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Technical Document 369

VLF/LF ATMOSPHERIC NOISE RECORDER:

Theory, operation, and maintenance

RK Cernius

25 July 1980

Final Report: February 1979 to July 1980

Approved for public release; distribution unlimited

NAVAL OCEAN SYSTEMS CENTER
SAN DIEGO, CALIFORNIA 92152

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

An analog noise recording system is described which is capable of 80-dB dynamic range recording and playback of vlf/lf noise phenomena in bandwidths up to 3 kHz.

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OBJECTIVE

To develop and test a vlf/lf atmospheric noise recorder that will permit recording and reproducing impulse noise with an 80-dB dynamic range for a noise bandwidth of up to 3 kHz.

RESULTS

A noise recording system using compression/expansion circuitry to overcome the inherent dynamic range limitation of analog magnetic tape recorders is capable of recording and playback of wide dynamic range noise processes. Field data show the system is capable of high fidelity recording and playback of band limited vlf/lf noise.

RECOMMENDATIONS

It is recommended that the vlf/lf noise recording system be used for testing vlf/lf communication and navigation systems whenever true performance in time variant atmospheric noise is desired. There are presently no other known approaches for atmospheric noise performance testing that can reproduce the temporal characteristics of vlf/lf atmospherics as can this system.

CONTENTS

CONTENTS (Continued)

INTRODUCTION

The vlf/lf atmospheric noise recorder consists of a noise processor and an auxiliary high quality analog tape recorder. The noise processor, with the specifications listed in table 1, when combined with a high quality tape recorder, will permit recording and reproducing impulse noise with an 80-dB dynamic range in a noise bandwidth of 1 to 3 kHz.

The frequency range of the noise recorder is 10 kHz to 60 kHz. It consists of a noise processor containing four identical parallel channels contained in a rack-mounted chassis, a variable frequency bandpass filter unit tape recorder in a second chassis, and a high quality analog magnetic tape recorder. (See figure 1.) The basic relationships of the functional sections of the atmospheric noise recorder are shown in figure 2 and are described in the following paragraphs.

The noise recorder is intended to be connected to the output of an antenna preamplifier. Two sets of plug-in fixed frequency bandpass filters (14.8 kHz and 28.5 kHz) are provided. These two filter sets may be used in any of the four channels. The variable filter (10–60 kHz) may be used in any channel which does not contain a set of fixed filters. The fourth channel is provided as a spare.

The gain of each channel may be independently varied by means of gain and attenuator switches located on the front panel. Light emitting diode (LED) indicators, located on the front panels of the processor and the variable filter, provide a visual indication of signal saturation at specific points within each channel.

A four-digit front panel indicator, shared among the four channels, provides a measure of the percentage of time the input signal exceeds a predetermined amplitude threshold.

The variable frequency bandpass filter is tuned by means of front panel rotary switches. Any frequency in the 10-kHz to 60-kHz band can be selected, with a resolution of 1 kHz. Pre- and postfilter variable gain switches are also contained on the front panel of the filter.

The magnetic analog tape recorder can be any high quality device such as the Honeywell Model 101.

SPECIFICATIONS

Table 1 contains the noise processor specifications.

DESCRIPTION OF NOISE PROCESSOR

OVERALL FUNCTIONAL DESCRIPTION

The noise processor consists of five major sections:

1. Amplifier-filter
2. Overload detector-indicator
3. Compressor
4. Expander
5. Threshold detector indicator

Table 1. Noise processor specifications.

Number of Channels:	Four parallel channels, one at each of the following frequencies: 14.8 kHz, 28.5 kHz and 10 kHz to 60 kHz (variable). One of the four channels is a spare.
Filter Characteristics:	14.8 kHz: −3 dB BW = 1.5 kHz −30 dB BW < 3 kHz 28.5 kHz: −3 dB BW = 2.9 kHz −30 dB BW < 6 kHz Variable: 10–60 kHz, variable BW, minimum BW is 10% of center frequency.
Maximum Gain: (from preamp input to compressor input)	85 dB (does not include variable filter gain)
Gain Control:	80 dB in 2-dB steps
Input Impedance:	Greater than 300 ohms
Noise Figure:	Less than 5 dB in vlf band operating from a 50-ohm source with fixed filters and maximum preamp gain.
Compressor:	Compresses 80-dB range signal into 40 dB for recording; maximum output level 1.6 V rms across 1 k shunted by 200 pF.
Expander:	Expands 40-dB range reproduce signal into 80 dB for playback; maximum output level 3.5 V rms across 1 k shunted by 1000 pF.
Linearity:	80 dB (maximum compression 1 dB) for each recorded and expanded channel within 10- to 30-kHz band.
Indicators:	Contains front panel 4-digit readout which displays percent exceedance information on a selected channel. Contains front panel LED indicators which flash when signal saturation occurs at any point within the channel amplifiers.
Power:	115 V ac ±10%, 47–420 Hz, less than 0.5 A.
Dimensions:	5.25"×19"×19" (H×W×D) rack mountable, less than 25 pounds.
Variable Filter:	Rockland Model 751A; see separate instruction manual for specifications on this unit.

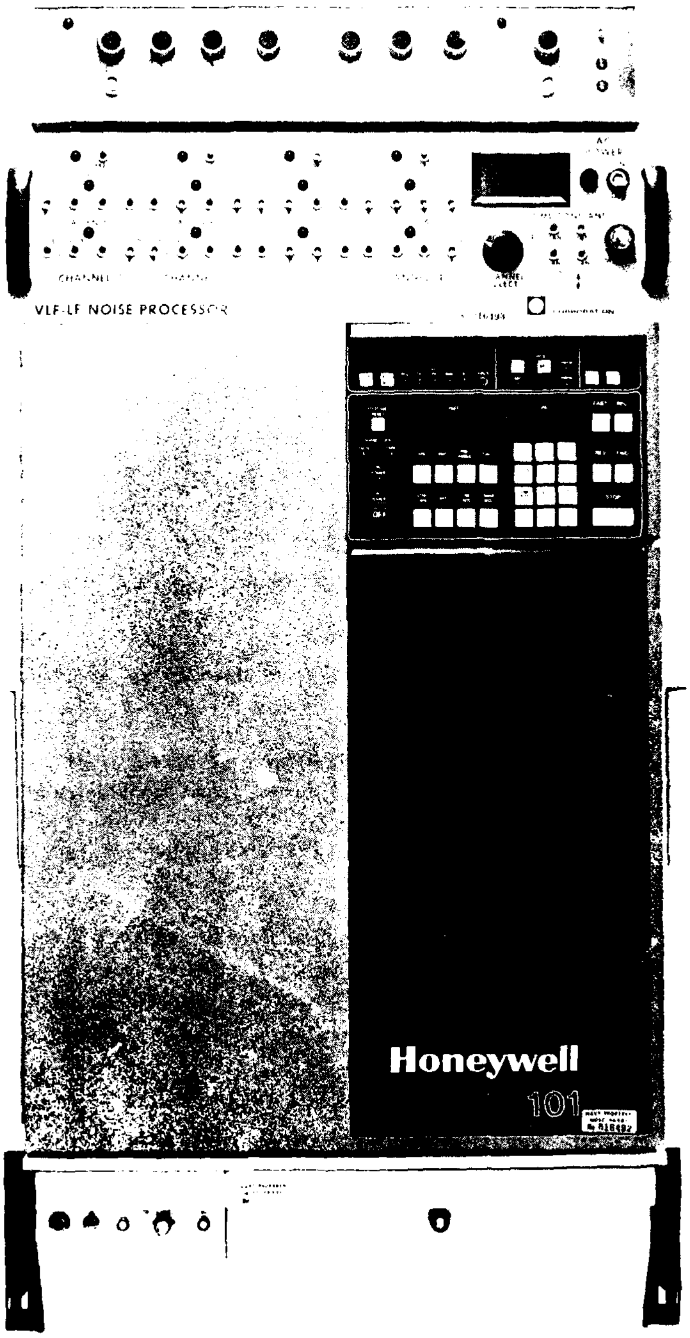


Figure 1. VLF/LF atmospheric noise recorder.

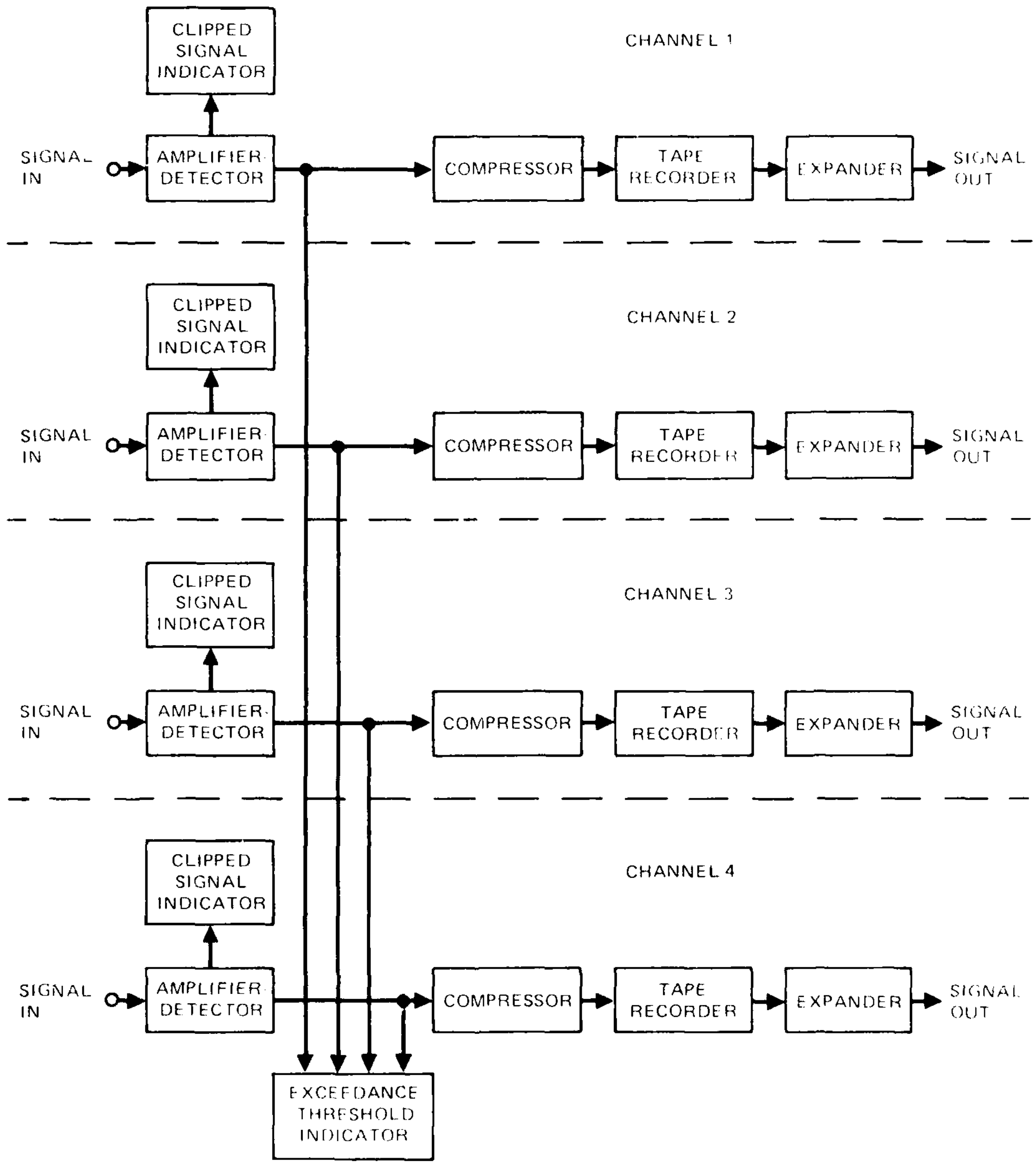


Figure 2. Atmospheric Noise Recorder block diagram.

AMPLIFIER-FILTER

The amplifier-filter section provides frequency selective gain for the noise bands of interest. The gain of each channel may be independently set for the conditions peculiar to that channel. Frequency selection is achieved through the use of bandpass filters. Two sets of plug-in fixed frequency filters (14.8 kHz and 28.5 kHz) are provided. These sets may be used in any of the four channels. The variable filter (10–60 kHz) may be used in any channel which does not contain a set of fixed filters.

OVERLOAD DETECTOR-INDICATOR

LED indicators are used to warn the operator when an overload condition exists due to excessive signal amplitude. Three points are monitored in each channel. In addition, the variable filter contains similar indicators to monitor the input and output signal levels.

COMPRESSOR

Prior to recording, the noise signals are conditioned by the compressor to reduce the dynamic range. A compression ratio of 2:1 is used. Thus, an input signal with an 80-dB dynamic range will be changed to a signal with a 40-dB dynamic range at the output of the compressor. This action produces a signal whose dynamic range is compatible with a good quality instrumentation type analog magnetic tape recorder.

EXPANDER

After playback by the tape recorder the signal is expanded to its original dynamic range in the expander.

THRESHOLD DETECTOR-INDICATOR

The percent of time that the compressor input signal level exceeds a threshold level is indicated on a 4-digit display. The time constant associated with this measurement is selected by a front panel switch, TIME CONSTANT. A second switch, CHANNEL SELECT, permits the EXCEEDANCE THRESHOLD indicator to be switched among the four channels.

CIRCUIT DESCRIPTION

The following paragraphs provide a discussion of the functional areas of the noise processor at a simplified circuit level. The simplified circuits described in these paragraphs correspond to the associated detailed schematic diagrams included in appendix A of this report.

Component reference designators mentioned in the text identify the component on the simplified circuit drawings and on the schematic diagrams. The reference designators for integrated circuits containing two or more gates or functions are presented in the text with a numeric suffix. This suffix corresponds to an integrated circuit pin of the particular gate or function. For example, the reference designator U6-11 identifies integrated circuit number 6 and the specific gate or function associated with pin 11.

AMPLIFIER-FILTER

See figure 3 and figure A-1 and A-2 (in appendix A) for an overview of the noise processor preamplifier and filter circuitry.

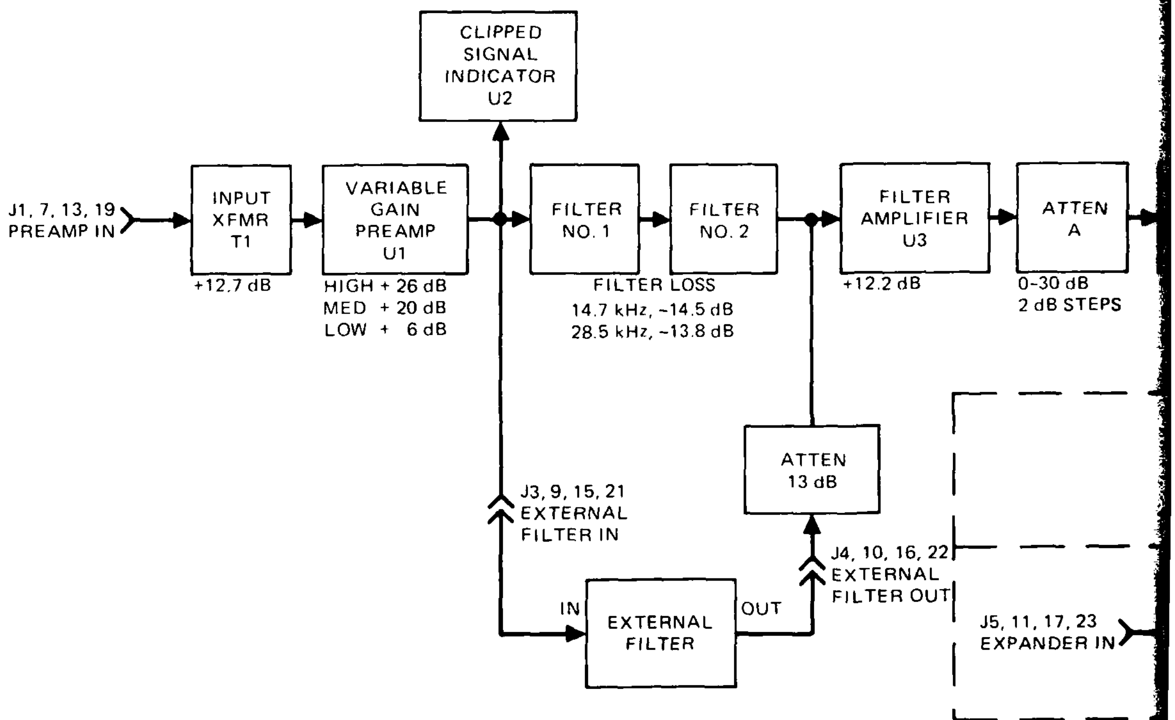
Preamplifier Circuitry. The input signal is transformer coupled, T1, to the preamplifier, U1. T1 is a step-up transformer and provides a voltage gain of about 12.7 dB to 13 dB depending upon frequency and preamplifier gain setting. The input impedance varies from about 350 ohms at 10 kHz to about 700 ohms at 60 kHz. The preamplifier gain is controlled by a front panel switch labeled PREAMP GAIN. This switch has three positions. These positions and the resultant preamplifier gains are: HIGH = +26 dB gain, MED = +20 dB gain, and LOW = +6 dB gain. The maximum preamplifier output with no clipping is about 7 V rms or 20 V peak-to-peak. The output of the preamplifier is fed to three places: a clipped signal indicator, a fixed frequency bandpass filter connector, and a rear panel BNC connector labeled EXTERNAL FILTER IN.

Fixed Frequency Bandpass Filters. Two sets of fixed frequency bandpass filters are provided with the processor. These filters are tuned to 14.8 kHz and 28.5 kHz. Figure 4 shows the response of the 14.8-kHz filter set. Figure 5 shows the response of the 28.5-kHz filter set. Each filter set consists of two cards. Each card contains a filter. When installed in the processor the filters are placed in series to increase the selectivity. The filter cards are clearly marked and should be used as a set. The order in which the filters are placed in the filter connectors is not important. Either filter card can be placed in either connector. The combined loss of the 14.8-kHz filter pair is about −14.5 dB at 14.8 kHz. The combined loss of the 28.5-kHz filter pair is about −13.8 dB at 28.5 kHz. The output of the filter pair is presented to the filter amplifier, U3. A schematic diagram of the bandpass filter is shown in appendix A, figure A-2.

Variable Frequency Bandpass Filter. A variable frequency bandpass filter is provided for those cases when noise at frequencies other than 14.8 kHz or 28.5 kHz is to be recorded. The filter is a Rockland Model 751A. Its characteristics are covered in a separate manual. For best selectivity the low pass cutoff frequency and the high pass cutoff frequency should be set to the same frequency. For this condition the resultant Q is about 10, and the response curve of figure 6 may be used to estimate the filter selectivity. Only one kind of filter should be used in a given channel at one time. If a fixed frequency filter set is to be used in a particular channel, the variable frequency filter should be removed from that channel.

The output of the variable frequency filter is attenuated by about 13 dB and then is applied to the filter amplifier, U3. The attenuator is used to insure that the maximum rated output of the variable frequency filter does not saturate the filter amplifier. The maximum rated output of the filter is 7 V rms.

Filter Amplifier. The filter amplifier, U3, provides about 12 dB of gain for the filter output signal. The maximum filter amplifier output is 7 V rms.


CLIPPED SIGNAL INDICATOR U2
J1, 7, 13, 19 PREAMP IN
INPUT XFMR T1
+12.7 dB
VARIABLE GAIN PREAMP U1
HIGH + 26 dB
MED + 20 dB
LOW + 6 dB
FILTER NO. 1
FILTER NO. 2
FILTER LOSS
14.7 kHz, ~14.5 dB
28.5 kHz, ~13.8 dB
FILTER AMPLIFIER U3
+12.2 dB
ATTEN A
0-30 dB
2 dB STEPS
ATTEN 13 dB
J3, 9, 15, 21 EXTERNAL FILTER IN
J4, 10, 16, 22 EXTERNAL FILTER OUT
IN
EXTERNAL FILTER
OUT
J5, 11, 17, 23 EXPANDER IN

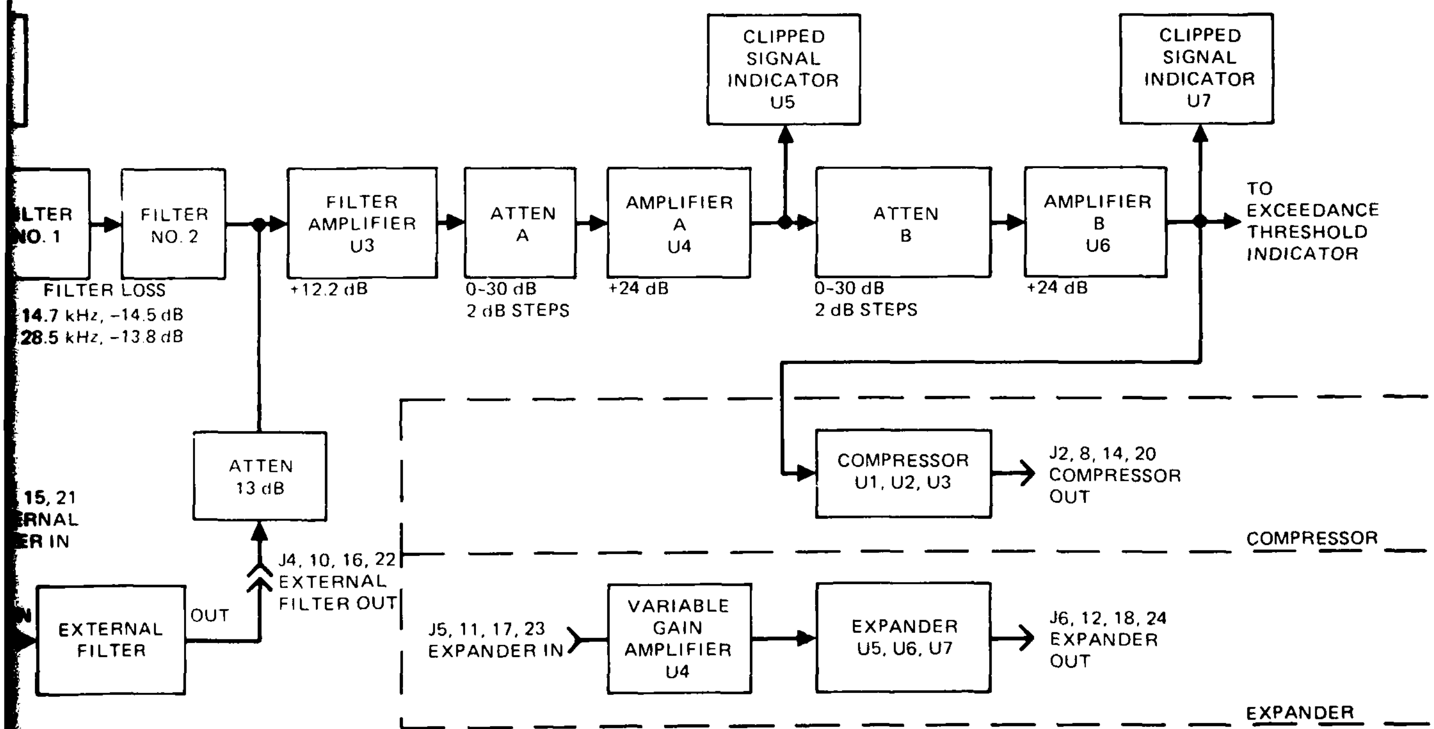


Figure 3. Amplifier-detector, compressor, and expander block diagram.

