HEWLETT-PACKARD COMPANY / OPERATING AND SERVICE MANUAL

187B

DUAL TRACE VERTICAL AMPLIFIER

CERTIFICATION

THE HEWLETT-PACKARD COMPANY CERTIFIES THAT THIS INSTRUMENT WAS THOROUGHLY TESTED AND INSPECTED AND FOUND TO MEET ITS PUBLISHED SPECIFICATIONS WHEN IT WAS SHIPPED FROM THE FACTORY.

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OPERATING AND SERVICE MANUAL

MODEL 187B

SERIALS PREFIXED: 121 -

DUAL TRACE VERTICAL AMPLIFIER

01166-1

Printed: JAN 1962

MANUAL CHANGES

MODEL 187B

DUAL TRACE VERTICAL AMPLIFIER

Manual Serial Prefixed: 121-
Manual Printed: 1/62

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

Instrument Serial Prefix	Make Manual Changes	Instrument Serial Prefix	Make Manual Changes
215-	1		

ERRATA

Figure 3-2,
CR501: should read CR503.
CR503: should read CR501.

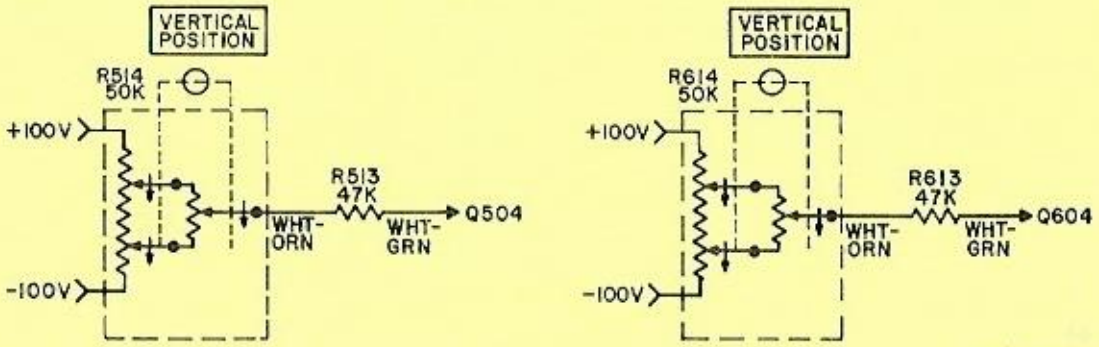
Figure 3-9,
Assembly A501 PROBE: should read A601 PROBE.
All reference designators in A601 should be in 600 series.

Table 4-1,
R535, 635: should be hp Stock No. 2100-0015; var, comp, 500K ohms ±20%. 1/4W.
CR511, 512, 515, 517, 611, 612, 615, 617: Change hp Stock No. to 1901-0104.
CR513, 613: Change hp Stock No. to 1902-0058.

Table 4-2,
Change hp Stock No. G-31A-12L to 1902-0058: Change TQ and RS to 3.
Add: hp Stock No. 2100-0015; var, comp, 500K ohms ±20%, 1/4W; Mfr. 71590; Mfr. Part No. Model 2; TQ 2; RS 1.
Add: hp Stock No. 1901-0104; Diode, Si; Mfr. 28480; TQ 8;RS 8.

CHANGE 1

CR507, 508, 509, 510, 607, 608, 609, 610: Change to diode, si; hp Stock No. 1901-0040; Mfr. 98925; Mfr. Part No. CMD7131; TQ 8; RS 8.
Knob, hp Stock No. G-74AU: Delete
Knob, hp Stock No. G-74CF: Delete
Add: Knob, 1", Black, hp Stock No. 0370-0029; Mfr. 28480; Mfr. Part No. 0370-0029.
R515, 516, 615, 616: Delete
R514, 614: Change to resistor, var, ww, lin, 50K ohms ±5%; hp Stock No. 2100-0352; Mfr. John Fluke; Mfr. Part No. 21A (Modified); TQ 2; RS 1.
See partial schematic below:



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Supplement A for 187B-900

Instrument Serial Prefix	Make Manual Changes	Instrument Serial Prefix	Make Manual Changes
215-	1		

CHANGE 1 (Cont'd)

Add C501, 601: Capacitor, fixed, titanium dioxide, 1 pf ±10%, 500 vdcw; Ⓟ Stock No. 0150-0029.
Add R502, 602: Resistor, fixed, deposited carbon, 100 ohms ±1%, 1/10W; Ⓟ Stock No. 0721-0014.
See partial schematic below:

Table 4-1,
CR501 thru CR504: Change to diode, gallium arsenide; Ⓟ Stock No. 1906-0001 (consists of 4 matched diodes).
CR601 thru CR604: Change to diode, gallium arsenide; Ⓟ Stock No. 1906-0001 (consists of 4 matched diodes).

Table 4-2,
Delete: Ⓟ Stock No. G-29L-52 and G-29L-58.
Add: Ⓟ Stock No. 1906-0001; diode, gallium arsenide; Mfr. 28480; Mfr. Part No. 1906-0001; TQ 8; RS 8.

MANUAL CHANGES

MODEL 187B

DUAL TRACE VERTICAL AMPLIFIER

Manual Serial Prefixed: 121-
Manual Printed: 1/62

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

Instrument Serial Prefix	Make Manual Changes	Instrument Serial Prefix	Make Manual Changes
118-	1, 2		
052-	1, 3		
043-	1, 3, 4		
039-	1, 3, 4		

CHANGE #1

Figure 3-8,
Change the value of R509 and R511 to 4000 ohms
Change the value of R510 to 2000 ohms

Figure 3-9,
Change the value of R609 and R611 to 4000 ohms
Change the value of R610 to 2000 ohms

Table of Replaceable Parts,
R509, 511, 609, 611: Change hp Stock No. to 0727-0115
R510, 610: Change hp Stock No. to 2100-0091

hp Stock No. 0727-0115: Change TQ column to read "8"
hp Stock No. 2100-0091: Change TQ column to read "3"

CHANGE #2

Figure 3-8,
Delete R535 and replace with a straight through connection

Figure 3-9,
Delete R635 and replace with a straight through connection

Table of Replaceable Parts,
R535, 635: Delete

Section III, MAINTENANCE, Paragraph 3-33,
Change step i to read: "Adjust Response Limit with R523 for less than 5% overshoot with RESPONSE optimized."

Change step k to read: "Repeat for channel B, using the Response Adjust Limit R623."

CHANGE #3

Figure 3-8,
Remove R576 (10K resistor) from pins 20 and 23 of P501. Move blue-white lead from pin 23 to pin 20 of P501. Add R576 (10K resistor) in series with the blue-white lead.

Figure 3-9,
Remove R676 (10K resistor) from pins 8 and 11 of P501. Move blue-orange lead from pin 11 to pin 8. Add R676 (10K resistor) in series with the blue-orange lead.

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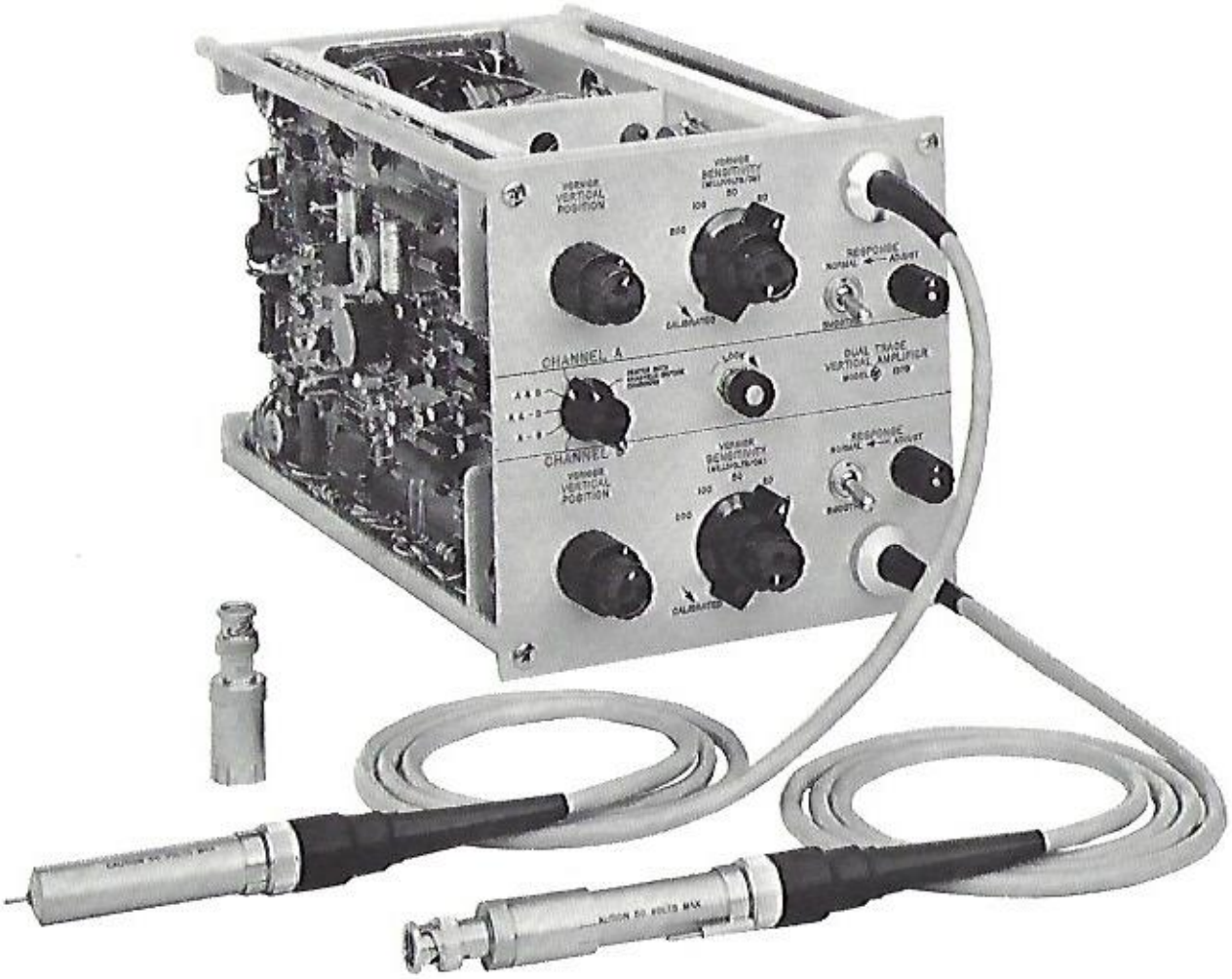


Figure 1-1. Model 187B Dual Trace Vertical Amplifier

SECTION I
OPERATION

1-1. GENERAL DESCRIPTION.

1-2. The Ⓟ Model 187B Dual Trace Amplifier is a plug-in vertical amplifier unit for use with the Ⓟ Model 185A/B Oscilloscope. The unit is shown in figure 1-1. The Model 187B provides the Model 185A/B Oscilloscope with a bandwidth always greater than 800 mc. Bandwidth as high as 1000 mc can be obtained with repetitive input signal uniform from cycle to cycle. The Model 187B has two identical but independent signal channels, each with its own sensitivity, position, and response controls and therefore can provide the oscilloscope with two signals simultaneously. A front-panel switch controls the presentation of the signals on the cathode ray tube (crt), permitting selection of the following operating conditions: 1) Channel A signal only, 2) Channel A and Channel B signals appearing simultaneously but as independent displays, 3) Channel A and Channel B signals appearing simultaneously, again as independent displays but with the polarity of the Channel B display inverted, 4) Channel A signal minus Channel B signal--differential display, and 5) Channel B signal only.

1-3. The Model 187B uses the sampling technique; that is, it samples or senses the amplitude at various points along an input signal instead of continuously monitoring the signal. Samples are taken each time a trigger pulse occurs, and the signal is plotted point-by-point on the crt of the Model 185A/B. The actual sampling rate is determined by the Model 185A/B, for triggers occurring faster than 100 kc and by the external trigger input for triggers below 100 kc.

1-4. All necessary connections between Model 187B and Model 185A/B Oscilloscope are made automatically when the plug-in unit is inserted into the oscilloscope. A lockscrew secures the Model 187B in place; always tighten the lockscrew after installing the plug-in to insure good electrical and mechanical connection.

1-5. INPUT PROBES.

1-6. Input signals are applied to the Model 187B through probes which are permanently attached to the unit. Signals can be up to 2 volts peak-to-peak without overloading the probes regardless of sensitivity range. Overload does not interfere with the presentation of a waveform or part of a waveform provided the probes have about 10 microseconds to recover. Therefore, be sure any overload precedes the signal to be viewed by at least 10 microseconds.

WARNING

Voltages greater than ±50 volts peak may damage the probes.

1-7. The basic probe has an axial pin for contacting a test point and a pin on a sliding ring around the

Table 1-1. Specifications

EACH CHANNEL

Passband: DC to greater than 800 mc at 3 db point. Less than 0.50 nsec rise time.* A passband of dc to greater than 1000 mc at 3 db point, corresponding to a rise time of less than 0.35 nsec, may be obtained if operation is limited to waveforms that are identical from occurrence to occurrence.

Overshoot or Undershoot: Less than 5%.*

Sensitivity: Calibrated ranges 10 mv/cm to 200 mv/cm in a 1, 2, 5 sequence. Vernier control between steps which increases sensitivity to 3 mv/cm.

Input: By means of input probes for each channel.

Noise: Approximately 2 mv peak-to-peak; reduced by approximately 5:1 in smoothed (noise compensation) position of response switch.

Input Impedance: 100K shunted by 2 pf.

Accessories Furnished:
187A-76A BNC Adapter, 2 supplied
187B-76F Adapter, 2 supplied

Accessories Available:
187A-76B Type N Adapter
187A-76C 10:1 Divider
187A-76D Blocking Capacitor
187B-76E 50-ohm T Connector

* The present lack of a pulse generator which can provide a pulse sufficiently fast and distortion free to serve as a waveform standard for the 187B makes it difficult to specify exactly the step response of the 187B. The specified rise time of less than 0.50 nsec is that observed from a tunnel-diode pulse generator and includes the effect of the rise time of the pulse generator itself, estimated to be about 0.2 nsec. The theoretical rise time of the 187B based on its measured bandwidth, which exceeds 800 mc, is less than 0.44 nsec.

body of the probe for contacting ground. The ground pin should contact ground as close as possible to the test point. The input impedance of the basic probe is 100K shunted by 2 pf.

1-8. Positioning and response interference, and interaction between channels may result if the probes are connected together or to the same test point. One foot of wire or cable between the probes provides sufficient isolation to avoid these effects.

1-9. ACCESSORIES.

1-10. There are a number of accessories which make the unit more versatile and easier to use. The accessories and their functions are listed below. Additional information on the use of the accessories is covered in Application Note 44D.

1-11. 187B-76F ADAPTER. This sleeve is used to connect accessories, with screw fittings, to the probe.

1-12. 187A-76A BNC ADAPTER. This adapter converts the probe input to a male BNC connector. The adapter provides a straight-through connection only and is not a cable matching termination.

1-13. 187A-76B TYPE N ADAPTER. This adapter converts the probe input to a male type N connector. The adapter provides straight-through connection only and is not a cable matching termination.

1-14. 187B-76C 10:1 DIVIDER. This unit decreases sensitivity by a factor of ten, so you can measure signals up to 20 volts peak-to-peak. The input impedance of the probe/divider is 1 megohm shunted by 2.5 pf. The divider itself has an axial pin like that of the basic probe for contacting test points.

1-15. 187A-76D BLOCKING CAPACITOR. This unit mounts directly on the probe or on the 10:1 divider to provide ac coupling. With the blocking capacitor mounted, you can connect the probe or probe/divider to dc voltages as high as 600 volts; however, the maximum ac signal remains 2 volts peak-to-peak for the probe and 20 volts peak-to-peak for the probe/divider. With the capacitor mounted directly on the probe, the rc time constant is such that a flat-topped, 1-μsec pulse sags only 1%; with the capacitor mounted on the 10:1 divider, a flat-topped, 1-μsec pulse sags only 0.1%. The blocking capacitor adds 0.3 to 0.5 pf shunt capacitance to the input. Remove the axial pin from the probe or divider before mounting the blocking capacitor.

1-16. 187B-76E TYPE N 50-OHM TEE CONNECTOR. The tee permits observation of signals in a 50 ohm system and can be placed in series with or at the end of a 50-ohm transmission line. When in series with the line, the tee neither disturbs the line nor appreciably attenuates the signal being transmitted. At 500 mc, insertion loss is less than 1 db and swr less than 1.5. When the tee is at the end of a line, the line is unterminated; however, you can terminate the line by connecting a low-reflection load such as the Ⓗ Model 908A 50-ohm load to the open end of the tee. Both ends of the tee have female type N connectors.

1-17. RESISTIVE DIVIDERS. Resistive dividers provide a low-capacity input (less than 0.4 pf shunt capacity) and input attenuation. The dividers can be used directly with the probes of the 187B or with the AC-16V Delay Line and 185A-76A Sync Take-Off when the Model 185A/B Oscilloscope is to be triggered with the vertical input signal. Divider data is listed in table 1-1. To provide their specified attenuation, the dividers must be terminated in 50 ohms.

Table 1-2. Resistive Dividers

Divider	Attenuation	Input Impedance (ohms)	Max. Input Voltage (rms)
185A-21C	5:1	250 (0.4 pf shunt)	10
185A-21D	10:1	500 (0.4 pf shunt)	12
185A-21E	50:1	2500 (0.4 pf shunt)	25
185A-21F	100:1	5000 (0.4 pf shunt)	35

1-18. The AC-16W Cable, a 3-ft, 50-ohm coaxial cable, permits use of the divider at the end of a flexible line for probing into circuits. To provide proper termination for the dividers or divider/cable combination, use the 187B-76E 50-ohm tee connector and 50-ohm load with the probes.

1-19. VERTICAL POSITION.

1-20. The VERTICAL POSITION controls provide continuous control up to a maximum which is equivalent to about ±2 volts dc on the input, regardless of sensitivity. As a result, you can position on the crt any portion of a signal which is less than about ±2 volts, and although parts of a signal may be as much as 60 screen diameters off screen, the first sample on the crt is valid. VERNIER controls provide fine adjustment of vertical position.

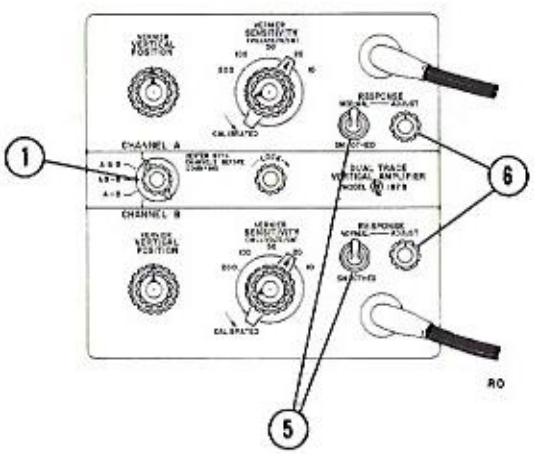
1-21. The Model 187B responds to dc as well as ac, and some unbalance in the probe is normal. For these reasons, vertical position may shift and require resetting when you change sensitivity. Also, dc zero depends somewhat on circuit impedance, so to determine zero level, de-energize the circuit under test rather than remove or short circuit the probe.

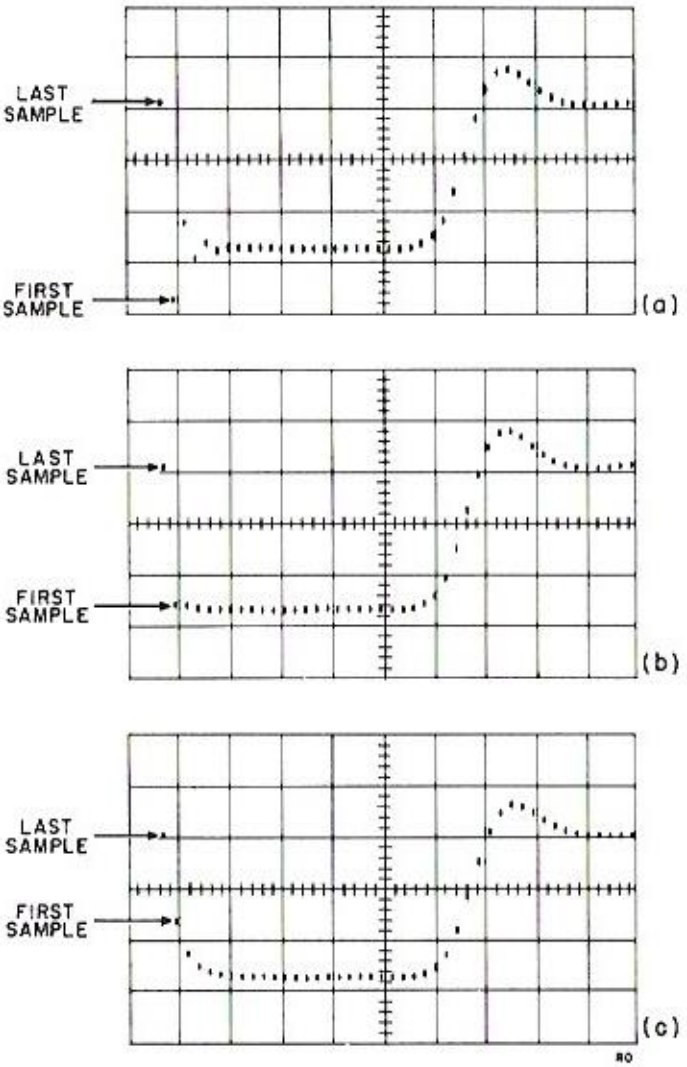
1-22. RESPONSE.

1-23. DEFINITION.

1-24. Response of the Model 187B is a measure of its sampling efficiency, its ability to follow any voltage change from sample to sample. Response is optimum when, within the rise time limits of the instrument, the vertical position of each sample on the crt 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 high, there is sample-to-sample overshoot and ringing. See figure 1-2.

1-25. The Model 187B provides two types of response, normal and smoothed, either of which can be selected from the front panel. Normal response is optimum, when properly adjusted (see below) and





1. Select channel A or B.
2. Connect probe to circuit under test.
3. Adjust Model 185A/B TIME SCALE and DELAY for a presentation on screen.
4. Adjust Model 187B SENSITIVITY for a display between 5 cm and 6 cm high.
5. Set RESPONSE switch to NORMAL.
6. Rotate RESPONSE ADJUST so second sample from left is on the waveform as shown in waveform (b).
7. Waveform (a) indicates response too high. high.
8. Waveform (c) indicates response too low.

