TYPE 304A and 304AR

OPERATING AND MAINTENANCE MANUAL

DUMONT

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DUMONT
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OPERATING AND MAINTENANCE
MANUAL

DU MONT

TYPES 304-A AND 304-AR
CATHODE-RAY OSCILLOGRAPHS

INTRODUCTION

This manual of operating and maintenance instructions covers information on both the Type 304-A (cabinet model) and Type 304-AR (rack mounting) Cathode-ray Oscillographs. Electrically, the two types are identical; mechanically, they are somewhat different. Wherever differences exist between the two types, these differences are clearly indicated. Otherwise, references throughout the manual to the Type 304-A pertain also to the Type 304-AR. Figures 1-1a and 1-1b show the external appearance of these instruments.

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SECTION I
GENERAL DESCRIPTION

1. INTRODUCTION

The Du Mont Type 304-A is a general-purpose cathode-ray oscillograph that enables rapid, accurate amplitude measurements of any portion of a 0-to 1000-volt signal, from d-c to over 50,000 cps. The high gain assures that the Type 304-A can be used directly with most transducers, while d-c amplification provides that the lowest frequency portions of signals will be faithfully reproduced.

To obtain the utmost from the Type 304-A, full advantage should be taken of the novel amplitude calibrating system of the instrument which permits signal amplitude measurements in volts directly from the screen. (See "Amplitude Calibration.") Unlike electro-mechanical devices, the Type 304-A is not restricted to rms or peak-to-peak readings of voltage, as any amplitude portion of the input signal may be measured with the instrument. Moreover, these measurements may be made in a minimum of time, qualifying the Type 304-A as a quantitative as well as a qualitative instrument.

The TYPE 5ADP-Cathode-ray Tube is employed in the Type 304-A. This tube is precision-built to tolerances far more stringent than in conventional tubes, and provides a deflection sensitivity up to twice that of conventional types, as well as a smaller spot size with no sacrifice in brilliance. The Types 304-A and 304-AR differ only in that the Type 304-AR is designed for mounting in a standard, 19-inch relay rack.

2. PHYSICAL CHARACTERISTICS

Physical specifications of both the Type 304-A and the Type 304-AR are given in convenient tabular form in Table 1-1. The Type 304-A is enclosed in a blue-gray metal cabinet complete with a convenient carrying handle. The Type 304-AR employs a standard relay rack panel, a dust cover and a bottom plate. The operating controls of both instruments are conveniently located on the front panel with vertical amplifier controls on the left and horizontal sweep controls on the right. In both instruments a convenient terminal panel, accessible at the rear, provides direct access to the deflection plates of the cathode-ray tube.

To facilitate calibration, the scale of the Type 304-A is numbered and edge illuminated, with a dimmer control provided on the front panel. Unidirectional signal amplitudes are measured with the aid of the left-hand scale, symmetrical signals with the aid of scale on the right hand. These scales make it especially convenient to photograph a trace with scale superimposed. The usual double-exposure technique is normally not necessary when employing an instrument with an illuminated scale; thus, valuable time is saved, and more accurate results are obtained. The Type 304-A is also provided with a suitable color filter over the CRT screen to improve visual contrast.

Provision is made for connection of balanced, as well as single-ended vertical input signals on the 0.1 VOLT FULL SCALE range. Balanced input may be obtained merely by disconnecting a jumper to ground from the lower Y-input terminal on the front panel.

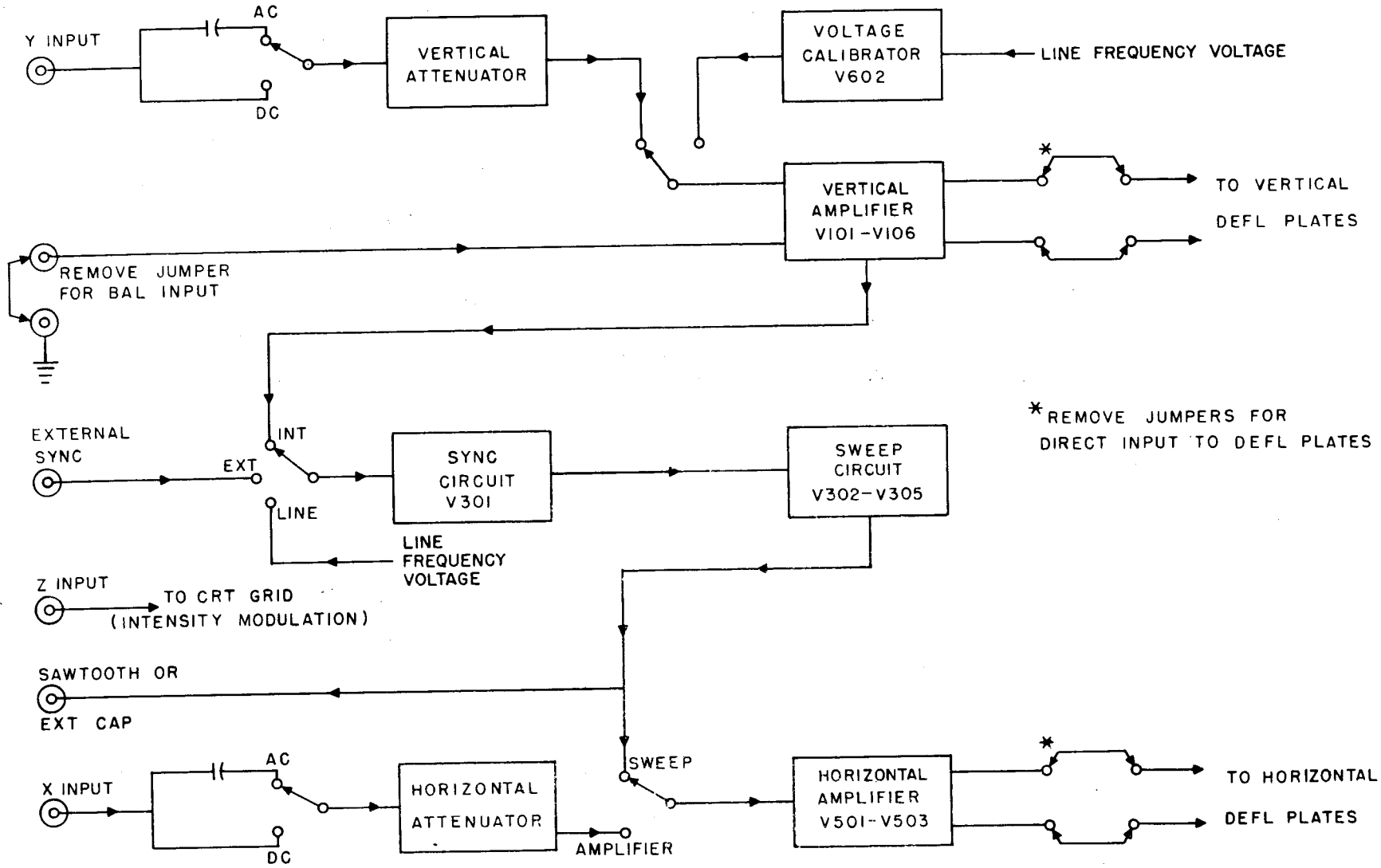


FIGURE 1-2 - SIMPLIFIED BLOCK DIAGRAM OF TYPE 304-A

Also provided on the front panel is a Z-axis input terminal for intensity modulation. This terminal connects directly to the grid of the cathode-ray tube, with positive signals increasing the intensity of the beam.

3. CIRCUITRY EMPLOYED

For a general understanding of the electrical circuits incorporated in this oscillograph, refer to the block diagram (Figure 1-2). A detailed explanation of the circuit operation will be found in Section III, THEORY OF OPERATION.

A very sensitive vertical amplifier is employed in the Type 304-A. With the amplifier set at full gain an applied a-c or d-c signal of 0.1 volt peak-to-peak will result in full-scale deflection of the electron beam. Increased stability is assured by regulation of the heaters of the vertical amplifier input stages.

To assist in observing random phenomena or recurrent pulses having relatively low duty cycles, the sweep circuit may be adjusted, by means of a front-panel control, so that the sweep is initiated by the signal itself (DRIVEN SWEEP). Both driven and recurrent sweeps may be expanded up to six times full-screen diameter with full positioning. To obtain sweeps of extremely long duration, provision is made for attaching external capacitances to convenient terminals, 0.5 second sweep being secured for each microfarad of external capacitance employed.

Stabilized synchronization minimizes horizontal jitter of traces, while sync limiting for both driven and recurrent operation prevents spurious or distorted response from excessive synchronizing signals.

For a thorough understanding of the capabilities of the Type 304-A the following sections, OPERATION and THEORY OF OPERATION, should be read carefully.

TABLE 1-1

PERFORMANCE SPECIFICATIONS

CATHODE-RAY TUBE	
Type	5ADP-
Accelerating Potential	Second Anode: +1600 volts; Intensifier +3000 volts } with respect to Cathode
Illuminated Scale	Engraved, illuminated scale over face of tube; dimmer control provided on front panel
VERTICAL CHANNEL (Y-AXIS)	
Deflection Factor	
Amplifier (at full gain)	0.1 volt peak-to-peak full scale; or 0.025 peak-to-peak volt/inch (0.009 rms volt/inch)
Direct	32-39 peak-to-peak volts/inch (12-14 rms volts inch)
Undistorted Deflection	At least 4 inches (limited by deflection-plate cutoff in the cathode-ray tube). Portions of expanded pattern (Up to 4 times full screen) will also have negligible distortion when positioned on screen
Sinusoidal Frequency Response (Thru Ampl)	
Direct Coupling	Flat to dc; down not more than 10% at 100 kilocycles
Capacitive Coupling	Down not more than 10% from 10 cycles to 100 kilocycles
Either Type Coupling	Down not more than 50% at 300 kilocycles
Transient Response (Thru Ampl)	
Rise Time (10% to 90%)	2 us or less
Overshoot	2% or less
Decay	Direct Coupling - None Capacitive Coupling - Less than 10% in 45 milliseconds
Input Voltage (To Ampl) - Maximum	
Single-ended	
Capacitive Coupling	1000 (dc plus peak ac)
Direct Coupling	1000 (dc plus peak ac) on all attenuation ranges except 0.1 v where it is 100 volts (dc plus peak ac)
Balanced	May be operated up to +2 volts with 0.4 volt peak-to-peak between grids (VOLTS FULL SCALE set at 0.1)
Input Coupling (To Ampl)	Capacitive or direct
Attenuation (Ampl Connection	By factors of 1,10,100, or 1000 +2% as selected by the VOLTS FULL SCALE switch (0.1V,1V,10V, or 100V, respectively)
Input Impedance	
Amplifier	
Single-ended	2 megohms, 50 μμf

TABLE 1-1

PERFORMANCE SPECIFICATIONS (Continued)

Balanced	4 megohms, 40 μμf
Direct	
Single-ended	1.5 megohms, 20 μμf
Balanced	3.0 megohms, 20 μμf
Positioning	Permits examination of screen of any portion of signal expanded to four times full-screen diameter

HORIZONTAL CHANNEL (X AXIS)

Deflection Factor	
Amplifier (at full gain)	0.3 peak-to-peak volt/inch (0.1 rms volt/inch)
Direct	40-50 peak-to-peak volts/inch (14-18 rms volts/inch)
Sinusoidal Frequency Response (Thru Ampl)	Same as for Vertical (Y-AXIS) Amplifier
Transient Response (Thru Ampl)	Same as for Vertical (Y-AXIS) Amplifier

Input Voltage (Maximum) to Ampl

Attenuator Setting	Peak-to-Peak Volts
1:1	18
10:1	180

Maximum with Attenuator in AC position 1000 volts (dc + peak ac)

Input Coupling (To Ampl)	Capacitive or Direct
Attenuation (Ampl Connection)	By factors of 1 or 10 ± 10%, as selected
Input Impedance	
Amplifier	2.2 megohms, 50 μμf
Direct	
Single-ended	1.5 megohms, 20 μμf
Balanced	3 megohms, 20 μμf
Linear-sweep Time Base	
Circuit	Type 6Q5G gas triode, for both driven and recurrent sweeps. Return trace is automatically blanked.
Frequency (Recurrent Sweep)	2 to 30,000 sawtooth cps. Sweep frequencies lower than 2 cps may be obtained by attaching external capacitance between SAWTOOTH/EXT CAP terminal and ground. For each microfarad of external capacitance, approximately 0.5 seconds of sweep time is secured.
Time Duration (Driven Sweep)	0.5 seconds to approximately 30 microseconds.
Expansion	To 6 times full-screen diameter with no appreciable distortion
Positioning	So any full-screen portion of expanded sweep may be examined on screen
Synchronization	INTernal, EXTernal or LINE frequency as selected, either polarity

TABLE 1-1

PERFORMANCE SPECIFICATIONS (Continued)

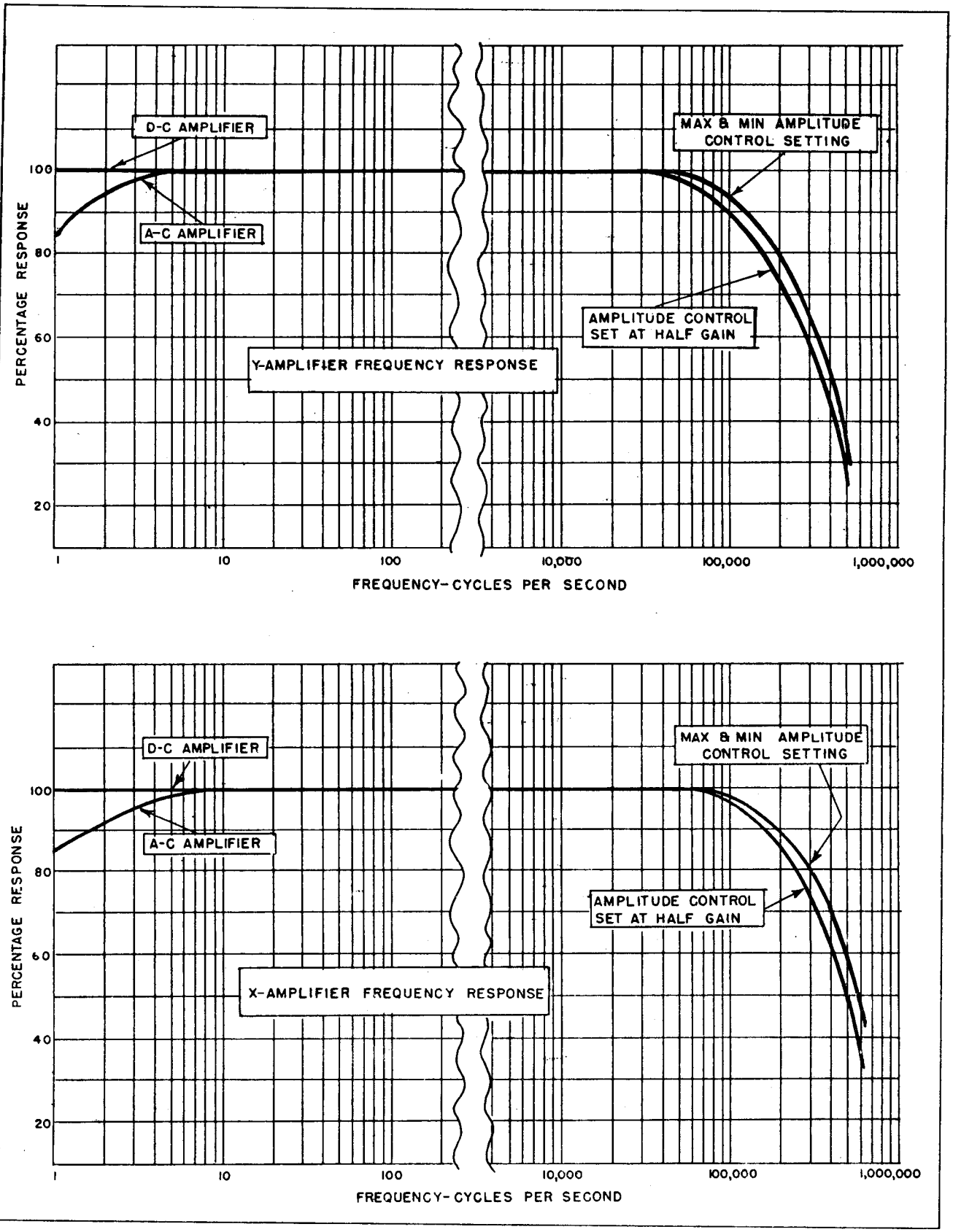
MAXIMUM PHOTOGRAPHIC	
Writing Rates (With P-11 screen phosphor)	Du Mont Type 297 (Polaroid-Land) Camera with f/2.8 lens -- 0.08 inch/us Du Mont Type 296 (35mm)Camera with f/2.8 lens -- 0.8 inch/us Du Mont Type 295 (35mm) Camera with f/1.5 lens -- 2.8 inches/us Du Mont Type 321 (35mm moving-film) Camera with f/1.5 lens-- 2.8 inches/us
INTENSITY MODULATION CIRCUIT (Z AXIS)	
Input Impedance	0.2 megohms, 80 μμf
Sensitivity	2-56 volts peak-to-peak(negative) will blank the beam depending on intensity setting
Polarity	Positive signals increase the intensity of the beam
CALIBRATION VOLTAGE	
Availability	To input of Vertical Ampl to means of front-panel switch
Waveshape	Square Wave
Frequency	Power Line
Amplitude	0.1 volt peak-to-peak
Accuracy (Amplitude) Over-all	±5% or better
SAWTOOTH OUTPUT	
Availibility	Front-panel terminal
Amplitude	5 volts peak-to-peak
Polarity	Positive
Frequency	2 to 30,000 cps,as selected. Sweep frequencies lower than 2 cps may be obtained by attaching external capacitance between this terminal and ground
Impedance	Approximately 45,000 ohms
POWER SUPPLY	
Primary-power Potential	115- or 230- rms volts ± 10%
Frequency	50-400 cps
Power Consumption	Approximately 110 watts
Fuse Protection	
115-volt operation	1.5 amperes
230-volt operation	0.75 amperes

TUBE COMPLEMENT

6 - 12AU7	1 - 0B2	2 - 1X2A	
2 - 6AQ5	2 - 6J6	2 - 6AL5	1 - (3-14)
1 - 6Q5G	1 - 5Y3GT	2 - 5963	1 - 5ADP-

TABLE 1-1

PERFORMANCE SPECIFICATIONS (Continued)



SECTION II
OPERATION

1. UNPACKING AND INSPECTING THE EQUIPMENT

The Du Mont Types 304-A and 304-AR Cathode-ray Oscillographs are shipped with all tubes in place and ready to operate. However, upon receipt, they should be inspected for any apparent damages, such as broken knobs, tubes, or other components. To slide the chassis of the Type 304-A out of its cabinet, remove the two screws at the back of the instrument. To remove the dust cover from the Type 304-AR, loosen the screws on either side and rear that hold the dust cover to the chassis.

