1%	309-098
R432A	X861-up	20.83 k	½ w		Prec.	1%	309-245
R432B	X861-up	11.48 k	½ w		Prec.	1%	309-192
R433	101-147	808 Ω	½ w		Prec.	1%	Use 309-030
	148-up	1.8 k	½ w		Prec.	1%	309-030
R434		500 Ω	.1 w	Var.	Comp.	Max. Gain Adj.	311-056
R435		560 k	½ w			5%	301-564
R437		2 x 100 k	2 w	Var.	Comp.	POSITION	311-028
R438		560 k	½ w			5%	301-564

Resistors *(cont)*

								Tektronix Part Number
R440		1 k	½ w					302-102
R443	101-8029	680 k	½ w				5%	301-684
R443	8030-up	470 k	½ w					301-474
R444		200 k	½ w				5%	301-204
R445	101-12109	3.3 meg	½ w					302-335
R445	12110-up	8.2 meg	½ w			Selected	(nominal value)	302-0825-00
R446		300 k	½ w			Prec.	1%	309-125
R447		60 k	½ w			Prec.	1%	309-041
R448		300 k	½ w			Prec.	1%	309-125
R450		1 k	½ w					302-102
R453	101-8029	680 k	½ w				5%	301-684
R453	8030-up	470 k	½ w				5%	301-474
R454		200 k	½ w				5%	301-204
R455	101-6629	47 k	½ w					302-473
	6630-up	100 k	½ w					302-104
R456	101-6629	5 k	2 w	Var.		Comp.	D.C. BAL.	311-011
R456	6630-up	10 k		Var.		Comp.	D.C. BAL.	311-191
R457	101-6629	47 k	½ w					302-473
R457	6630-up	100 k	½ w					302-104
R458	101-6629	22 k	½ w					302-223
R458	6630-up	10 k	½ w					302-103
R459		200 k	.1 w	Var.		Comp.	Diff. Bal.	311-106
R460		1 k	½ w					302-102
R461		47 k	½ w					302-473
R464	101-8029	33 k	½ w					302-333
R464	8030-up	120 k	½ w					302-124
R466	101-8029	68 k	2 w					306-683
R466	8030-up	82 k	2 w					306-823
R470		1 k	½ w					302-102
R474	101-8029	33 k	½ w					302-333
R474	8030-up	120 k	½ w					302-124
R477	101-8029X	15 k	½ w					302-153
R479	X8030-up	120 k	½ w					302-124
R480	101-8029	1 k	½ w					302-102
R480	8030-up	120 k	½ w					302-124
R481	101-8029	1 k	½ w					302-102
R481	8030-up	120 k	½ w					302-124
R482	X8030-up	120 k	½ w					302-124
R484		30 k	8 w			WW	5%	308-105
R485		30 k	8 w			WW	5%	308-105
R487		30 k	8 w			WW	5%	308-105
R490		800 k	½ w			Prec.	1%	309-110
R491	101-1279	100 k	½ w			Prec.	1%	309-045
	1280-1351	78 k	½ w			Prec.	1%	309-168
	1352-up	100 k	½ w			Prec.	1%	309-045
R493		250 k	2 w	Var.		Comp.	Min Gain Adj.	Use 311-032
R495		800 k	½ w			Prec.	1%	309-110
R496		150 k	½ w			Prec.	1%	309-049
R498	101-1279	100 k	½ w			Prec.	1%	309-045
	1280-1351	78 k	½ w			Prec.	1%	309-168
	1352-up	100 k	½ w			Prec.	1%	309-045
R601		50 Ω		Var.		WW	SCALE ILLUM.	311-055
R602		100 k	½ w					302-0104-00
R603		270 k	1 w					304-274
R604		33 k	½ w				5%	301-333

Resistors *(cont)*

							Tektronix Part Number
R606		1 meg	½ w				302-105
R607		1 k	½ w				302-102
R609		1 k	½ w				302-102
R611		4.5 k	10 w		WW	5%	308-021
R613		1 meg	½ w		Prec.	1%	309-014
R617		490 k	½ w		Prec.	1%	309-002
R621		33 k	½ w				302-333
R622		33 k	½ w				302-333
R624		470 k	½ w				302-474
R626		1.5 meg	½ w				302-155
R627		1 k	½ w				302-102
R628		1 k	½ w				302-102
R630		1 k	½ w				302-102
R632		470 k	½ w				302-474
R634		750 Ω	20 w		WW	5%	308-030
R636		333 k	1 w		Prec.	1%	310-056
R638		490 k	1 w		Prec.	1%	310-057
R642		33 k	½ w				302-333
R644	101-12259	470 k	½ w				302-474
R644	12260-up	100 k	½ w				302-0104-00
R646		1 k	½ w				302-102
R648		100 k	½ w			5%	301-104
R649		1.5 k	½ w			5%	301-152
R650		33 k	½ w				302-333
R652		2.2 meg	1 w				304-225
R654		1 k	½ w				302-102
R655		1 k	½ w				302-102
R656	101-12259	470 k	½ w				302-474
R656	12260-up	100 k	½ w				302-0104-00
R660		2.5 k	10 w		WW	5%	308-018
R662	101-10089	50 k	½ w		Prec.	1%	309-090
R662	10090-up	39.2 k	½ w	Prec.		1%	323-0346-00
R664		10 k	2 w		WW	—150 V Adj.	311-015
R666	101-10089	68 k	½ w		Prec.	1%	309-042
R666	10090-up	52.3 k	½ w	Prec.		1%	323-0358-00
R710		1 Ω	55 w		WW	5%	308-097
R711		1 Ω	55 w		WW	5%	308-097
R712A		3 Ω					
R712B		5 Ω	55 w		WW	5%	308-099
R712C		10 Ω					
R712D		30 Ω					
R716A		50 Ω	55 w		WW	5%	308-098
R716B		50 Ω					
R718A		50 Ω					
R718B		300 Ω	55 w		WW	5%	308-100
R718C		500 Ω					
R720		1 k	5 w		WW	1%	308-072
R721		3 k	5 w		WW	5%	308-062
R722		5.1 k	2 w			5%	305-512
R723		10 k	1 w				304-103
R724		30 k	1 w			5%	303-303
R725		51 k	1 w			5%	303-513
R730		1 meg	½ w		Prec.	1%	309-014
R731		100 Ω	½ w				302-101
R732		1 meg	½ w		Prec.	1%	309-014
R737		100 k	1 w				304-104

Resistors *(cont)*

							Tektronix Part Number
R802		82 k	1 w				304-823
R805		470 k	½ w				302-474
R808		47 k	½ w				302-473
R809		1.5 k	½ w				302-152
R811		1 k	1 w				304-102
R812		27 k	½ w				302-273
R814		2.2 meg	½ w				302-225
R816		2 meg	2 w	Var.	Comp.	—1700 V Adj.	311-042
R818		3.9 meg	2 w				306-395
R820		3.3 meg	2 w				306-335
R822	101-12419	2 meg	2 w	Var.	Comp.	FOCUS	311-043
R822	12420-up	2 meg		Var.		FOCUS	311-0043-02
R824		1.5 meg	2 w				306-155
R826	101-12419	2 meg	2 w	Var.	Comp.	INTENSITY	311-043
R826	12420-up	2 meg		Var.		INTENSITY	311-0043-02
R828		27 k	½ w				302-273
R834		50 k	2 w	Var.	Comp.	ASTIG.	311-023
R838		100 k	2 w	Var.	Comp.	Geom. Adj.	311-026

Switches

				Wired	Unwired
SW114	101-11489	Lever	STEPS/SEC		260-195
SW114	11490-up	Lever	STEPS/SEC		260-0195-01
SW145	101-11869	Lever	SINGLE FAMILY, REPETITIVE, OFF		260-190
SW145	11870-up	Lever	SINGLE FAMILY, REPETITIVE, OFF		260-0190-02
SW240	101-1088	Rotary	Base Step Gen. POLARITY		Use *050-021
	1089-up	Rotary	Base Step Gen. POLARITY		Use 260-0258-01
SW246		Rotary	STEP SELECTOR	*262-135	Use *260-0182-01
SW248		Rotary	SERIES RESISTOR	Use *262-673	Use *260-0183-01
SW249	101-11509	Lever	ZERO VOLTS-ZERO CURRENT	*262-164	*260-196
SW249	11510-up	Lever	ZERO VOLTS-ZERO CURRENT	*262-0164-00	260-0196-01
SW305	101-821	Rotary	HORIZONTAL VOLTS/DIV.	Use *050-104	Use *260-0184-01
	822-3659	Rotary	HORIZONTAL VOLTS/DIV.	Use *050-104	Use *260-0184-01
	3660-6054	Rotary	HORIZONTAL VOLTS/DIV.	Use *050-104	Use 260-0184-01
	6055-up	Rotary	HORIZONTAL VOLTS/DIV.	*262-494	Use *260-0184-01
SW340		Lever	Horiz. AMP. CAL.	*262-165	*260-198
SW405	101-792	Rotary	VERTICAL VOLTS/DIV. or CURRENTS/DIV.	*262-138	*260-185
	793-821	Rotary	VERTICAL VOLTS/DIV. or CURRENT/DIV.	Use *050-162	*260-185
	822-860	Rotary	VERTICAL VOLTS/DIV. or CURRENTS/DIV.	*262-189	Use *260-0243-01
	861-3659	Rotary	VERTICAL VOLTS/DIV. or CURRENTS/DIV.	*262-202	Use *260-0243-01
	3660-up	Rotary	VERTICAL VOLTS/DIV. or CURRENTS/DIV.	*262-417	Use *260-0243-01
SW432A	X861-up	SPST Push	(Normally closed)		260-248
SW432B	X861-up	SPST Push	(Normally open)		260-247
SW440		Lever	Vertical AMP. CAL.		260-198
SW601		Toggle	POWER		260-134
SW602	X861-up	Circuit Breaker	0.8 amp		260-249
SW706		Rotary	PEAK VOLTS RANGE		Use *260-0180-01
SW708		Rotary	Collector Sweep POLARITY		Use *260-0179-01
SW710		Rotary	DISSIPATION LIMITING RESISTOR	*262-134	Use *260-0181-01
SW730	101-5909	Lever	TRANSISTOR A—TRANSISTOR B		Use *050-070
SW730	5910-up	Lever	TRANSISTOR A—TRANSISTOR B		260-463
SW735		Rotary	BASE GROUNDED—EMITTER GROUNDED		Use *260-0189-01

Thermal Cut-out

			Tektronix Part Number
TK601		Thermal Cut-out, off at 128°	260-0070-00

Transformers

T601		L.V. Power		Use *120-0095-01
T701	101-12196	Variable-voltage	PEAK VOLTS	120-089
T701	12197-up	Variable-voltage	PEAK VOLTS	120-0476-00
T702		Collector Sweep		*120-094
T801†		CRT Supply		*120-093

Electron Tubes

V104		6AN8	154-078
V112		6AL5	154-016
V124		6AN8	154-078
V132		6AL5	154-016
V143		12AT7	154-039
V152		6AL5	154-016
V155		6AN8	154-078
V163		6AN8	154-078
V171	101-11199	6AU6	154-022
V171	11200-up	8425/6AU6	154-0022-07
V172		6AL5	154-016
V214†† } V224†† }		8426, aged	Use *157-0050-00
V233		12AU7	154-041
V254†† } V264†† }		8426, aged	Use *157-0050-00
V344†† } V354†† }		8426, aged	Use *157-0050-00
V364	101-10429	6AU6	154-0022-00
V364	10430-up	8425	154-0022-07
V374	101-10429	6AU6	154-0022-00
V374	10430-up	8425	154-0022-07
V384		6CG7	154-134
V444†† } V454†† }		8426, aged	Use *157-0050-00
V464	101-10429	6AU6	154-022
V464	10430-up	8425	154-0022-07
V474	101-10429	6AU6	154-022
V474	10430-up	8425	154-0022-07
V484		6CG7	154-134
V602		6BW4	154-119
V604		6AU6	154-022

†Furnished as a unit with C809.

††Selected pair. Furnished as a unit.

Electron Tubes *(cont)*

			Tektronix Part Number
V607		12B4	154-044
V624		6AU6	154-022
V627		6080	154-056
V642		6BW4	154-119
V644		6AN8	154-078
V649		5651	154-052
V657		12B4	154-044
V733		6AU6	154-022
V804		12AU7	154-041
V810		6AQ5	154-017
V812		5642	154-051
V822		5642	154-051
V859†	101-1351	T0520-31 CRT Standard Phosphor	Use *154-0343-00
V859	1352-up	T0520-31 CRT Standard Phosphor	Use *154-0343-00

Transistors

Q243	2N2148	Use 151-137
Q253	2N277	151-002

†S/N 101-1351 add *050-218 Kit.

Electrical Parts List
Type 175

Bulbs

		Tektronix Part Number
B231	Neon, NE-2	Use 150-0027-00
B266	Neon, NE-2	Use 150-0027-00
B601	Incandescent #47	150-001

Capacitors

Values fixed unless marked Variable.

Tolerance ±20% unless otherwise indicated.

C232	.001 μf	PTM	600 v	285-501
C238	.015 μf	PTM	400 v	285-512
C267	.001 μf	PTM	600 v	285-501
C620	2000 μf	EMC	30 v	Use 290-0086-00
C621	20,000 μf	EMC	30 v	290-131
C650	6.25 μf	EMT	300 v	290-025
C653	6.25 μf	EMT	300 v	290-025

Fuses

F601	3 Amp	3 AG	Slo-Blo	117 V oper.	50-60 cycle	159-005
F601	1.6 Amp	3 AG	Slo-Blo	234 V oper.	50-60 cycle	159-003
F602	3 Amp	3 AG	Slo-Blo	117 V oper.	50-60 cycle	159-005
F602	1.6 Amp	3 AG	Slo-Blo	234 V oper.	50-60 cycle	159-003

Resistors

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

R201		15 k		Var.		Volts/Step Adj.	Use 311-0571-00
R202		82 k	½ w		Prec.	1%	309-043
R203		3 k	½ w		Prec.	1%	309-182
R204	101-239	68 Ω	½ w				302-680
R204	240-up	200 Ω		Var.		+Step Adj.	311-158
R206		600 k	½ w		Prec.	1%	309-004
R207		100 k		Var.		STEP ZERO	311-026
R210		500 k	½ w		Prec.	1%	Use 309-140
R215		47 k	½ w				302-473
R216		4.7 k	½ w				
R217		20 k		Var.		Zero Adj.	311-018
R218		47 k	½ w				302-473
R222		150 k	½ w				302-154
R224		1 k	½ w				302-102
R231		1.5 meg	½ w				302-155
R232		100 k	½ w				302-104
R233		1 k	½ w				302-102
R235	101-764	22 k	2 w				306-223
R235	765-up	15 k	5 w		WW	5%	308-0108-00
R238		1.5 k	½ w				302-152
R241		500 Ω	5 w			1%	308-071
R242A-D		0.25 Ω	1 w		WW		(4) *308-090

Resistors *(cont)*

							Tektronix Part Number
R243A,B		125 Ω	25 w		WW	5%	(2) 308-035
R244A		0.5 Ω	50 w	Base Step			*308-182
R244B		1.25 Ω	20 w				
R244C		2.5 Ω	10 w				
R244D		5 Ω	8 w		Prec.	1%	*310-569
R244E		12.5 Ω	4 w		Prec.	1%	*310-576
R244F		500 Ω	½ w		Prec.	1%	309-179
R244G		250 Ω	½ w		Prec.	1%	309-178
R244H		100 Ω	½ w		Prec.	1%	309-112
R244J		50 Ω	½ w		Prec.	1%	309-128
R244K		25 Ω	½ w		Prec.	1%	309-177
R244L		10 Ω	4 w		Prec.	1%	*310-570
R244M		5 Ω	8 w		Prec.	1%	*310-569
R244N		2.5 Ω	10 w	Furnished with R244A,B,C			*308-182
R244P		1 Ω	25 w				
R244Q		0.5 Ω	50 w				
R244R		1 k	½ w				302-102
R244S		1 k	½ w				302-102
R245A		1 k	½ w		Prec.	1%	309-115
R245B		500 Ω	½ w		Prec.		
R245C		200 Ω	½ w		Prec.	1%	309-073
R245D		100 Ω	½ w		Prec.	1%	309-112
R245E		50 Ω	½ w		Prec.	1%	309-128
R245F		19.5 Ω	4 w		Prec.	1%	*310-574
R245G		9.5 Ω	4 w		Prec.	1%	*310-573
R245H		4.5 k	8 w		Prec.	1%	*310-575
R245J		1.5 Ω	8 w		Prec.	1%	*310-572
R245K		.5 Ω	8 w		Prec.	1%	*310-571
R246		.478 Ω	8 w	Furnished with R244A,B,C			*308-182
R251		1 k	½ w				302-102
R254		47 k	½ w				302-473
R255		4.7 k	½ w				302-472
R256		20 k		Var.		±Adj.	311-018
R257		47 k	½ w				302-473
R261		150 k	½ w				302-154
R264	101-179	470 k	½ w				Use 309-140
R264	180-up	500 k	½ w			1%	309-140
R266		1.5 meg	½ w				302-155
R267		100 k	½ w				302-104
R268		1 k	½ w				302-102
R269		47 k	1 w				304-473
R273		430 Ω	½ w			5%	301-431
R274	101-179	100 Ω	½ w				Use 301-101
R274	180-up	100 Ω	½ w			5%	301-101
R275	101-179	10 k	½ w				Use 309-121
R275	180-up	9.5 k	½ w		Prec.	1%	309-121
R315A		1.11 k	½ w		Prec.	1%	309-284
R315B		1.11 k	½ w		Prec.	1%	309-284
R315C		3.37 k	½ w		Prec.	1%	309-320
R315D		5.64 k	½ w		Prec.	1%	309-321
R315E		11.480 k	½ w		Prec.	1%	309-192
R315F		34.5 k	½ w		Prec.	1%	309-038
R315G		54 k	½ w		Prec.	1%	309-322
R316A		1.11 k	½ w		Prec.	1%	309-284

Resistors (cont)

						Tektronix Part Number
R316B		1.11 k	½ w	Prec.	1%	309-284
		3.37 k	½ w	Prec.	1%	309-320
R316D		5.64 k	½ w	Prec.	1%	309-321
R316E		11.48 k	½ w	Prec.	1%	309-192
R316F		34.5 k	½ w	Prec.	1%	309-038
R316G		54 k	½ w	Prec.	1%	309-322
R415A		10 Ω	Current Measuring			*308-181
R415B		5 Ω				
R415C		3 Ω				
R415D		1 Ω				
R415E		0.5 Ω				
R415F		0.3 Ω	Current Measuring Shunt			*308-180
R415G		0.1 Ω				
R415H		.05 Ω				
R415J		.03 Ω				
R415K		.01 Ω				
R415L		.005 Ω				
R415M		.005 Ω				
R501		500 Ω	10 w	WW		*308-183
R502		500 Ω	10 w	WW		*308-183
R506		500 Ω	10 w	WW		*308-183
R507		500 Ω	10 w	WW		*308-183
R510		120 Ω	5 w	WW	5%	308-163
R650		47 Ω	½ w			302-470
R653		47 Ω	½ w			302-470
R720		300 Ω	50 w	Furnished with R415A,D		*308-181
R740		100 Ω	½ w			302-101

Diodes

D610		1N1563A	152-035
D611		1N1563A	152-035
D616		1N1563A	152-035
D617		1N1563A	152-035
D620		1N1563A	152-035
D621		1N1563A	152-035
D622	X727-up	Silicon Replaceable by 1N1200	*152-0274-00
D623	X727-up	Silicon Replaceable by 1N1200	*152-0274-00
D710		45L10	152-028
D711		45L10	152-028
D716		TR351	152-029
D717		TR351	152-029

Transistors

Q233	101-569	2N250	151-018
Q233	570-up	2N2148	151-0137-00
Q243A		2N277	151-002
Q243B		2N277	151-002
Q243C		2N277	151-002
Q243D		2N277	151-002
Q620	101-726X	2N554	151-034
Q621	101-726X	2N554	151-034

Switches

			Tektronix Part Number Wired	Unwired
SW241		BASE POLARITY		*260-365
SW244		STEP SELECTOR	*262-382	*260-363
SW245		SERIES RESISTANCE	*262-383	*260-355
SW247		ZERO CURRENT; ZERO VOLTS		*260-339
SW315		HORIZONTAL DISPLAY; VOLTS/DIV.	*262-384	*260-364
SW415		VERT. DISP; COLLECTOR CURRENT/DIV.		*260-338
SW510	101-392	TRANSISTOR SELECTOR		Use *050-0208-00
SW510	393-up	TRANSISTOR SELECTOR		260-0636-00
SW601		POWER ON		260-199
SW603		115V Relay, SPST 20 amp		148-015
SW630		COLLECTOR SWEEP POLARITY		*260-366
SW701		CIRCUIT BREAKER		*260-337
SW720		PEAK VOLTS RANGE		*260-367
SW721		12V Relay, SPST 100 amp		148-014
SW731		12V Relay, SPST 100 amp		148-014
SW732		12V Relay, SPST 100 amp		148-014
SW735		12V Relay, SPST 100 amp		148-014
SW736		12V Relay, SPST 100 amp		148-014
SW741		12V Relay, SPST 100 amp		148-014
SW742		12V Relay, SPST 100 amp		148-014

