

**TEKTRONIX®**

7L12

SPECTRUM  
ANALYZER

INSTRUCTION MANUAL



# INSTRUCTION MANUAL

## 7L12 SPECTRUM ANALYZER

Serial Number

B060448



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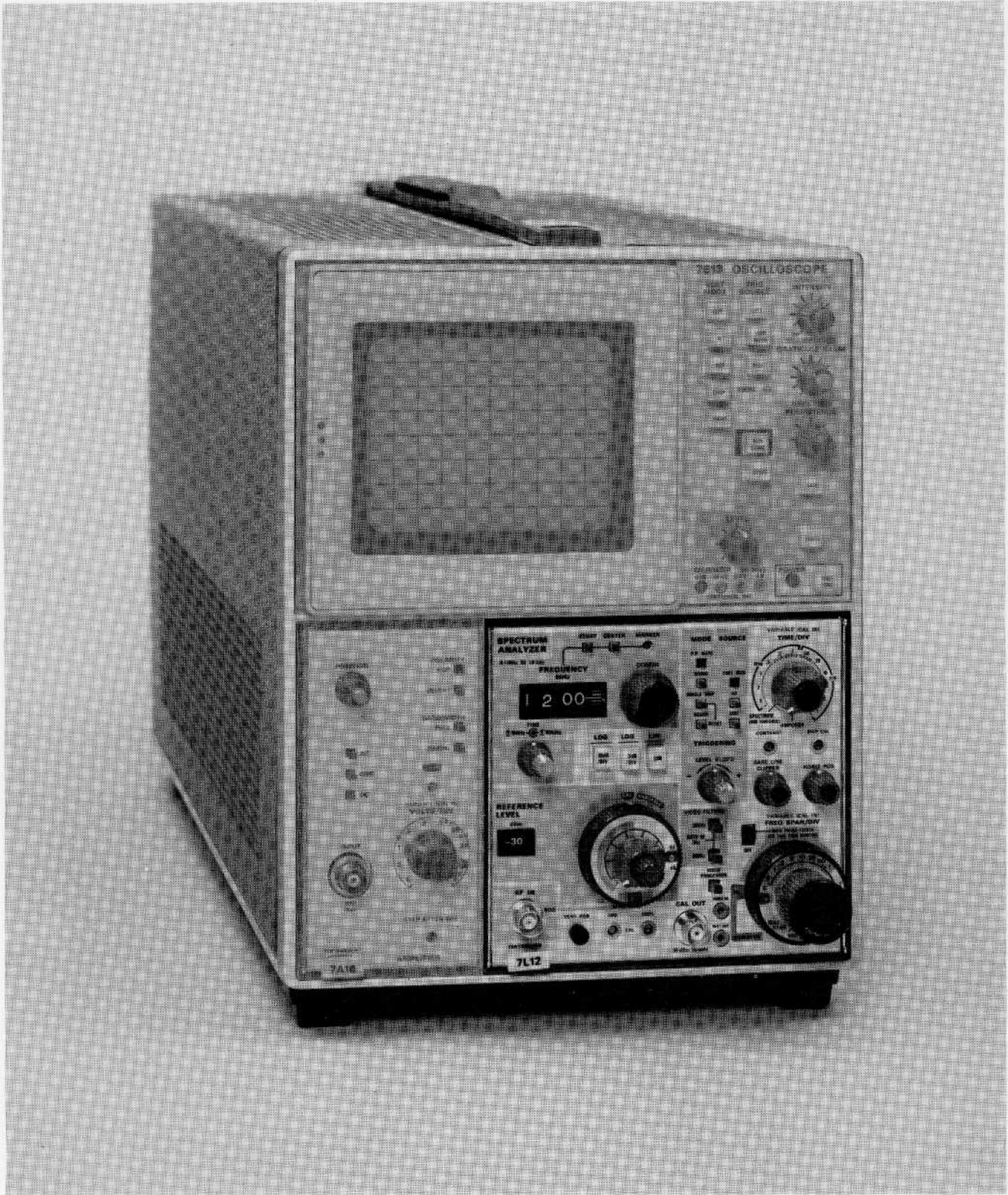


Fig. 1-1. 7L12 Spectrum Analyzer

# SPECIFICATIONS

## Introduction

This manual contains information required to operate, test, calibrate, and service the 7L12 Spectrum Analyzer. The manual is divided into ten major sections;

Section 1, General Information and Specifications.

Section 2, Operation Instructions: Information relative to installing and operating the instrument.

Section 3, Performance Check: Provides a complete procedure to check operational performance for an incoming acceptance check, or any additional performance checks that require test equipment to verify instrument specifications.

Section 4, Calibration Procedure: Describes test equipment setup and adjustment procedures required to align the instruments internal adjustments.

Section 5, Circuit Description: Provides basic and general circuit analysis that may be useful when servicing or operating the instrument.

Section 6, Maintenance Instructions: Describes routine and corrective maintenance procedures with detailed instructions for replacing assemblies, sub-assemblies, and individual components. An exploded drawing is part of section 9. Trouble-shooting procedures plus general information that may aid in servicing the instruments are also provided.

Section 7, Electrical Parts List: Provides information necessary to order replaceable parts and assemblies.

Section 8, Diagrams: Provides functional block diagram and detailed circuit schematics. Pictorial layout drawings, which show assembly, sub-assembly, and component locations are located adjacent to the diagram (usually on the back of the preceding diagram page). Waveforms and voltage data, for troubleshooting or circuit analysis, are also provided adjacent to or on the diagram.

Section 9, Mechanical Parts List, Exploded drawings and Accessories: Provides information necessary to order replaceable parts. Part List is cross-referenced to the Electrical Parts List. Exploded drawing shows sequence of assembly and identified assemblies.

Section 10, Manual Changes and Corrections: Provides history and updating information for the manual in the form of inserts. As the manual is updated these inserts are incorporated into the manual text and diagrams.

## Description

The 7L12 Spectrum Analyzer is a dual-width plug-in unit, for the 7000-Series Oscilloscopes. When used with any of these oscilloscopes, it displays a spectrum of signal energy within any frequency span to 1.8 GHz. The unit contains horizontal sweep and timing circuits, for frequency and time domain displays, and also means by which an external sweep source can be applied to slave the 7L12 to external devices, such as a recorder.

## SPECIFICATIONS

### ELECTRICAL CHARACTERISTICS

The following characteristics and features of the 7L12 Spectrum Analyzer are applicable after a warmup period of 30 minutes or more.

#### Center Frequency Operating Range and Accuracy

From 0.1 MHz to 1.8 GHz. Readout accuracy is within  $\pm (10 \text{ MHz} + 1\% \text{ of the dial readout})$ .

#### Frequency Span

Calibrated steps, in 1-2-5 sequence, from 500 Hz/Div to 100 MHz/Div. Accuracy is within 5% of the span selected and linearity is within 5%, over the center 8 divisions of a 10 division display.

Two additional positions MAX SPAN and 0 provide approximately 1.8 GHz (180 MHz/Div) of span, or fixed frequency operation, for time domain display. Span is continuously variable between steps.



## Specifications—7L12

### Display Flatness

±1.5 dB over any selected frequency span, with respect to the display level at 50 MHz.

### Display Modes

**LOG 10 dB/DIV:** Provides a calibrated 70 dB dynamic range. Accuracy within 1 dB/10 dB to a maximum of 1.5 dB over the 70 dB dynamic range.

**LOG 2 dB/DIV:** Provides a calibrated 14 dB dynamic range. Accuracy within ±0.4 dB/2 dB to a maximum of 1.0 dB over the 14 dB range.

**LIN:** Provides a linear display within 10%, over the graticule height.

### Reference Level

Calibrated levels in decade steps, from -100 dBm to +30 dBm, within ±2 dB. (Includes attenuator and gain switching effects when the two are not off-setting each other.) Reference level deviation between display modes is; less than 2 dB from 2 dB/DIV to 10 dB/DIV and less than 0.5 division from 2 dB/DIV to LIN. Note: This deviation is a function of the oscilloscope vertical linearity.

### Calibrator

50 MHz ±0.01% with an absolute amplitude level of -30 dBm ±0.3 dB, at 25°C.

### RF Attenuator

Calibrated 10 dB steps. Accuracy; ±0.2 dB or 1% of dB reading, whichever is greater.

### Gain

Four selector positions, bordered by a blue sector, provide 30 dB of change, in 10 dB steps, for the 10 dB/DIV display mode. These four, plus four additional positions, provide 70 dB of gain change for the 2 dB/DIV and the LIN mode displays.

Accuracy is within ±1 dB/10 dB step to a total of ±1.5 dB when the VARIABLE control is in its CAL detent.

The VARIABLE control, with approximately 10 dB range, provides continuous gain adjustment between each calibrated step.

### Resolution

Five resolution bandwidth selections from 300 Hz to 3 MHz, in decade steps, are provided. Bandwidth accuracy, at the 6 dB down level, is within 20% of the resolution selected. Shape factor over the 60 dB to 6 dB level is 4:1 or better (see Fig. 3-4). Signal level change over the five bandwidths is less than 0.5 dB.

### Sensitivity For A CW Signal

Signal + noise = Twice noise in LIN vertical mode (see Fig. 3-2). The following sensitivity characteristics apply at 50 MHz. Sensitivity may decrease gradually to 2 dB at 1.7 GHz and to 4 dB at 1.8 GHz.

Signal Level	Resolution Bandwidth
-115 dBm	300 Hz
-108 dBm	3 kHz
-100 dBm	30 kHz
-90 dBm	.3 MHz
-80 dBm	3 MHz

### Intermodulation Distortion (See Fig. 3-6)

Third order is down 70 dB or more from two -30 dBm signals within any frequency span. Second order is down 70 dB or more from two -40 dBm signals.

### Spurious Signals From Internal Sources

(Residual Response)

Equal to or less than -100 dBm, referred to the 1st mixer input.

### Incidental FM (See Fig. 3-5)

200 Hz (P-P) maximum, when phase locked, or 20 kHz (P-P) maximum in 5 seconds, when out of phase lock mode.

### Stability

Within 50 kHz, over a 1 hour period at a fixed temperature, when phase locked. Within 100 kHz when not phase locked over a 1 hour period, at a fixed temperature.

### Maximum Input Power Level

Linear Operation—RF attenuator at 0 dB; -30 dBm.

Safe Input levels—RF attenuator at 0 dB; +13 dBm. RF attenuator at 60 dB; +30 dBm (1 W average, 200 W peak). NOTE: These are input levels to the 1st mixer and the power rating of the attenuator.

### Sweep Rate

Calibrated sweeps, from 10 ms/Div (SPECTRUM position) to 1  $\mu$ s/Div (within 2%), are provided in 1-2-5 sequence. A VARIABLE control provides continuous variation between steps. When the TIME/DIV selector is in the SPECTRUM position, the range of the VARIABLE control is increased approximately 100X allowing the Time/Div to be increased to about 1 s/Div.

### Triggering

Signal source is AC coupled from either the vertical amplifier channels or the power line. Frequency range is approximately 15 Hz to 1 MHz. Sensitivities for the triggered modes are: 1)  $\leq 0.5$  division for the P-P AUTO mode 2)  $\leq 0.3$  division for the NORM mode 3)  $\leq 1.5$  division for

the SINGLE SWEEP mode. Sweep automatically recurs at the end of sweep holdoff time in the FREE RUN mode.

### Vertical Output Connector

Provides 50 mV  $\pm 5\%$  video signal per displayed division, about the CRT vertical center. Source impedance is approximately 1 k $\Omega$ . A maximum of 50 mV offset may be introduced by error from the mainframe vertical centering interface.

### Horizontal Input Connector

Requires a 10 V  $\pm 1$  V signal, with a starting reference of 0 V  $\pm 1$  V from a low impedance (300  $\Omega$  or less) source, to normalize the external sweep voltage to the 7L12 frequency span.



# OPERATING INSTRUCTIONS

## Introduction

This section describes: 1) Installation of the 7L12 into a 7000-Series Oscilloscope. 2) Function of the front panel controls, selectors, indicators and connectors. 3) General operation information, such as; adjustments required to mate the 7L12 to a 7000-Series Oscilloscope, signal application to the RF input, how to use the calibrator for accurate frequency and power level measurements, etc. 4)<sup>1</sup> Some typical applications.

The first steps of the General Operating information calibrate and check the analyzer Frequency Span/Div and the display modes. These steps serve as part of an acceptance check and describe how to obtain a display on the oscilloscope CRT. The Performance Check section of this manual refers to these steps as part of an acceptance checkout procedure.

Performing this Operational Checkout procedure, is recommended to acquaint you with the functions of the controls and selectors and the overall operation of the 7L12.

### CAUTION

*A safety latch, in addition to the front panel release, must be released before the 7L12 can be pulled from the oscilloscope compartment. The unit will pull out part way when the front panel release is pulled, then the spring safety latch must be pushed up before the unit will pull the rest of the way out. This safety latch is located underneath the right rail near the front corner (see Fig. 2-1).*

## FUNCTION OF THE FRONT PANEL CONTROLS AND ADJUSTMENTS

### Triggering

#### SOURCE

Either the vertical channels or the power line may be selected as the trigger source, by the front panel push-buttons. It is AC coupled and has a frequency range from

<sup>1</sup> TEKTRONIX Measurement Concept booklet; "Spectrum Analyzer Measurements Theory and Practice". Part No. 062-1334-00 is recommended treatise on applications and measurement evaluation.

≤15 Hz to ≥1 MHz. The INT push-button, selects the input signal to the 7L12 as the trigger source. The LINE push-button, selects a sample of the power line voltage as the trigger source. A third push-button causes the sweep circuit to free run.

#### MODE

**P-P AUTO:** Triggering occurs at the level and slope selected by the LEVEL and SLOPE controls. The peak to peak trigger signal amplitude required for INT triggering must equal or exceed 0.5 division. If trigger signal is absent, or beyond the amplitude and frequency limits specified, the sweep will free run (after hold-off time) at the rate selected by the TIME/DIV selector. The LEVEL control range adapts to changes in the triggering signal amplitude so its range corresponds to the peak to peak signal amplitude.

**NORM:** Triggering occurs at the level and slope selected by the SLOPE and LEVEL controls. The minimum signal amplitude for triggering must equal or exceed 0.3 division on the display. The LEVEL control selects the signal amplitude level. Triggering does not occur, when the setting of the LEVEL control is beyond the signal amplitude level.

**SINGLE SWP:** After the READY indicator is lighted, triggering will occur when the signal approaches 1.5 divisions of amplitude. Sweep is initiated as the signal amplitude and slope pass through that selected by the SLOPE and LEVEL controls. The circuit must be reset by pushing the RESET button before another sweep can be triggered.

**RESET-READY:** A pushbutton that resets the triggering circuit for single sweep operation. RESET-READY button lights when pushed, to indicate that the circuit is ready to be triggered.

#### LEVEL

A control that selects the amplitude at which triggering occurs for the various triggering modes.

#### SLOPE

A switch that selects the (+) positive or (−) negative slope of the signal for triggering direction.

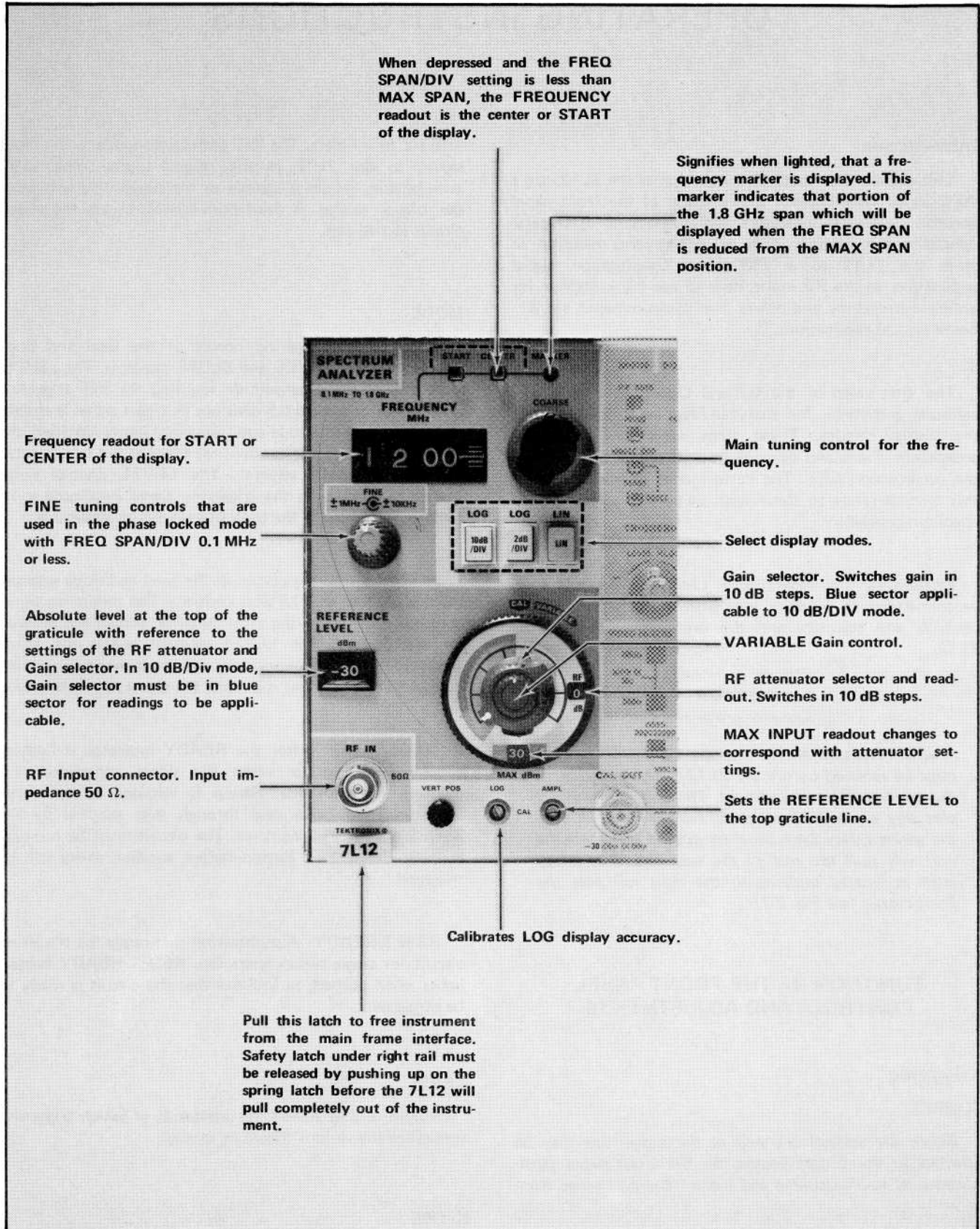


Fig. 2-1A. Controls, selectors and indicators that relate to the display, frequency, dynamic range, and reference levels.

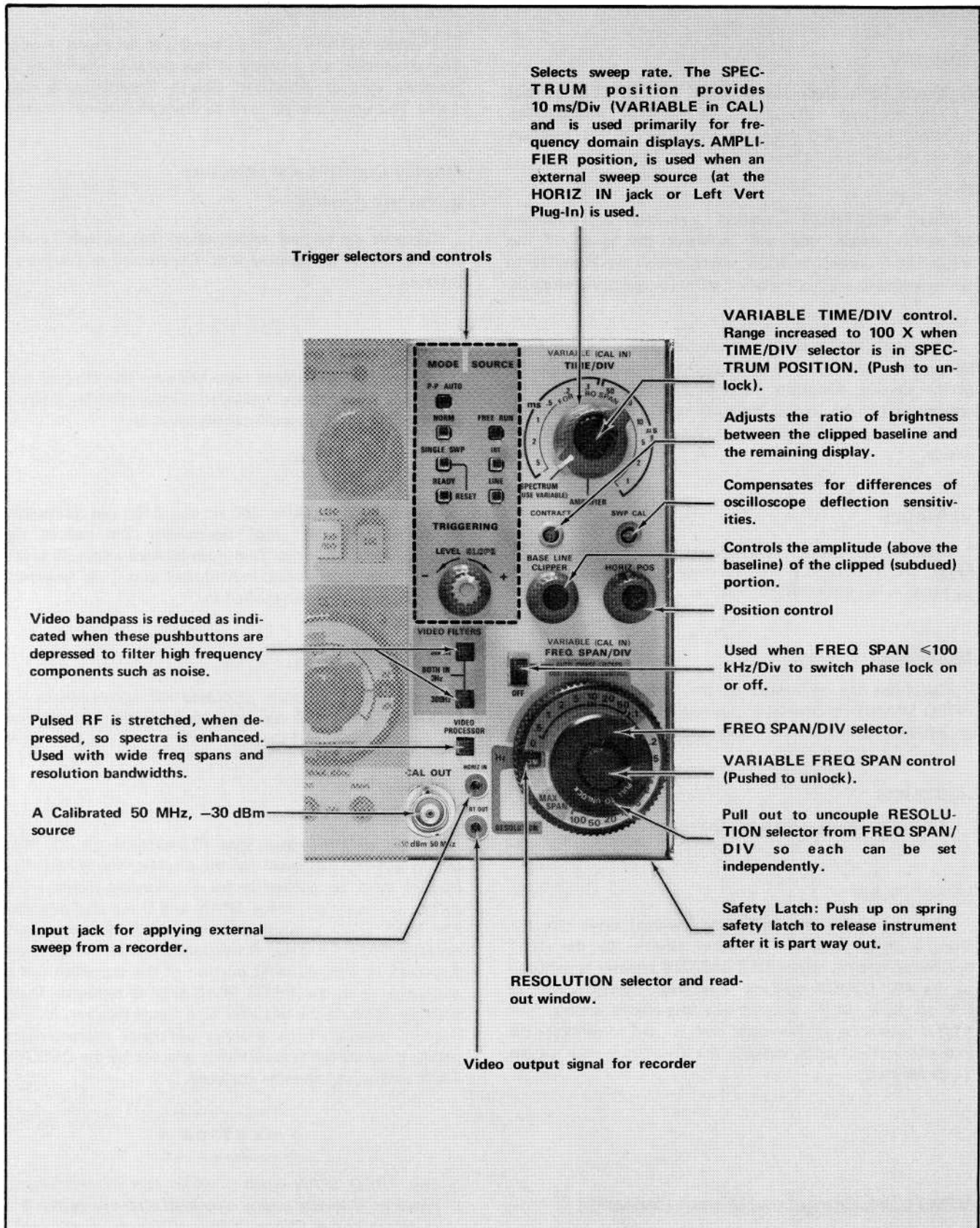


Fig. 2-1B. Controls and selectors that relate to the display; sweep, frequency span, resolution, video processing and phase lock.



## Operation—7L12

### Horizontal Sweep

#### TIME/DIV

Selects calibrated sweep rates (VARIABLE control pushed in) from 10 ms/Div. (SPECTRUM position) to 1  $\mu$ s/Div, in a 1-2-5 sequence. An AMPLIFIER position allows the analyzer to be swept from an external source.

The SPECTRUM position provides a calibrated 10 ms/Div sweep rate and increases the range of the VARIABLE control to 100X, which allows the Time/Div to be increased to approximately 1 s/Div for spectrum analysis.

The AMPLIFIER position is used to sweep the unit from an external sweep source which can be applied through one of the Vertical Amplifier units or through the HORIZ IN connector on the 7L12. External sweep may be used to slave the spectrum analyzer to a recorder or other external device.

#### VARIABLE

Provides continuous adjustment over the TIME/DIV range. The VARIABLE control range is increased from 3X to 100X in the SPECTRUM position.

#### SWEEP CAL

Calibrates the amplitude of the sweep voltage to the FREQ SPAN/DIV circuits and compensates for differences in deflection sensitivities between oscilloscopes.

#### HORIZ POS

Adjusts the horizontal centering of the display.

#### HORIZ IN Jack

Used to apply the horizontal (sweep) drive directly, from a chart recorder or other device, to the 7L12 horizontal circuits when the TIME/DIV selector is switched to the AMPLIFIER position. Requires a sweep voltage of 0 V to 10 V  $\pm$ 1 V, from a low impedance source. The  $\pm$ 1.0 V tolerance, at the upper end, is used to calibrate the external voltage ramp, making the frequency span of the 7L12 accurate.

### VERTICAL Control and Output Connector

#### VERT POS

Positions the CRT beam vertically.

#### VERT OUT Connector

Provides  $\pm$ 50 mV of video signal per displayed division. The amplitude and polarity of this signal is relative to the graticule vertical centerline. Source impedance is about 1 k $\Omega$ . The signal can be used to drive an external recorder.

### Display Controls and Selectors

#### BASELINE CLIPPER

Controls the vertical amplitude of that portion (baseline plus signal) of the display that is decreased or subdued in intensity.

#### CONTRAST

Adjusts the brightness ratio between the clipped (subdued) baseline and the unclipped display. Display intensity is set by the oscilloscope Intensity control.

#### VIDEO FILTERS

Three filters (30 kHz, 300 Hz and 3 Hz) can be switched in to restrict the video bandwidth and reduce high frequency components. Two push-buttons select 30 kHz or 300 Hz when depressed individually and 3 Hz is selected when both buttons are pushed in.

#### VIDEO PROCESSOR

Enhances the visibility of pulsed RF signals within wide frequency spans and resolution bandwidths by stretching the fall time of pulsed signals.

#### FREQ SPAN/DIV

Selects the frequency span (0.5 kHz/Div to 100 MHz/Div in a 1-2-5 sequence) for the display. The VARIABLE control must be pushed in for a calibrated display. Two additional positions, MAX SPAN and 0 are also provided. The MAX SPAN position, increases the frequency span to approximately 1.8 GHz. A frequency marker notch is also displayed to indicate what portion of the spectrum will be displayed when the FREQ SPAN/DIV is reduced. The 0 position converts the analyzer to a tuned receiver, for time domain display. Time analysis of signal characteristics, within the bandwidth capabilities selected by the RESOLUTION setting, can then be analysed.

#### CAUTION

*The FREQ SPAN knob provides ease in switching; however, if excess torque is applied after the switch is in either its full CW or CCW position, the aluminum bushing inside the knob may slip. This will misalign the coupling between the RESOLUTION and FREQ*

*SPAN selectors. If the coupling is misaligned, the selectors will double detent or switch with a grinding noise. Refer to Knob Removal and Installation instructions in the Maintenance section of the manual for realignment.*

#### VARIABLE (FREQ SPAN/DIV)

Push-push type switch and control. When it is out of its CAL detent, the control provides variable frequency span between each step of the FREQ SPAN/DIV selector. The control must be in the CAL detent for calibrated FREQ SPAN displays.

#### RESOLUTION

Selects five calibrated resolution bandwidths, from 300 Hz to 3 MHz (within 20%), in decade steps. Shape factor of the response, over the 60 dB to 6 dB amplitude levels, is 4:1 or better.

#### PULL TO UNLOCK

A concentric sleeve around the VARIABLE control that unlocks the RESOLUTION from the FREQ SPAN/DIV selector, and allows each selector to be independently set.

#### LOG 10 dB/DIV

Selects a display mode with a calibrated dynamic range of 70 dB (to the 7th graticule line from the top) at 10 dB/DIV. The bottom graticule division is not calibrated.

#### LOG 2 dB/DIV

When this button is depressed, the dynamic range of the display is a calibrated 14 dB at 2 dB/DIV.

#### LIN

Selects a linear display, that corresponds to the linear calibration on the left side of the graticule overlay.

#### REFERENCE LEVEL, RF Attenuation, and MAXimum Power Level Indicators and Selectors

Concentric controls that are connected in an electro-mechanical differential arrangement which select input attenuation and instrument gain.

The Input attenuation (from 0 dB to 60 dB) and Gain (0 dB to 70 dB) are selected in 10 dB steps. An electro-mechanical arrangement and readout windows establish and indicate to the user, MAXimum power input level (in dBm), RF attenuation (in dB), and the REFERENCE LEVEL (in

dBm) of the top graticule line. REFERENCE LEVEL is also displayed on CRT's of oscilloscopes with readout feature.

#### NOTE

*A blue tint borders the 10 dB/DIV display switch, and four positions of the Gain selector. This is to correlate REFERENCE LEVEL readout to Gain switch settings that are applicable in the 10 dB/DIV display mode. Readings outside the blue sector are erroneous because the gain is electrically locked out. The CRT readout will display the < symbol to signify the readings are erroneous. The dynamic window of the display will not exceed -130 dBm (REFERENCE LEVEL of 60 dBm plus 70 dB dynamic range of the 10 dB/DIV display). In the 2 dB/DIV display mode, the full 70 dB range of the Gain selector is usable. Switching the Gain fully CW with the RF attenuator at 0 dB, produces an accurate -100 dBm reference level. The dynamic range of the display is now -114 dBm (-100 dBm plus 14 dB graticule window, to the 7th graticule line).*

#### VARIABLE (Gain) Control

Provides at least 10 dB of gain variation. The REFERENCE LEVEL readout on the CRT changes to the < symbol to indicate an uncalibrated condition when it is out of its CAL detent. The readout of the REFERENCE LEVEL window on the 7L12 is only applicable when this control is in its CAL detent.

#### FREQUENCY MHz

Dial reads out the START-CENTER or MARKER frequency of the display. Frequency and dial readout are tuned by the COARSE control.

Depressing the START push-button, selects the start of the display or left (zero) graticule line as the frequency that is indicated by the dial readout. Depressing the CENTER push-button selects the center of the display as the frequency indicated in the readout window. When the FREQ SPAN/DIV is switched to MAX SPAN position, the MARKER indicator is lighted and a notch on the baseline of the display indicates the center of that portion of the span that will be displayed when the FREQ SPAN is reduced.

#### FINE Frequency Controls

Two concentric controls that provide fine tuning adjustment during phase lock operation or at spans which are 0.1 MHz/Div or less.

## Operation—7L12

### LOG and AMP CAL Adjustments

The LOG adjustment calibrates the logarithmic display accuracy and the AMP adjustment sets the REFERENCE LEVEL to the top graticule line.

### AUTO PHASE LOCK Switch

Used, in the phase locked modes, to disable the phase lock. The COARSE tuning control will then tune the center frequency without the 1st LO jumping between lock points. This provides a wider tuning range than that of the FINE controls.

### CAL OUT Connector

Provides an accurate  $-30$  dBm, 50 MHz signal. This signal provides an absolute reference on the display to check dBm readings and calibrate the REFERENCE LEVEL. Harmonics of the 50 MHz fundamental provide picket fence markers across the frequency span for accurate frequency and span measurements.

### RF INput Connector

A  $50\ \Omega$  input connector for applying the input RF signal to the 7L12. REFERENCE LEVEL indicator refers to the RF level at the RF INput. Refer to General Operating Information in regards to signal applications.

## GENERAL OPERATING INFORMATION<sup>2</sup>

This section describes how to mate the 7L12 to a 7000-Series Oscilloscope and how to use the main features of the instrument in making various measurements.

### NOTE

*External graticules are designed so they will compensate for parallax of the camera. Graticule markings will therefore be correct on photographed displays. Instructions on how to install graticule overlays, will be found in the mainframe manual under the subtitle light filters.*

### 1. Preliminary Front Panel Setup and Calibration Procedure to Match the 7L12 to the Oscilloscope Deflection Sensitivity

a. Plug the 7L12 Spectrum Analyzer into the center two compartments, of a four plug-in 7000-Series Oscilloscope, or into the right two compartments, of a three plug-in

7000-Series Oscilloscope. Ensure that the 7L12 is securely latched in the compartment so it cannot fall out if the oscilloscope is tipped forward.

b. Connect the oscilloscope mainframe to a suitable power source and switch the POWER on. Allow about 20 to 30 minutes for instrument stabilization.

c. Set the front panel controls as illustrated in Fig. 2-2 and connect the CAL OUT signal through a short coaxial cable to the RF INput.

d. Adjust the oscilloscope Intensity, Focus and Astigmatism controls for optimum display definition with normal intensity.

e. Depress the 2 dB/DIV display mode button. Position the baseline of the display to the bottom graticule line with the VERT POSition control and center the display with the HORIZ POSition control.

f. Depress the 10 dB/DIV (LOG) display button. Display should now resemble that shown in Fig. 2-2.

### NOTE

*When the oscilloscope has a CRT with P7 phosphor, a viewing hood will help shield ambient light and enhance the display information.*

### 2. Calibrate the Sweep Span

a. Switch the FREQ SPAN/DIV to MAX SPAN position, ensure that the VARIABLE (Freq Span) control is pushed in.

b. Position the 0 Hz response on the zero (left) graticule line with the HORIZ POS control.

c. Connect the CAL OUT signal to the RF INput, decrease the FREQ SPAN/DIV to 50 MHz and tune the 5th marker (250 MHz) to the center graticule line (see Fig. 2-3).

d. Calibrate the frequency span to 50 MHz/Div by adjusting the SWP CAL for 1 marker/division. It will be necessary to keep the 250 MHz marker centered with the COARSE FREQUENCY control as the sweep is calibrated. Final display should resemble that illustrated in Fig. 2-3.

<sup>2</sup> A treatise on spectrum analyzer measurements and applications is contained in TEKTRONIX Measurements Concept Booklet; "Spectrum Analyzer Measurement Theory and Practice:", Part No. 062-1334-00.



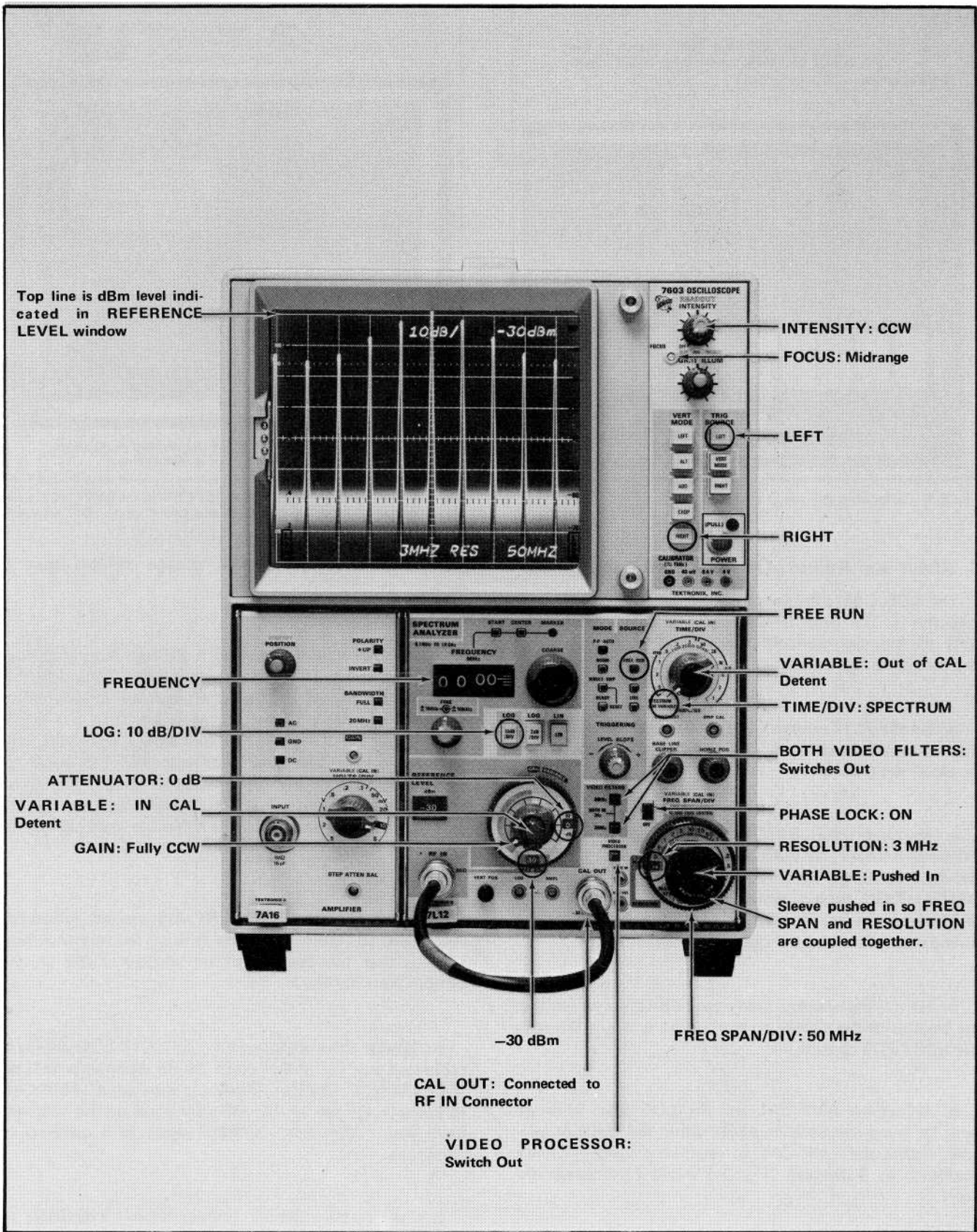


Fig. 2-2. 7L12 Spectrum Analyzer in a 7000-Series Oscilloscope illustrating initial settings of front panel controls and selectors. Circled (O) pushbuttons denote button depressed or position of selector.

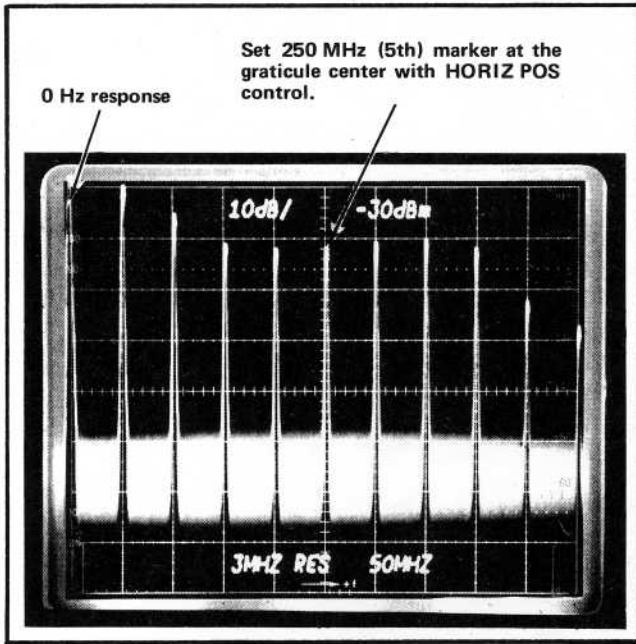


Fig. 2-3. Calibrating the sweep span.

### 3. Check and Adjust LOG-AMP Calibration

The LOG CAL adjustment calibrates the display so it is logarithmic. The AMP CAL adjustment sets the reference level to the top graticule line. There is no interaction between these two adjustments.

a. Set the 7L12 selectors and controls as directed in step 2 and tune the fundamental 50 MHz calibrator signal to the center of the graticule.

b. Uncouple the RESOLUTION selector from the FREQ SPAN/DIV, by pulling out the PULL TO UNLOCK sleeve, then switch the FREQ SPAN/DIV to 5 MHz. The RESOLUTION should remain at 3 MHz. As the FREQ SPAN is decreased, it may be necessary to re-adjust the tuning control to keep the signal centered on screen.

c. Switch the Display Mode to 2 dB/DIV and position the baseline of the display on the bottom graticule line with the VERT POS control.

d. Adjust the AMP CAL and the LOG CAL (if necessary) to bring the 50 MHz signal within the graticule window. Adjust the AMP CAL to establish a signal reference amplitude of 8 divisions (Fig. 2-4 shows a full screen display).

e. Switch in 10 dB of attenuation with the RF Attenuator and note the amplitude change of the signal in

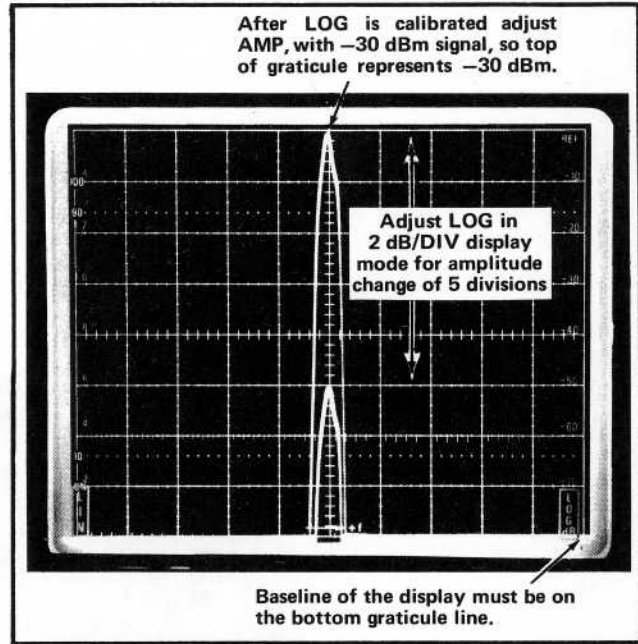


Fig. 2-4. Calibrating the LOG and REFERENCE LEVEL of the display (Double exposure to illustrate the two displays with reference to each other).

graticule divisions. Amplitude change should equal 5 divisions at 2 dB/DIV.

f. If the change is more than 5 divisions (e.g., amplitude decreases from 8 to 2.5 div.), adjust LOG CAL to further decrease the signal amplitude or increase the amplitude change. Conversely if the change is less than 5 divisions (e.g., amplitude changes from 8 to 3.5 div.), adjust the LOG CAL to increase the signal amplitude. NOTE: Correct for approximately 1/2 the total indicated error. This adjustment may seem opposite to what is expected; however, the LOG CAL adjustment shifts the reference level making the net result a correction to the amplitude change.

g. Switch out the 10 dB of RF Attenuation. Adjust the AMP CAL to return the signal level to the reference line. (Ensure that the baseline of the display is still on the bottom graticule line.)

h. Repeat these steps until the 2 dB/DIV LOG display is calibrated (see Fig. 2-4). Return the RF Attenuator to 0 dB (REFERENCE LEVEL -30 dBm), then adjust AMP CAL to position the top of the -30 dBm signal on the reference line. Ensure that the -30 dBm signal is 8 divisions in amplitude.

i. Change the display modes from 2 dB/DIV to 10 dB/DIV, then to LIN. Signal amplitude reference level should not change more than 2 dB from 2 dB/DIV to 10 dB/DIV, or 0.5 division from 2 dB/DIV to LIN mode.

#### 4. Check the 10 dB/DIV and LIN Mode Display Operation

a. After completing the LOG CAL and AMP CAL adjustments, described in step 3, depress the 10 dB/DIV button, ensure that the RF attenuator is at 0 dB and the Gain selector is fully CCW so the REFERENCE LEVEL reads -30 dBm.

b. Switch the FREQ SPAN/DIV to 1 MHz and the RESOLUTION to .3 MHz. Center the 50 MHz marker to the graticule center.

c. Increase the RF attenuator setting in 10 dB steps and note that the signal amplitude decreases 1 division each step.

d. Switch the RF attenuator back to 10 dB, and depress the LIN display mode button.

e. Ensure that the baseline of the display is at the bottom graticule line, and the 50 MHz signal is centered then adjust the VARIABLE Gain control for a signal amplitude of 6.3 divisions.

f. Switch the RF attenuator to 20 dB to add 10 dB of attenuation, and note that the signal amplitude decreases to approximately 2 divisions for a ratio change of 3.16 (this is equivalent to 10 dB in LIN mode).

g. Return the RF attenuator to 0 dB, the VARIABLE Gain control to CAL. The signal amplitude should return to full screen and the REFERENCE LEVEL should indicate -30 dBm.

#### 5. Adjust Contrast and Check Baseline Clipper Operation

The contrast ratio that is set between the clipped portion of the display baseline and the rest of the display depends on sweep rate, FREQ SPAN, RESOLUTION, and ambient light.

a. With the BASELINE CLIPPER set midrange, adjust the CONTRAST for the desired ratio between the clipped or subdued portion and the rest of the display. (Usually the contrast is adjusted so the clipped baseline portion is just visible.)

b. Adjust the BASELINE CLIPPER control so the baseline is subdued. If there is excessive noise it may be desirable to clip this noise level as well.

### USING THE ANALYZER

#### 1. Signal Application

The RF INPUT impedance to the 7L12 is 50 Ω. At high frequencies, impedance mismatches between the RF INPUT and the signal source can cause reflections in the transmission line which degrades instrument performance. Flat-

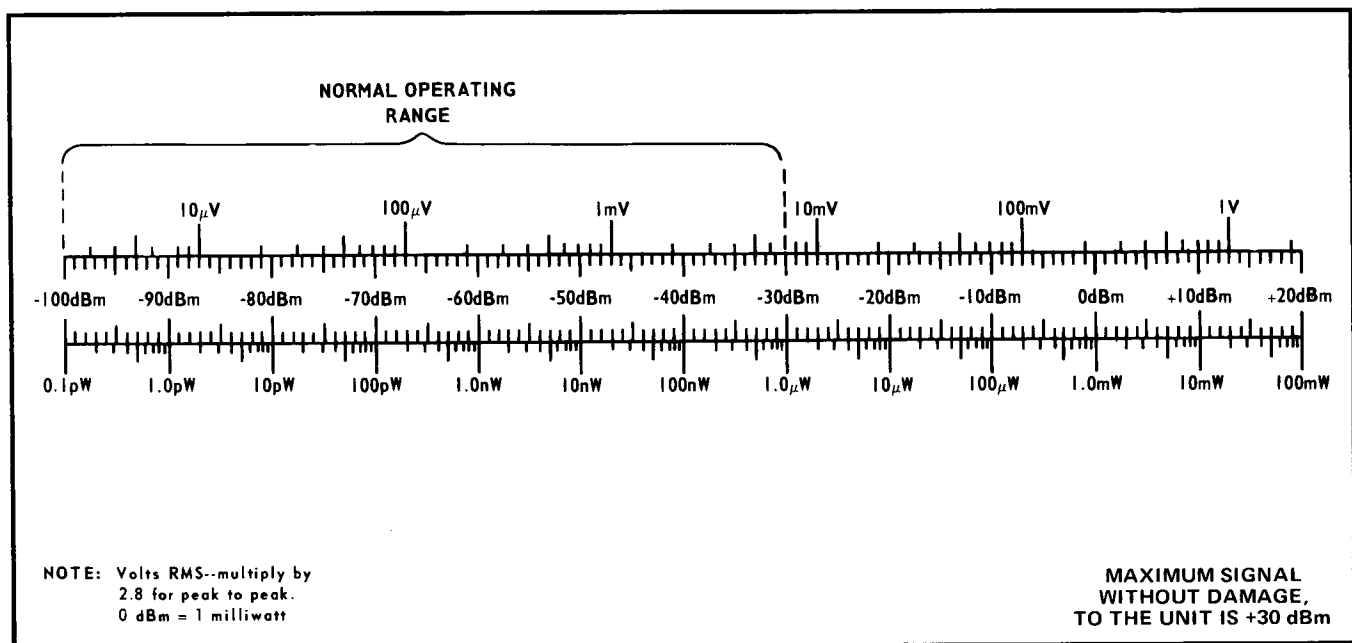


Fig. 2-5. Volts-dBm-Watts conversion chart for 50 Ω impedance.



**Operation—7L12**

ness, sensitivity, spurious response, etc. are all affected. To reduce mismatch, use good quality 50 Ω coaxial cable to connect the signal source to the RF INput and keep the cable as short as possible. Cable losses become excessive above frequencies of 1 GHz.

Avoid applying high level signals (above -30 dBm) to the 1st mixer of the 7L12. High level signals overload the mixer and may produce spurious signals. A conversion chart is shown in Fig. 2-5 to aid in determining input signal level, in dBm, μV, and μW, from a voltage or power source.

**CAUTION**

*The maximum power input level to the RF attenuator is 1 watt average or 200 watts peak. When the RF input signals are riding on a DC potential, use the DC Block (Part No. 015-0221-00), to prevent the DC from reaching the 1st mixer. When the signal source is 75 Ω and you are using the 75 Ω to 50 Ω minimum loss attenuator, a DC block is not required because one is incorporated in the attenuator.*

The 7L12 can be used with a 75 Ω signal source by using a 75 Ω to 50 Ω minimum loss attenuator. This attenuator is available as an optional accessory (refer to the optional accessories list in the catalog or Accessory page in the manual for ordering information). Sensitivity and power levels are often rated in dBm (dB with reference to 1 mW regardless of impedance). Sensitivity and power levels for 75 Ω systems is usually rated in dBmV (dB with reference to 1 mV across 75 Ω). Fig. 2-6 is a circuit diagram of a suitable matching pad for this purpose. The conversion from

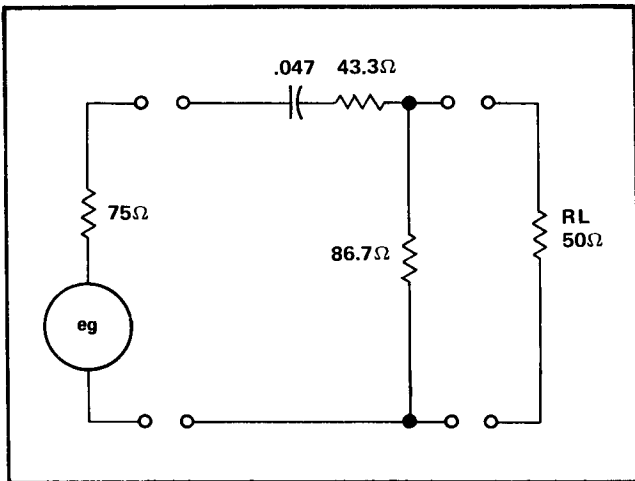


Fig. 2-6. Circuit of a 75 Ω to 50 Ω matching pad (AC coupled).

dBmV to dBm and dBm (75 Ω) to dBm (50 Ω) through matching attenuators is shown in Fig. 2-7 and described as follows:

$$(\text{dBmV, into } 75 \Omega) - (\text{dBm, at } 50 \Omega \text{ end}) = 54.46 \text{ dB}$$

[1] Therefore dBmV = 54.5 + dBm; e.g., -30 dBm (at the 50 Ω input) requires (-30) + (+54.5) or +24.5 dBmV at the 75 Ω input.

[2] dBm (75 Ω input) = dBm + 5.72 (50 Ω output); e.g., a -30 dBm input to the RF INput of the 7L12 requires, (-30) + (+5.7) or -24.3 dBm at the 75 Ω input of the pad.

[3] For some applications you may wish to know the relationship between dBm and dBμV. For 50 Ω this is dBμV = (dBm) + 107 dB.

These three relationships are shown in Fig. 2-7 for easy graphical conversion.

Spurious response, caused by signal overload into the 1st mixer, can be minimized if the signal amplitude is kept within the graticule limits. A recommended procedure is to adjust the Gain selector for some baseline noise on the display, then increase the RF Attenuator dB setting until the strongest signals are within the graticule limits. If this does not bring these signals within limits, add additional external attenuators.

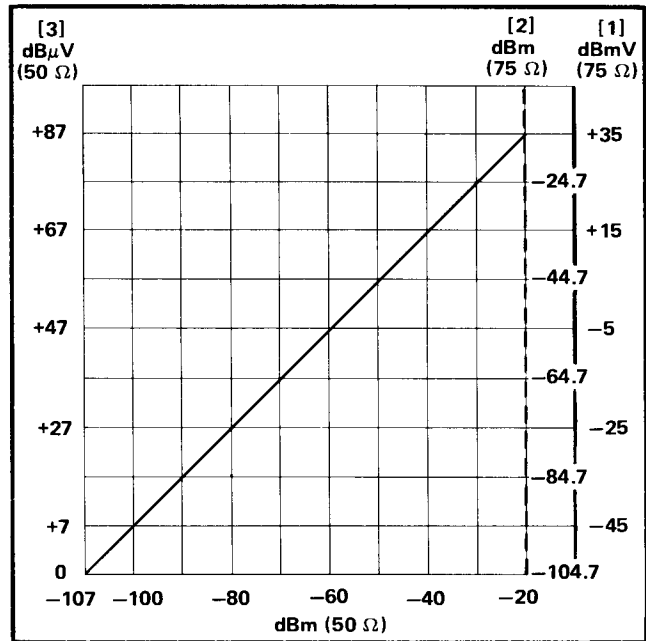


Fig. 2-7. Graph illustrating dBm to dBμV relationship.

## 2. Resolution, Sensitivity, and Frequency Span

Resolution is the ability of a spectrum analyzer to discretely display adjacent signals within a frequency span. This resolution ability is a function of analyzer bandwidth, sweep speed, frequency span, and incidental FM. The frequency span and sweep time are adjusted for minimum bandwidth to a CW signal. Theoretically, resolution and resolution bandwidth become synonymous at very long sweep times.

Resolution bandwidth is measured and specified for the 7L12, as the bandwidth (separation) at the 6 dB down point on the signal.

As the analyzer sweep speed is increased, the signal amplitude will decrease and bandwidth will increase, signifying that both sensitivity and resolution have been degraded.

The best resolution for a given frequency span and sweep time is expressed as:

$$\sqrt{\frac{\text{Frequency Span (in kHz)}}{\text{Sweep Time (in ms)}}}$$

Bandwidth determines both noise level and resolution capability of the analyzer. As the bandwidth decreases, the signal-to-noise level increases and results in improved sensitivity. Maximum sensitivity therefore, is obtained at the higher resolution settings.

The resolution of the 7L12 Spectrum Analyzer is optimized for most settings of the FREQ SPAN/DIV selector when the RESOLUTION control is in the coupled position. Resolution, however, can be selected independent of the FREQ SPAN by pulling the "PULL TO UNCOUPLE" sleeve around the VARIABLE FREQ SPAN control.

To adequately resolve pulsed spectrum information, the resolution bandwidth of the analyzer should be on the order of 1/10 the side lobe frequency width or the reciprocal of the pulse width. The RESOLUTION selector is usually set, after the sweep rate has been adjusted, for optimum main lobe detail.

## 3. Gain Desensitization Near 0 Hz

If the Gain selector is set for a REFERENCE LEVEL that is -50 dBm or more (e.g., -60 dBm) with the RF attenuator at 0 dB, a decrease in sensitivity will be noticed below 2 MHz. This effect is caused by the 0 Hz response overdriving the 1st IF amplifier. If you are operating between 0 Hz and 2 MHz do not set the Gain selector in this region.

## 4. Using the Video Filter

The video filter is used to reduce noise and high frequency components on the display, and when signals are closely spaced the filter will reduce modulation between the two signals. It can also be used to display the envelope of pulsed RF spectra that has a relatively high PRF; however, because the filter is basically an integrating circuit, low PRF signals produce poor results. Fig. 2-8 and Fig. 2-9 illustrate two ways that the VIDEO FILTER can be used.

## 5. Selecting Sweep Rate

The sweep rate for wide resolution bandwidths is usually set above the visual flicker setting. As the FREQ SPAN is changed it will affect resolution and sensitivity; therefore, as the frequency span is increased, sweep speed should be

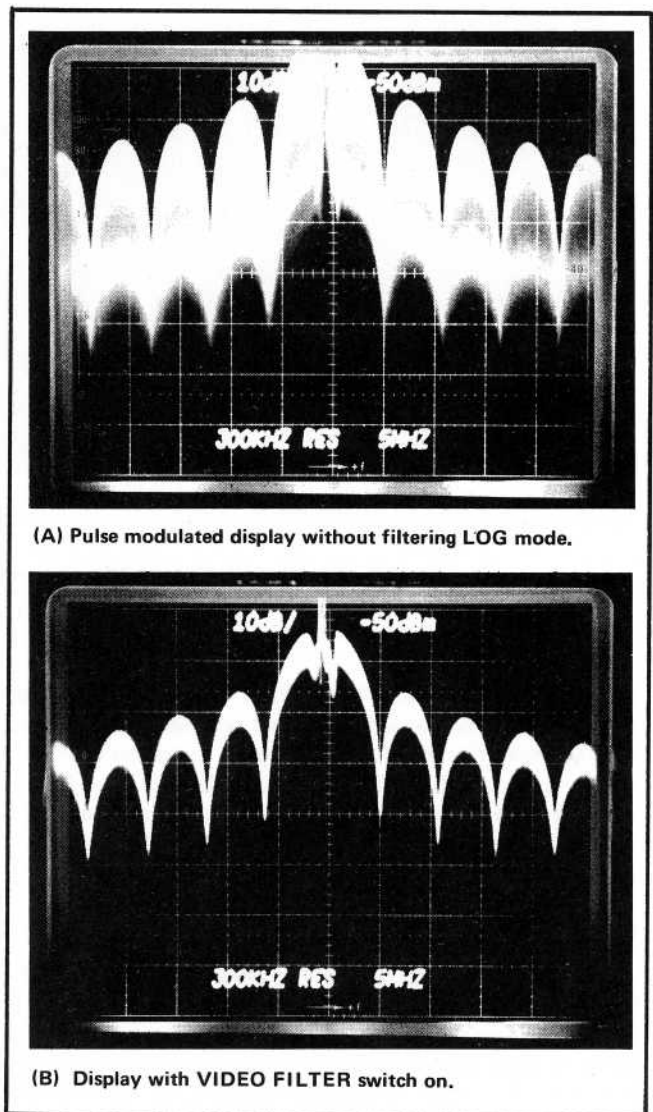


Fig. 2-8. Integrating the display with the VIDEO FILTER.

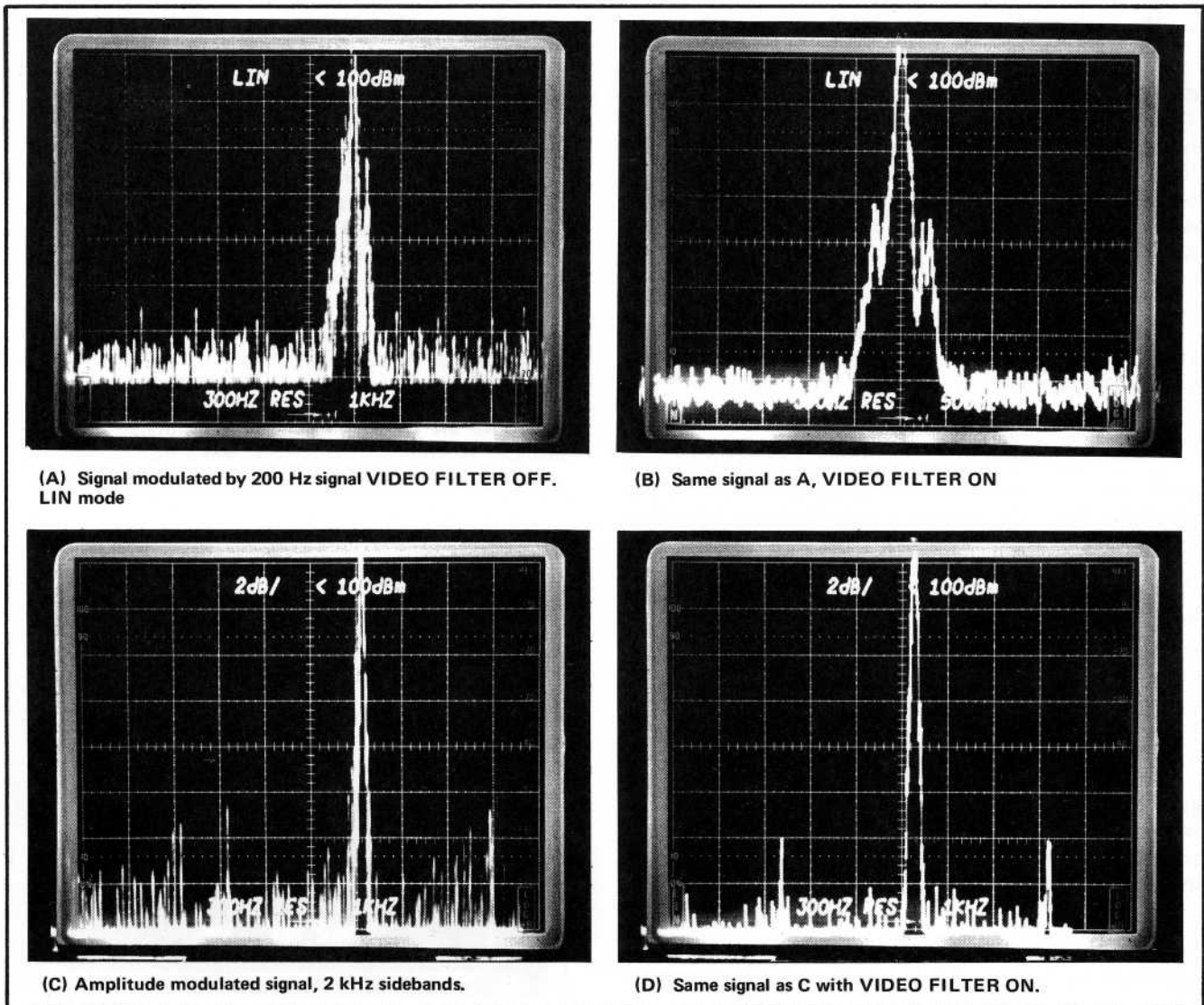


Fig. 2-9. Using the VIDEO FILTER and sweep speed to improve resolution capabilities of the analyzer.

decreased. When the FREQ SPAN is reduced to 0, the analyzer functions as a fixed tuned receiver so the analyzer displays time domain characteristics of the signal within the bandwidth capabilities of the analyzer. Sweep Time/Div can now be used to examine or analyze such characteristics as modulation pattern, pulsed repetition rates, etc.

### 6. Triggering the Display

The sweep trigger source is usually switched to the FREE RUN mode for spectrum displays; however, it may be desirable or necessary to trigger the display when the event is time related to some source, such as power line frequency; or, when the frequency span has been reduced to zero in order that a time domain analysis can be performed.

The sweep can be triggered, from an internal video signal on the display, or by the power line voltage. Trigger slope for any mode can be + or -, and the triggering level is adjustable over the amplitude range of the triggering signal.

These three triggering modes are provided:

P-P AUTO—which triggers the display through the peak to peak amplitude range of the signal. If the triggering signal is absent, the sweep is automatically recycled to provide a display baseline at all times.

NORM—requires a signal to trigger the display.

SINGLE SWEEP—cycles once after the trigger circuit has been RESET and a triggering signal applied.



The amplitude of triggering signal that is required to trigger the sweep, depends on the mode that is selected. Approximately 0.5 division of signal is required in the P-P AUTO mode, 0.3 division in the NORM mode, and 1.5 division for SINGLE SWEEP operation.

When triggering on pulsed spectra it may be necessary to adjust the FINE tuning, to shift the sweep start away from a null point, as illustrated in Fig. 2-10.

## 7. How to Sweep the Display Using an External Sweep Source

The 7L12 can be swept by an external voltage which is applied to the front panel HORIZ IN jack, and/or the output voltage of a Vertical Plug-In Unit which is plugged into the Left Vertical compartment of the oscilloscope. When the Time/Div selector is switched to the AMPLIFIER position it connects the input of the 7L12 horizontal sweep circuits to these two external sources. The following procedures describe how the analyzer can be swept from these sources.

### a. Sweeping the Analyzer from an External Voltage that is applied to the HORIZ IN jack.

A low impedance ( $\leq 300 \Omega$ ) voltage source, from 0 V  $\pm 1$  V to 10 V  $\pm 1$  V, is required to sweep the analyzer. 0 volts corresponds to 0 Hz and approximately 10 V corresponds to the high frequency end of any selected frequency span. The following procedure describes how to externally sweep the analyzer.

1) Calibrate the sweep span in the SPECTRUM position of the TIME/DIV selector, then switch the TIME/DIV to the AMPLIFIER position. Switch the oscilloscope A Trigger Source to Left Vert. (Remove any plug-in in the left compartment.)

2) Apply the external voltage source to the HORIZ IN jack. Adjust the upper end of the voltage around 10 V until the analyzer sweep span is calibrated. (Use the 7L12 Calibrator to calibrate the FREQ SPAN/DIV.)

### NOTE

*The frequency deviation across the selected span is a linear function (within 20%) of the input voltage. 5 V-DC should tune the analyzer to the center of the selected span.*

### b. Manual or Signal Sweeping with the Left Vertical Unit

A vertical amplifier unit, in the left vertical compartment of the oscilloscope, can be used to manually sweep the 7L12; or, an external voltage applied to the amplifier input will produce a vertical output signal that will sweep the analyzer. These procedures are described as follows:

#### 1) Manual Sweeping the Analyzer with the Position Controls

a.) Calibrate the analyzer sweep span in the SPECTRUM position of the TIME/DIV switch as previously described.

b) Switch the TIME/DIV selector to the AMPLIFIER position and switch the oscilloscope Trigger Source to Left Vertical.

c) Use the Left Vertical Amplifier Position control to manually sweep the 7L12 Spectrum Analyzer.

#### 2) Sweeping the Analyzer with a Signal Applied to the Input of the Vertical Amplifier Plug-In Unit

a) Calibrate the sweep span of the analyzer in the SPECTRUM position of the TIME/DIV switch, then switch to the AMPLIFIER position. Switch the oscilloscope Trigger Source to Left Vertical.

b) Apply the sweep signal or sweep voltage to the Input of the Vertical Amplifier. Switch the Input coupling of the amplifier to DC.

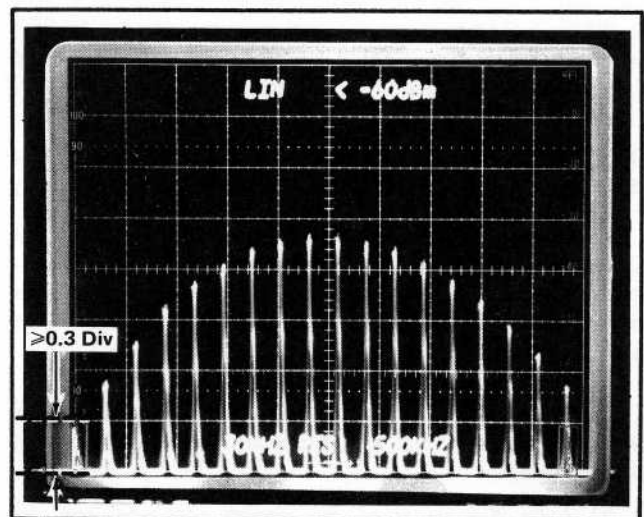


Fig. 2-10. The analyzer requires 0.3 division of signal to trigger the sweep on INT mode. Tune the spectrum null away from the sweep edge with the FINE controls.

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c) Use the Vertical Amplifier Position control to set the sweep position and its Volts/Div selector plus Variable control to calibrate the sweep span. (Use the 7L12 Calibrator to provide dispersion markers.)

### 8. External Triggered Operation Using a Vertical Amplifier Plug-In Unit as the Trigger Source

This procedure is applicable if an external trigger source (e.g., pulse generator) is used to trigger an event and the display of the 7L12 simultaneously.

a. Apply the trigger signal to both the Input of the vertical amplifier unit and the event to be triggered.

b. Switch the oscilloscope Vert Mode to Left and adjust the amplifier Volts/Div selector for a signal amplitude of at least 1.5 division.

c. Switch the Vert Mode to Right and the Trigger Source to Left Vert.

d. Set the 7L12 controls as follows; FREQ SPAN/DIV to MAX, RESOLUTION to 3 MHz, TIME/DIV to SPECTRUM, and Display Mode to 2 dB/DIV. Set TRIGGERING, for NORM Mode, Source to INT, and adjust the TRIGGERING SLOPE and LEVEL controls for the desired triggering point.

e. Position the 0 Hz response of the 7L12 display at the zero (left) graticule line with the HORIZ POS control, and the baseline of the display at the bottom graticule line, with the VERT POS control.

The analyzer is now triggered by an external source. If the event is a single shot, switch the TRIGGERING MODE to SINGLE SWP and arm the circuit by pushing the RESET button to light the READY indicator. Select the desired FREQ SPAN/RESOLUTION and display mode.

### 9. Using the CAL OUT Signal Reference for Accurate Frequency and Amplitude Measurements

Frequency measurements are enhanced by using the Calibrator frequency comb or picket fence of 50 MHz markers. The Calibrator accuracy is within 0.01%. Absolute frequency measurements within 2 MHz are possible by using either of the two methods described below.

#### Measuring the Frequency Span Between a Calibrator Marker and the Signal to Obtain an Absolute Frequency Measurement.

1) Tune the signal to the center graticule line, approaching this point from the low frequency side of the display. Couple the FREQ SPAN/DIV and RESOLUTION

selectors together and open up the display to obtain an accurate setting, by reducing the FREQ SPAN/DIV to 5 MHz and increasing RESOLUTION to .3 MHz. Adjust SWP CAL, if necessary, to calibrate the display for 10 divisions between the 50 MHz calibration markers. (Remember to approach the center point from the low frequency side.)

2) Connect the CAL OUT signal and the signal source through a BNC 'T' connector to the RF INput so both signal and markers are displayed.

3) Measure the frequency span between the signal and the nearest 50 MHz marker. (Frequency span is 5 MHz/Div.)

4) Add or subtract the frequency span to the respective marker to obtain the signal frequency. Since the maximum frequency span between the signal and marker is 25 MHz  $\pm 5\%$ , marker accuracy is 0.01% and human observation error is approximately 1/2 a minor division or 0.5 MHz. The accuracy using this method is within 2 MHz.

#### Measuring or Reading the Frequency After a Dial Correction Factor Has Been Established.

The dial is marked in 2 MHz increments with an incremental accuracy within 1%.

1) As described for the frequency span method, tune the signal to the graticule center-line, opening the display to 5 MHz/Div to obtain an accurate setting. Tune the signal to the center from the low frequency side.

2) Note the dial reading (i.e., 1002 MHz).

3) Apply the CAL OUT signal to the RF INput and tune the nearest 50 MHz marker to the graticule center-line, again approaching this point from the low frequency side.

4) Note the correction factor required for the dial. For example; a dial reading 1 MHz high requires a correction factor of  $-1$  MHz at this particular point.

5) Add this correction factor to the reading noted in step (2) for an absolute frequency measurement of 1001 MHz (1002 MHz  $-1$  MHz).

#### Measuring Absolute Signal Levels

Since the top of the graticule is a calibrated REFERENCE LEVEL and the graticule is calibrated in dB/Div, as

described in Preliminary Front Panel Calibration procedure, at the beginning of this section, it is easy to measure the absolute level of most signals.

1) Calibrate the graticule as previously described in step 3 of the General Operating Information. Ensure that the VARIABLE Gain control is in its CAL detent.

2) Connect the signal source to the RF INput, as described under Signal Application. Switch to the 10 dB/DIV or 2 dB/DIV display mode.

**NOTE**

*For maximum accuracy use the same cable that was used to calibrate the REFERENCE LEVEL and use the 2 dB/DIV display mode.*

3) Select RF attenuator and Gain selector settings that will bring the signal, to be measured, within the screen or graticule window.

**NOTE**

*If you are operating in the 10 dB/DIV mode, the Gain selector must be within the blue sector.*

4) Measure the absolute signal level as the number of graticule divisions (in dB) below the top graticule line plus the REFERENCE LEVEL readout in dBm. For example: A signal level 4.5 divisions below the top with a REFERENCE LEVEL readout of  $-60$  dBm, in the 2 dB/DIV display mode, is  $-60$  dBm  $+(-9$  dB) or  $-69$  dBm. This refers to the signal level at the RF INput connector. Add the insertion loss of any external attenuators and cables (if they are used) between the signal source and the RF INput.

**NOTE**

*The maximum input level to the RF INput, for linear operation, is  $-30$  dBm with 0 dB RF attenuation; or  $+30$  dBm with 60 dB of RF attenuation. Signals above this level can only be measured if an external attenuator is used.*

**Accurate Signal Level Difference Measurements in dB**

1) Using the 2 dB/DIV display mode, position the top of the lowest amplitude signal to a reference line within the graticule area with the VARIABLE Gain or VERT POSition controls. If display noise is excessive use the VIDEO FILTER and reduce the sweep speed to maintain signal amplitude, or decrease the RESOLUTION bandwidth.

2) Use the RF attenuator selector to reduce the amplitude of the larger signal until it is within the graticule area, and note the increased attenuator reading.

3) Measure the signal level from the reference line established for the smaller signal (graticule is calibrated in 2 dB/DIV) then add the change in RF attenuator reading to obtain the difference level (in dB) between the two signals.

**APPLICATIONS**

Applications for the spectrum analyzers, such as the 7L12, include; measuring intermodulation products, cross modulation, radiation interference, modulation percentage, modulation index, absolute and relative signal levels, etc. A treatise on measurement and signal evaluation is provided in TEKTRONIX; Measurement Concept booklet "Spectrum Analyzer Measurement Theory"; Part No. 062-1334-00 and Spectrum Analysis and CATV Systems brochure-A2515. If you desire assistance for a specific application or current information on additional applications, contact your local TEKTRONIX Field Office or representative.

# PERFORMANCE CHECK

## Introduction

This section contains two subparts; operational check-out procedure for incoming inspection and instrument familiarization, (this requires no test equipment), and a performance check procedure, requiring test equipment as the measurement standard to verify instrument specifications, such as calibrator accuracy, attenuator accuracy, plus triggering and sweep timing accuracy.

## OPERATIONAL PERFORMANCE and INSTRUMENT FAMILIARIZATION

This portion of this section contains a sequence of procedures that will check the operational performance of the 7L12. It provides an adequate incoming performance inspection and a good familiarization of the instrument operation. Because the 7L12 calibrator and attenuator are very accurate, they are used as the reference for this part of the performance check. If you desire, the calibrator and attenuator accuracy may be checked by referring to the second part of this section (page 3-8).

### 1. Preliminary Preparation

Perform the Preliminary Front Panel Setup Procedure described in the Operating Instructions and calibrate the 7L12 sweep to the oscilloscope deflection sensitivity. Adjust the contrast ratio between the clipped (subdued) baseline and the remaining display.

### 2. Check the 10 dB/DIV and LIN Mode Calibration

a. Switch the RF attenuator to 0 dB and turn the Gain selector fully CCW so the REFERENCE LEVEL readout is -30 dBm. Ensure that the VARIABLE Gain control is in its CAL detent. Set the FREQ SPAN/DIV to 50 kHz and the RESOLUTION bandwidth to 3 kHz. Tune the fundamental signal (50 MHz) to center screen with the FINE tuning controls.

#### NOTE

*Use the FINE tuning controls only when in PHASE LOCKED mode.*

b. Position the top of the signal to the top graticule line with the VERT POS control to establish a reference. Increase the RF attenuator settings in 10 dB steps noting that the signal amplitude decreases  $1 \pm 0.1$  division between

each step. (It may be easier to observe the change, if the VIDEO FILTER is switched in. If the VIDEO FILTER is used, decrease the sweep speed, with the VARIABLE Time/Div control, until the signal amplitude remains constant.)

c. Since the RF Attenuator range is only 60 dB, the last 10 dB step for the 70 dB dynamic range may be checked as follows:

1) Return the RF attenuator to 30 dB and insert a 20 dB attenuator between the RF INPUT and CAL OUT signal.

2) Adjust the signal amplitude to some graticule reference line (approximately 5th from the top) with the VARIABLE Gain control.

3) Increase the RF attenuator setting 20 dB and note that the signal is still visible above the noise. The total deviation over the 70 dB dynamic range must not exceed 1.5 dB or 0.75 minor divisions.

d. Remove the 20 dB attenuator and again apply the CAL OUT signal directly to the RF INPUT. Switch the VIDEO FILTER OFF and restore the sweep speed to CAL. Switch the RF attenuator to 10 dB, the FREQ SPAN/DIV to 1 MHz and the RESOLUTION to .3 MHz.

e. Change to a linear display, by depressing the LIN button. Position the baseline of the display on the bottom graticule line, then adjust the 50 MHz signal amplitude to 6.3 divisions with the VARIABLE Gain control.

f. Increase the RF Attenuation 10 dB, by switching to 20 dB. Note that the signal amplitude decreases to  $2.0 \pm 0.3$  divisions, for an amplitude change ratio of  $3.16 \pm 5\%$ .

g. Reset the VARIABLE Gain control to CAL position and the RF Attenuator to 0 dB.

### 3. Check the Frequency Readout Accuracy

a. With the Calibrator signal applied to the RF INPUT, set the FREQ SPAN/DIV to 10 MHz and the RESOLUTION bandwidth to 30 kHz. Switch the display mode to 10 dB/DIV.



## Performance—7L12

b. Set the FINE frequency controls midrange. Tune the FREQUENCY to 50 MHz with the COARSE control. Locate the 0 Hz response and 50 MHz fundamental, then position the 50 MHz marker to mid-screen with the HORIZ POS control.

c. Tune the FREQUENCY from low to high and check the dial readout accuracy in 50 MHz increments. Accuracy of the readout should be within  $\pm(10 \text{ MHz} + 1\%$  of the dial reading). The markers should move from right to left as the frequency is increased. Note: It is important that the frequency check points are approached from low to high when checking the readout accuracy.

### 4. Check the Gain Selector Accuracy and the Range of the VARIABLE Gain Control.

(Accuracy within  $\pm 1 \text{ dB}/10 \text{ dB}$  step. Variable range  $\approx 10 \text{ dB}$ .)

a. Apply the Calibrator signal to the RF INput. Switch the display mode to 10 dB/DIV, FREQ SPAN/DIV to 50 kHz, and the RESOLUTION bandwidth to 30 kHz. Switch the VIDEO FILTER in. Rotate the Gain selector fully CCW and switch RF attenuator to 50 dB. This establishes +20 dBm REFERENCE LEVEL.

b. Tune the 50 MHz fundamental signal to screen center and position the top of the signal to the 4th graticule line (from the top), with the VERT POSition control.

c. Check the VARIABLE Gain control range by switching it out of its CAL detent and rotating it fully CW. Range should equal approximately 10 dB (1 division or more). Return the control fully CCW to its CAL position.

d. Position the top of the 50 MHz signal to the 6th graticule line below the reference (top) with the VERT POSition control.

e. Check the Gain selector accuracy of the three 10 dB steps for the 10 dB/DIV mode (blue sector). Accuracy must equal 10 dB  $\pm 1 \text{ dB}$  between steps.

f. Change the display mode to 2 dB/DIV. Decrease the RF attenuator to 40 dB so the REFERENCE LEVEL is  $-20 \text{ dBm}$ . Tune the 50 MHz signal to screen center and position the top of the signal to the 5th (from the top) graticule line with the VERT POSition control.

g. Increase the Gain selector setting 10 dB (one position). Check for a signal amplitude increase of 10 dB  $\pm 1.0 \text{ dB}$  (5 div  $\pm 0.5 \text{ div}$ ).

h. Increase the RF attenuator to 50 dB, and reposition the top of the signal to the 5th graticule line. Check the accuracy of the next 10 dB step of the Gain selector.

i. Increase the RF attenuator setting to 60 dB switch the VIDEO FILTER ON and decrease sweep speed with the VARIABLE control to improve the signal symmetry. Check the accuracy of the next 10 dB Gain selector step.

j. Return the RF attenuator to the 0 dB setting. Loosely couple the calibrator signal to the RF INput, by positioning the cable BNC connector partially on the RF INput, until the signal amplitude is approximately 3 or 4 divisions. NOTE: A 50  $\Omega$ , 20 dB attenuator may be inserted in series with the Calibrator signal instead of the loosely coupled connection. The RF attenuator can then be set to 50 dB so the last 10 dB step of the Gain selector can be checked.

k. Position the top of the 50 MHz signal to the 6th graticule line. Check the accuracy of the final 10 dB step of the Gain selector.

l. Reconnect the calibrator signal to the RF INput, or remove the 20 dB attenuator and reconnect the calibrator signal.

### 5. Check the Operation of the VIDEO FILTER

The VIDEO FILTER should reduce the noise and high frequency components on the display. See Fig. 3-1. Note: When using the filter, the TIME/DIV setting (sweep speed) should be reduced to maintain signal amplitude and shape.

Apply the Calibrator signal to the RF INput and tune to one of the markers. Check the operation of the VIDEO FILTER on the display with RESOLUTION settings of 0.3 MHz and 3 kHz. (Filter should reduce noise.)

### 6. Check Sensitivity

( $-115 \text{ dBm}$  to  $-80 \text{ dBm}$ , depending on the resolution bandwidth.)

#### NOTE

*Sensitivity is measured in LIN mode.*

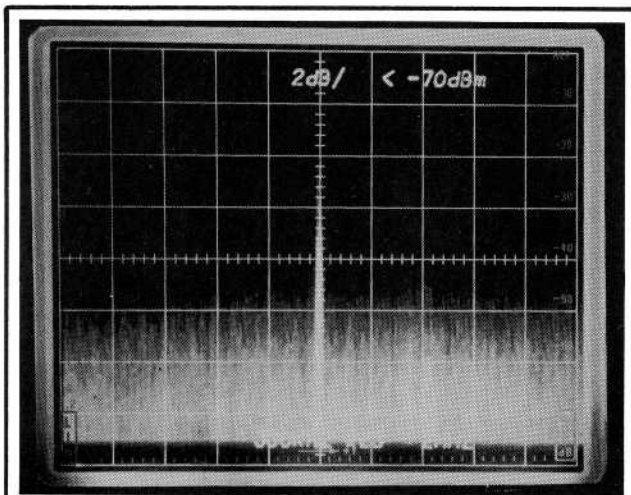
a. Apply the CAL OUT signal to the RF INput through a BNC-to-BNC 50  $\Omega$  coaxial cable. Depress the LIN mode pushbutton. Uncouple the FREQ SPAN/DIV selector and set the span for 2 MHz/Div with a RESOLUTION bandwidth of 3 MHz. Switch the RF attenuator to 0 dB and the Gain selector fully CCW. (The REFERENCE LEVEL readout should equal  $-30 \text{ dBm}$ .) Center the fundamental (50 MHz) signal on screen, verify that the

baseline of the display is on the bottom graticule line. The signal amplitude should equal approximately 8 divisions or full screen. Ensure that the TIME/DIV is in the SPECTRUM position.

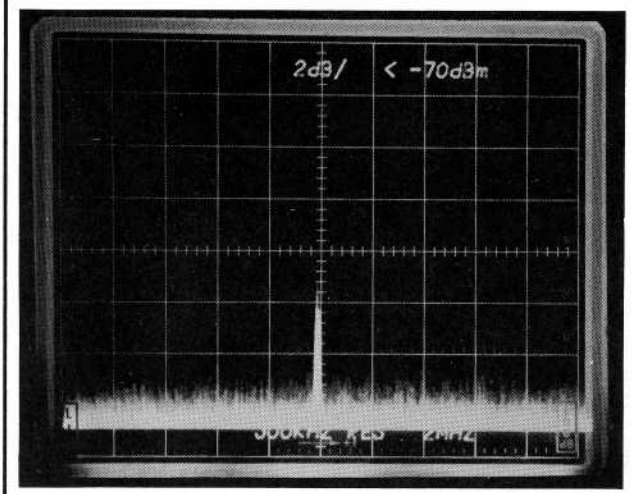
b. Increase the RF attenuator setting to 50 dB. Signal level into the 1st mixer of the 7L12 is now  $-80$  dBm ( $-30$  dBm from the Calibrator reduced 50 dB by the RF attenuator).

c. Measure the sensitivity (at 50 MHz) for a resolution bandwidth of 3 MHz, as follows:

1) Increase the Gain selector and the VARIABLE Gain control setting for a noise level of 1 division. (Display mode must be LIN.) Switch the VIDEO FILTER in. (The filter reduces noise so the display now represents the average noise level.) Set this average to 1 division with the VARIABLE Gain control.



(A) Display without filter



(B) Same display with video filter. Note decrease in noise level.

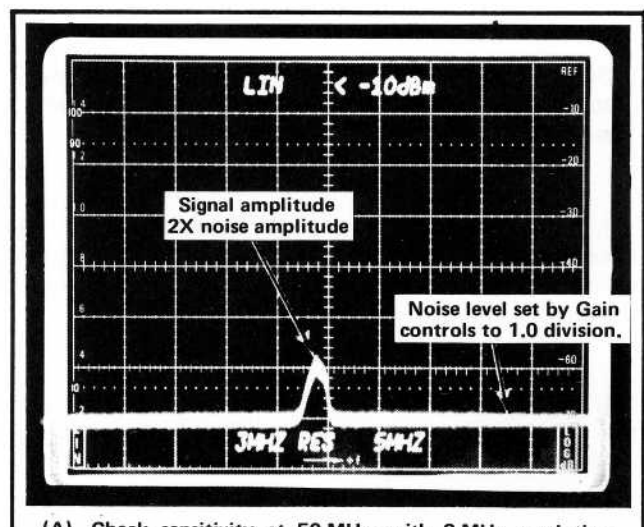
Fig. 3-1. Video Filter operation.

2) Signal amplitude should equal or exceed 2X the noise amplitude ( $S + N = 2N$ ). See Fig. 3-2A.

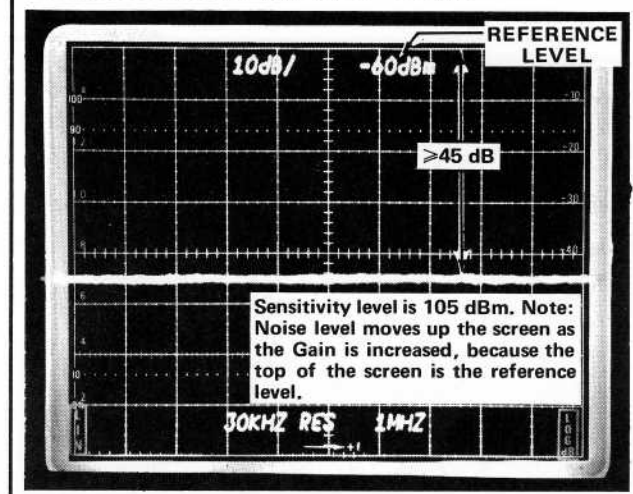
d. Remove the 50 MHz Calibrator signal to the RF INput. Return the VARIABLE Gain control to its CAL detent and switch the RF attenuator to 0 dB. Adjust Gain selector, if necessary, so the REFERENCE LEVEL reads  $-70$  dBm.

e. Switch the display mode to 2 dB/DIV. (VIDEO FILTER should still be in.)

f. Check—The average noise level, over the 20 MHz span, should be below the 5th graticule line from the reference (top of the graticule see Fig. 3-2B). This represents  $-80$  dBm (10 dB below  $-70$  dBm).



(A) Check sensitivity at 50 MHz, with 3 MHz resolution. Signal input level  $-30$  dBm, RF attenuation  $+50$  dB for a total input level to the 1st mixer of  $-80$  dBm.



(B) Average noise level, below the reference level is the sensitivity.

Fig. 3-2. Measuring sensitivity.

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Since sensitivity is a measure of signal to noise amplitude ( $S + N = 2N$ ), the noise amplitude in effect represents the sensitivity value. This was verified in step (c); therefore, the average noise level should be within or below the sensitivity that is specified for the resolution bandwidth.

g. Switch the FREQ SPAN/DIV selector to MAX SPAN position, and the GAIN selector one position CW to increase the Gain 10 dB.

h. Adjust the VARIABLE Gain control to position the average noise level so the gain slope, over the 1.8 GHz span, can be observed (see Fig. 3-3). The gain can increase to 2 dB at 1700 MHz plus an additional 2 dB (for a total of 4 dB) at 1800 MHz maximum.

### NOTE

*Because, the gain and baseline are referenced to the top of the graticule the baseline may shift with Gain selector changes.*

i. Switch the display to LIN mode, turn the Gain selector fully CCW and the VARIABLE Gain to its CAL detent. Position the display on the bottom graticule line then switch to the 10 dB/DIV display mode.

j. Set the RF attenuator to its 0 dB position and increase the Gain selector for a REFERENCE LEVEL reading of  $-60$  dBm (Gain selector should be in the blue sector).

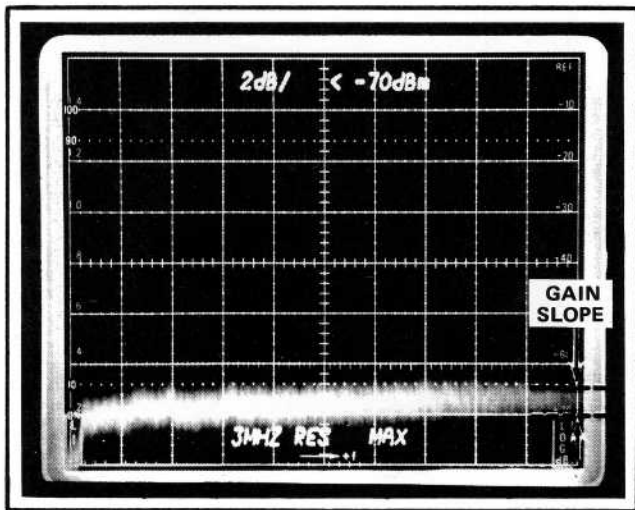


Fig. 3-3. Average noise level or gain increases as the frequency approaches 1.8 GHz. Maximum slope is 4 dB at 1.8 GHz.

k. Set FREQ SPAN/DIV to 1 MHz and the RESOLUTION bandwidth to .3 MHz. Ensure the FREQUENCY is tuned to 50 MHz. Note: The average noise level below  $-60$  dBm. Sensitivity for a resolution bandwidth of .3 MHz must equal or exceed  $-90$  dBm (noise level below the 3rd graticule line from the top).

l. Decrease the FREQ SPAN/DIV to 10 kHz and the RESOLUTION bandwidth to 30 kHz. Note that the average noise level must be below the 4th graticule line or  $-100$  dBm.

m. Decrease the RESOLUTION bandwidth to 3 kHz. Check that the sensitivity equals or exceeds  $-108$  dBm. (Average noise level is 4.8 or more divisions below the top reference line.)

n. Decrease the RESOLUTION bandwidth to 300 Hz. Check that the average noise level is below the 5th graticule line for a sensitivity that equals or exceeds  $-115$  dBm.

### NOTE

*If the Gain selector is set so the REFERENCE LEVEL is  $-50$  dBm or more (e.g.,  $-60$  dBm) with the RF attenuator at 0 dB, a decrease in sensitivity will be noticed below 2 MHz. This effect or desensitization, is caused by the 0 Hz response overdriving the 1st IF amplifier. If you are operating in this frequency range do not set the Gain selector this high.*

## 7. Check for Spurious Signals From Internal Sources (Residual Responses)

( $\leq -100$  dBm, referred to the RF Input.)

a. Remove any signal connected to the RF INPUT so it is free of signals from any external source. Switch the RF attenuator to 30 dB. This further isolates the 1st mixer from the RF Input connector.

b. Switch the VIDEO FILTER out, turn the Gain selector fully CCW and ensure that the VARIABLE Gain control is in its CAL detent. The REFERENCE LEVEL will now read 0 dBm, with the RF attenuator switched to the 30 dBm position. The signal level to the 1st mixer of the 7L12 however, is  $-30$  dBm, because the RF attenuator adds 30 dB.

c. Set the FREQ SPAN/DIV to 1 MHz and the RESOLUTION bandwidth to 30 kHz. Verify that TIME/DIV is in SPECTRUM position.

d. Switch to the 2 dB/DIV display mode, verify that the trace is on the bottom graticule line, then switch the display mode to 10 dB/DIV. The dynamic range of the graticule is now a calibrated 10 dB/DIV, with the top line representing  $-30$  dBm into the 1st mixer as described in step (b).

e. Tune slowly across the frequency band (0 to 1.8 GHz) checking for spurious signals. The amplitude of any spurious signal must not exceed  $-100$  dBm (signals above the 7th graticule line from the top). Note: Subtract 2 dB for noise which will be riding on top of the signal. If the spur is marginal (within 3 dB of specifications) and you desire to check its amplitude more accurately, proceed as follows:

1) Decrease the FREQ SPAN/DIV to 50 kHz or less and the RESOLUTION bandwidth to 3 kHz. (This will decrease the noise with respect to the signal amplitude.) Keep the signal centered on screen, with the FINE frequency controls, as the FREQ SPAN is decreased.

2) Decrease the sweep speed, with the VARIABLE Time/Div control, to maximize any spurious signal amplitude. Note that the spurious response amplitude does not exceed specifications.

f. Return the FREQ SPAN/DIV and RESOLUTION selectors to their original settings (step e).

## 8. Check Resolution Bandwidths and Shape Factor

(3 MHz to 300 Hz within 20%, in decade steps; shape factor 4:1)

a. Apply the Calibrator signal to the RF INput. Set the RF attenuator to 0 dB and turn the Gain selector fully CCW. The REFERENCE LEVEL should read  $-30$  dBm.

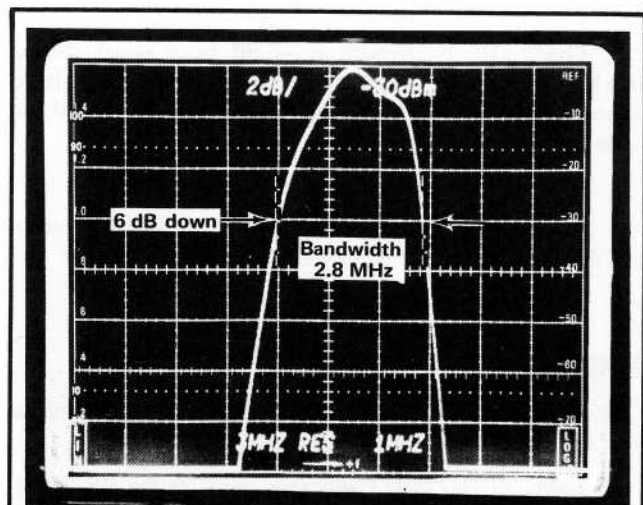
b. Set the FREQ SPAN/DIV to 1 MHz, and the RESOLUTION bandwidth to 3 MHz. Ensure that the VARIABLE FREQ SPAN control is in its CAL detent and the TIME/DIV is in SPECTRUM position.

c. Switch the display to 2 dB/DIV mode, and tune a 50 MHz marker to the screen center. Adjust the VARIABLE Gain control for a full screen display. Note: Position the baseline of the display on the bottom graticule line if necessary.

