TEMPORARY INSTRUCTION MANUAL

DU MONT®

TYPES 401-A AND 401-AR OSCILLOSCOPES

ALLEN B. DU MONT LABORATORIES, INC.

Instrument Division

760 BLOOMFIELD AVENUE, CLIFTON, NEW JERSEY

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FIGURE 1-1. TYPE 401-A OSCILLOSCOPE

SECTION 1. TECHNICAL SUMMARY

1-1. INTRODUCTION

This manual of operating and maintenance instructions covers information on both the Type 401-A (bench model) and Type 401-AR (rack mounted) Oscilloscopes. Electrically, the two types are identical; mechanically, they differ in exterior appearance. These differences are clearly indicated in the text. Otherwise, reference throughout the manual to the Type 401-A pertain also to the Type 401-AR.

1-2. PURPOSE

The Du Mont Type 401-A Oscilloscope is a quantitative instrument designed to be used for almost any general application. The high gain of this instrument assures that it can be used directly with many types of transducers, while dc amplification provides that the lowest frequency portions of signals will be faithfully reproduced.

1-3. FEATURES

5ADP- cathode-ray tube with 3000 volts over-all accelerating potential

Provisions for balanced or single-ended vertical and horizontal input signals

Identical frequency response and gain of both X and Y amplifiers extending from dc to 30% down at 100 Kc

Calibration voltage of 50 mv peak-to-peak, $\pm 2\%$, is provided for each amplifier independently

Calibrated linear sweep, writing rates from 250 milliseconds to 5 microseconds per cm in seven steps.

Uncalibrated linear sweep, continuously variable in writing rate from 250 milliseconds to 5 microseconds per cm

Provision for connection of external capacitance provided at rear of instrument for extension of sweep time

Driven or automatic sweep operation with automatic forward trace brightening

Examination on the screen of any portion of signal expanded up to at least three times full scale without distortion

Provision for Z-axis (intensity) modulation

Provisions for direct access to the deflection plates of the cathode-ray tube

Regulated high and low-voltage supplies

1-4. SPECIFICATIONS

The electrical and physical characteristics of the Types 401-A and 401-AR are listed in Table 1-1.

TABLE 1-1. SPECIFICATIONS

1. CATHODE-RAY TUBE

TYPE	5ADP- operated at a total accelerating potential of approximately 3000 volts
CRT SCALE	Engraved edge-lit scale and appropriate color filter over face of tube. Dimmer control varies illumination level from zero to intensity adequate for photographic recording

2. VERTICAL AMPLIFIER

INPUT COUPLING	
a. Single-ended signal	Direct or through capacitor of 600-volt rating to amplifier
b. Balanced Signal	Available at .01 D-C position of Y VOLTS/CENTIMETER switch
c. Direct to Deflection Plates	Provision is made for dc connection to the deflection plates. For best focus, an average dc potential of 265 volts with respect to ground should be maintained
d. Maximum Permissible Signal	600 volts (sum of signal + dc)
INPUT ATTENUATION	Provided by a frequency compensated attenuator with steps corresponding to full scale voltages of .01, 0.1, 1.0, and 10 volts $\pm 2\%$; OFF position is provided

INPUT IMPEDANCE

a. Through Amplifier

Single-ended .... 2 megohms, 55 uuf maximum

Balanced .... 2 megohms, 55 uuf maximum each side to ground

b. Direct to Deflection Plates

Single-ended .... No greater than 5 megohms should be used (Deflection plate return resistors are not supplied)

Balanced .... No greater than 10 megohms center-tapped to ground should be used (Deflection plate return resistors are not supplied)

SINUSOIDAL FREQUENCY RESPONSE
(Referred to sensitivity at 1 Kc)

a. High Frequency .... Down not more than 30% at 100 Kc

b. Low Frequency

Direct coupled .... Flat to dc

Capacitively coupled .... Down not more than 10% at 2 cycles

PULSE RESPONSE (to a step function)

a. Rise Time .... 3.5 microseconds or less

b. Overshoot .... 2% or less

c. Decay at top

Direct coupled .... None

Capacitively coupled .... 10% in 20 milliseconds nominal

DEFLECTION SENSITIVITY

a. Through Amplifier (at full gain)	1 cm minimum deflection from 0.01 dc volt
b. Direct to Deflection Plates	12 to 15 dc volts per cm
EXPANSION AND POSITIONING	Any portion of three times full scale deflection can be positioned on screen. Undistorted deflection is available over the visible portion of the trace at any position-control setting, provided that sensitivity is not decreased to less than 20% of maximum sensitivity. With sensitivity reduced to less than 20% of rated sensitivity, undistorted deflection is limited to approximately twice full screen

LINEARITY OF ON-SCREEN DISPLAY

a. Amplifier	1% of voltage for full scale on-screen deflection (with sensitivity set to 20% or more of rated sensitivity). Not worse than 10% difference between any 10% increments of voltage that produces full scale on-screen deflection.
b. Display (Amplifier linearity as viewed on CRT)	5% of deflection for 7.5 cm, $\pm$3.75 cm from center screen (within the limits of a 7.5 cm x 7.5 cm centered square with edges parallel to the X and Y axis with sensitivity set to 20% or more of rated sensitivity). Not worse than 10% difference between any 10% increments.

COMMON MODE

a. Common Mode Rejection .... Approximately 400 to 1 at maximum Y AMPLITUDE setting. (Y BAL and Y POSITION controls adjusted for maximum common mode rejection ratio)

b. Maximum Common Mode Signal.............................. 1 volt peak-to-peak

STABILITY

a. Varying Line Voltage (± 10%) .... Drift does not exceed a total of 2 cm (plus and/or minus 1 cm from screen center) in an 8-hour period

b. Constant Line Voltage .... Drift does not exceed a total of 1 cm in an 8-hour period

3. HORIZONTAL AMPLIFIER

(Identical to vertical amplifier except as shown)

DEFLECTION SENSITIVITY

a. Through Amplifier (At full gain) .... 1 cm minimum deflection from 0.01 dc volt input

b. Direct to Deflection Plates .... 16 to 20 dc volts per cm

BEAM GATE .... Automatic beam brightening during forward sweep. Beam is not visible during sweep retrace or while sweep is at rest. INTENSITY control overrides blanking for X-amplifier use

The beam gate may be used to gate the beam on for a time interval determined by the SWEEP RANGE and VERNIER controls when the X amplifier is being used

X & Y AMPLIFIER RELATIVE PHASE SHIFT CHARACTERISTICS (DC COUPLED)

a. Any Combination of X & Y AMPLITUDE Settings .... Phase shift does not exceed 1° below 2.5 Kc

b. X & Y AMPLITUDE Set at Maximum .... Phase shift does not exceed 3° below 100 Kc

4. AMPLITUDE CALIBRATION CIRCUIT

VOLTAGE CALIBRATOR

a. Waveshape and Frequency... Clipped sine wave at power-line frequency

b. Amplitude .... 50 mv peak-to-peak ±2% is provided for each amplifier independently

c. Availability...................... By means of the X CAL or Y CAL push-push switch which automatically disconnects the input from the amplifier and inserts the calibration signal. X calibrator is inoperative when DRIVen or AUTOmatic sweep is in use

5. SWEEP CIRCUIT

MODE	Vacuum tube sweep, driven or automatic as desired
SWEEP WRITING RATE	
a. Internal	
Calibrated	From 250 milliseconds to 5 microseconds per cm in 7 steps, with multipliers of 1, 2, and 5
Uncalibrated	Continuously variable from 250 milliseconds to 5 microseconds per cm
Accuracy	±5% on all ranges within center half scale
b. External	EXT SWP CAP terminals are provided (rear panel) for slower sweeps. See Section 2, Operation for further details
SWEEP EXPANSION	30 cm
HORIZONTAL POSITIONING	Sufficient to position any full scale portion of the expanded sweep (30 cm) or X INPUT signal on the screen
BEAM GATE	See Horizontal Amplifier Specifications
SWEEP TRIGGER OUTPUT	Trigger signal of approximately 5 volts amplitude available at TRIGGER OUTPUT front-panel terminal. Internal dc resistance to ground is 220K ohms, ±10%, 1/2 watt. Trigger pulse is negative at start of sweep and positive at end.

6. SYNC CIRCUIT

SYNC SOURCE........................ Positive or negative INTernal, power LINE, or EXTernal signals

SYNC SENSITIVITIES

a. Driven Sweep Can be Triggered by Signals Having the Following Characteristics:

1. Rate of rise

   EXT...........................80 volts/second minimum

   INT........................... 12.7 cm/second minimum

2. Duration — 0.2 microsecond minimum

3. Amplitude

   EXT...........................2.5 volts peak-to-peak minimum

   INT........................... 1 cm of vertical deflection minimum

4. Sinusoidal signal......... Sine waves from 10 cps to 100 Kc with a minimum peak-to-peak voltage of less than 5 volts (EXT), 2 cm of vertical deflection (INT); and from 2 cps to 250 Kc with larger amplitude

b. Automatic Sweep................Identical to Driven Sweep

7. INTENSITY MODULATION CIRCUIT

Z AXIS

a. Availability...................... Z INPUT terminal is provided on rear panel for signal input. This terminal is returned to ground through a 2.2 megohm resistor

b. Input Impedance.................. 10,000 ohms, 30 uuf minimum

c. Input Coupling.................. Internally the Z-axis signal is coupled through a 0.01 uf capacitor to the cathode of the CRT

d. Polarity.......................... Positive signals decrease beam intensity; 2 to 56 volts peak-to-peak depending on INTENSITY setting, will blank the beam

8. POWER SUPPLY

POWER REQUIREMENTS

Three regulated power supplies are available for the following power sources

a. 60 cycles per second line at 115 volts ±10%, Input power 110 watts.

b. 50 cycles per second line at either 115 volts ±10% or 230 volts ±10%. Input power 110 watts.

c. 50 to 400 cycles per second line 115 volts ±10%. Input power 140 watts at 115 volts line.

HIGH VOLTAGE SUPPLY.......... An electronically regulated rf supply system for generating CRT accelerating potentials is provided

9. PHYSICAL CHARACTERISTICS

	TYPE 401-A	TYPE 401-AR
Height	15-1/2 inches	8-3/4 inches
Width	8-3/4 inches	19 inches
Depth	21 inches	* 18-3/4 inches
Weight	45 pounds	45 pounds

* Measured from rear of front panel to rear end of instrument. Handles extend 1-1/2 inches in front.

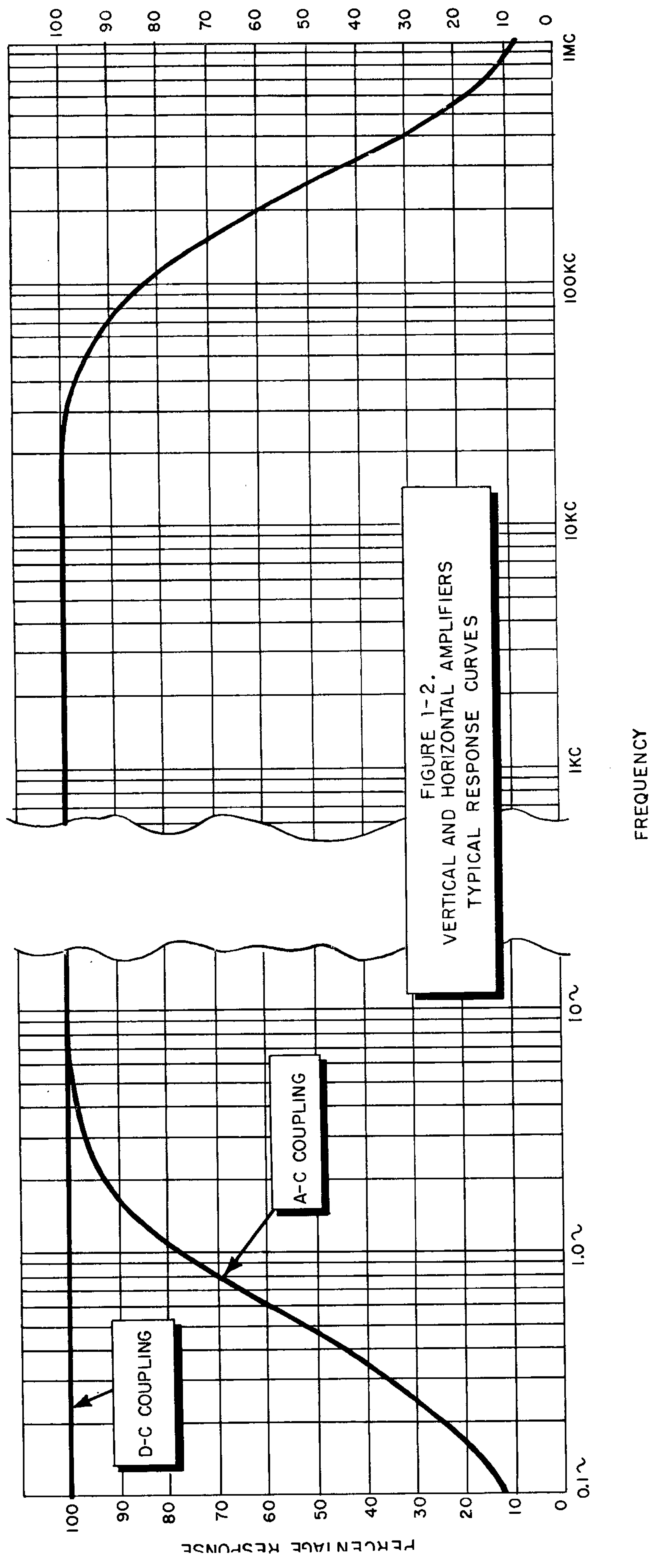


FIGURE 1-2.
VERTICAL AND HORIZONTAL AMPLIFIERS
TYPICAL RESPONSE CURVES

1-5. AVAILABLE DU MONT ACCESSORIES

Below is a list of Du Mont accessories that can be used with the Type 401-A Oscilloscope. Refer to Du Mont's catalog of Components and Accessories for detailed information on specifications and prices. In addition to the items listed below, Du Mont has a complete line of cameras for moving film and single-frame oscilloscopic recording.

Type or Part Number	Description
4800 4511	Color filter, green
4800 4512	Color filter, blue
4800 4513	Color filter, amber
316	Attenuator Probe
2507	Attenuator Probe
2609	Detector Probe
2613	Attenuator Probe (used with Type 2592-BØ Terminal Adapter
3010	Five-inch insulated probe tip for Type 2613 Probe
3004 0311	Hook-on tip for Type 2613 Probe
3600 5751	Insulated alligator tip for Type 2613 Probe
5101 6671	Needle-nose tip for Type 2613 Probe
2601-A	Movable Table, non-adjustable shelf
2602	Movable Table, adjustable shelf
2592-BØ	Terminal Adapter, unterminated, equipped with BNC receptacle
276-B or 276-C	Viewing Hood

SECTION 2. OPERATION

2-1. GENERAL

The Du Mont Types 401-A and 401-AR Oscilloscopes are shipped with all tubes in place and ready to operate. Since these instruments are portable, no special installation procedure is required. The -R model has a front panel 19 inches wide by 8-3/4 inches high for mounting the instrument in a standard relay rack or cabinet.

Normally the Type 401-A or 401-AR may be placed where most convenient for viewing while at the same time maintaining short signal leads. Although shielding has been provided, operation in very strong magnetic fields may cause spurious deflections and should be avoided. Reorientation or additional shielding of the instrument may be necessary to minimize the effects of such fields.

Two types of power supplies are used with the Oscilloscope: one contains a self-regulating power transformer employing a magnetic shunt and a resonant secondary winding; the other uses an electronic series passing tube regulator. The first type is supplied normally for 60-cps, 100/130-volt operation, with a 50-cps, 115/230-volt transformer available on special order. The second type of regulated power supply is arranged for operation between 50 and 400 cps, at 115 ±10% volts. The power required for full operation with the above supplies, is 140 watts for the electronic-regulated supply and 110 watts for the sola-regulated supply.

Remember that numerous accessory components are available from the Allen B. Du Mont Laboratories, Inc., to extend the usefulness of these Oscilloscopes. See paragraph 1-5 for further details.

2-2 FRONT AND REAR-PANEL FACILITIES

The front and rear-panel markings are essentially self-explanatory, and after carefully studying Table 2-1, the operator will find it possible to master the controls with a minimum of practice.

TABLE 2-1. CONNECTION AND CONTROL FACILITIES

1. FRONT PANEL

Name	Function
INTENSITY	Control: varies the trace brightness. See paragraph 2-8d in reference to Gated-beam Operation.
FOCUS	Control: adjusts the trace sharpness.
Y POSITION	Control: positions the trace vertically.
X POSITION	Control: positions the trace horizontally.
X BAL	Control: when properly adjusted, prevents horizontal movement of the trace when the X AMPLITUDE control is varied.
Y BAL	Control: when properly adjusted, prevents vertical movement of the trace when the Y AMPLITUDE control is varied.
X CAL	Push-push switch: provides 50 mv peak-to-peak calibration signal to horizontal amplifier input.
Y CAL	Push-push switch: provides 50 mv peak-to-peak calibration signal to vertical amplifier input.
SYNC	Switch: selects source of sweep synchronizing signals (EXT, LINE and INT).
SYNC LEVEL	Control: selects polarity and adjusts the amplitude of sweep synchronizing signals. Center of rotation marked "O" reduces sync signal to zero.
Y VOLTS/CM	Concentric controls: Outer knob provides for the direct full scale reading of the input signal in steps of .01, 0.1, 1.0 and 10 volts peak-to-peak for both capacitive or direct inputs when vertical amplifier is properly calibrated (see 2-7e for calibration procedure); grounds the input stage of the vertical amplifier in the OFF position.

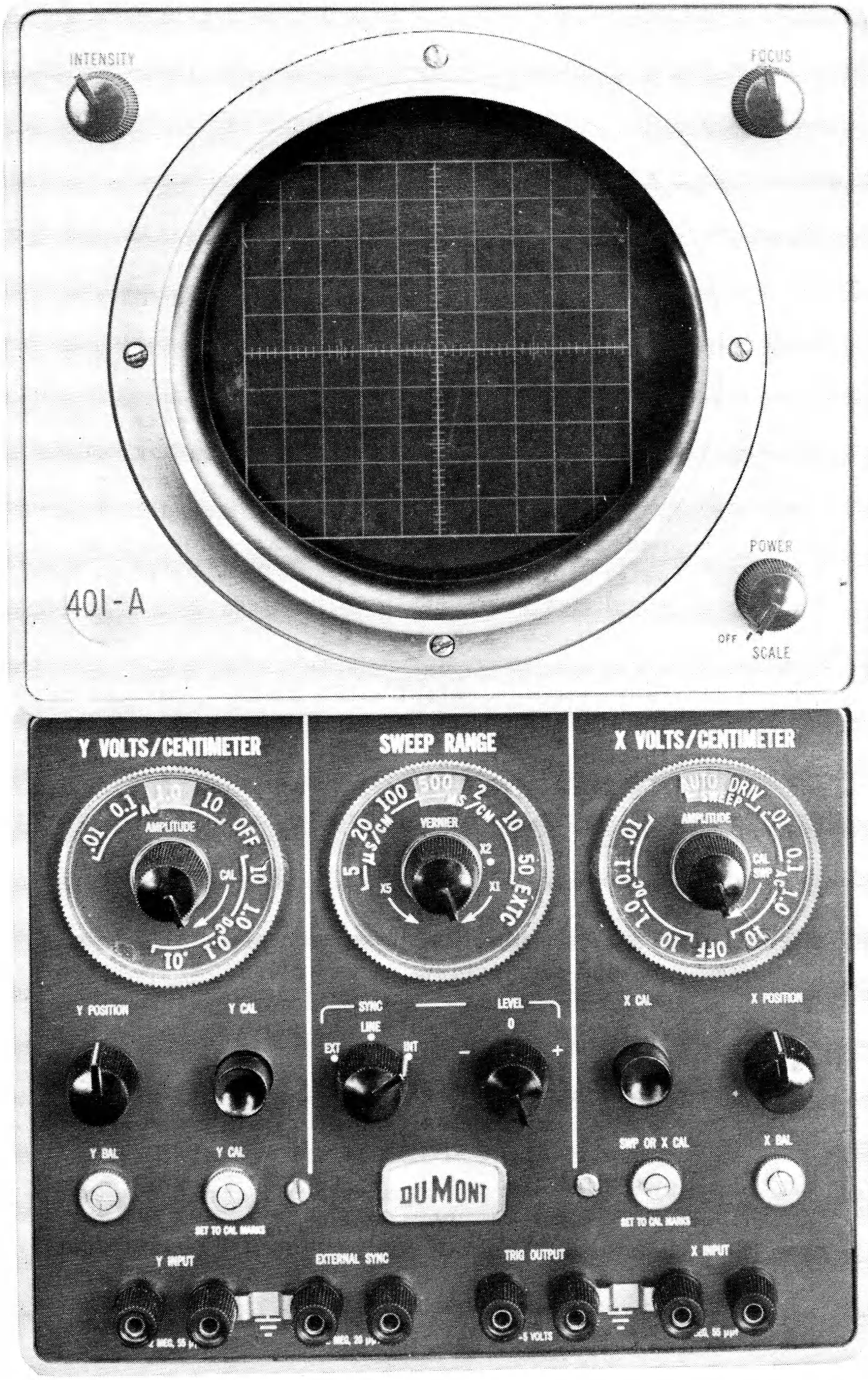


FIGURE 2-1. FRONT PANEL FACILITIES

Name	Function
Y AMPLITUDE	Inner knob provides continuous amplitude variation of vertical deflection.
Y CAL ADJ	Control: used for a calibrated adjustment of amplifier gain. This control is placed in the circuit by a switch (S103) operated when the Y AMPLITUDE control is turned fully clockwise.
	Concentric controls:
X VOLTS/CM	Outer knob same as Y VOLTS/CM except that X INPUT signals are applied to the horizontal amplifier and internal signals (DRIVen or AUTOmatic SWEEP) may be selected. Front-panel markings indicate voltages for full scale deflection (.01, 0.1, 1.0 and 10) when horizontal amplifier is properly calibrated. See 2-8e for calibration procedure.
X AMPLITUDE	Inner knob; control with switch; provides continuous amplitude variation of horizontal deflection (switch not actuated); when set fully CW (CAL SWP), switch is actuated, X AMPLITUDE control is inoperative and the instrument can be set for calibrated sweep.
SWEEP OR X CAL ADJ	Control: same purpose as Y CAL ADJ above. Placed in circuit by a switch (S303) operated when the X AMPLITUDE control is turned fully clockwise.
	Concentric controls:
SWEEP RANGE	Outer knob varies sweep writing rates in steps. When X AMPLITUDE is set to CAL SWP and VERNIER is set to X1, SWEEP RANGE switch provides calibrated sweep rates per knob markings. EXTC (external capacitor) position provides connection of external capacitance for lower sweep writing rates.