Thermal Cutout

TK601	Thermal Cutout 123°	260-246

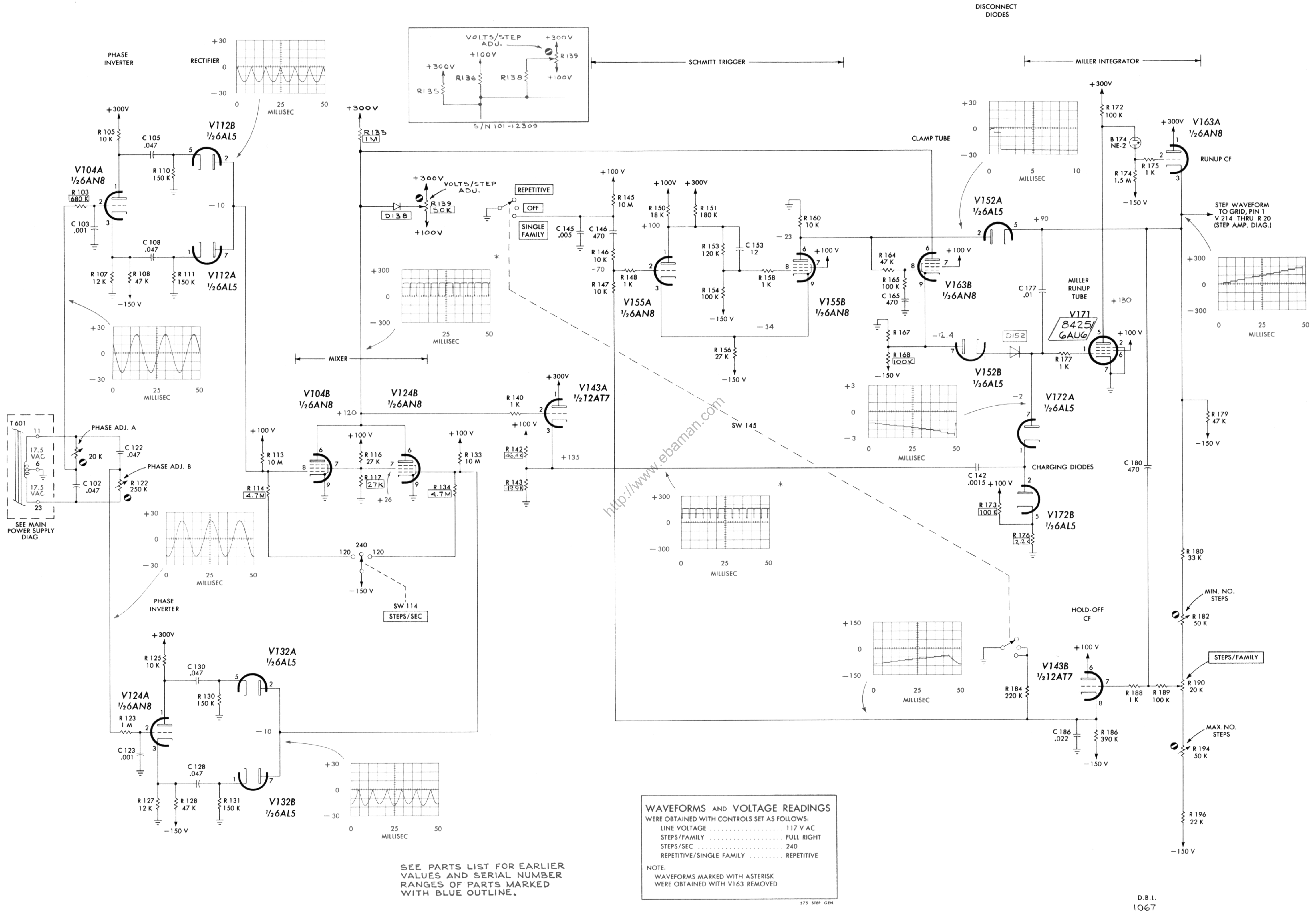
Transformers

T601	Base Step Power	*120-196
T701	Variable Auto	*120-189
T702	Collector Power	*120-197

Electron Tubes

V214 † / V224 †	8425 checked	Use *157-059
V233	6DJ8	154-187
V254 † / V264 †	8425 checked	Use *157-059

† Furnished as a unit.



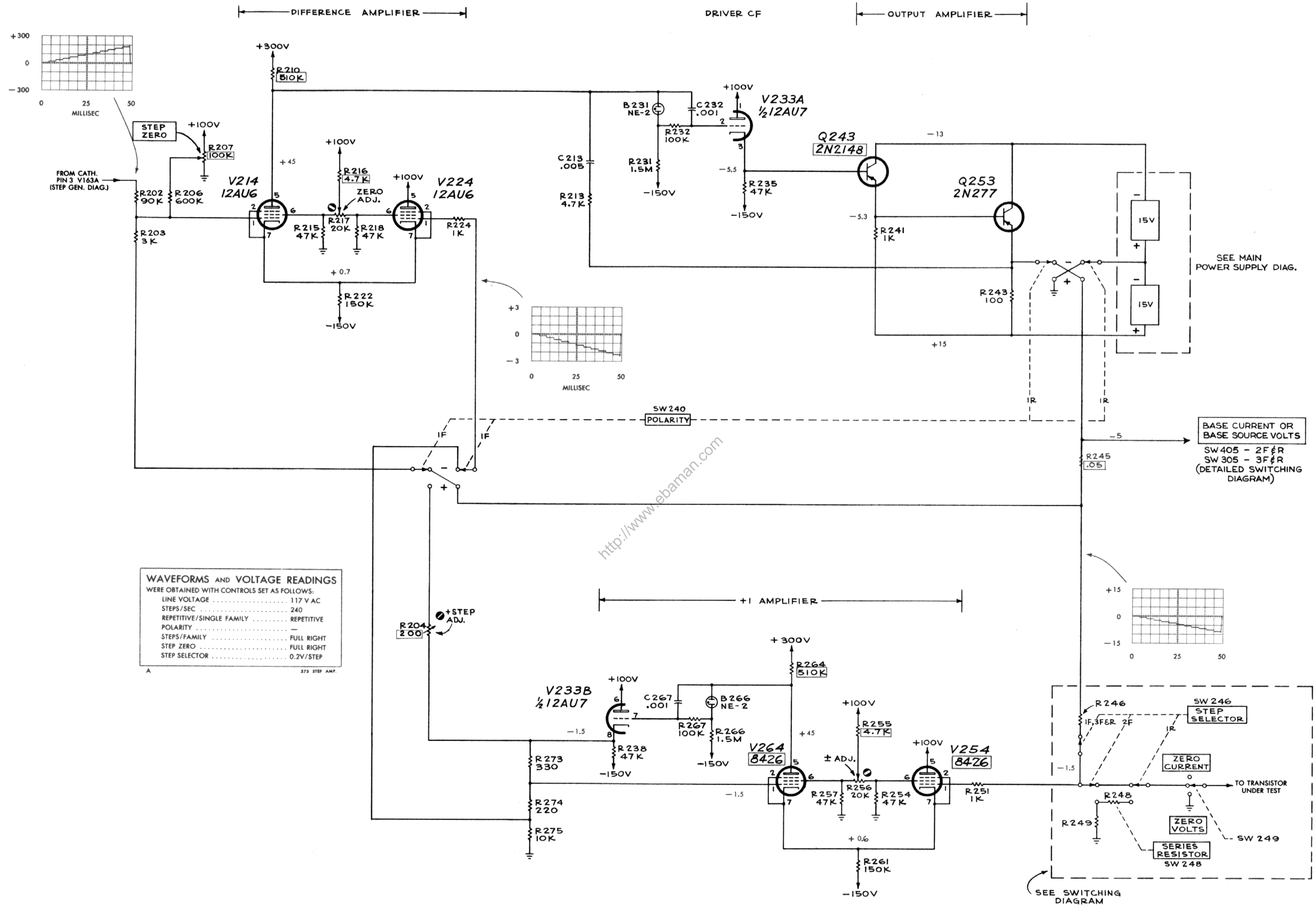
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

WAVEFORMS AND VOLTAGE READINGS
WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

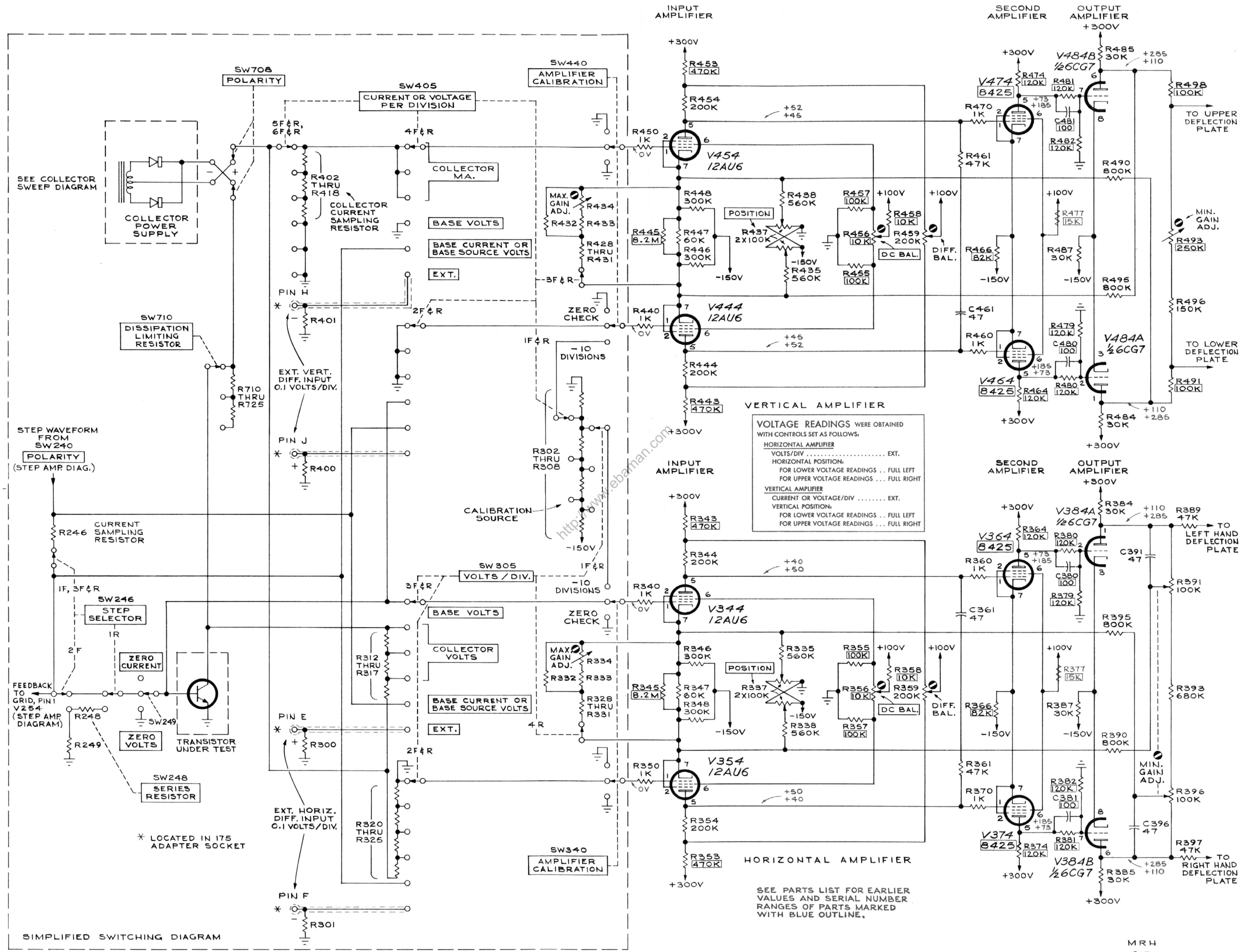
LINE VOLTAGE	117 V AC
STEPS/FAMILY	FULL RIGHT
STEPS/SEC	240
REPETITIVE/SINGLE FAMILY	REPETITIVE

NOTE:
WAVEFORMS MARKED WITH ASTERISK WERE OBTAINED WITH V163 REMOVED

575 STEP GEN.



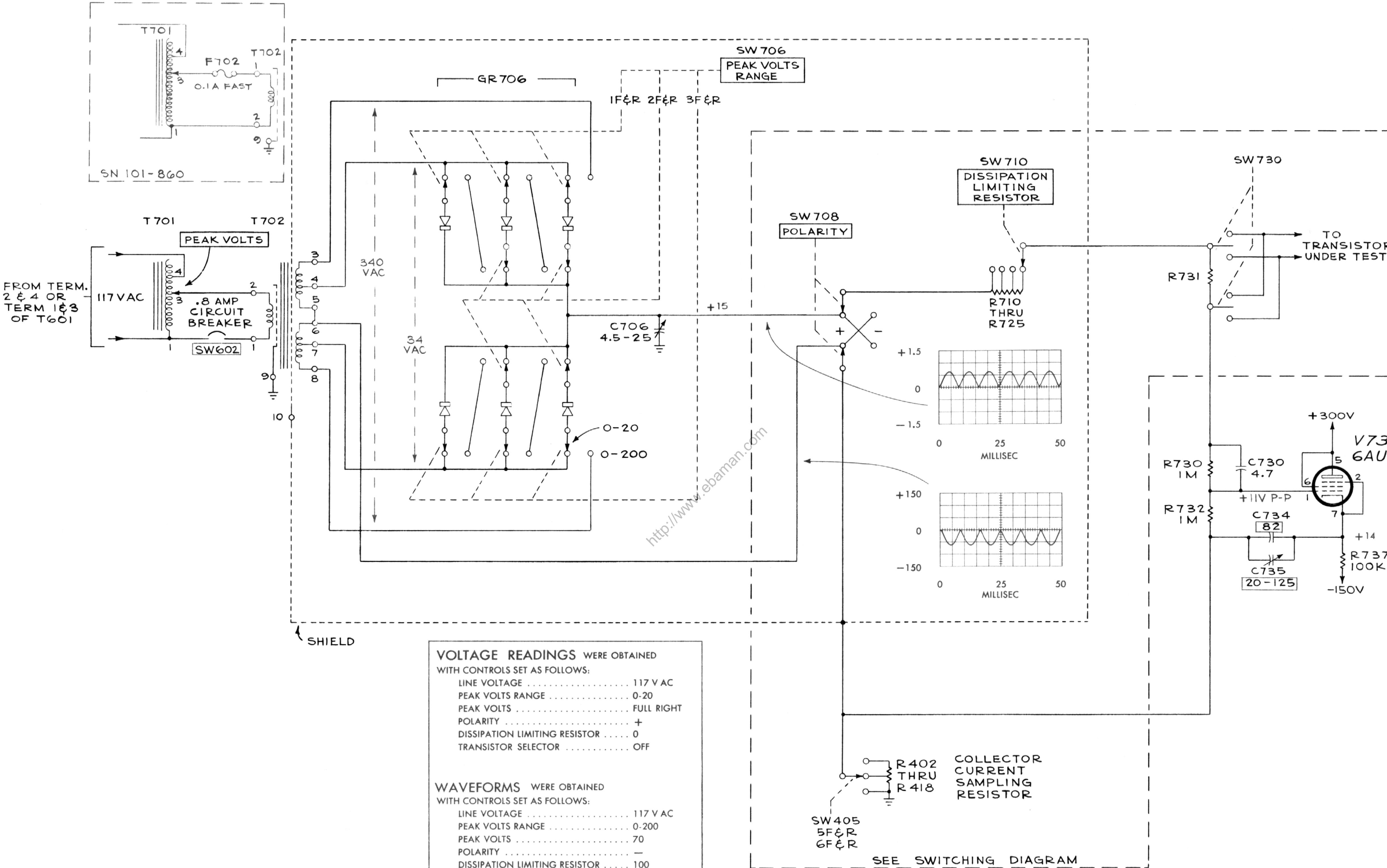
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.



TYPE 575 TRANSISTOR-CURVE TRACER

AF

HORIZONTAL & VERTICAL AMPLIFIERS



VOLTAGE READINGS WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

LINE VOLTAGE	117 V AC
PEAK VOLTS RANGE	0-20
PEAK VOLTS	FULL RIGHT
POLARITY	+
DISSIPATION LIMITING RESISTOR	0
TRANSISTOR SELECTOR	OFF

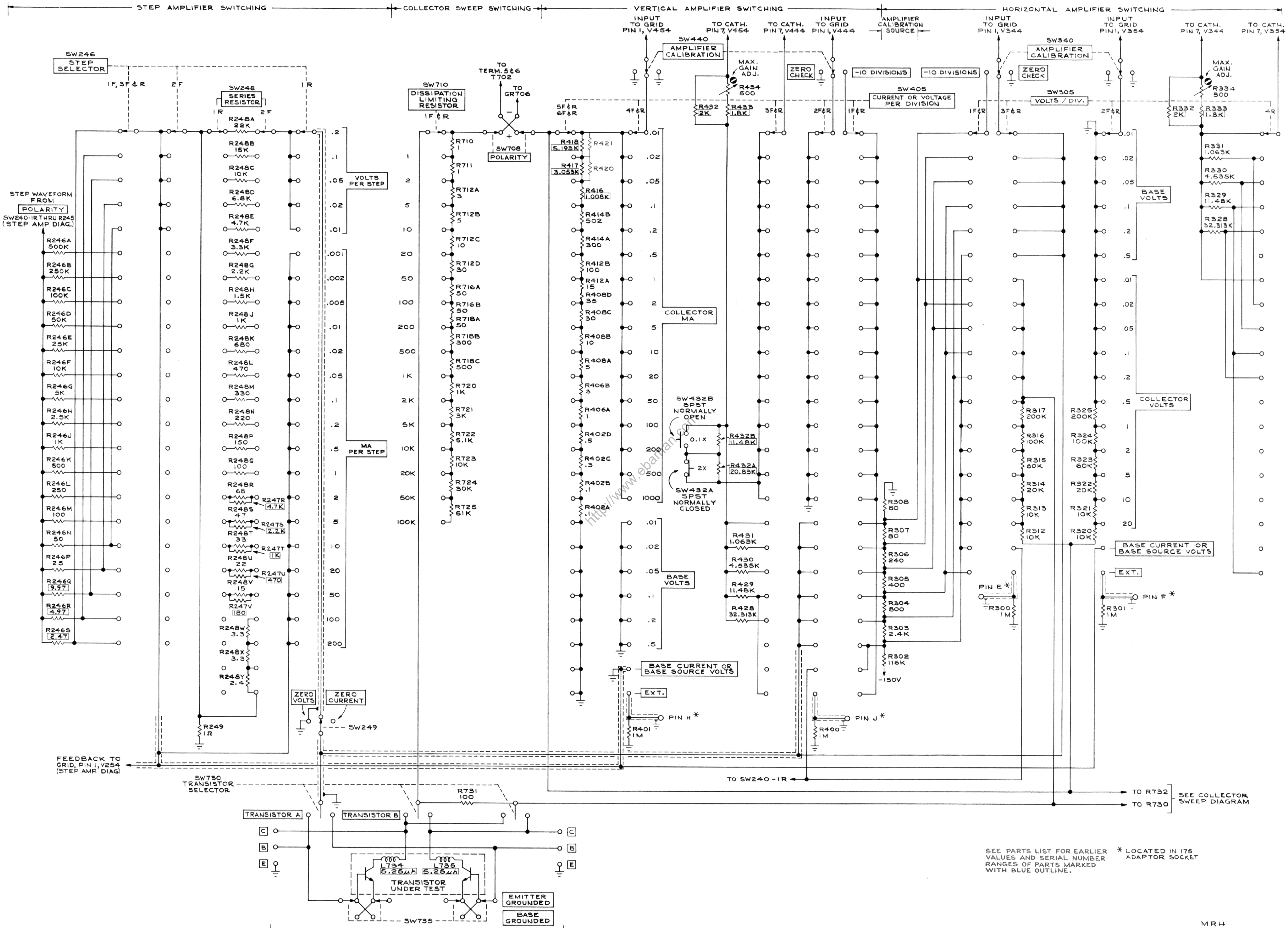
WAVEFORMS WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

LINE VOLTAGE	117 V AC
PEAK VOLTS RANGE	0-200
PEAK VOLTS	70
POLARITY	—
DISSIPATION LIMITING RESISTOR	100
CURRENT OR VOLTAGE/DIV	100 MA
TRANSISTOR SELECTOR	TRANSISTOR A
TERMINAL C	GROUNDED

