Errata

Title & Document Type: **1410A Sampling Vertical Amplifier Operating and Service Manual**

Manual Part Number: **01410-90902**

Revision Date: **May 1968**

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HP References in this Manual

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Agilent Technologies

OPERATING AND SERVICE MANUAL

Serial Prefix: 743-
Backdate Serial Prefix: 616-
Stock Number: 01410-90902

MODEL 1410A
SAMPLING VERTICAL AMPLIFIER

SERIALS PREFIXED: 743-

See Section VII For Instruments With
Other Serial Prefixes

02596-2

PRINTED: MAY 1968

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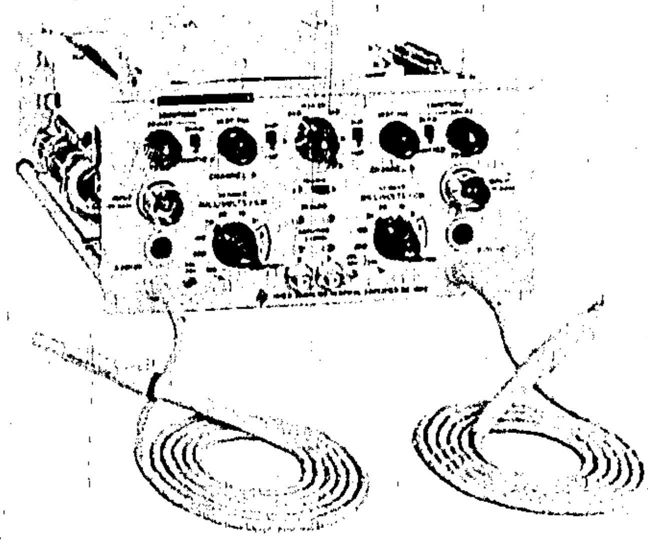


Figure 1-1. Model 1410A Sampling Vertical Amplifier

Table 1-1. Specifications

MODE OF OPERATION:

1. Channel A only.
2. Channel B only.
3. Channel A and Channel B.
4. Channel A and Channel B added algebraically.
5. Channel A vs. Channel B.

POLARITY: Either channel may be displayed either positive or negative up in any mode.

RISE TIME: Less than 350 ps.

BANDWIDTH: DC to 1 GHz.

OVERSHOOT: Less than 5%.

SENSITIVITY: Calibrated ranges from 1 mv/cm to 200 mv/cm in a 1, 2, 5 sequence. Vernier control provides continuous adjustment between ranges and increases maximum sensitivity to greater than 0.4 mv/cm.

ATTENUATOR ACCURACY: ±3%, ±5% SMOOTHED

ISOLATION BETWEEN CHANNELS: Greater than 40 db to 1 GHz.

INPUT IMPEDANCE:

Probes: 100k ohms shunted by 2 pf, nominal.
GR Type 874 Inputs: 50 ohms ±2% with 60ns internal delay lines for viewing leading edge of fast rise signals. Reflection from input connector is approx. 10%, using a 150 ps TDR system.

NOISE: (With sampling effeciency set to 100%, record amplitude set for 100 mv/cm, sweep set to 10 µsec/cm and input terminated in 50 ohms): Less than 8 mv amplitude from Y recorder output as measured on a true RMS Meter, from 5 mv/cm to 200 mv/cm. (Corresponds to approximately 1 mv observed noise on CRT excluding 10% of random dots. Noise decreases on automatically smoothed ranges 2 and 1 mv/cm. Smoothed position of smoothing switch reduces noise and jitter approximately 4:1. Vernier control provides continuous adjustment between the normal and smoothed modes.

DYNAMIC RANGE: ±2v pk-pk.

DRIFT: Less than 3 mv/hr after warm-up.

MAXIMUM SAFE INPUT:

Probes: ±50 volts.
50 ohm Inputs: ±5 volts.

TRIGGERING: Internal or external when using 50 ohm inputs.
Internal triggering selectable from Channel A or B.
External triggering necessary when using probes.

TIME DIFFERENCE BETWEEN CHANNELS (for probes or 50 ohm inputs): Less than 100ps.

RECORDER OUTPUTS: Front panel outputs provide 0.1 v/cm from a 500 ohm source. Gain adjustable from approximately 0.05 v/cm to 0.2 v/cm. DC level adjustable from approx. -1.5 v to +0.5 v.

WEIGHT: Net 10 lbs (4,5 kg). Shipping 15 lbs (6,8 kg).

SECTION I
GENERAL INFORMATION

1-1. SCOPE OF MANUAL.

1-2. This manual provides information for operating and servicing the hp Model 1410A Sampling Vertical Amplifier. This manual supplements the information presented in the Model 140 Series Oscilloscope manuals. For information on other plug-in units, refer to the manual for that particular unit. Specifications for the Model 1410A are listed in Table 1-1.

1-3. DESCRIPTION.

1-4. The Model 1410A Sampling Vertical Amplifier (Figure 1-1) is a two channel vertical plug-in designed for use with the Model 140 Series Oscilloscope and a sampling time base plug-in. The Model 1410A utilizes the sampling technique; that is, the amplifier samples the amplitude of the input signal at various times instead of continuously monitoring the signal as in conventional amplifiers. The Model 1410A permits observation of: two signals simultaneously, the algebraic sum or difference of two signals or an X-Y axis presentation. Each channel has a bandwidth of approximately 1 GHz and a rise time of less than 350 picoseconds.

1-5. Either channel may be displayed as positive or negative-up in any mode. Eight calibrated ranges of vertical sensitivity are provided, ranging from 1 mv/cm to 200 mv/cm in a 1, 2, and 5 sequence. A vernier control provides continuous adjustment between ranges and increases maximum sensitivity to greater than 0.4 mv/cm. A normal-smoothed switch reduces noise and jitter on the signal (in smoothed position) by about 4:1. The signal is automatically smoothed on the 1 and 2 MILLIVOLTS/CM range.

1-6. Front panel recorder outputs with both amplitude and dc level controls are provided. Rise time (T_R) and sampling effeciency (SMOOTHING) controls are located on the front panel for optimum compromise between rise time, overshoot, and noise.

1-7. Internal delay lines provide convenient internal triggering when using the 50 ohm inputs. Triggering is selectable from either channel A or channel B.

1-8. HORIZONTAL PLUG-IN COMPATIBILITY.

1-9. The Model 1410A can be used only with a sampling time base plug-in. At present, two horizontal units are available: the hp Model 1424A and Model 1425A.

1-10. FURNISHED ACCESSORIES.

1-11. The accessories furnished with the Model 1410A are described briefly in Table 1-2. These accessories

Table 1-2. Furnished Accesories, 01410-64501 Accessory Kit

hp Model No.	Name	Quantity	Purpose
10214A	10:1 Divider	2	Decreases input sensitivity of Model 187C by a factor of ten. (Minimum sensitivity with divider is 20 volts pk-pk.)
10216A	Isolator	2	Reduces vertical shift of trace base line when probe is moved to test point of different impedance.
10217A	Blocking Capacitor	2	Permits connection of Model 187C Probe to dc voltage levels of ±100 volts without damage to probe.
10218A	BNC Adapter	2	Permits connection of probe to female BNC connector.
10219A	GR Adapter	1	Permits connection of probe to Type 874 Coaxial Connector (manufactured by General Radio Co.).
10220A	Microdot Adapter	2	Permits connection of probe to Microdot connector (manufactured by Microdot Inc.).
10221A	50 ohm T Connector	1	Permits monitoring of signals in 50 ohm transmission lines without terminating the line or disturbing the signal.
10213-62102	Ground Clip	6	Attaches to probe for grounding purposes.
5020-0457	Probe Tip	6	Spare probe tips.
5020-0503	Probe Adj Tool	1	Used to optimize overshoot and rise time of the hp Model 10214A 10:1 Divider.
9211-1013	Accessory Box	1	Provides storage space for all furnished accessories.

increase the test compatibilities of the Sampling Vertical Amplifier. A more complete description of the furnished accessories is given in Paragraphs 3-39 through 3-47. For information on other accessories for use with the Model 1410A refer to a Hewlett-Packard Company Catalog or contact the nearest Hewlett-Packard Field Office (see rear of manual for addresses).

1-12. AVAILABLE ACCESSORIES.

1-13. Other accessories available for the Model 1410A are the Model 10203A 100:1 Divider and Model K01-10203A Divider Adapter. The 100:1 Divider may be used to reduce signal levels as high as 200 volts down to the 2 volts dynamic range of the Model 1410A. The Divider Adapter adapts the 100:1 Divider to the Model 1410A probe. Contact your nearest hp Sales/Service Office for further information on these accessories.

1-14. MANUAL IDENTIFICATION AND CHANGES.

1-15. Information in the manual applies directly to Model 1410A instruments with serial prefixes 743-. The serial prefix is the first three digits of the eight digit serial number (000-00000) used to identify each hp instrument. If the serial prefix is not 743-, a change sheet supplied with the manual will define the difference between the Model 1410A and the one described in the manual. Corrections to a manual due to errors that existed when it was printed are called Errata and will appear only on a change sheet (if any). For information pertaining to change sheets, contact your nearest Hewlett-Packard Sales/Service Office.

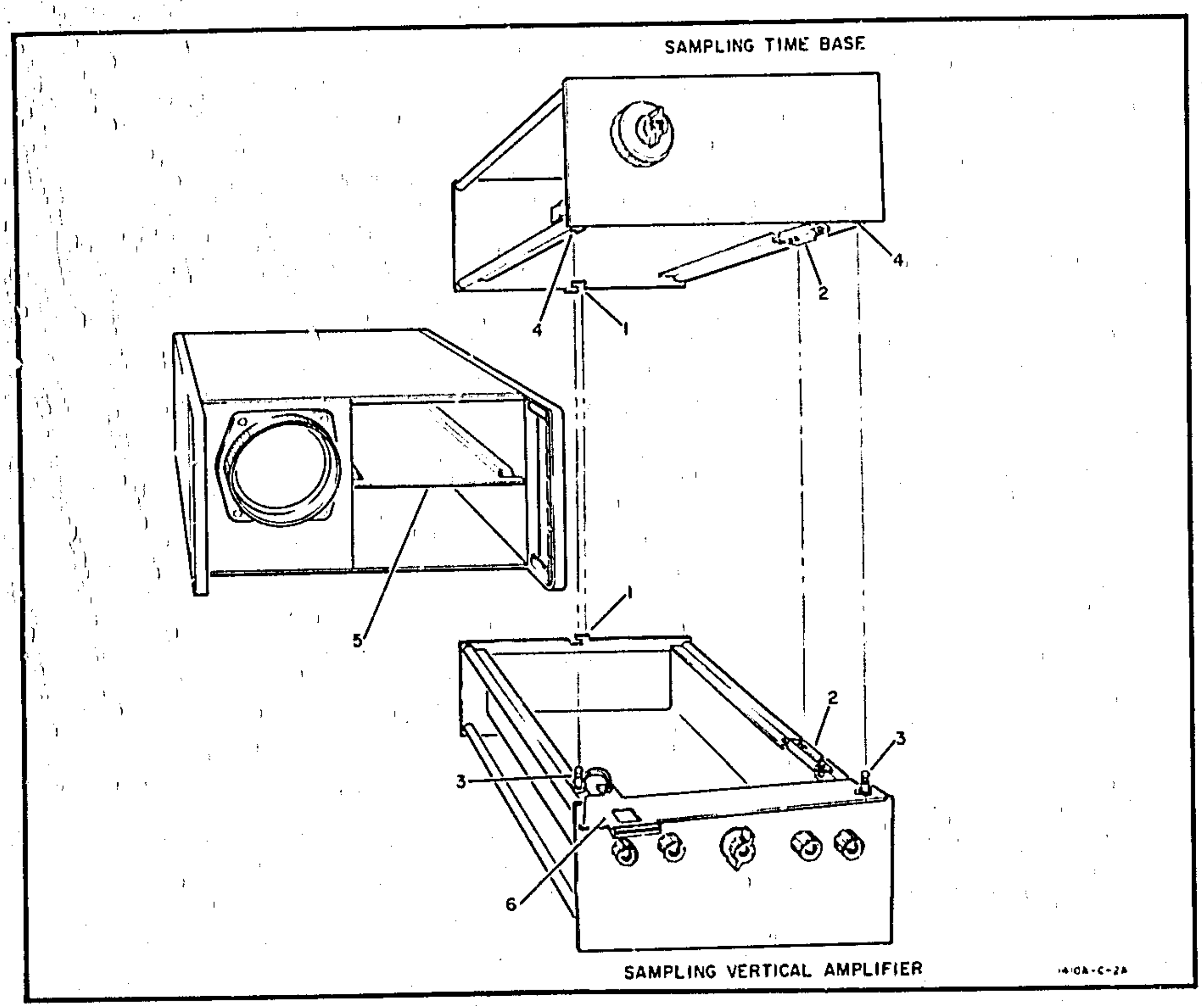


Figure 2-1. Procedure for locking plug-ins together

SECTION II
INSTALLATION

2-1. INITIAL INSPECTION.

2-2. MECHANICAL CHECK. Inspect the Model 1410A upon receipt for any damage which may have occurred in transit. Check for external damage such as broken knobs, bent or broken connectors, and dents or scratches on the panel surface. If damage is found, refer to Paragraph 2-7 for recommended claim procedure. Retain packing material for possible future use.

2-3. ELECTRICAL CHECK. Check the electrical performance of the Model 1410A as soon as possible after receipt; see Paragraph 5-3 for recommended performance checks. These checks, when performed, verify that the Model 1410A is operating within its specifications listed in Table 1-1. The performance checks are good test procedures for incoming quality-control inspection. Initial performance and accuracy of the instrument are certified as stated on the inside front cover of this manual. If the Model 1410A does not operate as specified, refer to Paragraph 2-7 for claim procedure.

2-4. PREPARATION FOR USE.

2-5. The Model 1410A Sampling Vertical Amplifier must first be locked to the sampling time base unit. To fasten the two units together place the time base unit above the Model 1410A and with a slight twisting action fasten the two rear interlocks together (see Figure 2-1, item 1). Press the time base down, being careful to properly align the jack and plug (item 2). The two guide pins at the front of the Model 1410A (item 3) should mate with their respective guide holes in the time base (item 4) and snap together.

2-6. To install the horizontal/vertical combination in the oscilloscope, first remove the dividing shield between the upper and lower compartments by pulling it straight out. Next, pull the locking lever outwards (item 5), and slide the combination into the oscilloscope. Pressing the locking lever inwards will now secure the two units to the oscilloscope.

Note

The deflection plate sensitivity of CRTs will differ slightly from one oscilloscope to another. For this reason, when the Model 1410A is installed in an oscilloscope for the first time, or when changed from one oscilloscope to another, the VERT CAL adjustment MUST be performed. This calibrates the amplifier gain to the deflection sensitivity of that particular oscilloscope. (See Figure 3-5 for procedure.)

2-7. CLAIMS.

2-8. The warranty statement applicable to all Hewlett-Packard Company instruments and products is provided inside the front cover of this manual. If physical damage is found or if operation is not as specified when the instrument is first received, notify the carrier and the nearest Hewlett-Packard Sales/Service Office immediately (see list in back of manual for addresses). The Sales/Service Office will arrange for repair or replacement without waiting for settlement of the claim with the carrier.

2-9. REPACKAGING FOR SHIPMENT.

2-10. If the Model 1410A is to be shipped to a Hewlett-Packard Sales/Service Office for service or repair, attach a tag showing owner (with address), instrument model number, full serial number of the instrument (all eight digits) and description of the service or repair required.

2-11. The original shipping carton and packaging material, with the exception of accordion-pleated pads, may be reusable, if undamaged. The Sales/Service Office will provide information and recommendations on materials to be used if the original packaging material is not available. Materials used for shipping an instrument should include the following:

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

Table 2-1. Shipping Carton Test Strengths

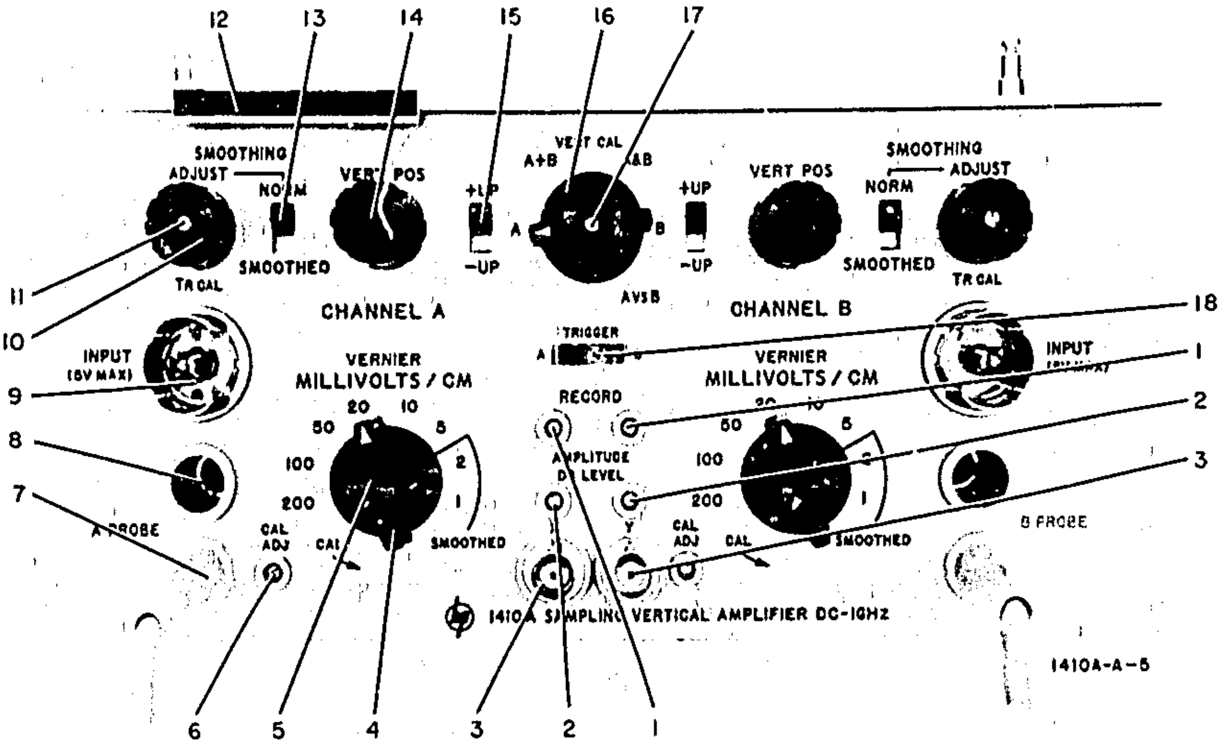
Gross Weight (lbs)	Carton Strength (test lbs)
up to 10	200
10 to 30	275
30 to 120	350
120 to 140	500
140 to 160	600

b. Heavy paper or sheets of cardboard to protect all instrument surfaces; use a nonabrasive material such as polyurethane or cushioned paper such as Kimpak around 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 securing outside of carton.

OPERATION



1. Adjusts AMPLITUDE of X and Y RECORD outputs.
2. Adjusts DC LEVEL of X and Y RECORD outputs.
3. BNC connector for X and Y RECORD outputs.
4. Changes vertical deflection factor in calibrated ranges of MILLIVOLTS/CM.
5. Changes deflection factor between calibrated ranges. Detent position (CAL) provides calibrated display.
6. Adjusts gain of Channel A.
7. Channel A probe cable.
8. Channel A probe receptacle, used when triggering the time base plug-in from signal source. Also provides convenient storage for probe when not in use.
9. Signal INPUT connector, when triggering time base from signal source.
10. Adjusts over-all sampling efficiency of Channel A.
11. Adjusts rise time to compensate for ambient temperature extremes.
12. Secures the horizontal/vertical combination to the oscilloscope.
13. Selects normal or smoothed response to reduce effect of noise or jitter.
14. Adjusts vertical position of signal or baseline.
15. Inverts polarity of signal presentation.
16. Selects one of five modes of presentation.
17. Calibrates gain of main vertical amplifier to deflection plate sensitivity of CRT.
18. Selects the trigger source (A or B) used to trigger the time base plug-in.

Figure 3-1. Controls and Connectors

SECTION III
OPERATION

3-1. INTRODUCTION.

3-2. This section includes explanation of instrument controls, front panel adjustments, available modes of operation, operating considerations regarding smoothing and rise time and step-by-step operating instructions. Since the Model 1410A and sampling time base are closely interdependent upon each other to achieve high-frequency sampling, the instructions presented in this section are supplemented by those given in the sampling time base manual.

3-3. FRONT PANEL FAMILIARIZATION.

3-4. The controls of the Model 1410A are described by function in Figure 3-1. Only Channel A controls and controls common to both channels are described. Channel B controls perform the same function as the corresponding controls in Channel A. Additional information on some of the controls is given in Paragraphs 3-5 through 3-17.

3-5. NORM-SMOOTHED. Normal response is used when viewing detailed waveforms and fast rise pulses. SMOOTHED response provides filtering of the input signal, thus reducing noise and jitter on the observed waveform. In the two highest vertical sensitivity ranges (1 and 2 mv/cm), response is automatically smoothed. When using these two highest ranges, the NORM-SMOOTHED switched should be in NORM position.

3-6. SMOOTHING ADJUST — T_R CAL. The SMOOTHING control adjusts the over-all sampling efficiency by controlling gain of the sampling loop. T_R CAL adjusts rise time of the instrument to compensate for extreme ambient temperature changes. Proper setting of these two controls is necessary to obtain accurate displays. Paragraphs 3-22 through 3-30 explain the procedures for making these adjustments.

3-7. VERT POS. This control changes the vertical position of the base line on the CRT graticule.

3-8. +UP, -UP. When this switch is in the +UP; positive-going signals are presented in a positive-up direction on the CRT. In -UP position, negative-going signals are presented in a positive-up direction.

3-9. MODE SELECTOR. The position of this switch determines which channel or combination of channels is displayed on the CRT. Five displays are available: A, A+B, A&B, B and A vs B. Refer to Paragraph 3-34 for detailed application of each of these modes.

3-10. VERT CAL. This adjustment calibrates vertical sensitivity of the main vertical amplifier stage, common to both A and B channels. This adjustment should be checked when the Model 1410A is installed in the oscilloscope for the first time or when the instrument is changed from one oscilloscope to another.

3-11. TRIGGER A-B. This switch selects the signal source (A or B) used to trigger the horizontal plug-in (when using 50 Ω input only).

3-12. INPUT. A GR type connector, used for signal inputs when internal triggering of the time base plug-in is desired. Input impedance is 50 ohms and the input connector is a General Radio type 874. Do not apply signals of more than 5 volts to this input.

3-13. A PROBE RECEPTACLE. The 50 ohm INPUT routes the incoming signal through a 60 nanosecond delay line, then sends the signal to the A PROBE receptacle. Here it is sampled by the Channel A probe. This time delay is necessary to compensate for an inherent time delay in the sampling system.

3-14. MILLIVOLTS/CM. This control selects the desired deflection factor. Smoothed response is automatically inserted on the two highest ranges (1 or 2 MILLIVOLTS/CM). The VERNIER control provides continuous adjustment between ranges. With the VERNIER set fully clockwise and sensitivity set to 1 MILLIVOLT/CM, the deflection factor is extended to at least 0.4 millivolts/cm. Detent position (CAL) gives a calibrated display.

3-15. RECORD AMPLITUDE. These controls adjust output amplitude of the X and Y recorder outputs.

3-16. DC LEVEL. These controls adjust the dc level of the X and Y recorder outputs.

3-17. CAL ADJ. These adjustments control gain of Channels A and B.

3-18. INPUT PROBES.

3-19. Input signals are applied to each channel through a small diameter probe permanently attached to the instrument by a cable. The probes have a colored identification band around their body. Channel A has a red band and Channel B probe has a blue band. Signals up to 2 v pk-pk can be applied without overloading the probes, regardless of MILLIVOLTS/CM setting.

3-20. An especially useful characteristic of the sampling system is that it does not suffer the large signal overload problem that is characteristic of conventional oscilloscopes. As a result, the sampling oscilloscope can display small-amplitude phenomena existing along the top or bottom of large signals, as illustrated in Figure 3-2. Here the upper trace shows a pulse displayed by one channel of the instrument using minimum sensitivity (200 mv/cm). The lower trace shows the detail on the top of the same pulse, displayed by the second channel, using 20 times as much sensitivity (10 mv/cm). Ringing and overshoot on the large pulse can thus be examined in detail. As long as the noise, etc., at the top of the pulse does not exceed the ±2 volt dynamic range of the sampling gate, the presentation is valid. If a probe is overloaded, a 10 microsecond delay is required prior to application of the waveform to be viewed. Without the 10 microsecond

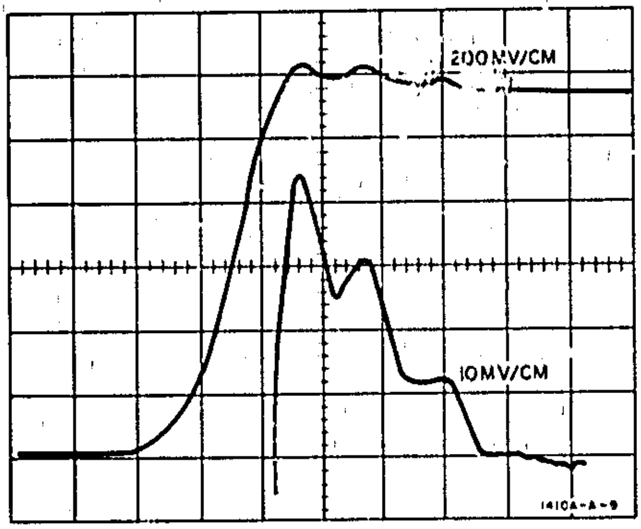


Figure 3-2. Non-overload Characteristics

delay, an overloaded probe will cause distortion of the incoming signal.

3-21. Interference to trace positioning and instrument response, and interaction between channels can result if both probe tips are connected to the same test point. To avoid these undesirable effects and to provide sufficient isolation between channels use the hp Model 10216A Isolator.

3-22. SAMPLING EFFICIENCY.

3-23. DEFINITION.

3-24. Sampling efficiency (response) of the Model 1410A is a measure of its ability to follow any change of input signal level from sample to sample. Response is optimum when (within the rise time limitations of the instrument) the vertical position of each sample corresponds exactly to the amplitude of the input signal at the time of the sample. If response is low, more than one sample is required to respond to a change. If response is too high, there will be sample-to-sample overshoot and ringing.

3-25. Sampling efficiency is dependent upon three factors: 1), the RC time constant of the sampling capacitance, and the signal source and sampling diode impedances; 2), length of time the sampling gate is "on" and 3), loop gain of the sampler/stretcher loop. The sampling time and RC time constant are fixed. However, since signal source impedance will vary as the probe is moved from one test point to another, the sampling efficiency will also vary. By making the loop gain variable (SMOOTHING ADJUST), the sampling efficiency can be quickly and conveniently optimized at any time. Figure 3-3 shows the procedure for optimizing the response.

3-26. The Model 1410A provides two types of response (sampling efficiency), normal and smoothed. Either type can be selected by the front panel NORM-SMOOTHED switch. Normal response is intended for use when viewing detailed waveforms and fast rise pulses. Smoothed response provides filtering of the input signal and reduces the effects of noise and jitter by about 4:1 compared to the effects seen on normal response. Use smoothed response when noise and jitter present in a signal are not desired in the observed waveform.

3-27. In addition to the smoothed operation selected by the switch, the input signal is automatically smoothed when the MILLIVOLTS/CM switch is set to either of its two highest sensitivity ranges (1 or 2 mv/cm). The automatic smoothing is progressive, being greater on the 1 mv/cm range.

Note

When using the 2 or 1 MILLIVOLTS/CM ranges, the NORM-SMOOTHED switch should always be in the NORM position.

3-28. OPTIMIZING SAMPLING EFFICIENCY.

3-29. Rise time (T_R CAL) of the Model 1410A is originally set for less than 350 psec at an ambient temperature of 25°C (77°F) and under normal circumstances should not require readjustment. However, if the ambient temperature exceeds 40°C (104°F), sampling efficiency decreases and rise time becomes faster. If the ambient temperature falls below 15°C (59°F), sampling efficiency increases and rise time becomes slower. If the system is operated at either temperature extreme, rise time and sampling efficiency should be reset as outlined in Paragraph 3-30.

3-30. To reset rise time and sampling efficiency to correct for temperature extremes, proceed as follows:

a. Turn system "on" and allow at least one hour for instruments to reach ambient temperature.

b. Using a fast rise time pulse generator such as the hp Model 1105A/1106A and a Model 10221A 50 ohm tee, adjust T_R CAL for a rise time of ≈320 psec (probe only). To prevent random triggering, it may be necessary to isolate the probe from the pulse generator with an air line (approximately 40 cm).

Note

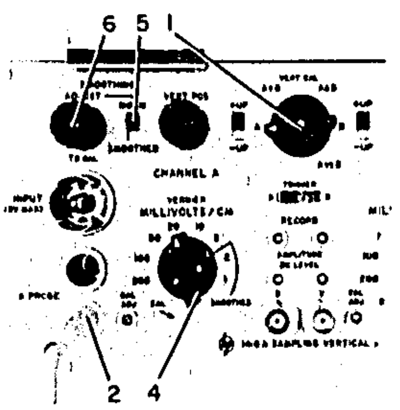
If the pulse generator signal is connected to the INPUT connector and routed through the delay line, rise time will be somewhat slower (≈350 psec). Air line isolation is not necessary.

c. Reset sampling efficiency with the SMOOTHING ADJUST (see Figure 3-3).

3-31. TRIGGERING FROM SIGNAL SOURCE.

3-32. A time delay exists between the time that the sync circuit in the horizontal plug-in is triggered, and the time that the sample is taken with the Model 1410A. Therefore, when triggering the time base from the signal source, connect the signal to the A or B INPUT connector and insert the probe into the receptacle. This allows the incoming signal to be amplified and sent directly to the time base for triggering purposes but delayed 60 nanoseconds before being sampled by the probe. This delay action permits observation of the leading edge of the "first" pulse.

3-33. The delay lines and sync amplifiers are completely independent of the Channel A and B amplifier circuits, therefore, the signal can be connected to the B INPUT and observed with the Channel A probe or vice-versa



1. Select channel to be adjusted.

2. Connect appropriate probe to signal test point. Signal should produce a level difference of approximately 5 cm between beginning and end of display on any range except 2 or 1 mv/cm.

3. Adjust horizontal plug-in to obtain presentation Adjust SCAN DENSITY for minimum density.

4. Adjust MILLIVOLTS/CM for display 5 to 6 cm high.

5. Set SMOOTHING switch to NORM.

6. Adjust SMOOTHING ADJUST so that second sample is part of waveform as shown in waveform a. Waveform b indicates response adjusted too high; waveform c indicates response adjusted too low.

