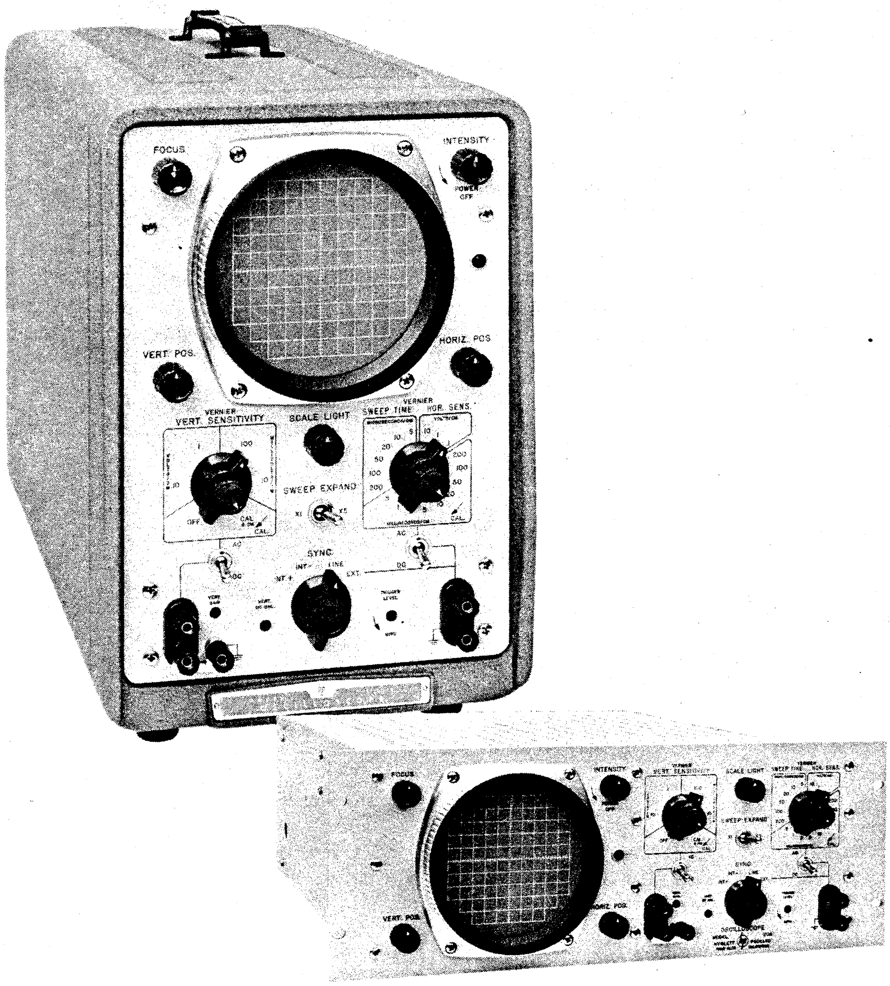
OPERATING AND SERVICING MANUAL

MODEL 120A/AR
OSCILLOSCOPE

SERIALS PREFIXED: 051 -

Stock No. 120A-900



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SPECIFICATIONS

SWEEP

Sweep Range:	1 μsec/cm to at least 0.5 sec/cm. 15 calibrated sweeps, accurate to within $\pm 5\%$, in a 1,2,5,10 ... sequence, 5 μsec/cm to 200 millisec/cm. Vernier permits continuous adjustment of sweep time between calibrated steps and extends the 200 millisec/cm step to at least 0.5 sec/cm.
Sweep Expand:	X5 sweep expansion may be used on all ranges and expands fastest sweep to 1 μsec/cm. Expansion is about the center of the CRT and expanded sweep accuracy is $\pm 10\%$.
Synchronization:	Automatic from 50 cps to 250 kc; internally from vertical deflection signals causing 1/2 cm or more vertical deflection; from external signals at least 2.5 volts peak-to-peak, and from line voltage.
Trigger Point:	Zero crossing, negative slope of external sync signals, zero crossing, positive or negative slope of vertical deflection signals. Screwdriver operated control overrides automatic and permits the trigger point to be set between -10 to +10 volts. Turning fully counterclockwise into auto restores automatic operation.

VERTICAL AMPLIFIER

Bandwidth:	DC coupled: dc to 200 kc. AC coupled: 2 cps to 200 kc. Bandwidth is independent of sensitivity setting.
Sensitivity:	10 millivolts/cm to 100 volts/cm. Four calibrated steps accurate within $\pm 5\%$, 10 mv/cm, 100 mv/cm, 1 v/cm, and 10 v/cm. Vernier permits continuous adjustment of sensitivity between steps and extends 10 v/cm step to at least 100 v/cm.
Internal Calibrator:	Calibrating signal automatically connected to vertical amplifier for standardizing of gain, accuracy $\pm 2\%$.
Input Impedance:	1 megohm, approximately 50 pf shunt.
Balanced Input:	On 10 mv/cm range. Input impedance 2 megohms shunted by approx. 25 pf.
Common Mode Rejection:	Rejection at least 40 db. Common mode signal must not exceed ± 3 volts peak.
Phase Shift:	Vertical and horizontal amplifiers have same phase characteristics within $\pm 2^{\circ}$ to 100 kc when verniers are fully clockwise.

HORIZONTAL AMPLIFIER

Bandwidth:	DC coupled: dc to 200 kc. AC coupled: 2 cps to 200 kc. Bandwidth is independent of attenuator setting.
Sensitivity:	0.1 volt/cm to 100 volts/cm. Three calibrated steps, accurate within $\pm 5\%$, 0.1 v/cm, 1 v/cm, and 10 v/cm. Vernier permits continuous adjustment of sensitivity between steps and extends 10 v/cm step to at least 100 v/cm.
Input Impedance:	1 megohm, nominal, shunted by approximately 60 pf.
Phase Shift:	Horizontal and vertical amplifiers have same phase characteristics within $\pm 2^{\circ}$ to 100 kc when verniers are fully clockwise.

SPECIFICATIONS (Cont'd)

GENERAL

Cathode Ray Tube: 5AQP1 mono-accelerator normally supplied; 2500 volt accelerating potential. P7 and P11 phosphors are also available. P2 is available if desired for special applications.

CRT Bezel: Light proof bezel provides firm mount for oscilloscope camera and is removed easily for quick change of filter.

CRT Plates: Direct connection to deflection plates via terminals on rear. Sensitivity approximately 20 v/cm.

Intensity Modulated: Terminals on rear. +20 volts to blank trace of normal intensity.

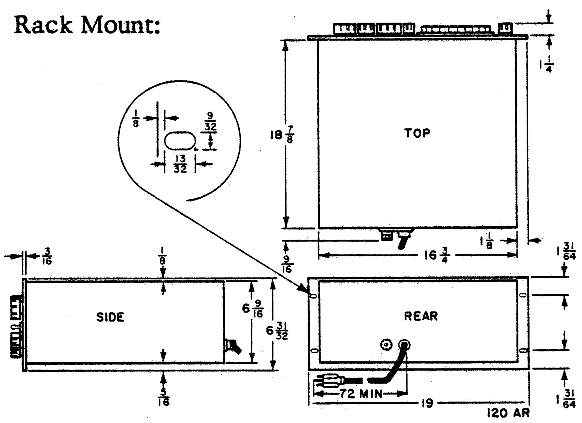
Filter Supplied: Color of filter compatible with CRT Phosphor supplied:

Green with P1 and P2
Amber with P7
Blue with P11

Illuminated Graticule: Edge lighted with controlled illumination, 10 cm x 10 cm, marked in cm squares. Major horizontal and vertical axes have 2 mm subdivisions.

Dimensions: Cabinet Mount: 9-3/4 in. wide, 15-5/8 in. high, 20-3/4 in. deep.

Rack Mount:



Weight: Cabinet Mount: Net 34 lbs; shipping 43 lbs.
Rack Mount: Net 32 lbs; shipping 48 lbs.

Power: 115/230 volts ±10%, 50-1000 cps; 130 watts.

Equipment Slides: Can be installed at the factory on special order for easy withdrawal of rack mount from equipment rack. ⓗⓟ Specification C01 120AR.

Accessories Available: AC-83A Viewing Hood; face-fitting molded rubber.

CONTENTS

SECTION I
GENERAL DESCRIPTION

1-1 GENERAL INFORMATION

The Model 120A dc to 200 kc Oscilloscope is a general purpose oscilloscope employing a 5AQP- mono-accelerator precision type cathode-ray tube. It can be used with either internal or external sweeps which can be either internally or externally synchronized and it can be obtained in either the cabinet or rack type mounting. Because of its high sensitivity and balanced input, the Model 120A may often be used directly with transducers, enabling you to see a direct presentation of phenomena desired without having to resort to preamplifiers. The balanced vertical amplifier may also be used as a differential amplifier amplifying the desired signals and rejecting extraneous induced signals.

The operation of all panel controls is discussed in Section II. Because of the straight-forward arrangement of the panel and conventional designations, the Oscilloscope is easy to operate.

Some of the special features of this oscilloscope are as follows:

DIRECT READING SWEEP TIMES

When you are using the 120A computations are avoided and possibilities of error are reduced by direct reading, calibrated sweeps. A single knob selects 15 calibrated sweeps from 5 microseconds/cm to 200 milliseconds/cm or determines the calibrated sensitivity of the horizontal amplifier. Continuous control of sweep time and horizontal sensitivity between calibrated steps is provided by a vernier control which also extends the 200 milliseconds/cm sweep time to at least 0.5 sec/cm and lowers the sensitivity of the 10 volt/cm step of the horizontal amplifier to at least 100 volts/cm.

LINEAR INTEGRATOR SWEEP GENERATOR

The accurate direct reading sweeps are obtained from a feedback type integrator which insures a high order linearity and stability. This type of sweep generator is more reliable and independent of tube characteristics than other types of sweep generator.

X5 SWEEP EXPANSION

You speed observation and analysis of transients by expanding a two centimeter segment of the trace to 10 centimeters for easy viewing of detail. This X5 sweep expander, may be used on all sweep time settings and expands the fastest sweep time to 1 microsecond/cm.

UNIQUE AUTOMATIC TRIGGERING

No time is wasted adjusting trigger controls on the ⓗ Model 120A, it's automatic, just connect the synchronizing signal to obtain a stable, steady trace. The automatic trigger ends hunting for the spot and facilitates establishing a base line when a synchronizing signal is not present because this circuit triggers the sweep generator to provide a baseline on the CRT in the absence of a synchronizing signal. The automatic baseline provision may be easily and quickly locked-out and an adjustable trigger level established. This lockout is located just behind the front panel where it is easily accessible with a screwdriver.

CALIBRATED AMPLIFIERS

Accurate voltage measurements on all kinds of waveforms are quickly made with the 120A, the amplifiers are calibrated and accurate within ±5%. A built-in calibrator which is accurate within ±2% permits quick verification and standardization of vertical amplifier sensitivity.

Phase shift measurements can be made accurately with this oscilloscope over a wide range of input frequencies. Relative phase shift between the vertical and horizontal amplifiers is less than 2° at 100 kc.

CABINET AND RACK MOUNTING

The ⓗ Model 120A Oscilloscope is available as a cabinet mount for bench or portable use and as a rack mount for installation in a standard 19 inch equipment rack. Only 7 inches of rack space is required for the 120AR and it may be supported in the rack by the front panel or on slides for easy withdrawal from the rack. Since both models are electrically identical and differ only in mechanical placement, this book applies to both models.

The equipment slides are available for the rack mount model at extra cost. They can also be installed at the factory on special order.

1-2 DAMAGE IN TRANSIT

After unpacking this instrument should any shipping damage become evident, refer to the "Claim for Damage in Shipment" paragraph on the warranty sheet in this manual.

1-3 POWER CORD

The three conductor power cable supplied with the instrument is terminated in a polarized three prong male connector recommended by the National Electrical Manufacturer's Association. The third contact is an offset round pin added to a standard two-blade ac plug which grounds the instrument chassis when used with the appropriate receptacle. To use this plug in a standard two contact outlet an adapter should be used to connect the NEMA plug to the two contact system. When the adapter is used the ground connection becomes a short lead from the adapter which can be connected to a suitable ground for the protection of operating personnel.

SECTION II
OPERATING INSTRUCTIONS

2-1 CONTROLS AND TERMINALS

Refer to Figure 2-1 for a complete explanation of the panel controls and terminals.

2-2 SYNCHRONIZATION

The Model 120A Oscilloscope may be adjusted to synchronize in reference to the input signal, the power line frequency or from an external signal.

In addition, in the internal synchronization positions, the slope and trigger level point may be adjusted. First, the polarity of the presentation on the screen of the cathode-ray tube may be adjusted by turning the SYNC switch to start the sweep on either a positive going (INT+) or a negative going (INT-) part of the waveform. If automatic sweep triggering at a zero voltage level is not desired, rotate the TRIGGER LEVEL control out of the AUTO position. Further rotation of the control will adjust the trigger level point on the incoming waveform at which the sweep will start.

The 120A features automatic sweep. This special circuit presents a trace on the face of the cathode-ray tube in the absence of an input. As soon as a signal is fed in the input the signal takes control of the sweep and triggers the sweep generator at the frequency of the input signal.

2-3 CALIBRATOR

An internal square-wave calibrator, with a nominal frequency of 400 cps, is provided for checking vertical amplifier calibration accuracy. The calibrator 60 millivolt output is connected internally to the vertical amplifier when the VERT. SENSITIVITY switch is placed in the CAL. position. No provision is made for internal connection between the horizontal amplifier and the calibrator. Horizontal amplifier calibration can be checked easily, since an external signal can be measured on the vertical amplifier and then applied to the horizontal amplifier.

2-4 AC OR DC COUPLING

AC coupling permits high gain to be employed without regard for the dc level involved. In the AC position the input signal (vertical or horizontal) is coupled to the amplifier through a capacitor which removes the dc component from the input. This coupling circuit has a low frequency cut-off at 2 cps. To avoid degrading input pulses or square waves below 200 cps it is advisable to use dc coupling. WHEN USING DC COUPLING THE DC COMPONENT MAY BE LARGE ENOUGH TO DEFLECT THE TRACE OFF THE FACE OF CRT. IF YOU ARE UNABLE TO FIND THE TRACE WITH THE VERTICAL POSITION CONTROL TRY AC COUPLING. When AC coupled the maximum dc that may be applied is 600 volts.

2-5 OPERATING PROCEDURES

Basic operating procedures are illustrated in the drawings that follow. Directions are given for the cabinet model but are the same for the rack mount model except that the placement of the controls is different.

The first two procedures are complete. The others are arranged to supplement the first two by showing the variations possible in using the oscilloscope. An index to these illustrations follows:

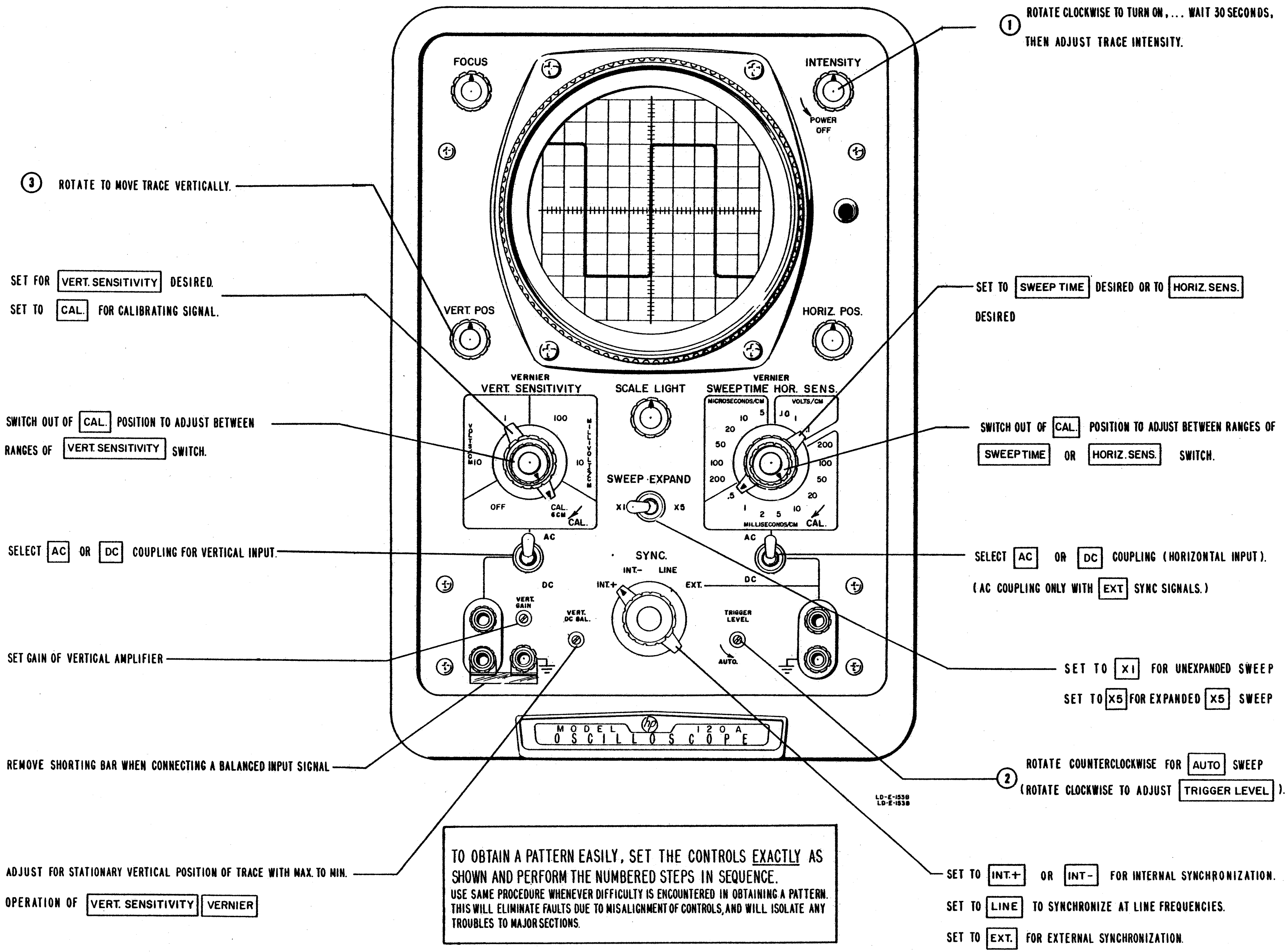
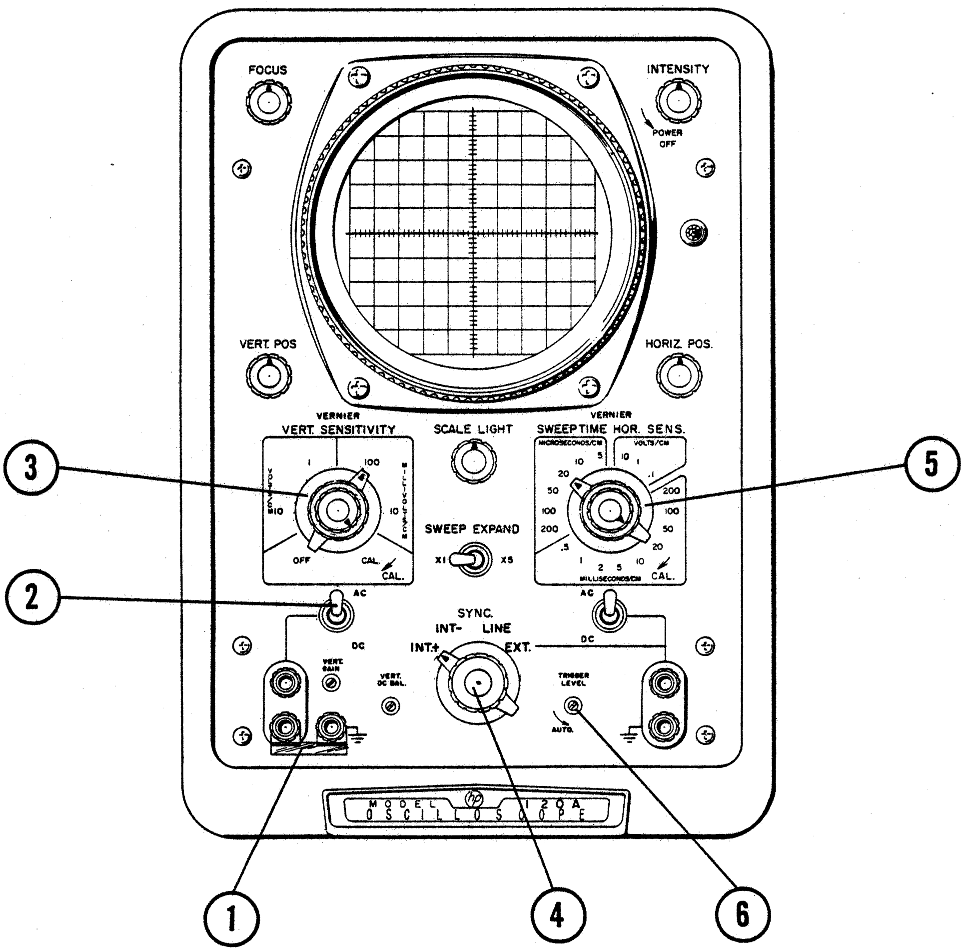


Figure 2-1. Front Panel Control Diagram

INTERNAL SWEEP—INTERNAL SYNCHRONIZATION



1. Feed vertical input signal to vertical INPUT terminals. Remove jumper to use balanced input (10 mv only).

2. Set AC-DC switch for type coupling desired.

3. Adjust VERTICAL SENSITIVITY control for desired sensitivity.

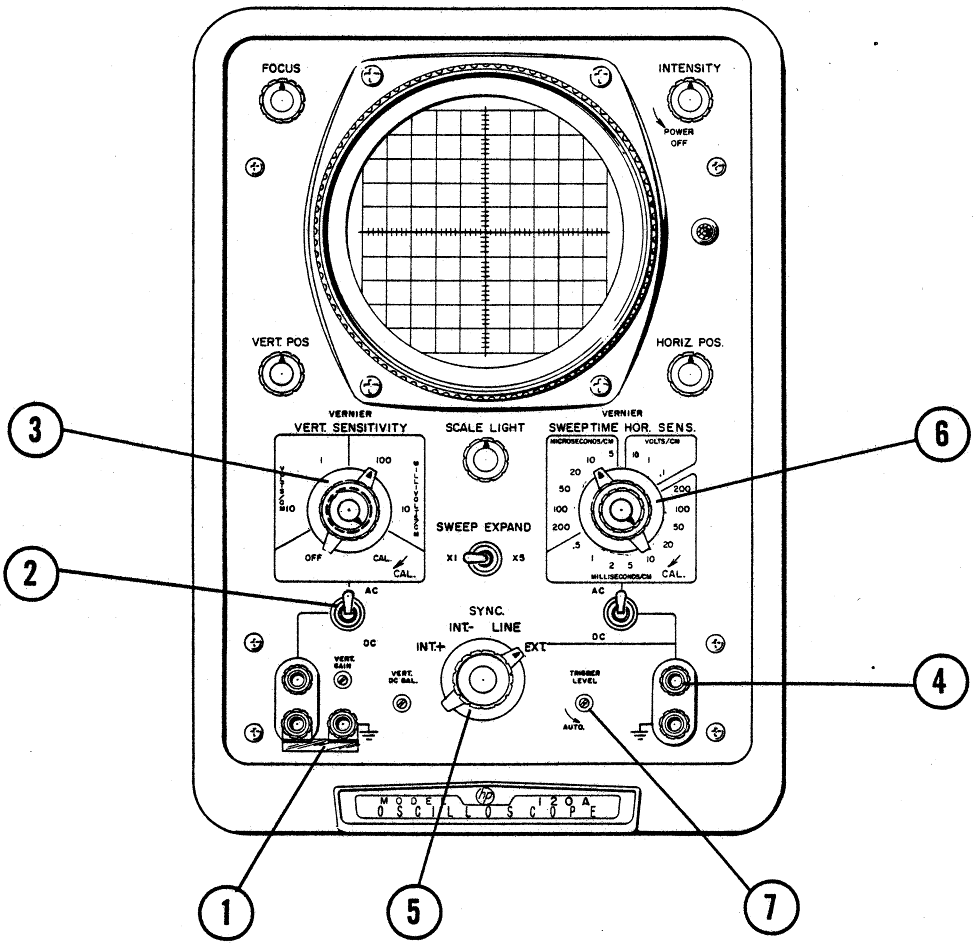
4. Set SYNCHRONIZATION switch to INTERNAL + or - , depending upon slope of trigger point desired.

