TM 11-6625-2482-14

TECHNICAL MANUAL

OPERATOR'S, ORGANIZATIONAL, DIRECT SUPPORT, AND

GENERAL SUPPORT MAINTENANCE MANUAL

(INCLUDING DEPOT REPAIR PARTS AND SPECIAL TOOLS LIST)

HEWLETT-PACKARD OSCILLOSCOPE 141A AND DUAL TRACE AMPLIFIER 1402A (AN/USM-320(V)1)

HEADQUARTERS, DEPARTMENT OF THE ARMY
JUNE 1973

WARNING

THIS EQUIPMENT USES DANGEROUS VOLTAGES. BE VERY CAREFUL WHEN WORKING ON THE LOW AND HIGH VOLTAGE POWER SUPPLIES AND THE CATHODE RAY TUBE.

CHANGE

No. 1

HEADQUARTERS,
DEPARTMENT OF THE ARMY
WASHINGTON, DC, *15 August 1978*

Operator, Organizational, Direct Support and General Support Maintenance Manual HEWLETT-PACKARD OSCILLOSCOPE 141A AND DUAL TRACE AMPLIFIER 1402A (AN/USM-320(V)1) (NSN 6625-00-181-1956)

This Change current as of January 1978

TM 11-6625-2482-14, 29 June 1973, is changed as follows:
1. Title is changed as shown above.
2. A vertical bar appears opposite changed material
3. Remove and insert pages as indicated below:

Remove	Insert
i through iv	i through iii
1-A.1 and 1-A.2	1-A.1/ 1-A.2 blank)
A-l	A-1/(A-2 blank)
B-l through B-6	B-l through B-S
C-1 through C-35	None

4. File this change sheet in front of the manual for reference purposes.

TECHNICAL MANUAL

No. 11-6625-2482-14

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, DC, *29 June 1973*

OPERATOR, ORGANIZATIONAL, DIRECT SUPPORT, AND GENERAL SUPPORT MAINTENANCE MANUAL
HEWLETT-PACKARD OSCILLOSCOPE 141A AND DUAL TRACE AMPLIFIER 1402A (AN/USM-320(V)1)
(NSN 6625-00-181-1956)

This technical manual is an authentication of the manufacturer's commercial literature and does not conform with the format and content specified in AR-319-3, Military Publications. This technical manual does, however, contain available information that is essential to the operation and maintenance of the equipment.

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Cont.)

LIST OF TABLES

Table 1-1. Specifications

PLUG-INS:

Accepts all Model 1400-series plug-ins; upper compartment for horizontal axis and lower compartment for vertical axis. Center shield may be removed to provide a double-sized compartment for a single dual-axis Model 1400-series unit.

CATHODE-RAY TUBE:

Type:

Post-accelerator storage tube; 7300 v accelerating potential; aluminized P31 phosphor; etched safety glass face plate reduces glare.

Graticule:

10 x 10 divisions (approx. 9.4 x 9.4 cm), parallax-free internal graticule; 5 subdivisions per major division on major horizontal and vertical axes, and on second and tenth horizontal graticule lines.

Intensity Modulation:

ac coupled, +20 volt pulse will blank trace of normal intensity; input terminals on rear panel.

Warranty:

CRT specifications (persistence, writing rate, brightness, storage time) warranted for one year.

PERSISTENCE:

Normal :

Natural persistence of P31 phosphor (about 40 u sec).

Variable :

NORMAL Writing Rate Mode: Continuously variable from less than 0.2 second to more than one minute (typically to two or three minutes).

MAX Writing Rate Mode: Typically varible from 0.2 second to 15 seconds.

ERASE

Manual; erasure takes approximately 200 msec, scope ready to record immediately after erasure (see options for remote erase).

WRITING RATE:

Conventional operation (using an hp 197A camera with f/1.9 lens and Polaroid 3000 speed film): 100 cm/u sec.

Storage:

NORMAL Mode: greater than 20 cm/ms.
MAX Mode: greater than 1 cm/u sec.

STORAGE TIME:

	NORMAL Writing Rate Mode	MAX Writing Rate Mode
STORE Mode (dim display)	longer than 1 hour	typically 15 minutes
VIEW Mode (bright display)	longer than 1 minute (typically 2 or 3 minutes)	typically 15 seconds

Brightness:

Greater than 100 foot-lamberts in NORMAL or VIEW; typically 5 foot-lamberts in STORE.

CALIBRATOR:

Type:

Line-frequency rectangular signal, approximately 0.5 μ sec rise time.

Voltage:

Two outputs: 1 volt and 10 volts pk-pk ±1% from 15° C to 35° C, ±3% from 0° C to 55° C.

BEAM FINDER:

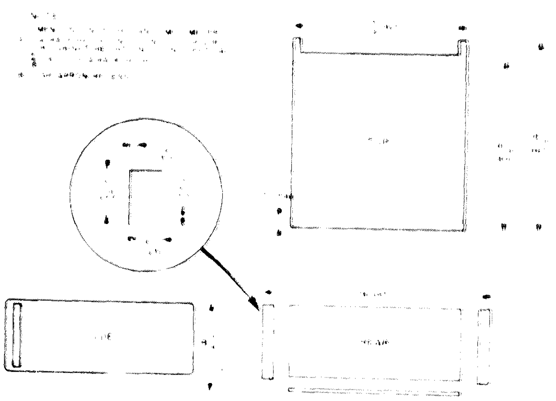
Pressing BEAM FINDER control brings trace on screen regardless of setting of horizontal, or vertical position controls.

GENERAL:

Power Requirements:

115 or 230 volts, ±10%, 50 to 60 Hz, normally less than 285 watts (varies with plug-in units).

Dimensions:



Weight:

Net, 40 lbs. (18 kg) (without plug-ins).
Shipping, 51 lbs. (23 kg).

OPTIONS: (Specify by option number.)

009: Remote erase. BNC input on rear panel: shorting to ground for at least 50 msec erases screen, with oscilloscope ready for use 200 msec after ground is removed; input draws 20ma from ground through a 600-ohm impedance to a -12 volt supply.

CHAPTER 1
HEWLETT-PACKARD OSCILLOSCOPE 141A

Section I. INTRODUCTION

1-A.1. SCOPE

This manual describes Hewlett-Packard Oscilloscope 141A with serial numbers prefixed 832- and 844-, and Dual Trace Amplifier 1402A with serial numbers prefixed 709- and 716-. It covers their operation, organizational, and direct and general support. Refer to TM 11-6625-2390-15 for information on Sweep Generator 1421A.

1-A.2. INDEXES OF PUBLICATIONS

a. Refer to the latest issue of DA Pam 310-4 to determine whether there are new editions, changes, or additional publications pertaining to this equipment.

b. Refer to the latest issue of DA Pam 310-7 to determine if there are current, applicable modification work orders (MWO's) pertaining to this equipment.

1-A.3. FORMS AND RECORDS

a. Reports of' Maintenance and Unsatisfactory Equipment. Maintenance forms, records, and reports which are to be used by maintenance personnel at all maintenance levels are listed in and prescribed by TM 38-750.

b. Report of Packaging and Handling Deficiencies. Fill out and forward DD Form 6 (Packaging Improvement Report) as prescribed in AR 700-58/NAVSUPINST 4030.29/AFR 71-13/MCO P4030.29A, and DLAR 4145.8.

c. Discrepancy in Shipment Report (DISREP) (SF 361). Fill out and forward. Discrepancy in Shipment Report (DISREP) (SF 361) as prescribed in AR 55-38 NAVSUPINST 4610.33B/AFR 75-18/ MCO P4610.19C and DLAR 4500.15.

1-A.3.1. REPORTING OF ERRORS

The reporting of errors, omissions, and recommendations for improving this publication by the individual user is encouraged. Reports should be submitted on DA Form 2028 (Recommended Changes to Publications and Blank Forms), and forwarded direct to Commander, US Army Communications and Electronics Materiel Readiness Command, ATTN: DRSEL-MA-Q, Fort Monmouth, NJ 07703.

1-A.3.2. REPORTING EQUIPMENT IMPROVEMENT RECOMMENDATIONS (EIR)

EIR's will be prepared using DA Form 2407, (Maintenance Request). Instructions for preparing EIR's are provided in TM 38-750, the Army Maintenance Management System. EIR's should be mailed direct to Commander, US Army Communications and Electronics Materiel Readiness Command, ATTN: DRSEL-MA-Q, Fort Monmouth, NJ 07703. A reply will be furnished direct to you.

1-A.3.3. ADMINISTRATIVE STORAGE

There are no administrative storage instructions **for this equipment.**

1-A.3.4. DESTRUCTION OF ARMY MATERIEL

Destruction of Army materiel to prevent enemy use shall be as prescribed in TM 750-244-2.

1-A.4. ITEMS COMPRISING AN OPERABLE EQUIPMENT.

NSN	Item	Quantity	Dimensions (in.) Height	Depth	Width	Weight (lbs)
6625-00-181-1956	Oscilloscope AN/USM-320(V)1	1	9	18-3/8	16-3/4	40
6625-00-181-1957	Hewlett-Packard Oscilloscope 141A	1	9	18-3/8	16-3/4	40
6625-00-249-4432	Hewlett-Packard Dual Trace Amplifier 1402A (PL1244/U)	1	4.062	13.5	8.812	6
6625-00-930-8119	Hewlett-Packard Sweep Generator 1421A (PL1245/U)	1	4.062	13.5	8.812	6

1-1. DESCRIPTION.

The hp Model 141A, Figure 1-1, is a conventional, general purpose Oscilloscope with the added features of variable persistence (duration of trace afterglow) and storage of CRT displays. Persistence is variable from 0.2 to more than 60 seconds; a display may be stored (at reduced intensity) for more than 1 hour or displayed at normal intensity for up to 1 minute. Stored displays can be erased in 100 milliseconds.

Variable persistence is especially useful for viewing slow-sweep signals. The persistence of the signals from electrocardiograms or other bio-chemical phenomena can be adjusted to provide a complete trace, yet to fade fast enough to prevent interference with the next trace. Display persistence of swept frequency and time domain reflectometry measurement readouts can be adjusted to eliminate flicker and still provide high resolution.

The storage feature of the Model 141A can be used to store single-shot waveforms and to later view or photograph the phenomena. Comparison of waveforms can be accomplished by storing several displays separately and then viewing them simultaneously.

The Model 141A accepts all hp Model 1400-series plug-in units. Amplifiers with bandwidths up to 20 MHz and sensitivities to 10 microvolts per centimeter are available as well as time domain reflectometry and swept frequency indicator units. Complete specifications for the Model 141A Oscilloscope are given in Table 1-1.

1-2. CATHODE RAY TUBE.

The Model 141A uses an internal graticule, P31 aluminized phosphor CRT with additional internal elements to provide the variable persistence and storage features. The tube is equipped with a nonglare safety face plate and the internal graticule eliminates parallax error in observing the display.

1-3. ASSOCIATED EQUIPMENT.

The Model 141A is normally operated

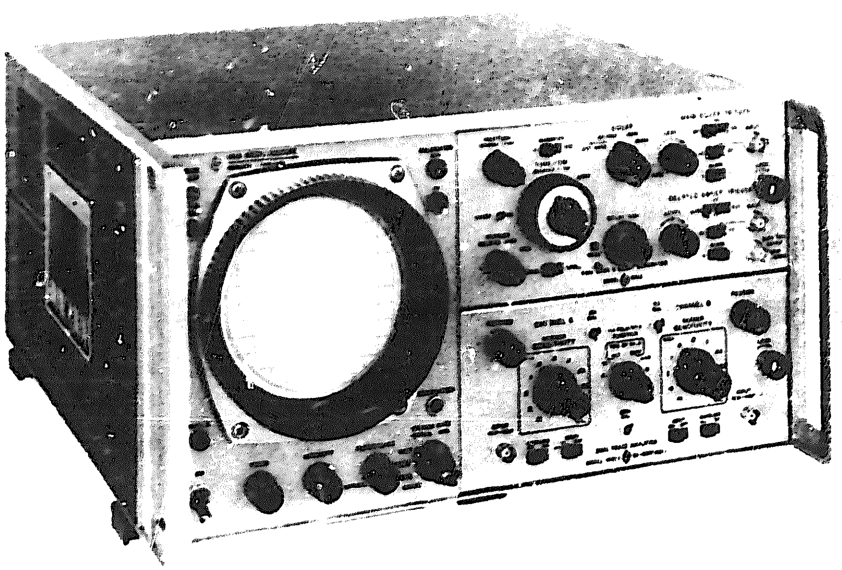


Figure 1-1. Model 141A Oscilloscope

with a vertical plug-in in the lower compartment and a horizontal plug-in in the upper compartment. Both plug-in compartments are the same size and the plug-in instruments may be interchanged for any special application. The divider shield, which separates the two compartments, may be removed and one double sized plug-in installed. Blank plug-in kits, both single and double sized, are available for user fabrication of special circuits. See Table 1-3 for power supply current limitations. See Table 1-1 in TM 11-6625-2390-15 for available plug-ins.

1-4. OPTION.

Option 09 for the Hewlett-Packard 141A Oscilloscope modifies the oscilloscope to provide a remote ERASE capability. Pulse Board A701 has additional circuitry to accomodate a reed relay.

Figure 1-2 is a schematic of the added circuit. The relay is actuated by a contact closure to ground via the BNC connector on the back panel.

Note that earlier instruments may have option 09 installed on an etched circuit board mounted adjacent to Pulse Board A701.

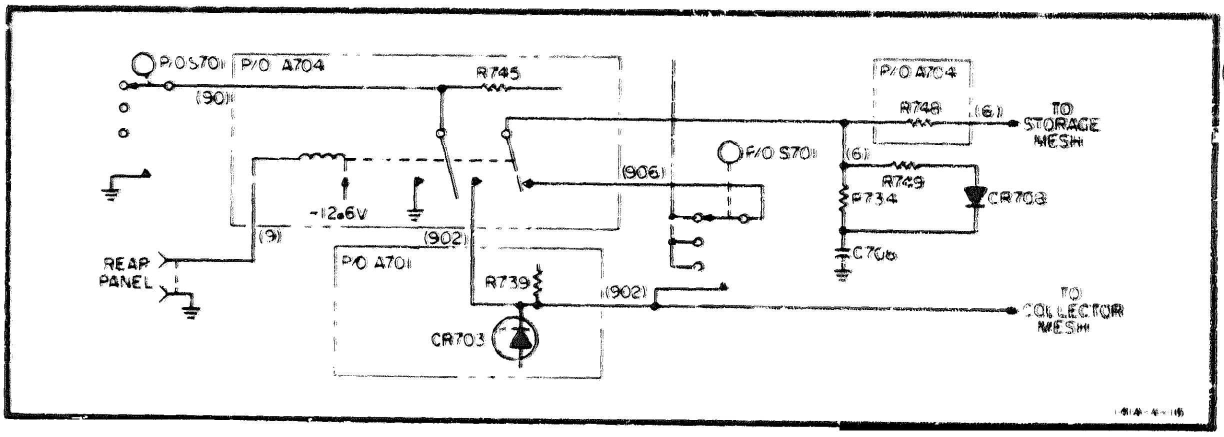


Figure 1-2. Remote ERASE Circuit

SECTION II
INSTALLATION

1-5. INITIAL INSPECTION

Mechanical Check. Check the instru-
t for external damage such as broken
trols or connectors, and dents or
atches on the panel surfaces. If dam-
is evident, see Paragraph 1-A.3. If
shipping carton is not damaged, check
cushioning material and note any
ns of severe stress as an indication
rough handling in transit. If the in-
ument appears undamaged, perform the
ctrical check (Subparagraph b.).
ain the packaging mate.ial for pos-
le future use.

Electrical Check. Check the elec-
cal performance of the Model 141A as
n as possible after receipt. Para-
phs 1-26.a. and b. contain perform-
e check procedures which will verify
trument operation within the speci-
ations listed in Table 1-1. Initial
formance and accuracy of the instru-
t are certified as stated on the in-
e front cover of this manual. If the
illoscope does not operate as speci-
d, refer to Paragraph 1-A.3.

1-6. PREPARATION FOR USE.

Power Requirements.
The Model 141A Oscilloscope re-
res a power source of either 115 or
volts ac, ±10%, single phase, 50 to
Hz, which can deliver approximately
watts. A rear panel switch provides
ection of the line voltage to be used.

CAUTION

Before placing this instrument in
operation, be sure and set rear panel
switch to agree with the line volt-
ge being used. Refer to Figure 1-5,
Proper Intensity Adjustment, to avoid
damaging CRT.

230-Volt Operation. If the instru-
t is to be operated from a 230-volt
rce, set the rear panel switch to 230.
line fuse, F401, must be changed to a
mp slow-blow fuse for 230-volt opera-
n. The fuse is accessible by removing
the bottom cover of the Model 141A; it is
identified in Figure 1-19.

c. Three-conductor Power Cable. The National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded for the protection of operating personnel. The Model 141A is equipped with a detachable, three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The offset (round) pin on the power cable connector is the ground pin. To preserve the protection feature when operating the Model 141A from a two-contact outlet, use a three-conductor to two-conductor adapter and connect the green lead on the adapter to ground at the power outlet.

d. Instrument Mounting.

(1) Modular Cabinet. The Model 141A is shipped from the factory as a bench instrument with the tilt stand, feet, and plastic trim in place. The top and bottom panel covers can be removed, giving complete accessibility to all components and adjustments. Sufficient space should be left around the sides of the cabinet to allow unrestricted air circulation.

(2) Rack Mounting. A kit for converting the modular cabinet to a rack mount is supplied with each Model 141A. Instructions for making the conversion are given below. Refer to Figure 1-3 as an aid to identifying parts.

(a) Detach tilt stand by pressing away from front feet; remove all plastic feet by depressing metal button and sliding foot free.

(b) Aluminum trim strips (behind each front handle) on sides of instrument have an adhesive back; use a thin-blade tool to remove them.

(c) Attach a rack-mounting flange, using screws provided in kit, in each space where trim strip was adhered; larger notch of flange should be positioned at instrument bottom.

(d) If Model 141A is to be placed in a rack above or below another hp instrument, choose a location which provides at least three inches of clearance around the rear and both sides.

The cooling fan and air filter require periodic lubrication and cleaning. Refer to Paragraph 1-29.b. for maintenance instructions.

1-7. REPACKAGING FOR SHIPMENT

If the Model 141A is to be repackaged for shipment, the original shipping carton and packaging material, with the exception of accordion-pleated pads, may be reusable, if undamaged. Materials used for shipping an instrument should include the following:

a. A double-walled carton, see Table 1-2 for test strength required.

b. Heavy paper or sheets of cardboard t protect all instrument surfaces; use a nonabrasive material such as polyurethan or cushioned paper such as Kimpack aroun all projecting parts.

c. At least 4 inches of Tightly-packed, industry approved shock-absorbing material such as extra firm polyurethane foam

d. Heavy-duty shipping tape for securin outside of carton.

Table 1-2. Shipping Carton Test Strengths

Gross Weight (lbs)	Carton Strength (test lbs)
up to 10	200
10 to 30	275
30 to 120	350
120 to 140	500
140 to 160	600

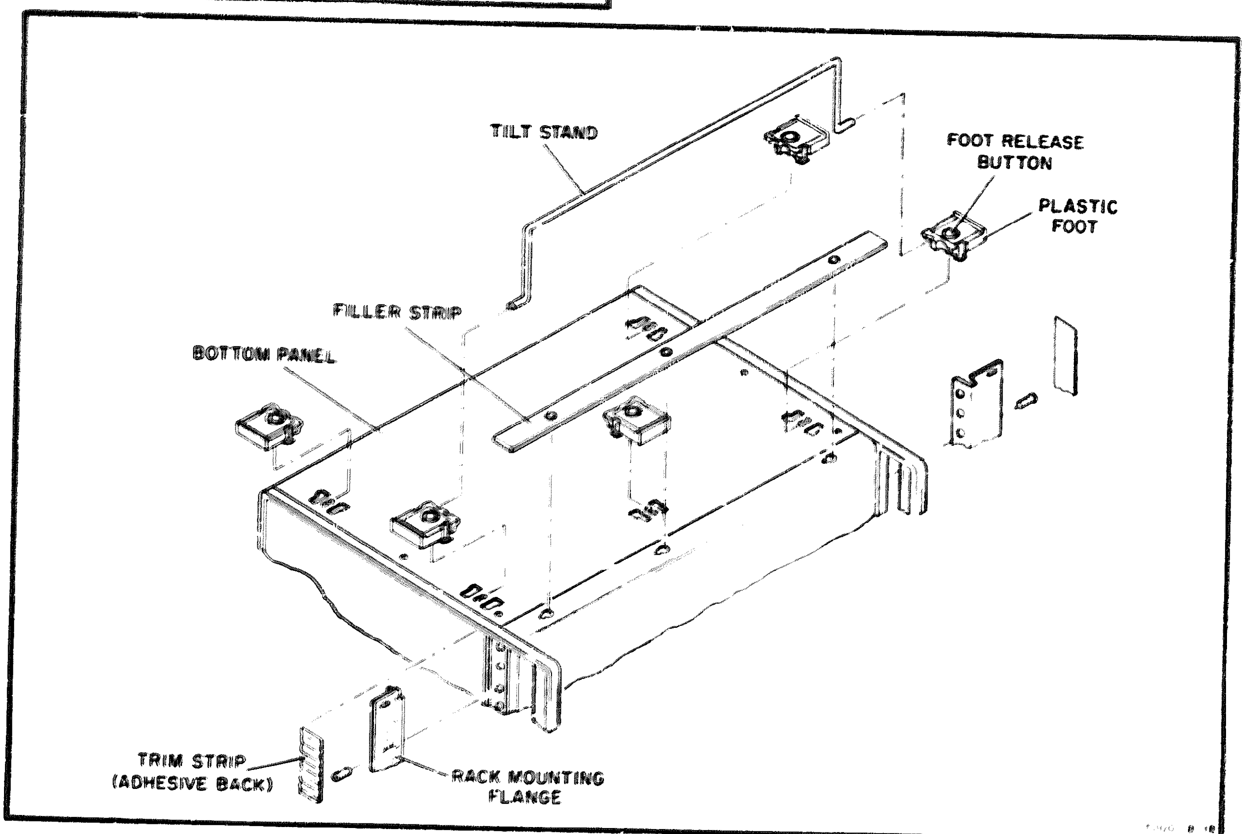


Figure 1-3. Rack Mounting Procedure

SECTION III

OPERATION

1-8. INTRODUCTION.

The Model 141A is a variable persistence, storage Oscilloscope which employs plug-in type vertical and horizontal amplifiers. The controls which affect the operation of the power supplies and cathode-ray tube are located on the Model 141A; all other controls are located on the plug-in amplifiers. The Model 141A includes the high and low-voltage power supplies, a calibrator circuit with 1 and 10 volt pk-pk outputs on the front panel, the CRT, and a pulse circuit for variable persistence and storage operation.

1-9. FRONT PANEL COMPONENTS.

Fig. 1-4 identifies the front panel controls and gives a brief functional description of each. Additional information on some of the controls is given below. A more detailed description of some of the controls and their function in variable persistence and storage operation is given in Paragraph 1-13.

a. TRACE ALIGN. The TRACE ALIGN adjustment is provided to compensate for manufacturing tolerances and external magnetic fields which may affect the CRT trace. The adjustment should be made when the trace does not appear parallel with the horizontal lines on the CRT graticule. To adjust the TRACE ALIGN, set the Presentation Selector to WRITE and adjust a free-running trace on the CRT; rotate the TRACE ALIGN adjustment as required to make the trace parallel to the graticule lines.

CAUTION

BEAM FINDER should be pressed only momentarily and then released. If it is held, damage to the CRT will occur.

b. BEAM FINDER. A very high dc input signal may drive the trace off the CRT screen. When the BEAM FINDER is pressed, the trace will be returned to the screen regardless of the setting of horizontal or vertical POSITION controls. If pressing the BEAM FINDER does not return a beam to the viewing area, set INTENSITY to the 10 o'clock position.

c. ASTIGMATISM. The ASTIGMATISM adjustment is provided to insure uniform focus of the trace over the entire CRT screen. To adjust the ASTIGMATISM, set Presentation Selector to WRITE, center a low-intensity spot on the CRT screen (WRITING RATE and PERSISTENCE both in NORMAL) and adjust FOCUS and ASTIGMATISM for a small, round, sharply focused spot.

1-10. REAR PANEL COMPONENTS.

a. 115 230 VOLT SWITCH. This switch, located at the bottom of the rear panel, must be set to the position which corresponds to the line voltage to be used. The Model 141A is shipped with a 4-amp fuse installed for 115-volt operation. If the Model 141A is to be connected to a 230-volt outlet, change the fuse to a 2-amp, slow-blow fuse supplied with the instrument.

b. Z-AXIS INPUT. The Z-AXIS INPUT terminals and selector switch are on the rear panel of the instrument. To externally modulate the trace intensity, set the switch to EXT, remove the shorting strap and connect the modulation signal to the terminals. The amplitude of the pulse required to blank the trace depends on the front panel INTENSITY control setting, and is approximately 20 volts positive for normal intensity settings. When not using external intensity modulation, connect the strap across the terminals and place the switch to INT.

1-11. PLUG-IN UNITS.

For normal operation, install a vertical plug-in in the lower compartment and a horizontal plug-in in the upper compartment. The compartment divider must be in place to provide proper shielding between the plug-ins. For double-size plug-in operation, remove the divider. All plug-ins installed should be securely locked in place with the plug-in front panel LOCK knob.

Deflection-plate sensitivity may vary slightly from one CRT to another. This may necessitate adjustment of the sensitivity calibration of plug-ins installed in the Model 141A for the first time, or when moved from one Model 141A to another. Refer to the Operating and Service Manual furnished with plug-in unit for the SENS CAL adjustment procedure.

1-12. DEFINITIONS.

Note

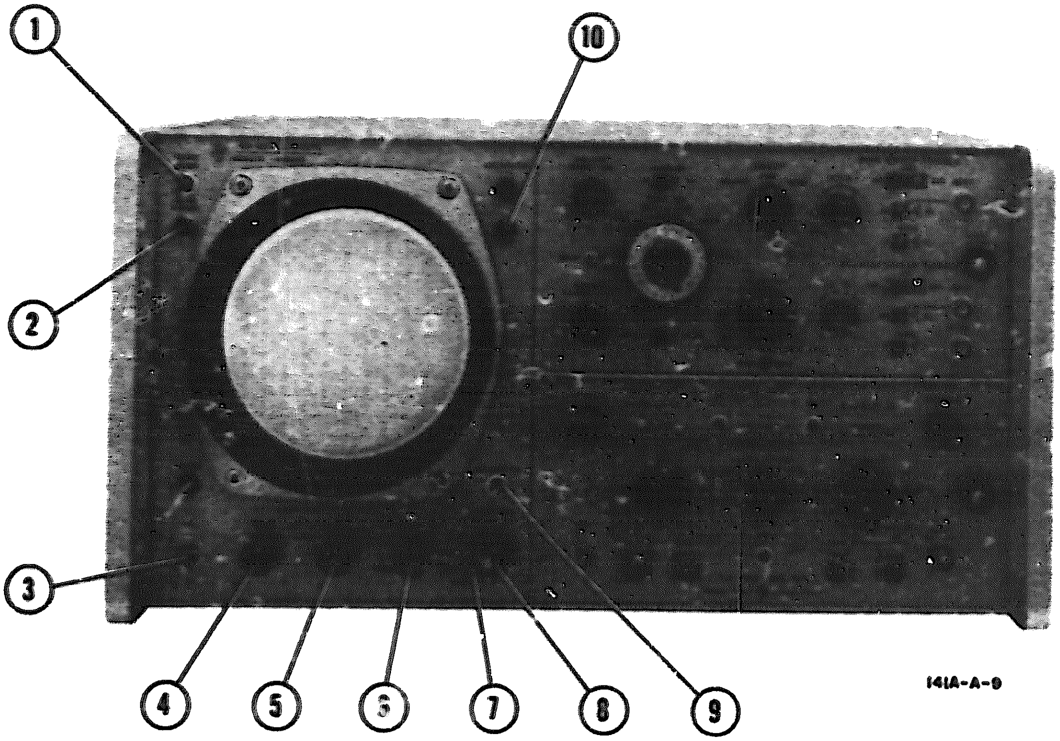
Always allow at least 15 minutes warm up before attempting to use the Model 141A.

Several words and phrases, the definition of which may vary slightly from common usage, are used to describe the operation of the Model 141A. The definitions of these words and phrases which apply to the Model 141A are as follows:

a. WRITE - To transform an input signal into a visible display on the CRT screen.

b. PERSISTENCE - The length of time a single sweep-written display remains visible on the CRT screen (INTENSITY and Sweep Time Constant).

c. STORE - To retain, at reduced intensity, a display which has been written on the CRT.



(1) Adjustment to set trace parallel with horizontal graticule lines.

(2) Momentary switch to return beam to CRT regardless of vertical and horizontal POSITION control settings. See CAUTION statement in Paragraph 1-96.

(3) ON position connects ac power to Oscilloscope and lights POWER indicator.

(4) Control for focusing beam on CRT.

(5) Control for setting intensity (brightness) of CRT display. See CAUTION statement in Paragraph 1-13.a.

(6) Control for setting trace persistence (afterglow) on CRT.

(7) Presentation Selector, for selecting function of CRT.

(8) Switch for selecting CRT writing rate.

(9) Adjustment to set roundness of CRT beam.

(10) 1 and 10-volt pk-pk, 60 Hz, calibrated square wave outputs.

Figure 1-4. Model 141A Controls

d. VIEW - To redisplay on the CRT screen, at normal intensity, a stored display.

e. ERASE - To remove all displays, and blooms which have been stored, or written with persistence on the CRT.

f. INTENSITY - The brightness of a display as it is written on the CRT screen (PERSISTENCE and Sweep Time constant).

g. BLOOM - A visible, non-symmetrical expansion of a display written on the CRT screen, Figure 1-8.

h. FADE POSITIVE - Appears as random green areas on a dark background in MAX. PERSISTENCE. See Figure 1-10.

i. BACKGROUND ILLUMINATION - A green cloud of illumination visible on the CRT screen. Figure 1-6.

j. SWEEP TIME - The time (in seconds, milliseconds, or microseconds) required for the beam to move horizontally one unit of distance (centimeter) across the CRT screen, when writing a display.

k. FADE NEGATIVE - A condition in which a portion of the trace or screen begins to dim.

m. BURN - A burn is permanent damage to the CRT phosphor or mesh resulting from excessive intensity being maintained for too long a period. Phosphor burns appear as a discolored area on the CRT screen. Mesh burns appear as spots or traces that are darker than the background illumination in the MAX. PERSISTENCE, MAX. WRITE modes.

1-13. CONTROL FUNCTIONS.

CAUTION

Excessive intensity may damage the CRT storage mesh. The INTENSITY setting for any sweep speed should be that intensity which just eliminates any trace blooming with minimum PERSISTENCE setting.

a. PERSISTENCE and INTENSITY. These controls contribute to the duration of afterglow of a display. Always set PERSISTENCE and INTENSITY as shown in Figure 1-8. The PERSISTENCE control sets the rate at which a display is erased; INTENSITY sets the brightness of the trace as it is written. With a given PERSISTENCE setting, the actual duration of trace afterglow may be increased by increasing the INTENSITY. Since the PERSISTENCE control sets the rate of erasing a written display, it follows that a brighter trace will require more time to be erased. Conversely, a display of low intensity will disappear more rapidly. The same principle applies to a stored display of high and low intensity.

b. PRESENTATION SELECTOR. This control selects the mode in which the CRT functions. In the ERASE position, the other three functions are disconnected and all stored and persisting displays are removed from the CRT. The WRITE position is the only position on the selector in which a display may be written on the CRT screen. The STORE position disconnects the WRITE function and retains written displays (at reduced intensity) on the CRT. INTENSITY and PERSISTENCE do not function in the STORE position. The VIEW position intensifies the stored display to a set brightness. Again, INTENSITY and PERSISTENCE do not affect the display.

c. WRITING RATE. In the MAX position, the rate of erasing a written display is decreased. Since the erasing rate is decreased, the entire screen becomes illuminated more rapidly and the display is obscured. The effective persistence and storage time are thus considerably reduced.

1-14. OPERATING TIPS.

These operating tips will provide the operator with a familiarity with instrument controls and aid in obtaining desired CRT display.

a. The persistence uniformity in NORMAL writing rate can be considerably improved by reducing the size of the useable display area. To accomplish this, reduce green flood-gun rings approximately 3/4 inch inside aluminum ring by adjusting R706, Collimator Adjustment.

b. For variable persistence operation, use minimum INTENSITY and maximum PERSISTENCE compatible with the desired display. (See Fig. 1-7.)

c. Use WRITING RATE in MAX only for fast sweep time, single-shot displays, or to improve the uniformity of trace intensity. The MAX position causes more rapid positive fading on the CRT and persistence or storage time of the display is thus reduced.

d. To store a display, set the Presentation Selector to WRITE, adjust the INTENSITY and PERSISTENCE for the desired display and rotate the Presentation Selector to STORE.

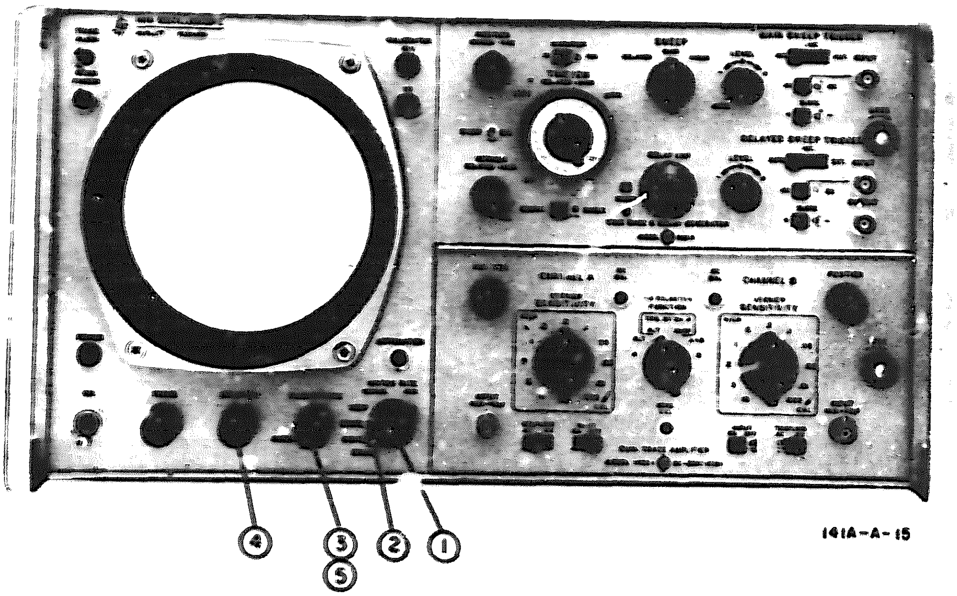
e. To view a stored display, rotate the Presentation Selector to VIEW.

f. To store more than one display, set Presentation Selector to WRITE, set PERSISTENCE fully clockwise and INTENSITY as required; allow first display to be written on the CRT. Set INTENSITY fully counter-clockwise and connect second signal to be stored. Reset vertical POSITION if second display is not to be superimposed on first. Slowly rotate INTENSITY clockwise until second display appears. Rotate Presentation Selector to STORE and both displays are stored.

g. A display stored when instrument power is turned off, will remain stored for several days. To observe a stored display, set Presentation Selector to VIEW and vertical position control ccw, before turning on the Model 141A.

h. To erase all persistent or stored displays, set Presentation Selector to WRITE and rotate PERSISTENCE control counterclockwise to (but not in) NORMAL detent, or rotate Presentation Selector to ERASE for approximately 1 second, then release. (First method not effective when WRITING RATE is set to MAX.)

i. When using the Model 141A for single sweep operation, the FOCUS control must be adjusted indirectly to obtain a well-defined trace. Set the sweep for single operation, erase the CRT trigger the single sweep and note trace definition. Change FOCUS setting as necessary each time and repeat preceding until sharpest trace is obtained.



VARIABLE PERSISTENCE MODE

1. Rotate WRITING RATE to NORMAL position.
2. Rotate Presentation Selector to WRITE.
3. Rotate PERSISTENCE control ccw to, but not in, NORMAL detent.
4. Adjust INTENSITY to a point where no blooming appears.

NORMAL PERSISTENCE MODE

1. Rotate WRITING RATE to NORMAL position.
2. Rotate Presentation Selector to WRITE.
3. Rotate PERSISTENCE control ccw to, but not in, NORMAL detent.
4. Adjust INTENSITY to a point where no trace blooming appears.
5. Set PERSISTENCE fully ccw into NORMAL detent. DO NOT INCREASE INTENSITY.

CAUTION

Trace blooming, Fig. 1-8, is the best indicator of excessive INTENSITY which can damage the CRT. However, blooming does not occur when PERSISTENCE is set to NORMAL. Therefore, DO NOT INCREASE INTENSITY WHEN PERSISTENCE IS SET TO NORMAL. Always be sure to repeat above procedure each time sweep speed or input signals change.

Figure 1-5. Proper Intensity Adjustment.

j. If only a portion of a slow sweep display is desired, switch the Presentation Selector to STORE when the trace has been written to the desired point; the write gun is blanked and the written portion is stored.

k. Use a viewing hood, if desired, to improve screen-display contrast.

m. If high intensity is used to write a trace on the CRT, it may not completely erase with one ERASE operation. Continue to erase the CRT in the normal manner taking care not to keep the Presentation Selector in ERASE for more than 1 second at any one time.

n. Fig. 1-6 thru 1-13 are provided to show typical CRT displays with various control settings and input signals. They are examples which, if duplicated by the operator, will aid in understanding the operation of the Model 141A. Fig. 1-13 shows small bright spots on the CRT screen which are caused by minute imperfections in the storage mesh.