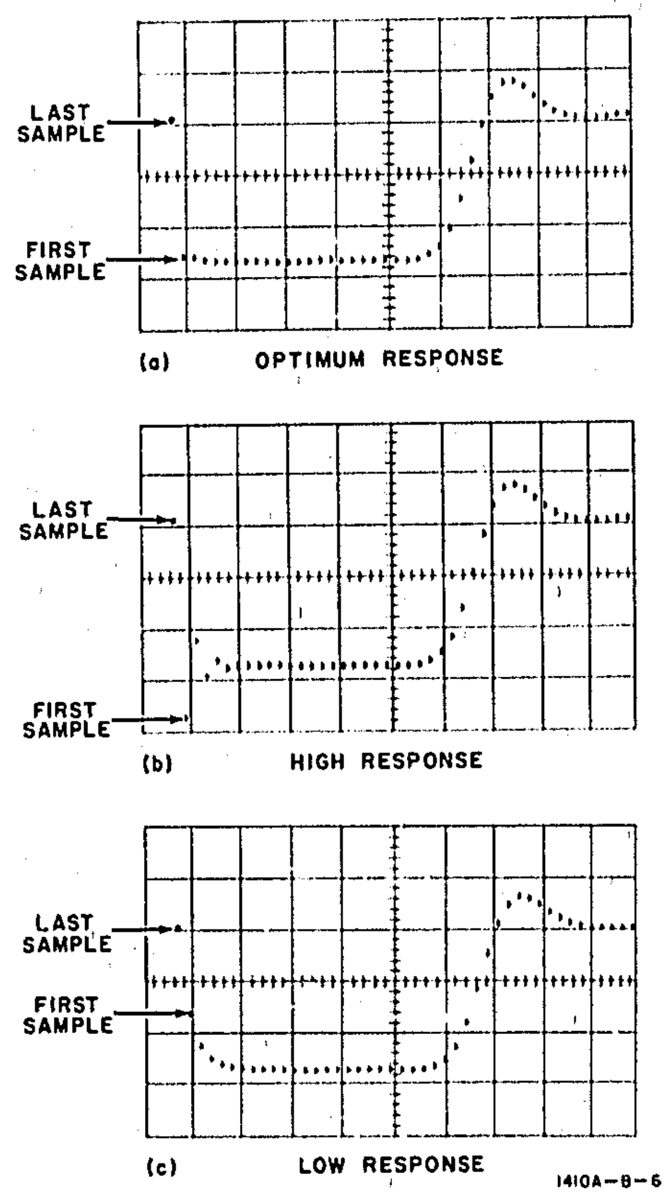


Figure 3-3. Optimizing Response

if so desired. Set the TRIGGER selector switch to correspond to the appropriate delay line being used. Set the mode selector switch to correspond to the appropriate probe being used.

3-34. MODES OF OPERATION.

3-35. DUAL TRACE OPERATION. Dual trace operation permits time and amplitude comparisons between Channel A and Channel B signals. Both channels sample at the same time and the two channels are alternately displayed on the CRT. Since the two channels are independent, they can be operated at different sensitivities without loss of calibration and thus, large signals can be compared to small ones, within the cross-talk specifications of the instrument. Dual trace operation is selected with the mode selector switch in the A & B position. The polarity switch makes possible a (+)A & (+)B, (-)A & (-)B, (+)A & (-)B or (-)A & (+)B display.

3-36. ALGEBRAIC ADDITION AND DIFFERENTIAL OPERATION. In the A+B Position, Channel A and Channel B signals are algebraically added. If both polarity switches are in the same relative position (both +UP or both -UP), the displayed signal will represent the algebraic sum of the two inputs [e. g. (+)A + (+)B or (-)A + (-)B] If the polarity switches are in dissimilar positions (one -UP and one +UP), the displayed signal will represent the algebraic sum of the two inputs [e. g. (+)A + (-)B or (-)A + (+)B], resulting in differential operation.

3-37. X-Y OPERATION. The A vs B mode provides an X-Y display. Channel A signals are amplified and sent to the vertical deflection plates in the usual manner as a Y-axis display. Channel B signals, however, are amplified, then routed to the horizontal amplifier in the time base plug-in and presented on the CRT as an X-axis display. Since both polarity switches remain operative in this mode, it is possible to present a (-)X vs (+)Y, (-)X vs (-)Y, (+)X vs (-)Y or a (+)X vs (+)Y display.

3-38. SINGLE CHANNEL OPERATION. By selecting either A or B position of the mode selector switch, single channel operation is obtained. The respective polarity switches enable the signal to be observed as a (+)A, (-)A, (+)B or (-)B.

3-39. USE OF ACCESSORIES.

3-40. MODEL 10214A, 10:1 DIVIDER. The 10:1 Divider decreases the input sensitivity of the Model 1410A by a factor of 10, thus permitting measurement of signals as great as 20 volts peak-to-peak. Input impedance of the probe-divider combination is 1 megohm shunted by 2.5 picofarads.

3-41. MODEL 10216A ISOLATOR. The Isolator effectively eliminates vertical changes in sampling efficiency, caused by source impedance changes as the probe-isolator combination is moved from one test point to another. When the isolator is used, the rise time of the Model 1410A is increased to approximately 0.7 nsec and input capacitance increases by no more than 3 picofarads.

3-42. MODEL 10217A BLOCKING CAPACITOR. The Blocking Capacitor allows measurement of signals that are ±50v from ground. Capacitance is .001 μf. The blocking capacitor contributes only 1% sag to a 1 μsec pulse when used with the probe alone. Sag to a 1 μsec pulse is 0.1% when the 10:1 Divider is used. The blocking capacitor may also be used with the probe-isolator combination, increasing input capacitance by no more than 3.5 picofarads.

3-43. MODEL 10218A BNC ADAPTER. This adapter allows connection of the probe to a male BNC connector.

3-44. MODEL 10219A GR ADAPTER. This adapter permits connection of the probe to a GR Type 874 Coaxial Connector (manufactured by General Radio Company).

3-45. MODEL 10220A MICRODOT SCREW-ON ADAPTER and 10223A MICRODOT SLIDE-ON ADAPTER. These adapters allow easy connection of the coaxial connectors and also provide a solid-ground reference.

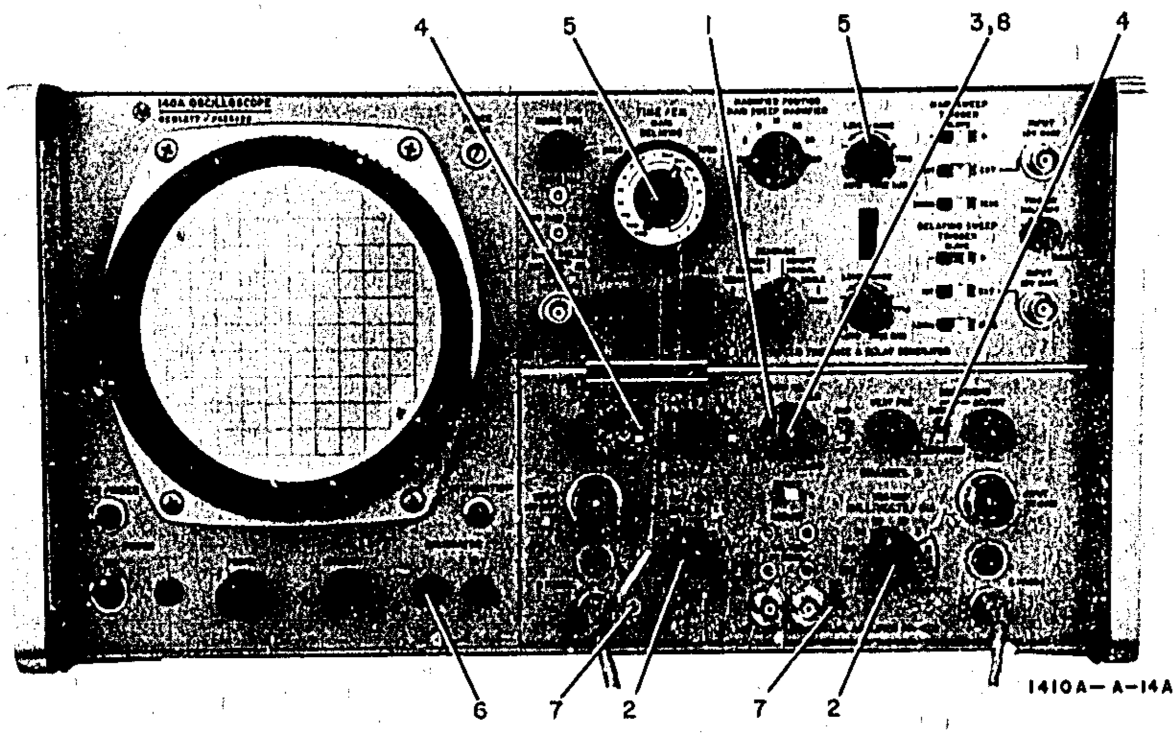
3-46. MODEL 10221A 50 OHM T CONNECTOR. The T connector permits monitoring of signals in 50 ohm transmission lines without terminating the line or disturbing the signal.

3-47. PROBE ADJ TOOL. This tool is used for adjusting overshoot and rise time of the hp Model 10214A 10:1 Divider (see Section V for adj procedure).

3-48. OPERATING PROCEDURES.

3-49. Front panel adjustment procedure is given in Figure 3-4. Normally, when changing the plug-in from one oscilloscope to another, or when installing for the first time, only the VERT CAL check should have to be made.

3-50. Common operating setups and step-by-step procedures for control setting are given in Figure 3-5 and 3-6. Each figure includes a front panel illustration of the Model 140A, the Model 1410A and the Model 1425A Time Base and Delay Generator. Where a control or connector is used in a procedural step of the instruction, the step number is called out from its corresponding control.



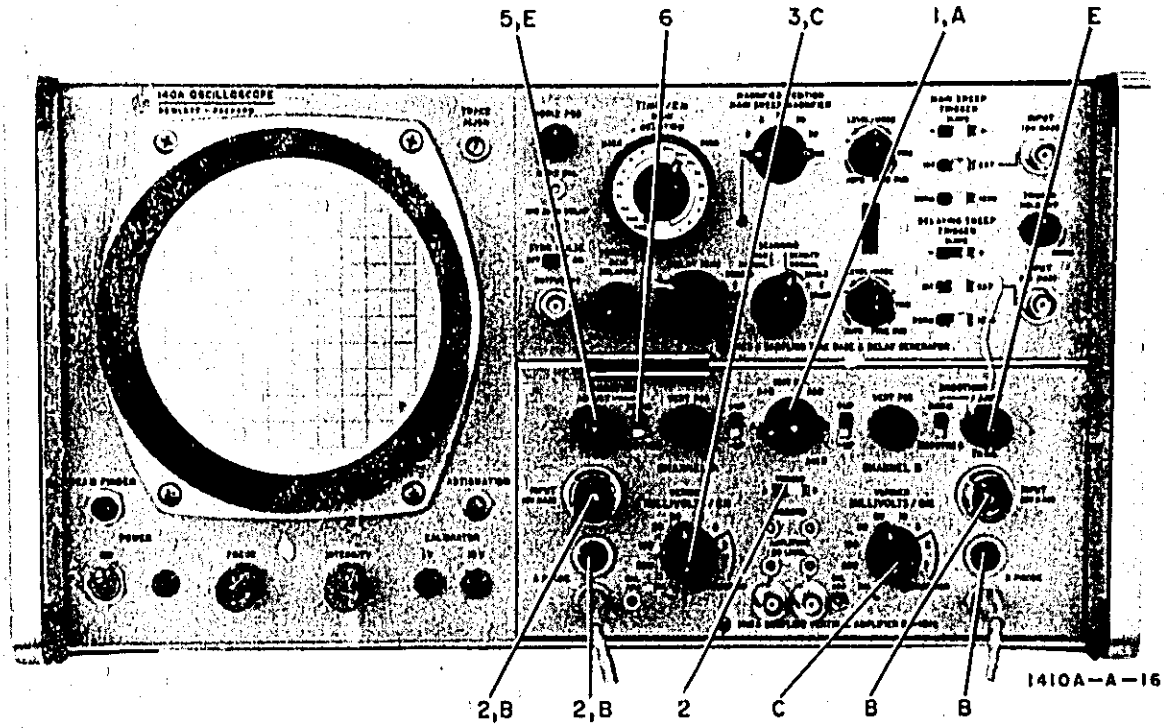
CAL ADJ AND VERT CAL

1. Set mode selector to A and B.
2. Set both MILLIVOLTS/CM to 100 and both VERNIERS to CAL.
3. Mechanically center VERT CAL adjustment.
4. Set both NORM-SMOOTHED switches to NORM.
5. Set TIME/CM to 100 μSEC/CM and sweep mode to FREE-RUN.
6. Connect both Channel A and B probes to the 1v CALIBRATOR output on the Model 140A front panel. Use of an alligator clip or banana jack may be helpful.
7. Adjust necessary channel CAL ADJ to make both channels have equal amplitude.
8. Adjust VERT CAL for exactly 10 cm of deflection.

Note

If enough range of VERT CAL cannot be obtained for 10 cm of deflection, the two CAL ADJ can be increased or decreased accordingly to provide necessary range.

Figure 3-4. Cal Adj. & Vert Cal



SINGLE TRACE

1. Set mode selector to A or B as desired.
2. Connect appropriate probe to signal test point. If signal is greater than 2v pk-pk, use an external attenuator. If it is desired to trigger the time base internally, connect signal to appropriate 50 ohm INPUT connector and insert probe into its receptacle. Set TRIGGER A-B to correspond to selected channel.

CAUTION

DO NOT CONNECT SIGNALS GREATER THAN ±50 VOLTS TO PROBE, OR MORE THAN ±5 VOLTS TO THE 50 OHM INPUT OR DAMAGE TO THE INSTRUMENT MAY RESULT.

3. Set MILLIVOLTS/CM and VERNIER as required.
4. Set time base controls as outlined in the time base operating and service manual.
5. Optimize response as shown in Figure 3-3.
6. Reduction of noise and jitter may be obtained by setting NORM-SMOOTHED to SMOOTHED.

Note

If the T_R CAL and/or SMOOTHING and/or VERT POS controls of the unused channel are maladjusted, the Model 1410A may have spurious oscillations that will degrade the operation of the channel being used.

DUAL TRACE

A. Set mode selector to A & B.

B. Connect probes to signal testpoints or connect signals to the 50 ohm INPUTs if internal triggering is desired. Observe maximum input voltage limits.

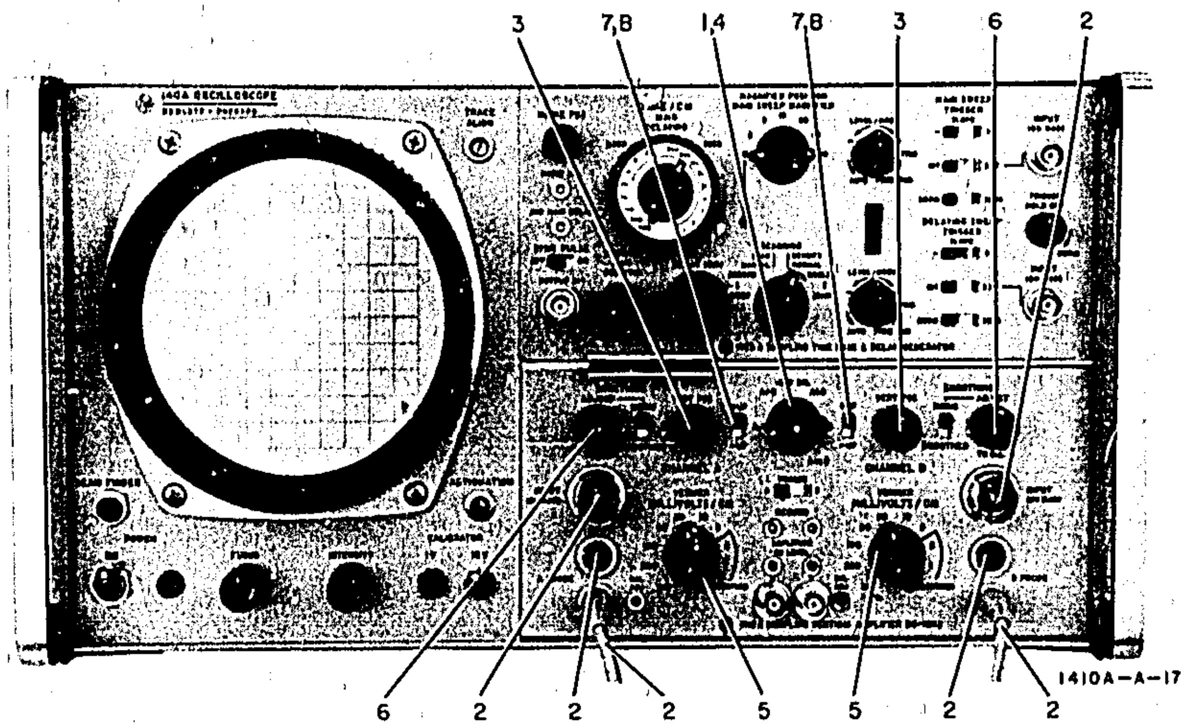
C. Set MILLIVOLTS/CM and VERNIER controls as required.

D. Set horizontal controls as required to obtain display.

E. Optimize response as shown in Figure 3-3 for both channels.

F. Two completely independent displays will be presented, enabling amplitude and time comparisons to be made.

Figure 3-5. Single Trace and Dual Trace



ALGEBRAIC ADDITION

1. Set mode selector to A & B.
2. Connect probes to signal testpoints or 50 ohm INPUTs as outlined in Figure 3-6.
3. Adjust both VERT POS controls to position baselines on screen.
4. Change mode selector to A + B.
5. For a meaningful display, set both MILLIVOLTS/CM and VERNIER controls to the same settings.
6. Optimize response for each channel as shown in Figure 3-3.
7. Set both polarity switches to the same position (both +UP or both -UP).
8. The resultant signal represents the algebraic sum of channel A and B signals [e.g. (+)A + (+)B or (-)A + (-)B] .

DIFFERENTIAL OPERATION

A. Perform steps 1 thru 6 of algebraic addition procedure.

B. Set one polarity switch to +UP and the other channel polarity switch to -UP.

C. The resultant signal will represent the algebraic difference between channel A and channel B signals. [e.g. (+)A + (-)B or (-)A + (+)B]

Figure 3-6. Algebraic Addition & Differential Operation

THEORY

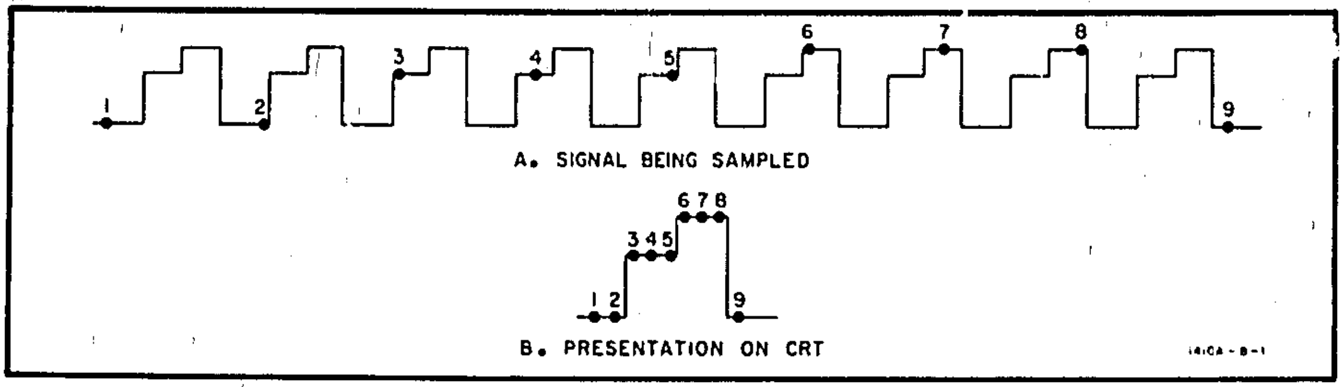


Figure 4-1. Sampling Technique

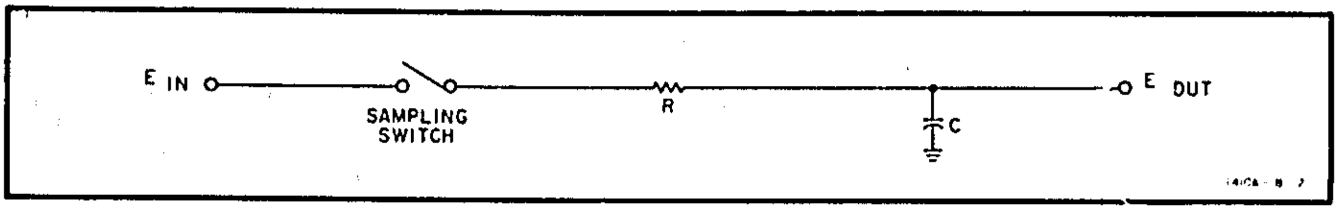


Figure 4-2. Basic Sampler

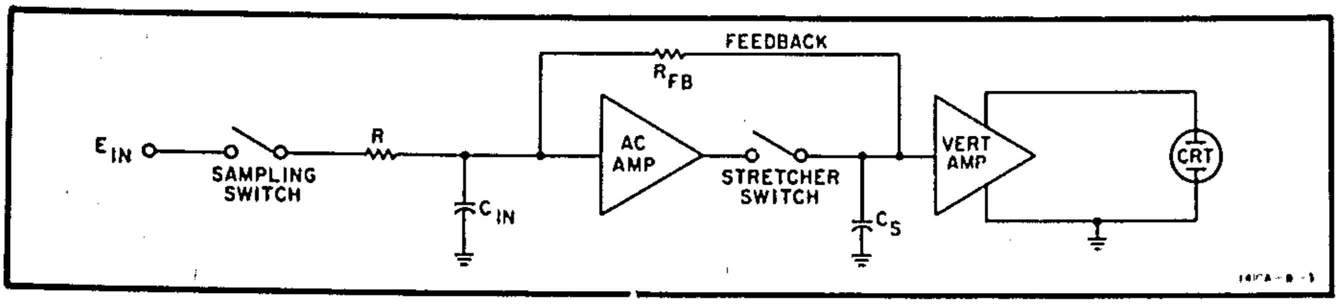


Figure 4-3. Basic Sai. pler with Vertical Amplifier

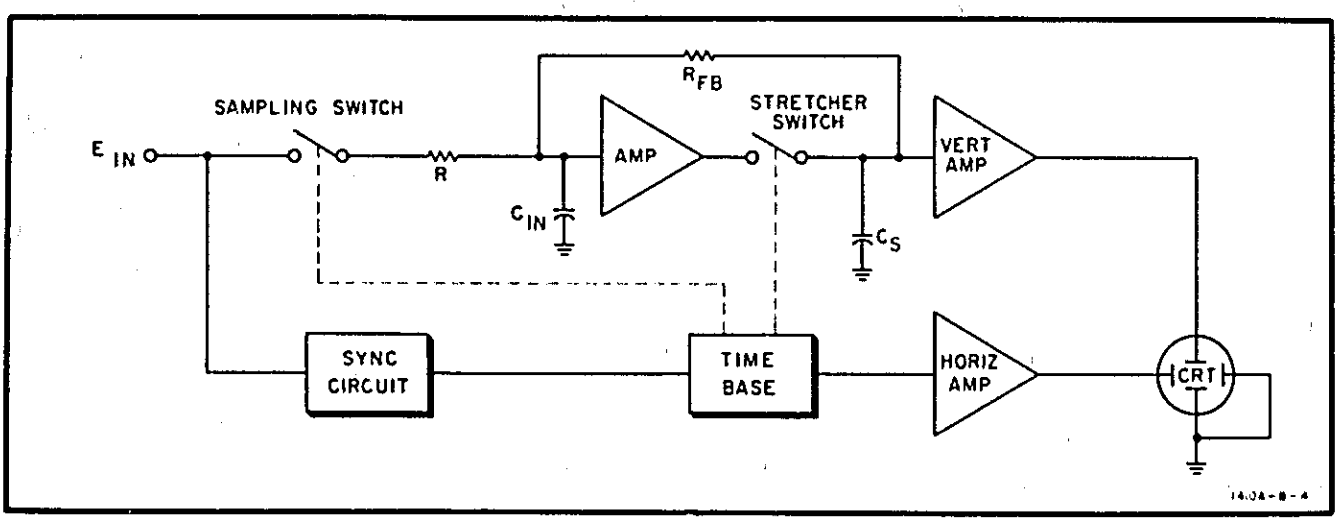


Figure 4-4. Entire Sa.. ing System

SECTION IV
PRINCIPLES OF OPERATION

4-1. INTRODUCTION.

4-2. This section provides circuit theory analysis of the Model 1410A Sampling Vertical Amplifier. Before covering the specific theory of the Model 1410A however, an explanation of sampling theory in general will be presented.

4-3. GENERAL SAMPLING THEORY.

4-4. Sampling oscilloscopes differ from "conventional" oscilloscopes in that instead of continuously monitoring the signal under test, the sampling device "samples" the signal amplitude at regulated intervals and in this manner synthetically reproduces the sampled signal. These samples are presented on the CRT as a series of dots (see Figure 4-1).

4-5. Changing the Scan Density control of the sampling time base plug-in enables one to see a minimum of approximately 50 samples in 10 cm to a maximum of more than 1000 samples (dots) in 10 cm. When Scan Density is at or near maximum setting, the series of dots will appear as a continuous line.

4-6. VERTICAL SAMPLING.

4-7. A basic sampling circuit is shown in Figure 4-2. It consists of a sampling switch, a series resistor, and a shunt capacitor to ground. At the instant that the switch is closed, the capacitor begins to charge. However, since the switch is closed for such a brief period, the capacitor will charge to only a small percentage of the actual signal amplitude (approximately 5%).

4-8. Figure 4-3 shows a sampler circuit with a vertical amplifier and feedback circuit added. Sampling is accomplished by momentarily closing the sampling switch. Some voltage determined by the RC time constant of the input resistance and capacitance, is transferred to the input capacitor C_{in}. This voltage is amplified and sent to the stretcher. The stretcher gate is on at the same time that the sampling gate is on but remains on for a much longer period of time. As a result, the stretcher capacitor has time to charge to the full voltage output of the ac amplifiers. This voltage is applied to the vertical amplifier where it is amplified sufficiently to drive the vertical deflection plates of the CRT. This new level is also fed back through a feedback attenuator, represented as R_{fb}, to the input capacitor. Gain of the ac amplifier, and feedback are designed so that the voltage fed back to the input capacitor will represent 100% of the sampled signal level. Thus, when the next sample is taken, only changes from the previous level will be detected.

4-9. HORIZONTAL SAMPLING.

4-10. The horizontal circuitry of a sampling oscilloscope differs greatly from that of a conventional oscilloscope. The primary function of the sampling time base is to generate a sampling command trigger for the vertical circuits and, to move the dots across the screen in uniform increments of time. Figure 4-4 shows an entire sampling system.

4-11. The horizontal scanner circuits consist of a sync circuit, time base, and horizontal amplifier. The sync circuit determines the sampling rate and establishes a reference point from which the sampling command trigger is given. The function of the time base circuit is to relay the sample command to the sampler and stretcher gates and "step" the dots across the CRT. The horizontal amplifier amplifies the horizontal deflection signal to sufficient amplitude to drive the horizontal deflection plates.

4-12. A conventional time base produces a linear sawtooth sweep, to continuously move the beam horizontally across the CRT. The sampling time base also moves the beam across the screen, but not as a continuous movement. It positions the beam horizontally when a sample is taken and holds the beam at this location until the next sample is taken. The beam is then repositioned to a point slightly later in time on the CRT and remains here until the next sample.

4-13. Figure 4-5 shows the horizontal deflection signals for both a conventional and sampling oscilloscope. The staircase ramp advances one step after each sample is taken.

4-14. When the staircase reaches a large enough level, to deflect the beam full screen, it is automatically

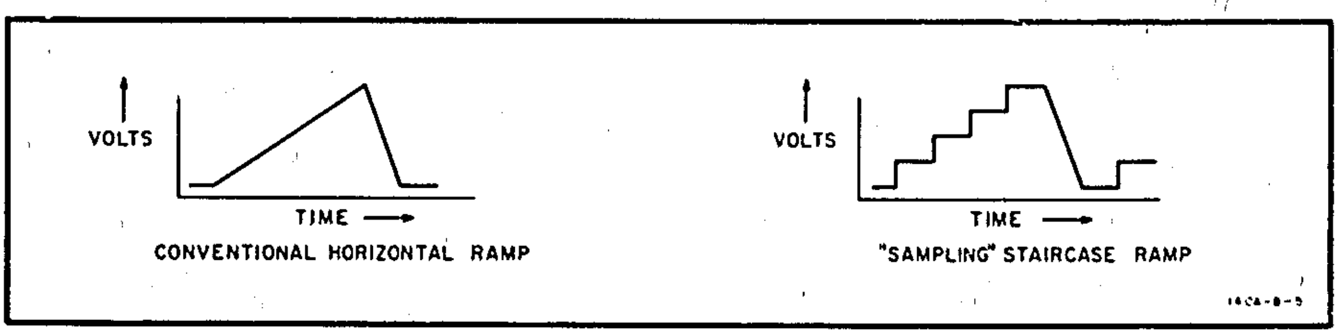


Figure 4-5. Horizontal Deflection Signals

reset (by discharging the staircase voltage) to start the next sweep. The net result of sampling a high-frequency signal and plotting it vertically against a horizontal staircase ramp, results in a synthetic reproduction of the original signal.

4-15. FIELD-EFFECT TRANSISTORS.

4-16. A relatively new component, the field-effect transistor (FET) is used in the Model 1410A. Basic characteristics of this device are described in the following paragraphs.

4-17. The FET combines some of the best properties of the vacuum tube with those of the transistor. Like a vacuum tube, it is a voltage controlled device with a high input impedance. Like the transistor, it has no filaments or microphonics, can operate at relatively low voltage and can be constructed from either N or P type material.

4-18. In its simplest form, the operation of an FET can be compared to a hand squeezing a garden hose. The FET is constructed (see Figure 4-6) by taking a bar (the hose) of silicon, doping it N (or P) and adding ohmic contacts. Next, a layer of P (or N) material (the hand) is built into the middle of the bar. When reverse-bias is applied between the section of P (or N) type material (called the gate) and the bar, movement of the carriers in the bar can be controlled.

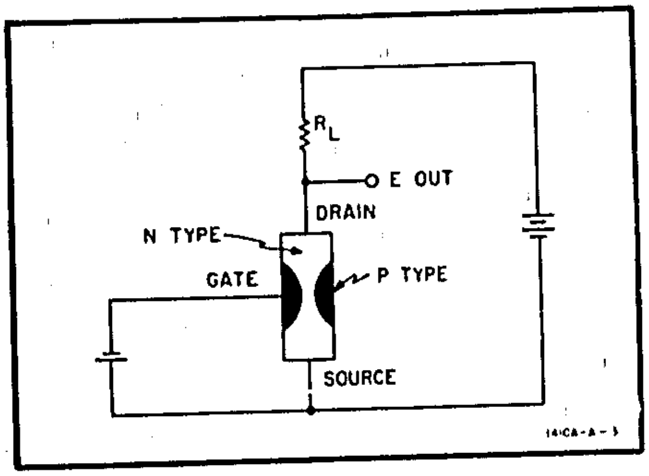


Figure 4-6. FET Construction

4-19. Figure 4-7 shows the symbols for the two main types of field-effect transistors. The gate can be compared to the base of a transistor or control grid of a vacuum tube. The source is equivalent to an emitter or cathode and the drain is similar to a collector or plate. Primary current flow is from source to drain, or vice versa, depending upon type of material used. By controlling the potential placed on the gate, the current through the device can be varied.

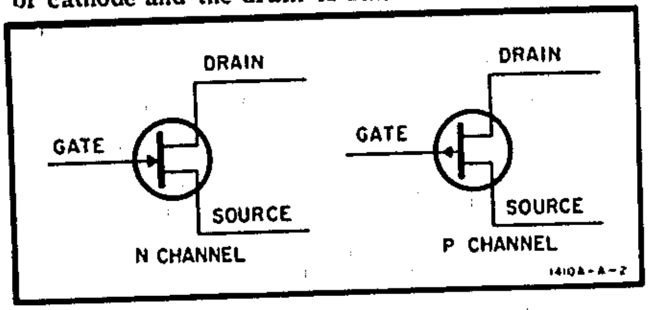


Figure 4-7. FET Symbols

4-20. When the FET is used as an amplifier (signal applied to gate, output from drain), a 180° phase inversion occurs. When used as a source follower (same as cathode or emitter follower), no phase inversion results.

4-21. MODEL 1410A OVER-ALL DESCRIPTION.

4-22. The primary function of the Model 1410A is to sample the signal under test and amplify the sample to sufficient amplitude to drive the vertical deflection plates of the CRT. Figure 4-8 shows the basic circuits and their relationships.

4-23. The sampling cycle is initiated when the pulse generator receives the sampling trigger from the horizontal plug-in. The pulse generator, when triggered, produces the sampling command trigger, sent to both Channel A and B samplers; the stretcher pulse sent to Channel A and B sampling loop; and the staircase trigger, sent to the horizontal plug-in.