Figure 1-2. Optimizing the Response Adjustment

is intended for most measurement situations. Normal response should be used when viewing non-uniform signals and fast pulse time. Smoothed response provides a filtering of the input signal that reduces the effects of noise and jitter by about 5:1 compared to the effects seen on normal response. Smoothed response is very useful for viewing noisy and unstable and non-uniform signals.

1-26. ADJUSTMENT.

1-27. NORMAL RESPONSE. Adjustment for optimum operating conditions are illustrated in figure 1-2. Any waveform that produces a level difference between the beginning and end of the display may be used for this adjustment.

1-28. The response should be checked occasionally during warmup. The response may also change slightly each time the probe is moved to a point of different impedance. If uniform pulses of nominal rise time (a few nanoseconds) are being viewed the response will rarely need readjustment once it has been set.

1-29. SMOOTHED RESPONSE. Obtain SMOOTHED RESPONSE by setting the response in the normal condition, as described in figure 1-2, and then moving the RESPONSE switch to SMOOTHED.

1-30. INCREASED PASSBAND. Increased passband may be obtained by adjusting the RESPONSE control, so the second sample is halfway between the first sample and the waveform. Although overshoot increases in this condition of operation, it is very useful when viewing transients between 0.5 ns and 0.35 ns. The instrument now requires more than one sample to display the amplitude of the input signal and therefore acts similar to smoothed response. This effect can be made negligible by selecting a time-scale so the step is displayed by at least 15 samples.

1-31. DUAL TRACE OPERATION.

1-32. Dual trace operation permits time and amplitude comparisons between the signals applied to the two channels of the Model 187B. Both channels sample at the same time, and the two channels are alternately connected to the crt at such a rate that both signals appear during the same sampling period. Thus corresponding samples on the two traces represent the same instant of time. Since the two channels are independent, you can operate them at different sensitivities without loss of calibration and so can compare large signals with small ones.

1-33. There are two types of dual channel operation: A&B and A&-B. On A&B positive-going signals produce positive-going waveforms on both channels. On A-B, the Channel B signal is inverted.

1-34. DIFFERENTIAL OPERATION.

1-35. Differential (A-B) operation permits observation of the difference between two signal voltages. This type of operation is useful when measuring signals which are balanced to ground, signals which are not referenced to ground, and signals which contain common hum, pickup, and other equal (common mode) components. As a differential amplifier, the Model 187B attenuates common mode signals 20 db.

1-36. Before switching to A-B, independently position the entire presentation from each channel on screen. Also, each time you change differential sensitivity, recheck vertical position of each channel separately.

1-37. DELAY LINES.

1-38. A finite delay exists between the time the sync circuit is triggered and the sample is taken. When triggering from the source being viewed, an external delay line must be inserted in the line supplying the vertical signal to offer a corresponding delay. The rise time of the delay line must be somewhat faster than the rise time of the signal to be viewed to eliminate waveform distortion.

1-39. The AC-16V was designed around a compromise between rise time and space. This delay line has a bandwidth of approximately 1000 mc with a nominal 1 ns rise time between the 0% and 90% points. These rise times are more than adequate for most measurements. For very fast rise times delay line load (AC-16V-76A) should be used with the delay line to compensate for the inherent coaxial cable rise time.

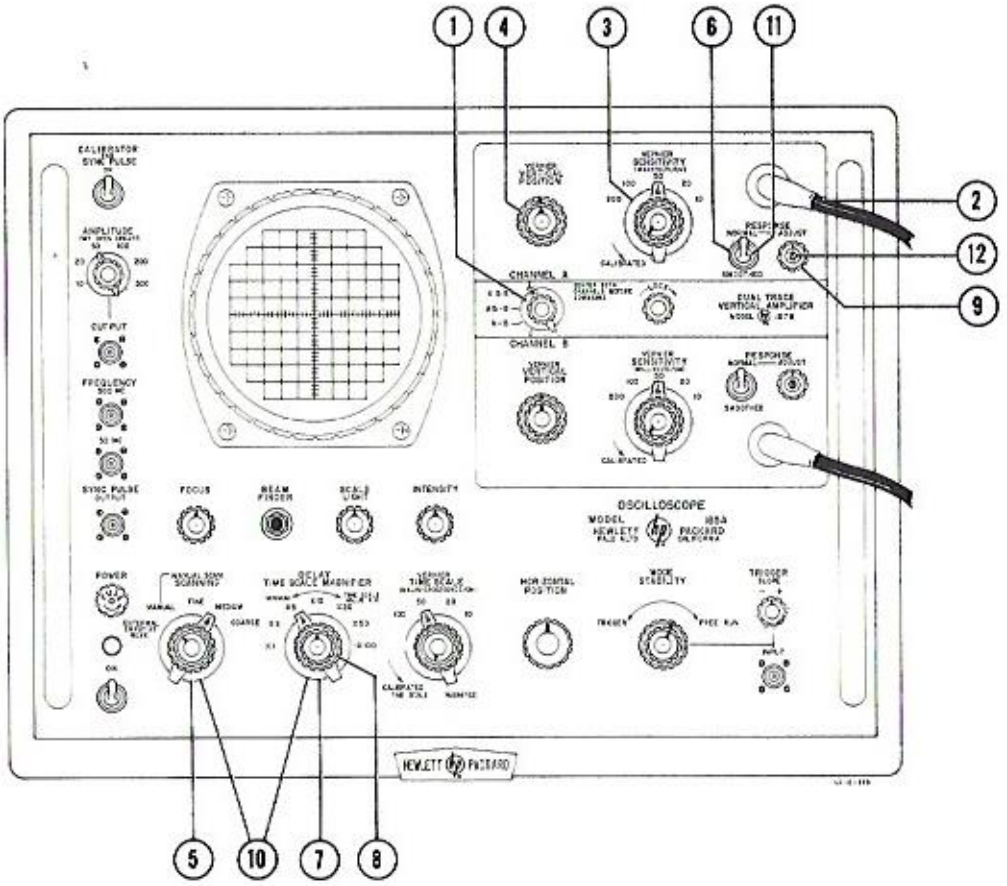
1-40. OPERATING INSTRUCTIONS.

1-41. The following figures give basic operating instructions for the Model 187B. These instructions supplement the instructions in the Model 185A/B Oscilloscope manual.

Figure 1-3. Single-Channel Presentation

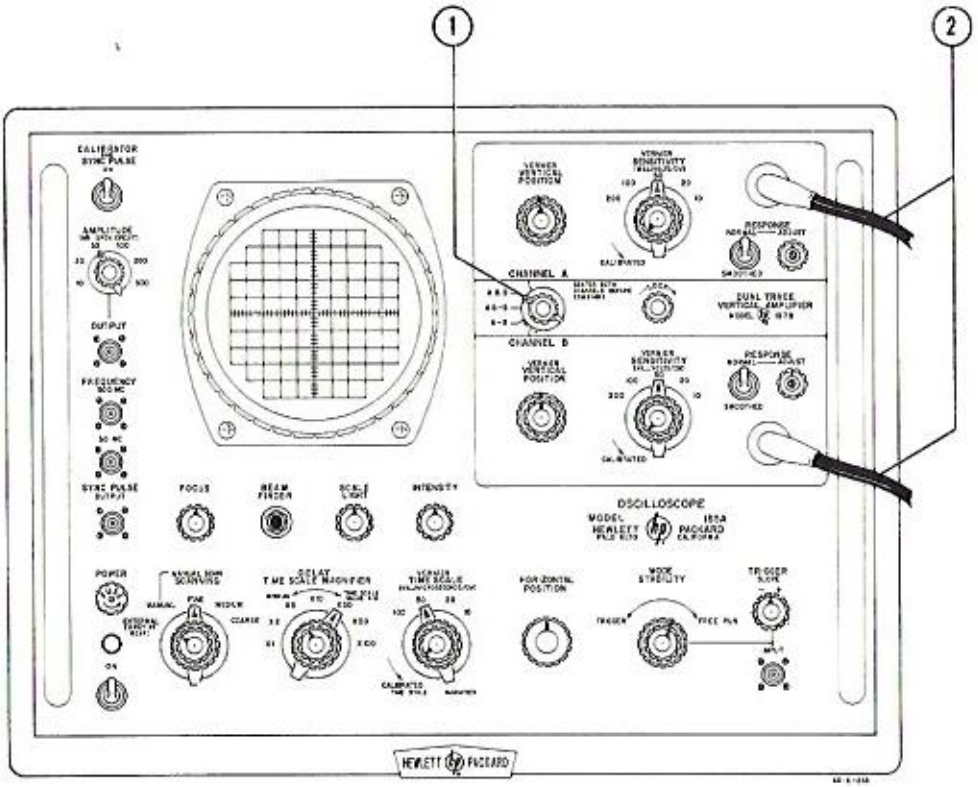
Figure 1-4. Dual-Channel Presentation

Figure 1-5. Differential Presentation



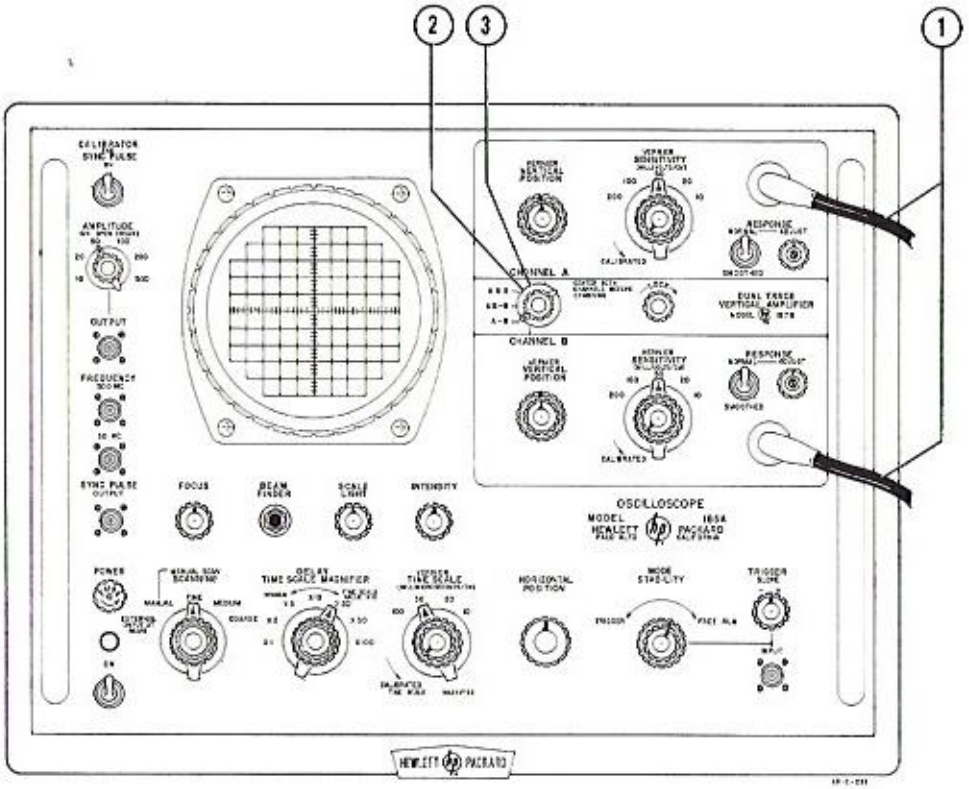
1. Select CHANNEL A.
2. Connect probe to test point. If signal is greater than 2 volts peak-to-peak, use external attenuator. Warning: Voltages greater than ±50 volts peak may damage probe.
3. Set SENSITIVITY as desired (set VERNIER to CALIBRATED for calibrated sensitivity).
4. Adjust VERTICAL POSITION as desired.
5. Set SCANNING to MEDIUM.
6. Set RESPONSE to NORMAL.
7. Set TIME SCALE MAGNIFIER to X2 or higher.
8. Adjust DELAY to produce a jump between first sample on left and waveform (maximum jump: 100 mv).
9. Set RESPONSE ADJUST to make second sample from left part of waveform (see figure 1-2). If range is limited, see step 12.
10. Return SCANNING, TIME SCALE MAGNIFIER, and DELAY to desired settings.
11. If desired, set RESPONSE to SMOOTHED to reduce noise effects. Rise time is affected less than 10% if rise on NORMAL is displayed by more than 26 samples.
12. Response Adjust Limit - see section III, paragraph 3-31.

Figure 1-3. Single-Channel Presentation



1. Select A&B to directly compare Channel A and Channel B signals. Select A&-B to compare Channel A signal with inverted Channel B signal.
2. Connect probes to signals to be viewed.
3. Set controls for each channel as instructed in Single-Channel Presentation.

Figure 1-4. Dual-Channel Presentation



1. Connect probes to signal(s) to be viewed.

2. Select A& B and set controls for each channel as instructed in Single-Channel Presentation. Be sure entire signal from each channel is on screen.

3. Select A - B. (If you change sensitivity, return to A & B and readjust VERTICAL POSITION controls to place both traces on-screen.)

Figure 1-5. Differential Presentation

SECTION II
CIRCUITS

2-1. INTRODUCTION.

2-2. The Model 187B is a plug-in dual channel vertical amplifier for the Model 185A/B Oscilloscope. The channels of the Model 187B are identical in their operation, so only Channel A is covered in this section.

2-3. The Models 185A/B and 187B combination utilizes the sampling techniques to synthesize high-frequency, repetitive waveforms without resorting to high-frequency amplifiers. The Model 187B senses the amplitude of a particular 0.5-nsec section of an input signal and applies this amplitude after amplification to the vertical amplifier of the Model 185A/B. This sensing or sampling occurs on the command of the Model 185A/B and occurs slightly later on each occurrence of the input signal. Each time the Model 187B is commanded to sample, the Model 185A/B moves the crt beam horizontally a distance corresponding to the added time delay from sample to sample, and each sample is stored or stretched and continuously displayed until the next sample. Figure 2-1 is a simplified illustration of the sampling technique.

2-4. BASIC OPERATION.

2-5. MODEL 187B AS FEEDBACK DEVICE.

2-6. The Model 187B is a feedback device which detects any difference or error between an input voltage and a previously stored output voltage and then nullifies that difference by changing the stored output voltage. Refer to figure 2-2. The stored voltage is fed back to a capacitance in the probe, and the voltage on this probe capacitance is compared to the input voltage during sampling time. If the voltage on the probe capacitance is different from the input voltage when the sampler gate opens, the capacitance charges or discharges toward the input voltage. Any error between the input voltage and the stored output voltage during sampling then, appears as a voltage change across the probe capacitance. This voltage change, amplified and stretched, corrects the stored output voltage to make it equal to the input voltage at the time of the sample.

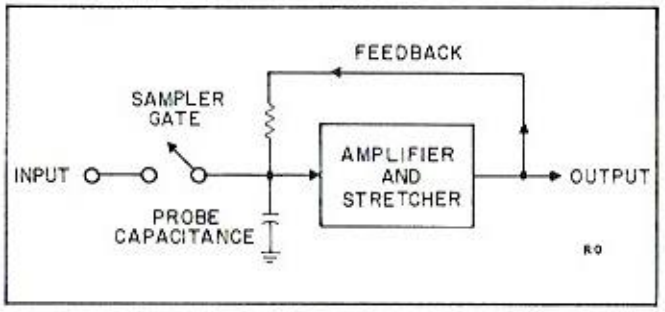


Figure 2-2. Sampler and Feedback

2-7. The sampler gate closes before the probe capacitance has time to charge or discharge fully. Amplifier gain is adjusted to compensate for this fact. Thus the loop gain is unity, and the feedback fully charges the probe capacitance to the level of the input after only one sample. This nulling arrangement stabilizes the sensitivity of the system by making it dependent only on the feedback and independent of the sampler and amplifier.

2-8. SIMPLIFIED OPERATION.

2-9. Figure 2-3 is a simplified block diagram of one channel of the 187B. The sampler pulse generator and blocking oscillator are common to both channels and operate the sampler gates, stretcher clamps, and

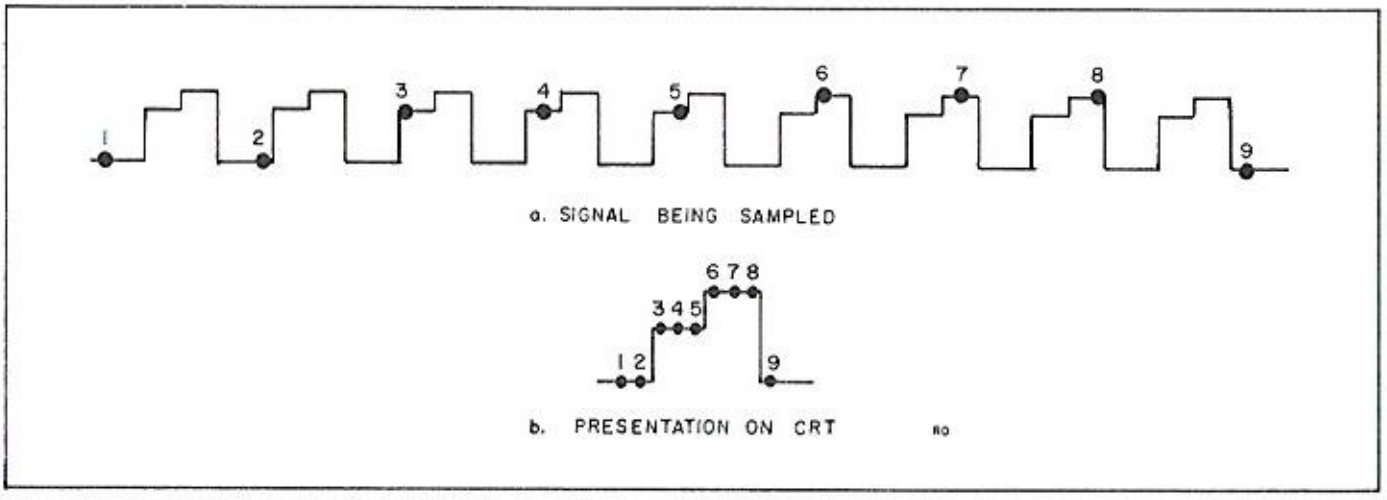


Figure 2-1. The Sampling Technique

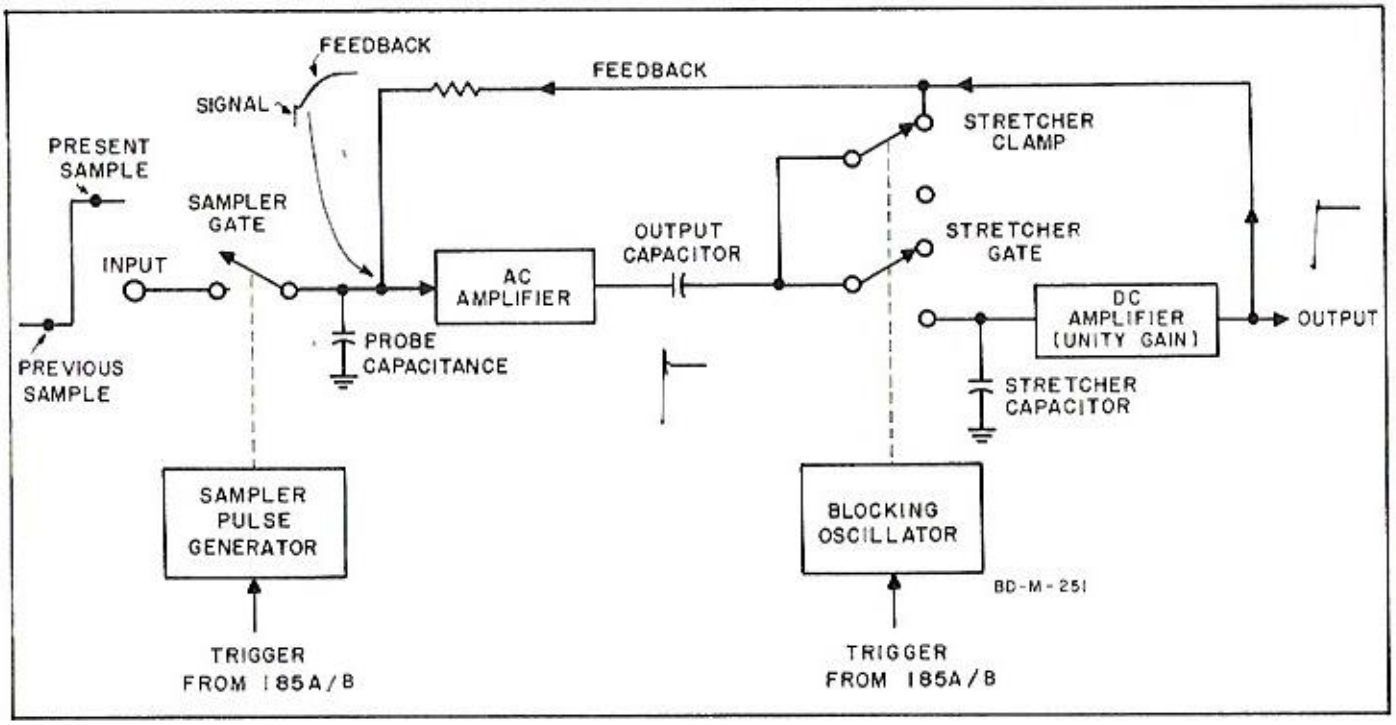


Figure 2-3. Simplified Block Diagram of One Channel

stretcher gates in both channels simultaneously. (For the purpose of illustration, the sampler and stretcher gates are shown as switches. However, gate and switch terminology are opposites: when a gate is open, it acts as a closed switch; when a gate is closed it acts as an open switch.)

2-10. Prior to a sample, the output of the Model 187B is at a level determined by the voltage stored on the stretcher capacitor. This voltage is fed back to the probe capacitance and to the output of an ac amplifier. Therefore, both the probe capacitance and the output coupling capacitor of the amplifier have this voltage stored on them.

2-11. The Model 185A/B simultaneously applies two triggers to the plug-in, one to the sampler pulse generator and one to the blocking oscillator. When triggered, the sampler pulse generator opens the sampler gate for about 0.5 nsec. If there is any difference between the input voltage and the voltage stored on the probe capacitance, the probe capacity starts to charge toward the level of the input. However, the capacitance has time to charge to a level only about 15% of the way between the previously stored level and the level of the input. The sampling efficiency of the sampler itself is therefore about 15%.

2-12. The voltage across the probe capacitance is the input to the ac amplifier. Since the amplifier is ac coupled, it is sensitive only to a voltage change on the probe capacitance. The output of the amplifier is the same polarity as the input and is applied to the stretcher.

