HEWLETT-PACKARD CO.

152B

DUAL TRACE AMPLIFIER

OPERATING AND SERVICING MANUAL

INSTRUCTION MANUAL CHANGES

MODEL 152B

DUAL TRACE AMPLIFIER

Serial 50 and above:

S503: change -hp- Stock No. to 310-229ABC

Change the following Stock Nos. in the Table of Replaceable Parts:

Shield: for attenuator alignment, -hp- Stock No. 152B-95B

Alignment attenuator (one): -hp- Stock No. 152B-95A

V503, V509, V510: change -hp- Stock No. to G-73Y

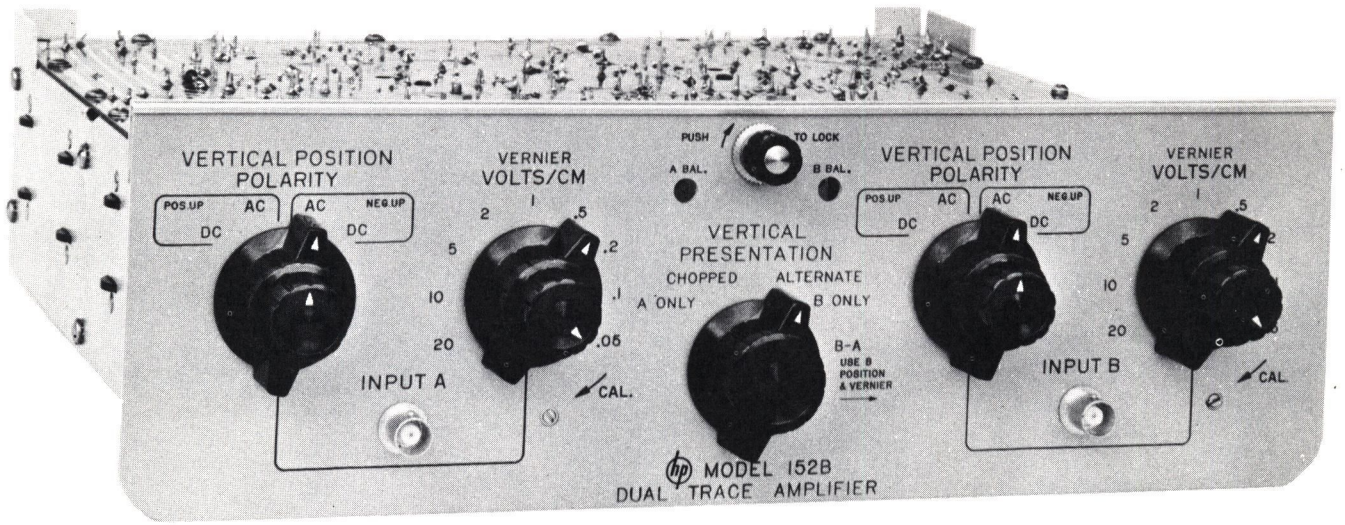
2/6/59
2/3/59

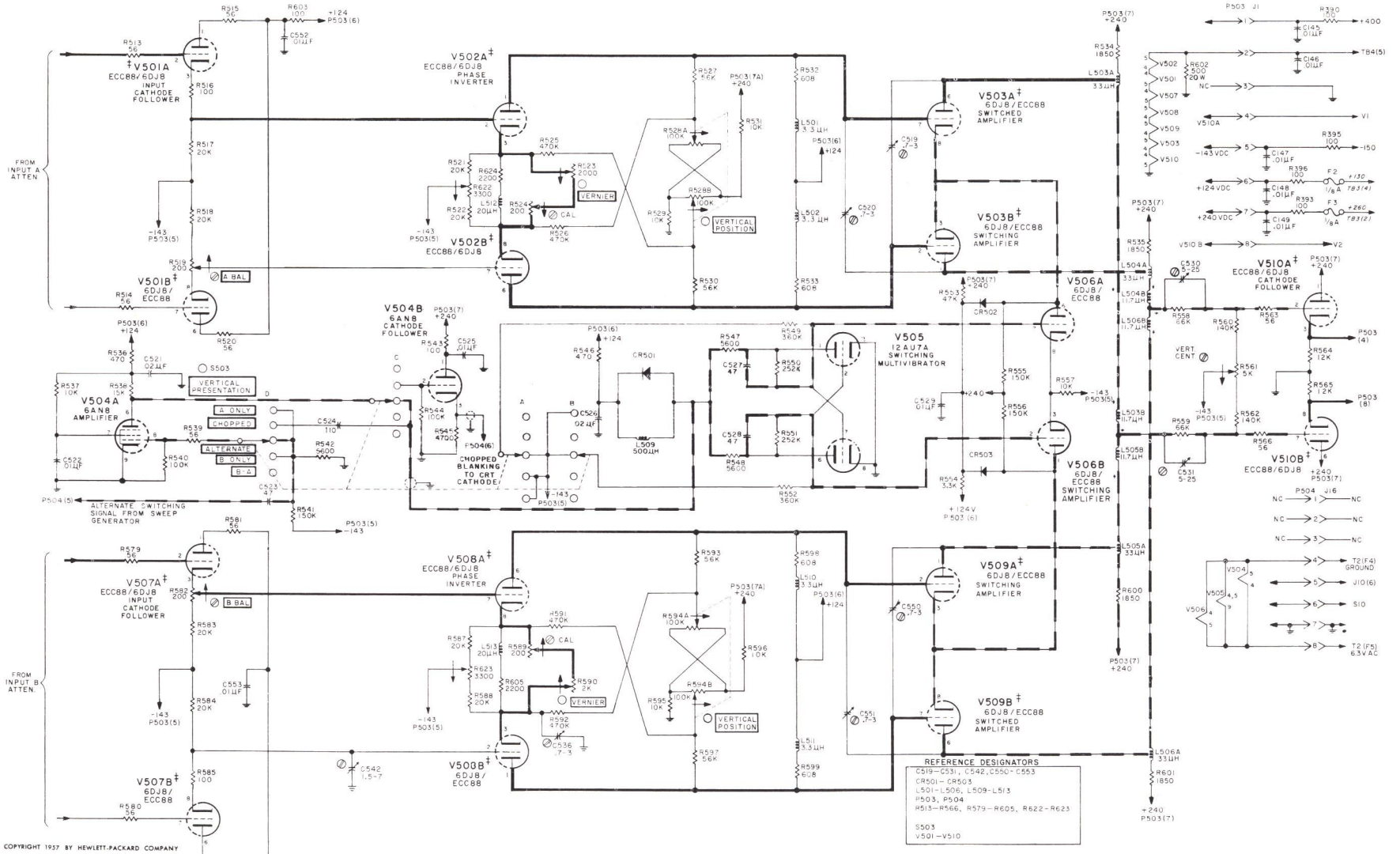
HEWLETT - PACKARD CO.

MODEL 152B DUAL TRACE AMPLIFIER

SPECIFICATIONS

DIFFERENTIAL INPUT	Both inputs may be switched to one channel to give differential input. The input attenuators may be set separately to allow mixing signals of different levels.
AMPLIFIER:	Channel B.
PRESENTATION:	Input B-Input A.
INPUT ATTENUATOR:	Use A and B channel attenuators simultaneously.
COMMON MODE REJECTION:	At least 40 db at maximum sensitivity, at least 30 db when using attenuators.
EACH CHANNEL	
SENSITIVITY RANGE:	0.05 v/cm to 50 v/cm.
INPUT ATTENUATOR:	9 calibrated ranges in 1, 2, 5, and 10 sequence from 0.05 v/cm to 20 v/cm. Accuracy ±5% A vernier permits continuous adjustment between ranges and extends the 20 v/cm range to at least 50 v/cm.
PASS BAND:	DC Coupled: dc to 10 mc, 0.035 μsecond rise time. AC Coupled: 2 cps to 10 mc, 0.035 μsecond rise time.
INPUT IMPEDANCE:	1 megohm (nominal) shunted by 30 μμf (approximately).
VERTICAL POSITIONING:	Individually adjustable.
POLARITY OF PRESENTATION:	Input signal as applied or inverted.
ELECTRONIC SWITCHING:	By alternate sweep or chopped at approximately 100 kc.
INPUT CONNECTORS:	BNC.
WEIGHT:	Net 6 lbs.





1528-50-1014

DUAL CHANNEL AMPLIFIER SCHEMATIC

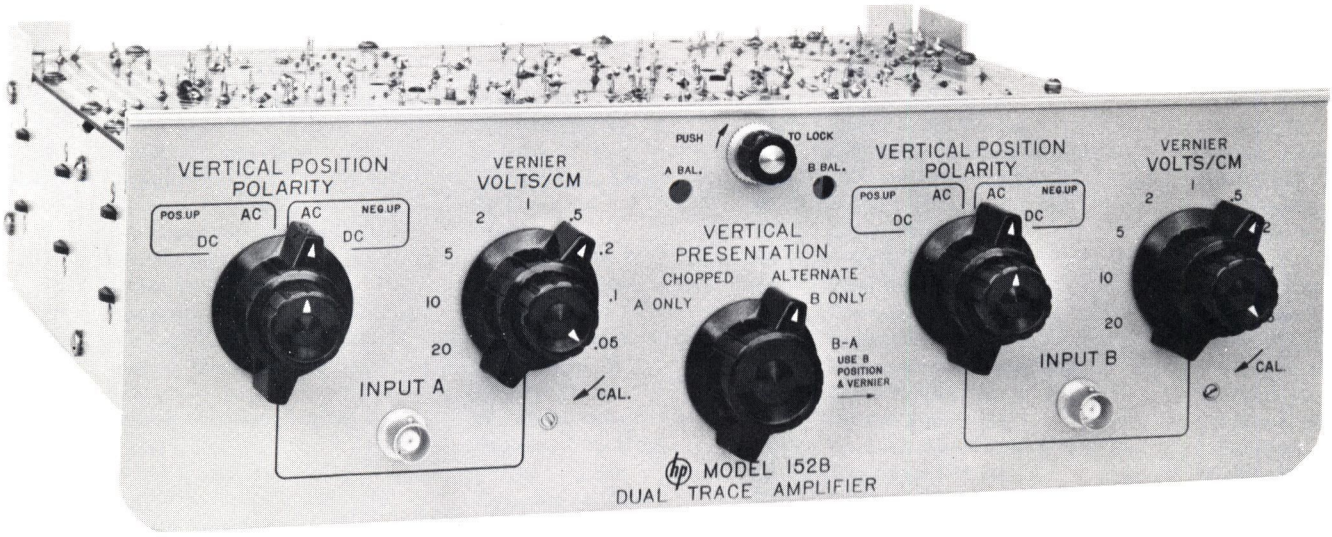
OPERATING AND SERVICING MANUAL

FOR

MODEL 152B

DUAL TRACE AMPLIFIER

SERIAL 50 AND ABOVE



152A002

SPECIFICATIONS

FOR

hp MODEL 152B DUAL TRACE AMPLIFIER
WHEN PLUGGED INTO hp MODEL 150A OSCILLOSCOPE

DIFFERENTIAL INPUT — Both inputs may be switched to one channel to give differential input. The input attenuators may be set separately to allow mixing signals of different levels.

AMPLIFIER: Channel B.

PRESENTATION: Input B-Input A.

INPUT ATTENUATOR: Use A and B channel attenuators simultaneously.

COMMON MODE REJECTION: At least 40 db at maximum sensitivity, at least 30 db when using attenuators.

EACH CHANNEL

SENSITIVITY RANGE: 0.05 v/cm to 50 v/cm.

INPUT ATTENUATOR: 9 calibrated ranges in 1, 2, 5, and 10 sequence from 0.05 v/cm to 20 v/cm. Accuracy ±5%.

A vernier permits continuous adjustment between ranges and extends the 20 v/cm range to at least 50 v/cm.

PASS BAND: DC Coupled: dc to 10 mc, 0.035 μsecond rise time.
AC Coupled: 2 cps to 10 mc, 0.035 μsecond rise time.

INPUT IMPEDANCE: 1 megohm (nominal) shunted by 30 μμf (approximately).

VERTICAL POSITIONING: Individually adjustable.

POLARITY OF PRESENTATION: Input signal as applied or inverted.

ELECTRONIC SWITCHING: By alternate sweep or chopped at approximately 100 kc.

INPUT CONNECTORS: BNC.

WEIGHT: Net 6 lbs.

