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THE TEKTRONIX COOKBOOK OF STANDARD AUDIO TESTS

using the 5L4N low frequency spectrum analyzer

STANDARD AUDIO TESTS

BY

CLIFFORD SCHROCK

ACKNOWLEDGEMENTS

The author would like to thank Linley Gumm and Gordon Long for their excellent technical assistance in the preparation of this paper. In addition, I would like to thank Joyce Lekas for her editorial assistance and Jeanne Galick for the illustrations and layout.

CONTENTS

PRELIMINARY INFORMATION

Maintaining a modern High-Fidelity-Stereo system today requires much more than a "trained ear." The high specifications of receivers and amplifiers can only be maintained by performing some of the standard measurements such as:

1. Power output
2. Harmonic distortion
3. Intermodulation distortion
4. Frequency response
5. Signal-to-Noise measurements

Unfortunately, because of the available test equipment and lengthy procedures that are required to "spec" a new or repaired amplifier, it usually doesn't get done.

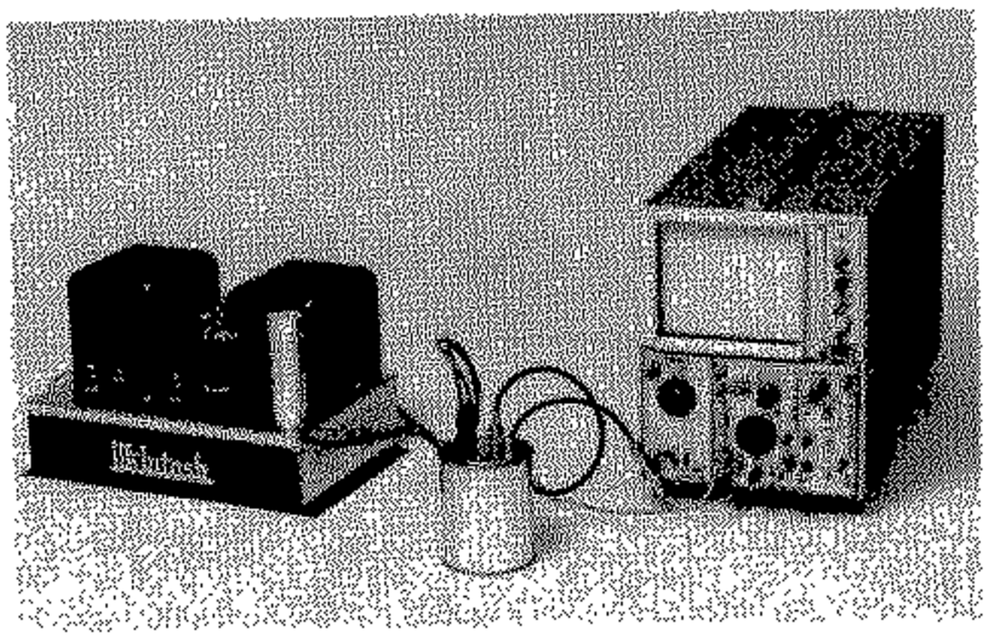

Figure 1 5L4N Low Frequency Analyzer and Mainframe with 5A15

This pamphlet describes an alternative test device and procedures that permit rapid, easy to understand, "spec'ing" and troubleshooting. The device, a Low Frequency Spectrum Analyzer, is now available, at a moderate price, to the Audio Industry. In addition, besides the standard measurements, the spectrum analyzer may be used effectively for expanding the standard tests or for special measurements such as the CCIF distortion or Bell Telephone multitone audio tests.

These descriptions are presented so that they can be followed by anyone with a technical background. Procedures apply to all the standard tests typically performed on high fidelity equipment.

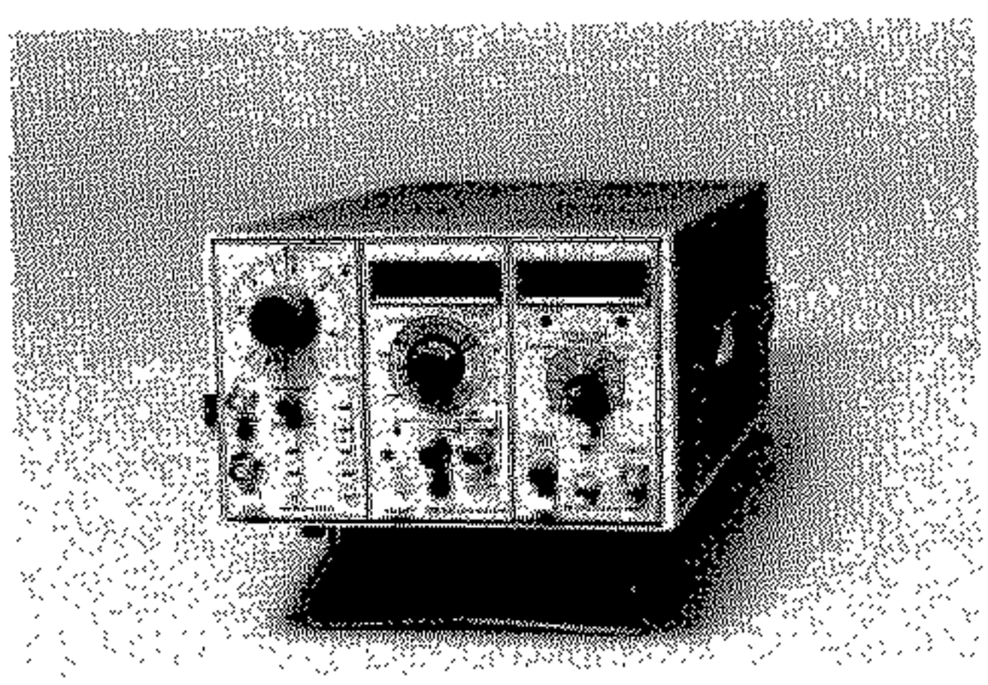

Figure 2 SG502, TM503, DM502, DC-504 Audio Test Package

Test Setups

The only major test equipment that is really required to "spec" an amplifier with our new techniques are; the Tektronix 5L4N Low Frequency Spectrum Analyzer plug-in unit with a 5100-Series mainframe, and an audio oscillator, such as the Tektronix SG502 (Figures 1 and 2).

Some complementary test equipment that may be useful would be a vertical amplifier plug-in, such as the 5A15, to be inserted beside the 5L4N so the mainframe can be used as a standard time domain oscilloscope; a digital multimeter, such as the DM502, that reads out in dB's, for troubleshooting; and a frequency counter, such as the DC-504. An attenuator with a 0 to 60 or 80 dB range can be a handy test device for audio measurements. Two kinds to consider are the variable (potentiometer) type or a step attenuator. You may want to build attenuators. Construction details are given in Figure 3 and 4 for both the step and variable types.

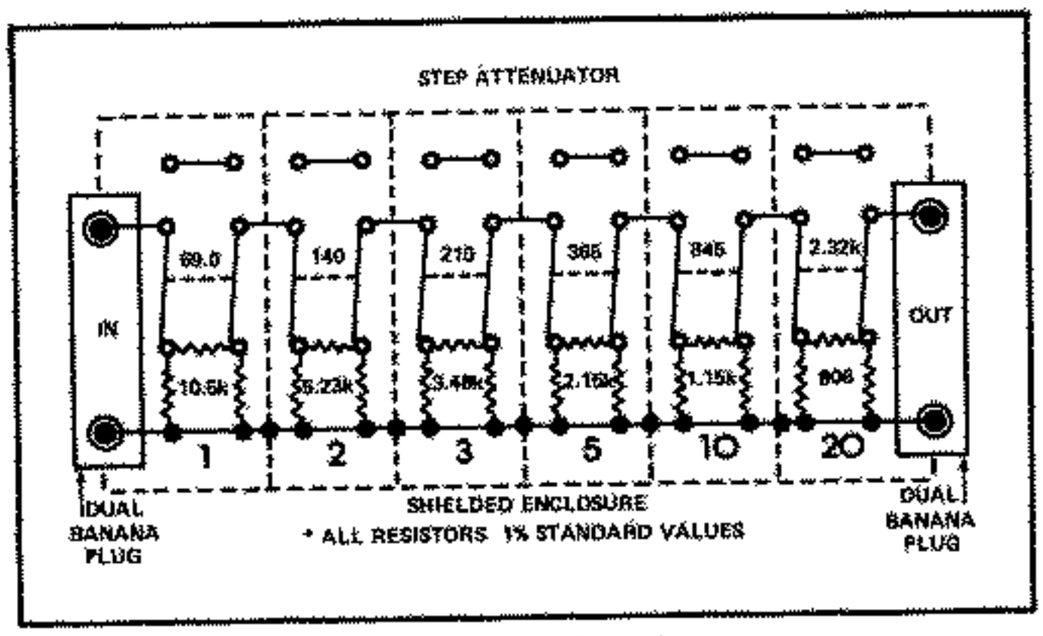

Figure 3 Construction Details for a Step Attenuator

Some complementary test equipment that may be useful would be a vertical amplifier plug-in, such as the 5A15, to be inserted beside the 5L4N so the mainframe can be used as a standard time domain oscilloscope; a digital multimeter, such as the DM502, that reads out in dB's, for troubleshooting; and a frequency counter, such as the DC-504. An attenuator with a 0 to 60 or 80 dB range can be a handy test device for audio measurements. Two kinds to consider are the variable (potentiometer) type or a step attenuator. You may want to build attenuators. Construction details are given in Figure 3 and 4 for both the step and variable types.

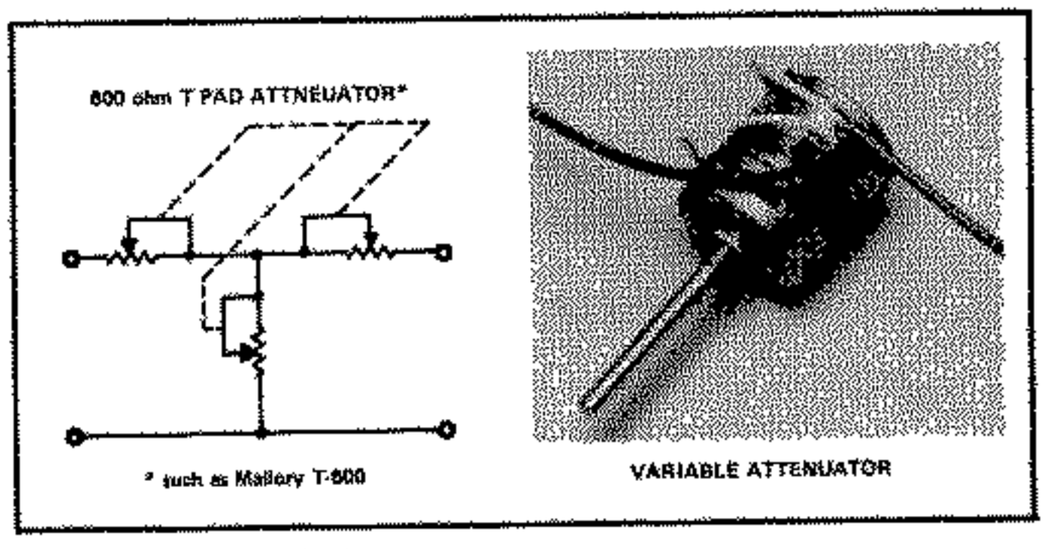

Figure 4 A Variable Attenuator

To ensure accurate measurements, certain precautions must be observed. AC power or high level RF fields from local radio or TV transmitters can interfere with the low level measurements encountered in Hi-Fi systems. The typical test setup, Figure 5, should be well shielded. Use a copper sheet for the test bench top and ground all equipment through short pieces of copper braid to the copper sheet. The use of an AC line filter on the bench plugs is also recommended. Try reversing the AC plugs on equipment to obtain minimum hum.

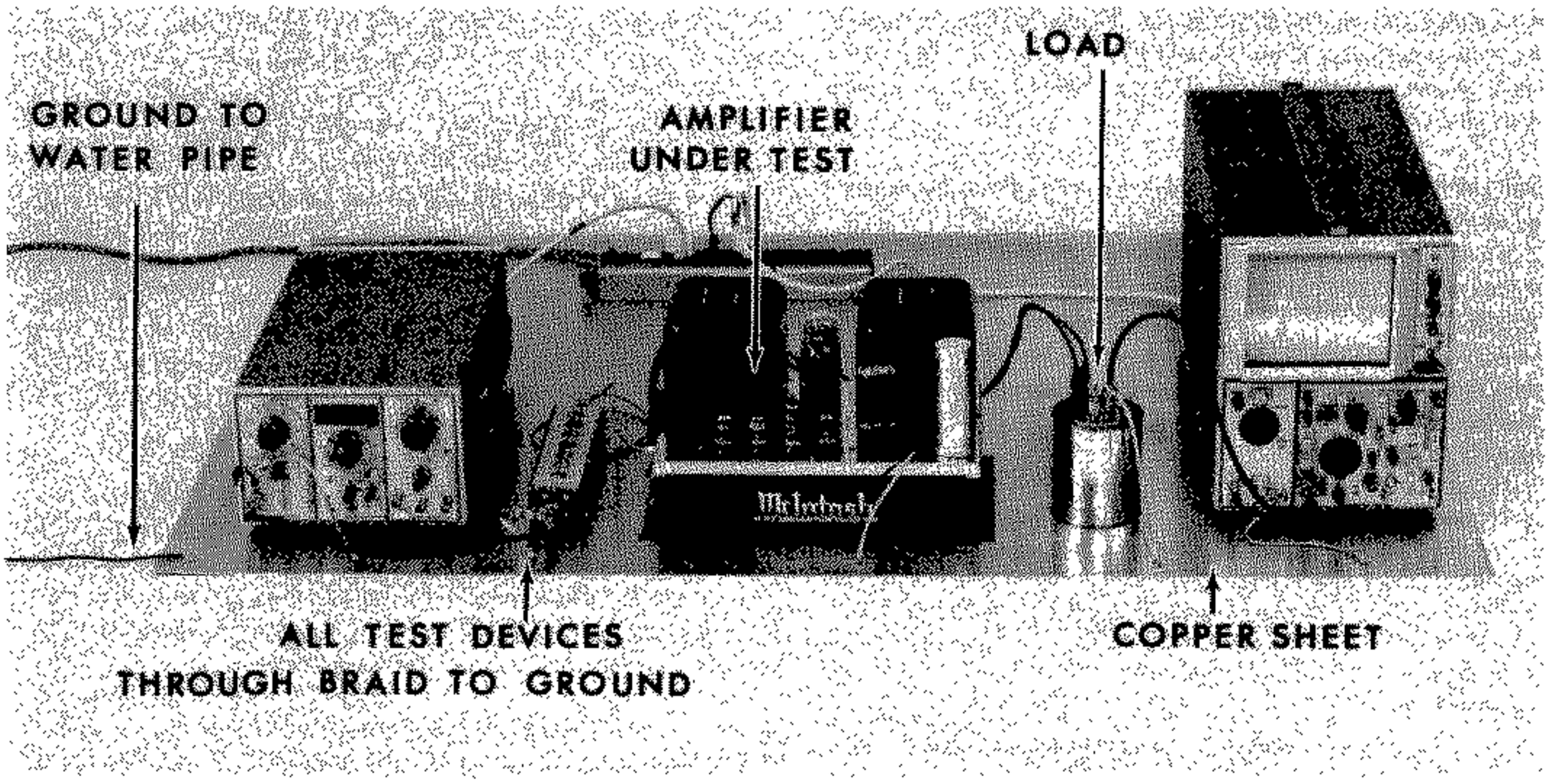

Figure 5 Typical Test Setup with Good Shielding

As a final note, wherever possible perform measurements with input signals about 30 dB above the measured reference sensitivity, using the volume control on the preamplifier to obtain reference power output.

CAUTION

Some consumer high fidelity equipment can constitute a shock hazard. Transformerless audio equipment can have line AC on the chassis, the control shafts, the input, and speaker leads. Transformer equipment can also have leakage to ground or defective bypass capacitors. The following precautions are recommended when testing equipment.

Before applying AC power to the bench make sure that:

1. All equipment is securely grounded to the bench top through the ground braid leads.
2. The bench ground is secure. Use No. 12 or larger wire for bench ground lead. Some water pipes ARE NOT ground. Test should be performed to insure a good ground.
3. The bench power should be well fused. A 5 amp plugstrip fuse should be used. The use of a Ground Fault Interrupter (GFI) is also recommended on the plugstrip circuit such as the 3M Model 2701.
4. When testing transformerless equipment, an isolation transformer should be used on the AC supply circuit. After applying AC power, exercise caution while adjusting amplifier and test equipment controls since hazardous potentials will **always** be present when making tests.

Load Matching

The degree to which amplifiers and preamplifier inputs and outputs are matched or loaded will affect the accuracy of the overall test.

Power amplifiers must be loaded to their characteristic impedance, within plus or minus 1% (usually 8 ohms). The resistor load should have no more than 2% reactive components. This restriction often precludes the use of some types of wirewound resistors. An accurate non-reactive, high power load can be constructed for the power level (wattage) and impedance required by connecting a number of one or two-watt carbon resistors in parallel. A photo of a homemade load constructed with 1 watt carbon resistors immersed in oil to dissipate extra power is shown in Figure 6.

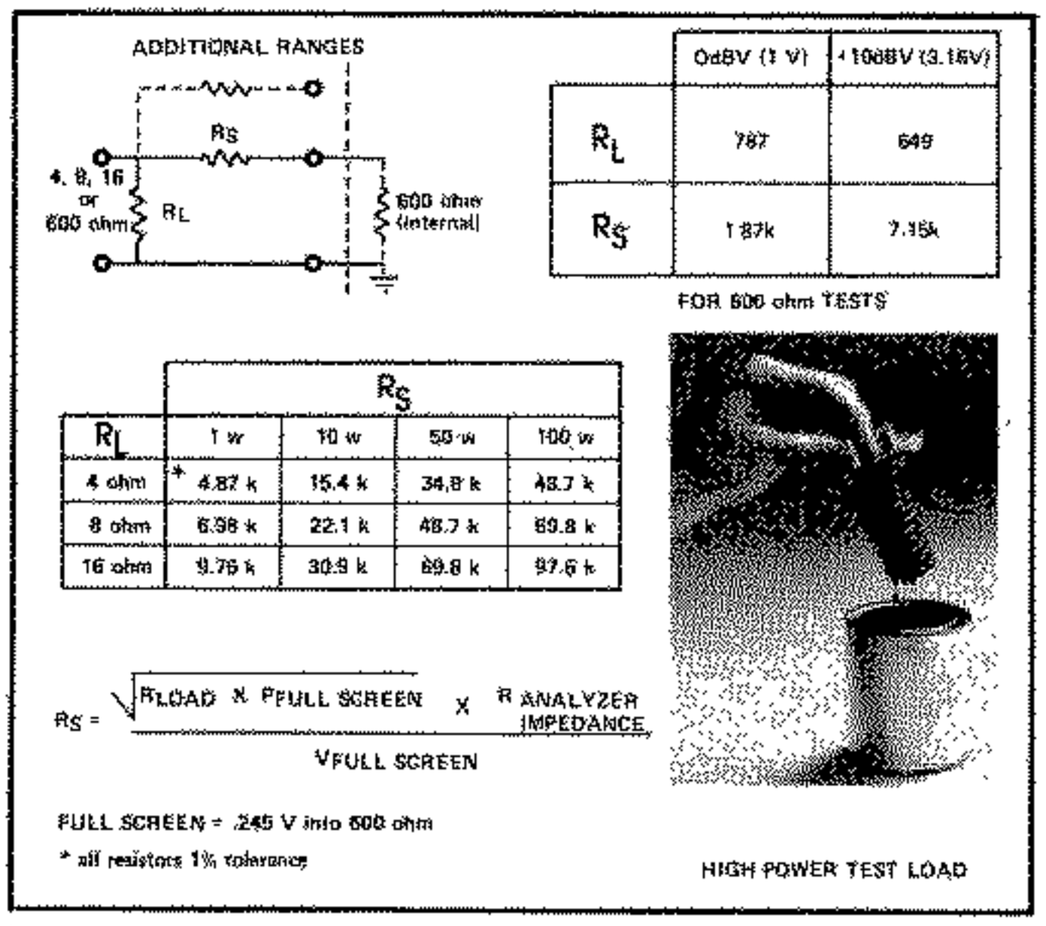

Figure 6 Load Matching Chart

The amplifier output must be matched to the 600 ohm spectrum analyzer input. A chart of values for 600 ohm amplifier matching pads as well as for other common values is also shown in Figure 6.

Preamplifiers should see a 100 kilohm slightly capacitive load such as the device in Figure 7 would provide.

Sometimes a test probe is the best way to test or troubleshoot a circuit. To maintain frequency response and minimal loading, use a 10X probe connected directly through the input of the analyzer. Select HI Z input. To measure higher voltages, construct a pad as illustrated in Figure 8.

The input signal supplied by a signal generator should be applied in series with an impedance equal to the source impedance for which the equipment was designed. With auxiliary inputs, it is considered standard to apply the signal in series with a resistance of 5000 ohms plus or minus 5%. Undriven channels should have their inputs terminated as described above.

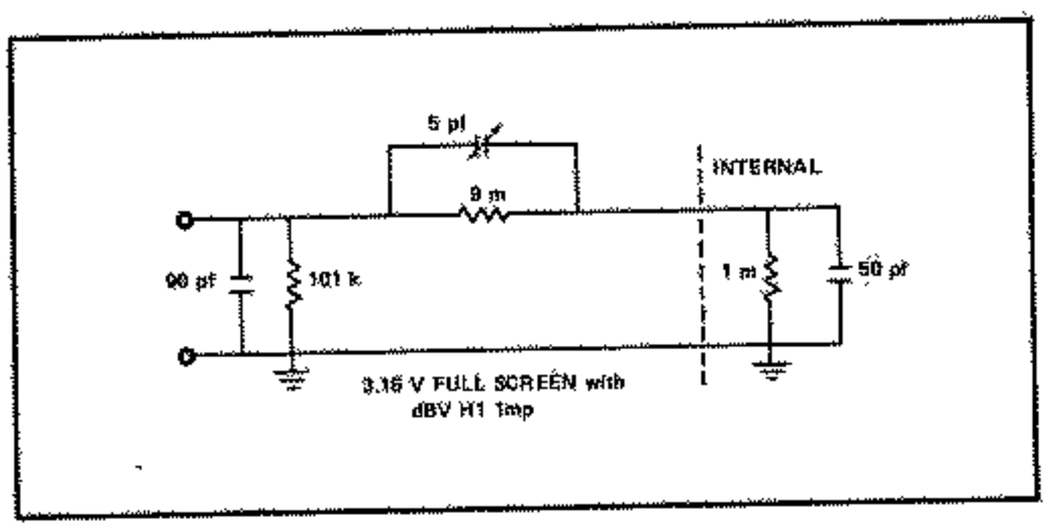

Figure 7 Preamp Load Pad

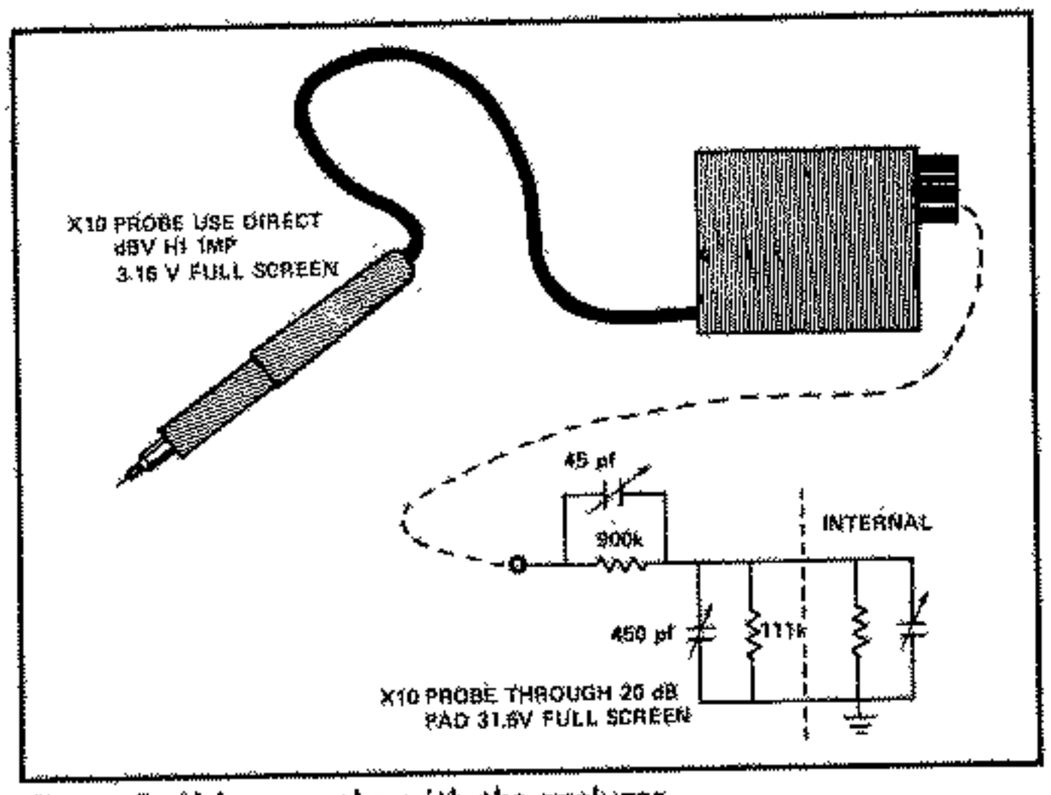

Figure 8 Using a probe with the analyzer

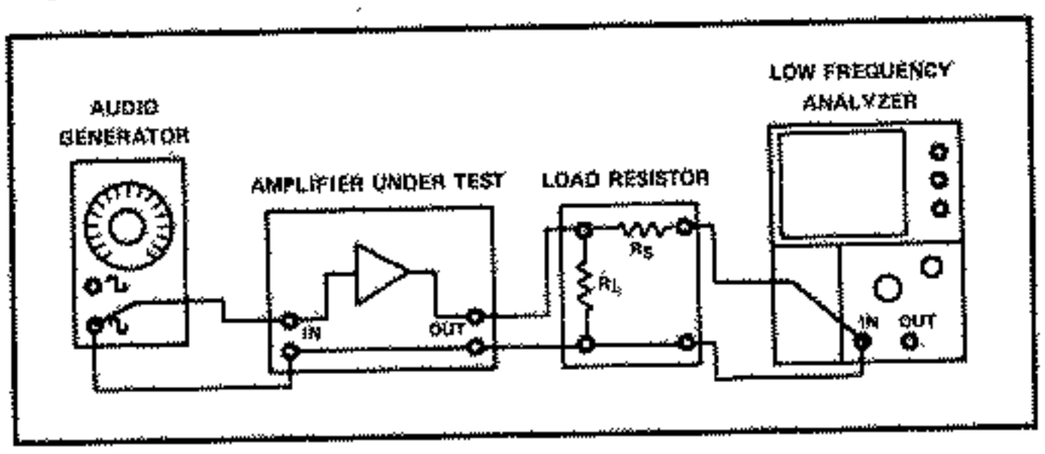

Figure 9 Equipment Setup for Measuring Power

TESTS
Power Output

Power Output of an amplifier can be roughly defined as the maximum power an amplifier can deliver per channel before distortion begins to impair the audio (music, etc.). Unfortunately, there is wide disparity in how much distortion different people will accept. Therefore, the most meaningful power output figures are obtained when the output is plotted against the amount of harmonic and intermodulation distortion.

Power measurements can be performed in many ways. A common procedure is to measure the continuous RMS output power of an amplifier for at least 30 seconds (to account for changes due to heat, power supply sag, etc.). Power measurement of stereo amplifiers is then made for each channel with both channels driven.

The Federal Trade Commission (FTC)[1] in November of 1974 enacted a regulation on measuring amplifier power output specifications.

Under this regulation, the amplifiers must be preconditioned by simultaneously operating all channels at one third of rated power for one hour using a 1000 Hz tone. Complete descriptions of these new rules are available through the FTC.

Other power tests exist, such as the IHF[2] and Music Power tests. These claim to give a better picture of an amplifier's ability to respond to sudden or instantaneous demands; however, the specifics will not be covered in this procedure.

Power Output Test Procedures

1. Select a load-matching resistor combination for the amplifier being tested from the chart in Figure 6. If the maximum power output is unknown, select a load-matching combination high enough to handle any anticipated power.

2. Connect the equipment as shown in Figure 9. Set all amplifier controls to their flat positions and set the volume control to maximum.

3. Select 1 kHz on the SG502 oscillator and carefully increase the output level until the tone is visible on the analyzer screen in the 10 dB/DIV mode.

4. Watch the 2nd (2 kHz) and 3rd (3 kHz) harmonics of the 1 kHz tone. Increase the output level until the amplitude of the 2nd or 3rd harmonic increases faster than the 1 kHz tone. The level at which the harmonics (distortion) begin to increase radically (faster than the tone reference) is generally considered to be the MAXIMUM UNDISTORTED POWER OUTPUT (Figure 10).

1. "F.T.C. Standard," as published in Stereo Review, Page 81, November 1974.
2. Institute of High Fidelity Standard Methods of Measurements for Audio Amplifiers, IHF-A-201 (1966).

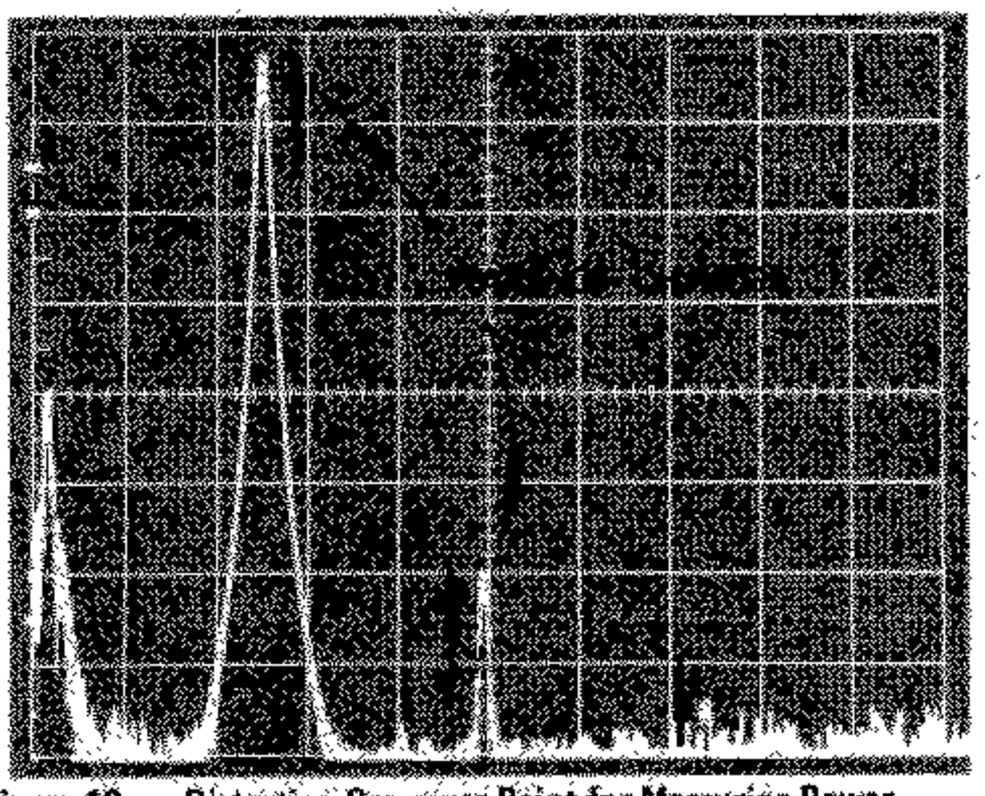

Figure 10 Distortion Crossover Point for Measuring Power

5. For the new FTC test,[3,4] all channels of a multi-channel (stereo) amplifier should be driven to the maximum power point before power is measured.

6. Power is determined by assuming the full screen display to be the value of the load-matching combination. Switch to the 2 dB/DIV mode and note the number of dB down from the top graticule line, as shown in Figure 11. This is the power output in dB below the full screen display and can be converted directly to watts.

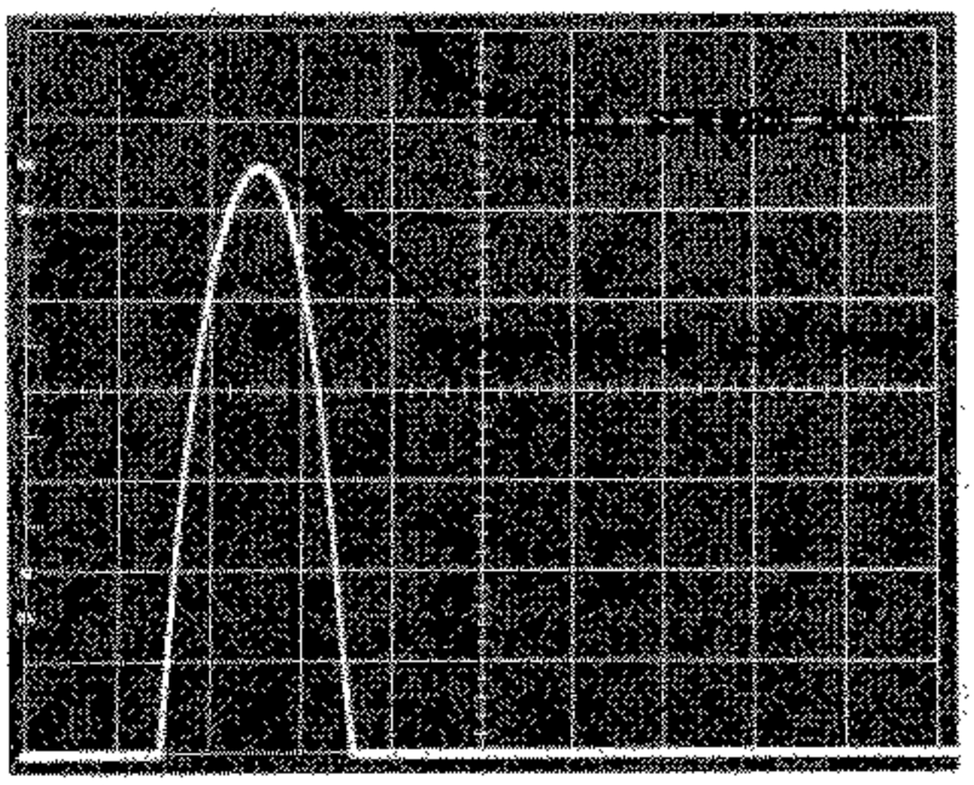

Figure 11 Calculating Power Output

Notes:

1. An alternative procedure for demonstrating maximum undistorted power is to simultaneously apply the 1 kHz tone through a plug-in vertical amplifier in the compartment next to the 5L4N and display the time domain sine wave on the scope. Increase the tone level until the sine wave visibly clips, as shown in Figure 12. The power level in dBV or dBM is then read on the spectrum analyzer display.

2. To satisfy the FTC[4] requirements, the rated power must be obtainable at all frequencies within the rated power band (width) without exceeding the total rated maximum harmonic distortion. Procedures on Power Bandwidth and Harmonic Distortion are contained in this application note and should be followed to satisfy the entire FTC regulation.

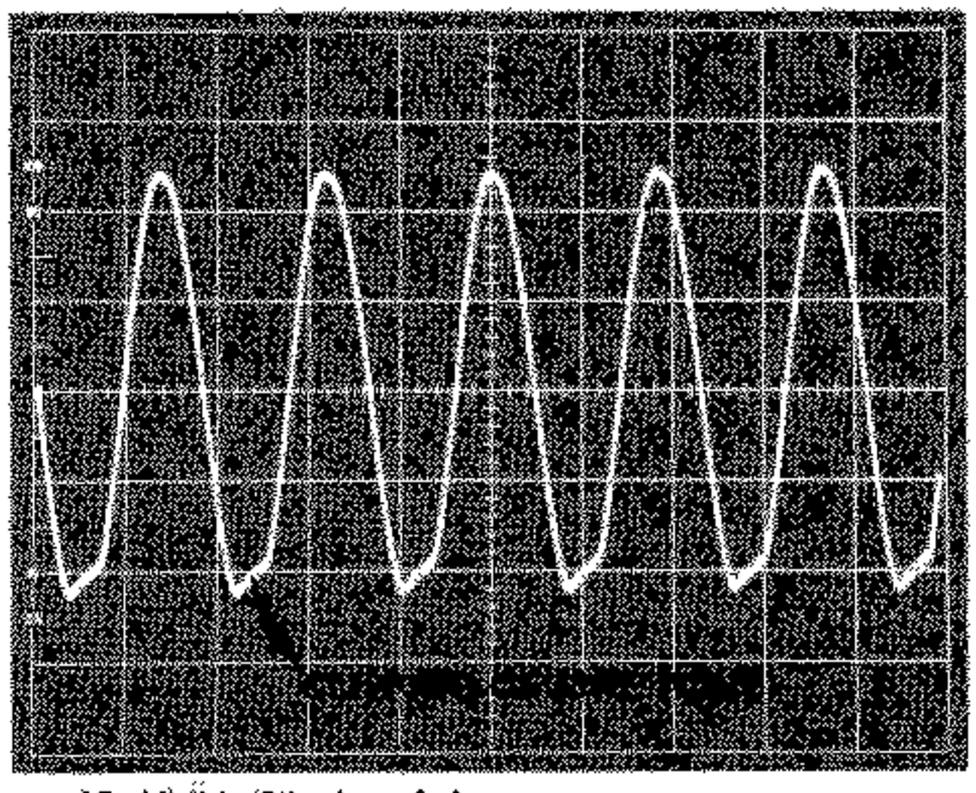

Figure 12 Visible Clipping of sine wave

Frequency Response

Frequency Response is a measure of the amplifier's ability to pass a wide range of frequencies in the audio spectrum. Ideally, one would strive to achieve a flat response; that is, all frequencies would pass through an amplifier with equal amplification. A Hi-Fi amplifier may have controls to modify the response. These may include tone controls (bass and treble), rumble and hum filters (low frequency rolloff), scratch filters (high frequency rolloff), and a variety of tailoring devices such as the RIAA, FM de-emphasis, and tape head equalization filters. The frequency response test should provide response information of the amplifier in the flat position and should also represent the limits and interaction of the tone controls and filters.

Response of a modern Hi-Fi system is generally measured from below 20 Hz to well beyond the 15 kHz audible limit. It is measured in dB of deviation across the audio spectrum.

The 5L4N Low Frequency Analyzer is ideally suited to frequency response testing since it has a self contained tracking generator and a log sweep 20 Hz to 20 kHz mode. An amplifier can be swept under a variety of different conditions in a matter of seconds, eliminating the need for tedious measurements and point to point plots. Multiple traces of conditions can be built up either on film or on a storage oscilloscope to obtain one picture of the complete response performance of an audio device.

The rated frequency response[3] is the frequency range over which the amplitude response does not vary more than plus or minus 3dB from the amplitude at 1000 Hz.

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3. EIA Standard Methods of Measurement for Audio Amplifiers Used in Home Equipment, RS-234-C (1971).
4. Larry Klein, "Amplifier Power-Output Ratings: A New FTC Trade Regulation Rule," Stereo Review, Vol. 35 No. 5, Page 79, November 1974.

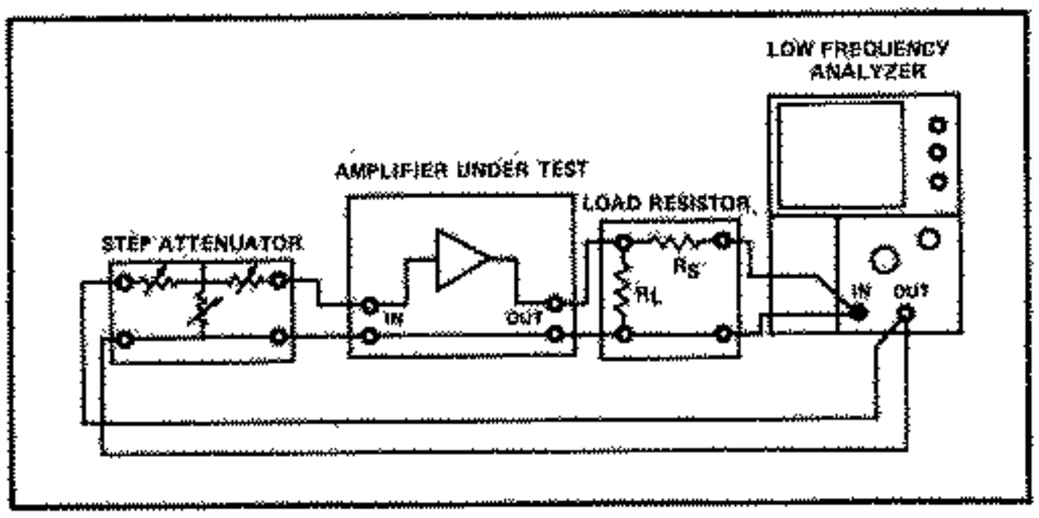


Figure 13 Frequency Response Equipment Setup

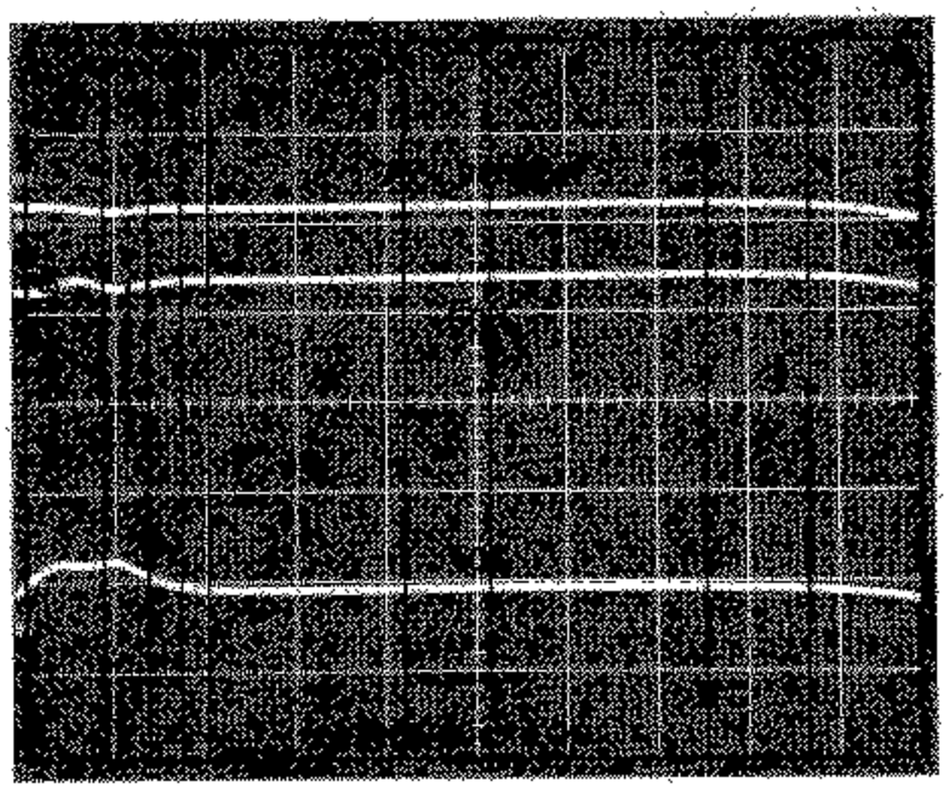


Figure 14 Frequency Response at 10%, 50% and 75% Power

Frequency Test Response Procedures

1. Select a load resistor matching pad combination for the rated power of the amplifier being tested. Connect the equipment as illustrated in Figure 13.

2. All tone controls and filters on the amplifier should be initially set for flat response. The volume (and/or loudness) controls should be set to maximum.

3. Use the LOG span on the 5L4N. An internal circuit jumper in the 5L4N provides either 20 Hz to 20 kHz, or a 100 Hz to 100 kHz LOG span. Select the 20 Hz to 20 kHz LOG span. Consult the instrument manual for details. Set the SPAN/DIV to LOG and the display mode to 10 dB/DIV (20 Hz corresponds to the left edge of the graticule). Install the Audio Graticule contained in this application note.

4. Begin the test with all the attenuation IN on the attenuator.

5. With the analyzer sweeping, reduce the attenuation of the attenuator until the rated power of the amplifier is achieved (as indicated on the display, taking the load-matching combination into account). The response, from 20 Hz to 20 kHz, should now be displayed.

6. Different power levels should also be checked such as 10% (-10 dB), 50% (-3 dB), and 75% (-1.25 dB) to see if variations occur in the response (Figure 14).

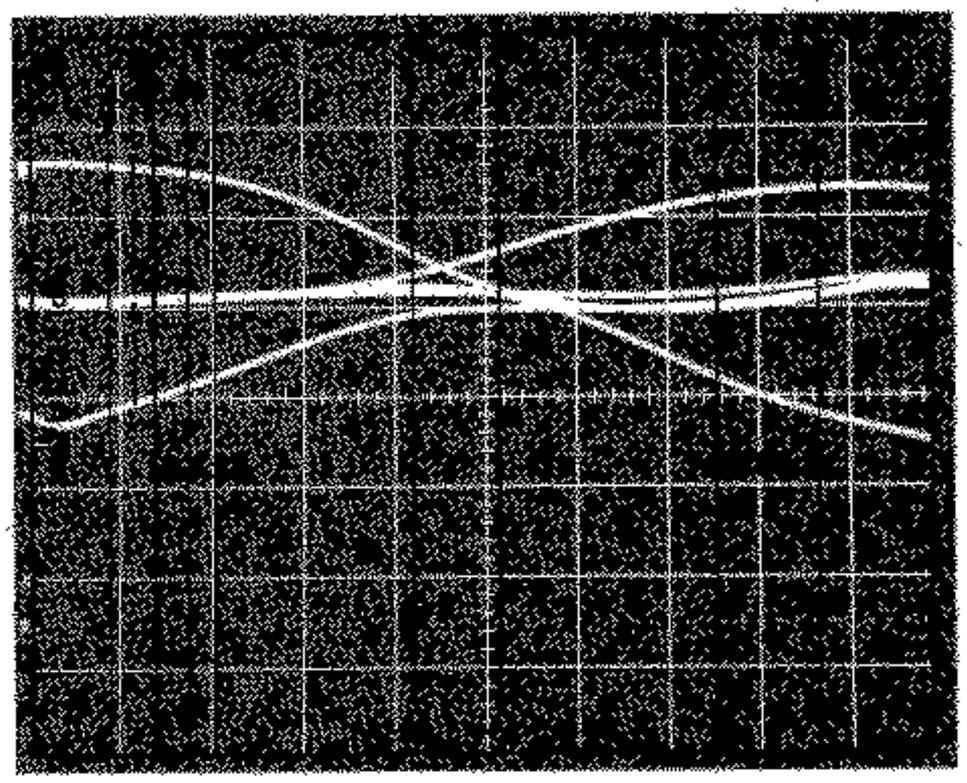


Figure 15 Tone Control Ranges

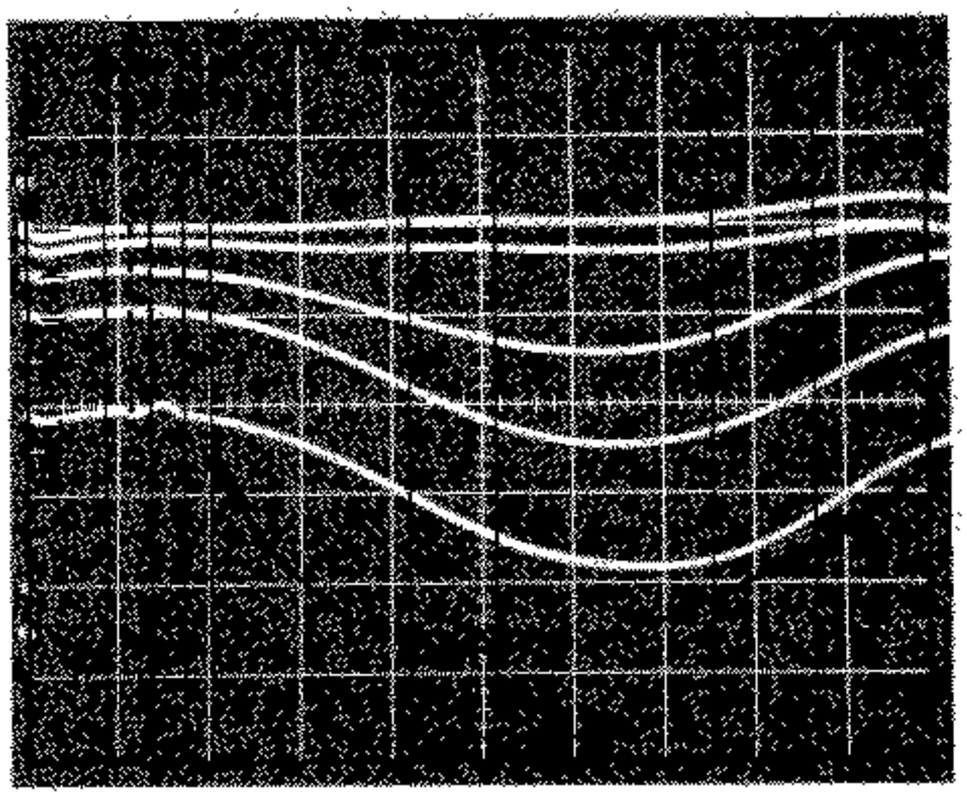


Figure 16 Loudness Control Effects

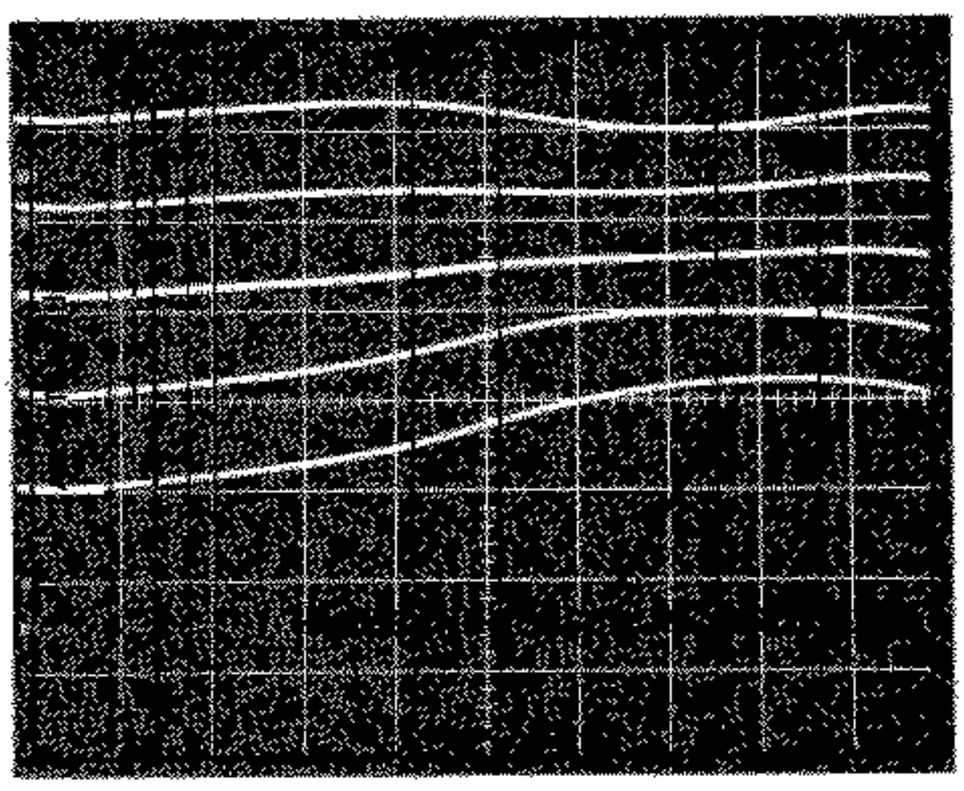


Figure 17 Response Action of Dolby "B" Encoder

7. The 2 dB/DIV display mode provides higher resolution of the response flatness.

8. The range and effect of the tone control and filters can be checked by varying these controls. If the 5L4N mainframe has storage or a camera is available, sequential displays of responses can be "built up" as shown in Figure 15.

Notes:

1. The effects produced by varying the loudness contour control can be observed (Figure 16) by sweeping the flat response each time the loudness control is increased by 1/8 turn.

2. The action of a Dolby B system encoder or decoder can be checked or noted by sweeping the device each time as the input level is reduced by 10 dB steps (Figure 17).

3. EIA standards[3] recommend that the frequency response be measured at a power output not higher than 10dB below the rated power output and not lower than 20dB above residual hum and noise.

Harmonic Distortion

Harmonic Distortion or THD (total harmonic distortion) is determined by measuring and summing the amplitude level of the various harmonics that occur when a single, pure tone is passed through an amplifier. This is the most common distortion test performed on amplifiers. Harmonics can be predicted to occur in sequence (2nd, 3rd, 4th, etc.). Therefore, a 1000 Hz tone would have a 2nd harmonic of 2000 Hz, a 3rd harmonic of 3000 Hz, etc. The harmonics represent various amounts of distortion as shown in Figure 18.[5]

The low frequency analyzer permits evaluation of the components contributing to THD and also makes it possible to visually and graphically reference output level (power) to distortion. The 5L4N in combination with the SG502 audio oscillator can make 70 dB THD (.034%) measurements. With auxiliary fixed filters, this range can be extended to measure 100 dB (.001%) THD. Complete details are contained in the notes that follow.

Harmonic distortion is generally plotted against frequency at different power levels across the audio spectrum. The following procedure describes one method of measuring harmonic distortion.

Procedures

1. This test is usually conducted when the power output of an amplifier is measured. The equipment setup is shown in Figure 9. Set the amplifier controls for a flat response and maximum volume.

2. Select a 1000 Hz[1] tone from the audio generator (SG502). Increase the output level until the reference power rating of the amplifier is reached, as indicated by the 2 dB/DIV display on the spectrum analyzer screen.

3. Harmonic distortion appears as multiple signals above the fundamental 1000 Hz tone. Switch to 10 dB/DIV mode and observe the position and amplitude of the 2nd harmonic (2000 Hz) relative to the 1000 Hz reference tone (Figure 19). The amplitude ratio between the two, in dB, is the second order harmonic distortion. This ratio can be converted to percentage of distortion by referring to the chart in Figure 20.

4. Similarly, the amplitude ratio between the reference and higher order components may be calculated and converted to percentage of distortion.

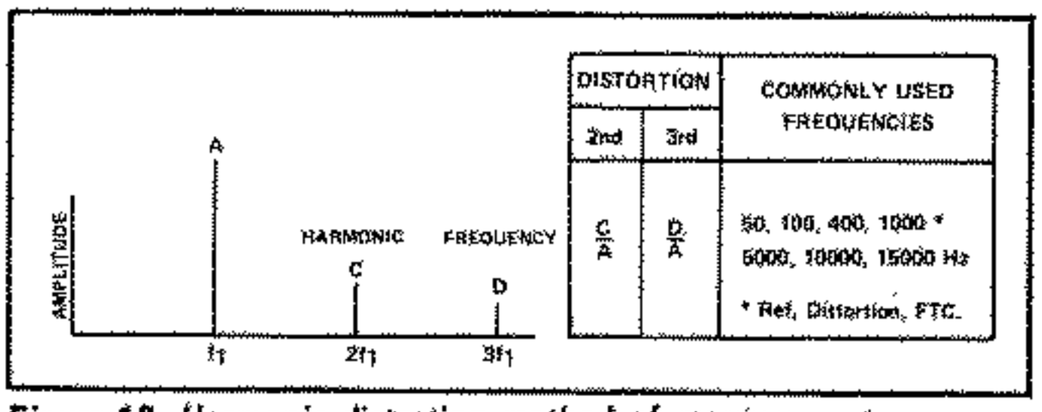


Figure 18 Harmonic distortion method of measurement

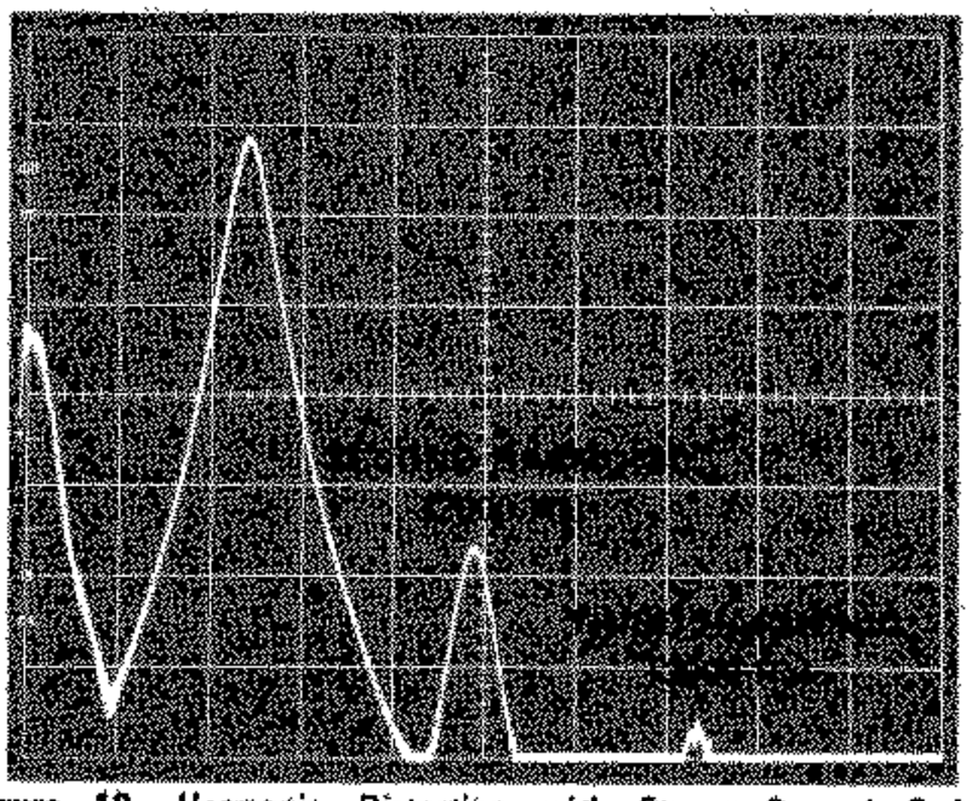


Figure 19 Harmonic Distortion with Strong Second Order Components

RATIO in dB	% of READING	RATIO in dB	% of READING
20. (40;60)	10% (1% .1%)	30 (50,70)	3.16% (.31,.031%)
21	8.9	31	2.87
22	7.94	32	2.51
23	7.08	33	2.24
24	6.31	34	2.00
25	5.62	35	1.78
26	5.01	36	1.59
27	4.47	37	1.41
28	3.98	38	1.26
29	3.55	39	1.12

Figure 20 Chart for Conversion from dB's to Percentage Readings

5. James S. Aagaard, "An Improved Method for the Measurement of Nonlinear Audio Distortion," IRE Transactions on Audio, Page 121, 1958.

5. THD (Total Harmonic Distortion)[6] is calculated by comparing the reference tone level to the RMS sum of all harmonic levels. The sum of the harmonics can be determined by using the chart in Figure 21.If all other harmonics are 6 dB or more down from the 2nd harmonic, one can disregard the higher order harmonics and use only the second to obtain an accurate THD figure (see Figure 22).

6. The harmonic distortion can be plotted against frequency at various power levels such as 10%, 50% and 100% on a suitable chart. This will produce results similar to those illustrated by Figure 23.

Note:

1. THD figures closer to actual operation can be obtained by setting the volume control at less than maximum, then increasing the output level of the audio generator to bring the power output of the amplifier up the rated reference.

2. The 70 dB (.031%) range of measurement that is possible with the 5L4N Low Frequency Spectrum Analyzer can be extended to 100 dB or more (.001%) by adding a band stop filter tuned to suppress the fundamental test tones between the amplifier and 5L4N INPUT. The oscillator must also be clean to 100 dB and may require extra bandpass filtering. Complete details for extended range measurements are shown in Figure 24.

3. In some situations, it may be difficult to distinguish between the harmonics and the noise floor. The noise floor may be moved down by selecting a slower sweep speed which will, in turn, automatically select a narrower RESOLUTION B.W.

4. EIA standards discuss a parameter called Low Power Distortion. It is the highest value of toal harmonic distortion(THD) measured on a 1kHz tone from 6dB to 26dB below the rated power output.

6. W.J. Warren and W.R. Hewlett, "An Analysis of the Intermodulation Method of Distortion Measurement," Proc. IRE, Vol. 36, Page 457, February 1948.

dB DIFFERENCE	ADD TO HIGHER LEVEL
Same (OdB)	3.01
1 dB	2.54
2	2.13
3	1.76
4	1.46
5	1.19
6	.97
7	.79
8	.64
9	.51

Figure 21 Correction Factors for Addition of Components

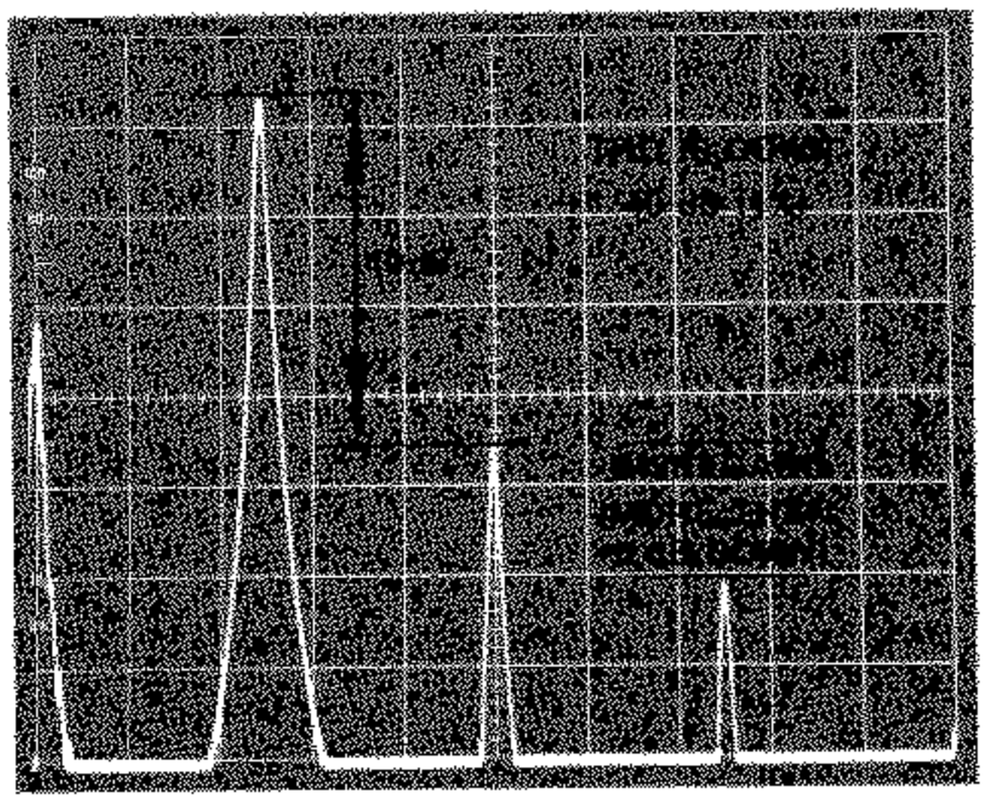


Figure 22 Calculating Percentage of Total Harmonic Distortion

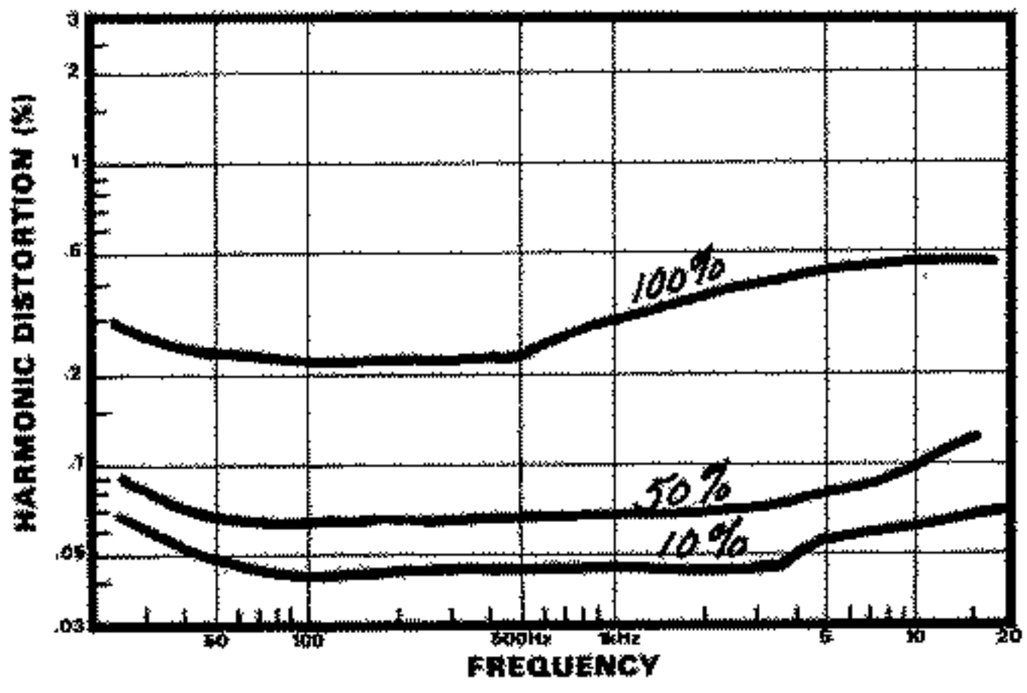
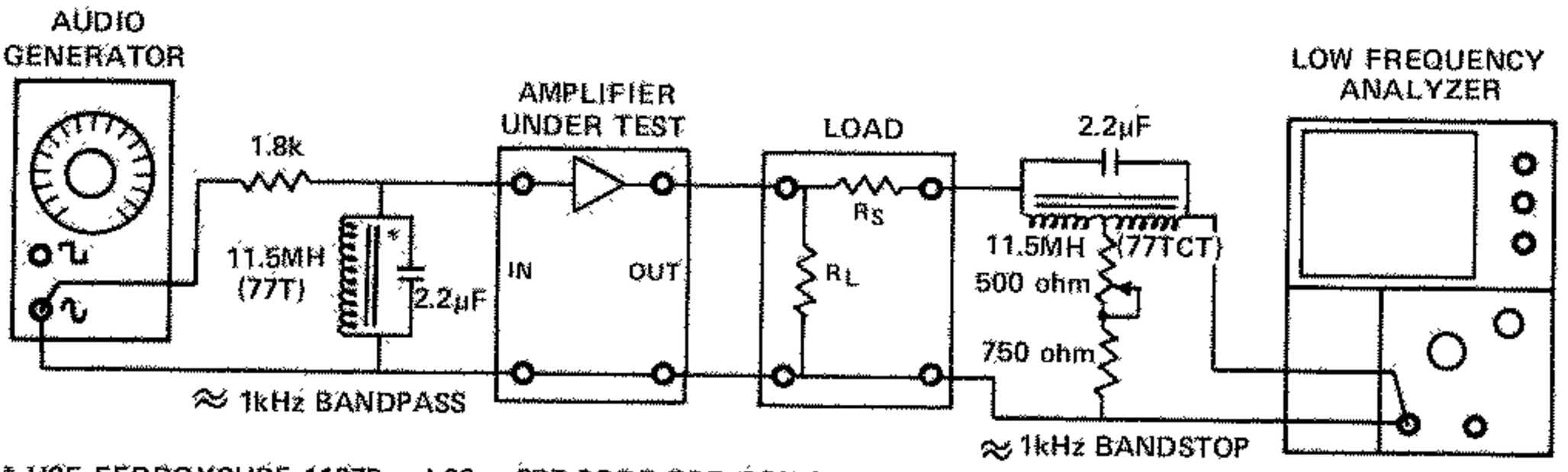


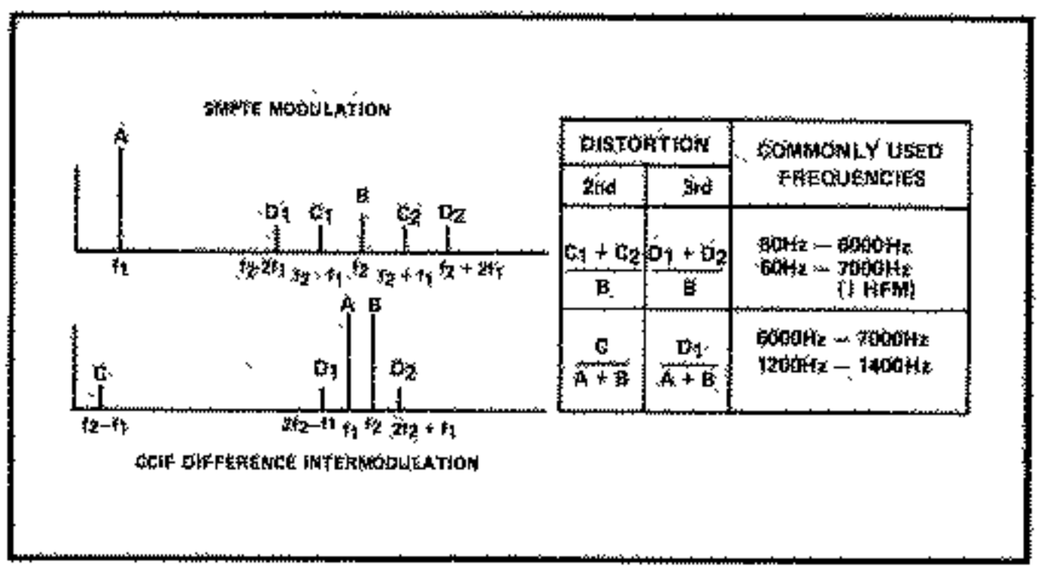
Figure 23 Harmonic Distortion Plotted vs Frequency at Different Power Levels



1. Set frequency of generator to bandstop filter null and adjust 500 ohm pot for best null indication (40 dB possible).
2. Check bandpass filter and make frequency equal to bandstop by varying capcitor value if necessary.
3. After connecting all equipment as in diagram, obtain reference level by bypassing bandstop filter. Then connect and read second, third, etc. harmonics.

Figure 24 Extending the Range of THD Measurements at 1 kHz

Intermodulation Distortion



DISTORTION		COMMONLY USED FREQUENCIES
2nd	3rd	
$\frac{C_1 + C_2}{B}$	$\frac{D_1 + D_2}{B}$	80Hz — 8000Hz 60Hz — 7000Hz (I HFM)
$\frac{C}{A+B}$	$\frac{D_1}{A+B}$	6000Hz — 7000Hz 1200Hz — 1400Hz

Figure 25 IM Methods of Measurement

Intermodulation Distortion is determined by putting two or more pure tones into an amplifier and measuring the amount one tone is transferred (cross modulated) onto the other.

Two commonly used intermodulation tests are described by the chart in Figure 25.

Measurement of Intermodulation Distortion[7] has always generated a lot of controversy. All involved agree that the various measurements produce numbers that relate to performance of audio equipment; however, everyone has his/her own idea about what frequencies to use, how many, the levels, etc.

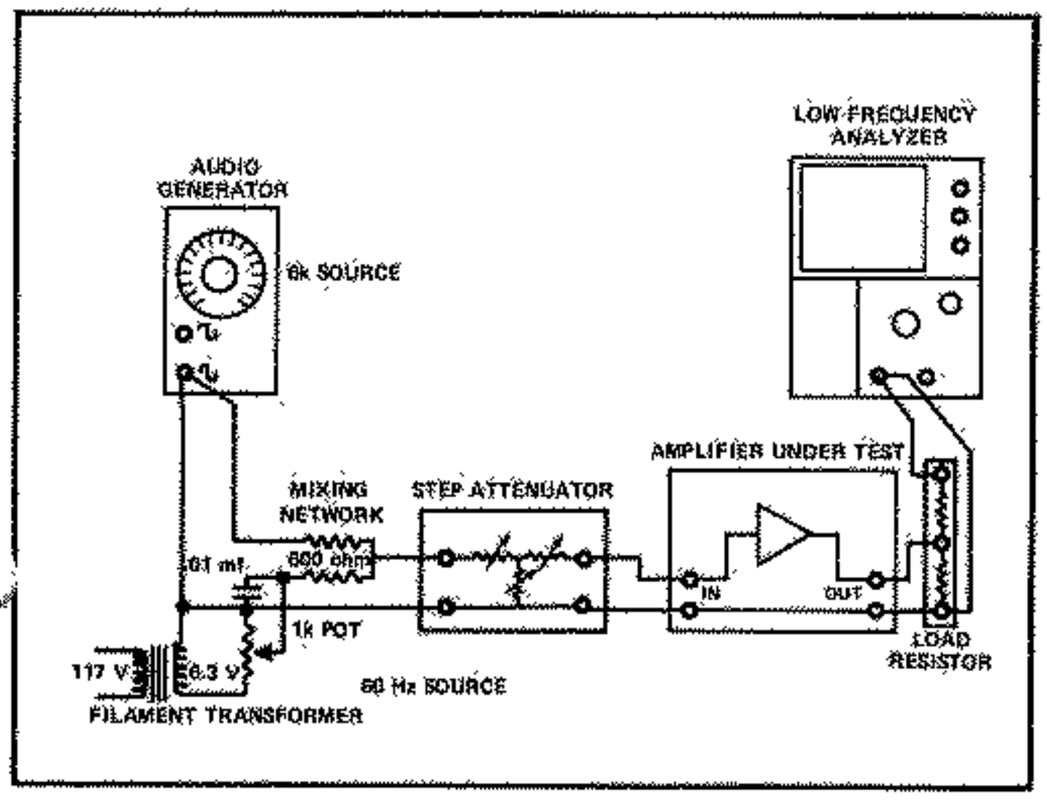


Figure 26 Equipment Setup for Intermodulation Measurement

Fortunately, the low frequency analyzer can handle all of the different known methods. The procedure presented below uses the Society of Motion Picture and Television Engineers (SMPTE) modulation method using two tones. The specific tones and ratios are recommended by the Institute of High Fidelity Manufacturers (IHFM).

Intermodulation Distortion Test Procedures

1. This test is usually conducted in conjunction with the power output measurement of an amplifier. Two tones must be used and carefully combined for Intermodulation Distortion measurement. The SMPTE method uses the filament transformer arrangement as shown in Figure 26 for the 60 Hz source, instead of a second audio generator.

7. Gerald Stanley and David McLaughlin, "Intermodulation Distortion: . . . Audio, Page 36, February 1972.

2. For the SMPTE Modulation method, select 60 Hz and 6000 Hz (7000 Hz for IHFM) in a voltage ratio of 4:1. This means that the 6000 Hz tone will be down 12 dB from the 60 Hz tone. This two tone generator setup can be checked directly with a low frequency analyzer (Figure 27).

3. Set the amplifier controls for a flat response, with the volume control set to maximum.

4. Drive the amplifier using the two tone generator to indicate 14 dB less than the rated power using the 6000 Hz tone as a reference point. The sum of the two tones will be equivalent to the rated power since the 60 Hz tone is 12 dB higher and the component of the 6000 Hz tone adds approximately 2 dB.

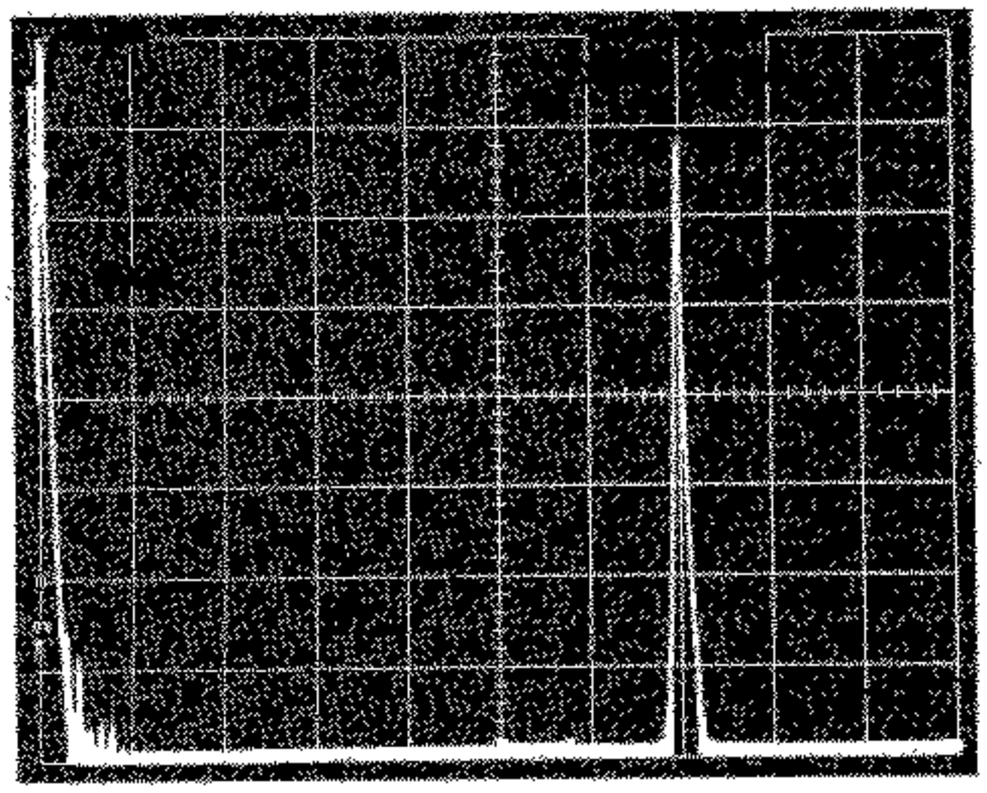


Figure 27 SMPTE Modulation Method Generator Output

5. Select 10 dB/DIV display mode and a SPAN/DIV of 100 Hz. Tune the 6000 Hz signal to center screen with the FREQUENCY control.

6. Figure 28 is a typical display. The sidebands that appear around the base of the 6000 Hz tone are modulation components of 60 and 120 Hz, generated by the 60 Hz tone. Use the chart in Figure 21 to calculate the sum of the 60 Hz, 120 Hz, and other visible modulation components that appear on one side of the carrier only. **Do not** add the upper and lower 60 Hz or 120 Hz components together. Percentage of intermodulation distortion can be calculated from the chart in Figure 20.

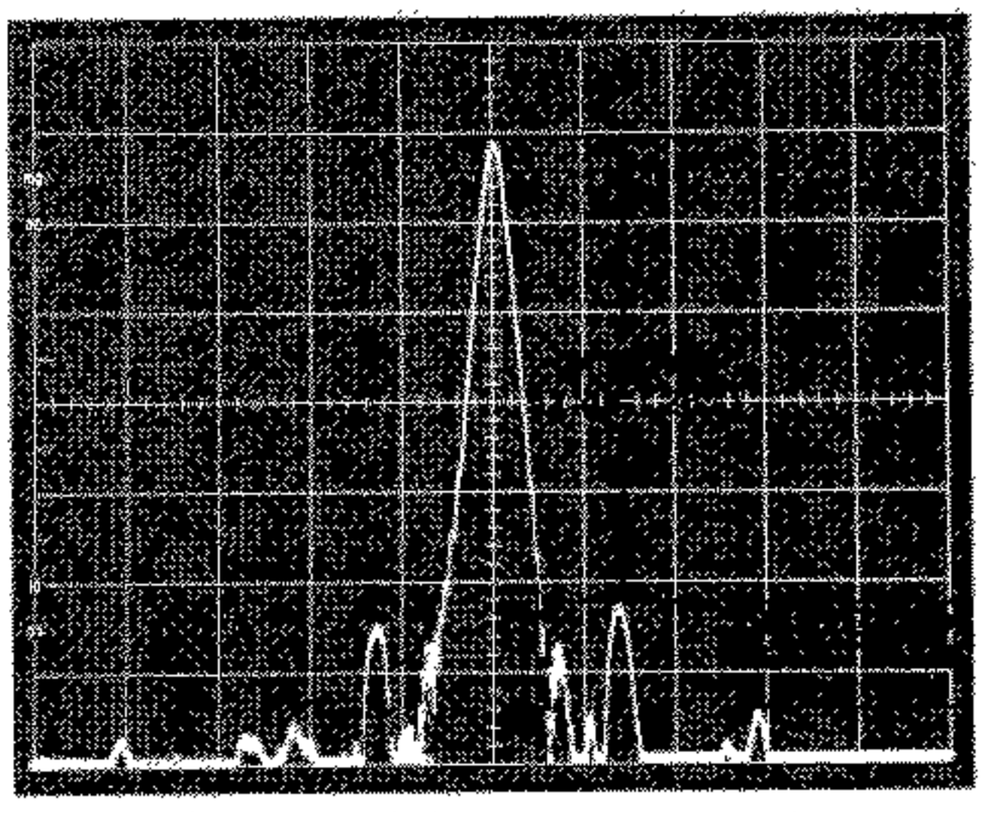


Figure 28 SMPTE Modulation Method of Measurement

Notes:

1. The CCIF Difference method of measuring requires a similar setup that uses two equal amplitude input signals from the signal generators. A typical display is shown in Figure 29.

2. Other intermodulation measurement methods, such as the Modified CCIF (symmetrical distortion), SMPE Three-Component, Noise and Notch, Impulse, and Multitone, can all be handled similarly.

3. The amount of IM distortion may decrease or change when the volume control setting is other than maximum, with the power output being maintained by increasing the signal generator output level.

4. A parameter called Low Power Intermodulation Distortion is discussed in the EIA standards. This is the highest IM distortion measured from power outputs from 6dB to 26dB below the rated power output.

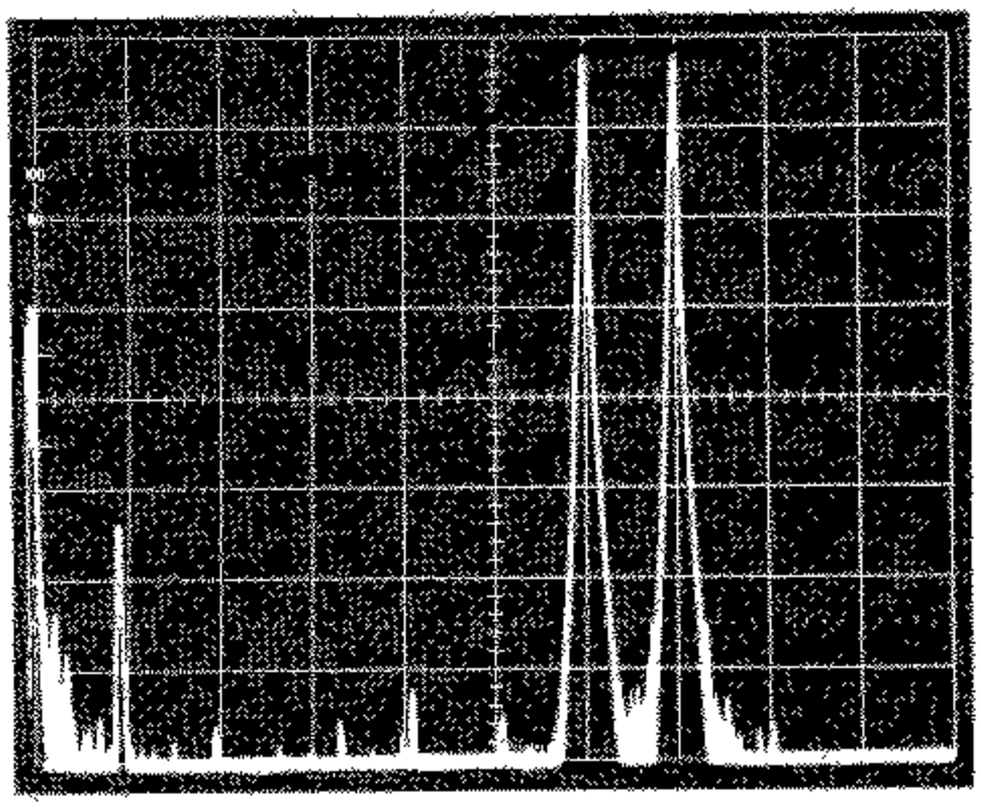


Figure 29 CCIF Difference Method of Measurement

Distortion vs Output

Distortion vs Output is a measure of the distortion for every power level of an audio amplifier system. By plotting the output power or voltage against the percentages of both harmonic (THD) and intermodulation (IM) distortion, one can readily determine the power capability for any distortion level.