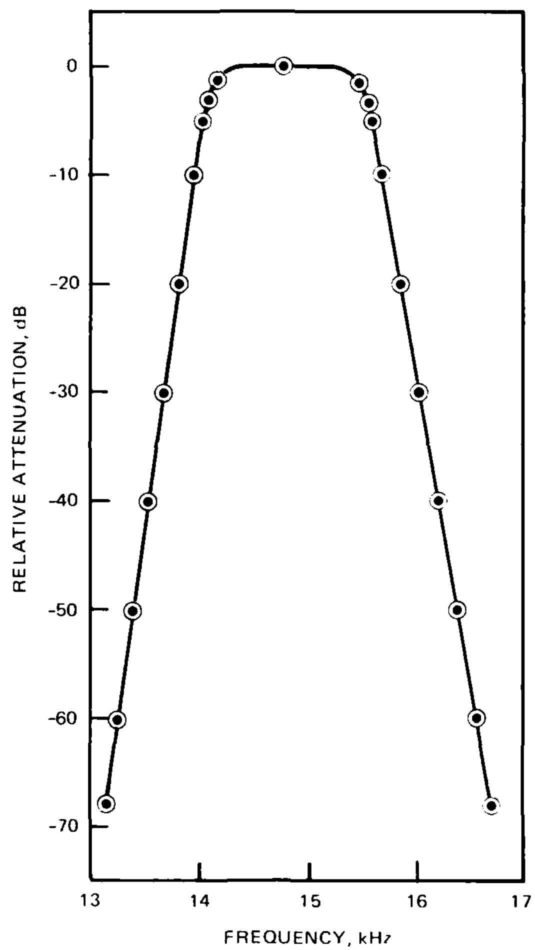


Figure 4. 14.8-kHz filter response.

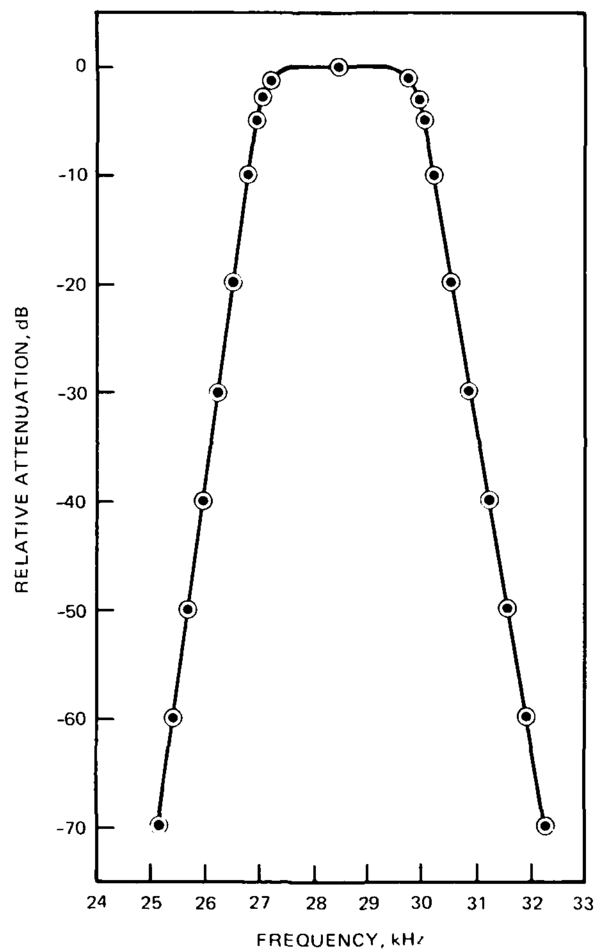


Figure 5. 28.5-kHz filter response.

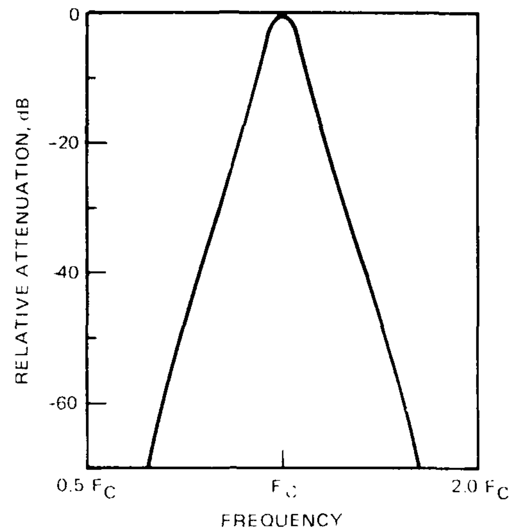


Figure 6. Rockland Model 751A
filter response.

Attenuators. Two identical attenuators, A and B, are provided for each channel. Each attenuator controls the signal level over a range of 30 dB in 2-dB steps. The total attenuation is equal to the sum of the individual switch attenuations. These are marked on the front panel above each switch. An attenuator is placed in the circuit when its switch handle is in the UP position. A schematic of the attenuators is shown in appendix A, figure A-3.

Amplifier A and Amplifier B. These two amplifiers are identical. Each provides 24 dB of gain. Amplifier A, U4, follows attenuator A and amplifier B, U6, follows attenuator B. Each amplifier is capable of providing a maximum output of 7 V rms, although the circuit which follows amplifier B limits its useful output to 3.5 V rms.

OVERLOAD DETECTOR-INDICATOR

See figures 3, A-1, and A-4 for an overview of the overload detector indicator circuitry.

The output signal levels of the preamplifier (U1), amplifier A (U4), and amplifier B (U6) are compared against fixed voltage levels equal to the maximum rated outputs of these circuits. If the output level of any of the three amplifiers exceeds the maximum rated output a front panel LED is illuminated, indicating an overload condition. Voltage comparators U2, U5,and U7 are the overload detectors for the preamplifier, amplifier A, and amplifier B, respectively. The reference voltage levels for U2 and U5 are +10 volts. The reference voltage level for U7 is +5 volts, as this is the maximum signal level that the compressor circuit can accommodate. The detectors respond to positive overloads only. It is assumed that a large negative signal excursion will be either preceded or followed by a large positive excursion.

The outputs of the voltage comparators are applied to monostable (one-shot) multivibrators, figure A-4. These multivibrators are used to stretch the overload pulses so that the flashing LED is easily discernible. The output pulsewidth of each multivibrator is about 50 milliseconds. In figure A-4, U1 and one-half of U2 are used for channel 1, the other halves of U2 and U3 are used for channel 2, U4 and one-half of U5 are used for channel 3, the other halves of U5 and U6 are used for channel 4.

COMPRESSOR

See figures 7, 8, and A-5 for an overview of the compressor circuitry.

The compressor uses an amplifier with a controlled variable gain to compress the dynamic range of the input signal so that the dynamic range of the output signal is one-half of the dynamic range of the input. Thus, a noise signal with an 80-dB dynamic range is reduced to a signal with 40-dB dynamic range which is much more easily handled by an analog magnetic tape recorder. Figure 7 illustrates the action of the compressor on the input signal. The maximum input signal to the compressor should be limited to 3.5 V rms or +13 dB relative to 0.775 V rms. If the input signal level is 3.5 V rms the compressor output signal level will be 1.64 V rms or +6.5 dB relative to 0.775 V. This is indicated in figure 7. Similarly, an input signal of 7.75 mV rms, or −40 dB relative to 0.775 V rms will produce an output of 77.5 mV rms or −20 dB relative to 0.775 V rms.

A simplified diagram of the compressor is shown in figure 8. In the compressor, the output signal is rectified and averaged and used to control the variable gain cell. The variable gain cell controls the overall gain of the amplifier. The compressor is designed so that an input signal of 0.775 V rms is not affected by the compressor (gain of unity). Input signals greater than 0.775 V rms are attenuated and input signals less than 0.775 V rms are amplified. If the input signal level decreases by 6 dB, the output of the compressor will start to decrease. This will cause the overall gain of the amplifier to increase by 3 dB, resulting in a net decrease of 3 dB in the compressor output signal level.

In figure A-5, the rectifier and variable gain cell are contained within U1. U2 is the amplifier and U3, in conjunction with C11, is used to average the output of the rectifier so that the gain control varies smoothly with signal level.

EXPANDER

See figures 7, 9 and A-5 for an overview of the expander circuitry.

The expander is a variable gain amplifier used to expand the dynamic range of its input signal so that the dynamic range of the output signal is twice the dynamic range of the input. Thus, the dynamic range of an input signal is increased from 40 dB to 80 dB at the output. Figure 7 illustrates the effect of the expander on signals applied to its input. The maximum input signal to the expander should be limited to 1.64 V rms or +6.5 dB relative to 0.775 V rms. An expander input signal of 77.5 mV rms or −20 dB relative to 0.775 V rms will produce an output of 7.75 mV rms or −40 dB relative to 0.775 V rms.

A simplified diagram of the expander is shown in figure 9. The variable gain element is placed at the input of the amplifier rather than in the feedback loop as is done in the compressor. The input signal is rectified and averaged and used to control the variable gain cell. The variable gain cell controls the overall gain of the amplifier. The expander is designed so that an input signal of 0.775 V rms is not affected by the expander (gain of unity).

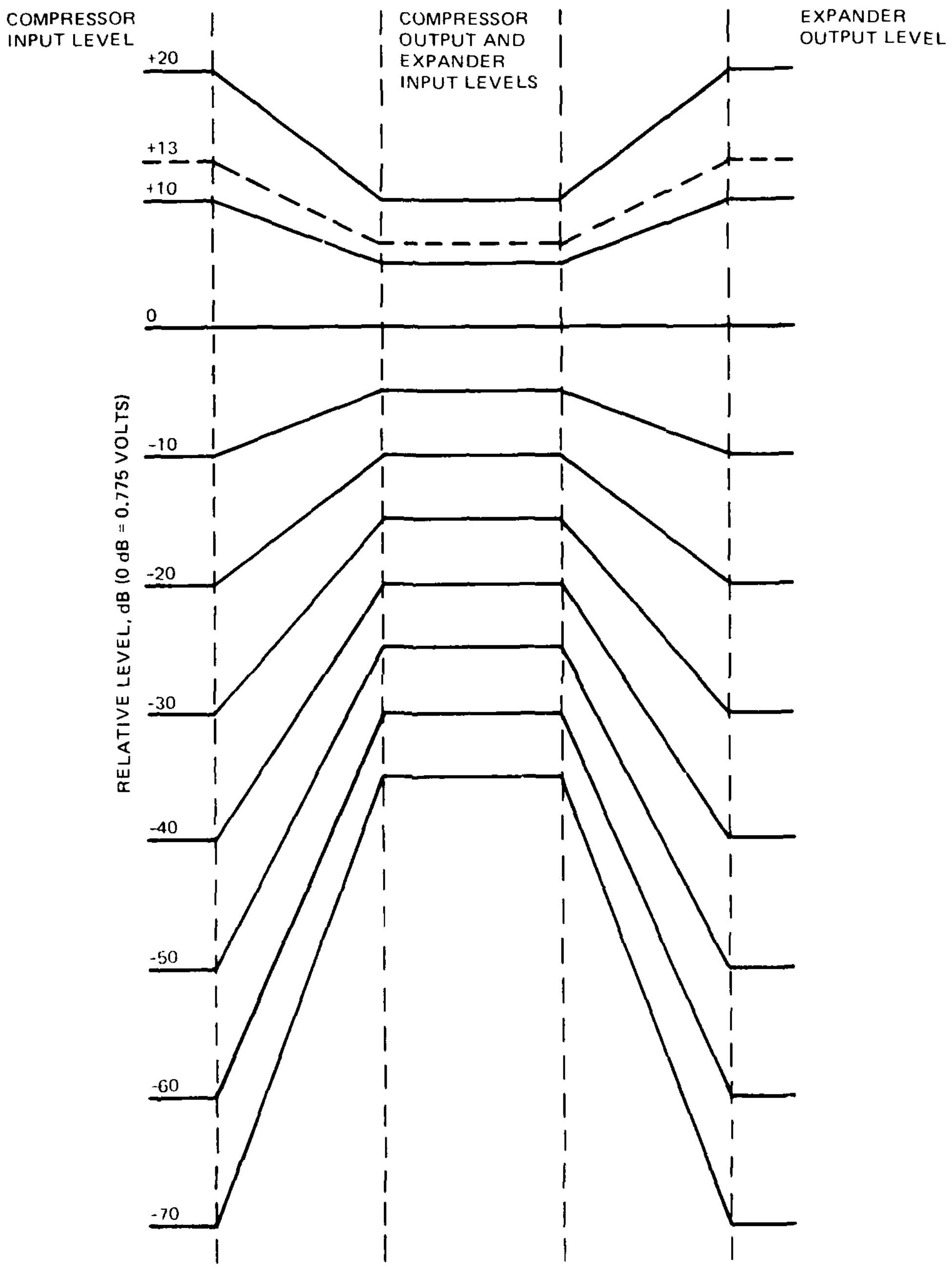


Figure 7. Compressor-expander characteristics.

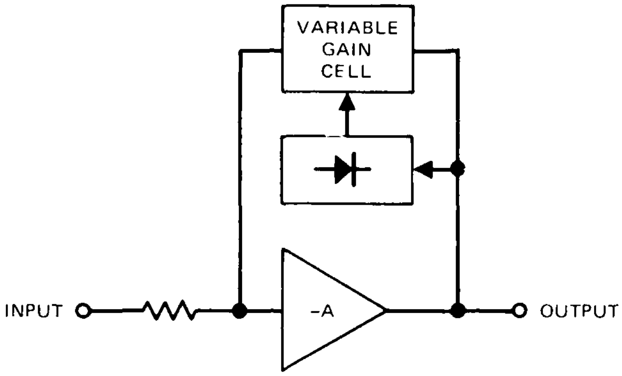


Figure 8. Compressor, simplified circuit diagram.

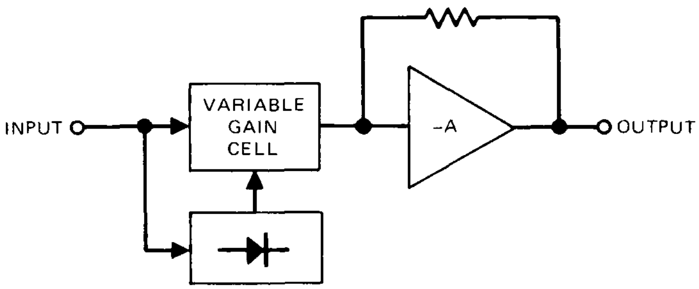


Figure 9. Expander, simplified circuit diagram.

Input signals greater than 0.775 V rms are amplified and input signals less than 0.775 V rms are attenuated. If the input signal level decreases by 6 dB the gain of the expander will decrease by 6 dB, resulting in a net decrease in the expander output of 12 dB.

In figure A-5, the rectifier and variable gain cell are contained within U5. U6 is the gain-controlled amplifier and U7, in conjunction with C23, is used to average the output of the rectifier so that the gain control varies smoothly with signal level. U4 is an amplifier used to compensate for any loss in the tape recorder channel. For proper operation the input to the expander should equal the output of the compressor. The maximum record and reproduce levels of the tape recorder may not be the same. For example, the Honeywell Model 101 Tape Recorder can be adjusted to accept a record level of 1.64 V rms, the maximum output of the compressor. The maximum reproduce level for this recorder is 10 V rms. The gain of U4 is adjusted to provide a 1.6 V rms signal at U4-6 when the input level is 1 V rms. U4 also provides a means of compensating for slight differences in the gain of the compressor and expander channels.

THRESHOLD DETECTOR-INDICATOR

See figures 10 and A-6 for an overview of the threshold detector circuitry.

The threshold detector-indicator circuitry is used to indicate the percent of time the input signal to the compressor is above some preset threshold level. The circuit samples the input signal at a 200-kHz rate and counts the number of samples above the selected threshold. Two threshold levels are available. These levels are set by potentiometers R1 and R2. The selection of a threshold level is controlled by a front panel switch, TIME CONSTANT. A switch is provided for each channel. In the MAX position the threshold level is set by R1. In the MIN position the threshold level is set by R2.

A 10-second or 100-second running average is performed on the data before it is displayed. The running average time is also selected by the TIME CONSTANT switch. The 10-second averaging time is used with the threshold set by R2. The 100-second averaging time is used with the threshold set by R1. The front panel indicator, EXCEEDANCE THRESHOLD, displays the percent of time that the signal exceeds the threshold. The full-scale readings are 9.999% and 0.999% for the MIN and MAX positions, respectively.

The circuit processes data from all four channels simultaneously, but displays data from only one channel. The input signal to each compressor is compared to the selected reference voltage in comparators U13–U16, figure A-6. If an input signal is greater than the reference voltage, the comparator output will be high. The output of the comparator and the 200-kHz clock signal are ANDed together to form the clock signal for the channel decode counter. The channel decode counters are allowed to count for one second. At the end of this second the count is added to 9/10 (99/100 for the long time constant) of the contents of the channel register and the counter is reset to zero. The running average circuitry is time shared among all four channels. This is done by staggering the one-second counting intervals. The end of the counting interval for channel two occurs 100 milliseconds after the end of the counting interval for channel one, etc. The running average is

$A_1 = 9/10\ A_0 + C_1$ (for the short time constant) or
$A_1 = 99/100\ A_0 + C_1$ (for the long time constant)

where A_1 is the new average, A_0 is the previous average and C_1 is the new count. The actual average used is selected by the front panel switch, TIME CONSTANT. The time constant of each channel is independent of the other channels. The channel displayed is selected by a front panel switch, CHANNEL SELECT. The display has no effect on the averaging circuitry.

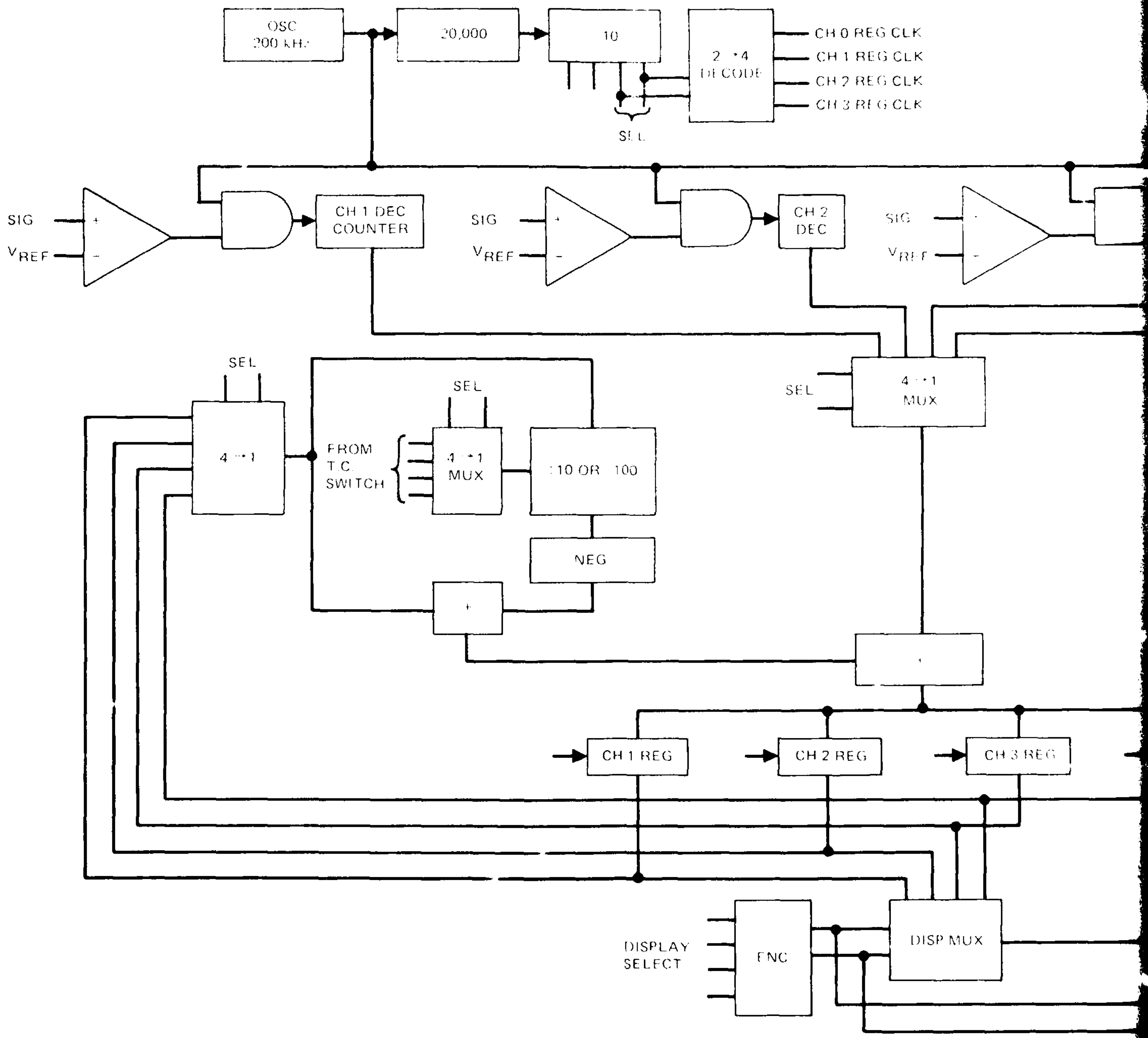
INSTALLATION AND OPERATING INSTRUCTIONS

INTRODUCTION

This section contains information regarding the installation and operation of the noise processor.

INPUT POWER

The noise processor should be powered from 115 volts, 47–420 Hz power.



