SECTION 3
CIRCUIT DESCRIPTION

Introduction

The Type 502A is a dual-beam, high gain low-frequency, oscilloscope employing a dual-gun cathode ray tube. The CRT has two sets of independent vertical deflection plates, one of each of the two identical vertical amplifiers, and one set of common horizontal deflection plates. Simultaneous horizontal deflections of both beams is provided by a single time-base generator and horizontal sweep amplifier circuit. In addition, the upper-beam deflection amplifier can be connected to the horizontal deflection plates, so that the instrument may be employed as a single-beam X-Y oscilloscope; or, by means of the EXTERNAL HORIZONTAL INPUT circuit, the instrument may be used as a dual-beam X-Y oscilloscope, with both traces plotted on the same X axis.

Vertical Amplifiers

The Type 502A circuitry is arranged so that the instrument can be used in any of the several configurations. It may be used as a conventional single-beam oscilloscope by applying an input signal to either of the vertical deflection amplifiers or it may be used to examine two waveforms simultaneously by applying input signals to both vertical amplifier systems; either amplifier may be used in the differential mode to examine differences between two signals.

The Upper-Beam Vertical and the Lower-Beam Vertical Deflection Amplifiers are identical, so the description that follows applies to both.

Vertical Input Switching

The Input Selector switch SW401 determines the mode of operation for the Vertical Amplifier. When in any of the three positions marked AC, the signal is AC-coupled through C400 (for Input A) and/or C401 (for Input B). When in any of the three positions marked DC, the signal is DC-coupled to the input stages of the amplifier.

When switched to A or B, the unused input grid is grounded to eliminate the effect of its Nuvistor's capacitance on the amplifier's high-frequency response. Grounding the grid also prevents pickup of unwanted signals when single-ended operation is desired. For single-ended operation, it is usually best to connect the signal to INPUT A, since a signal connected to INPUT B will always be inverted.

When the Input Selector switch is set to A-B (DIFF), the Vertical Amplifier operates as a differential amplifier and the difference between the A and B signals is displayed.

The basic deflection factor of either Vertical Amplifier is 100 μV/cm. However, by means of an input attenuator and by varying the emitter load resistance and collector degeneration in later stages, the vertical sensitivity can be decreased to 20 volts per centimeter calibrated or 50 volts per centimeter uncalibrated.

In the straight-through (.1 mVOLTS PER CM to .2 VOLTS PER CM positions of the SENSITIVITY switch, the 1 megohm grid resistors constitute the input resistance of the input amplifiers. In the range from 0.5 VOLTS/CM to 20 VOLTS/CM, a $\times$100 attenuator is connected into each input circuit. The bottom resistors in the dividers—R403D and E for Input A and R405D for Input B—shunt the grid resistors to create an equivalent resistance of 10 kilohms. This 10 kΩ equivalent resistance is in series with the 990 kΩ resistor in the upper end of the divider to produce a total input resistance of 1 megohm, the same input resistance we had in the $\times$1 positions of the switch.

The capacitance values in the attenuators are also selected, to provide a constant input capacitance regardless of the setting of the SENSITIVITY switch. In the $\times$1 position of the switch, the input capacitance is equal to the capacitance of C404 (for Input A) or C406 (for Input B) plus the stray capacitance of the wiring and other components in the circuit. C404 and C406 are adjusted with the SENSITIVITY switch set to one of the $\times$1 positions so that the total capacitance for each input is 47 pF.

Setting the SENSITIVITY switch to an attenuator position reduces this input capacitance to a very small value by adding series capacitance (C403C and C405C). The capacitors at the attenuator inputs shunt this small capacitance and are adjusted to bring the total capacitance at the input connectors back to 47 pF again. Thus, an attenuator probe, when connected to either input and properly adjusted, will work into an RC time constant of 1 megohm times 47 pF regardless of the position of the SENSITIVITY switch.

Vertical Input Amplifier

Q414-V414 and Q514-V514 form a cascode differential amplifier stage. In order that the Type 502A will operate in a true differential manner over the wide dynamic range of the instrument, static and dynamic balances are closely controlled throughout the amplifier. In addition, constant current and bootstrap circuits are used to provide better common-mode rejection. See Fig. 3-1.

The cathodes of the input Nuvistor vacuum tubes are coupled together by the cathode degeneration resistors R418 and R518. At the junction of these resistors, longtail cathode current is supplied by Q438, a constant-current transistor. Q434 provides a negative feedback from the output of the input stage to Q438. This feedback signal stabilizes the DC output level of the stage at approximately +100 volts as measured at the collectors of Q414 and Q514.

By keeping the current constant at both cathodes, common-mode signals are largely prevented from appearing at the collectors of Q414 and Q514. In addition, this longtailing helps to maintain fixed gain and linearity with large input signals.

Common-mode signals at the grids will produce essentially no change in the division of the cathode current between

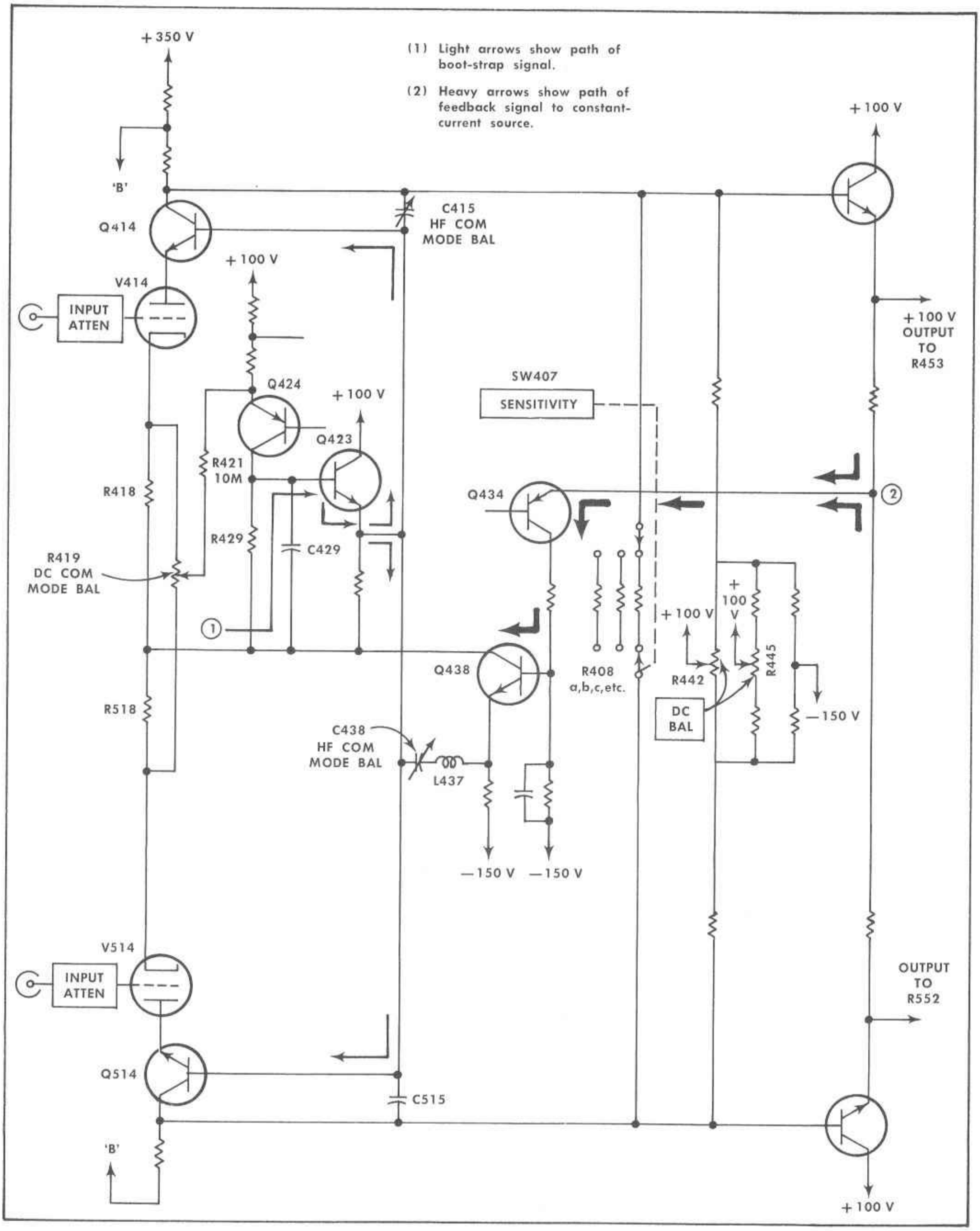

Fig. 3-1. Simplified diagram of input vertical amplifier. (1) Light arrows show path of boot-strap signal. (2) Heavy arrows show path of feedback signal to constant-current source.

the two sides. The common-cathode voltage will, however, follow the common-mode signal in the manner of a single cathode follower. To provide bootstrapping, this signal is coupled by C429 and R429 to the base of the bootstrap emitter follower Q423. The output signal at the emitter of Q423 will be nearly the same as the common-mode signal appearing at the input grids. This signal is applied to the bases of Q414 and Q514 so that the plate-to-cathode voltages on the input Nuvistors remain essentially constant. This bootstrap action, along with the constant-current action of Q438 and the feedback action of Q434, sets the operating conditions of the input amplifiers so that a common-mode signal will be canceled out.

C415 is adjusted to balance out the capacitive currents appearing at the outputs to provide high-frequency common-mode rejection; R419 is adjusted to balance out the resistive currents appearing at the outputs for low-frequency common-mode rejection.

C438 compensates for the common-mode capacitance found at various points in the signal path by injecting opposing current from the output of the bootstrap emitter follower Q423 into the emitter circuit of Q438. C438 is adjusted for minimum high-frequency common-mode signal at the outputs. It completes a positive feedback loop through C438, Q438, C429 and Q423. L437 dampens the tendency of this loop to oscillate.

Diodes D410 and D520 are connected between the grids and cathodes of the input Nuvistors to limit grid current during warmup.

When a large unbalanced signal is applied to the input of the Vertical Amplifier, a slight DC shift will occur due to the $\sim$2.5 seconds time constant in the amplifier[1]. To compensate for this time-constant, a network consisting of C420 and R420 is connected between the plates of the Nuvistors.

The SENSITIVITY switch sets the gain of the input amplifier by connecting precision resistors R408A, R408B, etc. in shunt with the Q414-Q514 collector load resistors. In the .1 mV/CM position, no resistor is switched in and the gain is approximately 30 times. D408 and D409 are placed across R408 to protect the following stages from damaging overloads if excessive voltages are applied to the input connections.