Name	Function
VERNIER	Inner knob provides continous variation of sweep writing rates within the limits established by the SWEEP RANGE switch. When X AMPLITUDE is set fully CW (CAL SWP), VERNIER control multiplies SWEEP RANGE settings by X1 (fully CW), by X5 (fully CCW), and by X2 (white dot).
X INPUT	Binding posts: connections for external signals to the vertical amplifier, either balanced or single-ended.
X INPUT	Binding posts: connections for external signals to the horizontal amplifier, either balanced or single-ended, except when X VOLTS/CM is set to DRIVen or AUTOmatic SWEEP.
EXTERNAL SYNC	Binding posts: provides for connection of external synchronizing signals to the EXT position of the SYNC switch.
TRIGGER OUTPUT	Binding posts: provides a trigger output for operation of auxiliary equipment.
POWER/SCALE	Control with switch: dimmer control varies illumination level of the CRT scale from zero to intensity adequate for photographic recording; switch attached provides means for turning power on and off.

2. REAR PANEL

Name	Function
EXT SWP CAP	Screw term.: provides connection for external sweep capacitor when SWEEP RANGE is set to EXTC (external capacitor).

Name	
X INPUT	Screw term.: terminals D1 (LEFT) and D2 (RIGHT) provide direct connection of signals to horizontal deflection plates. (The bottom terminals are the output of the horizontal amplifier and are connected by jumpers to the horizontal deflection plate terminals. See paragraph 2-9 for details.)
Y INPUT	Screw term.: terminals D3 (UP) and D4 (DOWN) provide direct connection of signals to vertical deflection plates. (The bottom terminals are the output of the vertical amplifier and are connected by jumpers to the vertical deflection plate terminals. See paragraph 2-9 for details.)
Z INPUT	Screw term. provides connection for external signals for intensity modulation of the trace.

2-3. PRECAUTION AGAINST SCREEN BURNING

A sharply focused spot of high intensity and small area should not be permitted to remain stationary on the screen for any length of time. Under such conditions, the entire beam energy is concentrated over a small area, thus subjecting the screen material to burning and discoloration. This condition is most likely to exist when using the driven mode of sweep operation, with the INTENSITY turned up, and no signal input.

2.4. ENERGIZING THE EQUIPMENT

To place the instrument in operation, plug the power cord into the proper power source and rotate the SCALE control clockwise. See Table 1-1 for power requirements. Allow several minutes for the instrument to warm up; in the meantime, set the various controls as indicated in Table 2-2. If the Oscilloscope has been exposed to abnormally high relative humidity, a longer warm-up time may be required to obtain stable operation.

TABLE 2-2. PRELIMINARY CONTROL SETTINGS

Control	Position
Y POSITION, X POSITION, & FOCUS	Center of range
INTENSITY	Approximately 1/3 CW
Y VOLTS/CM	OFF
Y AMPLITUDE	Center of range
SYNC	INT
SYNC LEVEL	Fully CCW
X VOLTS/CM	AUTOmatic SWEEP
X AMPLITUDE	Fully CW (CAL SWP)
SWEEP RANGE	10 MS/CM
VERNIER	Fully CW (X1)
X CAL, Y CAL	Out

2-5. BALANCE ADJUSTMENTS

Center the trace with the X and Y POSITION controls. Set the INTENSITY for normal brightness and the FOCUS for best definition. If the trace moves as the X and Y AMPLITUDE controls are moved, then the X and Y BALance controls require adjustment. Follow the steps listed below.

A. Y BALance

1. Set Y VOLTS/CM to OFF and Y AMPLITUDE control fully counterclockwise.

2. Center the trace with the Y POSITION control.

3. Set Y AMPLITUDE control fully clockwise (do not actuate switch).

4. Recenter the trace with Y BAL control.

5. Repeat steps 1 to 4 until no vertical movement is noted while varying the Y AMPLITUDE control throughout its range.

B. X BALance

Follow the same instructions provided above except that the corresponding X amplifier controls should be used instead of the Y controls listed.

Push in Y CAL and adjust Y AMPLITUDE to obtain a vertical deflection of about 2 inches. Adjust X AMPLITUDE to expand the pattern. Adjust the SYNC LEVEL and VERNIER controls for a stable pattern.

Note that the point from which the horizontal sweep expands depends upon the setting of the SWEEP EXPANSION POINT service adjustment. This may be set for expansion from either end or about the center of the trace as desired. See Section 10 of Table 4-2 for the instruction procedure of this control.

2-6. OPERATING HINTS FOR THE SWEEP CIRCUIT

a. DRIVEN SWEEP

Refer to Specifications, Table 1-1, for information on sync sensitivities, and to Table 2-1, for information on Panel controls.

A stable pattern for practically all types of signals can be obtained by using driven sweep; its use is mandatory for viewing random or non-periodic signals or periodic signals of low duty cycle. When operating the instrument in this manner, one sweep occurs for each signal impulse or submultiple thereof. Use of the driven sweep mode of operation, in the majority of applications, is the condition under which optimum performance can be expected of this equipment.

When the oscilloscope is set for driven sweep, the spot will be visible only during forward sweep time, provided the INTENSITY control is not set too far clockwise.

Table 2-3 lists the control settings and adjustment procedures for driven sweep operation.

b. RECURRENT SWEEP

In some applications it is desirable to have the sweep free-running, whether synchronized or not. To achieve this condition proceed as follows: set up the controls as indicated in Table 2-3, except that X VOLTS/CM is set to AUTOmatic SWEEP.

c. CALIBRATED SWEEP

The calibrated sweep writing rates in milliseconds or microseconds per cm is equal to the product of the SWEEP RANGE and VERNIER (set to a designated position) control settings only when the X AMPLITUDE control is set fully clockwise to CAL SWP (switch is actuated).

Table 2-4 lists the control settings for calibrated sweep operation. Any other front-panel setting will yield uncalibrated sweep.

TABLE 2-3. INITIAL CONTROL SETTINGS FOR DRIVEN SWEEP OPERATION

Control	Initial Setting
X VOLTS/CM	DRIVen SWEEP
X AMPLITUDE	Fully CCW
Y VOLTS/CM	Set as determined by amplitude of signal source or at .01
Y AMPLITUDE	Fully CCW
SYNC LEVEL	O
SYNC	INT
INTENSITY	Approximately 1/3 CW
FOCUS, X POSITION, & Y POSITION	Center of range

Procedure

a. Apply the desired signal to Y INPUT.

b. Adjust SYNC LEVEL to + or - (to initiate the sweep) and rotate X POSITION to center the pattern horizontally.

c. Adjust Y AMPLITUDE in conjunction with Y VOLTS/CM to obtain a vertical deflection of about 5 cm.

d. Gradually adjust X AMPLITUDE to expand the trace. If display tends to move off screen, either to the left or right, adjust the X BAL to position the pattern back on screen.

e. Rotate the SWEEP RANGE and VERNIER controls to obtain the desired number of cycles on screen. Readjust SYNC LEVEL if necessary.

f. Adjust the INTENSITY and FOCUS controls to obtain a sharp trace at a suitable brightness level.

g. If there is any multiple triggering of the sweep, the SYNC LEVEL control may be corrected to select the signal level which will best actuate the gate circuit. Thus, undesirable signals of lesser amplitude will not affect the sweep.

TABLE 2-4. CALIBRATED SWEEP WRITING RATES

Turn X AMPLITUDE fully clockwise to CAL SWP (Switch actuated)

SWEEP RANGE Position	VERNIER Position X1 (clockwise)	X2 (dot)	X5 (counterclockwise)
5 uS/CM	5 uS/CM	10 uS/CM	25 uS/CM
20 uS/CM	20 uS/CM	40 uS/CM	100 uS/CM
100 uS/CM	100 uS/CM	200 uS/CM	500 uS/CM
500 uS/CM	500 uS/CM	1mS/CM	2.5mS/CM
2 mS/CM	2 mS/CM	4 mS/CM	10 mS/CM
10 mS/CM	10 mS/CM	20 mS/CM	50 mS/CM
50 mS/CM	50 mS/CM	100 mS/CM	250 mS/CM
EXTC*	50 mS/CM	100 mS/CM	250 mS/CM

*Sweep rate for each microfarad of external capacitance.
Use Sprague Styracon or equivalent polystyrene film capacitor.

d. EXTENSION OF LOWER SWEEP WRITING RATES

Provision is made for connecting external capacitors to the EXT SWP CAP terminals (rear panel) to obtain lower sweep writing rates than provided for in the instrument. For lower sweep writing rates, proceed as follows:

CAUTION

The EXT SWP CAP terminals are approximately 150 volts above ground.

Turn off the power and set SWEEP RANGE to EXTC (external capacitor). The extension of the lower sweep writing rates in seconds per cm for each microfarad of external capacitance is as shown in Table 2-4.

A high-leakage- resistance capacitor (in excess of 1000 megohms) of the highest possible quality such as Sprague's Styracon is recommended. Ordinary paper capacitors have high temperature co-efficients and poor recovery characteristics. The results will depend entirely on the quality of the component. Tolerance of the capacitor should be $\pm 1\%$ to maintain external calibration equivalent to internal calibration.

e. SWEEP EXPANSION

When the switch on the X AMPLITUDE control is not actuated, sweep expansion up to a ratio of 4:1 (uncalibrated) may be obtained by this control. Under this condition, use of the X POSITION control enables any portion of the expanded sweep to be displayed on the screen.

The uncalibrated sweep writing rate is continuously variable over a 5:1 range when the VERNIER control is not set for sweep calibration and the fastest writing rate will be approximately 1.6 microseconds/cm.

2-7. OPERATING HINTS FOR THE VERTICAL AMPLIFIER

a. Y BAL ADJUSTMENT

When this control is properly adjusted, there will be no vertical displacement of the trace with changes in the setting of the Y AMPLITUDE control. For adjustment procedure, see paragraph 2-5.

b. SINGLE-ENDED Y INPUT

Signals to be observed are connected to the vertical channel through the Y INPUT terminal and ground. The Y VOLTS/CM permits capacitive or direct coupling of the signal to the compensated attenuator. The terminals for direct connection to the deflection plates are accessible at the rear of the cabinet. See paragraph 2-9 for details.

c. USE OF BALANCED INPUT

For balanced input, remove the link from the normally grounded Y INPUT terminal. The Y VOLTS/CM must be set to the .01 D-C position. The following explanation of the balanced-input feature may help the operator determine when this type of operation may be useful.

One of the features of the balanced-input circuit is the differential action of the amplifier. This circuit makes it possible to reject to a considerable degree any common-mode signal, while at the same time passing and amplifying the balanced-input signal. Thus, if there is any common-mode pickup of noise on test leads or in the equipment under test, such noise will be reduced materially on passing through the balanced-input amplifier circuit.

If there is an in-phase signal (common mode) riding on the balanced-input signal, the permissible input voltage (dc plus peak ac) will be reduced accordingly.

d. OPTIMUM COMMON MODE REJECTION ADJUSTMENT

To adjust for the best rejection of the unwanted common-mode signal, remove the jumper from the Y INPUT terminal. Apply a one-volt 60 cycle square-wave signal between both the Y INPUT terminals and ground. Set Y VOLTS/CM to .01 D-C and Y AMPLITUDE control for minimum deflection. If this does not reduce the amplitude of the trace to zero, set Y AMPLITUDE control approximately midway and vary the Y BAL control for minimum deflection. (It will be necessary to adjust the Y POSITION control as the Y BAL adjustment is being made to keep the beam centered vertically on the screen.) As now adjusted, it should be possible to go through the common-mode null with either Y AMPLITUDE or the Y BAL control.

NOTE: OBSERVATION OF SINGLE-ENDED SIGNALS, AFTER HAVING MADE THESE BALANCED-INPUT ADJUSTMENTS, WILL REQUIRE RESETTING OF THE Y BAL AND Y POSITION CONTROLS.

e. Y CALIBRATION

Amplitude measurements of the vertical signal may be made by using the built-in voltage calibrator. A calibrator signal is available internally, and may be substituted for the vertical signal by depressing the Y CAL push button. To make use of this signal for amplitude calibration, proceed as follows:

1. Turn Y AMPLITUDE control fully clockwise to actuate the switch.

2. Depress the Y CAL button to obtain pattern on screen.

3. Set the Y CAL screwdriver-adjusted control to give half-scale deflection (5 cm). The half-scale marks are provided for this purpose.

4. Depress Y CAL button to release the switch, removing the calibrator pattern.

With the Y AMPLITUDE control set fully clockwise and the switch actuated, the vertical amplifier functions as a voltmeter having a sensitivity of .01 volt, 0.1 volt, 1.0 volt or 10 volts per centimeter depending on the setting of the Y VOLTS/CM switch. Turning the Y AMPLITUDE control back allows it to be used to adjust the signal deflection as desired, while the calibrated condition is immediately available unchanged whenever the control is rotated fully clockwise to actuate the switch.

2-8. OPERATING HINTS FOR THE HORIZONTAL AMPLIFIER

a. GENERAL

The Types 401-A and 401-AR both contain identical horizontal and vertical amplifiers. This results in very small relative phase shift between X and Y signals. See Table 1-1 for additional information. For those applications where it is desirable to apply an external signal through the horizontal amplifier, the amplifier should first be adjusted for dc balance as outlined in the next paragraph.

b. X BAL ADJUSTMENT

When this control is properly adjusted, there will be no horizontal displacement of the spot with changes in the setting of the X AMPLITUDE control. For adjustment procedure, see paragraph 2-5.

c. X INPUT

When using the horizontal amplifier for external signals (X INPUT), set X VOLTS/CM to A-C or D-C. When this switch is set to either of these positions, the internal sweep is disconnected and the X INPUT terminals are connected to the horizontal amplifier. However, the sweep gate circuit is not disabled unless the SYNC LEVEL is set to "0". Application of single-ended or balanced signals to X INPUT is identical to that described for the vertical amplifier.

d. X AMPLIFIER GATED BEAM OPERATION

If gated beam operation is desired when using both the vertical and horizontal amplifiers, it can be obtained by triggering the sweep (which is placed in the driven mode when the X VOLTS/CM is set for external signals) with EXT, INT, or LINE signals just as in normal operation. Thus, it is possible while viewing external signals, to superimpose the brightening gate on the trace. The duration of the brightening gate may be adjusted by the SWEEP RANGE and VERNIER controls. If this feature is not desired, set SYNC LEVEL to "0".

e. X CALIBRATION

The procedure for making amplitude measurements of the horizontal signal is identical to that described for the vertical amplifier except that the X CAL and X AMPLITUDE controls are used.

Note that the SWP OR X CAL screwdriver-adjustment is one control used for calibrating either the sweep or the X amplifier but not both simultaneously. Readjusting the SWP OR X CAL control for X amplifier calibration will throw out any previous sweep calibration adjustment using this control.

2-9. DIRECT CONNECTION TO DEFLECTION PLATES

a. GENERAL

When applying signals to deflection plates, the highest-frequency signals that can be observed is not limited by the response of the built-in amplifiers but is dependent upon the input capacitance to the deflection plate terminals and/or transit time of the electrons between the deflection plates. Provided the impedance of the signal source is kept low, transit time is the only consideration. It should be remembered, however, that no amplification or attenuation is provided on direct input. See Table 1-1 for deflection sensitivities.

b. MAKING PROPER CONNECTIONS

CAUTION

Before making connections, shut off power.

Direct connection to the deflection plates can be made by removing links on deflection plate terminals at rear panel and by noting the following information:

1. External deflection plate return resistors must be provided. Singled-ended input, 5 megohms (maximum) either plate to ground; balanced input, 10 megohms (maximum) center-tapped to ground.

2. The average dc potential of approximately 280 volts above ground should be preserved on both pairs of deflection plates for best focus; however, the astigmatism adjustment (R412) has sufficient range for most potentials up to +400 volts.

3. This average dc level should be made adjustable to provide an astigmatism control for optimum focus adjustment.

4. A loss of positioning will occur.

c. DERIVING POSITIONING VOLTAGES (See Figure 2-2)

A suggested method of resolving the information noted in steps 1 through 4 of the preceding paragraph is as follows:

1. Disconnect the appropriate CRT deflection-plate links from their terminals (rear of cabinet).

2. Remove links on Amplifier terminals and bridge each pair of terminals with a series resistor (4.7 megohms) in each leg.

3. Connect the signal through blocking capacitors of at least 600 volts dc rating.

4. To avoid any possibility of cross-coupling effects, it is suggested that, when connecting a signal direct to deflection plates, the corresponding channel (X VOLTS/CM and/or Y VOLTS/CM) controls be switched to OFF.

Application of these steps does the following: 1, preserves the deflection-plate voltages; 2, eliminates the need for an external dc biasing voltage; and 3, readjustment of astigmatism is not required.

2-10. INTENSITY MODULATION

Positive signals applied to Z INPUT will decrease the beam intensity. To make this connection, shut off the power and apply the signal to the Z INPUT terminal at the rear of the instrument. Note: Z INPUT presents an impedance of 10,000 ohms and 30 uuf to the signal source, coupled through a 0.01-uf capacitor.