575 COLL. SWP.

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

GAB 964

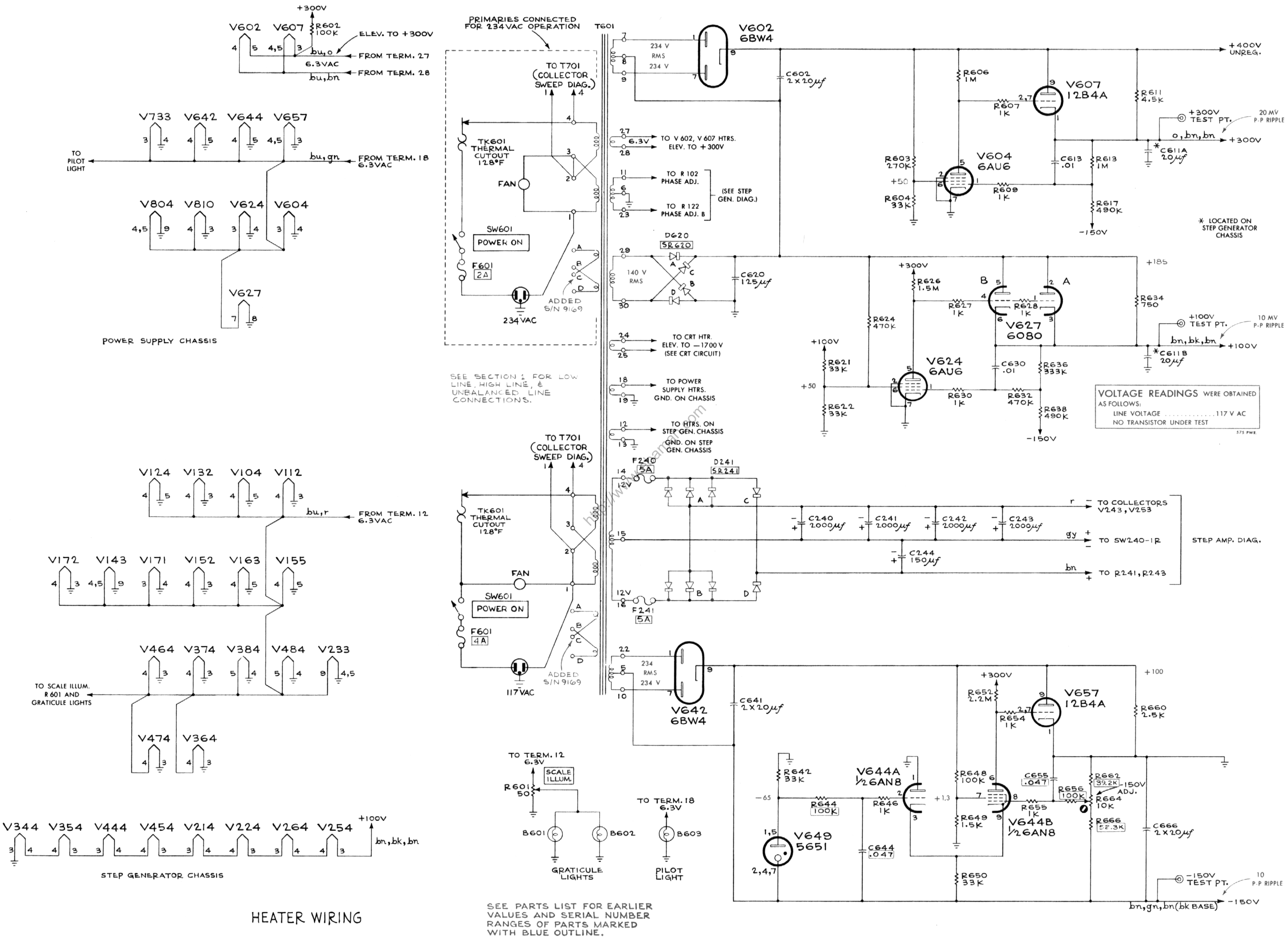


TYPE 575 TRANSISTOR-CURVE TRACER

AE

MRH 764

DETAILED SWITCHING DIAGRAM



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

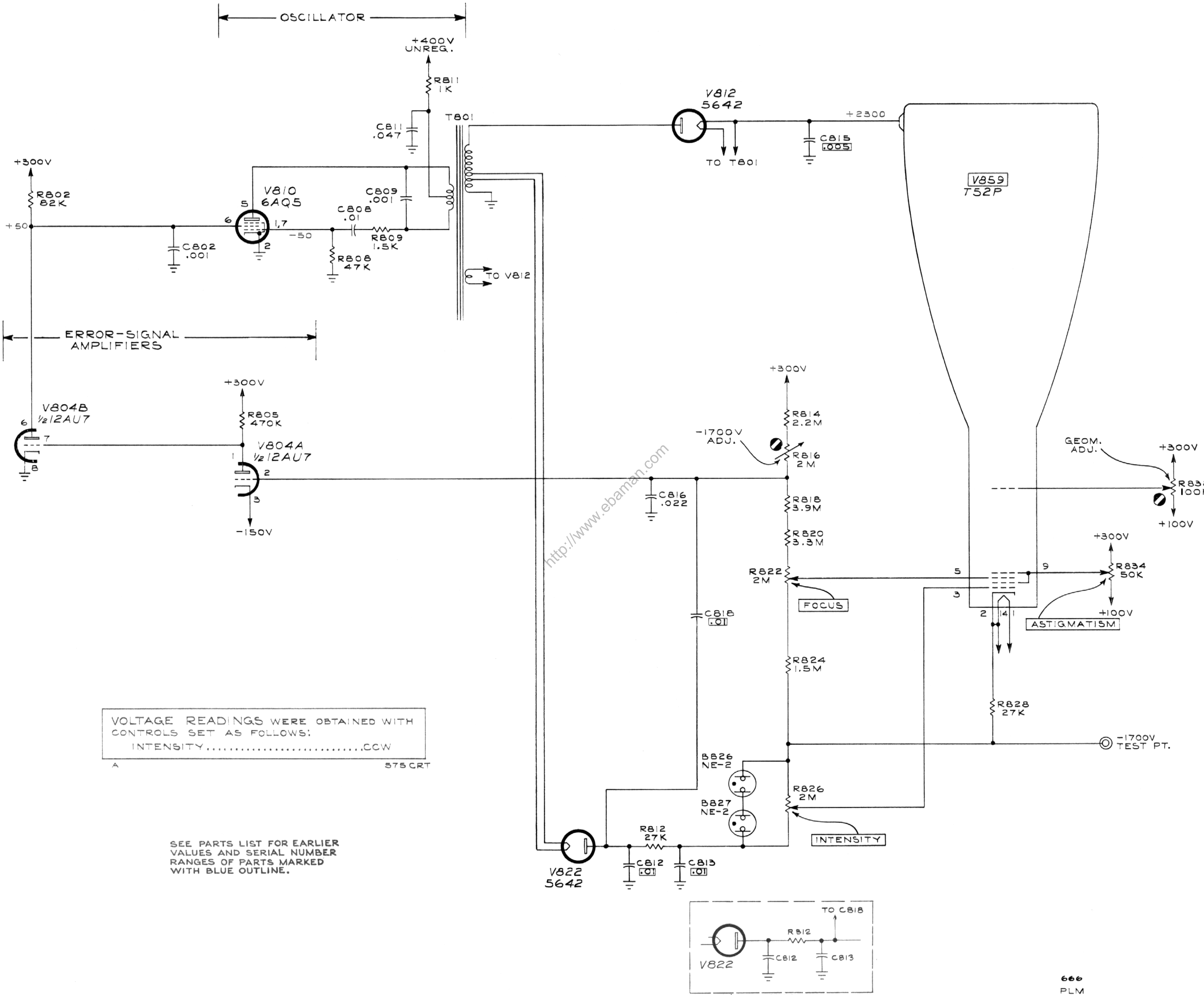
HEATER WIRING

MAIN POWER SUPPLY

T.D.B. 1067

TYPE 575 TRANSISTOR-CURVE TRACER

AG1



VOLTAGE READINGS WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:
INTENSITY..........................CCW

A 575 CRT

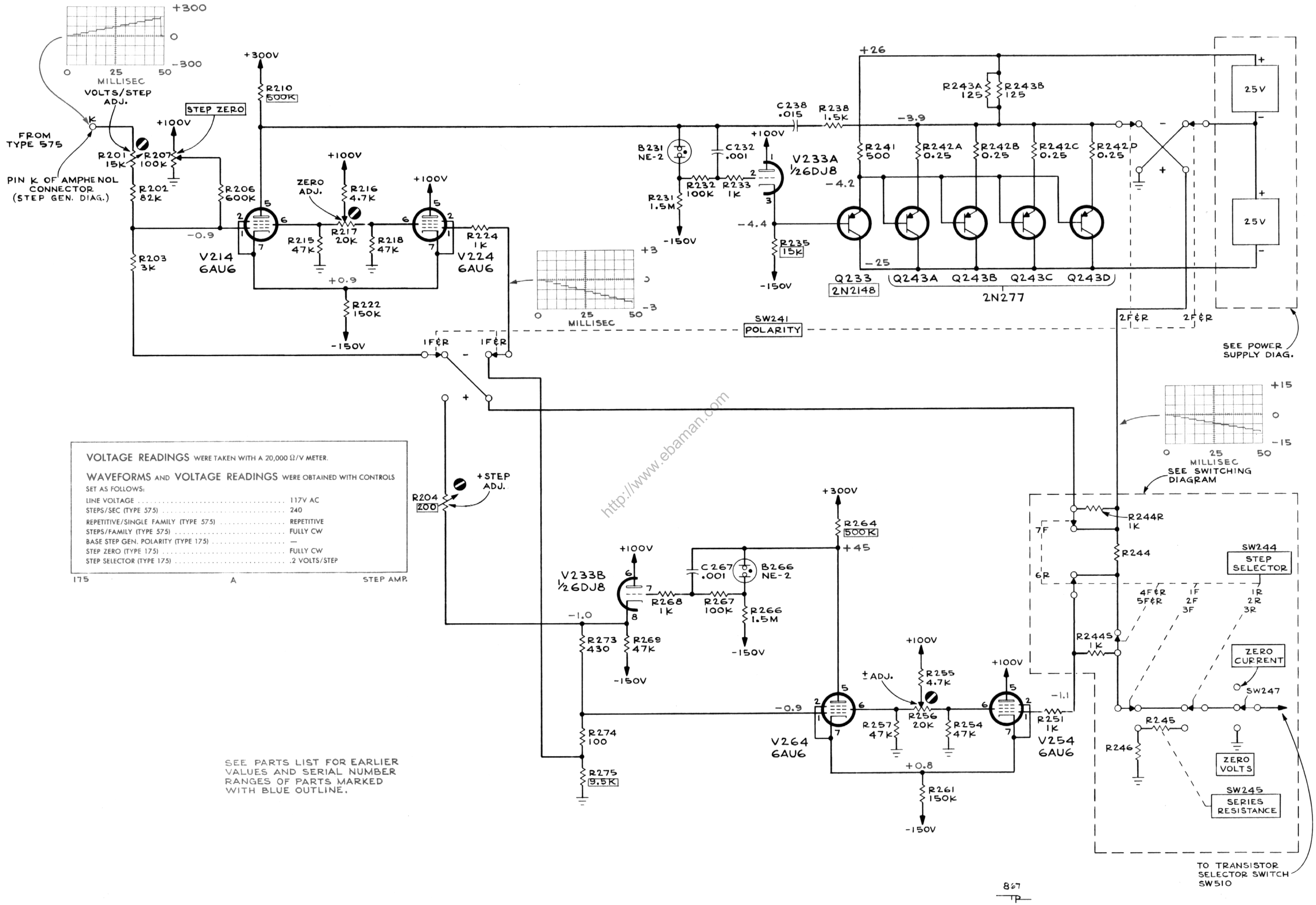
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

666
PLM

TYPE 575 TRANSISTOR-CURVE TRACER

AD1

CRT CIRCUIT



VOLTAGE READINGS WERE TAKEN WITH A 20,000 Ω/V METER.

WAVEFORMS AND VOLTAGE READINGS WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

LINE VOLTAGE	117V AC
STEPS/SEC (TYPE 575)	240
REPETITIVE/SINGLE FAMILY (TYPE 575)	REPETITIVE
STEPS/FAMILY (TYPE 575)	FULLY CW
BASE STEP GEN. POLARITY (TYPE 175)	—
STEP ZERO (TYPE 175)	FULLY CW
STEP SELECTOR (TYPE 175)	.2 VOLTS/STEP

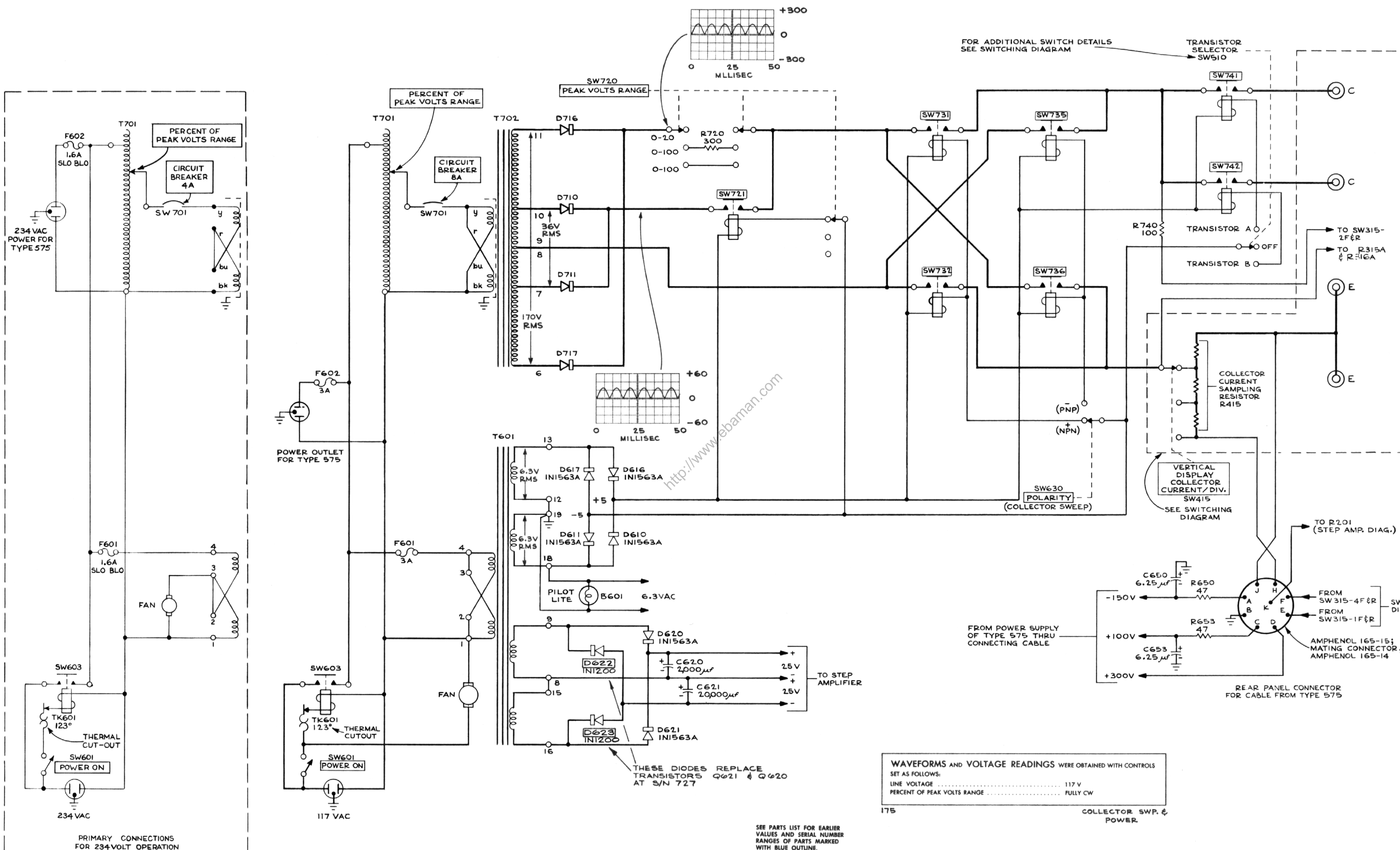
175 A STEP AMP.

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

867 TP

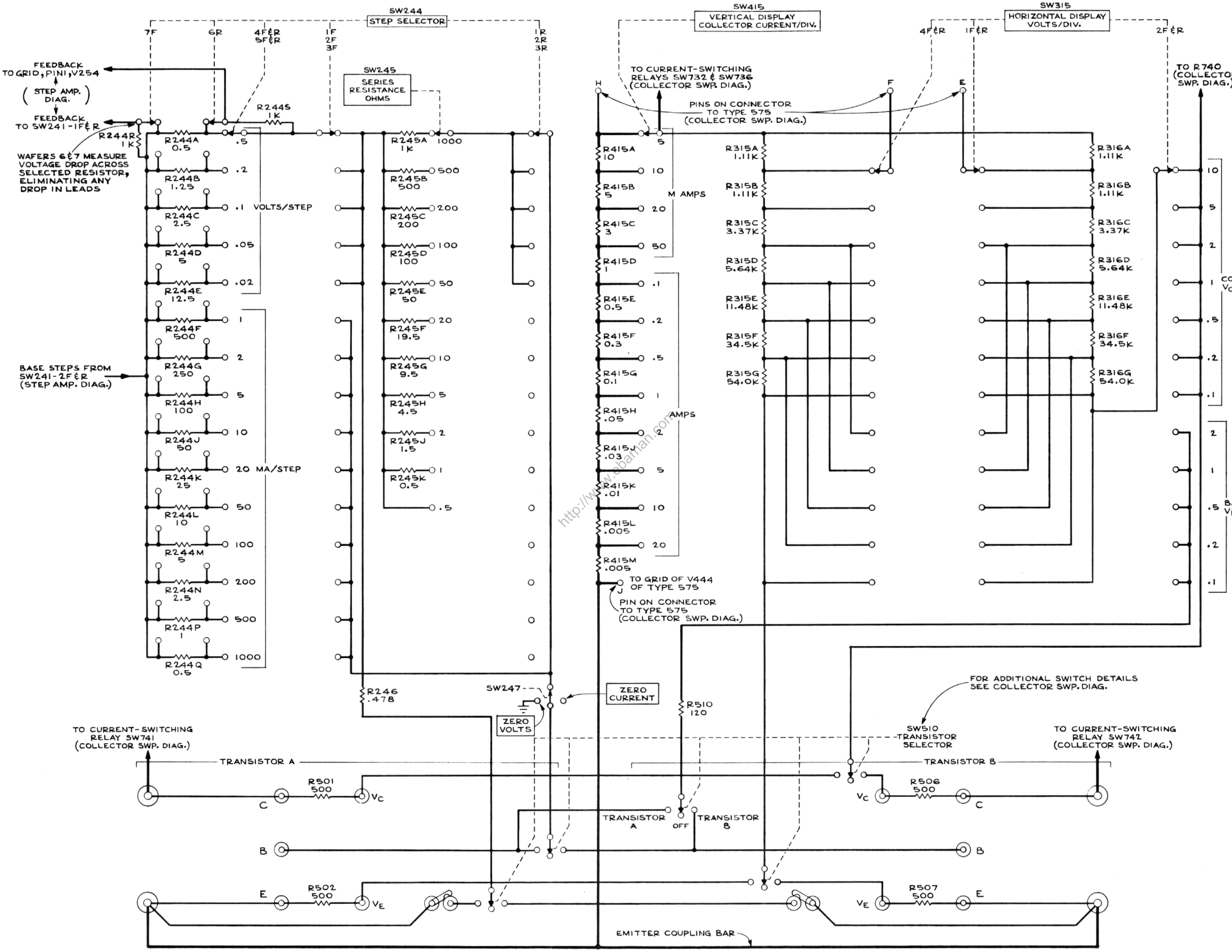
TYPE 175 TRANSISTOR-CURVE TRACER HIGH-CURRENT ADAPTOR D

STEP AMPLIFIER



TYPE 175 TRANSISTOR-CURVE TRACER HIGH-CURRENT ADAPTOR

COLLECTOR SWEEP & POWER SUPPLIES



TYPE 175 TRANSISTOR-CURVE TRACER HIGH-CURRENT ADAPTOR A3

03-21-62

SWITCHING DIAGRAM

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.

A single change may affect several sections. Sections of the manual are often printed at different times, so some of the information on the change pages may already be in your manual. Since the change information sheets are carried in the manual until ALL changes are permanently entered, some duplication may occur. If no such change pages appear in this section, your manual is correct as printed.

TEXT CORRECTION

Page 5-1 Recalibration Procedure

Calibrating the -150 V supply

CHANGE: paragraph 4a. to read:

Turn the instrument on and allow a ten minute warm-up period. After the ten minute warm-up period, switch the Horizontal AMPLIFIER CALIBRATION switch to -10 DIVISIONS and connect the precision voltmeter between pin 1 of V344 and ground. Set the Horizontal VOLTS/DIV switch to 0.1 BASE VOLTS. Adjust -150 V Adj. for exactly -1 V as read on the volt meter. Measure the voltages and record the percentage of error at the other BASE VOLTS switch positions as indicated by TABLE 5-2. These errors will be taken into account when calibrating the vertical and horizontal amplifiers.