5. Adjust SWEEP TIME-HORIZONTAL SENSITIVITY control for desired sweep speed.

6. If AUTOMATIC sweep is not desired, rotate TRIGGER LEVEL control to select level of trigger point.

Figure 2-2

INTERNAL SWEEP - EXTERNAL SYNCHRONIZATION



1. Feed vertical input signal to vertical input terminals. Remove jumper for balanced input (10 mv only).

2. Set AC-DC switch to type of input coupling desired.

3. Adjust VERTICAL SENSITIVITY control for desired deflection.

4. Feed external synchronization signal to horizontal input terminals (ac coupling only with external synchronization).

5. Set SYNCHRONIZATION switch to EXTERNAL.

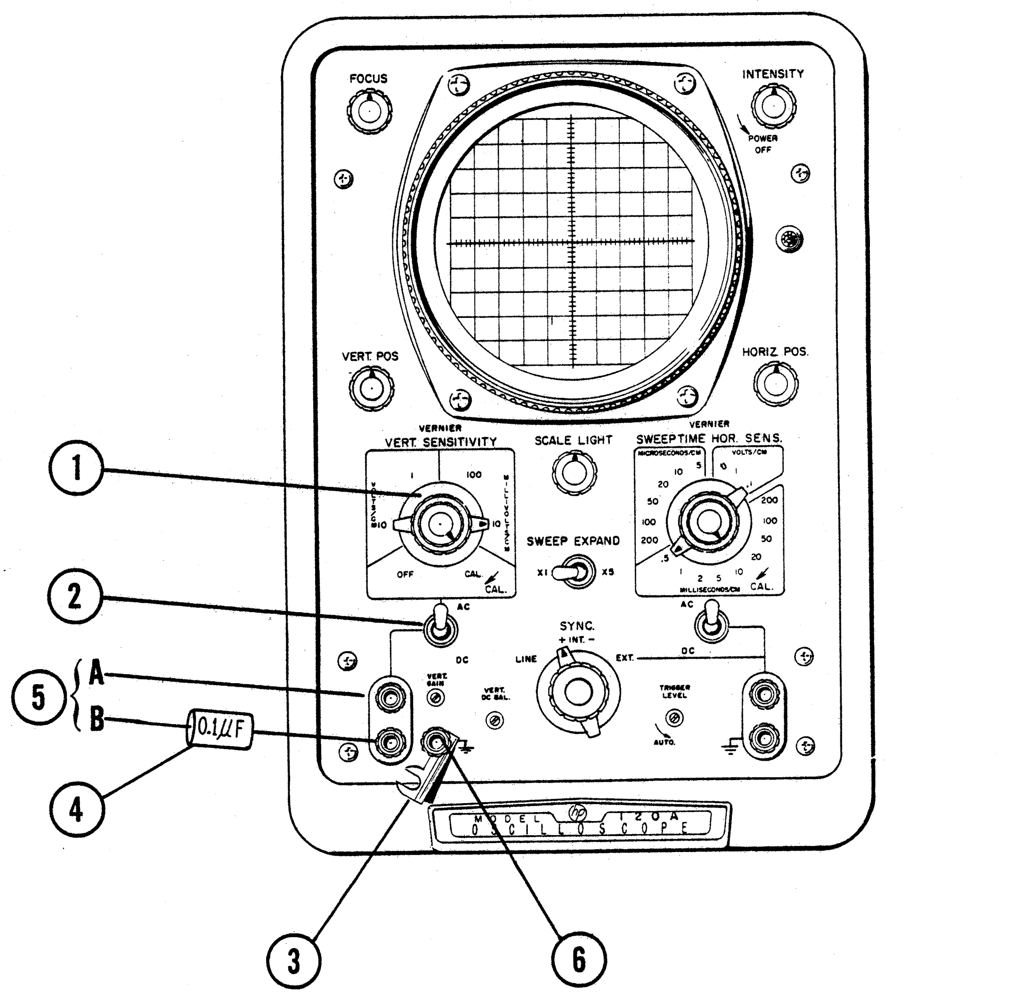
6. Adjust SWEEP TIME HORIZONTAL SENSITIVITY control for desired sweep speed.

7. Set TRIGGER LEVEL control to AUTOMATIC sweep or rotate TRIGGER LEVEL control to desired trigger-level point.

This procedure is useful when it is desired to observe phenomena occurring at random intervals.

Figure 2-3

AC COUPLING—BALANCED INPUT

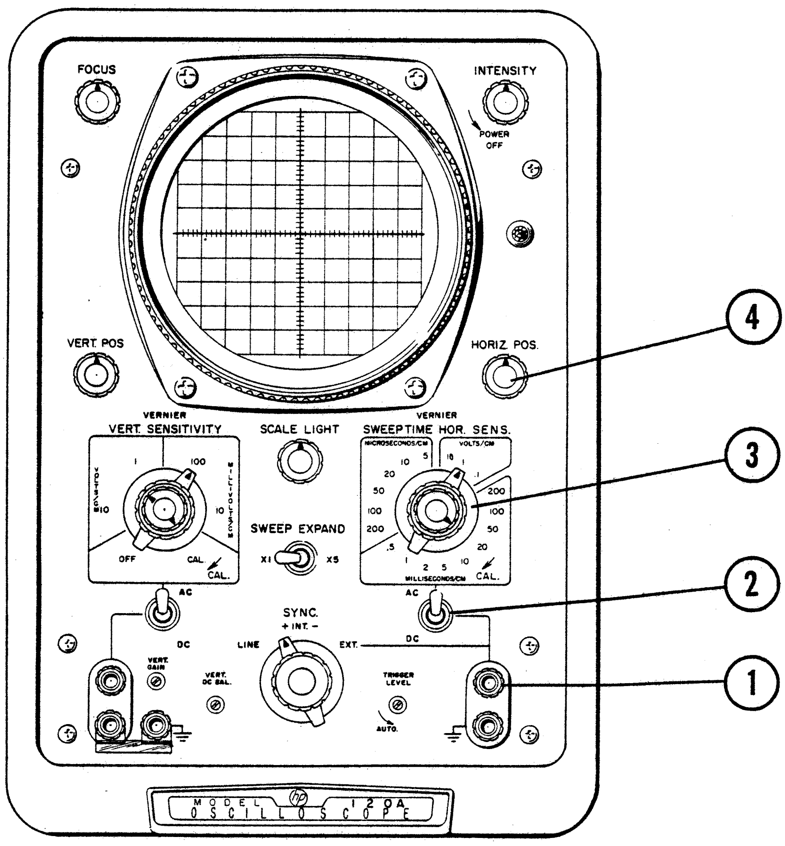


1. Set VERTICAL SENSITIVITY control to 10 millivolts/cm, input not balanced on higher ranges.
2. Set AC-DC switch to AC.
3. Disconnect shorting strap.
4. Connect 0.1 microfarad capacitor to bottom red terminal.
5. Connect input signal to A and B.
6. Ground input at the black terminal.

The capacitor must be used to block any dc.

Figure 2-4

EXTERNAL HORIZONTAL INPUT



RO/B

1. Apply signal to horizontal input terminals.

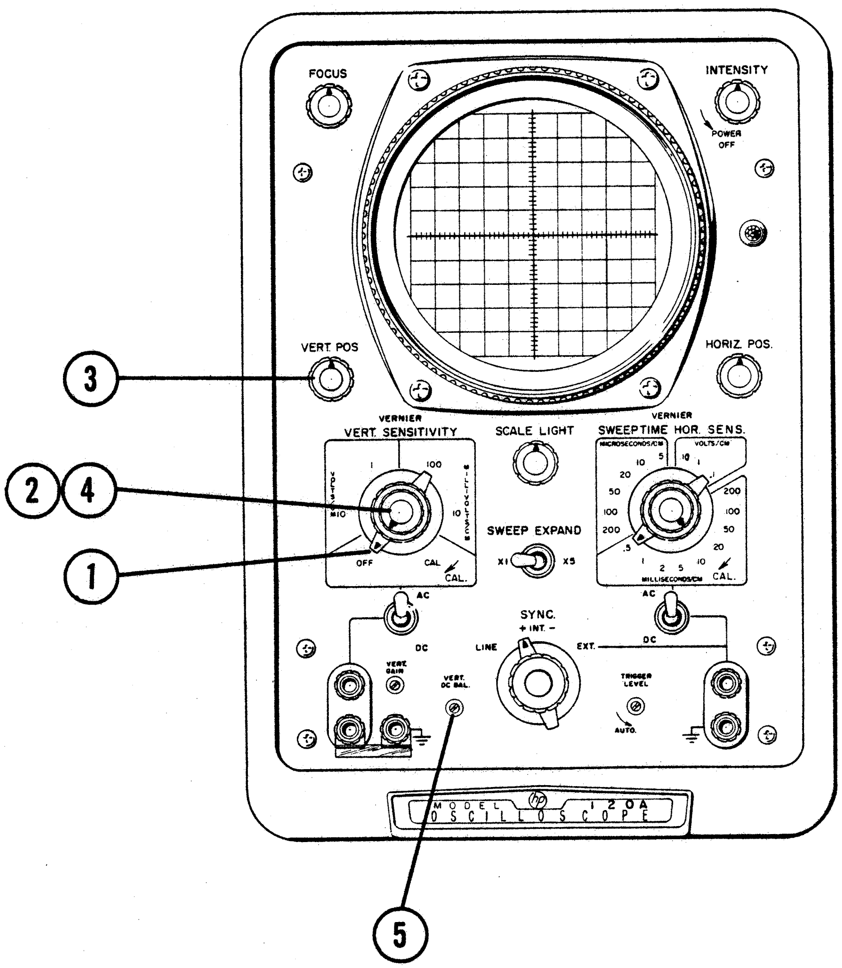
2. Set AC-DC switch for type input coupling desired.

3. Set SWEEP TIME-HORIZONTAL SENSISIVITY control for desired sensitivity.

4. Adjust horizontal position of pattern with HORIZONTAL POSITION control.

Figure 2-5

VERTICAL BALANCE ADJUSTMENT



1. Set VERTICAL SENSITIVITY control to OFF.

2. Turn VERNIER full counter-clockwise.

3. Center trace or spot vertically with VERTICAL POSITION control.

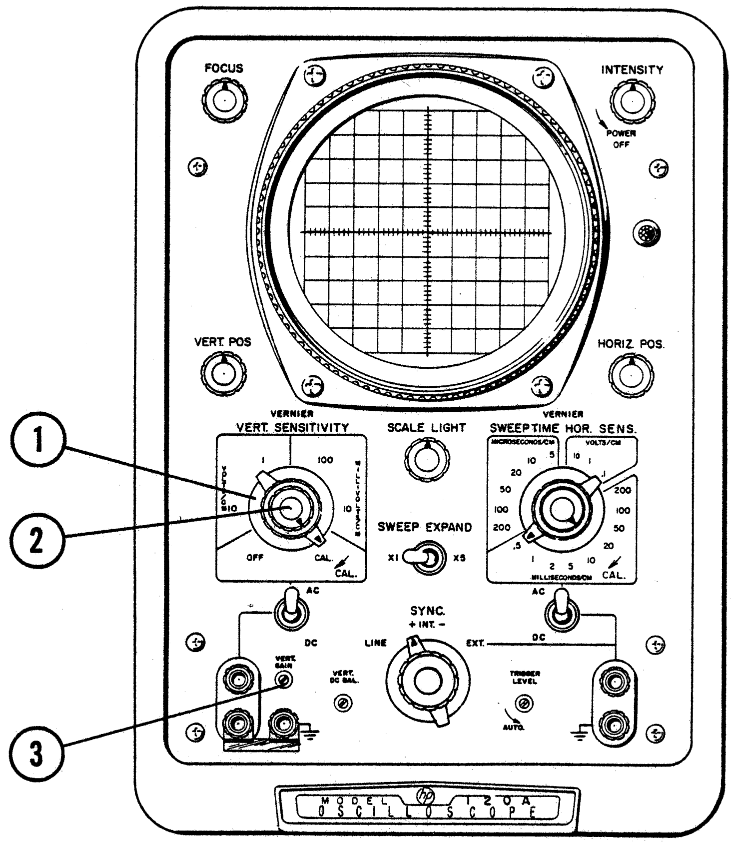
4. Turn VERNIER full clockwise.

5. Adjust VERTICAL DC BALANCE control to center trace or spot.

Repeat steps 2 through 5 until the trace or spot doesn't move as the VERNIER control is rotated.

Figure 2-6

VERTICAL SENSITIVITY CALIBRATION



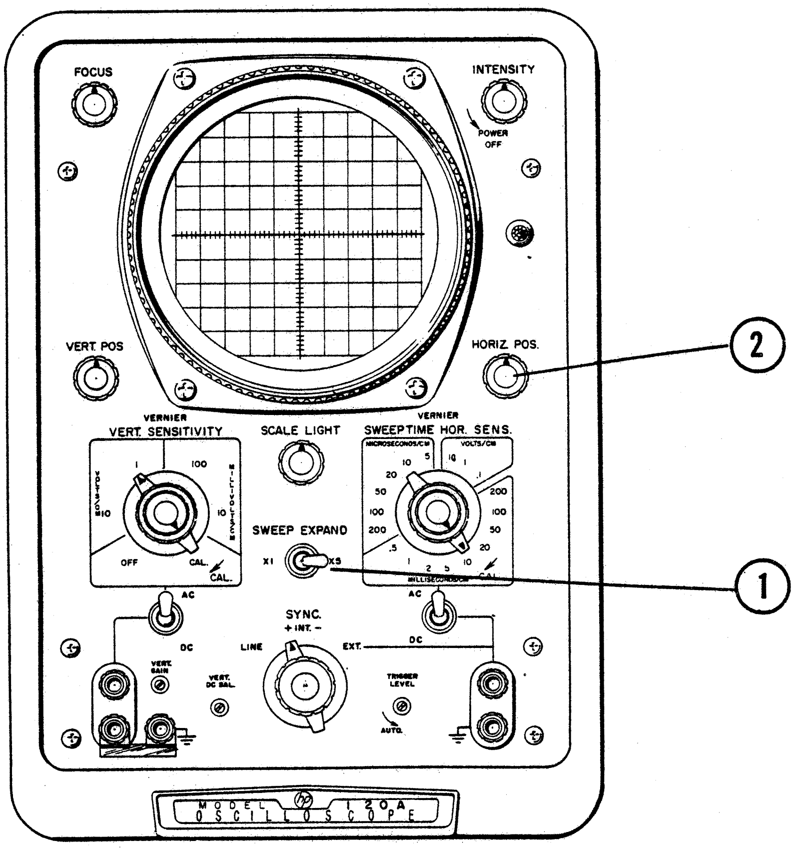
RO/B

1. Set VERTICAL SENSITIVITY control to CAL.
2. Set VERNIER to CAL.
3. Adjust VERT. GAIN control to give a pattern height of 6 centimeters.

The vertical amplifier is now calibrated so that the engraved markings on the VERTICAL SENSITIVITY control are accurate within ±5% whenever the VERNIER control is in the CAL. position.

Figure 2-7

INTERNAL SWEEP MAGNIFICATION



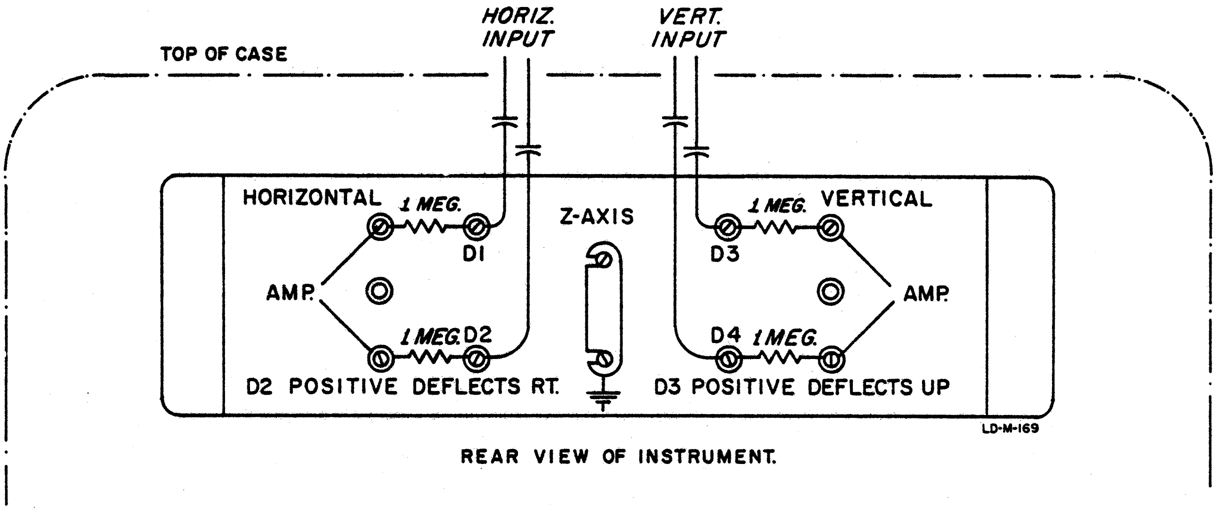
RO/B

1. Set the SWEEP EXPAND switch to X5.
2. Position the trace with the HORIZ. POS. control to view the desired portion of the trace.

With the SWEEP EXPAND switch in X5, the true sweep speed is the SWEEP TIME switch indication divided by 5.

Figure 2-8

CONNECTION TO DEFLECTION PLATES



RO

CAUTION - Deflection plates of cathode-ray tube operate at high dc potentials. TURN 120A OFF BEFORE REMOVING COVER PLATE FROM DEFLECTION PLATE TERMINALS.

To connect an external signal to the deflection plates:

A. AC COUPLED

1. Remove the jumpers going to terminals D1 and D2 for horizontal input and/or D3 and D4 for vertical input.
2. Connect 1 megohm 1/2 watt resistors in place of the jumpers removed in step 1.
3. Connect the vertical input blocking capacitors to terminals D3 and D4 and the horizontal input blocking capacitors to D3 and D4.

The POSITION controls on the 120A will still control the pattern and good focus will be maintained.

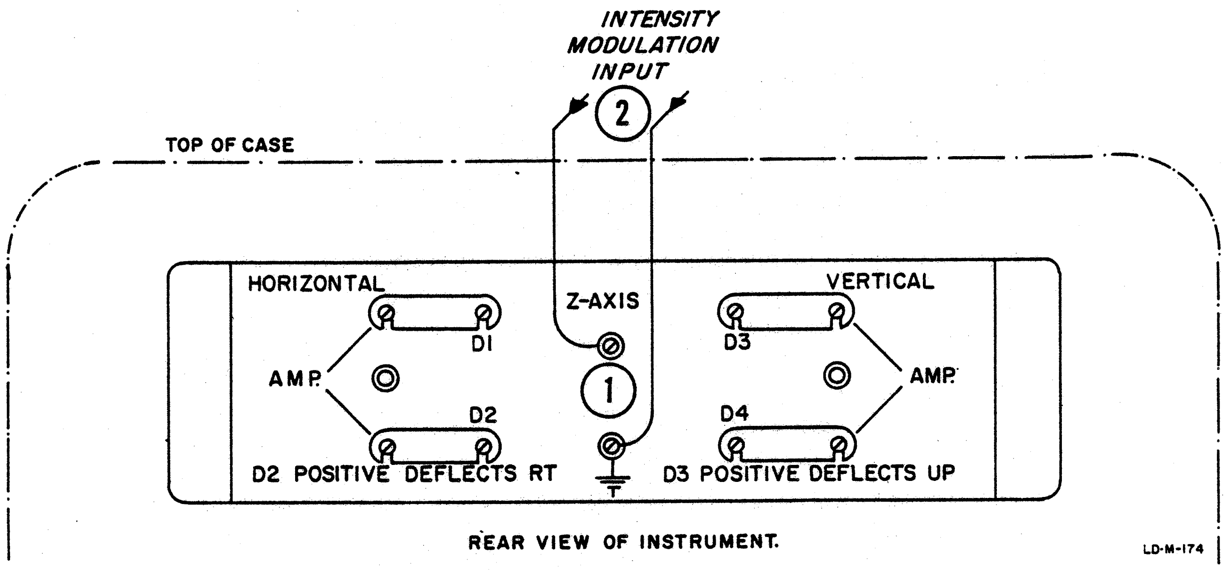
B. DIRECT COUPLED

1. Remove the jumpers going to terminals D1 and D2 for horizontal input and/or D3 and D4 for vertical input.
2. Connect leads from the vertical input directly to D3 and D4 and the lead from the horizontal input directly to D1 and D2.

POSITION controls will no longer control pattern. Position voltages must be furnished by the signal source. Best picture focus is obtained when plates are at +275V with respect to 120A chassis.