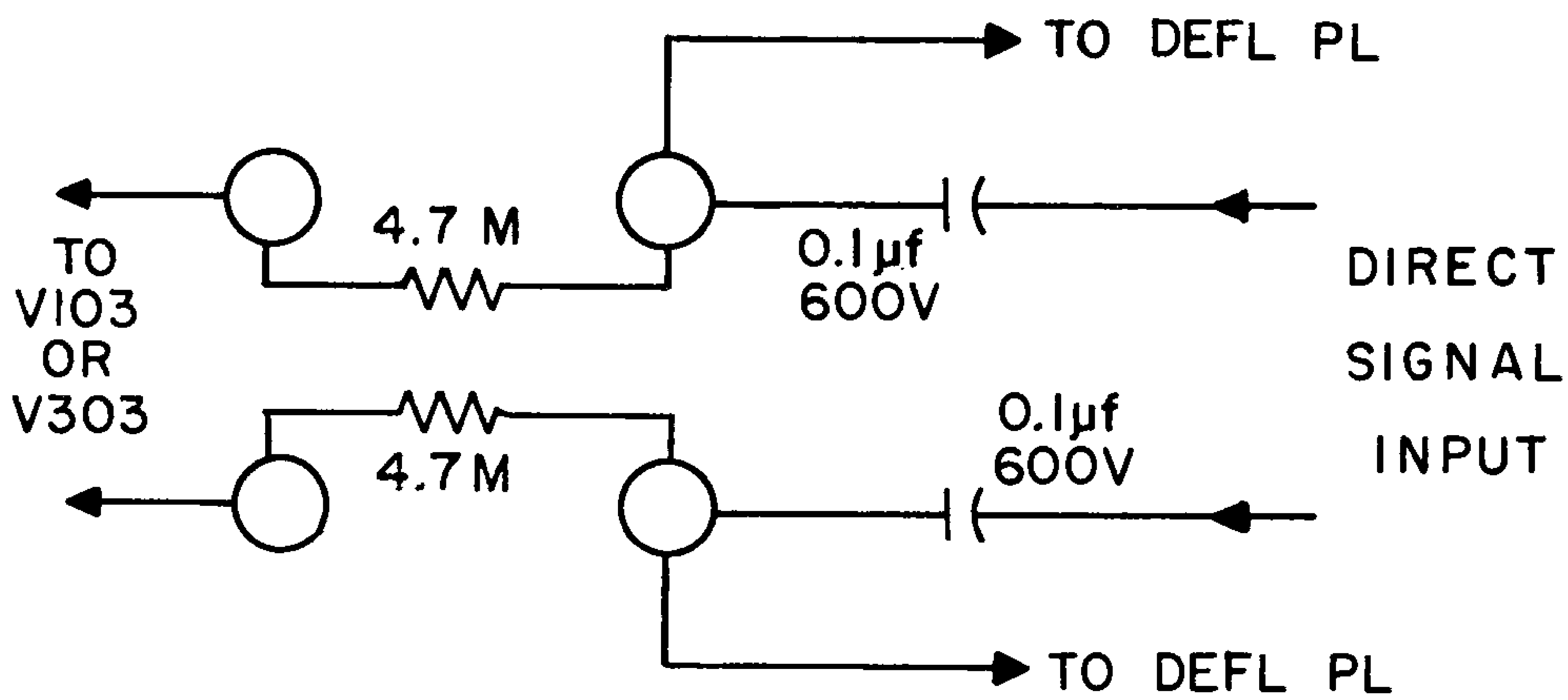


FIGURE 2-2. CIRCUIT FOR DERIVING POSITIONING VOLTAGE FOR SIGNALS COUPLED DIRECT TO DEFLECTION PLATES

2-11. MAKING RISE TIME MEASUREMENTS

Application of signals from an external time calibrator will facilitate pulse rise-time measurements. When making such measurements, the one factor which must be borne in mind for most accurate quantitative results is the pulse response characteristic of the vertical amplifier. This characteristic is related to the observed pulse rise time and the actual pulse rise time in the following manner:

$$t_p = \sqrt{(t_o)^2 - (t_a)^2}$$

Where: t_p = actual pulse rise time in microseconds

t_o = observed rise time of pulse in microseconds

t_a = amplifier rise time in microseconds

Once the amplifier rise time is known (see Table 1-1), the rise time of any pulse may be calculated.

2-12. OVER-ALL SWEEP CALIBRATION USING 50 OR 60-CYCLE LINE FREQUENCY

Over-all sweep calibration at the power-line frequency will normally provide a sufficiently high degree of accuracy. This is because the power-line frequency is generally held accurate to 0.5%, comparable to a finely focused spot on the screen. To adjust, proceed as follows:

1. Set X VOLTS/CENTIMETER to DRIVen SWEEP and AMPLITUDE to CAL SWP.
2. Set VERNIER to X1 and SWEEP RANGE to 10 MS/CM.
3. Set (Y) AMPLITUDE to CAL and SYNC to INT.
4. Push in Y CAL and adjust appropriate controls for a stable pattern.
5. For a 60-cycle line, adjust SWP or X CAL front-panel screwdriver control until 6 cycles of the calibration signal appears precisely in ten centimeters. All ranges will then be within the specified tolerance.
6. For a 50-cycle line, adjust SWP OR X CAL until 5 cycles of the calibration signal appears precisely ten centimeters.

SECTION 3. THEORY OF OPERATION

3-1. GENERAL

In following the theory discussion, it is suggested that the over-all block diagram of Figure 3-1 and the circuit schematics be referred to.

3-2. VERTICAL DEFLECTION CIRCUIT

a. INPUT CIRCUIT

The Y VOLTS/CM switch (S101) selects the desired attenuation of the input signal in decade steps from .01 volt to 10 volts/cm for both AC and DC inputs. The OFF position of this switch removes the input signal from the attenuator and grounds the grid (pin 2) of the input dc amplifier (V101A).

The input decade attenuators are RC compensated to maintain frequency and phase response and to present an impedance of 2.0 megohms in shunt with 55 uuf (maximum) to the circuit under test, regardless of the attenuation selected.

Provision is made for applying a balanced signal to Y INPUT when the Y VOLTS/CM switch is set to .01 (DC) position. For details on use of this feature, refer to the instructions contained in Operation, paragraph 2-7c.

b. DC AMPLIFIER OPERATION

The vertical deflection dc amplifiers comprise V101 through V103, inclusive. The dc balanced circuit arrangement provides good deflection amplifier stability. The input dc amplifier (V101) (which on balanced inputs, acts effectively as a differential amplifier) precedes the continuously variable Y AMPLITUDE control (R116). R115, in series with this control, prevents the operator from cutting the gain all the way to zero. Thus, any signal greater than full screen may be observed in its entirety only after the attenuator control (Y VOLTS/CM) is set at a higher voltage position or if the amplitude of the applied signal is reduced.

The normally grounded grid (pin 7) of V101B is brought out to the front-panel binding post (J102) so that balanced input operation may be obtained simply by removing the ground link between J102 and J103 (front-panel terminals). The resistors (R108 and R109) in series with the grids of V101 serve to protect the input circuit from damage due to excessive input voltage.

Figure 3-1
Functional Block Diagram of Circuits

To eliminate signs of power line harmonics on the trace, a small amount of power line harmonic voltage is taken from the filament circuit and applied through C112 to the first amplifier grid circuit. The Y HUM adjustments set the level required to cancel out any hum harmonic voltage in the input dc amplifier.

The Y BAL control (R112) equalizes the voltages at the ends of the Y AMPLITUDE control (R116). When this control is properly set, there will be no shifting (up and down) of the trace when Y AMPLITUDE control is rotated throughout its range with no signal applied to the amplifier. This control can also be used in conjunction with Y POSITION control to obtain maximum common mode rejection ratio when using balanced input signals. See Operation, paragraph 2-7d.

For amplitude measurements, a reference potential of 50 mv peak-to-peak is applied to the vertical input dc amplifier (V101A) by means of the push-push Y CAL switch (S102). This switch automatically disconnects the Y INPUT signal from the amplifier when the calibrator signal is applied. For details on making accurate amplitude measurements of the input signal, see Operation, paragraph 2-7e.

Provision is made for direct input to the vertical deflection plates. See Operation, paragraph 2-9, for use of this feature.

3-3 SYNC CIRCUIT

a. SYNC INPUT

The SYNC switch provides the source of the synchronizing signal in either the AUTOmatic or DRIVEN mode of operation. The INTernal sync signal is obtained through a divider from the plate of V103 in the vertical channel: LINE frequency sync is derived from the power supply: and EXTernal sync is obtained from an external source and it is applied to the EXTERNAL SYNC terminals.

V201A functions as a sync phase splitter. The SYNC LEVEL enables the operator to select the desired amplitude and polarity of the sync voltage. Following this control is the sync trigger generator, V201B and V202B.

b. GATE AND SWEEP CIRCUITS

DRIVEN SWEEP:

The trigger generator is essentially a signal amplitude selector. That is, V201B will abruptly change from full-off to full-on, or vice versa, depending upon the amplitude and polarity of the signal applied to its grid. In the DRIVEN mode of operation, the sensitivity of the trigger generator is established by the TRIG LEVEL adjustment, R211.

Operation is as follows: under stable conditions, V201B is at cutoff and V202B is fully conducting. V201B will remain at cutoff until the amplitude of a positive-going signal applied to its grid, reaches the threshold level of conduction. When this threshold level is exceeded, an abrupt transition from cutoff to full conduction will occur in V201B. Simultaneously, V202B will promptly stop conducting. V201B and V202B will revert to their original condition when the amplitude of the initiation signal falls slightly below the threshold level of conduction for V201B. This turn-off level at the grid of V201B is about 1 to 1-1/2 volts lower than the turn-on level at the threshold of conduction indicated above.

C209 and R221 differentiate the square wave at the plate of V201B. The resulting fast negative pulse is coupled to the grid of the gate generator, V202A, through a series triggering diode, CR201. As soon as the leading edge of the negative trigger (coupled by CR201 from C209) causes the grid of V202A to drop to the turn-off level of the gate generator, the regenerative action within the gate generator turns on V203A and further lowers the grid voltage to the point where both CR201 and V202A are biased beyond cutoff. Thus CR201 serves as a sync lockout stage. At the same time, V203A is fully conducting.

The biasing of CR201 immediately blocks the differentiated pulses from V201B until V202A is turned on again (and V203A is turned off) by the gate signal coupled to its grid by CR203.

When the sweep is initiated, a portion of the positive saw is coupled back from the cathode of V204B through R221 to the cathode of CR201. Since the cathode of the crystal is now positive with respect to its anode it becomes non-conductive during the forward sweep interval, thereby preventing the passage of unwanted sync signals.

CR203 couples saw voltage directly to the grid of V202A, eventually turning it on again and terminating the sweep. The hold-off voltage (saw fed back through R221) keeps CR201 biased off after CR203 has turned V202A back on again even though the voltage at the grid of V202A is now at its highest positive value. In the absence of the hold-off voltage, a negative trigger applied immediately after V202A is turned on by the positive saw through CR203, could turn V202A back off again before the differentiated saw appears across CR202. This would hold the sweep at the right side of the screen and prevent retrace.

An RC network, R221, C211 and R222 serves to decouple the triggers from the saw cathode follower, V204B.

To prevent unwanted triggering of the gate generator before the retrace is completed, a portion of the saw at the cathode of V204B is fed back through sections 2R and 1R of S202 to the gate generator at the grid of the now off V203A. The saw is differentiated through the next smaller capacitor of the SWEEP RANGE switch from that chosen by the switch position in operation, and is applied to the anode of CR202.

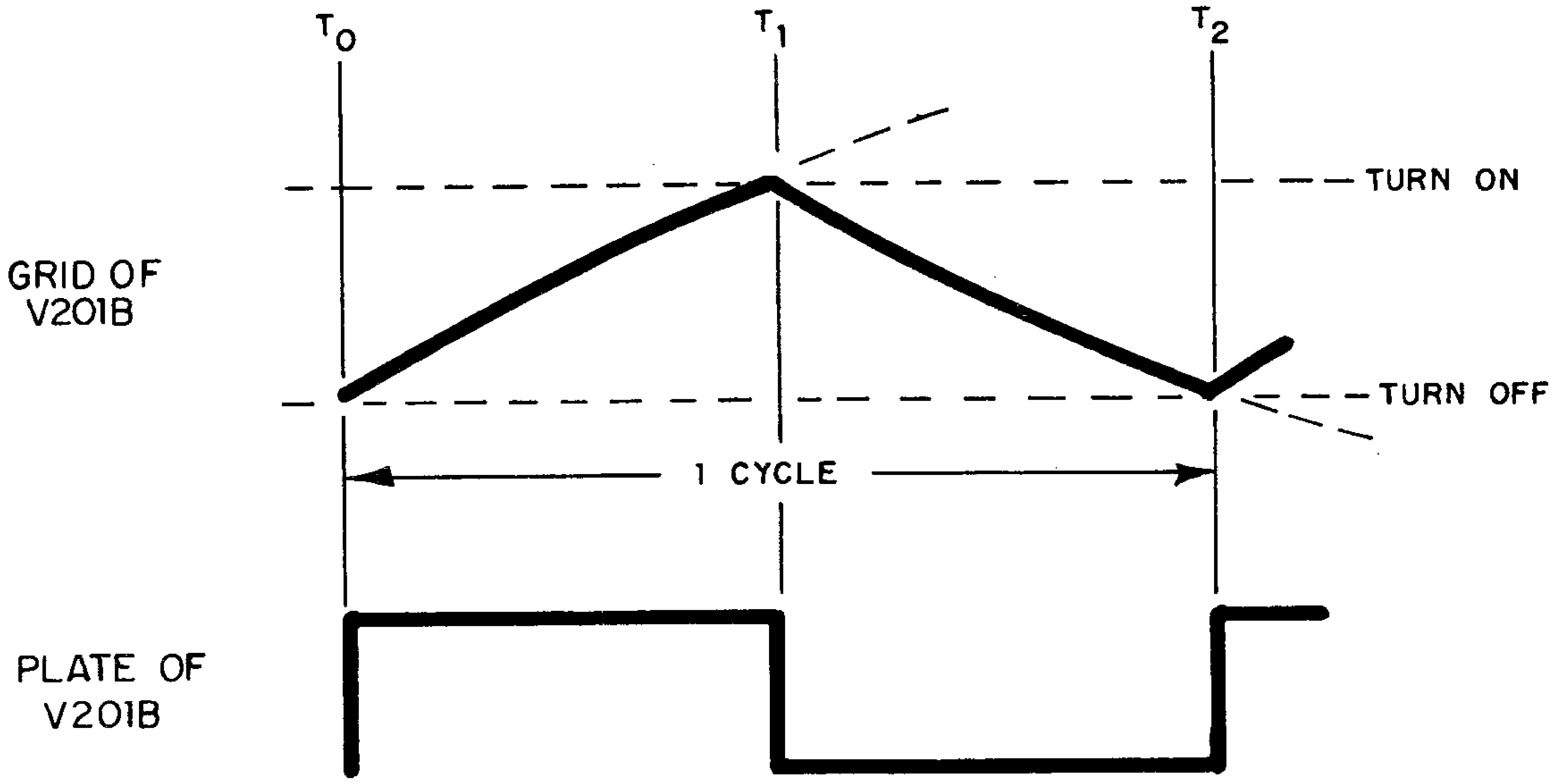
The saw voltage is going positive during the forward trace period; CR202 is inserted to ground this point during this time. This is to be sure that the V203A grid is not allowed to go positive enough to turn on. When the negative saw retrace pulse occurs, the plate of CR202, and, accordingly the grid of V203A, becomes highly negative. Since at the same time the hold-off voltages at CR203 and CR201 are removed, triggering could occur during the retrace interval. The negative pulse applied to the grid takes the place of the other hold-off voltages until retrace is completed. The smaller capacitor is chosen to be sure of a return to normal just before the next trigger.

AUTOMATIC SWEEP:

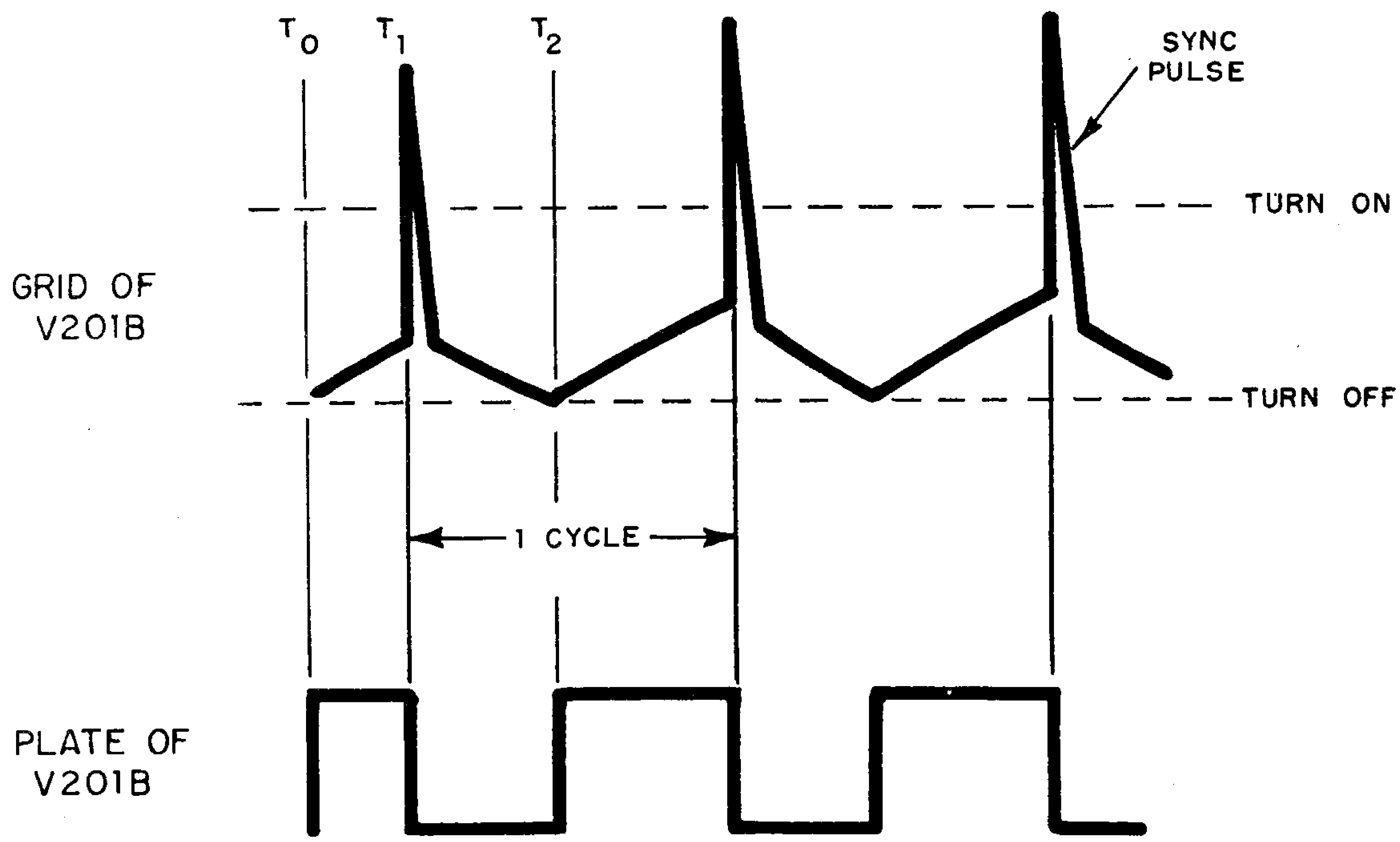
When the X VOLTS/CM switch is set to AUTOmatic, the TRIG LEVEL adjustment is disconnected and the feed-back resistor R217 is connected between the grids of the trigger generator.

In the following description, see the waveforms of Figure 3-2.

Assuming that a transition has just occurred, V201B is cut off and V202B is fully conducting (T_O), the plate voltage of V201B rises



A. NO SYNC SIGNAL



B. SYNC SIGNAL APPLIED

FIGURE 3-2. WAVEFORMS FOR AUTOMATIC SYNC and, through the attenuator of R216 and R218, the voltage rises at the grid of V202B. R217 tends to charge C206 up to the voltage at this grid. Before this point is reached, a bias voltage at V201B grid causes an increase of V201B plate current. Regeneration takes place to cause V201B to conduct fully and V202B to cut off (T_1).

The transition to full conduction of V201B causes its plate voltage to be reduced and, through the attenuator of R216 and R218, the voltage drops at the grid of V202B. R217 tends to discharge C206 down to the voltage at this grid. Before this point is reached, a bias voltage at V201B grid causes a decrease of V201B plate current. Again regeneration takes place to cause V201B to be cut off and V202B to conduct fully (T_2). This completes one cycle of automatic sync in the absence of an applied sync signal.

The above cycle is repetitive, and about 50 pulses per second are produced by the trigger generator for this mode of operation. Operation of this circuit from this point on is the same as for the DRIVEN sync.

If a sync signal is applied to the arm of R206, it will add to the waveform at the grid of V201B to produce a transition of the trigger generator earlier than its natural time and therefore produce synchronized output pulses (see Figure 3-2B).

c. GATE GENERATOR

V202A and V203A are connected as a bistable multivibrator. The GATE SENS adjustment R226 allows for a setting of the dc level required for the switching of the multivibrator.

V202A action is initiated by a negative signal from the trigger generator resulting in the familiar multivibrator switching action. The negative gate developed at the plate of V203A is connected to the gate cathode follower, V203B.

The output from V203B is used, 1, to control the beam gate generator, V402, which provides a brightening voltage during forward sweep time; and 2, is differentiated and coupled to the OUTPUT terminal. The latter condition results in a negative signal coincident with the start of the sweep and a positive signal at the end of the forward sweep for synchronization of auxiliary equipment. In addition, the gate cathode follower provides the regenerative loop for the gate generator.

d. POSITIVE SAW GENERATION

The negative gate output from the cathode of V203B is coupled to the grid of thesaw discharge tube, V204A, which is normally conducting and maintaining the sweep capacitor in a discharged state. This gate turns off V204A and allows the voltage at its plate to rise at a rate determined by R and C as determined by the setting of the SWEEP RANGE and VERNIER controls. The resultant sawtooth voltage is coupled to the saw cathode follower, V204B.