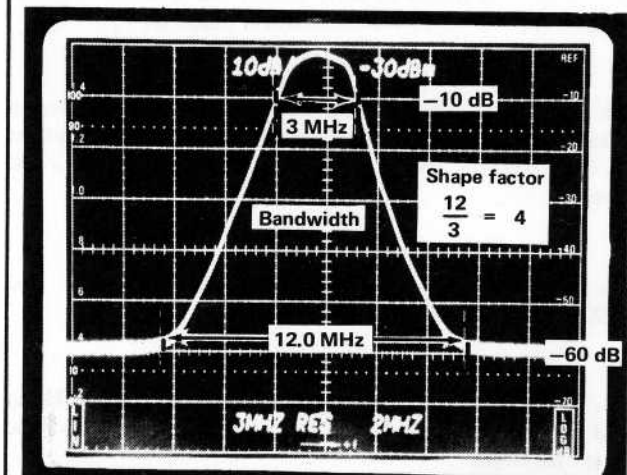
d. Check the bandwidth of the signal at the 6 dB down point (3 divisions at 2 dB/DIV; see Fig. 3-4A). Bandwidth must equal  $3$  MHz  $\pm 600$  kHz, ( $3.0 \pm 0.6$  divisions) with a frequency span of 1 MHz/DIV.

e. Switch the display mode to 10 dB/DIV and check the display shape factor (Fig. 3-4B). Return the display mode to 2 dB/DIV.

f. Decrease the FREQ SPAN/DIV to .1 MHz and the RESOLUTION bandwidth to .3 MHz. Keep the marker signal centered on screen with the FINE frequency tuning controls. Automatic phase lock switch must be on.



(A) Display mode 2 dB/DIV. Bandwidth measured at 6 dB down level. Resolution 3 MHz. Frequency Span 1 MHz/DIV.



(B) Display mode 10 dB/DIV. Shape factor is ratio of bandwidth at  $-60$  dB to  $-6$  dB levels.

Fig. 3-4. Two displays to illustrate resolution bandwidth and shape factor measurements.



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g. Check—The bandwidth at the 6 dB down point, must equal 300 kHz  $\pm$ 60 kHz, (3.0  $\pm$ 0.6 divisions). Check the shape factor as described in step e.

h. Reduce the FREQ SPAN/DIV to 10 kHz and the RESOLUTION bandwidth to 30 kHz.

i. Check the bandwidth at the 6 dB down point. Must equal 30 kHz  $\pm$ 6 kHz (3.0  $\pm$ 0.6 divisions). Note: It may be necessary to decrease sweep speed with the VARIABLE TIME/DIV control to maintain maximum sensitivity.

j. Reduce the FREQ SPAN/DIV to .5 kHz and the RESOLUTION bandwidth to 300 Hz. Center the display with FINE FREQUENCY controls.

k. Check—The bandwidth at  $-6$  dB, must equal 300 Hz  $\pm$ 60 Hz (0.6  $\pm$ 0.1 division). Shape factor is difficult to measure at this point, because of the masking effect of the noise at the 6 dB down point.

l. Return the FREQ SPAN/DIV to MAX SPAN position and the RESOLUTION bandwidth to 3 MHz.

## 9. Check Incidental FM

( $\leq$ 200 Hz when phase locked,  $\leq$ 20 kHz without phase lock.)

a. Apply the 50 MHz Calibrator signal to the RF INPUT. Switch the RF attenuator to 0 dB and the Gain fully CCW. Set the FREQ SPAN/DIV to .1 MHz, RESOLUTION to 30 kHz, display mode to LIN, switch the VIDEO FILTER out, and the AUTO PHASE LOCKED mode OFF.

b. Tune the FREQUENCY with the COARSE control to center one of the 50 MHz markers on screen, then adjust the Gain selector and VARIABLE Gain control for a full screen display.

c. Decrease FREQ SPAN/DIV to 10 kHz and RESOLUTION bandwidth to 3 kHz.

d. Check—The FM'ing of the displayed marker. FM'ing must not exceed 20 kHz (2.0 div). Fig. 3-5 illustrates how FM is measured.

e. Switch AUTO PHASE LOCKED mode on. Decrease FREQ SPAN/DIV to .5 kHz and the RESOLUTION bandwidth to 300 Hz. Decrease the sweep speed with the

VARIABLE TIME/DIV control to maximize the signal amplitude.

f. Check—The FM'ing with phase lock, must not exceed 200 Hz (2 minor divisions).

This completes a verification of the major characteristics of the 7L12. The remaining characteristics have indicated by tests to be reliable and can be accepted without further verification. However, if you desire to validate these remaining Characteristics (which requires test equipment) continue to the next part of this section.

## PERFORMANCE CHECKS WHICH REQUIRE TEST EQUIPMENT

### Introduction

The following procedures check, the accuracy of the 7L12 calibrator and RF attenuator, the display flatness, intermodulation distortion, video output amplitude, sweep triggering operation, sweep Time/Div accuracy, and external sweep operation. It does not include any internal adjustment or checks. If the instrument fails to meet a specified performance requirement, the adjustment procedure for the related circuits will be found under a similar title in the Calibration Procedure, Section 4.

### History Information

The instrument and manual are continually evaluated and updated. Circuits as well as procedures are modified. Procedures and information, applicable to earlier instruments, are included either as deviations within these steps or as subparts of the steps. These are clearly indicated in the procedure.

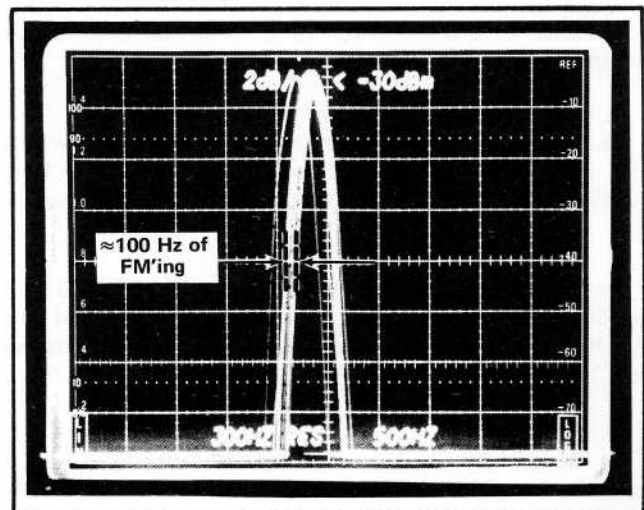


Fig. 3-5. Measuring incidental FM'ing.

### Equipment Required and Recommended

The following test equipment and fixtures are recommended to perform this portion of the performance check. Test equipment specifications are the minimum requirements, for accurate checks. Substitute equipment must meet or exceed these specifications.

Special calibration fixtures are used where necessary to facilitate the procedure. These are available from

Tektronix, Inc; and may be ordered through your local TEKTRONIX Field Office or representative.

When equipment required to check or verify a high tolerance specification is expensive or impractical to obtain a compromise is made. Notification of this compromise is a footnote to the equipment list, along with a statement that the high tolerance specification is not checked because of the compromise.

### EQUIPMENT LIST

#### NOTE

*This equipment is also required to recalibrate the instrument.*

Equipment or Test Fixture	Characteristics Required	Type or Model Recommended
Oscilloscope with CRT read-out feature. Dual Channel Vertical Plug-In Amplifier Unit.	Frequency bandwidth: 50 MHz Vertical sensitivity: 5 mV/Div to 5 V/Div.	TEKTRONIX 7603, 7904 with 7A12 or 7A18 vertical amplifier plug-in. (7503N can be used, if a substitute for the 7D14 Counter is used)
Time Mark Generator	Marker outputs: 1 s to 1 $\mu$ s Accuracy: 0.001%	TEKTRONIX 2901 with Harmonic Modulator, Part No. 067-0640-00 (Used to check TIME/DIV and FREQ SPAN/DIV accuracies)
Pulse Generator	Pulse period: 40 $\mu$ s Pulse duration: 20 ns Pulse amplitude: 50 mV	TEKTRONIX 2101 Pulse Generator (Used to check VIDEO PROCESSOR)
Digital Counter	To 50 MHz	TEKTRONIX 7D14 Digital Counter with a readout 7000-series oscilloscope and vertical amplifier unit. (Used to check 50 MHz accuracy of the Calibrator)
Signal Generators	Frequency range: 10 Hz to 1.8 GHz. Output Amplitude: 0 V to 5 V (10 Hz to 10 MHz); -110 dBm to 0 dBm (10 MHz to 1.8 GHz) Output variable and calibrated in dBm from 10 MHz to 1.8 GHz. Accuracy $\pm$ 1.0 dB	Used to check triggering and flatness characteristics
AF	1 Hz -1 MHz, output amplitude at least 10 V P-P. Output impedance 50 $\Omega$ to 600 $\Omega$	General Radio Model 1310A or Hewlett Packard Model 202C
HF	22 kHz -10 MHz	Hewlett Packard Model 8651A
VHF	10 MHz -480 MHz	Hewlett Packard Model 608D or 608E
UHF	450 MHz -1230 MHz and 800 MHz-4500 MHz	Hewlett Packard Model 612A and Hewlett Packard Model 8614A or 8614B

EQUIPMENT LIST (cont)

Equipment or Test Fixture	Characteristics Required	Type or Model Recommended
<sup>1</sup> Power Meter with 50 MHz Low Pass Filter;	Measure -30 dBm within ±0.1 dB. Filter must have rolloff ≥40 dB at 100 MHz.	General Microwave Model 454A; or, Hewlett Packard Model 432A.
or -30 dBm, 50 MHz Signal Source	Power source may be calibrated by Power Meter.	Hewlett Packard Model 608D or 608E.
or Vector Voltmeter	Frequency: 50 MHz	Hewlett Packard Model 8405A.
Two 18 inch 50 Ω low loss coaxial cable. BNC-to-BNC connectors	RG-58C/U less than 18"	TEKTRONIX Part No. 012-0076-00
Two, 10:1 50 Ω Attenuators		TEKTRONIX Part No. 011-0031-00
BNC 'T' connector		TEKTRONIX Part No. 103-0030-00
Pin-jack to pin-jack, jumper cable, 8 inches long	To apply a signal into the HORIZ IN jack or connect the VERT OUT signal to an external device; such as a recorder.	TEKTRONIX Part No. 012-0179-00 or 012-0181-00
Binding post BNC male adapter	To connect pin-jack through adapter to the Input of Vertical Amplifier Unit	TEKTRONIX Part No. 103-0033-00

<sup>1</sup> Three methods are described, to check output power level of the Calibrator. Refer to this step in the procedure, to determine which test equipment you desire.

**1. Check the Calibrator Frequency**

- a. Frequency check: (Accuracy 50 MHz ±0.01%)

The frequency of the calibrator may be checked by an accurate frequency counter, such as TEKTRONIX 7D14 Digital Counter Plug-In Unit with a readout 7000-Series Oscilloscope and a 50 MHz vertical plug-in unit, to amplify the -30 dBm 50 MHz signal to approximately 30 mV P-P to trigger the 7D14. (e.g., 7A15.) No procedure for this check is provided because the CAL OUT signal can be connected through an amplifier unit to the Input of the counter and note the frequency readout noted.

**2. Check Calibrator Output (-30 dBm ±0.3 dB)**

Three procedures are given; Vector Voltmeter method, Power Meter method, and using an accurate -30 dBm source. The output of the calibrator contains harmonics; therefore, direct measurement is not possible.

**Vector Voltmeter Method (Hewlett Packard Model 8405A Vector Voltmeter).**

- a) Terminate the "A" probe with a BNC 50 Ω feed-through termination and connect the probe, through the termination, to the CAL OUT connector on the 7L12.

- b) Switch the Vector Voltmeter frequency to 50 MHz.

- c) Check for an RMS reading between 6.85 mV to 7.3 mV (-30 dBm is 7.07 mV-RMS, into 50 Ω). If output is out of specification refer to Calibrator Output adjustment in the Calibration Procedure.

**Accurate Power Meter (within 0.1 dB) and a 50 MHz Low Pass Filter with 40 dB or more rolloff at 100 MHz: (General Microwave Power Meter Model 454A; or, Hewlett Packard Model 432A Power Meter).**

*NOTE*

*The insertion loss, of the filter, must be accounted for to an accuracy of 0.1 dB.*

a) Connect the power meter through the filter, to the CAL OUT connector.

b) Measure the output level.

**Using a –30 dBm Signal Source to check the Output by Signal Substitution Method.**

**NOTE**

*The power meters suggested for the second method can be used to verify the signal source output level.*

a) Set the FREQ SPAN/DIV to .5 MHz and the RESOLUTION bandwidth to .3 MHz. Switch the RF attenuator to 10 dB and the Gain selector fully CCW. Push the 2 dB/DIV LOG display button.

b) Apply 50 MHz, from the calibrated –30 dBm source, to the RF INput of the 7L12 and tune the signal to the graticule center. Adjust the VARIABLE Gain control to position the top of the signal to some reference line (2nd or 3rd from the top).

c) Disconnect the –30 dBm reference signal, then apply the 7L12 CAL OUT signal to the RF INput connector.

d) Check—The displacement of the 7L12 calibrator 50 MHz signal level, from the reference signal level. Must not exceed  $\pm 0.3$  dB (0.75 minor divisions with a 2 dB/DIV display mode).

e) If necessary, adjust the output of the calibrator as described in the Vector Voltmeter method, for –30 dBm.

### 3. Check RF Attenuator Accuracy

(Within  $\pm 0.2$  dB +1% of the dB readout)

**NOTE**

*The RF attenuator accuracy is checked at the factory to ensure that it is within specifications. This check will detect any component failure within the attenuator but it will not check the tolerance characteristics. If the exact attenuation error of the selector is required, a reference attenuator, calibrated by the user or manufacturer to more rigid specifications than the 7L12 RF attenuator, must be used.*

a. Set the front panel controls and selectors as follows:

RF Attenuator	0 dB
Gain	CCW
Display Mode	LOG 2 dB/DIV
FREQ SPAN/DIV	1 MHz
RESOLUTION	.3 MHz
Center Frequency	200 MHz

b. Apply a 60 dBm, 200 MHz signal, from the VHF signal generator to the RF INput. Adjust the Gain selector and VARIABLE Gain control for a signal amplitude reference of 4 divisions.

c. Check—The RF Attenuator selector accuracy by increasing the RF Attenuator setting in 10 dB increments, and decreasing the Variable Attenuator setting (on the VHF generator) 10 dB. The display amplitude should remain at 4 divisions  $\pm 0.2$  dB or 1% of the RF attenuator setting whichever is greater.

### 4. Check Display Flatness

(Maximum amplitude variation over the 100 kHz to 1.8 GHz frequency span must remain within  $\pm 1.5$  dB, with respect to the reference level established at 50 MHz).

a. Set the front panel controls and selectors as follows:

Center Frequency	50 MHz
Display Mode	2 dB/DIV
RF Attenuator	10 dB
Gain	Fully CCW
FREQ SPAN/DIV	MAX SPAN
RESOLUTION	3 MHz

b. Apply a –30 dBm, 50 MHz signal from the VHF signal generator to the RF INput of the 7L12. Adjust the VARIABLE Gain control for a reference amplitude of 6 divisions.

c. Check—The flatness response, by tuning the signal generator across its frequency range, maintaining a constant output level, and noting signal amplitude variations. Amplitude variations about the reference 6 division level should not exceed  $\pm 1.5$  dB (0.75 div).

d. Change to a UHF signal generator then a SHF signal generator as required, to check flatness over the remaining frequency span of the 7L12.



NOTE

Cable losses become significant at frequencies above 1.0 GHz. Use RG-8C cable with BNC to N adapter, or use very short cable lengths ( $\leq 1$  foot) between the signal generator and the 7L12 RF INput connector. Impedance levels between the source and RF INput are also important; refer to General Operating Information, Signal Amplification.

5. Check Intermodulation Distortion

(Third order distortion is down 70 dB or more from two -30 dBm signals within any frequency span. Second order distortion is down 70 dB or more from two -40 dBm signals. Fig. 3-6 illustrates third and second order intermodulation products.)

a. Set the FREQUENCY SPAN to 1 MHz/Div and RESOLUTION bandwidth to 30 kHz. Set the RF attenuator to 0 dB and the Gain selector fully CCW. REFERENCE LEVEL should readout -30 dBm. Switch the VIDEO FILTER off and the display mode to 10 dB/DIV.

b. Apply two signals, separated approximately 2 MHz, from the output of two 50  $\Omega$  signal sources, through 10X attenuators (for isolation) then through a BNC 'T' connector, to the RF INput of the 7L12. Fig. 3-7 illustrates this setup.

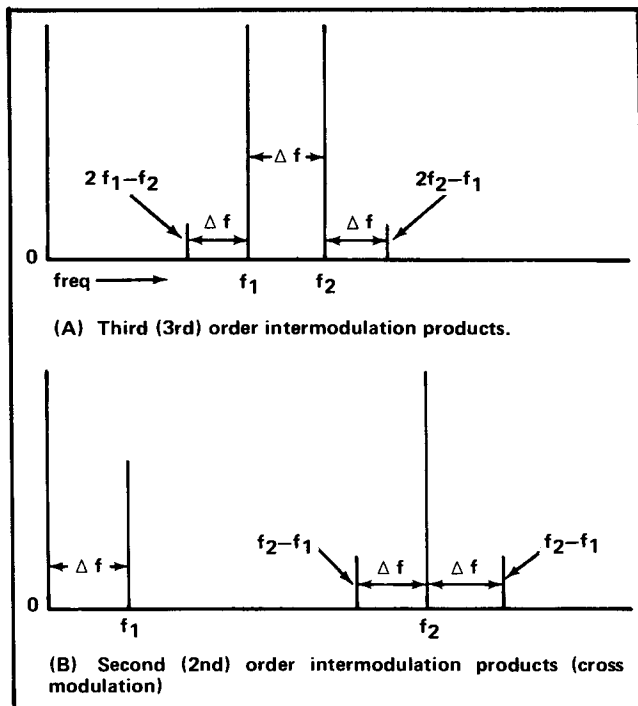


Fig. 3-6. Intermodulation products (distortion).

c. Adjust the output of both generators for signal amplitudes that are full screen (-30 dBm).

d. Check—Amount of third order intermodulation distortion, by noting the amplitude of the IM products. The amplitude of these IM products must be down 70 dB from the two signals, or below the 7th graticule line from the top (see Fig. 3-6A).

NOTE

Typically these intermodulation products are difficult to see. An alternate procedure, which will decrease noise, is to switch the VIDEO FILTER ON and use a very slow sweep, looking for any sidebands. If your oscilloscope has storage, use the Storage mode.

e. Tune the FREQUENCY towards 10 MHz until the 0 Hz response is on screen.

f. Tune one signal generator frequency to approximately 1 MHz and adjust its output for a signal level of -40 dBm or 1 division below the top of the graticule (-30 dBm reference). Note: Both generators must be connected as described in step (b).

g. Tune the FREQUENCY of the 7L12 to the frequency of the second signal generator and adjust the generator output for a signal level of -40 dBm. NOTE: Refer to step (b) and have the frequency above 10 MHz.

h. To increase the dynamic range of the display, so it is more than 60 dB, uncouple the RESOLUTION and decrease the resolution bandwidth to 3 kHz, then increase the Gain setting 10 dB. The REFERENCE LEVEL should now read -40 dBm. Slow the sweep speed, with the VARIABLE TIME/DIV control, until the signal amplitude is again full screen. The noise amplitude should now equal approximately 1 division. The dynamic range of the graticule, is now 70 dB.

i. Check—Second order intermodulation distortion must not exceed 1 division, or 70 dB below the two reference signals (see Fig. 3-6B).

6. Check VIDEO PROCESSOR Operation

(Processor should increase pulse falltime to at least 2.5  $\mu$ s per vertical division.)

**CAUTION**

Since the video processor responds only to pulsed spectra, a pulse generator is used to make this check. Use extreme care to insure that the pulse amplitude, into the RF INput of the 7L12, does not exceed 100 mV (100 mV is approximately  $-7$  dBm).

a. Switch the display mode to LIN and the VIDEO FILTER off. Set the TIME/DIV to SPECTRUM, the FREQ SPAN/DIV to 50 MHz, and the RESOLUTION bandwidth to 3 MHz. Switch the RF Attenuator to 0 dB and the Gain selector for a REFERENCE LEVEL readout of  $-50$  dBm.

b. Depress the CENTER frequency pushbutton and tune the FREQUENCY to center the 0 Hz response on screen.

c. After ensuring that the pulse generator output is below 1 V, apply its output through a 20 dB (10X)  $50 \Omega$  attenuator, to the RF INput of the 7L12.

d. Set the generator, pulse duration to 20 ns and its period to 40  $\mu$ s (.2  $\mu$ s and 40  $\mu$ s can be used if desired).

e. Adjust the oscilloscope Intensity and the 7L12 BASE LINE CLIPPER controls until the pulsed spectrum, about the 0 Hz response, can be observed (see Fig. 3-8). It may be necessary to adjust the output of the pulse generator to approximately 0.1 V; however, do not exceed 1 V peak.

f. Depress the VIDEO PROCESSOR pushbutton. Note, the intensity of the pulsed spectra should increase. Return the pushbutton to its off position.

g. Switch PHASE LOCKED mode OFF, and tune the 0 Hz response to the left edge of the screen. Decrease the FREQ SPAN/DIV to 0 and the TIME/DIV setting to the 10  $\mu$ s position. Switch the Trigger SOURCE to INT and the Trigger MODE to NORM, then adjust the Trigger LEVEL control for a triggered display of two or more pulses. NOTE: To increase the display amplitude, tune the FREQUENCY towards 10 MHz and increase the pulse generator output until the signal amplitude equals 4 divisions.

h. Depress the VIDEO PROCESSOR button and note that the pulse fall-time increases to approximately 10  $\mu$ s (2.5  $\mu$ s/DIV).

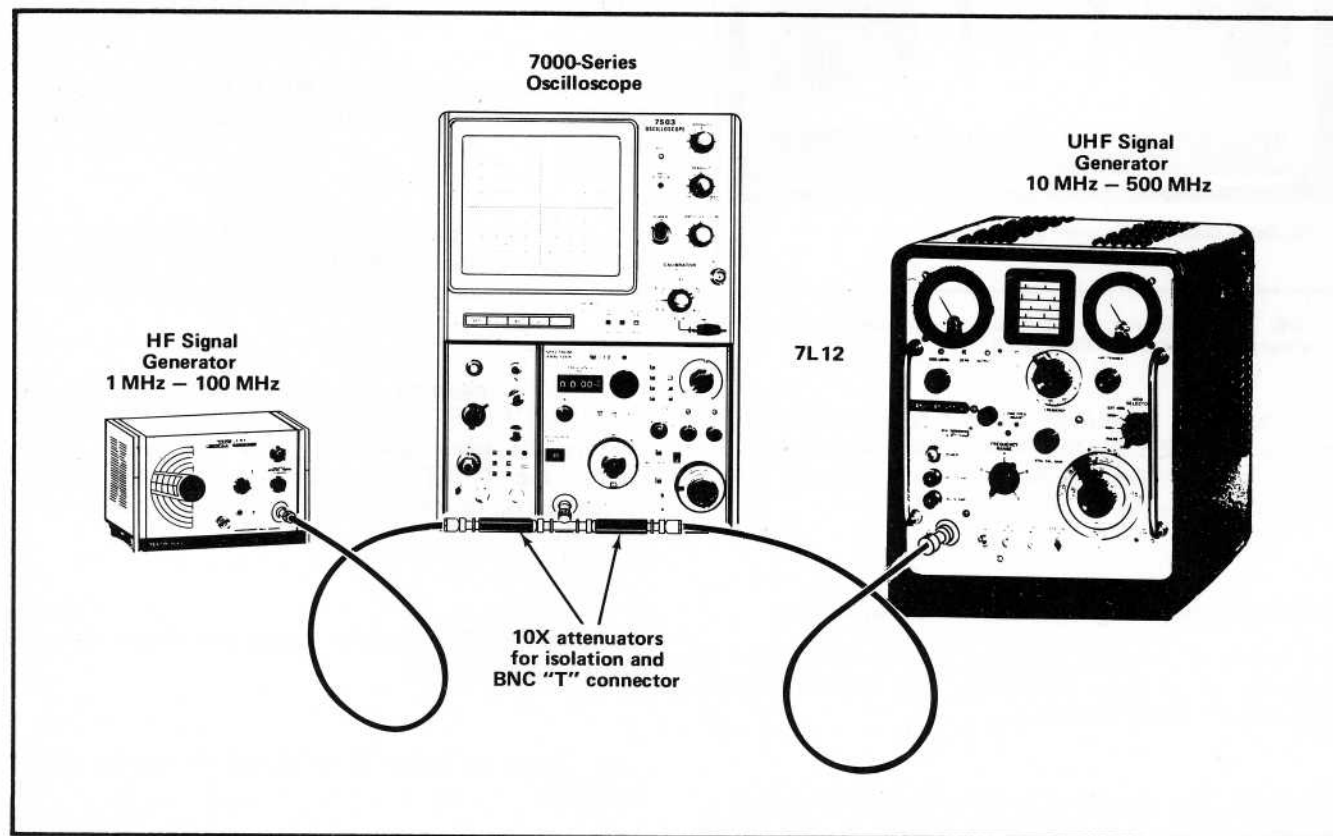
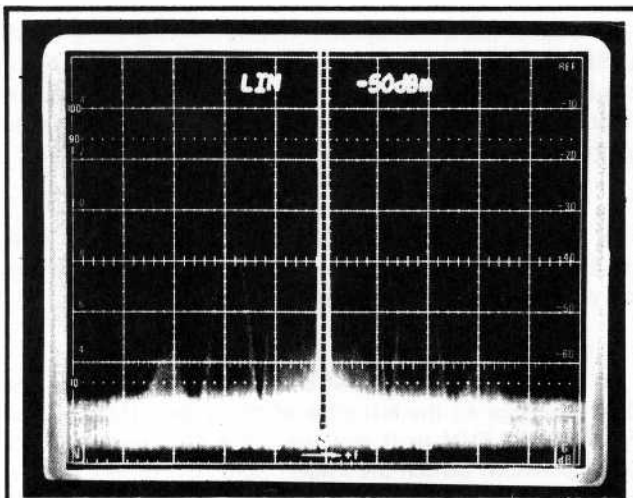
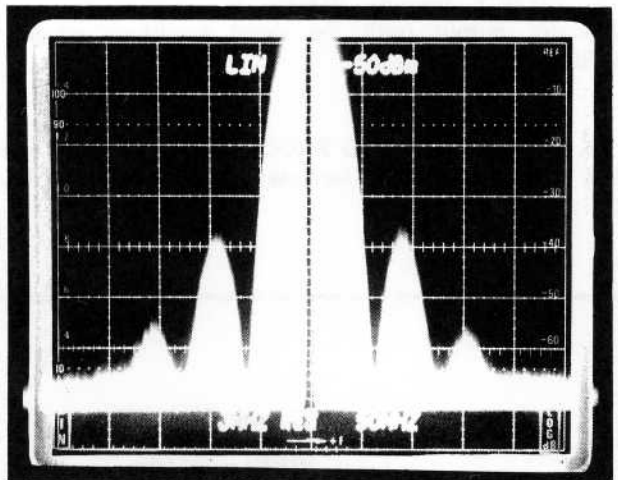


Fig. 3-7. Equipment setup and connections necessary to measure intermodulation distortion.



(A) Display without video processing.



(B) Same display with video processing.

Fig. 3-8. Typical display of a pulsed RF spectrum that illustrates the effect of the VIDEO PROCESSOR.

i. Return the TIME/DIV selector to its SPECTRUM position, the FREQ SPAN/DIV to 10 MHz, and release the VIDEO PROCESSOR pushbutton. Disconnect the pulse generator signal to the RF INput connector.

### 7. Check Triggering Operation and Sensitivity

a. Insert a vertical amplifier plug-in unit, with a sensitivity of at least 5 mV/Div, into the left plug-in compartment of the oscilloscope.

b. Apply the output of a sine-wave generator, with a frequency range from 15 Hz to 1 MHz, to the Input connector of the vertical amplifier unit. Set the Volts/Div to 1 V, and Input Coupling to AC or DC.

c. Switch the oscilloscope Vertical Mode and Trigger Source to Left Vertical.

d. Set the generator frequency to approximately 100 Hz, and adjust its output so the signal amplitude is approximately 0.5 V P-P.

e. Set the 7L12, TIME/DIV to the SPECTRUM position. Depress the INT, Trigger SOURCE pushbutton and the NORM, Trigger MODE pushbutton, then adjust the TRIGGER LEVEL control for a triggered display.

f. Decrease the signal generator output, or the Volts/Div setting of the vertical amplifier unit, to check the sweep triggering sensitivity. The sweep must trigger when the signal amplitude is equal to or less than 0.3 division. (The TRIGGER LEVEL control may require readjusting.)

g. Increase the generator frequency to approximately 1 MHz and switch the 7L12 TIME/DIV to 1  $\mu$ s.

h. Check—The sweep triggering sensitivity. The sweep should trigger when the display amplitude is  $\leq 0.3$  division. Switch the SLOPE from the + or - position and note that triggering occurs on the correct signal slope.

i. Change the 7L12 Trigger MODE to P-P AUTO. Check that the display triggers for a display amplitude  $\leq 0.5$  division.

j. Increase the display amplitude to 1.5 divisions. Change the Trigger MODE to SINGLE SWEEP, the TIME/DIV to 5 ms, and decrease the generator frequency to 100 Hz.

k. Check—Triggering for single sweep operation, by pushing the RESET button and noting that the sweep runs. Remove the signal generator signal to the RF INput. Depress the RESET button and note that the READY button lights, to indicate that the circuit is ready to be triggered.

l. Re-apply the generator signal and check that the sweep triggers and runs.

m. Change the Trigger SOURCE to LINE and the MODE to NORM.

n. Check that the sweep triggers at the line frequency.

o. Remove the signal generator signal to the RF INPUT and switch the Trigger SOURCE to FREE RUN. Note that the sweep free runs.

## 8. Check Video Signal Output Level

(50 mV  $\pm$ 5% per displayed division about the CRT center.)

a. Apply the VERT OUT signal to the Input of the vertical amplifier plug-in unit by using a pin-jack jumper cable and binding post to BNC adapter. Set the Volts/Div selector of the amplifier to 50 mV.

b. Apply the CAL OUT signal of the 7L12, to the RF INPUT. Set the FREQ SPAN/DIV to approximately 2 MHz and tune the FREQUENCY of the 7L12 to center one of the 50 MHz signals within the graticule area.

c. Adjust the RF attenuator and the Gain of the 7L12 for a signal amplitude of 4 divisions, then position the display about the vertical center of the CRT with the VERT POS control. Adjust the VARIABLE Gain control for a precise 4 division display.

d. Check—The video output amplitude should equal 200 mV  $\pm$ 10 mV, as measured by the vertical amplifier unit.

### NOTE

*Use Alternate or Chop display mode of the oscilloscope, so both the spectrum analyzer and the vertical amplifier displays can be observed.*

## 9. Check the Horizontal Input Voltage Requirement

(0 V to 10 V  $\pm$ 1 V with a starting reference of 0 V  $\pm$ 1 V, from a low impedance source, should sweep the analyzer the full span set by the FREQ SPAN/DIV selector.)

a. Set the FREQ SPAN/DIV to 50 MHz and the RESOLUTION bandwidth to 3 MHz. Set the TIME/DIV in the SPECTRUM position and slow the sweep speed by setting the VARIABLE control midrange. Set the display mode to 10 dB/DIV.

b. Switch the 7L12 TRIGGER SOURCE and MODE to FREE RUN and P-P AUTO, then switch the oscilloscope Trig Source to Left Vert and the Vertical Mode to Right. Plug a dual-channel, vertical amplifier into the left compartment. Set both Volts/Div to 5 (Variable in Cal), Display Mode to Ch2 and Trig Source to Ch 1.

c. Tune the 7L12 FREQUENCY towards 0000 until the 0 Hz response is centered on the graticule. Switch the TIME/DIV selector to AMPLIFIER position, then adjust the Ch 1 Position control, of the vertical amplifier, to center the spot at the peak of the 0 Hz response. (This should be at the same location as the 0 Hz response was in the SPECTRUM setting.)

d. Switch the oscilloscope Vertical Mode to Chop or Alt.

e. Apply the output of a audio sine wave generator (capable of at least 10 V P-P output) to Ch 2 Input of the vertical amplifier and the HORIZ IN jack of the 7L12 by using a coaxial cable, BNC 'T' connector, BNC to binding post adapter, and pin-jack to pin-jack jumper cable.

f. Set the generator frequency to about 2 Hz and adjust its output for about 10 V P-P (use the oscilloscope Ch 2 display to measure the signal amplitude).

g. Apply the 7L12 Calibrator signal to the RF INPUT. Adjust the signal generator output to calibrate the spectrum display for 250 MHz either side of graticule center (0 Hz response). Use the 50 MHz markers at 50 MHz/Div to calibrate the display.

h. Check—The generator signal output voltage should equal 10 V  $\pm$ 1 V.

## 10. Check Frequency Span Accuracy and Linearity

(Freq Span accuracy within 5%, Linearity accuracy within 5% over the center 8 divisions)

a. Apply the marker and trigger output from the time mark generator through the Harmonic Modulator to the RF INPUT of the 7L12. Set the 7L12 selectors and controls as follows:

FREQUENCY	800 MHz
Display Mode	10 dB/DIV
RF Attenuator	10 dB
Gain	CCW (REFERENCE LEVEL -20 dBm)
PHASE LOCKED Mode	ON
FREQ SPAN/DIV and RESOLUTION	Coupled (100 MHz and 3 MHz)

b. Check frequency span accuracy and linearity as per Table 3-1. Note: At some settings a better display may be obtained by using the VIDEO FILTER or by tuning the FREQUENCY to a different setting. When the VIDEO FILTER is used, the sweep speed must be decreased to obtain optimum marker amplitude.



TABLE 3-1

FREQ SPAN/DIV	RESOLUTION	Time Mark Marker	Generator Trigger	Markers/Div	Tolerance
100 MHz	3 MHz	2 ns	0	1/Div	5%
50 MHz	3 MHz	2 ns	0	1/2 Div	5%
20 MHz	300 kHz	2 ns	0	1/5 Div	5%
10 MHz	300 kHz	10 ns	.1 $\mu$ s	1/Div	5%
5 MHz	300 kHz	10 ns	.1 $\mu$ s	1/2 Div	5%
2 MHz	300 kHz	10 ns	.1 $\mu$ s	1/5 Div	5%
1 MHz	30 kHz	10 ns	1 $\mu$ s	1/Div	5%
.5 MHz	30 kHz	10 ns	1 $\mu$ s	1/2 Div	5%
.2 MHz	30 kHz	10 ns	10 $\mu$ s	2/Div	5%
.1 MHz	30 kHz	10 ns	10 $\mu$ s	1/Div	5%
50 kHz	3 kHz	10 ns	10 $\mu$ s	1/2 Div	5%
20 kHz	3 kHz	10 ns	10 $\mu$ s	1/5 Div	5%
10 kHz	300 Hz (uncoupled)	10 ns	.1 ms	1/Div	5%
5 kHz	300 Hz	10 ns	.1 ms	1/2 Div	5%
2 kHz	300 Hz	10 ns	.1 ms	1/5 Div	5%
1 kHz	300 Hz	10 ns	1 ms	1/Div	5%
.5 kHz	300 Hz	10 ns	1 ms	1/2 Div	5%

### 11. Check Time/Div Accuracy and the Range of the Variable Control

(Accuracy within 2%, range of VARIABLE control  $\geq 3X$ .)

a. Apply the marker output of a time mark generator, through a 50  $\Omega$  feedthrough termination, to the Input of vertical amplifier plug-in unit. Set the Volts/Div selector of the amplifier to 1 V.

b. Switch the oscilloscope Vertical Mode and Trigger Source selectors to Left Vertical. Switch the 7L12 TIME/DIV selector to the SPECTRUM position and ensure that the VARIABLE Time/Div control is pushed into its CAL detent.

c. Switch the 7L12 Trigger MODE to NORM and the Trigger SOURCE to INT. Adjust the TRIGGER LEVEL control for a triggered display.

d. Check the accuracy of the TIME/DIV selections by applying appropriate markers from the time mark generator, and noting the displacement error between graticule markers and the timing marker. The error must not exceed  $\pm 2\%$  (0.2 div) over the center 8 divisions of a 10 division display. Note: Use the HORIZ POSITION control to position

a marker on the 1st graticule line then note the error between each marker and its respective graticule line.

e. Set the TIME/DIV selector to 1 ms and apply .1 ms markers to the vertical amplifier plug-in unit.

f. Disengage the VARIABLE Time/Div control from its CAL detent, then rotate the control through its range and note that the TIME/DIV increases approximately 3X.

g. Switch the TIME/DIV selector to the SPECTRUM position. Turn the VARIABLE control fully CW. Apply 10 ms markers from the marker generator.

h. Rotate the VARIABLE control fully CCW apply 1 s markers from the time mark generator and note that the TIME/DIV has increased approximately 100X or to approximately 1 s/Div.

i. Disconnect the time mark generator marker output to the RF Input of the 7L12. Switch the oscilloscope Vert Mode and Trigger Source to the Right Vertical.

This completes the performance check for the 7L12. It will now perform within specification described in Section 1.

# CALIBRATION PROCEDURE

This section provides procedural information for internal checks and adjustment. Performing the complete procedure will recalibrate the instrument to its original specifications. After calibration, performance should be verified by repeating the Performance Check.

Limits, tolerances, and waveform illustrations are guides or aids to calibrate the instrument, they are not intended as instrument specifications, but only as typical values or waveforms. Actual values may exceed the listed tolerance with no loss in instrument performance.

## Complete or Partial Calibration

The instrument should be cleaned and inspected as outlined in the Maintenance section, before performing a complete calibration. Perform the checks and adjustments in sequence then verify the performance by repeating the Performance Check.

Some circuits within this instrument are inherently stable, and some require extensive facilities with expensive test equipment for calibration. For this reason, it may be desirable to perform only a partial calibration which can be done by turning to the desired step, prepare the instrument for adjustment, by referring to the nearest setup figure and control instructions that precede the step, then adjust as directed.

## History Information

The manual and instrument are subjected to a program, which evaluates and updates circuits. These modifications may require changes in the calibration procedure. History information that is applicable to earlier instruments is included either as a deviation within the step(s) or as a subpart to this step.

## Interaction

Adjustments that interact are noted and reference made to the affected adjustments.

## Equipment Required

Equipment for calibration includes the equipment listed for Performance Check plus the following additional equipment:

DC voltmeter: Checked to within 1% at 15 V, 5 V and 20 V; for example, Triplett Model 630-NA.

Adapter: BNC female to subminiature (SEAELECTRO) female. TEKTRONIX Part No. 175-1162-00, SEAELECTRO Part No. 51-077-6801.

Adapter: SEAELECTRO male to male. TEKTRONIX Part No. 103-0098-00, SEAELECTRO Part No. 51-072-0000.

Adapter: SEAELECTRO female to harmonica (multipin) connector. TEKTRONIX Part No. 175-1204-00.

Plug-in extenders (two): TEKTRONIX Part No. 067-0616-00.

## SHORT FORM PROCEDURE

The following abridged procedure provides a calibration record, an index to help locate adjustment steps, and a guide for the experienced calibrator.

7L12 Serial No. \_\_\_\_\_  
 Calibration Date \_\_\_\_\_  
 Calibrator \_\_\_\_\_

### TIME BASE SECTION

- |   | Page |
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| <input type="checkbox"/> 1. Adjust Sweep Triggering | 4-2  |
| <input type="checkbox"/> 2. Check and Adjust Timing | 4-4  |

### FUNCTION IF ALIGNMENT

- |  |     |
|--|-----|
| <input type="checkbox"/> 3. Adjust LIN Mode Baseline Offset              | 4-5 |
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### PHASE LOCK CIRCUIT

- |  |     |
|--|-----|
| <input type="checkbox"/> 5. Phase Lock Adjustments | 4-6 |
|--|-----|

### 2nd LO AND SHAPER CALIBRATION

- |   |     |
|---|-----|
| <input type="checkbox"/> 6. Adjust 2nd LO Sweep Shaper Range and Center Frequency | 4-8 |
|---|-----|

**Calibration—7L12**

7. Adjust Sweep Shaper 4-9

**VOLTAGE MEMORY CIRCUIT**

8. Adjust Voltage Memory (Cal and Offset) 4-10

9. Calibrating the 2nd Mixer and 2.095 GHz Filter 4-11

**FREQ SPAN AND MARKER CALIBRATION**

10. Adjust the 1st LO Power Supply Voltage and The Frequency Span of the Oscillator (Voltage 25 V DC, Span 1.8 GHz) 4-11

11. Calibrate MAX SPAN Marker 4-12

**50 MHz CALIBRATOR**

12. Adjust the Calibrator Output (-30 dBm ±3.0 dB) 4-13

**RESOLUTION**

13. Adjust the Bandpass of the 105 MHz IF Amplifier and 300 kHz Filter 4-13

14. Adjust the Resolution Gain Leveling Compensation 4-16

15. Preliminary Adjustment of the Gain Slope for the Resolution Amplifier 4-17

16. Adjust the Post Resolution Amplifier Gain 4-17

17. Minimize Intermodulation Products 4-18

1. Check the front panel controls and selectors for smooth operation and proper indexing.

2. Remove the 7L12 from the oscilloscope compartment. Remove the holding screw for the rackmounted center section and pull the section out to its latch position (Fig. 4-1).



*The slide rails, that support the center section, have a positive detent when they are half open. A slight pull is required to override this detent. DO NOT JERK the section because it may slam against the end stops and bind.*

*To replace the center section, turn the instrument on its side so the section can be pushed down into the instrument. Tap the assembly past the rail detents and ensure that the cables to the center boards are not binding its travel. See Fig. 4-1.*

3. Connect two flexible plug-in extenders between the 7L12 and the oscilloscope interface plugs.

4. Turn the power ON and allow 30 minutes or more for the instrument circuits to stabilize.

**TIME BASE SECTION**

**1. Adjust Sweep Triggering**

a. Plug a vertical amplifier unit into the Left Vertical compartment of the 7000-Series Oscilloscope.

b. Set the front panel selectors and controls as follows:

**7L12**

TIME/DIV	.1 ms
VARIABLE	Pushed in to CAL detent
SOURCE	INT
MODE	P-P AUTO

**Preliminary Procedure**

**NOTE**

*Instrument calibration should be performed within an ambient temperature of +20°C to +30°C after a warmup period (with power ON) of at least 30 minutes, to allow the instrument to stabilize.*

**Oscilloscope and Vertical Amplifier Unit**

Vertical Mode	Left
Horizontal Mode	A (if applicable)
TRIG SOURCE	Left Vert
Volts/Div	.2
Input Coupling	DC

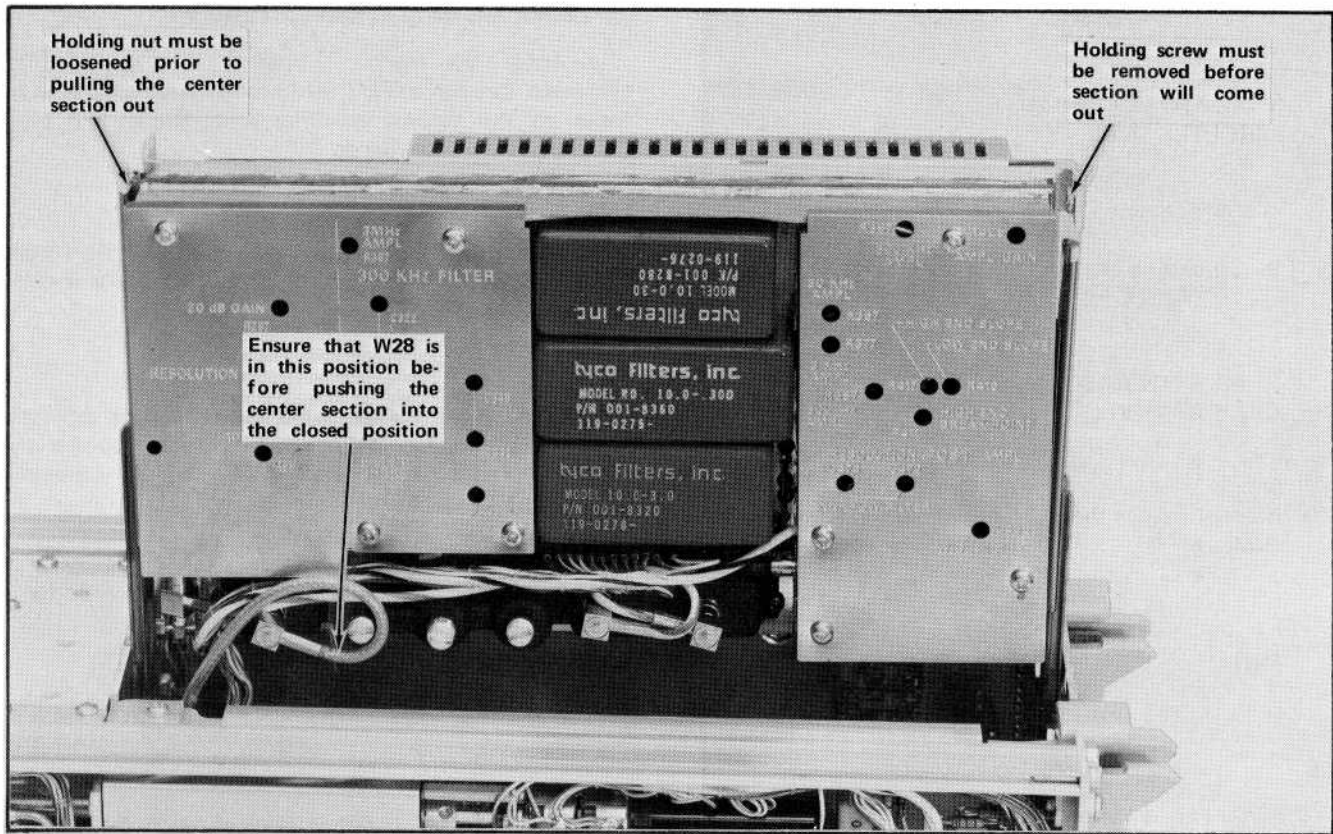


Fig. 4-1. Rackmounted center section pulled out to its latched detent, ready for servicing.

c. Adjust the sweep length to approximately 10.5 divisions with the front panel SWP CAL adjustment.

d. Apply a 40 mV signal, from the output of the oscilloscope Calibrator, to the Input of the vertical amplifier unit.

e. Adjust Trigger Level Centering (R1071, Fig. 4-2) until the sweep triggers at each position (+ and -) of the SLOPE selector.

f. Change the Triggering MODE to NORM then adjust the LEVEL control so the sweep again triggers at both positions of the SLOPE selector.

g. If the index mark on the LEVEL control is off center, loosen the Allen set-screws and reposition the control.

h. Change the Volts/Div (vertical amplifier unit) to 20 mV and adjust the amplifier Variable Volts/Div control for a display amplitude of 1.5 division.

i. Switch the 7L12 Trigger Mode to SINGLE SWP. Check that the sweep triggers after the RESET button is depressed, for both positions of the SLOPE selector.

j. Disconnect the Oscilloscope Calibrator signal to the Input of the vertical amplifier. Turn the 7L12 SLOPE control off center to either the + or - side. Check that the READY indicator lights when the RESET button is depressed to indicate that the trigger circuit is armed. Reconnect the Oscilloscope Calibrator signal. Note that the sweep is triggered as the SLOPE control is adjusted towards center and the READY indicator light goes out. Return the Variable Volts/Div control to its CAL detent position.

k. Remove the Calibrator signal to the vertical amplifier Input. Connect a 10X probe such as P6053A, on the Input connector of the amplifier.

l. Connect the probe tip to the junction of R1010 and A4 (Fig. 4-2). Switch the 7L12 Trigger MODE to NORM and SOURCE to LINE. Change the Vertical amplifier Volts/Div to 1 V. Check for approximately 2 V P-P line voltage at the junction. Disconnect and remove the probe tip from A4.



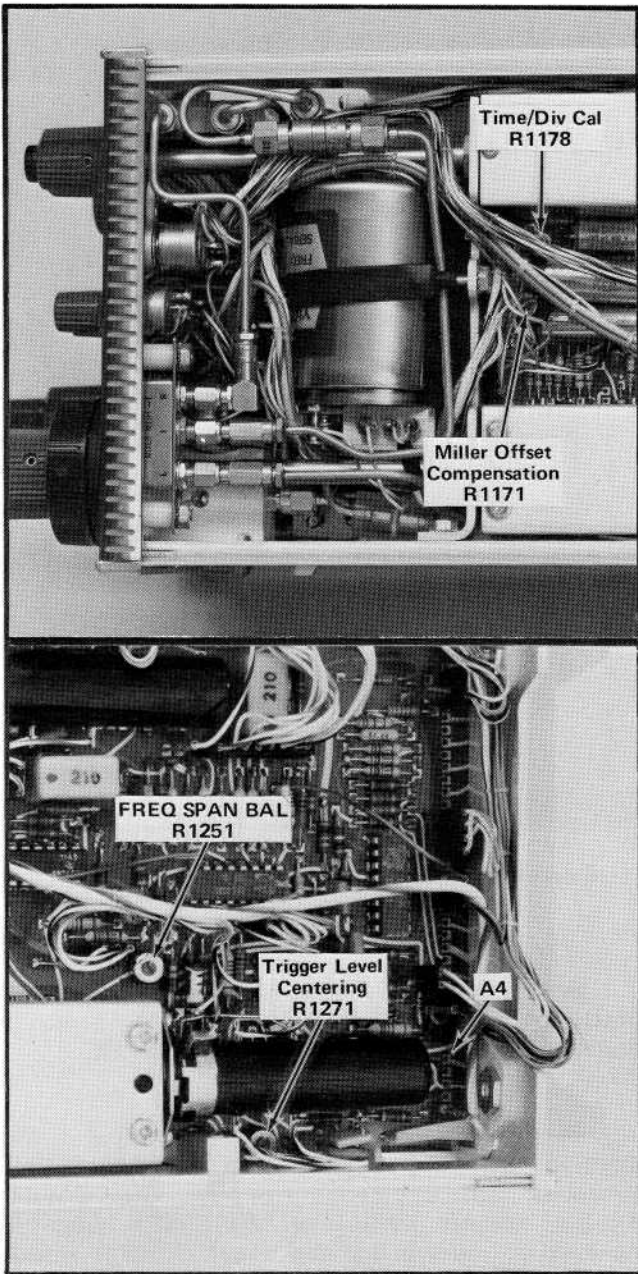


Fig. 4-2. Triggering and time base adjustments and test point.

## 2. Check and Adjust Sweep Timing

a. Apply the Marker Output from the time mark generator, through a  $50\ \Omega$  feedthrough termination, to the Input of the vertical amplifier unit. Switch the Input Coupling of the amplifier to DC.

b. Switch the 7L12 Triggering MODE to P-P AUTO and the SOURCE to INT. Ensure that the TIME/DIV is still a calibrated .1 ms/Div.

c. Apply .1 ms markers from the time mark generator and select a Volts/Div setting on the vertical amplifier unit that will produce a triggered display of .1 ms markers (about 0.5 V/Div).

d. Adjust the Time/Div Cal R1178 (Fig. 4-2) for 1 marker/division.

e. Change the 7L12 TIME/DIV to 1 ms and apply 1 ms markers.

f. Adjust the Miller Offset Compensation R1171 (Fig. 4-2) for 1 marker/division.

g. Change the marker output of the time mark generator to 5 ms markers. Check that the range of the TIME/DIV VARIABLE control is  $\geq 3X$ , by switching it out of its CAL detent and rotating it fully CCW. (At least 5 markers should be displayed within the 10 division display with the control fully CCW. Return the VARIABLE control to CAL detent.)

h. Check the timing accuracy of the remaining TIME/DIV steps. (Accuracy should be within 2% over the center 8 divisions of the display.)

i. Switch the TIME/DIV selector to the SPECTRUM position. Apply 1 s markers from the time mark generator.

j. Check the range of the VARIABLE TIME/DIV control. Range should have increased to 100X. The sweep speed should decrease to about 1 s/Div. Return the VARIABLE control to its CAL detent.

k. This completes the sweep adjustments. Switch the oscilloscope Vertical Mode to Right so the spectrum analyzer display can be observed.

m. With the 7L12 Trigger MODE in NORM, SOURCE in LINE, and the TIME/DIV at 5 ms, adjust the triggering LEVEL control and switch the SLOPE selector to both positions, checking that the sweep triggers on the line signal.

n. Change the Trigger SOURCE to FREE RUN and note that the sweep free runs for both positions of the SLOPE selector.

## FUNCTION IF ALIGNMENT

### Preliminary

Pull the harmonica (multipin) connector P560, to pins 1 and 2 on the Function IF circuit board (Fig. 4-3).

Set the following controls to the positions indicated.

RF Attenuator	0 dB
Gain Selector	Fully CCW
VARIABLE	CAL
Display Mode	LIN
TIME/DIV	SPECTRUM
VARIABLE	Pushed in to CAL detent
Triggering	
MODE	P-P AUTO
SOURCE	FREE RUN
FREQ SPAN/DIV	50 MHz
RESOLUTION	3M

### Oscilloscope

Vertical Mode	Right
Horizontal Mode	A (If applicable)

### 3. Adjust the Lin Mode Baseline Offset

a. Position the trace to the lower area of the graticule with the VERT POSition control.

b. Adjust the Lin Baseline Offset R803 (Fig. 4-3) clockwise from a fully CCW position to a point where the trace stops moving down. (Do not adjust past this point.)

c. Switch between LIN and LOG display modes, checking the baseline shift. Repeat the Offset adjustment if the baseline shifts.

### 4. Adjust the Gain Compensation and Reference Level

a. Switch the display mode to 2 dB/DIV and position the baseline of the display on the bottom graticule line if necessary.

b. Apply a 10 MHz  $-10$  dBm signal, from a calibrated signal source, through appropriate adapters (BNC female to SEAELECTRO female, SEAELECTRO male to male adapter, and SEAELECTRO female to harmonica connector) to P560 (Fig. 4-3). Note: Part numbers for these adapters are provided under Equipment Required List. If an accurate 10 dB, 50  $\Omega$  step attenuator is available, connect it in series with the signal source.

c. Adjust the 2 dB/Div Ref Level R801 (Fig. 4-3) so the trace is at the 5th graticule line down from the top.

d. Increase the signal input level 10 dB. Adjust the front panel LOG CAL for 5 division increase (trace is at the top graticule line).

e. Return the signal level to  $-10$  dBm. Repeat steps (c) and (d) until both the Reference Level and Logging circuits are calibrated.

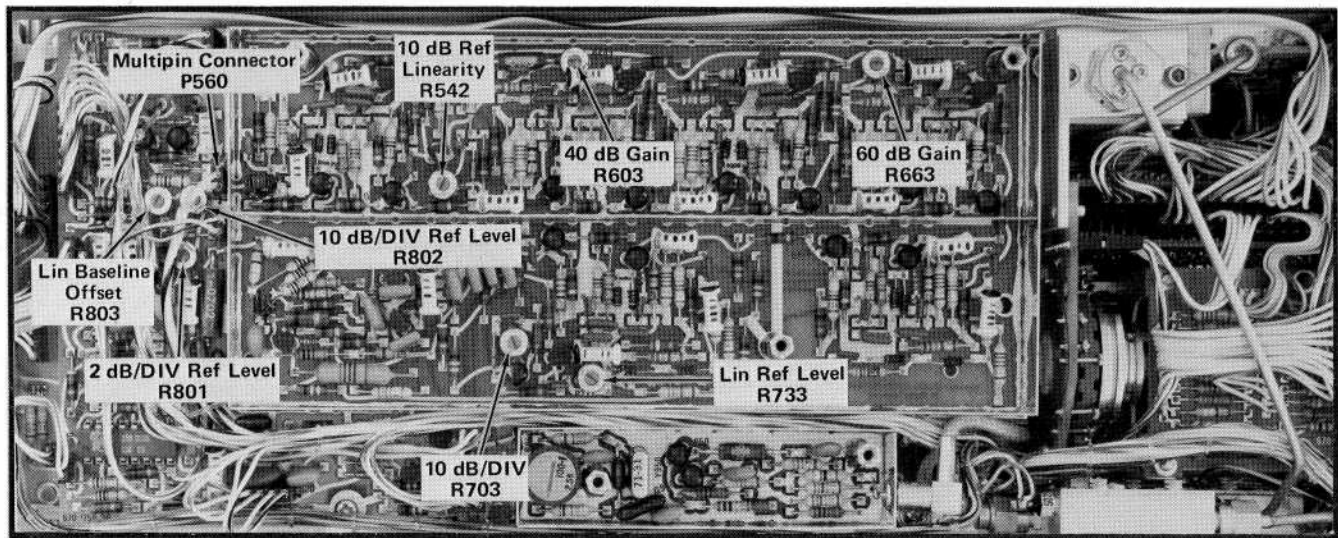


Fig. 4-3. Function IF calibration adjustments and test points.

**NOTE**

*Because of some mainframe drift it is advisable to periodically remove the signal and check that the display baseline returns to the bottom graticule line.*

f. Switch the display mode to LIN and the signal input level to 0 dBm.

g. Adjust Lin Ref Level R733 (Fig. 4-3) so the trace is at the top graticule line.

h. Switch the display mode to 10 dB/DIV. Decrease the signal input level until the trace is 3 divisions from the top graticule line.

i. Calibrate the center screen dynamic range to 20 dB (2 division) by adjusting 10 dB/Div R703 (Fig. 4-3) as the signal input level is changed 20 dB.

j. Set the signal input level to -40 dBm. Adjust 10 dB/Div Ref Level R802 (Fig. 4-3) so the trace is at graticule center.

k. Increase the signal level to 0 dBm then adjust the 10 dB Ref Linearity R542 (Fig. 4-3) so the trace is at the top graticule line.

l. Decrease the signal level in 10 dB steps, checking the display calibration for the 10 dB/DIV mode. Trace should shift down 1 division  $\pm 0.1$  division per each 10 dB step to a maximum of 1.5 dB over the 70 dB dynamic range. Repeat steps (h) through (k) until this accuracy is obtained.

m. Set the signal input level to -20 dBm and switch the display mode to 2 dB/DIV. If necessary adjust the trace to the bottom graticule line with the VERT POSition control.

n. Increase the Gain selector setting 50 dB for a REFERENCE LEVEL readout of -80 dBm.

o. Adjust the 40 dB Gain R603 (Fig. 4-3) so the trace is at the reference level or top of the graticule.

p. Decrease the signal level to -40 dBm. If necessary position the trace on the bottom graticule line with the VERT POS control.

q. Increase the Gain selector setting 20 dB for a REFERENCE LEVEL readout of -100 dBm.

r. Adjust the 60 dB Gain R663 (Fig. 4-3) so the trace is at the reference level.

s. Remove the signal from the input to the Function IF amplifier and replace the connector P560.

**PHASE LOCK CIRCUIT**

**Preliminary**

a. Plug a vertical amplifier unit into the Left compartment of the oscilloscope and connect a 10X probe to its Input. (A separate oscilloscope can be used if desired.)

b. Set the following front panel controls to their indicated positions:

**7L12**

TIME/DIV	SPECTRUM
START-CENTER	CENTER
FREQ SPAN/DIV	.1 MHz or less
RESOLUTION	3 kHz
AUTO PHASE LOCK	OFF
Display Mode	10 dB/DIV
FREQUENCY	Approximately 200 MHz or lower
REFERENCE LEVEL	0 dBm (Gain fully CCW)

**Oscilloscope**

Vert Mode	Chop
-----------	------

**Vertical Unit**

Volts/Div	.1
Input Coupling	DC

**5. Phase Lock Adjustments**

a. Remove the cover on the phase lock circuit. Turn the Loop Gain R1350 adjustment (Fig. 4-4) fully CW. Pull off the jumper, harmonica connector P1316, (between pin 6 of U1350 and C1362, Fig. 4-4).

b. Establish 0 V reference for the vertical amplifier display, by grounding the probe tip and position the trace to the center of the graticule. Connect the probe to C1355 at the junction with pin 6 of U1350 (see Fig. 4-4).

c. Adjust the DC Offset R51 (Fig. 4-5) of the error amplifier so the output of the compensating amplifier U1350 is 0 volt. Tune the Frequency of the 7L12 through

its range and note the DC shift. Adjust R51, if necessary so the DC shift averages about the 0 V level.

d. Replace the jumper connector P1316 (pulled in step a) and switch PHASE LOCK ON. Connect the probe tip to TP1370 and check for a sine wave with an amplitude of 100 mV or more and a period that is about 20 ms. (This indicates the compensating amplifier is searching or oscillating.)

e. Pull the harmonica connector for cable W69. Connect the probe tip to the center conductor of W69.

f. Check that the beat signal amplitude, over the frequency range of the 7L12 (Fig. 4-6), equals or exceeds 4 V P-P. (Beat signals will appear periodically as the oscillator sweeps the 1st LO through multiples of the 2.21 MHz reference oscillator.) Approach these beats slowly to make a good measurement.

If the amplitude is below 4 V P-P, it may be due to low output from either the 1st LO or the sampling driver for the reference oscillator.

g. Change the probe to TP1370 (Fig. 4-4). Replace the connector P1341 of W69 on its respective pins and change the vertical amplifier Volts/Div to 10 mV.

h. Slowly tune the FREQUENCY one direction then the other, noting which direction produces the least amount of trace deflection from graticule center.

i. Slowly tune the frequency towards the direction of least excursion, until it is approximately 210 mV (2.1 div from center or the 0 V reference).

j. Adjust the Loop Gain R1350 slowly CCW until the trace jumps towards center screen, indicating the circuit has locked.

k. Disconnect and remove the probe then replace the cover to the phase lock circuit.

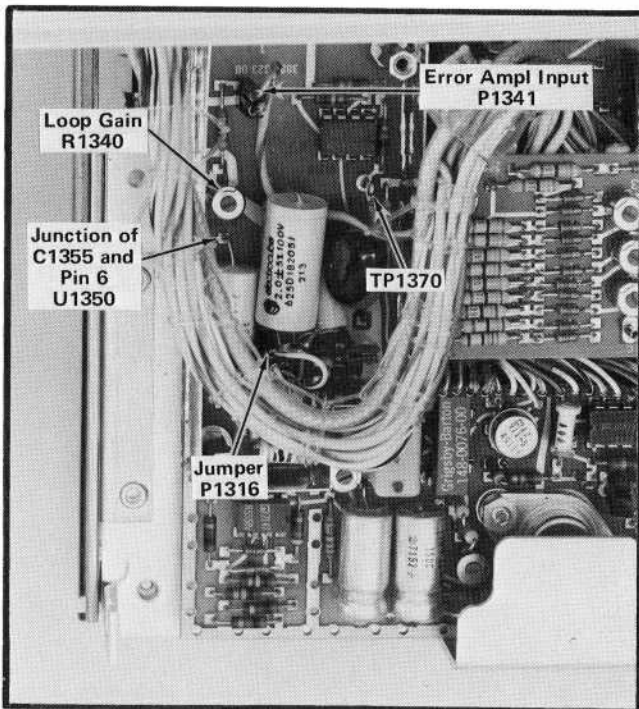


Fig. 4-4. Phase lock adjustments and TP.

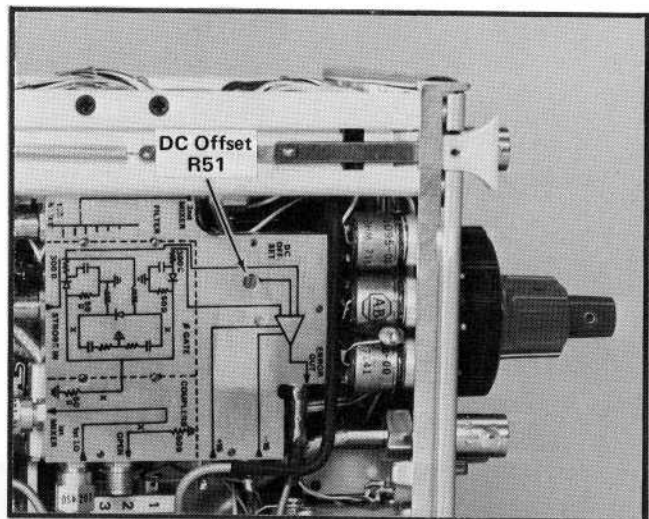


Fig. 4-5. Hybrid circuit module showing the location of the error amplifier balance adjustment.

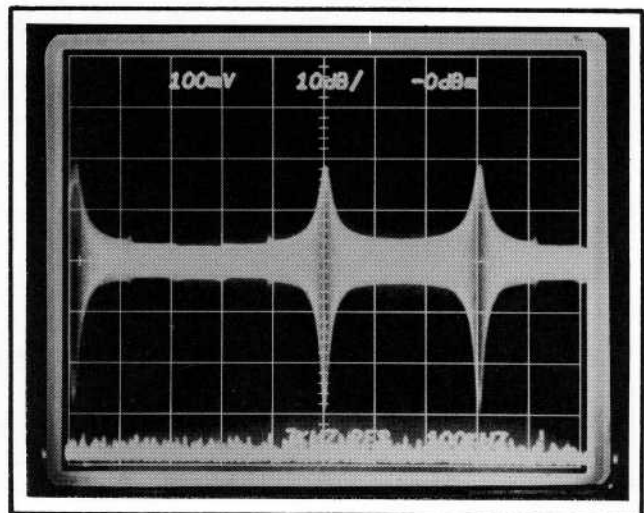


Fig. 4-6. Beat signals at the output of the error amplifier (W69).



## 2nd LO and Sweep Shaper Calibration

### Preliminary

Set the following front panel controls to the settings indicated.

#### 7L12

FREQ SPAN/DIV	.1 MHz
RESOLUTION	3 k
PHASE LOCK	ON
Display Mode	10 dB/DIV
RF Attenuator	10 dB
Gain CCW	
(REFERENCE LEVEL)	-20 dBm
START-CENTER	CENTER
FREQUENCY	50 MHz
Triggering	FREE RUN
TIME/DIV	SPECTRUM

#### Oscilloscope

Vert Mode                      Chop

#### Vertical Amplifier Unit

Volts/Div                      .5  
Input Coupling                DC

### 6. Adjust 2nd LO Sweep Range and Center Frequency

a. Establish a 0 V reference for the vertical amplifier display, by grounding the probe tip and position the trace to the graticule center. Now connect the 10X probe to pin 7 of P1315 on the phase lock board (Fig. 4-7).

b. Adjust Temp Comp R1778 (Fig. 4-7) for +13 V DC at pin 7 of P1315. (+ supply to the 2nd LO.)

c. Change the probe from pin 7 of P1315 to TP1754 (Fig. 4-7).

d. Preset R1701-R1702 (sweep shaper board) and R1637-R1598 (Fig. 4-7) fully CCW. Preset R1703 through R1711 (on the sweep shaper board) fully CW.

e. Apply 10 ns markers, modulated by 1  $\mu$ s and 10  $\mu$ s trigger signals in the Harmonic Modulator, to the RF INPUT.

f. Adjust the FINE frequency control to center the sweep shaper voltage ramp and the markers on screen (see Fig. 4-8). Note: The number of markers may not equal those displayed in the illustration and it may be necessary to adjust R1637 (Fig. 4-7) to shift the display so it is within the graticule area.

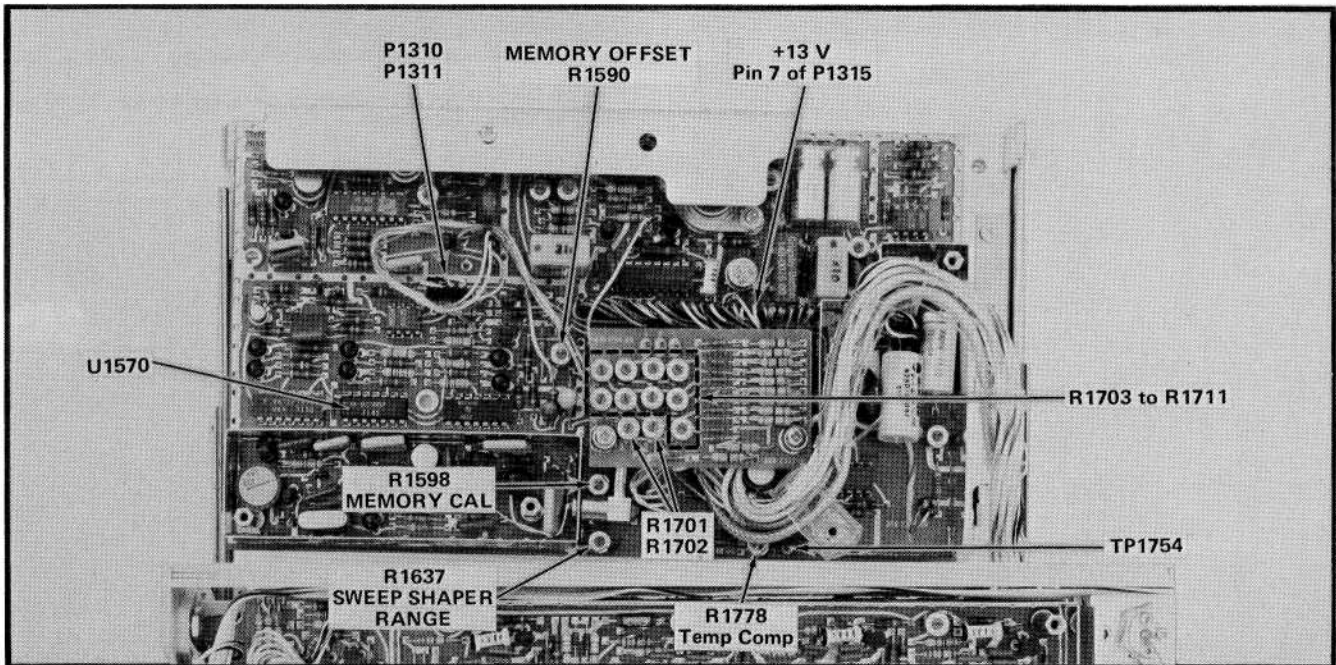


Fig. 4-7. 2nd LO and sweep shaper adjustments and test points.



g. If the 2nd LO is sweeping 6.5 MHz (6 to 7 major markers under the ramp, see Fig. 4-8) the Sweep Range of the 2nd LO requires no further adjustment. If the sweep range is incorrect, the Varactor assembly coupling (into the tuned cavity for the 2nd LO) must be changed. This is accomplished as follows:

- 1) Loosen the set screw on the Varactor assembly clamp (Fig. 4-9) with a 5/64 Allen wrench.
- 2) Adjust the 2nd LO Center Freq C71 (Fig. 4-9) to maximize the amplitude and number of markers under the ramp.
- 3) Turn the Varactor assembly coupling adjustment screw (Fig. 4-9) until the oscillator is sweeping 6.5 to 7 MHz. Readjust the center frequency as described in step 2), then tighten the Varactor assembly clamp.

**NOTE**

*This may require experimenting to find the optimum setting because of the interaction. At this time it is also a good idea to check the response of the 2.095 MHz filter and mixer assembly to see if they require adjustment. This can be done as follows:*

1) Switch the FREQ SPAN/DIV to 2 MHz, RESOLUTION to 30 kHz, and the Display Mode 2 dB/DIV.

2) Apply only 10 ns markers to the Input and tune one of the markers to the center of the screen with the COARSE tuning control.

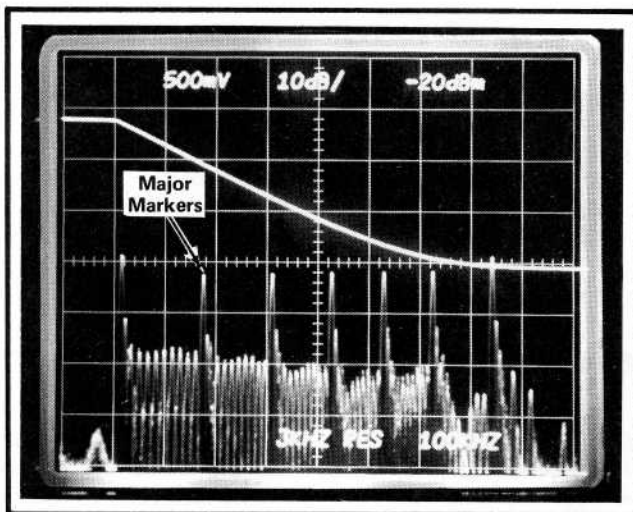


Fig. 4-8. Chop mode display, that illustrates; the sweep ramp to the sweep shaper circuit at TP1754 and the analyzer display of the frequency markers.

3) Tune the 2nd LO either side with adjustment C71, and note the response flatness of the filter. Response should remain flat (within 0.5 dB) to at least + or -5 MHz of center.

4) Return the center frequency of the cavity to the center of the graticule. If the filter or mixer need tuning refer to the replacement procedure in the Maintenance section.

**7. Adjust the Sweep Shaper (Fig. 4-7)**

**NOTE**

*These adjustments interact and may take time to obtain the best linearity over +3 MHz and -3 MHz range of the 2nd LO center frequency.*

a. Start the procedure by adjusting R1701 and R1702 to linearize the 1st few markers at the low voltage end of the ramp (right edge of the display, see Fig. 4-10). Do not be too concerned if the 1st few markers are not calibrated to 100 kHz/Div.

b. Adjust R1703 to open and calibrate the first portion of the sweep (see Fig. 4-10C) that follow the first few markers affected by adjustments R1701 and R1702. Now readjust R1701 and R1702 to linearize the 1st portion of the sweep as much as possible. (This portion of the adjustment procedure does not have to be precise.)

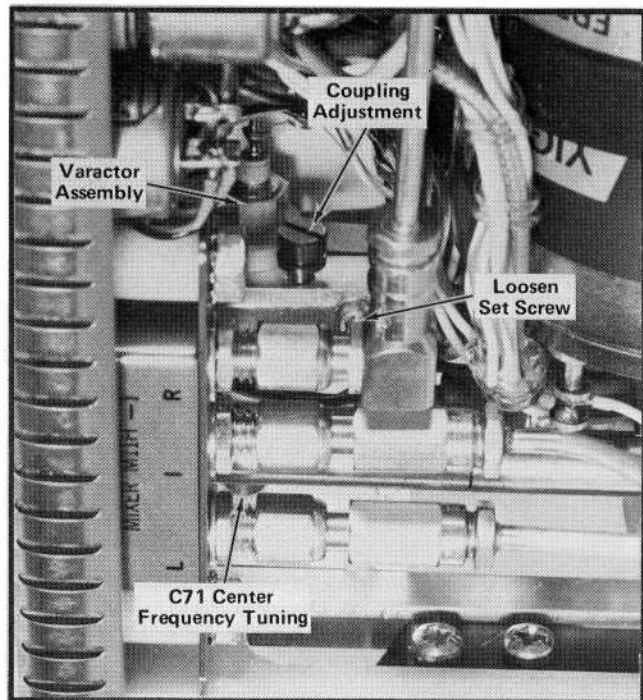
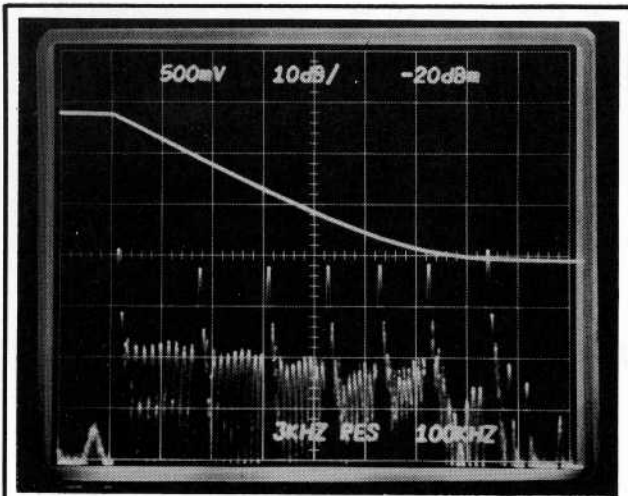
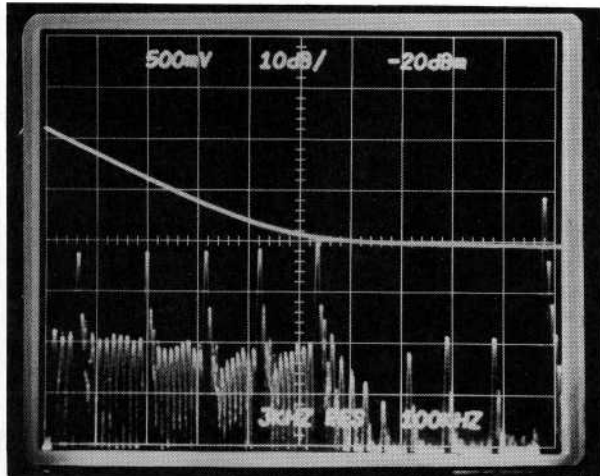


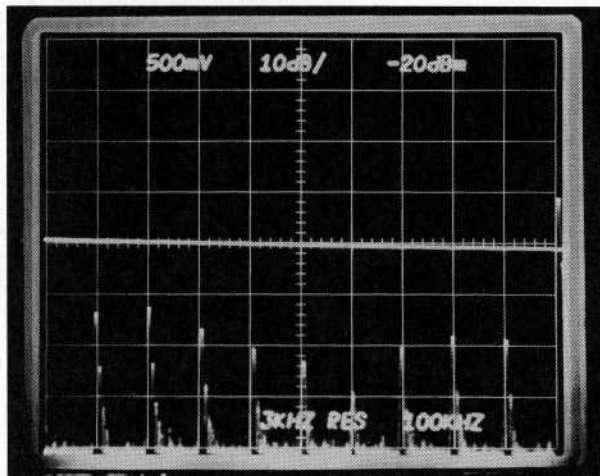
Fig. 4-9. Location of the 2nd LO adjustments.



(A) Sweep ramp collapsed. Note 6.5 MHz of sweep (six, 1 MHz markers) under the ramp.



(B) After R1701 and R1702 have been adjusted, to linearize the 1st portion of the sweep.



(C) Display after R1703 has been adjusted to calibrate and linearize the next portion of the sweep. Note: These three adjustments (C1701, C1702, C1703) all interact and require extra care when adjusting, before proceeding with the remaining adjustments.

Fig. 4-10. Series of pictures to illustrate the first few steps in adjusting the sweep shaper ramp to the 2nd LO.

c. Adjust R1704 through R1711 in numerical sequence, to calibrate the 6 MHz sweep span. Note that each adjustment affects a definite portion of the ramp. A slight readjustment of the preceding adjustment must be made after each sequential step. Use the FINE frequency controls and R1637-R1598 to move the sweep across the graticule as you progress towards the upper end of the sweep ramp. It may be necessary in some cases to pull U1560 to reach the upper end of the sweep. If U1560 is pulled, switch FREQ SPAN/DIV to .2 MHz then back to .1 MHz.

d. Replace U1560 and pull P1311 (Fig. 4-7).

e. Center the FINE frequency controls then adjust R1637 to center the sweep (starting at one end, move the center back about 3.3 MHz). Check that the FINE controls now adjust the 2nd LO through +1 MHz and -1 MHz either side of center frequency and ensure that this portion is linear and calibrated to 100 kHz/Div.

f. Check that the center FINE control, shifts the center frequency +0.1 MHz and -0.1 MHz.

g. Replace the jumper connector P1311. Disconnect and remove the 10X probe and the marker generator signals to the RF INput of the 7L12.

### Voltage Memory Circuit

#### Preliminary

Set the following front panel controls as indicated.

FREQ SPAN/DIV	100 MHz
RESOLUTION	30 kHz
TIME/DIV	SPECTRUM
Display Mode	2 dB/DIV
RF Attenuator	10 dB
REFERENCE LEVEL	-20 dBm
PHASE LOCK	ON
FINE (FREQUENCY)	Centered

#### 8. Adjust Voltage Memory

a. Apply a 400 MHz, -30 dBm signal, from the signal generator to the RF INput and tune the 7L12 Center FREQUENCY to center the applied signal on screen. Reduce the FREQ SPAN/DIV to .1 MHz and RESOLUTION bandwidth to 3 kHz keeping the signal centered on screen with the COARSE then FINE tuning controls. (FINE controls affect the tuning in the .1 MHz position.)

b. Remove the harmonica connector, for cable W69, from the phase lock search oscillator. Remove the jumpers P1311 and P1310 (Fig. 4-11) and connect one jumper between the center pins.

c. Adjust the Memory Cal R1598, for as stable a 400 MHz signal as possible then replace the harmonica connector for W69 on J1341 and the jumpers P1310, P1311 to their respective pins.

d. Switch the FREQ SPAN/DIV to .2 MHz and center the signal on screen with the COARSE FREQUENCY control.

e. Switch the FREQ SPAN between the .2 MHz/Div and .1 MHz/Div positions (no phase lock to phase lock mode) and note the signal offset. Adjust the Memory Offset R1590 (Fig. 4-11), with the FREQ SPAN/DIV, in the .2 MHz position, until the signal offset between no phase lock to phase lock mode is minimum.

f. Switch the PHASE LOCK OFF and the FREQ SPAN/DIV selector to the .1 MHz position. Slowly tune the COARSE FREQUENCY control to check that phase lock has been disabled. This is indicated by a smooth signal shift across the frequency span as the oscillator is tuned. If the oscillator was phase locked, the signal would jump from one locked position to the next.

### 9. Calibrating the 2nd Mixer and 2.095 GHz Filter

The 2nd mixer coupling into the filter cavity affects the response characteristics (bandpass) of the filter mixer assembly, the orientation affects the mixer balance. Mixer balance minimizes a 52.5 MHz spurious response signal.

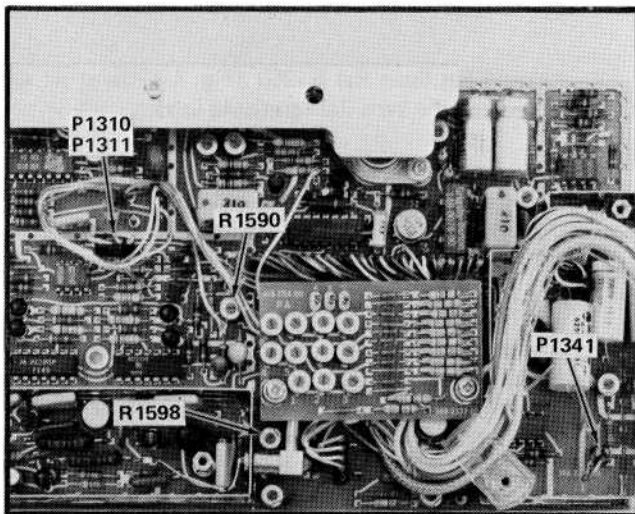


Fig. 4-11. Location of and connections required to calibrate the Voltage Memory circuit.

Since mixer orientation does not affect the bandpass of the two assemblies, the orientation can be adjusted without changing the coupling if you are careful.

A 105 MHz detector and a narrowband, high gain, differential amplifier plug-in unit are required as additional test equipment to adjust the coupling. These adjustments, are only required if either of the two assemblies have been replaced and are not part of the routine calibration adjustments. Replacement procedure plus adjustments are described in the Maintenance section of this manual.

### Frequency Span and Marker Calibration

#### NOTE

*The front panel SWP CAL adjustment must be set before doing this procedure. Approach all frequency check points from the low side.*

### 10. Adjust the 1st LO Power Supply Voltage and the Frequency Span of the Oscillator

a. Set the 1st LO floating power supply output voltage to 25 V DC by connecting a voltmeter between TP1532 and TP1534 and adjusting Voltage Set R1528 (Fig. 4-12). Disconnect the voltmeter after the voltage has been set.

b. Position the following front panel controls as indicated.

FREQUENCY SPAN/DIV (Coupled to RESOLUTION)	100 MHz
RESOLUTION	3 MHz
FREQUENCY	1800 MHz
FREQUENCY Readout	CENTER
FINE (Frequency Controls)	Centered
Display Mode	2 dB/DIV
RF Attenuator	10 dB
VIDEO FILTER	ON
Gain	-50 dBm REFER- ENCE LEVEL

c. Apply 2 ns (500 MHz) markers and the Trigger Output of the time mark generator, through the Harmonic Modulator, to the RF INput of the 7L12. Do not apply any trigger signal to the harmonic modulator. If necessary, adjust the Gain, to display the 1500 MHz marker (3rd 500 MHz marker) and the 10 ns markers. (The 10 ns markers will ride through with the 2 ns markers; however, their power level will be down approximately 10 dB from the 2 ns marker.)



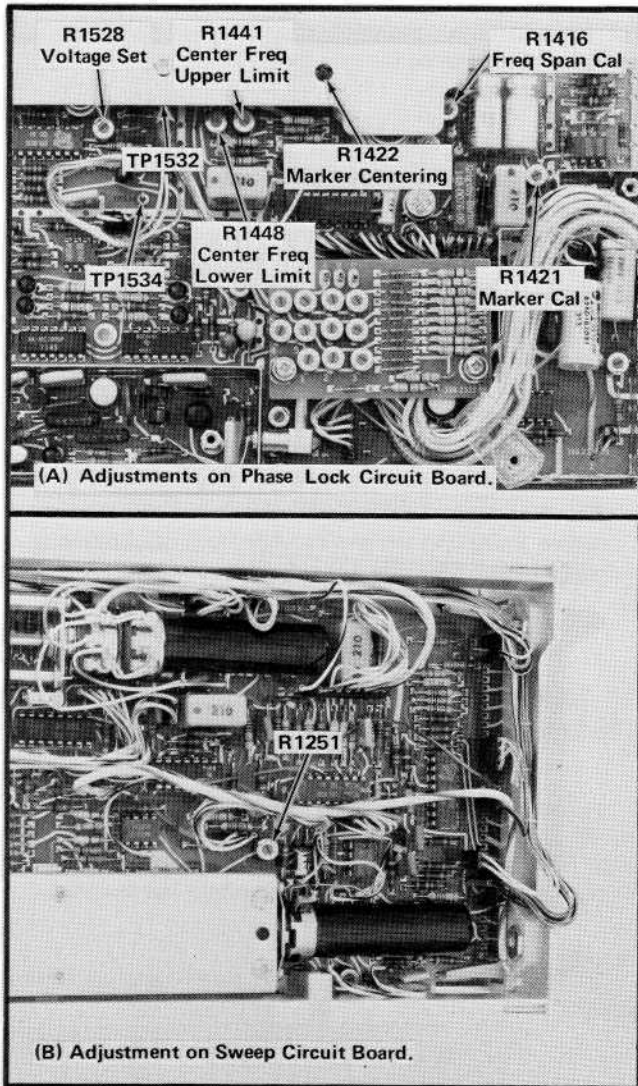


Fig. 4-12. Location of the adjustments for frequency span and marker (notch) calibration.

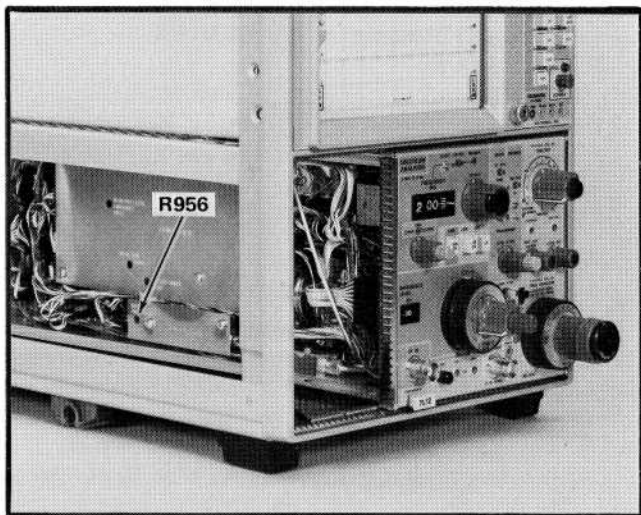


Fig. 4-13. Location of R956, calibrator output level adjustment.

d. Change the marker output of the time mark generator to 10 ns and locate the 1800 MHz marker. Adjust the Center Freq Upper Limit R1441 (Fig. 4-13) to center the 1800 MHz marker on the graticule. Decrease the FREQ SPAN/DIV to 2 MHz for the final adjustment of R1441. Note: Remember to approach the 1800 MHz FREQUENCY readout from the low side.

e. Return the FREQ SPAN/DIV to 100 MHz position and remove the time mark generator marker signals to the RF INPUT.

f. Tune the center FREQUENCY to 0000.

g. Adjust the Center Freq Lower Limit R1448 (Fig. 4-12A) to center the 0 Hz response in the graticule. (Reduce the FREQ SPAN/DIV to 2 MHz for the final adjustment.) Ensure that the FREQUENCY readout CENTER button is depressed.

h. Return the FREQ SPAN/DIV to 100 MHz and tune the center FREQUENCY to approximately 1000 MHz. Re-apply 10 ns markers through the Harmonic Modulator to the RF INPUT.

i. Adjust the Freq Span Cal R1416 (Fig. 4-12) for 1 marker/Div.

### 11. Calibrate MAX SPAN Marker

a. Switch the FREQ SPAN/DIV to MAX position. Remove the time marker signals to the 7L12 RF INPUT so the 0 Hz response is easily recognized. Tune the center FREQUENCY to 900 MHz.

b. Adjust Freq Span Bal R1251 (Fig. 4-12B) to set the 0 Hz response on the zero (left graticule line).

c. Center the marker (notch) under the graticule center line (900 MHz dial setting) with Marker Centering R1422 (Fig. 4-12A).

d. Change the center FREQUENCY readout to 1800 MHz. Re-apply the 2 ns markers, from the time mark generator, and note the location of the 1500 MHz marker. Change to 10 ns markers and adjust the Gain, if necessary, until the 1800 MHz marker is visible.

e. Center the marker (notch) under the 1800 MHz signal by adjusting Marker Cal R1421 (Fig. 4-12A).

This completes the center frequency and marker calibration.

### 50 MHz Calibrator

#### 12. Adjust the Calibrator Output (−30 dBm ±0.3 dB)

Since the output of the 7L12 Calibrator contains harmonics, direct power measurement is not possible. The following are suggested methods and procedures:

##### a. Vector Voltmeter Method (Hewlett Packard Model 8405A Vector Voltmeter)

1) Terminate the "A" probe, with a BNC 50 Ω feedthrough termination and connect the probe through the termination, to the CAL OUT connector on the 7L12.

2) Switch the Vector Voltmeter frequency to 50 MHz.

3) Check that the RMS reading is between 6.85 mV to 7.3 mV (−30 dBm is 7.07 mV RMS, into 50 Ω).

4) The calibrator output level can be adjusted by removing the left vertical plug-in unit and the oscilloscope left side panel to gain access to the 7L12 calibrator. Adjust R956 (Fig. 4-13) for an output level of −30 dBm (7.07 mV RMS).

##### b. Using a Power Meter (within 0.1 dB) and 50 MHz Low Pass Filter, with 40 dB or more rolloff at 100 MHz: (General Microwave Power Meter Model 454A, or Hewlett Packard Model 432A Power Meter).

#### NOTE

*The insertion loss of the filter, must be accounted for to an accuracy of 0.1 dB.*

1) Connect the power meter through the filter to the CAL OUT connector and measure the output level.

2) If necessary adjust the 7L12 calibrator output as described in method 1).

##### c. Accurate −30 dBm Signal Source (Signal substitution method).

#### NOTE

*The power meters that were recommended for the preceding method, can be used to verify the signal source output level.*

1) Set the FREQ SPAN/DIV to .5 MHz and the RESOLUTION to .3 MHz. Switch the RF attenuator to 10 dB and the Gain selector fully CCW. Push the 2 dB/DIV LOG display button.

2) Apply a calibrated −30 dBm 50 MHz signal to the RF INput of the 7L12 and tune the signal to the graticule center. Adjust the VARIABLE Gain control to position the top of the signal to a reference line (2nd or 3rd from the top).

3) Disconnect the −30 dBm reference signal, then apply the 7L12 CAL OUT signal to the RF INput connector.

4) Adjust the output of the 7L12 Calibrator, with R956 for −30 dBm.

### RESOLUTION

#### 13. Adjust the Bandpass of the 105 MHz IF Amplifier and 300 kHz Filter

a. Set the following front panel selectors to the positions indicated.

FREQUENCY	400 MHz
FREQ SPAN/DIV	1 MHz
RESOLUTION	30 kHz (Uncoupled from the FREQ SPAN/DIV selector)
Display Mode	2 dB/DIV
Phase Lock	On

b. Apply either a 400 MHz signal from a signal generator, or the 50 MHz CAL OUT signal from the 7L12 calibrator to the RF INput. Adjust the generator output or the Gain of the 7L12 until the 400 MHz signal is displayed on screen. Center the FINE tuning controls then tune the signal to the graticule center with the COARSE frequency tuning control.



**Calibration—7L12**

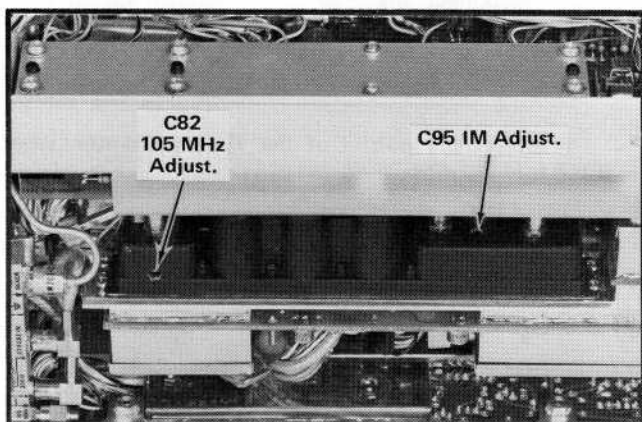
c. Change the RESOLUTION to 3 MHz and establish a signal amplitude of approximately 7 divisions with the generator output or the 7L12 VARIABLE Gain control.

d. Adjust the 105 MHz IF amplifier, and the wide filter bandpass characteristics; with C82, the 3 MHz helical resonator, (Fig. 4-14) and C456, in the filter circuit (Fig. 4-15) for a response that is similar to the illustrated in Fig. 4-17.