4-24. Contained within the sampler are the sampling diodes, acting as a gate. When the sampler receives the sampling command trigger from the pulse generator, the diodes are biased "on" and the sampler "samples" the signal level. This voltage level is sent to the sampling loop circuitry where it is amplified and converted to a differential signal.

4-25. The differential vertical signal from Channel A, B or both is sent to the main vertical amplifier. Here the signal(s) is amplified to sufficient level to drive the vertical deflection plates of the CRT. In the A vs B mode, Channel B signals are routed to the horizontal amplifier in the horizontal plug-in and presented as an X-axis display.

4-26. When the signal under test is also used to trigger the horizontal plug-in, the signal is applied to the INPUT jack on the front panel, and the appropriate channel probe is inserted into its corresponding PROBE socket. The incoming signal is amplified and sent to the horizontal plug-in as the sync trigger pulse, and also sent to a delay line where it is delayed approximately 60 nanoseconds. The delayed signal is then sent to the PROBE socket to be sampled by the probe. Because of the delay in the horizontal circuitry, the vertical signal must be delayed a corresponding amount, otherwise the leading edge of high frequency signals could not be observed.

4-27. BLOCK DIAGRAM DESCRIPTION.

4-28. Refer to Figure 8-1, detailed block diagram, for the following explanation. This diagram can be unfolded and thus referred to while reading the applicable text. Since this explanation will pertain only to Channel A, only Channel A blocks and blocks common to both channels, are shown in the diagram. Channel B theory of operation is identical to Channel A. Blocks common to both channels are the sampling pulse generator and switching multivibrator. The basic function of each is described in the following paragraphs.

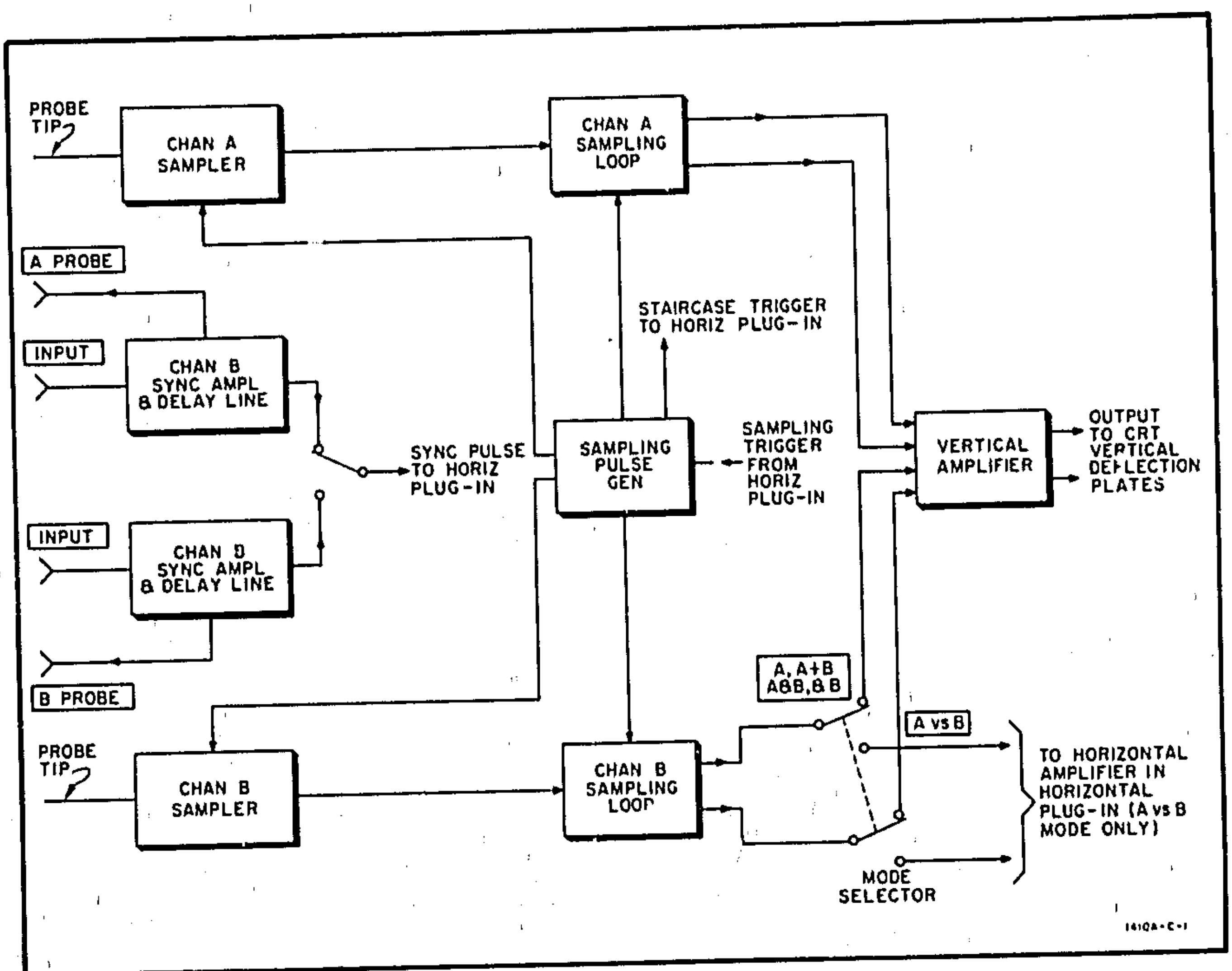


Figure 4-8. Over-all Block Diagram

4-29. The pulse generator circuit of the Model 1410A, upon receipt of the sampling trigger from the horizontal plug-in, generates three signals. First, the trigger is amplified and shaped, then sent to the sampling probe to gate "on" the sampling diodes. Second, the trigger is amplified and sent to the Channel A and B stretcher gate amplifier as the stretcher pulse. This stretcher pulse is also sent to the switching multivibrator (more on this later). Third, the pulse generator provides the staircase generator trigger, used in the horizontal plug-in.

4-30. The switching multivibrator controls the input to the main vertical amplifier stage (common to both A and B channels). This is accomplished by applying bias to the switching diodes in A and B channels. With the mode selector switch in A position, the diodes in A channel are biased "on" and the diodes in B channel are biased "off". This allows Channel A signals to pass to the output stage and be presented in the CRT. With the mode selector switch to position B, the Channel A diodes are "off" and Channel B diodes are "on", resulting in a display of Channel B signals. In the A+B mode, both Channel A and B switching diodes are biased "on" simultaneously, resulting in the summation of signals (algebraic addition). In the A & B mode, the diodes of Channel A and B are alternately biased "on" and "off", resulting in a dual-trace display. Finally, in the A vs B mode, Channel A diodes are biased "on" and Channel B diodes are biased "off". Thus, Channel A signals are sent to the output amplifier and the vertical deflection plates. Channel B signals are sent to the horizontal amplifier in the horizontal plug-in, resulting in an X-Y axis display.

4-31. The sampling probe is the device that actually performs the sampling. Contained within the probe are the sampling diodes, functioning as a switch. When the pulse generator gates the diodes "on", the input signal level is sampled. This sampled voltage is stored on the sampling capacitor and probe cable capacitance. Since the sampling period is quite short, the sampling capacitor will charge to only a small percentage of the actual signal level (approximately 5%).

4-32. The voltage across the probe capacitor is amplified by a preamplifier and then coupled through a forward attenuator to the ac amplifiers. Since the amplifiers are ac coupled, only changes in signal level will be detected and coupled to the amplifiers. The ac amplifier output is the same polarity as the input signal and is applied to the emitter followers and stretcher gate circuits.

4-33. At the same time that sampling occurs, the stretcher pulse is applied to the stretcher gate amplifier. Output of the stretcher gate amplifier is a pulse that turns on the stretcher gate; however, the stretcher gate is held on for a much longer period of time. This time interval is long enough for the voltage across the stretcher capacitor to charge to the full amount of the signal from the ac amplifier.

4-34. When the stretcher gate turns off, the stretcher capacitor has no discharge path, and the voltage across the capacitor remains essentially constant. Thus the sample is stretched until the next sampling cycle. The output of the Model 1410A then remains at this new level for the full interval between samples.

4-35. The potential placed on the stretcher capacitor now acts as the input to the dc amplifiers. Output from the dc amplifiers is sent three places. First, feedback is sent back to the emitter follower stage to charge the ac amplifier coupling capacitor (not shown) to the new level. Second, feedback is coupled through a feedback attenuator to the input preamplifier. Gain of the stages and feedback attenuation is such that this feedback signal will charge the sampling capacitor to 100% of the sampled signal level prior to the next sample.

4-36. The output signal from the dc amplifier is also sent to the differential preamplifier, where the single-ended input is converted to a differential signal. This differential signal is then sent to the switching diodes. Depending on the selected mode of operation, Channel A signals, Channel B signals or various combinations of both will be coupled to the main vertical amplifier circuits.

4-37. The main vertical amplifier amplifies the differential signal to sufficient amplitude to drive the vertical deflection plates. A portion of the signal is also coupled to the record differential amplifier circuitry to provide a Y-axis output for driver recorders, etc., etc.

4-38. CIRCUIT DETAILS.

4-39. SAMPLER.

4-40. The sampler consists basically of four diodes arranged as shown in Figure 4-9 and a biasing circuit for the diodes. The four sampler diodes are normally biased in the reverse direction by voltage from the biasing circuit. When the sampler pulses from the pulse generator overcome the reverse bias on the diodes, the sampler gates "on" and the input signal starts to charge the probe capacitance which consists of the sampler capacitance, C112, and the capacitance of the cable. When the sampler pulses end, the sampler gates "off".

4-41. Transformer T101 provides a low-impedance path for the sampler pulses, which have opposite polarity, and tends to cancel any unbalance between the pulses. However, T101, is a high impedance to the input signal which is in-phase at the two-windings of T101; thus the input signal is confined to the sampler.

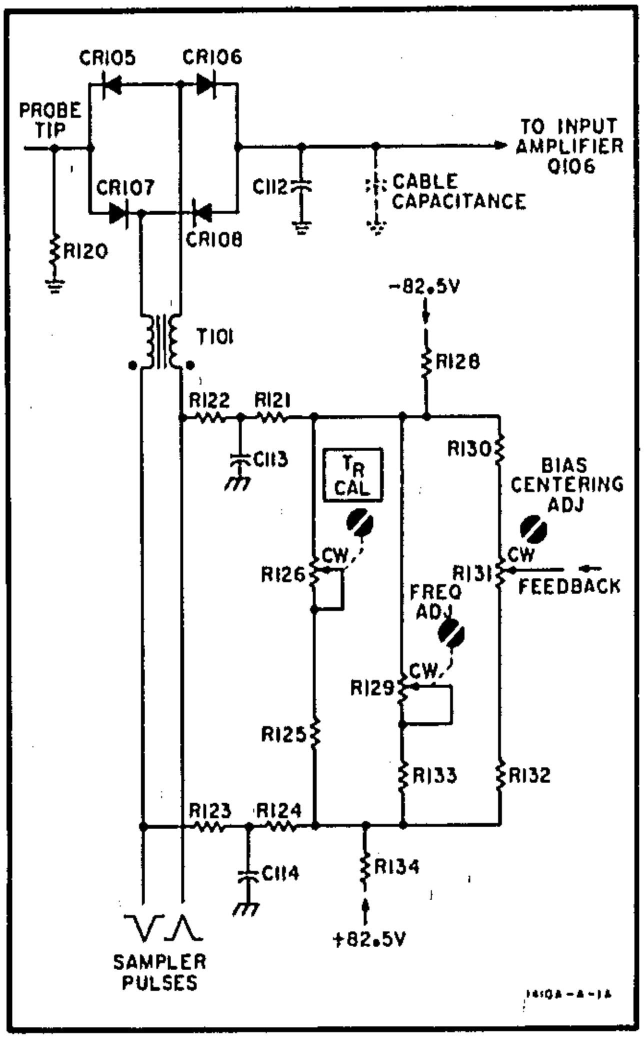


Figure 4-9. Channel A Bias Circuit

4-42. The biasing circuit applies about 4 volts reverse bias to the sampler diodes. The sampling pulses are approximately 4 volts in amplitude, hence, the pulses overcome the reverse bias, turning the diodes "on" and allowing sampling to occur. Should the signal level shift, the signal feedback level will also shift, and the bias network output will also shift. (See Figure 4-10.)

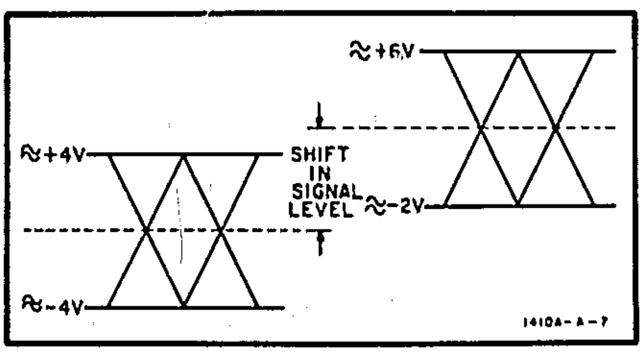


Figure 4-10. Signal Level vs Bias Voltage

4-43. Since the bias voltages will shift to keep the sampler output voltages centered between them, the input signal will turn on one of the sampler diodes if the signal varies more than about ±2 volts from the level of the voltage on the probe capacity. This factor limits the dynamic range of the Model 1410A to about 2v pk-pk. This 2 volt range is not necessarily centered about zero. Any signal or portion of a signal which can be positioned on the CRT is valid provided the input signal does not turn on the sampler diodes less than 10 μsec before a sample or 1 μsec after a sample.

4-44. PULSE GENERATOR.

4-45. The pulse generator (p/o Figure 8-5) provides the sampling pulses for the sampling diodes. Input to the pulse generator is a positive trigger from the horizontal plug-in. The signal is amplified and inverted by Q110 and its negative collector signal is coupled to the base of Q108. Q108 is normally off, but when the negative pulse is applied to its base it begins to conduct, causing its collector to go in a positive direction. This positive-going signal, is felt on the base of Q109, causing it to start conducting also. Q109's negative-going collector, in turn is felt on the base of Q108, causing it to conduct even harder. The net result of this regenerative (bootstrap) action is that Q108 turns on rapidly, with its collector voltage rising from -27 volts to approximately 0 volts. This fast rising positive pulse is coupled from the junction of C123 and R131 to the base of pulse amplifier Q111. Here it is amplified and inverted. The resulting negative collector signal (stretcher pulse) is sent to the Channel A and B stretcher gate circuits, and to the switching multivibrator. It is also sent through C129 to the horizontal plug-in as the staircase generator trigger signal.

4-46. The positive pulse from Q108 is also felt on the cathode of step-recovery diode CR110. Prior to the pulse, CR110 is forward-biased and conducting. When the positive pulse is applied, it reverse-biases the diode, causing reverse current to flow. The reverse current is supplied by the carriers stored during the forward-bias condition. Thus, the diode does not stop conducting immediately, and the voltage across it remains low as reverse current builds up. When the carriers at the junction are depleted, the diode stops conducting very suddenly. As a result, a very fast-rising positive pulse appears at the junction of CR110 and C121. This pulse, in passing through a balun transformer (T102), generates an opposite-going signal in the other winding. These positive and negative-going sampling pulses are applied through transformer T101 to the sampling diodes, CR105 thru CR108. Diode bias adjust R160, part of CR110 current supply circuit, is adjusted for maximum sampling pulse amplitude.

4-47. The over-all sampling efficiency of the Model 1410A depends upon three factors: 1) the RC time constant of the sampling capacitors and the signal source impedance; 2) the length of time the sampling gate is open; and 3) the loop gain of the amplifier. Since the source impedance will change as the probe is applied to different circuits, the front panel SMOOTHING control is provided to assure 100% sampling efficiency regardless of impedance changes. SMOOTHING adjusts the loop gain of the amplifier and should be checked each time that the probe is applied to a circuit.

4-48. Adjusting T_R CAL changes the amount of bias applied to the sampling diodes. This in turn (see Figure 4-11) changes the sampling time. Decreasing the sampling time has the effect of increasing bandwidth (improving rise time) however, the response will be smoothed since sampling efficiency has been reduced. Under normal conditions, T_R CAL should be set for <320 ps rise time. Rise time of the probe and delay line will be slightly greater (<350 ps). Bias centering adjust, R131, centers the dc bias level on the diodes and is normally set for minimum noise out of the probe tip. Frequency adjust R129 is set to allow maximum range of the T_R CAL adjustment. See Section V for adjustment procedures on these and other adjustments.

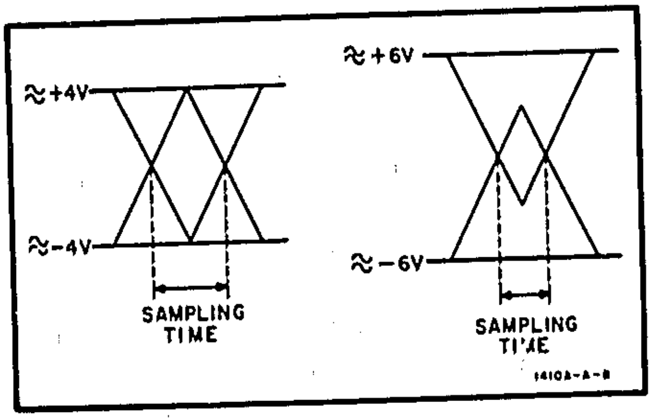


Figure 4-11. Sampling Time vs Bias Level

4-49. INPUT PREAMPLIFIER.

4-50. The input preamplifier stage is composed of a field-effect transistor Q106 and ac amplifier Q107. The sampled voltage, stored on capacitor Q112 and cable capacitance, is coupled directly to the gate of Q106. Q106 offers a high input impedance so that the sampled charge on the capacitor will not leak off. The inverted signal on the drain is sent to amplifier Q107 where it is again amplified and inverted. Gain of this stage is approximately 30. The collector signal of Q106 is ac coupled to the forward attenuator. Here the signal is attenuated on all ranges except the 1, 2, and 5 MILLIVOLT/CM ranges. The signal is then applied to ac amplifiers Q115 and Q116.

4-51. AC AMPLIFIER.

4-52. Gain of this stage is variable between 6 and 60. The exact amount of gain is controlled by the front panel SMOOTHING adjustment. The sampled signal change is again amplified and inverted by both Q115 and Q116 and the output is ac coupled through emitter followers Q117 and Q118 to the source of stretcher gate Q119.

4-53. STRETCHER GATE.

4-54. The stretcher gate Q119, normally off, is turned on by the stretcher pulse. The negative stretcher pulse from the pulse generator, amplified and inverted by Q125, results in a positive pulse being applied to the gate of Q119. This positive pulse turns on Q119 and the stretcher capacitor C139 starts to charge to the incoming signal level. Since the stretcher gate is held on for a relatively long period of time (approximately 250 nanoseconds), the stretcher capacitor has time to charge to the full amount of the input level.

4-55. When the stretcher pulse ends, Q119 turns off. Since both Q119 and Q120 are FET's, offering a high impedance, the stretcher capacitor has no discharge path and the potential placed upon it will remain constant. This voltage, stored on the stretcher capacitor, now acts as the input to the dc amplifiers.

4-56. DC AMPLIFIER.

4-57. DC amplifiers Q120 and Q121 generate the output of the sampling loop. Because of feedback from Q121 collector through R195 to Q120 source, gain of this stage is unity. Hence, the same voltage stored on the stretcher capacitor will appear on the collector of Q121. This voltage represents the output of the sampling loop and is sent to three places. Stretcher balance and gain adjustments are set so that display does not shift or change size when changing sensitivity ranges.

4-58. SIGNAL FEEDBACK.

4-59. Feedback from Q121 collector is fed back to emitter followers Q117 and Q118 to charge the ac amplifier coupling capacitor C137 to the new signal level. Feedback is also coupled through p/o S101 feedback attenuator to the sampling capacitor to charge it to 100% of the sampled signal level, except when using the 1 or 2 MILLIVOLTS/CM ranges. In these ranges, the signal is automatically smoothed and the feedback will represent less than 100% sampling efficiency. This feedback, before reaching the diodes, is sent through the diode bias circuitry. Here it will shift the dc bias level (if necessary) as described in Paragraph 4-42.

4-60. DIFFERENTIAL AMPLIFIER.

4-61. The signal at Q121 collector is also coupled through S103 to differential amplifier Q123 and Q124. The polarity switch determines whether the signal will be presented as a positive-up or negative-up signal on the CRT. At this stage the single-ended signal is converted to a differential signal. Gain is controlled by the sensitivity VERNIER and the CAL ADJ settings. Preamp balance adjust R205, is provided to balance the amplifier.

4-62. SWITCHING MULTIVIBRATOR.

4-63. The amplified differential signal from Q123 and Q124 collectors is sent to switching diodes CR501 through CR504. The switching multivibrator controls bias on diodes CR501 through CR508. By forward-biasing or reverse-biasing these diodes, Channel A, B, or combinations of both may be passed to the input current isolators Q501 and Q502. With the mode selector switch set for Channel A presentation, diodes CR506 and CR507 are forward-biased, in turn reverse-biasing CR505 and CR508, thus blocking Channel B signals. In the same manner Channel A diodes CR502 and CR503 are reverse-biased, keeping CR501 and CR504 forward-biased and allowing Channel A signals to pass to the input current isolators. When the mode selector is in B position, the above biasing conditions are reversed permitting Channel B signals to be displayed.

4-64. In the A+B mode, diodes CR502, CR503, CR506 and CR507 are all reverse-biased in turn keeping CR501, CR504, CR505, and CR508 forward-biased. This allows signals from both channels to be algebraically added and the displayed signal will represent the aglebraic sum of both A and B signals. In the A & B mode the negative stretcher pulse is applied to the base of trigger amplifier Q515. The positive collector signal of Q515 is used to trigger the switching multivibrator, alternately changing biasing conditions so that Channel A signals are displayed for one sampling cycle, and Channel B signals are displayed on the next sampling cycle. In the A vs B mode, the Channel A diodes are biased "on" and Channel B signals are routed through S501 to the horizontal amplifier in the horizontal plug-in for an X-Y display.

4-65. INPUT CURRENT ISOLATORS.

4-66. Depending on what mode of presentation is selected, the appropriate signal or combination of signals is applied to the emitters of input current isolators Q501 and Q502. Since the preceding stages of both Channel A and B differential amplifiers each draw approximately 1 ma of current from this stage, in order to keep current through Q501 and Q502 constant when in the A+B mode (both channels are connected) an additional current source is provided (+12.6 v to junction of R501 and R502).

4-67. The signals at Q501/Q502 collectors are applied to the bases of emitter followers Q503/Q504.

4-68. EMITTER FOLLOWERS.

4-69. Emitter followers Q503/Q504 couple the signal to differential amplifiers Q505/Q506. Differential signal amplitude is greatly reduced by depressing the BEAM FINDER switch. This causes relay amplifier Q509 to conduct, energizing K501. When K501 energizes, it places R505 in parallel with the resistive divider network R507 through R512. This greatly reduces the voltages applied to Q503/Q504 bases. The difference in deflection plate voltages will now be small enough to locate the trace regardless of signal amplitude or the setting of the POSITION control.

4-70. OUTPUT CASCODE AMPLIFIER.

4-71. The emitter follower outputs are sent to differential amplifier Q505/Q506. The amplified and inverted signal is coupled to the output current isolators Q507/Q508. Gain of this stage is calibrated with R524, VERT CAL. C504, frequency adjust, is used to adjust high frequency gain.

4-72. Y RECORD OUTPUT.

4-73. The signal voltage developed across resistive network R50. through R512 is applied to the bases of record differential amplifier Q510/Q511. Gain is controlled by front panel Y AMPLITUDE adjustment. The single-ended output from Q510 collector is sent through emitter follower Q512 to the front panel Y RECORD jack. R573, Y DC LEVEL, adjusts dc level of the output signal.

4-74. SYNC AMPLIFIER AND COMPENSATOR.

4-75. When suitable triggers are not available for triggering the horizontal plug-in, the vertical signal can be used. However, because of an inherent time delay in the sampling system, the vertical signal must also be delayed if the leading edge of the signal is to be observed. This is the main purpose of the sync amplifier and compensator circuitry (see Figure 8-18). The incoming signal, connected to J101, is sent two places. One portion is applied to amplifiers Q101 and Q102 where it is amplified. It is then coupled through S1, TRIGGER selector switch, then routed through P3 to the horizontal plug-in to initiate triggering.

4-76. The signal is also sent through DL101 where it is delayed 60 nanoseconds. Because of signal decay in the delay line, a RL compensating network consisting of L101, R101, and R102 is provided to sharpen rise time again. The signal is then applied to J102 where it will be sampled by the probe.

4-77. +12.6 V POWER SUPPLY.

4-78. All required operating voltages are provided by the oscilloscope except for the +12.6 v supply, shown in Figure 8-16. Here a 6.3 vac input is stepped up, rectified, filtered and regulated. Sensor amplifier Q578 will sense any variation of output voltage and apply an error signal through Q575 to the base of series regulator Q576 to increase or decrease current, compensating for the voltage change. Assume that the output voltage increases. The potential on Q578 base will go in a positive direction, causing its collector to go negative. This negative voltage, coupled thru control transistor Q575 to the base of Q576, causes it to conduct less. The voltage drop across series regulator Q576 will now increase by an amount equal to the original voltage increase, keeping the output amplitude constant.

4-79. Current limiter Q577 is normally biased off. If a short occurs across the output, the base of Q577 goes positive, thus turning it on. The negative-going collector voltage, coupled through Q575 to the base of the series regulator Q576 biases it off. The current that will flow through the external circuit is now limited to the current required to keep Q577 on. Additional overload protection is provided by fuse F575. R580 adjusts the output for exactly +12.6 v.

PERFORMANCE CHECK

Table 5-1. Required Test Equipment

Recommended Instrument		Required Characteristics	Ref. Par.	Required for
Type	Model			
DC Voltmeter	hp 412A	Voltage Range 0 - 100 vdc	5-21	+12.6 v Supply Adj.
Fast Rise Time Pulse Generator	hp 1105A/1106A or hp 213B	<90 psec rise time <5% overshoot	5-22 5-23 5-24 5-14 5-15 5-18 5-25	Stretcher Gain and Balance Adj. Stretcher Gate Width Adj. Sampling Bias Adj. Rise Time Check Overshoot Check Time Difference T_R CAL Range Adj.
High Frequency Oscilloscope	hp 180A/ 1801A/ 1821A	Bandwidth 20 MHz	5-26 5-12	Probe Noise Adj Recorder Output Check
UHF Signal Generator	hp 612A	1 GHz 0.1 v ±1%	5-13	Triggering Check
Variable Pulse Generator	hp 222A	2 v amplitude variable pulse width	5-10 5-11 5-12 5-16	Dynamic Range Check Isolation between Channels Check Recorder Outputs Check Vernier Check
Variable Power Supply	hp Harrison 6111A	0 - 2 v dc ±1%	5-9 5-28	Attenuator Accuracy Sensitivity Calibration
BNC Adapter	hp 10218A	Adapt probe to BNC	5-26	Probe Noise Adj.
Isolator	hp 10216A	Provide a constant Z for probe	5-27	Isolator Balance Adj.
50 ohm Tee	hp 10211A	GR/GR/probe connection	5-12 5-14 5-25	Recorder Outputs Check Rise Time and Polarity Check T_R CAL Range Adj.
50 ohm Load	GR874-W50	50 ohm load with GR connector	5-12 5-14 5-25 5-30	Recorder Outputs Rise Time and Polarity Check T_R CAL Range Adj Internal DC Balance
40 cm Air Line	GR874	50 ohm type with GR connectors	5-14 5-25	Rise Time and Polarity Check T_R CAL Range Adj.
true RMS meter	hp 3400A			

SECTION V
PERFORMANCE CHECK AND ADJUSTMENTS

5-1. INTRODUCTION.

5-2. This section includes adjustment procedures and a performance check. The performance check may be used as incoming inspection or after repairs or adjustments have been made to verify that the instrument meets the specifications listed in Table 1-1. When the initial performance check is made, the readings should be recorded on the enclosed Performance Test Record so that readings taken at a later date can be compared to the original readings. If adjustment is required, refer to Paragraph 5-19.

5-3. PERFORMANCE CHECK.

5-4. TEST EQUIPMENT REQUIRED.

5-5. Test equipment recommended for the performance check and adjustments is listed in Table 5-1. Similar instruments having the listed characteristics may be substituted.

5-6. PROCEDURE.

5-7. Install the Model 1410A in the oscilloscope and allow at least ten minutes for warm-up. The following checks should be performed in the same sequence as they are listed since control settings are all referenced to prior settings.

5-8. MODES OF OPERATION.

a. Set sampling Time Base controls as follows: (If an hp Model 1425A is used, settings will apply to MAIN SWEEP)

SYNC PULSE	ON
TIME/CM	1 μSEC/CM
VERNIER	CAL
MAGNIFIER	X1
SCANNING	NORMAL
Trigger LEVEL	AUTO
Trigger MODE	max cw
Trigger SLOPE	+
Trigger Source	INT
Trigger Sensitivity	SENS

b. Set Model 1410A controls as follows:

Channel A and B MILLIVOLTS/CM	50
Channel A and B Polarity	+UP
Mode Selector	A

c. Rotate Channel A VERT POS. Trace should move vertically.

d. Change Mode Selector to A+B. Both Channel A and B VERT POS controls should move the trace vertically.

e. Set Mode Selector to A & B. Two traces should appear. Channel A VERT POS should move one trace and Channel B VERT POS should move the other trace.

f. Change Mode Selector to B. Channel B VERT POS should move trace vertically.

g. Set Mode Selector to A vs B. Channel A VERT POS should move dot vertically and Channel B VERT POS should move dot horizontally.

5-9. ATTENUATOR ACCURACY.

a. Perform the CAL ADJ and VERT CAL adjustments as shown in Figure 3-4 and 3-5 prior to this check.

b. Connect the Channel A probe to the variable power supply output.

c. Set MILLIVOLTS/CM and power supply output as indicated in Table 5-2 and check each range for indicated deflection.

d. Repeat steps a, b, and c for Channel B.

Table 5-2. Attenuator Accuracy

MILLIVOLTS/CM	Power Supply Output	Deflection
200	2 v	10 cm ±3 mm
100	1 v	10 cm ±3 mm
50	0.5 v	10 cm ±3 mm
20	0.2 v	10 cm ±3 mm
10	0.1 v	10 cm ±3 mm
5	.05 v	10 cm ±3 mm
2	.02 v	10 cm ±5 mm
1	.01 v	10 cm ±5 mm

5-10. DYNAMIC RANGE.

a. Connect a variable amplitude Pulse Generator (hp Model 222A) to the Channel A INPUT connector. DO NOT EXCEED 5 VOLTS AMPLITUDE. Set pulse width to approximately 2 μsec at a rep rate of 5 kHz. Adjust for a 1 volt positive pulse.

b. Connect Channel A probe to its holder and set TRIGGER to A.

c. Set Time Base controls as follows:

Trigger Source	INT
Trigger Sensitivity	SENS
Trigger SLOPE	+
Trigger LEVEL / Trigger MODE	Adjust for stable display

d. Increase amplitude of Pulse Generator to at least 2 volts. Displayed waveform should not become distorted.

e. Change Pulse Generator polarity to negative and again observe waveform as amplitude is increased. Waveform should not become distorted until output exceeds 2 volts.

f. Change TRIGGER to B, connect Pulse Generator to B INPUT and repeat steps d and e for Channel B.

5-11. ISOLATION BETWEEN CHANNELS.

a. Connect the Model 222A output to A INPUT connector. Adjust for a +1 volt pulse. Place A and B probes in their respective sockets. Set TRIGGER to A.

b. Set Mode Selector to B. Set Channel B MILLIVOLTS/CM to 5.

c. Switch Channel A VERT POS through its entire range and observe deflections on Channel B. Deflection shall be less than 10 mv.

d. Connect signal to B, set TRIGGER to B, set Mode Selector to A and observe deflection on Channel A. Deflection shall be less than 10 mv.