Figure 2-9

INTENSITY MODULATION OPERATION



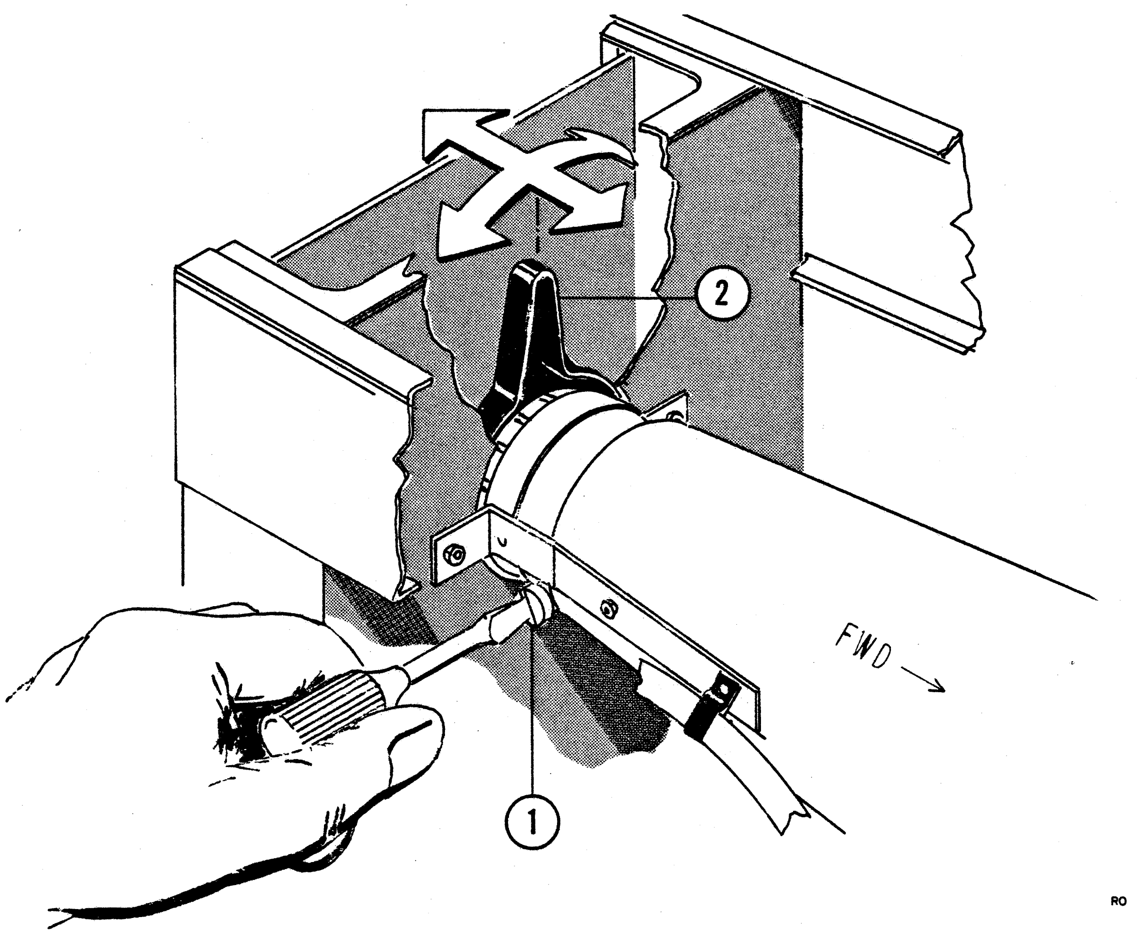
<u>CAUTION</u> - The deflection plates of the oscilloscope operate at a dc potential above ground. TURN THE INSTRUMENT OFF BEFORE REMOVING THE COVER PLATE FROM THE DEFLECTION PLATE TERMINALS, TO AVOID COMING IN CONTACT WITH HIGH VOLTAGES.

To intensity modulate with an external signal:

1. Remove the vertical jumper marked Z-axis.
2. Connect the external intensity modulation signal to these terminals (a negative signal will brighten the trace).

Figure 2-10

ALIGNING SCOPE TRACE WITH GRATICULE



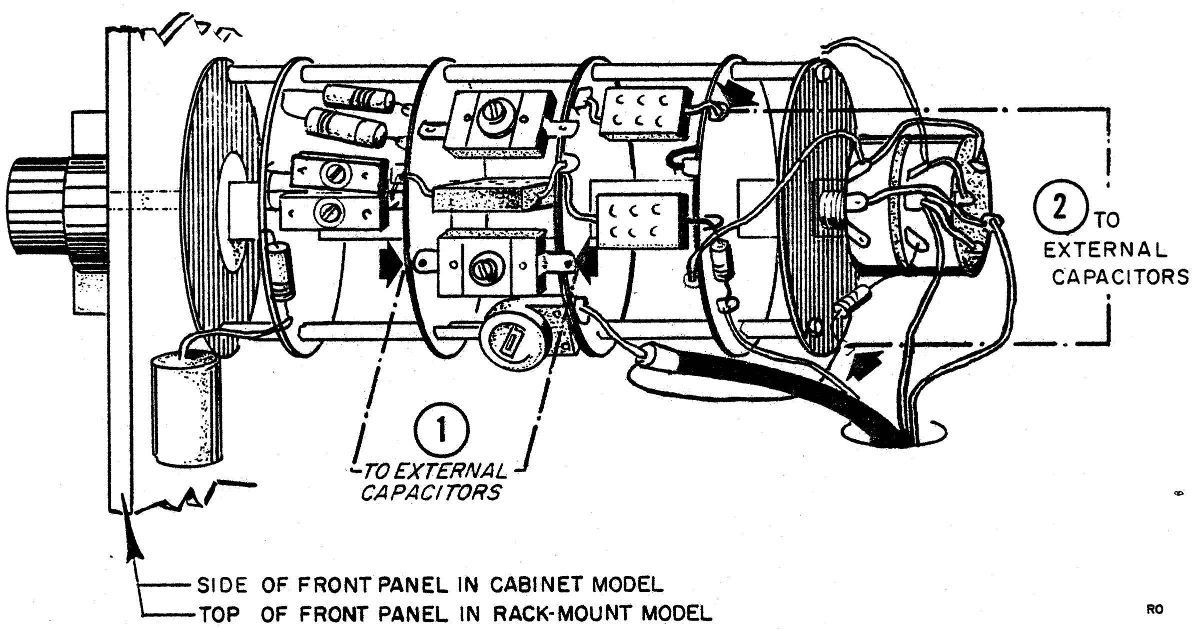
To align oscilloscope trace with graticule, remove oscilloscope from cabinet; then

1. Loosen locking clamp with screwdriver.
2. Adjust fiber lever to adjust position of cathode-ray tube in both radial and longitudinal directions. CAUTION HIGH VOLTAGE. TAKE CARE NOT TO TOUCH TERMINALS WHICH HAVE A HIGH POTENTIAL ON THEM.

When the cathode-ray tube is in desired position tighten locking clamp and replace instrument in cabinet.

Figure 2-11

CONNECTING EXTERNAL CAPACITORS TO EXTEND SWEEP TIME



To extend the sweep time, remove chassis from cabinet,

1. Connect external capacitor across capacitor shown on SWEEP TIME/CM switch.

2. Connect external capacitor from point shown to ground.

Values of both capacitors are the same and will be determined by the sweep speed desired. Note that the only ranges that these capacitors will affect are the 50, 100 and 200 MICROSECONDS/CM ranges. The extension of the sweep time is in proportion to the amount of capacity added to the circuit. For example, since the largest capacity in the circuits are .2 and .22 μfd, using 2 μfd capacitors will increase the calibration of the above ranges to approximately .5, 1, and 2 seconds/cm respectively.

This method will make no great sacrifice in linearity.

Figure 2-12

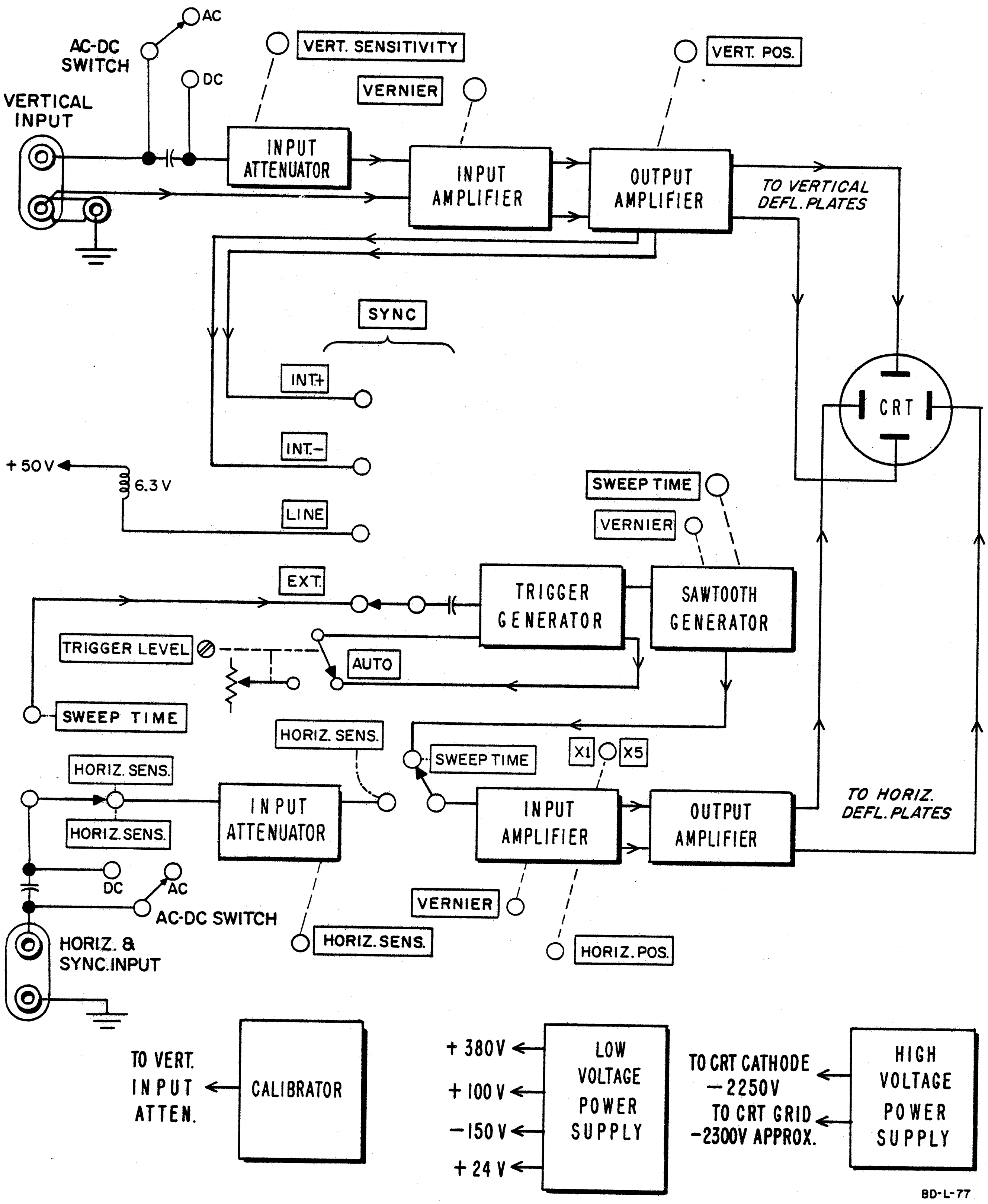


Figure 3-1. Model 120A Block Diagram

SECTION III
CIRCUIT DESCRIPTION

3-1 GENERAL CONTENT

This section contains a brief description of the over-all operation of the Model 120A Oscilloscope, descriptions of each major section and detailed descriptions of Schmitt triggers.

3-2 OVER-ALL OPERATION

The block diagram, Figure 3-1, shows the basic signal circuits in the Model 120A Oscilloscope.

A. VERTICAL AMPLIFIER

The vertical amplifier receives the input signal, amplifies it, and drives the vertical deflection plates. It provides attenuation of the input signal, determines the vertical position of the spot on the screen, and supplies a signal for internal synchronization.

B. HORIZONTAL AMPLIFIER

The horizontal amplifier receives an input signal either from the horizontal input terminals or from the internal sweep generator, amplifies the signal and drives the horizontal deflection plates. The horizontal amplifier provides attenuation of the horizontal input signal, magnification of the internal sweep, and determines the horizontal position of the spot on the screen.

C. SWEEP GENERATOR

The sweep generator consists of a trigger generator and a sawtooth generator. The trigger generator receives the synchronizing signal, either internally or externally, and converts it into a pulse which initiates the action of the sawtooth generator. The sawtooth generator will then go through one complete cycle. The sawtooth generator has feedback which automatically shuts itself off upon the completion of one cycle. Another pulse from the trigger generator will be needed before the action will start again. Thus the action of the sweep generator is precisely controlled. The sweep only starts when a synchronizing signal is received and then only at the same point on the waveform every time.

Trigger Generator - The trigger generator consists of a synchronizing circuit and a trigger generator. The synchronizing circuit receives a signal either from the vertical amplifier for internal synchronization (+ or -), from an internal 6.3 volt source for line frequency synchronization, or from the horizontal input terminals for external synchronization. The trigger generator converts the signal into a fast, constant amplitude pulse for operation of the start-stop trigger. The particular voltage which will trigger the trigger generator is determined by the trigger level control, when AUTOMATIC sweep is not in use.

Sawtooth Generator   The sawtooth generator consists of a start-stop trigger, an integrator switch, a sawtooth integrator, and a hold-off cathode follower.

The pulse from the trigger generator controls the start-stop trigger which in turn controls the integrator switch. The start-stop trigger also furnishes an unblanking pulse through the gate inverter to turn the trace on while the sweep is in progress.

The integrator switch controls the action of the sawtooth integrator. When this switch is closed the integrator output is effectively held at a reference voltage, thereby disabling the integrator. When a sweep signal is received this switch opens, permitting the sawtooth integrator to commence its sweep. Sweep speed is determined by the value of resistance and capacitance in the grid circuit of the sawtooth integrator and the voltage supplying the grid resistor.

To permit all circuits to recover after a trace, a bias voltage is applied to the start-stop trigger by the hold-off cathode follower, making the sawtooth generator insensitive to incoming signals during the hold-off time.

D. POWER SUPPLIES

This oscilloscope has two low voltage power supplies supplying +380 volts and -150 volts. Both of these supplies are fully regulated. The high voltage power supply is regulated and has an output of -2250 volts for the cathode-ray tube. The filament supply to the input tubes of the vertical amplifier is regulated by transistors.

E. CATHODE-RAY TUBE

The cathode-ray tube is a 5AQP- mono-accelerator type. It is normally supplied with a P1 phosphor screen but is available in the P7 and P11 phosphors also and P2 upon special order. P2 is not recommended because of low accelerating voltage. All are electrically interchangeable and the tube is easily changed. The mono-accelerator anode makes possible a simple astigmatism adjustment which requires no resetting when adjusting the FOCUS or INTENSITY controls. The deflection plate terminals are connected through removable jumpers at the rear of the instrument so that direct connections to the plates can be made easily.

F. CALIBRATOR

This oscilloscope has a built-in calibrator with which you can calibrate the sensitivity of the vertical amplifier ranges. The calibrator output is a 60 mv peak-to-peak square wave.

3-3 VERTICAL CHANNEL

The vertical amplifier consists of three parts, AC-DC switch, the input attenuator and the amplifier section proper.

A. INPUT ATTENUATOR

The Input Attenuator is a six position switch having CALIBRATOR, 10 and 100 MILLIVOLTS/CM, 1 and 10 VOLTS/CM and OFF positions. When the switch is in the CALIBRATOR position the input of the amplifier is directly connected to the output of the calibrator. Since the square-wave output of the calibrator is set to 60 millivolts, the gain of the amplifier should be adjusted to show a pattern height of 6 centimeters, with the VERNIER in the CALIBRATED position. This will calibrate the basic sensitivity of the oscilloscope. When used on the other ranges, precision, frequency adjusted attenuators are inserted ahead of the vertical amplifier. These attenuators give a ten to one attenuation between adjacent ranges. The sensitivity may be varied continuously between ranges by means of the VERNIER control. This control reduces the sensitivity of any range down to at least ten to one. Normally, the VERNIER control will be calibrated only in the CALIBRATED switch position. However, it may be calibrated to have a known fraction of the sensitivity of the ranges by setting the VERTICAL SENSITIVITY range switch to the CALIBRATOR position and adjusting the VERNIER control to the desired fraction of the normal six centimeter pattern. As long as the VERNIER control is left at this setting all ranges will have the same fractional sensitivity. The original sensitivity may be restored by merely rotating the VERNIER to the CALIBRATED position.

For ac coupling a .1 μfd capacitor is switched into the signal path by means of the AC-DC switch. This coupling has a low frequency cut-off at approximately 2 cycles per second. However, degradation of input pulses and other complex waveforms, such as square waves, occurs long before the cut-off frequency is reached. Therefore, use dc coupling for any such waveforms below about 200 cycles per second or whenever degradation of waveform is suspected.

Balanced input may be used by removing the jumper to the ground terminal. Balanced input will be found useful in applications where it is desired to amplify the out-of-phase (differential) signal and attenuate the in-phase (common mode) signal at the same time. This rejection is an inherent property of differential amplifiers such as are used in the vertical amplifier. Thus you can reject by better than 100 times any common-mode portion of the input signal while at the same time passing and amplifying the differential portion of the signal. This will prove to be advantageous very often. Many of the unwanted signals picked up along with desired differential signals are of the common-mode type. Noise, hum, etc., are in this class. By the use of balanced input to the differential amplifiers the picture obtained on the screen of the oscilloscope will improve considerably over that obtained using single-ended input.

The common-mode signal rejection is at least 40 db (100 times). When using balanced dc input certain limitations must be met. The proper operating points must be maintained on the input amplifier. The COMMON-MODE SIGNAL VOLTAGE EITHER POSITIVE OR NEGATIVE ON EITHER GRID MUST NOT EXCEED 3 VOLTS MINUS THE PEAK AMPLITUDE OF THE DIFFERENTIAL SIGNAL.

In addition, it may be found desirable to use differential input with a lower sensitivity input. The easiest way to desensitize up to one order of magnitude (ten times) is to use SENSITIVITY VERNIER. The amplifier is still balanced and signals up to 1 volt peak-to-peak can be easily handled provided the maximum common-mode signal is not exceeded.

B. VERTICAL AMPLIFIER

The vertical amplifier consists of three sets of balanced differential amplifiers in cascade. The last two stages are neutralized by plate-to-grid cross-neutralization. The first stage, with a 12AU7, has the balance and gain adjustments. The balance adjustment is a potentiometer in the cathode circuit which adjusts the current distribution between the two halves of the stage. The two gain adjustments consist of potentiometers connected between the two plates which adjust the resistance between the plates. The screwdriver adjustment, VERT. GAIN, R18, adjusts the basic gain of the amplifier. The front panel control, VERTICAL SENSITIVITY VERNIER, controls the gain over a ten-to-one range and varies the gain between step ranges of the main VERTICAL SENSITIVITY switch. The second balanced differential amplifier, V2, a 12AU7, has a potentiometer between its cathodes which controls the vertical position of the pattern (VERTICAL POSITION). The third balanced differential amplifier, V3, a 12AT7, is the output stage. The resistance between cathodes of this stage provides gain stability and improved linearity. The variable capacitor across this resistance adjusts the frequency response of this stage. In addition, synchronization signals are coupled from the plates of this tube and fed into the sweep generator to trigger the sweep for either INTERNAL+ or INTERNAL- synchronization. Since the sweep generator triggers only on the negative slope of the signal, provision is made so that the synchronizing signal can be taken inverted from the opposite half of the tube for INTERNAL+ synchronization.

3-4 HORIZONTAL CHANNEL

The Horizontal Amplifier consists of three parts, the AC-DC coupling switch, the Input Attenuator, and the Amplifier proper.

A. AC-DC COUPLING SWITCH

In the DC position the signals are fed directly into the grid of the first balanced amplifier. In the AC position the signals are fed in through a .1 μfd capacitor.

B. INPUT ATTENUATOR

The Input Attenuator consists of a three-position switch in decade steps, .1, 1, 10 VOLTS/CM. The attenuator is frequency compensated.

C. HORIZONTAL AMPLIFIER

The horizontal amplifier consists of two cross-neutralized balanced differential amplifiers in cascade. When the SWEEP TIME HORIZ. SENS. switch is moved from the sweep ranges to the horizontal sensitivity ranges the resistance between the cathodes of input amplifier V101, a 6DJ8, is switched to a leg having the horizontal sensitivity VERNIER control in series with the horizontal gain control from the SWEEP EXPAND switch which has either the X1 or X5 SWEEP EXPAND gain controls. The X1 leg has the X1 sweep gain adjustment to calibrate the unmagnified (X1) sweep while the X5 leg has the X5 sweep gain adjustment to calibrate the magnified (X5) sweep. The plates of the input amplifier (grids of the output amplifier) are connected with a variable capacitor to adjust the frequency response. The plates of the output amplifier V102, connect to the horizontal deflection plates through the direct connection links on the rear of the instrument.

3-5 SWEEP GENERATOR

The Sweep Generator consists of a trigger generator, a start-stop trigger, a gate inverter, an integrator switch, a sawtooth integrator and a hold-off cathode follower.

A. TRIGGER GENERATOR

The purpose of the trigger generator is to receive the synchronization signal and convert it into a fast, constant amplitude, pulse for operation of the start-stop trigger. Since the trigger generator and the start-stop trigger are forms of Schmitt trigger circuits a discussion of them follows:

A Schmitt trigger consists of two amplifiers A and B having a dc plate-to-grid coupling from amplifier A to amplifier B and dc cathode-to-cathode coupling. In the case of the Model 120A amplifier A is the pentode and amplifier B is the triode in both the Trigger Generator and the Start-Stop Trigger. The circuit has two stable states: A-side conducting, B-side cut off; B-side conducting, A-side cut off. Due to regenerative action the change-over from one state to the other is very rapid, producing fast rise and decay times from each side of the circuit, either of which can be used for triggering subsequent circuits.

If the A-side, the input side, is conducting and the grid voltage is driven lower than the lower hysteresis limit the circuit will switch state rapidly. The circuit will stay in this state until the input grid is driven above the upper hysteresis limit. At this time the circuit will switch back to its original state. The levels at which this switching action takes place can be adjusted to be close together, such as in the Trigger Generator, or widely spaced, such as in the Start-Stop Trigger. The dc voltage applied to the input grid will determine the state of the circuit.

To trigger the circuit, the A-side grid voltage must cross the particular hysteresis limit which will change the state of the circuit. If A-side is already conducting, which is the normal case in the Model 120A, driving the grid voltage positive through its upper hysteresis limit will have no effect, but driving the grid voltage negative through its lower hysteresis limit will put A-side out of conduction, and B-side into conduction.

The initial A-side grid bias can be placed inside or outside the hysteresis area, thus establishing the input voltage level required to change A's state. In the Trigger Generator the A-side grid bias is adjusted with the TRIGGER LEVEL control and is placed midway between the narrow upper and lower hysteresis limits in the AUTOMATIC position. Narrow limits are used so that the Trigger Generator will be sensitive and start the synchronizing action with a small input signal.

B. TRIGGER GENERATOR

The Trigger Generator is designed to be triggered on the negative slope of the synchronizing signal. In the AUTOMATIC position the bias on the input pentode stage is adjusted so that the pentode is conducting when waiting for a synchronizing signal and the triode section is cut off. In addition, the bias point is automatically adjusted to an optimum point where the Trigger Generator will trigger on most waveforms. A negative trigger pulse is needed to start the action of the sawtooth generator. When the pentode section of the Schmitt trigger is turned off and the triode is turned on, a negative pulse is produced. This pulse is differentiated in the output circuit of the Schmitt trigger and fed into the sawtooth generator to start the generator. Thus, an input signal which crosses the lower hysteresis limit will start the sweep. When the TRIGGER LEVEL control is turned to its extreme counterclockwise position (AUTO. position) the switches associated with the TRIGGER LEVEL control convert the Trigger Generator into a free-running multivibrator which operates at a frequency of approximately 100 cps. Thus the Trigger Generator in effect generates its own trigger in the absence of a signal and presents a trace on the face of the cathode-ray tube. As soon as a synchronizing signal is received the applied signal takes control of the synchronization.