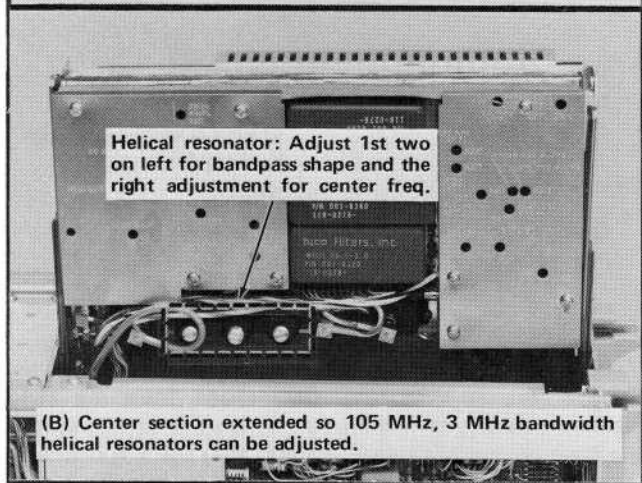
**NOTE**

*Keep the signal centered as the tuning adjustments are made. Switch back to 30 kHz or 3 kHz RESOLUTION periodically, to ensure that the signal is tuned to the graticule center. (This locates the center of the 10 MHz IF.) There is no recommended sequence of adjustments; however, the following is applicable for most instruments:*

1) Adjust C82 so the response moves slightly to the left of center or the low frequency side of the display.



(A) Input 105 MHz IF Adjustment and IM Adjustment C95.



(B) Center section extended so 105 MHz, 3 MHz bandwidth helical resonators can be adjusted.

**Fig. 4-14.** 105 MHz IF and 3 MHz bandwidth adjustments.

2) Adjust the input and center resonators to shape the display and the output resonator to keep the response centered.

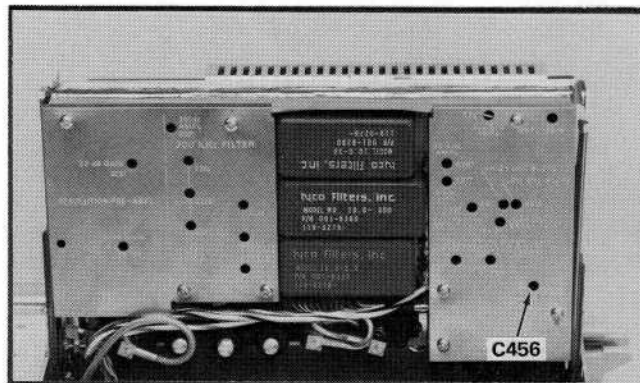
3) Adjust C456 (Fig. 4-15) for maximum bandwidth and amplitude.

Bandpass at the  $-6$  dB down point should equal 3 MHz  $\pm 10\%$ ; however, the specification is within 20% of the resolution bandwidth selected. The response flatness can vary as much as 2 dB. Fig. 4-16 illustrates this variation with dashed lines. The shape should resemble that of the illustration.

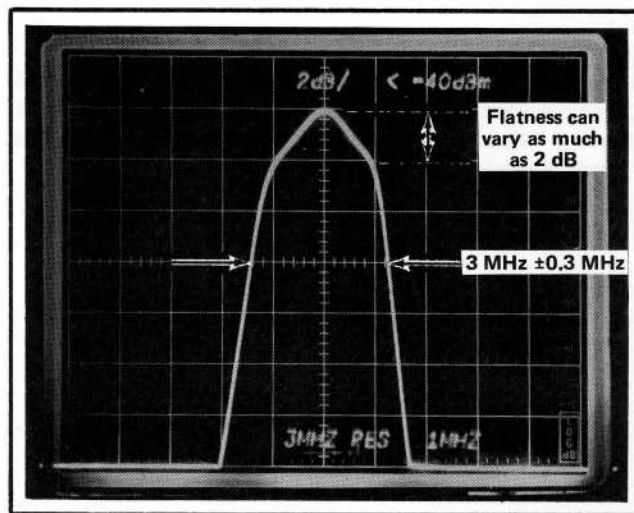
e. Set the FREQ SPAN/DIV to .1 MHz and the RESOLUTION to 30 kHz. Carefully center the signal with the FINE tuning controls.

**NOTE**

*It is important to calibrate in the phase lock mode.*



**Fig. 4-15.** Wide band filter adjust C456.



**Fig. 4-16.** Typical response characteristics for the 105 MHz and wide filter.

Remove the shield cover over the post resolution amplifier. Remove P304 (jumper for relay K357 see Fig. 4-17A). Remove P301 and P303 of cables W307 and W356. Connect P301 of cable W307 to J303. Ensure that the signal lead of P303 is connected to pin 1 of J303.

f. Change the RESOLUTION to 3 MHz. Adjust the narrow filter circuits with C472 and C475 (Fig. 4-17A) for a flat topped response that is similar to the illustration of Fig. 4-17B. NOTE: Keep the response centered as these adjustments are made. Do not change the front panel tuning controls or the frequency of the signal generator. Bandpass, at the 6 dB down point, should equal 500 kHz to 600 kHz.

g. Reconnect, the plugs for cables W307 and W356, to their respective pins and replace the jumper plug for relay K357.

h. Switch the RESOLUTION to 30 kHz FREQ SPAN/DIV at 100 kHz. Ensure that the signal is still centered on screen and if necessary tune to center with the FINE FREQUENCY controls then switch the RESOLUTION to 300 kHz.

i. Adjust the 300 kHz filter, with C322 through C348 (Fig. 4-18A), for a response that is similar to that shown in Fig. 4-18B.

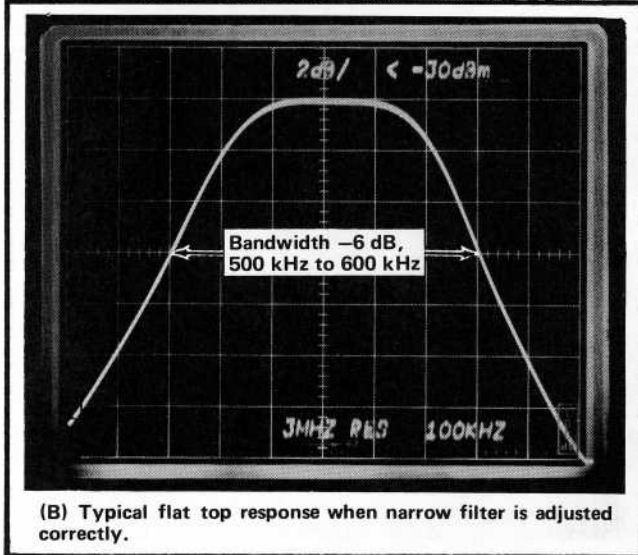
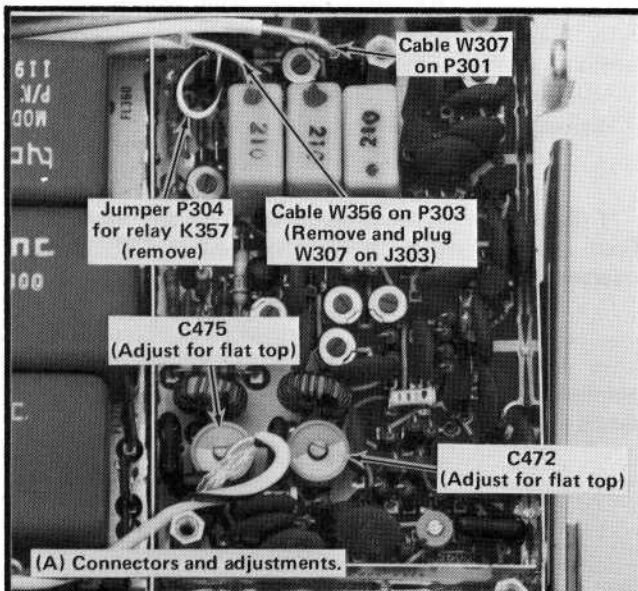


Fig. 4-17. Connections, adjustments, and typical response when adjusting the narrow post amplifier filter.

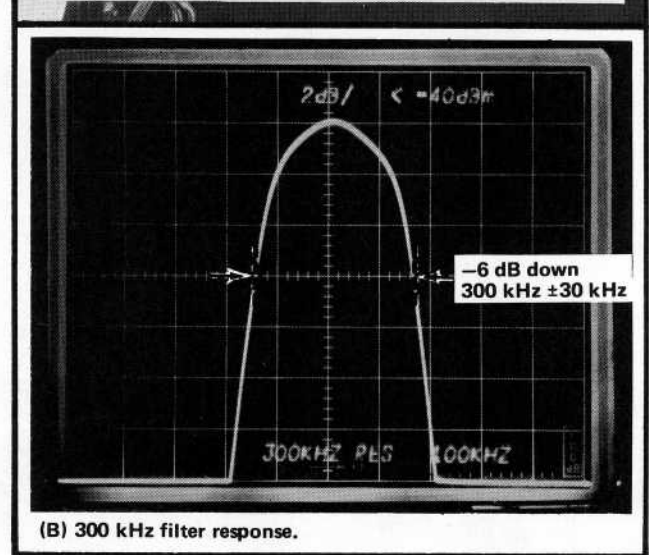
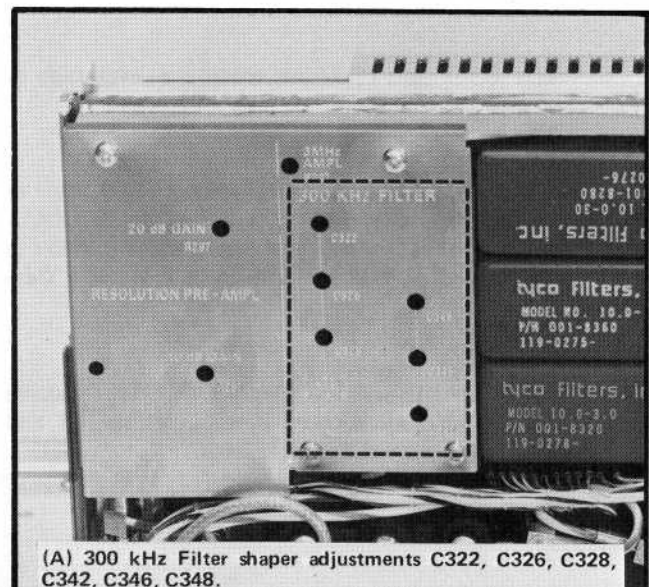


Fig. 4-18. 300 kHz filter adjustments and typical response characteristic.

NOTE: If the response is similar to the illustration of Fig. 4-18B, try tweaking each capacitor a slight amount. If the response is not centered or is asymmetrical, adjust the capacitors to center and peak the amplitude of the response, then adjust each filter until the response is symmetrical and 300 kHz  $\pm$ 10% wide. (The input and output resonators usually affect the centering and bandwidth of the display and the center resonators the display slope.)

### 14. Adjust the Resolution Gain Leveling Compensation

a. With the signal phase locked, reduce the FREQ SPAN/DIV to 10 kHz and switch the RESOLUTION to 30 kHz. Center the signal on screen with the VARIABLE tuning control and set the signal amplitude to approximately 7 division with the VARIABLE Gain control.

b. Preset R367 and R377 for maximum amplitude at 3 kHz and 30 kHz resolution.

c. Switch the RESOLUTION between 30 kHz at 10 kHz/Div and 3 kHz at 1 kHz/Div. Select the RESOLUTION setting with the lowest signal amplitude and adjust to a reference level of 7 divisions with the VARIABLE Gain control.

d. Compensate the gain for each RESOLUTION setting with the amplitude adjustments listed in Table 4-1 and

illustrated in Fig. 4-19A so the signal amplitude remains constant through all resolution settings. NOTE: Decrease the sweep speed to maximize the signal amplitude for the 300 Hz RESOLUTION setting.

TABLE 4-1

RESOLUTION	FREQUENCY SPAN/DIV	ADJUST
3 MHz	1 MHz	R307 (3 MHz Ampl)
.3 MHz	.1 MHz	R357 (300 kHz Ampl)
30 kHz	10 kHz	R367 (30 kHz Ampl)
3 kHz	1 kHz	R377 (3 kHz Ampl)
300 Hz	.5 kHz	R387 (300 Hz Ampl)

e. Change the FREQ SPAN/DIV to 1 MHz, RESOLUTION to 3 MHz, RF Attenuator to 0 dB, and Gain selector fully CCW. Position the baseline of the display on the bottom graticule line, then adjust the Gain selector and VARIABLE Gain control for a signal reference level of 7 divisions.

f. Switch the RF Attenuator to 10 dB and increase the Gain selector setting 10 dB (one position CW from the reference setting).

g. Adjust the 10 dB gain R267 (Fig. 4-19B) so the signal amplitude equals the 7 division reference amplitude established in step (e).

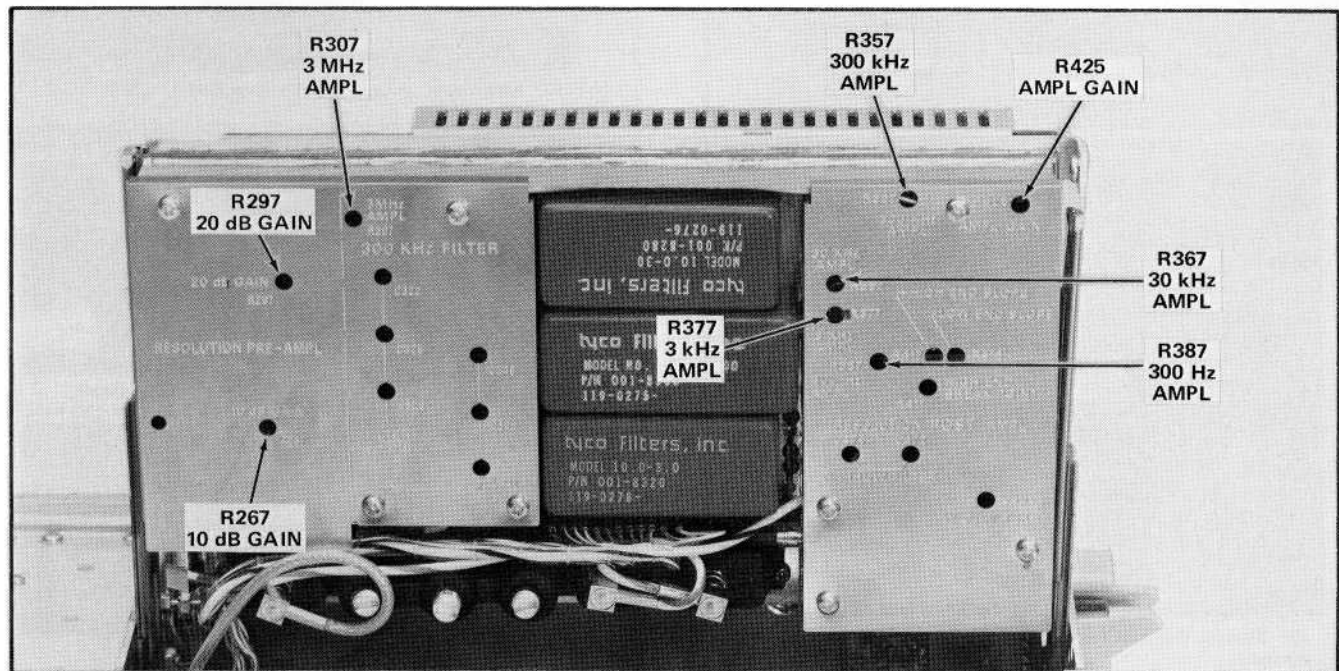


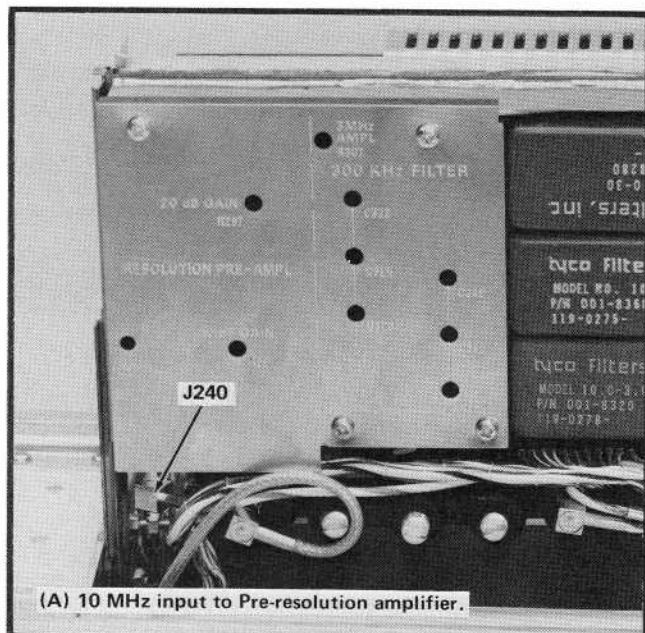
Fig. 4-19. Resolution gain compensating adjustments.



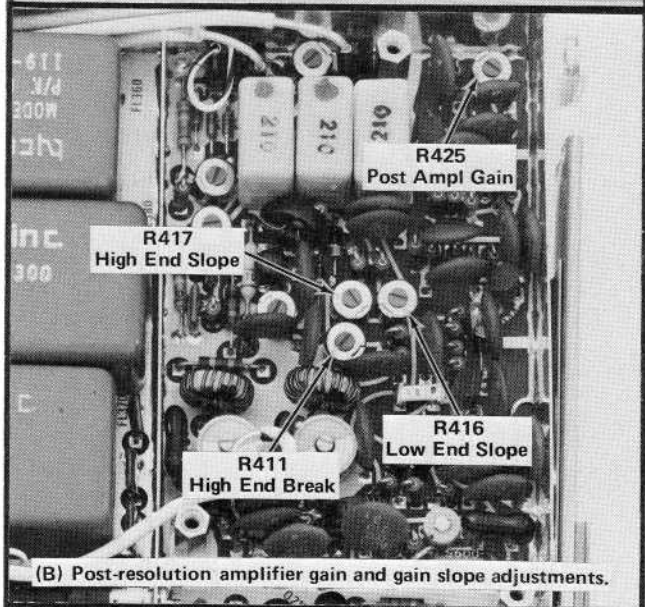
h. Increase the RF Attenuator setting to 20 dB and the Gain selector an additional 10 dB.

i. Adjust the 20 dB Gain R297 (Fig. 4-19B) so the signal amplitude is again 7 divisions.

j. Switch the RF Attenuator to 30 dB and increase the Gain selector 10 dB. Check that the signal amplitude equals 7 divisions  $\pm 0.5$  div. NOTE: Since there is no adjustment for 30 dB gain, it may be necessary to compromise between the 10 dB gain adjustment and the 20 dB gain adjustment.



(A) 10 MHz input to Pre-resolution amplifier.



(B) Post-resolution amplifier gain and gain slope adjustments.

Fig. 4-20. Adjustments for the gain slope.

### 15. Preliminary Adjustment of the Gain Slope for the Resolution Amplifier

a. Set the FREQ SPAN/DIV to MAX, RESOLUTION to .3 MHz, RF Attenuator to 0 dB, Gain selector fully CCW and the VARIABLE Gain control in its CAL detent so the REFERENCE LEVEL readout is  $-30$  dBm.

b. Apply a 10 MHz,  $\approx -35$  dBm signal to J240 (input to resolution pre-amplifier) see Fig. 4-20A.

c. Switch the Display Mode to 2 dB/DIV and adjust the signal generator output so the low frequency side of the display (left edge) crosses a reference graticule line (3 divisions from the top).

d. Adjust the High End Slope, R417, High End Break Point, R411, and the Low End Slope, R416, (Fig. 4-20B) for a gradual slope to the display as illustrated in Fig. 4-21. NOTE: This is an approximate adjustment, check the flatness response as per the procedure described in the Performance Check section, noting those portions of the span that need correcting; then, adjust that portion of the gain slope to establish a flat gain across the 1.8 GHz frequency span.

### 16. Adjust the Post Resolution Amplifier Gain

This adjustment sets the gain of the post resolution amplifier so an input signal level of  $-15$  dBm will provide full screen deflection.

a. Switch the FREQ SPAN/DIV to .1 MHz and the RESOLUTION to .3 MHz.

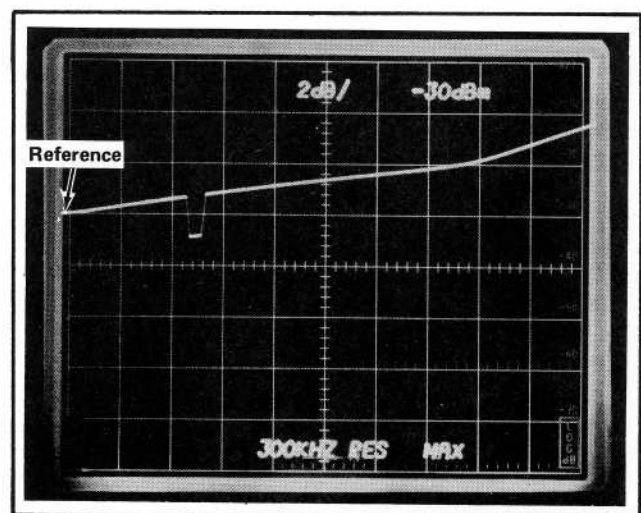


Fig. 4-21. Typical gain compensating slope. Final slope depends on flatness of the analyzer. Adjust after flatness has been checked (Gain at 1.8 GHz  $\approx 4$  dB, breakpoint  $\approx 2$  dB at 1.6 GHz).

## Calibration—7L12

b. Pull P303 of W356 and apply a 10 MHz,  $-15$  dBm signal, from the signal generator to pin 1 of J303, using appropriate adapters. Tune the generator frequency around 10 MHz to maximize the trace deflection.

c. Adjust the Post Resolution Ampl Gain R425 (Fig. 4-20B) for a display level of 8 divisions (full screen).

d. Replace P303 of W356 on J303 and the shield cover for the post resolution amplifier section.

## 17. Minimize Intermodulation Products

a. Set the following front panel controls as indicated:

FREQ SPAN/DIV	.5 MHz
RESOLUTION	30 kHz
Display Mode	10 dB/DIV
RF Attenuator	0 dB
Gain	Fully CCW
REFERENCE LEVEL	$-30$ dBm

b. Apply two signals separated by 1 MHz, from two  $50 \Omega$  signal generators, through 10X attenuators (for isolation) then through a BNC 'T' connector to the RF INput. (Fig. 3-8, in the Performance Section illustrates the equipment setup.)

c. Tune the 7L12 FREQUENCY to the center of the two signals and adjust the output of the generators so the amplitude of both signals is at least full screen, or until sidebands can be observed on the display.

d. Adjust IM Adj C95 (Fig. 4-22) to minimize the amplitude of the sidebands.

e. Remove the signal generator hookup to the 7L12 RF INput.

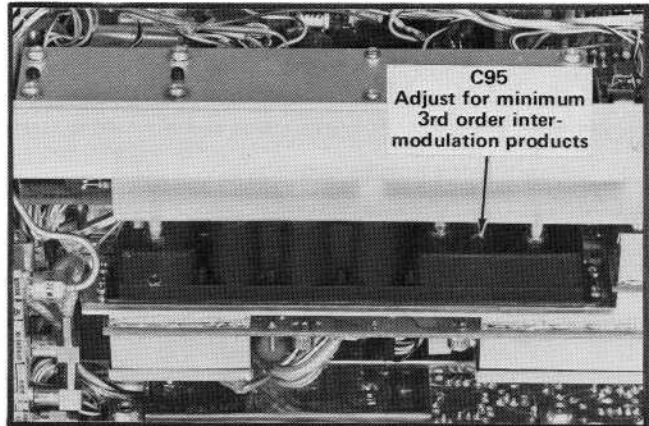


Fig. 4-22. Location of C95 (I.M. Adj) in 3rd mixer assembly.

This completes the calibration of the 7L12. The Performance Check will verify that all calibration adjustments have returned the instrument to Specifications.



# CIRCUIT DESCRIPTION

This section describes the functions of the major circuits in the 7L12 and their relationship to other circuits in the overall operation of the 7L12. The description is general, and intended as an aid for the technician or operator so he may better service or operate the instrument. A detailed description of circuit concepts, that are common to spectrum analyzers, are described in TEKTRONIX Concept booklet "Spectrum Analyzer Circuits", Part No. 062-1055-00.

This section begins with a functional block diagram description. This is followed by more detailed analysis of major circuits. Positive logic is used to describe logic operation. A block diagram at the front of the schematics, and the schematic diagrams include pertinent waveform and voltage data which should aid in troubleshooting and understanding the operation of the circuits. These waveforms and voltages are not absolute but are intended to help understand the signal flow and general operational function of each major circuit.

## Block Diagram

### Signal Path

The 7L12 is a swept front end spectrum analyzer that covers the frequency span from 0 to 1.8 GHz. As previously written, a detailed block diagram in the Diagrams section, illustrates signal paths and the function of each major circuit. Refer to this diagram as you read the following description.

Signals applied to the RF INput, can be attenuated from 0 dB to 60 dB by an accurate 10 dB step attenuator. From the attenuator, the signals pass through a 1.8 GHz low pass filter which attenuates frequencies above 2.1 GHz 50 dB or more. This prevents these higher frequencies from generating spurious responses in the 1st mixer.

Good balance is important in the 1st mixer if unwanted spurious signals are to be rejected. To maintain balance, the input and output of the balanced mixer is isolated from reflections or impedance changes down the line. A 3 dB pad isolates the input of the mixer from the output of the low pass filter and a traveling wave damper isolates the output of the mixer from reflections caused by mismatch impedance through the 2nd IF filter. Rejection of spurious signals with reference to the RF INput that are above 2.1 GHz are down at least 70 dB.

Signals within the 1.8 GHz span are converted to 2.095 GHz IF when they are mixed, in a balanced mixer, with the swept frequency from the 1st LO. The 1st LO (local oscillator) is tuned and swept over any portion of the frequency range, from 2.095 GHz to 3.9 GHz. Below frequency spans of 100 kHz/Div the 1st LO is not swept in frequency but is normally phase locked to a stable reference oscillator. The 2nd LO becomes the swept oscillator. Phase lock operation is described later.

The 2.095 GHz IF signal from the 1st mixer, is transmitted through the traveling wave damper (or filter), a 2.2 GHz low pass filter, and a 2.095 GHz bandpass filter (with a bandpass of 10 MHz) to the 2nd mixer. As previously stated, the traveling wave filter acts as a directional coupler to provide optimum transfer of the 2.095 GHz IF and terminates other frequencies. This improves the sensitivity of the mixer and eliminates the need for attenuators or pads between the two mixers.

The 2.095 GHz IF, with a bandpass of 10 MHz, is converted to 105 MHz IF, in the 2nd mixer by mixing 2.095 GHz with 2.2 GHz from the 2nd LO. In the 105 MHz IF, the signals are amplified and then the IF bandwidth is reduced to 3 MHz by three helical resonators in cascade.

The 2nd LO is the swept oscillator when the frequency span is 100 kHz/Div or less. The frequency span for the 2nd LO is 1 MHz or less. Its frequency can be tuned + or -1 MHz either side of center by the front panel FINE tuning controls.

The 105 MHz IF with the 3 MHz bandwidth, is next converted to 10 MHz by mixing 105 MHz with a crystal controlled 95 MHz 3rd local oscillator.

The 10 MHz output, from the 3rd mixer, is amplified in selectable 10 dB gain steps, then switched around or through bandpass resolution filters. Resolution selections provide bandwidths, in decade steps, from 3 MHz to 300 Hz. Signals within this 10 MHz IF, with a bandwidth determined by the Resolution selected, are amplified by a post resolution amplifier that provides both a variable gain control and compensating gain slope to offset the increased loss in sensitivity, through the microwave circuits, at the higher frequencies. The degree of gain slope, is adjustable and controlled by the sweep voltage that controls or sweeps the 1st LO. As the frequency increases, the gain of the amplifier increases to maintain a flat response across the 1.8 GHz span.

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Signals within the bandpass of the 10 MHz IF are then processed through the Function IF amplifier. This amplifier in conjunction with the pre-resolution amplifier, provides 10 dB selections in gain, from 0 to 70 dB and a linear or logarithmic display. Two log displays, 2 dB/Div and 10 dB selections in gain from 0 to 70 dB and a linear or sate for the gain variation as the resolution bandwidth and display modes are changed. The reference amplitude for each display mode remains constant for all combinations of RESOLUTION and Display mode. From the Function IF, signals are demodulated by a linear detector, amplified by a video amplifier, summed with voltage levels for vertical positioning and applied through push-pull amplifiers to the interface terminals of the oscilloscope mainframe.

Three auxilliary circuits can be switched into the video signal path. These circuits provide; video filtering of high frequency components such as noise, pulsed video signal processing, to stretch the fall time and enhance the brightness of pulsed spectra, and baseline suppression so waveform information can be photographed without flair (excessive illumination) from a bright baseline.

The marker or ditch that is displayed in the MAX SPAN position of the FREQ SPAN/DIV selector, is generated by a marker generator. This marker position is relative to the setting of the COARSE CF control and indicates to the operator that portion of the 1.8 GHz display that will be displayed at lesser frequency spans. The marker is injected into the video at a summing amplifier that drives the vertical output amplifier stage.

This completes the signal path of input signals. The remaining blocks or circuits are relative to frequency span, phase lock, frequency tuning, and the 50 MHz -30 dBm calibrator.

### Phase Lock or Frequency Stabilization

The 1st LO for the 7L12 is a yttrium-iron-garnett (YIG) tuned transistor oscillator. YIG is a material which changes its resonant frequency when subjected to a varying magnetic field. The intensity of the magnetic field is controlled by current through a tuning coil. When the oscillator is swept (MAX span to .2 MHz/Div) a current ramp from the YIG coil driver drives the tuning coil.

At frequency spans 0.1 MHz/Div and less, the 1st LO is normally automatically locked in phase to some multiple of a 2.21 MHz reference oscillator. The circuits that stabilize the 1st LO, for these narrow frequency spans, maintain incidental FM at less than 200 Hz P-P. This permits effective use of resolution bandwidths as narrow as 300 Hz. Phase lock is automatic, unless the front panel PHASE LOCK switch is in its OFF position.

When automatic phase lock is enabled, the current ramp to the tuning coil is removed and replaced by a constant current. A sinusoidal current is applied, as a search signal, to the FM coil in the YIG oscillator. This sweeps the resonator approximately 1.15 MHz about its center frequency until a lock point is found. After phase lock, the 1st LO frequency remains constant or locked in phase to some multiple of the reference oscillator.

As previously stated phase lock operation involves the comparison of the 1st LO oscillator to a reference oscillator via a phase detector. The output of the detector is a voltage that is proportional to the phase differential between the two oscillators. This voltage is amplified, filtered, and fed back in a manner to lock the oscillator to the reference and maintain a constant phase difference. It is important to note that while a phase difference exists, there is no frequency error. When locked, the long term frequency stability of the locked oscillator is that of some Nth multiple of the reference oscillator.

In the 7L12, the reference oscillator drives a pulse generator which generates relatively narrow (about 100 ps) output pulses. These pulses gate a sampler, which allow a portion of the locked oscillator waveform to pass through. Since the locked oscillator frequency is 1000 to 2000 times the reference oscillator frequency, output samples are produced at discrete multiples of the reference. These samples are integrated and develop the voltage that is fed back to control or lock the 1st LO.

The phase detector operation can be described by considering what happens when a step voltage is applied to one port of a directional coupler, as illustrated in Fig. 5-1. If port 1 receives the step voltage, port 2 has no output, port 3 has a rectangular pulse output and port 4 has the remaining energy.

A narrow rectangular pulse from the sampler driver, at the reference oscillator period, and the output of the 1st LO are applied through the directional coupler to a diode detector. The detector charges to the voltage of the

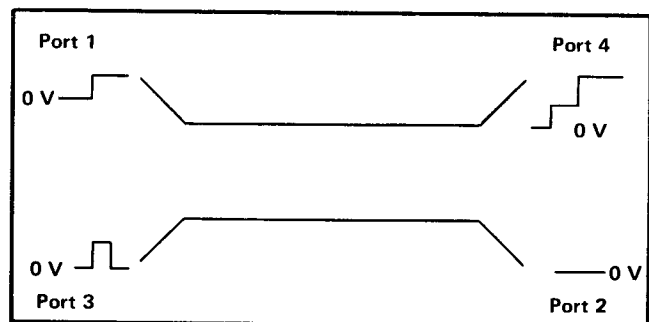


Fig. 5-1. Signal outputs of directional coupler with a step voltage applied to port 1.

rectangular pulse plus the amplitude (at that time) of the coupled oscillator signal. The summation of these signals is proportional to the phase difference between the 1st LO and the reference oscillator pulsed step voltage. This voltage is amplified by the error amplifier and drives the compensating amplifier. Output of the compensating amplifier then maintains a constant phase difference between the 1st LO and some multiple of the reference oscillator.

When the 1st LO switches from a swept oscillator to phase locked mode, its center frequency shifts to the first lock point it finds. The 2nd LO becomes the swept oscillator, therefore its center frequency must shift an equal amount and opposite to the 1st LO (in effect), to offset the center frequency change. This is accomplished by the memory offset digital circuit.

The digital system looks at the offset voltage of the 1st LO before and after phase lock then generates an offset voltage which is applied, through a summing amplifier, to the 2nd LO. The 2nd LO center frequency will now hold the displayed signal near the position it held before phase lock was established.

The 1st LO is hermetically sealed to increase operating time and must be replaced as a unit. The phase detector and 2nd LO assembly are also semisealed and should be replaced as a unit. See Maintenance Section.

## DETAILED CIRCUIT DESCRIPTION

The following analysis is more detailed than the block diagram in the theory of circuit operation. The objective is to aid in servicing or operating the instrument.

### Microwave Input Circuits

The step attenuator, 1.8 GHz low pass filter, 3 dB pad, 1st mixer, and traveling wave damper are complete assemblies that must be replaced as a unit if defective. The 2.2 GHz filter, 2.095 GHz bandpass filter and the 2nd mixer assembly consists of two sub-assemblies; 2.2 GHz low pass filter-2.095 GHz bandpass filter, and the 2nd mixer assembly. The bandpass and center frequency of the filters plus the balance of the mixer are adjustable.

The phase detector and 2nd LO assembly are composed of hybrid circuits, on ceramic substrates, and one circuit board mounted in separate chambers. The complete unit is then sealed with a conductive sealant. This seal should not be broken or repair attempted. The 2.2 GHz oscillator center frequency and sweep span are controlled by a resonant chamber that includes a Varactor assembly. The Varactor assembly tunes the resonant frequency of the chamber. Its function and effect on the oscillator are described later.

The 2.2 GHz low pass filter, 2.095 GHz bandpass filter, and 2nd mixer assembly, are tuned so the bandwidth is approximately 15 MHz. Bandpass and center frequency are tuned by series capacitors, C15, C16, C17, and the coupling of the mixer. The coupling will also affect the mixer efficiency and signal to noise ratio. The mixer, a single balanced type, is oriented in the chamber so one of two balance points provides the best rejection of a 52.5 MHz spur that is generated by IM products between the 1st and 2nd LO.

The active component for the 2nd LO is transistor Q20. Its collector load is a strip resonator that is coupled to a resonant tank assembly A70, the frequency determining circuit. The frequency of this resonant tank is tuned by Center Frequency adjustment C71 and a variable capacitance diode assembly. The 2nd LO is swept when the FREQ SPAN is .1 MHz/Div or less, by applying a calibrated portion of the sweep voltage to this Varactor diode assembly. The oscillator is swept 1 MHz or less depending on the FREQ SPAN selected. Calibration of the frequency span is partially determined by the coupling of this Varactor assembly into the resonant circuit.

Two band-reject filters, consisting of 1/4 wave-length stubs that are separated 1/4 wave-length along the 2nd mixer output transmission line, suppress 2.3 GHz (sum of 2.2 GHz and 105 MHz IF) and 4.3 GHz (sum of 2.2 GHz and 2.095 GHz) from reaching the 3rd IF.

The phase detector consists of; the sampling gate, error amplifier, and a directional coupler to the Aux Output. The sampling gate is turned on by strobe pulses from the sampling pulse driver at a 2.21 MHz rate. When the gate is open, the detector looks at discrete intervals of the 1st LO frequency and detects phase difference between it and some multiple of the 2.21 MHz reference oscillator. This detected difference is integrated, filtered and amplified by the error amplifier. The error amplifier output feeds this voltage back through a compensating amplifier to the FM coil of the 1st LO to maintain frequency stability and a constant phase difference.

The Aux Output jack J35 provides access to the swept frequency of the 1st LO.

### 105 MHz IF Amplifier, 3rd Mixer and Oscillator

Signals within the 10 MHz bandwidth of the 105 MHz IF, are amplified by Q85. The output load for Q85, is a three sectional helical resonator that is tuned so the bandwidth is reduced to 3 MHz. The 3rd mixer converts the 105 MHz IF to 10 MHz IF, by mixing 105 MHz with the output of a crystal controlled 95 MHz oscillator.

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Aperature coupling is used between each section of the helical resonator. The 3rd mixer is a double balanced or ring mixer with its output transformer coupled through transformer T95 to the 10 MHz pre-resolution amplifier. T95 is adjusted to minimize 3rd order intermodulation products of any signals within the 10 MHz bandwidth of the 105 MHz IF.

### 10 MHz IF Pre-resolution Amplifier and Resolution Filter Circuits

Three circuit blocks comprise the resolution circuit; the 10 MHz preamplifier, five selectable resolution filters, and a post-resolution amplifier. As the resolution bandwidth is selected, gain compensation is provided to maintain the signal level input to the Function IF amplifier. The Function IF amplifier is then adjusted so a constant signal reference level is maintained on the display for changes of resolution or display modes.

The signal path through the Resolution Preamplifier depends on the position of relay K280. This relay is energized in all positions of the Gain selector except the first two (0 dB and 10 dB). When energized, the signal path is through Q280 and Q290, which has a gain of 20 dB. Gain of the operational amplifier, containing Q250 and Q260, is increased by 10 dB when the base of Q270 is grounded through the Gain selector. This occurs every odd 10 dB step of the selector.

With the Gain selector fully CCW (0 dB), the 10 MHz input signal to T240 is amplified by the IF amplifier Q240 and the operational amplifier that contains Q250 and Q260. The front panel AMP CAL adjustment R80, sets the gain of Q240 so a  $-30$  dBm 50 MHz signal, at the RF INput provides full screen signal amplitude.

Switching the Gain selector one position CW, grounds the base of Q270 which turns the transistor on, pulling some of the feedback current to Q250. The closed loop gain of the stage is therefore increased 10 dB. Gain is accurately calibrated by the 10 dB gain adjustment R267.

Increasing the Gain selector position an additional 10 dB, opens the base of Q270 and energizes relay K280. The output of T264 is now switched through an additional Op Amp Q280-Q290, for 20 dB of gain.

Increasing the Gain position to 30 dB, again grounds the base of Q270, increasing the gain of the preamplifier an additional 10 dB for a total gain increase through the preamplifier of 30 dB. As previously described, the relay K280 remains energized through the remaining four positions of the Gain selector (total range of the selector is 70 dB, the rest of the gain variation being provided in the function IF).

The resolution section contains three crystal filters (for 300 Hz to 30 kHz resolution) and a 300 kHz coupled-resonator filter. The 300 kHz filter consists of six resonant sections and an amplifier. Signal path through or around the filters, is directed and controlled by relays K300, K357, K353, K356, K354, and K355. These relays are energized as the RESOLUTION cam switch S108A is switched to positions that connect the relay armature to the  $-15$  V power source.

Amplitude adjustments for each filter section, establish a consistent signal output level as the resolution is changed. The signal reference level on screen, therefore, remains constant through the RESOLUTION range. It is important when aligning the filters, that their center frequency is centered on the others. This is done by switching in one of the crystal filters periodically to re-establish the center of the bandpass for the 300 kHz and 3 MHz filters.

The resolution output amplifier provides approximately 15 dB of gain (at low frequencies) with a gain slope of approximately 4 dB of additional gain as the frequency increases to 1.8 GHz. This gain slope compensates for loss in sensitivity through the microwave circuits as the frequency increases. The response across the 1.8 GHz span therefore remains relatively flat (within  $\pm 1.5$  dB).

The gain slope is attained by applying a portion of the 1st LO (YIG oscillator) driving voltage to voltage divider circuits across the emitter load for Q430. As frequency of the 1st LO increases, the positive-going ramp turns the PIN diode CR415 on, then the PIN diode CR418 is turned on as the ramp reaches its upper limit. These diodes shunt the degenerative emitter resistance of Q430 and increases the gain of the stage. (Gain of the stage is a function of the emitter to collector impedance ratio.)

R411 (Hi End Break Point) adjustment, sets the voltage point (or frequency) that CR418 turns on. Since its current source is through R410 and R412, it produces a pronounced increase in the gain slope. The slope adjustments are set so the break point occurs at approximately 1.6 GHz. The slope increases the gain about 2 dB between 1.6 GHz and 1.8 GHz for a total of 4 dB above low frequency reference.

The 10 MHz IF input signal is channelled, by K357, through either a wide filter (3 MHz) or a narrow filter, for additional shaping and noise reduction. Bandpass of the narrow filter is between 500 kHz and 600 kHz. K357 is de-energized when the RESOLUTION is switched from 3 MHz to 0.3 MHz.

### Reference Oscillator and Sampling Gate Driver

The reference oscillator is a 2.21 MHz crystal controlled oscillator and amplifier that drives a snap-off diode to

generate a narrow pulse signal. These pulses drive the sampling gate in the phase detector.

Q1338 is turned on when the FREQ SPAN/DIV selector is set to some position within the phase lock mode. This turns Q1339 on, which supplies the current for Q1330 and the snap-off diode CR1330. Q1320 amplifies the crystal oscillator output and isolates the oscillator from the pulse generating circuit. Avalanche Voltage adjustment R1332, sets the avalanche point for the diode and is adjusted for a negative going strobe pulse to the sampling gate.

### Sweep Triggering

Triggering for the sweep generator circuit, is accomplished with operational amplifiers in a quad-amp IC package U1010. Either of two trigger sources or a free run mode can be selected by S101. When selected, the following occurs: 1) FREE RUN supplies +5 V to pin 2 of the gate generator U1140 and the generator runs without any trigger input. 2) LINE selection connects a sample of the line voltage from the mainframe to the non-inverting input of U1010B. 3) INT pushbutton selects the output of a differential amplifier U1010A which received its trigger signal from pins A20-B20 of the mainframe interface.

U1010C is a comparator, with one of its inputs looking at the DC output of U1060, which depends on the setting of the TRIGGER LEVEL control R100, and the other input of the comparator looking at the output of U1010B which depends on the selected trigger source.

An external sweep voltage applied to J100, or through the mainframe interface pins, is amplified by U1010A and U1010D, then applied through the contact S1 of K1200, to the horizontal output amplifier U1210A and U1210B.

### Sweep Generator and Holdoff

A sweep ramp of 10 V is generated by the IC U1160. Duration of this ramp depends on the timing circuits that are switched into the summing point of U1160 at pin 9. Timing current for the capacitors C1191, C1192, and C1193 is supplied through series resistors R1191, R1192, and R1193. Timing combinations are switched in a 1, 2, 5 sequence by the TIME/DIV selector. Current for these timing capacitors is through transistors Q1185 and Q1183. When the TIME/DIV selector is switched to the SPECTRUM position, cam 13 opens. The VARIABLE control now sets the base voltage of Q1183 and this in combination with the variable timing resistor increases the control range to at least 100X.

The sweep gate for the sweep generator, is generated by U1140. The positive gate output is directly coupled to the gate input of the sweep generator. At the same time a

negative gate from pin 15 of U1140, is amplified and inverted by Q1156 and applied as an unblanking gate to the mainframe CRT. During the time the gate is not running, pins 15 and 9 (– gate and lamp drive) are high. This output is applied through the two NAND gates U1110A and U1110B and produce a holdoff pulse to the mainframe.

When operating in the SINGLE SWP mode, the READY light is connected through Q1106 to the Lamp Drive output of U1140. When the gate generator is not running, the high state of the lamp drive output turns transistor Q1106 on and supplies current to light the READY indicator. When the gate generator runs, pin 9 goes low and cuts off Q1106. This turns the READY light off. The gate generator is reset by grounding one input of the NAND gate U1110C, through the RESET switch which triggers the SCR Q1117 and resets U1140.

In the P-P AUTO mode, relay K1130 is de-energized. Contacts S1 and S2 now connect the Triggering LEVEL potentiometer across the output of peak detector diodes, CR1050 and CR1051, so that the triggering level can be selected along any portion of the peak to peak excursion of the triggering signal.

The sweep output of U1160 (at pin 8) is connected through contact S1 of K1200 to the output amplifiers U1210A and U1210B. These amplifiers supply approximately 0.5 volt of push-pull drive to the oscilloscope horizontal deflection circuit.

Gain of U1210A (approximately 0.5) is set by SWP CAL adjustment R107.

### Sweep Span or Dispersion

A nominal sweep input of 10 V, from the sweep generator or external sweep source, is applied through S1 of K1200, R1250, and pin 1 of P1035 to the Op Amp U1260. The reference level (DC level) of the sweep is set by the voltage divider network of R1252, R1253, R1251, and the selection of either R110-R111 or R1255. In the CENTER frequency mode, the sweep output of U1260 is centered about 0 V, in the START frequency mode, the sweep ramp starts at 0 V. U1260 supplies the current to drive the attenuator network. This attenuator (FREQ SPAN) selects the frequency span in a 1, 2, 5 sequence and its output drives the YIG oscillator tuning coil except when the 7L12 is operated at spans less than .2 MHz/Div. At spans of 100 K and less, the sweep output is shaped by a sweep shaper circuit and drives the 2nd LO.

### YIG Coil Driver and Marker Generator

Sweep voltage from the FREQ SPAN attenuator, is applied to the Op Amp U1410 with a gain, that is calibrated



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by the Freq Span Cal adjustment R1416, of approximately one. The DC level from the COARSE CF control is summed with the sweep voltage by U1460. The output of U1460 drives emitter follower Q1470, which is part of a feedback loop through the YIG tuning coil and R1475 to the sweep input of U1460. This feedback loop establishes the current source for the tuning coil. The current ramp through R1478 develops a sweep voltage to drive the base of emitter follower Q1480 and provides the sweep voltage for the gain slope compensating circuit in the Resolution Post-amplifier.

Switching the FREQ SPAN/DIV selector to MAX position energizes K1450. This removes the COARSE center frequency output DC level to the amplifier U1460 and connects it to U1440B (part of the marker generator circuit). The YIG oscillator is now swept its full frequency span and a marker is generated that is commensurate to the position of the COARSE frequency control.

The output of U1140B is summed with the sweep voltage from U1410 at the input of U1420A. At the crossover point of these two voltages, the output of U1420A starts towards 0 V (see waveform photograph on the schematic). As the waveform crosses 0 V, diodes CR1432 and CR1433 switch and develop a negative notch or marker at the output of U1420B. This marker is then applied to the vertical output circuit to provide the center frequency marker on the display.

### Voltage Memory and Phase Lock Operation

When the FREQ SPAN/DIV is switched from .2 MHz to .1 MHz position and with the PHASE LOCK switch S120 closed, the 1st LO is automatically phase locked to some multiple of the 2.21 MHz reference oscillator. The 2nd LO then becomes the swept and tuned oscillator. The 1st LO center frequency may shift 2.21 MHz to find a lock point. The center frequency of the 2nd LO must shift an equal but opposite amount to compensate for the 1st LO center frequency change to keep the center or start frequency at their respective positions on screen. The correction factor required to feed to the 2nd LO, is determined by the voltage memory circuit. It samples the 1st LO error voltage, developed when it shifted center frequency, and produces an output voltage to pull the 2nd LO center frequency in the direction and amount required.

When the FREQ SPAN/DIV selector is switched to .1 MHz or less, +15 V is supplied through cam 12 to relays K1400 and K1470 and the voltage memory circuit.

K1400 disconnects the sweep ramp to the 1st LO tuning coil and connects the error amplifier output (through the FM coil of the YIG oscillator) to U1370. U1370 amplifies this error voltage and sets a voltage at one of the inputs to a comparator U1540B. The +15 V is applied through diode

CR1560 to the base of Q1561 to turn this transistor off and through R1555 to the input of a single shot multivibrator U1558.

Before phase lock mode is set, Q1561 conducts the current from the summing transistors, that are in series with the output of 64 increment counter (Q1564 through Q1588). The current through Memory Offset adjustment R1590, and R1591-CR1591-R1589 set the output of U1540A to a voltage that is close to 0 V. The Q output (pin 6) of the multivibrator U1558 is high at this time and U1540B is latched.

When the +15 V is applied to the multivibrator input, it toggles the output after some delay time. During this delay, Q1561 is turned off and the output of U1540A is set to its starting point. This point is a voltage below 0 V. The output of the multivibrator U1558 clears the two counters U1560 and U1570 and also unlatches (through CR1559 and CR1544) the oscillator Q1545. The oscillator starts oscillating and clocks the counter. The output of the counter is summed through the summing transistors and fed back, as a positive-going 64 increment staircase voltage ramp, to the other input (pin 6) of the comparator U1540B. When the staircase ramp (at pin 6) reaches the potential at pin 5, of the comparator, the output of the amplifier latches the counters and turns Q1545 off. The output of U1540A is now some DC level that equals the voltage necessary to shift the 2nd LO center frequency and compensate for the 1st LO shift when it found a phase lock mode. The signals will now return to their original position on screen as the frequency of the 2nd LO is now swept to its new center frequency, by the output voltage from the sweep shaper.

### YIG Oscillator Power Supply

This supply furnishes a regulated 25 V to the YIG oscillator. It uses +15 V and -15 V supplies from the mainframe as its source and floats with respect to the other voltages in the 7L12. It is protected against short circuits to the chassis ground or other supplies by transistors Q1506-Q1518, and catch diodes CR1514-CR1515, and CR1524-CR1525. An increase of current through R1502 or R1512 will turn on transistors Q1506 or Q1518 and collapse the 9 V reference to U1520A. The same increase of current can produce enough voltage drop across R1525 or R1514 to turn on diodes CR1514-CR1515, and CR1524-CR1525, which bias transistors Q1517-Q1525 off. Voltage output is set by adjusting R1528 for 25 V across TP1532 and TP1534.

### Sweep Shaper

The 2nd LO is swept from high to low frequency to display a frequency span from low to high. The output waveform from the shaper to the 2nd LO tuning cavity, is

negative-going with the most positive portion representing the highest frequency of the LO and the low frequency side of the display.

The sweep oscillator requires a nonlinear control voltage to its frequency determining components, to generate a linear frequency output<sup>1</sup>. This nonlinear sweep voltage requirement is due to the variable capacitance diode that is used to tune the 2nd LO frequency cavity. The linear voltage ramp from the FREQ SPAN attenuator circuit, is shaped into an exponential waveform by the sweep shaper circuit (see schematic diagram waveforms) so the 2nd LO frequency shift is linear with the movement of the CRT beam across the horizontal axis.

The sweep shaper consists of a diode-resistor network that is the input resistance to an operational amplifier (Q1740 and Q1754). As the sweep increases, the input resistance to the amplifier is changed.

The sweep ramp out of operational amplifier U1610B into the sweep shaper, is a positive-going ramp with an amplitude of approximately 0.8 V. The average DC level of this ramp is a negative potential which is a function of the DC summation of the voltage memory input to U1610A and the voltages set by the FINE tuning controls plus the voltage adjustment of the Shaper Range R1637.

Diodes CR1701 through CR1711, in series with their potentiometers R1701 through R1711, are sequentially turned off as the input sweep ramp becomes more positive. This decreases the gain of the operational amplifier, producing an exponential shaped output waveform so that the relatively large change at the positive end produces the required capacitance change of the Varactor diode to produce a linear shift of the 2nd LO frequency. Between two and three diodes change conduction for each 1 MHz of sweep range. The shaper output provides a linear frequency change of approximately 6.5 MHz over the center frequency range of the FINE tuning control and memory phase lock offset.

### Function IF Amplifier

The function IF consists of six cascode amplifier cells or blocks in cascade. Each cell operates as a linear or logarithmic amplifier to provide the gain characteristics required for the three display modes of the 7L12. The gain of each cell is a function of the emitter resistance of the input transistor. In the Log mode, as the signal level increases, diodes in the emitter circuit reduce the gain in each amplifier cell from 10 dB to 0 dB.

<sup>1</sup>A treatise on frequency linearization technique is provided in Circuit Concept book on Spectrum Analyzer Circuits; TEKTRONIX Part No. 062-1055-00.

When the operator depresses the 10 dB/DIV display button, +15 V is applied through S130A and pin 2 of P250 to the anodes of the log diodes; CR511-CR512, CR514-CR515, CR521-CR522, CR524-CR525, and CR531-CR532. These diodes are forward biased (with no signal input) and the amplifier cell operates at full gain. As the signal input level increases, the emitter voltage approaches the bias of the diodes and turn the diodes off. The amplifier gain therefore decreases to unity or 0 dB.

The gain of Q720-Q710 decreases to 0 dB first, the next 10 dB increase in signal causes the gain of Q680-Q670 to decrease to 0 dB, when diodes CR524-CR525 turn off. This action progresses towards the front of the IF Function amplifier to Q560-Q550 as the signal level continues to increase.

In the 2 dB/DIV mode, +15 V is applied to diodes CR527-CR528 and CR534-CR535 in the emitters of Q680 and Q720 and +15 V is removed from the anode of the 10 dB Log diodes. These diodes are now back biased.

CR534-CR535, in the emitter of Q720, and CR527-CR528 in the emitter of Q680, provide approximately 4 dB of log gain per amplifier cell. This provides two break points, at about 4 dB and 8 dB of the gain curve over the 14 dB dynamic window. These two break points change the curve slope sufficiently to shape the curve for 2 dB/DIV. R737 and R697 set the slope of the curve after the break point.

The 10 dB/Div and 2 dB/Div Ref Level adjustments R802 and R801, position the linear portion of the log gain curve (see Fig. 5-2) within the 8 division graticule window.

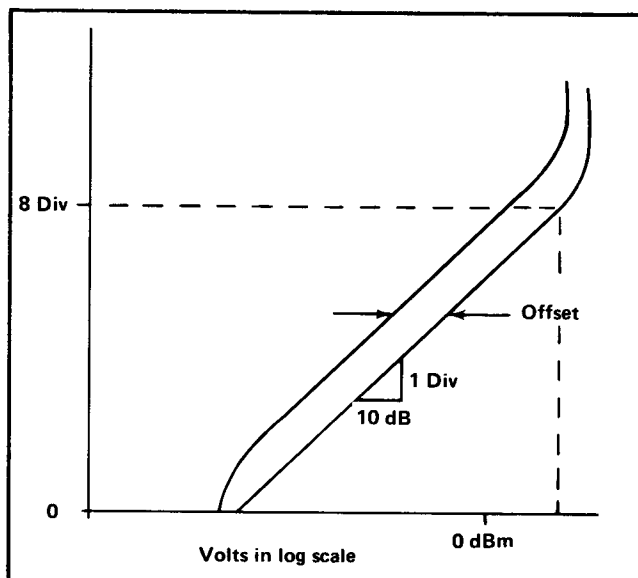


Fig. 5-2. Log converter curve.

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The 2 dB/DIV and LIN mode displays require at least 70 dB of gain through the analyzer's IF; therefore, additional gain is switched in the Function IF for the 40 to 70 dB (last four) positions of the IF Gain selector. S130A is de-energized when in the 2 dB or LIN mode. The base of transistors Q570 and Q600 now have a return path to ground through S83 and pin 4 of P84, in the 40 dB or 50 dB positions. Grounding the base of the transistors, turn them on and boost the gain through these amplifier cells an additional 10 dB per cell. Transistors Q630 and Q660 are turned on when S83 is switched to the 60 or 70 dB positions.

Gain of the Function IF amplifier, in the LIN and 2 dB modes is calibrated at the 40 dB and 60 dB steps by adjusting R603 and R664. Q730 is turned on when the LIN mode is selected and R733 sets the reference level of the display to the top of the graticule.

The output of Q700 is coupled to a linear detector. The linear detector consists of Q740 driving the common emitter amplifier Q750-Q760 with feedback through C766, the detector diodes CR772-CR771, resistors R775-R776, and C776 to the inverting input of the amplifier. The detected video at the anode of CR772 is then applied through a filter network to the Video Filter, Video Processor, and Vertical Output.

Linear Baseline Offset adjustment R803, compensates for baseline shift when the display mode is switched from LOG to LIN mode.

During the positive excursion of the IF signal, feedback current is supplied through CR772 and during the negative portion of the signal through CR771. This produces a circulating current through the diodes proportional to the average signal input level. The negative video output signal is developed across R772-R819 and R771.

### Video Filter, Processor, Baseline Clipper and Vertical Output

Video signals from the detector, are applied to operational amplifier U820B. Its feedback resistance, R826, is shunted by baseline clamping diodes and fast or slow video filter circuits that are switched in by U830 and U840.

CR826 and CR825 clamp the amplifier to prevent its output from going negative. With no signal in, the input of the amplifier is clamped by CR825, so it cannot shift positive and the output of the amplifier (at P820-2) is clamped by CR826 if it tries to shift negative.

The three sections of U840 are connected so they operate as OR gates to connect C840 in the feedback loop for U820B. Pulling pin 2 or 3 of P830 low, or closing the front panel 30 kHz switch S90C on, turns one section of U840 on to connect C840 in the feedback loop. Pin 2 of P830 is pulled low when the front panel RESOLUTION selector is switched to the 30 kHz position and pin 3 of P830 is pulled low when the RESOLUTION is switched to 3 kHz or 300 Hz position.

The three sections of U830 and one section of U840 are connected to operate as an AND-OR gate. When 300 Hz (S90A) switch is closed, one section of U830 is turned on to connect C830 in the feedback loop. Closing both S90A and S90C (300 Hz and 30 kHz) turns two sections of U830 and one section of U840 on, to connect C830, C832 and C840 in the feedback loop. The following logic describes the three filter combinations:

30 kHz = (30 kHz RESOLUTION) OR (3 kHz to 300 Hz RESOLUTION) OR (S90C closed)

300 Hz = (S90A closed)

3 Hz = (S90A) AND (S90C closed)

The output of U820B is isolated from summing amplifier U820C by Op Amp U820D. U820C sums the video signal with the VERT POSITION DC level setting and mixes the search marker, when present, with the video. The output of U820C drives the positive output for the oscilloscope interface, the inverting amplifier U820A (which drives the negative output to the oscilloscope interface) and the Baseline Clipper circuit.

Closing the VIDEO PROCESSOR switch S90B, turns Q880 on. Current through an emitter follower output transistor, of amplifier U820D, provides a fast charge path for C880 on the positive excursion of pulsed video signals and a long discharge time constant to stretch the decay time.

The Baseline Clipper consists of a current switch Q880-Q890 and logic circuit containing transistors Q895-Q898. This circuit can modulate the CRT beam intensity only when it receives an enabling signal from the mainframe through interface pin B7.

The mainframe switching signal, at B7, goes high when the 7L12 is displayed. This signal, turns Q895 on and allows the output of the common emitter current switch Q887-Q890 to drive the Z axis common (pin B17) and Aux Z axis (A17), through Q898, to produce the baseline clipping action. The switching point of the clipper is set by

the control R96. When Q887 is off, its collector goes high. This is coupled through CR887 to the base of Q898 and pulls interface pin A17 low. The CRT beam is not clipped when this state exists. When Q887 is turned on, the beam is clipped.

Video, or the average DC level out of U820C, can pull the base of Q890 up and cause Q887 and Q890 to switch at any level that is set by the Baseline Clipper control. Range of the control provides about 50% display clipping.

The contrast is set by setting the quiescent current, or bias, of CR898. This determines the degree of contrast between the clipped portion and the unclipped display.

### 50 MHz Calibrator

The calibrator is a crystal controlled oscillator. The oscillator is a multivibrator with the crystal Y950 in series with the feedback loop. Output of the oscillator is set by adjusting the oscillator current with R956 so the output level, at 50 MHz, is  $-30$  dBm. Output impedance is  $50 \Omega$ .

# MAINTENANCE INSTRUCTIONS

## Introduction

This section describes; recommended procedure for reducing or preventing instrument malfunction, troubleshooting, and corrective maintenance to repair the instrument. Preventive maintenance improves instrument reliability. Should the instrument fail to function properly, corrective measures should be taken immediately; otherwise, additional problems may develop within the instrument.

## PREVENTIVE MAINTENANCE

Preventive maintenance consists of cleaning, visual inspection, performance check, and if needed, a recalibration. The preventive maintenance schedule that is established for the instrument should be based on the environment the instrument is operated in and the amount of use. Under average conditions (laboratory situation) a preventive maintenance check should be performed every 1000 hours of instrument operation.

### Cleaning

Clean the instrument often enough to prevent dust or dirt from accumulating in or on it. Dirt acts as a thermal insulating blanket and prevents efficient heat dissipation. If it becomes damp it can provide electrical high resistance leakage paths between conductors and/or components.

**Exterior.** Clean the dust from the outside of the instrument by wiping or brushing the surface with a soft cloth or small brush. The brush will remove dust from around the front panel selector buttons. Hardened dirt may be removed with a cloth dampened in water that contains a mild detergent. Abrasive cleaners should not be used.

**Interior.** Normally the interior of the instrument will not require cleaning unless it has been left out of the oscilloscope plug-in compartment and uncovered for an extended period of time. Clean the interior by loosening accumulated dust with a dry soft brush, then remove the loosened dirt with low pressure air to blow the dust clear. (High velocity air can damage some components.) Hardened dirt or grease may be removed with a cotton tipped applicator dampened with a solution of mild detergent in water. Abrasive cleaners should not be used. If the circuit board assemblies need cleaning, remove the circuit board by referring to the instructions under Corrective Maintenance in this section.

After cleaning, allow the interior to thoroughly dry before applying power to the instrument.

### CAUTION

*Do not allow water to get inside any enclosed assembly or component such as; the cam switches, hybrid assemblies, differential RF Attenuator assembly, potentiometers, etc. Instructions for removing these assemblies and repairing are provided in the Corrective Maintenance section. Do not clean any plastic materials with organic cleaning solvents such as benzene, toluene, xylene, acetone or similar compounds because they may damage the plastic.*

### Lubrication

No components in this instrument require lubrication. The cam switches are self-lubricating.

### Visual Inspection

After cleaning, carefully check the instrument for such defects as defective connections, damaged parts, and improperly seated transistors and integrated circuits. The remedy for most visible defects is obvious; however, if heat-damaged parts are discovered, try to determine the cause of over-heating before the damaged part is replaced, otherwise the damage may be repeated.

### Transistor and Integrated Circuit Checks

Periodic checks of the transistors and integrated circuits are not recommended. The best measure of performance is the actual operation of the component in the circuit. Performance of these components is thoroughly checked during the performance check or recalibration, and any substandard transistors or integrated circuits will usually be detected at that time.

When handling MOS FET's keep the shorting strap in place until the transistor is in its socket.

### Performance Checks and Recalibration

The instrument performance should be checked after each 1000 hours of operation or every six months if the instrument is used intermittently to ensure maximum performance and assist in locating defects that may not be



apparent during regular operation. Instructions for conducting a performance check are provided in the Performance Check Section.

## TROUBLESHOOTING

The ability to recognize and locate trouble is acquired with experience and as you become familiar with the instrument. The following are a few aids and suggestions that may assist in locating a problem. After the defective assembly or component has been located, refer to Corrective Maintenance part of this section for removal and replacement instructions.

### Troubleshooting Aids

**Diagrams.** Block and circuit diagrams on foldout pages in the Diagrams section contain significant waveform and voltage information. The condition and setting used to obtain these waveforms is described at the beginning of the diagram section. Refer to the Electrical Part List Section for a description of all assemblies and components.

#### NOTE

*Corrections and modifications to the manual and instrument are described on inserts bound into the rear of the manual. Check this section for changes and corrections to the manual or the instrument.*

**Circuit Board Illustrations.** Electrical components, connectors, and test points are identified on circuit board diagrams located on the inside fold of the corresponding circuit diagram or the back of the preceding diagram. This allows the troubleshooter to trace and check the operation of each circuit, and physically locate circuit components.

**Wiring Color Code.** Color coded wires are used to aid circuit tracing. Power supply, DC voltage leads have either a white background for positive voltage or a violet background for negative voltage. Signal wires and coaxial cables use an identifying one-band or two-band color code.

**Multiple Terminal (Harmonica) Connector Holders.** Most intercircuit connections, are made through pin connectors which may be mounted in a harmonica type holder. The terminals in the holder are identified by numbers. Connector orientation to the circuit board is keyed by triangles on the holder and the circuit board (see Fig. 6-1). Some connectors contain more than one section, so sections can be disconnected for easier troubleshooting. All connectors are identified on the schematic and board with 'P' numbers.

**Resistor Color Code.** Brown composition resistors, metal-film resistors (identifiable by their gray body color) and some wire-wound resistors (usually light blue or gray-green) are used in the 7L12. The resistance value of a wire-wound resistor is printed on the body of the component. The resistance value of a composition resistor or metal-film resistor is color-coded on the component with EIA color-code (some metal-film resistors may have the value printed on the body).

**Capacitor Marking.** The capacitance value of a common disc capacitor or small electrolytic is marked in microfarads on the side of the component body. The white ceramic capacitors are color coded in picofarads.

**Diode Color Code.** The cathode of each glass encased diode is indicated by a stripe, a series of stripes or a dot. Fig. 6-2 illustrates diode types and polarity markings that are used in this instrument.

**Transistor and Integrated Circuit Electrode Configuration.** Lead identification for the transistors, MOS FET's, and IC's are shown in Fig. 6-3 and 6-4.

### General

The following procedure is recommended to isolate a problem and expedite repairs.

1. Ensure that the malfunction exists in the instrument. Check the operation of associated equipment and the operating procedure of the 7L12 (see Operating Instructions).

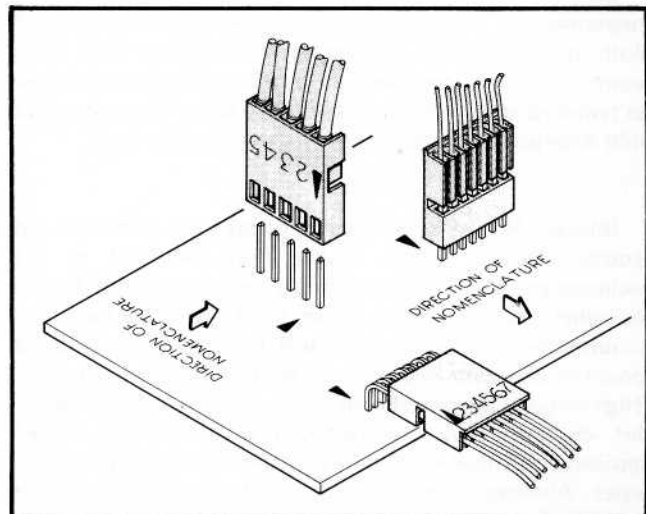


Fig. 6-1. Multipin circuit board connectors.

2. Determine and evaluate all trouble symptoms. Try to isolate the problem to a circuit or assembly. For example: Absence of a frequency marker notch in MAX position, could indicate a malfunction in the video summing stage, the marker generator, or the switching circuitry. A test oscilloscope will check the input to the video summing stage and isolate the problem to one or the other of the two circuits. The block diagram in the Diagrams section can aid in signal tracing and circuit isolation. It also shows the required signal level at different points to produce full screen deflection.

**CAUTION**

*When measuring voltages and waveforms, use extreme care in placing meter leads or probes. Because of high component density and limited access within the instrument, an inadvertent movement of the leads or probe could cause a short circuit. This may produce transient voltages which can destroy many components. The 1st LO (YIG oscillator) case is floating above chassis potential. Do not use its case as a ground reference point when measuring voltages. The power supply for the oscillator is short proof;*

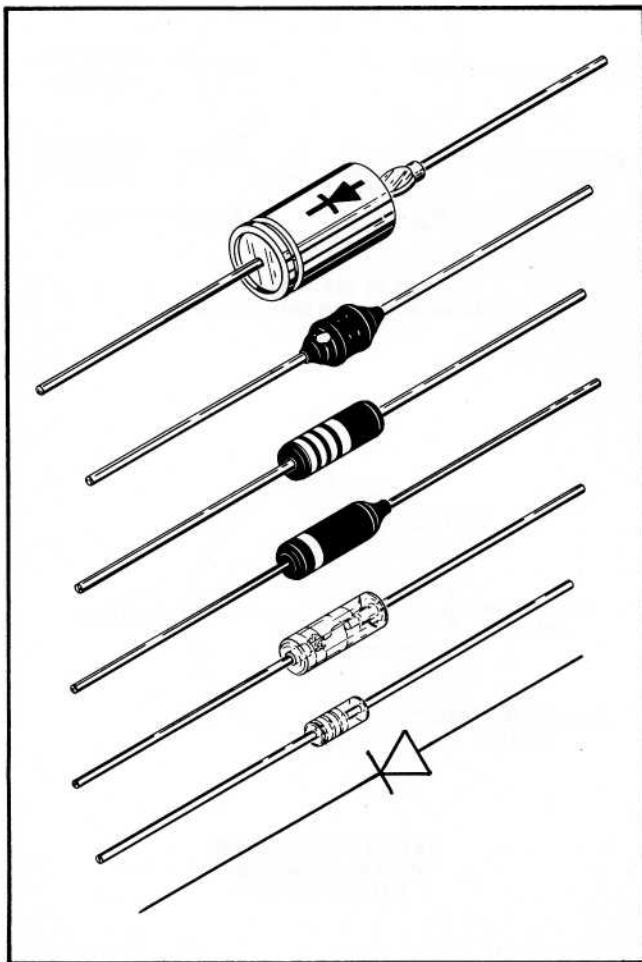


Fig. 6-2. Diode polarity markings.

*however, it should not be shorted to chassis ground over extended periods.*

3. Visually inspect the area or the assembly for such defects as broken or loose connections, improperly seated components, over-heated or burned components, chafed insulation or cracked insulators, etc. Repair or replace all obvious defects. In the case of overheated parts, try to determine the cause of overheating and correct before applying power.

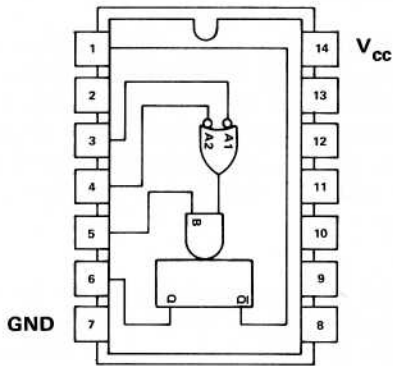
4. Check the calibration adjustments of the affected circuit, if applicable. Before changing the setting of any adjustment, note its position so it can be returned to its original setting. This will facilitate recalibration after the trouble has been located and repaired.

5. Semiconductor failures account for the majority of electronic equipment failures. Most semiconductor devices (transistors and IC's) are socket-mounted, therefore, substitution is often the most practical means for checking their performance. The following guide lines should be followed when substituting these components:

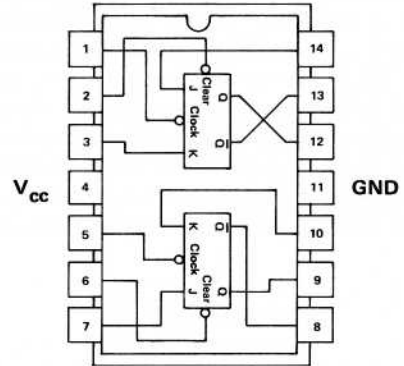
- a. First determine that circuit voltages are safe for the substituted component, so the replacement will not be damaged.
- b. Use only good components for substitution.
- c. Turn the power off before a component is substituted.
- d. Be sure the component (transistor or IC) is inserted properly in the socket (see Fig. 6-4).
- e. After the operational check, return the good components to their original sockets to reduce calibration time and run-in period.

**NOTE**

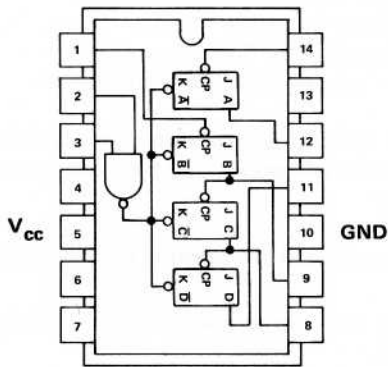
*If a substitute is not available, check the transistor or MOS FET with a dynamic tester such as the TEKTRONIX Type 576 Curve Tracer. Static type testers, such as an ohmmeter, can be used to check resistance ratios across some semiconductor junctions if no other method is available. (Do not measure resistance across MOS FET's because they are very susceptible to static charges.) Use the high resistance ranges ( $R \times 1\text{ k}$  or higher) so the external current is limited to less than 2 mA. If uncertain, measure the external current with an ammeter. Resistance ratios across base-to-emitter or base-to-collector junctions usually run 100:1 or higher. The ratio is measured by connecting the meter leads across the terminals, noting the reading, then reversing the leads and noting the second reading.*



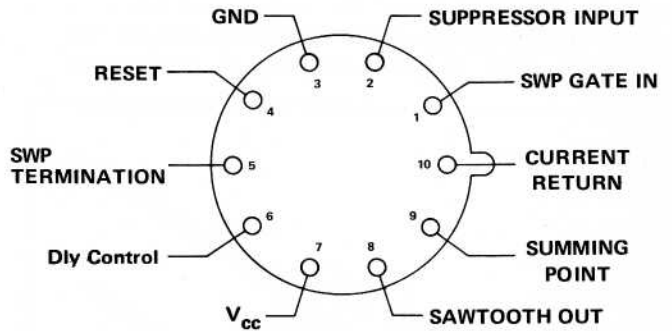
SN 74121 156-0072-00  
Monostable Multivibrator  
(U1558)



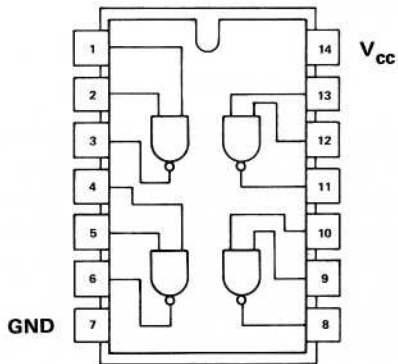
SN 7473 156-0039-00  
Dual J-K Master Slave Flip-Flop  
(U1560)



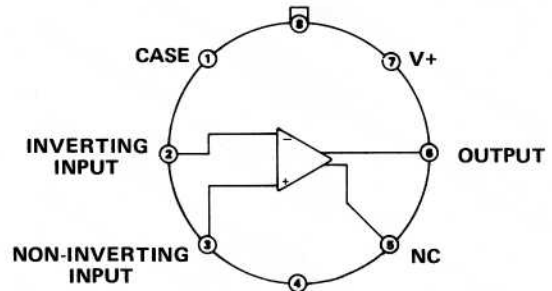
SN 7493 156-0032-00  
4-bit counter  
(U1570)



MO 18 155-0042-02  
Miller Runup and Delay Pickoff  
(U1160)

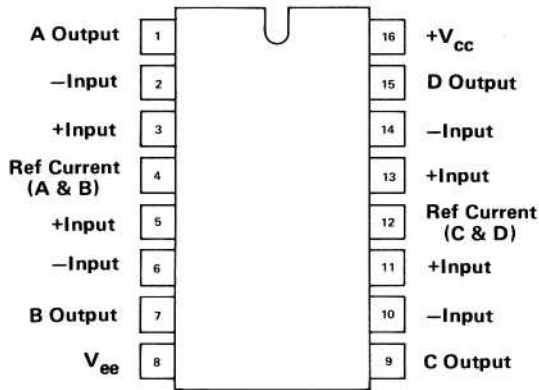


SN 7400 156-0030-00  
Four Input NAND Gate  
(U1110)

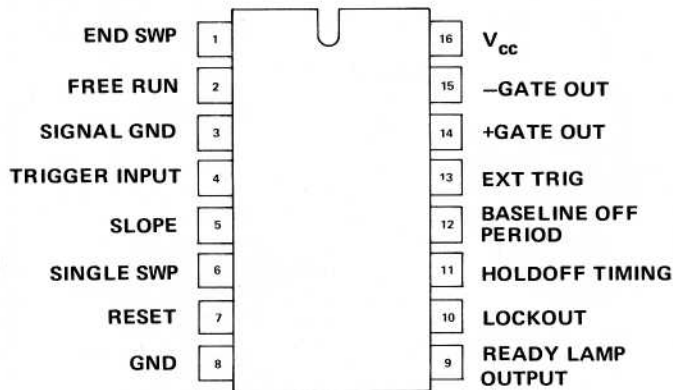


RAD 2911 156-0132-00  
Wide Band Op Amp  
(U1350, U1410)

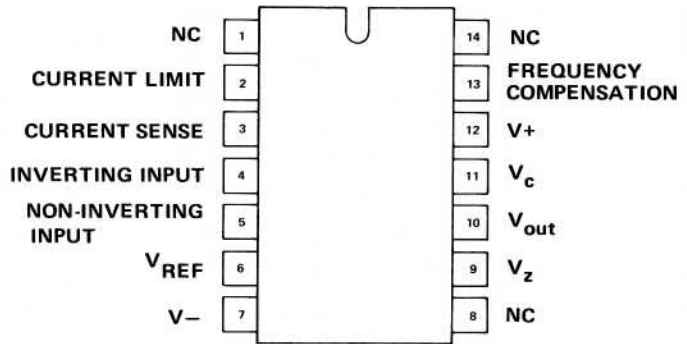
Fig. 6-3A. IC pin identification.



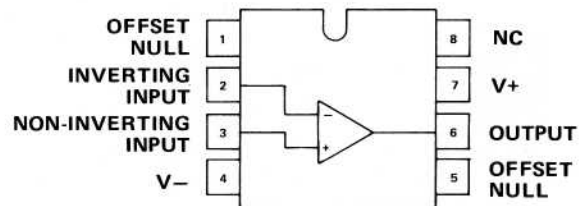
MO 53A 155-0035-00  
Quad Op Amp  
(U820, U1010, U1210, U1520)



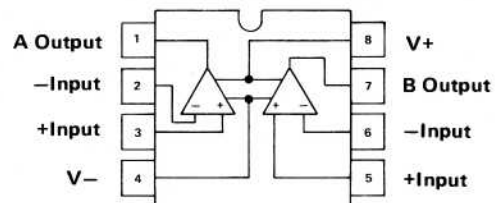
MO-42-NLO 155-0056-00  
Swp Control  
(U1140)



μA 723C 156-0071-00  
Voltage Regulator  
(U1460)



μA 741C 156-0067-01  
Op Amp  
(U1060, U1260, U1370)



N5558V 156-0158-00  
Dual Op Amp  
(U1420, U1440, U1540, U1610)

Fig. 6-3B. IC pin identification.

**Diode Checks.** Most diodes can be checked in the circuit by taking measurements across the diode and comparing these with voltages listed on the diagram. Forward-to-back resistance ratios can usually be taken by referring to the schematic and pulling appropriate transistors and pin connectors to remove low resistance loops around the diode.



*Do not use an ohmmeter scale with a high external current to check the diode junction. Do not check the forward-to-back resistance ratios of tunnel diodes or mixer diodes.*

**Integrated Circuit (IC) Checks.** Integrated circuits are most easily checked by direct replacement. When substitution is impossible, check input and output signal states as described in the circuit description and on the diagram. Lead configuration and data for the IC's used in this instrument are provided by Fig. 6-3.

Check calibration and performance after a faulty component has been replaced.

If the above procedure fails to locate the trouble, a more detailed analysis must be performed. The Circuit Description section describes the operational theory of each circuit and may aid to further evaluate the problem.

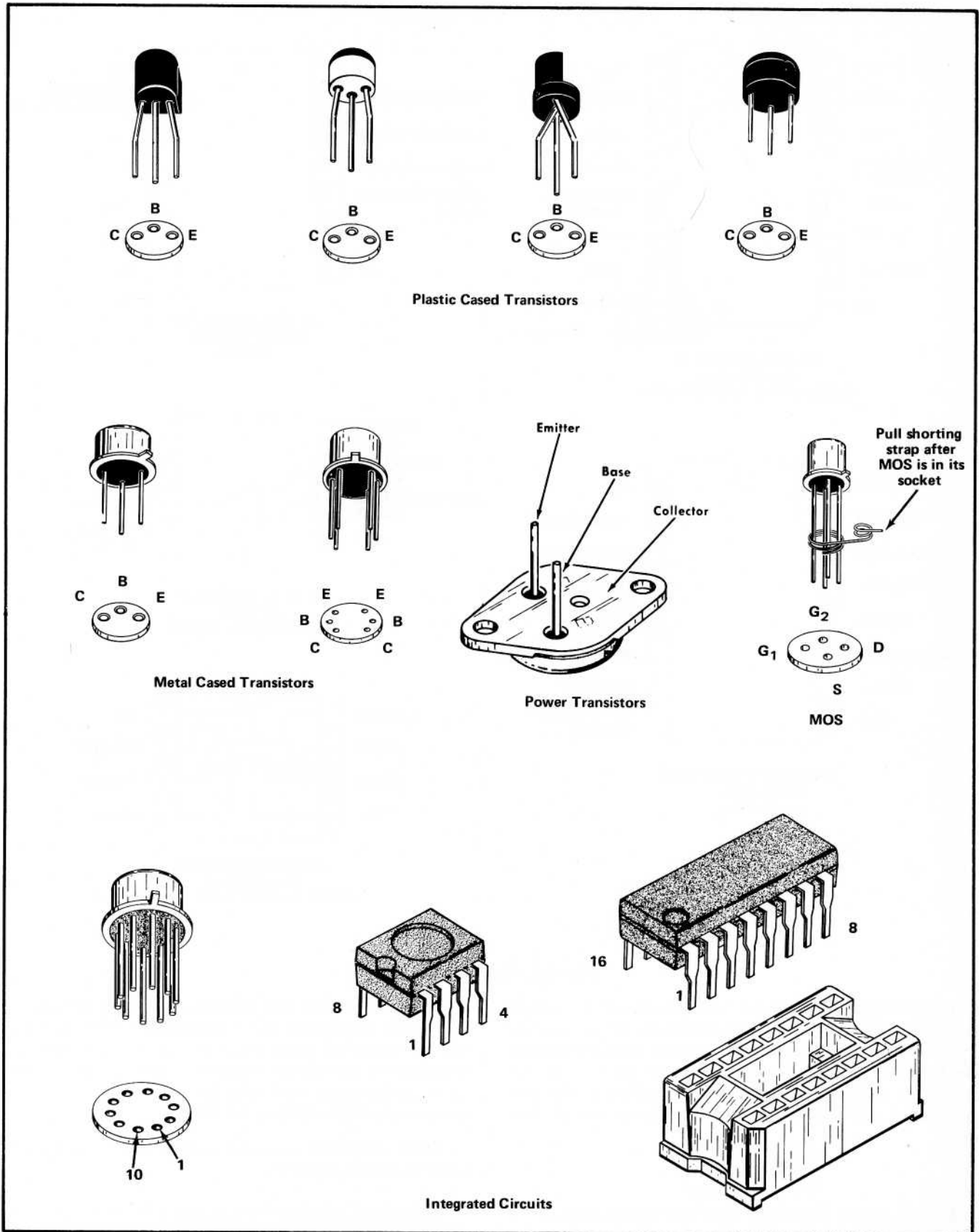


Fig. 6-4. Electrode configuration for socket mounted transistors, MOS's and IC's.



## CORRECTIVE MAINTENANCE

Corrective maintenance consist of component replacement and instrument repair. Special techniques and procedures, required to replace components in this instrument, are described here.

### Obtaining Replacement Parts

All electrical and mechanical parts replacements can be obtained through your local TEKTRONIX Field Office or representative. Many of the standard electronic components, however, can be obtained locally in less time than that required to order from Tektronix, Inc. Before purchasing or ordering replacement parts, consult the Parts List for value, tolerance and rating. The Parts section contains instructions on how to order these replacement parts.

#### NOTE

*When selecting the replacement parts, it is important to remember that the physical size and shape of the component may affect its performance in the circuit. Two assemblies, the Differential Assembly (which includes the RF Attenuator) and the Phase Detector and 2nd LO Assembly, are under TEKTRONIX repair/exchange program. Refer to the introductory page for the Parts List section or contact your local Field Service Center for exchange/repair rates.*

It is best to duplicate the original component as closely as possible. Parts orientation and lead dress should also duplicate those of the original part because some components are oriented to reduce or control circuit capacitance and inductance. After repair, the circuits may need recalibration.

### Soldering Technique



*Disconnect the instrument from its power source before replacing or soldering components.*

Some of the circuit boards in this instrument are multilayer; therefore, extreme caution must be used when a soldered component is removed or replaced. Excess heat from the soldering iron and bent component leads may pull the plating out of the hole. We suggest clipping the old component free, leaving enough lead length to solder the new component leads to. If you desire to remove the component leads; use a 15 watt pencil type iron, straighten the leads on the back side of the board, clip the old component free, then when the solder melts gently pull the soldered lead through the hole. A desoldering tool should be used to remove the old solder.

### Replacing the Square Pin for the Multi-pin Connectors

It is important not to damage or disturb the ferrule when removing the old stub of a broken pin. The ferrule is swaged into the circuit board and provides a base for soldering the pin connector.

If the broken stub is long enough, grasp it with a pair of needle nose pliers, apply heat with a small soldering iron to the pin base of the ferrule and pull the old pin out. (The pin is pressed into the ferrule so a firm pull is required to pull it out.)

If the broken stub is too short to grasp with pliers, use a small dowel (.028 inch in diameter) clamped in a vise to push the pin out of the ferrule after the solder has been heated.

The old ferrule can be cleaned by reheating the solder and placing a sharp object such as a toothpick or small dowel into the hole. A 0.031 drill mounted in a pin vise may also be used to ream the solder out of the old ferrule.

Use a pair of diagonal cutters to remove the ferrule from the new pin, then insert the pin into the old ferrule and solder the pin to both sides of the ferrule.

If it is necessary to bend the new pin, grasp the base of the pin with needle nose pliers and bend against the pressure of the pliers to avoid breaking the board around the ferrule.

## REPLACING ASSEMBLIES AND SUB-ASSEMBLIES

Most assemblies or sub-assemblies in this instrument can be easily removed and replaced. Some components and assemblies mounted between the front panel and the circuit board chassis require a detailed and sequential procedure. These replacements are described with illustrations and a step by step procedure.

### Maintenance Tools

Open end offset wrenches are required to loosen the nuts for the semi-rigid cable connectors. (See Fig. 6-5.) Two 15/64 inch wrenches and a 5/16 inch wrench that is ground so it will fit into the limited access space for P20 and P22 on the hybrid phase detector. The special 5/16 inch wrench may be ordered from TEKTRONIX (Part No. 003-0703-00) if desired.

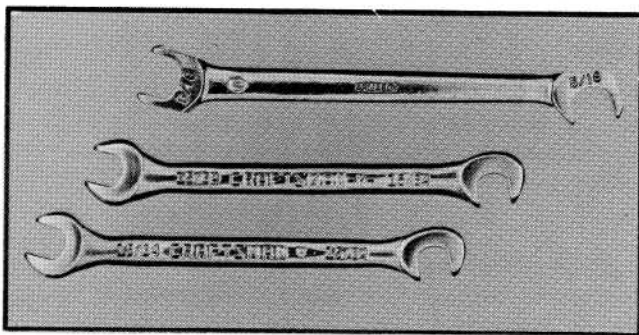


Fig. 6-5. Wrenches, including a special ground down 5/16, required to service the semi-rigid cable connectors.

### Front Panel Potentiometers

Front panel potentiometers are screwed into bushings swaged to the front sub-panel. A lock washer, between the bushing and the potentiometer shoulder, prevents the potentiometer from turning after it has been tightened.

Remove the knob, unsolder the leads, then use pliers (with tape over the jaws to prevent marring the surface) to unscrew the potentiometer out of the bushing.

When the potentiometer is replaced, screw it into the bushing so it locks in position, resolder the leads to their respective terminals (remember the terminals may not be orientated the same as the old) and replace the knobs. Ensure the knob is properly indexed to the markings on the front panel.

### Removing and Installing the Front Panel FREQ SPAN/RESOLUTION Knobs and Skirts

#### NOTE

*Turn all selectors to their full clockwise position. Position the other knobs that have no stop to some reference point.*

Removal: After switching the RESOLUTION and FREQ SPAN selectors fully CW, loosen the setscrews and remove the VARIABLE, FREQ SPAN, and RESOLUTION knobs.

#### Installation

1. With the RESOLUTION and FREQ SPAN cam switches turned fully clockwise, install the RESOLUTION knob and FREQ SPAN skirt so the forks seat firmly in the two holes at the top of the RESOLUTION knob skirt ring (see exploded Mechanical Drawing Fig. 1 in the Mechanical Parts section).

2. Turn the RESOLUTION knob clockwise, until the last "3M" position marker is centered in the resolution readout window, then lift the RESOLUTION knob away from the panel, for clearance, without removing the RESOLUTION knob skirt. Tighten the RESOLUTION knob set screws.

3. With the PULL TO UNLOCK insert knob pushed in to its detent position, slide the FREQ SPAN knob on the switch shaft until the spring loaded pin engages the slot in the hub of the RESOLUTION knob. The white index mark on the FREQ SPAN knob should be aligned with MAX SPAN on the RESOLUTION skirt ring. Tighten both setscrews firmly after centering the knob pin in the slot and allowing for knob clearance (use a piece of paper between the knobs).

4. Unlock the RESOLUTION from the FREQ SPAN selector by pulling out the PULL TO UNLOCK sleeve. Rotate each selector through its 19 positions to ensure you have full range of the selector and that they are indexing properly with the readout on the skirt.

5. Push in the PULL TO UNLOCK sleeve to re-engage the two selectors together. Now rotate both selectors through their range. Ensure that they detent positively and simultaneously. If the switching action seems rough or double detents exist, loosen the RESOLUTION knob setscrews and allow the outer shaft to slip into its detent position.

6. Install the VARIABLE knob so that only the black portion is visible when the switch is pushed to the CAL IN position.

### Replacing or Repairing the Cam Switches

#### CAUTION

*The alignment and spring tension of the cam switch contacts are critical and must be maintained for proper operation; therefore, replacing or repairing these switches should be performed only by experienced maintenance personnel. A repair kit which includes replacement contacts, alignment tools, and instructions for replacing the switch contacts, can be ordered from Tektronix, Inc. Order Part No. 040-0541-00. If assistance is desired, contact your local TEKTRONIX Field Office or representative.*

#### Preliminary

We recommend replacing the complete actuator assembly if any part of the actuator is defective. The following procedures describe how to replace the complete actuator for the FREQ SPAN/RESOLUTION selector and the TIME/DIV selector. Precise alignment and complex procedures are required to replace any section of these actuators.

Before removing the cam switch for repair or replacement, the Sweep Circuit board assembly must be removed. This procedure is described under Replacing Major Circuit Board Assemblies which follows this description.

## 1. FREQ SPAN/RESOLUTION Selector Replacement

- a. Unsolder the connections to the VARIABLE FREQ SPAN potentiometer switch assembly.
- b. Turn the circuit board over and remove the six (6) 4-40 screws and two (2) 2-56 screws that mount the actuator assembly to the board.
- c. Lift the actuator assembly from the board which will expose its related contacts.
- d. Clean and replace any contacts if necessary, as per the instructions with the repair kit.
- e. Replace the VARIABLE potentiometer switch assembly as follows:
  - 1) Remove two (2) 2-56 screws and lock washers from the potentiometer mounting plate, located at the rear of the actuator assembly.
  - 2) Pull the potentiometer switch assembly including the coupler and shaft, clear of the actuator assembly.

## 2. TIME/DIV Selector Replacement

- a. Unsolder the connections to the VARIABLE potentiometer switch assembly.
- b. Turn the board over and remove four (4) 4-40 screws that mount the actuator assembly to the circuit board.
- c. Lift the actuator assembly from the board to expose the related contacts for cleaning and repair, if necessary.
- e. Replace the VARIABLE potentiometer switch assembly as follows:
  - 1) Remove two (2) 2-56 screws and lockwashers from the mounting plate located at the rear of the actuator assembly.
  - 2) Pull the potentiometer switch assembly, including the coupler and shaft, clear of the actuator assembly.

## 3. Replacing the Cam Actuator and Potentiometer Switch Assemblies

To re-assemble these assemblies, reverse the above removal procedure.

## REPLACING THE MAJOR CIRCUIT BOARD ASSEMBLIES

### Replacing the Sweep Circuit Board

Position the FREQ SPAN/DIV/RESOLUTION, selectors fully CW. Set the TIME/DIV selector in the SPECTRUM

position. Loosen the knob locking screws with a 1/16 Allen wrench and remove the knobs.

Disconnect the harmonica (multipin) connectors and unsolder any cable wires to the board and the potentiometer switch assembly on each can switch assembly.

Remove the rear panel mounting screws and the panel, then remove the mounting nut for the TIME/DIV cam switch shaft and the mounting screws for the circuit board. (One screw is at the center front of the board; the other is through the bottom rail to a mounting post, see Fig. 6-6.)

Slide the board and switches back until they clear, then lift out.

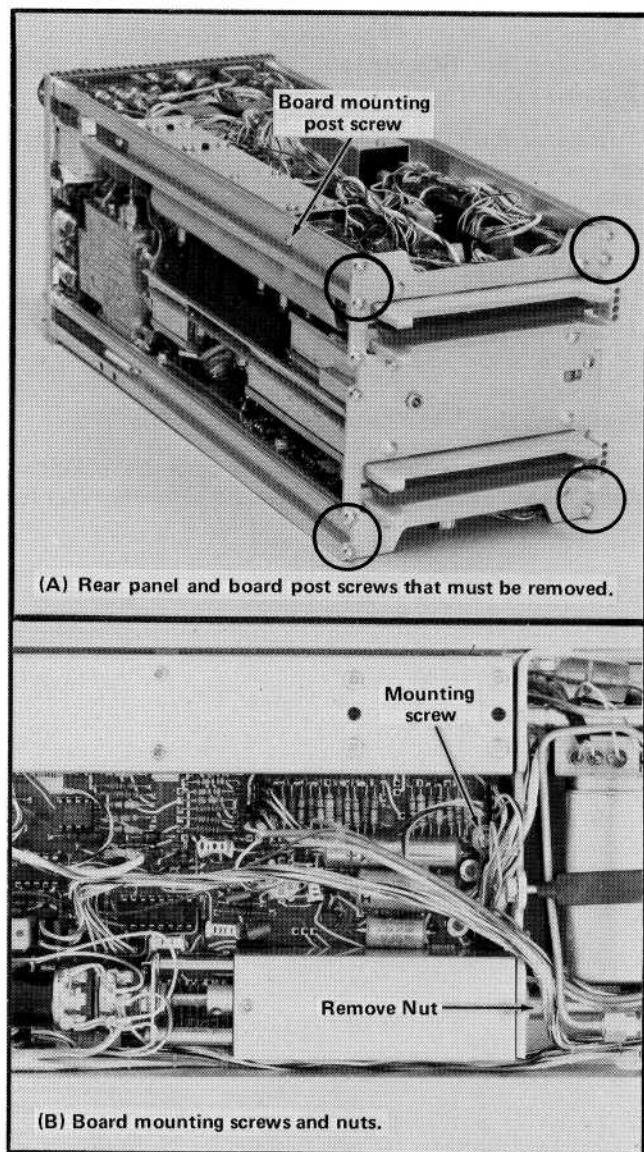


Fig. 6-6. Removing Sweep circuit boards.