5-12. RECORDER OUTPUTS.

a. Connect variable Pulse Generator to Channel A probe, terminated in 50 ohms. Adjust amplitude for 1 volt output.

b. Connect trigger output from Pulse Generator to the external trigger input of Time Base. Set trigger source to EXT, SLOPE to -, and adjust LEVEL and MODE for stable display.

c. Connect monitor oscilloscope to X RECORD output.

d. Note signal AMPLITUDE is adjustable from approximately .05 volts/cm to 0.2 volts/cm. DC LEVEL can be adjusted between -1.5 v to +0.5 v.

e. Connect monitor oscilloscope to Y RECORD output.

f. Note signal AMPLITUDE is adjustable from approximately .05 volts/cm to 0.5 volts/cm. DC LEVEL can be adjusted between approximately 1.5 v to 0.5 v.

5-13. TRIGGERING.

a. Set Time Base Controls as follows:

TIME/CM	10 μSEC/CM
Trigger Source	INT
Trigger Sensitivity	SENS
Trigger SLOPE	+

b. Set Mode Selector to A, TRIGGER to A, and insert Channel A probe into its receptacle.

d. Connect UHF Generator to A INPUT connector. Adjust for 500 MHz at 100 mv pk-pk. Adjust LEVEL to obtain proper sync.

d. Increase frequency to 1 GHz at 100 mv pk-pk.

e. Adjust LEVEL and observe that time base will sync.

f. Connect UHF Generator to B INPUT and switch TRIGGER to B.

g. Repeat steps c, d, and e for Channel B.

5-14. RISE TIME AND POLARITY.

a. Connect a fast rise time Pulse Generator (hp Model 1105A/1106A or hp Model 213B) to Channel A as shown in Figure 5-1. Set Pulse Generator TRIGGER to + and OUTPUT to +.

b. Set Time Base controls as follows:

TIME/CM	10 nSEC/CM
MAGNIFIER	X100
MODE	Adjust for stable display
LEVEL	AUTO

c. Set Model 1410A controls as follows:

Mode Selector	A
NORM-SMOOTHING	NORM
SMOOTHING	Optimized
SYNC PULSE	ON

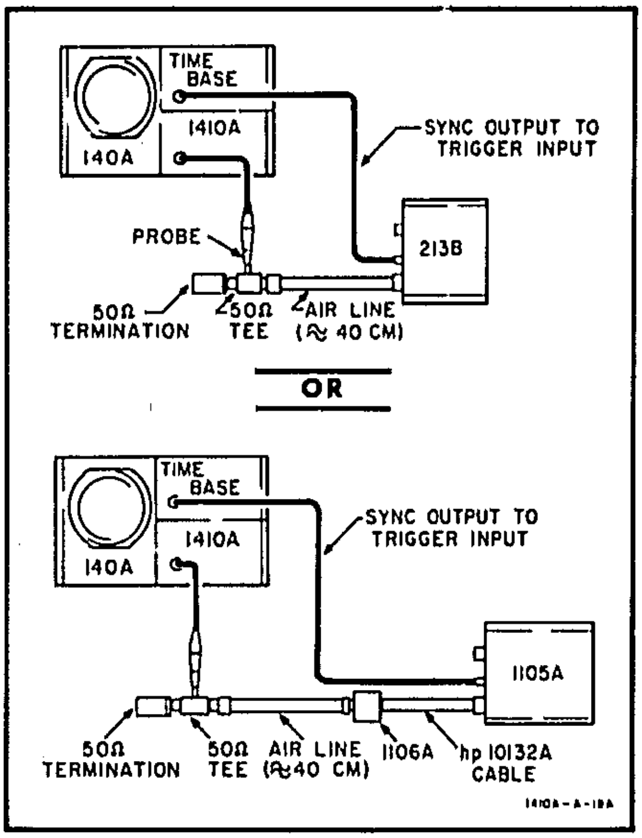


Figure 5-1. Setting Rise Time

d. Connect sync pulse output of the Time Base to trigger input of Pulse Generator and adjust sensitivity for pulse output.

e. Observe pulse rise time of <320 psec.

f. Change polarity switch and observe that pulse is inverted.

g. Repeat steps a through f for Channel B.

5-15. OVERSHOOT.

a. Connect a fast rise time Pulse Generator to the Channel A INPUT. Place probe in receptacle.

b. Set TIME/CM to 100 nSEC/CM.

c. Adjust MILLIVOLTS/CM and VERNIER for a 10 cm pulse.

d. Switch MILLIVOLTS/CM to 5. Adjust VERT POS to center top of pulse on CRT.

e. Observed overshoot should be less than 5 cm.

f. Repeat steps a through e for Channel B.

5-16. VERNIER.

a. Connect a variable Pulse Generator (hp Model 222A) to A INPUT and adjust for 1 cm pulse.

b. Rotate VERNIER fully clockwise. Pulse height should increase to at least 2.5 cm.

c. Repeat steps a and b for Channel B.

5-17. NOISE.

a. Disconnect signal from INPUT and insert probes in receptacles.

b. Set controls as follows:

TIME/CM	10 µSEC/CM
MODE	FREE RUN
TRIGGER HOLD-OFF	NORMAL
Y RECORD AMPLITUDE	Adjust for 100 mv/cm
SMOOTHING	NORM
SCANNING	MANUAL
SCAN DENSITY	Set dot for midscreen
MILLIVOLTS/CM (both)	5
Channel Selector	A

c. Connect a true RMS meter such as the hp Model 3400A to the Y RECORD Output. Set meter range to 0.01 volts.

d. Indicated noise shall be less than 8 mv on the meter. (This corresponds to approximately 1 mv of noise on the CRT, exclusing 10% of random dots.)

e. Change Channel Selector to B and repeat step d for Channel B.

5-18. TIME DIFFERENCE.

a. Connect a fast rise time Pulse Generator to the center terminal of a BNC Tee. Set Mode Selector to A and B. Using BNC adapters (hp 10218A) connect both probes to the ends of the Tee.

b. Using the VERT POS controls, set bottom of both pulses on screen.

c. Set horizontal TIME/CM to 1 nSEC/CM and MAGNIFIER to X10.

d. Switch both MILLIVOLTS/CM to 5.

e. Adjust triggering for a stable display and observe horizontal distance between leading edges of pulses. Distance should be less than 1 cm.

5-19. ADJUSTMENTS.

5-20. Procedures for adjusting the Model 1410A are described in Paragraphs 5-21 through 5-32. The adjustments can be made only after removing the bottom cover of the oscilloscope. For optimum results, check and adjust if necessary, the power supply voltages of the oscilloscope. Equipment required to perform the adjustments is listed in Table 5-1. Location of adjustments is shown in Figure 8-2.

5-21. +12.6 VDC SUPPLY.

a. Connect a voltmeter to the positive lead of the 47 µf electrolytic capacitor (C577) on the main vertical amplifier board. (Shown on Page 8-12, Figure 8-14.)

b. Adjust R580 for exactly +12.6 vdc.

5-22. STRETCHER GATE WIDTH.

a. Set Time Base to FREE-RUN, Time/cm to 10 nsec/cm and observe waveform at Q125 collector. Adjust Stretcher Gate Width (R183) for 300 nsec pulse width.

b. Observe waveform at Q325 collector. Adjust Channel B Stretcher Gate Width (R383) for 300 nsec pulse width.

5-23. STRETCHER BALANCE.

a. Connect a fast rise time Pulse Generator (hp Model 1105A/1106A or hp 213B) to Channel A INPUT. Insert probe into receptacle.

b. Set controls as follows:

MILLIVOLTS/CM	50
Channel Selector	A
Polarity	+UP
TRIGGER	A

c. Free-run the pulse generator and adjust time base controls for a stable display. Use internal triggering at 10 nsec/cm.

d. Optimize sampling efficiency. Alternately switch NORM-SMOOTHED switch between positions and adjust Channel A Stretcher Balance Adj (R189) so that display does not shift vertically while switching.

5-24. STRETCHER GAIN.

a. Continue to switch NORM-SMOOTHED switch between positions and adjust Stretcher Gain Adj (R194) for minimum amplitude shift.

b. Some interaction may occur between this and the previous adjustment; repeat both gain and balance adjustments for minimum vertical shift and amplitude change.

c. Connect pulse generator to Channel B INPUT, change both channel and trigger selectors for Channel B operation and repeat Paragraphs 5-23 and 5-24 for Channel B, adjusting R389 and R394.

5-25. T_R CAL RANGE.

a. Connect the fast rise Pulse Generator through a 40 cm air line to a 50 ohm Tee, terminated into 50 ohms (see Figure 5-1). Insert probe into Tee. Free-run the time base and use the SYNC PULSE output to trigger the pulse generator.

b. Set T_R CAL to midrange.

c. Observe rise time. Adjust R129 for a rise time of approximately 300 psec.

d. Adjust front panel T_R CAL for an observed rise time of 320 psec with less than 5% overshoot.

e. Repeat steps a thru d for Channel B, adjusting R329 and Channel B T_R CAL.

5-26. PROBE NOISE.

a. Disconnect equipment.

b. Connect Channel A probe directly to a monitor oscilloscope using the hp Model 10218A Adaptor.

c. Free-run the time base and center the trace on-screen with VERT POS. Observe spikes on monitor scope and adjust Centering Bias Adj (R131) for minimum spike amplitude. Keep trace centered on the test scope while making adjustment.

d. Repeat steps a thru c for Channel B.

e. Recheck rise time, since some interaction exists between this adjustment and T_R CAL.

5-27. ISOLATOR BALANCE.

a. Connect hp Model 10216A Isolator to Channel A probe and alternately open and short tip of isolator to isolator ground.

b. Observe baseline shift, and adjust green wires in probe cartridge (C110 and C111) for a shift less than 5 mv.

Note

To adjust capacity, move green wires one at a time away from ground. When the wire has been found which reduces the shift, trim or bend it for minimum shift and adjust the other wire to obtain less than 5 mv shift. The probe cover will need to be removed to adjust the wires and replaced to check baseline shift.

c. Repeat steps a and b for Channel B probe, adjusting C310 and C311.

5-28. SENSITIVITY CALIBRATION.

a. Perform the CAL ADJ and VERT CAL as shown in Figure 3-4.

b. Set variable power supply for .01 volts and connect to Channel A probe.

c. Set MILLIVOLTS/CM to 1 and alternately connect and disconnect the power supply. Adjust the Stretcher Gain R194 for exactly 10 cm of deflection.

d. Repeat steps a through c until no interaction occurs between this adjustment and the CAL ADJ.

e. Repeat steps b through d for Channel B.

5-29. AMPLIFIER PEAKING.

a. Disconnect power supply.

b. Set Mode Selector to A & B and both MILLIVOLTS/CM switch to 100.

c. Position both traces on screen 8 cm apart and set SCAN DENSITY fully counterclockwise (minimum).

d. Adjust amplifier peaking adj (C504) for best appearing dots (minimum tails).

5-30. INTERNAL DC BALANCE.

a. Connect a 50 ohm load to the GR type INPUT. Free-run the time base to obtain a baseline. Set vertical sensitivity to 2 mv/cm.

b. Switch polarity between +UP and -UP. Slowly adjust VERT POS and locate point where no trace shift exists while changing switch positions. Adjust Pre-amp Bal Adj (R205) to re-position baseline to center screen.

c. Repeat steps a and b for Channel B (R405).

5-31. CALIBRATING THE 10:1 DIVIDER.

5-32. To calibrate the hp Model 10214A Divider, observe a 75 kHz square wave using the divider. Obtain a 10 cm display, and optimize response. Observed overshoot should be 3%. If the overshoot is not 3%, using the probe adj tool, adjust for 3% overshoot. To do this, it is necessary to remove, adjust, replace, check, remove, etc., etc., the divider. Be sure to keep the response optimized while making the adjustment.

5-33. If the 10:1 division ratio is incorrect, the divider is defective and should be replaced.

CUT ALONG DOTTED LINE

PERFORMANCE CHECK RECORD

Instrument Serial Number ______

Paragraph	Check	Limit	
5-8	MODES OF OPERATION		
	A	____	
	A+B	____	
	A&B	____	
	B	____	
	A vs B	____	
		channel A	channel B
		Min — Max	Min — Max
5-9	ATTENUATOR ACCURACY		
	200	9.7 cm ____ 10.3 cm	9.7 cm ____ 10.3 cm
	100	9.7 cm ____ 10.3 cm	9.7 cm ____ 10.3 cm
	50	9.7 cm ____ 10.3 cm	9.7 cm ____ 10.3 cm
	20	9.7 cm ____ 10.3 cm	9.7 cm ____ 10.3 cm
	10	9.7 cm ____ 10.3 cm	9.7 cm ____ 10.3 cm
	5	9.7 cm ____ 10.3 cm	9.7 cm ____ 10.3 cm
	2	9.5 cm ____ 10.5 cm	9.5 cm ____ 10.5 cm
	1	9.5 cm ____ 10.5 cm	9.5 cm ____ 10.5 cm
5-10	DYNAMIC RANGE	-2 v ____	-2 v ____
		+2 v ____	+2 v ____
5-11	ISOLATION BETWEEN CHANNELS	____ <10 mv	____ <10 mv
5-12	RECORDER OUTPUTS		
	AMPLITUDE	.05 v/cm ____	.05 v/cm ____
		____ .2 v/cm	____ .2 v/cm
	DC LEVEL	-1.5 v ____	-1.5 v ____
		____ +0.5 v	____ +0.5 v
5-13	TRIGGERING	____	____
5-14	RISE TIME AND POLARITY		
	T_R	____ <350 ps	____ <350 ps
	POLARITY	____	____
5-15	OVERSHOOT	____ <5 mm	____ <5 mm
5-16	VERNIER	2.5 cm ____	2.5 cm ____
5-17	NOISE	____ <1 mv	____ <1 mv
5-18	TIME DIFFERENCE	____ <1 cm	____ <1 cm

PARTS LIST

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains the information necessary for ordering replaceable parts. Table 6-2 provides the following information:

a. hp Part Number.

b. Total Quantity (TQ) used in the instrument; given only the first time a part number is listed.

c. Description of part; see Table 6-1 for a list of the reference designators and abbreviations used.

6-3. Miscellaneous parts are listed at the end of Table 6-2.

6-4. ORDERING INFORMATION.

6-5. To order replacement part(s), direct the order or inquiry to the nearest Hewlett-Packard Sales/Service Office (see list at back of this manual). Provide the following information:

a. hp Part Number of item(s).

b. Model number and eight-digit serial number of instrument.

c. Quantity of part(s) desired.

6-6. To order a part not listed or identifiable in the table, provide the following information:

a. Model number and eight-digit serial number of instrument.

b. Part description, including function and location.

Note

Upon request, information will be supplied to allow ordering of applicable parts from manufacturers other than Hewlett-Packard. Contact the hp Sales/Service Office for details.

Table 6-1. List of Reference Designators and Abbreviations

REFERENCE DESIGNATORS

A	= assembly	F	= fuse	MP	= mechanical part	TP	= test point
B	= motor	FL	= filter	P	= plug	V	= vacuum tube, neon bulb, photocell, etc.
C	= capacitor	J	= jack	Q	= transistor	VR	= voltage regulator (diode)
CP	= coupling	K	= relay	R	= resistor		
CR	= diode	L	= inductor	RT	= thermistor		
DL	= delay line	LS	= speaker	S	= switch	W	= cable
DS	= device signaling (lamp)	M	= meter	T	= transformer	X	= socket
E	= misc electronic part	MC	= microcircuit	TB	= terminal board	Y	= crystal

ABBREVIATIONS

A	= amperes	GL	= glass	MTG	= mounting	RF	= radio frequency
AMPL	= amplifier	GRD	= grounded	MY	= "mylar"		
						S-B	= slow-blow
		H	= henries	N	= nano (10^{-9})	SCR	= screw
BP	= bandpass	HG	= mercury	N/C	= normally closed	SE	= selenium
		HR	= hour(s)	NE	= neon	SECT	= section(s)
CAR	= carbon	hp	= Hewlett-Packard	N/O	= normally open	SEMICON	= semiconductor
CCW	= counterclockwise			NPO	= negative positive zero (zero temperature coefficient)	SI	= silicon
CER	= ceramic	IF	= intermediate freq.			SIL	= silver
COEF	= coefficient	IMPG	= impregnated			SL	= slide
COM	= common	INCD	= incandescent	NSR	= not separately replaceable	SPL	= special
COMP	= composition	INCL	= include(s)				
CONN	= connector	INS	= insulation(ed)			TA	= tantalum
CRT	= cathode-ray tube	INT	= internal	OBD	= order by description	TD	= time delay
CW	= clockwise			OX	= oxide	TGL	= toggle
		K	= kilo = 1000			TI	= titanium
DEPC	= deposited carbon			PC	= printed circuit	TOL	= tolerance
		LIN	= linear taper	PF	= picofarads 10^{-12} farads	TRIM	= trimmer
ELECT	= electrolytic	LOG	= logarithmic taper				
ENCAP	= encapsulated	LPF	= low pass filter	PIV	= peak inverse voltage	μ	= micro = 10^{-6}
EXT	= external			P/O	= part of		
		M	= milli = 10^{-3}	POLY	= polystyrene	VAR	= variable
F	= farads	MEG	= meg = 10^{6}	PORC	= porcelain	VDCW	= dc working volts
FET	= field effect transistor	METFLM	= metal film	POS	= position(s)		
FXD	= fixed	MET OX	= metal oxide	POT	= potentiometer	W/	= with
		MFR	= manufacturer	PK-PK	= peak-to-peak	W	= watts
		MINAT	= miniature			WW	= wirewound
GE	= germanium	MOM	= momentary	RECT	= rectifier	W/O	= without

Table 6-2. Replaceable Parts

Ref Desig	hp Part No.		TQ	Description (See Table 6-1.)		
A101	01410-66507		1	A: Compensator board assy (chan A)		
A102	01410-66502		1	A: Sync take-off amp (chan A)		
A103	00187-66503		2	A: Probe Sampler board assy (chan A)		
A104	01410-66504		1	A: Input amplifier and pulse generator assy		
A105	01410-66505		1	A: Stretcher board assy		
A301	01410-66501		1	A: Compensator board assy (chan B)		
A302	01410-66503		1	A: Sync take-off amp (chan B)		
A303	00187-66503			A: Probe Sampler board assy (chan B)		
A501	01410-66506		1	A: Main Vertical Amplifier Assy		
A503	01410-63401		2	A: attenuator switch (A)		
A504	01410-63401			A: attenuator switch (B)		
C101	0180-0228		6	C: fxd ta 22 μf 10% 15vdcw		
C102	0160-0297		4	C: fxd my 1200 pf 10% 200vdcw		
C103	0150-0116		2	C: fxd cer 47 pf 10% 500vdcw		
C104	0180-0228			C: fxd ta 22 μf 10% 15vdcw		
C105	0180-0228			C: fxd ta 22 μf 10% 15vdcw		
C106	0160-0297			C: fxd my 1200 pf 10% 200vdcw		
C108	0170-0040		4	C: fxd my .047 μf 10% 200vdcw		
C109	0170-0040			C: fxd my .047 μf 10% 200vdcw		
C112				NSR: p/o A103		
C113	0150-0050		4	C: fxd cer 1000 pf 600vdcw		
C114	0150-0050			C: fxd cer 1000 pf 600vdcw		
C115	0160-0161		9	C: fxd my .01 μf 10%		
C118	0160-0153		6	C: fxd my 1000 pf 10%		
C119	0160-0153			C: fxd my 1000 pf 10%		
C120	0160-0161			C: fxd my .01 μf 10%		
C121	0160-0214		2	C: fxd cer 10 pf 500vdcw		
C122	0140-0190		3	C: fxd mica 39 pf 5% 300vdcw		
C123	0140-0204			C: fxd mica 47 pf 5% 300vdcw		
C124	0140-0178		1	C: fxd mica 560 pf 2% 300vdcw		
C125	0140-0176		3	C: fxd mica 100 pf 2% 300vdcw		
C126	0160-0161			C: fxd my .01 μf 10%		
C127	0160-0161			C: fxd my .01 μf 10%		
C128	0140-0176			C: fxd mica 100 pf 2% 300vdcw		
C129	0140-0176			C: fxd mica 100 pf 2% 300vdcw		
C130	0180-0155		8	C: fxd ta 2.2 μf 20% 20vdcw		
C131	0180-0155			C: fxd ta 2.2 μf 20% 20vdcw		
C132	0180-0155			C: fxd ta 2.2 μf 20% 20vdcw		
C133	0160-0161			C: fxd my .01 μf 10%		
C134	0180-1735		3	C: fxd ta 0.22 μf 10% 35vdcw		
C135	0160-0153			C: fxd my 1000 pf 10%		
C137	0160-0407		2	C: fxd cer 1000 pf 10% 500vdcw		
C138	0180-0155			C: fxd ta 2.2 μf 20% 20vdcw		
C139	0140-0200		4	C: fxd mica 390 pf 5% 300vdcw		

Table 6-2. Replaceable Parts (Cont'd)

Ref Desig	hp Part No.		TQ	Description (See Table 6-1.)		
C141	0140-0200			C: fxd mica 390 pf 5% 300vdcw		
C301	0180-0228			C: fxd ta 22 μf 10% 15vdcw		
C302	0160-0297			C: fxd my 1200 pf 10% 200vdcw		
C303	0150-0116			C: fxd cer 47 pf 10% 300vdcw		
C304	0180-0228			C: fxd ta 22 μf 10% 15vdcw		
C305	0180-0228			C: fxd ta 22 μf 10% 15vdcw		
C306	0160-0297			C: fxd my 1200 pf 10% 200vdcw		
C308	0170-0040			C: fxd my .047 μf 10% 200vdcw		
C309	0170-0040			C: fxd my .047 μf 10% 200vdcw		
C312				NSR: p/o A303		
C313	0150-0050			C: fxd cer 1000 pf 600vdcw		
C314	0150-0050			C: fxd cer 1000 pf 600vdcw		
C315	0160-0161			C: fxd cer .01 μf 600vdcw		
C318	0160-0153			C: fxd my 1000 pf 10%		
C319	0160-0153			C: fxd my 1000 pf 10%		
C320	0160-0161			C: fxd cer .01 μf 600vdcw		
C321	0160-0214			C: fxd cer 10 pf 500vdcw		
C322	0140-0190			C: fxd mica 39 pf 5% 300vdcw		
C331	0180-0155			C: fxd ta 2.2 μf 20% 20vdcw		
C332	0180-0155			C: fxd ta 2.2 μf 20% 20vdcw		
C333	0160-0161			C: fxd my .01 μf 10% 200vdcw		
C334	0180-1735			C: fxd ta .22 μf 10% 35vdcw		
C335	0160-0153			C: fxd my 1000 pf 10%		
C337	0160-0407			C: fxd cer 1000 pf 10% 500vdcw		
C338	0180-0155			C: fxd ta 2.2 μf 20% 20vdcw		
C339	0140-0200			C: fxd mica 390 pf 5% 300vdcw		
C341	0140-0200			C: fxd mica 390 pf 5% 300vdcw		
C501	0140-0194		2	C: fxd mica 110 pf 5% 300vdcw		
C502	0140-0194			C: fxd mica 110 pf 5% 300vdcw		
C503	0140-0199		1	C: fxd mica 240 pf 5% 300vdcw		
C504	0130-0016		1	C: var cer 5-25 pf		
C506	0180-1735			C: fxd ta .22 μf 10% 35vdcw		
C507	0140-0193		2	C: fxd mica 82 pf 5% 300vdcw		
C508	0140-0193			C: fxd mica 82 pf 5% 300vdcw		
C509	0140-0191		1	C: fxd mica 56 pf 5% 300vdcw		
C510	0180-0155			C: fxd ta 2.2 μf 20% 20vdcw		
C575	0180-1783		1	C: fxd elect 1000 μf 35vdcw		
C576	0160-0161			C: fxd my .01 μf 10% 200vdcw		
C577	0180-0097		1	C: fxd elect 47 μf 10% 35vdcw		
C580	0150-0052			C: fxd cer 0.05 μf 20% 400vdcw		

Table 6-2. Replaceable Parts (Cont'd)

Ref Desig	hp Part No.		TQ	Description (See Table 6-1.)		
CR105	1901-0340		8	CR: si		
CR106	1901-0340			CR: si		
CR107	1901-0340			CR: si		
CR108	1901-0340			CR: si		
CR110	1901-0182		1	CR: step recovery		
CR111	1901-0040		22	CR: si		
CR112	1901-0040			CR: si		
CR113	1901-0040			CR: si		
CR116	1901-0040			CR: si		
CR118	1901-0040			CR: si		
CR119	1901-0040			CR: si		
CR120	1901-0040			CR: si		
CR305	1901-0340			CR: si		
CR306	1901-0340			CR: si		
CR307	1901-0340			CR: si		
CR308	1901-0340			CR: si		
CR316	1901-0040			CR: si		
CR318	1901-0040			CR: si		
CR319	1901-0040			CR: si		
CR320	1901-0040			CR: si		
CR501	1901-0040			CR: si		
CR502	1901-0040			CR: si		
CR503	1901-0040			CR: si		
CR504	1901-0040			CR: si		
CR505	1901-0040			CR si		
CR506	1901-0040			CR: si		
CR507	1901-0040			CR: si		
CR508	1901-0040			CR: si		
CR510	1901-0040			CR: si		
CR511	1901-0040			CR: si		
CR512	1901-0033		1	CR: si		
CR575	1901-0026		4	CR: si		
CR576	1901-0026			CR: si		
CR577	1901-0026			CR: si		
CR578	1901-0026			CR: si		
CR579	1901-0040			CR: si		
DL101 DL301	01410-61603		1	DL: delay line assy matchedpair (includes J101 & J301)		
F575	2110-0001		1	F: 1 amp		

Table 6-2. Replaceable Parts (Cont'd)

Ref Desig	hp Part No.		TQ	Description (See Table 6-1.)		
J101				NSR: p/o DL101		
J102				Includes:		
	01410-21201		2	Bracket: compensator mount		
	01410-27608		2	Body: BNC adapter		
	01410-48301		2	Probe guide		
J301				NSR: p/o DL301		
J302				Includes:		
	01410-21201			Bracket: compensator mount		
	01410-27608			Body: BNC adapter		
	01410-48301			Probe guide		
J501	1250-0118		2	J: BNC		
J502	1250-0118			J: BNC		
K501				Includes:		
	0490-0189		1	Relay reed		
	0490-0191		1	Relay coil		
L101	9100-2254		2	L: fxd .39 µh		
L103	9140-0029		4	L: fxd 100 µh		
L104	9140-0120		2	L: fxd .1 µh		
L105	9140-0029			L: fxd 100 µh		
L108	9140-0146		2	L: fxd 10 µh		
L301	9100-2254			L: fxd .39 µh		
L303	9140-0029			L: fxd 100 µh		
L304	9140-0120			L: fxd .1 µh		
L305	9140-0029			L: fxd 100 µh		
L308	9140-0146			L: fxd 10 µh		
P1	1251-0055		1	P: panel plug, 24 contact		
P3	1251-1285		1	P: panel plug, 12 contact, 5 coaxial		
Q101	1854-0269		2	Q: si npn		
Q102	1853-0061		2	Q: si pnp		
Q106	1855-0020		2	Q: si FET N channel		
Q107	1853-0020		11	Q: si pnp		
Q108	1853-0010		5	Q: si pnp		
Q109	1854-0035		1	Q: si npn		
Q110	1854-0019		3	Q: si npn		
Q111	1854-0071		13	Q: si npn		
Q115	1853-0020			Q: si pnp		
Q116	1854-0071			Q: si npn		
Q117	1853-0010			Q: si pnp		
Q118	1854-0019			Q: si npn		
Q119	1855-0022		4	Q: si FET N channel		

Table 6-2. Replaceable Parts (Cont'd)

Ref Desig	hp Part No.		TQ	Description (See Table 6-1.)		
Q120	1855-0022			Q: si FET N channel		
Q121	1853-0020			Q: si pnp		
Q123	1854-0071			Q: si npn		
Q124	1854-0071			Q: si npn		
Q125	1853-0020			Q: si pnp		
Q301	1854-0269			Q: si npn		
Q302	1853-0061			Q: si pnp		
Q306	1855-0020			Q: si FET N channel		
Q307	1853-0020			Q: si pnp		
Q315	1853-0020			Q: si pnp		
Q316	1854-0071			Q: si npn		
Q317	1853-0010			Q: si pnp		
Q318	1854-0019			Q: si npn		
Q319	1855-0022			Q: si FET N channel		
Q320	1855-0022			Q: si FET N channel		
Q321	1853-0020			Q: si pnp		
Q323	1854-0071			Q: si npn		
Q324	1854-0071			Q: si npn		
Q325	1853-0020			Q: si pnp		
Q501	1854-0071			Q: si npn		
Q502	1854-0071			Q: si npn		
Q503	1854-0022			Q: si npn		
Q504	1854-0022			Q: si npn		
Q505	1854-0022		3	Q: si npn		
Q506	1854-0022			Q: si npn		
Q507	1854-0232		2	Q: si npn		
Q508	1854-0232			Q: si npn		
Q509	1854-0071			Q: si npn		
Q510	1853-0020			Q: si pnp		
Q511	1853-0020			Q: si pnp		
Q512	1854-0022			Q: si npn		
Q513	1853-0010			Q: si pnp		
Q514	1853-0010			Q: si pnp		
Q515	1853-0020			Q: si pnp		
Q575	1854-0039		2	Q: si 2N3053		
Q576	1854-0084		1	Q: si npn 2N3232		
Q577	1854-0039			Q: si 2N3053		
Q578	1854-0071			Q: si npn		
R1	2100-1717		2	R: var carbon comp 50k ohms, 20%		
R2	2100-2064		2	R: var carbon comp 20k ohms 10% 1/2w		

Table 6-2. Replaceable Parts (Cont'd)

Ref Desig	hp Part No.		TQ	Description (See Table 6-1.)		
R101	0757-0705		2	R: fxd metflm 75 ohms 1% 1/2w		
R102	0757-0284		4	R: fxd metflm 150 ohms 1% 1/8w		
R104	0757-0409		2	R: fxd metflm 274 ohms 1% 1/8w		
R105	0757-0401		4	R: fxd metflm 100 ohms 1% 1/8w		
R106	0757-0391		2	R: fxd metflm 39.2 ohms 1% 1/8w		
R110	0757-0394		7	R: fxd metflm 51.1 ohms 1% 1/8w		
R111	0757-0274		2	R: fxd metflm 1.21k ohms 1% 1/8w		
R113	0757-0158		2	R: fxd metflm 619 ohms 1% 1/2w		
R120				NSR: p/o A103		
R121	0757-0429		10	R: fxd metflm 1.82k ohms 1% 1/8w		
R122	0757-0394			R: fxd metflm 51.1 ohms 1% 1/8w		
R123	0757-0394			R: fxd metflm 51.1 ohms 1% 1/8w		
R124	0757-0429			R: fxd metflm 1.82k ohms 1% 1/8w		
R125	0757-0433		5	R: fxd metflm 3.32k ohms 1% 1/8w		
R126	2100-1710		2	R: var carbon comp 50k ohms 20% (Includes R210, 5k)		
R128	0757-0454		6	R: fxd metflm 33.2k ohms 1% 1/8w		
R129	2100-0364		3	R: var ww 20k ohms 5% 1/10w		
R130	0757-0429			R: fxd metflm 1.82k ohms 1% 1/8w		
R131	2100-1429		3	R: var ww 2k ohms 5% 1/10w		
R132	0757-0429			R: fxd metflm 1.82k ohms 1% 1/8w		
R133	0757-0429			R: fxd metflm 1.82k ohms 1% 1/8w		
R134	0757-0454			R: fxd metflm 33.2k ohms 1% 1/8w		
R135	0758-0017		4	R: fxd metflm 1.5k ohms 5% 1/2w		
R136	0758-0017			R: fxd metflm 1.5k ohms 5% 1/2w		
R137	0757-0449		3	R: fxd metflm 20k ohms 1% 1/8w		
R138	0757-0443		2	R: fxd metflm 11k ohms 1% 1/8w		
R139	0757-0422		5	R: fxd metflm 909 ohms 1% 1/8w		
R142	0757-0407			R: fxd metflm 200 ohms 1% 1/8w		
R143	0757-0763		4	R fxd metflm 27.4k ohms 1% 1/4w		
R145	0757-0761		4	R: fxd metflm 22.1k ohms 1% 1/4w		
R146	0757-0288		2	R: fxd metflm 9.09k ohms 1% 1/8w		
R147	0757-0044			R: fxd metflm 33.2k ohms 1% 1/4w		
R148	0757-0761			R: fxd metflm 22.1k ohms 1% 1/4w		
R150	0757-1100		2	R: fxd metflm 600 ohms 1% 1/8w		
R151	0757-1108		4	R: fxd metflm 300 ohms 1% 1/8w		
R152	0757-1102		2	R: fxd metflm 180 ohms 1% 1/8w		
R153	0757-1104		2	R: fxd metflm 60 ohms 1% 1/8w		
R154	0757-1107		8	R: fxd metflm 30 ohms 1% 1/8w		
R155	0757-1107			R: fxd metflm 30 ohms 1% 1/8w		
R156	0757-0458		4	R: fxd metflm 51.1k ohms 1% 1/8w		
R157	2100-0820		2	R: var ww 50k ohms 3% 2w		
R158	0683-0475		1	R: fxd metflm 4.7 ohms 1% 1/4w		
R159	0757-0449		4	R: fxd metflm 20k ohms 1% 1/8w		
R161	0757-0401			R: fxd metflm 100 ohms 1% 1/8w		
R162	0757-0280		11	R: fxd metflm 1k ohms 1% 1/8w		