A Federal Trade Commission rule requires complete disclosure of harmonic distortion (THD) using a 1000 Hz tone for all power output levels from 250 mW to rated power. This procedure has been followed for the THD measurement. IM specifications are not required to satisfy the FTC but are included in the following procedure.

Distortion/Output Test Procedures

1. Use the equipment setup and the procedure for harmonic distortion measurements and make a series of readings by using a 1000 Hz tone with a power output of 250 mW* increasing the output until the rated power of the amplifier is **exceeded.** Plot this data on a graph similar to that shown in Figure 30.

2. Use the equipment setup and the procedure for the intermodulation distortion measurements and make a series of readings that start with a power output of 250 mW increasing the output until the rated power of the amplifier is **exceeded.** Plot this data on the graph that was used to plot harmonic distortion.

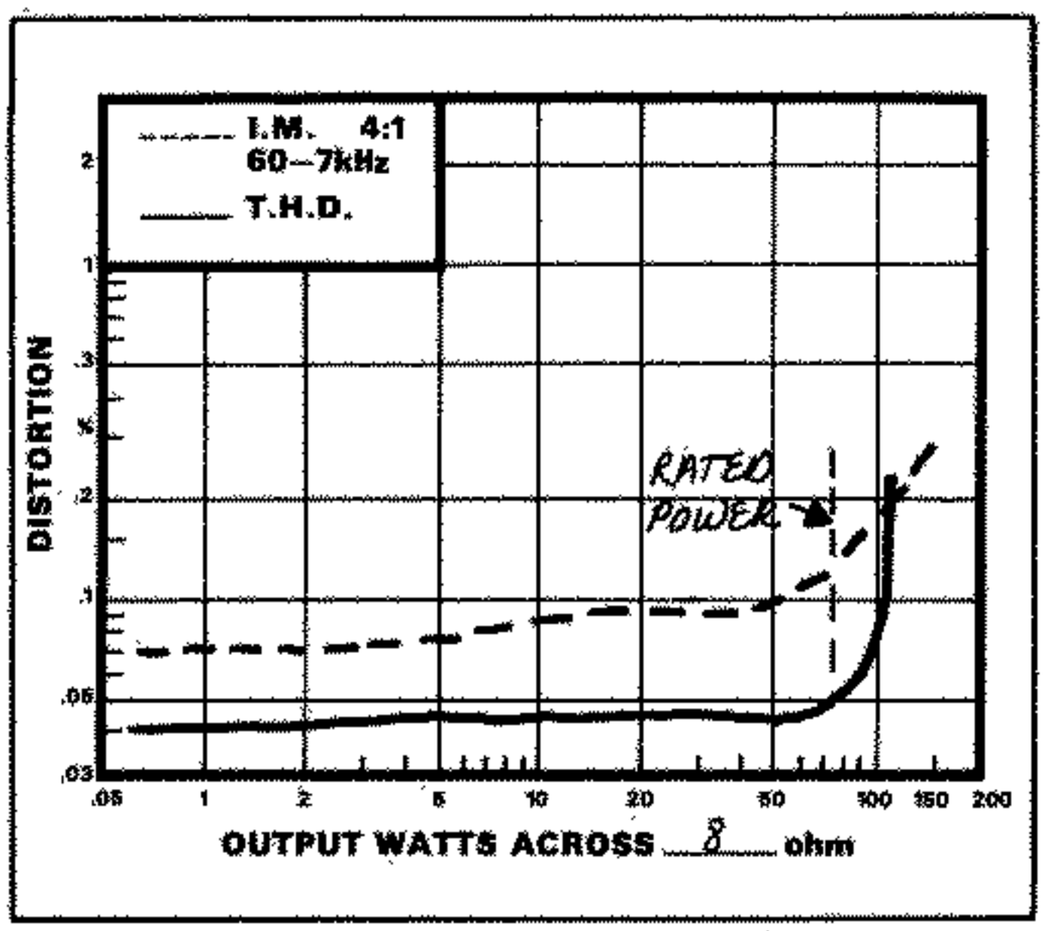


Figure 30 IM and THD Distortion of an Amplifier

* Recommended reference tone by FTC, November 1974.

Power Bandwidth

Power Bandwidth, for high fidelity test purposes[8], is defined as the frequency range between the two points where the distortion at a power output 3 dB below the reference power intersects the reference distortion line at full power. The reference distortion at full power is usually measured using a 1 kHz tone. Then the power output is held to 3 dB less than full power while the harmonic distortion THD is plotted for tones from 10 Hz to the upper frequency limits of the amplifier.

This test is performed using the same procedure as for THD except that the distortion curve is plotted at 3 dB less than rated power, and the frequency range of the measurement is much wider.

Power Bandwidth Test Procedures

1. Use the equipment setup shown in Figure 9. Use the procedures discussed under Harmonic Distortion for reference.

2. Measure the distortion of a 1 kHz tone at the rated power output of the amplifer. This is the REFERENCE DISTORTION and should be plotted on the chart as shown in Figure 31.

3. Reduce the power output by 3 dB (to 50%) and carefully begin plotting the distortion for frequencies of 20 Hz, 40 Hz, 60 Hz, 100 Hz, etc.

4. It is important to reset the 50% power reference as indicated on the low frequency analyzer, since the frequency response of the amplifier will vary.

5. Continue to measure at regular frequency intervals until the percentage of distortion becomes at least twice as high as the REFERENCE DISTORTION.

6. The frequency between the two crossover points is the Power Bandwidth of the amplifier.

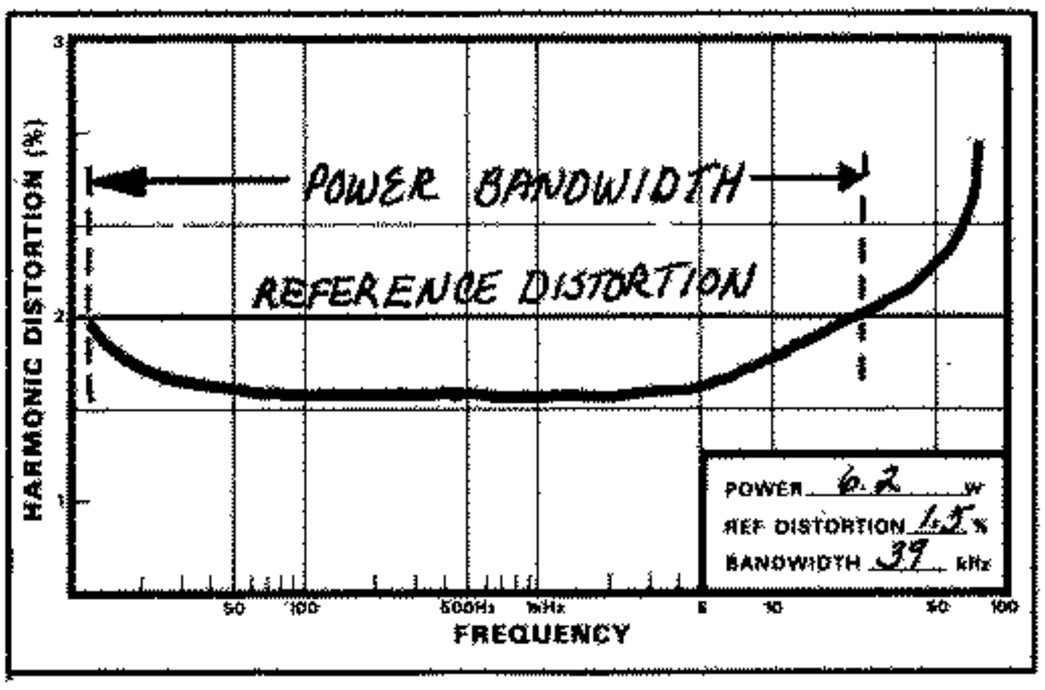


Figure 31 Power Bandwidth of an Amplifier

8. Edward C. Palmer, "8 Ways to Test Hi-Fi Amplifiers," Radio-Electronics, Vol. 44 No. 7, Page 37, July 1973.

Damping Factor

Damping Factor[8] is measure of output impedance versus frequency relative to a constant load R. It is an indirect measure of an amplifier's ability to remain stable while encountering speaker impedance changes (at different frequencies).

A simple way to measure damping factor is to measure the ratio at maximum power of the loaded output voltage to the unloaded output voltage. Care must be exercised during this measurement because some amplifiers cannot be driven to maximum power with a no load condition for more than a few seconds without damage.

Procedures

1. Use the equipment setup that is illustrated in Figure 32. Use a specially constructed or modified load-matching combination as shown. The load portion of the pad must be switchable.

2. Use a 2 dB/DIV display mode and apply a 1000 Hz tone. Increase the signal level to its rated output power.

For the EIA standard measurement, use a 100 Hz tone and use an output 6 dB less than the rated power output.

3. Switch to LIN mode and accurately note the voltage amplitude of the signal.

4. Disconnect the amplifier load with the switch and remeasure the signal voltage as shown in Figure 33. Duration of the no load condition should be kept short to protect the amplifier.

5. To calculate the damping factor: Damping Factor equals EL over ENL minus EL; where EL is voltage with load and ENL is voltage with no load.

6. If desired, the damping factor can be plotted for all frequencies from 20 Hz to 20 kHz as shown in Figure 34.

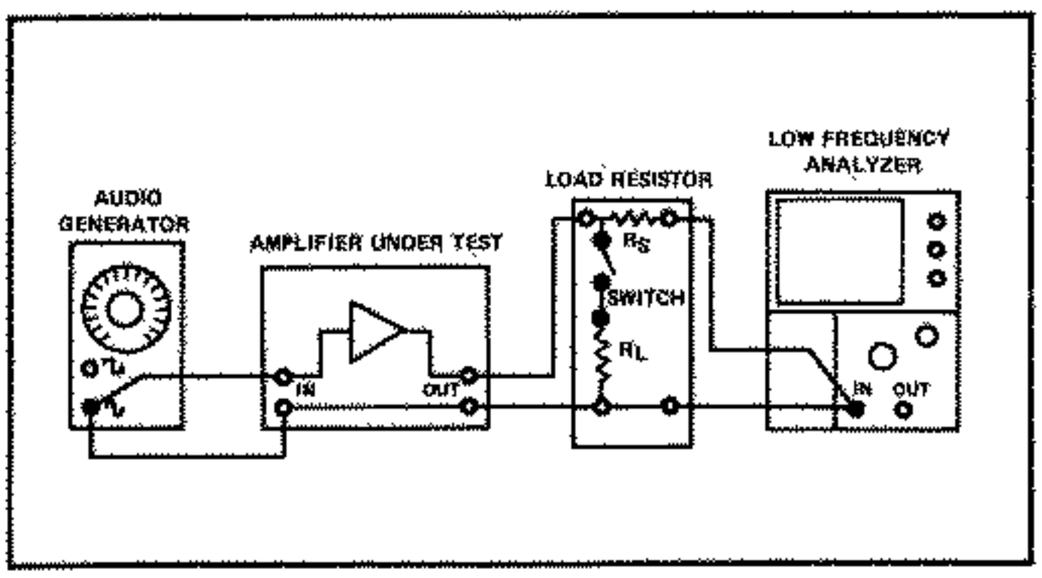


Figure 32 Damping Factor Measurements

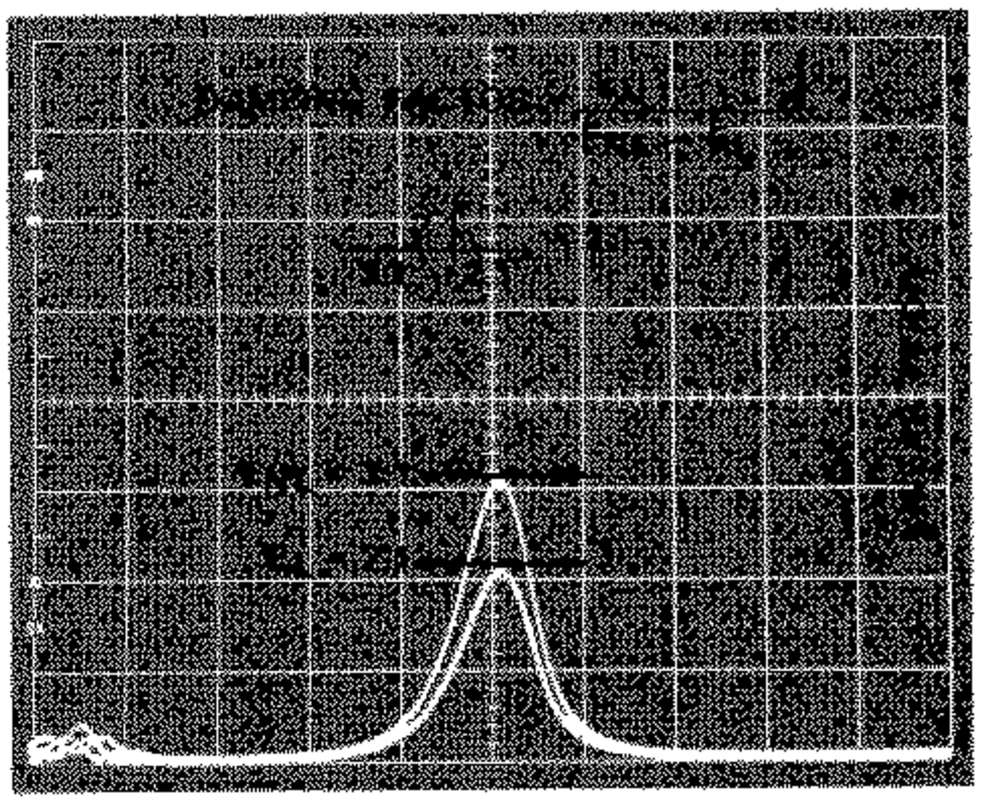


Figure 33 Damping Factor Indication

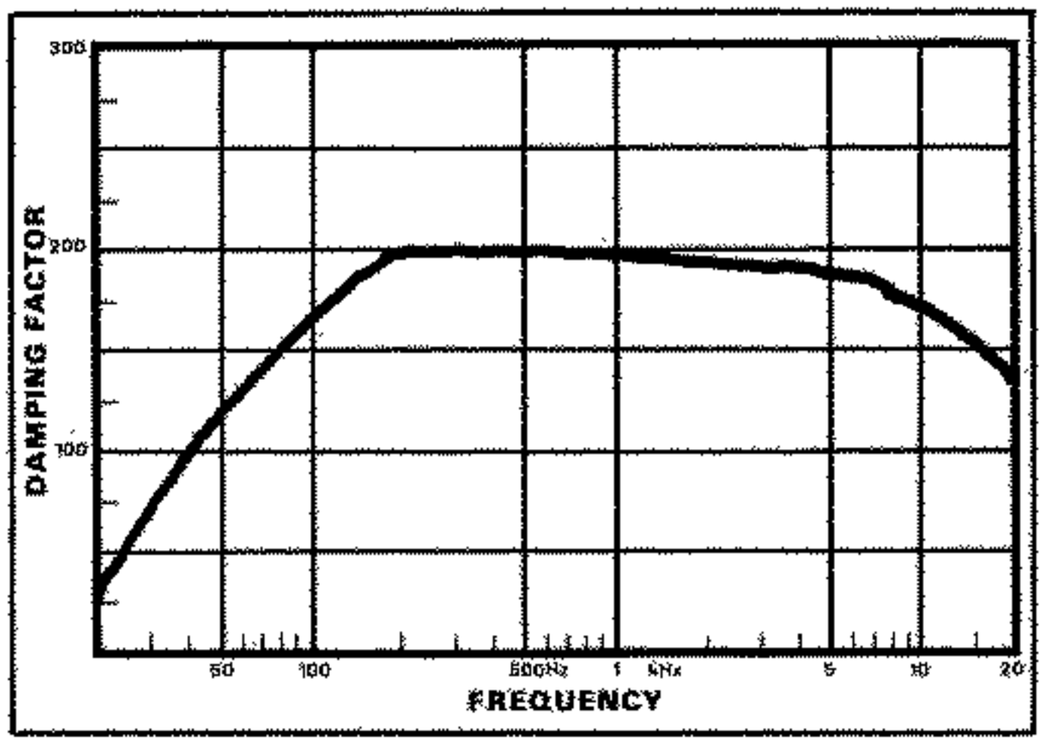


Figure 34 A Plot of Damping Factor vs Frequency

Signal to Noise Ratio

Signal to Noise Ratio[9] is a measurement of the ratio of the rated output of an amplifier to noise (mostly thermal noise). Ideally, one would like to be able to differentiate between noise and other problems such as hum.

Signal to noise ratio measurements are performed with a variety of techniques. Some of these techniques include the use of weighting filters that take into account the response sensitivity of the human ear (the Fletcher-Munsen effect), and other techniques use low pass filters to measure noise flatly across the audible range.

The Spectrum Analyzer can measure Signal to Noise Ratio easily if measurements do not specify the use of a weighting filter. In addition the analyzer permits rapid display of a noise parameter not normally attempted with traditional audio measuring sets. **Spectral-Noise Density**[10] can be easily determined and displayed. This is a plot of noise against frequency. This permits much more accurate evaluation of systems that alter or improve noise performance such as the

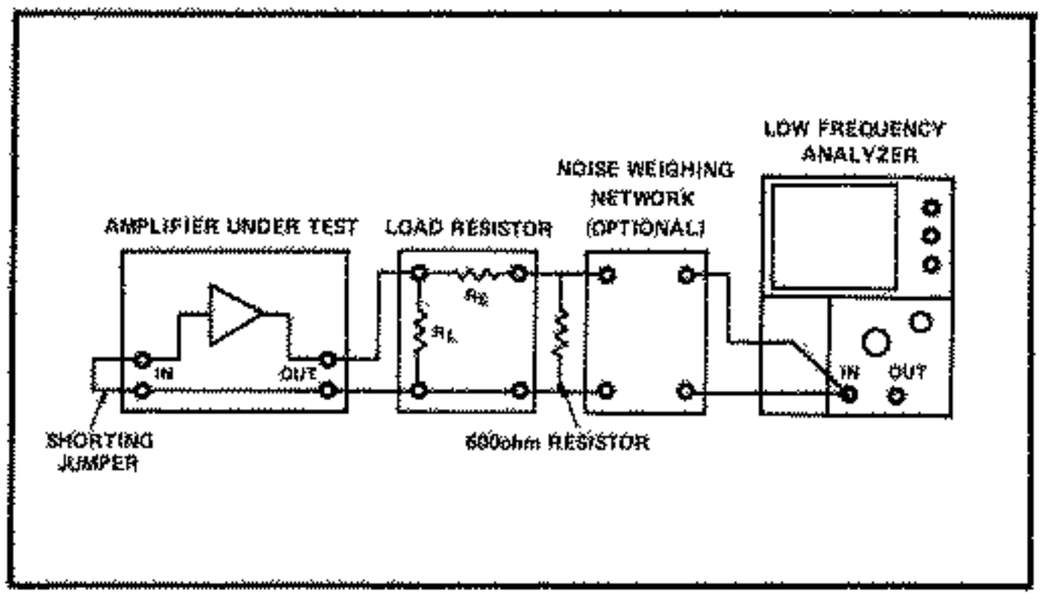


Figure 35 Equipment Connections to Measure S/N

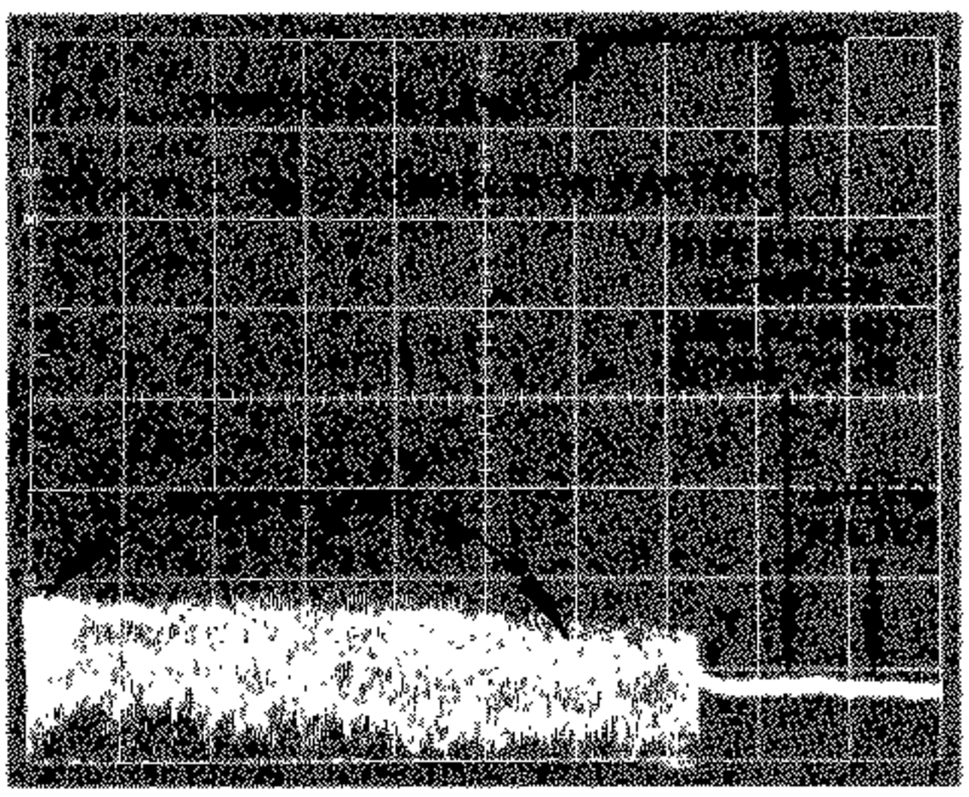


Figure 36 Measuring the Noise Floor

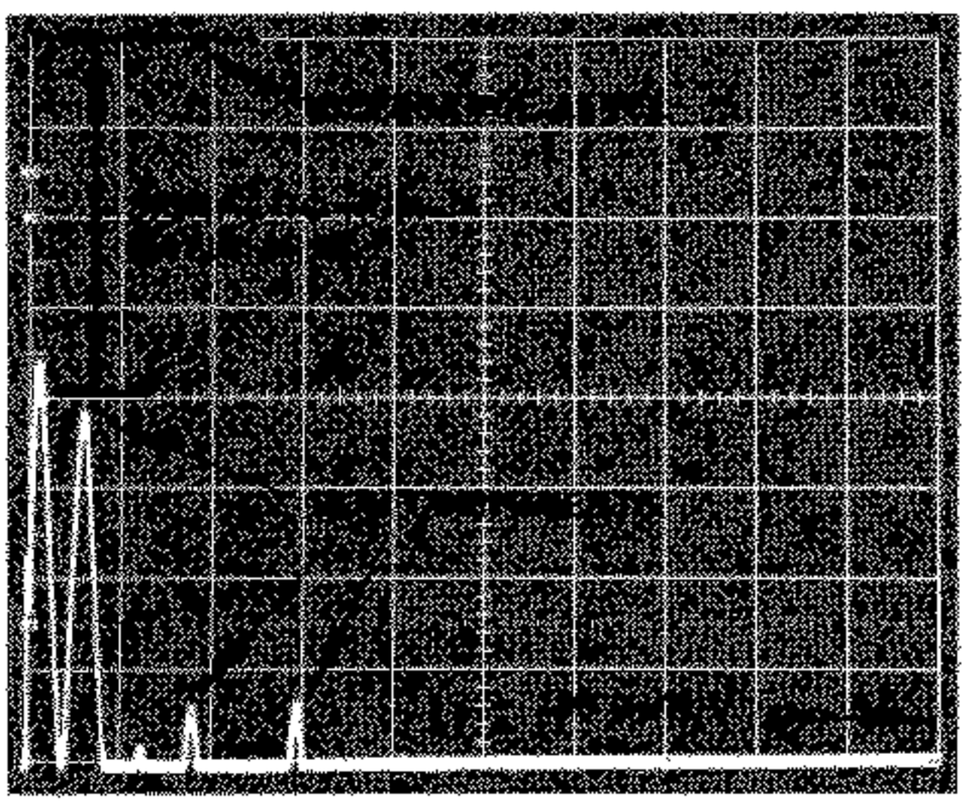


Figure 37 Example of S/N and Hum Measurements

Dolby systems, tape systems, FM receiving systems, and some modern preamplifiers.

Signal to Hum Ratio is measured while checking Spectral-Noise Density by comparing the residual 60 and 120 Hz components to the rated output of an amplifier. Hum is generally output signal components from the powerline frequency. In some modern amplifiers a high frequency power supply of 1 kHz or even supersonic (above 20 kHz) frequencies may be used. The residual signals from these frequency supplies must also be measured.

To produce a standard specification, it may be necessary to measure the weighted signal to noise ratio (WSNR).[11] The mathematically inclined can calculate this from the Spectral-Noise Density readings or one can use weighting filters with the tangential[12] method of measuring noise.

This technique is described briefly at the end of the Signal to Noise procedure.

Procedures

1. Set up the equipment as shown in Figure 35. Apply a 1000 Hz tone from the audio signal generator to the amplifier input. Adjust the signal level so the amplifier is driven at rated power output (volume control maximum) as indicated by the 2 dB/DIV display of the spectrum analyzer.

2. Set the RESOLUTION bandwidth to 3 kHz and select a span of 2 kHz/DIV.

3. Switch to the 10 dB/DIV display mode and note the amplitude of the 1000 Hz tone. This will be the **Signal Reference Level (VS).**

4. Switch the 1000 Hz tone off, install a shorting jumper and observe the noise floor on the display. Use the analyzer VIDEO FILTER to average the noise so the **amplitude of the noise floor (VN)** can be measured as shown in Figure 36.

5. The difference in amplitude (Figure 37) between the signal reference level and the noise floor, less a correction from the measured bandwidth (3 kHz) to the desired bandwidth (15 kHz), is the signal to noise ratio. The correction factor to be subtracted is 7 dB. Example: S/N equals VS minus VN minus Correction Factor; S/N equals 0 dB −72 dB − (−7 dB) = −65 dB (S/N).

6. If the noise floor does not appear flat, use a narrower RESOLUTION bandwidth to determine if the noise is, in fact, uneven, or if another problem such as hum is causing an uneven display. The shape of the noise floor from 20 Hz to 20 kHz is the Spectral-Noise Density, Figure 38.

---

9. "Standards on Electron Devices: Methods of Measuring Noise," Proc. IRE, Vol. 41, Pages 890-896, July 1953.

10. "Standards on Sound Recording and Reproducing: Methods and Measurement of Noise," Proc. IRE, Vol. 41, Pages 508-512, April 1953.

11. RETMA Standard Amplifiers for Sound Equipment, SE-101-A, July 1947, Reprinted by EIA, May 1973.

12. Gary Franklin and Troy Hatley, "Don't Eyeball Noise," Electronic Design 24, Pages 184-187, November 22, 1973.

Notes:

1. If the noise floor is below 80 dB, the gain of the analyzer can be increased in 10 dB steps until the noise floor is visible. Every step adds 10 dB spread between the signal and noise floor.

2. Signal to hum ratio can be determined by measuring the amplitude difference between the Signal Reference Level (step 3) and any 60 or 120 Hz hum components. An example is shown in Figure 37.

3. Signal to noise and signal to hum should be rechecked through different amplifier inputs and with reduced volume control settings to determine the exact characteristics of these parameters.

I. WEIGHTED SIGNAL TO NOISE

Weighted Signal to Noise measurements can be made using an oscilloscope display to measure the RMS amplitude of the noise. Unfortunately, it is not easy to "eyeball" the amount of noise on the screen; therefore, the tangential technique was derived to permit rapid, repeatable measurements of noise.

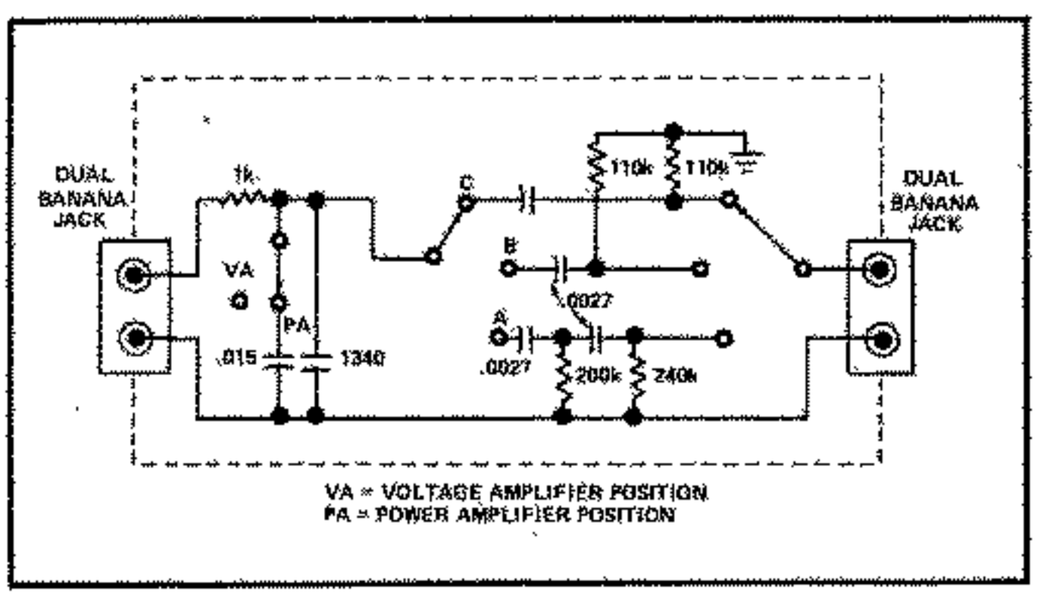


Figure 39 Weighting Network

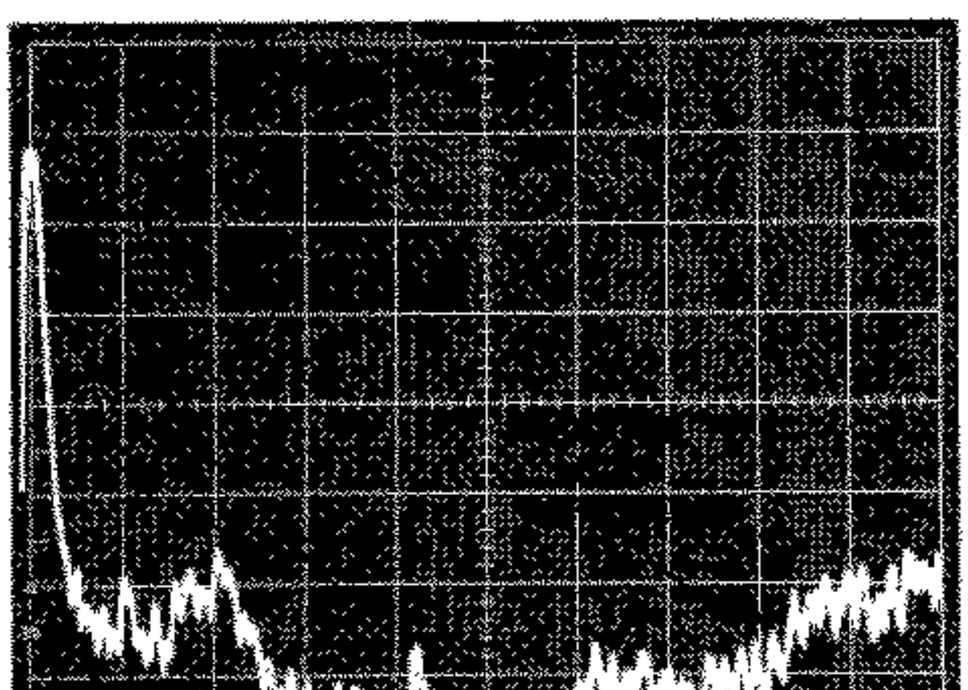


Figure 38 Spectral Noise Density Display

Various weighting filters may be specified for different kinds of equipment. The schematic of one commonly used type is shown in Figure 39.

To measure noise as recommended by the EIA standard the B section of the weighting filter shown in Figure 39 should be inserted in the test setup as shown in Figure 40.

Procedures

1. Set up the equipment as shown in Figure 40. Short the amplifier input. A dual trace vertical plug-in such as the Tektronix 5A18N must be used. If this procedure is used without a weighting filter, some form of a frequency limiting filter (usually a 15 kHz low pass) MUST be used.

2. Connect the noise to both vertical channels simultaneously in the alternate-sweep mode. Two noise traces will appear (Figure 41).

3. With both channels identically calibrated, adjust the voltage offset until the dark area between the two traces just disappears (Figure 42).

4. Disconnect the inputs and measure the separation between the two traces in volts. This is VN (Figure 43).

5. The ratio between the voltage at rated power output and the noise VN is the signal to noise ratio.

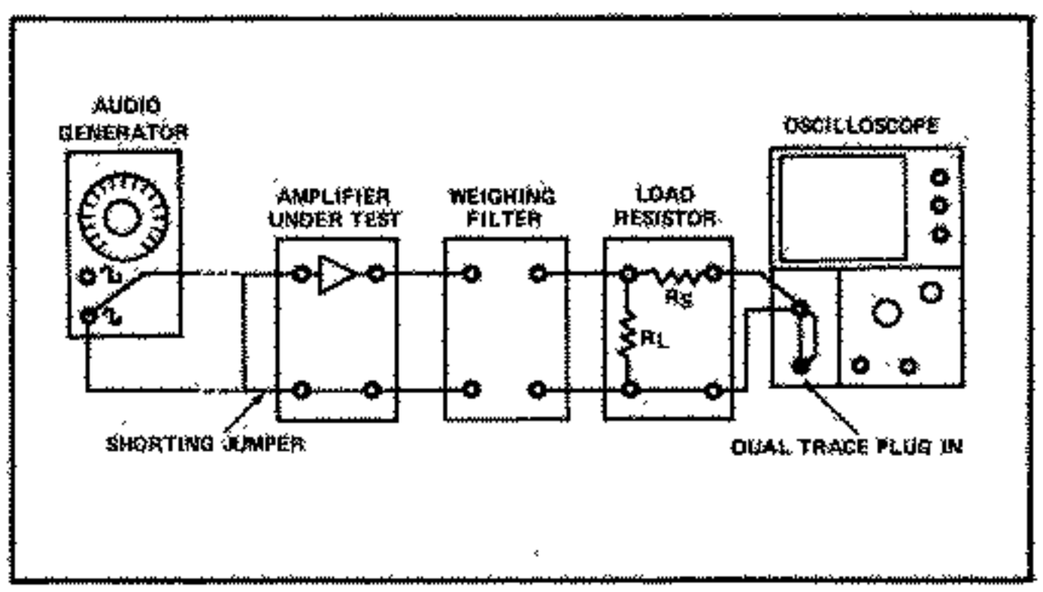


Figure 40 Equipment Setup for Weighted Signal to Noise Tests

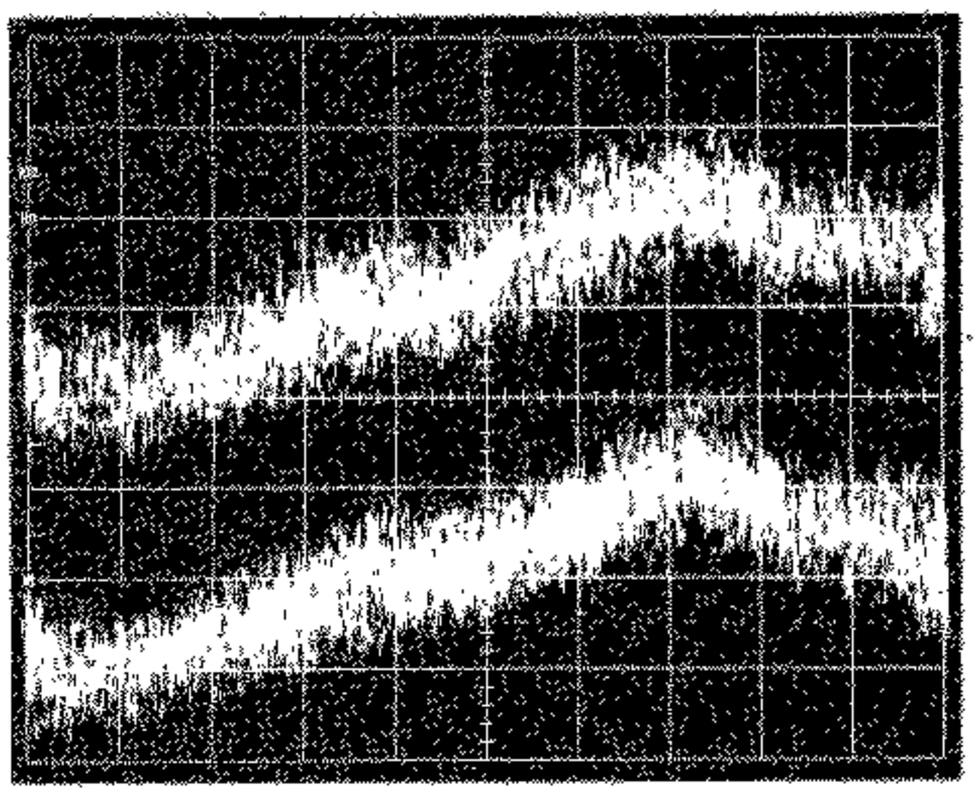


Figure 41 Dual Trace Display of Noise

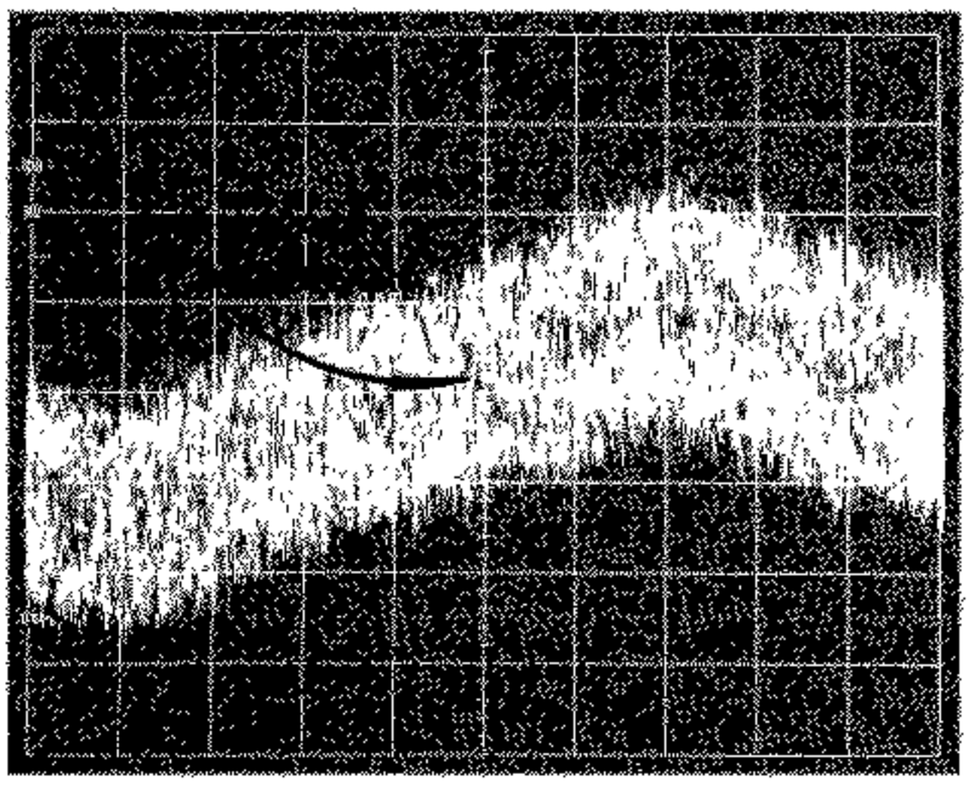


Figure 42 Offset Adjusted until Dark Area just Disappears

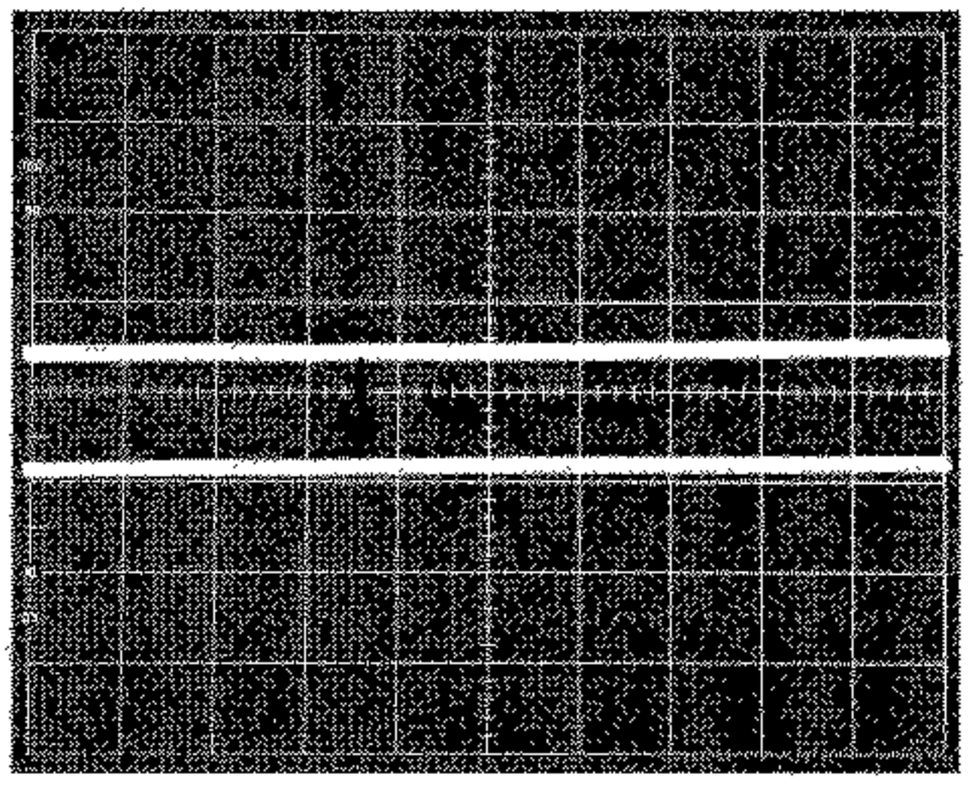


Figure 43 Measuring Separation between Two Traces

Square Wave Response

Square Wave Response is measured by passing first a 50 Hz then a 10 kHz square wave through an amplifier operating at its rated output. The resultant waveform provides a quick check of a number of parameters including frequency response, transient response, group delay, and distortion. This is strictly an oscilloscope type measurement once the rated power is determined.

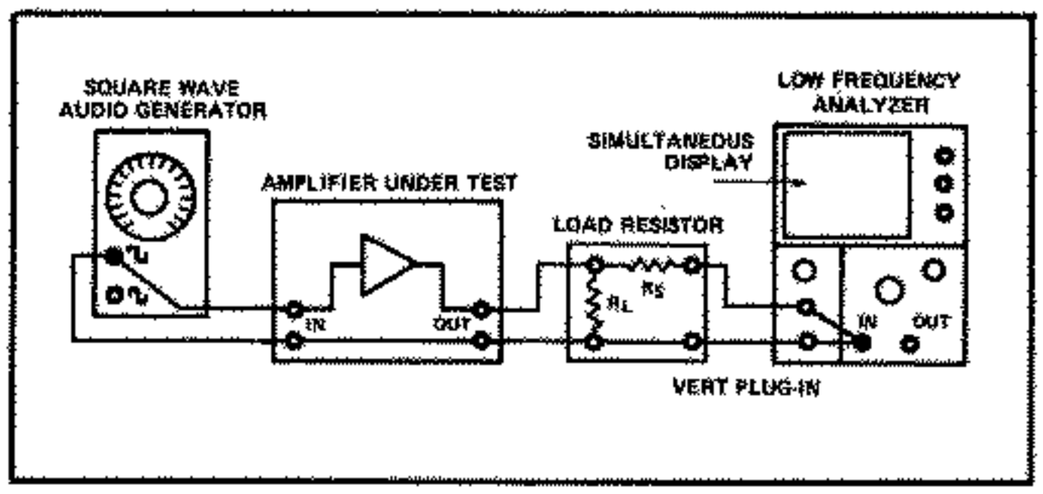


Figure 44 Equipment Setup for Square Wave Response

Procedures

1. Set up the equipment as shown in Figure 44. The square wave output of the Audio Generator (SG502) is applied to the amplifer. The output of the amplifier is connected through the load-matching combination network and split into both the low frequency spectrum analyzer and an amplifier plug-in unit. Set the amplifier controls for a flat response and the volume control to maximum.

2. The amplifier is driven at rated power output using a 50 Hz square wave. Rated power indication on the analyzer will be 2 dB below the rated power for a single tone, because the square wave spectrum contains less fundamental frequency power than a sine wave.

3. Observe the resultant square wave response of the vertical amplifier plug-in.

4. Change the square wave generator frequency to 10 kHz and observe the vertical amplifier response (Figure 45).

5. Some information to look for is: Rounded corners indicating frequency response deficiencies; transients which indicate damping or phase problems; and axis shift of the 50 Hz square which indicates poor low frequency coupling.

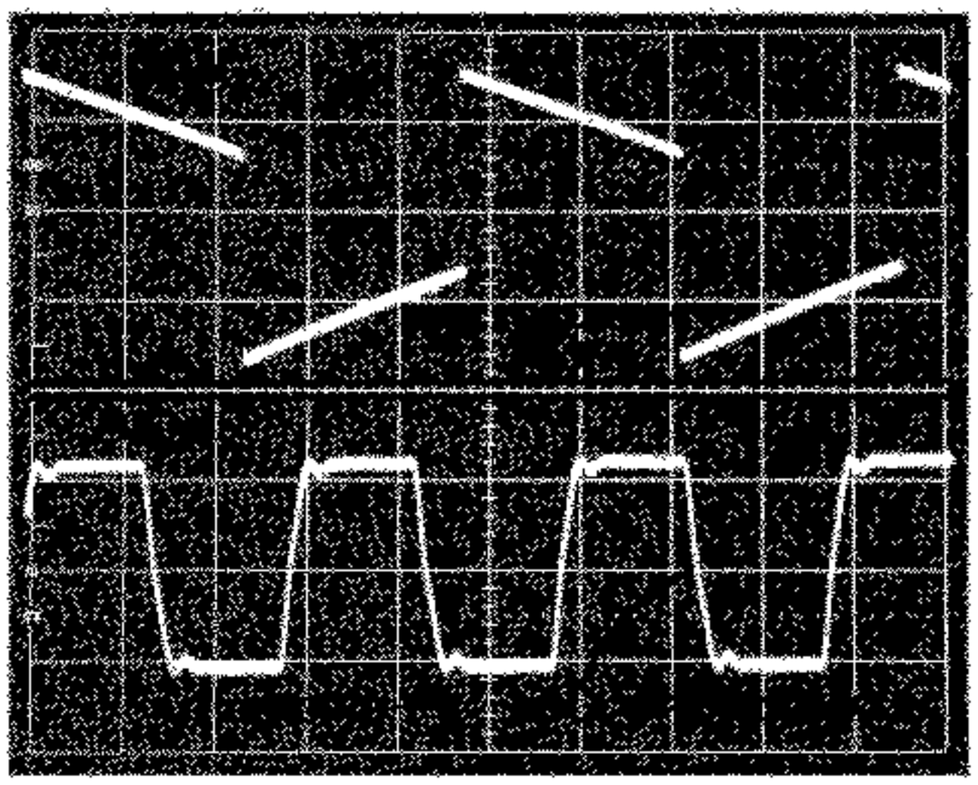


Figure 45 Display of 50 Hz and 10 kHz Square Waves

Crosstalk

Crosstalk is the amount of signal that leaks or spreads from one channel of a system into another channel or channels of the system. It is measured by driving all channels except one to rated output, then measuring the amount of signal that leaks into the idle channel. Crosstalk is usually expressed in dB's and is the ratio of the rated power output to the signal level on the idle channel.

With the Low Frequency Spectrum Analyzer, we can easily go one step further and measure the crosstalk at all frequencies from 20 Hz to 20 kHz, obtaining a display of crosstalk versus frequency in dB.

The EIA standard calls for separation (crosstalk) to be measured at 3 dB less than the Rated Power Output.

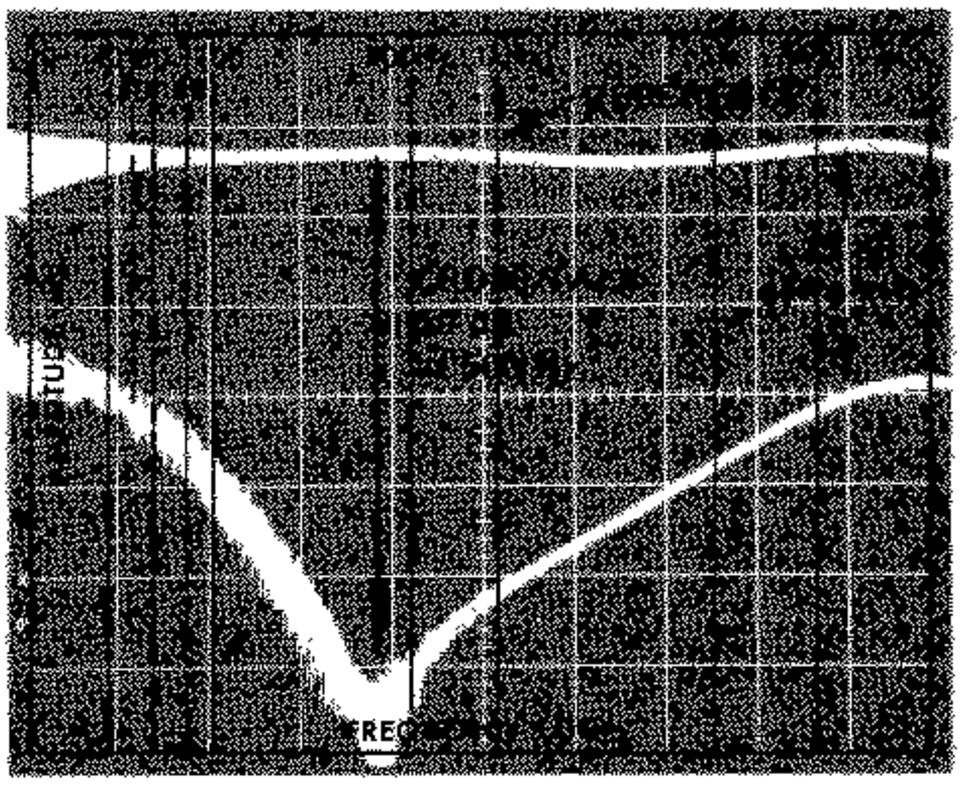


Figure 47 Crosstalk from One Channel to the Other

Procedures

1. Set up the equipment as shown in Figure 46. The switches may be deleted by plugging the input signal into various jacks as desired. All channel outputs must be properly terminated and unused inputs have a shielded matching resistor and not a shorting jumper connected from input to ground. Set all controls for a flat response and the volume control to maximum.

2. When testing four channel amplifiers, all the channels, except the one being measured, should be driven at rated power output.

3. Drive one channel to rated power output, using a 1000 Hz tone from the tracking generator output. Then sweep the channel using the LOG SWEEP to obtain a reference response.

4. Switch the analyzer input to the other channel and, using the LOG SWEEP MODE and log graticule, observe the crosstalk signal level in dB with respect to the reference response. The drop in dB from the rated power reference established on the other channel can be measured by using the 10 dB/DIV display mode on the spectrum analyzer (Figure 47).

5. Repeat the check on each adjoining channel.

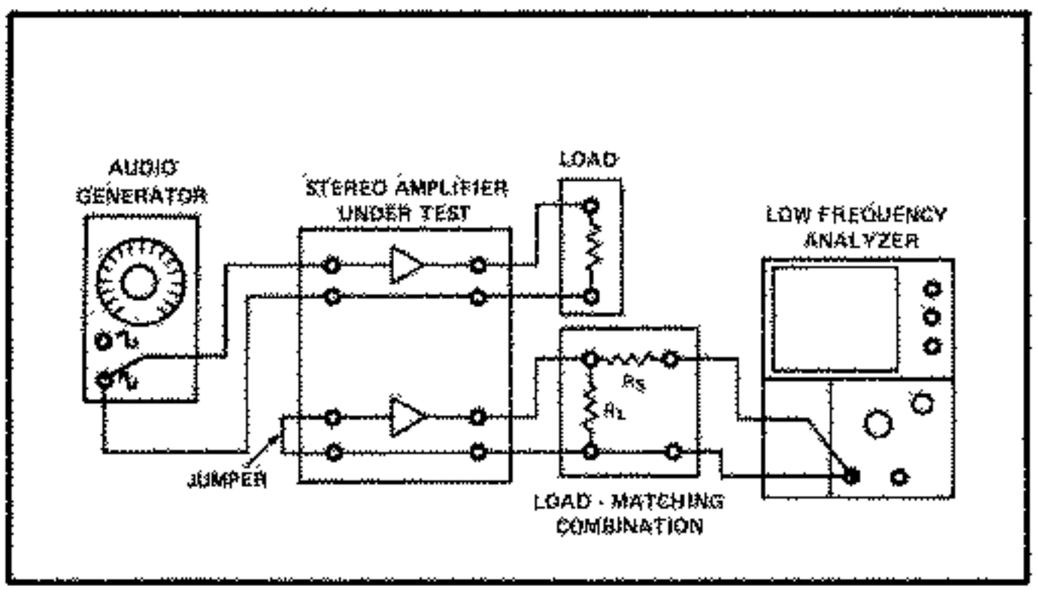


Figure 46 Setup for Measurement of Crosstalk

Sensitivity

Sensitivity checks determine how much signal (in volts) must be applied to each input terminal to drive an amplifier to its rated or some reference output. The overload point for each input is usually determined while making the sensitivity checks.

Procedures

1. Connect the equipment as shown in Figure 48. The switch is convenient though not absolutely necessary for this measurement.

2. Start with any amplifier input and use a 1000 Hz tone to drive the amplifier to its rated power output. The volume control and any input gain controls MUST be set at maximum.

3. Once rated power output is reached, switch the signal to the analyzer input. Select the LIN display mode and read the input voltage amplitude required to achieve amplifier rated power output. This voltage is the SENSITIVITY rating of the amplifier input tested.

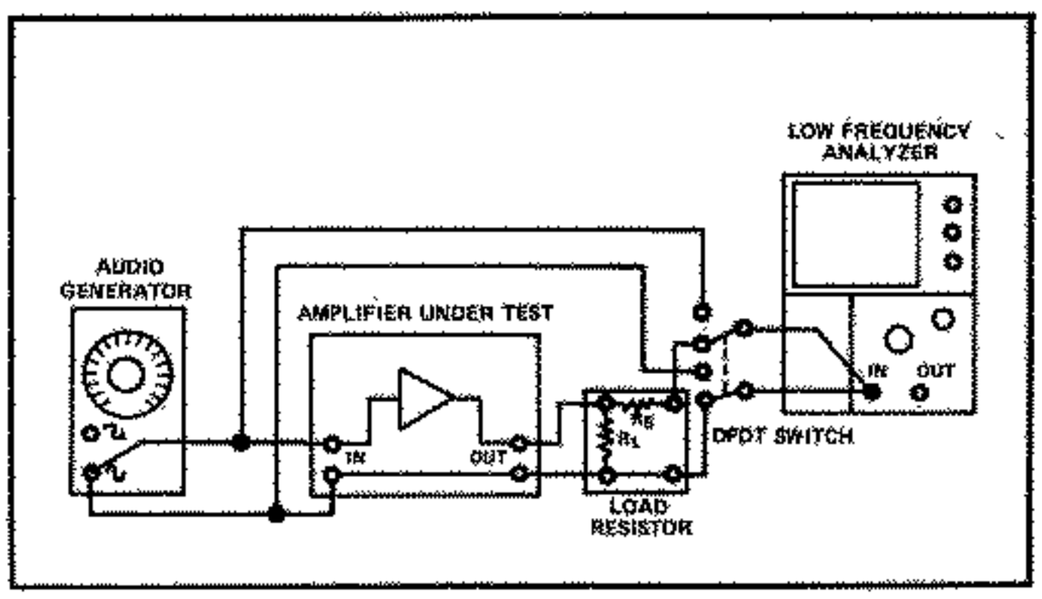


Figure 48 Sensitivity Equipment Setup

4. Using the THD procedures (part III), begin reducing the volume on the amplifier to indicate below rated output while increasing the level of the 1 kHz tone until the 2nd and 3rd harmonics increase more rapidly than the input signal. Remeasure the input voltage. This is the overload point for that input.

5. Continue this procedure for all inputs on the amplifier recording the results (Figure 49).

	SENSITIVITY FOR 10W OUTPUT		
	LEFT	RIGHT	(TYPICAL) OVERLOAD
PHONO HI	1.15mV	1.13mV	57mV
PHONO LO	.38mV	.38mV	21mV
AUX 1	63mV	61mV	3.4V
AUX 2	62mV	60mV	3.4V
TAPE MONITOR	105mV	103mV	8.1V
TUNER	63mV	61mV	3.4V
TAPE HEAD	.41mV	.41mV	20.5mV

Figure 49 Recorded Results of Sensitivity and Overload Tests

Transient Intermodulation Distortion

Transient Intermodulation Distortion (TIM)[13] is distortion in amplifiers that occurs principally during loud, high frequency passages. Most music contains some material that can cause TIM distortion. Amplifiers with large amounts of negative feedback are prone to TIM distortion because the amplifier loop, if improperly designed, requires too much time to respond to rapid transients.

Ever since the introduction of the transistor power amplifier, the "transistor sound" has been discussed. Even though in many cases a transistor amplifier tested better in terms of distortion than a tube counterpart, during a listening test the tube unit would unmistakably perform better. TIM distortion is one explanation of these discrepancies. Transistor amplifiers test excellent using steady state harmonic and intermodulation tests. However, music material generates amplifier distortion because of its transient nature.

A popular explanation of the source of TIM is that the transient reaches or exceeds the slew rate of the amplifier causing an instant, severe intermodulation condition until the negative feedback signal catches up with and corrects the distortion.

No measurement standards exist to date.[14] However, a square wave with a high frequency sine wave has been used to observe this distortion.

Presented below is a technique that used a 6 kHz sine wave mixed with a 500 Hz square wave to demonstrate TIM distortion. However, no single number results to adequately indicate the amplifier's performance.

Procedures

1. Connect the equipment as shown in Figure 50. Two SG502 Audio Generators must be combined as shown, one set to produce 500 Hz square waves, the other 6 kHz sine waves. A FG501 may be substituted for the square wave source. The square wave used should have excellent symmetry.

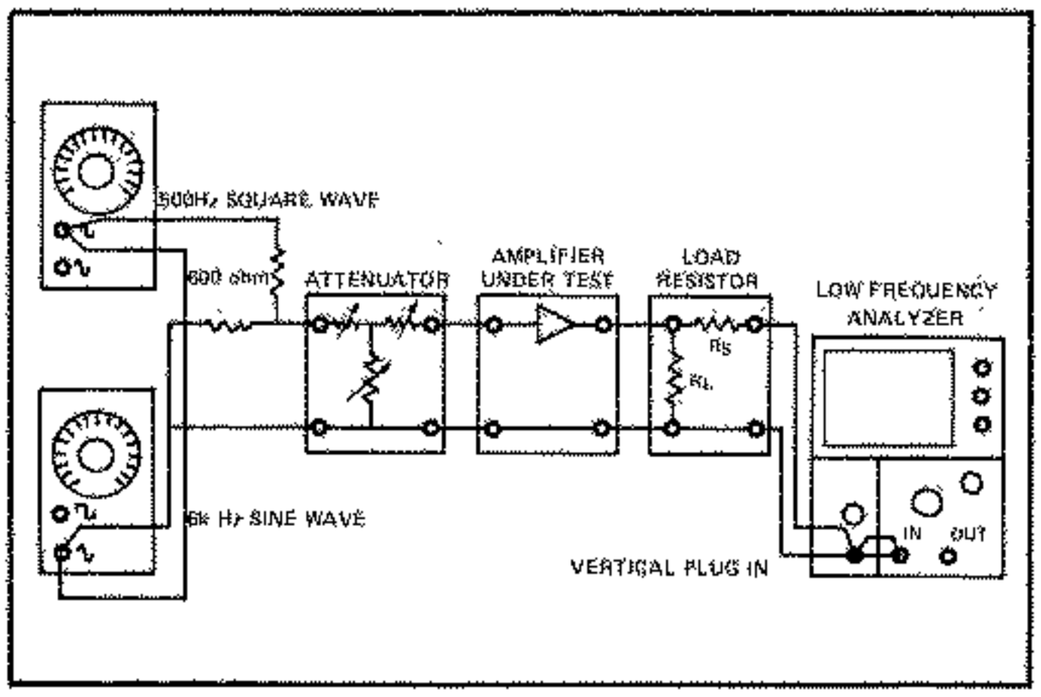


Figure 50 Equipment setup for TIM demonstration

2. Temporarily bypass the amplifier and set up the generator levels in a voltage ratio of about 5:1. Then carefully adjust the frequency of the 6 kHz generator until a stationary pattern is obtained similar to the top trace in Figure 51.

3. Reconnect the amplifier and remove attenuation until 50% of rated power is indicated by the 500 Hz fundamental on the analyzer display.

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13. Matti Otala, "Transient Distortion in Transistorized Audio Power Amplifiers," IEEE Transactions on Audio...., Vol. AU-18, No. 3, Page 234, September 1970.

4. One of the characteristics of TIM may appear on the oscilloscope display as in the lower trace of Figure 51. This display shows a temporary "swamping" of the 6 kHz tone immediately after the 500 Hz transition.

5. Bypass the amplifier again and select 1 kHz/DIV in the LINEAR sweep mode on the spectrum analyzer. Manually select a resolution bandwidth so that good sideband resolution is obtained as shown in Figure 52.

6. Observe the pattern obtained directly from the source. Note that the even harmonics of the 500 Hz signal are suppressed (Figure 52).

7. Reconnect the amplifier and note that TIM may be observed as 1 kHz sidebands of the 6 kHz signal as shown in Figure 53.

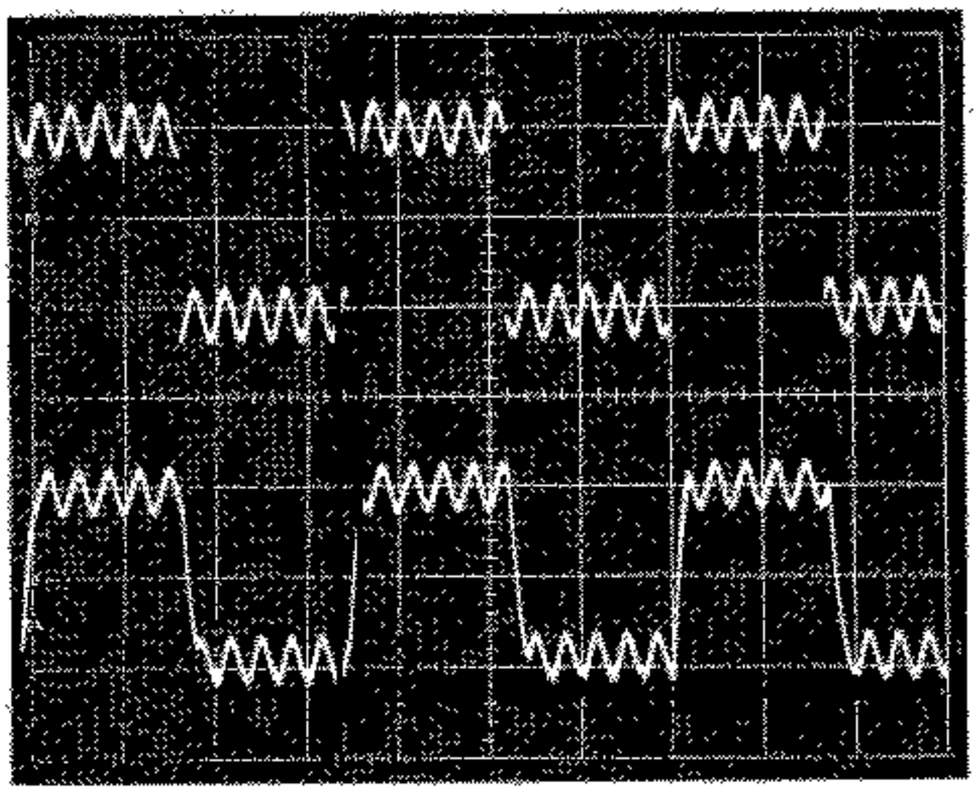

Figure 51 TIM Display in the Time Domain

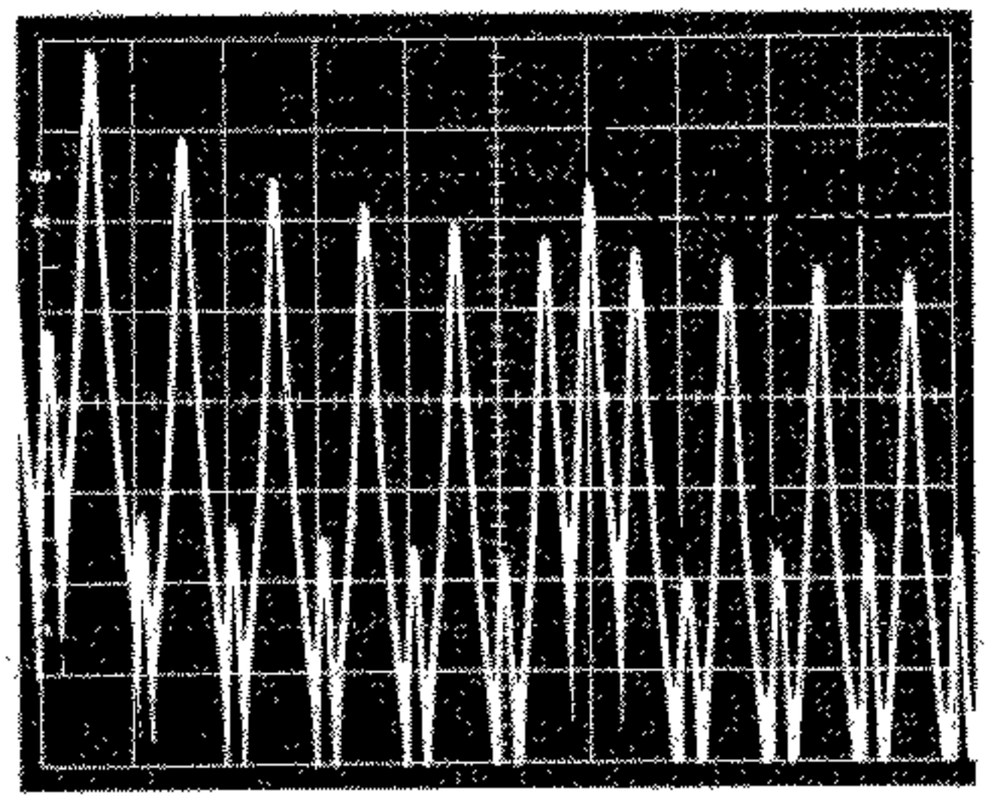

Figure 52 500 Hz 6 kHz source signal for TIM demonstration

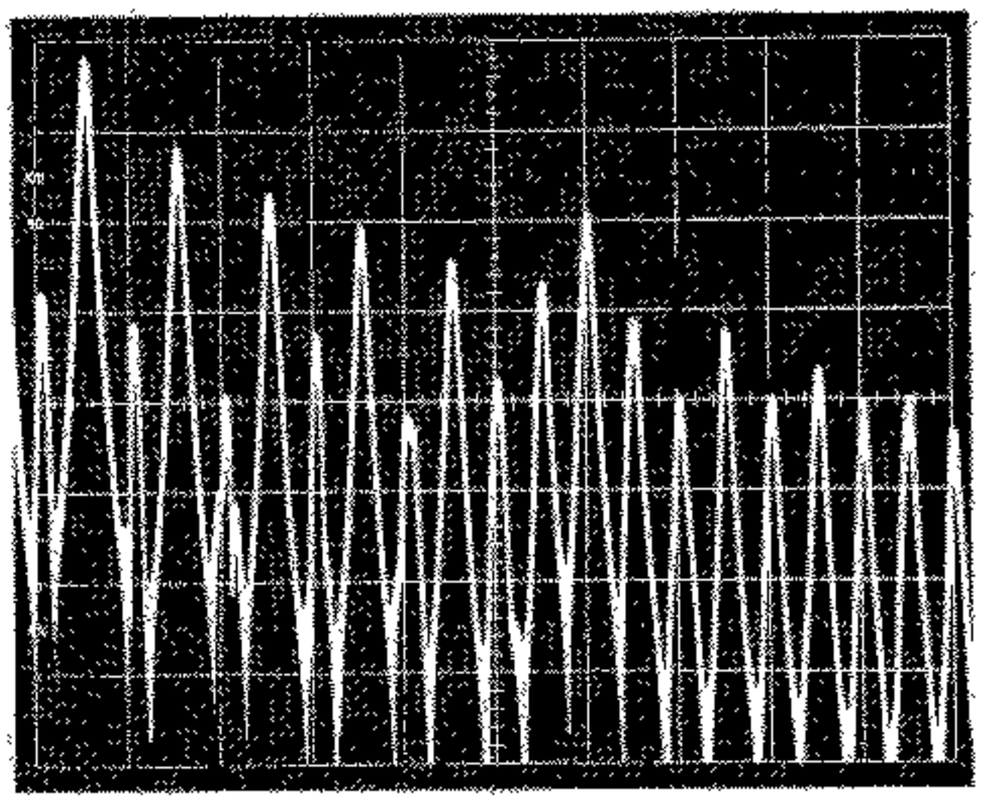

Figure 53 TIM Display in the Frequency Domain

14. W. Marshall Leach, "Transient IM Distortion in Power Amplifiers," Pages 34-41, Audio, February 1975.

SERVICING HINTS

The combination Low Frequency Spectrum Analyzer--Oscilloscope offers tremendous flexibility to permit rapid servicing of high quality Hi-Fi and stereo equipment. An oscilloscope probe can be connected directly to the front panel of the 5L4N making it easy to pinpoint problem areas.

While it is impossible to list all the steps and techniques one might use, the following are some of the things we came across while preparing this applications brochure.

A. BIAS VOLTAGE ADJUSTMENT

The adjustment of bias voltage on the output stage is traditionally done with a voltmeter or a distortion analyzer. The Low Frequency Analyzer can be connected to an amplifier and using a single tone (like 1 kHz) the bias can be quickly set for minimum harmonic amplitude. Then the output power can be reduced and the low level crossover distortion that sometimes occurs can be double checked.

B. INAUDIBLE FREQUENCIES

Sometimes a Hi-Fi system doesn't seem to perform correctly and the problem can be traced to overloading or distortion due to INAUDIBLE frequencies being passed by the amplifier.

The more common causes of these frequencies are inaccurate adjustment of the stereo traps (letting 19 and 38 kHz into the audio channel); tape recorder bias traps improperly adjusted; improper bypassing of inputs letting radio frequency energy into the amplifier; and sometimes an amplifier will just oscillate all by itself.

By using the 10 kHz/DIV MODE of the analyzer routinely when checking an amplifier, these kinds of problems will be immediately visible. Figure 54.

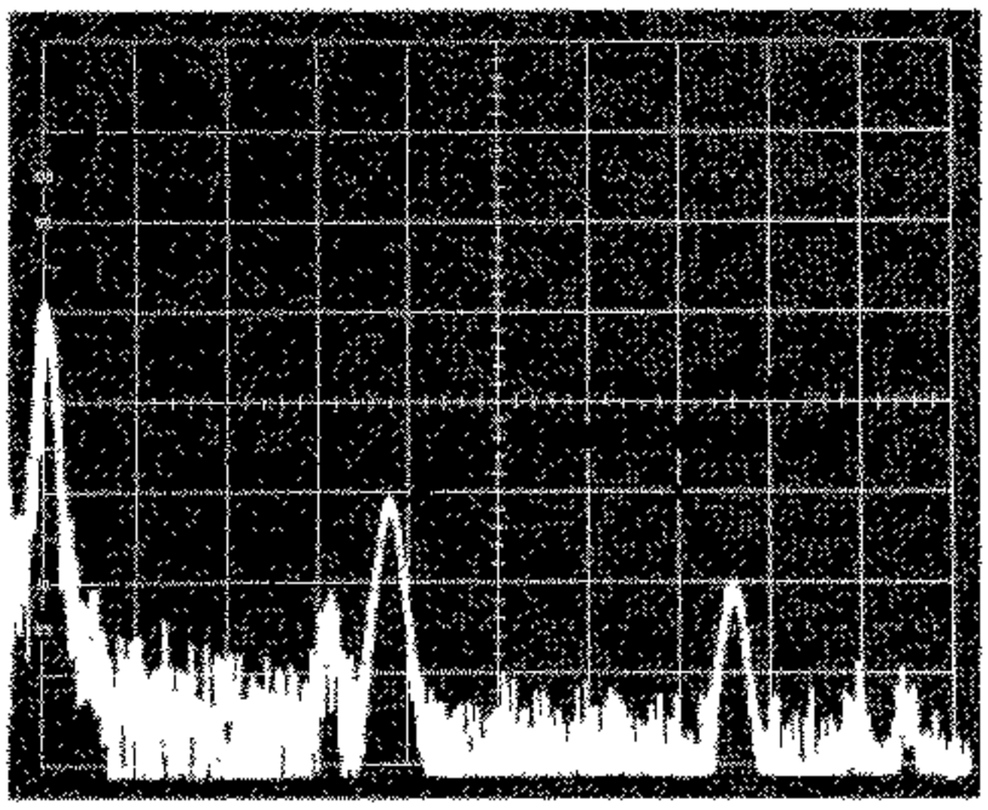

Figure 54 Misadjustment of stereo traps in Hi-Fi receiver

C. STAGE BY STAGE GAIN CHECK

Stage by Stage Gain Check are often used to find the source of a weak or distorted channel in an amplifier system. A modification of the stage by stage check can be performed with the Low Frequency Spectrum Analyzer using the tracking generator output. Insert the tracking generator into an amplifier input, and using a X10 oscilloscope probe, begin at the input stages of the amplifier and monitor the input and output of each stage.

Channels can be compared to each other or gain and response can be checked against the manufacturers' recommendations. Certain problems will be immediately obvious if they exist.

1. Gain differences will show up on the display.

2. Low frequency rolloff will indicate such things as defective stage coupling or output coupling capacitors.
3. High frequency rolloff could indicate defective emitter bypass capacitors or other associated problems.

The test can then be repeated with no signal on the amplifier input, watching the noise floor. A high noise floor rise between stages is characteristic of a defective or hot component.

Finally, using a 1 kHz tone, a stage by stage check can be performed while watching the 2nd and 3rd harmonics for signs of a stage with higher than normal distortion. Typically, the output stage should contribute most of the distortion in an amplifying system.

D. STYLUS PRESSURE ADJUSTMENTS

Phono cartridge weight adjustments are often one of the least understood areas of Hi-Fi. The manufacture attempts to recommend the lowest stylus pressure that produces minimum distortion. By using a continuous tone test record, and starting with a new stylus, the pressure is increased progressively until the lowest distortion (2nd and 3rd harmonics) of the tone are noted. This test can be easily duplicated in the shop using the low frequency analyzer.

A little imagination, and a low frequency spectrum analyzer can go a long way toward taking the mystery out of Hi-Fi repairs. Other equipment such as tape recorders, speakers, and electronic instruments (like organs) can be analyzed. Complete PA systems used in auditoriums can be swept and analyzed, or the acoustics and noise levels of an auditorium could be checked.

This pamphlet only covers one small application area for the low frequency analyzer. We hope that you will have an opportunity to experiment with our applications and expand them to fit your individual needs.

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STANDARD AUDIO TEST FORM

EQUIPMENT TESTED	PERSON PERFORMING TESTS
Manufacturer _____	_____
Model _____	_____
Serial No. _____	_____
	Date _____

POWER OUTPUT FOR _____ % OF THD

CHNL A _____ w CHNL C _____ w

CHNL B _____ w CHNL D _____ w

S/N at RATED POWER _____

DAMPING FACTOR _____

OUTPUT IMPEDANCE _____

INSERT PHOTO

Response at 10% , 50%, and 100% power

INSERT PHOTO

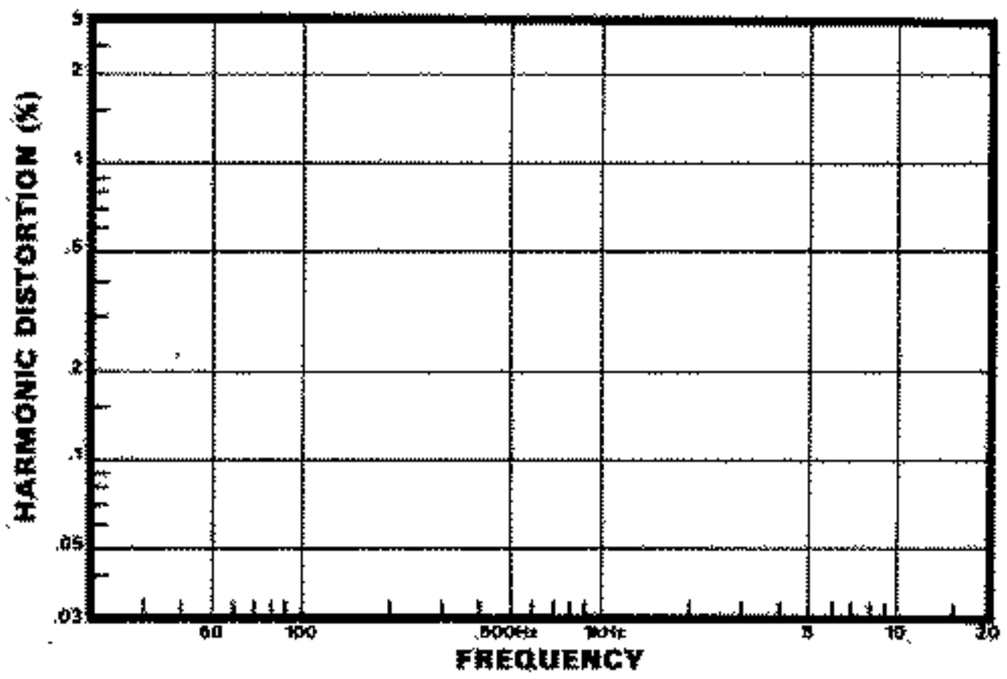
Tone control response at 50% power

INSERT PHOTO

Spectral - noise density

INSERT PHOTO

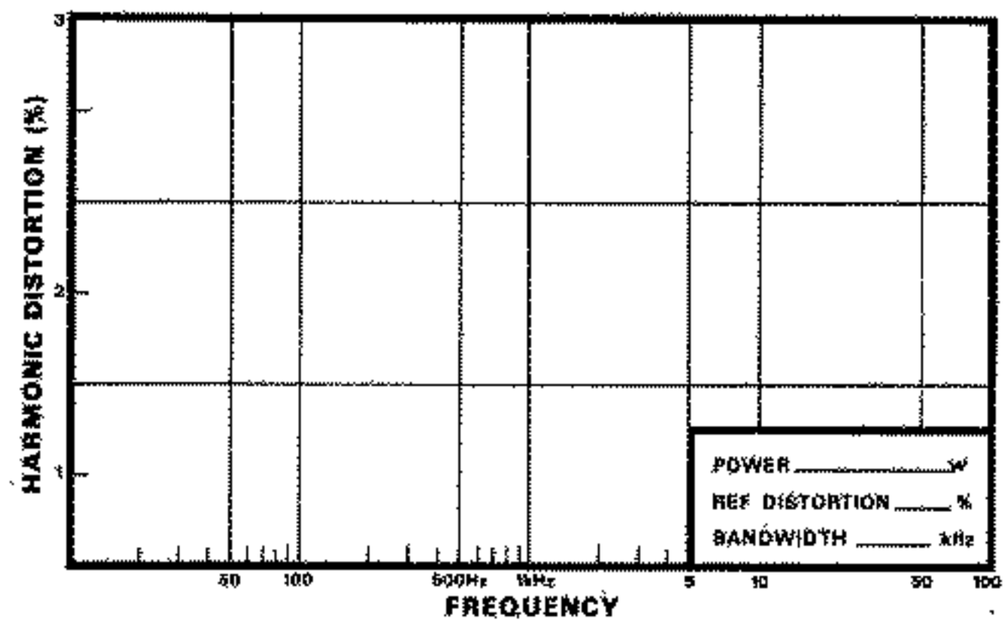
Square wave response 50 Hz - 10 kHz



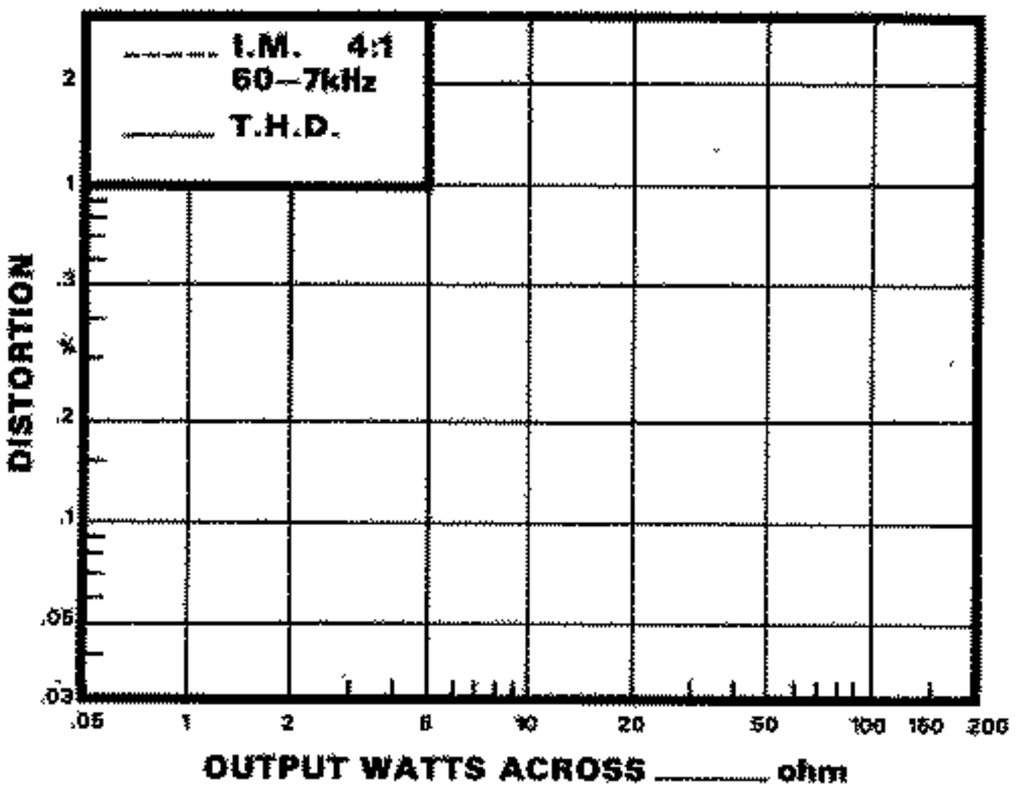
Harmonic distortion (THD)

	SENSITIVITY FOR OUTPUT		
	LEFT	RIGHT	(TYPICAL) OVERLOAD
PHONO HI			
PHONO LO			
AUX 1			
AUX 2			
TAPE MONITOR			
TUNER			
TAPE HEAD			

Sensitivity & Overload



Power bandwidth



Distortion and power

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SPECTRUM ANALYZER
INTERIM

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INSTRUCTION MANUAL

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SPECIFICATIONS -- 5L4N INTERIM

SECTION 1

GENERAL INFORMATION AND SPECIFICATIONS

Introduction

This is an interim manual containing some of the information that will be provided in the final manual. The manual (final) will be divided into ten major sections that provide the following information.