1-15. SINGLE-SHOT OPERATION.

a. To write with persistence or store a single-shot phenomena, trial setting of INTENSITY is the best approach. The amplitude of the phenomena and the sweep-time required to display it will affect the persistence. For example, with maximum PERSISTENCE and some settings of INTENSITY, a single-shot straight-line trace may bloom, Fig. 1-8, and a single-shot signal with amplitude variations of several centimeters may not cause blooms, Fig. 1-9. To determine the best INTENSITY setting, connect a signal which approximates the sweep time and amplitude of the single-shot signal to be written. Set PERSISTENCE fully clockwise and trigger a single sweep of the test signal. Set the INTENSITY as far clockwise as possible without causing blooming. Repeat the single sweep signal, erasing the display and setting the INTENSITY after each trace until the desired display is obtained. This setup should give maximum persistence to the single-shot display. After the single-shot signal has been written, turn the Presentation Selector to STORE to retain the display.

b. Single-shot signals which require a sweep time faster than 20 miscroseconds per centimeter can be written with more brighteness by setting the WRITING RATE to MAX. The screen will be unevenly illuminated after erasing when WRITING RATE is in MAX, however the INTENSITY can be set high enough to make

Note: A vertical amplifier plug-in, used in the horizontal compartment, may have less than specified bandwidth. Make the high frequency adjustments (plug-in manual) with the vertical amplifier in the horizontal compartment.

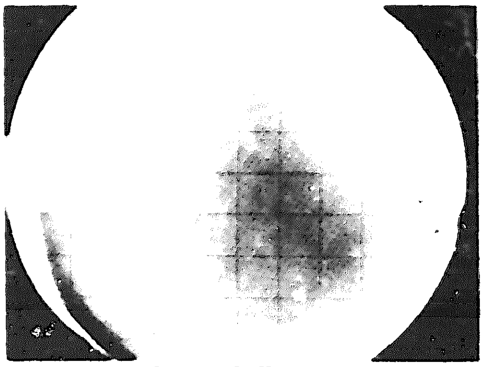


Figure 1-6. Background illumination occurs when erasing with WRITING RATE in MAX

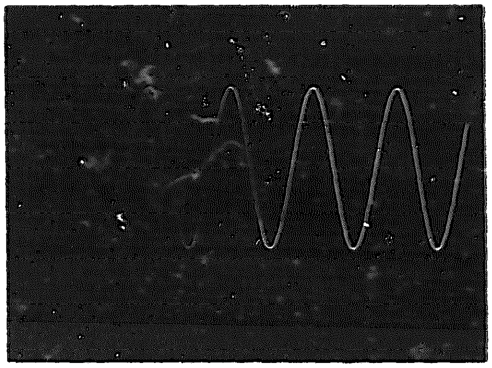


Figure 1-7. Variable persistence with a slow, repetitive sweep

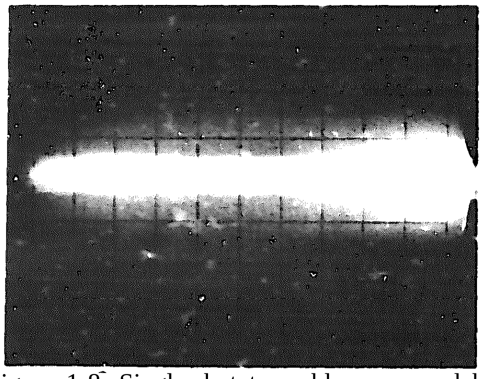


Figure 1-8. Single-shot trace bloom caused by INTENSITY and or PERSISTENCE set too high

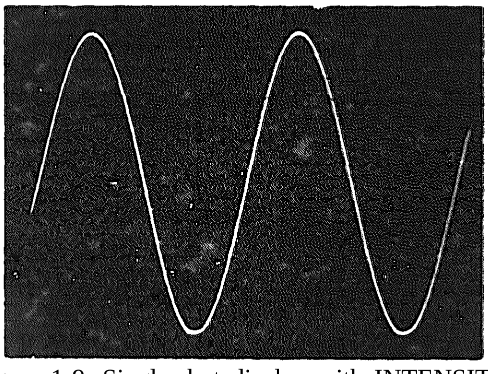


Figure 1-9. Single-shot display with INTENSITY and PERSISTENCE set the same as Figure 1-7

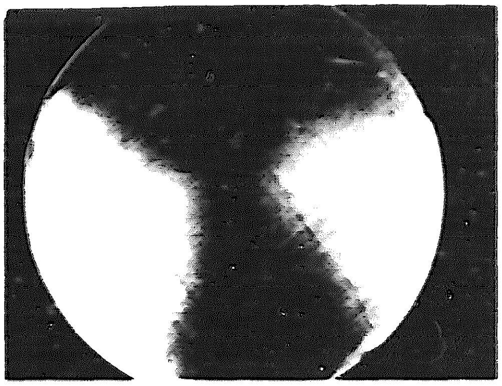


Figure 1-10. Fade positive which occurs after Presentation Sector is left in VIEW for 2 to 4 minutes

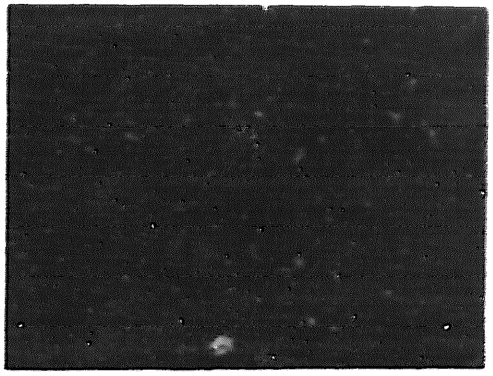


Figure 1-11. Single-shot 20 u sec/cm display

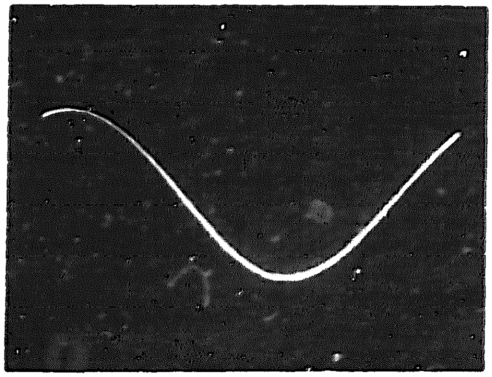


Figure 1-12. Same display as Fig. 1-11 after 3 minutes in VIEW

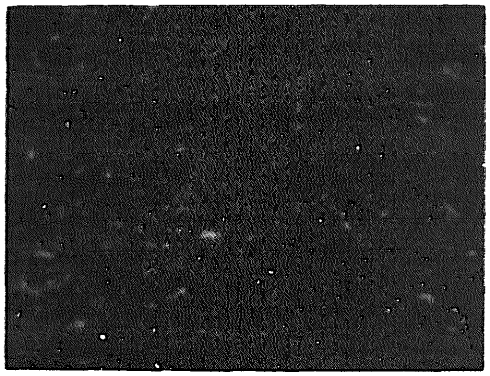


Figure 1-13. Small bright spots caused by minute imperfections in storage mesh

the display visible through the illumination. A display, written with WRITING RATE set to MAX, will be obscured by positive fading more rapidly than a display written with WRITING RATE set to NORMAL.

c. Single-shot signals which require a sweeptime between 200 and 20 microseconds per centimeter may have low brightness at the center of the screen. Fire a single-shot test signal with INTENSITY and PERSISTENCE fully clockwise and WRITING RATE in NORMAL, and if the center brightness is low, wait for one to three minutes for the low-brightness area to become brighter. Likewise, if the entire display brightness appears below a usable level, or the display is not visible at all, wait for one to five minutes for the display to appear. Figure 1-11 and 1-12.

d. For single-shot signals requiring a sweeptime from one to five minutes, set PERSISTENCE and WRITING RATE to NORMAL and INTENSITY as required to prevent blooms. Fire the single-shot signal and after the sweep is completed, rotate Presentation Selector to VIEW and PERSISTENCE out of NORMAL. The complete display may then be viewed for up to one minute or stored (Presentation Selector to STORE) for up to one hour.

SECTION IV

PRINCIPLES OF OPERATION

1-16. GENERAL

a. Refer to the block diagram, Fig. 1-14, for this explanation. The Model 141A Oscilloscope has four main circuits: a low-voltage supply, a high-voltage supply, a calibrator circuit, and a pulse circuit. The horizontal and vertical amplifier circuits are in the plug-in units and operate directly into the CRT.

b. LOW-VOLTAGE SUPPLY. The low-voltage supply uses 115 or 230 volts ac (rear panel switch), single phase, 50-60 Hz. Output voltages are -12.6, -100, +100 and +250 volts dc, all outputs are fused and are electronically regulated. Voltages are distributed to the high-voltage supply, the calibrator, pulse circuits, and to the horizontal and vertical plug-ins. 6.3 vac is supplied from the low voltage transformer to the main filament of the CRT and as a signal to the calibrator.

c. CALIBRATOR. The 6.3 vac applied to the calibrator circuit is shaped into a square wave (of line frequency) and applied to two front panel connectors, 10V and 1V (peak-to-peak amplitude). The 1-volt output is also supplied to the vertical and horizontal plug-ins for sensitivity calibration. Accuracy of the calibrating signal is ±1 .

d. HIGH-VOLTAGE SUPPLY. A transistorized oscillator and a step-up transformer are used to generate negative and positive high voltages for the CRT. Both the -5000 volt and -2350 volt supplies are electronically regulated.

e. PULSE CIRCUIT. This circuit generates a pulse of variable level and width. The pulse and other dc voltages from the circuit are applied to the storage and persistence elements in the CRT. All voltages from the low-voltage supply are used in the pulse circuit.

1-17. LOW-VOLTAGE SUPPLY.

a. General

(1) The low-voltage supply consists of: -100 volt supply, -100 volt supply, +250 volt supply and -12.6 volt supply. The +100 volt supply is independent, and provides a reference voltage for the -100 volt supply. The +250 volt and -12.6 volt supplies are dependent on the -100 volt supply for reference voltages.

(2) Fig. 1-15 is a simplified block diagram of regulator used in the low-voltage supply. The series regulator acts as a variable resistance in the regulated output. A sensor (or differential amplifier) compares the output voltage with a reference voltage (dc return

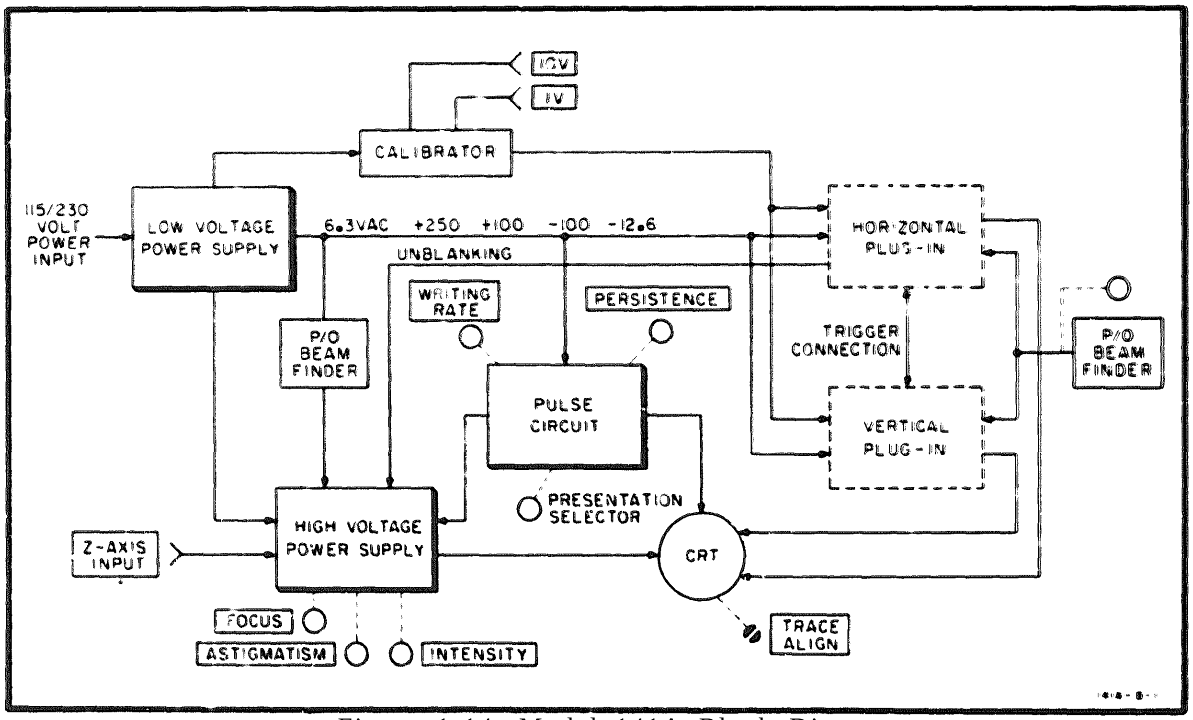


Figure 1-14. Model 141A Block Diagram

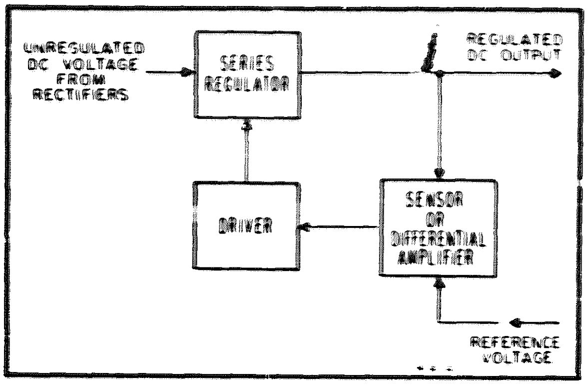


Figure 1-15. Regulated Power Supply Block Diagram

for the supply). The driver (emitter follower or amplifier) controls the bias on the series regulator, which effectively controls the series resistance. Any change in output voltage is fed back to the series regulator. The change in series resistance and the resulting voltage drop is opposite to the output voltage change; thus the output voltage is maintained at a constant level.

(3) Fig. FO-1 is a schematic diagram of the low voltage supply. The primary winding of transformer T401 is wired through a rear panel switch for quick conversion to either 115 or 230-vac operation. Line voltage is applied to the primary of T401 through an on-off switch, a fuse and a thermal switch. A pilot lamp is provided to indicate when power is applied to T401. Two shunt resistors are connected to the -250 volt supply to reduce series regulator power dissipation when high-current plug-ins are used. The shunts are wired one to each rear panel plug and the internal wiring of the plug-in determines whether the shunt is or is not used.

b. +100 VOLT SUPPLY. The ac voltage from secondary of T401 is rectified by CR441-CR444 and partially filtered by C441 and R441. The resulting dc voltage is applied through the Series Regulator, Q441, to the output. Differential Amplifier, Q447 Q448 compares the voltage across R447 and V441 with a sample of the output voltage. Any tendency of the output voltage to change is applied to the base of the Driver, Q442, which controls bias on Regulator, Q441. Series Regulator compensates for the change in output voltage by its change in series resistance and restores the output level to normal. The +100 volt output is adjusted by R453. Fuse F441 provides overload protection.

c. -100 VOLT SUPPLY. Reference voltage for the -100 volt supply is taken from the output of the +100 volt supply. The reference voltage across R467 is compared with a sample of -100 volt output across R473. The error voltage sensed by Differential Amplifier, Q463/Q464, is applied through the Driver, Q462, and Series Regulator, Q461. Series Regulator brings the -100 volt supply back into proper balance with respect to the +100 volt supply. AC voltage from T401 is rectified by CR461-CR464, partially filtered by C461/C462/R461, and the resulting dc voltage is applied by the Series Regulator, Q461, to the -100 volt output. Regulation is obtained as in the +100 volt supply. R471 adjusts the -100 volt output and fuse F461 provides overload protection.

d. -250 VOLT SUPPLY. Sensor Amplifier, Q423, in the -250 volt supply senses any variation in the output voltage, with respect to -100 volts. The error voltage is amplified by Driver, Q422, which applies corrective bias to Series Regulator, Q421. R432 adjusts the -250 volt output and fuse F421 provides overload protection. CR427 provides temperature compensation for Q423 and is normally forward-biased.

e. -12.6 VOLT SUPPLY. Sensor Amplifier, Q484, senses any variation of output voltage with respect to -100 volts and applies the error voltage to Driver Amplifier, Q482. The Driver increases signal current to the level required to control Series Regulator, Q481. The -12.6 volt output is adjusted by R488. Current Limiter, a protective circuit for the Series Regulator, is normally biased off. If an overload occurs across the -12.6 volt output, the base of Q483 goes positive by the voltage drop across R483 minus the forward breakdown voltage of CR483, turning Q483 on. The collector of Q483 is applied through Q482 to the base of Series Regulator, Q481, reducing the current flowing through Q481. The current which then flows through the external overload is limited to the current required to keep Q483 on. Additional overload protection is provided by fuse, F481.

1-18. CALIBRATOR.

The schematic diagram of the Calibrator circuit is shown in Fig. FO-3. The circuit consists of three parts: a tunnel diode square wave generator, a transistor switch, and a calibration network.

6.3 volts ac is applied through R491 to tunnel diode CR490, which generates a square wave at line frequency. Transistor switch Q490 is off during the time of the positive half-cycle of the square wave (when the voltage at the base is close to zero), and the collector voltage is thus at a level set by dc voltage divider R493, R495, and R496. When the negative-going portion of the square wave is applied to the base of Q490, the transistor conducts heavily, effectively shorting the collector to ground. The output of the Calibrator becomes zero volts. At the end of the negative input half-cycle, the bias of Q490 returns to zero, the transistor is switched off, and the output returns to its previous value.

Tunnel diode bias current is supplied through R492. The bias current sets an operating level for the diode which affects the symmetry of the square wave output. Cal Adj, R494, is used to set the dc voltage at the collector of Q490 to -10 volts when the transistor is off. Breakdown diode CR491 reduces the output impedance, and provides the temperature compensation for the circuit. Voltage divider R495/R496, reduces the 10 volt output to 1 volt. Both 10 and 1 volt outputs are available on the front panel of the Model 141A and the 1 volt output is available to both plug-ins.

1-19. HIGH-VOLTAGE SUPPLY.

a. Fig. 1-16 is a block diagram of the high-voltage supply. The output of a regulated transistor oscillator is stepped up in voltage and applied to a series of high voltage rectifiers. The positive output of the voltage doubler is connected to the post-accelerator

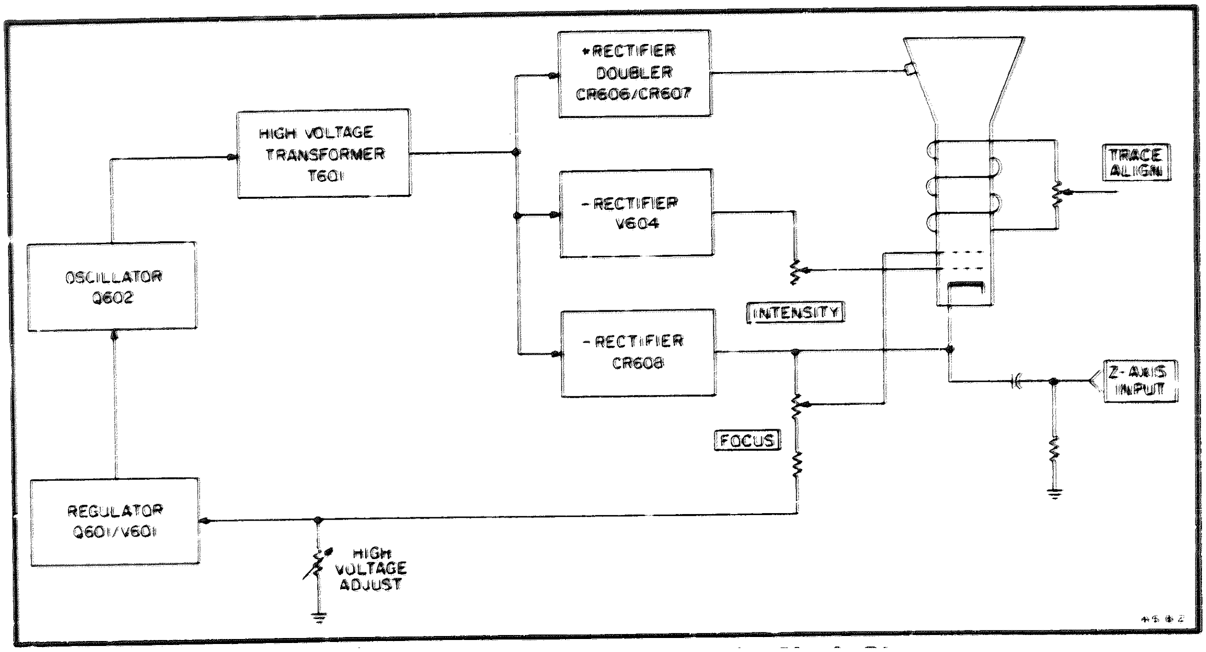


Figure 1-16. High-Voltage Power Supply Block Diagram

of the CRT. The negative output voltages are used in the gun assembly of the CRT and its associated controls. The Z-axis input can be used to apply intensity modulating signals to the CRT.

b. Fig. FO-2 is a schematic diagram of the high-voltage supply and the CRT. Oscillator Q602 operates at a frequency of approximately 32 kHz. Any change in the output voltage is applied to the grid of V601, which converts the voltage change to a current change. This current change is applied by Emitter Follower Q601 to the base of the oscillator transistor. The amplitude of oscillations is changed in such a direction as to oppose the original output voltage change. High-Voltage Adjust R619 sets the amplitude of oscillation to produce the correct output voltage.

c. Two separate negative supplies are used, one for the control grid of the CRT, and one to provide CRT cathode and focusing voltages. Both supplies use half wave rectifiers (V604 and CR608). The unblanking gate from the horizontal plug-in (pin 1, J2) is applied to the return side of the grid supply, and changes the negative grid voltage by about +50 volts to unblank the trace. A positive pulse of about 20 volts will blank the trace when applied to Z-axis input. When Z-axis input is not used, S601 is set to INT to receive chopped blanking from a dual-trace plug-in.

d. The voltage doubler circuit provides the 5 kV post-accelerating voltage applied to the CRT.

e. The ASTIGMATISM adjustment, R461, affects the roundness of the spot, and the Geometry adjustment, R643, is used to optimize pattern shape.

1-20. STORAGE CRT.

Refer to Fig. FO-2 for the schematic diagram of the storage CRT, V610. The CRT contains the conventional electron (writing) gun, deflection plates, post-accelerator, and phosphor screen. In addition, there are two flood guns (filaments, cathodes, and grids only), a collimator, a collector mesh, and a storage mesh. These added elements make possible the variable persistence and storage functions of the Model 141A.

a. FLOOD GUNS. The flood guns are physically located on the electron gun outside of the horizontal deflection plates. Horizontal Drivers, Q603, and Q604 prevent flood gun electrons from flowing through the deflection plates to the output stage of the plug-in. The gun operates continuously when the power switch is on. An electron cloud, which is emitted by the flood guns, is accelerated toward the CRT screen by collimator and collector mesh voltages. These electrons make stored or persisting displays visible. They are also used to erase stored and persisting displays.

b. COLLIMATOR. The collimator is an internal coating along the tapered portion of the CRT. A positive voltage applied to the collimator focuses the flood-gun electrons. The cloud electrons are formed into a column perpendicular to, and approximately equal to the diameter of, the CRT screen.

c. COLLECTOR MESH. The collector mesh is between the flood guns and the storage mesh (closest to the storage mesh). It is always positive with respect to the storage mesh except in the ERASE position of the Presentation Selector; both are then at the same potential. In addition to accelerating flood gun electrons, the collector mesh also repels positive ions generated by the flood guns.

d. STORAGE MESH. The storage mesh is just behind the CRT screen and is coated with non-conducting material. It is statically held at a slightly positive potential (approximately +3 volts). When the electron beam from the writing gun strikes the mesh coating, secondary electrons are emitted. This secondary

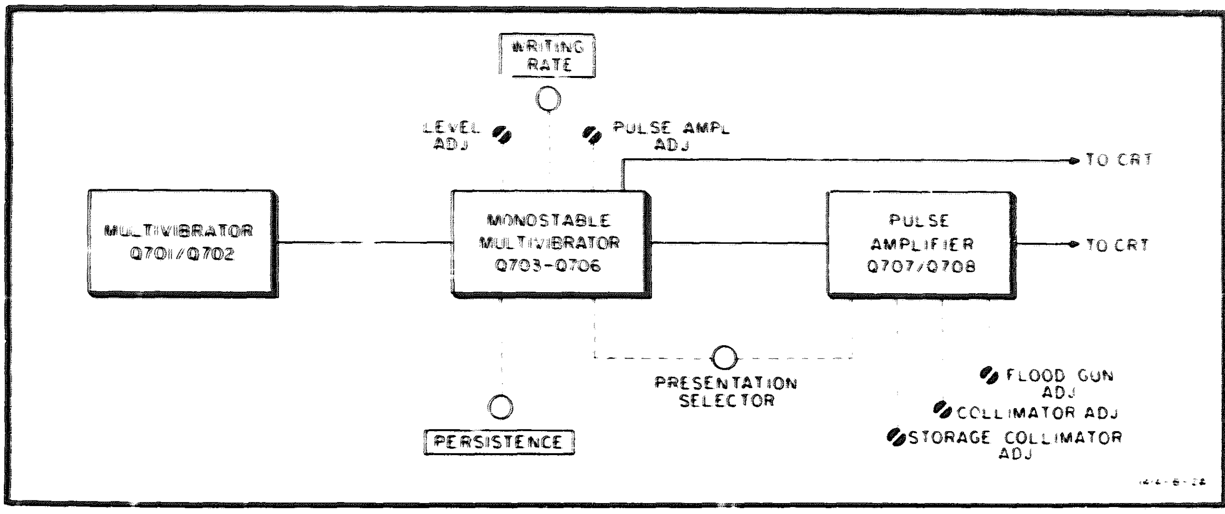


Figure 1-17. Pulse Circuit Block Diagram

emission creates a pattern of positive potential identical to the movement of the beam. Flood gun electrons are accelerated by this positive potential pattern and strike the phosphor screen, thus creating a visible display.

The storage mesh is continuously pulsed with a variable width pulse of approximately -11 volts. These pulses erase the positive pattern on the storage mesh by discharging the mesh coating. Time required for this erasing operation is determined by the width of the negative pulse. The positive pattern on the mesh may also be neutralized manually by connecting the collector and storage meshes (ERASE). The high positive potential (approximately -156 volts) allows more uniform discharging of the surface. When the storage mesh is disconnected from the collector mesh and returned to -3 volts, the coated surface is at a uniformly equal potential of -9 volts. In both cases, the screen is no illumination. The pattern may be lost by the storage mesh fading positive and allowing the entire screen to be illuminated. This occurs when positive ions from the flood gun raise the surface potential of the storage mesh in random areas sufficiently to allow flood gun electrons to strike the screen.

1-21. PULSE CIRCUIT

Fig. 1-17 is a simplified block diagram of the Pulse Circuit. A free running Multivibrator triggers a Monostable Multivibrator. The pulse width of the Monostable Multivibrator is varied by the setting of the PERSISTENCE control. The output of the Monostable Multivibrator is applied to the CRT storage mesh in the WRITE mode to control the display persistence. In STORE the output of the Monostable Multivibrator is amplified and applied to the CRT collimator.

Fig. FO-3 is a schematic of the Pulse Circuit. The Multivibrator Q701/702 free-runs at approximately 1200 Hz. The square wave output is differentiated by C703. The negative spike is blocked by CR701 and the positive spike is applied to Q703. The positive spike turns Q703 on and C705 couples a negative-going signal through Q704 to start turning Q705 off. Q704, an emitter follower, isolates the variable load of the PERSISTENCE control from Q705. The turning off of Q705 generates a positive-going signal at its collector. R708 couples this signal to Q703 driving it to saturation. C705 is now charged to -11 volt and begins to discharge toward ground through R730 and the PERSISTENCE control. When C705 reaches approx. -9.5 volt Q705 begins turning on. When Q705 turns on a negative-going signal is coupled through R708 to Q703 turning it off. C705 then continues to discharge to ground through R730 and the PERSISTENCE control in parallel.

a. The WRITE function of the Presentation Selector allows the 141A to be used as a normal or variable persistence oscilloscope.

b. The STORE function of the Presentation Selector allows the 141A to store a previously written trace for periods of one hour or more at reduced intensity. In this position of the Presentation Selector the negative pulses from Q706 are amplified by a normally-off two stage amplifier Q707/708. The output of Q708 is applied to the collimator. These negative pulses reduce the number of flood gun electrons reaching the storage mesh. In STORE the Monostable Multivibrator has a fixed pulse width determined by R729 and R730.

c. The VIEW function of the Presentation Selector enables the 141A to display the stored trace at full intensity for a short time. This time is dependent on the WRITING RATE selected to write the trace. In VIEW the Monostable Multivibrator is disabled and the collimator is held at a fixed positive level. Thus the flood gun electrons are continously accelerated toward the storage mesh and increase the intensity of the stored trace.

d. The WRITING RATE switch selects the collimator storage mesh potential. In NORMAL, the collimator is held at between +45 and +90 volts. In MAX the collimator is held at between +36 and +61 volts.

e. The PERSISTENCE control has a NORMAL detented position which disconnects everything from the

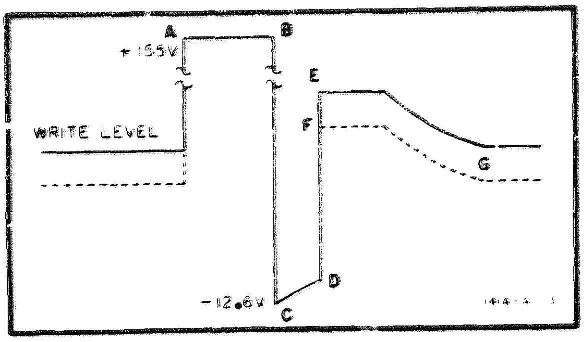


Figure 1-18. Erase: Functional Waveform

storage mesh but a -30V level determined by R737/738. This -30V level immediately discharges any positive potential or charge point occuring on the storage mesh due to electrons from the write beam striking the mesh. The persistence of the trace is then controlled entirely by the natural persistence of the phosphor coating.

1-22. CLAMP CIRCUIT.

The Clamp Circuit assists in erasing the CRT by momentarily clamping the storage mesh to -12.6 volts.

Fig. FO-3 includes a schematic of the clamp circuit. With the Presentation Selector out of ERASE, Q710 is off. Turning the Presentation Selector to ERASE grounds C710 through R745, saturating Q710. This places the collector at a -12.6 volts. Releasing the Presentation Selector allows C710 to charge through R746. Initially, when the Presentation Selector is released, the storage mesh goes to -12.6V. However, the charging of C710 begins to turn Q710 off and it cannot maintain the storage mesh at -12.6V. As soon as the clamp is broken the discharge current from C708 causes the voltage on the storage mesh to go to approx. +12V as determined by CR702 and the selected Write Level. When Q710 has completely turned off, C709 begins to discharge and the storage mesh returns to a level determined by the selected Write Level control. Fig. 1-18 is a graphical presentation of the ERASE function. Point A is the initiation point for the ERASE function; the Presentation Selector is rotated to the ERASE position. Point B is the point at which the Presentation Selector is released. Point C represents the voltage on the storage mesh immediately after the Presentation Selector is released. For practical purposes the time between B and C may be considered as instantaneous. Point D represents the point at which the clamp breaks and Q710 loses control of the voltage on the storage mesh. Note that there is a voltage difference between C and D of a few volts. Points E and F represent the selected Write Levels and show the "depth of erasure" of the CRT in the NORMAL and MAX position of the WRITING RATE switch respectively. The "depth of erasure" term describes how well the CRT is erased. A more positive voltage at this point results in a deeper erasure. Point G is the voltage level of the storage mesh after erasure.

1-23. TRACE ALIGN.

The Trace Align coil, L602, is located around the CRT near the screen. Adjustment of Trace Align, R650A/B, changes the magnitude and direction of current through the coil and rotates the trace into alignment with the CRT graticule.

1-24. PLUG-IN KIT FABRICATION.

The hp Model 10477A and Model 10487A Accessory Plug-ins are blank plug-in units for the Model 141A Oscilloscope. These two units permit the user to design his own special-purpose circuits. Current available from each of the Model 141A power supplies is show in Table 1-3. Do not exceed the capabilities in Table 1-3.

Table 1-3. Current Capability

Supply Voltage and J1/J2 pin number		Current Available at each Jack (J1 and J2)
+250 Vdc	9	0-50 ma
+250 Vdc	9	50-100 ma (pin 2 must be wired to pin 3 in the plug-in.)
+100 Vdc	2	0-137.5 ma
-100 Vdc	6	10-200 ma
-12.6 Vdc	21	0-0.9 amps
6.3 Vac	13-14	0-3.25 amps

Table 1-4. Equipment Required for Tests and Adjustments

Recommended Instrument	Model	Required for	Ref Par.	Required Characteristics
Voltmeter Calibrator	hp 738AR or 738 BR	Calibrator check; High Voltage Adjustment; Calibrator Adjustment	1-26.b 1-27.f 1-27.b	Outputs of 1 v and 10 v pk-pk; -300 v dc; ± 0.2%
DC Voltmeter	hp 412A	Low-voltage Adjustments	1-27.e	-100 to -100 volts, ± 1%
DC VTVM	hp 410B C	High-Voltage Adjustment	1-27.f	May be adapted for high voltage (-2.5 kv) measurement. Provision for altering calibration.
Voltage Divider	hp 11044A hp 11045A	High-Voltage Adjustment	1-27.f	Provide 100:1 division for vtvm; 2.5 and 30 kv rating.
Oscillator	hp 204B C or 200CD	Pulse Circuit Adjustment	1-27.k	800 Hz and 40 kHz

SECTION V

MAINTENANCE

1-25. INTRODUCTION

This section covers maintenance, trouble-shooting, and adjustment of the Model 141A Oscilloscope. A performance check is included which may be used at incoming inspection, or after adjustments have been made, to verify that the instrument meets specifications.

1-26. PERFORMANCE CHECK.

a. Crt. Controls.

(1) Install a single large plug-in or two small plug-in units in the Model 141A (vertical plug-in in the lower compartment, horizontal in the upper compartment).

(2) Set INTENSITY fully counterclockwise.

(3) Set PERSISTENCE counterclockwise just out of NORMAL detent and Presentation Selector to WRITE.

(4) Set POWER switch to ON.

(5) Check to see that CRT screen is lightly and evenly illuminated.

CAUTION

If the CRT screen is not lightly illuminated, turn POWER off and check that all CRT neck and bulb leads are connected. DO NOT rotate INTENSITY clockwise or the CRT may be damaged.

(6) Rotate PERSISTENCE into NORMAL detent and depress BEAM FINDER switch. A spot should appear on the screen.

(7) Set INTENSITY control to 12 o'clock and return beam to screen with POSITION controls. Check that counterclockwise rotation of INTENSITY control extinguishes beam and clockwise rotation gives brighter than normal intensity. Immediately return INTENSITY to 12 o'clock.

(8) The FOCUS and ASTIGMATISM adjustments should have sufficient range to defocus the beam in both extreme position and should give a sharp, round spot when close to mid-range. Adjust both controls for the sharpest display.

(9) The magnetic field in which the Model 141A is operated will affect the alignment of the trace on the CRT. Set a free-running trace and adjust the TRACE ALIGN to make the trace parallel with the horizontal graticule line.

(10) Set a free-running, 1 MSEC CM trace and center both POSITION controls.

(11) Rotate INTENSITY control slowly clockwise until a trace appears.

(12) Change sweep time to 0.2 SEC CM and observe that the trace disappears and that the moving beam spot has no tail.

(13) Rotate PERSISTENCE slowly clockwise and note that beam spot develops a tail; fully clockwise makes the complete trace remain on the screen.

(14) Rotate INTENSITY fully counterclockwise; trace should remain visible for one minute.

(15) Rotate INTENSITY slowly clockwise until trace blooms, then fully counterclockwise.

(16) Rotate Presentation Selector to ERASE for one second and release; screen should be dark.

(17) Rotate INTENSITY slowly clockwise until trace has normal intensity, then fully counterclockwise.

(18) Rotate PERSISTENCE counterclockwise, screen should be lightly illuminated and trace should disappear; rotate PERSISTENCE fully clockwise and screen should be dark.

(19) Repeat step (17).

(20) Rotate Presentation Selector to STORE; trace should remain visible at low intensity for one hour. Trace may be viewed, at normal intensity, any time during the hour of storage by rotating the Presentation Selector to VIEW. Viewing time decreases as time in storage increases.

(21) Set sweep time to 1µSEC/CM, Presentation Selector to WRITE, and WRITING RATE to MAX.

(22) Rotate Presentation Selector to ERASE for 1 second and release; screen should have a varying contrast across the graticule. (See "B", Fig. 1-22).

(23) Rotate INTENSITY slowly clockwise until trace appears.

(24) Set horizontal plug-in for single sweep.

(25) Rotate Presentation Selector to ERASE for 1 second and release.

(26) Arm sweep (if necessary) and trigger a single sweep.

(27) Trace should appear and remain on the screen for a short time, then the entire screen should slowly fade positive (total illumination).

b. Calibrator.

(1) Set: Vertical SENSITIVITY . . . . 0.05 V/CM
INPUT coupling . . . . DC
PERSISTENCE . . . . . . NORMAL detent

(2) Connect 1 VOLT pk-pk from the Voltmeter Calibrator to vertical INPUT.

(3) Adjust vertical VERNIER for exactly 10 cm deflection.

(4) Disconnect the Voltmeter Calibrator and connect the 1V CALIBRATOR output to the vertical INPUT.

(5) Deflection should be 10 cm ± 0.1 cm.

(6) Repeat steps a through e, using 0.5 V CM vertical SENSITIVITY and 10 volts from the Voltmeter Calibrator.

1-27. ADJUSTMENTS.

a. General

The adjustment procedures for the Model 141A are given in Para. 1-27.a. thru 1-27.j. Test equipment required is listed in Table 1-4. Similar test equipment having the required characteristics may be substituted for that recommended in the Table. If difficulty is encountered in making any adjustment, refer to Para. 1-28 for troubleshooting procedures.

b. PRELIMINARY SETUP. Plug-ins should be installed in both compartments before power supply adjustments are made; proper regulation may not occur with no load connected.

c. ADJUSTMENT COMPONENT IDENTIFICATION. All internal adjustment components are identified in Figure 1-19.

d. CONDENSED ADJUSTMENT PROCEDURE. Table 1-6 is a condensed adjustment procedure. The table may be useful after becoming familiar with the step-by-step procedures.

e. Adjustments of Low-Voltage Supply.