The voltage at the cathode of V204V is fed back attenuated to the grid of the nonconducting gate tube, V202A, via CR203 and the DURATION adjustment. This positive voltage restores the gate generator to its initial operating condition (when the sawtooth voltage reaches a predetermined level) thus terminating the sweep. The beam will sweep across the screen again only upon the application of another negative signal from the trigger generator to V202A.

From the junction of the attenuator consisting of R247 and R248, the sawtooth voltage is applied to the SWEEP EXPANSION POINT adjustment R249. As described in Table 4-2 Section 10, the sweep can be set to expand from the left, center or right as desired. The output from the arm of the SWEEP EXPANSION POINT adjustment is coupled to the input of the horizontal amplifier when the X VOLTS/CM control is set to SWEEP.

A high degree of linearity is achieved by causing the dc voltage of the charging source to rise at saw rate through use of a gas tube, E201, coupled to the sweep charging resistors. This essentially provides a constant-current charging source for the sweep capacitor. Since the charge across any capacitor is directly proportional to the current flowing into it, a constant (unvarying) current results in a uniform increase in charge or a linear sawtooth waveform.

The CAL X5 adjustment is used for setting the VERNIER ratios for calibrated sweep; further details are given in the Service Adjustment Chart, Table 4-2.

3-4. HORIZONTAL AMPLIFIER CIRCUIT

Since identical vertical and horizontal amplifiers are employed in the Type 401-A and 401-AR, the previously discussed theory for the vertical amplifier is equally applicable, except for the X VOLTS/CM and X AMPLITUDE controls. For use and functions of these controls see Section 2, Operation.

By means of the X VOLTS/CM switch, provision is made for the selection of internal or external signals for horizontal deflection. The internal signal is obtained from the driven or automatic sweep circuits described earlier. External signals may be applied to the X INPUT terminals.

When the X VOLTS/CM switch is set for external signals, the sweep circuit is not disabled unless the SYNC LEVEL control is set to "O". Thus, it is possible to trigger the sweep, while viewing external signals, to superimpose the brightening gate on the trace. For use of this feature, see Operation, paragraph 2-8d.

3-5. CATHODE-RAY TUBE AND BEAM GATE CIRCUITS

a. CATHODE-RAY TUBE

A Type 5ADP- cathode-ray tube (V401) is used, operating at a total accelerating potential of approximately 3000 volts.

b. FOCUS

Focusing of the beam for maximum sharpness of trace is accomplished by adjusting the FOCUS control (R415). The setting of this control establishes the relative potential difference between the focus anode and cathode. The vertical deflection plates (D3 and D4) and the horizontal deflection plates (D1 and D2) operate at an average dc potential of approximately 280 volts above ground. To avoid beam distortion, the second anode must operate at approximately the same dc potential. The second anode voltage is derived from the arm of the ASTIGmatism service adjustment (R401).

c. INTENSITY MODULATION

For intensity modulation of the beam, positive (blanking) or negative (brightening) signals may be applied to the Z INPUT terminal through a coupling capacitor (C402) to the cathode of the cathode-ray tube. See Table 1-1 for additional information.

d. BEAM GATE AND INTENSITY CIRCUITS

GENERAL DESCRIPTION:

The primary functions of the gate generator (V402) are 1, to provide return trace blanking for automatic sweep operation; and 2, when driven sweep operation is desired, to automatically turn on the cathode-ray tube beam for the duration of the forward sweep interval and then turn it off automatically at the end of this interval. This latter feature prevents film fogging and/or screen burning prior to the initiation of driven sweep.

A secondary function of the gate generator is to facilitate transfer of the source of the brightening gate from a low dc level (approximately 150 volts) to the high dc level of the cathode-ray tube grid (negative high voltage).

The primary and secondary functions are solved by the incorporation of a conventional bistable multivibrator (V402, beam gate generator). The mean dc level of this stage is equal to the average level of the cathode-ray tube accelerating potential. Thus, only short pulses are needed to trigger V402 on or off, enabling the use of a much smaller coupling capacitor.

DETAILED DESCRIPTION:

Under stable conditions, the constants of the beam gate circuit are such that V402B is at cutoff and V402A fully conducting. When the sweep starts, the negative leading edge of the gate coupled from the cathode of V203B is applied to the grid (pin 2) of V402A, turning off this stage and turning on V402B. Thus, the grid of the cathode-ray tube is held above cutoff for the duration of the forward sweep time. V402 is restored to its original condition by the positive-going trailing edge of the sweep gate.

INTENSITY:

The INTENSITY control (R406) is in series with the beam gate generator (V402). The output of V402 is connected to the grid of the cathode-ray tube (V401). Adjustment of the INTENSITY control varies the negative grid potential of V401 with respect to its cathode, which is held at a fixed positive potential relative to the -1300-volt supply by neon lamps E401 and E402.

3-6. REGULATED RF SUPPLY

a. GENERAL DESCRIPTION

Operating potentials for the proper intensity and focusing of the cathode-ray tube beam, are derived from the regulated rf power supply. This circuit consists of an rf power oscillator (V501), an rf type transformer having a high turns ratio and a ferrite core (T501), a two stage direct-coupled control amplifier (V504A,B), a -1300-volt diode rectifier (V502), and a +1800-volt diode rectifier (V503). Regulation is accomplished by sampling a portion of the rectified output, and feeding a correcting signal back through V504 to the screen grid of V501.

b. DETAILED DESCRIPTION

The rf power oscillator (V501), operating in the vicinity of 150-200 Kc, develops an ac potential across the primary of T501. The amplitude of this voltage is proportional to the screen voltage applied to V501. Hence, a change in the rectified output can be corrected by an appropriate increase or decrease in V501 screen potential. For example, a decrease in the rectified output would result in error voltage fed back to a two stage direct-coupled control amplifier (V504A and V504B). These stages supply the correction signal which is coupled to the screen of V501. The screen voltage is increased, which increases the ac output voltage across T501, thus, compensating for the decrease in output voltage mentioned earlier.

The advantages of an rf supply system of generating cathode-ray tube accelerating potentials, compared to that of a conventional "brute force" low-frequency system are:

1. Relative ease of incorporating control amplifiers to maintain constant, effectively low output impedance.

2. Elimination of high-voltage, high-capacitance filter, which are dangerous and bulky.

3. Sharp reduction in shock hazard due to the smaller capacitors used in the filter system.

3-7. LOW-VOLTAGE POWER SUPPLY

Two types of power supplies are used with the Types 401-A and 401-AR Oscilloscopes. One uses a self-regulating power transformer (T601) employing a magnetic shunt and a resonant secondary winding to minimize the effect of line-voltage variation. Once resonance is attained, it is used in conjunction with the magnetic shunt as the basis of maintaining the output voltage of the transformer constant.

The second supply is an electronically regulated type using a power transformer capable of operation from 50 to 400 cps. To identify the two power supplies, the symbol numbers assigned to the Sola-regulated supply are in the 600 series, while those assigned to the electronic-regulated supply are in the 1600 series. Both supplies are shown in the Schematic Diagram included in this Manual.

For the Sola-regulated supply, V601 is connected in a conventional full-wave rectifier circuit. The rectified output is filtered by a capacitor-input type filter (C601C, L601 and C601B).

For the electronic-regulated supply V1601 is the full-wave rectifier, applying its output to V1603, a series passing tube whose series resistance is adjusted by the sample fed back from R1616 through the dc amplifier V1602 to its control grid. If the +390 volts output changes due either to a change in input voltage or load current, the sample voltage changes and alters the passing tube grid voltage to return the output to +390.

V1604 is also a series passing tube for one of the +150 volt outputs. Here the grid is controlled by the +390 volts regulated. The remaining +150 volt output is controlled by the gas tube V1606.

3-8. VOLTAGE CALIBRATOR

The power-line frequency voltage from T601 (T1601) is applied to the voltage calibrator (V603 (V1605)) through limiting resistor R615 (R1626). With the plate of V603A (V1605A) (pin 7) tied to ground, any negative voltage impressed on this section will cause conduction, thus clamping the negative half cycle at approximately ground potential. On the positive half cycle, the voltage conduction occurs in the other half section (V603B (V1605B)) when the peak applied potential exceeds +150 volts, thus clipping the sine wave at that point. The resulting clipped sine wave voltage (150 volts peak-to-peak) is applied to two parallel voltage dividers containing the Y50 MV (R612 (R1633)) and X50 MV (R614 (R1634)) controls as shown in the power supply schematic.

The attenuated output (50 MV peak-to-peak) is coupled from the respective voltage divider to the corresponding vertical or horizontal amplifier when the appropriate calibrator button is pushed in. The Y 50 MV (R612 (R1633)) and X 50 MV (R614 (R1634)) service adjustments provide a means of setting the output of the calibrator to exactly 50 MV peak-to-peak.

SECTION 4. MAINTENANCE

4-1. GENERAL INFORMATION

To keep electronic units operating at top performance, it is desirable to check the equipment at regular intervals. How often it is checked will depend on the installation and the conditions of operation. In general, portable units moved about constantly will require more frequent service than units fastened down permanently.

For these regular checks, clean all dust and dirt from the unit, using a light air blast or soft brush. Be sure dust is removed from around tube socket contacts and terminal strip connections.

Compare the performance of the unit with the specifications provided in this Instruction Manual. Often a gradual degradation in performance will not be noted in daily operation, until finally the equipment stops operating completely.

In the design of this Du Mont equipment, care has been taken to use the proper tubes for the application desired, and to use them in such a manner that considerable weakening can take place before replacement is necessary. While checking tubes is desirable, a tube should only be replaced when it is actually causing a degradation in unit performance. A simple test for tube checking is to insert a tube known to be good and look for an improvement in performance.

WARNING

POTENTIALS AS HIGH AS 3000 VOLTS EXIST IN THIS INSTRUMENT. OBSERVE THE FOLLOWING PRECAUTIONS WHEN NECESSARY TO ENERGIZE THE EQUIPMENT WITH THE CABINET REMOVED.

1. Never work alone.
2. Make sure the chassis is properly grounded.
3. Disconnect power before changing any tubes.
4. Before touching any component, short the terminals to remove any possible charge that may remain after removing the power.

Do not touch any service adjustments unless test clearly indicates the need to do so. Such adjustments should not be attempted without a complete understanding of the proper procedure. Consult Tables 4-1 and 4-2 for special instructions.

4-2. GAINING ACCESS TO THE CHASSIS

The unit is enclosed in a cabinet which is composed of six removable panels (top, bottom, left and right sides; upper and lower panels at the rear). To gain access to the chassis, remove the two screws securing the top of each side panel, and loosen the bottom two screws. Lift off the panels. This will expose most of the tubes and service adjustments for normal maintenance.

After the side panels are removed, the top and bottom panels may be taken off if desired. To take off the bottom panel, remove the two flat head screws located on the fold-over on each side. The top panel is similarly removed except that two additional screws, located at either end of the handle, must be removed. Note: the top panel will not normally require removal. To take off the upper or lower or rear panel, remove the four screws securing them to the frame.

4-3. REPLACEMENT OF CATHODE-RAY TUBE

CAUTION

The cathode-ray tube should be handled with great care to prevent breakage and/or serious personal injury from flying glass. Do not employ force at any time. As an added precaution, it is advisable to wear safety goggles and gloves.

The following step-by-step procedure is suggested for replacing the cathode-ray tube:

1. Turn off power. Remove rear plate secured by four screws and the side panels.

2. Remove bezel, held by four screws at front panel.

3. Remove the cathode-ray tube socket and the intensifier button.

4. Loosen the cathode-ray tube clamp via screw through the access hole (located on the same side as the intensifier button).

5. Remove tube through front panel opening.

6. Remove the rubber pad from the old tube and install it on the new tube.

7. Install new tube through front panel opening, and replace the bezel.

8. Replace the tube socket and the intensifier button.

9. Apply power and check the sweep; it not horizontal, rotate the tube by the insulated handle as required.

10. Tighten the cathode-ray tube clamp securely to prevent rotation in handling. It is not possible to damage the tube in tightening due to the protection provided by the rubber pad.

4-4. ILLUMINATED SCALE LAMP AND PILOT LAMP REPLACEMENT

a. Defective scale lamps are removed as follows:

1. Turn off power, disconnect power cord and remove the side panels.
2. Remove the appropriate lamp assembly located on the rear side of the front panel by depressing the spring clip. The defective bulb may then be removed and replaced.

Remember that the scale lamps are connected in series-parallel. One defective lamp will cause two to be out at the same time. See the Schematic Diagram for the connection details.

b. Defective pilot lamp is removed as follows:

1. Turn off power and remove bottom panel.

2. With the unit upside down, replace the defective bulb.

4-5. GENERAL TROUBLE SHOOTING

The first step in correcting any trouble or failure that may occur is to isolate the section of the circuit causing the trouble. Such isolation can be accomplished by considering the circuit as composed of the basic sections shown in the over-all block diagram, Figure 3-1. As an aid to servicing, the Servicing Hint Chart, Table 4-4, has been provided.

The next step after isolating the trouble to a particular section is to determine the specific tube circuit involved. A replacement tube should be tried before attempting any other test. Tubes may be located by reference to Figures 4-1 through 4-5. Remember that when some tubes are replaced, associated service adjustment controls may need to be reset. See Table 4-3.

When using accessory probes or adapters, such as listed in paragraph 1-5 of this Manual, be sure the trouble is not originating in the accessory, before suspecting the Oscilloscope itself.

TABLE 4-1. TEST EQUIPMENT REQUIRED FOR SERVICE ADJUSTMENTS

The following units of test equipment are required for the adjustment procedures of Table 4-2. In Table 4-2, these units are identified by the reference number listed in the center column.

1. Volt-ohmmeter - 20,000-ohms-per-volt meter or a vacuum-tube voltmeter.

2. Square-wave Generator - Range, 1 Kc to 10 Kc.

3. Voltage Calibrator - Range, 0.01 to 10 volts peak to peak; ±1%.

4. Time Calibrator - Pulse repetition rate: 100 cps, 1 Kc, 10 Kc, 100 Kc and 1 Mc. Accuracy, ±1% or better. 2 volts peak.

5. Sine-wave Generator - Range, 1 Kc to 100 Kc.

PRECAUTION

DO NOT SET ANY SERVICE ADJUSTMENT WITHOUT FOLLOWING SPECIFIC INSTRUCTIONS AND SEQUENCE GIVEN IN TABLE 4-2. SOME ADJUSTMENTS ARE INTERDEPENDENT

TABLE 4-2. SERVICE ADJUSTMENT CHART

While many of the adjustments listed can be set independently, it should be noted that they should be adjusted in the order presented. At least, all those in any one section should be adjusted as described in order.

1. ELECTRONIC-REGULATED LOW VOLTAGE SUPPLY

Control	Test Equipment	Procedure
+390 V ADJUST R1616	1.	Place the meter between the +390 volt output and ground; across C1608 is suggested. Adjust +390 V ADJUST R1616 for +390 volts on the meter.

2. HIGH VOLTAGE SUPPLY AND CRT

Control	Test Equipment	Procedure
HV ADJUST R501	1.	Set INTENSITY fully counterclockwise. Use an insulated test probe and adjust the high-voltage negative supply to -1300 volts. Measurement may be made conveniently between counterclockwise end of INTENSITY control and ground.
ASTIGMATISM R401	--	Set appropriate front-panel controls to obtain spot on screen. Adjust ASTIGMATISM R401 simultaneously with FOCUS control for minimum spot size at normal INTENSITY setting.

Control	Test Equipment	Procedure
		When properly adjusted, the spot will always be round as the FOCUS control is rotated both clockwise and counterclockwise from the sharpest FOCUS setting.

3. VERTICAL AMPLIFIER

Control	Test Equipment	Procedure
Y VOLTS/CM Compensation Capacitors C106, C107, C108	2.	Apply a 10-Kc square wave to Y input. Set the Y VOLTS/CM switch as listed below. Adjust the appropriate capacitor to obtain a flat-top square wave.

Y VOLTS/CM	Adjust
0.1	C106
1.0	C107
10	C108

Control	Test Equipment	Procedure
V102 BIAS R121 V103 BIAS R125	1. & 2.	Set Y CAL button in. Set Y VOLTS/CM to OFF. Adjust V102 BIAS R121 for maximum gain. This is a preliminary setting to permit proper astigmatism adjustment and to minimize variations when the square wave is applied. Readjust ASTIGMATISM control as described in 2. HIGH VOLTAGE SUPPLY AND CRT on a previous page. *Set Y CAL button out. Set V103 BIAS R125 for +265 volts with spot centered as measured on D3 or D4 terminals on rear deflection plate panel. ** Apply a 10-Kc square wave at 5 volts peak-to peak into the Y input. Set Y VOLTS/CM to 1.0 A-C.

Control	Test Equipment	Procedure
		Set Y AMPLITUDE control for 3 cm of deflection. Set Y VOLTS/CM to 0.1 A-C. Adjust V102 BIAS R121 for a minimum change of peaking with a change in positioning. * Repeat section from * to * twice, starting at ** the second time.
Y LINEARITY R128	2.	Apply a 10-Kc square wave into the Y input. Set Y VOLTS/CM and Y AMPLITUDE to obtain 1 cm of vertical deflection near the center of the screen. Use the Y POSITION control to move the trace to the upper and lower limits of the screen. The deflection linearity should not change by more than 5%. If it does, move Y LIN R128 in small increments until such positioning indicates a linearity better than 5%. If such linearity cannot be achieved within the extreme positions of the Y LIN control, replace V103 and repeat procedure.
Y 50 MV R612 (R1633)	3.	Set Y VOLTS/CM to .01 D-C. Apply a 0.05-volt, ±1%, signal from an external voltage calibrator to Y input. Advance Y AMPLITUDE for a vertical deflection of half scale. Use the half-scale marks provided on the scale Y axis. Set Y CAL button in. Adjust Y 50 MV R612 (R1633) for the same half-scale deflection.

4. HORIZONTAL AMPLIFIER

Control	Test Equipment	Procedure
X VOLTS/CM Compensation Capacitors C306, C307, C308	2.	Apply a 10-Kc square wave to X input. Set the X VOLTS/CM switch as listed below. Adjust the appropriate capacitor until the dots at each end of the horizontal trace are of maximum relative intensity and in sharpest focus.
V302 BIAS R321 V303 BIAS R325	1. & 2.	Set X CAL button in. Set X VOLTS/CM to OFF. Adjust V302 BIAS R321 for maximum gain. This is a preliminary setting to permit proper astigmatism adjustment and to minimize variations when the square wave is applied. If it has not already been adjusted during the settings of the Vertical Amplifier, readjust the ASTIGMATISM control as described in 2. HIGH VOLTAGE SUPPLY AND CRT on a previous page. * Set X CAL button out. Set V303 BIAS R325 for +265 volts measured on D1 and D2 terminals on rear deflection plate panel. ** Apply a 10-Kc square wave at 5 volts peak-to-peak into the X input. Set X VOLTS/CM to 1.0 A-C. Set X AMPLITUDE control for 3 cm of deflection. Set X VOLTS/CM to 0.1 A-C.

X VOLTS/CM	Adjust
0.1	C306
1.0	C307
10	C308

Control	Test Equipment	Procedure
		Adjust V302 BIAS R321 for a minimum change of peaking with a change in positioning. * Repeat section from * to * twice, starting at ** the second time.
X LINEARITY R328	2.	Apply a 10-Kc square wave into the X input. Set X VOLTS/CM and X AMPLITUDE to obtain 1 cm of horizontal deflection near the center of the screen. Use the X POSITION control to move the trace to the upper and lower limits of the screen. The deflection linearity should not change by more than 5%. If it does, move X LIN R328 control in small increments until such positioning indicates a linearity better than 5%. If such linearity cannot be achieved within the extreme positions of the X LIN control, replace V303 and repeat procedure.
X 50 MV R614 (R1634)	3.	Set X VOLTS/CM to .01 D-C. Apply a 0.05-volt, ±1%, signal from an external voltage calibrator to X input. Advance X AMPLITUDE for a horizontal deflection of half scale. Use the half-scale marks provided on the scale X axis. Set X CAL button in. Adjust X 50 MV R614 (R1634) for the same half-scale deflection.