Section 1 -- General Information and Specifications: Contains the instrument description and specifications.

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

Section 3 -- Performance Check: Provides procedures to check the operational performance of the instrument plus additional performance check procedures that require test equipment to verify that instrument performance is in accordance to specifications.

Section 4 -- Calibration Procedure: Describes test equipment setup and adjustment procedures required to calibrate the instrument.

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 10. Troubleshooting procedures plus general information that may aid in servicing the instrument are also provided.

Section 7 -- Options and Modifications: Provides data on production options available.

Section 8 -- Electrical Parts List: Provides information necessary to order replaceable parts and assemblies.

Section 9 -- Diagrams: Provides functional block diagram and detailed circuit schematics. Located adjacent to the diagram (usually on the back of the preceding diagram) are pictorial layout drawings which show sub-assembly and component locations. IC logic diagrams, waveforms and voltage data, for troubleshooting or circuit analysis, are also provided adjacent to or on the diagram.

Section 10 -- Mechanical Parts List, Exploded Drawings and Accessories: Provides information necessary to order replaceable parts. The Parts List is cross-referenced to the Electrical Parts List. Exploded drawing shows sequence of assembly and identifies assemblies.

Section 11 -- Changes and Corrections: Provides updating information for the manual in the form of inserts. These inserts are incorporated into the manual text and diagrams when the manual is updated.

SPECIFICATIONS -- 5L4N INTERIM

Description

The 5L4N Spectrum Analyzer is a high performance, low frequency spectrum analyzer that plugs into and operates with the 5000-Series mainframe oscilloscopes. It is a swept front end analyzer which displays absolute amplitude information of signals within the frequency span of 0 Hz to 100 kHz.

The 5L4N features: Maximum sensitivity of -134 dBm (50Ω), -145 dBm (600Ω), -147 dBV (high Z) and 45 nV (Linear Mode). Intermodulation greater than 70 dB down. A differential (balanced) or single-ended input. Front panel imput impedance selections of 50 Ω, 600 Ω, or 1 MΩ shunted by 50 pF (high Z). A fully calibrated vertical display appropriate to input impedance selected, with 80 dB dynamic range. Reference level selections from -10 dBm/dBV to -130 dBm/dBV, and deflection factor from 50 mV/Div to 20 nV/Div. Incidental FM'ing less than 2 Hz. Variable resolution bandwidth from more than 3 kHz to less than 10 Hz and automatic resolution for all spans. Start or center frequency display selection. A tracking generator signal source. Two video filters for noise averaging. Internal, external or automatic triggered sweep.

The analyzer is a double width plug-in for the 5000-Series mainframe. It is used in the right vertical and horizontal spaces of a three plug-in mainframe.

ELECTRICAL CHARACTERISTICS

The following characteristics and features of the 5L4N Spectrum

Analyzer are applicable over the environmental specification criteria for the mainframe and after a warmup period of 30 minutes or more.

Frequency

Range: 0 to 100 kHz

Dial Readout Resolution: 500 Hz

Accuracy: ±3 kHz (FINE tune control midrange and Span/Div calibrated for 10 kHz)

Frequency Span

Calibrated spans from 10 kHz/Div to 20 Hz/Div, within 4%, in a 10-5-2 sequence, plus 0 Hz and LOG span are provided. The analyzer is a receiver in the 0 Hz position that provides time domain data within any selected resolution bandwidth, centered at the frequency tuned. The LOG position provides a full three decade logarithmic sweep from 100 Hz to 100 kHz.

Resolution

The resolution bandwidth is variable from 3 kHz or more to 10 Hz or less. An AUTO position (when the control is fully ccw in the AUTO detent) provides automatic resolution bandwidth compensation for the sweep rates less than 10 ms/div and frequency span combinations, including the LOG span sweep mode.

Shape Factor: Shape factor (from the 60 dB to 6 dB level) is 4:1 or less at 3 kHz, increasing to 10:1 or less from 10 Hz to 1 kHz. Line frequency sidebands of 50 Hz or more can be resolved up to 60 dB below the signal level.

Signal level change over the resolution bandwidth range is not more than 2 dB.

Stability

Within 30 Hz/10 min, at a fixed ambient temperature that is within the operating ranges.

Incidental FM

2 Hz (p-p) or less.

Video Filtering

300 Hz or 10 Hz of filtering can be selected to provide signal or noise averaging.

Amplitude Characteristics

Display Functions

10 dB/DIV: This mode provides a calibrated 80 dB dynamic range with an accuracy of .05 dB/dB to a total of 2 dB over the 80 dB dynamic window.

2 dB/DIV: This mode provides a calibrated 16 dB dynamic range with an accuracy that is within 0.1 dB/dB to a total of 1.0 dB over the 16 dB dynamic window.

LIN: V/DIV: This mode provides linear deflection with an accuracy that is within 3% of full scale, over the display window.

Display Range

Reference Level Selection (Log Mode)

Selection	Reference
dBV	0 dBV = 1 volt rms
dBm at 50 Ω	0 dBm (1 mW) = 223.6 mV rms
dBm at 600 Ω	0 dBm (1 mW) = 774.6 mV rms

Calibrated Reference Level Range and Accuracy

The display level is calibrated when the variable gain control is in the CAL detent (fully ccw). Variable control provides at least 10 dB increase in gain.

10 dB/DIV; Calibrated 10 dB steps from -10 dBm/dBV to -70 dBm/dBV, at the top of the display. Accuracy, with respect to the level for -40 dBm/dBV, is within 0.4 dB/10 dB to a total of 1 dB.

2 dB/DIV: Calibrated 10 dB steps from -10 dBm/dBV to -130 dBm/dBV, at the top of the display. Accuracy, with respect to the level for -40 dBm/dBV, is within 0.4 dB/10 dB to a total of 1 dB for -70 dBm/dBV and 2 dB for -130 dBm/dBV.

LIN/DIV: Calibrated steps in a 5-2-1 sequence, from 50 mV/Div to 20 nV/Div (rms). Accuracy is within 5% per decade to a total of 12% over the full range.

Display Flatness (20 Hz - 100 kHz)

Flatness within ±0.2 dB over any selected frequency span, with respect to the level of -40 dBV signal at 5 kHz.

CW Sensitivity (Signal level + noise = 2X noise)

The following characteristics are applicable with the input internally terminated or with a 600Ω or less source impedance:

Display Mode	Resolution Bandwidth 3 kHz	10 Hz
dBV	-123 dBV	-147 dBV
dBm 50 Ω	-110 dBm	-134 dBm
dBm 600 Ω	-121 dBm	-145 dBm
LIN	680 nV	45 nV

With the input open, displayed noise is the thermal noise of the input 1 MΩ/50 pF impedance.

Intermodulation Distortion (with the input signal level equal to or less than the reference level):

Third order products are down 70 dB or more from two -10 dBm/dBV signals, within any frequency span and 75 dB or more down from two -20 dBm/dBV signals, within any frequency span.

Spurious Signals from Internal Sources (Residual Response) with TRKG GEN and 5 kHz FREQ COMB OFF and the input terminated in an impedance of 600 Ω or less are:

Equal to or less than -130 dBm/dBV referred to the input

Line related spurii are less than -120 dBm/dBV

With high input impedance and single-ended, the high voltage oscillator in some mainframes causes spurii at 30 kHz and harmonics $\leq$100 dBV.

The zero (start) spur is less than -80 dBV or four divisions (10 dB/DIV) with -10 dBV to -40 dBV reference level range.

Input Characteristics

The INPUT connector is a floating two-conductor BNC connector that provides either a differential or single-ended input. Input selection is provided by a switch that grounds the outer conductor of the connector when it is in the SINGLE ENDED position. An accessory adapter (floating BNC to dual BNC) provides full shielding of the input signal leads.

NOTE

When operating in the DIFFerential mode, the INPUT connector is floating. The outer conductor therefore equals the voltage level of the external source. Since the external source voltage may be some high potential, the outer conductor voltage is clamped at ±10 V for safety.

Selectable input impedance provides; either high Z of 1 MΩ/50 pF, or internally terminated impedances of 600 Ω or 50 Ω ±2%.

Differential Input Characteristics

Common-mode signal range:	±10 volt

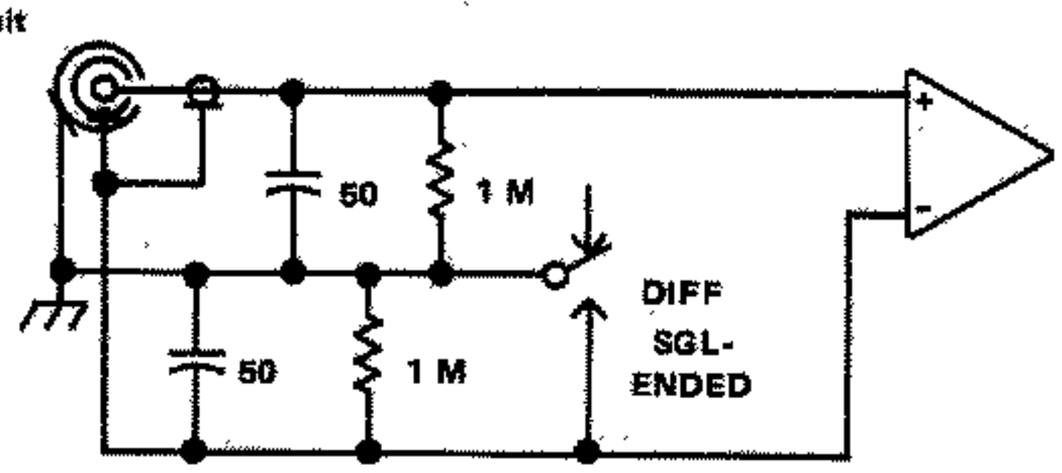
Maximum signal input:	
Low Z	5 volt (dc + peak ac); 250 mW at 50Ω, 125 mW at 600 Ω
High Z	100 volts (dc + peak ac); A fast-rise pulse signal ±30 V (or 4 V/μs) may open the 0.1 A input protective fuse.
Common-mode rejection ratio:	±70 dB

Single-ended Input Characteristics

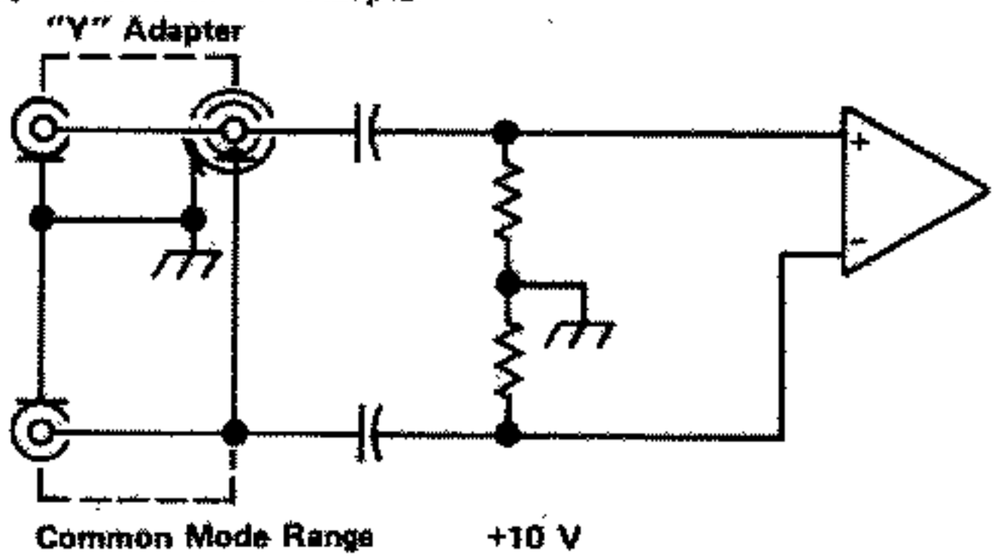
Maximum signal input for linear operation: -10 dBm/dBV (0.316 rms). Useful measurements can be performed with the input level 10 dB above the reference level. This overload condition will increase spurious responses but will not damage the input circuit.

INPUT CHARACTERISTICS AND IMPEDANCE SELECTORS

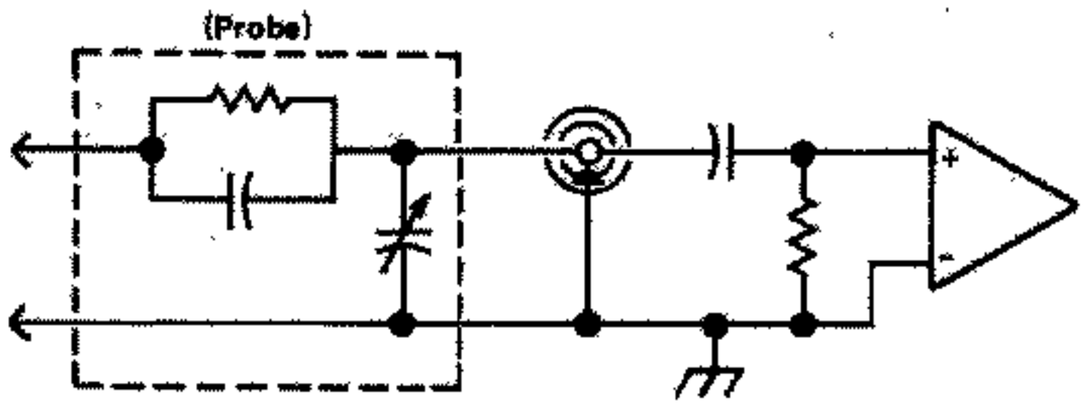
Basic Circuit



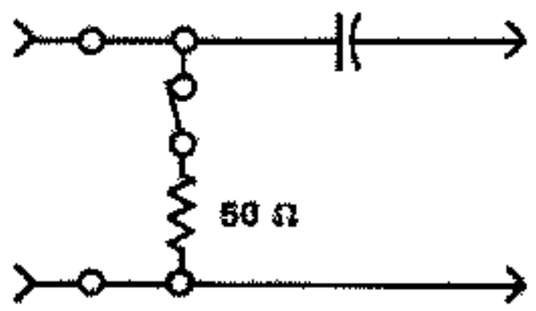
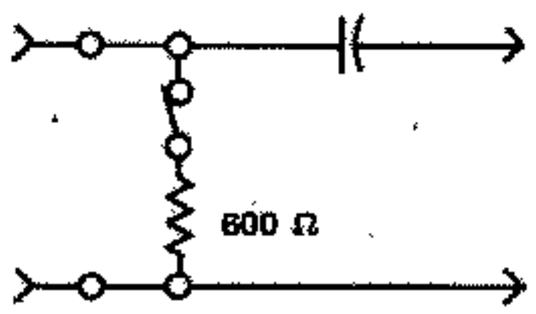
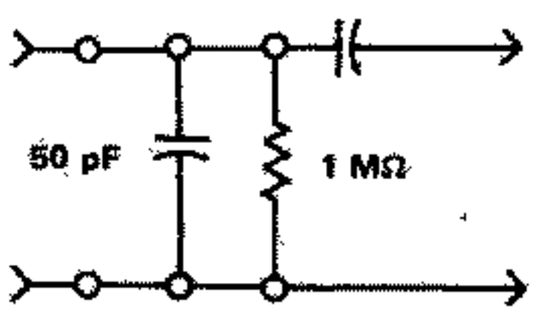
Differential Operation with "Y" Adapter



Single-Ended Operation with Probe



Impedance and Ref Lvl Selections

BUTTON	BASIC CKT	REF LVL
50 Ω		dBm (50 Ω)
600 Ω		dBm (600 Ω)
BOTH OUT		dBV

Sweep Characteristics

Linear Frequency Span: 20 Hz/Div, in a 10-5-2 sequence. Accuracy of the spans within 4%.

Log Frequency Span: 100 Hz to 100 kHz.

Zero Frequency Span: The analyzer operates as a tuned receiver for time domain analysis within the bandwidth (resolution) selected, centered at the tuned frequency.

Internal Sweep Source: Time base; 1 s/Div to 1 ms/Div within 5%, in decade steps. A 10X MULTR control increases this time to at least 10 s/Div and provides continuous sweep rate adjustment over the sweep rate range.

External Sweep: Requires 0 volt to 500 mV ±50 mV, from a 1 kΩ or less source, to sweep the full span. The 50 mV/DIV pushbutton must be depressed to externally sweep the analyzer.

Manual Sweep: Manual sweep is provided.

Triggering: Internal triggering from the LEFT VERTical plug-in unit or the analyzer video, requires at least 1.0 division of signal. External triggering from the EXT IN/OUT jack requires at least 250 mV of signal with a maximum safe input level of 20 V (dc + peak ac). Input impedance is approximately 1 MΩ. The 50 mV/DIV and both SOURCE buttons must be out to trigger the sweep from an external source.

AUTOmatic trigger selection provides a sweep baseline when a trigger signal is absent.

Single sweep triggering occurs each time the SWP button is pushed, when SGL SWP mode and positive SLOPE are selected.

Line triggering is provided.

External and internal triggering signals are ac coupled. Frequency range is approximately 10 Hz to 5 kHz.

Triggering level variable range is approximately 8 divisions peak-to-peak internal or 2 volt peak-to-peak external.

Output Characteristics

Tracking Generator: A 600Ω signal source with a frequency equal to the analyzer input frequency within 3 Hz. Calibrated output is -40 dBV ±0.2 dB (10 mV) open circuit, or -46 dBV when terminated into 600Ω. The open circuit output level can be varied from approximately .001 volt to 0.1 volt.

5 kHz FREQuency COMB: 600Ω source of 5 kHz ±.005% frequency markers for span calibration.

VIDEO OUT: Provides 250 mV ±3% of the video signal per displayed division (0 V to 2 V). Source impedance is about 1.0 kΩ.

EXT IN/OUT: Provides 500 mV ±25 mV per division of span, from 0 to 5 volts, when using internal or manual sweep.

ENVIRONMENTAL CHARACTERISTICS

This instrument will meet the electrical characteristics over the environmental limits of the 5000-Series mainframe. Complete details on test procedures, including failure criteria, etc., can be obtained from Tektronix, Inc. Contact your local Tektronix Field Office or representative.

STANDARD ACCESSORIES

1	Manual	070-1733-00
1	Adapter, FLTG BNC to Dual BNC	013-0156-00

OPTIONAL ACCESSORIES

1	BNC to Pin Jack Adapter Cable	175-1178-00
1	10X Probe (P6006), 6 foot, BNC	010-0160-00
1	Blank Plug-In Panel	016-0195-00

OPERATING INSTRUCTIONS - - 5L4N INTERIM

SECTION 2

Introduction

The 5L4N Spectrum Analyzer operates with a Tektronix 5000-Series mainframe oscilloscope. It is a double-width plug-in unit containing a horizontal and vertical section; therefore, it is installed in the horizontal and vertical compartments of the mainframe (right two compartments for three hole mainframes).

To install, align the upper and lower guide rails of the 5L4N with the plug-in compartment tracks and fully insert it until the front panel is flush with the oscilloscope panel. To remove, pull the release latch to disengage the unit from the plug-in compartment.

This section of the manual describes the following: 1) Front panel controls, selectors, adjustments, and connectors. 2) General operating information, such as; signal application, some typical applications, and measurement precautions. Preliminary adjustments and procedures required to match the 5L4N to the mainframe and the Operational checkout procedure are contained in Section 3.

Functions of the Front Panel Controls, Selectors, Adjustments, and Connectors

The following description of these front panel controls should help familiarize you with the instrument operation and its applications. Because there are numerous operational modes, many front panel controls and selections are used. This requires abbreviating the descriptive name of most controls. Figs. 2-1 A and B illustrate the location and partial function of these front panel selectors, controls, and connectors.

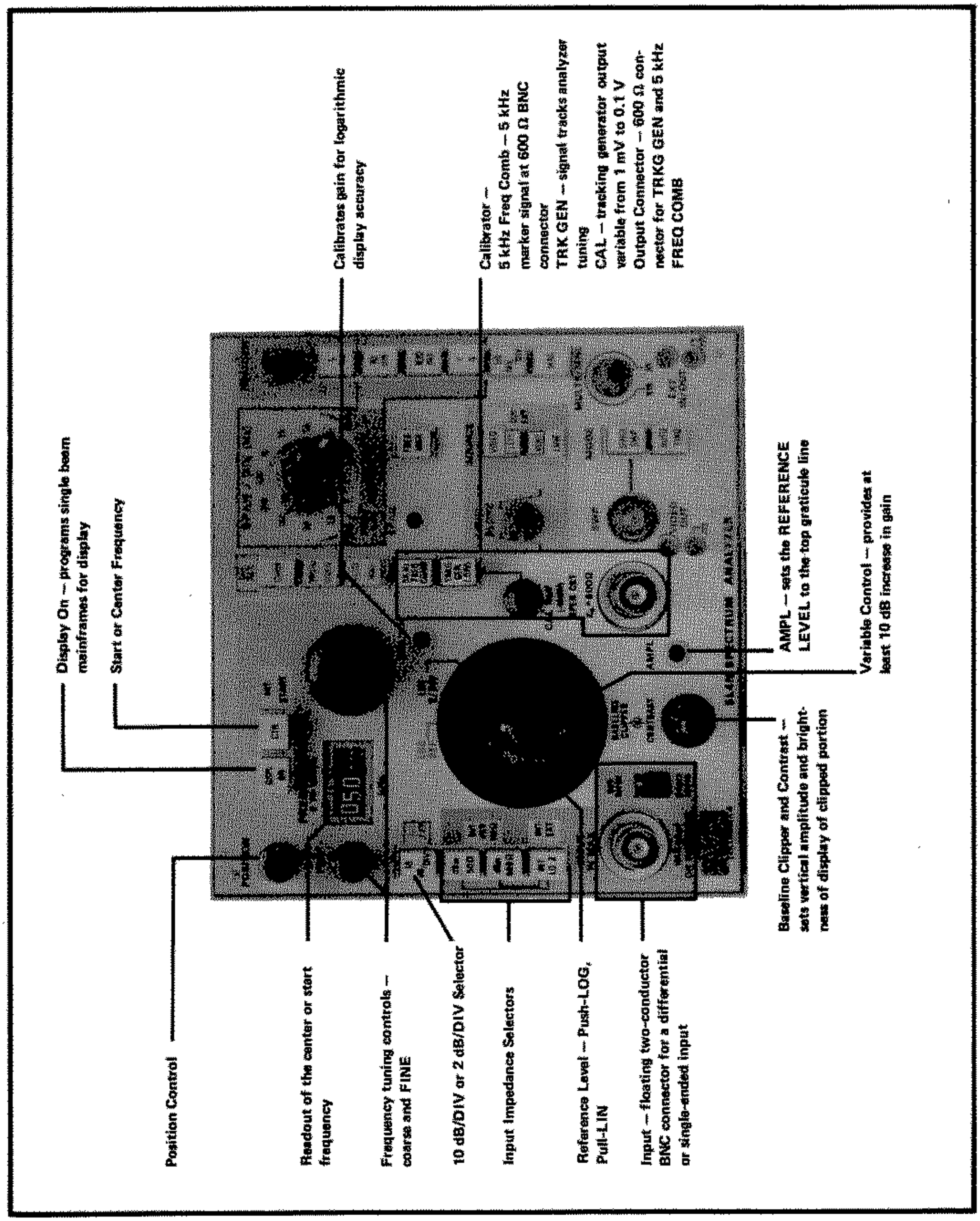


Fig. 2-1A. Front panel controls and selectors.

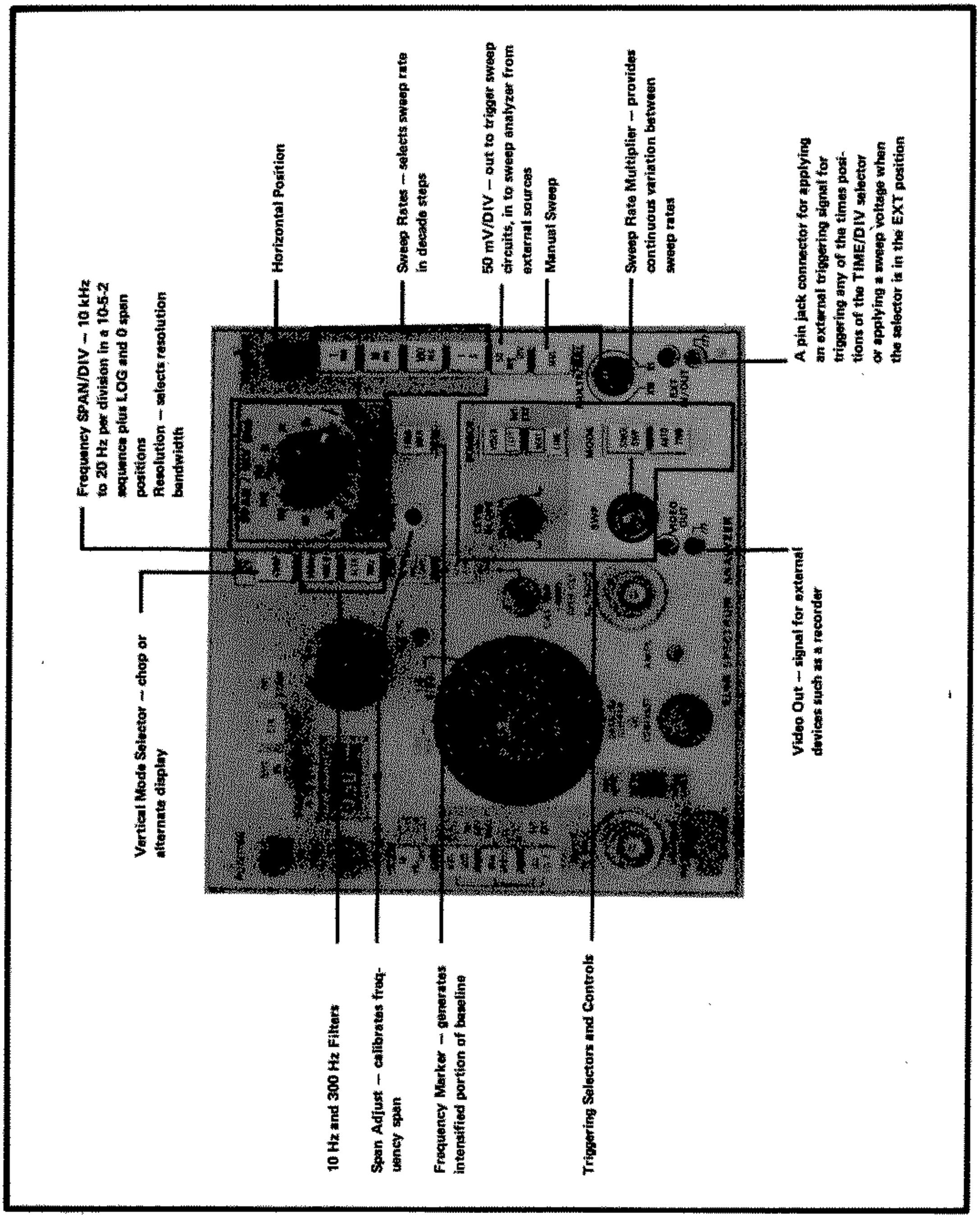


Fig. 2-18. Front panel controls and selectors.

General

The vertical deflection of the 5L4N display is calibrated in absolute values of dBm, dBV, and V/Div. The top graticule line for the crt is calibrated to the reference level indicated by a back lighted readout on the skirt of the reference level selector knob (see Reference Level and Deflection Factor Selector).

When the Reference Level or gain selector is pulled out, the V/DIV Sensitivity (rms) is read out on the V/Div scale on the selector skirt by a black lighted panel window. When the selector is pushed in, the reference level readout is illuminated on the log scale of the skirt. A display level of the 10 dB/DIV or 2 dB/DIV is selected by the 10 dB/DIV pushbutton when the display mode is logarithmic.

INPUT 1 V MAX Connector and DIFF INPUT/SINGLE ENDED Input Switch

This floating two-conductor BNC connector provides either a differential or single-ended input. A switch grounds the outer conductor when it is switched to the SINGLE ENDED position.

Input impedance can be high (1 MΩ/50 pF) or low (600 Ω or 50 Ω) depending on the selection of input impedance modes. The input Z is high (1 MΩ) when the INT LO Z pushbutton is out; however, if either the dBm 50 Ω or 600 Ω buttons are pushed in, the display reference level calibration (in dBm) corresponds to the voltage squared over the appropriate impedance (e.g. $E^2/50\ \Omega$ or $E^2/600\ \Omega$). Thus measurements of power relative to 1 mW (0 dBm) can be made without loading the circuit. When the INT LO Z button is pushed in, the input is internally terminated if either of the dBm buttons are pushed in. If both dBm buttons are out, the input

impedance remains 1 MΩ and the display is calibrated in voltage (0 dBV 1 V, rms). When LIN mode is selected, the input may be terminated in 50 or 600 Ω by pushing INT LO Z and the desired dBm button. Input impedance characteristics are illustrated by basic drawings shown in Section 1.

The INPUT connector is a floating two conductor BNC connector. The outer conductor of the connector is connected to one input of a differential amplifier, when the switch is in the SINGLE ENDED position the outer conductor is grounded.

In the differential mode, the common mode signal range is ±10 volts with a CMRR (common mode rejection ratio) greater than 70 dB. Maximum differential signal input at low impedance is 5 V (dc + peak ac) or (250 mW at 50 Ω and 125 mW at 600 Ω) and is determined by input termination power. The maximum dc input applied to the center conductor in high impedance input mode is 100 V.

The input line is protected by a 0.1 A fuse that opens when signals of 30 V or more with risetimes of 4 V/μs are applied.

For either single-ended or differential operation, the maximum signal input for specified operation is two signals equal to or less than the reference level. Measurements can be made however, with the input overloaded up to 10 dB above the reference level (0 dBm/dBV or 1 V) without damage to the input circuit. This overload will increase spurious signal level on the display.

CAUTION

When operating in the differential mode, the INPUT connector is floating. The outer conductor therefore equals the voltage level of the external source. Since the external source voltage may be some high potential the outer conductor is clamped by internal diodes to ±10 V for safety.

FREQUENCY

The frequency is tuned by coarse and fine controls. The frequency of either the start or center of the display is indicated by a dial. The display is offset so the dial frequency is at the start of the display with the CTR button out and centered when the button is pushed. In the full span (10 kHz/Div) or LOG span display, a marker can be switched on with the FREQ MKR pushbutton. This marker is an intensified portion of the display (approximately 0.5 division wide) to indicate to the operator, that portion of the display that will be center or start frequency for the narrower frequency spans.

The FINE frequency control range is about 400 Hz or ±200 Hz.

DSPL ON

When this button is depressed, single beam mainframes are programmed so the 5L4N signals are displayed.

Reference Level and Deflection Factor Selector---(PULL) LIN ---(PUSH) LOG

This knob selects the reference level and gain for logarithmic displays or the deflection factor (V/Div) for linear displays. The selected reference

level is displayed within a lighted window on the knob skirt. The LOG REF readout scale is backlighted when the knob is pushed in and the LIN V/DIV scale is backlighted when the selector is pulled out.

10 dB/DIV or 2 dB/DIV

When the display is logarithmic, this pushbutton selects either 10 dB/DIV or 2 dB/DIV calibrated displays. Dynamic range of the displays are 80 dB and 16 dB.

10 dB/Div Adjustment

The gain for the logarithmic displays can be calibrated with this adjustment. The 10 dB/DIV mode is usually calibrated, however, the accuracy of the 2 dB/Div mode can be increased with the same adjustment. This adjustment also affects the LIN deflection factor.

AMPL Adjustment

This adjustment sets the reference level to the top graticule line, or calibrates the Volts/Division after the 10dB/Div adjustment.

BASELINE CLIPPER

This control sets the vertical amplitude of the clipped portion (subdued intensity) of the display.

CONTRAST

This control adjusts the brightness ratio between the clipped (subdued) baseline and the unclipped portion of the display. Display

intensity is set by the mainframe Intensity control.

The clipper, contrast, and marker circuits are interlocked to the right vertical display of a single beam mainframe. These intensity modulations will appear on both traces of dual beam mainframes.

TRKG GEN

When this button is pushed, a tracking generator signal which precisely tracks the spectrum analyzer tuning, is applied to the 600 Ω BNC connector. The output level (open circuit) of this signal can be varied from 1 mV (open circuit) to 0.1 V. When the variable control is fully ccw or in the CAL detent, the output level is a calibrated -40 dBV signal behind 600 Ω. If this calibrated signal is applied to the INPUT connector, an amplitude reference level is provided for calibrating the display reference.

5 kHz FREQ COMB

When this button is pushed, a calibrated 5 kHz marker signal is provided at the 600 Ω BNC connector. If this signal is applied to the INPUT, a frequency comb or picket fence of markers will be displayed. These markers can be used to check and calibrate the frequency span. The amplitude of the 25 kHz multiples is larger than the 5 kHz markers so 25 kHz segments, across the span, are easily identified.

TRK Generator and 5 kHz FREQ COMB Output Connector

The output of the tracking generator or 5 kHz frequency comb is available at this 600 Ω BNC connector.

Video Filters

Two filters (300 Hz and 10 Hz) can be switched in to restrict the video bandwidth and reduce high video frequency components of the display. The filters are also used for display noise averaging.

CHOP

The crt display of 5000 Series single beam mainframes depends on how the vertical plug-in units are programmed. If the DSPLY ON button for both vertical units are depressed, the CHOP pushbutton selects either chop (button in) ar alternate (button out) display. The sweep rate for both the 5L4N and vertical plug-in unit, is the selected rate of the 5L4N time-base.

SPAN/DIV and RESOLUTION

The SPAN/DIV and RESOLUTION controls are coaxial but not mechanically coupled. The SPAN/DIV range is 10 kHz to 20 Hz per division in a 10-5-2 sequence plus LOG and 0 (zero) span positions. The LOG position covers 100 Hz to 100 kHz. This provides three decades of logarithmic span, each decade covers an equal number of horizontal divisions. For correct LOG span the Freq dial should be set at 50 kHz or the FREQ MKR button pushed. The 0 span position provides time domain display of the video frequencies within the selected analyzer bandwidth at the frequency tuned.

The RESOLUTION control selects the resolution bandwidth. An AUTO detent position (control full ccw) provides the highest resolution possible for a calibrated display as the frequency span and sweep rate are changed. In the LOG span mode, this position provides the highest (narrowest bandwidth)

resolution at the low frequency end of the span and lower resolution (wider bandwidth) at the high end. The resolution bandwidth range is variable from 3 kHz or more to 10 Hz or less.

SPAN Adjustment

This adjustment calibrates the frequency span by changing the horizontal gain.

FREQ MKR

When the FREQ MKR button is pushed and the SPAN/DIV is 10 kHz/div or LOG, a frequency marker, which appears as an intensified portion of the trace is generated. The displayed spectrum is 0 to 100 kHz, (100 Hz to 100 kHz in LOG.) This marker indicates to the observer, the location of the tuned frequency on the spectrum and the portion that will be displayed as center or start frequency when the SPAN/DIV is decreased below 10 kHz. The marker is difficult to observe if storage mode is used and the intensity is high.

Triggering and Sweep Controls

Triggering Modes

Three modes of triggering provide; automatic, single sweep, and triggered or normal display.

Triggering Sources

Four signal sources can be selected for triggering; line, the 5L4N video, the left vertical plug-in unit signal, and an external signal which is applied to the EXT IN/OUT jacks.

VIDEO - Pushing this button selects the 5L4N video as the trigger signal.

LINE - Pushing this button selects a sample of the mainframe line voltage as the trigger signal.

LEFT VERT - Pushing both the VIDEO and LINE buttons in, selects the signal from the left vertical plug-in unit as the triggering signal.

OUT EXT - When both TRIG SOURCE pushbuttons are out, the triggering signal source is the signal applied to the EXT IN/OUT jacks. 250 mV peak-to-peak of external signal is required to trigger the sweep. The maximum safe input voltage for external trigger is 20 volts (dc + peak ac). The external trigger signal is ac coupled to the internal sweep generator.

Triggering Modes

SGL SWP - With this button depressed and positive SLOPE selected, a sweep is initiated each time the SWP indicator button is pushed. The SWP button lights during sweep time.

AUTO TRIG - With this button depressed, the sweep automatically recurs at the end of holdoff time if a trigger signal is absent. The sweep triggers properly with inputs down to approximately 7 Hz.

MNL - Pushing this button connects the sweep circuits to the MULTR/MNL control so the sweep can be manually controlled.

LEVEL SLOPE

This control selects the amplitude and slope at which triggering occurs. Since the triggering signal is ac coupled, the midrange of either slope is the average level.

Sweep Rate s/DIV

Four pushbuttons select sweep rates from 1 s/Div to 1 ms/Div in decade steps. A MULTR/MNL control provides continuous variation between these steps and sweep rate increase to at least 10 s/Div. Sweep rates from 10 s/Div to 10 ms/Div are recommended for spectrum analyzer operation; sweep rates faster than 10 ms/Div are limited by the bandwidth of the 5L4N.

EXT IN/OUT

These pin jacks provide access to the analyzer sweep voltage, or provisions for applying an external sweep or trigger signal to the analyzer sweep circuits. Input impedance is about 1 MΩ for trigger mode and 30 kΩ or more in the external mode.

The signal output level is a 0 to 5 volt ramp when using internal sweep or manual scan. Input signal requirements are: 0 volt to 500 mV ramp to sweep the analyzer 10 divisions. This voltage range can be increased by a factor of 10 (0 V to 5 V) with the MULTR control. A 250 mV peak-to-peak or more signal is required to trigger the sweep circuits. (The 50 mV/DIV button must be out to trigger the sweep circuits, and pushed in when sweeping the analyzer from an external source.)

VIDEO OUT

These pin jacks provide access to the video signal of the analyzer. Output level is 250 mV per displayed division of signal. Source impedance is about 1 kΩ.

POSITION

These controls position the crt beam vertically (left control) and

horizontally (right control). The horizontal position control should be adjusted so the sweep starts at the left graticule line. The vertical position control should be adjusted so the baseline of a linear display is at the bottom graticule line.

USING THE ANALYZER

1. Signal Application

The INPUT connector is a floating two conductor BNC connector with its outer conductor connected through a switch (DIFF INPUT of SINGLE ENDED) to either, one input of a differential amplifier or to chassis ground.

Input Impedance: The input impedance for the 5L4N is 1 M Ω with approximately 47 pF shunt capacitance that can be changed to 50 Ω or 600 Ω by selectable internal terminations. This provides a simple procedure to measure signal levels from a 50 Ω or 600 Ω signal source. To measure, terminate the INPUT with the appropriate inpedance by depressing the INT LO Z button and the 50 Ω or 600 Ω dBm button.

If the signal source is high impedance, select the unterminated mode (1 m Ω) by disengaging the INT LO Z pushbutton. The 5L4N is calibrated in the units selected for the impedance selected. The Reference Level and Deflection Factor selector indicates the unit of calibration. Power measurements can be made without loading high impedance circuits.

Input Levels: In the differential mode, the common mode signal range is ±10 volts. Common mode rejection is greater than 70 dB. Maximum signal

amplitude for linear amplification at low impedance, is 5 volt (dc + peak ac), or 250 mW at 50 Ω and 125 mW at 600 Ω. Maximum signal input amplitude for linear amplification with high impedance is 100 volt (dc + peak ac).

The FLTG BNC to Dua BNC ("Y") adapter (part of the standard accessories) provides shielded input connection for two signals to the INPUT when operating in the differential mode.

The maximum signal input level for linear amplification, when operating in the single-ended mode, is -10 dBm/dBV or 0.316 volt. Meaningful measurement can be made with signal levels up to 10 dB above the reference level without damaging the input circuits. This overload however increases the spurious signal level on the display.

2. Resolution, Frequency Span and Sensitivity.

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'ing. The frequency span and sweep time are adjusted for minimum resolution 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 5L4N as the bandwidth (separation) at the 6 dB down point on the signal or when the notch between two merging signals is 6 dB down.

As the analyzer sweep rate is increased, signal amplitude will decrease and the effective analyzer bandwidth will increase, which means that both sensitivity and resolution have been degraded. The optimum resolution for a

given frequency span and sweep time, is expressed as:

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

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

The resolution bandwidth can be manually controlled or an automatic mode can be selected which provides automatic bandwidth changes to compensate for any changes of the frequency span. In the LOG span mode, the automatic resolution provides narrow bandwidths for the low frequency end of the span and broader bandwidth at the higher frequency end. This automatic mode provides good resolution for all frequency spans, however manual adjustment should be used to optimize resolution when operating with narrow frequency spans.

The frequency span is symmetrical about the center frequency. Wide spans are used when monitoring a frequency spectrum for spurious signals, check harmonic Distortion, etc. Narrow spans are used to analyze a particular signal within the spectrum, such as; identify type of modulation, the percentage of modulation, bandwidth characteristics, presence of distortion, etc. When wide spans are displayed the sweep rate is usually increased to eliminate flicker. This requires wide resolution bandwidths to maintain sensitivity. When narrow spans are used, the resolution needs to be increased which requires slow sweep rates.

As the sweep rate is increased, the amplitude of a cw signal will decrease and the bandwidth increases, which signifies that both the sensitivity and resolution have been degraded. The loss of the analyzer sensitivity due to sweep rate and dispersion can be expressed mathematically as:

$$\frac{S}{S_o} = \left[1 + 0.195\left(\frac{D}{TB^2}\right)^2\right]^{-1/4}$$

Where S/S_o is the ratio of the effective sensitivity to the analyzer measured sensitivity, at very slow sweep rates or zero dispersion.

D is the dispersion in hertz

B is the -3 dB bandwidth of the analyzer in hertz

T is the sweep time in seconds, or $\frac{T}{D}$ is the sweep rate.

Usually the frequency span is set with automatic resolution to the desired setting, the RESOLUTION and sweep rate are then adjusted for the best sensitivity and resolution.

3. Using the Video Filters

The video filters are used to average distributed signals such as noise, and high frequency components on the display. When signals are closely spaced, the filters may be useful to reduce modulation between the signals for easier analysis. When the filters are used a reduction in the sweep rate may be required to maintain maximum sensitivity and a calibrated display. With both filters (300 Hz and 10 Hz) in, the filtering action is slightly increased over 10 Hz but in most cases no change will be noticed.

4. Selecting the Sweep Rate

Because the sweep rate affects the resolution and sensitivity, it must be decreased as the frequency span and resolution bandwidth are decreased. The sweep rate selection for the 5L4N is 1 ms/Div to 1 s/Div with a 10X MULTR that increases the range to at least 10 s/Div. The 1 ms/Div rate is too fast for most spectrum analysis, it does, however, provide a sweep rate that is applicable for some time domain operation.

When the frequency span is reduced to 0, the analyzer functions as a tuned receiver so time domain characteristics of a signal within the bandwidth capability of the analyzer, can be performed. The RESOLUTION bandwidth therefore should be maximum (3 kHz) for time domain analysis.

5. Manual Sweep

This mode is used to examine a particular point or portion of the display such as one of the null points of a frequency modulated spectrum. Calibrate the sweep span with a timed sweep, then depress the MNL button for manual sweep. Use the MULTR/MNL control to scan the selected spectrum. The display is swept from left to right as the control is rotated clockwise.

6. Triggering the Display

The triggering modes are; triggered sweep from an external source or from one of three internal sources; automatic triggering, which automatically triggers the sweep if a trigger signal is absent; and single sweep (SGL SWP), which requires the operator to push the SWP button to initiate a sweep. Automatic (AUTO) mode is usually used if the display is not time related to some signal source and the display is a frequency domain.

The internal triggering sources are: 1) The 5L4N video from a fixed

tuned modulated signal or the vertical signal from the left vertical plug-in unit. The amplitude of these signals must equal or exceed one graticlue division and the frequency range is 2 Hz to 100 kHz. 2) The line voltage.

External triggering signals are applied to the EXT IN/OUT jacks. The signal amplitude must equal or exceed 250 mV with a maximum safe input of 20 V (dc + peak ac). Both SOURCE and the 50 mV/DIV button must be out to connect an external triggering signal to the sweep generator.

In the AUTO TRIG mode, the sweep will synchronize with triggering signals 7 Hz or higher.

The SWP button lights when the sweep is running. This feature is useful when photographing displays to indicate shutter time. The button does not arm the triggering circuits like some time base units.

7. Using an External Sweep Source

A voltage ramp of 50 mV from a 1 kΩ or less source is required to sweep the analyzer each division, or 0 to 500 mV the full span. 0 volt corresponds to the left edge of the span or low frequency end and 500 mV corresponds to the right edge or high frequency end. Before switching to external operation, (50 mV/DIV button in) calibrate the sweep span using the internal sweep source and the 5 kHz FREQ COMB as described under Operational Check. Apply the external voltage to the EXT IN/OUT jack. Adjust the upper end of the voltage (500 mV) until the sweep span is calibrated.

NOTE

The frequency deviation across the selected span is a linear function (within 20%) of the input voltage, so 50 mV dc sould tune the analyzer to the center of the selected frequency span.

8. Using the Tracking Generator

The tracking generator is a 600 Ω signal source of the analyzer tuning response that delivers -40 dBV (.01 V open circuit) to the output connector. This signal is used to calibrate the reference level of the display or as a swept frequency test signal to plot the response characteristics of some external device such as a filter. The output level can be varied from about 1 mV to 0.1 V open circuit.

If the response of some external device is to be plotted, connect the device between the TRK GEN output and the INPUT to the 5L4N.

9. Measuring Absolute Signal Levels

Since the top of the graticule is a calibrated reference level as per the selector readout, and the graticule is calibrated in dB/Div, it is easy to measure the absolute level of most signals.

1) Calibrate the graticule as previously described in the Operational Check procedure. Ensure that the reference level variable (gain) control is in its CAL detent.

2) Connect the signal source to the INPUT and select the appropriate input termination as described previously under Signal Application. Switch the display mode to 10 dB/DIV or 2 dB/DIV. For maximum accuracy, use the 2 dB/DIV display mode.

3) Select a reference level with the selector to bring the signal to be measured within the screen or graticule window.

NOTE

If you are operating in the 10 dB/DIV mode, the reference level selector must be within the -60 to -10 range.

4) The absolute signal level equals the number of dB graticule divisions from the reference level (top of the screen) to the signal reference (usually the signal peak) plus the reference level readout in dBm or dBV. For example: A signal level 4.5 divisions below the top graticule line, with a reference level readout of -60, in the 2 dB/DIV display mode, is -60 dBm/dBV + (-9 dB) or 69 dBm/dBV. This refers to the signal level at the INPUT connector. Add the insertion loss of any external attenuators and cables (if used) between the signal source and the INPUT.

NOTE

The maximum input level to the INPUT for linear amplification is -10 dBm/dBV (0.316 V rms). Signals above this level should be attenuated a calibrated amount to bring them within the measurement capabilities of the 5L4N.

10. 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 window with the reference selector and variable. If display noise is excessive, use the

VIDEO FILTERS or decrease the resolution bandwidth. Decrease the sweep rate to maintain signal amplitude.

2) Use the reference level selector to reduce the amplitude of the larger signal until it is within the graticule area, and not the increased attenuation or decreased gain reading (e.g. -60 to -20 is 40 dB).

3) Measure the signal level from the reference line established for the smaller signal, then add the change in reference level selector reading to obtain the difference level in dB between the two signals.

11. Measuring Relative Signal Amplitude to LIN V/DIV Display Mode

Relative signal levels can be made by setting the amplitude of one signal, with the reference level selector and variable control, to the 5th graticule line from the baseline (bottom graticule line). The relative amplitude of other signals to this reference can then be read as a percentage if each graticule division is 20% or 0.2 increment of an eight division window. For example; a signal that is 3 divisions in amplitude is 60% of the reference.

APPLICATIONS

Applications for spectrum analyzers include; measuring intermodulation products, cross modulation, radiation interference, modulation percentage modulation index, absolute and relative signal levels, etc. If you desire assistance for a specific application or current information on additional applications, contact your local Tektronix Field Office or representitive.

OPERATIONAL/PERFORMANCE CHECK -- 5L4N INTERIM

SECTION 3

Introduction

There are two parts to this section. The first part is an operational checkout of the instruments performance that is suitable for instrument familiarization and incoming inspections. The latter part which will appear in the final manual is a more stringent procedure that verifies performance specifications. The first part requires minimal test equipment, the latter part requires extensive and sophisticated test equipment.

NOTE

A storage or variable persistance mainframe oscilloscope is highly desirable because of the slow sweep speeds required to perform the following checks.

OPERATIONAL CHECK

Preliminary Adjustments to Calibrate the 5L4N to the Oscilloscope Mainframe

When the 5L4N Spectrum Analyzer unit is installed in the 5000-Series mainframe, it should be calibrated to the mainframe deflection sensitivities. The front panel calibration should be checked each time the instrument is first installed and turned on to ensure optimum accuracy.

Plug the 5L4N into the vertical and horizontal compartments of the mainframe. Connect the oscilloscope to a power source and switch the power on. Allow a few minutes for the instruments to stabilize.

Set the front panel controls as illustrated in Fig. 3-1 and apply the 5 kHz FREQ COMB signal to the INPUT through a short coaxial cable.

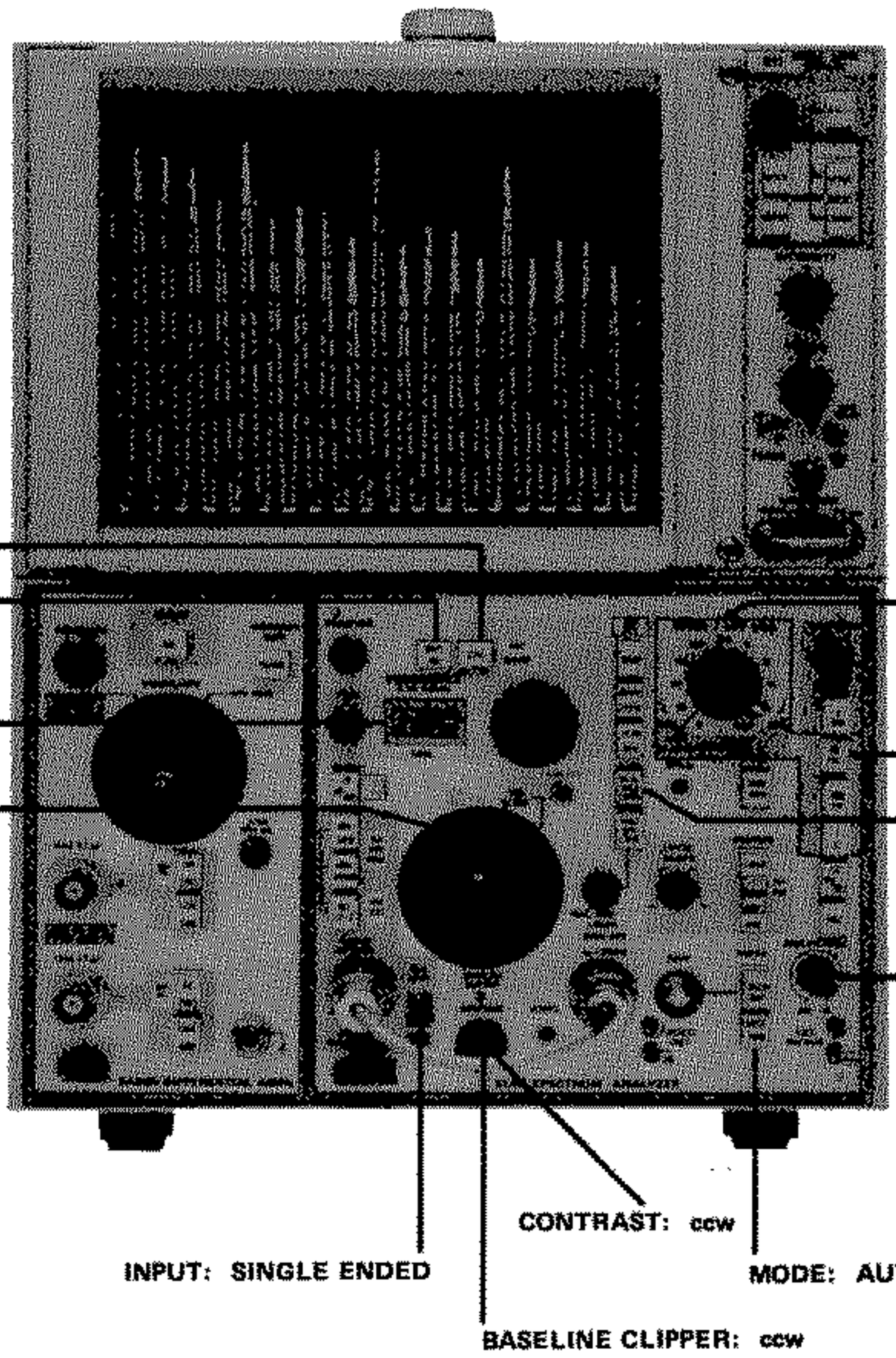
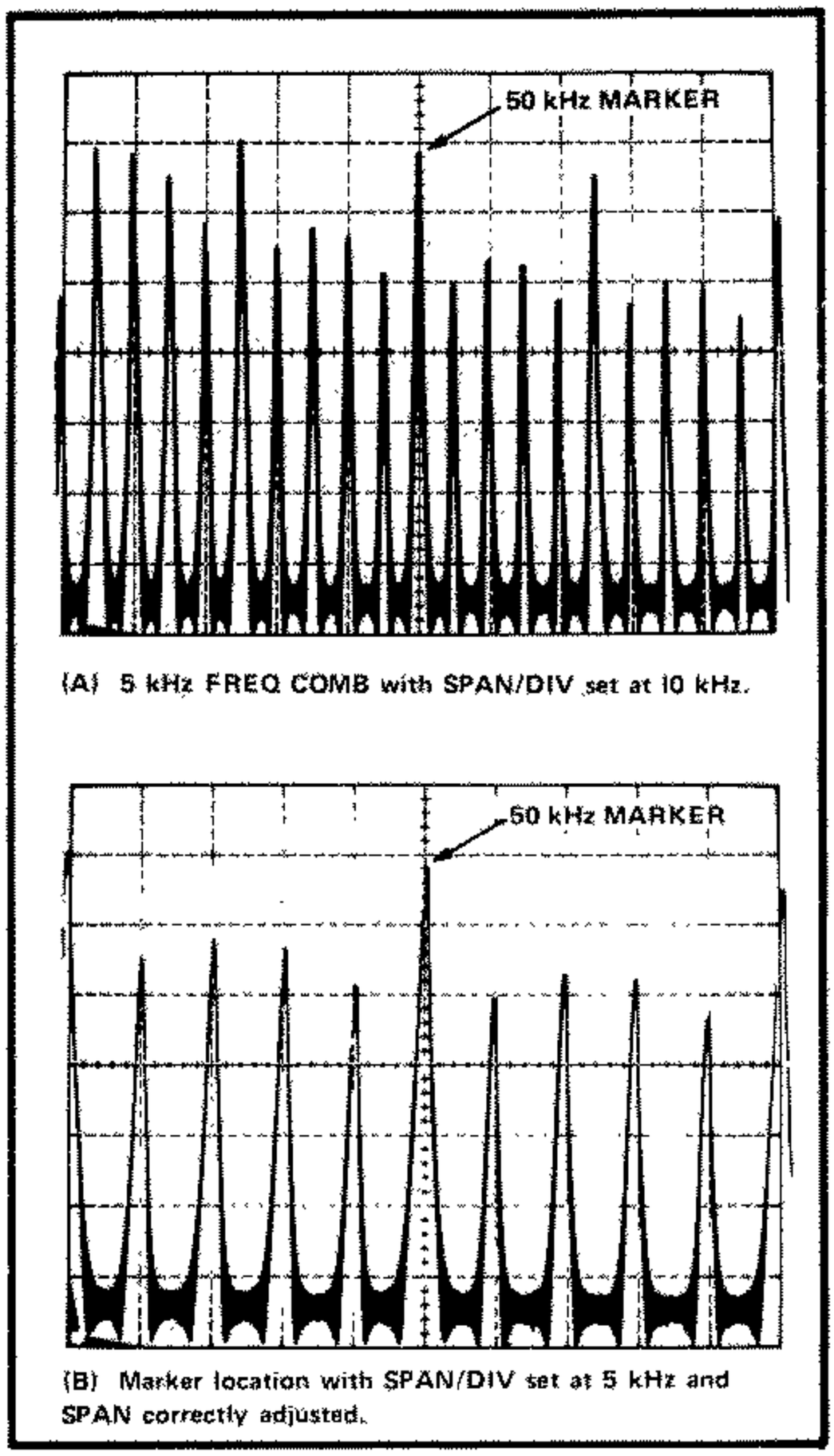


Fig. 3-1. Front panel control and selector positions for the initial operational check and front panel calibration.

With the display mode in 2 dB/Div (LOG), adjust the mainframe Intensity and Focus controls for the best display definition (it may be necessary to select a slower sweep rate to adjust Focus and Intensity); set the baseline of the display at the bottom graticule line and center the display with the horizontal POSITION control. Select the STORE mode if the mainframe has store capabilities.

Depress the 10 dB/DIV button. Adjust the RESOLUTION for the best marker definition. Display should now resemble the illustration shown in Fig. 3-2A.



(A) 5 kHz FREQ COMB with SPAN/DIV set at 10 kHz.

(B) Marker location with SPAN/DIV set at 5 kHz and SPAN correctly adjusted.

Fig. 3-2. Freq Span calibration.

Calibrate the Sweep Span

a. With the SPAN/DIV at 10 kHz, tune the 50 kHz marker to the center-line of the graticule, then decrease the SPAN/DIV to 5 kHz.

b. Calibrate the display span to 5 kHz/Div by adjusting the SPAN for 1 marker/division around the center 6 divisions. Final display should resemble the display illustrated in Fig. 3-2B.

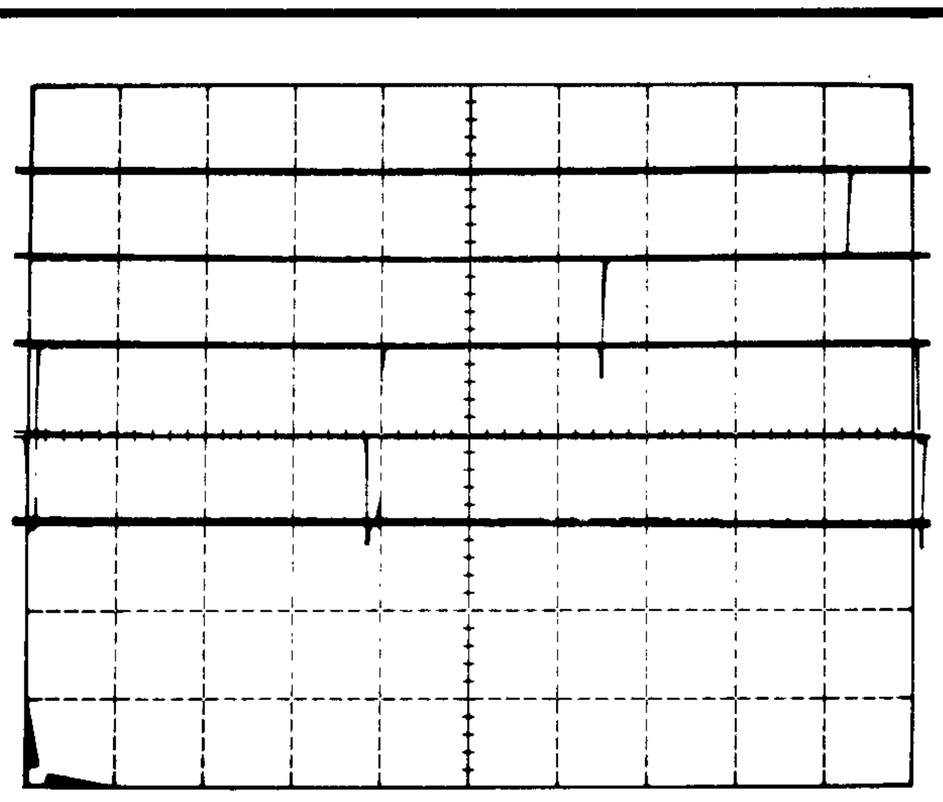
c. Release the 5 kHz FREQ COMB pushbutton to remove the 5 kHz signal from the INPUT.

Reference Level and Dynamic Range Calibration

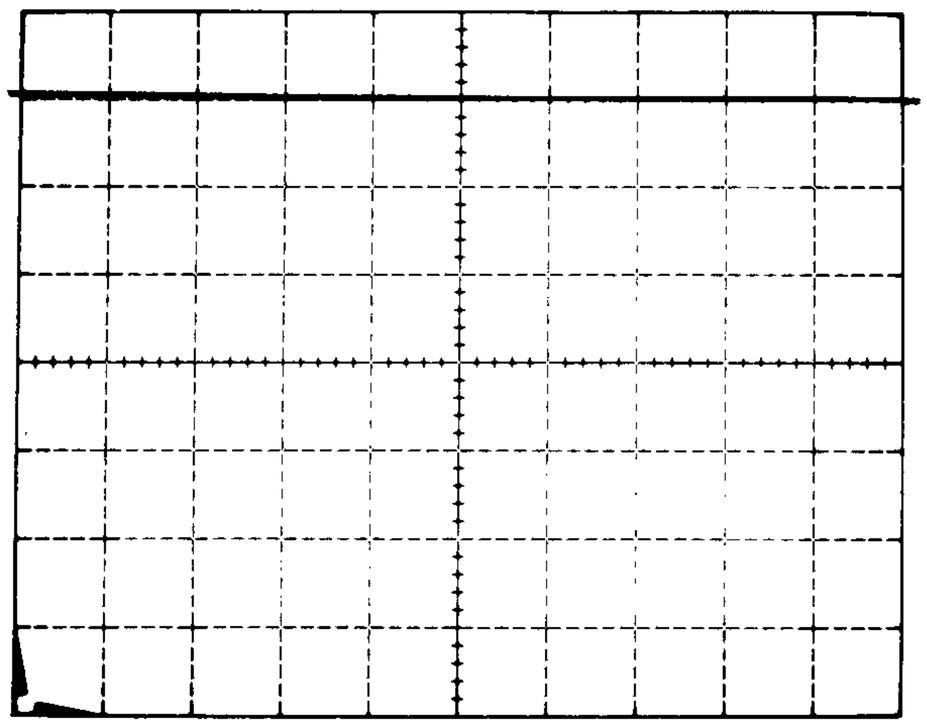
The 10 dB/DIV adjusts the log gain of the analyzer to calibrate the dynamic range of the display. The AMPL adjusts the display amplitude to the correct reference level on the graticule. There is no interaction between the two adjustments. The 10 dB/DIV adjustment is usually made in the 10 dB/DIV display mode, however, the accuracy of the 2 dB/DIV mode can be improved with this adjustment if desired.

1. The RESOLUTION bandwidth must be maximum or in the AUTO position and the sweep rate 10 ms/DIV or slower when calibrating the reference level. Apply the TRK GEN signal to the INPUT by pushing the TRK GEN (.01 V CAL) pushbutton in. Switch the display mode to 10 dB/DIV and the Reference Level to -10 dBV. Select high impedance input (all switches out). Set the SPAN/DIV to 1 K, the RESOLUTION to AUTO, and TIME/DIV to 10 ms or longer.

2. Switch the tracking generator CAL control out of the cal detent and adjust so the display (sweep) is -60 dBV (5th major division down from full scale).



(A) Stored display showing 10 dB increments of deflection when 10 dB/DIV gain is correctly adjusted.



(B) Calibrating the graticule reference level with the AMPL adjust.

Fig. 3-3. Displays illustrating 10 dB/DIV and AMPL correctly adjusted.

3. Switch the Reference Level selector in 10 dB steps between -10 dBV and -60 dBV and calibrate the log gain with the 10 dB/DIV adjustment so the display shifts in 10 dB increments (Fig. 3-3A). The TRKG GEN variable may be used to keep the trace lined up with major crt graticule lines.

4. After the Log gain has been calibrated, remove the TRK GEN signal by dis-engaging the pushbutton. Switch the display mode to 2 dB/DIV and position the baseline of the display at the bottom graticule line.

5. Set the Reference Level to -30 dBV, the display mode to 10 dB/DIV, switch the TRK GEN variable output control into its CAL detent (output is a calibrated -40 dBV) and push the TRK GEN button in to re-apply the calibrated signal to the INPUT.

6. Calibrate the amplitude reference with the AMPL adjustment so the display is -40 dBV on the graticule (1 division from the top graticule line, with the Reference Level selector at -30 dBV, see Fig. 3-3B.

Check Frequency Accuracy

1. Center the FINE frequency control and push the CTR pushbutton in. Switch the display mode to LIN by pulling out on the Reference Level selector, then set the selector for a V/DIV setting of 10 mV.

2. Apply the 5 kHz markers to the INPUT by disengaging the TRK GEN button and pushing the 5 kHz FREQ COMB button in.

3. Set the SPAN/DIV to 10 kHz, RESOLUTION to AUTO, and sweep rate for a satisfactory display (see Fig. 3-4). Note the higher amplitude 25 kHz markers.

4. Tune the frequency to 0000 then reduce the SPAN/DIV to 5 kHz.

5. Tune the frequency through the 100 kHz range checking the dial readout accuracy against the 25 kHz markers. Accuracy must equal or exceed ±3 kHz.

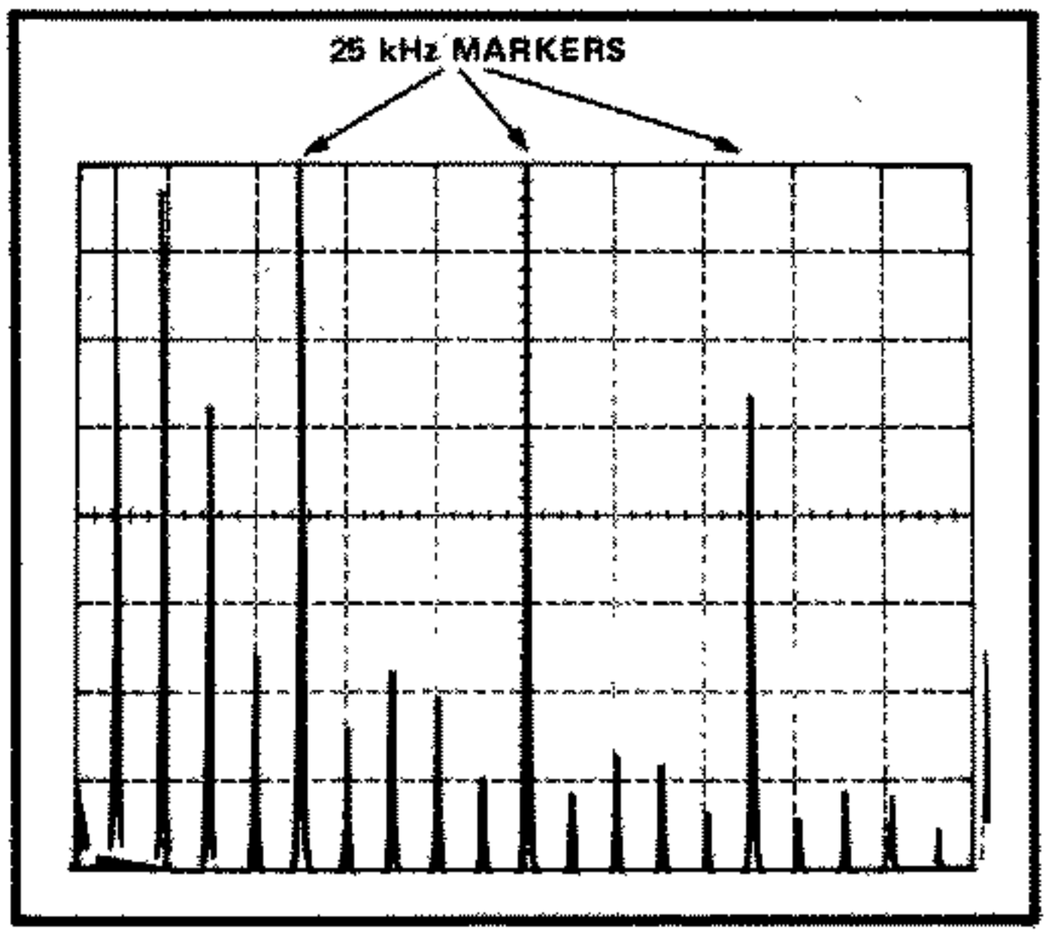


Fig. 3-4. 5 kHz FREQ COMB showing location of 25 kHz markers for checking frequency accuracy.

Check the 2 dB/DIV and LIN Mode of Operation

1. Apply the calibrated -40 dBV TRK GEN signal to the INPUT, switch the Reference Level selector to -30 and the display mode to 2 dB/DIV.

2. Display level should equal 5 divisions ±0.5 division below the top graticule line; -30 dBV + (-10 dB).

3. Pull the Reference Level selector out and switch the LIN mode V/DIV selector to 2 mV.

4. Display level should equal 5 divisions ±1.5 minor division.

Check the Log Span Operation

1. Apply the 5 kHz FREQ COMB to the INPUT, switch the Display Mode to LIN, and the V/DIV to 10 mV. Switch the frequency marker on by depressing the FREQ MKR button.

2. Switch the SPAN/DIV to LOG. Display should resemble the illustration in Fig. 3-5.

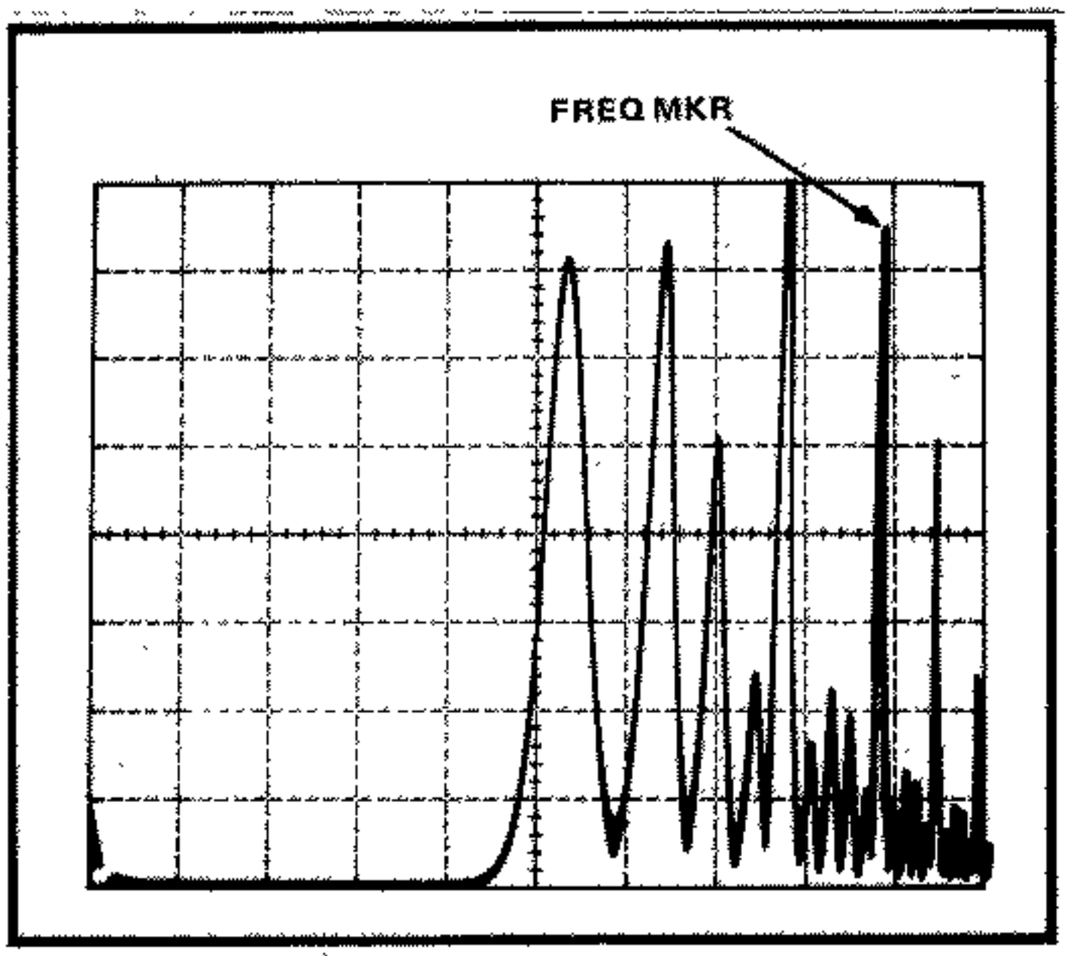


Fig. 3-5. 5 kHz FREQ COMB showing the location of the frequency markers.

Adjust the Contrast and Check Baseline Clipper Operation

The contrast between the clipped portion of the display baseline and the remaining display is subject to ambient light conditions, the sweep rate, frequency span, and resolution.

1. Set the BASELINE CLIPPER control midrange, then adjust the CONTRAST control for the desired contrast between the clipped or subdued portion and the rest of the display. The contrast is usually adjusted so the clipped baseline portion of the display is just visible.

2. Adjust the BASELINE CLIPPER control so the baseline of the display is clipped. If there is excessive noise it may be desirable to clip the noise level as well.

OPERATIONAL PERFORMANCE AND INSTRUMENT FAMILIARIZATION

This portion contains a sequence of procedures that check the operational performance of the 5L4N. It provides an adequate incoming performance inspection and a good familiarization of the instrument operation. Because the 5L4N tracking generator and 5 kHz comb are accurate signal sources, they are used as the reference for part of this check.

1. Preliminary Preparation

Perform the Preliminary adjustments described in the Operational Check and calibrate the sweep span, reference level, and dynamic range plus the preliminary operational checks.

2. Check the Reference Level Accuracy, Range of the Variable Gain Control, and Deflection Factor Accuracy

a. Set the sweep rate to 100 ms/Div, SPAN/DIV to 1 kHz, RESOLUTION to AUTO, Variable gain control in the CAL detent, and add 10 Hz filter.

b. Apply the TRK GEN signal through 10 dB and 1 dB step attenuators to the INPUT. Select the internal termination to match the impedance of the step attenuators (50 Ω dBm for Hewlett Packard Model 355D and 355C, 600 Ω dBm for Hewlett Packard Model 350D).

c. Switch the display mode to 10 dB/DIV and the Reference Level at -10 dBm. Set the 10 dB step attenuator to 0 and adjust the 1 dB step attenuator for a display level of 4 divisions (midscreen).

d. Check the accuracy of the gain selector by increasing then decreasing the gain selections as the step attenuator is increased or decreased to offset the change. Display level should remain within ±0.5 dB/10 dB or 1/4 minor division for each change in gain selection.

e. Return the 10 dB step attenuator to 0 dB and the 5L4N gain selector for a reference level of -10 dBm.

f. Decrease the 10 dB step attenuator 40 dB in 10 dB steps. Check the overall accuracy for a 40 dB change.

g. Return the 10 dB step attenuator to 0 dB then increase the 5L4N gain selector setting 40 dB. Check the accuracy for the 40 dB change.

h. Sum the deviation to obtain the error over the 80 dB window. Error must not exceed 2 dB or 1 minor deviation.

i. Rotate the variable gain control through its range checking the gain range. Should equal or exceed 10 dB. Return the variable control to the CAL detent.

j. Switch the display mode to 2 dB/DIV. Adjust the gain selector and variable gain so the display level is five divisions (three divisions from the reference level).

k. Switch the 1 dB step attenuator in 2 dB steps to check the display accuracy of the 2 dB/DIV mode. Must equal or exceed 0.2 dB/DIV or 0.2 dB/2dB steps.

l. Return the step attenuator to 0 dB and adjust the variable gain control so the display level is full screen or 8 divisions.

m. Switch in 10 dB with the 10 dB step attenuator and 16 dB with the 1 dB step attenuator.

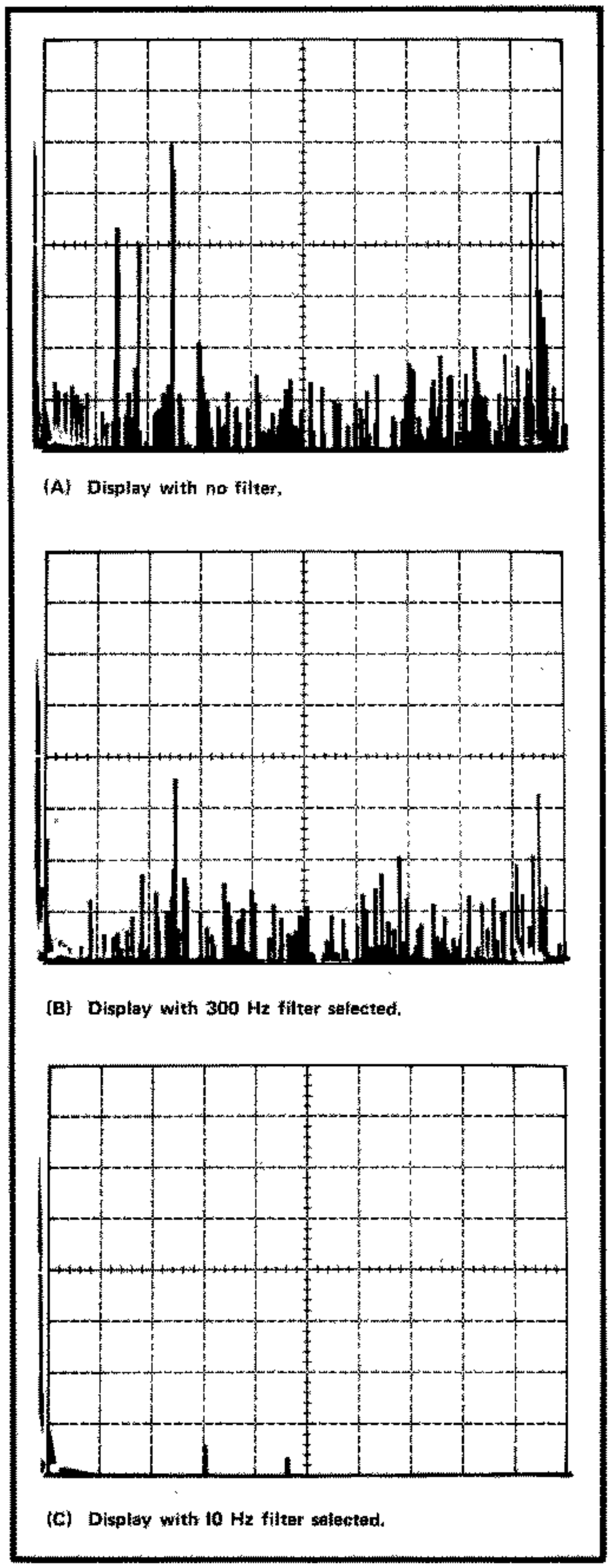
n. Check the 2 dB/DIV mode accuracy for a full 16 dB window. Accuracy must equal or exceed 1.0 dB or 0.5 division.

3. Check Incidental FM'ing and Stability (Incidental FM'ing 2Hz or less, stability 100 Hz/Hour)

a. With the 5 kHz COMB applied to the INPUT, and one of the 25 kHz markers tuned to the center of the display, decrease the SPAN/DIV and RESOLUTION bandwidth to 20 Hz and 10 Hz.

b. Switch the display mode to 2 dB/DIV, adjust the gain selector and variable control for a full screen display.

c. Measure the Incidental FM'ing of the displayed marker. The specification is 2 Hz or 0.1 divisions.



(A) Display with no filter.

(B) Display with 300 Hz filter selected.

(C) Display with 10 Hz filter selected.

Fig. 3-6. Photos showing the use of the video filters to reduce the displayed noise.

4. Check the Operation of the Video Filters

The VIDEO FILTERS average and reduce the noise level on the display, see Fig. 3-6.

a. Set the display mode to 2 dB/DIV; decrease the reference level until noise is displayed on the crt (approx. -120 dB).

b. Check the operation of the 300 Hz and 10 Hz filters, see Fig. 3-6.

