HEWLETT-PACKARD COMPANY

120A/AR

OSCILLOSCOPE

OPERATING AND SERVICING MANUAL

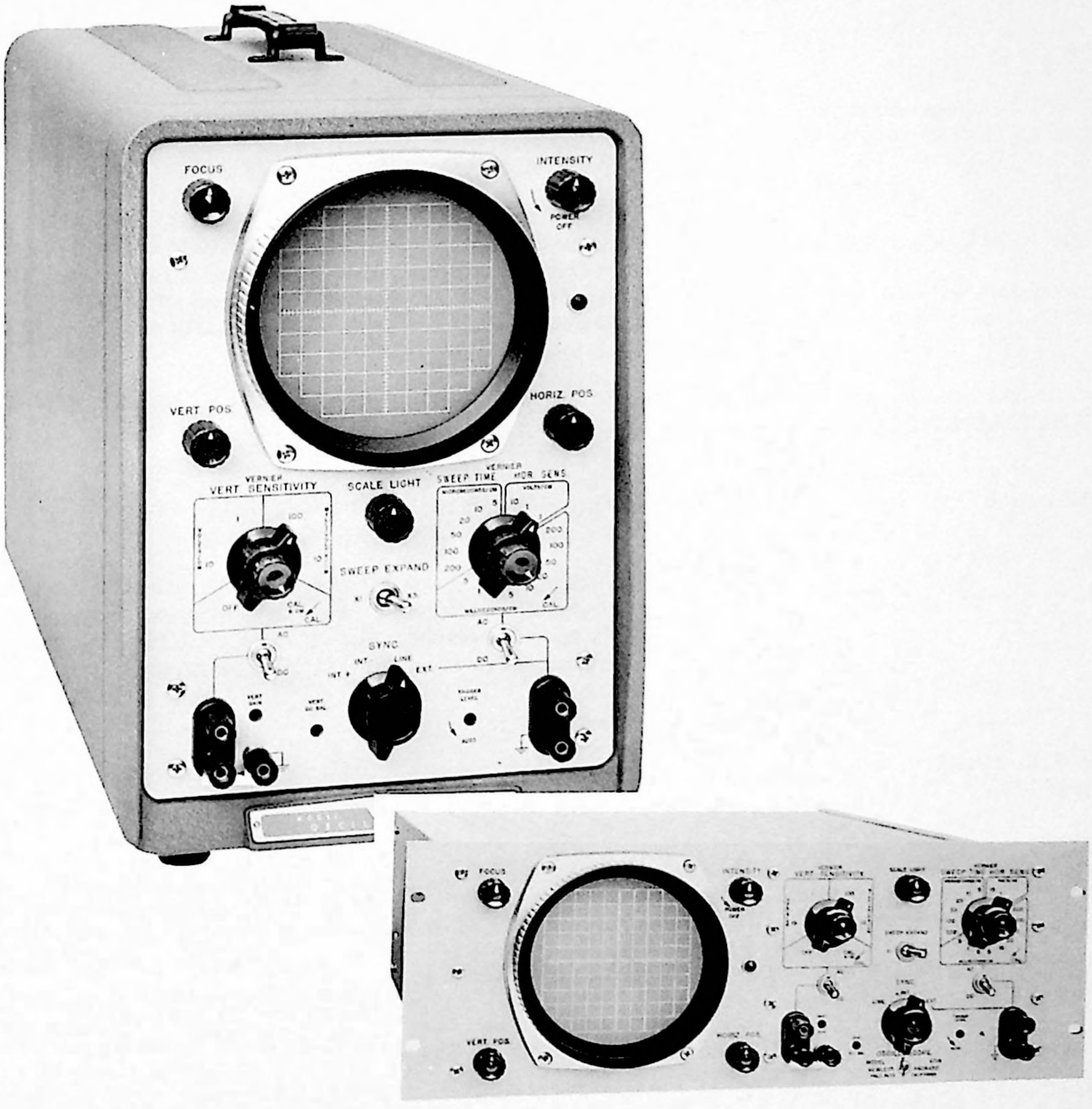
OPERATING AND SERVICING MANUAL

FOR

MODEL 120A/AR

OSCILLOSCOPE

SERIAL 101 AND ABOVE



275 PAGE MILL ROAD, PALO ALTO, CALIFORNIA, U.S.A.

120A001

SWEEP

Sweep Range:	1μsec/cm to at least 0.5 sec/cm. 15 Calibrated sweeps, accurate to within ±5%, in a 1, 2, 5, 10, . . . sequence, 5μsec/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 1μsec/cm. Expansion is about the center of the CRT and expanded sweep accuracy is ±10%.
Synchronization:	Internally from vertical deflection signals causing 1/2 cm or more vertical deflection, from line voltage, and from external signals at least 2.5 volts peak-to-peak.
Trigger Point:	Automatic: 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 counter-clockwise 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. 4 calibrated steps accurate within ±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 ±2%.
Input Connectors:	Banana jacks, spaced 3/4".
Input Impedance:	1 megohm, less than 50μμf shunt.
Balanced Input:	On 10 mv/cm range. Input impedance, 2 megohms shunted by less than 25μμf.
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 ±2° 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. 3 calibrated steps, accurate within ±5%, .1v/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 Connector:	2 banana plugs, spaced 3/4".
Input Impedance:	1 megohm, nominal, shunted by less than 100$\mu\mu$f.
Phase Shift:	Horizontal and vertical amplifiers have same phase characteristics within ±2° to 100 kc.

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 v to blank trace of normal intensity.
Filter Supplied:	Color of filter compatible with CRT phosphor supplied: Green with P1 and P2 Blue or 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" wide, 15" high, 21-1/4" deep. Rack Mount: 19" wide, 7" high, 21-1/4" deep. 19-1/2" deep behind panel.
Weight:	Cabinet Mount: Net 34 lbs., shipping 50 lbs. Rack Mount: Net 32 lbs., shipping 47 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 No. 12001.
Accessories Available:	AC-83A Viewing Hood; face-fitting molded rubber.

CONTENTS

CATHODE RAY TUBE FAILURE REPORT

(hp) Model No.____________ Serial No.____________

Tube Type____________

The cathode ray tube supplied in your Hewlett-Packard Oscilloscope and replacement cathode ray tubes purchased from (hp), are guaranteed against electrical failure for one year from the date of sale by the Hewlett-Packard Company. Broken tubes or tubes with burned phosphor are not included in this guarantee. All terms of the current (hp) warranty (included in all instruction manuals and catalogs) apply to this guarantee on the cathode ray tube.

Your local (hp) representative maintains a stock of replacement tubes and will be glad to process your warranty claim for you. Please consult him.

Whenever a tube is returned for a warranty claim, both sides of this sheet must be filled out in full and returned with the tube. Follow shipping instructions carefully to insure safe arrival of the tube at the factory.

SHIPPING INSTRUCTIONS

Extra care must be taken to be certain that tubes shipped back for credit be protected from transportation damage. If a tube arrives broken, delay will be caused in determining who is liable--the transportation company or the shipper. Many tubes will be subject to a laboratory examination to determine the cause of failure before credit can be allowed. Proper examination is either difficult or impossible when the tube is damaged from mishandling.

1) Carefully wrap the tube in 1/4" thick "kimpack", cotton batting, or other soft padding material.

2) Wrap the above in heavy kraft paper.

3) Pack in a rigid container which is at least 4 inches larger than the tube in each dimension.

4) Surround the tube with at least four inches of packed excelsior or similar shock absorbing material. Be certain that the packing is tight all around the tube.

5) Tubes returned from outside the continental United States should be packed in a wooden box.

6) Ship prepaid preferably by AIR FREIGHT or RAILWAY EXPRESS. Do not ship via parcel post or air parcel post.

CUT HERE !

CUT HERE !

CUT HERE !

FROM: DATE: ____________

NAME: ____________

COMPANY: ____________

ADDRESS: ____________

____

____

Person to contact for further information:

NAME: ____________

TITLE: ____________

COMPANY: ____________

ADDRESS: ____________

____

____

To process your claim quickly please enter the information indicated below:

1) TUBE SERIAL NO.: ____________

2)* ORIGINAL TUBE ________ REPLACEMENT TUBE ________

3) ORIGINAL HEWLETT-PACKARD PURCHASE ORDER NO. ____________

4) DATE PURCHASED: ____________

5) PURCHASED FROM: ____________

6) COMPLAINT: (Please describe nature of trouble) ____________

____

____

____

7) OPERATING CONDITIONS: (Please describe conditions prior to and at time of failure) ________

____

____

____

SIGNATURE: ____________

____

____

* Check one.

CUT HERE !

CUT HERE !

CUT HERE !

SECTION I
GENERAL DESCRIPTION

1-1 GENERAL INFORMATION

The Model 120A dc to 200 kc oscilloscope is a general purpose oscilloscope employing a 5-AQP 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.

Since the control layout on the front panel has been carefully organized and labeled for convenient operation, most controls will be self-explanitory. However, all external controls are discussed completely in Section II of this manual. A large fold-out view of the panel is included in Section II with all operating controls described.

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

15 DIRECT READING SWEEP TIMES ACCURATE WITHIN 5%

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 also insures a high order linearity and stability. This type sweep generator is much more reliable and independent of tube characteristics than other types of sawtooth voltage generators because negative feedback is inherent in its design, stabilizing its operation.

X 5 SWEEP EXPANSION

You speed observation and analysis of transients by expanding any two centimeter segments of a trace to 10 centimeters for easy viewing of detail. This X5 sweep expander, usually found only in more costly oscilloscopes, 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. Nor is that all, 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. In applications where it would be more convenient to have a baseline only in response to an applied trigger, as in photographic work involving transients, the automatic baseline provision may be easily and quickly locked-out and a trigger level established which is adjustable from at least -10 volts to +10 volts of an external trigger. This lockout can not be accidentally or inadvertantly actuated because it is located just behind the front panel where it is easily accessible with a screwdriver.

CALIBRATED AMPLIFIERS FOR MEASUREMENT AS WELL AS OBSERVATION

Accurate voltage measurements on all kinds of waveforms are quickly made with the 120A, the amplifiers are calibrated and accurate within ±5%. Reliability and confidence is assured by a built-in calibrator which is accurate within ±2% and so permits quick verification and standardization of vertical amplifier sensitivity. The high sensitivity and dc to 200 kc bandwidth which is independent of sensitivity make the 120A useful for medical, geophysical, and industrial applications.

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.

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 LINE VOLTAGES

The Oscilloscope, like other ⓗⓟ instruments, is shipped from the factory wired for 115 volt ac line operation unless otherwise specified in the order. However, the instrument may also be operated from a 230 volt ac line source if the proper conversion is made to the power transformer. This conversion is simple, and is described in the Maintenance section.

1-4 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 the outlet mounting box for the protection of operating personnel.

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 only for the rack mount model and at extra cost. They can also be installed at the factory on special order under Specification No. 12001.

1-5 ACCESSORIES AVAILABLE

An AC-83A Viewing Hood is available at extra cost. This is a face-fitting moulded rubber hood used to shade the face of the cathode-ray tube under high ambient light conditions. This will permit the use of lower trace intensity setting which is important especially with the phosphors susceptable to burning, such as the P7. Information concerning other cathode-ray tube phosphors and their corresponding filters will be found in the following table.

SECTION 1A
CERTIFICATION PROCEDURE

THIS CERTIFICATION PROCEDURE CAN BE COMPLETED WITH THE OSCILLOSCOPE CABINET IN PLACE AFTER A MINIMUM WARM-UP PERIOD OF 10 MINUTES. ANY MODEL 120A OSCILLOSCOPE PASSING THIS PROCEDURE WILL MEET SPECIFICATIONS.

THE TEST EQUIPMENT NECESSARY FOR THIS CERTIFICATION PROCEDURE MUST HAVE THE CHARACTERISTICS GIVEN UNDER "CERTIFICATION TEST EQUIPMENT".

1A-1 CERTIFICATION TEST EQUIPMENT

The following equipment is required to complete the performance tests:

a. "Reference Oscillator" such as the ⓗⓟ Model 200CD Wide Range Oscillator.

Frequency Range -
400 cps to 500 kilocycles.

Voltage Output -
rated 5 millivolts to 20 volts, adjustable.

Distortion - Less than 1%.

b. "Reference VTVM" such as the ⓗⓟ Model 400H Vacuum Tube Voltmeter.

Calibration -
average reading, rms calibrated.

Frequency Range -
400 cps to 500 kilocycles.

Voltage Range -
50 millivolts to 60 volts.

Accuracy -
Voltages given in this procedure are absolute values and do not include allowances for voltmeter accuracy.

c. "Time Interval Generator" such as the Tektronix Type 180 Time Mark Generator.

The frequencies required are decade steps from 10 megacycles to 1 cycle per second with an accuracy of ±0.3%.

d. "Calibration Generator" such as ⓗⓟ Specification 23678 Voltmeter Calibration Generator.

Voltage Required -
100 volts dc and 100 volts ac peak-to-peak at 400 cps or 1000 cps.

Voltage Accuracy - ±0.25%.

Attenuator -
to provide 100 volts to 20 millivolts with steps arranged in a 1 - 2 - 5 sequence.

Attenuator Accuracy - ±0.25%.

Distortion -
Less than 0.5%.

NOTE

The internal oscilloscope CALIBRATOR can be used in place of the "calibration generator". However, the ±2% accuracy of the CALIBRATOR signal must be considered in determining the measurement accuracy.

1A-2 VERTICAL AMPLIFIER

First, check balance and calibration as described in paragraph 4-10a, b.

a. Sensitivity

1) Connect the "calibration generator", set for 100 millivolts peak-to-peak, to the vertical input terminals.

2) Set VERT. SENSITIVITY switch to 10 MILLIVOLTS/CM and VERNIER to CAL.

3) Switch input coupling to DC.

4) Check the amplifier dc sensitivity by turning the "calibration generator" function selector between OFF and DC output. As the function selector is switched the CRT spot should shift 10±.5cm. Adjust VERT. POS. control, if necessary.

5) Turn VERT. SENSITIVITY VERNIER full counter-clockwise. Repeat step 4 above, but spot should shift 1 cm or less.

6) Turn VERT. SENSITIVITY VERNIER full clockwise to CAL. Set VERT. SENSITIVITY switch to 100 MILLIVOLTS/CM. Set "calibration generator" for 1 volt peak-to-peak output. Repeat step 4.

7) Set VERT. SENSITIVITY switch to 1 VOLT/CM. Set "calibration generator" for 100 volts peak-to-peak output. Repeat step 4.

1A-3 BANDWIDTH

1) Connect the "reference oscillator" through an attenuator to the vertical input terminals and monitor the input signal with the "reference VTVM".

2) Set the VERT. SENSITIVITY switch to 10 MILLIVOLTS/CM and adjust the output of the "reference oscillator" to give exactly 10 cm of vertical deflection. Observe the input voltage on the "reference VTVM".

3) Increase the frequency of the "reference oscillator" and adjust its output to maintain the input volt-

age constant as read on the "reference VTVM". Observe the frequency where the vertical deflection has decreased to 7.07 cm. Re-position pattern, if necessary. This frequency is the bandwidth of the vertical amplifier and should be greater than 200 kc.

1A-4 COMMON-MODE REJECTION

1) Remove the jumper from the lower vertical input terminal to ground and connect a lead from the lower red terminal to the upper red terminal.

2) Set the VERT. SENSITIVITY switch to 10 MILLIVOLTS/CM and the VERNIER to CAL.

3) Connect the "reference oscillator" between the two terminals and ground. Monitor this input with the "reference VTVM".

4) Set the frequency of the "reference oscillator" to 1 kc and adjust its output to read 0.35 volts rms on the "reference VTVM".

5) The vertical deflection on the 120A should be 1cm or less.

6) Replace the jumper removed in step 1.

1A-5 HORIZONTAL AMPLIFIER

First check balance as described in paragraph 4-11a. Next, check horizontal sensitivity by connecting a 1 kc signal from the "reference oscillator" to a calibrated vertical amplifier. Set the VERT. SENSITIVITY switch to .1 VOLTS/CM and the VERNIER to CAL. Set the output of the "reference oscillator" to give a vertical deflection of exactly 10 cm. Now feed the same signal into the horizontal input terminals. Set the HOR. SENS. switch to .1 VOLTS/CM and the VERNIER to CAL. Without changing the output of the "reference oscillator" the horizontal deflection should be from 9.5 to 10.5 cm. Repeat this procedure on the 1 and 10 VOLTS/CM ranges. If the sensitivity is not within specification, see paragraph 4-11b.

a. Sensitivity -
Conduct test exactly as for corresponding sensitivity steps of vertical amplifier.

b. Bandwidth -
Conduct test exactly as for vertical amplifier except use 0.1 VOLTS/CM sensitivity.

c. Phase Comparison -

1) Set HOR. SENS. switch to 0.1 VOLTS/CM and VERNIER to CAL. Set VERT. SENSITIVITY switch to 100 MILLIVOLTS/CM and VERNIER to CAL.

2) Connect a lead from the horizontal input terminal to the vertical input terminal.

3) Connect the "reference oscillator" to the paralleled input terminals.

4) Set the frequency of the "reference oscillator" at 1 kc and adjust its output to give 8 cm of deflection on either axis. Use VERT. and HORIZ. POS. controls as necessary. The presentation should be a straight line at about 45° inclination from either axis.

5) Increase the frequency of the "reference oscillator" and adjust its output to keep 8 cm of deflection.

6) Observe the frequency where the straight line opens to an ellipse with a minor axis separation of 0.2 cm. This frequency should be 100 kc or more.

1A-6 SWEEP GENERATOR

a. Triggering -

1) Set VERT. SENSITIVITY switch to 10 VOLTS/CM. Apply a 10 kc sine wave from the "reference oscillator" to the vertical input terminals and also to the horizontal input terminals. Make sure the TRIGGER LEVEL control is in the AUTO position.

2) Set the SYNC switch to INT+ and adjust the output of the "reference oscillator" to give about 6 cm of vertical deflection. Adjust SWEEP TIME switch to give several cycles displayed across the screen of the cathode-ray tube. The pattern should be stable with the signal "positive going" (upwards from the starting point).

3) Switch SYNC switch to INT-. Pattern should be "negative going" (downwards) from the starting point.

4) Switch SYNC switch to EXT. Pattern should be "negative going" (downwards) from the starting point.

5) Reduce output of "reference oscillator" until pattern looses synchronization. The pattern should be less than 0.25 cm in height.

6) Switch SYNC switch to INT- and repeat step 5. The pattern should be less than 0.5 cm in height.

7) Switch SYNC switch to INT+ and repeat step 5. The pattern should be less than 0.5 cm in height.

b. Sweep Calibration -

1) Connect the output of the "time interval generator" to the vertical input terminals.

TABLE IA-1. SWEEP TIME ACCURACY

SWEEP TIME/CM Switch Position	Timing Signal Frequency	Period	Cycles produced in 9.5 to 10.5cm
* 200 MILLISECONDS/CM	1 cycle	1 second	2
100 MILLISECONDS/CM	10 cycles	100 milliseconds	10
50 MILLISECONDS/CM	10 cycles	100 milliseconds	5
20 MILLISECONDS/CM	10 cycles	100 milliseconds	2
10 MILLISECONDS/CM	100 cycles	10 milliseconds	10
5 MILLISECONDS/CM	100 cycles	10 milliseconds	5
2 MILLISECONDS/CM	100 cycles	10 milliseconds	2
1 MILLISECONDS/CM	1,000 cycles	1 millisecond	10
.5 MILLISECONDS/CM	1,000 cycles	1 millisecond	5
200 MICROSECONDS/CM	1,000 cycles	1 millisecond	2
100 MICROSECONDS/CM	10 kilocycles	100 microseconds	10
50 MICROSECONDS/CM	10 kilocycles	100 microseconds	5
20 MICROSECONDS/CM	10 kilocycles	100 microseconds	2
10 MICROSECONDS/CM	100 kilocycles	10 microseconds	10
5 MICROSECONDS/CM	100 kilocycles	10 microseconds	5

* Use dc input coupling to avoid degrading input signal.

2) Set SWEEP TIME VERNIER to CAL, SYNC selector to INT+, SWEEP EXPAND switch to X1, Set SWEEP TIME switch to 1 MILLISECOND/CM.

3) Set "time interval generator" for 1000 cps or a 1 millisecond period. Adjust other oscilloscope controls to display the signal with a vertically centered peak-to-peak deflection from 2 to 6 cm. (For stable triggering from pulses the use of the TRIGGER LEVEL control may be necessary). This signal should produce 10 events in 10 ±0.5 cm of the horizontal deflection. If not see appropriate parts of section 4-12.

4) Check each step of the SWEEP TIME switch using the method of step 3 and using the frequencies given in table IA-1.

c. X5 Expanded Calibration

1) Repeat step 3 of paragraph b above with SWEEP EXPAND switch in X5 position. The signal as prescribed by step b, 3 should produce two events within a horizontal deflection in 9.0 to 11.0 cm.

2) Repeat step 4 above but using table IA-2.

TABLE IA-2. X5 MAGNIFICATION ACCURACY

SWEEP TIME/CM Switch Position	Timing Signal Frequency	Period	Cycles produced in 9.0 to 10.0cm
50 MILLISECONDS/CM	100 cycles	10 milliseconds	10
1 MILLISECOND/CM	1000 cycles	1 millisecond	2
5 MICROSECONDS/CM	100 kilocycles	10 microseconds	1

If the instrument fails to meet the specifications in this table see appropriate parts of section 4-12.

GENERAL CATHODE RAY TUBE PHOSPHOR AND FILTER INFORMATION

Below is a table of the most common phosphors used in oscillography. These phosphors have been found to meet all normal needs. hp oscilloscopes are furnished with any of these four types, except that the P2 phosphor normally should be used only in the hp 150A, as it has the necessary higher accelerating potential recommended for this type phosphor.

Suitable filters used in conjunction with the proper phosphor will enhance the usefulness of the oscilloscope by allowing the operator to select either a long or short persistence presentation.

APPLICATIONS

P1 High visual efficiency. Brilliant green trace at low accelerating potentials. Most commonly used where visual observation is the main use of the instrument. Suitable for photographic recording * of repetitive or transient phenomena if there is no need for moving-film photography. Relatively resistant to burn damage from a stationary sweep beam.

P2 Highly versatile dual purpose phosphor for use with accelerating potentials over 4KV: (1) A short-persistence blue-green flourescence. (2) A long persistence yellow-green phosphorescence. A yellow filter effectively attenuates the short persistence blue flash. A blue filter ** masks the long persistence yellow phosphorescence. The blue component has good photographic efficiency * and the persistence is short enough to allow continuous motion photography of almost all traces. The persistence of the yellow component is long enough to allow transients and low frequency traces to be observed easily. A green filter will give a presentation similar to a P1 phosphor. This phosphor is somewhat sensitive to burning. If screen burning is a consideration, the P1 phosphor is prefered.

P7 Similar to the P2 except more efficient * than the P2 with accelerating potentials below 5KV. May be used with filters ** to get both long and short persistence displays. This phosphor is more sensitive to burning than the other phosphors.

P11 A short-persistence blue trace having high photographic efficiency * especially suited to continuous motion recording as well as visual observation of moving phenomena. The P11 phosphor has a shorter persistence than a P2 phosphor viewed through a blue filter. This phosphor is also sensitive to burning.

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* NOTE - The P11 phosphor is the most sensitive for photographic purposes. If the exposure time using a P11 phosphor is arbitrarily called 1, the relative exposure time for the phosphors are P1 = 4; P2 = 5; P7 = 2; P11 = 1. Use of a blue filter will reduce the light available by approximately 30%, thus none should be used if very high speed traces are to be photographed.