CONTENTS

SECTION I
OPERATING INSTRUCTIONS

1-1 GENERAL INFORMATION

The ℗ Model 152B Dual Trace Amplifier is a plug-in vertical amplifier unit for use with the ℗ Model 150A High Frequency Oscilloscope. The Dual Trace Amplifier permits simultaneous observation of two electrical phenomena. These two traces can be presented alternately or chopped, as desired, depending upon the frequencies involved. In addition, differential presentation is available (channel B signal minus channel A signal). In all cases the dc to 10 mc bandpass of the basic unit is maintained. The sensitivity of both channels of the Dual Trace Amplifier is from 0.05 to 20 volts per centimeter and is continuously adjustable between ranges.

A single switch selects the presentation of the channels, the controls of which are duplicated on either side of the VERTICAL PRESENTATION control. For each channel, there is a separate INPUT jack, input POLARITY switch, and VOLTS/CM switch.

1-2 CONNECTION TO MODEL 150A

All connections of ℗ Model 152B Dual Trace Amplifier to the Model 150A Oscilloscope are made automatically through a plug-jack combination by inserting the 152B into the opening provided in the 150A. Voltages required to operate the Model 152B are furnished by the Model 150A. The latch that secures the plug-in amplifier in the oscilloscope has an integral locknut. This locknut must be released before the latch can operate. Always tighten the locknut after installing the plug-in amplifier to insure good electrical contact.

1-3 DAMAGE IN TRANSIT - WARRANTY REPAIRS

Refer to the warranty sheet in this manual.

1-4 OPERATING PROCEDURES

Basic oscilloscope operating procedures are given in the Model 150A oscilloscope instruction manual. The procedures which follow are intended to supplement those found in the Model 150A manual.

1-5 VERTICAL AC OR DC COUPLING

Under most conditions ac coupling will be used. It permits high gain to be employed without regard for the dc levels involved. In the ac position the input signal (vertical or external sync) is coupled to the instrument through a capacitor which removes the dc component. This coupling circuit has a low frequency cut off at 2 cps. Therefore, to avoid degrading input pulses or square waves below 10 cps it is advisable to use dc coupling. Use dc coupling to look at waveforms having an important dc component. WHEN USING DC COUPLING THE POSITION OF THE TRACE ON THE OSCILLOSCOPE SCREEN IS INFLUENCED BY THE DC LEVEL. IF THE TRACE CANNOT BE POSITIONED ON THE SCREEN, TRY AC COUPLING.

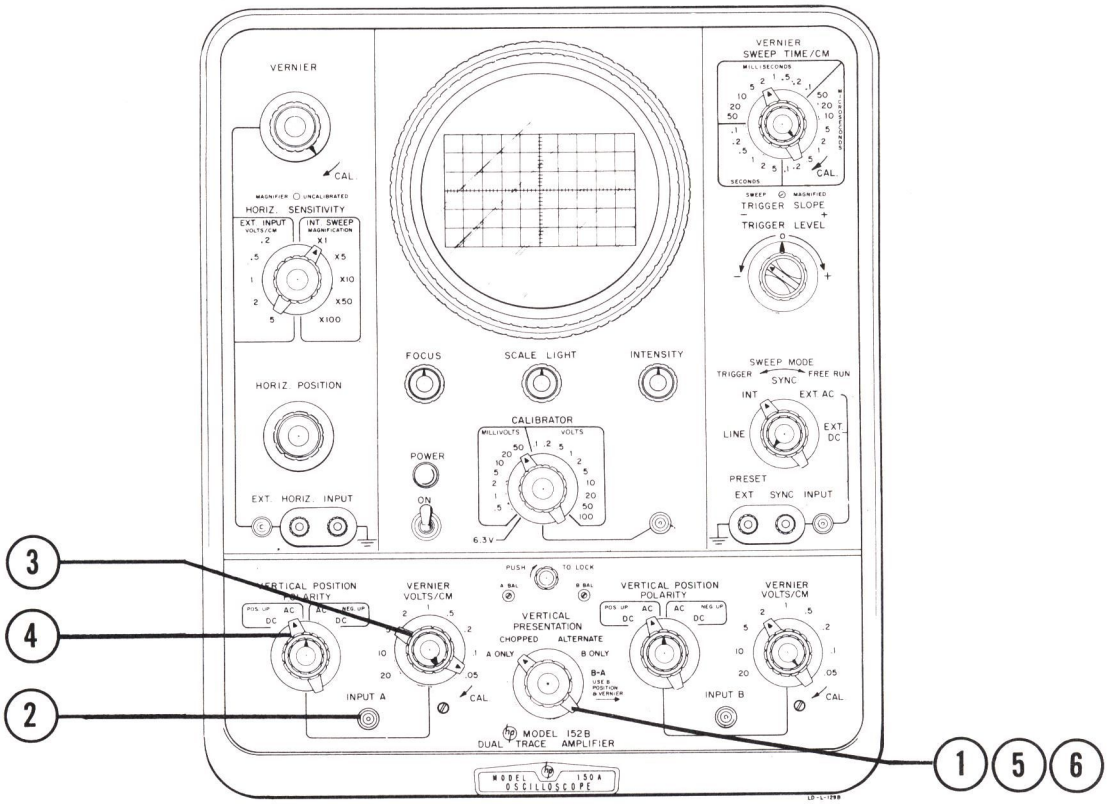
1-6 USE OF CHOPPED OR ALTERNATE SWEEP OPERATION

NOTE

When using either CHOPPED or ALTERNATE presentation for viewing related signals, the Model 150A Oscilloscope should be set for EXT SYNC and either the A or B channel waveform connected to the EXT SYNC INPUT terminals. When the two inputs are not related in frequency or where the additional loading of the EXT SYNC terminals is not desirable, the oscilloscope may be set for INT SYNC. When using internal synchronization, the best results will be obtained if the two traces are placed as close together as possible.

ALTERNATE presentation provides for alternate display of the two channels, i.e., one sweep presents the input to one channel while the next sweep presents the other channel in a continuing process. This arrangement gives the effect of a dual trace and permits two phenomena to be compared directly

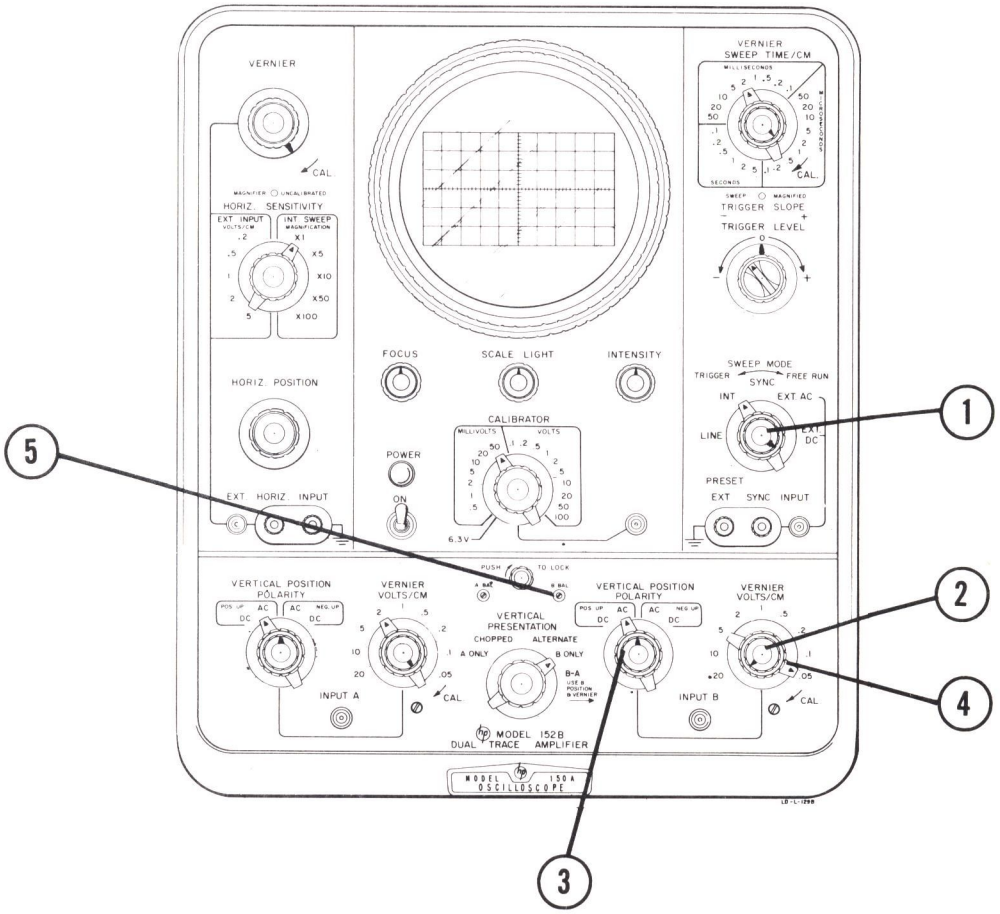
VERTICAL INPUT



1. Set to A only.
2. Place one of two input signals into INPUT A.
3. Adjust deflection sensitivity with VOLTS/CM switch.
4. Select polarity of presentation.
5. Switch to INPUT B and repeat above procedure on B side of panel.
6. Switch to ALTERNATE or CHOPPED for dual trace presentation.

Figure 1-1

VERTICAL BALANCE ADJUSTMENT



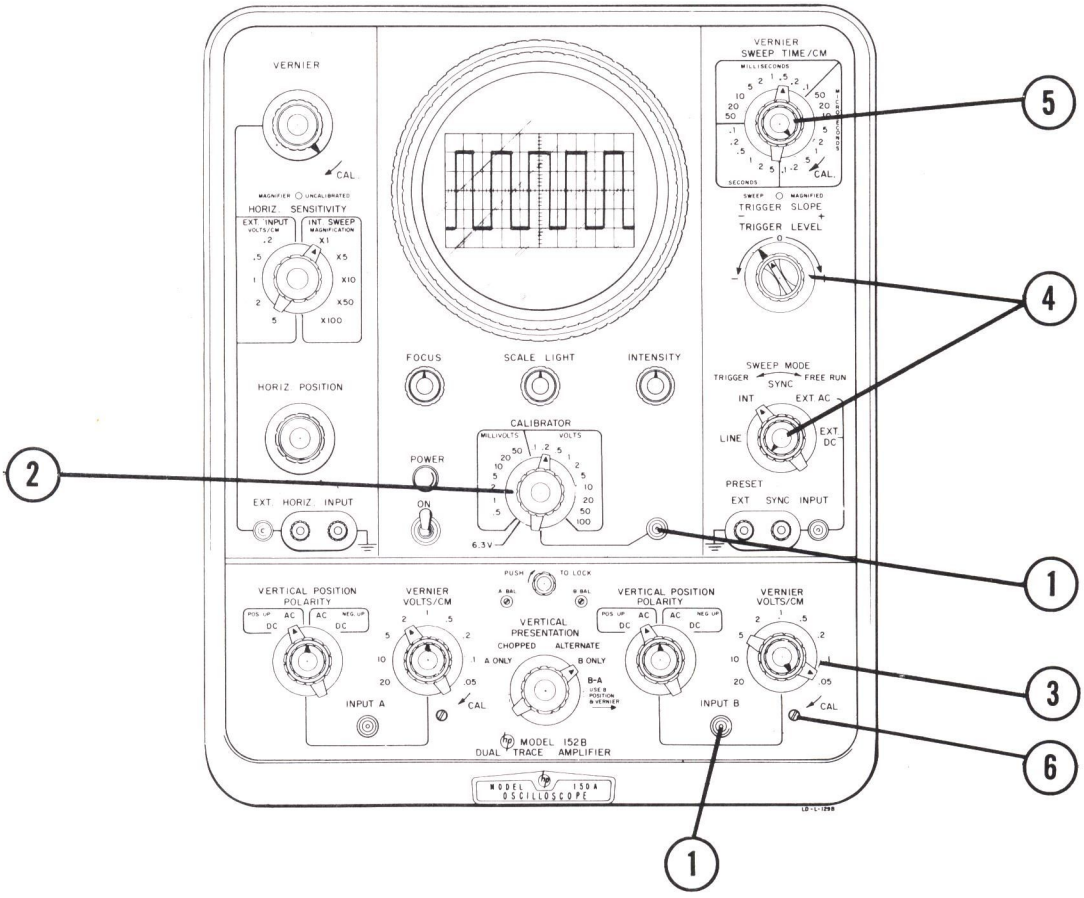
Procedure given for B channel, but is same for A channel.