In the variable TRIGGER LEVEL control position the feedback for self-triggering is disconnected and the bias level is adjustable. As this control is turned clockwise from the AUTOMATIC position, first the feedback is disconnected and then the control varies the bias level. As the bias is made more and more positive it will require a more negative signal to trigger the Trigger Generator. A differentiating circuit has been placed in the plate circuit of the final tube (triode) of the Trigger Generator to convert the output into a sharp spike.

C. START-STOP TRIGGER

This sharp output spike is then fed into the Start-Stop Trigger. This is another Schmitt trigger but it has rather wide hysteresis limits. The wide hysteresis limits are needed so that the generated sawtooth can be fed back to the start-stop trigger and thus terminate itself. The integrator output is fed back via the hold-off cathode follower to drive the start-stop trigger past the upper hysteresis limit. When this point is reached the Trigger changes state, causing the Integrator Switch to conduct. Then the voltage discharges through the resistance-capacitance network of the circuit. This voltage is not permitted to reach the lower hysteresis limit, however. A voltage is applied by the Hold-Off Cathode Follower to prevent this. Since this hold-off voltage is developed later on in the circuit, it will be explained later.

D. INTEGRATOR SWITCH

The Integrator Switch is controlled by the square-wave output of the Start-Stop Trigger. The Integrator Switch consists of two triodes, one of which is connected as a diode. While the circuit is awaiting a trigger, the diode is normally conducting, thus shorting out the Sawtooth Integrator. When a negative synchronizing signal is received, the Trigger Generator converts it into a negative pulse operating the Trigger Generator which, in turn, puts out a pulse. The negative pulse applied to the plate of the diode causes it to cut-off permitting the Sawtooth Integrator to commence operation. The triode section of the Integrator Switch serves to hold the output of the Sawtooth Integrator at a definite voltage (approximately 50 volts) so that the sawtooth will always start from the same point.

E. SAWTOOTH INTEGRATOR

The Sawtooth Integrator consists of a triode, and a pentode, Miller-type integrator, which generates essentially a linear, positive, rising, waveform which sweeps the trace across the face of the cathode-ray tube at a linear rate. The rate at which this sweep takes place is determined by the values of R and C in the grid circuit of the pentode. These values are varied for each range of the SWEEP TIME switch. When the Integrator Switch opens, the voltage applied to the resistance-capacitance combination tries to charge the capacitor through the resistance. However, the capacitor is connected between the grid and plate of an amplifier. As the voltage across the capacitor starts to change, the change, amplified by the tube and the output polarity reversed, is applied to the grid thus keeping the voltage relatively constant. Since there is a constant voltage across the resistance, a constant charging current must be flowing into the capacitor. Since the charging current is constant, and the values of the capacitor and charging circuit are constant, the voltage increase across the capacitor is linear.

The rising output waveform of the Sawtooth Integrator is fed through two neon bulbs to the triode section of the 6U8. The signal is then cathode-coupled through another bulb to the Hold-Off Cathode Follower which is used for isolation. Neon bulbs are used to drop the voltage down to the proper levels while at the same time furnishing a direct-coupled path for the signal. In general, the neon bulbs are shunted with a capacitor to improve the high-frequency response of the circuit. A resistance is also used in series to prevent the possibility of the neons oscillating.

F. HOLD-OFF CATHODE FOLLOWER

The rate at which the rising output Sawtooth Integrator reaches the upper hysteresis limit of the Start-Stop Trigger will be determined mainly by the resistance and capacitance in the grid circuit of the Sawtooth Integrator. However, after this signal has triggered the Start-Stop Trigger, this voltage will be returned to its original value fairly rapidly by the Integrator Switch. It is desired to prevent triggers from initiating another sawtooth until the integrator has time to discharge the timing capacitor and recover fully. The resistance-capacitor combination in the cathode of the hold-off cathode-follower accomplishes this by permitting only a slow decay on the grid voltage of the start-stop trigger to a voltage level 2 volts above the lower hysteresis limit. This level is set by the sweep stability control so that negative triggers from the trigger generator will reach below the lower hysteresis limit to trigger the start-stop trigger generator thus initiating a sweep.

The sweep length adjustment in the grid circuit of the Hold-Off Cathode Follower adjusts the voltage supplied to the circuit and thus the length of time that it will take the sweep to reach its upper hysteresis limit. The sweep stability control, in the cathode circuit of the Hold-Off Cathode Follower adjusts the bias on the Start-Stop Trigger. This is adjusted to place the voltage just above the lower hysteresis limits.

G. GATE OUT CATHODE FOLLOWER

Another function of the Start-Stop Trigger is to furnish a pulse to unblank the cathode-ray tube. The Gate Out Cathode Follower, V203A, couples the required positive pulse from the Start-Stop Trigger to the grid of the CRT for the duration of the sweep.

3-6 LOW VOLTAGE POWER SUPPLIES

The Low Voltage Power Supply consists of two separate supplies furnishing plate voltages, a regulated dc filament supply, and the usual ac filament supplies.

A. PLATE VOLTAGE SUPPLIES IN THE LOW VOLTAGE POWER SUPPLY

The Low Voltage Power Supply contains two plate voltage supplies, one furnishing +380 volts and +100 volts and the other furnishing -150 volts.

The positive plate supply voltage supply consists of a transformer, a 5Y3 rectifier, a 6U8 (pentode section) amplifier, and a 12B4A control tube in the usual regulated power supply configuration followed by a 6U8 (triode section) cathode follower. This supply has a +380 volts regulated and a +100 volt low-impedance supply from the cathode of the cathode follower.

The negative voltage supply consists of a transformer, a 6X4 rectifier, a 6AU6 amplifier, a 5651 voltage reference tube and a 12B4A control tube in the usual regulated power supply configuration. This supply has a single output at -150 volts. This supply is used for reference and in addition as a negative return for the circuits.

B. TRANSISTORIZED FILAMENT SUPPLY

This supply furnishes regulated +24 volts for use as a filament supply for two twelve-volt filament tubes in series. These tubes are the first two tubes in the Vertical Amplifier. Any change in the filament voltage of these tubes will be greatly amplified and appear as drift on the face of the cathode-ray tube. By supplying this filament voltage from a regulated source the possibility of drift due to the filament supply is greatly reduced.

The supply consists of a silicon power rectifier and two pnp transistors. A power transistor, Q301, connected as a grounded emitter amplifier, acts much the same as the series tube in a conventional vacuum-tube regulator. The control transistor, Q302, compares the regulated filament voltage with the -150 volt regulated supply and provides suitable bias for the power transistor to maintain the filament supply at +24 volts.

3-7 HIGH VOLTAGE POWER SUPPLY

The High Voltage Power Supply consists of a Hartley oscillator, two separate secondary winding supplies and two tube regulators.

The Hartley oscillator consists of a 6AQ5 oscillator tube, and a tapped winding on the high voltage transformer which is series fed from the +380 volt supply. This circuit oscillates at approximately 60 kc. This supply has two separate secondaries and two separate 5642 rectifier tubes. One of these supplies is connected to the grid. The INTENSITY and Intensity Limit potentiometers in series with the ground return of this supply determine the voltage on the intensity grid and thus the brilliance of the pattern.

The other secondary is connected to the cathode of the Cathode-Ray Tube. It is also connected to the regulator resistor string. Voltage is taken from this string and fed into the input of a two tube dc-coupled regulator (both sections of a 12AU7). The output of this regulator is then fed back to the screen of the Hartley oscillator in the proper phase to oppose any change in the dc output of the cathode supply

The Intensity Modulation terminals are also ac coupled to the cathode of the Cathode-Ray Tube. A negative voltage input will brighten the trace while a positive voltage of approximately twenty volts will blank the Cathode-Ray Tube from normal intensity.

3-8 CALIBRATOR

The Calibrator consists of two neon bulbs connected to put out a square wave with an amplitude of 60 millivolts. When the VERTICAL SENSITIVITY control is switched into the CALIBRATOR position this signal is applied to the vertical amplifier input. The pattern on the face of the Cathode-Ray Tube should then be adjusted to give a height of six centimeter (VERNIER in CALIBRATED). The oscilloscope will then be calibrated within ±5% to the sensitivities engraved on the front panel.

Operation of the calibrator is explained, with reference to the schematic of the Calibrator (on the Low Voltage and Filament Supply schematic), as follows:

When the switch, S2, is in the off position both sides of the neons are at the same potential, so there is no action.

When the switch is turned to the on position, the voltage at the top of the neons will try to go to +380 volts since no current is being drawn. I301 will fire first as the voltage across it will increase more rapidly because it is returned to the negative supply. When I301 fires it will draw current through R358. However, the voltage across R358 will build up slowly because C334 must be charged at the same time. When this capacitor allows the voltage drop across R358 to rise, the voltage at the top of the neons will also rise. When this voltage rises to 70 volts (approximately) above ground, I302 will fire and stay lit until the voltage across C334 discharges through R358 to a voltage approximately 70 volts below the voltage at the top of the neons. I301 will now fire and the action will repeat itself.

I302 is thus alternately turned off and on at a rate of about 400 cps. The output of the calibrator is taken from the current passing through this neon. The output is approximately a square wave which can be set with R365 to be of exactly 60 millivolts in amplitude. When the output of this calibrator is fed into the vertical amplifier it will show a pattern six centimeters in height when the amplifier is calibrated.

SECTION IV
MAINTENANCE

4-1 INTRODUCTION

This section contains instructions for adjusting and servicing the Model 120A Oscilloscope. Whenever possible standard, readily obtainable, components have been used. Other special components may be obtained directly from the Hewlett-Packard Company. When ordering directly from ⓗⓟ be sure to specify model and serial number of instrument and description of component as given in Table of Replaceable Parts together with the stock number.

In general, sections in the Model 120A will be found behind the front panel controls for that section. The power supplies are in the rear. Controls and tubes are marked on the chassis. The material in this section is divided according to circuit functions, each section having a complete set of adjustment instructions. The material in this section is as follows:

4-2 Removing the Cabinet
4-3 Connecting for 230-Volt Power Lines
4-4 Tube Replacement
4-5 Isolating Troubles to Major Sections
4-6 Condensed Test and Adjustment Procedure
4-7 Adjustment Procedure
4-8 Turn On
4-9 Power Supplies
4-10 Trigger Generator
4-11 Vertical Amplifier
4-12 Horizontal Amplifier
4-13 Sweep Generator

4-2 REMOVING THE CABINET

Disconnect power cord and remove two large screws on rear of cabinet. Do not remove any front panel screws. Slide oscilloscope forward out of cabinet.

CAUTION

When the cabinet is removed, dangerous voltages are exposed. Take adequate safety precautions, especially when working around the CRT terminals and power supplies.

4-3 CONNECTING FOR 230-VOLT POWER LINES

The 120A is normally shipped from the factory with the dual primary of the power transformer windings connected in parallel for use on 115-volt ac lines. The windings can easily be reconnected in series for use on 230-volt power, if desired. First find the power supply input terminal strip located next to the power transformer. Notice that the two outer terminals on each side are jumpered together, connecting the windings in parallel. Remove these jumpers and connect an insulated jumper between the second and fourth terminals, connecting the windings in series.

4-4 TUBE REPLACEMENT

Tubes with standard EIA characteristics can be used for replacement. In a great number of cases, malfunction can be traced to a defective or weak tube. Check tubes by substitution and replace only those proven to be weak or defective. Results obtained by the use of a "tube checker" can be erroneous and misleading. Mark original tubes to insure their being returned to the same socket if not replaced.

The heaters of V1 and V2 are in series and a burn-out of either one will turn off the other. See tube replacement chart Table 4-1.

When replacing the CRT, see steps 2, 3, and 4 of paragraph 4-8.

TABLE 4-1. TUBE AND TRANSISTOR REPLACEMENT CHART

Circuit Ref.	Tube or Transistor Type and Function	Tests and/or Adjustments
Q301 Q302	2N301 Regulator 2N383 Amplifier	Check +24 volt power supply output
V1 V2	12AU7 Vert. Input Amp. 12AU7 Vert. Amp.	Check Vertical Balance and Gain

TABLE 4-1. CONT'D.

Circuit Ref.	Tube or Transistor Type and Function	Tests and/or Adjustments
V3	12AT7 Vert. Output Amp.	Check Vertical Gain, Balance & Square Wave Response
V101 V102	6DJ8/ECC88 Horiz. Amp. 12AT7 Horiz. Output Amp.	Entire Horiz. Amp. test procedure, X1 & X5 sweep calibration and compensation.
V201	6AN8 Trigger Generator	Check Trigger sensitivity
V202	6U8 Start-Stop Trigger	Check Sweep Stability Control adjustment
V203 V204 V205	12AU7 Gate-Out & Hold-Off Cathode Follower 12AU7 Integrator Switch 6U8 Sawtooth Generator	None
V301 V302 V303 V304	12AU7 Amplifier 6AQ5 Oscillator 5642 H.V.Rectifier 5642 H.V.Rectifier	Check H.V.Power Supply Output
V305	5AQP1, 2, 7, or 11 CRT	See adjustments under "TURN ON" & also check Vert. & Horiz. Gain
V306	5AR4/GZ34 Rectifier	None
V307	12B4A Regulator	Check +380 volt power supply output
V308	6U8 Amplifier	Check +380 & +100 volt power supply output voltages
V309	6X4 Rectifier	None
V310 V311 V312	12B4A Regulator 6AU6 Amplifier 5651 Reference	Check -150 volt power supply output

4-5 ISOLATING TROUBLES TO MAJOR SECTIONS

NOTE

IF NO TRACE CAN BE OBTAINED ON THE CRT FACE, SET ALL CONTROLS EXACTLY AS SHOWN IN FIGURE 2-1.

IF THE INSTRUMENT WILL NOT OPERATE, check that power is being applied to the instrument and that the power cord is making good contact. Check the fuse by substitution. If still inoperative, remove cabinet and check continuity through ac power circuit.

IF INSTRUMENT TURNS ON BUT WILL NOT PERFORM SOME FUNCTION, be sure that the cause is not maladjustment of the front panel controls. Set the TRIGGER LEVEL control to AUTO. Try to localize the trouble to a particular main section by checking the controls and how well they perform their functions.

AFTER DETERMINING INOPERATIVE SECTION, visual and electrical inspection will pinpoint the repair that is necessary. Avoid making any adjustment until the cause of the malfunction has been corrected.

Check tubes as described in paragraph 4-4. Return tubes to their original sockets unless replaced.

The two sides of the differential amplifier circuits are normally balanced to position the spot in the center of the CRT. A fault in either side will usually unbalance the circuit and cause the spot to move off the screen. To bring the spot back, short together the control grids (or the plates) of the two sides of one stage. This eliminates signals of all types, dc unbalance, jitter, etc. originating prior to the shorted points. If shorting the two halves of a stage together does not bring the spot on the screen and hold the spot motionless, a subsequent circuit is faulty. Continue this process through the amplifier until the spot does appear. After isolating the fault to a particular stage, check plate, grid, and cathode circuits of the stage and the preceding stage for the cause of the unbalanced condition.

4-6 CONDENSED TEST AND ADJUSTMENT PROCEDURE

All the basic tests and adjustments are covered in the following Table 4-2. This procedure is for instruments that are functioning. If the instrument is not operating, refer to paragraph 4-5, Isolating Troubles to Major Sections.

TABLE 4-2. MODEL 120A CONDENSED TEST AND ADJUSTMENT PROCEDURE

Test	External Equipment Required	Procedure	Adjust	Notes
1. Low Voltage Power Supply	DC vtvm with 1% accuracy	Measure all low voltage power supply outputs, should be within the following limits: -150 ± 4 volts +100 ± 3 volts +380 ±10 volts + 24 ± 1 volt	Do not adjust if within limits. Adjust R344 for -150 volts.	Check sweep calibration if -150V is adjusted.
2. Vertical Amplifier Balance	None	VERT. SENS. to 10 mv/cm, VERNIER full ccw	Position spot in center of screen with VERT. POS.	Repeat as required
		Rotate VERNIER full cw	Center spot with VERT.DC BAL.	
3. Vertical Amplifier Gain	400 cycle voltage Calibration Generator	VERT.SENS.to 10 mv/cm, VERNIER to CAL. Connect 100 mv p-p from Calibration Generator to vertical input	Adjust VERT. GAIN (R18) for 10 cm deflection	
4. Calibrator	None	VERT.SENS. switch and VERNIER to CAL.	Adjust CALIBRATOR SET (R356) for 6.0 cm deflection	
5. Horizontal Balance	None	HOR.SENS. to 10 v/cm, VERNIER to CAL., VERT.SENS. to OFF	Center spot with HOR. POS.	Repeat as required
		Turn VERNIER full ccw	Center spot with HORIZ. BALANCE (R110)	
6. Horizontal Amplifier Gain	400 cycle Voltage Calibration Generator	HOR.SENS to .1 v/cm, VERNIER to CAL., VERT.SENS. to OFF Connect 1.0 volt p-p from Calibration Generator to horizontal input.	Set HORIZ.GAIN (R114) for 10 cm deflection	
7. Horizontal Amplifier Sweep Gain	Time Marker Generator	SWEEP TIME 5 MS/CM, SWEEP EXPAND X 1. Apply 5 ms markers to vertical input.	Adjust trigger level for stable pattern. Adjust R107 for marker coincidence with 1 cm graticule marks	
		Change time markers to 1 ms. SWEEP EXPAND to X5.	Adjust R108 for marker coincidence with 1 cm graticule marks	
8. Horizontal Amplifier Compensation	Oscilloscope with low capcity probe	SWEEP TIME 10 µsec/cm., SWEEP EXPAND to X1 Connect probe to either horizontal deflection plate terminal pin 1 or 6 of V102 Adjust sweep start to center of screen.	Adjust C105 to compensate flyback	
		SWEEP EXPAND to X5. Adjust sweep start to center of screen.	Adjust C106 to compensate flyback	
9. Trigger Sensitivity	1) Oscilloscope with 10:1 probe 2) 50 cps to 250 kc oscillator 3) AC VTVM	SYNC to EXT., TRIGGER LEVEL to AUTO. DC couple a 250 kc sine wave of .7 volts rms into the EXT.SYNC input. Couple scope to body of R204 (a 3.6K, 1/2W resistor on pin 6 of V201).	Set trigger sensitivity control (R247) just clockwise of the point where stable triggers are obtained.	Check for stable triggers from 50 cps to 250 kcs with 0.5 volt rms
10. Sweep Stability	DC VTVM	Disconnect all ext. inputs. Connect VTVM (-100 volt scale) to pin 8 of V203, VERT.SENS. to OFF, SWEEP TIME 0.5 ms, SYNC.INT., TRIGGER LEVEL full ccw but not in AUTO.	Slowly adjust SWEEP STABILITY (R228) until sweep begins. Repeat several times and note voltage just prior to sweep start. Set R228 for 2 volts more positive.	
11. Sweep Length	250 kc sine wave Oscillator	SWEEP TIME switch to 200 microsecond/cm. Connect 250 kc sine wave to vertical input.	Adjust signal voltage or VERT. SENS. to produce 4 to 10 cm deflection. Adjust SWEEP LENGTH control for 10.5 cm trace length.	

4-7 ADJUSTMENT PROCEDURE

Usually a particular oscilloscope will not need complete testing and calibration. Only one or two tests will be needed and they can be done without completing the entire test procedure.

The following procedures are listed in a recommended sequence for a complete test and calibration operation. In general, tubes are the main cause of trouble and new ones should be tried before making adjustments or other component replacements.

Specifications for the ⓗⓟ Model 120A Oscilloscope are given in the front of this manual. The following test procedure contains extra checks to help you analyze a particular instrument. These extra checks and the data they contain can not be considered as specifications.

A fifteen minute warm-up and power supply output voltage measurements are always recommended before making any other test or adjustment.

4-8 TURN ON

1) Measure resistance from the power supplies to ground with an ⓗⓟ Model 410B Voltmeter. They should be within 25% of the following:

+380 volt supply	50K ohms
+100	50K ohms
-150	12K ohms
+ 24	5.5K (remove 12AU7)

Measure resistances to ground into the vertical and horizontal input terminals for all switch positions, place AC-DC switches in DC position. As measured with an ⓗⓟ Model 410B Voltmeter these resistances should read:

VERT. SENSITIVITY	= 1 megohm
OFF	= ∞
CAL.	= ∞
SWEEP TIME HOR. SENS.	= 1 megohm

When turning the oscilloscope on for the first time after repair in any power supply circuit, turn the intensity and one positioning control full counterclockwise before applying power. Failure to follow this precaution may cause permanent cathode-ray tube damage.

2) Turn instrument on (see precaution above) and measure the output voltage of the internal power supplies. If you are able to get a small, round, and sharply focused spot with good brilliance, the high voltage power supply can be assumed to be operating properly.

If necessary, the high voltage can be measured at the FOCUS control terminal with the orange wire. Control R308 can be adjusted to set this voltage to -2250 volts.

3) If R308 setting is changed, adjust FOCUS and ASTIGMATISM (R316) controls at low intensity to obtain a small, round, and sharply focused spot.

4) If the cathode-ray tube physical position has been changed, check trace alignment with bezel. Turn TRIGGER LEVEL control fully counterclockwise to AUTO. Set SWEEP TIME switch to 50 MICROSECONDS/CM. The CRT trace should be parallel with the graticule. The CRT face should be positioned just behind the filter in the bezel. If CRT face and filter touch, Newton rings will occur.

4-9 POWER SUPPLIES

The power supplies in the oscilloscope are extremely stable and will require infrequent adjustment. The output voltages should be measured at regular intervals but unnecessary adjustments should be avoided.

CAUTION

When first turning an oscilloscope on after power supply repairs, turn the intensity and either positioning control full counterclockwise before applying power. Failure to follow this precaution can cause permanent cathode-ray tube damage.

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1) Turn instrument on and allow at least 15 minutes for warm-up.

2) Turn sweep generator off by turning the SWEEP TIME - HOR. SENS. switch to 10 VOLTS/CM.

3) Measure power supply output voltages with line voltage set to 115 volts. The points at which the various voltages appear can be identified by the wire color code given in Table 4-3. The voltages will normally be within the limits given in Table 4-3. Control R344 can be adjusted if necessary to set the -150 volt supply within limits.

If adjustment of the -150 volt supply was necessary, you will also have to check all Sweep Generator and Calibrator adjustments.

TABLE 4-3. REGULATED POWER SUPPLY TOLERANCES

Nominal Voltage	Normal Ripple*	Color Code	Voltage Tolerance*
-150	3 mv	Purple	± 4 volts
+380	40 mv	Red	±10 volts
+100	4 mv	Yellow	± 3 volts
+ 24	40 mv	White**	± 1 volt

* With line voltage set to 115 volts.
** In vertical amplifier.