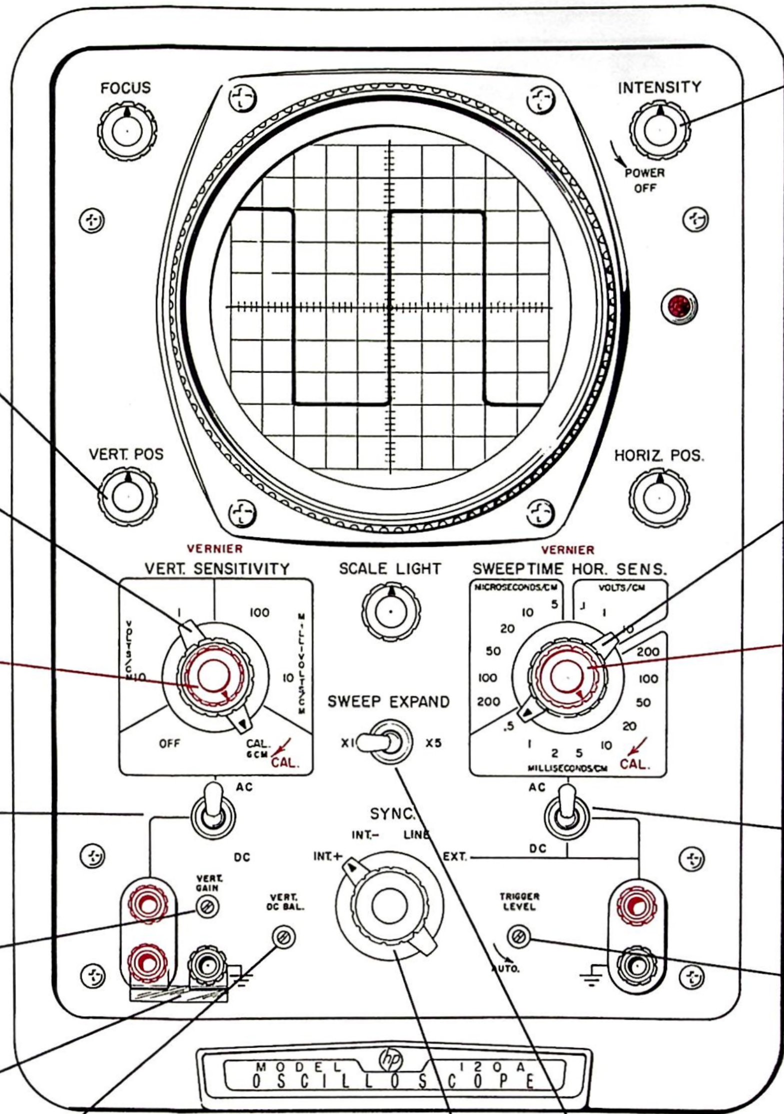
** NOTE - When using the P2 or P7 phosphors with a blue filter, the image will be quite dim. Care must be taken not to turn the intensity too high to overcome this, as the screen may be easily damaged. The use of a viewing hood is highly recommended when operating the oscilloscope with a blue filter. The use of the hood at all times is good practice, as the intensity may be set to a lower level which will help protect the CRT phosphor from possible damage.

INFORMATION ON CATHODE RAY PHOSPHORS

Designation	Color Fluorescent	Color Phosphorescent	Spectral Range Between 10% Points	Spectral Peak	Persistence
P1	Green	Green	4900 - 5800 Å	5250 Å	Medium (20 millisec.)
P2	Blue-green	Yellow-green	4500 - 6400	5430 both phosphors	One Short One Long
P7	Blue-white	Yellow	3900 - 6500	2 components 5580, 4400	One Short One Long
P11	Blue	Blue	4000 - 5500	4600	Short (2 millisec.)

FIGURE 2-1
FRONT PANEL CONTROL DIAGRAM

TO OBTAIN A PATTERN EASILY, SET THE CONTROLS EXACTLY AS SHOWN AND PERFORM THE NUMBERED STEPS IN SEQUENCE.
USE SAME PROCEDURE WHENEVER DIFFICULTY IS ENCOUNTERED IN OBTAINING A PATTERN THIS WILL ELIMINATE FAULTS DUE TO MISALIGNMENT OF CONTROLS, AND WILL ISOLATE ANY TROUBLES TO MAJOR SECTIONS.



(1) ROTATE CLOCKWISE TO TURN ON, ... WAIT 30 SECONDS, THEN ADJUST TRACE INTENSITY.

(3) ROTATE TO MOVE TRACE VERTICALLY.

SET FOR [VERT. SENSITIVITY] DESIRED.
SET TO [CAL.] FOR CALIBRATING SIGNAL.

SET TO [SWEEP TIME] DESIRED OR TO [HORIZ. SENS.] DESIRED

SWITCH OUT OF [CAL.] POSITION TO ADJUST BETWEEN RANGES OF [VERT. SENSITIVITY] SWITCH.

SWITCH OUT OF [CAL.] POSITION TO ADJUST BETWEEN RANGES OF [SWEEPTIME] OR [HORIZ. SENS.] SWITCH.

SELECT [AC] OR [DC] COUPLING FOR VERTICAL INPUT.

SELECT [AC] OR [DC] COUPLING (HORIZONTAL INPUT).
(AC COUPLING ONLY WITH [EXT] SYNC SIGNALS.)

SET GAIN OF VERTICAL AMPLIFIER

(2) ROTATE COUNTERCLOCKWISE FOR [AUTO] SWEEP (ROTATE CLOCKWISE TO ADJUST [TRIGGER LEVEL]).

REMOVE SHORTING BAR WHEN CONNECTING A BALANCED INPUT SIGNAL

LD-E-153
LD-E-153

SET TO [X1] FOR UNEXPANDED SWEEP
SET TO [X5] FOR EXPANDED [X5] SWEEP

ADJUST FOR STATIONARY VERTICAL POSITION OF TRACE WITH MAX. TO MIN. OPERATION OF [VERT. SENSITIVITY] [VERNIER]

SET TO [INT.+] OR [INT.–] FOR INTERNAL SYNCHRONIZATION.
SET TO [LINE] TO SYNCHRONIZE AT LINE FREQUENCIES.
SET TO [EXT.] FOR EXTERNAL SYNCHRONIZATION

SECTION II
OPERATING INSTRUCTIONS

2-1 CONTROLS AND TERMINALS

The panel of the Model 120A has been designed to be as self-explanitory as possible. You may be able to operate the 120A without instructions if you have operated oscilloscopes before. However, a complete description of the functions of the controls follows:

2-2 POWER AND CRT CONTROLS

Power and Intensity Control - Turn the oscilloscope on by turning this control just out of the extreme counter-clockwise position. After the oscilloscope has warmed up, adjust the intensity of the trace by turning this control further. Rotating this control clockwise increases the intensity. In most cases the oscilloscope will show a trace on the screen with only this adjustment. If no trace shows put the controls exactly as shown of the facing two color fold-out sheet, and follow the numbered steps.

Scale Light - Rotate this control clockwise to increase the scale illumination.

Focus - Rotate this control for optimum sharpness of the trace.

Vertical Position - Rotate this control clockwise to move the trace upward.

Horizontal Position - Rotate this control clockwise to move the trace to the right.

2-3 VERTICAL PRESENTATION CONTROLS

Vertical Sensitivity - This six position switch controls the sensitivity of the vertical presentation. It has six positions marked OFF, 10 and 1 VOLTS/CM, 100 and 10 MILLIVOLTS/CM and CALIBRATOR, respectively. The 10 and 1 VOLTS/CM, and the 100 and 10 MILLIVOLTS/CM positions adjust the sensitivity of the vertical presentation.

In the CALIBRATOR position a square wave of 60 mv amplitude is applied to the vertical input for calibration purposes. When in this position the pattern should be adjusted for a height of six centimeters with the VERTICAL GAIN control (make sure VERNIER is in CALIBRATED). Use the VERNIER control concentric with the VERTICAL SENSITIVITY control, for continuous adjustment between ranges. Set the VERNIER control in the CALIBRATED position for the engraved sensitivity markings to be accurate (±5%).

Each VERTICAL SENSITIVITY position can be reduced in sensitivity by a known amount by the use of the calibration square wave. Switch the VERTICAL SENSITIVITY switch to the CALIBRATOR position and the VERNIER to the CALIBRATED position. The square wave pattern should be six centimeters in height. However, this sensitivity may be reduced to a known fraction of the engraved sensitivities with the VERNIER control. For example, if you wish the sensitivity to be one-half of that shown on the panel markings set the VERNIER control so that you get a pattern height of only three centimeters. As long as the VERNIER is left in this position the sensitivities should be multiplied by two to get the true readings. Note that the original calibration can be recovered simply by returning the VERNIER to its CALIBRATED position.

For balanced or differential input (10 mv/cm) remove the shorting jumper between the bottom red terminal and the black (ground) terminal. Feed the balanced signals into the red terminals and the common return to the black (ground) terminal. Balanced input will be found useful in application where it is desired to amplify the (out-of-phase) differential signal applied to both grids and attenuate the (in-phase) common-mode signal (see Figure 2-15). Thus you can reject to a considerable degree any common-mode signal while at the same time passing and amplifying the differential signal. If there is any pickup of hum or noise in the equipment under test or the test leads, such extraneous signals will be attenuated while the desired signal will be amplified.

Vertical Gain - Adjust the vertical gain with this control (see instructions for the VERTICAL SENSITIVITY control).

Vertical DC Balance - Adjust this control so that the trace does not move when the VERTICAL SENSITIVITY VERNIER is rotated.

AC - DC Switch - Select either ac or dc input coupling for the vertical amplifier with this switch.

Although vertical amplifier response is rated as being down no more than 3 db at 200 kc, this rating is intentionally conservative. For 20 instruments the average response at 200 kc was 86.6% or -1 1/4 db and the lowest response of the 20 was 81%. From these data it can be seen that the instrument is useable in many, if not most, cases to view waveforms up to at least 500 kc. The instrument thus has considerably more flexibility than might be inplied by simply stating that the 3 db point is rated at 200 kc. Coupled with this response characteristic is the fact that the sweep circuits are designed to trigger from frequencies up to 600 kc.

2-4 SYNCHRONIZATION

The Model 120A oscilloscope is an oscillosynchroscope. That is, it may be adjusted to synchronize or start the sweep in reference to another signal. This reference or synchronizing signal may be the input signal (set SYNC control at INT+ or INT-), the power line frequency (SYNC set to LINE) or from an external signal (SYNC control set to EXT.)

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. Then, if automatic sweep triggering at a zero voltage level (usual case) is not desired, rotate the TRIGGER LEVEL control out of the AUTO position. The automatic sweep feature will stop. 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. Thus, even when a synchronizing signal is absent the Trigger Generator will trigger itself and present a sweep on the face of the cathode-ray tube. On an ordinary oscilloscope some adjustment of controls is usually necessary to trigger the sweep generator and present a picture on the screen, On the 120A, however, all adjustments may be made before the signal is fed into the unit, 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.

2-5 SYNC. CONTROLS

A four position (INT+, INT-, LINE, and EXT) switch which determines the type of signal used for synchronization. Internal triggering can be accomplished from a line voltage (LINE) or internally (INT + or -) from an applied vertical input signal of sufficient amplitude to produce a vertical deflection of .5 cm or more on the screen.

Sweep Time - Horizontal Sensitivity - This eighteen position switch controls the sweep time and the horizontal sensitivity of the horizontal presentation. Fifteen positions control the internal sweep speed and the remaining three positions control the horizontal sensitivity to an external input. Set to the SWEEP TIME section to view a signal with an internal sweep. Select the proper sweep speed with the SWEEP TIME switch which controls the sweep time per centimeter in fifteen calibrated ranges in a 1, 2, 5, 10 . . sequence from 5 microseconds/centimeter to 200 milliseconds/centimeter. Use the concentric VERNIER control to provide continuous adjustment of sweep speeds between ranges by reducing the sweep speed. Set the VERNIER in the full clockwise, CALIBRATED, position to obtain ±5% accuracy with the engraved markings.

The slowest calibrated sweep provided on the instrument is 1/5 second/cm which can be extended with the SWEEP TIME VERNIER to at least 1/2 second/cm or 5 seconds for the full 10 cm sweep. If need occurs for a slower sweep, the range can be extended indefinitely by connecting a pair of external condensers into the sweep circuits. Refer to the operating plate, Figure 2-14, to find the placement of these condensers in the circuit. The condenser mentioned in step 1 must be a high-quality type with high leakage resistance and good recovery characteristics. No loss of sweep linearity occurs if a capacitor with these specifications is used. The second capacitor is connected to the hold-off circuits and does not require a special condenser.

Sweep Expand - A two position (X1 - X5) switch. Set this switch in the X1 position to view the pattern without magnification. Switch to the X5 position to view a 2 centimeter portion of the pattern magnified five times. Also, a sweep speed of 1 microsecond/sec may be obtained by means of the X5 expansion of the sweep on the fastest range.

Select the two centimeter portion to be magnified with the HORIZONTAL POSITION control.

Trigger Level - Normally, a trace will be displayed in the absence of a signal, since the oscilloscope is triggered automatically. However, you may select the point of triggering and stop the AUTOMATIC triggering with the TRIGGER LEVEL control. Move this front panel screwdriver control clockwise away from the AUTOMATIC switch position (extreme counterclockwise) only for special triggering. In the AUTOMATIC position the sweep is self-triggered in the absence of a triggering signal. When a signal is fed in, the signal controls the triggering action. In the AUTOMATIC position the trigger circuit is adjusted to optimum setting to trigger on the majority of waveforms and at a zero trigger level. As you rotate the control clockwise from the AUTOMATIC switch position the automatic sweep feature will stop. Further rotation of this control permits you to adjust the triggering level of the pattern, within limits.

2-6 HORIZONTAL AMPLIFIER

The SWEEP TIME - HOR. SENS. switch also controls the sensitivity of the horizontal amplifier when it is used with an external input. The three sensitivity ranges of the horizontal amplifier are .1, 1, and 10 VOLTS/CM. The sensitivity of the amplifier may be increased to 100 VOLTS/CM by means of the VERNIER control.

Even though the circuitry of the vertical and horizontal amplifiers is not identical, the bandshapes and phase characteristics are identical, at least to well above 100 kc. As a result the instrument is rated as having not more than 2° differential phase shifts below 100 kc and is thus well suited to phase difference measurements. In fact, because the horizontal amplifier has basically an even wider response than the vertical, an adjustment (C107, Phase Adjustment) is provided in the horizontal amplifier so that phase differences can, if desired, be minimized at individual frequencies above 100 kc. The adjustment consists of a small variable capacitor which acts to set the first high-frequency corner of the horizontal amplifier for optimum agreement with that of the vertical. At the factory this adjustment is set for optimum agreement at 100 kc.

2-7 CALIBRATOR

An internal square-wave calibrator with an accuracy of ±2% and a nominal frequency of 400 cps is provided for checking amplifier calibration accuracy. The calibrator is connected internally to the input of the vertical amplifier when the VERT. SENSITIVITY switch is placed in the CAL. position. When in the CAL. position a 60 millivolt square wave is fed into the vertical amplifier input for calibration purposes. Because of the inherent stability and medium sensitivity of the horizontal amplifier, no provision is made for internal connection between that amplifier and the calibrator. Horizontal amplifier calibration can be checked easily, however, since an external signal can be measured on the vertical amplifier and then applied to the horizontal as a check. Little adjustment of the horizontal amplifier is necessary.

In either automatic or trigger operation the sweep circuits will trigger from signals over a range from 600 kc to below 5 cycles (50 cps for automatic operation). Between 10 cps (50 cps for automatic) and 200 kc the minimum deflection needed for triggering from displayed waveforms is 0.5 cm peak-to-peak. Beyond this range an increase in this minimum will occur, but at 600 kc, for example, triggering will usually occur on waveforms that give 2 cm deflection. For external trigger signals a minimum amplitude of 2-1/2 volts peak-to-peak is required for the minimum frequency to 200 kc ranges.

2-8 EXTERNAL SYNCHRONIZATION CONTROLS

Switch the SYNCHRONIZATION control to the EXTERNAL position. Feed in the external synchronization signal (2.5 volts or more peak-to-peak) into the horizontal input terminals at the lower right corner of the front panel. The external synchronization signal is always ac coupled and synchronizes on the negative slope of the signal. When using the trigger level control the trace will trigger on the negative slope of signals within the range of +10 and -10 volts, approximately (see Figure 2-2).

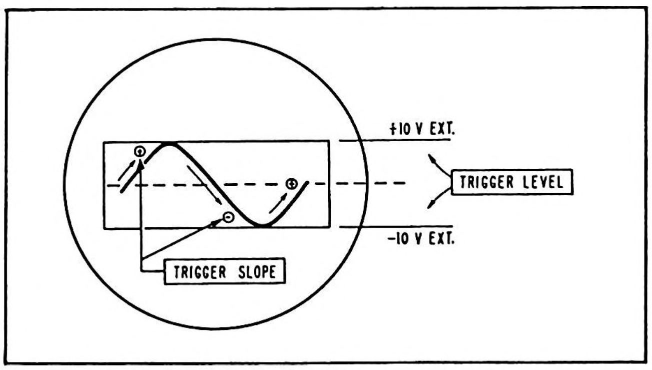


Figure 2-2. Triggering

2-9 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 wave. This coupling circuit has a low frequency cut-off at 2 cps; however, to avoid degrading input pulses or square waves below 200 cps it is advisable to use dc coupling. WHEN USING DC COUPLING THE AVERAGE VALUE OF THE DC DETERMINES THE POSITION OF THE SWEEP ON THE OSCILLOSCOPE. IF YOU ARE UNABLE TO FIND THE SWEEP WITH THE VERTICAL POSITION CONTROL WHEN USING DC COUPLING, CHECK THE AVERAGE DC LEVEL TO SEE THAT IT ISN'T TOO HIGH THEREBY DEFLECTING THE BEAM OFF OF THE SCREEN. When AC coupled the maximum dc that may be applied is 600 v.

NOTE

An external capacitor must be connected in the input lead to the middle input terminal (see Figure 2-5) if balanced ac coupling is used, since a dc signal on this terminal will unbalance the amplifier and might throw the pattern off of the screen.

2-10 REAR ACCESS TERMINALS

The following terminals are accessible through the rear access port of the instrument cabinet:

Horizontal and vertical deflection plates.

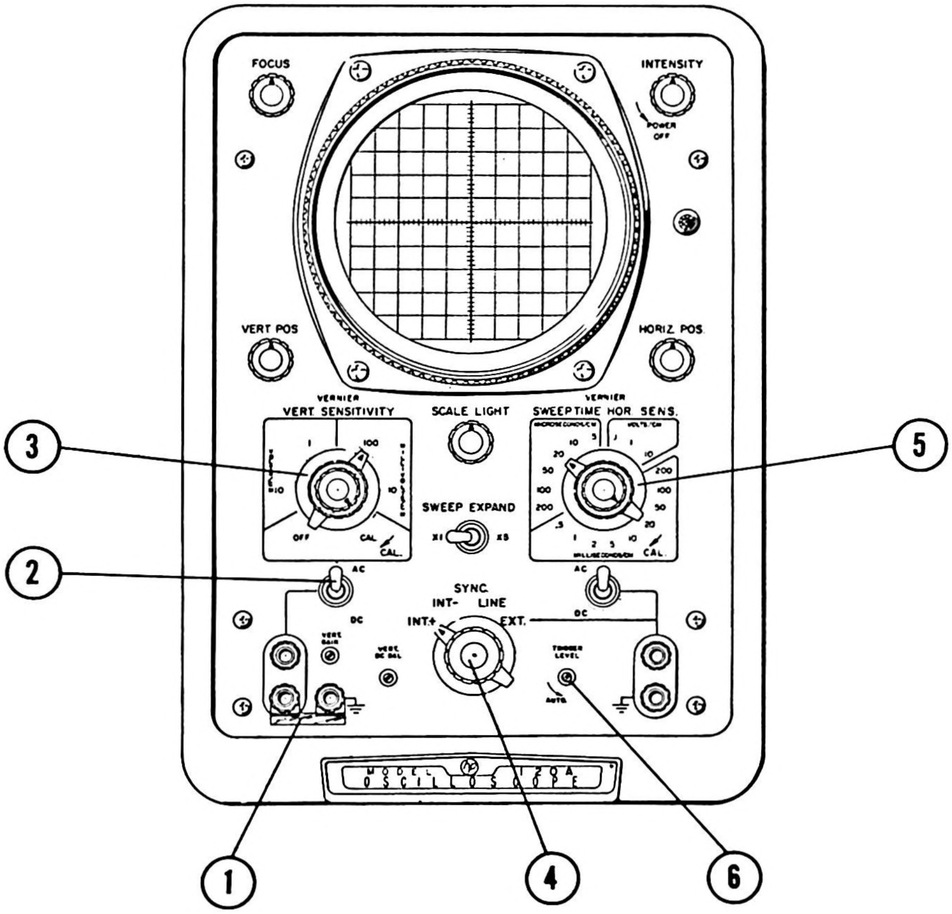
A terminal for CRT intensity (Z-axis) modulation.

2-11 OPERATING PLATES

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:

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 (balanced ac coupling, see Figure 2-5).

3. Adjust VERTICAL SENSITIVITY control for desired sensitivity.

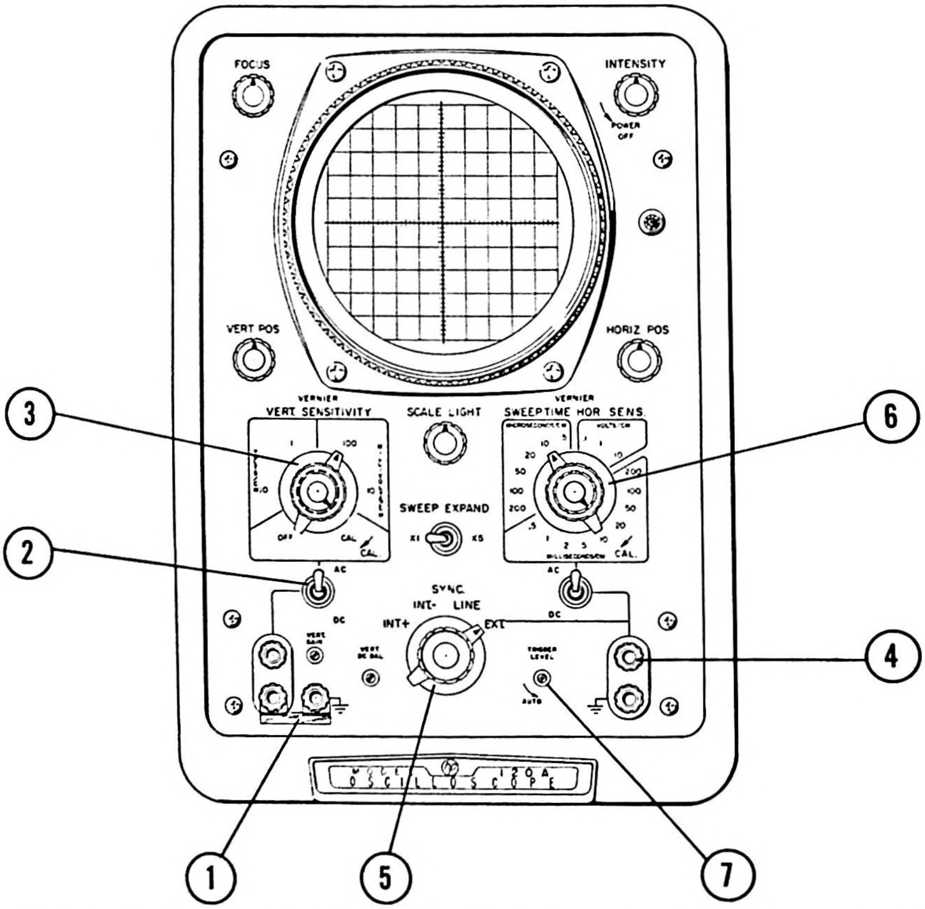
4. Set SYNCHRONIZATION switch to INTERNAL (+ or -), depending upon slope of trigger point desired (see Figure 2-2).

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 2-3

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 (balanced ac, see Figure 2-5).

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.

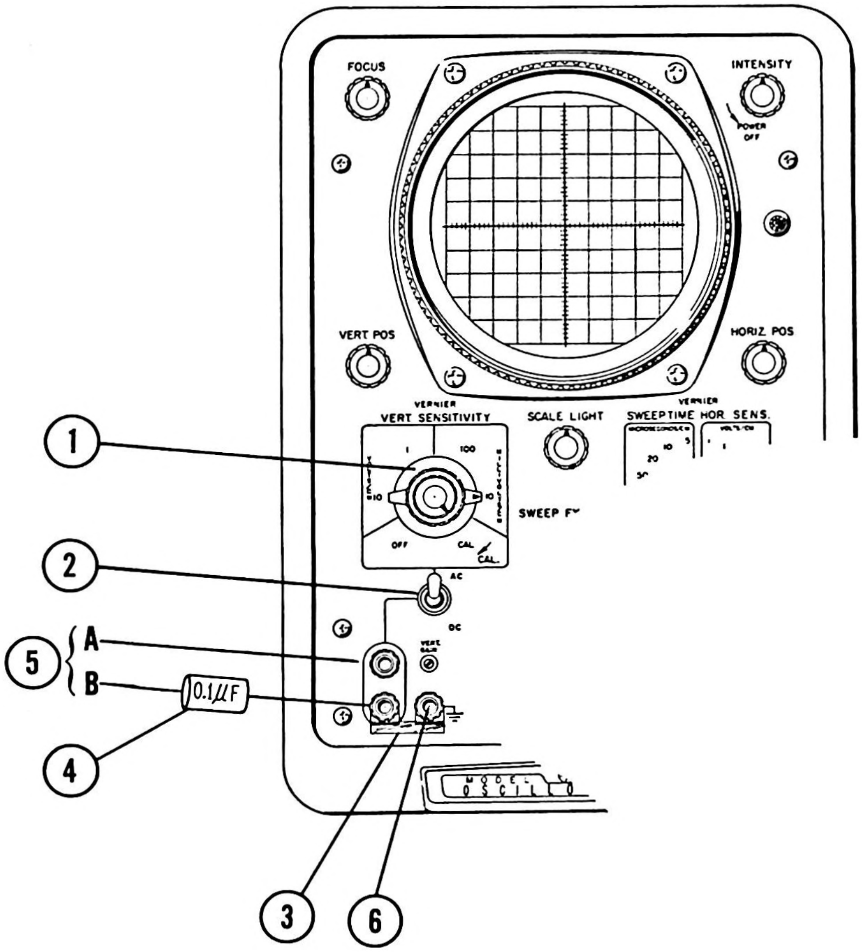
6. Adjust SWEEP TIME HORIZONTAL SENSITIVITY control for desired sweep speed.