1. Set SWEEP MODE control to FREE RUN.
2. Set VERNIER to minimum (full counterclockwise).
3. Center trace with VERTICAL POSITION control.
4. Switch VERNIER to CAL (full clockwise).
5. Adjust B-BAL control to return trace to center of scope.

Repeat steps 2 to 5 until trace remains centered.

Figure 1-2

VERTICAL CALIBRATION



This procedure assumes that vertical balance adjustments (Figure 2-1) have been made.

1. Connect CALIBRATOR output (or any accurate ac voltage) to the vertical INPUT

2. Set CALIBRATOR to the .2 volt position (use 2 volt position if AC-21A probe is used).

3. Set VOLTS/CM switch to .05, and switch VERNIER to CAL.

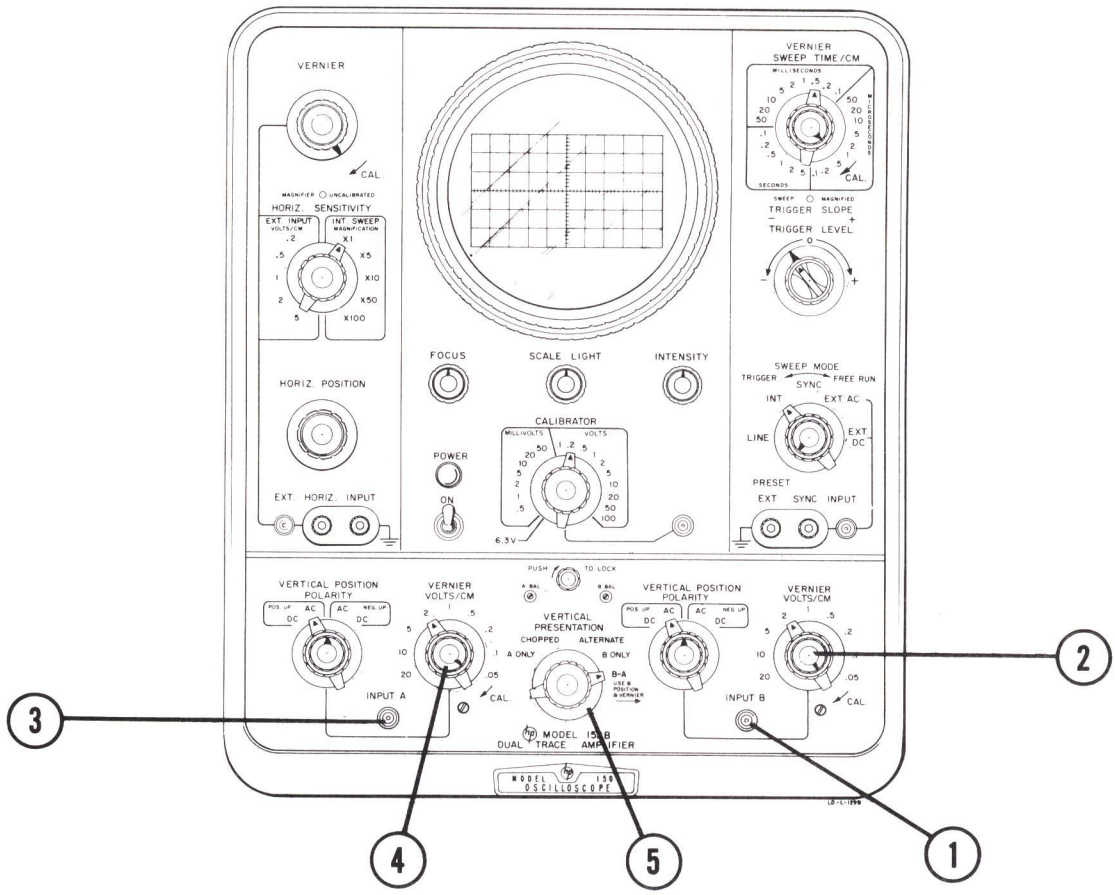
4. Sync scope internally.

5. Use convenient sweep speed (approximately .5 MILLISECONDS/CM.

6. Adjust R589 (accessible through front panel as shown) to obtain a vertical deflection of exactly 4 centimeters on scope graticule.

Figure 1-3

DIFFERENTIAL INPUT



To measure the difference between two signals:

1. Connect the larger signal to **INPUT B.**
2. Adjust channel B sensitivity with the **VOLTS/CM** switch. (**VERNIER** in **CAL**).
3. Connect the smaller signal to **INPUT A.**
4. Adjust channel A sensitivity with the **VOLTS/CM** switch to the same sensitivity as channel B in step 2.
5. Switch the **VERTICAL PRESENTATION** control to **B-A** (B minus A).

Adjust the pattern by means of the B channel **VERTICAL POSITION** control, if necessary.

Figure 1-4

on the face of the cathode-ray tube. A typical example of this usage is indicated in Figure 1-5, where the upper trace shows a gate waveform while the lower trace shows pulses that have been passed through the gate. These time comparisons are essentially errorless, since the sweeps that present the two inputs are identical and also the time delays in the two channels are equal within 2 millimicroseconds. On the fastest sweep of 0.02 microsecond/cm any horizontal displacement is thus less than 1 mm or of the same order of magnitude as the trace resolution.

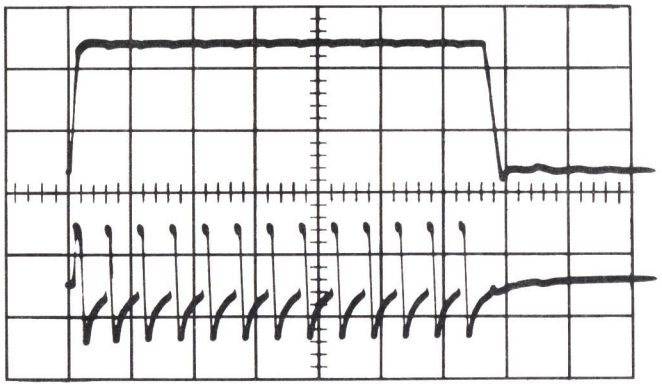


Figure 1-5. Typical use of dual-trace operation

CHOPPED presentation is useful in comparing two inputs that require a relatively slow sweep speed. In this presentation the vertical input is alternately switched between channels at a 100 kc rate. When the sweep repetition rate is slow compared with the 100 kc switching rate the net effect is the same as the ALTERNATE presentation except the flicker effect will be noticeably reduced. The CHOPPED presentation is also useful when comparing two voltages of a non-repetitive nature.

1-7 MODEL 152B DUAL TRACE AMPLIFIER AS A DIFFERENTIAL AMPLIFIER

The Model 152B may also be used as a differential amplifier. That is, the input to channel A can be subtracted from the input to channel B. Only the difference between these two signals will be displayed on the screen of the cathode-ray tube in the Model 150A Oscilloscope. Differential input will be found useful in applications where it is desired to

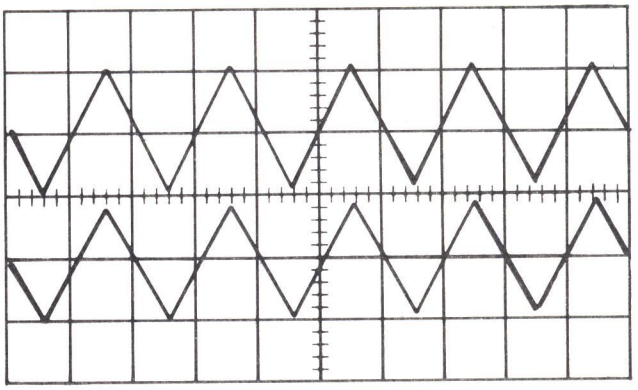


Figure 1-6. Chopped Operation

amplify the out-of-phase (differential) signal and attenuate the in-phase (common-mode) signal at the same time. See Figure 1-7 for explanation of differential and common-mode signals.

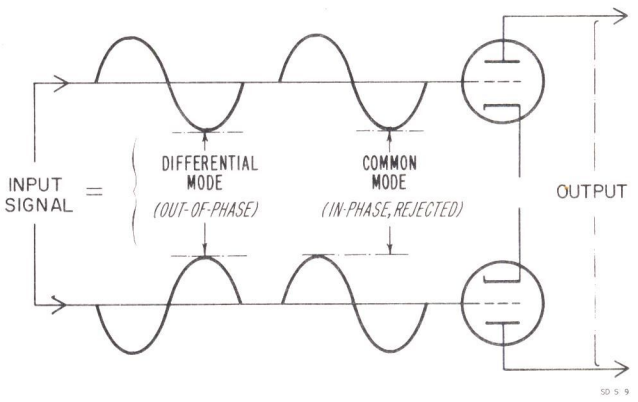


Figure 1-7. Differential Amplifier Input

This rejection is an inherent property of differential amplifiers. The common-mode portion of the input signal is attenuated 30 db. Unwanted signals such as noise and hum introduced into the connecting leads are of the common-mode type and are rejected by the differential input.

The differential amplifier input is useful when connections are made to a balanced system, since the balance to ground is preserved.

To use the Model 152B as a differential amplifier rotate the VERTICAL PRESENTATION switch to the position marked B-A. In this position the two channels are connected so that the channel A signal is fed into one side of the channel B input while the normal input to channel B is fed into the other side of the channel B amplifier in the normal manner. Thus the input to channel A will be subtracted from the input to channel B. The output of the channel B amplifier is then presented on the screen of the cathode-ray tube in the Model 150A Oscilloscope. Since the differential signal goes through the channel B amplifier only, the channel B POSITION and VOLTS/CM VERNIER controls must be adjusted. Normally, the channel A VOLTS/CM switch should be set to the same value as the channel B VOLTS/CM switch.

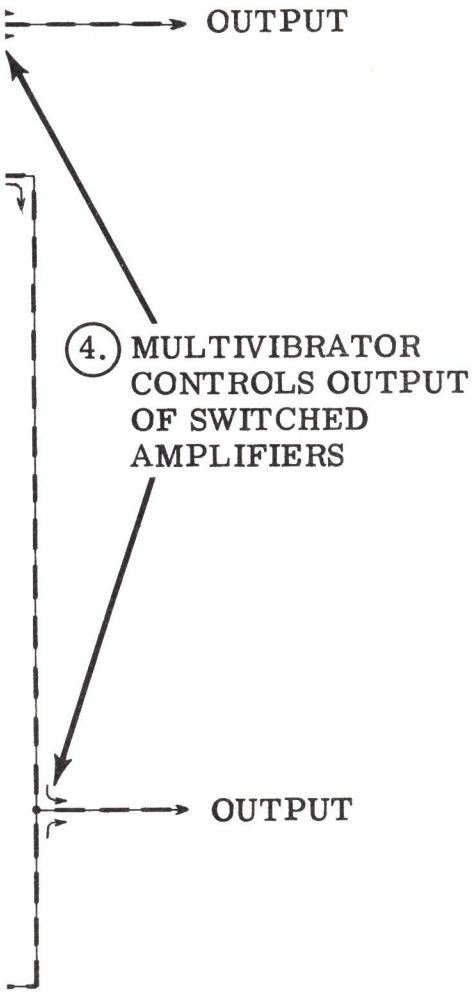
Load both channels equally. For instance, input cables must be same length. Failure to observe this precaution will cause difference of phase between input signals.