2-13. The blocking oscillator opens the stretcher gate and unclamps the stretcher input at the same time that the sampler pulse generator opens the sampler gate. However, the stretcher gate and clamp are operated for 0.5 μsec, 1000 times longer than the sampler gate is opened. This time interval is long enough for the voltage across the stretcher capacitor to change by the full amount of the signal from the ac amplifier. When the stretcher gate closes, the stretcher capacitor has essentially no discharge path, so the voltage across the capacitor remains essentially constant (and the sample is stretched) until the next sample. The output of the Model 187B then remains at the new level for the full interval between samples. Since the sampling rate is between 50 cps and 100 kc, each 0.5-nsec sample is stretched anywhere from 10 μsec to 20 msec.

2-14. The new output level is fed back to the capacitance in the probe. AC amplifier gain is set so that the feedback charges the probe capacitance to the full value of the input voltage at the time of the sample. This feedback has the effect of raising the overall sampling efficiency to 100%.

2-15. The new output level is also fed back to the amplifier output capacitor by the stretcher clamp. The feedback changes the charge on the amplifier output capacitor to correspond to the new output level. The Model 187B is then ready for another sample command from the Model 185A/B.

2-16. If there is no change in input level from sample to sample, there is no voltage change across the probe capacitance. Consequently, there is no input to and no output from the ac amplifier, and the amplifier output capacitor holds the input to the stretcher capacitor constant while the stretcher is unclamped and the stretcher gate is open. Therefore, there is no

change at the output of the Model 187B and the probe capacitance remains charged to the level of the input. The Model 187B, then, extracts energy from the circuit under test only when the signal level changes from one sample to the next.

2-17. COMPLETE BLOCK DIAGRAM.

2-18. Figure 2-4 is a complete block diagram of Channel A. The sampling gate, probe capacitance, and cathode follower V501 are in the probe. The cathode follower is a buffer between the probe capacitance and the forward attenuator to maximize the discharge time of the capacitance and provide sufficient drive to the ac amplifier through the forward attenuator.

2-19. Cathode follower V503 is a buffer between ac amplifier V502 and the stretcher to provide sufficient drive to charge stretcher capacitor C518. The voltage across the stretcher capacitor is applied to dc amplifier V504/Q502. The dc amplifier has a gain slightly greater than unity to make the combined gain of cathode follower V503, stretcher gate, and the amplifier equal to unity. The output of the dc amplifier is the output of the channel and is the source of the feedback to the probe capacitance and the output capacitor of the ac amplifier. The feedback is applied to the probe capacitance through a feedback attenuator and emitter follower Q504.

2-20. The feedback attenuator determines the sensitivity of the channel by fixing the amount of feedback applied to the probe capacitance. Although the feedback is positive on a per sample basis, overall feedback is negative because it is the feedback prior to a sample that is compared to the input voltage during a sample. Thus, sensitivity or gain is inversely proportional to the feedback factor, as in any nulling system.

2-21. The feedback to the probe capacitance is positive on a per sample basis. However, the inherent delay in the circuitry prevents the feedback signals from appearing at the output of ac amplifier V502 until after the input to cathode follower V503 is clamped. Thus, positive feedback effects are eliminated.

2-22. Blocking oscillator Q503 applies a blanking pulse to the Model 185A/B in addition to operating the stretcher gate and clamp. The pulse blanks the crt and prevents sampling and stretching transients from appearing.

2-23. Front-panel controls are shown on the block diagram (figure 2-4). The ADJUST control permits some adjustment of the sampling efficiency of the sampler (see below). The VERTICAL POSITION control effectively adds a voltage in series with the feedback. The output of the channel then changes until the feedback cancels the positioning voltage. This type of positioning permits position adjustment up to an equivalent of about ±2 volts at the input regardless of sensitivity.

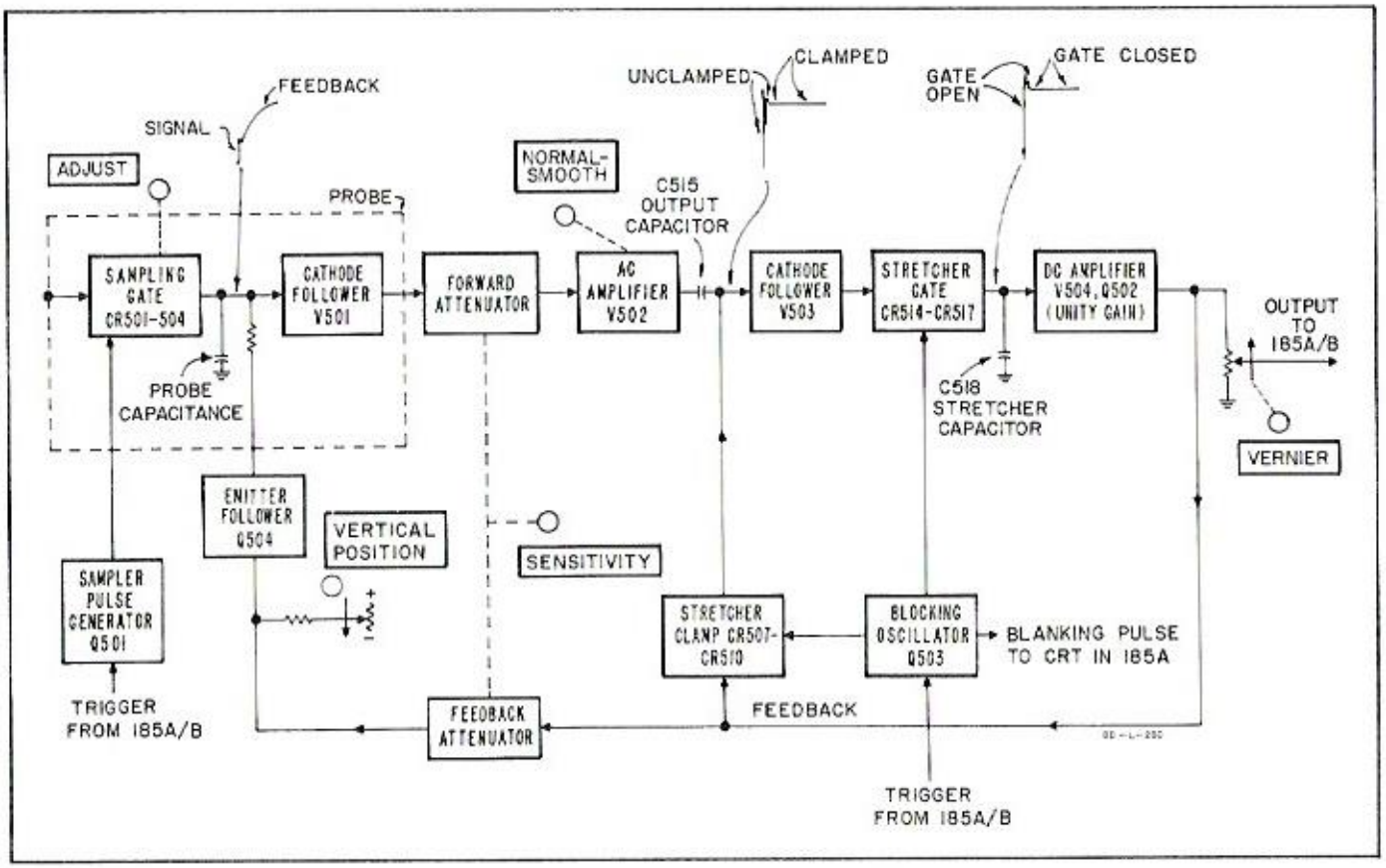


Figure 2-4. Complete Block Diagram of Channel A

2-24. The SENSITIVITY switch controls both forward and feedback attenuators. The forward attenuator inversely tracks the feedback attenuator to maintain a constant loop gain regardless of sensitivity and maintain the overall sampling efficiency of the channel. The NORMAL-SMOOTHED switch reduces the gain of the ac amplifier by a factor of five when set to SMOOTH and so reduces the overall sampling efficiency by the same factor. Thus more than one sample is required to nullify a difference between a voltage stored on the probe capacity and an input voltage. The result is a filtering action which does not affect sensitivity but reduces the effects of noise and jitter. The sensitivity VERNIER control permits continuous adjustment of sensitivity between fixed settings of the SENSITIVITY switch.

2-25. The Vertical Presentation switch, not shown on the block diagram, determines the presentation on the crt of the Model 185A/B Oscilloscope. However, the circuits controlled by the switch are in the oscilloscope itself. Thus both channels of the Model 187B continuously apply their signals to the oscilloscope, and signal selection occurs in the oscilloscope.

2-26. CIRCUITS.

2-27. The sampler pulse generator sampler, and stretcher circuits are described below. The remaining circuits of the Model 187B are conventional and are not covered here.

2-28. SAMPLER PULSE GENERATOR.

2-29. Figure 2-5 is a schematic diagram of the sampler pulse generator. The generator consists of a blocking oscillator with a pulse-shaping diode, CR524, at the output. Prior to a trigger from the Model 185A/B Oscilloscope, CR524 is forward biased and conducting. When the trigger from the oscilloscope fires the blocking oscillator, the blocking oscillator applies reverse bias to CR524, and reverse current flows in the diode. The reverse current is supplied by the carriers in the junction as they are swept out of the junction by the reverse bias. Thus the diode does not stop conducting immediately, and the voltage across it remains low. When the carriers in the junction are depleted, the diode stops conducting very suddenly. As a result, a very fast-rising, negative-going signal appears at the anode of CR524; and a very fast-rising, positive-going signal appears at the cathode of CR524. Capacitors C505 and C506 and associated circuit components differentiate the signals into positive and negative pulses about 2 nsec long. It is the 0.5 ns top of these pulses that actuate the sampler gate.

2-30. SAMPLER.

2-31. The sampler consists of a four-diode gate and associated circuitry, as shown in figure 2-6. All four diodes of the sampler gate are normally biased in the reverse direction by voltage derived from a resistive divider, and the gate is closed. The pulses from the sampler pulse generator overcome the reverse bias and open the diode gate. The input signal then starts to charge the probe capacitance, which is the input capacitance to cathode follower V501 including the wiring capacitance between the sampler switch and the cathode follower. After the pulses cease, the diode gate again closes. The feedback signal then slowly charges the probe capacitance to the level of the input at the time of the sample. In addition, the feedback shifts the bias voltages applied to the diode gate to center the capacitance voltage between the bias voltages.

2-32. Transformer T501 is a low-impedance path for the two sampler pulses, which have opposite polarity,

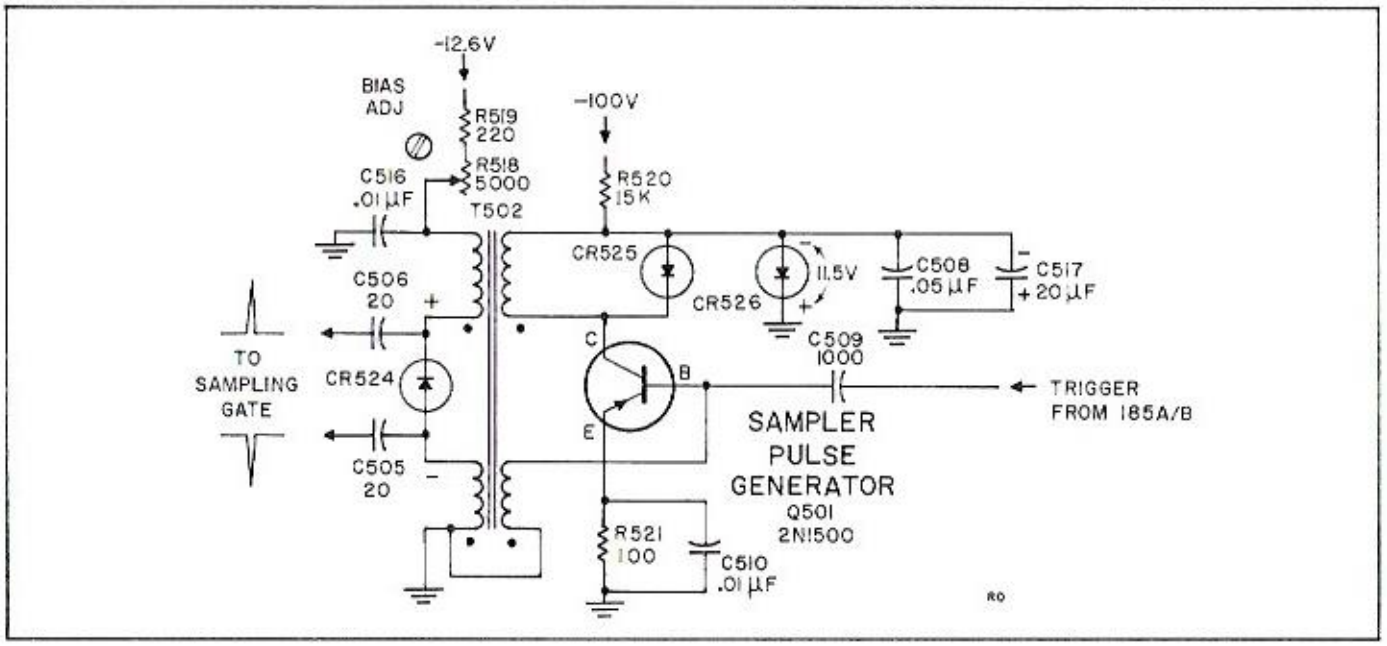


Figure 2-5. Sampler Pulse Generator

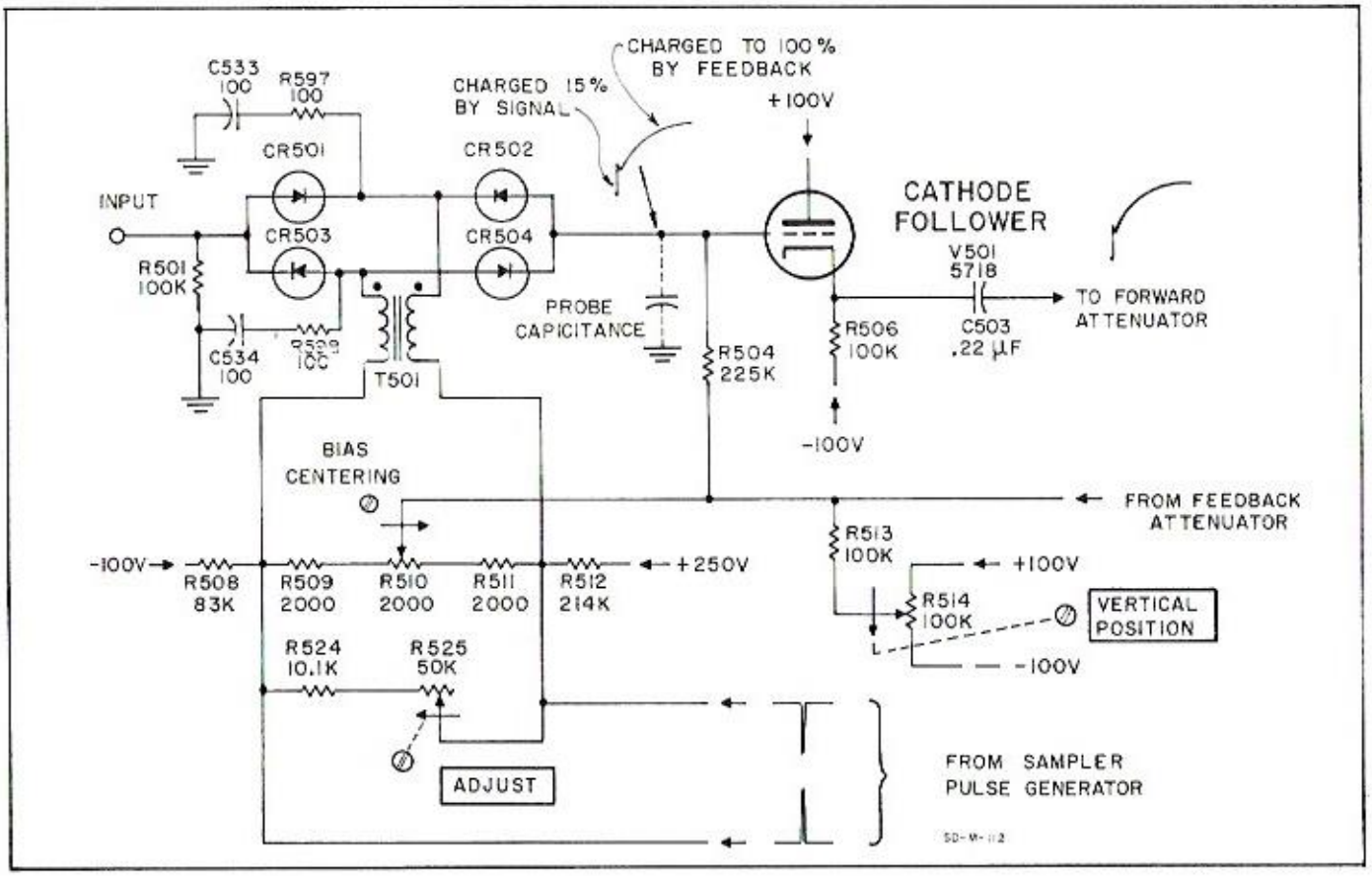


Figure 2-6. Sampler

and it tends to cancel any unbalance between the pulses. However, the transformer is a high impedance to the input signal, which is applied as in-phase signal to the two windings; so the transformer confines the input signal to the sampler.

2-33. The biasing network applies about four volts bias to the sampler gate diodes. Since the bias voltages are shifted so that the sampler output voltage is centered between them, the input signal will turn on one of the input diodes if the signal varies more than about ±2 volts from level of the voltage on the probe capacity. This factor limits the dynamic range of the Model 187B to about 2 volts. 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.

2-34. The overall sampling efficiency of the Model 187B depends upon (1) the time constant of the probe capacitance and the signal source impedance, (2) the length of time the sampler gate is open, and (3) the loop gain of the Model 187B. The loop gain is fixed. To make up for changes in source impedance from one test point to another, the ADJUST control permits some adjustment of sampling time. The control actually adjusts the bias applied to the sampler diodes. Figure 2-7 shows how bias changes vary the sampling time.

2-35. The rise time of the instrument is equal to the sample time (width of the sample) since this is the minimum time the unit can respond to a perfect step. Since step function is averaged over the sample time, decreasing the sample time, figure 2-7, will effectively speed up the response of the instrument and hence increase the passband.

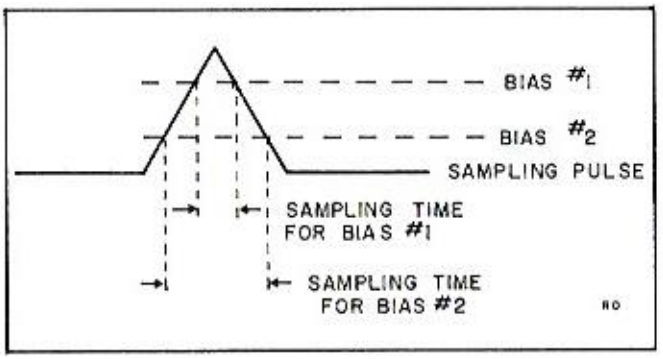


Figure 2-7. Sampling Time vs Sampler Bias

2-36. The amplitude of the sampler pulses varies some during instrument warmup and with sampling rate. The ADJUST control also permits adjustment of sampler bias to maintain a constant sampling time under these conditions. In any case, the ADJUST control should always be set for an overall sampling

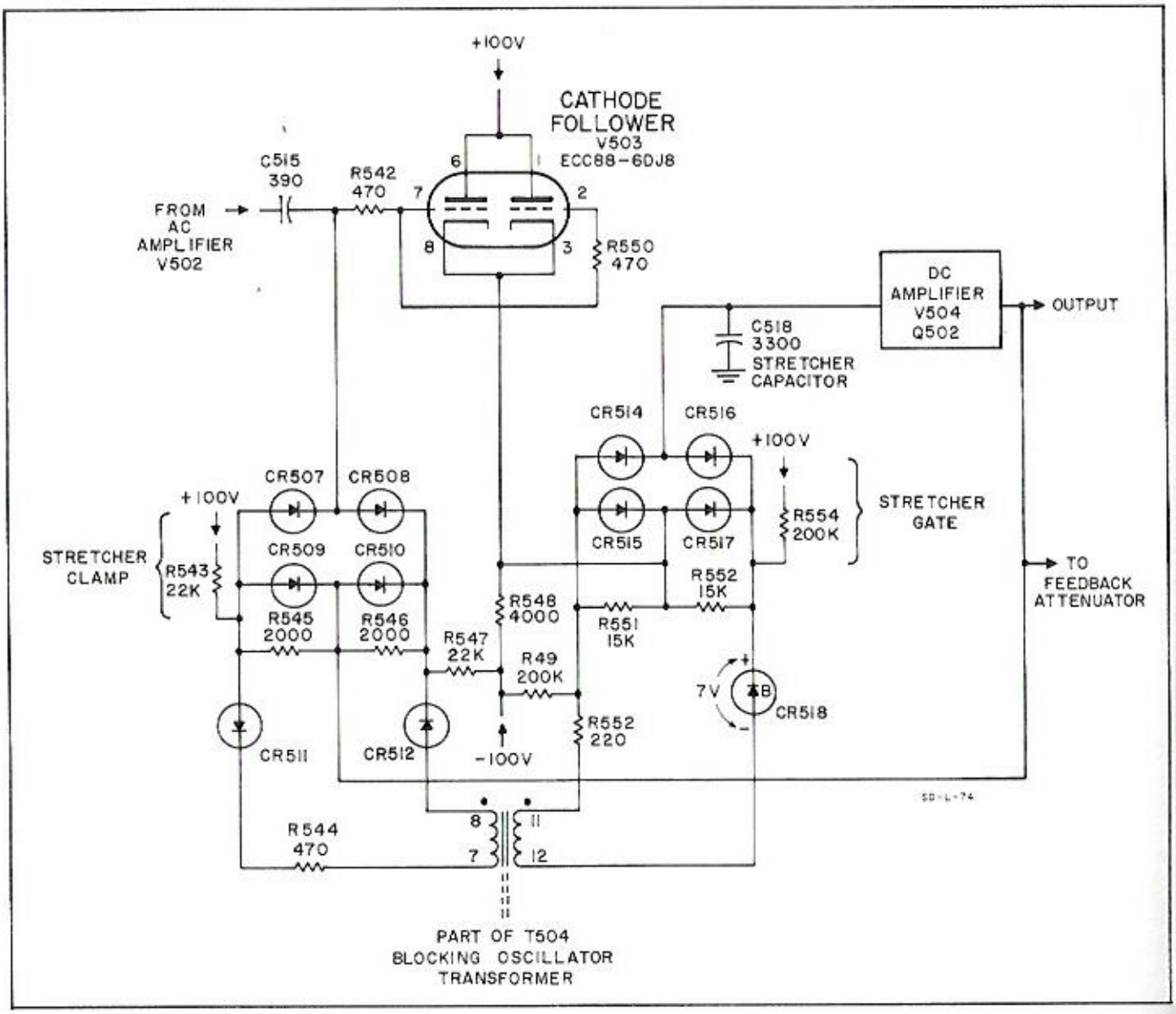


Figure 2-8. Stretcher

efficiency of 100% (optimum response); otherwise rise time is affected, for it is directly related to sampling time.