OSC
200 kHz
20,000
10
2 → 4
DECODE
CH 0 REG CLK
CH 1 REG CLK
CH 2 REG CLK
CH 3 REG CLK
SEL
SIG
VREF
CH 1 DEC
COUNTER
CH 2
DEC
SEL
4 → 1
MUX
4 → 1
FROM
T.C.
SWITCH
10 OR 100
NEG
CH 1 REG
CH 2 REG
CH 3 REG
DISPLAY
SELECT
ENC
DISP MUX

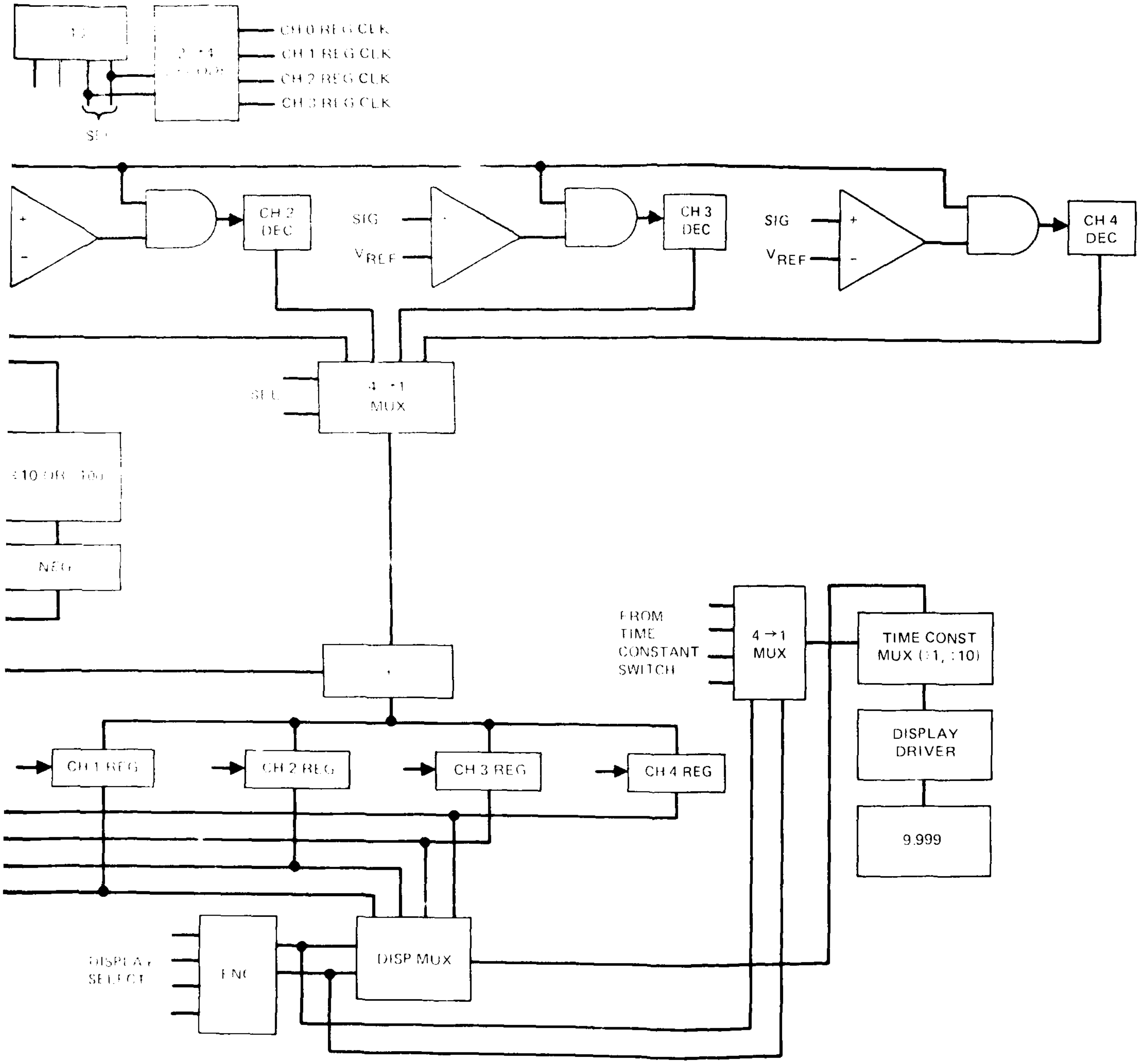


Figure 10. Threshold detector-indicator, block diagram.

RACK INSTALLATION

The noise processor can be mounted in a standard 19-inch equipment rack. The front panel height is 5.25 inches. The rear of the chassis should be supported, because the front panel is not designed to support the entire weight of the unit.

CONTROLS, INDICATORS AND CONNECTORS

The functions of the front panel controls and indicators are given in table 2. Rear panel connectors are described in table 3.

Table 2. Front panel control and indicator functions.

NAME	FUNCTION
PREAMP GAIN switch	Controls gain of preamplifier
PREAMP GAIN LED	Flashes when preamplifier output is overloaded
ATTN A switches	Controls signal amplitude at input of amplifier A
ATTN A LED	Flashes when amplifier A output is overloaded
ATTN B switches	Controls signal amplitude at input of amplifier B
ATTN B LED	Flashes when amplifier B output is overloaded
EXCEEDANCE THRESHOLD display	Indicates percent of time output signal exceeds a preset threshold level
CHANNEL SELECT switch	Selects channel to which EXCEEDANCE THRESHOLD display applies
TIME CONSTANT switches	Selects time constant for EXCEEDANCE THRESHOLD display. MAX is 100 seconds, MIN is 10 seconds. Also selects threshold level.
AC POWER switch	Turns instrument ON or OFF

Table 3. Rear panel connector functions.

NAME	FUNCTION
PREAMP IN	Signal input to preamplifier
COMPRESSOR OUT	Signal output from compressor
EXTERNAL FILTER IN	Provides signal to input of external filter
EXTERNAL FILTER OUT	Signal output from external filter
EXPANDER IN	Signal input to expander
EXPANDER OUT	Signal output from expander

FILTER SELECTION AND INSTALLATION

Each channel is identical except for the filter employed. Choose either a set of the fixed frequency filters or the variable filter. If possible, the fixed filters should be used because their noise performance is better and they provide greater selectivity. If a set of fixed filters is to be used, insert both filters in the filter connectors. Both filters must be tuned to the same frequency and both must be in place; however, either filter can be plugged into either connector. If the variable filter is to be used, both filter connectors must be empty. The input of the variable filter should be connected to EXTERNAL FILTER IN. The output of the variable filter should be connected to EXTERNAL FILTER OUT. Set the high pass cutoff switches and the low pass cutoff switches to the desired frequency. It is desirable that both switches be set to the same frequency. This will provide maximum selectivity.

PREAMPLIFIER GAIN ADJUSTMENT

Connect the signal to be recorded to the PREAMP IN connector of the selected channel. Observe the PREAMP GAIN LED. This LED indicator will flash whenever the preamp output is overloaded. Adjust the PREAMP GAIN switch for an acceptable rate of overload flashes. Noise performance is improved at the higher gain settings.

EXTERNAL FILTER GAIN ADJUSTMENT

If the external filter is used, set the prefilter gain switch for an acceptable rate of overload flashes on the prefilter LED indicator. Noise performance is improved at the higher gain settings. Set the postfilter gain switch for an acceptable rate of overload flashes on the postfilter LED indicator.

ATTENUATOR A AND ATTENUATOR B ADJUSTMENTS

Adjust ATTEN A and ATTEN B for an acceptable rate of overload flashes on their respective LEDs. ATTEN A should be adjusted first.

EXCEEDANCE THRESHOLD CHECK

Check that the EXCEEDANCE THRESHOLD readings for both the short and long TIME CONSTANTS are acceptable. Allow sufficient time for the readings to stabilize. The short time constant is 10 seconds and requires about 25–30 seconds to stabilize. The long time constant is 100 seconds and requires about 250–300 seconds (4–5 min) to stabilize. If the threshold readings are too high, the attenuation of ATTEN B should be increased. If the threshold readings are too low, the attenuation of ATTEN B should be decreased. These suggested changes assume that the PREAMP GAIN and ATTEN A and ATTEN B have already been properly adjusted as described above.

TAPE RECORDER ADJUSTMENTS

PRERECORDING

1. Set the tape recorder at the minimum speed that will produce acceptable recordings for the frequency band of interest. If a Honeywell Model 101 tape recorder with wideband Group II FM record capability is used, then 7-1/2 ips is satisfactory for frequencies up to 30 kHz and 15 ips is satisfactory for frequencies up to 60 kHz.

2. Adjust the gain of the record electronics so that a maximum input signal level of 1.6 V rms at the frequency of interest can be recorded.

3. Connect the record input connector of the selected tape recorder channel to the COMPRESSOR OUT connector on the rear of the processor.

The system is now ready to record.

RECORDING

If the recording period is very long the level of the noise will undoubtedly change. Should the noise level increase it will be necessary to either reduce the gain of the preamplifier and external filter (if used) or increase the attenuation of ATTEN A and/or ATTEN B. If noise outside of the band of interest increases, as evidenced by an increase in the flashing rates of the PREAMP GAIN LED and the prefilter OVERLOAD LED on the external filter, the gain at these points should be reduced until an acceptable overload rate is indicated. A reduction in the preamplifier or prefilter gains should probably be accompanied by an increase in gain at a later point in the system.

A guide for setting the channel gain of the noise processor is to place as much gain as possible prior to the filter. This condition will produce the least contamination by system self-noise. This action must be tempered by the overload rates of the various stages in the processor.

Playback. Adjust the gain of the reproduce electronics so that when a signal, recorded at a level of 1.6 V rms at the frequency of interest, is reproduced the output level of the reproduced signal is 1 V rms.

NOISE PROCESSOR DURING PLAYBACK

Connect the output of the tape recorder reproduce amplifier to the EXPANDER IN connector. The expanded, restored signal is available at the EXPANDER OUT connector.

ADJUSTMENTS

OPERATOR ADJUSTMENTS

Operator adjustments consist of changing those controls likely to require attention prior to, or during the course of, recording data. These controls are located on the front panel. Included are:

1. Preamplifier gain
2. Filter bandwidth
3. Attenuator settings
4. Time constant selection
5. Channel selected for display

PREAMPLIFIER GAIN

The gain of the preamplifier [illegible] the maximum value consistent with acceptable overload rates. The LED [illegible] preamplifier gain switch will flash whenever the preamplifier [illegible] about the maximum rated output of the preamplifier [illegible] distortion in the form of clipping begins to occur.

If the preamplifier [illegible] percent of time that the output is clipped, then [illegible] contaminated by system self-noise. The effects of one [illegible] effects of the other. If it is necessary to obtain record [illegible] noise, set the gain low. If low amplitude, high prob [illegible] set the gain high.

FILTER BANDWIDTH

If the noise frequency [illegible] with the center frequencies of the fixed filters, use the fixed filters. [illegible] performance and selectivity are better than the variable frequency filter.

Selectivity becomes an important consideration in the presence of a station signal whose frequency is close to the noise frequency band of interest. If the station signal is recorded with the noise, when the recording is played back through the expander the signal will raise the tape recorder noise level at the expander output. This effect on the tape recorder noise will be present even if the station signal is eventually filtered out of the expander output. To understand how this occurs, consider figure 7. If the interfering station level corresponds to −40 dB in figure 7, during those times when it is the strongest signal present the compressor gain will be held at +20 dB. The station signal will be recorded at a −20 dB level. During playback the station signal will set the expander attenuation at −20 dB so that the station signal will appear at the expander output at a level of

-40 dB, as it should. However, tape recorder noise, which might typically be at the -35 dB level in figure 7 (assumes tape recorder SNR of 48 dB in bandwidth of interest), will also be attenuated by only -20 dB and will appear at the expander output at a level of -55 dB. If the station signal were not present, the expander attenuation could be as much as -34 dB (assumes compressor input level of -68 dB). The same level of recorder noise would now be reduced to -69 dB at the expander output for an increase in SNR of 14 dB. Figure 11 illustrates the effect of an interfering station on the resultant SNR of the reproduced noise. The information displayed on the vertical axis is the ratio of the signal level of an interfering station to the maximum noise level (+13 dB in figure 7). The horizontal axis gives the SNR at the output of the expander, assuming the interfering station is filtered at the expander output. The "signal" is atmospheric noise and the "noise" is the tape recorder noise. Data are plotted for several tape recorder signal-to-noise ratios. The maximum output SNR is limited by the compressor-expander circuitry to about 80 dB.

Figure 11 may be more clearly understood by considering the following example. Assume that noise in the bandwidth of the fixed 14.8-kHz filter is to be recorded. Assume further that an Omega signal at 13.6 kHz is received on the system antenna at a signal strength that is -30 dB relative to the peak noise signals. Figure 4 indicates that a signal at 13.6 kHz will be attenuated by -35 dB in the 14.8 kHz filter. Thus, the total attenuation of the Omega signal will be -65 dB relative to the maximum noise level. Assume a tape recorder SNR of 50 dB for the bandwidth and the selected tape speed. Figure 11 indicates that the output SNR is 76 dB.

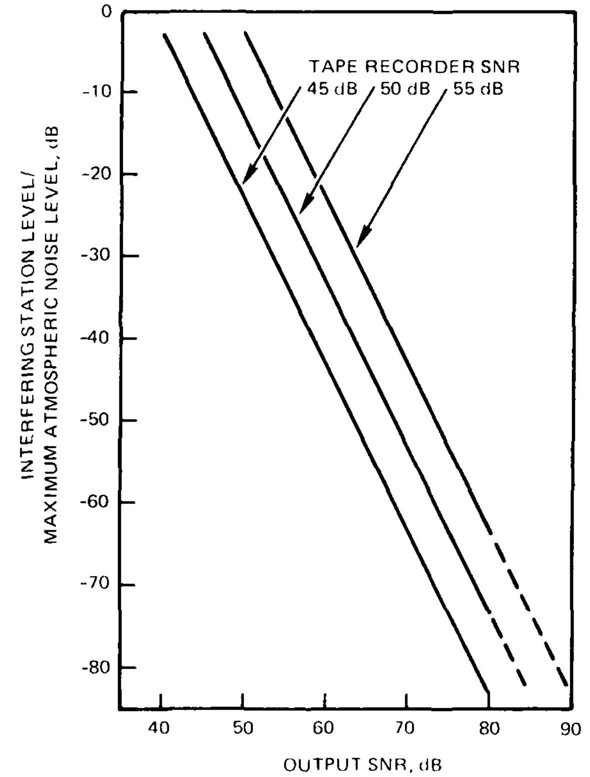


Figure 11. Effect of interfering station.

ATTENUATOR SETTINGS

Attenuator A precedes amplifier A. Adjust it so that the output of amplifier A only occasionally exceeds the maximum rated output of 7V rms. The LED located immediately above the switches of attenuator A will flash whenever the output exceeds 7 V rms.

Attenuator B precedes amplifier B. The rated output of amplifier B is also 7 V rms; however, the compressor, which follows amplifier B, can accept only 3.5 V rms at its input. Because of this, the LED associated with attenuator B will flash whenever the output of amplifier B exceeds 3.5 V rms. Adjust attenuator B so that this condition occurs only occasionally.

TIME CONSTANT SWITCH

The TIME CONSTANT switch should normally be set to the MIN position while performing an initial channel set-up. EXCEEDANCE THRESHOLD readings will respond more rapidly to gain changes in this mode. Once an acceptable EXCEEDANCE THRESHOLD reading is obtained, place the TIME CONSTANT switch in the MAX position.

CHANNEL SELECT SWITCH

This switch should be set to display the EXCEEDANCE THRESHOLD reading of the channel that is of particular interest at any given time. Normally this will be the channel that is experiencing the largest changes. The display can be switched at any time and does not affect the averaging operation.

MAINTENANCE ADJUSTMENTS

There are several adjustments that do not require attention during normal operating periods. These adjustments are associated with the compressor, the expander, and the threshold circuitry. The top cover of the chassis must be removed to gain access to these controls.

COMPRESSOR

The compressor contains two potentiometers, R4 and R9. R4 provides a means of reducing the harmonic distortion generated within the compressor. R9 reduces the effects of signal feed-through. These controls should require attention only when a component in the compressor circuit fails and is replaced.

The harmonic distortion control, R4, should be adjusted before correcting for signal feed-through. To adjust R4, temporarily parallel C11 with a one-microfarad capacitor, using clip leads. If the capacitor is polarized, the plus terminal should be connected to the end of C11 that is closest to E3 (see figure A-3). Remove any filters associated with the channel to be adjusted and input a 10-kHz sine wave signal into the EXTERIOR FILTER OUT BNC which is located on the rear panel. Adjust the level so that the signal at the compressor input (E1 in figure A-3) is 0.775 V rms. The compressor gain should be 0 dB at this signal level. Using an oscilloscope, compare the compressor output signal with the input signal. Adjust R4 for the match between the two signals. After completion of this adjustment, remove the one-microfarad capacitor.

R9, signal feed-through, should now be checked. A bandwidth limited repetitive tone burst is required for this adjustment. This can be produced by feeding a tone burst signal into the preamplifier input and using a set of fixed frequency bandpass filters. The rf frequency of the tone should be set to the center frequency of the filter. Set the level of the tone burst so that the signal amplitude at the input of the compressor (E1 in figure A-3) is about 1.4 V peak-to-peak. Using an oscilloscope, observe the output of the compressor. Adjust R9 for best symmetry about the zero level at the tail of the pulse.

EXPANDER

There are three adjustments associated with the expander. R15 sets the gain of the input amplifier, R21 controls the harmonic distortion generated within the expander, and R18 reduces the effects of signal feed-through. R21 and R18 should require adjustment only when a component in the expander circuit fails and is replaced. The setting of R15 should be checked if U5 fails and is replaced or if the ratio between the maximum recorded level and the maximum reproduced level is other than 1.6 (this is the ratio that should exist between these two levels for the Honeywell 101 tape recorder). The order of adjustment should be R21, R18 and R15.

To adjust R21, temporarily parallel C23 with a one-microfarad capacitor, using clip leads. If the capacitor is polarized, the plus terminal should be connected to the end of C23 that is closest to E9 (see figure A–3). Inject a 10-kHz sine wave signal into the EXPANDER IN BNC which is located on the rear panel. Adjust the signal level so that the signal at U5-14 of the compressor-expander board is 0.775 V rms. The expander gain should be 0 dB at this signal level. Using an oscilloscope, compare the expander output signal with the input signal. Adjust R21 for the best match between the two signals. After completion of this adjustment, remove the one-microfarad capacitor.

To adjust R18, expander signal feed-through, a bandwidth limited repetitive tone burst is required. (See compressor adjustments.) Connect the COMPRESSOR OUT BNC to the EXPANDER IN BNC. Set the level of the tone burst so that the signal amplitude at U5-14 on the compressor-expander board is about 1.4 V peak-to-peak. Using an oscilloscope, observe the output of the expander (BNC on rear panel). Adjust R18 for best symmetry about the zero level at the tail of the pulse.

To properly adjust R15, the difference between the record and reproduce levels of the tape recorder used with the system must be known. Adjust R15 so that when a signal is recorded and reproduced the level of the signal at the expander output (rear panel BNC) is equal to the level of the signal at the compressor input (E1 of figure A-3). A convenient method of doing this for the Honeywell 101 recorder is to connect the expander output to the compressor input (both available at the rear panel) through a 1.2 k-ohm series resistor. This value of resistor, when combined with the input resistance of the expander (2 k ohms) will simulate the loss between the record and reproduce levels of the Honeywell 101 recorder. Obtain a signal at the input of the compressor (E1 of figure A-3) by injecting a sine wave into the preamplifier input. The frequency should be chosen to be within the bandwidth of the filter installed in the channel. The amplitude should be set for about 1 V rms at the compressor input. Using an oscilloscope, observe both the compressor input and the expander output. Adjust R15 so that they are equal in amplitude.

EXCEEDANCE THRESHOLD

Two different threshold levels can be selected by the TIME CONSTANT switch. These threshold levels are determined by the settings of R1 and R2 (see figure A-6). R1 controls the threshold level for the MAX position of the TIME CONSTANT switch and R2 controls the threshold level for the MIN position. The levels may be conveniently measured at U13-3 (see figure A-5). The TIME CONSTANT switch should be in the MAX position to measure the output of R1 and in the MIN position to measure the output of R2.

The correct settings for the two threshold levels should be based on the expected noise distribution and on the percent of time that the compressor input signal is permitted to exceed the maximum rated value. The compressor can process a maximum input level of 3.6 V rms or 5 V zero-to-peak. Assume it is decided that compressor saturation will be allowed to occur 0.001 percent of the time. This means that the input signal to the compressor will exceed a level of 5 V, zero-to-peak, 0.001 percent of the time. The expected amplitude probability distribution should be examined to determine the relative amplitude level that will be exceeded about 0.5 percent of the time. R1 should be set to this level. The full scale exceedance threshold value for the maximum time constant position is 0.999 percent. If the threshold is set at 1 percent the averaging circuitry and the display may be saturated an appreciable portion of the time. Setting the threshold level somewhat higher than the 1-percent value (smaller percentage) will provide useful readings even if the noise level increases. Similarly, the relative amplitude level that will be exceeded about 5 percent of the time should be determined from the expected amplitude probability distribution. R2 should be set to this level. As an example, assume that the 0.5-percent level and the 5-percent level are 20 dB and 30 dB, respectively, below the 0.001 level. R1 would be adjusted for a level of +0.5 V dc and R2 would be adjusted for a level of +0.158 V dc. The threshold detectors respond to positive signal peaks only; however, the averaging circuitry is designed to indicate an exceedance threshold that is twice that measured. It is assumed that the input signal level will be below –E volts for the same fraction of time that it is above +E volts, where +E volts is the threshold level.

SYSTEM PERFORMANCE RESULTS

During May 1980 the atmospheric noise recorder was field tested at the NOSC vlf Test Facility in Sentinel, Arizona, a site well away from sources of urban man-made noise. The input of the atmospheric noise recorders was connected to a five-foot-diameter tuned loop antenna which is part of the Megatek statistical noise analyzer[1]. The field test set-up was arranged as shown in figure 12.

As shown, it was possible to record as well as to simultaneously analyze the vlf noise picked up by the antenna and then, during playback, to compare the fidelity of noise recordings. In this manner it was possible to compare statistical noise properties between off-the-air reception and playback from the magnetic tape recorder. The data taken compared impulse space statistics (temporal data), amplitude probability distribution (APD) data, and voltage deviation (V_d) a measure of impulsiveness defined as the ratio of noise envelope rms value to average value.

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[1] Atmospheric Noise Amplitude and Temporal On-Line/Off-Line Monitoring Service, Megatek Corporation Report No. R2017-006-1F-1, performed under contract N00123-78-C-0191, dated 15 November 1980.

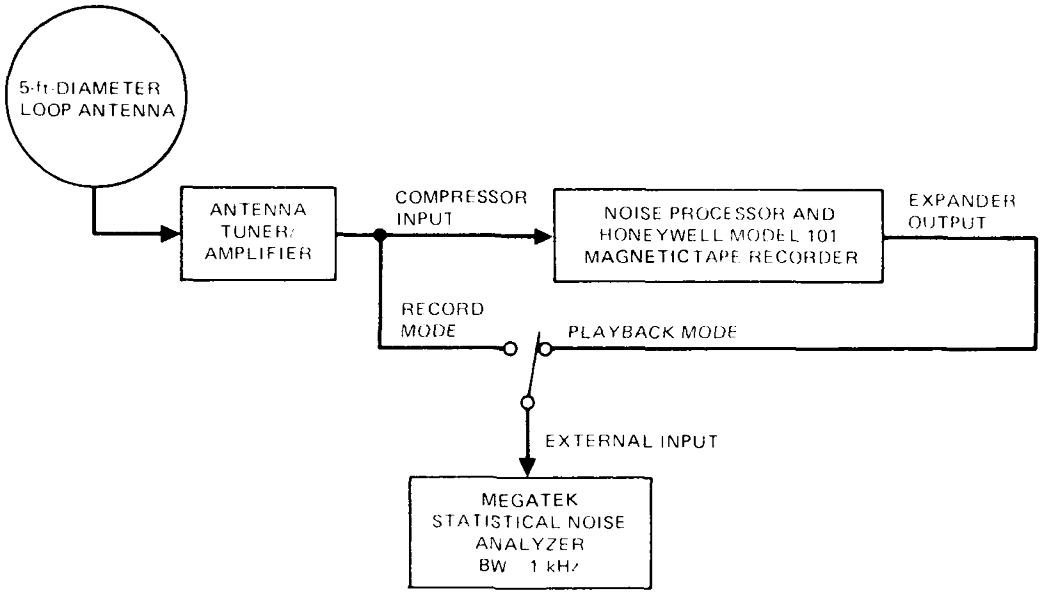


Figure 12. Atmospheric noise recorder performance test set-up.

Two frequencies were used during the test — 14.7 kHz and 28 kHz. Figures 13 and 14 show 6-minute data point V_d measurements at each test frequency. The figures indicate excellent fidelity on playback up to V_ds of 12 dB and 15 dB for 14.7 and 28.0 kHz, respectively. Recordings at V_d = 20 dB have a fidelity loss of only 2 to 3 dB.