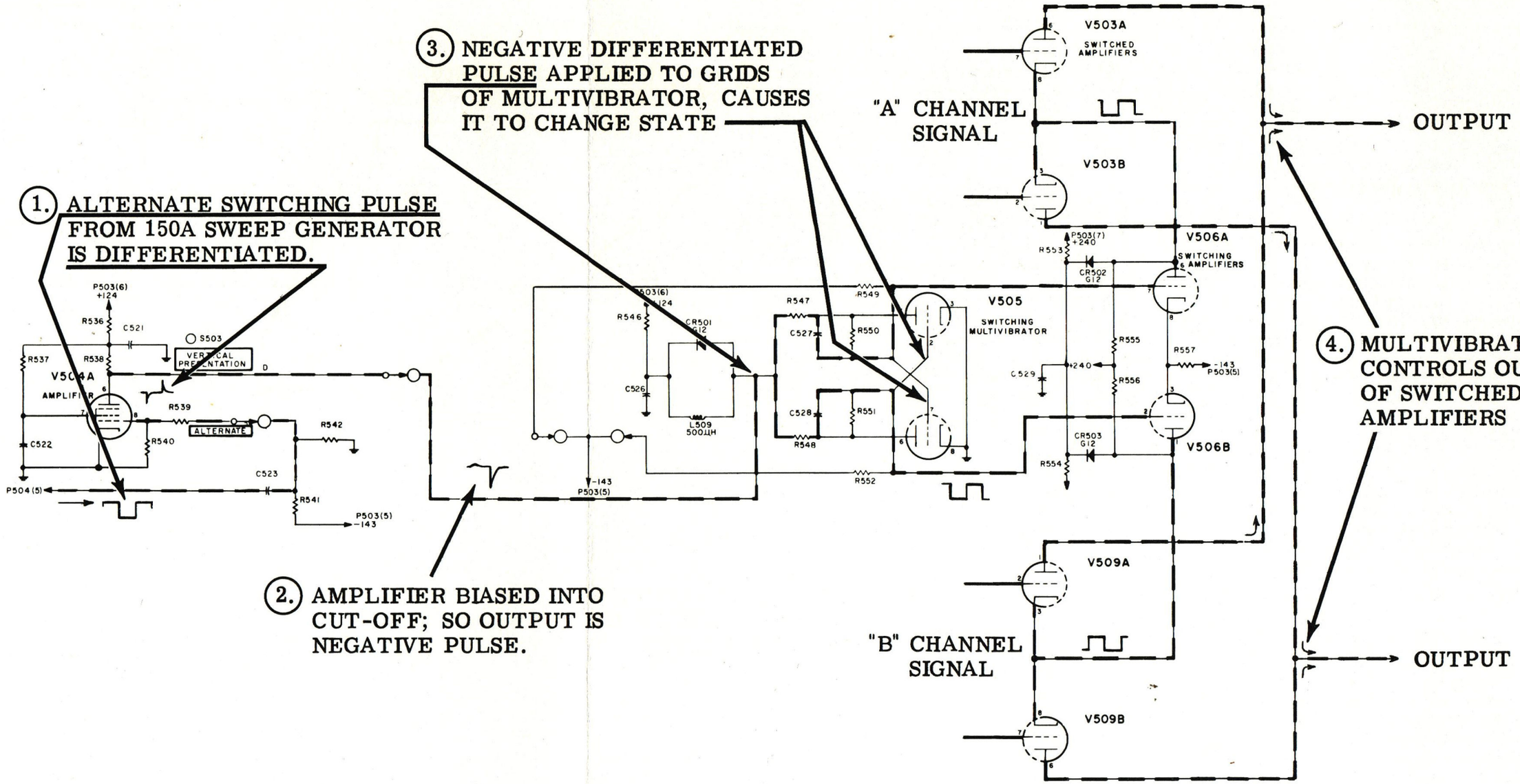
NOTE

The input to either channel during B-A presentation must not exceed 30 times the setting of the VOLTS/CM switch for that particular channel. For example if the VOLTS/CM switch is set to 1 the INPUT to that channel must not exceed 30 volts peak to peak. The amplitude of the input to each channel may be checked by switching to A ONLY and B ONLY prior to making the B-A measurement.

Under certain conditions it may be desired to use the Model 152B as a differential amplifier with the VOLTS/CM switches for the two channels set to different ranges. Since the shunt capacities to ground will no longer be balanced, some overshoot on fast rise-time waveforms may occur. A maximum of six percent overshoot will occur when the VOLTS/CM switch on one channel is at maximum sensitivity and the same switch on the other channel is at minimum sensitivity.

FIGURE 2-1
SIMPLIFIED SWITCHING SCHEMATIC





ALTERNATE SWEEP OPERATION

For CHOPPED operation, multivibrator free-runs at about 100 kc

SECTION II
THEORY OF OPERATION

2-1 CIRCUIT DESCRIPTION

The Model 152B Dual Trace Amplifier plug-in contains two identical vertical amplifiers, each with an input-sensitivity range switch and trace positioning circuit. The output signals of the two amplifiers are combined and the resultant signal is fed through push-pull cathode followers to the Main Vertical Amplifier in the main instrument chassis. All circuits are direct-coupled; for ac coupling a blocking capacitor is switched between the vertical input connector and the input attenuator.

At the input to each channel, compensated voltage dividers provide attenuation of the input signal to control the vertical sensitivity of each channel. Each step of attenuation is separate and independent of the others because there is no cascading of attenuator sections.

The first stage of the Dual Channel Amplifier consists of a push-pull cathode follower; one side receives the input signal, as determined by the input POLARITY switch; the input to the other side is bypassed to ground. The BAL. control adjusts the grid bias on one side of the phase inverter so that the position of the trace will remain stationary when the VERNIER control is varied. This requires that the bias on the two tubes remain unchanged, which in turn requires that the VERNIER gain control be connected between points having no dc potential difference. The BAL. control adjusts the grid bias to one side of the phase inverter so that this condition is met.

The two cathodes of the second stage are connected together through the VERNIER and CAL. potentiometers. These potentiometers vary the cathode-to-cathode coupling and introduce cathode degeneration to vary the gain of the stage, and at the same time permit the stage to act as a phase inverter.

Moving the position of the spot is accomplished by varying the dc level equally and oppositely on the two plates of the phase inverter. The dc levels as well as the signals are then direct coupled to the following amplifiers. To prevent a change in current through the cathode resistors when the POSITION potentiometers are varied, a portion of the position-determining voltage is fed back to each cathode in such a manner that the currents remain unchanged.

The third stage of the unit is a switched amplifier. These amplifiers can be turned on or off manually by the VERTICAL PRESENTATION switch, or rapidly during ALTERNATE or CHOPPED operation. The plate circuits of both the "A" and "B" channel switched amplifiers are common but no interaction takes place as the amplifiers cannot operate simultaneously.

The Dual Channel Amplifier also contains a switching multivibrator for switching the two channels off and on during CHOPPED and ALTERNATE operation.

For CHOPPED operation, the Switching Multivibrator free-runs at approximately 100 kilocycles, switching each of the channels off and on at this rate. During CHOPPED operation a fast negative pulse is taken from the Switching Multivibrator and applied through V504B to the CRT intensity grid so that the chopping lines between the two traces will be blanked out.

For ALTERNATE operation, a high negative bias converts the free-running multivibrator to a bistable flip-flop.

A signal obtained from the Sweep Generator at the end of each sweep switches the Multivibrator from one channel to the other, thus alternately turning on one channel for one sweep, the other channel for the next.

In differential operation (B-A on VERTICAL PRESENTATION switch), the signal fed into the INPUT B terminal goes through the channel B attenuator to the VERTICAL PRESENTATION switch. It then by-passes the POLARITY switch, and is fed directly to the input of the channel B amplifier. The signal fed into the INPUT A connector goes through the channel A attenuator to the VERTICAL PRESENTATION switch. It then by-passes the POLARITY switch and is fed directly into the opposite side of the balanced channel B amplifier. A positive going voltage fed into INPUT B will deflect the beam on the screen of the Model 150A upwards. However, a positive going voltage fed into INPUT A will deflect the beam downwards since this signal is fed into the opposite side of the balanced channel B amplifier. The POLARITY switches are not operative in the B-A switch position operation.

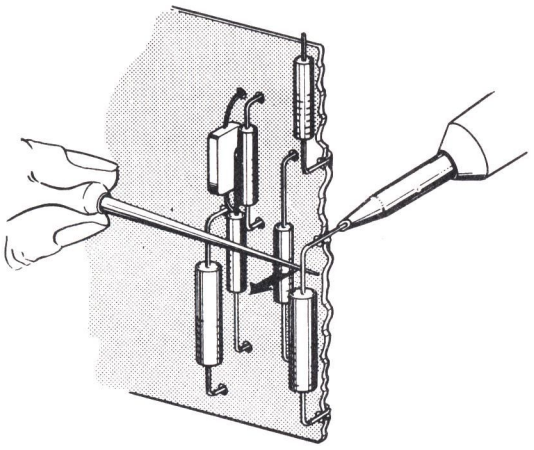
SERVICING ETCHED CIRCUIT BOARDS

Excessive heat or pressure can lift the copper strip from the board. Avoid damage by using a low power soldering iron (50 watts maximum) and following these instructions. Copper that lifts off the board should be cemented in place with a quick drying acetate base cement having good electrical insulating properties.

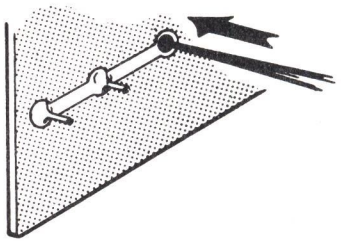
Use only high quality rosin core solder when repairing etched circuit boards. **NEVER USE PASTE FLUX.** After soldering, clean off any excess flux and coat the repaired area with a high quality electrical varnish or laquer.

A break in the copper should be repaired by soldering a short length of tinned copper wire across the break.

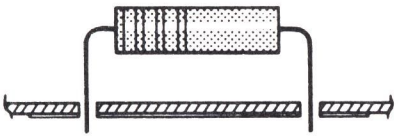
When replacing tube sockets it will be necessary to lift each pin slightly, working around the socket several times until it is free.



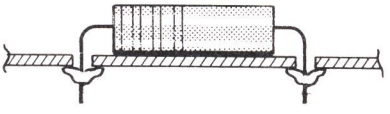
1. Apply heat sparingly to lead of part to be replaced. Remove part from card as iron heats the lead.



2. Using a small awl, carefully clean inside of hole left by old part.



3. Bend clean tinned leads on new part and carefully insert through holes on board.



4. Hold part against board and solder leads. Avoid overheating the board.

SECTION III
MAINTENANCE

3-1 INTRODUCTORY

The procedures that follow are listed in a sequence that is most easily followed when the entire procedure is to be completed. In many instances, only one or two parts of the procedure will be needed and they can be done without completing all other tests.

A ten to fifteen minute warm-up and a check of the power supply output voltages is always recommended before making any other tests or adjustments.

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

3-2 ISOLATING MALFUNCTIONS

As the instrument ages it is to be expected that a drift will occur which must be compensated for by internal adjustments. However, should there be a component failure in the balanced amplifiers, the spot will be thrown off the screen of the CRT and usually out of the range of adjustment of the balance and position controls. Starting at the output of the amplifier, short the corresponding grids of the stages together, one at a time. If the trace (spot) returns to the screen, the fault is prior to the stage with the shorted grids. When shorting the grids of one stage together does not return the spot to the screen, the fault has been isolated to that stage, or if a balancing control is in this stage it may be out of adjustment.

After the particular stage in which the fault lies has been located, find the particular faulty component by comparing the voltage and resistance measurements with the values given in the voltage and resistance diagram.

3-3 IMPORTANT SERVICE PROCEDURE

A heater-cathode short in tubes V502, V503, V508, V509 and/or V510 will cause either or both fuses F2 and F3 to burn out. These fuses are located on the Model 150A at the rear of the plug-in amplifier opening.

3-4 ADJUST VERTICAL BALANCE

a. Allow unit to warm up 30 minutes immediately before balancing.

b. Connect a jumper between pins 4 and 8 of connector P503. This is the LEFT connector when viewed from the front panel. Turn the SWEEP MODE control fully clockwise to FREE RUN to get a trace. Note the vertical position of the trace. This is the "zero output" point referred to subsequently. Remove the jumper.

c. Connect jumper across the ends of R558 and R559 toward the front of the plug-in amplifier.

d. Adjust R561 (Vert. Cent.) potentiometer for "zero output", then remove jumper.

CHANNEL A

e. Set VERTICAL PRESENTATION switch to A ONLY.

f. Set VOLTS/CM to 20 and VERNIER to CAL.

g. Switch POLARITY selector from AC POS. UP to AC NEG. UP. The trace should not move more than 0.4 cm. If it moves more, replace V501 and repeat.

h. Connect a jumper between pins 2 and 7 of V503, which are the two bare wires between V502 and V503. Replace V503 if the trace is more than 2 centimeters from the "zero output" position. Remove the jumper.

i. Connect a jumper across the variable taps of the VERTICAL POSITION control.

j. Set R524 (small screwdriver adjustment on front panel at end of CAL. arrowhead) to maximum gain (fully clockwise).

k. Adjust R519 (A BAL. potentiometer) for "zero output". (Note: If it is impossible to make this adjustment, replace V501 or V502, and repeat steps g, i, j, and k.)

l. Set VERNIER control to minimum gain (fully counterclockwise).

m. Adjust R622 for "zero output", within 1 cm of "zero output" is close enough.

n. Return VERNIER to CAL. (fully clockwise).

o. Check range of R519 (A BAL. potentiometer) from fully clockwise to fully counterclockwise. The trace should move at least 5 cm in each direction. If not, replace V501 or V502 and repeat. Return R519 to the "zero output" position.

p. Remove jumper connected in step i. The Amplifier Gain must now be set.