2. LOCATION AND INSTALLATION

a. GENERAL

Since the Type 304-A is a portable test instrument, no special installation procedure is required. The Type 304-AR has a front panel 19 inches wide by 8-23/32 inches high for mounting the instrument in a standard relay rack or cabinet.

Normally, the Type 304-A may be placed where most convenient for viewing the screen. It is always desirable to employ the shortest possible signal leads to either instrument to avoid stray pickup.

Although magnetic and electrostatic shielding has been provided in the design of the instrument, operation in strong fields such as are found near transmitters, transformers, and power-generating equipment, etc., may introduce spurious deflections, and should be avoided.

Electrostatic pickup may be minimized by the use of shielded input cables and connections and with a good electrical ground on the chassis of the instrument. Spurious magnetic deflections may be eliminated or reduced to an unobjectionable point by removing the oscillograph from the immediate vicinity of the disturbance; orienting the instrument in the field so that spurious deflection is at a minimum; or in extreme cases, by adding additional magnetic shielding in the form of a large iron or steel container in which the entire instrument may be placed.

b. LINE VOLTAGE AND FREQUENCY

The Types 304-A and 304-AR Cathode-ray Oscillographs are supplied for operation from a 50 to 400-cycle source of power at 115 or 230 volts rms. Unless otherwise specified by the customer when ordering, the instrument is shipped from the factory for operation on 115-volt line. A tag on the handle will specify the proper line voltage. To change from 115-volt to 230-volt line operation or vice versa, see Section IV on Maintenance.

c. POWER REGULATION

The Type 304-A will operate satisfactorily with steady line-voltage variations of ±10% from the specified value, due to the regulator circuits employed in the instrument. How-

ever, greater than 10 per cent variation may cause the power supply to operate erratically with consequent unsatisfactory performance of the oscillograph. Where line-voltage variations are excessive, it is recommended that a constant-voltage transformer be employed in the power line to the instrument. If such a regulator is used, precautions should be taken to avoid the effects of stray magnetic fields as discussed in paragraph 2a above.

> - WARNING -
>
> Potentials as high as 3000 volts are employed in this instrument. Such voltages are extremely dangerous; and every possible safety precaution should be taken to avoid contact with this potential. The instrument is safe when enclosed in its cabinet and should not be operated with the chassis withdrawn except for purposes of adjustment or repair. When necessary to energize the oscillograph with the chassis outside its cabinet, refer to the precautions given in paragraph 2 of Section IV, Maintenance.

3. TURNING ON THE INSTRUMENT

A dual function power switch and scale illumination control is provided; the front panel designation is SCALE. To place the instrument in operation, plug the power cord into the line outlet, and turn on the power switch. Allow approximately 30 seconds for the instrument to warm up; in the meantime, set the various controls as indicated in Table 2-1.

4. PRECAUTION AGAINST SCREEN BURNING

A sharply focused line or spot of high intensity, having short length or small area, respectively, should not be permitted to remain stationary on the screen for any considerable length of time. Under such conditions, the entire energy of the beam is concentrated over a small area, thus subjecting the screen material to burning and discoloration.

5. CONTROLS AND TERMINALS

a. GENERAL

The markings on the front panel adjacent to each control (See Figure 2-1) are essentially self-explanatory, and the operator should find it possible to master the controls with a minimum of experimentation.

b. CONTROL AND TERMINAL FUNCTIONS

Table 2-2 lists all front-panel controls and terminals and gives the function of each. Also, specific problems, which may be encountered in operating the instrument, are explained in this table.

TABLE 2-1

PRELIMINARY SETTING OF CONTROLS

CONTROL	POSITION
Y POSITION	center of range
X POSITION	center of range
INTENSITY	fully counterclockwise
FOCUS	center of range
SYNC SELECTOR	INTernal
SYNC AMPLITUDE	"0"
X SELECTOR	RECURrent SWEEP
Y AXIS VOLTS FULL SCALE	OFF
MULTIPLIER	fully counterclockwise
(X) AMPLITUDE	fully counterclockwise
SWEEP VERNIER	center of range
SWEEP RANGE	50-250
CALIBRATOR push button	released (out)

c. SYNCHRONIZATION OF SWEEP

(1) RECURRENT SWEEP

As a general rule, it is desirable to set the SYNC SELECTOR switch at INTernal. Thus, low-amplitude signals applied to the Y INPUT are amplified sufficiently before application to the sync circuits to produce stable synchronization of the sweep generators. Provision is also made for 'EXTernal sync, which is useful particularly in those cases where varying amplitudes of the same waveform are to be viewed in rapid succession. LINE-frequency sync is provided particularly as a convenience in synchronizing line-frequency signals applied direct to the deflection plates, in noting phase shifts of line-frequency signals with respect to the power line and as an aid in synchronizing line-frequency signals of low-amplitude or having a high noise content.

The proper manner of sync adjustment is as follows:

(a) Set the X SELECTOR at RECUR SWEEP.

(b) Set the SYNC SELECTOR at EXT, INT or LINE depending upon the signal to be synchronized as discussed above.

(c) Set the SYNC AMPLITUDE control at "0."

(d) Adjust the SWEEP RANGE and SWEEP VERNIER controls to obtain the desired number of cycles of the signal on the screen and to stop the travel of the pattern as nearly as possible.

(e) Rotate the SYNC AMPLITUDE control either clockwise or counterclockwise to lock the pattern stationary, depending upon whether it is desired to have the beginning of the trace positive going or negative going, respectively.

TABLE 2-2

TABLE OF OPERATING CONTROLS AND TERMINALS

*FRONT PANEL CONTROLS		
Name of Control or Terminal	Reference Symbol	Function
INTENSITY	R407	Changes the intensity of the trace.
FOCUS	R405	Adjusts focus of the trace.
Y POSITION	R116	Changes the vertical position of the trace.
X POSITION	R510	Changes the horizontal position of the trace.
D-C BAL (Y AXIS)	R110	When properly adjusted, prevents change in the vertical position of the trace when the MULTIPLIER control is varied.
D-C BAL (X AXIS)	R506	When properly adjusted, prevents change in the horizontal position of the trace when the (X) AMPLITUDE control is varied.
Y AXIS VOLTS FULL SCALE	S101	Provides for the direct peak-to-peak reading of the input signal in steps 0.1V, 1V, 10V and 100V for both a-c and d-c inputs. OFF position also provided.
MULTIPLIER	R112	Controls amplitude of the vertical deflection.
X SELECTOR	S501	Selects internal or external signal for the horizontal deflection. The internal signal is linear sawtooth sweep, either recurrent or driven. On external signals, either d-c or a-c coupling at attenuation ratios of 1 or 10 is provided. OFF position also provided.
(X) AMPLITUDE	R514	Controls the amplitude of horizontal deflection.
SWEEP RANGE	S302	Varies sweep frequency in steps.
SWEEP VERNIER	R316	Provides continuous variation of sweep frequency when used in conjunction with SWEEP RANGE.
SYNC SELECTOR	S301	Selects synchronizing signals, internal, line-frequency, or external.
SYNC AMPLITUDE	R308	Selects phase and varies amplitude of sync voltage.
CALIBRATOR	S102	When pushed in, provides calibrating voltage to check setting of MULTIPLIER.
SCALE	R411	Varies the illumination intensity of the illuminated scale. Switch attached provides means for turning power on and off.

TABLE 2-2

TABLE OF OPERATING CONTROLS AND TERMINALS (Continued)

FRONT PANEL TERMINALS		
Name of Control or Terminal	Reference Symbol	Function
EXTERNAL SYNC	J301	Provides for connection of external sync signals when the SYNC SELECTOR is at EXT.
Y INPUT	J101 J102 J103	Provides for the connection of external signals to the Y amplifier. A jumper is provided for conventional single-ended input. Remove jumper for balanced input (no attenuation).
X INPUT	J501 J502	Provides for connection of external signals to the X amplifier.
SAWTOOTH or EXT CAP	J302	Provides for sweep sawtooth voltage at front panel. Also provides for connection of an external capacitor for low-frequency sweeps. Sawtooth output is available only when X SELECTOR is set at SWEEP.
Z INPUT	J401	Provides for connection of external signals to intensity modulate the trace.

**BACK-OF-PANEL TERMINALS (Accessible at Rear of Cabinet or Dust Cover)		
Name of Control or Terminal	Reference Symbol	Function
DEFLECTION PLATE INPUT TERMINALS "UP" and "DOWN"	J107 J111	Provides for connection of signals to vertical deflection plates direct (through capacitor).
DEFLECTION PLATE INPUT TERMINALS "RIGHT" and "LEFT"	J506 J510	Provides for connection of signals to horizontal deflection plates direct (through capacitor).
Y-AXIS	J104 J105 J106 J108 J109 J110	Provides "Direct" or "Through Amplifier" connection of vertical deflection voltages.
X AXIS	J503 J504 J505 J507 J508 J509	Provides for "Direct" or "Through Amplifier" connection of horizontal deflection voltages.

* Refer to Figure 2-1 for identification of front-panel controls.
** See Figure 2-3 for identification of deflection-plate input terminals.

(2) DRIVEN SWEEP

The DRIVEN SWEEP mode generally is employed for viewing random or aperiodic signals or periodic signals having a low duty cycle. When operating the instrument in this manner, one cycle excursion of the sweep occurs for each signal impulse or multiple thereof. To operate in this mode, proceed as follows:

(a) USING INTERNAL SYNC

1. Set SYNC SELECTOR at INT, SYNC AMPLITUDE at "0," X SELECTOR at OFF, and advance the (X) AMPLITUDE control approximately 1/4 turn. If necessary, position the beam to center of screen.

2. Apply signal to be observed to Y INPUT terminals, and adjust the VOLTS FULL SCALE and MULTIPLIER controls for approximately 1-1/2 inch vertical deflection.

3. Place the X SELECTOR in DRIVEN SWEEP position, and rotate the SYNC AMPLITUDE control until a steady sweep is observed. The setting of the SYNC AMPLITUDE control may be critical.

4. Adjust SWEEP RANGE and SWEEP VERNIER controls until, with periodic input signals, a steady pattern with the desired number of cycles is obtained; or, with aperiodic or low-duty cycle signals, the complete waveform appears on the sweep.

5. Adjust the X POSITION and (X) AMPLITUDE controls, if necessary, to obtain the desired portion of the trace on screen.

(b) USING EXTERNAL SYNC

When very high-frequency signals are to be observed, it may be helpful to resort to EXTernal sync to avoid erratic triggering of the sweeps. For EXTernal sync operation, proceed as follows:

1. Set SYNC SELECTOR at EXT and all other controls as described under "Using Internal Sync," paragraph 5c (2a).

2. Apply the EXTernal sync signal by connecting a test lead between the Y INPUT and EXTERNAL SYNC front-panel terminals; or, for most effective triggering from non-sinusoidal signals, apply the sync signal through a differentiating network having a time constant of approximately 10 per cent of the period of the sync employed. For details of the differentiating circuit, see Figure 2-2.

d. OBTAINING LOW-FREQUENCY SWEEPS

Provision is made for connecting external capacitors to the SAWTOOTH or EXT CAP terminal on the front panel to obtain lower frequency sweeps than provided for in the instrument. The lowest sweep frequency obtainable without resorting to external capacitors is two cycles per second. For lower frequency sweeps, proceed as follows:

(1) Set the SWEEP RANGE switch to EXT CAP, and position the SWEEP VERNIER control fully counterclockwise.

(2) Connect an external capacitor as determined from Table 2-3 between the SAWTOOTH or EXT cap and ground terminals. Depending upon the value of capacitance chosen, the sweep

frequency will be approximately as shown in the table. The SWEEP VERNIER may be employed to vary the sweep frequency over a limited range.

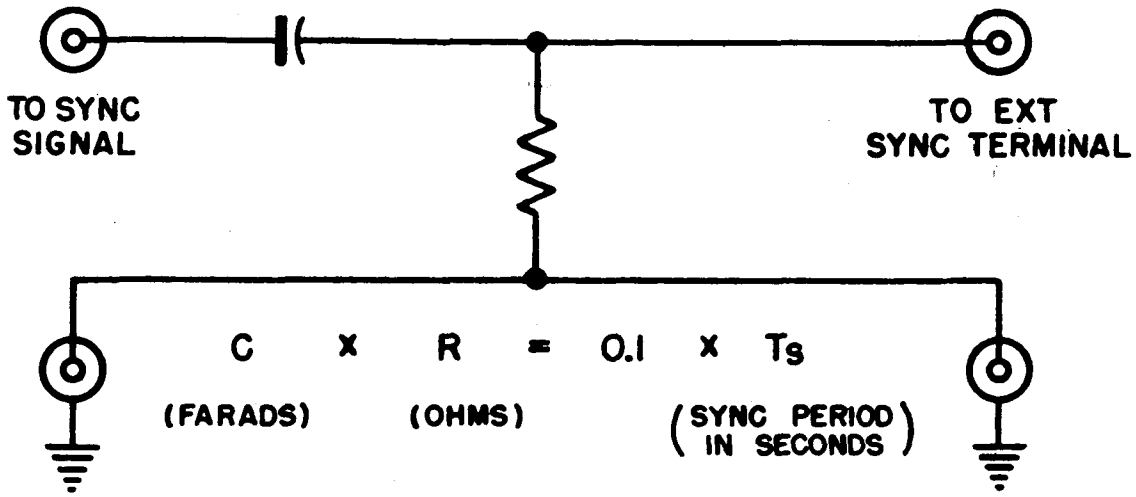


FIGURE 2-2 - DIFFERENTIATING CIRCUIT FOR USE IN ESTABLISHING STABLE DRIVEN SWEEP

TABLE 2-3

EXTERNAL CAPACITORS FOR LOW-FREQUENCY SWEEPS

Sweep Frequency	Sweep Duration	External Capacitance Required*
1 cps	1 second	2 µf
0.5 cps	2 seconds	4 µf
0.25	4 seconds	8 µf
0.1	10 seconds	20 µf

*A high-leakage-resistance capacitor must be employed such as a paper or plastic dielectric type. A 20 uf capacitor is the highest value recommended. Too large a capacitor tends to produce a distorted sawtooth waveform.

e. AMPLITUDE CALIBRATION

The calibrated VOLTS FULL SCALE attenuator switch and MULTIPLIER control provide a ready means for determining peak-to-peak input-signal amplitude for both a-c and d-c inputs. The product of the dial readings (VOLTS FULL SCALE and MULTIPLIER) gives the approximate peak-to-peak voltage for four inches of deflection.

For rough measurement of input signal voltage, proceed as follows:

(1) With input signal applied, adjust the VOLTS FULL SCALE switch and MULTIPLIER control to produce a convenient vertical deflection.

(2) Multiply the product of the readings of these controls by the vertical deflection produced (in inches) and divide by four to obtain the input signal amplitude (in peak-to-peak volts).

For most accurate measurements, a square-wave calibrating voltage is provided for accurate setting of the MULTIPLIER control. The procedure is as follows:

(1) With no signal applied to the Y INPUT terminals, set the front-panel controls as follows:

PRE-SET POSITIONS OF CONTROLS

CONTROL	POSITION
MULTIPLIER	At position where accurate calibration is desired
X SELECTOR	RECUR SWEEP
SWEEP RANGE	50 - 250
SYNC SELECTOR	LINE
Y POSITION	So trace is centered on screen

(2) Push in the CALIBRATOR switch and adjust the SWEEP VERNIER and SYNC AMPLITUDE controls for several square-wave cycles or a band on the cathode-ray screen.

(3) Referring to the Calibration Chart, Table 2-4, determine the deflection to be observed at the particular setting of the MULTIPLIER control. If necessary, vary the screwdriver adjustment, accessible through the small hole at the left side of the cabinet, to produce proper deflection. The MULTIPLIER control is thus accurately calibrated at this one position only. The MULTIPLIER may be adjusted to produce the deflection required so that the sensitivity is accurate.

(4) Apply Y INPUT signal and note beam deflection produced.

(5) Multiply signal deflection (in inches) by the sensitivity in volts per inch obtained from Table 2-5, making certain to pick the sensitivity corresponding to the VOLTS FULL SCALE switch position employed. The resulting figure is the signal amplitude in volts. Note: For accurate calibration of input signals higher than 50 kc. an external calibrator at the same frequency as the input signal should be employed.

f. INTENSITY MODULATION

The Z INPUT terminal on the front panel provides the facility for brightening or blanking the beam on the screen. Positive-going signals brighten the beam while negative-doing signals blank it. A negative signal of 2 to 56 volts peak, dependent upon the intensity level, will blank the beam if applied between the Z INPUT terminal and ground.

TABLE 2-4

CALIBRATION CHART

	"MULTIPLIER" POSITION				
	1.0	1.5	2	4	10
VERT. DEFL. (IN.)	4.0	2.7	2.0	1.0	0.4

TABLE 2-5

VERTICAL CHANNEL SENSITIVITY
AT VARIOUS SETTINGS OF "VOLTS FULL SCALE" AND
"MULTIPLIFER" CONTROLS*

"VOLTS FULL SCALE" POSITION	"MULTIPLIER" POSITION 1.0	1.5	2	4	10
0.1	0.1V / 0.025V	0.15V / 0.0375V	0.2V / 0.05V	0.4V / 0.1V	1V / 0.25V
1	1V / 0.25V	1.5V / 0.375V	2V / 0.5V	4V / 1V	10V / 2.5V
10	10V / 2.5V	15V / 3.75V	20V / 5V	40V / 10V	100V / 25V
100	100V / 25V	150V / 37.5V	200V / 50V	400V / 100V	1000V / 250V

* Figures above / line are peak-to-peak volts full scale (4 inches vertical deflection)
Figures below / line are peak-to-peak volts per inch of vertical deflection

g. DIRECT CONNECTION TO DEFLECTION PLATES

(1) GENERAL

When applying signals direct to deflection plates, the highest-frequency signal that can be observed is not limited by the response of the built-in amplifiers but is dependent only upon the input capacity 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" and that approximately 15 rms volts are required to produce an inch of beam deflection.

(2) MAKING PROPER CONNECTIONS

- CAUTION -

Turn Power Off before making any connections to the rear terminal board. Some of these terminals are at approximately 200 volts d-c above ground.