DC BAL controls R442 and R445 adjust the relative DC levels at the collectors of Q414 and Q514 so that there will be no current flow through R408. With this configuration, a change in R408 will not affect the DC level at the output of the stage and therefore will not affect the position of the trace's baseline on the CRT.

Emitter followers Q453A & B provide a high impedance load for the input paraphase amplifier so that gain-setting by R408 will not be affected by the load of the second amplifier stage. Transistor pairs using common heat shields are used for the emitter-follower pair and the amplifier pair to reduce unbalance caused by thermal differences. When a change in the characteristics occurs in one transistor because of a change in temperature, the other transistor of the pair will be equally affected. Additional thermal stability is introduced by R461-C461 and R561-C561.

Current for Q453A & B is supplied through R452 and R552 from Q434, which also couples the negative feedback signal from Q453A & B to Q438 to set the input amplifier operating levels.

[1]This is sometimes referred to as "slump". See Jacob Millman and Herbert Taub, "Pulse and Digital Circuits", McGraw-Hill, New York, 1962. Page 120.

Output Vertical Amplifier

The push-pull signal from emitter-followers Q453A and B is amplified in the second amplifier stage of Q464A and B. Variable sensitivity is obtained by the use of degenerative common-emitter coupling. In the CAL position of the VARIABLE SENSITIVITY control R466, SW466 is closed to short out R466 so the gain of the stage is maximum. As the control is rotated a few degrees counterclockwise, SW466 is opened so the control can be used to vary the amount of emitter degeneration and thus control the gain of the stage.

Vertical positioning of the trace is accomplished through the action of the POSITION control R469. As the control is rotated in either direction from its midrange position, the control varies the relative DC biasing on Q474 and Q574 by increasing the current applied to the base of one transistor while decreasing the current applied to the other.

The gain of the output driver stage of Q474 and Q574 is set by R475, a common-emitter degeneration control. In the Upper-Beam Amplifier circuit, when the amplifier is connected to the horizontal deflection plates by SW489, this resistor is paralleled by R478 to change the gain to compensate for the decreased sensitivity of the horizontal deflection plates as compared to the vertical deflection plates.

Q474 and Q574 drive the final stage of the amplifier, a hybrid push-pull cascode amplifier with common-emitter degeneration. R485 and C485 provide high-frequency equalization to compensate for distributed and CRT capacitance.

V484A and B are used for the final amplifier stage to provide the high output voltages needed to drive the CRT deflection plates. The potential at the grids of both triodes is held constant by zener diode D471.

When internal triggering of the Time-Base Generator is desired (TRIGGER SELECTOR in either of the UPPER or LOWER positions), a sample of the vertical-output signal is used to develop the triggering pulse. This sample, obtained from the plate circuit of V484A, is coupled through a frequency-compensated voltage divider to V493A, a cathode follower which drives the Time Base Trigger and VERTICAL SIG OUT circuitry. DC Trig control R491 is adjusted to set the cathode voltage of V493A to zero when triggering with DC coupling and with the beam positioned at its respective zero-center graticule line.

The VERT SIG OUT cathode follower V493B is direct coupled to the output of V493A to provide a vertical signal output of approximately 2 volts per centimeter of deflection (dependent upon the actual CRT sensitivity).

Depressing the trace FINDER button SW496 decreases the gain of the output stage to bring the track back onto the CRT if a high amplitude input signal or a misadjusted DC BAL control has moved it off the screen.

For single-beam applications where equal horizontal and vertical-deflection factors are desirable, the UPPER BEAM amplifier is connected to the CRT horizontal deflection plates by placing the HORIZ DEF PLATE SELECTOR switch SW489 in the UPPER BEAM AMP position (see Fig. 3-2). This provides a sensitivity of 0.1 millivolts per centimeter to 20 volts per centimeter and differential input for both horizontal and vertical deflection. Only the lower beam will be displayed on the CRT; the upper beam will be deflected

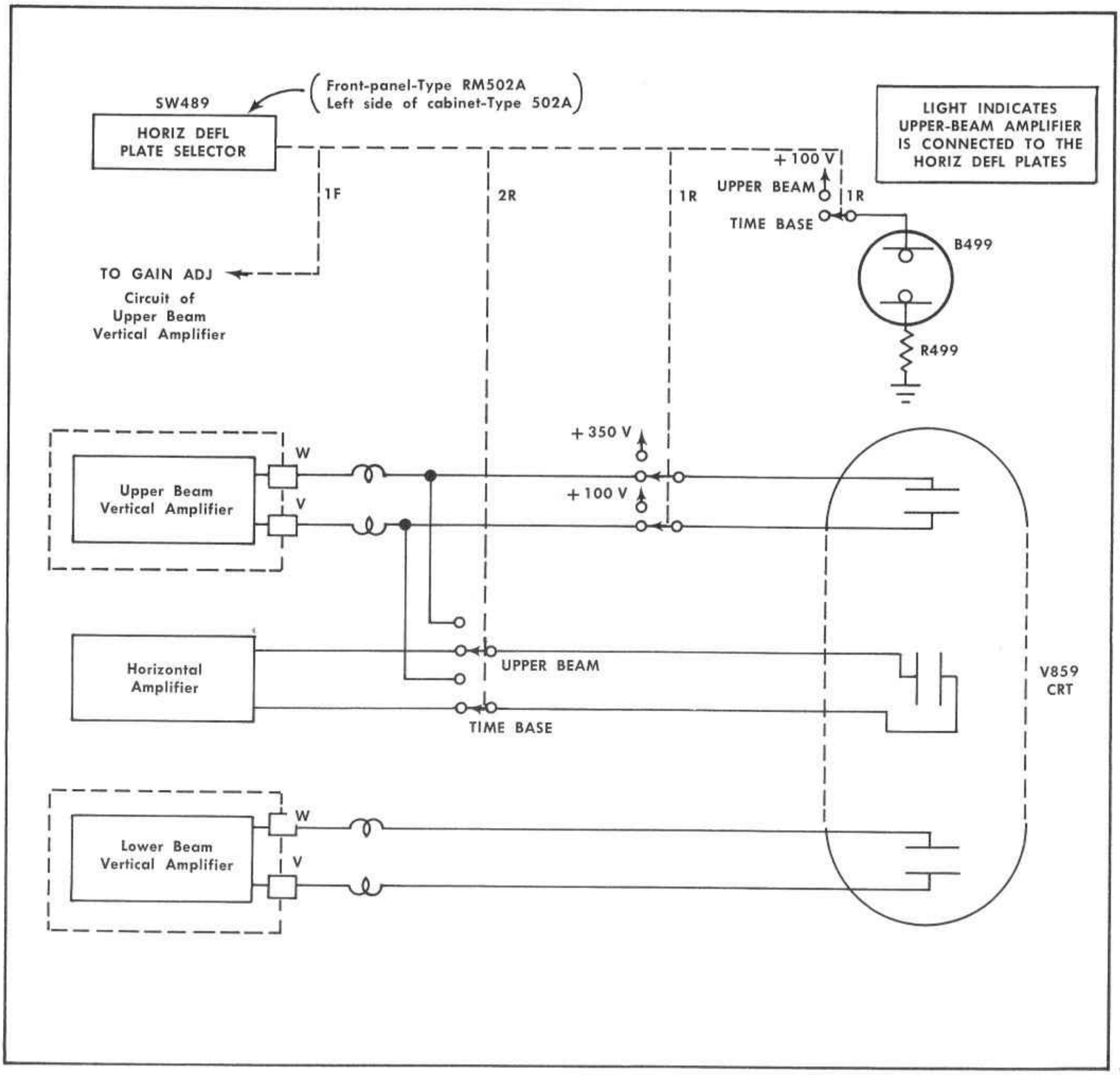

Fig. 3-2. CRT deflection plate switching.

off the screen by applying +350 volts to the upper deflection plate and +100 volts to the other deflection plate. Panel light B499 indicates when the Upper Beam amplifier is connected to the horizontal deflection plates.

TIME-BASE TRIGGER

The Time-Base Trigger circuit consists of a triggering-signal amplifier V24 and a multivibrator (Schmitt Trigger) circuit V45. The function of the trigger circuitry is to produce a negative-going rectangular pulse at the plate of V45A whose repetition rate is the same as that of the trigger-ing signal. This negative step is then differentiated to produce a negative spike (trigger) to trigger the Time-Base Generator in the proper time sequence. A positive spike is also produced by the differentiation process, but this spike is not used.

The signal from which the rectangular output is produced may emanate from one of four sources. When the TRIGGER SELECTOR switch is in the LINE position, a 6.3-volt signal at the power line frequency is used for this application. When the switch is in the UPPER or LOWER position (AC or DC), the signal is obtained from the Upper or Lower Beam Vertical Amplifier, respectively. In the EXT position (AC or DC), the signal is obtained from an external source through a front-panel connector (TRIGGER INPUT). In any of the