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 2-4

AC COUPLING—BALANCED INPUT

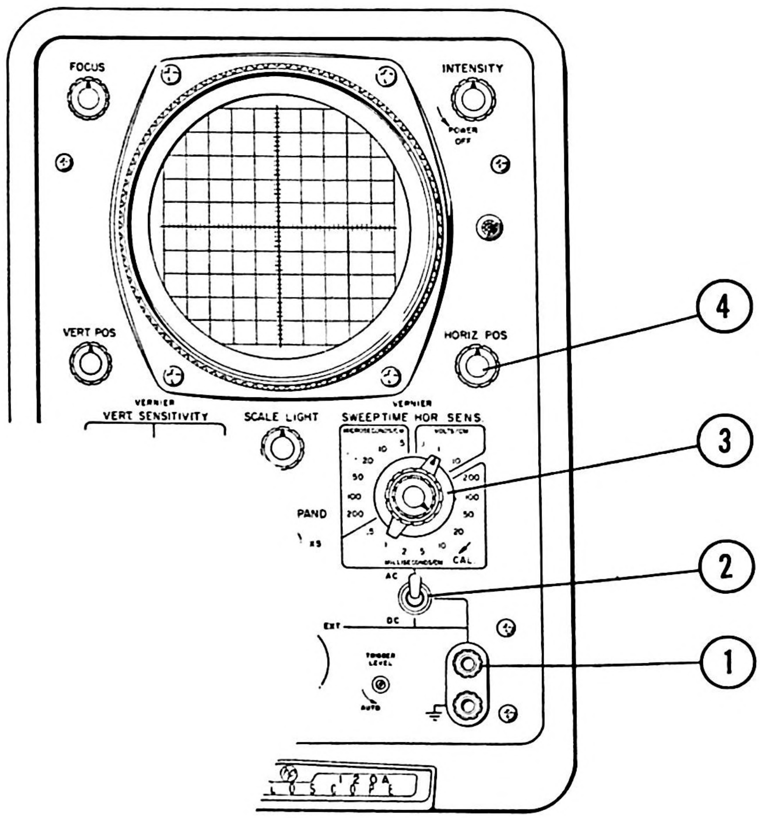


1. Set VERTICAL SENSITIVITY control to 10 millivolts/cm.
2. Set AC-DC switch to AC.
3. Disconnect shorting strap.
4. Connect 0.1 microfarad capacitor to bottom red terminal.
5. Connect input signal to A and B.
6. Connect common return to black terminal.

The capacitor must be used to block any dc which would unbalance the input amplifier.

Figure 2-5

EXTERNAL HORIZONTAL INPUT

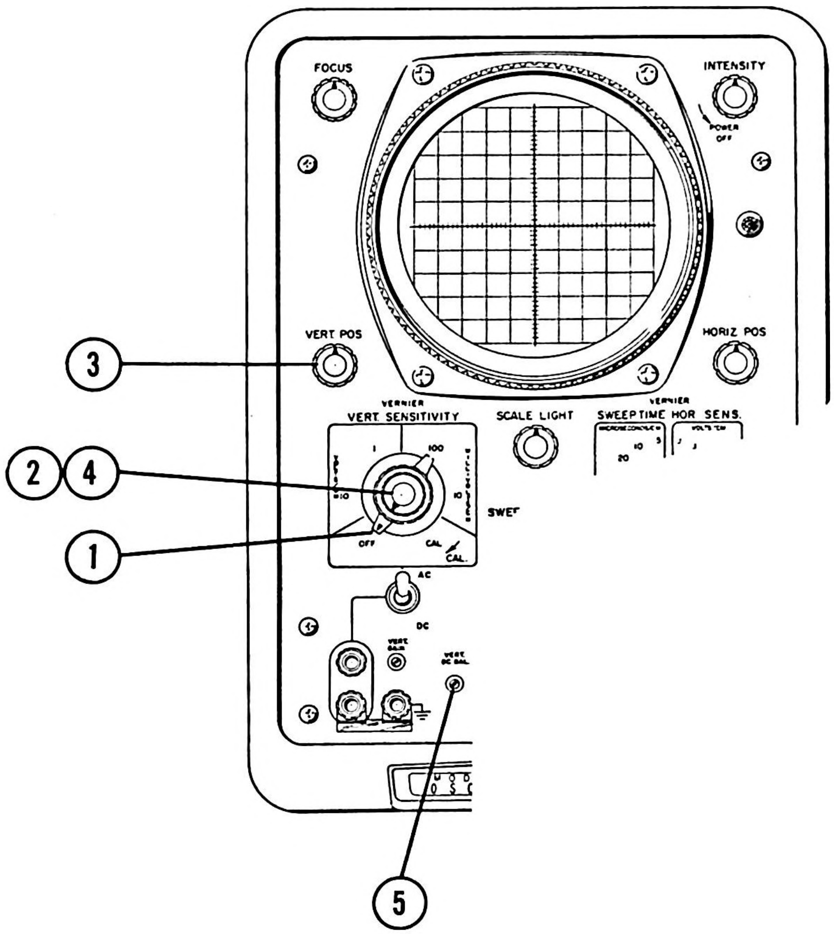


1. Feed horizontal signal to horizontal input terminals.
2. Set AC-DC switch for type input coupling desired (balanced ac coupling, see Fig. 2-5).
3. Set SWEEP TIME-HORIZONTAL SENSITIVITY control for desired sensitivity.
4. Adjust horizontal position of pattern with HORIZONTAL POSITION control.

This type of input will be found useful for viewing Lissajous patterns, etc.

Figure 2-6

VERTICAL BALANCE ADJUSTMENT

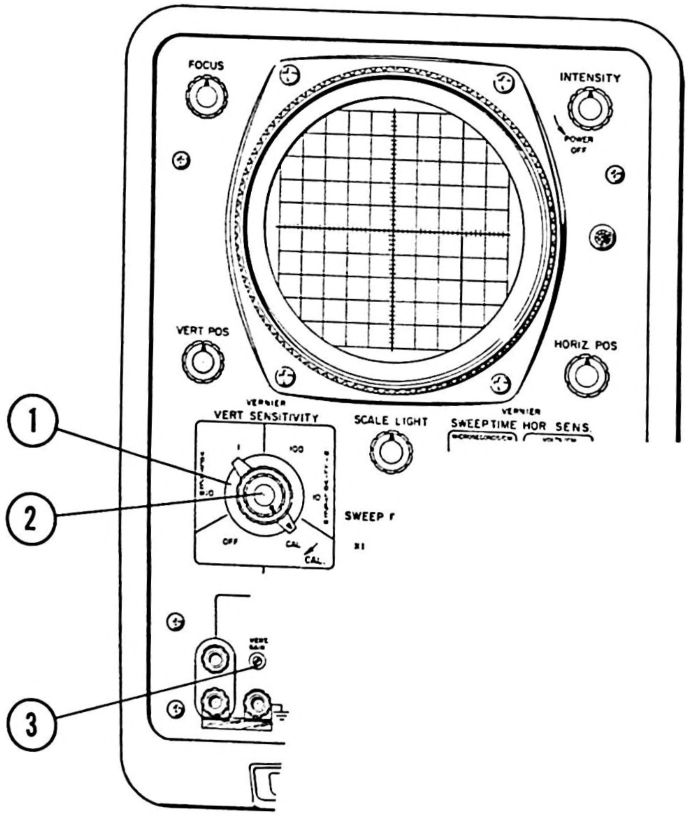


1. Set VERTICAL SENSITIVITY control to OFF.
2. Turn VERNIER full counter-clockwise.
3. Center trace or spot vertically with VERTICAL POSITION control.
4. Turn VERNIER full clockwise.
5. Adjust VERTICAL DC BALANCE control to center trace or spot.

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

Figure 2-7

VERTICAL SENSITIVITY CALIBRATION

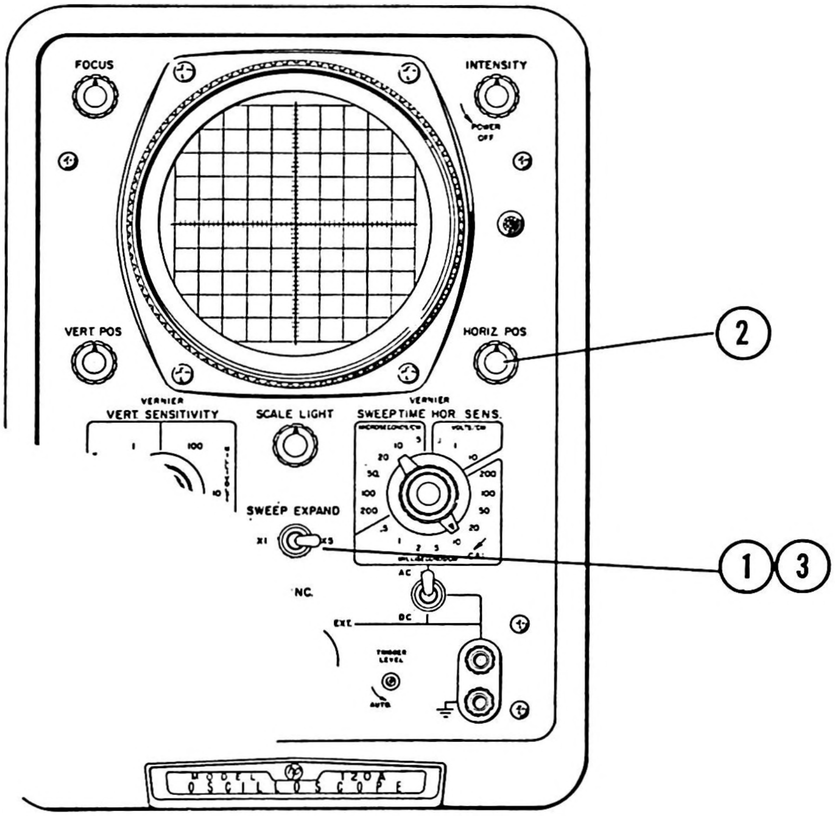


1. Set VERTICAL SENSITIVITY control to CALIBRATOR position.
2. Set VERNIER to CALIBRATED position.
3. Adjust VERTICAL GAIN control to give a pattern height of 6 centimeters.

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 returned to the CALIBRATED position.

Figure 2-8

INTERNAL SWEEP MAGNIFICATION



1. Make sure SWEEP EXPAND switch is in X1 position.

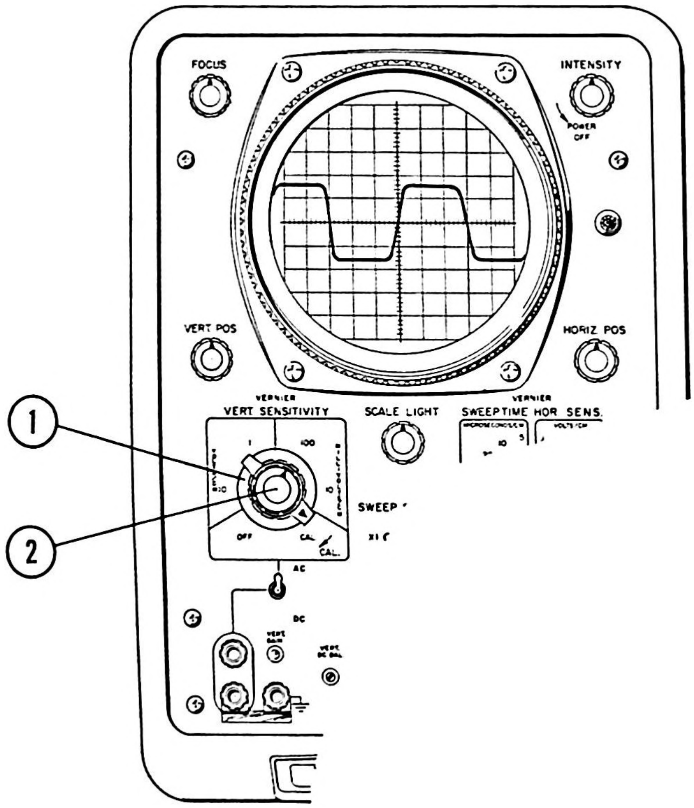
2. After obtaining pattern, center the 2 centimeters pattern to be magnified on the center vertical axis with HORIZONTAL POSITION control.

3. Set SWEEP EXPAND switch to X5.

Any 2 centimeter portion of the pattern may be selected to be viewed magnified five times by adjustment of the HORIZONTAL POSITION control.

Figure 2-9

INTERMEDIATE CALIBRATION



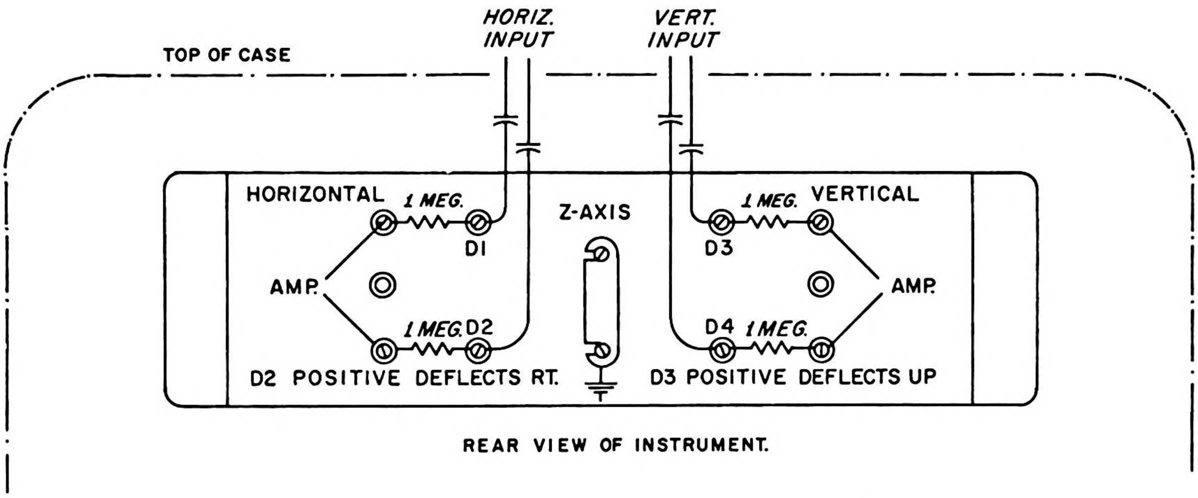
It may be desirable at times to set the calibration of the vertical amplifier at a known fraction of its engraved calibration. To do so proceed as follows:

1. Set VERTICAL SENSITIVITY switch to CALIBRATOR.

2. Adjust VERNIER control to obtain desired fraction of normal six centimeter high square wave. For example, in the illustration the pattern is adjusted to be three centimeters high thereby halving the sensitivity (multiply all of the engraved calibration markings by two). Note that basic calibration of oscilloscope has not been disturbed. Original calibration may be restored when desired by merely switching VERNIER back to calibrated position.

Figure 2-10

CONNECTION TO DEFLECTION PLATES



REAR VIEW OF INSTRUMENT.

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 condensers to terminals D3 and D4 and the horizontal input blocking condensers to D3 and D4.

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

B. DIRECT COUPLED

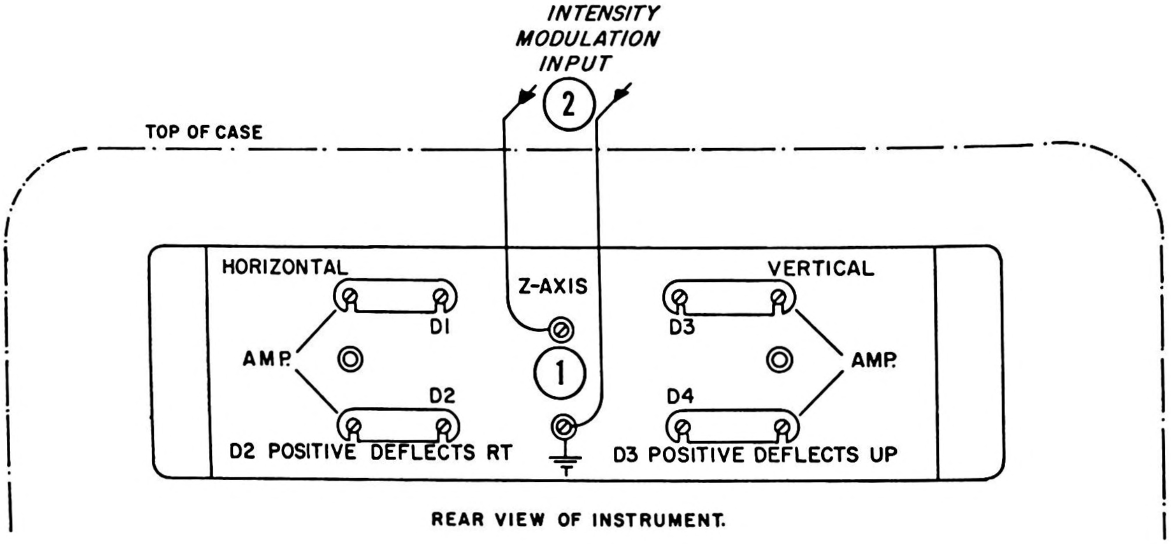
1. Remove the jumpers going to terminals D1 and D2 for horizontal input and/or D3 and D4 for vertical input.

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.

Figures 2-11

INTENSITY MODULATION OPERATION



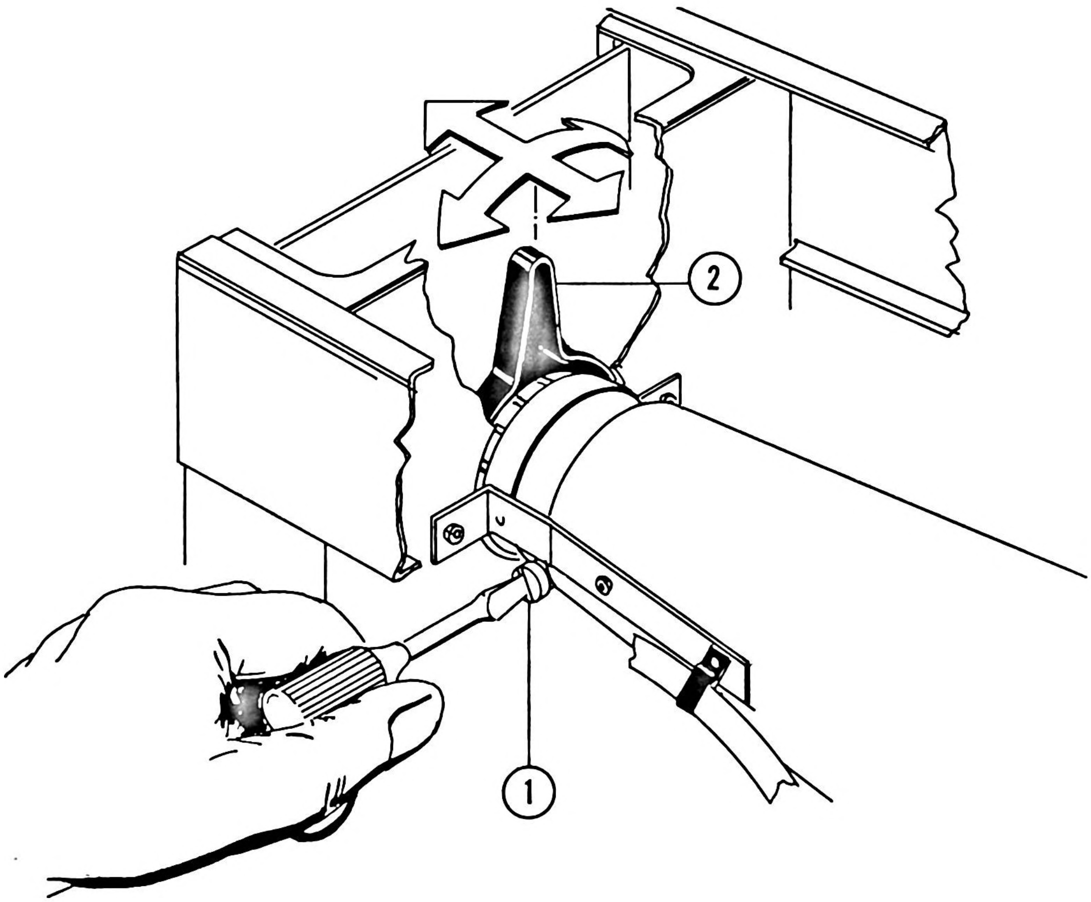
CAUTION - The deflection plates of the oscilloscope operate at a dc potential above ground. TURN THE INSTRUMENT OFF BEFORE REMOVING THE COVER PLATE FROM THE DEFLECTION PLATE TERMINALS, TO AVOID COMING IN CONTACT WITH HIGH VOLTAGES.

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 2-12

ALIGNING SCOPE TRACE WITH GRATICULE



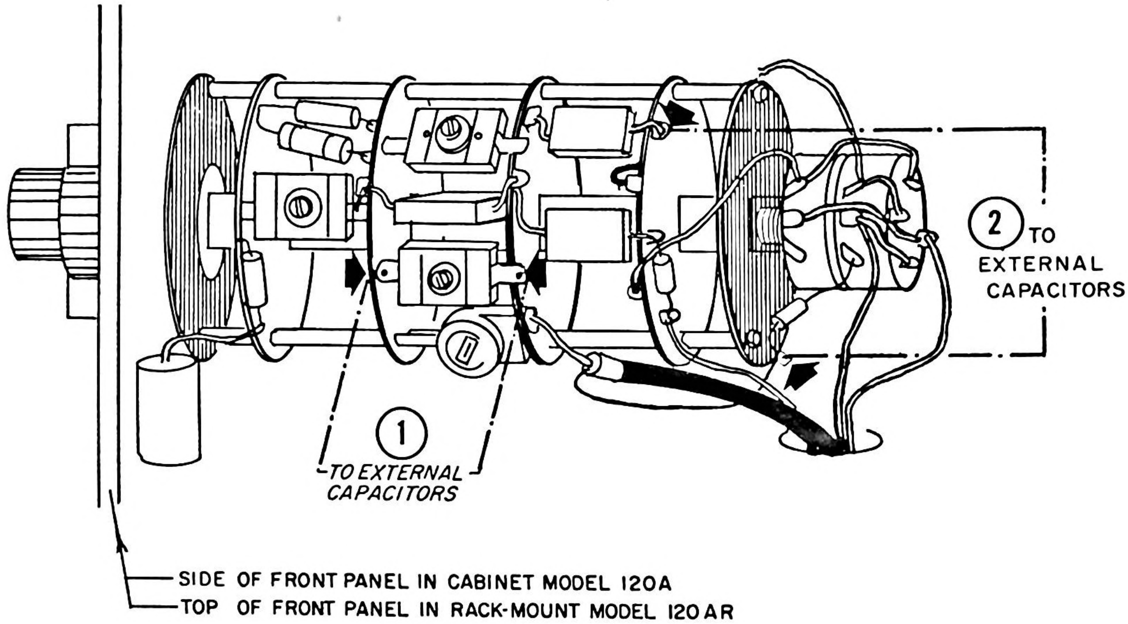
To align oscilloscope trace with graticule, remove oscilloscope from cabinet; then

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 2-13

CONNECTING EXTERNAL CONDENSERS TO EXTEND SWEEP TIME



To extend the sweep time, remove chassis from cabinet,

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

2. Connect external condenser from point shown to ground.

Values of both condensers are the same and will be determined by the sweep speed desired. Note that the only ranges that these condensers 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 mfd condensers will increase the calibration of the above ranges to approximately .5, 1, and 2 seconds/cm respectively.

Unlike adding condensers at an external terminal at the rear, this method will make no great sacrifice in linearity.

Figure 2-14

ADDITIONAL WAYS OF USING YOUR MODEL 120A OSCILLOSCOPE

INTERMEDIATE CALIBRATION
It may be desired to set the calibration of the vertical amplifier to a known fraction of its engraved calibration. Proceed as shown in Figure 2-10.

BALANCED INPUT
(other than 10 MILLIVOLTS/CM range).

Normal instructions for balanced input mentions its use of the 10 MILLIVOLTS/CM range only, since this range is the only one that has a balanced input as the attenuator is in only one side of the signal path.

The easiest way to desensitize the balanced amplifier, up to ten times the engraved sensitivity, is to use the VERNIER control. This desensitization may be calibrated by means of the procedures described in Figure 2-10.

However, under certain conditions the attenuator may be used alone. For instance, if you wish to compare two signals, one of which varies over a greater range than the other, connect the lead from the wide variation signal to the upper red terminal and use the attenuator. Connect the less widely varying signal to the lower red terminal and the common return to the black terminal.