Measure the output of each low-voltage supply, and adjust it to the value shown in Table 1-5. Measurement may be made on any wire bearing indicated color code. Para. 1-28.b. gives allowable ripple.

Table 1-5. Low-Voltage Adjustments

Supply (Volts)	Wire Color Code	Adjustment
+100	White/Red	+100V Adj R453
-100	Violet	-100V Adj R471
-12.6	White/Violet	-12.6V Adj R488
+250	Red	+250V Adj R432

f. Adjustments of High-Voltage Supply.

(1) Connect the Voltage Divider to the DC probe of a Model 410B C Voltmeter.

(2) Set Voltmeter to 3-volt -DC range.

(3) Set the Voltmeter Calibrator for -300 volts DC output, and connect divider tip to the output.

(4) Set the gain adjustment of the Model 410B C (located at the rear of the instrument) for a reading of exactly 3 volts.

(5) Set the Voltmeter to the 30-volt range, and measure the high voltage supply. This may be done at the junction of R651 and R652.

(6) Set High Voltage Adjust R619 for -2350 volts.

(7) Recalibrate the Model 410B/C.

g. Intensity Limit Adjustment.

(1) Remove plug-ins; short pins 1 and 2 of J2.

(2) Set R612, Intensity Limit, fully ccw.

(3) Set INTENSITY control to 12 o'clock.

(4) Adjust R612 until spot is just visible. Remove short and reinstall plug-ins.

h. Astigmatism Adjustment.

(1) Center a low-intensity spot on the CRT.

(2) Adjust FOCUS and ASTIGMATISM for a small, round, sharply-focused spot.

i. Geometry Adjustment.

(1) Set: TRIGGER LEVEL . . . . AUTO
SWEEP TIME . . . . 0.2 MSEC CM

(2) Connect a 400-kHz signal from the Audio Oscillator to the vertical INPUT of the amplifier plug-in.

(3) Adjust vertical and horizontal controls to obtain a pattern 8 cm high.

(4) Adjust Geometry, R643, to obtain the straightest possible edges on the rectangular pattern.

j. Calibrator Adjustment.

(1) Connect a 10 VOLT Pk-Pk signal from the Voltmeter Calibrator to the vertical amplifier INPUT.

(2) Set amplifier SENSITIVITY to 0.5V CM, INPUT coupling to DC.

(3) Adjust vertical VERNIER for exactly 10 cm deflection.

(4) Disconnect the Voltmeter Calibrator, and connect the 10V CALIBRATOR output to the amplifier INPUT.

(5) Set Cal Adj, R494, for exactly 10 cm deflection.

k. Pulse Circuit Adjustment.

The following procedure covers all five of the adjustments in the pulse circuit. The adjustments covered are: Normal Write Level (R743); Normal Write Collimator (R725); Maximum Write Level (R714); Maximum Write Collimator (R727); and Flood Gun (R726).

(1) Set Presentation Selector to WRITE, PERSISTENCE counterclockwise to, but not in, NORMAL detent and WRITING RATE to MAX.

(2) Set Normal Write Level Adjust, R743, fully counterclockwise.

(3) Set Max Write Level Adj, R714, fully clockwise.

(4) Set Normal Write Collimator, R725, halfway between stops.

(5) Set Flood Gun Adj, R726, fully clockwise.

(6) Rotate Presentation Selector to ERASE for 1 second and quickly release.

(7) Rotate Coll Max Write Adj, R727, so that the non-concentric green rings of illumination visible within the viewing area of the screen are located with the outer green ring just touching the aluminum ring on either of the sides, opposite side should be within 1/16" of aluminum ring (see "A", Figure 1-22).

(8) Rotate Presentation Selector to ERASE for 1 second and quickly release.

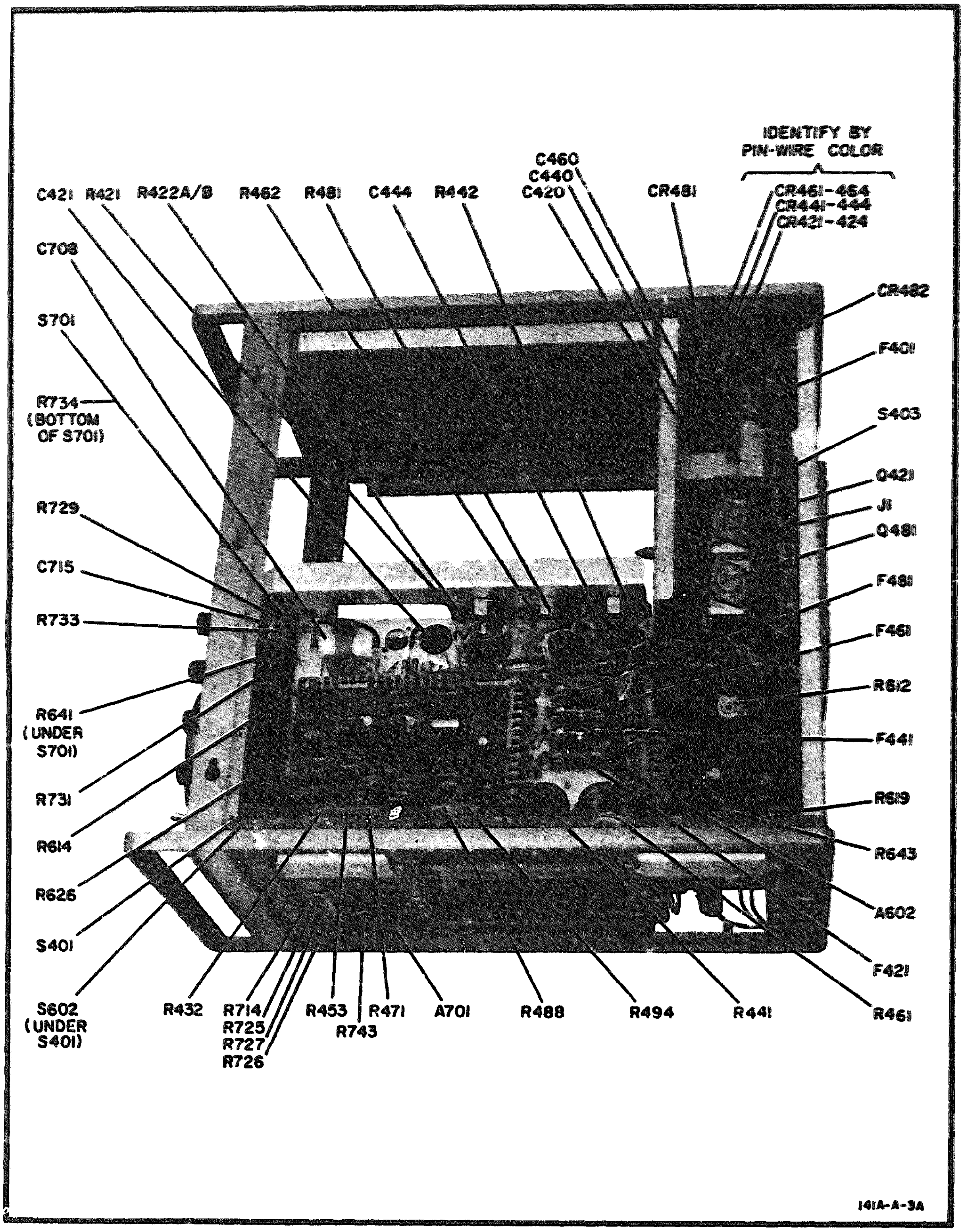


Figure 1-19. Adjustment and Component Locations, Bottom View

Table 1-6. Condensed Adjustment Procedure

Test	External Equipment Required	Procedure	Adjust
Low Voltage Supplies	DC Voltmeter	Measure: -100 v (Violet) -12.6 v (White/Violet) -100 v (White/Red) -250 v (Red)	 R471 R488 R453 R432
High Voltage Supply	DC VTVM; 100:1 Divider; Voltmeter Calibrator	a. Calibrate Divider - Voltmeter combination. b. Measure -2350 v	R619 for -2350 volts
Intensity Limit	None	Refer to Paragraph 1-27.g.	R612 until spot is just extinguished.
Astigmatism	None	Center a low-intensity spot.	FOCUS and ASTIGMATISM for sharp spot.
Geometry	Oscillator	a. TRIGGER LEVEL to AUTO SWEEP TIME to 0.2 MSEC/CM b. Connect 400 kHz sine wave to vertical INPUT. c. Obtain pattern 8 cm high.	R643 for straightest edges.
Calibrator	Voltmeter Calibrator	a. SENSITIVITY to 0.5 V/CM b. Apply 10 v pk-pk from Voltmeter Calibrator to vertical INPUT. c. Adjust vertical VERNIER for 10 cm deflection. d. Connect 10 V CALIBRATOR to vertical INPUT.	Cal Adj R494 for 10 cm deflection.

(9) Adjust R726 counterclockwise until the inner ring on either side just disappears. Now rotate R726 20° clockwise. Overlap of non-concentric rings must now be visible after CRT is erased. Erase CRT after each change.

(10) Rotate PERSISTENCE fully clockwise.

(11) Rotate Presentation Selector to ERASE for 1 second and quickly release.

(12) Rotate R714 counterclockwise in small increments, erasing after each change, for the most uniform light green background illumination of the screen. Background should be light enough to just see a fine wire mesh appearing with varying contrast across the entire graticule (see "B", Figure 1-22).

(13) Set the sweep time to 10 μsec/cm, turn the INTENSITY off, sweep to Normal, Presentation Selector to WRITE, WRITING RATE to MAX, and PERSISTENCE counterclockwise to, but not in, NORMAL detent.

(14) Connect Oscillator output to vertical plug-in input. Set Oscillator frequency to 40 kHz and slowly rotate INTENSITY until trace appears. Set vertical sensitivity for 10 cm deflection (see "C", Figure 1-22).

(15) Set horizontal plug-in to single sweep.

(16) Rotate INTENSITY control to 3 o'clock and rotate PERSISTENCE fully clockwise.

(17) Rotate Presentation Selector to ERASE for 1 second and quickly release.

(18) Arm sweep and trigger a single sweep.

(19) 80-90% of trace should remain on screen for at least 15 seconds and then slowly fade positive (total illumination). If necessary, readjust FOCUS for sharp trace without returning to Normal Sweep.

(20) If trace rapidly fades into the surrounding green background, rotate R714 slightly clockwise to reduce the intensity of the background illumination. If the trace appears and then rapidly disappears into a dark background, rotate R714 counterclockwise to increase the brightness of the green background illumination.

(21) Switch WRITING RATE to NORMAL, PERSISTENCE ccw to, but not in, NORMAL detent. Adjust R725, erasing the CRT after each change, so two non-concentric rings of illumination are brought into the viewing area of the screen. Readjust R725 so that the inner green rings on both sides are moved just off-screen behind the aluminum band (Refer to "D", Fig-

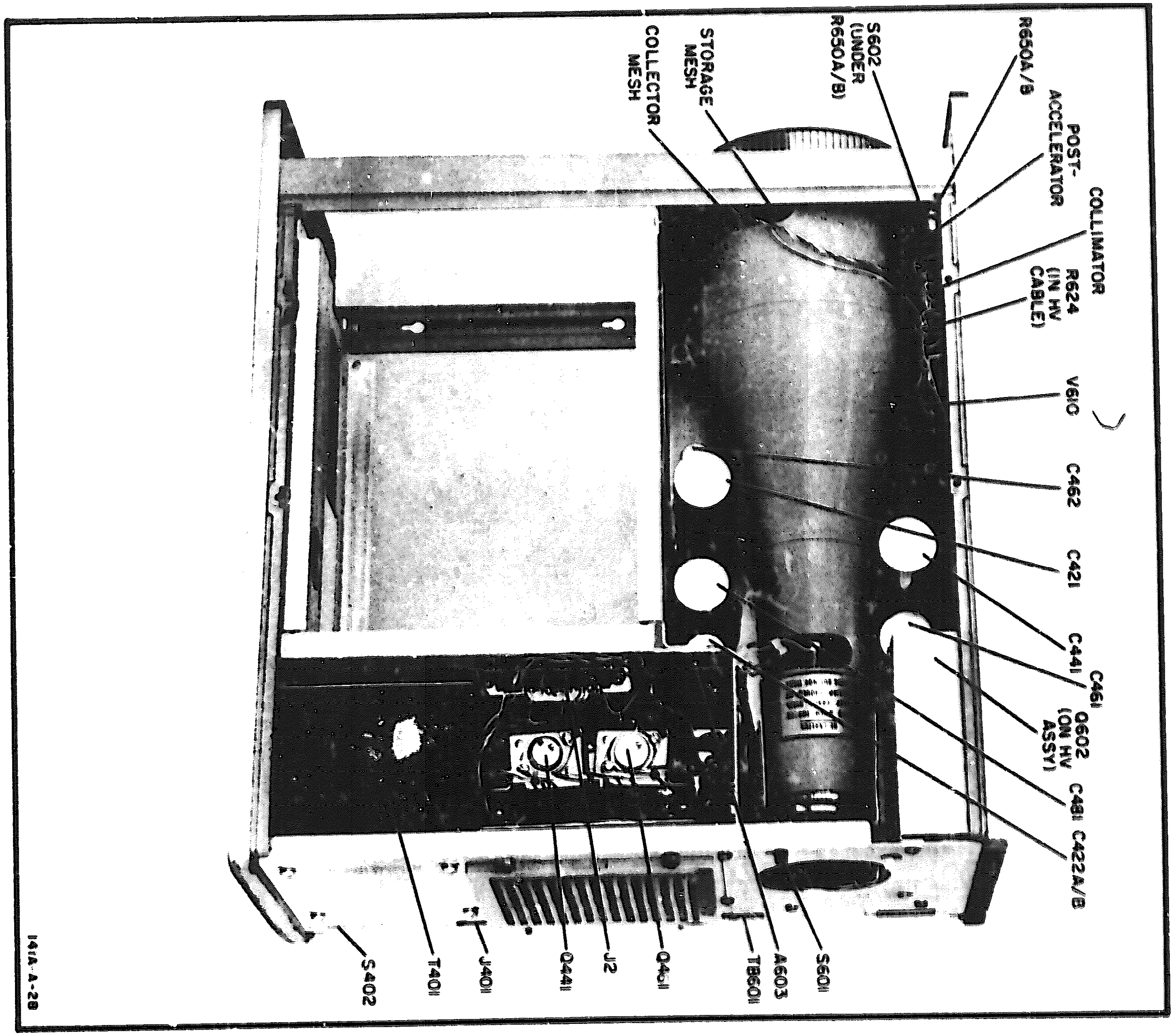


Figure 1-20. Component Locations, Top View

1-22). Occasionally these green rings may be off-center with respect to the aluminum mask. Storage and persistence uniformity may be improved by moving these inner rings back into the viewing area by not more than 1/16".

(22) Set sweep time to 0.5 ms/cm, INTENSITY off, and sweep to normal.

(23) Adjust Oscillator frequency to 800 Hz, then rotate INTENSITY slowly clockwise until sine wave trace appears. Adjust vertical sensitivity for 10 cm of deflection (see "E", Figure 1-22).

(24) Set horizontal plug-in for single sweep.

(25) Rotate INTENSITY control to 3 o'clock and rotate PERSISTENCE fully clockwise.

(26) Rotate Presentation Selector to ERASE for 1 second and quickly release.

(27) Arm sweep and trigger a single sweep.

(28) 80-90% of trace should remain on the screen for approximately one minute. A hood should be used for this check. If necessary, readjust FOCUS for sharp trace without returning to Normal sweep.

(29) If trace is not continuous (see "F", Figure 1-22), adjust R743 clockwise in small increments, repeating steps bb through dd at each increment to obtain specified conditions.

Note

Adjusting R743 too far clockwise will cause green blotches to appear on screen after 1 second erase and the screen will rapidly fade positive, reducing storage time.

1-28. TROUBLESHOOTING.

a. Low-Voltage supply.

(1) **Transistors.** The series regulator transistors are located on the fan assembly. Each is easily replaced by removing the two screws and pulling the transistor from its socket. All other low voltage power supply transistors are located on the low-voltage circuit board.

DC voltages shown on the low voltage schematic diagram were measured to ground, with Model 1402A and 1421A plug-ins installed. Voltages may vary slightly when other plug-ins are used. Correct voltages for points not marked for voltage are generally obvious by being connected (directly or indirectly) to a supply output. Transistor base voltage in most cases should not measurably differ from emitter voltage when measured with respect to ground. Voltage drops across breakdown diodes are indicated on the schematic.

(2) EXCESSIVE RIPPLE. Excessive 120 Hz ripple on any supply can usually be traced to either input filter or regulator circuit by comparing ripple voltages at the rectifier outputs with values given on the schematic. For ripple above specified value, check C421, C441, C461 or C481. 60 Hz ripple above specified value at these points indicates an open rectifier or low-gain amplifier transistors. Maximum ripple on supply outputs (at 115 Vac with maximum load on supply) is: 10 mv at +250v; 7 mv at +100v and -100v; and 2 mv at -12.6v.

(3) FUSES. If the -12.6, -100, +100 or +250 volt supply should be accidentally shorted to ground, the fuse for that particular supply will blow. This cuts off current in the supply and protects the transistors.

The -12.6 volt supply is fused, and employs a current limiter, Q483, for protection against brief shortings of the output to ground. The supply should immediately function normally upon removal of the short, provided the fuse has not blown.

(4) ISOLATING TROUBLES. Trouble in the +100 volt supply can be reflected in the operation of all other low voltage power supply outputs. If +100 volt supply is incorrect, proper circuit repair may eliminate the trouble. If +100 volt supply is correct, follow these steps in their given order:

(a) Check the -100 volt supply. The +250 volt and -12.6 volt supplies are referenced to this supply. A fault in the -100 volt supply can cause malfunction of either of the other two. If the -100 volt supply is incorrect, proper circuit repair may eliminate trouble in the +250 volt or -12.6 volt supply. If the -100 volt supply is correct, proceed to the next step.

(b) The +250 volt supply is referenced to the -100 volt supply. If trouble here has not been eliminated by checking the -100 volt supply, the trouble lies in this circuit and can be located by making the proper circuit and component checks as described in Subpara. a.

(c) A trouble that appeared to be in the -12.6 volt supply may have been eliminated by the above procedures. If not, it will be necessary at this point to make thorough voltage and component checks of the supply.

b. High-Voltage Supply.

If one high-voltage supply output is zero but other outputs are normal, one of the rectifiers is likely at fault. Normal DC voltages are given on the high voltage schematic.

If there is no high-voltage output, observe the waveforms at the collector of Q602 (blue wire). If an approximately 30 kHz 20-volt peak-to-peak sine wave appears for short intervals, the trouble is probably a defective component in the rectifier filter divider networks. If no waveform appears, use Table 1-7.

If the high-voltage output is incorrect and cannot be adjusted to the correct value, use Table 1-8.

If the -2350 volt supply seems to be operating properly, the +5 kv post-accelerator potential may be checked by removing the left side instrument cover and measuring the 5-kv voltage at the board termination of the thick red lead.

c. Pulse circuit.

A good knowledge of the operating procedures and an understanding of the principles of operation of the Model 141A are helpful when troubleshooting the pulse circuit. Refer to Section III for operating procedures and Section IV for principles of operation. Always use the turn-on procedure given in Paragraph 1-26 if the Model 141A is not operating properly.

Table 1-7. Troubleshooting High-Voltage Supply, No Voltage

1. Check Q602, L601, and the associated transformer primary for open circuits or shorts. Replace any bad components.

Procedure	Indication	Conclusion
2. Remove the edge-on connector which goes to the emitter of Q601 (yellow wire). Connect this lead through a 2K resistor to -12.6 volts (any white-violet wire).	Rectifier (V602-V605) filament lights.	Proceed to step 3.
	Filament doesn't light.	Proceed to step 4.
3. Replace edge-on connector, and change V601.	Filament lights.	Q601 was bad.
	Filament doesn't light.	Check biasing circuitry of V601. Then check Q601 and associated circuitry.
4. Check T601 and rectifier load circuit for opens or shorts. Then lift one lead of C613, C614, C615, C616, C621, C623, and turn instrument on again.	Filament lights.	Put capacitors back one at a time until the bad one causes filaments to go out.
	Filament doesn't light.	Trouble probably with transformer T601.

Table 1-8. Troubleshooting High-Voltage Supply, Incorrect Voltage

Procedure	Effect	Conclusion
1. Remove Nuvistor V601 from its socket.	Output drops to zero.	Proceed to step 2.
	Output remains at an incorrect value.	Q601 shorted.
2. Replace V601 in its socket, and lift one end of R601.	Output drops.	Trouble probably in the resistor divider network R611, R619 - R634.
	Output remains at an incorrect value.	V601 bad.

All dc voltages from the low-voltage supply are used in the pulse circuit. When a malfunction occurs, check all voltages connected to the pulse circuit board. If all low voltages are ok, check the high voltages at the high-voltage circuit board. These checks will, by elimination, isolate the trouble to one general circuit. If both supplies are ok, check the waveforms at test points shown on the schematic diagram, Figure FO-3. Check dc voltages to isolate defective components in a stage where an improper, or no waveform is present. Conditions for measurements and waveforms for test points are given in Fig. 1-29. The PERSISTENCE control should vary the pulse width of the waveforms observed at test points 4 through 8. With PERSISTENCE just out of NORMAL detent, Presentation Selector in WRITE, and no pulse present at test point 8, persistence will be maximum; this indicates a trouble in the multivibrator or pulse generator circuit. When a normal pulse, which is not variable, is present at test point 8, persistence is minimum, this indicates a malfunction in the PERSISTENCE control or Presentation Selector.

The pulse amplifier circuit functions only in the STORE position of the Presentation Selector. In all other positions, a steady dc voltage is applied to the collimator. If all modes, except STORE, operate properly, check waveforms 9, 10 and 11 in the pulse amplifier circuit.

1-29. PERIODIC MAINTENANCE

a. Electrical Maintenance.

Perform the electrical adjustments once every 6 months and after repair or component replacement.

b. Mechanical Maintenance.

Inspect the air filter at the rear of the instrument and clean it before it becomes clogged and restricts air flow. To clean the filter, wash it thoroughly in warm water and detergent. Dry the filter thoroughly before installing it on the instrument. Oil the motor (one point) with light machine oil, once every 6 months.

1-30. INSTRUMENT REPAIR.

Chassis-mounted components are identified in Fig. 1-19 & 1-20. Components on circuit boards are identified in figures near the applicable schematic (also see (also see Table 1-9).

Fig. 1-30 is an exploded view drawing of the Model 141A frame. All parts are identified by description and hp part number.

1-31. MAJOR COMPONENT CONTROL.

a. CRT Removal and Replacement. To remove the CRT, proceed as follows:

WARNING

To prevent personal injury, always wear a face mask or goggles and gloves when handling the CRT. Handle the CRT carefully.

(1) Remove top cover of instrument. (Top view drawing of Model 141A shown on inside of top cover.)

(2) Remove bezel and discharge post-accelerator lead and CRT connection to chassis ground.

(3) Disconnect the clip-on leads from the bulb of the CRT.

(4) Disconnect the clip-on leads from the neck of the CRT.

(5) Loosen the clamp at the CRT socket.

(6) Remove the socket from the CRT base; pry loose carefully.

(7) Place one hand on the CRT face and, with the other hand, slide the CRT forward and out of the instrument. Use care since neck pins can damage the trace alignment coil.

(8) To replace the CRT, first reconnect the white blue collimator lead (routed through CRT shield on left) while CRT is about four inches out from front panel.

(9) Reverse above procedure and be sure all bulb and neck leads are connected BEFORE turning power on.

(10) Check the trace alignment and geometry adjustments, Para. 1-9.a. and 1-27.1. respectively.

b. Fan Removal and Replacement. Use the following procedure for removing, and reverse the procedure for replacing the cooling fan.

(1) Remove the top and bottom covers of the Model 141A.

(2) Disconnect the white-gray and white-green-gray wires from the fan terminals.

(3) Remove all transistor heat sinks from the fan assembly and push them out of the way.

(4) Remove the four fan mounting nuts on the rear panel of the instrument.

(5) Lift out the fan assembly.

c. HV Deck Removal and Replacement. Most of the components on the high voltage deck can be replaced without removing the assembly. Other components can be removed and replaced by moving the deck part way out (without disconnecting wires). Refer to Fig. 1-21 for mounting screws and wire identification; use the following procedure for removing the high voltage deck.

(1) Remove the left side and top covers.

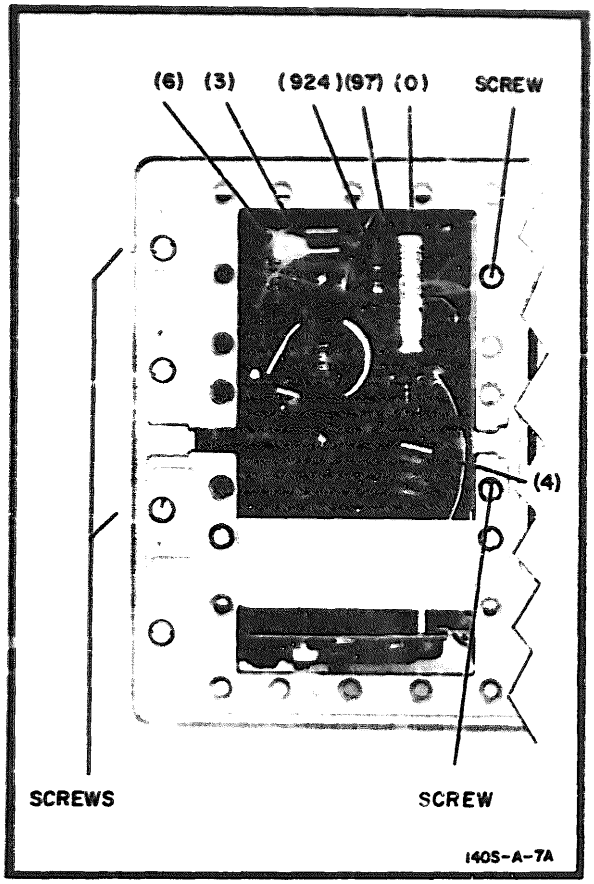


Figure 1-21. High Voltage Deck Removal

(2) Disconnect the 6 wires from the board and remove the 4 mounting screws; see Fig. 1-21 for wire and screw identification.

(3) Disconnect the post-accelerator lead from the CRT and short the CRT pin and lead to the chassis.

(4) Push the wires aside, tilt the deck away from the left side of the instrument and lift it out.

1-32. SERVICING CIRCUIT BOARDS.

The Model 141A has circuit boards of the plated through type. When servicing this type board, components can be removed and replaced by applying a soldering iron tip to the component connection on either side of the board. When removing a component with multiple leads, such as potentiometers, move the soldering iron tip from lead to lead while applying moderate pressure to the component to lift it from the board. Excessive solder can be removed by applying heat and rotating a wooden toothpick in the hole. Hewlett-Packard Service Note M-20D contains additional information on the repair of circuit boards; important considerations are as follows:

a. Do not apply excessive heat.

b. Apply heat to component leads and remove component with a straight pull away from the board.

c. Do not force replacement component lead into the hole.

d. If the metal conductor lifts from the board, it can be cemented back with a quick-drying acetate base cement having good insulating properties. If the metal conductor is broken, solder a good conducting bare wire to the conductor so it bridges the break.

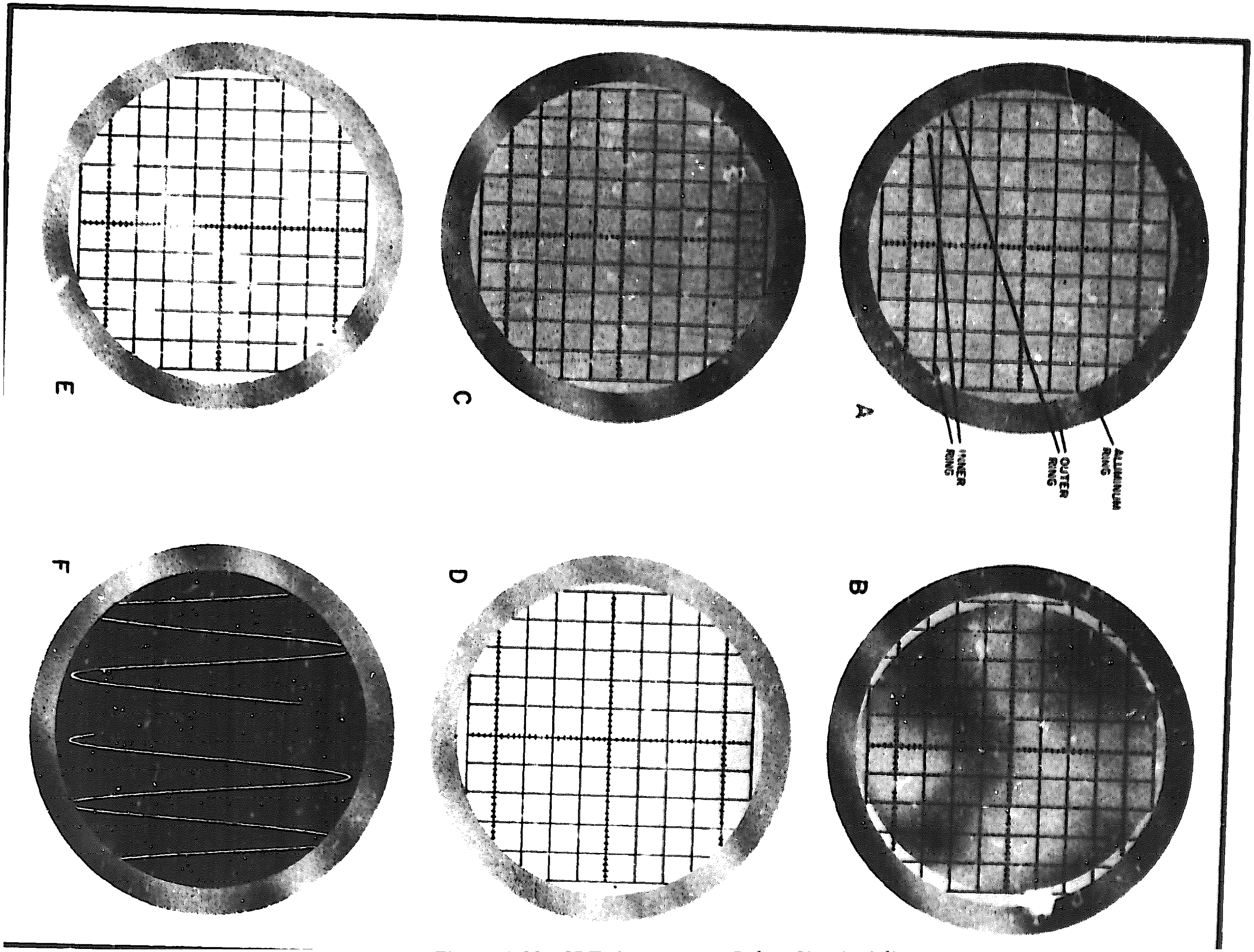


Figure 1-22. CRT Appearance, Pulse Circuit Adjustments.

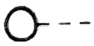
Table 1-9. Schematic Diagram Notes

Refer to MIL-STD-15-1A for schematic symbols not listed in this table.

 = Etched circuit board

 = Front panel marking

 = Rear panel marking

 = Front panel control

 = Screwdriver adjustment

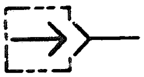
P/O = Part of

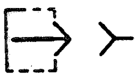
CW = Clockwise end of variable resistor

N C = No connection

 = Waveform test point (with number)

 = Common electrical point (with letter) not necessarily ground

 = Single pin connector on board

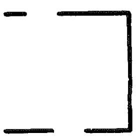
 = Pin of a plug-in board (with letter or number)

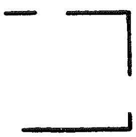
 = Main signal path

 = Primary feedback path

 = Secondary feedback path

* = Optimum value selected at factory, average value shown; part may have been omitted.

 = Module outline

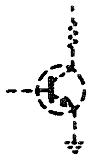
 = Assembly outline

= Field effect transistor (N-channel)

 = Breakdown diode

 = Tunnel diode

 = Step recovery diode

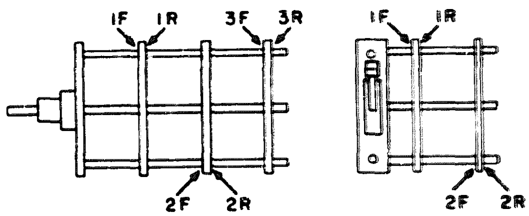
 = Circuits or components drawn with dashed lines (phantom) show function only and are not intended to be complete. The circuit or component is shown in detail on another schematic.

Unless otherwise indicated:
- resistance in ohms
- capacitance in picofarads
- inductance in microhenries

Wire colors are given by numbers in parentheses using the resistor color code [(925) is wht-red-grn].