Figure 2-3 shows the location and identification of the terminals provided for making direct connection to the deflection plates. To make connections, follow the instructions given on the terminal board. It will be necessary to move the jumpers from the "through amplifier" position to the "deflection plates" position as indicated and to connect the signal to be observed to the appropriate UP, DOWN, LEFT or RIGHT terminals. The designations, UP, DOWN, LEFT and RIGHT denote for each terminal the direction of deflection resulting from the application thereto of a positive-going signal.

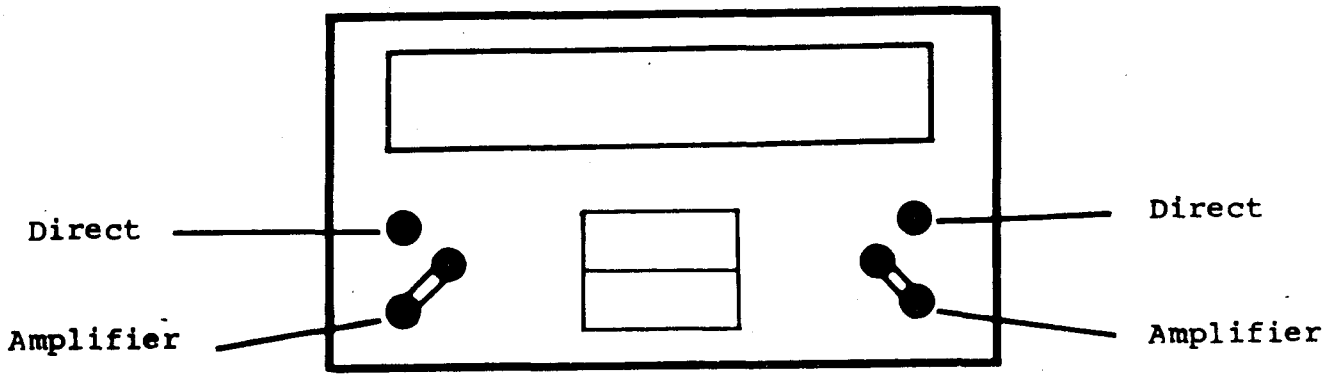


Figure 2-3 Rear Panel View of Type 304-A

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

(a) SINGLE-ENDED INPUT

For single-ended input, connect a jumper between UP or DOWN terminal and ground (vertical deflection plates) depending on whether a negative-or positive-going signal, applied to the ungrounded terminal, is to deflect the beam up or down, respectively. Connect the signal between the ungrounded terminal (UP or DOWN) and GROUND. In a similar manner, the horizontal deflection plates (RIGHT or LEFT) may be connected for single-ended input.

(b) BALANCED INPUT

For balanced input signals, connect the signal between the terminals designated UP and DOWN (vertical deflection plates) and/or between the terminals designated RIGHT and LEFT (horizontal deflection plates).

(c) POSITIONING

Beam positioning may be obtained by means of the appropriate POSITIONING controls on the front panel in the same manner as when employing the "amplifier" connection.

(d) RESTORING THE INSTRUMENT TO NORMAL "AMPLIFIER" OPERATION

When restoring the instrument to normal "amplifier" operation, remove the signal from the DEFLECTION-PLATE INPUT TERMINALS. Replace the jumpers as indicated in the instructions on the terminal board, and apply the signal to the front-panel terminals.

6. PHOTOGRAPHING OSCILLOGRAMS

Permanent photographic records of oscillograms, with or without the superposition of the calibrated scale, are readily obtainable from the Type 304-A. Since the calibrated scale may be illuminated, the oscillogram and scale can generally be photographed simultaneously.

Du Mont manufactures several oscillograph-record cameras, both still and moving-film types, specifically designed for effective photo-recording. Information on these cameras as well as techniques of recording is available upon request.

7. USE OF BALANCED INPUT

By removing the jumper between one of the Y INPUT terminals and ground, it is possible to feed a balanced-input signal to the vertical (Y-AXis) amplifier. No attenuation is provided on balanced input; however, the operator may find this feature extremely convenient for various applications. The following explanation of the balanced-input feature may help the operator to determine when this type of operation may be useful or desirable.

If there is an in-phase signal applied to both inputs (known as a "common-mode" signal) superimposed on the balanced-input signal, the maximum input signal (d-c plus peak signal a-c) will be accordingly reduced.

One of the features of the balanced-input circuit is the differential action of the first stage in the Y 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 pickup of noise on test leads or in the equipment under test, such noise will be reduced materially on passing through the balanced-input circuit of the Type 304-A. The waveforms shown in Figure 2-4 illustrate the advantage of the balanced-input connection over the single-ended in such cases. In this figure, a test signal, on which a "nuisance" signal is superimposed is shown on the cathode-ray tube screen when the signal is applied to the balanced input of the Type 304-A. Then, the same signal with the same "nuisance" voltage riding on it, is passed through a network to convert it to unbalanced output and is applied to the unbalanced-input connections of the Type 304-A. Note how much greater the amplitude of the common-mode signal appears with the unbalanced-input connection.

To adjust for the best rejection of the unwanted common-mode signal, remove the jumper from the Y INPUT terminal. Feed a one-volt 60 cycle square-wave signal between both the Y INPUT terminals and ground. Set VOLTS FULL SCALE (D-C) switch at 0.1 and the MULTIPLIER control fully clockwise. Note the beam deflection produced. Vary the MULTIPLIER control for minimum deflection. If this does not reduce the amplitude of the trace to zero, set the MULTIPLIER control approximately midway, and vary the (Y) D-C BAL front-panel screwdriver adjustment for minimum deflection. (It will be necessary to adjust the Y POSITION control as the (Y) D-C 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 MULTIPLIER control or the (Y) D-C BAL adjustment.

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

SECTION III
THEORY OF OPERATION

1. GENERAL

In following the theory discussion, it is suggested that the simplified block diagram of the Type 304-A (Section I) and the over-all circuit schematic (just inside the back cover of the manual) be referred to in addition to the simplified and unit schematic in this section.

2. CATHODE-RAY TUBE CIRCUIT

a. GENERAL

A simplified schematic of the cathode-ray tube circuit is shown in Figure 3-1. A Type 5ADP- (V401) is employed, operating at a total accelerating potential of 3000 volts, with the intensifier +1600 volts above and the cathode -1400 volts below chassis ground.

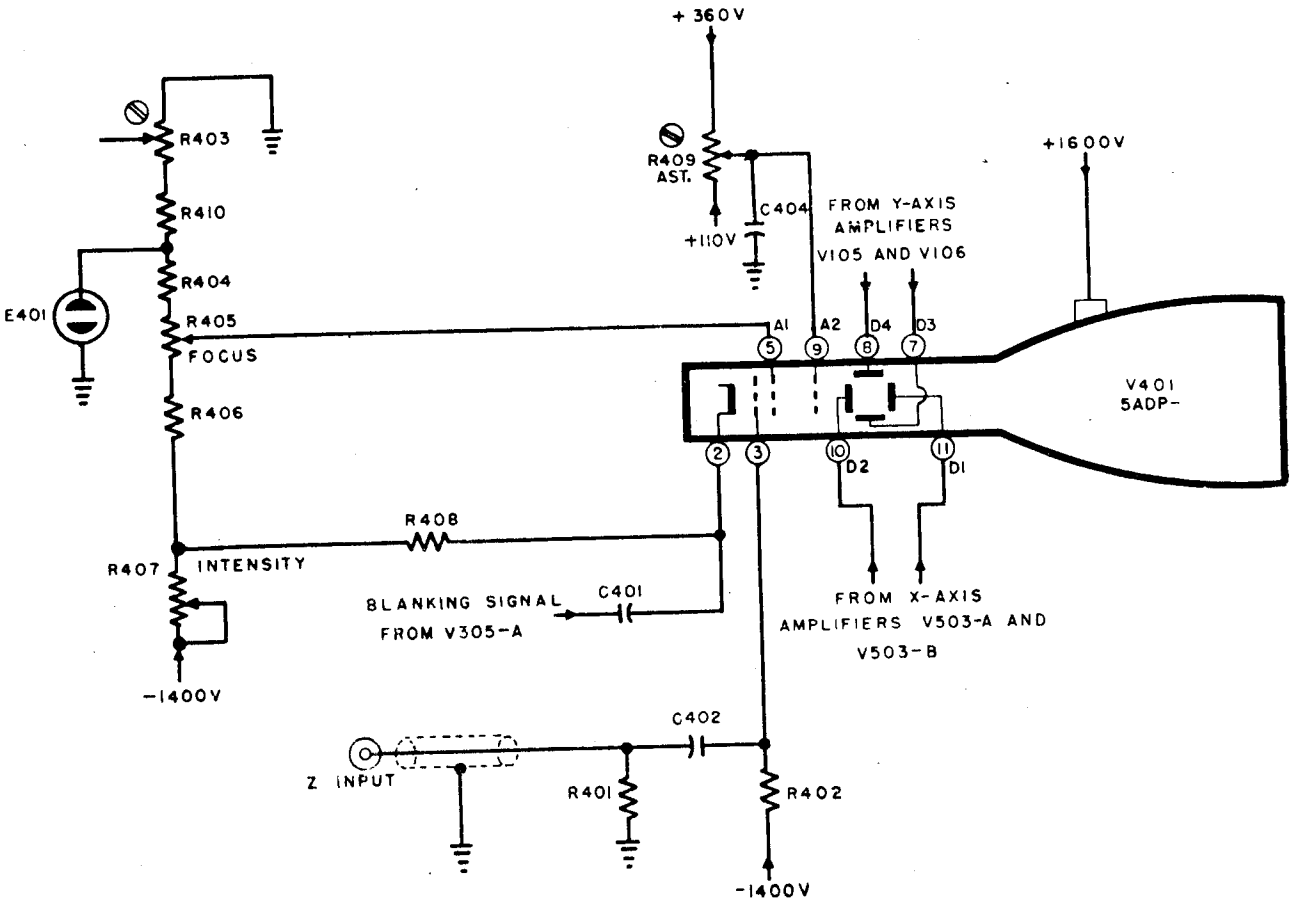


FIGURE 3-1 - CATHODE-RAY TUBE CIRCUIT (SIMPLIFIED SCHEMATIC)

b. INTENSITY

First anode and cathode potentials for the cathode-ray tube are obtained from the voltage divider (R403 through R407). The intensity of the beam is adjusted by varying the INTENSITY control (R407). This control varies the cathode potential more or less positive with respect to the grid, which is held at a fixed negative potential.

c. FOCUS

Focusing of the beam for maximum "sharpness" of trace is accomplished by adjusting the FOCUS control (R405). The setting of this control establishes the relative potential difference between anodes (A1) and (A2). The vertical deflection plates (D3 and D4) and the horizontal deflection plates (D1 and D2) operate at an average d-c potential of approximately 200 volts above ground. To avoid beam distortion, the second anode (A2) must operate at approximately the same d-c potential. The second anode voltage is obtained from the arm of potentiometer R409.

d. INTENSITY MODULATION

For the purpose of intensity modulation of the beam traces, positive (brightening) or negative (blanking) signals may be applied from the Z INPUT terminals through coupling capacitor C402 to the grid of the cathode-ray tube.

3. VERTICAL DEFLECTION CIRCUIT (Y AXIS)

a. GENERAL

To facilitate circuit analysis, the vertical-deflection circuit may be considered as consisting of: (1) a frequency-compensated attenuator; (2) a voltage calibrator for determining input-signal amplitudes and (3) a high-gain, wide-band vertical (Y-axis) amplifier for increasing the amplitude of low-level signals for suitable display on the cathode-ray tube screen.

b. INPUT ATTENUATOR

A simplified schematic of the input attenuator (calibrated in peak-to-peak volts full scale) is shown in Figure 3-2. The decade attenuators are R-C compensated to maintain frequency and phase response and to present an impedance of 2.0 megohms in shunt with 50

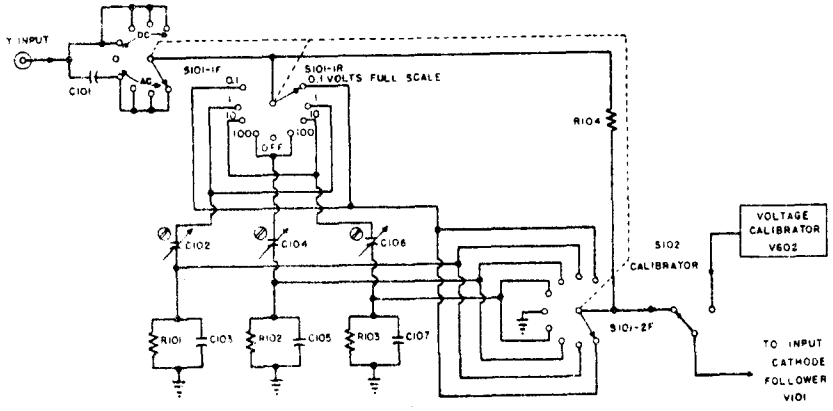


FIGURE 3-2 - INPUT ATTENUATOR--VERTICAL CHANNEL (SIMPLIFIED SCHEMATIC)

μuf to the circuit under test irrespective of the attenuation selected. The VOLTS FULL SCALE attenuator switch (S101) provides for attenuation of the input signal in decade steps of 1, 10, 100, 1000, for both a-c and d-c inputs. The OFF position of this switch removes the input signal from the attenuator and grounds the grid (pin 2) of the cathode follower (V101). Markings on the front panel for the various switch positions designate full scale sensitivity in volts when the MULTIPLIER (gain) control is set at "1."

c. VOLTAGE CALIBRATOR

(1) GENERAL

The location of the voltage calibrator in the vertical deflection circuit is shown by a block on the input attenuator schematic, Figure 3-2. A simplified schematic of the calibrator circuit is shown in Figure 3-3.

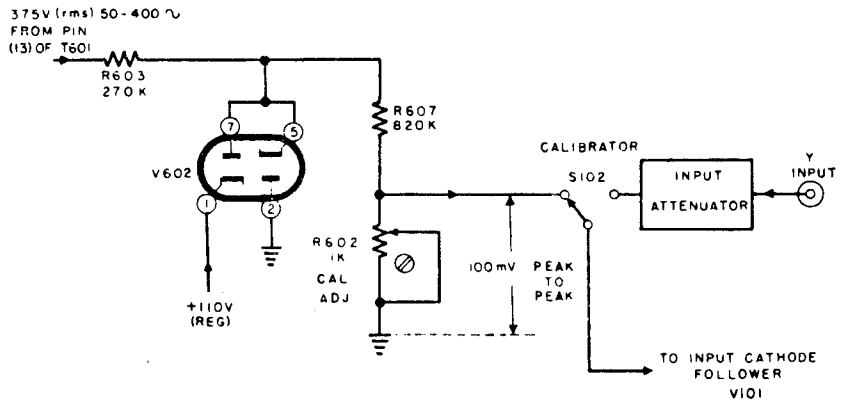


FIGURE 3-3 - VOLTAGE CALIBRATOR CIRCUIT (SIMPLIFIED SCHEMATIC)

A reference potential of 0.1 volt (100 mv) peak-to-peak is fed to the input cathode follower by the CALIBRATOR switch (S102). For details on making accurate amplitude measurements of the input signal, refer to the instructions contained in Section II, paragraph 5e.

(2) CIRCUIT DESCRIPTION

Referring to Figure 3-3, the 50-400-cycle voltage from the 375-volt winding on T601 is applied to V602 through limiting resistor R603. On the positive half cycle the voltage build-up across the divider (R607 and R602) is limited to slightly greater than +110 volts peak due to conduction through V602 from cathode (pin 1) to plate (pin 7). The other half of V602 conducts on the negative half cycle thus clamping the top of R607 to essentially ground potential during this time. The result is a 50-400-cycle square-wave voltage of approximately +110 volts peak-to-peak amplitude appearing across the divider network (R607 and R602). The attenuated output potential is coupled from the junction of R607 and R602 to the CALIBRATOR switch (S102). R602 (CALIBRATOR ADJ) provides a means of varying the calibration voltage to provide exactly 0.1 volt (100 mv) peak-to-peak.

d. VERTICAL (Y-AXIS) AMPLIFIER

(1) INPUT CATHODE FOLLOWER

The circuit of the vertical amplifier is shown in Figure 3-4. V101 is connected as a cathode follower (which on balanced inputs acts effectively as a differential amplifier) and precedes the continuously variable MULTIPLIER (amplitude) control (R112). R113, in

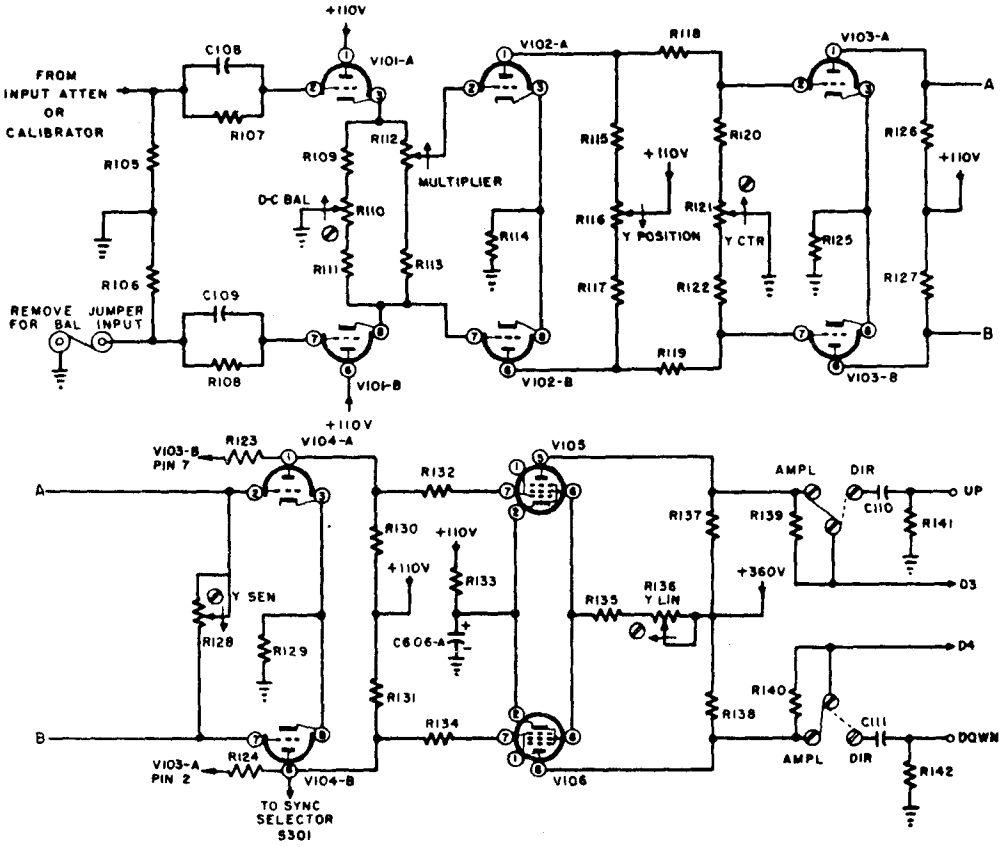


FIGURE 3-4 - VERTICAL AMPLIFIER CIRCUIT (SIMPLIFIED SCHEMATIC)

series with this control, prevents the operator from cutting the gain all the way to zero. Thus, any signal large enough to saturate the input stage will cause greater than full-screen deflection and can be observed only after the attenuator control (VOLTS FULL SCALE) is set at a higher voltage position or if the amplitude of the applied signal is reduced. This feature prevents inadvertent introduction of distortion into the signal from circuit action within the oscillograph. The normally grounded (pin 7) grid of V101 is brought out to the front-panel jack J102 so that balanced input operation may be obtained simply by removing the jumper between J102 and J103 (front-panel terminals). The resistors (R107 and R108) in series with the grids of V101 serve to protect the input circuit from damage due to excessive input voltage. Shunting capacitors C108 and C109 provide frequency compensation.