Table 6-2. Replaceable Parts (Cont'd)

Ref Desig	hp Part No.		TQ	Description (See Table 6-1.)		
R163	0757-0416		10	R: fxd metflm 511 ohms 1% 1/8w		
R164	0757-0394			R: fxd metflm 51.1 ohms 1% 1/8w		
R165	0757-0843		2	R: fxd metflm 15k ohms 1% 1/2w		
R166	0757-0442		8	R: fxd metflm 10k ohms 1% 1/8w		
R167	0757-0283			R: fxd metflm 2k ohms 1% 1/8w		
R168	0757-0280			R: fxd metflm 1k ohms 1% 1/8w		
R169	0757-0843			R: fxd metflm 15k ohms 1% 1/8w		
R170	0757-0410		5	R: fxd metflm 301 ohms 1% 1/8w		
R171	0757-0410			R: fxd metflm 301 ohms 1% 1/8w		
R172	0757-0430		2	R: fxd metflm 2.21k ohms 1% 1/8w		
R173	0757-0451		2	R: fxd metflm 24.3k ohms 1% 1/8w		
R174	0757-0280			R: fxd metflm 1k ohm 1% 1/8w		
R175	0757-0419		2	R: fxd metflm 681 ohms 1% 1/8w		
R176	0757-0428		2	R: fxd metflm 1.62k ohms 1% 1/8w		
R178	0757-0415		2	R: fxd metflm 475 ohms 1% 1/8w		
R179	0757-0417		2	R: fxd metflm 562 ohms 1% 1/8w		
R180	0757-0283			R: fxd metflm 2k ohms 1% 1/8w		
R181	0757-0442			R: fxd metflm 10k ohms 1% 1/8w		
R182	0757-0442			R: fxd metflm 10k ohms 1% 1/8w		
R183	2100-0755		2	R: var ww 1k ohm 5%		
R184	0757-0422			R: fxd metflm 909 ohms 1% 1/8w		
R185	0757-0280			R: fxd metflm 1k ohm 1% 1/8w		
R186	0757-0435		2	R: fxd metflm 3.92k ohms 1% 1/8w		
R188	0757-0341		2	R: fxd metflm 30.1k ohms 1% 1/4w		
R189	2100-0944		4	R: var metflm 200k ohms 5%		
R190	0757-0178		2	R: fxd metflm 100 ohms 1% 1/8w		
R193	0757-0442			R: fxd metflm 10k ohms 1% 1/8w		
R194	2100-0944			R: var metflm 200k ohms 5%		
R195	0757-0280			R: fxd metflm 1k ohm 1% 1/8w		
R197	0757-0190		2	R: fxd metflm 20k ohms 1% 1/2w		
R198	0757-0416			R: fxd metflm 511 ohms 1% 1/8w		
R199	0757-0416			R: fxd metflm 511 ohms 1% 1/8w		
R200	0757-0416			R: fxd metflm 511 ohms 1% 1/8w		
R201	0757-0442		2	R: fxd metflm 10k ohms 1% 1/8w (factory selected value, 10k is typical)		
R202	2100-2115		2	R: var carbon comp 5k ohms 1/2w w/switch		
R203	2100-1715		2	R: var comp 2k ohms 20% 1/2w		
R204	0757-0464		6	R: fxd metflm 90.9k ohms 1% 1/8w		
R205	2100-1777		1	R: var ww 20k ohms 10% 1/2w		
R206	0757-0464			R: fxd metflm 90.9k ohms 1% 1/8w		
R209	0757-0405		2	R: fxd metflm 162 ohms 1% 1/8w		
R210				NSR: p/o R126		
R211	0757-0438		3	R: fxd metflm 5.11k ohms 1% 1/8w		
R212	0757-1094		2	R: fxd metflm 1.47k ohms 1% 1/8w		
R213	0757-1107			R: fxd metflm 30 ohms 1% 1/8w		
R214	0757-1095		2	R: fxd metflm 1.44k ohms 1% 1/8w		
R215	0757-1107			R: fxd metflm 30 ohms 1% 1/8w		
R216	0757-1096		2	R: fxd metflm 1.36k ohms 1% 1/8w		
R217	0757-1103		2	R: fxd metflm 90 ohms 1% 1/8w		
R218	0757-1097		2	R: fxd metflm 1.2k ohms 1% 1/8w		
R219	0757-0284			R: fxd metflm 150 ohms 1% 1/8w		
R220	0757-1098		2	R: fxd metflm 945 ohms 1% 1/8w		
R221	0757-1108			R: fxd metflm 300 ohms 1% 1/8w		
R222	0757-1101		2	R: fxd metflm 360 ohms 1% 1/8w		
R223	0757-1099		2	R: fxd metflm 900 ohms 1% 1/8w		

Table 6-2. Replaceable Parts (Cont'd)

Ref Desig	hp Part No.		TQ	Description (See Table 6-1.)		
R224	0757-0427		3	R: fxd metflm 1.5k ohms 1% 1/8w		
R225	0757-0426		1	R: fxd metflm 1.5k ohms 1% 1/8w		
R226	0757-1093		2	R: fxd metflm 3k ohms 1% 1/8w		
R301	0757-0795			R: fxd metflm 75 ohms 1% 1/2w		
R302	0757-0284			R: fxd metflm 150 ohms 1% 1/8w		
R304	0757-0409			R: fxd metflm 274 ohms 1% 1/8w		
R305	0757-0401			R: fxd metflm 100 ohms 1% 1/8w		
R306	0757-0391			R: fxd metflm 39.2 ohms 1% 1/8w		
R310	0757-0394			R: fxd metflm 51.1 ohms 1% 1/8w		
R311	0757-0274			R: fxd metflm 1.21k ohms 1% 1/8w		
R313	0757-0158			R: fxd metflm 619 ohms 1% 1/2w		
R320				NSR: p/o A303		
R321	0757-0429			R: fxd metflm 1.82k ohms 1% 1/8w		
R322	0757-0394			R: fxd metflm 51.1 ohms 1% 1/8w		
R323	0757-0394			R: fxd metflm 51.1 ohms 1% 1/8w		
R324	0757-0429			R: fxd metflm 1.82k ohms 1% 1/8w		
R325	0757-0433			R: fxd metflm 3.32k ohms 1% 1/8w		
R326	2100-1710			R: var carbon comp 50k ohms 20% (includes R410, 5k)		
R328	0757-0454			R: fxd metflm 33.2k ohms 1% 1/8w		
R329	2100-0364			R: var ww 20k ohms 5% 1w		
R330	0757-0429			R: fxd metflm 1.82k ohms 1% 1/8w		
R331	2100-1429			R: var ww 2k ohms 5% 1w		
R332	0757-0429			R: fxd metflm 1.82k ohms 1% 1/8w		
R333	0757-0429			R: fxd metflm 1.82k ohms 1% 1/8w		
R334	0757-0454			R: fxd metflm 33.2k ohms 1% 1/8w		
R335	0758-0017			R: fxd metflm 1.5k ohms 5% 1/2w		
R336	0758-0017			R: fxd metflm 1.5k ohms 5% 1/2w		
R337	0757-0449			R: fxd metflm 20k ohms 1% 1/8w		
R338	0757-0443			R: fxd metflm 11k ohms 1% 1/8w		
R339	0757-0422			R: fxd metflm 909 ohms 1% 1/8w		
R342	0757-0407			R: fxd metflm 200 ohms 1% 1/8w		
R343	0757-0763			R: fxd metflm 27.4k ohms 1% 1/4w		
R345	0757-0761			R: fxd metflm 22.1k ohms 1% 1/4w		
R346	0757-0288			R: fxd metflm 9.09k ohms 1% 1/8w		
R347	0757-0044			R: fxd metflm 33.2k ohms 1% 1/4w		
R348	0757-0761			R: fxd metflm 22.1k ohms 1% 1/4w		
R350	0757-1100			R: fxd metflm 600 ohms 1% 1/8w		
R351	0757-1108			R: fxd metflm 300 ohms 1% 1/8w		
R352	0757-1102			R: fxd metflm 180 ohms 1% 1/8w		
R353	0757-1104			R: fxd metflm 60 ohms 1% 1/8w		
R354	0757-1107			R: fxd metflm 30 ohms 1% 1/8w		
R355	0757-1107			R: fxd metflm 30 ohms 1% 1/8w		
R356	0757-0458			R: fxd metflm 51.1k ohms 1% 1/8w		
R357	2100-0820			R: var ww 50k ohms 3% 2w		

Table 6-2. Replaceable Parts (Cont'd)

Ref Desig	hp Part No.		TQ	Description (See Table 6-1.)		
R370	0757-0410			R: fxd metflm 301 ohms 1% 1/8w		
R371	0757-0410			R: fxd metflm 301 ohms 1% 1/8w		
R372	0757-0430			R: fxd metflm 2.21k ohms 1% 1/8w		
R373	0757-0451			R: fxd metflm 24.3k ohms 1% 1/8w		
R374	0757-0280			R: fxd metflm 1k ohm 1% 1/8w		
R375	0757-0419			R: fxd metflm 681 ohms 1% 1/8w		
R376	0757-0428			R: fxd metflm 1.62k ohms 1% 1/8w		
R378	0757-0415			R: fxd metflm 475 ohms 1% 1/8w		
R379	0757-0417			R: fxd metflm 562 ohms 1% 1/8w		
R380	0757-0283			R: fxd metflm 2k ohms 1% 1/8w		
R381	0757-0442			R: fxd metflm 10k ohms 1% 1/8w		
R382	0757-0442			R: fxd metflm 10k ohms 1% 1/8w		
R383	2100-0755			R: var ww 1k ohm 5%		
R384	0757-0422			R: fxd metflm 909 ohms 1% 1/8w		
R386	0757-0435			R: fxd metflm 3.92k ohms 1% 1/8w		
R388	0757-0341			R: fxd metflm 30.1k ohms 1% 1/4w		
R389	2100-0944			R: var metflm 200k ohms 20%		
R390	0757-0178			R: fxd metflm 100 ohms 1% 1/8w		
R393	0757-0442			R: fxd metflm 10k ohms 1% 1/8w		
R394	2100-0944			R: var metflm 200k ohms 20%		
R395	0757-0280			R: fxd metflm 1k ohm, 1% 1/8w		
R396	0757-0283			R: fxd metflm 2k ohms 1% 1/8w		
R397	0757-0190			R: fxd metflm 20k ohms 1% 1/2w		
R398	0757-0416			R: fxd metflm 511 ohms 1% 1/8w		
R399	0757-0416			R: fxd metflm 511 ohms 1% 1/8w		
R400	0757-0416			R: fxd metflm 511 ohms 1% 1/8w		
R401	0757-044			R: fxd metflm 10k ohms 1% 1/8w (factory selected value, 10k is typical		
R402	2100-2115			R: var carbon comp 5k ohms 1/2w w/switch		
R403	2100-1715			R: var comp 2k ohms 20% 1/2w		
R404	0757-0464			R: fxd metflm 90.9k ohms 1% 1/8w		
R405	2100-0364			R: var ww 20k ohms 5% 1w		
R406	0757-0464			R: fxd metflm 90.9k ohms 1% 1/8w		
R409	0757-0405			R: fxd metflm 162 ohms 1% 1/8w		
R410				NSR: p/o R326		
R411	0757-0438			R: fxd metflm 5.11k ohms 1% 1/8w		
R412	0757-1094			R: fxd metflm 1.47k ohms 1% 1/8w		
R413	0757-1107			R: fxd metflm 30 ohms 1% 1/8w		
R414	0757-1095			R: fxd metflm 1.44k ohms 1% 1/8w		
R415	0757-1107			R: fxd metflm 30 ohms 1% 1/8w		
R416	0757-1096			R: fxd metflm 1.36k ohms 1% 1/8w		
R417	0757-1103			R: fxd metflm 90 ohms 1% 1/8w		
R418	0757-1097			R: fxd metflm 1.2k ohms 1% 1/8w		
R419	0757-0284			R: fxd metflm 150 ohms 1% 1/8w		
R420	0757-1098			R: fxd metflm 945 ohms 1% 1/8w		
R421	0757-1108			R: fxd metflm 300 ohms 1% 1/8w		
R422	0757-1101			R: fxd metflm 360 ohms 1% 1/8w		
R423	0757-1099			R: fxd metflm 900 ohms 1% 1/8w		
R424	0757-0427			R: fxd metflm 1.5k ohms 1% 1/8w		
R425	0757-0427			R: fxd metflm 1.5k ohms 1% 1/8w		
R426	0757-1093			R: fxd metflm 3k ohms 1% 1/8w		

Table 6-2. Replaceable Parts (Cont'd)

Ref Desig	hp Part No.		TQ	Description (See Table 6-1.)		Mfr Part No.
R501	0757-0440		3	R: fxd metflm 7.5k ohms 1% 1/8w		
R502	0757-0440			R: fxd metflm 7.5k ohms 1% 1/8w		
R503	0757-0421		1	R: fxd metflm 825 ohms 1% 1/8w		
R504	0757-0280			R: fxd metflm 1k ohm 1% 1/8w		
R505	0757-0438			R: fxd metflm 5.11k ohms 1% 1/8w		
R506	0757-0410			R: fxd metflm 301 ohms 1% 1/8w		
R507	0757-0762		2	R: fxd metflm 24.3k ohms 1% 1/4w		
R508	0757-0445		2	R: fxd metflm 13k ohms 1% 1/8w		
R509	0757-0433			R: fxd metflm 3.32k ohms 1% 1/8w		
R510	0757-0433			R: fxd metflm 3.32k ohms 1% 1/8w		
R511	0757-0445			R: fxd metflm 13k ohms 1% 1/8w		
R512	0757-0762			R: fxd metflm 24.3k ohms 1% 1/4w		
R513	0757-0444		2	R: fxd metflm 12.1k ohms 1% 1/8w		
R514	0757-0444			R: fxd metflm 12.1k ohms 1% 1/8w		
R517	0757-0749		4	R: fxd metflm 6.19k ohms 1% 1/4w		
R518	0757-0749			R: fxd metflm 6.19k ohms 1% 1/4w		
R519	0757-0433			R: fxd metflm 3.32k ohms 1% 1/8w		
R520	0757-0749			R: fxd metflm 6.19k ohms 1% 1/4w		
R521	0757-0749			R: fxd metflm 6.19k ohms 1% 1/4w		
R522	0757-0416			R: fxd metflm 511 ohms 1% 1/8w		
R523	0757-0280			R: fxd metflm 1k ohm 1% 1/8w		
R524	2100-1716		1	R: var ww 5k ohms 5% 1-1/2w		
R525	0757-0416			R: fxd metflm 511 ohms 1% 1/8w		
R528	0757-0845		2	R: fxd metflm 18.2k ohms 1% 1/2w		
R529	0757-0845			R: fxd metflm 18.2k ohms 1% 1/2w		
R531	0757-0461		1	R: fxd metflm 68.1k ohms 1% 1/8w		
R532	0757-0479		1	R: fxd metflm 392k ohms 1% 1/8w		
R533	0757-0464			R: fxd metflm 90.9k ohms 1% 1/8w		
R534	0757-0442			R: fxd metflm 10k ohms 1% 1/8w		
R535	2100-1734			R: var carbon comp 20k ohms 10% 1/2w		
R536	0757-0464			R: fxd metflm 90.9k ohms 1% 1/8w		
R537	2100-1717			R: var comp 50k ohms 20% 1/2w		
R538	0757-0465		3	R: fxd metflm 100k ohms 1% 1/8w		
R539	0757-0440			R: fxd metflm 7.5k ohms 1% 1/8w		
R540	0757-0159		1	R: fxd metflm 1k ohm 1% 1/2w		
R541	0757-0416			R: fxd metflm 511 ohms 1% 1/8w		
R545	0757-0422			R: fxd metflm 909 ohms 1% 1/8w		
R546	0757-0281		5	R: fxd metflm 2.74k ohms 1% 1/8w		
R547	0757-0454			R: fxd metflm 33.2k ohms 1% 1/8w		
R548	0757-0280			R: fxd metflm 1k ohm 1% 1/8w		
R549	0757-0280			R: fxd metflm 1k ohm 1% 1/8w		
R550	0757-0454			R: fxd metflm 33.2k ohms 1% 1/8w		
R551	0757-0281			R: fxd metflm 2.74k ohms 1% 1/8w		
R552	0757-0458			R: fxd metflm 51.1k ohms 1% 1/8w		
R553	0757-0458			R: fxd metflm 51.1k ohms 1% 1/8w		
R555	0757-0281			R: fxd metflm 2.74k ohms 1% 1/8w		
R556	0757-0281			R: fxd metflm 2.74k ohms 1% 1/8w		
R557	0757-0281			R: fxd metflm 2.74k ohms 1% 1/8w		

Table 6-2. Replaceable Parts (Cont'd)

Ref Desig	hp Part No.		TQ	Description (See Table 6-1.)		
R575	0811-0929		1	R: fxd ww 0.51 ohms 5% 2w		
R576	0757-0401			R: fxd metflm 100 ohms 1% 1/8w		
R577	0757-0465			R: fxd metflm 100k ohms 1% 1/8w		
R578	0757-0480		1	R: fxd metflm 432k ohms 1% 1/8w		
R579	0757-0447		1	R: fxd metflm 16.2k ohms 1% 1/8w		
R580	2100-1429			R: var ww 2k ohms 5% 1w		
R581	0757-0465			R: fxd metflm 100k ohms 1% 1/8w		
R582	0757-0449			R: fxd metflm 20k ohms 1% 1/8w		
S1	01410-66508		5	S: slide, trigger selector		
S101				NSR: p/o A503		
S102	3101-0199			S: slide norm, sens		
S103	3101-0199			S: slide slope		
S301				NSR: p/o A504		
S302	3101-0199			S: slide, norm, sens		
S303	3101-0199			S: slide, slope		
S501	01410-61901		1	S: mode selector		
T101				NSR: p/o A103		
T102	01410-66002		2	T: balun		
T301				NSR: p/o A303		
T302	01410-66002			T: balun		
T575	9100-0111		1	T: power		
VR103	1902-0578		1	VR: avalanche 27 v 1%		
VR105	1902-0590		2	VR: avalanche 4.42 v 1 w 5%		
VR106	1902-0036		2	VR: avalanche 6.19 v 400 mw 10%		
VR305	1902-0590			VR: avalanche 4.42 v 1w 5%		
VR306	1902-0036			VR: avalanche 6.19 v 400 mw 10%		
VR501	1902-0199		2	VR: avalanche 10 v		
VR502	1902-0199			VR: avalanche 10 v		
VR503	1902-3356		1	VR: avalanche 56.2 v 10%		

Table 6-2. Replaceable Parts (Cont'd)

Ref Desig	hp Part No.		TQ	Description (See Table 6-1.)		
				MISCELLANEOUS		
	0370-0099		2	Knob, millivolts/cm		
	0370-0134		2	Knob, vernier		
	0370-0308		1	Knob, mode selector		
	0370-0309		2	Knob, smoothing		
	0370-0310		2	Knob, vert pos		
	0510-0054		2	Grip ring		
	00187-62101		2	Probe housing assy		
	01410-00101		1	Deck		
	01410-00201		1	Panel, front		
	01410-00202		1	Panel, sub		
	01410-00203		1	Panel, rear		
	01410-04101		1	Cover, delay lines		
	01410-23701		2	Rod, lower support		
	01410-23702		1	Rail, upper right		
	01410-23703		1	Rail, upper left		
	01410-24701		2	Pins, guide and locking		
	01410-61601		1	Cable assy, main		
	01410-61612		2	Cable assy, probe		
	01410-64001		1	Handle assy		
				ACCESSORIES		
	10214A		2	10:1 Divider		
	10216A		2	Isolator		
	10217A		2	Blocking Capacitor		
	10218A		2	BNC Adapter		
	10219A		1	GR Adapter		
	10220A		2	Microdot Adapter		
	10221A		1	50 ohm T Connector		
	10213-62102		6	Ground Clip		
	5020-0457		6	Probe Tip		
	5020-0503		1	Probe Adj Tool		
	9220-1263		1	Tray, upper		
	9220-1264		1	Tray, lower		
	9211-1013		1	Accessory Box, (includes trays)		

BACK DATING
MANUAL
CHANGES

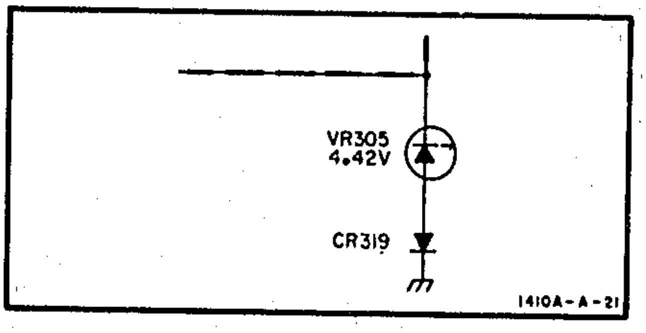


Figure 7-1

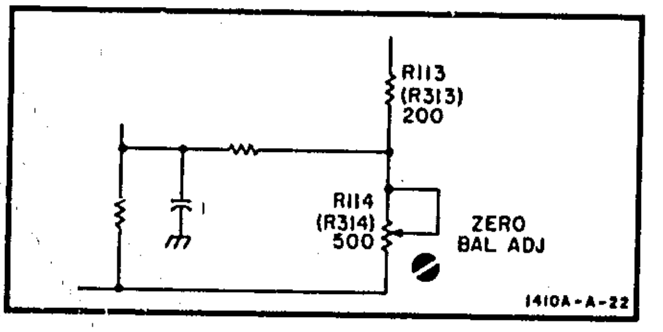


Figure 7-2

SECTION VII
MANUAL CHANGES AND OPTIONS

7-1. MANUAL CHANGES.

7-2. This manual applies directly to the standard Model 1410A Sampling Vertical Amplifier having a serial prefix 743-. The following paragraphs provide instructions for modifying this manual to cover older or newer instruments. Refer to the separate "Manual Changes" sheet supplied with this manual for Errata.

7-3. OLDER INSTRUMENTS.

7-4. Table 7-1 contains information on changes required to adapt this manual to an older instrument (lower serial prefix number). Check Table 7-1 for your instrument serial prefix and make the changes indicated. Note that these changes adapt the manual to cover a particular instrument as manufactured and therefore do not apply to an instrument subsequently modified in the field.

Table 7-1. Manual Changes

Serials Prefixed	Make Changes
730-	1 and 2
728-	1 thru 3
715-	1, 3 and 4
703-	1, 3, 4 and 5
619-	1, 3, 4, 5, and 6

7-5. NEWER INSTRUMENTS.

7-6. As changes are made in the Model 1410A, newer instruments may have serial prefixes higher than 743-. The manual for these newer instruments will be supplied with a "Manual Changes" sheet which contains all necessary updating information. If the serial prefix of your particular instrument is higher than the one listed at the front of this manual and no "Manual Changes" sheet has been provided, contact your nearest Hewlett-Packard Sales/Service Office.

7-7. OPTIONS.

7-8. Options for an hp instrument are standard modifications installed at the factory. At the present time, no options are offered for the Model 1410A.

7-9. SPECIAL INSTRUMENTS.

7-10. Modified versions (per customer's specifications) of any hp instrument are available on special order. The manual for these special instruments (having electrical modifications) will include a separate insert sheet that describes the modification and any special manual changes in addition to the "Manual Changes" sheet (if applicable). Contact the nearest hp Sales/Service Office if either of these sheets is missing from the manual of a special instrument. Be sure to refer to the instrument by its full specification name and number.

CHANGE 1

Section VI, Replaceable Parts,
R396: Delete.
Page 8-11, Figure 8-13,
R396: Delete and interchange diodes to be as shown in Figure 7-1.

CHANGE 2

Section VI, Replaceable Parts,
R178, R378: Change to hp Part No. 0757-0419;
R: fxd metflm 681 ohms ±1% 1/8w.
R179, R379: Change to hp Part No. 0757-0411;
R: fxd metflm 332 ohms ±1% 1/8w.
Page 8-7, Figure 8-8,
R178: Change value to 681 ohms.
R179: Change value to 332 ohms.
Page 8-11, Figure 8-13,
R378: Change value to 681 ohms.
R379: Change value to 332 ohms.

CHANGE 3

Section VI, Replaceable Parts,
Add: VR101, VR102, VR301, and VR302; hp Part No. 1902-0174; VR avalanche 82.5v, ±10%, mfr hp; TQ4.
Page 8-5, Figure 8-5,
Add: VR101, 82.5v in parallel with C108.
Add: VR102, 82.5v in parallel with C109.
Page 8-9, Figure 8-11,
Add: VR301, 82.5v in parallel with C308.
Add: CR302, 82.5v in parallel with C309.

CHANGE 4

Section VI, Replaceable Parts,
Q503 and Q504: Change to hp Part No. 1854-0022.

CHANGE 5

Section V, Adjustment Procedure,
Insert the following adjustment procedure between the Stretcher Gain and Balance Adjustment and the T_R Cal Range Adjustment.

Sampling Bias Adj.
a. Set Time Base SCAN DENSITY fully ccw.
b. Connect a fast rise time Pulse Generator to Channel A GR type INPUT. Insert probe into receptacle. Adjust Diode Bias Adj (R160) for maximum separation of first two dots on left side of display. Keep response optimized with SMOOTHING ADJUST.

Section VI, Replaceable Parts,
C123: Change description to hp Part No. 0140-0190; C: fxd mica 39 pf 5% 300vdcw.
R135, R136, R335 and R336: Change description to hp Part No. 0758-0033; R: fxd metflm 2k ohms 5% 1/2w.
R147 and R347: Change description to hp Part No. 0757-0763; R: fxd metflm 27.4k ohms 1% 1/4w.
R159: Change description to hp Part No. 0757-0283; R: fxd metflm 2000 ohms 1% 1/8w.
Add: R160; hp Part No. 2100-0363; R: var ww 10k ohms 5% 1/10w.

Page 8-5, Figure 8-5,
C123: Change value to 39 pf.
R135 and R136: Change value to 2000 ohms.
R147: Change value to 27.4k ohms.
R159: Change value to 2000 ohms.
Add: R160; variable 10k pot in series between R159 and the -12.6v supply. Connect wiper to top end of pot. Label the pot Diode Bias Adj.

Page 8-9, Figure 8-11,
R335 and R336: Change value to 2000 ohms.
R347: Change value to 27.4k ohms.

CHANGE 6

Section V, Adjustment Procedure,
Add the following paragraphs:

Trigger Balance Adjustment,
This adjustment controls the dc level of the signal being sent to the time base for internal triggering and should not normally require readjustment. However, if components are replaced, readjustment may be necessary for that channel. Adjust as follows:
a. Connect a dc voltmeter to Q102 collector.
b. Adjust R114 for 0vdc with no input.
c. Change mode selector to B and connect voltmeter to Q302 collector.
d. Adjust R314 for 0vdc with no input.

Section VI, Replaceable Parts,
C580: Delete.
Add: R112, R114, R312 and R314; hp Part No. 0757-0273; R: fxd metflm 3.01k ohms 1% 1/8w.
R113 and R313: Change description to hp Part No. 0757-0407; R: fxd metflm 200 ohms 1% 1/8w.

Page 8-10, Figure 8-12,
C580: Delete.

Page 8-15, Figure 8-18,
Add: R112 and R312 and make connections as shown in Figure 7-2.
R113 and R313: Change value to 200 ohms.
Make corresponding circuit connections to B channel.

SCHEMATIC DIAGRAMS

SECTION VIII
SCHEMATICS AND TROUBLESHOOTING

8-1. INTRODUCTION.

8-2. This section contains schematic diagrams, information regarding repair and replacement, component identification, and troubleshooting tips. Table 8-1 provides general schematic notes, defining the symbols and conventions used in the schematics.

8-3. COMPONENT IDENTIFICATION.

8-4. Components located on etched circuit boards are identified in photos adjacent to the applicable schematic except for Channel B preamplifier and stretcher components. These components are identified in the same figure as their corresponding Channel A components. Components located on the chassis are identified in Figures 8-9 and 8-10. Adjustment locations are shown in Figure 8-2.

8-5. REPAIR AND REPLACEMENT.

8-6. Most all electrical components are accessible for replacement from the component side of the etched circuit board. Section VI provides a detailed parts list to allow ordering of replacement parts. Mechanical and miscellaneous parts are listed at the end of the table. If satisfactory repair or operation cannot be accomplished, contact the nearest Hewlett-Packard Sales/Service Office (addresses at rear of this manual). If shipment for repair is recommended, see Section II for recommended repackaging information.

8-7. SERVICING ETCHED CIRCUIT BOARDS.

8-8. The Model 1410A has etched circuit boards which are plated-through type. When servicing this type of board, components may be removed or replaced from either side of the board. When replacing large components, such as potentiometers, rotate the soldering iron tip from lead to lead while applying pressure to the part to lift it from the board. HP Service Note M-20D contains additional information on the repair of etched circuit boards, however, the important considerations are as follows:

a. Do not apply excessive heat.

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

c. Use a toothpick or wooden splinter to clean holes.

d. Do not force leads of replacement component into holes.

8-9. If the plated metal surface (conductor) lifts from the board, it may be cemented back with a quick-drying acetate base cement (use sparingly) having good insulating properties. An alternate method of repair is to solder a good conducting wire along the damaged area.

8-10. REPLACING REED RELAY.

8-11. The reed relay consists of two separately replaceable parts, the coil and the reed. To replace the reed:

a. Unsolder both reed leads from the circuit board.

b. Bend one end of one lead so it can be removed from the opposite end of the coil.

CAUTION

Hold the lead of the reed with long-nosed pliers when bending the lead. Bend only the flexible lead to avoid cracking glass capsule.

c. Remove the reed.

d. Insert the new reed through coil.

e. Using long-nosed pliers, bend the reed leads to fit into the circuit holes.

f. Solder reed leads into place.

8-12. To replace a coil:

a. Remove the reed according to the above procedure.

b. Unsolder and remove the coil.

c. Replace and resolder the coil.

d. Replace the reed.

8-13. TROUBLESHOOTING.

8-14. The first and most important prerequisite for successful troubleshooting is an understanding of how the instrument is designed to operate and correct usage of front panel controls. Often times, suspected malfunctions are simply caused by improper control settings or circuit hook-ups such as: low intensity, maladjusted horizontal trigger level or mode, mode selector in wrong position, etc. Section III (Operation), including explanation of controls and connectors and general operating consideration, and Section IV (Principles of Operation) which explains circuit theory, are intended to satisfy this information requirement.