0 - Black	5 - Green
1 - Brown	6 - Blue
2 - Red	7 - Violet
3 - Orange	8 - Gray
4 - Yellow	9 - White

Switch wafers are identified as follows:



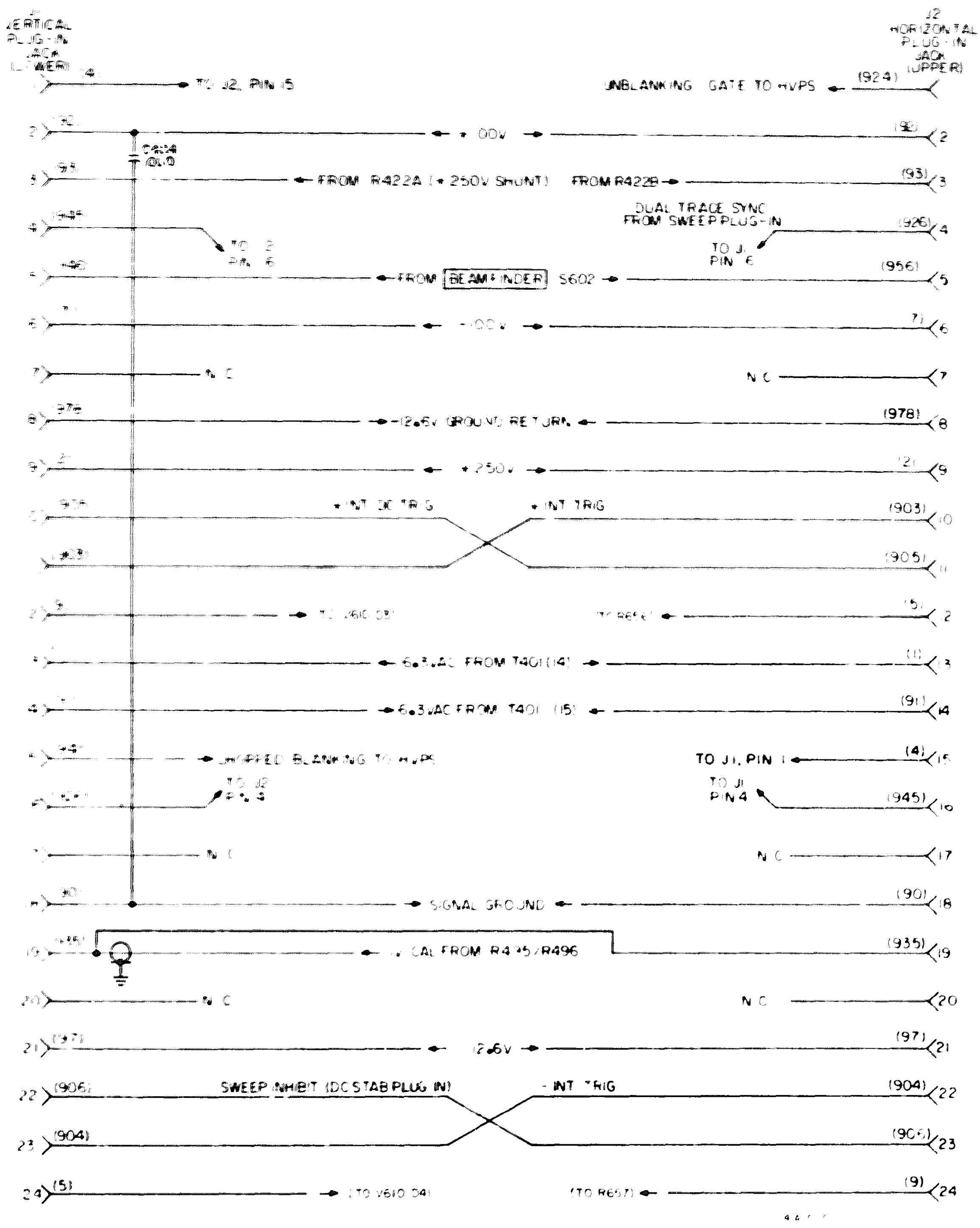
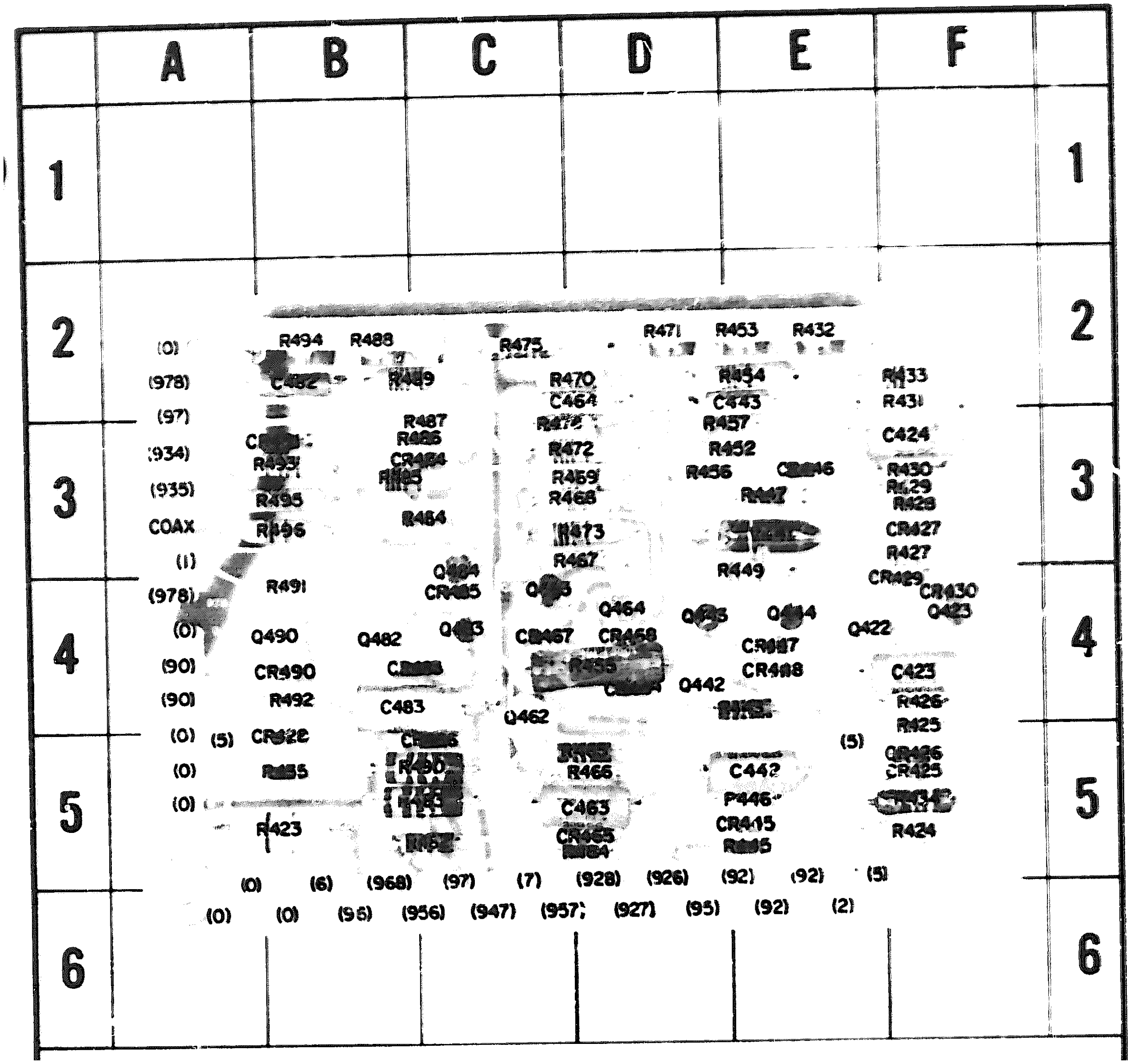
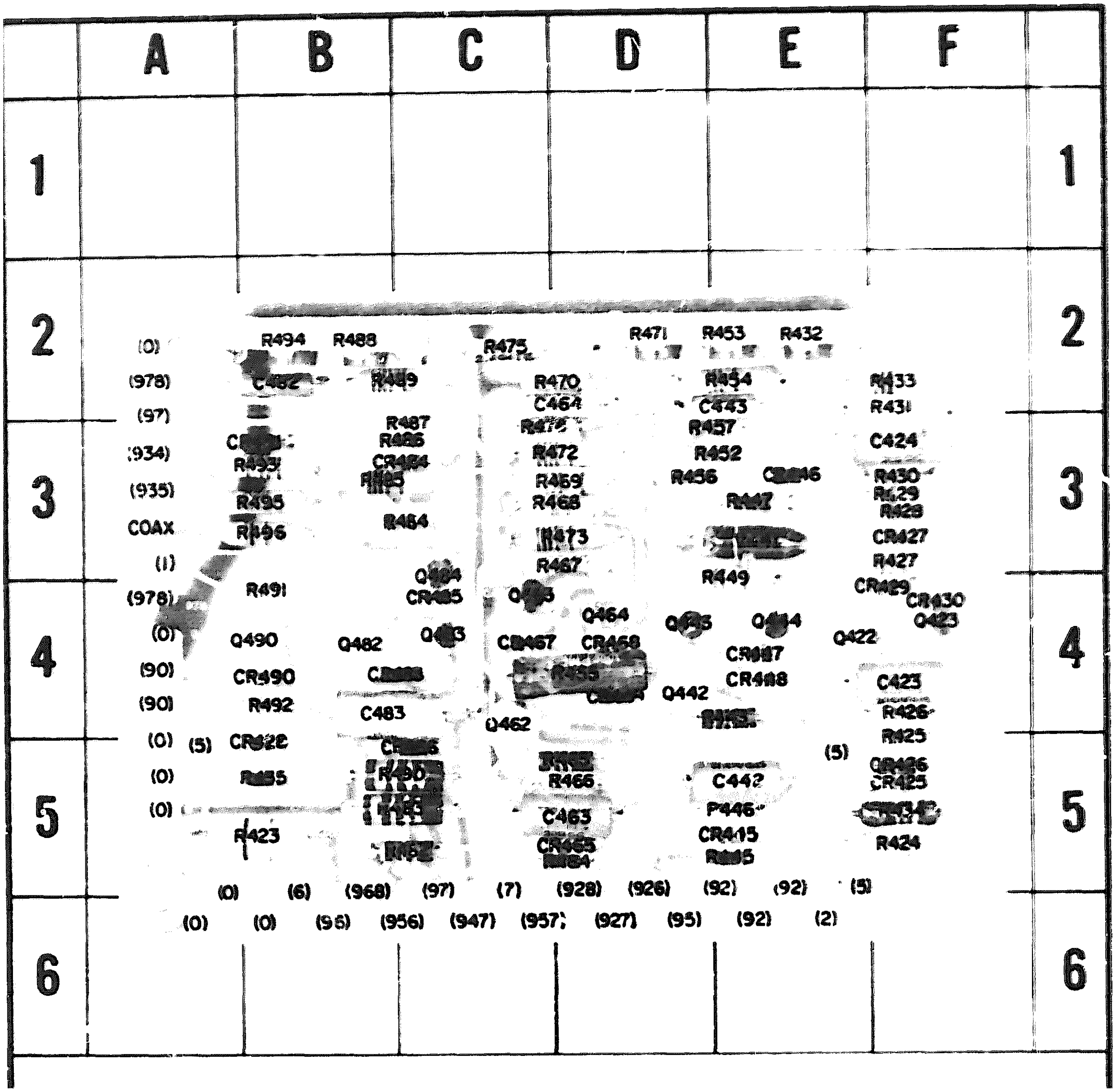


Figure 1-23. Plug-In Jack Connections



REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC
C433	F-4	CR447	E-4	Q444	E-4	R430	F-3	R456	D-3	R483	C-5
C424	F-3	CR448	E-4	Q462	C-4	R431	F-2	R457	E-3	R484	C-3
C442	E-5	CR449	D-4	Q463	C-4	R432	F-2	R464	D-5	R485	B-3
C443	E-2	CR465	D-5	Q464	D-4	R433	F-2	R465	D-5	R486	C-3
C463	D-5	CR466	C-5	Q482	B-4	R434	F-5	R466	D-5	R487	C-3
C464	D-2	CR467	C-4	Q483	C-4	R435	B-5	R467	D-3	R488	[illegible]
C482	B-2	CR468	D-4	Q484	C-4	R443	F-4	R468	D-3	R489	[illegible]
C483	B-4	CR483	C-4	Q490	B-4	R445	F-5	R469	D-3	R490	[illegible]
CR425	F-5	CR484	C-3	R423	B-5	R446	F-5	R470	D-2	R491	B-4
CR426	F-5	CR485	C-4	R424	F-5	R447	F-3	R471	D-2	R492	B-4
CR427	F-3	CR490	B-4	R425	F-5	R449	F-4	R472	D-3	R493	B-3
CR428	B-5	CR491	B-3	R426	F-4	R452	E-3	R473	D-3	R494	B-2
CR429	F-4	Q422	F-4	R427	F-3	R453	F-2	R474	C-3	R495	B-3
CR430	F-4	Q423	F-4	R428	F-3	R454	F-2	R475	C-2	R496	B-3
CR445	E-5	Q442	D-4	R429	F-3	R455	D-4	R482	C-5	V441	F-3
CR446	E-3	Q443	D-4								

Figure 1-24. Component Identification, Low Voltage Board A401.



REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC
C433	F-4	CR447	E-4	Q444	E-4	R430	F-3	R456	D-3	R483	[illegible]
C424	[illegible]-3	CR448	E-4	Q462	C-4	R431	F-2	R457	E-3	R484	C-3
C442	E-5	CR449	D-4	Q463	C-4	R432	F-2	R464	D-5	R485	[illegible]
C443	E-2	CR465	D-5	Q464	D-4	R433	F-2	R465	D-5	R486	C-3
C463	D-5	CR466	C-5	Q482	B-4	R434	F-5	R466	[illegible]	R487	C-3
C464	D-2	CR467	C-4	Q483	C-4	R435	B-5	R467	D-3	R488	[illegible]
C482	B-2	CR468	D-4	Q484	C-4	R443	F-4	R468	D-3	R489	[illegible]
C483	B-4	CR483	C-4	Q490	B-4	R445	F-5	R469	D-3	R490	[illegible]
CR425	F-5	CR484	C-3	R423	B-5	R446	F-5	R470	D-2	R491	B-4
CR426	F-5	CR485	C-4	R424	F-5	R447	F-3	R471	D-2	R492	B-4
CR427	F-3	CR490	B-4	R425	F-5	R449	F-4	R472	D-3	R493	B-3
CR428	B-5	CR491	B-3	R426	F-4	R452	E-3	R473	D-3	R494	B-2
CR429	F-4	Q422	F-4	R427	F-3	R453	F-2	R474	C-3	R495	B-3
CR430	F-4	Q423	F-4	R428	F-3	R454	F-2	R475	C-2	R496	B-3
CR445	E-5	Q442	D-4	R429	F-3	R455	D-4	R482	C-5	V441	F-3
CR446	E-3	Q443	D-4								

Figure 1-24. Component Identification, Low Voltage Board A401.

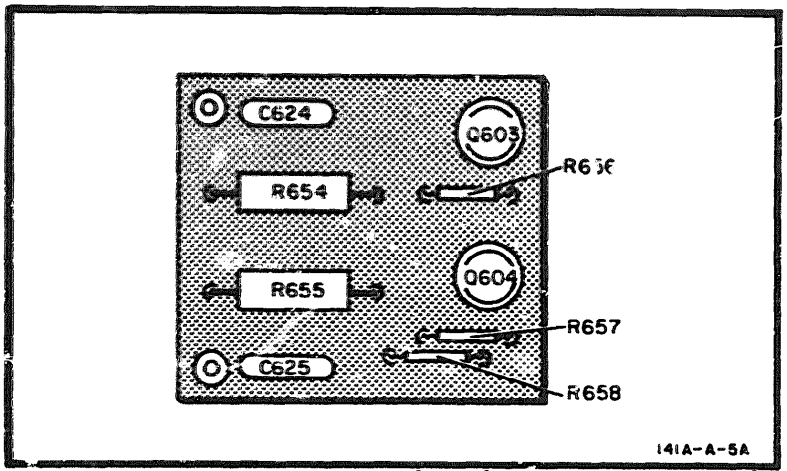
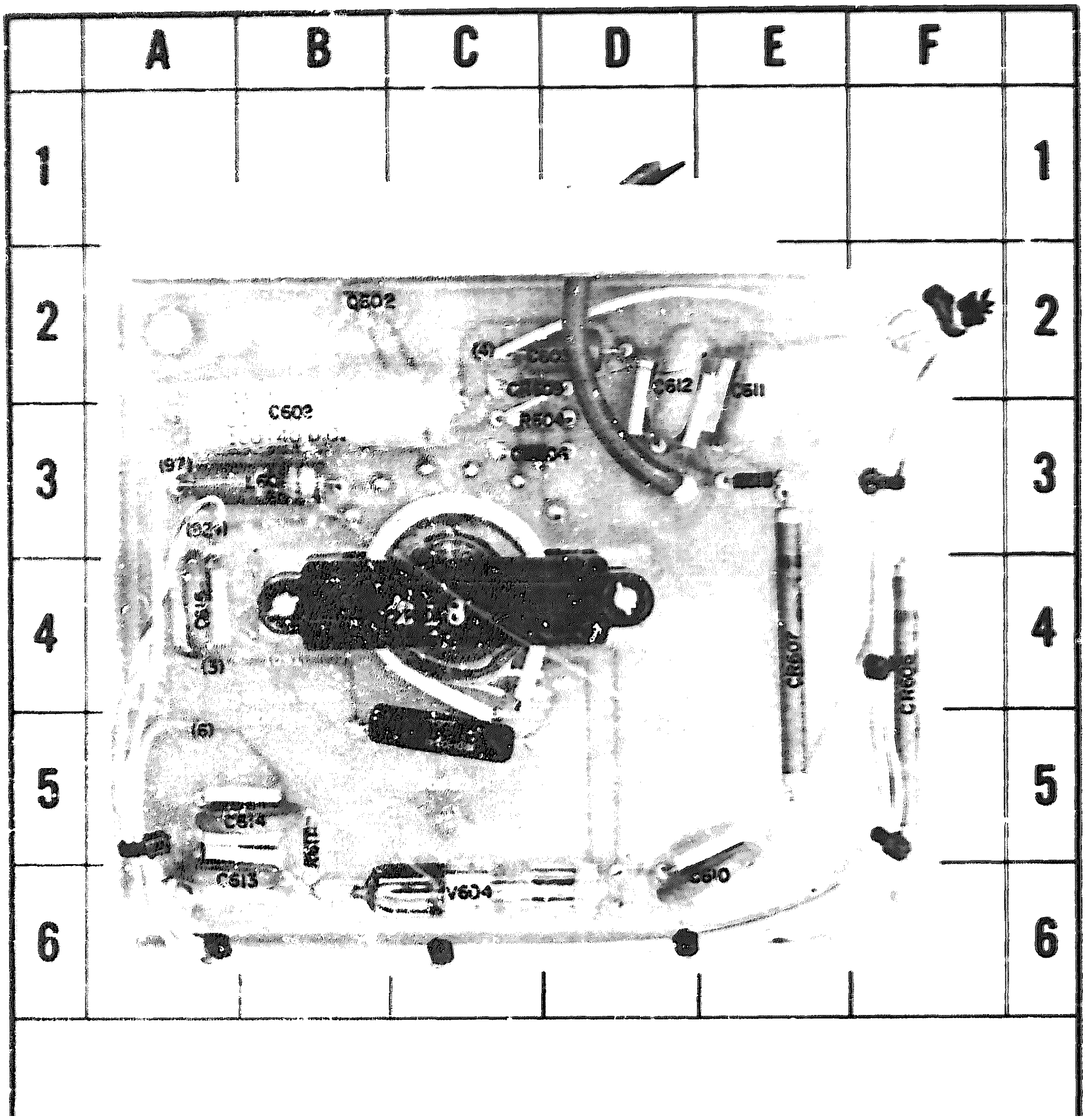


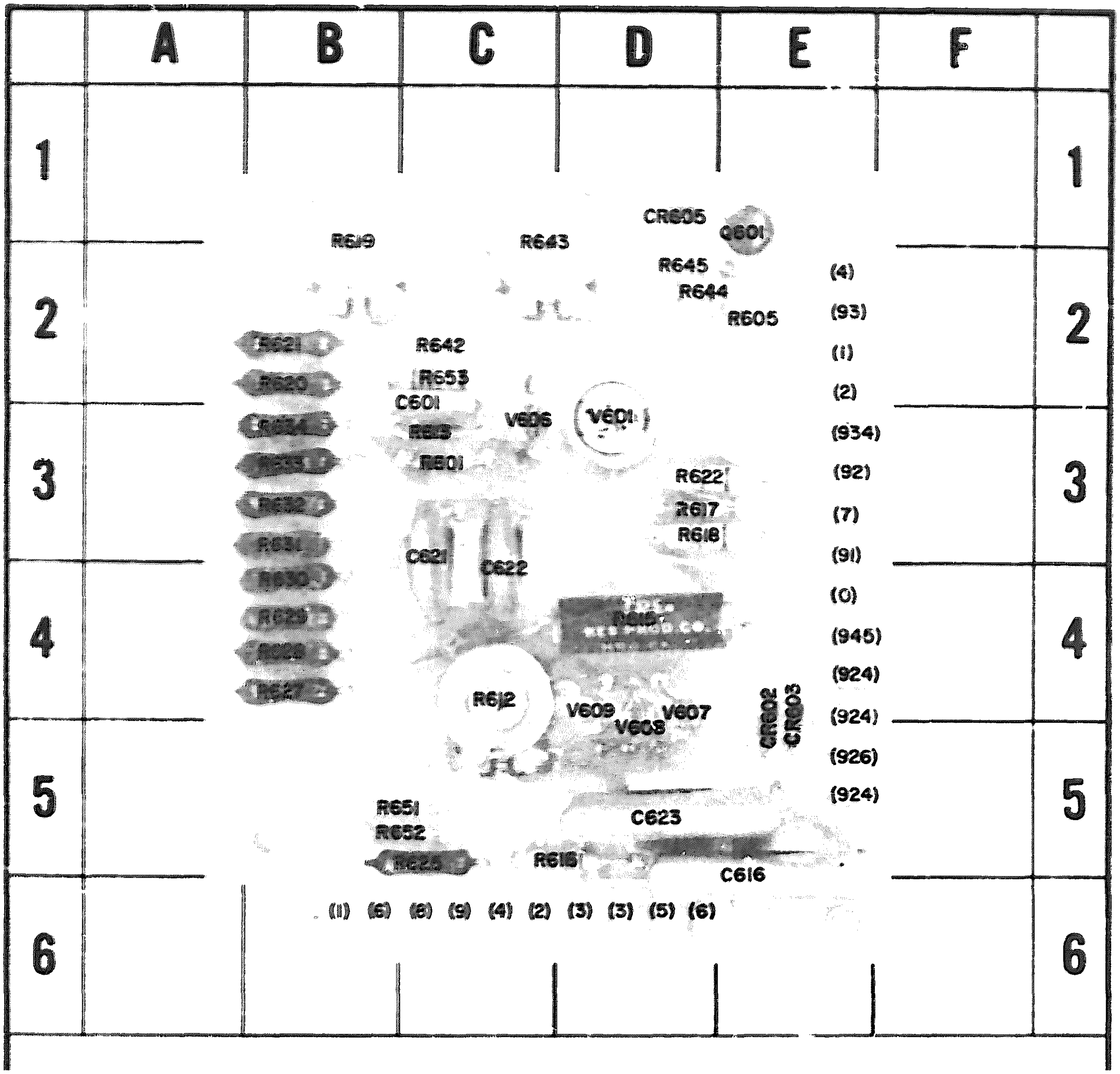
Figure 1-25. Component Identification, Horizontal Driver Board A603



REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC
C602	B-3	C613	A-6	CR607	E-4	R604	D-3
C603	D-2	C614	B-5	CR608	C-5	R610	E-3
C610	E-6	C615	A-3	CR609	C-2	R611	B-5
C611	E-2	CR604	C-3	L601	B-3	T601	C-4
C612	D-3	CR606	F-4	Q602	B-2	V604	C-6

1405-A-1A

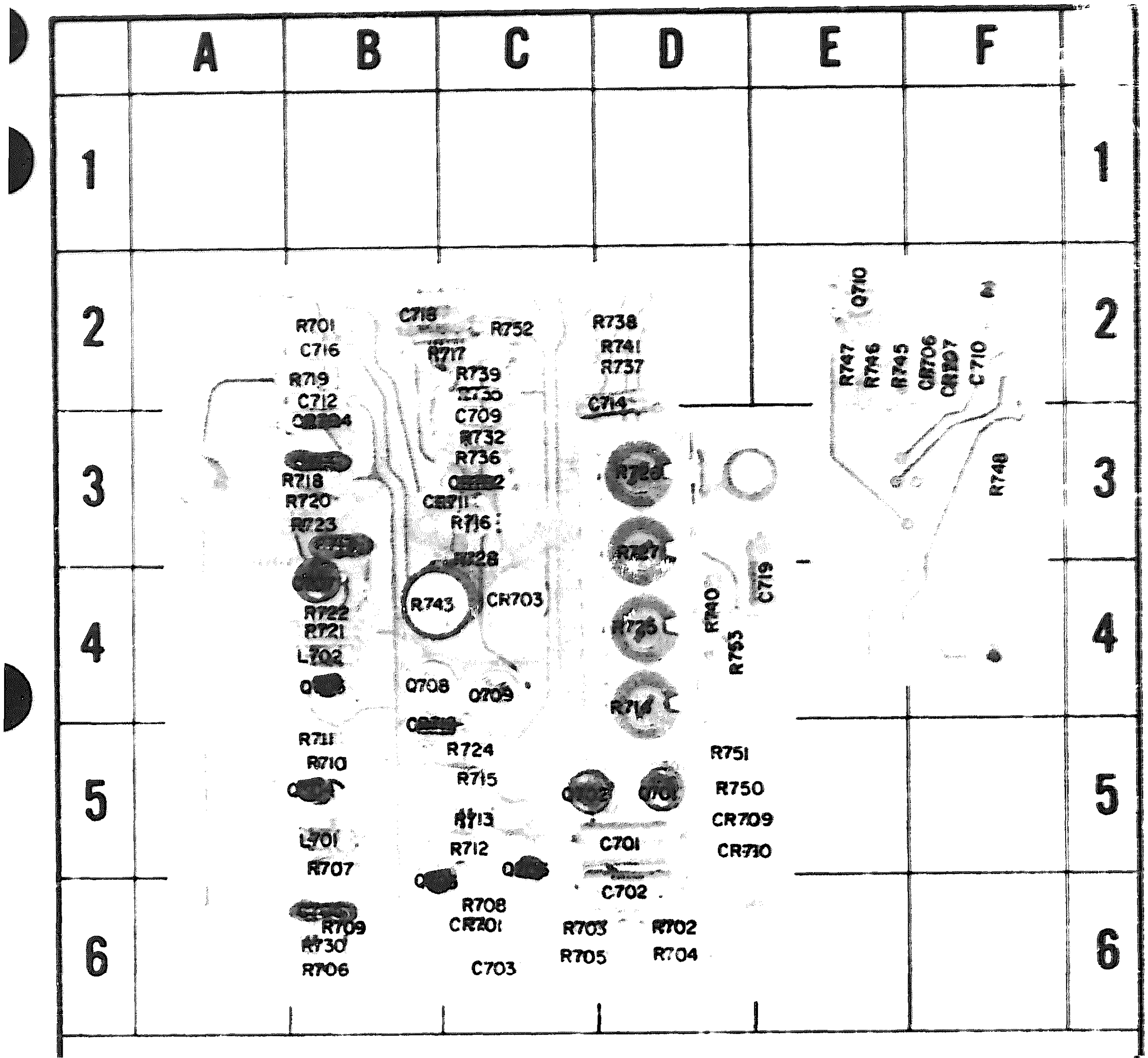
Figure 1-26. Component Identification, High Voltage Rectifier Deck and Board A601.



REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC
C601	C-2	R616	D-5	R633	B-3
C616	E-5	R617	D-3	R634	B-3
C621	C-3	R618	D-3	R642	C-2
C622	C-4	R619	B-1	R643	C-1
C623	D-5	R620	B-2	R644	D-2
CR602	E-5	R621	B-2	R645	D-2
CR603	E-4	R622	D-3	R651	C-5
CR605	D-1	R625	C-5	R652	C-5
Q601	E-1	R627	B-4	R653	C-2
R601	C-2	R628	B-4	V601	D-3
R605	E-2	R629	B-4	V606	C-3
R612	C-4	R630	B-4	VR607	D-4
R613	C-3	R631	B-3	VR608	D-5
R615	D-4	R632	B-3	VR609	D-4

141A-A-6A

Figure 1-27. Component Identification, High Voltage Regulator Board A602



REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC
C701	D-5	CR704	B-3	Q709	C-4	R715	C-5	R732	C-3
C702	D-6	CR709	D-5	R701	B-2	R716	C-3	R735	C-2
C703	C-6	CR710	D-5	R702	D-6	R717	C-2	R736	C-3
C705	B-6	CR711	B-3	R703	C-6	R718	B-3	R737	D-2
C709	C-3	CR712	B-5	R704	C-6	R719	B-2	R738	D-2
C712	B-2	L701	B-5	R705	C-6	R720	B-3	R739	C-2
C713	B-3	L702	B-4	R706	B-6	R721	B-4	R740	D-4
C714	D-2	Q701	D-5	R707	B-5	R722	B-4	R741	D-2
C715	B-2	Q702	C-5	R708	C-6	R723	B-3	R743	B-4
C717	B-3	Q703	B-6	R709	B-6	R724	C-5	R750	D-5
C718	B-2	Q704	B-5	R710	B-5	R725	D-4	R751	D-5
C719	E-4	Q705	B-4	R711	B-5	R726	D-3	R752	C-2
CR701	C-6	Q706	C-5	R712	C-5	R727	D-3	R753	D-4
CR702	C-3	Q707	B-4	R713	C-5	R728	C-3		
CR703	C-4	Q708	B-4	R714	D-4	R730	B-6		

REF DESIG	GRID LOC
C710	E-2
CR706	E-2
CR707	E-2
Q710	E-2
R745	E-2
R746	E-2
R747	E-2
R748	E-3

1414-A-8C

Figure 1-28. Component Identification. Pulse Board A701 and Clamp Board A704.

CONDITIONS FOR WAVEFORM MEASUREMENT

For numbers 1 thru 3 and 5 thru 8:

Model 141A;

Presentation Selector . . . . WRITE
PERSISTENCE . . . . fully ccw
WRITING RATE . . . . NORMAL
INTENSITY . . . . fully ccw

Test Oscilloscope;
SENSITIVITY . . . . 0.2 V/CM
SWEEP TIME . . . . 0.2 MS/CM

For number 4, same as 1 thru 3 and 5 thru 8 except:

Test Oscilloscope;
SENSITIVITY . . . . 0.5 V/CM

For number 9 same as 1 thru 3 and 5 thru 8 except:

Model 141A;

Presentation Selector . . . . STORE

Test Oscilloscope;
SENSITIVITY . . . . 0.1 V/CM
SWEEP TIME . . . . 0.1 MS/CM

For number 10 same as 9 except:

Test Oscilloscope;

SWEEP TIME . . . . 20 μS/CM

For number 11 same as 10 except:

Test Oscilloscope;

SENSITIVITY . . . . 2 V/CM

Note

The voltage levels given in the following waveforms are intended for reference only and may vary somewhat with the adjustment of the Model 141A.

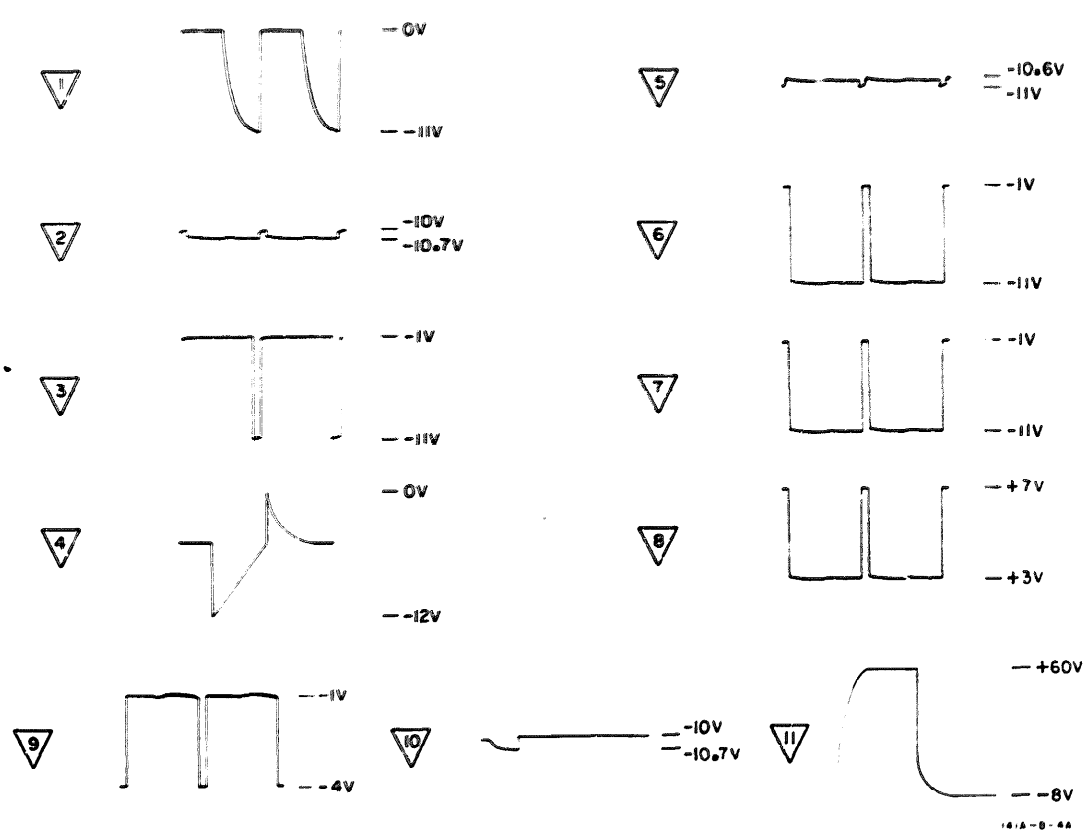


Figure 1-29. Waveforms

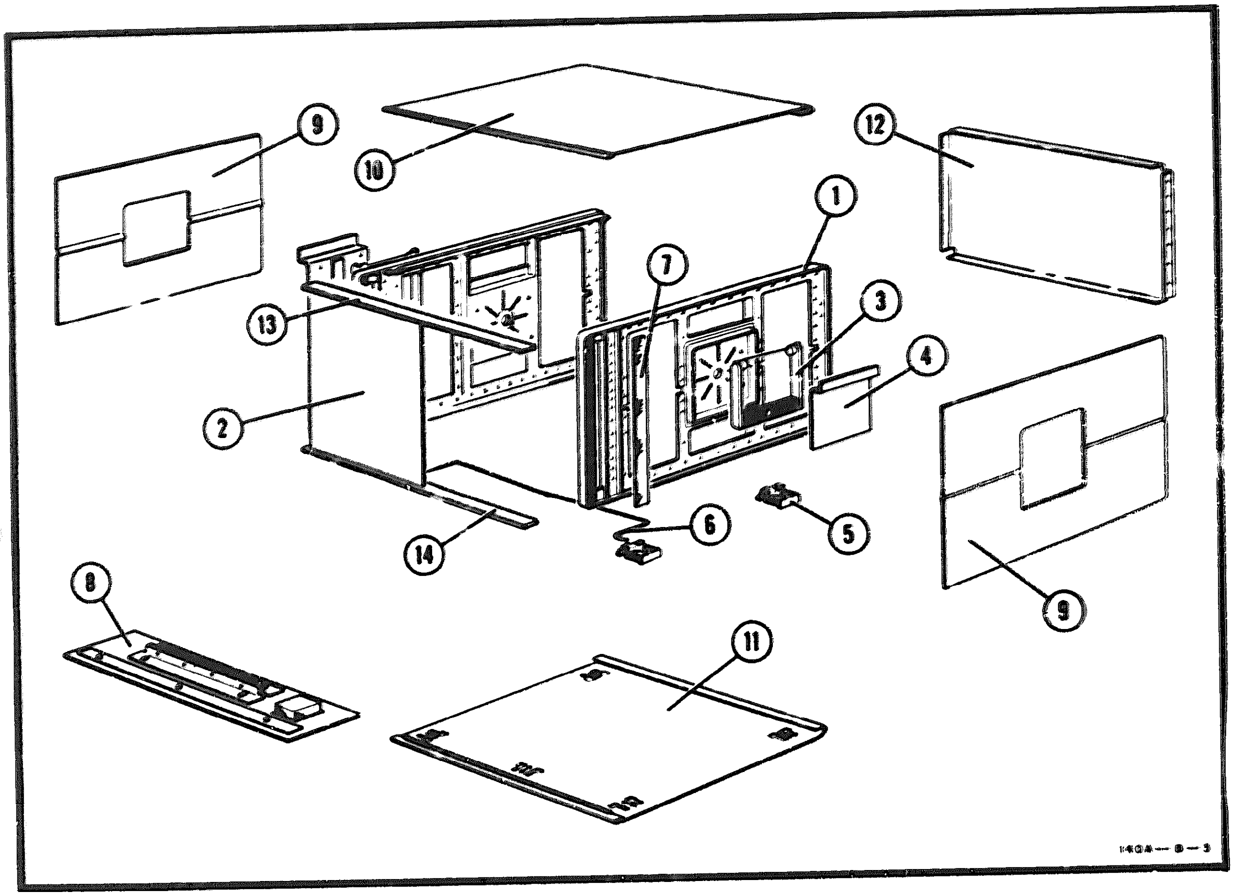


Figure 1-30. Cabinet Parts, Exploded view

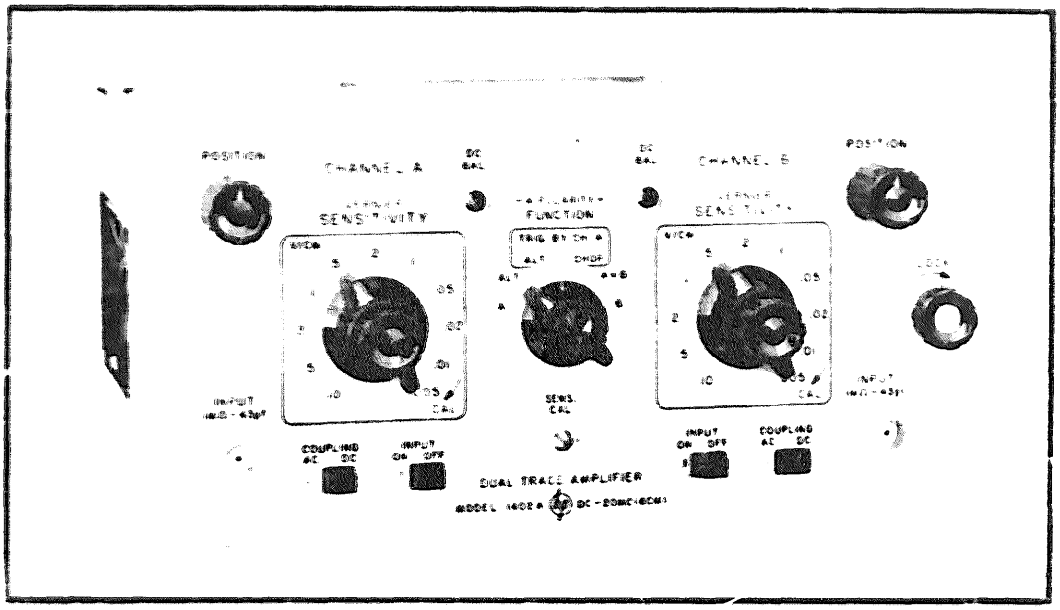


Figure 2-1. Model 1402A Dual Trace Amplifier

Table 2-1. Specifications

MODE OF OPERATION:

1. Channel A alone.
2. Channel B alone.
3. Channel A and Channel B displayed on alternate sweeps.
4. Channel A and Channel B displayed by switching at approximately 100 kc, with trace blanking during switching.
5. Channel A and Channel B added algebraically; polarity of Channel A may be inverted to obtain differential operation.

SENSITIVITY:
Each channel has sensitivities from 5 mv/cm to 10 v/cm in 11 calibrated ranges in a 1, 2, 5 sequence. Vernier allows continuous adjustment between calibrated ranges and extends minimum sensitivity to at least 25 v/cm. Attenuator accuracy ±3%.

BANDWIDTH: (6 cm reference signal)
DC coupled: dc to 20 mc.
AC coupled: 2 cps to 20 mc.
In a Model 143A Oscilloscope,
DC coupled: dc to 15 mc.
AC coupled: 2 cps to 15 mc.

RISE TIME: Less than 20 nsec with 6 cm step input.

SIGNAL DELAY:
Signal is delayed so that leading edge of fast rise signals is visible at start of sweep.

COMMON MODE REJECTION:
(In B-A mode). At least 40 db on 5, 10, and 20 mv/cm ranges, at least 30 db on 50 mv/cm to 10 v/cm. Sine wave common mode signal not to exceed 150 cm (e.g., 150 volts on 1 v/cm range) or a frequency of 500 kc.

INPUT IMPEDANCE: 1 megohm shunted by 43 pf.

MAXIMUM INPUT:
600 volts (dc + peak ac).

WEIGHT: Net, 6 lbs. (2,7 kg). Shipping, 8 lbs. (3,6 kg).

POWER: Supplied by oscilloscope.

CHAPTER 2

DUAL TRACE AMPLIFIER 1402A

SECTION I
GENERAL INFORMATION

2-1. DESCRIPTION.

a. The hp Model 1402A Dual Trace Amplifier, Fig. 2-1, is a 20-Mc DC-coupled amplifier plug-in unit which has been designed for use with hp Model 140-series oscilloscopes. It contains dual amplifying channels for amplification of two separate input signals, for a function control which determines the presentation of the signal on the screen of the oscilloscope cathode-ray tube. The amplified signals from the Model 1402A are applied directly to the deflection plates of the CRT. Power is supplied to the plug-in unit by the oscilloscope.

b. The Model 1402A provides the Model 140-series oscilloscopes with calibrated sensitives from a 5 millivolts per centimeter to 10 volts per centimeter. DC coupling is available at all sensitivities, with provision for AC coupling at the input. The Model 1402A Oscilloscope may be used in either the vertical or horizontal plug-in compartments of the Model 140A Oscilloscope, and sensitivity is the same horizontally as vertically. Front-panel gain adjustments are provided to calibrate the sensitivity for both amplifier channels. Frequency-compensated probes are available for use with the Model 1402A.

c. In dual tra e operation, the two signals are presented on the screen either on alternate sweeps of the time base (ALT) or alternately on the same sweep (CHOP) at a chopped rate of approximately 100 kc. Except for special cases such as single-shot high-speed phenomena, these two modes accomodate all dual-trace applications. Internal triggering uses the Channel A signal: optionally the combined signal may be selected for triggering in the ALTernate mode. In single trace operation, either one of the signals is presented while the opposite channel is switched off. Algebraic addition (A+B) presents the sum of the two input signals. Dual X-Y displays also are possible (see Figure 2-9).