2-37. STRETCHER.

2-38. Figure 2-8 is a schematic diagram of the stretcher. Between the samples, the stretcher clamp diodes, CR507-CR510, are forward biased and appear as a closed switch between the output of the dc amplifier V504/Q502 and the input to cathode follower V503. Diodes CR511 and CR512 help limit the current through the 7-8 winding of transformer T504 between samples, thus helping to keep the forward bias current for the clamp diodes from being shunted through the transformer, and yet provide a low impedance path for the pulse from the transformer. Also between samples the stretcher gate diodes, CR514-CR517, are reverse biased and appear as an open switch between cathode follower V503 and stretcher capacitor C518. Breakdown diode CR518 limits the reverse bias to about 7 v.

2-39. When blocking oscillator Q503 (not shown) fires, it applies reverse bias to the stretcher clamp diodes and forward bias to the stretcher gate diodes. Then the grids of cathode follower V503 are free to follow any signal from ac amplifier V502, and the signal from the cathode follower will pass through the stretcher gate to stretcher capacitor C518. If there is no signal from the ac amplifier, C515 maintains the previous level at the input to cathode follower V503. After the blocking oscillator pulse ceases, the cathode follower grid is again clamped to the output of the dc amplifier, and the stretcher capacitor is disconnected from the cathode follower.

2-40. The stretcher capacitor is in the grid circuit of V504, the input stage of the dc amplifier. Since it is important that C518 maintain its charge between samples, V504 is a 5654 tube, a type which characteristically has low grid current.

SECTION III
MAINTENANCE

3-1. INTRODUCTION.

3-2. This section contains information covering maintenance and repair of the Model 187B Dual Trace Vertical Amplifier. Included is a performance check to verify proper operation of the instrument. The complete check can be made from the front panel with the instrument installed in a Model 185A/B Oscilloscope. The check is a good test as part of incoming quality control inspection and preventive maintenance.

3-3. TEST EQUIPMENT.

3-4. The equipment recommended for testing and repairing the Model 187B is listed in table 3-1, Maintenance Test Equipment and Accessories.

Table 3-1. Maintenance Test Equipment and Accessories

Instrument Type	Designation	Required Characteristics	Use
Oscilloscope	AN/USM-105A or ℗ 160B with 162A Dual Trace Vertical Amplifier and AC-21A Probe or ℗ 150A with 152B Dual Trace Vertical Amplifier and AC-21A Probe	Passband: dc to at least 10 mc Imput Impedance: 10 megohms (with probe) Sensitivity: 0.05 v/div to 10 v/div	Observe waveforms for troubleshooting and adjustment
DC Voltmeter/ Ohmmeter	ME-25A/U or ℗ Model 412A or ℗ Model 410B	Voltage Range: 1 v to 300 v Imput Impedance: at least 100 megohms Resistance Range: from less than 100 ohms to at least 100 megohms	Voltage and resistance measurements
Pulse Generator	℗ Model 213A	Rise Time: 0.5 nsec or less Amplitude: about 0.4 v Must sync from 0.5 v external pulse	Signal source for performance check and adjustment
Tee Connector for 187B Probes	℗ 187B-76E	Characteristic Impedance: 50 ohms	Permit 50-ohm termination of 187B probes
50-ohm Termination Load	℗ Model 908A	Impedance: 50 ohms	Terminate Tee connector
Attenuator	℗ Model 355B	Attenuation Range: 20 to 30 db Passband: dc to at least 500 mc Impedance: 50 ohms	Attenuate signals to convenient amplitudes for use in adjustment
Plug-in Extender*	℗ 185A-39A		Permit operation of 187B outside 185A/B Oscilloscope

* Extension cable can be used in place of plug-in extender. To fabricate a cable, wire together like-numbered pins of 24-pin male and female connectors--Amphenol 26-4100-24P and 26-4200-24S. Use standard insulated wire for all pins but 7, 17, and 19; use 50-ohm coaxial cable for these pins. Make cable about 18 inches long to allow plug-in to rest on bench in front of oscilloscope.

3-5. PERFORMANCE CHECK.

3-6. The following tests determine the operational status of the Model 187B. The tests are made with the instrument installed in the Model 185A/B Oscilloscope.

3-7. VERTICAL POSITIONING.

a. Set MODE to FREE RUN and SCANNING to FINE (Model 185A) or full clockwise (Model 185B).

b. Set Vertical Presentation to CHANNEL A, and SENSITIVITY to 200. Connect BNC adapter (187A-76A and 187B-76F sleeve) to end of probe.

c. Rotate VERTICAL POSITION from one extreme to the other. Trace should move well off screen in both directions and should be well on screen with VERTICAL POSITION centered. If vertical position is faulty, refer to the troubleshooting section.

d. Repeat for Channel B.

3-8. RESPONSE.

a. Set TIME SCALE to 10, TIME SCALE MAGNIFIER to X2, SCANNING to FINE, MODE to FREE RUN, and CALIBRATOR AND SYNC PULSE to ON.

b. Set channel selector to CHANNEL A and connect Channel A probe to 50-mc calibrator output of Model 185A/B.

c. Set Channel A SENSITIVITY to give a signal 2- to 4-cm deflection on crt; set Channel A RESPONSE to NORMAL.

d. Adjust DELAY to provide step between first sample on left of crt and waveform; be sure step is less than 100 mv.

e. Optimize response by varying ADJUST until second sample is part of waveform (see figure 1-2). Final setting of ADJUST control should be between 10 o'clock and 3 o'clock. If not, check step response adjustment.

f. Set RESPONSE to SMOOTHED. Jump from first sample to waveform should require several samples. In addition, presentation on crt should shift vertically less than 3 cm and amplitude should remain constant as RESPONSE is switched from NORMAL to SMOOTHED. If shift is excessive or amplitude changes, check stretcher gain and balance adjustment.

g. Repeat for Channel B.

3-9. SAG.

a. Set Vertical Presentation to Channel A.

b. Set MODE to FREE RUN, then to TRIGGER to stop sampling.

c. Spot should drift vertically at a rate less than 10 cm/sec. If drift is excessive, see troubleshooting paragraph 3-22a.

d. Repeat for Channel B.

3-10. VERTICAL DISPLAY.

a. Set TIME SCALE to 10, TIME SCALE MAGNIFIER to X5, SCANNING to FINE, MODE to FREE RUN, and CALIBRATOR AND SYNC PULSE to ON.

b. Connect Channel A probe through Divider 187A/B-76E to sync pulse out and Channel B probe to 50-mc calibrator; use 187A-76A BNC adapters.

c. Set Vertical Presentation to A & B, SENSITIVITY controls to give each signal 2- to 4-cm deflection, and VERTICAL POSITION controls to slightly separate the traces.

d. Set Vertical Presentation to each position and check for correct display on crt. If display is incorrect, check switch, then main vertical amplifier in Model 185A.

3-11. SENSITIVITY CALIBRATION.

a. Select any time scale; set SCANNING to FINE, MODE to FREE RUN, and AMPLITUDE CALIBRATOR to ON.

b. Set Vertical Presentation to CHANNEL A and connect Channel A probe to amplitude calibrator OUTPUT with 187A-76A BNC adapter.

c. Set Channel A sensitivity VERNIER to CALIBRATED and check calibration at each of the calibrator switch settings.

d. Repeat for Channel B.

e. If sensitivity calibration of either channel is in error by more than 5% check the input to the main vertical amplifier of the Model 185A/B versus signal deflection on the crt (main vertical sensitivity: 50 mv/cm) and check instrument introducing the error.

3-12. RISE TIME AND OVERSHOOT.

a. Set TIME SCALE to 10, TIME SCALE MAGNIFIER to X1, SCANNING to FINE, MODE to FREE RUN, and CALIBRATOR AND SYNC PULSE to ON.

b. Set Vertical Presentation to CHANNEL A, SENSITIVITY to 100, and RESPONSE to NORMAL.

c. Connect Model 185A/B SYNC PULSE OUTPUT to TRIGGER of Model 213A pulse generator. See figure 3-1. (If Model 185A Oscilloscope has serial prefix 023- or above, set Model 213A TRIGGER to POS; for Model 185A prefix below 023 and Model 185B set TRIGGER to Neg.)

d. Connect 187B-76E 50-ohm Tee connector to Channel A probe and terminate one end in 50 ohms.

e. Select positive pulse output of pulse generator and connect it to terminated Channel A probe through 50-ohm coaxial cable at least 3 ft long.

f. Adjust pulse generator SENSITIVITY control for stable step (leading edge of pulse) on crt.

g. Set TIME SCALE MAGNIFIER to X20.

h. Optimize response:

(1) Adjust Delay to place step at right end of display such that first sample at left of display is 50 to 100 mv above display base line.

(2) Set ADJUST of Channel A to make second sample part of base line.

i. Readjust DELAY to center step on crt.

j. Note rise time and overshoot. Rise time of the Model 187B (10 to 90%) should be less than 0.5 nsec, and overshoot less than 5% of the pulse amplitude. If either is excessive, check response adjustment.

Note

Measured rise time is the RMS of the Model 187B and Pulse Generator rise time.

k. Switch to negative pulse output of pulse generator.

m. Note rise time and overshoot. If either is excessive, check step response adjustment.

n. Repeat for Channel B.

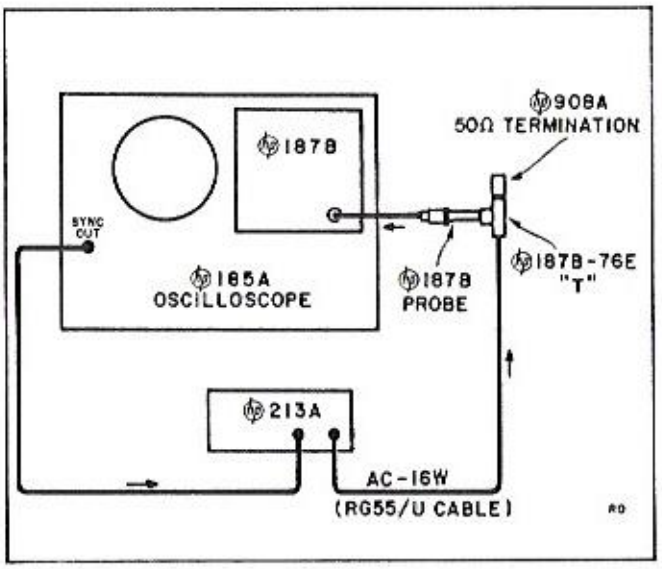


Figure 3-1. Test Setup for Measuring Rise Time and Overshoot

3-13. NOISE.

a. Leave setup same as in Rise Time and Overshoot procedure above (paragraph 3-12).

b. Adjust DELAY to delay leading edge of pulse off screen.

c. Set SENSITIVITY to 10.

d. Observe noise (vertical width of trace); it should be approximately 3 mv peak-to-peak. If noise is excessive, refer to troubleshooting paragraph.

e. Repeat for other channel.

3-14. TROUBLESHOOTING.

3-15. INTRODUCTION.

3-16. The following is a troubleshooting guide for the Model 187B. The procedure calls for waveform analysis and voltage measurements to indicate the faulty circuit. Additional voltage and resistance measurements may be necessary to locate the actual component at fault. Voltages are included on schematic diagrams.

3-17. The points at which waveforms are to be viewed are given test-point numbers. The location of each test point is indicated in figures 3-3 and 3-4 and on the schematic diagrams. Corresponding test points in the two channels have the same number but have a suffix A or B to indicate the channel with which they are associated.

3-18. If in the course of troubleshooting and repair you replace a semiconductor diode, transistor, or vacuum tube listed in table 3-2, make the indicated adjustment before putting the instrument back into service. Should you replace any other component associated with one of the transistors or vacuum tube listed, make the adjustment indicated for that transistor or tube.

Table 3-2. Adjustment following Replacement of Diodes, Transistors, and Tubes

Circuit Element	Function	Adjustment
CR501-CR504	Sampling Gate	Sampler Balance
CR514-CR517	Channel A Stretcher Gate	Channel A Stretcher Gain and Balance
CR524	Pulse Shaper	Pulse Generator Bias
CR614-CR617	Channel B Stretcher Gate	Channel B Stretcher Gain and Balance
Q502	Amplifier	Channel A Stretcher Gain and Balance
Q503	Blocking Oscillator	Stretcher Pulse Length
Q602	Amplifier	Channel B Stretcher Gain and Balance
V502	Amplifier	Channel A Step Response
V504	Amplifier	Channel A Stretcher Gain and Balance
V602	Amplifier	Channel B Step Response
V604	Amplifier	Channel B Stretcher Gain and Balance

3-19. LOCATING TROUBLE AFFECTING BOTH CHANNELS EQUALLY.

3-20. The two signal channels of the Model 187B are independent except for sampler pulse generator Q501 and blocking oscillator Q503. These circuits operate the sampling gates, stretcher gates, and stretcher clamps of both channels simultaneously. Therefore if both channels exhibit the same trouble, it is probably caused by the sampler pulse generator or the blocking oscillator.

a. Excessive noise on both channels with response optimized.

(1) If noise amplitude varies with sensitivity, check waveforms in sampler pulse generator (test points 6 through 9).

(2) If noise does not vary with sensitivity, trouble is not in sampler pulse generator or samplers. Check each channel for noise.

b. Other troubles affecting both channels equally (no positioning control, jitter, etc.).

(1) Check waveforms of sampler pulse generator and blocking oscillator (test points 6 through 11).

3-21. LOCATING TROUBLE AFFECTING ONE CHANNEL ONLY.

3-22. In the procedures below, Channel A is used as an example. The procedure for Channel B is identical.

a. Sag or vertical elongation of individual samples at low sampling rates.

(1) Replace V504 or substitute tube from other channel. If trouble persists, return old tube and proceed to step (2).

(2) Obtain free-running presentation on Model 185A/B, then rotate MODE fully counter-clockwise to stop sampling. If spot drifts off bottom of crt screen replace CR514. If spot drifts off top of crt screen replace CR516.

b. Excessive noise.

(1) If noise varies with sensitivity, it is probably in the sampling gate. Check CR502 and CR504 first.

(2) If noise does not vary with sensitivity, it is most likely to be in the stretcher gate or amplifier circuits that follow. You can generally find the faulty component by gently tapping individual components and noting reaction on the crt. Try diodes, particularly CR518 first.

c. Faulty positioning control, faulty sensitivity control, etc.

(1) Check sampling gate diodes (in probe) for leakage:

(a) Set MODE to TRIGGER and remove any external trigger signal.

(b) Ground overall feedback of Channel A as instructed in figure 3-3.

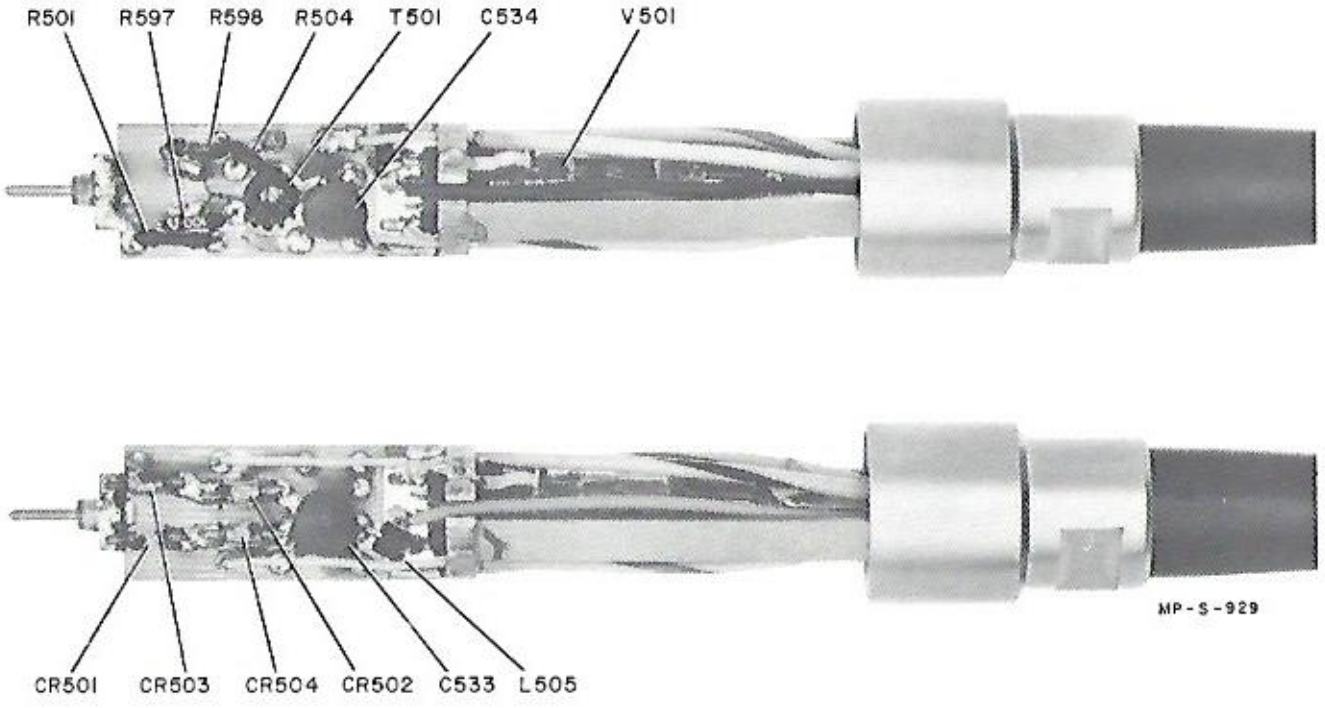


Figure 3-2. Probe Component Location

(c) Remove sleeve from Channel A Probe. (See paragraph 3-36 for instructions on removal and replacement of probe sleeve.)

(d) Measure voltage at junction of CR501 and CR503. See figure 3-2. Voltage should be zero. If it is more positive than about 0.1 volt, replace CR501. If voltage is more negative than about 0.1 volt, replace CR503.

(e) Measure voltage at junction of CR502 and CR504. Voltage should be zero. If it is greater than ±0.2 volt, remove V501 to determine if voltage is due to grid current in V501. If voltage returns to zero, replace V501. If voltage remains excessive, replace CR502 if voltage is positive; replace CR504 if voltage is negative.

(f) If indications are normal, replace probe sleeve.

(2) Check sampling gate for balance:

(a) Set MODE to FREE RUN.

(b) Ground overall feedback of Channel A as instructed in figure 3-3.

(c) Attach 187A-76A BNC adapter to Channel A probe and connect probe directly to vertical input of external oscilloscope.

(d) Obtain free-running sweep on external oscilloscope; set sensitivity to 0.1 v/cm and sweep time to about 0.1 msec/cm.

(e) Rotate Bias Centering (R510) of Model 187B through its entire range. Pulses out of probe should vary continuously from maximum positive to maximum negative, and maximum positive and negative amplitudes should be about equal. If unbalance of maximum amplitudes exceeds about 4:1, check probe diodes. Check CR501 first if unbalance is in favor of positive pulses; check CR503 first if unbalance is in favor of negative pulses.

(3) Check waveforms through Channel A.

(a) For Model 185A set MODE to FREE RUN, CALIBRATOR AND SYNC PULSE to ON, and AMPLITUDE to 500.

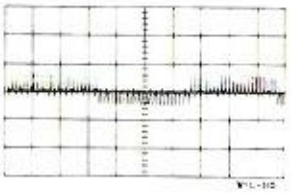
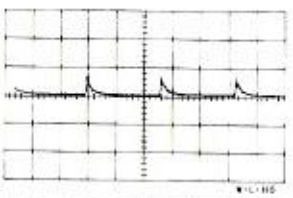
(b) For Model 185B use external 1 kc square-wave generator (℗ 211A) with 0.5 v output using 187A-76A BNC adapter; connect Channel A probe to amplitude calibrator OUTPUT or the external square wave generator.

(c) Set SENSITIVITY to 50, VERNIER to CALIBRATED, and RESPONSE to NORMAL.

(d) Observe waveforms at test points 1 through 5. Refer to table 3-3. Check first circuit to give faulty indication.

Table 3-3. Waveforms

The waveforms shown below were taken on an ℗ 150A Oscilloscope with 152B Dual Trace Amplifier. The AC-21A Probe was used for all waveforms except those at test point 1, where the full sensitivity of the 150A/152B was required. Sensitivity (including effect of probe when used), sweep speed, coupling and triggering for the 150A/152B are indicated with each waveform.

Test Point	150A Sweep Speed, Sensitivity, Coupling and Triggering	Waveform	Remarks
1 (a)	0.1 msec/cm 0.05 v/cm ac coupling internal trigger		Ground overall feedback (see figure 3-3); vary ADJUST and Bias Centering to make waveform symmetrical and 1 to 2 cm high. This adjustment affects waveforms at test points 1 through 5. Faulty waveform — Possible fault Unbalance positively — CR502 or bias circuit Unbalance negatively — CR504 or bias circuit
1 (b)	5 μsec/cm 0.5 v/cm ac coupling internal trigger		Also check negative-going portion of waveform to see that it is approximately symmetrical with waveform shown.