5. Check Resolution Bandwidths (Bandwidth variable from $\geq$ 3 kHz to $\leq$ 10 Hz)

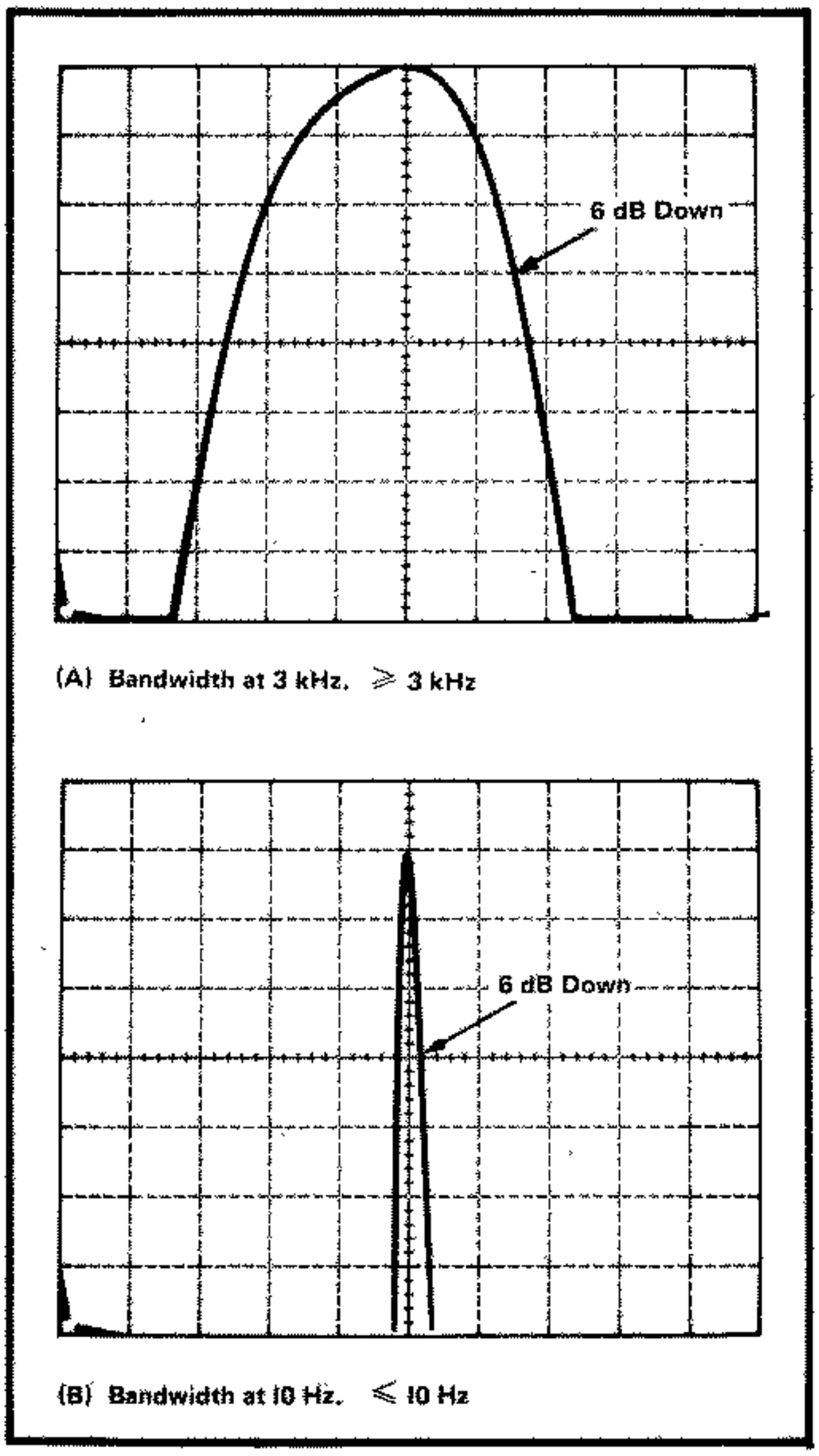
a. Apply the 5 kHz COMB to the INPUT and tune one of the 25 kHz markers to the center of the screen.

b. Turn the RESOLUTION control fully cw to the 3 kHz position and decrease the SPAN/DIV to 1 kHz.

c. Switch the display mode to 2 dB/DIV. Adjust the reference level and gain variable for a full screen display.

NOTE

Ensure that the sweep rate is low enough so the display is symmetrical and the baseline of the display is the bottom graticule line.



(A) Bandwidth at 3 kHz. ⩾ 3 kHz

(B) Bandwidth at 10 Hz. ⩽ 10 Hz

Fig. 3-7. Checking the bandwidth at 3 kHz and 10 Hz.

d. Check the bandwidth of the signal at the 6 dB down level (see Fig. 3-7A). Bandwidth must equal 3 kHz or more.

e. Decrease the SPAN/DIV to 20 Hz, turn the RESOLUTION control fully ccw and decrease the sweep rate to 1 s/DIV or slower. Keep the signal centered on screen with the FINE tuning control as the SPAN/DIV is decreased. Adjust the reference level and gain variable for a full screen display.

f. Using the Vertical Position control, position the top of the display one division down from the top of the graticule, see Fig. 3-7B. This permits the minor divisions, of the center graticule line, to be used in determining the bandwidth.

g. Check the bandwidth at the 6 dB down level. Bandwidth must equal 10 Hz or less.

6. Check Internal Noise Level and Sensitivity

a. Terminate the 5L4N in 600 Ω by depressing the dBm/600 Ω and INT LO Z buttons.

b. Set the vertical mode to 2 dB/Div and the reference level to -120 dBm.

c. Set the resolution to the widest bandwidth (full cw) and the frequency SPAN/DIV at 5 kHz.

d. Depress the 10 Hz video filter to average the observed noise level.

e. The noise level which is the same as the sensitivity should be less than -121 dBm.

f. Set the resolution to the narrowest bandwidth (full ccw) and the reference level to -130 dBm.

g. The noise level should be less than -145 dBm.

7. Check for Residual Responses

a. Set the frequency SPAN/DIV at 10 kHz, and resolution in AUTO (detent full ccw).

b. Set the zero Hz marker to the left edge of the crt by setting the center frequency at 50 kHz.

c. Set the LOG REF to -120 dBm with 10 Hz video filter in.

d. Terminate the 5L4N in 600Ω by depressing the INT LO Z and dBm/600Ω buttons.

e. All residual responses (excepting the zero Hz marker) should be below -130 dBm.

ELECTRICAL REPLACEABLE 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 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.

SPECIAL NOTES AND SYMBOLS

X000	Part first added at this serial number
00X	Part removed after this serial number

ITEM NAME

In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

ABBREVIATIONS

ACTR	ACTUATOR
ASSY	ASSEMBLY
CAP	CAPACITOR
CER	CERAMIC
CKT	CIRCUIT
COMP	COMPOSITION
CONN	CONNECTOR
ELCTLT	ELECTROLYTIC
ELEC	ELECTRICAL
FXD	FIXED
INCAND	INCANDESCENT
LED	LIGHT EMITTING DIODE
NONWIR	NON WIREWOUND
PLSTC	PLASTIC
QTZ	QUARTZ
RECP	RECEPTACLE
RES	RESISTOR
RF	RADIO FREQUENCY
SEL	SELECTED
SEMICOND	SEMICONDUCTOR
SENS	SENSITIVE
SEP	SEPARATELY
VAR	VARIABLE
WW	WIREWOUND
XFMR	TRANSFORMER
XTAL	CRYSTAL

CROSS INDEX MFR. CODE NUMBER TO MANUFACTURER

MFR.CODE	MANUFACTURER	ADDRESS	CITY,STATE,ZIP
00853	Sangamo Electric Co., S. Carolina Div.	P. O. Box 128	Pickens, SC 29671
01002	General Electric Co., Industrial and Power Capacitor Products Dept.	John St.	Hudson Falls, NY 12839
01121	Allen-Bradley Co.	1201 2nd St. South	Milwaukee, WI 53204
01295	Texas Instruments, Inc., Components Group	P. O. Box 5012	Dallas, TX 75222
01884	Sprague Electric Co., Dearborn Electronics	P. O. Box 1076	Longwood, FL 32750
02111	Spectrol Electronics Corp.	17070 East Gale Ave.	City of Industry, CA 91745
02735	RCA Corp., Solid State Division	Route 202	Somerville, NY 08876
04713	Motorola, Inc., Semiconductor Products Div.	5005 E. McDowell Rd.	Phoenix, AZ 85008
07263	Fairchild Semiconductor, A Div. of Fairchild Camera and Instrument Corp.	464 Ellis St.	Mountain View, CA 94040
07910	Teledyne Semiconductor	12515 Chadron Ave.	Hawthorne, CA 90250
08806	General Electric Co., Miniature Lamp Products Dept.	Nela PK.	Cleveland, OH 44112
10389	Chicago Switch, Inc.	2035 Wabansia Ave.	Chicago, IL 60647
11237	CTS Keene, Inc.	3230 Riverside Ave.	Paso Robles, CA 93446
12040	National Semiconductor Corp.	Commerce Drive	Danbury, CT 06810
12697	Clarostat Mfg. Co., Inc.	Lower Washington St.	Dover, NH 03820
15818	Teledyne Semiconductor	1300 Terra Bella Ave.	Mountain View, CA 94040
18324	Signetics Corp.	811 E. Arques	Sunnyvale, CA 94086
27014	National Semi-Conductor Corp.	2900 San Ysidro Way	Santa Clara, CA 95051
28480	Hewlett-Packard Co., Corporate Hq.	1501 Page Mill Rd.	Palo Alto, CA 94304
50522	Monsanto Co., Electronic Special Products	10131 Bubb Rd.	Cupertino, CA 95014
56285	Sprague and Carleton		Avon Keene, NH 03431
56289	Sprague Electric Co.		North Adams, MA 01247
71279	Cambridge Thermionic Corp.	445 Concord Ave.	Cambridge, MA 02138
72136	Electro Motive Mfg. Co., Inc., The	South Park and John Streets	Willimantic, CT 06226
72982	Erie Technological Products, Inc.	644 W. 12th St.	Erie, PA 16512
73138	Beckman Instruments, Inc., Helipot Div.	2500 Harbor Blvd.	Fullerton, CA 92634
75042	TRW Electronic Components, IRC Fixed Resistors, Philadelphia Division	401 N. Broad St.	Philadelphia, PA 19108
75915	Littelfuse, Inc.	800 E. Northwest Hwy	Des Plaines, IL 60016
76493	Bell Industries, Inc., Miller, J. W., Div.	P. O. Box 5825	Compton, CA 90224
80009	Tektronix, Inc.	P. O. Box 500	Beaverton, OR 97005
80031	Mepco/Electa Inc., A North American Phillips Co.	Columbia Rd.	Morristown, NJ 07960
80294	Bourns, Inc., Instrument Div.	6135 Magnolia Ave.	Riverside, CA 92506
81483	International Rectifier Corp.	9220 Sunset Blvd.	Los Angeles, CA 90069
86684	RCA Corp., Electronic Components	415 S. 5th St.	Harrison, NJ 07029
90201	Mallory Capacitor Co., Div. of P. R. Mallory Co., Inc.	3029 E. Washington St.	Indianapolis, IN 46206
91637	Dale Electronics, Inc.	P. O. Box 609	Columbus, NB 68601
91836	Kings Electronics Co., Inc.	40 Marbledale Road	Tuckahoe, NY 10707
97979	Reon Resistor Corp.	420 Lincoln Hwy.	Fraser, PA 19355

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A50	670-3427-00			CKT BOARD ASSY:INPUT LOW PASS IMPEDANCE	80009	670-3427-00
A100	670-3440-00			CKT BOARD ASSY:MIXER	80009	670-3440-00
A300	670-3439-00			CKT BOARD ASSY:VARIABLE RESOLUTION	80009	670-3439-00
A430	670-3425-00			CKT BOARD ASSY:CRYSTAL MOUNTING	80009	670-3425-00
A440	670-3436-00			CKT BOARD ASSY:DISPLAY FUNCTION AMPL	80009	670-3436-00
A580	670-3437-00			CKT BOARD ASSY:DETECTOR	80009	670-3437-00
A680A1	670-3432-00			CKT BOARD ASSY:VERT GAIN SWITCH	80009	670-3432-00
A680A2	670-3422-00			CKT BOARD ASSY:LOG/LIN SWITCH	80009	670-3422-00
A690	670-3431-00			CKT BOARD ASSY:VERT INTERFACE	80009	670-3431-00
A700	670-3433-00			CKT BOARD ASSY:SWEEP GEN AND AMPL	80009	670-3433-00
A800	670-3430-00			CKT BOARD ASSY:FREQ SPAN RESP	80009	670-3430-00
A900	670-3438-00			CKT BOARD ASSY:CALIB SHAPER	80009	670-3438-00
A1100	670-3423-00			CKT BOARD ASSY:START CENTER SWITCH	80009	670-3423-00
A1150	670-3434-00			CKT BOARD ASSY:MAIN MOTHER	80009	670-3434-00
A1250	670-3429-00			CKT BOARD ASSY:HORIZ INTERFACE	80009	670-3429-00
A1300	670-3435-00			CKT BOARD ASSY:TRANSVERSE INTERFACE	80009	670-3435-00
A1320	670-3426-00			CKT BOARD ASSY:LEFT MOTHER	80009	670-3426-00
A1340	670-3424-00			CKT BOARD ASSY:RIGHT MOTHER	80009	670-3424-00
C50	281-0501-00			CAP.,FXD,CER DI:4.7PF,+/-1PF,500V	72982	301-000S2H0479F
C54	285-0650-00			CAP.,FXD,PLSTC:0.027UF,5%,100V		
C56	281-0203-00			CAP.,VAR,PLSTC:2-10PF,100V	80031	C010EA/10E
C58	281-0207-00			CAP.,VAR,PLSTC:2-18PF,100V	80031	HT10EA-218
C60	285-0650-00			CAP.,FXD,PLSTC:0.027UF,5%,100V		
C62	281-0203-00			CAP.,VAR,PLSTC:2-10PF,100V	80031	C010EA/10E
C64	281-0501-00			CAP.,FXD,CER DI:4.7PF,+/-1PF,500V	72982	301-000S2H0479F
C100	290-0717-00			CAP.,FXD,ELCTLT:15UF,20%,50V		
C102	290-0717-00			CAP.,FXD,ELCTLT:15UF,20%,50V		
C104	290-0717-00			CAP.,FXD,ELCTLT:15UF,20%,50V		
C106	290-0717-00			CAP.,FXD,ELCTLT:15UF,20%,50V		
C125	281-0661-00			CAP.,FXD,CER DI:0.8PF,+/-0.1PF,500V	72982	301-000C0G0808B
C130	290-0718-00			CAP.,FXD,ELCTLT:22UF,20%,35V		
C134	290-0536-00			CAP.,FXD,ELCTLT:10UF,20%,25V	90201	TDC106M025FL
C136	283-0637-00			CAP.,FXD,MICA D:20PF,2.5%,100V	00853	D151E200D0
C137	283-0626-00			CAP.,FXD,MICA D:1800PF,5%,500V	00853	D19E182J0500
C138	283-0672-00			CAP.,FXD,MICA D:200PF,1%,500V	00853	D155F201F0
C140	283-0104-00			CAP.,FXD,CER DI:2000PF,5%,500V	72982	811-565B202J
C142	283-0670-00			CAP.,FXD,MICA D:375PF,1%,500V	00853	D155F3750F0
C144	283-0626-00			CAP.,FXD,MICA D:1800PF,5%,500V	00853	D19E182J0500
C146	283-0631-00			CAP.,FXD,MICA D:95PF,1%,100V	00853	D151E950F0
C148	283-0605-00			CAP.,FXD,MICA D:678PF,1%,300V	00853	D153F678F0
C152	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C164	290-0530-00			CAP.,FXD,ELCTLT:68UF,20%,6V	90201	TDC686M006FL
C168	290-0721-00			CAP.,FXD,ELCTLT:100UF,20%,20V		
C180	290-0536-00			CAP.,FXD,ELCTLT:10UF,20%,25V	90201	TDC106M025FL
C184	290-0722-00			CAP.,FXD,ELCTLT:100UF,20%,10V		
C198	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039651105Z
C200	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C202	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C204	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039651105Z
C206	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C208	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C209	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C210	283-0249-00			CAP.,FXD,CER DI:0.068UF,10%,50V	72982	8131N075WR5683K
C212	281-0204-00			CAP.,VAR,PLSTC:2-22PF,100V	80031	C010EA-20E
C213	285-0683-00			CAP.,FXD,PLSTC:0.022UF,5%,100V	01002	64F15AC223
C214	281-0204-00			CAP.,VAR,PLSTC:2-22PF,100V	80031	C010EA-20E
C215	283-0065-00			CAP.,FXD,CER DI:0.001UF,5%,100V	72982	805-505B102J
C216	283-0249-00			CAP.,FXD,CER DI:0.068UF,10%,50V	72982	8131N075WR5683K
C218	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600

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Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
C220	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C224	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C228	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C230	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C234	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C236	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C240	283-0065-00			CAP.,FXD,CER DI:0.001UF,5%,100V	72982	805-505B102J
C254	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C264	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C270	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C274	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C280	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C284	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C286	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C290	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C292	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C294	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039651105Z
C295	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C297	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C300	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C302	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039651105Z
C304	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C306	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C308	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C309	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C310	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C312	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C316	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C318	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C320	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C322	281-0610-00			CAP.,FXD,CER DI:2.2PF,+/-0.1PF,500V	72982	374-001C0J0229B
C324	281-0204-00			CAP.,VAR,PLSTC:2-22PF,100V	80031	C010EA-20E
C326	283-0604-00			CAP.,FXD,MICA D:304PF,2%,300V	00853	D153F3040G0
C328	281-0125-00			CAP.,VAR,MICA D:90-400PF,175V	72136	T51917-1
C329	281-0504-00			CAP.,FXD,CER DI:10PF,+/-1PF,500V	72982	301-000C0G0100F
C330	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C338	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C346	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C348	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C350	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C352	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C354	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039651105Z
C356	281-0610-00			CAP.,FXD,CER DI:2.2PF,+/-0.1PF,500V	72982	374-001C0J0229B
C358	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C360	281-0204-00			CAP.,VAR,PLSTC:2-22PF,100V	80031	C010EA-20E
C362	283-0077-00			CAP.,FXD,CER DI:330PF,5%,500V	56289	40C94A3
C364	281-0125-00			CAP.,VAR,MICA D:90-400PF,175V	72136	T51917-1
C366	281-0504-00			CAP.,FXD,CER DI:10PF,+/-1PF,500V	72982	301-000C0G0100F
C370	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C374	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C375	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C376	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C378	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C380	281-0580-00			CAP.,FXD,CER DI:470PF,10%,500V	72982	301-000Z5D0471K
C382	281-0204-00			CAP.,VAR,PLSTC:2-22PF,100V	80031	C010EA-20E
C384	281-0125-00			CAP.,VAR,MICA D:90-400PF,175V	72136	T51917-1
C385	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039651105Z
C386	281-0504-00			CAP.,FXD,CER DI:10PF,+/-1PF,500V	72982	301-000C0G0100F
C388	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C392	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
C394	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C396	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C398	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C400	281-0580-00			CAP.,FXD,CER DI:470PF,10%,500V	72982	301-000Z5D0471K
C402	281-0204-00			CAP.,VAR,PLSTC:2-22PF,100V	80031	C010EA-20E
C404	281-0125-00			CAP.,VAR,MICA D:90-400PF,175V	72136	T51917-1
C406	281-0504-00			CAP.,FXD,CER DI:10PF,+/-1PF,500V	72982	301-000C0G0100F
C410	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C414	283-0756-00			CAP.,FXD,MICA D:4700PF,5%,300V		
C416	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C418	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C420	283-0634-00			CAP.,FXD,MICA D:65PF,1%,100V	00853	D151E650F0
C422	283-0756-00			CAP.,FXD,MICA D:4700PF,5%,300V		
C424	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C426	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C428	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C441	283-0167-00			CAP.,FXD,CER DI:0.1UF,10%,100V	72982	8131N147W5R104K
C444	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039651105Z
C446	283-0167-00			CAP.,FXD,CER DI:0.1UF,10%,100V	72982	8131N147W5R104K
C448	283-0167-00			CAP.,FXD,CER DI:0.1UF,10%,100V	72982	8131N147W5R104K
C450	283-0167-00			CAP.,FXD,CER DI:0.1UF,10%,100V	72982	8131N147W5R104K
C452	283-0167-00			CAP.,FXD,CER DI:0.1UF,10%,100V	72982	8131N147W5R104K
C454	283-0167-00			CAP.,FXD,CER DI:0.1UF,10%,100V	72982	8131N147W5R104K
C460	283-0167-00			CAP.,FXD,CER DI:0.1UF,10%,100V	72982	8131N147W5R104K
C476	283-0167-00			CAP.,FXD,CER DI:0.1UF,10%,100V	72982	8131N147W5R104K
C478	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C482	281-0628-00			CAP.,FXD,CER DI:15PF,5%,600V	72982	301-000C0G0150G
C488	283-0167-00			CAP.,FXD,CER DI:0.1UF,10%,100V	72982	8131N147W5R104K
C490	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C492	283-0167-00			CAP.,FXD,CER DI:0.1UF,10%,100V	72982	8131N147W5R104K
C496	283-0167-00			CAP.,FXD,CER DI:0.1UF,10%,100V	72982	8131N147W5R104K
C514	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C516	283-0167-00			CAP.,FXD,CER DI:0.1UF,10%,100V	72982	8131N147W5R104K
C520	283-0167-00			CAP.,FXD,CER DI:0.1UF,10%,100V	72982	8131N147W5R104K
C534	281-0592-00			CAP.,FXD,CER DI:4.7PF,+/-0.5PF,500V	72982	301-023C0H0479D
C536	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C540	283-0167-00			CAP.,FXD,CER DI:0.1UF,10%,100V	72982	8131N147W5R104K
C550	283-0167-00			CAP.,FXD,CER DI:0.1UF,10%,100V	72982	8131N147W5R104K
C556	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039651105Z
C580	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C582	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C584	285-0643-00			CAP.,FXD,PLSTC:0.0047UF,5%,100V	01002	64F10AC472
C586	281-0605-00			CAP.,FXD,CER DI:200PF,10%,500V	72982	301-000Y5D0201K
C588	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C594	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C596	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C599	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C610	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C616	283-0268-00			CAP.,FXD,CER DI:0.015UF,10%,50V	72982	8131N075W5R153K
C618	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C622	283-0001-00			CAP.,FXD,CER DI:0.005UF,+100-0%,500V	72982	831-559E502P
C624	283-0328-00			CAP.,FXD,CER DI:0.03UF,+80-20%,200V	72982	8131N225651303Z
C626	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039651105Z
C627	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C628	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C629	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C632	281-0630-00			CAP.,FXD,CER DI:390PF,5%,500V	72982	301-000Y5D0391J
C640	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C642	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C666	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P

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C674	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C692	290-0517-00			CAP.,FXD,ELCTLT:6.8UF,20%,35V	56289	196D685X0035KA1
C693	283-0087-00			CAP.,FXD,CER DI:300PF,10%,1000V		
C694	283-0065-00			CAP.,FXD,CER DI:0.001UF,5%,100V	72982	805-505B102J
C698	290-0517-00			CAP.,FXD,ELCTLT:6.8UF,20%,35V	56289	196D685X0035KA1
C700	290-0297-00			CAP.,FXD,ELCTLT:39UF,10%,10V	56289	150D396X9010B2
C710	285-0809-00			CAP.,FXD,PLSTC:1UF,10%,50V	01884	LP88A1A105K
C736	283-0211-00			CAP.,FXD,CER DI:0.1UF,10%,200V	72982	8141208W5R104K
C738	290-0134-00			CAP.,FXD,ELCTLT:22UF,20%,15V	56289	150D226X0015B2
C740	283-0080-00			CAP.,FXD,CER DI:0.022UF,+80-20%,25V	56289	19C611
C742	283-0204-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N058651103M
C748	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039651105Z
C749	281-0629-00			CAP.,FXD,CER DI:33PF,5%,600V	72982	308-000COG0330G
C750	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039651105Z
C762	281-0524-00			CAP.,FXD,CER DI:150PF,+/-30PF,500V	72982	301-000X5U0151M
C776	283-0204-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N058651103M
C810	281-0551-00			CAP.,FXD,CER DI:390PF,10%,500V	72982	301-000X5P0391K
C814	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C816	283-0204-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N058651103M
C876	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039651105Z
C900	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039651105Z
C902	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C903	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039651105Z
C916	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039651105Z
C919	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C920	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039651105Z
C922	290-0512-00			CAP.,FXD,ELCTLT:22UF,20%,15V	56285	196D226X0015KA1
C927	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C928	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C932	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C936	290-0718-00			CAP.,FXD,ELCTLT:22UF,20%,35V		
C962	290-0718-00			CAP.,FXD,ELCTLT:22UF,20%,35V		
C988	290-0718-00			CAP.,FXD,ELCTLT:22UF,20%,35V		
C990	290-0512-00			CAP.,FXD,ELCTLT:22UF,20%,15V	56285	196D226X0015KA1
C996	283-0267-00			CAP.,FXD,CER DI:0.01UF,20%,500V	72982	841-541C103M
C998	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C999	290-0718-00			CAP.,FXD,ELCTLT:22UF,20%,35V		
C1000	290-0512-00			CAP.,FXD,ELCTLT:22UF,20%,15V	56285	196D226X0015KA1
C1004	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C1006	283-0249-00			CAP.,FXD,CER DI:0.068UF,10%,50V	72982	8131N075WR5683K
C1018	281-0509-00			CAP.,FXD,CER DI:15PF,+/-1.5PF,500V	72982	301-000C0G0150K
C1020	281-0125-00			CAP.,VAR,MICA D:90-400PF,175V	72136	T51917-1
C1022	283-0110-00			CAP.,FXD,CER DI:0.005UF,+80-20%,150V	56289	19C242B
C1024	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C1026	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C1030	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C1034	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039651105Z
C1036	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C1038	283-0756-00			CAP.,FXD,MICA D:4700PF,5%,300V		
C1040	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039651105Z
C1041	283-0190-00			CAP.,FXD,CER DI:47UF,5%,50V	72982	8141N077W5R474J
C1042	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039651105Z
C1043	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C1044	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039651105Z
C1046	290-0526-00			CAP.,FXD,ELCTLT:6.8UF,20%,6V	90201	TDC685M006EL
C1048	290-0526-00			CAP.,FXD,ELCTLT:6.8UF,20%,6V	90201	TDC685M006EL
C1052	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C1060	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C1066	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C1068	283-0728-00			CAP.,FXD,MICA:120PF,+/-1%,500V	00853	DM15-5F121F0

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
C1070	283-0626-00			CAP.,FXD,MICA D:1800PF,5%,500V	00853	D19E182J0500
C1072	283-0692-00			CAP.,FXD,MICA D:670PF,1%,300V		
C1073	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855-547E103Z
C1074	290-0526-00			CAP.,FXD,ELCTLT:6.8UF,20%,6V	90201	TDC685M006EL
C1172	281-0509-00			CAP.,FXD,CER DI:15PF,+/-1.5PF,500V	72982	301-000C0G0150K
C1210	290-0530-00			CAP.,FXD,ELCTLT:68UF,20%,6V	90201	TDC686M006FL
C1212	290-0530-00			CAP.,FXD,ELCTLT:68UF,20%,6V	90201	TDC686M006FL
C1250	283-0204-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N058651103M
C1252	290-0517-00			CAP.,FXD,ELCTLT:6.8UF,20%,35V	56289	196D685X0035KA1
C1253	283-0087-00			CAP.,FXD,CER DI:300PF,10%,1000V		
C1256	283-0065-00			CAP.,FXD,CER DI:0.001UF,5%,100V	72982	805-505B102J
C1268	290-0517-00			CAP.,FXD,ELCTLT:6.8UF,20%,35V	56289	196D685X0035KA1
C1306	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C1307	283-0204-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N058651103M
CR54	152-0246-00	XB010151		SEMICOND DEVICE:SILICON,400PIV,200MA	07910	CD12676
CR56	152-0246-00	XB010151		SEMICOND DEVICE:SILICON,400PIV,200MA	07910	CD12676
CR112	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR114	152-0246-00			SEMICOND DEVICE:SILICON,400PIV,200MA	07910	CD12676
CR116	152-0246-00			SEMICOND DEVICE:SILICON,400PIV,200MA	07910	CD12676
CR118	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR159	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR162	152-0246-00	B010100	B010150X	SEMICOND DEVICE:SILICON,400PIV,200MA	07910	CD12676
CR164	152-0246-00	B010100	B010150X	SEMICOND DEVICE:SILICON,400PIV,200MA	07910	CD12676
CR212 CR214 CR216 CR218	153-0044-00			SEMICOND,DEVICE:SILICON,15V,MATCHED	80009	153-0044-00
CR540	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR614	152-0322-00			SEMICOND DEVICE:SILICON,15V	28480	5082-2672
CR616	152-0322-00			SEMICOND DEVICE:SILICON,15V	28480	5082-2672
CR630	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR632	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR680	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR682	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR684	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR686	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR702	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR724	152-0322-00			SEMICOND DEVICE:SILICON,15V	28480	5082-2672
CR744	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR746	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR866	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR868	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR878	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR932	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR940	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR942	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR944	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR946	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR948	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR950	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR952	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR960	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR964	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR966	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR968	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR970	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR972	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR974	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR976	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152

Electrical Parts List—5L4N

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
CR978	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR985	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR988	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR994	152-0597-00			SEMICOND DEVICE:VOLT VAR CAP,330PF,10%		
CR1032	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1216	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1218	152-0322-00			SEMICOND DEVICE:SILICON,15V	28480	5082-2672
CR1220	152-0322-00			SEMICOND DEVICE:SILICON,15V	28480	5082-2672
CR1222	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1224	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1226	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1264	152-0107-00			SEMICOND DEVICE:SILICON,375V,400MA	80009	152-0107-00
DS680	150-0111-00			LAMP,GLOW:NEON,1.2MA	08806	2AC-AT
DS682	150-0111-00			LAMP,GLOW:NEON,1.2MA	08806	2AC-AT
F56	159-0056-00			FUSE,CARTRIDGE:0.1A,125V,FAST-BLOW	75915	279-100
F62	159-0056-00	B010100	B010150X	FUSE,CARTRIDGE:0.1A,125V,FAST-BLOW	75915	279-100
J5	131-0274-00			CONNECTOR,RCPT,:BNC	91836	KC79-67
J6	131-0274-00			CONNECTOR,RCPT,:BNC	91836	KC79-67
J7	136-0387-00			JACK,TIP:GRAY	71279	4352-1-0318
J8	136-0387-00			JACK,TIP:GRAY	71279	4352-1-0318
K110	148-0035-00			RELAY,ARMATURE:SPDT,15VDC,600 OHM	80009	148-0035-00
K160	148-0034-00			RELAY,ARMATURE:DPDT,15VDC,600 OHM	80009	148-0034-00
L138	114-0178-00			COIL,RF:1300-3000UH		
L142	114-0337-00			COIL,RF:650-1300UH		
L146	114-0337-00			COIL,RF:650-1300UH		
L212	114-0209-00			COIL,RF:28-60UH,CORE NOT REPLACEABLE	80009	114-0209-00
L324	114-0341-00			COIL,RF:7.13-7.35MH	80009	114-0341-00
L364	114-0341-00			COIL,RF:7.13-7.35MH	80009	114-0341-00
L384	114-0341-00			COIL,RF:7.13-7.35MH	80009	114-0341-00
L404	114-0341-00			COIL,RF:7.13-7.35MH	80009	114-0341-00
L414	114-0200-00			COIL,RF:60-120UH		
L420	114-0200-00			COIL,RF:60-120UH		
L580	114-0200-00			COIL,RF:60-120UH		
L616	108-0324-00			COIL,RF:130UH	76493	70F102A1
L1038	114-0200-00			COIL,RF:60-120UH		
L1068	114-0337-00			COIL,RF:650-1300UH		
Q110	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q115	151-0188-00			TRANSISTOR:SILICON,PNP	04713	2N3906
Q125	151-1027-00			TRANSISTOR:SILICON,JFE,N-CHAN	80009	151-1027-00
Q130A,B	151-0261-00			TRANSISTOR:SILICON,PNP,DUAL	12040	NS7410
Q135	151-0302-00			TRANSISTOR:SILICON,NPN	04713	2N2222A
Q140	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q145	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q150	151-0188-00			TRANSISTOR:SILICON,PNP	04713	2N3906
Q155	151-0188-00			TRANSISTOR:SILICON,PNP	04713	2N3906
Q160	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q165	151-0188-00			TRANSISTOR:SILICON,PNP	04713	2N3906
Q170	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q175	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q180	151-0302-00			TRANSISTOR:SILICON,NPN	04713	2N2222A
Q210	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q215	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q230	151-0188-00			TRANSISTOR:SILICON,PNP	04713	2N3906
Q235	151-1021-00			LAMP,LED:SILICON,JFE	50522	MAN73
Q240	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q245	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q250	151-1021-00			LAMP,LED:SILICON,JFE	50522	MAN73

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
Q255	151-1021-00			LAMP,LED:SILICON,JFE	50522	MAN73
Q260	151-1021-00			LAMP,LED:SILICON,JFE	50522	MAN73
Q265	151-1021-00			LAMP,LED:SILICON,JFE	50522	MAN73
Q275	151-1021-00			LAMP,LED:SILICON,JFE	50522	MAN73
Q280	151-0188-00			TRANSISTOR:SILICON,PNP	04713	2N3906
Q285	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q290	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q295	151-0188-00			TRANSISTOR:SILICON,PNP	04713	2N3906
Q320	151-0188-00			TRANSISTOR:SILICON,PNP	04713	2N3906
Q325	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q330	151-1006-00			TRANSISTOR:SILICON,JFE,N-CHANNEL	15818	U1491
Q335	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q340A,B	151-0232-00			TRANSISTOR:SILICON,NPN,DUAL	12040	NS7348
Q350	151-0188-00			TRANSISTOR:SILICON,PNP	04713	2N3906
Q360	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q365	151-1005-00			TRANSISTOR:SILICON,JFE,N-CHANNEL	15818	U1490
Q370	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q375	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q380	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q385	151-1005-00			TRANSISTOR:SILICON,JFE,N-CHANNEL	15818	U1490
Q390	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q395	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q400	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q405	151-1006-00			TRANSISTOR:SILICON,JFE,N-CHANNEL	15818	U1491
Q410	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q420	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q460	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q465	151-1021-00			LAMP,LED:SILICON,JFE	50522	MAN73
Q480	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q495	151-1021-00			LAMP,LED:SILICON,JFE	50522	MAN73
Q500	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q505	151-1021-00			LAMP,LED:SILICON,JFE	50522	MAN73
Q530	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q535	151-1021-00			LAMP,LED:SILICON,JFE	50522	MAN73
Q560	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q580	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q590	151-0188-00			TRANSISTOR:SILICON,PNP	04713	2N3906
Q595	151-0188-00			TRANSISTOR:SILICON,PNP	04713	2N3906
Q600	151-1066-00			TRANSISTOR:SILICON,FE,P-CHANNEL	15818	P1182E
Q620	151-1021-00			LAMP,LED:SILICON,JFE	50522	MAN73
Q625	151-1021-00			LAMP,LED:SILICON,JFE	50522	MAN73
Q660	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q665	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q670	151-0188-00			TRANSISTOR:SILICON,PNP	04713	2N3906
Q672	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q674	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q675	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q680	151-0188-00			TRANSISTOR:SILICON,PNP	04713	2N3906
Q682	151-0188-00			TRANSISTOR:SILICON,PNP	04713	2N3906
Q695	151-0334-00			TRANSISTOR:SILICON,NPN	80009	151-0334-00
Q700	151-0188-00			TRANSISTOR:SILICON,PNP	04713	2N3906
Q745	151-1045-00	XB010151		TRANSISTOR:SILICON,JFE,P-CHANNEL	80009	151-1045-00
Q750A,B	151-0261-00			TRANSISTOR:SILICON,PNP,DUAL	12040	NS7410
Q770	151-0341-00			TRANSISTOR:SILICON,NPN	07263	2N3565
Q775	151-0341-00			TRANSISTOR:SILICON,NPN	07263	2N3565
Q810	151-0292-00			TRANSISTOR:SILICON,NPN	01295	TIS100
Q920A,B	151-0232-00			TRANSISTOR:SILICON,NPN,DUAL	12040	NS7348
Q925	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q930	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q935	151-0301-00			TRANSISTOR:SILICON,PNP	04713	2N2907A

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
Q995	151-0219-00			TRANSISTOR:SILICON,PNP		
Q1005	151-0282-00			TRANSISTOR:SILICON,NPN	02735	2N5179
Q1010	151-0282-00			TRANSISTOR:SILICON,NPN	02735	2N5179
Q1020	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q1025	151-0188-00			TRANSISTOR:SILICON,PNP	04713	2N3906
Q1160	151-0190-00			TRANSISTOR:SILICON,NPN	04713	2N3904
Q1190A,B	151-0232-00			TRANSISTOR:SILICON,NPN,DUAL	12040	NS7348
Q1260	151-0335-00			TRANSISTOR:SILICON,PNP	80009	151-0335-00
Q1265	151-0335-00			TRANSISTOR:SILICON,PNP	80009	151-0335-00
R3	311-1104-00			RES.,VAR,NONWIR:10K OHM,10%,0.50W	12697	381-CM40095
R4	311-0546-00			RES.,VAR,NONWIR:10K OHM,20%,0.75W	97979	TK0546G
R6	311-0546-00			RES.,VAR,NONWIR:10K OHM,20%,0.75W	97979	TK0546G
R8 | R10	311-1411-00			RES.,VAR,NONWIR:1K OHM X 10K OHM,20%,0.50W		
R14	311-1045-00			RES.,VAR,NONWIR:250K OHM,10%,0.50W		
R20	311-1045-00			RES.,VAR,NONWIR:250K OHM,10%,0.50W		
R22 | R24	311-1486-00			RES.,VAR,NONWIR:100K OHM X 2K OHM,20%,0.25W		
R26	311-1095-00			RES.,VAR,NONWIR:10K OHM,20%,0.50W	11237	300SF-3P1631
R28	311-1045-00			RES.,VAR,NONWIR:250K OHM,10%,0.50W		
R30	311-1324-00			RES.,VAR,WW:10K OHM,5%,2W	02111	534-9572
R32	311-0387-00			RES.,VAR,NONWIR:5K OHM,20%	11237	41027
R50	321-0510-00			RES.,FXD,FILM:2M OHM,1%,0.125W	75042	CEAT0-2004F
R52	321-0510-00			RES.,FXD,FILM:2M OHM,1%,0.125W	75042	CEAT0-2004F
R54	322-0618-00			RES.,FXD,FILM:50 OHM,1%,0.25W	75042	CEBT0-50R00F
R56	321-0661-00			RES.,FXD,FILM:600 OHM,1%,0.125W	75042	CEAT0-6000F
R58	315-0471-00			RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R100	315-0220-00			RES.,FXD,COMP:22 OHM,5%,0.25W	01121	CB2205
R102	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R104	315-0303-00			RES.,FXD,COMP:30K OHM,5%,0.25W	01121	CB3035
R106	315-0202-00			RES.,FXD,COMP:2K OHM,5%,0.25W	01121	CB2025
R108	315-0220-00			RES.,FXD,COMP:22 OHM,5%,0.25W	01121	CB2205
R109	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R110	301-0621-00			RES.,FXD,COMP:620 OHM,5%,0.50W	01121	EB6215
R112	315-0473-00			RES.,FXD,COMP:47K OHM,5%,0.25W	01121	CB4735
R114	321-0085-00			RES.,FXD,FILM:75 OHM,1%,0.125W	75042	CEAT0-75R00F
R116	321-0175-00			RES.,FXD,FILM:649 OHM,1%,0.125W	75042	CEAT0-6490F
R118	321-0252-00			RES.,FXD,FILM:4.12K OHM,1%,0.125W	75042	CEAT0-4121F
R120	321-0263-00			RES.,FXD,FILM:5.36K OHM,1%,0.125W	75042	CEAT0-5361F
R122	321-0326-00			RES.,FXD,FILM:24.3K OHM,1%,0.125W	75042	CEAT0-2432F
R124	321-0252-00			RES.,FXD,FILM:4.12K OHM,1%,0.125W	75042	CEAT0-4121F
R126	321-0001-00			RES.,FXD,FILM:10 OHM,1%,0.125W	75042	CEAT0-10R00F
R128	321-0178-00			RES.,FXD,FILM:698 OHM,1%,0.125W	75042	CEAT0-6980F
R130	321-0251-00			RES.,FXD,FILM:4.02K OHM,1%,0.125W	75042	CEAT0-4021F
R131	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	75042	CEAT0-1001F
R132	321-0175-00			RES.,FXD,FILM:649 OHM,1%,0.125W	75042	CEAT0-6490F
R134	321-0244-00			RES.,FXD,FILM:3.4K OHM,1%,0.125W	75042	CEAT0-3401F
R136	315-0471-00			RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R138	321-0183-00			RES.,FXD,FILM:787 OHM,1%,0.125W	75042	CEAT0-7870F
R140	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R148	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R150	321-0181-00			RES.,FXD,FILM:750 OHM,1%,0.125W	75042	CEAT0-7500F
R151	315-0153-00			RES.,FXD,COMP:15K OHM,5%,0.25W	01121	CB1535
R152	315-0270-00			RES.,FXD,COMP:27 OHM,5%,0.25W	01121	CB2705
R153	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R154	321-0181-00			RES.,FXD,FILM:750 OHM,1%,0.125W	75042	CEAT0-7500F
R156	315-0681-00			RES.,FXD,COMP:680 OHM,5%,0.25W	01121	CB6815
R157	315-0330-00			RES.,FXD,COMP:33 OHM,5%,0.25W	01121	CB3305
R158	301-0621-00			RES.,FXD,COMP:620 OHM,5%,0.50W	01121	EB6215

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R159	315-0473-00			RES.,FXD,COMP:47K OHM,5%,0.25W	01121	CB4735
R160	311-1274-00			RES.,VAR,NONWIR:500K OHM,10%,0.50W		
R161	321-0510-00			RES.,FXD,FILM:2M OHM,1%,0.125W	75042	CEAT0-2004F
R162	315-0102-00			RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R163	321-0510-00			RES.,FXD,FILM:2M OHM,1%,0.125W	75042	CEAT0-2004F
R164	315-0396-00			RES.,FXD,COMP:39M OHM,5%,0.25W	01121	CB3965
R165	311-1007-00			RES.,VAR,NONWIR:20 OHM,20%,0.50W	80294	3329HG48-200
R166	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	75042	CEAT0-1002F
R168	321-0222-00			RES.,FXD,FILM:2K OHM,1%,0.125W	75042	CEAT0-2001F
R169	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	75042	CEAT0-1002F
R170	321-0222-00			RES.,FXD,FILM:2K OHM,1%,0.125W	75042	CEAT0-2001F
R172	321-0183-00			RES.,FXD,FILM:787 OHM,1%,0.125W	75042	CEAT0-7870F
R174	321-0244-00			RES.,FXD,FILM:3.4K OHM,1%,0.125W	75042	CEAT0-3401F
R180	321-0260-00			RES.,FXD,FILM:4.99K OHM,1%,0.125W	75042	CEAT0-4991F
R182	321-0207-00			RES.,FXD,FILM:1.4K OHM,1%,0.125W	75042	CEAT0-1401F
R184	315-0472-00			RES.,FXD,COMP:4.7K OHM,5%,0.25W	01121	CB4725
R186	321-0135-00			RES.,FXD,FILM:249 OHM,1%,0.125W	75042	CEAT0-2490F
R188	307-0113-00			RES.,FXD,COMP:5.1 OHM,5%,0.25W	01121	CB51G5
R190	321-0183-00			RES.,FXD,FILM:787 OHM,1%,0.125W	75042	CEAT0-7870F
R192	321-0048-00			RES.,FXD,FILM:30.9 OHM,1%,0.125W		
R194	321-0058-00			RES.,FXD,FILM:39.2 OHM,1%,0.125W	75042	CEAT0-39R20F
R195	311-1273-00			RES.,VAR,NONWIR:200K OHM,10%,0.50W		
R198	315-0393-00			RES.,FXD,COMP:39K OHM,5%,0.25W	01121	CB3935
R199	321-0035-00			RES.,FXD,FILM:22.6 OHM,1%,0.125W		
R200	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R202	315-0470-00			RES.,FXD,COMP:47 OHM,5%,0.25W	01121	CB4705
R204	315-0220-00			RES.,FXD,COMP:22 OHM,5%,0.25W	01121	CB2205
R206	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R208	315-0470-00			RES.,FXD,COMP:47 OHM,5%,0.25W	01121	CB4705
R209	315-0220-00			RES.,FXD,COMP:22 OHM,5%,0.25W	01121	CB2205
R210	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	75042	CEAT0-1002F
R212	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R214	321-0218-00			RES.,FXD,FILM:1.82K OHM,1%,0.125W	75042	CEAT0-1821F
R216	321-0273-00			RES.,FXD,FILM:6.81K OHM,1%,0.125W	75042	CEAT0-6811F
R218	321-0135-00			RES.,FXD,FILM:249 OHM,1%,0.125W	75042	CEAT0-2490F
R219	315-0332-00			RES.,FXD,COMP:3.3K OHM,5%,0.25W	01121	CB3325
R220	315-0104-00			RES.,FXD,COMP:100K OHM,5%,0.25W	01121	CB1045
R222	315-0104-00			RES.,FXD,COMP:100K OHM,5%,0.25W	01121	CB1045
R224	315-0104-00			RES.,FXD,COMP:100K OHM,5%,0.25W	01121	CB1045
R226	315-0104-00			RES.,FXD,COMP:100K OHM,5%,0.25W	01121	CB1045
R228	315-0104-00			RES.,FXD,COMP:100K OHM,5%,0.25W	01121	CB1045
R229	315-0104-00			RES.,FXD,COMP:100K OHM,5%,0.25W	01121	CB1045
R230	315-0272-00			RES.,FXD,COMP:2.7K OHM,5%,0.25W	01121	CB2725
R232	315-0220-00			RES.,FXD,COMP:22 OHM,5%,0.25W	01121	CB2205
R234	321-0258-00			RES.,FXD,FILM:4.75K OHM,1%,0.125W	75042	CEAT0-4751F
R235	311-1265-00			RES.,VAR,NONWIR:2K OHM,10%,0.50W	80294	3329P-L58-202
R236	321-0227-00			RES.,FXD,FILM:2.26K OHM,1%,0.125W	75042	CEAT0-2261F
R240	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R242	315-0100-00			RES.,FXD,COMP:10 OHM,5%,0.25W	01121	CB1005
R244	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	75042	CEAT0-1001F
R246	315-0682-00			RES.,FXD,COMP:6.8K OHM,5%,0.25W	01121	CB6825
R250	321-0293-00			RES.,FXD,FILM:11K OHM,1%,0.125W	75042	CEAT0-1102F
R252	321-0204-00			RES.,FXD,FILM:1.3K OHM,1%,0.125W	75042	CEAT0-1301F
R254	321-0164-00			RES.,FXD,FILM:499 OHM,1%,0.125W	75042	CEAT0-4990F
R256	321-0244-00			RES.,FXD,FILM:3.4K OHM,1%,0.125W	75042	CEAT0-3401F
R260	321-0233-00			RES.,FXD,FILM:2.61K OHM,1%,0.125W	75042	CEAT0-2611F
R262	315-0104-00			RES.,FXD,COMP:100K OHM,5%,0.25W	01121	CB1045
R264	315-0104-00			RES.,FXD,COMP:100K OHM,5%,0.25W	01121	CB1045
R266	321-0205-00			RES.,FXD,FILM:1.33K OHM,1%,0.125W	75042	CEAT0-1331F
R268	321-0204-00			RES.,FXD,FILM:1.3K OHM,1%,0.125W	75042	CEAT0-1301F

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R269	315-0472-00			RES.,FXD,COMP:4.7K OHM,5%,0.25W	01121	CB4725
R270	315-0104-00			RES.,FXD,COMP:100K OHM,5%,0.25W	01121	CB1045
R272	315-0104-00			RES.,FXD,COMP:100K OHM,5%,0.25W	01121	CB1045
R273	315-0104-00			RES.,FXD,COMP:100K OHM,5%,0.25W	01121	CB1045
R274	315-0104-00			RES.,FXD,COMP:100K OHM,5%,0.25W	01121	CB1045
R278	321-0287-00			RES.,FXD,FILM:9.53K OHM,1%,0.125W	75042	CEAT0-9531F
R280	315-0272-00			RES.,FXD,COMP:2.7K OHM,5%,0.25W	01121	CB2725
R282	315-0220-00			RES.,FXD,COMP:22 OHM,5%,0.25W	01121	CB2205
R284	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	75042	CEAT0-1001F
R286	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R288	315-0100-00			RES.,FXD,COMP:10 OHM,5%,0.25W	01121	CB1005
R289	315-0682-00			RES.,FXD,COMP:6.8K OHM,5%,0.25W	01121	CB6825
R290	321-0126-00			RES.,FXD,FILM:200 OHM,1%,0.125W	75042	CEAT0-2000F
R291	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R292	315-0162-00			RES.,FXD,COMP:1.6K OHM,5%,0.25W	01121	CB1625
R293	315-0102-00			RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R294	315-0220-00			RES.,FXD,COMP:22 OHM,5%,0.25W	01121	CB2205
R295	315-0223-00			RES.,FXD,COMP:22K OHM,5%,0.25W	01121	CB2235
R296	315-0302-00			RES.,FXD,COMP:3K OHM,5%,0.25W	01121	CB3025
R297	321-0225-00			RES.,FXD,FILM:2.15K OHM,1%,0.125W	75042	CEAT0-2151F
R298	321-0332-00			RES.,FXD,FILM:28K OHM,1%,0.125W	75042	CEAT0-2802F
R300	315-0241-00			RES.,FXD,COMP:240 OHM,5%,0.25W	01121	CB2415
R302	315-0100-00			RES.,FXD,COMP:10 OHM,5%,0.25W	01121	CB1005
R304	315-0470-00			RES.,FXD,COMP:47 OHM,5%,0.25W	01121	CB4705
R306	315-0470-00			RES.,FXD,COMP:47 OHM,5%,0.25W	01121	CB4705
R308	315-0470-00			RES.,FXD,COMP:47 OHM,5%,0.25W	01121	CB4705
R309	315-0470-00			RES.,FXD,COMP:47 OHM,5%,0.25W	01121	CB4705
R310	321-0260-00			RES.,FXD,FILM:4.99K OHM,1%,0.125W	75042	CEAT0-4991F
R312	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R314	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R316	315-0470-00			RES.,FXD,COMP:47 OHM,5%,0.25W	01121	CB4705
R318	315-0203-00			RES.,FXD,COMP:20K OHM,5%,0.25W	01121	CB2035
R320	315-0183-00			RES.,FXD,COMP:18K OHM,5%,0.25W	01121	CB1835
R322	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	75042	CEAT0-1002F
R324	315-0302-00			RES.,FXD,COMP:3K OHM,5%,0.25W	01121	CB3025
R325	311-1263-00			RES.,VAR,NONWIR:1K OHM,10%,0.50W	73138	62PT-347-0
R328	321-0256-00			RES.,FXD,FILM:4.53K OHM,1%,0.125W	75042	CEAT0-4531F
R329	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	75042	CEAT0-1001F
R330	311-1259-00			RES.,VAR,NONWIR:100 OHM,10%,0.50W	80294	3329P-L58-101
R332	321-0106-00			RES.,FXD,FILM:124 OHM,1%,0.125W	75042	CEAT0-1240F
R334	315-0153-00			RES.,FXD,COMP:15K OHM,5%,0.25W	01121	CB1535
R336	315-0224-00			RES.,FXD,COMP:220K OHM,5%,0.25W	01121	CB2245
R338	315-0241-00			RES.,FXD,COMP:240 OHM,5%,0.25W	01121	CB2415
R340	315-0754-00			RES.,FXD,COMP:750K OHM,5%,0.25W	01121	CB7545
R342	321-0318-00			RES.,FXD,FILM:20K OHM,1%,0.125W	75042	CEAT0-2002F
R343	321-0251-00			RES.,FXD,FILM:4.02K OHM,1%,0.125W	75042	CEAT0-4021F
R344	321-0431-00			RES.,FXD,FILM:301K OHM,1%,0.125W	75042	CEAT0-3013F
R348	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R350	315-0470-00			RES.,FXD,COMP:47 OHM,5%,0.25W	01121	CB4705
R352	315-0203-00			RES.,FXD,COMP:20K OHM,5%,0.25W	01121	CB2035
R354	315-0183-00			RES.,FXD,COMP:18K OHM,5%,0.25W	01121	CB1835
R356	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	75042	CEAT0-1002F
R358	315-0302-00			RES.,FXD,COMP:3K OHM,5%,0.25W	01121	CB3025
R364	315-0220-00			RES.,FXD,COMP:22 OHM,5%,0.25W	01121	CB2205
R365	311-1263-00			RES.,VAR,NONWIR:1K OHM,10%,0.50W	73138	62PT-347-0
R368	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	75042	CEAT0-1001F
R369	321-0286-00			RES.,FXD,FILM:9.31K OHM,1%,0.125W	75042	CEAT0-9311F
R370	321-0132-00			RES.,FXD,FILM:232 OHM,1%,0.125W	75042	CEAT0-2320F
R372	315-0153-00			RES.,FXD,COMP:15K OHM,5%,0.25W	01121	CB1535
R374	315-0241-00			RES.,FXD,COMP:240 OHM,5%,0.25W	01121	CB2415

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R375	311-1259-00			RES.,VAR,NONWIR:100 OHM,10%,0.50W	80294	3329P-L58-101
R376	315-0512-00			RES.,FXD,COMP:5.1K OHM,5%,0.25W	01121	CB5125
R377	315-0153-00			RES.,FXD,COMP:15K OHM,5%,0.25W	01121	CB1535
R378	315-0470-00			RES.,FXD,COMP:47 OHM,5%,0.25W	01121	CB4705
R380	315-0472-00			RES.,FXD,COMP:4.7K OHM,5%,0.25W	01121	CB4725
R382	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	75042	CEAT0-1002F
R384	315-0470-00			RES.,FXD,COMP:47 OHM,5%,0.25W	01121	CB4705
R385	311-1263-00			RES.,VAR,NONWIR:1K OHM,10%,0.50W	73138	62PT-347-0
R386	321-0286-00			RES.,FXD,FILM:9.31K OHM,1%,0.125W	75042	CEAT0-9311F
R388	321-0132-00			RES.,FXD,FILM:232 OHM,1%,0.125W	75042	CEAT0-2320F
R389	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	75042	CEAT0-1001F
R390	311-1259-00			RES.,VAR,NONWIR:100 OHM,10%,0.50W	80294	3329P-L58-101
R391	315-0153-00			RES.,FXD,COMP:15K OHM,5%,0.25W	01121	CB1535
R392	315-0241-00			RES.,FXD,COMP:240 OHM,5%,0.25W	01121	CB2415
R394	315-0153-00			RES.,FXD,COMP:15K OHM,5%,0.25W	01121	CB1535
R396	315-0512-00			RES.,FXD,COMP:5.1K OHM,5%,0.25W	01121	CB5125
R398	315-0470-00			RES.,FXD,COMP:47 OHM,5%,0.25W	01121	CB4705
R400	315-0472-00			RES.,FXD,COMP:4.7K OHM,5%,0.25W	01121	CB4725
R402	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	75042	CEAT0-1002F
R405	311-1263-00			RES.,VAR,NONWIR:1K OHM,10%,0.50W	73138	62PT-347-0
R406	321-0256-00			RES.,FXD,FILM:4.53K OHM,1%,0.125W	75042	CEAT0-4531F
R408	315-0241-00			RES.,FXD,COMP:240 OHM,5%,0.25W	01121	CB2415
R410	311-1259-00			RES.,VAR,NONWIR:100 OHM,10%,0.50W	80294	3329P-L58-101
R412	321-0106-00			RES.,FXD,FILM:124 OHM,1%,0.125W	75042	CEAT0-1240F
R414	315-0153-00			RES.,FXD,COMP:15K OHM,5%,0.25W	01121	CB1535
R416	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R418	315-0470-00			RES.,FXD,COMP:47 OHM,5%,0.25W	01121	CB4705
R424	311-1263-00			RES.,VAR,NONWIR:1K OHM,10%,0.50W	73138	62PT-347-0
R426	321-0126-00			RES.,FXD,FILM:200 OHM,1%,0.125W	75042	CEAT0-2000F
R428	315-0682-00			RES.,FXD,COMP:6.8K OHM,5%,0.25W	01121	CB6825
R429	315-0102-00			RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R440	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R442	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R444	315-0220-00			RES.,FXD,COMP:22 OHM,5%,0.25W	01121	CB2205
R446	315-0470-00			RES.,FXD,COMP:47 OHM,5%,0.25W	01121	CB4705
R448	315-0470-00			RES.,FXD,COMP:47 OHM,5%,0.25W	01121	CB4705
R450	315-0470-00			RES.,FXD,COMP:47 OHM,5%,0.25W	01121	CB4705
R452	315-0470-00			RES.,FXD,COMP:47 OHM,5%,0.25W	01121	CB4705
R454	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R456	315-0102-00			RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R458	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R460	315-0472-00			RES.,FXD,COMP:4.7K OHM,5%,0.25W	01121	CB4725
R461	321-0235-00			RES.,FXD,FILM:2.74K OHM,1%,0.125W	75042	CEAT0-2741F
R462	321-0154-00			RES.,FXD,FILM:392 OHM,1%,0.125W	75042	CEAT0-3920F
R464	321-0373-00			RES.,FXD,FILM:75K OHM, 1%,0.125W	75042	CEAT0-7502F
R466	321-0251-00			RES.,FXD,FILM:4.02K OHM,1%,0.125W	75042	CEAT0-4021F
R468	321-0371-00			RES.,FXD,FILM:71.5K OHM,1%,0.125W	75042	CEAT0-7152F
R470	321-0203-00			RES.,FXD,FILM:1.27K OHM,1%,0.125W	75042	CEAT0-1271F
R472	321-0371-00			RES.,FXD,FILM:71.5K OHM,1%,0.125W	75042	CEAT0-7152F
R474	315-0224-00			RES.,FXD,COMP:220K OHM,5%,0.25W	01121	CB2245
R476	315-0104-00			RES.,FXD,COMP:100K OHM,5%,0.25W	01121	CB1045
R478	315-0104-00			RES.,FXD,COMP:100K OHM,5%,0.25W	01121	CB1045
R479	315-0224-00			RES.,FXD,COMP:220K OHM,5%,0.25W	01121	CB2245
R480	315-0113-00			RES.,FXD,COMP:11K OHM,5%,0.25W	01121	CB1135
R482	321-0251-00			RES.,FXD,FILM:4.02K OHM,1%,0.125W	75042	CEAT0-4021F
R484	315-0153-00			RES.,FXD,COMP:15K OHM,5%,0.25W	01121	CB1535
R486	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R488	315-0104-00			RES.,FXD,COMP:100K OHM,5%,0.25W	01121	CB1045
R490	315-0224-00			RES.,FXD,COMP:220K OHM,5%,0.25W	01121	CB2245
R491	321-0235-00			RES.,FXD,FILM:2.74K OHM,1%,0.125W	75042	CEAT0-2741F

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R492	321-0371-00			RES.,FXD,FILM:71.5K OHM,1%,0.125W	75042	CEAT0-7152F
R493	321-0154-00			RES.,FXD,FILM:392 OHM,1%,0.125W	75042	CEAT0-3920F
R494	321-0251-00			RES.,FXD,FILM:4.02K OHM,1%,0.125W	75042	CEAT0-4021F
R496	321-0373-00			RES.,FXD,FILM:75K OHM, 1%,0.125W	75042	CEAT0-7502F
R500	321-0203-00			RES.,FXD,FILM:1.27K OHM,1%,0.125W	75042	CEAT0-1271F
R502	321-0371-00			RES.,FXD,FILM:71.5K OHM,1%,0.125W	75042	CEAT0-7152F
R504	315-0113-00			RES.,FXD,COMP:11K OHM,5%,0.25W	01121	CB1135
R506	321-0251-00			RES.,FXD,FILM:4.02K OHM,1%,0.125W	75042	CEAT0-4021F
R508	315-0153-00			RES.,FXD,COMP:15K OHM,5%,0.25W	01121	CB1535
R510	315-0682-00			RES.,FXD,COMP:6.8K OHM,5%,0.25W	01121	CB6825
R512	315-0104-00			RES.,FXD,COMP:100K OHM,5%,0.25W	01121	CB1045
R514	315-0105-00			RES.,FXD,COMP:1M OHM,5%,0.25W	01121	CB1055
R516	321-0154-00			RES.,FXD,FILM:392 OHM,1%,0.125W	75042	CEAT0-3920F
R518	321-0251-00			RES.,FXD,FILM:4.02K OHM,1%,0.125W	75042	CEAT0-4021F
R520	321-0373-00			RES.,FXD,FILM:75K OHM, 1%,0.125W	75042	CEAT0-7502F
R522	321-0235-00			RES.,FXD,FILM:2.74K OHM,1%,0.125W	75042	CEAT0-2741F
R524	321-0203-00			RES.,FXD,FILM:1.27K OHM,1%,0.125W	75042	CEAT0-1271F
R526	321-0371-00			RES.,FXD,FILM:71.5K OHM,1%,0.125W	75042	CEAT0-7152F
R528	321-0371-00			RES.,FXD,FILM:71.5K OHM,1%,0.125W	75042	CEAT0-7152F
R530	315-0113-00			RES.,FXD,COMP:11K OHM,5%,0.25W	01121	CB1135
R532	315-0153-00			RES.,FXD,COMP:15K OHM,5%,0.25W	01121	CB1535
R533	315-0562-00			RES.,FXD,COMP:5.6K OHM,5%,0.25W	01121	CB5625
R534	321-0251-00			RES.,FXD,FILM:4.02K OHM,1%,0.125W	75042	CEAT0-4021F
R536	315-0105-00			RES.,FXD,COMP:1M OHM,5%,0.25W	01121	CB1055
R538	321-0139-00			RES.,FXD,FILM:274 OHM,1%,0.125W	75042	CEAT0-2740F
R540	315-0104-00			RES.,FXD,COMP:100K OHM,5%,0.25W	01121	CB1045
R541	321-0373-00			RES.,FXD,FILM:75K OHM, 1%,0.125W	75042	CEAT0-7502F
R542	321-0251-00			RES.,FXD,FILM:4.02K OHM,1%,0.125W	75042	CEAT0-4021F
R544	321-0235-00			RES.,FXD,FILM:2.74K OHM,1%,0.125W	75042	CEAT0-2741F
R546	321-0218-00			RES.,FXD,FILM:1.82K OHM,1%,0.125W	75042	CEAT0-1821F
R548	321-0371-00			RES.,FXD,FILM:71.5K OHM,1%,0.125W	75042	CEAT0-7152F
R552	321-0371-00			RES.,FXD,FILM:71.5K OHM,1%,0.125W	75042	CEAT0-7152F
R554	315-0224-00			RES.,FXD,COMP:220K OHM,5%,0.25W	01121	CB2245
R556	315-0104-00			RES.,FXD,COMP:100K OHM,5%,0.25W	01121	CB1045
R558	321-0251-00			RES.,FXD,FILM:4.02K OHM,1%,0.125W	75042	CEAT0-4021F
R560	315-0153-00			RES.,FXD,COMP:15K OHM,5%,0.25W	01121	CB1535
R562	315-0113-00			RES.,FXD,COMP:11K OHM,5%,0.25W	01121	CB1135
R566	315-0153-00			RES.,FXD,COMP:15K OHM,5%,0.25W	01121	CB1535
R580	321-0257-00			RES.,FXD,FILM:4.64K OHM,1%,0.125W	75042	CEAT0-4641F
R581	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R582	321-0161-00			RES.,FXD,FILM:464 OHM,1%,0.125W	75042	CEAT0-4640F
R584	315-0620-00			RES.,FXD,COMP:62 OHM,5%,0.25W	01121	CB6205
R586	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R588	315-0222-00			RES.,FXD,COMP:2.2K OHM,5%,0.25W	01121	CB2225
R590	315-0330-00			RES.,FXD,COMP:33 OHM,5%,0.25W	01121	CB3305
R592	315-0102-00			RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R593	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R594	315-0472-00			RES.,FXD,COMP:4.7K OHM,5%,0.25W	01121	CB4725
R596	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R598	315-0302-00			RES.,FXD,COMP:3K OHM,5%,0.25W	01121	CB3025
R599	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R600	311-1273-00			RES.,VAR,NONWIR:200K OHM,10%,0.50W		
R602	321-0423-00			RES.,FXD,FILM:249K OHM,1%,0.125W	75042	CEAT0-2493F
R604	321-0423-00			RES.,FXD,FILM:249K OHM,1%,0.125W	75042	CEAT0-2493F
R605	311-1273-00			RES.,VAR,NONWIR:200K OHM,10%,0.50W		
R606	315-0104-00			RES.,FXD,COMP:100K OHM,5%,0.25W	01121	CB1045
R608	321-0304-00			RES.,FXD,FILM:14.3K OHM,1%,0.125W	75042	CEAT0-1432F
R610	321-0155-00			RES.,FXD,FILM:402 OHM,1%,0.125W	75042	CEAT0-4020F
R612	321-0155-00			RES.,FXD,FILM:402 OHM,1%,0.125W	75042	CEAT0-4020F
R614	321-0254-00			RES.,FXD,FILM:4.32K OHM,1%,0.125W	75042	CEAT0-4321F

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R616	321-0251-00			RES.,FXD,FILM:4.02K OHM,1%,0.125W	75042	CEAT0-4021F
R618	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	75042	CEAT0-1001F
R620	315-0562-00			RES.,FXD,COMP:5.6K OHM,5%,0.25W	01121	CB5625
R622	321-0181-00			RES.,FXD,FILM:750 OHM,1%,0.125W	75042	CEAT0-7500F
R624	321-0309-00			RES.,FXD,FILM:16.2K OHM,1%,0.125W	75042	CEAT0-1622F
R626	315-0474-00			RES.,FXD,COMP:470K OHM,5%,0.25W	01121	CB4745
R628	315-0474-00			RES.,FXD,COMP:470K OHM,5%,0.25W	01121	CB4745
R630	321-0290-00			RES.,FXD,FILM:10.2K OHM,1%,0.125W	75042	CEAT0-1022F
R632	321-0347-00			RES.,FXD,FILM:40.2K OHM,1%,0.125W	75042	CEAT0-4022F
R634	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	75042	CEAT0-1001F
R635	311-1273-00			RES.,VAR,NONWIR:200K OHM,10%,0.50W		
R636	315-0474-00			RES.,FXD,COMP:470K OHM,5%,0.25W	01121	CB4745
R638	315-0102-00			RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R642	315-0102-00			RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R644	321-0211-00			RES.,FXD,FILM:1.54K OHM,1%,0.125W	75042	CEAT0-1541F
R646	315-0222-00			RES.,FXD,COMP:2.2K OHM,5%,0.25W	01121	CB2225
R648	315-0124-00			RES.,FXD,COMP:120K OHM,5%,0.25W	01121	CB1245
R650	315-0202-00			RES.,FXD,COMP:2K OHM,5%,0.25W	01121	CB2025
R652	321-0251-00			RES.,FXD,FILM:4.02K OHM,1%,0.125W	75042	CEAT0-4021F
R654	321-0251-00			RES.,FXD,FILM:4.02K OHM,1%,0.125W	75042	CEAT0-4021F
R656	315-0393-00			RES.,FXD,COMP:39K OHM,5%,0.25W	01121	CB3935
R660	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	75042	CEAT0-1002F
R662	321-0295-00			RES.,FXD,FILM:11.5K OHM,1%,0.125W	75042	CEAT0-1152F
R663	315-0512-00			RES.,FXD,COMP:5.1K OHM,5%,0.25W	01121	CB5125
R664	315-0154-00			RES.,FXD,COMP:150K OHM,5%,0.25W	01121	CB1545
R666	315-0102-00			RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R667	315-0472-00			RES.,FXD,COMP:4.7K OHM,5%,0.25W	01121	CB4725
R668	315-0471-00			RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R670	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R672	315-0333-00			RES.,FXD,COMP:33K OHM,5%,0.25W	01121	CB3335
R676	315-0333-00			RES.,FXD,COMP:33K OHM,5%,0.25W	01121	CB3335
R678	315-0472-00			RES.,FXD,COMP:4.7K OHM,5%,0.25W	01121	CB4725
R680	315-0184-00			RES.,FXD,COMP:180K OHM,5%,0.25W	01121	CB1845
R685	311-1766-00			RES.,VAR,NONWIR:10K OHM,10%,0.50W		
R690	321-0241-00			RES.,FXD,FILM:3.16K OHM,1%,0.125W	75042	CEAT0-3161F
R691	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R692	315-0822-00			RES.,FXD,COMP:8.2K OHM,5%,0.25W	01121	CB8225
R694	321-0306-00			RES.,FXD,FILM:15K OHM,1%,0.125W	75042	CEAT0-1502F
R695	311-1267-00			RES.,VAR,NONWIR:5K OHM,10%,0.50W	73138	62PT-3500-502K
R696	315-0471-00			RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R698	321-0315-00			RES.,FXD,FILM:18.7K OHM,1%,0.125W	75042	CEAT0-1872F
R699	308-0248-00			RES.,FXD,WW:150 OHM,1%,5W	91637	RS2A-B150R0F
R700	315-0100-00			RES.,FXD,COMP:10 OHM,5%,0.25W	01121	CB1005
R702	321-0260-00			RES.,FXD,FILM:4.99K OHM,1%,0.125W	75042	CEAT0-4991F
R704	301-0681-00			RES.,FXD,COMP:680 OHM,5%,0.50W	01121	EB6815
R705	321-0325-00			RES.,FXD,FILM:23.7K OHM,1%,0.125W	75042	CEAT0-2372F
R710	311-1275-00			RES.,VAR,NONWIR:1M OHM,10%,0.50W		
R712	323-0488-00			RES.,FXD,FILM:1.18M OHM,1%,0.50W	75042	CECT0-1184F
R714	321-0408-00			RES.,FXD,FILM:174K OHM,1%,0.125W	75042	CEAT0-1743F
R715	311-1260-00			RES.,VAR,NONWIR:250 OHM,10%,0.50W	73138	62PT-345-0
R716	315-0102-00			RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R717	321-0348-00			RES.,FXD,FILM:41.2K OHM,1%,0.125W	75042	CEAT0-4122F
R718	315-0474-00			RES.,FXD,COMP:470K OHM,5%,0.25W	01121	CB4745
R719	321-0318-00			RES.,FXD,FILM:20K OHM,1%,0.125W	75042	CEAT0-2002F
R720	321-0429-00			RES.,FXD,FILM:287K OHM,1%,0.125W	75042	CEAT0-2873F
R722	321-0399-00			RES.,FXD,FILM:140K OHM,1%,0.125W	75042	CEAT0-1403F
R724	321-0319-00			RES.,FXD,FILM:20.5K OHM,1%,0.125W	75042	CEAT0-2052F
R726	309-0087-00			RES.,FXD,FILM:5M OHM,1%,0.50W		
R728	325-0072-00			RES.,FXD,FILM:10M OHM,1%,0.50W		
R730	323-0498-00			RES.,FXD,FILM:1.5M OHM,1%,0.50W		

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R732	321-0402-00			RES.,FXD,FILM:150K OHM,1%,0.125W	75042	CEAT0-1503F
R734	321-0306-00			RES.,FXD,FILM:15K OHM,1%,0.125W	75042	CEAT0-1502F
R736	315-0472-00			RES.,FXD,COMP:4.7K OHM,5%,0.25W	01121	CB4725
R740	311-1268-00			RES.,VAR,NONWIR:10K OHM,10%,0.50W	73138	62PT-351-0
R742	315-0470-00			RES.,FXD,COMP:47 OHM,5%,0.25W	01121	CB4705
R744	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R745	311-1268-00			RES.,VAR,NONWIR:10K OHM,10%,0.50W	73138	62PT-351-0
R746	315-0105-00			RES.,FXD,COMP:1M OHM,5%,0.25W	01121	CB1055
R750	315-0100-00			RES.,FXD,COMP:10 OHM,5%,0.25W	01121	CB1005
R752	315-0913-00			RES.,FXD,COMP:91K OHM,5%,0.25W	01121	CB9135
R754	315-0823-00			RES.,FXD,COMP:82K OHM,5%,0.25W	01121	CB8235
R755	311-1267-00			RES.,VAR,NONWIR:5K OHM,10%,0.50W	73138	62PT-3500-502K
R756	315-0104-00			RES.,FXD,COMP:100K OHM,5%,0.25W	01121	CB1045
R760	315-0153-00			RES.,FXD,COMP:15K OHM,5%,0.25W	01121	CB1535
R762	321-0244-00			RES.,FXD,FILM:3.4K OHM,1%,0.125W	75042	CEAT0-3401F
R764	321-0230-00			RES.,FXD,FILM:2.43K OHM,1%,0.125W	75042	CEAT0-2431F
R770	321-0381-00			RES.,FXD,FILM:90.9K OHM,1%,0.125W	75042	CEAT0-9092F
R772	321-0420-00			RES.,FXD,FILM:232K OHM,1%,0.125W	75042	CEAT0-2323F
R774	315-0222-00			RES.,FXD,COMP:2.2K OHM,5%,0.25W	01121	CB2225
R776	315-0513-00			RES.,FXD,COMP:51K OHM,5%,0.25W	01121	CB5135
R778	315-0102-00			RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R802	315-0623-00			RES.,FXD,COMP:62K OHM,5%,0.25W	01121	CB6235
R810	315-0513-00			RES.,FXD,COMP:51K OHM,5%,0.25W	01121	CB5135
R812	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	75042	CEAT0-1002F
R813	315-0274-00			RES.,FXD,COMP:270K OHM,5%,0.25W	01121	CB2745
R814	321-0327-00			RES.,FXD,FILM:24.9K OHM,1%,0.125W	75042	CEAT0-2492F
R816	315-0104-00			RES.,FXD,COMP:100K OHM,5%,0.25W	01121	CB1045
R818	315-0475-00			RES.,FXD,COMP:4.7M OHM,5%,0.25W	01121	CB4755
R820	321-0202-00			RES.,FXD,FILM:1.24K OHM,1%,0.125W	75042	CEAT0-1241F
R822	321-0299-00			RES.,FXD,FILM:12.7K OHM,1%,0.125W	75042	CEAT0-1272F
R824	315-0125-00			RES.,FXD,COMP:1.2M OHM,5%,0.25W	01121	CB1255
R825	311-1286-00			RES.,VAR,NONWIR:50K OHM,10%,0.50W		
R826	321-0251-00			RES.,FXD,FILM:4.02K OHM,1%,0.125W	75042	CEAT0-4021F
R830	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	75042	CEAT0-1002F
R832	315-0393-00			RES.,FXD,COMP:39K OHM,5%,0.25W	01121	CB3935
R834	321-0361-00			RES.,FXD,FILM:56.2K OHM,1%,0.125W	75042	CEAT0-5622F
R835	311-1765-00			RES.,VAR,NONWIR:1K OHM,20%,0.50W		
R836	321-0306-00			RES.,FXD,FILM:15K OHM,1%,0.125W	75042	CEAT0-1502F
R840	321-0341-00			RES.,FXD,FILM:34.8K OHM,1%,0.125W	75042	CEAT0-3482F
R842	321-0367-00			RES.,FXD,FILM:64.9K OHM,1%,0.125W	75042	CEAT0-6492F
R844	315-0134-00			RES.,FXD,COMP:130K OHM,5%,0.25W	01121	CB1345
R846	321-0411-00			RES.,FXD,FILM:187K OHM,1%,0.125W	75042	CEAT0-1873F
R848	315-0334-00			RES.,FXD,COMP:330K OHM,5%,0.25W	01121	CB3345
R850	315-0105-00			RES.,FXD,COMP:1M OHM,5%,0.25W	01121	CB1055
R852	321-0285-01			RES.,FXD,FILM:9.09K OHM,0.5%0.125W	75042	CEAT0-9091D
R854	321-0619-00			RES.,FXD,FILM:1.012K OHM,0.25%,0.125W	75042	CEAT2-10120C
R856	321-0098-01			RES.,FXD,FILM:102 OHM,0.5%,0.125W	75042	CEAT0-1020D
R858	321-0287-00			RES.,FXD,FILM:9.53K OHM,1%,0.125W	75042	CEAT0-9531F
R860	321-0231-00			RES.,FXD,FILM:2.49K OHM,1%,0.125W	75042	CEAT0-2491F
R862	321-0210-00			RES.,FXD,FILM:1.5K OHM,1%,0.125W	75042	CEAT0-1501F
R864	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	75042	CEAT0-1001F
R866	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	75042	CEAT0-1002F
R867	315-0682-00			RES.,FXD,COMP:6.8K OHM,5%,0.25W	01121	CB6825
R868	315-0104-00			RES.,FXD,COMP:100K OHM,5%,0.25W	01121	CB1045
R870	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	75042	CEAT0-1002F
R872	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	75042	CEAT0-1002F
R873	321-0289-00			RES.,FXD,FILM:10K OHM,1%,.0.125W	75042	CEAT0-1002F
R874	321-0510-00			RES.,FXD,FILM:2M OHM,1%,0.125W	75042	CEAT0-2004F
R876	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	75042	CEAT0-1002F
R878	315-0113-00			RES.,FXD,COMP:11K OHM,5%,0.25W	01121	CB1135

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R900	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R902	315-0220-00			RES.,FXD,COMP:22 OHM,5%,0.25W	01121	CB2205
R903	315-0220-00			RES.,FXD,COMP:22 OHM,5%,0.25W	01121	CB2205
R910	307-0103-00			RES.,FXD,COMP:2.7 OHM,5%,0.25W	01121	CB27G5
R912	307-0103-00			RES.,FXD,COMP:2.7 OHM,5%,0.25W	01121	CB27G5
R914	307-0103-00			RES.,FXD,COMP:2.7 OHM,5%,0.25W	01121	CB27G5
R916	315-0102-00			RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R918	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R919	315-0220-00			RES.,FXD,COMP:22 OHM,5%,0.25W	01121	CB2205
R920	311-1263-00			RES.,VAR,NONWIR:1K OHM,10%,0.50W	73138	62PT-347-0
R921	321-0222-00			RES.,FXD,FILM:2K OHM,1%,0.125W	75042	CEAT0-2001F
R922	315-0152-00			RES.,FXD,COMP:1.5K OHM,5%,0.25W	01121	CB1525
R924	321-0277-00			RES.,FXD,FILM:7.5K OHM,1%,0.125W	75042	CEAT0-7501F
R926	321-0249-00			RES.,FXD,FILM:3.83K OHM,1%,0.125W	75042	CEAT0-3831F
R927	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R928	321-0286-00			RES.,FXD,FILM:9.31K OHM,1%,0.125W	75042	CEAT0-9311F
R930	321-0244-00			RES.,FXD,FILM:3.4K OHM,1%,0.125W	75042	CEAT0-3401F
R932	315-0121-00			RES.,FXD,COMP:120 OHM,5%,0.25W	01121	CB1215
R934	321-0184-00			RES.,FXD,FILM:806 OHM,1%,0.125W	75042	CEAT0-8060F
R936	321-0126-00			RES.,FXD,FILM:200 OHM,1%,0.125W	75042	CEAT0-2000F
R938	321-0126-00			RES.,FXD,FILM:200 OHM,1%,0.125W	75042	CEAT0-2000F
R939	321-0243-00			RES.,FXD,FILM:3.32K OHM,1%,0.125W	75042	CEAT0-3321F
R940	321-0176-00			RES.,FXD,FILM:665 OHM,1%,0.125W	75042	CEAT0-6650F
R941	321-0294-00			RES.,FXD,FILM:11.3K OHM,1%,0.125W	75042	CEAT0-1132F
R942	321-0302-00			RES.,FXD,FILM:13.7K OHM,1%,0.125W	75042	CEAT0-1372F
R944	321-0308-00			RES.,FXD,FILM:15.8K OHM,1%,0.125W	75042	CEAT0-1582F
R946	321-0314-00			RES.,FXD,FILM:18.2K OHM,1%,0.125W	75042	CEAT0-1822F
R947	321-0319-00			RES.,FXD,FILM:20.5K OHM,1%,0.125W	75042	CEAT0-2052F
R948	321-0323-00			RES.,FXD,FILM:22.6K OHM,1%,0.125W	75042	CEAT0-2262F
R950	321-0163-00			RES.,FXD,FILM:487 OHM,1%,0.125W	75042	CEAT0-4870F
R951	321-0145-00			RES.,FXD,FILM:316 OHM,1%,0.125W	75042	CEAT0-3160F
R952	321-0150-00			RES.,FXD,FILM:357 OHM,1%,0.125W	75042	CEAT0-3570F
R954	321-0153-00			RES.,FXD,FILM:383 OHM,1%,0.125W	75042	CEAT0-3830F
R956	321-0155-00			RES.,FXD,FILM:402 OHM,1%,0.125W	75042	CEAT0-4020F
R957	321-0156-00			RES.,FXD,FILM:412 OHM,1%,0.125W		
R958	321-0128-00			RES.,FXD,FILM:210 OHM,1%,0.125W	75042	CEAT0-2100F
R960	311-1268-00			RES.,VAR,NONWIR:10K OHM,10%,0.50W	73138	62PT-351-0
R961	321-0273-00			RES.,FXD,FILM:6.81K OHM,1%,0.125W	75042	CEAT0-6811F
R962	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	75042	CEAT0-1001F
R964	315-0624-00			RES.,FXD,COMP:620K OHM,5%,0.25W	01121	CB6245
R966	321-0261-00			RES.,FXD,FILM:5.11K OHM,1%,0.125W	75042	CEAT0-5111F
R967	321-0280-00			RES.,FXD,FILM:8.06K OHM,1%,0.125W	75042	CEAT0-8061F
R968	321-0295-00			RES.,FXD,FILM:11.5K OHM,1%,0.125W	75042	CEAT0-1152F
R970	321-0307-00			RES.,FXD,FILM:15.4K OHM,1%,0.125W	75042	CEAT0-1542F
R971	321-0317-00			RES.,FXD,FILM:19.6K OHM,1%,0.125W	75042	CEAT0-1962F
R972	321-0326-00			RES.,FXD,FILM:24.3K OHM,1%,0.125W	75042	CEAT0-2432F
R974	321-0333-00			RES.,FXD,FILM:28.7K OHM,1%,0.125W	75042	CEAT0-2872F
R976	321-0091-00			RES.,FXD,FILM:86.6 OHM,1%,0.125W	75042	CEAT0-86R60F
R977	321-0132-00			RES.,FXD,FILM:232 OHM,1%,0.125W	75042	CEAT0-2320F
R978	321-0147-00			RES.,FXD,FILM:332 OHM,1%,0.125W	75042	CEAT0-3320F
R980	321-0156-00			RES.,FXD,FILM:412 OHM,1%,0.125W		
R981	321-0163-00			RES.,FXD,FILM:487 OHM,1%,0.125W	75042	CEAT0-4870F
R982	321-0169-00			RES.,FXD,FILM:562 OHM,1%,0.125W	75042	CEAT0-5620F
R984	321-0143-00			RES.,FXD,FILM:301 OHM,1%,0.125W	75042	CEAT0-3010F
R985	311-1268-00			RES.,VAR,NONWIR:10K OHM,10%,0.50W	73138	62PT-351-0
R986	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	75042	CEAT0-1002F
R988	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	75042	CEAT0-1001F
R989	315-0624-00			RES.,FXD,COMP:620K OHM,5%,0.25W	01121	CB6245
R990	321-0265-00			RES.,FXD,FILM:5.62K OHM,1%,0.125W	75042	CEAT0-5621F
R992	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	75042	CEAT0-1002F