2-2. PROBES.

Frequency- compensated probes are recommended for measuring in high impedance circuits, or for reducing signal voltage applied to the Model 1402A. The 10:1 Divider Probes, Model 10001A/B (30 Mc) and Model 10003A (50 Mc), provide an effective input impedance of 10 megohms shunted by 10 pf. The 50:1 Divider Probe, Model 10002A/B (30 Mc), provides an effective input impedance of 9 megohms shunted by 2.5 pf. The calibrator on the front panel of the oscilloscope provides a square wave which may be used for the probe compensation adjustment described in the Operating Note supplied with the probe.

SECTION II
INSTALLATION

2-3. INITIAL INSPECTION.

a. **Mechanical Check.** Check the instrument for external damage such as broken controls or connectors, and dents or scratches on the panel surfaces. If damage is evident, see Paragraph 1-A.3. If the shipping carton is not damaged, check the cushioning material and note any signs of severe stress as an indication of rough handling in transit. If the instrument appears undamaged, perform the electrical check given in the following paragraph.

b. Electrical Check. Check the electrical performance of the Model 1402A as soon as possible after receipt. Paragraph 2-18 contains performance check procedures which will verify instrument operation within the specifications listed in Table 2-1. This check is also suitable for incoming quality control inspection. If the Model 1402A does not perform within the specifications when received, refer to Paragraph 1-A.3.

2-4. REPACKAGING.

The original shipping carton and packing material, with the exception of the accordian-pleated pads, should be used for reshipment. The accordian-pleated pads are fatigued with one use and are not reusable. Materials used should include: (1)a double-walled carton (check with a freight carrier for test strength required), (2) heavy paper or sheets of cardboard to protect all instrument surfaces; use extra material around projecting parts of the instrument, (3) at least four inches of tightly-packed shock-absorbing material surrounding the instrument.

2-5. PREPARATION FOR USE.

The Model 1402A is an amplifier plug-in unit for the Model 140-series Oscilloscopes. In the Model 140A Oscilloscope the Model 1402A can be used in either plug-in compartment, but it is normally used as a vertical amplifier in the lower plug-in compartment, while the upper compartment is used for the sweep plug-in unit. To install the Model 1402A, slide the unit into the appropriate compartment in the oscilloscope front panel. Lock the plug-in in place to ensure good electrical and mechanical connection. All necessary power for the Model 1402A is supplied by the oscilloscope.

SECTION III

OPERATING INSTRUCTIONS

2-6. INTRODUCTION.

The Model 1402A Dual Trace Amplifier contains two amplifier channels, with provision for display of either or both signals on the cathode-ray tube of a Model 140-series oscilloscope. With the exception of FUNCTION, A POLARITY, and SENS CAL, all controls and inputs are duplicated: one set for Channel A at left, the other for Channel B at right. Figure 2-3 lists the functions of the controls and connectors.

2-7. OPERATING PROCEDURES.

Fig. 2-4 thru 2-9 give step-by-step operating instructions for the Model 1402A. These instructions are keyed to individual controls. Additional information on the various modes of presentation is given in Paragraph 2-8. The DC Balance and Sensitivity Calibration adjustments, Figures 2-4 & 2-5, are to be made before using the Model 1402A. Sensitivity calibration should be checked each time the Model 1402A is transferred from one compartment to the other, or from one oscilloscope to another. The Model 1402A may be used in either vertical or horizontal plug-in compartments of the Model 140A oscilloscope; however, chopped blanking takes place only when the Model 1402A is used in the lower (vertical) compartment.

2-8. MODES OF PRESENTATION.

a. SINGLE CHANNEL. Either Channel A or Channel B may be displayed by switching the FUNCTION control fully counterclockwise (A) or fully clockwise (B). In either position the unused channel is switched off, so that it is not necessary to disconnect input signal. When internal triggering is used, time base triggering is from the signal displayed.

b. ALTERNATE. In ALTernate operation, the Model 1402A connects the output of one channel to the CRT for the duration of one sweep, and the output of the other channel for the duration of the next sweep. Alternate operation is Intended for comparing signals which require fast sweep speeds. Although the sweep may be triggered by an external trigger signal which is synchronized with both vertical signals, internal triggering may be used. each sweep being triggered by the signal of the channel which is about to be presented. This mode is useful when two signals unrelated in time are to be displayed.

c. ALTERNATE. TRIG BY CH. A. This mode is similar to the alternate mode of operation described in subpara. b. except that internal sweep triggering is from the Channel A signal only. This method of triggering permits accurate time comparisons between the two signals.

d. CHOPPED. In CHOPped operation the Model 1402A switches channels at a rate of approximately 100 kc, so both signals appear during each sweep. Chopped operation is intended for comparing signals which require sweep speeds below about 50 microseconds per centimeter, that is, sweep speeds which are low compared to the 100-kc switching rate. This type of operation permits precise time comparisons because both signals are displayed on the same sweep. When internal triggering is used, the Channel A signal is used to trigger the time base. Switching transients are blanked when the Model 1402A is used in the vertical (lower) compartment of the Model 140A oscilloscope.

e. ALGEBRAIC ADDITION. In A+B operation, the sum of in-phase signals applied to Channels A and B is presented on screen; or, in the case of out-of-phase (differential) signals, the difference of the two signals is presented. Differential (B-A) operation is obtained by switching A POLARITY to negative (-). The B-A mode presents the sum of out-of-phase (differential) signals, or the difference of in-phase signals. Common-mode rejection may be improved by slight adjustment of one sensitivity VERNIER or the other to null the common-mode signal seen on the screen. Use only one VERNIER in order to maintain a calibrated display.

f. DUAL X-Y. Two independent X-Y displays may be presented on the CRT of the Model 140A Oscilloscope by using two Model 1402A plug-ins, or one Model 1402A and another 1400-series dual-trace vertical amplifier. Operating instructions are given in Figure 2-9. For X-Y measurement above 10 kc the delay line of the Model 1402A may cause phase-shift errors greater than 2° when used with a 1400-series plug-in that does not contain a delay line. Two Model 1402A's, however, are matched closely enough that less than 2° of phase shift beyond 100 kc is assured, and less than 3° to 1 Mc is typical.

g. If higher-frequency X-Y operation is desired, the following modification and adjustments must be performed.

(1) Disconnect the delay line in both both Model 1402A's.

(2) Connect a 10-20 ohm, 1/4 watt resistor between the L402,/R408 junction and L404/R415 junction in both Model 1402A's. Refer to Figure FO-7.

(3) Connect a 10-20 ohm, 1/4 watt resistor between the L401/R407 junction and L403/R411 junction in both Model 1402A's.

NOTE

Jumpering the amplifier leads with these resistors damps oscillation tendencies.

(4) Install the Model 1402A's in the Model 140A, and insert the same high-frequency signal into both units using Channel A or B functions.

(5) Adjust C433, C441, and C461 in the lower Model 1402A, as necessary, between the 1-10 Mc band for minimum phase shift on a 45° line display. C461 is dominant through the 1-4 Mc band, C441 from 4 to 8 Mc, and C433 above 8 Mc, although all three interact to some extent.

The maximum signal sizes to minimize distortion are 10 X 10 cm for signals below 10 Mc, and 6 X 6 cm (centered) for signals above 10 Mc. When these limits are observed, the 1402A X-Y operation may typically be less than 3° of phase shift or distortion through 20 Mc.

(6) When normal use of the Model 1402A's is again desired; remove the resistors installed above, and reconnect the delay lines. The Model 1402A in the upper compartment should still be calibrated. The Model 1402A in the lower compartment must be re-compensated for high frequency performance, using the procedure supplied in Paragraph 2-19.1.

2-9. BANDWIDTH.

The bandwidth specification of the Model 1402A is 20 megacycles, referenced to a low frequency display of 6 centimeters. Linearity is such that the 6-cm display may be positioned anywhere over the 10 x 10 cm area of the CRT graticule without significant distortion or loss of bandwidth. Fig. 2-2 illustrates a typical bandwidth curve. When used in a Model 143A Oscilloscope, the bandwidth specification is 15 mc.

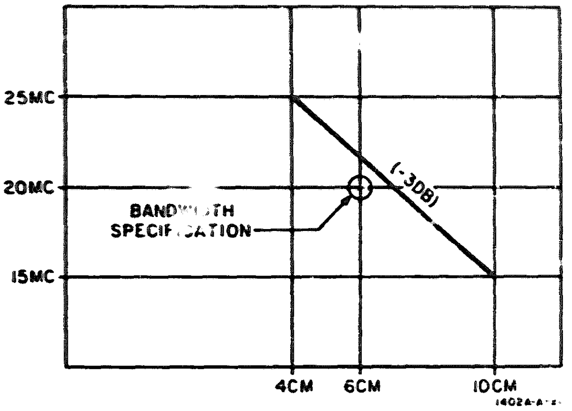
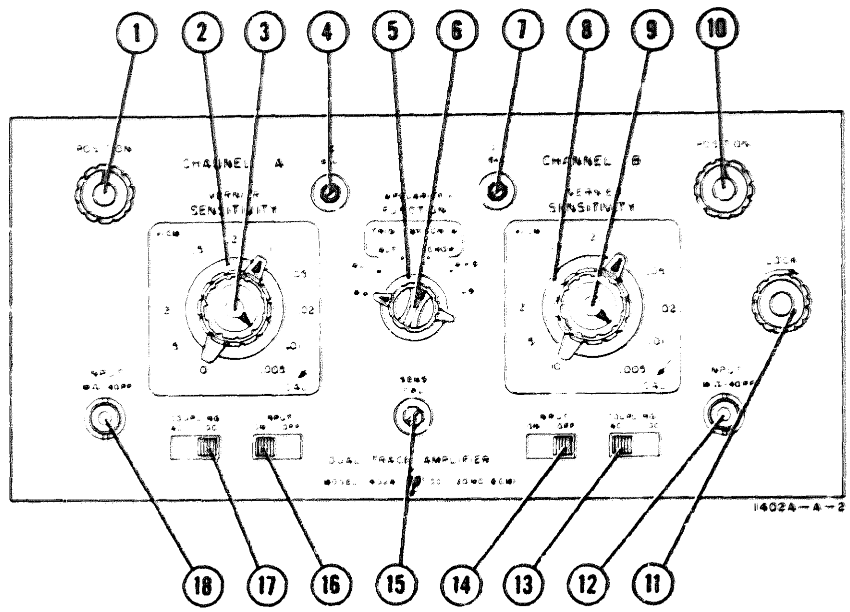


Figure 2-2. Model 1402A Bandwidth



1. Positions Channel A trace vertically on CRT.

2. Selects sensitivity of Channel A.

3. Provides continuous adjustment between steps of SENSITIVITY switch.

4. Balances Channel A amplifier to prevent vertical shift of trace when sensitivity is changed.

5. Selects signals displayed, mode of display, and signal (Channel A or combined) to be used for internal triggering.

6. Determines polarity of Channel A display.

7. Balances Channel B amplifier.

8. Selects sensitivity of Channel B.

9. Provides continuous adjustment between steps of SENSITIVITY.

10. Positions Channel B trace vertically on CRT.

11. Locks plug-in unit in place.

12. Signal input connector for Channel B.

13. Selects AC coupling or DC coupling at Channel B input.

14. Connects (ON) or disconnects (OFF) signal to Channel B.

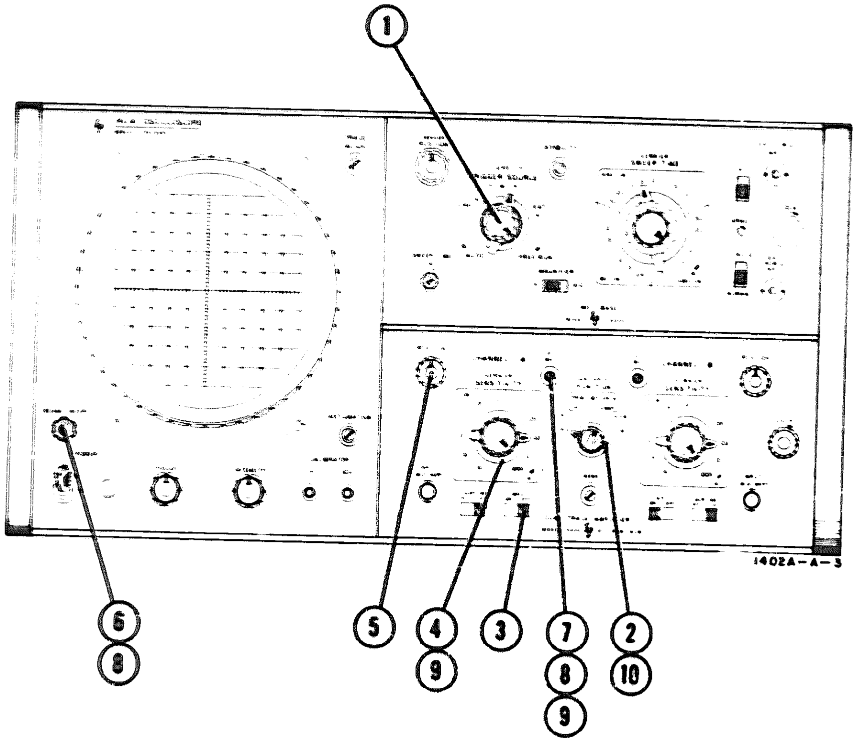
15. Calibrates sensitivity of the Model 1402A.

16. Connects or disconnects signal to Channel A.

17. Selects AC coupling or DC coupling at Channel A input.

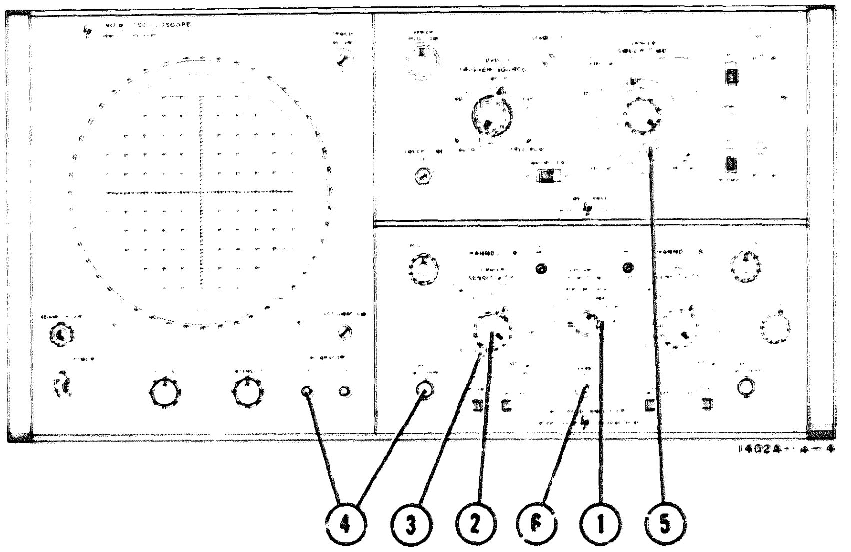
18. Signal input connector for Channel A.

Figure 2-3. Controls and Connectors



1. Set LEVEL to FREE RUN.
2. Select Channel A.
3. Set INPUT to OFF.
4. Set Channel A SENSITIVITY to .02 V/CM.
5. Center Channel A POSITION control.
6. Depress BEAM FINDER switch.
7. Adjust DC BAL to center trace.
8. Release BEAM FINDER and recenter trace with DC BAL.
9. Adjust DC BAL for no vertical shift as SENSITIVITY is varied between .02 V/CM and .005 V/CM.
10. Select Channel B and repeat steps 3 through 9, using corresponding Channel B controls.

Figure 2-4. DC Balance Adjustment



1. Select Channel A.

2. Set Channel A VERNIER to CAL.

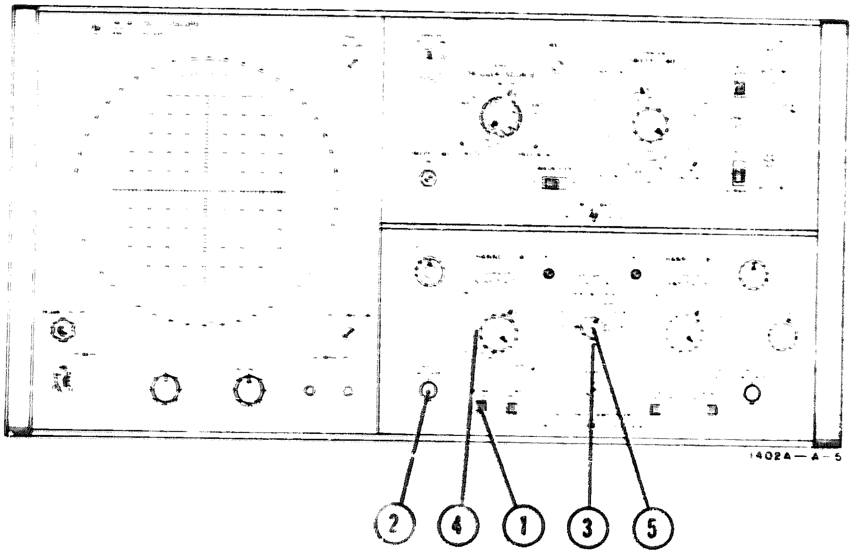
3. Set Cnannel A SENSITIVITY to .1 V CM.

4. Connect 1V CALIBRATOR to Channel A INPUT.

5. Set SWEEP TIME to display a convenient number of cycles.

6. Adjust SENS CAL for exactly 10 centimeters of vertical deflection.

Figure 2-5. Sensitivity Calibration



1. Set COUPLING to DC if DC coupling is desired, or to AC to block large DC components.

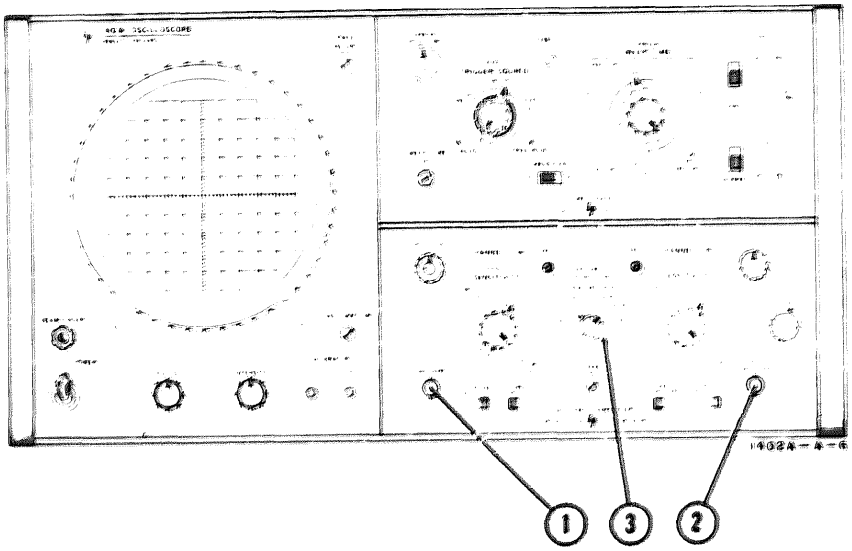
2. Connect signal to INPUT.

3. Select Channel A (or B).

4. Set SENSITIVITY to the desired range. For calibrated sensitivity, set VERNIER to CAL.

5. Set A POLARITY to (+) for normal positive-up presentation, or to (-) if inverted display is desired. (This control is effective for Channel A only.)

Figure 2-6. Single Channel Operation



1. Connect one signal to Channel A INPUT, and set Channel A controls as desired (procedure shown in Figure 2-6.).

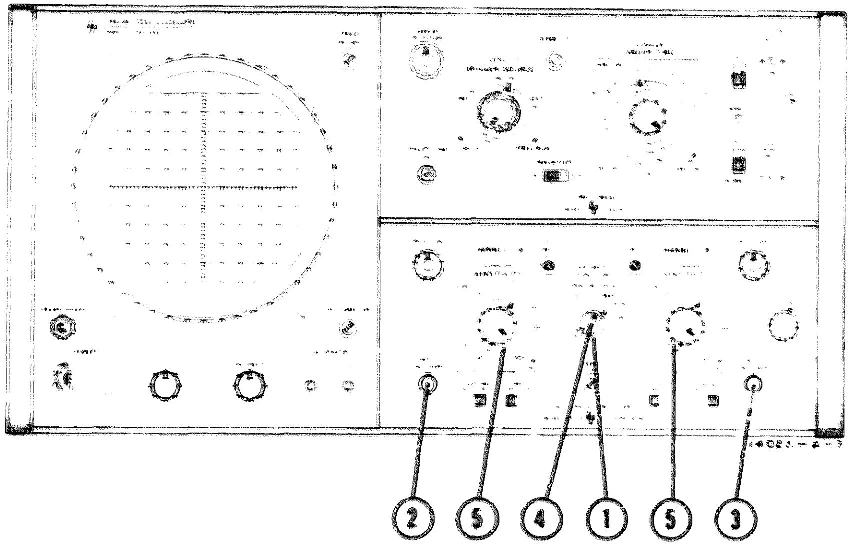
2. Connect second signal to Channel B INPUT and set Channel B controls as desired.

3. Select CHOP for display of both signals during the same sweep, or ALT for display of signal on alternate sweeps. (Chopped operation is suitable for slower sweep rates; alternate operation for fast sweep rates.)

Note

Internal triggering in the mode shown is on both channels (alternately); the next two clockwise positions of the FUNCTION control use the Channel A signal only.

Figure 2-7. Dual Trace Operation



1. Select A+B.

2. Connect one signal to Channel A INPUT.

3. Connect second signal to Channel B INPUT.

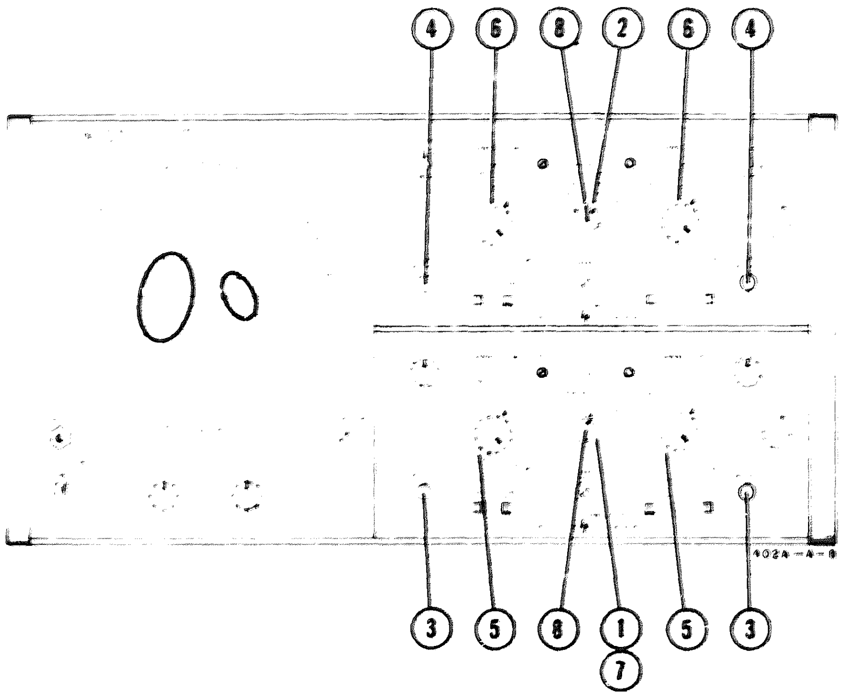
4. Set A POLARITY TO (+).

5. Set SENSITIVITY switches as desired, with identical settings for best results.

Note

Differential (B-A) operation is obtained by setting A POLARITY to (-) in Step 4.

Figure 2-8. Algebraic Addition



1. Set FUNCTION of vertical (lower) Model 1402A plug-in to CHOP.

2. Set FUNCTION of horizontal (upper) Model 1402A plug-in to ALT.

3. Connect Y (vertical) signals to Channel A INPUT and Channel B INPUT of vertical (lower) plug-in.

4. Connect X (horizontal) signals to Channel A INPUT and Channel B INPUT of horizontal (upper) plug-in.

5. Adjust vertical sensitivities for desired Y-deflection.

6. Adjust horizontal sensitivities for desired X-deflection.

7. If necessary, switch vertical (lower) FUNCTION control out of and into CHOP until desired comparison of X and Y signals is obtained (Channels A with A and B with B, or A with B and B with A). Use POSITION controls to identify which channels are being compared.

8. The A POLARITY switches can be used to reverse Channel A signals in both plug-ins.

Note

Two signals applied to a Model 1402A (set to CHOP) may also be compared with one signal applied to a single-channel plug-in in the other compartment.

Figure 2-9. Dual X-Y Operation For Two Independent Displays

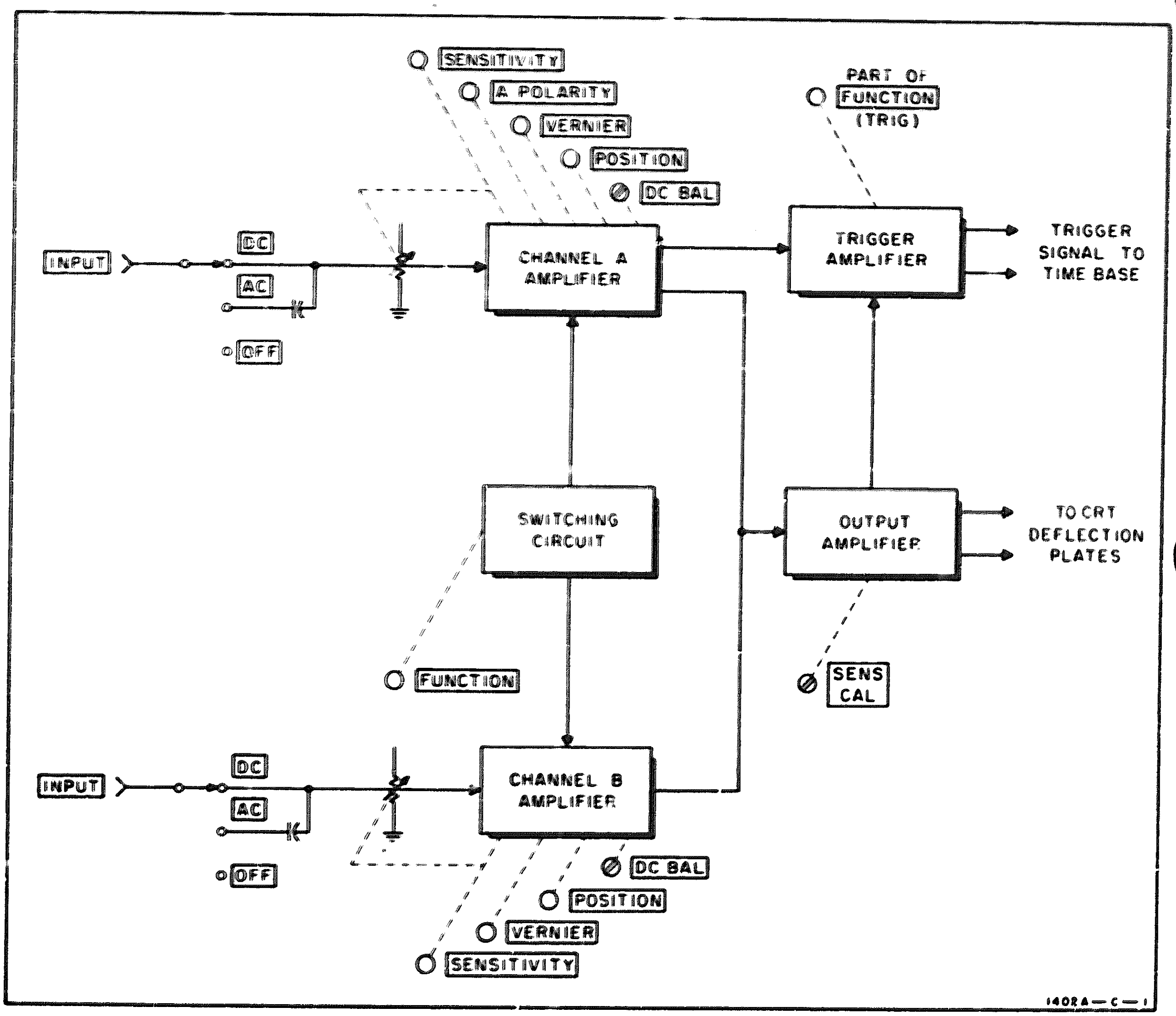


Figure 2-10. Model 1402A Block Diagram

SECTION IV

CIRCUIT DESCRIPTION

2-10. OVERALL DESCRIPTION.

The Model 1402A Dual Trace Amplifier contains five basic circuits: two independent differential amplifiers (Channels A and B), an output amplifier, a switching circuit, and a trigger amplifier. The relationship of these circuits is shown in the block diagram, Fig. 2-10. The input signal for each channel is DC-coupled or AC-coupled through an input attenuator to the amplifiers, or may be disconnected (OFF). No input attenuation is used on the three most sensitive ranges. With the exception that a polarity-reversing switch is provided for Channel A only, the two input amplifier channels are essentially identical. The switching circuit turns on either or both channels for one of the five modes of presentation selectable by the FUNCTION control (A, ALT, CHOP, A-B, or B). Signal from either or both Channel A and Channel B is applied to the differential output amplifier, which drives the deflection plates of the oscilloscope cathode-ray tube. A part of the FUNCTION switch is used to select either Channel A signal or the combined signal from the output amplifier for application to the trigger amplifier. The differential signal from the trigger amplifier is connected through the oscilloscope to a time base plug-in unit for sweep triggering. The single sensitivity calibration control, SENS CAL, is located in the output amplifier; the two input channels do not require separate front-panel gain adjustments, since these circuits are very insensitive to aging and temperature effects.

2-11. CIRCUIT DETAILS.

Refer to Fig. FO-4 thru FO-8 for the following circuit descriptions. Channel B operation is similar to Channel A, except as noted in the Channel A description.

2-12. CHANNEL A.

The signal is AC- or DC-coupled through S101A and S101B to the input attenuator. On the two most sensitive settings of the attenuator, two switch wafers are used to bypass the attenuator sections, and the change of sensitivity is accomplished in the amplifier. The next (.02) position also uses no input attenuation. The remaining less sensitive ranges switch in one or two of the four attenuator networks, which provide attenuation ratios of 2.5:1 (R111, R112), 5:1 (R113, R114), 10:1 (R101, R102), 100:1 (R103, R104). Variable capacitors in these networks are adjusted to maintain these ratios for high frequencies by capacitive division.

Input overload protection is provided by R120, V102, and CR101. DC BAL control R140 adjusts the DC level in the lower half of the amplifier, so that with no input signal the emitters of Q103 and Q104 will be at the same voltage. Thus when amplifier gain is changed (by operating SENSITIVITY control), the position of the trace will not shift. The VERNIER control R149, when rotated counterclockwise, reduces signal amplitude by shunting signal around the bases of Q103 and Q104. R150C calibrates amplifier gain for all ranges of SENSITIVITY except .01 and .005, which are calibrated (after R150C is correctly set) by R150A and R150B respectively. The output of differential amplifier Q103, Q104 can be reversed in Channel A by S103. POSITION control R170A, B varies the DC level at the output of the Channel A circuit for positioning of the display on the CRT. Signal is coupled through switching diodes CR110 and CR113 (when these diodes are switched on) to the output amplifier.

2-13. SWITCHING CIRCUIT.

The switching circuit consists of a blocking oscillator, a blanking pulse amplifier, and a multivibrator. The switching circuit applies either cutoff bias or conducting bias to the switching diodes at the output of each amplifier channel (CR110 through CR113, and CR210 through CR213) and thus determines which channel is on at a given time. Fig. 2-11 is a simplified diagram of the switching circuit.

a. BLOCKING OSCILLATOR. Depending on the position of FUNCTION switch S301, Blocking Oscillator Q301 can be astable, monostable, or disabled. When the emitter of Q301 is returned through R307 to the -100 volt supply (CHOP function), the circuit is permitted to oscillate with a free-running frequency of about 200 kilocycles. The positive-going voltage at the collector is coupled through C321 to switch the multivibrator; since the multivibrator must switch twice for a full cycle, multivibrator frequency is 100 kc. When the emitter of Q301 is returned to ground (ALT function), the circuit is biased off in a monostable condition and will produce a pulse each time the negative-going gate signal is received through C301 and CR301. Thus in the ALTernate mode, the multivibrator switches once for each sweep of the time base. Opening the emitter lead in the A, A-B, and B positions disables the circuit for these functions.

b. BLANKING PULSE AMPLIFIER. The positive-going portion of the pulse from the blocking oscillator has no effect on Q302; the negative backswing, however, turns this transistor on, producing a positive pulse which blanks the CRT beam. Transients caused by switching in the CHOPped mode thus do not appear on the CRT screen. The time period between the start of the blocking oscillator pulse and the negative-going backswing is about 200 nanoseconds, which corresponds to the signal delay introduced in the output amplifier. Thus blanking starts at the same time as any transient which may appear. CR303 is reverse-biased in CHOP mode, but in all other positions is forward-biased to ground undesirable blanking transients.

c. MULTIVIBRATOR. Transistors Q303 and Q304 are connected in a bistable multivibrator circuit. Depending on the position of the FUNCTION switch the multivibrator may be switched by positive triggers from Blocking Oscillator Q301 (ALT or CHOP), locked in either of its two stable states (A or B), or disabled (A+B). Fig. 2-11 illustrates signal conditions for ALTernate operation at a time when Q303 has been switched on (output more negative) and Q304 has been cut off (output more positive). With these output voltages, CR111 and CR112 are forward-biased, which shorts Channel A signal. The current of Channel A output transistors Q103 and Q104 flows through Q303 of the multivibrator. Diodes CR110 and CR113 are reverse-biased, which disconnects Channel A output from the output amplifier. Channel A is therefore "off". In Channel B, diodes CR211 and CR212 are biased off and CR210 and CR213 are foward-biased, which permits signal from Channel B output transistors Q203 and Q204 to be coupled to the output amplifier. Channel B is therefore "on". When the next sweep starts, a positive trigger from Q301 reverses the states of Q303 (off) and Q304 (on). This reverse-biases the four diodes which were on (CR111, CR112, CR210, and CR213), and forward-biases those which were off (CR110, CR113, CR211, and CR212). Thus Channel A is switched on and Channel B is switched off, and for each following successive sweep, the two channels will be switched alternately on and off. In CHOP mode, the channels are switched at a 100-kc rate, as determined by the free-running rate of the blocking oscillator. In the A position of the FUNCTION switch, -12.6 volts is applied through R332 to CR211 and CR212, which forward-biases these diodes and reverse-biases CR210 and CR213. The multivibrator is disabled by R334 which limits current available to Q303 and Q304, and the output of Q303 is near ground (less negative than when conducting). Diodes CR111 and CR112 are therefore reverse-biased, and Channel A signal is coupled through CR110

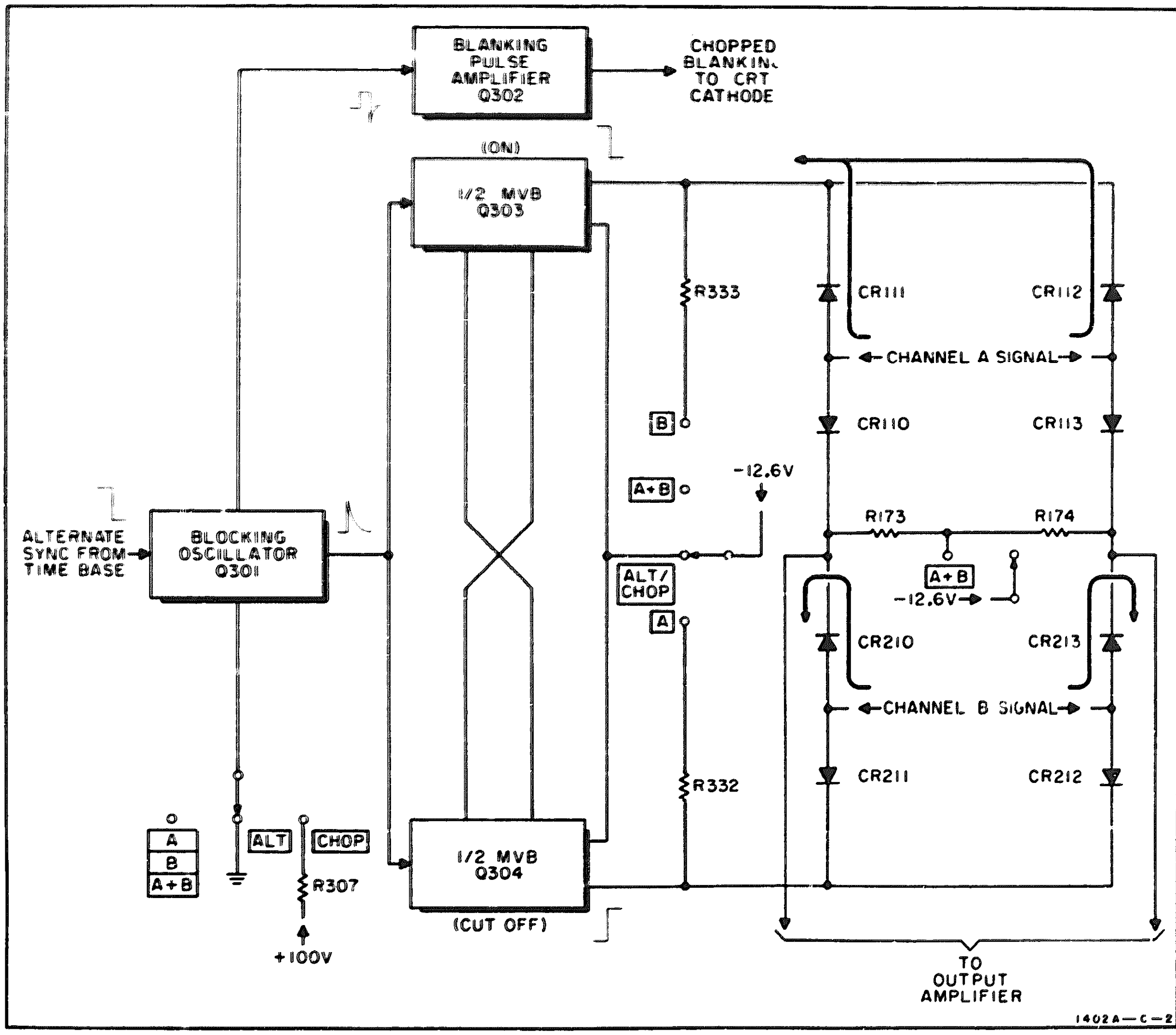


Figure 2-11. Switching Circuit Simplified

and CR113 to the output amplifier. In the B position of the FUNCTION switch, the reverse situation holds true, with -12.6 volts being applied through R333. In the A-B mode the multivibrator is also held inoperative by R334, and -12.6 volts is applied to the junction of R173 and R174, which forward-biases CR110 CR113, CR210, and CR213 while reverse-biasing CR111, CR112, CR211, and CR212. The signals of both channels are thus added and applied to the output amplifier.