**NOTE**

Refer to *Cam Switch Replacement procedure*, if the cam switches are to be replaced.

Replace the circuit board assembly, by reversing the removal procedure. Remember to use the same knob reference point before tightening the set screws and check that the selectors index properly through their range.

**Replacing the IF Function Circuit Board**

Remove the cover on the Calibrator, so the cable between the box and the outer rail can be removed; then remove or unplug the harmonica connectors and P900 (output of the calibrator) from the interface board. Remove the two mounting screws and lift the board assembly out of the instrument.

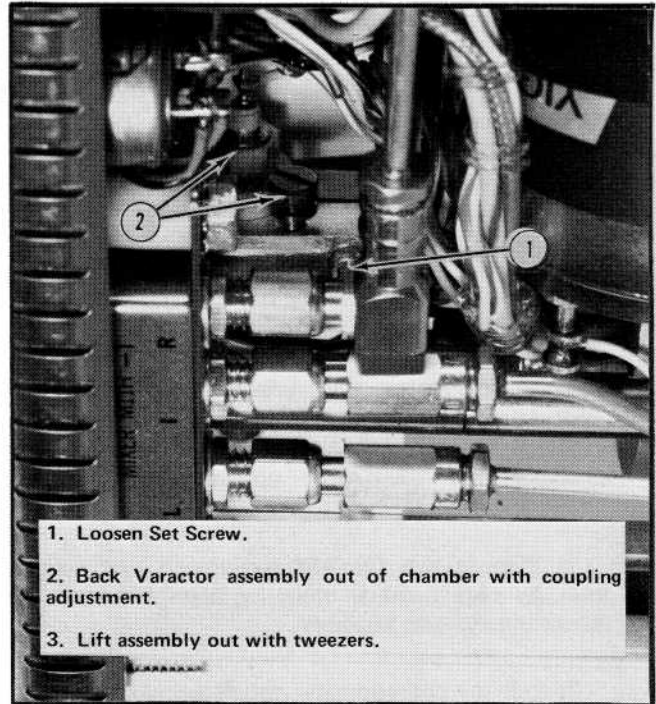
**Replacing the Resolution Circuit Board Assembly (Fig. 6-7)**

Unsolder the +15 volt lead to the 105 MHz IF assembly and unplug the external cabling to the board. Unscrew and remove the (8) mounting posts that hold the board to the chassis. Lift the circuit board assembly off of its chassis.

**REPLACING ASSEMBLIES**

**Replacing the 2nd LO Varactor Assembly**

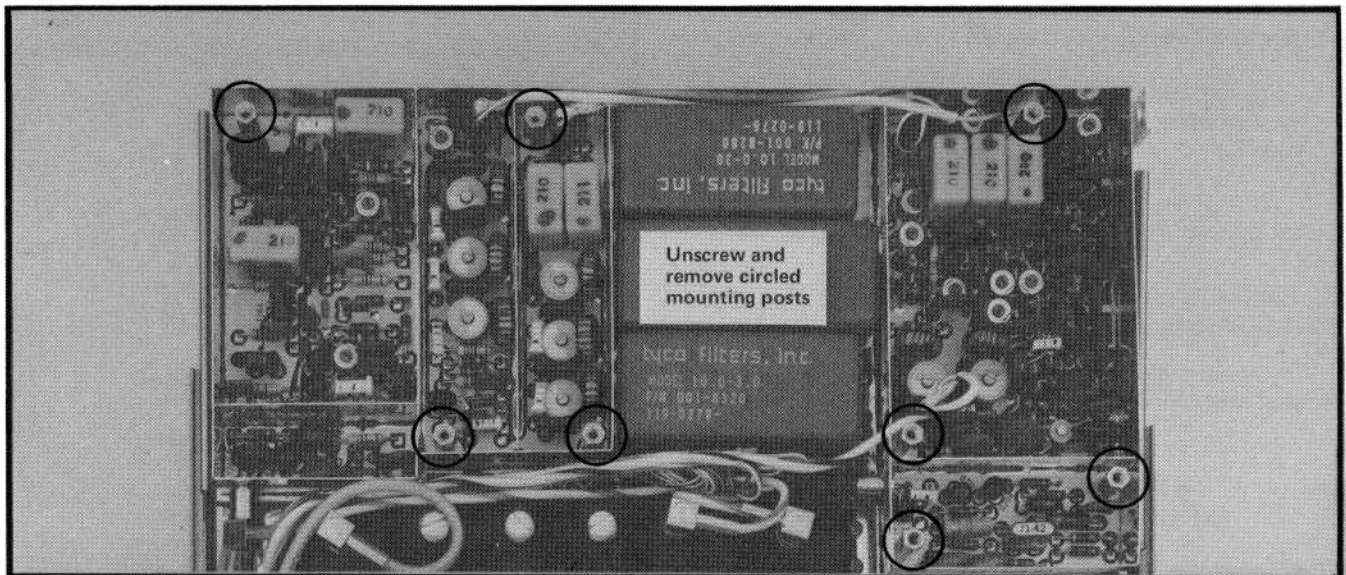
The Varactor assembly is held in place by a friction clamp. The clamp is loosened by unscrewing the Allen set



**Fig. 6-8. Removing the Varactor assembly.**

screw shown in Fig. 6-8. After the assembly has been loosened, move it out of its tuning cavity by turning the coupling adjusting screw counterclockwise.

Use tweezers or needle nose pliers to lift the assembly out of the cavity and to the side of the instrument so the voltage and signal leads can be unsoldered.



**Fig. 6-7. Removing the resolution circuit board assembly.**



Solder the leads to the new assembly then replace it into the cavity. Turn the coupling adjustment screw clockwise to position the assembly partially into the cavity.

Calibrate the sweep range of the 2nd LO and center frequency as described in the Calibration section of the manual.

**NOTE**

*This procedure assumes the microwave circuits ahead of the 2nd LO are aligned. If the bandpass filter is misaligned then the detailed procedure for alignment of both the 2nd LO and filter must be performed.*

**Replacing The 2.095 GHz Filter Assembly**

1. Loosen setscrew and lift mixer out of its cavity.
2. Loosen and remove screws for low pass filter.
3. Loosen connector for W 7 to Traveling Wave Damper assembly.
4. Remove 2.095 GHz Filter mounting screws and slide assembly out of the unit. Do not bend W 7.
5. Replace the assembly by reversing the procedure.
6. Calibrate as per description under Replacing the 2nd Mixer Assembly.

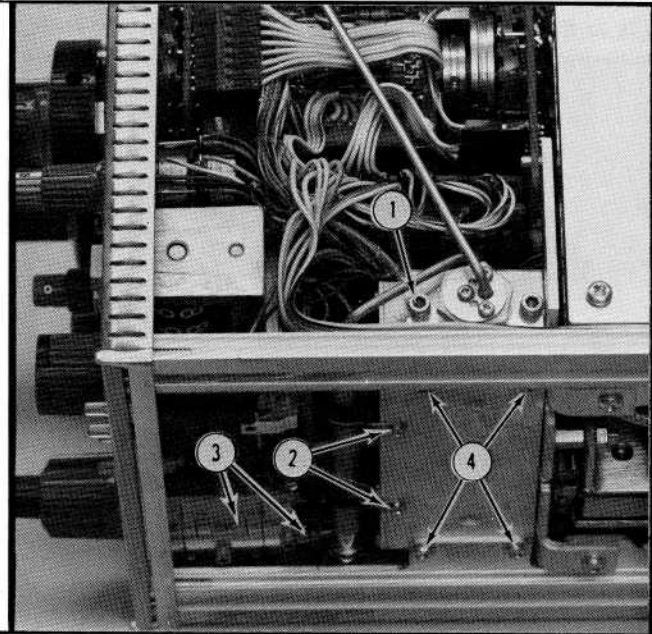


Fig. 6-9. Replacing the 2.095 GHz Filter assembly.

**Replacing the 1st (YIG) Oscillator Assembly**

1. Remove semi-rigid cable W6.
2. Remove W 4.
3. Loosen and remove nut and swing strap out of the way.
4. Lift assembly out of its cradle.
5. Unsolder wires.
6. Replace using the reverse procedure.
7. Refer to Frequency Span and Marker Calibration adjustment to calibrate new oscillator.

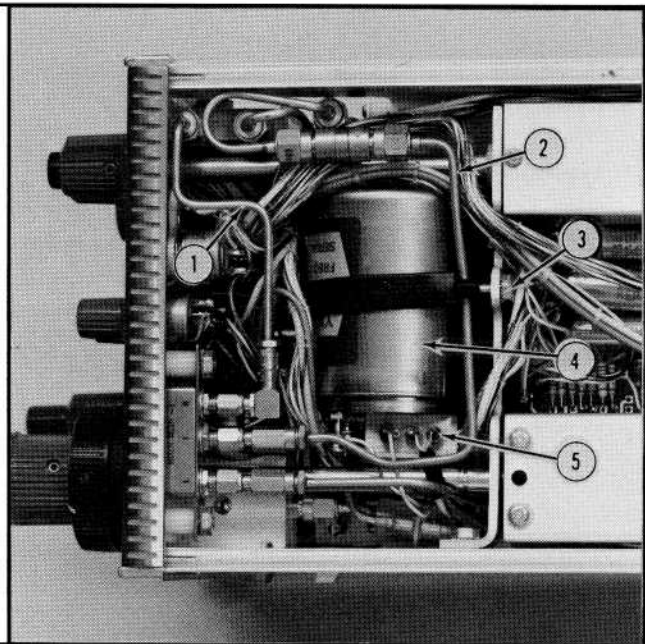


Fig. 6-10. Replacing the 1st (YIG) oscillator assembly.



**CAUTION**

The nuts that tighten the connectors for the semi-rigid cable plugs should be tightened so they are just snug or slightly more than finger tight. If a slight torque does not loosen the nut, a second wrench should be used to hold the rigid portion of the connector (see Fig. 6-11).

When the cables are replaced, torque these connector nuts so the fit is snug or the cable assembly starts to twist.

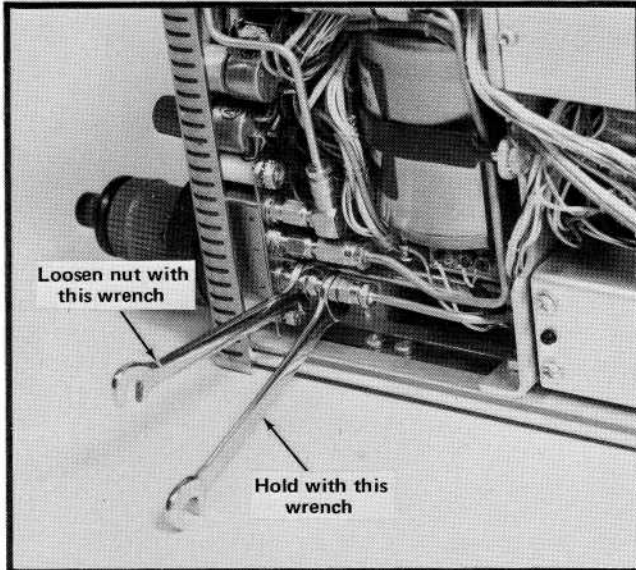


Fig. 6-11. Proper method to loosen or tighten plugs for the semi-rigid cable.

### Replacing the 2nd Mixer Assembly

The coupling of the 2nd mixer affects the response of the 2.095 GHz bandpass filter and mixer assemblies; therefore, replacement of either assembly requires re-adjustment of the filter tuning and mixer coupling.

This adjustment requires the following equipment:

1. A  $50\ \Omega$  crystal detector with a frequency range to 105 MHz; such as Hewlett Packard Model 8471A.

2. A narrow bandpass (1 kHz or less) high gain (0.2 mV/Div) vertical amplifier; such as TEKTRONIX 7A22 Differential Amplifier Plug-In unit.

3. (Optional) A low pass filter (flat to approximately 110 MHz). This filter prevents the output of the 2nd LO (2.2 GHz) from developing some DC output level from the crystal detector. This DC may drive a DC coupled signal to the vertical amplifier out of the graticule display window. If the vertical amplifier is a 7A22, with an adjustable low frequency cutoff of approximately 0.1 Hz, no filter is required.

The 2nd mixer orientation (rotation) affects the mixer balance and reduces spurious responses that are generated by the products of the 1st LO and 1st mixer plus the products of the 2nd LO and 2nd mixer. Two positions  $180^\circ$  from each other will balance the mixer, usually only one of these provides the best balance.

The following describes how to replace the assembly and alignment procedure.

1. Loosen Allen set screw.
2. Loosen and disconnect P20.
3. Lift mixer assembly and W 20 out of the cavity and instrument.
4. Install the replacement in approximately the same position as the old. Tighten the clamp on the mixer so it can still be moved with finger pressure. Plug P20 onto J20 and tighten the nut until it is just snug.

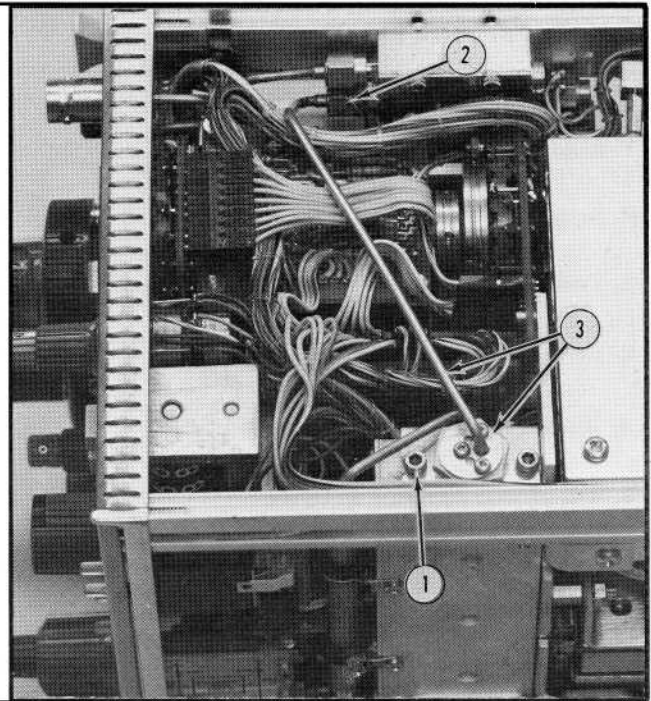


Fig. 6-12. Replacing the 2nd Mixer assembly.

**Adjust the response of the filter and mixer assemblies.**

1. Set the following front panel controls as indicated:

FREQUENCY	50 MHz
FREQ SPAN/DIV	50 MHz
RESOLUTION	300 kHz
Display Mode	10 dB/DIV
RF Atten	0 dB
Gain	CCW

2. Apply a  $-30$  dBm, 52.5 MHz signal from a signal generator to the RF INPUT. Tune the center frequency so the applied signal is centered on screen. It may be necessary to increase the signal generator output level to obtain a signal if the bandpass filter is detuned.

3. Remove the signal generator signal from the RF INPUT and look for a spurious signal near 52.5 MHz. Open up the display by decreasing the FREQ SPAN after the spur is located and adjust the sweep rate to obtain maximum signal amplitude.

4. Rotate the mixer assembly to minimize the spurious signal amplitude.

5. Set the TIME/DIV to 5 ms, FREQ SPAN/DIV to 5 MHz, RESOLUTION to 300 kHz and Display Mode to 2 dB/DIV.

6. Re-apply the 50 MHz signal, from the signal generator, to the RF INPUT and carefully tune the signal to the center of the graticule.

7. Remove P28 (Fig. 6-13) from the 105 MHz output of the hybrid and connect a 105 MHz crystal detector (through appropriate adapters) between the 105 MHz IF output and the Input to the narrow band (1 kHz) high gain amplifier. Switch the oscilloscope Vertical Mode to Right or Chop, so the amplifier output can be observed. Switch the input coupling of the amplifier to DC. If the amplifier

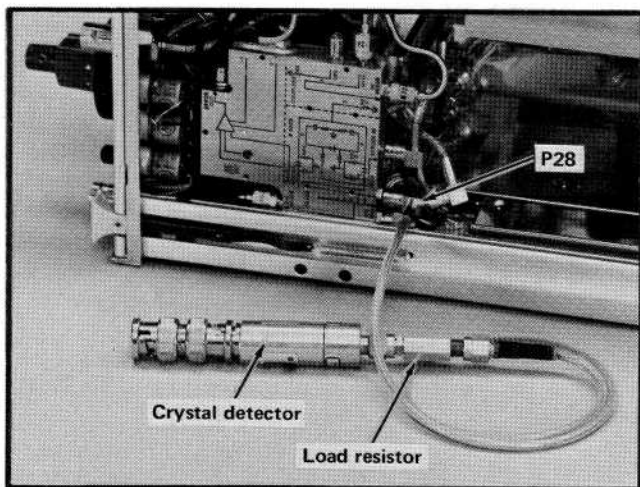


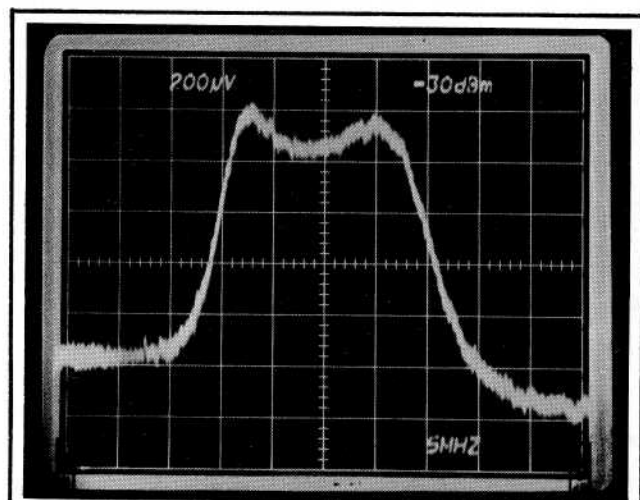
Fig. 6-13. Connecting a crystal detector to the 105 MHz output of the hybrid assembly.

has selectable bandwidth, set the HF point to 1 kHz and the LF point to .1 Hz.

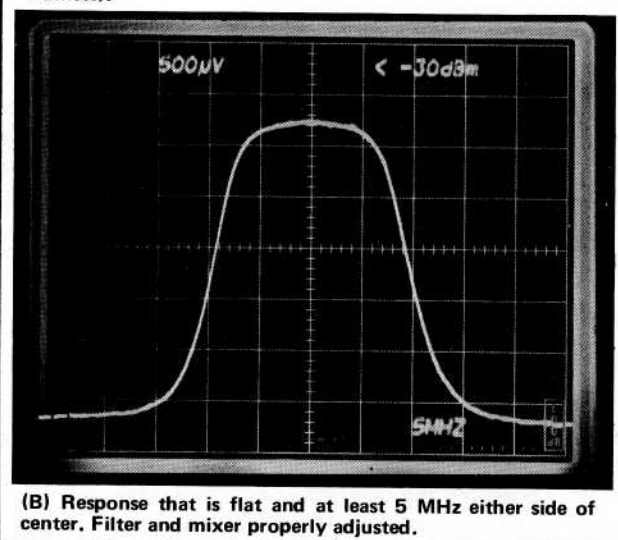
**NOTE**

*If the amplifier does not have selectable bandwidth, use a LP filter between the 105 MHz output and the detector. If the bandpass filter alignment is nearly correct a signal level of approximately 0 dBm, with a Volts/Div deflection factor of 0.5 mV will provide a display amplitude that is adequate for adjusting the filter and mixer coupling.*

8. Adjust the signal generator output for a display amplitude of approximately 5 divisions (see Fig. 6-14). Check the response flatness by using the Variable attenuator control of the signal generator to measure the amplitude variations in dB across the top of the display. Flatness should measure within  $\pm 0.5$  dB, bandpass should equal or exceed 5 MHz either side of center. If flatness or bandpass are not correct proceed with step (9).



(A) Response that needs correction ( $>0.5$  dB deviation in flatness).



(B) Response that is flat and at least 5 MHz either side of center. Filter and mixer properly adjusted.

Fig. 6-14. Illustration showing unsatisfactory response and good response through the 2.095 MHz BP filter and 2nd mixer.

9. Adjust C15, C16, C17, and the coupling of the mixer for a flat topped display that is centered about the graticule center.

**CAUTION**

*Do not rotate the mixer, because this will introduce a 52.5 MHz spur that was minimized in the first part of this procedure.*

A treatise of coupled resonators and this type of filter is given in TEKTRONIX Circuit Concept Booklet 062-1055-00. Fig. 3-15 of this booklet shows filters similar to the type used in the 7L12.

Fig. 6-14 illustrates both a satisfactory and unsatisfactory response for the filter-mixer combination.

10. Reconnect P28 to the 105 MHz output of the hybrid circuit. Recheck the signal location to ensure it is still centered. Decrease the FREQ SPAN/DIV to 1 MHz then tune the FINE frequency control through its range while checking the response flatness across the 2 MHz band. Signal level must remain within 0.5 dB of average level.

11. Remove signal from the RF INput and re-check amplitude of the 52.5 MHz spur to ensure that the mixer assembly orientation was not changed.

### Replacing the Phase Detector and 2nd LO Hybrid Assembly

Loosen both P22 and P72 then remove W22.

Loosen and remove the remaining plugs to the hybrid assembly.

Loosen the two mounting screws that go through the bottom rail (step 17 of Replacing Differential assembly) and lift the assembly out of the unit.

Unsolder the leads to the hybrid box.

Install the replacement by reversing the removal procedure. Torque the nuts, for the plugs of the semi-rigid cables so they are snug. Tighten until the cable begins to twist.

Refer to 2nd LO and Sweep Shaper Calibration for alignment procedure for the replacement hybrid.

### Replacing the Differential Attenuator Assembly

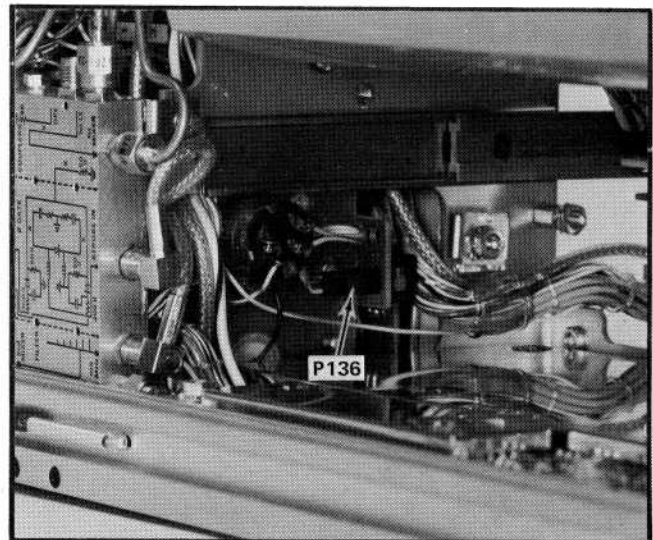
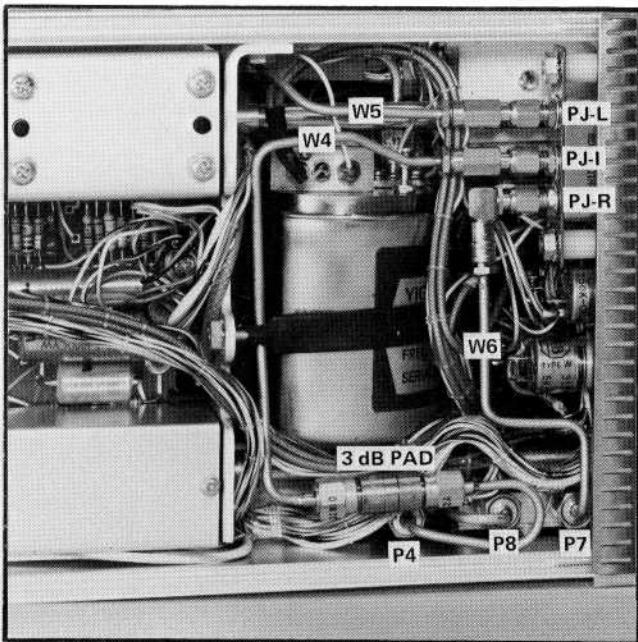
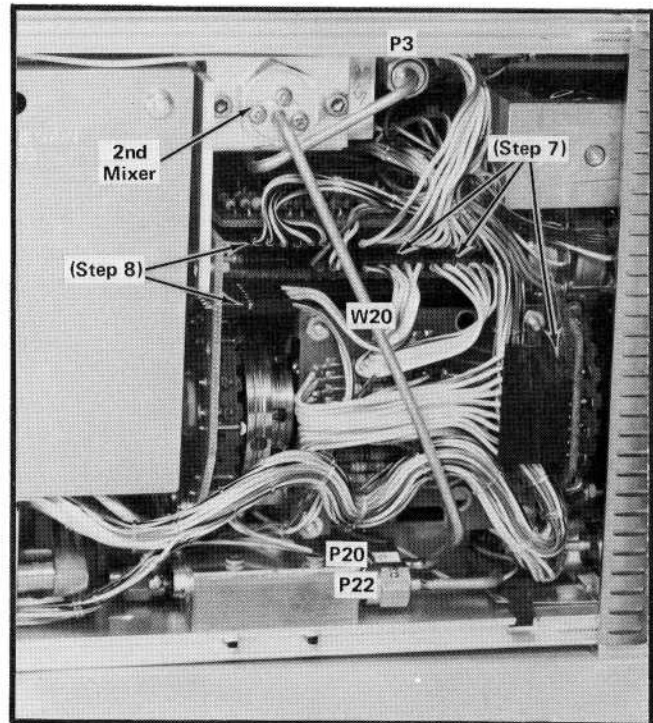
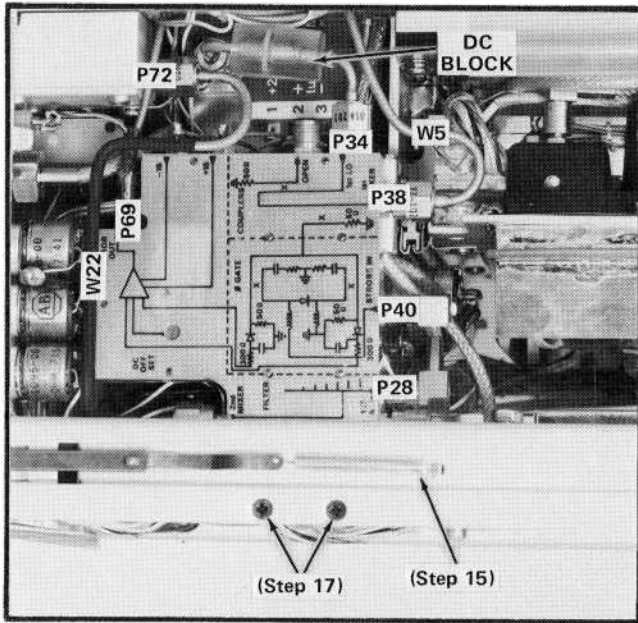
Removing the differential assembly requires the removal of the front panel and sub-panel, the hybrid (phase detector and 2nd LO) circuit, and most of the semi-rigid coaxial cables. Loosening the connectors for these cables requires a special 5/16 inch and two 15/64 inch open end wrenches. The special 5/16 inch wrench is ground to fit into limited access areas around P20 and P22. It can be ordered from Tektronix, Inc., (see Maintenance Tools).

**CAUTION**

*Do not use pliers to loosen or tighten these connectors. The connectors are torqued so they are slightly tighter than finger tight. If the nut on the plug does not loosen readily, use a second wrench as illustrated in Fig. 6-11 to hold the rigid portion of the connector so the cable does not bend or the connector at the jack does not twist.*

The following procedure, the exploded drawing in the Mechanical Parts section, and the pictorial illustrations that accompany this procedure, describe and illustrate the sequence required to replace the assembly.

1. Loosen P38-PJL and remove W5 (between the hybrid and 1st mixer).
2. Loosen and remove P34 from the hybrid.
3. Unplug P40, P28, and P69 from the hybrid.
4. Loosen P22 and P72 and remove cable W22.
5. Loosen P1 and remove from the RF input jack.
6. Loosen P20 and disconnect from the hybrid.
7. Unplug the harmonica connectors of the cables to the reference level readout board.
8. Disconnect the harmonica to the gain selector switch board and the display mode selector board.
9. Loosen and disconnect P1-P5 then swing the cable W4, the 3 dB pad, and the cable W3, out 90°.
10. Loosen and remove PR-P6 and remove W6.
11. Loosen and disconnect P7 from the traveling wave damper.
12. Turn all the front panel knobs fully clockwise (TIME/DIV to 1  $\mu$ s) and remove the knobs. Remove the nuts and plate against the panel for the FREQ/SPAN and RESOLUTION selectors. Remove the COARSE tuning control knob. Note; the spring behind the COARSE tuning control knob maintains pressure on the knob and provides smooth rotation of the control. This spring must be replaced when re-assembling.
13. Pry the front panel loose and remove. Note: Four indents at the top and bottom of the front panel hold it to the sub-panel.
14. Pull the center chassis out on its slide and remove harmonica connector P136 to the Reference Level Readout board. Unsolder the three wires indicated to Variable Gain potentiometer.



Location of connectors and cables to be disconnected when the Differential Attenuator Assembly is removed.

15. Disconnect the spring on the PULL TO UNLOCK latch.

16. Remove the (8) screws holding the sub-panel to the side, top and bottom rails.

17. Remove the two screws that hold the hybrid assembly to the side rail, then lift the assembly out and to the side. NOTE: Do not unsolder the leads to the hybrid assembly.

18. Pull the front sub-panel forward, until it clears the selector shafts.

19. Pull the attenuator, and differential assembly out and to the left so the Variable Gain shaft clears the front sub-panel.

Replacement procedure is the reverse of the removal procedure described above. When the knobs are replaced, ensure that they are indexed correctly by rotating the selectors through their range. Remember all knobs were positioned fully clockwise prior to removal. Torque the nuts for the semi-rigid connectors until snug, or until the rigid portion of the cable assembly starts to twist or warp.



# ELECTRICAL PARTS LIST

Replacement parts should be ordered from the Tektronix Field Office or Representative in your area. Changes to Tektronix products give you the benefit of improved circuits and components. Please include the instrument type number and serial number with each order for parts or service.

## ABBREVIATIONS AND REFERENCE DESIGNATORS

A	Assembly, separable or repairable	FL	Filter	PTM	paper or plastic, tubular molded
AT	Attenuator, fixed or variable	H	Heat dissipating device (heat sink, etc.)	R	Resistor, fixed or variable
B	Motor	HR	Heater	RT	Thermistor
BT	Battery	J	Connector, stationary portion	S	Switch
C	Capacitor, fixed or variable	K	Relay	T	Transformer
Cer	Ceramic	L	Inductor, fixed or variable	TP	Test point
CR	Diode, signal or rectifier	LR	Inductor/resistor combination	U	Assembly, inseparable or non-repairable
CRT	cathode-ray tube	M	Meter	V	Electron tube
DL	Delay line	Q	Transistor or silicon-controlled rectifier	Var	Variable
DS	Indicating device (lamp)	P	Connector, movable portion	VR	Voltage regulator (zener diode, etc.)
Elect.	Electrolytic	PMC	Paper, metal cased	WW	wire-wound
EMC	electrolytic, metal cased	PT	paper, tubular	Y	Crystal
EMT	electrolytic, metal tubular				
F	Fuse				

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
ASSEMBLIES				
A1 <sup>1</sup>	119-0331-00			DIFFERENTIAL ASSEMBLY
A1A1	670-1760-00			REFERENCE LEVEL READOUT Circuit Board Assembly
A4	119-0310-00			MIXER UNIT, PF, double balanced
A6	119-0342-00			HYBRID CIRCUIT ENCLOSURE
A10	119-0333-00			FILTER ASSEMBLY, 2.095 GHz
A11	119-0306-00			MIXER UNIT, single balanced
A20 <sup>1</sup>	119-0338-00			HYBRID CIRCUIT ASSEMBLY
A30 <sup>1</sup>	119-0289-00			OSCILLATOR ASSEMBLY, 2-4 GHz
A70	119-0332-00			TUNED CAVITY, 2 nd LO
A70A1	119-0105-02			VARACTOR ASSEMBLY
A80	119-0334-00			IF MODULE ASSEMBLY, 105 MHz
A80A1	670-1745-00			105 MHz IF Circuit Board Assembly
A80A2	205-0152-01			SHELL, tuned cavity, 2/tuning screws & cap
A90	670-1749-00	B010100	B039999	VIDEO FILTER & PROCESSOR Circuit Board Assembly
A90	670-1749-01	B040000		VIDEO FILTER & PROCESSOR Circuit Board Assembly
A101	670-1751-00			TRIG SOURCE SWITCH Circuit Board Assembly
A102	670-1748-00			TRIG MODE Circuit Board Assembly
A110	670-1750-00			START CTR FREQ SWITCH Circuit Board Assembly
A130	672-0037-00			DISPLAY MODE Circuit Board Assembly
A130A1	670-1752-00			DISPLAY MODE SW CONNECTOR Circuit Board Assembly
A130A2	670-1753-00			DISPLAY MODE RESISTOR Circuit Board Assembly
A200	670-1759-00			RESOLUTION Circuit Board Assembly
A500	670-1756-00	B010100	B019999	FUNCTION IF Circuit Board Assembly
A500	670-1756-01	B020000	B039999	FUNCTION IF Circuit Board Assembly
A500	670-1756-02	B040000		FUNCTION IF Circuit Board Assembly
A800	670-1757-00			FUNCTION IF CONNECTOR Circuit Board Assembly
A1000	670-1758-00	B010100	B039999	SWEEP DISPERSION Circuit Board Assembly
A1000	670-1758-01	B040000		SWEEP DISPERSION Circuit Board Assembly
A1300	670-1755-00	B010100	B029999	PHASE LOCK Circuit Board Assembly
A1300	670-1755-01	B030000	B039999	PHASE LOCK Circuit Board Assembly
A1300	670-1755-02	B040000		PHASE LOCK Circuit Board Assembly
A1700	670-1754-00			SWEEP SHARPER Circuit Board Assembly

<sup>1</sup>See Mechanical Parts List page 9-1 for repair and replacement program information.



## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
ATTENUATORS				
AT1 <sup>1</sup>				Attenuator, STEP
AT3	015-1024-00			Attenuator, 3dB
CAPACITORS				
C80	281-0618-00			4.7 pF, Cer, 200 V, $\pm 0.5$ pF
C82	281-0139-00			2.5-9 pF, Var, Cer
C83	283-0238-00			0.01 $\mu$ F, Cer, 50 V, 10%
C84	281-0697-00			5000 pF, Cer, 100 V, +100%-0%
C85	283-0156-00			1000 pF, Cer, 200 V, +100%-0%
C86	283-0156-00			1000 pF, Cer, 200 V, +100%-0%
C95	281-0122-00			2.5-9 pF, Var, Cer, 100 V
C201	283-0080-00			0.022 $\mu$ F, Cer, 25 V, -80%-20%
C204	283-0642-00			33 pF, Mica, 300 V, $\pm 0.5$ pF
C207	283-0080-00			0.022 $\mu$ F, Cer, 25 V, +80%-20%
C211	283-0080-00			0.022 $\mu$ F, Cer, 25 V, -80%-20%
C212	281-0616-00			6.8 pF, Cer, 200 V, $\pm 0.5$ pF
C230	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C231	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C232	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C241	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C242	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C244	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C248	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C250	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C253	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C258	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C260	281-0562-00			29 pF, Cer, 500 V
C261	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C267	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C270	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C272	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C280	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C281	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C283	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C288	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C290	281-0562-00			39 pF, Cer, 500 V
C292	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C294	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C296	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C300	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C320	283-0642-00			33 pF, Mica, 300 V, $\pm 0.5$ pF
C321	283-0603-00			113 pF, Mica, 300 V, 2%
C322	281-0092-00			9-35 pF, Var, Cer
C323	281-0615-00			3.9 pF, Cer, 200 V $\pm 0.5$ pF
C324	283-0644-00			150 pF, Mica, 500 V, 1%
C325	281-0092-00			9-35 pF, Var, Cer
C326	281-0615-00			3.9 pF, Cer, 200 V, $\pm 0.5$ pF
C327	283-0618-00			130 pF, Mica, 300 V, 2%
C328	281-0092-00			9-35 pF, Var, Cer
C329	281-0727-00			12.8 pF, Cer, 500 V, 1%
C333	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C338	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C340	281-0727-00			12.8 pF, Cer, 500 V, 1%
C341	283-0618-00			130 pF, Mica, 300 V, 2%
C342	281-0092-00			9-35 pF, Var, Cer

<sup>1</sup>Furnished as a unit with A1.

## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
CAPACITORS (cont)				
C343	281-0615-00			3.9 pF, Cer, 200 V, $\pm 0.5$ pF
C344	283-0644-00			150 pF, Mica, 500 V, 1%
C345	281-0092-00			9-35 pF, Var, Cer
C346	281-0615-00			3.9 pF, Cer, 200 V, $\pm 0.5$ pF
C347	283-0603-00			113 pF, Mica, 300 V, 2%
C348	281-0092-00			9-35 pF, Var, Cer
C349	283-0642-00			33 pF, Mica, 300 V, $\pm 0.5$ pF
C353	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C354	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C383	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C385	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C388	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C390	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C391	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C392	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C411	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C415	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C418	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C420	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C422	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C424	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C428	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C430	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C432	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C438	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C440	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C442	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C444	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C445	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C448	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C450	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C452	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C455	283-0665-00			190 pF, Mica, 100 V, 1%
C456	281-0123-00			5-25 pF, Var, Cer, 100 V
C457	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C458	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C462	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C468	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C470	281-0716-00			13.8 pF, Cer, 500 V, 1%
C471	283-0618-00			130 pF, Mica, 300 V, 2%
C472	281-0092-00			9-35 pF, Var, Cer,
C473	281-0612-00			5.6 pF, Cer, 200 V, $\pm 0.5$ pF
C474	283-0603-00			113 pF, Mica, 300 V, 2%
C475	281-0092-00			9-35 pF, Var, Cer
C476	283-0600-00			43 pF, Mica, 500 V, 5%
C477	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C479	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C500	283-0177-00			1 $\mu$ F, Cer, 25 V, +80%-20%
C501	283-0177-00			1 $\mu$ F, Cer, 25 V, +80%-20%
C502	283-0177-00			1 $\mu$ F, Cer, 25 V, +80%-20%

## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description
CAPACITORS (cont)				
C511	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C514	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C517	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C521	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C523	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C524	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C527	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C531	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C534	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C538	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C546	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C547	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C551	283-0167-00			0.1 $\mu$ F, Cer, 100 V, 10%
C554	281-0523-00			100 pF, Cer, 350 V, 20%
C560	281-0504-00			10 pF, Cer, 500 V, 10%
C562	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C566	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C567	283-0167-00			0.1 $\mu$ F, Cer, 100 V, 10%
C571	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C572	283-0167-00			0.1 $\mu$ F, Cer, 100 V, 10%
C574	281-0620-00			21 pF, Cer, 500 V, 1%
C581	283-0167-00			0.1 $\mu$ F, Cer, 100 V, 10%
C584	281-0523-00			100 pF, Cer, 350 V, 20%
C596	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C597	283-0167-00			0.1 $\mu$ F, Cer, 100 V, 10%
C601	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C602	283-0167-00			0.1 $\mu$ F, Cer, 100 V, 10%
C604	281-0620-00			21 pF, Cer, 500 V, 1%
C611	283-0167-00			0.1 $\mu$ F, Cer, 100 V, 10%
C614	281-0523-00			100 pF, Cer, 350 V, 20%
C626	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C627	283-0167-00			0.1 $\mu$ F, Cer, 100 V, 10%
C631	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C632	283-0167-00			0.1 $\mu$ F, Cer, 100 V, 10%
C634	281-0620-00			21 pF, Cer, 500 V, 1%
C641	283-0167-00			0.1 $\mu$ F, Cer, 100 V, 10%
C644	281-0523-00			100 pF, Cer, 350 V, 20%
C656	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C657	283-0167-00			0.1 $\mu$ F, Cer, 100 V, 10%
C661	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C662	283-0167-00			0.1 $\mu$ F, Cer, 100 V, 10%
C664	281-0620-00			21 pF, Cer, 500 V, 1%
C671	283-0167-00			0.1 $\mu$ F, Cer, 100 V, 10%
C674	281-0523-00			100 pF, Cer, 350 V, 20%
C685	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C686	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C687	283-0167-00			0.1 $\mu$ F, Cer, 100 V, 10%
C697	281-0576-00			11 pF, Cer, 500 V, 5%
C701	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C704	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C711	283-0167-00			0.1 $\mu$ F, Cer, 100 V, 10%
C714	281-0580-00			470 pF, Cer, 500 V, 10%
C727	283-0167-00			0.1 $\mu$ F, Cer, 100 V, 10%
C725	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%

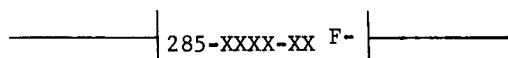
## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
CAPACITORS (cont)				
C726	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C731	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C732	283-0167-00			0.1 $\mu$ F, Cer, 100 V, 10%
C734	281-0577-00			14 pF, Cer, 500 V, 5%
C737	281-0576-00			11 pF, Cer, 500 V, 5%
C741	283-0177-00			1 $\mu$ F, Cer, 25 V, +80%-20%
C744	281-0511-00			22 pF, Cer, 500 V, 10%
C748	283-0177-00			1 $\mu$ F, Cer, 25 V, +80%-20%
C751	283-0177-00			1 $\mu$ F, Cer, 25 V, +80%-20%
C757	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C766	283-0000-00			0.001 $\mu$ F, Cer, 500 V, +100%-0%
C767	283-0177-00			1 $\mu$ F, Cer, 25 V, +80%-20%
C776	283-0167-00			0.1 $\mu$ F, Cer, 100 V, 10%
C811	281-0550-00			120 pF, Cer, 500 V, 10%
C813	281-0504-00			10 pF, Cer, 500 V, 10%
C814	283-0641-00			180 pF, Mica, 100 V, 1%
C816	283-0639-00			56 pF, Mica, 100 V, 1%
C817	283-0599-00			98 pF, Mica, 500 V, 5%
C820	283-0177-00			1 $\mu$ F, Cer, 25 V, +80%-20%
C823	283-0177-00			1 $\mu$ F, Cer, 25 V, +80%-20%
C826	281-0504-00			10 pF, Cer, 500 V, 10%
C827	283-0104-00	B010100	B039999X	2000 pF, Cer, 500 V, 5%
C828	283-0177-00	B010100	B039999X	1 pF, Cer, 25 V, +80%-20%
C830	285-0808-00	XB040000		0.1 $\mu$ F, Plastic, 50 V, 10%
C832	290-0536-00	XB040000		10 $\mu$ F, Elect., 25 V, 20%
C840	285-0659-00	XB040000		0.001 $\mu$ F, PTM, 100 V, 10%
C850	281-0578-00			18 pF, Cer, 500 V, 5%
C852	283-0000-00			0.001 $\mu$ F, Cer, 500 V, +100%-0%
C857	281-0523-00			100 pF, Cer, 350 V, 20%
C858	281-0523-00			100 pF, Cer, 350 V, 20%
C876	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C877	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C878	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C879	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C880	283-0010-00			0.05 $\mu$ F, Cer, 50 V
C890	281-0509-00			15 pF, Cer, 500 V, 10%
C892	283-0191-00			0.022 $\mu$ F, Cer, 50 V, 20%
C898	281-0518-00			47 pF, Cer, 500 V, 20%
C950	283-0598-00			253 pF, Mica, 300 V, 5%
C951	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C952	283-0000-00			0.001 $\mu$ F, Cer, 500 V, +100%-0%
C953	283-0000-00	B010100	B039999	0.001 $\mu$ F, Cer, 500 V, +100%-0%
C953	283-0005-00	B040000		0.01 $\mu$ F, Cer, 250 V, +100%-0%
C954	283-0000-00			0.001 $\mu$ F, Cer, 500 V, +100%-0%
C962	283-0000-00			0.001 $\mu$ F, Cer, 500 V, +100%-0%
C1000	283-0177-00			1 $\mu$ F, Cer, 25 V, +80%-20%
C1003	283-0177-00			1 $\mu$ F, Cer, 25 V, +80%-20%
C1010	283-0212-00			2 $\mu$ F, Cer, 50 V, 20%
C1011	283-0080-00			0.022 $\mu$ F, Cer, 25 V, +80%-20%
C1028	283-0212-00			2 $\mu$ F, Cer, 50 V, 20%
C1049	283-9177-00			1 $\mu$ F, Cer, 25 V, +80%-20%
C1060	283-0177-00			1 $\mu$ F, Cer, 25 V, +80%-20%
C1061	283-0177-00			1 $\mu$ F, Cer, 25 V, +80%-20%
C1075	281-0613-00			10 pF, Cer, 200 V, 10%
C1110	283-0177-00			1 $\mu$ F, Cer, 25 V, +80%-20%

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
CAPACITORS (cont)				
C1115	283-0198-00			0.22 $\mu$ F, Cer, 50 V, 20%
C1142	281-0523-00			100 pF, Cer, 350 V, 20%
C1143	283-0177-00			1 $\mu$ F, Cer, 25 V, +80%-20%
C1145	290-0415-00			5.6 $\mu$ F, Elect., 25 V, 10%
C1146	281-0543-00			270 pF, Cer, 500 V, 10%
C1147	285-0898-00			0.47 $\mu$ F, PTM, 100 V, 10%
C1151	281-0513-00			27 pF, Cer, 500 V, 20%
C1155	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C1157	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C1160	283-0198-00			0.22 $\mu$ F, Cer, 50 V, 20%
C1164	283-0003-00			0.01 $\mu$ F, Cer, 150 V, +80%-20%
C1166	281-0509-00			15 pF, Cer, 500 V, 10%
C1167	281-0523-00			100 pF, Cer, 350 V, 20%
C1191	295-0148-00			0.001 $\mu$ F
C1192				0.099 $\mu$ F, Timing capacitor
C1193				1 $\mu$ F
C1206	283-0177-00			1 $\mu$ F, Cer, 25 V, +80%-20%
C1207	283-0177-00			1 $\mu$ F, Cer, 25 V, +80%-20%
C1215	281-0613-00			10 pF, Cer, 200 V, 10%
C1222	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C1300	283-0059-00			1 $\mu$ F, Cer, 25 V, +80%-20%
C1301	283-0059-00			1 $\mu$ F, Cer, 25 V, +80%-20%
C1302	283-0059-00			1 $\mu$ F, Cer, 25 V, +80%-20%
C1303	283-0094-00			27 pF, Cer, 200 V, 10%
C1304	283-0003-00			0.1 $\mu$ F, Cer, 150 V, +80%-20%
C1314	283-0052-00			105 pF, Cer, 500 V, 1%
C1326	283-0052-00			105 pF, Cer, 500 V, 1%
C1336	283-0129-00			0.56 $\mu$ F, Cer, 100 V, 20%
C1337	283-0129-00			0.56 $\mu$ F, Cer, 100 V, 20%
C1339	283-0129-00			0.56 $\mu$ F, Cer, 100 V, 20%
C1340	283-0052-00			105 pF, Cer, 500 V, 1%
C1350	281-0518-00			47 pF, Cer, 500 V, 20%
C1355	285-0913-00			3 $\mu$ F, PTM, 50 V, 5%
C1356	285-0919-00			22 $\mu$ F, Plastic, 100 V, 10%
C1362	285-1048-00			2 $\mu$ F, Plastic, 100 V, 5%
C1380	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C1381	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C1382	290-0519-00			100 $\mu$ F, Elect., 20 V, 20%
C1410	281-0528-00			82 pF, Cer, 500 V, 10%
C1411	283-0000-00			0.001 $\mu$ F, Cer, 500 V, +100%-0%
C1441	290-0512-00			22 $\mu$ F, Elect., 15 V, 20%
C1453	290-0517-00			6.8 $\mu$ F, Elect., 35 V, 20%
C1474	283-0060-00			100 pF, Cer, 200 V, 5%
C1476	290-0513-00			510 $\mu$ F, Elect., 25 V, +75%-10%
C1477	290-0513-00			510 $\mu$ F, Elect., 25 V, +75%-10%
C1500	283-0059-00			1 $\mu$ F, Cer, 25 V, +80%-20%

<sup>1</sup>Individual timing capacitors in this assembly must be ordered by the 9 digit part number, letter suffix and tolerance printed on the timing capacitor to be replaced.  
Example:



The letter suffix and the tolerance should be the same for all of the timing capacitors in the assembly.



## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
CAPACITORS (cont)				
C1510	283-0059-00			1 $\mu$ F, Cer, 25 V, +80%-20%
C1518	283-0059-00			1 $\mu$ F, Cer, 25 V, +80%-20%
C1520	283-0067-00	XB030000		0.001 $\mu$ F, Cer, 200 V, 10%
C1522	290-0536-00			10 $\mu$ F, Elect., 25 V, 20%
C1527	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C1530	290-0528-00			15 $\mu$ F, Elect., 50 V, 20%
C1538	283-0059-00			1 $\mu$ F, Cer, 25 V, +80%-20%
C1539	290-0536-00			10 $\mu$ F, Elect., 25 V, 20%
C1542	283-0238-00			0.01 $\mu$ F, Cer, 50 V, 10%
C1545	283-0238-00			0.01 $\mu$ F, Cer, 50 V, 10%
C1546	283-0059-00			1 $\mu$ F, Cer, 25 V, -80%-20%
C1556	290-0525-00			4.7 $\mu$ F, Elect., 50 V, 20%
C1558	290-0535-00			33 $\mu$ F, Elect., 10 V, 20%
C1611	290-0525-00			4.7 $\mu$ F, Elect., 50 V, 20%
C1638	290-0532-00			150 $\mu$ F, Elect., 6 V, 20%
C1741	283-0238-00			0.01 $\mu$ F, Cer, 50 V, 10%
C1748	281-0551-00			390 pF, Cer, 500 V, 10%
C1754	281-0504-00			10 pF, Cer, 500 V, 10%
C1756	283-0111-00			0.1 $\mu$ F, Cer, 50 V
C1771	290-0532-00			150 $\mu$ F, Elect., 6 V, 20%
C1775	290-0525-00			4.7 $\mu$ F, Elect., 50 V, 20%
C1776	290-0531-00			100 $\mu$ F, Elect., 10 V, 20%
C1781	290-0531-00			100 $\mu$ F, Elect., 10 V, 20%
C1941	290-0527-00			15 pF, Elect., 20 V, 20%
DIODES				
CR91	153-0044-00			Silicon, replaceable by A1108, matched quad
CR92				
CR93				
CR94				
CR242	152-0524-00			Silicon, PIN, 100 V, 25 $\Omega$ , at 100 mA
CR280	152-0141-02			Silicon, replaceable by 1N4152
CR355	152-0141-02			Silicon, replaceable by 1N4152
CR356	152-0141-02			Silicon, replaceable by 1N4152
CR357	152-0141-02			Silicon, replaceable by 1N4152
CR415	152-0524-00			Silicon, PIN, 100 V, 25 $\Omega$ , at 100 mA
CR418	152-0524-00			Silicon, PIN, 100 V, 25 $\Omega$ at 100 mA
CR444	152-0524-00			Silicon, PIN, 100 V, 25 $\Omega$ at 100 mA
CR457	152-0141-02			Silicon, replaceable by 1N4152
CR478	152-0141-02			Silicon, replaceable by 1N4152
CR511	152-0322-00			Silicon, replaceable by A1108
CR512	152-0322-00			Silicon, replaceable by A1108
CR514	152-0322-00			Silicon, replaceable by A1108
CR515	152-0322-00			Silicon, replaceable by A1108
CR517	152-0322-00			Silicon, replaceable by A1108
CR518	152-0322-00			Silicon, replaceable by A1108
CR521	152-0322-00			Silicon, replaceable by A1108
CR522	152-0322-00			Silicon, replaceable by A1108
CR524	152-0322-00			Silicon, replaceable by A1108
CR525	152-0322-00			Silicon, replaceable by A1108
CR527	152-0322-00			Silicon, replaceable by A1108
CR528	152-0322-00			Silicon, replaceable by A1108
CR531	152-0322-00			Silicon, replaceable by A1108
CR532	152-0322-00			Silicon, replaceable by A1108
CR534	152-0322-00			Silicon, replaceable by A1108
CR535	152-0322-00			Silicon, replaceable by A1108
CR540	152-0141-02			Silicon, replaceable by 1N4152

## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
DIODES (cont)				
CR546	152-0322-00			Silicon, replaceable by A1108
CR547	152-0322-00			Silicon, replaceable by A1108
CR701	152-0141-02			Silicon, replaceable by 1N4152
CR771	152-0322-00			Silicon, replaceable by A1108
CR772	152-0322-00			Silicon, replaceable by A1108
CR801	152-0141-02			Silicon, replaceable by 1N4152
CR802	152-0141-02			Silicon, replaceable by 1N4152
CR825	152-0141-02			Silicon, replaceable by 1N4152
CR826	152-0141-02			Silicon, replaceable by 1N4152
CR842	152-0141-02	B010100	B039999X	Silicon, replaceable by 1N4152
CR843	152-0141-02	B010100	B039999X	Silicon, replaceable by 1N4152
CR854	152-0141-02			Silicon, replaceable by 1N4152
CR887	152-0141-02			Silicon, replaceable by 1N4152
CR888	152-0141-02			Silicon, replaceable by 1N4152
CR895	152-0141-02			Silicon, replaceable by 1N4152
CR898	152-0141-02			Silicon, replaceable by 1N4152
CR1050	152-0141-02			Silicon, replaceable by 1N4152
CR1051	152-0141-02			Silicon, replaceable by 1N4152
CR1077	152-0141-02			Silicon, replaceable by 1N4152
CR1078	152-0141-02			Silicon, replaceable by 1N4152
CR1130	152-0141-02			Silicon, replaceable by 1N4152
CR1133	152-0141-02			Silicon, replaceable by 1N4152
CR1149	152-0141-02			Silicon, replaceable by 1N4152
CR1157	152-0141-02			Silicon, replaceable by 1N4152
CR1200	152-0141-02			Silicon, replaceable by 1N4152
CR1320	152-0322-00			Silicon, replaceable by A1108
CR1330	152-0322-00			Silicon, replaceable by A1108
CR1368	152-0141-02			Silicon, replaceable by 1N4152
CR1369	152-0141-02			Silicon, replaceable by 1N4152
CR1400	152-0141-02			Silicon, replaceable by 1N4152
CR1432	152-0141-02			Silicon, replaceable by 1N4152
CR1433	152-0141-02			Silicon, replaceable by 1N4152
CR1450	152-0141-02			Silicon, replaceable by 1N4152
CR1476	152-0141-02			Silicon, replaceable by 1N4152
CR1514	152-0141-02			Silicon, replaceable by 1N4152
CR1515	152-0141-02			Silicon, replaceable by 1N4152
CR1524	152-0141-02			Silicon, replaceable by 1N4152
CR1525	152-0141-02			Silicon, replaceable by 1N4152
CR1543	152-0141-02			Silicon, replaceable by 1N4152
CR1544	152-0141-02			Silicon, replaceable by 1N4152
CR1550	152-0141-02			Silicon, replaceable by 1N4152
CR1559	152-0141-02			Silicon, replaceable by 1N4152
CR1560	152-0141-02			Silicon, replaceable by 1N4152
CR1589	152-0141-02			Silicon, replaceable by 1N4152
CR1590	152-0141-02			Silicon, replaceable by 1N4152
CR1591	152-0141-02			Silicon, replaceable by 1N4152
CR1629	152-0141-02			Silicon, replaceable by 1N4152
CR1701	152-0141-02			Silicon, replaceable by 1N4152
CR1702	152-0141-02			Silicon, replaceable by 1N4152
CR1703	152-0141-02			Silicon, replaceable by 1N4152
CR1704	152-0141-02			Silicon, replaceable by 1N4152
CR1705	152-0141-02			Silicon, replaceable by 1N4152
CR1706	152-0141-02			Silicon, replaceable by 1N4152

## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
DIODES (cont)				
CR1707	152-0141-02			Silicon, replaceable by 1N4152
CR1708	152-0141-02			Silicon, replaceable by 1N4152
CR1709	152-0141-02			Silicon, replaceable by 1N4152
CR1710	152-0141-02			Silicon, replaceable by 1N4152
CR1711	152-0141-02			Silicon, replaceable by 1N4152
CR1721	152-0141-02			Silicon, replaceable by 1N4152
CR1754	152-0141-02			Silicon, replaceable by 1N4152
VR1518	152-0123-00			Zener, selected from 1N935A, 0.5 W, 9 V, 5%
VR1626	152-0461-00			Zener, replaceable by 1N821, 0.4 W, 6.2 V, 5%
BULBS				
DS90A, B <sup>4</sup>		BO10100	BO29999	
DS90A, B, C <sup>4</sup>		BO40000		
DS101 <sup>1</sup>				
DS102 <sup>2</sup>				
DS103 <sup>2</sup>				
DS114 <sup>3</sup>	150-0048-00			Incandescent, #683, 5 V, 60 mA
DS116 <sup>3</sup>				
FILTERS				
FL2	119-0294-00			Filter, Low Pass, 1.8 GHz
FL360	119-0276-00			Filter, Bandpass, 10 MHz
FL370	119-0278-00			Filter, Bandpass, 10 MHz
FL380	119-0275-00			Filter, Bandpass, 10 MHz
CONNECTORS				
J80	131-0156-00			Coax, mini
J92	131-0156-00			Coax, mini
J95	131-0156-00			Coax, mini
J98	131-0779-00			Jack, TIP
J99	131-0818-00			Receptacle, electrical, female, BNC
J100	131-0779-00			Jack, TIP
J211	131-0391-01			Receptacle, electrical, snap-on male
J240	131-0391-01			Receptacle, electrical, snap-on male
J900	131-0391-01			Receptacle, electrical, snap-on male
J1348	131-0391-01			Receptacle, electrical, snap-on male
RELAYS				
K281	148-0088-00			Relay, 120 mW, DPDT
K300	148-0087-00			Relay, 90 mW, SPDT
K353	148-0087-00			Relay, 90 mW, SPDT
K354	148-0088-00			Relay, 120 mW, DPDT
K355	148-0088-00			Relay, 120 mW, DPDT
K356	148-0087-00			Relay, 90 mW, SPDT
K357	148-0088-00			Relay, 120 mW, DPDT
K1130	148-0088-00			Relay, 120 mW, DPDT
K1200	148-0087-00			Relay, 90 mW, SPDT
K1400	148-0088-00			Relay, 120 mW, DPDT
K1450	148-0088-00			Relay, 120 mW, DPDT
K1470	148-0076-00			Relay, mag reed, 100 V, 10 W

<sup>1</sup>Furnished as a unit with A101.

<sup>2</sup>Furnished as a unit with A102.

<sup>3</sup>Furnished as a unit with A110.

<sup>4</sup>Furnished as a unit with A90.

## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
INDUCTORS				
L30(7)	276-0507-00			Core, ferramic suppressor
L31(7)	276-0507-00			Core, ferramic suppressor
L80	108-0215-00			1.1 $\mu$ H
L82	108-0706-00			146 nH
L86	108-0703-00			3 $\mu$ H
L87	108-0704-00			3.27 $\mu$ H
L88	108-0705-00			3.56 $\mu$ H
L202	108-0315-00			0.22 $\mu$ H
L204	108-0062-00			0.45 $\mu$ H
L230	108-0395-00			64 $\mu$ H
L231	108-0395-00			64 $\mu$ H
L232	108-0395-00			64 $\mu$ H
L254	108-0406-00			80 $\mu$ H
L284	108-0406-00			80 $\mu$ H
L292	108-0406-00			80 $\mu$ H
L321	108-0701-00			1.32 $\mu$ H
L324	108-0701-00			1.32 $\mu$ H
L327	108-0701-00			1.32 $\mu$ H
L341	108-0701-00			1.32 $\mu$ H
L344	108-0701-00			1.32 $\mu$ H
L347	108-0701-00			1.32 $\mu$ H
L390	108-0395-00			64 $\mu$ H
L391	108-0395-00			64 $\mu$ H
L392	108-0395-00			64 $\mu$ H
L455	108-0095-00			1.4 $\mu$ H
L471	108-0701-00			1.32 $\mu$ H
L474	108-0701-00			1.32 $\mu$ H
L533	108-0240-00			820 $\mu$ H
L548	108-0443-00			25 $\mu$ H
L813	108-0702-00			36 $\mu$ H
L816	108-0443-00			25 $\mu$ H
L950	108-0538-00			2.7 $\mu$ H
L951	108-0666-00			900 $\mu$ H
L954	276-0507-00			Core, ferramic suppressor
L958	276-0507-00			Core, ferramic suppressor
L1300	108-0395-00			64 $\mu$ H
L1310	276-0507-00			Core, ferramic suppressor
L1330	108-0395-00			64 $\mu$ H
L1336	108-0395-00			64 $\mu$ H
TERMINATION				
P29	015-1025-00			Termination, coax
TRANSISTORS				
Q85	151-1055-00			Silicon, FET, replaceable by 3N159
Q114	151-0207-00			Silicon, NPN, replaceable by 2N3415
Q116	151-0207-00			Silicon, NPN, replaceable by 2N3415
Q204	151-0269-00			Silicon, NPN, replaceable by SE3005
Q211	151-0269-00			Silicon, NPN, replaceable by SE3005
Q240	151-0269-00			Silicon, NPN, replaceable by SE3005
Q250	151-0269-00			Silicon, NPN, replaceable by SE3005
Q260	151-0269-00			Silicon, NPN, replaceable by SE3005
Q270	151-0220-00			Silicon, PNP, replaceable by 2N4122
Q280	151-0269-00			Silicon, NPN, replaceable by SE3005
Q290	151-0269-00			Silicon, NPN, replaceable by SE3005

## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
TRANSISTORS (cont)				
Q330	151-0269-00			Silicon, NPN, replaceable by SE3005
Q380	151-0269-00			Silicon, NPN, replaceable by SE3005
Q420	151-0220-00			Silicon, PNP, replaceable by 2N4122
Q430	151-0220-00			Silicon, PNP, replaceable by 2N4122
Q440	151-0220-00			Silicon, PNP, replaceable by 2N4122
Q450	151-0220-00			Silicon, PNP, replaceable by 2N4122
Q460	151-0220-00			Silicon, PNP, replaceable by 2N4122
Q540	151-0195-00			Silicon, NPN, selected from MPS6515
Q550	151-0269-00			Silicon, NPN, replaceable by SE3005
Q560	151-0269-00			Silicon, NPN, replaceable by SE3005
Q570	151-0220-00			Silicon, PNP, replaceable by 2N4122
Q580	151-0269-00			Silicon, NPN, replaceable by SE3005
Q590	151-0269-00			Silicon, NPN, replaceable by SE3005
Q600	151-0220-00			Silicon, PNP, replaceable by 2N4122
Q610	151-0269-00			Silicon, NPN, replaceable by SE3005
Q620	151-0269-00			Silicon, NPN, replaceable by SE3005
Q630	151-0220-00			Silicon, PNP, replaceable by 2N4122
Q640	151-0269-00			Silicon, NPN, replaceable by SE3005
Q650	151-0269-00			Silicon, NPN, replaceable by SE3005
Q660	151-0220-00			Silicon, PNP, replaceable by 2N4122
Q670	151-0269-00			Silicon, NPN, replaceable by SE3005
Q680	151-0269-00			Silicon, NPN, replaceable by SE3005
Q700	151-0269-00			Silicon, NPN, replaceable by SE3005
Q710	151-0269-00			Silicon, NPN, replaceable by SE3005
Q720	151-0269-00			Silicon, NPN, replaceable by SE3005
Q730	151-0220-00			Silicon, PNP, replaceable by 2N4122
Q740	151-0195-00			Silicon, NPN, selected from MPS6515
Q750	151-0221-00			Silicon, PNP, replaceable by 2N4258
Q760	151-0221-00			Silicon, PNP, replaceable by 2N4258
Q827	151-1006-00	B010100	B039999X	Silicon, FET, selected from 2N4304 or replaceable by U1491
Q828	151-1006-00	B010100	B039999X	Silicon, FET, selected from 2N4304 or replaceable by U1491
Q841	151-0220-00	B010100	B039999X	Silicon, PNP, replaceable by 2N4122
Q842	151-0220-00	B010100	B039999X	Silicon, PNP, replaceable by 2N4122
Q843	151-0220-00	B010100	B039999X	Silicon, PNP, replaceable by 2N4122
Q880	151-0195-00			Silicon, NPN, selected from MPS6515
Q887	151-0195-00			Silicon, NPN, selected from MPS6515
Q890	151-0195-00			Silicon, NPN, selected from MPS6515
Q895	151-0269-00			Silicon, NPN, replaceable by SE3005
Q898	151-0269-00			Silicon, NPN, replaceable by SE3005
Q950	151-0269-00			Silicon, NPN, replaceable by SE3005
Q960	151-0269-00			Silicon, NPN, replaceable by SE3005
Q1106	151-0188-00			Silicon, PNP, replaceable by 2N3906
Q1117	151-0503-00			Silicon, SCR, replaceable by 2N5060
Q1156	151-0333-00			Silicon, NPN, selected from MPS918
Q1183	151-0273-00			Silicon, NPN, selected from 2N5249
Q1185	151-0276-00			Silicon, PNP, replaceable by 2N5087
Q1300	151-0190-01			Silicon, NPN, replaceable by 2N3904 or TE3904
Q1310	151-0192-00			Silicon, NPN, selected from MPS6521
Q1320	151-0327-00			Silicon, PNP, replaceable by TN4258
Q1330	151-0288-00			Silicon, NPN, replaceable by A210
Q1338	151-0228-00			Silicon, PNP, selected from 2N4888



## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
TRANSISTORS (cont)				
Q1339	151-0250-00			Silicon, NPN, selected from FPS5551M
Q1470	151-0148-00			Silicon, NPN, selected from 40250
Q1480	151-0195-00			Silicon, NPN, selected from MPS6515
Q1506	151-0188-00			Silicon, PNP, replaceable by 2N3906
Q1517	151-0136-00			Silicon, NPN, replaceable by 2N3053
Q1518	151-0190-01			Silicon, NPN, replaceable by 2N3904 or TE3904
Q1525	151-0136-00			Silicon, NPN, replaceable by 2N3053
Q1545	151-0510-00			Silicon, unijunction, replaceable by 2N4852
Q1561	151-0188-00			Silicon, PNP, replaceable by 2N3906
Q1564	151-0190-01			Silicon, NPN, replaceable by 2N3904 or TE3904
Q1568	151-0190-01			Silicon, NPN, replaceable by 2N3904 or TE3904
Q1574	151-0190-01			Silicon, NPN, replaceable by 2N3904 or TE3904
Q1578	151-0190-01			Silicon, NPN, replaceable by 2N3904 or TE3904
Q1584	151-0190-01			Silicon, NPN, replaceable by 2N3904 or TE3904
Q1588	151-0190-01			Silicon, NPN, replaceable by 2N3904 or TE3904
Q1740A, B	151-0232-00			Silicon, NPN, replaceable by NS7348 or selected from 2N2919, dual
Q1754	151-0188-00			Silicon, PNP, replaceable by 2N2906
Q1770A, B	151-0232-00			Silicon, NPN, replaceable by NS7348 or selected from 2N2919, dual
Q1776	151-0341-00			Silicon, NPN, replaceable by 2N3565
RESISTORS				
R80	311-0328-00			1 k $\Omega$ , Var
R82 <sup>1</sup>	311-1291-00			1 k $\Omega$ , Var
R84	315-0114-00			110 k $\Omega$ , 1/4 W, 5%
R85	315-0393-00			39 k $\Omega$ , 1/4 W, 5%
R86	315-0221-00			220 $\Omega$ , 1/4 W, 5%
R91	317-0510-00			51 $\Omega$ , 1/8 W, 5%
R92	317-0510-00			51 $\Omega$ , 1/8 W, 5%
R93	317-0510-00			51 $\Omega$ , 1/8 W, 5%
R94	317-0510-00			51 $\Omega$ , 1/8 W, 5%
R95	311-0328-00			1 k $\Omega$ , Var
R96	311-1095-00			10 k $\Omega$ , Var
R97	311-0326-00			10 k $\Omega$ , Var
R98	311-1095-00			10 k $\Omega$ , Var
R100 <sup>2</sup>	311-1203-00			100 k $\Omega$ , Var
R105A, B	311-1309-01			2 x 500 k $\Omega$ , Var
R106	311-1045-00			250 k $\Omega$ , Var
R107	311-0387-00			5 k $\Omega$ , Var
R109	311-1017-01			20 k $\Omega$ , Var
R110	315-0123-00			12 k $\Omega$ , 1/4 W, 5%
R111	315-0104-00			100 k $\Omega$ , 1/4 W, 5%
R113	315-0333-00			33 k $\Omega$ , 1/4 W, 5%
R115	315-0332-00			3.3 k $\Omega$ , 1/4 W, 5%
R124	311-1215-00			2 k $\Omega$ , Var
R125A, B	311-1162-00			2 x 10 k $\Omega$ , Var
R130	321-0402-00			150 k $\Omega$ , 1/8 W, 1%
R131	321-0373-00			75 k $\Omega$ , 1/8 W, 1%
R132	321-0356-00			49.9 k $\Omega$ , 1/8 W, 1%
R133	321-0356-00			49.9 k $\Omega$ , 1/8 W, 1%
R134	321-0335-00			30.1 k $\Omega$ , 1/8 W, 1%
R135	321-0327-00			24.9 k $\Omega$ , 1/8 W, 1%

<sup>1</sup>Furnished as a unit with S82.

<sup>2</sup>Furnished as a unit with S100.

## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description
RESISTORS				
R136	321-0344-00			37.4 k $\Omega$ , 1/8 W, 1%
R137	321-0327-00			24.9 k $\Omega$ , 1/8 W, 1%
R138	321-0344-00			37.4 k $\Omega$ , 1/8 W, 1%
R139	321-0356-00			49.9 k $\Omega$ , 1/8 W, 1%
R140	321-0402-00			150 k $\Omega$ , 1/8 W, 1%
R141	321-0321-00			21.5 k $\Omega$ , 1/8 W, 1%
R142	321-0344-00			37.4 k $\Omega$ , 1/8 W, 1%
R143	321-0321-00			21.5 k $\Omega$ , 1/8 W, 1%
R144	321-0344-00			37.4 k $\Omega$ , 1/8 W, 1%
R145	321-0373-00			75 k $\Omega$ , 1/8 W, 1%
R146	321-0335-00			30.1 k $\Omega$ , 1/8 W, 1%
R147	321-0344-00			37.4 k $\Omega$ , 1/8 W, 1%
R148	321-0402-00			150 k $\Omega$ , 1/8 W, 1%
R149	321-0344-00			37.4 k $\Omega$ , 1/8 W, 1%
R150	321-0402-00			150 k $\Omega$ , 1/8 W, 1%
R160	321-0373-00			75 k $\Omega$ , 1/8 W, 1%
R161	321-0306-00			15 k $\Omega$ , 1/8 W, 1%
R162	321-0402-00			150 k $\Omega$ , 1/8 W, 1%
R163	321-0327-00			24.9 k $\Omega$ , 1/8 W, 1%
R164	321-0321-00			21.5 k $\Omega$ , 1/8 W, 1%
R165	321-0402-00			150 k $\Omega$ , 1/8 W, 1%
R166	321-0373-00			75 k $\Omega$ , 1/8 W, 1%
R167	321-0344-00			37.4 k $\Omega$ , 1/8 W, 1%
R168	321-0344-00			37.4 k $\Omega$ , 1/8 W, 1%
R169	321-0356-00			49.9 k $\Omega$ , 1/8 W, 1%
R170	321-0402-00			150 k $\Omega$ , 1/8 W, 1%
R180	321-0344-00			37.4 k $\Omega$ , 1/8 W, 1%
R181	321-0356-00			49.9 k $\Omega$ , 1/8 W, 1%
R182	321-0373-00			75 k $\Omega$ , 1/8 W, 1%
R183	321-0335-00			30.1 k $\Omega$ , 1/8 W, 1%
R184	321-0327-00			24.9 k $\Omega$ , 1/8 W, 1%
R185	321-0321-00			21.5 k $\Omega$ , 1/8 W, 1%
R186	321-0315-00			18.7 k $\Omega$ , 1/8 W, 1%
R187	321-0310-00			16.5 k $\Omega$ , 1/8 W, 1%
R188	321-0300-00			13 k $\Omega$ , 1/8 W, 1%
R189	321-0402-00			150 k $\Omega$ , 1/8 W, 1%
R190	321-0335-00			30.1 k $\Omega$ , 1/8 W, 1%
R191	321-0402-00			150 k $\Omega$ , 1/8 W, 1%
R192	321-0402-00			150 k $\Omega$ , 1/8 W, 1%
R193	321-0327-00			24.9 k $\Omega$ , 1/8 W, 1%
R194	321-0373-00			75 k $\Omega$ , 1/8 W, 1%
R195	321-0327-00			24.9 k $\Omega$ , 1/8 W, 1%
R196	321-0402-00			150 k $\Omega$ , 1/8 W, 1%
R201	315-0242-00			2.4 k $\Omega$ , 1/4 W, 5%
R202	315-0221-00			220 $\Omega$ , 1/4 W, 5%
R205	315-0272-00			2.7 k $\Omega$ , 1/4 W, 5%
R207	315-0470-00			47 $\Omega$ , 1/4 W, 5%
R210	315-0510-00			51 $\Omega$ , 1/4 W, 5%
R211	315-0470-00			47 $\Omega$ , 1/4 W, 5%
R214	315-0181-00			180 $\Omega$ , 1/4 W, 5%
R215	315-0622-00			6.2 k $\Omega$ , 1/4 W, 5%

## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R240	315-0220-00			22 $\Omega$ , 1/4 W, 5%
R242	315-0472-00			4.7 k $\Omega$ , 1/4 W, 5%
R244	315-0510-00			51 $\Omega$ , 1/4 W, 5%
R245	315-0301-00			300 $\Omega$ , 1/4 W, 5%
R247	315-0301-00			300 $\Omega$ , 1/4 W, 5%
R248	315-0302-00			3 k $\Omega$ , 1/4 W, 5%
R250	321-0277-00			7.5 k $\Omega$ , 1/8 W, 1%
R251	315-0220-00			22 $\Omega$ , 1/4 W, 5%
R253	315-0910-00			91 $\Omega$ , 1/4 W, 5%
R254	321-0143-00			301 $\Omega$ , 1/8 W, 1%
R255	315-0100-00			10 $\Omega$ , 1/4 W, 5%
R257	321-0202-00			1.24 k $\Omega$ , 1/8 W, 1%
R258	321-0158-00			432 $\Omega$ , 1/8 W, 1%
R260	315-0220-00			22 $\Omega$ , 1/4 W, 5%
R261	315-0331-00			330 $\Omega$ , 1/4 W, 5%
R264	321-0072-00			54.9 $\Omega$ , 1/8 W, 1%
R266	315-0100-00			10 $\Omega$ , 1/4 W, 5%
R267	311-0622-00			100 $\Omega$ , Var
R268	315-0391-00			390 $\Omega$ , 1/4 W, 5%
R270	315-0202-00			2 k $\Omega$ , 1/4 W, 5%
R272	315-0511-00			510 $\Omega$ , 1/4 W, 5%
R275	315-0390-00			39 $\Omega$ , 1/4 W, 5%
R276	315-0203-00			20 k $\Omega$ , 1/4 W, 5%
R280	315-0105-00			1 M $\Omega$ , 1/4 W, 5%
R281	321-0277-00			7.5 k $\Omega$ , 1/8 W, 1%
R282	315-0220-00			22 $\Omega$ , 1/4 W, 5%
R283	315-0910-00			91 $\Omega$ , 1/4 W, 5%
R284	321-0143-00			301 $\Omega$ , 1/8 W, 1%
R285	315-0100-00			10 $\Omega$ , 1/4 W, 5%
R287	321-0202-00			1.24 k $\Omega$ , 1/8 W, 1%
R288	321-0158-00			432 $\Omega$ , 1/8 W, 1%
R290	315-0431-00			430 $\Omega$ , 1/4 W, 5%
R291	315-0220-00			22 $\Omega$ , 1/4 W, 5%
R292	315-0331-00			330 $\Omega$ , 1/4 W, 5%
R293	315-0105-00			1 M $\Omega$ , 1/4 W, 5%
R294	321-0072-00			54.9 $\Omega$ , 1/8 W, 1%
R295	315-0100-00			10 $\Omega$ , 1/4 W, 5%
R296	315-0680-00			68 $\Omega$ , 1/4 W, 5%
R297	311-0605-00			200 $\Omega$ , Var
R298	315-0391-00			390 $\Omega$ , 1/4 W, 5%
R300	315-0220-00			22 $\Omega$ , 1/4 W, 5%
R306	321-0077-00			61.9 $\Omega$ , 1/8 W, 1%
R307	311-0622-00			100 $\Omega$ , Var
R308	315-0121-00			120 $\Omega$ , 1/4 W, 5%
R330	321-0165-00			511 $\Omega$ , 1/8 W, 1%
R331	315-0470-00			47 $\Omega$ , 1/4 W, 5%
R333	315-0201-00			200 $\Omega$ , 1/4 W, 5%
R334	321-0172-00			604 $\Omega$ , 1/8 W, 1%
R337	321-0097-00			100 $\Omega$ , 1/8 W, 1%
R338	315-0132-00			1.3 k $\Omega$ , 1/4 W, 5%

## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R353	315-0220-00			22 $\Omega$ , 1/4 W, 5%
R354	315-0220-00			22 $\Omega$ , 1/4 W, 5%
R356	321-0077-00			61.9 $\Omega$ , 1/8 W, 1%
R357	311-0622-00			100 $\Omega$ , Var
R358	315-0121-00			120 $\Omega$ , 1/4 W, 5%
R366	321-0077-00			61.9 $\Omega$ , 1/8 W, 1%
R367	311-0622-00			100 $\Omega$ , Var
R368	315-0121-00			120 $\Omega$ , 1/4 W, 5%
R376	321-0077-00			61.9 $\Omega$ , 1/8 W, 1%
R377	311-0622-00			100 $\Omega$ , Var
R378	315-0121-00			120 $\Omega$ , 1/4 W, 5%
R380	321-0068-00			49.9 $\Omega$ , 1/8 W, 1%
R383	315-0112-00			1.1 k $\Omega$ , 1/4 W, 5%
R384	321-0136-00			255 $\Omega$ , 1/8 W, 1%
R385	315-0104-00			100 k $\Omega$ , 1/4 W, 5%
R386	315-0101-00			100 $\Omega$ , 1/4 W, 5%
R387	311-0605-00			200 $\Omega$ , Var
R388	315-0242-00			2.4 k $\Omega$ , 1/4 W, 5%
R410	315-0102-00			1 k $\Omega$ , 1/4 W, 5%
R411	311-0609-00			2 k $\Omega$ , Var
R412	315-0102-00			1 k $\Omega$ , 1/4 W, 5%
R415	315-0752-00			7.5 k $\Omega$ , 1/4 W, 5%
R416	311-1035-00			50 k $\Omega$ , Var
R417	311-1266-00			2.5 k $\Omega$ , Var
R418	315-0302-00			3 k $\Omega$ , 1/4 W, 5%
R420	315-0133-00			13 k $\Omega$ , 1/4 W, 5%
R422	315-0471-00			470 $\Omega$ , 1/4 W, 5%
R423	315-0151-00			150 $\Omega$ , 1/4 W, 5%
R424	315-0750-00			75 $\Omega$ , 1/4 W, 5%
R425	311-0605-00			200 $\Omega$ , Var
R427	315-0621-00			620 $\Omega$ , 1/4 W, 5%
R428	315-0821-00			820 $\Omega$ , 1/4 W, 5%
R430	315-0133-00			13 k $\Omega$ , 1/4 W, 5%
R432	315-0301-00			300 $\Omega$ , 1/4 W, 5%
R433	315-0301-00			300 $\Omega$ , 1/4 W, 5%
R437	315-0621-00			620 $\Omega$ , 1/4 W, 5%
R438	315-0821-00			820 $\Omega$ , 1/4 W, 5%
R440	315-0133-00			13 k $\Omega$ , 1/4 W, 5%
R442	315-0301-00			300 $\Omega$ , 1/4 W, 5%
R443	315-0301-00			300 $\Omega$ , 1/4 W, 5%
R445	315-0242-00			2.4 k $\Omega$ , 1/4 W, 5%
R447	315-0621-00			620 $\Omega$ , 1/4 W, 5%
R448	315-0821-00			820 $\Omega$ , 1/4 W, 5%
R450	315-0133-00			13 k $\Omega$ , 1/4 W, 5%
R451	315-0102-00			1 k $\Omega$ , 1/4 W, 5%
R452	315-0202-00			2 k $\Omega$ , 1/4 W, 5%
R453	315-0121-00			120 $\Omega$ , 1/4 W, 5%
R455	315-0471-00			470 $\Omega$ , 1/4 W, 5%
R456	315-0220-00			22 $\Omega$ , 1/4 W, 5%
R457	315-0102-00			1 k $\Omega$ , 1/4 W, 5%

## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R458	315-0821-00			820 $\Omega$ , 1/4 W, 5%
R460	315-0133-00			13 k $\Omega$ , 1/4 W, 5%
R461	315-0102-00			1 k $\Omega$ , 1/4 W, 5%
R462	315-0202-00			2 k $\Omega$ , 1/4 W, 5%
R463	315-0121-00			120 $\Omega$ , 1/4 W, 5%
R467	315-0511-00			510 $\Omega$ , 1/4 W, 5%
R468	315-0301-00			300 $\Omega$ , 1/4 W, 5%
R477	315-0391-00			390 $\Omega$ , 1/4 W, 5%
R478	315-0621-00			620 $\Omega$ , 1/4 W, 5%
R479	315-0511-00			510 $\Omega$ , 1/4 W, 5%
R511	321-0097-00			100 $\Omega$ , 1/8 W, 1%
R512	321-0315-00			18.7 k $\Omega$ , 1/8 W, 1%
R514	321-0097-00			100 $\Omega$ , 1/8 W, 1%
R515	321-0315-00			18.7 k $\Omega$ , 1/8 W, 1%
R517	321-0097-00			100 $\Omega$ , 1/8 W, 1%
R518	321-0315-00			18.7 k $\Omega$ , 1/8 W, 1%
R521	321-0097-00			100 $\Omega$ , 1/8 W, 1%
R522	321-0315-00			18.7 k $\Omega$ , 1/8 W, 1%
R524	321-0097-00			100 $\Omega$ , 1/8 W, 1%
R525	321-0315-00			18.7 k $\Omega$ , 1/8 W, 1%
R527	321-0205-00			1.33 k $\Omega$ , 1/8 W, 1%
R528	321-0261-00			5.11 k $\Omega$ , 1/8 W, 1%
R531	321-0097-00			100 $\Omega$ , 1/8 W, 1%
R532	321-0315-00			18.7 k $\Omega$ , 1/8 W, 5%
R534	321-0205-00			1.33 k $\Omega$ , 1/8 W, 1%
R535	321-0261-00			5.11 k $\Omega$ , 1/8 W, 1%
R537	316-0104-00			100 k $\Omega$ , 1/4 W, 10%
R539	316-0103-00			10 k $\Omega$ , 1/4 W, 10%
R540	315-0153-00			15 k $\Omega$ , 1/4 W, 5%
R542	311-0633-00			5 k $\Omega$ , Var
R543	315-0102-00			1 k $\Omega$ , 1/4 W, 5%
R544	321-0120-00			174 $\Omega$ , 1/8 W, 1%
R546	321-0120-00			174 $\Omega$ , 1/8 W, 1%
R547	315-0105-00			1 M $\Omega$ , 1/4 W, 5%
R550	316-0101-00			100 $\Omega$ , 1/4 W, 10%
R551	315-0201-00			200 $\Omega$ , 1/4 W, 5%
R552	321-0190-00			931 $\Omega$ , 1/8 W, 1%
R554	316-0101-00			100 $\Omega$ , 1/4 W, 10%
R556	315-0620-00			62 $\Omega$ , 1/4 W, 5%
R560	321-0178-00			698 $\Omega$ , 1/8 W, 1%
R562	321-0297-00			12.1 k $\Omega$ , 1/8 W, 1%
R563	321-0350-00			43.2 k $\Omega$ , 1/8 W, 1%
R564	316-0101-00			100 $\Omega$ , 1/4 W, 10%
R566	321-0184-00			806 $\Omega$ , 1/8 W, 1%
R567	315-0201-00			200 $\Omega$ , 1/4 W, 5%
R571	315-0202-00			2 k $\Omega$ , 1/4 W, 5%



## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R572	315-0511-00			510 $\Omega$ , 1/4 W, 5%
R574	321-0148-00			340 $\Omega$ , 1/8 W, 1%
R576	321-0337-00			31.6 k $\Omega$ , 1/8 W, 1%
R580	316-0101-00			100 $\Omega$ , 1/4 W, 10%
R581	315-0201-00			200 $\Omega$ , 1/4 W, 5%
R582	321-0190-00			931, 1/8 W, 1%
R584	316-0101-00			100 $\Omega$ , 1/4 W, 10%
R586	315-0620-00			62 $\Omega$ , 1/4 W, 5%
R590	321-0297-00			12.1 k $\Omega$ , 1/8 W, 1%
R591	321-0350-00			43.2 k $\Omega$ , 1/8 W, 1%
R596	321-0184-00			806 $\Omega$ , 1/8 W, 1%
R597	315-0201-00			200 $\Omega$ , 1/4 W, 5%
R600	316-0104-00			100 k $\Omega$ , 1/4 W, 10%
R601	315-0202-00			2 k $\Omega$ , 1/4 W, 5%
R602	315-0511-00			510 $\Omega$ , 1/4 W, 5%
R603	311-0605-00			200 $\Omega$ , Var
R604	321-0134-00			243 $\Omega$ , 1/8 W, 1%
R606	321-0337-00			31.6 k $\Omega$ , 1/8 W, 1%
R610	316-0101-00			100 $\Omega$ , 1/4 W, 10%
R611	315-0201-00			200 $\Omega$ , 1/4 W, 5%
R612	321-0190-00			931 $\Omega$ , 1/8 W, 1%
R614	316-0101-00			100 $\Omega$ , 1/4 W, 10%
R616	315-0620-00			62 $\Omega$ , 1/4 W, 5%
R620	321-0297-00			12.1 k $\Omega$ , 1/8 W, 1%
R621	321-0350-00			43.2 k $\Omega$ , 1/8 W, 1%
R626	321-0184-00			806 $\Omega$ , 1/8 W, 1%
R627	315-0201-00			200 $\Omega$ , 1/4 W, 5%
R631	315-0202-00			2 k $\Omega$ , 1/4 W, 5%
R632	315-0511-00			510 $\Omega$ , 1/4 W, 5%
R634	321-0148-00			340 $\Omega$ , 1/8 W, 1%
R636	321-0337-00			31.6 k $\Omega$ , 1/8 W, 1%
R640	316-0101-00			100 $\Omega$ , 1/4 W, 10%
R641	315-0201-00			200 $\Omega$ , 1/4 W, 5%
R642	321-0190-00			931 $\Omega$ , 1/8 W, 1%
R644	316-0101-00			100 $\Omega$ , 1/4 W, 10%
R646	315-0620-00			62 $\Omega$ , 1/4 W, 5%
R650	321-0297-00			12.1 k $\Omega$ , 1/8 W, 1%
R651	321-0350-00			43.2 k $\Omega$ , 1/8 W, 1%
R656	321-0184-00			806 $\Omega$ , 1/8 W, 1%
R657	315-0201-00			200 $\Omega$ , 1/4 W, 5%
R660	316-0104-00			100 k $\Omega$ , 1/4 W, 10%
R661	315-0202-00			2 k $\Omega$ , 1/4 W, 5%
R662	315-0511-00			510 $\Omega$ , 1/4 W, 5%
R663	311-0605-00			200 $\Omega$ , Var
R664	321-0134-00			243 $\Omega$ , 1/8 W, 1%
R666	321-0337-00			31.6 k $\Omega$ , 1/8 W, 1%
R670	316-0101-00			100 $\Omega$ , 1/4 W, 10%
R671	315-0201-00			200 $\Omega$ , 1/4 W, 5%
R672	321-0190-00			931 $\Omega$ , 1/8 W, 1%
R674	316-0101-00			100 $\Omega$ , 1/4 W, 10%
R676	315-0620-00			62 $\Omega$ , 1/4 W, 5%

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R680	321-0297-00			12.1 kΩ, 1/8 W, 1%
R681	321-0350-00			43.2 kΩ, 1/8 W, 1%
R686	321-0184-00			806 Ω, 1/8 W, 1%
R687	315-0201-00			200 Ω, 1/4 W, 5%
R696	321-0337-00			31.6 kΩ, 1/8 W, 1%
R697	321-0152-00			374 Ω, 1/8 W, 1%
R698	321-0297-00			12.1 kΩ, 1/8 W, 1%
R701	315-0202-00			2 kΩ, 1/4 W, 5%
R702	316-0104-00			100 kΩ, 1/4 W, 10%
R703	311-0609-00			2 kΩ, Var
R704	315-0131-00			130 Ω, 1/4 W, 5%
R710	316-0101-00			100 Ω, 1/4 W, 10%
R711	315-0821-00			820 Ω, 1/4 W, 5%
R712	321-0132-00			232 Ω, 1/8 W, 1%
R714	321-0120-00			174 Ω, 1/8 W, 1%
R716	315-0620-00			62 Ω, 1/4 W, 5%
R720	321-0297-00			12.1 kΩ, 1/8 W, 1%
R721	321-0350-00			43.2 kΩ, 1/8 W, 1%
R726	321-0184-00			806 Ω, 1/8 W, 1%
R727	315-0201-00			200 Ω, 1/4 W, 5%
R731	315-0202-00			2 kΩ, 1/4 W, 5%
R732	315-0511-00			510 Ω, 1/4 W, 5%
R733	311-0634-00			500 Ω, Var
R734	315-0391-00			390 Ω, 1/4 W, 5%
R736	321-0337-00			31.6 kΩ, 1/8 W, 1%
R737	321-0152-00			374 Ω, 1/8 W, 1%
R738	321-0297-00			12.1 kΩ, 1/8 W, 1%
R741	315-0910-00			91 Ω, 1/4 W, 5%
R742	315-0751-00			750 Ω, 1/4 W, 5%
R744	316-0101-00			100 Ω, 1/4 W, 5%
R745	315-0302-00			3 kΩ, 1/4 W, 5%
R747	321-0193-00			1 kΩ, 1/8 W, 1%
R748	321-0268-00			6.04 kΩ, 1/8 W, 1%
R750	315-0300-00			30 Ω, 1/4 W, 5%
R751	321-0041-00			26.1 Ω, 1/8 W, 1%
R752	323-0126-00			200 Ω, 1/2 W, 1%
R753	316-0104-00	B010100	B039999X	100 kΩ, 1/4 W, 10%
R755	321-0235-00			2.74 kΩ, 1/8 W, 1%
R756	321-0223-00			2.05 kΩ, 1/8 W, 1%
R757	315-0300-00			30 Ω, 1/4 W, 5%
R762	321-0289-00			10 kΩ, 1/8 W, 1%
R766	301-0102-00			1 kΩ, 1/2 W, 5%
R767	316-0101-00			100 Ω, 1/4 W, 10%
R771	321-0193-00			1 kΩ, 1/8 W, 1%
R772	321-0164-00			499 Ω, 1/8 W, 1%
R775	321-0126-00			200 Ω, 1/8 W, 1%
R776	321-0126-00			200 Ω, 1/8 W, 1%
R801	311-0613-00			100 kΩ, Var
R802	311-0613-00			100 kΩ, Var
R803	311-0613-00			100 kΩ, Var
R806	316-0104-00			100 kΩ, 1/4 W, 10%
R807	315-0204-00			200 kΩ, 1/4 W, 5%
R808	315-0275-00			2.7 MΩ, 1/4 W, 5%
R819	321-0164-00			499 Ω, 1/8 W, 1%

## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R820	315-0470-00			47 $\Omega$ , 1/4 W, 5%
R821	315-0303-00			30 k $\Omega$ , 1.4 W, 5%
R822	315-0303-00			30 k $\Omega$ , 1/4 W, 5%
R823	315-0470-00			47 $\Omega$ , 1/4 W, 5%
R824	315-0821-00			820 $\Omega$ , 1/4 W, 5%
R825	315-0512-00			5.1 k $\Omega$ , 1/4 W, 5%
R826	321-0261-00			5.11 k $\Omega$ , 1/8 W, 1%
R827	315-0105-00	BO10100	BO39999X	1 M $\Omega$ , 1/4 W, 5%
R828	315-0105-00	BO10100	BO39999X	1 M $\Omega$ , 1/4 W, 5%
R829	321-0181-00			750 $\Omega$ , 1/8 W, 1%
R830	316-0103-00	BO10100	BO39999	10 k $\Omega$ , 1/4 W, 10%
R830	316-0104-00	BO40000		100 k $\Omega$ , 1/4 W, 10%
R831	316-0104-00	BO10100	BO39999X	100 k $\Omega$ , 1/4 W, 10%
R832	316-0104-00	BO10100	BO39999X	100 k $\Omega$ , 1/4 W, 10%
R835	316-0104-00	BO10100	BO39999X	100 k $\Omega$ , 1/4 W, 10%
R836	316-0104-00	BO10100	BO39999X	100 k $\Omega$ , 1/4 W, 10%
R837	316-0104-00	BO10100	BO39999X	100 k $\Omega$ , 1/4 W, 10%
R838	316-0104-00	BO10100	BO39999X	100 k $\Omega$ , 1/4 W, 10%
R840	316-0104-00	XBO40000		100 k $\Omega$ , 1/4 W, 10%
R841	316-0104-00	BO10100	BO39999X	100 k $\Omega$ , 1/4 W, 10%
R842	316-0104-00	BO10100	BO39999X	100 k $\Omega$ , 1/4 W, 10%
R852	315-0431-00			430 $\Omega$ , 1/4 W, 5%
R854	315-0134-00			130 k $\Omega$ , 1/4 W, 5%
R855	315-0333-00			33 k $\Omega$ , 1/4 W, 5%
R856	315-0433-00			43 k $\Omega$ , 1/4 W, 5%
R857	315-0470-00			47 $\Omega$ , 1/4 W, 5%
R858	315-0391-00			390 $\Omega$ , 1/4 W, 5%
R859	315-0471-00	XBO20000		470 $\Omega$ , 1/4 W, 5%
R860	315-0391-00			390 $\Omega$ , 1/4 W, 5%
R861	315-0431-00			430 $\Omega$ , 1/4 W, 5%
R862	315-0102-00			1 k $\Omega$ , 1/4 W, 5%
R864	321-0193-00			1 k $\Omega$ , 1/8 W, 1%
R865	321-0195-00			1.05 k $\Omega$ , 1/8 W, 1%
R866	315-0471-00	XBO20000		470 $\Omega$ , 1/4 W, 5%
R867	315-0202-00			2 k $\Omega$ , 1/4 W, 5%
R868	315-0511-00			510 $\Omega$ , 1/4 W, 5%
R871	321-0068-00			49.9 $\Omega$ , 1/8 W, 1%
R872	321-0068-00			49.9 $\Omega$ , 1/8 W, 1%
R873	321-0068-00			49.9 $\Omega$ , 1/8 W, 1%
R874	321-0068-00			49.9 $\Omega$ , 1/8 W, 1%
R880	315-0202-00			2 k $\Omega$ , 1/4 W, 5%
R881	315-0220-00	XBO20000		22 $\Omega$ , 1/4 W, 5%
R882	321-0274-00			6.98 k $\Omega$ , 1/8 W, 1%
R883	321-0172-00			604 $\Omega$ , 1/8 W, 1%
R884	321-0277-00			7.5 k $\Omega$ , 1/8 W, 1%
R886	316-0101-00			100 $\Omega$ , 1/4 W, 10%
R887	321-0259-00			4.87 $\Omega$ , 1/8 W, 1%
R889	321-0198-00			1.13 k $\Omega$ , 1/8 W, 1%
R890	321-0193-00			1 k $\Omega$ , 1/8 W, 1%
R891	321-0193-00			1 k $\Omega$ , 1/8 W, 1%
R892	315-0470-00			47 $\Omega$ , 1/4 W, 5%
R894	315-0202-00			2 k $\Omega$ , 1/4 W, 5%
R895	321-0306-00			15 k $\Omega$ , 1/8 W, 1%
R896	315-0202-00			2 k $\Omega$ , 1/4 W, 5%

## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R898	315-0432-00			4.3 k $\Omega$ , 1/4 W, 5%
R951	315-0101-00			100 $\Omega$ , 1/4 W, 5%
R952	321-0240-00			3.09 k $\Omega$ , 1/8 W, 1%
R954	321-0001-00			10 $\Omega$ , 1/8 W, 1%
R955	321-0193-00			1 k $\Omega$ , 1/8 W, 1%
R956	311-0540-00			2.5 k $\Omega$ , Var
R958	321-0193-00			1 k $\Omega$ , 1/8 W, 1%
R959	321-0066-00			47.5 $\Omega$ , 1/8 W, 1%
R960	321-0240-00			3.09 k $\Omega$ , 1/8 W, 1%
R962	321-0066-00			47.5 $\Omega$ , 1/8 W, 1%
R964	321-0154-00			392 $\Omega$ , 1/8 W, 1%
R966	321-0073-00			56.2 $\Omega$ , 1/8 W, 1%
R967	321-0073-00			56.2 $\Omega$ , 1/8 W, 1%
R1000	315-0100-00			10 $\Omega$ , 1/4 W, 5%
R1001	315-0303-00			30 k $\Omega$ , 1/4 W, 5%
R1002	315-0303-00			30 k $\Omega$ , 1/4 W, 5%
R1003	315-0100-00			10 $\Omega$ , 1/4 W, 5%
R1010	315-0472-00			4.7 k $\Omega$ , 1/4 W, 5%
R1011	315-0101-00			100 $\Omega$ , 1/4 W, 5%
R1012	315-0104-00			100 k $\Omega$ , 1/4 W, 5%
R1020	321-0068-00			49.9 $\Omega$ , 1/8 W, 1%
R1021	321-0335-00			30.1 k $\Omega$ , 1/8 W, 1%
R1022	321-0193-00			1 k $\Omega$ , 1/8 W, 1%
R1023	321-0068-00			49.9 $\Omega$ , 1/8 W, 1%
R1025	321-0356-00			49.9 k $\Omega$ , 1/8 W, 1%
R1026	321-0318-00			20 k $\Omega$ , 1/8 W, 1%
R1030	321-0289-00			10 k $\Omega$ , 1/8 W, 1%
R1031	315-0113-00			11 k $\Omega$ , 1/4 W, 5%
R1033	321-0239-00			3.01 k $\Omega$ , 1/8 W, 1%
R1034	321-0297-00			12.1 k $\Omega$ , 1/8 W, 1%
R1036	315-0153-00			15 k $\Omega$ , 1/4 W, 5%
R1041	321-0297-00			12.1 k $\Omega$ , 1/8 W, 1%
R1042	321-0309-00			16.2 k $\Omega$ , 1/8 W, 1%
R1045	321-0239-00			3.01 k $\Omega$ , 1/8 W, 1%
R1046	321-0258-00			4.75 k $\Omega$ , 1/8 W, 1%
R1049	321-0222-00			2 k $\Omega$ , 1/8 W, 1%
R1050	315-0395-00			3.9 M $\Omega$ , 1/4 W, 5%
R1051	315-0395-00			3.9 M $\Omega$ , 1/4 W, 5%
R1052	315-0102-00			1 k $\Omega$ , 1/4 W, 5%
R1053	315-0472-00			4.7 k $\Omega$ , 1/4 W, 5%
R1054	315-0103-00			10 k $\Omega$ , 1/4 W, 5%
R1055	315-0102-00			1 k $\Omega$ , 1/4 W, 5%
R1056	315-0103-00			10 k $\Omega$ , 1/4 W, 5%
R1057	315-0472-00			4.7 k $\Omega$ , 1/4 W, 5%
R1067	315-0103-00			10 k $\Omega$ , 1/4 W, 5%
R1068	321-0269-00			6.19 k $\Omega$ , 1/8 W, 1%
R1070	321-0251-00			4.02 k $\Omega$ , 1/8 W, 1%
R1071	311-0613-00			100 k $\Omega$ , Var
R1073	321-0385-00			100 k $\Omega$ , 1/8 W, 1%
R1075	315-0103-00			10 k $\Omega$ , 1/4 W, 5%
R1076	315-0102-00			1 k $\Omega$ , 1/4 W, 5%
R1077	315-0153-00			15 k $\Omega$ , 1/4 W, 5%
R1078	315-0303-00			30 k $\Omega$ , 1/4 W, 5%

## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R1104	315-0471-00			470 $\Omega$ , 1/4 W, 5%
R1105	315-0271-00			270 $\Omega$ , 1/4 W, 5%
R1110	315-0100-00			10 $\Omega$ , 1/4 W, 5%
R1111	315-0101-00			100 $\Omega$ , 1/4 W, 5%
R1112	315-0122-00			1.2 k $\Omega$ , 1/4 W, 5%
R1114	315-0102-00			1 k $\Omega$ , 1/4 W, 5%
R1115	315-0105-00			1 M $\Omega$ , 1/4 W, 5%
R1117	315-0101-00			100 $\Omega$ , 1/4 W, 5%
R1118	315-0102-00			1 k $\Omega$ , 1/4 W, 5%
R1120	315-0822-00			8.2 k $\Omega$ , 1/4 W, 5%
R1131	315-0223-00			22 k $\Omega$ , 1/4 W, 5%
R1133	315-0822-00			8.2 k $\Omega$ , 1/4 W, 5%
R1135	315-0822-00			8.2 k $\Omega$ , 1/4 W, 5%
R1136	315-0103-00			10 k $\Omega$ , 1/4 W, 5%
R1138	315-0223-00			22 k $\Omega$ , 1/4 W, 5%
R1139	315-0240-00			24 $\Omega$ , 1/4 W, 5%
R1140	315-0240-00			24 $\Omega$ , 1/4 W, 5%
R1141	315-0102-00			1 k $\Omega$ , 1/4 W, 5%
R1142	315-0102-00			1 k $\Omega$ , 1/4 W, 5%
R1143	315-0100-00			10 $\Omega$ , 1/4 W, 5%
R1145	315-0223-00			22 k $\Omega$ , 1/4 W, 5%
R1146	315-0104-00			100 k $\Omega$ , 1/4 W, 5%
R1149	315-0103-00			10 k $\Omega$ , 1/4 W, 5%
R1150	315-0103-00			10 k $\Omega$ , 1/4 W, 5%
R1151	315-0222-00			2.2 k $\Omega$ , 1/4 W, 5%
R1153	315-0303-00			30 k $\Omega$ , 1/4 W, 5%
R1155	315-0101-00			100 $\Omega$ , 1/4 W, 5%
R1156	315-0152-00			1.5 k $\Omega$ , 1/4 W, 5%
R1157	315-0101-00			100 $\Omega$ , 1/4 W, 5%
R1158	315-0101-00			100 $\Omega$ , 1/4 W, 5%
R1160	307-0111-00			3.6 $\Omega$ , 1/4 W, 5%
R1161	315-0222-00			2.2 k $\Omega$ , 1/4 W, 5%
R1162	315-0223-00			22 k $\Omega$ , 1/4 W, 5%
R1163	321-0260-00			4.99 k $\Omega$ , 1/8 W, 1%
R1164	321-0289-00			10 k $\Omega$ , 1/8 W, 1%
R1167	315-0131-00			130 $\Omega$ , 1/4 W, 5%
R1168	315-0561-00			560 $\Omega$ , 1/4 W, 5%
R1171	311-1035-00			50 k $\Omega$ , Var
R1172	315-0153-00			15 k $\Omega$ , 1/4 W, 5%
R1173	321-0144-00			309 $\Omega$ , 1/8 W, 1%
R1174	321-0827-03			3.61 k $\Omega$ , 1/8 W, 1/4%
R1175	321-0680-03			35.3 k $\Omega$ , 1/8 W, 1/4%
R1177	321-0410-00			182 k $\Omega$ , 1/8 W, 1%
R1178	311-0607-00			10 k $\Omega$ , Var
R1183	321-0385-00			100 k $\Omega$ , 1/8 W, 1%
R1185	321-0385-00			100 k $\Omega$ , 1/8 W, 1%
R1186	315-0102-00			1 k $\Omega$ , 1/4 W, 5%
R1191	321-0421-03			237 k $\Omega$ , 1/8 W, 1/4%
R1192	321-0404-03			158 k $\Omega$ , 1/8 W, 1/4%
R1193	321-0941-03			59.25 k $\Omega$ , 1/8 W, 1/4%

## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R1206	315-0100-00			10 $\Omega$ , 1/4 W, 5%
R1207	315-0100-00			10 $\Omega$ , 1/4 W, 5%
R1208	315-0303-00			30 k $\Omega$ , 1/4 W, 5%
R1209	315-0303-00			30 k $\Omega$ , 1/4 W, 5%
R1210	321-0289-00			10 k $\Omega$ , 1/8 W, 1%
R1211	321-0257-00			4.64 k $\Omega$ , 1/8 W, 1%
R1213	321-0297-00			12.1 k $\Omega$ , 1/8 W, 1%
R1214	321-0309-00			16.2 k $\Omega$ , 1/8 W, 1%
R1215	321-0262-00			5.23 k $\Omega$ , 1/8 W, 1%
R1217	315-0101-00			100 $\Omega$ , 1/4 W, 5%
R1218	315-0152-00			1.5 k $\Omega$ , 1/4 W, 5%
R1220	321-0338-00			32.4 k $\Omega$ , 1/8 W, 1%
R1222	321-0380-00			88.7 k $\Omega$ , 1/8 W, 1%
R1223	321-0384-00			97.6 k $\Omega$ , 1/8 W, 1%
R1225	321-0193-00			1 k $\Omega$ , 1/8 W, 1%
R1227	315-0681-00			680 $\Omega$ , 1/4 W, 5%
R1228	315-0302-00			3 k $\Omega$ , 1/4 W, 5%
R1230	321-0193-00			1 k $\Omega$ , 1/8 W, 1%
R1235	321-0193-00			1 k $\Omega$ , 1/8 W, 1%
R1237	315-0681-00			680 $\Omega$ , 1/4 W, 5%
R1238	315-0302-00			3 k $\Omega$ , 1/4 W, 5%
R1250	321-0260-00			4.99 k $\Omega$ , 1/8 W, 1%
R1251	311-0633-00			5 k $\Omega$ , Var
R1252	321-0256-00			4.53 k $\Omega$ , 1/8 W, 1%
R1253	321-0323-00			22.6 k $\Omega$ , 1/8 W, 1%
R1254	321-0354-01			47.5 k $\Omega$ , 1/8 W, 1/2%
R1255	321-0354-01			47.5 k $\Omega$ , 1/8 W, 1/2%
R1260	321-0276-00			7.32 k $\Omega$ , 1/8 W, 1%
R1263	321-0193-00			1 k $\Omega$ , 1/8 W, 1%
R1264	321-0197-00			1.1 k $\Omega$ , 1/8 W, 1%
R1284	321-0205-01			1.33 k $\Omega$ , 1/8 W, 1/2%
R1286	321-0250-01			3.92 k $\Omega$ , 1/8 W, 1/2%
R1287	321-0270-01			6.34 k $\Omega$ , 1/8 W, 1/2%
R1288	321-0949-01			5.45 k $\Omega$ , 1/8 W, 1/2%
R1289	321-0947-01			1.28 k $\Omega$ , 1/8 W, 1/2%
R1290	321-0946-01			509 $\Omega$ , 1/8 W, 1/2%
R1291	321-0945-01			268 $\Omega$ , 1/8 W, 1/2%
R1292	321-0944-01			83.8 $\Omega$ , 1/8 W, 1/2%
R1293	321-0741-01			40.9 $\Omega$ , 1/8 W, 1/2%
R1294	321-0943-01			24.2 $\Omega$ , 1/8 W, 1/2%
R1295	321-1020-01			16 $\Omega$ , 1/8 W, 1/2%
R1300	315-0470-00			47 $\Omega$ , 1/4 W, 5%
R1302	315-0101-00			100 $\Omega$ , 1/4 W, 5%
R1303	321-0234-00			2.67 k $\Omega$ , 1/8 W, 1%
R1306	321-0250-00			3.92 k $\Omega$ , 1/8 W, 1%
R1310	315-0102-00			1 k $\Omega$ , 1/4 W, 5%
R1311	321-0234-00			2.67 k $\Omega$ , 1/8 W, 1%
R1316	321-0250-00			3.92 k $\Omega$ , 1/8 W, 1%
R1326	321-0247-00			3.65 k $\Omega$ , 1/8 W, 1%
R1332	311-0532-00			1.5 k $\Omega$ , Var



## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R1334	308-0393-00			1.6 k $\Omega$ , 3 W, WW, 5%
R1337	315-0101-00			100 $\Omega$ , 1/4 W, 5%
R1338	315-0472-00			4.7 k $\Omega$ , 1/4 W, 5%
R1339	315-0273-00			27 k $\Omega$ , 1/4 W, 5%
R1347	308-0298-00			560 $\Omega$ , 3 W, WW, 5%
R1350	311-1266-00			2.5 k $\Omega$ , Var
R1351	321-0156-00			412 $\Omega$ , 1/8 W, 1%
R1352	321-0277-00			7.5 k $\Omega$ , 1/8 W, 1%
R1354	321-0289-00			10 k $\Omega$ , 1/8 W, 1%
R1355	321-0029-00			19.6 $\Omega$ , 1/8 W, 1%
R1356	321-0333-00			28.7 k $\Omega$ , 1/8 W, 1%
R1357	321-0098-00			102 $\Omega$ , 1/8 W, 1%
R1362	321-0294-00			11.3 k $\Omega$ , 1/8 W, 1%
R1371	315-0103-00			10 k $\Omega$ , 1/4 W, 5%
R1373	315-0104-00			100 k $\Omega$ , 1/4 W, 5%
R1377	321-0001-00			10 $\Omega$ , 1/8 W, 1%
R1378	315-0103-00			10 k $\Omega$ , 1/4 W, 5%
R1411	321-0969-01			4.87 k $\Omega$ , 1/8 W, 1/2%
R1413	321-0654-00			10.1 $\Omega$ , 1/8 W, 1%
R1415	321-0262-00			5.23 k $\Omega$ , 1/8 W, 1%
R1416	311-0635-00			1 k $\Omega$ , Var
R1420	321-0289-00			10 k $\Omega$ , 1/8 W, 1%
R1421	311-0633-00			5 k $\Omega$ , Var
R1422	311-0613-00			100 k $\Omega$ , Var
R1423	315-0104-00			100 k $\Omega$ , 1/4 W, 5%
R1425	315-0105-00			1 M $\Omega$ , 1/4 W, 5%
R1427	321-0222-00			2 k $\Omega$ , 1/8 W, 1%
R1429	321-0295-00			11.5 k $\Omega$ , 1/8 W, 1%
R1431	315-0104-00			100 k $\Omega$ , 1/4 W, 5%
R1432	315-0472-00			4.7 k $\Omega$ , 1/4 W, 5%
R1434	315-0101-00			100 $\Omega$ , 1/4 W, 5%
R1435	315-0203-00			20 k $\Omega$ , 1/4 W, 5%
R1436	315-0102-00			1 k $\Omega$ , 1/4 W, 5%
R1437	315-0102-00			1 k $\Omega$ , 1/4 W, 5%
R1438	315-0104-00			100 k $\Omega$ , 1/4 W, 5%
R1440	321-0353-00			46.4 k $\Omega$ , 1/8 W, 1%
R1441	311-0635-00			1 k $\Omega$ , Var
R1442	321-0239-00			3.01 k $\Omega$ , 1/8 W, 1%
R1447	321-0181-00			750 $\Omega$ , 1/8 W, 1%
R1448	311-0634-00			500 $\Omega$ , Var
R1450	321-0193-01			1 k $\Omega$ , 1/8 W, 1/2%
R1452	321-0193-01			1 k $\Omega$ , 1/8 W, 1/2%
R1453	315-0101-00			100 $\Omega$ , 1/4 W, 5%
R1470	315-0391-00			390 $\Omega$ , 1/4 W, 5%
R1471	315-0222-00			2.2 k $\Omega$ , 1/4 W, 5%
R1472	301-0152-00			1.5 k $\Omega$ , 1/2 W, 5%
R1474	321-0260-00			4.99 k $\Omega$ , 1/8 W, 1%
R1475	321-0193-00			1 k $\Omega$ , 1/8 W, 1%
R1476	315-0102-00			1 k $\Omega$ , 1/4 W, 5%
R1477	315-0103-00			10 k $\Omega$ , 1/4 W, 5%

## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R1478	308-0694-00			25 $\Omega$ , 5 W, WW, 1%
R1480	315-0101-00			100 $\Omega$ , 1/4 W, 5%
R1481	315-0221-00			220 $\Omega$ , 1/4 W, 5%
R1482	315-0302-00			3 k $\Omega$ , 1/4 W, 5%
R1502	307-0103-00			2.7 $\Omega$ , 1/4 W, 5%
R1504	315-0102-00			1 k $\Omega$ , 1/4 W, 5%
R1506	315-0102-00			1 k $\Omega$ , 1/4 W, 5%
R1508	315-0102-00			1 k $\Omega$ , 1/4 W, 5%
R1512	307-0103-00			2.7 $\Omega$ , 1/4 W, 5%
R1514	307-0103-00			2.7 $\Omega$ , 1/4 W, 5%
R1516	315-0152-00			1.5 k $\Omega$ , 1/4 W, 5%
R1518	321-0289-00			10 k $\Omega$ , 1/8 W, 1%
R1520	315-0683-00			68 k $\Omega$ , 1/4 W, 5%
R1521	315-0683-00			68 k $\Omega$ , 1/4 W, 5%
R1522	315-0102-00			1 k $\Omega$ , 1/4 W, 5%
R1524	315-0681-00			680 $\Omega$ , 1/4 W, 5%
R1525	307-0103-00			2.7 k $\Omega$ , 1/4 W, 5%
R1527	321-0289-00			10 k $\Omega$ , 1/8 W, 1%
R1528	311-0635-00			1 k $\Omega$ , Var
R1529	321-0264-00			5.49 k $\Omega$ , 1/8 W, 1%
R1532	321-0318-00			20 k $\Omega$ , 1/8 W, 1%
R1534	321-0260-00			4.99 k $\Omega$ , 1/8 W, 1%
R1536	315-0332-00			3.3 k $\Omega$ , 1/4 W, 5%
R1538	315-0681-00			680 $\Omega$ , 1/4 W, 5%
R1540	315-0104-00			100 k $\Omega$ , 1/4 W, 5%
R1543	315-0103-00			10 k $\Omega$ , 1/4 W, 5%
R1545	315-0104-00			100 k $\Omega$ , 1/4 W, 5%
R1546	315-0101-00			100 $\Omega$ , 1/4 W, 5%
R1547	315-0101-00	B010100	B019999	100 $\Omega$ , 1/4 W, 5%
R1547	315-0470-00	B020000		47 $\Omega$ , 1/4 W, 5%
R1548	315-0470-00			47 $\Omega$ , 1/4 W, 5%
R1549	315-0101-00			100 $\Omega$ , 1/4 W, 5%
R1550	315-0101-00			100 $\Omega$ , 1/4 W, 5%
R1555	315-0472-00			4.7 k $\Omega$ , 1/4 W, 5%
R1556	315-0102-00			1 k $\Omega$ , 1/4 W, 5%
R1558	315-0203-00			20 k $\Omega$ , 1/4 W, 5%
R1559	315-0152-00			1.5 k $\Omega$ , 1/4 W, 5%
R1560	315-0104-00			100 k $\Omega$ , 1/4 W, 5%
R1561	315-0102-00			1 k $\Omega$ , 1/4 W, 5%
R1562	315-0472-00			4.7 k $\Omega$ , 1/4 W, 5%
R1563	315-0203-00			20 k $\Omega$ , 1/4 W, 5%
R1564	315-0125-00			1.2 M $\Omega$ , 1/4 W, 5%
R1566	315-0472-00			4.7 k $\Omega$ , 1/4 W, 5%
R1568	315-0624-00			620 k $\Omega$ , 1/4 W, 5%
R1572	315-0472-00			4.7 k $\Omega$ , 1/4 W, 5%
R1574	321-0434-00			324 k $\Omega$ , 1/8 W, 1%
R1576	315-0472-00			4.7 k $\Omega$ , 1/4 W, 5%
R1578	321-0405-00			162 k $\Omega$ , 1/8 W, 1%
R1582	315-0472-00			4.7 k $\Omega$ , 1/4 W, 5%
R1584	321-0376-00			80.6 k $\Omega$ , 1/8 W, 1%
R1586	315-0472-00			4.7 k $\Omega$ , 1/4 W, 5%
R1588	321-0347-00			40.2 k $\Omega$ , 1/8 W, 1%

## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS (cont)				
R1589	321-0314-00			18.2 k $\Omega$ , 1/8 W, 1%
R1590	311-0607-00			10 k $\Omega$ , Var
R1591	321-0342-00			35.7 k $\Omega$ , (nominal value), selected
R1593	321-0251-00			4.02 k $\Omega$ , 1/8 W, 1%
R1594	321-0294-00			11.3 k $\Omega$ , 1/8 W, 1%
R1596	321-0289-00			10 k $\Omega$ , 1/8 W, 1%
R1597	321-0260-00			4.99 k $\Omega$ , 1/8 W, 1%
R1598	311-0634-00			500 $\Omega$ , Var
R1610	321-0260-00			4.99 k $\Omega$ , 1/8 W, 1%
R1611	315-0301-00			300 $\Omega$ , 1/4 W, 5%
R1614	321-0193-00			1 k $\Omega$ , 1/8 W, 1%
R1616	321-0193-00			1 k $\Omega$ , 1/8 W, 1%
R1617	321-0126-00			200 $\Omega$ , 1/8 W, 1%
R1623	321-0187-00			866 $\Omega$ , 1/8 W, 1%
R1626	301-0123-00			12 k $\Omega$ , 1/2 W, 5%
R1629	301-0123-00			12 k $\Omega$ , 1/2 W, 5%
R1633	321-0303-00			14 k $\Omega$ , 1/8 W, 1%
R1636	321-0402-00	BO10100	BO39999	150 k $\Omega$ , 1/8 W, 1%
R1636	315-0155-00	BO40000		1.5 M $\Omega$ , 1/4 W, 5%
R1637	311-0607-00			10 k $\Omega$ , Var
R1638	321-0235-00			2.74 k $\Omega$ , 1/8 W, 1%
R1701	311-0660-00			200 k $\Omega$ , Var
R1702	311-0660-00			200 k $\Omega$ , Var
R1703	311-0660-00			200 k $\Omega$ , Var
R1704	311-0660-00			200 k $\Omega$ , Var
R1705	311-0660-00			200 k $\Omega$ , Var
R1706	311-0660-00			200 k $\Omega$ , Var
R1707	311-0660-00			200 k $\Omega$ , Var
R1708	311-0660-00			200 k $\Omega$ , Var
R1709	311-0660-00			200 k $\Omega$ , Var
R1710	311-0660-00			200 k $\Omega$ , Var
R1711	311-0660-00			200 k $\Omega$ , Var
R1721	321-0150-00			357 $\Omega$ , 1/8 W, 1%
R1722	321-0139-00			274 $\Omega$ , 1/8 W, 1%
R1723	321-0139-00			274 $\Omega$ , 1/8 W, 1%
R1724	321-0139-00			274 $\Omega$ , 1/8 W, 1%
R1725	321-0139-00			274 $\Omega$ , 1/8 W, 1%
R1726	321-0139-00			274 $\Omega$ , 1/8 W, 1%
R1727	321-0139-00			274 $\Omega$ , 1/8 W, 1%
R1728	321-0139-00			274 $\Omega$ , 1/8 W, 1%
R1729	321-0139-00			274 $\Omega$ , 1/8 W, 1%
R1730	321-0139-00			274 $\Omega$ , 1/8 W, 1%
R1731	321-0139-00			274 $\Omega$ , 1/8 W, 1%
R1741	315-0101-00			100 $\Omega$ , 1/4 W, 5%
R1742	315-0751-00			750 $\Omega$ , 1/4 W, 5%
R1743	315-0752-00			7.5 k $\Omega$ , 1/4 W, 5%
R1748	315-0101-00			100 $\Omega$ , 1/4 W, 5%
R1751	321-0306-00			15 k $\Omega$ , 1/8 W, 1%
R1754	301-0243-00			24 k $\Omega$ , 1/2 W, 5%
R1756	315-0152-00			1.5 k $\Omega$ , 1/4 W, 5%
R1759	315-0101-00			100 $\Omega$ , 1/4 W, 5%
R1771	321-0239-00			2.01 k $\Omega$ , 1/8 W, 1%
R1772	321-0105-00			121 $\Omega$ , 1/8 W, 1%
R1773	315-0822-00			8.2 k $\Omega$ , 1/4 W, 5%

## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description
RESISTORS (cont)				
R1775	321-0338-00			32.4 k $\Omega$ , 1/8 W, 1%
R1776	321-0260-00			4.99 k $\Omega$ , 1/8 W, 1%
R1778	311-0978-00			250 $\Omega$ , Var
R1779	321-0188-00			887 $\Omega$ , 1/8 W, 1%
R1781	322-0139-00			274 $\Omega$ , 1/4 W, 1%
R1782	322-0145-00			316 $\Omega$ , 1/8 W, 1%
R1901	321-0402-00			150 k $\Omega$ , 1/8 W, 1%
R1902	321-0327-00			24.9 k $\Omega$ , 1/8 W, 1%
R1903	321-0402-00			150 k $\Omega$ , 1/8 W, 1%
R1904	321-0356-00			49.9 k $\Omega$ , 1/8 W, 1%
R1905	321-0335-00			30.1 k $\Omega$ , 1/8 W, 1%
R1906	321-0335-00			30.1 k $\Omega$ , 1/8 W, 1%
R1907	321-0344-00			37.4 k $\Omega$ , 1/8 W, 1%
R1908	321-0373-00			75 k $\Omega$ , 1/8 W, 1%
R1909	321-0402-00			150 k $\Omega$ , 1/8 W, 1%
R1910	321-0344-00			37.4 k $\Omega$ , 1/8 W, 1%
R1911	315-0154-00			150 k $\Omega$ , 1/4 W, 5%
R1912	315-0753-00			75 k $\Omega$ , 1/4 W, 5%
R1914	315-0154-00			150 k $\Omega$ , 1/4 W, 5%
R1915	321-0344-00			37.4 k $\Omega$ , 1/8 W, 1%
R1916	315-0154-00			150 k $\Omega$ , 1/4 W, 5%
R1917	315-0753-00			75 k $\Omega$ , 1/4 W, 5%
R1918	315-0154-00			150 k $\Omega$ , 1/4 W, 5%
R1919	315-0154-00			150 k $\Omega$ , 1/4 W, 5%
R1920	321-0306-00			15 k $\Omega$ , 1/8 W, 1%
R1921	321-0373-00			75 k $\Omega$ , 1/8 W, 1%
R1930	321-0402-00			150 k $\Omega$ , 1/8 W, 1%
R1931	321-0373-00			75 k $\Omega$ , 1/8 W, 1%
R1932	315-0154-00			150 k $\Omega$ , 1/4 W, 5%
R1933	321-0402-00			150 k $\Omega$ , 1/8 W, 1%
R1934	321-0373-00			75 k $\Omega$ , 1/8 W, 1%
R1935	321-0356-00			49.9 k $\Omega$ , 1/8 W, 1%
R1936	321-0344-00			37.4 k $\Omega$ , 1/8 W, 1%
R1937	321-0356-00			49.9 k $\Omega$ , 1/8 W, 1%
R1941	307-0106-00			4.7 $\Omega$ , 1/4 W, 5%
R1944	321-0344-00			37.4 k $\Omega$ , 1/8 W, 1%
R1945	321-0402-00			150 k $\Omega$ , 1/8 W, 1%
R1946	321-0344-00			37.4 k $\Omega$ , 1/8 W, 1%
R1947	321-0356-00			49.9 k $\Omega$ , 1/8 W, 1%
R1948	321-0327-00			24.9 k $\Omega$ , 1/8 W, 1%
R1949	321-0321-00			21.5 k $\Omega$ , 1/8 W, 1%
R1950	321-0402-00			150 k $\Omega$ , 1/8 W, 1%
R1951	321-0335-00			30.1 k $\Omega$ , 1/8 W, 1%
R1952	321-0344-00			37.4 k $\Omega$ , 1/8 W, 1%
R1954	321-0300-00			13 k $\Omega$ , 1/8 W, 1%
R1955	321-0300-00			13 k $\Omega$ , 1/8 W, 1%
R1956	321-0402-00			150 k $\Omega$ , 1/8 W, 1%
R1960	321-0356-00			49.9 k $\Omega$ , 1/8 W, 1%
R1961	321-0344-00			37.4 k $\Omega$ , 1/8 W, 1%
R1962	321-0335-00			30.1 k $\Omega$ , 1/8 W, 1%
R1963	321-0310-00			16.5 k $\Omega$ , 1/8 W, 1%
R1964	321-0356-00			49.9 k $\Omega$ , 1/8 W, 1%
R1965	321-0344-00			37.4 k $\Omega$ , 1/8 W, 1%
R1966	321-0344-00			37.4 k $\Omega$ , 1/8 W, 1%

## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
SWITCHES				
S82 <sup>1</sup>				CAL
S83 <sup>2</sup>				Rotary, GAIN (REFERENCE LEVEL SELECTOR)
S90A, B <sup>3</sup>	670-1749-00	B010100	B039999	Pushbutton, VIDEO FILTER and VIDEO PROCESSOR
S90A, B, C <sup>3</sup>	670-1749-01	B040000		Pushbutton, VIDEO FILTER and VIDEO PROCESSOR
S100 <sup>4</sup>				TRIGGERING SLOPE
S101A, B, C <sup>3</sup>	670-1751-00			Pushbutton, TRIGGER SOURCE SELECTOR
S102A, B, C, D <sup>3</sup>	670-1748-00			Pushbutton, TRIGGER MODE SELECTOR
S104 <sup>5, 3</sup>	105-0289-00			Cam, TIME/DIV
S105A, B, C <sup>6</sup>				
S108A, B <sup>7, 3</sup>	105-0288-00	B010100	B039999	Cam, FREQUENCY SPAN/DIV
S108A, B <sup>7, 3</sup>	105-0288-01	B040000		Cam, FREQUENCY SPAN/DIV
S109A, B				Push-push, VARIABLE FREQUENCY SPAN CAL
S110A <sup>3</sup>	670-1750-00			START/CENTER
S110B <sup>3</sup>				Pushbutton, SELECTOR
S120	260-1470-00			Slide, PHASE LOCK
S130	260-1360-00			Pushbutton, DISPLAY MODE SELECTOR
S180 <sup>2</sup>				Rotary, REFERENCE LEVEL dBm SELECTOR
TRANSFORMERS				
T90	120-0776-00			Toroid, 3 windings
T92	120-0778-00			Toroid, three 4 turn windings
T95	120-0777-00			Toroid, 2 windings
T211	120-0779-00			Toroid, two 4 turn windings
T240	120-0774-00			Toroid, 2 windings
T245	120-0774-00			Toroid, 2 windings
T264	120-0775-00			Toroid, 2 windings
T280	120-0772-00			Toroid, 2 windings
T294	120-0775-00			Toroid, 2 windings
T380	120-0773-00			Toroid, 2 windings
T457	120-0774-00			Toroid, 2 windings
T560	120-0780-00			Toroid, 2 windings
INTEGRATED CIRCUITS				
U820	155-0035-00			Quad operational amplifier
U830	156-0352-00	XB040000		Dual compl pair plus inverter, replaceable by CD4007AE
U840	156-0352-00	XB040000		Dual compl pair plus inverter, replaceable by CD4007AE
U1010	155-0035-00			Quad operational amplifier
U1060	156-0067-00			Operational amplifier, replaceable by UA741C
U1110	156-0030-00			Quad 2-input positive nand gate, replaceable by SN7400N
U1140	155-0056-00			Sweep control
U1160	155-0042-02			Miller integrator and delay pickoff
U1210	155-0035-00			Quad operational amplifier
U1260	156-0067-00			Operational amplifier, replaceable by UA741C

<sup>1</sup>Furnished as a unit with R82.

<sup>2</sup>Furnished as a unit with A1.

<sup>3</sup>See Mechanical Parts List for replacement parts.

<sup>4</sup>Furnished as a unit with R100.

<sup>5</sup>Furnished as a unit with S105A, B, C, and R105A, B.

<sup>6</sup>Furnished as a unit with S104 and R105A, B.

<sup>7</sup>Furnished as a unit with S109 and R109.

<sup>8</sup>Furnished as a unit with S108 and R109.

ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
INTEGRATED CIRCUITS (cont)				
U1350	156-0132-00			Operational amplifier, wide band, low noise, replaceable by HA2-911-5
U1370	156-0067-00			Operational amplifier, replaceable by UA741C
U1410	156-0132-00			Operational amplifier, wide band, low noise, replaceable by HA2-911-5
U1420	156-0158-00			Dual operational amplifier, replaceable by N5558V
U1440	156-0158-00			Dual operational amplifier, replaceable by N5558V
U1460	156-0071-00			Voltage regulator, replaceable by UA723C
U1520	155-0035-00			Quad operational amplifier
U1540	156-0158-00			Dual operational amplifier, replaceable by N5558V
U1558	156-0072-00			Single monostable multivibrator, one shot, replaceable by SN74121N
U1560	156-0039-00			Dual 15 MHz J-K master-slave flip-flop, replaceable by SN7473N
U1570	156-0032-00			Single 10 MHz 1-&-3-bit binary ripple counter, replaceable by SN7493N
U1610	156-0158-00			Dual operational amplifier, replaceable by N5558V
CABLE ASSEMBLIES				
W1	175-1317-00			J1 to J2
W2	175-1321-00			J3 to J4
W3	175-1326-00			J5 to J8
W4	175-1325-00			J9 to J1
W5	175-1327-00			JL to J38
W6	175-1328-00			JR to J6
W7	175-1318-00			J7 to A10
W20 <sup>1</sup>	175-1315-00			J20 to A11
W22	175-1316-00			J22 to J72
W28	175-1371-00			J28 to J80
W34 <sup>2</sup>	175-1322-00			J34 to A30
W40	175-1373-00			J40 to J1348
W69	179-1742-00			P1341 to J69
W92	175-1374-00			J92 to J211
W95	175-1372-00			J95 to J240
W307	175-1352-00			P300 to P301
W356	175-1353-00			P302 to P303
W900	175-1370-00			J900 to J99
CRYSTALS				
Y204	158-0074-00			Crystal unit quartz, 95 MHz
Y950	158-0068-00			Crystal unit quartz, 50 MHz
Y1300	158-0076-00			Crystal unit quartz, 2.21 MHz

<sup>1</sup>Part of All.  
<sup>2</sup>Includes DC Block.



# SECTION 8

## DIAGRAMS AND CIRCUIT BOARD ILLUSTRATIONS

### Symbols and Reference Designators

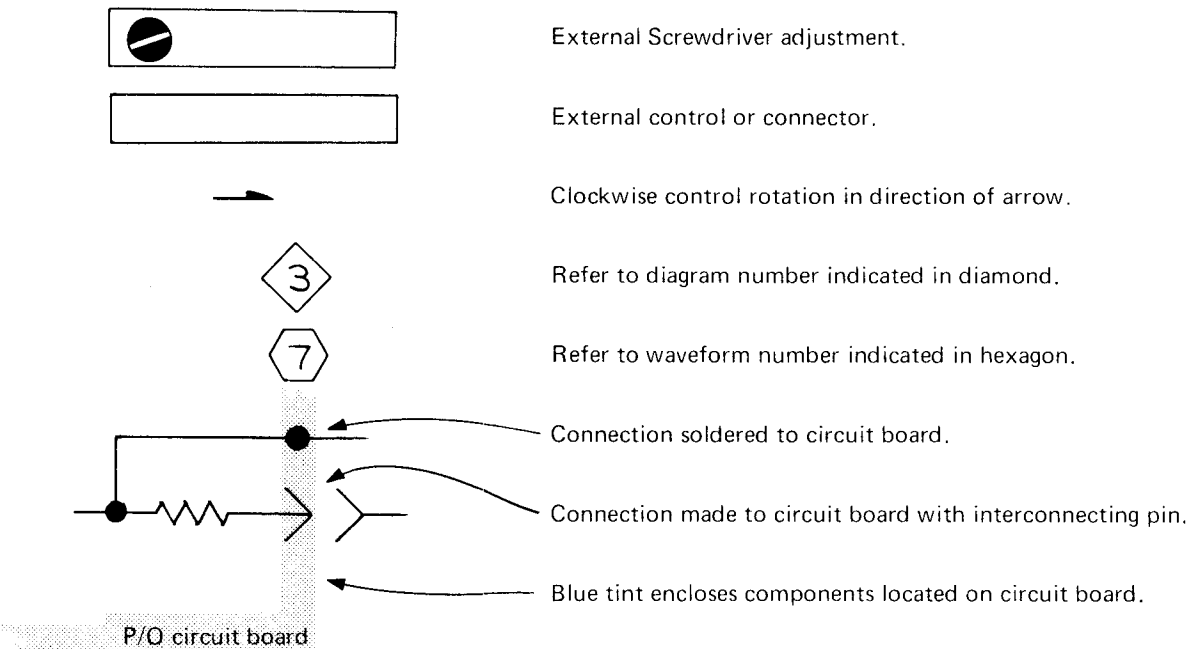
Electrical components shown on the diagrams are in the following units unless noted otherwise:

Capacitors =	Values one or greater are in picofarads (pF). Values less than one are in microfarads ( $\mu$ F).
Resistors =	Ohms ( $\Omega$ )

Symbols used on the diagrams are based on USA Standard Y32.2-1967.

Logic symbology is based on MIL-STD-806B in terms of positive logic. Logic symbols depict the logic function performed and may differ from the manufacturer's data.


The following special symbols are used on the diagrams:



The following prefix letters are used as reference designators to identify components or assemblies on the diagrams.

A	Assembly, separable or repairable (circuit board, etc.)	LR	Inductor/resistor combination
AT	Attenuator, fixed or variable	M	Meter
B	Motor	Q	Transistor or silicon-controlled rectifier
BT	Battery	P	Connector, movable portion
C	Capacitor, fixed or variable	R	Resistor, fixed or variable
CR	Diode, signal or rectifier	RT	Thermistor
DL	Delay line	S	Switch
DS	Indicating device (lamp)	T	Transformer
F	Fuse	TP	Test point
FL	Filter	U	Assembly, inseparable or non-repairable (integrated circuit, etc.)
H	Heat dissipating device (heat sink, heat radiator, etc.)	V	Electron tube
HR	Heater	VR	Voltage regulator (zener diode, etc.)
J	Connector, stationary portion	Y	Crystal
K	Relay		
L	Inductor, fixed or variable		

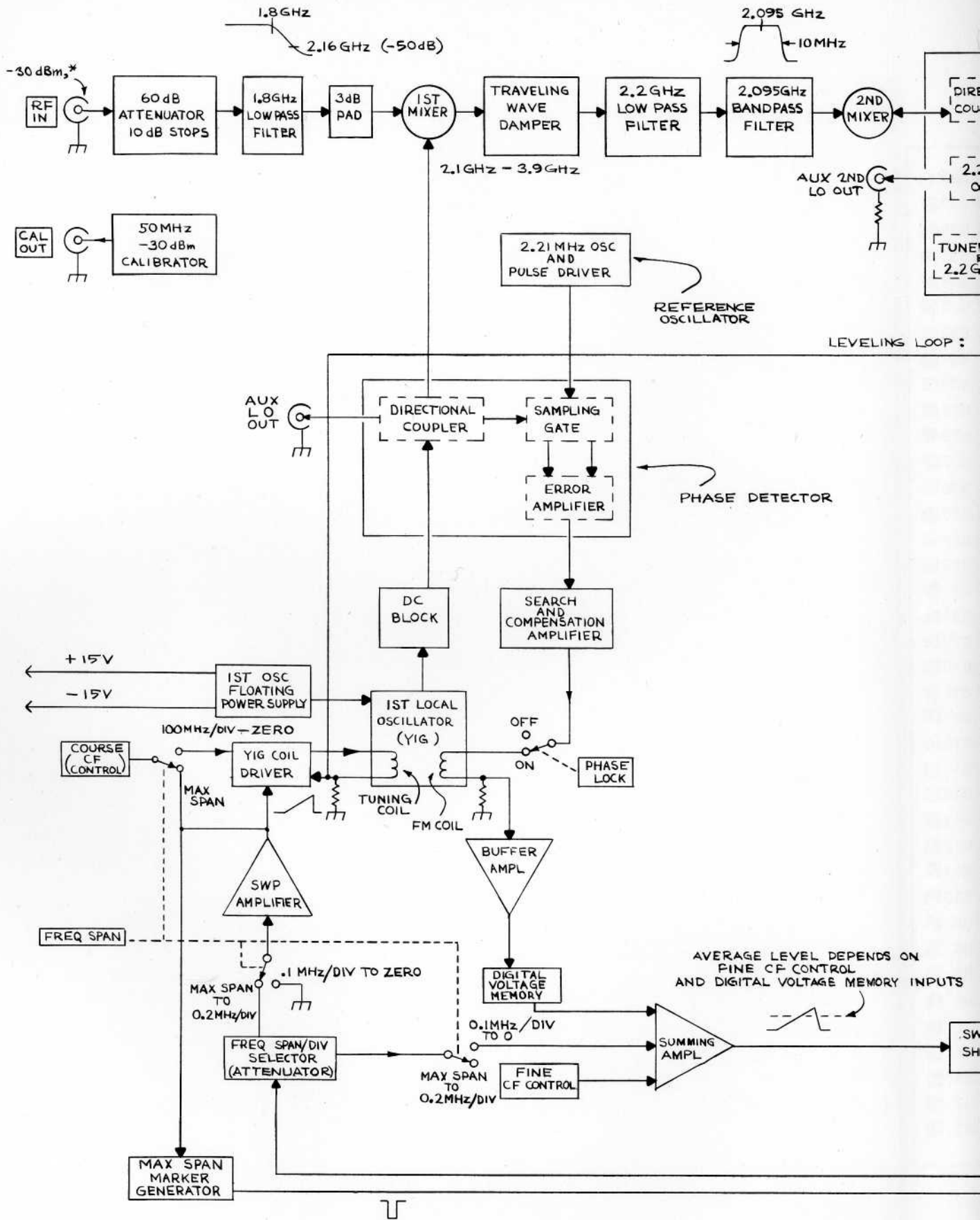
## WAVEFORM AND VOLTAGE INFORMATION

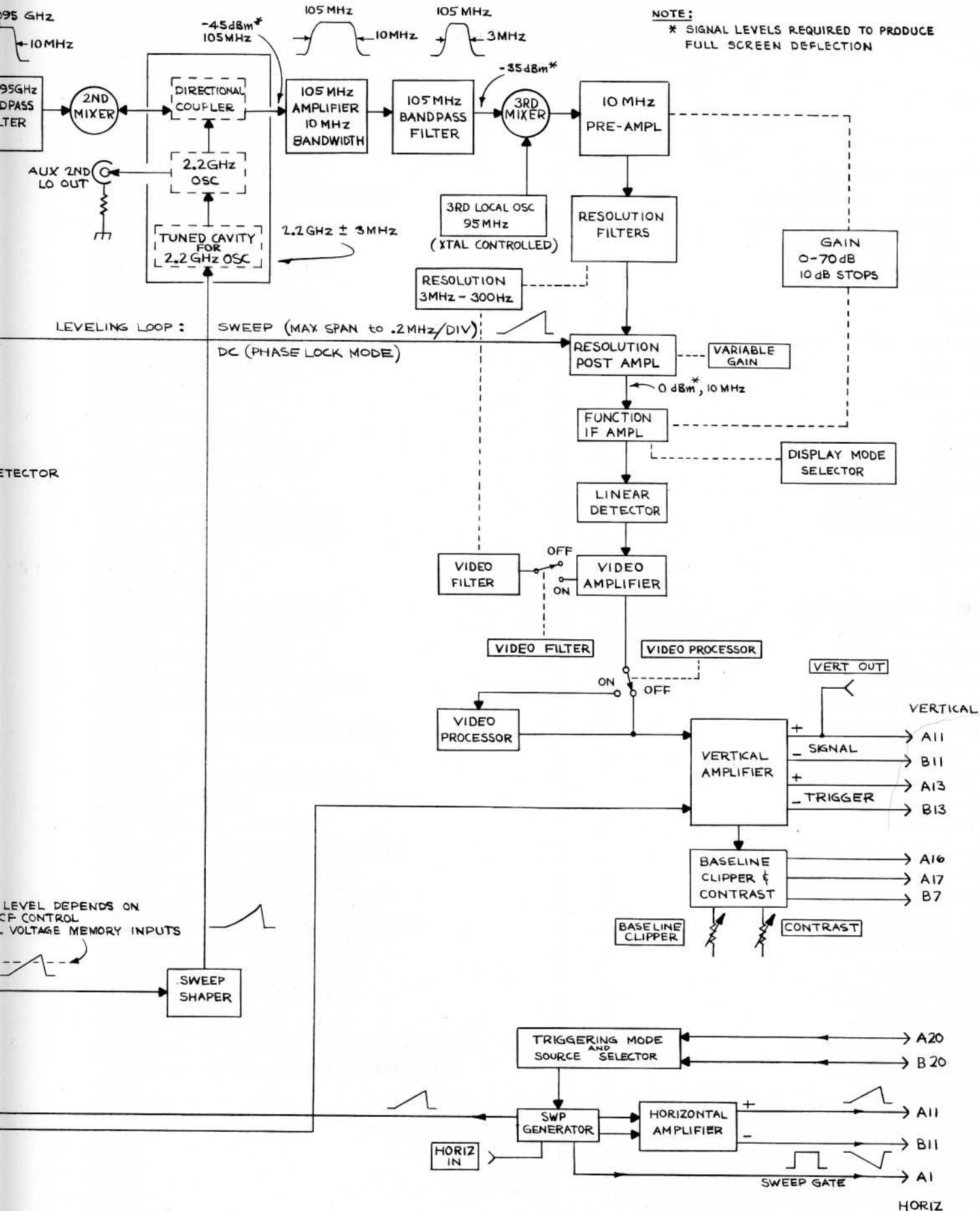
Waveforms at the  point indicated on the diagrams, are photographs taken with a TEKTRONIX Recording Camera. A DC to 500 MHz, 10X probe (P6053A) and a DC to 100 MHz vertical amplifier (7A16) were used for minimum loading and optimum response.

Signal waveforms through the IF and video stages are shown using the oscilloscope Chop or Alt mode. These show both the signal at the point indicated and the spectrum display. The signal source has a variable output attenuator. Signal level into the RF INput and other waveform data are indicated with each illustration, either as readout or extra data with the waveform.

Sweep signals, frequency span voltages, etc. are shown using a DC coupled probe. Therefore, DC levels are indicated as well as signal amplitudes. The spectrum analyzer triggering source was LINE; therefore these waveforms are time related.

Signal levels indicated on the block diagram, will produce full screen deflection if the circuits are functioning properly.



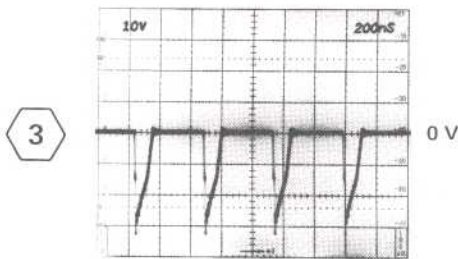
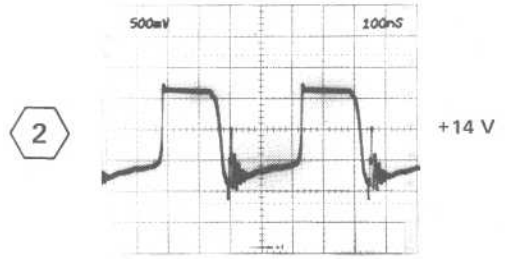
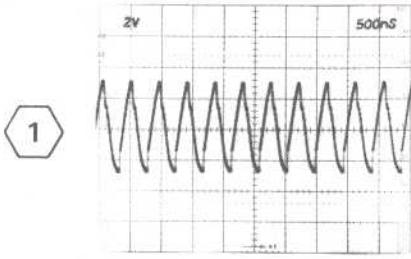


6-6-72 DL  
BLOCK DIAGRAM 1

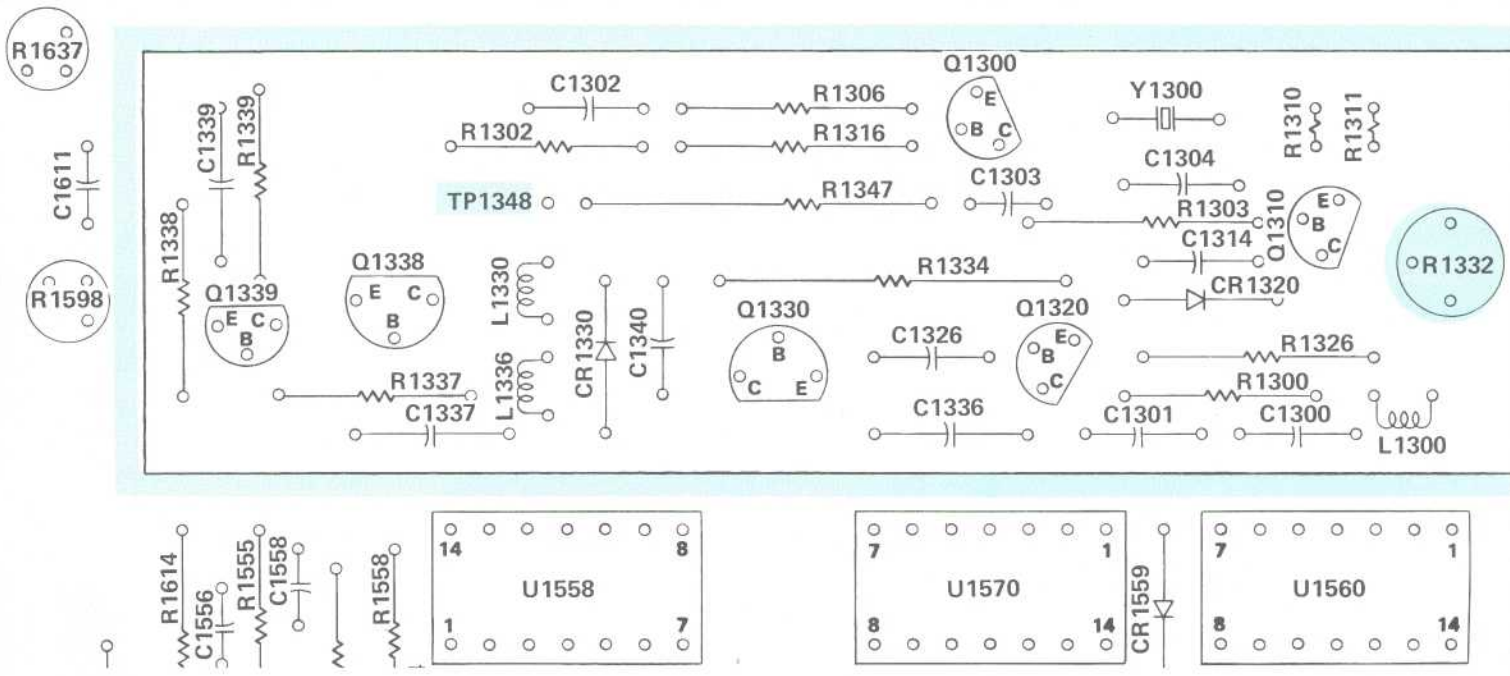
(A)



(Phase Lock Mode)

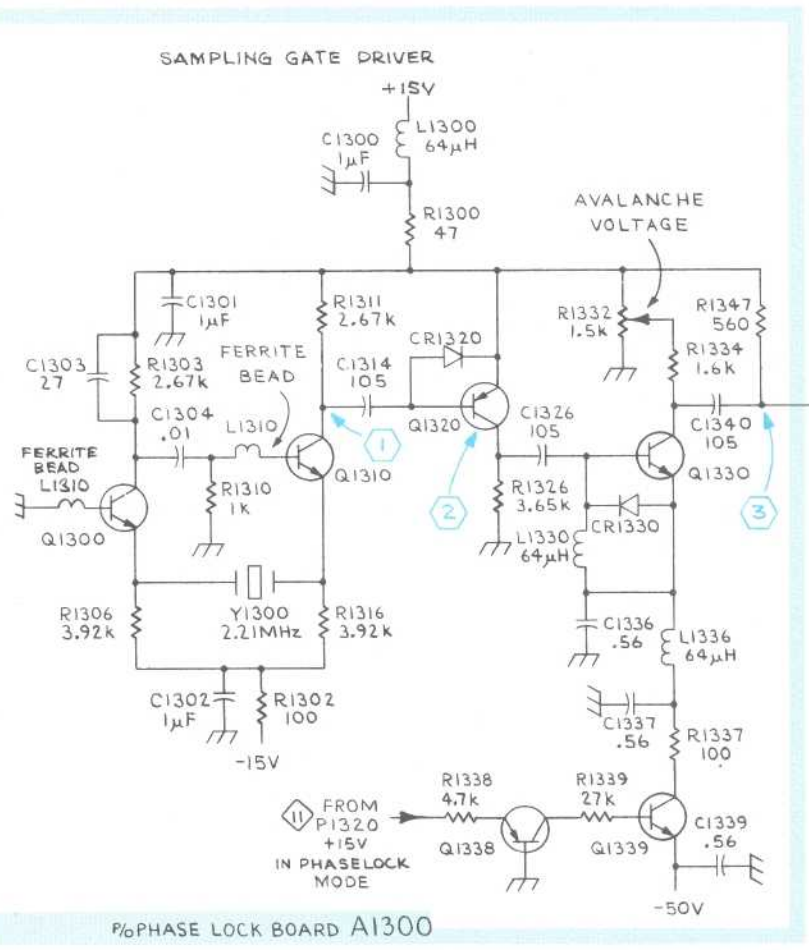
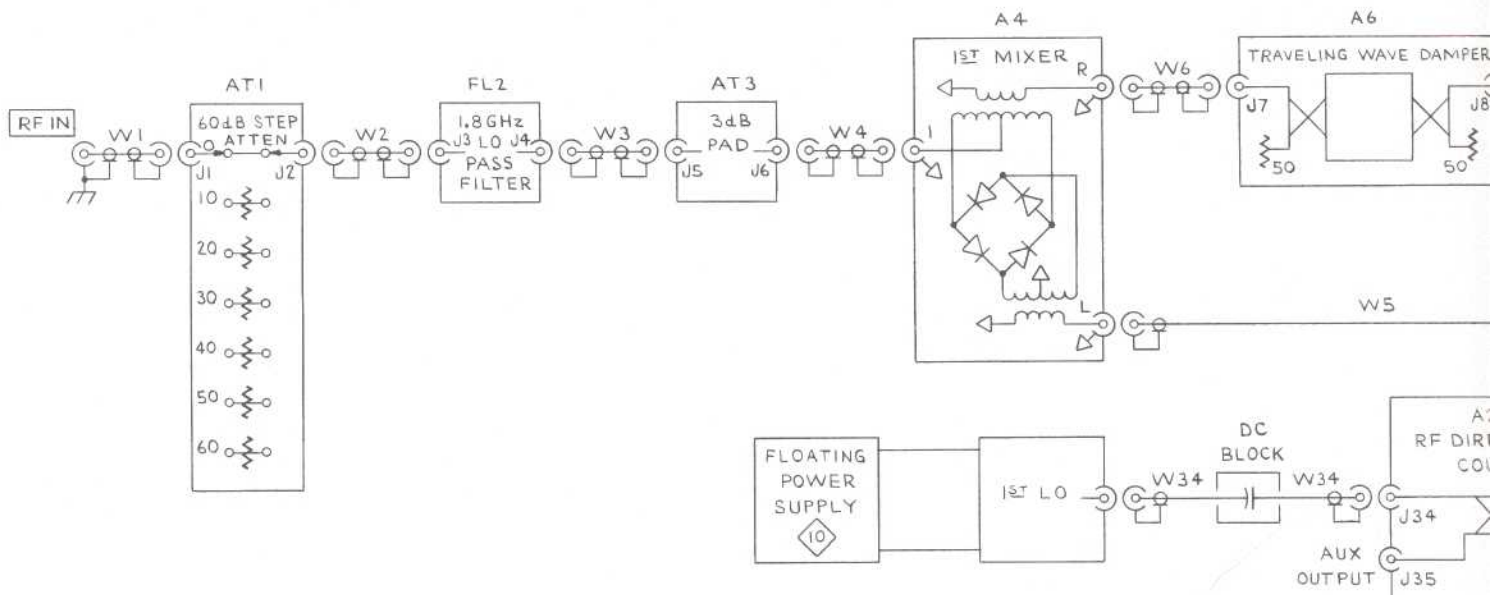


12

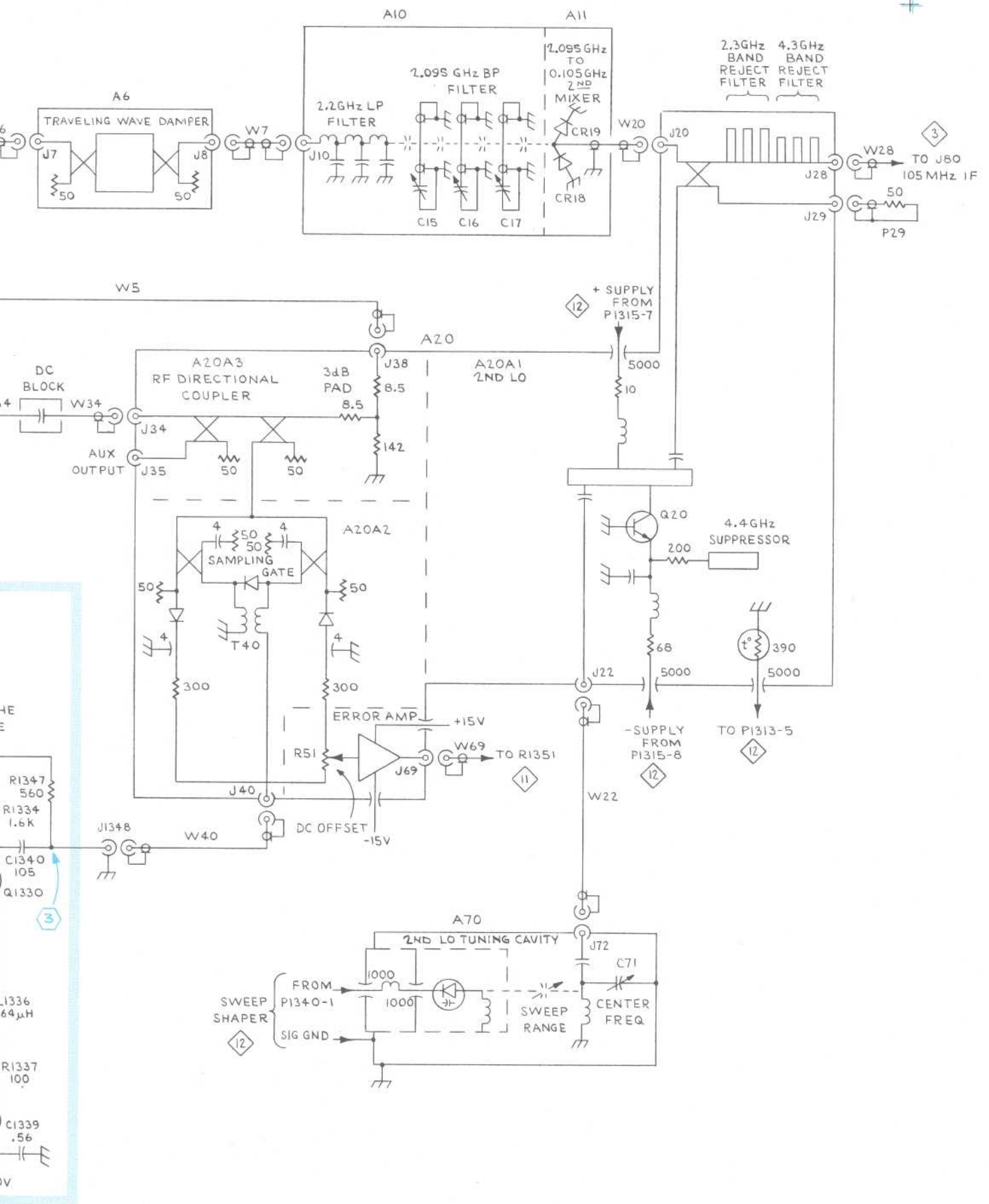


P/O A1300 Phase Lock Circuit Board



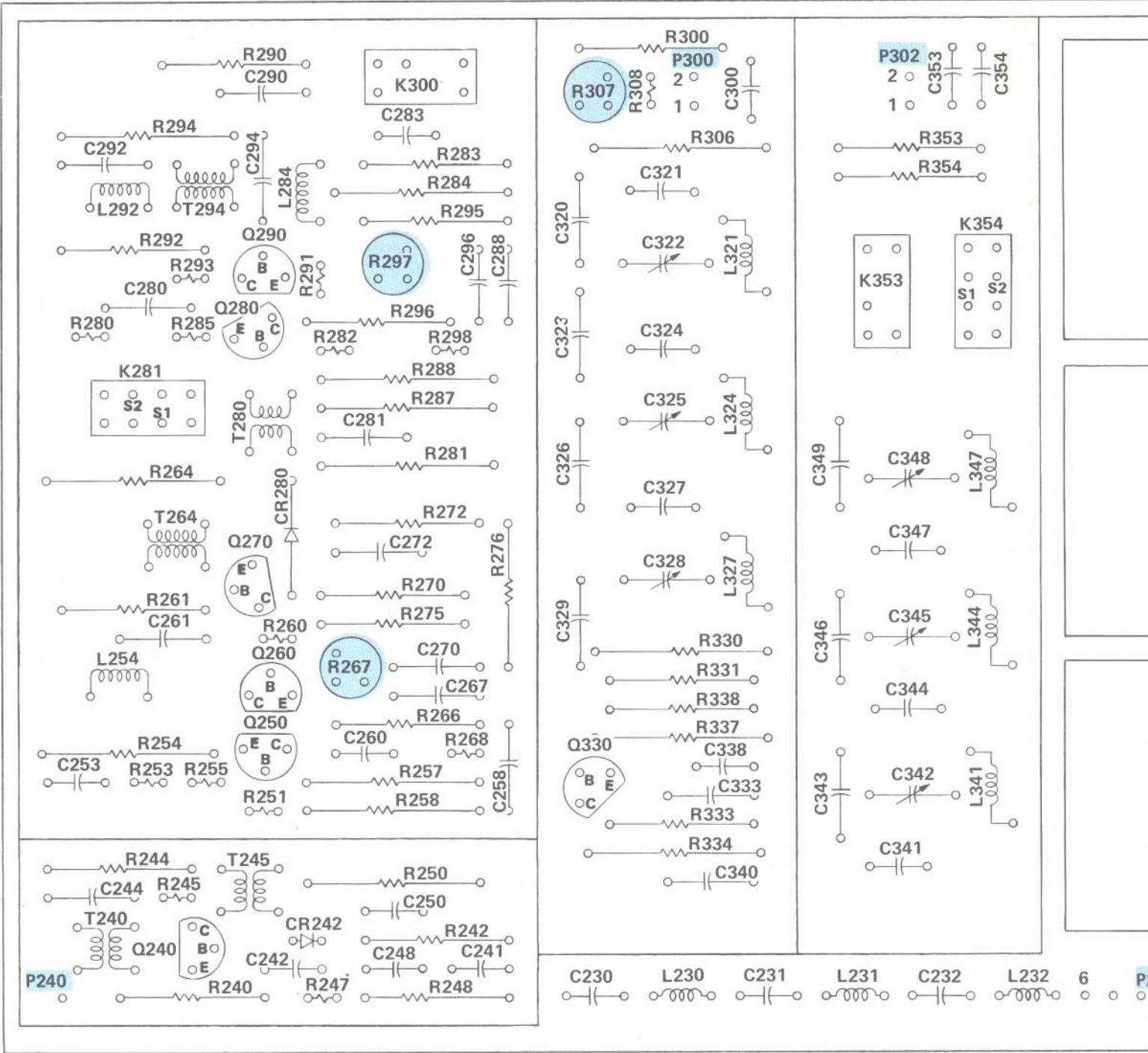


PHASE LOCK BOARD A1300

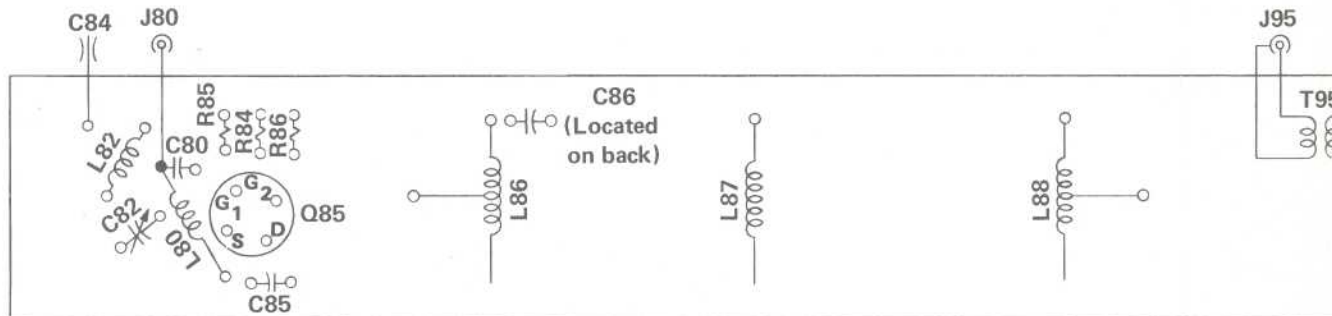


6-5-72 NL

MICROWAVE ASSEMBLIES 2



A200 Resolution Circuit Board



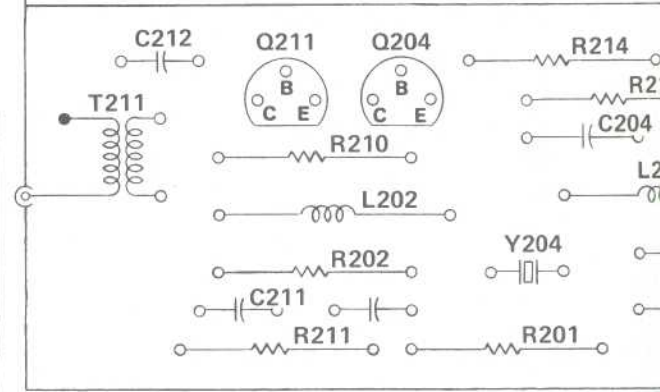
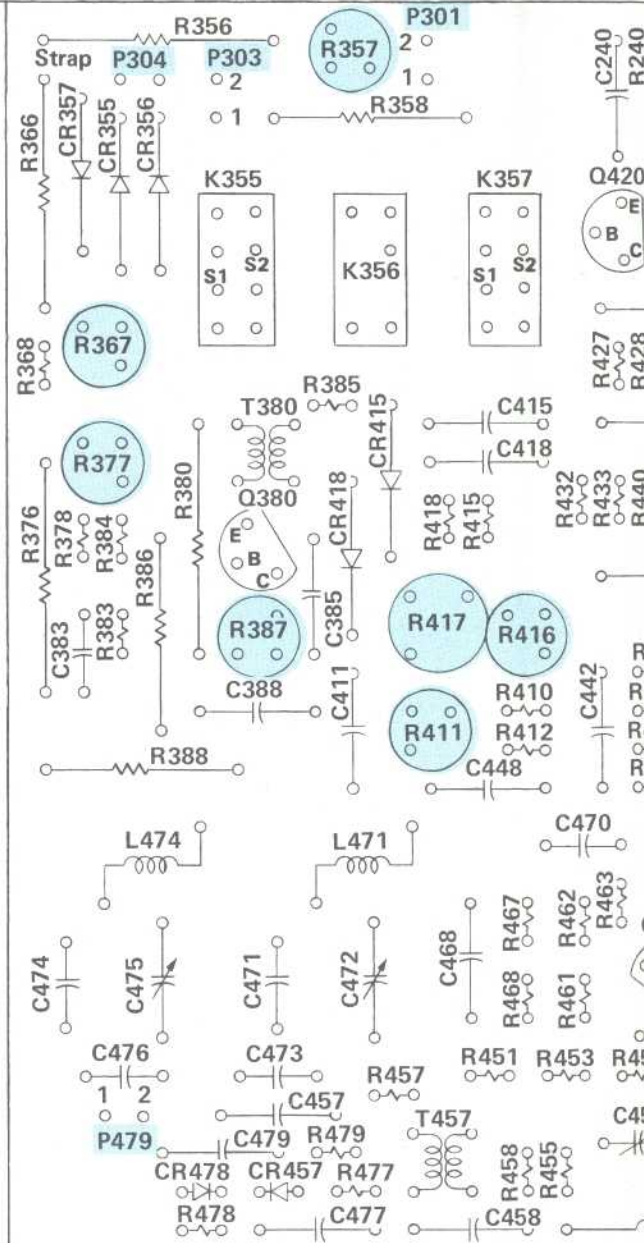
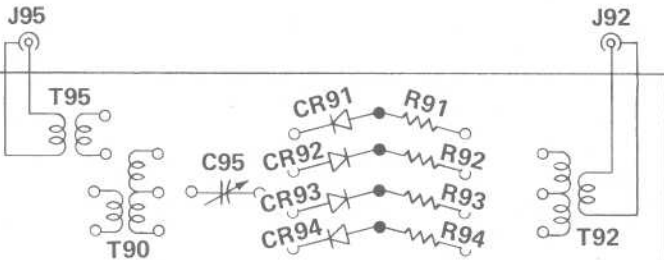
A80A1 105 MHz Amplifier and 3rd Mixer Circuit Board

FL360

FL380

FL370

2 6 P200 1 5 P201 1 P416 L391 L390 L392

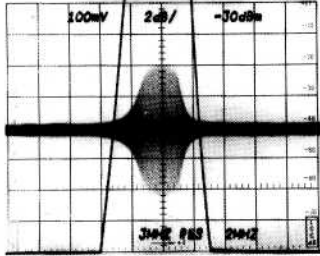






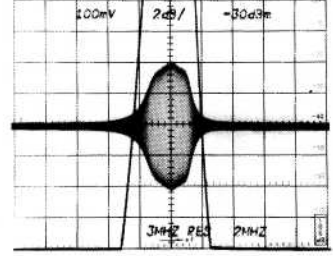
Input -10 dBm Time/Div 5 ms

1

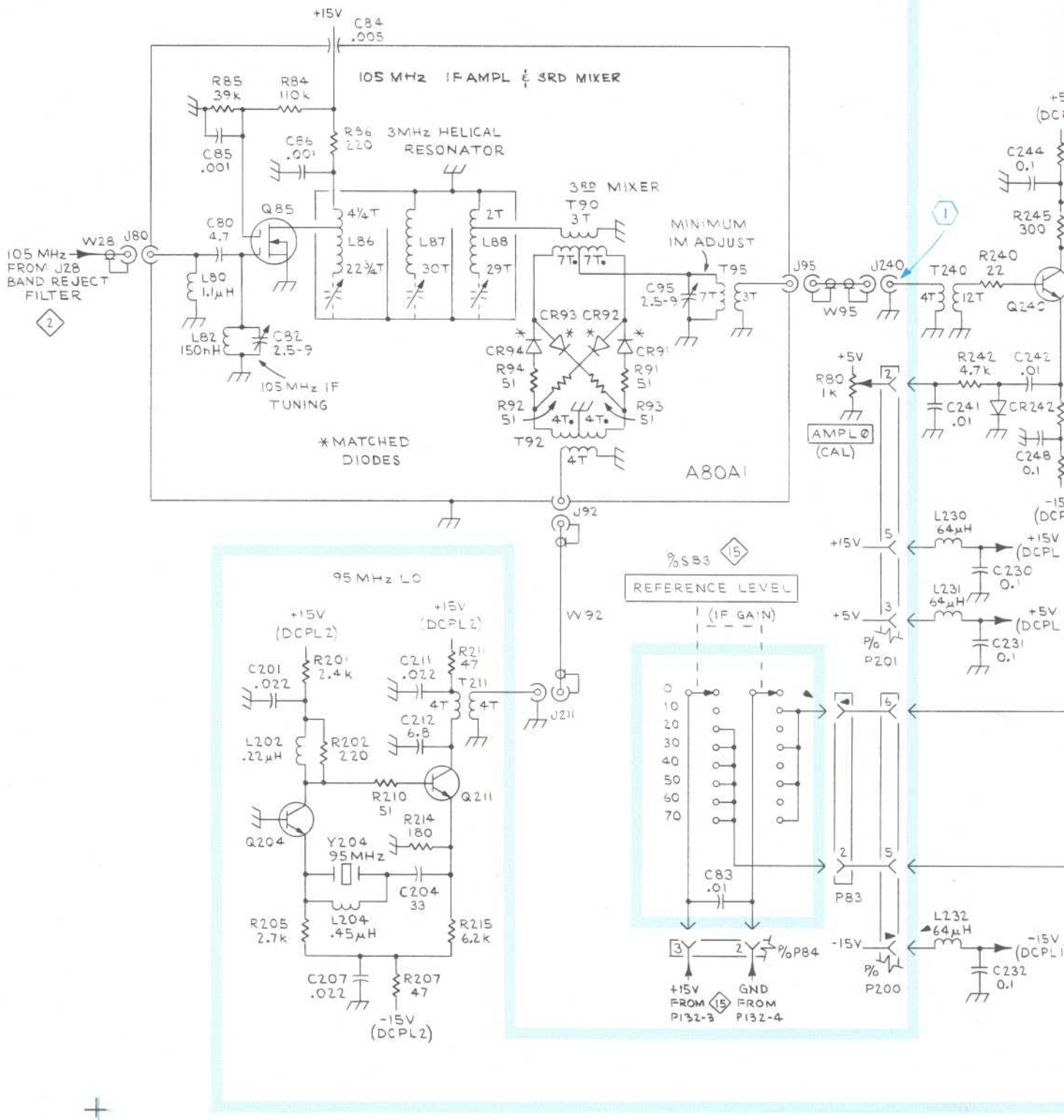


Input -18 dBm Time/Div 5 ms

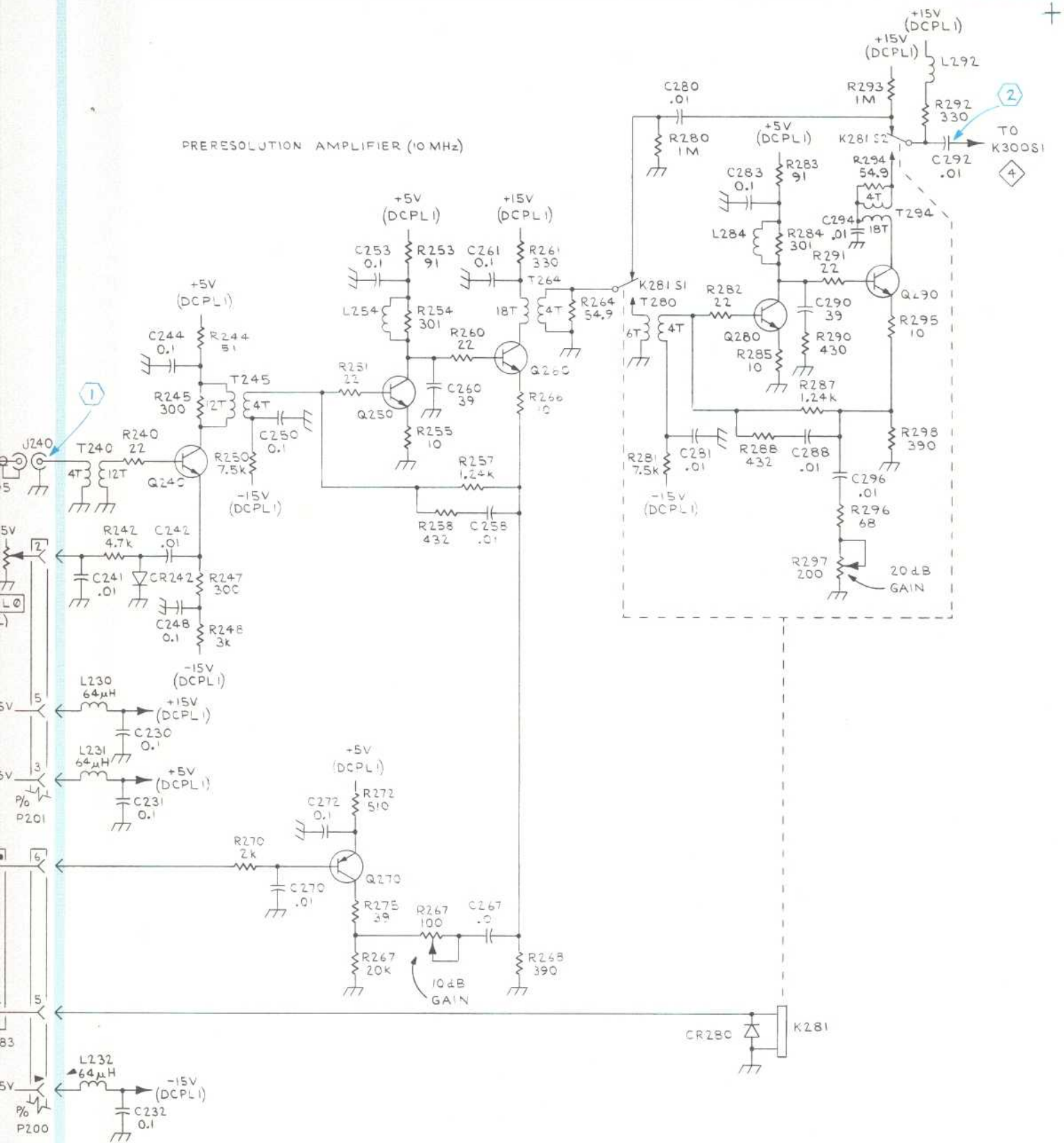
2





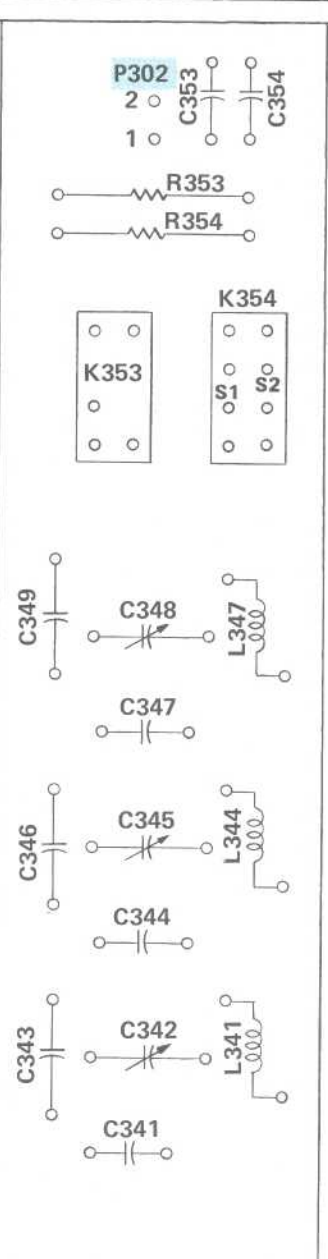
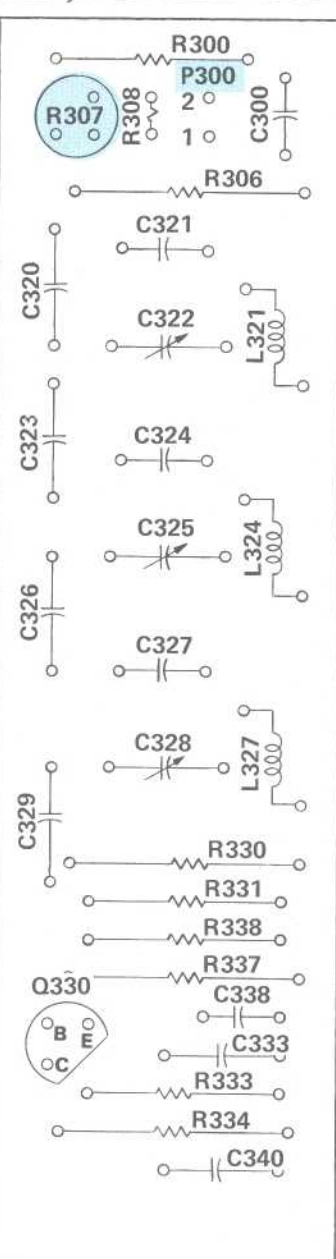
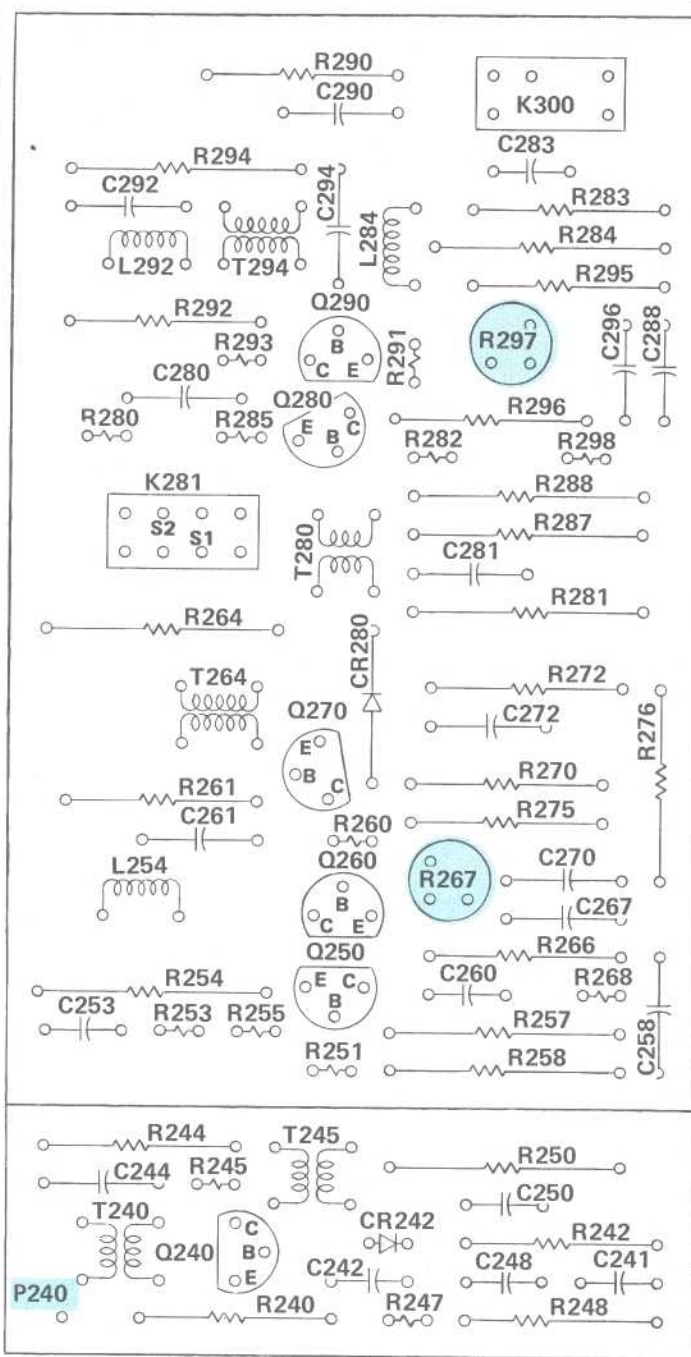


PRERESOLUTION AMPLIFIER (10 MHz)



PRERESOLUTION CIRCUIT BOARD A200

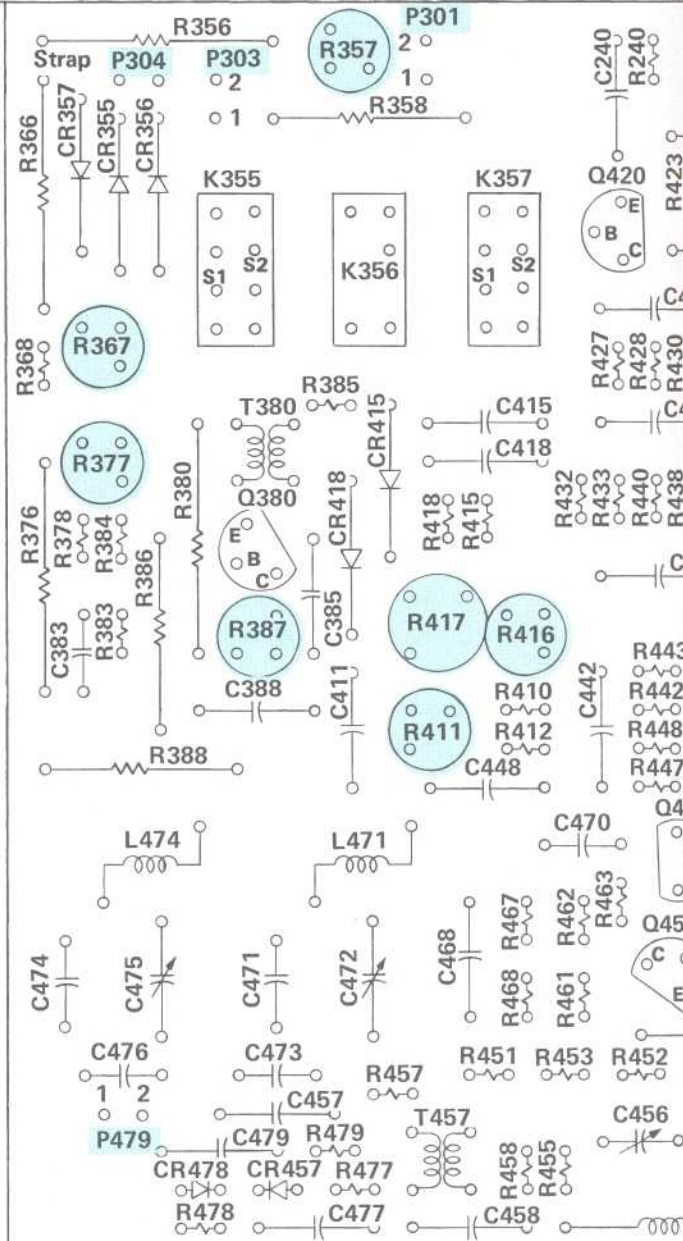
NL 572



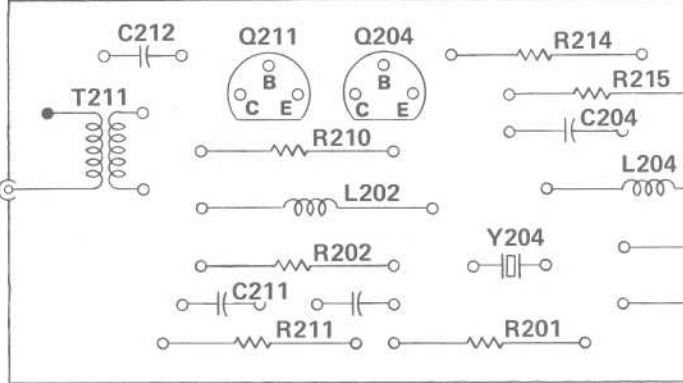
FL360

FL380

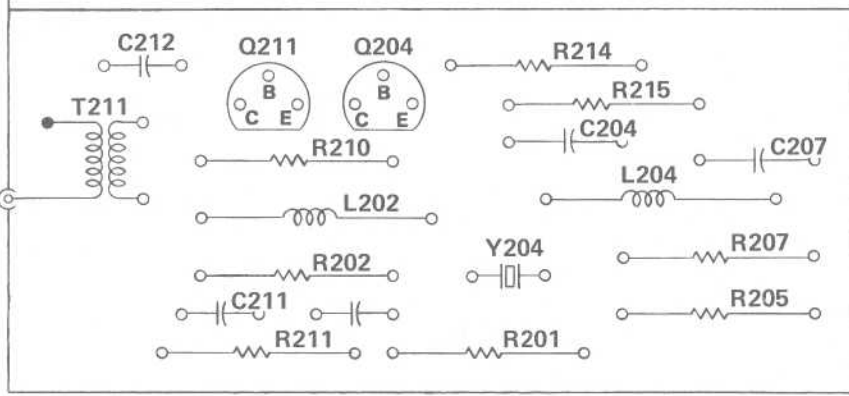
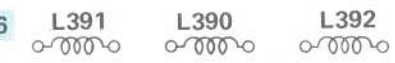
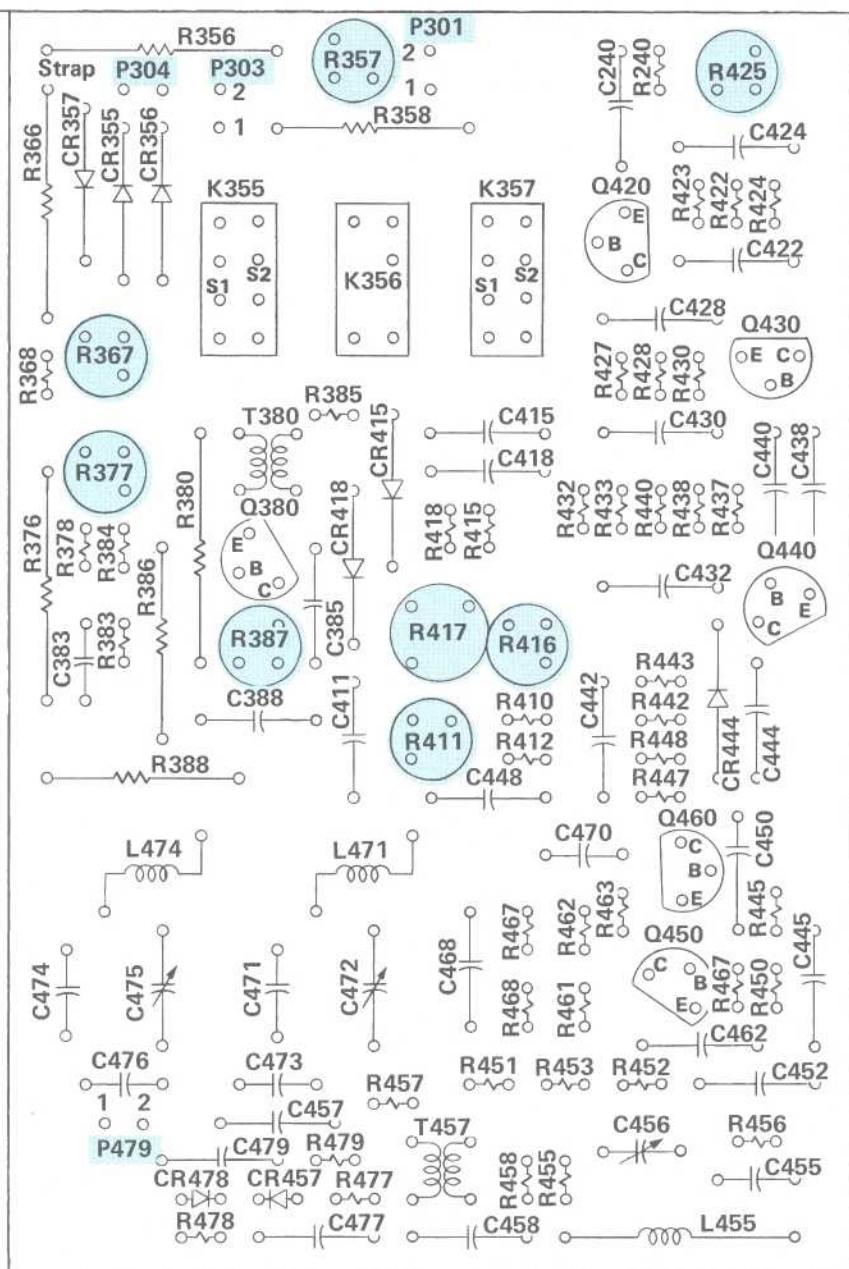
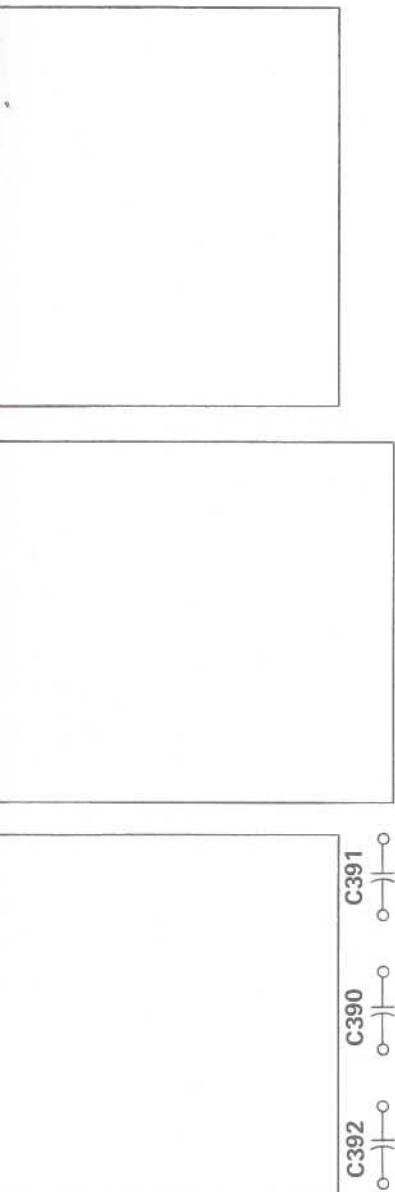
FL370