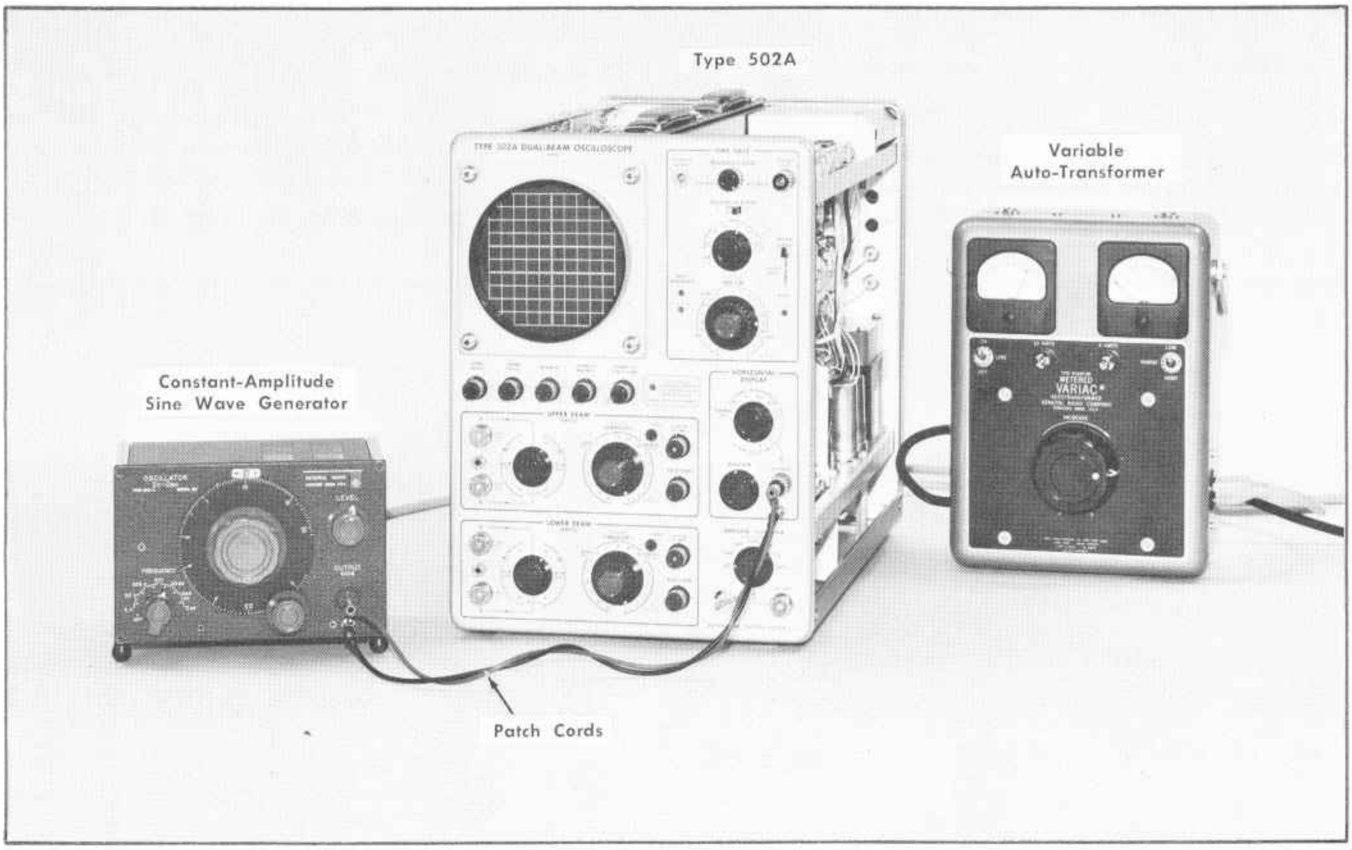

Fig. 6-17. Test equipment setup for checking External Horizontal bandwidth (step 17).

17. Check External Horizontal Display Bandwidth

a. Connect the test equipment as shown in Fig. 6-17.

b. Apply a 10 kHz signal from the sine-wave generator to the EXTERNAL HORIZONTAL INPUT connector.

c. With the HORIZONTAL DISPLAY switch in the .1 EXT VOLTS/CM position, adjust the Amplitude control of the generator for exactly 6 centimeters of horizontal deflection.

d. Set the Frequency control of the generator to 100 kHz. The trace should be $\geq$4.2 centimeters in length.

e. Disconnect the sine-wave generator and set the HORIZONTAL DISPLAY switch to NORMAL (×1).

VERTICAL AMPLIFIERS

Preset the controls as follows:

TRIGGERING LEVEL	RECURRENT
MODE	NORMAL
TIME/CM	2 mSEC
HORIZONTAL DISPLAY	NORMAL (×1)
INPUT SELECTOR (Both)	A DC
VERT POSITION (Both)	Align the traces with the appropriate graticule center horizontal lines
VERT SENSITIVITY (Both)	.2 VOLTS PER CM
HORIZ. DEF. PLATE SELECTOR	TIME BASE AMP

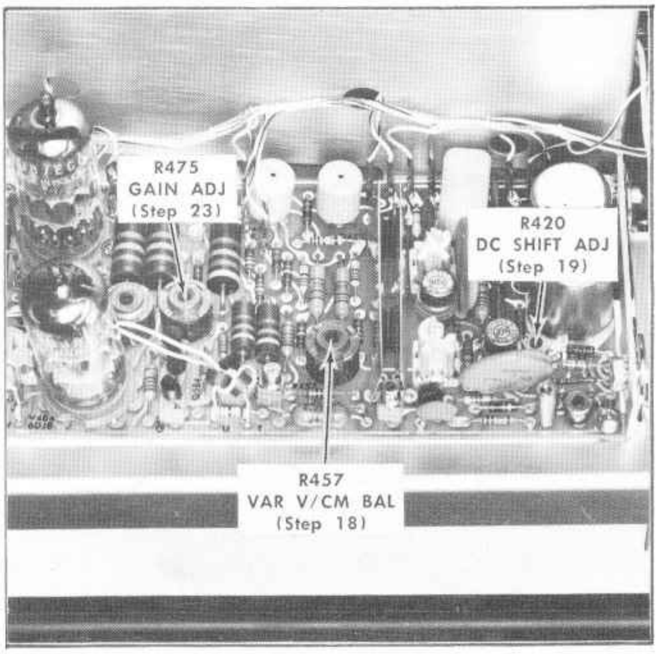

Fig. 6-18. Location of vertical amplifier adjustments (steps 18, 19 and 23).

18. Adjust DC BALANCE Controls

a. Ground the input to the 4-way connector.

b. Set both DC BAL knobs to midrange.

c. Set the Upper Beam COARSE DC BAL adjustment for no trace shift as the SENSITIVITY switch is rotated between .2 VOLTS PER CM and .1 mVOLTS PER CM.

d. Repostion the trace to the Upper Beam graticule center horizontal line and repeat the COARSE DC BAL adjustment.

e. Set the SENSITIVITY switch to .2 VOLTS PER CM.

f. Set the Variable V/CM Balance adjustment R457 (see Fig. 6-18) for no vertical shift of the trace when the VARIABLE SENSITIVITY control is rotated through its range.

g. Repeat (c) through (f) for the Lower Beam Amplifier.

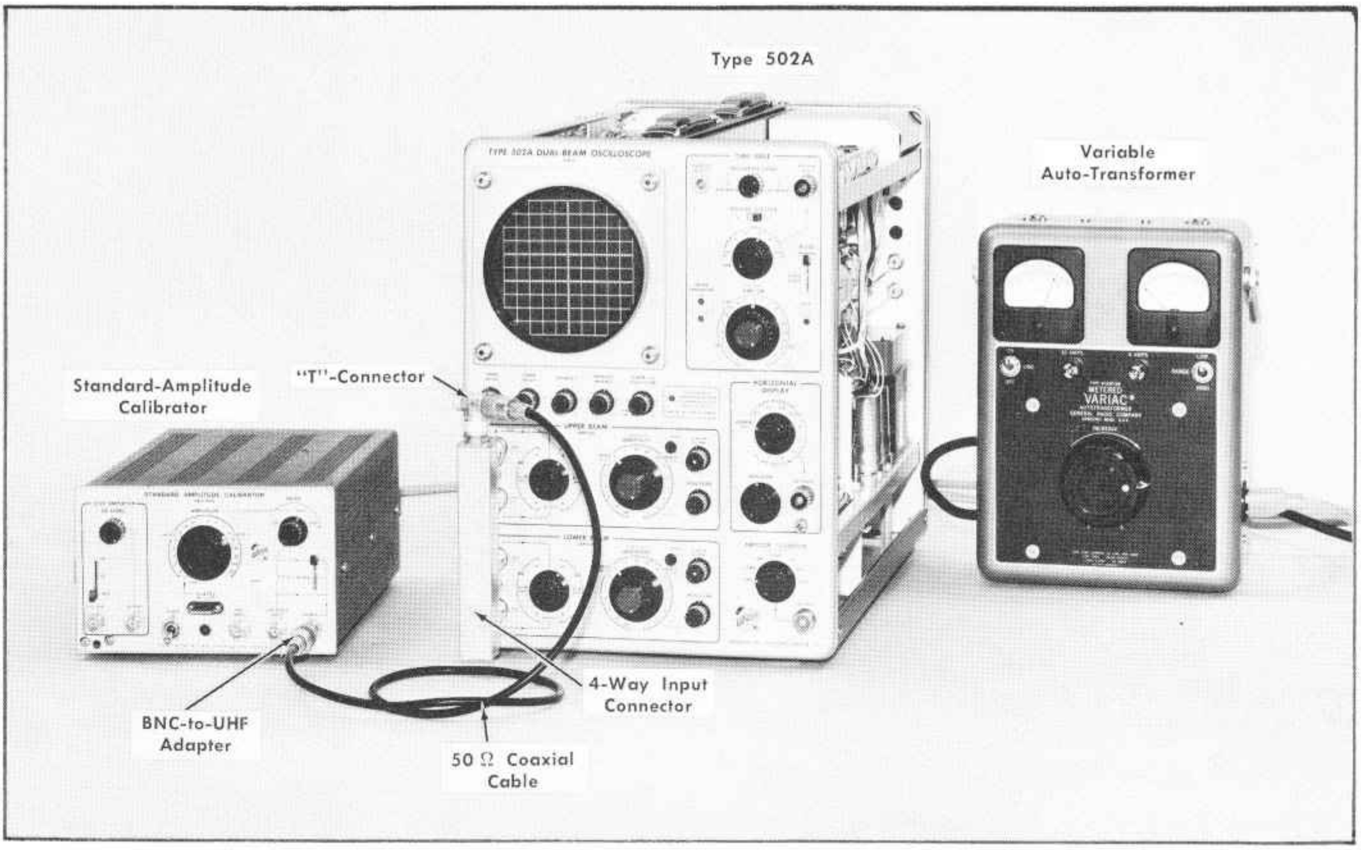

Fig. 6-19. Test equipment setup for steps 19 through 25.

19. Adjust DC Shift Compensation

a. Set up the equipment as shown in Fig. 6-19.

b. Set the controls of the SAC for a 2 volt square-wave signal.

c. While switching the SENSITIVITY switch back and forth between .2 and .5 VOLTS PER CM, set the DC Shift adjustment R420 (see Fig. 6-18) for minimum drift when switching to the .5 VOLTS PER CM position.

d. Repeat the above procedure for the other vertical amplifier.

20. Check Input Grid Current

a. Disconnect the SAC and ground the 4-way input connector.

b. Set both SENSITIVITY switches to .1 mVOLTS PER CM.

c. Switch the INPUT SELECTOR switches from A DC to A AC and from B DC to B AC. Neither trace should shift more than 3 centimeters.

21. Check for Excessive Noise

a. Ground the 4-way input connector.

b. Set both SENSITIVITY switches to .1 mVOLTS PER CM.

c. Average random noise level should not exceed 3 mm. (See Fig. 6-20.)