8-15. The following paragraphs outline procedures for locating and clearing problems in the Model 1410A. DC Voltages are indicated on the schematics for most active components (transistors, FET's, etc). Typical waveform test points (▽with a number enclosed) are also placed on the schematics at various points along main signal paths. The numbers inside the test point symbols are keyed to a corresponding waveform adjacent to the schematic. These voltages and waveforms provide an invaluable aid when troubleshooting the instrument. Applications include: checking gain of a particular stage, locating a differential amplifier unbalance, or pin pointing a faulty transistor, etc.

When using these voltages and/or waveforms for troubleshooting, always refer to the specific conditions outlined for the measurements, also listed adjacent to the schematics.

8-16. If trouble is suspected, first perform a visual inspection of the instrument. Look for loose or burned components that might suggest a source of trouble. If no obvious trouble is found, check the power supply voltages in the oscilloscope main chassis. Refer to the oscilloscope manual for specific voltages and tolerances. Also check the ±82.5 volt and +12.6 volt supplies in the Model 1410A. If all voltages are correct, then refer to the following paragraphs for your indicated trouble.

8-17. PROBE TROUBLE. Poor rise time, excessive noise, signal breakup, distortion or trace shifting (in one channel) is usually caused by a faulty probe assembly. To locate the trouble, first ascertain that the alternate channel is operating properly by observing a known signal. If the presentation is valid, then replace the suspected probe board with the good probe board from the alternate channel. Observe a known signal on the faulty channel. If the problem is corrected, replace the appropriate probe board assembly. If the problem persists, check the probe cable for shorts, opens, etc. If the cable checks good, trouble is most likely in the ac amplifier or stretcher circuitry for that channel.

8-18. The diodes on the probe assembly are separately replaceable. This is a delicate operation, but can be accomplished with a small, low voltage soldering iron and extreme caution. Be sure to use a heat sink when removing and replacing the diodes. If it is not desirable to replace the diode(s) in the field, the entire board assembly can be ordered.

8-19. If the trouble exists in both channels, check the sampling diode bias adjustments (Frequency Adj, and Bias Centering Adj), and the pulse generator circuits.

8-20. NO VERTICAL DISPLAY, EITHER CHANNEL. Trouble of this nature is most likely caused by some function that is common to both channels; such as the pulse generator, switching multivibrator or main vertical amplifier. First check to see that the positive sampling trigger from the horizontal plug-in is present at the base of Q110. This pulse initiates the entire vertical sampling process and if the time base has malfunctioned, the vertical system may also be inoperative. If this pulse is present, proceed to check the pulse generator, etc., using the typical waveforms and dc voltages.

8-21. NO DISPLAY, ONE CHANNEL. First determine that the probe assembly is good (see Paragraph 8-17). Next apply a square wave from a pulse generator, as outlined in the Conditions for Typical Waveforms, to the defective channel and monitor signal thru each successive stage until the malfunction is found. Also check the switching multivibrator and switching diodes.

8-22. LOW AMPLIFIER GAIN. Whenever over-all amplifier gain is too low to be properly adjusted with the CAL ADJ or VERT CAL controls, the typical waveforms can be used to trace the problem. By checking the relative gain of each stage, the faulty stage can usually be found. Also check for a faulty attenuator switch.

8-23. TRACE OFF SCREEN. Change mode switch and connect input signal to the opposite channel. If the problem still exists, then the trouble is most likely an unbalanced condition in the main vertical amplifier. The stage that is unbalanced can be identified by shorting together like elements in both halves of a stage (emitter-to-emitter, etc.). The stage that causes the trace to return on-screen, when common elements are shorted, is the one with the faulty component. DC voltages and/or resistance readings can be used now to positively identify the faulty part.

8-24. MODE SWITCHING. If the proper mode of operation cannot be obtained, first check the switching diodes CR501 through CR508 and CR510 through CR512. If these diodes are good, then check the switching multivibrator Q513 and Q514 and associated circuitry. If the problem arises only in the A & B mode, check trigger amplifier Q515 and its input, the stretcher pulse from Q111.

8-25. TROUBLESHOOTING THE STRETCHER LOOP. Problems such as low gain, distortion, etc., will usually be caused by either the sampler assembly or the stretcher circuitry. If the stretcher circuit is suspected, first check to see that the stretcher pulse at Q125 (Q325 for channel B) collector is present. Pulse should be approximately 0.3 μsec wide.

8-26. Obtaining meaningful waveforms in the stretcher circuitry is extremely difficult. To effectively troubleshoot the stretcher, set up the dc voltage conditions as outlined in Figure 8-8 and check voltages as indicated on the schematic. Voltages are not listed on the channel B schematics, however, conditions and voltages are the same as shown for channel A. DC voltages may vary slightly from one instrument to another and variations of up to 15% are permissible. All voltages are referenced to ground.

Table 8-1. Symbols.

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)
G D S	=	Field Effect Transistor (N channel)
	=	Avalanche (zener) diode
	=	Tunnel diode
	=	Step recovery diode
P/O	=	Part of
*	=	Optimum value selected at factory, average value shown; part may have been omitted.
N.C.	=	No connection

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

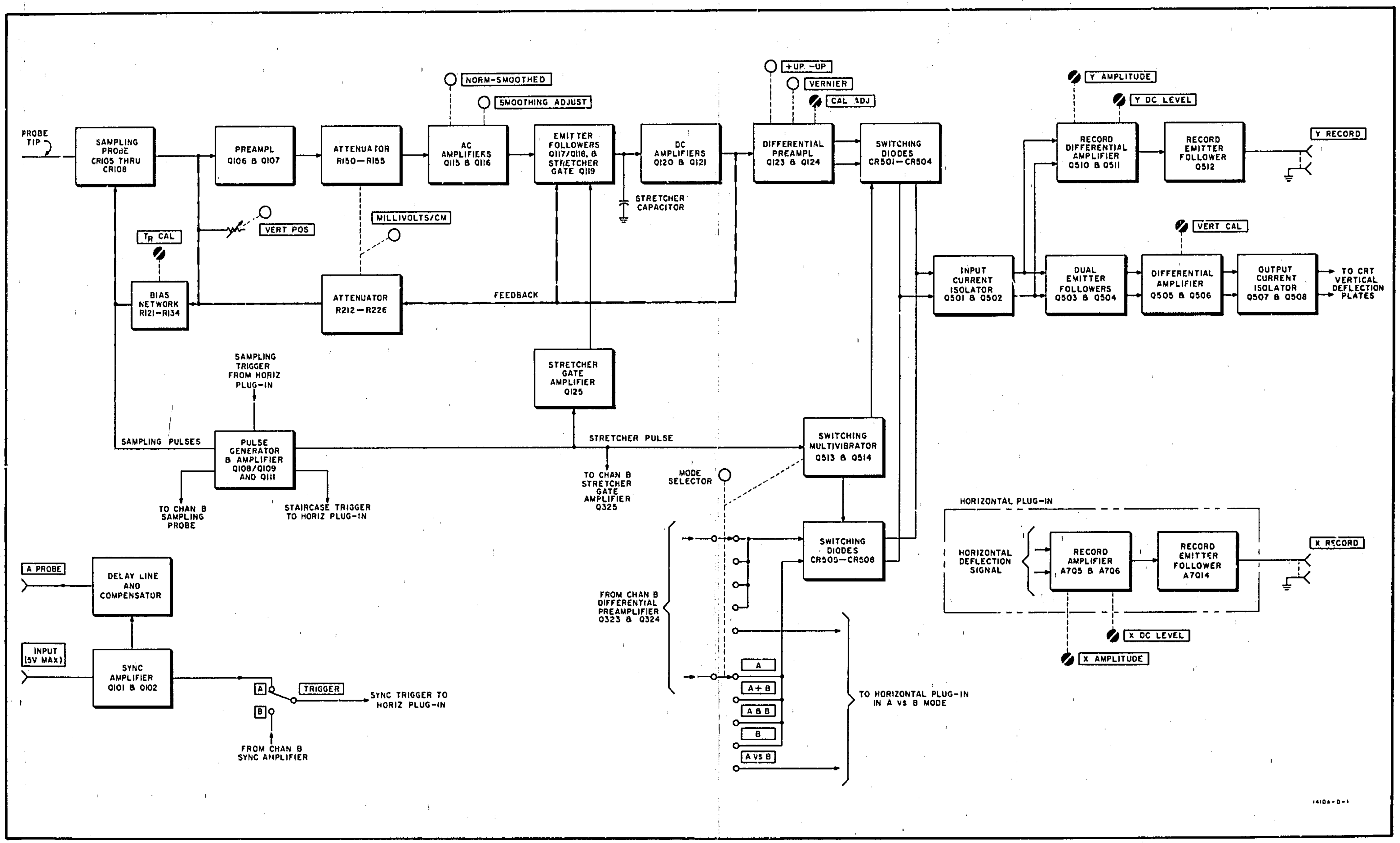


Figure 8-1. Detailed Block Diagram

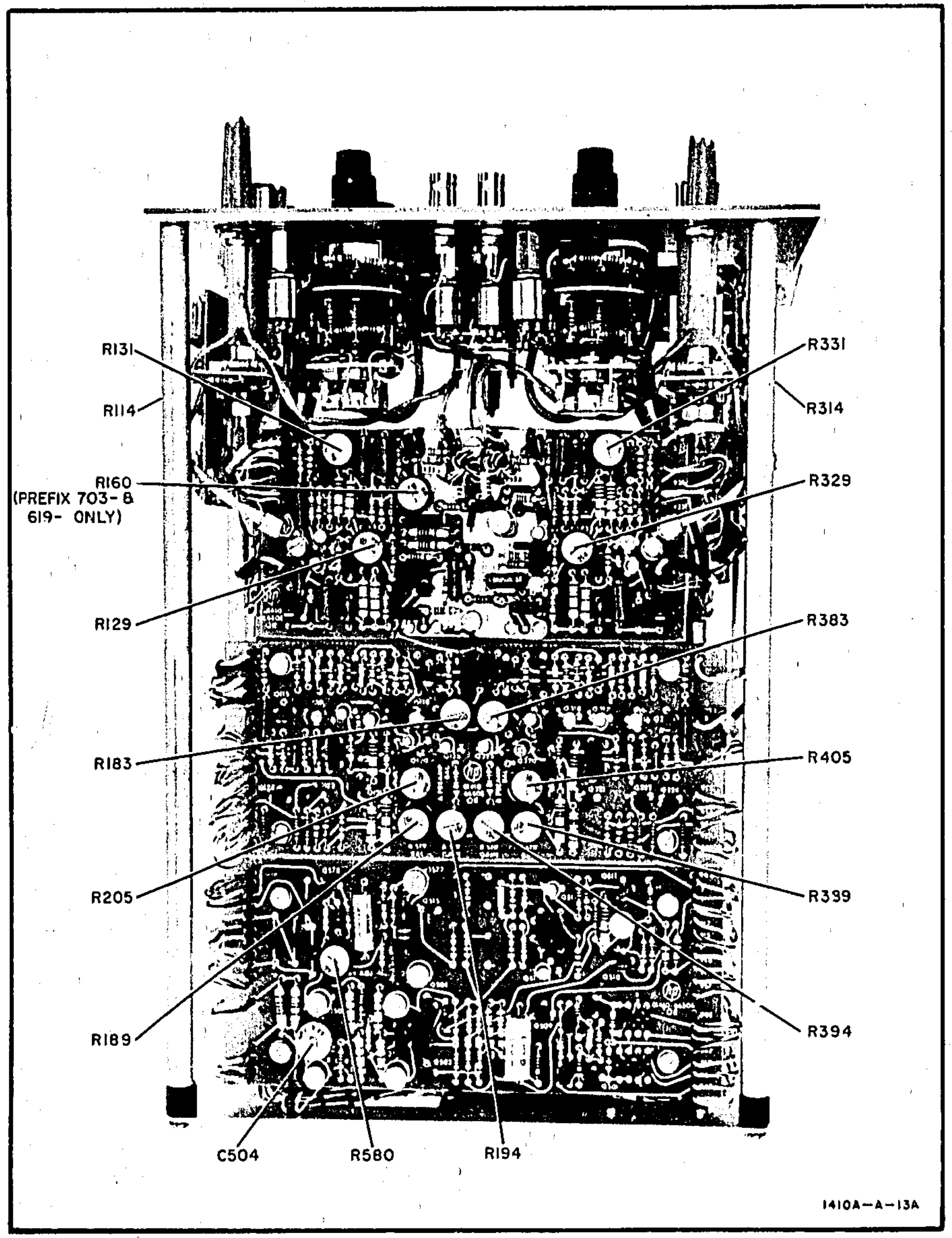


Figure 8-2. Adjustment Locations

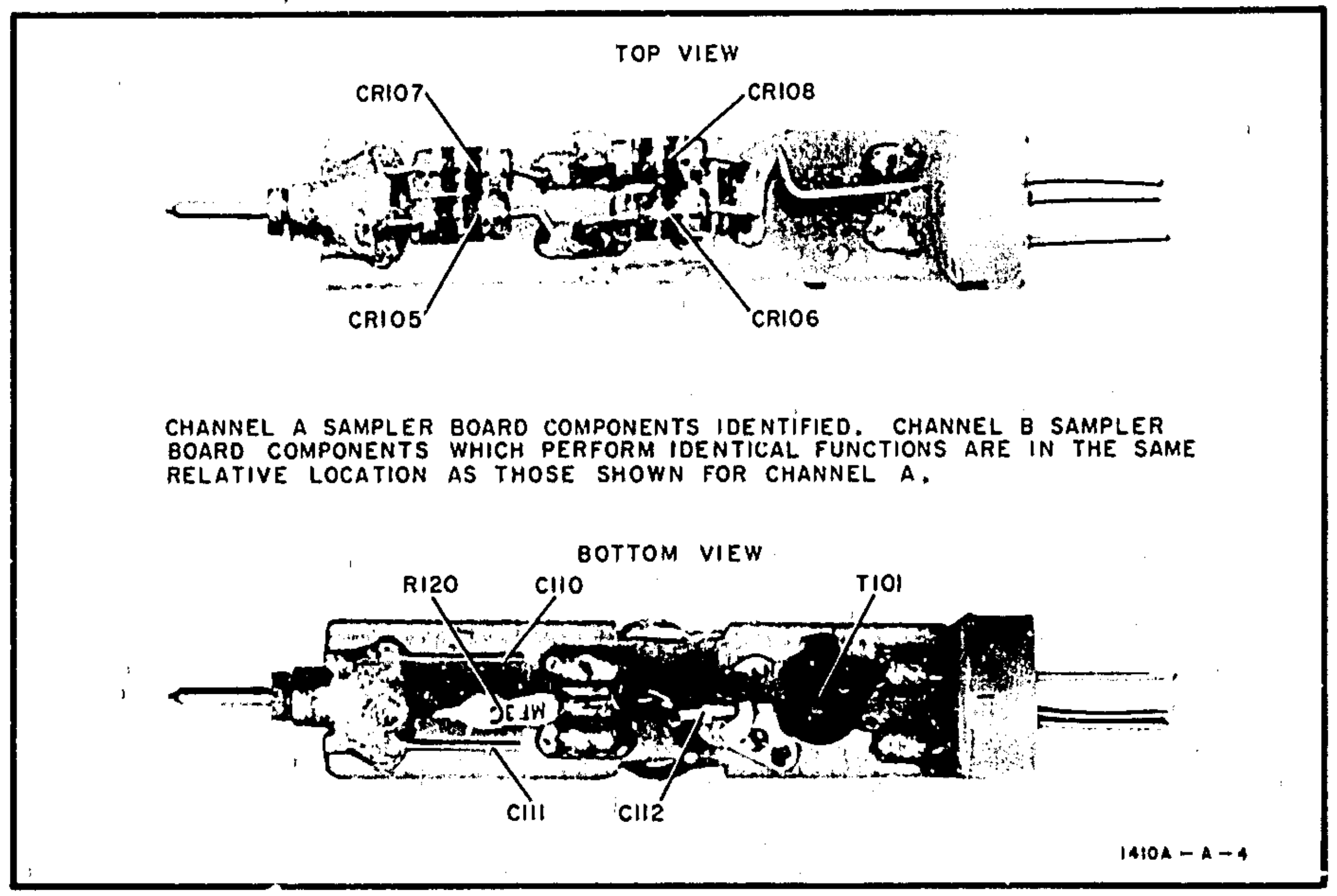
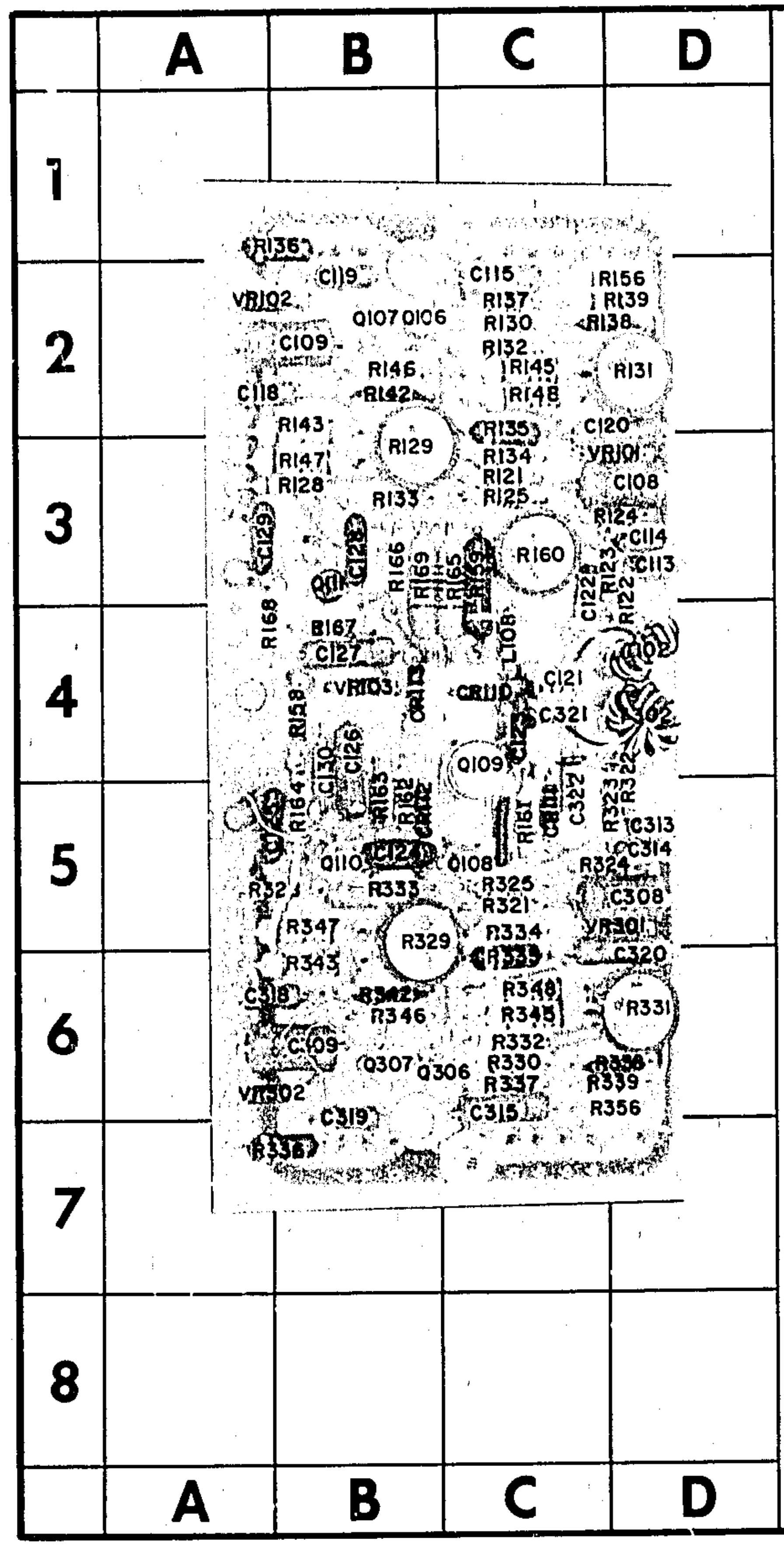


Figure 8-3. Component Identification, Sampler Assemblies (A103 and A303)



REF DESIG	GRID LOC	REF DESIG	GRID LOC
C106	D-3	R136	A-1
C109	B-2	R137	C-2
C113	D-3	R138	C-2
C114	D-3	R139	D-2
C115	C-2	R142	B-2
C118	A-2	R143	B-2
C119	B-2	R145	C-2
C120	C-2	R146	B-2
C121	C-4	R147	B-3
C122	C-4	R148	C-2
C123	C-4	R156	D-2
C124	B-5	R158	B-4
C125	A-5	R159	C-3
C126	B-4	R160	C-3
C127	B-4	R161	C-5
C128	B-3	R162	B-5
C129	A-3	R163	B-5
C130	B-4	R164	B-5
C308	D-5	R165	C-3
C309	B-6	R166	B-3
C313	D-5	R167	B-4
C314	D-5	R168	A-4
C315	C-6	R169	B-3
C318	A-6	R321	C-5
C319	B-6	R322	C-5
C320	D-6	R323	C-5
C321	C-4	R324	C-5
C322	C-5	R325	C-5
CR110	C-4	R328	A-5
CR111	C-5	R329	B-5
CR112	B-5	R330	C-6
CR113	B-4	R331	D-6
L108	C-4	R332	C-6
Q106	B-2	R333	B-5
Q107	B-2	R334	C-5
Q108	C-5	R335	C-6
Q109	C-4	R336	A-7
Q110	B-5	R337	C-6
Q111	B-3	R338	D-6
Q306	B-6	R339	D-6
Q307	B-6	R342	C-6
R121	C-3	R343	B-6
R122	D-4	R345	C-6
R123	C-3	R346	B-6
R124	D-3	R347	B-5
R125	C-3	R348	C-6
R128	B-3	R356	D-6
R129	B-3	T102	D-4
R130	C-2	T302	D-4
R131	D-2	VR101	D-3
R132	C-2	VR102	A-2
R133	B-3	VR103	B-4
R134	C-3	VR301	D-5
R135	C-2	VR302	A-6

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Figure 8-4. Component Identification, Preamplifier and Pulse Generator (A104)

DC VOLTAGE MEASUREMENT CONDITIONS

a. Set Model 1410A controls as follows:

MILLIVOLTS/CM (both channels). . . 200
TRIGGER. . . . . A
NORM-SMOOTHED (both channels) . NORM
Polarity. . . . . . . (both channels) . . +UP
VERT POS . . . . (both channels) midrange
VERNIER. . . . . (both channels). . . CAL
SMOOTHING ADJ . . . . midrange

b. Connect junction of R139 and R156 to ground.

c. Locate R180 on both the schematic and circuit board (refer to Figures 8-7 and 8-8). Unsolder the end of R180 that is common to R197 (20k), R195 (1k) and the MILLIVOLTS/CM switch (end of R180 closest to rear of instrument). Connect this loose end of the resistor to ground. This connects the bases of Q117 and Q118 to ground through 2k ohms.

d. Connect the gate of Q120 (see Figures 8-7 and 8-8) to ground.

e. DC voltages will vary slightly from one instrument to another. Normal variations of up to 15% are permissible. All voltages are referenced to ground.

CONDITIONS FOR TEST POINT WAVEFORMS

a. Set Model 1410A controls as follows:

MILLIVOLTS/CM . (both channels) . . . 20
VERNIER. . . . . . (both channels) . . CAL
Mode . . . . A
NORM-SMOOTHED (both channels) . NORM
Polarity . . . . +UP
TRIGGER. A
SMOOTHING ADJUST . . . . . . optimized

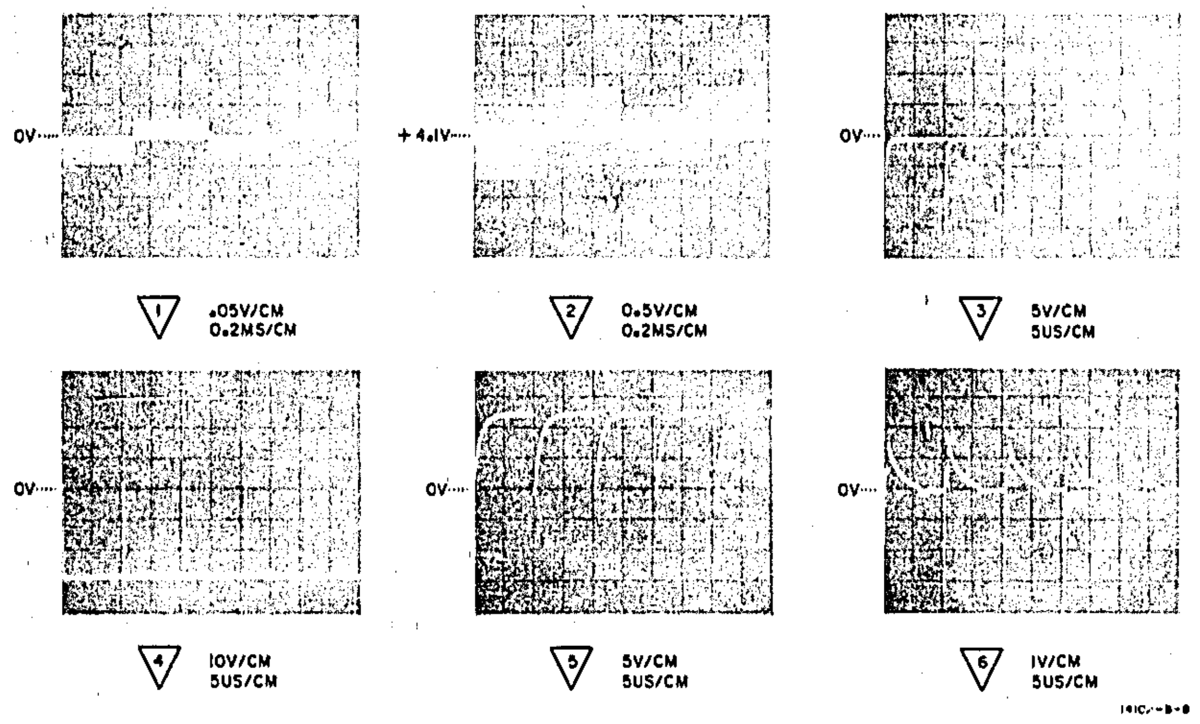
b. Set sampling time base controls as follows:

MAIN TIME/CM. . . . . 100 nSEC/CM
Trigger Level . . . . max clockwise
Trigger Mode . . . . max clockwise
TRIGGER HOLD-OFF . . . . . . NORMAL
Trigger Source . . . . EXT
Trigger SLOPE. . . . . -
SCANNING . . . . NORMAL

c. Using a variable pulse generator such as the hp Model 222A, apply a positive 0.2 volt pk-pk square wave to A INPUT. Set frequency for 1 kHz. Use the trigger output of the pulse generator to externally sync the time base. Insert channel A probe into its holder.

d. Waveforms were photographed using an hp Model 180A Oscilloscope, Model 1801A Dual Channel Vertical Amplifier, Model 1821A Time Base and Delay Generator and a Model 197A Oscilloscope Camera.

e. The relative gain of stages may vary slightly from that shown in waveforms, depending on the exact setting of SMOOTHING ADJUST.