If ranges other than the 10 MILLIVOLTS/CM range are used with balanced input, an additional attenuator will be required. This attenuator must be frequency compensated. Connect this attenuator between the signal source and the bottom red terminal. For ease of operation this attenuator should have the same attenuation ranges as in the oscilloscope itself. The most convenient attenuator would be one which is a copy of the input attenuator in the Vertical Amplifier.

In operation, the balanced signal should be attenuated equally in both paths by switching both attenuators simultaneously. This will keep the amplifier balanced and will enable you to operate the amplifier with balanced input in the same manner as single-ended operation.

With any type of operation the operating range of the grids of the input amplifiers must not be exceeded. THE SIGNAL APPLIED TO THE GRIDS MUST NOT EXCEED 3.0 VOLT PEAK AT ANY TIME. Thus, the arithmetic sum of the peak common-mode (in-phase) signal and the peak differential (out-of-phase) signal must not exceed 3.0 volts. This specification is for voltage on the grids or for the input voltage when on the straight-through range (10 MILLIVOLTS/CM). When the attenuators are used the voltage limit at the input may be increased by the same amount as the sensitivity was reduced.

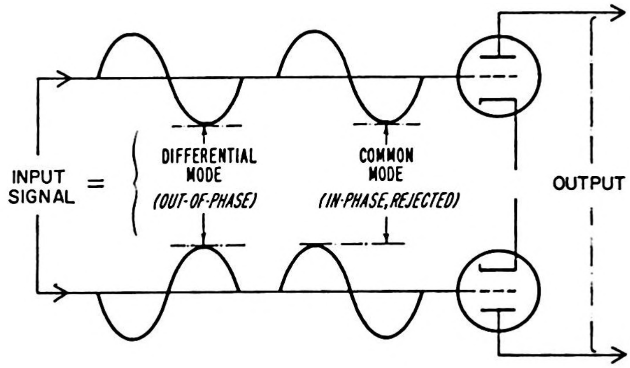
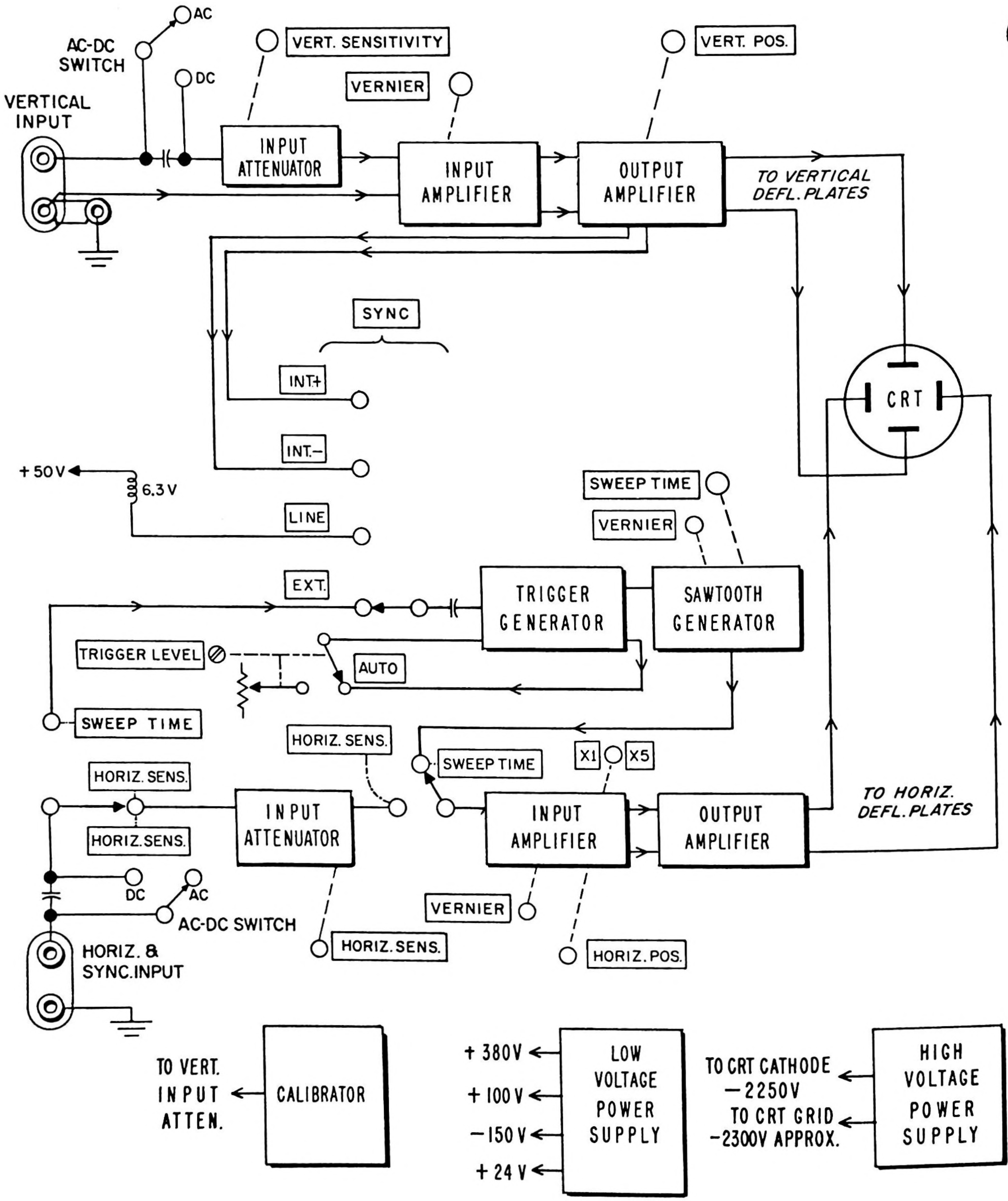


Figure 2-15.
Types of Input for Differential Amplifiers.

TROUBLE-SHOOTING
An oscilloscope is a very versatile tool for trouble-shooting not only other equipment but also itself. When part of the oscilloscope is not operating other sections, that are operating, may be used to find the fault in the non-operating section. For instance, if the sweep is not operating but the vertical amplifier is, use the vertical amplifier as a voltmeter to trouble-shoot the sweep generator.

Numerous other special uses are possible, such as using regulated voltages for calibration if the calibrator is not working. These situations will come to mind as the situation demands if it is kept in mind that an oscilloscope consists of a number of sections which may be used independently.

ADDITIONAL COMMON-MODE REJECTION
If greater than 40db (100 times) common-mode (in-phase) signal rejection is desired, connect a low-resistance balance potentiometer between the supply ends of the plate resistors of the input tube of the vertical amplifier. The arm of the potentiometer goes to the + 99 volt supply. In operation, this potentiometer is adjusted for maximum rejection of the common-mode signal.


AC
AC-DC SWITCH
DC
VERTICAL INPUT
VERT. SENSITIVITY
VERNIER
VERT. POS.
INPUT ATTENUATOR
INPUT AMPLIFIER
OUTPUT AMPLIFIER
TO VERTICAL DEFL. PLATES
SYNC
INT+
INT.−
CRT
+50V
6.3V
LINE
SWEEP TIME
VERNIER
EXT.
TRIGGER GENERATOR
SAWTOOTH GENERATOR
TRIGGER LEVEL
AUTO
SWEEP TIME
HORIZ. SENS.
SWEEP TIME
X1
X5
HORIZ. SENS.
HORIZ. SENS.
INPUT ATTENUATOR
INPUT AMPLIFIER
OUTPUT AMPLIFIER
TO HORIZ. DEFL. PLATES
DC
AC
AC-DC SWITCH
VERNIER
HORIZ. & SYNC. INPUT
HORIZ. SENS.
HORIZ. POS.
TO VERT. INPUT ATTEN.
CALIBRATOR
+380V
+100V
−150V
+24V
LOW VOLTAGE POWER SUPPLY
TO CRT CATHODE −2250V
TO CRT GRID −2300V APPROX.
HIGH VOLTAGE POWER SUPPLY

SECTION III
CIRCUIT DESCRIPTION

3-1 GENERAL CONTENT

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

3-2 OVERALL OPERATION

The block diagram 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 removeable 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 60mv 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 .1μfd condenser 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 the wanted 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. (see page 2-17)

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 12AZ7, is the output stage. The resistance between cathodes of this stage provides gain stability and improved linearity. The 50-380$\mu\mu$f condenser 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. <u>AC - DC Coupling Switch</u> - 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 .1μfd condenser.

b. <u>Input Attenuator</u> - The Input Attenuator consists of a three-position switch in decade steps, .1, 1, 10 VOLTS/CENTIMETER. The attenuator is frequency-compensated.

c. <u>Horizontal Amplifier</u> - The horizontal amplifier consists of two cross-neutralized balanced differential amplifiers in cascade. When the SWEEP TIME HORIZONTAL SENSITIVITY 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 horiz. gain set 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 X 5 leg has the exp. X5 gain adjustment to calibrate the magnified (X 5) sweep. The plates of the input amplifier (grids of the output amplifier) are connected with a 2-25$\mu\mu$f condenser to adjust the frequency response. The plates of the output amplifier V 102, another 12AZ7, connects 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. <u>Trigger Generator</u> - 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 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 counter-clockwise 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 feed-back 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 condenser through the resistance. However, the condenser is connected between the grid and plate of an amplifier. As the voltage across the condenser 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 condenser. Since the charging current is constant, and the values of the capacitor and charging circuit are constant, the voltage increase across the condenser is highly 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 condenser 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-condenser 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 Inverter - Another function of the Start-Stop Trigger is to furnish a pulse to blank and unblank the Cathode-ray Tube. Since both a positive and a negative pulse is needed, a phase inverter is inserted in the signal path. The positive unblanking pulse is condenser-coupled to the grid of the Cathode-ray Tube. This ac-coupled path will turn the Cathode-ray Tube on rapidly, for fast signals. However, being only ac-coupled, it does not furnish any voltage to hold it on for the duration of the sweep. This is the function of the negative gate signal. The signal from the plate of the phase inverter is fed directly into the section of the High Voltage Power Supply that is connected to the cathode of the Cathode-ray Tube. The cathode is also connected to the resistor string that controls the regulation of the oscillator in the High Voltage Power Supply. The negative pulse is fed into this regulator string at a slow enough rate that the regulator can take control keeping the -2250 volt cathode supply constant. This requires that the high voltage oscillator put less energy into the cathode winding of the high voltage transformer. The grid winding being tightly coupled also receives proportionally less energy and its dc output changes by the amount of the applied gate signal. Since this supply provides the dc reference for the cathode-ray tube grid, a path has been provided for the dc coupling of this unblanking signal.

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 critical filament voltage 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 transformer, a 1N1081 silicon power rectifier, and two pnp type transistors, one CTP1113 and one TS-600C, as regulators. The CTP1113 is operated with a grounded emitter acting similar to a series tube in a conventional regulator circuit. The TS-600C is an emitter follower driving the CTP1113, and acts as the control amplifier. Reference voltage is obtained from the -150 supply with a 1% divider .

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.

a. Hartley Oscillator - 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 positive gate unblanking pulse is also ac-coupled into this supply to unblank the cathode-ray tube quickly as is explained under the Gate Inverter part of the section on the Sweep Generator.

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 negative unblanking pulse is direct-coupled to this supply to keep the Cathode-ray Tube unblanked for the duration of the sweep.

The resistance-capacitance values of this circuit are fast enough so that in combination with the ac-coupled positive gate the pattern will unblank quickly and remain on. 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 centimeters (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, S 2, 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. I 301 will fire first as the voltage across it will increase more rapidly because it is returned to the negative supply. When I 301 fires it will draw current through R 358. However, the voltage across R 358 will build up slowly because C 334 must be charged at the same time. When this condenser allows the voltage drop across R 358 to rise, the voltage at the top of the neons will also rise. When this voltage rises to 70 volts (approx.) above ground, I 302 will fire and stay lit until the voltage across C 334 discharges through R 358 to a voltage approximately 70 volts below the voltage at the top of the neons. I 301 will now fire and the action will repeat itself.
I 302 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 R 365 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

> Adjustments and voltages referred to in this maintenance section are intended for maintenance purposes only and are not intended to be interpreted as specifications.

4-1 INTRODUCTION

This section contains instructions for adjusting and servicing the Model 120A Oscilloscope, Components of the Model 120A are readily accessible by removing the instrument from the cabinet. All tubes and transistors are removeable from above the chassis while other individual components are easily reached from below the chassis. Conventional point-to-point wiring is used throughout so that the Model 120A may be easily repaired with only the minimum of tools. 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 controls for that section on the front panel. The power supplies are in the rear; the low voltage on top of the chassis and the high voltage in the shielded box underneath and the transistor-regulated filament supply on the upper chassis brace. 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 and, at the rear of the manual, a schematic and a voltage-resistance diagram. 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	Adjustment Procedure.
4-7	Turn On.
4-8	Power Supplies.
4-9	Trigger Generator.
4-10	Vertical Amplifier.
4-11	Horizontal Amplifier.
4-12	Sweep Generator.

4-2 REMOVING THE CABINET

First, remove the power cord from the wall receptacle. Remove the two large screws at the rear of the cabinet. Do not remove any screws from the front panel. Push the instrument from the cabinet by pushing the rear of the chassis through the power cord hatch at the rear of the instrument. Now slide the instrument from the cabinet by pulling forward. Pull the power cord through hole in the cabinet. The instrument will now be completely free for servicing.

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, unless otherwise specified on the order. 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. Do not attempt to use this instrument on any voltage direct current. DO NOT ATTEMPT TO OPERATE THIS INSTRUMENT WITH A HIGHER VOLTAGE THAN 130 VOLTS IF CONNECTED FOR 115 VOLTS INPUT OR ABOVE 260 VOLTS IF CONNECTED FOR 230 VOLT OPERATION. Higher voltages will damage the transistors.

4-4 TUBE REPLACEMENT

The heaters of V1 and V2 are connected in series from a regulated dc voltage obtained from the Low-Voltage Power Supply. If one of these tubes burns out the other will go out also. Replace tubes one at a time. If replacing a tube does not cure the trouble, replace the original tube as it is necessary to perform tests when replacing some tubes. See the tube replacement chart.

4-5 ISOLATING TROUBLES TO MAJOR SECTIONS

If no trace can be found on the face of the cathode-ray tube set all of the controls exactly as shown on the two color fold-out diagram at the beginning of section II.

IF THE INSTRUMENT DOESN'T OPERATE AT ALL, check the ac circuit. First, check to see that the power is supplied to the wall socket and that the plug is securely in the socket. Next, check the fuse by substitution, even though the original fuse appears good. If the instrument still won't turn on, remove it from the cabinet and check continuity through the switch, the transformer and the wiring.

IF THE INSTRUMENT TURNS ON BUT DOESN'T PERFORM SOME FUNCTION, first be sure that the cause isn't mis-setting of the front panel controls. Set TRIGGER LEVEL control to AUTO. If this isn't the trouble, try to localize the trouble to a particular main section by operating all functions of the instrument and observing which it will perform and which it will not perform. From these observations it should be possible to determine in which section the fault lies.

AFTER THE TROUBLE HAS BEEN LOCALIZED TO A PARTICULAR SECTION, check visually for failures, such as, charred resistors or tubes not lit. Two common sources of trouble are tubes and mis-alignment of controls. Check the tubes before attempting realignment of controls since it is a sure method of finding the trouble while the results may be inconclusive if realignment is attempted first and the trouble is a tube. If one of the tubes isn't lit, check it by substitution. Just because a tube isn't lit doesn't mean that it is defective. V1 and V2 tubes are in series and a burn-out of any one of them will turn off both tubes in this circuit. Check them one at a time by substitution. Always replace the original tube if no fault is found. Do not replace tubes indiscriminately since in some cases it is necessary to realign the circuits when replacing tubes (see tube replacement chart). The tubes may also be checked in a tube tester for burnout. However, when checking tubes for other than filament continuity it is better to check by substitution since tube characteristics other than those checked by the tester may be used in the instrument. After it has been determined that the fault isn't tubes, check alignment of the controls for the faulty section by referring to the appropriate adjustment section. If the section won't align, check resistances and voltages with the aid of the resistance-voltage chart. Start by measuring the voltages of the main power leads from the power supply, then measure voltages at the sockets of tubes in the circuits which are suspected. When trouble shooting direct-coupled, push-pull circuits, the two sides of the circuit are normally balanced and cause the spot to be stationary in the center of the scope screen. 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. which originate prior to the shorted points. If shorting the two halves of a stage together does not bring the spot on the screen and hold it motionless, a subsequent circuit is faulty. By continuing this process through the amplifier the trouble can be isolated to a small circuit area. If shorting the plates together returns the spot, the trouble can be in the plate-load resistors or in the grid or cathode circuits of the following stage, etc.

After the faulty components have been located, replace them with good. These components may be obtained at regular radio parts stores as long as the ratings and tolerances, as shown in the parts list, are observed. In a few instances, the components have to be specially selected from regular stock. In these cases the special tolerances are spelled out. In general, these parts must be ordered from the factory, unless the customer has access to a electrical measuring bridge and a stock of parts from which to select. Regular parts may also be ordered from the factory if time is not important. We will send parts by air, if so instructed, at additional cost. When ordering parts, please include as much information as possible, especially the parts description as it appears in the parts list, the model number and the serial number.

4-6 ADJUSTMENT PROCEDURE

The following is a complete adjustment procedure for the Model 120A. Normally you will need to do only the procedures associated with the circuits under repair.

However, do not overlook the possibility of a fault in another circuit affecting the faulty circuit, such as, low power-supply voltages affecting other circuits. In case of difficulty, the Model 120A can be trouble-traced by following the alignment procedure in its entirety. Directions are given for the cabinet model but are the same for the rack-mount model except for location.

4-7 TURN ON

a. Measure resistances from the power supplies to ground with a (hp) 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 a (hp) Model 410B Voltmeter these resistances should read:

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

b. Turn on 120A and set -150 (115v input) with R344. This voltage point is any of the purple wires. Check voltage at the other power supplies. Set the high voltage to -2250 volts with R308. This voltage can be measured conveniently at the orange lead to the FOCUS control.

CAUTION

When turning the instrument on for the first time after repair work in any power supply circuit, turn the intensity, the H. V. adjust control and the H. V. limit control full counter-clockwise before applying power. Failure to follow this precaution may result in a permanently damaged cathode-ray tube.

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c. Adjust FOCUS and ASTIGMATISM, R316, controls at low intensity to obtain a small, round, and sharply focused spot.

d. Turn Sweep Stability control R228 full counter-clockwise so sweep free-runs. Set SWEEP TIME switch to 5 MILLISECONDS / CM. Align CRT so that the trace and graticule are parallel. Be sure that the CRT face is positioned just behind the filter in the bezel, but not touching as Newton rings will occur.

4-8 POWER SUPPLIES

a. Measure -150v bus (any purple wire) with a (hp) 410B voltmeter. Set this voltage to -150 volts with R344. Measure hum on this same bus with a (hp) 400D voltmeter. Check regulation from 102 to 128 volts by observing the ripple change. Turn the sweep off while measuring ripple. The following are the specifications for the various supplies:

Max. Ripple	102v	115v	128v	Wire Color	Allowable Variation(115v in)
-150 supply	3mv	3mv	3mv	Purple	Set to -150v
+ 380	60mv	20mv	20mv	Red	± 10v
+ 100		4mv		Yellow	± 3v
+ 24	60mv	40mv	40mv	White (Vert. amp.)	± 1v

b. Measure the cathode voltage of the cathode-ray tube. This voltage may be measured on the orange wire going to the FOCUS Potentiometer. DANGER HIGH VOLTAGE! Measure this voltage with a (hp) 450A High Voltage Probe connected to a (hp) 410B Voltmeter. Set this voltage to -2250 with R308. Using .0068μfd 5kv voltage rating condenser for blocking, measure the ripple on the cathode and grid (green wire), pin 3-can be measured through hole in handle of the cathode-ray tube with a (hp) 400D. Cathode ripple should be less than 350 millivolts and grid ripple less than 50 millivolts rms.

c. Check orientation of INTENSITY knob. Set knob to 9 o'clock. Set Intensity Limit, R322, so that the sweep on the screen of the cathode-ray tube is just extinguished. Check for best focusing in center third of FOCUS control and set ASTIGMATISM control, R316, for a small round spot.

d. With sweep at 1 MILLISECONDS/ CM, turn SWEEP TIME VERNIER down about 3:1. Feed a 1kc signal into the Vertical Input. Tune VERNIER to observe horizontal hum modulation on the sweep. Switch EXPAND switch to X5 and adjust hum balance potentiometer, R360, to minimize modulation.

The CRT shields should not be subjected to shock as they will then lose their shielding properties. They will then have to be demagnetized which is most easily done by annealing.

4-9 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:

a. Check -150 volts and reset, if necessary.

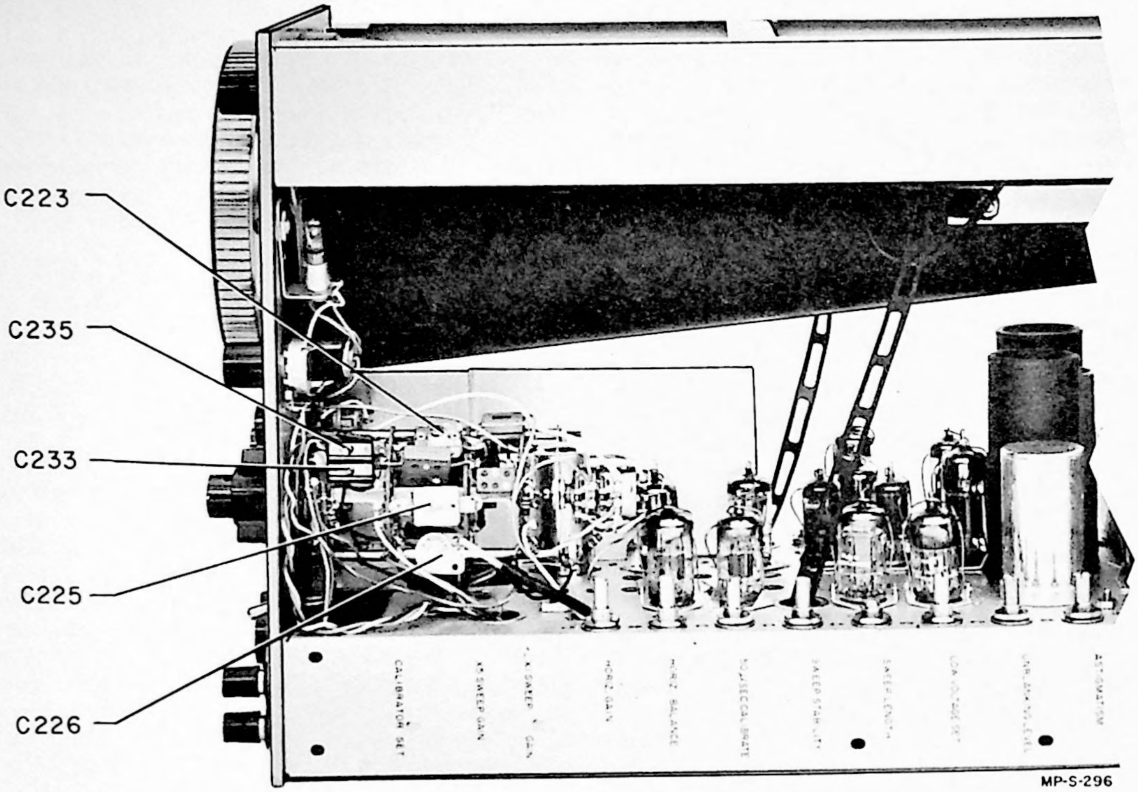

Figure 4-1. Most Internal Calibration Controls are Located In An Easily-Reached Row Along Side of Chassis. (See also Figure 4-2.).

b. Stability Adjustment
Set VERT. SENSITIVITY to CAL.
SWEEP TIME to 0.5 MILLISECONDS
SYNC to INT.
TRIGGER LEVEL to AUTO.

Connect ⓗp410B (-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.

c. External Trigger Sensitivity
Set SYNC switch to EXT.
TRIGGER LEVEL to AUTO.
Horizontal AC-DC switch to DC.

Connect a 10 kc sine wave of 0.3v 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 0.5v rms over this range. Check the rate when the control is in the AUTO. position -- should be about 120 ±50 cps.

d. Sync Polarity
Set TRIGGER LEVEL to AUTO.
VERT. SENSITIVITY to 1 VOLTS/CM

Feed 2v rms of 1kc sine wave into the Vertical Amplifier and into the sync. terminals (right-hand terminals on the front panel). Switch SYNC switch to INT - first, and then to EXT. The first half cycle should be negative going in each case. Switch to INT+ and it should be positive going.

e. TRIGGER LEVEL
Set SYNC switch to 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 + 2cm from the average value of the signal. Switch SYNC switch to EXT. Adjust input signal for 20v peak-to-peak. Range of TRIGGER LEVEL control should exceed this signal.

f. Internal Trigger Sensitivity
Set SYNC switch to INT+
SWEEP TIME switch to 50 MICROSECONDS/CM
Vertical AC-DC switch to DC

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 0.4cm when the triggers become unsteady. Check triggering from 50 cps to 250 kc.