CHANNEL B

Repeat the above procedure using corresponding Channel B controls.

3-5 ADJUST VERTICAL CENTERING

a. Set SWEEP MODE to "FREE RUN" and VERTICAL PRESENTATION to "ALTERNATE".

b. Superimpose the two traces with the VERTICAL POSITION controls for both channels set equally on opposite sides of the center of their adjustment ranges.

c. Adjust R561 as required to center the two superimposed traces.

3-6 ADJUST PUSH-PULL AMPLIFIER NEUTRALIZATION

a. Set SWEEP TIME/CM to ".1 MICROSECONDS" and SYNC to "EXT. AC".

b. Connect a 10 MC sine wave signal source to INPUT A and to EXT. SYNC. INPUT. Set VERTICAL PRESENTATION to "A ONLY".

c. Adjust the VOLTS/CM switch for channel A to .2 VOLTS/CM and adjust the 10 MC signal amplitude to obtain a peak to peak vertical deflection of 6 centimeters.

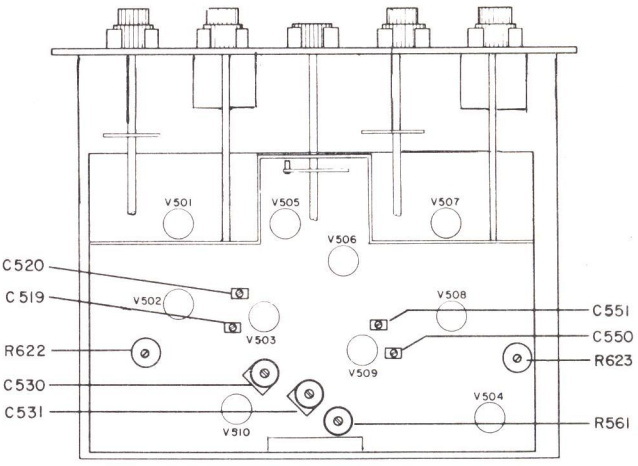


Figure 3-1. Bottom View of Dual Trace Amplifier

d. Rotate the "A" VOLTS/CM switch to the .1 VOLTS/CM range. Set VERTICAL PRESENTATION TO "B ONLY".

e. Adjust C519 and C520 simultaneously for a minimum signal on the oscilloscope trace.

f. Repeat the above procedure using corresponding controls for channel B and adjusting C550 and 551.

3-7 ADJUST FREQUENCY RESPONSE OF PUSH-PULL CATHODE FOLLOWER OUTPUT

a. Set VERTICAL PRESENTATION to "CHOPPED" and SWEEP TIME/CM to "2 MICROSECONDS".

b. Connect pin 6 of tube V504 to EXT. SYNC. INPUT through an AC-21A probe. This is the connector near V504 to which a blue wire is soldered.

c. Center and superimpose both traces with the two VERTICAL POSITION controls.

d. Connect the "75 Ω" output of an hp Model 211A Square Wave Generator set to 1000 cps to "INPUT A". Set POLARITY of channel A to "POS. UP AC".

e. Set VOLTS/CM for channel A to "1 VOLTS/CM" and adjust the 211A amplitude to obtain a vertical deflection of approximately 6 centimeters.

f. Set VOLTS/CM for channel A to ".1 VOLTS/CM". The channel B trace will be a broken line with approximately equal line segments and spaces. Each line segment is actually composed of two traces.

g. Adjust C530 and C531 to make the two traces of each line segment as parallel as possible.

h. Adjust the delay line termination in the 150A Main Vertical Amplifier.

If the Main Vertical Amplifier has C15,a variable mica capacitor, mounted between V3 and V4 adjust it to superimpose the two parallel lines. If the instrument does not have C15 adjust the value of C13 to superimpose the two traces. (C13 may be 50 to 400 $\mu\mu$f, and in some instruments it may be two individual capacitors, one across C5 and one across C6.)

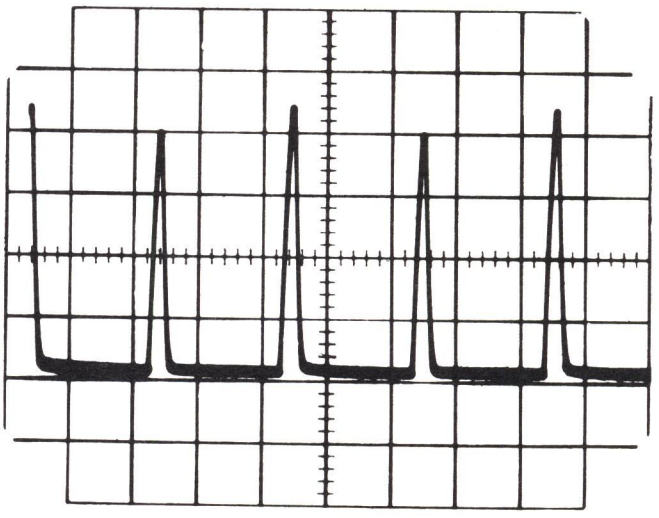


Figure 3-2. Chopped Blanking Waveshape

3-8 CHECK CHOPPED BLANKING ACTION

a. Set VERTICAL PRESENTATION to "CHOPPED". Adjust both VERTICAL POSITION controls to place the channel A trace 1 centimeter above center and the channel B trace 1 centimeter below center.

b. Set SWEEP TIME/CM to "1 MICROSECOND" and SYNC. to "INT".

c. Set SWEEP MODE to "PRESET" and INTENSITY for normal brilliance. Set Z axis modulation switch to "EXT. Z".

d. The resultant pattern on the oscilloscope will appear as a square wave with ringing and overshoot. Symmetry should be better than 45% - 55%. The period for one cycle of the square wave should be approximately 10 centimeters, indicating a frequency of 100 kc.

e. Rotate SWEEP MODE clockwise just off of "PRESET".

f. Set the test oscilloscope for positive up and connect the probe from this oscilloscope to pin 6 of V504. This is the connector near V504 to which a blue wire is soldered. The waveform obtained should have a peak to peak amplitude of 40 to 60 volts and appear as shown in Figure 3-2.

Replace V505 to correct for poor symmetry and diode CR501 to correct for poor waveshape on the bottom. Replace V504 to correct for low amplitude.

3-9 CHECK ALTERNATE DRIVE ACTION

a. Set VERTICAL PRESENTATION to "ALTERNATE" and SWEEP MODE to "FREE RUN". Adjust VERTICAL POSITION controls to place the channel A trace 1 centimeter above center and the channel B trace 1 centimeter below center.

b. Set SWEEP TIME/CM to ".1 MICROSECOND" and SYNC. to "EXT. AC".

c. Rotate the INTENSITY control counterclockwise. Both traces should disappear at the same time, indicating equal trace brightness. If the traces do not have approximately equal intensity, replace V505 or V506.

d. Set the test oscilloscope for positive up and connect the probe from this oscilloscope to pin 6 of V504. This is the connector near V504 to which a blue wire is soldered. The waveform obtained should have a peak to peak amplitude of at least 12 volts and appear as shown in Figure 3-3.

If the peak to peak amplitude is less than 12 volts, replace V504 or diode CR501.

3-10 ADJUST AMPLIFIER GAIN

CAUTION

The voltmeter used for this check must not be grounded, since both sides of the input will be 125 volts above ground.

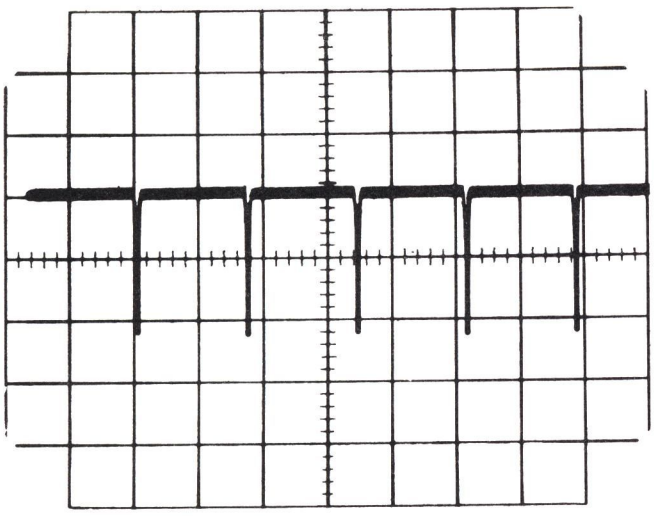


Figure 3-3. Alternate Drive Waveshape

a. Adjust VERTICAL POSITION controls to superimpose the two traces on the graticule center.

b. Set both VOLTS/CM switches to ".05" and both VERNIER controls to "CAL".

c. Set VERTICAL PRESENTATION to "A ONLY". Connect a 0.1 volt rms 400 cps, sine wave signal source to INPUT A.

d. Connect an hp Model 400D voltmeter between pins 3 and 8 of V510. These two points are the connectors near V510 to which purple leads from J503 are connected.

e. Adjust R524 (accessible on the front panel just below and slightly to the right of the VOLTS/CM switch) to obtain a 400D indication of 1 volt rms which will indicate that channel A has a gain of 20 db.

f. Repeat the above steps using corresponding B channel controls.

3-11 ADJUST AMPLIFIER COMMON MODE REJECTION

Before making this adjustment the balance, gain, and neutralization adjustments must be completed. An alignment attenuator is required for this adjustment. This attenuator is available from the Hewlett-Packard Company and is listed in the Table of Replaceable Parts at the back of this manual.

a. Set the VERTICAL PRESENTATION switch to B-A, both VOLTS/CM switches to .05 and VERNIER controls in CAL.

b. Connect a 10 mc sine wave having an amplitude of 5 volts peak to peak to both inputs. Be sure both inputs are in phase by using equal lengths of cable between each input and the generator.

c. Adjust C542 for minimum deflection.

d. Rotate the "B" VERNIER fully counterclockwise and adjust C536 for minimum deflection.

e. Disconnect the 10 mc signal from both inputs.

3-12 ADJUST INPUT ATTENUATOR FREQUENCY RESPONSE

An alignment attenuator, plug-in extender, and a shield for attenuator alignment will be required for this step. All these items are listed in the miscellaneous section of the Table of Replaceable Parts at the end of this manual.

a. Turn the instrument off and install the plug-in extender and alignment shield. Attach the alignment attenuator to the channel A input. Turn on the oscilloscope.

b. Set the controls on the oscilloscope as follows:

SYNC. SELECTOR ---------- EXT. AC
SWEEP TIME/CM ---------- .2 MILLISECONDS
VERTICAL PRESENTATION------- ALTERNATE
VERNIER, A and B ---------- CALIBRATE
POLARITY, A and B ----------POS. UP, DC
SWEEP MODE ---------- PRESET
HORIZ. SENSITIVITY----------INT. SWEEP, X1
TRIGGER LEVEL and SLOPE---For a stable trace

c. Connect the output of the CALIBRATOR to the EXT SYNC INPUT and to the alignment attenuator previously connected to channel A. Use shielded leads for these connections.

d. Set the A channel attenuator to .05 and B channel to 20 VOLTS/CM. Set the CALIBRATOR to .5 VOLTS and center the A channel square wave.

e. Adjust the B channel VERTICAL POSITION control to center the trace just below the top of the A channel square wave. This straight line is used as a reference when adjusting the attenuator frequency response.

f. Adjust C517 for the best square wave.