22. Check Vertical Drift vs. Line-Voltage Change

a. With the 4-way input connector still grounded, change the output of the auto-transformer through the line-voltage operating range (see Table 6-1.)

b. Check the movement of the trace. It should not shift more than 3 centimeters above or below the original level.

c. Set the autotransformer back to the correct (nominal) line voltage.

TABLE 6-8

SENSITIVITY in VOLTS PER CM	Standard Amplitude Calibrator Output	Check for Display:
.1 mV	.5 mV	5 cm ± 1.5 mm
.2 mV	1 mV	5 cm ± 1.0 mm
.5 mV	2 mV	4 cm ± 0.8 mm
1 mV	5 mV	5 cm ± 1.0 mm
2 mV	10 mV	5 cm ± 1.0 mm
5 mV	20 mV	4 cm ± 0.8 mm
10 mV	50 mV	5 cm ± 1.0 mm
20 mV	.1 mV	5 cm ± 1.0 mm
50 mV	.2 V	4 cm ± 0.8 mm
.1	.5 V	5 cm ± 1.0 mm
.2	1 V	5 cm ± 1.0 mm
.5	2 V	4 cm ± 0.8 mm
1	5 V	5 cm ± 1.0 mm
2	10 V	5 cm ± 1.0 mm
5	20 V	4 cm ± 0.8 mm
10	50 V	5 cm ± 1.0 mm
20	100 V	5 cm ± 1.0 mm

23. Adjust Vertical Gain

a. Set both SENSITIVITY switches to 10 mVOLTS PER CM. (Be sure that both VARIABLE SENSITIVITY controls are in the CALIBRATED position for Steps 23 and 24.)

b. Apply a 50 mV square wave signal from the Standard Amplitude Calibrator to the 4-way connector.

c. Set both INPUT SELECTOR switches to A DC.

d. Set both Vertical Gain Adjustments R475 (see Fig. 6-18) for exactly 5 centimeters of deflection for each beam.

24. Check Vertical Sensitivity

a. Check the sensitivity accuracy of both vertical amplifiers as directed in Table 6-8. Gain Adjustment R475 may be readjusted slightly if necessary to gring the displays within tolerance.

25. Check Range of VARIABLE SENSITIVITY Control

a. Leave both SENSITIVITY switches set at 20 VOLTS PER CM.

b. Set both INPUT SELECTOR switches to A DC.

c. Set the Standard Amplitude Calibrator for a 100 volt square wave.

d. Turn the VARIABLE SENSITIVITY controls fully counterclockwise and check for ≤ 2 centimeters of vertical deflection.

NOTES

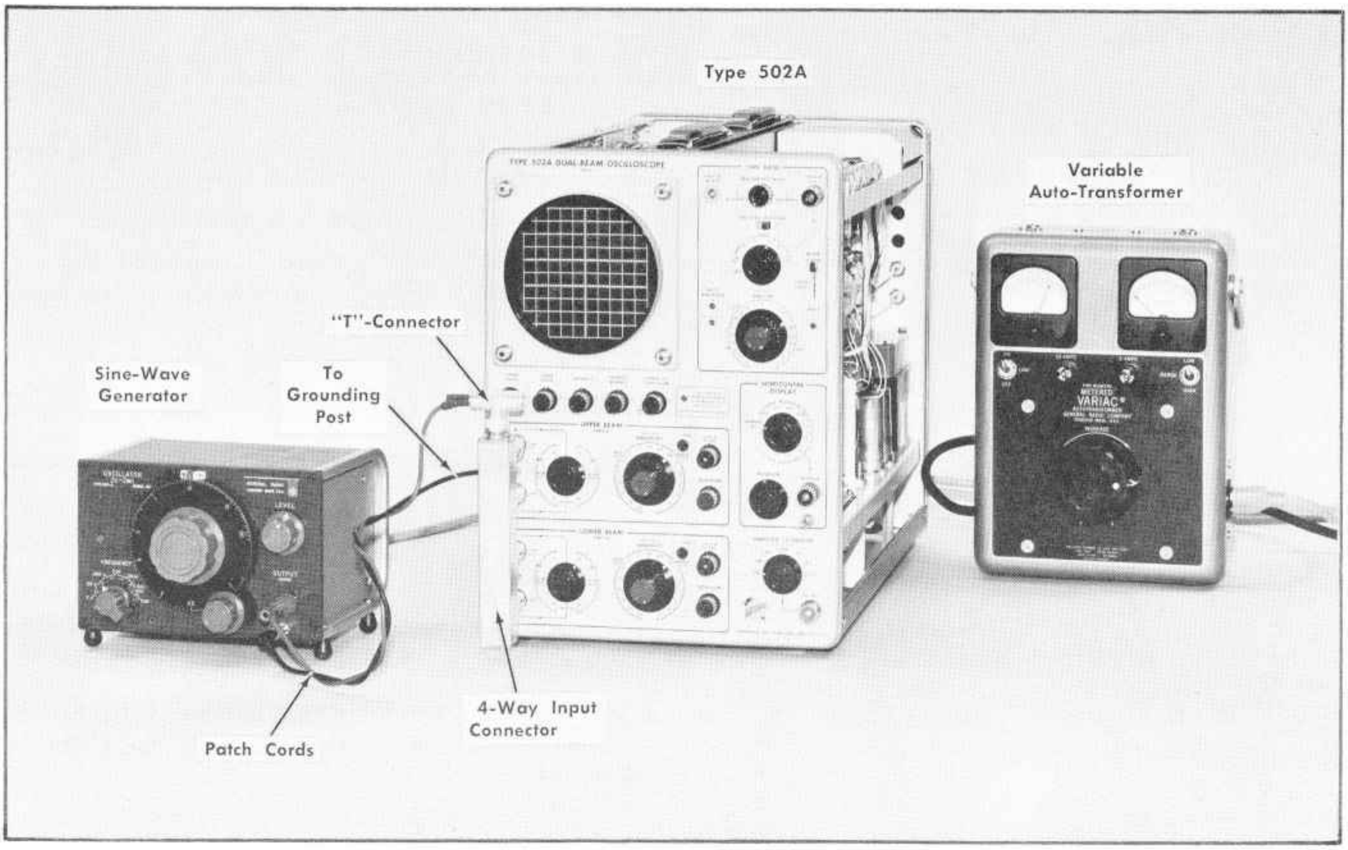

Fig. 6-20. Test equipment setup for checking and adjusting Common-Mode dynamic range (step 26).

26. Check Common Mode Dynamic Range

a. Connect the equipment as shown in Fig. 6-20.

b. Set the Upper Beam INPUT SELECTOR switch to A-B (DIFF).

c. Set the generator for a 1 kHz signal and turn down its signal amplitude.

d. Set the Upper Beam SENSITIVITY switch to 10 mVOLTS PER CM.

e. Increase the output amplitude of the generator signal. The display should not "break up" (see Fig. 6-21) until the signal amplitude is at least 30 volts peak to peak.

f. Check the Lower Beam Amplifier dynamic range in the same way.

NOTE

The Common-Mode Dynamic Range Check described above serves as a check of the overall amplifier performance. If the distortion appears at input voltages below 30 volts peak to peak, correct the trouble before continuing with the calibration.

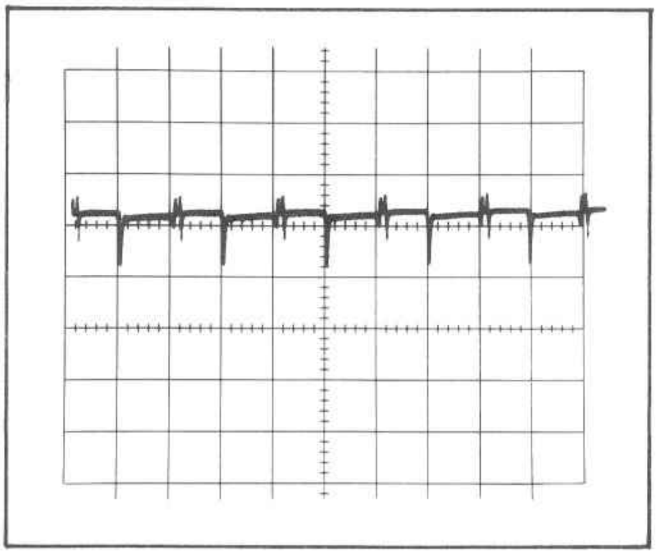

Fig. 6-21. CRT display showing effect of exceeding common-mode dymanic range limit (step 26).