Figure 15 compares the APD and impulse space statistics for a 1-hour period. Figure 15(a) gives the off-the-air impulse space statistics for 10 consecutive 6-minute threshold levels from 7.94 μV/m to 15.8 μV/m. Also shown are the minimum, median, and maximum off-the-air APD curves for the 1-hour sample. Figure 15(b) shows the same data during playback. Figure 15(a) is a transparent overlay which makes it possible to compare the fidelity of the playback atmospheric noise statistics to the off-the-air statistics by overlaying 15(b) with 15(a). It is clear in the case of these two figures that reasonable fidelity was achieved, and that both APD and the essence of the temporal characteristics of the noise were preserved. The data also show some differences in gain between off-the-air and playback modes. However, this factor is of little importance.

Figure 16 is a one-hour comparison taken during relatively high V_d conditions (nearby storms). In this instance the 80-dB capability of the noise processor becomes critical. One sees by overlaying 16(b) with 16(a) that the fidelity achieved in this case was not as good as that shown in the previous figure. This is because attempting to preserve the full range of atmospheric noise impulses required setting the processor gain such that processor self-noise contributed to the recorded noise output. (V_d = 20 dB noise requires dynamic range greater than 80 dB). This is apparent in the approximate 6-dB increase in APD Gaussian noise component (a shift of 6 dB to the left by the playback APD curves) and the differences in low threshold level impulse curves between off-the-air and playback. However, the overall noise recorded is considered sufficient to provide realistic testing of modems in atmospheric noise at V_ds near 18 dB in a 1-kHz bandwidth.

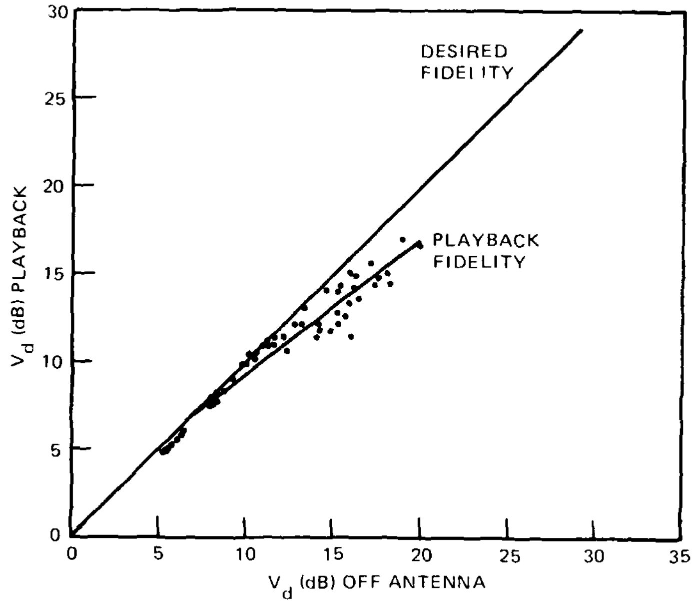


Figure 13. Noise recorder fidelity test (14.7 kHz).

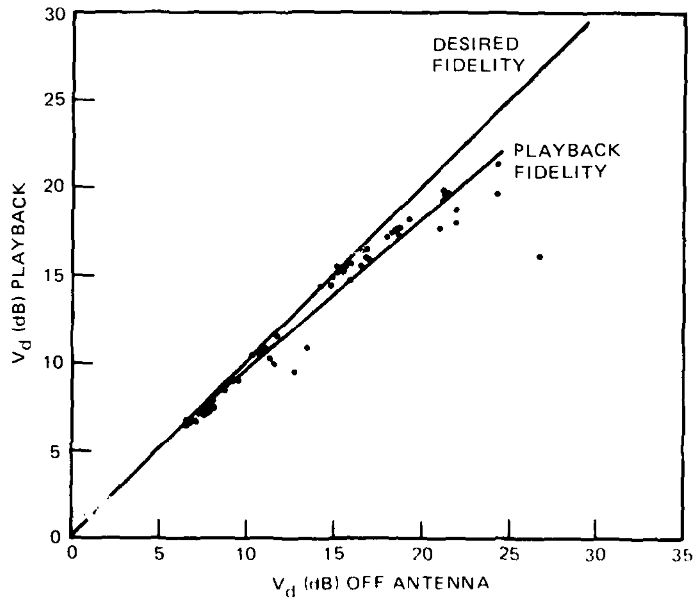


Figure 14. Noise recorder fidelity test (28.0 kHz).

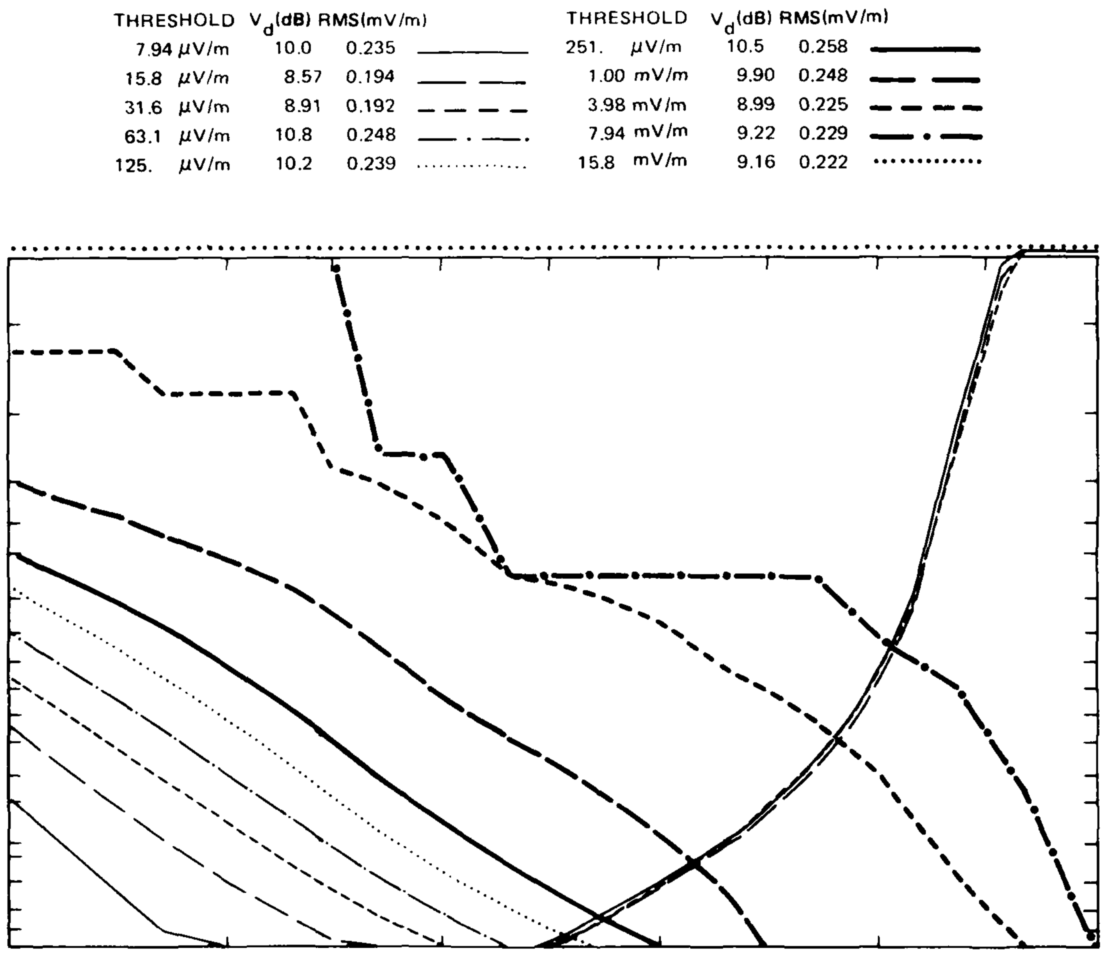


Figure 15(a). 28.0-kHz off-the-air ($V_d \approx 10$ dB).

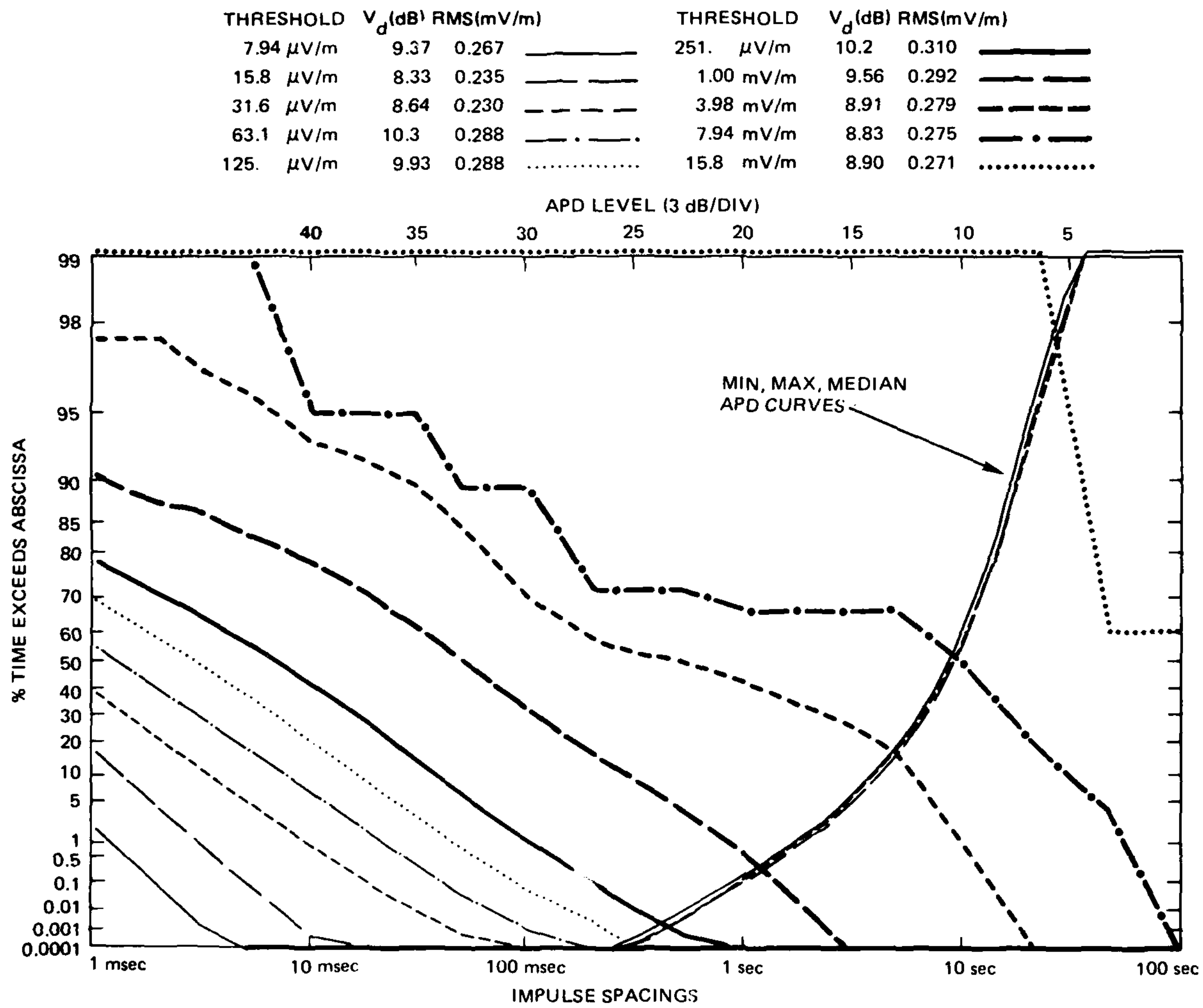


Figure 15(b). 28.0-kHz playback ($V_d \approx 10$ dB).

THRESHOLD	V_d(dB)	RMS(mV/m)	THRESHOLD	V_d(dB)	RMS(mV/m)
7.94 μV/m	20.3	0.829	251. μV/m	21.6	1.03
15.8 μV/m	19.5	0.727	1.00 mV/m	20.7	0.949
31.6 μV/m	19.5	0.654	3.98 mV/m	21.0	0.909
63.1 μV/m	19.0	0.642	7.94 mV/m	19.4	0.614
125. μV/m	21.5	1.01	15.8 mV/m	17.1	0.399

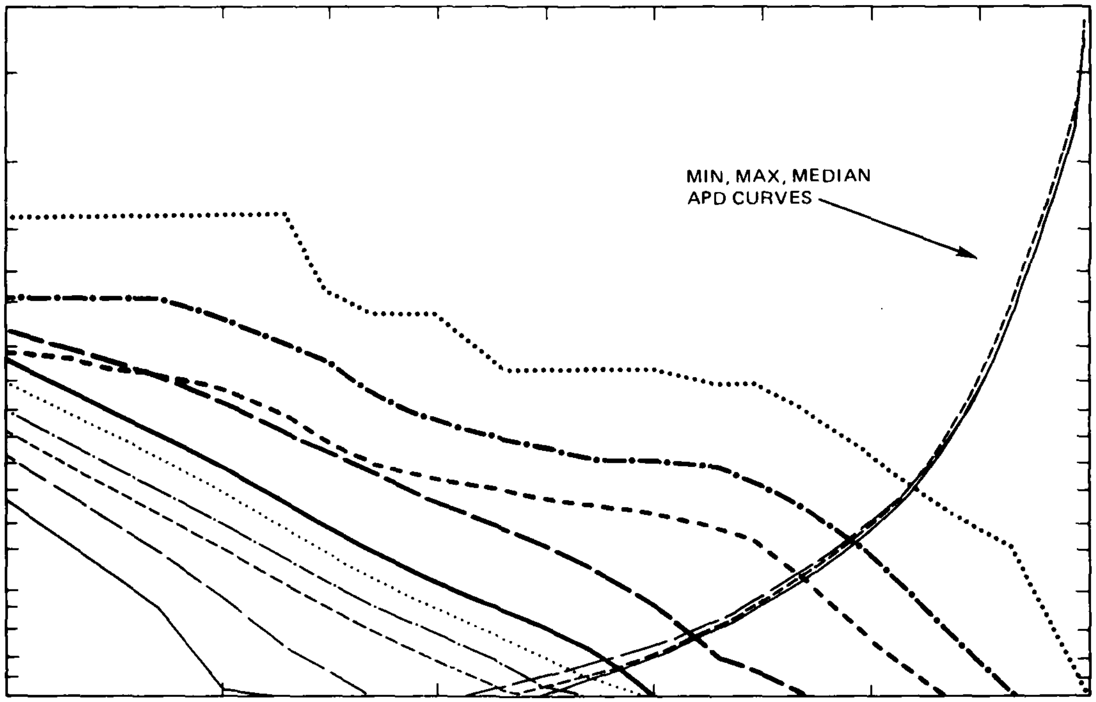


Figure 16(a). 28.0-kHz off-the-air ($V_d \approx 20$ dB).

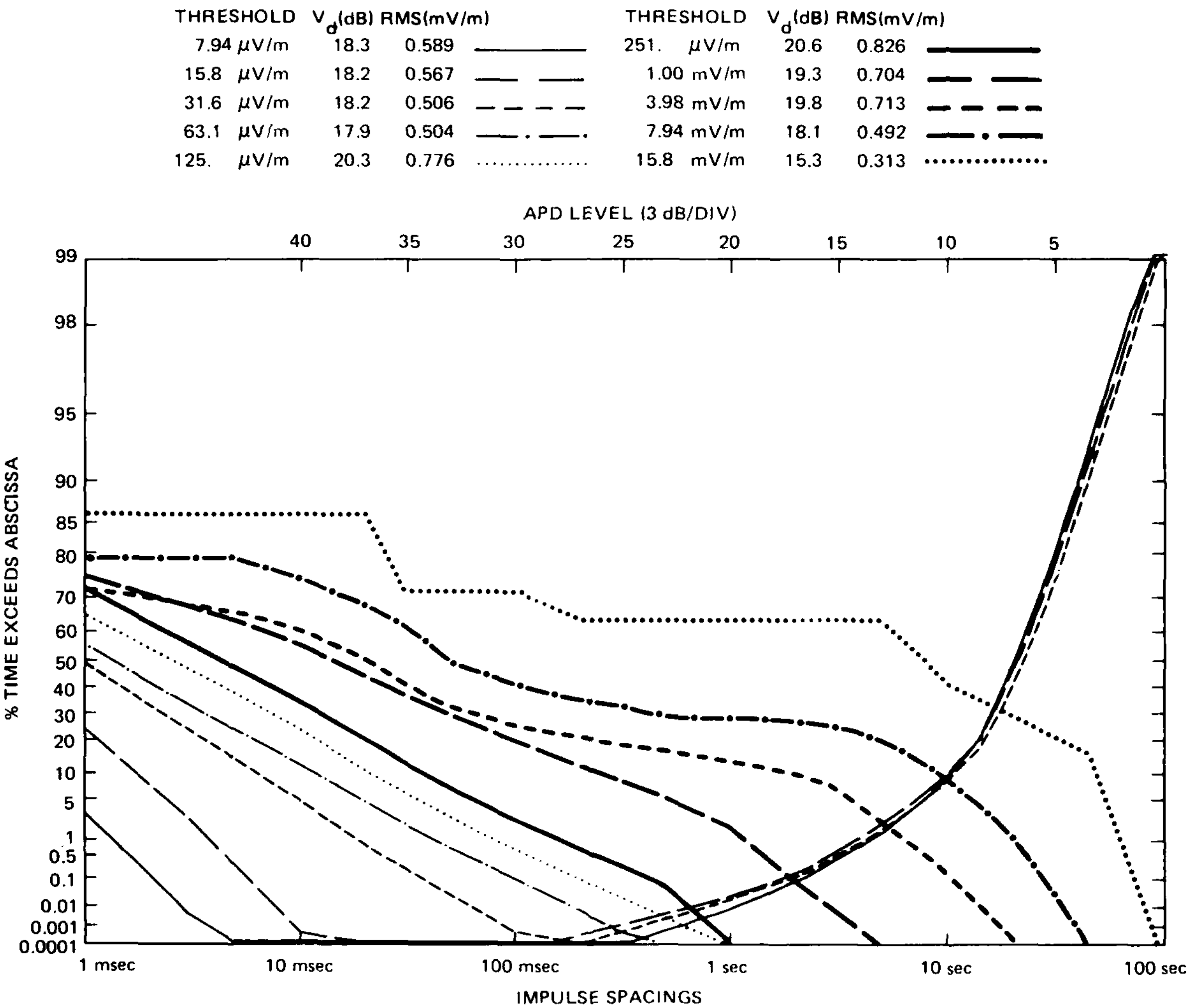
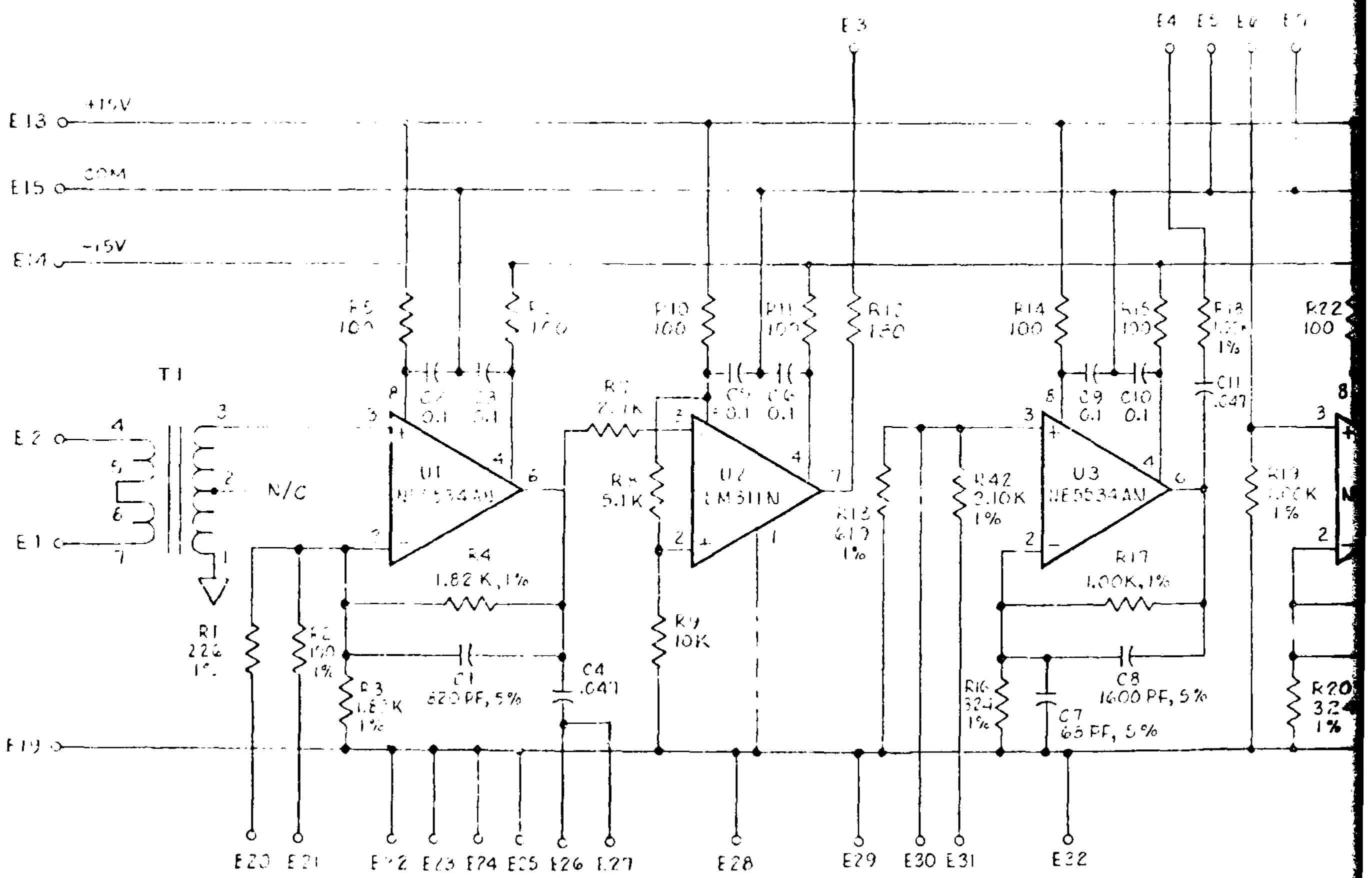


Figure 16(b). 28.0-kHz playback ($V_d \approx 20$ dB).

APPENDIX A: SCHEMATIC CIRCUIT DIAGRAMS

This appendix contains schematic diagrams of all of the circuits used in the noise processor. Also included in this section is interconnection information for each of the circuit boards. An interconnection diagram is provided for the chassis, the amplifier-detector boards, the compressor-expander boards and the multivibrator board. Only one channel is shown on the diagram. The other three channels are identical. The interconnections between the threshold detector-indicator boards are given in table A-1.