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R994	321-0164-00			RES.,FXD,FILM:499 OHM,1%,0.125W	75042	CEAT0-4990F
R995	311-1268-00			RES.,VAR,NONWIR:10K OHM,10%,0.50W	73138	62PT-351-0
R996	321-0314-00			RES.,FXD,FILM:18.2K OHM,1%,0.125W	75042	CEAT0-1822F
R998	321-0164-00			RES.,FXD,FILM:499 OHM,1%,0.125W	75042	CEAT0-4990F
R999	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R1000	315-0470-00			RES.,FXD,COMP:47 OHM,5%,0.25W	01121	CB4705
R1002	315-0152-00			RES.,FXD,COMP:1.5K OHM,5%,0.25W	01121	CB1525
R1004	315-0100-00			RES.,FXD,COMP:10 OHM,5%,0.25W	01121	CB1005
R1006	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R1007	315-0471-00			RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R1008	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R1010	321-0241-00			RES.,FXD,FILM:3.16K OHM,1%,0.125W	75042	CEAT0-3161F
R1013	315-0150-00			RES.,FXD,COMP:15 OHM,5%,0.25W	01121	CB1505
R1014	321-0241-00			RES.,FXD,FILM:3.16K OHM,1%,0.125W	75042	CEAT0-3161F
R1016	315-0471-00			RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R1018	315-0270-00			RES.,FXD,COMP:27 OHM,5%,0.25W	01121	CB2705
R1020	311-1265-00			RES.,VAR,NONWIR:2K OHM,10%,0.50W	80294	3329P-L58-202
R1022	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R1024	315-0822-00			RES.,FXD,COMP:8.2K OHM,5%,0.25W	01121	CB8225
R1025	311-1265-00			RES.,VAR,NONWIR:2K OHM,10%,0.50W	80294	3329P-L58-202
R1026	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R1028	315-0473-00			RES.,FXD,COMP:47K OHM,5%,0.25W	01121	CB4735
R1030	315-0473-00			RES.,FXD,COMP:47K OHM,5%,0.25W	01121	CB4735
R1032	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R1034	315-0222-00			RES.,FXD,COMP:2.2K OHM,5%,0.25W	01121	CB2225
R1036	315-0472-00			RES.,FXD,COMP:4.7K OHM,5%,0.25W	01121	CB4725
R1038	315-0471-00			RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R1040	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R1041	315-0241-00			RES.,FXD,COMP:240 OHM,5%,0.25W	01121	CB2415
R1042	315-0102-00			RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R1044	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R1046	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R1048	315-0512-00			RES.,FXD,COMP:5.1K OHM,5%,0.25W	01121	CB5125
R1050	321-0244-00			RES.,FXD,FILM:3.4K OHM,1%,0.125W	75042	CEAT0-3401F
R1052	315-0512-00			RES.,FXD,COMP:5.1K OHM,5%,0.25W	01121	CB5125
R1054	315-0183-00			RES.,FXD,COMP:18K OHM,5%,0.25W	01121	CB1835
R1055	311-1260-00			RES.,VAR,NONWIR:250 OHM,10%,0.50W	73138	62PT-345-0
R1056	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R1058	315-0273-00			RES.,FXD,COMP:27K OHM,5%,0.25W	01121	CB2735
R1060	311-1260-00			RES.,VAR,NONWIR:250 OHM,10%,0.50W	73138	62PT-345-0
R1062	315-0183-00			RES.,FXD,COMP:18K OHM,5%,0.25W	01121	CB1835
R1064	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R1066	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R1068	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R1074	321-0204-00			RES.,FXD,FILM:1.3K OHM,1%,0.125W	75042	CEAT0-1301F
R1076	321-0204-00			RES.,FXD,FILM:1.3K OHM,1%,0.125W	75042	CEAT0-1301F
R1150	315-0124-00			RES.,FXD,COMP:120K OHM,5%,0.25W	01121	CB1245
R1152	315-0473-00			RES.,FXD,COMP:47K OHM,5%,0.25W	01121	CB4735
R1154	315-0272-00			RES.,FXD,COMP:2.7K OHM,5%,0.25W	01121	CB2725
R1156	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R1158	315-0203-00			RES.,FXD,COMP:20K OHM,5%,0.25W	01121	CB2035
R1160	315-0752-00			RES.,FXD,COMP:7.5K OHM,5%,0.25W	01121	CB7525
R1162	315-0153-00			RES.,FXD,COMP:15K OHM,5%,0.25W	01121	CB1535
R1164	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	75042	CEAT0-1001F
R1166	315-0201-00			RES.,FXD,COMP:200 OHM,5%,0.25W	01121	CB2015
R1170	315-0510-00			RES.,FXD,COMP:51 OHM,5%,0.25W	01121	CB5105
R1172	321-0188-00			RES.,FXD,FILM:887 OHM,1%,0.125W	75042	CEAT0-8870F
R1174	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R1176	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
R1178	321-0661-00			RES.,FXD,FILM:600 OHM,1%,0.125W	75042	CEAT0-6000F

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R1180	315-0105-00			RES.,FXD,COMP:1M OHM,5%,0.25W	01121	CB1055
R1190	311-1263-00			RES.,VAR,NONWIR:1K OHM,10%,0.50W	73138	62PT-347-0
R1192	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	75042	CEAT0-1002F
R1194	321-0172-00			RES.,FXD,FILM:604 OHM,1%,0.125W	75042	CEAT0-6040F
R1195	311-1272-00			RES.,VAR,NONWIR:100K OHM,10%,0.50K	73138	62PT-355-0
R1196	321-0343-00			RES.,FXD,FILM:36.5K OHM,1%,0.125W	75042	CEAT0-3652F
R1198	321-0402-00			RES.,FXD,FILM:150K OHM,1%,0.125W	75042	CEAT0-1503F
R1200	311-1269-00			RES.,VAR,NONWIR:20K OHM,10%,0.50W	73138	62PT-352-0
R1202	321-0356-00			RES.,FXD,FILM:49.9K OHM,1%,0.125W	75042	CEAT0-4992F
R1204	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	75042	CEAT0-1002F
R1205	311-1265-00			RES.,VAR,NONWIR:2K OHM,10%,0.50W	80294	3329P-L58-202
R1206	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R1208	321-0259-00			RES.,FXD,FILM:4.87K OHM,1%,0.125W	75042	CEAT0-4871F
R1210	321-0256-00			RES.,FXD,FILM:4.53K OHM,1%,0.125W	75042	CEAT0-4531F
R1212	321-0256-00			RES.,FXD,FILM:4.53K OHM,1%,0.125W	75042	CEAT0-4531F
R1214	321-0259-00			RES.,FXD,FILM:4.87K OHM,1%,0.125W	75042	CEAT0-4871F
R1215	311-1265-00			RES.,VAR,NONWIR:2K OHM,10%,0.50W	80294	3329P-L58-202
R1216	315-0155-00			RES.,FXD,COMP:1.5M OHM,5%,0.25W	01121	CB1555
R1218	315-0102-00			RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R1220	316-0685-00			RES.,FXD,COMP:6.8M OHM,10%,0.25W	01121	CB6851
R1222	315-0155-00			RES.,FXD,COMP:1.5M OHM,5%,0.25W	01121	CB1555
R1224	315-0102-00			RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R1225	311-1268-00			RES.,VAR,NONWIR:10K OHM,10%,0.50W	73138	62PT-351-0
R1226	315-0474-00			RES.,FXD,COMP:470K OHM,5%,0.25W	01121	CB4745
R1228	315-0102-00			RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R1230	315-0223-00			RES.,FXD,COMP:22K OHM,5%,0.25W	01121	CB2235
R1250	321-0241-00			RES.,FXD,FILM:3.16K OHM,1%,0.125W	75042	CEAT0-3161F
R1252	315-0822-00			RES.,FXD,COMP:8.2K OHM,5%,0.25W	01121	CB8225
R1253	315-0103-00			RES.,FXD,COMP:10K OHM,5%,0.25W	01121	CB1035
R1254	321-0306-00			RES.,FXD,FILM:15K OHM,1%,0.125W	75042	CEAT0-1502F
R1255	311-1267-00			RES.,VAR,NONWIR:5K OHM,10%,0.50W	73138	62PT-3500-502K
R1256	321-0315-00			RES.,FXD,FILM:18.7K OHM,1%,0.125W	75042	CEAT0-1872F
R1258	315-0471-00			RES.,FXD,COMP:470 OHM,5%,0.25W	01121	CB4715
R1260	307-0113-00			RES.,FXD,COMP:5.1 OHM,5%,0.25W	01121	CB51G5
R1262	308-0248-00			RES.,FXD,WW:150 OHM,1%,5W	91637	RS2A-B150R0F
R1264	307-0104-00			RES.,FXD,COMP:3.3 OHM,5%,0.25W	01121	CB33G5
R1266	308-0248-00			RES.,FXD,WW:150 OHM,1%,5W	91637	RS2A-B150R0F
R1305	315-0102-00			RES.,FXD,COMP:1K OHM,5%,0.25W	01121	CB1025
R1306	315-0271-00			RES.,FXD,COMP:270 OHM,5%,0.25W	01121	CB2715
R1307	315-0271-00			RES.,FXD,COMP:270 OHM,5%,0.25W	01121	CB2715
R1308	315-0271-00			RES.,FXD,COMP:270 OHM,5%,0.25W	01121	CB2715
R1309	315-0101-00			RES.,FXD,COMP:100 OHM,5%,0.25W	01121	CB1015
S5	260-0960-00			SWITCH,SLIDE:2A AT 120VAC	10389	23-021-006
S21	260-0779-00			SWITCH,PUSH:SWP		
S51, S52, S53, S54	260-1707-00			SWITCH,PUSH:INPUT IMPEDANCE SELECTOR		
S685	263-1093-00			ACTR ASSY,CAM SW:VERT GAIN SELECTOR	80009	263-1093-00
S714				SWITCH,PUSH:50MV/DIV		
S715				SWITCH,PUSH:MNL		
S716	260-1702-00			SWITCH,PUSH:100MS		
S717				SWITCH,PUSH:10MS		
S718				SWITCH,PUSH:1MS		
S719				SWITCH,PUSH:		
S800	263-1081-00			ACTR ASSY,CAM SW:FREQ SPAN	80009	263-1081-00
S812, S814	260-1704-00			SWITCH,PUSH:VIDEO LEFT SWITCH,PUSH:LINE VERT		
S816, S818	260-1227-01			SWITCH,PUSH:DP,2-BUTTON SWITCH,PUSH:AUTO TRIG	80009	260-1227-01

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S860	260-1132-00			SWITCH,PUSH:FREQ MKR	80009	260-1132-00
S1121	260-1708-00			SWITCH,PUSH:CTR		
S1122	XXX-XXXX-XX			SWITCH,PUSH:DISPLAY ON		
S1151	260-1706-00			SWITCH,PUSH:CHOP		
S1214	260-1132-00			SWITCH,PUSH:1 BUTTON,DOUBLE POLE	80009	260-1132-00
S1215	260-1132-00			SWITCH,PUSH:1 BUTTON,DOUBLE POLE	80009	260-1132-00
S1216	260-1706-00			SWITCH,PUSH:VIDEO FILTER 10 HZ		
S1218	260-1706-00			SWITCH,PUSH:VIDEO FILTER 300 HZ		
T56	120-0440-00			XFMR,TOROID:6 TURNS BIFILAR	80009	120-0440-00
T62	120-0440-00			XFMR,TOROID:6 TURNS BIFILAR	80009	120-0440-00
T212	120-0954-00			XFMR,TOROID:14 TURNS 2 TRIFILAR	80009	120-0954-00
T218	120-0954-00			XFMR,TOROID:14 TURNS 2 TRIFILAR	80009	120-0954-00
T320	120-0957-00			XFMR,RF:POT CORE	80009	120-0957-00
T350	120-0956-00			XFMR,TOROID:3 WINDINGS	80009	120-0956-00
T380	120-0956-00			XFMR,TOROID:3 WINDINGS	80009	120-0956-00
T400	120-0956-00			XFMR,TOROID:3 WINDINGS	80009	120-0956-00
T1000	120-0955-00			XMFR,TOROID:4 WINDINGS	80009	120-0955-00
U290	307-1025-00			OPT ISOLATOR:LIGHT EMITTING DIODE		
U295	156-0067-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	07263	U6T7741393
U338	307-1025-00			OPT ISOLATOR:LIGHT EMITTING DIODE		
U340	156-0158-00			MICROCIRCUIT,LI:DUAL OPERATIONAL AMPLIFIER	18324	S5558V
U374	307-1025-00			OPT ISOLATOR:LIGHT EMITTING DIODE		
U392	307-1025-00			OPT ISOLATOR:LIGHT EMITTING DIODE		
U408	307-1025-00			OPT ISOLATOR:LIGHT EMITTING DIODE		
U470	156-0048-00			MICROCIRCUIT,LI:FIVE NPN TRANSISTOR ARRAY	86684	CA3046
U490	156-0048-00			MICROCIRCUIT,LI:FIVE NPN TRANSISTOR ARRAY	86684	CA3046
U510	156-0048-00			MICROCIRCUIT,LI:FIVE NPN TRANSISTOR ARRAY	86684	CA3046
U540	156-0048-00			MICROCIRCUIT,LI:FIVE NPN TRANSISTOR ARRAY	86684	CA3046
U620	156-0067-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	07263	U6T7741393
U630	156-0067-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	07263	U6T7741393
U640	156-0067-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	07263	U6T7741393
U650	156-0067-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	07263	U6T7741393
U660	156-0067-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	07263	U6T7741393
U690	156-0105-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	27014	LM301AN
U750	155-0055-00			MICROCIRCUIT,LI:MONOLITHIC,TRIG & SWEEP	80009	155-0055-00
U812	156-0067-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	07263	U6T7741393
U830	156-0158-00			MICROCIRCUIT,LI:DUAL OPERATIONAL AMPLIFIER	18324	S5558V
U860	156-0158-00			MICROCIRCUIT,LI:DUAL OPERATIONAL AMPLIFIER	18324	S5558V
U960	156-0158-00			MICROCIRCUIT,LI:DUAL OPERATIONAL AMPLIFIER	18324	S5558V
U1040	156-0177-00			MICROCIRCUIT,DI:DUAL LINE RECEIVER		
U1042	156-0039-00			MICROCIRCUIT,DI:DUAL J-K FLIP FLOP	04713	MC7473P
U1044	156-0079-00			MICROCIRCUIT,DI:DECADE COUNTER,TTL	07263	9390PC
U1046	156-0079-00			MICROCIRCUIT,DI:DECADE COUNTER,TTL	07263	9390PC
U1047	156-0079-00			MICROCIRCUIT,DI:DECADE COUNTER,TTL	07263	9390PC
U1060	156-0130-00			MICROCIRCUIT,LI:BALANCED MODEM	04713	MC1496G
U1174	156-0132-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER		
U1190	156-0158-00			MICROCIRCUIT,LI:DUAL OPERATIONAL AMPLIFIER	18324	S5558V
U1225	156-0067-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	07263	U6T7741393
U1250	156-0105-00			MICROCIRCUIT,LI:OPERATIONAL AMPLIFIER	27014	LM301AN
U1305	156-0047-00			MICROCIRCUIT,DI:3-INPUT NAND GATE	01295	SN7410N
VR54	152-0149-00	XB010151		SEMICOND DEVICE:ZENER,0.4W,10V,5%	04713	1N961B
VR56	152-0149-00	XB010151		SEMICOND DEVICE:ZENER,0.4W,10V,5%	04713	1N961B
VR106	152-0243-00			SEMICOND DEVICE:ZENER,0.4W,15V,5%	81483	1N965B
VR130	152-0227-00			SEMICOND DEVICE:ZENER,0.4W,6.2V,5%	81483	69-6585
VR164	152-0227-00			SEMICOND DEVICE:ZENER,0.4W,6.2V,5%	81483	69-6585
VR690	152-0461-00			SEMICOND DEVICE:ZENER,0.4W,6.2V,5%	04713	1N821
VR802	152-0226-00			SEMICOND DEVICE:ZENER,0.4W,5.1V,5%	81483	69-6584
VR1048	152-0279-00			SEMICOND DEVICE:ZENER,0.4W,5.1V,5%	07910	1N751A
VR1250	152-0461-00			SEMICOND DEVICE:ZENER,0.4W,6.2V,5%	04713	1N821
Y430	158-0094-00			XTAL UNIT,QTZ:249.975 KHZ,0.0005%		
Y432	158-0094-00			XTAL UNIT,QTZ:249.975 KHZ,0.0005%		
Y434	158-0094-00			XTAL UNIT,QTZ:249.975 KHZ,0.0005%		
Y436	158-0094-00			XTAL UNIT,QTZ:249.975 KHZ,0.0005%		
Y438	158-0094-00			XTAL UNIT,QTZ:249.975 KHZ,0.0005%		

DIAGRAMS AND CIRCUIT BOARD ILLUSTRATIONS

Symbols and Reference Designators

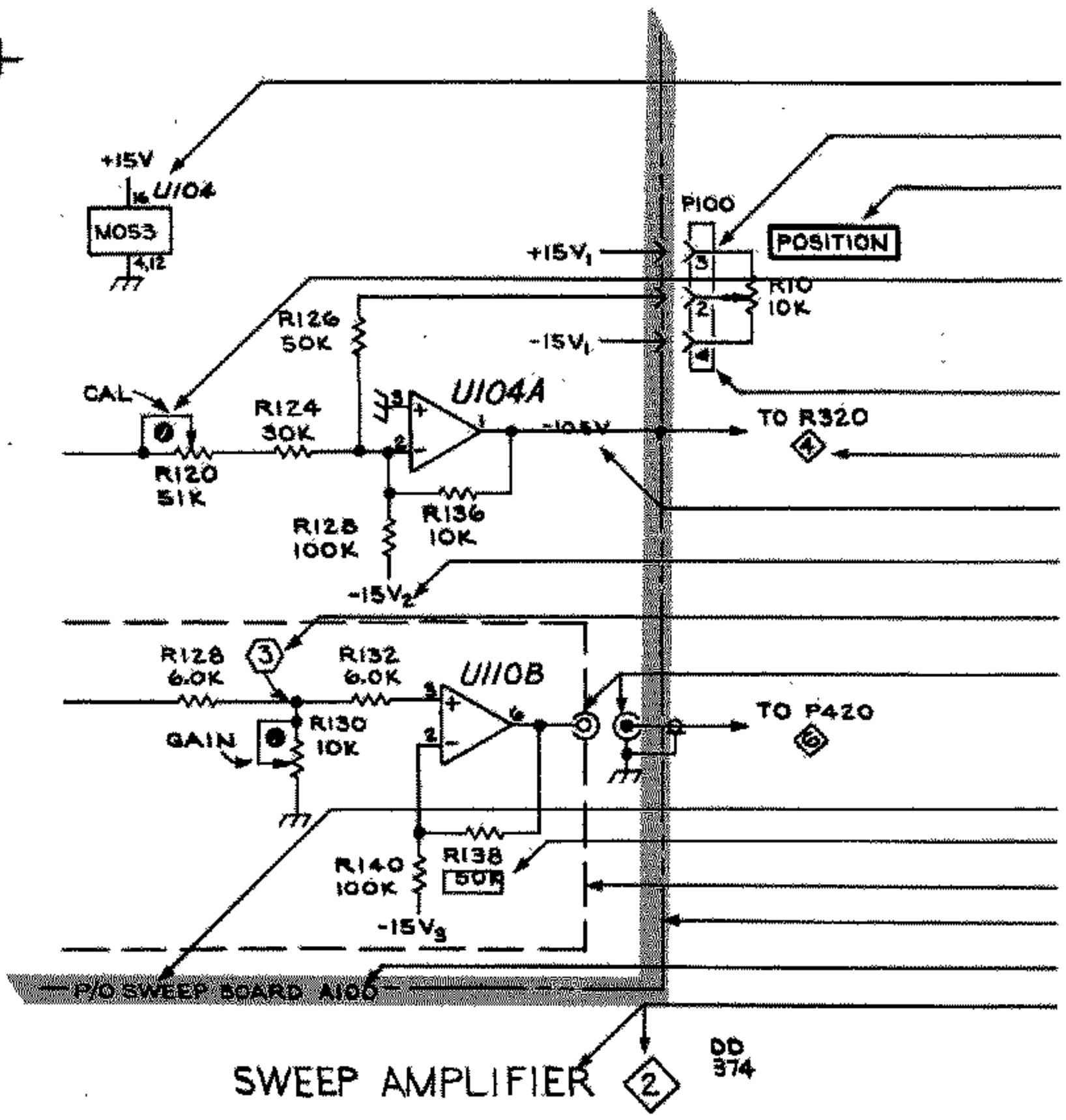
Electrical components shown on the diagrams are in the following units unless noted otherwise:

Capacitors =	Values one or greater are in picofarads (pF). Values less than one are in microfarads (μF).
Resistors =	Ohms (Ω).

Symbols used on the diagrams are based on ANSI Y32.2, 1970 Standards. Exceptions and additions are shown on the diagram sample.

Logic symbology is based on ANSI Y32.14-1973 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:



IC Voltage and Pin-Out Data

Plug to Circuit Board

Front Panel Adjustment or Control

Internal Screwdriver Adjustment

Plug Index

Refer to Diagram Number

Test Voltage

Decoupled or Filtered Voltage

Refer to Waveform

Coaxial Connector

Board Name

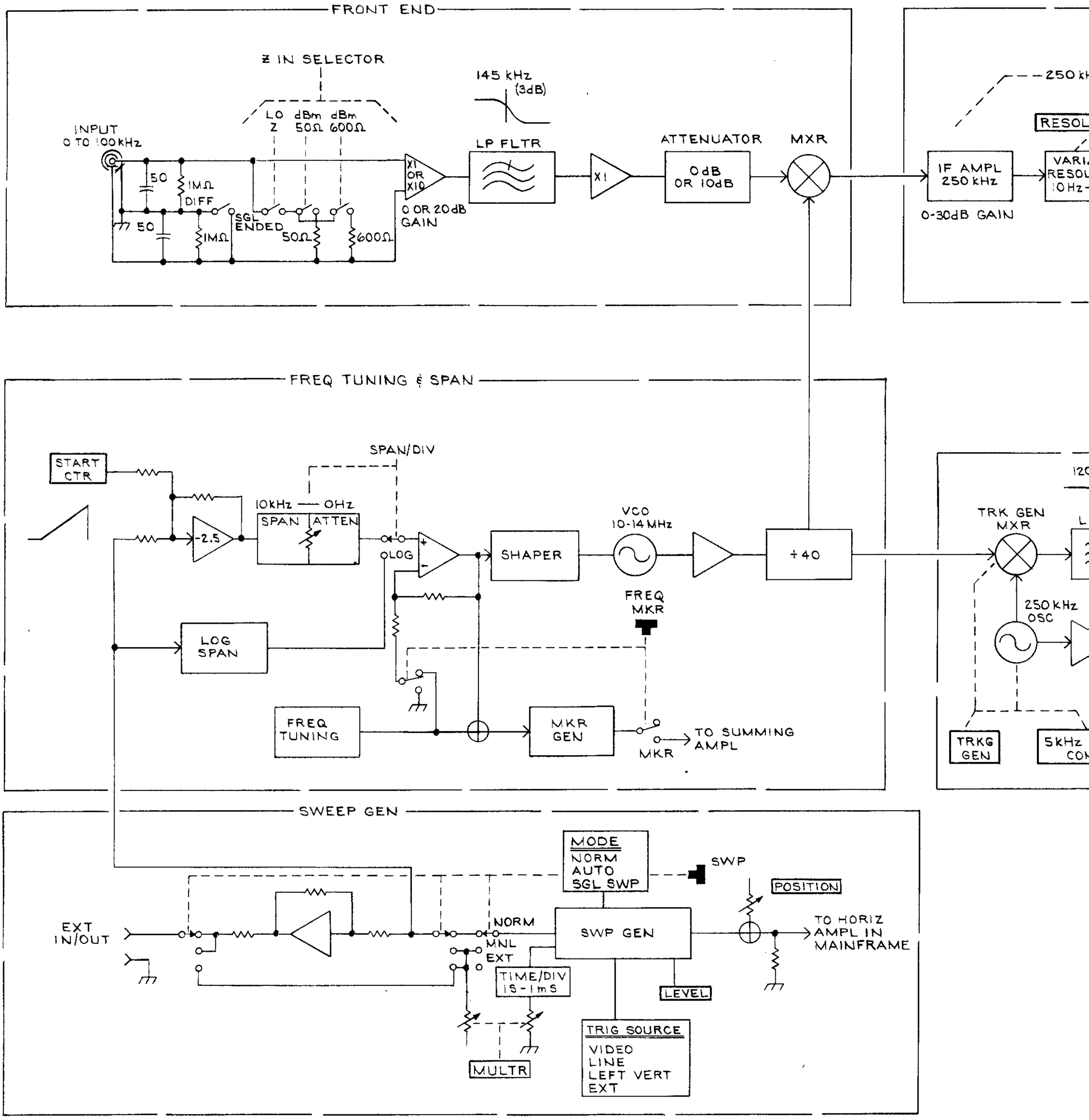
Modified Component-See Parts List

Shield

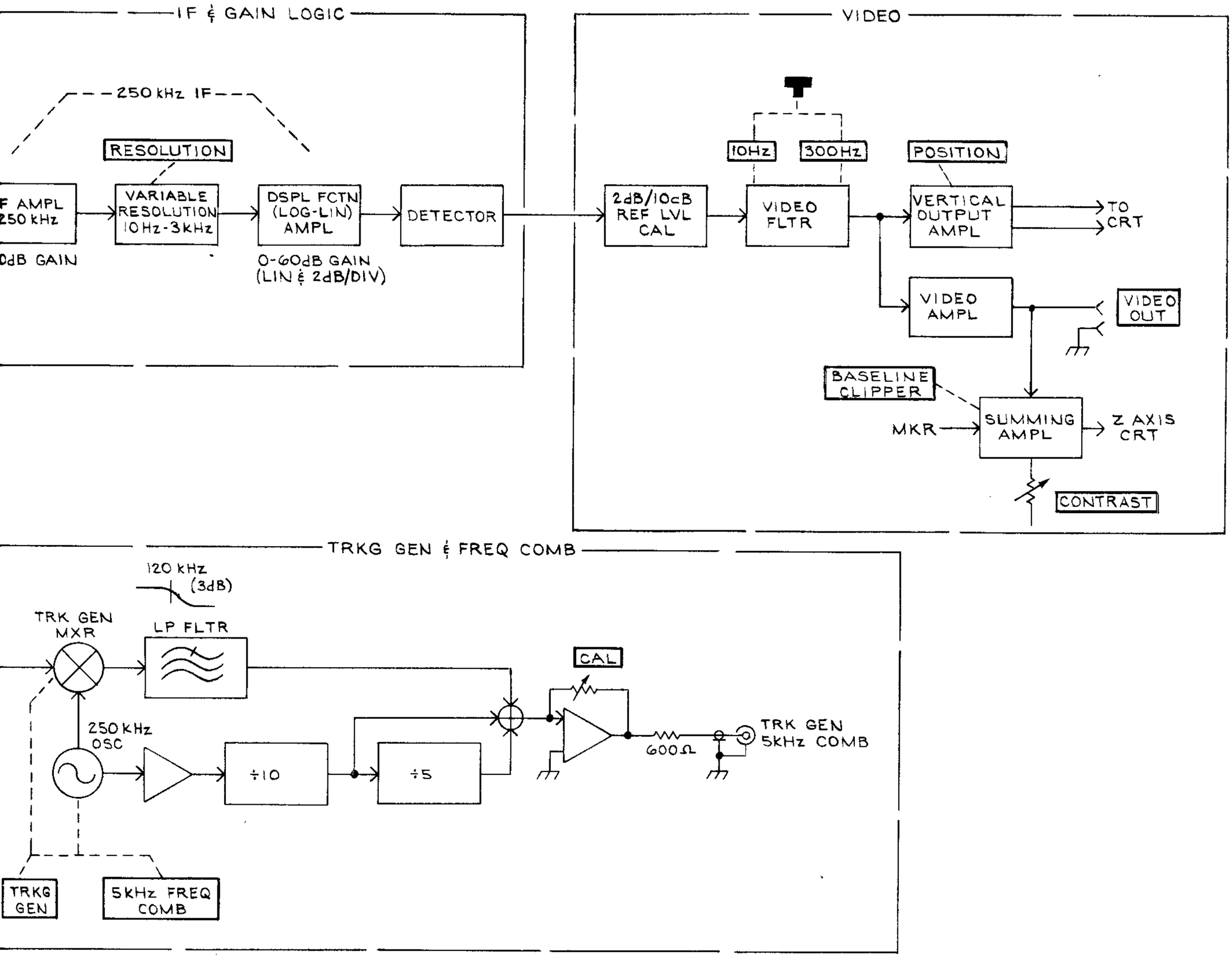
Circuit Board Outlined in Blue

Assembly Number

Schematic Name and Number


FRONT END
Z IN SELECTOR
LO Z
dBm 50Ω
dBm 600Ω
INPUT
0 TO 100kHz
50
1MΩ
DIFF
50
1MΩ
SGL ENDED
50Ω
600Ω
X1 OR X10
0 OR 20dB GAIN
145 kHz
(3dB)
LP FLTR
X1
ATTENUATOR
0dB OR 10dB
MXR
250 kH
RESOL
IF AMPL 250 kHz
0-30dB GAIN
VARI.
RESOL
10Hz
FREQ TUNING & SPAN
START CTR
-2.5
SPAN/DIV
10kHz — 0Hz
SPAN
ATTEN
LOG
SHAPER
VCO 10-14 MHz
÷40
FREQ MKR
LOG SPAN
FREQ TUNING
MKR GEN
MKR
TO SUMMING AMPL
TRK GEN MXR
250 kHz OSC
TRKG GEN
5kHz
SWEEP GEN
MODE
NORM
AUTO
SGL SWP
SWP
POSITION
EXT IN/OUT
NORM
MNL
EXT
SWP GEN
TO HORIZ AMPL IN MAINFRAME
TIME/DIV 1S - 1mS
LEVEL
MULTR
TRIG SOURCE
VIDEO
LINE
LEFT VERT
EXT

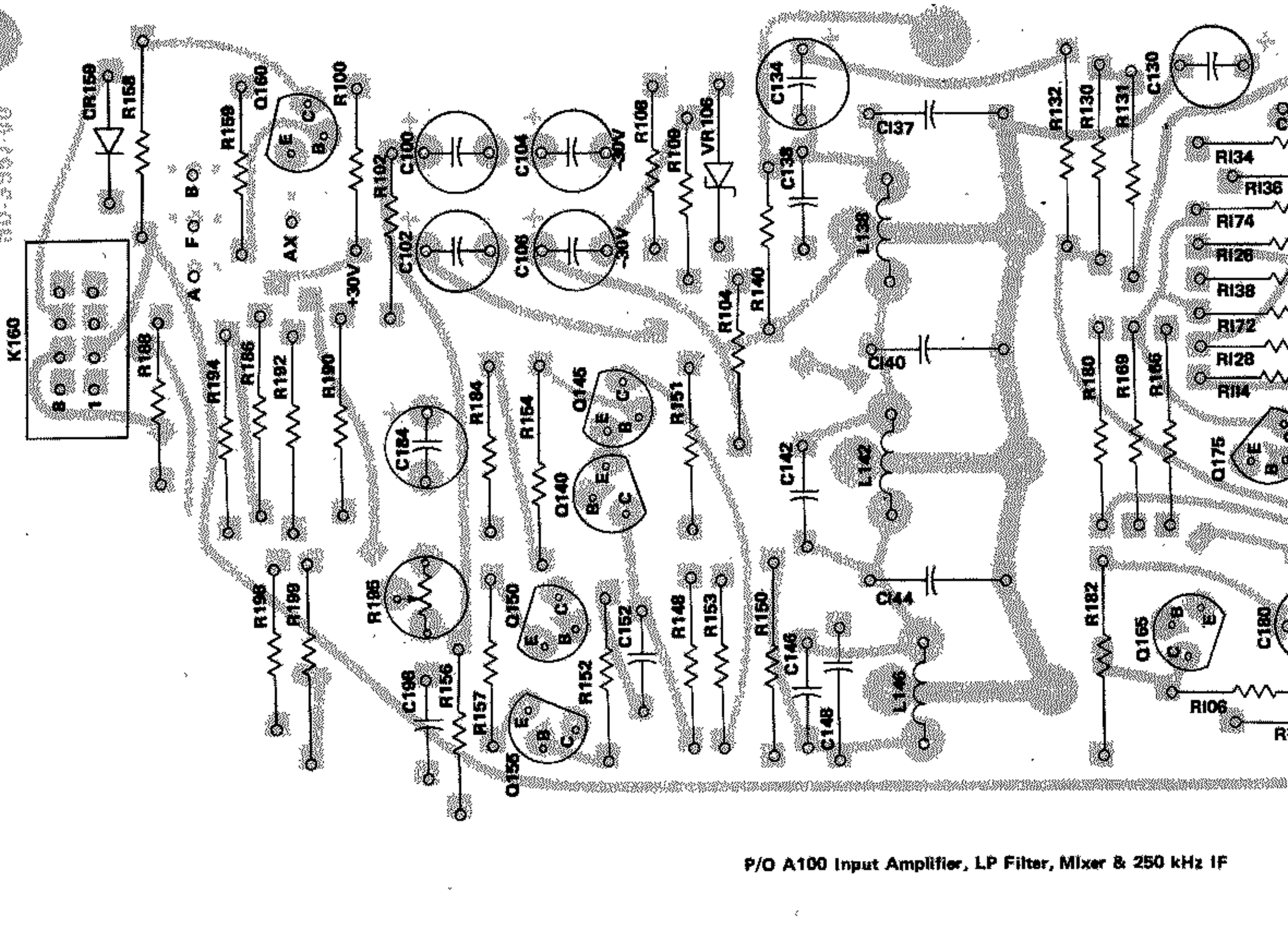
5L4N



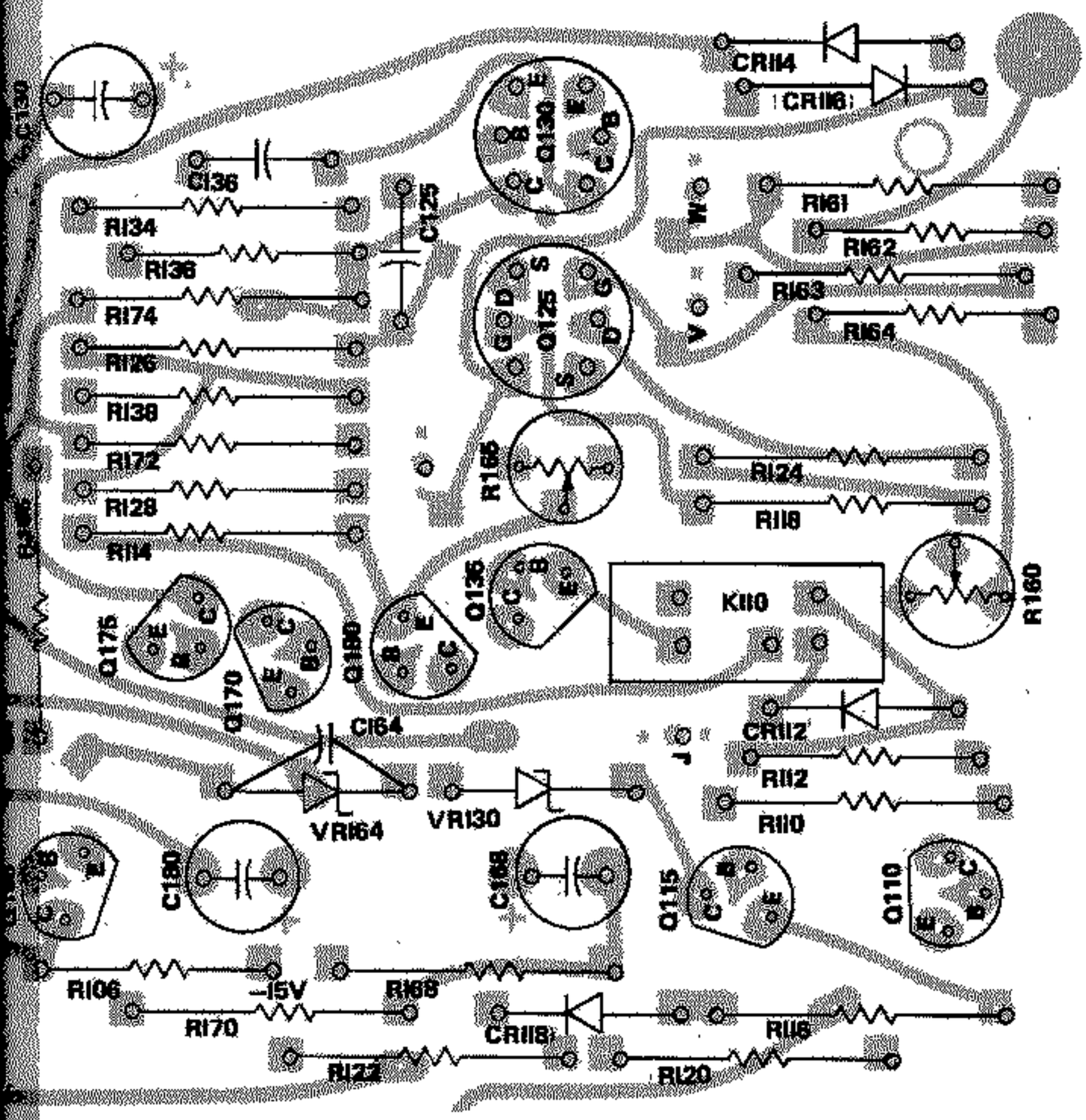
DD474

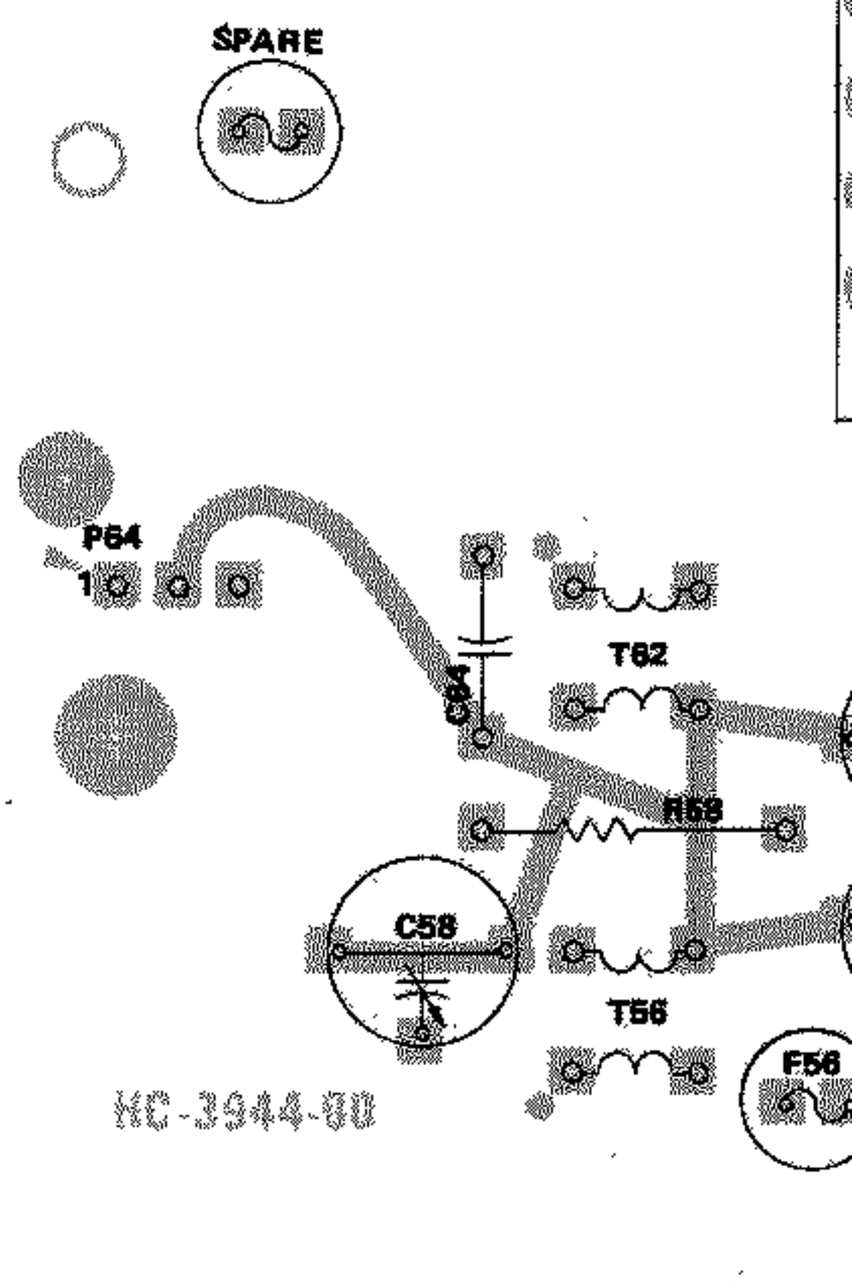
BLOCK DIAGRAM

BLOCK DIAGRAM

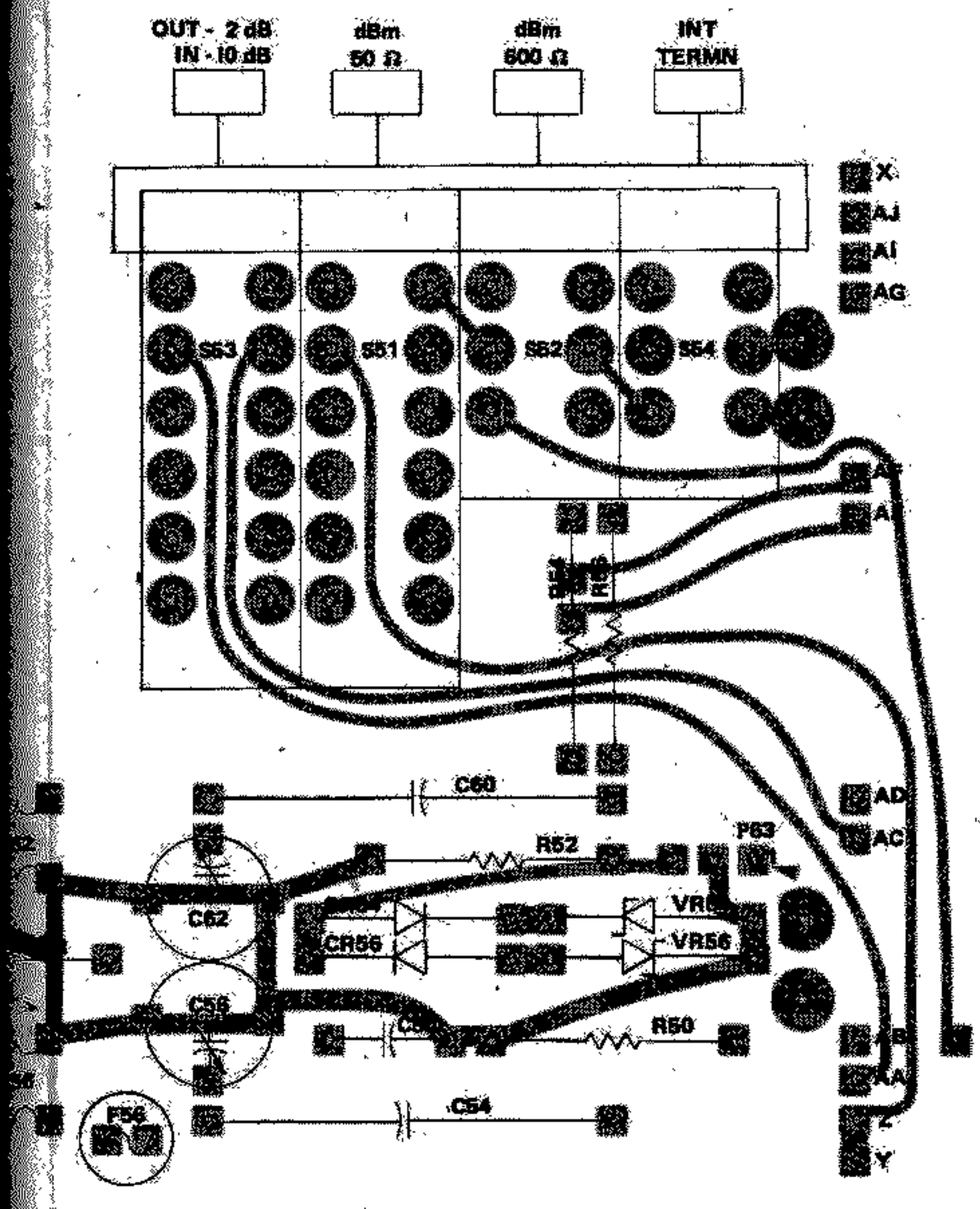


P/O A100 Input Amplifier, LP Filter, Mixer & 250 kHz IF

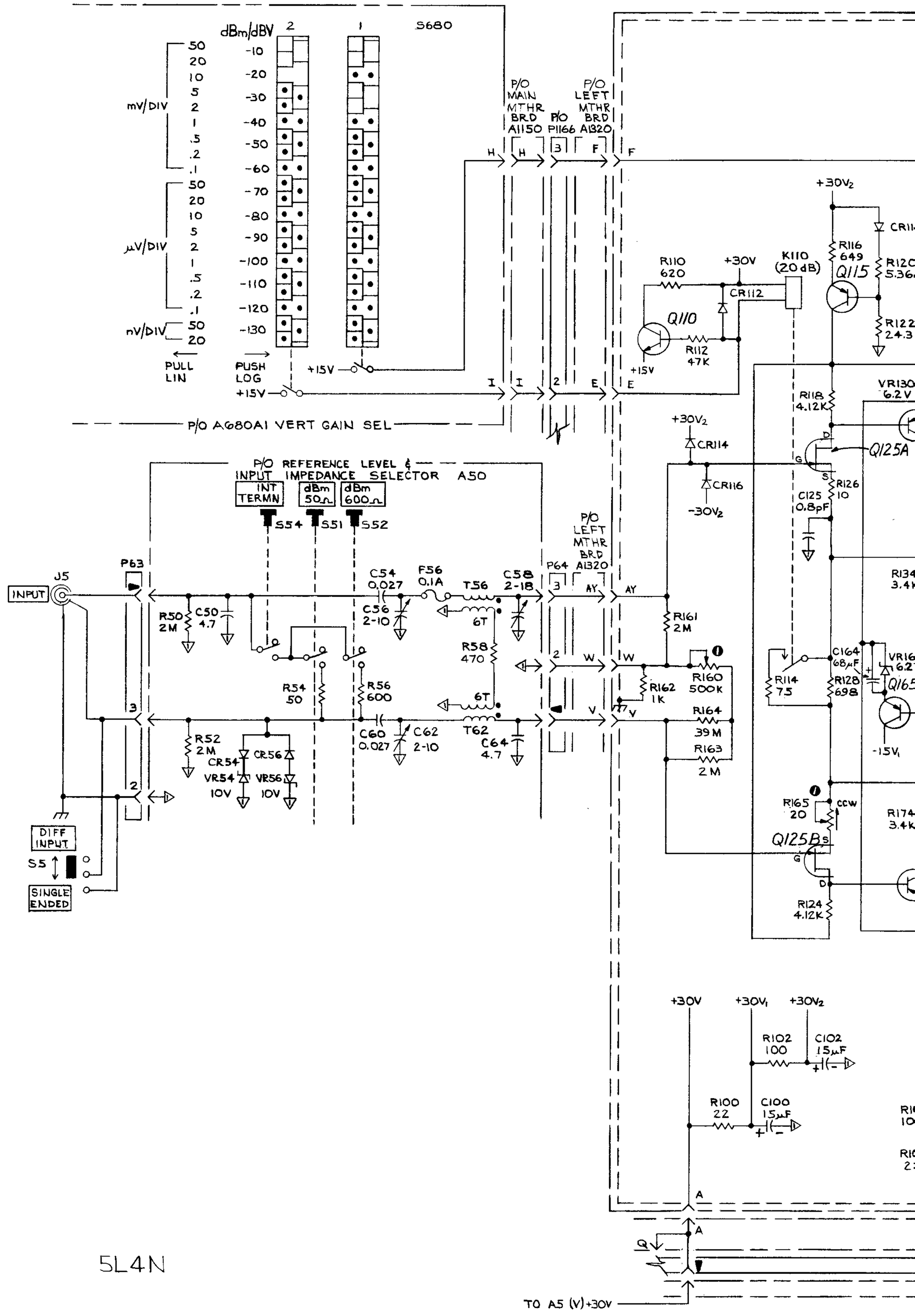




A50 Hi/Lo Inpu



30 Hi/Lo Input Impedance & LOG Display Selector


S680
dBm/dBV
2
1
50
20
10
5
2
1
.5
.2
.1
mV/DIV
50
20
10
5
2
1
.5
.2
.1
µV/DIV
50
20
nV/DIV
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
PULL LIN
PUSH LOG
+15V
+15V
P/O MAIN MTHR BRD A1150
P/O P1166
P/O LEFT MTHR BRD A1320
H
I
E
F
P/O A680A1 VERT GAIN SEL
P/O REFERENCE LEVEL & INPUT IMPEDANCE SELECTOR A50
INT TERMN
dBm 50Ω
dBm 600Ω
S54
S51
S52
P63
J5
INPUT
C54 0.027
F56 0.1A
T56
C58 2-18
C56 2-10
6T
R50 2M
C50 4.7
R58 470
R54 50
R56 600
6T
R52 2M
CR54
CR56
VR54 10V
VR56 10V
C60 0.027
C62 2-10
T62
C64 4.7
DIFF INPUT
S5
SINGLE ENDED
P64
AY
W
V
R161 2M
R162 1k
R160 500K
R164 39M
R163 2M
+30V2
CR114
CR116
-30V2
+30V
R110 620
CR112
K110 (20dB)
Q110
R112 47K
Q115
R116 649
R120 5.36
R122 2.43
R118 4.12K
D
G
S
Q125A
R126 10
C125 0.8pF
VR130 6.2V
R134 3.4K
C164 68µF
R114 7.5
R128 698
VR16 6.2
Q165
-15V1
R165 20
CCW
Q125B
R174 3.4K
R124 4.12K
+30V
+30V1
+30V2
R102 100
C102 15µF
R100 22
C100 15µF
A
TO A5 (V) +30V

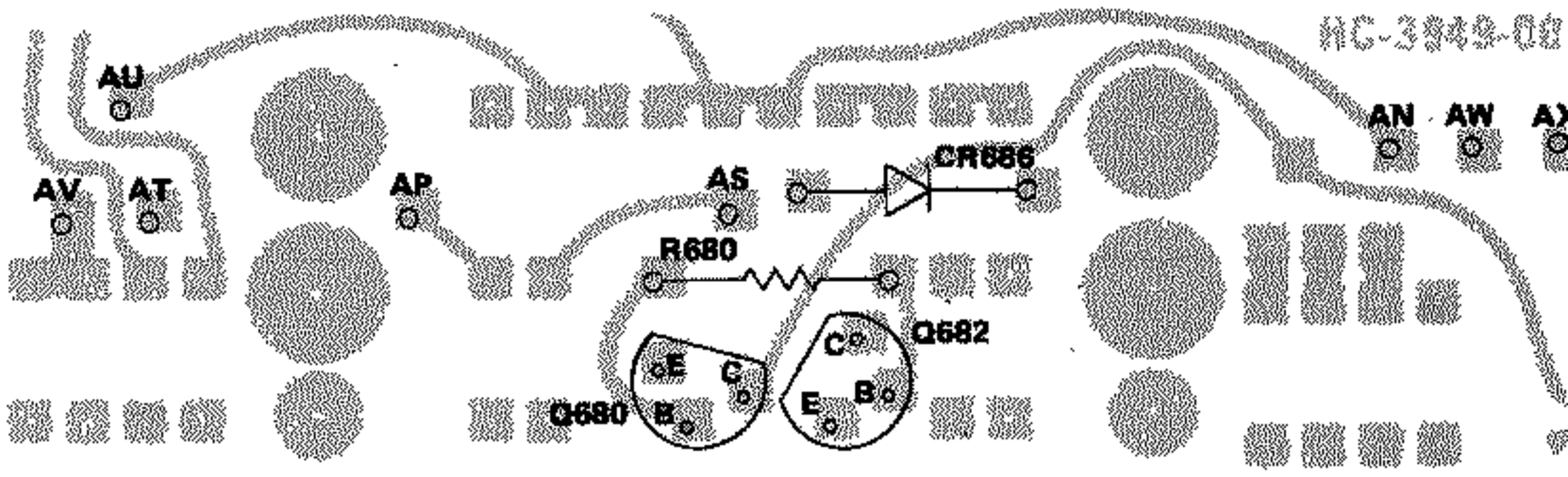
R158 620
+30V
K160 (10 dB)
CR159
Q160
+15V
R159 47K
+30V2
CR118
R116 649
Q115
R120 5.36K
R122 24.3K
R131 1K
C130 2.2µF
+30V2
L138 3.0mH
L142 1.3mH
L146 1.3mH
+30V1
R153 10K
+30V1
R148 10K
C152 .001
R152 27
+30V1
R157 33
R156 680
Q150
Q155
R130 4.02K
VR130 6.2V
Q130A
R132 649
C134 10µF
C138 200
C142 375
C146 95
Q140
Q145
R154 750
Q125A
Q135
C137 1800
C140 2000
C144 1800
C148 678
R150 750
R151 1.5K
-30V1
R126 10
R140 100
C136 20
R134 3.4K
R136 470
R138 787
Q170
C164 68µF
VR164 6.2V
R128 698
Q165
R166 10K
R168 2K
C168 100µF
-30V2
R170 2K
Q175
R169 10K
-15V1
-15V2
R172 787
CCW
R174 3.4K
+30V2
Q180
R180 4.99K
Q130B
C180 10µF
R182 1.40K
R186 249
C184 100µF
R184 4.7K
-30V1
R188 5.1
R190 787
TO T218 (MIXER)
2
R192 30.9
R194 39.2
+30V1
R198 39K
R199 22.6
R195 200K
C198 1µF
-30V1
-15V1
-15V2
R106 2K
C102 15µF
VR106 15V
R104 30K
-30V2
C106 15µF
R109 100
-30V1
R108 22
C104 15µF
SHIELD
B
P/O MIXER BRD A100
B
P/O A1320 LEFT MTHR BRD
2
P/O P1165
P/O A1150 MAIN MTHR BD
TO B5 (V) -30V

INPUT IMPD SEL AMPL & LP FILTER 1

INPUT Z SEL AMPL & LP FILTER 1

SS 4-74

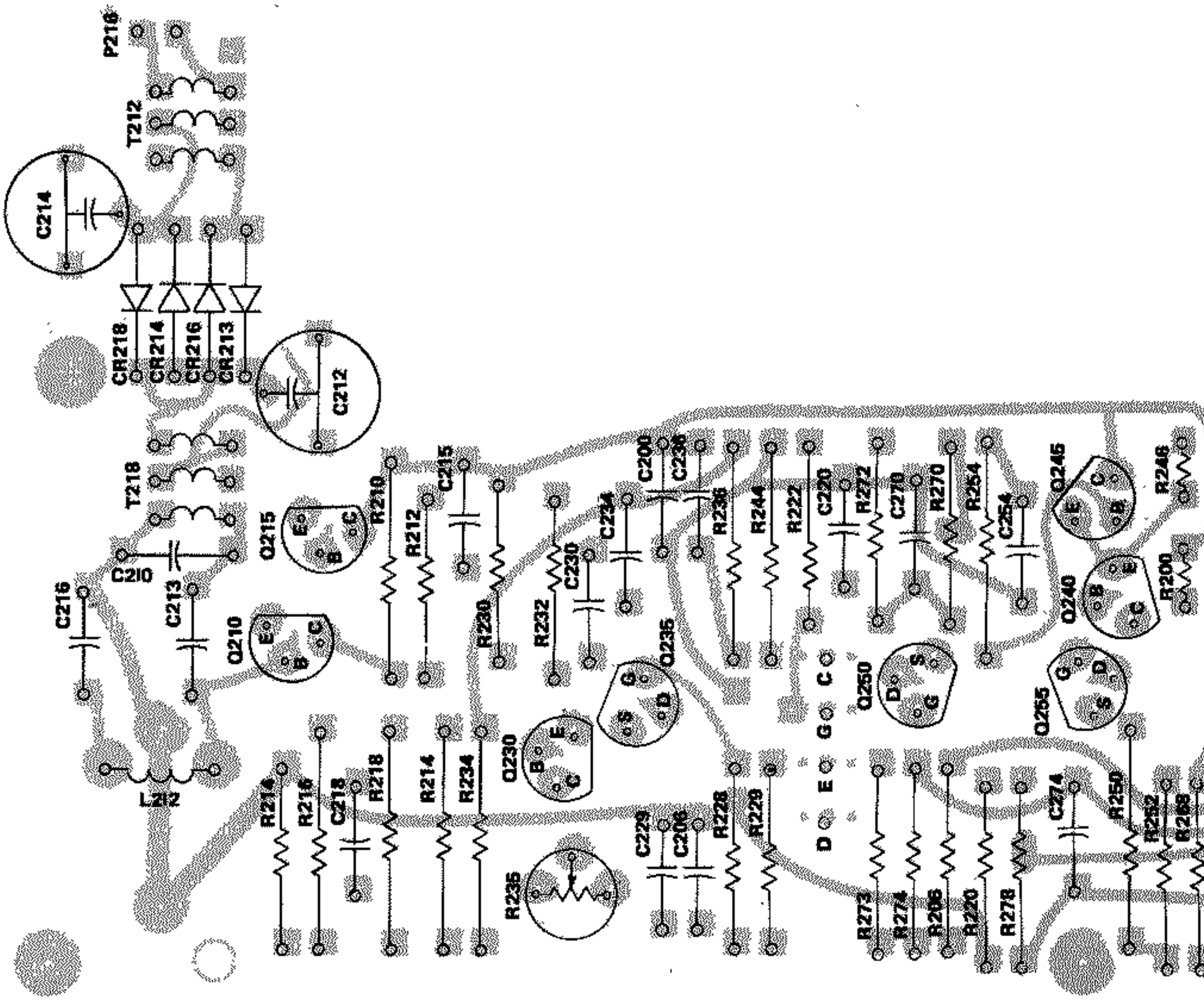
5L4N



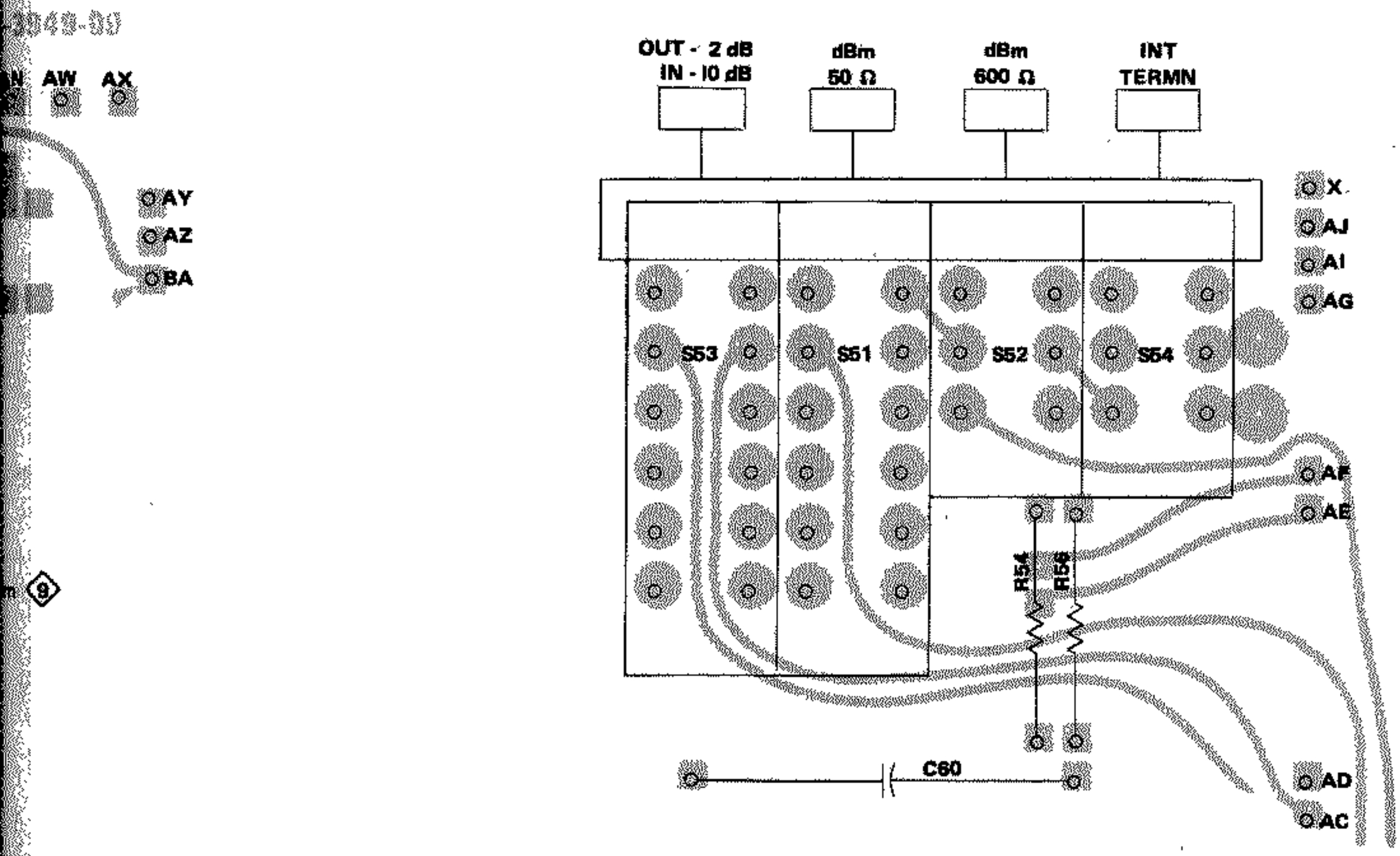
P/O A690A1 Vertical Sensing Selector

A1150 Main Mother Board component location shown on back of Diagram 9

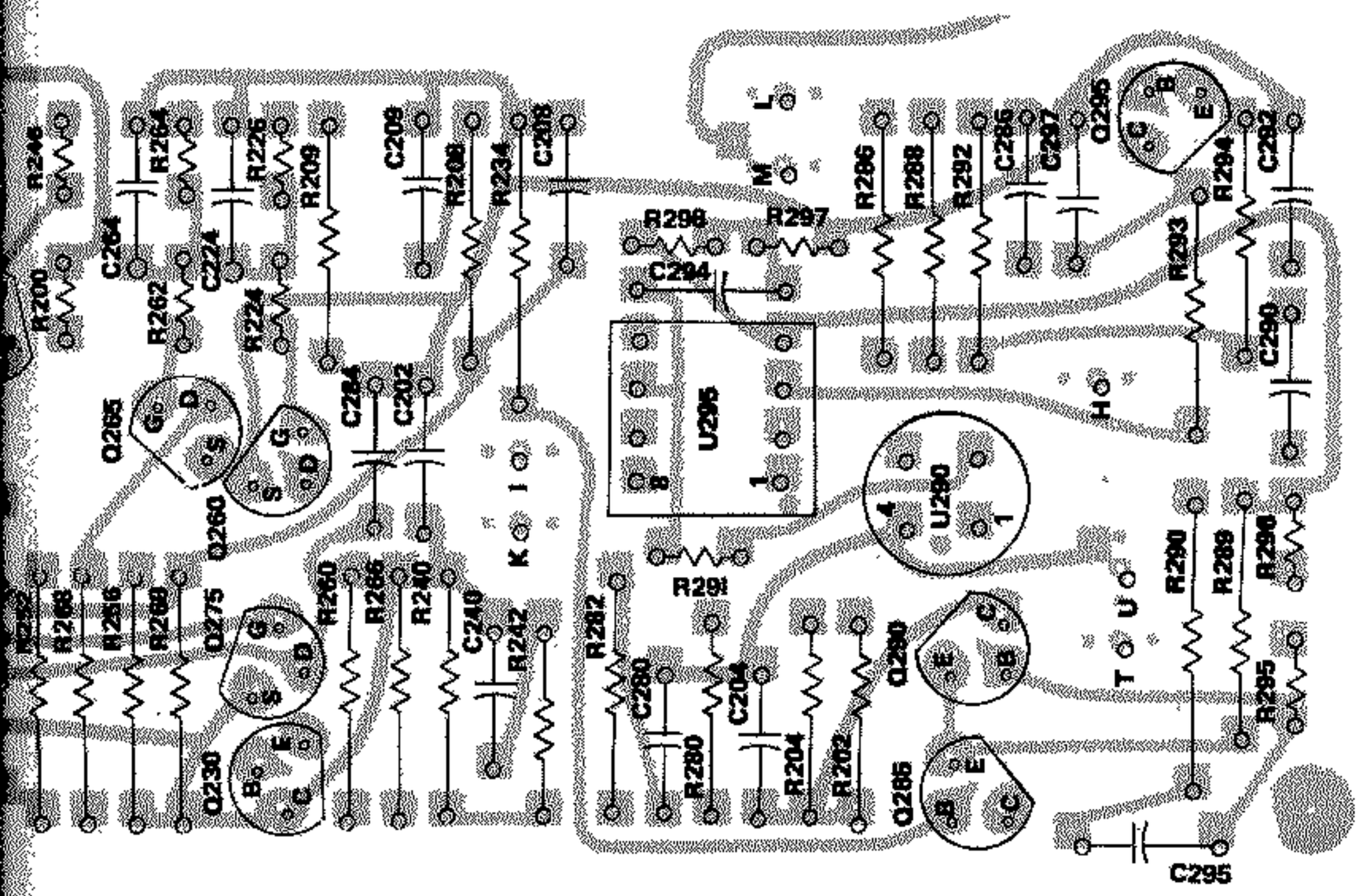
COMPONENT LOCATIONS
FOR DIAGRAM 2



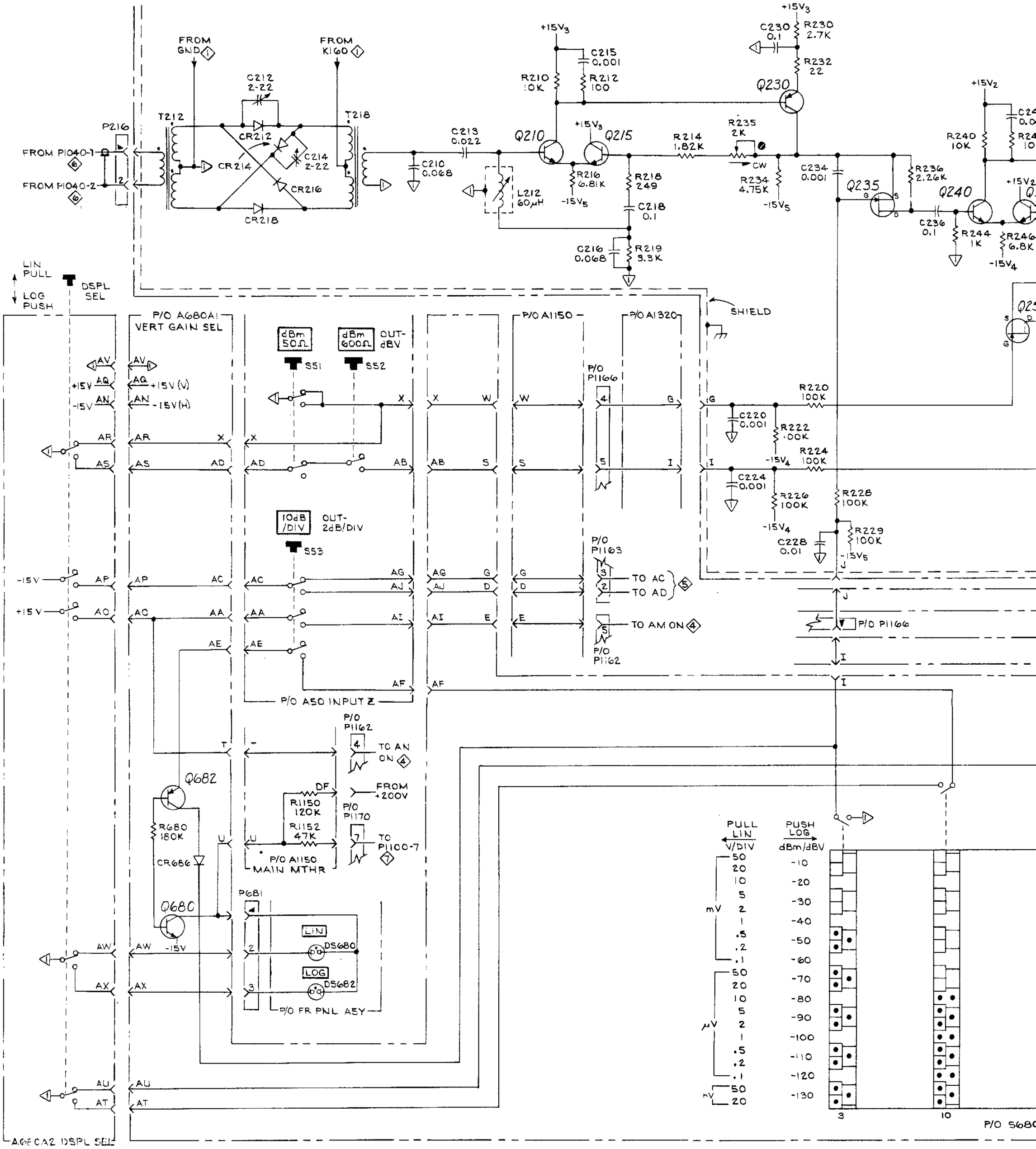
P/O A100 Input Amplifier, LP Filter, Mixer & 250



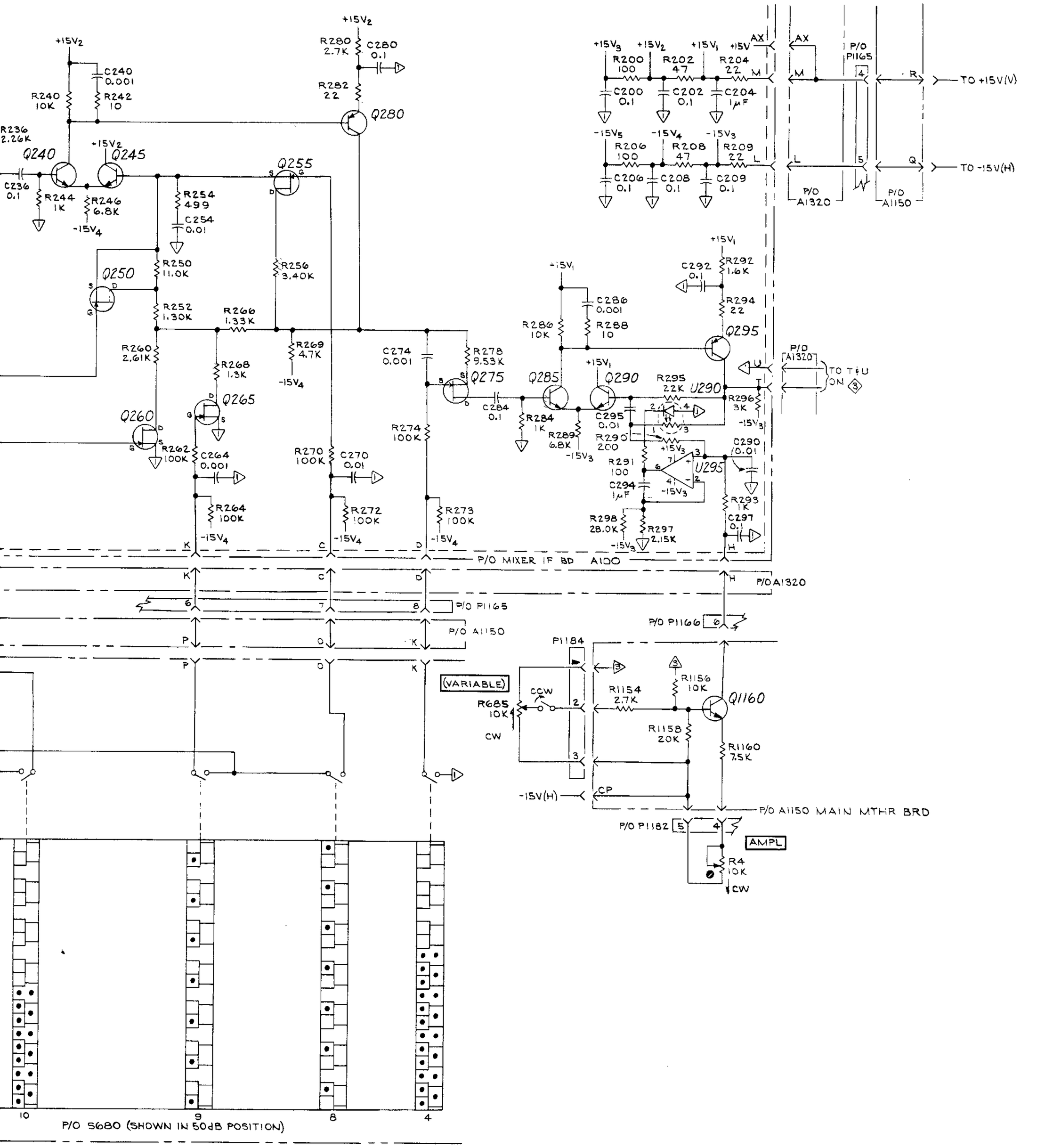
P/O A50 Hi/Lo Input Impedence & LOG Display Selector



Mixer & 250 kHz IF


FROM GND
FROM K160
C212 2-22
T212
T218
P216
FROM P1040-1
FROM P1040-2
CR212
CR214
CR216
CR218
C214 2-22
C213 0.022
C210 0.068
L212 60μH
+15V3
C215 0.001
R210 10K
R212 100
Q210
Q215
R214 1.82K
R235 2K
CW
R234 4.75K
-15V5
R216 6.81K
R218 249
C218 0.1
C216 0.068
R219 3.3K
C230 0.1
R230 2.7K
R232 22
Q230
C234 0.001
Q235
R236 2.26K
+15V2
R240 10K
Q240
C236 0.1
R244 1K
R246 6.8K
-15V4
SHIELD
LIN PULL
LOG PUSH
DSPL SEL
P/O A680A1 VERT GAIN SEL
dBm 50Ω
dBm 600Ω
OUT-dBV
S51
S52
10dB /DIV
OUT-2dB/DIV
S53
P/O A50 INPUT Z
P/O A1150
P/O A1320
P/O P1166
P/O P1163
P/O P1162
TO AC
TO AD
TO AM ON
R220 100K
C220 0.001
R222 100K
R224 100K
C224 0.001
R226 100K
R228 100K
R229 100K
C228 0.01
Q682
R680 180K
CR686
Q680
P681
P/O P1162
TO AN ON
P/O P1170
FROM +200V
R1150 120K
R1152 47K
P/O A1150 MAIN MTHR
TO P1100-7
LIN
LOG
DS680
DS682
P/O FR PNL ASY
PULL LIN V/DIV
PUSH LOG dBm/dBV
mV
μV
nV
P/O S680
A6F6A2 DSPL SEL

5L4N

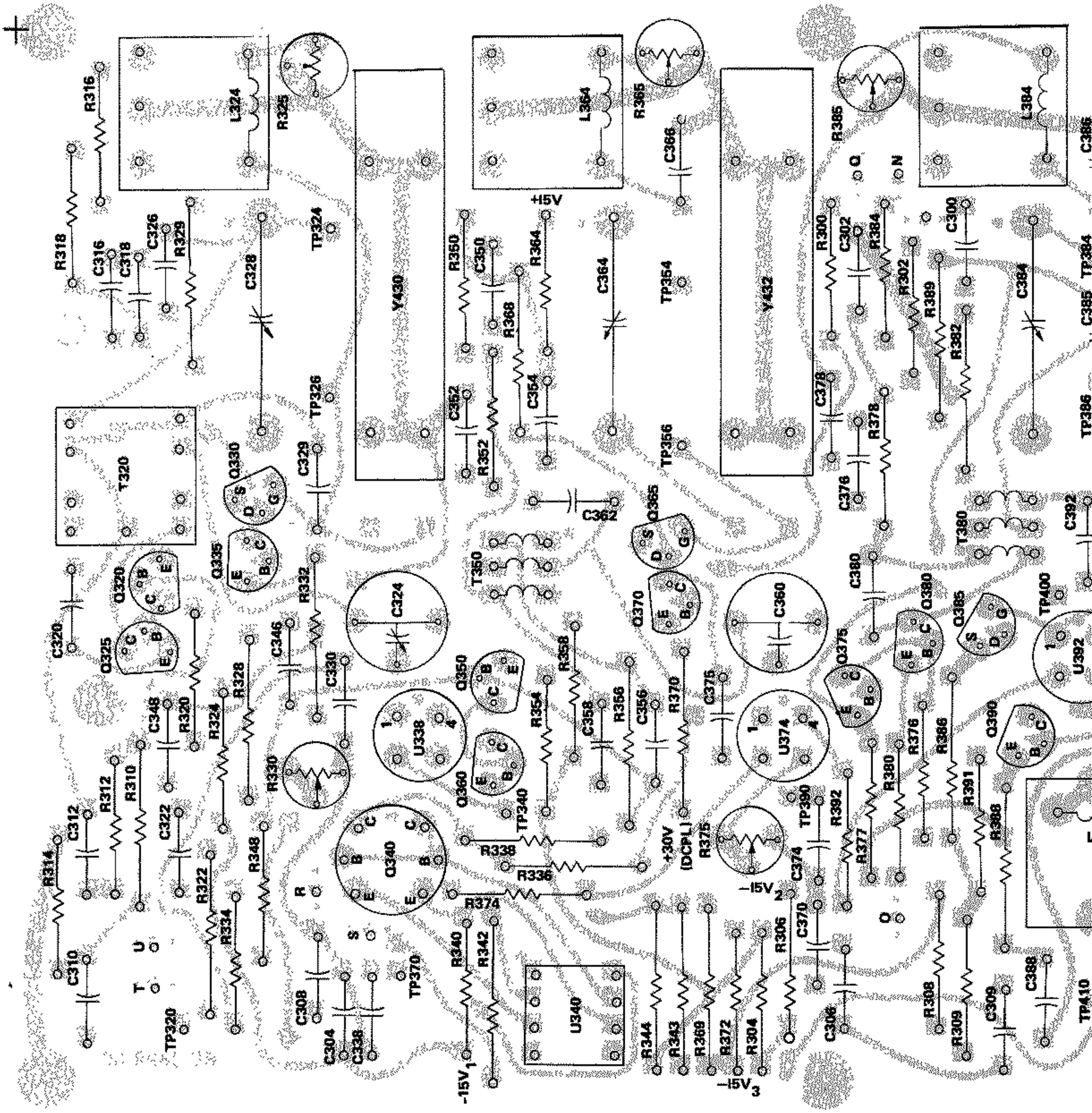


DD 474

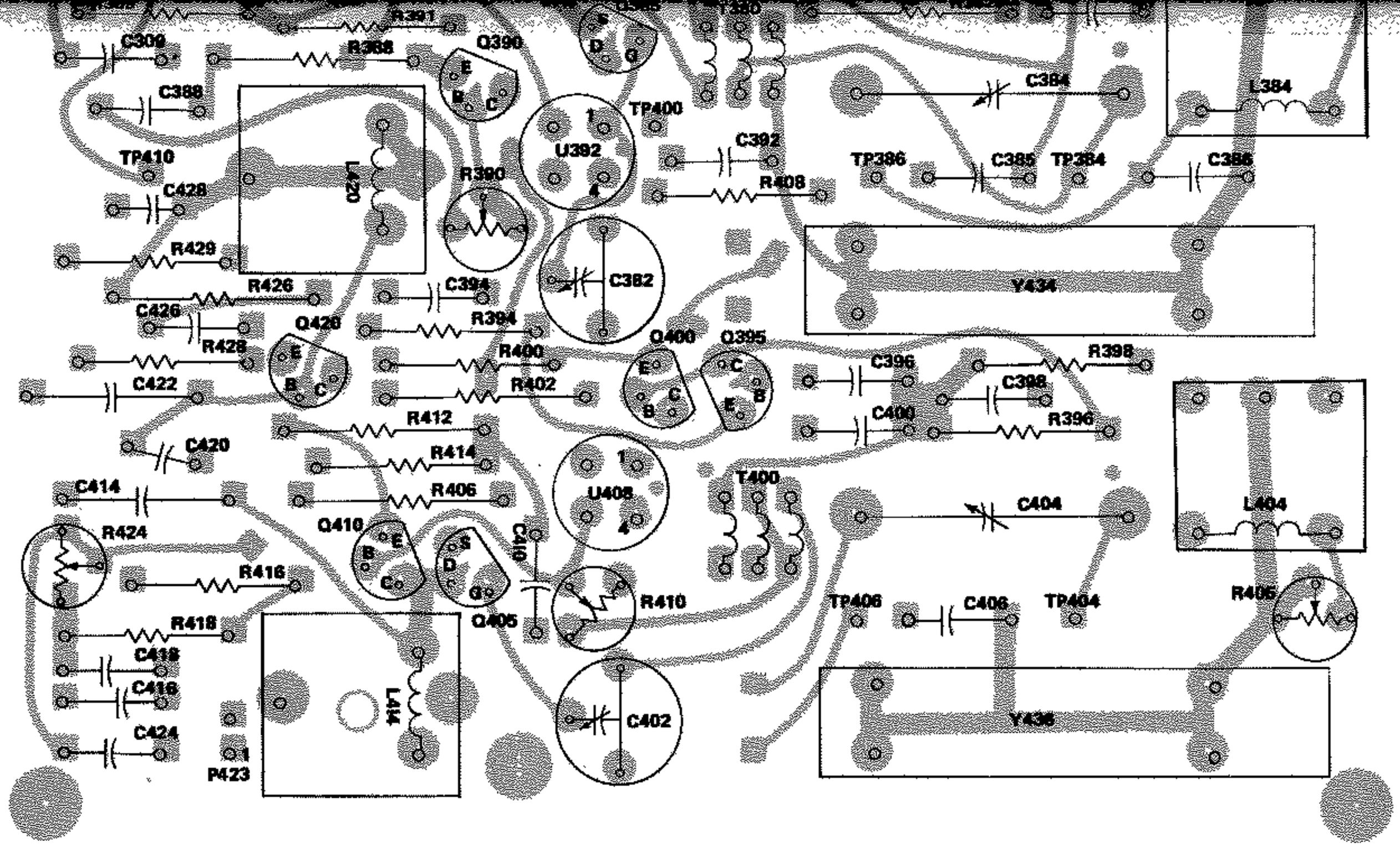
MIXER & 250kHz SWITCHED GAIN AMPL ◇2

MIXER & 250 kHz SWITCHED GAIN AMPL ◇2

5L4N



A300 Variable Resolution


R391
C309
R388
Q390
C388
TP410
C428
L420
R390
R429
R426
C394
C426
R428
R394
Q420
R400
C422
R402
R412
C420
R414
C414
R406
Q410
R424
C416
R410
R416
R418
C418
C424
P423
L414
C402
U392
TP400
C392
R408
C382
U408
T400
C384
L384
TP386
C385
TP384
C386
Y434
Q400
Q395
C396
R398
C398
C400
R396
C404
L404
TP406
C406
TP404
R405
Y436

TO A5 +30V (V)
TO +15V (V)
TO B2 +5V (V)
P/O A1150 MAIN
P/O P1165
P/O A1320 LEFT
Q
N
P
R300 240 +30V1
C300 0.1
R302 10 +5V1
C302 1µF
TO PIN 8 U340 +15V1
R364 22
R384 47
C354 1µF
C385 1µF
FROM Q295
C316 0.1
R316 47
C318 0.1
R318 20K
C320 0.1
T320
C324 2-22
C326 304pf
C328 90-400
Y430 250 kHz
C310 0.01
R310 4.99K
R312 100
C312 0.01
Q320
Q325
R320 18K
R324 3K
C322 2.2
-15V1
TP320
TP324
TP326
R322 10K
R314 100
L324 7.35mH
R325 1K CW
Q330
R329 1K
R328 4.53K
-15V3
C329 10
C346 0.01
C350 0.1
R350 47
C352 0.1
R352 20K
C358 0.1
T350
C360 2-22
C362 330
C364 90-400
Y432 250 kHz
Q350
Q360
R348 100
C348 0.01
R354 18K
R358 3K
C356 2.2
TP354
TP356
R356 10K
Q335
R330 100 CW
C330 0.01
R332 124
R334 15K
Q365
R368 1K
R369 9.31K
C366 10
L364 7.35mH
R365 1K CW
Q370
R370 232
R372 15K
R375 100 CW
+5V1
C378 0.1
R378 47
C380 470
T380
C382 2-22
C384 90-400
R376 5.1K
C376 0.1
Q375
Q380
C375 0.01
R377 15K
R380 4.7K
-15V2
TP384
R382 10K
L385 1K
U340
+15V1
NS558V
-15V1
U338
U374
+30V1
R336 220K
R338 240
C338 0.1
TP340
R374 240
C374 0.1
TP370
Q340B
Q340A
R340 750K
U340A
R343 4.02K
R342 20K
U340B
R344 301K
R309 47
C309 0.1
-15V4
R308 47
C308 0.1
-15V3
R306 47
C306 0.1
-15V2
R304 47
C304 .01
-15V1
SHIELD
S
R
O
P/O P1166
P/O P1175
TO RESOLUTION 8
DV
CO
A2 (V) UTILITY GND
CP
TO B15 -15V (H)
P/O A1320 LEFT MTHR BRD
P/O P1165
P/O A1150 MAIN MTHR BRD
5L4N

TO +15V (V)
TO B2 +5V (V)
P/O A1150 MAIN MTHR. BRD
P/O P1165
P/O A1320 LEFT MTHR. BRD
N
P
R302 10
+5V$_1$
C302 1μF
R384 47
C385 1μF
R418 47
C418 0.1
+5V$_1$
R378 47
C378 0.1
T380
C382 2-22
17T
C380 470 30T
C376 0.1
C384 90-400
Y434 250 kHz
Q385
R389 1K
R386 9.31K
-15V$_4$
Q375
Q380
R380 4.7K
-15V$_2$
TP384
TP386
C386 10
R382 10K
L384 7.35mH
R385 1K CW
R375 100 CW
Q390
C388 .01
R388 23Ω
R391 15K
-15V$_4$
R390 100 CW
+5V$_1$
R398 47
C398 0.1
T400
C402 2-22
17T
C400 470 30T
R396 5.1K
C396 0.1
C404 90-400
Y436 250 kHz
Q395
Q400
C394 0.01
R394 15K
R400 4.7K
-15V$_2$
TP404
TP406
R402 10K
L404 7.35mH
R405 1K CW
Q405
R406 4.53K
-15V$_4$
C416 0.1
R416 100
L414 120μH
C420 65
C414 4700pF
L420 12.0μH
C422 4700pF
Q410
C410 .01
R412 124
R414 15K
-15V$_4$
R410 100 CW
R424 1K
P423
TO P448-2
TO P448-1
④
C424 0.01
Q420
C426 .01
R426 200
R428 6.8K
C428 0.01
R429 1K
-15V$_4$
U392
R392 240
C392 0.1
TP390
U408
R408 240
+30V$_1$
TP400
TP410
C374 0.1

NOTE:

1. 250 KHz CRYSTALS ARE PART OF A PLUG-IN CIRCUIT BOARD ASSEMBLY, A430, SEPARATE FROM A300.