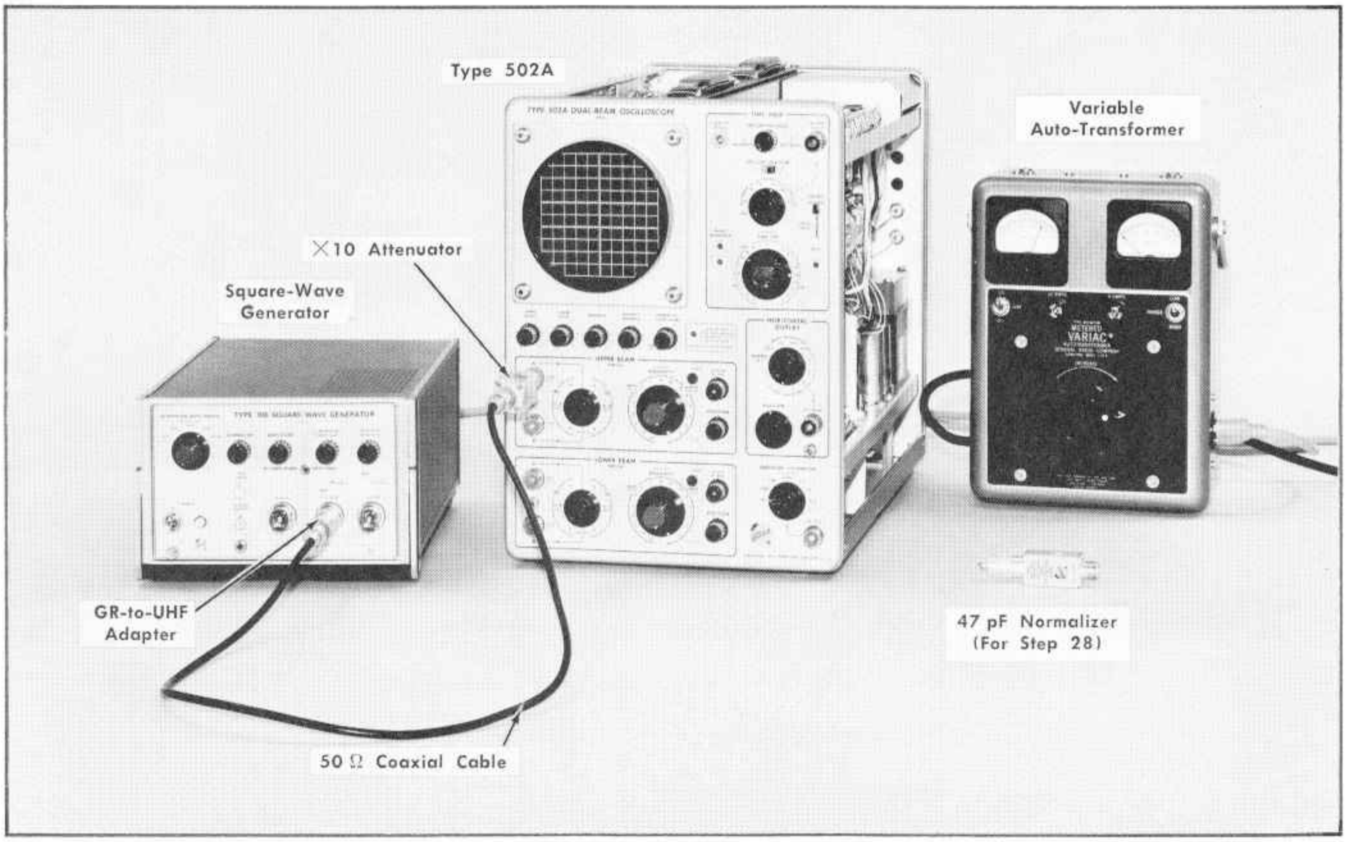

Fig. 6-22. Test equipment setup for adjusting HF compensation (step 27) and input compensation (step 28).

27. Adjust High Frequency Compensation

a. Connect the equipment as shown in Fig. 6-22.

b. Preset the following controls:

Type 502A

INPUT SELECTOR (Both)	A DC
SENSITIVITY (Both)	10 mVOLTS PER CM
TIME/CM	20 μSEC

Square-wave Generator

Frequency	10 kHz
Amplitude	6 cm display

c. Set the Upper Beam HF Compensation adjustment C496 (see Fig. 6-23A) for optimum response. Aberrations (tilt, overshoot, etc.) should not exceed 1.2 mm.

d. Move the signal to the Lower Beam A INPUT and repeat the above procedure for the Lower Beam C496 (see Fig. 6-23B).

28. Adjust Input Compensation

a. Connect the 47 pF Input Capacitance Normalizer between the input cable and the Upper Beam A INPUT connector.

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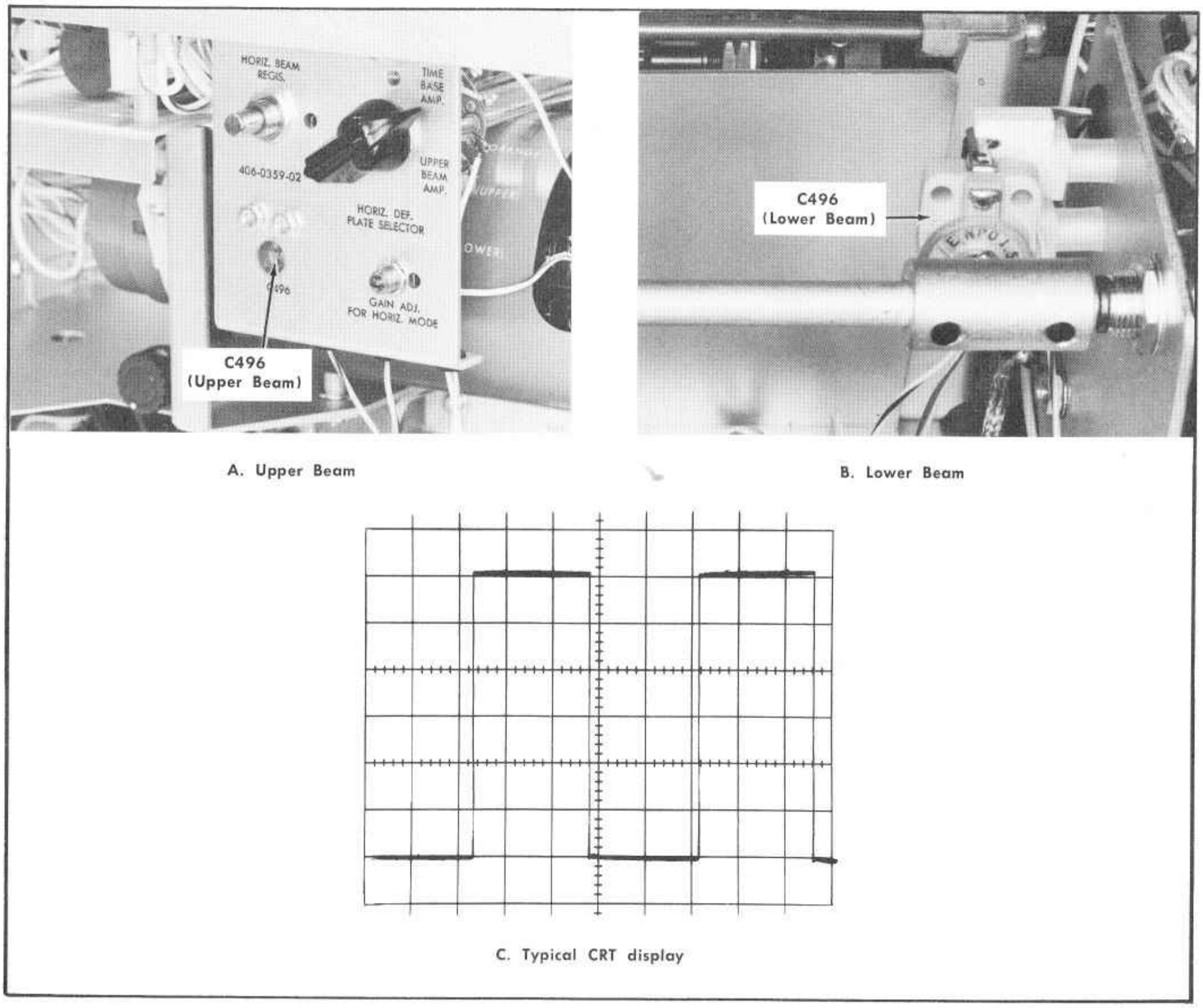


Fig. 6-23. Location of high-frequency compensation capacitors C496 and typical CRT display showing proper adjustment (step 27).

NOTES

NOTE

The 47 pF Normalizer must be connected directly to the A INPUT connector. If a BNC-to-UHF adapter or the 4-way connector is used between the INPUT connector and the Normalizer, the additional lead capacitance will cause C404 and C406 to be misadjusted.

b. Set the TIME/CM switch to .2 mSEC.

c. Set the square-wave generator for a 1 kHz output signal.

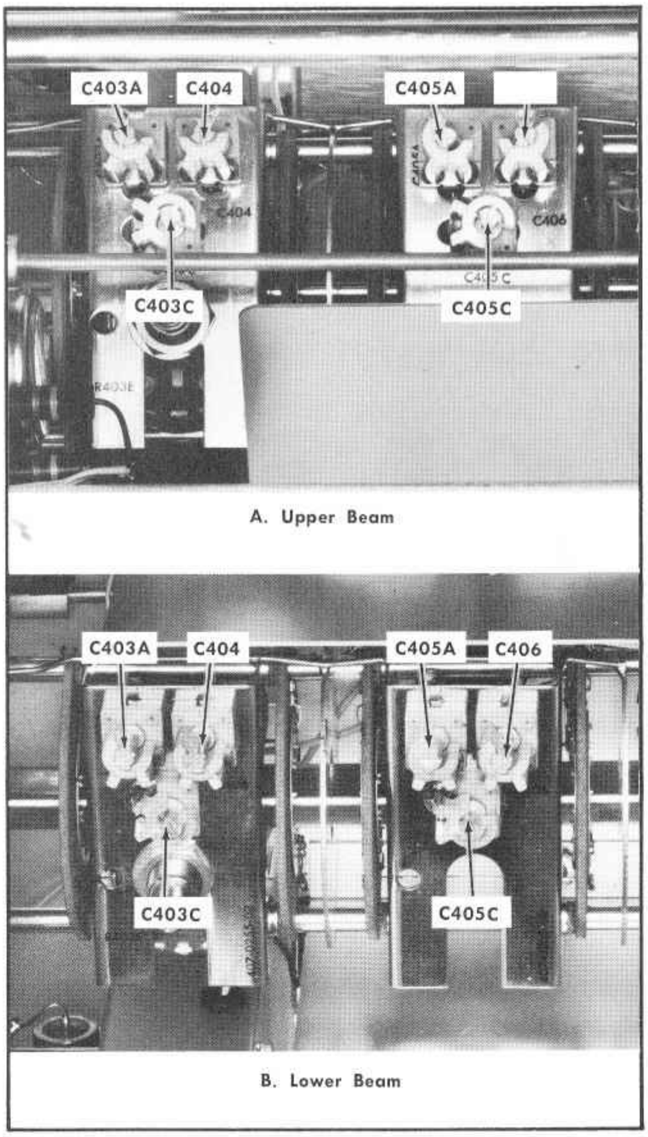
d. Adjust the Upper Beam input compensation capacitors (see Fig. 6-24A) as directed in Table 6-9. Connect the 47 pF Normalizer to the B INPUT connector for the B DC adjustments. Adjust the output of the generator for a 5 centimeter display each time the SENSITIVITY switch setting is changed.

TABLE 6-9

INPUT SELECTOR	SENSITIVITY (PER CM)	Adjust	For
A DC	.2 VOLTS	C404	Level flat-top
	.5 VOLTS	C403A	Level flat-top
		C403C	Square corner
B DC[3]	.2 VOLTS	C406	Level flat-top
	.5 VOLTS	C405A	Level flat-top
		C405C	Square corner

[3]INPUT B displays are inverted—use the bottom of the waveform.

e. Move the 47 pF Normalizer to the Lower Beam Amplifier and repeat the above adjustments. (See Fig. 6-24B for locations.)



A. Upper Beam

B. Lower Beam

Fig. 6-24. Location of input compensation capacitors (step 24c).