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

h. Line Synchronization
Set SYNC switch to LINE
TRIGGER LEVEL to AUTO.

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

4-10 VERTICAL AMPLIFIER

a. Balance
Set VERT. SENSITIVITY control to 10 VOLTS/CM
HOR. SENS. control to 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.

b. Set Gain
Set VERT. SENSITIVITY to 10 MILLIVOLTS/CM
VERT. SENSITIVITY VERNIER to CAL
With 100 millivolts peak-to-peak from a Voltmeter Calibration Generator set Vertical Amplifier VERT. GAIN control to give exactly 10cm of deflection. Check this setting at high and low line voltage.

c. Calibrator
Set VERT. SENSITIVITY switch to CAL
VERT. SENSITIVITY VERNIER control to CAL
SWEEP TIME switch to 2 MILLISECONDS/CM

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

d. DC Shift, Hum and Microphonics
Set vertical (left) AC-DC switch to DC
VERT. SENSITIVITY switch to 10 MILLIVOLTS/CM
VERT. SENSITIVITY VERNIER control to CAL
HORIZ. SENSITIVITY switch to 10 VOLTS/CM

Short input. Switch input from DC to AC. The spot should shift not more than 0.2cm. There should be no distortion of the spot due to hum or ripple. Remove short and apply open shielded 3/4" plug. Check again for spot distortion. When jarring the 120A with a shorted input there should be no vertical instability greater than 1/2cm. Switch from HOR. SENS. positions to SWEEP TIME positions on the SWEEP TIME HOR. SENS. switch. The spot should not move vertically more than 0.1cm.

e. Compression
Set VERT. SENSITIVITY switch to 10 MILLIVOLTS/CM
VERT. SENSITIVITY VERNIER to CAL
Connect an insulated (hp) 400D across the vertical deflection plate terminals. CAUTION HIGH VOLTAGE! Switch to 1 volt range on the 400D. Apply 1kc signal to vertical input terminals and adjust output of signal generator for a reading of .95v on the 400D when spot is positioned to the center of screen. Position the spot to top line of the graticule and read 400D. Position the spot to bottom line of graticule and read 400D. The difference of each reading from the reference .95volts is the compression in percent. Compression should be less than 6%.

f. Square Wave Response
Set VERT. SENSITIVITY switch to 10 MILLIVOLTS/CM
VERT. SENSITIVITY VERNIER control to CAL
SYNC switch to INT+
TRIGGER LEVEL control to AUTO.
SWEEP TIME control to 10 MICROSECONDS/CM
Apply 50 kc square wave to vertical input terminals. Adjust generator for 8cm deflection. Adjust C15 for best square wave response. A maximum of 2% overshoot is permitted.

g. Attenuator Compensation
Set VERT. SENSITIVITY to 100 MILLIVOLTS/CM
VERT. SENSITIVITY VERNIER to CAL

SYNC switch to INT
TRIGGER LEVEL control to AUTO.
SWEEP TIME control to 200 MICROSECONDS/CM

Apply 5 kc square wave to vertical input terminals. Adjust for 8cm 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 8cm deflection. Adjust C2 for flat response. Switch Vertical Sensitivity to 10 V/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%.

h. Overload
Set Vertical AC-DC switch to AC
VERT. SENSITIVITY switch to 1 VOLTS/CM
VERT. SENSITIVITY VERNIER to CAL
SYNC switch to INT+
TRIGGER LEVEL control to AUTO.
SWEEP TIME switch to 10 MICROSECONDS / CM

Apply 50 kc square wave to vertical input terminals. Adjust for exactly 3cm deflection. Switch VERT. SENSITIVITY control to 100 MILLIVOLTS/CM. Check range of VERT. POS. control by positioning each peak of square wave beyond center screen. Observe overshoot or undershoot of square wave at midscreen. One-half centimeter is maximum permitted deviation from squareness. Turn VERT. SENSITIVITY VERNIER full counter-clockwise. Check for less than 3cm of square wave and for excessive rounding or overshoot. Return VERNIER to CAL. Reduce input to give exactly 3cm of deflection. Switch VERT. SENSITIVITY control to 10 MILLIVOLTS/CM. Check for overload as before.

i. Frequency Response
Set VERT. SENSITIVITY switch to 10 MILLIVOLTS/CM
VERT. SENSITIVITY VERNIER to CAL

Apply 2 kc sine wave to vertical input terminals and also measure this input with a ⓗ400D. Adjust input signal for exactly 10cm 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 8cm.

4-11 HORIZONTAL AMPLIFIER

a. Balance
Set HOR. SENS. switch to 10 VOLTS/CM
HOR. SENS. VERNIER to CAL
VERT. SENSITIVITY to OFF

Position spot to center of screen with HORIZ. POS. control. Turn HOR. SENS. VERNIER full counter-clockwise 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.

b. Set Gain
Set HOR. SENS. control to 0.1 VOLTS/CM
HOR. SENS. VERNIER control to CAL

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

c. DC shift, Hum, and Microphonics.
Set Horizontal AC-DC switch to DC
HOR. SENS. switch to 0.1 VOLTS/CM
HOR. SENS. VERNIER to CAL

Short input. Switch Horizontal AC-DC switch from DC to AC. Spot should not shift more than 0.05cm. There should be no distortion of the spot due to hum or ripple. Remove short and apply open shielded 3/4" plug. Check again for spot distortion. When jarring 120A with input shorted there should be no horizontal instability.

d. Compression
Set HOR. SENSITIVITY switch to 0.1 VOLTS/CM
HOR. SENSITIVITY VERNIER to CAL.

Connect insulated ⓗ400D across horizontal deflection plate terminals. DANGER, HIGH VOLTAGE! Switch to 1 volt range on 400D. Apply 1kc sine wave to Horizontal input terminals and adjust for a reading of 0.95 volts on the 400D when the spot is positioned to the center of the screen. Position the spot to the right-hand edge line of the graticule and read the 400D. Position the spot to the lef-hand edge line of the graticule and read the 400D. The difference of each reading from the reference 0.95 is the compression in percent. A maximum of 6% is permitted.

e. Square Wave Response
Set HOR. SENSITIVITY switch to 0.1 VOLTS/CM
HOR. SENSITIVITY VERNIER to CAL

Connect Sawtooth generator to Vertical input terminals. Apply 50 kc square wave to Horizontal input terminals and also use same signal to trigger Sawtooth Generator. Adjust C107 for minimum capacity. Adjust C110 for optimum square wave. A maximum of 2% overshoot is permitted.

f. Attenuator Compensation
Set HOR. SENSITIVITY switch to 1 VOLTS/CM
HOR. SENSITIVITY VERNIER to CAL

Apply 5 kc square wave to Horizontal input terminals and also use same signal to trigger a Sawtooth Generator connected to Vertical input terminals. Adjust

C235 on horizontal attenuator for flat response. Switch HOR. SENS. switch 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 1%.

g. Overload
Set HOR. SENS. switch to 1 VOLTS/CM
HOR. SENS. VERNIER to CAL
Apply 50 kc square wave to Horizontal input terminals and also use same signal to trigger Sawtooth Generator. Adjust output of Sawtooth Generator for exactly 3cm deflection. Switch HOR. SENS. switch to 0.1 VOLTS/CM. Observe overshoot and undershoot of square wave at midscreen. One-half centimeter is maximum permitted deviation from squareness. Turn HOR. SENS. VERNIER full counter-clockwise. Check for less than 3cm of square wave and for excessive rounding and overshoot. A maximum of 2% overshoot is permitted. Return VERNIER to CAL.

h. Phase Adjustment
Set HOR. SENS. switch to 0.1 VOLTS/CM
HOR. SENS. VERNIER to CAL
VERT. SENSITIVITY switch to 100 MILLIVOLTS/CM
VERT. SENSITIVITY VERNIER to CAL.
Apply 100 kc sine wave to both Vertical and Horizontal inputs. Adjust amplitude to give about 6cm 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 V/CM and 1 V/CM ranges also.

4-12 SWEEP GENERATOR

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

a. X1 Calibration
Set SWEEP TIME switch to 5 MILLISECONDS/CM
SWEEP EXPAND switch to X1
Apply 100 cps from a Time Marker Generator to Vertical input terminals. Adjust TRIGGER LEVEL control and choose either INT+ or - for best pattern. Adjust X1 Sweep Gain Adjustment, R107, so that the markers coincide with every other major division on the graticule.

b. X 5 Calibration
Set SWEEP EXPAND switch C 5
Apply 1 kc from Time Marker Generator to Vertical input terminals. Adjust TRIGGER LEVEL control for best pattern. Adjust X 5 Sweep Gain Adjustment R108, so that the markers coincide with each major division on the graticule.

c. Sweep Attenuator Compensation
Set SWEEP TIME switch to 10 MICROSECONDS/CM, SWEEP EXPAND switch to X1
Set C214 to mid-value. Attach 50:1 probe to an additional monitor oscilloscope calibrator output and compensate probe. Attach this probe to pin 2 of V101A to view sawtooth at input to Horizontal Amplifier. Apply 10 kc marker pips from a Marker Generator to the Vertical input terminals. Adjust C214 to compensate fly-back of sawtooth.

d. X1 - X5 Compensation
Set SWEEP EXPAND switch to X1
Connect 50:1 probe to output of Horizontal Amplifier, pin 1 or 6 of V102. Position start of sweep to center of screen with HORIZ. POS. control. Adjust C105 for compensation of fly-back of sawtooth. Switch SWEEP EXPAND switch to X 5 and adjust C106 for proper compensation. Remove probe.

e. Calibrate 50 millisecond Adjustment Control.
Set SWEEP TIME to 50 MILLISECONDS/CM
Apply 10 cps time markers to Vertical input terminals. Adjust 50 ms Calibrate adjustment, R251 for marker coincidence with every other major division on the graticule.

f. Calibrate 0.5 millisecond Adjustment Control
Set SWEEP SPEED TO .5 MILLISECONDS/CM
Apply 1 kc time markers from a Time Marker Generator to the Vertical input terminals. Adjust C223 for marker coincidence with every other major marker on the graticule.

g. Calibrate 50 MICROSECONDS/CM Adjustment Control
Set SWEEP SPEED control to 50 MICROSECONDS/CM
Apply 10 kc time markers from a Marker Generator to the Vertical input terminals. Adjust C225 for marker coincidence with every other major division on the graticule.

h. Calibrate 5 MICROSECONDS/CM Adjustment Control
Set SWEEP SPEED switch to 5 MICROSECONDS/CM
Apply 100 kc from Time Marker Generator to the Vertical input terminals. Adjust C226 for marker coincidence with every other major division on the graticule.

i. Calibrate SWEEP TIME VERNIER range
Set SWEEP TIME switch to 10 MICROSECONDS/CM
Apply 10 kc time markers from a Marker Generator

to the Vertical input terminals. Check for at least 3 markers displayed within 10cm when the SWEEP TIME VERNIER is turned full counter-clockwise. Return VERNIER to CAL.

j. Sweep Length
Set SWEEP TIME control to 200 MICROSECONDS/CM

Apply 1 megacycle time markers from a Time Marker Generator to the Vertical input terminal. Adjust TRIGGER LEVEL control for stable pattern, if necessary. Adjust Sweep Length Adjustment, R225, foı 10.5cm of sweep. Check at high and low line voltages.

k. Linearity
Set SWEEP EXPAND switch to X1

SWEEP TIME switch to 5, 10, 100, 200 MICROSECONDS/CM; 1, 10, 20, 50, 100, 200 MILLISECONDS /CM and with the SWEEP EXPAND switch in the X5 position 5 and 200 MICROSECONDS/CM; and 5 MILLISECONDS/CM.

Choose the appropriate marker rate and check the sweep linearity on the ranges listed for X1 and for X5. A maximum non-linearity of 3% is permitted.

l. Hum
Set SWEEP TIME switch to 1 MILLISECOND/CM
SYNC to INT
TRIGGER LEVEL control to AUTO.
SWEEP EXPAND switch to X1

Apply 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 .05cm shiftiin the trace.

m. Starting Point Variation
Set SWEEP TIME switch to 5 MICROSECONDS/CM
SYNC switch to INT
TRIGGER LEVEL control to the AUTO position
SWEEP EXPAND switch to X1

While triggering from 1 kc source, switch SWEEP TIME switch one position at a time down to 10 MILLISECONDS/CM and look for horizontal movement of the starting point. A maximum of 0.25cm is permitted. Look for evidence of rounding or overshoot of gate waveform.

n. Hold-Off
Set SYNC switch to INT
TRIGGER LEVEL to AUTO.
SWEEP EXPAND switch to X1.

Apply 500 kc triggers from a oscillator to the Vertical input terminals. Set the input line voltage to 102 volts. Switch the SWEEP TIME switch through its ranges and look for any pulling of the starting point of the sweep. No pull-in is permitted. Return the line voltage to 115 volts.

o. Unblanking
Set SWEEP TIME switch to 5 MILLISECONDS/CM
SYNC switch to EXT
TRIGGER LEVEL control to AUTO
VERT. SENSITIVITY switch to OFF

Apply 10 kc sine wave to the Horizontal input terminals. Adjust Unblanking Level Adjustment, R219, for uniform brightness from start to finish of the trace. Readjustment of intensity will be necessary. Switch SWEEP SPEED switch to 20 MILLISECONDS/CM. Turn HORIZ. POS. to each extreme. It should be possible to bring the starting point and the 10cm point of the sweep to center screen.

p. Common-mode Rejection
Set VERT. SENSITIVITY switch to 10 MILLIVOLTS/CM
VERT.SENSITIVITY VERNIER control to CAL
SWEEP TIME to 0.5 MILLISECONDS/CM

Check balance of vertical amplifier (par. 4-10A). Apply 1 kc sine wave from ⓗ200CD to Vertical input terminals through a ⓗ350B Attenuator with 600 ohm termination. With the 200CD at maximum output, switch in attenuation until 1cm of signal is displayed. Change input to balanced (remove jumper) and feed same signal into both grids. Remove attenuation until a 1cm of deflection is again achieved. The attenuation removed should be greater than 40 db.

q. Interference
Set VERT. SENSITIVITY switch to 10 MILLISECONDS/CM
VERT. SENSITIVITY VERNIER to CAL.
SWEEP TIME switch to 10 MICROSECONDS/CM
SYNC switch to INT
TRIGGER LEVEL control to INT

Apply 100kc square wave signal to ext. sync terminal from 600 ohm output of ⓗ211A with output turned to maximum. Put open shielded 3/4" plug on vertical input terminal. Observe amplitude of interference in vertical pattern. Maximum allowable is 0.3cm.

TABLE 4-1. REPLACEMENT CHART

IF YOU REPLACE	FUNCTIONS	PERFORM TESTS AS GIVEN IN SECTION:
Q 301	Regulator Transistor	4-7 a; 4-8 a;
Q 302	Amplifier Transistor	4-7 a; 4-8 a;
S 1	AC-DC Switch	None
S 2	Vertical Sensitivity Switch	4-10 a, b, g, h, i;
S 101	AC-DC Switch	None
S 102	Sweep Expand Switch	None
S 201	Sync Switch	4-9 c, h;
S 202	Trigger Level	4-9 d-g;
S 204	Sweep Time-Horizontal Sensitivity	4-11 a-h; 4-12 a-g;
S 205	Sweep Expand Switch	None
S 301	Intensity-ON Switch	4-8 c;
S 303	Scale Light Control	None
V 1	Input Amplifier Tube	4-10 a, b, d;
V 2	Amplifier Tube	4-10 a, b, d, e;
V 3	Output Amplifier Tube	4-10 a-f;
V 101	Amplifier Tube	4-11 a-h; 4-12 a, b;
V 102	Output Amplifier Tube	4-11 a-h; 4-12 a, b;
V 201	Trigger Generator Tube	4-9 a-h;
V 202	Start-Stop Trigger Tube	4-9 b;
V 203	Gate Inverter Tube	4-12 o;
V 204	Integrator Switch Tube	None
V 205	Sawtooth Integrator Tube	4-12 a, b, k;
V 301	Amplifier Tube	4-8 b;
V 302	Oscillator Tube	4-8 b;
V 303	Rectifier Tube	4-8 b;
V 304	Rectifier Tube	4-8 b;
V 305	Cathode Ray Tube	4-7 c, d; 4-8 b; 4-10 b; 4-11 b; 4-12 a, b;
V 306	Rectifier Tube	4-8 a;
V 307	Regulator Tube	4-8 a;
V 308	Amplifier Tube	4-8 a;
V 309	Rectifier Tube	4-8 a;
V 310	Regulator Tube	4-8 a;
V 311	Amplifier Tube	4-8 a;
V 312	Reference Tube	4-8 a;

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, counterclockwise 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.

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.

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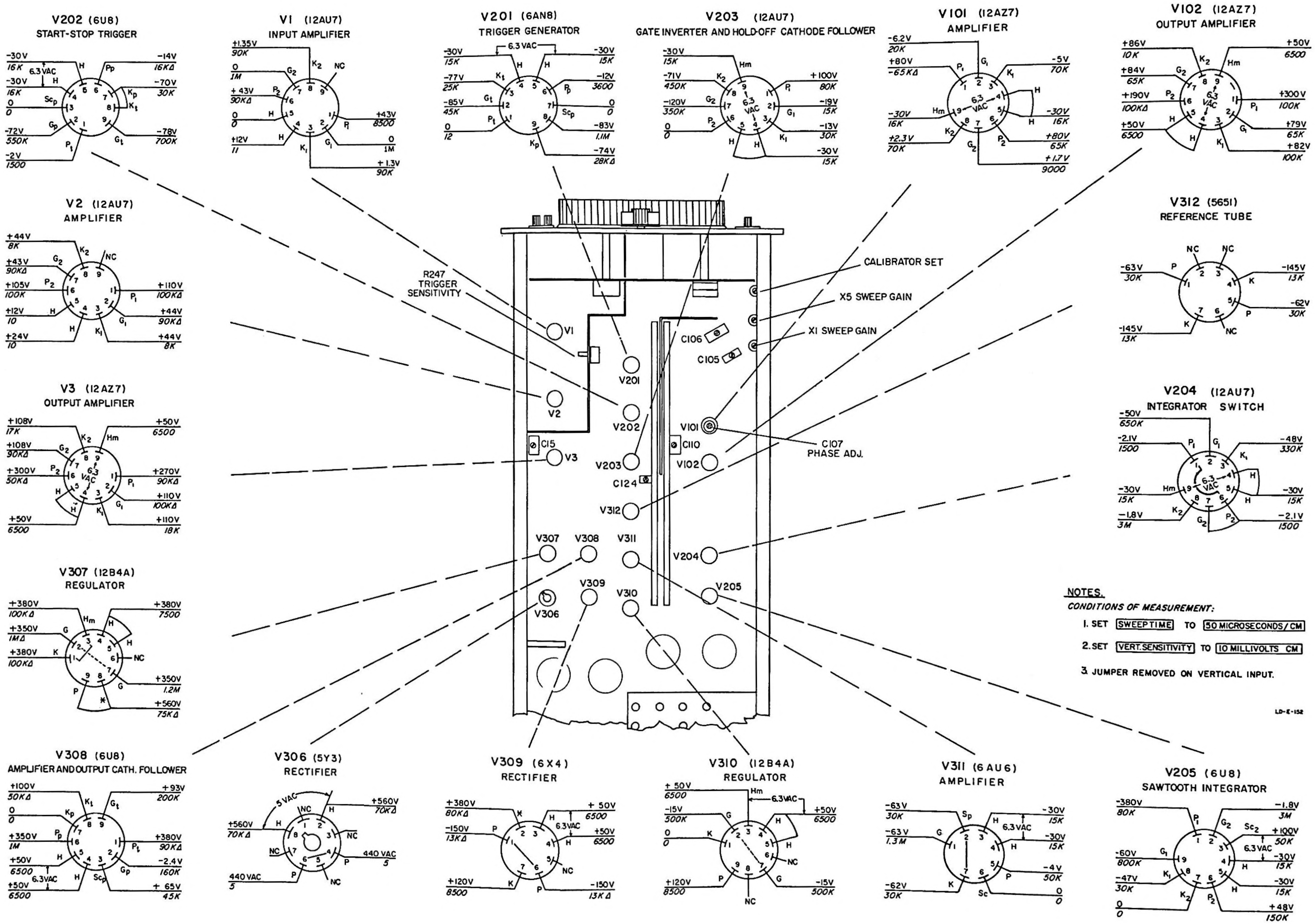
4. A solid line between socket terminals indicates a connection external to the tube between the terminals; a dotted line between terminals indicates a connection inside the tube. Voltage and resistance are given at only one of the two joined terminals.

FIGURE 4-2
ADJUSTMENT LOCATION AND
VOLTAGE RESISTANCE
DIAGRAM

MODEL 120A / AR

VOLTAGE-RESISTANCE DIAGRAM

(VIEWED FROM BELOW)



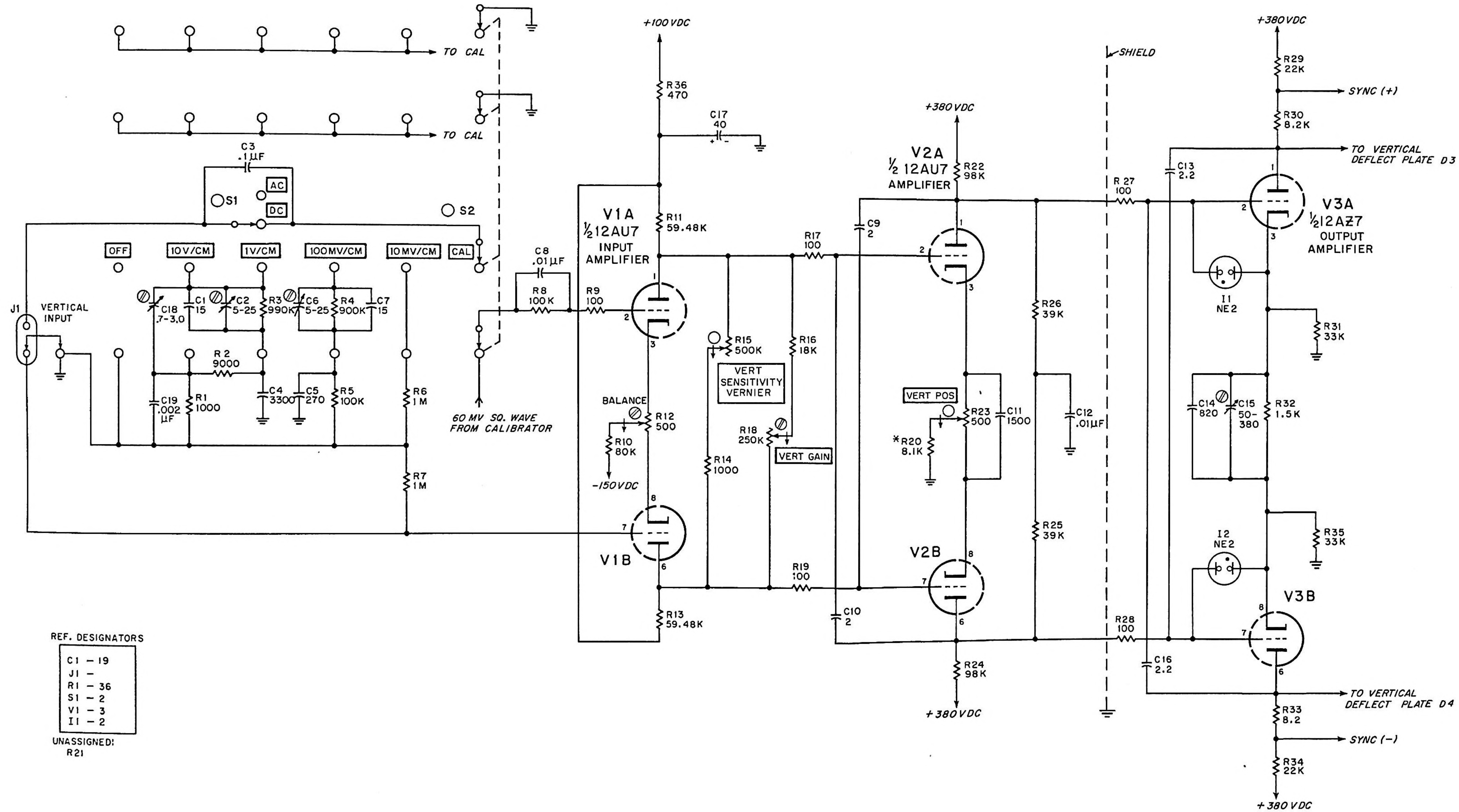
NOTES.