2-14. OUTPUT AMPLIFIER.

Signals from Channel A or Channel B (or both in A-B mode) are amplified by common base amplifiers Q401 Q402 and are applied to delay lines DL401 and DL402. The purpose of the delay introduced by these lines is to permit starting of the sweep trace in advance of the display of a vertical signal. Thus if a fast-rise vertical signal is also used to trigger the sweep, the entire pulse rise will be displayed on the CRT screen. Trigger pickoff is ahead of the delay lines, at the junctions of R401 R402 and R405 R406. Position Adjustment R409 sets DC levels to be the same in both halves of the output amplifier. Adjustment is made by centering the trace with no DC differential input to Q401 Q402. SENS CAL control R423 adjusts signal degeneration between the bases of Q405 and Q406, and is set for calibrated sensitivity of the Model 1402A. High-frequency adjustments C433, C441, and C461 adjust high-frequency gain in the third, fourth, and sixth stages respectively. Each of the three adjustments provides frequency compensation of a different time constant, and the adjustment having the longest time constant, C461, should be adjusted first. Diodes CR451, CR452, CR461, and CR462 are normally reverse-biased, and provide voltage overload protection for V401A B, V402, and V403 by clamping the cathodes of these tubes to -12.6 volts. Output Plate Voltage adjustment R460 adjusts the voltage applied to the deflection plates for optimum focus operation of the CRT. The BEAM FINDER switch, located on the oscilloscope front panel, reduces current available to output tubes V402 and V403 by allowing R474 to be inserted in series with the cathode supply. With stage current thus reduced, the difference in CRT deflection plate voltages will be small enough to locate the trace on screen, regardless of signal amplitude or the setting of POSITION controls.

2-15. TRIGGER AMPLIFIER.

Differential signal from Channel A is applied to Q501 and Q502, and differential signal from the output amplifier (which may be either Channel A or Channel B signal, or both) is applied to Q503 and Q504. A part of FUNCTION switch S301 selects either one of these trigger sources (Channel A only for the two dual trace functions designated TRIG BY CH. A, or the combined signal for the four remaining positions) and the signal is AC-coupled through C511 and C512 to differential amplifier Q505, Q506. Slightly less sensitive triggering may be noted on TRIG BY CH. A ALT when using the 5 and 20 millivolt settings of the SENSITIVITY control. Sync Bal adjustment R514 balances the differential signal applied to the time base. The output of the second differential amplifier, Q507 Q508 is applied through emitter followers Q509 and Q510 to the time base plug-in. Diode CR541 is reverse-biased in all function positions except CHOP, effectively disconnecting C541 and C542. In CHOP position CR541 is forward-biased, which places C541 and C542 across the output of Q507 and Q508. This reduces the bandwidth of the stage and prevents switching transients from being applied to the time base triggering circuit. Extended bandwidth is not required in the CHOP mode since this type of display is suitable only for vertical signals considerably below the 100-kc chopping rate The calibrator voltage divider, shown on the trigger amplifier schematic, divides the 1-volt line-frequency calibrator voltage to calibrated voltages of 120 millivolts, 60 millivolts, and 30 millivolts. These voltages are available at terminal posts on the trigger amplifier board for use in checking sensitivity calibration (see para. 2-19.g. for recommended procedure in making sensitivity adjustment).

2-16. DUAL X-Y SWITCHING.

When two Model 1402A amplifiers are used for dual X-Y measurements, the vertical plug-in (lower compartment of the Model 140A) is used in CHOP MODE. The frequency of the blocking oscillator in this plug-in (about 200 kc) determines the switching rate of both units, and provides chopped blanking to the CRT in the oscilloscope. The blocking oscillator waveform is applied through the oscilloscope to the base of the blocking oscillator in the horizontal plug-in. The horizontal plug-in (upper compartment of the Model 140A) is used in ALT mode, and since the blocking oscillator is in the monostable condition, it is triggered by the 200-kc switching waveform received from the vertical plug-in, and thus switches at the same rate. Because the multivibrators in the two Model 1402A's will not always be in the same state when the first chopping pulse is received, the selection of channels for X-Y comparison is random (not selectable from the front panel). However, by operating the FUNCTION switch of the vertical plug-in out of and into CHOP a few times, the desired X and Y channels can be caused to switch on together, thus permitting comparison of Channel A with A and B with B, or A with B and B with A.

Table 2-2. Equipment Required For Test and Adjustments

Instrument Type	Recommended Model	Required Characteristics	Required for	Ref Para
1. Signal Generator	Textronix Type 190	Frequency 50 kc to 20 Mc; output 1v - 2v	Common-Mode Rejection Check; Bandwidth Check	2-18.c 2-18.e
2. Voltmeter Calibrator	hp 738AR	AC output 50 mv to 100 v p-p; accuracy ±0.5%	Sensitivity Check	2-18.d.
3. Pulse Generator	Tektronix Type 107	Output 250 mv; rise time less than 5 ns; frequency 400 kc	Rise Time Check; High Frequency Adjustment	2-18.f. 2-19.i.
4. Square Wave Generator	hp 211A	Frequency 10 kc; output 0.2 v	Attenuator Compensation Adjustment	2-19.[illegible].
5. DC Voltmeter	hp 412A	Full-scale range 1v, 100 v; accuracy 1%; floating common lead	DC Level Adjustment; Trigger Amplifier Balance Adjustment	2-19.f. 2-19.j.
6. Audio Oscillator	hp 200CD	Output 3v p-p; frequency 400 cps	Sensitivity Adjustment	2-19.g.
7. L-C Meter	Tektronix Type 130	To indicate 43 pf	Input Capacity Adjustment	2-19.h.

SECTION V

MAINTENANCE

2-17. INTRODUCTION.

This section covers maintenance, troubleshooting, and adjustment of the Model 1402A Dual Trace Amplifier. The performance check Paragraph 2-18) may be used at incoming inspection or after adjustments have been made to verify that the instrument meets its specifications (Table 2-1).

2-18. PERFORMANCE CHECK.

The performance check is intended to determine whether or not the instrument is operating within its specifications. If adjustment is required, refer to Para. 2-19. To check calibrator accuracy and other specifications for the oscilloscope, refer to the oscilloscope manual.

a. TEST EQUIPMENT.

Test equipment recommended for the performance check is listed in Table2-2, items 1 through 3. Similar instruments having the listed characteristics may be substituted.

b. PROCEDURE.

Install the Model 1402A in the desired plug-in compartment of an ℎ Model 140-series oscilloscope, depending on whether the plug-in is intended for use as a horizontal or a vertical amplifier. In the following performance check procedure it is assumed that the lower (vertical) compartment of the Model 140A is being used to test the Model 1402A.

c. COMMON-MODE REJECTION.

(1) Set: FUNCTION . . . . ALT
A POLARITY . . . . (-)
VERNIER (both) . . . . CAL
Channel A and B SENSITIVITY . . 0.2

(2) Apply a 500 kilocycle signal from the Signal Generator (see Table 5-1) to both Channel A and Channel B INPUT connectors.

(3) Adjust Signal Generator output for 10-cm display on both traces.

(4) Set: FUNCTION . . . . A+B
Channel A and B SENSITIVITY . . . 0.02

(5) Display height should not be greater than 1 centimeter.

(6) Set Channel A and B SENSITIVITY to .01.

(7) Display height should not be greater than 2 centimeters.

(8) Set: FUNCTION . . . . ALT
Channel A and B SENSITIVITY . . . 0.1

(9) Adjust Signal Generator output for 10-cm display on both traces.

(10) Set: FUNCTION . . . . A+B
Channel A and B SENSITIVITY . . . 0.005

(11) Display height should not be greater than 2 centimeters.

d. SENSITIVITY.

(1) Set: FUNCTION . . . . A
SENSITIVITY (A) 0.02
VERNIER (A) . . . . CAL

(2) Connect Voltmeter Calibrator output to Channel A INPUT.

(3) Check all SENSITIVITY ranges by setting Voltmeter Calibrator and SENSITIVITY controls as shown in Table 2-3. Vertical deflection in each case should be 10 cm ±0.3 cm.

(4) Repeat Steps (1)thru(3) for Channel B.

Table 2-3. Sensitivity Check

SENSITIVITY	Calibrator Output
10 V/CM	100 VOLTS
5	50
2	20
1	10
.5	5
.2	2
.1	1
.05	.5
.02	.2
.01	.1
.005	.05

e. BANDWIDTH.

(1) Set: FUNCTION . . . . A
SENSITIVITY (A) 0.005
VERNIER (A) . . . . CAL

(2) Apply a 1 Mc signal from Signal Generator to Channel A INPUT. Use a 50-ohm load across output of Signal Generator.

(3) Adjust Signal Generator amplitude for 6 cm deflection.

(4) Change freq. to 20 Mc(in Model 143A change freq. to 15 Mc). Vertical deflection should be 4.2 cm or greater.

(5) Repeat Steps (1)thru(4) for Channel B.

Note

When a Model 1402A is installed for the first time in a Model 140A Oscilloscope with a serial prefix of 407-, 413-, 425-, or 437-, proceed as follows to obtain full bandwidth and rise time.

(a) Remove variable capacitor C1 from the Model 140A.

(b) Readjust C461 in Model 1402A for optimum flat top on pulse.

f. RISE TIME.

(1) Connect Pulse Generator to Channel A INPUT. Attach a 50-ohm load across output of Pulse Generator.

(2) Set: FUNCTION . . . . A
SENSITIVITY (A) 0.02
VERNIER . . . . CAL
SWEEP TIME . . . . 0.5 USEC/CM
Sweep MAGNIFIER X10

(3) Obtain a 5-cm step. Rise time from 10% to 90% points on pulse should be less than 18 nanoseconds.

Note

When a Model 1402A is installed for the first time in a Model 140A Oscilloscope with a serial prefix of 407-, 413-, 425-, or 437-, proceed as follows to obtain full bandwidth and rise time.

(a) Remove variable capacitor C1 from the Model 140A

(b) Readjust C461 in Model 1402A for optimum flat top on pulse.

2-19. ADJUSTMENTS.

Subpara. c. thru j give the adjustment procedure for the Model 1402A. If difficulty is encountered in making any adjustment, refer to Paragraph 2-20 for troubleshooting procedures.

a. EQUIPMENT NEEDED FOR ADJUSTMENTS. Test equipment recommended for the adjustment procedure is listed in Table 2-2, items 3 through 7. Similar instruments having the listed characteristics may be substituted.

b. LOCATION OF ADJUSTMENTS. Figure 2-12 shows the location of all internal adjustments in the Model 1402A.

c. PRELIMINARY PROCEDURE.

Install the Model 1402A in the lower compartment of the oscilloscope. If a Model 140A Oscilloscope is used, install another plug-in, preferably a time base such as the Model 1420A or Model 1421A, in the upper compartment. Turn on the instrument and allow several minutes for warmup.

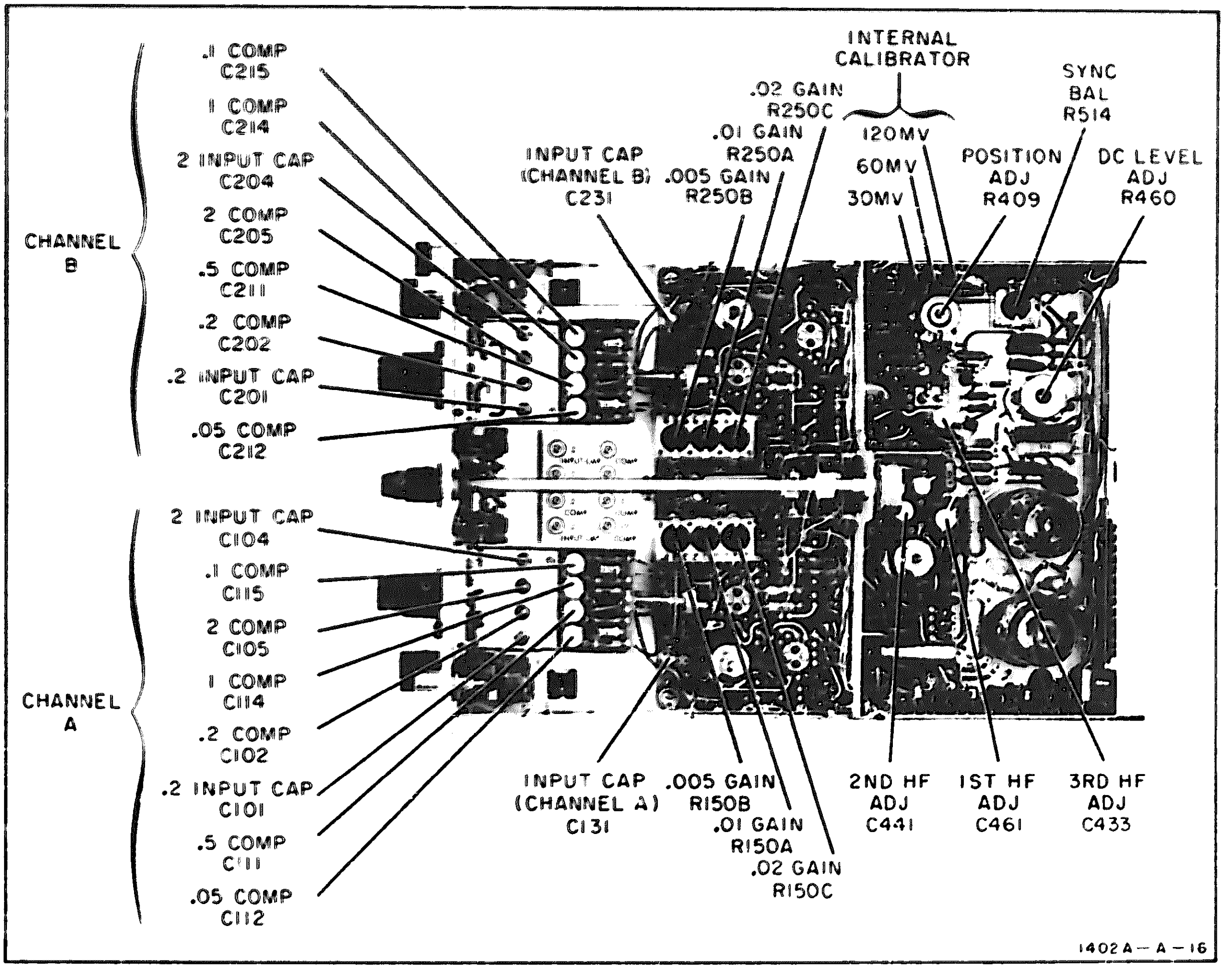


Figure 2-12. Location of Adjustments

d. DC BALANCE ADJUSTMENT.

Adjust DC BAL to eliminate trace shift when SENSITIVITY is switched between .005 V/CM and .02 V/CM. Perform for both channels.

e. POSITION ADJUSTMENT.

(1) Set: FUNCTION . . . . CHOP
POSITION controls . . . . . . 12 O'clock

(2) Center both traces about center of screen with Position Adj R409.

f. DC LEVEL ADJUSTMENT.

(1) Short the plates of V402 and V403 together and measure the voltage between this short and the +250 volt supply. This may be done by clipping one voltmeter lead to pins 12 and 24 (together) of P1, the 24-pin connector in the Model 140A, and the other voltmeter lead to the +250 volt supply.

(2) Set the voltage to 79 volts with DC Level Adj R460.

g. SENSITIVITY ADJUSTMENT.

(1) Set: SENSITIVITY . . . . 0.02 V/CM
VERNIER . . . . CAL
INPUT (Channel A) . . . . ON
INPUT (Channel B) . . . . OFF

(2) Connect 0.1v p-p signal from Voltmeter Calibrator to Channel A INPUT.

(3) Turn SENS CAL completely clockwise.

(4) Set .02 Gain adjustment for about 6 cm deflection.

(5) Adjust SENS CAL for exactly 5 cm. deflection.

(6) Change signal input to 0.2v p-p and readjust SENS CAL for 10 cm deflection. Change signal input to 0.1v p-p.

(7) Set SENSITIVITY to .01 V/CM.

(8) Set .01 Gain adjustment for 10 cm deflection.

(9) Change signal input to 0.05v p-p.

(10) Set SENSITIVITY to .005 V/CM.

(11) Set .005 Gain adjustment for 10 cm deflection.

(12) Set: FUNCTION . . . . A-B
A POLARITY . . . . (-)
A&B SENSITIVITY . . . . . . .02 V/CM
INPUT (Channel B) . . . . ON

(13) Apply 3v p-p 400 cps sine wave to both Channel A&B inputs.

(14) Adjust Channel B .02 Gain adjustment for minimum deflection.

(15) Change sine wave amplitude to 2v p-p.

(16) Set SENSITIVITY to .01 V/CM.

(17) Set Channel B .01 Gain adjustment for minimum deflection.

(18) Change sine wave amplitude to 1v p-p.

(19) Set SENSITIVITY to .005 V/CM.

(20) Set Channel B .005 Gain adjustment for minimum deflection.

h. INPUT CAPACITY AND ATTENUATOR COMPENSATION ADJUSTMENT.

Note

Adjustments are given for Channel A with corresponding Channel B adjustments in parentheses, e.g. C131 (231). Perform adjustments for Channel A, then repeat for Channel B when instructed.

(1) Set SENSITIVITY to .02 V/CM.

(2) Connect L-C Meter to Channel A INPUT and adjust C131 (231) for 43 pf. Repeat for Channel B.

(3) Apply 10 kc square wave to Channel A INPUT. Obtain a pattern 10 cm high, and make the adjustments indicated in Table 2-4. Repeat for Channel B.

(4) Connect L-C Meter to Channel A INPUT and adjust C101 (C201) with SENSITIVITY at .2, and C104 (C204) with SENSITIVITY at 2 for 43 pf.

Table 2-4. Attenuator Adjustment

SENSITIVITY (V/CM)	Capacitor
.05	C112 (212)
.1	C115 (215)
.2	C102 (202)
.5	C111 (211)
1	C114 (214)
2	C105 (205)

i. HIGH FREQUENCY ADJUSTMENTS.

(1) Set: SENSITIVITY (A) . . . . 0.02 V/CM
VERNIER (A) . . . . CAL
FUNCTION . . . . A

(2) Connect 400 kc Pulse Generator signal to Channel A INPUT through 50-ohm termination.

(3) Obtain a 6 cm deflection and adjust C461, C441, and C433 for optimum flat top on pulse.

Note

When a Model 1402A is installed for the first time in a Model 140A Oscilloscope with a serial prefix of 407-, 413-, 425-, or 437-, proceed as follows to obtain full bandwidth and rise time.
(a) Remove variable capacitor C1 from the Model 140A.
(b) Readjust C461 in Model 1402A for optimum flat top on pulse.

j. TRIGGER AMPLIFIER BALANCE.

(1) Measure the DC voltage between the output leads of the trigger amplifier. This may be done at the ends of R551 and R552 which are connected to the black and white coax leads.

(2) Set this voltage to zero with Sync Bal adjustment R514. Should be 0 ±.5 volt.

Table 2-5. Troubleshooting for Unbalance

OUTPUT AMPLIFIER			
Step	Short Together	Effect	Common Fault (or Procedure)
1	Pins 3 and 8 of V401	Trace centers	Proceed to next step
		Trace does not center	V402, or V403, or CR461 or CR462
2	Pins 2 and 7 of V401	Trace centers	Proceed to next step
		Trace does not center	V401 or CR451 or CR452
3	Junction of R431 and Q405 Collector to Junction of R436 and Q406 Collector	Trace centers	Proceed to next step
		Trace does not center	Q407 or Q408
4	Junction of R421 and R422 to Junction of R425 and R424	Trace centers	Proceed to next step
		Trace does not center	Q405 or Q406
5	Junction of R411 and L405 to Junction of R415 and L406	Trace centers	Proceed to next step
		Trace does not center	Q403 or Q404
INPUT AMPLIFIERS			
6	Base of Q103 to Base of Q104 (Center both POSITION controls)	Trace Centers	Proceed to next step
		If the trace does not center on one channel, check the other channel before making a component replacement. If only one channel checks normal, the "Common Fault" is then one of the transistors (Q103/Q104 or Q203/Q204) in the channel where the trace does not center. If the trace fails to center on both channels the trouble may be one of the following: (1) either (or both) matched transistor pair (Q103/Q104 or Q203/Q204), or (2) incorrect switching circuit levels (see Table 2-7) or (3) the common-base stage, Q401/Q402, in the output amplifier.	
7	Base of Q101 to Base of Q102	Trace centers	Proceed to next step
		Trace does not center	Q101 or Q102
8	Junction of R132 and V102 to Pin 7 of V101	Trace centers	R140
		Trace does not center	V101, or CR101, or CR102

NOTE: Steps 6 through 8 may be used for Channel B: reference designations are 200-series

2-20. TROUBLESHOOTING.

The following paragraphs outline procedures for locating and clearing problems in the Model 1402A. Be sure that the trouble cannot be cleared by making an adjustment.

a. LOW AMPLIFIER GAIN. Whenever overall gain is too low to be adjusted properly with the SENS CAL control, waveforms for the Model 140A 10V CALIBRATOR signal are provided for troubleshooting. To locate the trouble, trace the calibrator signal from the input through each successive stage, using the test points and waveforms (1 through 11), until the faulty stage is located. Switching from Channel A to Channel B will aid in determining whether the trouble is in the output amplifier or one of the input amplifiers.

b. UNBALANCE. Unbalance in a differential amplifier is generally caused by malfunction of a component(s) on one side of stage of the amplifier and

Table 2-6. Switching Troubleshooting

SWITCHING CONDITIONS		TROUBLESHOOTING PROCEDURE		
Operates	Does Not Operate	Check	Condition	Repair Procedure
Chop, Alt	A, B, or A+ B	DC Voltages at Test Points 20 and 21 (see Table 2-7)	Voltages in error	Check for good switch connections and solder joints.
A, B, A+ B	ALT and Chop	a. Waveforms at Test Point 19 (transistor case and collector are tied together)	No signal	Replace Q301
			Signal present	Proceed to b.
		b. Waveforms at test point 20 or 21	(1) No signal	(2) Replace Q303 and/or Q304
			(3) Still no signal	(4) Trace signal through multivibrator circuit.
A, B, A+ B and Chop	ALT	Waveforms at Test Point 23	No Signal	Check Time Base plug-in and J1 P1 connections.
			Signal present	Replace CR301
	No blanking in CHOP position	Waveform at Test Point 22 (Pin 15 of J1 in 140A)	Signal present	a. Check Z Axis switch on rear panel of 140A for INT position. b. If still not operating check for good connections on switch. c. If still not operating replace switch.
			No Signal	a. Remove CR303. b. If signal appears replace CR303. c. If still no signal proceed to d.
			d. No Signal	e. Replace Q302
			f. Still no signal	g. Trace signal through circuit.

can be isolated to either input amplifier or to the output amplifier by setting the FUNCTION control first to one channel and then to the other. If balance is possible on one channel and not the other the unbalance is not in the output amplifier and unnecessary steps can be eliminated.

c. IMPROPER SWITCHING OPERATION. Table 2-6 is provided for step-by-step troubleshooting. Troubleshooting voltages are listed in Table 2-7.

d. INSUFFICIENT TRIGGER AMPLITUDE. Insufficient amplitude of the trigger signal can be caused either by low gain in the input amplifier or in the trigger amplifier. Input amplifier gain can be checked by procedures in subpara. a. Low gain in the trigger amplifier can be located by tracing a Model 140A 10V CALIBRATOR signal connected to either input, through each stage of amplification using test point waveforms (12 - 17).

Waveforms at Test Points 18 and 19 are also provided for troubleshooting when Channel A signal is used for triggering.

2-21. ADJUSTMENTS FOLLOWING COMPONENT REPLACEMENT.

Table 2-8 lists adjustments to be made after replacement of tubes, transistors, or diodes.

2-22. SERVICING ETCHED CIRCUIT BOARDS.

Etched circuit boards used in the Model 1402A have components on one side of the board with a plated conductive layer of metal through component holes. hp Service Note M-20D also contains useful information on etched circuit repair. The important steps and considerations are:

a. Use a low heat (37 to 47.5 watts, less than 800° F idling temperature), slightly bent chisel tip (1/16 to 1/8 inch diameter) soldering iron, and a small diameter, high tin content solder. If a rosin solder is used, clean the area thoroughly after soldering.

b. Components may be removed by placing the soldering iron on the component lead on either side of the board, and pulling up on the lead. If heat is applied to the component side of the board, greater care is required to avoid damage to the component (especially true for diodes). If heat damage may occur, grip the lead with a pair of pliers to provide a heat sink between the soldering iron and component.

c. If a component is obviously damaged or faulty, clip the leads close to the component and then unsolder the leads from the board.

d. Large components such as potentiometers and tube sockets may be removed by rotating the soldering iron from lead to lead and applying steady pressure to lift the part free (the alternative is to clip the leads of a damaged part).

e. Since the conductor part of the etched circuit board is a metal-plated surface, covered with solder, use care to avoid overheating and lifting the conductor from the board. A conductor may be cemented back in place with a quick-drying acetate base cement (use sparingly) having good insulating properties. Another method for repair is to solder a section of good conduction wire along the damaged area.

f. Clear the solder from the circuit board hole before inserting a new component lead. Heat the solder in the hole, remove the iron, and quickly insert a pointed non-metallic object, such as a toothpick.

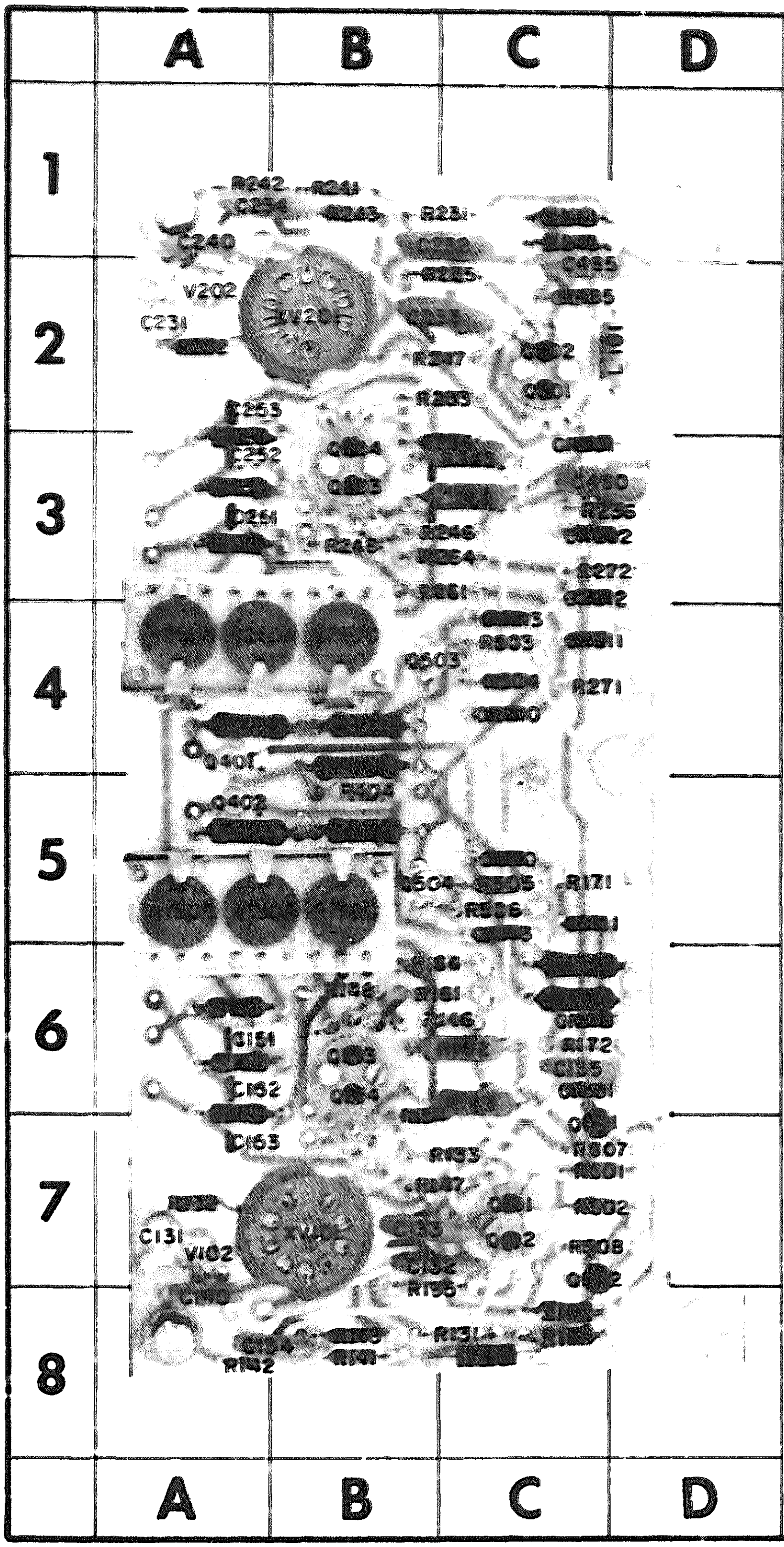
g. Shape the new component leads and clip to proper length. Insert the leads in the holes and apply heat and solder, preferably on the conductor side

Table 2-7. Switching Circuit troubleshooting Voltages

FUNCTION	DC Voltage at Test Point 20	DC Voltages at Test Point 21
A	-2.5	-4.1
ALT	-3.1	-3.1
ALT	-3.1	-3.1
CHOP	-3.1	-3.1
A+B	-1.1	-1.1
B	-4.1	-2.5

Table 2-8. Adjustments Following Component Replacement

Component	Function	Adjustment	Ref Para.
	INPUT AMPLIFIERS		
V102, 202,	Grid Overload Neon Lamp	None	
V101, 201	Cathode Follower	Input Capacity .005, .01, .02 Gain DC BAL	2-19.h. 2-19.g. 2-19.d.
Q101, 102, 201, 202	Emitter Follower	.005, .01, .02 Gain DC BAL	2-19.g. 2-19.d.
Q103, 104, 203, 204	Differential Amplifier (replace in pairs)	.005, .01, .02 Gain DC BAL	2-19.g. 2-19.d.
CR111, 112, 211, 212	Gating Diode	None	
CR110, 113, 210, 213	Isolation Diode	None	
	OUTPUT AMPLIFIER		
Q401, 402	Amplifier	DC BAL SENS CAL Position Adj.	2-19.d. 2-19.g. 2-19.e.
Q403, 404	Emitter Follower	DC BAL SENS CAL	2-19.d. 2-19.g.
Q405, 406	1st Differential Amplifier	DC BAL SENS CAL 1st, 2nd, 3rd HF Adj.	2-19.d. 2-19.g. 2-19.i.
Q407, 408	2nd Differential Amplifier	DC BAL SENS CAL 1st, 2nd, 3rd HF Adj.	2-19.d. 2-19.g. 2-19.i.
V401	Cathode Follower	DC BAL SENS CAL 1st, 2nd, 3rd HF Adj.	2-19.d. 2-19.g. 2-19.i.
V402, 403	Output Differential Amplifier	DC BAL SENS CAL 1st, 2nd, 3rd HF Adj.	2-19.d. 2-19.g. 2-19.i.
CR451, 452, 461, 462	Transient Protection Diode	None	
	TRIGGER AMPLIFIER		
Q501, 502, 503, 504	Emitter Follower	None	
Q505, 506, 507, 508	Differential Amplifier	Sync Bal	2-19.j.
Q509, 510	Emitter Follower	Sync Bal	2-19.j.
CR541	Chop Operation H. F. Transient Diode	None	
	SWITCHING CIRCUIT		
CR301, 302, 304, 305	Clipper Diode	None	
CR303	Blocking Diode	None	
Q301	Blocking Oscillator	None	
Q302	Blanking Pulse Amplifier	None	
Q303, 304	Multivibrator	None	



REF DESIG	GRID LOC	REF DESIG	GRID LOC
C131	A7	R150B	A5
C132	B7	R150C	B5
C133	B7	R151	A6
C134	A8	R152	A6
C135	C6	R153	A6
C140	A8	R161	B6
C151	A6	R162	C6
C152	A6	R163	C6
C153	A7	R164	B6
C231	A2	R171	C5
C232	B1	R172	C6
C233	B2	R173	C6
C234	A1	R174	C6
C240	A1	R231	B1
C251	A3	R232	A2
C252	A3	R233	B2
C253	A2	R234	B3
C480	C3	R235	B2
C485	C2	R236	C3
CR101	C6	R241	B1
CR110	C5	R242	A1
CR111	C5	R243	B1
CR112	C6	R244	C1
CR113	C5	R245	C1
CR201	C3	R246	B3
CR202	C3	R247	B2
CR210	C4	R248	B3
CR211	C4	R250A	A4
CR212	C3	R250B	A4
CR213	C4	R250C	B4
L101	C2	R251	A3
Q101	C7	R252	A3
Q102	C7	R253	A3
Q103	B6	R261	B3
Q104	B6	R262	C3
Q201	C2	R263	C3
Q202	C2	R264	B3
Q203	B3	R271	C4
Q204	B3	R272	C3
Q401	A4	R401	B4
Q402	A5	R402	A4
Q501	C7	R403	B4
Q502	C7	R404	B5
Q503	B4	R405	A5
Q504	B5	R406	B5
R131	C8	R481	C8
R132	A7	R485	C2
R133	B7	R501	C7
R134	B6	R502	C7
R135	B8	R503	C4
R141	B8	R504	C4
R142	A8	R505	C5
R143	B8	R506	C5
R144	C8	R507	C7
R145	C8	R508	C7
R146	B6	V102	A7
R147	B7	V202	A2
R148	B6	XV101	B7
R150A	A5	XV201	B2

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Figure 2-13. Component Locations on Input Amplifier Board A9

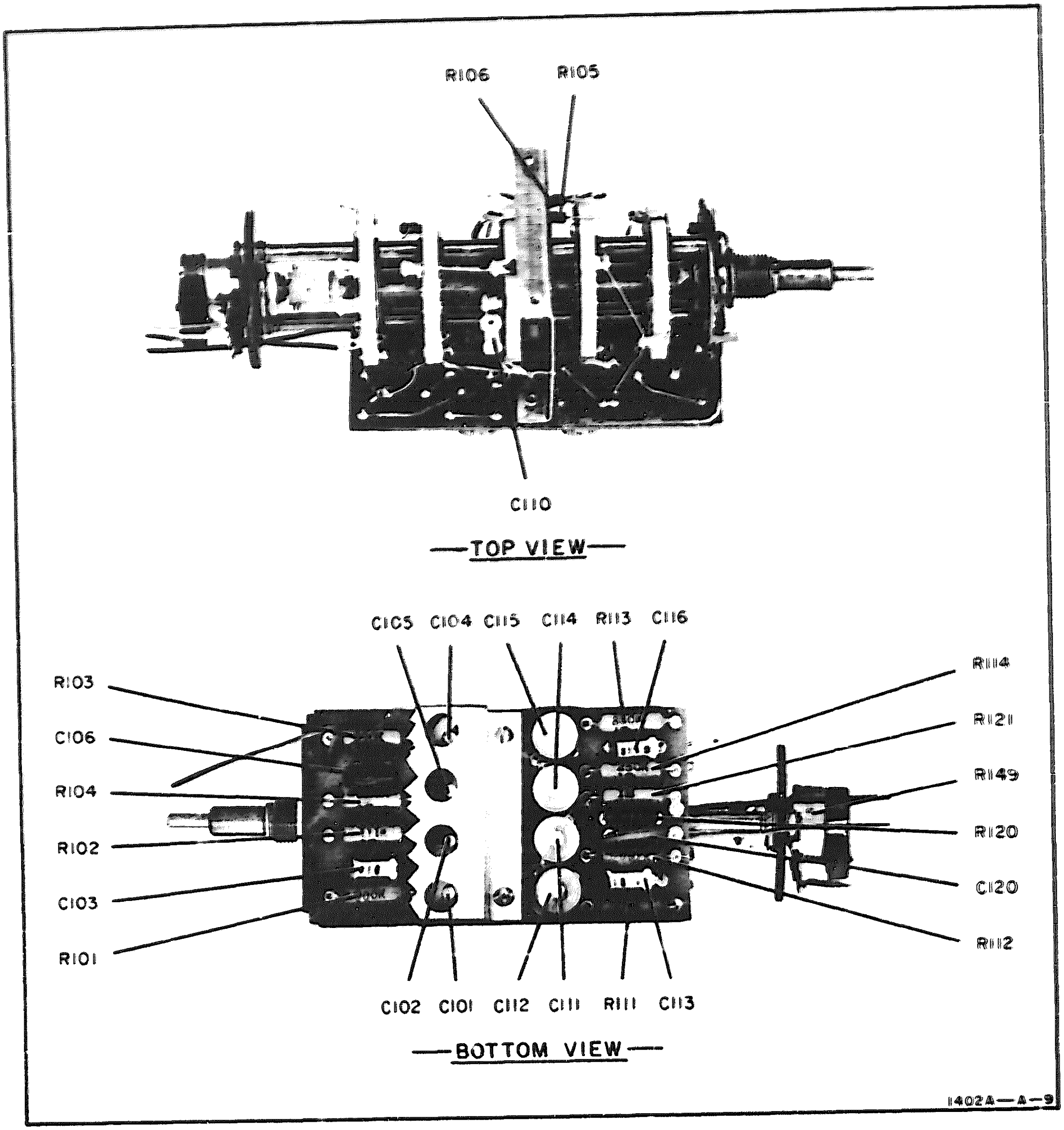


Figure 2-14. Component Locations on Channel A Sensitivity Switch

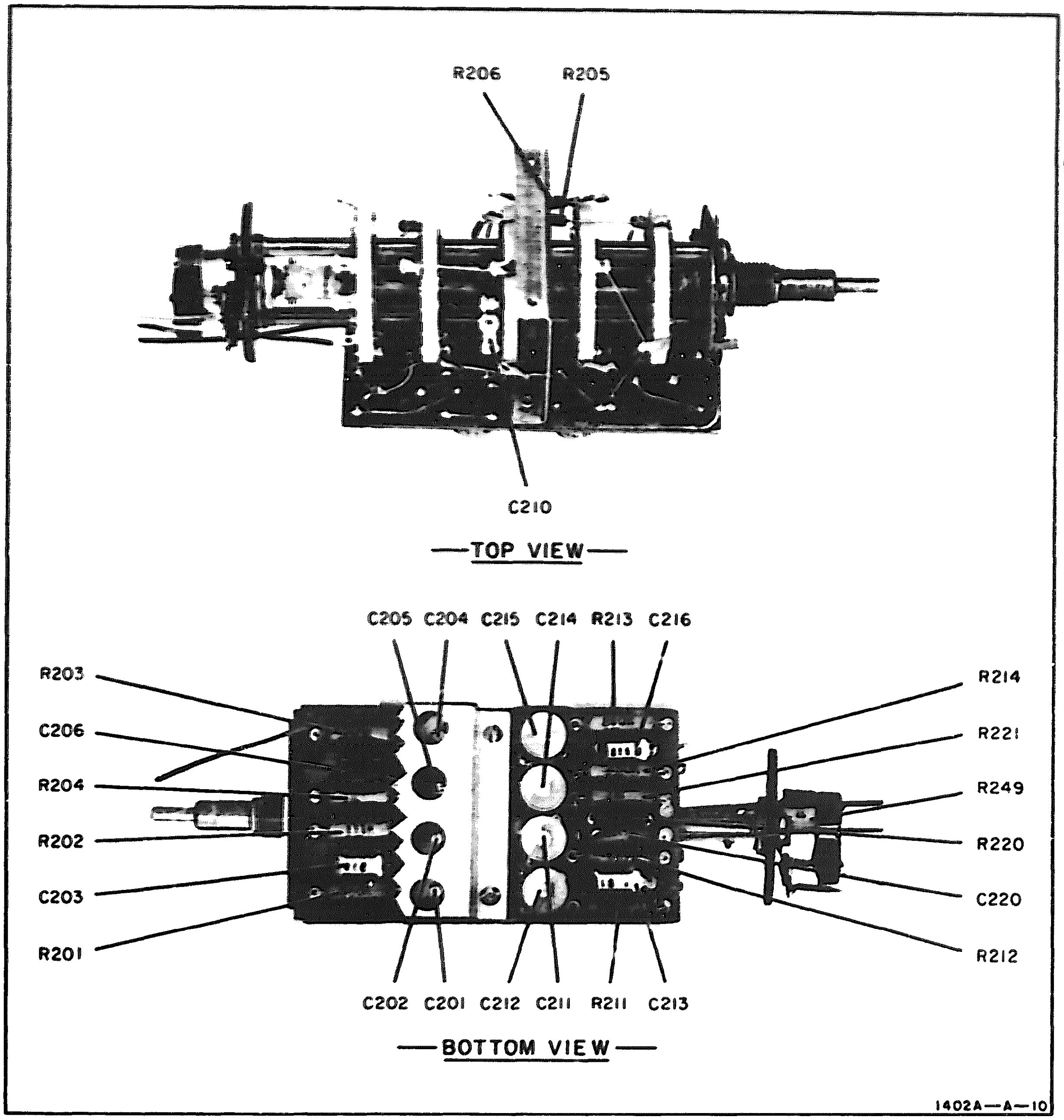


Figure 2-15. Component Locations on Channel B Sensitivity Switch

Table 2-9. Schematic Diagram Notes

Refer to MIL-STD-15-1 for schematic symbols not listed in this table.