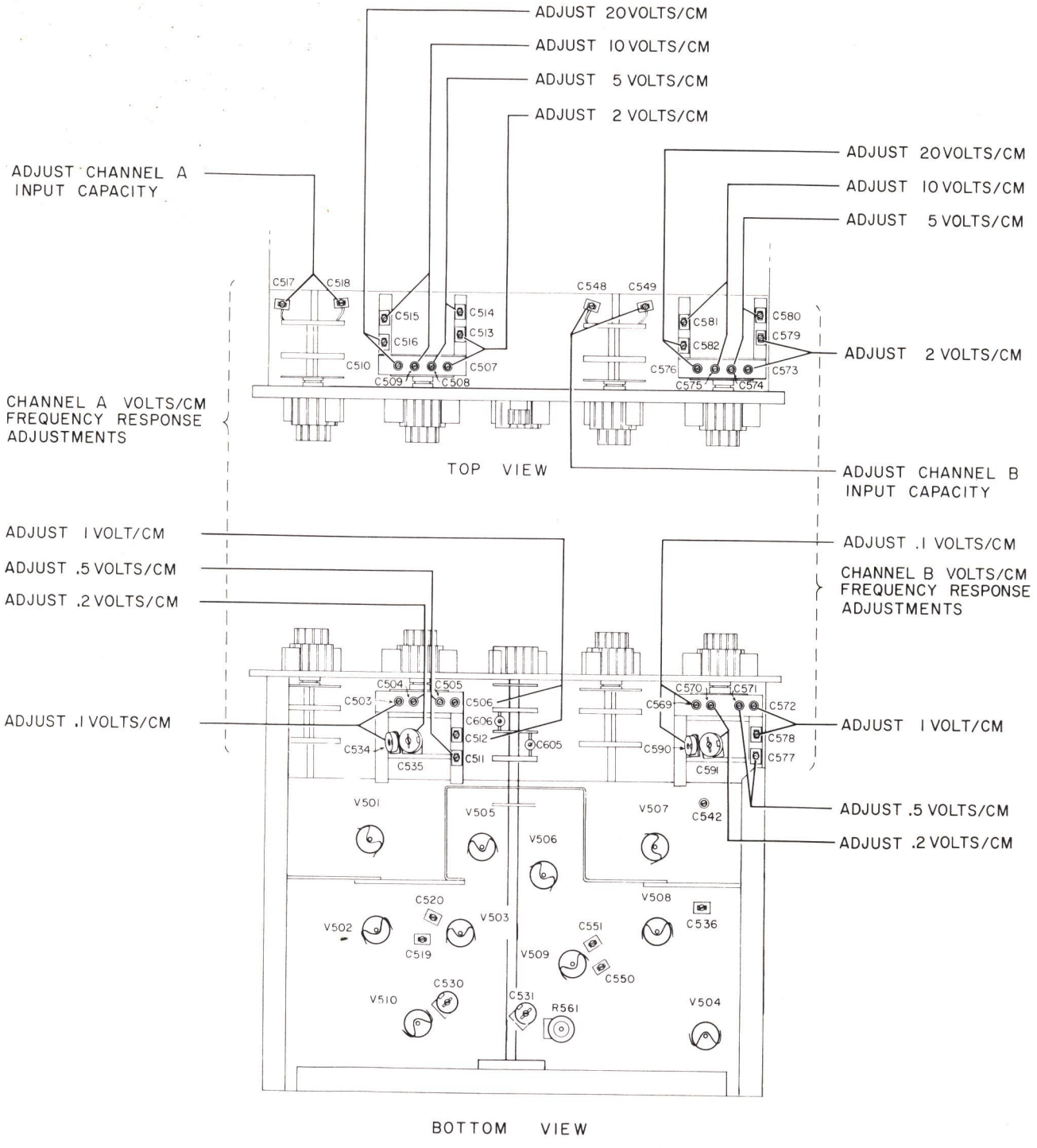


Figure 3-4. Adjustments on hp Model 152B

g. Change A channel POLARITY to NEG UP - DC and shift the B channel reference line to the bottom of the square wave. Adjust C518 for the best square wave.

h. Switch the A channel VOLTS/CM to 20 and shift the alignment attenuator and input to B channel.

i. Set the B channel VOLTS/CM switch to .05 and adjust C548 for the best square wave again using the A channel trace at the top of the square wave for a reference.

j. Switch the B channel POLARITY to NEG. UP -DC and shift the A channel reference line to the bottom of the square wave. Adjust C549 for the best square wave.

k. Return both POLARITY switches to POS UP - DC and adjust the remaining steps on the B channel attenuator using the input amplitude and adjustment specified in the following table. In the remaining steps the reference line must be positioned at the top of the square wave. For example on the .1 VOLTS/CM range set the CALIBRATOR to 1 VOLT and adjust C569 and C590 until the best possible square wave is obtained. Always adjust the capacitor that is listed first before attempting the second, since the first has a longer time constant and much more noticeable effect. Repeat the adjustments in each position until no further improvement is possible.

l. After completing the B channel adjustments move the alignment attenuator and input to A channel. Leave the B channel attenuator on 20 VOLTS/CM and start the A channel alignment on the .1 VOLTS/CM range proceeding through all ranges.

m. Turn off the power and remove the alignment shield and the plug-in extender.

3-13 ADJUST ATTENUATOR COMMON MODE REJECTION

A pair of alignment attenuators are required for this procedure. They are available from the Hewlett-Packard Company and are listed in the miscellaneous section in the Table of Replaceable Parts at the back of this manual.

Table 4-1. Input Attenuator Frequency Response Adjustments

VOLTS/CM RANGE	INPUT VOLTS	CHANNEL A ADJ.	CHANNEL B ADJ.
.1	1	C503 C534	C569 C590
.2	2	C504 C535	C570 C591
.5	5	C505 C511	C571 C577
1	10	C506 C512	C572 C578
2	20	C507 C513	C573 C579
5	50	C508 C514	C574 C580
10	100	C509 C515	C575 C581
20	100	C510 C516	C576 C582

a. Set the VERTICAL PRESENTATION switch to B-A, both VOLTS/CM switches to .05, and both VERNIER controls to CAL.

b. Connect an alignment attenuator to each input.

c. Connect a square wave generator to the A channel alignment attenuator. Shunt the input of the B channel alignment attenuator with a resistance equal to the output impedance of the square wave generator. Set the amplitude of the square wave to produce a 6 centimeter deflection at 1 kc.

d. Adjust C605 for the best square wave.

e. Reverse the two alignment attenuators, the input is now being applied to B channel. Adjust C606 for the best square wave.

f. Check all steps of both input attenuators for good square wave response, maintaining a deflection of 6 centimeters where possible. If the waveform varies from range to range it is an indication that the attenuator frequency response adjustments, paragraph 3-12 must be repeated.

g. Disconnect the input termination from one of the alignment attenuators. This is the resistor that was connected in step c.

h. Set the square wave generator frequency to 100 kc and connect to both alignment attenuators using equal lengths of shielded cable.

i. Rotate both input attenuators simultaneously through the .1 to 20 VOLTS/CM range, starting with both on .1 VOLTS/CM. The deflection on the screen should never exceed 3% of the input voltage.

j. Repeat para. 3-11 and 3-13 until no further improvement is possible.

SCHEMATIC DIAGRAM NOTES

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

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

3. Arrows on potentiometers indicate clockwise rotation as viewed from the shaft end.

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

5. Rotary switch schematics are electrical representations.

6. ‡ indicates a selected part. See Table of Replaceable Parts.

VOLTAGE AND RESISTANCE DIAGRAM NOTES

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

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

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

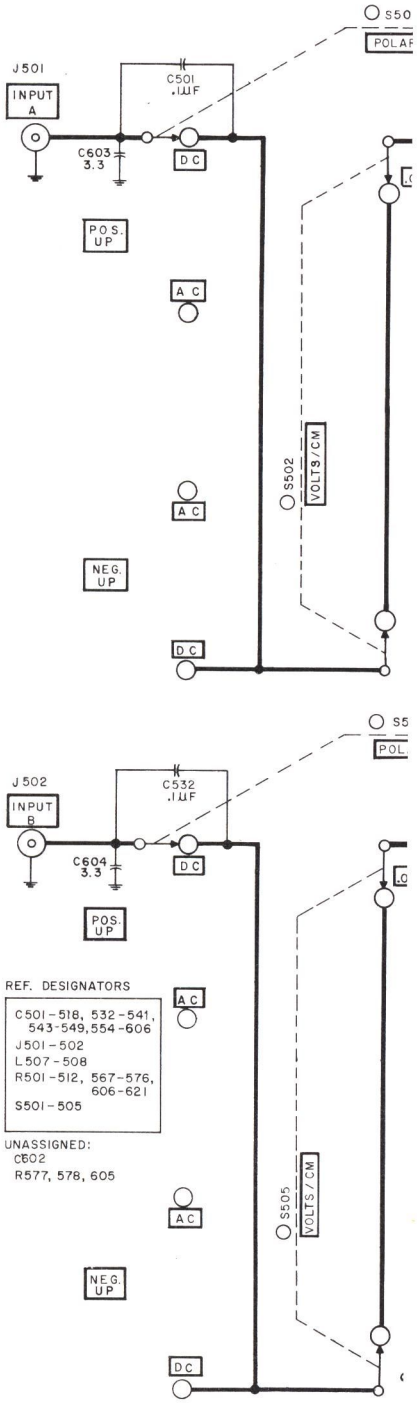
A socket terminal with an asterisk may be used as a tie point and may have a voltage and resistance shown.

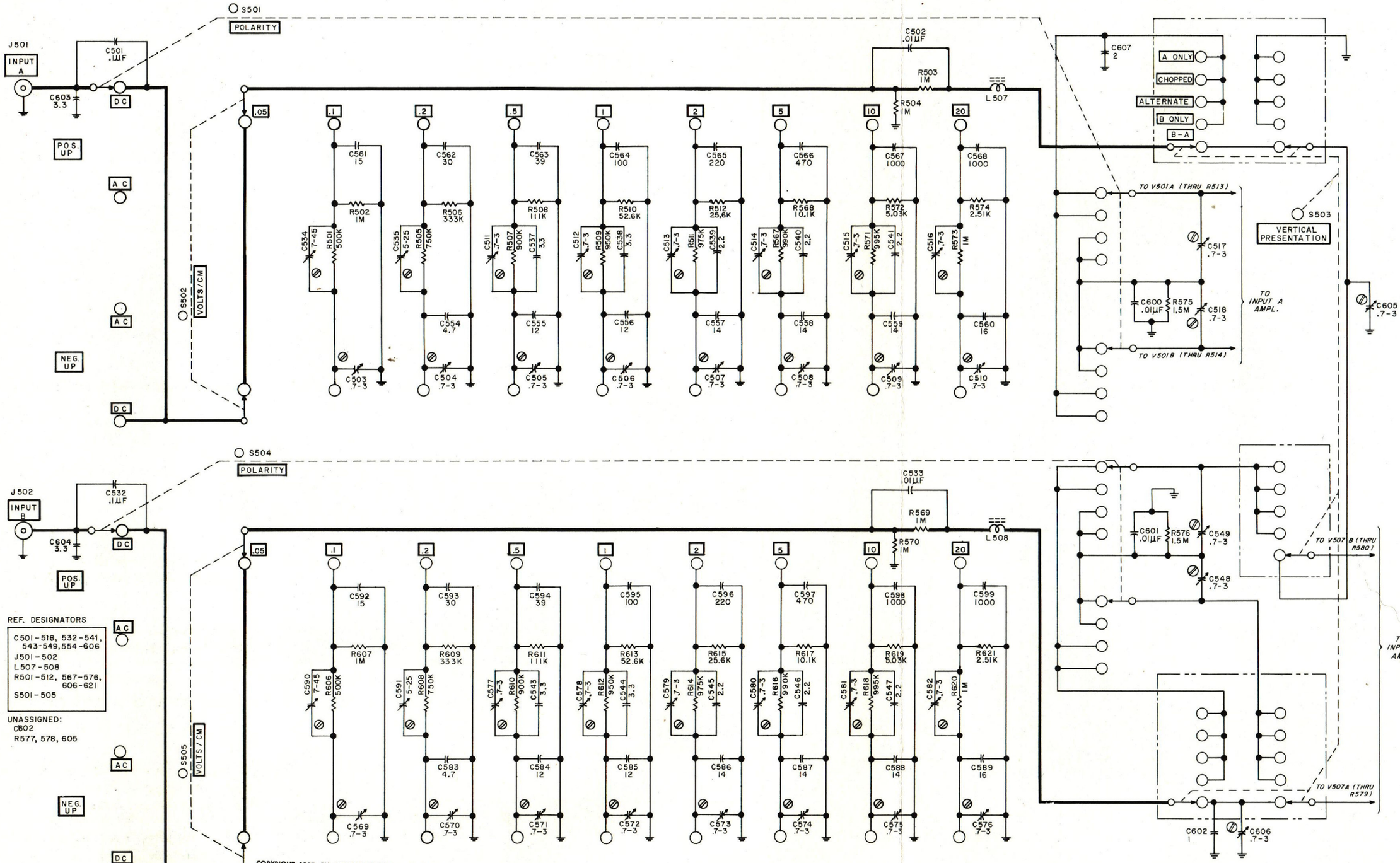
2. Voltages values shown are for guidance; values may vary from those shown due to tube aging or normal differences between instruments. Resistance values may vary considerably from those shown when the circuit contains potentiometers, crystal diodes, or electrolytic capacitors.