4) You may wish to check regulation of each power supply voltage as the power line voltage is varied between 103 to 127 volts. All regulated voltages should remain within ±1% over this range of line voltage.

5) Measure the ripple voltage on the various supplies, they should approximate the values given in Table 4-3 with the line voltage set to 115 volts.

6) Measure CRT cathode voltage at FOCUS control terminal with the orange wire. An ⓗp 410B VTVM with a 459A Voltage Multiplier Probe is recommended. If necessary, control R308 can be adjusted to set this voltage to -2250 volts.

7) Adjust FOCUS control for best focus and set ASTIGMATISM control R316 for a small round spot. Set pointer on INTENSITY knob to 9 o'clock and adjust Intensity Limit control R322 so that the CRT spot is just extinguished. These adjustments are usually required only if the setting of the high voltage control has been changed.

4-10 TRIGGER GENERATOR

The Trigger Generator must be working in order to adjust the Vertical and Horizontal Amplifiers. Also, these amplifiers must be adjusted before the Sawtooth Generator can be adjusted. To check the Trigger Generator proceed as follows:

1) Check power supply according to paragraph 4-9.

2) Stability Adjustment:

Set controls as follows,

VERT. SENSITIVITY - - - - - - - - - CAL.
SWEEP TIME - - - - - 0.5 MILLISECONDS
SYNC - - - - - - - - - - - - - - - - INT
TRIGGER LEVEL - - - - - - - - - - - AUTO

Connect ⓗp 410B (-100v range) to pin 8 V203. Rotate Sweep Stability Control, R228, ccw until sweep is triggered, then back off until it just stops. Take a voltage reading which should be about -72 volts. Now connect a clip lead from pin 1 V201 to ground. Slowly rotate R228 ccw until the sweep starts free-running, then back off until it just stops. Take a voltage reading which should be about -78 volts. The difference between these two readings is the amplitude of the triggers and must be between 5 and 7 volts. While the triggers are shorted (clip lead from pin 1 V201 to ground) set R228 to 2.0 volts more positive than the last reading. This is the proper setting for the stability control.

3) External Trigger Sensitivity:

Set controls as follows,

SYNC - - - - - - - - - - - - - - - - EXT.
TRIGGER LEVEL - - - - - - - - - - - AUTO
Horizontal AC-DC - - - - - - - - - - - - DC

Connect a 250 kc sine wave of 0.7v rms into the SYNC terminals. With a 10:1 or better a 50:1 probe and oscilloscope observe the output triggers from the Trigger Generator as you increase the Trigger Sensitivity control R247. Increase trigger sensitivity until stable triggers are obtained. Check trigger sensitivity from 50 cps to 250 kc. Stable triggering should be obtained with less than 0.7v rms over this range. Disconnect input, set TRIGGER LEVEL to AUTO -- the Trigger Generator should free-run.

A useable indication for this adjustment can also be obtained by clipping the oscilloscope probe over the body of resistor R204. This is the plate resistor for V201A.

4) TRIGGER LEVEL:

Set controls as follows,

SYNC - - - - - - - - - - - - - - - - INT+

Adjust input for 8 cm of deflection. Rotate TRIGGER LEVEL control clockwise and see that the starting point of sweep moves upward. The range of this control should be at least +2 cm from the average value of the signal. Switch SYNC switch to EXT. Adjust input signal for 20 v peak-to-peak. Range of TRIGGER LEVEL control should exceed this signal.

5) Internal Trigger Sensitivity:

Set controls as follows,

SYNC - - - - - - - - - - - - - - - INT +
SWEEP TIME - - - 50 MICROSECONDS/CM
Vertical AC-DC - - - - - - - - - - - DC

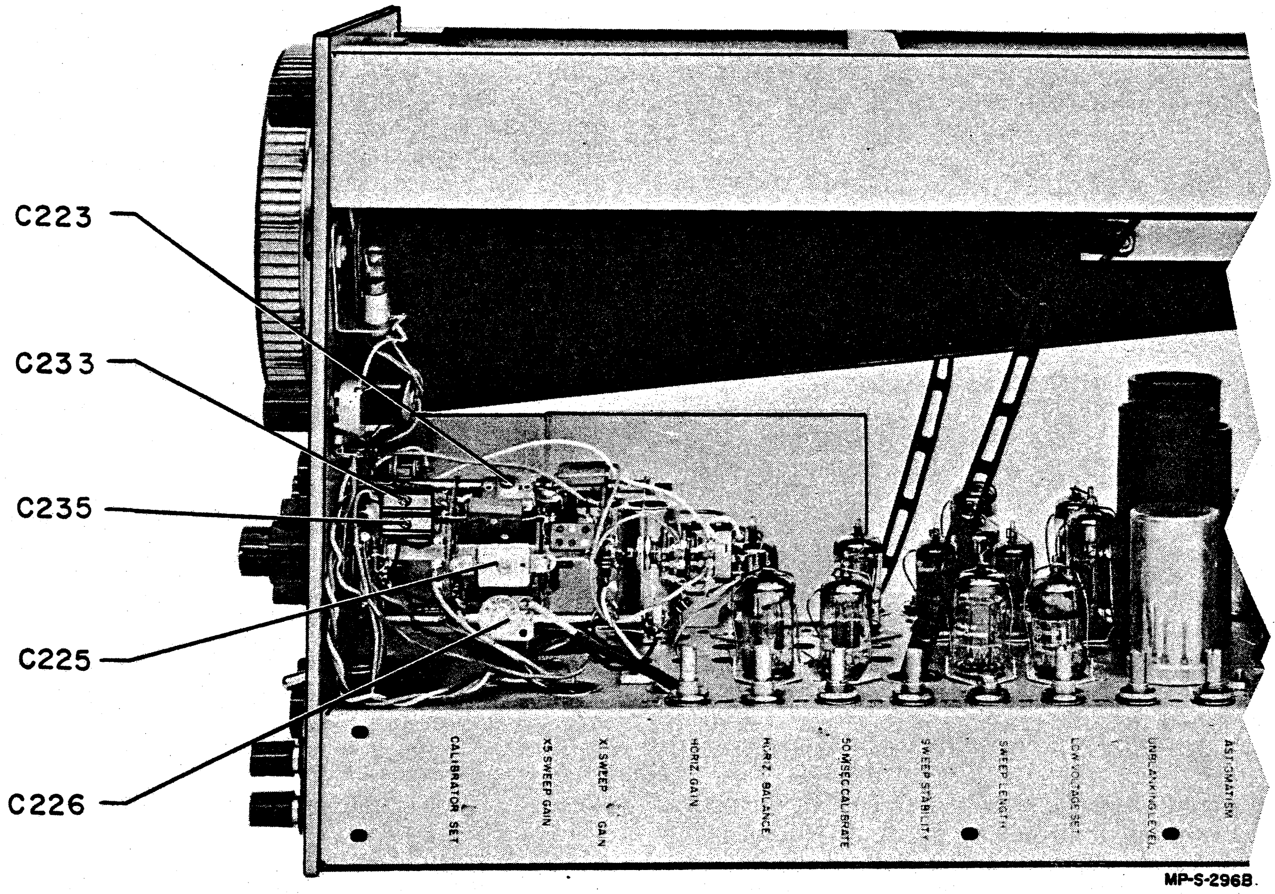


Figure 4-1. Most Internal Calibration Controls are Located in an Easily-Reached Row along side of Chassis. (See also Figure 4-2.)

With a 10 kc sine wave fed into the Vertical Amplifier, decrease the input to the point where the triggers are becoming unsteady (observe triggers as above). Vertical deflection should be less than 0.5 cm when the triggers become unsteady. Check triggering from 50 cps to 250 kc.

6) Trigger Level Sensitivity:

Repeat tests in the two previous paragraphs using TRIGGER LEVEL control (adjust for maximum sensitivity). Check using same sensitivity specifications over range from 10 cps to 250 kc.

7) Line Synchronization:

Set controls as follows,

SYNC - - - - - - - - - - - - - - - - LINE
TRIGGER LEVEL - - - - - - - - - - - AUTO

The normal 60 cycle pickup in Vertical Amplifier should give a stable pattern.

4-11 VERTICAL AMPLIFIER

1) Balance:

Set controls as follows,

VERT. SENSITIVITY - - - - - 10 VOLTS/CM
HOR. SENS. - - - - - - - - - 10 VOLTS/CM

Turn VERT. SENSITIVITY VERNIER full counterclockwise and position spot to center with VERT. POS. control. Turn VERNIER clockwise and reposition spot to center with VERT. DC BAL. control. Repeat this sequence until there is no movement of spot as VERNIER is rotated. Set VERT. POS. control to the center. Spot should now be on the screen.

2) Gain:

Set controls as follows,

VERT. SENSITIVITY - - 10 MILLIVOLTS/CM
VERT. SENSITIVITY VERNIER - - - - CAL

With 100 millivolts peak-to-peak from a Voltmeter Calibration Generator set Vertical Amplifier VERT. GAIN control to give exactly 10 cm of deflection. Check this setting at high and low line voltage.

3) Calibrator:

Set controls as follows,

VERT. SENSITIVITY - - - - - - - - - - CAL
VERT. SENSITIVITY VERNIER - - - - CAL
SWEEP TIME - - - - 2 MILLISECONDS/CM

Check deflection polarity by varying R356. The top of the calibrator square wave should move. Set R356 for 6.0 cm of calibrator deflection. Check symmetry -- should be 40-60% or better.

4) Square Wave Response:

Set controls as follows,

VERT. SENSITIVITY - - 10 MILLIVOLTS/CM
VERT. SENSITIVITY VERNIER - - - - CAL
SYNC - - - - - - - - - - - - - - - - - INT +
TRIGGER LEVEL - - - - - - - - - - - AUTO
SWEEP TIME - - - - 10 MICROSECONDS/CM

Apply 50 kc square wave to vertical input terminals. Adjust generator for 8 cm deflection. Adjust C15 (see Figure 4-2) for best square wave response. A maximum of 2% overshoot is permitted.

5) Attenuator Compensation:

Set controls as follows,

VERT. SENSITIVITY - - 100 MILLIVOLTS/CM
VERT. SENSITIVITY VERNIER - - - - CAL
SYNC - - - - - - - - - - - - - - - - - INT
TRIGGER LEVEL - - - - - - - - - - - AUTO
SWEEP TIME - - - 200 MICROSECONDS/CM

Apply 5 kc square wave to vertical input terminals. Adjust for 8 cm deflection. Adjust C6 on vertical attenuator for a flat top square wave. Switch VERT. SENSITIVITY control to 1 VOLT/CM and increase input to give 8 cm deflection. Adjust C2 for flat response. Switch Vertical Sensitivity to 10 VOLT/CM and check for flat response. Should be within 1%. Now switch back through the four attenuator positions and check for 10:1 steps. All should be 10:1 within 1%.

6) Frequency Response:

Set controls as follows,

VERT. SENSITIVITY - - 10 MILLIVOLTS/CM
VERT. SENSITIVITY VERNIER - - - - - CAL

Apply 2 kc sine wave to vertical input terminals and also measure this input with an ⓗⓟ Model 400D. Adjust input signal for exactly 10 cm deflection. Note reading on 400D. Apply 200 kc sine wave and adjust the input to the same reading on 400D. Deflection on screen should be greater than 8 cm.

4-12 HORIZONTAL AMPLIFIER

1) Balance:

Set controls as follows,

HOR. SENS. - - - - - - - - - - 10 VOLTS/CM
HOR. SENS. VERNIER - - - - - - - - - CAL
VERT. SENSITIVITY - - - - - - - - - OFF

Position spot to center of screen with HORIZ. POS. control. Turn HOR. SENS. VERNIER full counterclockwise position and reposition with Horizontal Balance Adjustment, R110. Turn HOR. SENSITIVITY VERNIER to CAL and center spot with HORIZ. POS. control. Repeat until there is no movement of spot when VERNIER is rotated. Set HORIZ. POS. control to center. The spot should now be on the screen.

2) Gain:

Set controls as follows,

HOR. SENS. - - - - - - - - - 0.1 VOLTS/CM
HOR. SENS. VERNIER - - - - - - - - CAL

Apply 1.0 v peak-to-peak from a Voltmeter Calibration Generator to the Horizontal input terminals. Set Horiz. Gain Adjustment, R114, for exactly 10 cm of deflection. Check this setting at high and low line voltages.

3) Square Wave Response:

Set controls as follows,

HOR. SENSITIVITY - - - - 0.1 VOLTS/CM
HOR. SENSITIVITY VERNIER - - - - - - CAL

Connect 8 kc (approximately) sine wave to Vertical input terminals and sync-in terminal of square wave generator. Adjust the gain on the oscillator for 10 cm deflection. Apply 50 kc square wave to Horizontal input terminals, and adjust the square wave amplitude for 6 to 8 cm deflection. Adjust C107 for minimum capacity. Adjust C110 for best square wave response. A maximum of 2% overshoot is permitted.

4) Attenuator Compensation:

Set controls as follows,

HOR. SENSITIVITY - - - - - - 1 VOLTS/CM
HOR. SENSITIVITY VERNIER - - - - - CAL

Connect 800 cps (approximately) sine wave to Vertical input terminals and sync-in terminal of square wave generator. Adjust the gain on the oscillator for 10 cm deflection. Apply 5 kc square wave to Horizontal input terminals and adjust the square wave amplitude for 6 to 8 cm deflection. Adjust C235 on horizontal attenuator for flat response. Set HOR. SENS. to 10 VOLTS/CM and adjust C233 for flat response. Now switch back through the three attenuator ranges and check for 10:1 division. Division should be within 5%.

5) Phase Adjustment:

Set controls as follows,

HOR. SENS. - - - - - - - - 0.1 VOLTS/CM
HOR. SENS. VERNIER - - - - - - - - - CAL
VERT. SENSITIVITY - - 100 MILLIVOLTS/CM
VERT. SENSITIVITY VERNIER - - - - - CAL

Apply 100 kc sine wave to both Vertical and Horizontal inputs. Adjust amplitude to give about 6 cm of deflection in each direction. Adjust C107 for closure of the pattern. Switch both VERT. SENSITIVITY and HOR. SENS. to 10 VOLTS/CM. Increase input to obtain approximately the same pattern as before. Adjust C18 for closure of pattern. Increase the input frequency until the pattern just opens. This frequency should be greater than 150 kc. Check phase adjustment on .1 VOLT/CM and 1 VOLT/CM ranges also.

4-13 SWEEP GENERATOR

The Vertical and Horizontal amplifiers must be adjusted before the Sweep Generator can be adjusted completely.

1) X1 Calibration:

Set controls as follows,

SWEEP TIME - - - - 10 MILLISECONDS/CM
SWEEP EXPAND - - - - - - - - - - - - X1

Connect 10-millisecond time marker to Vertical input terminals. Adjust TRIGGER LEVEL control and choose either INT + or - for best pattern. Adjust X1 Sweep Gain Adjustment, R107, for 1 marker per centimeter.

2) X5 Calibration:

Set controls as follows,

SWEEP EXPAND - - - - - - - - - - - - X5

Apply 10-millisecond time marker to Vertical input terminals. Adjust TRIGGER LEVEL control for best pattern. Adjust X5 Sweep Gain Adjustment R108, for 1 marker per 5 centimeter.

3) Sweep Linearity Adjustments:

Set controls as follows,

SWEEP TIME - - - 10 MICROSECONDS/CM
VERNIER to CALIBRATE
SWEEP EXPAND - - - - - - - - - - - - X1

Connect 10-microsecond time marker to Vertical input terminals and adjust VERTICAL SENSITIVITY, SYNC, and TRIGGER LEVEL for best presentation. Adjust HORIZONTAL POSITION so last marker on the trace is aligned with last graticule marking. Adjust C226 (see Figure 4-2) so last five markers coincide with every major graticule divisions (one marker per centimeter). Set R225, Sweep Length Adjustment, to obtain approximately 10 cm of sweep. Adjust C214 (see Figure 4-2) so first five markers on the trace coincide with every major graticule divisions. If necessary adjust HORIZONTAL POSITION so last marker on the trace is always aligned with last graticule marking.

Change SWEEP TIME to 5 MICROSECONDS/CM and apply 1-microsecond time marker to Vertical input terminals. Adjust VERTICAL SENSITIVITY, SYNC, and TRIGGER LEVEL for best presentation. Adjust HORIZONTAL POSITION so sweep starts on left-hand graticule mark. Adjust C105 (see Figure 4-2) for equal spacing of markers on first portion of sweep (five markers per centimeter).

Change SWEEP TIME to 20 MICROSECONDS/CM and SWEEP EXPAND TO X5. Apply 1-microsecond time marker to Vertical input and adjust for best presentation. Adjust HORIZONTAL POSITION so sweep starts on left-hand graticule mark. Adjust C106 (see Figure 4-2) for equal spacing of markers on first portion of sweep (four markers per centimeter).

4) Calibrate 50-microseconds/cm Sweep:

Set controls as follows,

SWEEP TIME - - - 50 MICROSECONDS/CM
VERNIER to CALIBRATE
SWEEP EXPAND - - - - - - - - - - - X1

Connect 100-microsecond time marker to Vertical input terminals and adjust VERTICAL SENSITIVITY, SYNC, and TRIGGER LEVEL for best presentation. Adjust C225 (see Figure 4-1) for marker coincidence with every other major graticule division (one marker per 2 centimeters).

5) Calibrate 0.5-millisecond/cm Sweep:
Set controls as follows,

SWEEP TIME - - - .5 MILLISECONDS/CM
VERNIER to CALIBRATE
SWEEP EXPAND - - - - - - - - - - - - X1

Connect 1-millisecond time marker to Vertical input terminals and adjust VERTICAL SENSITIVITY, SYNC, and TRIGGER LEVEL for best presentation. Adjust C223 (see Figure 2-1) for marker coincidence with every other major graticule division (one marker per 2 centimeters).

6) Calibrate 50-milliseconds/cm Sweep

Set controls as follows,

SWEEP TIME - - - 50 MILLISECONDS/CM
VERNIER to CALIBRATE
SWEEP EXPAND - - - - - - - - - - - - X1

Connect 100-millisecond time marker to Vertical input terminals and adjust VERTICAL SENSITIVITY, SYNC, and TRIGGER LEVEL for best presentation. Adjust R251, 50 msec Calibrate, for marker coincidence with every other major graticule division (one marker per 2 centimeters).

7) Sweep Length:

Set controls as follows,

SWEEP TIME - - - 200 MICROSECONDS/CM

Connect 1-microsecond time markers to the Vertical input terminal. Adjust TRIGGER LEVEL control for stable pattern, if necessary. Adjust Sweep Length Adjustment, R225, for 10.5 cm of sweep.

8) Hum:

Set controls as follows,

SWEEP TIME - - - - 1 MILLISECOND/CM
SYNC - - - - - - - - - - - - - - - - - - INT
TRIGGER LEVEL - - - - - - - - - - AUTO
SWEEP EXPAND - - - - - - - - - - - - X1

Connect 1 kc sine wave to the Vertical input terminals. Turn the SWEEP TIME VERNIER down approximately 3:1 and tune to observe hum modulation on sweep. Switch SWEEP EXPAND switch to X5. Adjust Hum Balance control, R360, for minimum hum. In addition, there should be less than .05 cm shift in the trace.

Mechanical shock can magnetize the CRT shield and destroy its shielding properties. Demagnetization is most easily accomplished by annealing.

9) Common-mode Rejection:

Set controls as follows,

VERT. SENSITIVITY - - 10 MILLIVOLTS/CM
VERT. SENSITIVITY VERNIER - - - - CAL
SWEEP TIME - - - 0.5 MILLISECOND/CM

Check balance of vertical amplifier (paragraph 4-11 step 1). Apply 1 kc sine wave from ⓗⓟ 200CD to Vertical input terminals through an ⓗⓟ 350B Attenuator with 600 ohm termination. With the 200CD at maximum output, switch in attenuation until 1 cm of signal is displayed. Change input to balanced (remove jumper) and feed same signal into both grids. Remove attenuation until a 1 cm of deflection is again achieved. The attenuation removed should be greater than 40 db.

SCHEMATIC DIAGRAM NOTES

1. Heavy solid line shows main signal path; heavy dashed line shows control, secondary signal, or feedback path.

2. Heavy box indicates front-panel engraving; light box indicates chassis marking.

3. Arrows on potentiometers indicate clockwise rotation as viewed from the round shaft end, counter-clockwise from the rectangular shaft end.

4. Resistance values in ohms, inductance in microhenries, and capacitance in micromicrofarads unless otherwise specified.

5. Rotary switch schematics are electrical representations; for exact switching details refer to the switch assembly drawings.

6. Relays shown in condition prevailing during normal instrument operation.

7. ‡ indicates a selected part. See parts list.

8. Interconnecting parts and assemblies are shown on cable diagram.

9. * Value adjusted at factory. Part may be omitted.

VOLTAGE AND RESISTANCE DIAGRAM NOTES

1. Each tube socket terminal is numbered and lettered to indicate the tube element and pin number, as follows:

*	=	no tube element	P	=	plate
H	=	heater	T	=	target (plate)
K	=	cathode	R	=	reflector or repeller
G	=	control grid	A	=	anode (plate)
Sc	=	screen grid	S	=	spade
Sp	=	suppressor grid	Sh	=	shield
Hm	=	heater mid-tap	NC	=	no external connection to socket
IS	=	internal shield	Δ	=	indefinite reading due to circuit (see 2.)

The numerical subscript to tube-element designators indicates the section of a multiple-section tube; the letter subscript to tube-element designators indicates the functional difference between like elements in the same tube section, such as t for triode and p for pentode.

A socket terminal with an asterisk may be used as a tie point and may have a voltage and resistance shown.

2. Voltages values shown are for guidance; values may vary from those shown due to tube aging or normal differences between instruments. Resistance values may vary considerably from those shown when the circuit contains potentiometers, crystal diodes, or electrolytic capacitors.

3. Voltage measured at the terminal is shown above the line, resistance below the line; measurements made with an electronic multimeter, from terminal to chassis ground unless otherwise noted.

4. A solid line between socket terminals indicates a connection external to the tube between the terminals; a dotted line between terminals indicates a connection inside the tube. Voltage and resistance are given at only one of the two joined terminals.