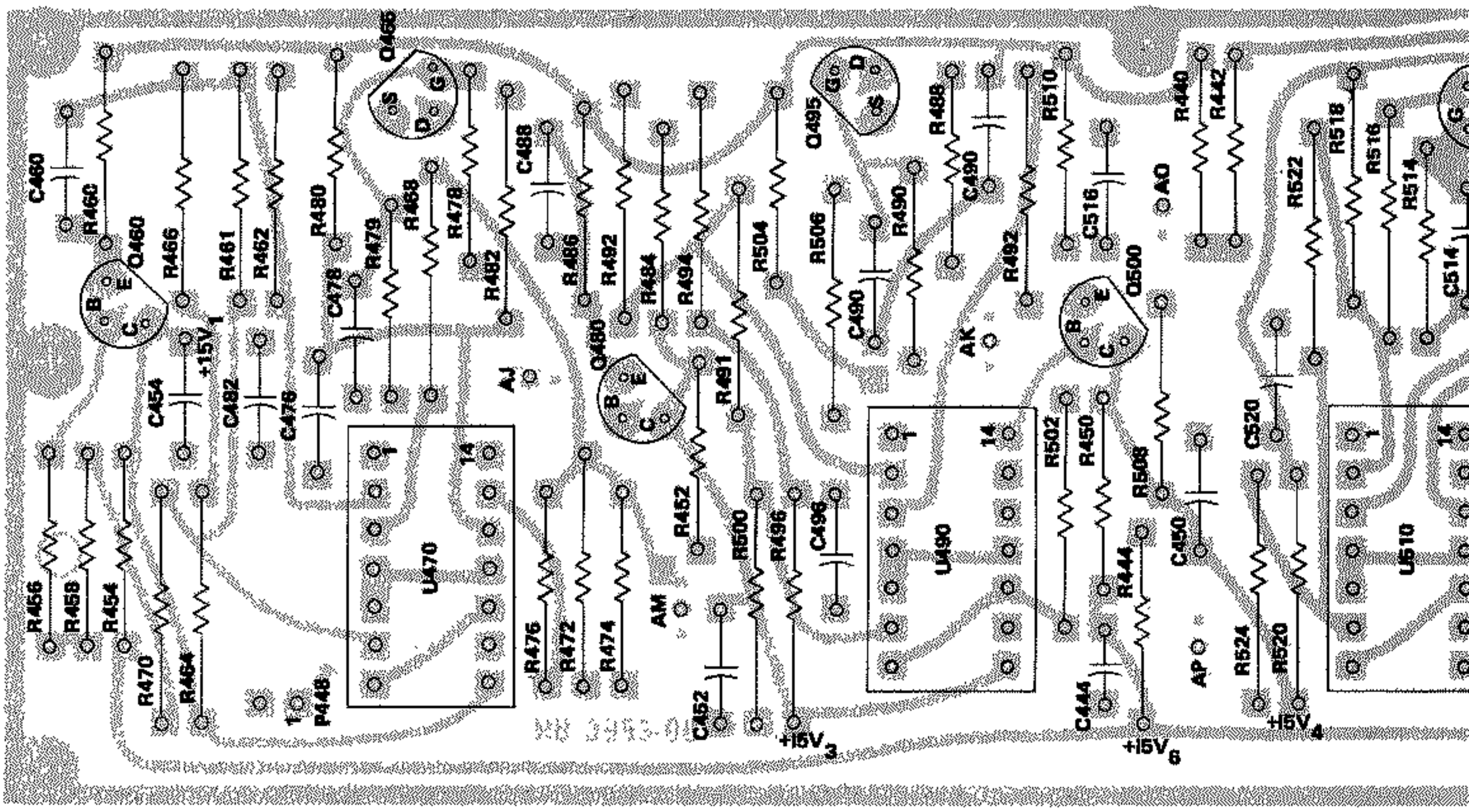
SHIELD

VARIABLE RESOLUTION BRD A300

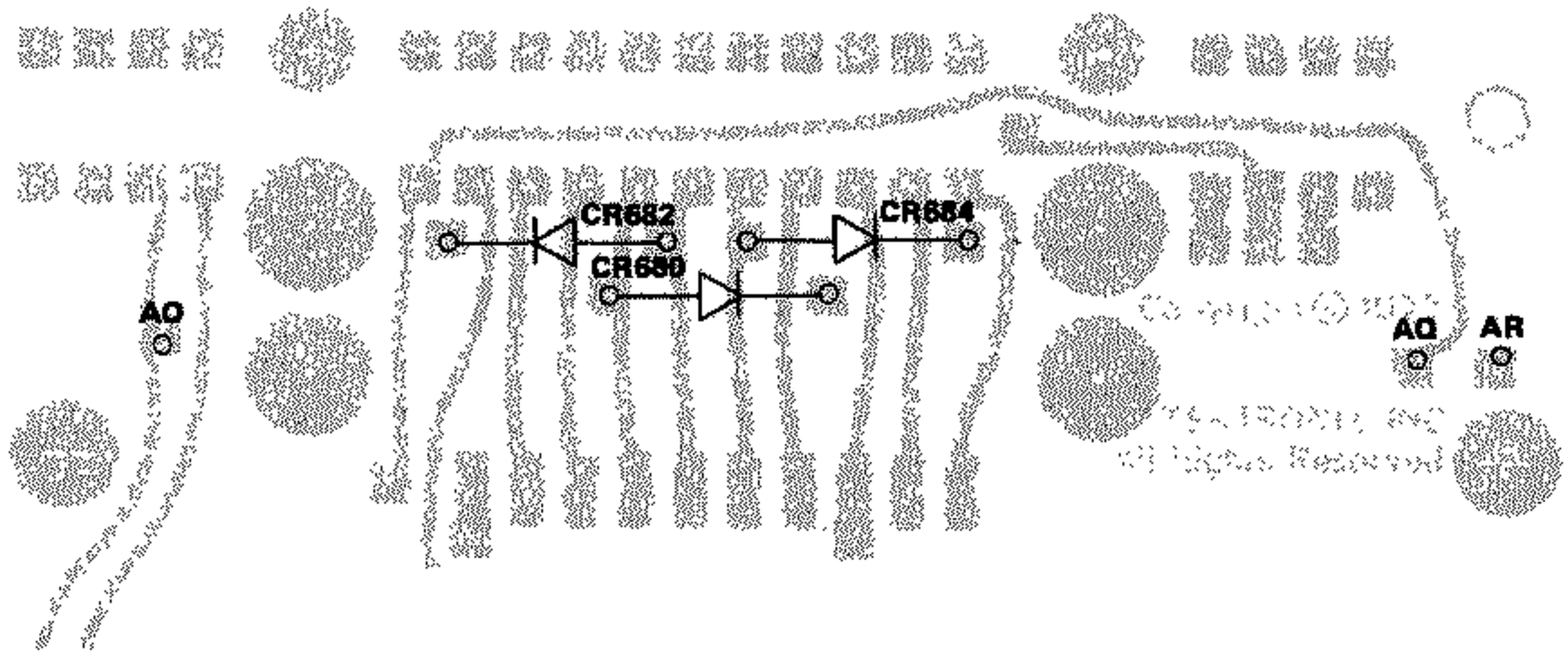
VARIABLE RESOLUTION ③

5L4N

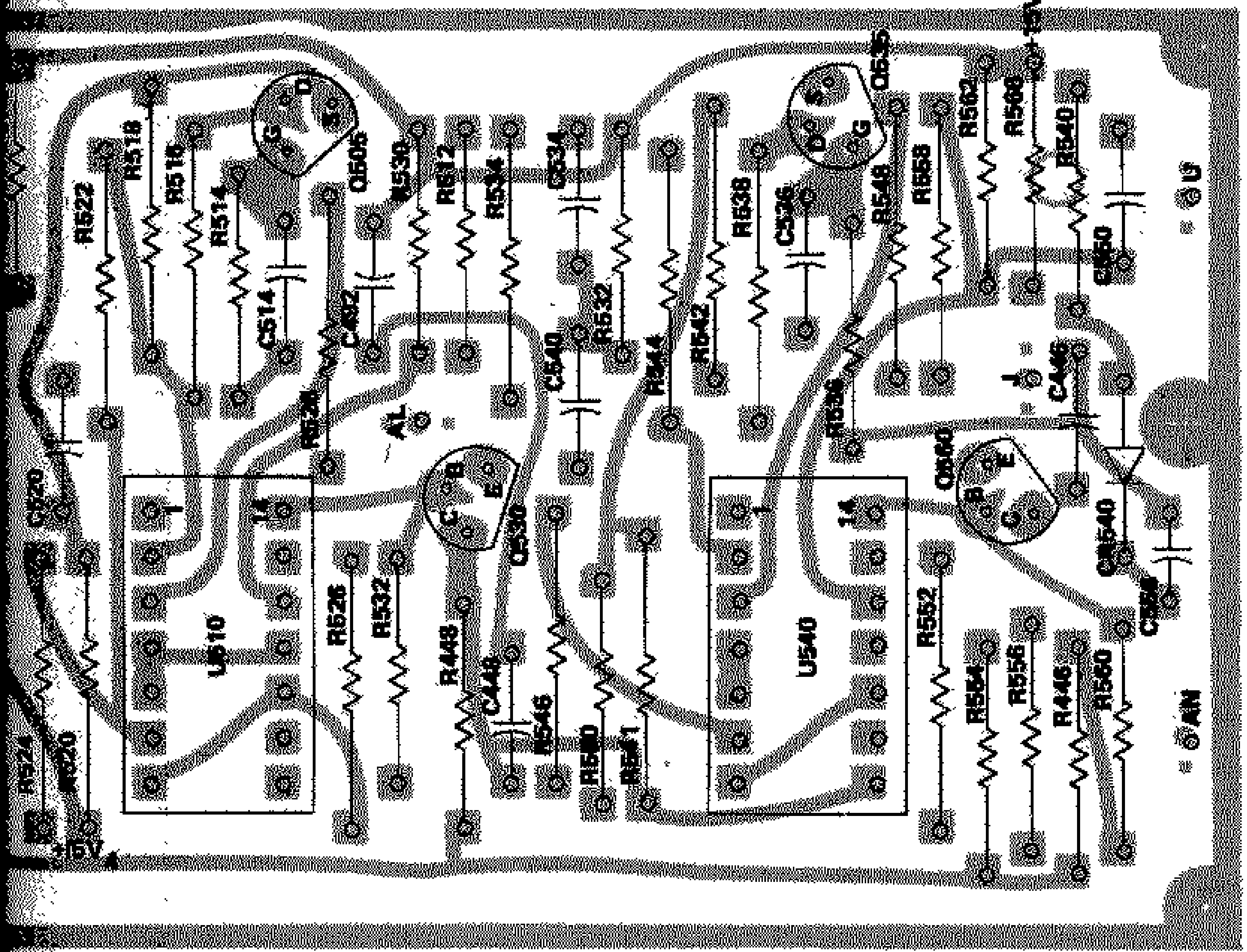
COMPONENT LOCATIONS
FOR DIAGRAM 4



A440 Display Function Amplifier

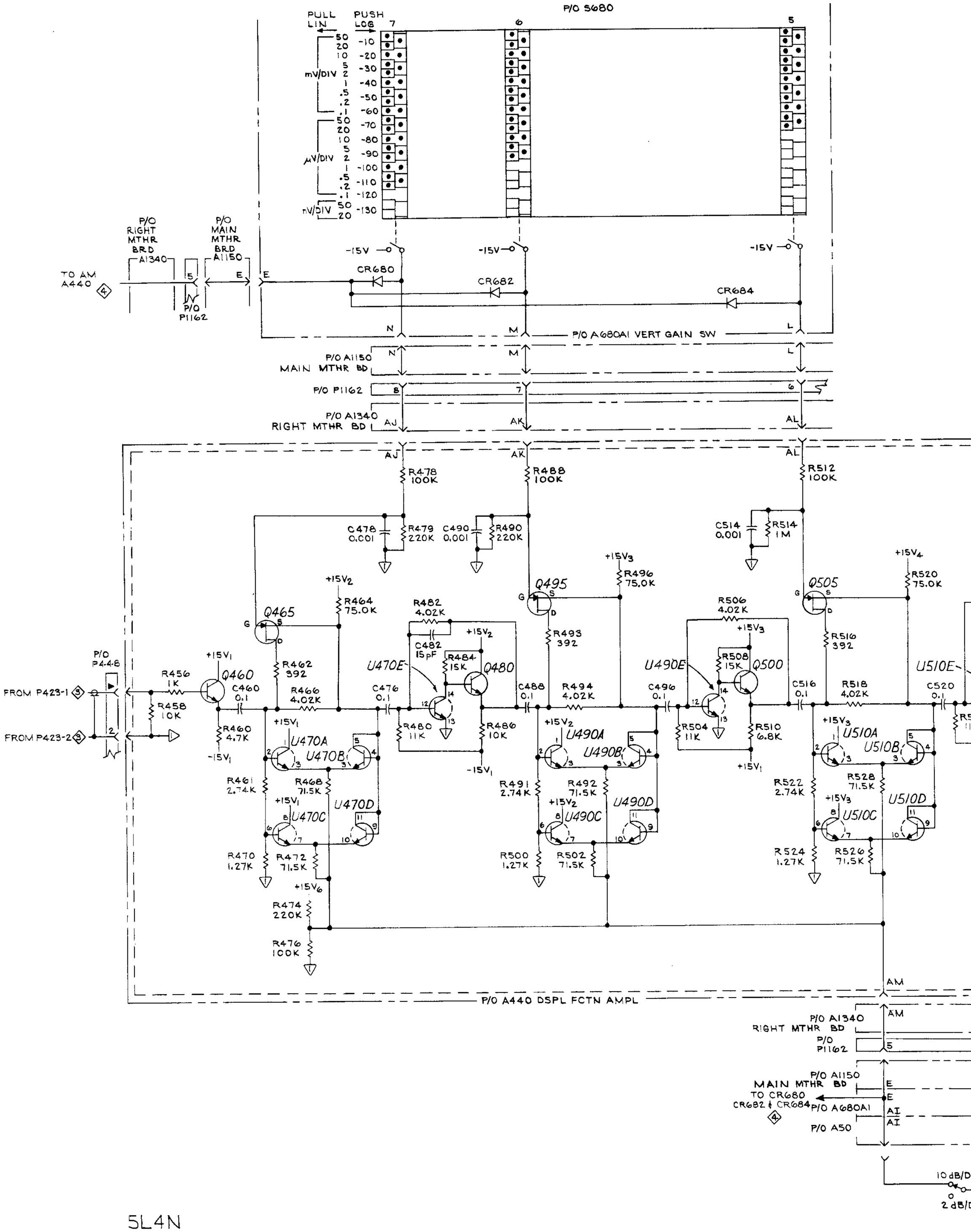


P/O A680A1 Vertical Sensing Selector

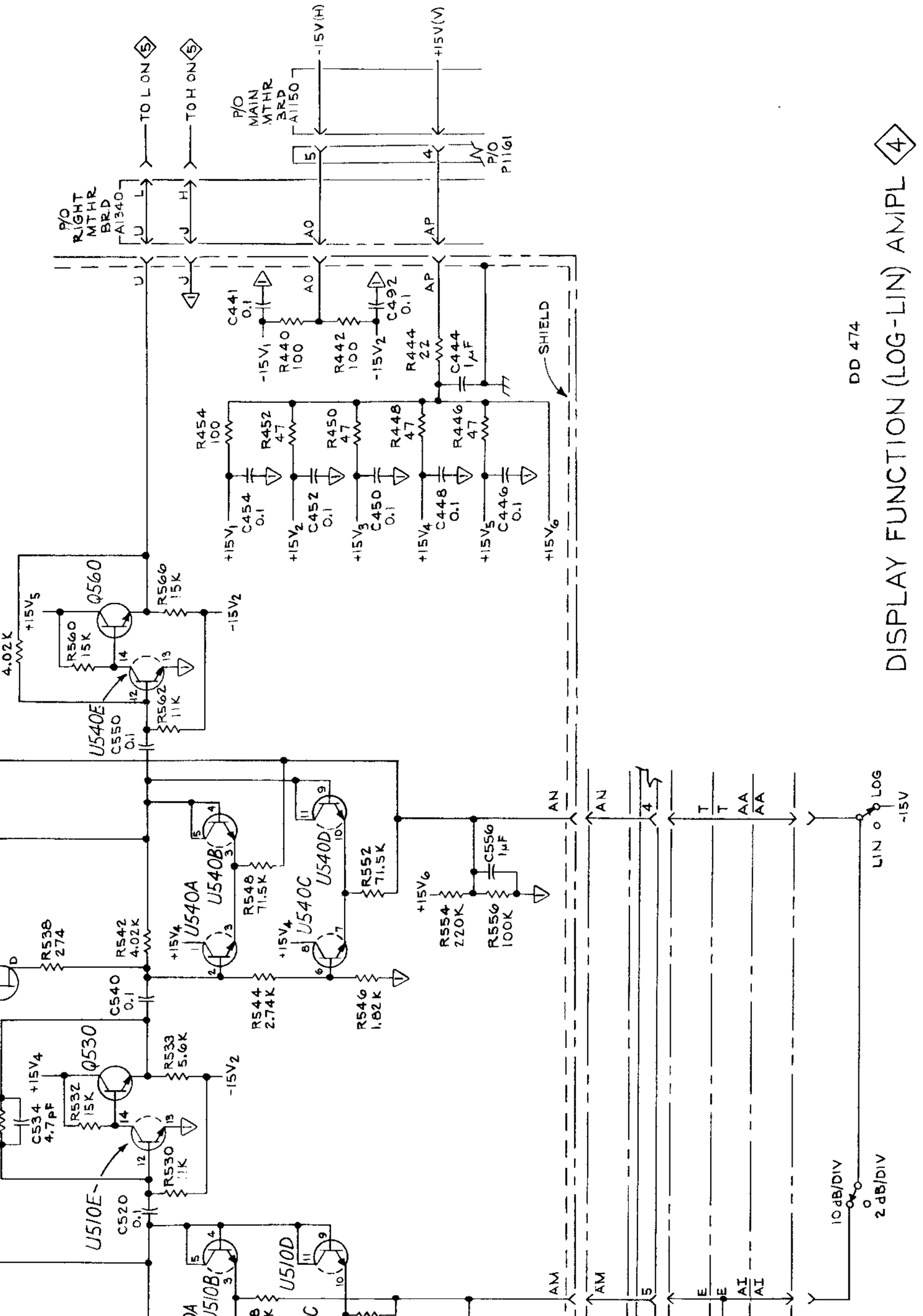


R522
R518
R516
R514
C514
Q505
G
D
S
R530
R512
R534
C534
C482
R528
R532
C540
R544
R542
R538
C536
R548
R558
R562
R566
R540
C550
Q535
+15V2
C446
R536
Q530
Q500
C520
U510
U540
R526
R448
C448
R546
R550
R552
R554
R556
R446
R560
C540
C555
+15V4
R524
R520
A IN
G U
1
14

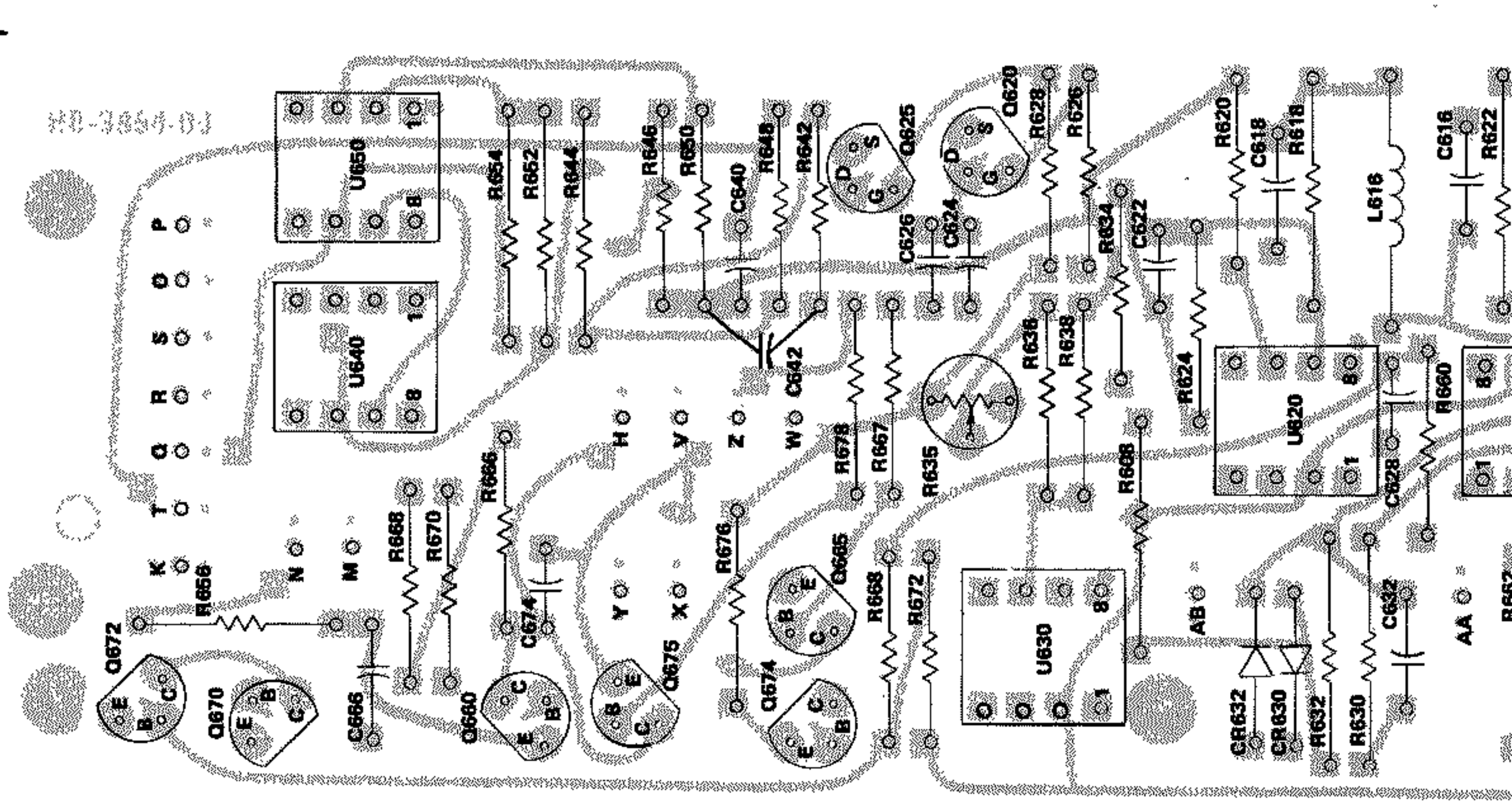
Amplifier


P/O S680
PULL LIN
PUSH LOG
7
6
5
mV/DIV
μV/DIV
nV/DIV
50
20
10
5
2
1
.5
.2
.1
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-15V
CR680
CR682
CR684
P/O A1340 RIGHT MTHR BD
P/O A1150 MAIN MTHR BD
P/O P1162
TO AM A440
P/O A680A1 VERT GAIN SW
R478 100K
R488 100K
R512 100K
C478 0.001
R479 220K
C490 0.001
R490 220K
C514 0.001
R514 1M
+15V2
+15V3
+15V4
R464 75.0K
R496 75.0K
R520 75.0K
Q465
Q495
Q505
R482 4.02K
C482 15pF
R484 15K
Q480
R493 392
R506 4.02K
R508 15K
Q500
R516 392
U470E
U490E
U510E
P/O P4-4-8
FROM P423-1
FROM P423-2
R456 1K
R458 10K
+15V1
Q460
C460 0.1
R462 392
R466 4.02K
C476 0.1
C488 0.1
R494 4.02K
C496 0.1
C516 0.1
R518 4.02K
C520 0.1
R460 4.7K
R480 11K
R486 10K
R504 11K
R510 6.8K
U470A
U470B
U490A
U490B
U510A
U510B
R461 2.74K
R468 71.5K
R491 2.74K
R492 71.5K
R522 2.74K
R528 71.5K
U470C
U470D
U490C
U490D
U510C
U510D
R470 1.27K
R472 71.5K
R500 1.27K
R502 71.5K
R524 1.27K
R526 71.5K
R474 220K
R476 100K
P/O A440 DSPL FCTN AMPL
TO CR680 CR682 & CR684
P/O A50
10 dB/D
2 dB/D

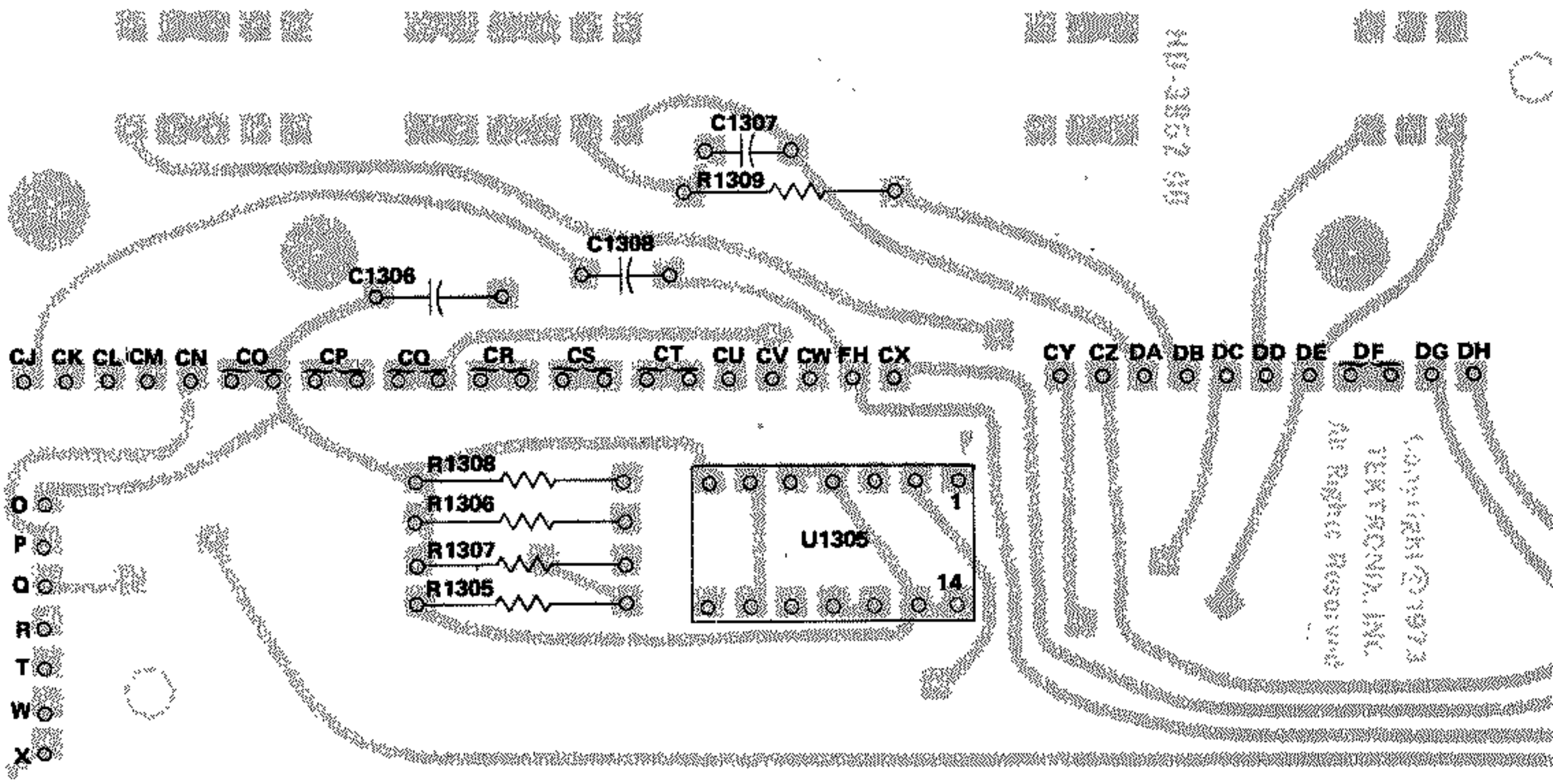
5L4N


DISPLAY FUNCTION (LOG-LIN) AMPL ④
DD 474
P/O RIGHT MTHR BRD A1340
P/O MAIN MTHR BRD A1150
P/O P1161
TO L ON ⑤
TO H ON ⑤
-15V(H)
+15V(V)
SHIELD
U540A
U540B
U540C
U540D
U540E
U510A
U510B
U510C
U510D
U510E
Q560
Q535
Q530
CR540
10 dB/DIV
2 dB/DIV
LIN
LOG
-15V

5L4N

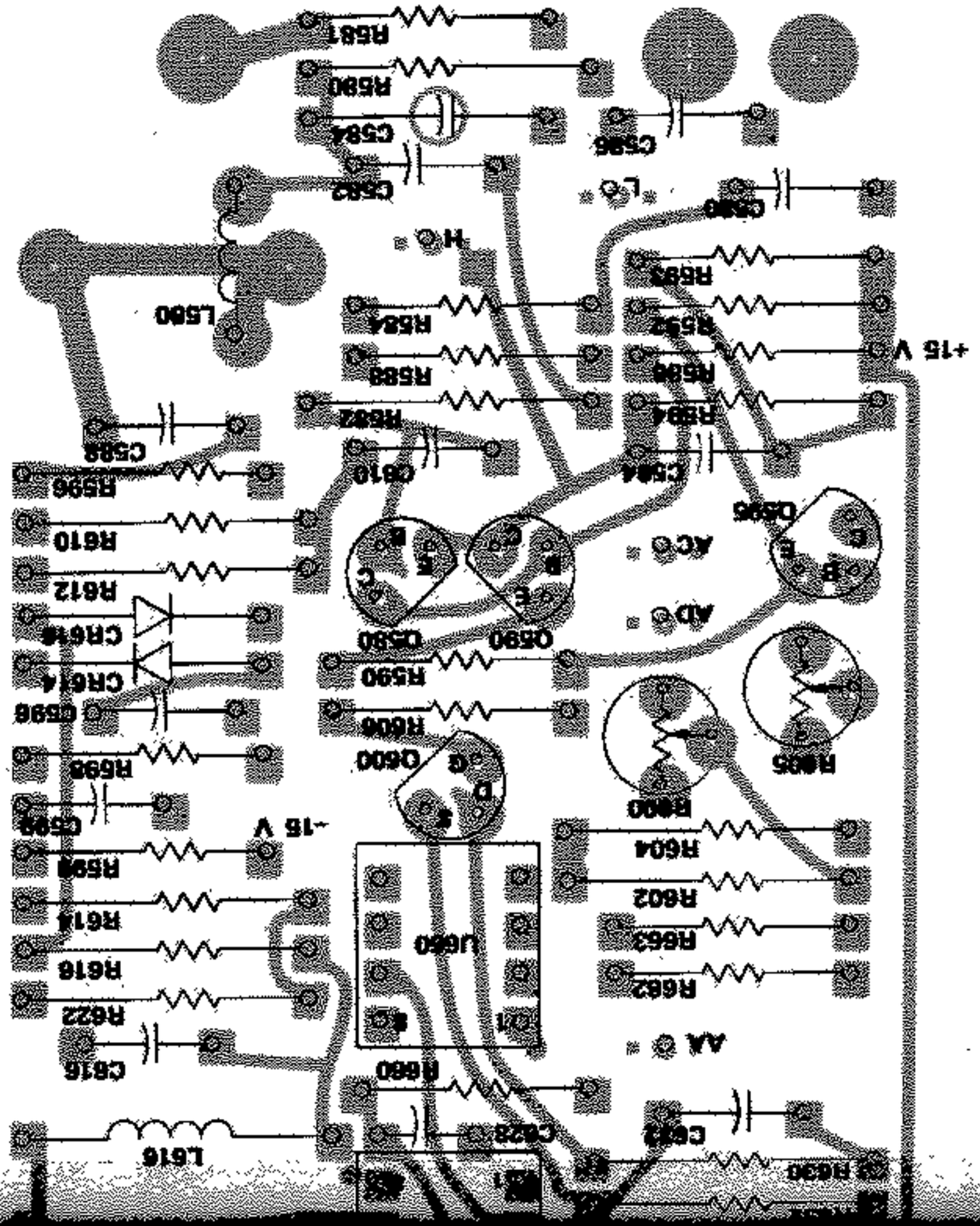


A680 Detector, Video Filter & Video Amplifier Circuit Board



A1300 Vertical Transverse Interface & Chop Logic Circuit Board

A1150 Main Mother Board component location shown on back of Diagram ⑨



P/O HI/LO IMP & LOG DSPL SEL A5O

+15V

LIN / LOG

10dB/DIV / 2dB/DIV

AD

AC

P/O AE

R600 200K AD 10dB REF CAL

R605 200K 2dB REF CAL

R602 249K

R604 249K

R622 750

R606 100K

P/O RIGHT MTHR BRD A1340

FROM PINS U & J ON ④

J H

L

H

C580 0.01

R580 4.64K

L580 120μH

C582 0.01

R582 464

C584 .0047μF

R581 100

+15V

R586 10K

C586 200

R584 62

Q580

R590 33

Q590

Q595

R592 1K

R593 10K

R594 4.7K

C594 0.01

R588 2.2K

R596 10K

R598 3K

C588 0.01

C596 0.1

R599 100

C599 0.1

-15V

C610 0.1

R610 402

R614 4.32K

CR614

CR616

R612 402

R616 4.02K

L616 10mH

C616 0.015

C618 0.01

R618 1K

U620

741C

R620 5.6K

R634 1.0K

C622 .005

R624 16.2K

Q620

C624 0.033

Q625

C626 1μF

R635 200K

R636 470K

R638 1K

P/O MAIN MTHR BRD A1150

+15V

-15V

X

W

VIDEO FILTER 10Hz

VIDEO FILTER 300Hz

S1216

S1218

P/O MAIN MTHR BRD A1150

P/O P1164

P/O RIGHT MTHR BRD A1340

2

O

P

10

Y

C627 0.001

R626 470K

C629 0.001

R628 470K

FROM R1228 (MARKER GEN) ⑧

P/O P1163

U1305C

U1305A

U1305B

R1308 270

R1306 270

R1307 270

R1305 1K

C1306 .1μF

TO PIN A

U1305

SN7410 156-0047

CU

Z

P/O MAIN MTHR BRD A1150

P/O RIGHT MTHR BRD A1340

P/O P1163

R667 4.7K

DH

DG

A

B

P/O P1310

P/O P1262

P/O A1250

P/O P1311

P/O P1260

P/O A690

P/O TRANSV INTFC & CHOP LOGIC A1300

A2 (H&V)

TO DH & DG ⑦

B21(H)

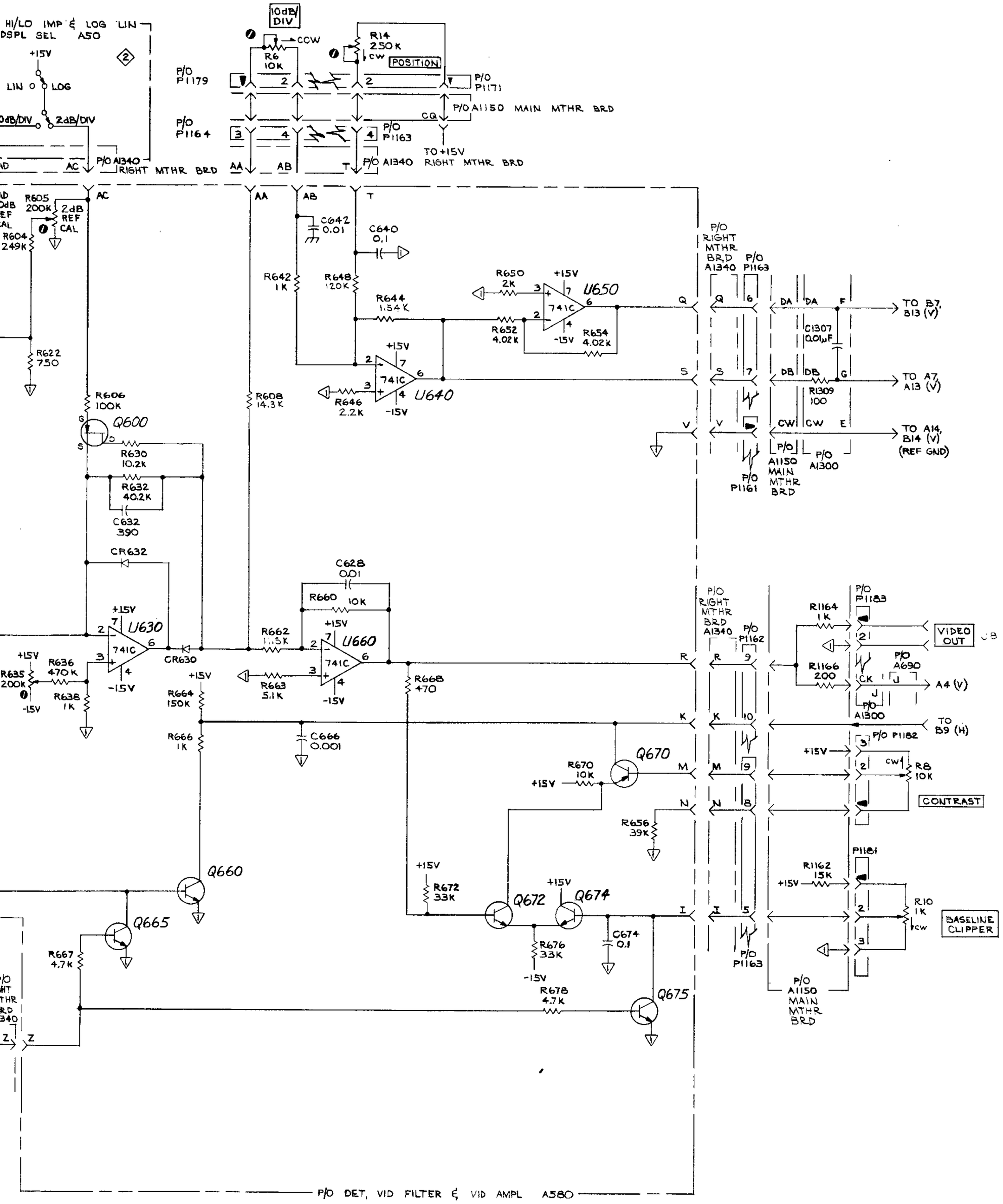
A18(H)

A20 (H)

B19 (V)

A19 (V)

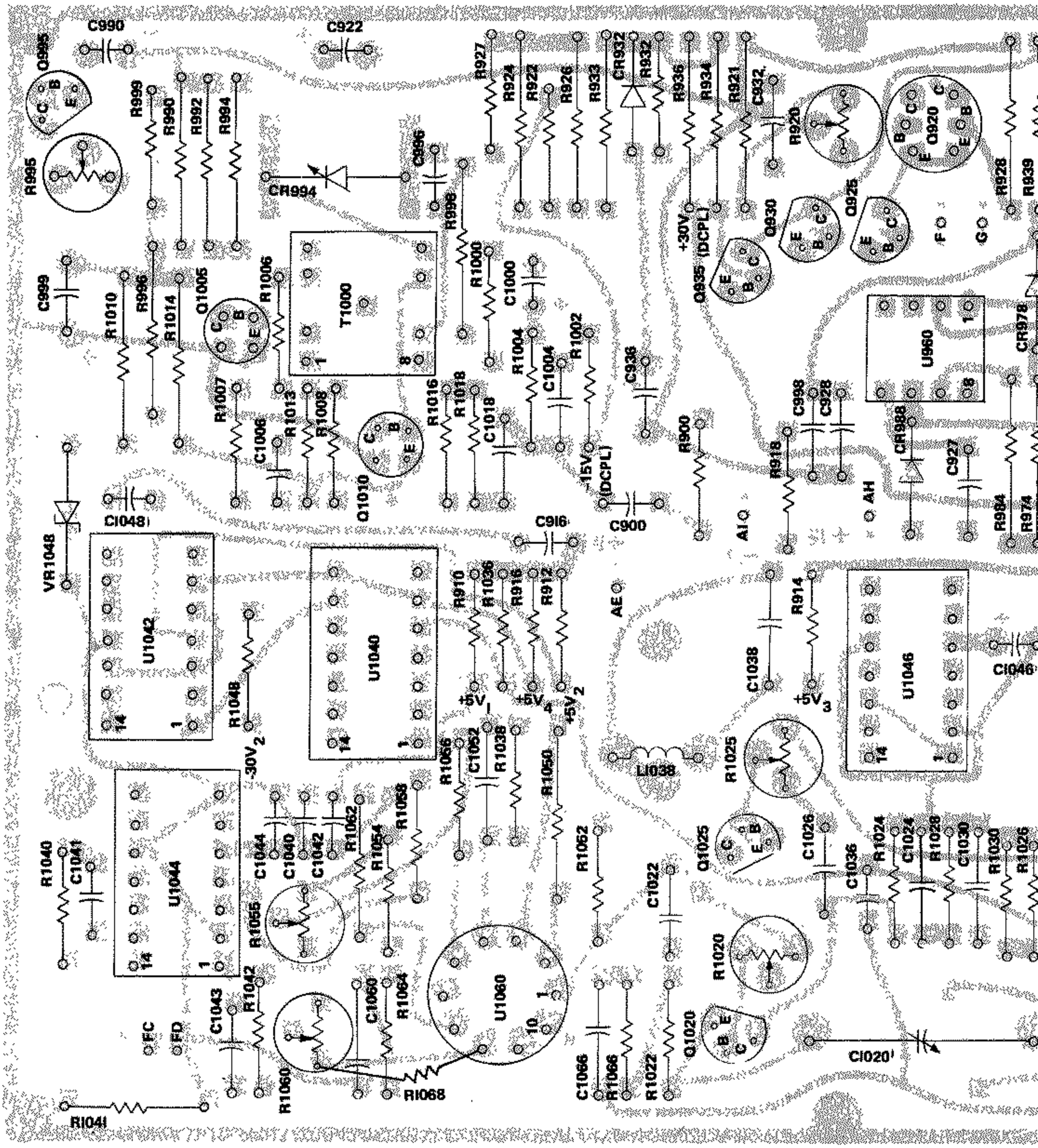
5L4N



DET, VID FILTER & VID AMPL ⑤

SS 574

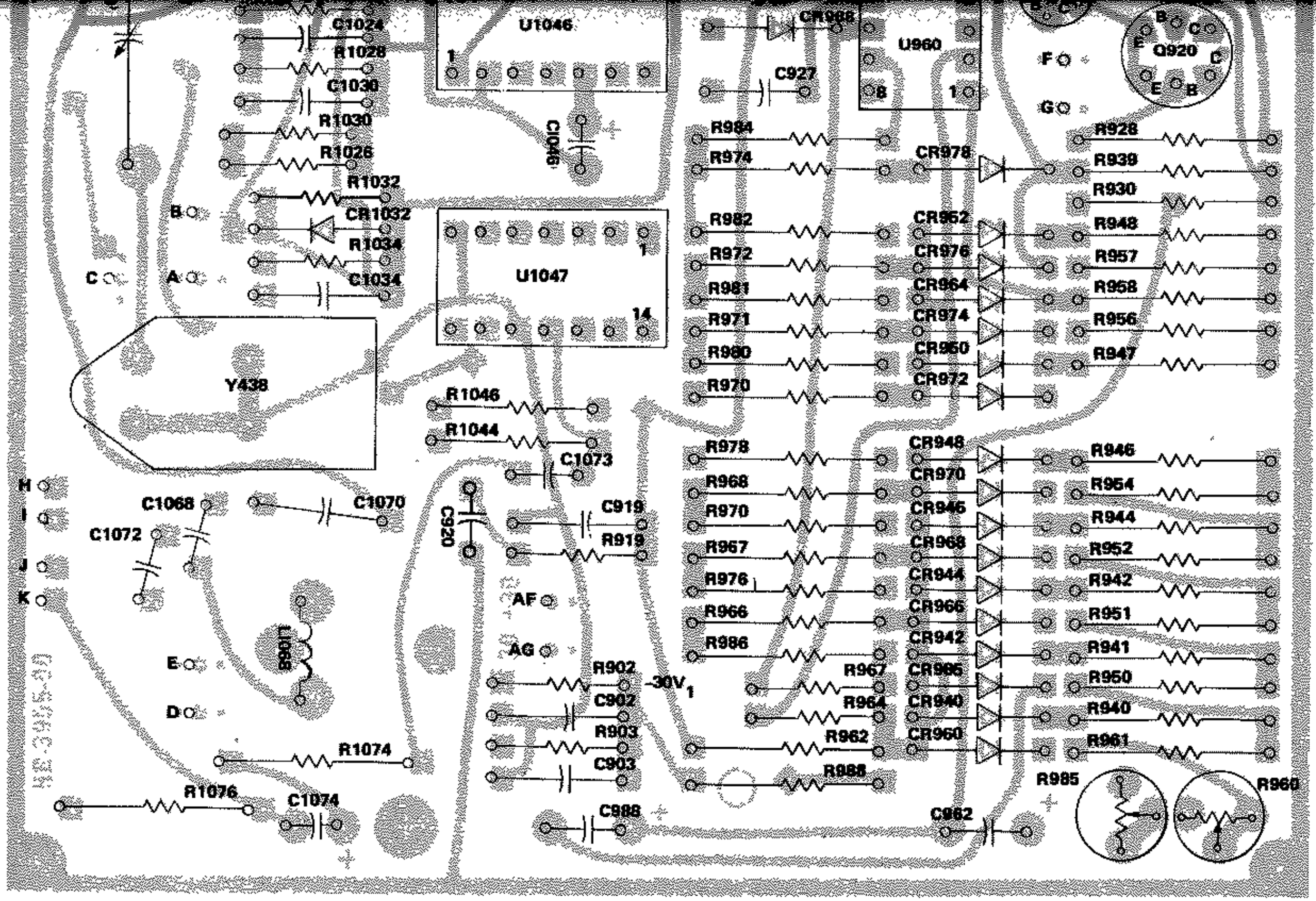
DET VID FLTR & VID AMPL ⑤



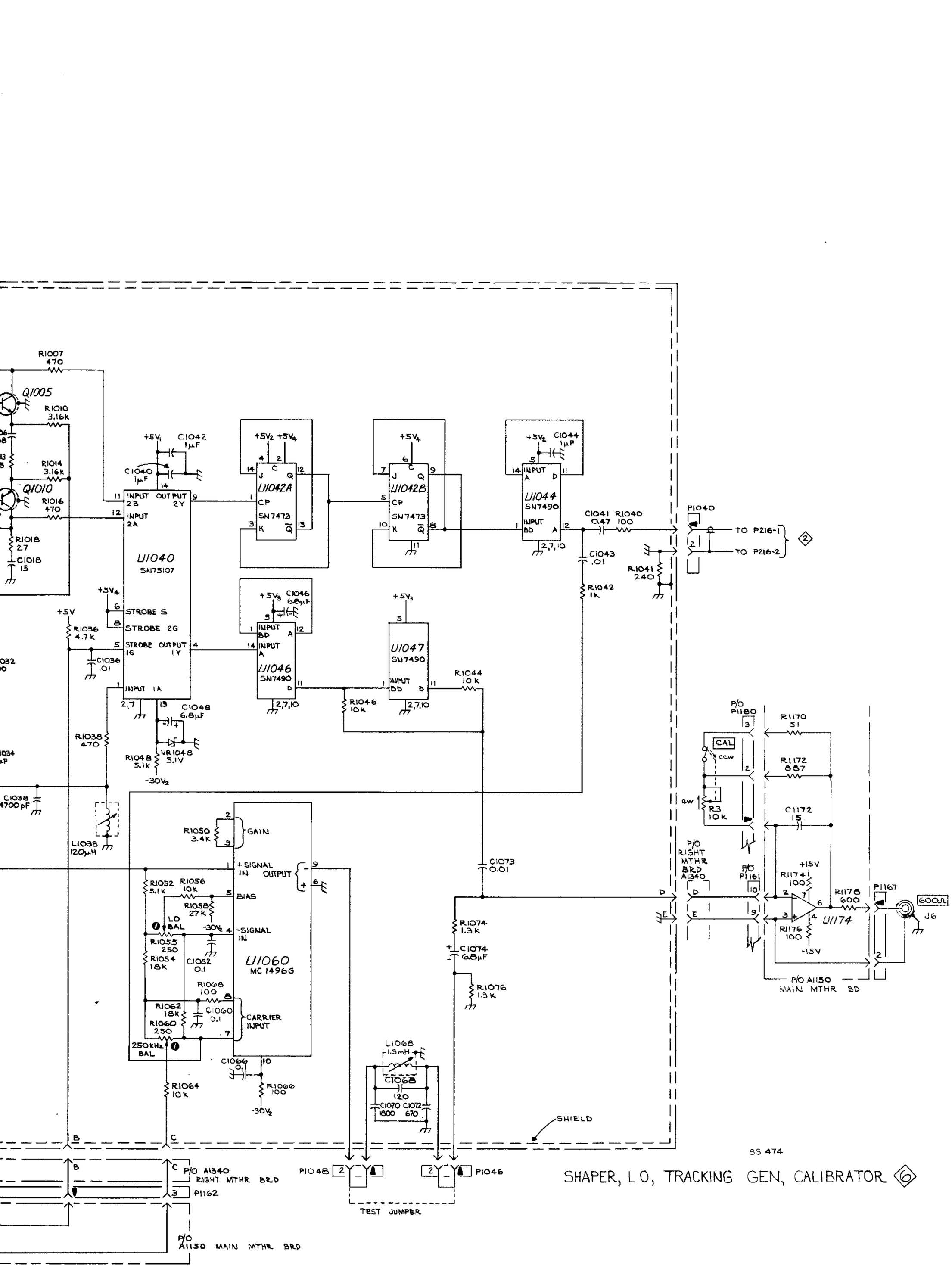
A900 Shaper, LO, Tracking Generator & Calibrator

A1150 Main Mother Board component location shown on back of D

Shown on back of Diagram ⑨



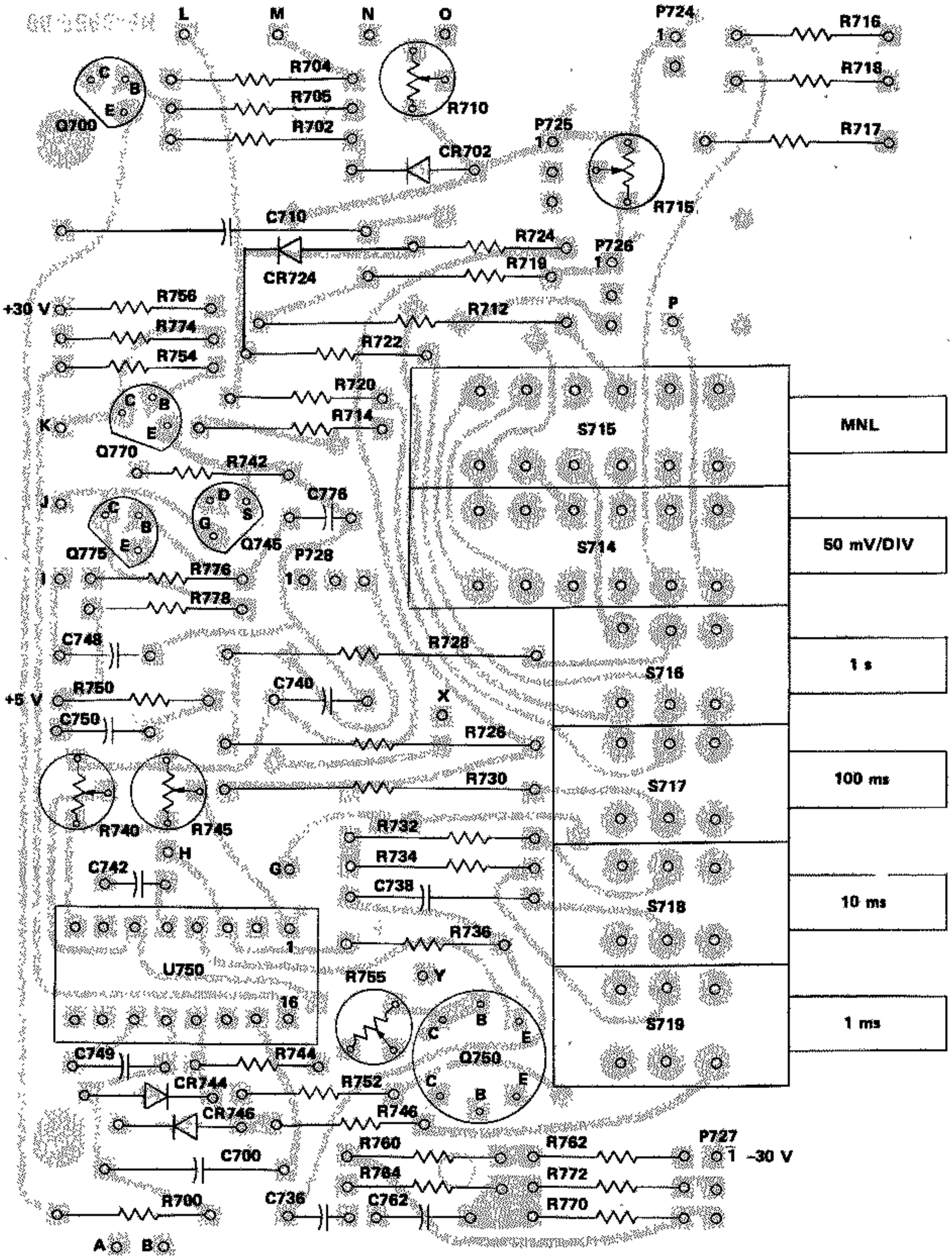
B2 (V)
+15V (V)
A5 (V)
B5 (V)
-15V (H)
P/O A1150 MAIN MTHR BD
P/O P1161
P/O A1340 RIGHT MTHR BD
AE
AH
AF
AG
AI
+5V
+5V1
+5V2
+5V3
+5V4
R910 2.7
R912 2.7
R914 2.7
R916 1K
C916 1μF
R918 100
AX
C920 1μF
+15V (DCPL)
R919 22
C919 0.1
+30V (DCPL)
R902 22
C902 0.1
-30V1
R903 22
-30V2
C903 1μF
R900 100
C900 1μF
-15V (DCPL)
T1000
R1006 100
R1007 470
Q1005
R1010 3.16k
R1000 47
C1000 22μF
R1002 1.5k
C1006 .068
R1013 15
R1014 3.16k
Q1010
R1016 470
R1008 100
R1018 2.7
C1018 15
C1004 .01
R1004 10
C1040 1μF
+30V (DCPL)
R936 200
C936 22μF
R938 200
CR932
R932 120
R934 806
C932 .001
Q935
R939 3.32k
R930 3.4k
R928 9.31k
R990 5.62k
50 kHz C.F.
R995 10k
R996 18.2k
C990 22μF
Q995
CR994 241pF
R994 499
R992 10.0k
C996 0.01
R998 499
C998 .01
R999 100
C999 22μF
+30V (DCPL)
R1026 100
P/O MAIN MTHR BRD A1150
P/O RIGHT MTHR BRD A1340
TO P1176-2
TO P1176-1
P/O P1161
50 kHz SPAN
R920 1K
R921 2K
Q920
Q930
Q925
R926 3.83k
R922 1.5k
C922 22μF
R924 7.5k
-15V (DCPL)
R927 100
-30V1
R1024 8.2k
C1024 0.1
R1028 47K
R1030 47K
C1030 0.1
CR1032
R1032 100
+5V3
Q1025
R1034 2.2k
OSC LEVEL
C1026 .01
R1025 2K
C1034 1μF
FREQ TRACKING
Q1020
250 kHz
Y438
C1020 90-400 pF
R1022 10K
R1020 2K
TRACK GEN LEVEL
C1022 .005
-30V2
C1038 4700pF
+5V
R1036 4.7K
C1036 .01
+5V4
INPUT 2B
INPUT 2A
INPUT 1A
STROBE
R1038 470
L1038 120μH
R1048 5.1K
CR940 CR942 CR944 CR946 CR948 CR950 CR952
R940 665
R941 11.3k
R942 13.7k
R944 15.8k
R946 18.2k
R947 20.5k
R948 22.6k
R950 487
R951 316
R952 357
R954 383
R956 402
R957 412
R961 6.81k
R958 210
+30V (DCPL)
100 kHz SPAN
R962 1K
CR960
R964 620k
R960 10k
C962 22μF
U960A
CR964
CR966 CR968 CR970 CR972 CR974 CR976 CR978
R966 5.11k
R967 8.06k
R968 11.5k
R970 15.4k
R971 19.6k
R972 24.3k
R974 28.7k
R976 86.6
R977 232
R978 332
R980 412
R981 487
R982 562
R986 10k
R984 301
0 Hz SPAN
CR985
R985 10k
R988 1k
C988 22μF
R989 620k
CR988
U960B
+15V (DCPL)
C927 0.01
N5558V
U960
C928 0.01
-15V (DCPL)
P/O A900 (SHAPER, LO, TRK GEN & CAL)
TRKG GEN
5kHz FREQ CONV
S1214
S1215
5L4N



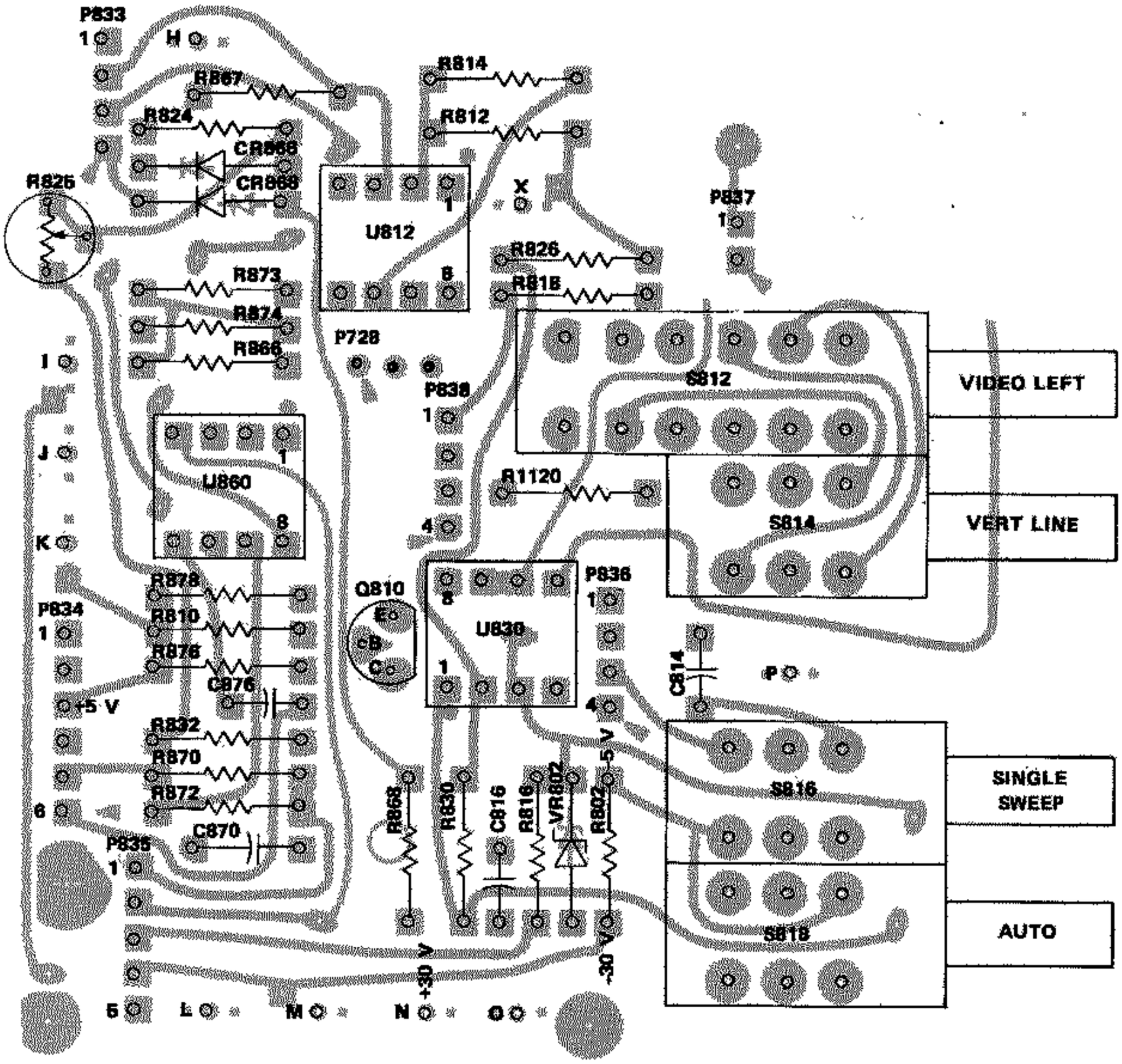
SS 474

SHAPER, L O, TRACKING GEN, CALIBRATOR ⑥

SHAPER, LO TRKG GEN, CALIBRATOR ⑥



A700 Sweep Generator & Amplifier Circuit Board



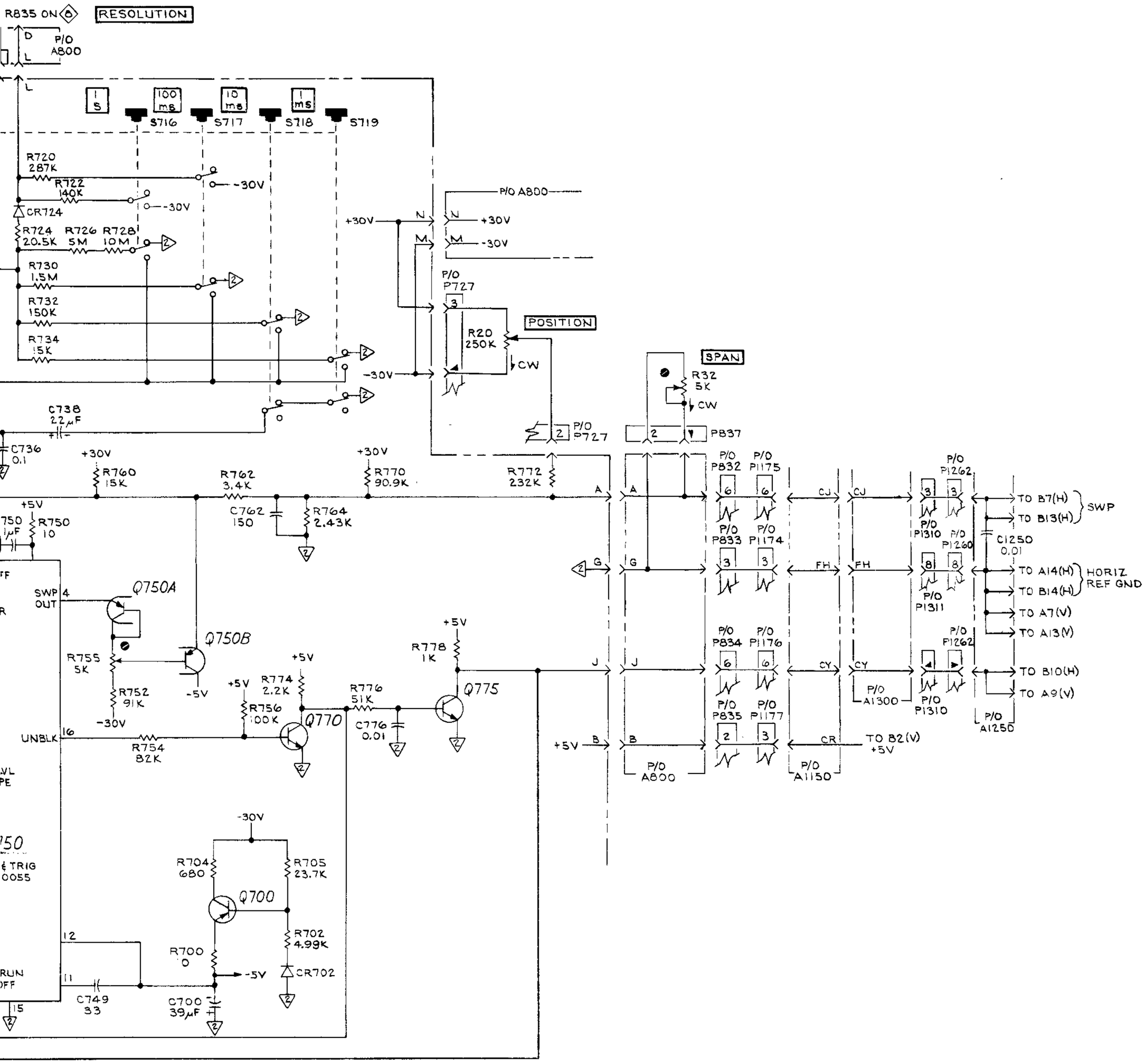
HC-3947-00

P/O A800 Frequency Span Selector, Trigger Mode & Source Selector Circuit Board

A1150 Main Mother Board component location shown on back of Diagram ⑨

MULTR
R22 100K CW
R24 2K CW
P725 3 2
P726 3 2
R835 ON 6
D P/O A800 L
RESOLUT
L
I S
50mV/DIV
MNL
IN FOR EXT SWP
S714
S715
+30V
R712 1.18M
R717 41.2K
R718 470K
R710 1M
-30V
C710 1μF
R714 174K
+30V
R719 20K
X10 SWP CAL
R715 250
R720 287K
R722 140K
CR724
R724 20.5K
R726 5M
R728 10M
R730 1.5M
R732 150K
R734 15K
EXT IN/OUT
J7
P724
R716 1K
P/O A800 FREQ SPAN BRD
VIDEO LEFT
LINE VERT
BOTH OUT EXT
BOTH IN LEFT VERT
S812
S814
U812 741C
+15V
-15V
R812 10K
R814 24.9K
TO X ON 8
TO H ON 8
R736 4.7K
C738 2.2μF
C736 0.1
+30V
R760 15K
+5V
C750 1μF
R750 10
C742 0.01
R742 47
P728
LEVEL/SLOPE
R26 10K CW
C740 0.022
R740 10K
SWP LG
R745 10K
XI SWP CAL
R755 5K
R752 91K
-30V
R754 82K
UNBLK
TRIG LVL & SLOPE
2φ
U750
SWP & TRIG 155-0055
HOLDOFF
TMG
MILLER INPUT
SWP OUT
Q750
TRIGGER MODE
SGL SWP
AUTO TRIG
S816
S818
C814 0.1
R818 4.7M
P/O P1178
P/O P838
RIGHT OR VIDEO TRIG A4(H)
LINE TRIG B3(H)
LEFT VERT B4(H)
CL
CN
CM
P/O A1150
+5V
R816 100K
C816 0.01
-5V
R810 51K
Q810
VR802 5.1V
R802 62K
C810 390
R813 270K
+5V
CR746
R744 10K
Q745
CR744
R746 1M
C748 1μF
TRIG IN
FREE RUN HOLDOFF
C749 33
P/O A700 SWEEP BRD
SWP
S21
P/O P836
P/O P838
P/O P834
P/O P1176
P/O P1178
CX
TO B15(H)
R1180 1M DF
DF M
TO +200V A1(V)
P/O A1300
R1150 120K
P/O A680
CHOP
OUT ALT
S1151
R1152 47K
DISPLAY ON
S1122
P/O P1170
DG
DH
DD
CS
DC
DE
TO A18(H)
TO A20(H)
TO B18(V)
TO B5(V)
TO A19(V)
TO B19(V)
P/O A1100
P/O P1100
P/O A1150 MAIN MTHR BRD

5L4N

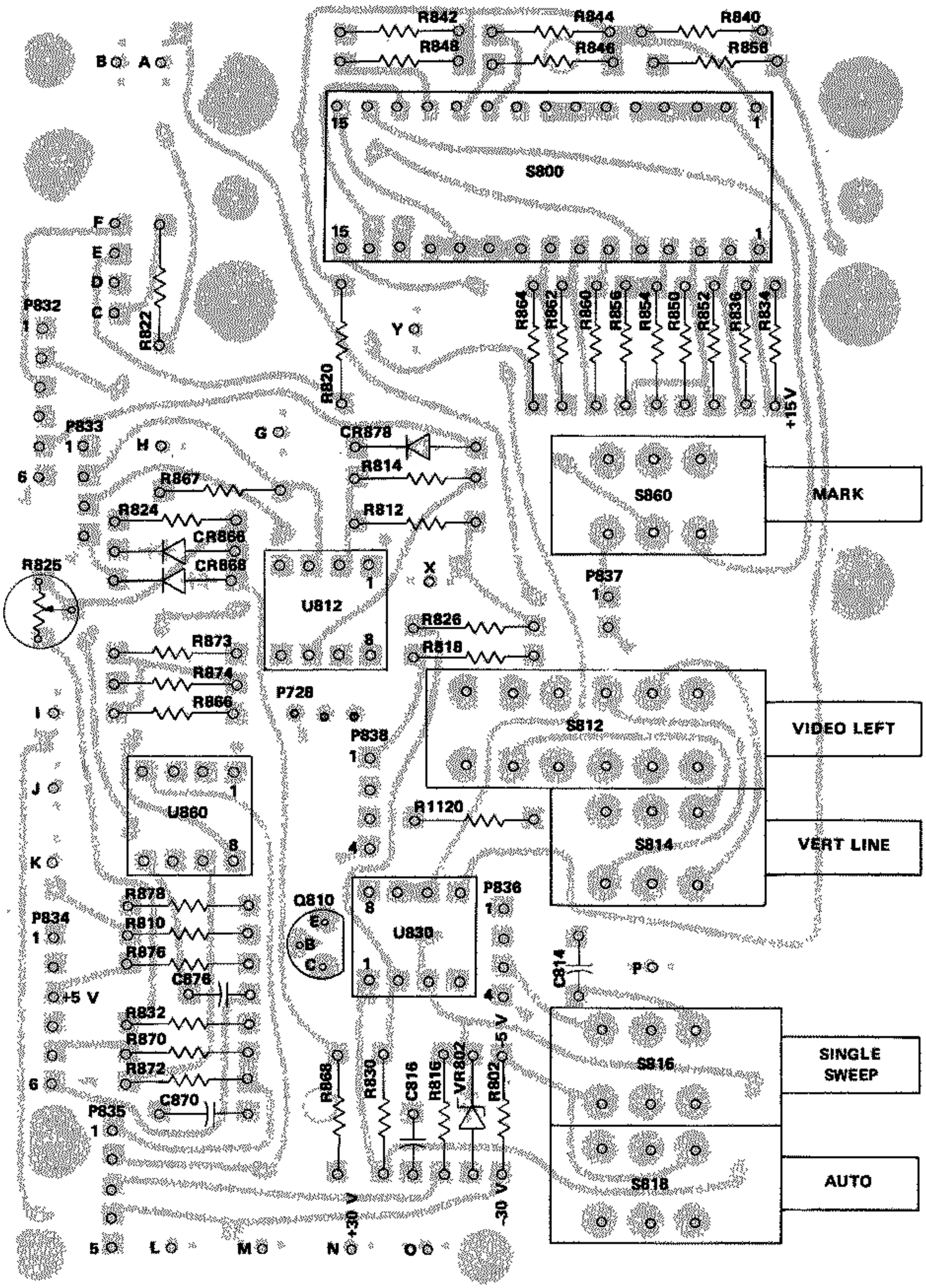


SWEEP BRD

DD 374

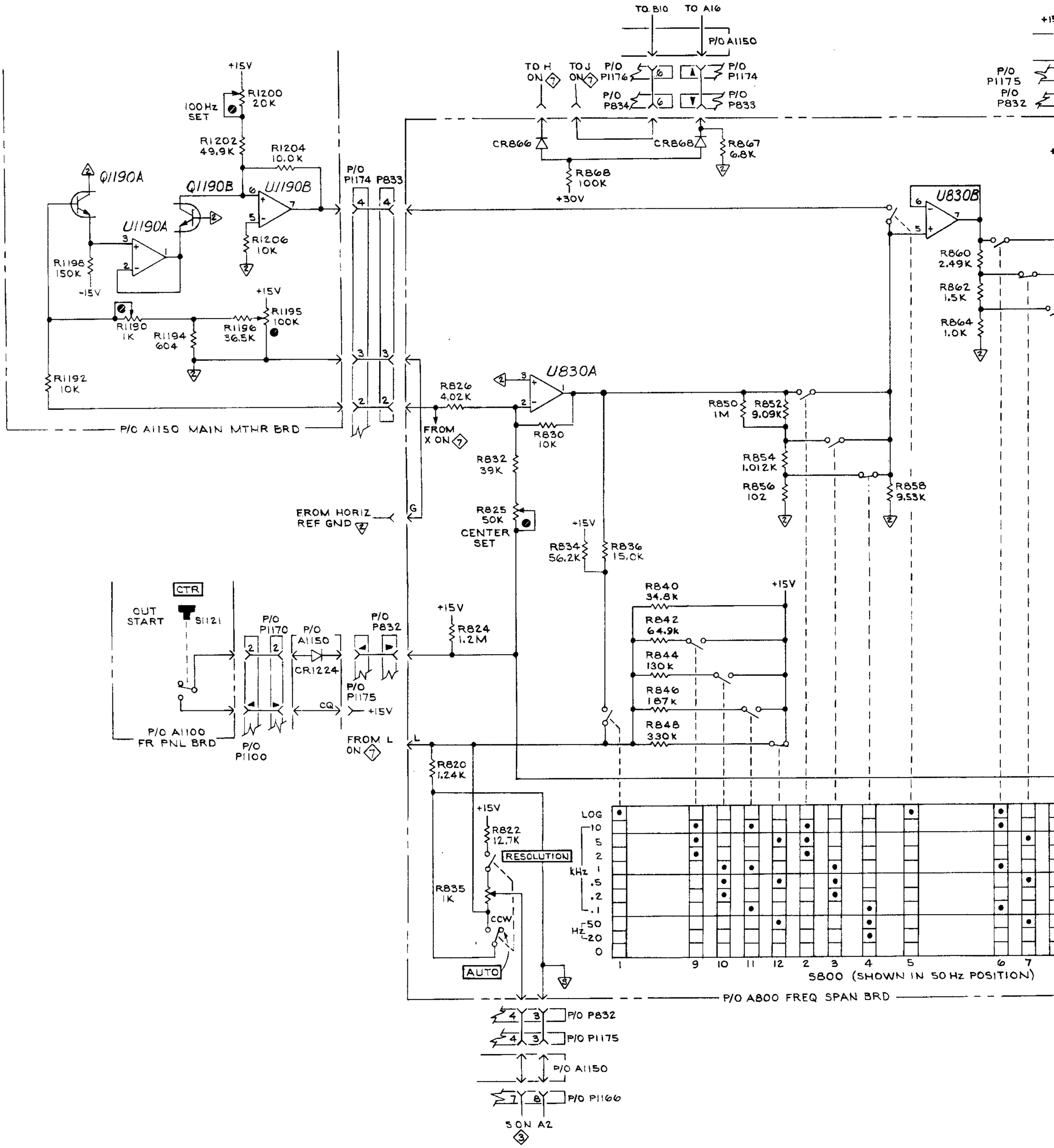
SWEEP GEN & AMPL ◇7

COMPONENT LOCATIONS FOR DIAGRAM 8



A800 Frequency Span Selector, Trigger Mode & Source Selector Circuit Board

A1150 Main Mother Board component location shown on back of Diagram 9


TO B10
TO A16
P/O A1150
TO H ON 7
TO J ON 7
P/O P1176
P/O P1174
P/O P834
P/O P833
P/O P1175
P/O P832
CR866
CR868
R867 6.8K
R868 100K
+30V
+15V
R1200 20K
100Hz SET
R1202 49.9K
R1204 10.0K
Q1190A
Q1190B
U1190B
U1190A
R1206 10K
R1198 150K
-15V
R1190 1K
R1194 604
R1196 36.5K
R1195 100K
R1192 10K
P/O P1174 P833
P/O A1150 MAIN MTHR BRD
U830B
R860 2.49K
R862 1.5K
R864 1.0K
U830A
R826 4.02K
FROM X ON 7
R830 10K
R832 39K
R825 50K CENTER SET
FROM HORIZ REF GND 2
R834 56.2K
R836 15.0K
R850 1M
R852 9.09K
R854 1.012K
R856 102
R858 9.53K
R840 34.8K
R842 64.9K
R844 130K
R846 187K
R848 330K
CTR
OUT START
S1121
P/O P1170
P/O A1150
P/O P832
CR1224
CQ
P/O P1175
P/O A1100 FR PNL BRD
P/O P1100
FROM L ON 7
R824 1.2M
R820 1.24K
R822 12.7K
RESOLUTION
R835 1K
CCW
AUTO
LOG
10
5
2
kHz 1
.5
.2
.1
50
Hz 20
0
1 9 10 11 12 2 3 4 5 6 7
S800 (SHOWN IN 50 Hz POSITION)
P/O A800 FREQ SPAN BRD
P/O P832
P/O P1175
P/O A1150
P/O P1166
5 ON A2

5L4N

+15V(V) +15V(H) +5V(V) -30V(V) +30V(V)

P/O A1150

TO ⑦

P/O P1175 P/O P832 P/O P1177 P/O P835 P/O A700

+15V -15V +5V -30V +30V

U830B

R860 2.49K R862 1.5K R864 1.0K

U860A

R866 10K R870 10K R874 2M R873 10K FREQ MKR S860 R872 10K

+15V

U860B R876 10K C876 1μF R878 11K CR878

P/O P834 P/O P835 P/O P832 P/O P834 P/O P1176 P/O P1177 P/O P1175 P/O P1176

MARKER GEN

+15V R1216 1.5M CR1216 CR1218 R1218 1K +15V R1226 470K U1225 CR1220 CR1222 R1220 6.8M R1222 1.5M R1224 1K -15V R1225 10K CR1226 R1228 1K R1230 22K R1205 2K CAL R1208 4.87K R1210 4.53K C1210 68μF R1215 2K 100kHz CAL R1212 4.53K C1212 68μF R1214 4.87K -15V