The D-C Balance adjustment (D-C BAL), R110, equalizes the voltage at the ends of the MULTIPLIER (amplitude) control. When this adjustment is properly set, there will be no shifting (up and down) of the trace on moving the MULTIPLIER control from minimum to maximum with no input signal to the amplifier.

(2) PUSH-PULL AMPLIFIERS

The vertical deflection amplifiers comprise V102 through V106, inclusive. The d-c balanced circuit arrangement of the tubes provides good deflection amplifier stability. The first push-pull amplifier (V102) is preceded by the MULTIPLIER control which varies the amplitude of the input signal after passing through V101.

With the Y POSITION control (R116) set at its mechanical center, the Y CTR back-of-panel control (R121) is normally adjusted to equalize the voltage drops across load resistors R115 and R117 so that the beam trace will be in the vertical center of the cathode-ray tube. The positioning system provided is such that even with a vertical deflection equivalent to four times full-screen diameter, any full screen portion of this vertical deflection may be centered on the screen by the Y POSition control. The Y SEN back-of-panel adjustment (R128) is used to set the sensitivity of the Y-deflection system to 100 millivolts peak-to-peak full scale through the amplifier. This control provides a variable low resistance path between the plates of the second push-pull amplifier, V103, and the input to the third push-pull stage, V104.

Voltage for the screen grids of V105 and V106 in the last push-pull stage is obtained from an unregulated supply source to allow the sensitivity of the circuit to rise with increased line voltage. This is designed to compensate for the reduction in the sensitivity of the cathode-ray tube caused by increased accelerating potentials resulting from the increased line voltage. Hence, variation in over-all sensitivity due to line-voltage fluctuations is minimized. The Y LIN back-of-panel control (R136) is a variable screen-dropping resistor for the output tubes (V105 and V106) thus controlling the linearity of the output signal. Additional high frequency compensation is obtained by means of degenerative feed back through resistors R123 and R124.

(3) DIRECT INPUT

Provision is made for direct input to the vertical deflection plates at rear-panel terminals through series input capacitors C110 and C111. The coupling capacitors are required since the deflection plates are maintained at approximately +200 volts with respect to ground to prevent beam distortion.

4. SYNC AND SWEEP CIRCUITS

a. GENERAL

A simplified schematic of the sync and sweep circuits is shown in Figure 3-5. Provision is made for both driven and recurrent sweeps with expansion to six times full-screen diameter; the positioning range being sufficient to allow viewing on screen of any portion of the expanded sweep. The recurrent sweep may be synchronized or the driven sweep triggered by signals of either positive or negative polarity through the incorporation of a phase-splitting stage.

b. SYNCHRONIZATION

The SYNC SELECTOR switch (S301) provides for selection of the synchronizing signal; INTernal (signal obtained from the Y-axis amplifier); LINE-frequency; or EXTernal (signal obtained from an external source). V301-A functions as a sync phase splitter. The SYNC AMPLITUDE control (R308) enables the operator to select the desired amplitude and polarity of the sync voltage. The output from the first sync amplifier (V301-B is coupled to the grid of the sweep generator (V303) through C305 and R312. The plate of diode V302 is connected at the junction of R311 and R312; however, the cathode is connected to ground only when the X SELECTOR switch is set at RECURrent SWEEP.

When thus connected in the circuit, this diode limits the sync voltage that can be applied to the sweep generator (V303) to prevent distortion of the sweep waveform which could result from over-sync. V302 also prevents the grid-circuit capacitance of the sweep

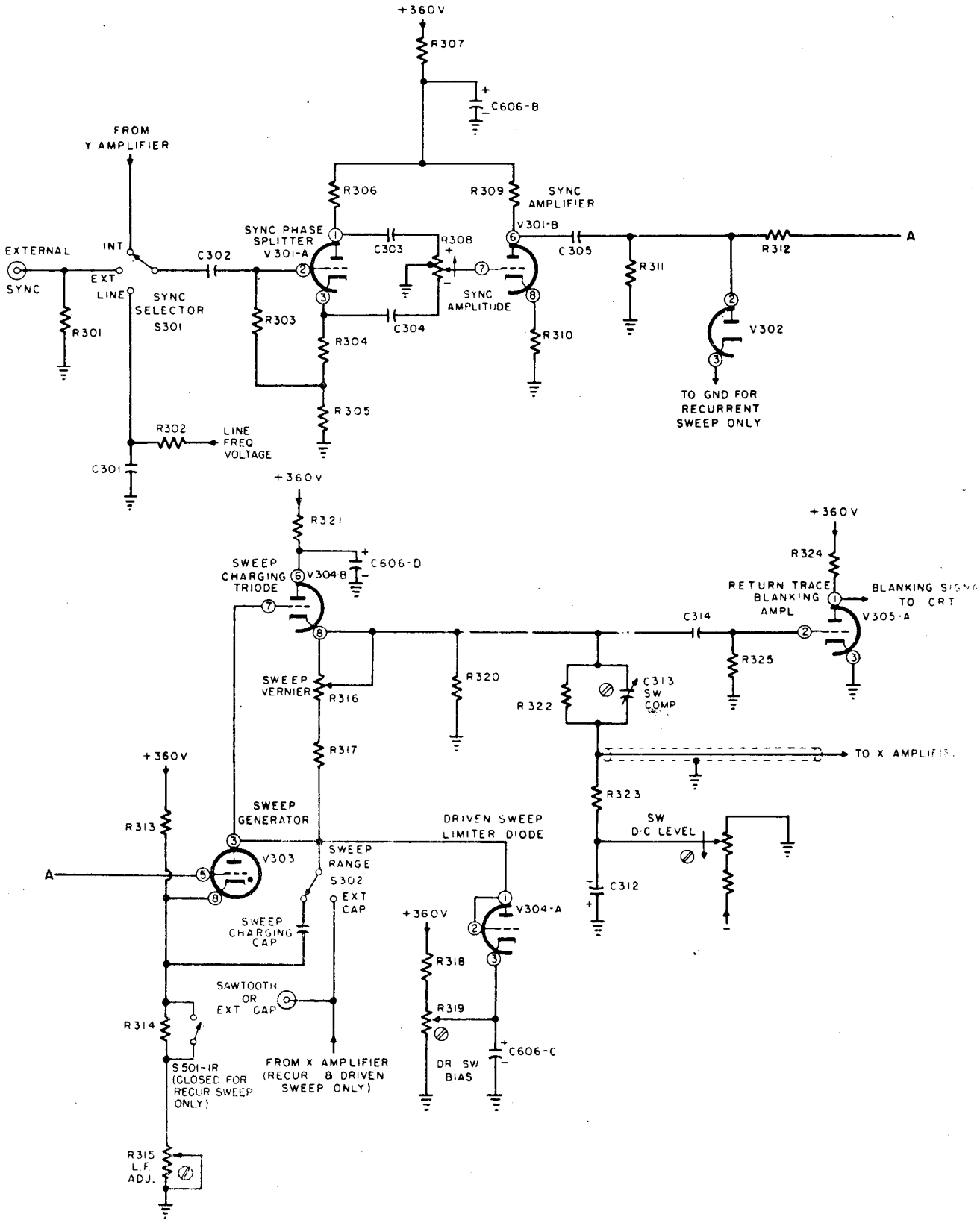


FIGURE 3-5 - SYNC AND SWEEP CIRCUITS (SIMPLIFIED SCHEMATIC)

generator (V303) from charging to a positive potential at the higher sweep frequencies which would result in premature firing and erratic operation of V303. The useful sweep range is thus extended at the high-frequency end.

c. RECURRENT SWEEP

Gas triode V303 is employed to develop the sawtooth voltage necessary to obtain the linear sweep. The cathode of this gas triode is heated and emits electrons as in the ordinary heater-type triode, but the inert gas in the tube ionizes so that when the voltage between the cathode and the plate reaches a certain value, an arc occurs causing the tube to appear as a veritable short circuit. This "breakdown" or "firing" point depends upon the bias at the grid with respect to the cathode, the bias being determined by a voltage-divider network consisting of R313 and R315. With a specific negative bias applied to V302, it will "fire" at only one value of plate voltage. To facilitate circuit analysis, only one sweep capacitor is shown in Figure 3-5, connected between the plate and cathode of the gas triode. This capacitor is charged from the +360-volt supply through sweep-charging triode (V304-B, R316, R317 and the cathode bias resistance R315) until the plate voltage becomes high enough to "fire" the tube. At this time, the sweep capacitor is discharged until the plate-to-cathode voltage falls to the arc-extinction potential (about 20 volts). When this occurs, V303 no longer conducts and the charging cycle commences all over again. The SWEEP VERNIER control (R316) provides a fine adjustment of the sweep frequency by controlling the rate at which the sweep capacitor is charged.

The circuit of V304-B serves two functions: (1) to simulate the behavior of a constant current source for the linearization of the charging rate to the sweep capacitor and (2) to function as a sweep output cathode follower. The resultant sawtooth sweep appearing across the sweep output cathode follower load resistor (R320) is applied to a frequency-compensated voltage divider (R322, C313, and R323) which attenuates the sweep to approximately one fifth of the original value. The lower end of the voltage divider is connected to an adjustable negative bias at the arm of the SW DC LEVEL control (R403). When this back-of-panel adjustment is properly set, equal sweep-trace expansion from both sides of center screen will be obtained as the X AMPLITUDE control is advanced. The output from the voltage divider is coupled to the input of the X-axis amplifier when the X SELECTOR switch is set at the SWEEP position.

It is generally desirable to view only the forward portion of the sweep trace. This requires blanking of the return trace. To accomplish this, a negative pip is generated at the end of the forward trace by the differentiating circuit composed of R325 and C314. This negative pip is applied to the grid of the return-trace blanking amplifier (V305-A). The resulting positive pulse at the plate of V305-A is coupled to the cathode of the cathode-ray tube to "turn-off" the beam during the interval of the return trace.

Certain applications may require sweep frequencies lower than two cycles per second. For such applications a very low-frequency time base may be obtained by connecting an external capacitor between the SAWTOOTH or EXT CAP front-panel terminal and ground when the SWEEP RANGE switch is set at EXT CAP. The larger the capacitor employed, the greater the R-C time constant and the lower the frequency.

d. DRIVEN SWEEP

For operation in the driven-sweep mode, the gas triode (V303) will not "fire" except when triggered by a positive pulse applied to its grid. Each positive pulse of sufficient amplitude initiates a single cycle of sawtooth voltage. When the X SELECTOR switch is at

DRIVEN, the bias on the cathode of V303 is increased because of the addition of R314 in the voltage divider network. With this additional bias, a higher plate voltage must be applied to V303 before it "fires". The driven-sweep limiter diode (V304-A) prevents the plate of the gas triode from reaching the potential necessary for ionization under steady-state conditions. The functioning of this limiter is as follows: The limiter (V304-A) will conduct when the forward portion of the sawtooth waveform reaches a certain amplitude as determined by the DRIVEN SW BIAS back-of-panel control adjustment (R319) in the cathode circuit. Upon conduction, the voltage across the sweep charging capacitor is arrested at this point; and when R319 is properly set, the voltage is of insufficient magnitude to fire that gas triode (V303).

The driven sweep is initiated by applying a positive pulse of sufficient magnitude to the grid of V303. This enables the tube to "fire" at a plate potential lower than that established by the fixed bias on the cathode. The sweep capacitor quickly discharges through the ionized conduction path of V303 to the extinction potential. At this point, conduction no longer occurs, and the sweep capacitor again charges. The driven sweep cycle is complete when the sweep capacitor is again charged to the level established by the driven-sweep limiter diode (V304-A). The beam will sweep the screen again only upon application of another positive pulse to the grid of the gas triode.

5. HORIZONTAL DEFLECTION CIRCUIT (X AXIS)

a. GENERAL

A simplified schematic of the horizontal (X-axis) amplifier is shown in Figure 3-6. The horizontal amplifier, preceded by an input attenuator, consists of an input cathode follower, a paraphase amplifier stage and an output push-pull amplifier.

b. CIRCUIT THEORY

(1) X SELECTION

By means of the X SELECTOR switch (S501) provision is made for selection of internal or external signals for horizontal deflection. The internal signal is obtained from the linear sawtooth sweep circuit previously discussed. Either d-c or a-c external signals may

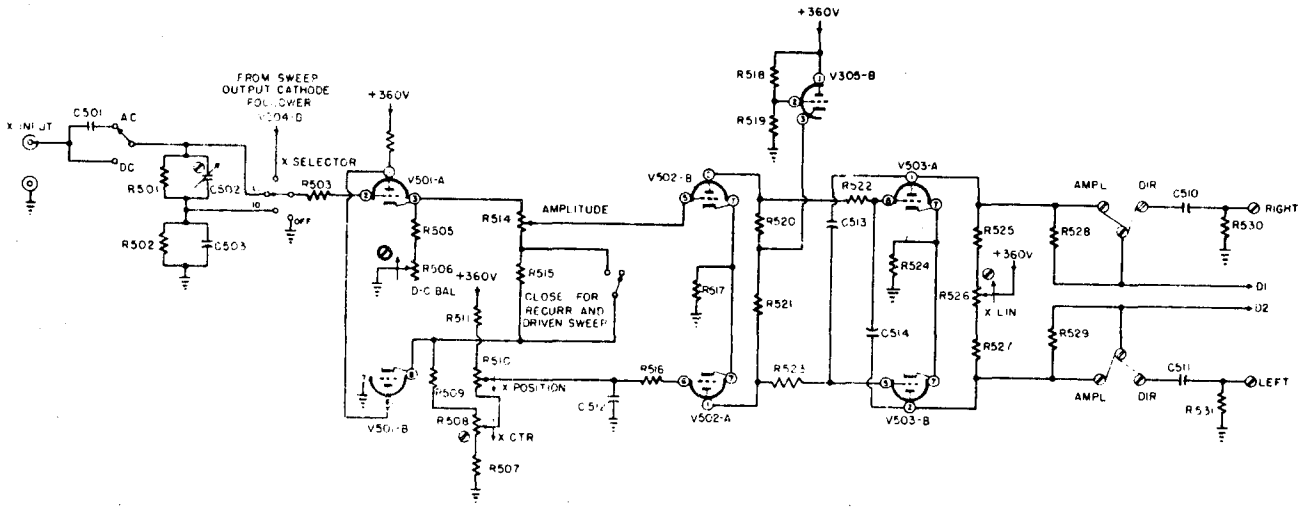


FIGURE 3-6 - HORIZONTAL AMPLIFIER CIRCUIT (SIMPLIFIED SCHEMATIC)

be applied through the X attenuator, which provides attenuation ratios of 1 or 10. An OFF position is provided on this switch, which grounds the grid of the input cathode follower (V501-A).

(2) INPUT CATHODE FOLLOWER

V501-A and V501-B are connected in a cathode-follower circuit. V501-B has no signal applied to it; its function being solely to maintain the grid (pin 6) of the paraphase amplifier stage (V502) at signal ground potential while allowing d-c positioning voltage to be applied. The d-c balance adjustment (R506, X D-C BAL) is used to equalize the d-c voltage at the ends of the AMPLITUDE CONTROL. When this adjustment is properly set, there will be no shifting (left or right) of the trace when moving the AMPLITUDE control from minimum to maximum with no input to the amplifier.

The over-all gain of the X amplifier is varied by the AMPLITUDE control (R514). To prevent the operator from inadvertently overloading the input cathode follower with resultant signal distortion, R515 is connected in series with the AMPLITUDE control. The value chosen for R515 is such that with the AMPLITUDE control set for minimum gain, a signal large enough to overload the input cathode follower (V501) will cause the beam to be deflected off the screen of the cathode-ray tube and thus require additional attenuation to be employed. The range of the AMPLITUDE control is such that a signal, which causes 5 inches deflection of the electron beam on the screen at maximum AMPLITUDE control setting, will be cut down to between 0.1 and 0.5 inch at the minimum setting.

The input cathode follower is designed so as to maintain the cathode (pin 8) of V501-B at a constant signal potential of zero volts with respect to ground. This is important if V502 is to operate as a true paraphase amplifier with low distortion.

Assume that a positive-going signal is applied to the grid (pin 2) of V501-A. This tube will conduct more heavily, causing more current through the series cathode network consisting of R514, R515, R509, R508 and R507. The total current through the latter three resistances is not only determined by the cathode current just mentioned but also in part by the current flowing through V501-B. The increased plate current of V501-A produces a voltage drop across R504 in the plate circuit, which lowers the plate voltage on V501-B, resulting in less plate current through this latter tube and the series network, R509, R508 and R507. This decrease in current through these resistances, when R504 is properly chosen, is just equal and opposite in phase to the current through the V501-A cathode network previously mentioned. Thus, the junction of R515 and R509 remains at the same (zero) potential.

(3) PARAPHASE AMPLIFIER

V502 is connected in a conventional paraphase amplifier circuit with plate voltage supplied through the series dropping stage (V305-B) from the +360-volt supply. V305-B, in addition to providing the proper voltage drop, serves as a low-impedance path to ground through the power supply.