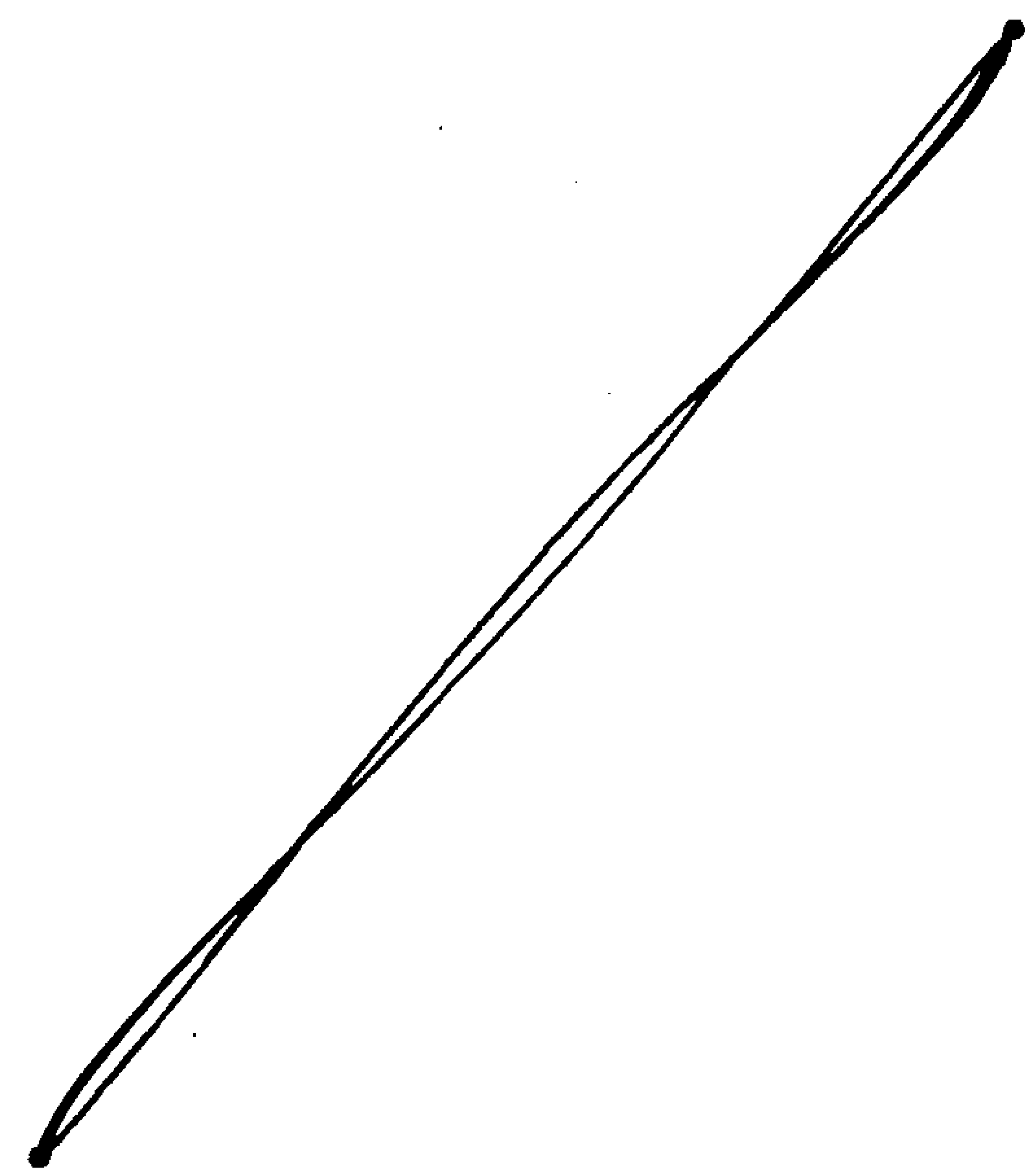
5. HUM BALANCING

Control	Test Equipment	Procedure
HUM BAL R603 (R1603) X & Y HUM R107, R307	--	Set X and Y AMPLITUDE controls fully clockwise without actuating CAL switches. Set X and Y VOLTS/CM switches to .01 D-C. Shield X and Y input terminals. The power line ripple should not exceed 1 mm of screen deflection. If it does, adjust HUM BAL R603 (R1603), and X and Y HUM R107, R307 controls for minimum deflection.

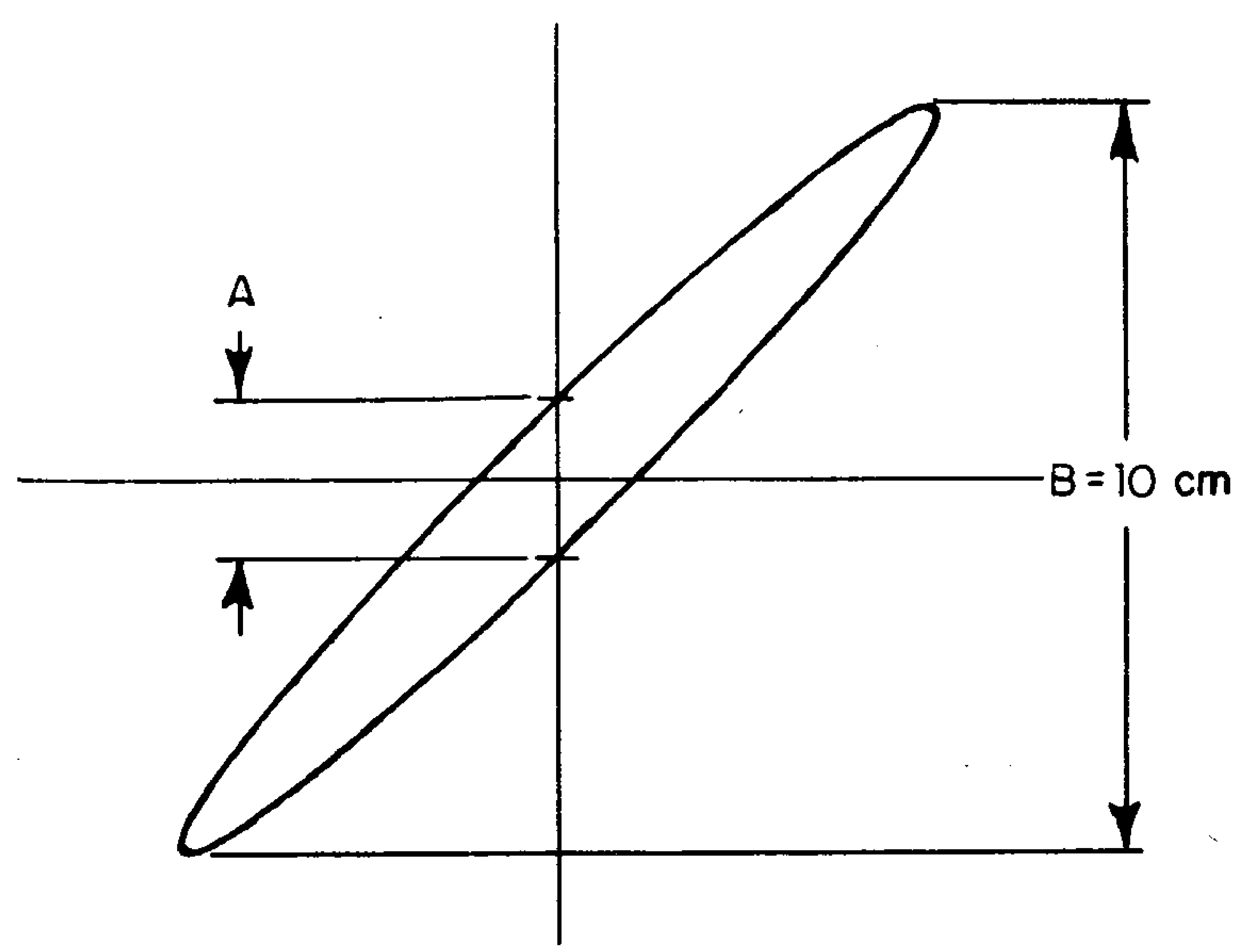
6. PHASE BALANCING

Control	Test Equipment	Procedure
PHASE BAL C121, C321	2. & 5.	Set Y VOLTS/CM to .01 D-C. Set Y AMPLITUDE fully clockwise without actuating CAL switch. Set X VOLTS/CM to .01 D-C. Set X AMPLITUDE fully clockwise without actuating CAL switch. Set PHASE BAL C121, C321 to minimum capacity (pool of solder on rotor turned away from power supply). Apply 10-Kc square wave to both the X and Y inputs. Adjust output of generator to obtain 8 cm Y deflection. The resulting X deflection will be between 5 and 7-1/2 cm depending upon gain and CRT sensitivity. Adjust PHASE BAL C121, C321 to obtain the following pattern on the screen.

Control	Test Equipment	Procedure



To check the relative phase shift, apply a 100-Kc sine wave to both the X and Y inputs. The pattern obtained should be as shown below.



DIMENSION "A" SHOULD NOT EXCEED 5mm (3° FROM SIN θ = A/B).

At or below 5-Kc sinewave input, the phase shift should not exceed 1-3/4 mm (1°) for any combination of AMPLITUDE control and VOLTS/CM switch settings.

7. DEFLECTION PLATE NEUTRALIZER

Control	Test Equipment	Procedure
NEUTRALIZER C322	2.	Apply 10-Kc square wave to Y input. Set Y VOLTS/CM and Y AMPLITUDE for 10 cm vertical deflection. Set X VOLTS/CM to OFF. Adjust NEUTRALIZER C322 for minimum horizontal deflection.

8. SWEEP CIRCUITS

Control	Test Equipment	Procedure
Alignment of SYNC LEVEL knob to zero marking	--	Set X VOLTS/CM to AUTO. Set Y VOLTS/CM to 10 D-C. Set SWEEP RANGE to 2 MS/CM Set VERNIER fully clockwise to X1. Set SYNC switch to LINE. Set Y CAL button in. Adjust the X and Y AMPLITUDE and position the trace to occupy a square of about 4 cm in the center of the screen. At the zero marking of the SYNC LEVEL control the waveform should <u>not</u> be in sync. Rotate this control first towards "-" and then "+" until the waveform <u>is</u> in sync. Note the knob position in each case. For an accurate zero setting, these two positions should be symmetrical about the zero point. If not, loosen the knob set screw and reset the knob on the shaft so that it is aligned with the "O" marking when the shaft position is midway between the two "in-sync" points determined above.

Control	Test Equipment	Procedure
GATE SENS R226	--	Set DURATION R245 to center of range. Set GATE SENS R226 fully counterclockwise. Set TRIG LEVEL R211 to center of range. Set SWEEP EXPANSION POINT to center of range. R249 Set SYNC switch to EXT. Set SYNC LEVEL fully clockwise. Set X VOLTS/CM to AUTO. Advance GATE SENS R226 slowly clockwise until the sweep starts, then turn it a quarter turn (90^o) past this point.
TRIG LEVEL R211	--	Set Y CAL button in. Set Y AMPLITUDE for 2 cm of vertical deflection. Set SYNC switch to INT. Set X VOLTS/CM to DRIV. Adjust TRIG LEVEL R211 so that the calibrator signal starts at the middle of its vertical rise.

9. SWEEP CALIBRATION

Control	Test Equipment	Procedure
SWEEP OR X CAL R317	4.	Set SWEEP RANGE to 2 MS/CM. Set VERNIER fully clockwise to X1. Set X VOLTS/CM to DRIV. Set SYNC switch to INT. Set SYNC LEVEL fully clockwise. Set X AMPLITUDE fully clockwise and actuate CAL SWP switch. Apply a timing signal of 1000-us pulses to the Y input. Set Y VOLTS/CM and Y AMPLITUDE to obtain 1 cm of vertical deflection. Set SWEEP OR X CAL R317 to produce 2 timing pulse per cm.

Control	Test Equipment	Procedure
DURATION R245	4.	Adjust DURATION R245 for a sweep length of 10 cm.
CAL X5 R239	4.	Set VERNIER fully counterclockwise to X5. Apply a timing signal of 10,000-us pulses to the Y input. Adjust CAL X5 R239 to produce 1 timing pulse per cm.
Alignment of VERNIER knob to X2 dot	4.	Apply a timing signal of 1000-us pulses to the Y input. Adjust VERNIER to produce 4 timing pulses per cm. At this point, the VERNIER knob should be aligned with the X2 dot. If it is not, loosen the knob setscrew and align it with the dot without turning the control shaft. Tighten the setscrew again.
Sweep Trimmer C215	4.	Set SWEEP RANGE to 5 uS/CM. Set VERNIER fully clockwise to X1. Apply a timing signal of 10-us pulses to the Y input. Set Y AMPLITUDE to obtain 3 cm of vertical deflection. Using an insulated or non-metallic screwdriver, adjust Sweep Trimmer C215 to produce 1 timing pulse per 2 cm.

10. SWEEP EXPANSION POINT

Control	Test Equipment	Procedure
SWEEP EXPANSION POINT R249	--	Check that X Bal is properly adjusted; see Section 2-8, b, for details. Set X AMPLITUDE fully counterclockwise. Set SYNC switch to LINE. Set SYNC LEVEL fully clockwise. Set VERNIER fully clockwise to X1.

Control	Test Equipment	Procedure
		Set SWEEP RANGE to 2 MS/CM. Set Y CAL button in. Set Y AMPLITUDE to obtain 2 cm of vertical deflection.
		Left side expansion
		Adjust X POSITION to set vertical trace on screen under the left side scale marking. Set X AMPLITUDE fully clockwise without actuating switch. Using the SWEEP EXPANSION POINT R249, reposition the start of the now expanded trace under the left side scale marking.
		If the above adjustments have been made with care, the sweep will expand from the left side of the screen when the X AMPLITUDE control is rotated.
		Right side expansion
		Use the same procedure as above, except set the trace under the right side scale marking.
		Center expansion
		First make the initial settings as for the end expansions described above.
		Adjust X POSITION to set the vertical trace on the screen under the center scale marking. Adjust X AMPLITUDE to obtain 10 cm of horizontal deflection.

Control	Test Equipment	Procedure
		Using the SWEEP EXPANSION POINT R249, center the 10-cm deflection about the center scale marking. It may be necessary to set the X AMPLITUDE and SWEEP EXPANSION POINT controls together to make this adjustment. If the above adjustments have been made with care, the sweep will expand equally about the center marking of the scale when the X AMPLITUDE control is rotated.

TABLE 4-3. ADJUSTMENTS TO BE MADE WHEN REPLACING TUBES

Symbol	Type	Adjustments to be Checked (See Tabel 4-2)
V101 & V102	ECC82/12AU7	V102 BIAS R121, Y HUM R107
V103	6BK7-B	V103 BIAS R125, Y LIN R128
V201	12AU7	TRIG LEVEL R211
V202 & V203	6U8	GATE SENS R226
V204	12AU7	DURATION R245, CAL X5 R239
V301 & V302	ECC82/12AU7	V302 BIAS R321, X HUM R307
V303	6BK7-B	V303 BIAS R325, X LIN R238
V401	5ADP-	ASTIG R401
V402	12AU7	NONE
V501	6AQ5	If circuit operated properly before
V502	1X2-A	tube failure, no adjustments should
V503	5642	be required. Otherwise adjust
V504	6U8	HV ADJ R501.
V601	5V4-G	Calibration controls
V602	OA2	Calibration controls
V603	6AL5	Check X 50 MV (R614) and Y 50 MV (R612) against a known standard. If no standard is available these controls should not be touched.
V1601	GZ-34	Calibration controls, +390 V ADJ (R1616)
V1602	6AU6-A	+390 V ADJ (R1616)
V1603	6BX7-GT	+390 V ADJ (R1616)
V1604	6CL6	NONE
V1605	6AL5	Check X 50 MV (R1634) and Y 50 MV (R1633) against a known standard. If no standard is available, these controls should not be touched.

TABLE 4-4. SERVICING HINT CHART

NOTES: 1. This chart tabulates the following information:

a. Symptoms of tube or component failure.

b. Symptoms arising from misalignment of service adjustments; see Table 4-2 for the adjustment procedure.

2. Some of the symptoms indicated in this chart might be caused by failure of some component associated with the circuit under a analysis.

1. VERTICAL AMPLIFIER

Symptom		Component or Adjustment to be Checked	
1a.	No vertical deflection	1a.	V101 to V103
2a.	Y VOLTS/CM is set to OFF; trace shifts vertically with changes in setting of Y AMPLITUDE control	2a.	Y BAL (R112) See Section 2, Operation
3a.	Power-line frequency ripple noted on trace	3a.	HUM BAL (R603 (R1603)) and Y HUM (R107)
4a.	Size of pattern changes as it is positioned vertically on the screen	4a.	Y LIN (R128)
5a.	A 10-Kc square-wave signal is distorted at any one range of the Y VOLTS/CM switch	5a.	Y Compensation Capacitors (C106 to C108)
6a.	Relative phase shift is greater than normal	6a.	Phase Balance Trimmer (C121)
7a.	Y internal calibration voltage is either too high or too low	7a.	Y 50 MV (R612 (R1633))

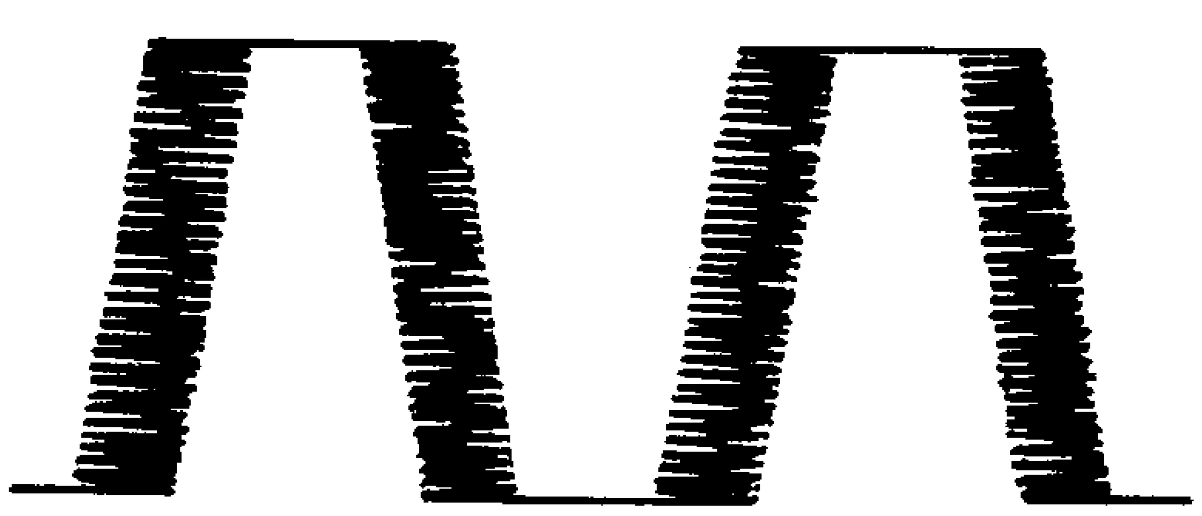
2. SYNC AND SWEEP

	Symptom		Component or Adjustment to be Checked
1b.	No sync; instrument is set for AUTO sweep	1b.	V201 to V203. Refer to Table 1-1 for data on sync sensitivity
2b.	No sync; instrument is set for DRIVEN sweep; AUTO sweep is OK	2b.	TRIG LEVEL (R211), V201, and/or V202. Refer to Table 1-1 for data on sync sensitivity
3b.	No sweep; X VOLTS/CM set to SWEEP and SYNC set to INT	3b.	See 1c
4b.	No sweep; X VOLTS/CM set to SWEEP and SYNC set to INT; horizontal amplifier checks OK	4b.	GATE SENS (R226) and/or V201 to V204
5b.	Sweep length is less than 10 cm; instrument is set for calibrated sweep	5b.	DURATION (R245)
6b.	Sweep does not expand equally on either side of center when the X AMPLITUDE is varied	6b.	SWEEP EXPANSION POINT (R249)
7b.	All calibrated sweep writing rates are either too fast or too slow	7b.	SWEEP OR X CAL (R317)
8b.	Calibrated sweep writing rates are correct when VERNIER is set to X1, incorrect at X2	8b.	See Table 4-2 for alignment of VERNIER knob to X2
9b.	Calibrated sweep writing rates are correct at X1, incorrect at X5	9b.	CAL X5 (R239)

Symptom	Component or Adjustment to be Checked
10b. 5 uS/CM calibrated sweep range out of tolerance; all other ranges are OK	10b. Sweep Trimmer (C215)
11b. Error in writing rate noted on one or more portions of the screen	11b. E403 and/or V204
12b. Undesired intensity modulation of trace noted when X VOLTS/CM is set for external signals	12b. Set SYNC to EXT and SYNC LEVEL to center of range. For further information, see "Gated Beam Operation" in Section 2
13b. No sweep in any one range of the SWEEP RANGE control	13b. See the table below
14b. Undesired horizontal modulation of trace as illustrated below. Calibration signal shown.	14b. Neon bulb oscillating; check E201 or E403.