CONDITIONS OF MEASUREMENT:

1. SET SWEEPTIME TO 50 MICROSECONDS/CM
2. SET VERT. SENSITIVITY TO 10 MILLIVOLTS CM
3. JUMPER REMOVED ON VERTICAL INPUT.

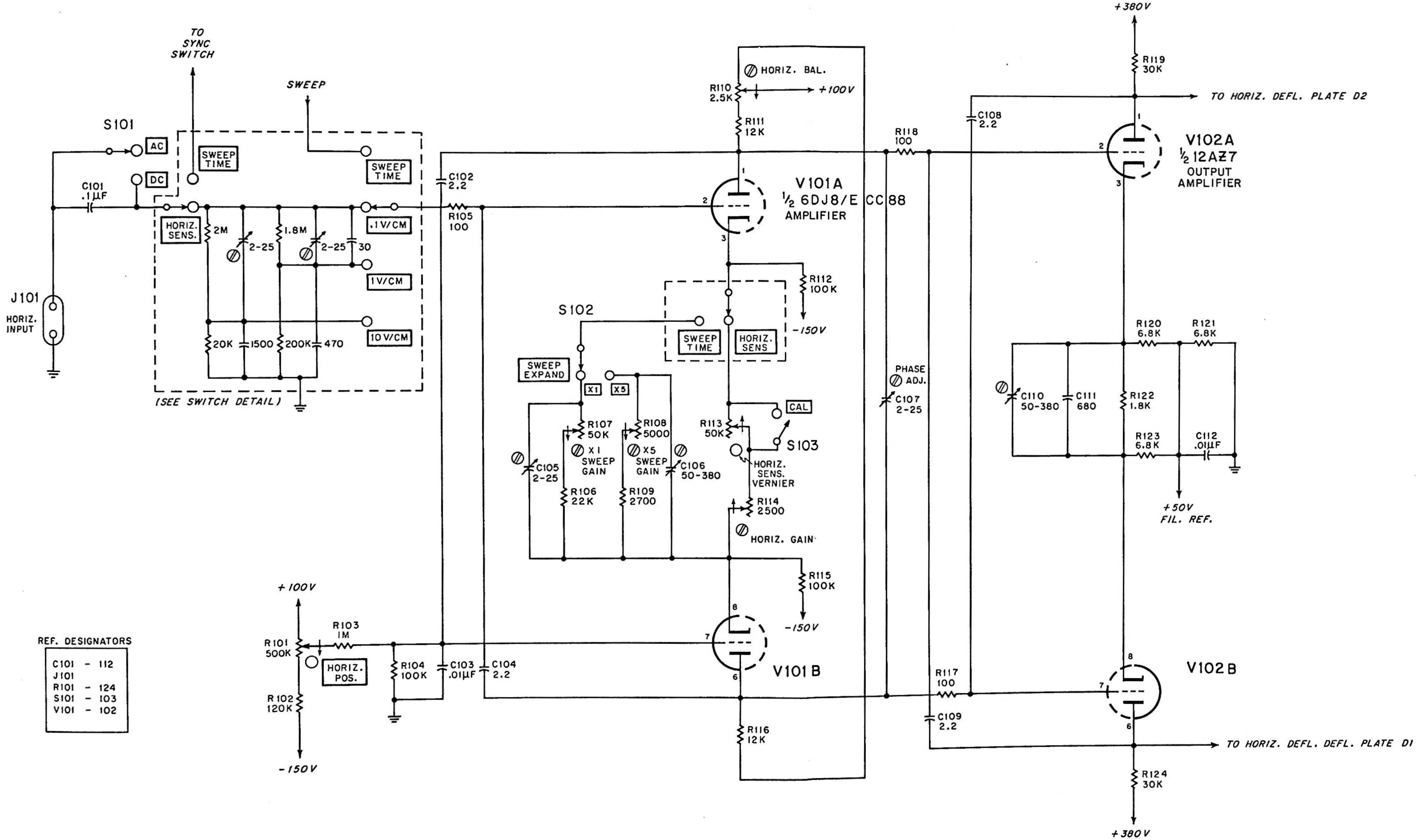
LD-E-152

FIGURE 4-3.
VERTICAL AMPLIFIER



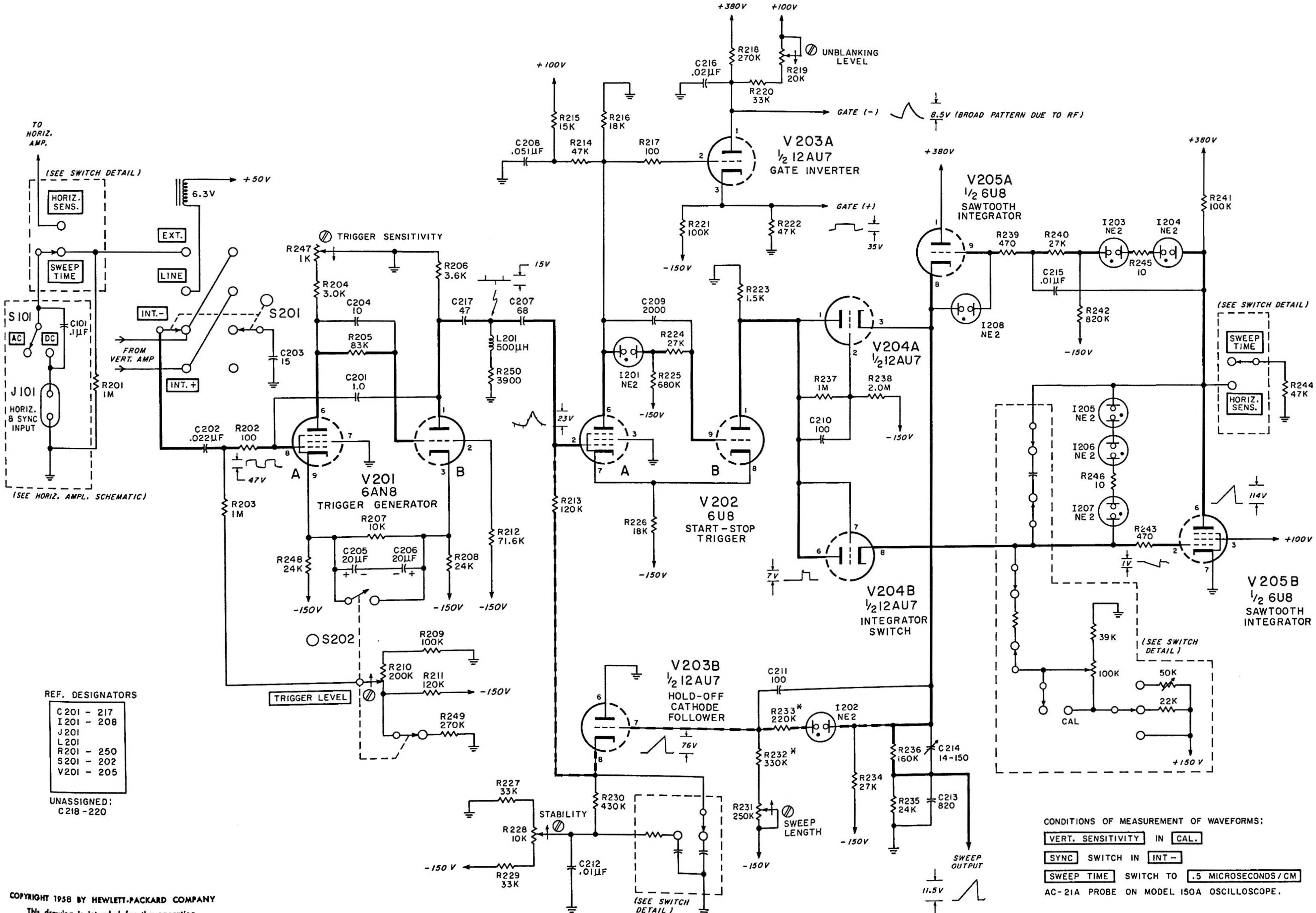
120A - VA - 101AB

FIGURE 4-4.
HORIZONTAL AMPLIFIER



120A - HA - 101AB

FIGURE 4-5.
SWEEP GENERATOR



REF. DESIGNATORS

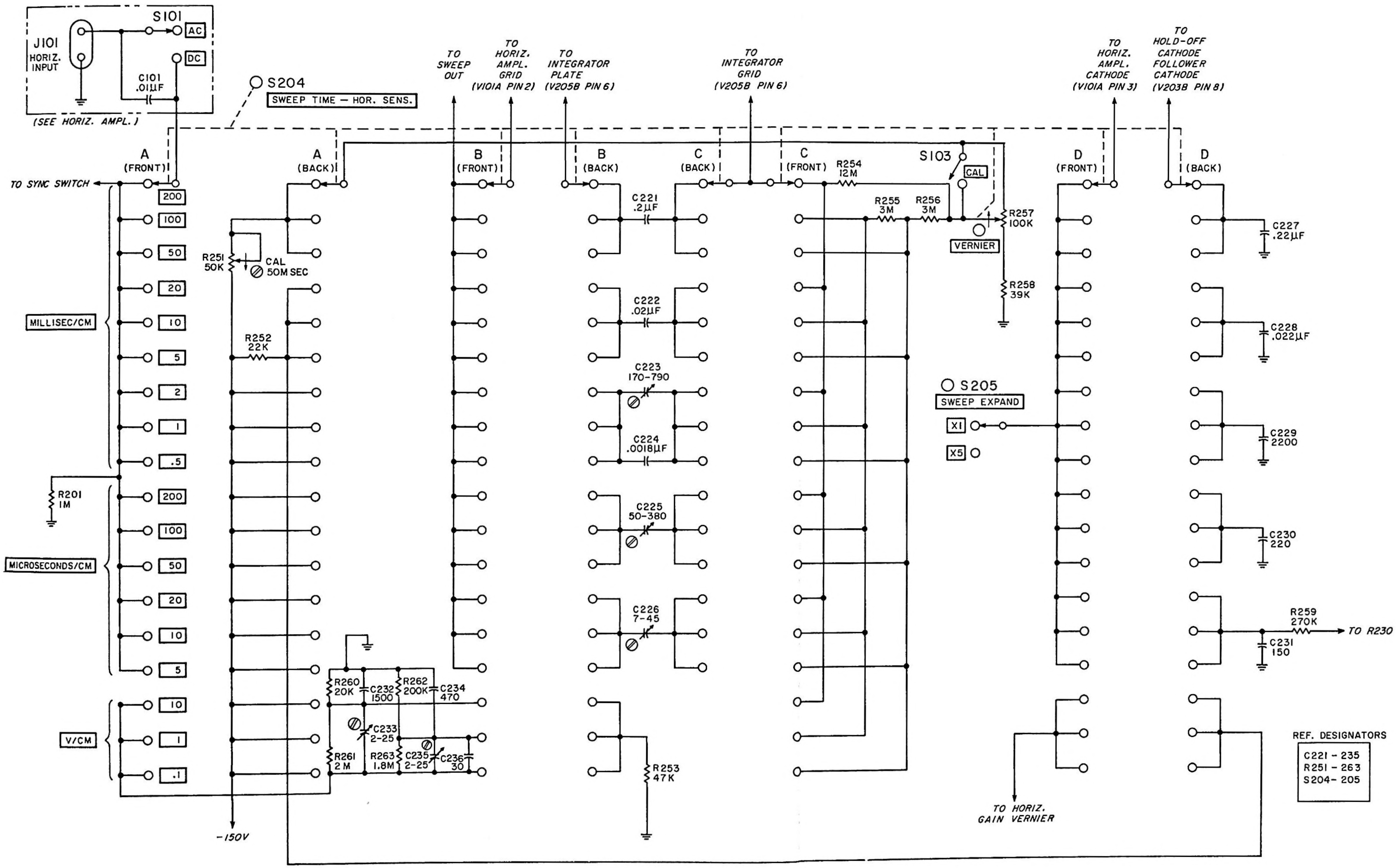
C201 - 217
I201 - 208
J201
L201
R201 - 250
S201 - 202
V201 - 205

UNASSIGNED:
C218-220

CONDITIONS OF MEASUREMENT OF WAVEFORMS:
VERT. SENSITIVITY IN CAL.
SYNC SWITCH IN INT-
SWEEP TIME SWITCH TO .5 MICROSECONDS/CM
AC-21A PROBE ON MODEL 150A OSCILLOSCOPE.

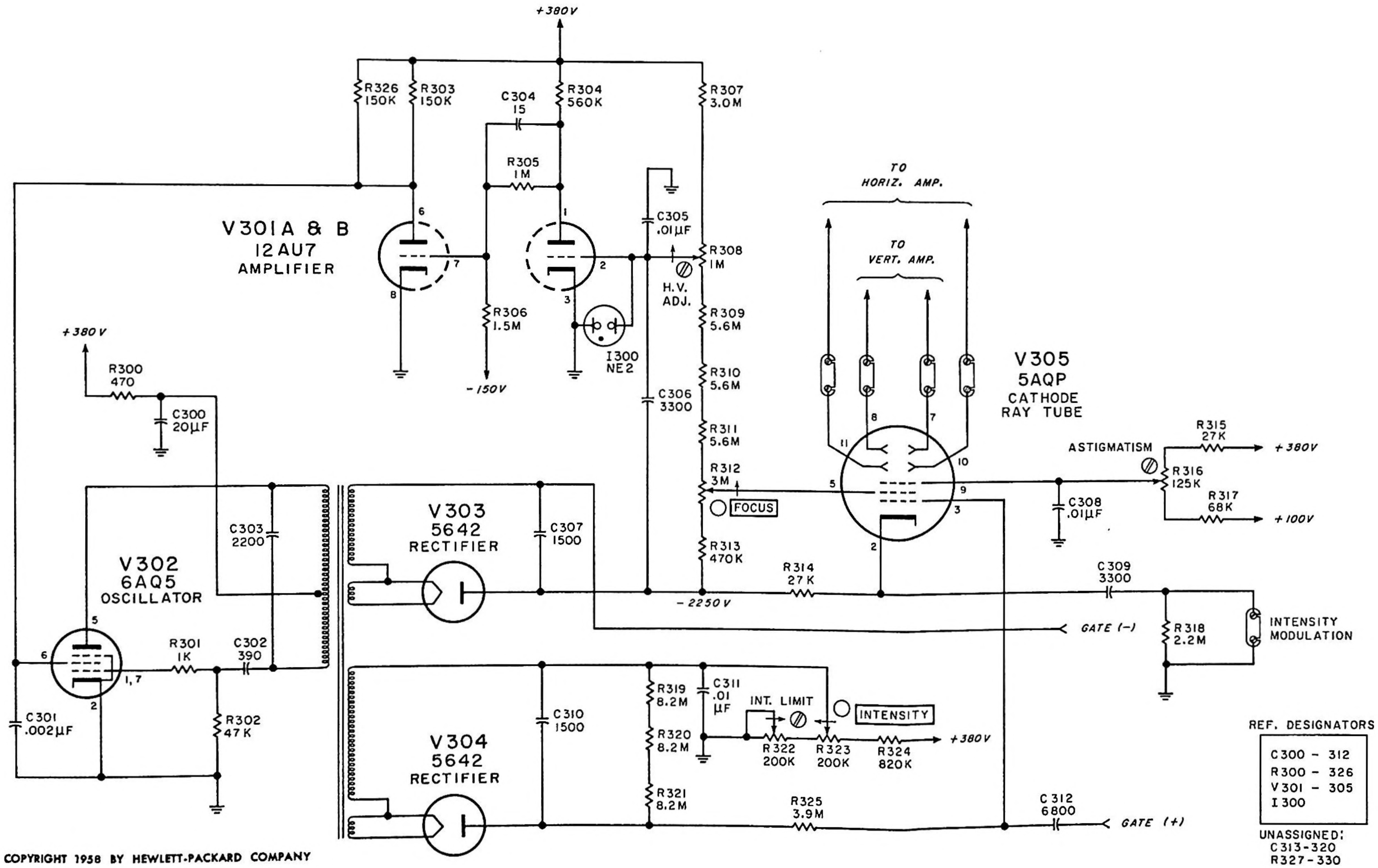
120A-88-101AB

FIGURE 4-6.
SWEEP TIME SWITCH



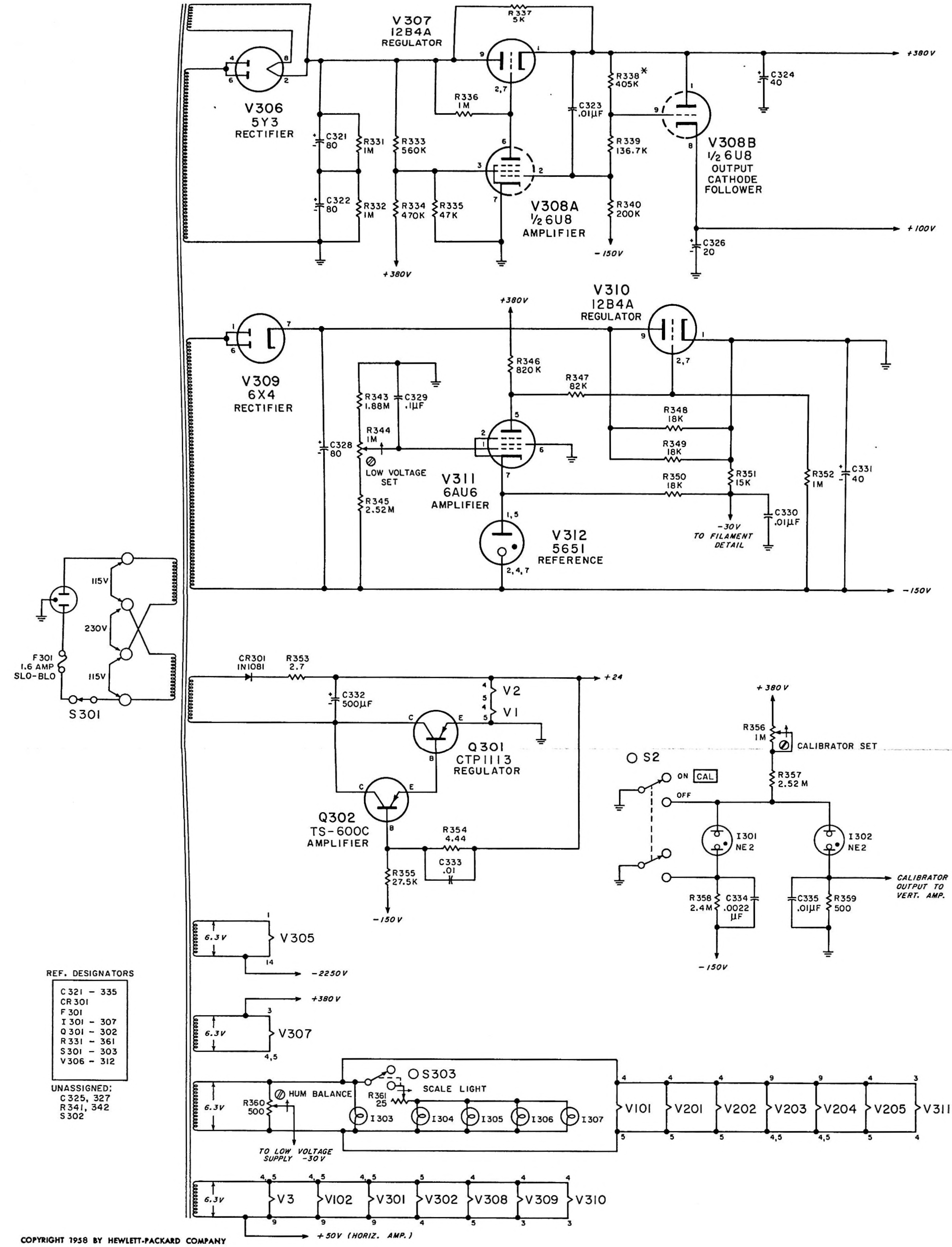
120A-ST-101AB

FIGURE 4-7.
HIGH VOLTAGE POWER SUPPLY



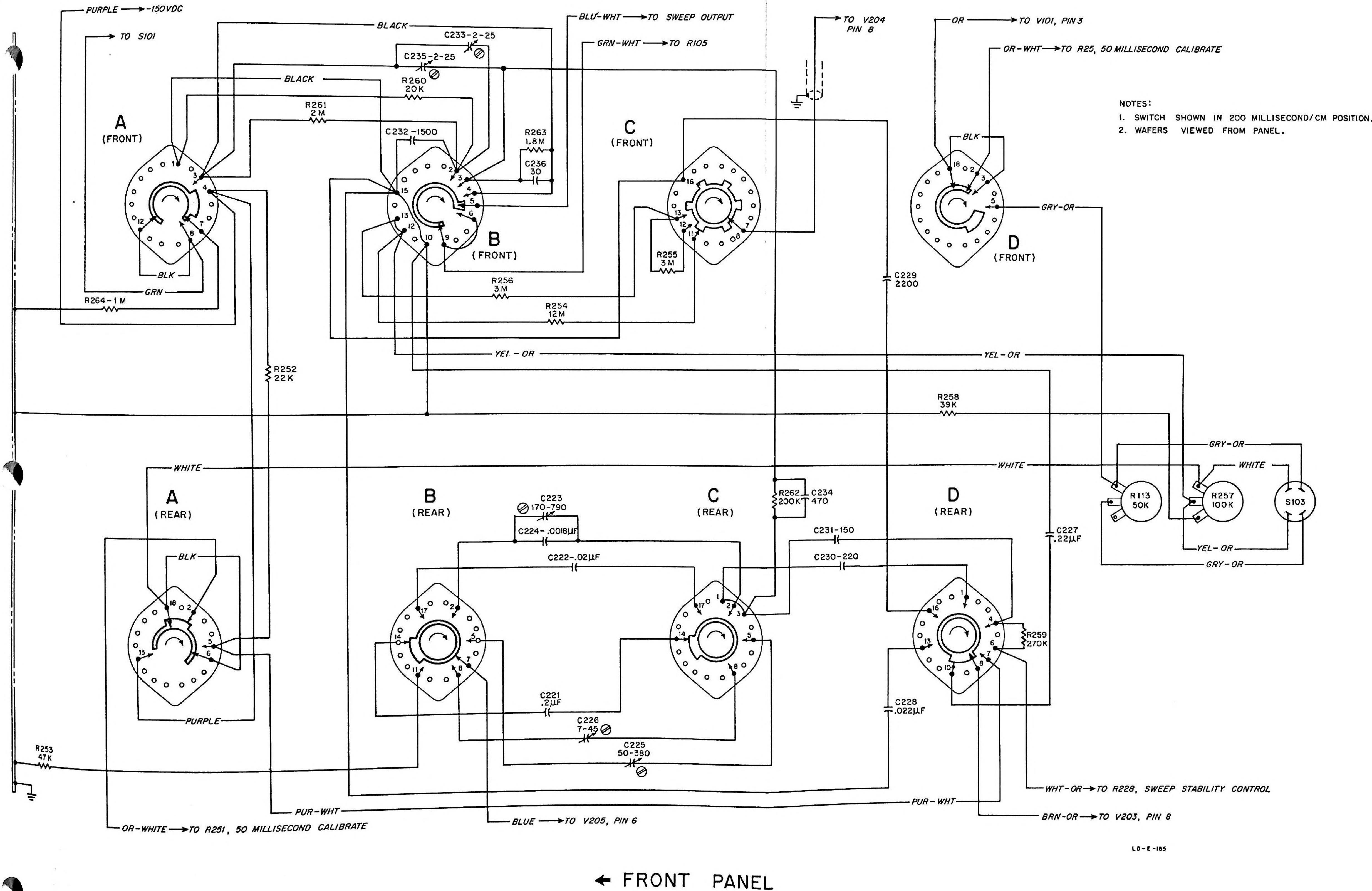
120A - HVPS - 101AB

FIGURE 4-8.
LOW VOLTAGE AND
FILAMENT SUPPLY



120A - LV & F - 101AB

FIGURE 4-9
SWEEP TIME SWITCH
ASSEMBLY DIAGRAM


PURPLE → -150VDC
TO S101
BLACK
C233-2-25
C235-2-25
BLACK
R260 20K
R261 2M
C232-1500
R263 1.8M
C236 30
BLU-WHT → TO SWEEP OUTPUT
GRN-WHT → TO R105
TO V204 PIN 8
OR → TO V101, PIN 3
OR-WHT → TO R25, 50 MILLISECOND CALIBRATE
NOTES:
1. SWITCH SHOWN IN 200 MILLISECOND/CM POSITION.
2. WAFERS VIEWED FROM PANEL.
A (FRONT)
B (FRONT)
C (FRONT)
D (FRONT)
BLK
GRN
R264-1M
R256 3M
R254 12M
R255 3M
C229 2200
GRY-OR
YEL-OR
R252 22K
R258 39K
WHITE
A (REAR)
B (REAR)
C (REAR)
D (REAR)
C223 170-790
C224-.0018μF
C222-.02μF
R262 200K
C234 470
C231-150
C230-220
C227 .22μF
R113 50K
R257 100K
S103
R259 270K
C221 .2μF
C226 7-45
C225 50-380
C228 .022μF
PURPLE
R253 47K
PUR-WHT
OR-WHITE → TO R251, 50 MILLISECOND CALIBRATE
BLUE → TO V205, PIN 6
WHT-OR → TO R228, SWEEP STABILITY CONTROL
BRN-OR → TO V203, PIN 8
LO-E-165
← FRONT PANEL

CUT HERE ! CUT HERE ! CUT HERE !