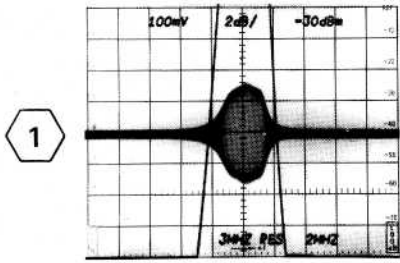
A200 Resolution Circuit Board



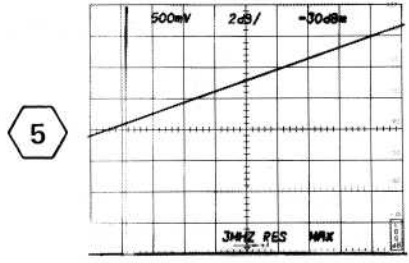




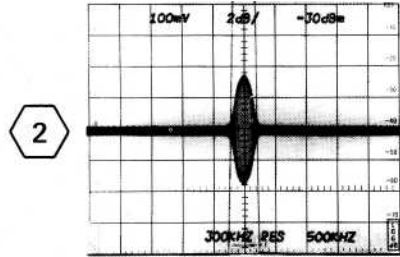
Input -18 dBm Time/Div 5 ms



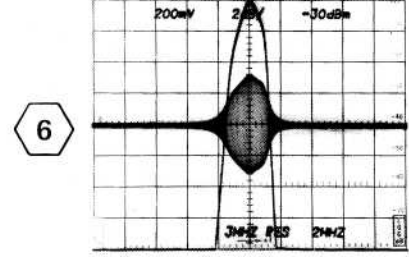
Input -30 dBm



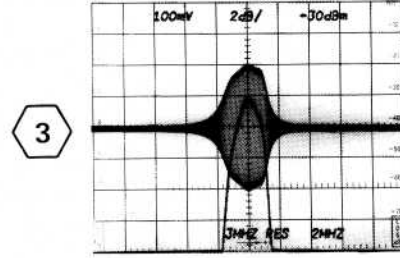
Input -18 dBm



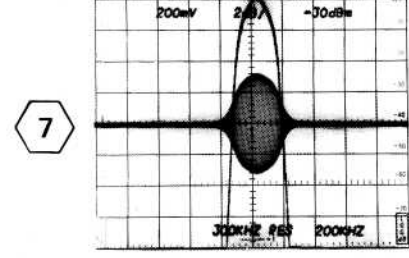
Input -30 dBm (Wide Filter)



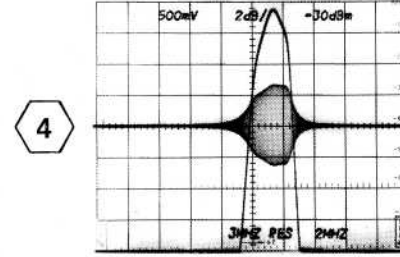
Input -35 dBm Time/Div 5 ms



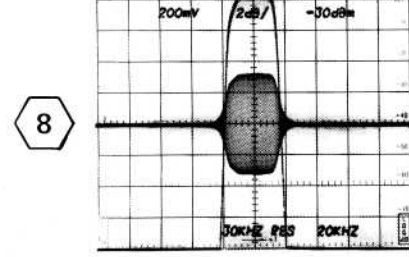
Input -30 dBm (Narrow Filter)



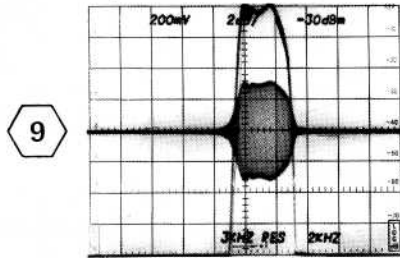
Input -30 dBm



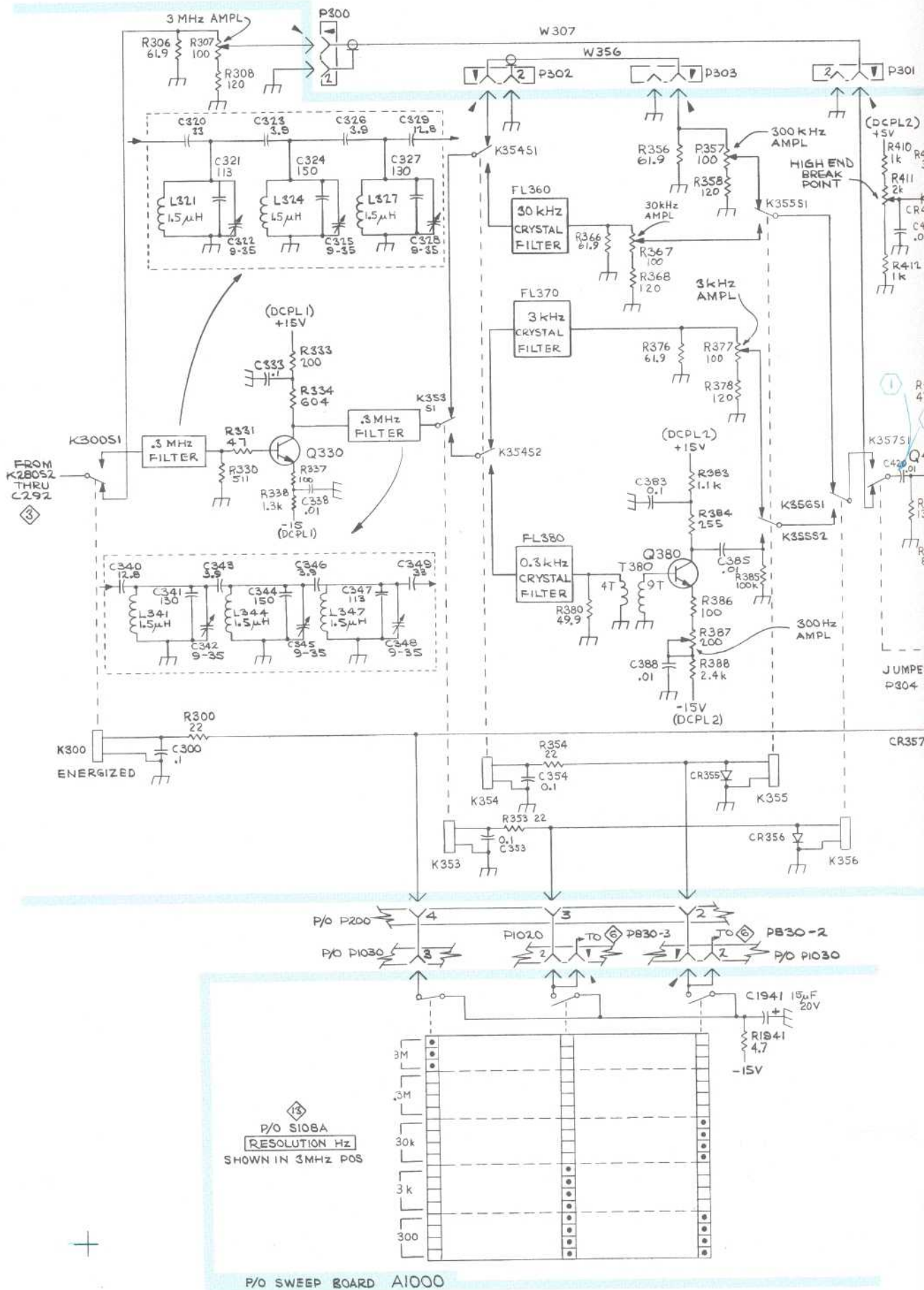
Input -30 dBm (30 kHz Filter)



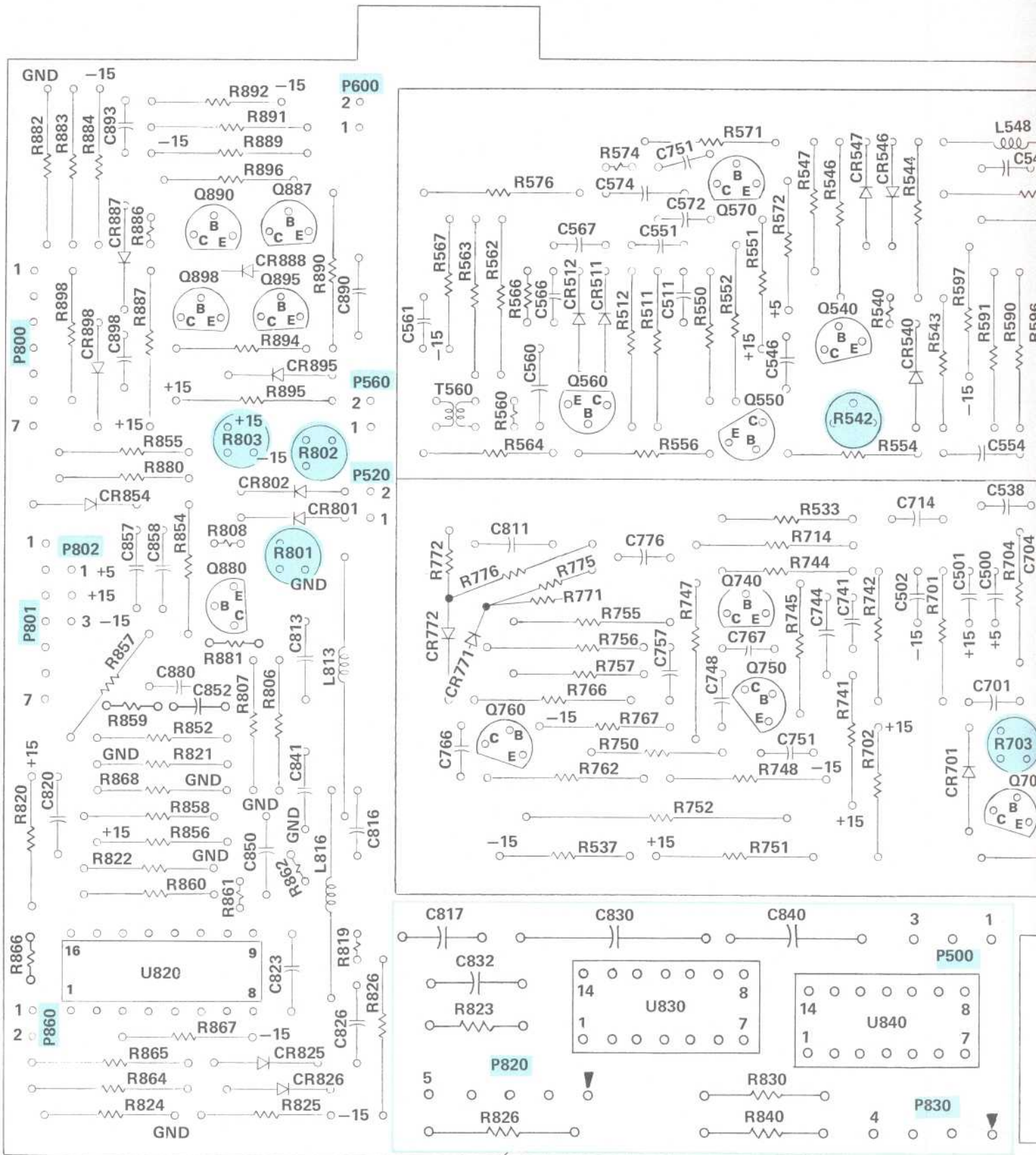
Input -30 dBm (30 kHz Filter)









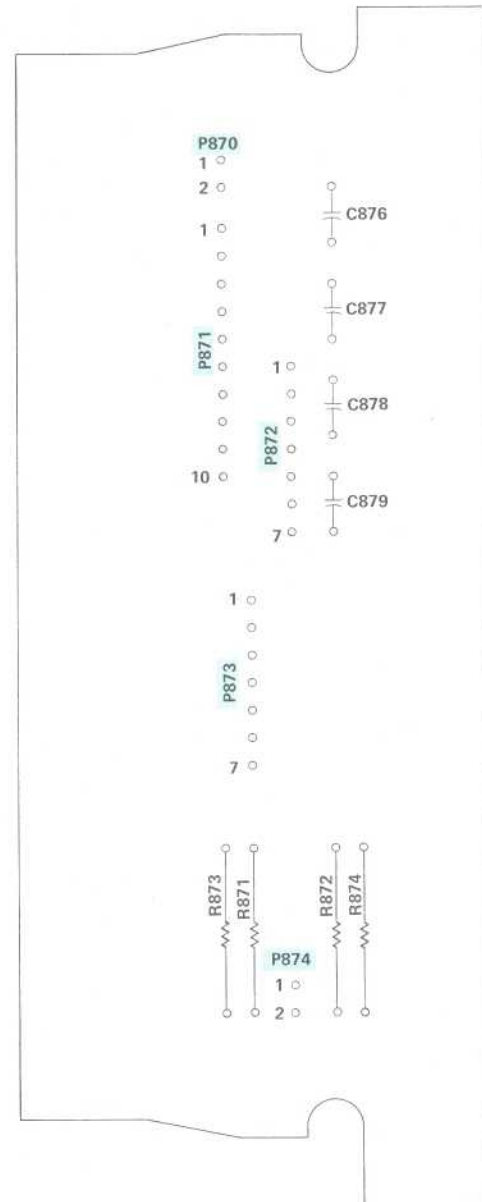
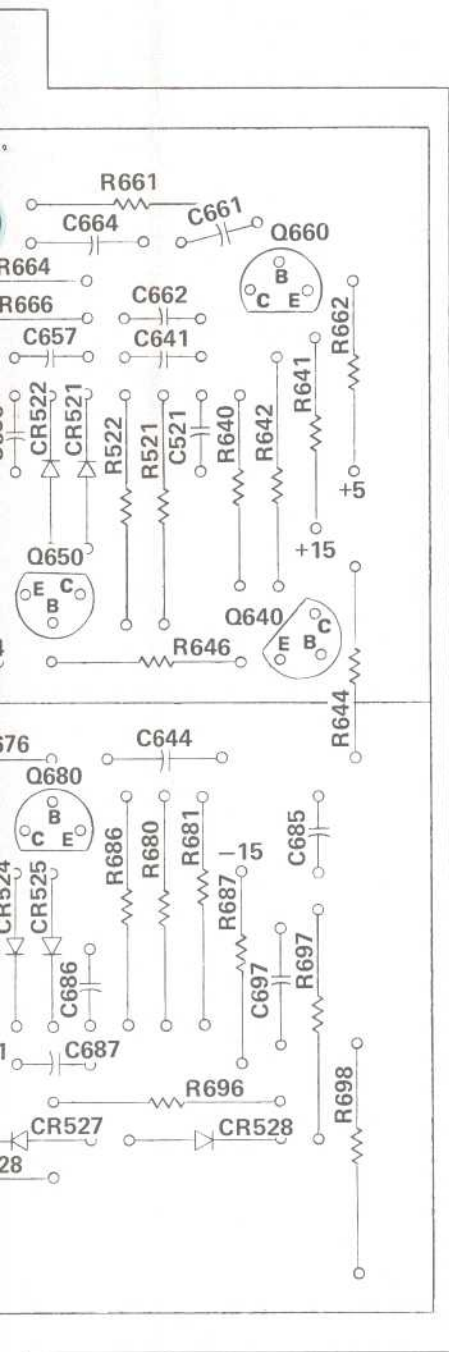


Changed SN B040000

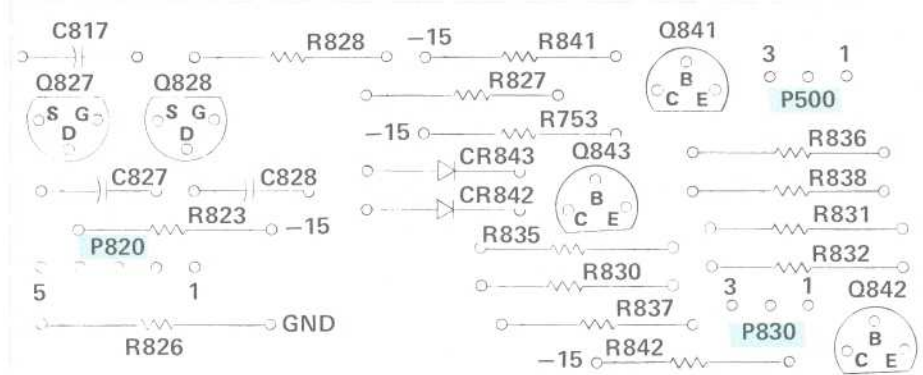
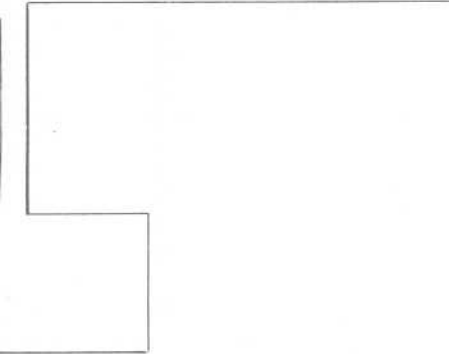
A500 Function



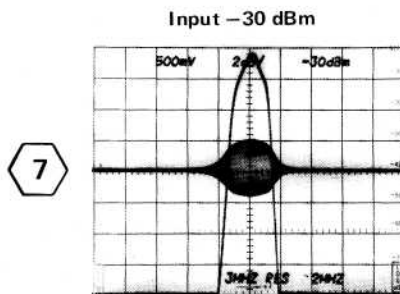
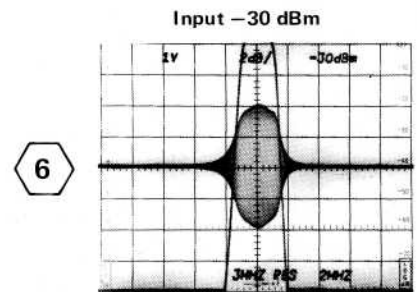
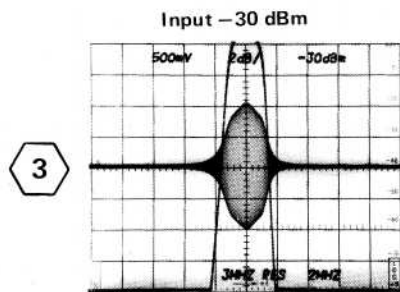
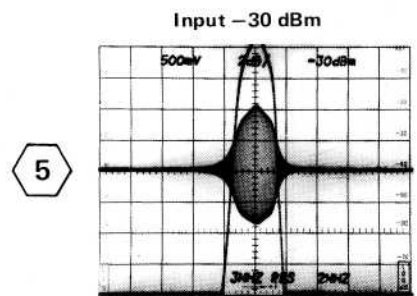
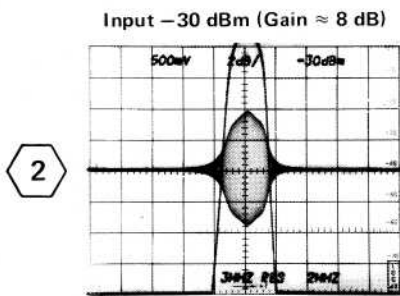
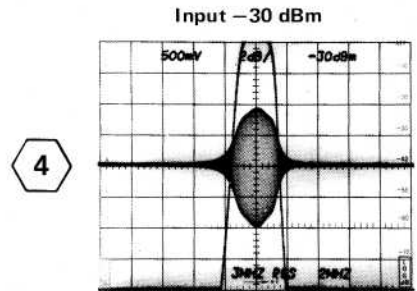
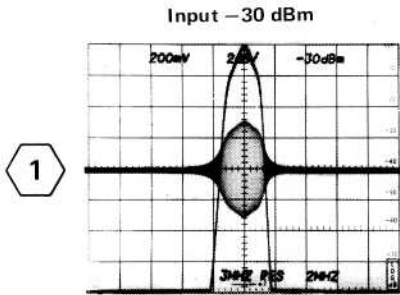




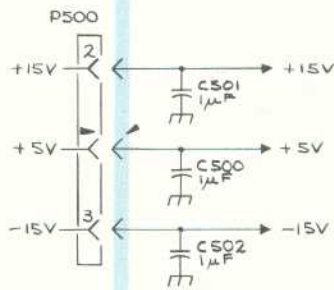
A800 Function I.F. Connector Circuit Board (A)



Below SN B040000

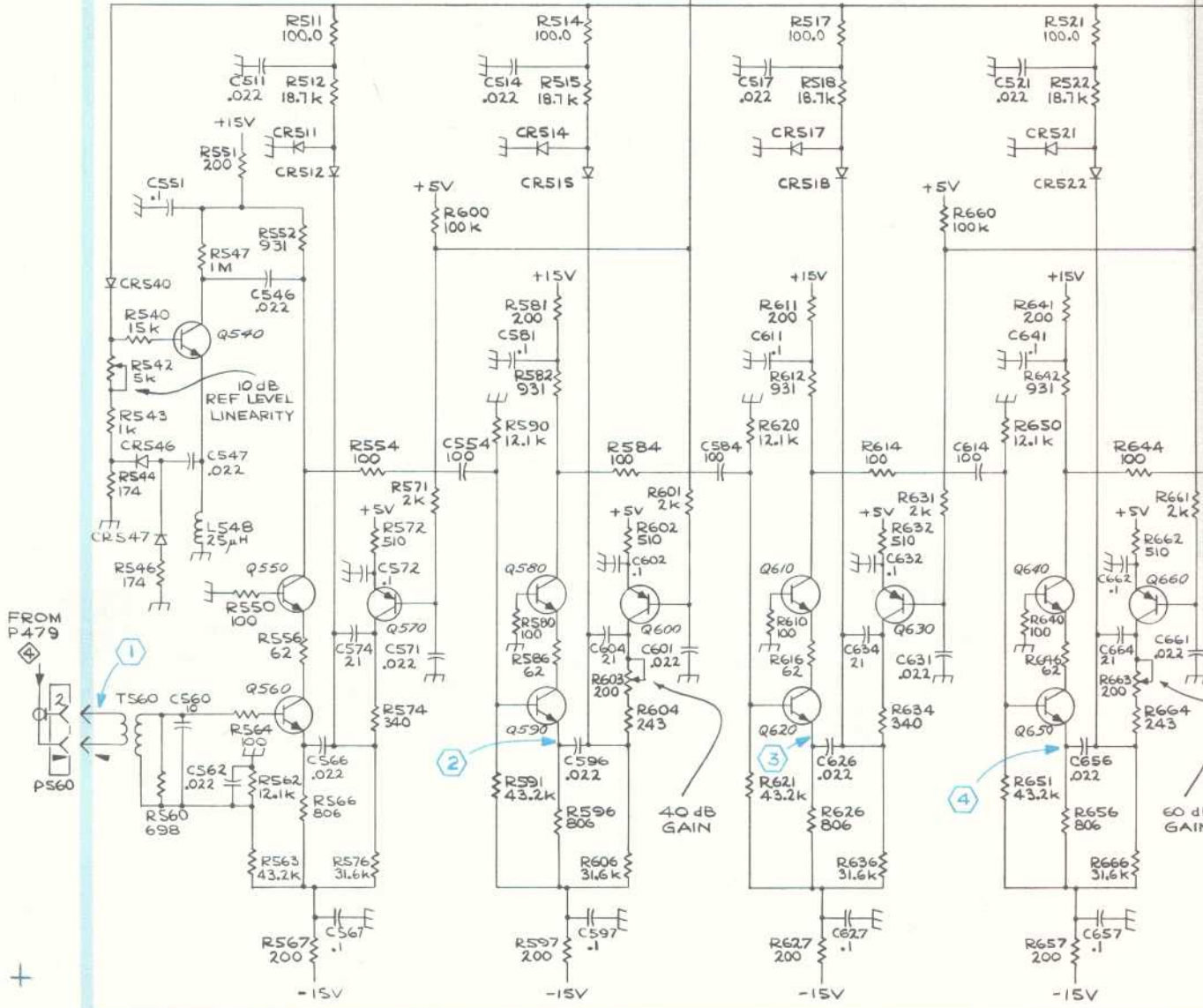
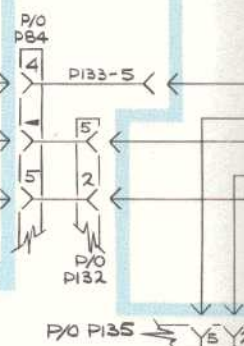






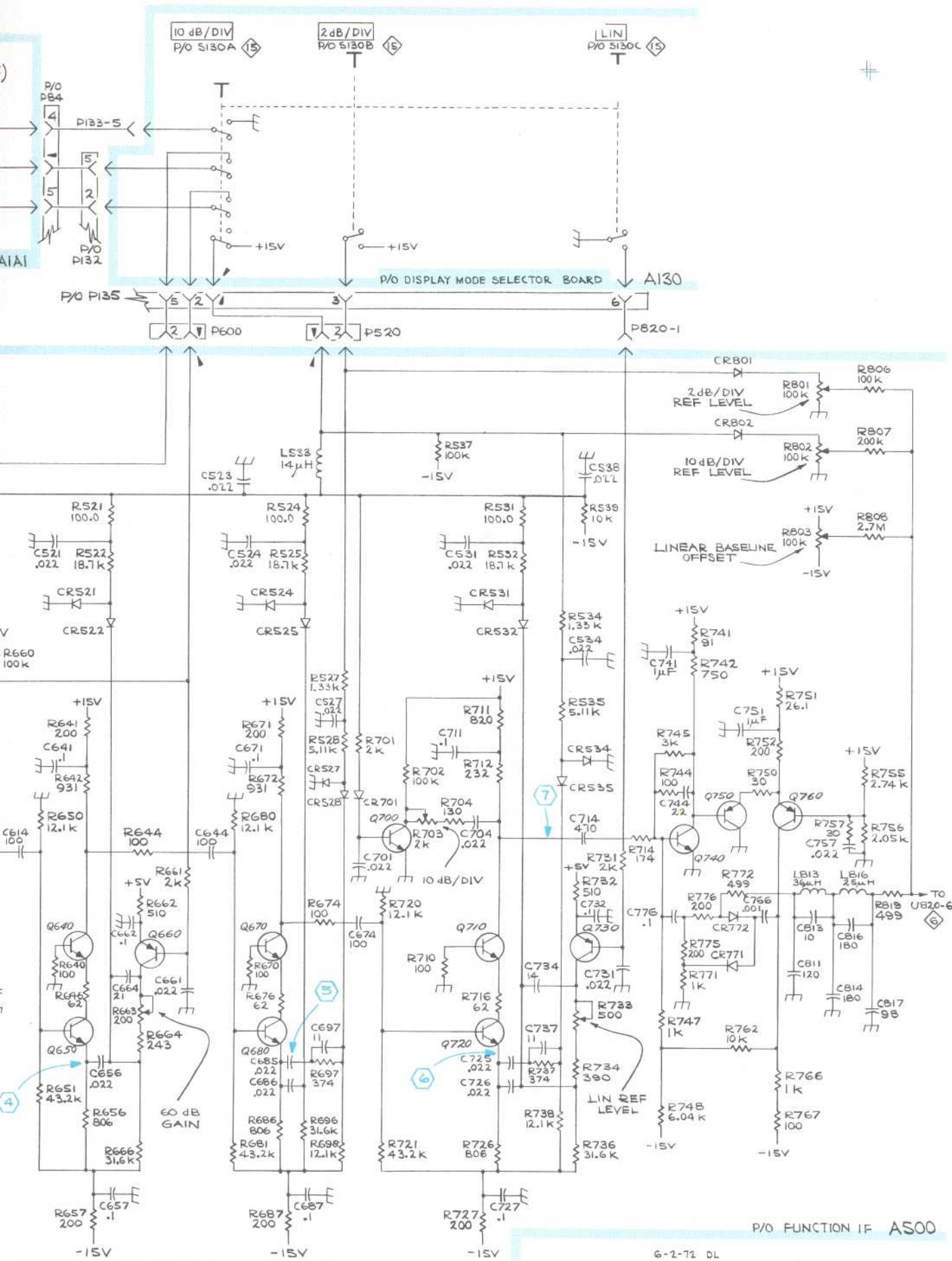
P/O 583 (5)  
IF GAIN (REFERENCE)  
LEVEL

P/O REFERENCE LEVEL READOUT BOARD A1A1



7L12

(A)



10 dB/DIV  
P/O S130A

2dB/DIV  
P/O S130B

LIN  
P/O S130C

P/O DISPLAY MODE SELECTOR BOARD

2dB/DIV  
REF LEVEL

10dB/DIV  
REF LEVEL

LINEAR BASELINE  
OFFSET

60 dB  
GAIN

LIN REF  
LEVEL

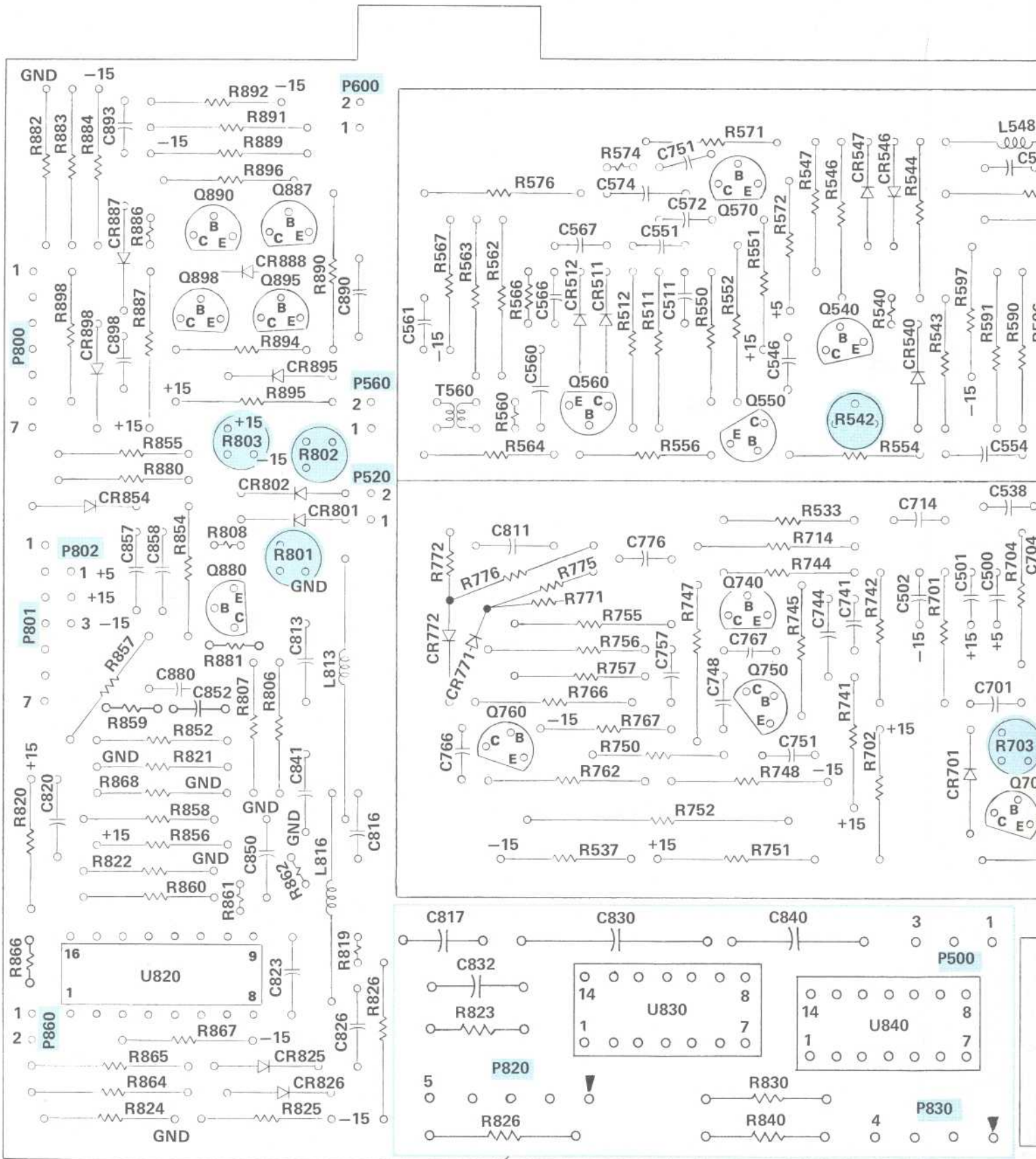
P/O FUNCTION IF A500

6-2-72 DL

FUNCTION IF

(A)

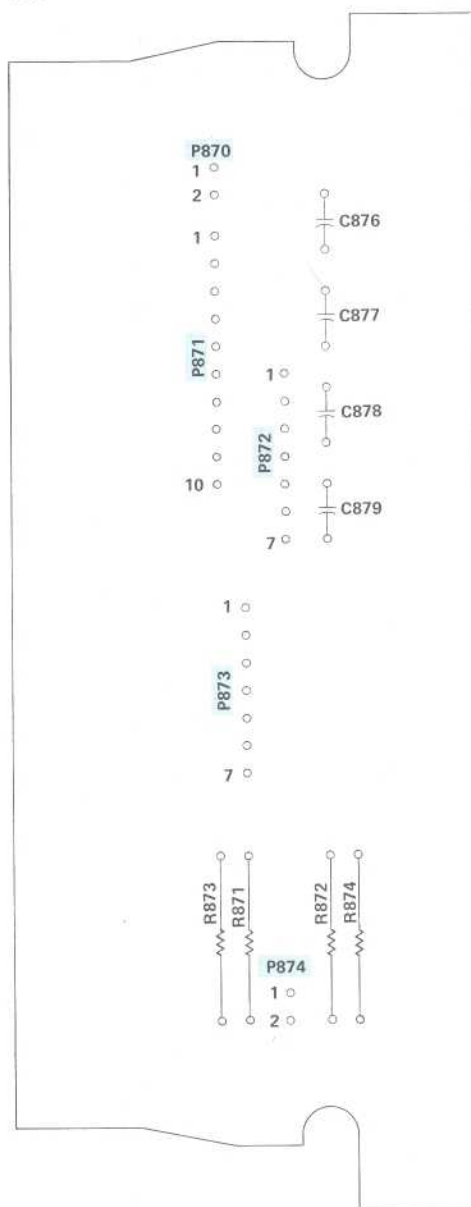
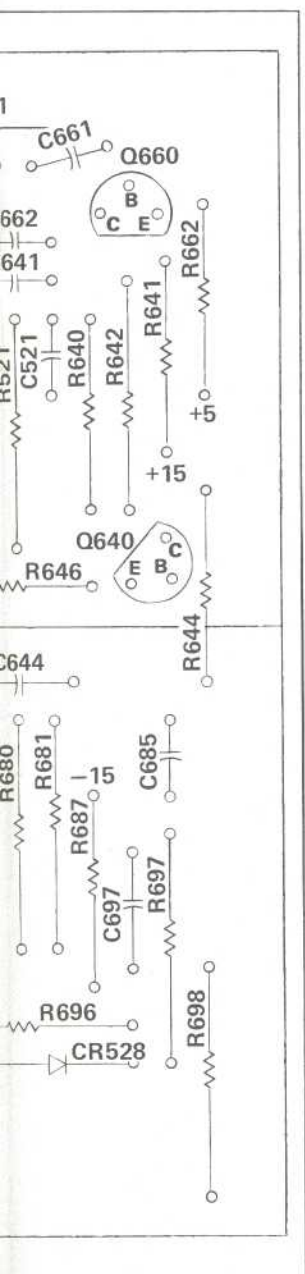




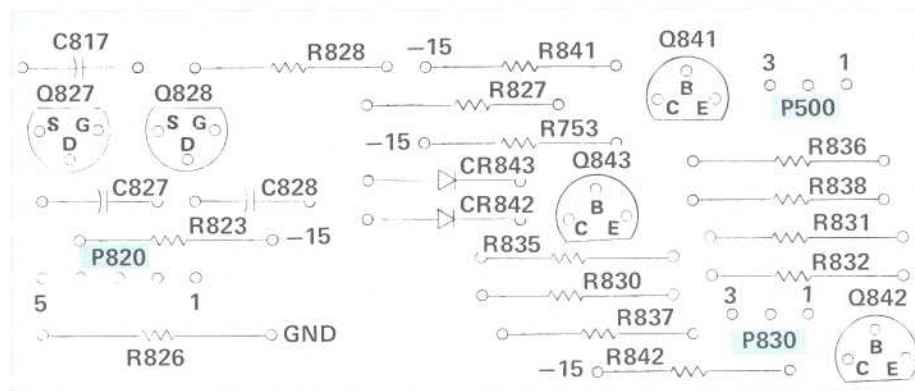
Changed SN B040000

A500 Function





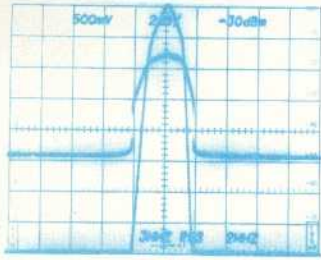
A800 Function I.F. Connector Circuit Board



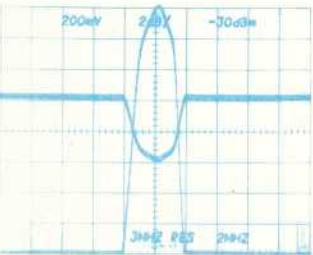
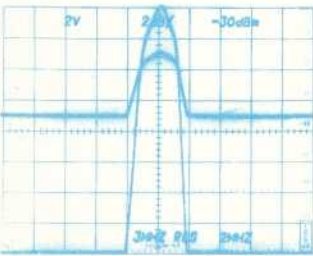
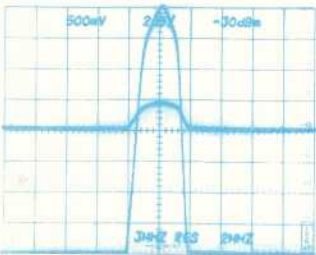
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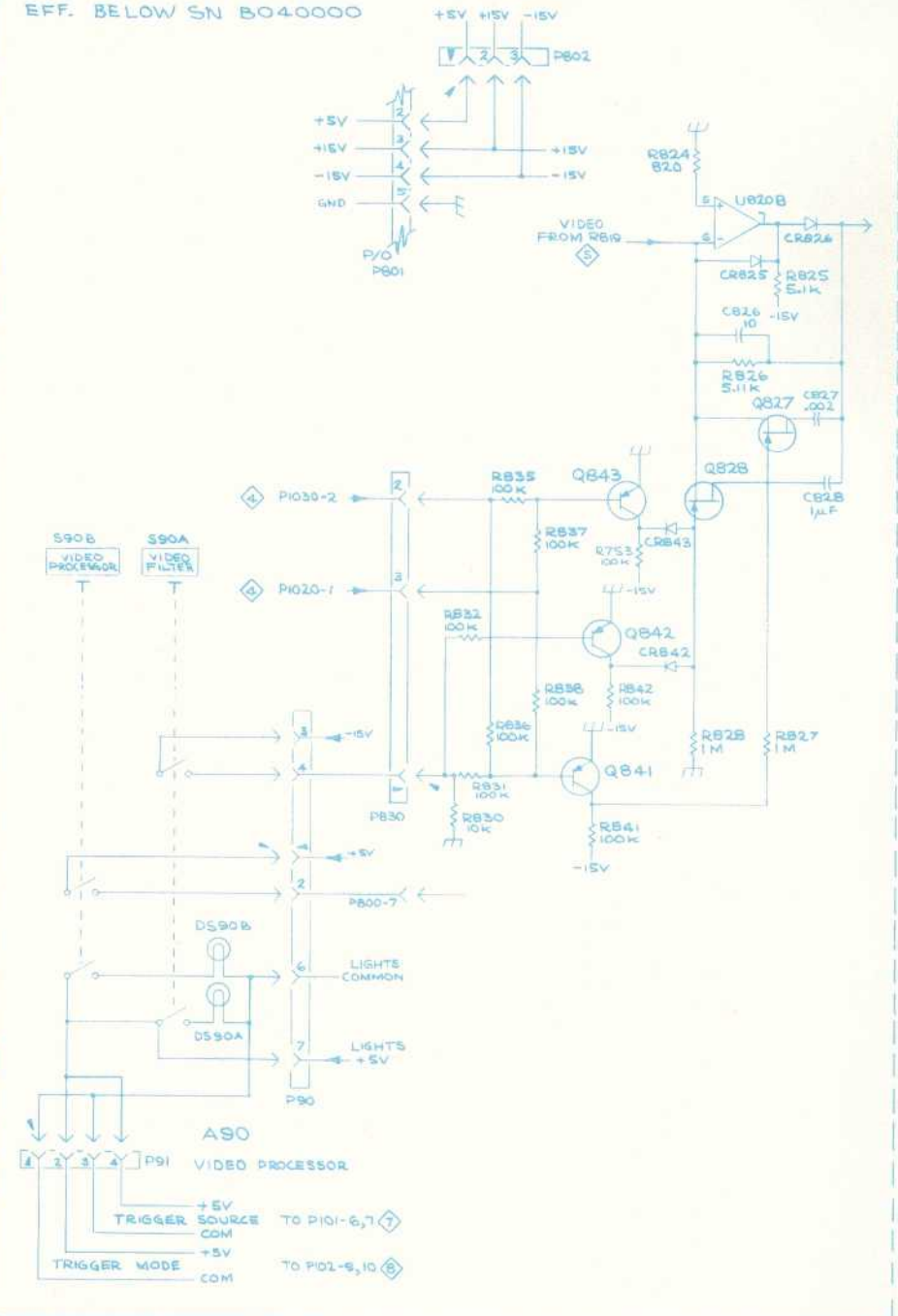
Input -30 dBm



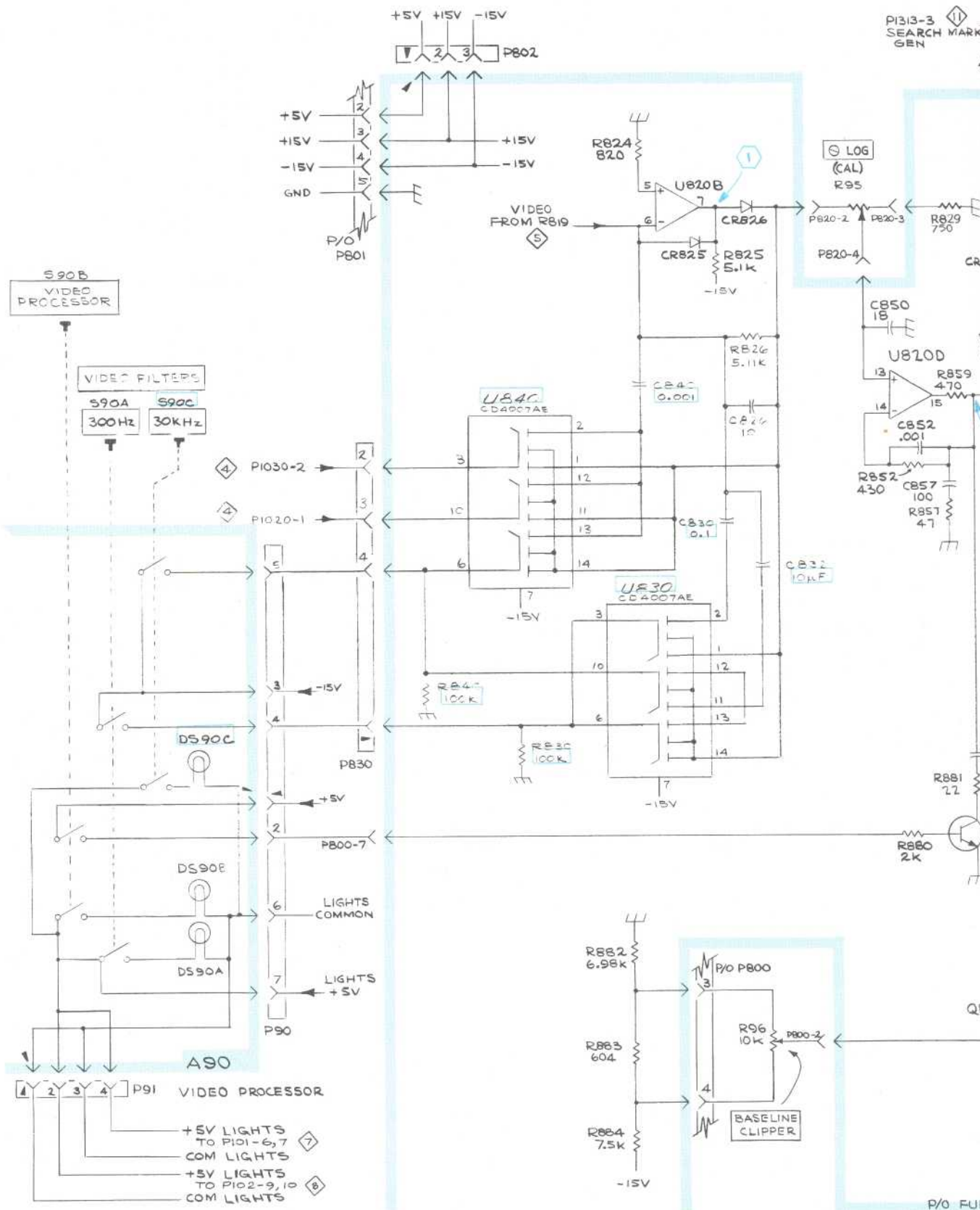
0V



EFF. BELOW SN B040000





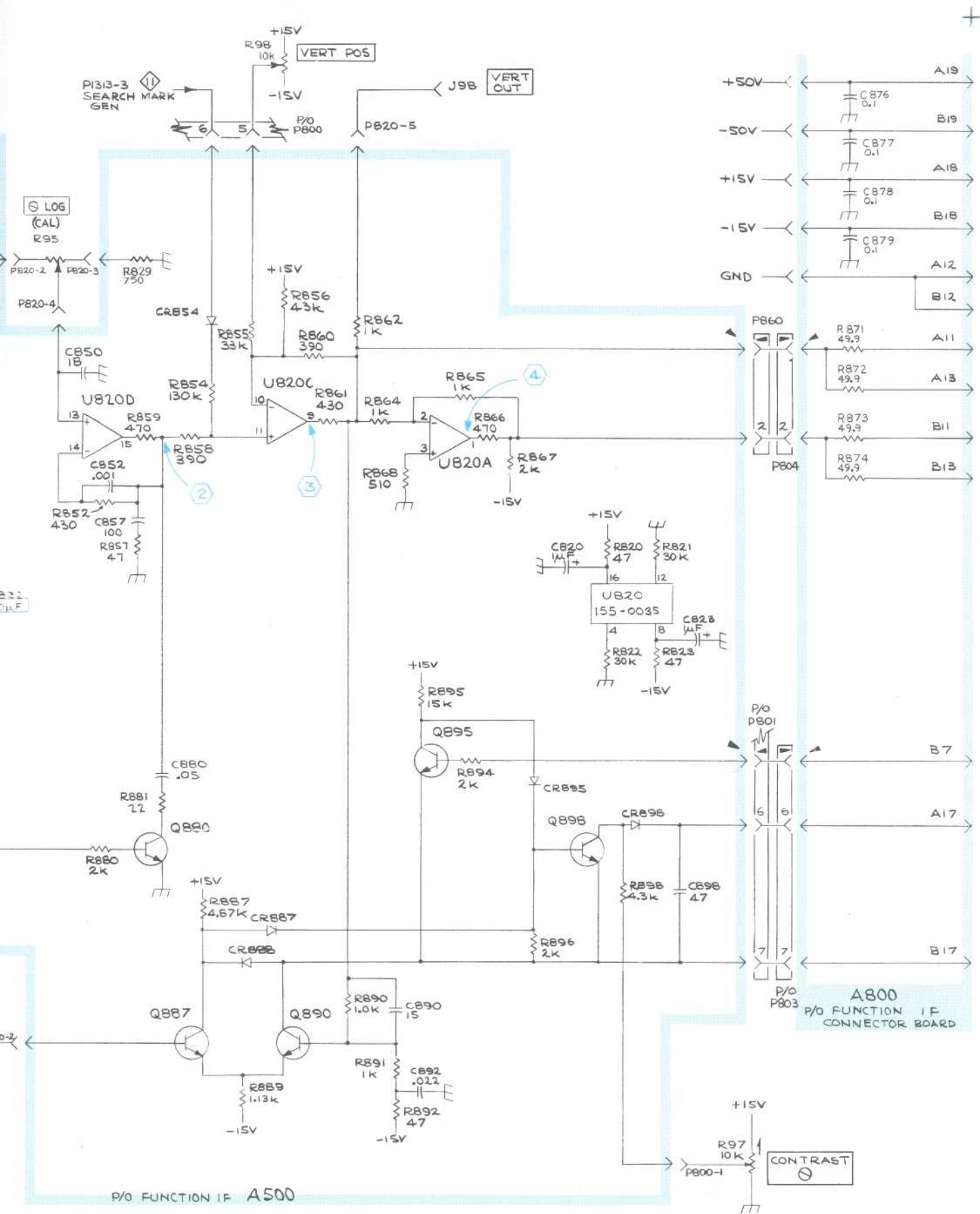


SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

+

7L12

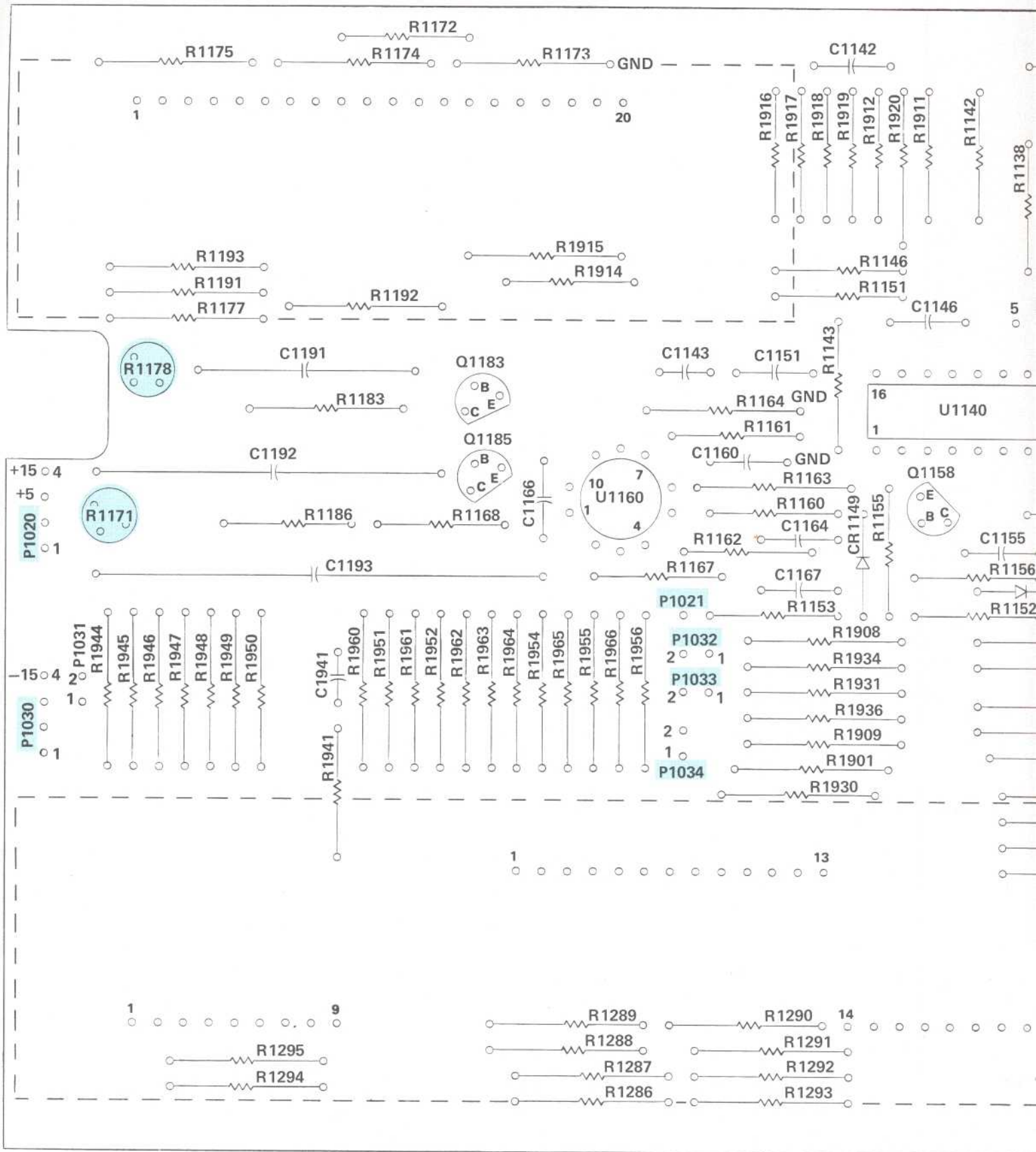
Ⓢ

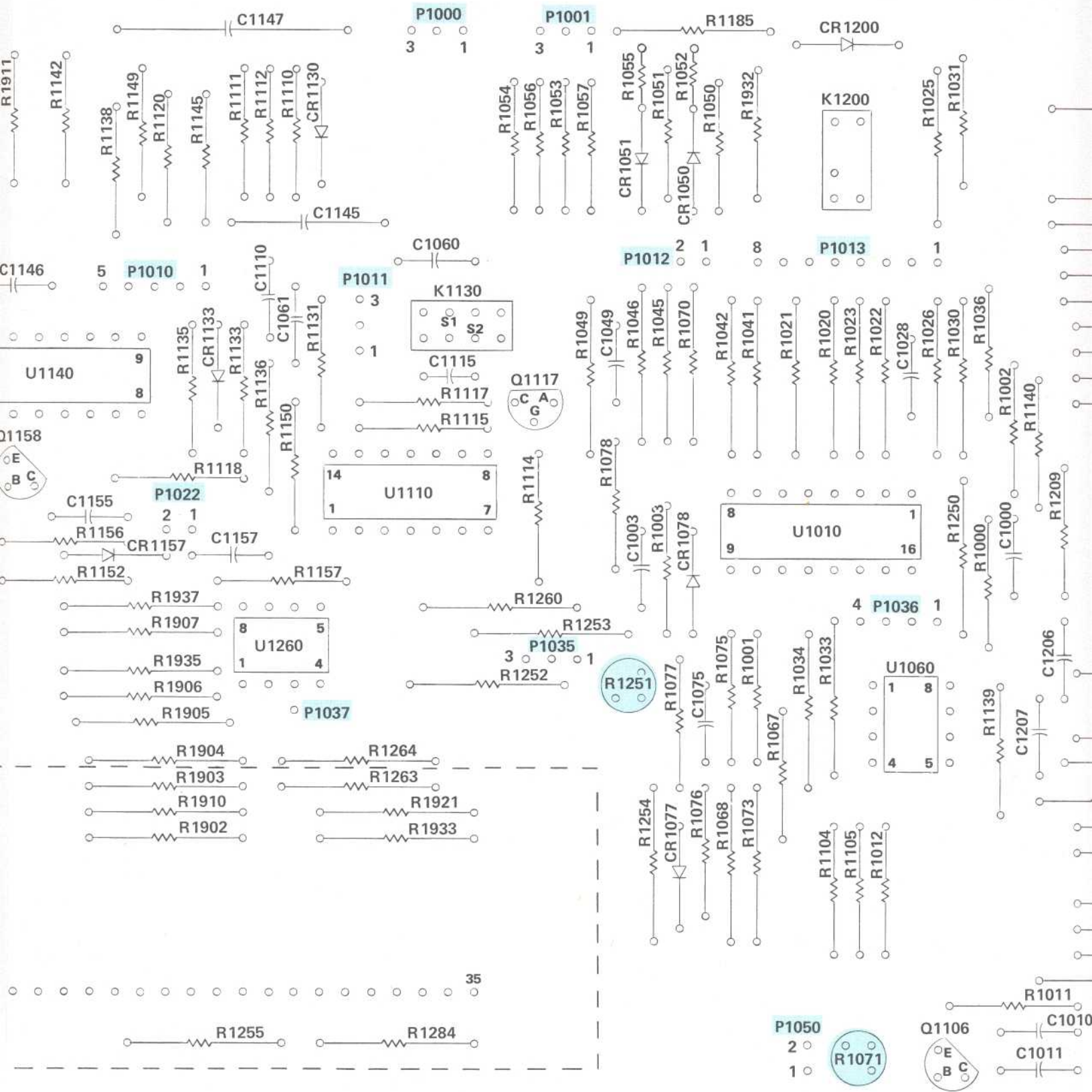


P/O FUNCTION IF A500

A800  
P/O FUNCTION IF  
CONNECTOR BOARD

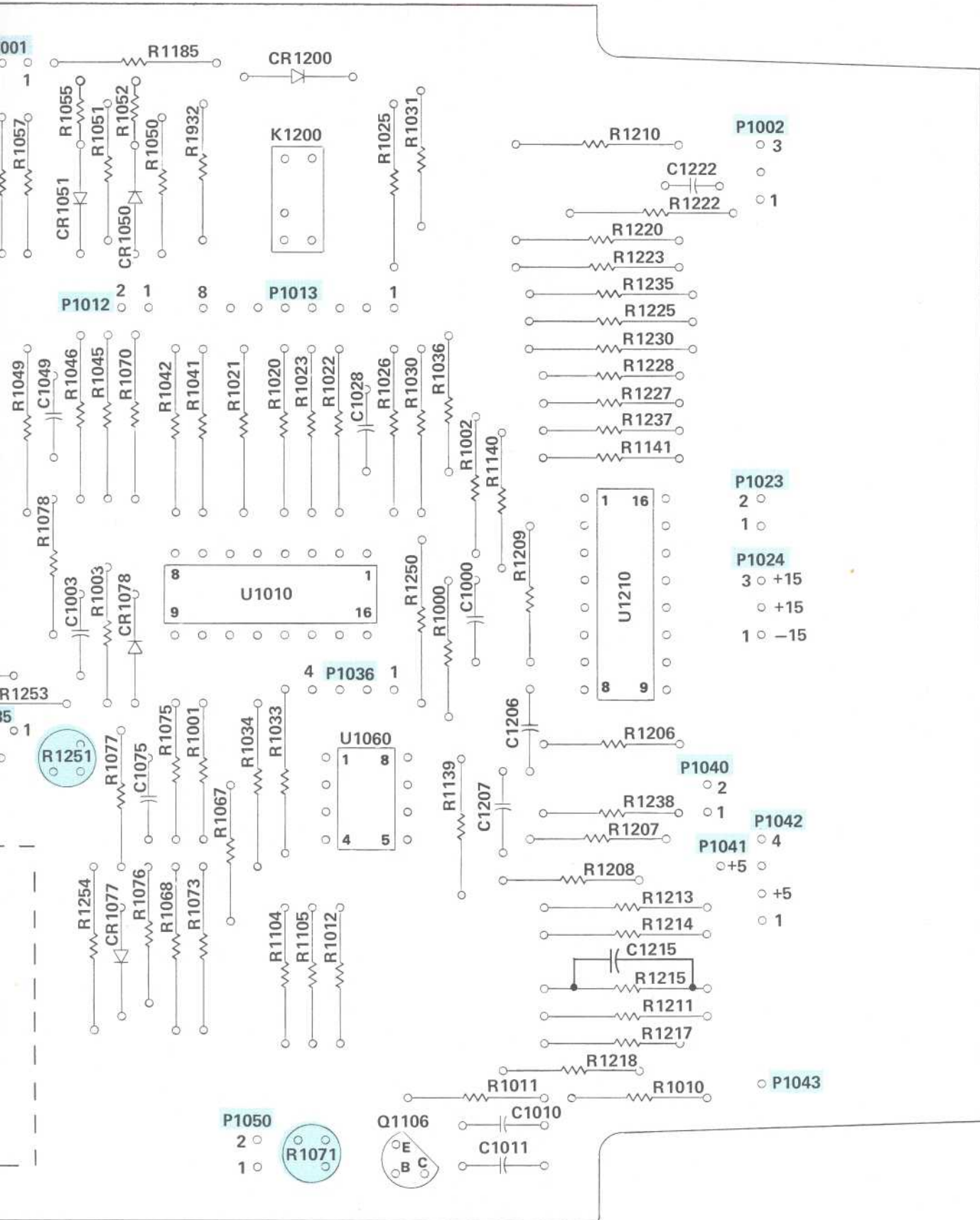
VIDEO-FILTERS, PROCESSOR,  
BASELINE CLIPPER & VERTICAL OUTPUT





A1000 Sweep Circuit Board





001  
1

P1012  
2  
1  
8

P1013  
1

P1002  
3  
1

P1023  
2  
1

P1024  
3  
+15  
+15  
-15

P1036  
4  
1

P1040  
2  
1

P1042  
4

P1041  
+5  
+5  
1

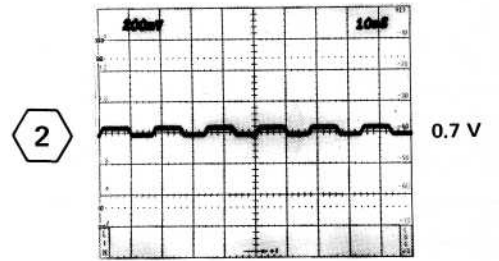
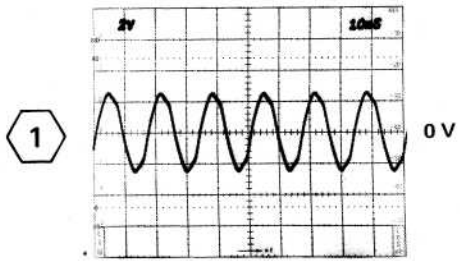
P1043

P1050  
2  
1

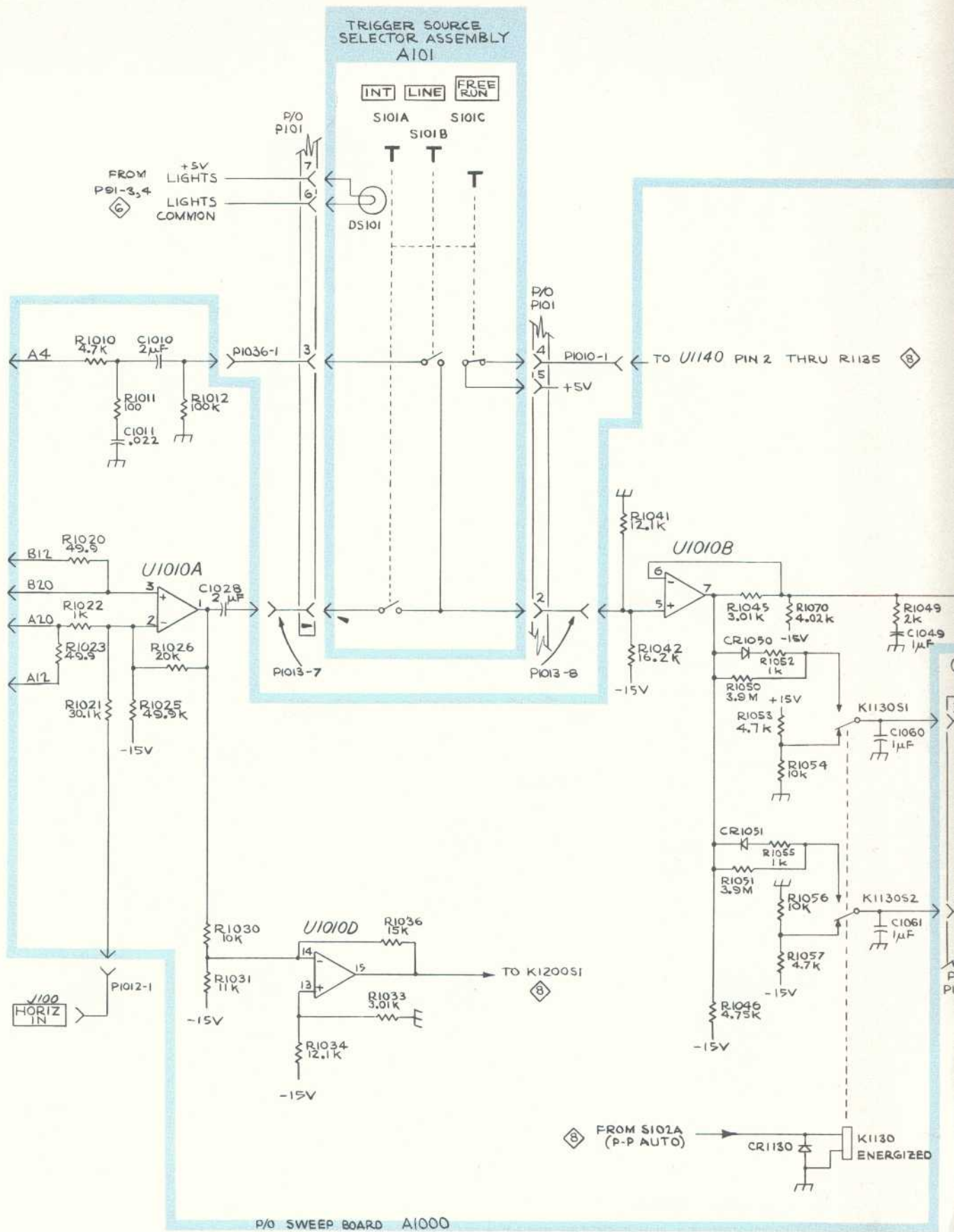
Q1106  
E  
B  
C

+

(A)



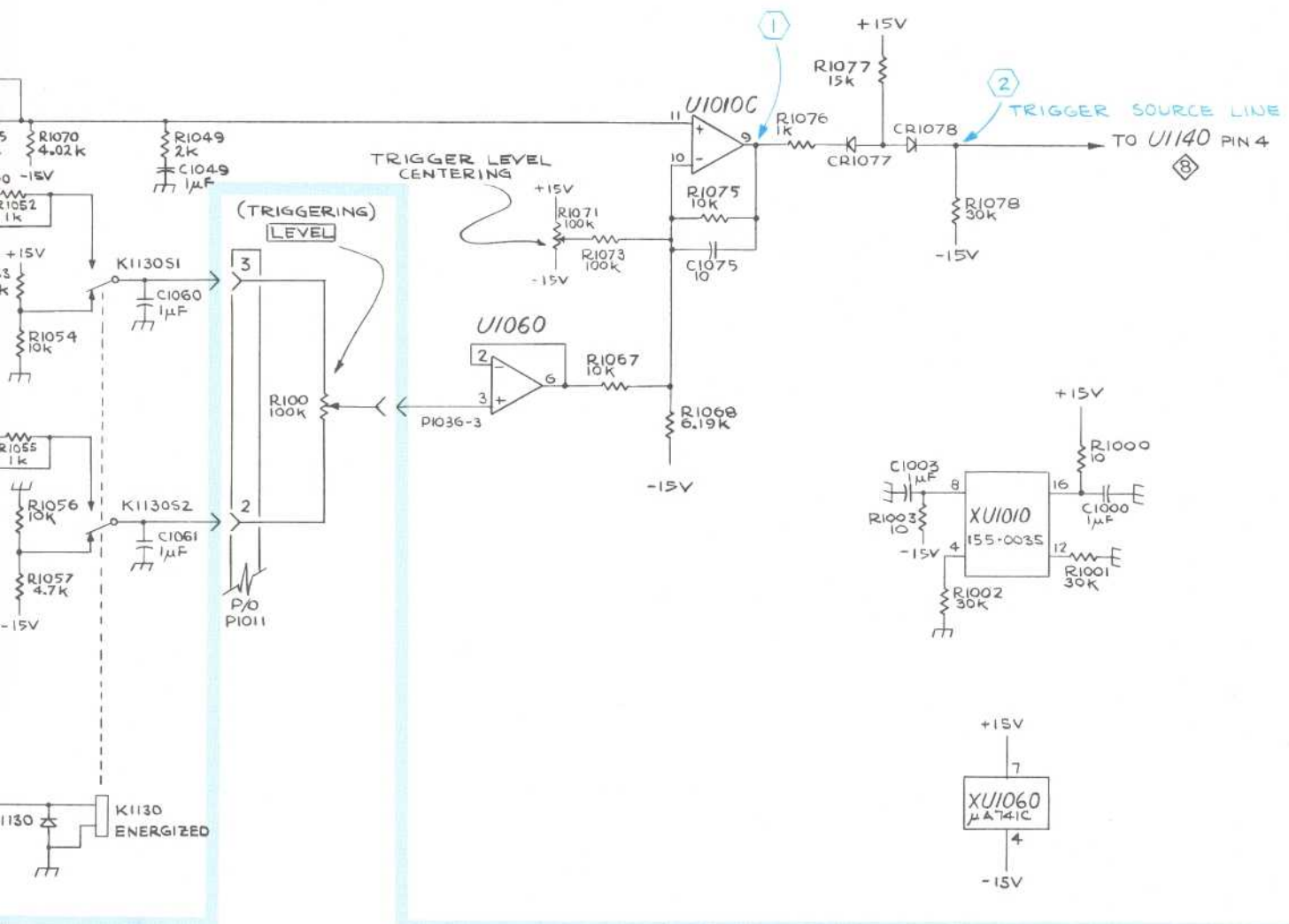




+

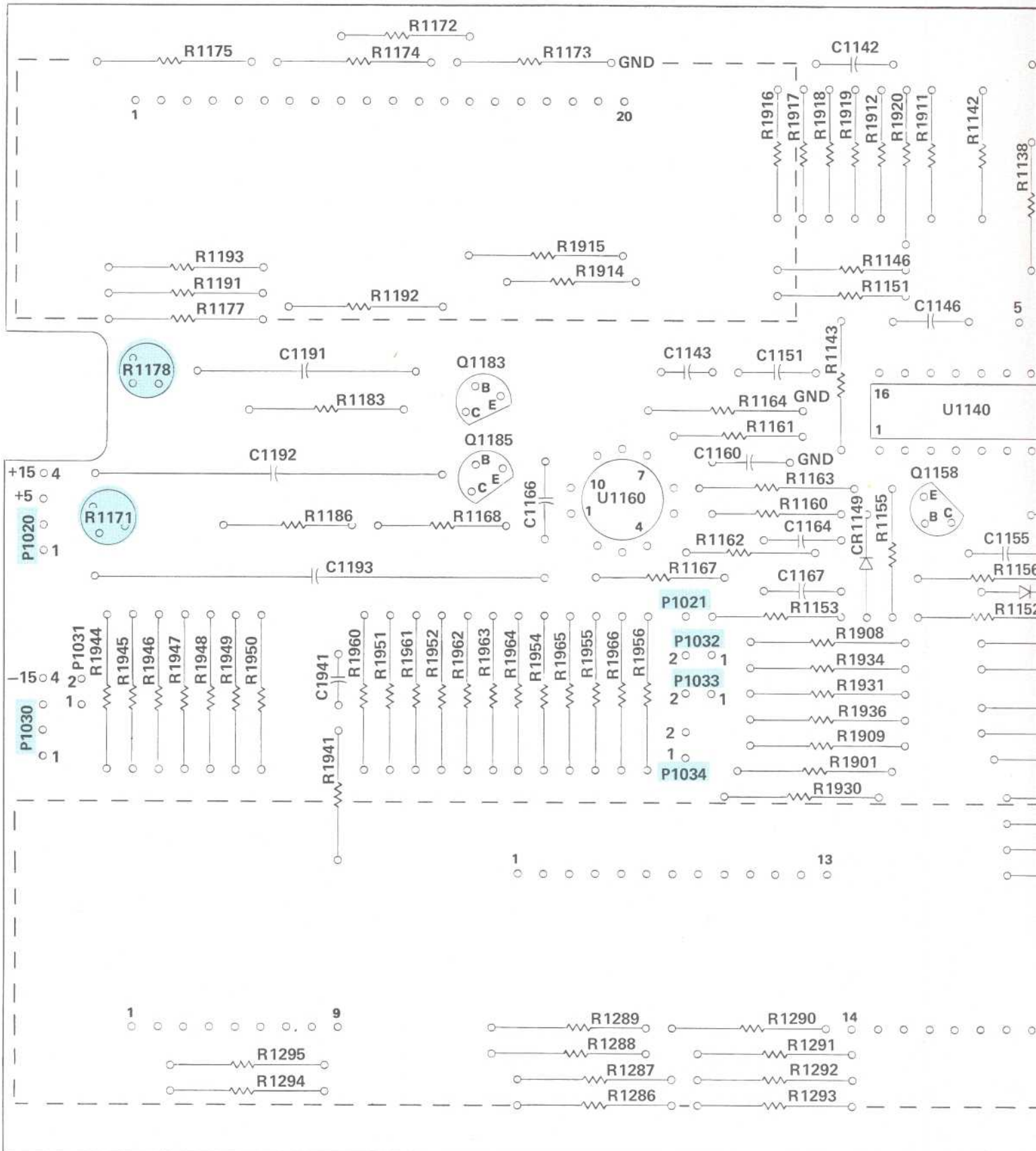
+

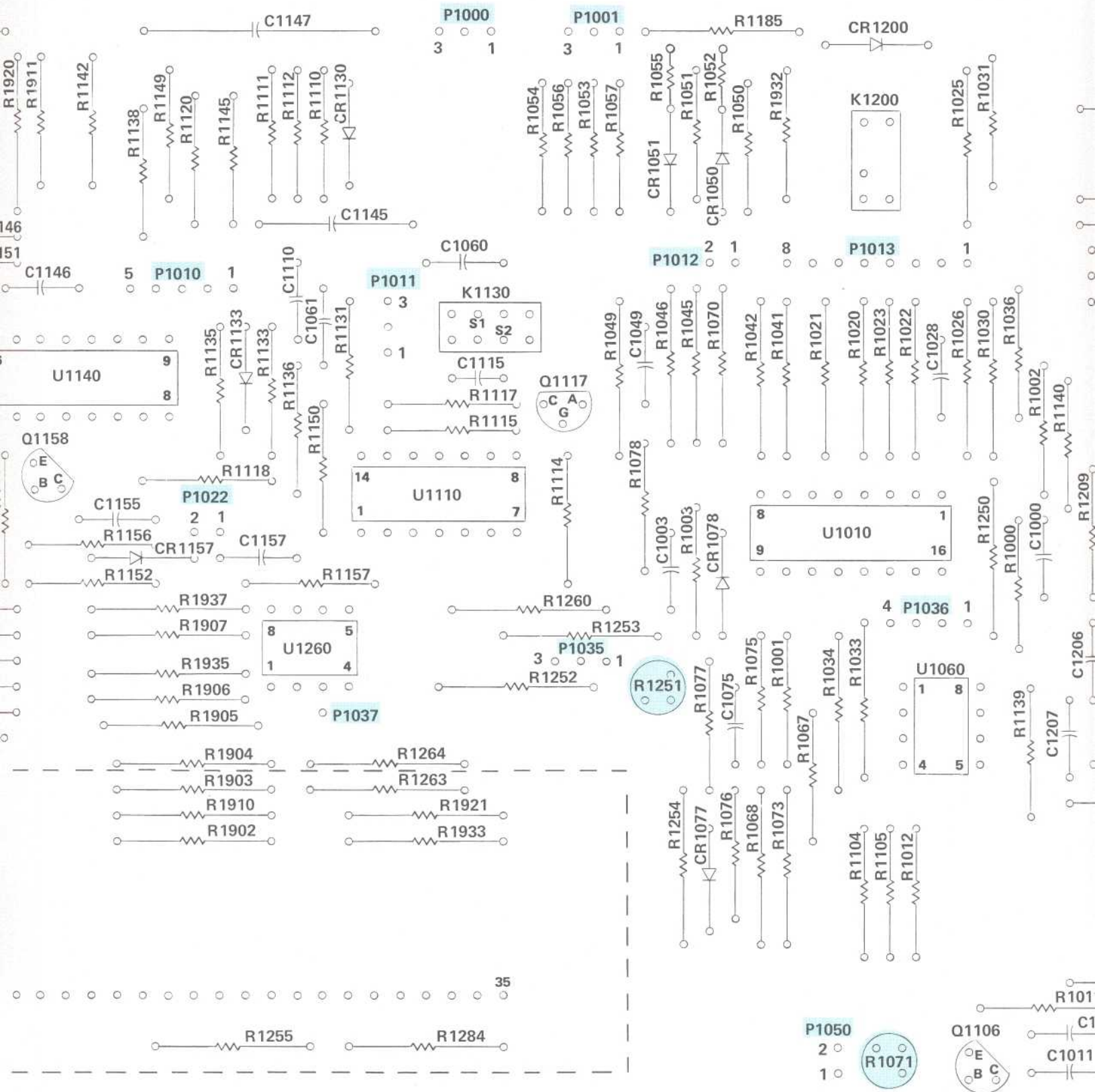
2 THRU R1135 8



(A)

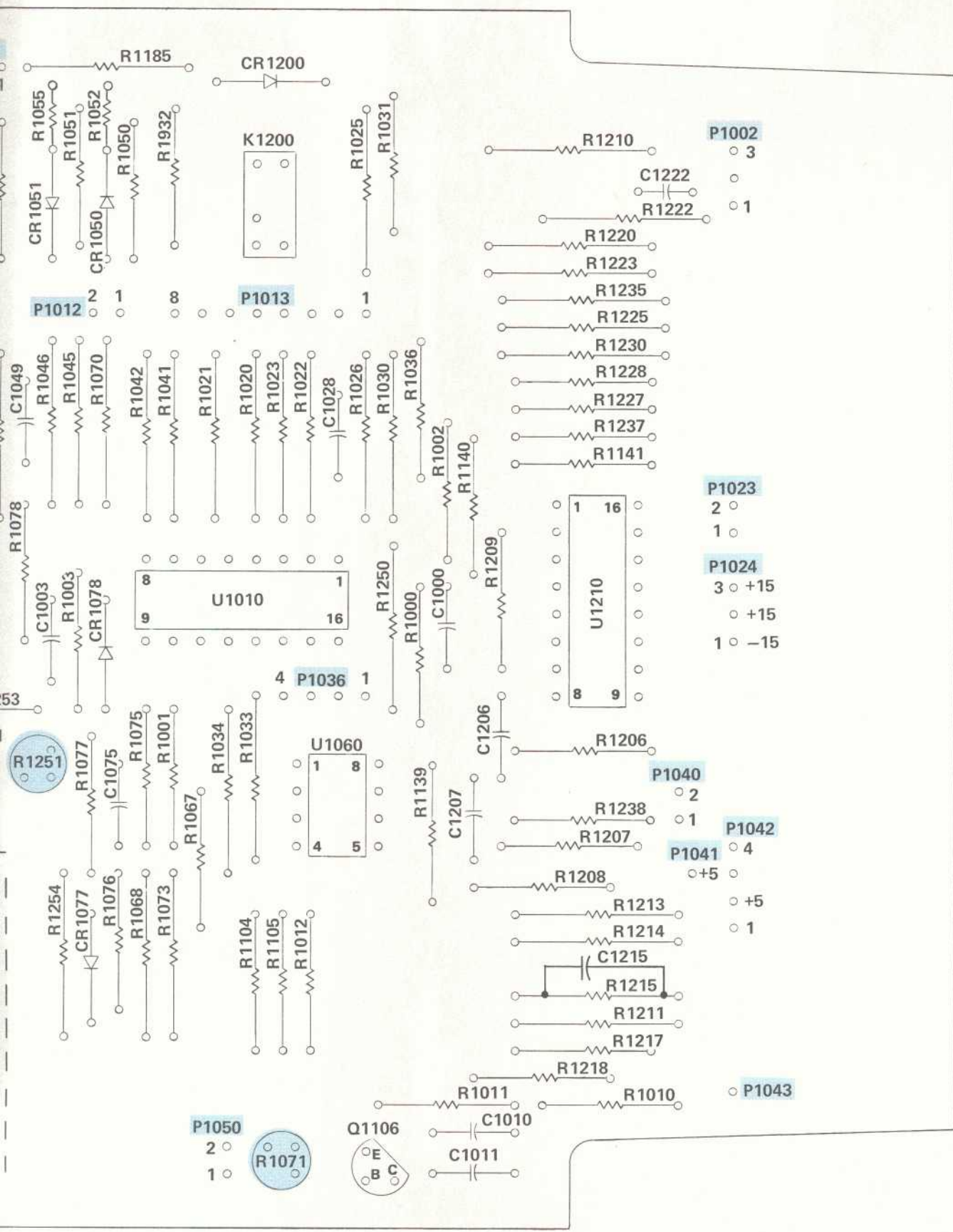
SWEEP TRIGGERING 7  
6-6-72 DL





A1000 Sweep Circuit Board





P1012  
 2  
 1  
 8

P1013  
 1

P1002  
 3  
 1

P1023  
 2  
 1

P1024  
 3 +15  
 +15  
 1 -15

P1036  
 4  
 1

P1040  
 2  
 1

P1042  
 4

P1041  
 +5  
 +5  
 1

P1043

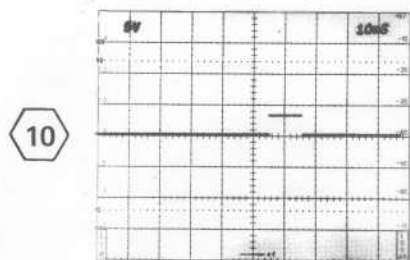
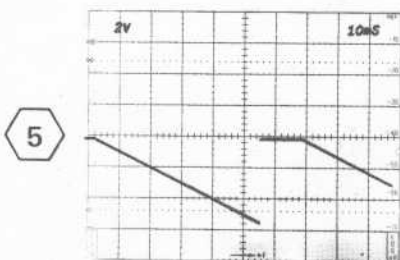
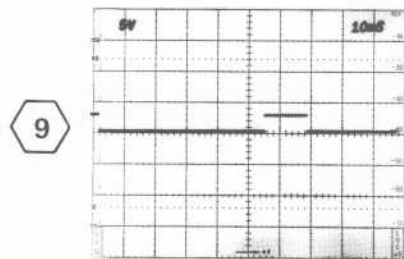
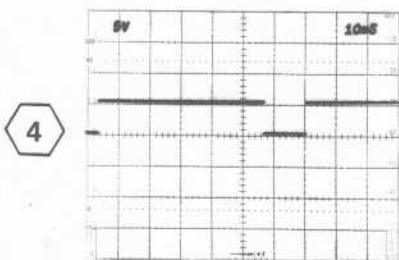
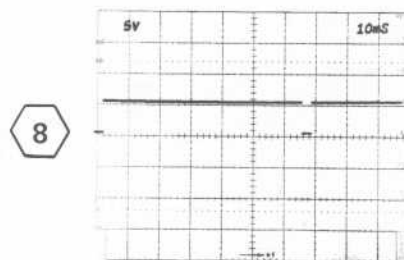
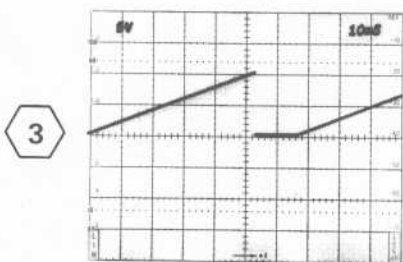
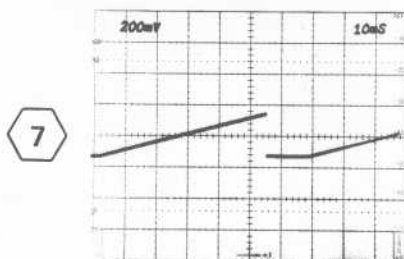
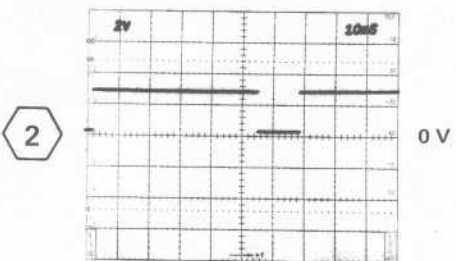
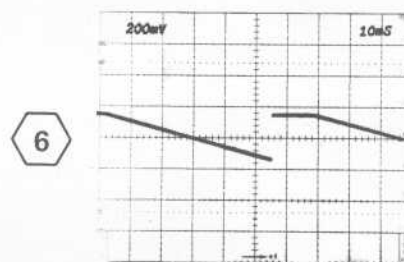
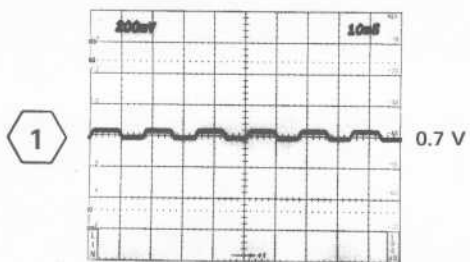
P1050  
 2  
 1



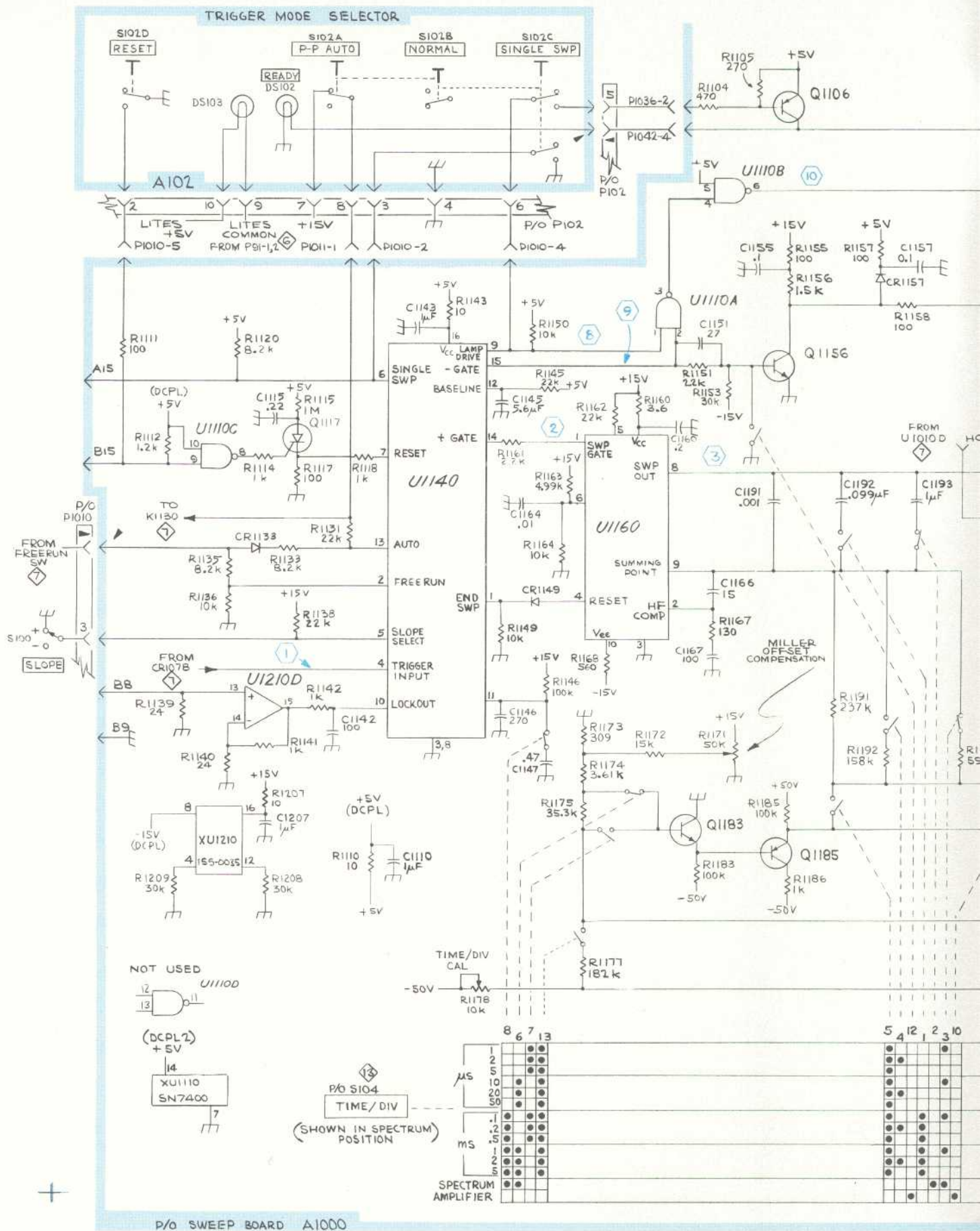
C1010  
 C1011

+

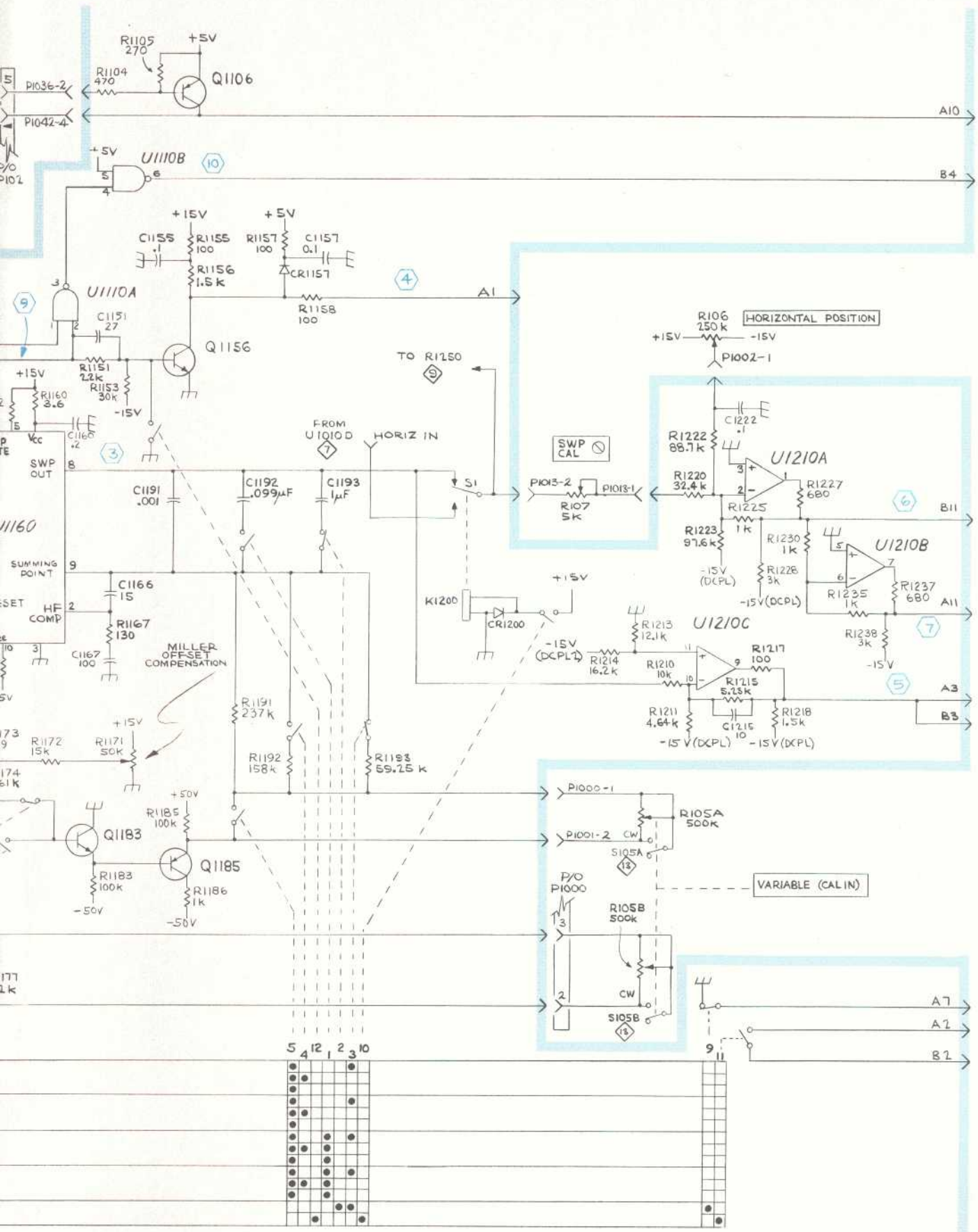
(A)







P/O SWEEP BOARD A1000



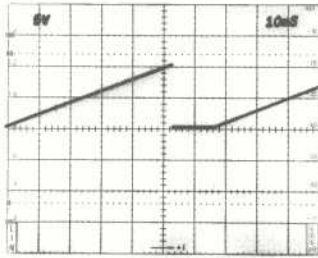
(A)