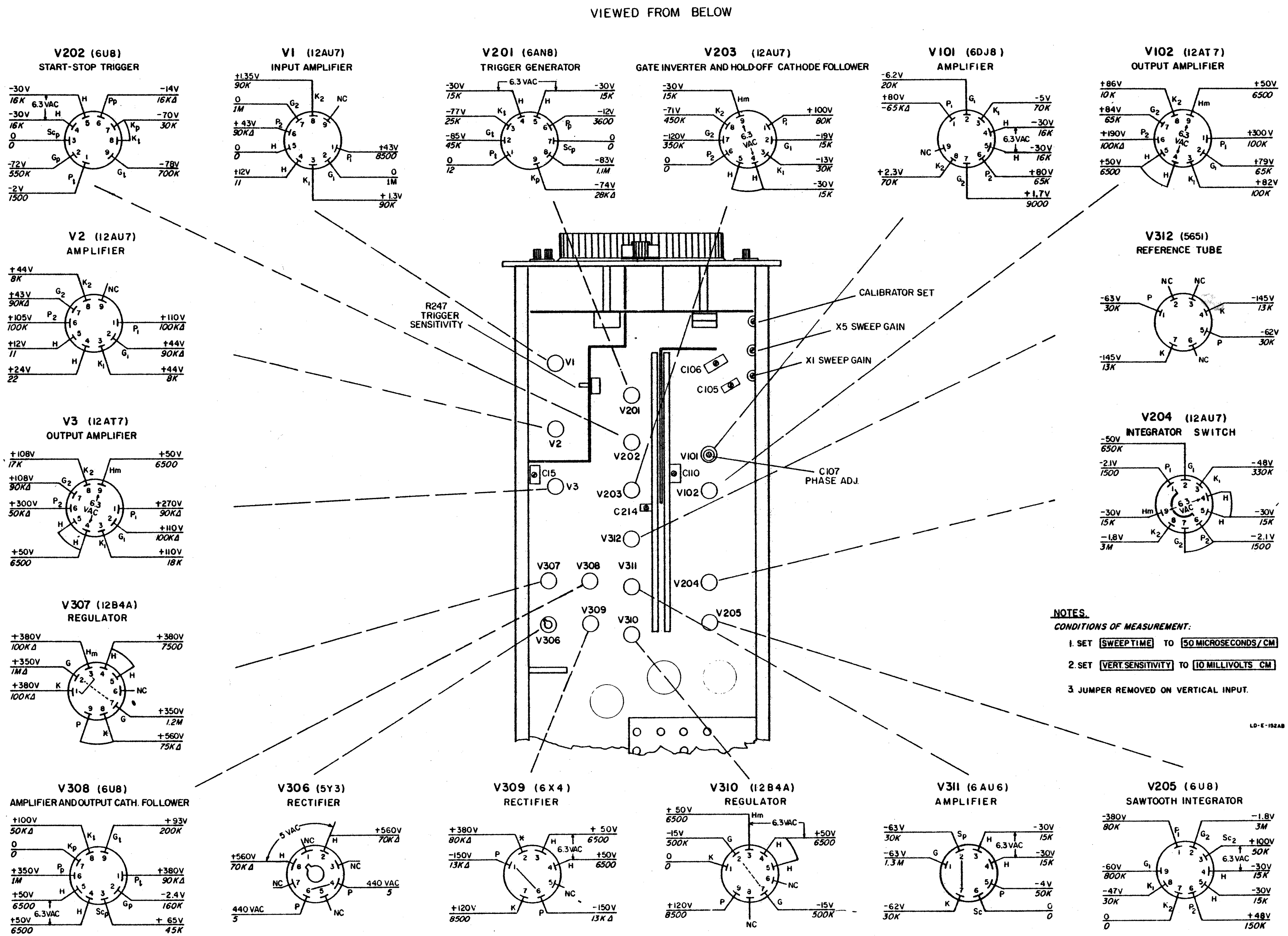
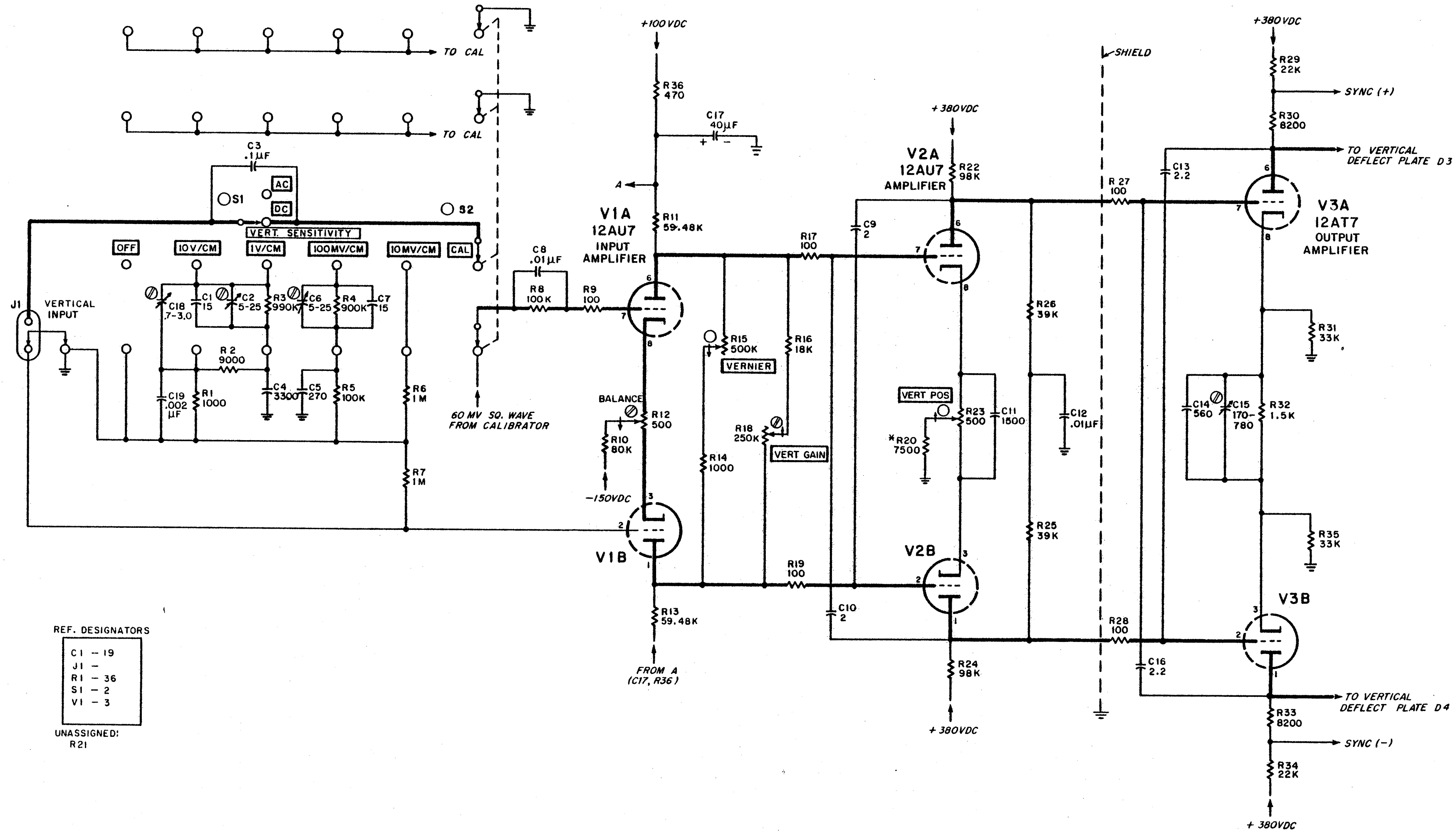


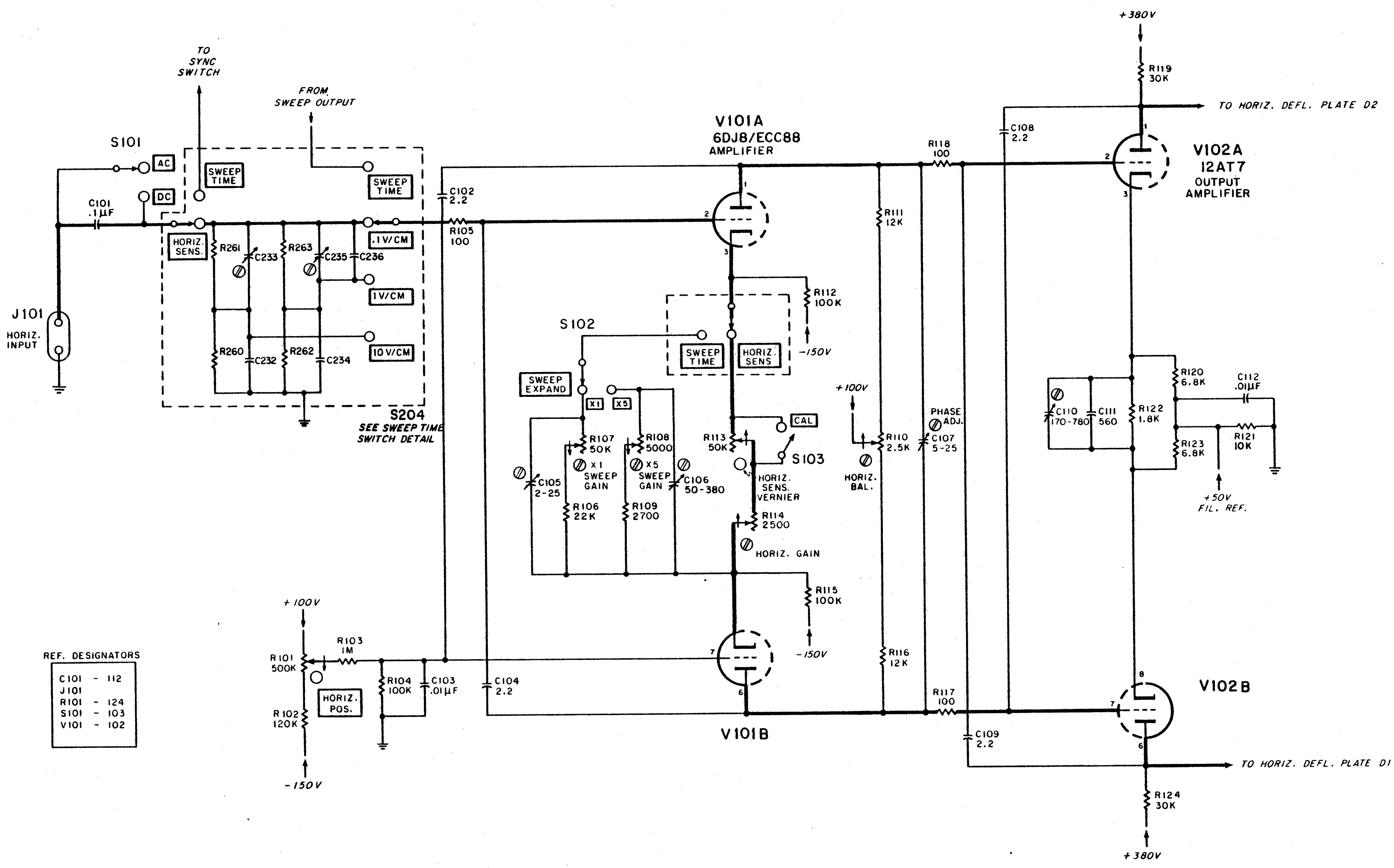
Figure 4-2. Adjustment Location and Voltage Resistance Diagram



120A-VA - T-051A

Figure 4-3. Vertical Amplifier

00016-2



120A - HA -T-051A

Figure 4-4. Horizontal Amplifier

00016-2

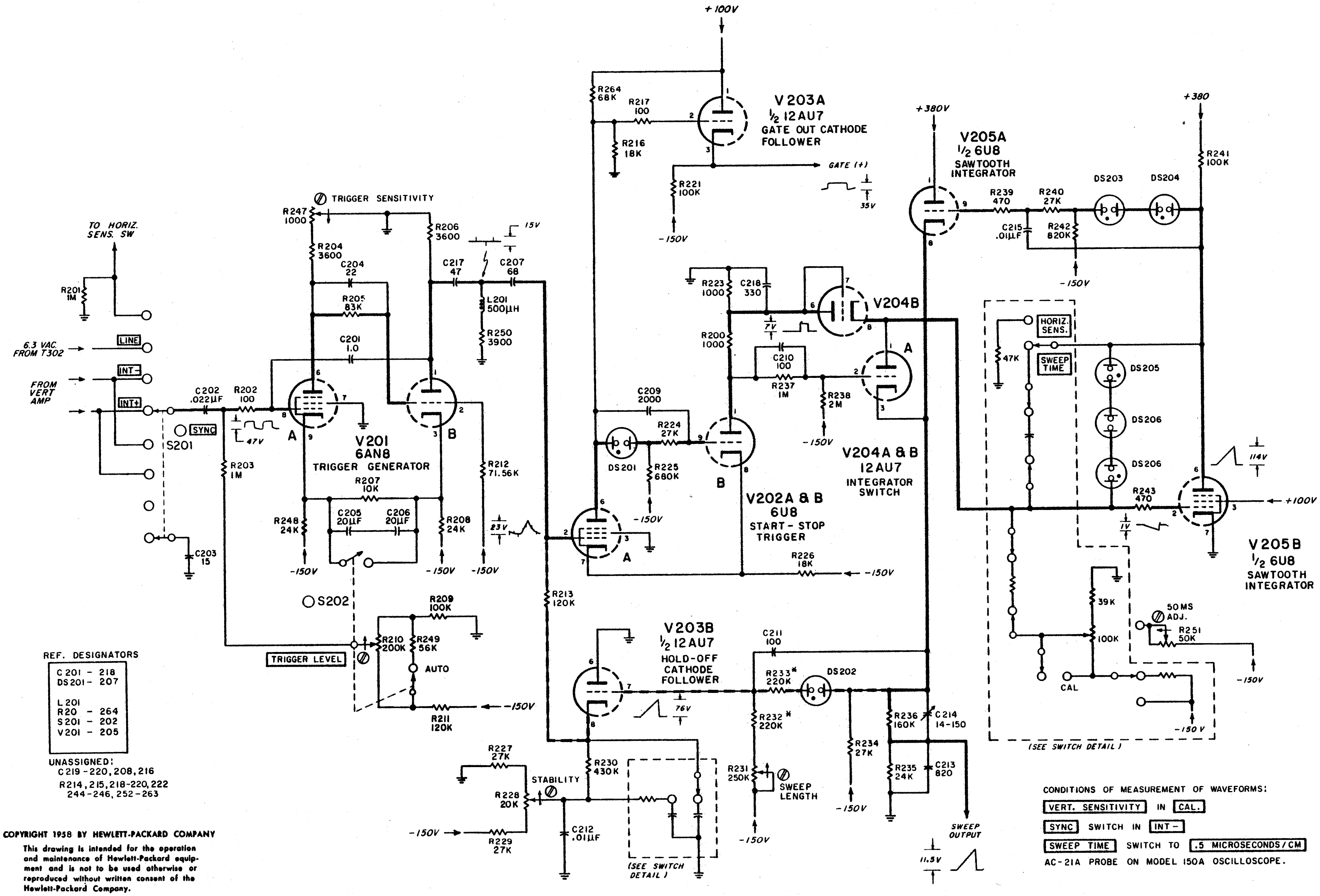


Figure 4-5. Sweep Generator

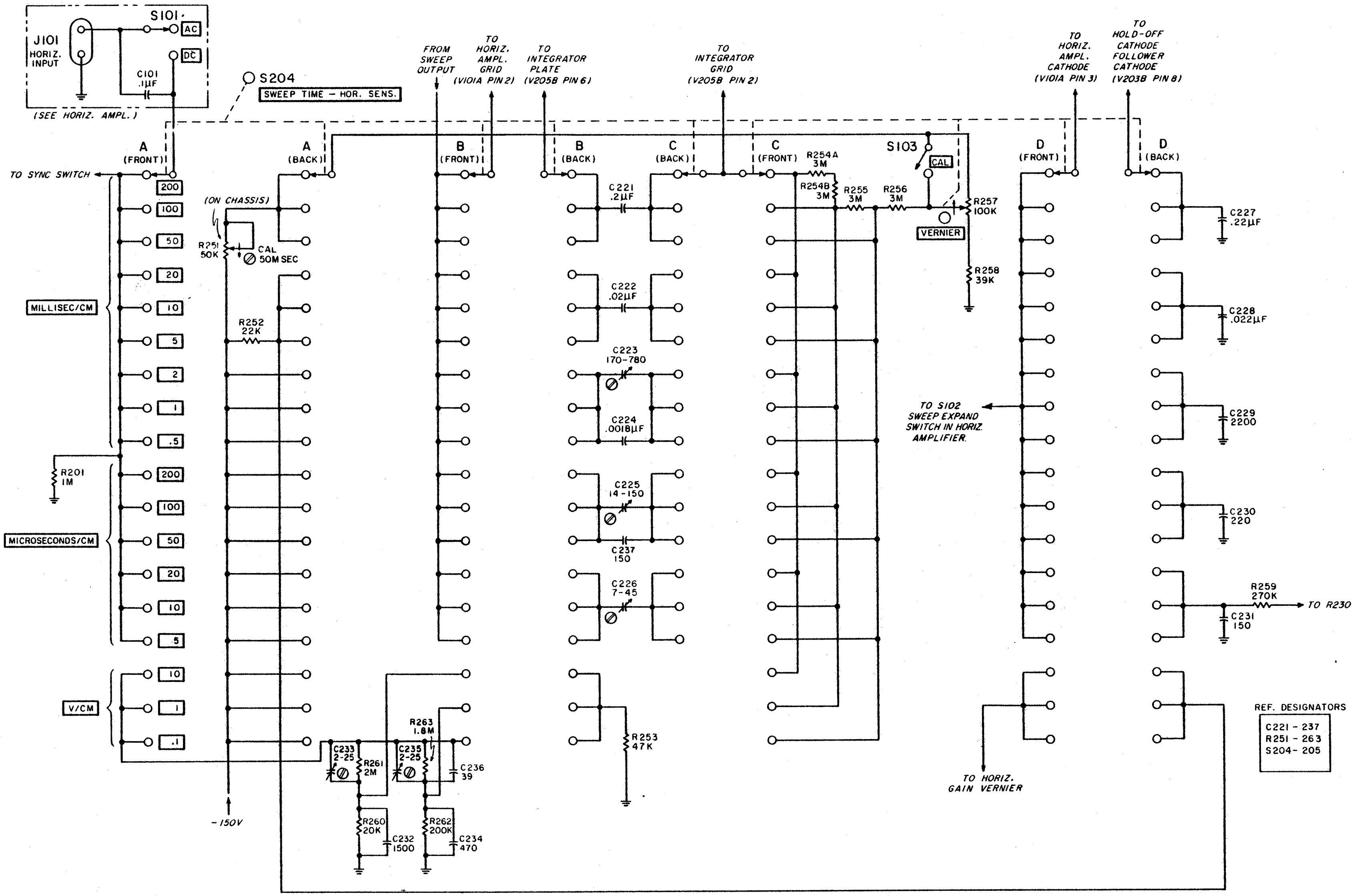
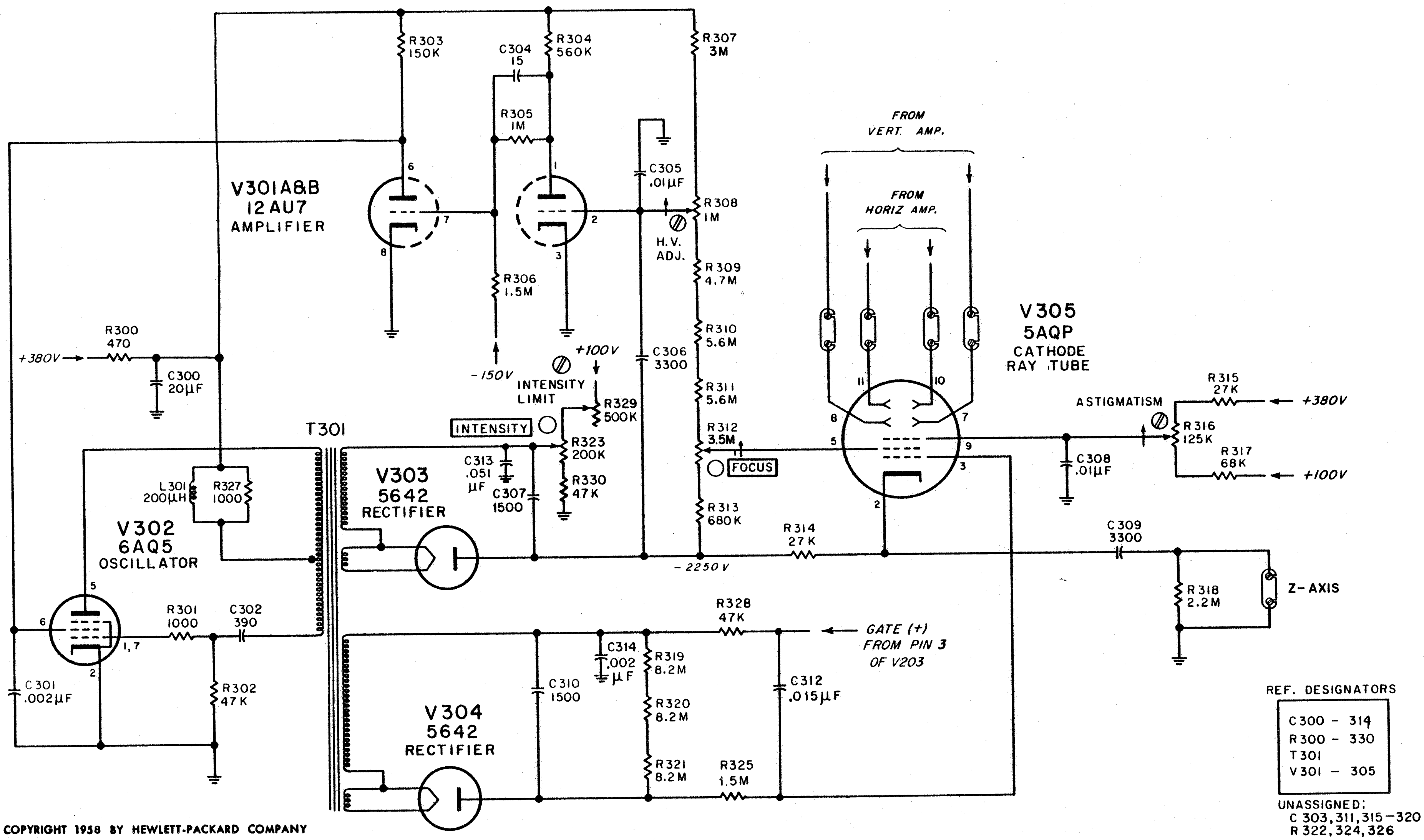


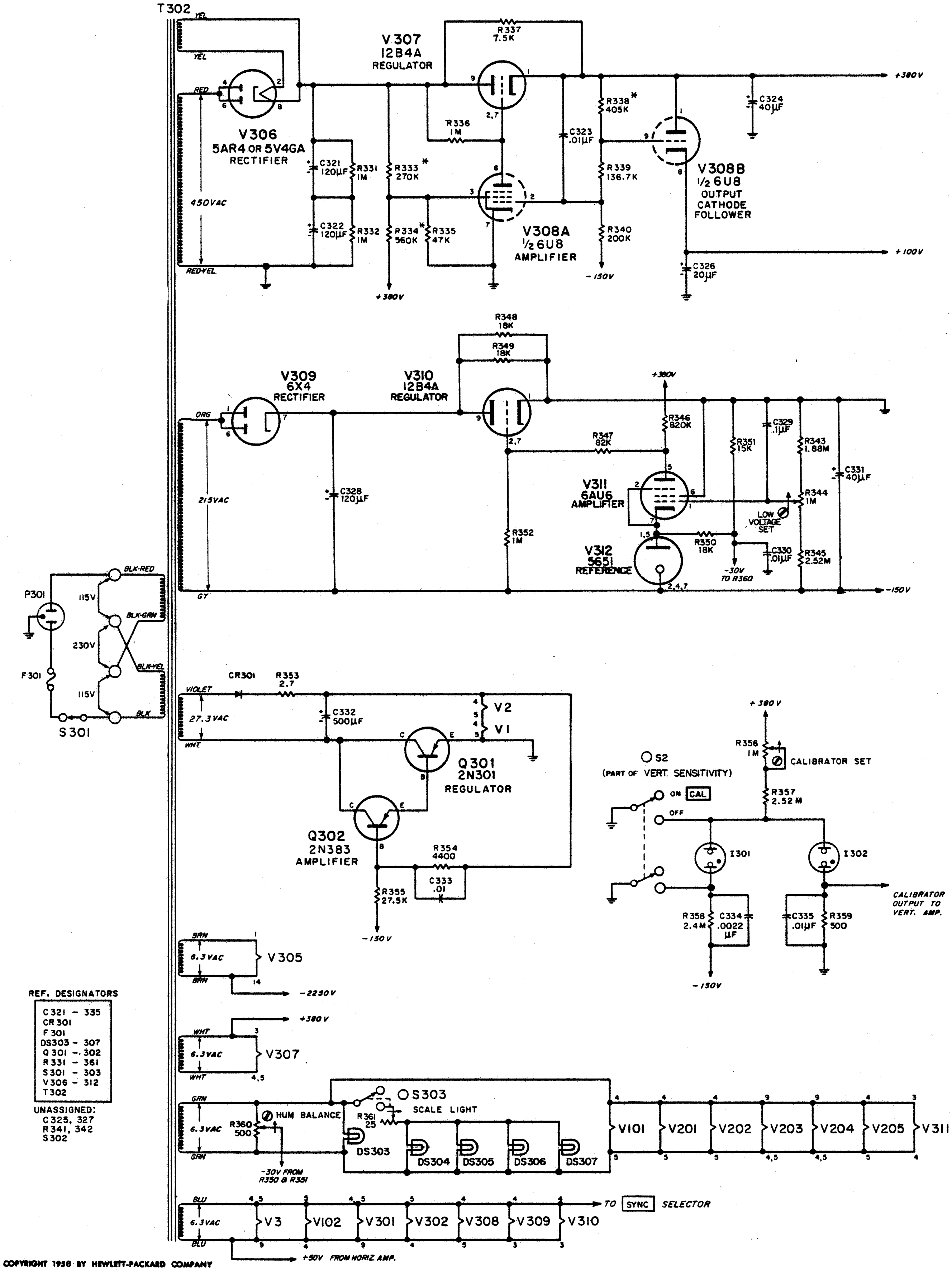
Figure 4-6. Sweep Time Switch

120A - ST - T-05IA



120A - HVPS - T-051A

Figure 4-7. High Voltage Power Supply



120A - LV & F - T051A

Figure 4-8. Low Voltage and Filament Supplies

SECTION V
TABLE OF REPLACEABLE PARTS

NOTE

Standard components have been used in this instrument, whenever possible. Special components may be obtained from your local Hewlett-Packard representative or from the factory.