13b.

SWEEP RATE set to	Defective Capacitor
50 MS/CM	C223
10 MS/CM	C222
2 MS/CM	C221
500 uS/CM	C219
100 uS/CM	C218
20 uS/CM	C217
5 uS/CM	C216 and/or C215



3. HORIZONTAL AMPLIFIER

Symptom	Component or Adjustment to be Checked
1c. No horizontal deflection; internal sweep circuit is normal	1c. V301 to V303
2c. X VOLTS/CM is set to OFF; trace shifts horizontally with changes in setting of X AMPLITUDE control	2c. X BAL (R312)
3c. Power-line frequency ripple noted on trace	3c. HUM BAL (R603 (R1603)) and X HUM (R307)
4c. Size of pattern changes as it is positioned horizontally on the screen	4c. X LIN (R328)
5c. A 10-Kc square-wave signal is distorted at any one range of the X VOLTS/CM switch	5c. X Compensation Capacitors (C306 to C308)
6c. Relative phase shift is greater than normal	6c. Phase Balance Trimmer (C321)
7c. All calibrated sweep writing rates are either too fast or too slow	7c. SWEEP OR X CAL (R317)
8c. X internal calibration voltage is either too high or too low	8c. X 50 MV (R614 (R1634))

4. HIGH VOLTAGE SUPPLY, CRT AND BEAM GATE

	Symptom		Component or Adjustment to be Checked
1d.	No spot on cathode-ray tube screen	1d.	V401 and/or V503 also see 1a and 1c
2d.	Poor high-voltage regulation	2d.	V501 and/or V504
3d.	-HV output is too high or too low	3d.	-HV ADJ(R501)
4d.	Bright spot noted at left side of screen; visible return trace	4d.	V402
5d.	Non-uniform focused pattern as it is positioned over the screen	5d.	ASTIG (R401)

5. SOLA-REGULATED LOW VOLTAGE SUPPLY

	Symptom		Component Adjustment to be Checked
1e.	Dead unit; primary line fuse, F604 is OK	1e.	Heater fuse, F603 and/or B+ fuse F601
2e.	Dead unit; all fuses are OK	2e.	V601
3e.	Dead unit; all fuses and rectifier (V601)are OK	3e.	Refer to schematic and check P502 and J601
4e.	No calibrator pattern when X CAL and/or Y CAL buttons are pushed in	4e.	V603
5e.	Calibrator pattern rounded on top or bottom, looks like a sine wave	5e.	V603

Symptom	Component or Adjustment to be Checked
6e. Calibrated sweep writing rates and output of voltage calibrator flunctuates	6e. V602
7e. Output voltages are very low	7e. C602. This capacitor has been selected to resonate with T601. If replacement is necessary, replace it with one having the same color dot stamped on the end of laminations (SOLA)
8e. Output voltage varies; line voltage within tolerance	8e. T601 is intended for use with 60-cycle power line mains. Changes in the frequency of the supply voltage will be directly reflected in the output voltage. A change of about 1.8% in output voltage will occur for every 1% change in input frequency, and in the same direction as the frequency change

6. ELECTRONIC-REGULATED LOW VOLTAGE SUPPLY

Symptom	Component or Adjustment to be Checked
1f. Dead unit	1f. Primary fuse F1601, or V1601
2f. +390 V incorrect, +390 V ADJUST cannot correct	2f. Defective V1603, V1602, V1606
3f. +390 V OK, but +150 V incorrect	3f. Defective V1604
4f. No calibrator pattern when X CAL and/or Y CAL buttons are pushed in	4f. V1605

Symptom	Component or Adjustment to be Checked
5f. Calibrator pattern rounded on top or bottom, looks like a sine wave	5f. V1605
6f. Calibrated sweep writing rates and output of voltage calibrator flunctuates	6f. V1604

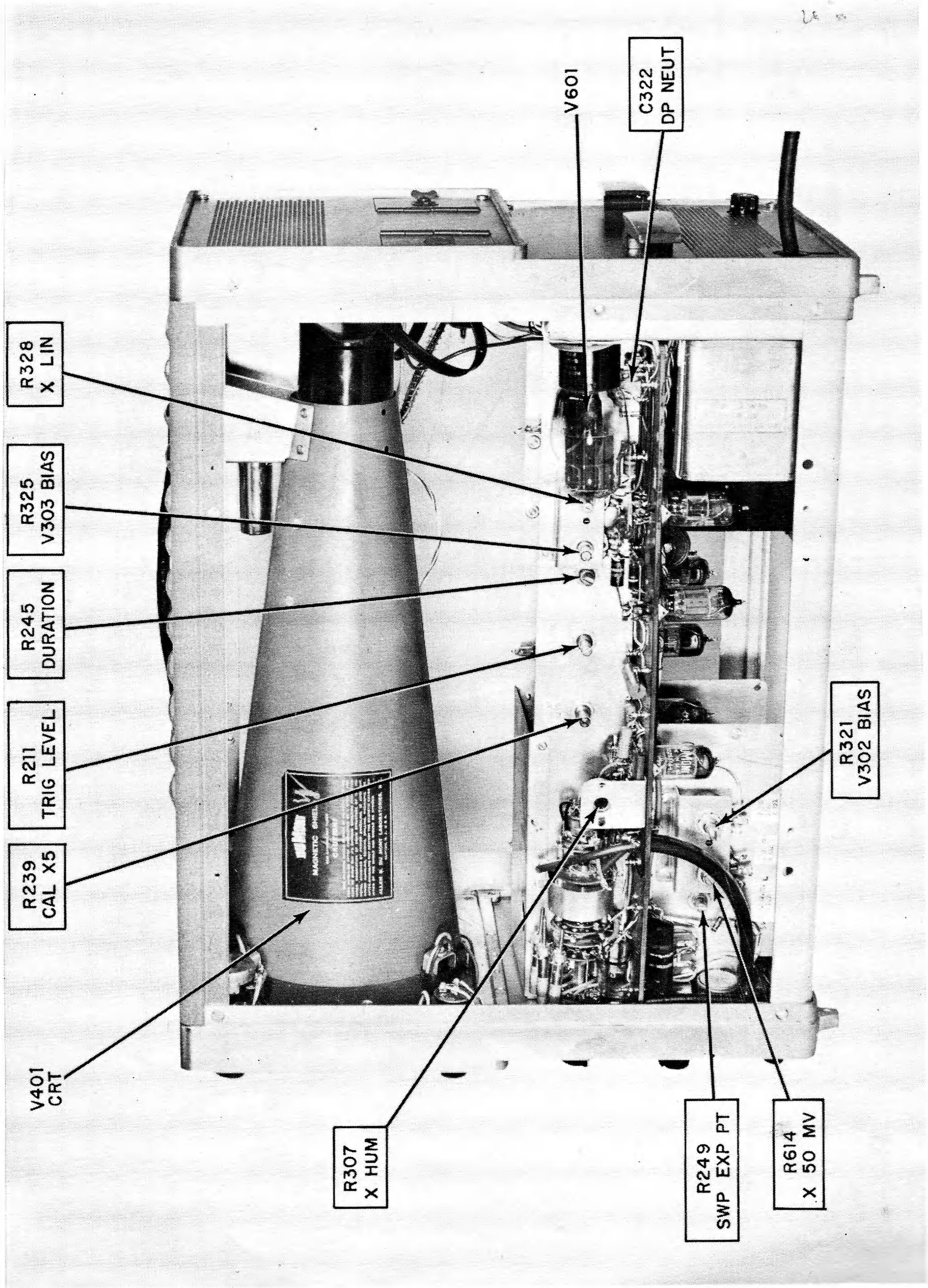


FIGURE 4-1. RIGHT SIDE VIEW (SOLA SUPPLY)

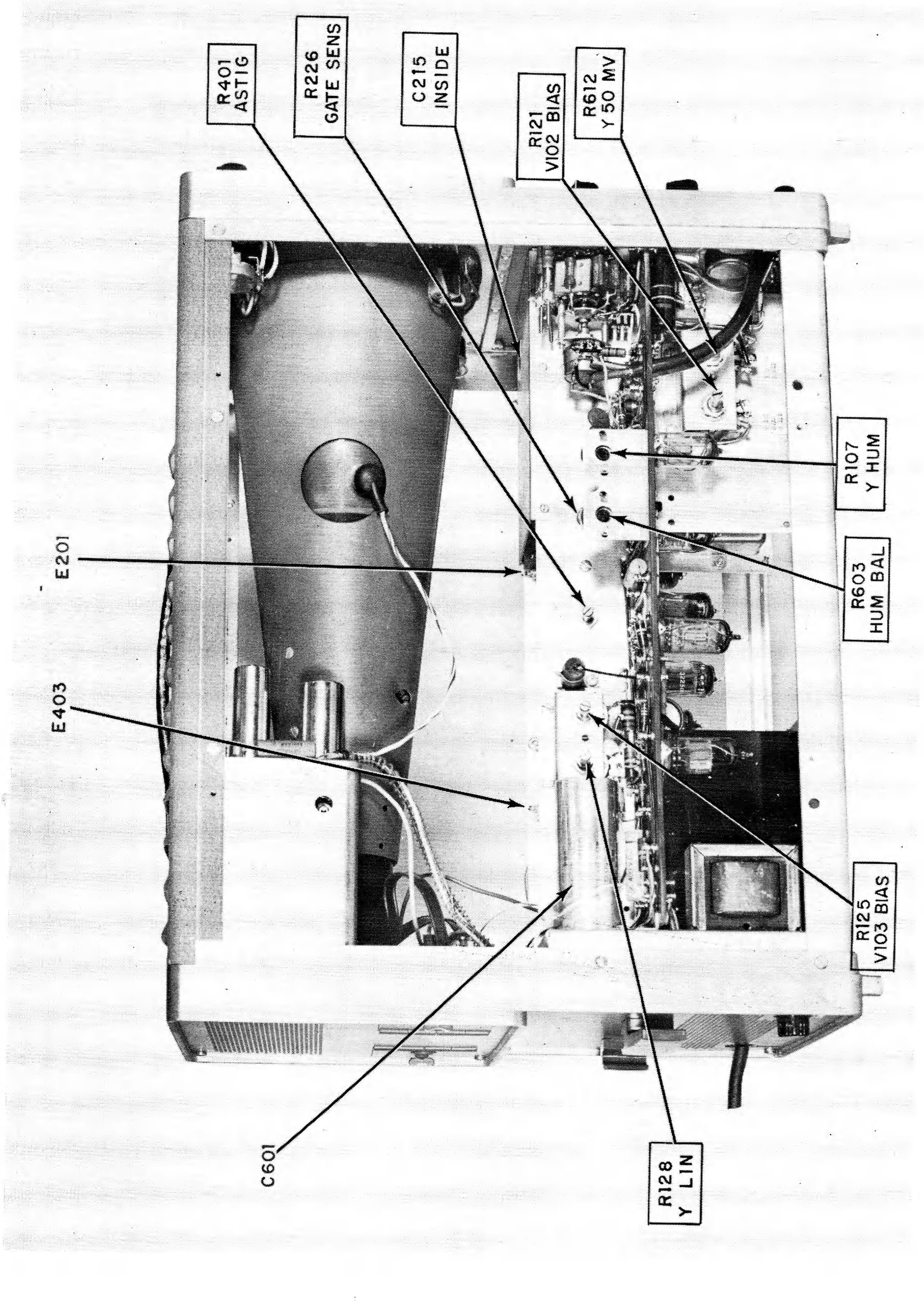


FIGURE 4-2. LEFT SIDE VIEW-1 (SOLA SUPPLY)

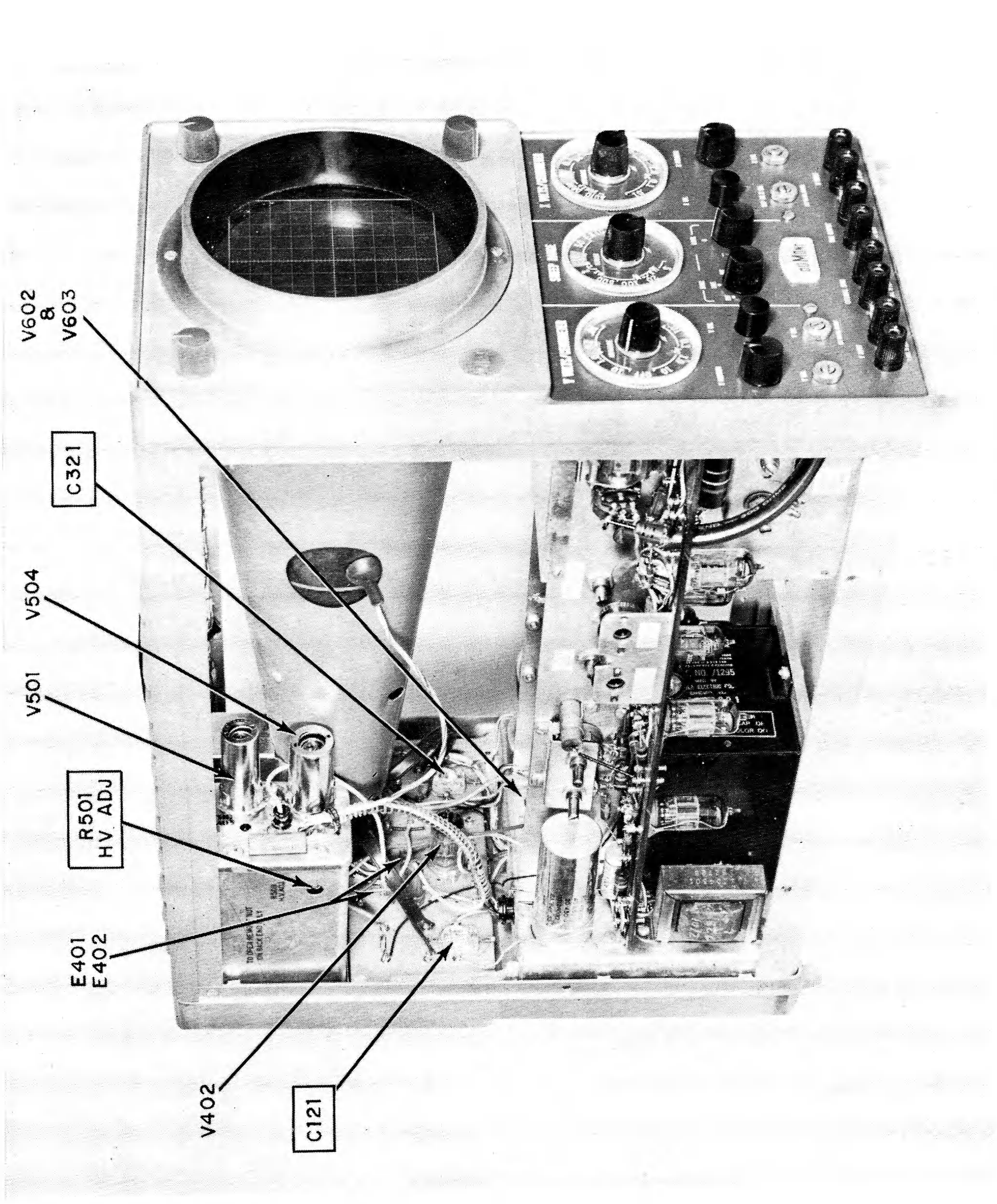


FIGURE 4-3. LEFT SIDE VIEW-2 (SOLA SUPPLY)

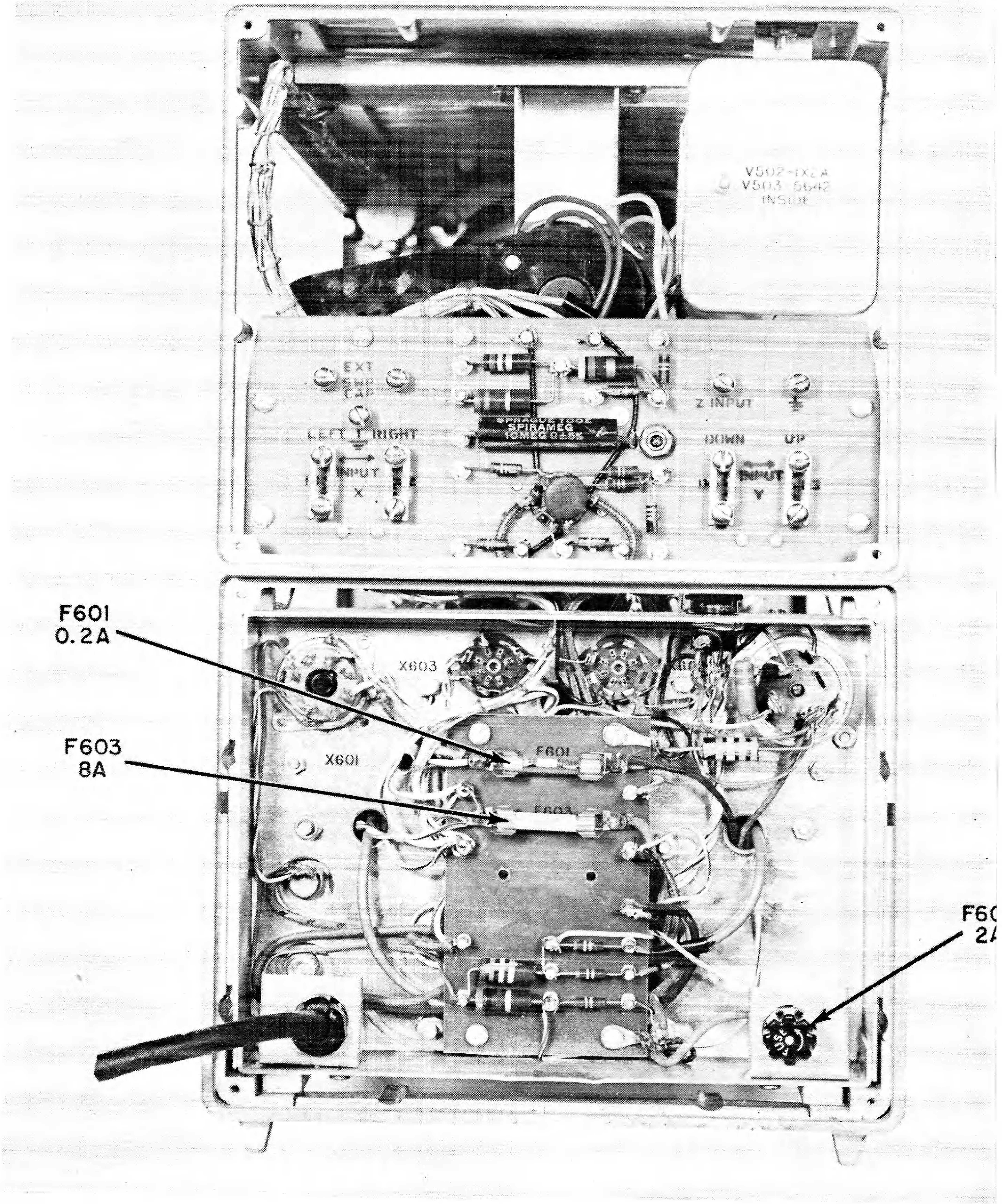


FIGURE 4-4. REAR VIEW (SOLA SUPPLY)