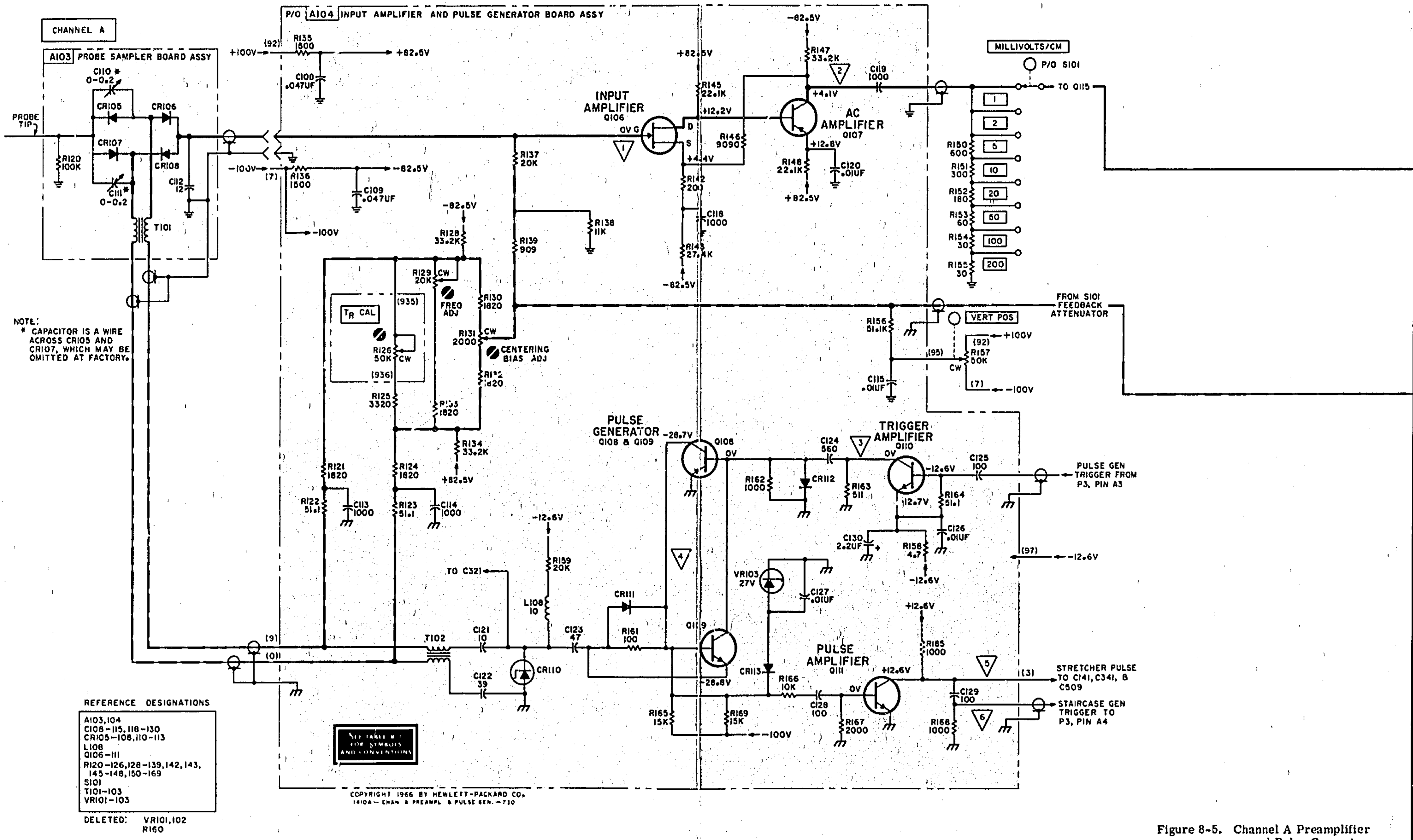


Figure 8-5. Channel A Preamplifier and Pulse Generator

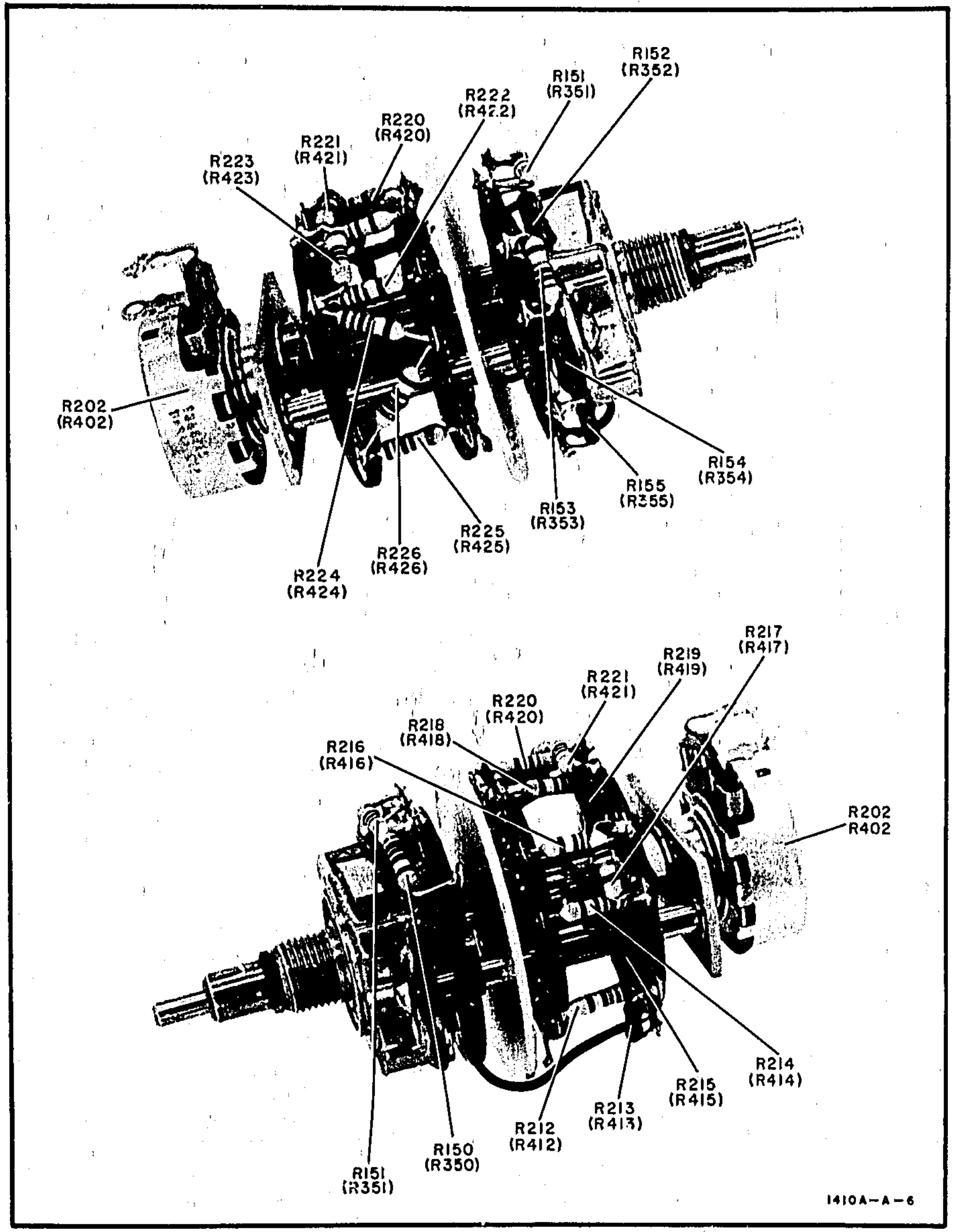
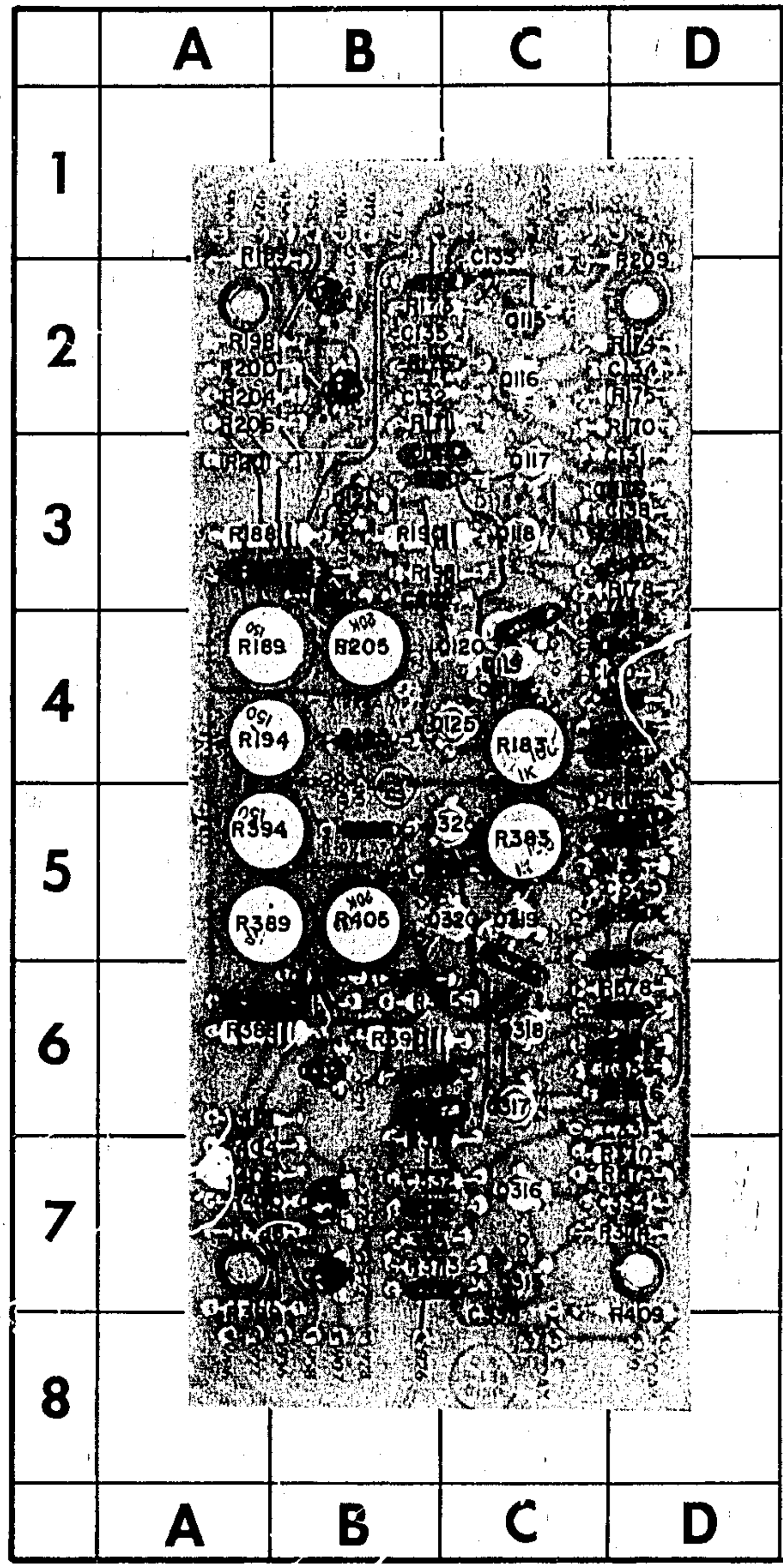


Figure 8-6. Attenuator Switch (A503 and A504)



REF DESIG	GRID LOC	REF DESIG	GRID LOC
C131	D-3	R179	D-4
C132	D-2	R180	B-3
C133	C-1	R181	D-3
C134	D-2	R182	D-3
C135	B-2	R183	C-4
C137	B-3	R184	D-4
C138	D-3	R185	D-5
C139	C-4	R186	D-4
C140	D-4	R188	A-3
C141	D-4	R189	A-4
C331	D-6	R190	B-3
C332	B-7	R193	B-4
C333	C-8	R194	A-4
C334	D-7	R195	B-3
C335	B-7	R197	A-3
C337	B-6	R198	A-2
C338	D-6	R199	A-1
C339	C-6	R200	A-2
C340	D-5	R201	A-3
C341	D-5	R204	A-2
CR116	D-3	R205	B-4
CR117	D-4	R206	A-2
CR118	C-4	R209	D-1
CR119	B-3	R370	D-7
CR316	D-6	R371	B-7
CR317	D-5	R372	B-7
CR318	D-5	R373	B-7
CR319	B-6	R374	D-7
Q115	C-2	R375	D-7
Q116	C-2	R376	B-7
Q117	C-3	R378	D-6
Q118	C-3	R379	D-6
Q119	C-4	R380	B-6
Q120	C-4	R381	D-6
Q121	B-3	R382	D-6
Q123	B-2	R383	C-5
Q124	B-2	R384	D-5
Q125	C-4	R386	D-5
Q315	C-7	R388	A-6
Q316	C-7	R389	A-5
Q317	C-6	R390	B-6
Q318	C-6	R393	B-5
Q319	C-5	R394	A-5
Q320	C-5	R395	B-6
Q321	B-6	R397	A-6
Q323	B-7	R398	A-7
Q324	B-7	R399	A-8
Q325	C-5	R400	A-7
R170	D-2	R401	A-6
R171	B-2	R404	A-7
R172	B-2	R405	B-5
R173	B-2	R406	A-7
R174	D-2	R409	D-8
R175	D-2	VR105	B-3
R176	B-2	VR305	B-6
R178	D-3		

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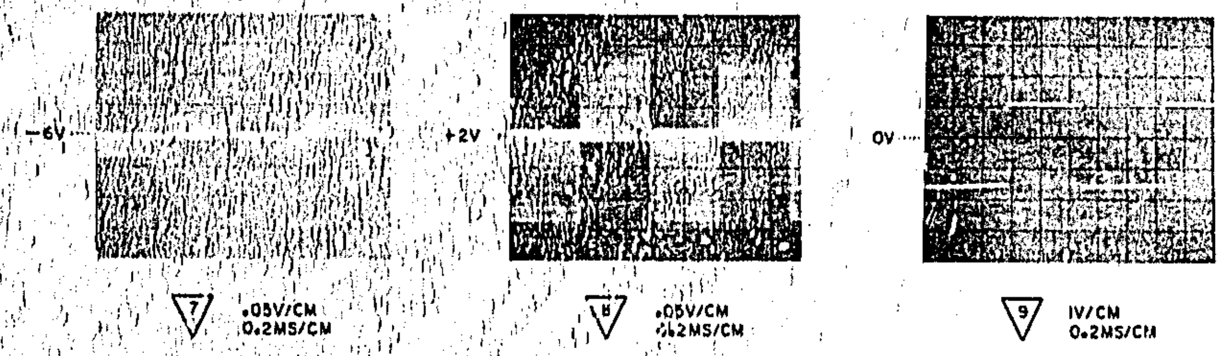
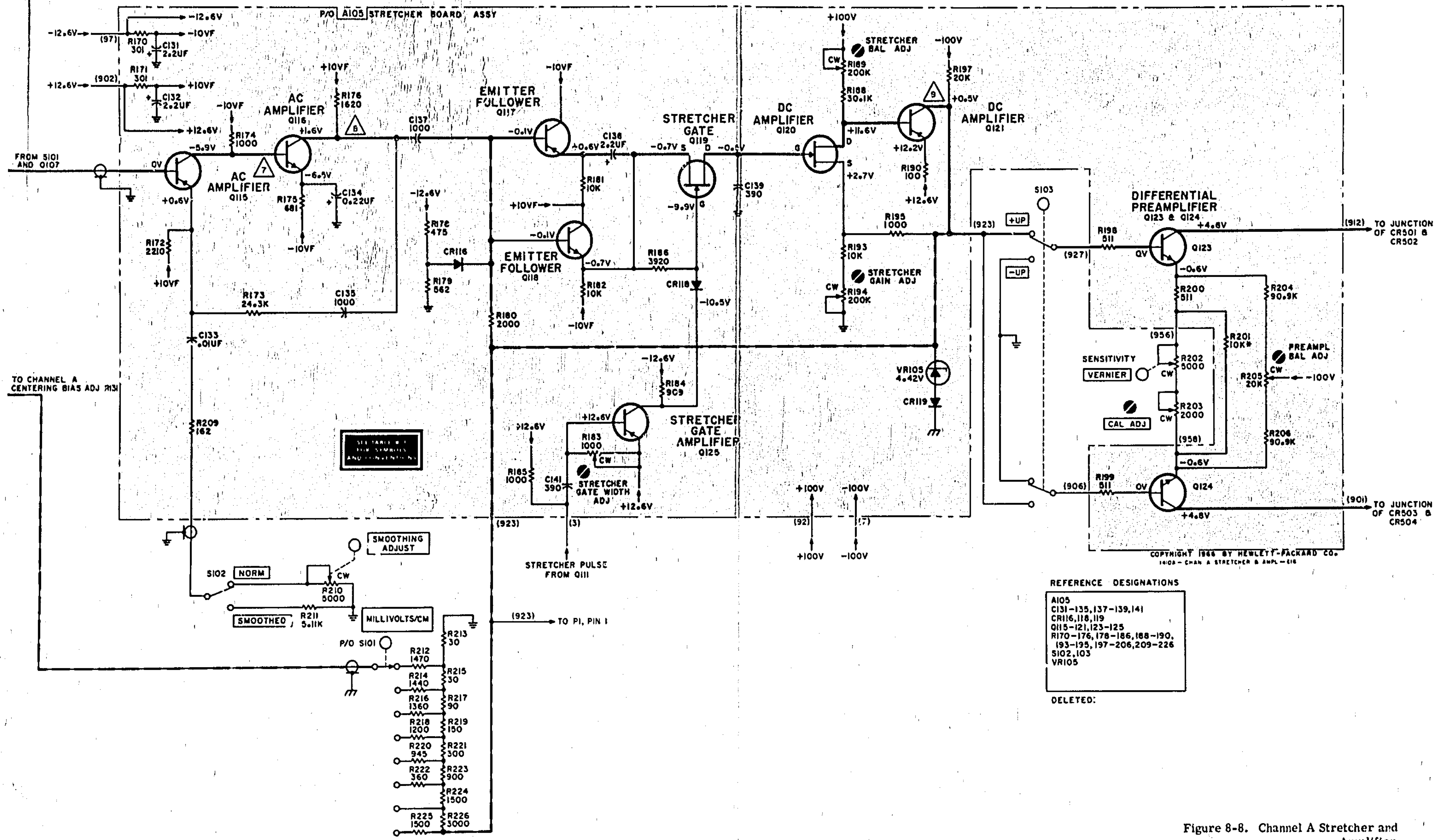
Figure 8-7. Component Identification, Stretcher and Amplifier (A105)

Conditions for voltage and waveform measurements are listed adjacent to Figure 8-5.





REFERENCE DESIGNATIONS

A105
C131-135,137-139,141
CR116,118,119
Q115-121,123-125
R170-176,178-186,188-190, 193-195,197-206,209-226
S102,103
VR105

DELETED:

Figure 8-8. Channel A Stretcher and Amplifier

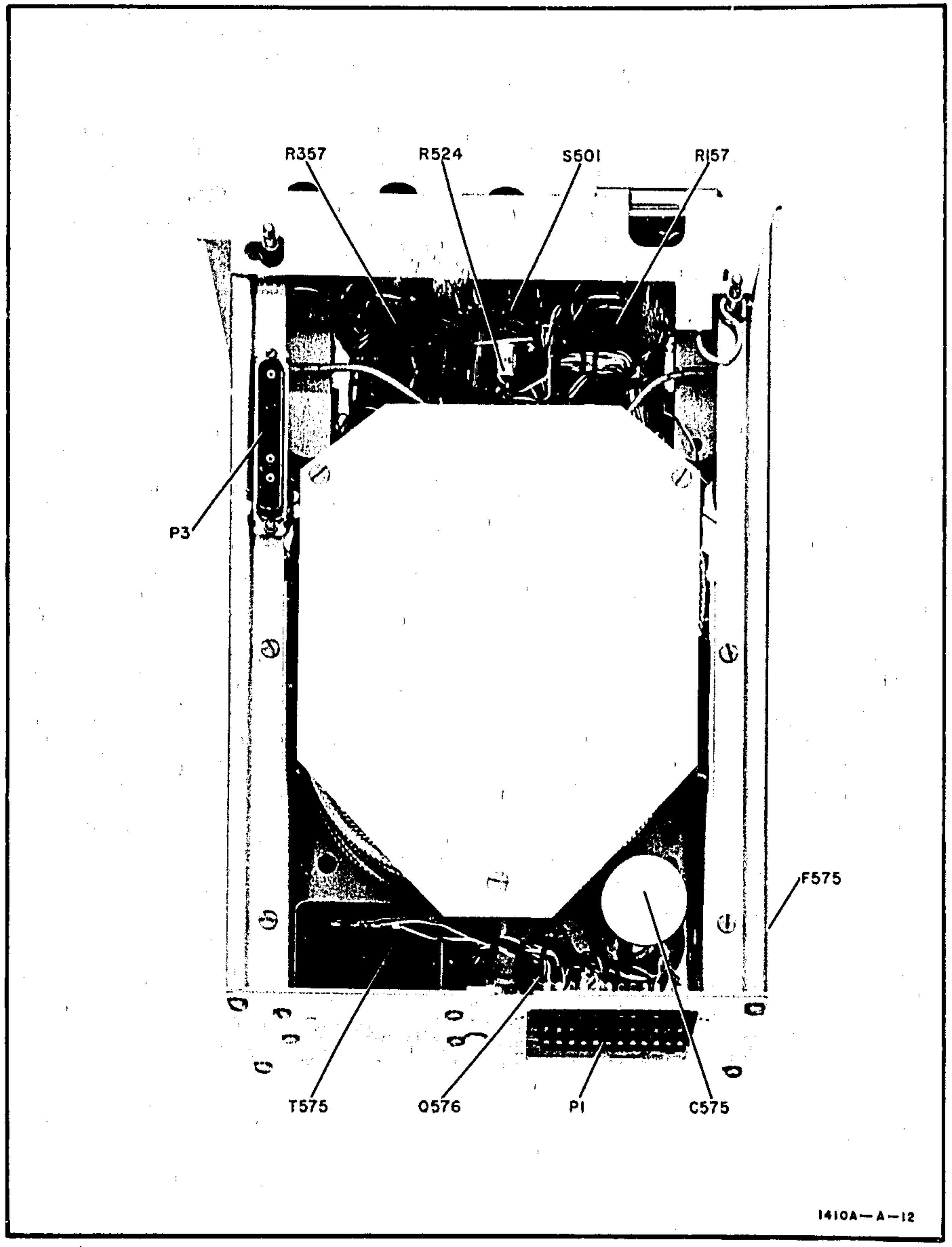


Figure 8-9. Chassis Component Identification (top view)

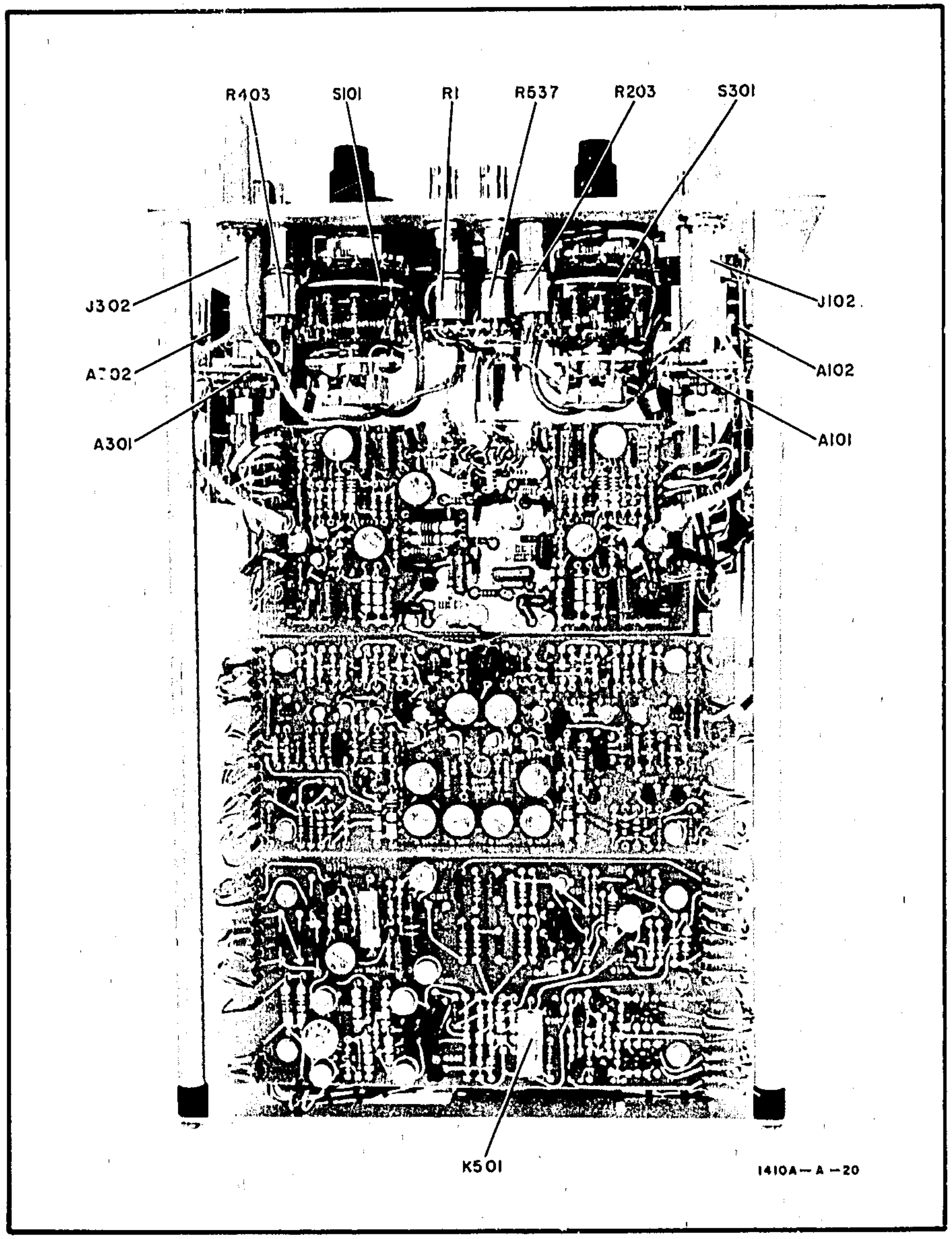


Figure 8-10. Chassis Component Identification (bottom view)

Refer to Channel A Preamplifier schematic (Figure 8-5) for dc voltages, waveforms, and conditions for measurements.

Channel B Preamplifier components are identified in Figure 8-4.

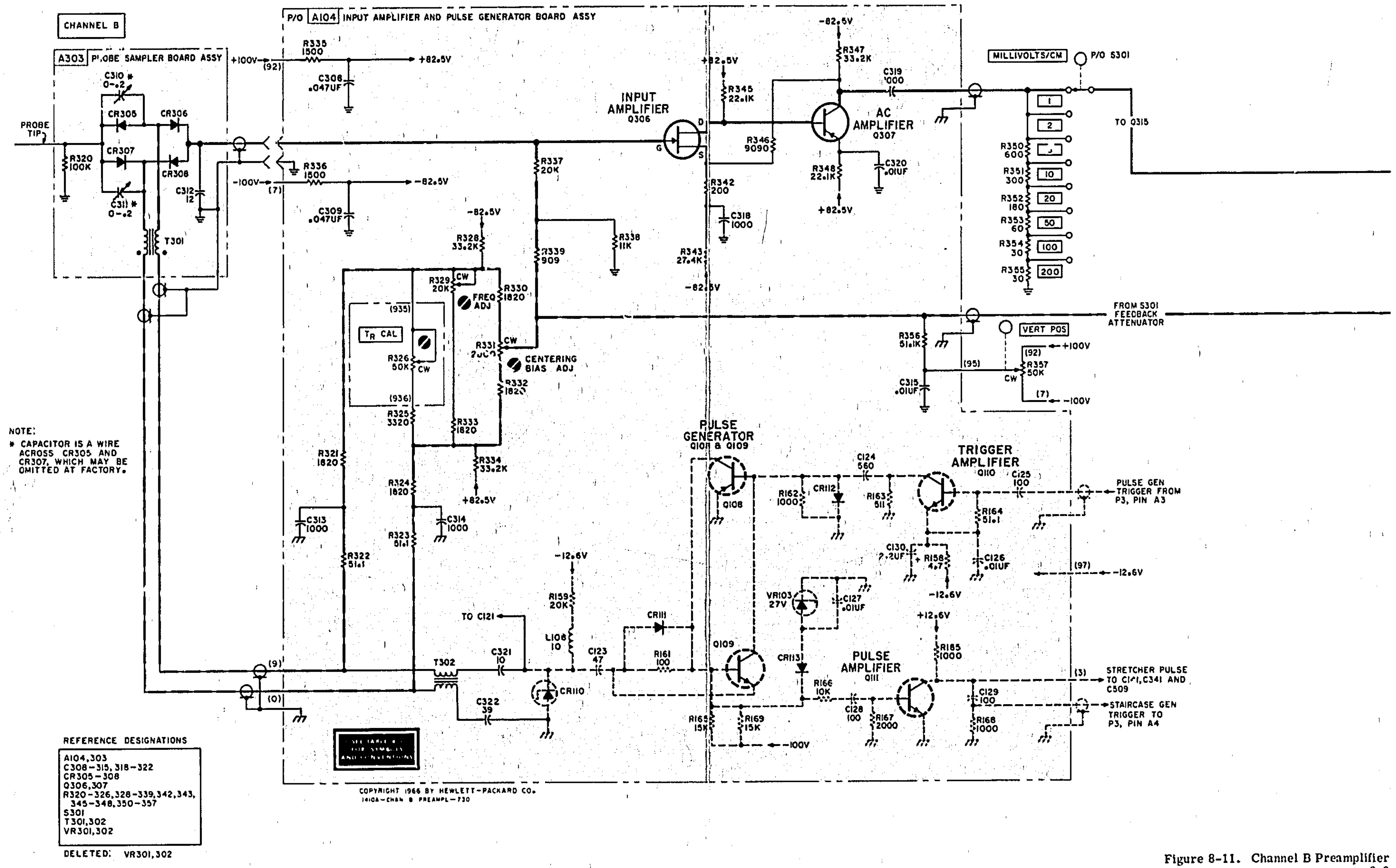


Figure 8-11. Channel B Preamplifier

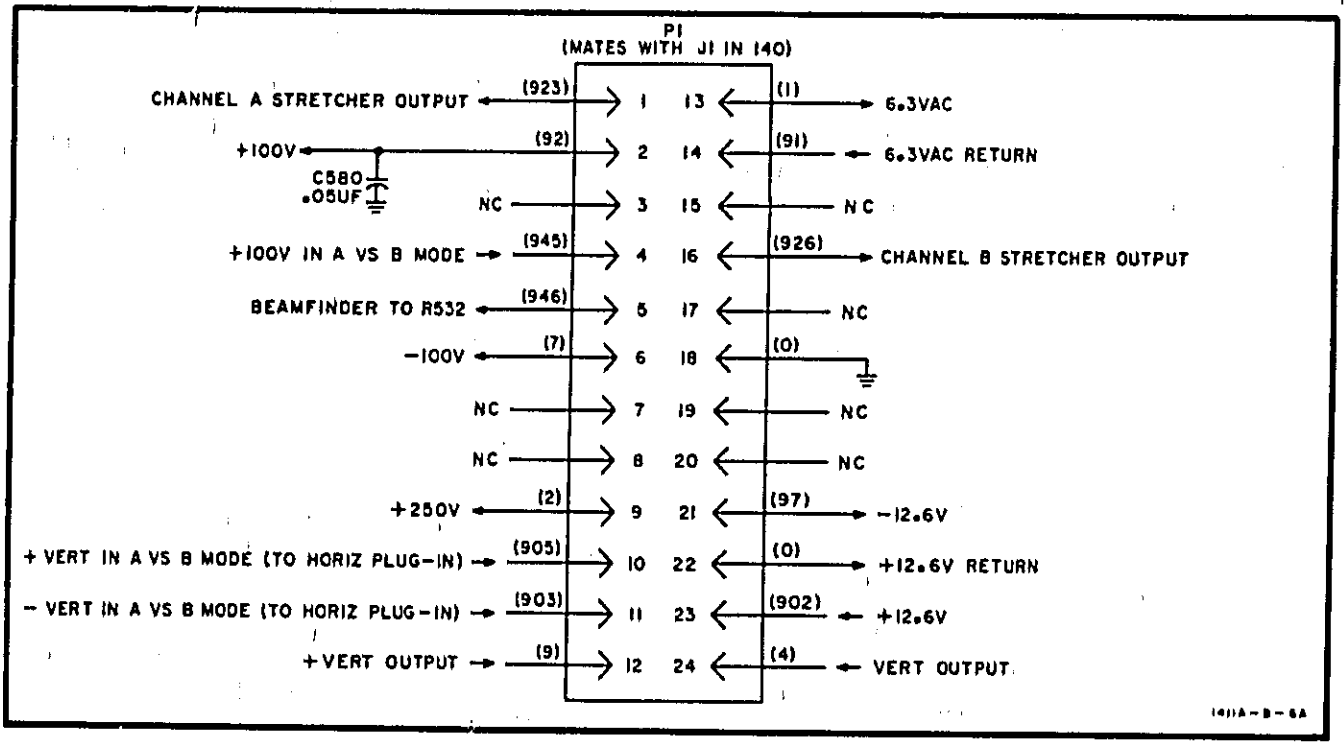


Figure 8-12. Rear Panel Connector

Refer to Channel A Stretcher schematic (Figure 8-8) for dc voltages and waveforms.

Conditions for measurements are given adjacent to Figure 8-5.

Channel B Stretcher and Amplifier components are identified in Figure 8-7.