TABLE 5-2

HORIZONTAL BASE VOLTS	Correct readings in volts	Max Allowable error
0.2	2	20 mV
0.5	5	50 mV
0.05	0.5	5 mV
0.02	0.2	2 mV
0.01	0.1	1 mV

NOTE

To avoid damage to precision voltmeter, keep the AMPLIFIER CALIBRATION switch in -10 DIVISIONS position as long as the voltmeter is connected to pin 1 of V344.

TEXT CORRECTION

Page 6-6 Maintenance

Checking Switch Resistance

CHANGE: last 5 lines, left column to read:

To perform the measurements, you will need five precision (1%) resistors of the following values and ratings: 100 ohms, 2 watts; 2 ohms, 50 watts; 0.05 ohms, 50 watts; 0.005 ohms, 100 watts; and 10 ohms, 20 watts. These resistors will be referred to by their resistance values only. The set of four resistors containing the five values listed may be ordered from Tektronix, Inc. The Tektronix part number for the set is 015-0042-00.

Page 6-8

REPLACE: TABLE II with the following table:

TABLE II

A	B	C	D	Trace should cross at these intersections	
				E	F
Test Resistor (015-0042-00)	PEAK VOLTS RANGE	Vertical Display	Horizontal Display Vce	Horizontal Div From Left Edge Graticule Line	Vertical Div From Bottom Graticule Line
.005 Ω	0-20	20	.1	10 div	10 div
.005 Ω	0-20	10	.1	5 div	10 div
.05 Ω	0-20	5	.2	10 div	8 div
.05 Ω	0-20	2	.1	10 div	10 div
.05 Ω	0-20	1	.1	5 div	10 div
2 Ω	0-20	.5	1	10 div	10 div
10 Ω	0-100	.2	2	10 div	10 div
10 Ω	0-20	.1	1	10 div	10 div
10 Ω	0-20	.05	.5	10 div	10 div
10 Ω	0-20	.02	.2	10 div	10 div
10 Ω	0-20	.01	.1	10 div	10 div
10 Ω	0-20	.005	.1	5 div	10 div

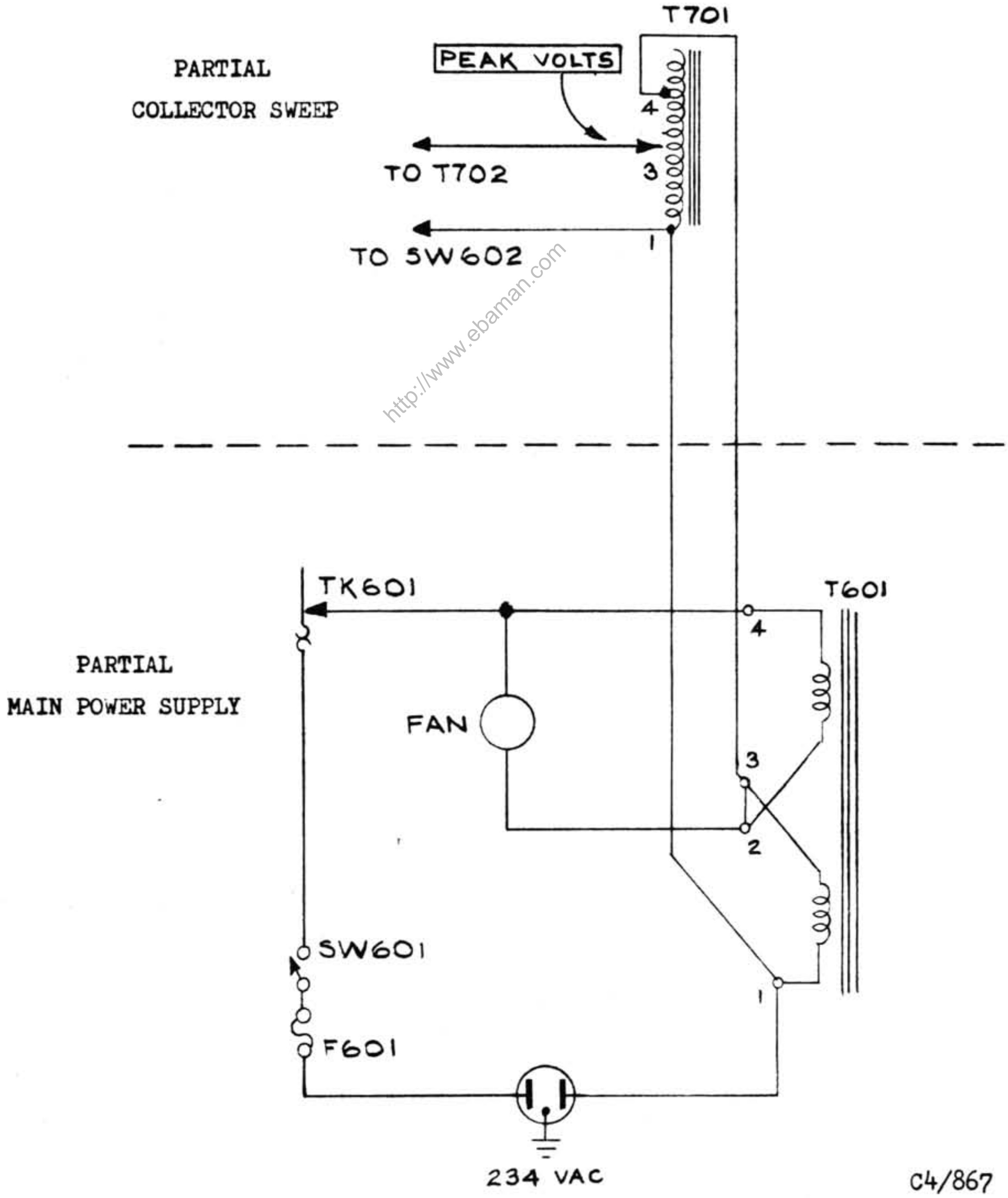
SCHEMATIC CORRECTIONS

COLLECTOR SWEEP-575
MAIN POWER SUPPLY
600 THRU 699

NOTE

When the Type 575 is operated from a 230 volt unbalanced line--one power wire is always close to ground--different connections are required for the Peak Volts Powerstat, T701.

Connect pin 1 of T701 to pin 1 of T601
Connect pin 4 of T701 to pin 3 of T601
Connect one fan lead to pin 2 of T601
Connect the other fan lead to pin 4 of T601



TYPE 575 TENT SN 12420

TYPE 575-122C TENT SN 12430

PARTS LIST CORRECTION

CHANGE TO:

R822	311-0043-02
R826	311-0043-02

TYPE 575 TENT SN 12197

TYPE 575-122C TENT SN 12209

PARTS LIST CORRECTION

CHANGE TO:

T701	120-0476-00	Variable-voltage	PEAK VOLTS

M11,904/867

TYPE 575 TENT SN 12110

TYPE 575-122C TENT SN 12120

PARTS LIST AND SCHEMATIC CORRECTIONS

CHANGE TO:

R345	302-0825-00	8.2 meg	1/2 w	Selected (nominal value)
R445	302-0825-00	8.2 meg	1/2 w	Selected (nominal value)

M12,361/767

TYPE 175 TENT SN 765

SCHEMATIC AND PARTS LIST CORRECTION

CHANGE TO:

R235	308-0108-00	15 K	5 W	5%

M12,459/867

TYPE 575 TENT SN 12310

TYPE 575-122C TENT SN 12330

PARTS LIST CORRECTION

REMOVE:

R136	323-0414-00	200 k	1/2 W	1%
R138	323-0452-00	499 k	1/2 W	1%

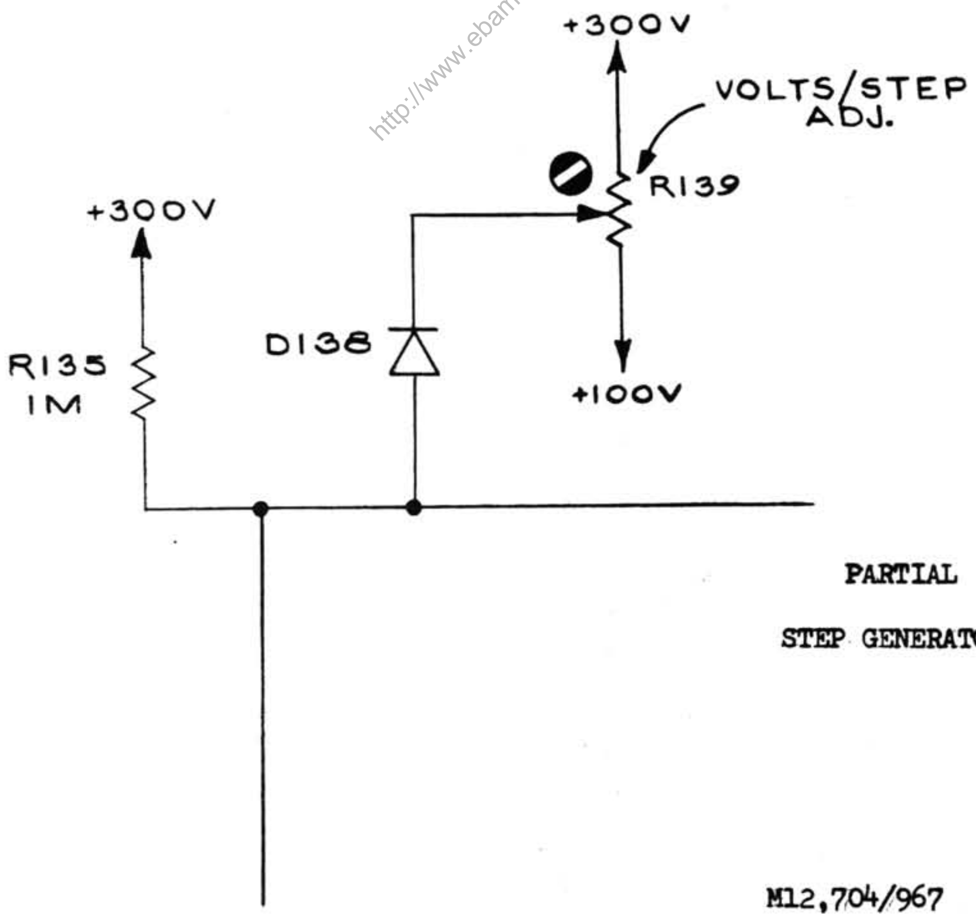
CHANGE TO:

R135	301-0105-00	1 MΩ	1/2 W	5%
R168	302-0104-00	100 k	1/2 W	10%

ADD:

D138	152-0107-00	Silicon	1N647

SCHEMATIC CORRECTION



PARTIAL

STEP GENERATOR

M12,704/967

TYPE 575 TENT SN 12260

TYPE 575-122C TENT SN 12280

PARTS LIST AND SCHEMATIC CORRECTION

CHANGE TO:

C644	285-0519-00	0.047 µF	400 V
C655	285-0519-00	0.047 µF	400 V
R114	302-0475-00	4.7 MΩ	1/2 W
R134	302-0475-00	4.7 MΩ	1/2 W
R644	302-0104-00	100 k	1/2 W
R656	302-0104-00	100 k	1/2 W

M12,715/867

TYPE 175 TENT SN 852

PARTS LIST CORRECTION

CHANGE TO:

SW721	148-0014-01	10 V Relay	50 amp
SW731	148-0014-01	10 V Relay	50 amp
SW735	148-0014-01	10 V Relay	50 amp
SW736	148-0014-01	10 V Relay	50 amp
SW741	148-0014-01	10 V Relay	50 amp
SW742	148-0014-01	10 V Relay	50 amp

M12,894/268

TYPE 175 **TENT SN 880**

PARTS LIST CORRECTION

CHANGE	TO:				
R244J	322-0618-00	50Ω	¼ W	Prec.	1 %
R245E	322-0618-00	50Ω	¼ W	Prec.	1 %

M13,307/868

TYPE 175 TENT SN 860

ELECTRICAL PARTS LIST CORRECTION

CHANGE TO:

T701	120-0578-00	Variable Auto

M13,687/368

TYPE 575 TENT SN 14110

ELECTRICAL PARTS LIST CORRECTION

REMOVE:

R274	301-0221-00	220 Ω	1/2 W	5%

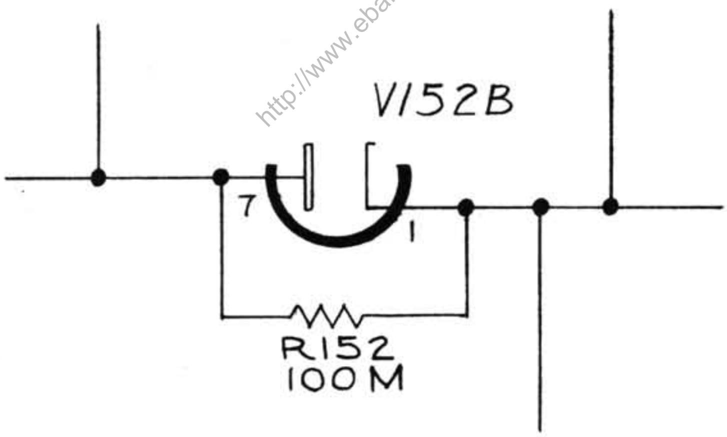
CHANGE TO:

R273	301-0561-00	560 Ω	1/2 W	5%

ADD:

R152	317-0107-00	100 MΩ	1/8 W	5%

SCHEMATIC CORRECTION



PARTIAL
STEP GENERATOR

M14,419/869

ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTION

CHANGE TO:

R243	308-0070-00	300 Ω	5 W	WW	1%

TYPE 175 - TENT. S/N 393

PARTS LIST CORRECTION

CHANGE TO:

SW510	TRANSISTOR SELECTOR	*260-636

M6983/664

SECTION 1 SPECIFICATIONS

Base Step Generator (Page 1-1, Paragraph 3)

CHANGE TO:

5 voltage-step ranges from .01 volt/step to .2 volt/step ±3%, with output impedance adjustable from 1 ohm to 22 thousand ohms ±10%, plus 0.1 ohm (wiring and switch contact resistance).

SECTION 5 RECALIBRATION PROCEDURE

2. Checking the Series Resistor Switch (Page 5-1, Line 6)

CHANGE TO:

(±10%)

9. Horizontal Gain (Page 5-3, Paragraph a.)

CHANGE TO:

Last sentence should read as follows:

If not, alternately adjust the horizontal MIN GAIN ADJ and the Horizontal POSITION control until the deflection is exactly 10 divisions.

Type 175 Tent. S/N 570

PARTS LIST CORRECTION

Change to:

Q233	151-0137-00	2N2148

MODIFICATION KIT

SILICON RECTIFIER

For Tektronix Type 575 Transistor-Curve Tracer
Serial numbers 101-4929

040-0223-00

DESCRIPTION

This modification replaces the selenium rectifiers with silicon rectifiers. Silicon rectifiers offer more reliability and longer life.

The following selenium rectifiers are replaced: SR241 (part number 106-0043-00); SR620 (106-0044-00).

Publication:
Instructions for 040-0223-00
March 1966

Supersedes:
December 1965

PARTS LIST

Quantity	Description				Part Number
1 ea	Assembly, silicon rectifier, consisting of:				
2 ea	Strip, cer, 3/4 x 7 notches, clip-mounted				124-0089-00
6 ea	Diode, silicon,	500-750 mA	400 PIV		152-0066-00
2 ea	Diode, silicon	15 A	100 PIV		152-0088-00
2 ea	Fuse, w/pigtail,	5 A	fast-blo		159-0053 00
1 ea	Lug, solder, SE4, w/2 wire holes				210-0201-00
1 ea	Grommet, rubber, 1/4"				348-0002-00
4 ea	Spacer, nylon-molded, 0.156				361-0008-00
1 ea	Bracket, silicon rectifier mounting				406-0815-00
1 ea	Wire, #20 solid,	4 in.	white-red		(175-0510-00)
3 ea	Washer, flat, 6L x 3/8				210-0803-00
3 ea	Screw, 6-32 x 5/16 PHS, Phillips				211-0507-00
2 ea	Screw, 4-40 x 1/4 PHS, thread-forming type B, Phillips				213-0088-00
1 ea	Spool, w/3 ft. silver-bearing solder				214-0210-00

INSTRUCTIONS

IMPORTANT: When soldering to the ceramic strips, use the silver-bearing solder supplied with this kit.

( ) 1. Remove the air filter from the rear of the instrument.

( ) 2. Remove the six screws which hold the fan ring to the rear panel and move the fan assembly to one side. Do not unsolder the two fan motor leads.

( ) 3. Unsolder all the wires from the selenium rectifier stacks, SR241 and SR620, located behind the fan motor.

( ) Unsolder the two wires from the thermal cutout, mounted on the selenium rectifier bracket.

( ) 4. Remove the selenium rectifiers and brackets from the instrument.

NOTE: One of the nuts holding a bracket to the chassis is under the high voltage shield and can be removed with the use of a needle-nose pliers.

( ) 5. Remove the thermal cutout from the selenium rectifier bracket and install it on the silicon rectifier bracket (from kit), using the 4-40 x 1/4 thread-forming screws from the kit.

NOTE: Mount the solder lug between the screw head and the thermal cutout (see Fig 1, step 5).

( ) 6. Mount the silicon rectifier assembly (from kit), as shown in Fig 1. Use the 6-32 x 5/16 PHS screws and #6 flat washers (from kit), placing a flat washer under each screw head. (Insert screws from bottom of chassis.)

( ) 7. Wire the silicon rectifier assembly, as shown in Fig 2.

( ) Resolder the wires, unsoldered in step 3, to the thermal cutout.

THIS COMPLETES THE INSTALLATION.

( ) Check wiring for accuracy.

( ) Replace the air filter, removed in step 1, and the fan assembly, displaced in step 2.

( ) Turn the instrument on and check the power supplies for proper voltages and regulation.

NOTE: If adjustments are made to the power supply, it will be necessary to check the calibration of the instrument.

( ) Place the Manual insert page in your Instruction Manual.

JT:cet

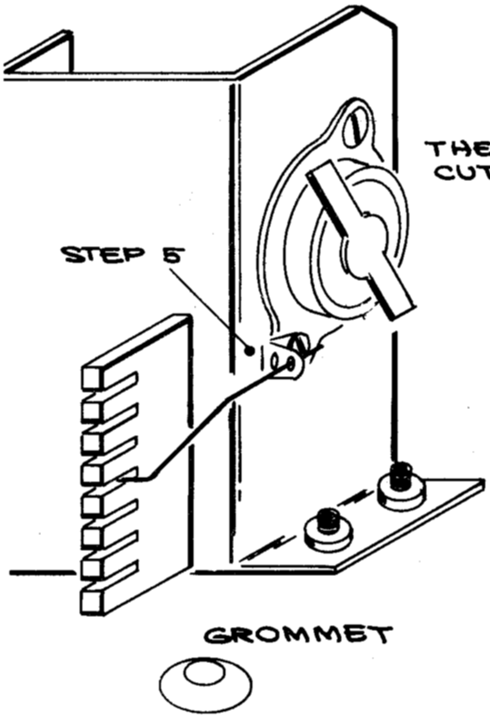


Fig 1

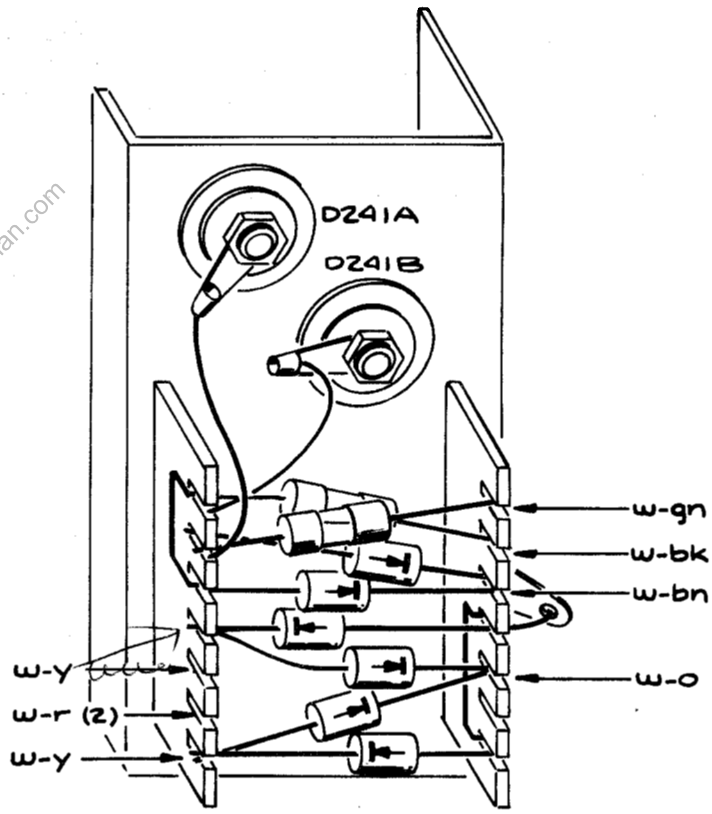
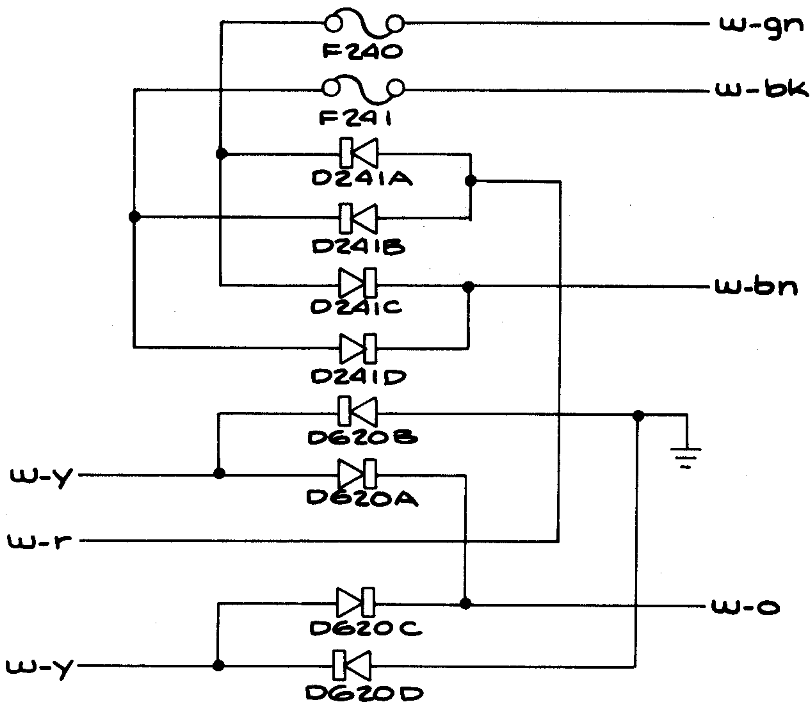


Fig 2
(See wiring schematic on following page.)