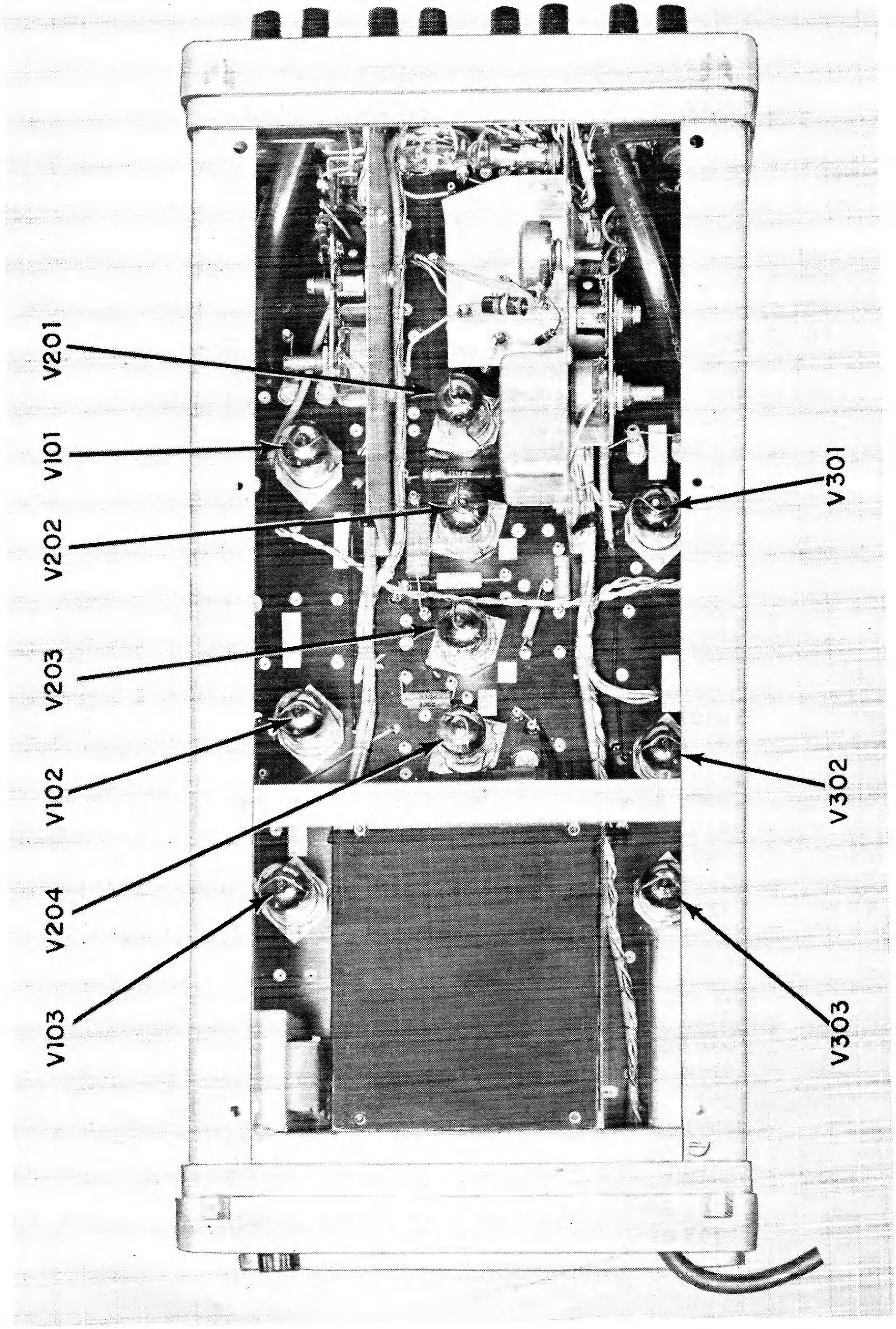


FIGURE 4-5. BOTTOM VIEW (SOLA SUPPLY)

SECTION 5. COMPONENT PARTS LISTS

5-1. ELECTRICAL

Symbol Numbering System:

100 Series	-	Vertical Amplifier
200 Series	-	Sync and Sweep
300 Series	-	Horizontal Amplifier
400 Series	-	Indicator and Beam Gate
500 Series	-	High Voltage Supply
600 Series	-	Sola-Regulated Low Voltage Supply
1600 Series	-	Electronic-Regulated Low Voltage Supply

Symbol	Du Mont Part Number	Description
	CAPACITORS (fixed, mica, ±10%, 500 V unless otherwise specified)	
C101	0312 8220	paper, .1 uf, ±20%, 600 V
C102	0302 0480	270 uuf
C103	0302 9430	820 uuf
C104	0303 3650	8200 uuf
C105	0302 0820	24 uuf, ±5%
C106 to C108	0316 9631	variable, glass, 1-12 uuf, 600 V
C109	0301 9650	ceramic, .01 uuf, +80-20%, 450 V
C111	0301 9650	ceramic, .01 uf, +80-20%, 450 V
C112	0302 0390	47 uuf
C113	0301 3230	ceramic, 5 uuf, ±.5 uuf
C114 & C115	0315 2450	composition, .5 uuf, ±20%
C117 & C118	0315 2480	composition, 1.5 uuf, ±20%,
C119	0319 1615	paper, .1 uf, ±20%, 400 V
C121	0300 7790	variable, ceramic, 1.5-7 uuf
C201	0300 4170	paper, .05 uf, +20-10%, 600 V
C202	0302 0390	47 uuf
C203	0318 1000	electrolytic, 20 uf, +50-10%, 250 V
C204 & C205	0319 1535	paper, .47 uf, ±20%, 200 V
C206	0301 9650	ceramic, .01 uf, +80-20%, 450 V
C207	0313 8390	paper, .33 uf, 100 V
C208 & C209	0305 5520	22 uuf
C211	0305 5840	470 uuf, 300 V
C212	0302 0330	15 uuf

Symbol	Du Mont Part Number	Description
C213	0305 5750	200 uuf
C214	0302 0820	24 uuf, ±5%
C215	0300 3070	variable, ceramic, 4-30 uuf
C216	0302 0820	24 uuf, ±5%
C217	0326 0620	350 uuf, ±1%, 300 V
C218	0316 1570	1950 uuf, ±1%
C219	0318 7730	.01 uf, ±1%, 300 V
C221	0326 0610	.04 uf, ±1%, 300 V
C222	0319 0721	plastic, .2 uf, ±1%, 200 V
C223	0319 0712	plastic, 1 uf, ±1%, 200 V
C224	0326 1580	47 uuf, ± 5%
C301	0312 8220	paper, .1 uf, ±20%, 600 V
C302	0302 0480	270 uuf
C303	0302 9430	820 uuf
C304	0303 3650	8200 uuf
C305	0302 0820	24 uuf, ±5%,
C306 to C308	0316 9631	variable, glass, 1-12 uuf, 600 V
C309	0301 9650	ceramic, .01 uf +80-20%, 450 V
C311	0301 9650	ceramic, .01 uf, +80-20%, 450 V
C312	0302 0390	47 uuf
C314 & C315	0315 2450	composition, .5 uf, ±20%
C317 & C318	0315 2480	composition, 1.5 uuf, ±20%
C321 & C322	0300 7790	variable, ceramic, 1.5-7 uuf
C401	0301 9650	ceramic, .01 uf, +80-20%, 450 V
C402	0316 4930	ceramic, .01 uf, +100-0%, 2 KV
C403	0316 8650	ceramic, 22 uuf, 2 KV
C404 & C405	0301 9650	ceramic, .01 uuf, +80-20%, 450 V
C406	0315 3750	ceramic, .005 uf, +100-0%
C501	0316 4930	ceramic, .01 uf, +100-0%, 2 KV
C503	0314 6090	ceramic, 1.5 uuf, ±.5 uuf, 5 KV
C504	0319 1615	paper, .1 uf, ±20%, 400 V
C505	0316 4930	ceramic, .01 uf, +100-0%, 2 KV
C601	0312 6030	electrolytic, 40 x 80 x 20, +50-10%, 450 V
C602	--	paper, .85 uf nominal, 850 V (matched to T601)
C603	0315 7590	electrolytic, 50 uf, +50 -10%, 250 V
C604 & C605	0319 1531	paper, .1 uf, ±20%, 200 V
C609 & C610 C1609 & C1610	0301 9650	ceramic, 0.01 uf, +80 -20%, 450 V

Symbol	Du Mont Part Number	Description
C1601 & C1602	0301 4460	electrolytic, 125 uf, +50-10%, 350 V
C1603	0301 9650	ceramic, .01 uf, +80-20%, 450 V
C1604 & C1605	0319 1531	paper, .1 uf, ±20%, 200 V
C1606	0301 9260	paper, .1 uf, ±20%, 400 V
C1607	0315 7590	electrolytic, 50 uf, +50-10%, 250 V
C1608	0301 4710	electrolytic, 10 uf, +75-10%, 450 V
	RECTIFIERS	
CR201 & CR202	2600 0940	1N54A
CR203	2600 1530	1N34A
	LAMPS	
DS601	1200 1370	incandescent, bayonet, .25 ampere
DS602 to DS605	1201 0960	incandescent, bayonet, .16 ampere
DS1601	1200 1370	incandescent, bayonet, .25 ampere
DS1602 to DS1605	1201 0960	incandescent, bayonet, .16 ampere
	REGULATORS	
E201	1200 9051	lamp,neon, bayonet
E401 & E402	1200 8931	lamp,neon
E403	1200 9051	lamp, neon, bayonet
	FUSES	
F601	1100 0900	2/10 ampere, slow blow
F603	1100 0820	8 amperes
F604	1100 0780	2 amperes
F1601	1100 0780	2 amperes
	RECEPTACLES	
J501	0905 4900	jack, tip, black
J503	0900 7200	jack, tip, red
J601	0905 0380	female, 5 pins
J1601	0905 0380	female, 5 pins

Symbol	Du Mont Part Number	Description
	INDUCTORS	
L201	2101 6951	fixed, 680 uh, ±5%
L501	2100 3810	fixed, 9.1 mh
L601	2101 7281	fixed, 10 h
	CONNECTORS	
P501	0905 0130	plug, tip, black
P502	0905 0370	male, 5 pins
P503	0900 7310	plug, tip, red
	RESISTORS (fixed, composition, ±10%, 1/2 watt, unless otherwise spcified)	
R101	0221 8450	film, 2M ohms, ±1%
R102	0221 8440	film, 250K ohms, ±1%
R103	0221 8430	film, 20.4K ohms, ±1%
R104	0221 8420	film, 2K ohms, ±1%
R105	0221 8450	film, 2M ohms, ±1%
R106	0204 1270	2M ohms, ±5%
R107	0106 6190	variable, 10K ohm, ±20% (Y HUM)
R108 & R109	0203 2560	220K ohms
R111	0203 0490	1100 ohms
R112	0105 6070	variable, 250 ohms, ±20%, (Y BAL)
R113 & R114	0228 6370	film, 121K ohms, ±1%
R115	0203 1780	1200 ohms
R116	See S103	
R117	0108 1380	variable, 25K ohms, ±20%, 2 W (Y CAL)
R119	0228 6590	film, 9100 ohms, ±1%, 1 W
R121	0108 1550	variable, 2500 ohms, ±20%, 2 W (V102 BIAS)
R122	0101 1410	variable, 500 ohms, ±20% (Y POS)
R123 & R124	0203 3960	100K ohms, ±5%, 1 W
R125	0103 3260	variable, 5K ohms, ±20%, 2W (V103 BIAS)
R126	0203 6740	12K ohms, ±5%, 2 W
R127	0203 6820	27K ohms, ±5%, 2 W
R128	0103 3270	variable, 10K ohms, ±20%, 2 W (Y LIN)

Symbol	Du Mont Part Number	Description
R129	0203 3730	11K ohms, ±5%, 1 W
R131	0203 6770	16K ohms, ±5%, 2 W
R132	0203 2210	4.7M ohms
R201	0203 2170	2.2M ohms
R202	0203 1850	4700 ohms
R203	0203 1890	10K ohms
R204	0203 1800	1800 ohms
R205	0203 1880	8200 ohms
R206	0101 4200	variable, 200K ohms, ±20%, ((SYNC) LEVEL)
R207	0203 2050	220K ohms
R208	0203 2010	100K ohms
R209	0228 5490	film, 250K ohms, ±1%
R211	0107 2280	variable, 25K ohms, ±20%, .3 W (TRIG LEVEL)
R212	0228 6030	film, 330K ohms, ±1%
R213	0203 0600	3300 ohms, ±5%
R214	0203 0650	5100 ohms, ±5%
R215	0203 0630	4300 ohms, ±5%
R216	0228 6030	film, 330K ohms, ±1%
R217	0203 1270	2M ohms, ±5%
R218	0228 5570	film, 500K ohms, ±1%
R219	0203 0880	47K ohms, ±5%
R221	0203 1980	56K ohms
R222	0203 1810	2200 ohms
R223	0203 0720	10K ohms, ±5%
R224	0203 0810	24K ohms, ±5%
R225	0228 6210	film, 1.3M ohms, ±1%
R226	0108 1550	variable, 2500 ohms, ±20%, 2 W (GATE SENS)
R227	0228 6150	film, 1M ohms, ±1%
R228	0203 1050	240K ohms, ±5%
R229	0203 0720	10K ohms, ±5%
R231	0203 0810	24K ohms, ±5%
R232	0228 6640	film, 43K ohms ±1%, 1 W
R233	0228 5770	film, 27K ohms, ±1%
R234	0203 1840	3900 ohms
R235	0203 5050	220K ohms, 1 W
R236	0228 5630	film, 600K ohms, ±1%
R237	See S202	
R238	0203 1350	4.3 M ohms, ±5%
R239	0107 1614	variable, 2M ohms, ±20%, 2 W (CAL X5)

Symbol	Du Mont Part Number	Description
R241	0203 1770	1K ohms
R242	0233 2590	wire wound, 22K ohms, ±1%, 7 W
R243	0203 0590	3K ohms, ±5%
R244	0203 1770	1K ohms
R245	0108 1550	variable, 2500 ohms,±20%, 2 W (DURATION)
R246	0228 6540	film, 11K ohms, ±1%, 1 W
R247	0203 6930	75K ohms, ±5%, 2 W
R248	0203 0430	620 ohms, ±5%
R249	0107 2280	variable, 25K ohms, ±20%, .3 W (SW. EXP. PT.)
R251	0203 2090	470K ohms
R301	0221 8450	film, 2M ohms, ±1%
R302	0221 8440	film, 250K ohms, ±1%
R303	0221 8430	film, 20.4K ohms, ±1%
R304	0221 8420	film, 2K ohms, ±1%
R305	0221 8450	film, 2M ohms, ±1%
R306	0204 1270	2M ohms, ±5%
R307	0106 6190	variable, 10K ohms, ±20%, (X HUM)
R308 &309	0203 2560	220K ohms
R311	0203 0490	1100 ohms
R312	0105 6070	variable, 250 ohms, ±20% (X BAL)
R313 & R314	0228 6370	film, 121K ohms, ±1%
R315	0203 1780	1200 ohms
R316	See S303	
R317	0108 1380	variable, 25K ohms, ±20%, 2 W (X CAL)
R318	0203 1780	1200 ohms
R319	0228 6590	film, 9100 ohms, ±1%, 1 W
R321	0108 1550	variable, 2500 ohms, ±20%, 2 W (V302 BIAS)
R322	0101 1410	variable, 500 ohms, ±20% (X POS)
R323 & R324	0203 3960	100K ohms, ±5%, 1 W
R325	0103 3260	variable, 5K ohms, ±20%, 2 W (V303 BIAS)
R326	0203 6740	12K ohms, ±5%, 2 W
R327	0203 6820	27K ohms, ±5%, 2 W
R328	0103 3270	variable, 10K ohms, ±20%, 2 W (X LIN)

Symbol	Du Mont Part Number	Description
R331	0203 6820	27K ohms, ±5%, 2 W
R401	0106 7910	variable, 200K ohms, ±20%, 2 W (ASITG)
R402	0203 2170	2.2M ohms
R403	0203 1890	10K ohms
R404	0203 2030	150K ohms
R405	0203 1950	33K ohms
R406	0107 1371	variable, 250K ohms, ±20%, (INTENSITY)
R407	0203 2090	470K ohms
R408	0203 1030	200K ohms, ±5%
R409	0203 1940	27K ohms
R411	0203 2030	150K ohms
R412	0203 2090	470K ohms
R413	0203 8160	1.8M ohms, 2 W
R414	0203 2030	150K ohms
R415	0107 1372	variable, 5M ohms, ±20% (FOCUS)
R416	0203 2170	2.2M ohms
R417	0203 8210	4.7M ohms, 2 W
R418	0203 5100	560K ohms, 1 W
R419	0203 2050	220K ohms
R501	0101 8410	variable, 1M ohms, ±20% (HV ADJ)
R502	0210 0690	wire wound, 1.5 ohms
R503	0203 6600	3300 ohms, ±5%, 2 W
R504	0203 2090	470K ohms
R505	0203 8290	22M ohms, 2 W
R506	0210 0570	wire wound, .47 ohm
R508	0228 7570	film, 10M ohms, ±5%, 1 W
R509	0203 8290	22M ohms, 2 W
R510	0228 6800	film, 2.7M ohms ±1%, 1 W
R511	0210 9380	wire wound, 25K ohms, ±5%, 5 W
R512	0203 1980	56K ohms
R513	0203 2030	150K ohms
R601	0203 1960	39K ohms
R602	0203 1940	27K ohms
R603	0106 6090	variable, 500 ohms, ±20% (HUM BAL)
R604	0203 1930	22K ohms
R605	0203 8130	1M ohms, 2 W
R606	0203 1690	220 ohms
R607	0203 8070	330K ohms, 2 W

Symbol	Du Mont Part Number	Description
R608	0203 4800	1800 ohms, 1 W
R609 & R610	0203 2120	820 ohms
R611	0203 1890	10K ohms
R612	0105 3700	variable, wire wound, 1K ohms, 2 W (Y 50 MV)
R613	0203 1890	10K ohms
R614	0105 3700	variable, wire wound, 1K ohms, 2 W (X 50 MV)
R615	0203 8060	270K ohms, 2 W
R616	0210 6330	wire wound, 7500 ohms, ±5%, 10 W
R617/S601	0107 1631	variable, wire wound, 50 ohms, 2 W (SCALE) including S601 switch (POWER)
R618 & R619	0203 0430	620 ohms, ±5%
R620 & R621	0203 1710	330 ohms
R1601	0203 1960	39K ohms
R1602	0203 1940	27K ohms
R1603	0106 6090	variable, 500 ohms, ±20% (HUM BAL)
R1604	0203 6090	24 ohms, ±5%, 2 W
R1605 & R1606	0203 8010	100K ohms, 2 W
R1607	0203 7130	510K ohms, ±5% 2 W
R1608	0203 1000	150K ohms, ±5%
R1609	0203 4080	330K ohms, ±5% 1 W
R1610	0203 2130	1M ohms
R1611	0210 6270	wire wound, 25K ohms, ±5%, 10 W
R1612 & R1613	0203 1730	470 ohms
R1615	0228 6150	film, 1M ohms, ±1%
R1616	0105 7880	variable, 100K ohms (+390 V ADJ)
R1617/S1601	0107 1631	variable, wire wound, 50 ohms, 2 W (SCALE) including S1601 switch (POWER)
R1618	0228 5580	film, 540K ohms, ±1%
R1619 & R1620	0203 1590	33 ohms
R1621	0228 5640	film, 667K ohms, ±1%
R1622	0228 5510	film, 380K ohms, ±1%
R1623	0210 6260	wire wound, 20K ohms, ±5%, 10 W
R1624	0203 8130	1M ohms, 2 W
R1625	0203 1930	22K ohms
R1626	0203 8060	270K ohms, 2 W
R1627 & R1628	0203 2120	820K ohms
R1629 & R1630	0203 1890	10K ohms

Symbol	Du Mont Part Number	Description
R1631 & R1632	0203 1710	330 ohms
R1633	0105 3700	variable, wire wound, 1K ohms, 2 W (Y 50 MV)
R1634	0105 3700	variable, wire wound, 1K ohms, 2 W (X 50 MV)
R1635 & R1636	0203 0430	620 ohms, ±5%
R1637 & R1638	0228 7480	wire wound, 7K ohms, ±5%, 20 W
	CURRENT REGULATOR	
RT1601	0228 7500	
	SWITCHES	
-- consisting of:	0501 4891	Assembly
S101	0501 4892	rotary, 3 decks, 9 positions (Y VOLTS/CM)
R116/S103	0107 1621	Resistor, variable, composition, 25K ohms, ±20%, 1/4 W (Y AMPLITUDE) including S103 switch (CAL)
-- consisting of:	0501 3091	Assembly
S301	0501 3092	rotary, 5 decks, 11 positions (X VOLTS/CM)
R316/S303	0107 1621	Resistor, variable, composition, 25K ohms, ±20%, 1/4 W (X AMPLITUDE) including S303 switch (CAL)
-- consisting of:	0501 3101	Assembly
S202	0501 3102	rotary, 2 decks, 7 positions (SWEEP RANGE)
R237	0106 4910	Resistor, variable, composition, 5M ohms, ±20%, 1/2 W (VERNIER)

Symbol		Du Mont Part Number	Description
S101		See 0501 4891	Switch Assembly above
S102		0500 6793	push-push (Y CAL)
S103		See 0501 4891	Switch Assembly above
S201		0500 9662	rotary, 1P3T (SYNC)
S202		See 0501 3101	Switch Assembly above
S301		See 0501 3091	Switch Assembly above
S302		0500 6793	push-push (X CAL)
S303		See 0501 3091	Switch Assembly above
S601		See R617/R601	
S1601		See R1617/S1601	
		TRANSFORMERS	
T501		2000 7311	High Voltage
T601		2000 9891	Power (60 cps, 115 volts)
	or	2001 0881	Power (50 cps, 115/230 volts)
T1601		2001 2061	Power (50 to 400 cps, 115 volts)
		TUBES	
V101 & V102		2501 1610	ECC82/12AU7 (Yellow)
V103		2501 1540	6BK7-B
V201		2500 0130	12AU7 (Red)
V202 & V203		2501 1840	6U8-A
V204		2500 0130	12AU7 (Red)
V301 & V302		2501 1610	ECC82/12AU7 (Yellow)
V303		2501 1540	6BK7-B
V401		2500 7390	5ADP1, medium persistence, green
	or	2500 7400	5ADP2, long persistence, blue-green
	or	2500 7420	5ADP7, long persistence, yellow
	or	2500 7430	5ADP11, short persistence, blue
V402		2500 0130	12AU7

Symbol	Du Mont Part Number	Description
V501	2500 0340	6AQ5
V502	2500 6490	1X2-A
V503	2500 5740	5642
V504	2501 1840	6U8A
V601	2501 1180	5V4-GA
V602	2500 0300	OA2
V603	2500 0020	6AL5
V1601	2501 1560	GZ34/5AR4
V1602	2501 1550	6AU6-A
V1603	2500 7810	6BX7-GT
V1604	2500 7820	6CL6
V1605	2500 0020	6AL5
V1606	2500 0300	OA2
	CABLE	
W601	5026 9641	Power
W1601	5026 9641	Power

NOTES FOR TYPES 401-A AND 401-AR OSCILLOSCOPES:

1. CAPACITIES ARE IN MICROMICROFARADS UNLESS OTHERWISE SPECIFIED.
2. RESISTANCES ARE IN OHMS, K=THOUSAND, M=MILLION.
3. CONNECTOR TERMINALS SHOWN FROM WIRING SIDES.
4. FRONT PANEL FACILITIES ARE UNDERLINED; ⊘ INDICATES SERVICE ADJUSTMENTS.
5. ROTARY SWITCHES ARE SHOWN FULLY COUNTER-CLOCKWISE AS VIEWED FROM FRONT PANEL; ARROW INDICATES CLOCKWISE ROTATION.
6. ALTERNATE CONNECTIONS AND COMPONENTS:

SOLA REGULATED SUPPLY	ELECTRONIC REGULATED SUPPLY
R202 AND C203 USED, AND X CONNECTS TO Z.	R202 AND C203 NOT USED, AND Y CONNECTS TO Z.
ALL +150V POINTS ARE FROM SAME SOURCE IN SOLA REGULATED SUPPLY.	+150V ● AND +150V ▼ ARE FROM INDICATED SOURCES IN ELECTRONIC REGULATED SUPPLY.
+410V FROM SOLA REGULATED SUPPLY.	+390V FROM ELECTRONIC REGULATED SUPPLY.