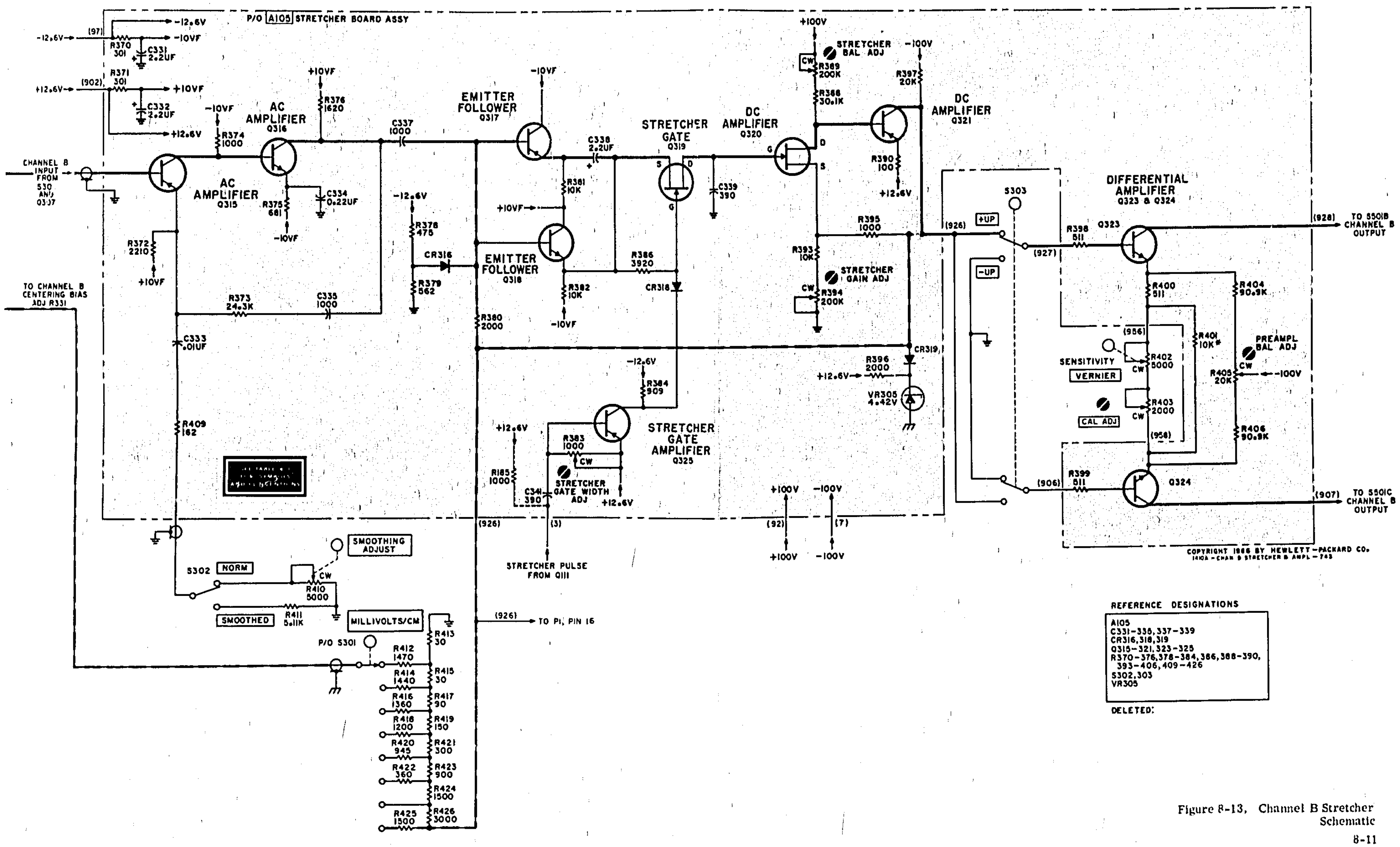
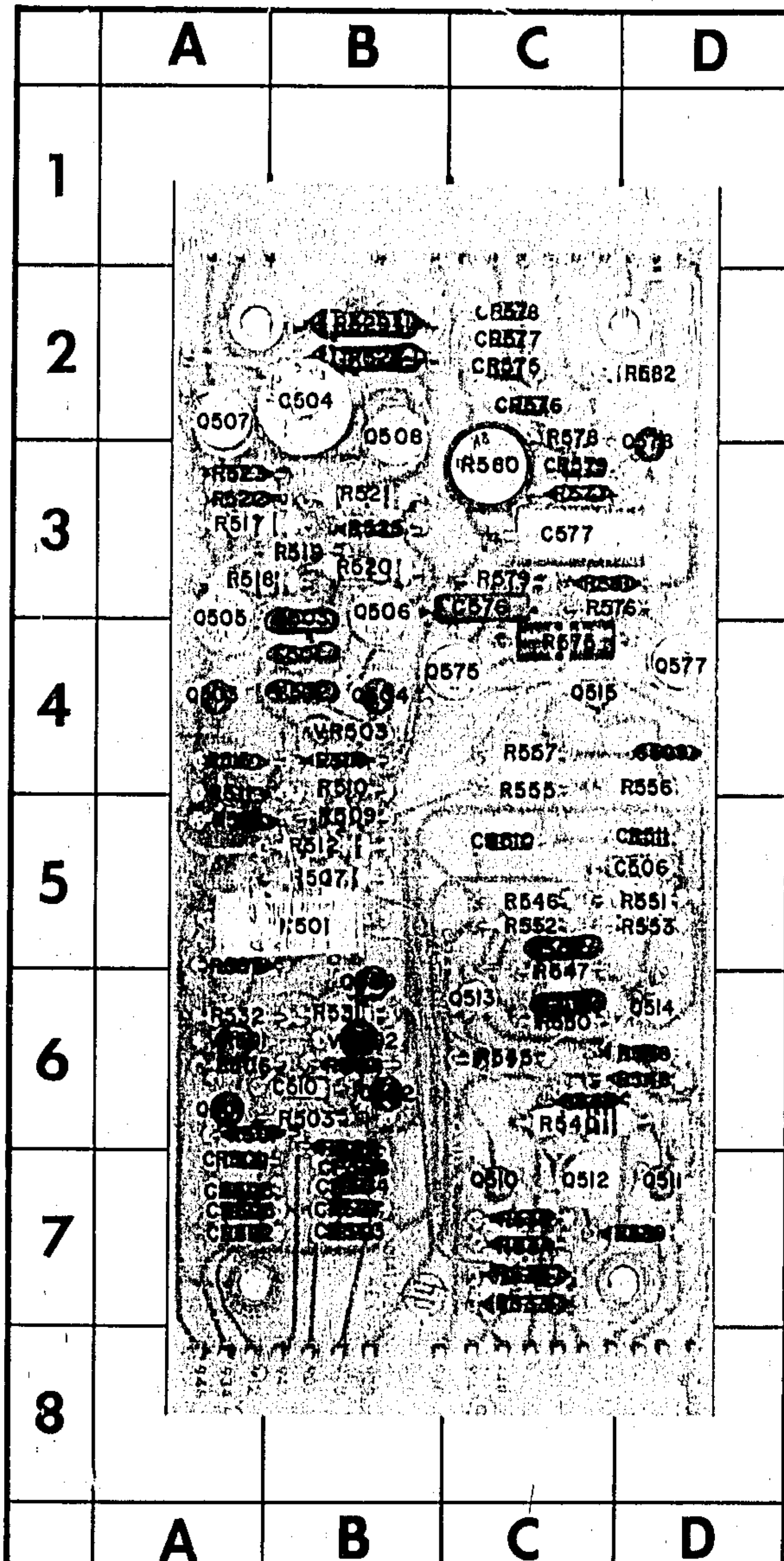


Figure 8-13, Channel B Stretcher Schematic



REF DESIG	GRID LOC	REF DESIG	GRID LOC
C501	B-4	R507	B-5
C502	B-4	R508	A-5
C503	B-3	R509	B-5
C504	B-2	R510	B-4
C505	D-5	R511	A-4
C507	C-5	R512	B-5
C508	C-6	R513	A-4
C509	D-4	R514	B-4
C510	B-6	R517	A-3
C576	C-3	R518	A-3
C577	C-3	R519	B-3
CR501	A-7	R520	B-3
CR502	A-7	R521	B-3
CR503	B-7	R522	A-3
CR504	B-7	R523	A-3
CR505	A-7	R525	B-3
CR506	A-7	R528	B-2
CR507	B-7	R529	B-2
CR508	B-7	R531	B-6
CR510	C-5	R532	A-6
CR511	D-5	R533	C-7
CR575	C-2	R534	C-7
CR576	C-2	R536	C-7
CR577	C-2	R538	C-7
CR578	C-2	R539	D-7
CR579	C-3	R540	C-6
K501	B-5	R541	C-6
Q501	A-6	R545	C-6
Q502	B-6	R546	C-5
Q503	A-4	R547	C-5
Q504	B-4	R548	D-6
Q505	A-3	R549	D-6
Q506	B-3	R550	C-6
Q507	A-2	R551	D-5
Q508	B-2	R552	C-5
Q509	B-6	R553	D-5
Q510	C-7	R555	C-4
Q511	D-7	R556	D-4
Q512	C-7	R557	C-4
Q513	C-6	R575	C-4
Q514	D-6	R576	C-3
Q515	C-4	R577	C-3
Q575	B-4	R578	C-2
Q577	D-4	R579	C-3
Q578	D-2	R580	C-3
R501	A-6	R581	C-3
R502	B-6	R582	D-2
R503	B-6	VR501	A-6
R504	B-6	VR502	B-6
R505	A-5	VR503	B-4
R506	A-6		

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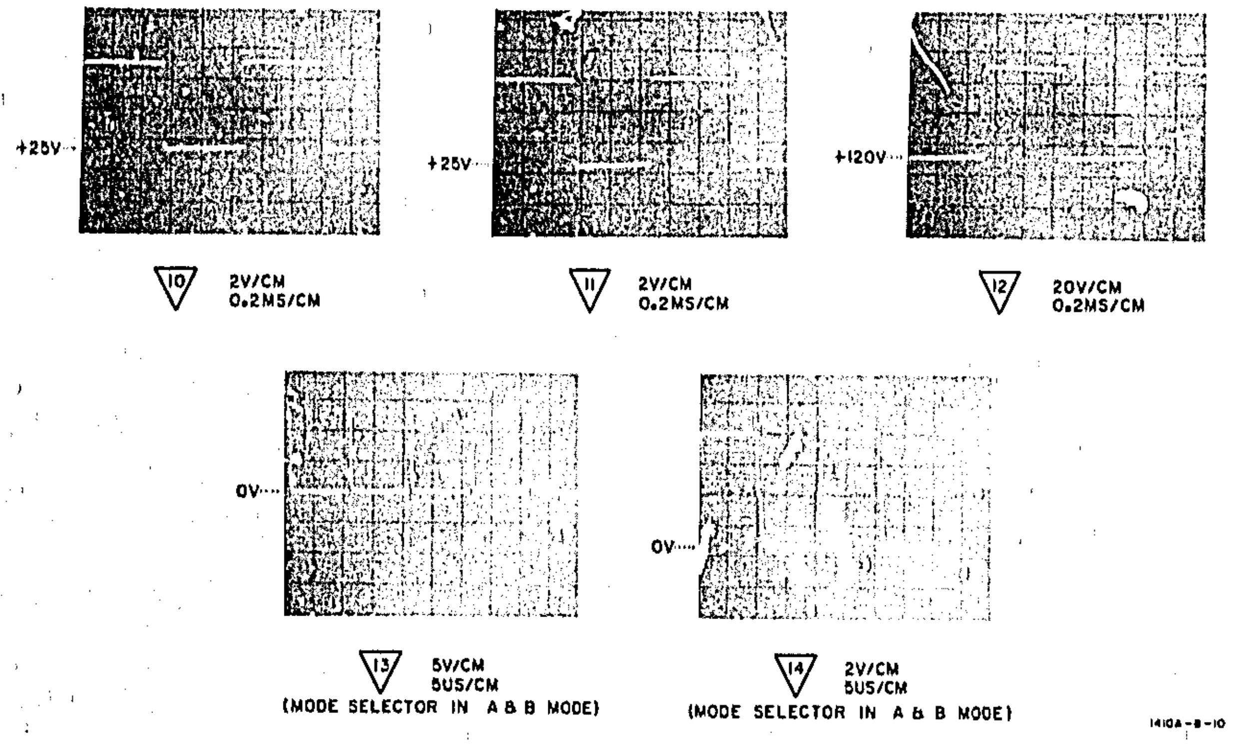
Figure 8-14. Component Identification, Main Vertical Amplifier (A501)

Refer to Figure 8-5 for conditions for dc voltage and waveform measurements.



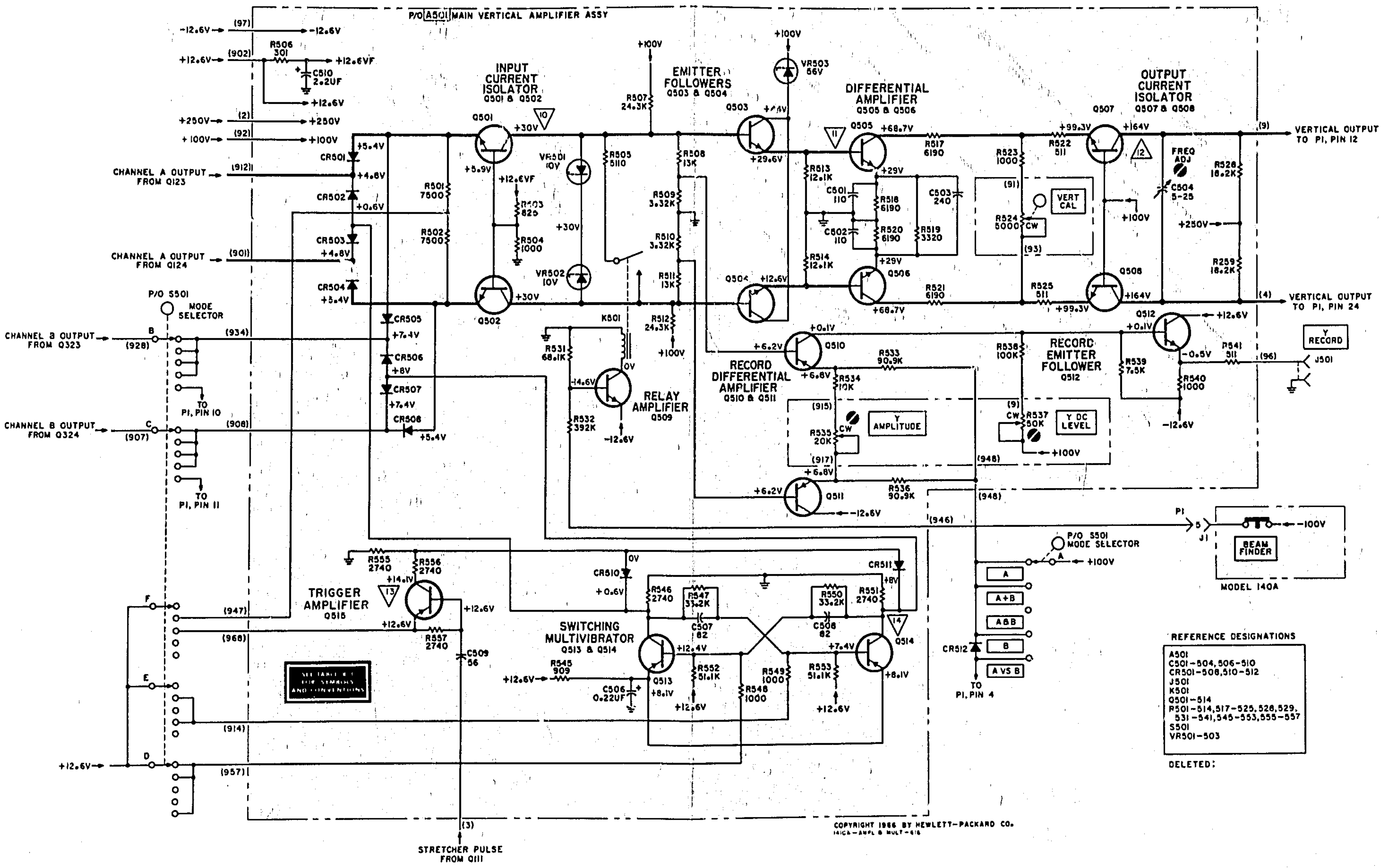


Figure 8-15. Main Vertical Amplifier

Refer to Figure 8-14 for component identification.

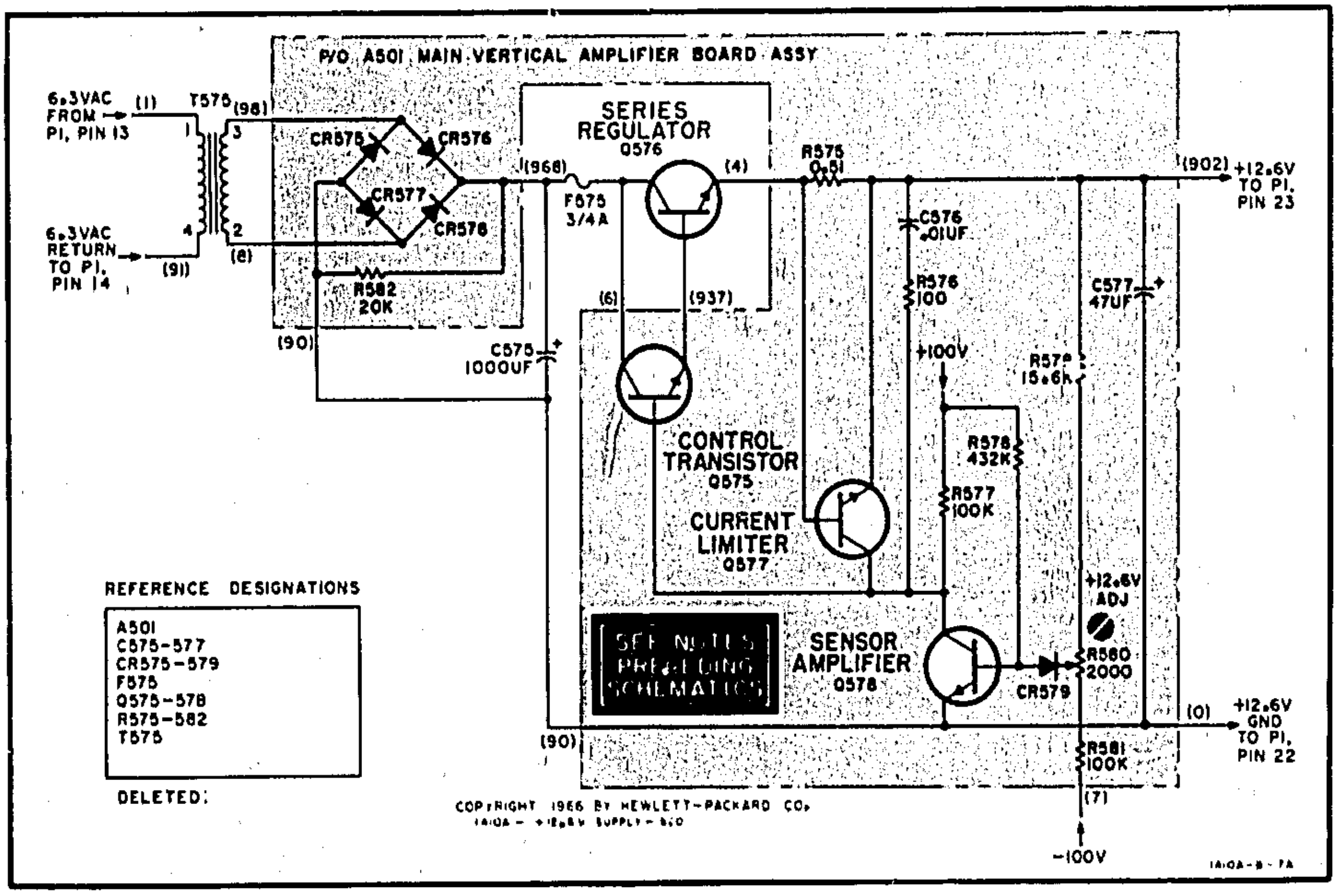
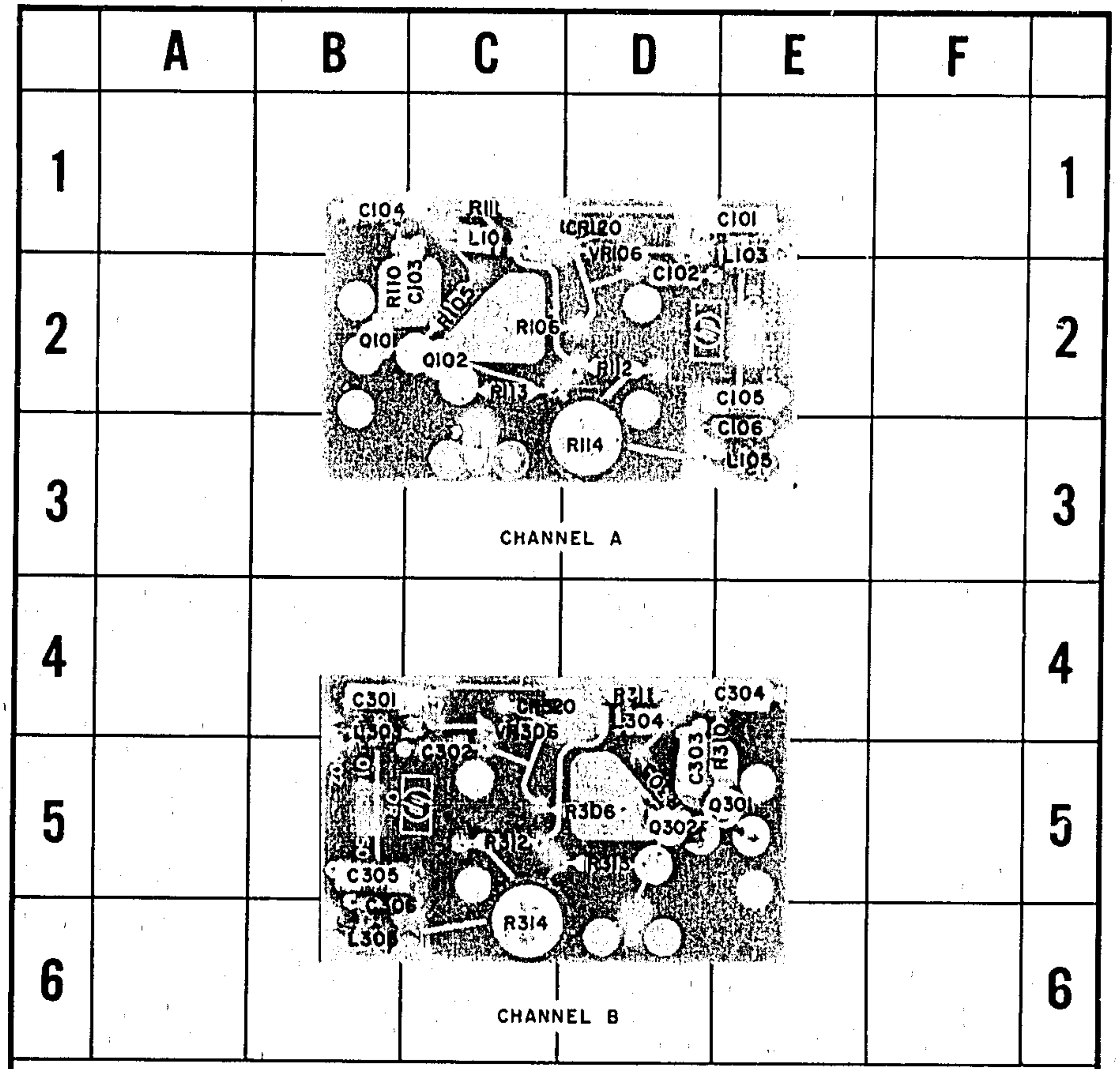


Figure 8-16. +12.6 V Power Supply.



CHANNEL A								CHANNEL B							
REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC
C101	E-1	C106	E-3	Q101	B-2	R111	C-1	C301	B-4	C306	B-6	Q301	F-5	R311	D-4
C102	D-2	CR120	D-1	Q102	C-2	R112	D-2	C302	C-5	CR320	C-4	Q302	D-5	R312	C-5
C103	C-2	L103	E-2	R105	C-2	R113	C-2	C303	D-5	L303	B-4	R305	D-5	R313	D-5
C104	B-1	L104	C-1	R106	C-2	R114	D-3	C304	F-4	L304	D-4	R306	D-5	R314	C-6
C105	E-2	L105	E-3	R110	B-2	VR106	D-2	C305	B-5	L305	B-6	R310	F-5	VR306	C-4

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Figure 8-17. Component Identification, Sync Take-off Assemblies (A102 and A302)

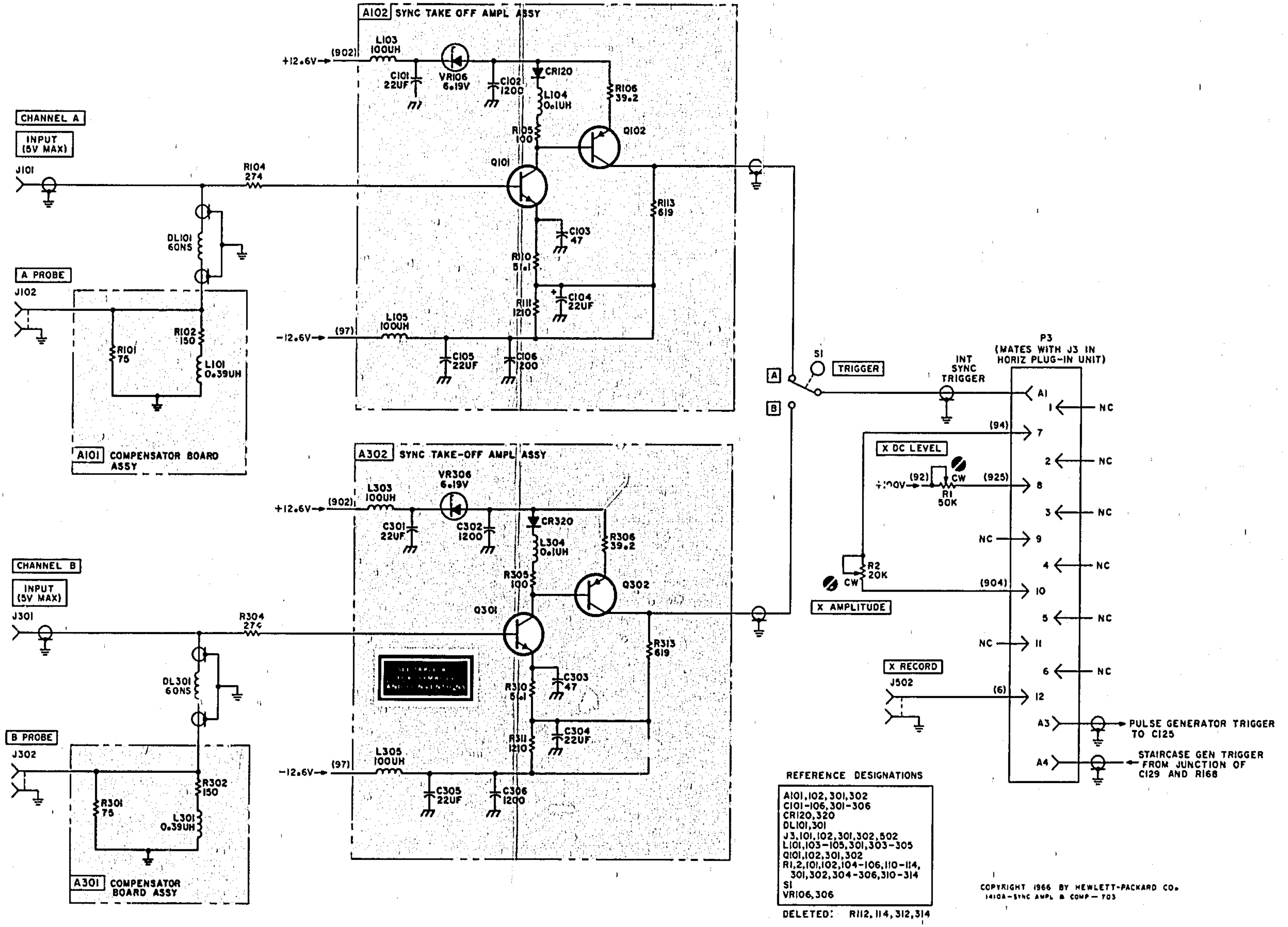

Figure 8-18. Sync Take-off

MANUAL CHANGES

MANUAL CHANGES

MODEL 1410A

SAMPLING VERTICAL AMPLIFIER

Manual Serials Prefixed: 743–
Manual Printed: MAY 1968

Make all changes listed below as Errata. Check the following table for your instrument serial prefix and/or serial number and make listed change(s) to the manual:

Serial Prefix or Number	Make Changes	Serial Prefix or Number	Make Changes
904–	1		
1210A	1,2		

ERRATA

Throughout this manual, measurements and adjustments are often made to derive indications of value per centimeter of display. When this unit is used with an oscilloscope where the divisions on the CRT are in other than centimeters, selections are per CRT division.
In certain places throughout this manual, a 10-centimeter vertical display is specified for some adjustments. When using this plug-in with oscilloscopes having CRT grid heights less than 10 divisions, select a reduced vertical sensitivity to derive the full display specified.

Table 6-2,
C123: Change to HP Part No. 0160-0182; 1; C: fxd mica 47 pf 5% 300 vdcw.
Add: L109: HP Part No. 9170-0016; 1; L: bead.

Table 7-1,
Change Serials Prefixed 619– to 616–.

Page 8-5, Figure 8-5,
Add L109 in series between C123 and the junction of L108 and CR110.

Page 8-15, Figure 8-18,
Delete connection from C104 to R113 (shorts R111 as drawn).
Delete connection from C304 to R313 (shorts R311 as drawn).

CHANGE 1

Table 6-2,
R202, R402: Change to HP Part No. 2100-2823; R: var 50k ohms 10cc log w/detent.
R203, R403: Change to HP Part No. 2100-2488; R: var comp 10k ohms ±20%.
Delete: R201, R401.
MISCELLANEOUS: Cable assy, main, HP Part No. 01410-61601; change to HP Part No. 01410-61616.

Figure 8-8 and 8-13,
Change schematic. See Figure 1.

Δ CHANGE 2

Table 6-2, Page 6-13,
MISCELLANEOUS: Probe housing assy, HP Part No. 00187-62101; Change to HP Part No. 00187-62102.
MISCELLANEOUS: Cable assy; probe, HP Part No. 01410-61612; Change to HP Part No. 01410-61617

13 June 1972
Δ = Latest additions to this change sheet.
This change sheet supersedes all prior change sheets for this manual.

Supplement A for
01410-90902

Instrument Serial Prefix	Make Manual Changes
904-	1
1210A	1,2

Instrument Serial Prefix	Make Manual Changes

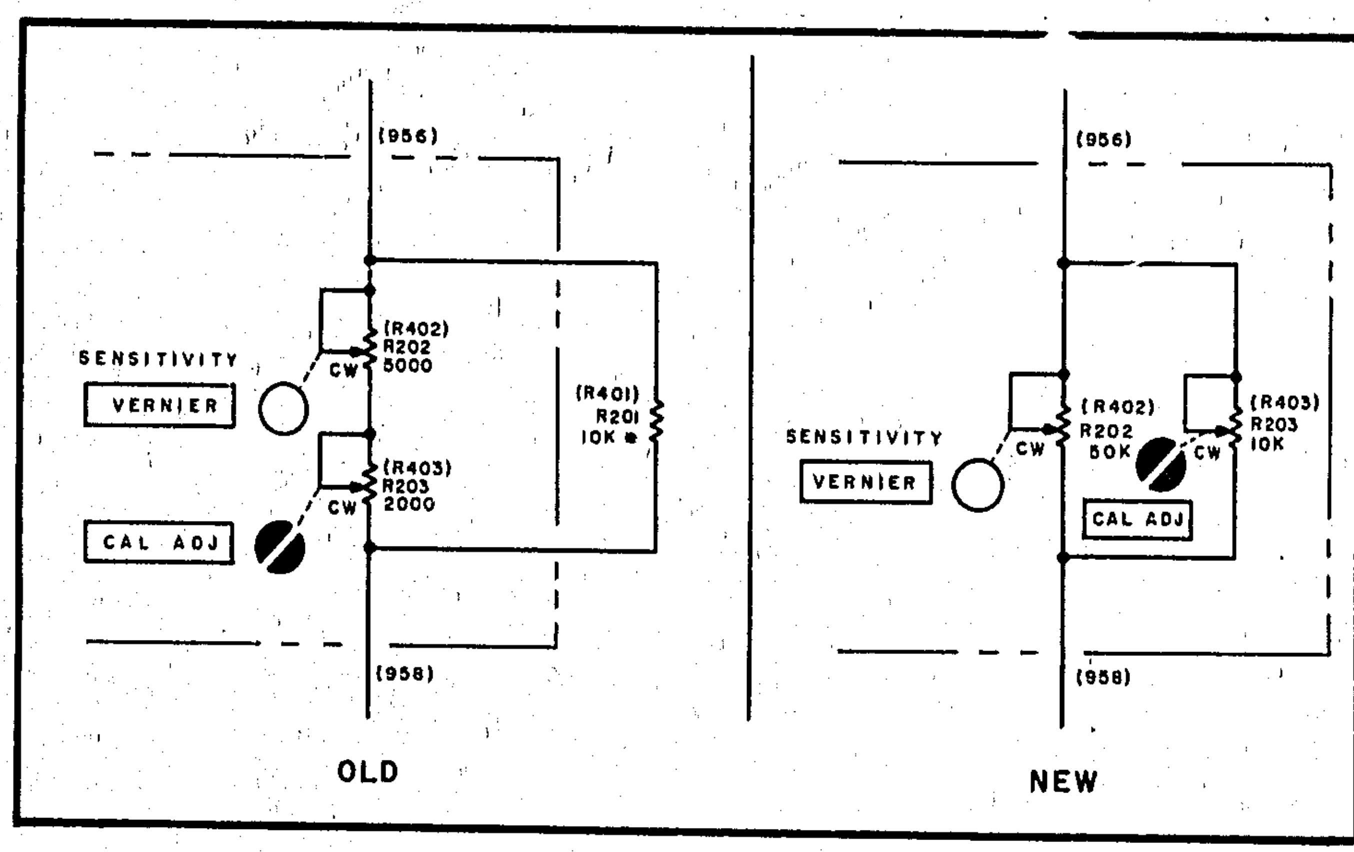

FIGURE I

13 June 1972