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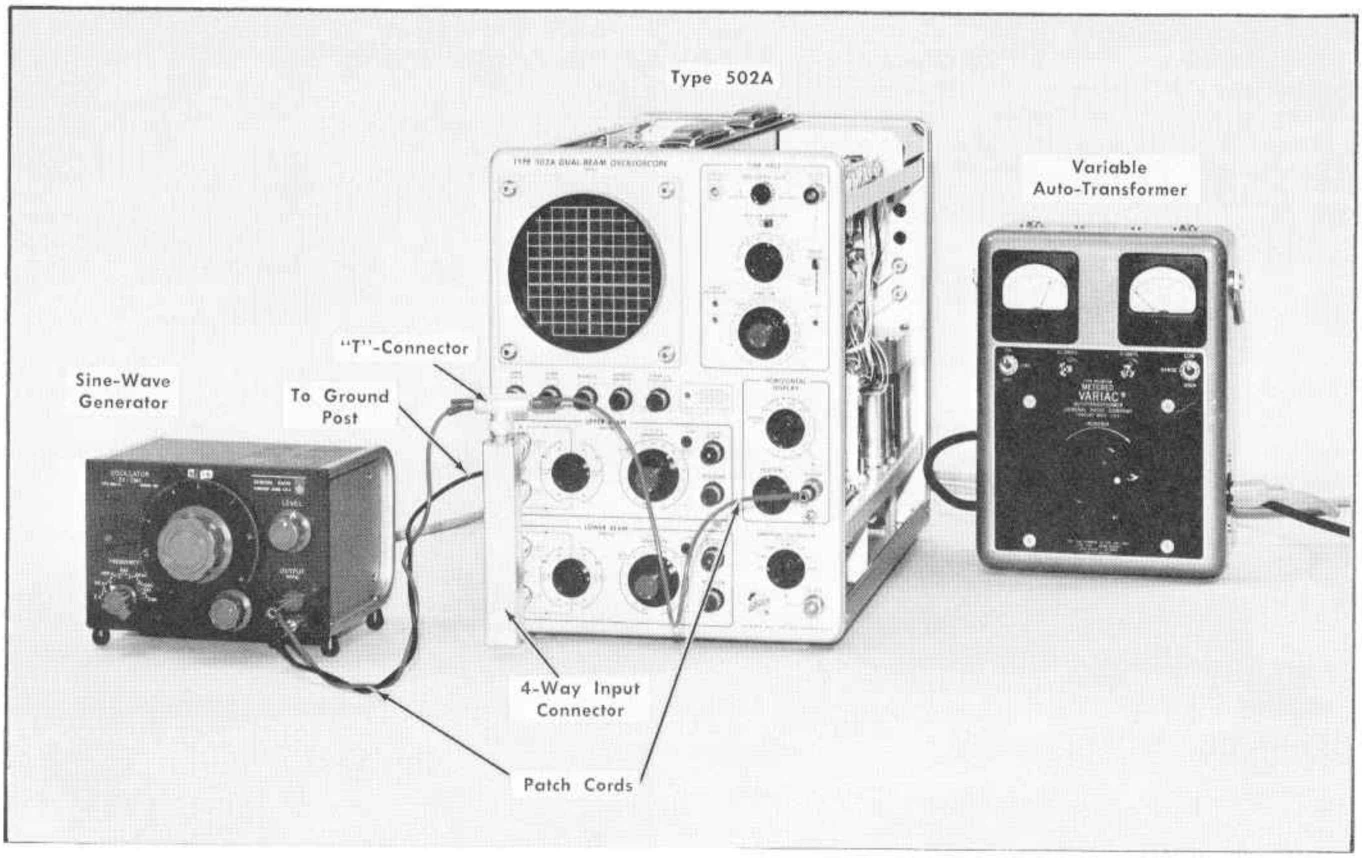


Fig. 6-25. Test equipment setup for adjusting and checking common-mode balance (step 29 and 30).

29. Adjust Amplifier Common-Mode Balance

(.1 mVOLTS PER CM to .5 VOLTS PER CM)

a. Set up the equipment as shown in Fig. 6-25.

b. Adjust the generator for a 50-Hz 10-volt peak-to-peak signal.

c. Set the TIME/CM switch to .1 mSEC.

d. Set both INPUT SELECTOR switches to A-B DC and position the Lower Beam display off the screen.

e. Adjust the Upper Beam Amplifier common-mode balance adjustments as directed in Table 6-10. (See Fig. 6-26 for the location of these adjustments.)

f. R419, C415, and C438 interact, so repeat the adjustments until all three are properly set.

g. Position the Upper Beam display off the screen, position the Lower Beam display on the screen, and adjust the Lower Beam common mode balance as directed in Table 6-10.

h. Readjust the signal generator to provide a 50-kHz 10-volt sine-wave signal.

i. Check both amplifiers as directed in Table 6-11.

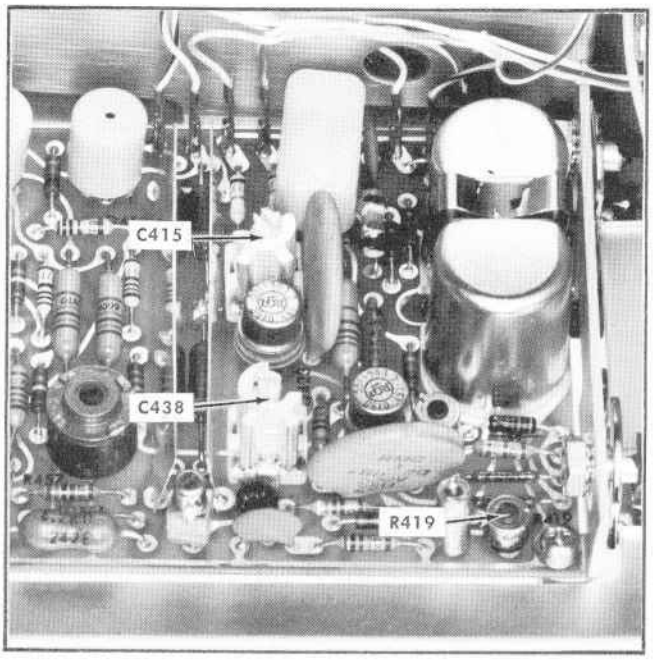


Fig. 6-26. Location of amplifier common-mode balance adjustments (step 29).

TABLE 6-10

SENSITIVITY (PER CM)	HORIZONTAL DISPLAY	Sine-Wave Frequency	Adjust	For
.1 mVOLTS	1 EXT VOLT/CM	50 Hz	R419	Minimum tilt
		50 kHz	C415	Minimum loop opening (See Fig. 6-27)
.2 VOLTS	NORMAL	50 kHz	C438	Minimum deflection

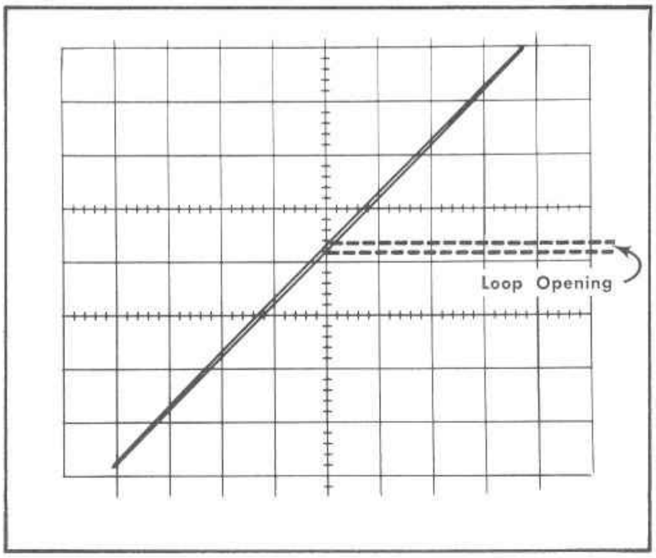


Fig. 6-27. Lissajous loop display for adjusting C415 (Table 6-10).

TABLE 6-11

SENSITIVITY (PER CM)	Maximum Deflection
.2 VOLTS to 5 mVOLTS	.5 mm
2 mVOLTS	1 mm
1 mVOLTS	2 mm
.5 mVOLTS	4 mm
.2 mVOLTS	1 cm
.1 mVOLTS	2 cm

30. Adjust Common-Mode Balance of Input Attenuator

(.5 to 20 VOLTS PER CM)

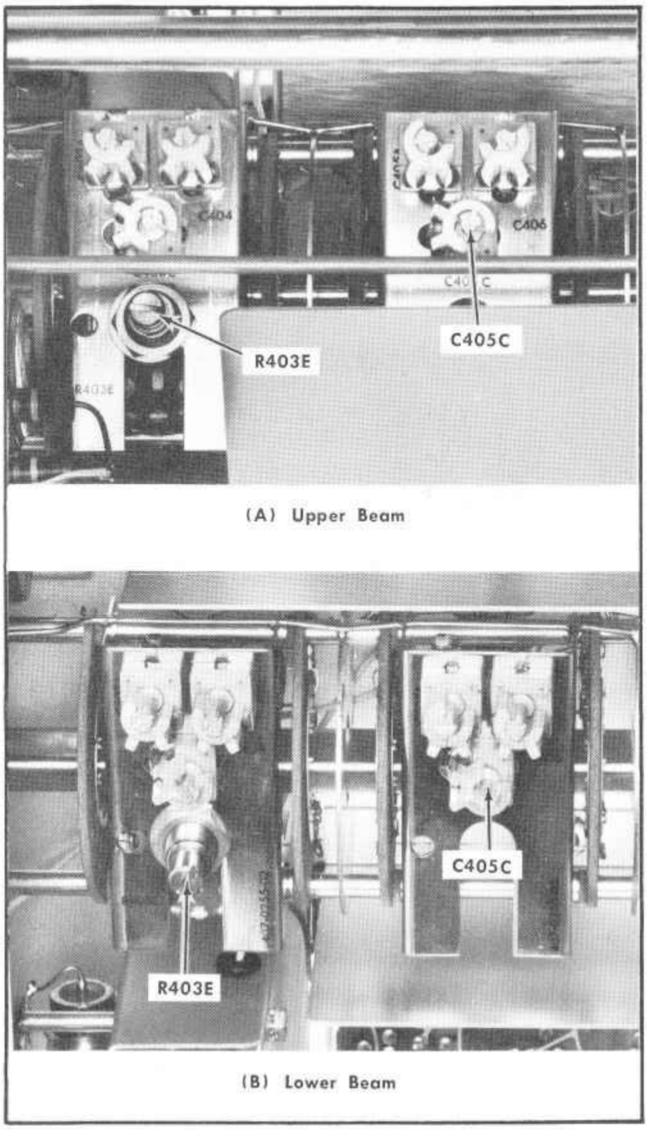
a. Preset the following controls:

Type 502A

INPUT SELECTOR (Both)	A-B DC
SENSITIVITY (Both)	.5 VOLTS PER CM
TIME/CM	10 mSEC

Sine-Wave Generator

Frequency	50 Hz
Amplitude	50 volts peak to peak



(A) Upper Beam

(B) Lower Beam

Fig. 6-28. Location of attenuator common-mode balance adjustments (step 30).

b. Adjust R403E on the Upper Beam SENSITIVITY switch (see Fig. 6-28) for minimum common-mode deflection of the Upper-Beam trace. When R403E is properly adjusted, there should be no discernible common-mode display (5000:1 CMRR = 0.2 mm deflection).

c. Change the sine-wave frequency to 50 kHz.

d. Change the TIME/CM switch to the .1 mSEC position.

e. Adjust C405C on the Upper Beam SENSITIVITY switch (see Fig. 6-28) for $\leq$2 mm of common-mode signal (500:1 CMRR). Note: C405C was previously adjusted in Step 28.

f. Change the sine-wave frequency to 1 kHz.

g. Change the TIME/CM switch to the 5 mSEC position.

h. Check for $\leq$2 mm of common-mode signal (500:1 CMRR).

i. Repeat (b) through (h) for the Lower Beam Amplifier.

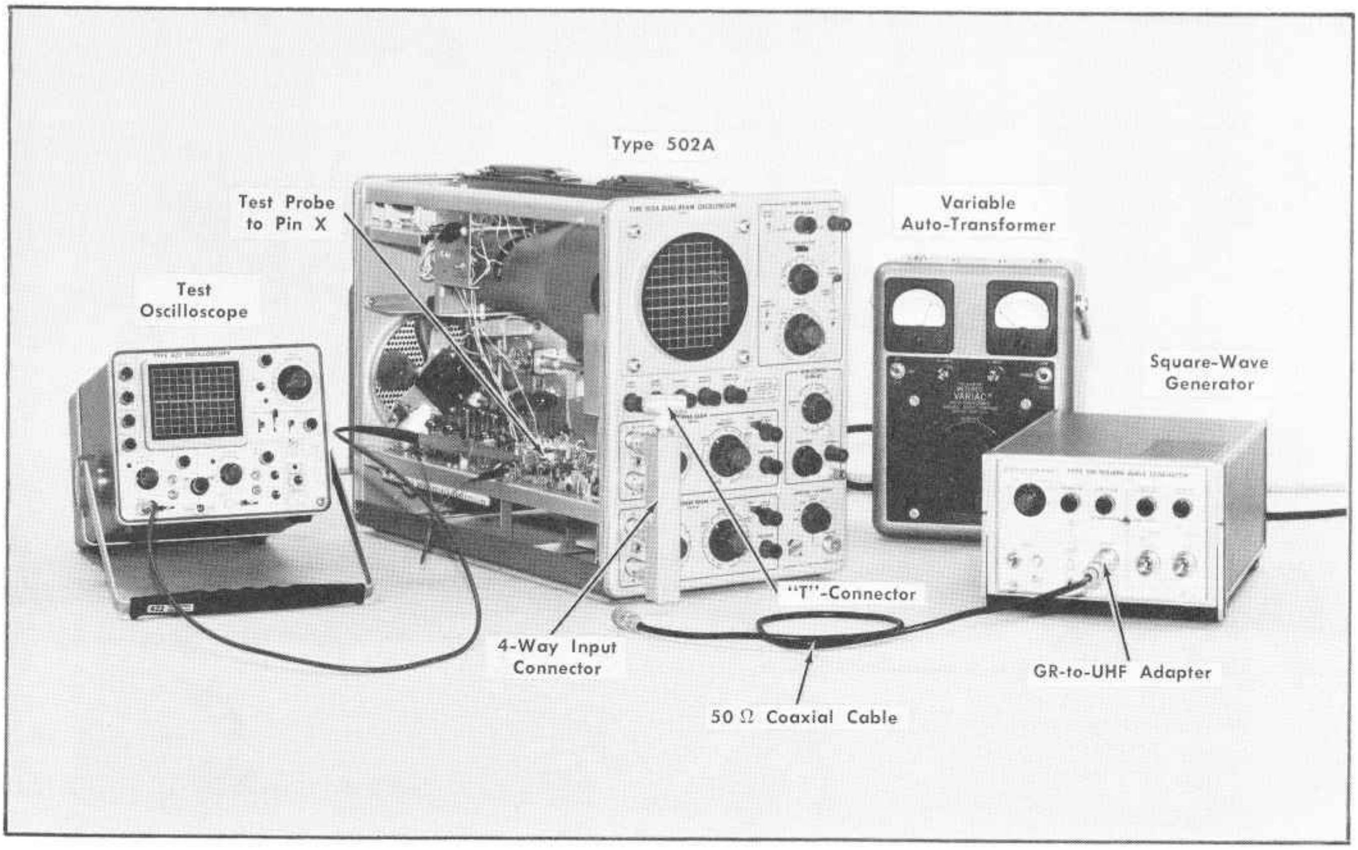


Fig. 6-29. Test equipment setup for adjusting trigger output (step 31).

31. Adjust Level and Compensation of Trigger Output and Vertical Signal Output

a. Set up the equipment as shown in Fig. 6-29. (Do not connect the square-wave signal to the Type 502A until step (e) below.)

b. Preset the following controls:

Type 502A

INPUT SELECTOR (Both)	A DC
SENSITIVITY (Both)	.2 VOLTS PER CM
TIME/CM	.5 mSEC

Square-Wave Generator

Frequency	1 kHz

c. Position the traces to the respective upper and lower beam graticule center horizontal lines.

d. Set R491 (see Fig. 6-30) for zero volts at Pin X.

e. Connect the generator to the 4-way connector and set its Amplitude control for a 5 centimeter display.

f. Move the test oscilloscope probe to the rear-panel Upper Beam Vertical Signal Out connector.

g. Check for a test oscilloscope display amplitude of about 10 volts.

h. Set C487 (see Fig. 6-30) for the best square-wave response on the test oscilloscope display.

i. Disconnect the square-wave generator.

j. Repeat (d) through (i) for the Lower Beam Amplifier.

k. Disconnect the test oscilloscope from the Type 502A.

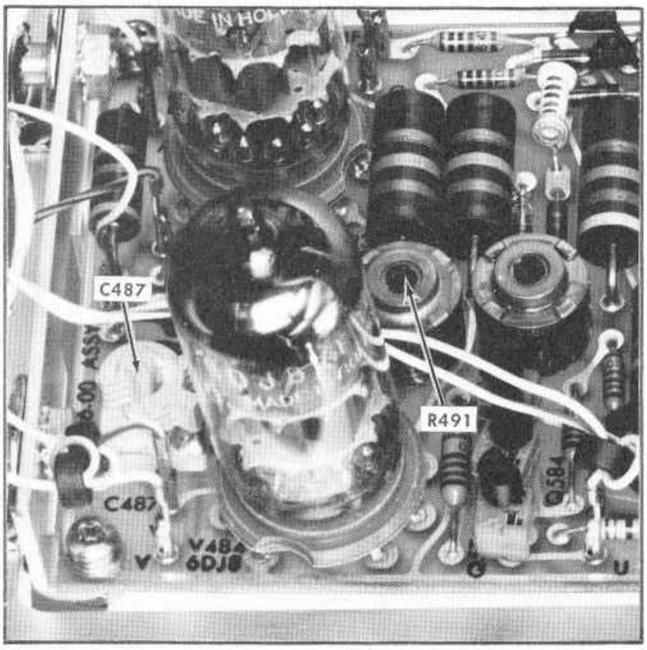
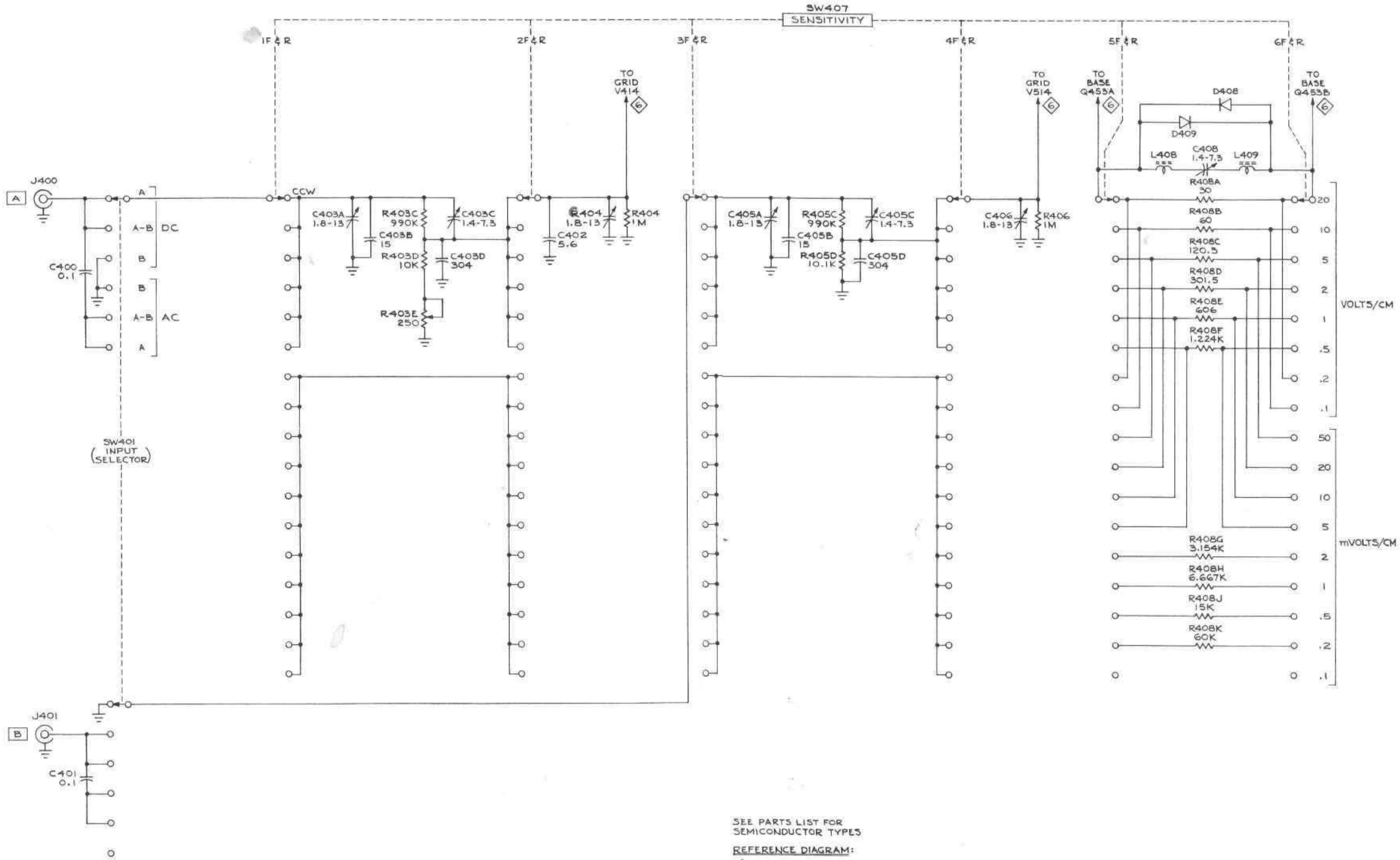


Fig. 6-30. Location of trigger output adjustments (step 31).