(4) PUSH-PULL OUTPUT STAGE

The output of the paraphase amplifier is direct-coupled to a push-pull output amplifier (V503). Plate voltage for this stage is obtained from the +360-volt supply through a linearity control (R526, X LIN). This control is provided to compensate for any unbalance in the circuit caused by asymmetry of the two halves of the tube.

C513 and C514 provide sufficient feedback to cancel out the input capacitance of V502, resulting in improvement of the high-frequency response of the amplifier.

(5) BEAM POSITIONING

Beam positioning is accomplished by varying the bias voltage on V502-B with respect to that on V502-A through adjustment of the X POSITION control (R510). R508 (X CTR) is a back-of-panel adjustment in series with R510 for use in centering the beam on the screen with the X POSITION control set midway. This allows for equal positioning either side of center or may be adjusted for greater position in either direction from center, if desired.

(6) DIRECT INPUT

Connecting a signal direct to horizontal deflection plates is accomplished in the same manner as for vertical input discussed in paragraph 3d (3).

6. POWER SUPPLY

a. GENERAL

The circuit of the power supplies is shown on the over-all schematic at the back of the manual. As an aid in understanding the circuit, consider the power supply as consisting of three separate voltages: (1) low-voltage positive supply, (2) high-voltage positive and negative supply, and (3) heater supply.

b. FUNCTIONS

The low-voltage positive supply provides the necessary d-c potential for operation of the X and Y amplifiers, the sync and sweep circuits and, in addition, provides potential for the second anode of the cathode-ray tube. The high-voltage negative supply provides cathode, grid and first anode potentials for the cathode-ray tube. In addition, it furnishes the necessary bias for the SWeep DC LEVEL control. The high-voltage positive supply provides the necessary potential at the intensifier electrode of the cathode-ray tube. The heater supply furnishes the necessary low-voltage a-c potentials for proper operation of tube heaters.

c. LOW-VOLTAGE POWER SUPPLY

The low-voltage rectifier (V605) is connected in a full-wave rectifier circuit. The rectifier output is filtered by a capacitor-input type filter (C602, L601, and C601). The full-voltage output from the filter (+360 volts) is regulated by V601 to provide +110 volts regulated. The unregulated +360-volt output supplies the Y amplifier output stages, sync, sweep, and X amplifier. In addition, this supply furnishes voltage to the second anode of the cathode-ray tube.

d. HIGH-VOLTAGE POWER SUPPLY

The high-voltage power supply contains two rectifier circuits. These rectifiers provide the cathode-ray tube intensifier-anode potential as well as operating potentials for proper intensity and focusing of the cathode-ray tube beam. V604 is employed in a -1400 volt half-wave rectifier circuit from which the cathode, grid and first anode electrodes of the cathode-ray tube are supplied. The rectified output from this stage is filtered by a single pi section of an R-C type filter (C605, R606, and C604).

V603 is also connected in a half-wave rectifier circuit, the output from which is filtered by a single section R-C type filter. Potential at the output of this filter is approximately +1600 volts and supplies the necessary potential to the intensifier electrode of the cathode-ray tube.

e. REGULATED HEATER SUPPLY

A regulated heater supply on the first and second stages of the Y-axis amplifier provides good vertical stability. A series-connected thermal regulator (V606) controls the heater temperature to stabilize cathode emission over a ±10% range of variation in supply voltage. In addition, a HUM BALance potentiometer (R144) is included in the filament circuit of V101 and V102 to reduce line-frequency modulation to a minimum.

SECTION IV
MAINTENANCE

WARNING!

This equipment employs high voltages that are dangerous and may be fatal if contacted by operating personnel. Extreme caution should be exercised when working on the equipment.

1. GENERAL SYSTEM TROUBLE SHOOTING

It is assumed that maintenance personnel are thoroughly familiar with the physical make-up of the equipment, the installation and operating procedures, and the detailed theory of operation given elsewhere in this handbook.

Maintenance personnel must be prepared to repair and adjust the equipment should it fail in operation. The trouble must be located; and after repairs have been made, the equipment must be tested and adjusted to conform to the original specifications. Maintenance personnel must endeavor to find the source of the trouble that causes each equipment failure, particularly when the trouble is a recurrent one. The recurrence of a fault usually indicates the effect, not the cause, has been remedied. No back-of-panel adjustment should be undertaken except where evidence points to trouble in the particular section of the instrument affected by the control.

2. THEORY OF LOCALIZATION

The first step in correcting any trouble or failure that may occur is to isolate the section of the circuit that is 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 1-2. Trouble ordinarily occurs in only one section at a time; thus, it is usually necessary to correct only the one trouble. As an aid in servicing, Trouble Shooting Chart, Table 4-1, indicates causes and remedies for certain specific troubles.

The next step after isolating the trouble to a particular section is to determine the tube circuit involved. A replacement tube should be tried before attempting any other tests. If trouble persists, voltage and resistance measurements should be made.

An over-all schematic of the circuit, together with a tube location diagram (Figure 4-5), will be found at the back of this section and should be consulted while trouble shooting. A list of component electrical parts, including descriptions, will be found following the tube location diagram.

TABLE 4-1

TROUBLE SHOOTING CHART

POWER SUPPLY AND CRT CIRCUITS		
Symptom	Probable Cause	Remedy
POWER indicator lamp fails to light.	SCALE switch in OFF position.	Turn SCALE (POWER) switch on.
	No a-c line voltage.	Trace line failure.
	POWER indicator lamp open.	Replace I405.
	Power cable defective.	Repair or replace cable.
	Filament transformer defective. (Check by measuring voltage across POWER indicator lamp, terminals 7 and 8, which should measure 6.3 volts a-c).	Replace T601.
	Fuse defective.	Replace F601.
	115-230 Voltage Selector Switch (S601) defective.	Make certain the 115/230 voltage selector switch is set at the proper voltage. Check continuity of switch with POWER at OFF. Replace switch if found defective. CAUTION: S601 must be wired in accordance with the overall schematic drawing to insure the proper phase relationship of primary transformer T601.
Line fuse blows instantly when POWER switch is turned "on".	Defective rectifier tube or filter capacitor.	Check filter capacitors C606-A, C606-B, C606-C, C606-D, C601 and C602 for low resistance or short. If found OK, replace rectifier tubes V603, V604 and V605. NOTE: If a filter capacitor is shorted, quite probably a rectifier tube may also be defective.
Some filaments fail to light.	Defective tube or tubes.	Replace burned out tubes.
	Broken lead from filament transformer. (Check filament voltage at tube socket and continuity to filament transformer T601).	Repair.
	Filament transformer, T601, defective. (Check filament voltage at each winding of T601).	Replace.
Vertical displacement of trace with no input to Y amplifier.	No +110V regulated supply.	Replace Voltage Regulator V601.
Low beam intensity; increased deflection sensitivity of cathode-ray tube. (No voltage on intensifier, A3.)	Positive high voltage rectifier defective.	Replace V603.
	R604 open circuited.	Replace.
	C603 or R605 shorted.	Replace.

TABLE 4-1

TROUBLE SHOOTING CHART (Continued)

Symptom	Probable Cause	Remedy
No spot on cathode-ray tube screen.	Defective negative high voltage rectifier V604. (Check voltage on cathode-ray tube--cathode (pin 2), grid (pin 3), first anode (pin 5). If voltage appears on any of these electrodes, as per Table 4-2, this is probably not the cause.)	Replace V604.
	C605 shorted.	Replace.
	R606 open-circuited.	Replace.
	C604 shorted.	Replace.
No spot on cathode-ray tube screen. (All CRT voltages normal.)	Defective cathode-ray tube (V401).	Replace V401.*
No sweep. Horizontal deflection circuit (X axis) checks OK.	X SELECTOR switch is not set at RECURrent SWEEP.	Rotate switch to RECURrent SWEEP.
	Inadequate amplitude of sync signal when X SELECTOR is set at DRIVEN.	Adjust SYNC AMPLITUDE control for the proper phase and amplitude of the synchronization signal.
	INTENSITY control set too low.	Increase INTENSITY.
	Sweep generator (V303) inoperative.	Check tube.* Check pin voltages and continuity to ground per Table 4-2.
	Sweep output cathode follower (V304-B) Inoperative.	Check tube.* Check pin voltages and continuity to ground per Table 4-2.
	Sweep charging capacitors defective (C306, C307, C308, C310 and C311).	Replace defective capacitors.
No sweep. X SELECTOR switch set at RECURrent	DRiven SWeep BIAS out of adjustment (R319).	Readjust bias so that sweep starts operating. (Refer to the paragraph entitled, "Factory Adjustment for the Sweep Circuit" in this Section).
Sweep fails to expand equally in both directions as the AMPLITUDE control is advanced.	SWeep DC LEVEL control out of adjustment (R403).	Readjust R403.
Nonlinearity of sweep observed at a frequency of approximately 300 cycles per second.	Sweep-output attenuator trimmer requires adjustment (C313).	Refer to the paragraph entitled, "Factory Adjustment for the Sweep Circuit" in this Section.
No sweep available at SAW-TOOTH or EXTERNAL capacitor terminal when X SELECTOR switch is set at RECURrent SWEEP; sweep is present on cathode-ray tube screen.	Sweep coupling capacitor open (C505).	Replace.
	R512 open.	Replace.
	R513 shorted.	Replace. Check continuity of SWEEP RANGE switch (Section S302-1R).

TABLE 4-1

TROUBLE SHOOTING CHART (Continued)

Symptom	Probable Cause	Remedy
Horizontal trace present on cathode-ray tube screen when X SELECTOR switch is set at DRIVEN SWEEP. SYNC AMPLITUDE control is set at "0."	Driven sweep limiter diode (V304-A) inoperative.	Check tube.* Check pin voltages and continuity to ground per Table 4-2. If V304-A checks OK, the DRiven SWeep BIAS is out of adjustment. Refer to the paragraph entitled, "Factory Adjustment for the Sweep Circuit" for the proper adjustment procedure.
Loss of synchronization	Sync amplifier and phase splitter (V301) inoperative.	Check tube.* Check pin voltages and continuity to ground per Table 4-2.
	SYNC SELECTOR switch is not in the proper position for the desired mode of operation.	Set SYNC SELECTOR switch at INTernal when X SELECTOR switch is set at either DRIVEN or RECURrent SWEEP. External sync signals may be employed if SYNC SELECTOR is set at EXTernal.
		If X SELECTOR is set at AMPLIFIER (AC or DC), SYNC SELECTOR must be set at EXTernal. If line frequency excitation is employed, SYNC SELECTOR should be set at LINE.
	SYNC AMPLITUDE control is not set to the proper polarity.	Change polarity.
	Defective coupling capacitors: C302, C303, C304 or C301.	Replace defective capacitor.
Return trace is visible with normal INTENSITY control setting.	Differentiating network C314 and R325 defective.	Replace.
	Return trace blanking amplifier (V305-A) inoperative.	Check tube.* Check pin voltages and continuity to ground per Table 4-2.
	Return trace blanking coupling capacitor open (C401).	Replace defective capacitor.
No sync of vertical deflection signals when SYNC SELECTOR switch is set at INTernal.	SYNC AMPLITUDE control defective (R308).	Replace.
	Sync coupling capacitor open (C302).	Replace.
	Sync amplifier and phase splitter (V301) inoperative.	Check tube.* Check pin voltages and continuity to ground per Table 4-2.
X SELECTOR switch is set at either DRIVEN or RECURrent SWEEP. Sweep is distorted at the maximum setting of the SYNC AMPLITUDE control.	Sync limiter diode (V302) inoperative.	Replace defective diode.

TABLE 4-1

TROUBLE SHOOTING CHART (Continued)

Symptom	Probable Cause	Remedy
An appropriate negative signal applied to Z INPUT does not blank the trace.	Intensity modulation coupling capacitor open (C402).	An appropriate negative signal of approximately 15 volts peak is necessary to blank the trace. If no result is experienced when this amplitude of signal is applied to Z Input, replace C402.
	R401 shorted.	Replace.
	Z INPUT coaxial cable open.	Check continuity of cable with SCALE switch at OFF. Repair or replace if found defective.
An appropriate signal is applied to Y INPUT. No vertical displacement of the trace results.	VOLTS FULL SCALE (attenuator) switch is set at OFF.	Set VOLTS FULL SCALE (attenuator) to either A-C or D-C AMPLIFIER.
	One or more of the vertical deflection circuit tubes are inoperative (V101 through V106 inclusive).	Check tubes.* Check pin voltages and continuity to ground per Table 4-2.
No vertical signal when VOLTS FULL SCALE is set at A-C AMPLIFIER; signal is present when VOLTS FULL SCALE is switched to D-C AMPLIFIER.	Input coupling capacitor open (C101).	Replace.
A 10-kc square wave, applied to Y INPUT, is distorted at 1V, 10V, 100V, positions of the VOLTS FULL SCALE (attenuator) switch.	Y attenuator compensation capacitors out of adjustment (C102, C104 and C106).	Refer to the paragraph entitled, "Factory Adjustments for the Y Amplifier" for the proper adjustment procedure.
Y POSITION control is set at center of its range; trace is not centered vertically on cathode-ray tube screen.	Position centering adjustment (Y CTR) out of adjustment (R121).	Set VOLTS FULL SCALE at OFF and Y POSITION control at the mechanical center of its range; adjust R121 to bring the trace on the cathode-ray tube to the vertical center of the screen.
VOLTS FULL SCALE is set at OFF; CRT trace shifts (up and down) with changes in the setting of the MULTIPLIER (amplitude) control.	D-C BALance control out of adjustment (R110)	Refer to the paragraph entitled, "Factory Adjustments for the Y Amplifier" in this Section for the proper adjustment procedure.
Size of pattern changes as it is positioned vertically on CRT screen.	Y LINearity out of adjustment (R136).	Refer to the paragraph entitled, "Factory Adjustment for the Y Amplifier" in the Section for the proper adjustment procedure.
No vertical displacement of CRT trace when a signal is applied to the appropriate vertical deflection-plate input terminals. (Jumpers are connected for direct input).	Direct input coupling capacitor(s) open (C110 and/or C111).	Replace.

TABLE 4-1

TROUBLE SHOOTING CHART (Continued)

Symptom	Probable Cause	Remedy
HORIZONTAL DEFLECTION CIRCUIT (X AXIS)		
No sweep. Sweep circuit checks OK; X SELECTOR is set at RECURrent SWEEP.	Check continuity of X SELECTOR SWitch (Section S501-2R). Horizontal deflection circuit (X axis) inoperative.	Repair or replace if found defective. Check horizontal deflection circuit (X axis) as outlined in this chart below.
An appropriate signal is applied to X INPUT. No horizontal displacement of the trace results. (X SELECTOR is set at either A-C or D-C AMPLIFIER).	One or more of the horizontal deflection circuit tubes are inoperative (V305-B and V501 through V503).	Check Tubes.* Check pin voltages and continuity to ground per Table 4-2.
No horizontal signal when X SELECTOR is set at A-C AMPLIFIER; signal is present when X SELECTOR is switched to D-C AMPLIFIER.	Input coupling capacitor open (C501).	Replace.
X POSITION control is set at center of its range; trace is not centered horizontally on the cathode-ray tube screen.	Position centering adjustment (X CTR) out of adjustment (R508).	Set X SELECTOR at OFF and X POSITION control at the mechanical center of its range; adjust R508 to bring the trace on the cathode-ray tube to the horizontal center of the screen.
X SELECTOR is set at OFF; CRT trace shifts (left and right) with changes in the setting of the AMPLITUDE control.	D-C BALance control out of adjustment (R506).	Refer to the paragraph entitled "Factory Adjustments for the X Amplifier" in this Section for the proper adjustment procedure.
Size of pattern changes as it is positioned horizontally on CRT screen.	X LINearity out of adjustment (R526).	Refer to the paragraph entitled "Factory Adjustments for the X Amplifier" in this Section for the proper adjustment procedure.
No horizontal displacement of CRT trace when a signal is applied to the appropriate horizontal deflection-plate input terminals. (Jumpers are connected for direct input.)	Direct input coupling capacitor(s) open (C510 and/or C511).	Replace.

*If tube replacement is necessary, refer to "Adjustments to be Made When Replacing Tubes," Table 4-3.

3. CIRCUIT VOLTAGES AND RESISTANCES

Table 4-2 lists voltages and resistances from tube pins to ground. Unless otherwise specified, voltage measurements are made with a meter having an internal resistance of 20,000 ohms per volt. Voltages measured with a meter having a lower internal resistance may in some cases be lower than the values shown in the table.

TABLE 4-2

VOLTAGE AND RESISTANCE MEASUREMENTS*

Preset front-panel controls according to the following chart:			
CONTROL	POSITION	CONTROL	POSITION
Y POSITION	CENTER	VOLTS FULL SCALE	OFF
X POSITION	CENTER	X SELECTOR	RECUR
INTENSITY	MAX CCW	SWEEP RANGE	50-250
FOCUS	MAX CW	MULTIPLIER	4
SYNC SELECTOR	LINE	(X) AMPLITUDE	MAX CCW
SWEEP VERNIER	CENTER	CALIBRATOR	OFF
SYNC AMPLITUDE	MAX CCW		

TABLE 4-2

VOLTAGE AND RESISTANCE MEASUREMENTS

TUBE			PIN NUMBERS								
Symbol	Type	Function	1	2	3	4/	5/	6	7	8	9/
V101	5963	Input Cathode Follower	20K	220K	4.4K	0-250 -0	0-250 -0	20K	220K	4.4K	0-250 -0
			110V	0V	5V	0-6.3 Volts AC	0-6.3 Volts AC	110V	0V	5V	6.3-0 Volts AC
V102	5963	Paraphase Amplifier	20K	5K	1.5K	0-250 -0	0-250 -0	20K	4.4K	1.5K	0-250 -0
			62V	5.5V	7V	12.6 -6.3V AC	12.6 -6.3 AC	62V	5.5V	7V	6.3-0 Volts AC
V103	12AU7	1st Push-Pull Amplifier	30K	17.5K	8.2K	0	0	30K	17.5K	8.2K	0
			65V	32V	33V	3.2V AC	3.2V AC	65V	32V	33V	3.2V AC
V104	12AU7	2nd Push-Pull Amplifier	20K	30K	28K	0	0	22K	30K	28K	0
			100V	65V	65V	3VAC	3VAC	100V	65V	65V	3VAC
V105	6AQ5	3rd Push-Pull Amplifier		18K	0	0	44K	140K	24K		
				107V	3VAC	3VAC	180V	218V	100V		
V106	6AQ5	3rd Push-Pull Amplifier		18K	0	0	44K	140K	24K		
				107V	3VAC	3VAC	180V	218V	100V		
V301	12AU7	(a) Sync Amplifier (b) Sync Phase Splitter	90K	2.2K Meg.	10K	0	0	280K	100K	1.8K	0
			100V	**10V	19V	3VAC	3VAC	20V	0V	0.8V	3VAC
V302	6AL5	Sync Limiter Diode		100K	0	0	0				
				-0.5V	3VAC	3VAC	0V				
V303	6Q5G	Sweep Generator		0	330K	1K	120K		0	2K	
				3VAC	30V	4.2V	-0.4 V		3VAC	3.6V	
V304	12AU7	(a) Driven Sweep Limiter (b) Sweep Output Cathode Follower	350K	350K	20K	0	0	35K	350K	175K	
			30V	30V	55V	3VAC	3VAC	340V	30V	60V	3VAC

*Obtained when using a 20,000 ohms/volt test meter. Readings are typical and nominal and may vary by as much as 20% or more in some cases. All voltages are d-c unless otherwise indicated.