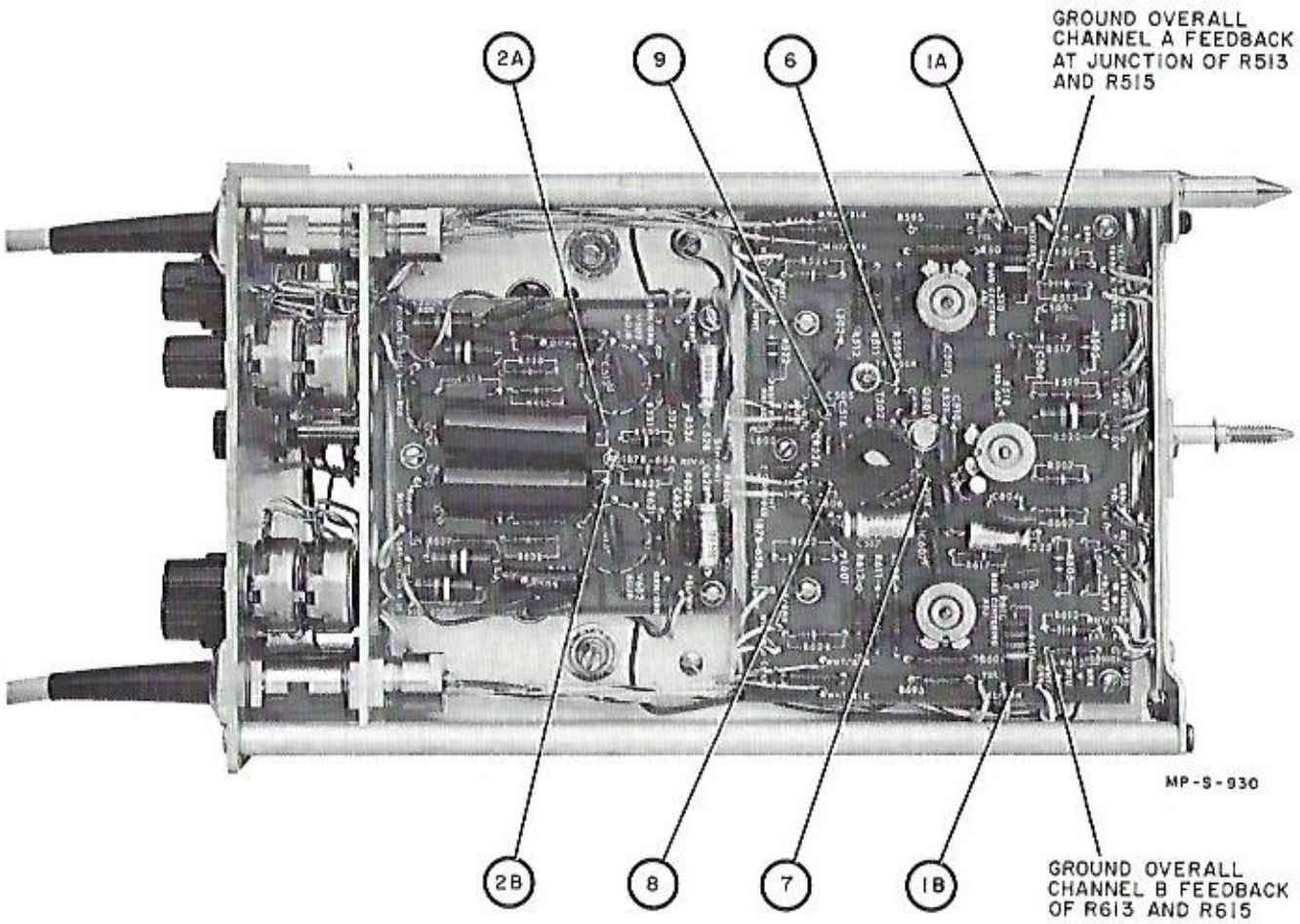
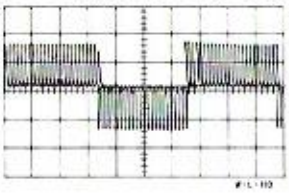
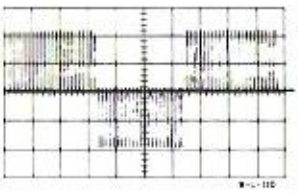


Figure 3-3. Location of Test Points on Right Side

Table 3-3. Waveforms (Cont'd.)

Test Point	150A Sweep Speed, Sensitivity, Coupling and Triggering	Waveform	Remarks	
2	0.1 msec/cm 0.5 v/cm ac coupling internal trigger		Leave overall feedback grounded; disconnect and ground stretcher feedback (see figure 3-4). Reset symmetry with adj. and bias centering as for test point 1. These conditions hold for test points 2 through 5.	
3	0.1 msec/cm 0.5 v/cm dc coupling-- center line = 0 v internal trigger		Faulty waveform Clamps to positive voltage Clamps to negative voltage Does not clamp cleanly (increase sweep speed to see effect) No signal Unsymmetrical in favor of positive pulses Unsymmetrical in favor of negative pulses Low amplitude and poor clamping	Possible fault CR508 open CR507 open CR509 or CR510 open CR511 or CR512 open CR508 leaky CR507 leaky CR509 or CR510 leaky

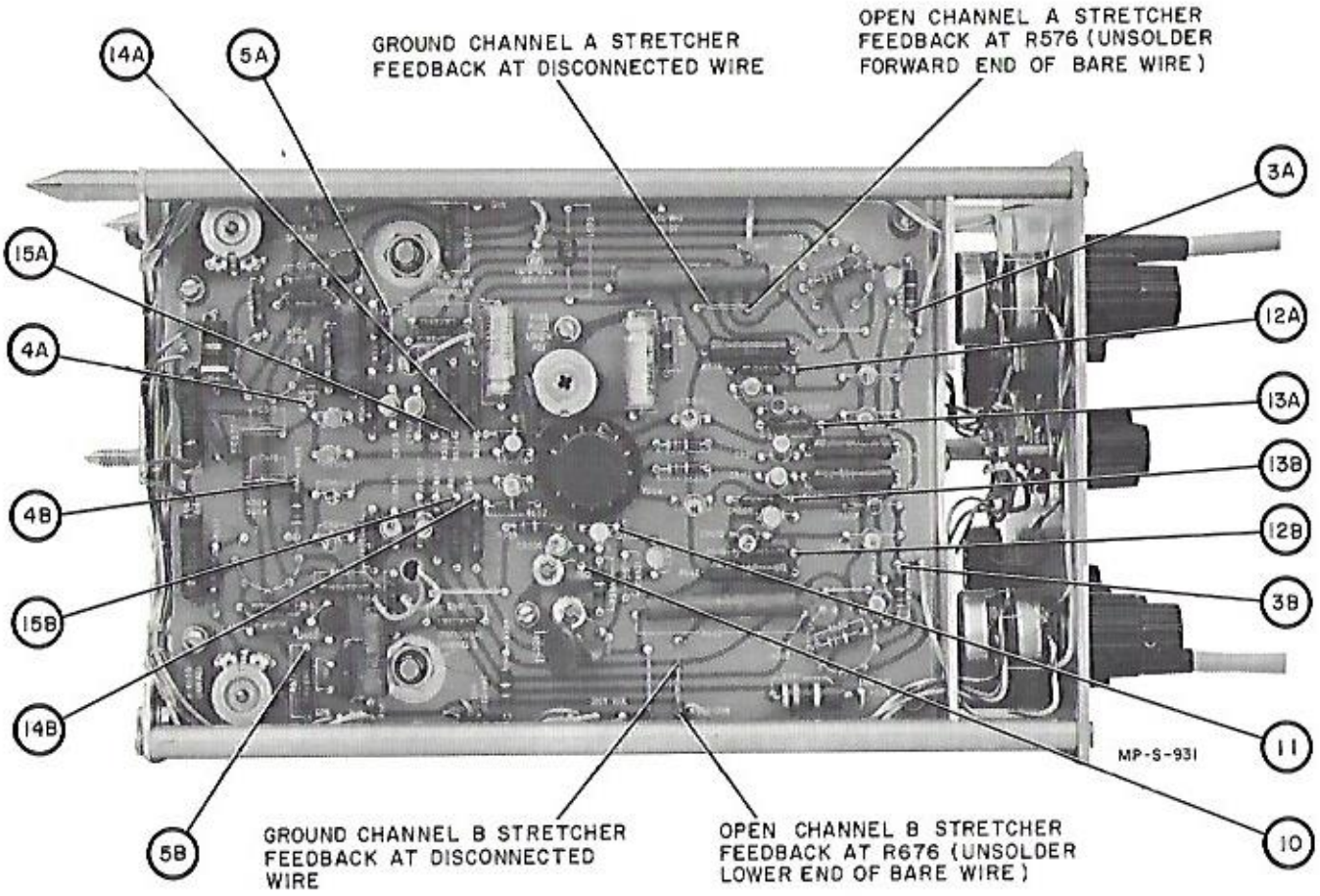


Figure 3-4. Location of Test Points on Left Side

Table 3-3. Waveforms (Cont'd.)

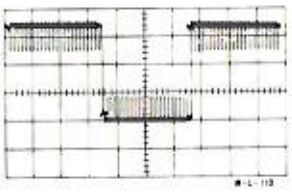
Test Point	150A Sweep Speed, Sensitivity, Coupling and Triggering	Waveform	Remarks	
4	0.1 msec/cm 0.5 v/cm dc coupling-- bottom line = 0 v internal trigger		Faulty waveform	Possible fault
			No signal (base line only)	CR514, CR516, or CR518 open
			Low amplitude, positive slope normal, negative slope exponential	CR515 open
			Low Amplitude, rise and fall very slow	CR517 open
			Negative sag between samples	CR514 leaky
			Positive sag between samples	CR516 leaky
			Positive sag between samples on negative portion of signal only	CR515 leaky
			Low amplitude, positive spikes on positive portion of signal	CR517 leaky

Table 3-3. Waveforms (Cont'd.)

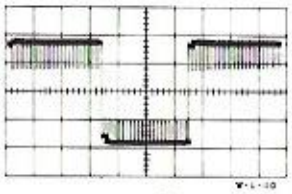
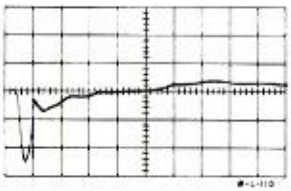
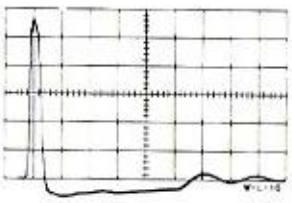
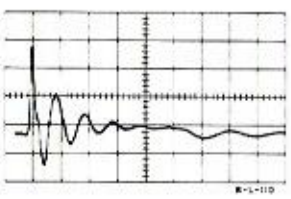
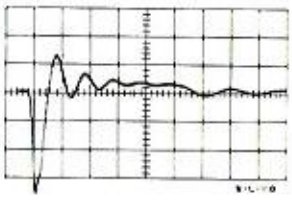
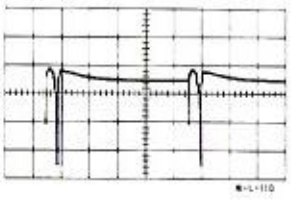
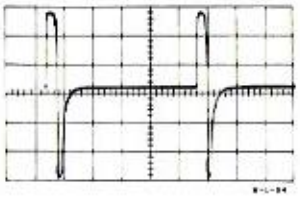
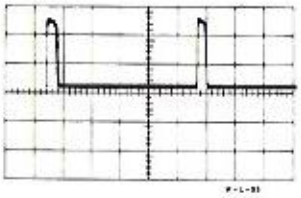
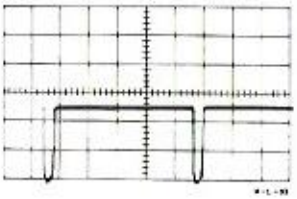
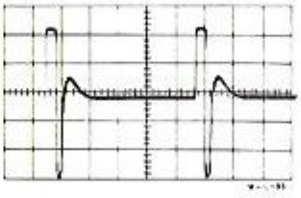
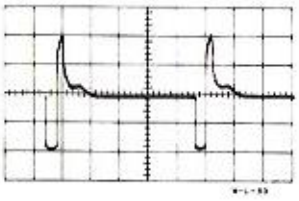
Test Point	150A Sweep Speed, Sensitivity, Coupling and Triggering	Waveform	Remarks
5	0.1 msec/cm 0.5 v/cm dc coupling-- center line = 0 v internal trigger		If waveforms at test points 1 through 5 are normal, check for this waveform reduced 4:1 at input to 185A main vertical amplifier. If waveform there is normal, check feedback circuits disrupted to obtain these waveforms.
6	0.2 μsec/cm 2 v/cm dc coupling-- center line = 0 v ext. trigger from test point 6--		
7	0.5 μsec/cm 2 v/cm dc coupling-- top line = 0 v ext. trigger from test point 6--		
8	0.2 μsec/cm 0.5 v/cm dc coupling-- center line = 0 v ext. trigger from test point 6--		Note that first part of waveforms at 8 and 9 are similar except opposite in polarity.
9	0.2 μsec/cm 0.5 v/cm dc coupling ext. trigger from test point 6--		
10	2 μsec/cm 1 v/cm dc coupling-- center line = 0 v ext. trigger from test point 6--		

Table 3-3. Waveforms (Cont'd.)

Test Point	150A Sweep Speed, Sensitivity, Coupling and Triggering	Waveform	Remarks
11	2 μsec/cm 5 v/cm ac coupling-- center line = 0 v ext. trigger from test point 6--		
12	2 μsec/cm 2 v/cm ac coupling ext. trigger from test point 6--		
13	2 μsec/cm 2 v/cm ac coupling ext. trigger from test point 6--		
14	2 μsec/cm 2 v/cm ac coupling ext. trigger from test point 6--		
15	2 μsec/cm 2 v/cm ac coupling ext. trigger from test point 6--		

3-23. ADJUSTMENTS.

3-24. Use the plug-in extender or the extension cable to operate the Model 187B outside the Model 185A/B while making the adjustments that follow. Location of adjustments are shown in figures 3-5 and 3-6.

3-25. STRETCHER PULSE LENGTH.

a. Set MODE to FREE RUN.

b. Observe collector waveform of blocking oscillator Q503 on an external oscilloscope.

c. Set pulse length adj. R588 for pulse with 0.75 microseconds.

3-26. PULSE GENERATOR BIAS.

3-27. Two procedures follow. Use procedure 1 if the Model 187B is to be adjusted in the Model 185A Oscilloscope with serial prefix 023 or above or a Model 185B. Use procedure 2 if the Model 185A oscilloscope has serial prefix below 023.

3-28. PROCEDURE 1.

a. Set TIME SCALE to 100, TIME SCALE MAGNIFIER to X10, SCANNING to MEDIUM or MID RANGE, MODE to FREE RUN, and CALIBRATOR and SYNC PULSE to ON.

b. Set vertical presentation to CHANNEL A, SENSITIVITY to 100, RESPONSE to SMOOTHED, and ADJUST to 12 o'clock.

c. Connect 187B-76E 50 ohm tee to channel A probe and terminate one end of the tee connector with a 50 ohm load.

d. Connect terminated probe to SYNC PULSE OUTPUT through a 20-db attenuator.

e. Adjust DELAY to center leading edge of sync pulse on crt screen.

f. Adjust channel A sensitivity VERNIER to make pulse 6 cm high.

g. Set Bias Adj. R518 for maximum distance between first two samples at left end of display. Readjust DELAY as necessary to keep leading edge on screen.

3-29. PROCEDURE 2.

a. Set TIME SCALE to 100, TIME SCALE MAGNIFIER to X10, SCANNING to MEDIUM, MODE to FREE RUN, and CALIBRATOR and SYNC PULSE to ON.

b. Set Vertical Presentation to CHANNEL A, SENSITIVITY to 100, RESPONSE to SMOOTHED, and ADJUST to 12 o'clock.

c. Connect 187B-76E 50 ohm tee to channel A probe and terminate one end of tee connector with 50-ohm load.

d. Connect terminated probe to SYNC PULSE OUTPUT through 20 db attenuator.

e. Adjust DELAY to place sync pulse at right end of display and provide maximum vertical distance between first sample at left end of display and flat portion of display.

f. Adjust Channel A sensitivity VERNIER to make display 6 cm high.

g. Set Bias Adj. R518 for maximum distance between first and second samples. Readjust DELAY as necessary to keep display 6 cm high.

3-30. SAMPLER BALANCE.

a. Set TIME SCALE to 10, TIME SCALE MAGNIFIER to X2, SCANNING to FINE or full clockwise, MODE to FREE RUN, and CALIBRATOR and SYNC PULSE to ON.

b. Connect Channel A probe to 50 mc calibrator output with 187B-76A BNC adapter.

c. Set vertical presentation to CHANNEL A, RESPONSE to NORMAL, and SENSITIVITY to give adequate deflection on crt.

d. Optimize response.

(1) Adjust DELAY to give step no greater than 100 mv between first sample at left end of display and waveform.

(2) Set ADJUST to make second sample part of waveform.

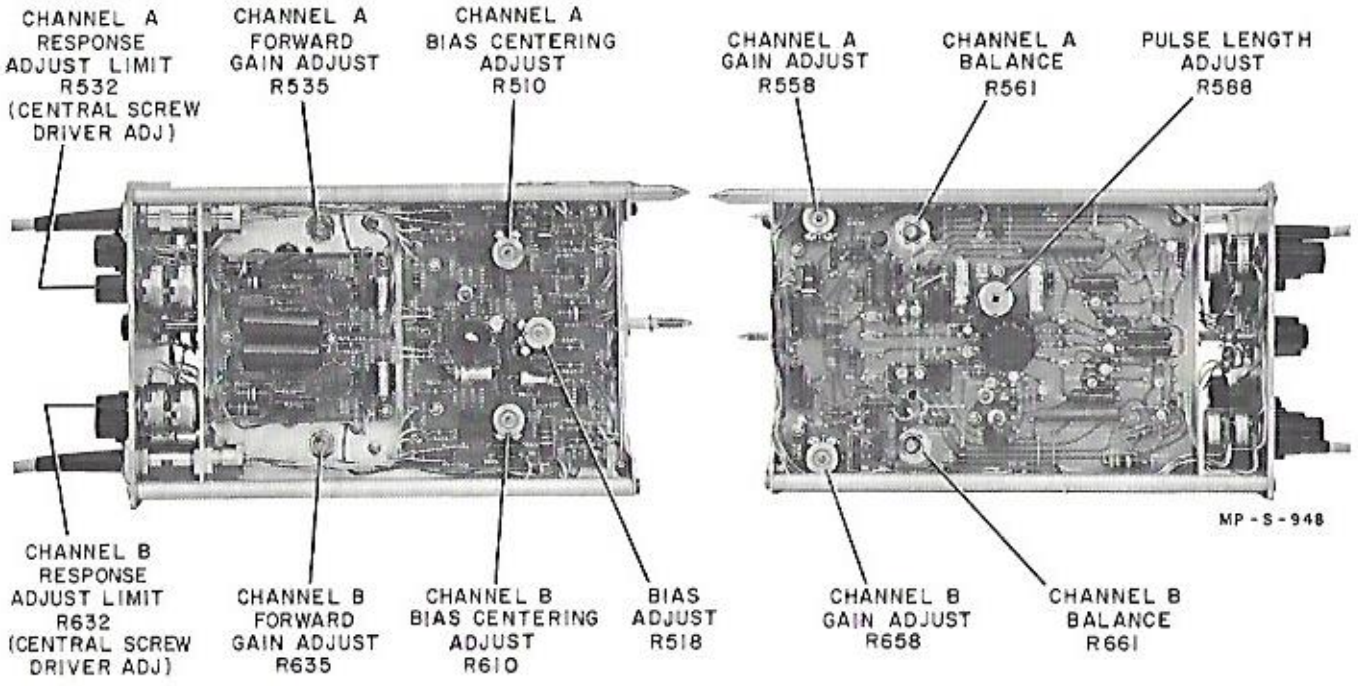


Figure 3-5. Adjustment Location

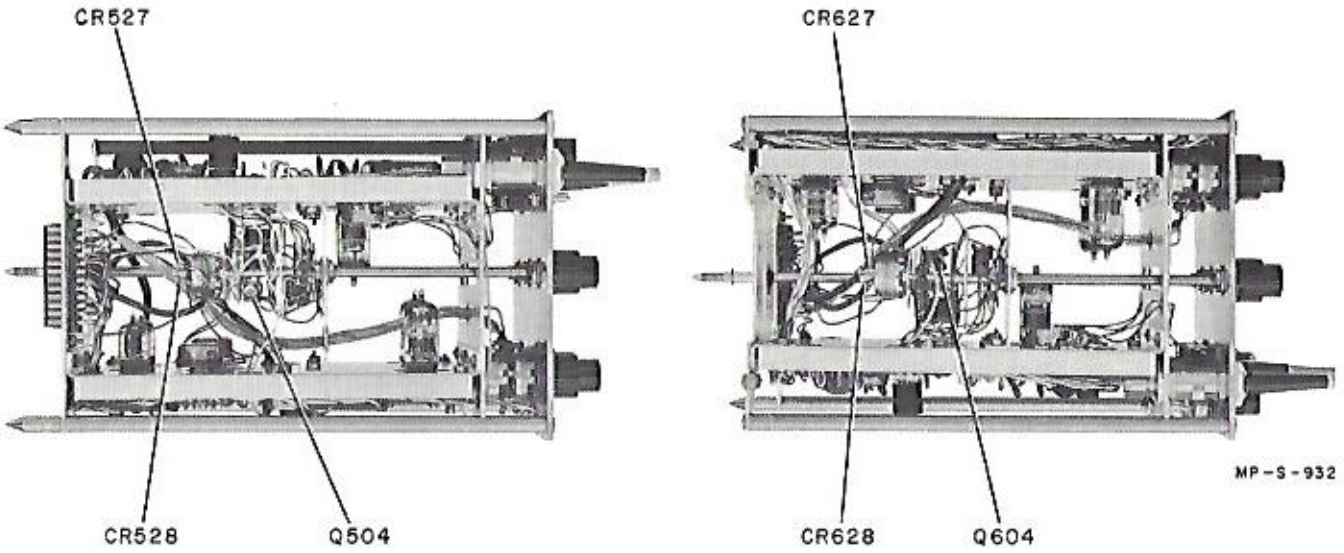


Figure 3-6. Model 187B Top and Bottom Views

e. Connect channel A probe to vertical input of external oscilloscope.

f. Obtain free running sweep on external oscilloscope and set its sensitivity to about 0.05 v/cm.

g. Set Bias centering Adj. R510 for minimum pulse amplitude out of probe. Maintain optimum response and vertical centering while making this adjustment.

h. Repeat for channel B using Bias centering Adj. R610.

3-31. RESPONSE ADJUST LIMIT.

a. Recheck PULSE GENERATOR BIAS Adjustment 3-26.

b. Set RESPONSE ADJUST control to 12 o'clock.

c. Adjust Response Adjust Limit R523 for optimum response (see figure 1-2).

d. Repeat for channel B using Limit Adjust R623.