F240
w-gn
F241
w-bk
D241A
D241B
D241C
w-bn
D241D
D620B
w-y
D620A
w-r
D620C
w-o
w-y
D620D

SILICON RECTIFIER

Type 575 -- s/n 101-4929

Installed in Type 575 s/n _______ Date _______

GENERAL INFORMATION

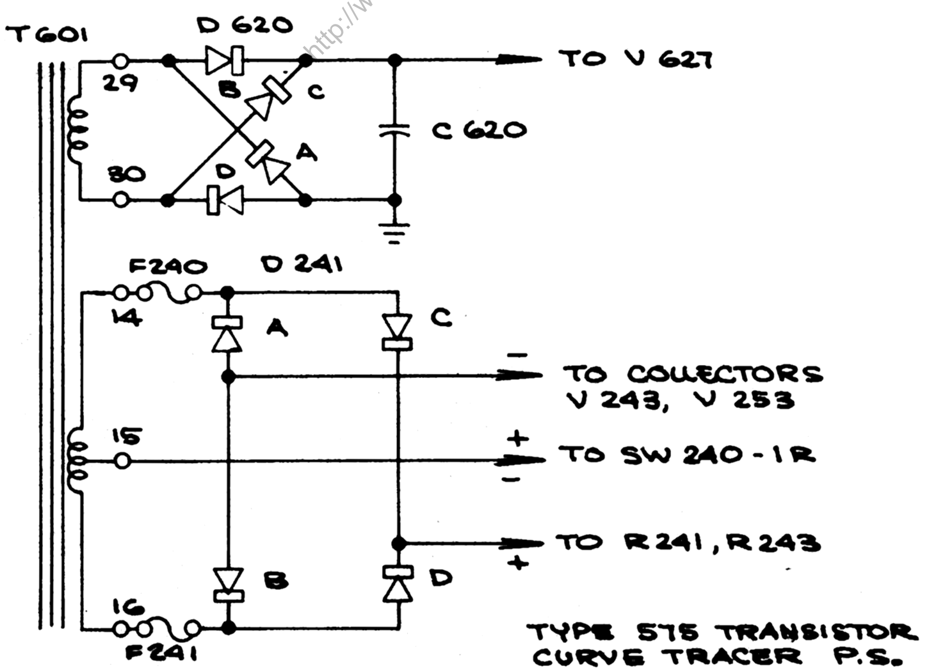
This modification replaces the selenium rectifiers with silicon rectifiers. Silicon rectifiers offer more reliability and longer life.

ELECTRICAL PARTS LIST

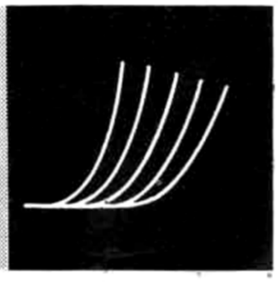
Only new parts listed.

Ckt. No.	Part Number	Description		
		DIODES		
D241A, B	152-0088-00	15 A	100 PIV	silicon
D241C, D	152-0066-00	500-750 mA	400 PIV	silicon
D620A, B, C, D	152-0066-00	500-750 mA	400 PIV	silicon
		FUSES		
F240	159-0053-00	5 A	fast-blo	w/pigtail
F241	159-0053-00	5 A	fast-blo	w/pigtail

SCHEMATIC



SOME TRANSISTOR MEASUREMENTS USING THE TYPE 575



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Request Form 1281

CONTENTS

INTRODUCTION

This material has been prepared primarily to acquaint the new user of the Tektronix Type 575 Transistor Characteristic-Curve Tracer with the fundamental measurements of transistor parameters and characteristics. It is intended to augment the Type 575 Instruction Manual.

We will not attempt to relate the broad field of solid-state physics to transistor characteristics, nor will we translate the characteristics to circuit design equations. This information is beyond the scope of this booklet and may be found in current publications. The Type 575 is intended for measuring the transistor characteristics which exist well below alpha cut-off, commonly measured between DC and 1000 cycles; hence we will not consider any high-frequency measurements.

We have chosen to give examples of measuring the four "hybrid", or h, parameters from the characteristic curves, although the admittance, impedance or other parameters could be measured on the Type 575 as well. Further, we have given examples predominantly in common emitter configuration, although there are no restrictions so far as the Type 575 is concerned in making measurements using common base or common collector configurations with either PNP or NPN transistors.

In most cases, a word description of the function being performed on the transistor will be used. A glossary of symbols is given in order to avoid confusion in the changing language of the transistor art.

The visual display of a family of transistor characteristic curves using oscilloscopic techniques employing synchronously stepped and swept voltage-current sources offers certain advantages over the DC point-by-point measurement technique:

(1) Small irregularities in the characteristics are visible which may escape observation by the point-by-point method.

(2) The extremes in the variation of a parameter value may be observed without altering the operating conditions.

(3) The changing magnitudes of two parameters may be observed simultaneously, as well as the dependence of one upon another.

(4) The short duration and lower duty cycle of the peak sweeping voltages or currents applied to the transistor produce less thermal rise than does the steady-state DC condition which occurs in point-by-point measurements. Inaccuracies due to thermal gradients are thereby minimized.

(5) For the same reason as noted in (4), the maximum ratings of the transistor may be observed without exceeding the safe limit of its power dissipation; thus incipient junction-breakdowns are minimized.

(6) Observation, comparison, or a permanent record by photographic techniques of the transistor characteristics may be made more rapidly than by the point-to-point plot, thus affording a savings in manpower and economy.

(7) A resistive load line may be constructed in the family of characteristic curves so that dynamic performance data for the transistor may be forecast.

Transistor characteristic curves may be found to deviate from the published "nominal" characteristic curves considerably more than found even in vacuum tubes. The Type 575 contains certain built-in calibration checks which assure the accuracy of the instrument. The theory of self-checking is explained in the section devoted to Functional Operation. Detailed checks and adjustment procedures are given in the Instruction Manual for the Type 575.

The Type 575 user is encouraged to read the section devoted to the Functional Operation of the Type 575 to aid in developing measurements peculiar to his own individual design or testing problem. In this way, he may fully utilize the versatility of the instrument.

FUNCTIONAL OPERATION OF THE TYPE 575

Two signals are developed in the Type 575 to be applied to the transistor. One is constant current or constant voltage steps, and the other is a variable amplitude half-sine wave. The two are synchronized so that for the duration of one step, or one-half step, there is one excursion of the half-sine voltage from zero (ground) to maximum and back to zero.

We will first direct our attention to the Base Step Generator shown to the left on Figure 1.

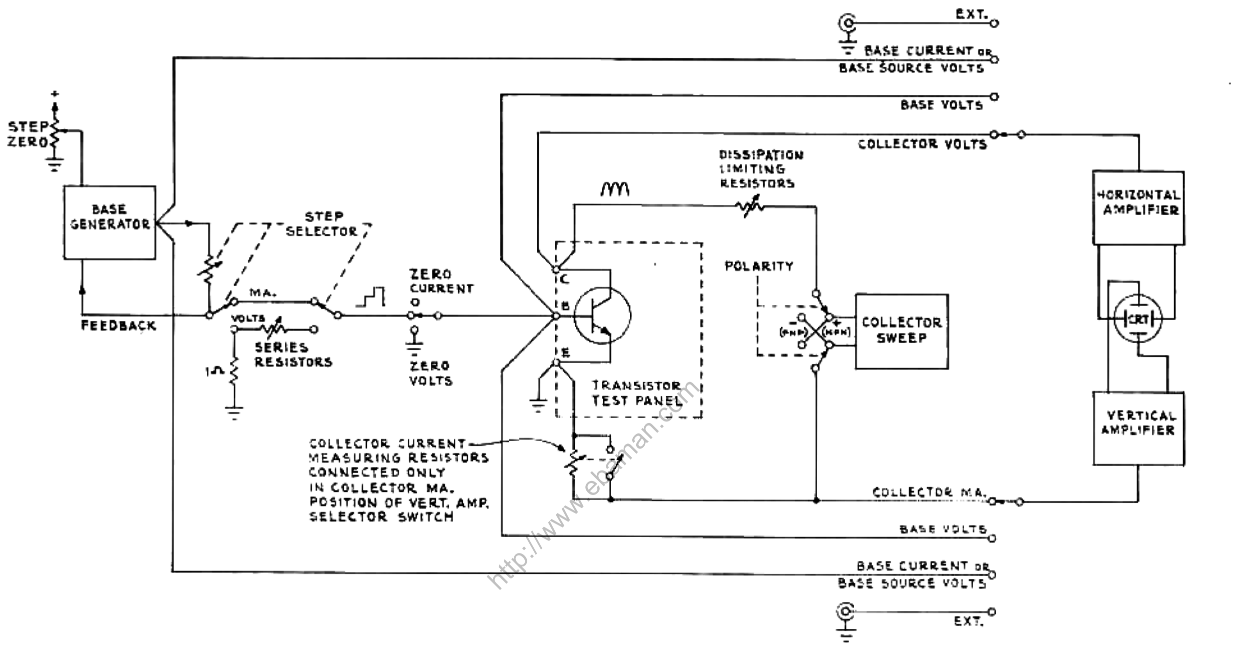


Fig. 1. Type 575 Functional Block Diagram.

The Base Step Generator produces from 4 to 12 steps (STEPS/FAMILY) in selected amplitude increments of constant current or constant voltage (STEP SELECTOR). The duration of each step is either 1/120 or 1/240 of a second (STEPS/SEC). The steps may be made repetitive, to occur once, or made inoperative and held at zero step level (REPETITIVE-SINGLE FAMILY OFF). The steps may be made positive or negative in polarity (POLARITY) with the zero step value adjustable by a small amount positive or negative from ground (STEP ZERO) to start the stair-steps on the zero current or zero volts input curve.

The output of the Base Step Generator is fed through a switch to the Base (B) terminal of the test fixture. The switch provides a means of disconnecting the Base terminal from the Base Step Generator to either open or short the terminal to ground (ZERO CURRENT-ZERO VOLTS). When constant voltage steps are being generated by the Base Step Generator, selected values of series resistance may be inserted between the generator and the Base terminal (SERIES RESISTOR). The output impedance of the Base Step Generator when producing constant voltage is one ohm, and when producing constant current the output impedance is, of course, very high.

The Collector Sweep source of half-sine voltage is shown at the right of Figure 1. The peak collector sweep voltage is variable in amplitude (PEAK VOLTS) from zero to 20 volts rated at 10 amps, or from zero to 200 volts rated at one amp (PEAK VOLTS RANGE). A fuse is provided to protect the collector supply from overload. The polarity of the half-sine shaped voltage excursions may be made positive or negative from ground (POLARITY + NPN-PNP). The duration of sweep from zero to maximum and back to zero is always 1/120 of a second.

The collector supply, which has a source impedance of .25 ohms in the twenty-volt range or 15 ohms in the 200-volt range, may be fed directly to the collector terminal of the test fixture, or variable resistance values may be inserted (DISSIPATION LIMITING RESISTORS). The collector supply ground return is direct to ground except when the Vertical display switch is in one of the COLLECTOR MA positions, at which time current measuring resistances are inserted. The value of resistance is dependent upon the position of the COLLECTOR MA switch and varies from .1 ohm in the 1000 Ma/ Division position to 10 K-ohms in the .01 Ma/ Division position. The specific value of resistance on each position of the switch is given in tabular form on the chart on top of the instrument. Thus the collector load resistance (load line) is known at all times by summing the resistance inserted manually (DISSIPATION LIMITING RESISTOR), the supply source impedance, and the collector current measuring resistance, determined as explained above.

The third terminal of the transistor test fixture marked "E" is ground. The transistor test board, which is not entirely shown in Figure 1, has a switch for transferring all connection from the left-hand terminals and socket to the right-hand terminals and socket with a neutral Off position. Another switch is provided to switch the <u>sockets</u> <u>only</u> from grounded base to grounded emitter.

This completes the generator functions of the Type 575, and we will now discuss the display portion of Figure 1.

The Horizontal display switch (HORIZONTAL-VOLTS/DIV) may select any one of four inputs: (1) BASE CURRENT OR BASE SOURCE VOLTS, (2) BASE VOLTS, (3) COLLECTOR VOLTS, (4) EXTERNAL.

In the BASE VOLTS or COLLECTOR VOLTS positions, the amplifier is connected to either the Base terminal or Collector terminal of the test fixture, respectively. The amplifier gain is controlled so that each major division on the CRT graticule corresponds to the value indicated on the selector switch.

In the BASE CURRENT OR BASE SOURCE VOLTS position of the Horizontal display switch, the horizontal amplifier is connected to the Base Step Generator output. Under these conditions, each major division on the CRT graticule corresponds to the value indicated on the Base Step Generator-STEP SELECTOR switch.

In the External position of the Horizontal display switch, the horizontal amplifier input is connected as a differential amplifier, to two coax jacks on the rear of the instrument. The scale factor for the CRT graticule on Ext. is fixed at 0.1 volts per major division, and the frequency response is 300 kc (3 db down).

It will be noted in Figure 1 that the Vertical display switch and vertical amplifier function in the same way as the horizontal circuits just discussed, when the (1) BASE CURRENT OR BASE SOURCE VOLTS, (2) BASE VOLTS, and (3) EXTERNAL positions are selected.

When the Vertical Amplifier is switched to COLLECTOR MA, however, it measures the voltage across the collector current measuring resistors. The vertical amplifier gain is held constant and the size of the current measuring resistance is changed by the COLLECTOR MA switch so that each major vertical division on the CRT graticule is the value indicated on the COLLECTOR MA switch.

Both the Horizontal and Vertical circuits have switches provided (AMPLIFIER ZERO CHECK-CALIBRATE) which ground the input to remove any signal for the purpose of positioning the beam on the CRT graticule. The same switches provide a calibrating voltage for checking horizontal and vertical amplifier gain.

It is worthy of note that the instrument provides many other ways of checking itself. For instance, one amplifier may be checked against the other by selecting a BASE VOLTS display on each amplifier and observing the angle of the diagonal row of dots. Either amplifier may check the Base Step Generator output voltage by selecting the same scale factor on the amplifier as the VOLTS/STEP on the STEP SELECTOR switch, and so on.

DISPLAY AND OPERATING CONSIDERATIONS

The polarities of the Base Steps and Collector Sweep signals are selected independently. The normal operating polarities for a transistor (reverse-biased collector and forward-biased emitter) are indicated on the front panel of the Type 575 to serve as a reminder to avoid possible damage to the transistor under test. The independent selection of base and collector signal polarities may be used to advantage. For instance, the emitter may be reverse-biased in order to measure the amount of current or voltage required to decrease the collector current I_{cbo} or I_{ceo} to a minimum value.

Some precautions which may be exercised in making measurements on a transistor of unknown limitations are: (1) Leave the TRANSISTOR A - TRANSISTOR B switch in the neutral (off) position when the initial signal amplitudes are selected and when the transistor is inserted, (2) In the initial selection of signals, start with small values of base steps and collector voltages with maximum sensitivity of the Horizontal and Vertical Display switches, (3) Use a minimum number of Base STEPS/FAMILY (four or five), (4) Insert a collector DISSIPATION LIMITING RESISTOR to limit the collector current to a safe value. The collector current measuring resistances are in series with the collector only when the Vertical Display switch is in the COLLECTOR MA position as shown in Figure 1. In order to preclude excessive collector current and possible damage to the transistor, it is important to select an adequate value of DISSIPATION LIMITING RESISTOR prior to switching the Vertical display switch from the COLLECTOR MA positions to any other position where collector current is not displayed. A chart, permanently attached to the top of the Type 575, provides a handy reference for choosing the DISSIPATION LIMITING RESISTOR for given values of collector-peak voltage and collector peak-power dissipation.

If it is not known whether the transistor is NPN or PNP, the beam may be centered on the CRT graticule and alternate PNP and NPN polarities applied to the transistor. The signals may be increased in small increments until it becomes apparent which characteristics are normal. As an added precautionary measure, the SINGLE FAMILY switch may be used in conjunction with the other precautions previously noted.

When NPN transistor characteristics are displayed, the Horizontal and Vertical POSITION controls should normally be adjusted to place the beam in the lower-left corner of the graticule. The family of characteristic curves appear in the first quadrant with positive values of currents and voltages increasing up and to the right. For PNP transistors, the Horizontal and Vertical POSITION controls are normally adjusted to place the beam in the upper-right hand corner of the graticule, and the family of characteristic curves then appears in the third quadrant. Increasing values of negative currents and voltages thus appear down and to the left, in keeping with convention.

The CALIBRATE position of the AMPLIFIER ZERO CHECK-CALIBRATE switch on the Horizontal and Vertical amplifiers deflects the beam down 10 divisions for the Vertical Amplifier and left 10 divisions for the Horizontal Amplifier. Thus, the beam position for the calibrate check should be in the upper-right-hand corner of the CRT graticule.

The STEP ZERO control permits adjustment of the base step generator to start from actual zero current or actual zero volts, rather than from some residual value of current or voltage. In this way, the absolute value of any base step is the product of the step number times the step incremental value indicated on the STEP SELECTOR switch. Proper adjustment is achieved when the "zero" current step from the base step generator is moved from a slightly forward residual current condition to a position that just coincides with the trace position obtained with the ZERO CURRENT-ZERO VOLTS switch in the ZERO CURRENT position. When the base step generator is supplying constant voltage steps, the ZERO VOLTAGE switch position would be applicable in the same way.

The faint traces which may appear between base steps and from the last step back to the zero step occur during the short transition interval between the steps. The transition traces will always occur at one end or the other in the family of curves, depending upon the position of the STEPS/SEC switch. Since they generally contribute nothing to the display and do not affect the calibration of the display in any way, a position of the STEPS/SEC switch is generally chosen to minimize their appearance. In some displays, the transition traces may serve a useful purpose, such as assisting in the construction of a load line in the collector family of curves.

A given parameter may be measured from one of several displays of the current and voltage relationships involved in the parameter. The display chosen depends upon the particular parameter and the characteristics of the transistor under test. The display that should be used is, of course, the one which yields the most accurate measurement or vivid display of that parameter. The user may sometimes prefer to measure other parameters that may be combined in a formula to produce a more accurate end result. A typical example is found in the relationship between α (Alpha), the common base forward current transfer ratio and β (Beta), the common emitter forward current transfer ratio. It can be seen from Figure 10 that the change in collector current for a given change in emitter current is very close to one. In common emitter, the change in collector current is considerably more than the change in base current, as can be seen in Figure 2. Since α and β are related by $\alpha = \beta/(\beta+1)$, we may find β to a greater degree of accuracy, as far as scaling is concerned, and solve for α.