E3
E4
E13
+15V
E15
COM
-15V
T1
N/C
E2
E1
R1
226
R3
1%
R4
1.82 K, 1%
C1
820 PF, 5%
C4
.047
U1
U2
R9
10K
R10
100
R13
1%
R12
R14
100
R42
2.10K
1%
U3
NE5534AN
R17
1.00K, 1%
C8
1600 PF, 5%
R16
324
1%
C7
65 PF, 5%
C9
0.1
C10
0.1
C11
.047
R22
100
R20
1%
E19
E20
E21
E24
E26
E28
E29
E30
E31
E32

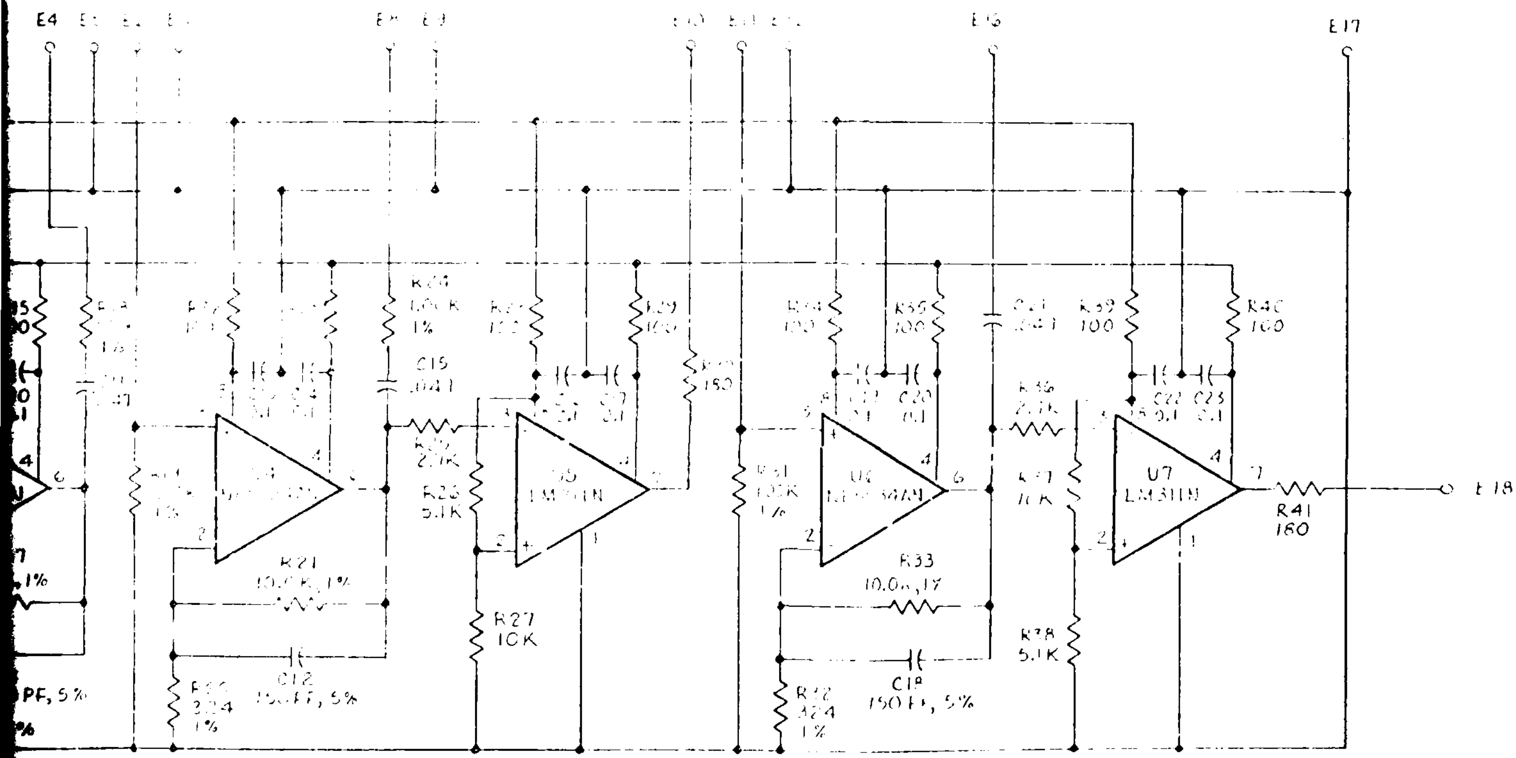


Figure A-1. Amplifier detector board schematic diagram.

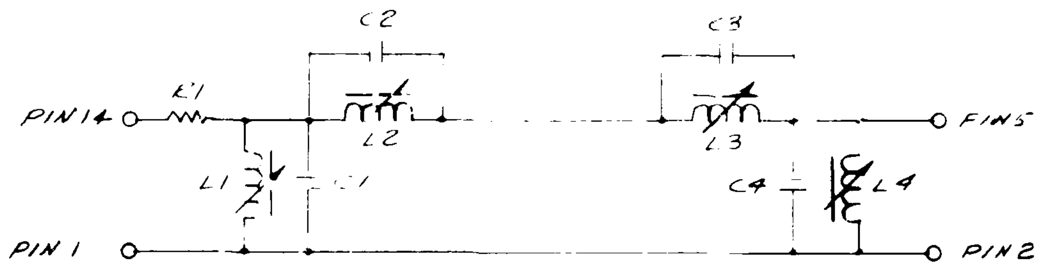


Figure A-2. Bandpass filter board schematic diagram.

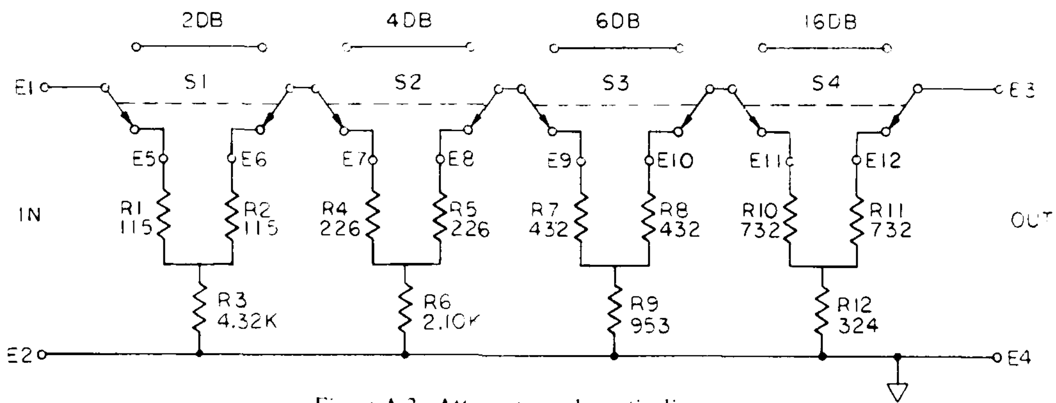
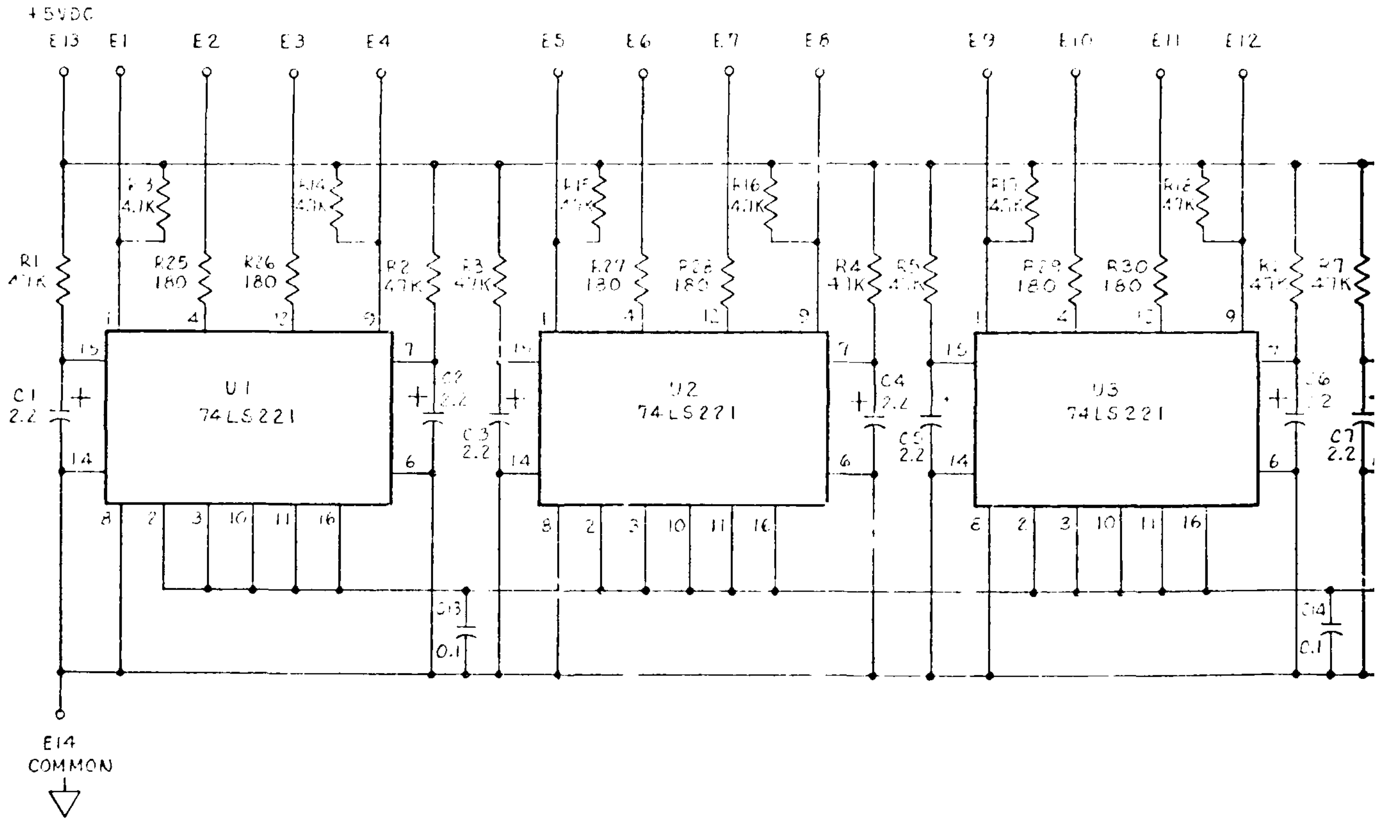


Figure A-3. Attenuator, schematic diagram.


+5VDC
E13
E1
E2
E3
E4
E5
E6
E7
E8
E9
E10
E11
E12
U1
74LS221
U2
74LS221
U3
74LS221
E14
COMMON

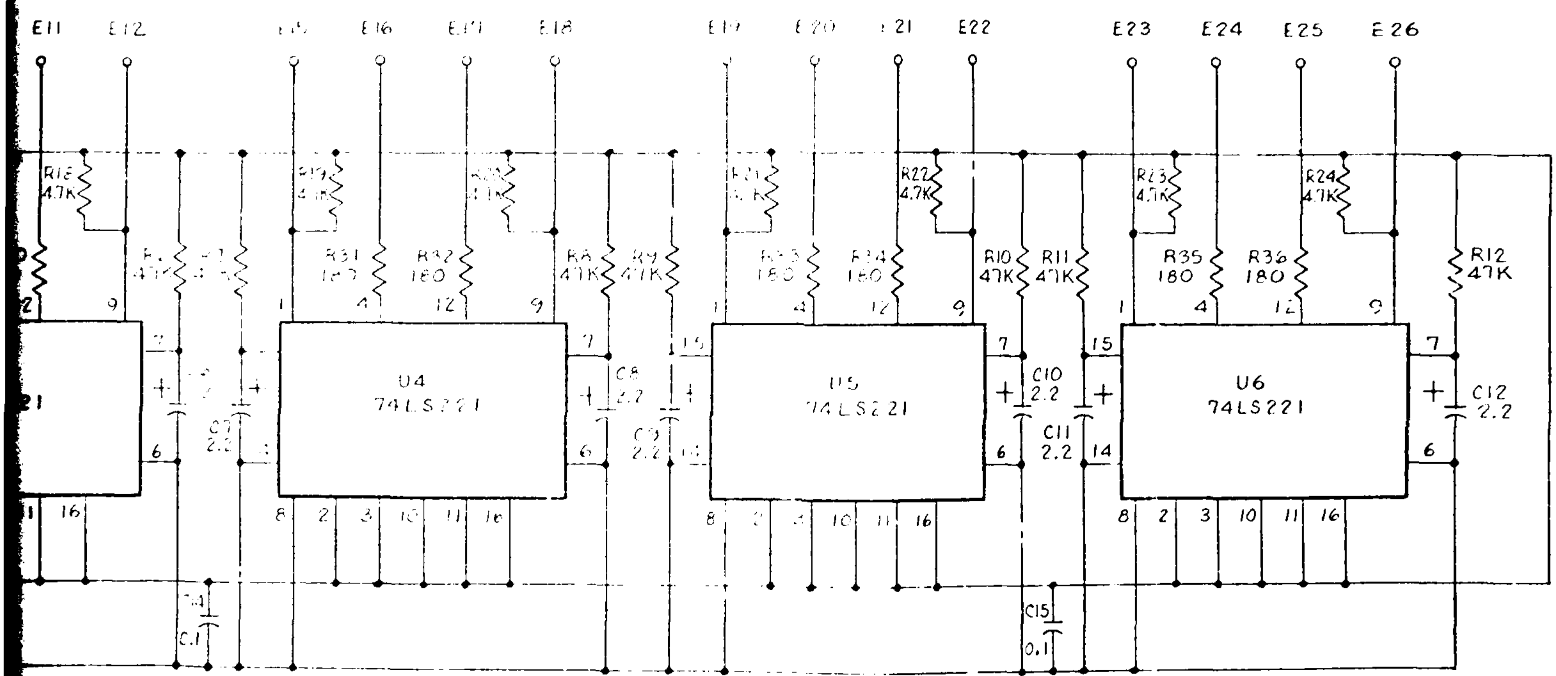
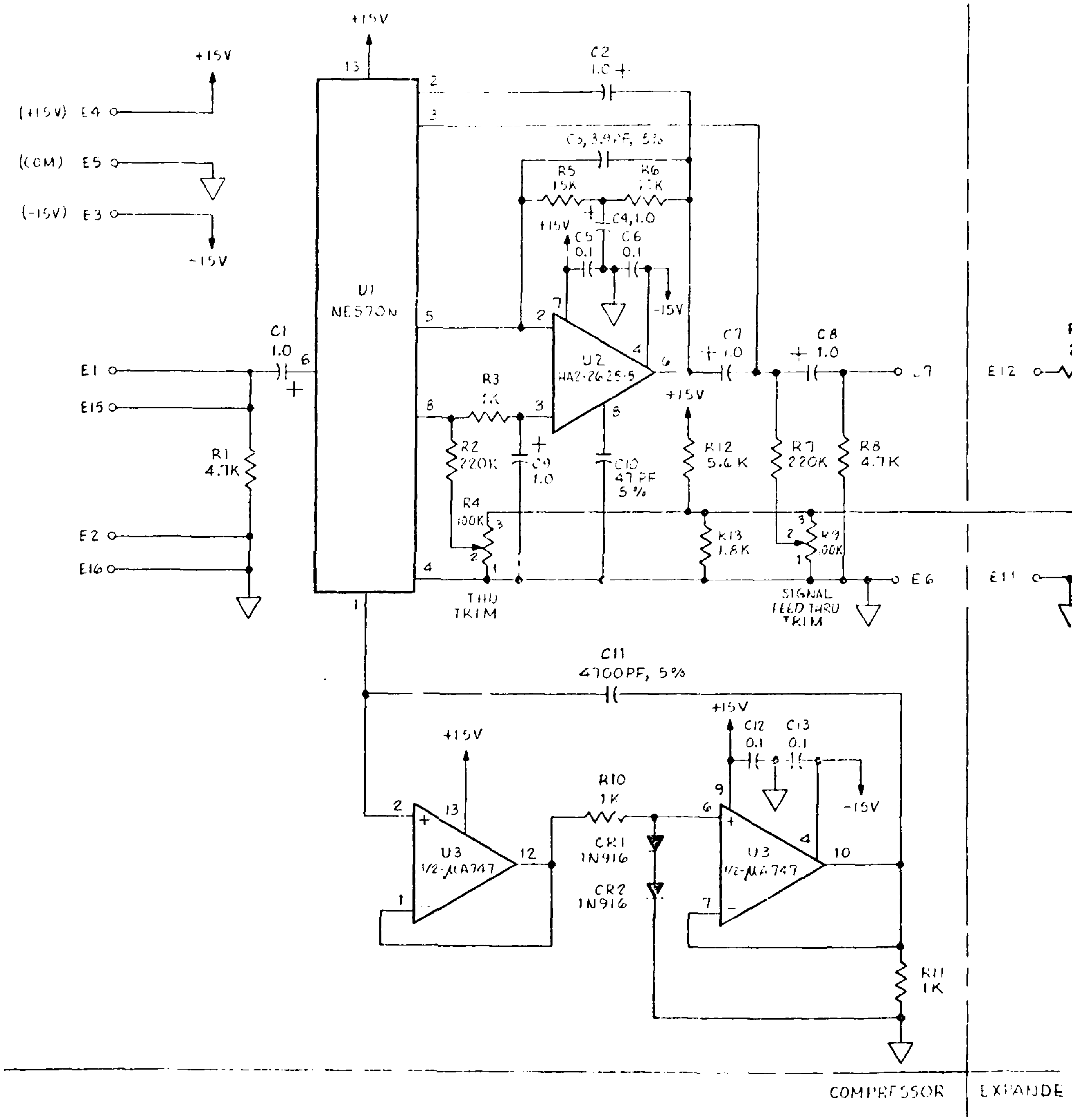


Figure A-4. Monostable multivibrator board, schematic diagram.


+15V
(+15V) E4
(COM) E5
(-15V) E3
-15V
U1
NE570N
C1
1.0
E1
E15
R1
4.7K
E2
E16
C2
1.0
C5, 3.9PF, 5%
R5
15K
C4, 1.0
C5
0.1
C6
0.1
U2
HA2-2625-5
R3
1K
R2
220K
C9
1.0
C10
47PF
5%
R4
100K
THD
TRIM
C7
1.0
C8
1.0
R12
5.6K
R7
220K
R8
4.7K
R13
1.8K
E6
SIGNAL
FEED THRU
TRIM
E12
E11
C11
4700PF, 5%
C12
0.1
C13
0.1
R10
1K
CR1
1N916
CR2
1N916
U3
1/2-μA747
R11
1K
COMPRESSOR
EXPANDE

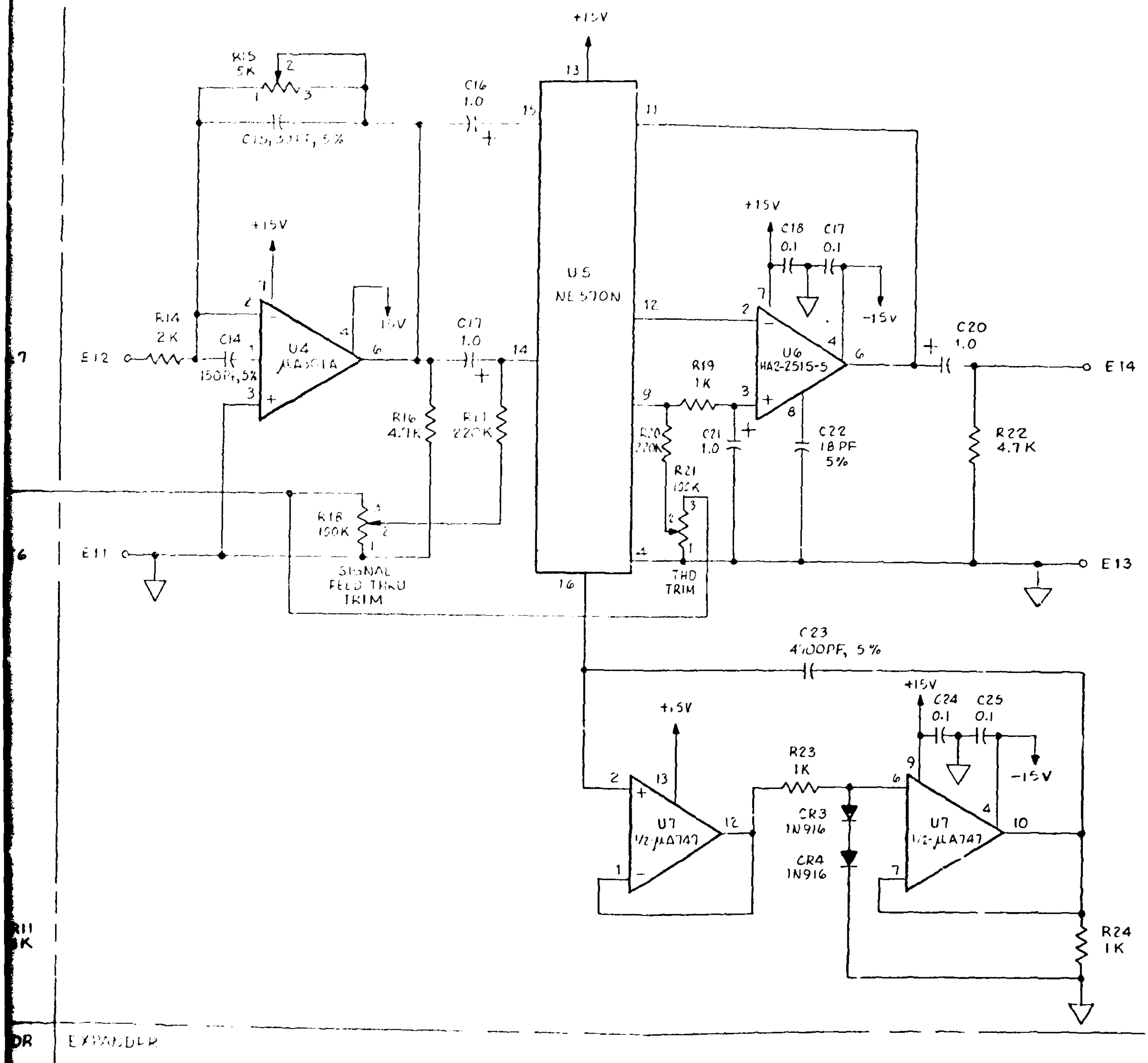
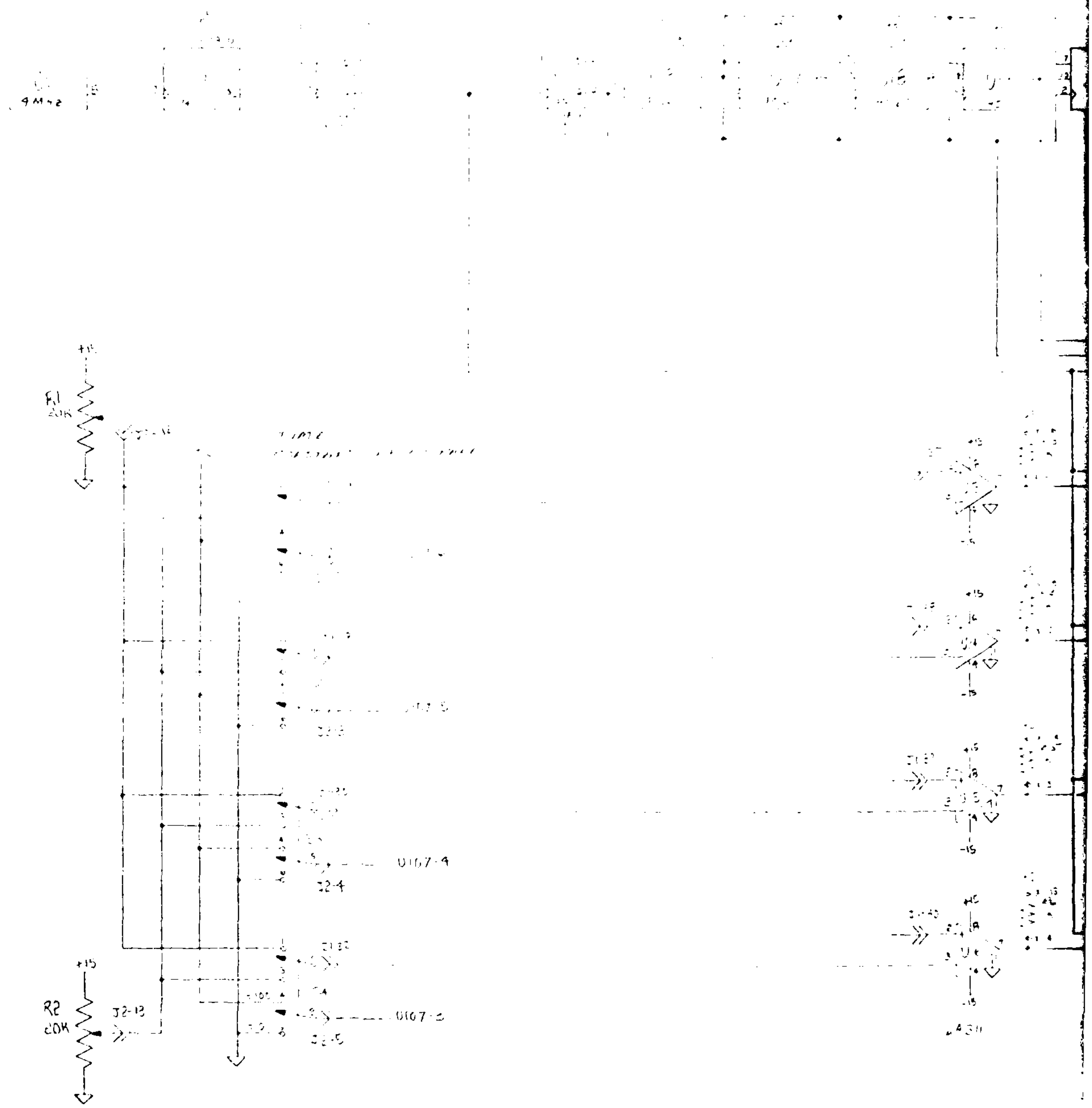


Figure A-5. Compressor-expander board, schematic diagram.