TABLE 4-2

VOLTAGE AND RESISTANCE MEASUREMENTS (Continued)

TUBE			PIN NUMBERS									
Symbol	Type	Function	1	2	3	4/	5/	6	7	8	9/	
V305	12AU7	(a) Return Trace Blanking Amplifier (b) Series Dropping Triode	125K 35V	15K -0.3V	0 0V	0 3VAC	0 3VAC	20K 340V	125K 65V	18K 75V	0 3VAC	
V501	12AU7	Input Cathode Follower	30K 310V	200K 0V	8K 18V	0 3.1V AC	0 3.1V AC	30K 310V	0 0V	6K 18V	0 3.1V AC	
V502	6J6	Paraphase Amplifier	28K 58V	28K 58V	0 3VAC	0 3VAC	7K 18V	10K 18V	5.6K 19V			
V503	6J6	Push-Pull Amplifier	83K 200V	83K 200V	0 3VAC	0 3VAC	28K 58V	28K 58V	12K 75V			
V601	OB2	+110V Voltage Regulator					20K 110V		0 0V			
V602	6AL5	Voltage Calibrator	65K 128V	0 0V	0 3VAC	0 3VAC	200K 65V		200K 65V			
V603	1X2A	+1600 V Rectifier	2K 1600V DC	2K 1600V DC								CAP 1380VAC
V604	1X2A	-1400 V Rectifier	10 Meg 1380V AC	10 Meg 1380V AC								CAP -1400 VDC
V605	5Y3GT	+340 V Rectifier		20K 370V		175 400V AC		175 400V AC		20K 370V		
V606	3-14	Amperite Regulator		5.5 5.6V AC					6.5 24.5V AC	5.5 5.8V AC		
V401	5ADP-	Cathode-ray Tube	1 1 Meg -1400 V	2 1 Meg -1400 V	3 1.2 Meg -1400 V	5 700K -900 V	7 45K +180 V	8 45K +180 V	9 44K 190V	10 100K 200V	11 70K 200V	14 A3 1 Meg 0 -1400 V +1600 V

**Obtained when using a vacuum-tube voltmeter.
/Values on V101 and V102 depend upon setting of grounded arm HUM BALance potentiometer (R144)

It should be remembered that all values are nominal, and considerable variation may be experienced due to various line-voltage conditions and component tolerance. Generally, a variation of ±10% is to be expected and ±20% may not be uncommon. Good judgment is often required to determine if a particular deviation is indicative of trouble.

4. SELECTING 115- OR 230-VOLT LINE

Provision is made in the Types 304-A and 304-AR for changing from 115- to 230-volt line operation or vice versa. To accomplish this, remove the chassis or dust cover and set the 115/230-volt selector switch (S601), located at the rear of the chassis, at the desired voltage. Replace fuses in accordance with the appropriate note on the over-all schematic at the back of this section.

5. FACTORY ADJUSTMENTS

a. GENERAL

> - WARNING -
>
> POTENTIALS AS HIGH AS 3000 VOLTS ARE EMPLOYED IN THIS EQUIPMENT. 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. (Do not depend upon a ground connection made by touching the chassis. Make ground connections directly to one of the ground binding posts.)
>
> (3) Remove power before changing any tube or attaching any test leads. Remove power cord from the line outlet.
>
> (4) Before touching any component, short the terminals to remove any possible charge that may remain after turning off the power.
>
> (5) Work with one hand in your pocket.

In order to avoid component pre-selection, a number of factory adjustments have been included in this instrument. Only two such adjustments are necessary if the instrument is operating normally. These are the D-C BALance adjustments for the X and Y amplifiers, located on the front panel of the instrument. Certain factory adjustments may need to be reset when replacing tubes; Table 4-3 lists these adjustments. Before making any adjustments, a 10-minute warm-up period should be allowed. For identification and location of the back-of-panel controls, see Figures 4-1 through 4-3.

b. TEST EQUIPMENT REQUIRED

Description	Range of Characteristics
Volt-ohmmeter	20,000 ohms/volt test meter or VTVM
Voltage Calibrator	Du Mont Type 264-B or equivalent
Square-wave Generator	60 cycles to 10kc

c. FACTORY ADJUSTMENTS FOR Y AMPLIFIER

(1) Position Centering Adjustment (Y CTR) - R121 - This adjustment is set to bring the trace on the cathode-ray tube to the center of the screen vertically with no signal input (VOLTS FULL SCALE) at OFF and Y POSITION control at the mechanical center of its range (pointing up).

(2) Sensitivity Adjustment (Y SEN) - R128 - This control should be set to give the amplifier a sensitivity of 9 millivolts per inch rms or 25 millivolts per inch d-c at full gain. To make this adjustment, refer to the paragraph entitled "Factory Adjustments for the Voltage Calibrator" in this section.

TABLE 4-3

ADJUSTMENTS TO BE MADE WHEN REPLACING TUBES

Tube Reference Symbol	Type	1st Readjustment	2nd Readjustment	3rd Readjustment
V101**	5963	(Y) D-C BAL (R110)	HUM BAL (R144)	
V102**	5963	Y CTR (R121)	Y SEN (R128)	*Y CTR (R121)
V103	12AU7+	Y SEN (R128)	Y CTR (R121)	
V104	12AU7+	Y LIN (R136)	Y SEN (R128)	Y CTR (R121)
V105	6AQ5	Y LIN (R136)	Y SEN (R128)	Y CTR (R121)
V106	6AQ5	Y LIN (R136)	Y SEN (R128)	Y CTR (R121)
V301	12AU7+			
V302	6Q5G	DR SW BIAS (R319)	SW D-C LEVEL (R403)	LF ADJ (R315)
V303	12AU7+			
V304	12AU7+			
V401	5ADP-	Y SEN (R128)	Y CTR (R121)	
V501**	12AU7+	(X) D-C BAL (R506)	X CTR (R508)	
V502	6J6	X CTR (R508)		
V503	6J6	X LIN (R526)		
V601	OB2			
V602	6AL5	CAL ADJ (R602)	Y SEN (R128)	Y CTR (R121)
V603	1X2A			
V604	1X2A			
V605	5Y3GT			
V606	3-14			

*The Y CTR control needs readjustment at this point because the Y POSITION control is dependent on Y SEN. The latter control cannot be listed as the second readjustment when replacing V102 because in doing so may result in displacing the pattern so far off the screen that the Y POSITION control has no effect on the pattern.

**V101, V102, and V501 are preselected tubes and may prove critical in replacement. The Du Mont Instrument Service Department can supply tubes specifically selected for these positions.

+Type 5963 tubes may be substituted for Type 12AU7 with no loss in performance, provided balanced tubes are selected where necessary.

(3) Hum Balance Adjustment (HUM BAL) - R144 - This control should be adjusted to give minimum ripple on the trace. To make this adjustment, shield the Y INPUT terminals and the bottom of the chassis (under the Y attenuator), and set the VOLTS FULL SCALE switch and MULTIPLIER to give maximum amplifier sensitivity. Then adjust HUM BALance potentiometer (R144) to give minimum residual ripple (0.02" max.).

(4) Linearity Adjustment (Y LIN) - R136 - To make this adjustment, apply a square-wave signal to the Y INPUT and adjust for 1 inch vertical deflection at the center of the screen. Position pattern 1-1/2 inches up and 1-1/2 inches down and observe whether vertical size of pattern becomes greater, or smaller, away from the center of the screen. If the size changes, adjust the Y LIN control until a minimum change in size with positioning occurs. When this adjustment is made, reset the Y CTR adjustment (R121). It may also be necessary to recheck the Y SEN adjustment (R128).

(5) D-C Balance Adjustment (D-C BAL) - R110 - In addition to the back-of-panel factory adjustments, the amplifier is supplied with a D-C Balance control, which may be adjusted by means of a screwdriver at the front panel. See Figure 2-1 for location. When this adjustment is properly set, there will be no shifting in the zero position (up and