When ordering parts always include:

1. hp Stock Number.
2. Complete description of part including circuit reference.
3. Model number and serial number of instrument.
4. If part is not listed, give complete description, function and location of part.

Corrections to the Table of Replaceable Parts are listed on an Instruction Manual Change sheet at the front of this manual.

RECOMMENDED SPARE PARTS LIST

Column RS in the Table lists the recommended spare parts quantities to maintain one instrument for one year of isolated service. Order complete spare parts kits from the Factory Parts Sales Department. ALWAYS MENTION THE MODEL AND SERIAL NUMBERS OF INSTRUMENTS INVOLVED.

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. *	hp Stock No.	TQ			
C1	Capacitor: fixed, mica, 15 pf ±10%, 500 vdcw	76433	0140-0004	4			
C2	Capacitor: variable, trimmer, ceramic, 5-25 pf	72982	0130-0012	3			
C3	Capacitor: fixed, mylar, 0.1 μf ±20%, 600 vdcw	09134	0170-0022	1			
C4	Capacitor: fixed, mica, 3300 pf ±10%, 500 vdcw	76433	0140-0029	1			
C5	Capacitor: fixed, mica, 270 pf ±10%, 500 vdcw	76433	0140-0015	1			
C6	Same as C2						
C7	Same as C1						
C8	Capacitor: fixed, paper, .01 μf ±10%, 400 vdcw	72928	0160-0054	3			
C9, 10	Capacitor: fixed, titanium dioxide, 2 pf ±5%, 500 vdcw	78488	0150-0031	2			
C11	Capacitor: fixed, mica, 1500 pf ±20%, 500 vdcw	76433	0140-0058	2			
C12	Same as C8						
C13	Capacitor: fixed, titanium dioxide, 2.2 pf ±10%, 500 vdcw	78488	0150-0015	6			
C14	Capacitor: fixed, mica, 560 pf ±10%, 500 vdcw	00853	0140-0044	2			
C15	Capacitor: variable, mica, 170-780 pf, 175 vdcw	72136	0131-0003	3			
C16	Same as C13						
C17	Capacitor: fixed, electrolytic, 4 sections 20 μf/sect., 450 vdcw includes C300, C326	56289	0180-0025	1			
C18	Capacitor: variable, polystyrene, 0.7-3.0 pf, 350 vdcw	72982	0132-0005	1			
C19	Capacitor: fixed, ceramic, .002 μf ±20%, 1000 vdcw	91480	0150-0023	4			
C20 thru C100	Not assigned						

* Refer to "List of Manufacturers' Codes".
TQ Total Quantity used in the instrument.
RS Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. *	hp Stock No.	TQ			
C101	Capacitor: fixed, paper, 0.1 μf ±10%, 600 vdcw	56289	0160-0001	1			
C102	Same as C13						
C103	Capacitor: fixed, ceramic, .01 μf ±20%, 1000 vdcw	56289	0150-0012	8			
C104	Same as C13						
C105	Capacitor: variable, mica, 2-25 pf, 175 vdcw	72136	0131-0005	3			
C106	Capacitor: variable, mica, 50-380 pf, 175 vdcw	72136	0131-0001	1			
C107	Same as C2						
C108, 109	Same as C15						
C110	Same as C15						
C111	Same as C14						
C112	Same as C 103						
C113 thru C200	Not assigned						
C201	Capacitor: fixed, titanium dioxide, 1 pf, ±10%, 500 vdcw	78488	0150-0029	1			
C202	Capacitor: fixed, paper, .022 μf ±10%, 600 vdcw	56289	0160-0003	2			
C203	Same as C1						
C204	Capacitor: fixed, mica, 22 pf ±5%, 300 vdcw	76433	0140-0034	1			
C205, 206	Capacitor: fixed, electrolytic, 20 μf, 25 vdcw	56289	0180-0045	2			
C207	Capacitor: fixed, mica, 68 pf ±10%, 500 vdcw	00853	0140-0025	1			
C208	Not assigned						
C209	Same as C19						
C210	Capacitor: fixed, mica, 100 pf ±5%, 300 vdcw	76433	0140-0041	1			

* Refer to "List of Manufacturers' Codes".
TQ Total Quantity used in the instrument.
RS Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. *	hp Stock No.	TQ			
C211	Capacitor: fixed, mica, 100 pf ±10%, 500 vdcw	76433	0140-0054	1			
C212	Same as C103						
C213	Capacitor: fixed, mica, 820 pf ±10%, 500 vdcw	76433	0140-0010	1			
C214	Capacitor: variable, mica, 14-150 pf, 175 vdcw	72136	0131-0004	2			
C215	Same as C103						
C216	Not assigned						
C217	Capacitor: fixed, mica, 47 pf ±10%, 500 vdcw	76433	0140-0032	1			
C218	Capacitor: fixed, mica, 330 pf ±10%, 500 vdcw	00853	0140-0043	1			
C219, 220	Not assigned						
C221	Capacitor: fixed, mylar, 0.2 µf ±5%, 200 vdcw	84411	0170-0028	1			
C222	Capacitor: fixed, mylar, .02 µf, ±5%, 200 vdcw	84411	0170-0027	1			
C223	Same as C15						
C224	Capacitor: fixed, mylar, .00181 µf ±5%, 200 vdcw	84411	0170-0026	1			
C225	Same as C214						
C226	Capacitor: variable, ceramic, 7-45 pf, 500 vdcw	72982	0130-0001	1			
C227	Capacitor: fixed, paper, .22 µf ±10%, 400 vdcw	56289	0160-0018	1			
C228	Same as C202						
C229	Capacitor: fixed, paper, 220 pf ±10%, 600 vdcw	56289	0160-0007	2			
C230	Capacitor: fixed, mica, 220 pf ±10%, 500 vdcw	76433	0140-0031	1			
C231	Capacitor: fixed, mica, 150 pf ±10%, 500 vdcw	72982	0140-0055	1			

* Refer to "List of Manufacturers' Codes".
TQ Total Quantity used in the instrument.
RS Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. *	hp Stock No.	TQ			
C232	Same as C11						
C233	Same as C105						
C234	Capacitor: fixed, mica, 470 pf ±10%, 500 vdcw	76433	0140-0027	1			
C235	Same as C105						
C236	Capacitor: fixed, mica, 39 pf ±5%, 500 vdcw	76433	0140-0035	1			
C237	Capacitor: fixed, silver mica, 150 pf ±5%, 500 vdcw	00656	0140-0067	1			
C238 thru C299	Not assigned						
C300	Part of C17						
C301	Same as C19						
C302	Capacitor: fixed, mica, 390 pf ±5%, 500 vdcw	00853	0140-0016	1			
C303	Not assigned						
C304	Same as C1						
C305	Same as C8						
C306	Capacitor: fixed, paper, .0033 μf ±20%, 6000 vdcw	56289	0160-0046	2			
C307	Capacitor: fixed, paper, 1500 pf ±20%, 5000 vdcw	56289	0160-0061	2			
C308	Same as C103						
C309	Same as C306						
C310	Same as C307						
C311	Not assigned						
C312	Capacitor: fixed, paper, .015 μf ±10%, 3000 vdcw	56289	0160-0062	1			
C313	Capacitor: fixed, paper, .051 μf, ± 10%, 200 vdcw	00853	0170-0003	1			
C314	Same as C19						

* Refer to "List of Manufacturers' Codes".
TQ Total Quantity used in the instrument.
RS Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. *	hp Stock No.	TQ			
C315 thru C320	Not assigned						
C321	Capacitor: fixed, electrolytic, 1 section, 120 μf, 350 vdcw	56289	0180-0042	1			
C322	Capacitor: fixed, electrolytic, 2 sections 120 x 40 μf, 450 vdcw (includes C324)	56289	0180-0030	2			
C323	Capacitor: fixed, paper, .01 μf ±10%, 600 vdcw	56289	0160-0002	1			
C324	Part of C322						
C325	Not assigned						
C326	Part of C17						
C327	Not assigned						
C328	Same as C322 (includes C331)						
C329	Capacitor: fixed, paper, 0.1 μf ±10%, 400 vdcw	56289	0160-0013	1			
C330	Same as C103						
C331	Part of C322						
C332	Capacitor: fixed, electrolytic, 1 section, 500 μf, 50 vdcw	56289	0180-0047	1			
C333	Same as C103						
C334	Same as C229						
C335	Same as C103						
CR1 thru CR300	Not assigned						
CR301	Diode, silicon, power: 500 ma, 100 volts PIV	75042	1901-0008	1			
DS1 thru DS302	Not assigned						
DS303	Lamp incandescent: 2 pin, #12	24455	2140-0012	1			
DS304 thru DS307	Lamp incandescent: 6-8 V, .15 amp, #47	24455	2140-0009	4			

* Refer to "List of Manufacturers' Codes".
TQ Total Quantity used in the instrument.
RS Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. *	hp Stock No.	TQ			
I1 thru I200	Not assigned						
I201 thru I204	Lamp, neon: aged and selected (green code)	28480	G-84D	6			
I205, 206 207	Lamp, neon: aged and selected (blue code)	28480	G-84B	3			
I208 thru I300	Not assigned						
I301, 302	Same as I201						
F1 thru F300	Not assigned						
F301	Fuse, slow-blow: 2 amp, for 115 volt operation	71400	2110-0006	1			
	Fuse, slow-blow: 1 amp, for 230 volt operation	71400	2110-0007				
J1	Binding Post, insulated: red	28480	AC-10D	2			
	Binding Post, insulated, black, with ground link	28480	G-76K	1			
J2 thru J100	Not assigned						
J101	Binding Post, insulated: red	28480	AC-10D				
	Binding Post, insulated: black	28480	AC-10C	1			
L201	Coil, RF: 500 μh	99848	9140-0022	1			
L301	Coil, RF: 200 μh	28480	9140-0019	1			
P301	Power Cord	28480	8120-0050	1			
Q301	Transistor, power: 2N301	02735	1850-0038	1			
Q302	Transitor, amplifier: 2N383	94154	1850-0040	1			

* Refer to "List of Manufacturers' Codes".
TQ Total Quantity used in the instrument.
RS Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. *	hp Stock No.	TQ			
R1	Resistor: fixed, deposited carbon, 1000 ohms ±1%, 1/2 W	19701	0727-0100	1			
R2	Resistor: fixed, deposited carbon, 9000 ohms ±1%, 1/2 W	19701	0727-0152	1			
R3	Resistor: fixed, deposited carbon, 990, 000 ohms ±1%, 1/2 W	19701	0727-0269	1			
R4	Resistor: fixed, deposited carbon, 900, 000 ohms ±1%, 1/2 W	19701	0727-0259	1			
R5	Resistor: fixed, deposited carbon, 100, 000 ohms ±1%, 1/2 W	19701	0727-0208	1			
R6, 7	Resistor: fixed, composition, 1 megohm ±5%, 1/2 W	01121	0686-1055	3			
R8	Resistor: fixed, composition, 100, 000 ohms ±10%, 1/2 W	01121	0687-1041	2			
R9	Resistor: fixed, composition, 100 ohms ±10%, 1/2 W	01121	0687-1011	10			
R10	Resistor: fixed, deposited carbon, 80, 000 ohms ±1%, 1 W	19701	0730-0062	1			
R11	Resistor: fixed deposited carbon, 59480 ohms ±1%, 1/2 W	19701	0727-0197	2			
R12	Resistor: variable, wirewound, 500 ohms, 2 W	71450	2100-0054	1			
R13	Same as R11						
R14	Resistor: fixed, composition, 1000 ohms ±10%, 1/2 W	01121	0687-1021	4			
R15	Resistor: variable, composition, 500, 000 ohms ±20%, 1/4 W	71450	2100-0174	1			
R16	Resistor: fixed, composition, 18, 000 ohms ±10%, 1/2 W	01121	0687-1831	3			
R17	Same as R9						
R18	Resistor: variable, composition, 250, 000 ohms ±20%, 1/4 W	71450	2100-0175	1			
R19	Same as R9						

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TQ Total Quantity used in the instrument.
RS Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. *	ⓗⓟ Stock No.	TQ	RS		
R20	Resistor: fixed, deposited carbon, 7500 ohms ±1%, 1 W Optimum value selected at factory. Average value shown.	19701	0730-0024	1	1		
R21	Not assigned						
R22	Resistor: fixed, deposited carbon, 98,000 ohms ±1%, 1 W	19701	0730-0068	2	1		
R23	Resistor: variable, composition, linear taper, 500 ohms ±10%	12697	2100-0019	1	1		
R24	Same as R22						
R25, 26	Resistor: fixed, composition, 39,000 ohms ±10%, 1/2 W	01121	0687-3931	2	1		
R27, 28	Same as R9						
R29	Resistor: fixed, composition, 22,000 ohms ±5%, 2 W	01121	0693-2235	2	1		
R30	Resistor: fixed, composition, 8200 ohms ±10%, 1 W	01121	0690-8221	2	1		
R31	Resistor: fixed, composition, 33,000 ohms ±10%, 2 W	01121	0693-3331	2	1		
R32	Resistor: fixed, composition, 1500 ohms ±10%, 1/2 W	01121	0687-1521	1	1		
R33	Same as R30						
R34	Same as R29						
R35	Same as R31						
R36	Resistor: fixed, composition, 470 ohms ±10%, 1/2 W	01121	0687-4711	3	1		
R37 thru R100	Not assigned						
R101	Resistor: variable, composition, linear taper, 500,000 ohms	71590	2100-0015	2	1		
R102	Resistor: fixed, composition, 120,000 ohms ±5%, 1/2 W	01121	0686-1245	3	1		
R103	Resistor: fixed, composition, 1 megohm ±10%, 1/2 W	01121	0687-1051	8	2		

* Refer to "List of Manufacturers' Codes".
TQ Total Quantity used in the instrument.
RS Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. *	ⓗⓟ Stock No.	TQ	RS		
R104	Same as R8						
R105	Same as R9						
R106	Resistor: fixed, composition, 22,000 ohms ±10%, 1/2 W	01121	0687-2231	1	1		
R107	Resistor: variable, composition, linear taper, 50,000 ohms ±20%	71590	2100-0013	2	1		
R108	Resistor: variable, composition, linear taper, 5000 ohms	71590	2100-0011	1	1		
R109	Resistor: fixed, composition, 2700 ohms ±10%, 1/2 W	01121	0687-2721	1	1		
R110	Resistor: variable, composition, 2500 ohms ±20%, 1/2 W	71590	2100-0067	2	1		
R111	Resistor: fixed, composition, 12,000 ohms ±5%, 1/2 W	01121	0686-1235	2	1		
R112	Resistor: fixed, composition, 100,000 ohms ±10%, 1 W	01121	0690-1041	3	1		
R113	Resistor: variable, composition, 2 sections, 50,000 ohms ±20% rear section: 100,000 ohms ±20%, includes R257 and S103	71450	2100-0173	1	1		
R114	Same as R110						
R115	Same as R112						
R116	Same as R111						
R117,118	Same as R9						
R119	Resistor: fixed, composition, 30,000 ohms ±5%, 2 W	01121	0686-3035	2	1		
R120	Resistor: fixed, composition, 6800 ohms ±10%, 1/2 W	01121	0687-6821	2	1		
R121	Resistor: fixed, composition, 10,000 ohms ±10%, 2 W	01121	0693-1031	1	1		
R122	Resistor: fixed, composition, 1800 ohms ±10%, 1/2 W	01121	0687-1821	1	1		
R123	Same as R120						
R124	Same as R119						

* Refer to "List of Manufacturers' Codes".
TQ Total Quantity used in the instrument.
RS Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. *	Stock No.	TQ	RS		
R125 thru R199	Not assigned						
R200	Same as R14						
R201	Same as R103						
R202	Same as R9						
R203	Same as R103						
R204	Resistor: fixed, composition, 3600 ohms ±5%, 1/2 W	01121	0686-3625	2	1		
R205	Resistor: fixed, deposited carbon, 83,000 ohms ±1%, 1/2 W	19701	0727-0202	1	1		
R206	Same as R204						
R207	Resistor: fixed, composition, 10,000 ohms ±10%, 1/2 W	01121	0687-1031	1	1		
R208	Resistor: fixed, composition, 24,000 ohms ±5%, 1 W	01121	0689-2435	2	1		
R209	Resistor: fixed, composition, 100,000 ohms ±5%, 1/2 W	01121	0686-1045	1	1		
R210	Resistor: variable, composition, 200,000 ohms ±20%, 1/4 W includes S202	71450	2100-0171	2	1		
R211	Same as R102						
R212	Resistor: fixed, deposited carbon, 71,560 ohms ±1%, 1/2 W	19701	0727-0201	1	1		
R213	Same as R102						
R214, 215	Not assigned						
R216	Same as R16						
R217	Same as R9						
R218 thru R220	Not assigned						
R221	Same as R112						
R222	Not assigned						
R223	Resistor: fixed, deposited carbon, 1000 ohms ±1%, 1/2 W	19701	0727-0100	1	1		

* Refer to "List of Manufacturers' Codes".
TQ Total Quantity used in the instrument.
RS Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. *	hp Stock No.	TQ	RS		
R224	Resistor: fixed, composition, 27,000 ohms ±10%, 1/2 W	01121	0687-2731	6	2		
R225	Resistor: fixed, composition, 680,000 ohms ±10%, 1/2 W	01121	0687-6841	1	1		
R226	Resistor: fixed, composition, 18,000 ohms ±10%, 2 W	01121	0693-1831	1	1		
R227	Same as R224						
R228	Resistor: variable, composition, linear taper, 20,000 ohms ±30%, 1/3 W	71450	2100-0260	1	1		
R229	Same as R224						
R230	Resistor: fixed, composition, 430,000 ohms ±5%, 1/2 W	01121	0686-4345	1	1		
R231	Resistor: variable, composition, linear taper, 250,000 ohms	71450	2100-0158	1	1		
R232,233	Resistor: fixed, composition, 220,000 ohms ±10%, 1/2 W	01121	0687-2241	2	1		
R234	Resistor: fixed, metal film, 27,000 ohms ±10%, 4 W	07115	0771-0006	1	1		
R235	Resistor: fixed, composition, 24,000 ohms ±5%, 1/2 W	01121	0686-2435	1	1		
R236	Resistor: fixed, composition, 160,000 ohms ±5%, 1/2 W	01121	0686-1645	1	1		
R237	Same as R7						
R238	Resistor: fixed, composition, 2 megohms ±5%, 1/2 W	01121	0686-2055	1	1		
R239	Resistor: fixed, composition, 470 ohms ±10%, 1/2 W	01121	0687-4711	1	1		
R240	Same as R224						
R241	Resistor: fixed, composition, 100,000 ohms ±10%, 2 W	01121	0693-1041	1	1		
R242	Resistor: fixed, composition, 820,000 ohms ±10%, 1/2 W	01121	0687-8241	2	1		
R243	Same as R36						

* Refer to "List of Manufacturers' Codes".
TQ Total Quantity used in the instrument.
RS Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. *	hp Stock No.	TQ	RS		
R244	Not assigned						
R245,246	Resistor: fixed, composition, 10 ohms ±10%, 1/2 W	01121	0687-1011	2	1		
R247	Resistor: variable, composition, 1000 ohms ±30%, 3 W	71450	2100-0155	1	1		
R248	Same as R208						
R249	Resistor: fixed, composition, 56,000 ohms ±5%, 1/2 W	01121	0686-5635	1	1		
R250	Resistor: fixed, composition, 3900 ohms ±10%, 1/2 W	01121	0687-3921	1	1		
R251	Same as R107						
R252	Resistor: fixed, composition, 22,000 ohms ±10%, 1/2 W	01121	0687-2231	1	1		
R253	Resistor: fixed, composition, 47,000 ohms ±10%, 1 W	01121	0690-4731	1	1		
R254A,B thru R256	Resistor: fixed, deposited carbon, 3 megohms ±1%, 1/2 W	19701	0727-0292	3	1		
R257	Part of R113						
R258	Resistor: fixed, composition, 39,000 ohms ±10%, 1/2 W	01121	0687-3931	1	1		
R259	Resistor: fixed, composition, 270,000 ohms ±10%, 1/2 W	01121	0687-2741	1	1		
R260	Resistor: fixed, deposited carbon, 20,000 ohms ±1%, 1/2 W	19701	0727-0173	1	1		
R261	Resistor: fixed, deposited carbon, 2 megohms ±1%, 1/2 W	19701	0727-0287	1	1		
R262	Resistor: fixed, deposited carbon, 200,000 ohms ±1%, 1/2 W	19701	0727-0221	1	1		
R263	Resistor: fixed, deposited carbon, 1.8 megohms ±1%, 1/2 W	19701	0727-0285	1	1		
R264	Resistor: fixed, composition, 68,000 ohms ±10%, 1/2 W	01121	0687-6831	2	1		