R1
R2
20K
+15
J2-13
J2-4
J2-5
U107-4
U107-5

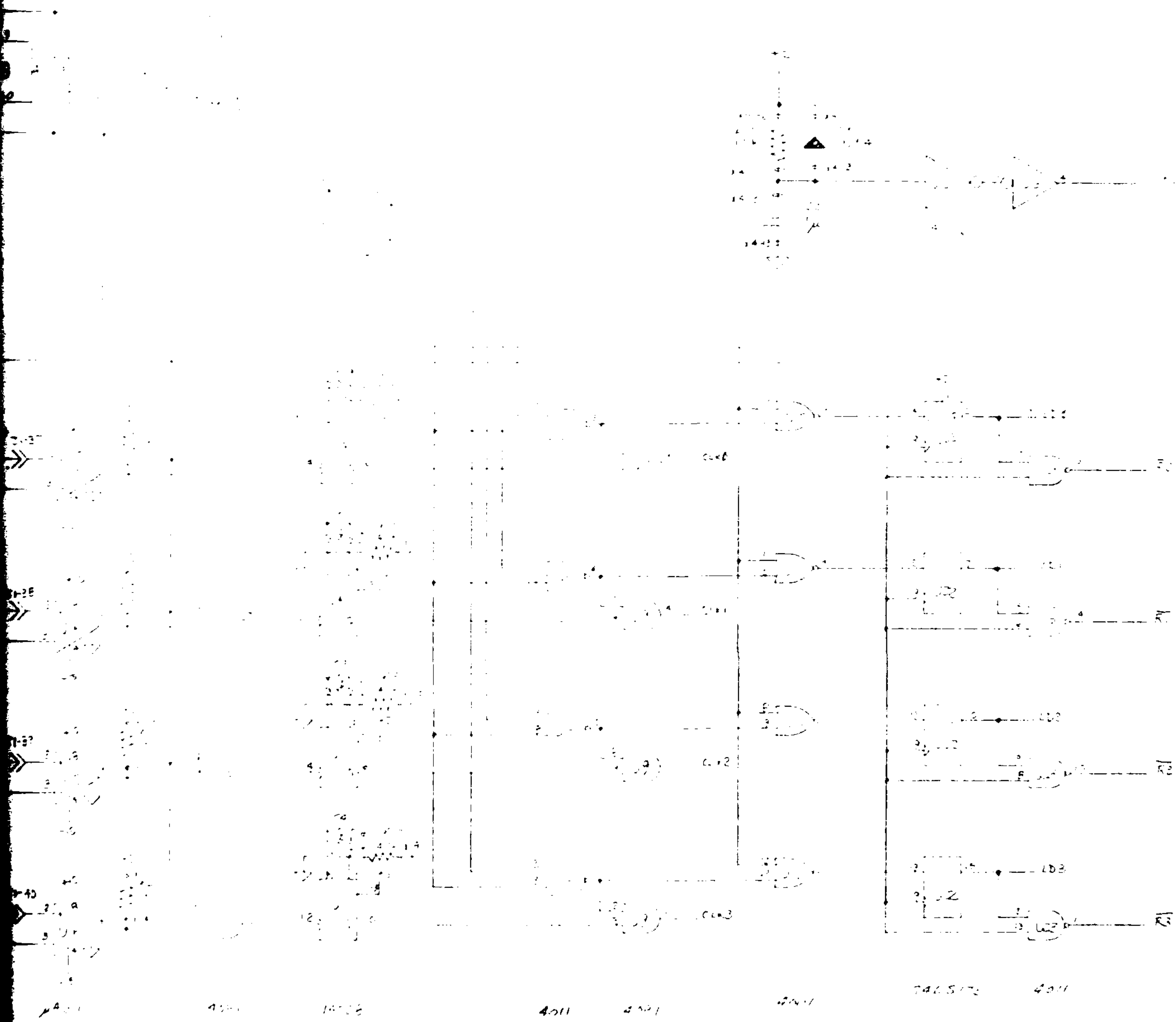
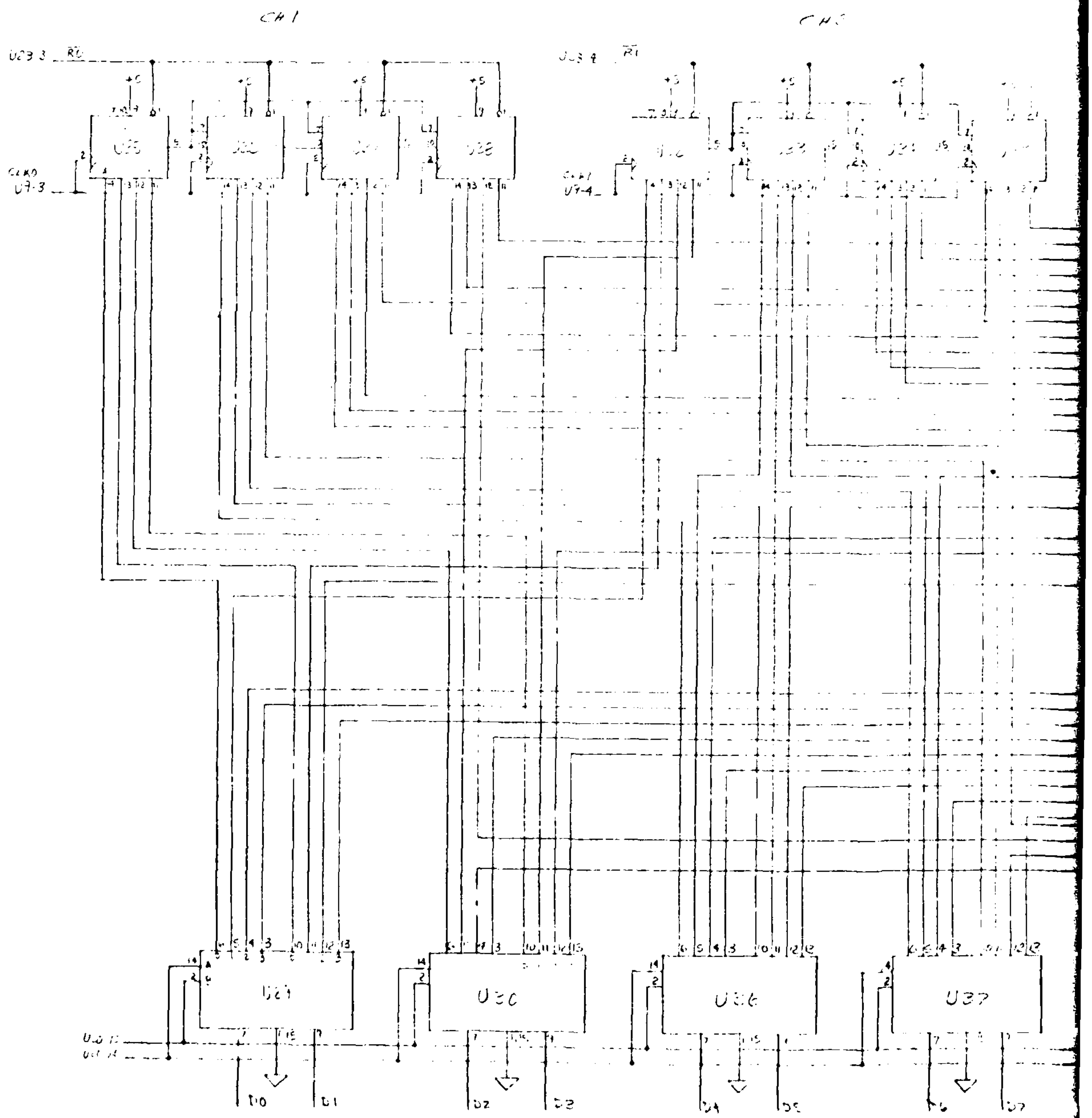


Figure A-6. Threshold detector-indicator, schematic diagram.


CH 1
+5
U30
U36
U37
D1
D2
D3
D5
D7

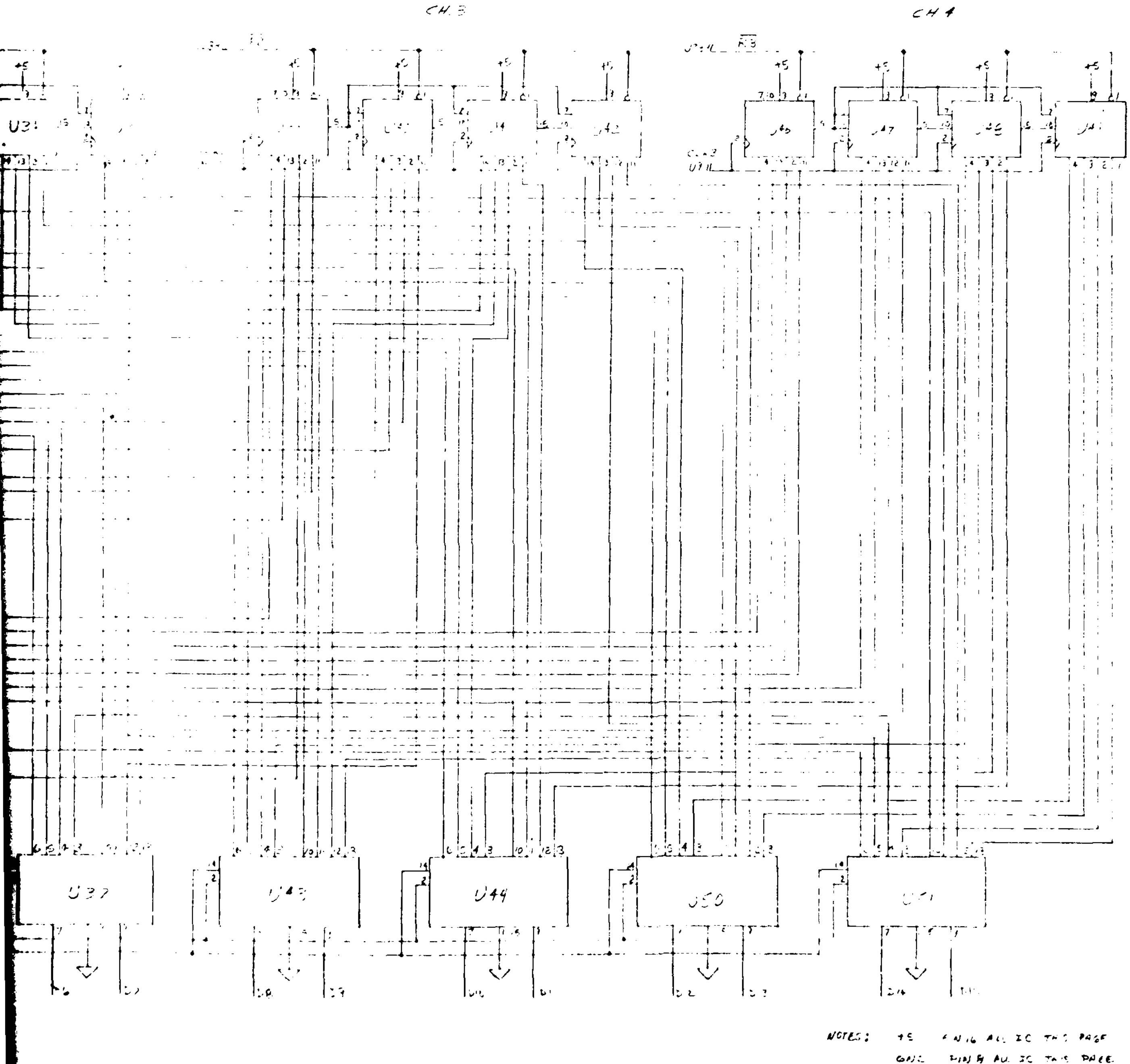
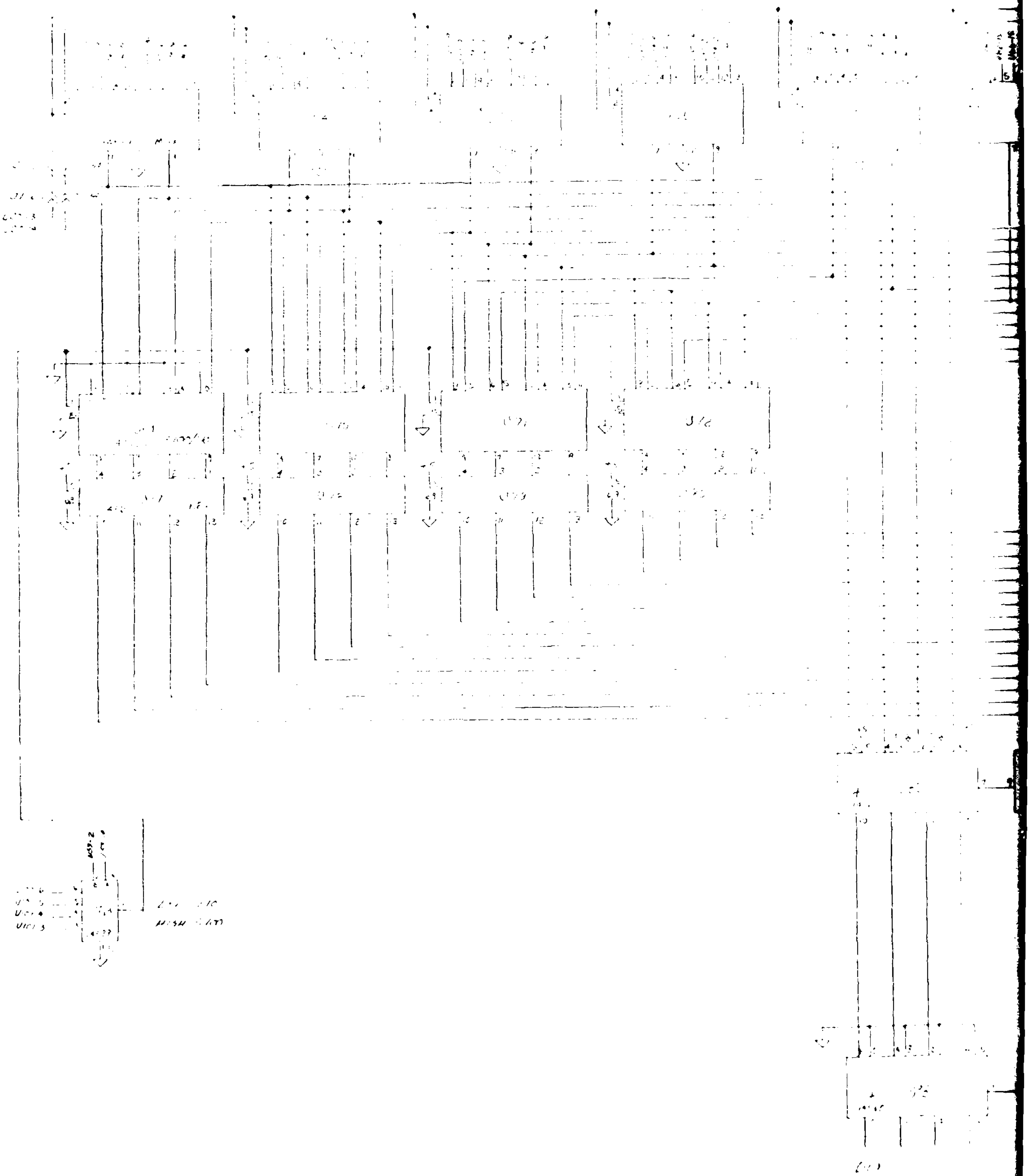


Figure A-6. Continued.



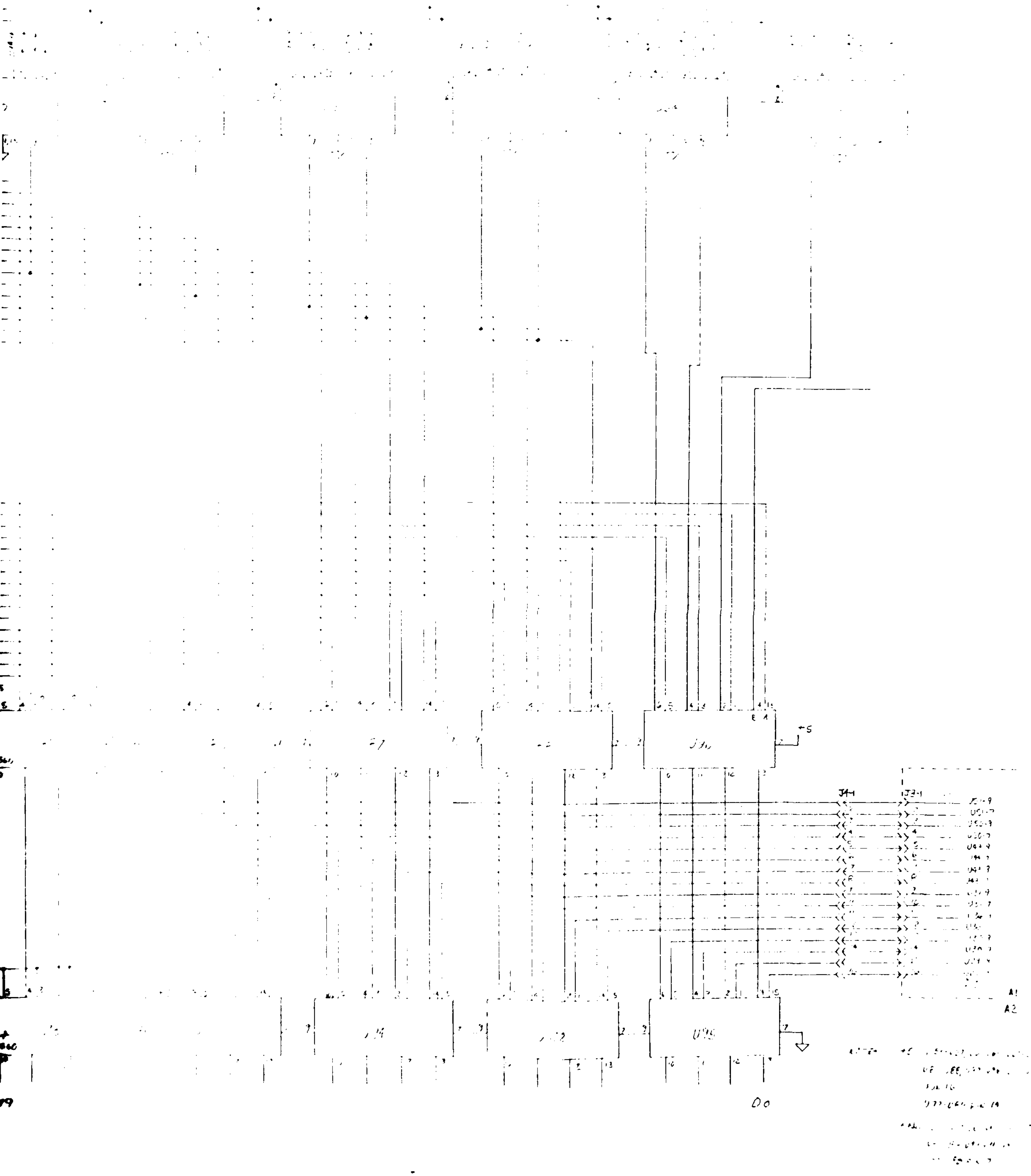
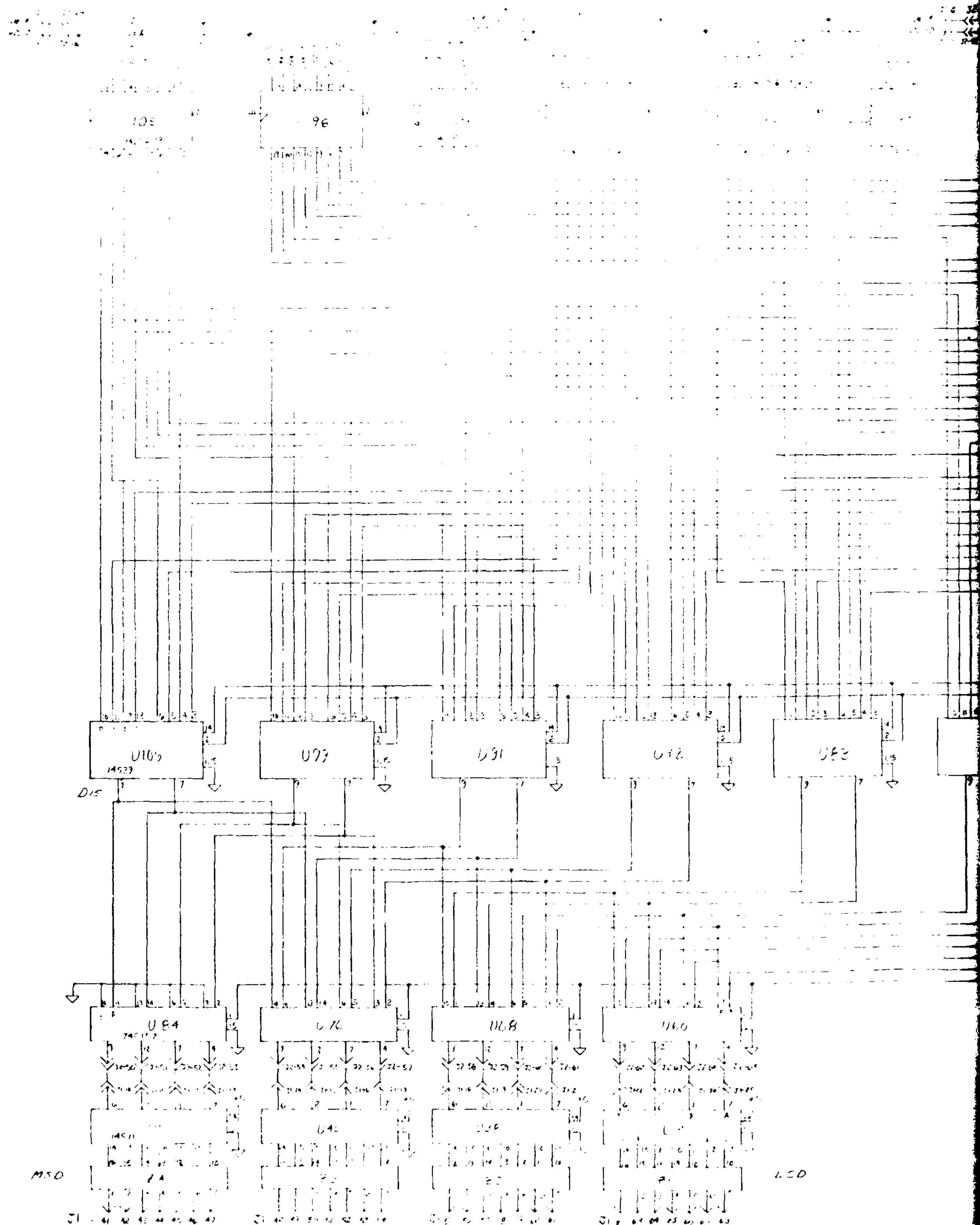


Figure A-6. Continued.