3-32. STRETCHER BALANCE AND GAIN.

a. Set TIME SCALE to 10, TIME SCALE MAGNIFIER to X2, SCANNING to FINE or full clockwise, MODE to FREE RUN, and CALIBRATOR and SYNC PULSE to ON.

b. Set vertical presentation to CHANNEL A.

c. Connect Channel A probe to 50 mc calibrator output with 187A-76A BNC adapter and set SENSITIVITY to give adequate deflection on crt, and optimize Response Adjust.

d. While switching RESPONSE between NORMAL and SMOOTHED, set Bal Adj. R561 for no vertical shift of display and set Gain Adj. R558 for no change in amplitude of display. These adjustments interact; repeat them as necessary.

e. Repeat for channel B using Bal Adj. R661 and Gain Adj. R658.

3-33. STEP RESPONSE.

a. Set TIME SCALE to 10, TIME SCALE MAGNIFIER to X1, SCANNING to FINE or full clockwise, MODE to FREE RUN, and CALIBRATOR and SYNC PULSE to ON.

b. Set Vertical Presentation to CHANNEL A, SENSITIVITY to 100, RESPONSE to NORMAL, and ADJUST to about 12 o'clock.

c. Connect SYNC PULSE OUTPUT to + TRIGGER of pulse generator. See figure 3-1.

d. Connect 187B-76E 50-ohm tee connector to Channel A probe and terminate one end with 50-ohm load.

e. Select positive pulse output of pulse generator to terminated Channel A probe through 50-ohm coaxial at least 3 ft long.

f. Adjust pulse generator for stable step (leading edge of pulse) on crt.

g. Set TIME SCALE MAGNIFIER to X20.

h. Adjust DELAY to place leading edge of pulse on crt screen.

i. Adjust Fwd Gain R535 and Response Adjust Limit R523 for rise time of 0.5 nsec with less than 5% overshoot with response optimized.

j. Select negative pulse from pulse generator and check rise time and overshoot.

k. Repeat for Channel B; adjust Fwd Gain R635 and Response Adjust Limit R623.

m. Recheck sampler balance.

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.

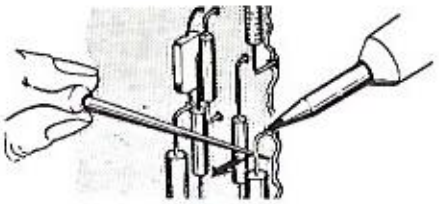
A break in the copper should be repaired by soldering a short length of tinned copper wire across the break.

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 lacquer.

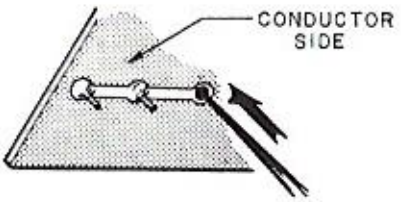
When replacing components with multiple mounting pins such as tube sockets, electrolytic capacitors, and potentiometers, it will be necessary to lift each pin slightly, working around the components several times until it is free.

WARNING: If the specific instructions outlined in the steps below regarding etched circuit boards without eyelets are not followed, extensive damage to the etched circuit board will result.

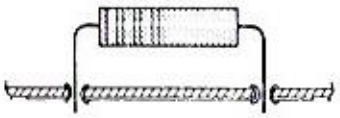
1. Apply heat sparingly to lead of component to be replaced. If lead of component passes through an eyelet in the circuit board, apply heat on component side of board. If lead of component does not pass through an eyelet, apply heat to conductor side of board.



2. Reheat solder in vacant eyelet and quickly insert a small awl to clean inside of hole. If hole does not have an eyelet, insert awl or a #57 drill from conductor side of board.



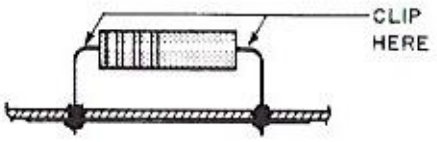
3. Bend clean tinned leads on new part and carefully insert through eyelets or holes in board.



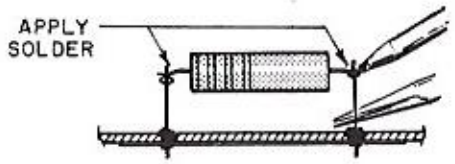
4. Hold part against board (avoid overheating) and solder leads. Apply heat to component leads on correct side of board as explained in step 1.

In the event that either the circuit board has been damaged or the conventional method is impractical, use method shown below. This is especially applicable for circuit boards without eyelets.

1. Clip lead as shown below.



2. Bend protruding leads upward. Bend lead of new component around protruding lead. Apply solder using a pair of long nose pliers as a heat sink.



This procedure is used in the field only as an alternate means of repair. It is not used within the factory.

Figure 3-7. Servicing Etched Circuit Boards

3-34. REPLACEMENT OF COMPONENTS AND ASSEMBLIES.

3-35. REPLACEMENT OF SEMICONDUCTOR DEVICES. Semiconductor diodes and transistors can be damaged by excessive heat. To solder and unsolder these elements, use a low-power soldering iron and place a heat sink such as long-nose pliers on the lead of the component between the body and the point to which you apply heat. In addition, isolate the instrument from ground or ground the body of the soldering iron to prevent leakage voltage from damaging the component.

3-36. REPLACEMENT OF COMPONENTS ON ETCHED CIRCUIT BOARDS. The proper techniques for replacing components on etched circuit boards are illustrated in figure 3-8.

3-37. REMOVAL AND REPLACEMENT OF PROBE SLEEVE.

a. Loosen knurled ring; unscrew sleeve from base.

b. Carefully slide sleeve off probe. To replace sleeve, reverse above procedure.

CAUTION

Screw sleeve into probe base just far enough for lip inside front of sleeve to contact disk at front of probe. If you screw the sleeve too far into the probe base, the lip will exert pressure on the probe diodes and may damage them.

3-38. REPLACEMENT OF PROBE DIODES. The probe diodes are held in place with spring clips. Use care to keep from springing the clips, when removing or replacing the diodes.

SCHEMATIC DIAGRAM NOTES

1. Unless otherwise noted, values are given in ohms, microhenries, and picofarads.
2. Titles enclosed in boxes indicate front-panel engraving.
3. Voltages other than supply voltages are typical and may vary from instrument to instrument (the collector voltages of Q501 may vary up to ±10 volts). Input resistance of voltmeter used exceeds 100 megohms.
4. Voltages measured with no signal applied and controls set as follows:

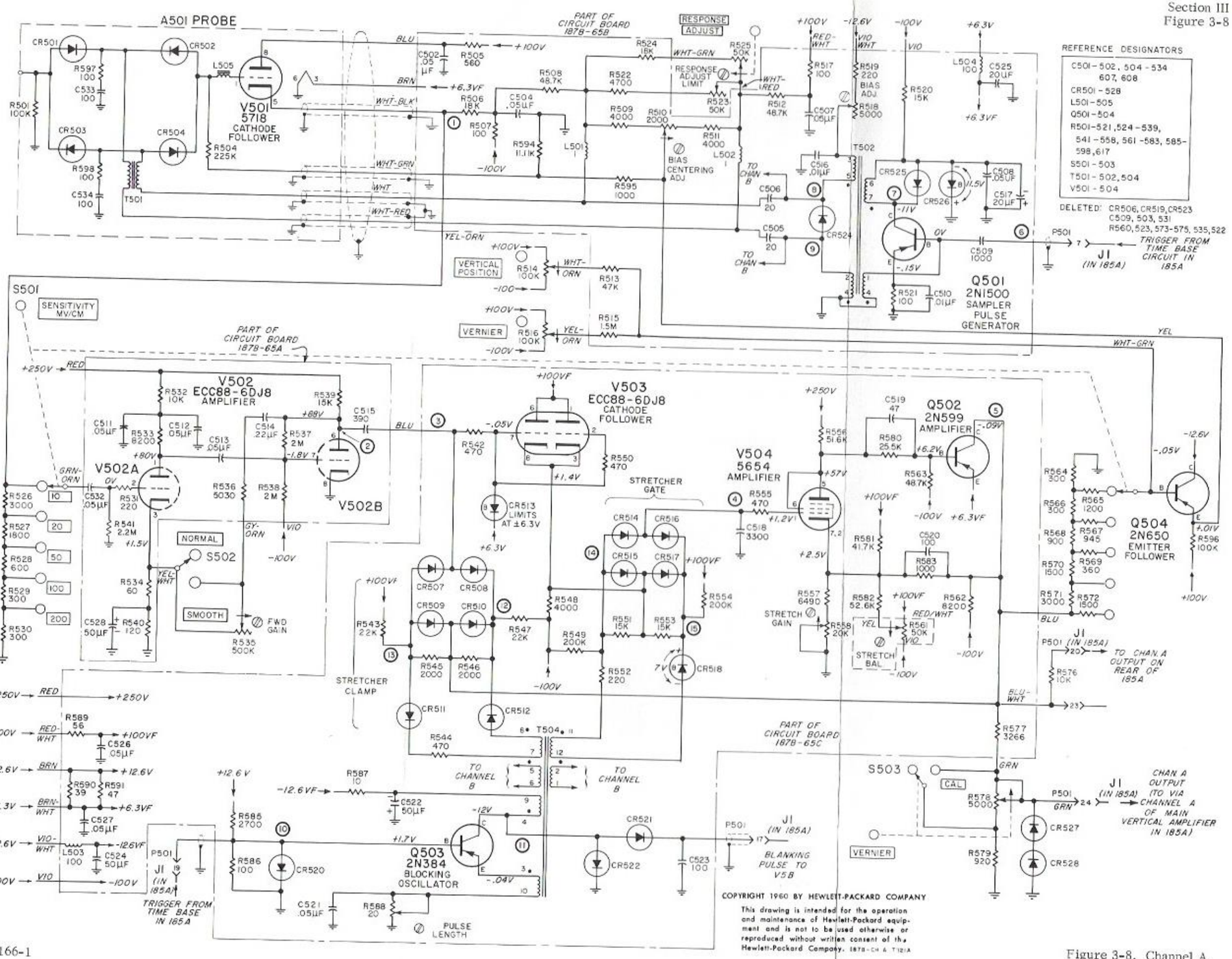
   MODE (Model 185A/B Oscilloscope) . . . . . FREE RUN

   SENSITIVITY 200

   RESPONSE . . . . . NORMAL

   ADJUST . . . . . 12 o'clock

   VERTICAL POSITION . . . . . on center trace on crt



01166-1

Figure 3-8. Channel A

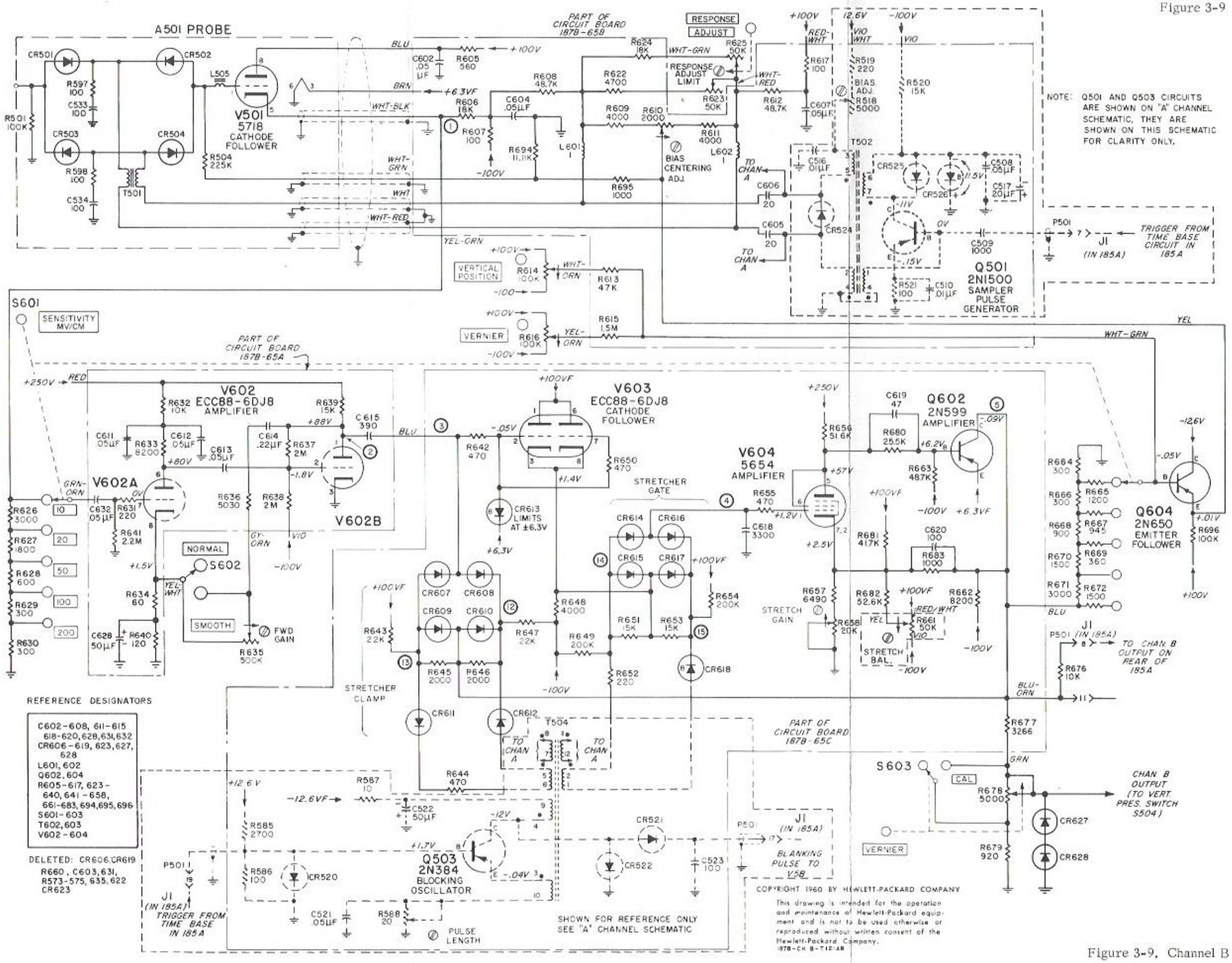


Figure 3-9. Channel B

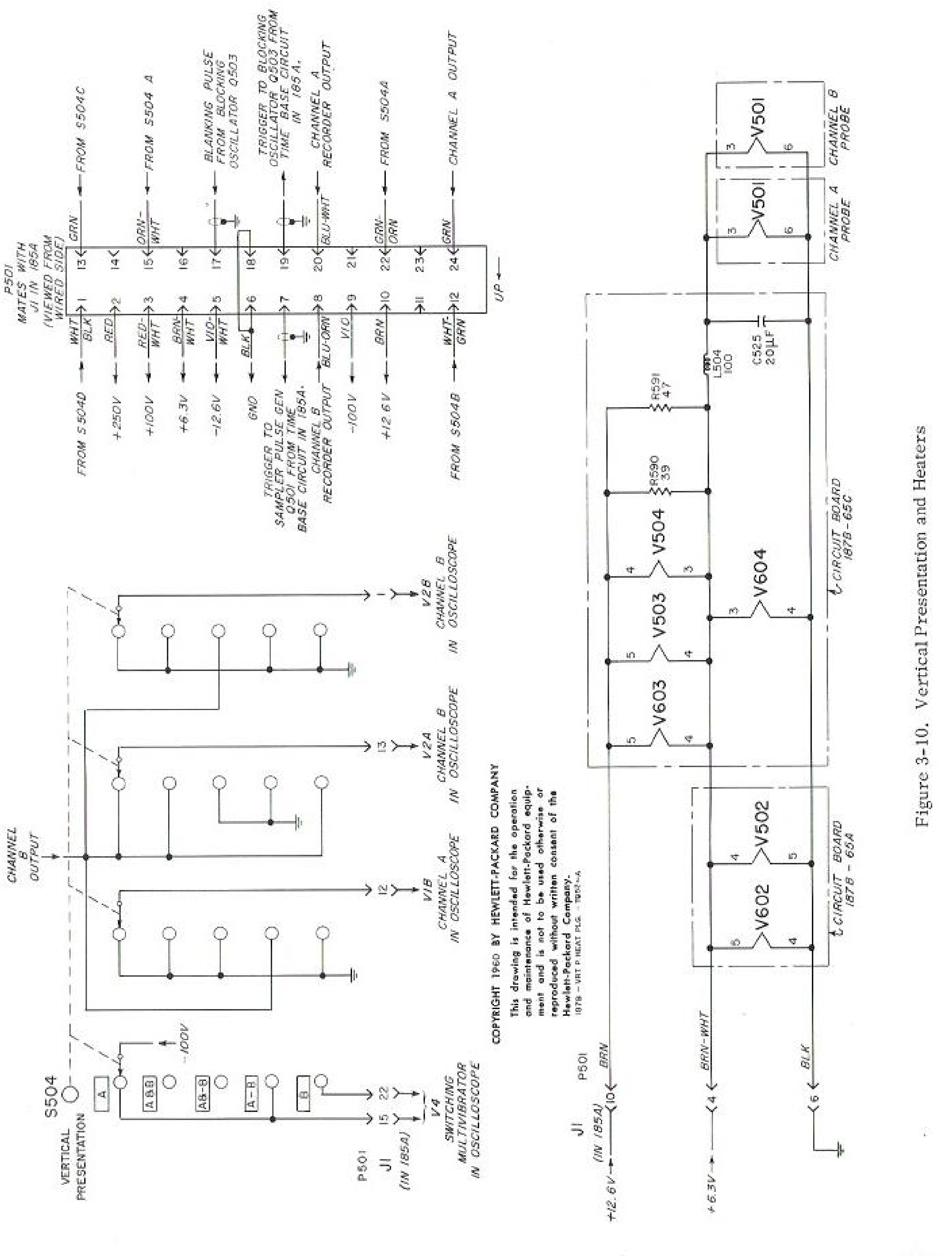


Figure 3-10. Vertical Presentation and Heaters

SECTION IV
REPLACEABLE PARTS

4-1. INTRODUCTION.

4-2. This section contains information for ordering replacement parts. Table 4-1 lists parts in alpha-numerical order of their reference designators and indicates the description and ℗ stock number of each part, together with any applicable notes. Table 4-2 lists parts in alpha-numerical order of their ℗ stock numbers and provides the following information on each part:

a. Description of the part (see list of abbreviations below).

b. Manufacturer of the part in a five-digit code; see list of manufacturers in appendix.

c. Typical manufacturer's stock number.

d. Total quantity used in the instrument (TQ column).

e. Recommended spare part quantity for complete maintenance during one year of isolated service (RS column).

4-3. Miscellaneous parts not indexed in table 4-1 are listed at the end of table 4-2.

4-4. ORDERING INFORMATION.

4-5. To order a replacement part, address order or inquiry either to your authorized Hewlett-Packard sales representative or to

CUSTOMER SERVICE
Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California

or, in Western Europe, to

Hewlett-Packard S.A.
Rue du Vieux Billard No. 1
Geneva, Switzerland.

4-6. Specify the following information for each part:

a. Model and complete serial number of instrument.

b. Hewlett-Packard stock number.

c. Circuit reference designator.

d. Description.

4-7. To order a part not listed in tables 4-1 and 4-2, give a complete description of the part and include its function and location.

REFERENCE DESIGNATORS

A	= assembly
B	= motor
C	= capacitor
CR	= diode
DL	= delay line
DS	= device signaling (lamp)
E	= misc electronic part
F	= fuse
FL	= filter
J	= jack
K	= relay
L	= inductor
M	= meter
P	= plug
Q	= transistor
R	= resistor
RT	= thermistor
S	= switch
T	= transformer
V	= vacuum tube, neon bulb, photocell, etc.
W	= cable
X	= socket
XF	= fuseholder
XV	= tube socket
XDS	= lampholder

ABBREVIATIONS

bp	= bandpass
bwo	= backward wave oscillator
c	= carbon
cer	= ceramic
cmo	= cabinet mount only
coef	= coefficient
com	= common
comp	= composition
conn	= connection
crt	= cathode-ray tube
dep	= deposited
det	= detector
EIA	= Tubes and transistors selected for best performance will be supplied if ordered by ℗ stock numbers; tubes or transistors meeting Electronic Industries' Association standards will normally result in instrument operating within specifications
elect	= electrolytic
encap	= encapsulated
f	= farads
fxd	= fixed
Ge	= germanium
grd	= ground (ed)
h	= henries
Hg	= mercury
impg	= impregnated
incd	= incandescent
ins	= insulation (ed)
K	= kilo
lin	= linear taper
log	= logarithmic taper
m	= milli = 10^{-3}
M	= megohms
ma	= milliamperes
minat	= miniature
mfg	= metal film on glass
mfr	= manufacturer
mtg	= mounting
my	= mylar
NC	= normally closed
Ne	= neon
NO	= normally open
NPO	= negative positive zero-zero temperature coefficient
nsr	= not separately replaceable
obd	= order by description
p	= peak
pc	= printed circuit board
pf	= picofarads = 10^{-12} farads
pp	= peak-to-peak
piv	= peak inverse voltage
pos	= position(s)
poly	= polystyrene
pot	= potentiometer
rect	= rectifier
rot	= rotary
rms	= root-mean-square
rmo	= rack mount only
s-b	= slow-blow
Se	= selenium
sect	= section(s)
Si	= silicon
sl	= slide
td	= time delay
TiO_2	= titanium dioxide
tog	= toggle
tol	= tolerance
trim	= trimmer
twt	= traveling wave tube
var	= variable
w/	= with
W	= watts
ww	= wirewound
w/o	= without
*	= optimum value selected at factory, average value shown (part may be omitted)

01194-2

Table 4-1. Reference Designation Index

Circuit Reference	Ⓟ Stock No.	Description #	Note
A1 thru A500		Not Assigned	
A501	187B-21A	Assy, probe (red); includes: C533 CR502 L505 R597 V501 C534 CR503 R501 R593 CR501 CR504 R504 T501	a
A502	187B-34A	Assy, attenuator; includes: CR527 R526 thru R530 R579 CR528 R564 thru R572 R596 Q504 R578 S501	
A503	187B-65A	Assy, etched circuit: pre-amp, includes: C511 thru C515 C628 R631 thru R634 C528 C632 R636 thru R641 C532 R531 thru R534 XV502 C611 thru C615 R536 thru R541 XV602	
A504	187B-65B	Assy, etched circuit: sampler, includes: C502 L502 R595 C504 thru C510 L504 R605 thru R613 C516 L601 R615 C517 L602 R617 C525 Q501 R622 C602 R505 thru R513 R624 C604 thru C607 R515 R694 CR524 thru CR526 R517 thru R522 R695 L501 R524 XT502 R594	
A505	187B-65C	Assy, etched circuit: stretcher, includes: C518 thru C524 Q503 R662 C526 Q602 R663 C527 R542 thru R558 R677 C618 thru C620 R562 R680 thru R683 CR507 thru CR518 R563 T504 CR520 thru CR522 R577 XV503 CR607 thru CR618 R580 thru R583 XV504 L503 R585 thru R591 XV603 Q502 R642 thru R658 XV604	
A506 thru A600		Not Assigned	
A601	187B-21B	Assy, probe (black); includes: C633 CR602 L605 R697 V601 C634 CR603 R601 R698 CR601 CR604 R604 T601	a
A602	187B-34A	Assy, attenuator; includes: CR627 R626 thru R630 R679 CR628 R664 thru R672 R696 Q604 R678 S601	
C1 thru C501		Not Assigned	
C502	0150-0052	fxd, cer, 0.05 μf ±20%, 400 vdcw	
C503		Not Assigned	
C504	0150-0052	fxd, cer, 0.05 μf ±20%, 400 vdcw	
C505, 506	0150-0061	fxd, cer, 20 pf ±10%, 100 vdcw	
C507, 508	0150-0052	fxd, cer, 0.05 μf ±20%, 400 vdcw	
C509	0150-0050	fxd, cer, 1K pf, 600 vdcw	