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

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

FIGURE 3-5
INPUT SWITCHING SCHEMATIC





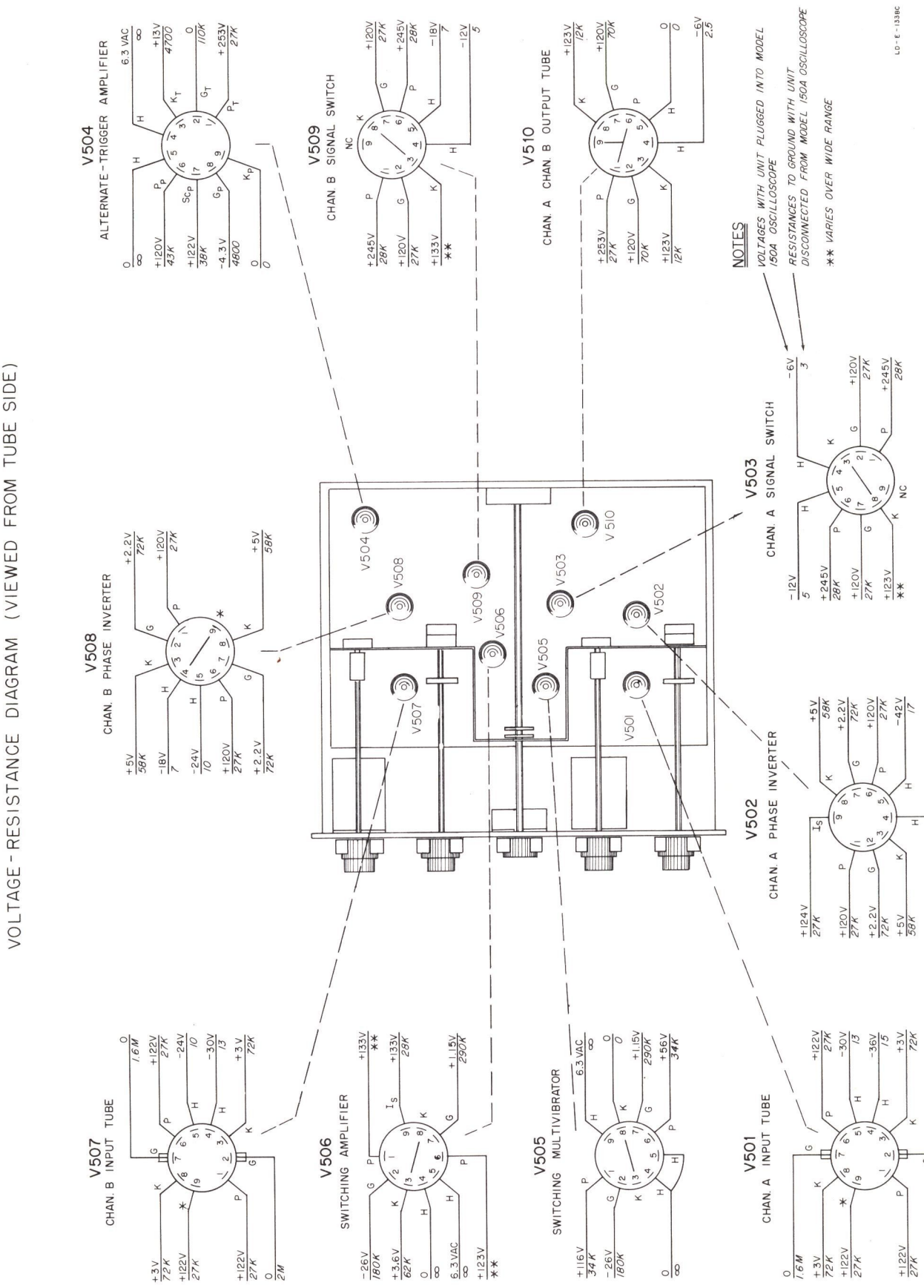
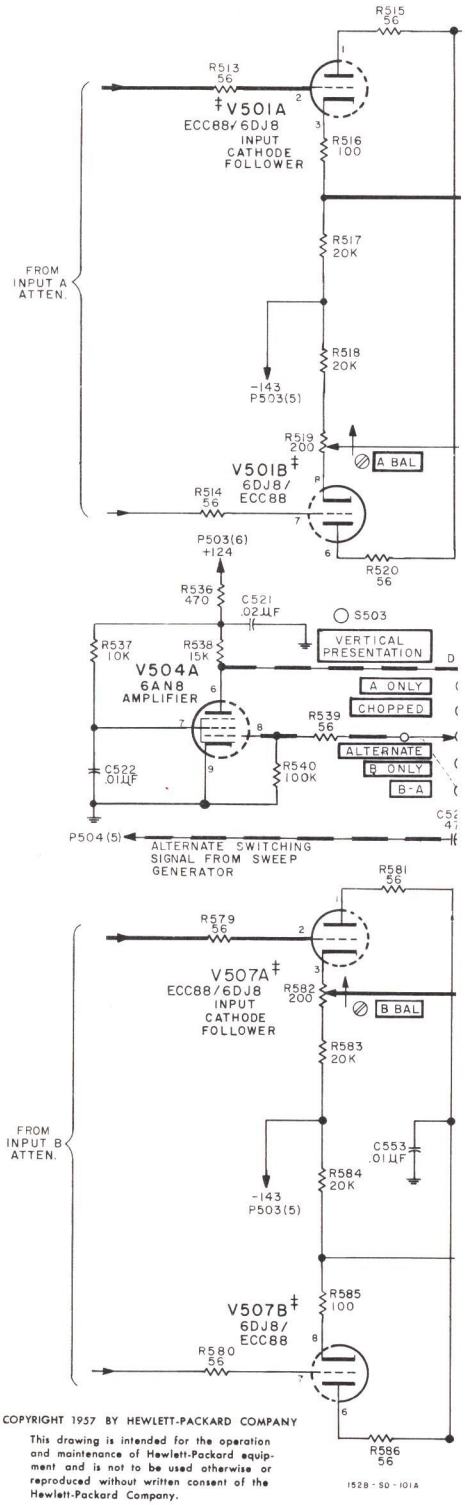


Figure 3-6

FIGURE 3-7
DUAL CHANNEL AMPLIFIER SCHEMATIC



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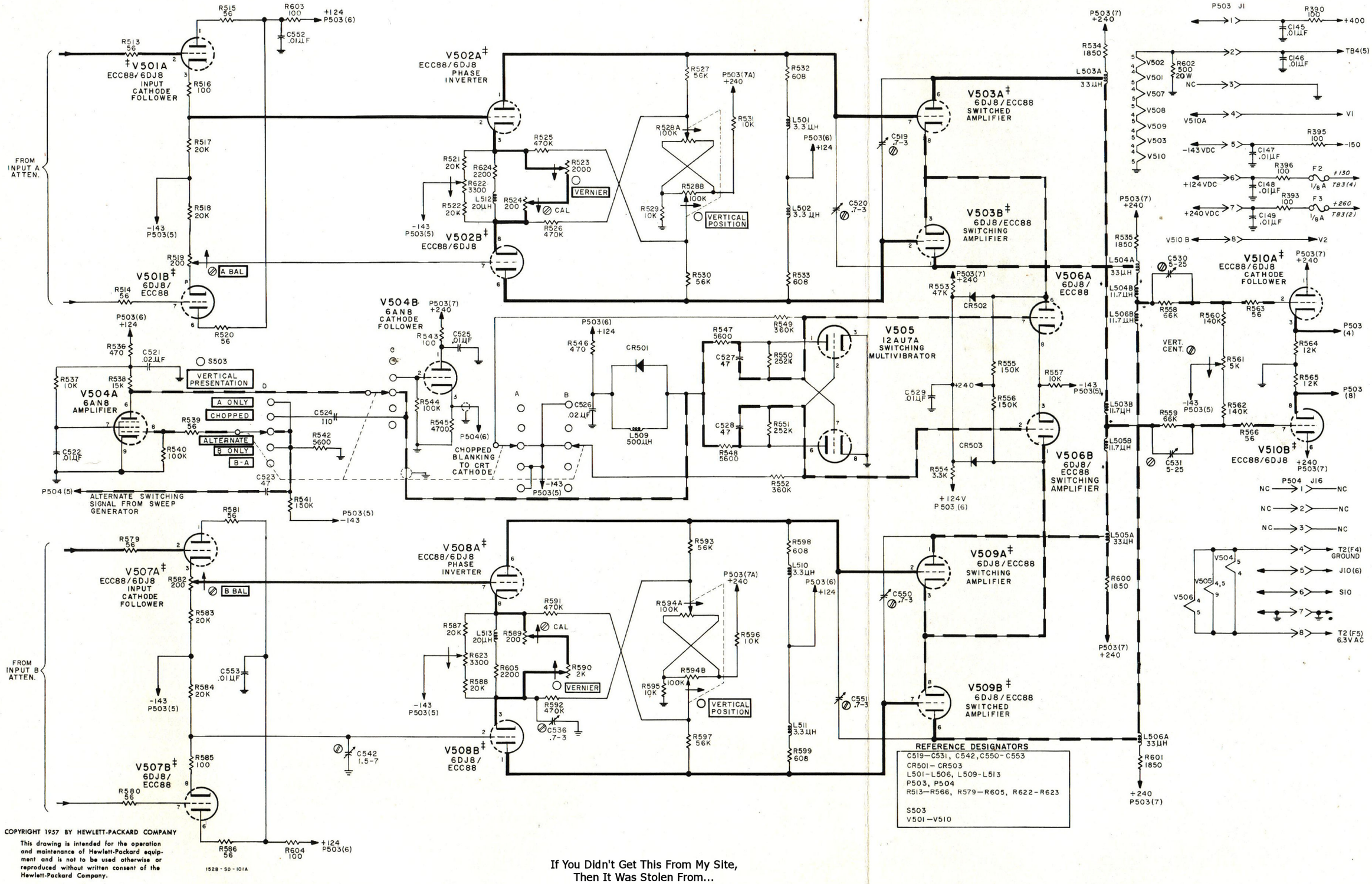

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1528-SO-101A

REFERENCE DESIGNATORS

C519—C531, C542, C550-C553
CR501—CR503
L501—L506, L509—L513
P503, P504
R513—R566, R579—R605, R622—R623

S503
V501—V510

SECTION IV
TABLE OF REPLACEABLE PARTS

NOTE

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

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

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

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	℗ STOCK NO.	#			
C501	Capacitor: fixed, mylar, 0.1 μf, ±20%, 600 vdcw Texas Capacitor Co.	16-110	2			
C502	Capacitor: fixed, ceramic, .01 μf, tol. ±20%, 250 vdcw CW*	15-135	4			
C503 thru C518	Capacitor: variable, polystyrene, 0.7-3.0 μμf L*	13-30	35			
C519, 520	Capacitor: variable, plastic, 0.7-3.0 μμf, 350 vdcw L*	13-26	4			
C521	Capacitor: fixed, ceramic disc, .02 μf, tol. + 100, - 0%, 600 vdcw G*	15-85	2			
C522	Capacitor: fixed, ceramic, .01 μf, -0 + 100%, 1000 vdcw CC*	15-43	5			
C523	Capacitor: fixed, ceramic, 47 μμf, ±5%, 500 vdcw, NPO temp. coeff. K*	15-34	1			
C524	Capacitor: fixed, ceramic, 110 μμf, ±2%, 500 vdcw K*	15-22	1			
C525	Same as C522					
C526	Same as C521					
C527, 528	Capacitor: fixed, mica, 47 μμf, ±5%, 300 vdcw V*	14-74	2			
C529	Same as C522					
C530, 531	Capacitor: variable, trimmer, ceramic, 5-25 μμf, NPO temp. coeff L*	13-28	2			
C532	Same as C501					
C533	Same as C502					
C534	Capacitor: variable, ceramic, 7-45 μμf, 500 vdcw L*	13-1	2			
C535	Capacitor: variable, ceramic, 5-25 μμf L*	13-35	2			