SWEEP GENERATOR & HOLDOFF

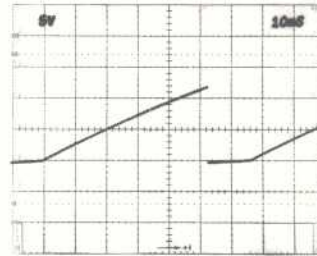
67L DL

8

1

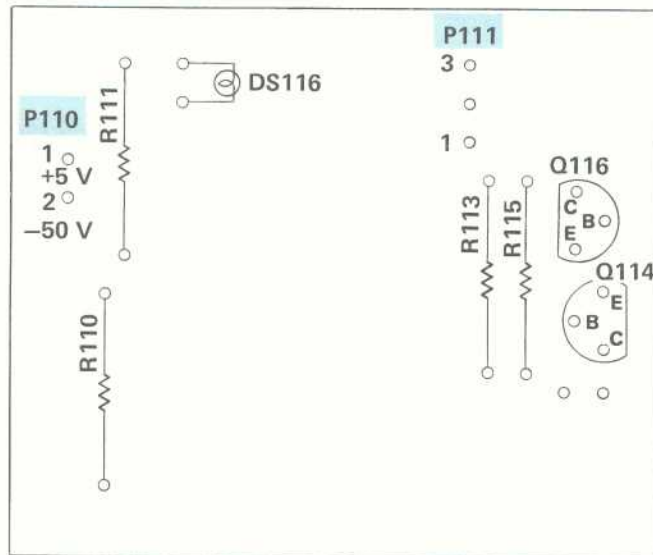


2



+

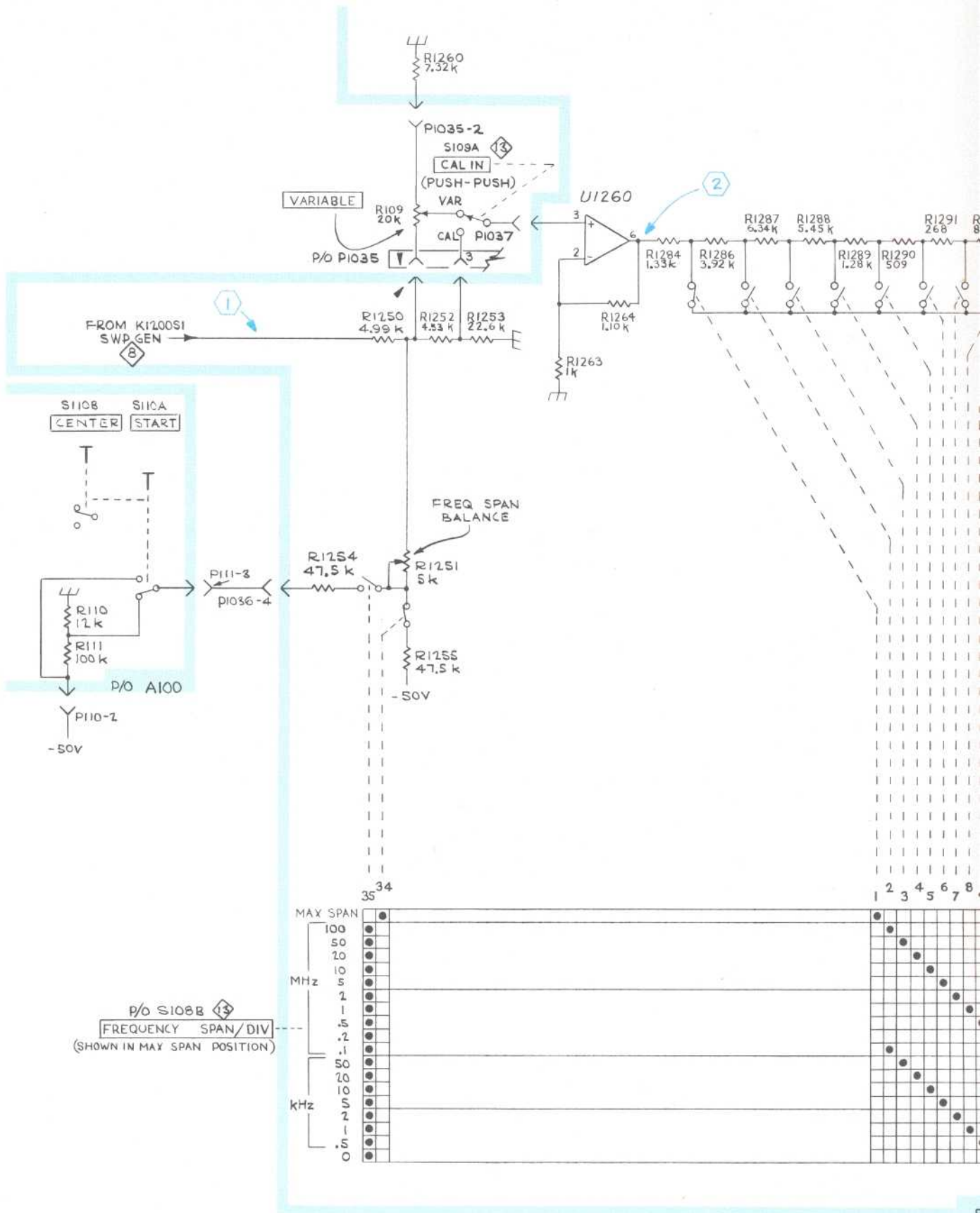
7L12



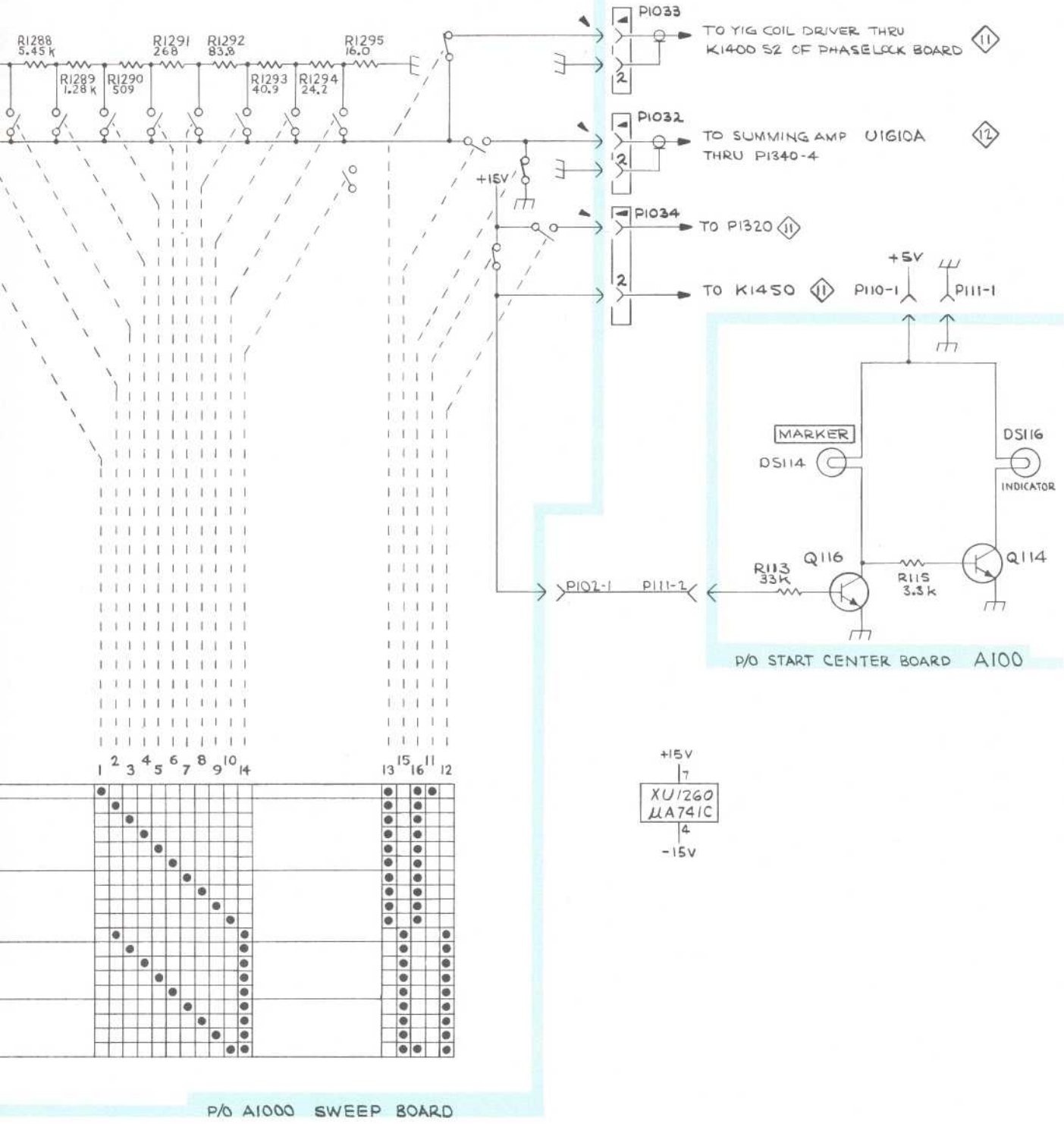
A110 Start-Center Selector Circuit Board

Ⓐ

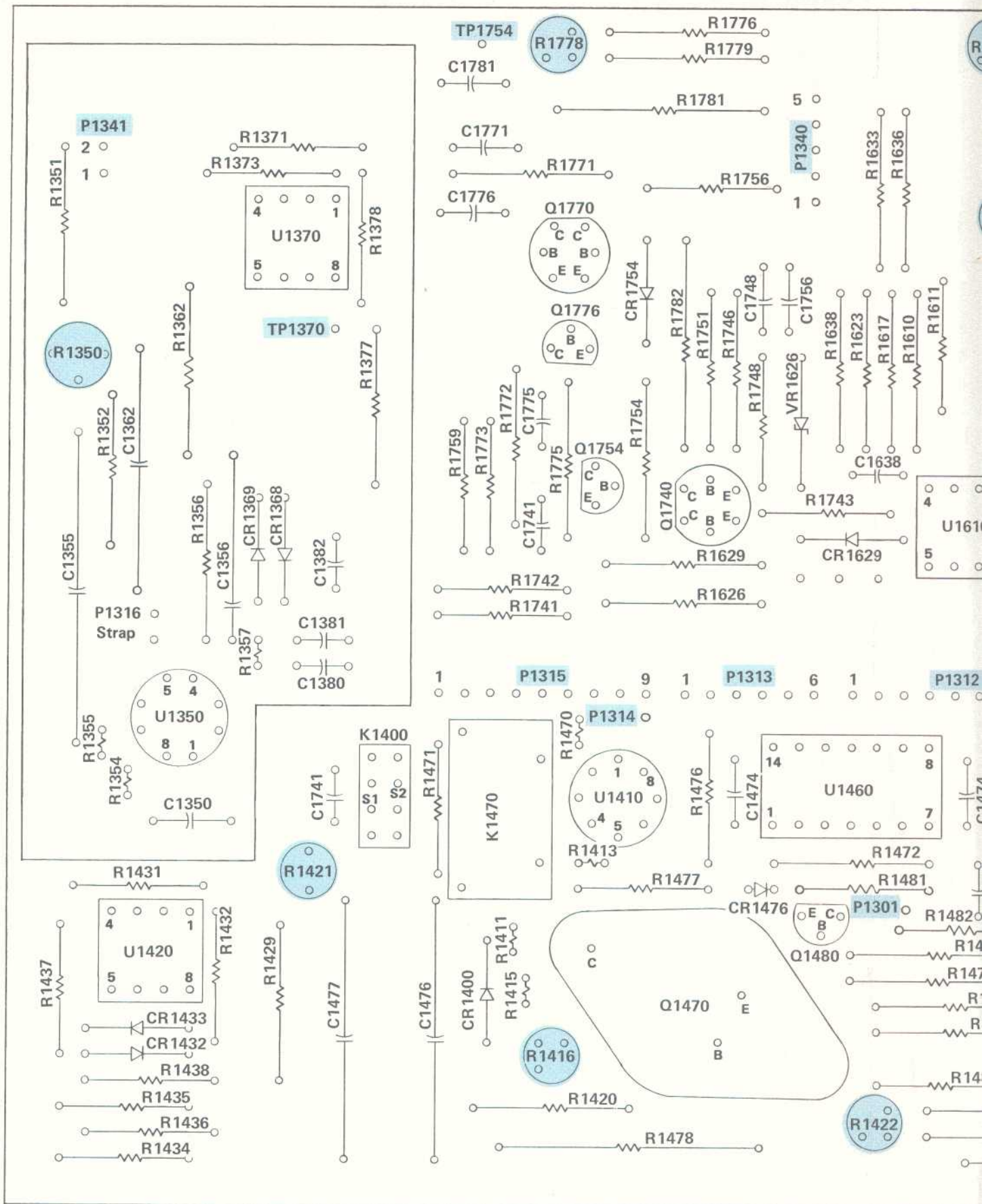
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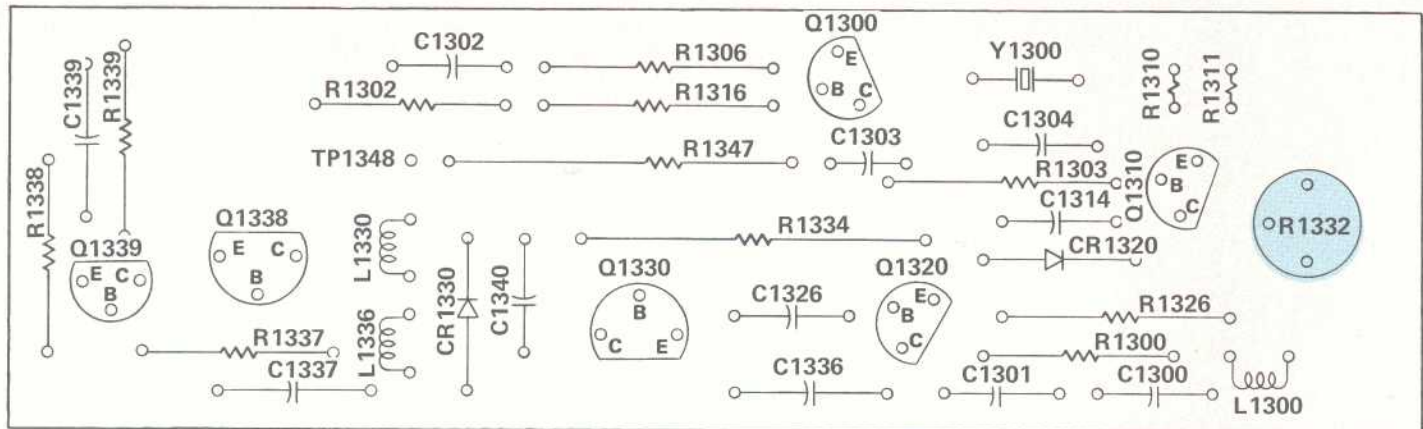




1637

C1611

R1598



1

8

CR1450

C1453

74

5

1440

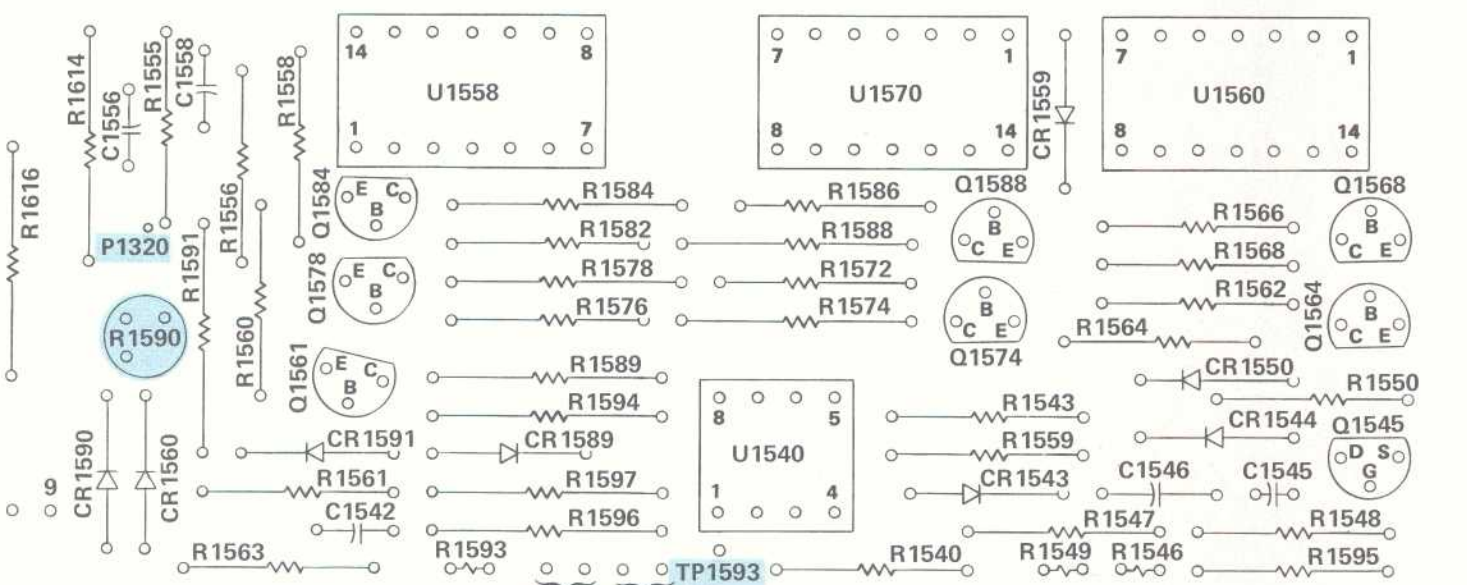
1442

30

R1423

R1427

R1425



P1311 P1310 Straps

P1300

TP1534

1

3

C1530

C1527

CR1525

R1527

CR1524

R1525

TP1532

C1538

R1536

R1538

R1521

R1520

C1529

R1534

R1529

R1532

\*C1520

R1528

Q1525

R1524

C1522

R1522

R1518

R1536

R1538

R1521

R1520

C1529

R1534

R1529

R1532

\*C1520

R1528

Q1525

R1524

C1522

R1522

R1518

C1518

VR1518

R1514

R1516

R1504

R1502

Q1506

Q1518

Q1517

Q1518

Q1518

Q1517

Q1518

Q1518

Q1518

Q1518

Q1518

Q1518

Q1518

Q1518

Q1518

Q1518

Q1518

C1500

C1510

C1510

Q1506

Q1518

Q1517

Q1518

Q1518

Q1518

Q1518

Q1518

Q1518

Q1518

Q1518

Q1518

Q1518

Q1518

Q1518

Q1518

C1500

C1510

C1510

Q1506

Q1518

Q1517

Q1518

Q1518

Q1518

Q1518

Q1518

Q1518

Q1518

Q1518

Q1518

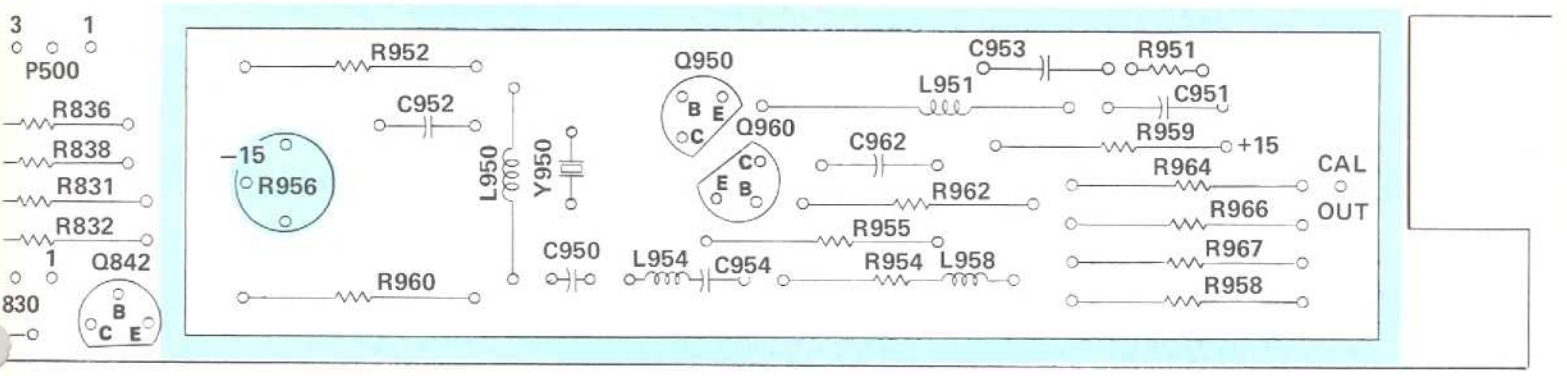
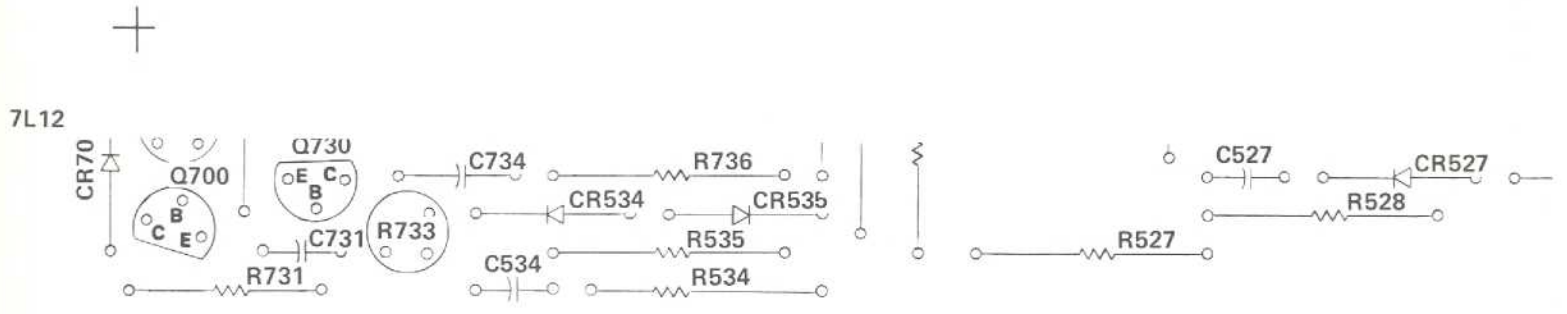
Q1518

Q1518

Q1518

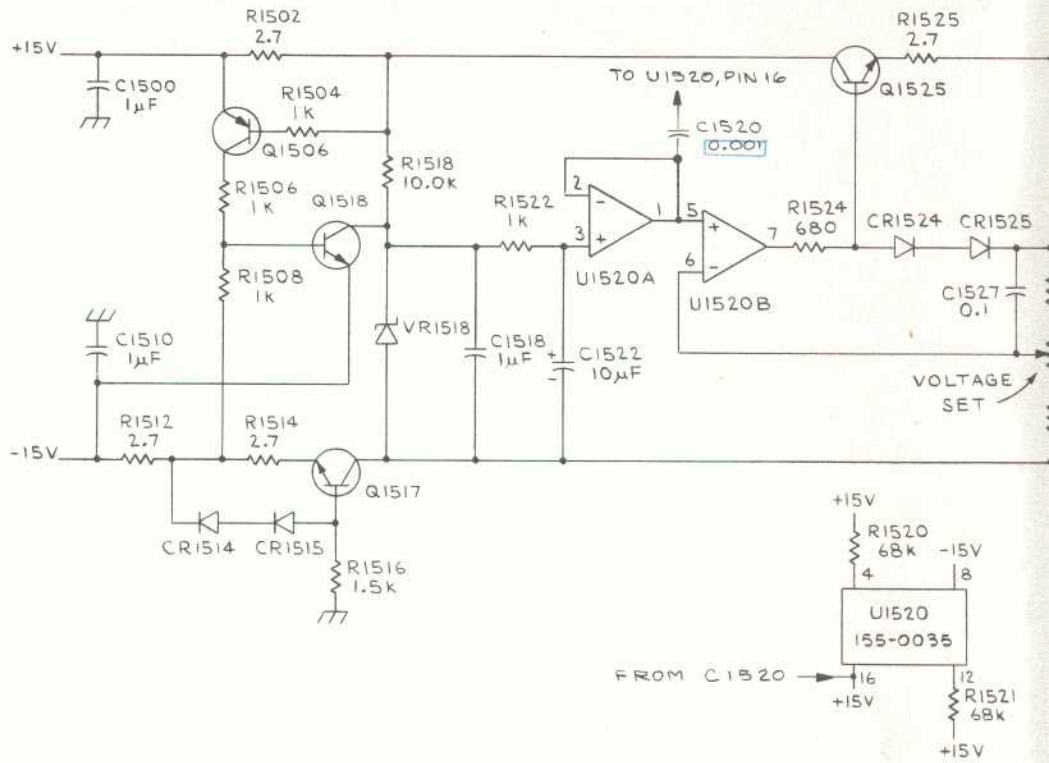
Q1518

\*Added SN B030000

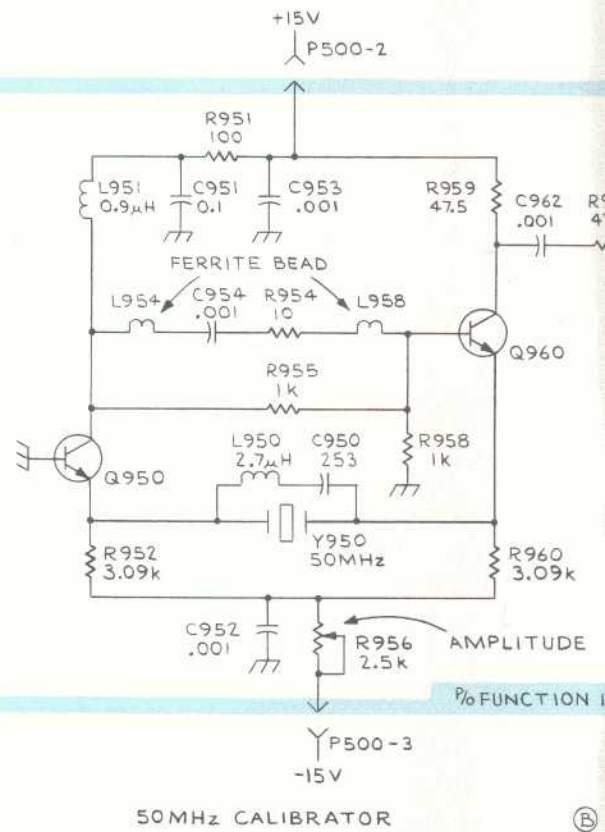


P/O A500 Function I.F. Circuit Board





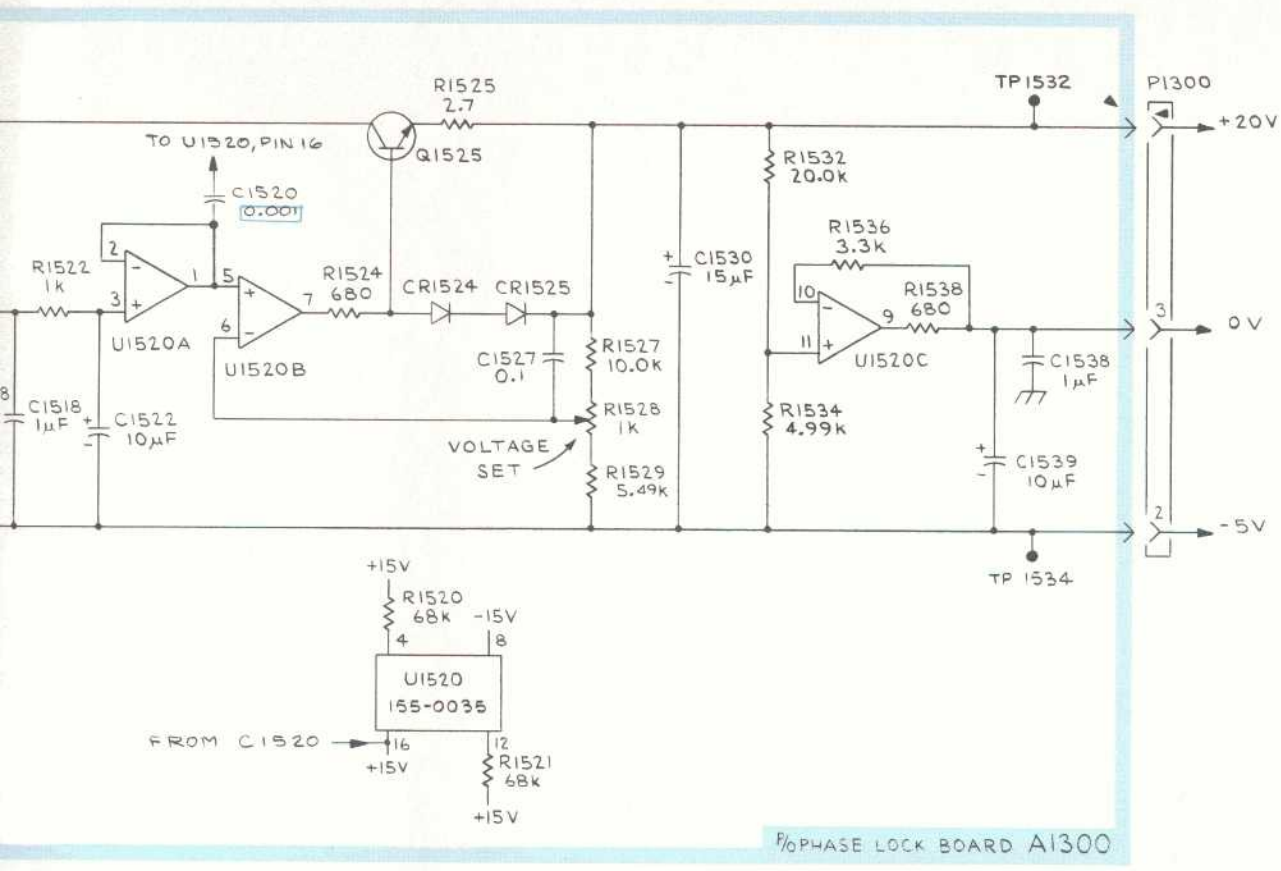
1ST LO POWER SUPPLY (FL)



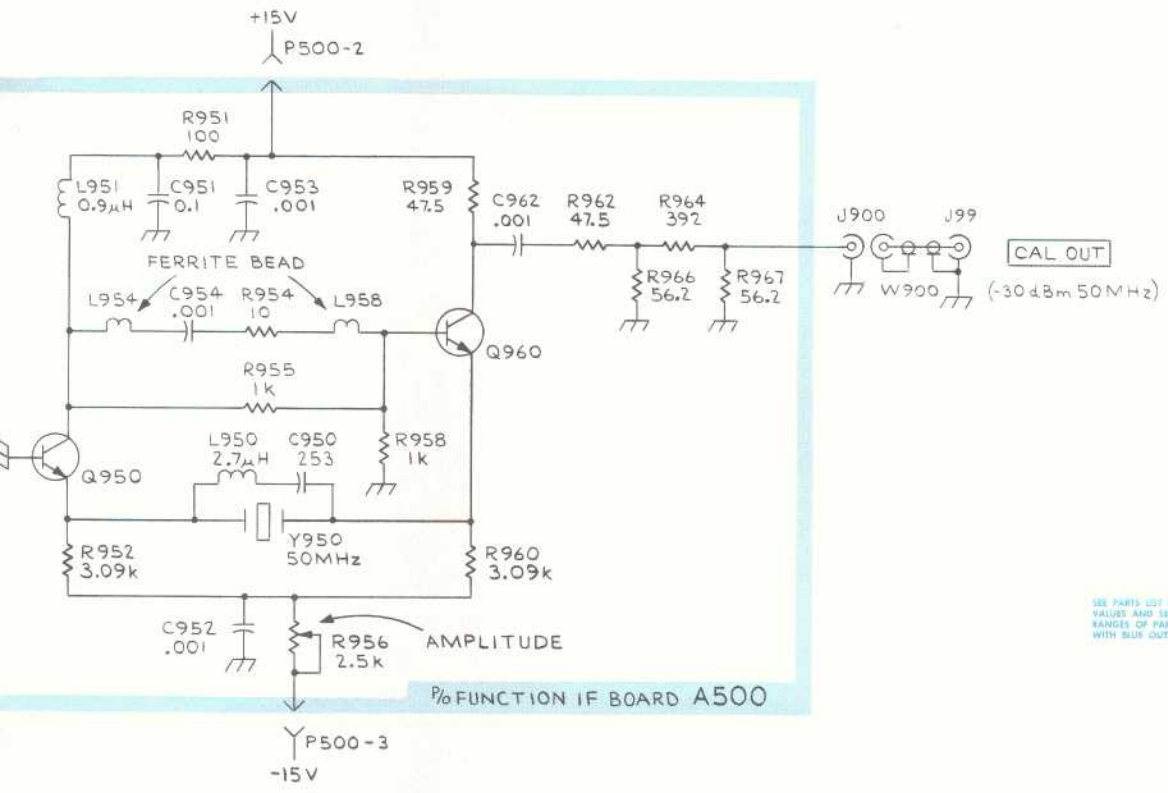
+

7L12

ⓑ



1<sup>ST</sup> LO POWER SUPPLY (FLOATING)



SEE PARTS LIST FOR EXACT VALUES AND SERIAL NUMBERS RANGES OF PARTS MARKED WITH SILK OUTLINE

50MHz CALIBRATOR

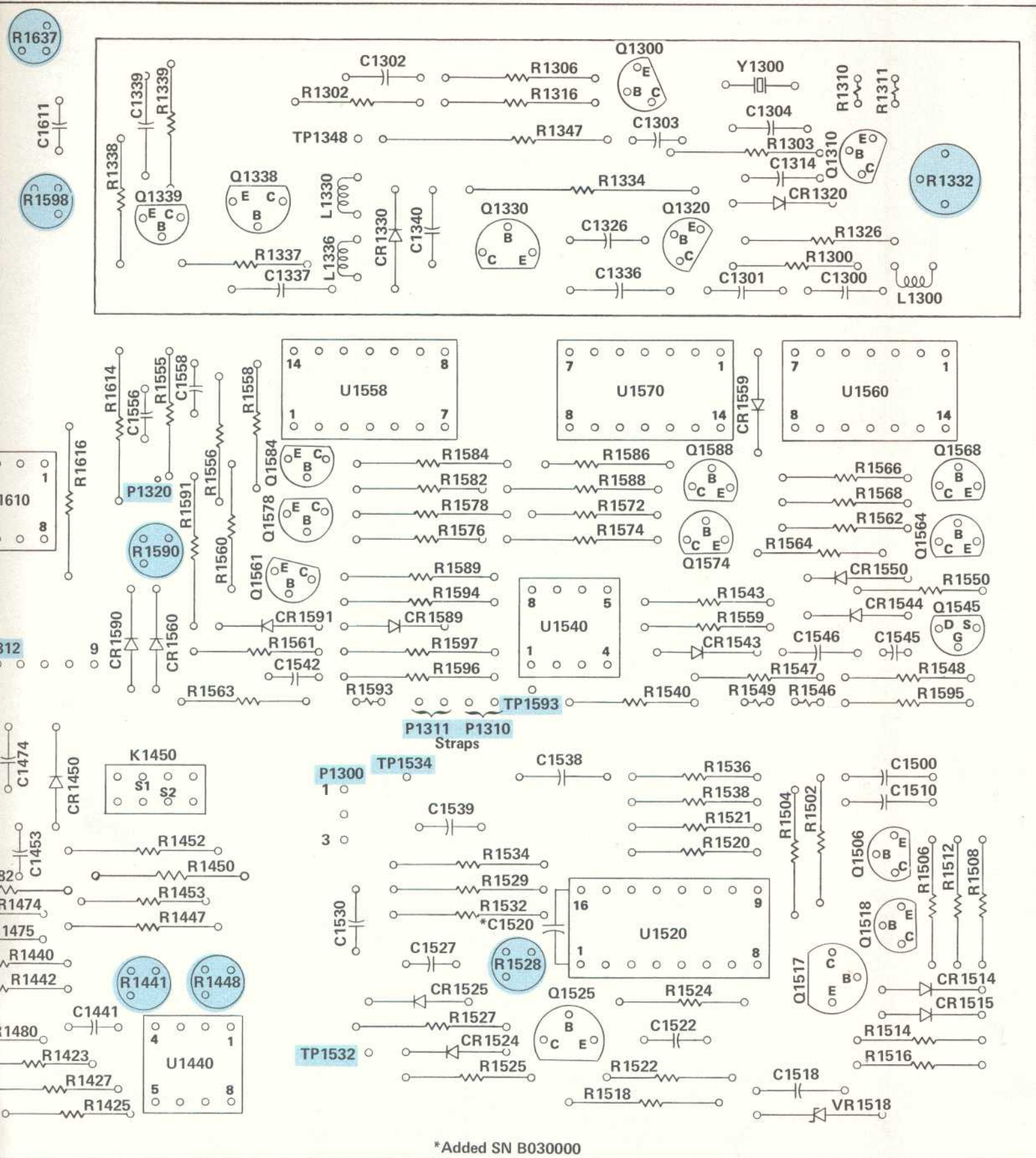
ⓑ

1<sup>ST</sup> LO POWER SUPPLY & CALIBRATOR 10

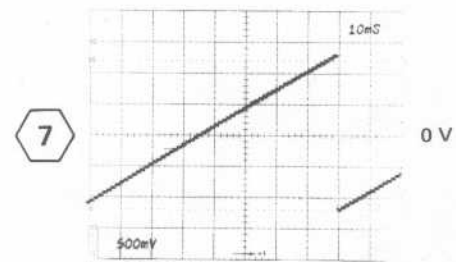
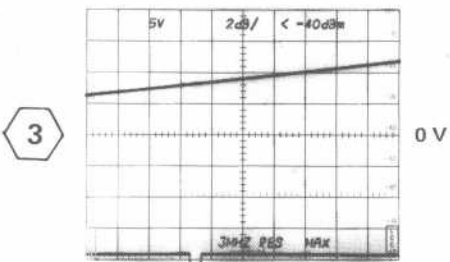
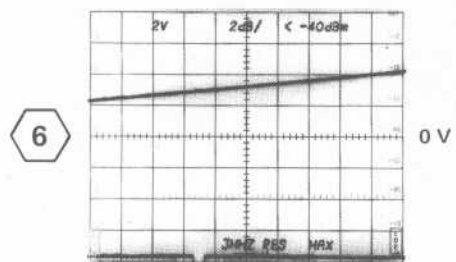
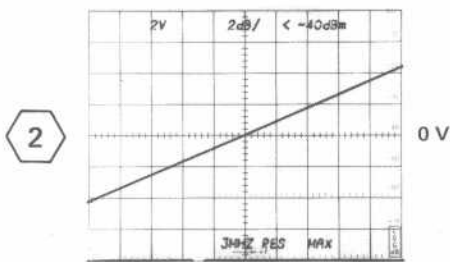
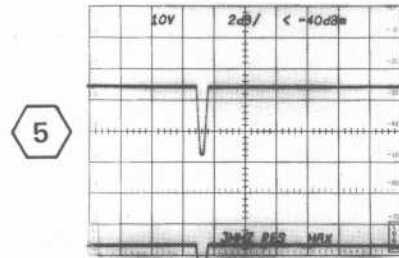
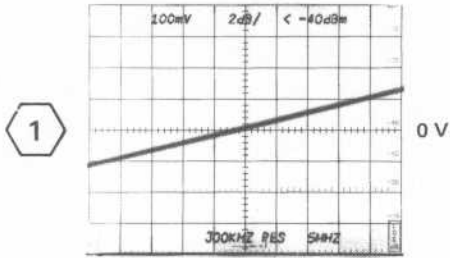
1272 NL



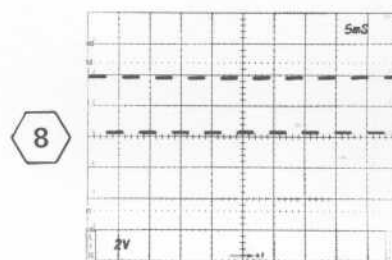
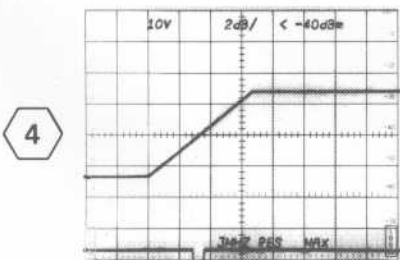




Phase Lock Circuit Board

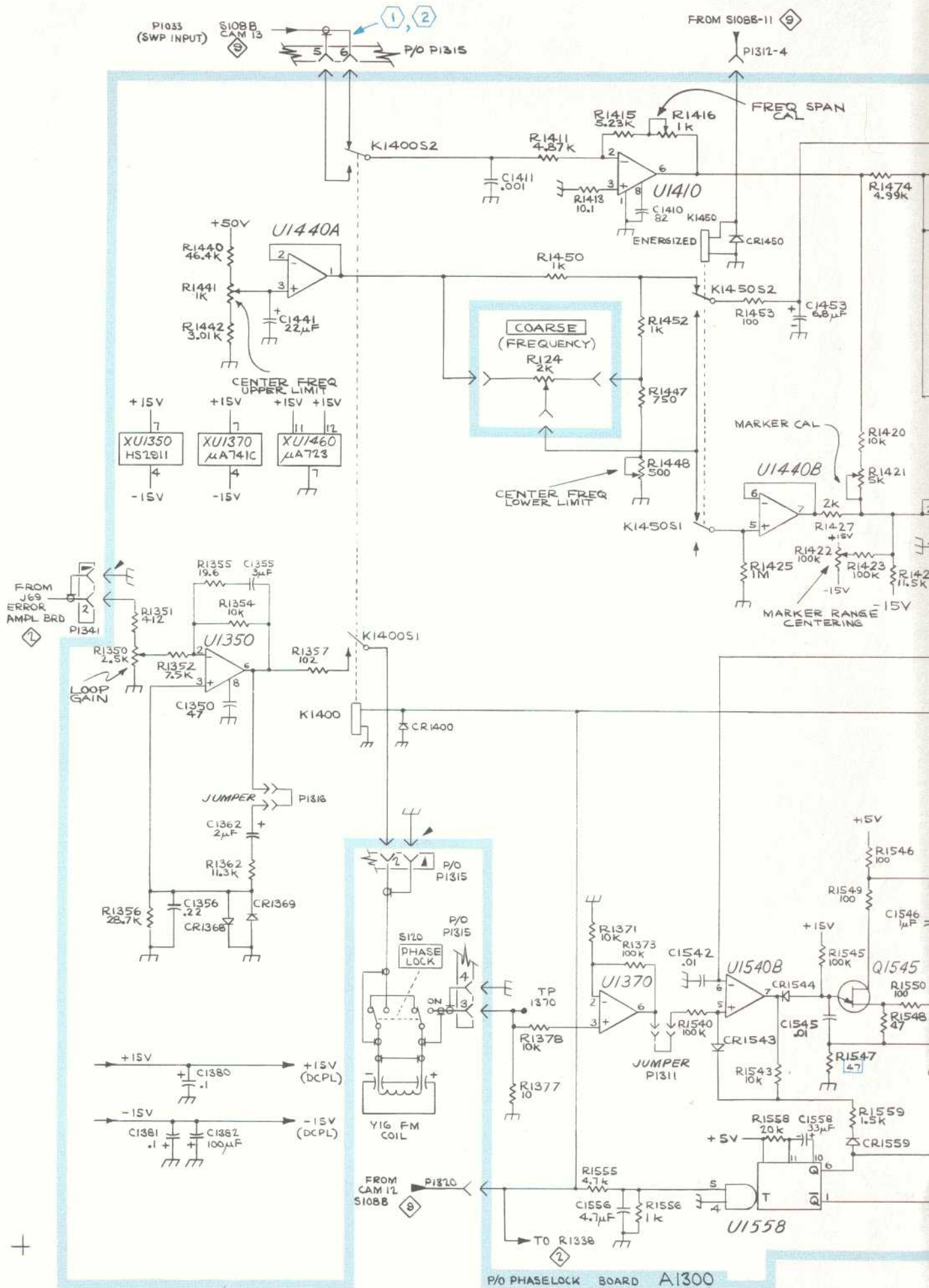


Pin 7 of U1540 open to allow circuit to run



Pin 7 of U1540 open





7L12

P/O PHASELOCK BOARD A1300

(B)

FREQ SPAN

CR1450

MARKER CAL

U1440B

MARKER RANGE CENTERING

+15V FROM SWP BOARD

Q1470

FERRITE BEADS (7)

1ST YIG OSC COIL

FERRITE BEADS (7)

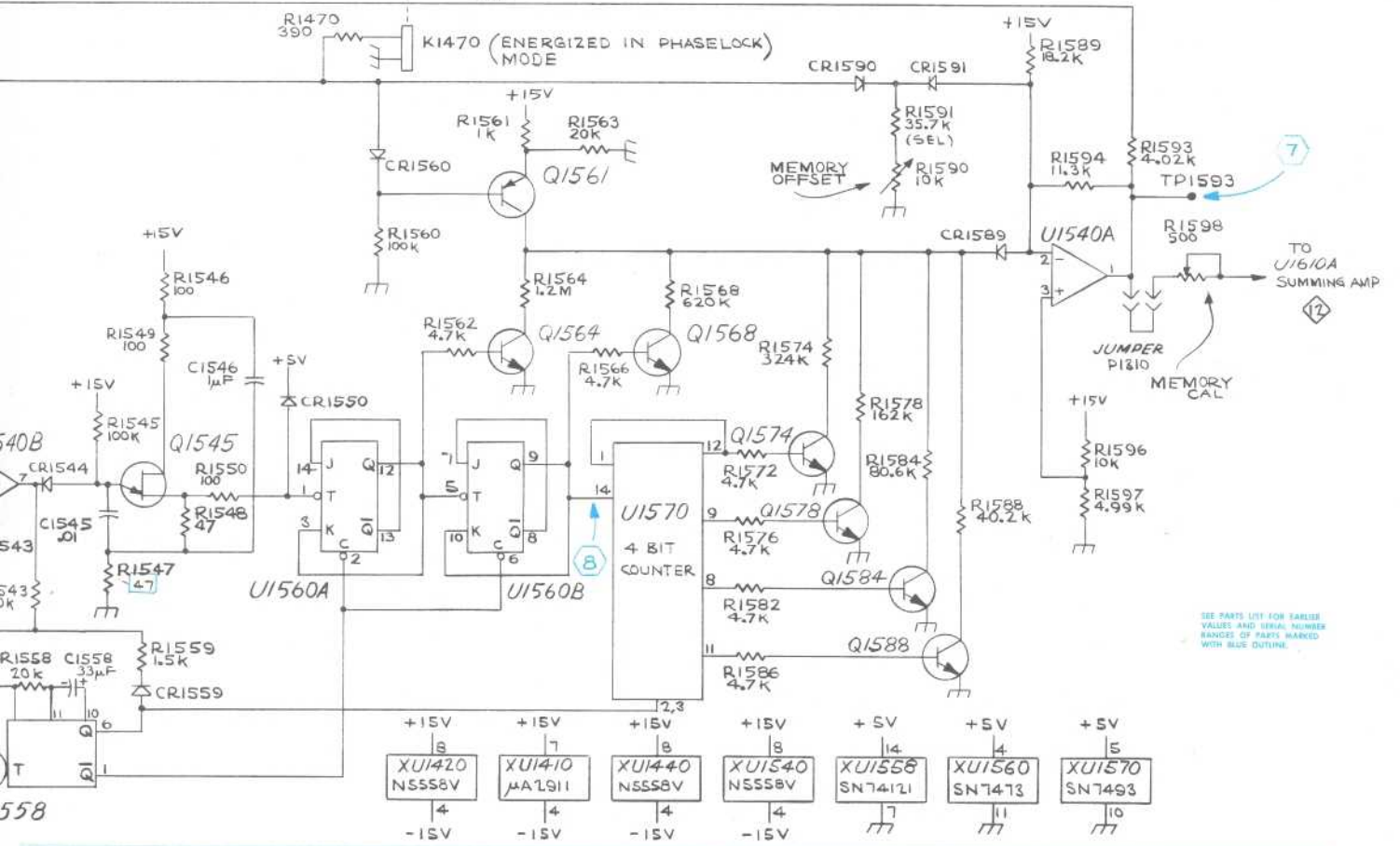
Q1480

P1301

TO (GAIN SLOPE) RESOLUTION BOARD THRU P416

P13B-3

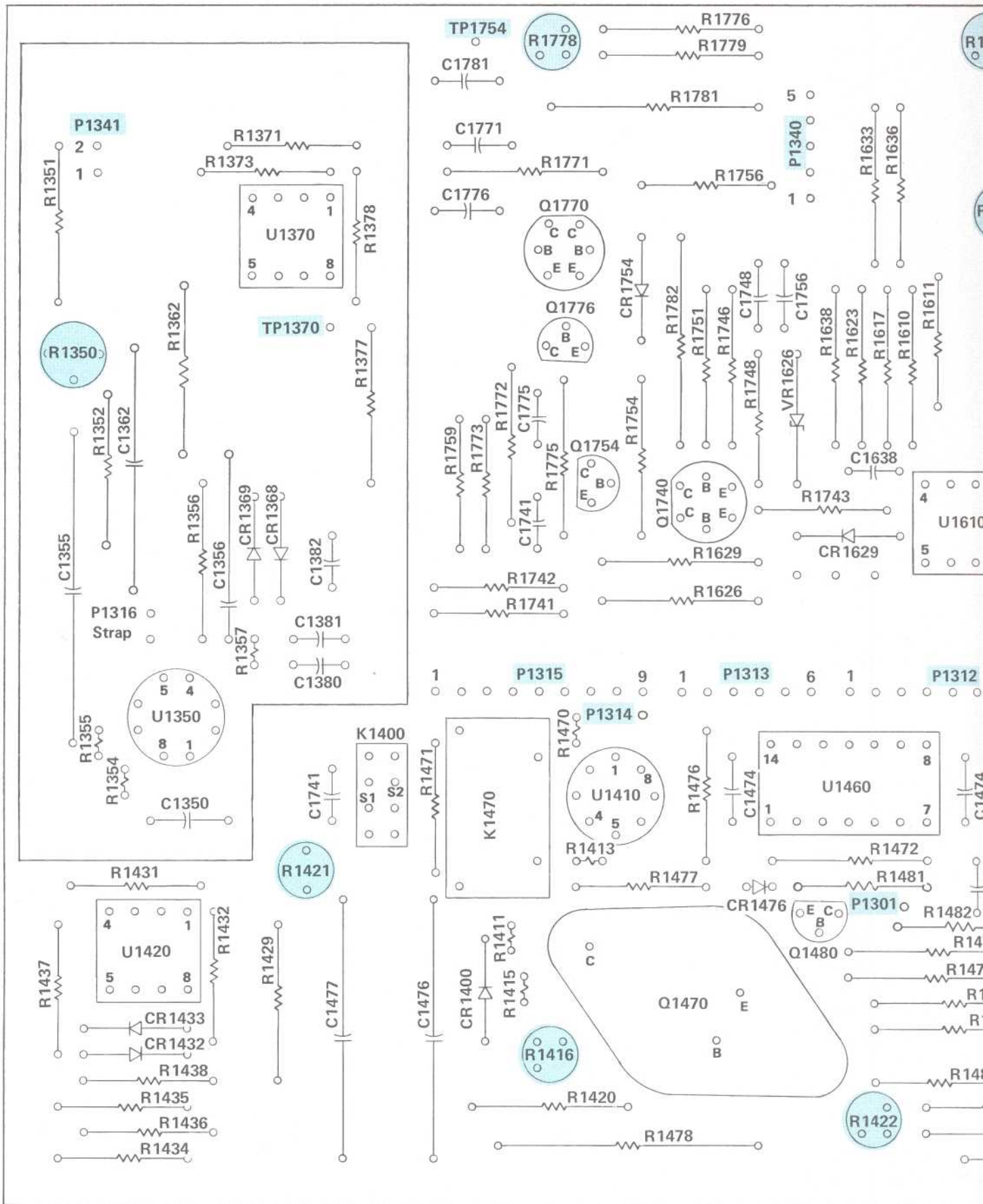
TO VERTICAL SUMMING AMP U810C THRU P800-6



SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

MARKER GEN, YIG COIL DRIVER  
VOLTAGE MEMORY AND PHASE LOCK

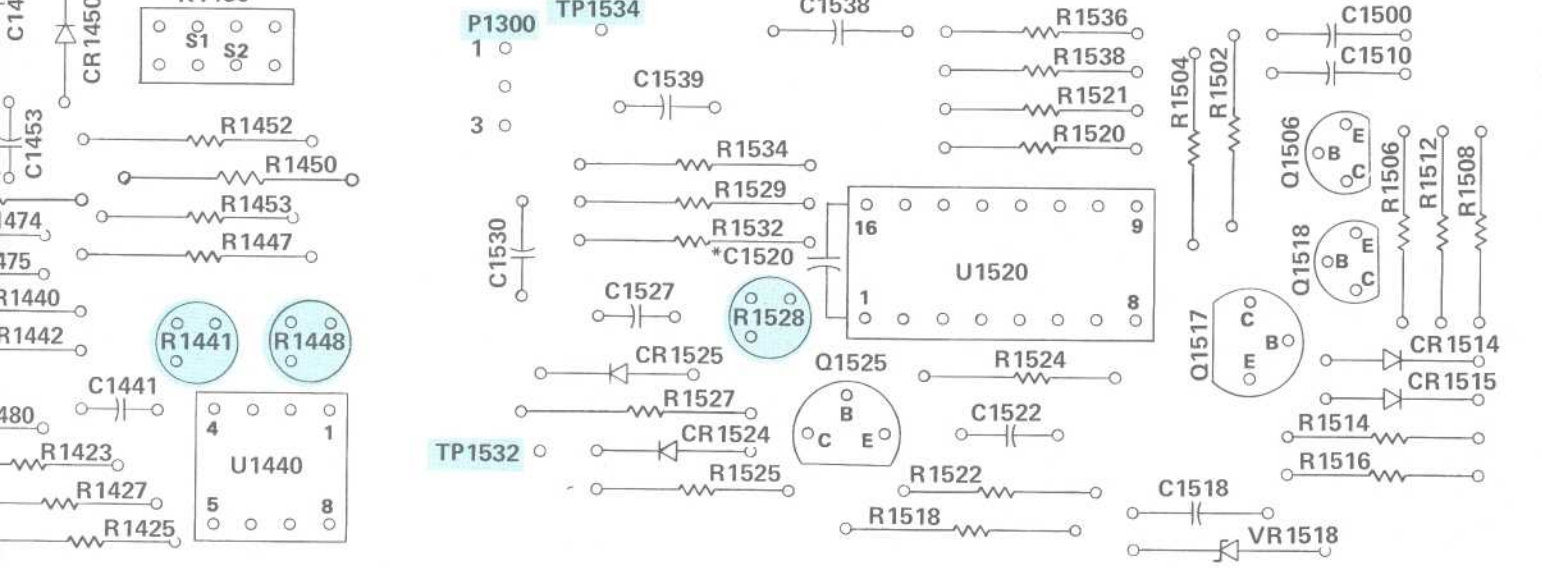
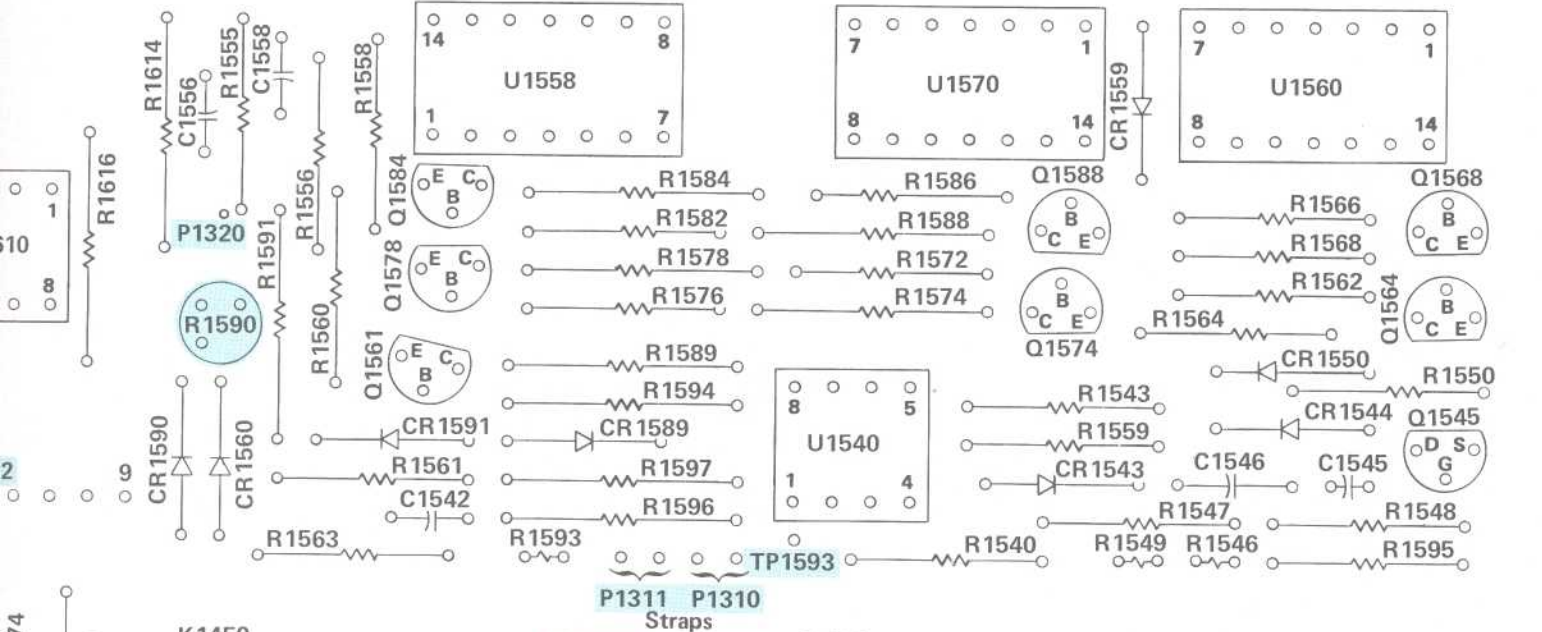
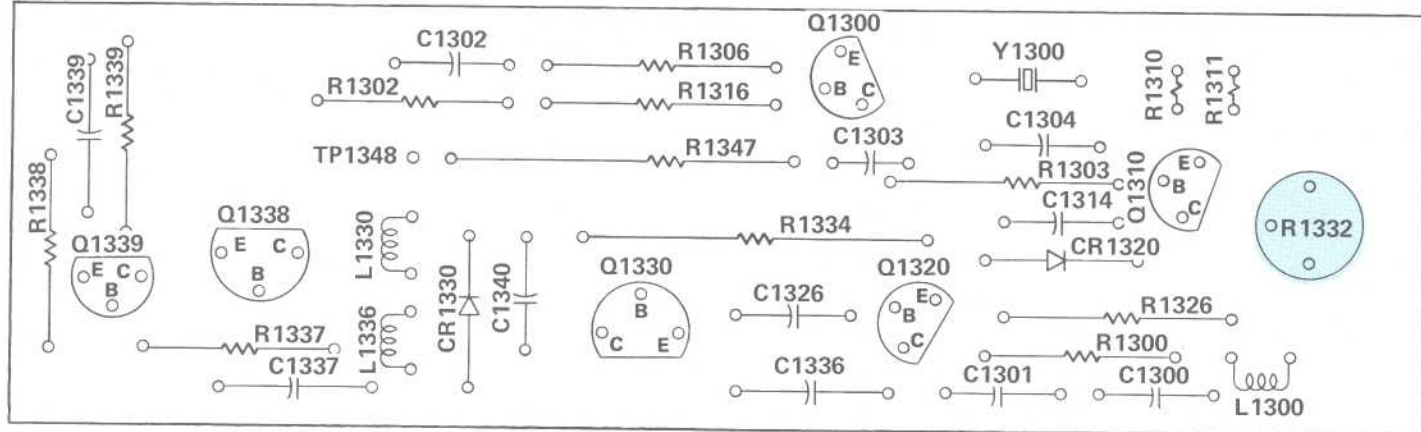




R1637

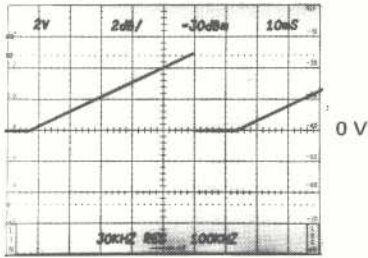
C1611

R1598

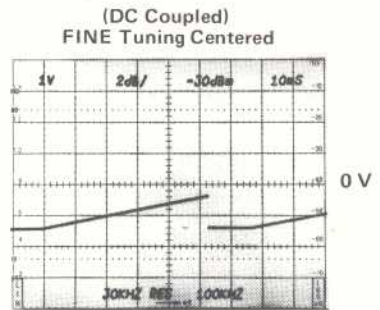


\*Added SN B030000

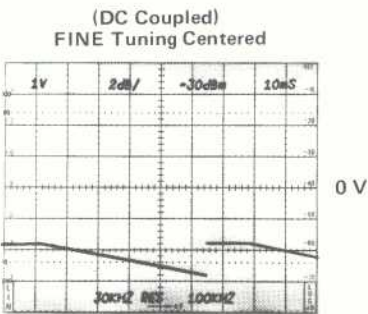
1



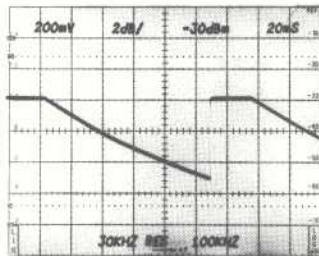
3



2

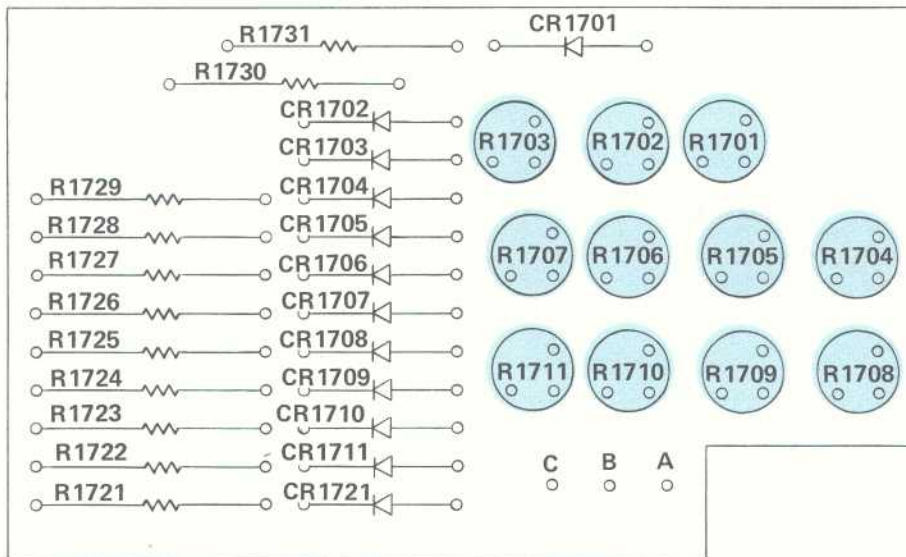


4



+

7L12

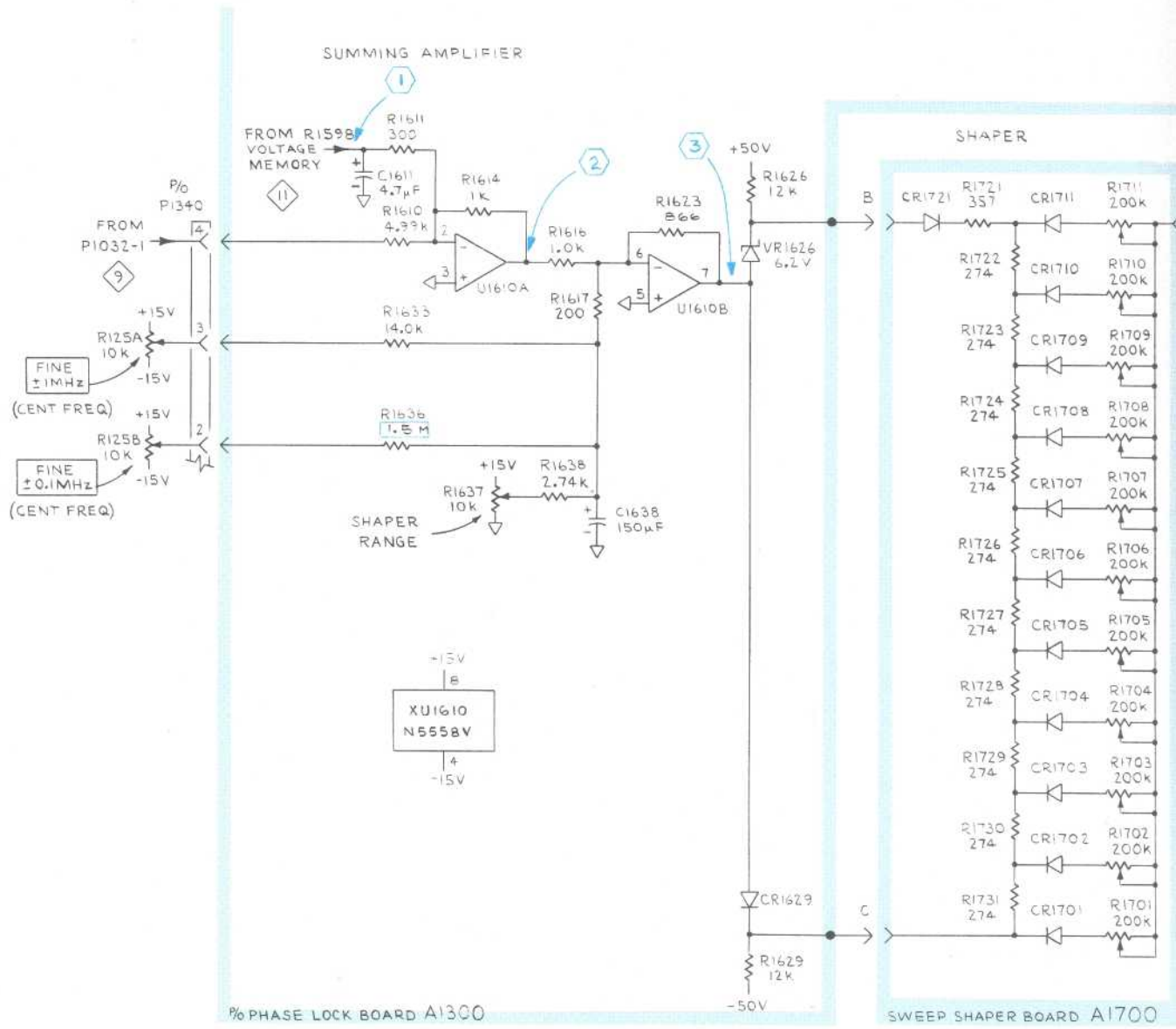


A1700 Sweep Shaper Circuit Board

(A)

+



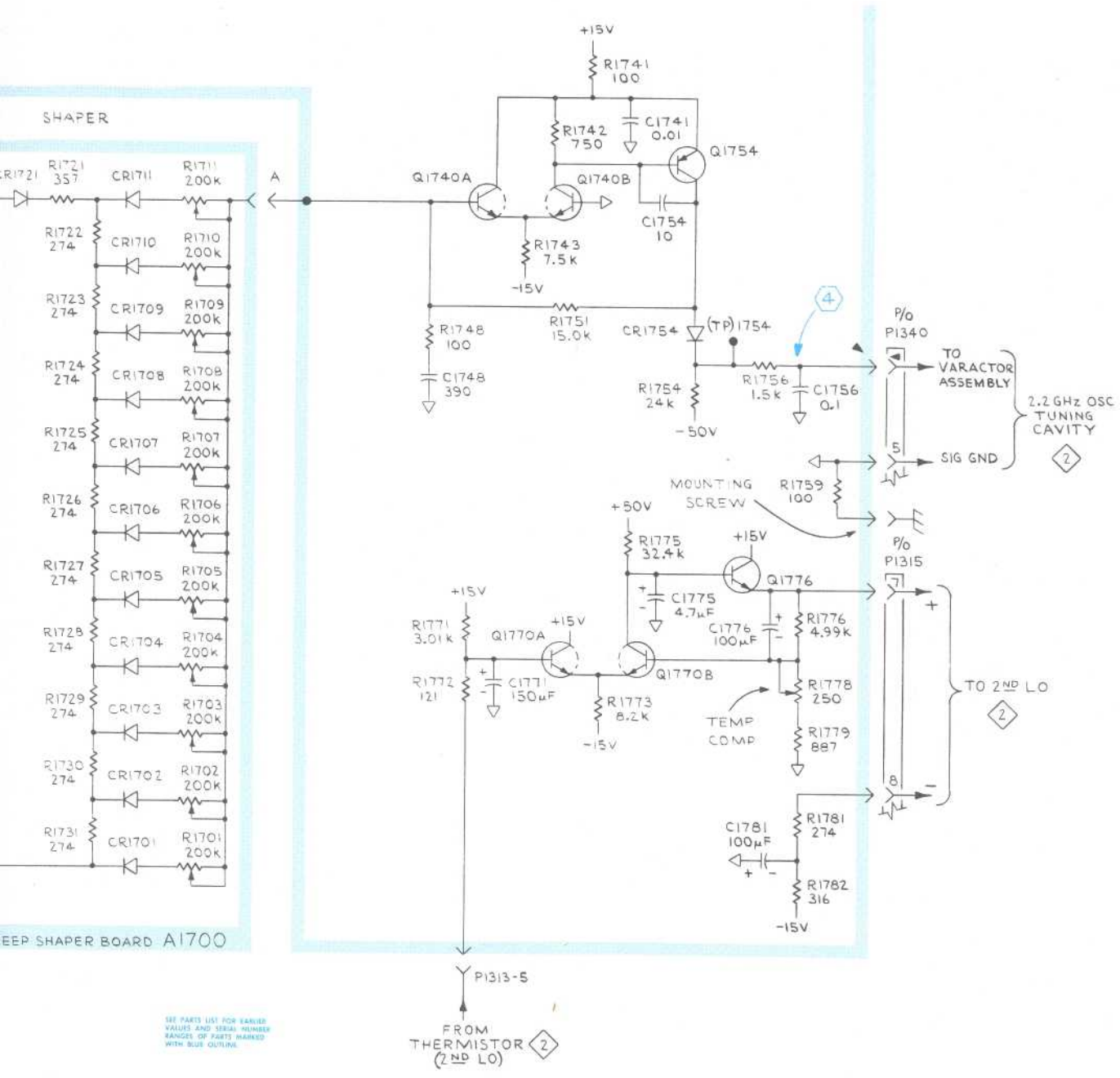


+

7L12

Ⓟ

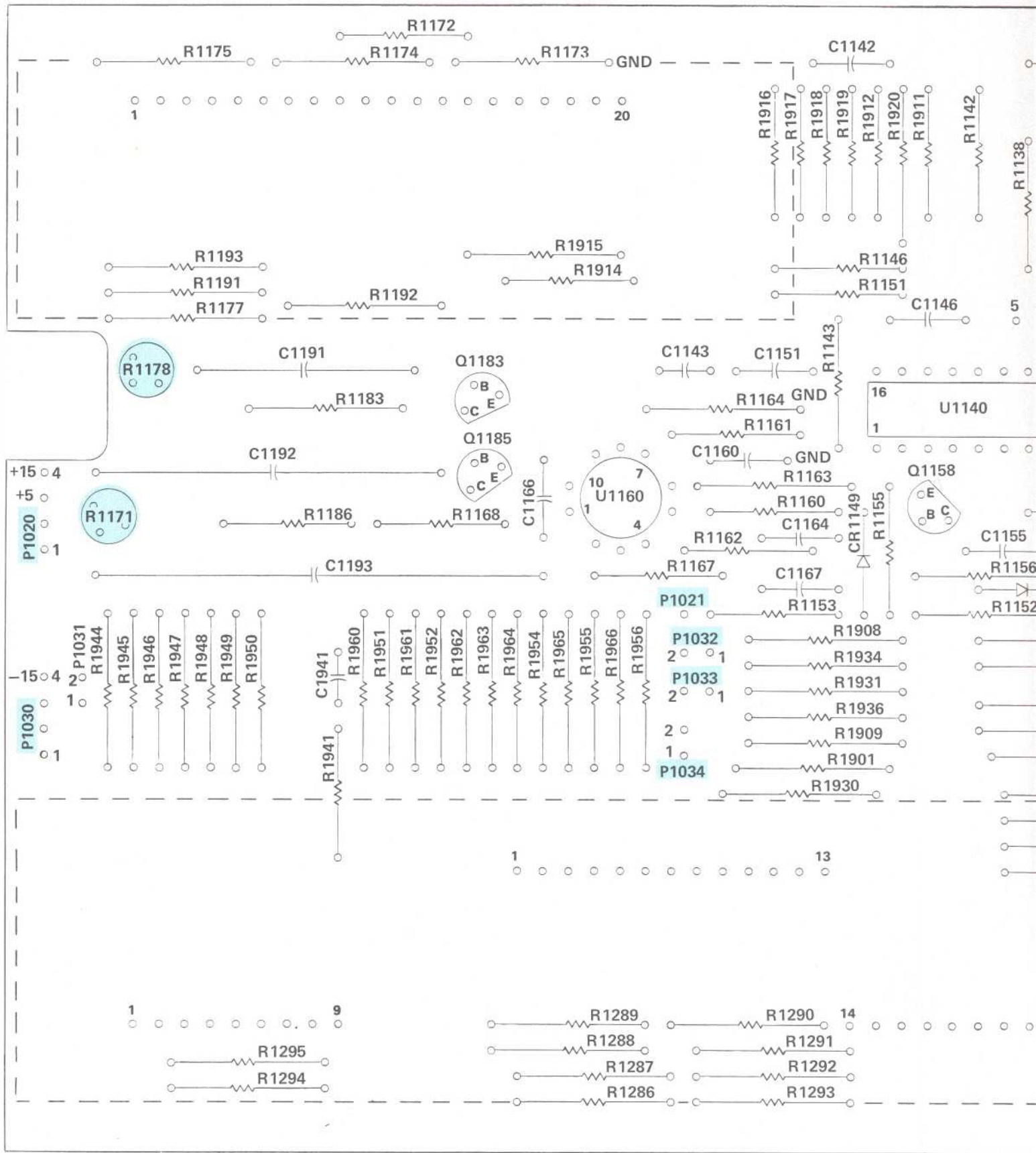
SEE PARTS LIST FOR VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE

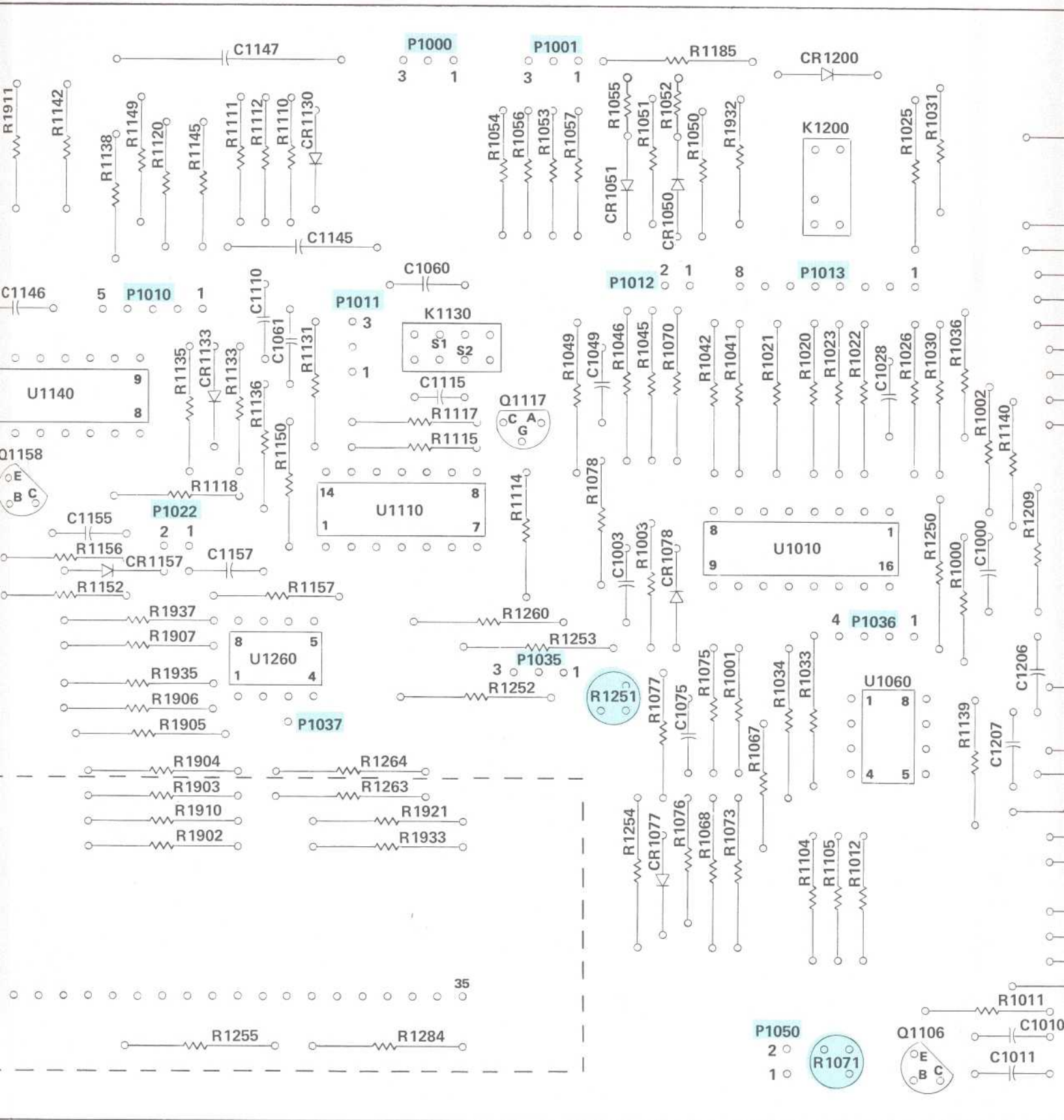


(B)

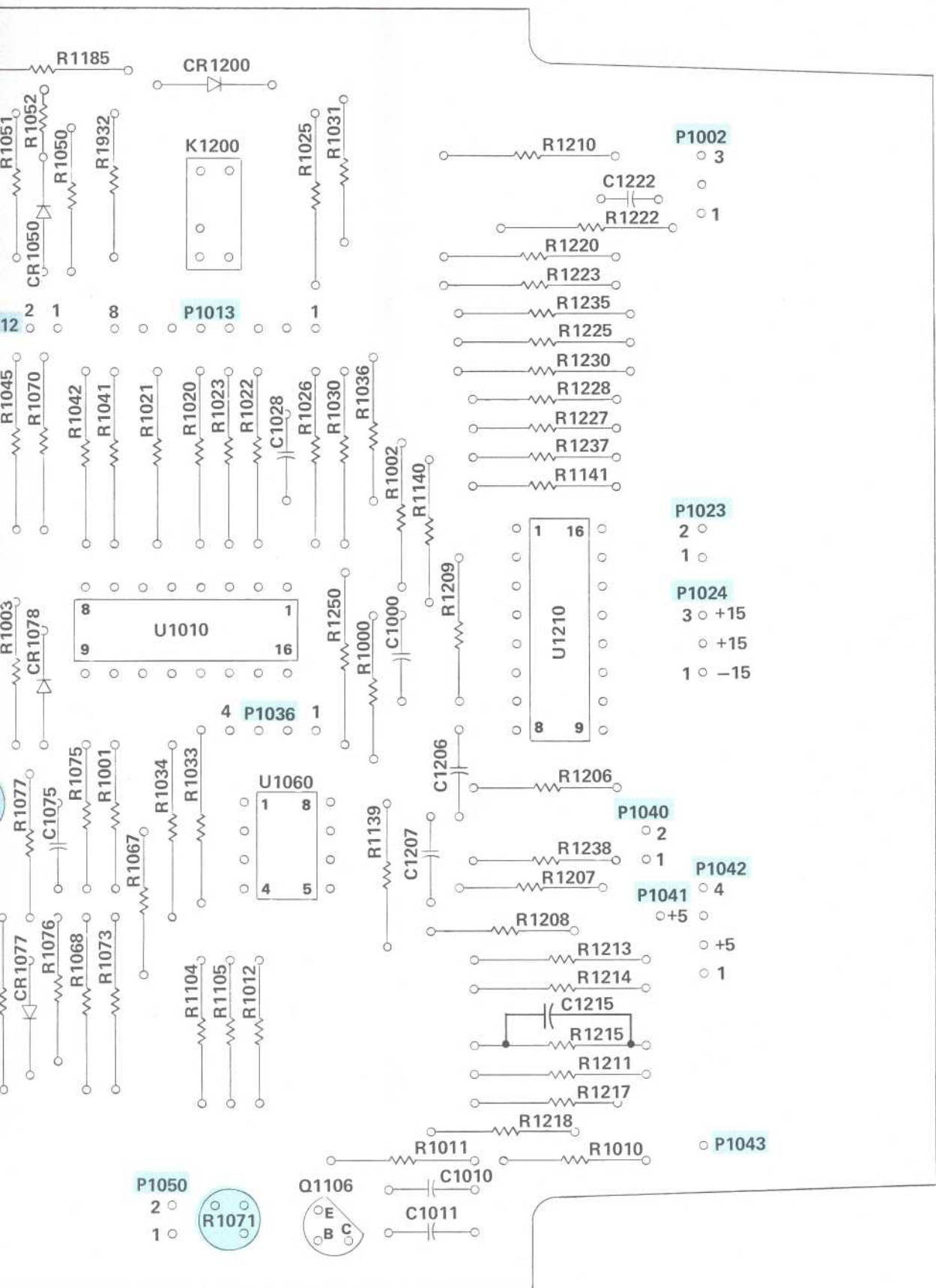
1272 NL  
SWEEP SHAPER



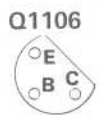




A1000 Sweep Circuit Board



P1050  
2  
1



C1010  
C1011

P1043

P1041  
+5

P1042  
4  
+5  
1

P1040  
2  
1

P1024  
3 +15  
+15  
1 -15

P1023  
2  
1

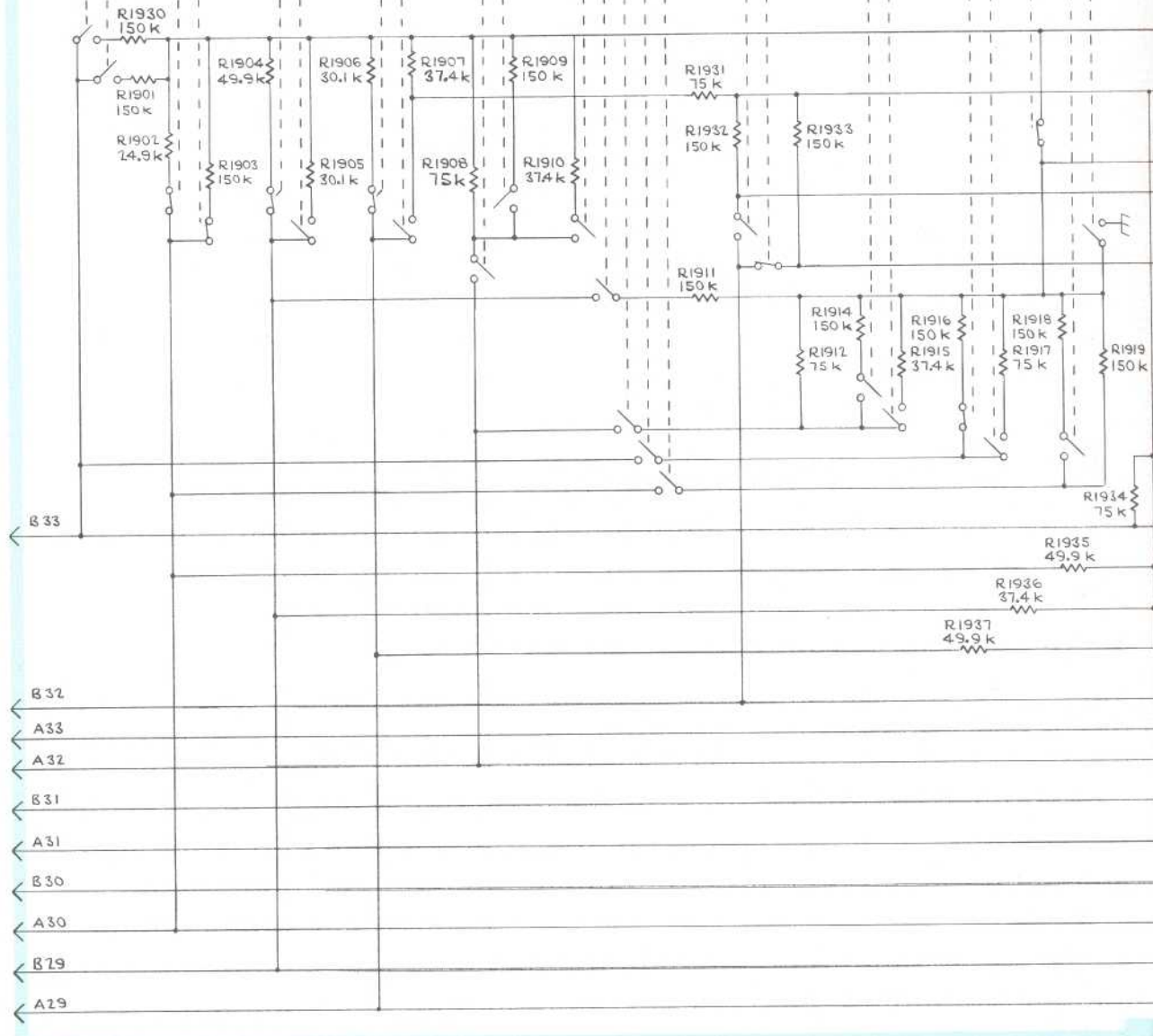
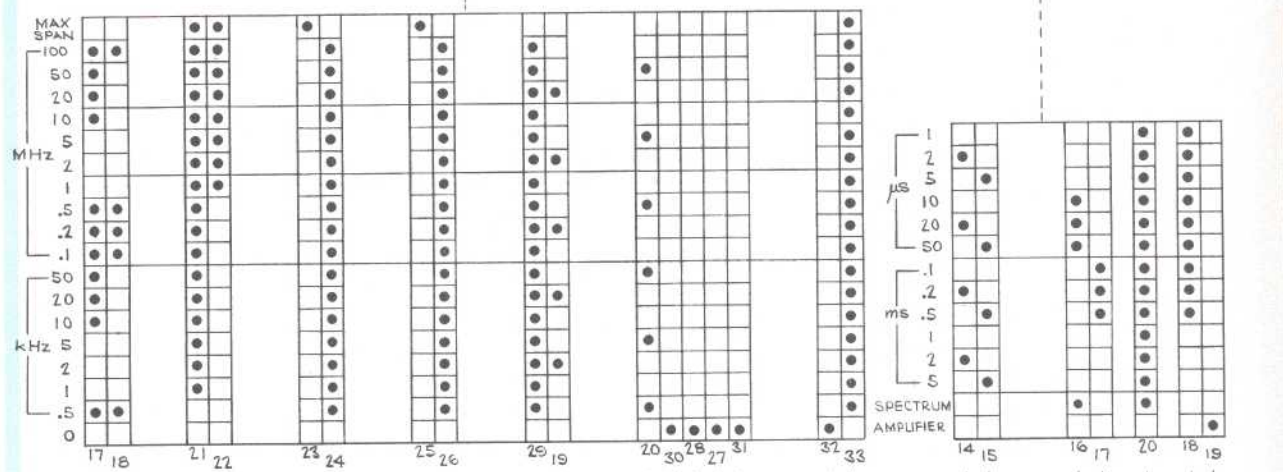
P1002  
3  
1

P1013  
8  
1

12  
2  
1

P/O S108B S  
 FREQUENCY SPAN/DIV (SHOWN IN MAX SPAN POSITION)

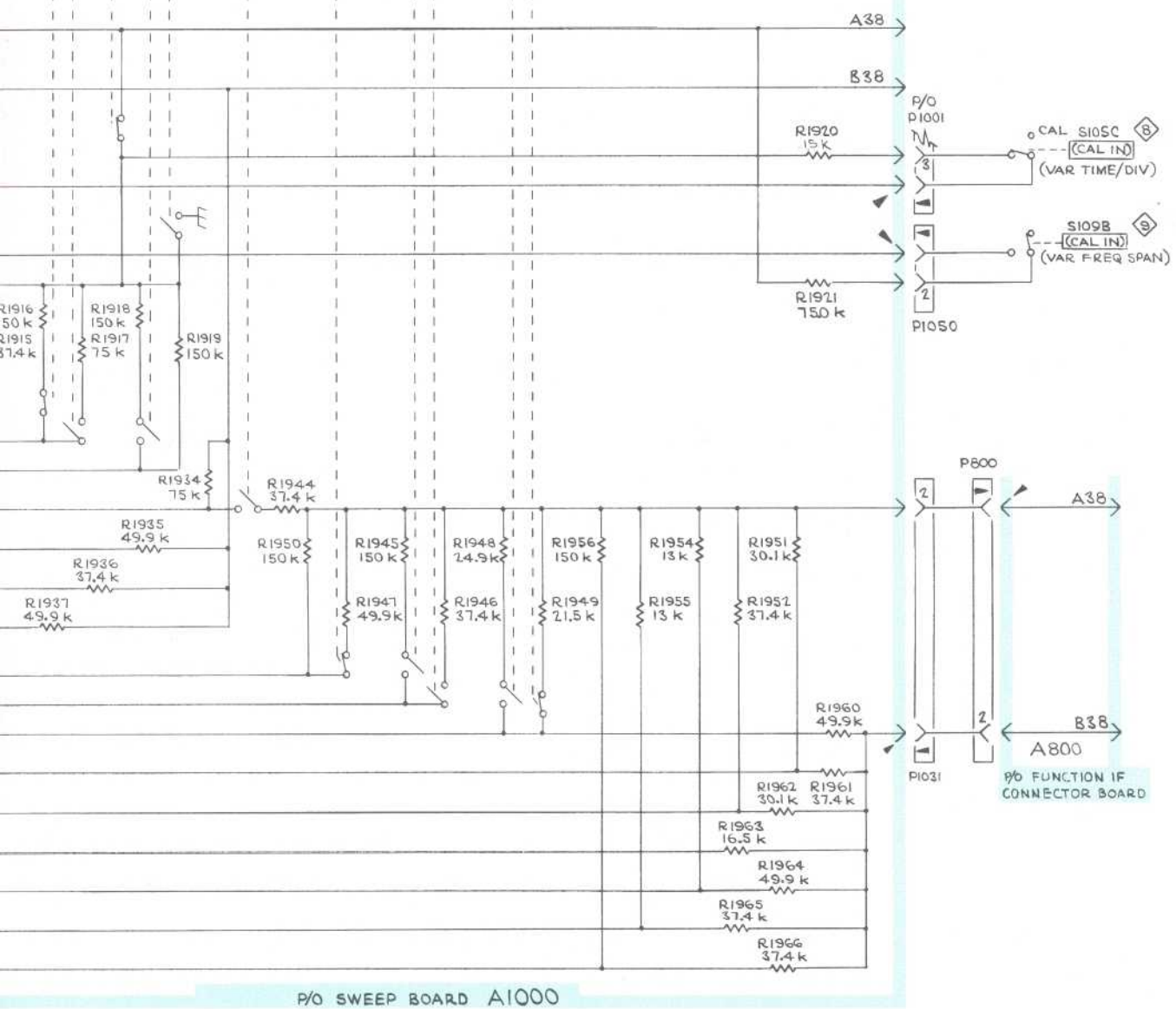
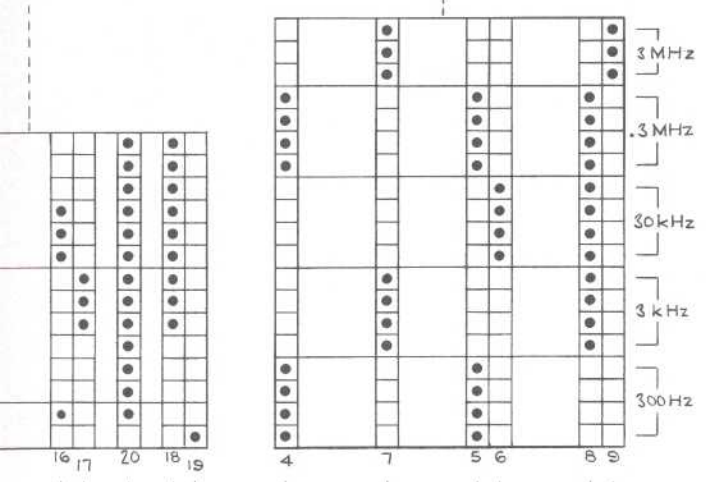
P/O S104 B (SHOWN IN SPECTRUM POSITION)  
 TIME/DIV



+



P/O S104 (8) TIME/DIV. (SHOWN IN SPECTRUM POSITION)  
 P/O S108A (4) RESOLUTION HZ (SHOWN IN 3MHz POSITION)