96
U84
MSD
LSD

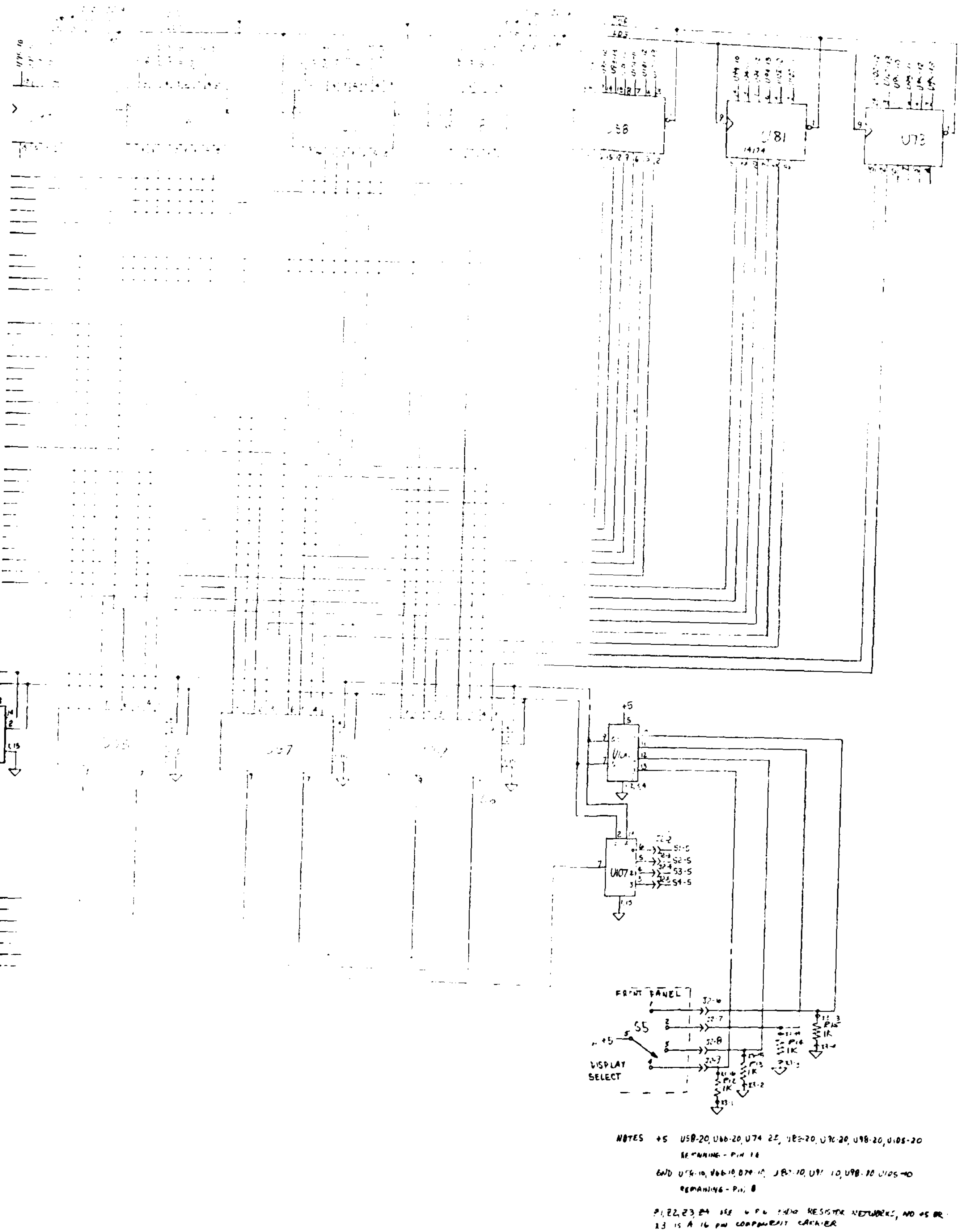
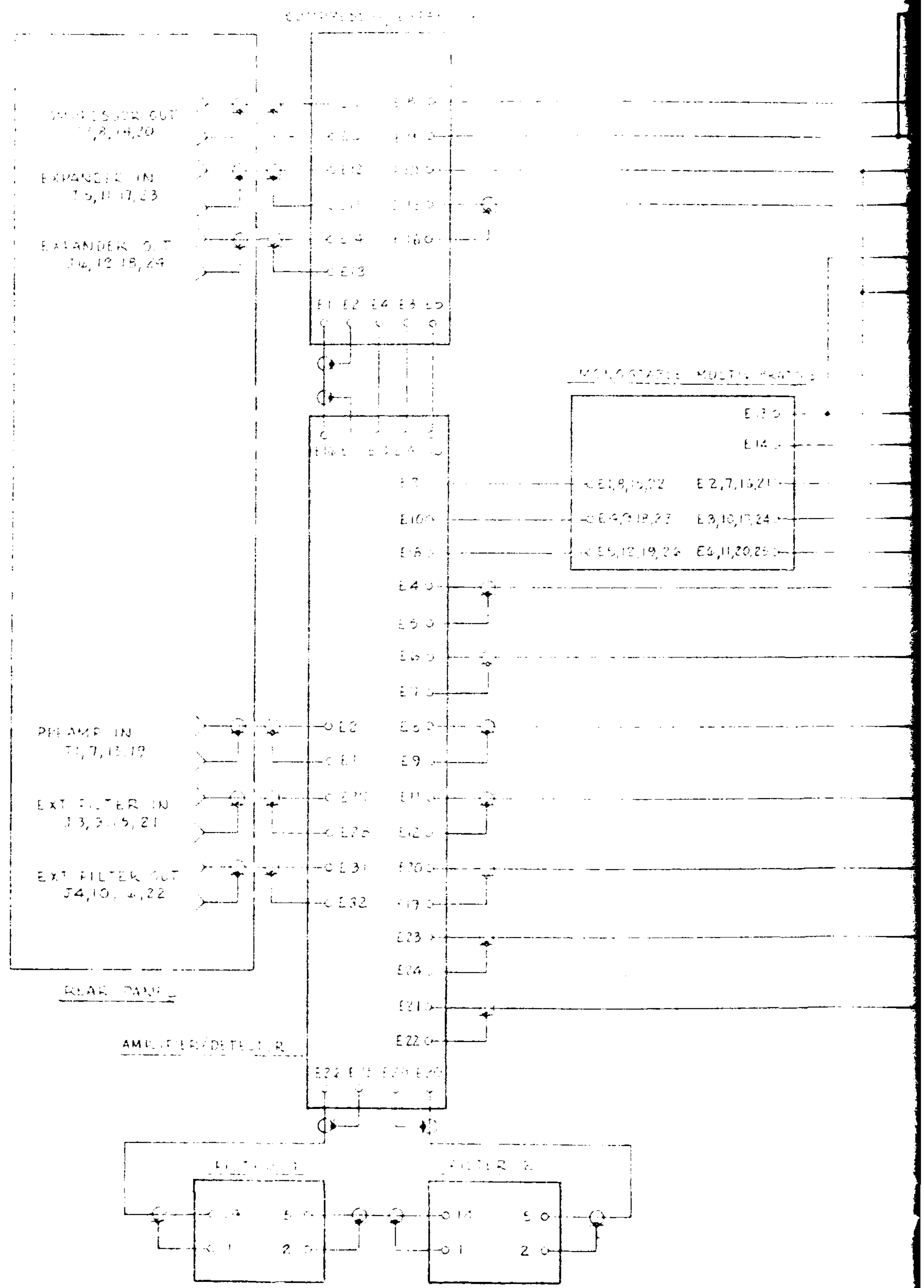
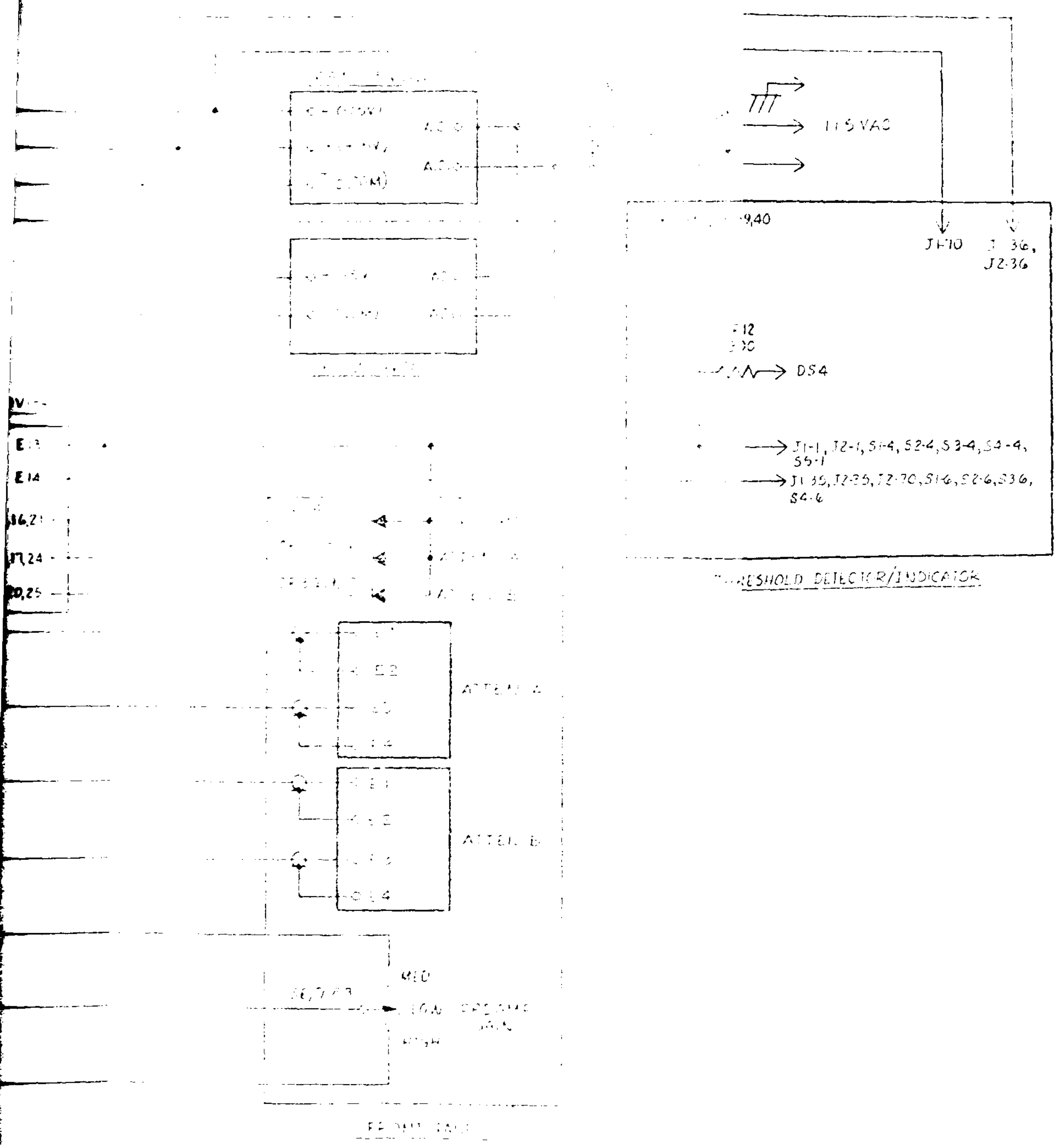


Figure A-6. Continued.



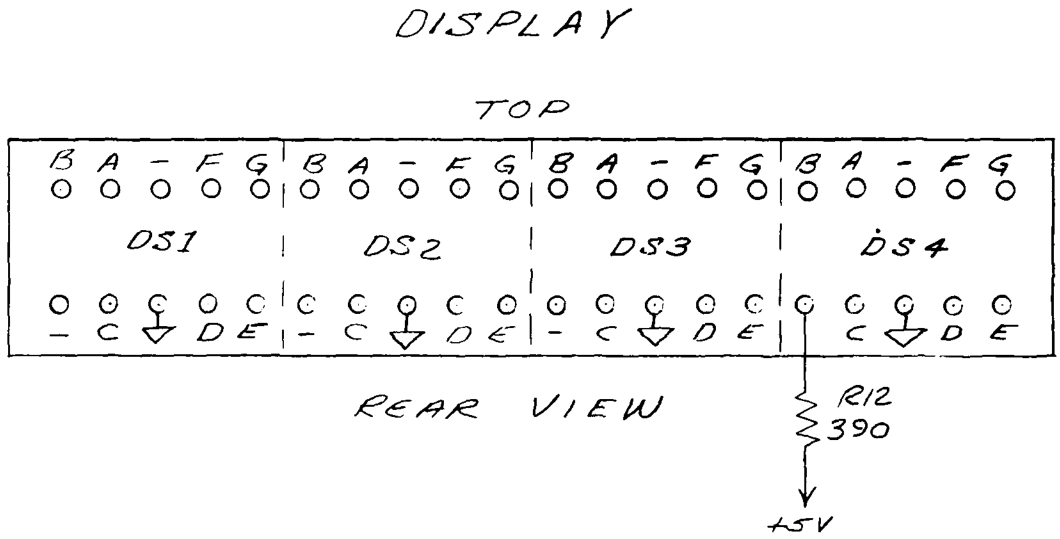
EXPANDER IN
EXPANDER OUT
PREAMP IN
EXT FILTER IN
EXT FILTER OUT
REAR PANEL
E 2,7,16,21
E3,10,17,24
E4,11,20,25
E4
E9
E23
E24
E22

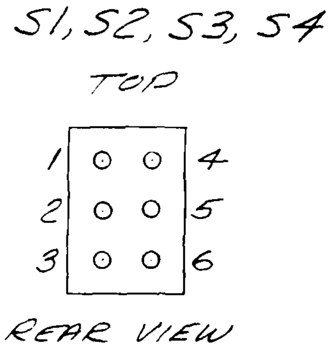


NOTE:

WHEN COMPONENTS OR CONNECTIONS ARE IDENTIFIED BY A SERIES OF FOUR NUMBERS, THE FIRST ONE REFERS TO CHANNEL 1, 2ND NO. TO 2, 3RD NO. TO CH 3, AND 4TH NO. TO CH4.

Figure A-7. Noise processor interconnection diagram.





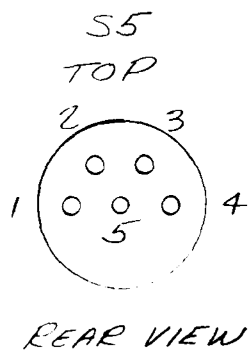


Figure A-8. Terminal identification.

Table A-1. Threshold detector-indicator interconnections.

From	To	From	To	From	To
J1-1	+5V	J1-24	J2-64	J1-47	DS4-A
J1-2	J2-37	J1-25	J2-65	J1-48	DS3-G
J1-3	J2-38	J1-26	S1-2	J1-49	DS3-F
J1-4	J2-39	J1-27	S1-5	J1-50	DS3-E
J1-5	J2-40	J1-28	S2-2	J1-51	DS3-D
J1-6	J2-41	J1-29	S2-5	J1-52	DS3-C
J1-7	J2-42	J1-30	S3-2	J1-53	DS3-B
J1-8	J2-43	J1-31	S3-5	J1-54	DS3-A
J1-9	J2-44	J1-32	S4-2	J1-55	DS2-G
J1-10	J2-50	J1-33	S4-5	J1-56	DS2-F
J1-11	J2-51	J1-34	J2-34	J1-57	DS2-E
J1-12	J2-52	J1-35	COM	J1-58	DS2-D
J1-13	J2-53	J1-36	+15V	J1-59	DS2-C
J1-14	J2-54	J1-37	CH.1 OUT	J1-60	DS2-B
J1-15	J2-55	J1-38	CH.2 OUT	J1-61	DS2-A
J1-16	J2-56	J1-39	CH.3 OUT	J1-62	DS1-G
J1-17	J2-57	J1-40	CH.4 OUT	J1-63	DS1-F
J1-18	J2-58	J1-41	DS4-G	J1-64	DS1-E
J1-19	J2-59	J1-42	DS4-F	J1-65	DS1-D
J1-20	J2-60	J1-43	DS4-E	J1-66	DS1-C
J1-21	J2-61	J1-44	DS4-D	J1-67	DS1-B
J1-22	J2-62	J1-45	DS4-C	J1-68	DS1-A
J1-23	J2-63	J1-46	DS4-B	J1-69	J2-69
				J1-70	-15V

Table A-1. Threshold detector-indicator interconnections (cont'd).

From	To	From	To	From	To
J2-1	+5V	J2-23	N/C	J2-47	N/C
J2-2	S1-5	J2-24	N/C	J2-48	N/C
J2-3	S2-5	J2-25	N/C	J2-49	N/C
J2-4	S3-5	J2-26	N/C	J2-50	J1-10
J2-5	S4-5	J2-27	N/C	J2-51	J1-11
J2-6	S5-1	J2-28	N/C	J2-52	J1-12
J2-7	S5-2	J2-29	N/C	J2-53	J1-13
J2-8	S5-3	J2-30	N/C	J2-54	J1-14
J2-9	S5-4	J2-31	N/C	J2-55	J1-15
J2-10	N/C	J2-32	N/C	J2-56	J1-16
J2-11	N/C	J2-33	N/C	J2-57	J1-17
J2-12	S1-1, S2-1	J2-34	J1-34	J2-58	J1-18
	S3-1, S4-1	J2-35	COM	J2-59	J1-19
J2-13	S1-3, S2-3	J2-36	+15V	J2-60	J1-20
	S3-3, S4-3	J2-37	J1-2	J2-61	J1-21
J2-14	N/C	J2-38	J1-3	J2-62	J1-22
J2-15	N/C	J2-39	J1-4	J2-63	J1-23
J2-16	N/C	J2-40	J1-5	J2-64	J1-24
J2-17	N/C	J2-41	J1-6	J2-65	J1-25
J2-18	N/C	J2-42	J1-7	J2-66	N/C
J2-19	N/C	J2-43	J1-8	J2-67	N/C
J2-20	N/C	J2-44	J1-9	J2-68	N/C
J2-21	N/C	J2-45	N/C	J2-69	J1-69
J2-22	N/C	J2-46	N/C	J2-70	COM

Table A-1. Threshold detector-indicator interconnections (cont'd).

From	To	From	To	From	To
J3-1	J4-1	DS1-A	J1-68	DS4-A	J1-47
J3-2	J4-2	DS1-B	J1-67	DS4-B	J1-46
J3-3	J4-3	DS1-C	J1-66	DS4-C	J1-45
J3-4	J4-4	DS1-D	J1-65	DS4-D	J1-44
J3-5	J4-5	DS1-E	J1-64	DS4-E	J1-43
J3-6	J4-6	DS1-F	J1-63	DS4-F	J1-42
J3-7	J4-7	DS1-G	J1-62	DS4-G	J1-41
J3-8	J4-8	DS2-A	J1-61	S1-1	J2-12
J3-9	J4-9	DS2-B	J1-60	S1-2	J1-26
J3-10	J4-10	DS2-C	J1-59	S1-3	J2-13
J3-11	J4-11	DS2-D	J1-58	S1-4	+5V
J3-12	J4-12	DS2-E	J1-57	S1-5	J1-27
J3-13	J4-13	DS2-F	J1-56	S1-6	COM
J3-14	J4-14	DS2-G	J1-55	S2-1	J2-12
J3-15	J4-15	DS3-A	J1-54	S2-2	J1-28
J3-16	J4-16	DS3-B	J1-53	S2-3	J2-13
		DS3-C	J1-52	S2-4	+5V
		DS3-D	J1-51	S2-5	J1-29
		DS3-E	J1-50	S2-6	COM
		DS3-F	J1-49		
		DS3-G	J1-48		

Table A-1. Threshold detector-indicator interconnections (cont'd).

From	To
S3-1	J2-12
S3-2	J1-30
S3-3	J2-13
S3-4	+5V
S3-5	J1-31
S3-6	COM
S4-1	J2-12
S4-2	J1-32
S4-3	J2-13
S4-4	+5V
S4-5	J1-33
S4-6	COM
S5-1	J2-6
S5-2	J2-7
S5-3	J2-8
S5-4	J2-9
S5-5	+5V

APPENDIX B: LISTS OF REPLACEABLE PARTS

This appendix contains parts lists and parts location diagrams for the circuitry used in the noise processor.