Unless otherwise indicated:
capacitance in picofarads
inductance in microhenries
resistance in ohms

Symbol		Meaning
	=	Etched circuit board
	=	Front panel marking
	=	Rear panel marking
	=	Front panel control
	=	Screwdriver Adjustment
CW	=	Clockwise end of variable resistor
	=	Primary signal path
	=	Feedback path
	=	Waveform test point (with number)
	=	Common point (with letter)
	=	Avalanche (zener) diode
	=	Tunnel diode
	=	Step recovery diode

Numbers in parentheses indicate wire color using resistor color code, e.g. WHT-RED-GRN is (9-2-5).

0 - Black	5 - Green
1 - Brown	6 - Blue
2 - Red	7 - Violet
3 - Orange	8 - Gray
4 - Yellow	9 - White

P/O	=	Part of
*	=	Optimum value selected at factory, average value shown; part may have been omitted.
N.C.	=	No connection

Table 2-10. Conditions for Waveform Measurement in Channel A, Channel B, Output, and Trigger Amplifiers (Test Points 1 through 18)

Model 1402A settings:

FUNCTION	A
SENSITIVITY	0.02 V/CM
COUPLING	DC
INPUT	ON
VERNIER	CAL

Connect 120 mv calibrator signal (see Figure 5-1 to Channel A INPUT.

Test Oscilloscope settings:

TRIGGER SOURCE	+ EXT
LEVEL	AUTO
SWEEP TIME	2 MSEC/CM

Connect 10V CALIBRATOR of Model 140A to external trigger input of Test Oscilloscope.

Test points are indicated for upper half of differential stages only. Square wave signal in the lower half is the same but inverted.

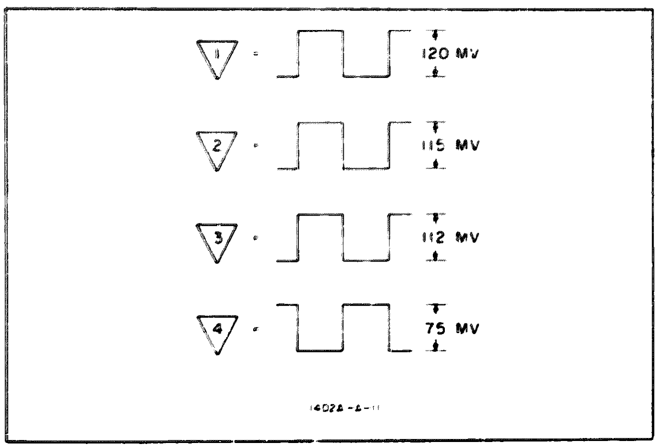


Figure 2-16. Waveforms at Test Points in Channel A

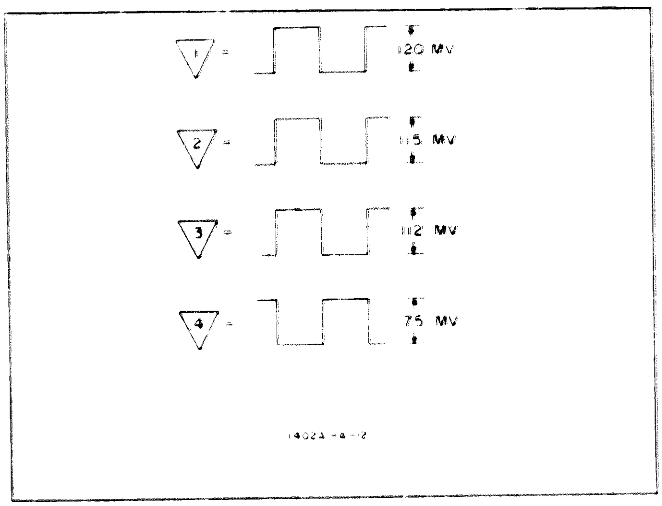
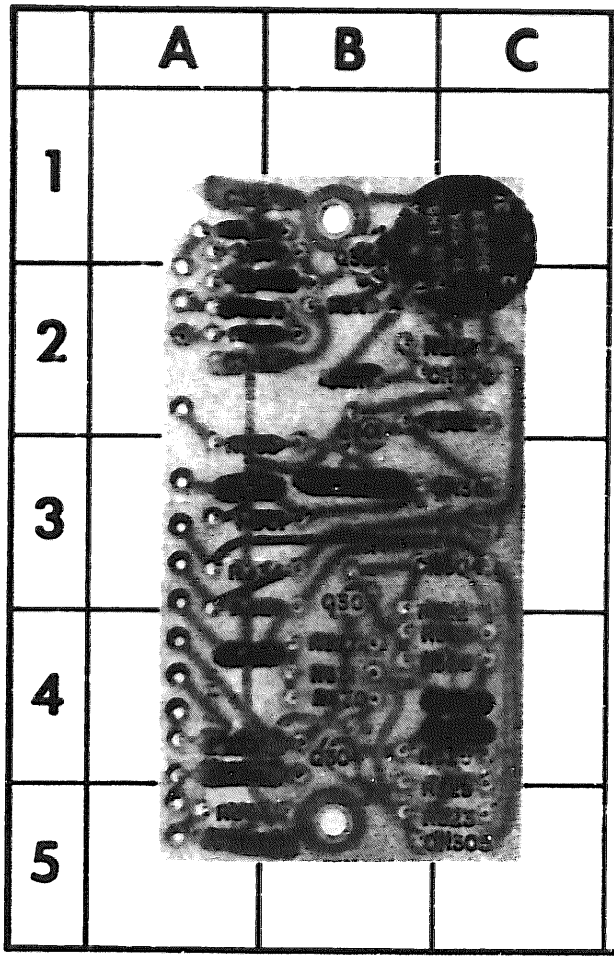


Figure 2-17. Waveforms at Test Points in Channel B



REF DESIG	GRID LOC
C301	A3
C303	A5
C304	B3
C311	B2
C312	A1
C313	A2
C321	A4
C322	C4
C323	C4
CR301	C3
CR302	C2
CR303	A2
CR304	C3
CR305	C5
Q301	B2
R302	C2
R303	A5
R304	C2
R305	A3
R311	B2
R312	A1
R313	A2
R314	A1
R321	A3
R322	C3
R323	C5
R325	C4
R326	C4
R327	B4
R328	C4
R329	C5
R330	B4
R331	B4
R332	A4
R333	A4
R334	A3
T301	C1

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Figure 2-18. Component Locations Switching Circuit Board A2

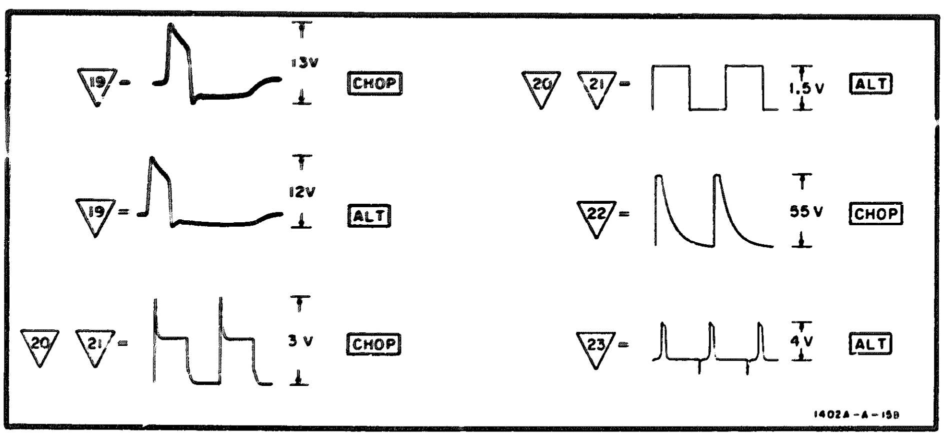


Figure 2-19. Waveforms at Test Points in Switching Circuit

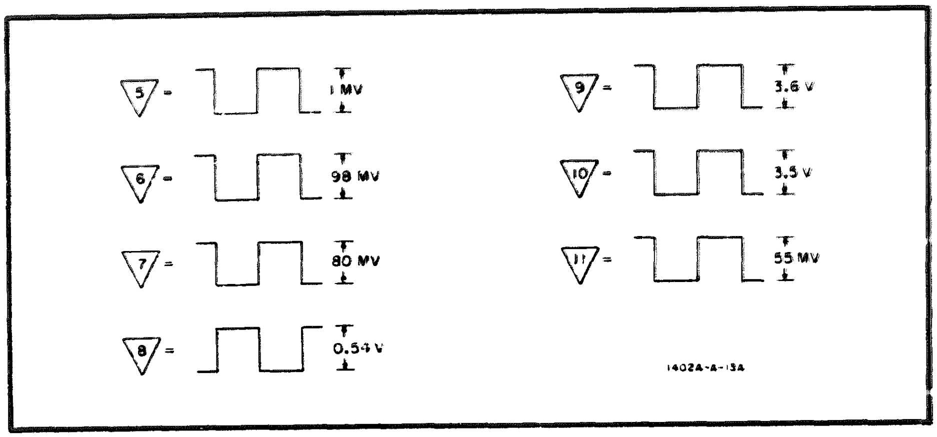
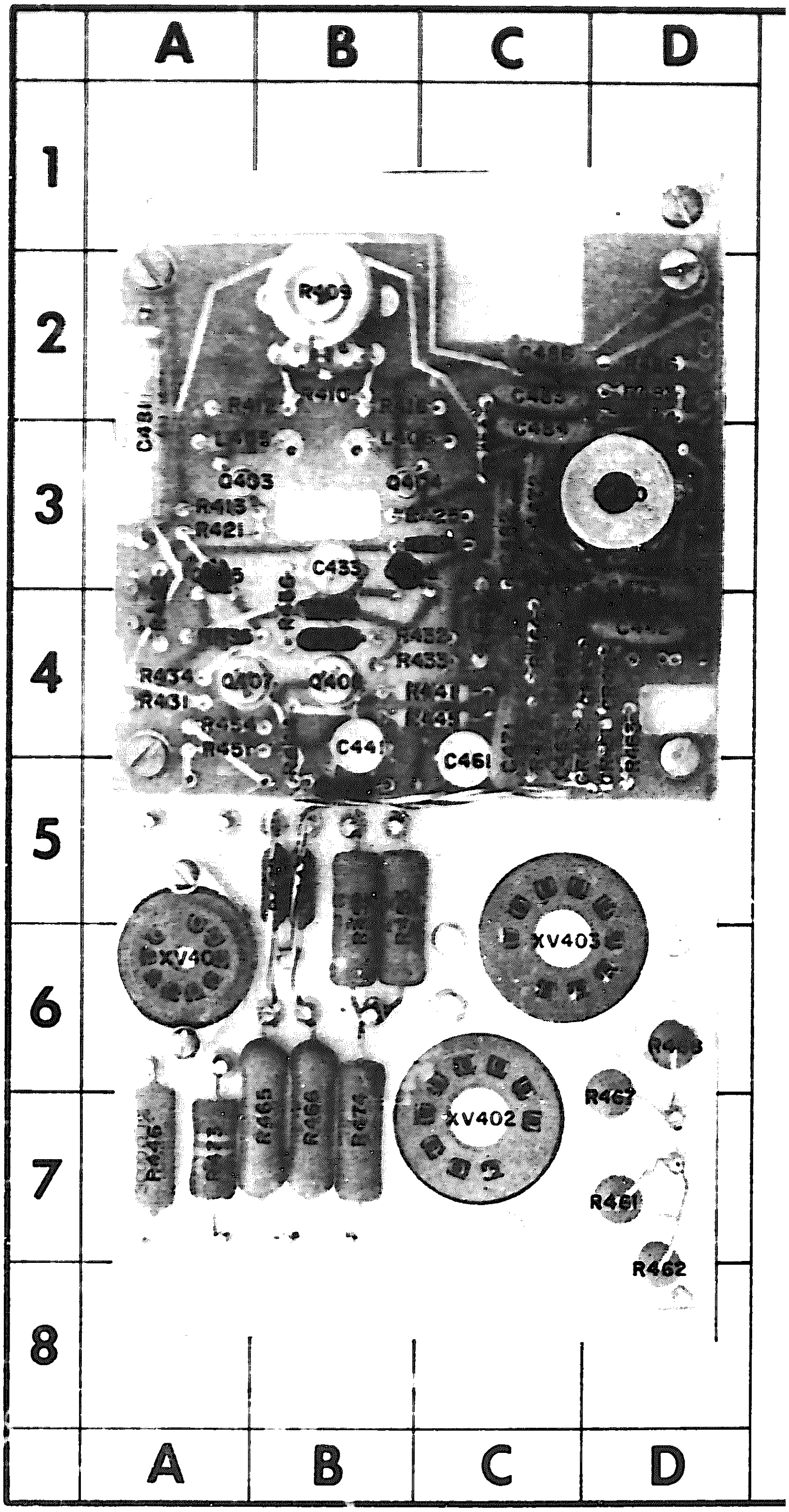
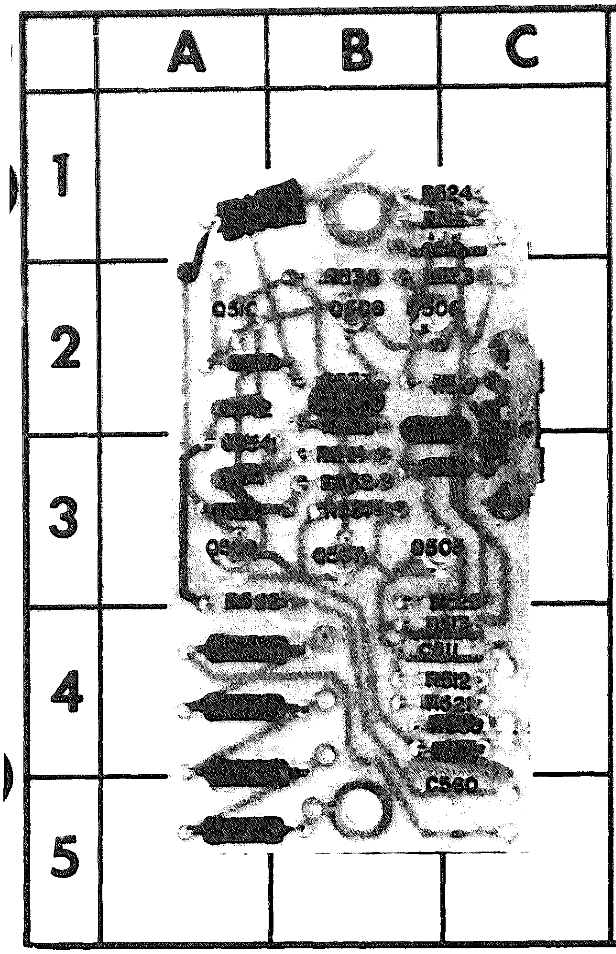


Figure 2-20. Waveforms at Test Points in Output Amplifier



REF DESIG	GRID LOC	REF DESIG	GRID LOC
C431	B4	R425	B3
C432	B4	R431	A4
C433	B3	R432	B4
C441	B4	R433	B4
C442	D4	R434	A4
C460	B5	R435	A4
C461	C4	R436	B4
C462	C4	R441	C4
C463	C4	R442	B5
C471	C4	R443	B5
C472	C3	R444	B4
C473	D3	R445	C4
C481	A3	R446	A7
C482	C3	R451	A4
C483	C2	R452	B5
C484	C3	R453	B5
C486	B2	R454	A4
CR451	D4	R460	D3
CR452	C4	R461	D7
CR461	D4	R462	D8
CR462	C4	R463	D4
L405	D3	R464	C4
L406	B3	R465	B7
Q403	A3	R466	B7
Q404	B3	R467	D6
Q405	A3	R468	D6
Q406	B3	R472	C4
Q407	D4	R473	A7
Q408	B4	R474	B7
R409	B2	R475	C3
R410	B2	R482	C4
R412	·A2	R483	D2
R413	A2	R484	D2
R414	C3	R486	D2
R416	B2	XV401	A6
R421	A3	XV402	C7
R422	A4	XV403	C6
R424	B3		

Figure 2-21. Component Locations on Output Amplifier Board A10 and Deck



REF DESIG	GRID LOC
C511	B4
C512	C1
C521	B2
C531	B2
C541	A3
C542	A2
C560	C5
CR541	A3
Q505	B3
Q506	B2
Q507	B3
Q508	B2
Q509	A3
Q510	A2
R512	C4
R513	B4
R514	C2
R515	C2
R516	B1
R521	B4
R522	B3
R523	B2
R524	B1
R525	C3
R531	B3
R532	B3
R533	B2
R534	B2
R535	B2
R541	B3
R542	A3
R551	A3
R552	A2
R560	C4
R561	C4
R571	A4
R572	A4
R573	A4
R574	A5

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Figure 2-22. Component Locations on Trigger Amplifier Board A3

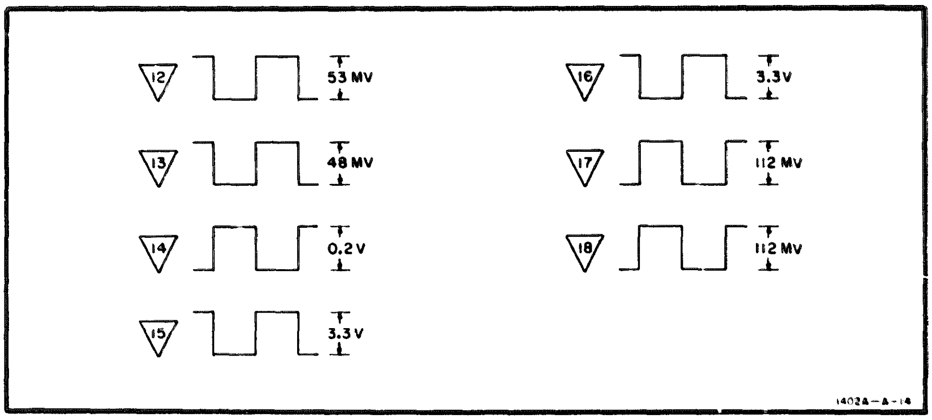

Figure 2-23. Waveforms at Test Points In Trigger Amplifier

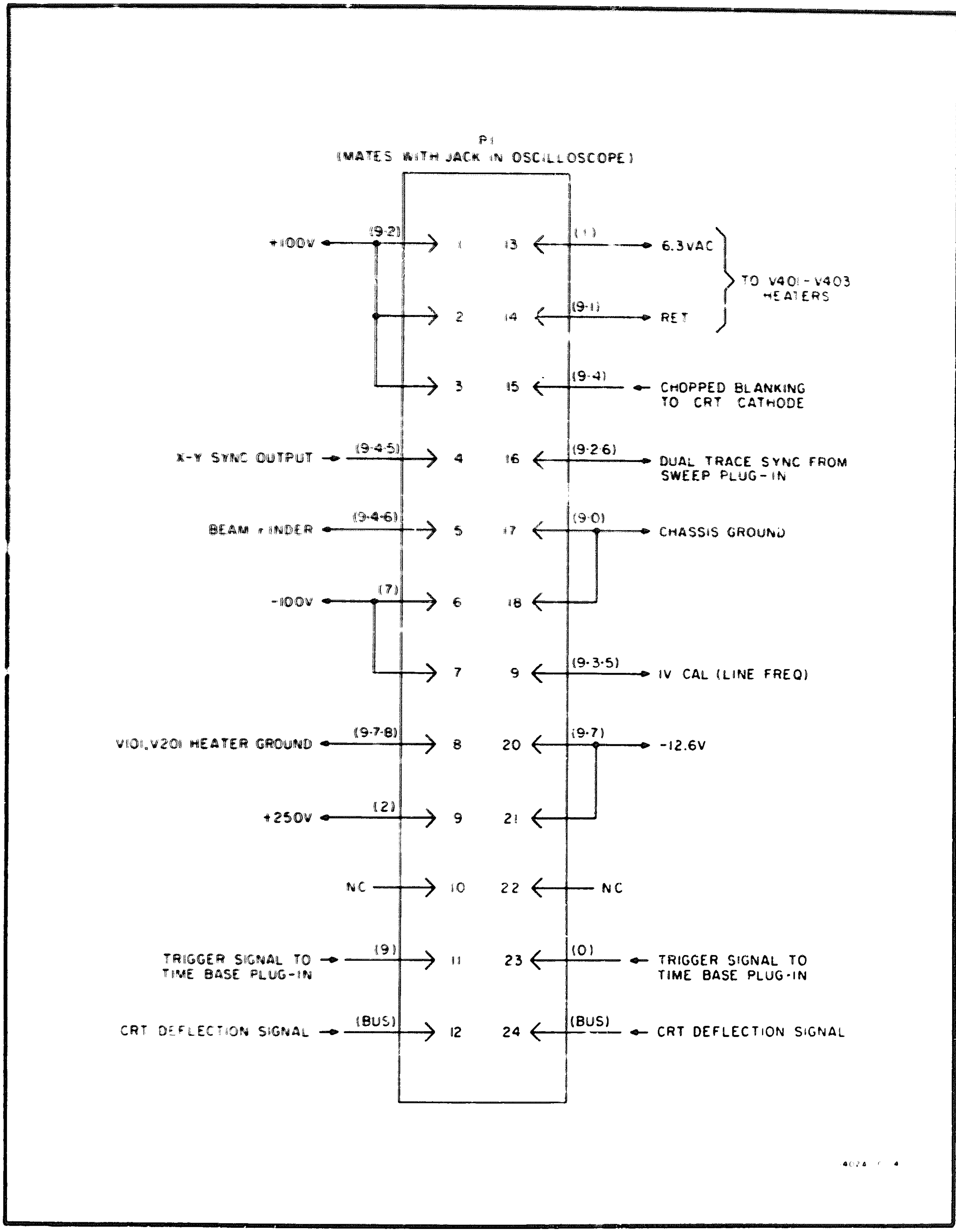

Figure 2-24. Interconnection Plug Shematic Diagram

APPENDIX A
REFERENCES

The following publications contain information applicable to the operation and maintenance of the Hewlett-Packard Model 141A Oscilloscope:

DA Pam 310-4	Index of Technical Manuals, Technical Bulletins, Supply Manuals (types 7, 8, and 9), Supply Bulletins, and Lubrication Orders
DA Pam 310-7	U. S. Army Equipment Index of Modification Work Orders
TB 746-10	Field Instructions for Painting and Preserving Electronics Command Equipment Including Camouflage Pattern Painting of Electrical Equipment Shelters.
TB SIG 355-1	Depot Inspection Standard for Repaired Signal Equipment
TB SIG 355-2	Depot Inspection Standard for Refinishing Repaired Signal Equipment
TB SIG 355-3	Depot Inspection Standard for Moisture and Fungus Resistant Treatment
TM 38-750	Army Equipment Record Procedures
TM 11-6625-2390-15	Operator, Organizational, DS, GS, and Depot Maintenance Manual: Oscilloscope AN/USM-309(V)1, Oscilloscope OS-193P/U (Hewlett-Packard Model 140A), Amplifier AM-6169/USM-309(V) (Hewlett-Packard Model H06-1405A), and Generator, Sweep TD-5037/USM-509 (Hewlett-Packard Model 1421A)
TM 750-244-2	Procedures for Destruction of Electronics Materiel to Prevent Enemy Use.

APPENDIX B

MAINTENANCE ALLOCATION

Section I. INTRODUCTION

B-1. General.

This appendix provides a summary of the maintenance operations for AN/USM-320(V)1. It authorizes categories of maintenance for specific maintenance functions on repairable items and components and the tools and equipment required to perform each function. This appendix may be used as an aid in planning maintenance operations.

B-2. Maintenance Function.

Maintenance functions will be limited to and defined as follows:

a. Inspect. To determine the serviceability of an item by comparing its physical, mechanical, and/or electrical characteristics with established standards through examination.

b. Test. To verify serviceability and to detect incipient failure by measuring the mechanical or electrical characteristics of an item and comparing those characteristics with prescribed standards.

c. Service. Operations required periodically to keep an item in proper operating condition, i.e., to clean (decontaminate), to preserve, to drain, to paint, or to replenish fuel, lubricants, hydraulic fluids, or compressed air supplies.

d. Adjust. To maintain, within prescribed limits, by bringing into proper or exact position, or by setting the operating characteristics to the specified parameters.

e. Align. To adjust specified variable elements of an item to bring about optimum or desired performance.

f. Calibrate. To determine and cause corrections to be made or to be adjusted on instruments or test measuring and diagnostic equipments used in precision measurement. Consists of comparisons of two instruments, one of which is a certified standard of known accuracy, to detect and adjust any discrepancy in the accuracy of the instrument being compared.

g. Install. The act of emplacing, seating, or fixing into position an item, part, module (component or assembly) in a manner to allow the proper functioning of the equipment or system.

h. Replace. The act of substituting a serviceable like type part, subassembly, or module (component or assembly) for an unserviceable counterpart.

i. Repair. The application of maintenance services (inspect, test, service, adjust, align, calibrate, replace) or other maintenance actions (welding, grinding, riveting, straightening, facing, remachining, or resurfacing) to restore serviceability to an item by correcting specific damage, fault, malfunction, or failure in a part, subassembly, module (component or assembly), end item, or system.

j. Overhaul. That maintenance effort (service/action) necessary to restore an item to a completely serviceable/operational condition as prescribed by maintenance standards (i.e., DMWR) in appropriate technical publications. Overhaul is normally the highest degree of maintenance performed by the Army. Overhaul does not normally return an item to like new condition.

k. Rebuild. Consists of those services/actions necessary for the restoration of unserviceable equipment to a like new condition in accordance with original manufacturing standards. Rebuild is the highest degree of materiel maintenance applied to Army equipment. The rebuild operation includes the act of returning to zero those age measurements (hours, miles, etc.) considered in classifying Army equipments/components.

B-3. Column Entries.

a. Column 1, Group Number. Column 1 lists group numbers, the purpose of which is to identify components, assemblies, subassemblies, and modules with the next higher assembly.

b. Column 2, Component/Assembly. Column 2 contains the noun names of components, assemblies, subassemblies, and modules for which maintenance is authorized.

c. Column 3, Maintenance Functions. Column 3 lists the functions to be performed on the item listed in column 2. When items are listed without maintenance functions, it is solely for purpose of having the group numbers in the MAC and RPSTL coincide.

d. Column 4, Maintenance Category. Column 4 specifies, by the listing of a “worktime” figure in the appropriate subcolumn(s), the lowest level of maintenance authorized to perform the function listed in column 3. This figure represents the active time required to perform that maintenance function at the indicated category of maintenance. If the number or complexity of the tasks within the listed maintenance function vary at different maintenance categories, appropriate "worktime" figures will be shown for each category. The number of task-hours specified by the "worktime" figure represents the average time required to restore an item (assembly, subassembly, component, module, end item or system) to a serviceable condition under typical field operating conditions. This time includes preparation time, troubleshooting time, and quality assurance/quality control time in addition to the time required to perform the specific tasks identified for the maintenance functions authorized in the maintenance allocation chart. Subcolumns of column 4 are as follows:

C - Operator/Crew
O - Organizational
F - Direct Support
Ii - General Support
D - Depot

e. Column 5, Tools and Equipment. Column 5 specifies by code, those common tool sets (not individual tools) and special tools, test, and support equipment required to perform the designated function.

f. Column 6, Remarks. Column 6 contains an alphabetic code which leads to the remark in section IV, Remarks, which is pertinent to the item opposite the particular code.

B-4. Tool and Test Equipment Requirements (Sec III).

a. Tool or Test Equipment Reference Code. The numbers in this column coincide with the numbers used in the tools and equipment column of the MAC. The numbers indicate the applicable tool or test equipment for the maintenance functions.

b. Maintenance Category. The codes in this column indicate the maintenance category allocated the tool or test equipment.

c. Nomenclature. This column lists the noun name and nomenclature of the tools and test equipment required to perform the maintenance functions.

d. National/NATO Stock Number. This column lists the National/NATO stock number of the specific tool or test equipment.

e. Tool Number. This column lists the manufacturer's part number of the tool followed by the Federal Supply Code for manufacturers (5-digit) in parentheses.

B-5. Remarks (Sec IV).

a. Reference Code. This code refers to the appropriate item in section II, column 6.

b. Remarks. This column provides the required explanatory information necessary to clarify items appearing in section I I.

SECTION II MAINTENANCE ALLOCATION CHART
FOR
OSCILLOSCOPE AN/USM-320(V)1

(1) GROUP NUMBER	(2) COMPONENT/ASSEMBLY	(3) MAINTENANCE FUNCTION	(4) MAINTENANCE CATEGORY C	O	F	H	D	(5) TOOLS AND EQPT.	(6) REMARKS
Text	OSCILLOSCOPE AN/USM-320(V)1								A
Text	OSCILLOSCOPE OS-207(P)/V (HP 141A)	Inspect		0.1					
		Test				1.0		1thru7	
		Service		0.1					
		Adjust				0.8		1thru7	
		Calibrate				1.0		1thru7	
		Repair				2.5		1thru8	
		Repair		0.5				8	
Text	DUAL TRACE AMPLIFIER PL-1244/U (HP 1402A)	Inspect		0.1					
		Test				1.0		1,2,6 thru12	
		Service		0.1					
		Adjust				0.7		1,2,6 thru12	
		Repair				2.0		1,2,6 thru12	
		Repair		0.5				8	
Text	SWEEP GENERATOR PL-1245/U (HP 14211A)	Replace			0.2				B

SECTION III TOOL AND TEST EQUIPMENT REQUIREMENTS FOR

OSCILLOSCOPE AN/USM-320(V)1

TOOL OR TEST EQUIPMENT REF CODE	MAINTENANCE CATEGORY	NOMENCLATURE	NATIONAL/NATO STOCK NUMBER	TOOL NUMBER
1	H	VOLTMETER CALIBRATOR HP 738BR	*	
2	H	DC VOLTMETER HP 412A or ME-266/USM-183	6625-00-821-2688	
3	H	DC VTVM HP 410C or ME-303/U	6625-00-902-7140	
4	H	VOLTAGE DIVIDER HP 11045A	*	
5	H	VOLTAGE DIVIDER HP 11044A or MX-2571/U	6625-00-511-5383	
6	H	SIGNAL GENERATOR HP 200CD or SG-239/FQQ	6625-00-806-5033	
7	H	TRANSISTOR TEST SET, SIERRA 219C or TS-1836A/U	6625-00-893-2628	
8	O,H	TOOL KIT, ELECTRONIC EQUIPMENT TK-105/G	5180-00-610-8177	
9	H	SIGNAL GENERATOR TEK 190B	*	
10	H	PULSE GENERATOR TEK 107	*	
11	H	SQUARE WAVE GENERATOR HP 211A or SG-299( )/U	6625-00-624-3516	
12	H	LC METER TEK 130	*	

*The National Stock Numbers that are missing from this list have been requested and will be added by a change to the list upon receipt.

SECTION IV. REMARKS

REFERENCE CODE	REMARKS
A	No maintenance functions on end item, all maintenance functions are performed on components.
B	See TM 11-625-2790-15 for maintenance allocation.

*U.S. GOVERNMENT PRINTING OFFICE: 1976-765096/1004

By Order of the Secretary of the Army:

CREIGHTON W. ABRAMS
General, United States Army
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USASA (2)
USAMB (10)
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USACDCEC (5)
USACDCCEA (1)
USACDCCEA Ft Huachuca (1)
OS Maj Comd (2)
USASTRATCOM (5)
USASTRATCOM-CONUS (3)
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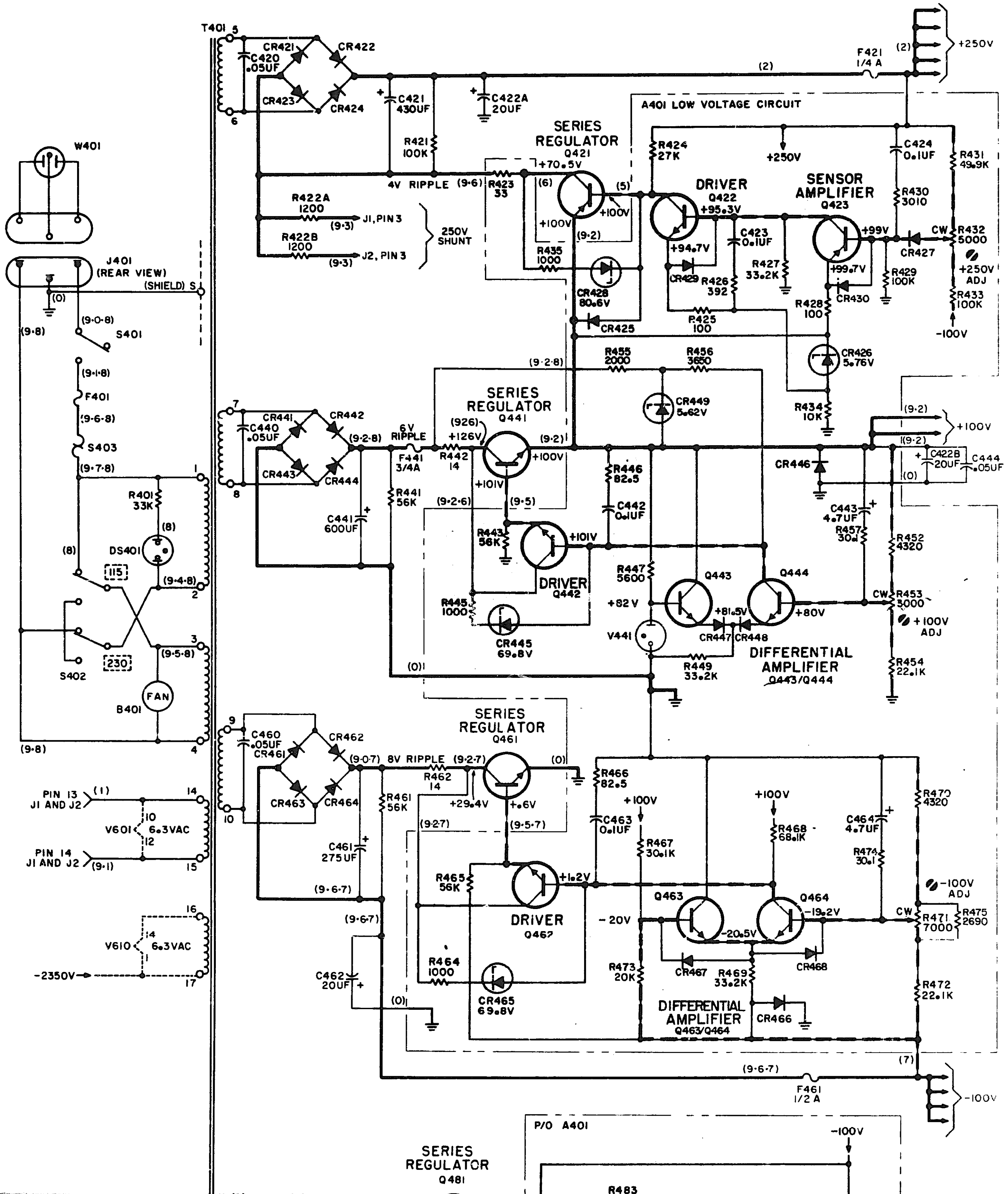
USASTRATCOM-PAC (3)
USASTRATCOM SIG GP-T (10)
USASTRATCOM SIG GP-Okinawa (3)
USASTRATCOM SIG GP-Japan (5)
USASTRATCOM Comm OP FAC, Korea (3)
USASTRATCOM SIG Bde, Korea (3)
USASTRATCOM SIG GP-Taiwan (2)
LOGCOMDS (5)
Eighth USA (5)
Sig FLDMS (PAC) (1)
SAAD (10)
TOAD (10)
LEAD (7)
USACSA (2)
TECOM (2)
JISA (ECOM) (2)
USA Ascom Depot (3)
USA Cp Carroll Depot (3)
Units org under fol TOE :
(1 copy each)
11-15
11-45
11-97
11-98
11-158
11-302
11-303
11-347
11-357
11-367
11-368
11-377
11-500 (AA-AC)
29-118
29-134
29-136
29-137

NG: None.