NOTES



SEE PARTS LIST FOR SEMICONDUCTOR TYPES

REFERENCE DIAGRAM:

⑥ INPUT VERTICAL DIAGRAM

MRH
966

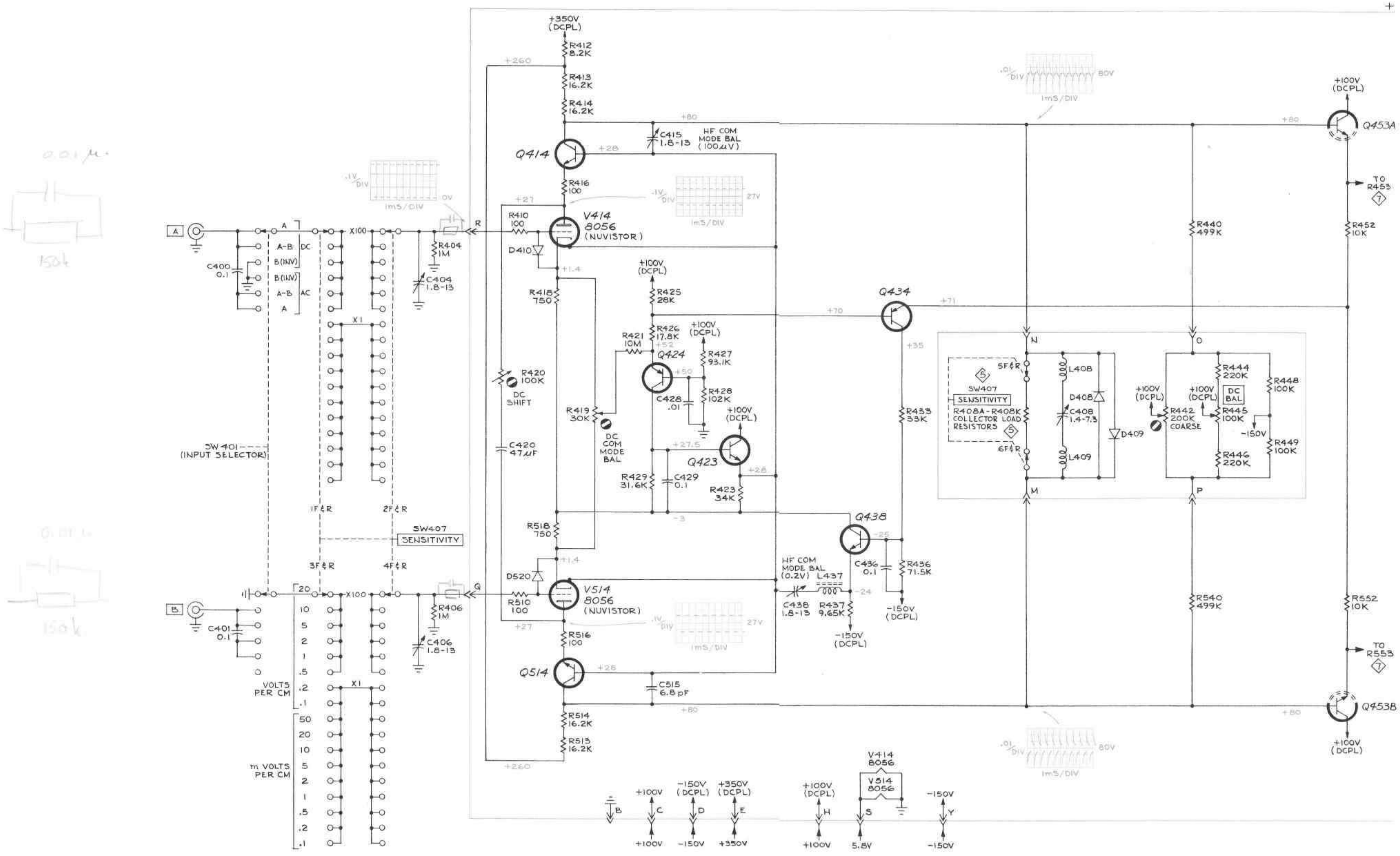
S/N 25997-UP

TYPE 502A OSCILLOSCOPE

F

VERTICAL ATTENUATOR SWITCH ⑤

VERT ATTEN SWITCH ⑤



SEE PARTS LIST FOR SEMICONDUCTOR TYPES

REFERENCE DIAGRAMS:

⟨5⟩ VERTICAL ATTENUATOR SWITCH

⟨7⟩ OUTPUT VERTICAL AMPLIFIER

TYPE 502A OSCILLOSCOPE

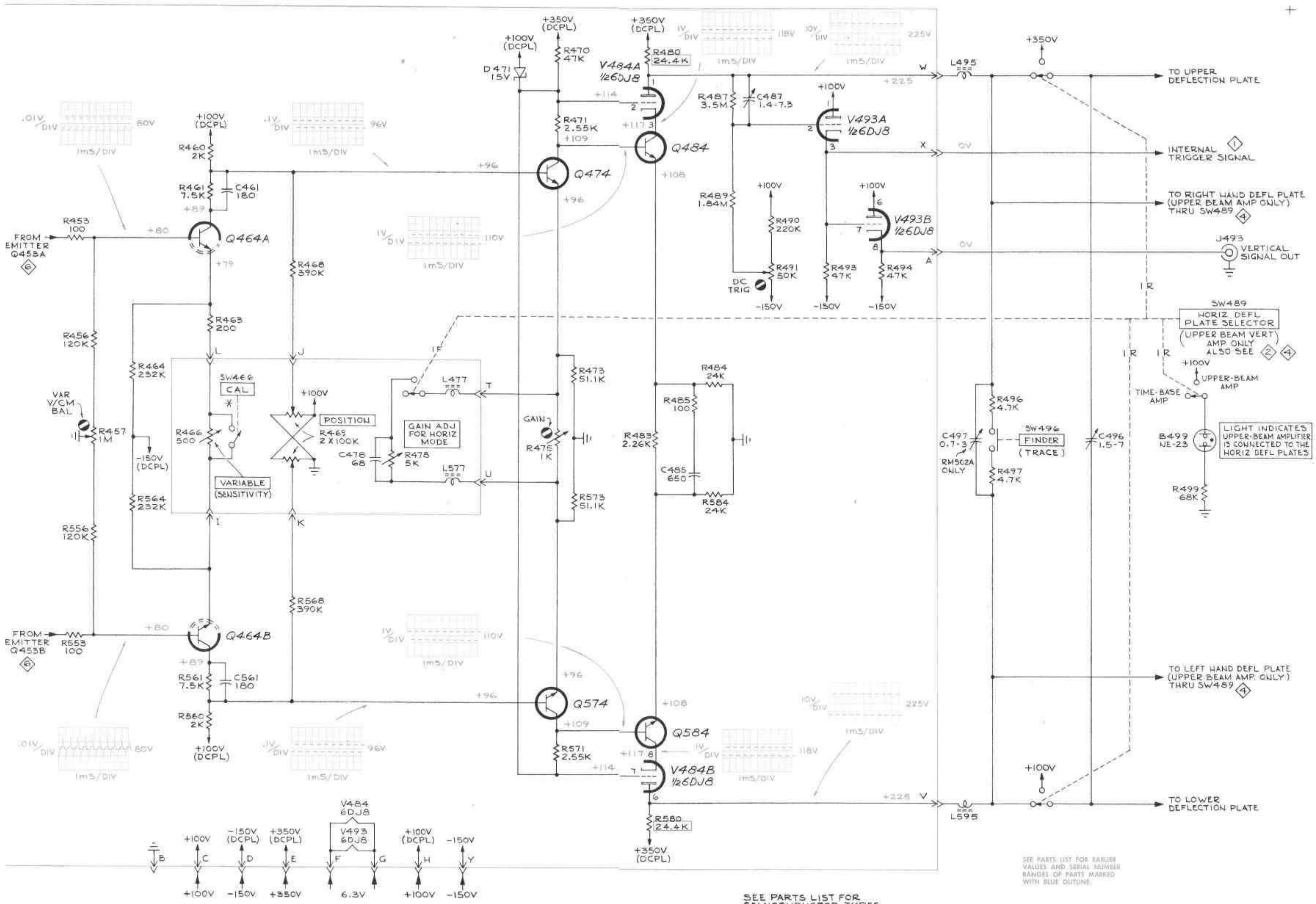
S/N 25997-UP

INPUT VERTICAL AMPLIFIER ⟨6⟩

CIRCUIT NUMBERS 400-453 510-552

MRH 467

INPUT VERT AMPLIFIER ⟨6⟩



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

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

REFERENCE DIAGRAMS:

- ① TIME-BASE TRIGGER
- ② TIME-BASE GENERATOR
- ④ HORIZONTAL AMPLIFIER
- ⑥ INPUT VERTICAL AMPLIFIER

* SW466, GANGED WITH R466, IS CLOSED ONLY WHEN R466 IS FULL CW

S/N 25997 - UP

OUTPUT VERTICAL AMPLIFIER ⑦

CIRCUIT NUMBERS
453-499
553-595

MRH
267

TYPE 502A OSCILLOSCOPE