CATHODE RAY TUBE FAILURE REPORT

hp Model No.______________ Serial No.______________

Tube Type______________

The cathode ray tube supplied in your Hewlett-Packard Oscilloscope and replacement cathode ray tubes purchased from hp, are guaranteed against electrical failure for one year from the date of sale by the Hewlett-Packard Company. Broken tubes or tubes with burned phosphor are not included in this guarantee. All terms of the current hp warranty (included in all instruction manuals and catalogs) apply to this guarantee on the cathode ray tube.

Your local hp representative maintains a stock of replacement tubes and will be glad to process your warranty claim for you. Please consult him.

Whenever a tube is returned for a warranty claim, both sides of this sheet must be filled out in full and returned with the tube. Follow shipping instructions carefully to insure safe arrival of the tube at the factory.

SHIPPING INSTRUCTIONS

Extra care must be taken to be certain that tubes shipped back for credit be protected from transportation damage. If a tube arrives broken, delay will be caused in determining who is liable--the transportation company or the shipper. Many tubes will be subject to a laboratory examination to determine the cause of failure before credit can be allowed. Proper examination is either difficult or impossible when the tube is damaged from mishandling.

1) Carefully wrap the tube in 1/4" thick "kimpack", cotton batting, or other soft padding material.

2) Wrap the above in heavy kraft paper.

3) Pack in a rigid container which is at least 4 inches larger than the tube in each dimension.

4) Surround the tube with at least four inches of packed excelsior or similar shock absorbing material. Be certain that the packing is tight all around the tube.

5) Tubes returned from outside the continental United States should be packed in a wooden box.

6) Ship prepaid preferably by AIR FREIGHT or RAILWAY EXPRESS. Do not ship via parcel post or air parcel post.

FROM: DATE: ____________________

NAME: ____

COMPANY: ____

ADDRESS: ____

____

____

Person to contact for further information:

NAME: ____

TITLE: ____

COMPANY: ____

ADDRESS: ____

____

____

To process your claim quickly please enter the information indicated below:

1) TUBE SERIAL NO.: ____________________________

2)* ORIGINAL TUBE __________ REPLACEMENT TUBE __________

3) ORIGINAL HEWLETT-PACKARD PURCHASE ORDER NO. ____________________

4) DATE PURCHASED: ____________________________

5) PURCHASED FROM: ____

6) COMPLAINT: (Please describe nature of trouble) ____________________

____

____

____

7) OPERATING CONDITIONS: (Please describe conditions prior to and at time of failure) ______

____

____

____

SIGNATURE: ____________________________

____

* Check one. ____________________________

CUT HERE ! CUT HERE ! CUT HERE !

SECTION V
TABLE OF REPLACEABLE PARTS

NOTE

Any changes in the Table of Replaceable Parts will be listed on a Production Change sheet at the front of this manual.

When ordering parts from the factory always include the following information:

Instrument Model Number
Serial Number
hp Stock Number of Part
Description of Part

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗⓟ STOCK NO.	#			
C1	Capacitor: fixed, mica, 15$\mu\mu$f, ±10%, 500 vdcw V*	14-15	4			
C2	Capacitor: variable, trimmer, ceramic, 5-25$\mu\mu$f L*	13-28	2			
C3	Capacitor: fixed, mylar, tubular, 0.1μf, ±20%, 600 vdcw Texas Capacitor Co.	16-110	1			
C4	Capacitor: fixed, mica, 3300$\mu\mu$f, ±10%, 500 vdcw V*	14-64	1			
C5	Capacitor: fixed, mica, 270$\mu\mu$f, ±10%, 500 vdcw V*	14-42	1			
C6	Same as C2					
C7	Same as C1					
C8	Capacitor: fixed, paper dielectric, .01μf, ±10%, 400 vdcw AJ*	16-109	4			
C9, 10	Capacitor: fixed, titanium dioxide dielectric, 2.0$\mu\mu$f, ±5%, 500 vdcw DD*	15-118	2			
C11	Capacitor: fixed, mica, 1500$\mu\mu$f, ±20%, 500 vdcw V*	14-1500	2			
C12	Same as C8					
C13	Capacitor: fixed, titanium dioxide dielectric, 2.2$\mu\mu$f, ±10%, 500 vdcw DD*	15-52	6			
C14	Capacitor: fixed, mica, V* 820$\mu\mu$f, ±10%, 500 vdcw	14-28	2			
C15	Capacitor: variable, 50-380$\mu\mu$f	13-5	4			
C16	Same as C13					
C17	Capacitor: fixed, electrolytic, 2 sections, 120 x 40μf, 450 vdcw CC*	18-51HP	4			
C18	Capacitor: variable, polystyrene dielectric, 0.7-3.0$\mu\mu$f, 350 vdcw L*	13-38	1			
C19	Capacitor: fixed, ceramic, disc, type, .002μf, ±20%, 1000 vdcw Radio Materials Corp.	15-80	3			
C20 thru C100	These circuit references not assigned					

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
 # Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	#			
C 101	Capacitor: fixed, paper dielectric, 0.1μf, ±10%, 600 vdcw	CC*	16-1	1			
C 102	Same as C 13						
C 103	Capacitor: fixed, ceramic dielectric, .01μf, tol. -0% +100% 1000 vdcw	CC*	15-43	8			
C 104	Same as C 13						
C 105	Capacitor: variable, trimmer, ceramic, 5-25μμf	L*	13-28	1			
C 106	Same as C 15						
C 107	Capacitor: variable, trimmer, 2-25μμf,	OO*	13-34	3			
C 108, 109	Same as C 13						
C 110	Same as C 15						
C 111	Capacitor: fixed, mica, 680μμf, ±10%, 500 vdcw	Z*	14-21	1			
C 112	Same as C 103						
C 113 Thru C200	These circuit references not assigned						
C201	Capacitor: fixed, titanium dioxide dielectric, 1.0μμf, ±10%, 500 vdcw	DD*	15-102	1			
C202	Capacitor: fixed, paper dielectric, .022μf, ±10%, 600 vdcw	CC*	16-12	2			
C203	Same as C 1						
C204	Capacitor: fixed, mica, 10μμf, ±10%, 500 vdcw	V*	14-10	1			
C205, 206	Capacitor: fixed, electrolytic, 20μf, 25 vdcw	CC*	18-66	2			
C207	Capacitor: fixed, mica, 68μμf, ±10%, 500 vdcw	Z*	14-60	1			
C208	Capacitor: fixed, paper dielectric, .02μf, ±5%, 600 vdcw	Z*	16-52	2			
C209	Same as C 19						

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
\# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗⓟ STOCK NO.	#			
C210	Capacitor: fixed, mica, 100μμf, ±5%, 300 vdcw V*	14-76	1			
C211	Capacitor: fixed, mica, 100μμf, ±10%, 500 vdcw V*	14-100	1			
C212	Same as C103					
C213	Same as C14					
C214	Capacitor: variable, mica dielectric, 14-150μμf, 175 vdcw QQ*	13-33	1			
C215	Same as C103					
C216	Same as C208 CC*					
C217	Capacitor: fixed, mica, 47μμf, ±10%, 500 vdcw V*	14-67	1			
C218 thru C220	These circuit references not assigned					
C221	Capacitor: fixed, mylar dielectric, 0.2μf, ±5%, 200 vdcw CW*	16-121	1			
C222	Capacitor: fixed, mylar dielectric, .02μf, ±5%, 200 vdcw CW*	16-120	1			
C223	Capacitor: variable, mica, 170-780μμf, 175 vdcw QQ*	13-32	1			
C224	Capacitor: fixed, mylar dielectric, .00181μf, ±5%, 200 vdcw CW*	16-119	1			
C225	Same as C15					
C226	Capacitor: variable, ceramic dielectric, 7-45μμf, 500 vdcw L*	13-1	1			
C227	Capacitor: fixed, paper dielectric .22μf, ±10%, 400 vdcw CC*	16-48	1			
C228	Same as C202					
C229	Capacitor: fixed, paper dielectric, 2200μμf, ±10%, 600 vdcw CC*	16-22	2			
C230	Capacitor: fixed, mica, 220μμf, ±10%, 500 vdcw V*	14-66	1			
C231	Capacitor: fixed, mica, 150μμf, ±10%, 500 vdcw L*	14-150	1			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	(hp) STOCK NO.	#			
C232	Same as C 11					
C233	Same as C 107					
C234	Capacitor: fixed, mica, 470$\mu\mu$f, ±10%, 500 vdcw V*	14-62	1			
C235	Same as C 107					
C236	Capacitor: fixed, silver mica dielectric, 30$\mu\mu$f, ±5%, 500 vdcw Z*	15-146	1			
C237 thru C299	These circuit references not assigned					
C300	Capacitor: fixed, electrolytic, 4 sections, 20μf/sect., 450 vdcw CC*	18-42HP	3			
C301	Same as C 19					
C302	Capacitor: fixed, mica, 390$\mu\mu$f, ±5%, 500 vdcw Z*	14-43	1			
C303	Capacitor: fixed, mica, 2200$\mu\mu$f, ±10%, 500 vdcw Z*	14-52	1			
C304	Same as C 1					
C305	Same as C8					
C306	Capacitor: fixed, paper, .0033μf, ±20%, 6000 vdcw CC*	16-94	2			
C307	Capacitor: fixed, oil filled paper, 1500$\mu\mu$f, ±20%, 5000 vdcw CC*	16-125	2			
C308	Same as C 103					
C309	Same as C306					
C310	Same as C307					
C311	Same as C8					
C312	Capacitor: fixed, paper dielectric, .015μf, ±10%, 3000 vdcw CC*	16-126	1			
C313 thru C320	These circuit references not assigned					
C321	Capacitor: fixed, electrolytic, 1 section, 120μf, 350 vdcw CC*	18-62HP	1			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
\# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗ STOCK NO.	#			
C322	Same as C17 (includes C324)						
C323	Capacitor: fixed, paper dielectric, .01μf, ±10%, 600 vdcw	CC*	16-11	1			
C324	Part of C322						
C325	This circuit reference not assigned						
C326	Same as C300						
C327	This circuit reference not assigned						
C328	Same as C17 (includes C 331)						
C329	Capacitor: fixed, paper dielectric, 0.1μf, ±10%, 400 vdcw	CC*	16-35	1			
C330	Same as C163						
C331	Part of C328						
C332	Capacitor: fixed, electrolytic, 1 section, 500$\mu\mu$f, 50 vdcw	CC*	18-68HP	1			
C333	Same as C103						
C334	Same as C229						
C335	Same as C103						
CR301	Rectifier, silicon: 100V, 1N1081	Audio Devices	212-134	1			
DS or I							
DS201, 202	Lamp, neon: aged and selected (blue code)	HP*	G-84B	7			
DS203, 204	Lamp, neon: aged and selected (green code)	HP*	G-84D	2			
DS205, 206 207	Same as DS201						
DS208	Lamp, neon: 1/25 W	O*	211-43	1			
DS209 thru DS300	These circuit references not assigned						
DS301, 302	Same as DS201						
DS303 thru DS307 I see DS	Lamp, incandescent: 6-8V, .15 amp, #47	N*	211-47	5			

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
 # Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	#			
F301	Fuse, cartridge: 1.6 amp, slo-blo, 115V	E*	211-15	1			
	or						
	Fuse, cartridge: 0.8 amp, slo-blo, 230V	E*	211-57				
J1	Binding post insulator: double, black	HP*	AC-54A	2			
	Binding post, insulated: red-	HP*	AC-10D	2			
	Connector Assembly: binding post and ground link	HP*	G-76K	1			
J2 thru J 100	These circuit references not assigned						
J 101	Binding Post insulator: double, black	HP*	AC-54A				
	Binding Post, insulated: red	HP*	AC-10D				
	Binding post, insulated: black	HP*	AC-10C	1			
L201	Coil, R. F.: 500μh	CG*	48-37	1			
Q301	Transistor, power: CTP1113, Regulator	Clevite Transistor Prod.	213-2	1			
Q302	Transistor: TS-600C, Amplifier	Clevite Transistor Prod.	213-1	1			
R1	Resistor: fixed, deposited Carbon, 1000 ohms, ±1%, 1/2W	NN*	33-1K	1			
R2	Resistor: fixed, deposited carbon, 9000 ohms, ±1%, 1/2W	NN*	33-9K	1			
R3	Resistor: fixed, deposited carbon, 990,000 ohms, ±1%, 1/2W	NN*	33-990K	1			
R4	Resistor: fixed, deposited carbon, 900,000 ohms, ±1%, 1/2W	NN*	33-900K	1			
R5	Resistor: fixed, deposited carbon, 100,000 ohms, ±1%, 1/2W	NN*	33-100K	1			
R6, 7	Resistor: fixed, composition, 1 megohm, ±5%, 1/2W	B*	23-1M-5	3			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	#			
R8	Resistor: fixed, composition, 100,000 ohms, ±10%, 1/2W	B*	23-100K	3			
R9	Resistor: fixed, composition, 100 ohms, ±10%, 1/2W	B*	23-100	10			
R10	Resistor: fixed, deposited carbon, 80,000 ohms, ±1%, 1 W	NN*	31-80K	1			
R11	Resistor: fixed, deposited carbon film, 59.48K ohms, ±1%, 1/2W	NN*	33-59.48K	2			
R12	Resistor: variable, wirewound, 500 ohms, 2 W	BO*	210-73	1			
R13	Same as R11						
R14	Resistor: fixed, composition, 1000 ohms, ±10%, 1/2W	B*	23-1K	1			
R15	Resistor: variable, composition, 500,000 ohms, ±20%, 1/4W	BO*	210-227	1			
R16	Resistor: fixed, composition, 18,000 ohms, ±10%, 1/2W	B*	23-18K	2			
R17	Same as R9						
R18	Resistor: variable, composition, 250,000 ohms, ±20%, 1/4W	BO*	210-228	1			
R19	Same as R9						
R20	Resistor: fixed, deposited carbon, 8100 ohms, ±1%, 1 W Electrical value adjusted at factory,	NN*	31-8.1K	1			
R21	This circuit reference not assigned						
R22	Resistor: fixed, deposited carbon, 98,000 ohms, ±1%, 1 W	NN*	31-98K	2			
R23	Resistor: variable, composition, linear taper, 500 ohms, ±10%	I*	210-25	1			
R24	Same as R22						
R25, 26	Resistor: fixed, composition, 39,000 ohms, ±10%, 1/2W	B*	23-39K	2			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
\# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	#			
R27, 28	Same as R9						
R29	Resistor: fixed, composition, 22,000 ohms, ±5%, 2 W	B*	25-22K-5	2			
R30	Resistor: fixed, composition, 8200 ohms, ±10%, 1 W	B*	24-8200	2			
R31	Resistor: fixed, composition, 33,000 ohms, ±10%, 2 W	B*	25-33K	2			
R32	Resistor: fixed, composition, 1500 ohms, ±10%, 1/2W	B*	23-1500	1			
R33	Same as R30						
R34	Same as R29						
R35	Same as R31						
R36	Resistor: fixed, composition, 470 ohms, ±10%, 1/2W	B*	23-470	3			
R37 thru R100	These circuit references not assigned						
R101	Resistor: variable, composition, linear taper, 500,000 ohms	G*	210-20	1			
R102	Resistor: fixed, composition, 120,000 ohms, ±5%, 1/2W	B*	23-120K-5	2			
R103	Resistor: fixed, composition, 1 megohm, ±10%, 1/2W	B*	23-1M	8			
R104	Same as R8						
R105	Same as R9						
R106	Resistor: fixed, composition, 22,000 ohms, ±10%, 1/2W	B*	23-22K	1			
R107	Resistor: variable, composition, linear taper, 50,000 ohms, ±20%	G*	210-18	1			
R108	Resistor: variable, composition, linear taper, 5000 ohms	G*	210-15	1			
R109	Resistor: fixed, composition, 2700 ohms, ±10%, 1/2W	B*	23-2700	1			
R110	Resistor: variable, composition, 2500 ohms, ±20%, 1/2W	G*	210-98	2			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
\# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	hp STOCK NO.	#			
R111	Resistor: fixed, composition, 12,000 ohms, ±10%, 1/2W B*	23-12K	2			
R112	Resistor: fixed, composition, 100,000 ohms, ±10%, 1 W B*	24-100K	2			
R113	Resistor: variable, composition, 2 sections, 50,000 ohms, ±20% rear section: 100,000 ohms, ±20% BO*	210-226	2			
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 B*	25-30K-5	2			
R120, 121	Resistor: fixed, composition, 6800 ohms, ±10%, 1/2W B*	23-6800	3			
R122	Resistor: fixed, composition, 1800 ohms, ±10%, 1/2W B*	23-1800	1			
R123	Same as R120					
R124	Same as R119					
R125 thru R200	These circuit references not assigned					
R201	Same as R103					
R202	Same as R9					
R203	Same as R103					
R204	Resistor: fixed, composition, 3000 ohms, ±5%, 1/2W B*	23-3K-5	1			
R205	Resistor: fixed, deposited carbon, 83,000 ohms, ±1% 1/2W NN*	33-83K	1			
R206	Resistor: fixed, composition, 3600 ohms, ±5%, 1/2W B*	23-3600-5	1			
R207	Resistor: fixed, composition, 10,000 ohms, ±10%, 1/2W B*	23-10K	1			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
\# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	#			
R208	Resistor: fixed, composition, 24,000 ohms, ±5%, 1 W	B*	24-24K-5	2			
R209	Same as R8						
R210	Resistor: variable, composition, 200,000 ohms, ±20%, 1/4W	BO*	210-224	3			
R211	Resistor: fixed, composition, 120,000 ohms, ±5%, 1/2W	B*	23-120K-5	1			
R212	Resistor: fixed, deposited carbon, 71.56K ohms, ±1%, 1/2W	NN*	33-71.56K	1			
R213	Same as R102						
R214	Resistor: fixed, composition, 47,000 ohms, ±10%, 1/2W	B*	23-47K	1			
R215	Resistor: fixed, composition, 15,000 ohms, ±10%, 1/2W	B*	23-15K	1			
R216	Same as R16						
R217	Same as R9						
R218	Resistor: fixed, composition, 270,000 ohms, ±10%, 1 W	B*	24-270K	1			
R219	Resistor: variable, composition, linear taper, 20,000 ohms, ±20% 1/3 W	BO*	210-213	1			
R220	Resistor: fixed, composition, 33,000 ohms, ±10%, 1/2W	B*	23-33K	3			
R221	Resistor: fixed, composition, 100,000 ohms, ±10%, 1 W	B*	24-100K	1			
R222	Resistor: fixed, composition, 47,000 ohms, ±10%, 1/2W	B*	23-47K	3			
R223	Resistor: fixed, deposited carbon film, 1.5K ohms, ±1%, 1/2W	NN*	33-1.5K	1			
R224	Resistor: fixed, composition, 27,000 ohms, ±10%, 1/2W	B*	23-27K	2			
R225	Resistor: fixed, composition, 680,000 ohms, ±10%, 1/2W	B*	23-680K	1			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
 # Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	#			
R226	Resistor: fixed, composition, 18,000 ohms, ±10%, 2 W	B*	25-18K	1			
R227	Same as R220						
R228	Resistor: variable, potentiometer, composition, linear taper, 10,000 ohms, ±30%, 1/3 W	BO*	210-219	1			
R229	Same as R220						
R230	Resistor: fixed, composition, 430,000 ohms, ±5%, 1/2W	B*	23-430K-5	1			
R231	Resistor: variable, linear taper, composition, 250,000 ohms,	BO*	210-88	1			
R232	Resistor: fixed, composition, 330,000 ohms, ±10%, 1/2W	B*	23-330K	1			
R233	Resistor: fixed, composition, 220,000 ohms, ±10%, 1/2W	B*	23-220K	1			
R234	Resistor: fixed, glass body, 27,000 ohms, ±10%, 4 W	AB*	334-27K	1			
R235	Resistor: fixed, composition, 24,000 ohms, ±5%, 1/2W	B*	23-24K-5	1			
R236	Resistor: fixed, composition, 160,000 ohms, ±5%, 1/2W	B*	23-160K-5	1			
R237	Same as R7						
R238	Resistor: fixed, composition, 2 megohms, ±5%, 1/2W	B*	23-2M-5	1			
R239	Resistor: fixed, composition, 470 ohms, ±10%, 1/2 W	B*	23-470	1			
R240	Same as R224						
R241	Resistor: fixed, composition, 100,000 ohms, ±10%, 2 W	B*	25-100K	1			
R242	Resistor: fixed, composition, 820,000 ohms, ±10%, 1/2W	B*	23-820K	2			
R243	Same as R36						
R244	Resistor: fixed, composition, 47,000 ohms, ±10%, 1 W	B*	24-47K	1			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	#			
R245, 246	Resistor: fixed, composition, 10 ohms, ±10%, 1/2W	B*	23-10	2			
R247	Resistor: variable, composition, 1000 ohms, ±30%, 3 W	BO*	210-207	1			
R248	Same as R208						
R249	Resistor: fixed, composition, 270,000 ohms, ±5%, 1/2W	B*	23-270K-5	1			
R250	Resistor: fixed, composition, 3900 ohms, ±10%, 1/2W	B*	23-3900	1			
R251	Same as R113						
R252	Resistor: fixed, composition, 22,000 ohms, ±10%, 1/2W	B*	23-22K	1			
R253	Resistor: fixed, composition, 47,000 ohms, ±10%, 1 W	B*	24-47K	1			
R254	Resistor: fixed, deposited carbon, 12 megohms, ±1%, 1 W	NN*	31-12M	1			
R255, 256	Resistor: fixed, deposited carbon, 3 megohms, ±1%, 1/2W	NN*	33-3M	2			
R257	Part of S204 (not separately replaceable)						
R258	Resistor: fixed, composition, 39,000 ohms, ±10%, 1/2W	B*	23-39K	1			
R259	Resistor: fixed, composition, 270,000 ohms, ±10%, 1/2W		23-270K				
R260	Resistor: fixed, deposited carbon, 20,000 ohms, ±1%, 1/2W	NN*	33-20K	1			
R261	Resistor: fixed, deposited carbon film, ceramic body, 2 megohms, ±1%, 1/2W	NN*	33-2M	1			
R262	Resistor: fixed, deposited carbon, 200,000 ohms, ±1%, 1/2W	NN*	33-200K	1			
R263	Resistor: fixed, deposited carbon, 1.8 megohms, ±1%, 1/2 W	NN*	33-1.8M	1			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗⓟ STOCK NO.	#			
R264 thru R299	These circuit references not assigned					
R300	Same as R36					
R301	Resistor: fixed, composition, 1000 ohms, ±10%, 1/2W B*	23-1000	1			
R302	Same as R222					
R303	Resistor: fixed, composition, 150,000 ohms, ±5%, 2 W B*	25-150K-5	2			
R304	Resistor: fixed, composition, 560,000 ohms, ±10%, 1 W B*	24-560K	2			
R305	Same as R103					
R306	Resistor: fixed, composition, 1.5 megohms, ±10%, 1/2W B*	23-1.5M	1			
R307	Resistor: fixed, composition, 3 megohms, ±5%, 1/2W B*	23-3M-5	1			
R308	Resistor: variable, composition, linear taper, 1 megohm, ±30% G*	210-111	3			
R309, 310 311	Resistor: fixed, composition, 5.6 megohms, ±10%, 2 W B*	25-5.6M	3			
R312	Resistor: variable, composition, linear taper, 3 megohms, ±20%, 1/4 W BO*	210-225	1			
R313	Resistor: fixed, composition, 470,000 ohms, ±10%, 1/2W B*	23-470K	1			
R314, 315	Resistor: fixed, composition, 27,000 ohms, ±10%, 1/2W B*	23-27K	2			
R316	Resistor: variable, linear taper, 125,000 ohms BO*	210-110	1			
R317	Resistor: fixed, composition, 68,000 ohms, ±10%, 1/2W B*	23-68K	1			
R318	Resistor: fixed, composition, 2.2 megohms, ±10%, 1/2W B*	23-2.2M	1			
R319, 320 321	Resistor: fixed, composition, 8.2 megohms, ±10%, 2 W B*	25-8.2M	3			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗ STOCK NO.	#			
R322	Resistor: variable, 200,000 ohms, ±10%	BO*	210-22	1			
R323	Same as R210 (includes S301)						
R324	Resistor: fixed, composition, 820,000 ohms, ±10%, 1/2W	B*	23-820K	1			
R325	Resistor: fixed, composition, 3.9 megohms, ±10%, 1/2W	B*	23-3.9M	1			
R326	Same as R303						
R327 thru R330	These circuit references not assigned						
R331, 332	Same as R103						
R333	Same as R304						
R334	Resistor: fixed, composition, 470,000 ohms, ±10%, 1 W	B*	24-470K	1			
R335	Same as R222						
R336	Same as R103						
R337	Resistor: fixed, wirewound, 5000 ohms, ±10%, 10 W	S*	26-8	1			
R338	Resistor: fixed, deposited carbon, 405,000 ohms, ±1%, 1/2 W	NN*	33-405K	1			
R339	Resistor: fixed, deposited carbon, 136.7K ohms, ±1%, 1/2 W	NN*	33-136.7K	1			
R340	Resistor: fixed, deposited carbon, 200,000 ohms, -±1%, 1/2 W	NN*	33-200K	1			
R341, 342	These circuit references not assigned						
R343	Resistor: fixed, deposited carbon, 1.88 megohms, ±1%, 1/2 W	NN*	33-1.88M	1			
R344	Same as R308						
R345	Resistor: fixed, deposited carbon, 2.52 megohms, ±1%, 1/2 W	NN*	33-2.52M	1			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	#			
R346	Same as R242						
R347	Resistor: fixed, composition, 82,000 ohms, ±10%, 1/2 W	B*	23-82K	1			
R348, 349	Resistor: fixed, composition, 18,000 ohms, ±10%, 2 W	B*	25-18K	2			
R350	Same as R16						
R352	Same as R103						
R353	Resistor: fixed, composition, 2.7 ohms, ±10%, 1 W	B*	24-2.7	1			
R354	Resistor: fixed, deposited carbon, 4.44K ohms, ±1%, 1/2 W	NN*	33-44.4K	1			
R355	Resistor: fixed, deposited carbon, 27,500 ohms, ±1%, 1/2 W	NN*	31-27.5K	1			
R356	Same as R308						
R357	Resistor: fixed, deposited carbon, 2.52 megohms, ±1%, 1/2 W	NN*	33-2.52M	1			
R358	Resistor: fixed, composition, 2.4 megohms ±5%, 1 W	B*	24-24M-5	1			
R359	Resistor: fixed, deposited carbon, 500 ohms, ±1%, 1/2 W	NN*	33-500	1			
R360	Resistor: variable, linear taper, 500 ohms, ±30%, 3/10 W	BO*	210-115	1			
R361	Resistor: variable, wirewound, 25 ohms, ±10%, 2 W (includes S303)	BO*	210-188	1			
S1	Switch, toggle: SPST	D*	310-11	2			
S2	Vertical Sensitivity Switch	HP*	120A-19A	1			
S3 thru S100	These circuit references not assigned						
S101	Same as S1						
S102	Switch, toggle: SPDT	D*	310-12	1			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
\# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗ STOCK NO.	#			
S 103-S200	These circuit references not assigned						
S201	Sync Switch, (rotary)		310-238	2			
S202	Part of R210						
S203	This circuit reference not assigned						
S204	Sweep Time and Horizontal Sensitivity Switch	HP*	120A-19B	1			
S205	Sweep Expand Switch, SPDT	D*	310-12	1			
S206 thru S300	These circuit references not assigned						
S301	Part of R323						
S302	This circuit reference not assigned						
S303	Part of R361						
V 1, AB, 2 AB	Tube, electron: aged	ZZ*	212-12AU7	5			
V3 AB	Tube, electron:	ZZ*	212-12AZ7	1			
V4 thru V 100	These circuit references not assigned						
V 101 A	Tube, electron:		212-6DJ8	2			
V 102	Same as V3						
V 103 thru V200	These circuit references not assigned						
V201	Tube, electron: 6AN8	ZZ*	212-6AN8	1			
V202	Tube, electron:	ZZ*	212-6U8	2			
V203, 204	Same as V 1						
V205	Same as V202						
V206 thru V300	These circuit references not assigned						
V301	Same as V 1						
V302	Tube, electron: 6AQ5	ZZ*	212-6AQ5	1			
V303, 304	Tube, electron: 5642	ZZ*	212-5642	2			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	#			
V305	Tube, cathode ray: (phosphor as requested)	ZZ*	212-5AQP 1, 2, 7 or 11	1			
V306	Tube, electron: 5Y3	ZZ*	212-5Y3	1			
V307	Tube, electron: 12B4	ZZ*	212-12B4	2			
V308	Same as V202						
V309	Tube, electron: 6X4	ZZ*	212-6X4	1			
V310	Same as V307						
V311	Tube, electron: 6AU6	ZZ*	212-6AU6	1			
V312	Tube, electron: 5651	ZZ*	212-5651	1			
	MISCELLANEOUS						
	Collar	HP*	G32J	1			
	Coupler, insulated	HP*	AC-32A	1			
	Filter, CRT:			1			
	amber	HP*	120A-83A				
	blue	HP*	120A-83B				
	green	HP*	120A-83G				
	Fuseholder	T*	140-16	1			
	Graticule, CRT	HP*	120A-83C	1			
	Jewel, pilot lamp	AD*	145-23A	1			
	Knob: FOCUS, INTENSITY, VERT. POS., HORIZ. POS., SCALE LIGHT	HP*	G-74D	5			
	Knob: SYNC	HP*	G-74N	1			
	Knob: VERT. SENSITIVITY, SWEEP TIME HOR. SENS.	HP*	G-74Q	2			
	Knob: VERNIER (red)	HP*	G-74AU	2			
	Pilot lamp, socket	AD*	145-25	1			
	Power cord	Elec. Cords Co.	812-56	1			
	Power, transformer	Paeco	910-167	1			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	#			
	Socket, tube: 9 pin contact	H*	120-2	1			
	Socket, tube: 9 pin contact	AE*	120-10	14			
	Socket, tube: 7 pin contact	AE*	120-11	4			
	Socket, tube: 7 pin contact, miniature	H*	120-22	1			
	Socket, tube: 8 contact	H*	120-27	1			
	Socket, transistor	H*	120-62	1			
	Socket, CRT	AE*	120-57	1			
	Tube, shield	AE*	122-9	1			
	Tube, shield	H*	122-10	1			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