See introduction to this section

Table 4-1. Reference Designation Index (Cont'd)

Circuit Reference	Stock No.	Description #	Note
C510	0150-0012	fxd, cer, 0.01 µf ±20%, 1000 vdcw	
C511 thru C513	0150-0052	fxd, cer, 0.05 µf ±20%, 400 vdcw	
C514	0160-0018	fxd, paper, 0.22 µf ±10%, 400 vdcw	
C515	0140-0037	fxd, mica, 390 pf ±5%, 500 vdcw	
C516	0150-0012	fxd, cer, 0.01 µf ±20%, 1000 vdcw	
C517	0180-0049	fxd, elect, 20 µf, 50 vdcw	
C518	0150-0079	fxd, cer, 3.3K pf ±10%, 500 vdcw	
C519	0150-0010	fxd, cer, 47 pf ±5%, 500 vdcw	
C520	0150-0073	fxd, cer, 100 pf ±10%, 500 vdcw	
C521	0150-0052	fxd, cer, 0.05 µf ±20%, 400 vdcw	
C522	0180-0058	fxd, elect, 50 µf -10% +100%, 25 vdcw	
C523	0150-0073	fxd, cer, 100 pf ±10%, 500 vdcw	
C524	0180-0058	fxd, elect, 50 µf -10% +100%, 25 vdcw	
C525	0180-0045	fxd, elect, 20 µf, 25 vdcw	
C526, 527	0150-0052	fxd, cer, 0.05 µf ±20%, 400 vdcw	
C528	0180-0033	fxd, elect, 50 µf, 6 vdcw	
C529 thru C531		Not Assigned	
C532	0150-0052	fxd, cer, 0.05 µf ±20%, 400 vdcw	
C533, 534	0150-0073	fxd, cer, 100 pf ±10%, 500 vdcw	
C535 thru C601		Not Assigned	
C602	0150-0052	fxd, cer, 0.05 µf ±20%, 400 vdcw	
C603		Not Assigned	
C604	0150-0052	fxd, cer, 0.05 µf ±20%, 400 vdcw	
C605, 606	0150-0061	fxd, cer, 20 pf ±10%, 100 vdcw	
C607	0150-0052	fxd, cer, 0.05 µf ±20%, 400 vdcw	
C608 thru C610		Not Assigned	
C611 thru C613	0150-0052	fxd, cer, 0.05 µf ±20%, 400 vdcw	
C614	0160-0018	fxd, paper, 0.22 µf ±10%, 400 vdcw	
C615	0140-0037	fxd, mica, 390 pf ±5%, 500 vdcw	
C616, 617		Not Assigned	
C618	0150-0079	fxd, cer, 3.3K pf ±10%, 500 vdcw	
C619	0150-0010	fxd, cer, 47 pf ±5%, 500 vdcw	
C620	0150-0073	fxd, cer, 100 pf ±10%, 500 vdcw	
C621 thru C627		Not Assigned	
C628	0180-0033	fxd, elect, 50 µf, 6 vdcw	
C629 thru C631		Not Assigned	
C632	0150-0052	fxd, cer, 0.05 µf ±20%, 400 vdcw	
C633, 634	0150-0073	fxd, cer, 100 pf ±10%, 500 vdcw	

See introduction to this section

Table 4-1. Reference Designation Index (Cont'd)

Circuit Reference	Stock No.	Description #	Note
CR1 thru CR500		Not Assigned	
CR501	G-29L-52	Diode, Si	
CR502	G-29L-58	Diode, Si	
CR503	G-29L-52	Diode, Si	
CR504	G-29L-58	Diode, Si	
CR505, 506		Not Assigned	
CR507 thru CR512	G-29D-8	Diode, Si	
CR513	G-31A-12A	Diode, Si	
CR514	G-29M-9	Diode, Si	
CR515	G-29D-8	Diode, Si	
CR516	G-29M-9	Diode, Si	
CR517	G-29D-8	Diode, Si	
CR518	G-29A-74	Diode, Si	
CR519		Not Assigned	
CR520	G-29D-8	Diode, Si	
CR521	1910-0011	Diode, Ge: Type HD-2135A-5	
CR522	G-29D-15	Diode, Si	
CR523		Not Assigned	
CR524	G-29J-38	Diode, Si	
CR525	G-29L-76	Diode, Si	
CR526	G-31A-12L	Diode, Si	
CR527, 528	G-29A-10	Diode, Si	
CR529 thru CR600		Not Assigned	
CR601	G-29L-52	Diode, Si	
CR602	G-29L-58	Diode, Si	
CR603	G-29L-52	Diode, Si	
CR604	G-29L-58	Diode, Si	
CR605, 606		Not Assigned	
CR607 thru CR612	G-29D-8	Diode, Si	
CR613	G-31A-12A	Diode, Si	
CR614	G-29M-9	Diode, Si	
CR615	G-29D-8	Diode, Si	
CR616	G-29M-9	Diode, Si	
CR617	G-29D-8	Diode, Si	
CR618	G-29A-74	Diode, Si	
CR619 thru CR626		Not Assigned	
CR627, 628	G-29A-10	Diode, Si	
L1 thru L500		Not Assigned	

See introduction to this section

Table 4-1. Reference Designation Index (Cont'd)

Circuit Reference	Stock No.	Description#	Note
L501, 502	9140-0018	Inductor, fxd: 1 μh	
L503, 504	9140-0029	Inductor, fxd: 100 μh	
L505	9170-0029	Core, ferrite bead: green, 0.047" I.D. x 0.138" O.D. x 0.118" long	
L506 thru L600		Not Assigned	
L601, 602	9140-0018	Inductor, fxd: 1 μh	
L603, 604		Not Assigned	
L605	9170-0029	Core, ferrite bead: green, 0.047" I.D. x 0.138" O.D. x 0.118" long	
P1 thru P500		Not Assigned	
P501	1251-0055	Connector, male: 24 pin	
Q1 thru Q500		Not Assigned	
Q501	1850-0051	Transistor: 2N1500	
Q502	1850-0019	Transistor: 2N599	
Q503	1850-0029	Transistor: selected	
Q504	1850-0048	Transistor: 2N650	
Q505 thru Q601		Not Assigned	
Q602	1850-0019	Transistor: 2N599	
Q603		Not Assigned	
Q604	1850-0048	Transistor: 2N650	
R1 thru R500		Not Assigned	
R501	0721-0004	fxd, dep c, 100K ohms ±1%, 1/8 W	
R502, 503		Not Assigned	
R504	0721-0010	fxd, dep c, 225K ohms ±1%, 1/8 W	
R505	0687-5611	fxd, comp, 560 ohms ±10%, 1/2 W	
R506	0693-1831	fxd, comp, 18K ohms ±10%, 2 W	
R507	0687-1011	fxd, comp, 100 ohms ±10%, 1/2 W	
R508	0727-0193	fxd, dep c, 48.7K ohms ±1%, 1/2 W	
R509	0727-0132	fxd, dep c, 4K ohms ±1%, 1/2 W	
R510	2100-0090	var, comp, lin, 2K ohms ±30%, 1/3 W	
R511	0727-0132	fxd, dep c, 4K ohms ±1%, 1/2 W	
R512	0727-0193	fxd, dep c, 48.7K ohms ±1%, 1/2 W	
R513	0687-4731	fxd, comp, 47K ohms ±10%, 1/2 W	
R514	2100-0177	var, comp, dual concentric, "U" lin 100K ohms ±20%, 1.5 W front, 1.34 W rear	
R515	0687-1551	fxd, comp, 1.5M ±10%, 1/2 W	
R516	2100-0177	var, comp, dual concentric, "U" lin, 100K ohms ±20%, 1.5 W front, 1.34 W rear	
R517	0687-1011	fxd, comp, 100 ohms ±10%, 1/2 W	

See introduction to this section

Table 4-1. Reference Designation Index (Cont'd)

Circuit Reference	ⓗ Stock No.	Description #	Note
R518	2100-0091	var, comp, lin, 5K ohms ±30%, 1/3 W	
R519	0687-2211	fxd, comp, 220 ohms ±10%, 1/2 W	
R520	0393-1531	fxd, comp, 15K ohms ±10%, 2 W	
R521	0687-1011	fxd, comp, 100 ohms ±10%, 1/2 W	
R522	0687-4721	fxd, comp, 47K ohms ±10%, 1/2 W	
R523	2100-0141	var, comp, lin, 50K ohms ±20%, 1/4 W	
R524	0687-1831	fxd, comp, 18K ohms ±10%, 1/2 W	
R525	2100-0044	var, comp, lin, 50K ohms ±10%	
R526	0727-0124	fxd, dep c, 3K ohms ±1%, 1/2 W	
R527	0727-0112	fxd, dep c, 1800 ohms ±1%, 1/2 W	
R528	0727-0081	fxd, dep c, 600 ohms ±1%, 1/2 W	
R529, 530	0727-0065	fxd, dep c, 300 ohms ±1%, 1/2 W	
R531	0687-2211	fxd, comp, 220 ohms ±10%, 1/2 W	
R532	0393-1031	fxd, comp, 10K ohms ±10%, 2 W	
R533	0761-0001	fxd, mfg, 8.2K ohms ±5%, 1 W	
R534	0727-0031	fxd, dep c, 60 ohms ±1%, 1/2 W	
R535		Not Assigned	
R536	0727-0136	fxd, dep c, 5030 ohms ±1%, 1/2 W	
R537, 538	0686-2055	fxd, comp, 2M ±5%, 1/2 W	
R539	0393-1531	fxd, comp, 15K ohms ±10%, 2 W	
R540	0727-0044	fxd, dep c, 120 ohms ±1%, 1/2 W	
R541	0687-2251	fxd, comp, 2.2M ±10%, 1/2 W	
R542	0687-4711	fxd, comp, 470 ohms ±10%, 1/2 W	
R543	0730-0039	fxd, dep c, 22K ohms ±1%, 1 W	
R544	0687-4711	fxd, comp, 2.2M ±10%, 1/2 W	
R545, 546	0727-0115	fxd, dep c, 2K ohms ±1%, 1/2 W	
R547	0730-0039	fxd, dep c, 22K ohms ±1%, 1 W	
R548	0774-0001	fxd, mfg, 4K ohms ±10%, 5 W	
R549	0727-0221	fxd, dep c, 200K ohms ±1%, 1/2 W	
R550	0687-4711	fxd, comp, 470 ohms ±10%, 1/2 W	
R551	0727-0168	fxd, dep c, 15K ohms ±1%, 1/2 W	
R552	0687-2211	fxd, comp, 220 ohms ±10%, 1/2 W	
R553	0727-0168	fxd, dep c, 15K ohms ±1%, 1/2 W	
R554	0727-0221	fxd, dep c, 200K ohms ±1%, 1/2 W	
R555	0687-4711	fxd, comp, 470 ohms ±10%, 1/2 W	
R556	0730-0052	fxd, dep c, 51.6K ohms ±1%, 1 W	
R557	0727-0143	fxd, dep c, 6490 ohms ±1%, 1/2 W	
R558	2100-0093	var, comp, lin, 20K ohms ±20%, 1/4 W	
R559, 560		Not Assigned	
R561	2100-0028	var, comp, 50K ohms ±10%	

See introduction to this section

Table 4-1. Reference Designation Index (Cont'd)

Circuit Reference	Stock No.	Description #	Note
R562	0767-0007	fxd, mfg, 8.2K ohms ±5%, 3 W	
R563	0727-0193	fxd, dep c, 48.7K ohms ±1%, 1/2 W	
R564	0727-0065	fxd, dep c, 300 ohms ±1%, 1/2 W	
R565	0727-0105	fxd, dep c, 1.2K ohms ±1%, 1/2 W	
R566	0727-0065	fxd, dep c, 300 ohms ±1%, 1/2 W	
R567	0727-0098	fxd, dep c, 945 ohms ±1%, 1/2 W	
R568	0727-0095	fxd, dep c, 900 ohms ±1%, 1/2 W	
R569	0727-0068	fxd, dep c, 360 ohms ±1%, 1/2 W	
R570	0727-0110	fxd, dep c, 1.5K ohms ±1%, 1/2 W	
R571	0727-0124	fxd, dep c, 3K ohms ±1%, 1/2 W	
R572	0727-0110	fxd, dep c, 1.5K ohms ±1%, 1/2 W	
R573 thru R575		Not Assigned	
R576	0686-1035	fxd, comp, 10K ohms ±5%, 1/2 W	
R577	0727-0126	fxd, dep c, 3266 ohms ±1%, 1/2 W	
R578	2100-0226	var, comp, lin, 5K ohms ±20%, 1/2 W w/switch	
R579	0727-0096	fxd, dep c, 920 ohms ±1%, 1/2 W	
R580	0727-0180	fxd, dep c, 25,500 ohms ±1%, 1/2 W	
R581	0727-0189	fxd, dep c, 41.7K ohms ±1%, 1/2 W	
R582	0727-0196	fxd, dep c, 52.6K ohms ±1%, 1/2 W	
R583	0727-0100	fxd, dep c, 1K ohms ±1%, 1/2 W	
R584		Not Assigned	
R585	0687-2721	fxd, comp, 2.7K ohms ±10%, 1/2 W	
R586	0687-1011	fxd, comp, 100 ohms ±10%, 1/2 W	
R587	0687-1001	fxd, comp, 10 ohms ±10%, 1/2 W	
R588	2100-0227	var, ww, lin, 20 ohms ±10%, 1 W	
R589	0687-5601	fxd, comp, 56 ohms ±10%, 1/2 W	
R590	0692-3905	fxd, comp, 39 ohms ±5%, 2 W	
R591	0693-4701	fxd, comp, 47 ohms ±10%, 2 W	
R592, 593		Not Assigned	
R594	0727-0161	fxd, dep c, 11,110 ohms ±1%, 1/2 W	
R595	0727-0100	fxd, dep c, 1K ohms ±1%, 1/2 W	
R596	0687-1041	fxd, comp, 100K ohms ±10%, 1/2 W	
R597, 598	0721-0014	fxd, dep c, 100 ohms ±1%, 0.1 W	
R599, 600		Not Assigned	
R601	0721-0004	fxd, dep c, 100K ohms ±1%, 1/8 W	
R602, 603		Not Assigned	
R604	0721-0010	fxd, dep c, 225K ohms ±1%, 1/8 W	
R605	0687-5611	fxd, comp, 560 ohms ±10%, 1/2 W	
R606	0393-1831	fxd, comp, 18K ohms ±10%, 2 W	

See introduction to this section

Table 4-1. Reference Designation Index (Cont'd)

Circuit Reference	℗ Stock No.	Description #	Note
R607	0687-1011	fxd, comp, 100 ohms ±10%, 1/2 W	
R608	0727-0193	fxd, dep c, 48.7K ohms ±1%, 1/2 W	
R609	0727-0132	fxd, dep c, 4K ohms ±1%, 1/2 W	
R610	2100-0090	var, comp, lin, 2K ohms ±30%, 1/3 W	
R611	0727-0132	fxd, dep c, 4K ohms ±1%, 1/2 W	
R612	0727-0193	fxd, dep c, 48.7K ohms ±1%, 1/2 W	
R613	0687-4731	fxd, comp, 47K ohms ±10%, 1/2 W	
R614	2100-0177	var, comp, dual concentric "U" lin, 100K ohms ±20%, 1.5 W front, 1.34 W rear	
R615	0687-1551	fxd, comp, 1.5M ±10%, 1/2 W	
R616	2100-0177	var, comp, dual concentric, "U" lin, 100K ohms ±20%, 1.5 W front, 1.34 W rear	
R617	0687-1011	fxd, comp, 100 ohms ±10%, 1/2 W	
R618 thru R621		Not Assigned	
R622	0687-4721	fxd, comp, 4.7K ohms ±10%, 1/2 W	
R623	2100-0141	var, comp, lin, 50K ohms ±20%, 1/4 W	
R624	0687-1831	fxd, comp, 18K ohms ±10%, 1/2 W	
R625	2100-0044	var, comp, lin, 50K ohms ±10%.	
R626	0727-0124	fxd, dep c, 3K ohms ±1%, 1/2 W	
R627	0727-0112	fxd, dep c, 1.8K ohms ±1%, 1/2 W	
R628	0727-0081	fxd, dep c, 600 ohms ±1%, 1/2 W	
R629, 630	0727-0065	fxd, dep c, 300 ohms ±1%, 1/2 W	
R631	0687-2211	fxd, comp, 220 ohms ±10%, 1/2 W	
R632	0393-1031	fxd, comp, 10K ohms ±10%, 2 W	
R633	0761-0001	fxd, mfg, 8.2K ohms ±5%, 1 W	
R634	0727-0031	fxd, dep c, 60 ohms ±1%, 1/2 W	
R635		Not Assigned	
R636	0727-0136	fxd, dep c, 5030 ohms ±1%, 1/2 W	
R637, 638	0686-2055	fxd, comp, 2M ±5%, 1/2 W	
R639	0693-1531	fxd, comp, 15K ohms ±10%, 2 W	
R640	0727-0044	fxd, dep c, 120 ohms ±1%, 1/2 W	
R641	0687-2251	fxd, comp, 2.2M ±10%, 1/2 W	
R642	0687-4711	fxd, comp, 470 ohms ±10%, 1/2 W	
R643	0730-0039	fxd, dep c, 22K ohms ±1%, 1 W	
R644	0687-4711	fxd, comp, 470 ohms ±10%, 1/2 W	
R645, 646	0727-0115	fxd, dep c, 2K ohms ±1%, 1/2 W	
R647	0730-0039	fxd, dep c, 22K ohms ±1%, 1 W	
R648	0774-0001	fxd, mfg, 4K ohms ±10%, 5 W	

See introduction to this section

Table 4-1. Reference Designation Index (Cont'd)

Circuit Reference	⊕ Stock No.	Description #	Note
R649	0727-0221	fxd, dep c, 200K ohms ±1%, 1/2 W	
R650	0687-4711	fxd, comp, 470 ohms ±10%, 1/2 W	
R651	0727-0163	fxd, dep c, 15K ohms ±1%, 1/2 W	
R652	0687-2211	fxd, comp, 220 ohms ±10%, 1/2 W	
R653	0727-0168	fxd, dep c, 15K ohms ±1%, 1/2 W	
R654	0727-0221	fxd, dep c, 200K ohms ±1%, 1/2 W	
R655	0687-4711	fxd, comp, 470 ohms ±10%, 1/2 W	
R656	0730-0052	fxd, dep c, 51.6K ohms ±1%, 1 W	
R657	0727-0143	fxd, dep c, 6490 ohms ±1%, 1/2 W	
R658	2100-0093	var, comp, lin, 20K ohms ±20%, 1/4 W	
R659, 660		Not Assigned	
R661	2100-0028	var, comp, 50K ohms ±10%	
R662	0767-0007	fxd, mfg, 8.2K ohms ±5%, 3 W	
R663	0727-0193	fxd, dep c, 48.7K ohms ±1%, 1/2 W	
R664	0727-0065	fxd, dep c, 300 ohms ±1%, 1/2 W	
R665	0727-0105	fxd, dep c, 1.2K ohms ±1%, 1/2 W	
R666	0727-0035	fxd, dep c, 300 ohms ±1%, 1/2 W	
R667	0727-0093	fxd, dep c, 945 ohms ±1%, 1/2 W	
R668	0727-0095	fxd, dep c, 900 ohms ±1%, 1/2 W	
R669	0727-0068	fxd, dep c, 360 ohms ±1%, 1/2 W	
R670	0727-0110	fxd, dep c, 1.5K ohms ±1%, 1/2 W	
R671	0727-0124	fxd, dep c, 3K ohms ±1%, 1/2 W	
R672	0727-0110	fxd, dep c, 1.5K ohms ±1%, 1/2 W	
R673 thru R675		Not Assigned	
R676	0686-1035	fxd, comp, 10K ohms ±5%, 1/2 W	
R677	0727-0126	fxd, dep c, 3266 ohms ±1%, 1/2 W	
R678	2100-0226	var, comp, lin, 5K ohms ±20%, 1/2 W w/switch	
R679	0727-0096	fxd, dep c, 920 ohms ±1%, 1/2 W	
R680	0727-0180	fxd, dep c, 25.5K ohms ±1%, 1/2 W	
R681	0727-0189	fxd, dep c, 41.7K ohms ±1%, 1/2 W	
R682	0727-0196	fxd, dep c, 52.6K ohms ±1%, 1/2 W	
R683	0727-0100	fxd, dep c, 1K ohms ±1%, 1/2 W	
R684 thru R693		Not Assigned	
R694	0727-0161	fxd, dep c, 11,110 ohms ±1%, 1/2 W	
R695	0727-0100	fxd, dep c, 1K ohms ±1%, 1/2 W	
R696	0687-1041	fxd, comp, 100K ohms ±10%, 1/2 W	
R697, 698	0721-0014	fxd, dep c, 100 ohms ±1%, 0.1 W	

See introduction to this section

Table 4-1. Reference Designation Index (Cont'd)

Circuit Reference	Stock No.	Description #	Note
S1 thru S500		Not Assigned	
S501		nsr; part of A502	
S502	3101-0001	Switch, tog: SPST	
S503		part of R578	
S504	3100-0240	Switch, rot: 1 sect, 5 pos	
S505 thru S600		Not Assigned	
S601		nsr; part of A602	
S602	3101-0001	Switch, tog: SPST	
S603		part of R678	
T1 thru T500		Not Assigned	
T501	187B-60A	Assy, balun coil	
T502	187A-60D	Transformer: sampling pulse generator	
T503		Not Assigned	
T504	187A-60C	Transformer, pulse	
T505 thru T600		Not Assigned	
T601	187B-60A	Assy, balun coil	
V1 thru V500		Not Assigned	
V501	1921-0011	Tube, elect: 5718	
V502, 503	1932-0022	Tube, elect: 6DJ8/ECC88	
V504	1923-0001	Tube, elect: 5654	
V505 thru V600		Not Assigned	
V601	1921-0011	Tube, elect: 5718	
V602, 603	1932-0022	Tube, elect: 6DJ8/ECC88	
V604	1923-0001	Tube, elect: 5654	
XT1 thru XT501		Not Assigned	
XT502	1200-0053	Socket, tube: 7 pin minat	
XV1 thru XV501		Not Assigned	
XV502	1200-0048	Socket, tube: 9 pin minat	
XV503	1200-0047	Socket, tube: 7 pin minat	
XV504	1200-0048	Socket, tube: 9 pin minat	
XV505 thru XV601		Not Assigned	
XV602	1200-0048	Socket, tube: 9 pin minat	
XV603	1200-0047	Socket, tube: 7 pin minat	
XV604	1200-0048	Socket, tube: 9 pin minat	
a. A501 and A601 are identical except for color of cable boot.			