P/O P1161 TO G ON ⑥ TO F ON ⑥

P/O P1163 P/O A1340 TO Q660 ⑤

P1172 FINE R28 250K CW

P1173 FREQUENCY TUNING R30 10K CW

P/O A1150 MAIN MTHR BRD

50 Hz POSITION)

6 7 8 14 13 15

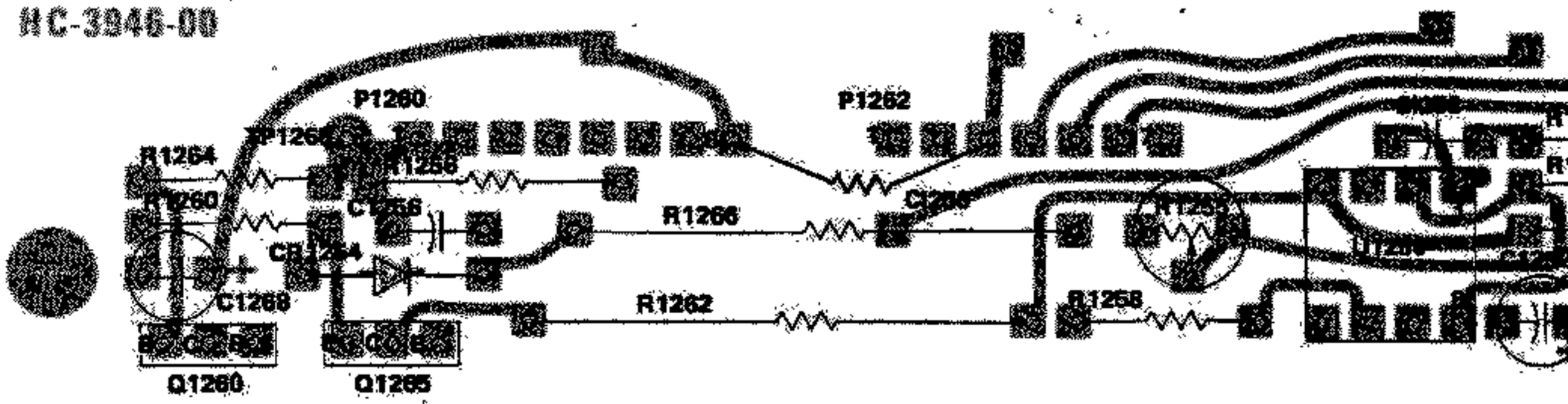
U830 & U860

+15V 8 N5558 4 -15V

DD 474

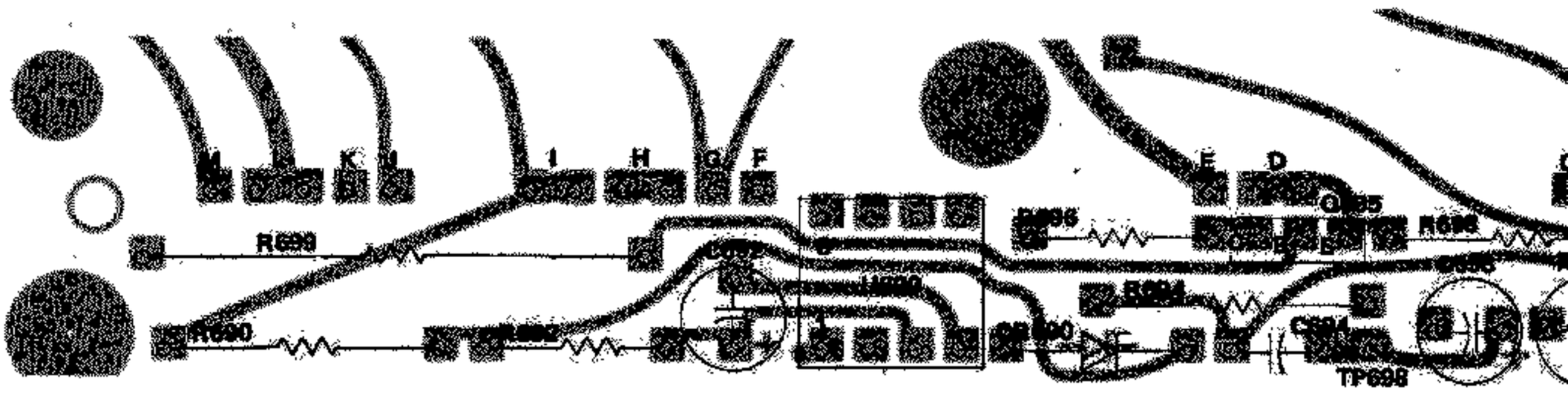
FREQ SPAN, MARKER GEN & FREQ TUNING ⑧

5L4N

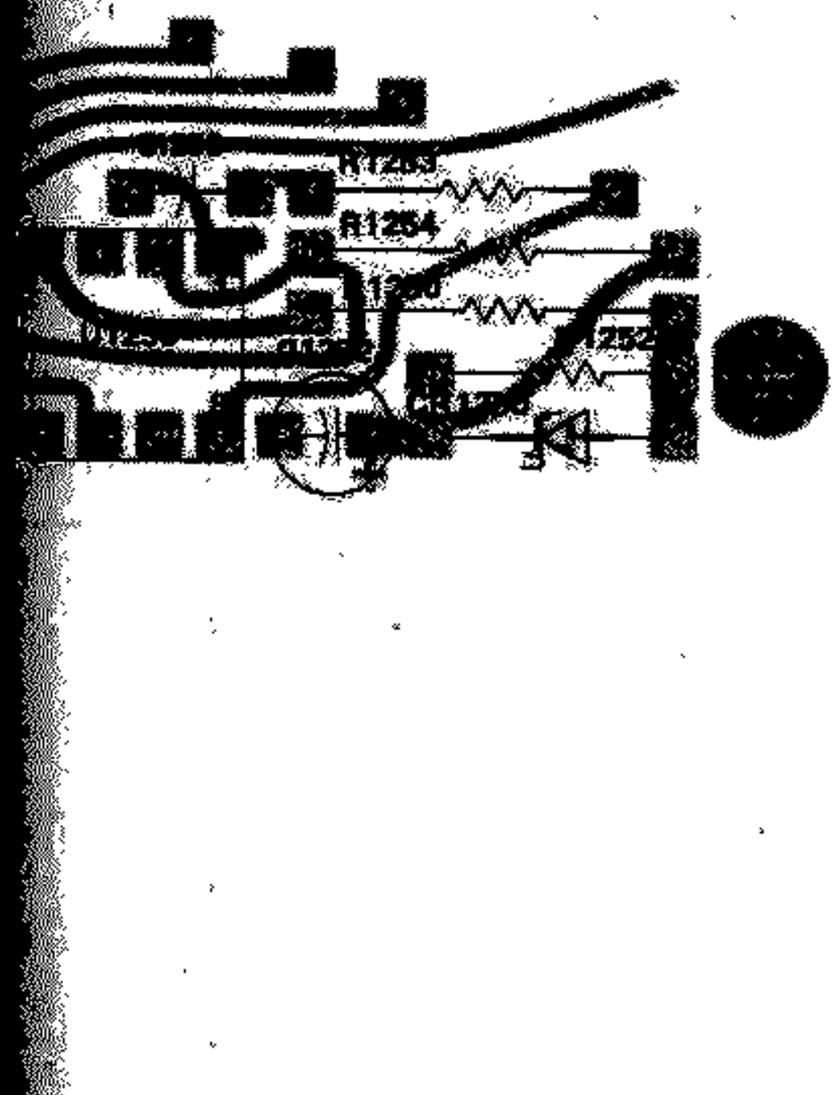


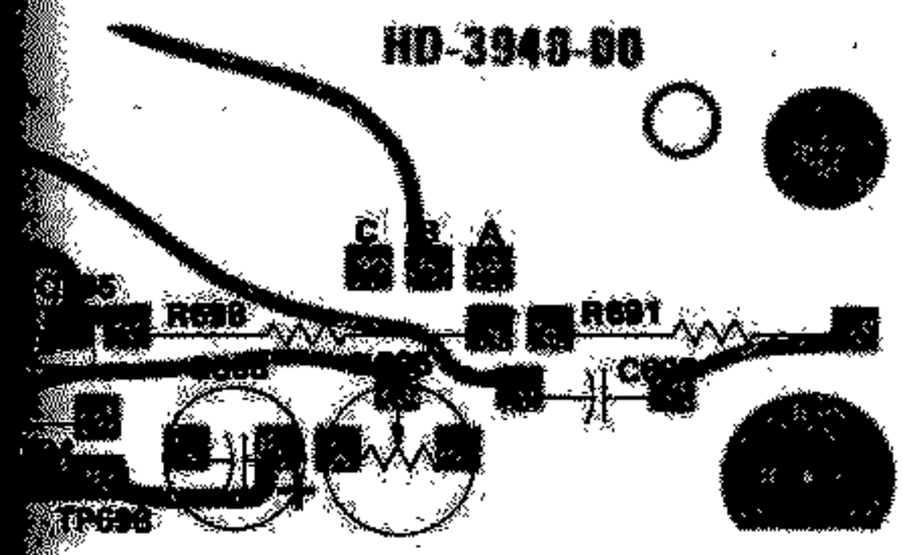
A690 Vertical Interface & +15 V Supply

COMPONENT LOCATIONS
FOR DIAGRAM 9

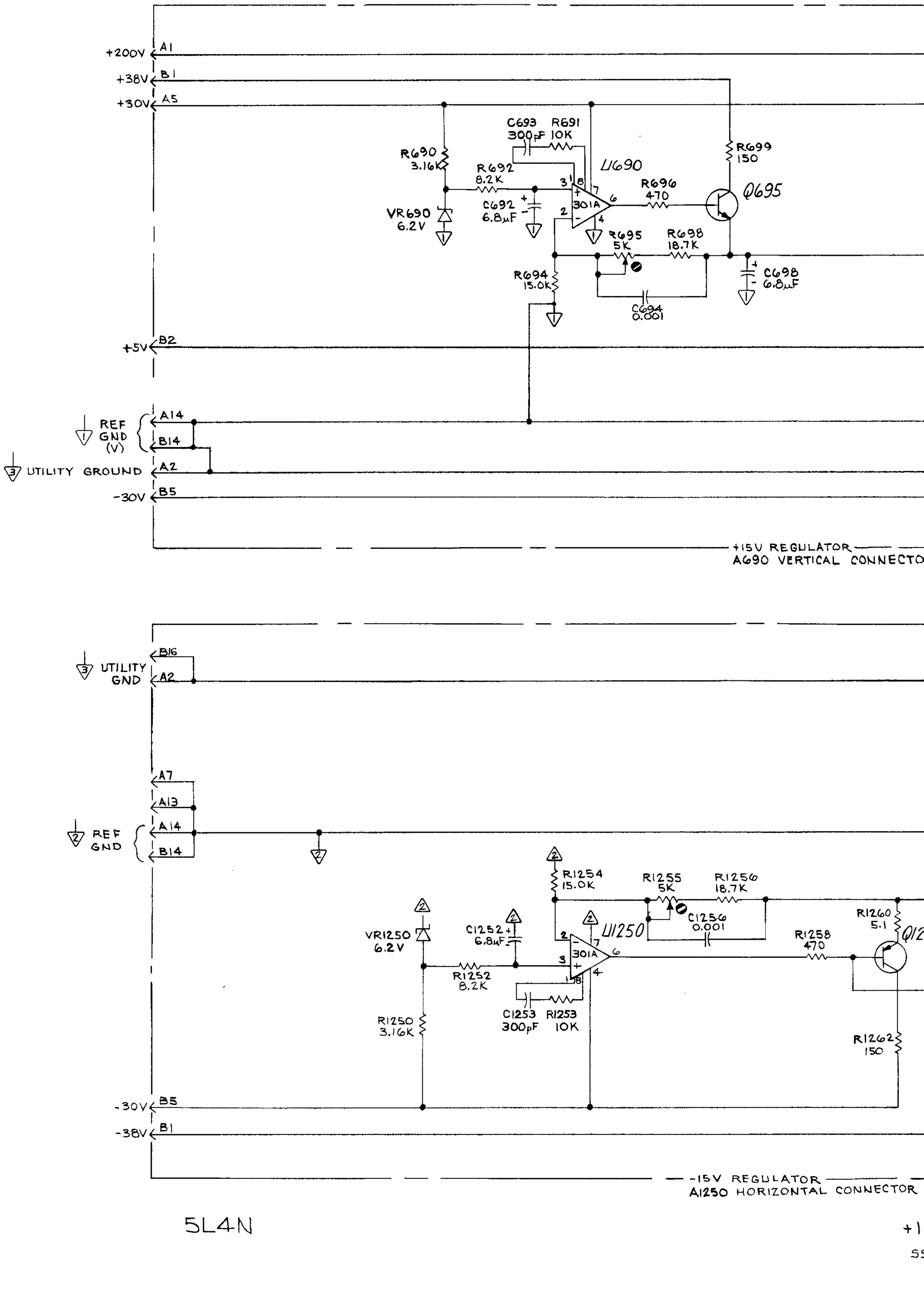


A1250 Detector Video Filter & Video Amplifier Circuit Board





uit Board


+200V A1
+38V B1
+30V A5
C693 300pF
R691 10K
R690 3.16K
R692 8.2K
U690
301A
R699 150
Q695
R696 470
VR690 6.2V
C692 6.8µF
R695 5K
R698 18.7K
R694 15.0K
C698 6.8µF
C694 0.001
+5V B2
REF GND (V)
A14
B14
UTILITY GROUND
A2
-30V B5
+15V REGULATOR
A690 VERTICAL CONNECTO
B16
UTILITY GND
A2
A7
A13
A14
B14
REF GND
R1254 15.0K
R1255 5K
R1256 18.7K
C1256 0.001
U1250
VR1250 6.2V
C1252 6.8µF
R1252 8.2K
C1253 300pF
R1253 10K
R1250 3.16K
R1258 470
R1260 5.1
R1262 150
-30V B5
-38V B1
-15V REGULATOR
A1250 HORIZONTAL CONNECTOR

5L4N

P/O A1300 — MAIN MTHR BRD P/O A1150

M — M DF — DF → TO DF (7)

I — I CT — CT → TO P1161-2 (6); TO P1165-1 (3); TO P1177-1 (8)

TO AQ (2); TO P1161-4 (6); TO P1175-5 (8); TO P1171-1 (5); TO P1170-1 (8); TO P1165-4 (3); TO P1182-3 (5)

+15V — D — D CQ — CQ

TP698

K — K CR — CR → TO P1177-3 (8); TO P1161-6 (6); TO P1165-3 (3)

TO AV; TO P1184-1 (2)

E — E CW — CW → TO P1181-3; TO P1183-2 (5); TO P1161-1

TO P1175-3 (8); TO P1166-8 (3)

L — L CO — CO

H — H CS — CS → TO P1170-6 (7); TO P1165-2 (1); TO P1177-2 (8); TO P1161-3 (6)

GULATOR
ERTICAL CONNECTOR

P/O P1262 — 7 — 7 — P/O P1310

P/O A1300 — CO — CO → TO P1166-8 (3); TO P1175-3 (8)

O

P/O P1260 — 8 — 8 — P/O P1311

AA — FH — FH → TO P1161-7 (6); TO P1176-1; TO P1174-3 (8); TO P1177-4

TO P1161-5 (6); TO P1165-5 (3); TO P1182-5; TO P1184-3 (2); TO AN

AH — CP — CP

-15V — TP1268

C1268 6.8μF (2)

R1260 5.1 — Q1260

R1258 470

R1264 3.3 — Q1265

R1262 150

CR1264

R1266 150

TOR
NTAL CONNECTOR

+15V & -15V REGULATORS & POWER DISTRIBUTION (9)

SS 474

5L4N

CHOP-IN
ALT-OUT

S1151

300 Hz
VIDEO

S1218

FLTR
10 Hz

S1216

5 kHz
FREQ COMB

S1215

TRK GEN
(DIV CAL)

S224

P1171

R1211

R1212

P1172

P1174

P1173

CR1224

C1216

R120

P1175

P1177

P1178

P1179

R1170

R1172

R1182

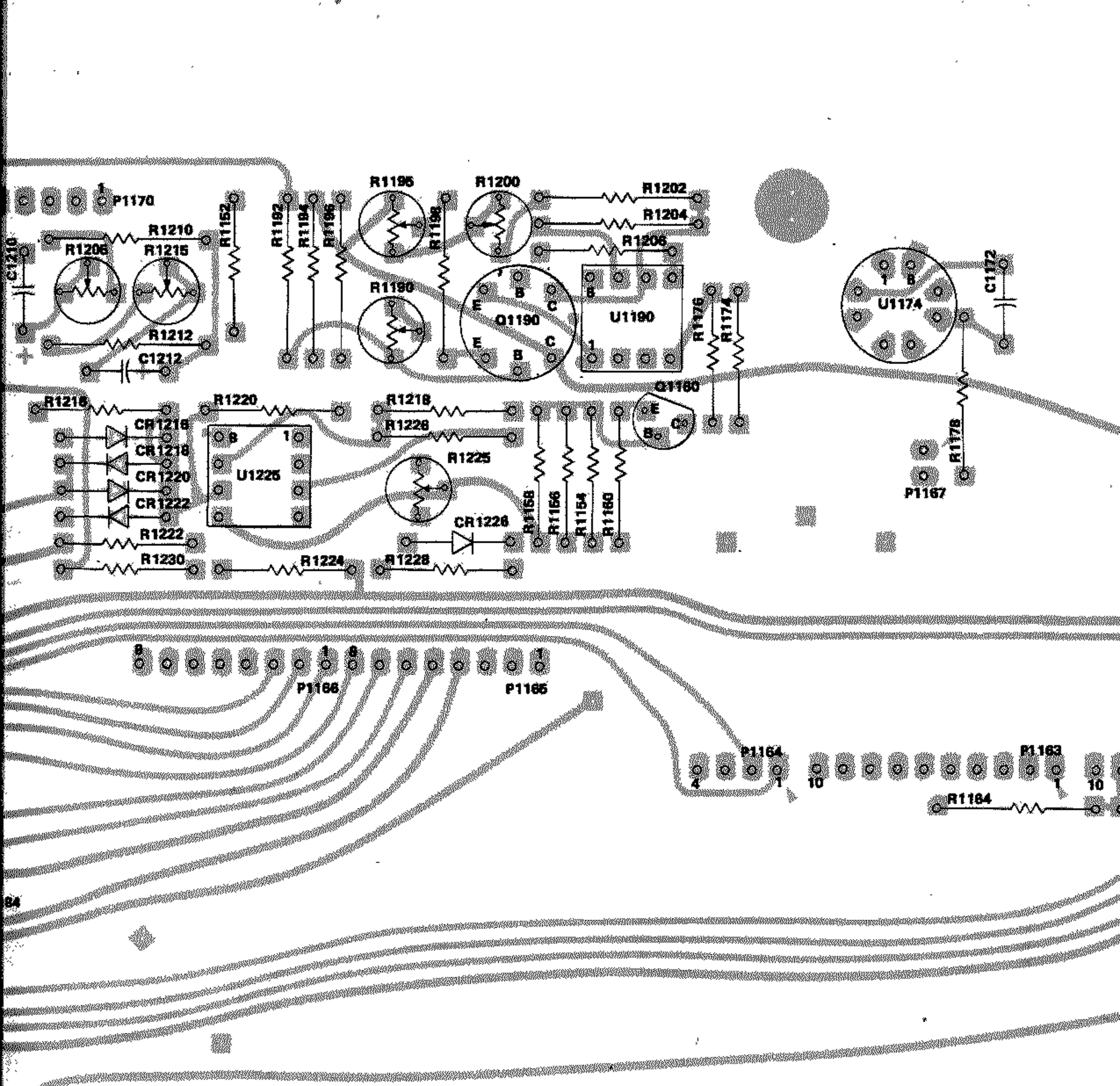
P1180

P1181

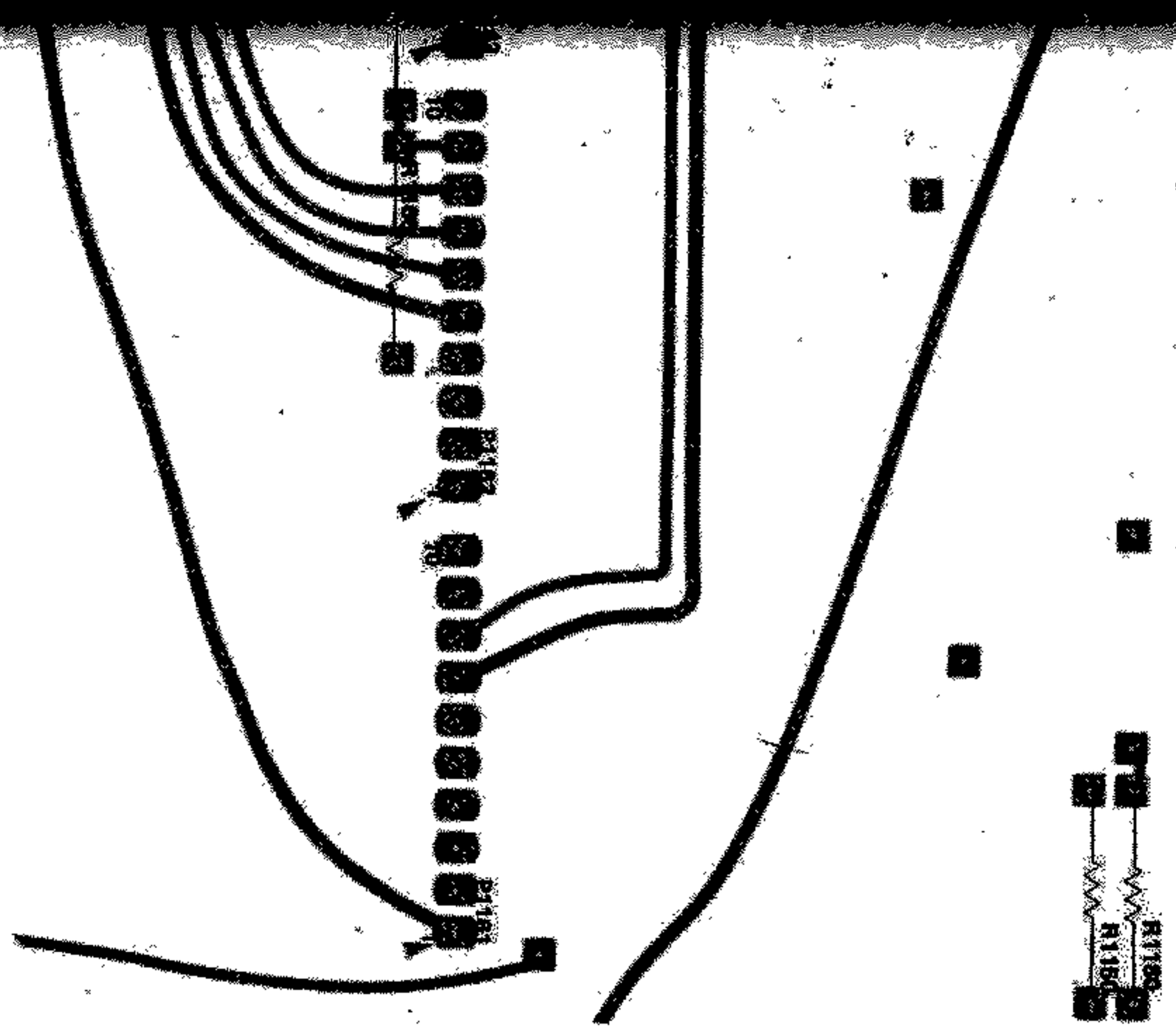
P1184

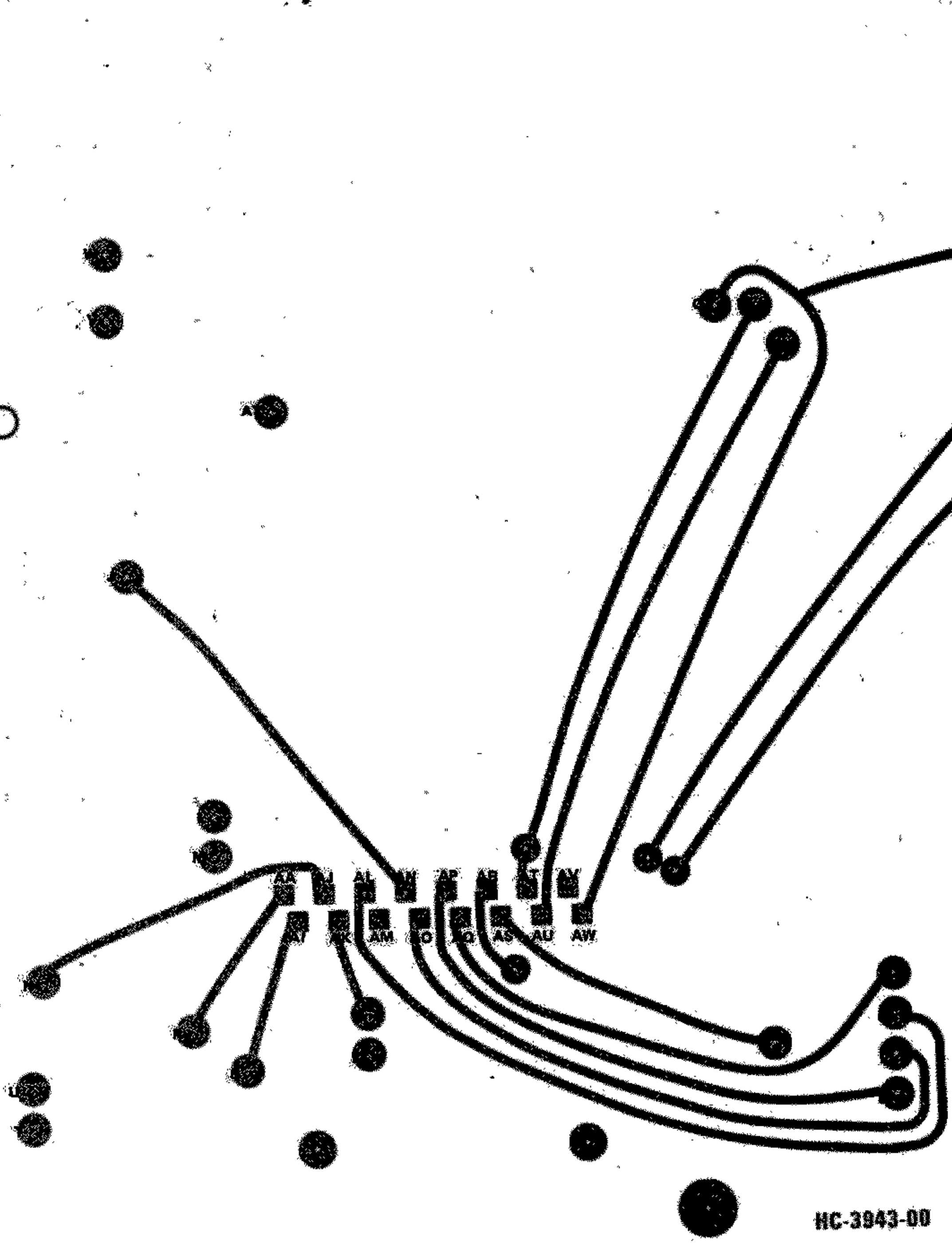
P1182

P1183



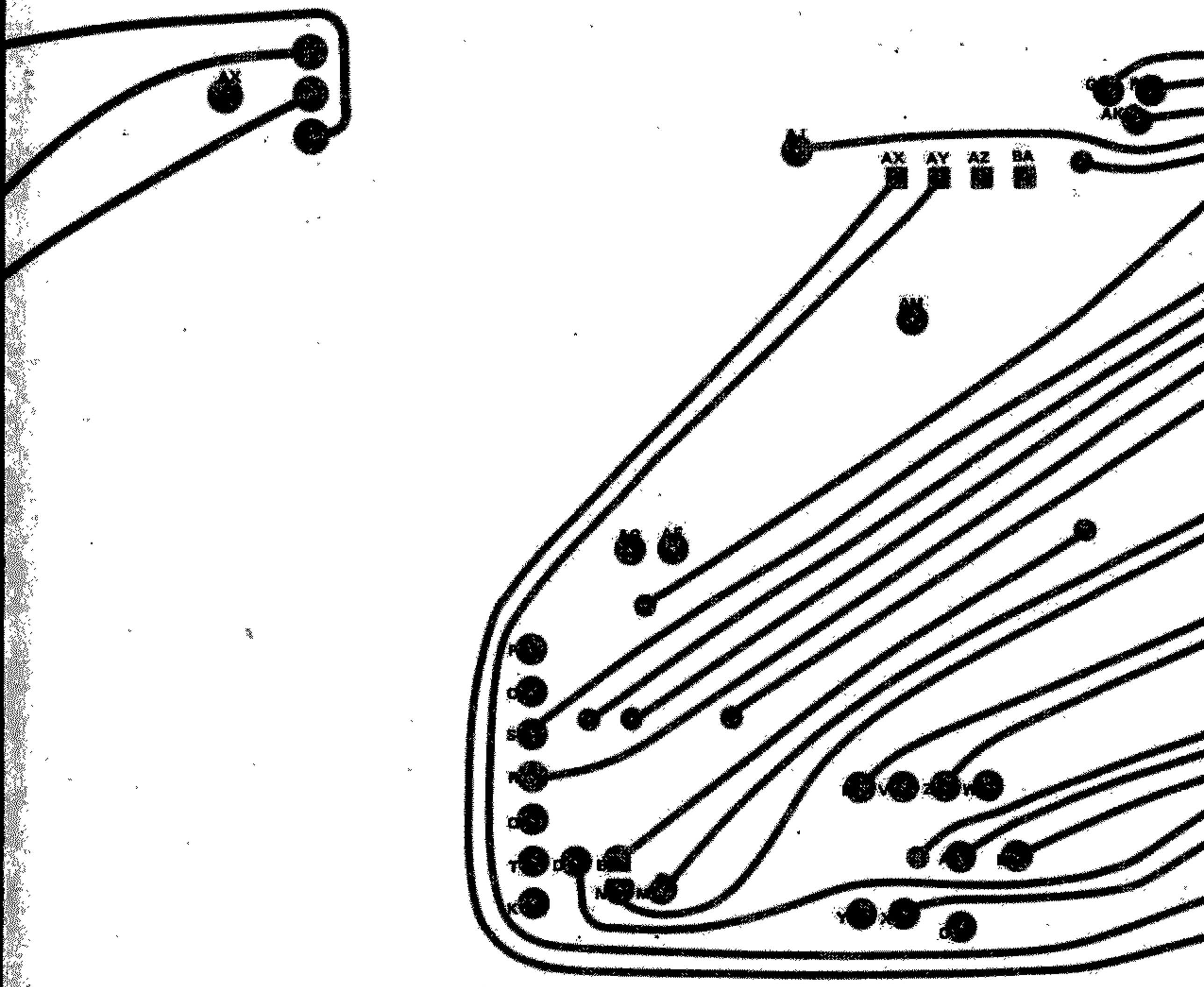
A1150 Main Mother, Frequency Tuning & Log Span Amplifier Circuit Board



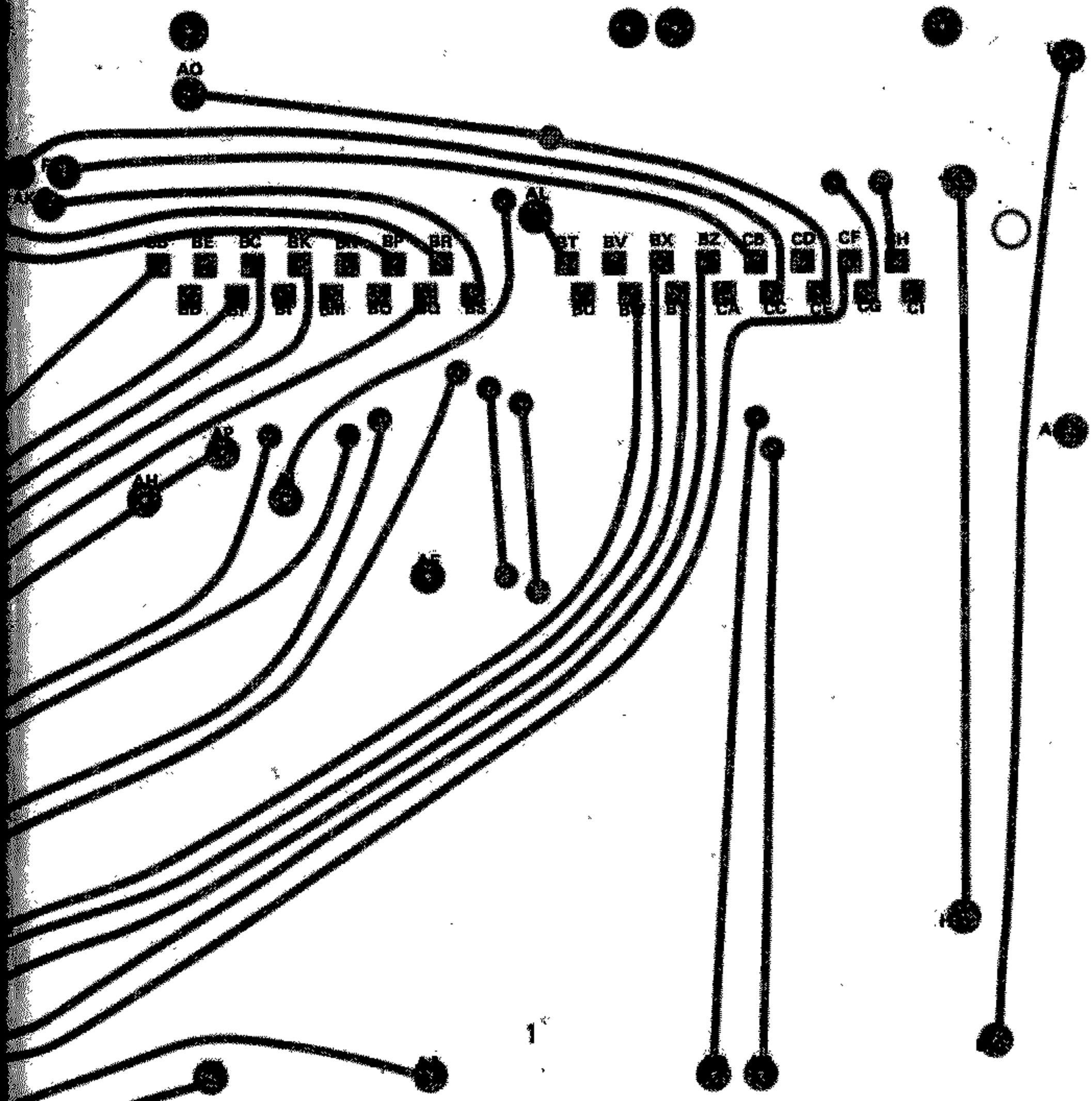


HC-3943-00

A1340 Right Mother Board


AX
AY
AZ
BA

5L4N



A1320 Left Mother Board

COMPONENT LOCATION FOR
A1320 & A1340

IN

FRONT PANEL	Display–Start Center Selector	Vertical Interface & +15 V Supply	Variable Resolution	Input Amplifier, LP Filter, Mixer & 250 kHz IF	Left Mother Board	Hi/Lo Input Impedance & LOG Display Selector	Display Se (LOG–L
	A1100	A690	A300	A100	A1320	A50	A680
BASELINE CLIPPER R10							
VIDEO OUT J8							
AMPL. CAL R4							
POSITION R14							
CONTRAST R8							
INPUT BNC J5							

VERT REF GND

+15V

UTILITY GND

+5V

-30V

P1100-1

P1100-6

P1100-7

A14

B14

A2

B2

B5

E

D

L

K

H

P433-2

U

T

O

N

P64-1

P64-2

P64-3

P63-1

P63-3

P63-2

Y

AG

AC

AD

AE

AF

AA

X

5L4N

INTERCONNECT CHART

t & y	Display Selector (LOG–LIN)	Vertical Sensing Selector	Vertical Transverse Interface & Chop Logic	Main Mother, Frequency Tuning & Log Span Amplifier	Horizontal Transverse Interface & Chop Logic	Right Mother Board	Shaper, LO, Tracking Generator & Calibrator	Display Function Amplifier	Detector Filter & Ampli
	A680A2	A680A1	A1300	A1150	A1300	A1340	A900	A440	A58
				P1181-1	P1174-2				
				P1181-2	P1169-5	J			I
								P448-2	
				P1181-3		J		J	
			E	CW	CW	H			H
	AY	AY	Y	Y	P1161-1	V			V
Y		Y							
				P1183-2					
				P1184-1					
		LOG/LIN VAR R685		P1184-2					
				P1184-3	P1177-4				
					P1161-5	W			W
				P1183-1		AO		AO	
				P1182-5		AI	AI		
	AN	AN	Q	Q					
				P1165-5	CP	CP	P1311-H2		
				P1182-4	P1164-2	O			O
AG		AG	G	G	P1163-3	AC			AC
				P1166-3	P1164-1	P			P
	AT	AT	H	H	P1163-10	Y			Y
	AU	AU	I	I	P1163-1	Z			Z
				P1166-2	CU	CU	P1311-3		
				P1166-1	P1162-10	K			K
AC		AC	J	J	CV	CV	P1310-2		
	AP	AP	K	K	P1161-8	F	F		
				P1165-8	P1176-2				
				P1165-7		L			L
AD		AD	O	O		U		U	
	AS	AS	P	P	P1176-3				
				P1165-6	CX	CX	P1311-7		
AE		AE	L	L	P1162-6	AL		AL	
AF		AF	M	M	P1162-7	AK		AK	
				P1171-2	P1163-4	T			T
				P1171-1					
				P1170-1	P1175-5				
	AQ	AQ	R	R					
				P1165-4	P1161-4	AH	AH		
						AP		AP	
			D	CQ	CQ	X			X
				P1182-3		C	C		
				P1182-2	P1162-3	M			M
				P1182-1	P1163-9	N			N
AA		AA	T	T	P1163-8	AN		AN	
	AO	AO			P1162-4				
X		X			CY	CY	P1310-1		
	AR	AR	W	W	P1176-6				
				P1166-4	P1162-2	A	A		
					P1162-1	B	B		
			L	CO	CO	CO	P1310-7		
				P1166-8	P1175-3				
				P1166-7	P1175-4				
AJ		AJ	D	D	P1163-2	AD			AD
AI		AI	E	E	P1162-5	AM		AM	
				P1165-3	P1161-6	AE	AE		
			K	CR	CR	P1177-3			
				P1170-6					
			H	CS	CS	P1177-2			
				P1165-2	P1161-3	AG	AG		
				P1170-7	P1162-9	R			R
				P1169-6					

Display Function Amplifier	Detector, Video Filter & Video Amplifier	Horizontal Interface & −15 V Supply	Sweep Generator & Amplifier	Frequency Span Selector, Trigger Mode & Source Selector		FRONT PANEL
A440	A580	A1250	A700	A800		

P833-2
X
X
I
P448-2
J
H
V
W
AO
P835-4
I I
Y Y
H H
O O
P P
P836-1
P836-2
P836-3
P836-4
SWP S21
P726-3
P726-2
P726-1
MULT 2K R24
P728-3
P728-2
P728-1
LEVEL/ SLOPE R26
P1260
1 + 2
-15V
O
AC
P
Y
Z
P1260-3 B21
K
P1262-2 B9
K K
L
P834-2
U
P834-3
P1260-7 B15
AL
AK
T
P832-5
AP
X
M
N
AN
A9
P1262-1
B10
UTILITY GND
J J
P834-6
B16
P1262-7
A2
P832-3
P832-4
AD
AM
L L
B B
P835-3
P835-2
M M
R
P727-1
P727-2
POSIT R2
INTE

POSITION R14

CONTRAST R8

INPUT BNC J5

10 dB/ DIV R6

LOG/LIN NEONS

TG/CAL OUT 600Ω

FINE R28

FREQ R30

CAL R3

P1100-1

P1100-3

P1100-5

P1100-7

P1100-6

P1100-4

P1100-2

P423-1

P216-2

P216-1

P64-3

P63-1

P63-3

P63-2

+15V

UTILITY GND

+5V

-30V

+30V

+200V

A2

A5

A19

A4

B18

A7

A13

B7

B13

B19

B2

B5

L

K

H

I

B

J

C

G

F

A

M

AY

N

M

AX

D

G

R

S

P

B

H

Q

A

AA

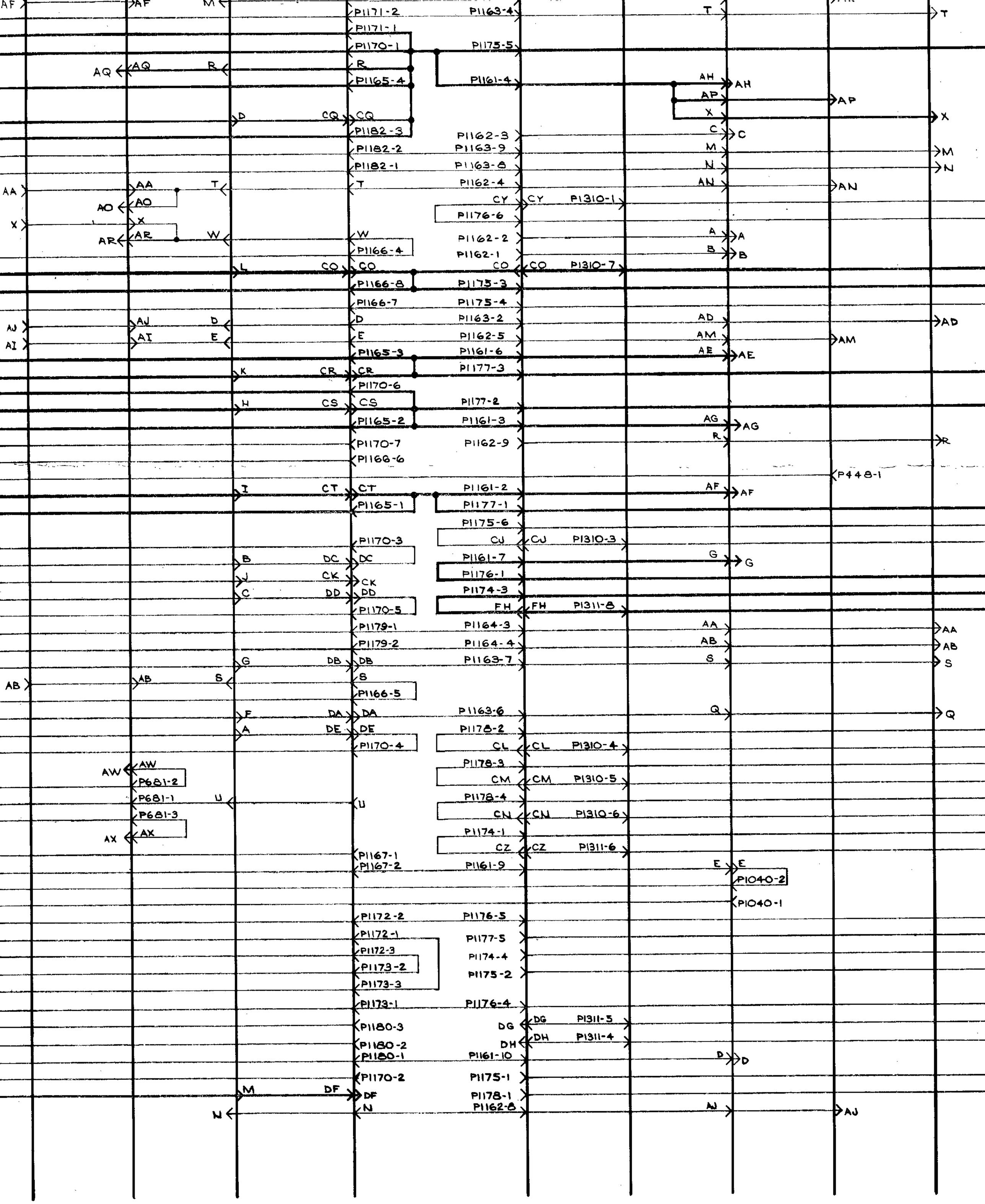
X

AJ

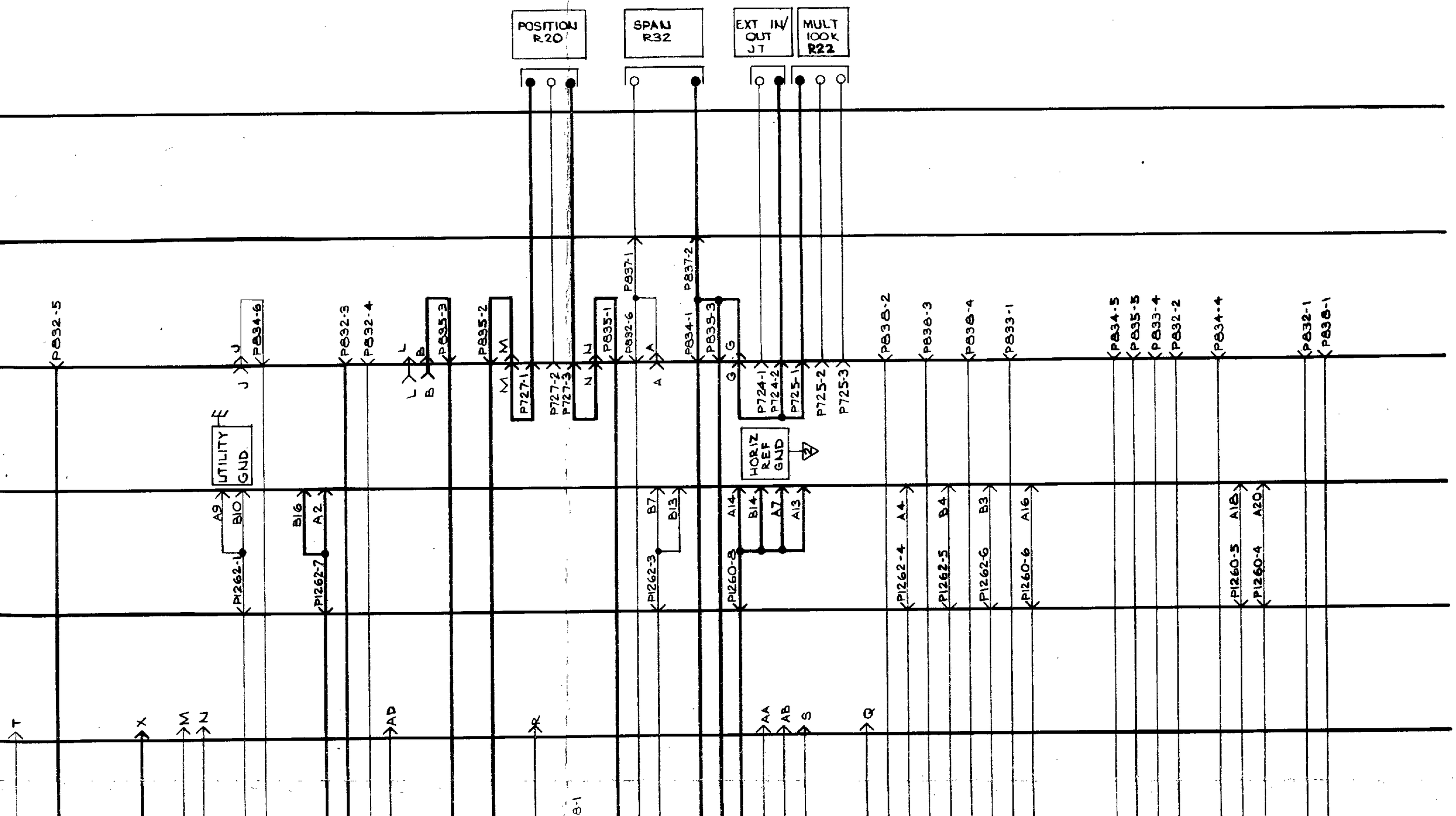
AI

AB

I


AF
AF
M
P1171-2
P1163-4
T
T
P1171-1
P1170-1
P1175-5
AQ
AQ
R
R
P1165-4
P1161-4
AH
AH
AP
AP
X
X
D
CQ
CQ
P1182-3
C
C
P1162-3
M
M
P1182-2
P1163-9
N
N
P1182-1
P1163-8
AA
AA
T
T
P1162-4
AN
AN
AO
AO
CY
CY
P1310-1
P1176-6
X
X
AR
AR
W
W
P1162-2
A
A
P1166-4
B
B
P1162-1
L
CO
CO
CO
CO
P1310-7
P1166-8
P1175-3
P1166-7
P1175-4
AJ
AJ
D
D
P1163-2
AD
AD
AI
AI
E
E
P1162-5
AM
AM
P1165-3
P1161-6
AE
AE
K
CR
CR
P1177-3
P1170-6
H
CS
CS
P1177-2
P1165-2
P1161-3
AG
AG
R
P1170-7
P1162-9
P1166-6
P448-1
I
CT
CT
P1161-2
AF
AF
P1165-1
P1177-1
P1175-6
P1170-3
CJ
CJ
P1310-3
B
DC
DC
P1161-7
G
G
J
CK
CK
P1176-1
C
DD
DD
P1174-3
P1170-5
FH
FH
P1311-8
P1179-1
P1164-3
AA
AA
P1179-2
P1164-4
AB
AB
G
DB
DB
P1163-7
S
S
AB
AB
S
P1166-5
F
DA
DA
P1163-6
Q
Q
A
DE
DE
P1178-2
P1170-4
CL
CL
P1310-4
AW
AW
P1178-3
P6B1-2
CM
CM
P1310-5
P6B1-1
U
U
P1178-4
P6B1-3
CN
CN
P1310-6
AX
AX
P1174-1
CZ
CZ
P1311-6
P1167-1
E
E
P1167-2
P1161-9
P1040-2
P1040-1
P1172-2
P1176-5
P1172-1
P1177-5
P1172-3
P1174-4
P1173-2
P1175-2
P1173-3
P1173-1
P1176-4
P1180-3
DG
DG
P1311-5
P1180-2
DH
DH
P1311-4
P1180-1
P1161-10
D
D
P1170-2
P1175-1
M
DF
DF
P1178-1
N
N
P1162-8
AJ
AJ

INTERCONNECT CHART



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.

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MANUAL CHANGE INFORMATION

PRODUCT 5L4N
EFF SN B010100-up

CHANGE REFERENCE C1/774
DATE 7-19-74/REV.

CHANGE:	DESCRIPTION

Pilot Change #9

TEXT CORRECTION

Page 2-21, Step 2, Line 2

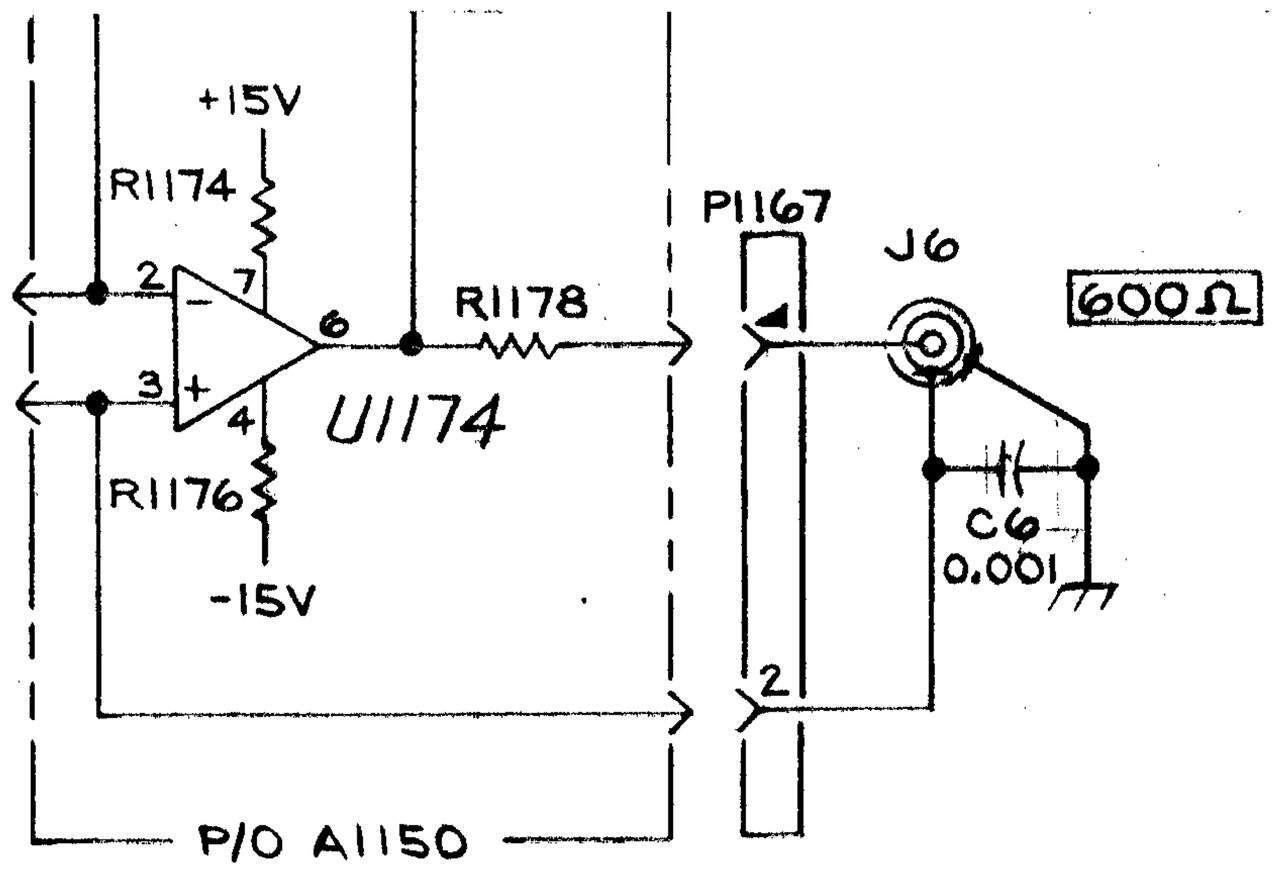
CHANGE TO READ:

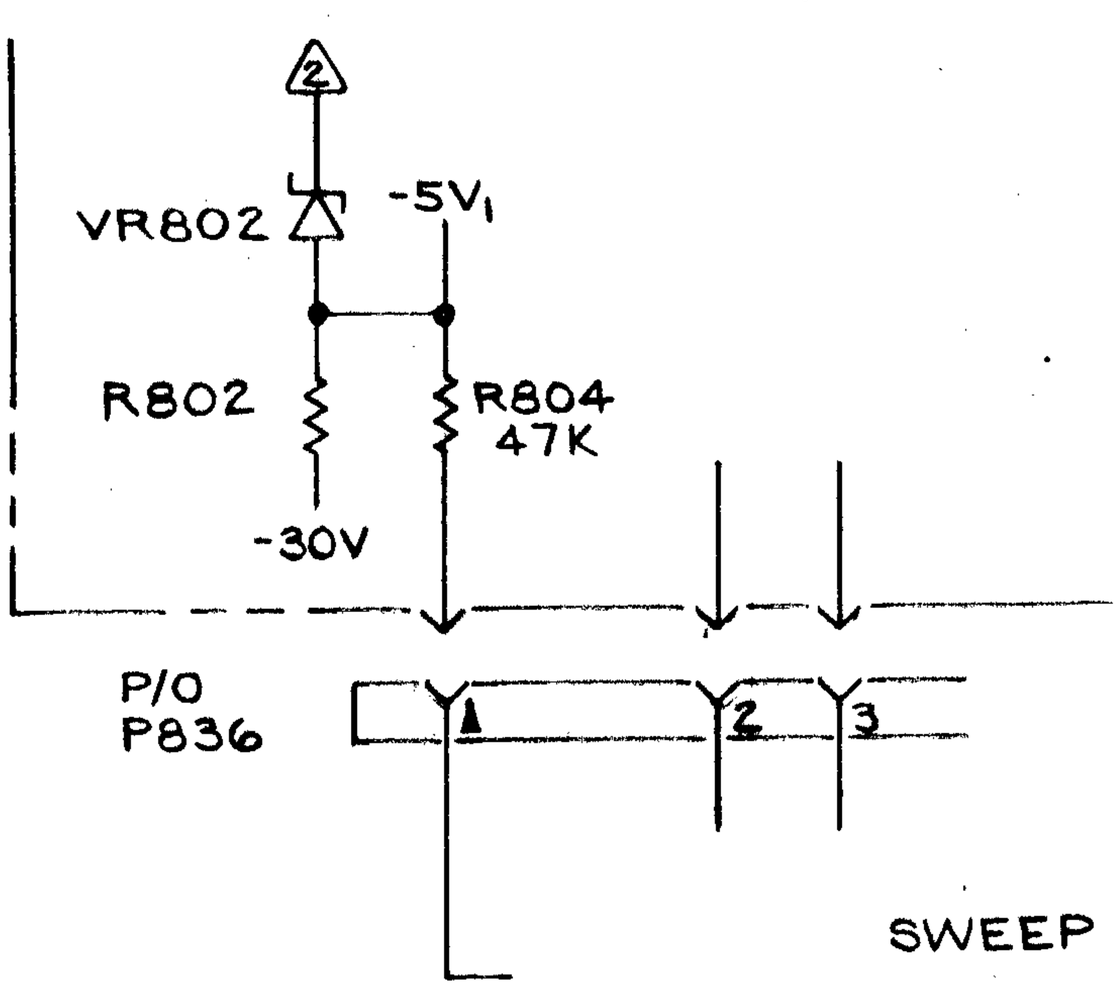
larger signal until it is within the graticule area, and note the increased

ELECTRICAL PARTS LIST AND SCHEMATIC CHANGES

ADD:

C6	283-0000-00	CAP.,FXD,CER DI:0.001µF,+100-0%, 500 V
R804	315-0473-00	RES.,FXD,COMP:47K OHM,5%, 0.25 W





SHAPER, LO, TRACKING GEN, CALIBRATOR 6

SWEEP GEN & AMPL 7

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MANUAL CHANGE INFORMATION

PRODUCT 5L4N
EFF SN B010100-up

CHANGE REFERENCE C2/874
DATE 8-6-74

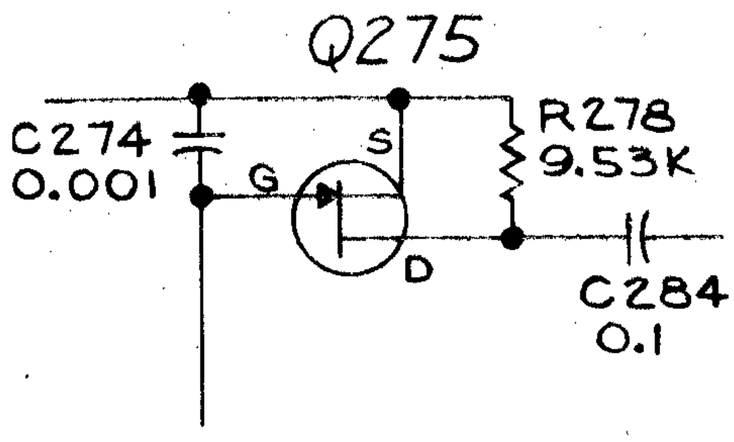
CHANGE:	DESCRIPTION

Pilot Change #11

ELECTRICAL PARTS LIST AND SCHEMATIC CHANGES

CHANGE TO:

Q680	151-0292-00	TRANSISTOR:SILICON, NPN



PARTIAL-
MIXER & 250kHz SWITCHED
GAIN AMPL ◇2

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MANUAL CHANGE INFORMATION

PRODUCT 5L4N INTERIM
EFF SN B010100-up

CHANGE REFERENCE C3/874
DATE 8-22-74

CHANGE:	DESCRIPTION

Pilot Changes #12 & #13 TEXT CORRECTION

Page 1-8 Line 1

CHANGE TO READ: The zero (start) spur is less than -70 dBV or five divisions...

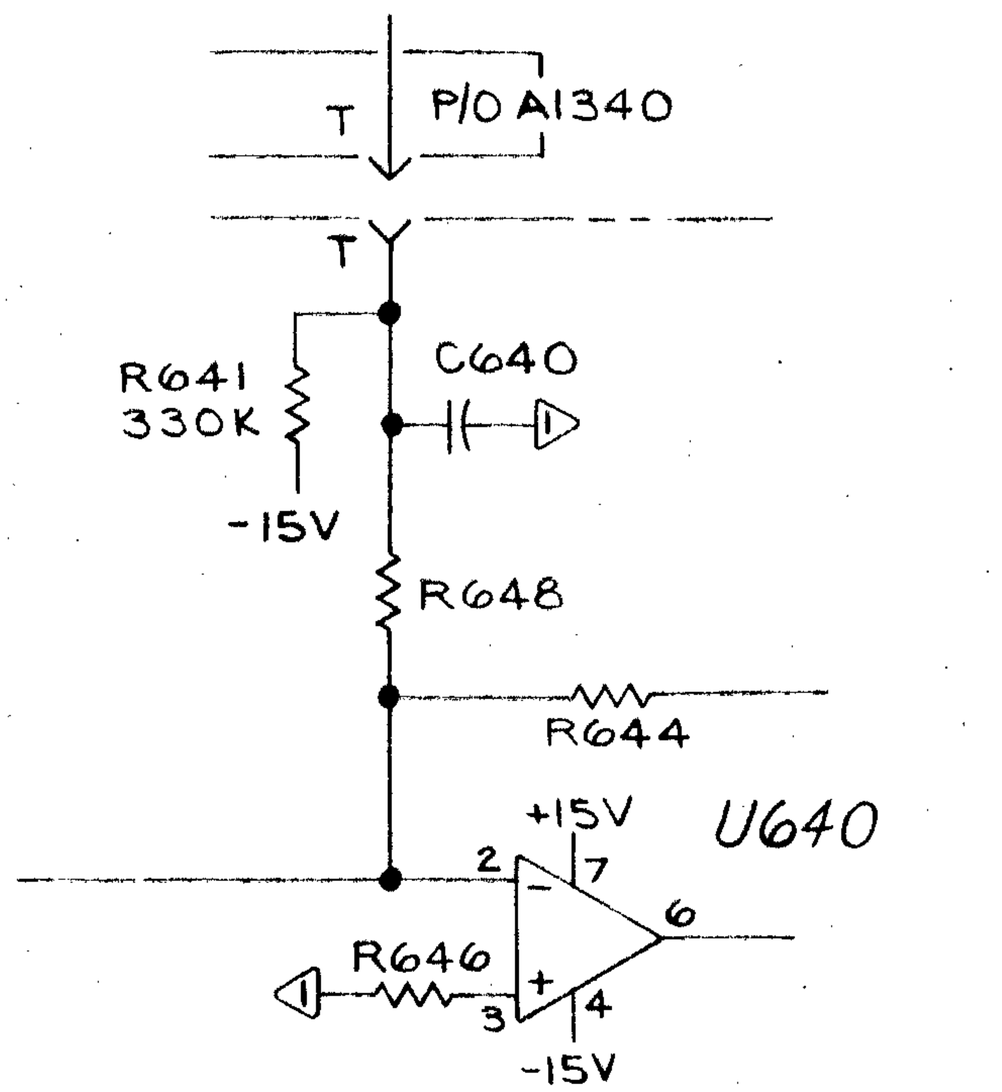
ELECTRICAL PARTS LIST AND SCHEMATIC CHANGES

CHANGE TO:

C125	281-0529-00	CAP.FXD,CER DI:1.5 PF (NOMINAL VALUE) SELECTED
C329	281-0504-00	CAP.FXD,CER DI:10 PF (NOMINAL VALUE) SELECTED
C366	281-0504-00	CAP.FXD,CER DI:10 PF (NOMINAL VALUE) SELECTED
C386	281-0504-00	CAP.FXD,CER DI:10 PF (NOMINAL VALUE) SELECTED
C406	281-0504-00	CAP.FXD,CER DI:10 PF (NOMINAL VALUE) SELECTED
R648	315-0154-00	RES.FXD,COMP:150K OHM, 5%, 0.25W
R702	321-0264-00	RES.FXD,FILM:5.49K OHM, 1%, 0.125W

ADD:

R641	315-0334-00	RES.FXD,COMP:330K OHM, 5%, 0.25W



P/O DET, VID FILTER & VID AMPL 5

TEKTRONIX®
committed to technical excellence

MANUAL CHANGE INFORMATION

PRODUCT 5L4N
EFF SN B010100-up

CHANGE REFERENCE C4/974
DATE 9-11-74

CHANGE:	DESCRIPTION

#16,#17,#18,#19 ELECTRICAL PARTS LIST AND SCHEMATIC CHANGES

CHANGE TO:

C125	281-0178-00	CAP.,VAR,PLSTC:1-4 PF
Q165	151-0435-00	TRANSISTOR, SILICON, PNP, MPSA65
R712	315-0125-00	RES.,FXD,COMP:1.2M OHM, 5%, 0.25W
R1210	321-0262-00	RES.,FXD,FILM:5.23K OHM, 1%, 0.125W
R1212	321-0262-00	RES.,FXD,FILM:5.23K OHM, 1%, 0.125W
R1214	321-0252-00	RES.,FXD,FILM:4.12K OHM, 1%, 0.125W

TEKTRONIX®
committed to technical excellence

MANUAL CHANGE INFORMATION

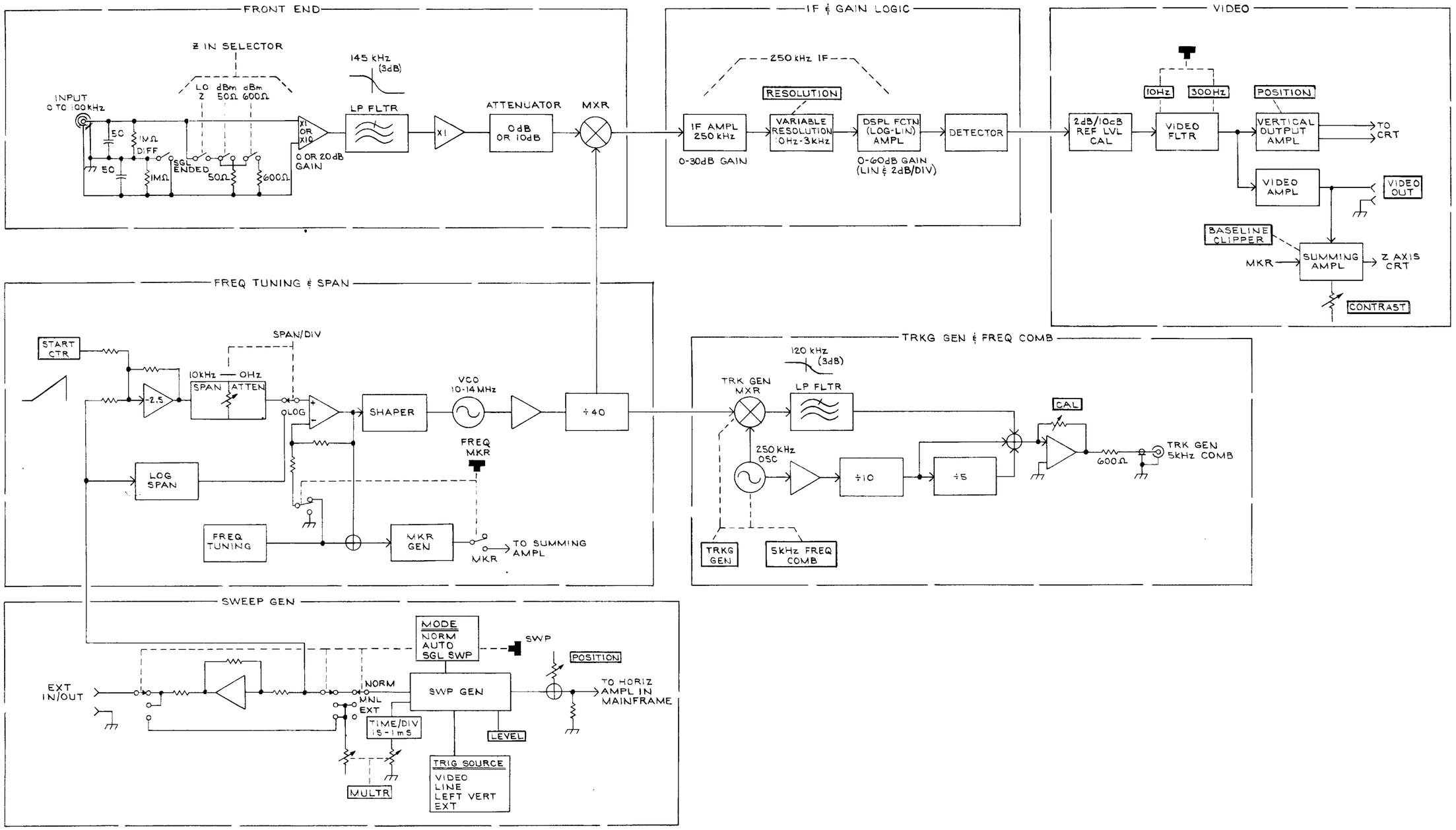
PRODUCT 5L4N

CHANGE REFERENCE C5/1074

DATE 10-7-74

CHANGE:	DESCRIPTION

A 3 wire multi-pin extender cable has been added to the 5L4N instrument package. This cable permits the left wing of the instrument to be extended for maintenance and calibration.



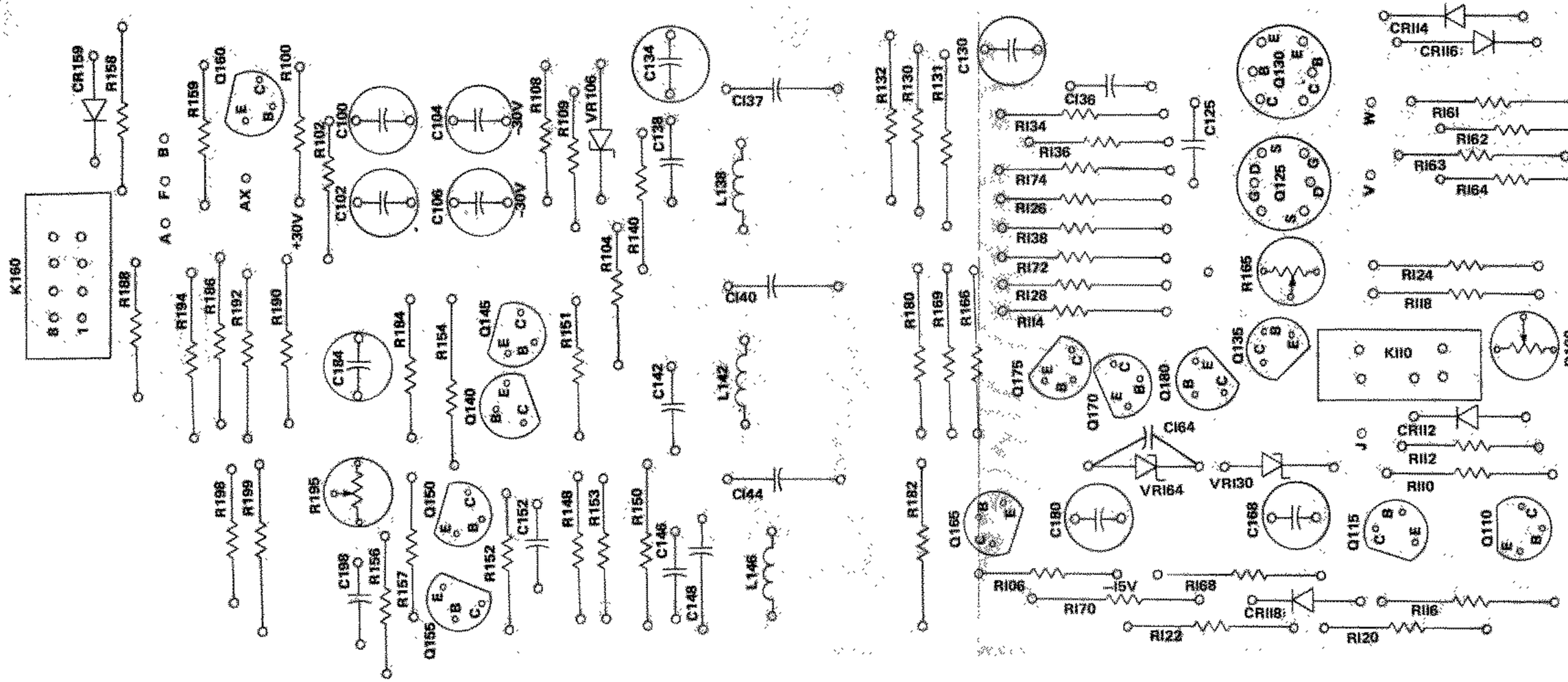
DD474

5L4N

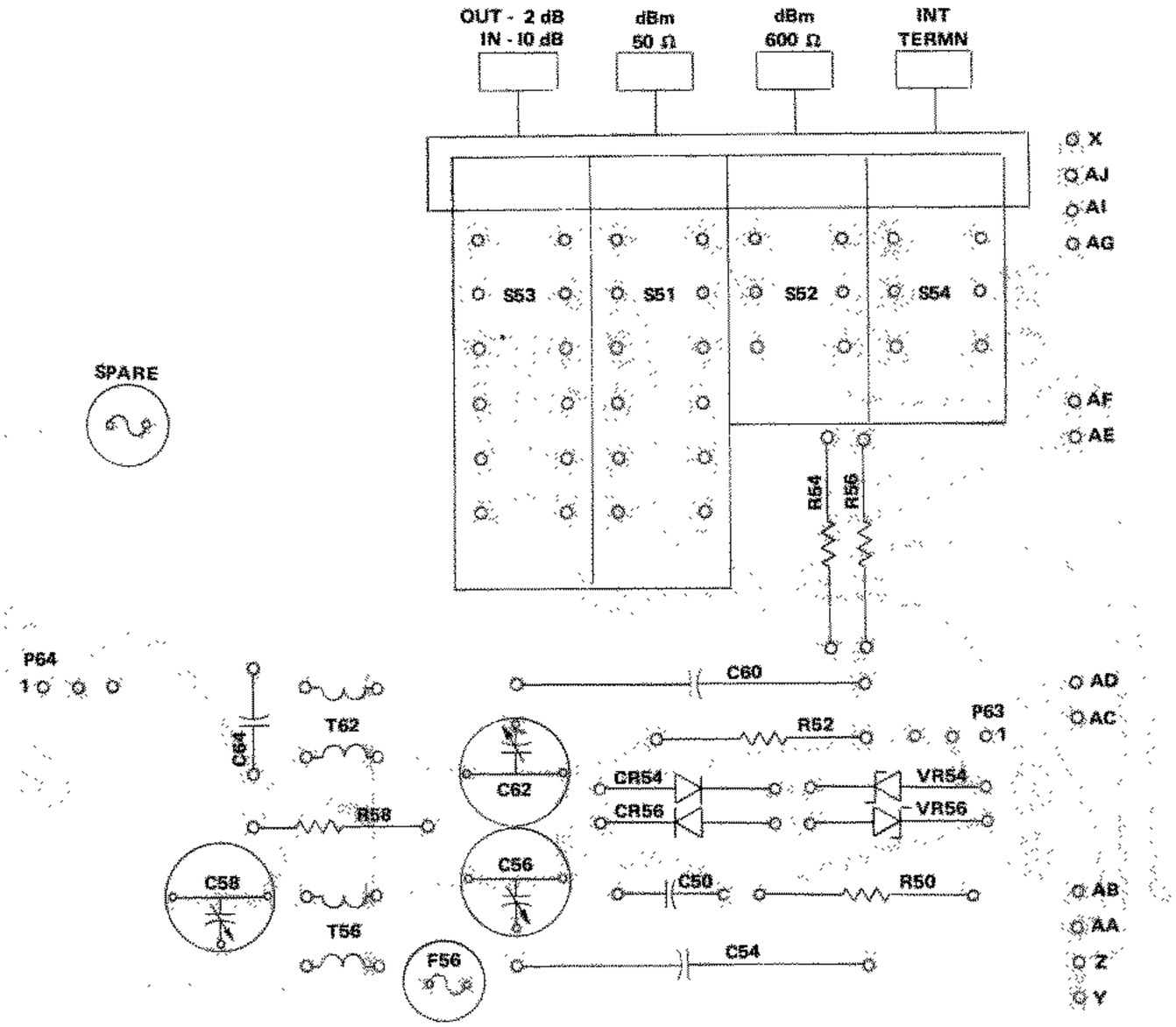
BLOCK DIAGRAM

5L4N

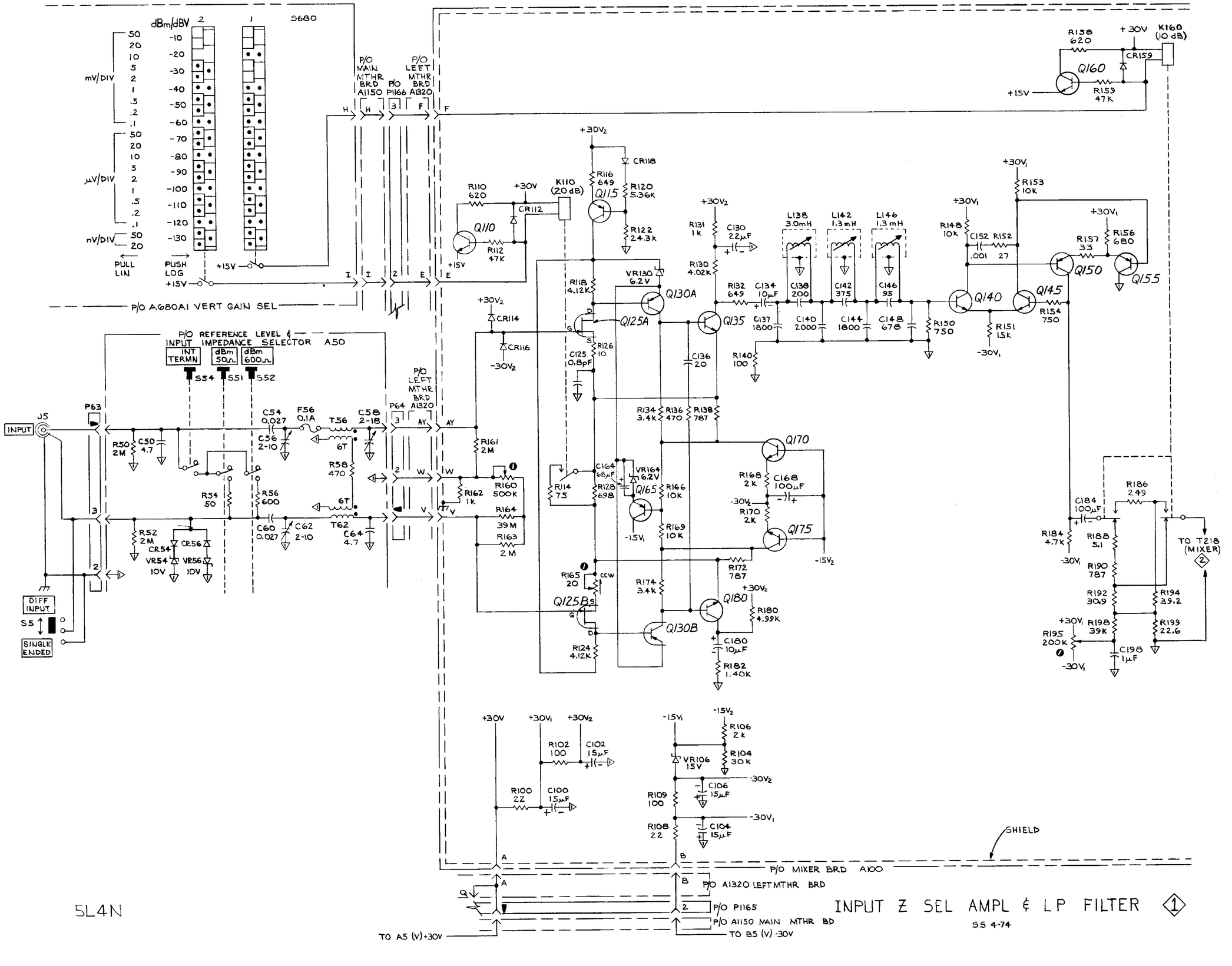
COMPONENT LOCATIONS
FOR DIAGRAM 1



P/O A100 Input Amplifier, LP Filter, Mixer & 250 kHz IF



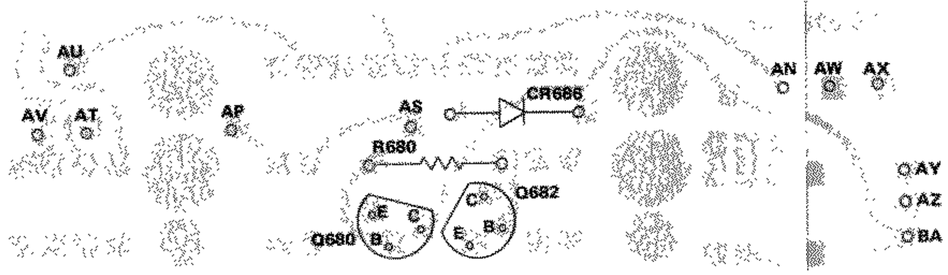
A50 Hi/Lo Input Impedance & LOG Display Selector