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TQ Total Quantity used in the instrument.
RS Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. *	hp Stock No.	TQ	RS		
R265 thru R299	Not assigned						
R300	Same as R36						
R301	Same as R14						
R302	Resistor: fixed, composition, 47,000 ohms ±10%, 1/2 W	01121	0687-4731	4	1		
R303	Resistor: fixed, composition, 150,000 ohms ±10%, 2 W	01121	0693-1541	1	1		
R304	Resistor: fixed, composition, 560,000 ohms ±10%, 1 W	01121	0690-5641	2	1		
R305	Same as R103						
R306	Resistor: fixed, composition, 1.5 megohms ±10%, 1/2 W	01121	0687-1551	2	1		
R307	Resistor: fixed, composition, 3 megohms ±5%, 1/2 W	01121	0686-3055	1	1		
R308	Resistor: variable, composition, linear taper, 1 megohm ±30%	71590	2100-0074	3	1		
R309	Resistor: fixed, composition, 4.7 megohms ±10%, 2 W	01121	0693-4751	1	1		
R310, 311	Resistor: fixed, composition, 5.6 megohms ±10%, 2 W	01121	0693-5651	2	1		
R312	Resistor: variable, composition, 3.5 megohms ±30%, 1/2 W	12697	2100-0105	1	1		
R313	Resistor: fixed, composition, 680,000 ohms ±10%, 1/2 W	01121	0687-6841	1	1		
R314,315	Same as R224						
R316	Resistor: variable, linear taper, 125,000 ohms	71450	2100-0073	1	1		
R317	Same as R264						
R318	Resistor: fixed, composition, 2.2 megohms ±10%, 1/2 W	01121	0687-2251	1	1		
R319 thru R321	Resistor: fixed, composition, 8.2 megohms ±10%, 2 W	01121	0693-8251	3	1		

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TQ Total Quantity used in the instrument.
RS Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. *	Stock No.	TQ	RS		
R322	Not assigned						
R323	Same as R210 (includes S301)						
R324	Not assigned						
R325	Same as R306						
R326	Not assigned						
R327	Same as R14						
R328	Same as R302						
R329	Same as R101						
R330	Same as R302						
R331,332	Same as R103						
R333	Resistor: fixed, composition, 270,000 ohms ±10%, 1 W Optimum value selected at factory Average value shown	01121	0690-2741	1	1		
R334	Same as R304 Optimum value selected at factory Average value shown						
R335	Same as R302						
R336	Same as R103						
R337	Resistor: fixed, wirewound, 7500 ohms ±10%, 10 W	35434	0816-0007	1	1		
R338	Resistor: fixed, deposited carbon, 405,000 ohms ±1%, 1/2 W Optimum value selected at factory Average value shown	19701	0727-0240	1	1		
R339	Resistor: fixed, deposited carbon, 136,700 ohms ±1%, 1/2 W	19701	0727-0216	1	1		
R340	Resistor: fixed, deposited carbon, 200,000 ohms ±1%, 1/2 W	19701	0727-0221	1	1		
R341,342	Not assigned						
R343	Resistor: fixed, deposited carbon, 1.88 megohms ±1%, 1/2 W	19701	0727-0286	1	1		

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TQ Total Quantity used in the instrument.
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TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. *	Stock No.	TQ	RS		
R344	Same as R308						
R345	Resistor: fixed, deposited carbon, 2.52 megohms ±1%, 1/2 W	19701	0727-0289	1	1		
R346	Same as R242						
R347	Resistor: fixed, composition, 82,000 ohms ±10%, 1/2 W	01121	0687-8231	1	1		
R348,349	Resistor: fixed, composition, 18,000 ohms ±10%, 2 W	01121	0693-1831	2	1		
R350	Same as R16						
R351	Resistor: fixed, composition, 15,000 ohms ±10%, 1/2 W	01121	0687-1531	1	1		
R352	Same as R103						
R353	Resistor: fixed, composition, 2.7 ohms ±10%, 1 W	01121	0699-0005	1	1		
R354	Resistor: fixed, deposited carbon, 4440 ohms ±1%, 1/2 W	19701	0727-0134	1	1		
R355	Resistor: fixed, deposited carbon, 27,500 ohms ±1%, 1/2 W	19701	0730-0044	1	1		
R356	Same as R308						
R357	Resistor: fixed, deposited carbon, 2.52 megohms ±1%, 1/2 W	19701	0727-0289	1	1		
R358	Resistor: fixed, composition, 2.4 megohms ±5%, 1/2 W	01121	0686-2455	1	1		
R359	Resistor: fixed, deposited carbon, 500 ohms ±1%, 1/2 W	19701	0727-0077	1	1		
R360	Resistor: variable, wirewound, linear taper, 500 ohms ±30%, 3/10 W	71450	2100-0078	1	1		
R361	Resistor: variable, wirewound, 25 ohms ±10%, 2 W, includes S303	71450	2100-0140	1	1		

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TQ Total Quantity used in the instrument.
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TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. *	hp Stock No.	TQ	RS		
S1	Switch, toggle: SPST	04009	3101-0001	2	1		
S2	Vertical Sensitivity Switch Assembly	28480	120A-19A	1	1		
S3 thru S100	Not assigned						
S101	Same as S1						
S102	Switch, toggle: SPDT, SWEEP EXPAND	04009	3101-0002	1	1		
S103	Part of R113						
S104 thru S200	Not assigned						
S201	Switch, rotary: SYNC	76854	3100-0175	1	1		
S202	Part of R210						
S203	Not assigned						
S204	Sweep Time and Horizontal Sensitivity Switch Assembly	28480	120A-19B	1	1		
S205 thru S300	Not assigned						
S301	Part of R323						
S302	Not assigned						
S303	Part of R361						
T301	Transformer, high voltage	28480	120A-11A-1	1	1		
T302	Transformer,power	28480	9100-0095	1	1		
V1AB V2AB	Tube, electron: 12AU7 Tubes selected for best performance will be supplies by -hp- (if ordered by -hp- stock number), but tubes meeting EIA standards will normally result in the instrument operating within specifications.	28480	G-73R	2	2		
V3AB	Tube, electron: 12AT7	33173	1932-0027	2	2		

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TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr. *	-hp- Stock No.	TQ	RS		
V4 thru V100	Not assigned						
V101AB	Tube, electron: 6DJ8/ECC88 Tubes selected for best performance will be supplied by -hp- (if ordered by -hp- stock number), but tubes meeting EIA standards will normally result in the instrument operating within specifications.	28480	G-73Z	1	1		
V102	Same as V3						
V103 thru V200	Not assigned						
V201	Tube, electron: 6AN8	82219	1933-0001	1	1		
V202	Tube, electron: 6U8	33173	1933-0004	3	3		
V203,204	Tube, electron: 12AU7	33173	1932-0029	3	3		
V205	Same as V202						
V206 thru V300	Not assigned						
V301	Same as V203						
V302	Tube, electron: 6AQ5	82219	1923-0018	1	1		
V303,304	Tube, electron: 5642	82219	1920-0001	2	2		
V305	Tube, cathode ray: (normally supplied with P1 phosphor. P2, 7, or 11 also available)	82170	2090-0007	1	1		
V306	Tube, electron: 5AR4 or 5V4GA	33173	1930-0003	1	1		
V307	Tube, electron: 12B4A	33173	1921-0010	2	2		
V308	Same as V202						
V309	Tube, electron: 6X4	33173	1930-0016	1	1		
V310	Same as V307						
V311	Tube, electron: 6AU6	33173	1923-0021	1	1		
V312	Tube, electron: 5651	86684	1940-0001	1	1		

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TQ Total Quantity used in the instrument.
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TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	Mfr.*	hp Stock No.	TQ	RS		
	MISCELLANEOUS						
	Bail, cabinet tilting	28480	G-44A-5	1	0		
	Bracket and base clamp assembly for CRT	28480	120A-12A	1	0		
	Chassis slides, pair, nylon, right and left	28480	G-16G/H	1	0		
	Coupler, insulated	28480	AC-32A				
	Detent, cabinet bail, plastic	28480	400D-44A	2	0		
	Filter, CRT: amber	28480	120A-83A		0		
	blue	28480	120A-83B		0		
	green	28480	120A-83G		0		
	Fuseholder	75915	1400-0007	1	1		
	Graticule, CRT	28480	120A-83C	1	0		
	Insulator, binding post: double black	28480	AC-54A	4	0		
	Jewel, pilot lamp	72765	1450-0020	1	0		
	Knob: FOCUS, INTENSITY, VERT. POS., HORIZ. POS., SCALE LIGHT	28480	G-74D	5	0		
	Knob: SYNC	28480	G-74N	1	0		
	Knob: VERT. SENSITIVITY SWEEP TIME HOR. SENS.	28480	G-74Q	•2	0		
	Knob: VERNIER (red)	28480	G-74AU	2	0		
	Lever to adjust CRT position	28480	130A-49B				
	Rear protective board, "Caution High Voltage"	28480	120A-41C				
	Socket, tube: 9 pin	91662	1200-0008	14	1		
	Socket, tube: 7 pin	91662	1200-0009	3	1		
	Socket, tube: 7 pin	71785	1200-0017	1	1		
	Socket, tube: octal	71785	1200-0020	1	1		
	Socket, transistor	71785	1200-0041	1	1		
	Socket, CRT	91662	1200-0037	1	1		
	Strap, copper, for high voltage transformer	28480	120A-11A-2				
	Tube, shield	91662	1220-0008	1	0		
	Tube, shield	71785	1220-0009	1	0		

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TQ Total Quantity used in the instrument.
RS Recommended spares for one year isolated service for one instrument.

LIST OF MANUFACTURERS

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

CODE NO.	MANUFACTURER	ADDRESS
00334	Humidial Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00656	Aerovox Corp.	New Bedford, Mass.
00781	Aircraft Radio Corp.	Boonton, N.J.
00853	Sangamo Electric Co., Cap. Div.	Marion, Ill.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	Pacific Semiconductors, Inc.	Culver City, Calif.
01295	Texas Instruments, Inc. Semiconductor Components Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America Semiconductor and Materials Div.	Somerville, N.J.
02777	Hopkins Engineering Co.	San Francisco, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04404	Dymec Inc.	Palo Alto, Calif.
04651	Special Tube Operations of Sylvania Electronic Systems	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04777	Automatic Electric Sales Corp.	Northlake, Ill.
05624	Barber Colman Co.	Rockford, Ill.
05783	Stewart Engineering Co.	Soquel, Calif.
06004	The Bassick Co.	Bridgeport, Conn.
06812	Torrington Mfg. Co., West. Div.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08718	Cannon Electric Co. Phoenix Div.	Phoenix, Ariz.
08733	Camloc Fastener Corp.	Los Angeles, Calif.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S. Inc.	Lowell, Mass.
09134	Texas Capacitor Co.	Houston, Texas
09250	Electro Assemblies, Inc.	Chicago, Ill.
10646	Carborundum Co.	Niagara Falls, N.Y.
12697	Clarostat Mfg. Co.	Dover, N.H.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
15909	The Daven Co.	Livingston, N.J.
16758	Delco Radio Div. of G. M. Corp.	Kokomo, Ind.
18873	E. I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G. E., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G. E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
37942	P. R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
44655	Ohmite Mfg. Co.	Skokie, Ill.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
54294	Shallcross Mfg. Co.	Selma, N.C.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Pittsburgh, Pa.
62119	Universal Electric Co.	Owosso, Mich.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
70119	Advance Electric and Relay Co.	Burbank, Calif.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70563	Amperite Co., Inc	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71450	Chicago Telephone Supply Co.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C. P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A. O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Div. of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74455	J. H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	Industrial Products Co.	Danbury, Conn.
74970	E. F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Mfg. Co., Inc.	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littlefuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C. W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Chicago, Ill.
77068	Bendix Corp., Bendix Pacific Div.	No. Hollywood, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77342	Potter and Brumfield, Inc.	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77634	Radio Essentials Inc.	Mt. Vernon, N.Y.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
78283	Signal Indicator Corp.	New York, N.Y.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80130	Times Facsimile Corp.	New York, N.Y.
80248	Oxford Electric Corp.	Chicago, Ill.
80411	Acro Manufacturing Co.	Columbus, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Tube Division	Quincy, Mass.

From: F.S.C. Handbook Supplements
H4-1 Dated July 1960
H4-2 Dated July 1960

LIST OF MANUFACTURERS

CONTINUED

CODE NO.	MANUFACTURER	ADDRESS
81483	International Rectifier Corp.	El Segundo, Calif.
82042	Carter Parts Co.	Skokie, Ill.
82170	Allen B. DuMont Labs., Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc., Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Spencer Thermostat, Div. of Texas Instruments, Inc.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82893	Vector Electronic Co.	Glendale, Calif.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Union, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A. J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85474	R. M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91418	Radio Materials Co.	Chicago, Ill.

CODE NO.	MANUFACTURER	ADDRESS
91506	Augat Brothers, Inc.	Attleboro, Mass.
91637	Dale Products, Inc.	Columbus, Neb.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91929	Micro-Switch Div. of Minneapolis Honeywell Regulator Co.	Freeport, Ill.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94144	Raytheon Mfg. Co., Receiving Tube Div.	Quincy, Mass.
94145	Raytheon Mfg. Co., Semi-conductor Div.	Newton, Mass.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	Carlstadt, N.J.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95265	National Coil Co.	Sheridan, Wyo.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98220	Francis L. Mosley	Pasadena, Calif.
98291	Sealectro Corp.	New Rochelle, N.Y.
98405	Carad Corp.	Redwood City, Calif.

CODE NO.	MANUFACTURER	ADDRESS
98734	Palo Alto Engineering Co., Inc.	Palo Alto, Calif.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
99313	Varian Associates	Palo Alto, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99957	Technology Instruments Corp. of Calif.	No. Hollywood, Calif.

THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

0000A	Amp, Inc.	Hawthorne, Calif.
0000B	Chicago Telephone of Calif.	S. Pasadena, Calif.
0000C	Connor Spring Mfg. Co.	San Francisco, Calif.
0000D	Connex Corp.	Oakland, Calif.
0000E	Fisher Switches, Inc.	San Francisco, Calif.
0000F	Malco Tool and Die	Los Angeles, Calif.
0000G	Microwave Engineering Co.	Palo Alto, Calif.
0000H	Philco Corp. (Lansdale Tube Division)	Lansdale, Pa.
0000I	Telefunken (c/o American Elite)	New York, N.Y.
0000J	Ti Tal, Inc.	Berkeley, Calif.
0000K	Transitron Electronic Sales Corp.	Wakefield, Mass.
0000L	Winchester Electronics, Inc.	Santa Monica, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000N	Nahm-Bros. Spring Co.	San Leandro, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.

From: F.S.C. Handbook Supplements
H4-1 Dated July 1960
H4-2 Dated July 1960

hp MANUAL CHANGES

MODEL 120A

OSCILLOSCOPE

Manual Serial Prefixed: 051-
Manual Printed: 1/61

To adapt this manual to instruments with other serial prefixes check for errata below, and make changes shown in tables.

Instrument Serial Prefix	Make Manual Changes	Instrument Serial Prefix	Make Manual Changes
ALL SERIALS	ERRATA		
138-	1		
149-	1, 2		

ERRATA: Figure 4-5 (sweep Generator schematic),
Change reference designator DS to read I, i. e., DS201 to I201, DS202 to I202, etc.

Figure 4-8, The value of R354 should be 4440 ohms.

Table of Replaceable Parts,
C205, 206: Change to capacitor, fixed, electrolytic, 20μf, 25 vdcw; hp Stock No. 0180-0076; Mfr. 56289.
C335: Change to capacitor, fixed ceramic, 0. 02 μf, ±10%, 600 vdcw; hp Stock No. 0150-0024; Mfr. 91418.
△ R29: Change hp Stock No. to 0692-2235.
Under MISCELLANEOUS: Fuseholder: Change hp Stock No. to 1400-0084.

CHANGE 1 R119, 124: Change to resistor, fixed composition, 36, 000 ohms ±5%, 2W; hp Stock No. 0692-3635; Mfr. 01121.

R122: Change to resistor, fixed, composition, 2400 ohms ±5%, 1/2W; hp Stock No. 0686-2425; Mfr. 01121.

CHANGE 2 Figure 4-8 (Low Voltage and Filament Supplies), make the following changes in the transformer connections for T302.

SECONDARY CONNECTIONS

TERMINAL	SCHEMATIC WIRE COLOR	WINDING
5	Red-Yellow	450 volts rms at 150 ma
6	Red	
7	Yellow	5.0 volts rms at 2 amps
8	Yellow	
9	Orange	2. 5 volts rms at 115 ma
10	Gray	
11	Blue	6. 3 volts rms at 3. 3 amps
12	Blue	
13	Green	6. 3 volts rms at 3. 3 amps
14	Green	
15	White	6. 3 volts rms at 0. 6 amps
16	White	
17	Brown	6. 3 volts rms at 0.6 amps
18	Brown	
19	Violet	27. 3 volts rms at 330 ma
20	White	

PRIMARY CONNECTIONS

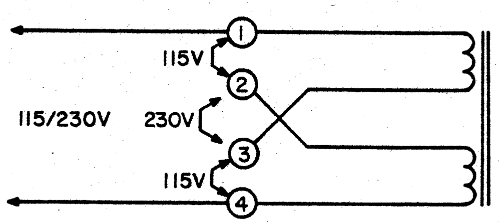


Table of Replaceable Parts,
T302: Change to transformer, power; hp Stock No. 9100-0158; Mfr. 98734.

20 September 1967

Supplement A for
120A-900

MANUAL CHANGES

MODEL 120A

OSCILLOSCOPE

Manual Serial Prefixed: 051-

To adapt this manual to instruments with other serial prefixes check for errata below, and make changes shown in tables.

Instrument Serial Number	Make Manual Changes
All	ERRATA
2753 to 5751	1
1952 to 2572	1, 2
1752 to 1951	1, 2, 3
1151 to 1751	1, 2, 3, 4

Instrument Serial Number	Make Manual Changes
951 to 1150	1, 2, 3, 4, 5
551 to 950	1, 2, 3, 4, 5, 6
451 to 550	1, 2, 3, 4, 5, 6, 7
351 to 450	1, 2, 3, 4, 5, 6, 7, 8
1 to 350	1,2,3,4,5,6,7,8,9

ERRATA: To clarify the locations of the multisection filter capacitors, change reference designators as follows:

Old Ref. Des.	New Ref. Des.	Capacity	Capacitor Marking
C17 C300 C326	C17A,B C17C C17D	2 X 20 µf 20 µf 20 µf	▭ & △ ⌓ NO MARK Cover Com. Neg.
C322 C324	C322A C322B	120 µf 40 µf	⌓ ▭ △ Com. Neg.
C328 C331	C328A C328B	120 µf 40 µf	⌓ ▭ △ Com. Neg.
C321	—	—	+ = ⌓ - = △

CHANGE 1

C329: Delete

C330: Change to 0.1 µf, hp Stock No. 0160-0013.

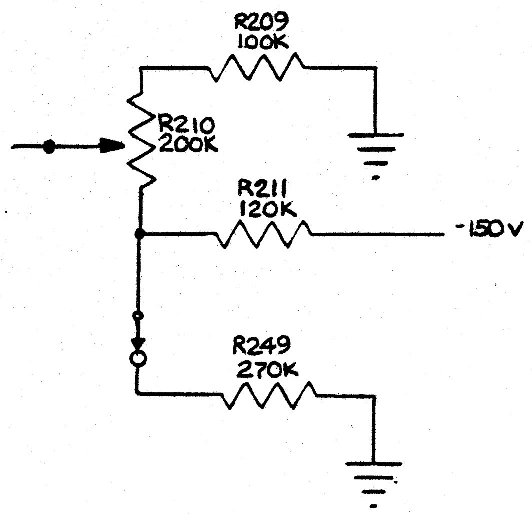
(over)

6/27/62

Supplement B for 120A-900

Instrument Serial Number	Make Manual Changes	Instrument Serial Number	Make Manual Changes
All	ERRATA	951 to 1150	1,2,3,4,5
2753 to 5751	1	551 to 950	1,2,3,4,5,6,
1952 to 2572	1, 2	451 to 550	1,2,3,4,5,6,7
1752 to 1951	1, 2, 3	351 to 450	1,2,3,4,5,6,7,8
1151 to 1751	1, 2, 3, 4	1 to 350	1,2,3,4,5,6,7,8,9

CHANGE 1 (cont.) R228: Change to 10K ohms, Stock No. 2100-0167.
R249: Change to 270K ohms, Stock No. 0686-2745.
S202: Change portion of S202 circuit containing R210 to the following:



CHANGE 2 R121:: Change value to 6.8K ohms.

CHANGE 3 Add R326: 150K ohms (same as R302), in parallel with R302.

CHANGE 4 C110: Change to 50 to 380 pf, Stock No. 0131-0001.
C111: Change to 680 pf, Stock No. 0140-0007.

CHANGE 5 L301, R327: Delete and replace with a wire jumper.
R254: Change to 12M, Stock No. 0730-0145. Change connection from R255 to R257 rotor.

CHANGE 6 Add DS208: 1/25W neon lamp, Stock No. 2140-0008, between V205, pin 8 and pin 9.
Add DS300: 1/25W neon lamp, Stock No. 2140-0008, between V301, pin 3 and pin 2.
V306: Change to type 5Y3 tube.

Instrument Serial Number	Make Manual Changes	Instrument Serial Number	Make Manual Changes
All	ERRATA	951 to 1150	1,2,3,4,5
2753 to 5751	1	551 to 950	1,2,3,4,5,6
1952 to 2572	1, 2	451 to 550	1,2,3,4,5,6,7
1752 to 1951	1, 2, 3	351 to 450	1,2,3,4,5,6,7,8
1151 to 1751	1, 2, 3, 4	1 to 350	1,2,3,4,5,6,7,8,9

CHANGE 7

C218: Delete
R200: Delete and replace with wire jumper.
R223: Change to 1,500 ohms, Stock No. 0730-0017.

CHANGE 8

R309: Change to 5.6M, Stock No. 0693-5651.
R312: Change to 3.5M, Stock No. 2100-0172.
R313: Change to 470K ohms, Stock No. 0687-4741.

CHANGE 9

C204: Change to 10 µf, Stock No. 0140-0002.
C225: Change to 50 to 380 pf, Stock No. 0131-0001.
C237: Delete
R204: Change to 3000 ohms, Stock No. 0686-3025.