See introduction to this section

Table 4-1. Reference Designation Index (Cont'd)

Circuit Reference	Stock No.	Description #	Note
		MISCELLANEOUS	
	G-74Q	Knob: concentric bar w/arrow (SENSITIVITY)	
	G-74AU	Knob: 3/4" concentric, red w/arrow (VERNIER)	
	G-74CA	Knob: 5/8", black w/arrow (ADJUST)	
	G-74CE	Knob: 5/8" black (LOCK)	
	G-74CF	Knob: 1" concentric, black w/arrow (VERTICAL POSITION)	
	G-74CG	Knob: 3/4" bar w/2 arrows (VERTICAL PRESENTATION)	
	187A-76A	Assy, BNC adapter	
	187B-76F	Sleeve, grounding (for 187A-76A Adapter)	
	187B-21A-6	Pin, center (for probe)	
	187B-21A-8	Assy, probe ground	

See introduction to this section

Table 4-2. Replaceable Parts

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
G-29A-10	Diode, Si	28480	G-29A-10	4	4		
G-29A-74	Diode, Si	28480	G-29A-74	2	2		
G-29D-8	Diode, Si	28480	G-29D-8	17	17		
G-29D-15	Diode, Si	28480	G-29D-15	1	1		
G-29J-38	Diode, Si	28480	G-29J-38	1	1		
G-29L-52	Diode, Si	28480	G-29L-52	4	4		
G-29L-58	Diode, Si	28480	G-29L-58	4	4		
G-29L-76	Diode, Si	28480	G-29L-76	1	1		
G-29M-9R	Diode, Si	28480	G-29M-9	4	4		
G-31A-12A	Diode, Si	28480	G-31A-12A	2	2		
G-31A-12L	Diode, Si	28480	G-31A-12L	1	1		
187A-60C	Transformer, pulse	28480	187A-60C	1	1		
187A-60D	Transformer: sampling pulse generator	28480	187A-60D	1	1		
187B-21A	Assy, probe (red): includes: C533 CR502 L505 R597 V501 C534 CR503 R501 R598 CR501 CR504 R504 T501	28480	187B-21A	1	1		
187B-21B	Assy, probe (black); includes: C633 CR602 L605 R697 V601 C634 CR603 R601 R698 CR601 CR604 R604 T601	28480	187B-21B	1	1		
187B-34A	Assy, attenuator; A502 -(includes: CR527 R526 thru R530 R579 CR528 R564 thru R572 R596 Q504 R578 S501) A602 - (includes: CR627 R626 thru R630 R679 CR628 R664 thru R672 R696 Q604 R678 S601)	28480	187B-34A	2	0		
187B-60A	Assy, balun coil 28480	28480	187B-60A	2	1		
187B-65A	Assy, etched circuit: pre-amp, includes: C511 thru C515 R531 thru R534 C528 R536 thru R541 C532 R631 thru R634 C611 thru C615 R636 thru R641 C628 XV502 C632 XV602	28480	187B-65A	2	0		

See introduction to this section

Table 4-2. Replaceable Parts (Cont'd)

Stock No.	Description#	Mfr.	Mfr. Part No.	TQ	RS		
187B-65B	Assy, etched circuit: sampler, includes: C502 R505 thru R513 C504 thru C510 R515 C516 R517 thru R522 C517 R524 C525 R594 C602 R595 C604 thru C607 R605 thru R613 CR524 thru CR526 R615 L501 R617 L502 R622 L504 R624 L601 R694 L602 R695 Q501 XT502	28480	187B-65B	2	0		
187B-65C	Assy, etched circuit: stretcher, includes: C518 thru C524 R577 C526 R580 thru R583 C527 R585 thru R591 C618 thru C620 R642 thru R658 CR507 thru CR518 R662 CR520 thru CR522 R663 CR607 thru CR618 R677 L503 R680 thru R683 Q502 T504 Q503 XV503 Q602 XV504 R542 thru R558 XV603 R562 XV604 R563	28480	187B-65C	2	0		
0140-0037	fxd, mica, 390 pf ±5%, 500 vdcw	76433	RCM15E391J	2	1		
0150-0010	fxd, cer, 47 pf ±5%, 500 vdcw	96095	SI47mmf ±5%, NPO	2	1		
0150-0012	fxd, cer, 0.01 µf ±20%, 1000 vdcw	56289	29C214A3-H-1038	2	1		
0150-0050	fxd, cer, 1K pf, 600 vdcw	84411	Type E	1	1		
0150-0052	fxd, cer, 0.05 µf ±20%, 400 vdcw	05729	20X503MC4	18	4		
0150-0061	fxd, cer, 20 pf ±10%, 100 vdcw	56289	53C47	4	1		
0150-0073	fxd, cer, 100 pf ±10%, 500 vdcw	56289	40C200A2	7	2		
0150-0079	fxd, cer, 3.3K pf ±10%, 500 vdcw	72982	811-000-Y5FO332K	2	1		
0160-0018	fxd, paper, 0.22 µf ±10%, 400 vdcw	56289	160P22494	2	1		
0180-0033	fxd, elect, 50 µf, 6 vdcw	56289	30D133A1	2	1		
0180-0045	fxd, elect, 20 µf, 25 vdcw	56289	Type 30D	1	1		
0180-0049	fxd, elect, 20µf, 50 vdcw	56289	30D198A1	1	1		
0180-0058	fxd, elect, 50 µf -10% +100%, 25 vdcw	56289	30D186A1	2	1		
0686-1035	fxd, comp, 10K ohms ±5%, 1/2 W	01121	EB1035	2	1		
0686-2055	fxd, comp, 2M ±5%, 1/2 W	01121	EB2055	4	1		
0687-1001	fxd, comp, 10 ohms ±10%, 1/2 W	01121	EB1001	1	1		
0687-1011	fxd, comp, 100 ohms ±10%, 1/2 W	01121	EB1011	6	2		
0687-1041	fxd, comp, 100K ohms ±10%, 1/2 W	01121	EB1041	2	1		

See introduction to this section

Table 4-2. Replaceable Parts (Cont'd)

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
0687-1551	fxd, comp, 1.5M ±10%, 1/2 W	01121	EB1551	2	1		
0687-1831	fxd, comp, 18K ohms ±10%, 1/2 W	01121	EB1831	2	1		
0687-2211	fxd, comp, 220 ohms ±10%, 1/2 W	01121	EB2211	5	2		
0687-2251	fxd, comp, 2.2M ±10%, 1/2 W	01121	EB2251	2	1		
0687-2721	fxd, comp, 2.7K ohms ±10%, 1/2 W	01121	EB2721	1	1		
0687-4711	fxd, comp, 470 ohms ±10%, 1/2 W	01121	EB4711	8	2		
0387-4721	fxd, comp, 4.7K ohms ±10%, 1/2 W	01121	EB4721	2	1		
0687-4731	fxd, comp, 47K ohms ±10%, 1/2 W	01121	EB4731	2	1		
0687-5601	fxd, comp, 56 ohms ±10%, 1/2 W	01121	EB5601	1	1		
0687-5611	fxd, comp, 560 ohms ±10%, 1/2 W	01121	EB5611	2	1		
0692-3905	fxd, comp, 39 ohms ±5%, 2 W	01121	HB3905	1	1		
0693-1031	fxd, comp, 10K ohms ±10%, 2 W	01121	HB1031	2	1		
0693-1531	fxd, comp, 15K ohms ±10%, 2 W	01121	HB1531	3	1		
0693-1831	fxd, comp, 18K ohms ±10%, 2 W	01121	HB1831	2	1		
0693-4701	fxd, comp, 47 ohms ±10%, 2 W	01121	HB4701	1	1		
0721-0004	fxd, dep c, 100K ohms ±1%, 1/8 W	19701	DC1/8R5, obd#	2	1		
0721-0010	fxd, dep c, 225K ohms ±1%, 1/8 W	19701	DC1/8R5, obd#	2	1		
0721-0014	fxd, dep c, 100 ohms ±1%, 0.1 W	80031	C-1, obd#	4	1		
0727-0031	fxd, dep c, 60 ohms ±1%, 1/2 W	19701	DC1/2CR5, obd#	2	1		
0727-0044	fxd, dep c, 120 ohms ±1%, 1/2 W	19701	DC1/2CR5, obd#	2	1		
0727-0065	fxd, dep c, 300 ohms ±1%, 1/2 W	19701	DC1/2CR5, obd#	8	2		
0727-0068	fxd, dep c, 360 ohms ±1%, 1/2 W	19701	DC1/2BR5, obd#	2	1		
0727-0081	fxd, dep c, 600 ohms ±1%, 1/2 W	19701	DC1/2AR5, obd#	2	1		
0727-0095	fxd, dep c, 900 ohms ±1%, 1/2 W	19701	DC1/2CR5, obd#	2	1		
0727-0096	fxd, dep c, 920 ohms ±1%, 1/2 W	19701	DC1/2CR5, obd#	2	1		
0727-0098	fxd, dep c, 945 ohms ±1%, 1/2 W	19701	DC1/2CR5, obd#	2	1		
0727-0100	fxd, dep c, 1K ohms ±1%, 1/2 W	19701	DC1/2CR5, obd#	4	1		
0727-0105	fxd, dep c, 1.2K ohms ±1%, 1/2 W	19701	DC1/2CR5, obd#	2	1		
0727-0110	fxd, dep c, 1.5K ohms ±1%, 1/2 W	19701	DC1/2CR5, obd#	4	1		
0727-0112	fxd, dep c, 1.8K ohms ±1%, 1/2 W	19701	DC1/2CR5, obd#	2	1		
0727-0115	fxd, dep c, 2K ohms ±1%, 1/2 W	19701	DC1/2CR5, obd#	4	1		
0727-0124	fxd, dep c, 3K ohms ±1%, 1/2 W	19701	DC1/2CR5, obd#	4	1		
0727-0126	fxd, dep c, 3266 ohms ±1%, 1/2 W	19701	DC1/2AR5, obd#	2	1		
0727-0132	fxd, dep c, 4K ohms ±1%, 1/2 W	19701	DC1/2CR5, obd#	4	1		
0727-0136	fxd, dep c, 5030 ohms ±1%, 1/2 W	19701	DC1/2CR5, obd#	2	1		
0727-0143	fxd, dep c, 6490 ohms ±1%, 1/2 W	19701	DC1/2CR5, obd#	2	1		
0727-0161	fxd, dep c, 11,110 ohms ±1%, 1/2 W	19701	DC1/2AR5	2	1		

See introduction to this section

Table 4-2. Replaceable Parts (Cont'd)

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
0727-0168	fxd, dep c, 15K ohms ±1%, 1/2 W	19701	DC1/2CR5, obd#	4	1		
0727-0180	fxd, dep c, 25.5K ohms ±1%, 1/2 W	19701	DC1/2CR5, obd#	2	1		
0727-0189	fxd, dep c, 41.7K ohms ±1%, 1/2 W	19701	DC1/2CR5, obd#	2	1		
0727-0193	fxd, dep c, 48.7K ohms ±1%, 1/2 W	19701	DC1/2AR5, obd#	6	2		
0727-0196	fxd, dep c, 52.6K ohms ±1%, 1/2 W	19701	DC1/2CR5, obd#	2	1		
0727-0221	fxd, dep c, 200K ohms ±1%, 1/2 W	19701	DC1/2AR5, obd#	4	1		
0730-0039	fxd, dep c, 22K ohms ±1%, 1 W	19701	DC1R5	4	1		
0730-0052	fxd, dep c, 51.6K ohms ±1%, 1 W	19701	DC1R5, obd#	2	1		
0761-0001	fxd, mfg, 8.2K ohms ±5%, 1 W	07115	Style N25	2	1		
0767-0007	fxd, mfg, 8.2K ohms ±5%, 3 W	07115	LPI-3	2	1		
0774-0001	fxd, mfg, 4K ohms ±10%, 5 W	07115	LPI-5	2	1		
1200-0047	Socket, tube: 7 pin minat	91662	3708-2-4	2	1		
1200-0048	Socket, tube: 9 pin minat	91662	3908-2-4	4	1		
1200-0053	Socket, tube: 7 pin minat	71785	111-51-11-069	1	1		
1251-0055	Connector, male: 24 pin	02660	26-4100-24P	1	1		
1850-0019	Transistor: 2N599	11711	2N599	2	2		
1850-0029	Transistor: selected	28480	1850-0029	1	1		
1850-0048	Transistor: 2N650	04713	2N650	2	2		
1850-0051	Transistor: 2N1500	87216	obd#	1	1		
1910-0011	Diode, Ge: Type HD-2135A-5	73293	HD-2135A-5	1	1		
1921-0011	Tube, elect: 5718	80131	5718	2	2		
1923-0001	Tube, elect: 5654	80131	5654	2	2		
1932-0022	Tube elect: 6DJ8/ECC88	80131	6DJ8/ECC88	4	4		
2100-0028	var, comp, 50K ohms ±10%	01121	JA2L048S503UC	2	1		
2100-0044	var, comp, lin, 50K ohms ±10%	01121	JA1N056S503UA	2	1		
2100-0090	var, comp, lin, 2K ohms ±30%, 1/3 W	11237	UPE-70 Special obd#	2	1		
2100-0091	var, comp, lin, 5K ohms ±30%, 1/3 W	11237	UPE-70 Special obd#	1	1		
2100-0093	var, comp, lin, 20K ohms ±20%, 1/4 W	11237	UPE-70 Special obd#	2	1		
2100-0141	var, comp, lin, 50K ohms ±20%, 1/4 W	11237	Type 70, obd#	2	1		
2100-0177	var, comp, dual concentric, "U" lin, 100K ohms ±20%, 1.5 W front, 1.34 W rear	01121	JJC	4	1		
2100-0226	var, comp, lin, 5K ohms ±20%, 1/2 W w/switch	11237	VF45	2	1		
2100-0227	var, ww, lin, 20 ohms ±10%, 1 W	11236	110	1	1		
3100-0240	Switch, rot: 1 sect, 5 pos	76854	204049-N1	1	1		
3101-0001	Switch, tog: SPST	04009	AH&H80994-H	2	1		
9140-0018	Inductor, fxd: 1 μh	99848	205-11-10	4	1		
9140-0029	Inductor, fxd: 100 μh	99848	3100-15-101	2	1		
9170-0029	Core, ferrite bead: green, 0.047" I.D. x 0.138" O.D. x 0.118" long	02114	56-590-65/4A	2	1		

See introduction to this section

Table 4-2. Replaceable Parts (Cont'd)

ⓟ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
	MISCELLANEOUS						
G-74Q	Knob: concentric bar w/arrow (SENSITIVITY)	28480	G-74Q	2	0		
G-74AU	Knob: 3/4" concentric, red w/arrow (VERNIER)	28480	G-74AU	4	0		
G-74CA	Knob: 5/8" black w/arrow (ADJUST)	28480	G-74CA	2	0		
G-74CE	Knob: 5/8" black (LOCK)	28480	G-74CE	1	0		
G-74CF	Knob: 1" concentric, black w/arrow (VERTICAL POSITION)	28480	G-74CF	2	0		
G-74CG	Knob: 3/4" bar w/2 arrow (VERTICAL PRESENTATION)	28480	G-74CG	1	0		
187A-76A	Assy, BNC adapter	28480	187A-76A	2	1		
187B-76F	Sleeve, grounding (for 187A-76A Adapter)	28480	187B-76F	2	1		
187B-21A-6	Pin, center (for probe)	28480	187B-21A-6	1	1		
187B-21A-8	Assy, probe ground	28480	187B-21A-8	1	1		

See introduction to this section

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

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

CODE NO.	MANUFACTURER	ADDRESS
00334	Humidial Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00853	Sangamo Electric Company, Ordill Division (Capacitors)	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	Pacific Semiconductors, Inc.	Culver City, Calif.
01295	Texas Instruments, Inc. Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp.	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroscube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Morristown, N.J.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04062	Elmenco Products Co.	New York, N.Y.
04222	HI-Q Division of Aerovox	Myrtle Beach, S.C.
04298	Elgin National Watch Co., Electronics Division	Burbank, Calif.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Prods., Inc. Electronic Tube Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Division	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04870	P M Motor Co.	Chicago, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05624	Barber Colman Co.	Rockford, Ill.
05729	Metropolitan Telecommunications Corp., Metro Cap. Div.	Brooklyn, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
06004	The Bassick Co.	Bridgeport, Conn.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08717	Sloan Company	Burbank, Calif.
08718	Cannon Electric Co. Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S. Inc.	Lowell, Mass.
09026	Babcock Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11312	Microwave Electronics Corp.	Palo Alto, Calif.
11711	General Instrument Corporation Semiconductor Division	Newark, N.J.
11717	Imperial Electronics, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12697	Clarostat Mfg. Co.	Dover, N.H.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
15909	The Daven Co.	Livingston, N.J.
16758	Delco Radio Div. of G. M. Corp.	Kokomo, Ind.
18873	E. I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G.E., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
37942	P. R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C. A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Company	Lexington, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Swissvale, Pa.
62119	Universal Electric Co.	Owosso, Mich.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66346	Wollensak Optical Co.	Rochester, N.Y.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp.	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71450	CTS Corp.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C. P. Clare & Co.	Chicago, Ill.
71528	Standard-Thomson Corp., Clifford Mfg. Co. Div.	Waltham, Mass.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A. O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	Hamden, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74455	J. H. Winns, and Sons	Winchester, Mass.

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APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

CODE NO.	MANUFACTURER	ADDRESS
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E. F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littelfuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C. W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J. W. Miller Co.	Los Angeles, Calif.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Chicago, Ill.
77068	Bendix Pacific Division of Bendix Corp.	No. Hollywood, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77342	Potter and Brumfield, Div. of American Machine and Foundry	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
78283	Signal Indicator Corp.	New York, N.Y.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wesco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Association Any brand tube meeting EIA standards	Washington, D.C.
80207	Unimax Switch, Div. of W. L. Maxson Corp.	Wallingford, Conn.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Laboratories, Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Fulton Controls Co.	Columbus 16, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Components Div., Industr. Tube Operations	Newton, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs., Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc., Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls, Inc., Div. of Texas Instruments, Inc., Spencer Prods.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83125	Pyramid Electric Co.	Darlington, S.C.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Union, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A. J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85474	R. M. Bracemonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Havan, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87216	Philco Corp. (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89636	Carter Parts Div. of Economy Baler Co.	Chicago, Ill.
89665	United Transformer Co.	Chicago, Ill.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers, Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Eico Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91921	Minneapolis-Honeywell Regulator Co., Micro-Switch Division	Freeport, Ill.
92196	Universal Metal Products, Inc.	Bassett Puente, Calif.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94144	Raytheon Mfg. Co., Industrial Components Div., Receiving Tube Operation	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div., California Street Plant	Newton, Mass.
94148	Scientific Radio Products, Inc	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	East Paterson, N.J.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95264	Lorco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95354	Methode Mfg. Co.	Chicago, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96256	Thordarson-Meissner Div. of Maguire Industries, Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98405	Cerad Corp.	Redwood City, Calif.
98734	Palo Alto Engineering Co., Inc.	Palo Alto, Calif.
98821	North Hills Electric Co.	Mineola, N.Y.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Ill.
99957	Technology Instrument Corp. of Calif.	Newbury Park, Calif.

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

0000F	Malco Tool and Die	Los Angeles, Calif.
0000I	Telefunken (c/o American Elite)	New York, N.Y.
0000L	Winchester Electronics, Inc.	Santa Monica, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000N	Nahm-Bros. Spring Co.	San Leandro, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000T	Texas Instruments, Inc. Metals and Controls Div.	Versailles, Ky.
0000U	Tower Mfg. Corp.	Providence, R.I.
0000W	Webster Electronics Co. Inc.	New York, N.Y.
0000X	Spruce Pine Mica Co.	Spruce Pine, N.C.
0000Y	Midland Mfg. Co. Inc.	Kansas City, Kans.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AA	British Radio Electronics Ltd.	Washington, D.C.
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000CC	Computer Diode Corp.	Lodi, N.J.
000DD	General Transistor	Los Angeles, Calif.
000EE	A. Williams Manufacturing Co.	San Jose, Calif.
000FF	Carmichael Corrugated Specialties	Richmond, Calif.
000GG	Goshen Die Cutting Service	Goshen, Ind.

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WARRANTY

All our products are warranted against defects in materials and workmanship for one year from the date of shipment. Our obligation is limited to repairing or replacing products (except tubes) which prove to be defective during the warranty period. We are not liable for consequential damages.

For assistance of any kind, including help with instruments under warranty, contact your authorized hp Sales Representative for instructions. Give full details of the difficulty and include the instrument model and serial numbers. Service data or shipping instructions will be promptly sent to you. There will be no charge for repair of instruments under warranty, *except transportation charges*. Estimates of charges for non-warranty or other service work will always be supplied, if requested, before work begins.

CLAIM FOR DAMAGE IN SHIPMENT

Your instrument should be inspected and tested as soon as it is received. The instrument is insured for safe delivery. If the instrument is damaged in any way or fails to operate properly, file a claim with the carrier or, if insured separately, with the insurance company.

SHIPPING

On receipt of shipping instructions, forward the instrument prepaid to the destination indicated. You may use the original shipping carton or any strong container. Wrap the instrument in heavy paper or a plastic bag and surround it with three or four inches of shock-absorbing material to cushion it firmly and prevent movement inside the container.

GENERAL

Your authorized hp Sales Representative is ready to assist you in any situation, and you are always welcome to get directly in touch with Hewlett-Packard service departments:

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