7. USE OF JUMPER DEPENDS UPON BIAS RANGE OF CATHODE-RAY TUBE USED.
8. "A" SECTION CLOSES AND "B" SECTION OPENS WHEN CONTROL IS ROTATED FULLY CLOCKWISE.

Figure 5-1
Schematic of Deflection Amplifiers Sweep and Indicator Circuits (9800 1086-4, Sheet 1)

Figure 5-2
Schematic of Low Voltage Supplies
(9800 1086-4, Sheet 2)

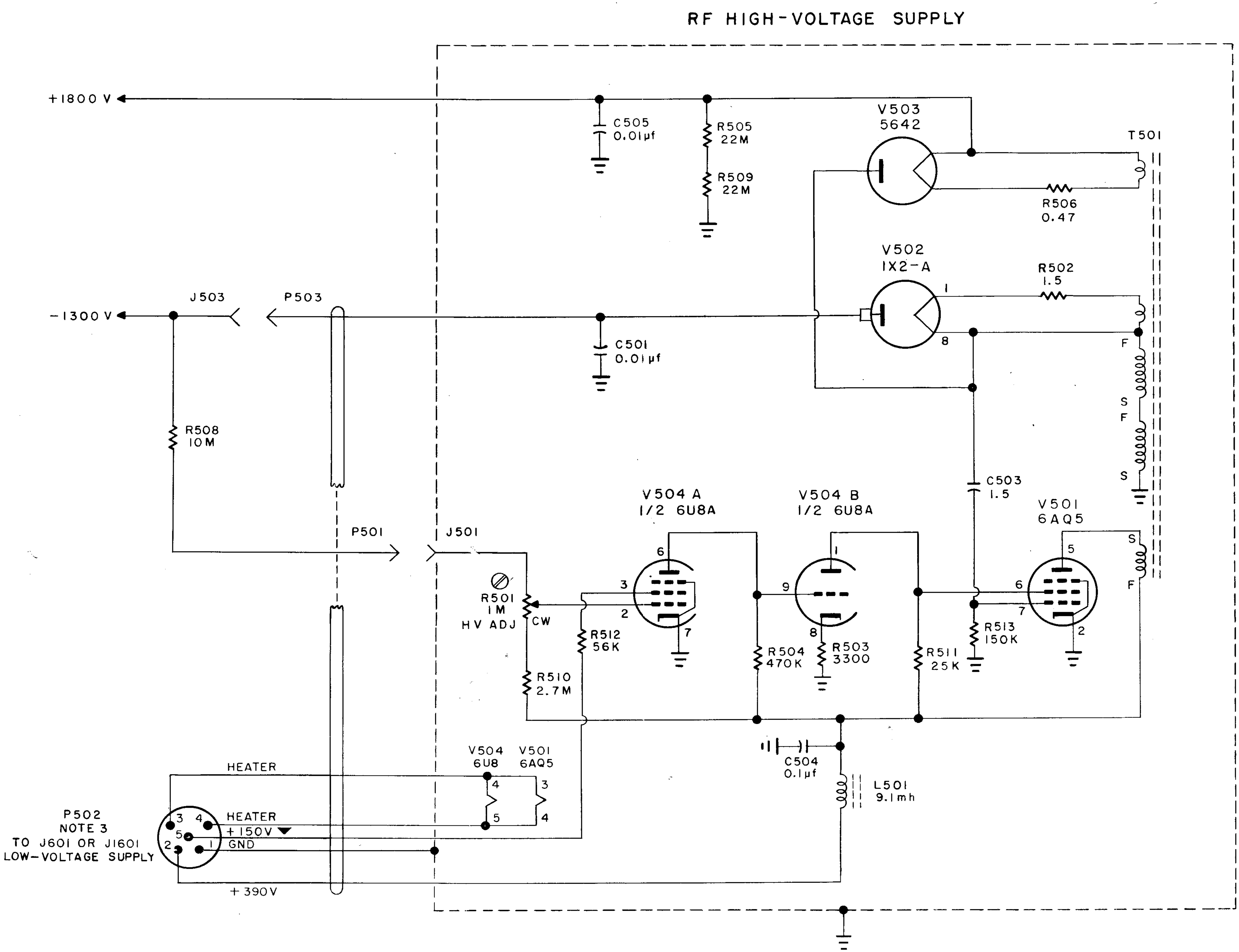


Figure 5-3
Schematic of High Voltage Supply
(9800 1086-4, Sheet 3)

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Instrument Division

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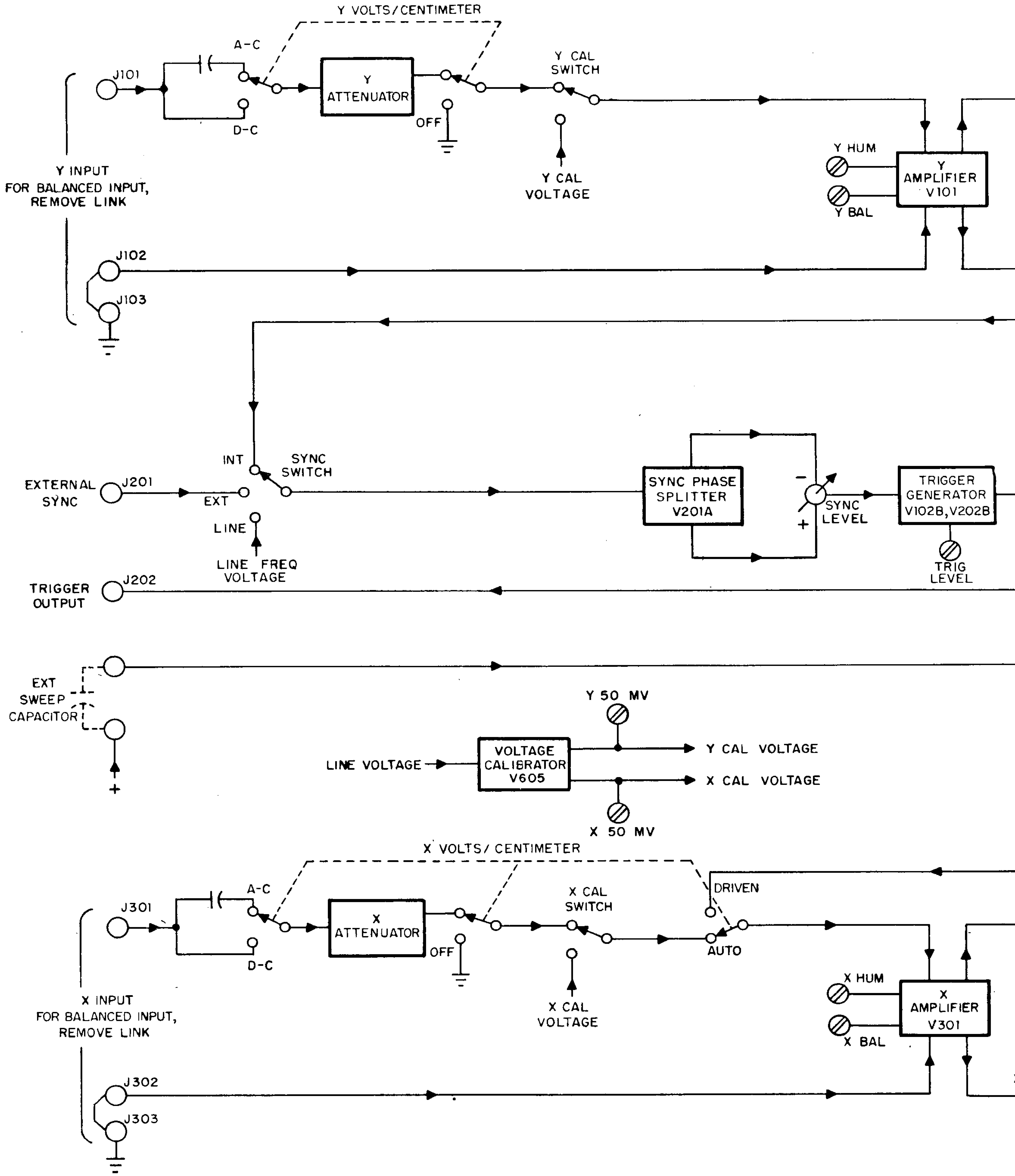
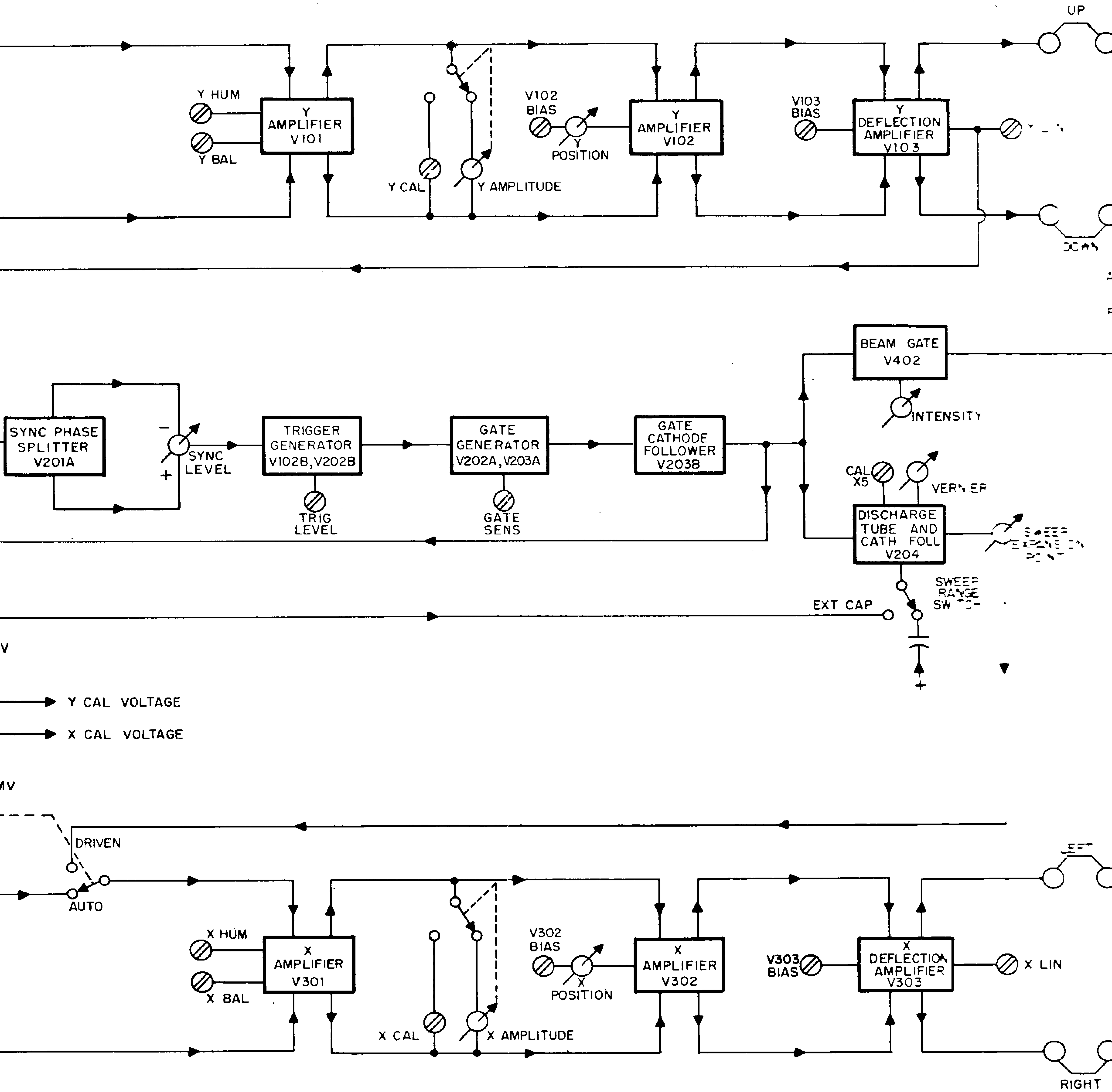


Y VOLTS/CENTIMETER
A-C
J101
D-C
Y ATTENUATOR
OFF
Y CAL SWITCH
Y CAL VOLTAGE
Y HUM
Y AMPLIFIER V101
Y BAL
Y INPUT
FOR BALANCED INPUT, REMOVE LINK
J102
J103
INT
SYNC SWITCH
EXTERNAL SYNC
J201
EXT
LINE
LINE FREQ VOLTAGE
SYNC PHASE SPLITTER V201A
SYNC LEVEL
TRIGGER GENERATOR V102B, V202B
TRIG LEVEL
TRIGGER OUTPUT
J202
EXT SWEEP CAPACITOR
Y 50 MV
LINE VOLTAGE
VOLTAGE CALIBRATOR V605
Y CAL VOLTAGE
X CAL VOLTAGE
X 50 MV
X VOLTS/CENTIMETER
DRIVEN
A-C
J301
D-C
X ATTENUATOR
OFF
X CAL SWITCH
X CAL VOLTAGE
AUTO
X HUM
X AMPLIFIER V301
X BAL
X INPUT
FOR BALANCED INPUT, REMOVE LINK
J302
J303



UP
Y HUM
Y BAL
Y AMPLIFIER V101
Y CAL
Y AMPLITUDE
V102 BIAS
Y POSITION
Y AMPLIFIER V102
V103 BIAS
Y DEFLECTION AMPLIFIER V103
BEAM GATE V402
INTENSITY
SYNC PHASE SPLITTER V201A
SYNC LEVEL
TRIGGER GENERATOR V102B, V202B
TRIG LEVEL
GATE GENERATOR V202A, V203A
GATE SENS
GATE CATHODE FOLLOWER V203B
CAL X5
DISCHARGE TUBE AND CATH FOLL V204
SWEEP RANGE
EXT CAP
Y CAL VOLTAGE
X CAL VOLTAGE
DRIVEN
AUTO
X HUM
X BAL
X AMPLIFIER V301
X CAL
X AMPLITUDE
V302 BIAS
X POSITION
X AMPLIFIER V302
V303 BIAS
X DEFLECTION AMPLIFIER V303
X LIN
RIGHT

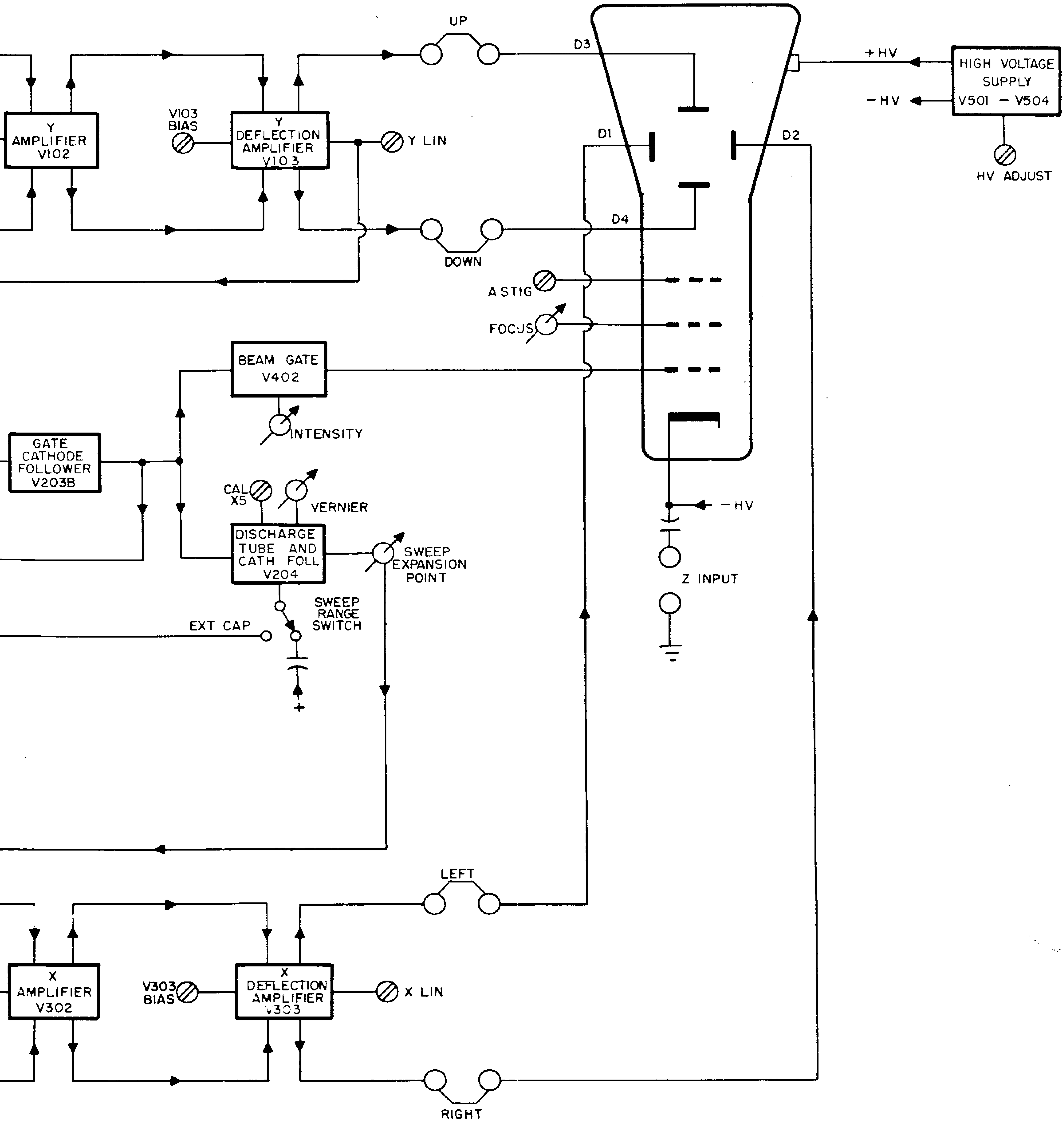


Figure 3-1
Functional Block Diagram of Circuits