LIST OF CODE LETTERS USED IN TABLE OF REPLACEABLE PARTS TO DESIGNATE THE MANUFACTURERS

CODE LETTER	MANUFACTURER	ADDRESS
A	Aerovox Corp.	New Bedford, Mass.
B	Allen-Bradley Co.	Milwaukee 4, Wis.
C	Amperite Co.	New York, N. Y.
D	Arrow, Hart & Hegeman	Hartford, Conn.
E	Bussman Manufacturing Co.	St. Louis, Mo.
F	Carborundum Co.	Niagara Falls, N. Y.
G	Centralab	Milwaukee 1, Wis.
H	Cinch-Jones Mfg. Co.	Chicago 24, Ill.
HP	Hewlett-Packard Co.	Palo Alto, Calif.
I	Clarostat Mfg. Co.	Dover, N. H.
J	Cornell Dubilier Elec. Co.	South Plainfield, N. J.
K	Hi-Q Division of Aerovox	Olean, N. Y.
L	Erie Resistor Corp.	Erie 6, Pa.
M	Fed. Telephone & Radio Corp.	Clifton, N. J.
N	General Electric Co.	Schenectady 5, N. Y.
O	General Electric Supply Corp.	San Francisco, Calif.
P	Girard-Hopkins	Oakland, Calif.
Q	Industrial Products Co.	Danbury, Conn.
R	International Resistance Co.	Philadelphia 8, Pa.
S	Lectrohm Inc.	Chicago 20, Ill.
T	Littlefuse Inc.	Des Plaines, Ill.
U	Maguire Industries Inc.	Greenwich, Conn.
V	Micamold Radio Corp.	Brooklyn 37, N. Y.
W	Oak Manufacturing Co.	Chicago 10, Ill.
X	P. R. Mallory Co., Inc.	Indianapolis, Ind.
Y	Radio Corp. of America	Harrison, N. J.
Z	Sangamo Electric Co.	Marion, Ill.
AA	Sarkes Tarzian	Bloomington, Ind.
BB	Signal Indicator Co.	Brooklyn 37, N. Y.
CC	Sprague Electric Co.	North Adams, Mass.
DD	Stackpole Carbon Co.	St. Marys, Pa.
EE	Sylvania Electric Products Co.	Warren, Pa.
FF	Western Electric Co.	New York 5, N. Y.
GG	Wilkor Products, Inc.	Cleveland, Ohio
HH	Amphenol	Chicago 50, Ill.
II	Dial Light Co. of America	Brooklyn 37, N. Y.
JJ	Leecraft Manufacturing Co.	New York, N. Y.
KK	Switchcraft, Inc.	Chicago 22, Ill.
LL	Gremar Manufacturing Co.	Wakefield, Mass.
MM	Carad Corp.	Redwood City, Calif.
NN	Electra Manufacturing Co.	Kansas City, Mo.
OO	Acro Manufacturing Co.	Columbus 16, Ohio
PP	Alliance Manufacturing Co.	Alliance, Ohio
QQ	Arco Electronics, Inc.	New York 13, N. Y.
RR	Astron Corp.	East Newark, N. J.
SS	Axel Brothers Inc.	Long Island City, N. Y.
TT	Belden Manufacturing Co.	Chicago 44, Ill.
UU	Bird Electronics Corp.	Cleveland 14, Ohio
VV	Barber Colman Co.	Rockford, Ill.
WW	Bud Radio Inc.	Cleveland 3, Ohio
XX	Allen D. Cardwell Mfg. Co.	Plainville, Conn.
YY	Cinema Engineering Co.	Burbank, Calif.
ZZ	Any brand tube meeting RETMA standards.	
AB	Corning Glass Works	Corning, N. Y.
AC	Dale Products, Inc.	Columbus, Neb.
AD	The Drake Mfg. Co.	Chicago 22, Ill.
AE	Elco Corp.	Philadelphia 24, Pa.
AF	Hugh H. Eby Co.	Philadelphia 44, Pa.
AG	Thomas A. Edison, Inc.	West Orange, N. J.
AH	Fansteel Metallurgical Corp.	North Chicago, Ill.
AI	General Ceramics & Steatite Corp.	Keasbey, N. J.
AJ	The Gudeman Co.	Sunnyvale, Calif.
AK	Hammerlund Mfg. Co., Inc.	New York 1, N. Y.
AL	Industrial Condenser Corp.	Chicago 18, Ill.
AM	Insuline Corp. of America	Manchester, N. H.
AN	Jennings Radio Mfg. Corp.	San Jose, Calif.
AO	E. F. Johnson Co.	Waseca, Minn.
AP	Lenz Electric Mfg. Co.	Chicago 47, Ill.
AQ	Micro-Switch	Freeport, Ill.
AR	Mechanical Industries Prod. Co.	Akron 8, Ohio
AS	Model Eng. & Mfg., Inc.	Huntington, Ind.
AT	The Muter Co.	Chicago 5, Ill.
AU	Ohmite Mfg. Co.	Skokie, Ill.
AV	Resistance Products Co.	Harrisburg, Pa.
AW	Radio Condenser Co.	Camden 3, N. J.
AX	Shallcross Manufacturing Co.	Collingdale, Pa.
AY	Solar Manufacturing Co.	Los Angeles 58, Calif.
AZ	Sealectro Corp.	New Rochelle, N. Y.
BA	Spencer Thermostat	Attleboro, Mass.
BC	Stevens Manufacturing Co.	Mansfield, Ohio
BD	Torrington Manufacturing Co.	Van Nuys, Calif.
BE	Vector Electronic Co.	Los Angeles 65, Calif.
BF	Weston Electrical Inst. Corp.	Newark 5, N. J.
BG	Advance Electric & Relay Co.	Burbank, Calif.
BH	E. I. DuPont	San Francisco, Calif.
BI	Electronics Tube Corp.	Philadelphia 18, Pa.
BJ	Aircraft Radio Corp.	Boonton, N. J.
BK	Allied Control Co., Inc.	New York 21, N. Y.
BL	Augat Brothers, Inc.	Attleboro, Mass.
BM	Carter Radio Division	Chicago, Ill.
BN	CBS Hytron Radio & Electric	Danvers, Mass.
BO	Chicago Telephone Supply	Elkhart, Ind.
BP	Henry L. Crowley Co., Inc.	West Orange, N. J.
BQ	Curtiss-Wright Corp.	Carlstadt, N. J.
BR	Allen B. DuMont Labs	Clifton, N. J.
BS	Excel Transformer Co.	Oakland, Calif.
BT	General Radio Co.	Cambridge 39, Mass.
BU	Hughes Aircraft Co.	Culver City, Calif.
BV	International Rectifier Corp.	El Segundo, Calif.
BW	James Knights Co.	Sandwich, Ill.
BX	Mueller Electric Co.	Cleveland, Ohio
BY	Precision Thermometer & Inst. Co.	Philadelphia 30, Pa.
BZ	Radio Essentials Inc.	Mt. Vernon, N. Y.
CA	Raytheon Manufacturing Co.	Newton, Mass.
CB	Tung-Sol Lamp Works, Inc.	Newark 4, N. J.
CD	Varian Associates	Palo Alto, Calif.
CE	Victory Engineering Corp.	Union, N. J.
CF	Weckesser Co.	Chicago 30, Ill.
CG	Wilco Corporation	Indianapolis, Ind.
CH	Winchester Electronics, Inc.	Santa Monica, Calif.
CI	Malco Tool & Die	Los Angeles 42, Calif.
CJ	Oxford Electric Corp.	Chicago 15, Ill.
CK	Camloc-Fastener Corp.	Paramus, N. J.
CL	George K. Garrett	Philadelphia 34, Pa.
CM	Union Switch & Signal	Swissvale, Pa.
CN	Radio Receptor	New York 11, N. Y.
CO	Automatic & Precision Mfg. Co.	Yonkers, N. Y.
CP	Bassick Co.	Bridgeport 2, Conn.
CQ	Birnbach Radio Co.	New York 13, N. Y.
CR	Fischer Specialties	Cincinnati 6, Ohio
CS	Telefunken (c/o MVM, Inc.)	New York, N. Y.
CT	Potter-Brumfield Co.	Princeton, Ind.
CU	Cannon Electric Co.	Los Angeles, Calif.
CV	Dynac, Inc.	Palo Alto, Calif.
CW	Good-All Electric Mfg. Co.	Ogallala, Nebr.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument for any reason.

WARRANTY

Hewlett-Packard Company warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Klystron tubes as well as other electron tubes, fuses and batteries are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and when upon our examination it is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

1. Notify us, giving full details of the difficulty, and include the model number and serial number. On receipt of this information, we will give you service data or shipping instructions.

2. On receipt of shipping instructions, forward the instrument prepaid, to the factory or to the authorized repair station indicated on the instructions. If requested, an estimate of the charges will be made before the work begins provided the instrument is not covered by the warranty.

SHIPPING

All shipments of Hewlett-Packard instruments should be made via Truck or Railway Express. The instruments should be packed in a strong exterior container and surrounded by two or three inches of excelsior or similar shock-absorbing material.

DO NOT HESITATE TO CALL ON US

HEWLETT-PACKARD COMPANY

Laboratory Instruments for Speed and Accuracy

275 PAGE MILL ROAD PALO ALTO, CALIF. U.S.A.

CABLE "HEWPACK"

INSTRUCTION MANUAL CHANGES

MODEL 130A

OSCILLOSCOPE

<u>Serial 3935 and above:</u>

C71, C75: change from .047uf to
capacitor, fixed, paper, .047uf, ±10%, 1000 vdcw;
-hp- Stock No. 16-114; Mfr., CC

HEWLETT - PACKARD CO.

INSTRUCTION MANUAL CHANGES

MODEL 120A

OSCILLOSCOPE

NOTE: V3 and V102 may be 12AT7 instead of 12AZ7

Serial 151 and above:

C321: change to
capacitor, fixed, electrolytic, 120uf, 350 vdcw;
-hp- Stock No. 18-62HP; Mfr., CC

C322, C328: change to
capacitor, fixed, electrolytic, 2 sections, 120 x 40uf,
450 vdcw; -hp- Stock No. 18-51HP; Mfr., CC
C322 is in the same can as C324
C328 is in the same can as C331

Serial 351 and above:

C225: change to
capacitor, variable, mica, 14-150uuf, 175 vdcw;
-hp- Stock No. 13-33; Mfr., QQ

C204: change to
capacitor, fixed, mica, 22uuf, ±5%, 300 vdcw;
-hp- Stock No. 14-69; Mfr., V

ADD C237: C237 is parallel with C225
capacitor, fixed, silver mica, 150uuf, ±5%, 500 vdcw;
-hp- Stock No. 15-31; Mfr., A

R204: change to
resistor, fixed, composition, 3600 ohms, ±5%, 1/2 W;
-hp- Stock No. 23-3.6K-5; Mfr., B

Paragraph 4-9C TRIGGER GENERATOR, change to read;

Connect a 250kc sine wave of 0.7rms......

(third line from bottom) with less than 0.7rms.....

HEWLETT - PACKARD CO.

Serial 451 and above:

R309: change to
resistor, fixed, composition, 4.7 megohms, ±10%, 2 W; -hp- Stock No. 25-4.7M; Mfr., B

R312: change to
resistor, variable, composition, 3.5 megohms, ±30%, 1/2 W; -hp- Stock No. 210-150; Mfr., I

R313: change to
resistor, fixed, composition, 680,000 ohms, ±10%, 1/2 W; -hp- Stock No. 23-680K; Mfr., B

Serial 551 and above:

R223: change to
resistor, fixed, deposited carbon, 1000 ohms, ±1%, 1/2 W; -hp- Stock No. 33-1K; Mfr., NN

ADD R200: resistor, fixed, composition, 1000 ohms, ±10%, 1/2 W; -hp- Stock No. 23-1K; Mfr., B

ADD C218: capacitor, fixed, mica, 330uuf, ±10%, 500 vdcw; -hp- Stock No. 14-79; Mfr., Z

V102: change from "Same as V3" to
tube, electron, 12AT7; -hp- Stock No. 212-12AT7; Mfr., ZZ

V3 AB: change from 12AZ7 to
tube, electron, 12AT7; -hp- Stock No. 212-12AT7; Mfr., ZZ

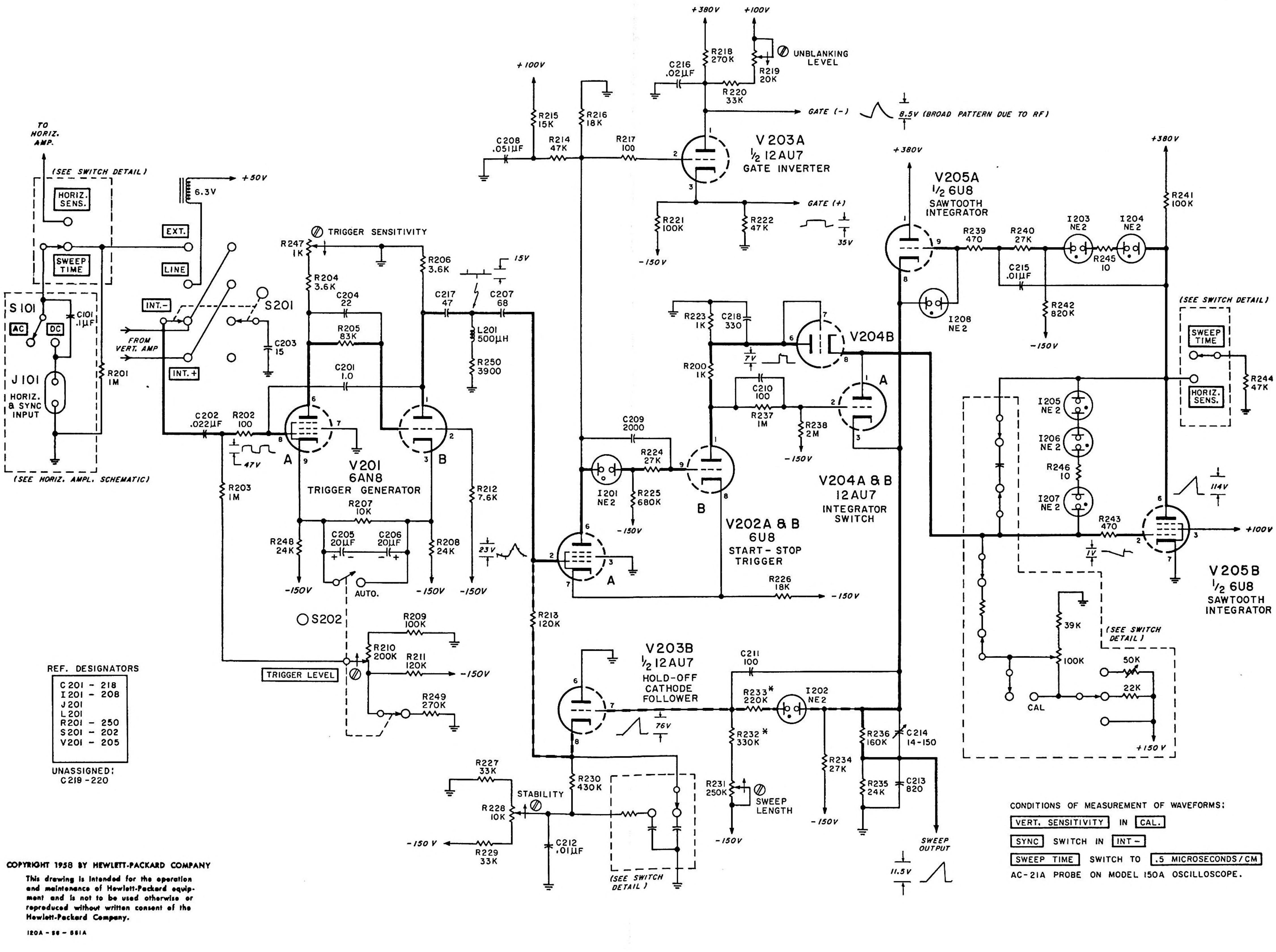
R231: change -hp- Stock No. from 210-88 to
-hp- Stock No. 210-210

ERRATA

Section IV, paragraph 4-10g
Attenuator Compensation

Set VERT SENSITIVITY TO 100 MILLIVOLTS/CM etc.

......Switch Vertical sensitivity to 10 V/CM and increase input to give 8 cm deflection. Adjust C18 for flat response. (ADD THE UNDERSCORED LINE IN THE MANUAL). Should be ....



TO HORIZ. AMP.
(SEE SWITCH DETAIL)
HORIZ. SENS.
SWEEP TIME
EXT.
LINE
INT.-
INT.+
6.3V
+50V
S101
AC
DC
C101 .1µF
J101 HORIZ. & SYNC INPUT
R201 1M
FROM VERT. AMP
S201
C203 15
(SEE HORIZ. AMPL. SCHEMATIC)
TRIGGER SENSITIVITY
R247 1K
R204 3.6K
C204 22
R205 83K
C201 1.0
R206 3.6K
C202 .022µF
R202 100
47V
V201 6AN8 TRIGGER GENERATOR
R203 1M
R207 10K
R248 24K
C205 20µF
C206 20µF
R208 24K
-150V
AUTO.
S202
C217 47
C207 68
15V
L201 500µH
R250 3900
R212 7.6K
23V
R209 100K
R210 200K
R211 120K
TRIGGER LEVEL
R249 270K
+100V
C208 .051µF
R215 15K
R214 47K
R216 18K
R217 100
+380V
C216 .02µF
R218 270K
R219 20K
UNBLANKING LEVEL
R220 33K
GATE (-)
8.5V (BROAD PATTERN DUE TO RF)
V203A 1/2 12AU7 GATE INVERTER
R221 100K
R222 47K
GATE (+)
35V
R223 1K
C218 330
7V
V204B
R200 1K
C210 100
R237 1M
R238 2M
C209 2000
R224 27K
I201 NE2
R225 680K
V204A & B 12AU7 INTEGRATOR SWITCH
V202A & B 6U8 START-STOP TRIGGER
R226 18K
R213 120K
V203B 1/2 12AU7 HOLD-OFF CATHODE FOLLOWER
76V
C211 100
R233* 220K
I202 NE2
R232* 330K
R231 250K
SWEEP LENGTH
R234 27K
R236 160K
C214 14-150
R235 24K
C213 820
SWEEP OUTPUT
11.5V
R227 33K
STABILITY
R228 10K
R229 33K
R230 430K
C212 .01µF
(SEE SWITCH DETAIL)
V205A 1/2 6U8 SAWTOOTH INTEGRATOR
R239 470
R240 27K
I203 NE2
I204 NE2
R245 10
C215 .01µF
R242 820K
I208 NE2
R241 100K
R244 47K
I205 NE2
I206 NE2
R246 10
I207 NE2
R243 470
1V
114V
V205B 1/2 6U8 SAWTOOTH INTEGRATOR
39K
100K
50K
22K
CAL
+150 V
REF. DESIGNATORS
C201 - 218
I201 - 208
J201
L201
R201 - 250
S201 - 202
V201 - 205
UNASSIGNED: C219 -220
CONDITIONS OF MEASUREMENT OF WAVEFORMS:
VERT. SENSITIVITY IN CAL.
SYNC SWITCH IN INT-
SWEEP TIME SWITCH TO .5 MICROSECONDS/CM
AC-21A PROBE ON MODEL 150A OSCILLOSCOPE.
120A - 58 - 881A