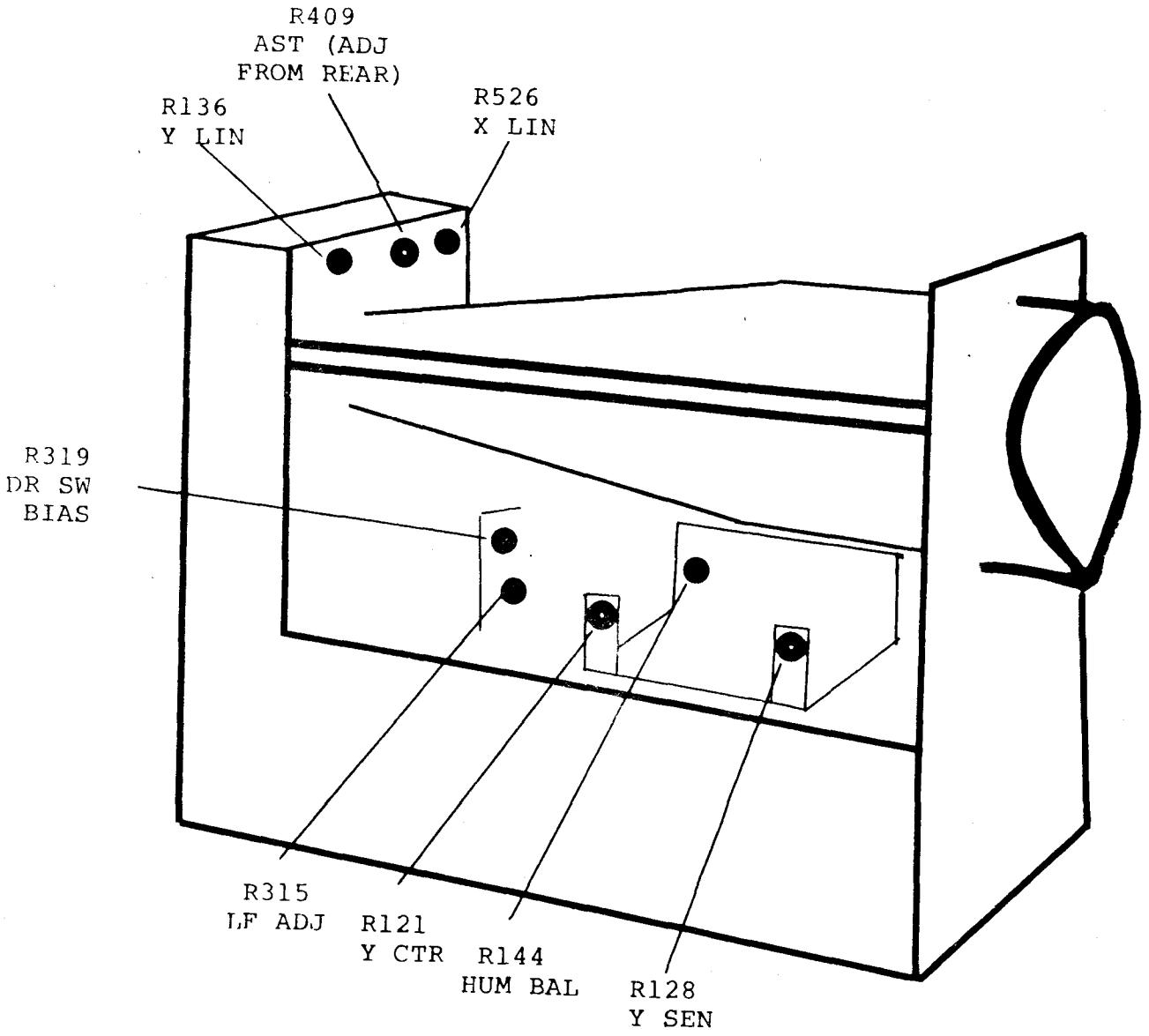


FIGURE 4-1a
IDENTIFICATION OF BACK-OF-PANEL CONTROLS
LEFT SIDE, TYPE 304-A

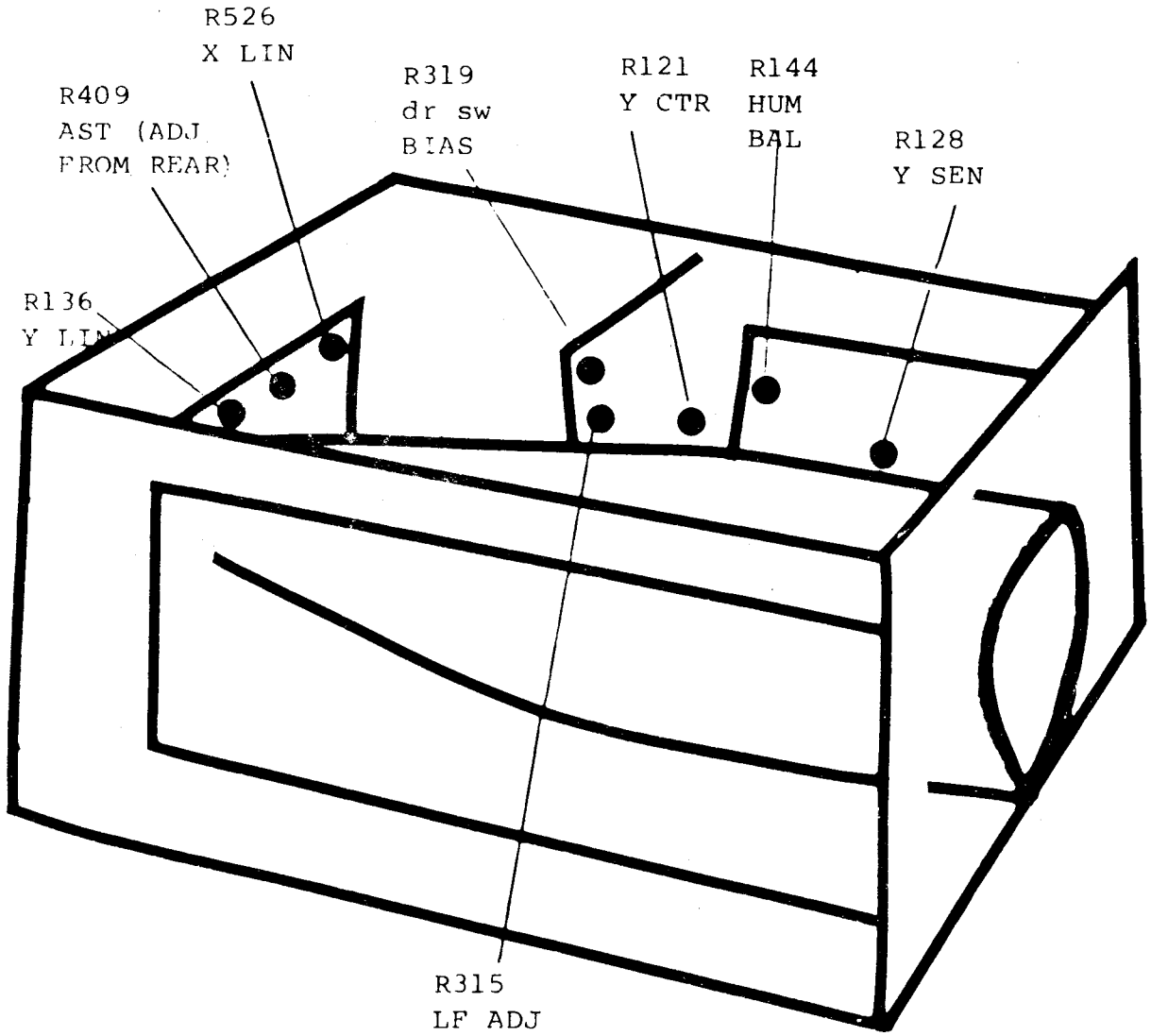


FIGURE 4-1b - IDENTIFICATION OF BACK-OF-PANEL CONTROLS, LEFT SIDE, TYPE 304-AR

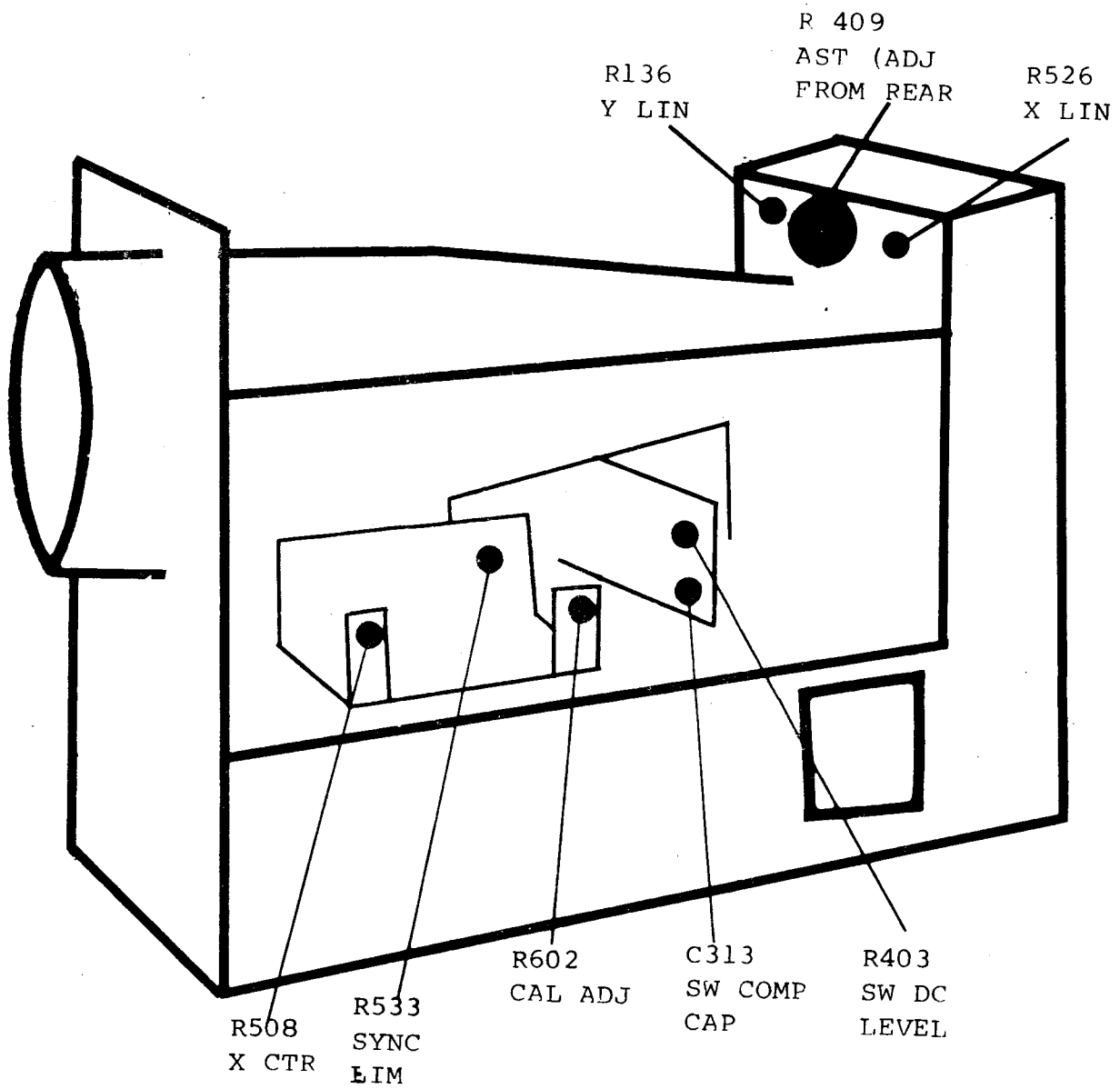


FIGURE 4-2a - IDENTIFICATION OF BACK-OF PANEL CONTROLS, RIGHT SIDE, TYPE 304-A

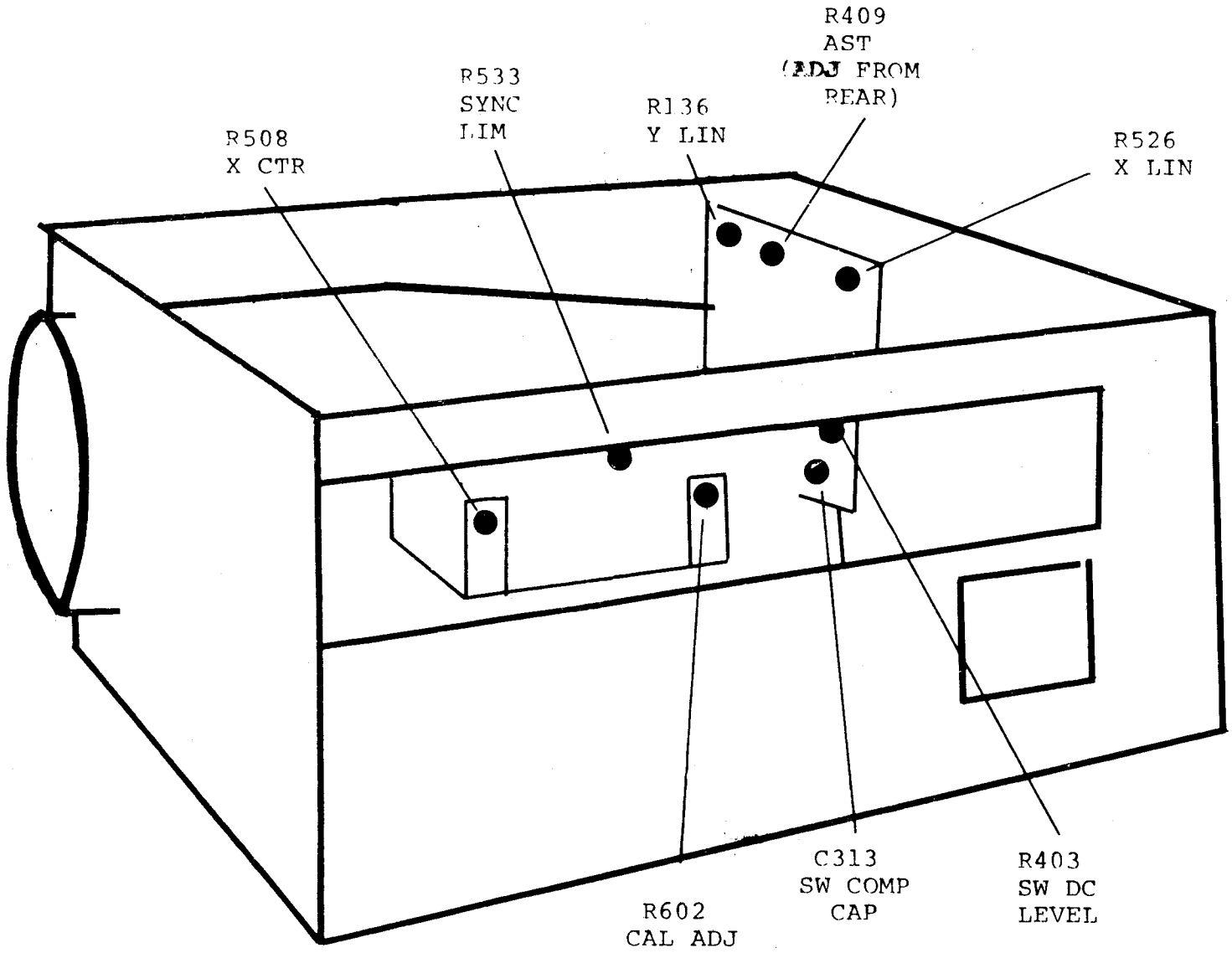


FIGURE 4-2b
IDENTIFICATION OF BACK-OF-PANEL CONTROLS
RIGHT SIDE, TYPE 304-AR

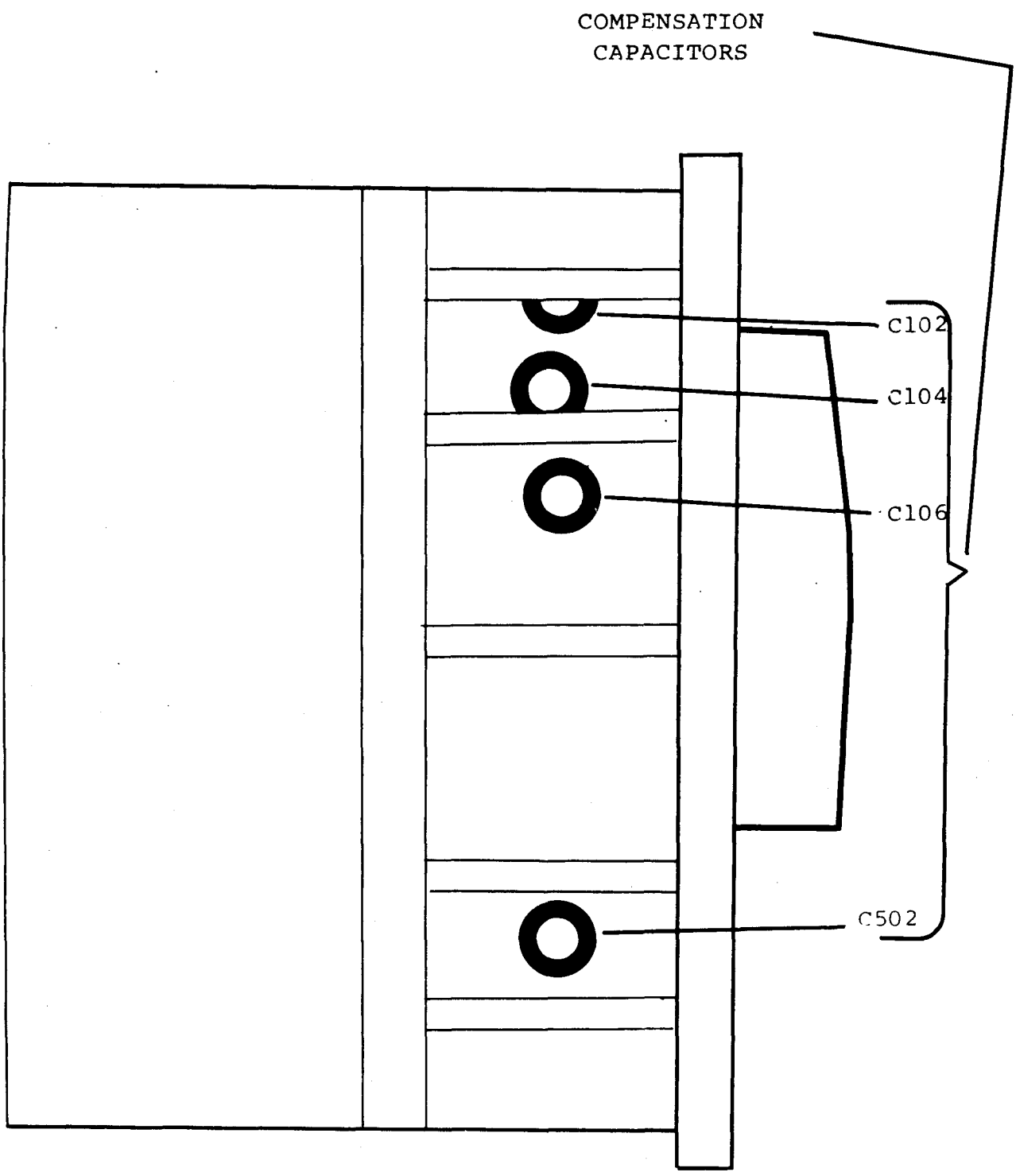


FIGURE 4-3 - IDENTIFICATION OF BACK-OF-PANEL CONTROLS, BOTTOM FRONT

down) with changes in the setting of the MULTIPLIER control. Since this adjustment requires occasional resetting, owing to aging of components, it is made readily accessible to the operator. To set the D-C Balance adjustment, set the VOLTS FULL SCALE switch to the OFF position and the MULTIPLIER control at the extreme left. Position the trace to the vertical center of the cathode-ray tube. Set the MULTIPLIER control to 1, and adjust D-C Balance to return the trace to its previous position. It should now be possible to move the MULTIPLIER control from 10 to 1 without any vertical displacement resulting. Repeat the adjustment procedure if any vertical displacement is observed.

(6) Input Attenuator Compensation Capacitors - The trimmer capacitors C102, C104 and C106 are used for compensating the input attenuator (VOLTS FULL SCALE) in the 1V, 10V, and 100V positions respectively. Compensation should be adjusted by applying a 10-kc square wave to the Y INPUT terminals and adjusting the appropriate trimmer to pass the square wave with minimum of distortion. In Figure 4-4 "A" represents proper adjustments, while "B" and "C" represent conditions of over-compensation and undercompensation, respectively.

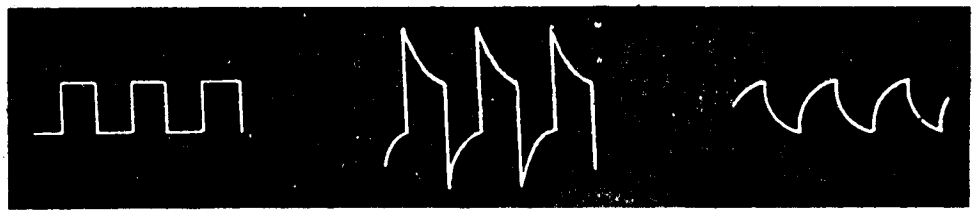


FIGURE 4-4 - WAVEFORMS ENCOUNTERED IN ADJUSTING THE Y ATTENUATOR

d. FACTORY ADJUSTMENTS FOR X AMPLIFIER

(1) Linearity Adjustment (X LIN) - R526 - To set this adjustment, obtain a one-inch sweep in the horizontal center of the screen. Position the pattern 1-1/2 inches to the left and 1-1/2 inches to the right of center; observe whether the horizontal amplitude of the pattern is greater at the left side or the right side of center. Then adjust R526 until the pattern has the same amplitude on both sides of center.

(2) D-C Balance Adjustment (D-C BAL) - R506 - When this control is properly adjusted, there will be no shifting in the zero position (left and right) with changes in the setting of the (X) AMPLITUDE control. Position the trace in the horizontal center of the cathode-ray tube screen. Increase the AMPLITUDE control to 100 (fully clockwise) and adjust the D-C Balance to return the trace to its previous position. It should now be possible to move the AMPLITUDE control over its full range without any horizontal displacement taking place. Repeat the adjustment procedure if any horizontal displacement is observed.

(3) Position Centering Adjustment (X CTR) - R508 - With no signal input (X SELECTOR at OFF) and the X POSITION control at the mechanical center of its range (pointing up), adjust R508 to bring the trace on the cathode-ray tube to the center of the screen horizontally.

(4) X Attenuator Compensation Capacitor - C502 - This adjustment is made by applying the 10-kc square-wave signal to the X INPUT terminals and setting the X SELECTOR switch at 10. It is not necessary to apply a signal to the Y INPUT. Proper adjustment of the X

attenuator is obtained when the dots at each end of the horizontal trace are of maximum relative intensity and in sharpest focus.

e. FACTORY ADJUSTMENTS FOR THE SWEEPS

(1) Driven Sweep Bias (DR SW BIAS) - R319 - To properly adjust for normal operation of the driven sweep, set the SWEEP RANGE switch at the 2-10 cps position; set the SYNC AMPLITUDE control at zero, the SWEEP VERNIER fully clockwise and the SYNC LIMITING (screwdriver) adjustment fully counterclockwise. Push in the CALIBRATOR button, and adjust the MULTIPLIER control for about 0.4 inch vertical deflection. Set the X SELECTOR switch to DRIVEN SWEEP and adjust the driven sweep bias potentiometer until the sweep just stops and a vertical bar appears. Check this setting with the SWEEP VERNIER turned completely counterclockwise also making certain that this adjustment in no way affects normal operation of the sweep on RECURrent. Set the SYNC SELECTOR switch at INT. It should now be possible to trigger the "driven sweep" by rotating the SYNC AMPLITUDE control either way from "0." Check for proper triggering of the "driven sweep" with the SWEEP VERNIER control turned completely counterclockwise. If the sweep fails to trigger in this case, increase the vertical amplitude of the signal to a maximum of 0.75 inches. If the SYNC AMPLITUDE control, when fully advanced, still does not trigger the "driven sweep," the sweep thyratron (V303) may be defective.

(2) SYNC LIMITER (SYNC LIM) - R533 - Adjust the DRiven SWeep BIAS control as outlined in paragraph e (1) above. Adjust pattern for 0.4 inch vertical deflection and advance the SYNC AMPLITUDE control just enough to trigger the sweep. Proper adjustment of the SYNC LIMiter control is obtained by advancing it from its extremely counterclockwise position to a point where the sweep stops and then "backing it off" to a point where the sweep just starts again and is stable.

(3) Sweep DC Level Adjustment (SW DC LEVEL) - R403 - This adjustment should be made so as to allow the sweep to expand equally in both directions as the (X) AMPLITUDE control is advanced.

(4) Sweep-output Attenuator Trimmer - C313 - The sweep-output attenuator is adjusted for optimum linearity and minimum "tail" of the sawtooth waveform, using a frequency of approximately 300 cps. To adjust, set the X SELECTOR at RECURrent SWEEP, SWEEP RANGE switch at 250-1250; connect a test lead from the SAWTOOTH TEST SIGNAL terminal to the Y INPUT terminal and adjust to two-inch vertical deflection. Observe the waveform on the cathode-ray tube screen of the Type 304-A while adjusting the trimmer for minimum "tail" on the sawtooth wave.

(5) Sweep Low-frequency Adjustment (LF ADJ) - R315 - Feed a four-cycle sine-wave signal to the Y INPUT terminal. With SWEEP RANGE set at the 2-10 position and SWEEP VERNIER set at 10, adjust R315 for a two-cycle pattern on the screen.

f. FACTORY ADJUSTMENTS FOR THE VOLTAGE CALIBRATOR

(1) Voltage Calibrator Adjustment (CAL ADJ) - R602 - The voltage calibrator adjustment is set by comparison with a Du Mont Type 264-B Voltage Calibrator or equivalent, connected to the Y INPUT terminals. Set front-panel controls as follows:

CONTROL	POSITION
VOLTS FULL SCALE	0.1
MULTIPLIER	1
X SELECTOR	RECURrent SWEEP
SWEEP RANGE	50-250
SYNC SELECTOR	LINE

Push the CALIBRATOR switch and adjust the SYNC AMPLITUDE and SWEEP VERNIER controls for several cycles display on the cathode-ray tube screen. The proper adjustment is obtained when CAL ADJ (R602) is adjusted to produce the same vertical displacement of the beam (CALIBRATOR switch pushed in) as a 0.1 volt signal from the standard voltage calibrator produces (CALIBRATOR switch released .... e.g. out).