5L4N

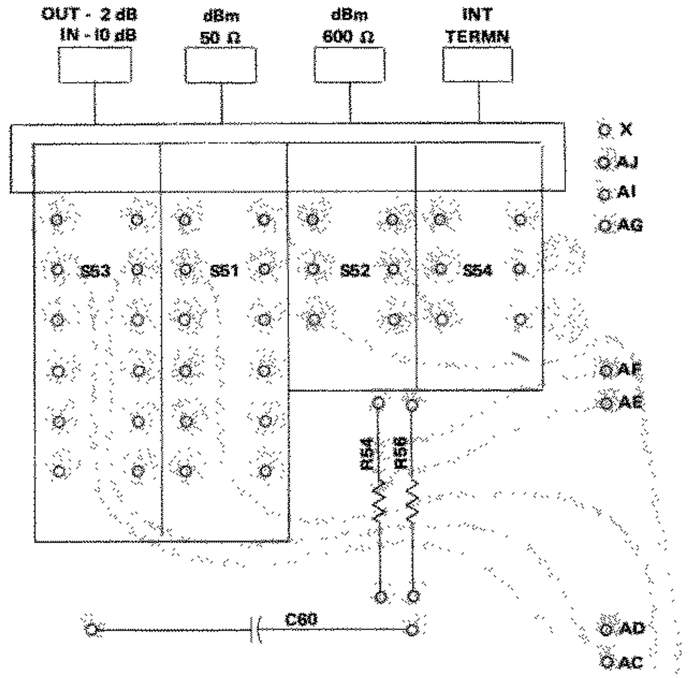
INPUT Z SEL AMPL & LP FILTER ①

SS 4-74

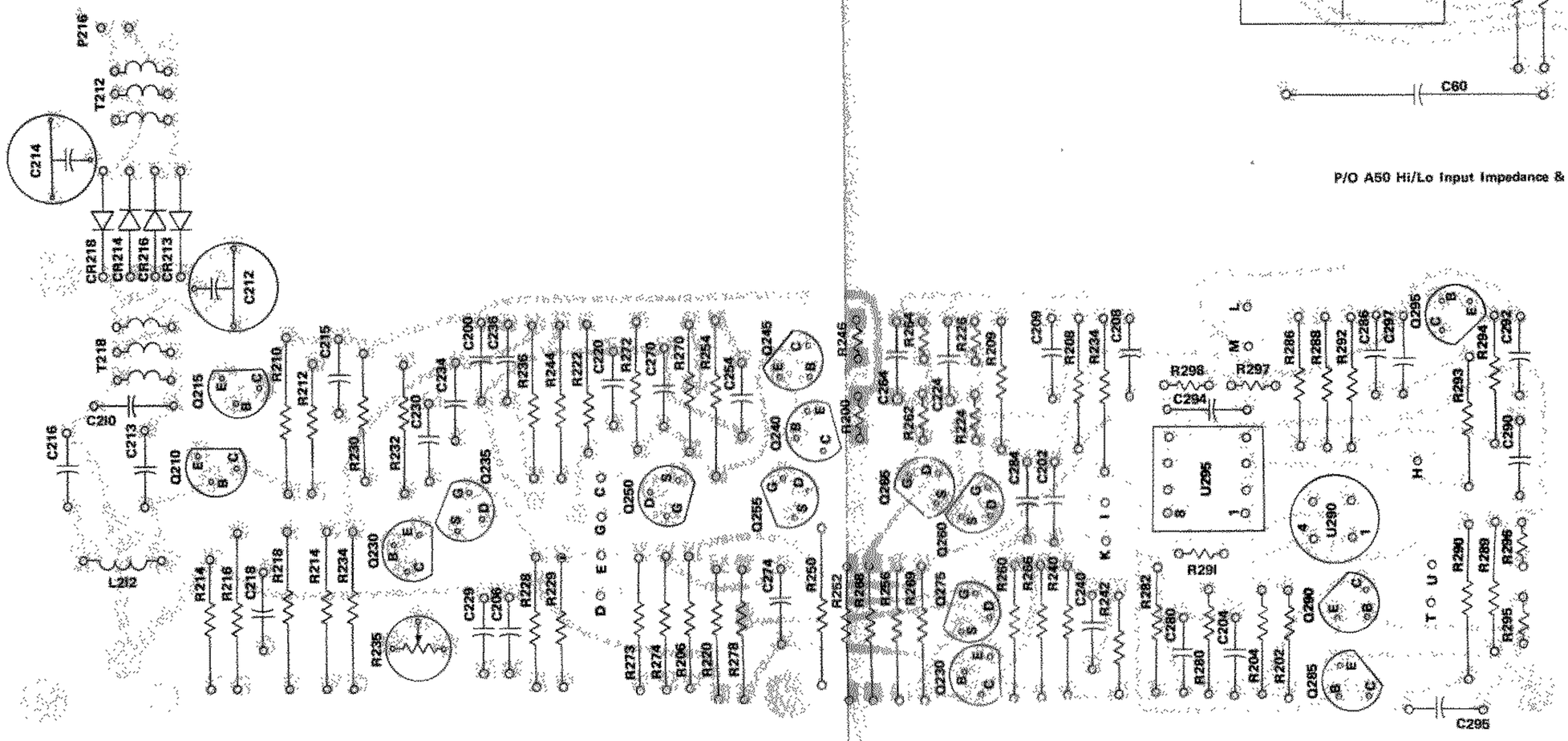


P/O A680A1 Vertical Sensing Selector

A1150 Main Mother Board component location shown on back of Diagram 8

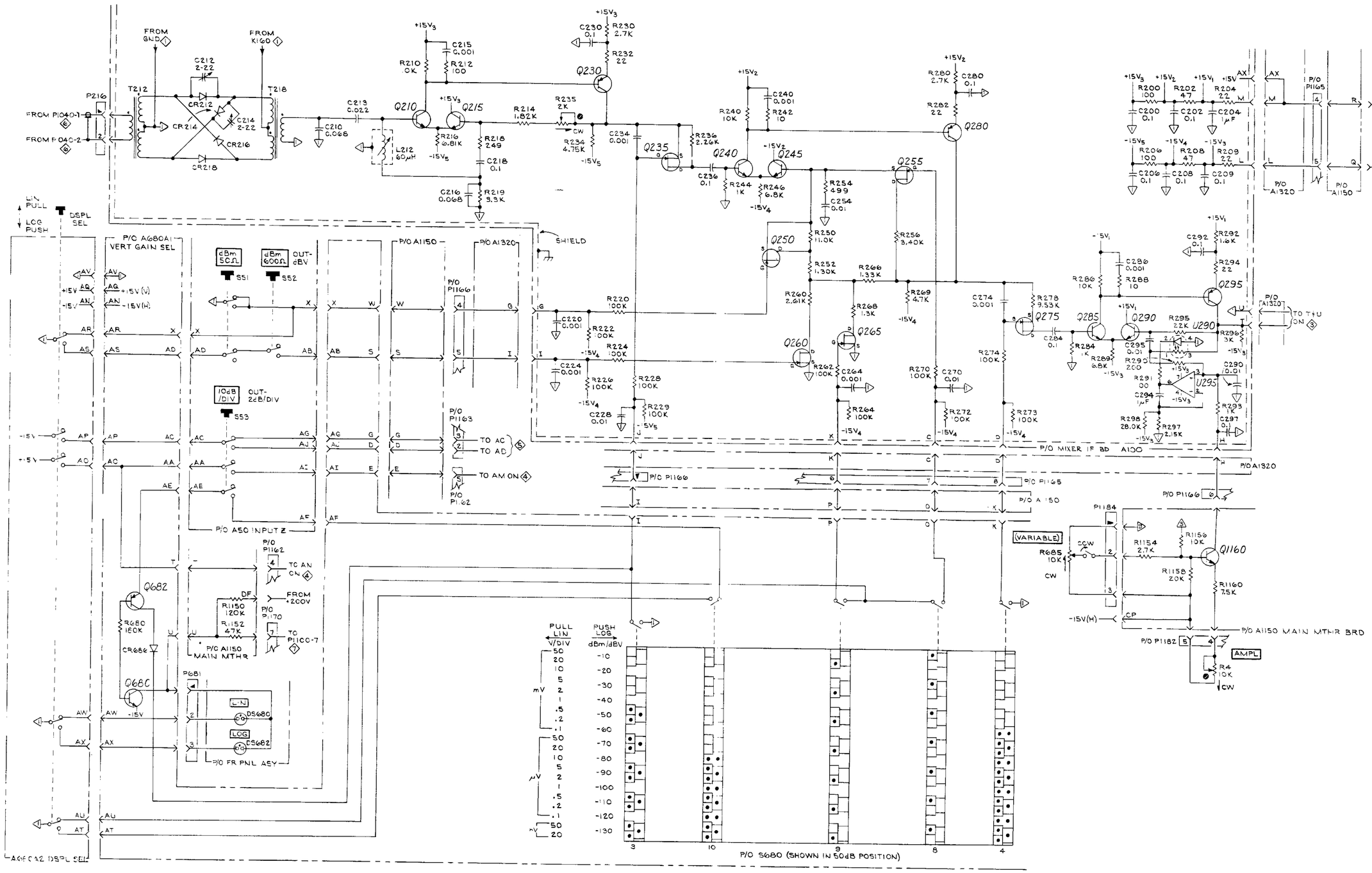


P/O A50 Hi/Lo Input Impedance & LOG Display Selector



P/O A100 Input Amplifier, LP Filter, Mixer & 250 kHz IF

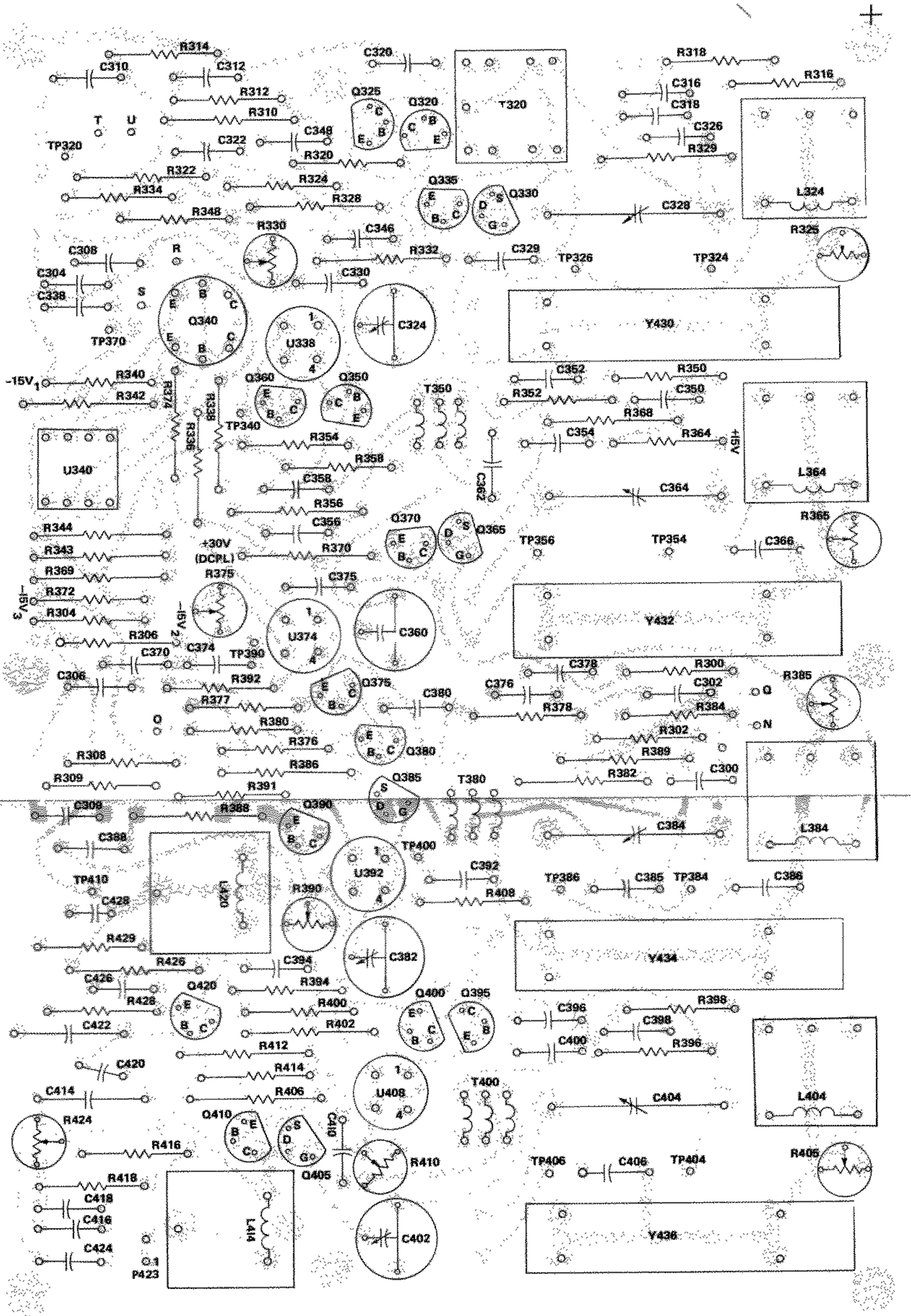
COMPONENT LOCATIONS FOR DIAGRAM 2

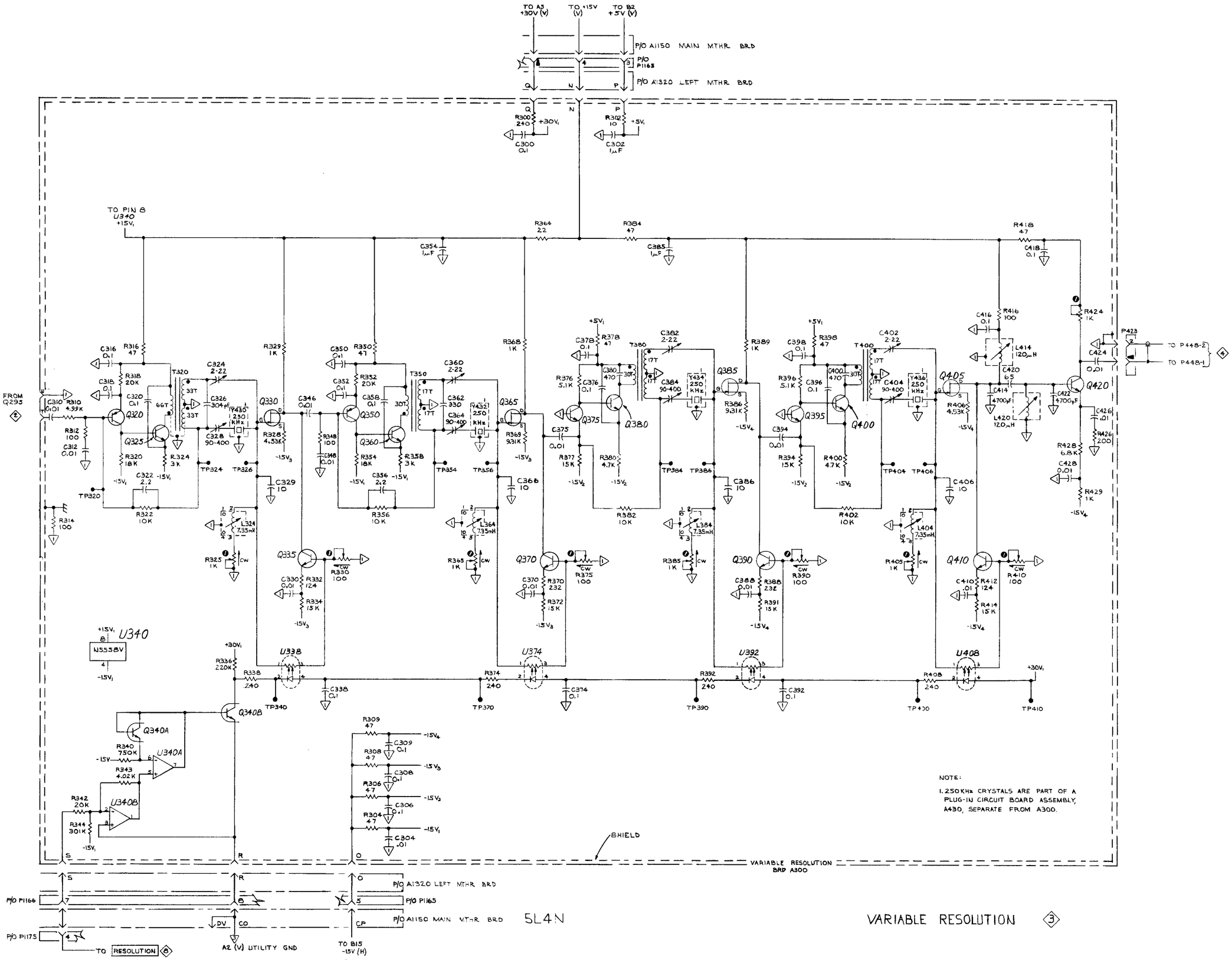


DD 474

5L4N

MIXER & 250 kHz SWITCHED GAIN AMPL ◇2


A300 Variable Resolution
5L4N
R314
C310
C312
R312
R310
C320
T320
R318
R316
C316
C318
C326
R329
L324
R325
Q325
Q320
T
U
TP320
C322
C348
R320
R322
R334
R324
R328
R348
Q335
Q330
C328
R330
C346
R332
C329
TP326
TP324
C308
C304
C338
S
R
TP370
Q340
U338
C324
Y430
-15V1
R340
R342
R374
R338
R336
Q360
Q350
TP340
R354
R358
C358
R356
C356
T350
C352
R350
R352
C350
R368
C354
R364
+15V
L364
C362
C364
R365
U340
R344
R343
R369
R372
R304
-15V3
-15V2
+30V
(DCPL)
R370
Q370
Q365
TP356
TP354
C366
R375
C375
U374
C360
Y432
R306
C370
C374
TP390
C306
R392
R377
C375
C380
C376
R378
C378
R300
C302
R384
R385
Q
N
R380
R376
Q380
R302
R389
R382
C300
R308
R309
R386
R391
Q385
T380
C309
R388
Q390
C384
L384
C388
TP400
TP410
C428
L420
U392
C392
R408
TP386
C385
TP384
C386
R390
C382
Y434
R429
R426
C426
R428
C422
C394
R394
R400
R402
Q420
Q400
Q395
C396
C398
C400
R398
R396
L404
C404
C420
C414
R424
R412
R414
R406
U408
T400
Q410
C410
R410
Q405
R416
R418
C418
C416
C424
P423
L414
C402
TP406
C406
TP404
R405
Y436



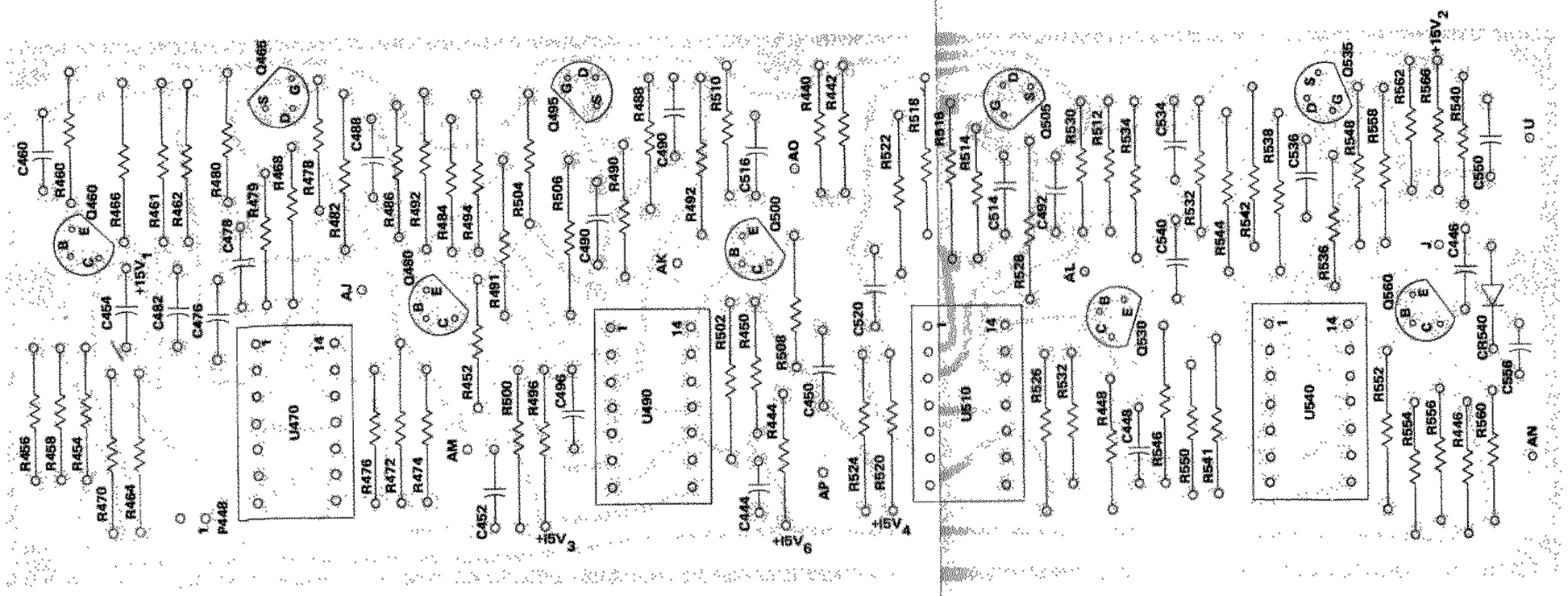
NOTE:

1. 250 KHz CRYSTALS ARE PART OF A PLUG-IN CIRCUIT BOARD ASSEMBLY, A430, SEPARATE FROM A300.

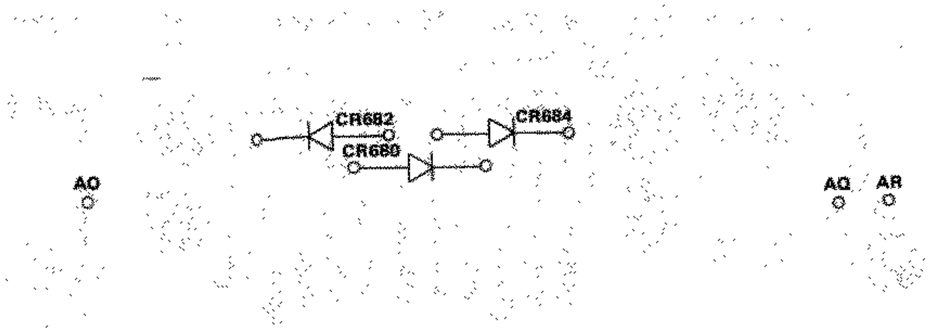
VARIABLE RESOLUTION ③

5L4N

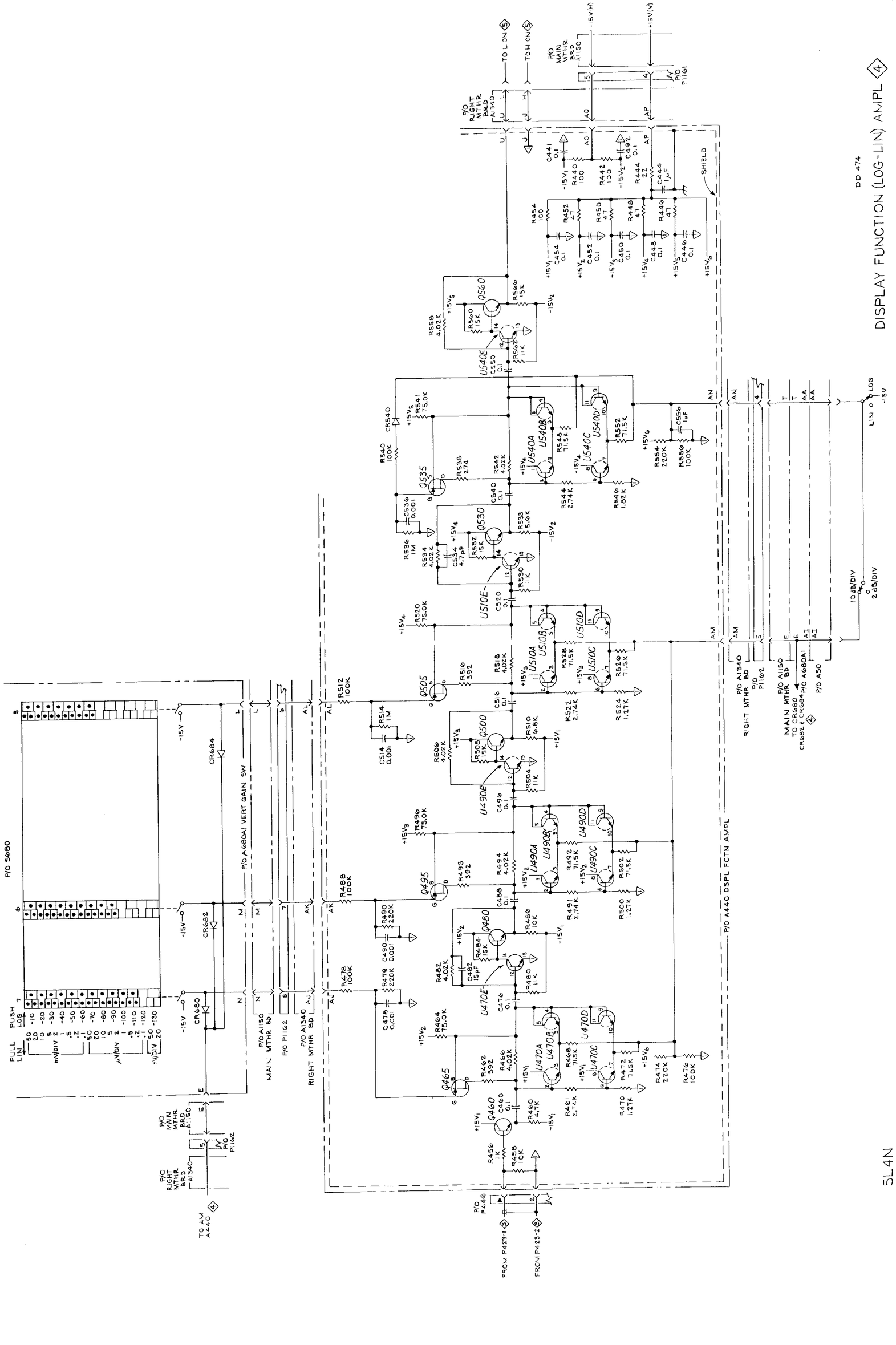
FOR DIAGRAM 4



A440 Display Function Amplifier



P/O A680A1 Vertical Sensing Selector

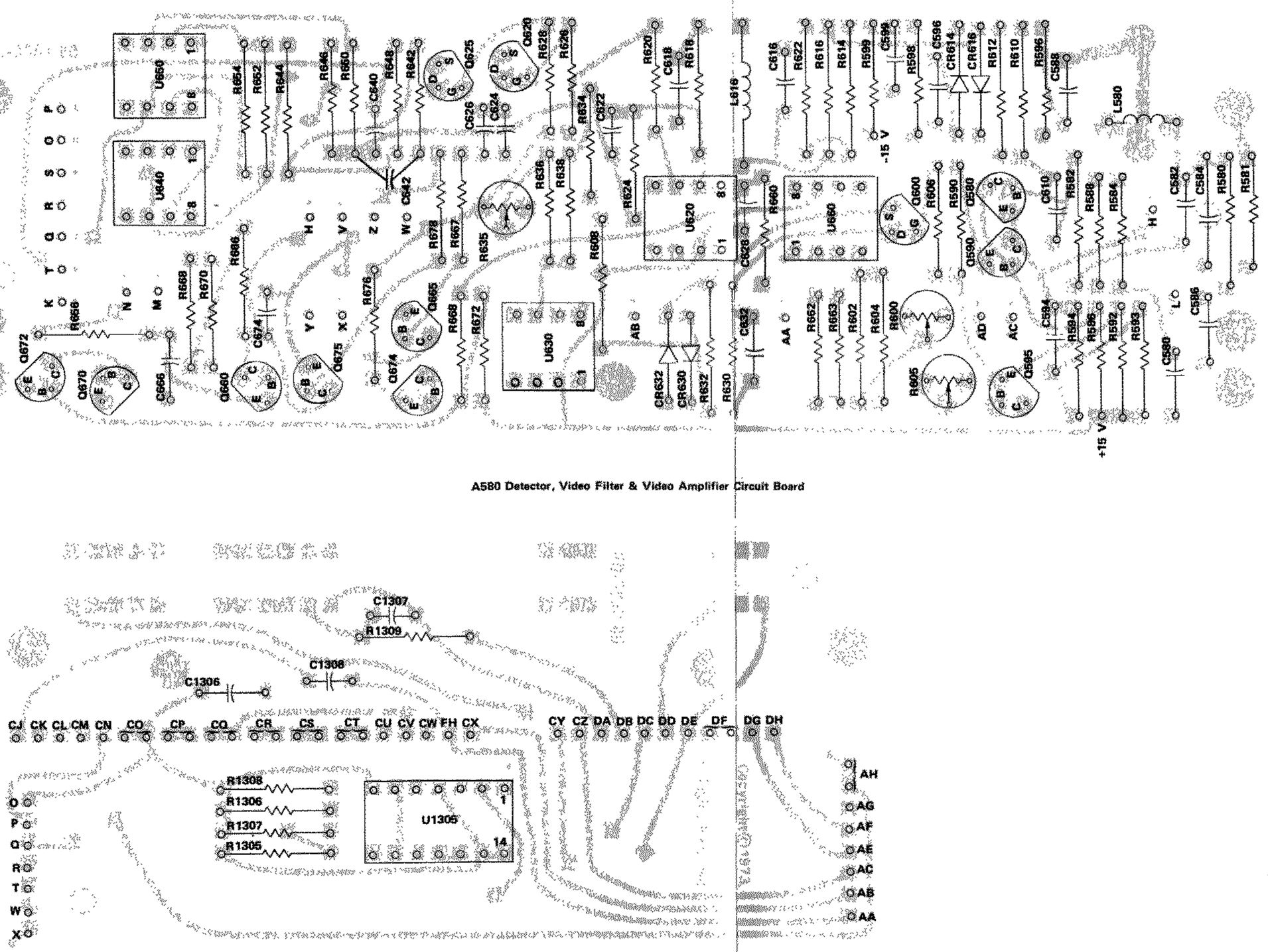

DISPLAY FUNCTION (LOG-LIN) AMPL ④
DD 474
P/O A440 DSPL FCTN AMPL
P/O 5680
PUSH LOG
PULL LIN
mV/DIV
µV/DIV
nV/DIV
-15V
CR684
CR682
CR680
P/O A680A1 VERT GAIN SW
P/O A1150 MAIN MTHR BD
P/O P1162
P/O A1340 RIGHT MTHR BD
P/O MAIN MTHR BRD A1150
P/O RIGHT MTHR BRD A1340
TO A1V A440 ④
FROM P423-1 ③
FROM P423-2 ③
P/O P446
TO L ON ⑤
TO H ON ⑤
P/O MAIN MTHR BRD A1150
P/O P1161
-15V(H)
+15V(V)
SHIELD
Q560
Q535
Q530
Q505
Q500
Q495
Q480
Q465
Q460
U540E
U540A
U540B
U540C
U540D
U510E
U510A
U510B
U510C
U510D
U490E
U490A
U490B
U490C
U490D
U470E
U470A
U470B
U470C
U470D
LIN
LOG
10dB/DIV
2dB/DIV
RIGHT MTHR Bd
MAIN MTHR Bd
TO CR680 & CR684
P/O A680A1
P/O A50

5L4N

5L4N

COMPONENT LOCATIONS
FOR DIAGRAM 5

A580 Detector, Video Filter & Video Amplifier Circuit Board



A1300 Vertical Transverse Interface & Chop Logic Circuit Board

A1150 Main Mother Board component location shown on back of Diagram ⑨

P/O HI/LO IMP & LOG LIN DSPL SEL A50

+15V
LIN
LOG
10dB/DIV
2dB/DIV
P/O A1340 RIGHT MTHR BRD

10dB/DIV
CCW
R6 10K
R14 2.50K CW
POSITION
P/O P1179
P/O P1171
P/O P1164
P/O P1163
P/O A1150 MAIN MTHR BRD
TO +15V
P/O A1340 RIGHT MTHR BRD

R600 200K 10dB REF CAL
R605 200K 2dB REF CAL
R602 249K
R604 249K
R622 750
R606 100K
R608 14.3K
Q600
R630 10.2K
R632 40.2K
C632 390
CR632
CR630

C642 0.01
C640 0.1
R642 1K
R648 120K
R644 1.54K
R646 2.2K
R650 2K
R652 4.02K
R654 4.02K
U650
U640
741C
-15V

P/O RIGHT MTHR BRD A1340
P/O P1163
TO B7, B13 (V)
C1307 0.01μF
TO A7, A13 (V)
R1309 100
TO A14, B14 (V) (REF GND)
P/O A1150 MAIN MTHR BRD
P/O A1300
P/O P1161

FROM PINS U E J ON
P/O RIGHT MTHR BRD A1340
C580 0.01
R580 4.64K
L580 120μH
C582 0.01
R582 464
C584 .0047μF
R581 100
C586 200
R586 10K
R584 62
Q580
R590 33
Q590
Q595
R592 1K
R593 10K
R594 4.7K
C594 0.01

R588 2.2K
R596 10K
R598 3K
C588 0.01
C596 0.1
R599 100
C599 0.1
C610 0.1
-15V

P/O MAIN MTHR BRD A1150
+15V
-15V
R610 402
R614 4.32K
CR614
CR616
R612 402
R616 4.02K
L616 10mH
C616 0.015
C618 0.01
R618 1K
R620 5.6K
U620
741C
C622 .005
R624 16.2K
Q620
C624 0.033
Q625
C626 1μF
C627 0.001
R626 470K
C629 0.001
R628 470K

R634 1.0K
R635 200K
R636 470K
R638 1K
U630
C628 0.01
R660 10K
U660
R662 11.5K
R663 5.1K
R668 470
R664 150K
R666 1K
C666 0.001
Q660
Q665
R667 4.7K

R670 10K
Q670
R656 39K
R672 33K
Q672
Q674
C674 0.1
R676 33K
R678 4.7K
Q675

P/O RIGHT MTHR BRD A1340
P/O P1162
R1164 1K
P/O P1183
VIDEO OUT
R1166 200
P/O A690
A4 (V)
P/O A1300
TO B9 (H)
P/O P1182
R8 10K
CONTRAST
P1181
R1162 15K
R10 1K
BASELINE CLIPPER
P/O A1150 MAIN MTHR BRD

VIDEO FILTER 10 Hz
VIDEO FILTER 300Hz
S1216
S1218
P/O MAIN MTHR BRD A1150
P/O P1164
P/O RIGHT MTHR BRD A1340
C627 0.001
R626 470K
C629 0.001
R628 470K
-15V
FROM R122.8 (MARKER GEN.)
P/O P1163

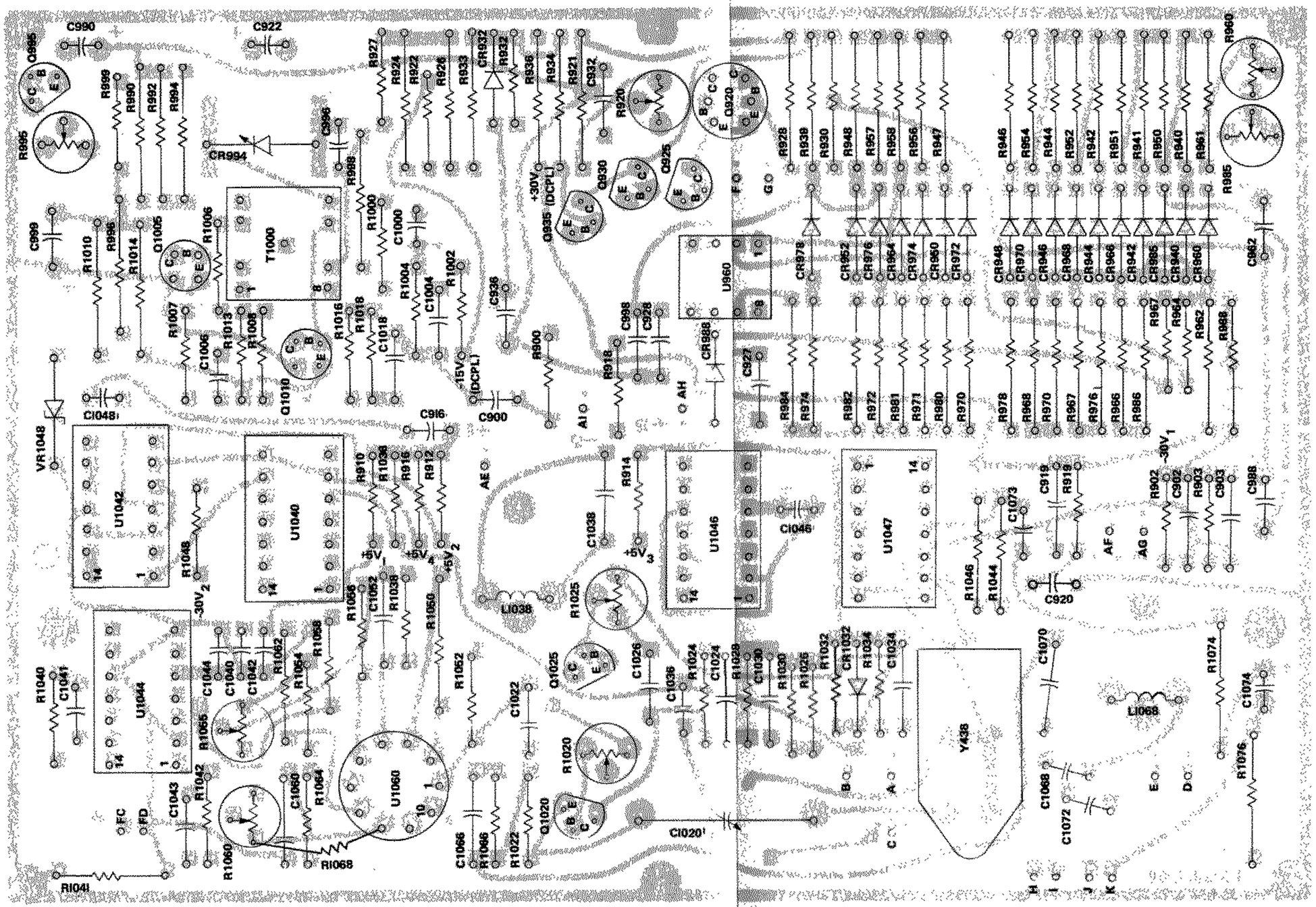
U1305C
U1305A
U1305B
R1308 270
R1306 270
R1307 270
R1305 1K
C1306 .1μF
TO PIN A
U1305
SN7410 156-0047
P/O MAIN MTHR BRD A1150
P/O RIGHT MTHR BRD A1340
P/O P1163
P/O P1310
P/O P1262
P/O A1250
P/O P1311
P/O P1260
P/O A1250
P/O A690
P/O TRANSV INTFC & CHOP LOGIC A1300
P/O DET, VID FILTER & VID AMPL A580
A2 (H&V)
TO DH & DG
B21(H)
A18(H)
A20 (H)
B19 (V)
A19 (V)

5L4N

DET, VID FILTER & VID AMPL 5

SS 574

DET VID FLTR & VID AMPL 5



A900 Shaper, LO, Tracking Generator & Calibrator

A1150 Main Mother Board component location shown on back of Diagram 9

COMPONENT LOCATIONS FOR DIAGRAM 6

SHAPER, L O, TRACKING GEN, CALIBRATOR ◇6

SS 474

SHIELD

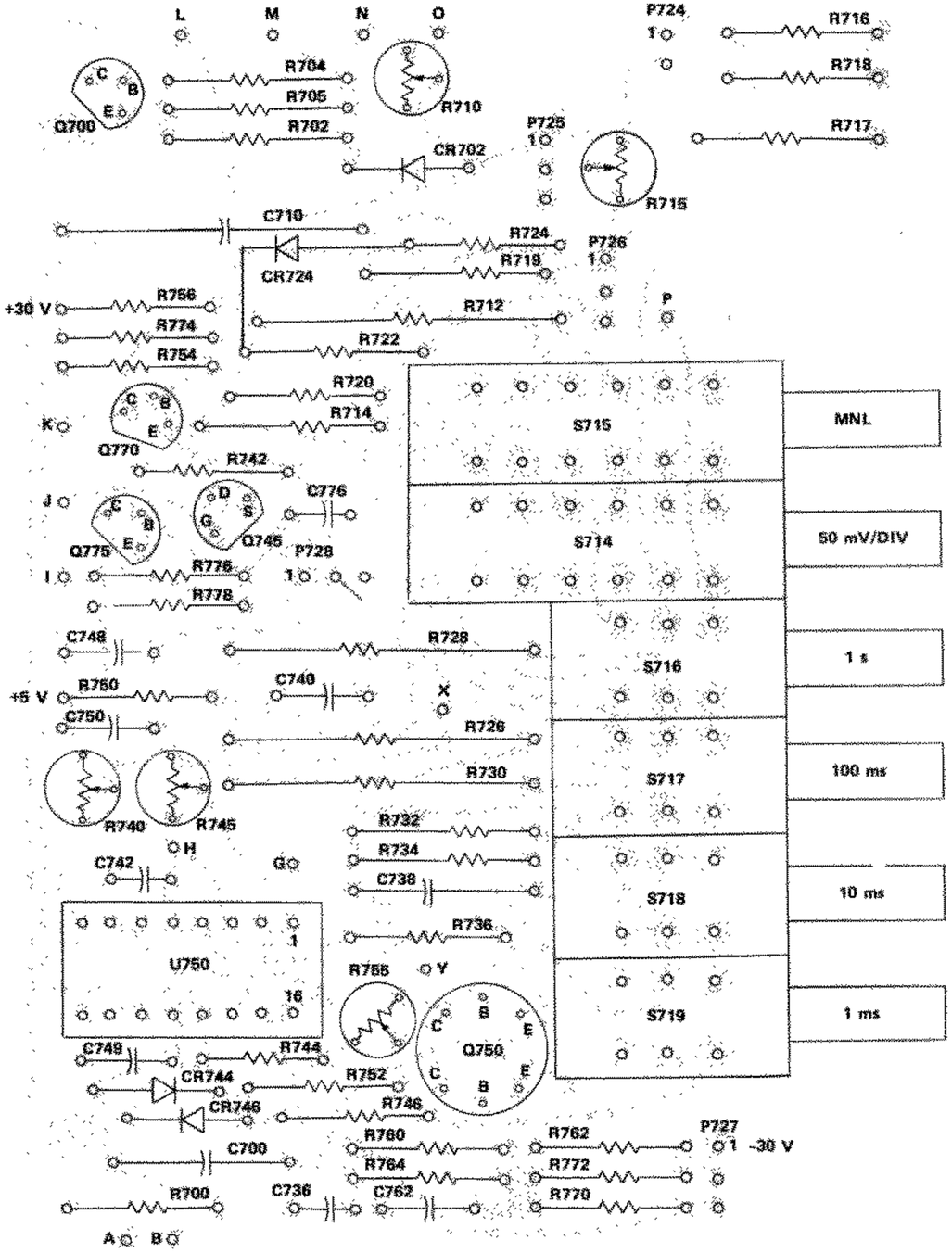
TEST JUMPER

P/O A1340 RIGHT MTHR B&D

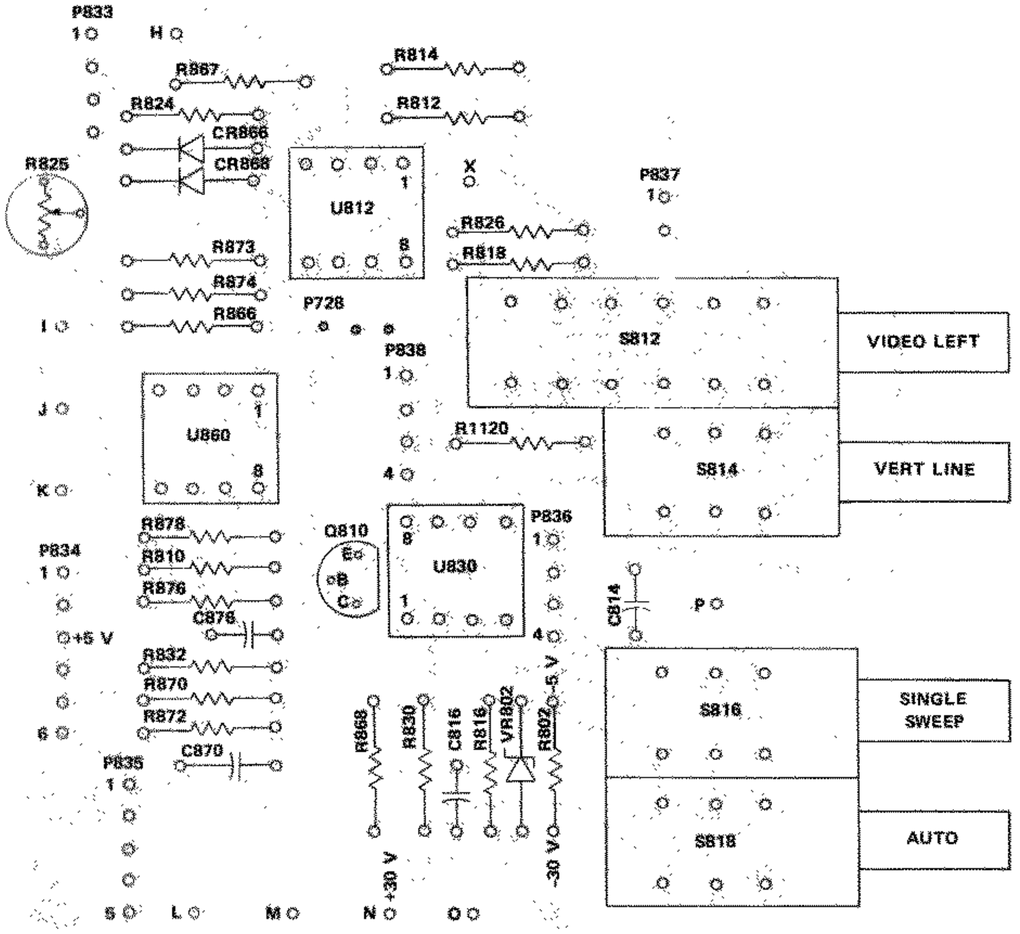
P/O A1150 MAIN MTHR B&D

P/O A900 (SHAPER, LO, TRK GEN & CAL)

5L4N



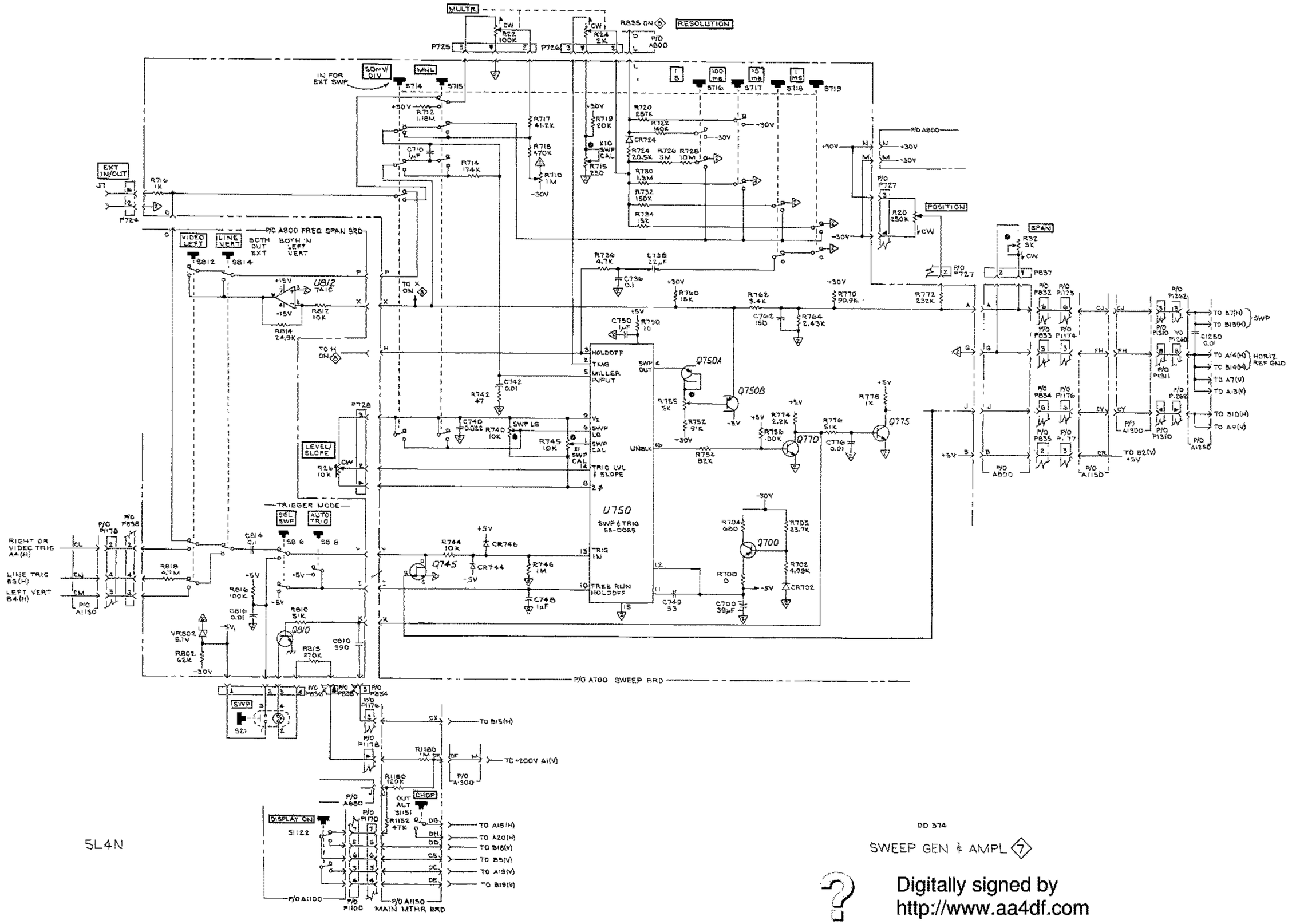
A700 Sweep Generator & Amplifier Circuit Board



P/O A800 Frequency Span Selector, Trigger Mode & Source Selector Circuit Board

A1150 Main Mother Board component location shown on back of Diagram ⑨

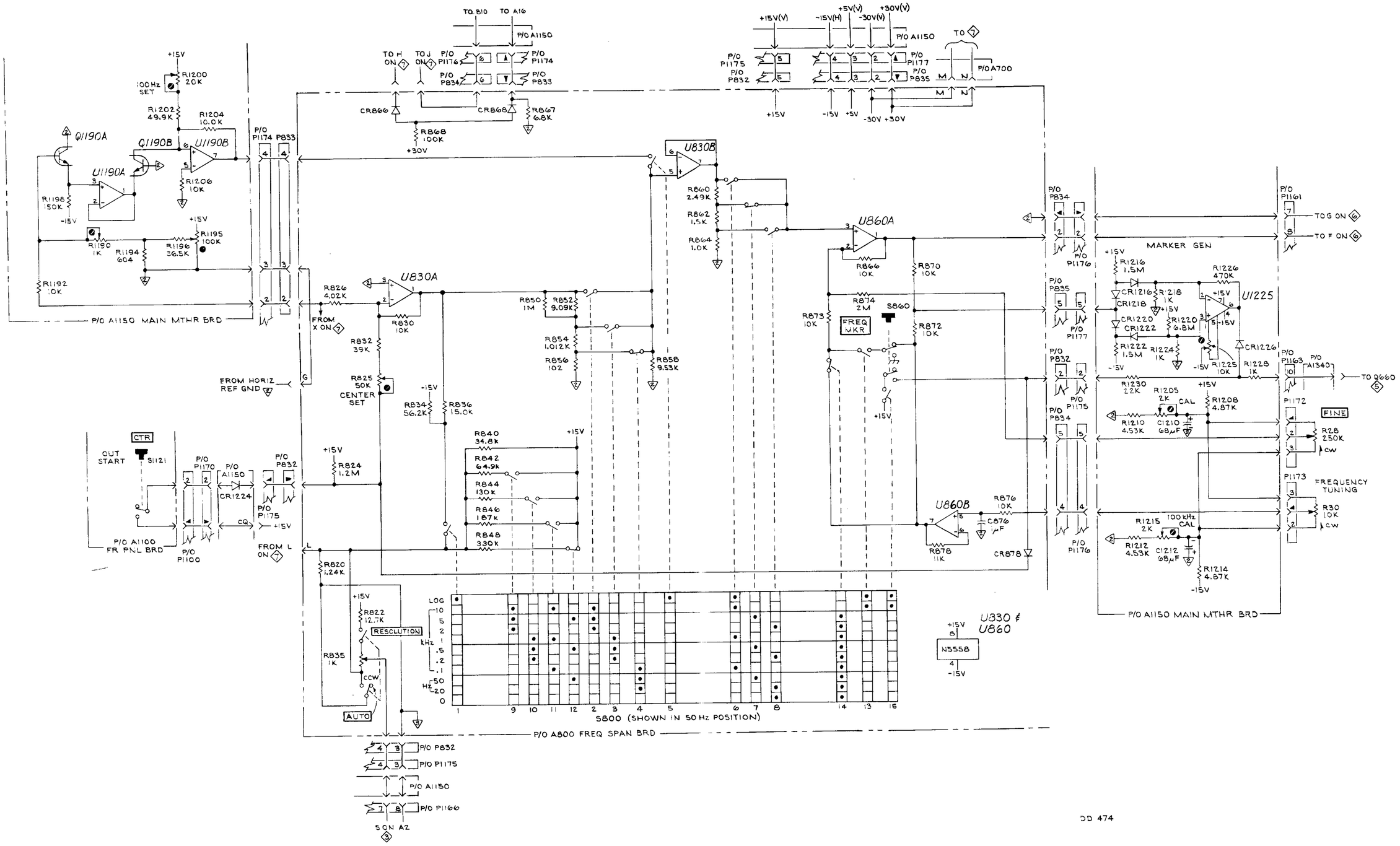
COMPONENT LOCATIONS FOR DIAGRAM 7



5L4N

DD 374

SWEEP GEN & AMPL 7

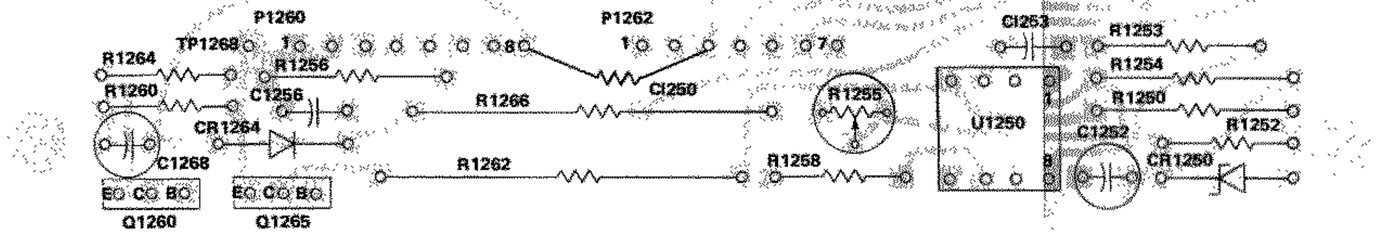


DD 474

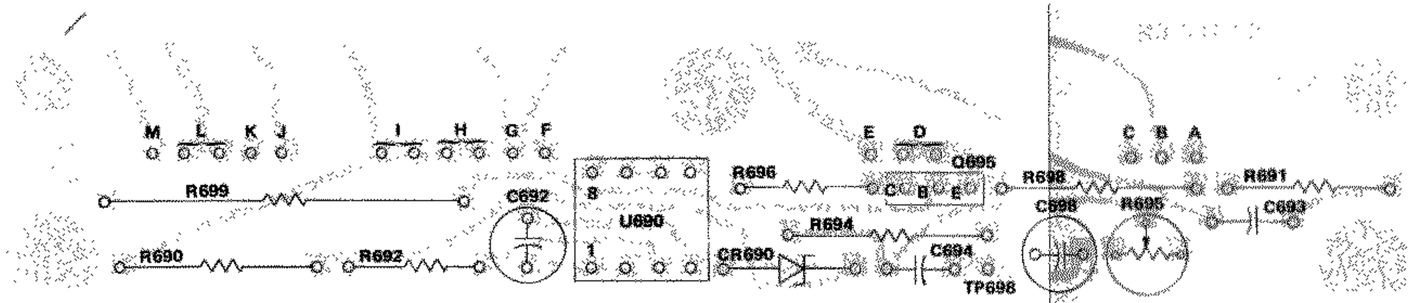
5L4N

FREQ SPAN, MARKER GEN & FREQ TUNING 8

5L4N

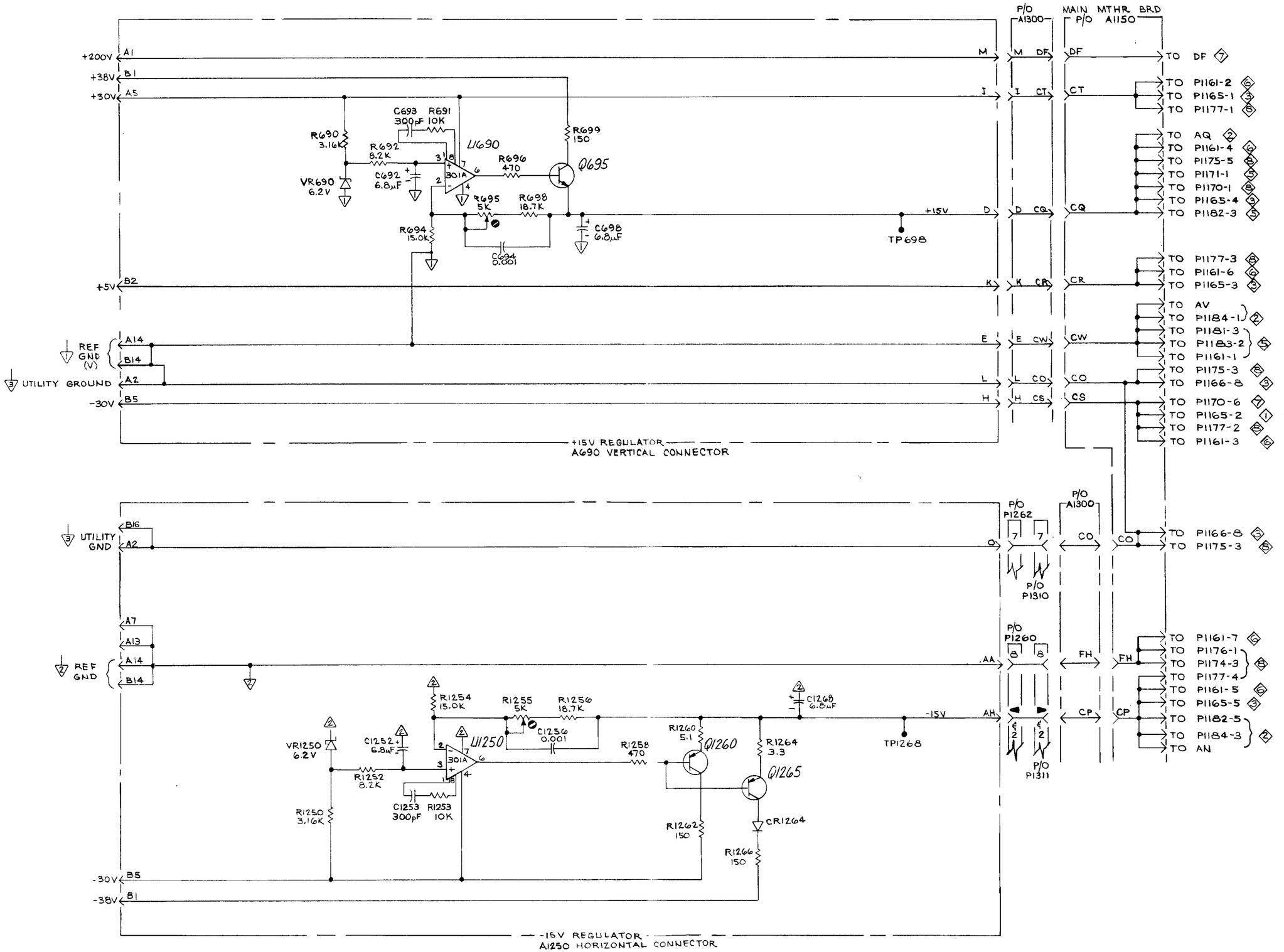


A690 Vertical Interface & +15 V Supply



A1250 Detector Video Filter & Video Amplifier Circuit Board

FOR DIAGRAM 9

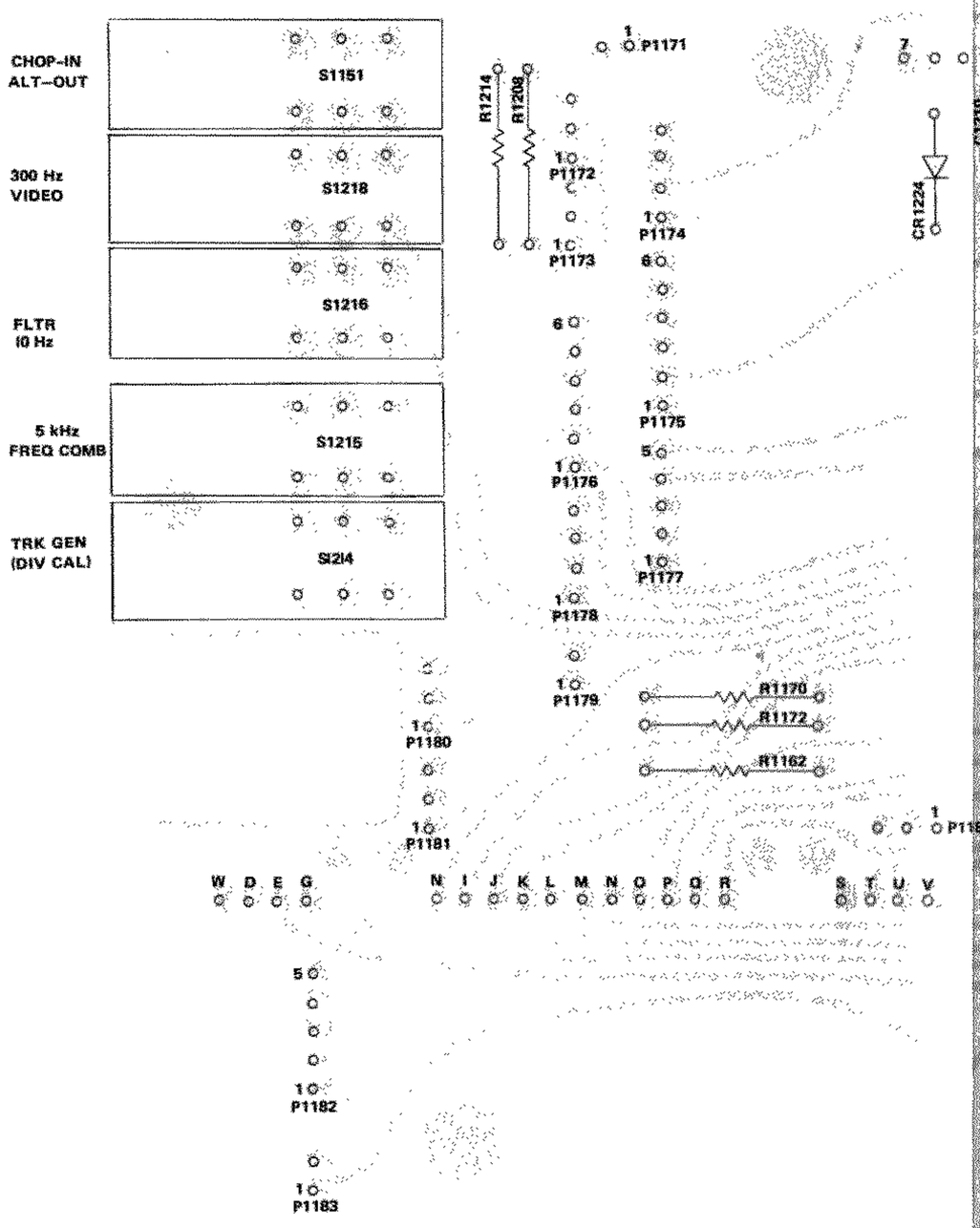


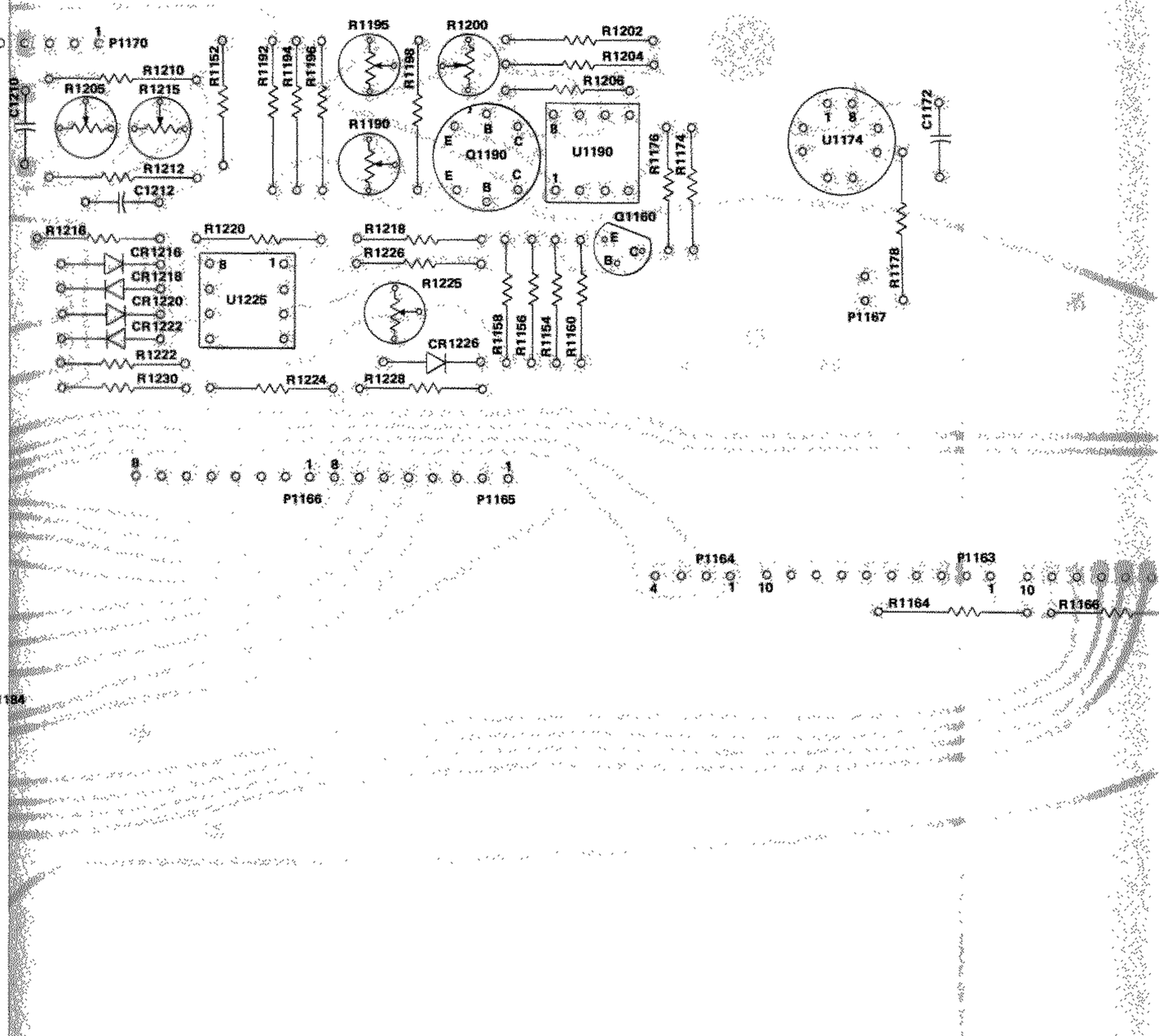
5L4N

+15V & -15V REGULATORS & POWER DISTRIBUTION 9

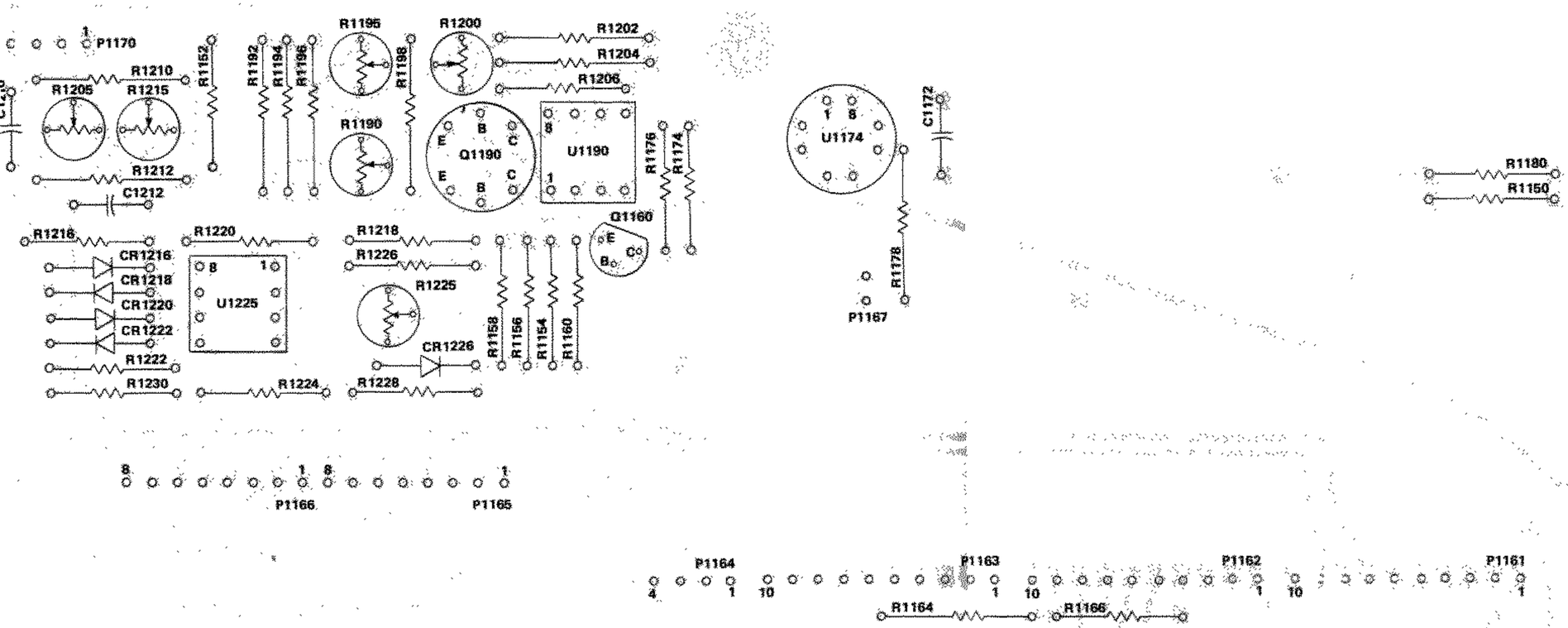
SS 474

5L4N

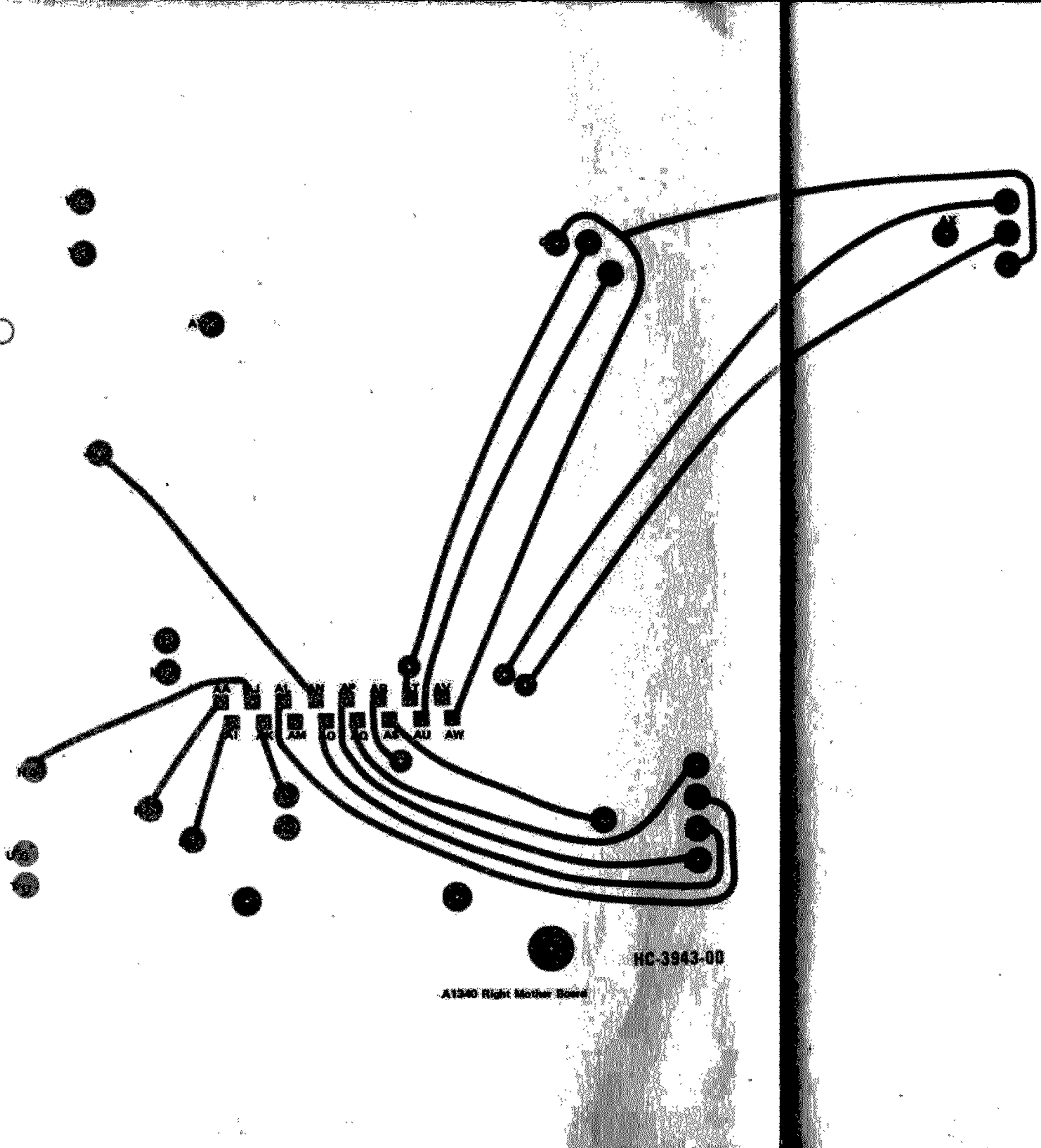




A1150 Main Mother, Frequency Tuning & Log Span Amplifier Circuit Board



A1150 Main Mother, Frequency Tuning & Log Span Amplifier Circuit Board



A1340 Right Mother Board

A1320 Left Mother Board

COMPONENT LOCATION FOR
A1320 & A1340

5L4N

INTERCONNECT CHART

FRONT PANEL	Display-Start Center Selector	Vertical Interface & +15 V Supply	Variable Resolution	Input Amplifier, LP Filter, Mixer & 250 kHz IF	Left Mother Board	Hi/Lo Input Impedance & LOG Display Selector	Display Selector (LOG–LIN)	Vertical Sensing Selector	Vertical Transverse Interface & Chop Logic	Main Mother, Frequency Tuning & Log Span Amplifier	Horizontal Transverse Interface & Chop Logic	Right Mother Board	Shaper, LO, Tracking Generator & Calibrator	Display Function Amplifier	Detector, Video Filter & Video Amplifier	Horizon Interfac -15 V No
	A1100	A690	A300	A100	A1320	A50	A680A2	A680A1	A1300	A1150	A1300	A1340	A900	A440	A580	A12

BASELINE CLIPPER R10

VIDEO OUT J8

AMPL. CAL R4

POSITION R14

CONTRAST R8

INPUT ENC J15

VERT REF GND

UTILITY GND

+15V

+5V

P1100-6

-30V

P1100-7

P1100-1

P64-1

P64-2

P64-3

P63-1

P63-3

P63-2

LOG/LIN VAR R685

P1311-H2

P1311-3

P1311-7

P1310-1

P1310-2

P1310-7

P1260 J

P1260 K

P1260 L

P1260 M/N

P1260 P/R

P1260 S/T

P1260 U/V

P1260 W/X

P1260 Y/Z

P1260 AA/AB

P1260 AC/AD

P1260 AE/AF

P1260 AH/AJ

P1260 AK/AL

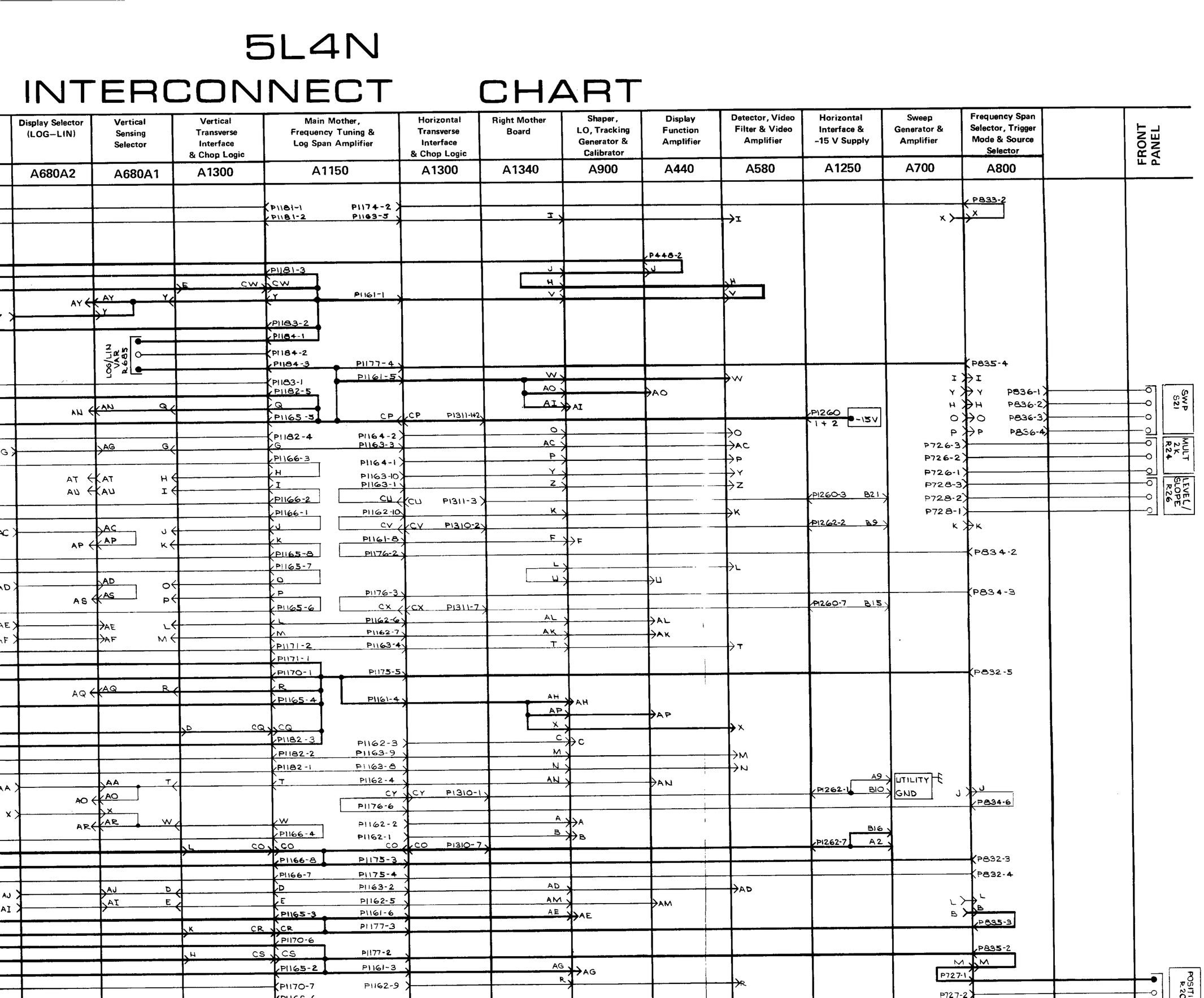
P1260 AM/AN

P1260 1+2

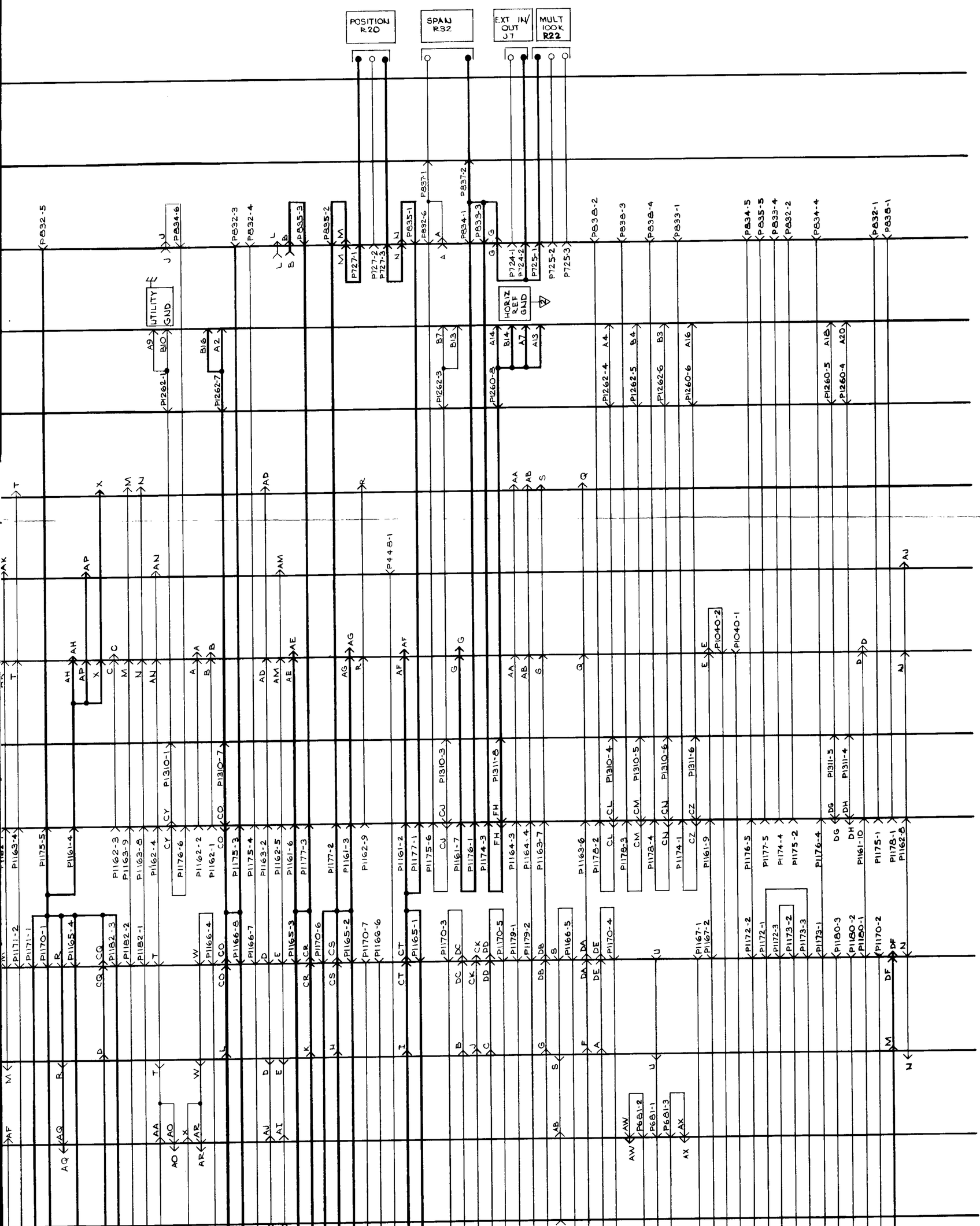
5L4N

INTERCONNECT CHART

Display Selector (LOG–LIN)	Vertical Sensing Selector	Vertical Transverse Interface & Chop Logic	Main Mother, Frequency Tuning & Log Span Amplifier	Horizontal Transverse Interface & Chop Logic	Right Mother Board	Shaper, LO, Tracking Generator & Calibrator	Display Function Amplifier	Detector, Video Filter & Video Amplifier	Horizontal Interface & -15 V Supply	Sweep Generator & Amplifier	Frequency Span Selector, Trigger Mode & Source Selector		FRONT PANEL
A680A2	A680A1	A1300	A1150	A1300	A1340	A900	A440	A580	A1250	A700	A800		




POSITION R14
CONTRAST R8
INPUT BNC J5
UTILITY GND
10dB/DIV R6
LOG/LIN NEONS
TG/CAL OUT 600Ω
FINE R28
FREQ R30
CAL R3
+15V
+5V
-30V
+30V
+200V
P1100-1
P1100-7
P1100-3
P1100-5
P1100-4
P1100-2
P423-1
P216-2
P216-1
P448-1
P1040-2
P1040-1


POSITION R20
SPAN R32
EXT IN/ OUT J7
MULT 100K R22
HORIZ REF GND
UTILITY GND
P832-5
P834-6
P832-3
P832-4
P835-3
P835-2
P727-1
P727-2
P727-3
P835-1
P832-6
P837-1
P834-1
P833-3
P837-2
P724-1
P724-2
P725-1
P725-2
P725-3
P838-2
P838-3
P838-4
P833-1
P834-5
P835-5
P833-4
P832-2
P834-4
P832-1
P838-1
P1262-1
P1262-7
P1262-3
P1260-8
P1262-4
P1262-5
P1262-6
P1260-6
P1260-5
P1260-4
P1171-2
P1171-1
P1170-1
P1165-4
P1175-5
P1161-4
P1163-4
P1162-3
P1163-9
P1163-8
P1162-4
P1310-1
P1176-6
P1162-2
P1162-1
P1310-7
P1175-3
P1175-4
P1163-2
P1162-5
P1161-6
P1177-3
P1170-6
P1177-2
P1165-2
P1161-3
P1162-9
P1170-7
P1166-6
P1161-2
P1177-1
P1165-1
P1175-6
P1310-3
P1161-7
P1176-1
P1174-3
P1311-6
P1164-3
P1164-4
P1163-7
P1179-1
P1179-2
P1170-5
P1170-3
P1166-5
P1163-6
P1178-2
P1310-4
P1178-3
P1310-5
P1178-4
P1310-6
P1174-1
P1311-6
P1161-9
P1040-2
P1040-1
P1172-2
P1176-5
P1177-5
P1174-4
P1175-2
P1173-2
P1173-3
P1176-4
P1311-5
P1180-3
P1311-4
P1180-2
P1161-10
P1180-1
P1175-1
P1178-1
P1162-8
P1170-2
P681-2
P681-1
P681-3
P1166-4
P1162-2
P1162-1
P1166-8
P1166-7
P1163-2
P1162-5
P1161-6
P1177-3
P1161-2
P1177-1
P1165-1
P1170-3
P1167-1
P1167-2
P1172-2
P1172-1
P1173-1
P1180-3
P1180-2
P1180-1
P1170-2
P1175-1
P1178-1
P1162-8
P448-1