A word may be in order regarding "small signal hybrid, or h, parameters". In small signal operation, linearity should exist over the operating range of the parameter and the value of the parameter should be independent of the signal amplitude. Ordinarily, the active region of a transistor without defects is quite uniform, and a cursory examination of the family of characteristics will verify that linearity exists over the operating range of the parameter. The versatility of the Type 575 provides for making "small signal" measurements as well as "large signal" measurements. In order to verify that the parameter value, or operating region, of the transistor is independent of the signal amplitude, additional measurements of the parameter may be made adjacent to, or within, the intended operating region and the resulting values compared. For instance, the base step values may be reduced and the number of steps increased to examine a smaller segment within the same operating region, etc.

We have selected a primary and an alternate display for measuring each of the four "h" parameters. We may arbitrarily categorize the displays as illustrating Output Characteristics shown in Figures 2, 3, 4, and 5, and Input Characteristics shown in Figures 6, 7, 8, and 9. Two "h" parameters are measurable from each display, consequently the displays in Figures 4, 5, 8, and 9 are the same as Figures 2, 3, 6, and 7, respectively.

The most commonly published and probably most useful families of curves are the Collector Family shown in common emitter configuration in Figure 2, and Input Characteristic Curves shown in common emitter configuration in Figure 6. A common base configuration for a Collector Family of characteristic curves is shown in Figure 10.

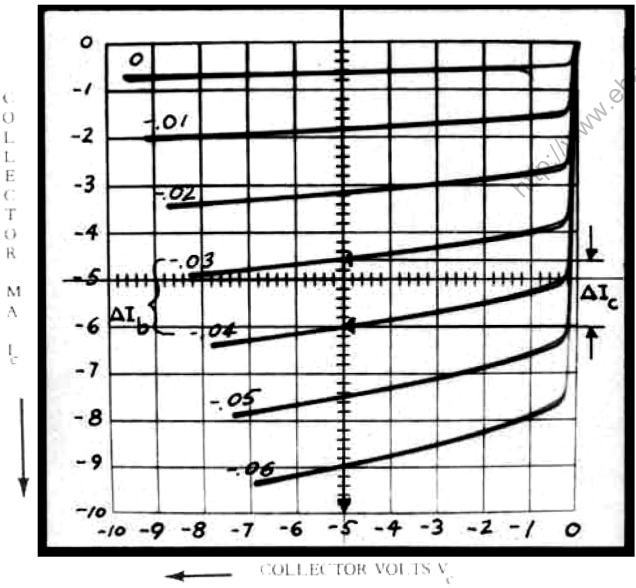
BASE to COLLECTOR CURRENT GAIN β, or COMMON EMITTER FORWARD CURRENT TRANSFER RATIO h_{fe}.

This parameter is determined by measuring the change in collector current produced by a change in base current at a specified collector voltage.

$$\beta \text{ or } h_{fe} = \frac{\Delta I_c}{\Delta I_b} \quad |V_c|$$

$$\beta \text{ or } h_{fe} = \frac{1.4 \times (1 \times 10^{-3})}{.01 \times 10^{-3}} = \frac{1.4}{.01} = \underline{140} \quad (V_c = -5 \text{ volts})$$

$$\alpha = \frac{\beta}{B+1} = \frac{140}{140+1} = \underline{.992} \quad (V_c = -5 \text{ Volts})$$



DISPLAY

Vertical:
Coll. Ma = 1.0 Ma/Div.

Horizontal:
Coll. Volts = 1.0 V/Div.

Step Selector:
Ma/Step = -.01 Ma/Step.

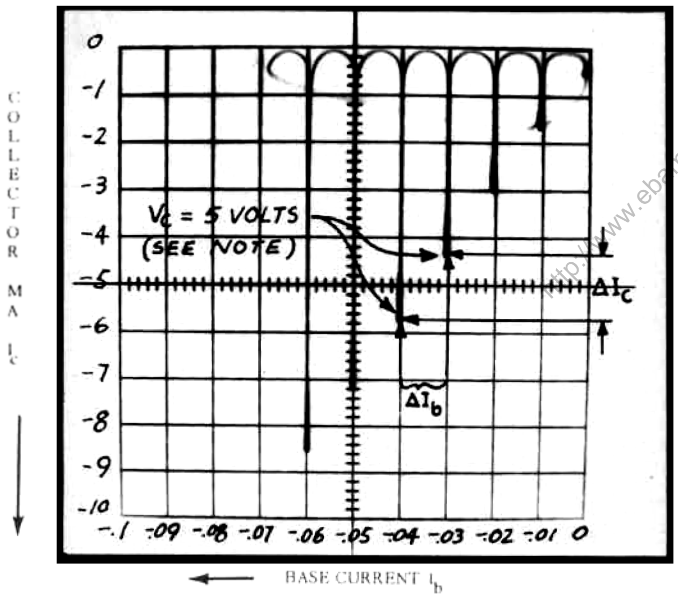
Dissipation Limiting
Resistor = 200 Ohms.

Fig. 2. Collector family of curves, I_c vs V_c, (I_b), for PNP transistor in common emitter configuration.

$$\beta \text{ or } h_{fe} = \frac{\Delta I_c}{\Delta I_b} \quad |V_c|$$

$$\beta \text{ or } h_{fe} = \frac{1.4 \times (1 \times 10^{-3})}{.01 \times 10^{-3}} = \frac{1.4}{.01} = \underline{140} \quad (V_c = -5 \text{ Volts})$$

$$\alpha = \frac{\beta}{\beta + 1} = \frac{140}{140+1} = \underline{.992} \quad (V_c = -5 \text{ Volts})$$



DISPLAY

Vertical:
Coll. Ma = 1.0 Ma/Div.

Horizontal:
Base Current = .01 Ma/Div.

Step Selector:
Base Current = -.01 Ma/Step.

Collector Volts:
(See Note) = -5.0 Volts.

Dissipation Limiting
Resistor = 200 Ohms.

Fig. 3. Output characteristic curves, I_C vs I_b, (V_C), for PNP transistor in common emitter configuration.

Note: Collector PEAK VOLTS adjusted to produce 5.0 Volts for the third and fourth base step by switching Horizontal display to COLLECTOR VOLTS and reading value from graticule.

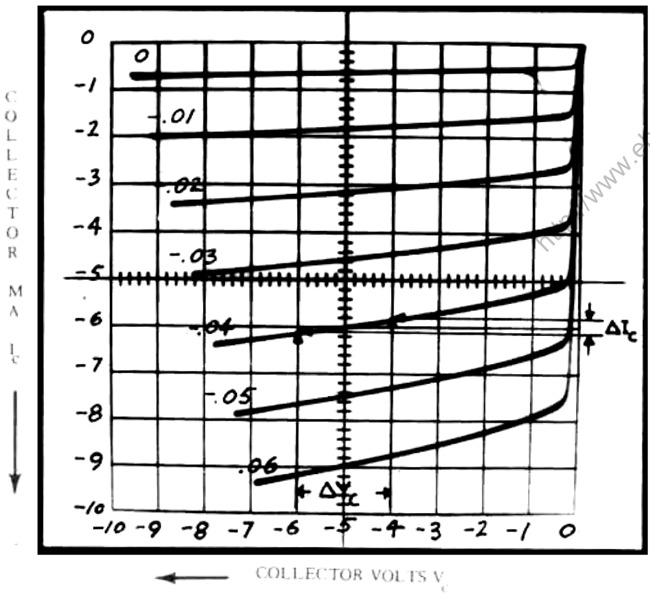
OUTPUT ADMITTANCE h_{oe}

The Output Admittance is determined by measuring the change in collector current produced by a change in collector voltage at a specified value of base current. The result is expressed in mhos.

$$h_{oe} = \frac{\Delta I_c}{\Delta V_c} \quad |I_b|$$

$$h_{oe} = \frac{.3 \times (1 \times 10^{-3})}{2} = .00015 \text{ mhos} = 150 \ \mu\text{mhos}$$

$$(I_b = -.04 \text{ ma})$$



DISPLAY
Vertical:
Coll. Ma=1.0 Ma/Div.

Horizontal:
Coll. Volts=1.0 V/Div.

Step Selector:
Ma/Step=-.01 Ma/Step.

Dissipation Limiting
Resistor =200 Ohms.

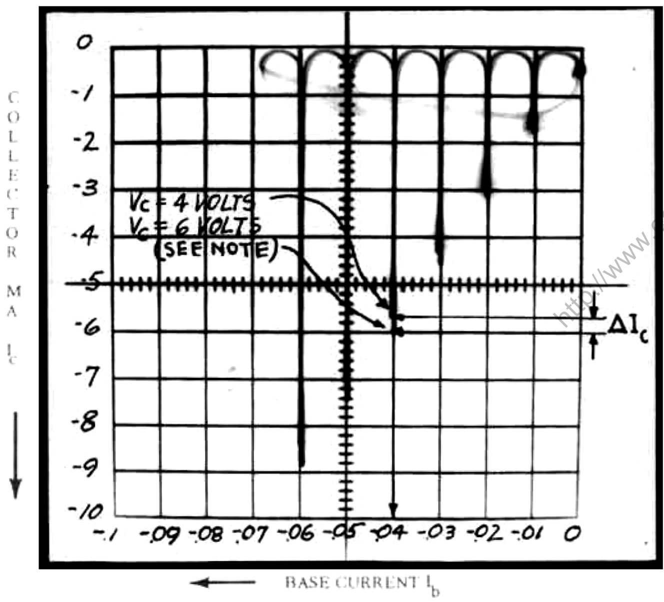
Fig. 4. Collector family of curves, I_C vs V_C, (I_b), for PNP transistor in common emitter configuration.

ALTERNATE DISPLAY FOR MEASURING h_{oe}

For the purpose of illustrating the h_{oe} measurement from the alternate display, a double exposure was made with all values constant except collector voltage which was increased from 4 to 6 volts for the second exposure.

$$h_{oe} = \frac{\Delta I_c}{\Delta V_c} \quad |I_b|$$

$$h_{oe} = \frac{.3 \times (1 \times 10^{-3})}{2} = .00015 \text{ mhos} = \underline{150\ \mu\text{mhos}} \quad (I_b = -.04 \text{ ma.})$$



DISPLAY

First Exposure

Vertical:
Coll. Ma=1.0 Ma/Div.

Horizontal:
Base Current=.01 Ma/Div.

Step Selector:
Base Current=-.01 Ma/Step.

Collector Volts:
(See Note)=-4 Volts.

Dissipation Limiting
Resistor=200 Ohms.

Second Exposure

Collector Volts increased to -6 Volts.

Fig. 5. Output characteristic curves, I_C vs I_b with V_C = 4 volts and V_C = 6 volts, for PNP transistor in common emitter configuration.

Note:

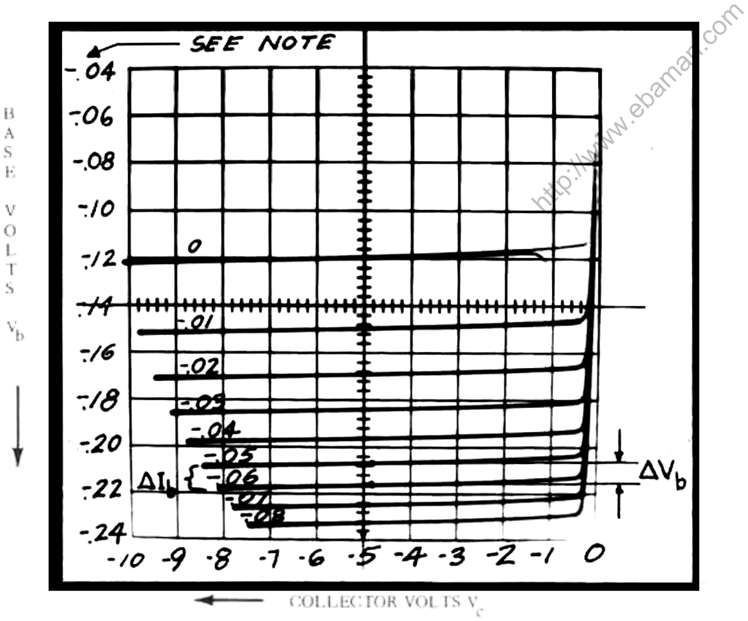
Collector PEAK VOLTS adjusted to produce 4 Volts and then 6 Volts for the fourth base step by switching Horizontal display to COLLECTOR VOLTS and reading value from graticule.

INPUT IMPEDANCE h_{ie}

The Input Impedance is determined by measuring the change in base voltage resulting from a change in base current at a specified collector voltage.

$$h_{ie} = \frac{\Delta V_b}{\Delta I_b} \quad |V_c|$$

$$h_{ie} = \frac{.4 \times .02}{.01 \times 10^{-3}} = \frac{.008}{10^{-6}} = \underline{800 \text{ ohms}} \; (V_c = -5 \text{ volts})$$



DISPLAY

Vertical:
Base Volts=.02 V/Div.

Horizontal:
Coll. Volts=1.0 V/Div.

Step Selector:
Base Current=-.01 Ma/Step.

Dissipation Limiting
Resistor=200 Ohms.

Vertical Position:
(See Note) Up 2 Div.

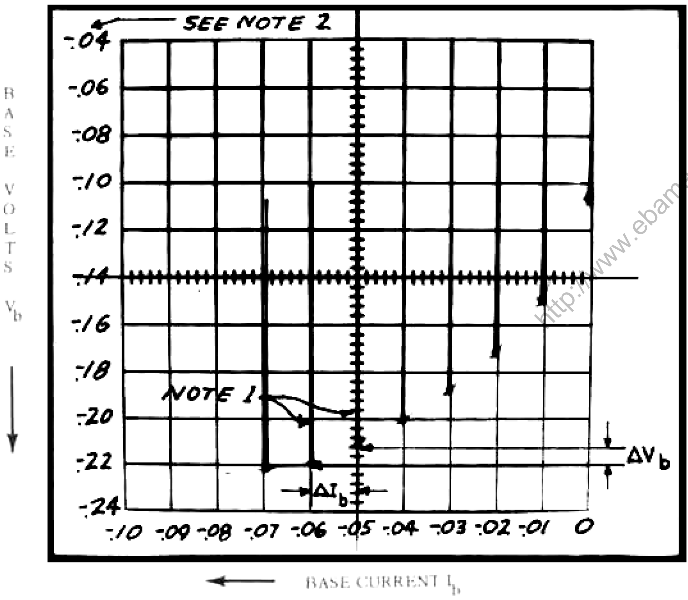
Fig. 6. Input characteristic curves, V_b vs V_c, (I_b), for PNP transistor in common emitter configuration.

Note: After establishing the display in the normal manner, the presentation was repositioned upward exactly two major divisions using one of the base steps as a reference. This was done in order to use the highest base volts sensitivity while maintaining the most useful portion of the curves on the graticule.

ALTERNATE DISPLAY FOR MEASURING h_{ie}

$$h_{ie} = \frac{\Delta V_b}{\Delta I_b} \quad |V_c|$$

$$h_{ie} = \frac{.4 \times .02}{.01 \times 10^{-3}} = \frac{.008}{10^{-6}} = \underline{800 \text{ ohms}} \; (V_c = -5 \text{ Volts})$$



DISPLAY

Vertical:
Base Volts=.02 V/Div.

Horizontal:
Base Current=.01 Ma/Div.

Step Selector:
Base Current=-.01 Ma/Step.

Collector Volts:
(See Note 1)=-5V/Div.

Dissipation Limiting
Resistor=0 Ohms.

Vertical Position:
(See Note 2)=Up 2 Div.

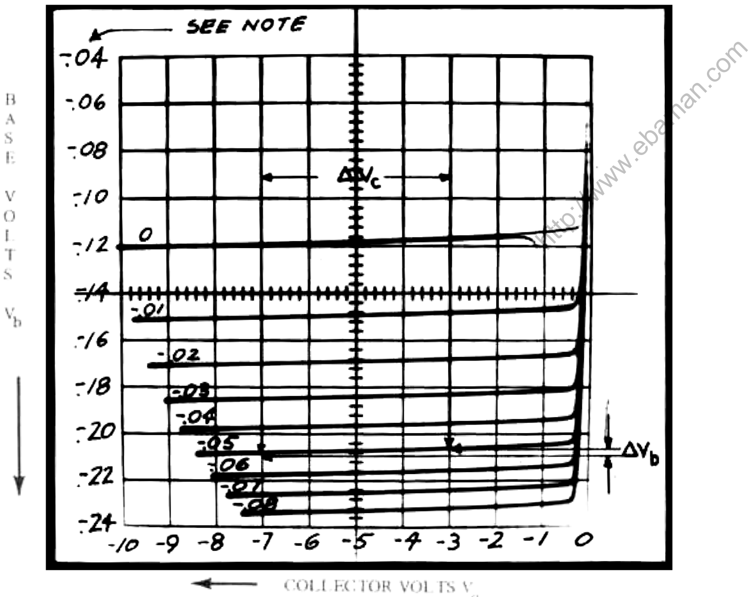
Fig. 7. Input characteristic curves, V_b vs I_b,(V_C), for PNP transistor in common emitter configuration.

Note 1: Collector PEAK VOLTS adjusted to produce 5.0 Volts for the fifth and sixth base step by switching Horizontal display to COLLECTOR VOLTS and reading value from graticule.

Note 2: After establishing the display in the normal manner, the presentation was repositioned upward exactly two major divisions using one of the base steps as a reference. This was done in order to use the highest base volts sensitivity while maintaining the most useful portion of the curves on the graticule.

REVERSE VOLTAGE AMPLIFICATION FACTOR h_{re}

The Reverse Voltage Amplification Factor is determined by measuring the change in base voltage which accompanies a change in collector voltage at a specified base current.



DISPLAY

Vertical:
Base Volts=.02 V/Div.

Horizontal:
Coll. Volts=1.0 V/Div.

Step Selector:
Base Current=-.01 Ma/Step.

Dissipation Limiting
Resistor=200 Ohms.

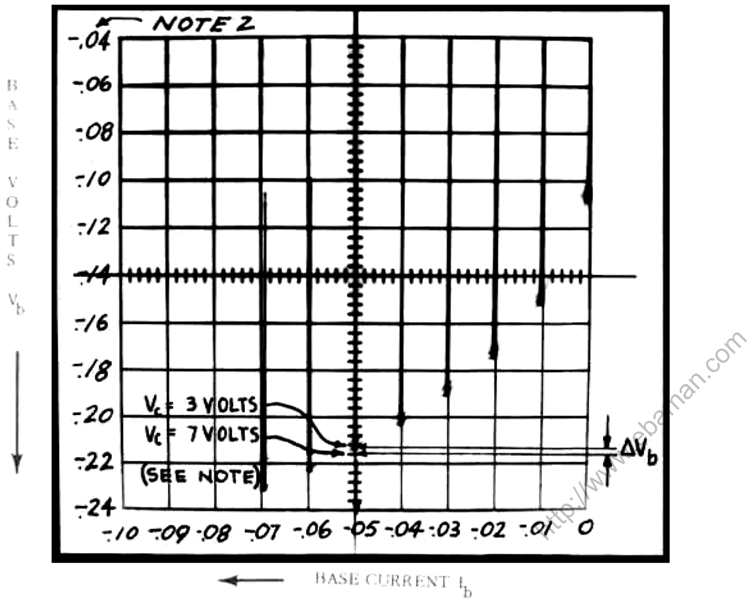
Vertical Position:
(See Note)=Up 2 Div.

Fig. 8. Input characteristic curves, V_b vs V_c, (I_b), for PNP transistor in common emitter configuration.

Note: After establishing the display in the normal manner, the presentation was repositioned upward exactly two major divisions using one of the base steps as a reference. This was done in order to use the highest base volts sensitivity while maintaining the most useful portion of the curves on the graticule.

ALTERNATE DISPLAY FOR MEASURING h_{re}

For the purpose of illustrating the h_{re} measurement from the alternate display, a double exposure was made with all values constant except collector voltage which was increased from 3 to 7 Volts for the second exposure.



DISPLAY

First Exposure

Vertical:
Base Volts=.02 V/Div.

Horizontal:
Base Current=.01 Ma/Div.

Step Selector:
Base Current= -.01 Ma/Div.

Collector Volts:
(See Note 1)=-3 Volts .

Dissipation Limiting
Resistor=0 Ohms .

Vertical Position:
(See Note 2)=Up 2 Div.

Second Exposure

Collector Volts increased
to -7 Volts.

Fig. 9. Input characteristic curves, V_b vs I_b with V_c = 3 volts and V_c = 7 volts, for PNP transistor in common emitter configuration.