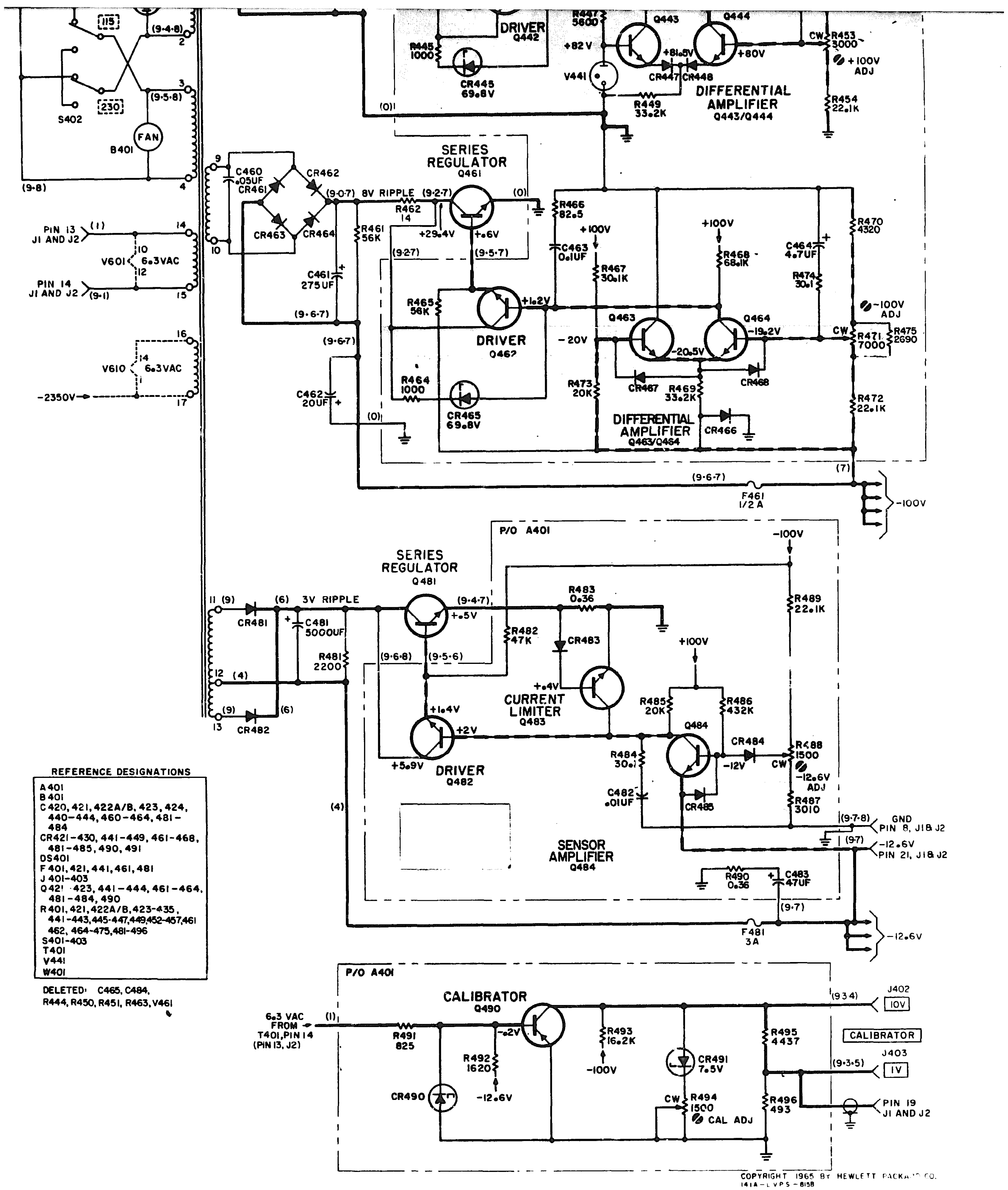
USAR : None.

For explanation of abbreviations used, see AR 310-50.

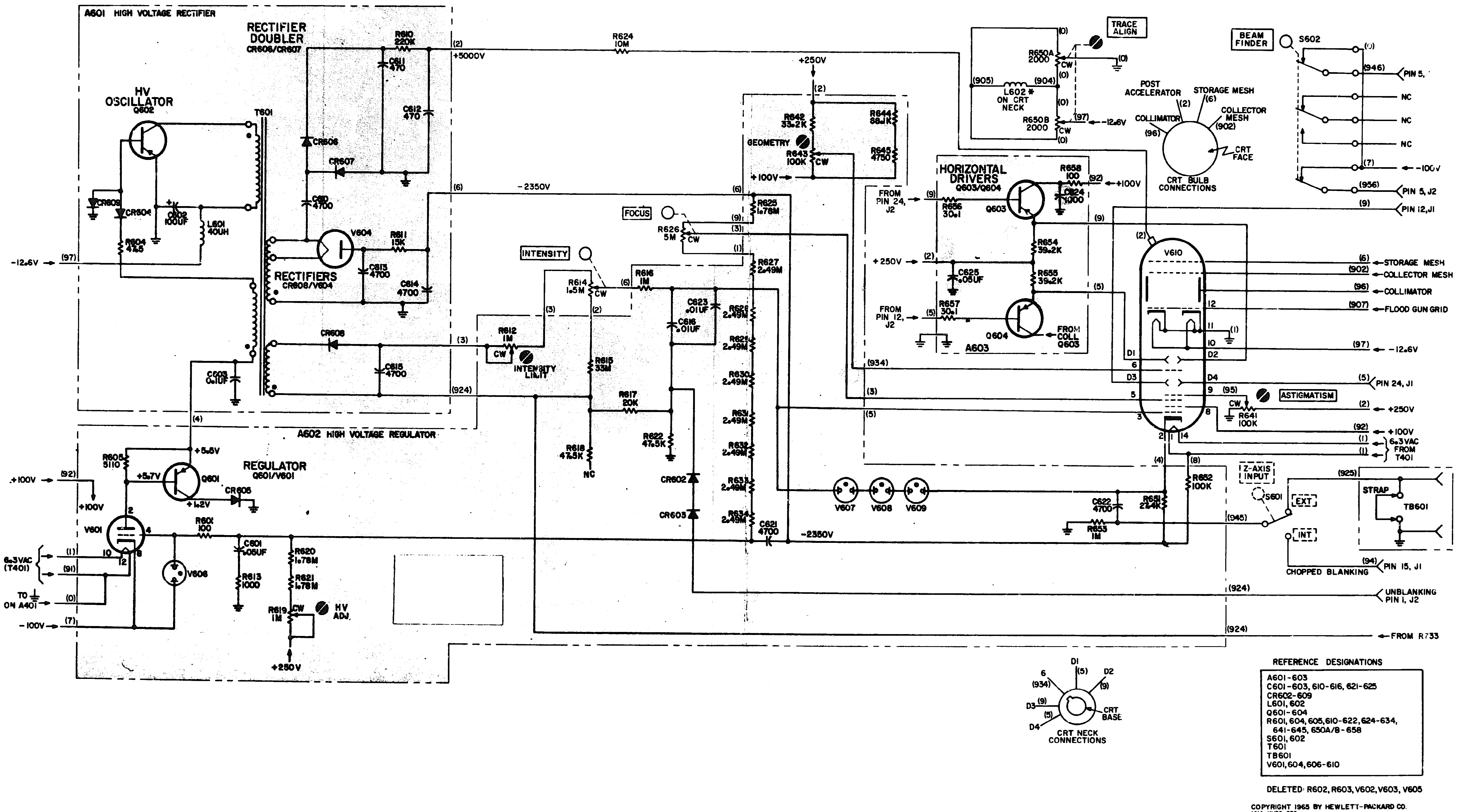
* U.S. GOVERNMENT PRINTING OFFICE: 1973-714-594/406



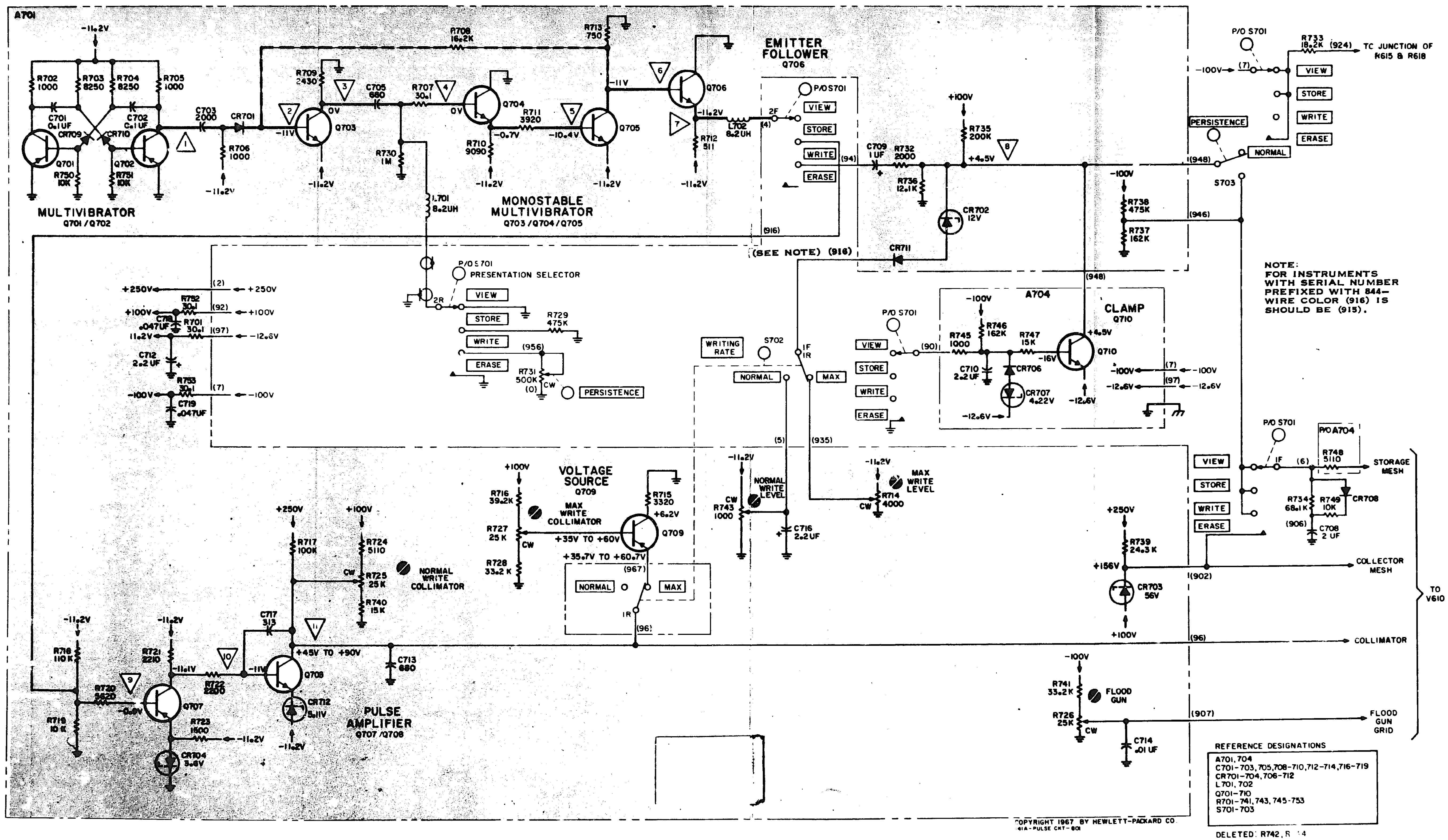
T401
CR421
CR422
C420 .05UF
CR423
CR424
C421 430UF
C422A 20UF
(2)
F421 1/4 A
+250V
A401 LOW VOLTAGE CIRCUIT
W401
SERIES REGULATOR Q421
R421 100K
+70.5V
4V RIPPLE
R423 33
+100V
R422A 1200
J1, PIN 3
R422B 1200
J2, PIN 3
250V SHUNT
R435 1000
CR428 80.6V
CR425
DRIVER Q422
+95.3V
+94.7V
CR429
R424 27K
+250V
SENSOR AMPLIFIER Q423
+99V
+99.7V
C423 0.1UF
R427 33.2K
R426 392
R425 100
R428 100
CR430
CR426 5.76V
R434 10K
C424 0.1UF
R430 3010
R431 49.9K
R432 5000
CR427
R429 100K
+250V ADJ
R433 100K
-100V
J401 (REAR VIEW)
(SHIELD)
S401
F401
S403
R401 33K
DS401
115
230
S402
B401
FAN
R455 2000
R456 3650
CR449 5.62V
SERIES REGULATOR Q441
CR441
CR442
C440 .05UF
CR443
CR444
6V RIPPLE
F441 3/4A
R442 14
+126V
+100V
+101V
R441 56K
C441 600UF
R443 56K
DRIVER Q442
R445 1000
CR445 69.8V
R446 82.5
C442 0.1UF
R447 5600
+82V
V441
Q443
Q444
+81.5V
+80V
CR447
CR448
R449 33.2K
DIFFERENTIAL AMPLIFIER Q443/Q444
CR446
C443 4.7UF
R457 30.1
C422B 20UF
C444 .05UF
+100V
R452 4320
R453 5000
+100V ADJ
R454 22.1K
SERIES REGULATOR Q461
C460 .05UF
CR461
CR462
CR463
CR464
8V RIPPLE
R462 14
R461 56K
+29.4V
+.6V
C461 275UF
R465 56K
+1.2V
DRIVER Q462
R464 1000
CR465 69.8V
C462 20UF
R466 82.5
C463 0.1UF
+100V
R467 30.1K
R468 68.1K
Q463
Q464
-20V
-20.5V
-19.2V
CR467
CR468
R473 20K
R469 33.2K
CR466
DIFFERENTIAL AMPLIFIER Q463/Q464
C464 4.7UF
R474 30.1
R470 4320
-100V ADJ
R471 7000
R475 2690
R472 22.1K
F461 1/2 A
-100V
PIN 13 J1 AND J2
PIN 14 J1 AND J2
V601
6.3VAC
V610
6.3VAC
-2350V
P/O A401
SERIES REGULATOR Q481
3V RIPPLE
R483 0.36
R489



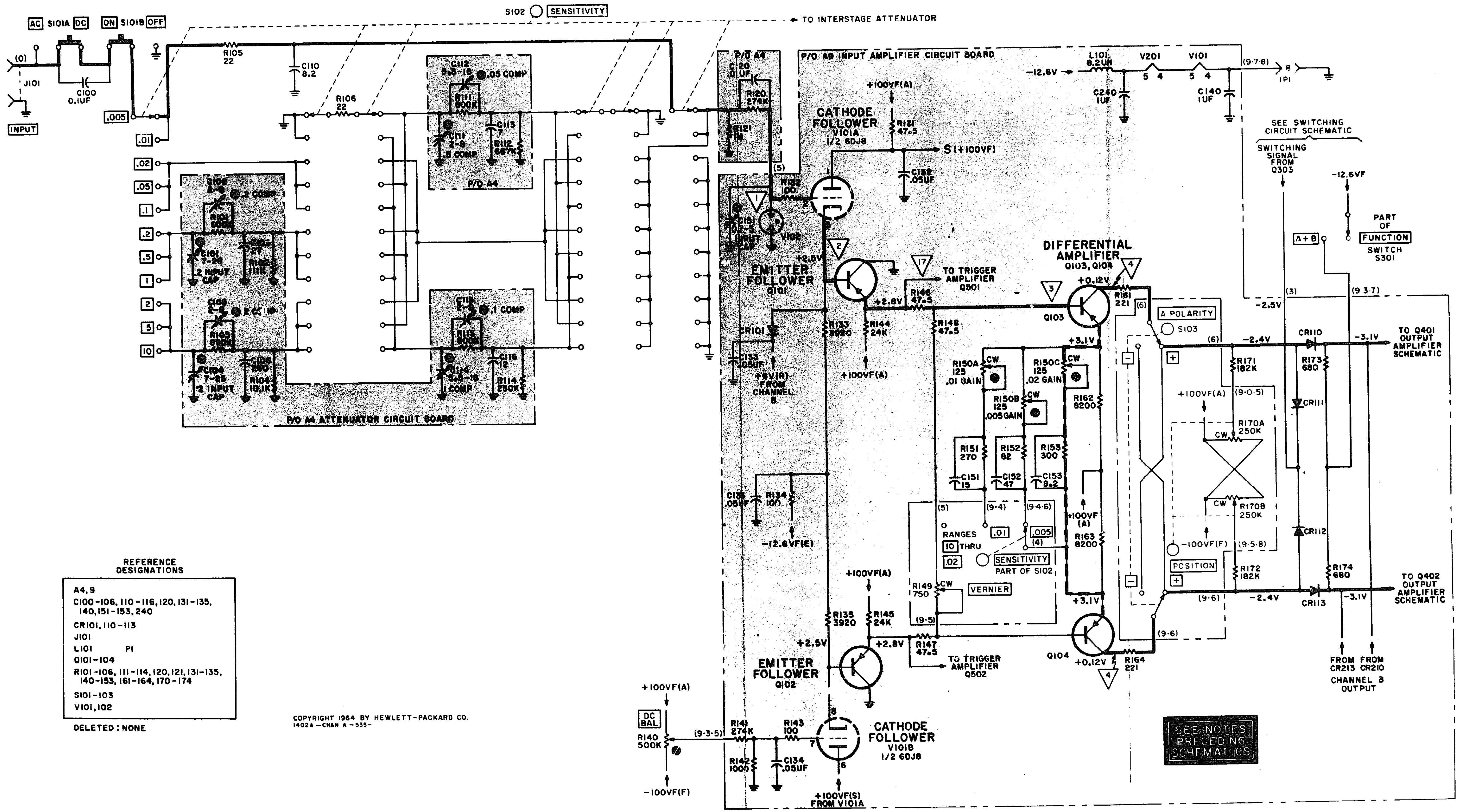
FO-1. Oscilloscope 141A Low Voltage Schematic Diagram



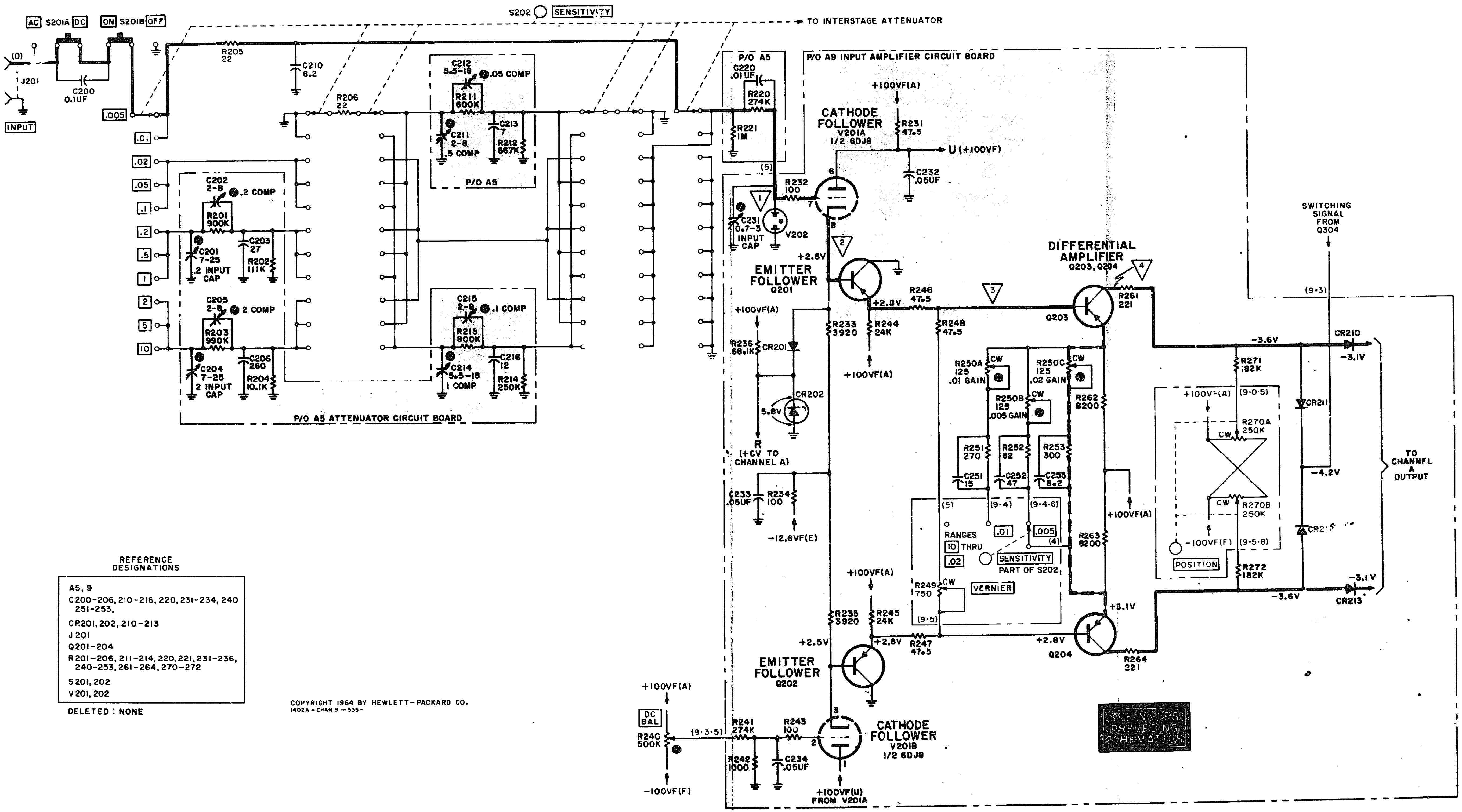
FO-2. Oscilloscope 141A, High Voltage Schematic Diagram



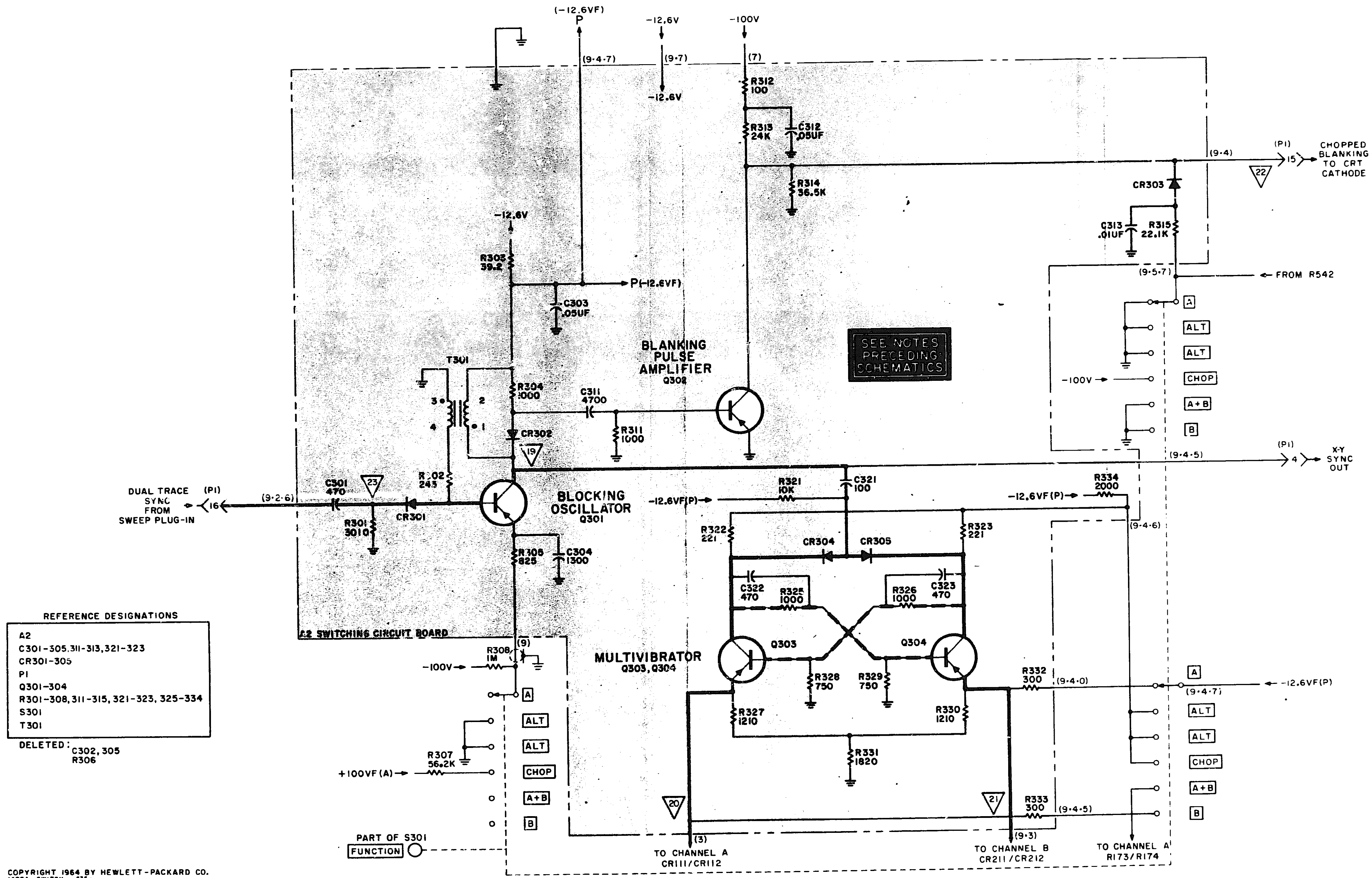
FO-3. Oscilloscope 141A, Pulse Circuit Schematic Diagram



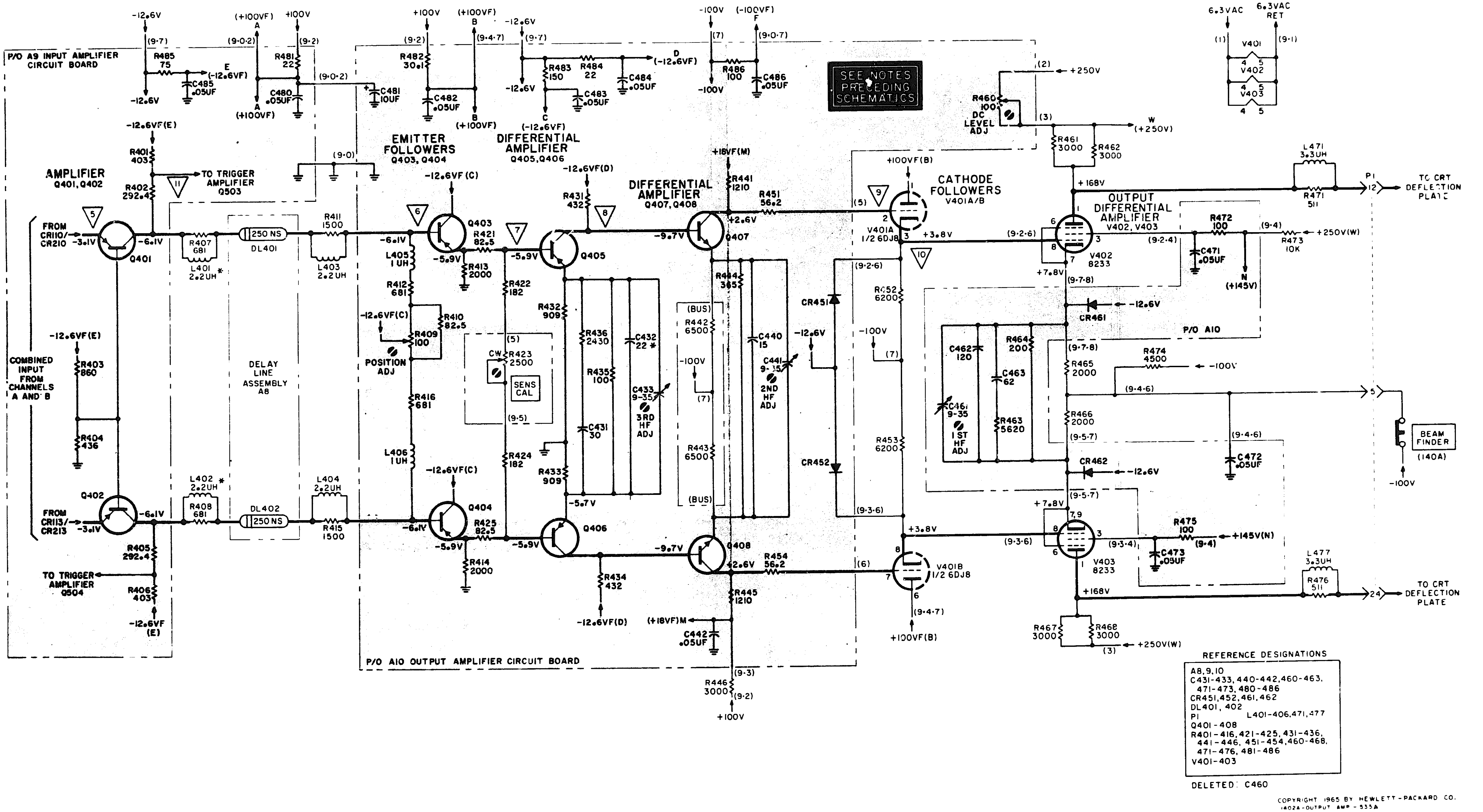
FO-4. Dual Trace Amplifier 1402A, Channel A Amplifier Schematic Diagram



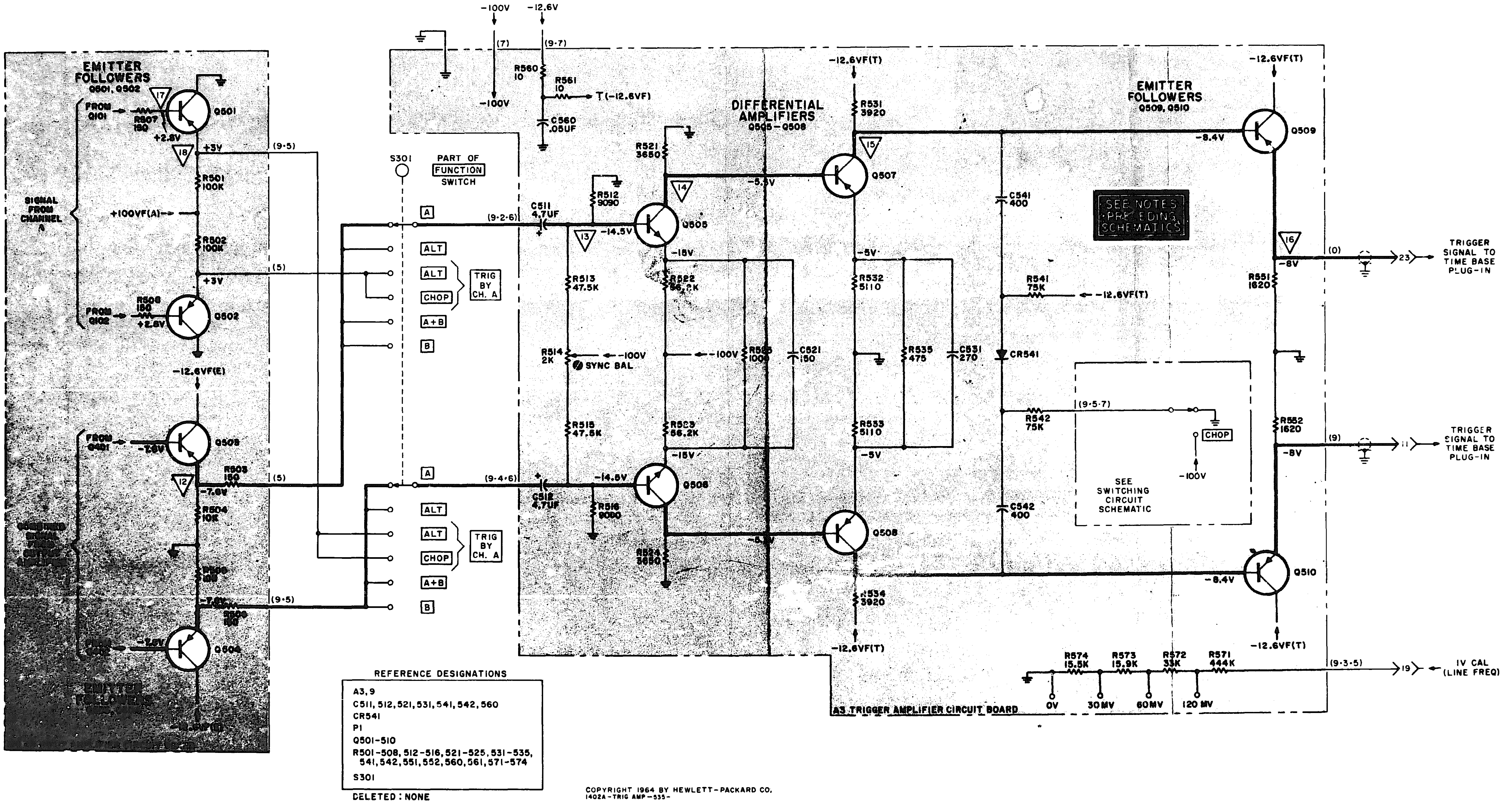
FO-5. Dual Trace Amplifier 1402A, Channel B Amplifier Schematic Diagram



FO-6. Dual Trace Amplifier 1402A, Switching Circuit Schematic Diagram



FO-7. Dual Trace Amplifier 1402A, Output Amplifier Schematic Diagram



FO-8. Dual Trace Amplifier 1402A, Trigger Amplifier Schematic Diagram

END

01-03-83

DATE

DEPARTMENT OF THE ARMY

MICROFORM
TEST TARGET

150 MM

1.0 mm (e= .81 mm)

ABCDEFGHIJKLMNOPQRSTUVWXYZ1234567890
abcdefghijklmnopqrstuvwxyz$¢£/%#½¼¾—=+×&@*

1.5 mm (e= 1.09 mm)

ABCDEFGHIJKLMNOPQRSTUVWXYZ1234567890
abcdefghijklmnopqrstuvwxyz$¢£/%#½¼¾—=+×&@*

2.0 mm (e= 1.37 mm)

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz
1234567890$¢£/%#½¼¾—=+×&@*

2.5 mm (e= 1.77 mm)

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz
1234567890$¢£/%#½¼¾—=+×&@*

1.0 mm (e= .81 mm)

ABCDEFGHIJKLMNOPQRSTUVWXYZ1234567890
abcdefghijklmnopqrstuvwxyz$¢£/%#½¼¾—=+×&@*

1.5 mm (e= 1.09 mm)

ABCDEFGHIJKLMNOPQRSTUVWXYZ1234567890
abcdefghijklmnopqrstuvwxyz$¢£/%#½¼¾—=+×&@*

2.0 mm (e= 1.37 mm)

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz
1234567890$¢£/%#½¼¾—=+×&@*

2.5 mm (e= 1.77 mm)

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz
1234567890$¢£/%#½¼¾—=+×&@*

200 MM

250 MM

By Order of the Secretary of the Army:

BERNARD W. ROGERS
General, United States Army
Chief of Staff

Official:

J. C. PENNINGTON
Brigadier General, United States Army
The Adjutant General

Distribution:
Active Army:
USAINSCOM (2)
OS Maj Comd (2)
USACC (5)
HQ 7th Sig Comd (3)
USACC-EUR (3)
USACC-PAC (3)
USACC Sig Gp. Okinawa (3)
USACC-Japan (5)
USACC Comm Op Fac, Korea (3)
USACC Sig Bde, Korea (3)
USACC Sig Gp. Taiwan (2)
Eighth USA (3)
LBAD (2)
SAAD (10)
TOAD (10)
USACSA (2)
TECOM (2)
Ft Monmouth (HISA) (33)
USA Ascom Dep (3)
USA Cp Carroll Dep (2)
Units org under fol TOE:
(1 cy each unit)
11-15
11-45
11-97
11-98
11-302
11-303
11-347
11-357
11-367
11-368
11-377
11-500(AA-AC)
29-118
29-134
29-136
29-137

NG: None
USAR: None
For explanation of abbreviations used, see AR 310-50.