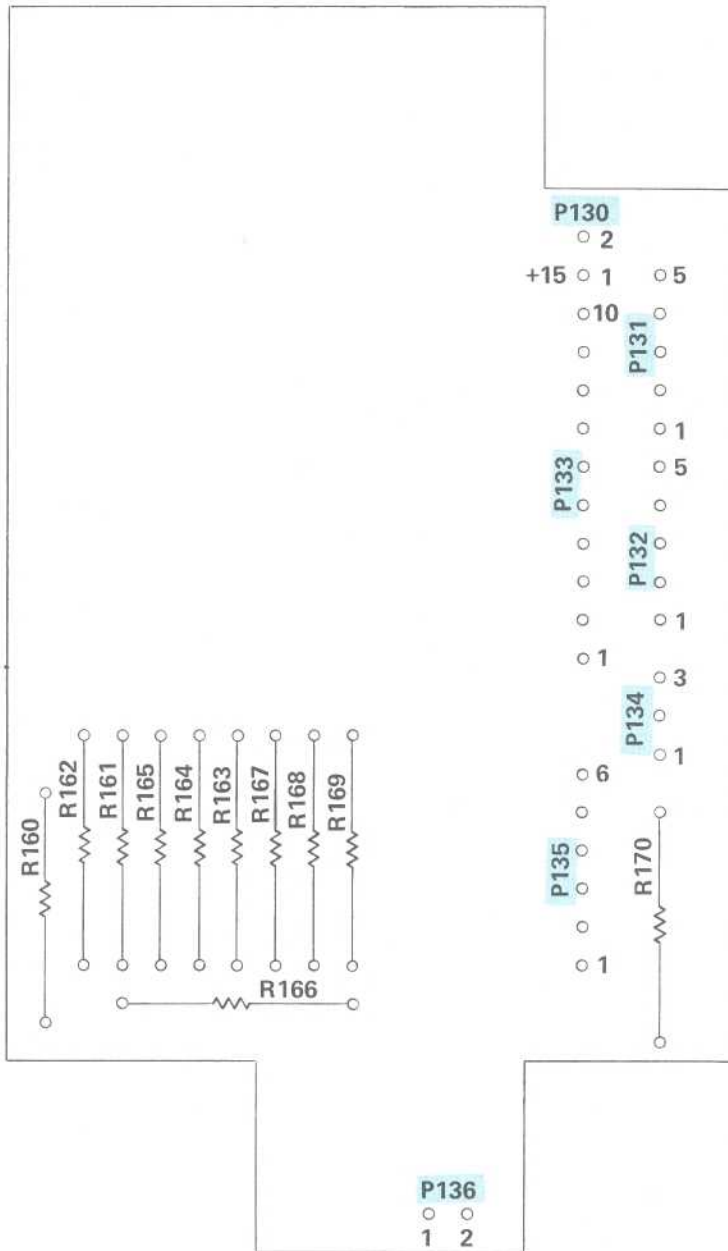


P/O SWEEP BOARD A1000





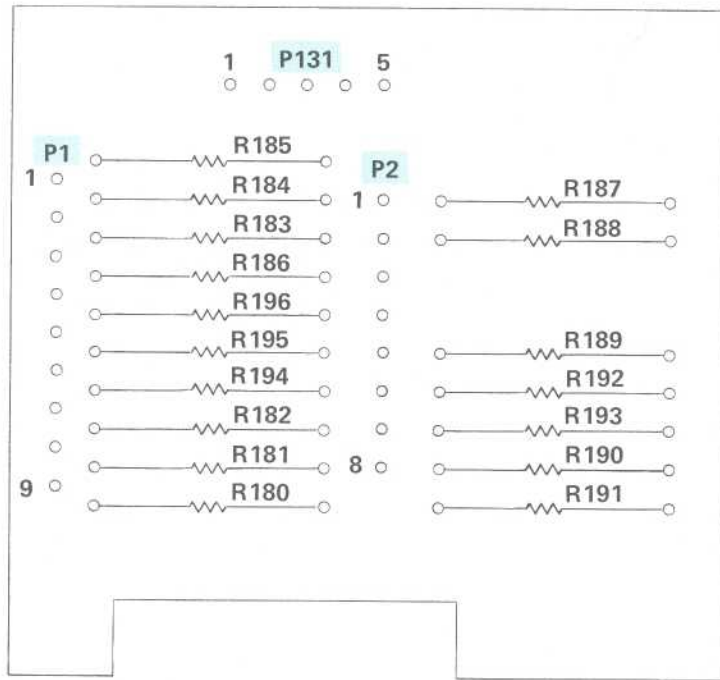
7L12



P/O A130A1 Display Mode Connector Circuit Board (A)

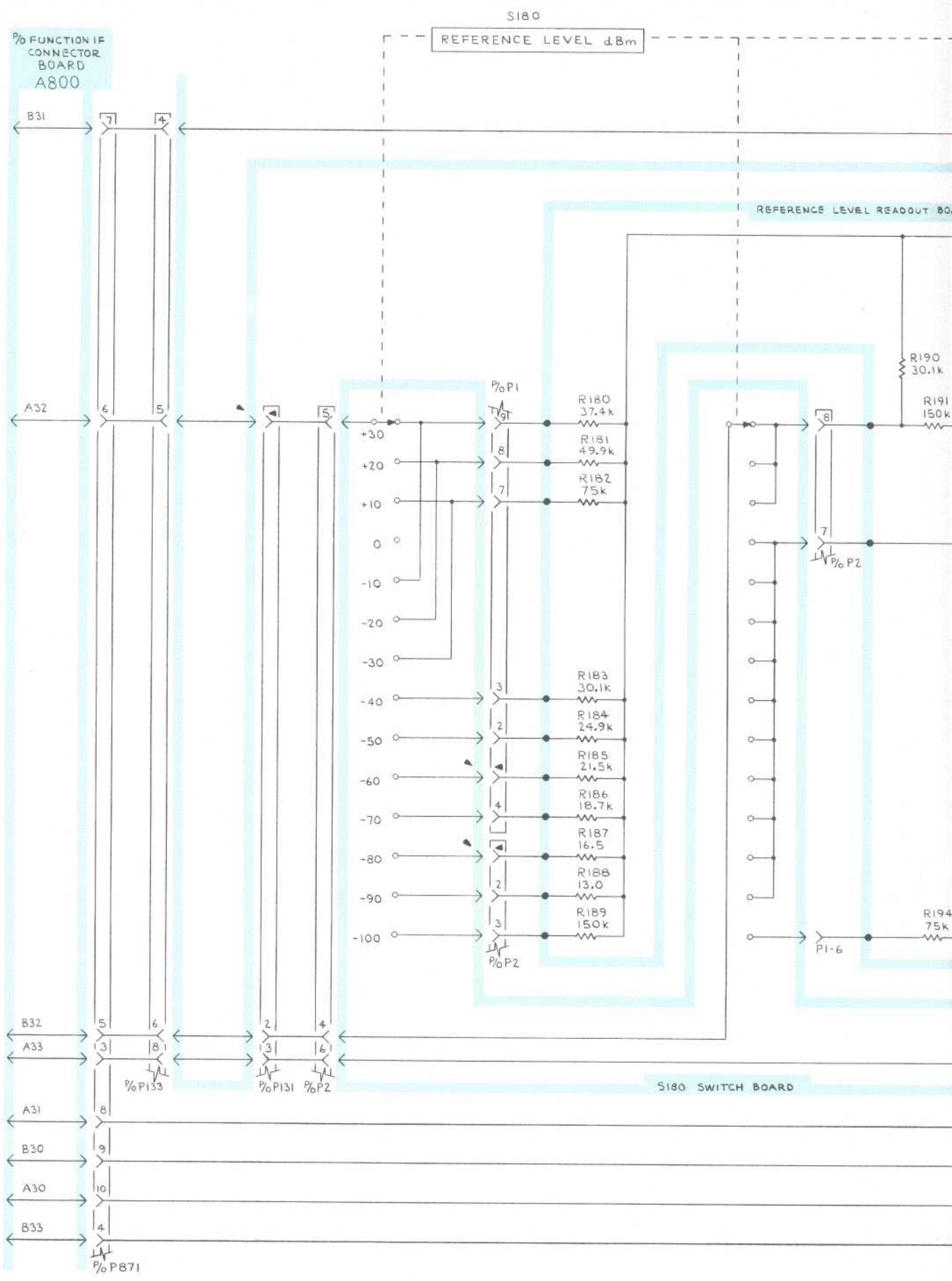


+ 7L12

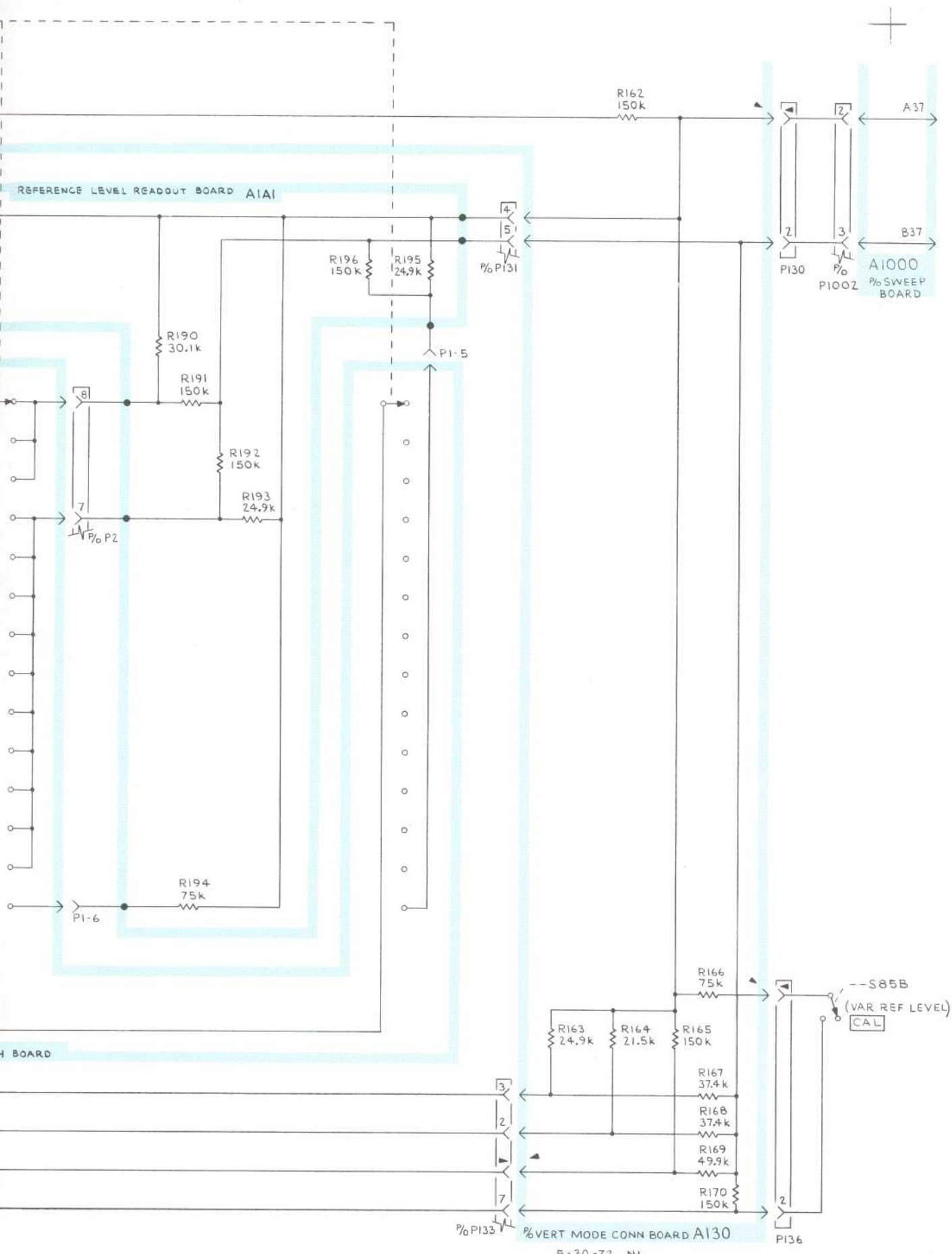


A1A1 Reference Level Readout Circuit Board (A)

+



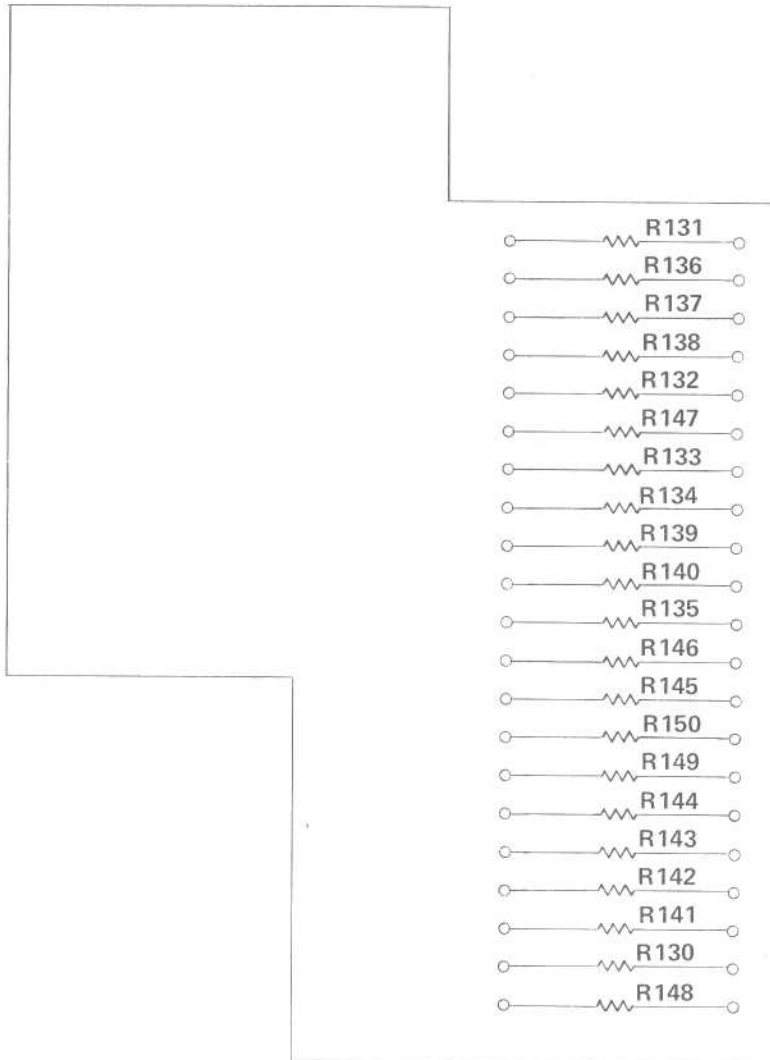
+ 7L12



(A)

5-30-72 NL  
REFERENCE LEVEL READOUT 14

7L12

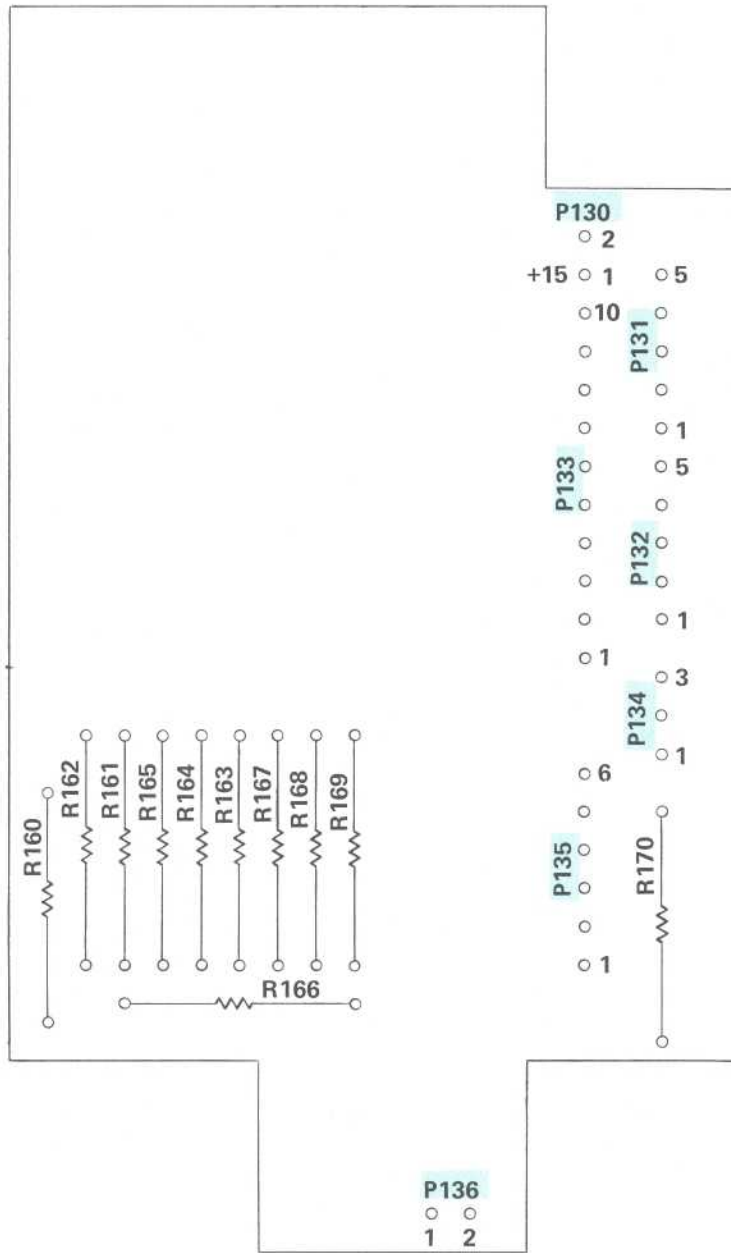


P/O A130A2 Display Mode Resistor Circuit Board

Ⓐ



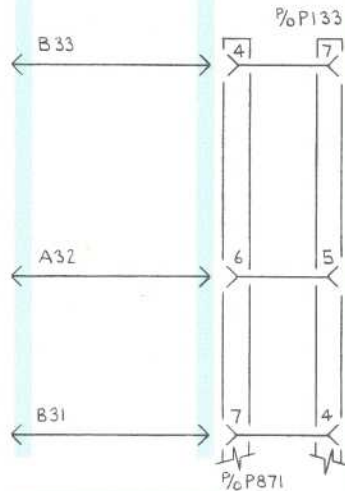
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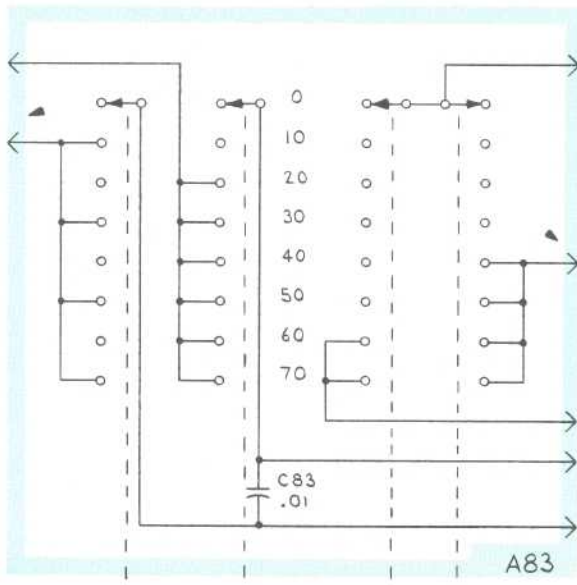
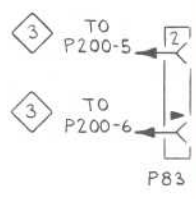
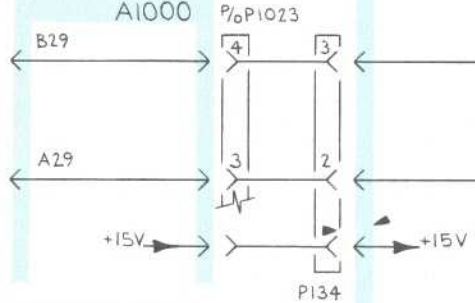
P/O A130A1 Display Mode Connector Circuit Board

Ⓐ

FUNCTION IF CONNECTOR BOARD A800

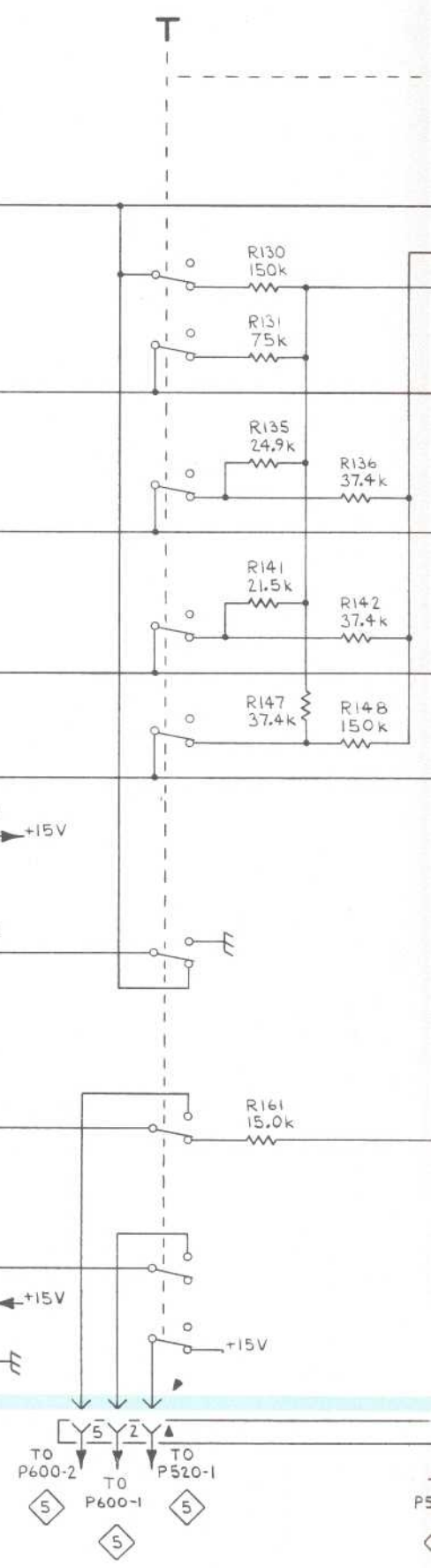


SWEEP BOARD A1000



S83 REFERENCE LEVEL (IF GAIN)

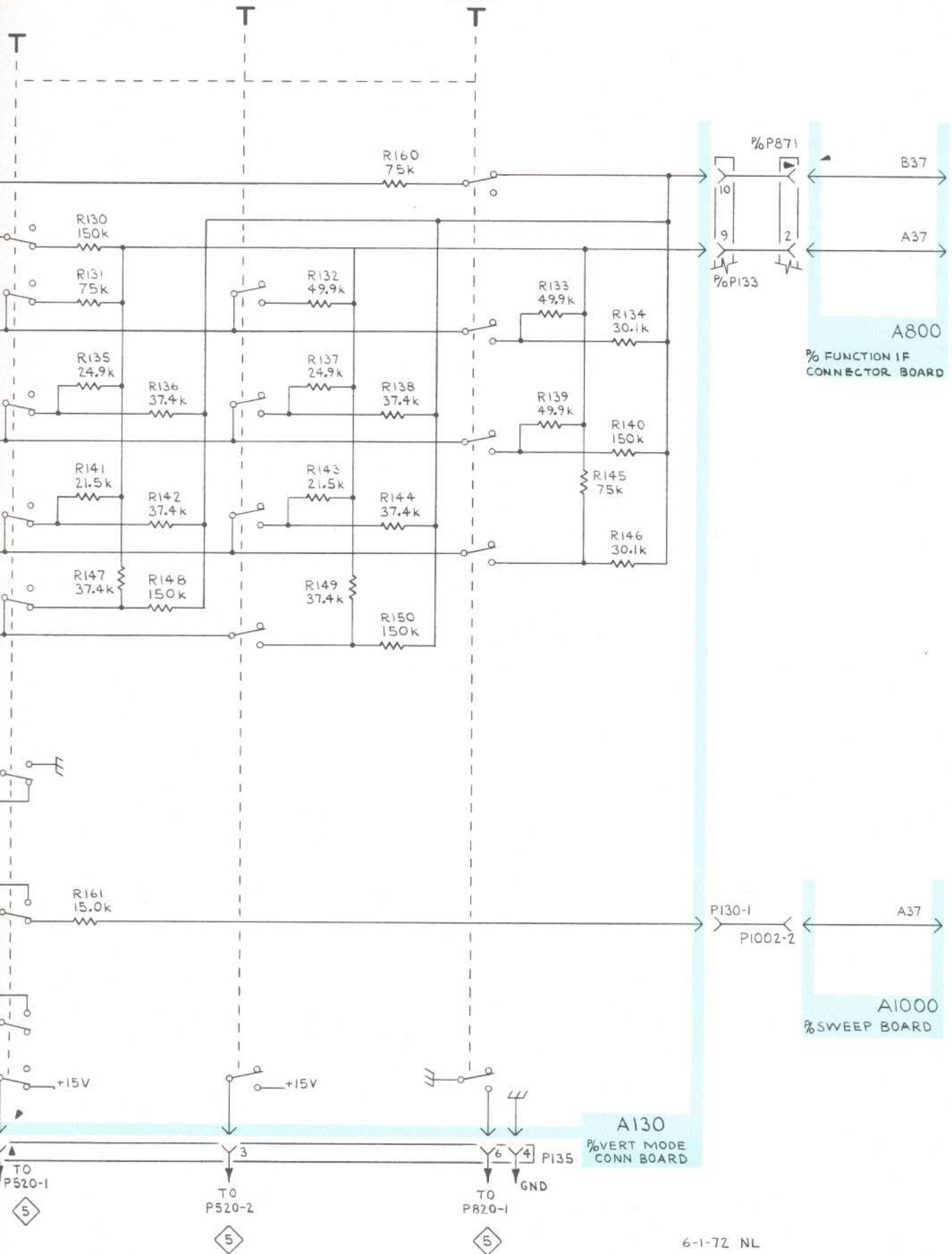
7L12



S130A  
B/DIV

S130B  
2dB/DIV

S130C  
LIN



+

6-1-72 NL

# **SECTION 9**

## **MECHANICAL PARTS LIST**

### **PARTS ORDERING INFORMATION**

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to TEKTRONIX instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial or model number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

### **PARTS REPAIR AND REPLACEMENT PROGRAM**

Assemblies that contain a number of hybrid circuits or substrates in a semisealed module; or complex assemblies that require special tools or knowledge to service, may be returned to your local TEKTRONIX Field Office for repair or replacement. Refer to parts price list or your local TEKTRONIX Field Office for replacement or repair service.

When repair only is desired, send the faulty assembly to your TEKTRONIX Field Office, stating that you wish to have it repaired. The faulty assembly will then be repaired and returned to you. You will be billed for parts and labor.

When immediate replacement is desired, send the faulty assembly to your TEKTRONIX Field Office, stating that you wish to have it replaced. A new assembly will then be sent. You will be billed for a new assembly minus credit for the faulty assembly.

## FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations which appear either on the back of the diagrams or on pullout pages immediately following the diagrams of the instruction manual.

## INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the Description column.

*Assembly and/or Component*  
*Detail Part of Assembly and/or Component*  
*mounting hardware for Detail Part*  
*Parts of Detail Part*  
*mounting hardware for Parts of Detail Part*  
*mounting hardware for Assembly and/or Component*

Mounting hardware always appears in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation.

**Mounting hardware must be purchased separately, unless otherwise specified.**



# MECHANICAL PARTS LIST

Replacement parts should be ordered from the Tektronix Field Office or Representative in your area. Changes to Tektronix products give you the benefit of improved circuits and components. Please include the instrument type number and serial number with each order for parts or service.

## ABBREVIATIONS

BHB	binding head brass	h	height or high	OHB	oval head brass
BHS	binding head steel	hex.	hexagonal	OHS	oval head steel
CRT	cathode-ray tube	HHB	hex head brass	PHB	pan head brass
csk	countersunk	HHS	hex head steel	PHS	pan head steel
DE	double end	HSB	hex socket brass	RHS	round head steel
FHB	flat head brass	HSS	hex socket steel	SE	single end
FHS	flat head steel	ID	inside diameter	THB	truss head brass
Fil HB	fillister head brass	lg	length or long	THS	truss head steel
Fil HS	fillister head steel	OD	outside diameter	w	wide or width

FIGURE 1

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q † y	Description
		Eff	Disc		
1-1	366-0402-00			1	KNOB, gray, w/handle--FREQUENCY MHz (coarse)
	- - - - -			-	knob includes:
	213-0153-00			2	SETSCREW, 5-40 x 0.125 inch, HSS
-2	214-1226-01			1	SPRING
-3	210-1011-00			2	WASHER, plastic, 0.13 ID x 0.375 inch OD
-4	366-1380-00			1	KNOB, red--VARIABLE CAL (gain)
	- - - - -			-	knob includes:
	213-0153-00			1	SETSCREW, 5-40 x 0.125 inch, HSS
-5	366-1029-00			1	KNOB, gray--GAIN SELECTOR
	- - - - -			-	knob includes:
	213-0153-00			2	SETSCREW, 5-40 x 0.125 inch, HSS
-6	354-0418-00			1	RING, knob skirt
-7	358-0414-00			1	BUSHING, sleeve, 0.128 ID x 0.25 OD x 0.20 in. lg
-8	366-1336-00			1	KNOB, charcoal--RF ATTENUATOR
	- - - - -			-	knob includes:
	213-0153-00			2	SETSCREW, 5-40 x 0.125 inch, HSS
-9	366-1388-00			1	KNOB, red--VARIABLE (CAL IN) Frequency Span
	- - - - -			-	knob includes:
	213-0153-00			1	SETSCREW, 5-40 x 0.125 inch, HSS
-10	366-1393-00			1	KNOB ASSEMBLY--UNCOUPLING (Resolution/ frequency span)
	- - - - -			-	knob includes:
	213-0153-00			2	SETSCREW, 5-40 x 0.125 inch, HSS
-11	354-0419-00	B010100	B039999	1	RING, knob skirt
	354-0419-01	B040000		1	RING, knob skirt
-12	366-1361-00	B010100	B039999	1	KNOB, charcoal--RESOLUTION
	366-1361-01	B040000		1	KNOB, charcoal--RESOLUTION
	- - - - -			-	knob includes:
	213-0153-00			2	SETSCREW, 5-40 x 0.125 inch, HSS
-13	366-1391-00			2	KNOB, gray--SLOPE & FINE, w/setscrew
-14	366-1077-00			2	KNOB, gray--LEVEL & FINE
	- - - - -			-	each knob includes:
	213-0153-00			1	SETSCREW, 5-40 x 0.125 inch, HSS
-15	366-0494-00			2	KNOB, gray--BASE LINE CLIPPER & HORIZ POS
	- - - - -			-	each knob includes:
	213-0153-00			1	SETSCREW, 5-40 x 0.125 inch, HSS
-16	366-1389-00			1	KNOB, black--VERT POS, w/setscrew

Mechanical Parts List-7L12

FIGURE 1

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
1-17	366-1166-00			1	KNOB, red--VARIABLE (CAL IN)
	- - - - -			-	knob includes:
	213-0153-00			1	SETSCREW, 5-40 x 0.125 inch, HSS
-18	366-1057-00			1	KNOB, gray--TIME/DIV
	- - - - -			-	knob includes:
	213-0153-00			2	SETSCREW, 5-40 x 0.125 inch, HSS
-19	358-0216-00			1	BUSHING, front panel, 0.257 ID x 0.412 inch OD
-20	358-0301-00			4	BUSHING, plastic
-21	366-1257-62			1	PUSHBUTTON--10dB/DIV
-22	366-1257-61			1	PUSHBUTTON--2dB/DIV
-23	366-1257-89			1	PUSHBUTTON--LIN
-24	337-1064-04			1	SHIELD, electrical, right side
-25	337-1064-08			1	SHIELD, electrical, left side
-26	366-1058-29			1	KNOB, latch
	- - - - -			-	mounting hardware: (not included w/knob)
-27	214-1095-00			1	PIN, spring, split
-28	105-0076-00			1	RELEASE BAR, latch
-29	214-1280-00			1	SPRING, helical extension, 1.126 inches long
-30	214-1054-00			1	SPRING, flat
-31	105-0075-00			1	BOLT, latch
-32	348-0235-00			2	SHIELDING GASKET
-33	426-0831-00			1	FRAME, readout
-34	426-0681-00			3	FRAME, pushbutton
-35	175-1321-00			1	CABLE ASSEMBLY, electrical (W2)
-36	175-1326-00			1	CABLE ASSEMBLY, electrical (W3)
-37	015-1024-00			1	ATTENUATOR (AT3)
-38	175-1325-00			1	CABLE ASSEMBLY, electrical (W4)
-39	175-1327-00			1	CABLE ASSEMBLY, electrical (W5)
-40	175-1316-00			1	CABLE ASSEMBLY, electrical (W22)
-41	175-1317-00			1	CABLE ASSEMBLY, electrical (W1)
-42	175-1322-00			1	CABLE ASSEMBLY, electrical (W34)
-43	175-1328-00			1	CABLE ASSEMBLY, electrical (W6)
	175-1370-00			1	CABLE ASSEMBLY, electrical (W900)
	- - - - -			-	cable assembly includes:
-44	131-0375-00			1	CONNECTOR, right angle
-45	131-0818-00			1	CONNECTOR, receptacle, BNC, w/hardware (J99)
-46	119-0294-00			1	FILTER, low pass, DC to 1.80 GHz
	- - - - -			-	mounting hardware: (not included w/filter)
-47	211-0069-00			2	SCREW, 2-56 x 0.125 inch, PHS
-48	343-0352-00			2	CLAMP
-49	348-0003-00			2	GROMMET, rubber, 0.312 inch diameter
-50	119-0333-00			1	FILTER ASSEMBLY, 2.095 GHz (A10)
	- - - - -			-	mounting hardware: (not included w/filter assy)
-51	211-0007-00			4	SCREW, 4-40 x 0.188 inch, PHS

FIGURE 1

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
1-52	119-0306-00			1	MIXER UNIT, single balanced (All)
-53	354-0412-00			1	RING, knob skirt
	- - - - -			-	mounting hardware: (not included w/ring)
-54	210-0405-00			2	NUT, hex., 2-56 x 0.188 inch
-55	401-0137-00			1	BEARING, snap-in
-56	- - - - -			1	CIRCUIT BOARD ASSEMBLY--SWEEP DISPERSION (See A1000 electrical list)
	- - - - -			-	mounting hardware: (not included w/circuit board assembly)
-57	211-0116-00			2	SCREW, sems, 4-40 x 0.312 inch, PHB
-58	220-0547-01			1	NUT, block
	211-0101-00			1	SCREW, 4-40 x 0.25 inch, 100° csk, FHS
-59	210-0590-00			1	NUT, hex., 0.375-32 x 0.438 inch
-60	354-0412-00			1	RING, knob skirt
	- - - - -			-	mounting hardware: (not included w/ring)
-61	210-0419-00			1	NUT, shouldered, 0.375-32
-62	333-1459-00	B010100	B039999	1	PANEL, front
	333-1459-01	B040000		1	PANEL, front
-63	426-0859-00			1	FRAME, readout, center frequency
-64	200-0935-00			1	COVER, lampholder
-65	378-0602-01			1	LENS, indicator light
-66	352-0157-00			1	LAMPHOLDER
-67	260-1470-00			1	SWITCH, slide (S120)
-68	131-0779-00			2	JACK, tip
-69	- - - - -			1	CIRCUIT BOARD ASSEMBLY--START CTR FREQ (See A110 electrical list)
	- - - - -			-	circuit board assembly includes:
-70	131-0589-00			5	TERMINAL, pin, 0.46 inch long
-71	136-0252-04			6	SOCKET, pin connector
	- - - - -			-	mounting hardware: (not included w/circuit board assembly)
-72	211-0156-00			1	SCREW, 1-72 x 0.25 inch, 82° csk, FHS
-73	119-0335-00			1	COUNTER ASSEMBLY
	- - - - -			-	mounting hardware: (not included w/counter assy)
-74	211-0101-00			2	SCREW, 4-40 x 0.25 inch, 100° csk, FHS
-75	119-0342-00			1	HYBRID CIRCUIT ENCLOSURE(A6)
	- - - - -			-	mounting hardware: (not included w/hybrid circuit enclosure)
-76	211-0087-01			2	SCREW, 2-56 x 0.188 inch, 82° csk, FHS
-77	- - - - -			1	CIRCUIT BOARD ASSEMBLY--TRIG SOURCE (See A101 electrical list)
	- - - - -			-	circuit board assembly includes:
-78	131-0608-00			7	TERMINAL, pin, 0.365 inch long
	- - - - -			-	mounting hardware: (not included w/circuit board assembly)
-79	211-0156-00			2	SCREW, 1-72 x 0.25 inch, 82° csk, FHS

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FIGURE 1

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
1-80	- - - - -			1	CIRCUIT BOARD ASSEMBLY--TRIG MODE (See A102 electrical list)
	- - - - -			-	circuit board assembly includes:
-81	131-0608-00			10	TERMINAL, pin, 0.365 inch long
	- - - - -			-	mounting hardware: (not included w/circuit board assembly)
-82	211-0156-00			2	SCREW, 1-72 x 0.25 inch, 82° csk, FHS
-83	119-0310-00			1	MIXER UNIT, RF, double balanced (A4)
	- - - - -			-	mounting hardware: (not included w/mixer unit)
-84	210-0586-00			2	NUT, keps, 4-40 x 0.25 inch
-85	361-0046-00			2	SPACER, 4-40 x 0.50 inch long
-86	119-0332-00			1	TUNED CAVITY, 2nd LO (A70)
	- - - - -			-	mounting hardware: (not included w/tuned cavity)
-87	211-0105-00			2	SCREW, 4-40 x 0.188 inch, 100° csk, FHS
-88	- - - - -			1	CIRCUIT BOARD ASSEMBLY--VIDEO FILTER & PROCESSOR (See A90 electrical list)
	- - - - -			-	circuit board assembly includes:
-89	131-0608-00	B010100	B039999	10	TERMINAL, pin, 0.365 inch long
	131-0608-00	B040000		11	TERMINAL, pin, 0.365 inch long
	- - - - -			-	mounting hardware: (not included w/circuit board assembly)
-90	211-0101-00			2	SCREW, 4-40 x 0.25 inch, 100° csk, FHS
-91	344-0199-00			2	CLIP, spring tension
-92	361-0418-00	B010100	B039999	1	SPACER
	361-0418-01	B040000		1	SPACER
-93	- - - - -			1	RESISTOR, variable
	- - - - -			-	mounting hardware: (not included w/resistor)
-94	210-0583-00			2	NUT, hex., 0.25-32 x 0.312 inch
-95	210-0223-00			1	TERMINAL, lug, 0.25 inch diameter, SE
-96	- - - - -			1	RESISTOR, variable
	- - - - -			-	mounting hardware: (not included w/resistor)
	210-0046-00			1	WASHER, lock, internal, 0.261 ID x 0.40 inch OD
-97	- - - - -			1	RESISTOR, variable
	- - - - -			-	mounting hardware: (not includes w/resistor)
-98	210-0223-00			1	TERMINAL, lug, 0.25 inch diameter, SE
-99	- - - - -			1	RESISTOR, variable
	- - - - -			-	mounting hardware: (not included w/resistor)
-100	210-0583-00			1	NUT, hex., 0.25-32 x 0.312 inch
-101	- - - - -			1	RESISTOR, variable
	- - - - -			-	mounting hardware: (not included w/resistor)
-102	210-0583-00			1	NUT, hex., 0.25-32 x 0.312 inch

FIGURE 1

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
1 2 3 4 5					
1-103	- - - - -			1	RESISTOR, variable
	- - - - -			-	mounting hardware: (not included w/resistor)
-104	210-0583-00			1	NUT, hex., 0.25-32 x 0.312 inch
	210-0223-00			1	TERMINAL, lug, 0.25 inch diameter, SE
-105	- - - - -			1	RESISTOR, variable
	- - - - -			-	mounting hardware: (not included w/resistor)
	210-0046-00			1	WASHER, lock, internal, 0.261 ID x 0.40 inch OD
-106	- - - - -			1	RESISTOR, variable
	- - - - -			-	mounting hardware: (not included w/resistor)
	210-0046-00			1	WASHER, lock, internal, 0.261 ID x 0.40 inch OD
-107	- - - - -			1	RESISTOR, variable
	- - - - -			-	mounting hardware: (not included w/resistor)
-108	210-0223-00			1	TERMINAL, lug, 0.25 inch diameter, SE
-109	386-2023-00	B010100	B039999	1	SUBPANEL, front
	386-2023-01	B040000		1	SUBPANEL, front
	- - - - -			-	mounting hardware: (not included w/subpanel)
-110	213-0192-00			8	SCREW, thread forming, 6-32 x 0.50 inch, Fil HS
-111	119-0338-00 <sup>1</sup>			1	HYBRID CIRCUIT ASSEMBLY (A20)
	- - - - -			-	mounting hardware: (not included w/hybrid
	- - - - -			-	circuit assembly)
-112	211-0008-00			1	SCREW, 4-40 x 0.25 inch, PHS
-113	211-0088-00			2	SCREW, 2-56 x 0.281 inch, 82° csk, FHS
-114	119-0331-00 <sup>1</sup>			1	DIFFERENTIAL ASSEMBLY (A1)
-115	214-1061-00			1	SPRING, flat, sliding ground
-116	119-0289-00 <sup>1</sup>			1	OSCILLATOR ASSEMBLY, 2-4 GHz (A30)
	- - - - -			-	mounting hardware: (not included w/oscillator
	- - - - -			-	assembly)
-117	210-0586-00			2	NUT, keps, 4-40 x 0.25 inch
-118	346-0001-02			1	STRAP, retaining
-119	214-1622-00			1	HEATSINK, oscillator
	- - - - -			-	mounting hardware: (not included w/heatsink)
-120	211-0504-00			2	SCREW, 6-32 x 0.25 inch, PHS
-121	210-0811-00			2	WASHER, fiber
-122	386-2039-00			1	SUPPORT, oscillator
	- - - - -			-	mounting hardware: (not included w/support)
-123	211-0008-00			2	SCREW, 4-40 x 0.25 inch, PHS
-124	211-0038-00			1	SCREW, 4-40 x 0.312 inch, 100° csk, FHS
-125	210-0586-00			1	NUT, keps, 4-40 x 0.25 inch

1

See page 9-1 for repair and replacement program information.



Mechanical Parts List-7L12

FIGURE 1

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
1-126	200-1359-00			1	COVER, circuit board, plastic
-127	337-1564-00			1	SHILED, electrical, function IF top
	- - - - -			-	mounting hardware: (not included w/shield)
-128	211-0007-00			4	SCREW, 4-40 x 0.188 inch, PHS
-129	337-1562-00			1	SHIELD, electrical, cal. top
	- - - - -			-	mounting hardware: (not included w/shield)
-130	211-0007-00			2	SCREW, 4-40 x 0.188 inch, PHX
-131	- - - - -			1	CIRCUIT BOARD ASSEMBLY--FUNCTION IF (See
	- - - - -			-	A1300 electrical list)
	- - - - -			-	mounting hardware: (not included w/circuit
	- - - - -			-	board assembly)
-132	211-0116-00			2	SCREW, sems, 4-40 x 0.312 inch, PHB
-133	210-0586-00			2	NUT, keps, 4-40 x 0.25 inch
-134	672-0037-00			1	CIRCUIT BOARD ASSEMBLY--DISPLAY MODE (A130)
	- - - - -			-	mounting hardware: (not included w/circuit
	- - - - -			-	board assembly)
-135	210-0586-00			2	NUT, keps, 4-40 x 0.25 inch
-136	361-0046-00			2	SPACER, 4-40 x 0.50 inch long
-137	343-0013-00			1	CLAMP, cable, 0.375 inch diameter
	- - - - -			-	mounting hardware: (not included w/clamp)
-138	210-0586-00			1	NUT, keps, 4-40 x 0.25 inch
-139	210-0863-00			1	WASHER, D-shape, 0.191 ID x 0.515 inch
-140	386-2225-00			1	SUPPORT, circuit board
	- - - - -			-	mounting hardware: (not included w/support)
-141	211-0008-00			1	SCREW, 4-40 x 0.25 inch, PHS
-142	337-1593-00			1	SHIELD ASSEMBLY
	- - - - -			-	mounting hardware: (not included w/shield assy)
-143	211-0007-00			2	SCREW, 4-40 x 0.188 inch, PHS
-144	343-0013-00			1	CLAMP, cable, 0.375 inch diameter
-145	210-0863-00			1	WASHER, D-shape, 0.191 ID x 0.515 inch OD
-146	129-0338-00			2	POST, hex. stud, 4-40 x 0.188 inch
-147	337-1594-00			1	SHIELD, electrical
	- - - - -			-	mounting hardware: (not included w/shield)
-148	211-0007-00			2	SCREW, 4-40 x 0.188 inch, PHS
-149	129-0338-00			2	POST, hex. stud, 4-40 x 0.188 inch

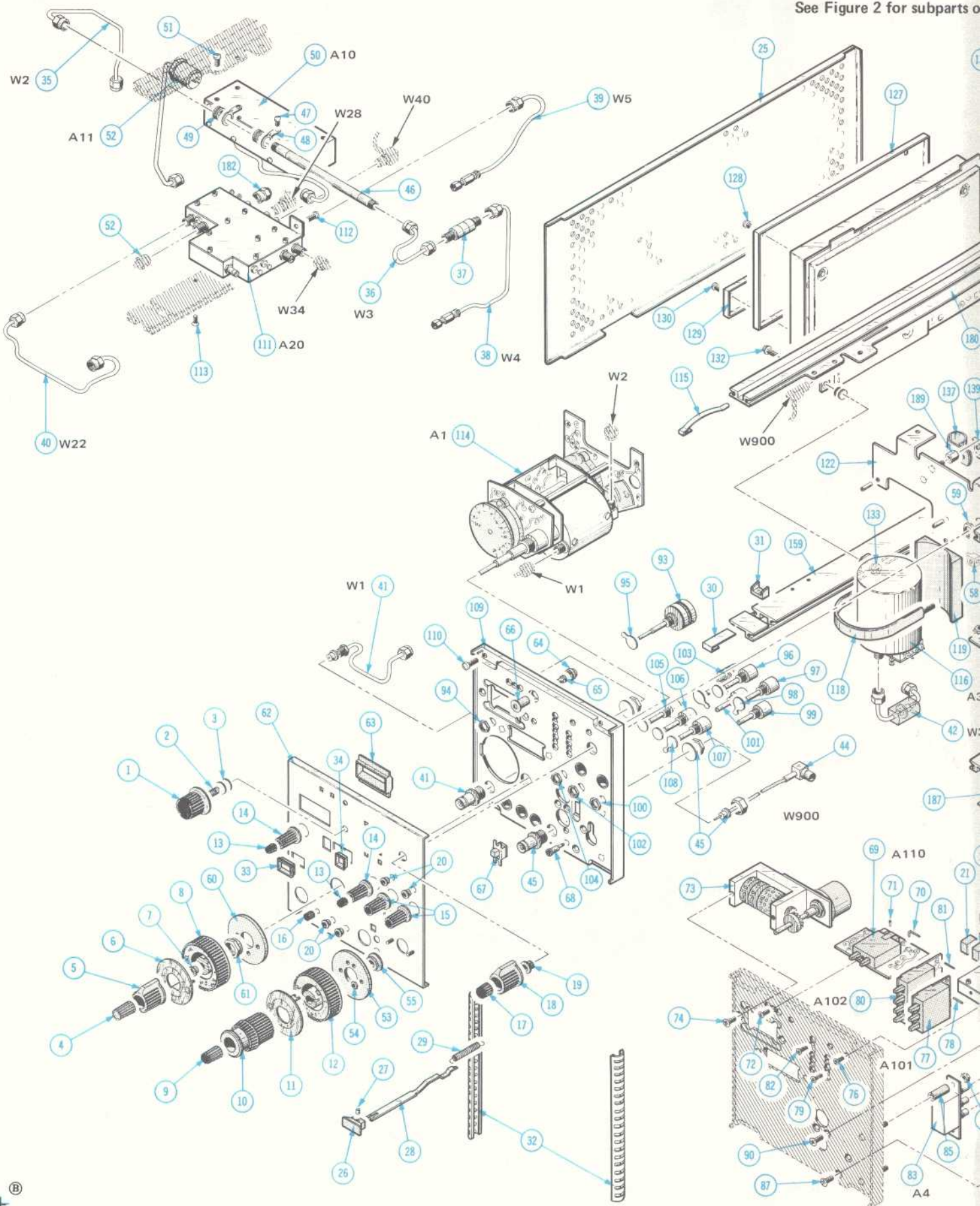
## FIGURE 1

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
1-150	337-1579-00	-	-	1	SHIELD, electrical, variable resistor, top left
	-	-	-	-	mounting hardware: (not included w/shield)
-151	211-0007-00			4	SCREW, 4-40 x 0.188 inch, PHS
-152	129-0338-00			4	POST, hex. stud, 4-40 x 0.188 inch
-153	337-1578-00	-	-	1	SHIELD, electrical, variable resistor, top right
	-	-	-	-	mounting hardware: (not included w/shield)
-154	211-0007-00			4	SCREW, 4-40 x 0.188 inch, PHS
-155	129-0338-00			4	POST, hex. stud, 4-40 x 0.188 inch
-156	386-2048-00	-	-	1	PANEL, rear
	-	-	-	-	mounting hardware: (not included w/panel)
-157	213-0192-00			8	SCREW, thread forming, 6-32 x 0.50 inch, Fil HS
-158	211-0008-00			1	SCREW, 4-40 x 0.25 inch, PHS
-159	426-0778-00			1	FRAME SECTION, lower left
-160	426-0776-00			1	FRAME SECTION, lower right
-161	351-0284-00			1	GUIDE, rail
	-	-	-	-	mounting hardware: (not included w/guide)
-162	213-0192-00			2	SCREW, thread forming, 6-32 x 0.50 inch, Fil HS
-163	351-0217-01			1	GUIDE, circuit board, plastic
	-	-	-	-	mounting hardware: (not included w/guide)
-164	211-0504-00			4	SCREW, 6-32 x 0.25 inch, PHS
-165	220-0557-00			4	NUT, sleeve, 6-32 x 0.344 inch
-166	351-0217-01			1	GUIDE, circuit board, plastic
	-	-	-	-	mounting hardware: (not included w/guide)
-167	211-0504-00			3	SCREW, 6-32 x 0.25 inch, PHS
-168	211-0578-00			1	SCREW, 6-32 x 0.438 inch, PHS
-169	361-0326-00			1	SPACER
-170	220-0556-00			4	NUT, sleeve, 6-32 x 0.344 inch
-171	179-1740-00			1	WIRING HARNESS, sweep
	-	-	-	-	wiring harness includes:
-172	131-0707-00			78	CONNECTOR, terminal
	131-0708-00			3	CONNECTOR, terminal
-173	352-0169-00			4	HOLDER, terminal connector, 2 wire (black)
-174	352-0161-00			7	HOLDER, terminal connector, 3 wire (black)
	352-0162-00			4	HOLDER, terminal connector, 4 wire (black)
-175	352-0163-00			1	HOLDER, terminal connector, 5 wire (black)
	352-0165-00			1	HOLDER, terminal connector, 7 wire (black)
-176	352-0166-00			1	HOLDER, terminal connector, 8 wire (black)
-177	352-0168-00			1	HOLDER, terminal connector, 10 wire (black)
	352-0171-00			5	HOLDER, terminal connector, 1 wire (black)

FIGURE 1

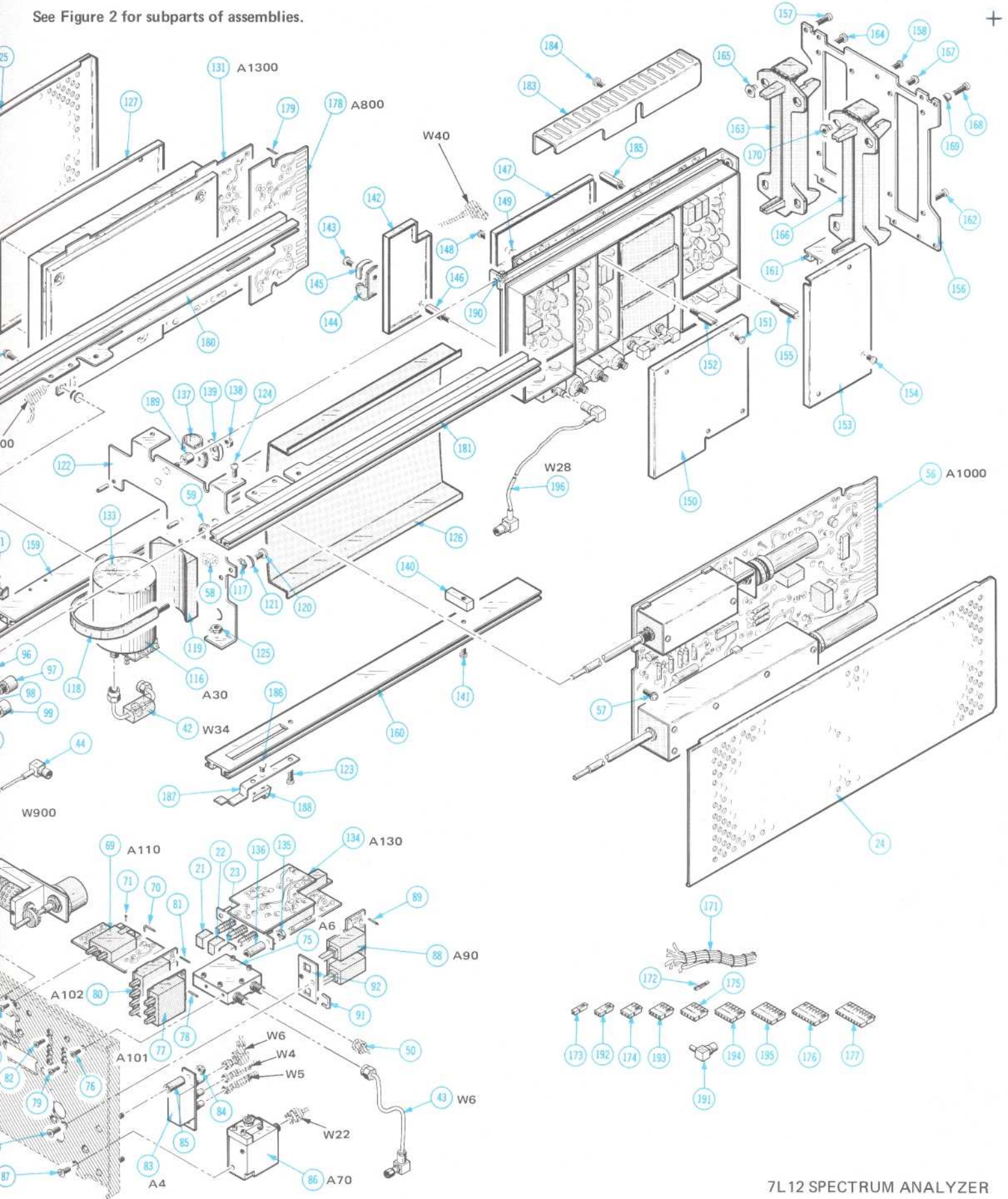
Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q † y	Description
		Eff	Disc		
1-178	- - - - -			1	CIRCUIT BOARD ASSEMBLY--FUNCTION IF CONNECTOR (See A800 electrical list) circuit board assembly includes:
-179	131-0608-00			28	TERMINAL, pin, 0.365 inch long
-180	426-0777-00			1	FRAME SECTION, upper left
-181	426-0779-00			1	FRAME SECTION, upper right
-182	015-1025-00			1	TERMINATION
-183	337-1723-00			1	SHIELD mounting hardware: (not included w/shield)
-184	211-0008-00			1	SCREW, 4-40 x 0.25 inch, PHS
-185	129-0354-00			1	POST, hex. stud, 4-40 x 0.188 x 0.54 inch long
	105-0404-01			1	CATCH, latch catch includes:
-186	211-0008-00			1	SCREW, 4-40 x 0.25 inch, PHS
	211-0005-00			1	SCREW, 4-40 x 0.125 inch, PHS
-187	214-1792-00			1	SPRING, latch
-188	105-0404-00			1	CATCH, latch, safety
-189	361-0126-00			1	SPACER, sleeve, 0.25 inch long
-190	210-0586-00			1	NUT, keps, 4-40 x 0.25 inch
	179-1742-00	B010100	B039999	1	WIRING HARNESS, Phase lock
	179-1742-01	B040000		1	WIRING HARNESS, Phase lock wiring harness includes:
	131-0707-00	B010100	B039999	79	CONNECTOR, terminal
	131-0707-00	B040000		81	CONNECTOR, terminal
	131-0708-00			8	CONNECTOR, terminal
	131-0155-00			1	CONNECTOR, coaxial
	175-1373-00			1	CABLE ASSEMBLY, RF (W40) cable assembly includes:
-191	131-0375-00			2	CONNECTOR, right angle
	352-0171-00			3	HOLDER, terminal connector, 1 wire (black)
-192	352-0169-00			8	HOLDER, terminal connector, 2 wire (black)
	352-0161-00	B010100	B039999	2	HOLDER, terminal connector, 3 wire (black)
	352-0161-00	B040000		1	HOLDER, terminal connector, 3 wire (black)
-193	352-0162-00	B010100	B039999	1	HOLDER, terminal connector, 4 wire (black)
	352-0162-00	B040000		2	HOLDER, terminal connector, 4 wire (black)
	352-0163-00			2	HOLDER, terminal connector, 5 wire (black)
-194	352-0164-00			4	HOLDER, terminal connector, 6 wire (black)
-195	352-0165-00			1	HOLDER, terminal connector, 7 wire (black)
	352-0167-00			2	HOLDER, terminal connector, 9 wire (black)
-196	175-1371-00			1	CABLE ASSEMBLY, RF (W28) cable assembly includes:
	131-0375-00			2	CONNECTOR, right angle

See Figure 2 for subparts o





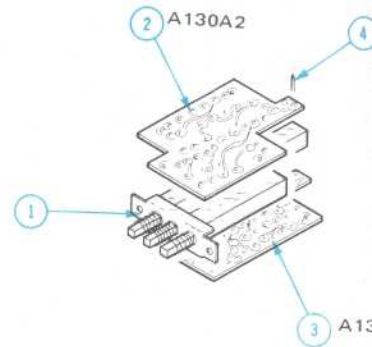
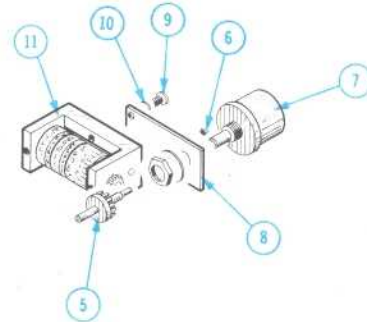
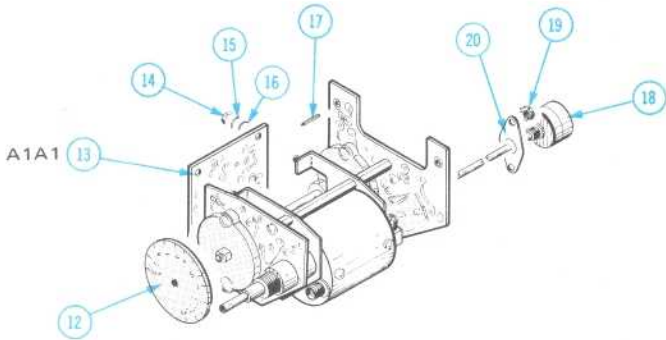
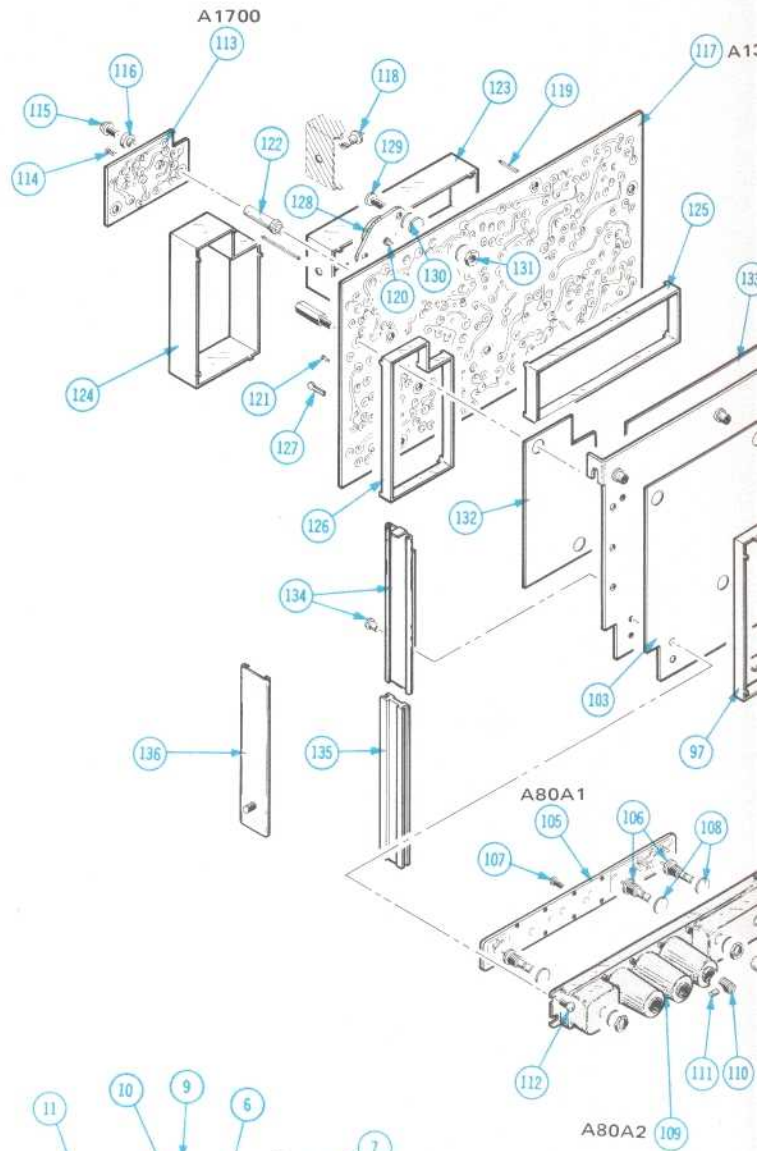
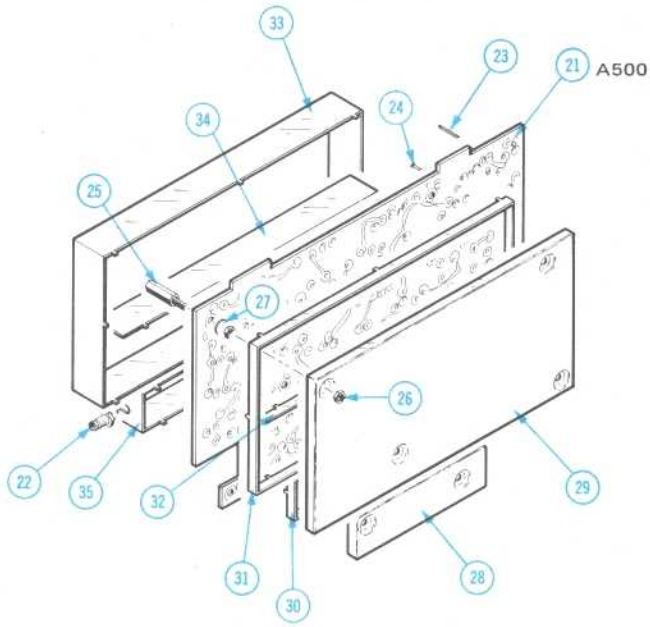
See Figure 2 for subparts of assemblies.



7L12 SPECTRUM ANALYZER



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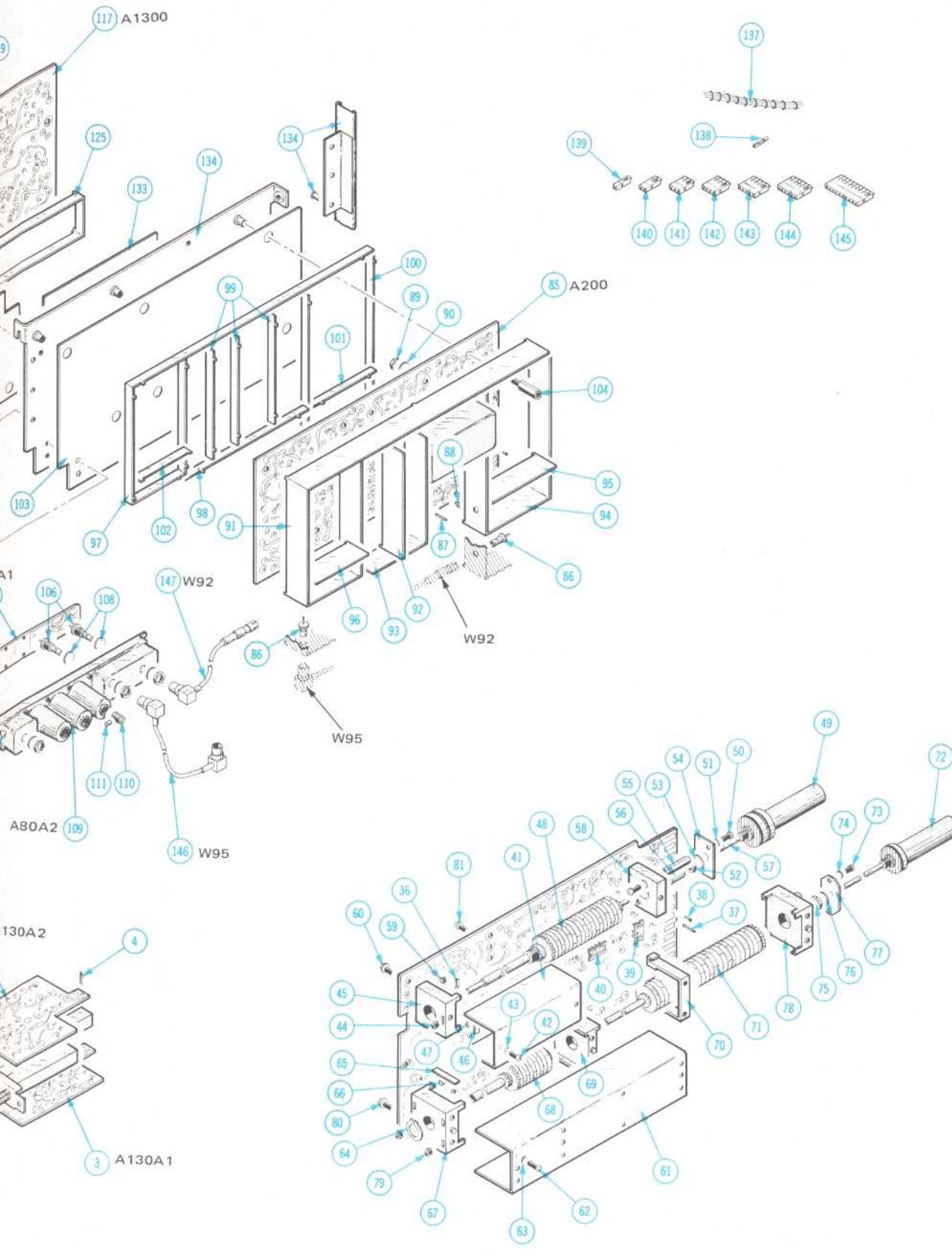


FIGURE 2

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q	Description
		Eff	Disc		
					1 2 3 4 5
2-	672-0037-00			1	CIRCUIT BOARD ASSEMBLY--DISPLAY MODE (A130)
	- - - - -			-	circuit board assembly includes:
-1	260-1360-00			1	SWITCH, push (S130)
-2	- - - - -			1	CIRCUIT BOARD ASSEMBLY--DISPLAY MODE RESISTOR
	- - - - -			-	(See A130A2)
-3	- - - - -			1	CIRCUIT BOARD ASSEMBLY--DISPLAY MODE SW
	- - - - -			-	CONNECTOR (See A130A1 electrical list)
	- - - - -			-	circuit board assembly includes:
-4	131-0589-00			13	TERMINAL, pin, 0.46 inch long
	131-0592-00			18	TERMINAL, pin
	131-0608-00			2	TERMINAL, pin, 0.365 inch long
	119-0335-00			1	COUNTER ASSEMBLY
	- - - - -			-	counter assembly includes:
-5	384-1095-00			1	SHAFT, extension, w/gear
	- - - - -			-	mounting hardware: (not included w/shaft)
-6	213-0048-00			1	SETSCREW, 5-40 x 0.125 inch, HSS
-7	- - - - -			1	RESISTOR, variable (See R124 electrical list)
-8	386-2021-00			1	PLATE, mounting, counter assembly
	- - - - -			-	mounting hardware: (not included w/plate)
-9	211-0098-00			2	SCREW, 4-40 x 0.375 inch, CHS
-10	210-0054-00			2	WASHER, lock, split, 0.188 ID x 0.212 inch OD
-11	331-0283-01			1	COUNTER, w/gear
	119-0331-00			1	DIFFERENTIAL ASSEMBLY (See A1 electrical list)
	- - - - -			-	differential assembly includes:
-12	331-0288-00			1	DIAL, panel
-13	- - - - -			1	CIRCUIT BOARD ASSEMBLY--REFERENCE LEVEL READOUT
	- - - - -			-	(See A1A1)
	- - - - -			-	mounting hardware: (not included w/circuit board assembly)
-14	210-0405-00			4	NUT, hex., 2-56 x 0.188 inch
-15	210-0001-00			4	WASHER, lock, internal, 0.092 ID x 0.18 inch OD
-16	210-1008-00			4	WASHER, flat, 0.09 ID x 0.188 inch OD
-17	131-0608-00			32	TERMINAL, pin, 0.365 inch long
-18	- - - - -			1	RESISTOR, variable (See R82 & S82 electrical list)
	- - - - -			-	mounting hardware: (not included w/resistor)
-19	210-0586-00			2	NUT, keps, 4-40 x 0.25 inch
-20	386-2029-00			1	PLATE, variable resistor
-21	- - - - -			1	CIRCUIT BOARD ASSEMBLY--FUNCTION IF (See A500 electrical list)
	- - - - -			-	circuit board assembly includes:
-22	131-0391-01			1	CONNECTOR, receptacle
-23	131-0608-00	B010100	B039999	36	TERMINAL, pin, 0.365 inch long
	131-0608-00	B040000		37	TERMINAL, pin, 0.365 inch long
-24	136-0252-04			118	SOCKET, pin connector
	136-0252-01			2	SOCKET, pin connector
-25	129-0354-00			6	POST, stud, 4-40 x 0.188 inch
	- - - - -			-	mounting hardware for each: (not included w/post)
-26	210-0406-00			2	NUT, hex., 4-40 x 0.188 inch
-27	210-1002-00			1	WASHER, flat, 0.125 ID x 0.25 inch OD
-28	337-1563-00			1	SHIELD, electrical, calibrate, bottom cover
-29	337-1568-00			1	SHIELD, electrical, function IF, bottom cover
-30	337-1556-00			1	SHIELD, electrical, calibrate, bottom
-31	337-1570-00			1	SHIELD, electrical, function IF, bottom wraparound

FIGURE 2

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
2-32	337-1569-00			1	SHIELD, electrical, function IF, bottom center
-33	337-1566-00			1	SHIELD, electrical, function IF, top wraparound
-34	337-1565-00			1	SHIELD, electrical, function IF, top center
-35	337-1557-00			1	SHIELD, electrical, calibrate, top
-	-	-	-	1	CIRCUIT BOARD ASSEMBLY--SWEEP DISPERSION (See A1000)
-	-	-	-	-	circuit board assembly includes:
-36	131-0604-00			70	CONTACT, electrical (See maintenance section for repair)
-37	131-0608-00			66	TERMINAL, pin, 0.365 inch long
-38	136-0252-04			113	SOCKET, pin connector
-39	136-0336-00			1	SOCKET, relay, 5 pin
-40	136-0337-00			1	SOCKET, relay, 8 pin
-	105-0289-00			1	ACTUATOR ASSEMBLY--TIME/DIV
-	-	-	-	-	actuator assembly includes:
-41	200-0952-01			1	COVER
-	-	-	-	-	mounting hardware: (not included w/cover)
-42	211-0022-00			2	SCREW, 2-56 x 0.188 inch, PHS
-43	210-0001-00			2	WASHER, lock, internal, 0.092 ID x 0.18 inch OD
-44	210-0405-00			2	NUT, hex., 2-56 x 0.188 inch
-	354-0219-00			1	RING, retaining
-45	401-0054-00			1	BEARING, front
-46	214-1139-00 <sup>1</sup>			-	SPRING, flat, gold
-	214-1139-02 <sup>1</sup>			-	SPRING, flat, green
-	214-1139-03 <sup>1</sup>			-	SPRING, flat, red
-47	214-1127-00			1	ROLLER, detent
-48	105-0290-00			1	DRUM, time/div
-49	-	-	-	1	RESISTOR, variable
-	-	-	-	-	mounting hardware: (not included w/resistor)
-50	211-0022-00			4	SCREW, 2-56 x 0.188 inch, PHS
-51	210-0001-00			4	WASHER, lock, internal, 0.92 ID x 0.18 inch OD
-52	210-0583-00			1	NUT, hex., 0.25-32 x 0.312 inch
-53	210-0046-00			1	WASHER, lock, internal, 0.261 ID x 0.40 inch OD
-	210-0905-00			1	WASHER, flat, 0.256 ID x 0.438 inch OD
-54	386-2095-00			1	PLATE, mounting
-55	129-0328-00			2	POST, 2-56 x 0.156 x 0.812 inch long
-56	376-0039-00			1	COUPLING, shaft
-	-	-	-	-	coupling includes:
-	213-0075-00			2	SETSCREW, 4-40 x 0.094 inch, HHS
-57	384-1115-00			1	SHAFT, extension, 7.60 inches long
-58	401-0056-00			1	BEARING, rear
-59	210-0406-00			4	NUT, hex., 4-40 x 0.188 inch
-	-	-	-	-	mounting hardware: (not included w/actuator assy)
-60	211-0116-00			4	SCREW, sems, 4-40 x 0.312 inch, PHB
-	105-0288-00	B010100	B039999	1	ACTUATOR ASSEMBLY--DISPERSION/RESOLUTION
-	105-0288-01	B040000		1	ACTUATOR ASSEMBLY--DISPERSION/RESOLUTION
-	-	-	-	-	actuator assembly includes:
-61	200-1289-00			1	COVER
-	-	-	-	-	mounting hardware: (not included w/cover)
-62	211-0008-00			6	SCREW, 4-40 x 0.25 inch, PHS
-63	210-0004-00			6	WASHER, lock, internal, 0.12 ID x 0.26 inch OD
-	211-0022-00			2	SCREW, 2-56 x 0.188 inch, PHS
-	210-0001-00			2	WASHER, lock, internal, 0.092 ID x 0.18 inch OD

1  
Replace only with part bearing the same color code as the original part in your instrument.

FIGURE 2

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
2-64	354-0391-00			2	RING, retaining
-65	214-1139-00 <sup>1</sup>			-	SPRING, flat, gold
	214-1139-02 <sup>1</sup>			-	SPRING, flat, green
	214-1139-03 <sup>1</sup>			-	SPRING, flat, red
-66	214-1127-00			4	ROLLER, detent
-67	401-0081-02			1	BEARING, front
-68	105-0291-00	B010100	B039999	1	DRUM, resolution
	105-0291-01	B040000		1	DRUM, resolution
-69	401-0115-00			1	BEARING, center
-70	407-0926-00			1	BRACKET, cover
-71	105-0292-00	B010100	B039999	1	DRUM, frequency span
	105-0292-01	B040000		1	DRUM, frequency span
-72	- - - - -			1	RESISTOR, variable
	- - - - -			-	mounting hardware: (not included w/resistor)
-73	211-0022-00			2	SCREW, 2-56 x 0.188 inch, PHS
-74	210-0001-00			2	WASHER, lock, internal, 0.092 ID x 0.18 inch OD
-75	210-0583-00			1	NUT, hex., 0.25-32 x 0.312 inch
-76	210-0046-00			1	WASHER, lock, internal, 0.261 ID x 0.40 inch OD
-77	386-1792-00			1	PLATE, mounting
	210-0905-00			1	WASHER, flat, 0.256 ID x 0.438 inch OD
-78	401-0081-01			1	BEARING, front, w/inserts
	376-0039-00			1	COUPLING, shaft
	- - - - -			-	coupling includes:
	213-0075-00			2	SETSCREW, 4-40 x 0.094 inch, HSS
	384-1116-00			1	SHAFT, extension, 10.125 inches long
-79	210-0406-00			12	NUT, hex., 4-40 x 0.188 inch
	- - - - -			-	mounting hardware: (not included w/actuator assy)
-80	211-0116-00			6	SCREW, sems, 4-40 x 0.312 inch, PHB
-81	211-0182-00			2	SCREW, sems, 2-56 x 0.312 inch, PHB
	119-0332-00			1	TUNED CAVITY, 2nd LO (A70)
	- - - - -			-	tuned cavity includes:
-82	213-0288-00			1	SCREW, tuning
-83	213-0214-00			1	SCREW, 2-56 x 0.375 inch, CHS
-84	119-0105-02			1	VARACTOR ASSEMBLY (A70A1)
-85	- - - - -			1	CIRCUIT BOARD ASSEMBLY--RESOLUTION (See A200 electrical list)
	- - - - -			-	circuit board assembly includes:
-86	131-0391-01			2	CONNECTOR, receptacle
-87	131-0608-00			22	TERMINAL, pin, 0.365 inch long
	136-0234-00			2	RECEPTACLE, electrical
-88	136-0252-01			47	SOCKET, pin connector
	136-0252-04			45	SOCKET, pin connector
-89	210-0586-00			6	NUT, keps, 4-40 x 0.25 inch
-90	210-1092-00			6	WASHER, flat, 0.147 ID x 0.312 inch OD
-91	337-1572-00			1	SHIELD, electrical, top 1
-92	337-1573-00			1	SHIELD, electrical, top 2
-93	337-1574-00			1	SHIELD, electrical, top 3
-94	337-1575-00			1	SHIELD, electrical, top 4
-95	337-1576-00			1	SHIELD, electrical, top 5

<sup>1</sup> Replace only with part bearing the same color code as the original part in your instrument.



FIGURE 2

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q † y	Description
		Eff	Disc		
2-96	337-1588-00			1	SHIELD, electrical, top 6
-97	337-1580-00			1	SHIELD, electrical, bottom 1
-98	337-1581-00			1	SHIELD, electrical, bottom 2
-99	337-1582-00			3	SHIELD, electrical, bottom 3
-100	337-1583-00			1	SHIELD, electrical, bottom 4
-101	337-1584-00			1	SHIELD, electrical, bottom 5
-102	337-1590-00			1	SHIELD, electrical, bottom 6
-103	348-0293-00			1	SHIELDING GASKET, electrical, resolution
-104	129-0338-00			12	POST, hex. stud, 4-40 x 0.188 inch
	119-0334-00			1	IF MODULE ASSEMBLY 105 MHz (A80)
	- - - - -			-	IF module assembly includes:
-105	- - - - -			1	CIRCUIT BOARD ASSEMBLY--105 MHz IF (See
	- - - - -			-	A80A1 electrical list)
	- - - - -			-	circuit board assembly includes:
-106	131-0156-00			3	CONNECTOR, coaxial
	- - - - -			-	mounting hardware: (not included w/
	- - - - -			-	circuit board assembly)
-107	211-0125-00			8	SCREW, 1-72 x 0.25 inch, PHS
-108	210-0010-00			3	WASHER, lock, internal, 0.20 ID x 0.376
	- - - - -			-	inch OD
-109	205-0152-01			1	SHELL ASSEMBLY, tuned cavity (A80A2)
	- - - - -			-	shell assembly includes:
	205-0152-00			1	SHELL, tuned cavity
-110	213-0269-00			3	SCREW, tuning, 0.25-40 x 0.312 inch long
-111	377-0376-00			3	INSERT, anti-rotation, tuning screw
	- - - - -			-	mounting hardware: (not included w/IF
	- - - - -			-	module assembly)
-112	211-0069-00			4	SCREW, 2-56 x 0.125 inch, PHS
-113	- - - - -			1	CIRCUIT BOARD ASSEMBLY--SWEEP SHAPER (See
	- - - - -			-	A1700 electrical list)
	- - - - -			-	circuit board assembly includes:
-114	136-0263-03			3	SOCKET, pin terminal
-115	211-0116-00			2	SCREW, sems, 4-40 x 0.312 inch, PHB
-116	361-0301-00			2	SPACER, sleeve, 4-40 x 0.105 inch high
-117	- - - - -			1	CIRCUIT BOARD ASSEMBLY--PHASE LOCK (See
	- - - - -			-	A1300 electrical list)
	- - - - -			-	circuit board assembly includes:
-118	131-0391-01			1	CONNECTOR, receptacle
	131-0592-00			3	TERMINAL, pin, 0.885 inch long
-119	131-0608-00			43	TERMINAL, pin, 0.365 inch long
-120	136-0234-00			2	RECEPTACLE, electrical
-121	136-0252-04			185	SOCKET, pin connector
	136-0337-00			2	SOCKET, relay, 8 pin
-122	351-0184-00			2	GUIDE-POST, lock, 0.58 inch long
-123	337-1587-00			1	SHIELD, electrical, top 1
-124	337-1586-00			1	SHIELD, electrical, top 2
-125	337-1591-00			1	SHIELD, electrical, lower left
-126	337-1592-00			1	SHIELD, electrical, lower right
-127	214-0579-00			5	TERMINAL, test point

FIGURE 2

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q † y	Description
		Eff	Disc		
2-128	- - - - -	-	-	1	TRANSISTOR
	- - - - -	-	-	-	mounting hardware: (not included w/transistor)
-129	211-0507-00			2	SCREW, 6-32 x 0.312 inch, PHS
-130	210-1092-00			4	WASHER, flat, 0.147 ID x 0.312 inch OD
-131	210-0407-00			2	NUT, hex., 6-32 x 0.25 inch
-132	348-0311-00			1	SHIELDING GASKET, electrical, right
-133	348-0294-00			1	SHIELDING GASKET, electrical, left
-134	441-1018-00			1	CHASSIS
	- - - - -	-	-	-	chassis includes:
	210-0659-00			4	EYELET
	351-0345-00			1	SLIDE, guide, rear
	351-0338-00			1	SLIDE, guide, front
-135	351-0339-00			2	SLIDE, guide, intermediate
-136	351-0340-00			2	GUIDE, slide
-137	179-1743-00			1	WIRING HARNESS, resolution
	- - - - -	-	-	-	wiring harness includes:
-138	131-0707-00			23	CONNECTOR, terminal
	131-0708-00			2	CONNECTOR, terminal
-139	352-0171-00			2	HOLDER, terminal connector, 1 wire (black)
-140	352-0169-00			3	HOLDER, terminal connector, 2 wire (black)
-141	352-0161-00			1	HOLDER, terminal connector, 3 wire (black)
-142	352-0162-00			1	HOLDER, terminal connector, 4 wire (black)
-143	352-0163-00			1	HOLDER, terminal connector, 5 wire (black)
-144	352-0164-00			1	HOLDER, terminal connector, 6 wire (black)
-145	352-0168-00			2	HOLDER, terminal connector, 10 wire (black)
-146	175-1372-00			1	CABLE ASSEMBLY, RF (W95)
	- - - - -	-	-	-	cable assembly includes:
	131-0375-00			2	CONNECTOR, right angle
-147	175-1374-00			1	CABLE ASSEMBLY, RF (W92)
	- - - - -	-	-	-	cable assembly includes:
	131-0155-00			1	CONNECTOR
	131-0375-00			1	CONNECTOR, right angle

## OPTIONAL ACCESSORIES

Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Q					Description
				1	2	3	4	5	
015-0221-00			1						COUPLING CAP, BNC connector, each end
011-0112-00			1						IMPEDANCE MATCHING NETWORK, 75 $\Omega$ to 50 $\Omega$
011-0057-00			1						IMPEDANCE MATCHING NETWORK, 50 $\Omega$ to 75 $\Omega$
011-0118-00 <sup>1</sup>			1						IMPEDANCE MATCHING NETWORK, 75 $\Omega$ to 50 $\Omega$ , 11.25 dB loss

### OPTIONS TO 7000-SERIES OSCILLOSCOPES

CRT with P7 phosphor and time domain graticule. The external graticule for spectrum analyses (part of standard accessories) should be used.

CRT with P7 phosphor and an internal spectrum analyzer graticule (designated P7SA). This is recommended when the oscilloscope mainframe is to be used exclusively with spectrum analyzer systems.

<sup>1</sup>This attenuator is used to convert dBm to dBmV. Add 60 dB to that indicated.

STANDARD ACCESSORIES

+

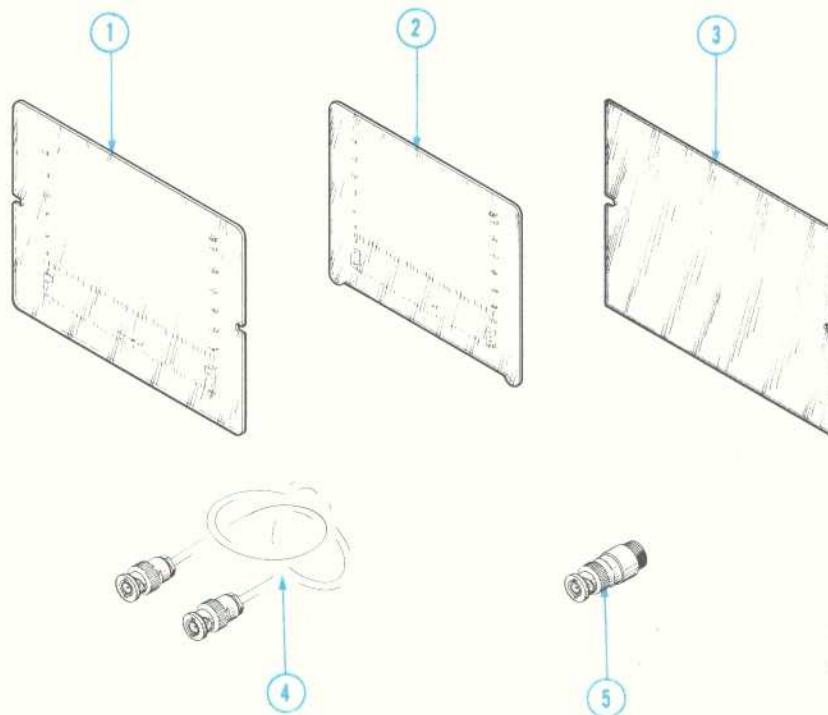


Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Qty	Q					Description
		Eff	Disc		1	2	3	4	5	
3-1	337-1439-01			1						SHIELD, implosion
-2	337-1159-02			1						SHIELD, implosion
-3	378-0684-01			1						FILTER, light, CRT, amber
-4	012-0113-00			1						CABLE ASSEMBLY, RF, male BNC connector both ends
-5	103-0058-00			1						ADAPTER, connector, BNC to M
	070-1298-01			1						MANUAL, instruction (not shown)



# REPACKAGING

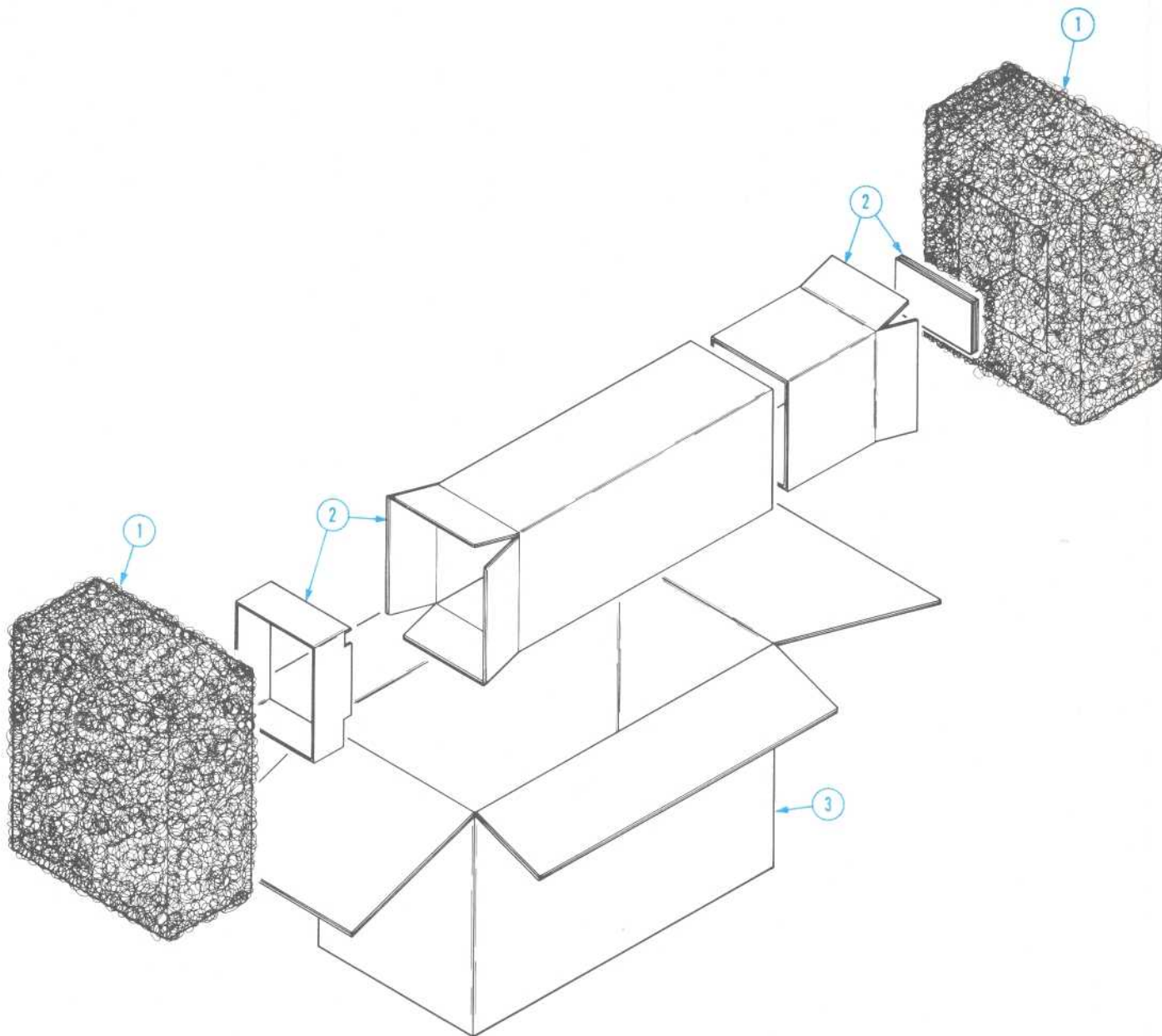


Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Qty	Description
		Eff	Disc		
4-	065-0187-00			1	CARTON ASSEMBLY
-1	004-1221-00			-	carton assembly includes:
-2	004-1169-00			2	END CAP
-3	004-0651-00			1	PAD SET, 4 piece
				1	CARTON



## **MANUAL CHANGE INFORMATION**

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Sections of the manual are often printed at different times, so some of the information on the change pages may already be in your manual. Since the change information sheets are carried in the manual until ALL changes are permanently entered, some duplication may occur. If no such change pages appear in this section, your manual is correct as printed.



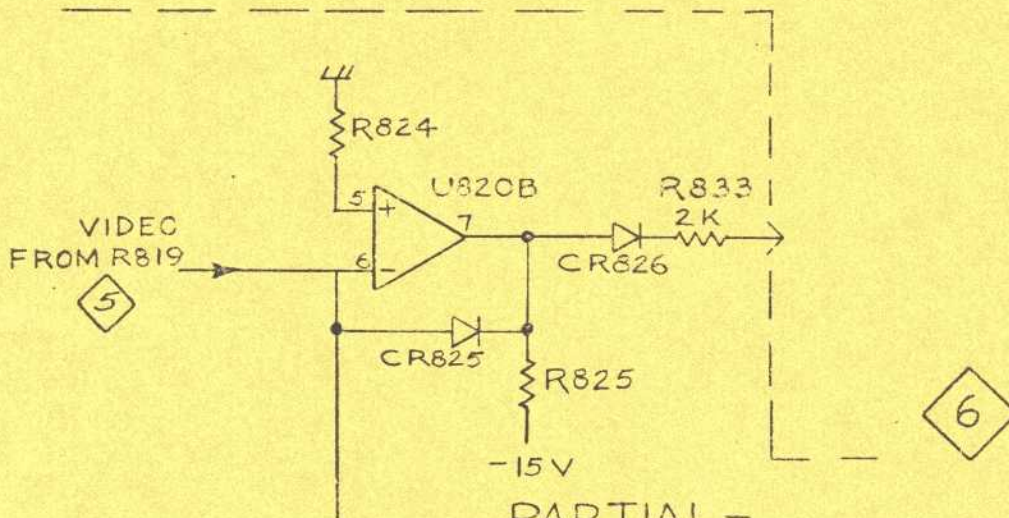
ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTION

CHANGE TO:

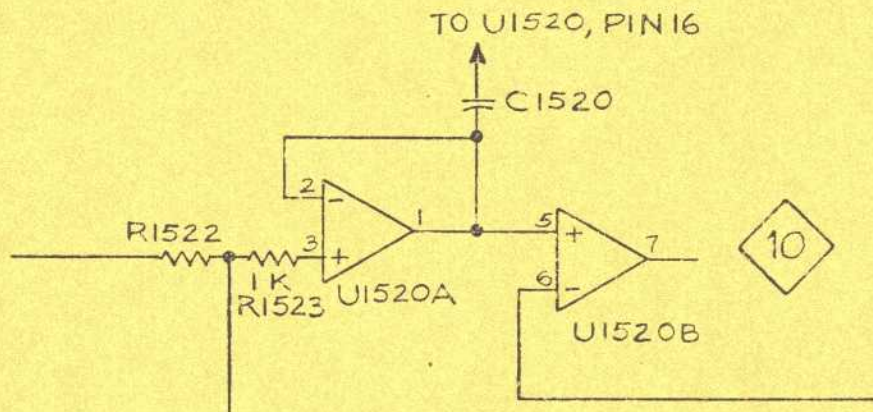
A500	670-1756-03	FUNCTION IF Circuit Board Assembly
A1300	670-1755-03	PHASE LOCK Circuit Board Assembly

ADD:

R833	315-0202-00	2 k $\Omega$ , 1/4 W, 5%
R1523	315-0102-00	1 k $\Omega$ , 1/4 W, 5%



PARTIAL-  
VIDEO-FILTERS, PROCESSOR,  
& OUTPUT



PARTIAL-  
1ST LO POWER SUPPLY  
& CALIBRATOR