(2) Amplitude Calibration of Y Amplifier

Adjust the front-panel controls as indicated in the preceding paragraph to obtain several cycles display on the screen. Adjust R128 (Y SENsitivity adjustment) for a vertical deflection of four inches. The Y amplifier is now adjusted for a sensitivity of 25 millivolts peak-to-peak per inch at full gain. To release the CALIBRATOR switch, push in.

g. OTHER FACTORY ADJUSTMENTS

(1) Astigmatism Control (AST) - R409 - Apply a 60-cycle sine-wave test signal to the Y INPUT terminal. Synchronize one or two cycles of this signal on the screen, and expand the trace to full-screen diameter. Adjust the FOCUS control for sharpest trace. Then ad-

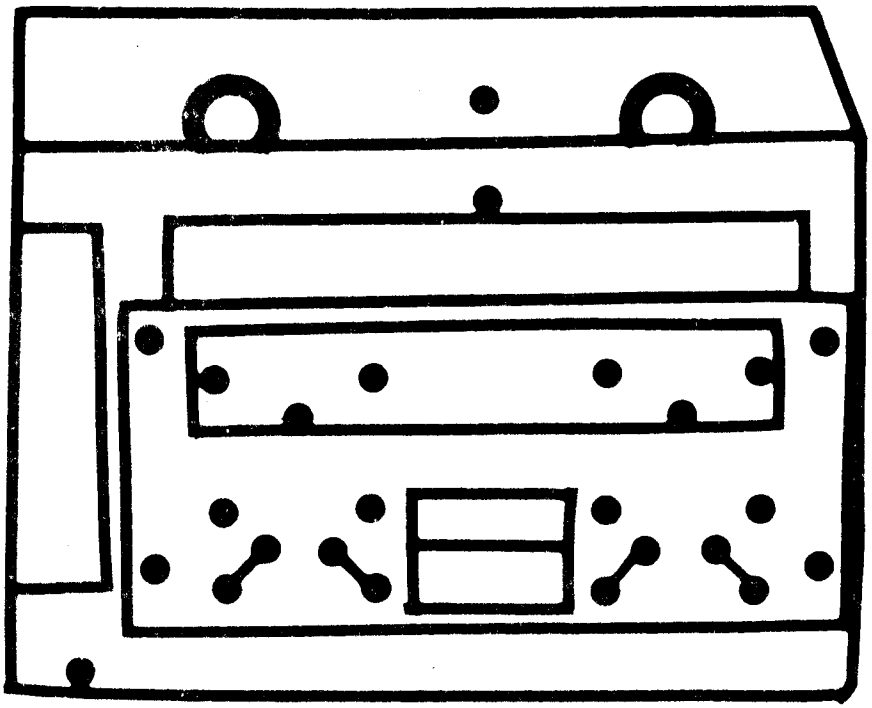


FIGURE 4-5 - REAR PANEL VIEW OF TYPE 304-AR SHOWING AST CONTROL (R409)

just the ASTigmatism control (by means of a screwdriver inserted through the hole provided in the rear of the cabinet) for uniform width of trace from start to finish. It will probably be necessary to readjust the FOCUS control simultaneously with the ASTigmatism potentiometer to maintain best focus. Once properly adjusted, the ASTigmatism control should require no further attention under normal conditions.

6. REPLACEMENT OF CATHODE-RAY TUBE

a. TYPE 304-A

To replace the Type 5ADP - Cathode-ray Tube in the Type 304-A, removal of the old tube may be accomplished as follows: Disconnect the power cord from the line; remove the two screws holding the rear of the cabinet; and carefully slide the instrument forward until it is clear of the cabinet. Detach the circular ring (bezel) and calibrated scale from the front panel by removing the four screws which hold them in place. Next, loosen the screw holding the tube-base clamp. Remove the cathode-ray tube socket, and the intensifier button. The tube may now be removed through the front-panel opening.

Insert the new cathode-ray tube through the front-panel opening and the tube shield. When inserting the tube, the intensifier pin should be on the left side of the tube as viewed from the front of the instrument. Push the tube in far enough so that the base goes into the base clamp provided. Connect the base socket to the tube.

> CAUTION
>
> The cathode-ray tube should be inserted with great care to prevent damage which might result in personal injury. Do not employ force at any time. As an added precaution, wear safety goggles and gloves.

Connect the intensifier button to the intensifier pin. Replace the calibrated scale and the bezel; move the tube forward so that it just touches the scale. Connect the power cord to the line; turn on the instrument and set X SELECTOR to RECURrent SWEEP. If the resulting trace is not horizontal, rotate the tube slightly until it is. Disconnect the power cord from the line and tighten the tube-base clamp.

Slide the instrument back into its cabinet and replace the two screws at the rear which hold the chassis in place.

b. TYPE 304-AR

To replace the Type 5ADP- Cathode-ray Tube in the Type 304-AR, first remove the dust cover by loosening the screws on either side and rear that hold the dust cover to the chassis. In all other respects, removal and replacement of the cathode-ray tube is accomplished in the manner described for the Type 304-A.

7. ILLUMINATED CALIBRATED SCALE

As an aid in amplitude and time calibration, both for visual measurements and for permanent records by photographic recording, an illuminated scale over the face of the cathode-ray tube, provided with a dimmer control, is a part of the Type 304-A. The illumination

lamps are located behind the front panel. To replace a defective lamp, remove the cabinet as indicated in paragraph 5 above. Slide the lamp assembly from the tongue support and replace the defective bulb. To insure proper illumination, when replacing the lamp assembly, make certain that the bulb enters the front-panel aperture provided for it as far as it will go.

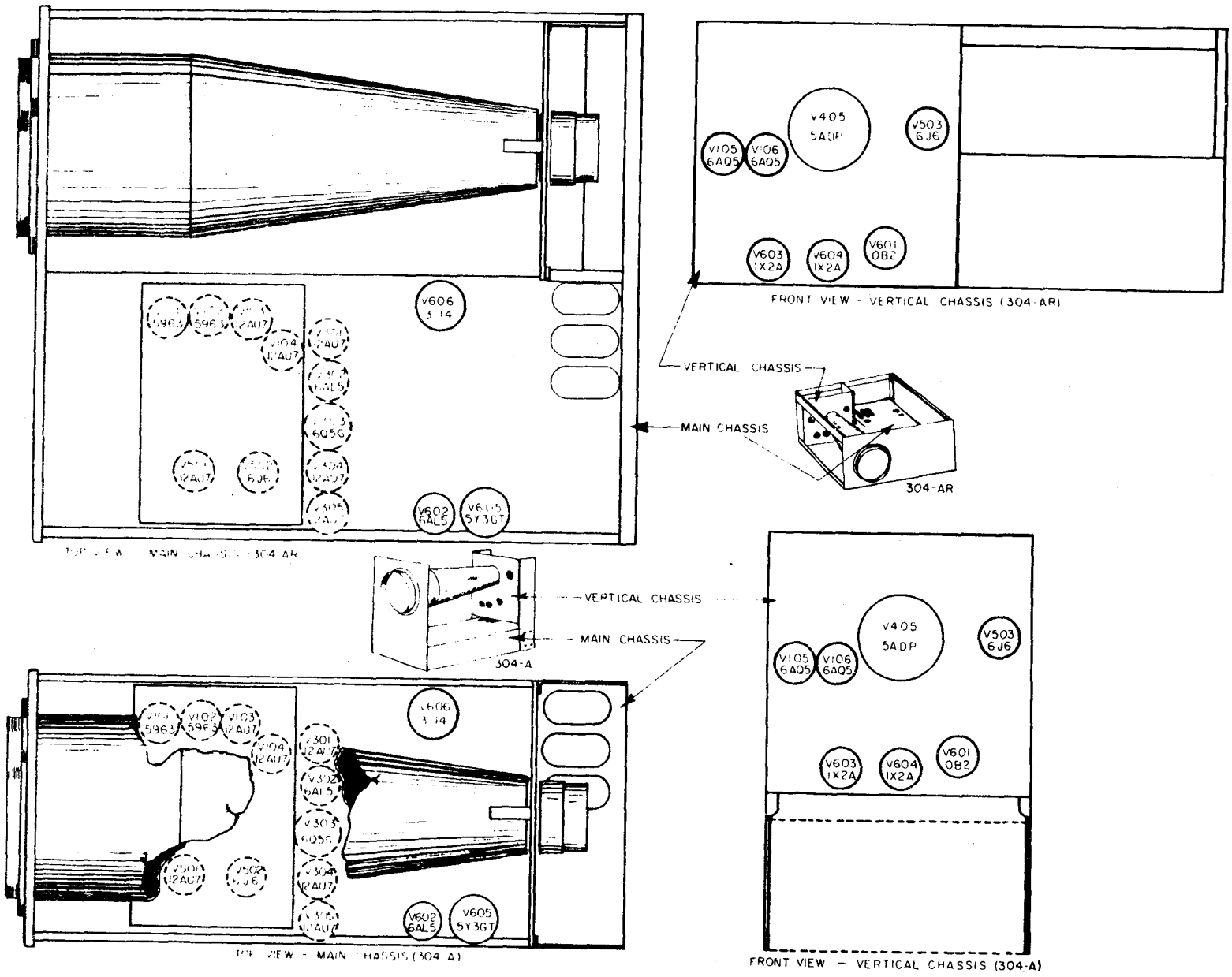


FIGURE 4-6 - TUBE LOCATION DIAGRAM, TYPES 304-A AND 304-AR

TYPES 304-A/304-AR CATHODE-RAY OSCILLOGRAPH

Symbol	Part Number	Description
	CAPACITORS (All capacitors are fixed, mica, ±10%, 500 V unless otherwise specified)	
C101	0300 0460	paper, 0.1 uf +20 -10%, 1000 V
C102	0300 3040	variable, ceramic, 3-12 uuf
C103	0302 0420	82 uuf
C104	0300 3040	variable, ceramic, 3-12 uuf
C105	0302 9440	1000 uuf
C106	0300 3040	variable, ceramic, 3-12 uuf
C107	0303 3640	6800 uuf, 300 V
C108 & C109	0301 5920	ceramic, 0.01 uf, +100 - 0%, 450V
C110 & C111	0300 0460	paper, 0.1 uf, +20 -10%, 1000 V
C112 & C113	0315 2470	composition, 1 uuf, +20%
C301	0301 5920	ceramic, 0.01 uf, +100 - 0%, 450 V
C302	0300 4170	paper, 0.05 uf, +20 - 10%, 600 V
C303 to C305	0313 7100	paper, 0.47 uf, ±20%, 200 V
C306	0302 0450	150 uuf
C307	0302 9440	1000 uuf
C308	0303 3640	6800 uuf, 300V
C309	0300 0040	electrolytic, 25 uf, +150 - 25%, 50V
C310	0300 3160	paper, 0.04 uf, 400V
C311 A,B	0300 3910	paper, 0.5/0.5 uf, +20 - 10%, 600V
C312	0300 0040	electrolytic, 25 uf, +150 - 25%, 50V
C313	0300 3040	variable, ceramic, 3-12 uuf
C314	0302 0430	100 uuf
C401	0301 6360	paper, 0.05 uf, +20 - 10%, 2000 V
C402	0316 4930	ceramic, 0.01 uf, +100 -0%, 2000 V
C403	0301 5340	paper, 1 uf, +30 -20%, 200V
C404	0301 5920	ceramic, 0.01 uf, +100 -0%, 450V
C501	0300 0460	paper, 0.1 uf, +20 -10%, 1000 V
C502	0300 3040	variable, ceramic, 3-12 uuf
C503	0302 0430	100 uuf
C505	0300 0040	electrolytic, 25 uf, +150 -25%, 50 V
C510 & C511	0300 0460	paper, 0.1 uf, +20 -10%, 1000 V
C512	0302 0430	100 uuf
C513 & C514	0315 2470	composition, 1 uuf, ±20%
C601	0301 2470	electroylytic, 80 uf, +40 -10%, 475 V
C602	0313 7620	paper, 2 uf, +20 -10%, 600 V
C603 to C605	0301 7750	paper, 0.5 uf, +20 -10%, 2000 V
C606 A,B,C,D	0300 2350	electrolytic, 10/10/10/10 uf, +70 -20%, 450 V
C607	0300 0220	electrolytic, 4 uf, +75 -25%, 450 V
	REGULATOR, NEON	
E401	1200 3960	lamp, glow, NE-2
	FUSES	
F601	1100 0770	1.5 amperes, 115-volt operation
	1100 0750	0.75 ampere, 230-volt operation
	LAMPS	
I401 to I405	1200 1310	incandescent, bayonet, 150 ma, 6.3 V
	CONNECTORS, ELECTRICAL, FEMALE	
J101 & J102	5101 7950	post, binding, black, captive head
J103	5100 7080	post, binding, black, non-captive head
J301 & J302	5101 7950	post, binding, black, captive head
J401	5101 7950	post, binding, black, captive head
J501 & J502	5101 7950	post, binding, black, captive head

Symbol	Part Number	Description
	INDUCTOR	
L601	2101 7281	10 h
	RESISTORS (Resistance values in ohms; K=thousand, M=million. All resistors are fixed, composition, ±10%, 1/2 W unless otherwise specified)	
R101	0221 8440	250K, ±1%
R102	0221 8430	20.4K, ±1%
R103	0221 8420	2K, ±1%
R104 & R105	0221 8450	2M, ±1%
R106	0204 1270	2M, ±5%
R107 & R108	0203 2050	220K
R109	0203 1850	4700
R110	0105 3500	variable, 2K, ±20%, 1/4 W
R111	0203 1850	4700
R112	0101 8600	variable, 25K, ±20%
R113	0203 0540	1800, ±5%
R114	0203 0520	1500
R115	0203 0740	12K, ±5%
R116	0101 1400	variable, 1200, ±20%
R117	0203 0740	12K, ±5%
R118 to R120	0203 6800	22K, ±5%, 2 W
R121	0101 4090	variable, 2 K, ±20%
R122	0203 6800	22K, ±5%, 2 W
R123 & R124	0204 1200	1M, ±5%
R125	0203 0700	8200, ±5%
R126 & R127	0203 0800	22K, ±5%,
R128	0101 4030	variable, 50K, ±20%
R129	0203 0820	27K, ±5%
R130 & R131	0203 0660	5600, ±5%
R132 to R134	0203 1610	47
R135	0203 7970	47K, 2 W
R136	0105 3990	variable, 100K, ±20%, 2 W
R137 & R138	0210 8110	wire wound, 25K, ±5%, 10 W
R139 & R140	0203 2210	4.7M
R141 & R142	0203 2170	2.2M
R143	0203 6960	100K, ±5%, 2 W
R144	0105 3600	variable, wire wound, 1K ±20%, 1-1/2 W
R145	0203 0930	75K, ±5%
R301	0203 2170	2.2M
R302	0203 2130	1M
R303	0203 2170	2.2M
R304	0203 0540	1800, ±5%
R305	0203 0700	8200, ±5%
R306	0203 1890	10K
R307	0203 5010	100K, 1 W
R308	0101 6220	variable, 200K, ±20%
R309	0203 2050	220K
R310	0203 0540	1800, ±5%
R311	0203 2010	100K
R312	0203 1910	15K
R313	0203 6960	100K, ±5%, 2 W
R314	0203 0480	1K, ±5%
R315	0102 3910	variable, wire wound, 2K, ±20%, 1-1/2 W
R316	0101 4390	variable, 250K
R317	0203 0790	20K, ±5%
R318	0203 7990	68K, 2 W
R319	0101 4030	variable, 50K, ±20%
R320	0203 2050	220K
R321	0203 1910	15K
R322	0204 1200	1M, ±5%
R323	0204 1040	220K, ±5%
R324	0203 8010	100K, 2 W
R325	0203 1910	15K
R326	0203 2060	270K

Symbol	Part Number	Description
R401	0203 2170	2.2M
R402	0203 2050	220K
R403	0101 4030	variable, 50K, ±20%
R404	0203 7140	560K, ±5%, 2 W
R405	0100 8860	variable, 200K, ±20%
R406	0203 5050	220K, 1 W
R407	0100 8780	variable, 100K, ±20%
R408	0203 1910	15K
R409	0105 3990	variable, 100K, ±20%, 2 W
R410	0203 0930	75K, ±5%
R411	0104 4422	variable, wire wound, 6, 2 W
R412	0203 2050	220K
R501	0204 1270	2M, ±5%
R502	0204 1040	220K, ±5%
R503	0203 1610	47
R504	0203 0720	10K, ±5%
R505	0203 1850	4700
R506	0105 3510	variable, 10K, ±20%, 1/4 W
R507	0203 0680	6800, ±5%
R508	0101 4080	variable, 1K, ±20%
R509	0203 0480	1K, ±5%
R510	0101 4500	variable, 10K, ±20%
R511	0203 4160	680K, ±5%, 1 W
R512	0203 1970	47K
R513	0203 2170	2.2M
R514	0101 8600	variable, 25K, ±20%
R515	0203 0540	1800, ±5%
R516	0203 1610	47
R517	0203 0660	5600, ±5%
R518	0203 1160	680K, ±5%
R519	0204 1000	150K, ±5%
R520 & R521	0203 0720	10K, ±5%
R522 & R523	0203 1610	47
R524	0203 4900	12K, 1 W
R525	0203 6890	51K, ±5%, 2 W
R526	0105 3960	variable, 25K, ±20%, 2 W
R527	0203 6890	51K, ±5%, 2 W
R528 & R529	0203 2210	4.7M
R530 & R531	0203 2170	2.2M
R532	0203 3870	43K, ±5%, 1 W
R533	0102 3920	variable, wire wound, 3K, ±20%, 1-1/2 W
R601	0210 6800	wire wound, 10K, ±5%, 20 W
R602	0105 3700	variable, wire wound, 1K, 2 W
R603	0203 8060	270K, 2 W
R604	0203 5010	100K, 1 W
R605	0203 8250	10M, 2 W
R606	0203 8030	150K, 2 W
R607	0206 3810	820K, ±5%, 1 W
R608	0203 1970	47K
RT601	0214 2600	current regulator, 3-14
	SWITCHES (All rotary switches are phenolic and the angle of throw is 30° between positions unless otherwise specified)	
S101	0500 3232	rotary, 2 sections, 3 poles, 9 positions
S102	0500 6793	push push, 2P2T
S301	0500 6541	rotary, 60°, 1 section, 1 pole, 3 positions.
S302	0500 6571	rotary, 2 sections, 3 poles, 7 positions
S501	0500 6561	rotary, 2 sections, 4 poles, 7 positions
S601	0500 0420	slide, DPDT
S602	0104 4422	part of R411, on-off switch
	TRANSFORMERS	
T601	2000 7792	power, 50-400 cycles

Symbol	Part Number	Description
	TUBES	
V101 to V104	2501 1610	ECC82/12AU7
	2500 0130	Alternate for 2501 1610
V105 & V106	2501 1750	6AQ5A
	2500 0340	Alternate for 2501 1750
V301	2501 1610	ECC82/12AU7
	2500 0130	Alternate for 2501 1610
V302	2500 0020	6AL5
V303	2500 0640	6Q5G
V304	2501 1610	ECC82/12AU7
	2500 0130	Alternate for 2501 1610
V305	2501 1610	ECC82/12AU7
	2500 0130	Alternate for 2501 1610
V401	2500 7390*	5ADP1
	2500 7400*	5ADP2
	2500 7410*	5ADP4
	2500 7420*	5ADP7
	2500 7430*	5ADP11
	2500 7440	5ADP31
	* Depending on sales order	
V501	2501 1610	ECC82/12AU7
	2500 0130	Alternate for 2501 1610
V502 & V503	2500 0190	6J6
V601	2500 0360	OB2
V602	2500 0020	6AL5
V603 & V604	2500 6490	1X2A
V605	2500 0220	5Y3GT
	CABLE	
W601	5026 9641	assembly, power, electrical, 3-conductor, #18 AWG, 72 inches

45003801	SCALE, ILLUM
48003311	FILTER, GREEN
48003312	FILTER, BLUE
48003313	FILTER, AMBER