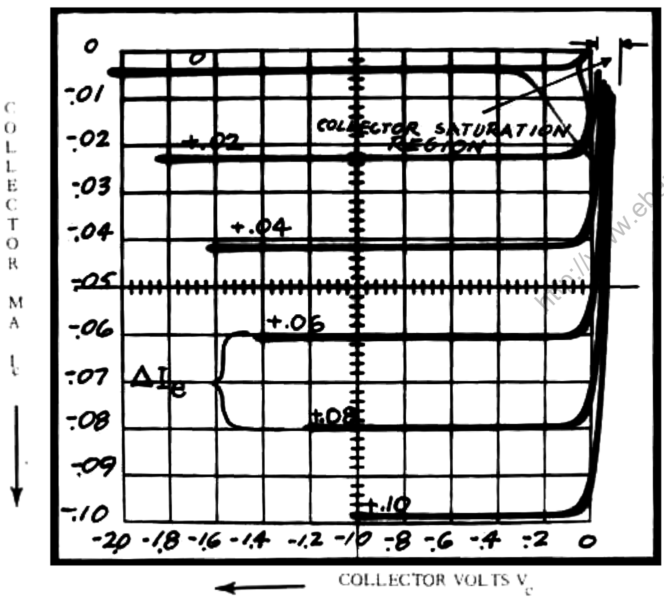
Note 1: Collector PEAK VOLTS adjusted to produce 3.0 Volts and then 7 volts for the fifth base step by switching Horizontal display to COLLECTOR VOLTS and reading value from the graticule.

Note 2: After establishing the display in the normal manner, the presentation was repositioned upward exactly two major divisions using one of the base steps as a reference. This was done in order to use the highest base volts sensitivity while maintaining the most useful portion of the curves on the graticule.

COMMON BASE CONFIGURATION

The parameters for the common base or common collector configurations may be handled in the same manner as just illustrated for common emitter configuration. From observation of the collector family of output characteristics in common base configuration, as illustrated in Figure 10, it is clear that h_{fb} or α which equals $\Delta I_c / \Delta I_e$ and h_{ob} which equals $\Delta I_c / \Delta V_c$ are difficult to scale from the graticule. This is quite normal, and it may be anticipated that variations between transistors will not appear as vividly as they would in common emitter operation.

The set of curves in Figure 10, by themselves, are principally informative in the "saturation region", which appears to the right of zero collector volts. It will be recalled that in common base configuration, unlike the common emitter configuration, the polarity of the emitter is opposite in sign to that of the collector. The apparent forward biasing of the collector in the "saturation region" results from emitter current and hence appears opposite in polarity to the applied collector voltage. Its magnitude may approach the magnitude of the emitter voltage; however, it can never exceed it.



DISPLAY

Vertical:
Coll. Ma=.01 Ma/Div.

Horizontal:
Coll. Volts=.2 V/Div.

Base Selector:
Base Current=+.02 Ma/
Step (Applied to Emitter).

Dissipation Limiting
Resistor=0 Ohms.

Fig. 10. Collector family of curves, I_c vs V_c, (I_e), for PNP transistor in common base configuration.

When it is desired to include the saturation region on the graticule scale, the display may be repositioned one or more major divisions with the Horizontal POSITION control without degrading the incremental scale calibrations. The AMPLIFIER ZERO CHECK switch may be used to establish a zero reference. An expanded display of the saturation region may be chosen by changing the Horizontal COLLECTOR VOLTS.

In common base configuration, when the horizontal or vertical display switch is changed from the COLLECTOR positions to the BASE positions to show the emitter characteristics, the curves progress from the edge of the graticule to some point off the screen. This is a result of collector and emitter biasing polarities as mentioned before. The display will appear in the correct perspective by repositioning the trace to the opposite edge of the graticule. Repositioning the display may be accomplished as mentioned before by using the appropriate POSITION control in conjunction with the appropriate AMPLIFIER ZERO CHECK switch.

COLLECTOR CUTOFF

The collector current which flows with zero emitter current (common base) I_{cbo} or with zero base current (common emitter) I_{ceo} may be measured directly from the collector family of curves. The STEP ZERO adjustment should be accurately set, or the ZERO CURRENT-ZERO VOLTS switch may be held in the ZERO CURRENT position. This will open the element of the transistor that is connected to the Base terminal of the test fixtures to assure zero-current conditions. Typical measurements are shown in Figure 11 and Figure 12.

Small values of I_{cbo} or I_{ceo}, such as encountered in typical silicon transistors, may become difficult to measure on even the most sensitive COLLECTOR MA range. The section devoted to Modifications for Special Applications describes a circuit modification in the Type 575 to obtain one microamp per division on the COLLECTOR MA display; however, a simpler method may be employed quite successfully by using an external resistor in the " common" lead of the transistor and measuring the voltage drop across the resistor with the Vertical BASE VOLTS display. The input terminal of the transistor is not connected, but remains open to obtain zero input current. Depending upon conditions, it is possible to measure collector currents in the order of one-hundredth of a microamp. The method is described as follows:

Referring to Figure 1, it can be seen that with the ZERO CURRENT-ZERO VOLTS switch in the ZERO CURRENT position, the Base terminal is disconnected from the Base Generator; however, the Vertical Amplifier remains connected to the terminal when it is in the BASE VOLTS positions. With an external resistance between the Base terminal of the test fixture and the E (ground) terminal, we may measure the voltage across the resistance which, of course, is directly related to the current through it. For measuring I_{cbo}, the transistor is connected with the collector to the C terminal, the base connected to the Base terminal, and the emitter is not connected. For measuring I_{ceo}, the base and emitter leads of the transistor are merely interposed.

Using a 100 K ohms resistance produces the following vertical scale factors on the graticule:

Vertical Base Volts	Vertical Scale Factor
.01 Volts/Div.	.1 μamp/Div.
.02 " "	.2 " "
.05 " "	.5 " "
.1 " "	1.0 " "
.2 " "	2.0 " "
.5 " "	5.0 " "

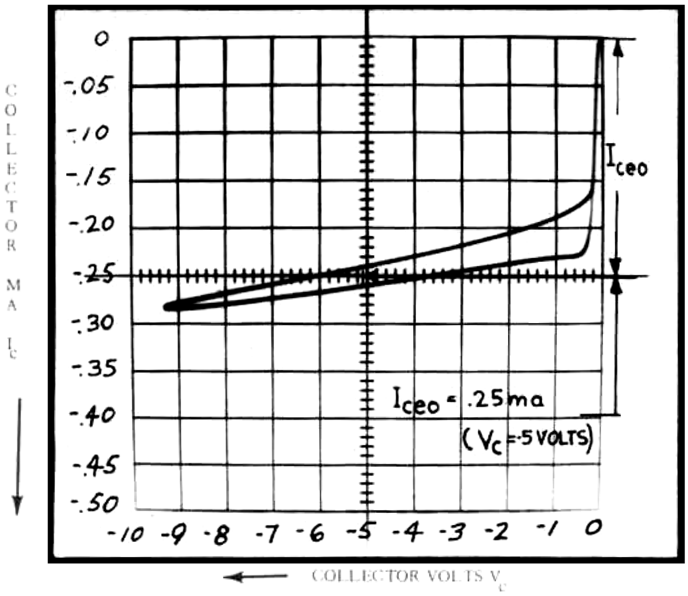
The resistor should be non-inductive (1/2 watt or 1 watt) and have a value of at least one percent tolerance to be compatible with the accuracy of the rest of the system. The transistor and resistor lead lengths should be kept short to avoid hum pickup in the external circuit, which would cause large " loops" . Hum pick-up from stray magnetic fields can be minimized by using a grounded metal enclosure around the transistor, test terminals and resistor. The internal capacities of the transistor may also limit the minimum current-measuring capability by causing an intolerably large hysteresis loop in the current display. Where it is desirable to ignore the transistor internal capacity, the steady state dc value of the collector current may be considered to exist at the center of the hysteresis loop in the collector current display. This may be verified by decreasing the collector PEAK VOLTS until only the peak of the collector sweep occurs at the point in question.

Leakage current between transistor terminals in the external circuit or test board should be avoided since this would contribute an error to the actual leakage of the transistor itself.

It is advisable to check the Vertical Amplifier dc balance to preclude ambiguity when switching between BASE VOLTS ranges. Any shift may be eliminated by holding the AMPLIFIER ZERO CHECK switch up and adjusting DC BAL for minimum vertical movement of the trace as the Vertical BASE VOLTS switch is rotated through its six positions.

A typical display using this measuring technique is shown in Figure 13. A simplified schematic of the system is shown in Figure 14.

The reader may recognize from examination of the Type 575 System Functional Block Diagram, Figure 1, that it is possible to connect the Base SERIES RESISTORS between emitter and base by placing the STEP SELECTOR in the BASE VOLTS position. Zero input current or voltage from the Base Generator can be obtained by placing the REPETITIVE-OFF-SINGLE FAMILY switch in the OFF position providing the STEP ZERO control has been properly adjusted. This feature may be used to advantage in exploring the collector current that exists with various values of base to emitter resistance. It may also serve the purpose of the external resistor used for measuring low values of I_{cbo} and I_{ceo}. Limitations are imposed by the values indicated on the Base SERIES RESISTORS and their tolerance, which is 5 percent. As mentioned before, whenever the REPETITIVE-OFF-SINGLE FAMILY switch is used in the OFF position to obtain the zero current or zero voltage display, it is important that the STEP ZERO control be properly adjusted to assure zero input to the transistor from the Base Generator.



DISPLAY

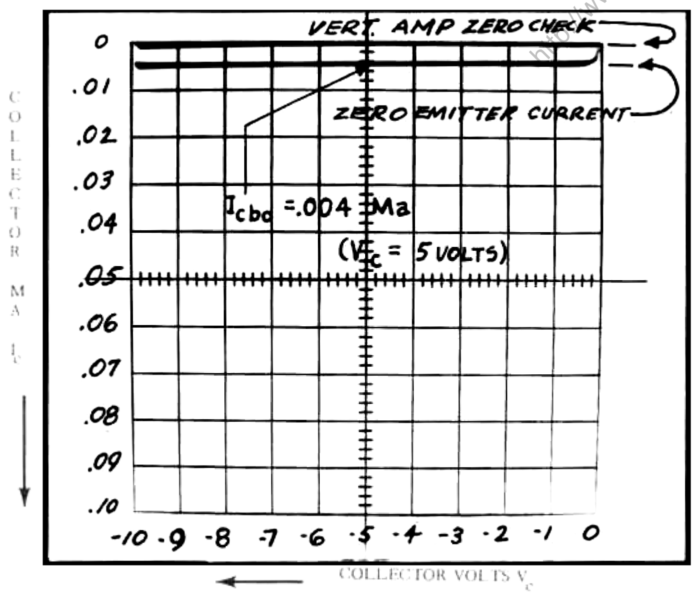
Vertical:
Coll. Ma = .05 Ma/Div.

Horizontal:
Coll. Volts = 1.0 V/Div.

Base Step = 0 Current
(Open Base).

I_{ceo} = .25 Ma
(V_C = -5 Volts).

Fig. 11. I_C vs V_C, (I_b = O, Emitter Open) curve for PNP transistor in common base configuration.



DISPLAY

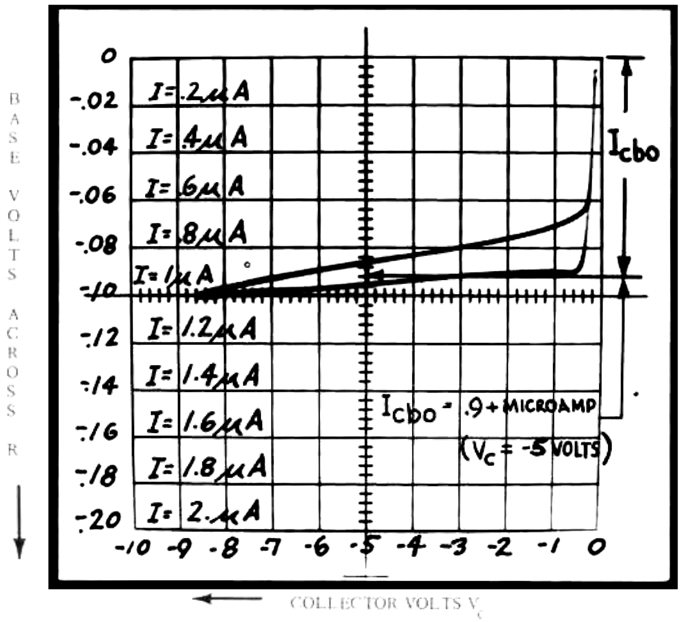
Vertical:
Coll. Ma = .01 Ma/Div.

Horizontal:
Coll. Volts = 1.0 V/Div.

Base Step = 0 Current
(Open Emitter).

I_{cbo} = .004 ma.
(V_c = -5 Volts).

Fig. 12. I_C vs V_C, (I_e = O Emitter open) curve for PNP transistor in common base configuration.



DISPLAY

Vertical:
Base Volts = .02 V/Div.
(across external 100 K resistor - see text).

Horizontal:
Coll. Volts = 1.0 V/Div.

Base Step = 0 Current (Open Emitter).

I_{cbo} = .9+ microamp (V_c = -5 Volts).

Fig. 13. I_c vs V_c, (I_e = O, Emitter open) curve for PNP transistor in common base configuration.

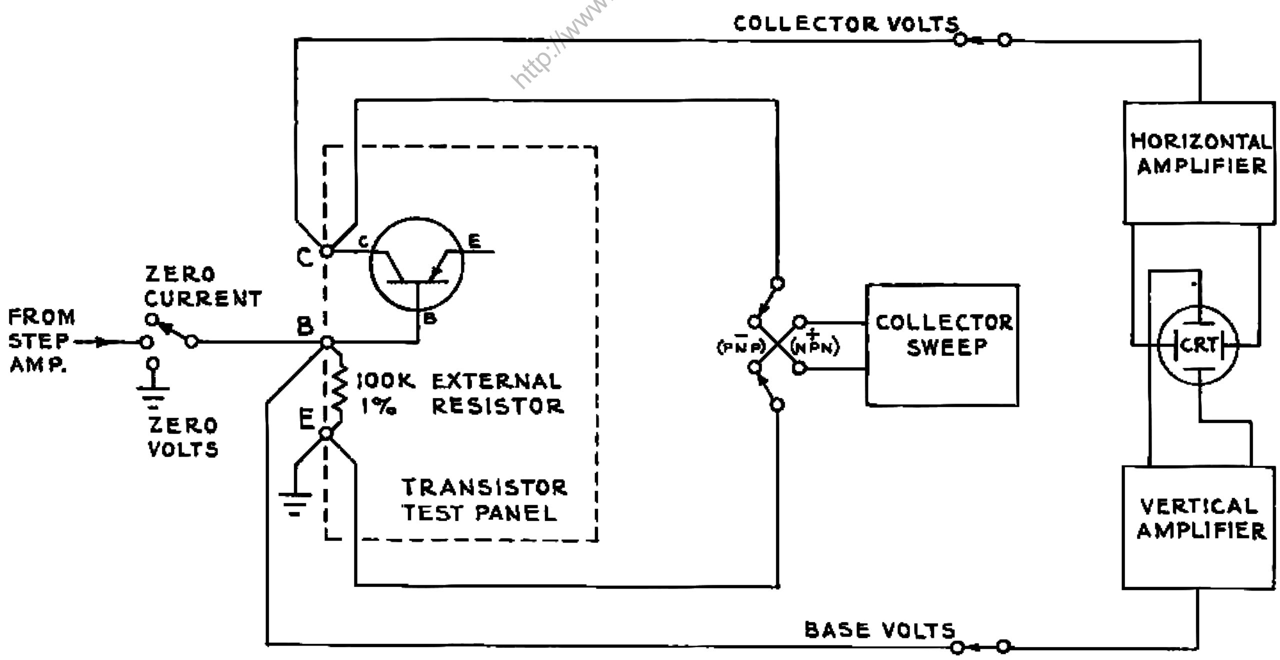


Fig. 14. System for measuring low values of I_{cbo} or I_{ceo}.

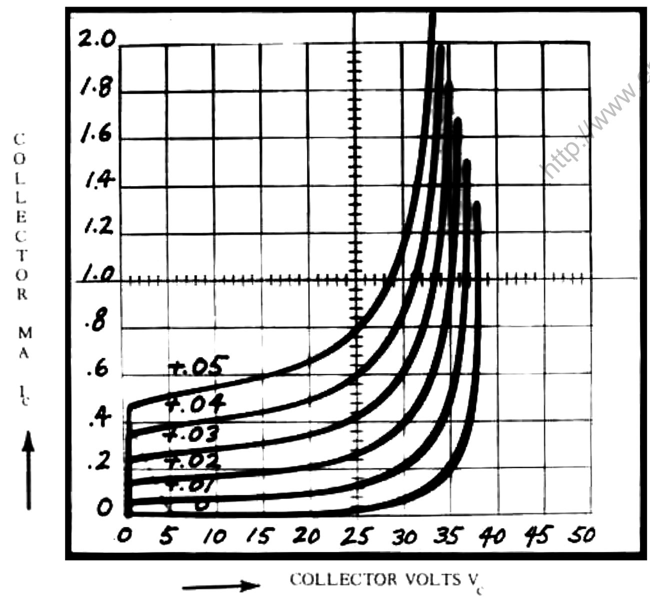
COLLECTOR BREAKDOWN VOLTAGES

As the voltage is increased on a reverse biased collector of a transistor, a point will be reached where the collector current increases rapidly and may become essentially independent of the collector voltage. We will show several measurements of the breakdown characteristics, but will not attempt to differentiate between the phenomena referred to as avalanche, punch-through, zener breakdown, or carrier multiplication, since they are largely dependent upon the configuration, type, and geometry of the transistor.

Figures 15, 16, and 17 show the breakdown characteristics for the same transistor under various operating conditions. It will be noted that the breakdown voltage varies depending upon how the transistor base and emitter are connected and what their source impedance is.

In each of the measurements, a value of collector DISSIPATION LIMITING RESISTOR was inserted to "catch" the collector current and prevent excessive thermal rise and possible damage to the transistor.

Under certain conditions, some transistors will exhibit a negative resistance characteristic in the breakdown region as occurred in Figure 16. In this particular case, oscillation is present in the upper portion of the negative resistance region. In some transistors, oscillation may occur in some other region of the characteristic curve and may be recognized by the faint and ragged, or erratic, behavior of the trace on the display. Point contact transistors are especially susceptible to oscillation under certain operating conditions and particularly in common emitter configuration, since Alpha is commonly greater than one, and they are inherently short-circuit unstable.



DISPLAY

Vertical:
Coll. Ma = 0.2 Ma/Div.

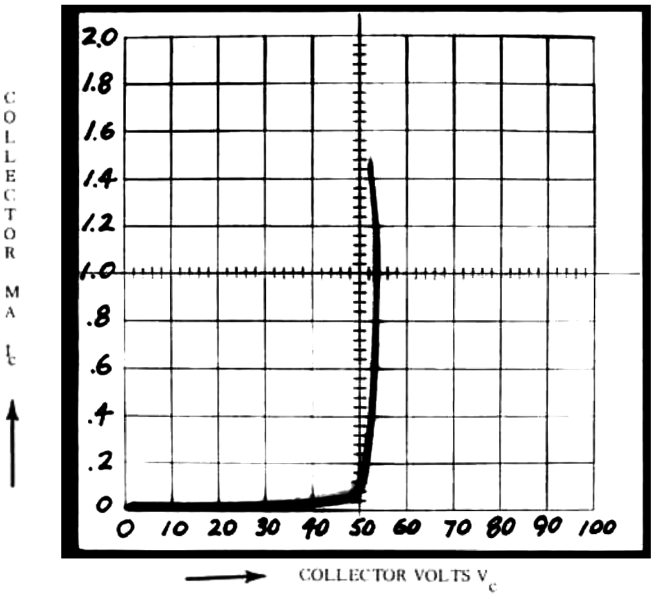
Horizontal:
Coll. Volts = 5 V/Div.

Step Selector:
Base Current = +.01 Ma/Step.

Collector Peak Volts
Range = 0 - 200 Volts.

Dissipation Limiting
Resistor = 5 K Ohms.

Fig. 15. Collector Breakdown characteristic curves, I_c vs V_c, (I_b) for NPN transistor in common emitter configuration.



DISPLAY

Vertical:
Coll. Ma = .2 Ma/Div.

Horizontal:
Coll. Volts = 10 V/Div.

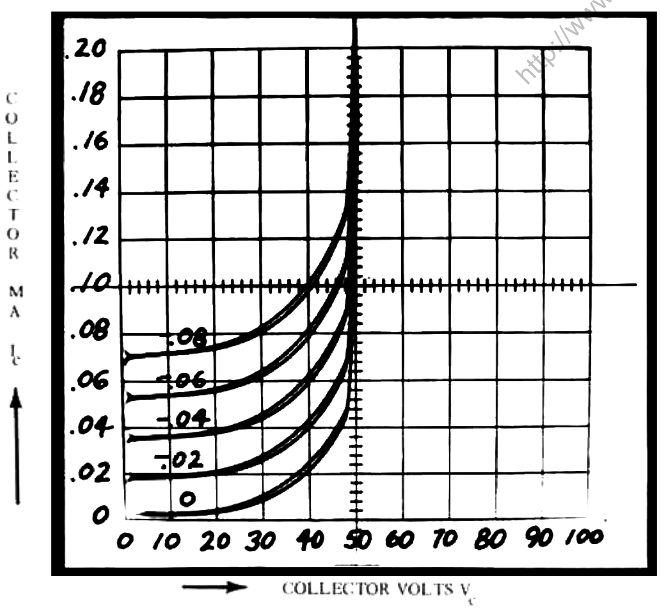
Base and Emitter=0 Volts (Ground).