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

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		℗ STOCK NO.	#			
C536	Same as C503						
C537, 538	Capacitor: fixed, ceramic, 3.3 μμf, ±3%, 500 vdcw	L*	15-179	2			
C539 thru C541	Capacitor: fixed, ceramic, 2.2 μμf, ±3%, 500 vdcw	L*	15-178	3			
C542	Capacitor: variable, ceramic, 1.5-7 μμf, NPO	E*	13-27	1			
C543, 544	Same as C537						
C545 thru C547	Capacitor: fixed, titanium dioxide, 2.2 μμf, ±10%, 500 vdcw	DD*	15-52	3			
C548, 549	Same as C503						
C550, 551	Same as C519						
C552, 553	Same as C522						
C554	Capacitor: fixed, titanium dioxide, 4.7 μμf, ±5%, 500 vdcw	DD*	15-142	2			
C555, 556	Capacitor: fixed, titanium dioxide, 12 μμf, ±5%, 500 vdcw	DD*	15-165	4			
C557, 558, 559	Capacitor: fixed, ceramic, 14 μμf, ±3%, 500 vdcw	L*	15-171	6			
C560	Capacitor: fixed, ceramic, 16 μμf, ±3%, 500 vdcw	L*	15-172	2			
C561	Capacitor: fixed, mica, 15 μμf, ±5%, 300 vdcw	V*	15-137	2			
C562	Capacitor: fixed, silver mica, 30 μμf, ±5%, 500 vdcw	Z*	15-146	2			
C563	Capacitor: fixed, mica, 39 μμf, ±5%, 300 vdcw	V*	14-70	2			
C564	Capacitor: fixed, mica, 100 μμf, ±5%, 300 vdcw	V*	14-76	2			

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

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	℗ STOCK NO.	#			
C565	Capacitor: fixed, silver mica, 220 μμf, ±5%, 500 vdcw V*	15-76	2			
C566	Capacitor: fixed, mica, 470 μμf, ±5%, 500 vdcw J*	15-141	1			
C567, 568	Capacitor: fixed, mica, 1000 μμf, ±5%, 500 vdcw J*	15-114	4			
C569 thru C582	Same as C503					
C583	Same as C554					
C584, 585	Same as C555					
C586, 587, 588	Same as C557					
C589	Same as C560					
C590	Same as C534					
C591	Same as C535					
C592	Same as C561					
C593	Same as C562					
C594	Same as C563					
C595	Same as C564					
C596	Same as C565					
C597	Same as C566					
C598, 599	Same as C567					
C600, 601	Same as C502					

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

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ℌ STOCK NO.	#			
C602	Capacitor: fixed, titanium dioxide, 1 μμf, ±10%, 500 vdcw	DD*	15-102	1			
C603, 604	These circuit references not assigned						
C605, 606	Capacitor: variable, plastic, 0.7-3 μμf, 350 vdcw	L*	13-37	2			
C607	Capacitor: fixed, titanium dioxide, 2 μμf, ±5%, 500 vdcw	DD*	15-118	1			
CR501	Crystal, diode	BU*	212-G12	1			
CR502, 503	Crystal, diode	BU*	212-G11A	2			
J501, 502	Connector, type BNC	LL*	125-UG-1094/U	2			
L501, 502	Coil, RF, 3.3 μh	CG*	48-55	4			
L503A/B L504A/B L505A/B L506A/B	R. F. Coil Assembly: 42 μh/15 μh Note: Refer to factory service department. Replacement requires special test equipment not generally available.	HP*					
L507, 508	Bead, shielding Ferroxcube		911-63	2			
L509	Coil, r.f., 500 μh	CG*	48-37	1			
L510-511	Same as L501						
L512, 513	Coil, 20 μh	CG*	48-84	2			
P503, 504	Connector, male: 8 contact	HH*	125-5	2			
R501	Resistor: fixed, carbon film, 500,000 ohms, ±1%, 1/2 W	NN*	33-500KR	2			
R502	Resistor: fixed, carbon film, 1 megohm, ±1%, 1/2 W	NN*	33-1MR	6			
R503	Resistor: fixed, composition, 1 megohm, ±10%, 1/2 W	B*	23-1M	2			
R504	Same as R502						

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

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	℗ STOCK NO.	#
R505	Resistor: fixed, carbon film, 750,000 ohms, ±1%, 1/2 W NN*	33-750KR	2
R506	Resistor: fixed, carbon film, 333,000 ohms, ±1%, 1/2 W NN*	33-333KR	2
R507	Resistor: fixed, carbon film, 900,000 ohms, ±1%, 1/2 W NN*	33-900KR	2
R508	Resistor: fixed, carbon film, 111,000 ohms, ±1%, 1/2 W NN*	33-111KR	2
R509	Resistor: fixed, carbon film, 950,000 ohms, ±1%, 1/2 W NN*	33-950KR	2
R510	Resistor: fixed, carbon film, 52.6K ohms, ±1%, 1/2 W NN*	33-52.6KR	2
R511	Resistor: fixed, carbon film, 975,000 ohms, ±1%, 1/2 W NN*	33-975KR	2
R512	Resistor: fixed, carbon film, 25.6K ohms, ±1%, 1/2 W NN*	33-25.6KR	2
R513, 514 515	Resistor: fixed, composition, 56 ohms, ±10%, 1/2 W B*	23-56	11
R516	Resistor: fixed, composition, 100 ohms, ±10%, 1/2 W B*	23-100	5
R517, 518	Resistor: fixed, metal film, 20,000 ohms, ±2%, 1 W AB*	331-20K	8
R519	Resistor: variable, 200 ohms, ±20%, 1/4 W BO*	210-158	4
R520	Same as R513		
R521, 522	Same as R517		
R523	Resistor: variable, composition, linear taper, 2000 ohms, ±30%, with switch BO*	210-236	2
R524	Same as R519		
R525, 526	Resistor: fixed, composition, 470,000 ohms, ±10%, 1/2 W B*	23-470K	4
R527	Resistor: fixed, composition, 56,000 ohms, ±10%, 1/2 W B*	23-56K	4

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

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	℔ STOCK NO.	#			
R528A/B	Resistor: variable, composition, 100,000 ohms, ±10%, 2 W BO*	210-131	2			
R529	Resistor: fixed, composition, 10,000 ohms, ±10%, 1/2 W B*	23-10K	5			
R530	Same as R527					
R531	Same as R529					
R532, 533	Resistor: fixed, deposited carbon, 608 ohms, ±1%, 1/2 W NN*	33-608	4			
R534, 535	Resistor: fixed, deposited carbon, 1850 ohms, ±1%, 1/2 W NN*	33-1850	4			
R536	Resistor: fixed, composition, 470 ohms, ±10%, 1/2 W B*	23-470	2			
R537	Same as R529					
R538	Resistor: fixed, composition, 15,000 ohms, ±10%, 1 W B*	24-15K	1			
R539	Same as R513					
R540	Resistor: fixed, composition, 100,000 ohms, ±10%, 1/2 W B*	23-100K	2			
R541	Resistor: fixed, composition, 150,000 ohms, ±10%, 1/2 W B*	23-150K	3			
R542	Resistor: fixed, composition, 5600 ohms, ±10%, 1/2 W B*	23-5600	1			
R543	Same as R516					
R544	Same as R540					
R545	Resistor: fixed, composition, 4700 ohms, ±10%, 1 W B*	24-4700	1			
R546	Same as R536					

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

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	℗ STOCK NO.	#
R547, 548	Resistor: fixed, composition, 5600 ohms, ±10%, 1 W B*	24-5600	2
R549	Resistor: fixed, composition, 360,000 ohms, ±5%, 1/2 W B*	23-360K -5	2
R550, 551	Resistor: fixed, deposited carbon, 252,000 ohms, ±1%, 1/2 W NN*	33-252K	2
R552	Same as R549		
R553	Resistor: fixed, composition, 47,000 ohms, ±10%, 1/2 W B*	23-47K	1
R554	Resistor: fixed, composition, 3300 ohms, ±10%, 1/2 W B*	23-3300	1
R555, 556	Same as R541		
R557	Resistor: fixed, glass body, 10,000 ohms, ±5%, 5 W AB*	335-10K -5	1
R558, 559	Resistor: fixed, deposited carbon, 66,000 ohms, ±1%, 1/2 W NN*	33-66K	2
R560	Resistor: fixed, deposited carbon, 140,000 ohms, ±1%, 1/2 W NN*	33-140K	2
R561	Resistor: variable, composition, linear taper, 5000 ohms, ±30%, 1/3 W BO*	210-134	1
R562	Same as R560		
R563	Same as R513		
R564, 565	Resistor: fixed, composition, 12,000 ohms, ±10%, 2 W B*	25-12K	2
R566	Same as R513		
R567	Resistor: fixed, carbon film, 990,000 ohms, ±1%, 1/2 W NN*	33-990KR	2
R568	Resistor: fixed, carbon film, 10.1K ohms, ±1%, 1/2 W NN*	33-10.1KR	2

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

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ℎ STOCK NO.	#			
R569	Same as R503						
R570	Same as R502						
R571	Resistor: fixed, carbon film, 995,000 ohms, ±1%, 1/2 W	NN*	33-995KR	2			
R572	Resistor: fixed, carbon film, 5.03K ohms, ±1%, 1/2 W	NN*	33-5.03KR	2			
R573	Same as R502						
R574	Resistor: fixed, carbon film, 2.51K ohms, ±1%, 1/2 W	NN*	33-2.51KR	2			
R575, 576	Resistor: fixed, composition, 1.5 megohms, ±10%, 1/2 W	B*	23-1.5M	2			
R577, 578	These circuit references not assigned						
R579, 580, 581	Same as R513						
R582	Same as R519						
R583, 584	Same as R517						
R585	Same as R516						
R586	Same as R513						
R587, 588	Same as R517						
R589	Same as R519						
R590	Same as R523						

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

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ℎp STOCK NO.	#			
R591, 592	Same as R525					
R593	Same as R527					
R594A/B	Same as R528A/B					
R595, 596	Same as R529					
R597	Same as R527					
R598, 599	Same as R532					
R600, 601	Same as R534					
R602	Resistor: fixed, wirewound, 500 ohms, ±10%, 20 W S*	27-5	1			
R603, 604	Same as R516					
R605	Resistor: fixed, composition, 2200 ohms, ±10%, 1/2 W B*	23-2200	2			
R606	Same as R501					
R607	Same as R502					
R608	Same as R505					
R609	Same as R506					
R610	Same as R507					

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

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	℔ STOCK NO.	#
R611	Same as R508		
R612	Same as R509		
R613	Same as R510		
R614	Same as R511		
R615	Same as R512		
R616	Same as R567		
R617	Same as R568		
R618	Same as R571		
R619	Same as R572		
R620	Same as R502		
R621	Same as R574		
R622, 623	Resistor: variable, composition, 3300 ohms, ±30%, 1/3 W BO*	210-235	2
R624	Same as R605		
S501	Polarity Switch Assembly, A channel HP*	152B-19B	1
S502	VOLTS/CM Switch Assembly HP*	152A-34B	2
S503	Vertical Presentation switch W*	310-178	1
S504	Polarity Swtich Assembly, B channel HP*	152B-19C	1

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

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗ STOCK NO.	#
S505	Same as S502			
V501, 502	Tube, electron: 6DJ8/ECC88 Tubes selected for best performance will be supplied by ⓗ (if ordered by ⓗ Stock No.), but tubes meeting RETMA standards will normally result in the instrument operating within specifications.	ZZ*	G-73Z	4
V503	Tube, electron: 6DJ8/ECC88 Tubes selected for best performance will be supplied by ⓗ (if ordered by ⓗ Stock No.), but tubes meeting RETMA standards will normally result in the instrument operating within specifications.	ZZ*	G-73R	3
V504	Tube, electron: 6AN8	ZZ*	212-6AN8	1
V505	Tube, electron: 12AU7A	ZZ*	212-12AU7A	1
V506	Tube, electron: 6DJ8/ECC88	ZZ*	212-6DJ8	1
V507, 508	Same as V501			
V509, 510	Same as V503			
XV501 thru XV510	Socket, tube: 9 pin	H*	120-49	10
	MISCELLANEOUS			
	Alignment attenuator (one)	HP*	152B-38A	
	Connector, BNC	LL*	125-UG-1094/U	1
	Extender, for servicing plug-in amplifiers	HP*	150A-95L	
	Knob: VERTICAL PRESENTATION (black)	HP*	G-74N	1

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

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	℗ STOCK NO.	#			
	Knob: POLARITY and VOLTS/CM (black) HP*	G-74Q	4			
	Knob: VERTICAL POSITION and VERNIER (red) HP*	G-74AU	4			
	Shield: for attenuator alignment HP*	152B-38B				
	Tube clamp mounting ring for 9 pin miniature printed circuit tube socket HP*	G-52F	10			

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

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

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

CLAIM FOR DAMAGE IN SHIPMENT

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

WARRANTY

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

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

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

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

SHIPPING

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

DO NOT HESITATE TO CALL ON US

HEWLETT-PACKARD COMPANY
Laboratory Instruments for Speed and Accuracy
275 PAGE MILL ROAD PALO ALTO, CALIF. U.S.A.
CABLE "HEWPACK"