Collector Peak Volts
Range = 0 - 200 Volts.

Dissipation Limiting
Resistor = 5 K Ohms .

Fig. 16. Collector breakdown characteristics, I_c vs V_c, (I_e and I_b = O volts), of NPN transistor with Emitter and base grounded.

Note: In the collector current region above 1.6 Ma, the trace which cannot be seen in the photograph becomes barely visible due to oscillation. Damage could occur to the transistor if this high current escaped observation and were allowed to exist too long. The Collector DISSIPATION LIMITING RESISTORS should always be inserted as one protective measure.



DISPLAY

Vertical:
Coll. Ma= .02 Ma/Div.

Horizontal:
Coll. Volts = 10.0 V/Div.

Step Selector:
Base Current = -.02 Ma/Step.
(Applied to Emitter)

Collector Peak Volts
Range = 0 - 200 Volts .

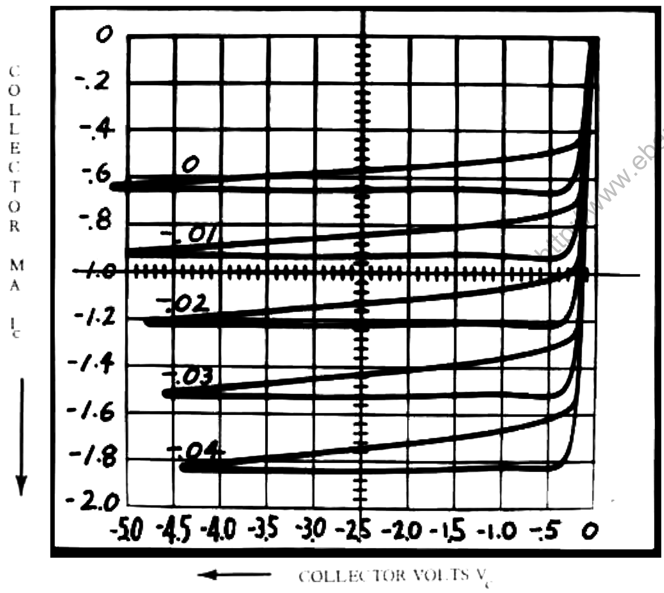
Dissipation Limiting
Resistor = 5 K Ohms .

Fig. 17. Collector breakdown conditions, I_c vs V_c, (I_e), of NPN transistor in common base configuration.

MISCELLANEOUS DISPLAYS

COLLECTOR CAPACITY

The effect of collector capacity may become quite pronounced in some transistors. The loop resulting from the collector-to-base capacity causes a displacement current to add and subtract from the base current of the transistor. The effect is most pronounced in common emitter configuration with low base drive, high collector voltage, and the greatest expansion of the vertical COLLECTOR MA display. The capacity effect is more pronounced at the knee of the curve in the collector family because of the sudden change in collector current in the transistor. At the same time, the rate of change of the collector half-sine shape sweep voltage is maximum; that is, near the beginning and end of the cycle when a high value of collector peak voltage is used. As explained in a preceding section, the equivalent steady state dc value of collector current may be established by decreasing the collector PEAK VOLTS until only the peak of the collector sweep occurs at the point in question. The approximate magnitude of the capacity may be measured by adding a capacitor of 10 to 1000 micromicrofarads between the base and collector terminals. The transistor capacity is approximately equal to the capacity of the external capacitor when the vertical size of the loop is doubled. A comparison of Figure 18 and Figure 19 illustrates the effects of the collector to base capacitance.



DISPLAY

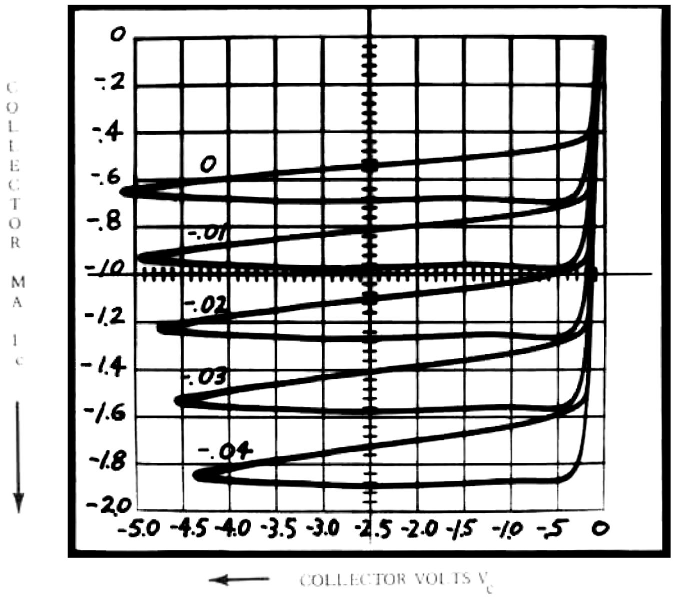
Vertical:
Coll. Ma = .2 Ma/Div.

Horizontal:
Coll. Volts = .5 V/Div.

Base Step = -.01 Ma/Step.

Note: Collector capacity appears as loops in the collector current display.

Fig. 18. Collector family of curves, I_C vs V_C, (I_b), for PNP power transistor in common emitter configuration.



DISPLAY

Vertical:
Coll. Ma = .2 Ma/Div.

Horizontal:
Coll. Volts = .5 V/Div.

Base Step = -.01 Ma/Step.

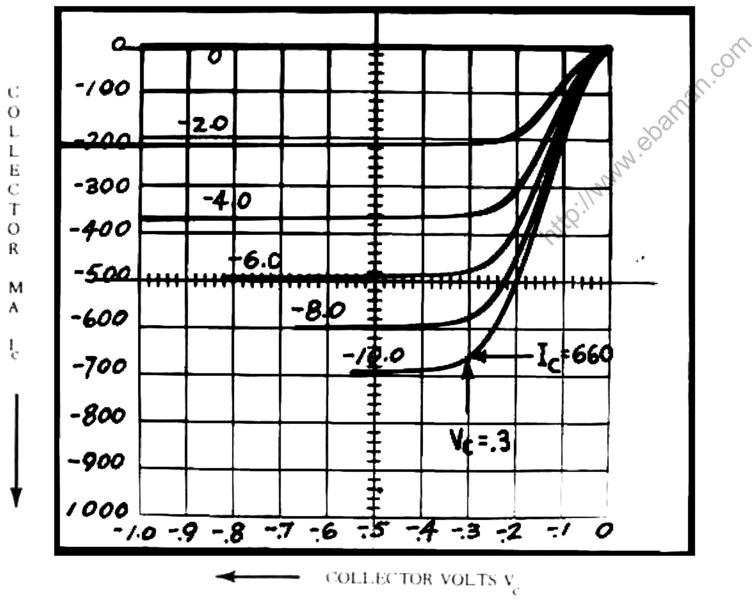
Note: External 560 $\mu\mu$f capacitor added between Base and Collector.

Fig. 19. Collector family of curves, I_c vs V_c, (I_b), for PNP power transistor with 560$\mu\mu$f additional capacitance between base and collector in the common emitter configuration.

The collector voltage between zero and the "active region", or the point at which the collector current becomes essentially independent of the collector voltage is commonly referred to as the "saturation voltage". The ratio of this "saturation voltage" to the collector current at which it is measured is usually called the collector "saturation resistance". The input current and/or collector current should be specified to define the point at which the collector "saturation voltage" is measured. For collector "saturation resistance" the input current and collector current, or voltage, is generally specified. Large or small values of "saturation voltage" may be measured easily on the Type 575 by selecting the appropriate scale factor for the horizontal COLLECTOR VOLTS. A typical display is shown in Figure 20. The onset of saturation may be considered to occur at the knee of the curves.

$V_{cs} = .3$ volts when $I_c = 660$ ma and $I_b = 10$ ma

$$R_{cs} = \frac{V_{cs}}{I_c} = \frac{.3}{660 \times 10^{-3}} = \frac{.3}{.66} = .45^{+} \text{ ohms}$$



DISPLAY

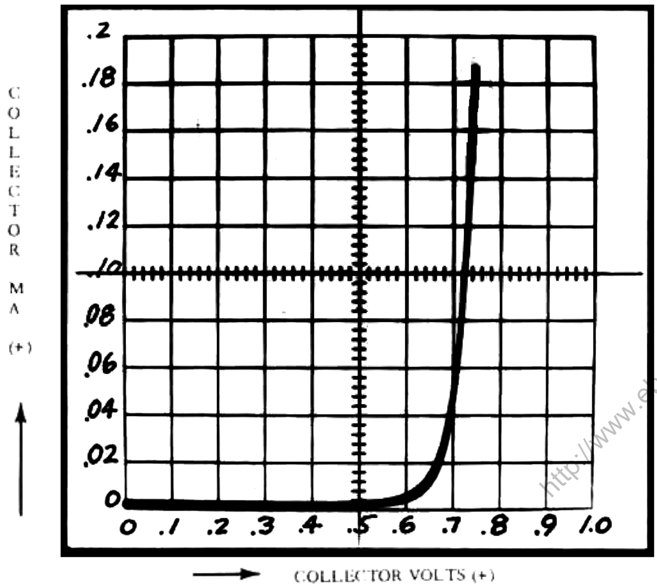
Vertical:
Coll. Ma = 100 Ma/Div.

Horizontal:
Coll. Volts = .1 V/Div.

Step Selector:
Ma/Step = -2 Ma/Step.

Fig. 20. Collector family of curves, I_c vs V_c, (I_b) in the collector saturation region for a PNP transistor in the common emitter configuration.

Forward conduction or reverse voltage breakdown of a diode may be displayed on the Type 575 by the simple expedient of using the collector sweep supply as a voltage source. The graticule will present the E-I plot when COLLECTOR MA is selected on the Vertical display and COLLECTOR VOLTS is selected on the horizontal display. Collector DISSIPATION LIMITING RESISTORS should be inserted to preclude excessive current through the diode. Appropriate selection of the positive or negative collector sweep voltage makes it unnecessary to remove and re-insert the diode when comparing forward and reverse currents. The collector sweep voltage is limited to 200 volts peak. Zener diode characteristics are shown in Figure 21 and Figure 22.



DISPLAY

Vertical:
Coll. Ma = .02 Ma/Div.

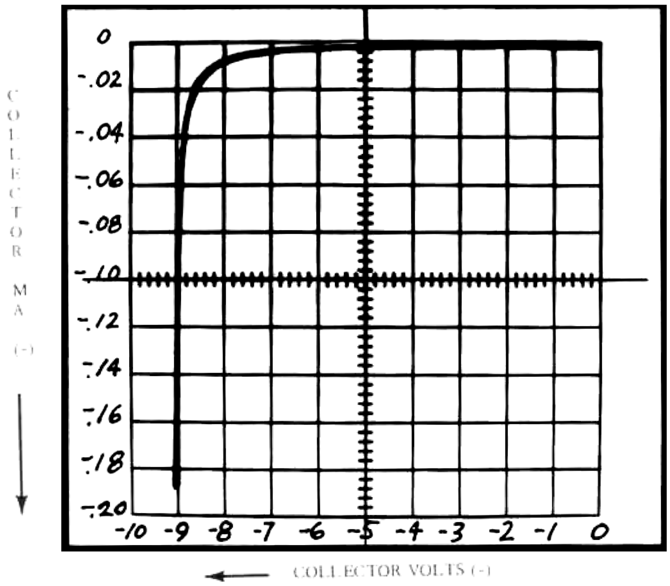
Horizontal:
Coll. Volts = .1 V/Div.

Dissipation Limiting
Resistor = 500 Ohms.

Diode Connections:

Cathode = E (ground).
Plate = C (Collector).

Fig. 21. Zener diode forward conduction characteristic.



DISPLAY

Vertical:
Coll. Ma = .02 Ma/Div.

Horizontal:
Coll. Volts = 1.0 V/Div.

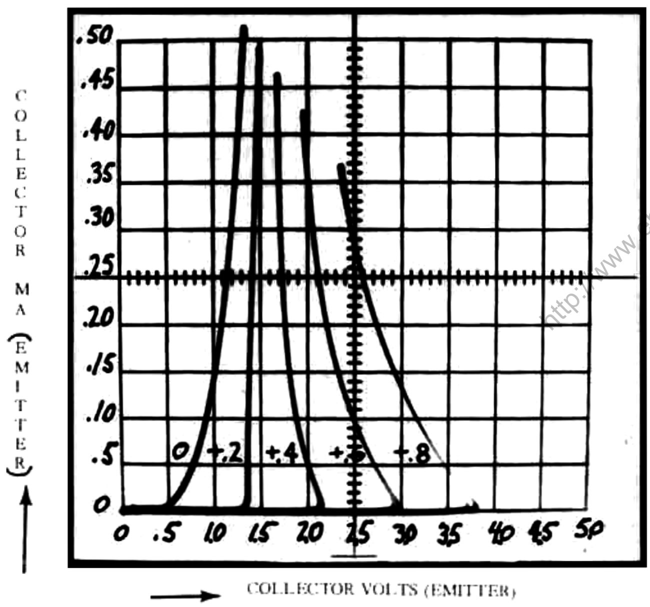
Dissipation Limiting
Resistor = 500 Ohms.

Diode Connections:

Cathode = E (ground).
Plate = C (Collector).

Fig. 22. Zener diode reverse breakdown characteristic.

The emitter characteristics of the double-base junction diode may be displayed on the Type 575 by connecting the emitter to the Collector (C) terminal, Base-two to the Base (B) terminal, and Base-one to ground terminal (E). The emitter current for zero Base Current input is established by the Collector Peak Volts and appears as the first vertical trace in the display. As the constant current base steps are increased, sufficient Base-two to Base-one bias is developed to produce a family of emitter characteristics, as shown in Figure 23. By selecting BASE VOLTS on the Horizontal display, the input bias voltage for each curve may be determined. The negative resistance characteristics of the emitter appear on the second, third, and fourth Base steps in Figure 23. The interbase family of characteristic curves shown in Figure 24 is obtained by connecting Base-two of the transistor to the Collector (C) terminal, the emitter to the Base (B) terminal, and Base-one to ground terminal (E). The graticule scale factors and the magnitude of the input current are given with each illustration.



DISPLAY

Vertical:
Coll. Ma = .05 Ma/Div.
(Emitter Current).

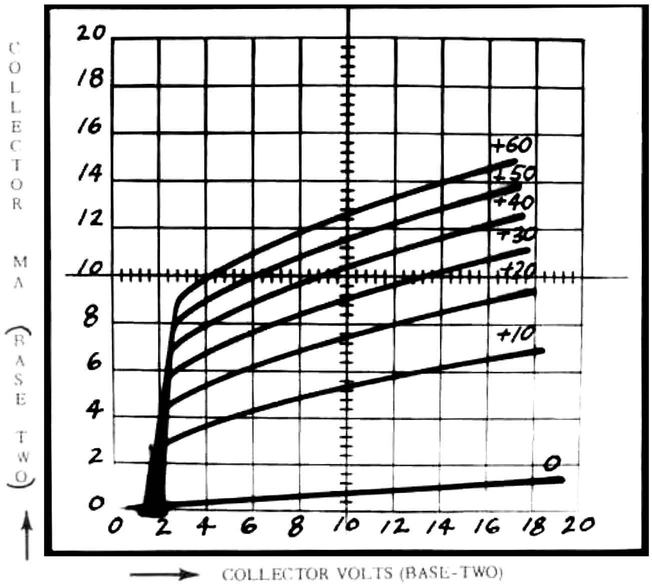
Horizontal:
Coll. Volts = .5 V/Div.
(Emitter Voltage).

Base Step = + .2 Ma/Step
(Applied to Base-two).

Dissipation Limiting
Resistor = 5 K Ohms.

Polarity = (+) NPN.

Fig. 23. Double-base junction diode emitter characteristic.



DISPLAY

Vertical:
Coll. Ma = 2 Ma/Div.
(Base-two Current).

Horizontal:
Coll. Volts = 2 V/Div.
(Base-two Voltage).

Base Step = +10 Ma/Step
(Applied to Emitter).

Dissipation Limiting
Resistor = 100 Ohms.

Polarity = (+) NPN.

Fig. 24. Double-base junction diode interbase characteristic.

MODIFICATIONS FOR SPECIAL APPLICATIONS

VERTICAL SCALE INCREASED BY A FACTOR OF TWO

It is possible to decrease the sensitivity of the vertical amplifier by one-half so that the value of each VERTICAL CURRENT OR VOLTAGE position is multiplied by a factor of two. For instance, the 1000 MA/DIV position of the COLLECTOR MA display is increased from 1 amp/division to 2 amp/division. This may be particularly useful for measuring collector current values between 10 and 20 amps. To accomplish this change it is only necessary to change the value of R429 from 11.48 K ohms to 32.31 K ohms. The one-percent resistor is located on the top of the Vertical display switch SW405C. The collector supply is capable of delivering 20 amps for short periods of time at low collector voltages. The collector supply power limitation is protected by a one-amp fuse in the primary circuit of the supply. The fuse is located on the front panel of the Type 575 with the COLLECTOR SWEEP controls.

VERTICAL SCALE DECREASED BY A FACTOR OF ONE-TENTH

The sensitivity of the vertical amplifier may be increased by a factor of ten so that the value of each VERTICAL CURRENT OR VOLTAGE position is divided by 1/10. In measuring small values of collector current, for instance, the vertical scale factor is changed from .01 ma/division to .001 ma/division. The change may be accomplished by shorting out R429, a one-percent, 11.48 K ohms resistor located on top of the Vertical display switch SW405C. The lead length should be held to a minimum to avoid hum pick-up. An alternate method of measuring small values of collector current is given in an earlier section devoted to measuring collector cutoff current.

SINGLE TRACE DISPLAY

Through the proper selection of the BASE STEP SELECTOR, STEPS/FAMILY, POLARITY and STEP ZERO controls on the Type 575, one of a family of base steps can be made to coincide with a predetermined value of input current or voltage, as long as it is within the maximum ratings of the base generator. However, if it is required that only one value of input current or voltage be selected for single trace display, it can be accomplished by substituting a fixed voltage to the step amplifier in place of the staircase steps from the step generator. The Step Generator, as we have used the term in preceding discussions, actually consists of a Step Generator followed by a Step Amplifier. Referring to the Step Generator schematic in the Instruction Manual for the Type 575, the fixed voltage should be applied to the 1 K resistor R175 which connects to grid pin 2 of V163 (6AN8) after removing the connection of R175 from the junction of R174 (1.2 Meg) and B174. The fixed dc voltage can be derived from a divider network and potentiometer to obtain a range of from -20 volts to +170 volts, which corresponds approximately to the zero step and the 12th step of the step generator. The division of current or voltage by the STEP SELECTOR switch is still effective since it is in the output of the step amplifier. The calibration of the single trace output current or voltage may be obtained by displaying the transistor characteristics in the normal manner and then substituting the fixed voltage to duplicate the trace desired. A more sophisticated circuit may be devised using precision resistors for fixed voltage taps which, when once calibrated, will not require further adjustment. The regulated voltages within the Type 575 may be used as a source for the divider arrangement as long as precautions are taken against drawing more than several milliamps current in the divider. It should be remembered that the average transistor current could be higher for single trace display than for the family of curves. The increased power dissipation of the transistor could cause shifting of the curve as a result of heating.

DEFINITIONS OF SYMBOLS

I_{cbo} Collector current when collector junction is reverse-biased and zero current flows in the emitter or it is open circuit.

I_{ceo} Collector current when collector junction is reverse-biased and zero current flows in the base or it is open circuit.

α DC or low-frequency forward-current gain or forward-current transfer ratio in common base configuration.

β DC or low-frequency forward-current gain or forward current transfer ratio in common emitter configuration.

h_{fe} Same as B (Beta).

h_{oe} DC or low-frequency output admittance in common-emitter configuration.

h_{ie} DC or low-frequency input impedance in common-emitter configuration.

h_{re} DC or low-frequency reverse voltage amplification factor in common-emitter configuration.

h_{fb} Same as α (Alpha).

h_{ob} DC or low-frequency output admittance in common-base configuration.

I_c DC or low-frequency value of collector current.

V_c DC or low-frequency value of collector voltage measured at the collector terminal of the transistor.

I_b DC or low-frequency value of base current.

V_b DC or low-frequency value of base voltage measured at the base terminal of the transistor.

I_e DC or low-frequency value of emitter current.

V_e DC or low-frequency value of emitter voltage measured at the emitter terminal of the transistor.

Δ A small increment of the symbol to which it is attached.

V_{cs} DC or low-frequency value of collector voltage at which the collector current becomes essentially independent of the input voltage or current.

R_{cs} Collector saturation resistance or the ratio of the collector saturation voltage to the collector current at which the collector saturation voltage was measured. (Specify input current or voltage at measuring point.)

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