Material List

DATE ____________ JOB NO. ____________

DRAWN ____________ QUANTITY ____________

CHK ____________ TITLE AMPLIFIER-DETECTOR BOARD

ASS'Y NO. REV SHT OF

ITEM	STOCK/PART NO.	DESCRIPTION	MFR. SPEC	QTY				REF. DES	UNIT COST	TOT PRICE	
1		RES FXD FILM 100 1% 1/8W		1				R2			
2		RES FXD FILM 226 1% 1/8W		1				R1			
3		RES FXD FILM 324 1% 1/8W		3				R16, R20, R32			
4		RES FXD FILM 619 1% 1/8W		1				R13			
5		RES FXD FILM 1.00K 1% 1/8W		5				R17-R19, R24, R31			
6		RES FXD FILM 1.82K 1% 1/8W		2				R3, R4			
7		RES FXD FILM 2.10K 1% 1/8W		1				R42			
8		RES FXD FILM 10.0K 1% 1/8W		2				R21, R33			
9		RES FXD COMP 100 5% 1/4W		14				R5, R6, R10, R11, R14,			
								R15, R22, R23, R28, R29, R34			
								R35, R39, R40			
10		RES FXD COMP 180 5% 1/4W		3				R12, R30, R41			
11		RES FXD COMP 2.7K 5% 1/4W		3				R7, R25, R36			
12		RES FXD COMP 5.1K 5% 1/4W		3				R8, R26, R38			
13		RES FXD COMP 10K 5% 1/4W		3				R9, R27, R37			
14		CAP FXD MICA 68pF 5% 500V		1				C7			
15		CAP FXD MICA 150pF 5% 500V		2				C12, C18			
16		CAP FXD MICA 820pF 5% 500V		1				C1			
17		CAP FXD MICA 1600pF 5% 500V		1				C8			
18		CAP FXD CER .047 10% 100V		4				C4, C11, C15, C21			
19		CAP FXD CER 0.1 10% 100V		14				C2, C3, C5, C6, C9, C10			
								C13, C14, C16, C17, C19			
								C20, C22, C23			
20	NE5534AN	OP AMP	NAT	4				U1, U3, U4, U6			
21	LM311N	COMP	SIG.	3				U2, U5, U7			
22	F-5753	TRANSFORMER 50 OHM:1K	PICO	1				T1			

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Material List

DATE ____ DRAWN ____ CHK ____

TITLE MULTIVIBRATOR BOARD

JOB NO. ____ QUANTITY ____

ASS'Y NO. ____ REV. ____ SHT ____ OF ____

ITEM	STOCK/PART NO.	DESCRIPTION	MFR SPEC	QTY.				REF DES.	UNIT COST	TOT PRICE	
1		RES FXD COMP 180 5% 1/4W		12				R25-R36			
2		RES FXD COMP 4.7K 5% 1/4W		12				R13-R24			
3		RES FXD COMP 47K 5% 1/4W		12				R1-R12			
4		CAP FXD CER 0.1 10% 100V		3				C13-C15			
5		CAP FXD TANT [illegible] 10% [illegible]		12				C1-C12			
6	74LS221N	DUAL MONO MULTIVIBRATOR		6				U1-U6			

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Material List

DATE ______ DRAWN ______ CHK. ______

TITLE COMPRESSOR-EXPANDER BOARD

JOB NO. ______ QUANTITY ______ ASS'Y NO. ______ REV ______ SHT ___ OF ___

ITEM	STOCK/PART NO.	DESCRIPTION	MFR/SPEC	QTY.				REF. DES.	UNIT COST	TOT PRICE	
1		RES FXD COMP 1K 5% 1/4W		6				R3,R10,R11,R19,R23,R24			
2		RES FXD COMP 1.8K 5% 1/4W		1				R13			
3		RES FXD COMP 4.7K 5% 1/4W		4				R1, R8, R16, R22			
4		RES FXD COMP 5.6K 5% 1/4W		1				R12			
5		RES FXD COMP 15K 5% 1/4W		2				R5, R6			
6		RES FXD COMP 220K 5% 1/4W		4				R2, R7, R17, R20			
7		RES FXD COMP 2K 5% 1/4W		1				R14			
8	3250P-1-502	RES VAR WW 5K 5% 1W	BOURNS	1				R15			
9	3299W-1-104	RES VAR CER 100K 10% 1/2W	BOURNS	4				R4, R9, R18, R21			
10		CAP FXD MICA 3.9pF 5% 500V		1				C3			
11		CAP FXD MICA 18pF 5% 500V		1				C22			
12		CAP FXD MICA 39pF 5% 500V		1				C15			
13		CAP FXD MICA 47pF 5% 500V		1				C10			
14		CAP FXD MICA 150pF 5% 500V		1				C14			
15		CAP FXD MICA 4700pF 5% 500V		2				C11, C23			
16		CAP FXD CER 0.1 10% 100V		8				C5, C6, C12, C13, C18, C19			
								C24, C25			
17		CAP FXD TANT 1.0 10% 35V		10				C1, C2, C4, C7-C9, C16			
								C17, C20, C21			
18	UA741CN	OP AMP	FAIR	2				U3, U7			
19	NE570N	COMPANDER	SIG.	2				U1, U5			
20	HA2-2515-5	OP AMP	HARRIS	1				U6			
21	HA2-2625-5	OP AMP	HARRIS	1				U2			
22	UA301AN	OP AMP	FAIR	1				U4			
23	1N914	DIODE		4				CR1-CR4			

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Material List

DATE ____ DRAWN ____ CHK ____

TITLE 14.8 kHz BANDPASS FILTER

JOB NO. ____ QUANTITY ____ ASS'Y NO. ____ REV. ____ SHT ___ OF ___

ITEM	STOCK/PART NO.	DESCRIPTION	MFR/SPEC	QTY.				REF. DES.	UNIT COST	TOT PRICE	
1		CAP FXD POLYSTY 0.228 uF 2%		2				C1, C4			
2		CAP FXD POLYSTY .0346 uF 2%		1				C2			
3		CAP FXD POLYSTY .0454 uF 2%		1				C3			
4		COIL VAR FERRITE 0.507 mH 2%		2				L1, L4			
5		COIL VAR FERRITE 2.55 mH 2%		1				L2			
6		COIL VAR FERRITE 3.34 mH 2%		1				L3			
7		RES FXD COMP 620 5% 1/4W		1				R1			

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Material List

DATE ____________ JOB NO. ____________

DRAWN ____________ QUANTITY ____________

CHK ____________ TITLE 28.5 kHz BANDPASS FILTER

ASS'Y NO.

REV

SHT OF

ITEM	STOCK PART NO.	DESCRIPTION	MFR SPEC	QTY				REF. DES.	UNIT COST	TOT PRICE	
1		CAP FXD POLYSTY 0.114uF 2%		2				C1, C4			
2		CAP FXD POLYSTY 0.172uF 2%		1				C2			
3		CAP FXD POLYSTY .0228uF 2%		1				C3			
4		COIL VAR FERRITE 0.274mH 2%		2				L1, L4			
5		COIL VAR FERRITE 1.37mH 2%		1				L2			
6		COIL VAR FERRITE 1.81mH 2%		1				L3			
7		RES FXD COMP 620 5% 1/4W		1				R1			

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Material List

DATE ______ DRAWN ______ CHK. ______ TITLE ATTENUATOR

JOB NO. ______ QUANTITY ______ ASS'Y NO. ______ REV ______ SHT OF

ITEM	STOCK/PART NO.	DESCRIPTION	MFR/SPEC	QTY.				REF. DES	UNIT COST	TOT PRICE	
1		RES FXD FILM 115 1% 1/8W		2				R1, R2			
2		RES FXD FILM 226 1% 1/8W		2				R4, R5			
3		RES FXD FILM 324 1% 1/8W		1				R12			
4		RES FXD FILM 432 1% 1/8W		2				R7, R8			
5		RES FXD FILM 732 1% 1/8W		2				R10, R11			
6		RES FXD FILM 953 1% 1/8W		1				R9			
7		RES FXD FILM 2.10K 1% 1/8W		1				R6			
8		RES FXD FILM 4.32K 1% 1/8W		1				R3			

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Material List

DATE ______ JOB NO. ______

DRAWN ______ QUANTITY ______

CHK ______ TITLE THRESHOLD DETECTOR - INDICATOR

ASS'Y NO. ______ REV ______ SHT 1 OF 2

ITEM	STOCK/PART NO.	DESCRIPTION	MFR/SPEC	QTY.	REF. DES.	UNIT COST	TOT PRICE
1	[illegible]	RES VAR CER [illegible] 1/2W	BOURNS	2	R1, R2		
2		RES FXD COMP 1K 5% 1/4W		8	R3-R6, R12-R15		
3		RES FXD COMP 4.7K 5% 1/4W		4	R7-R10		
4		RES FXD COMP 10K 5% 1/4W		1	R11		
5		RES FXD COMP 390 5% 1/4W		1	R12		
6	4116R-[illegible]-331	RES FXD NETWORK 330 5%	BOURNS	4	Z1-Z4		
7		CAP FXD MICA 56 pF 5%		4	C1-C4		
8		CAP FXD TANT 1uF 10%		1	C5		
9	[illegible]	DISPLAY LED [illegible] HIGH	[illegible]	4	DS1-DS4		
10	1N914	DIODE, SILICON		1	CR1		
11	[illegible]	OSCILLATOR 4 MHZ	DALE	1	U1		
12	[illegible]	MICROCIRCUIT		1	U2		
13	4011B	MICROCIRCUIT		2	U3, U23		
14	[illegible]	MICROCIRCUIT		2	U4, U11		
15	[illegible]	MICROCIRCUIT		1	U6		
16	[illegible]	MICROCIRCUIT		1	U7		
17	[illegible]	MICROCIRCUIT		21	U8, U17-U20, U25-U28		
					U32-U35, U39-U4[illegible]		
					U46-U49		
[illegible]	[illegible]	MICROCIRCUIT		2	U9, U12		
[illegible]	[illegible]	MICROCIRCUIT		1	U10		
[illegible]	[illegible]	MICROCIRCUIT		4	U13-U16		
[illegible]	[illegible]	MICROCIRCUIT		1	U21		
[illegible]	[illegible]	MICROCIRCUIT		1	U22		

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DATE ____ DRAWN ____ CHK ____

TITLE THRESHOLD DETECTOR - INDICATOR

JOB NO. ____ QUANTITY ____ ASS'Y NO. ____

REV. ____ SHT 2 OF 2

ITEM	STOCK PART NO.	DESCRIPTION	MFR SPEC	QTY				REF. DES.	UNIT COST	LOT PRICE	
23	14539	MICROCIRCUIT		[illegible]				U29,U30,U36,U37,U43			
								U44,U50,U51,U53-U57			
								U59,U61-U65,U67,U75			
								U83,U91,U92,U99,U106			
								U107			
24	14511	MICROCIRCUIT		4				U31,U38,U45,U52			
25	74LS273	MICROCIRCUIT		[illegible]				U58,U66,U74,U82,U90			
								U98, U105			
26	74C157	MICROCIRCUIT		[illegible]				U60,U68-U72,U76,U84			
27	40174	MICROCIRCUIT		[illegible]				U73,U81			
28	14561	MICROCIRCUIT		4				U77-U80			
29	14560	MICROCIRCUIT		11				U85-U88,U93-U96			
								U101-U103			
30	40175	MICROCIRCUIT		3				U89,U97,U104			
31	14532	MICROCIRCUIT		1				U100			

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Material List

DATE ______ JOB NO. ______

DRAWN ______ QUANTITY ______

CHK ______ TITLE CHASSIS

ASS'Y NO. ______ REV ______ SHT ___ OF ___

ITEM	STOCK/PART NO.	DESCRIPTION	MFR/SPEC	QTY.				REF. DES	UNIT COST	TOT PRICE	
1		FUSE, 1A, 250V, SLO-BLO						F1			
2	507-4538-1431-610	INDICATOR, NEON, REL	DIALCO	1				DS5			
3	MV5025	INDICATOR, LED	MONSANTO	12				CR1-CR12			
4	DB15-35	POWER SUPPLY, ± 15 VOLT	ACOPIAN	1				PS1			
5	5EB150	POWER SUPPLY 5 VOLT	ACOPIAN	1				PS2			

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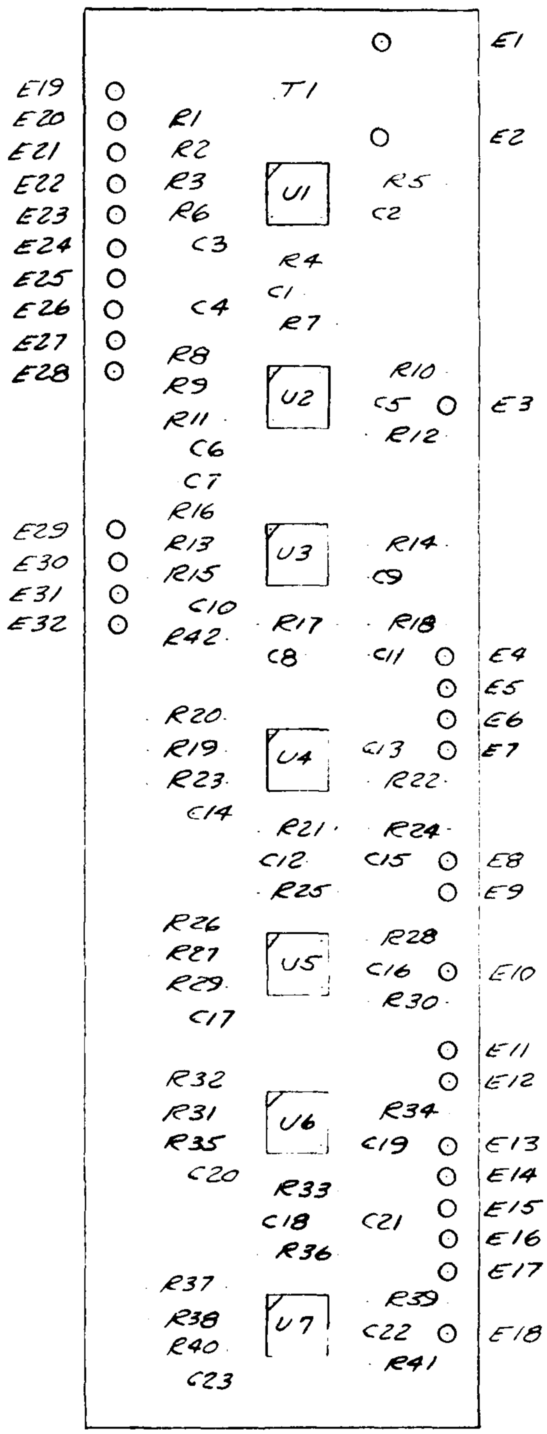

Figure B-1. Amplifier-detector board, parts location diagram.

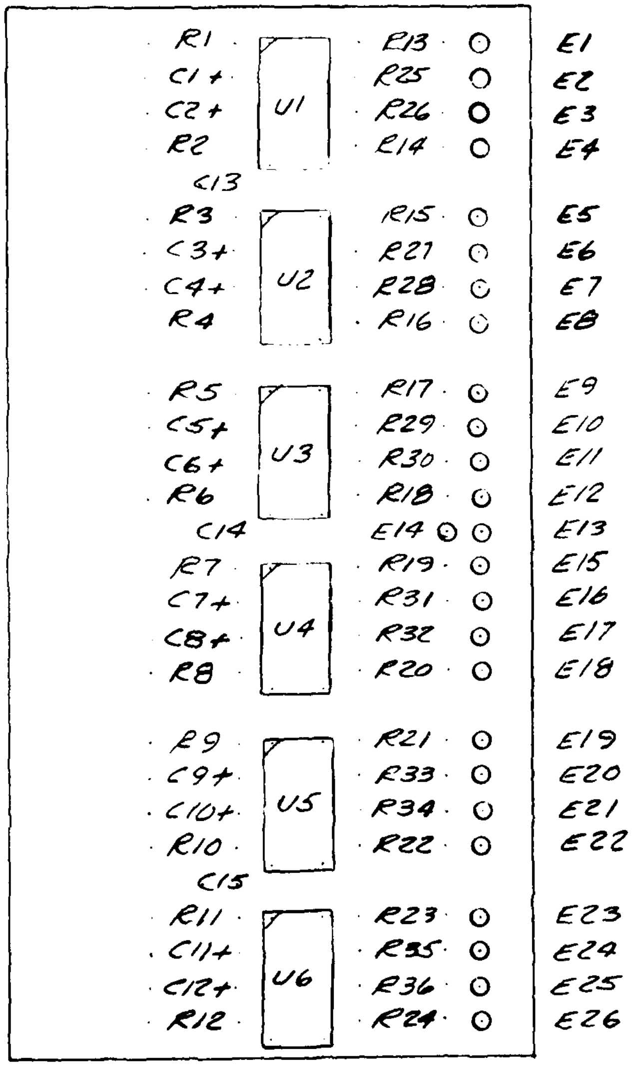

Figure B-2. Monostable multivibrator board, parts location diagram.

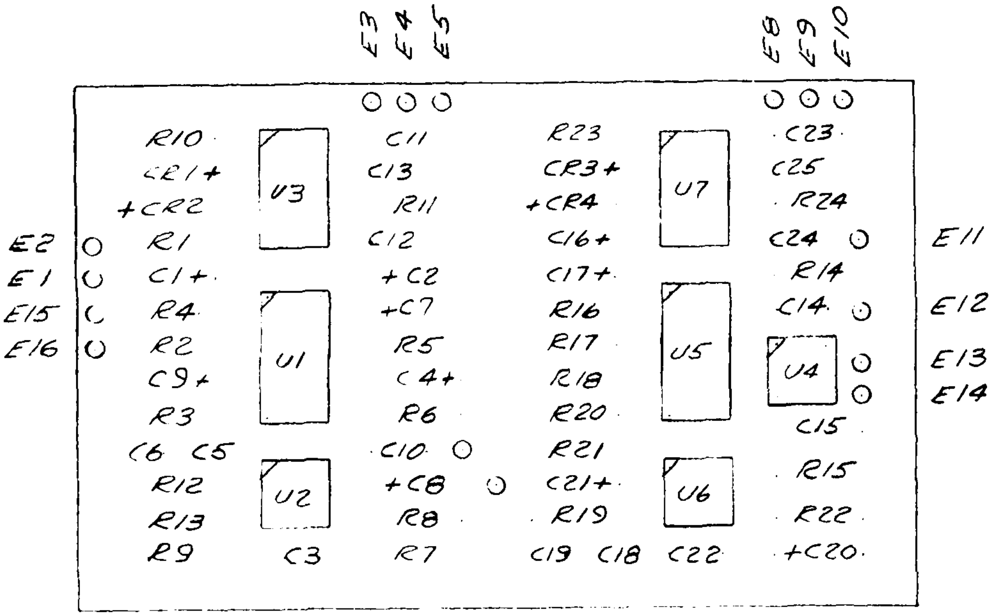

Figure B-3. Compressor-expander board, parts location diagram.

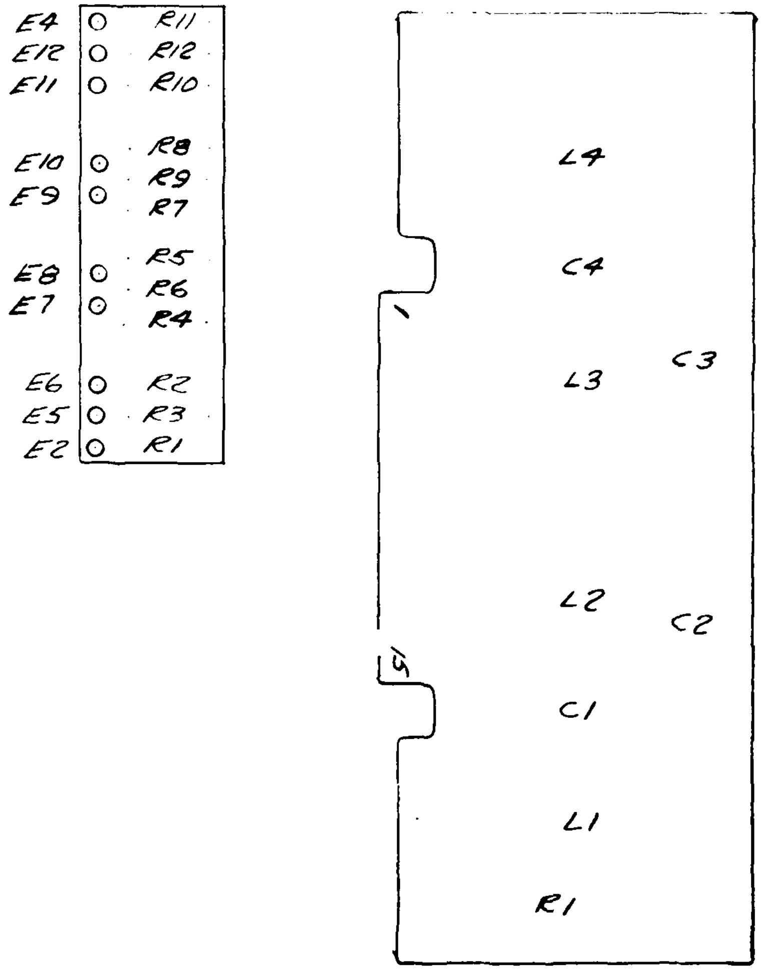

Figure B-4. Attenuator & bandpass filter boards, parts location diagram.

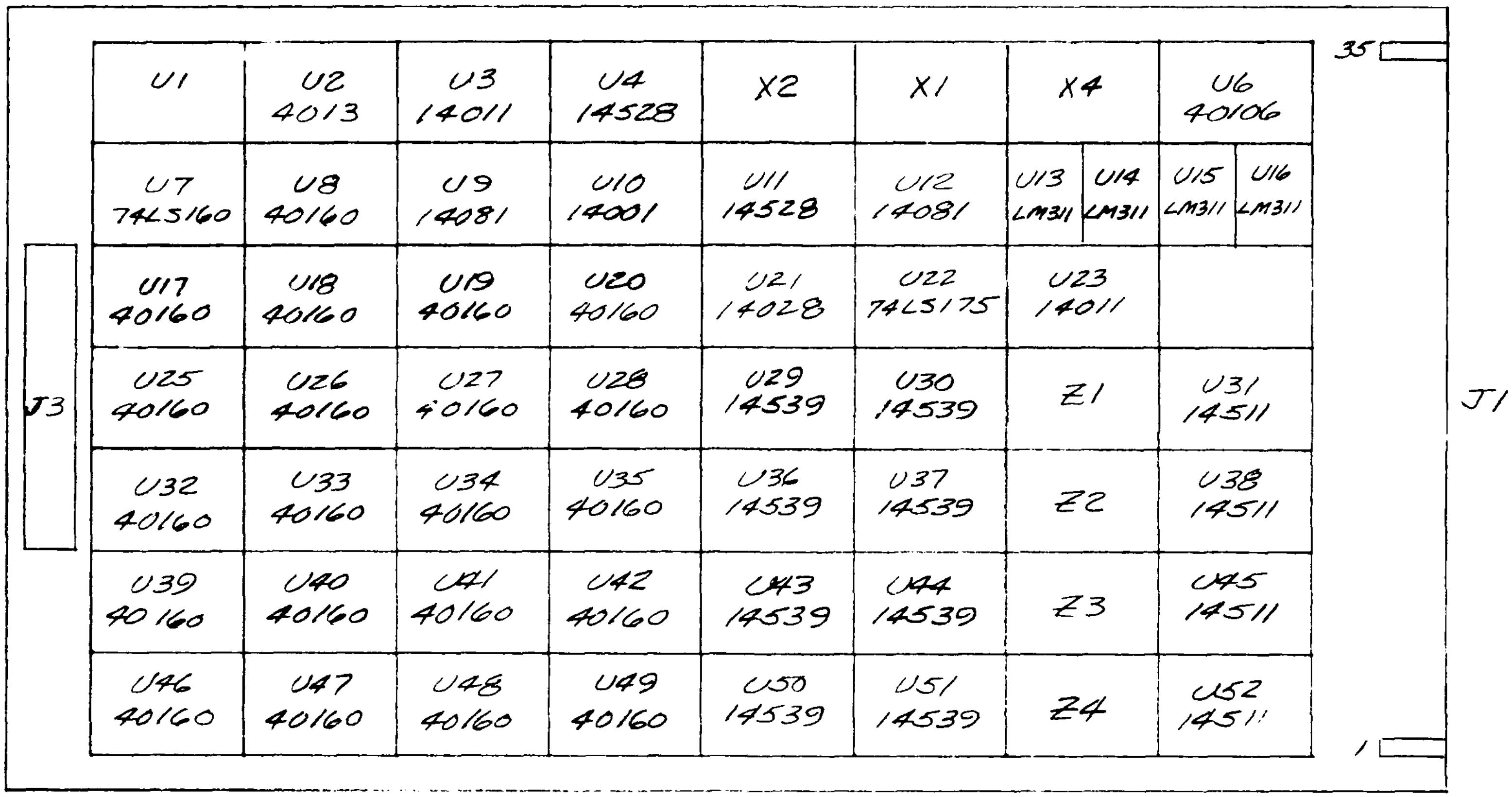

Figure B-5. Parts location, threshold det. A1.

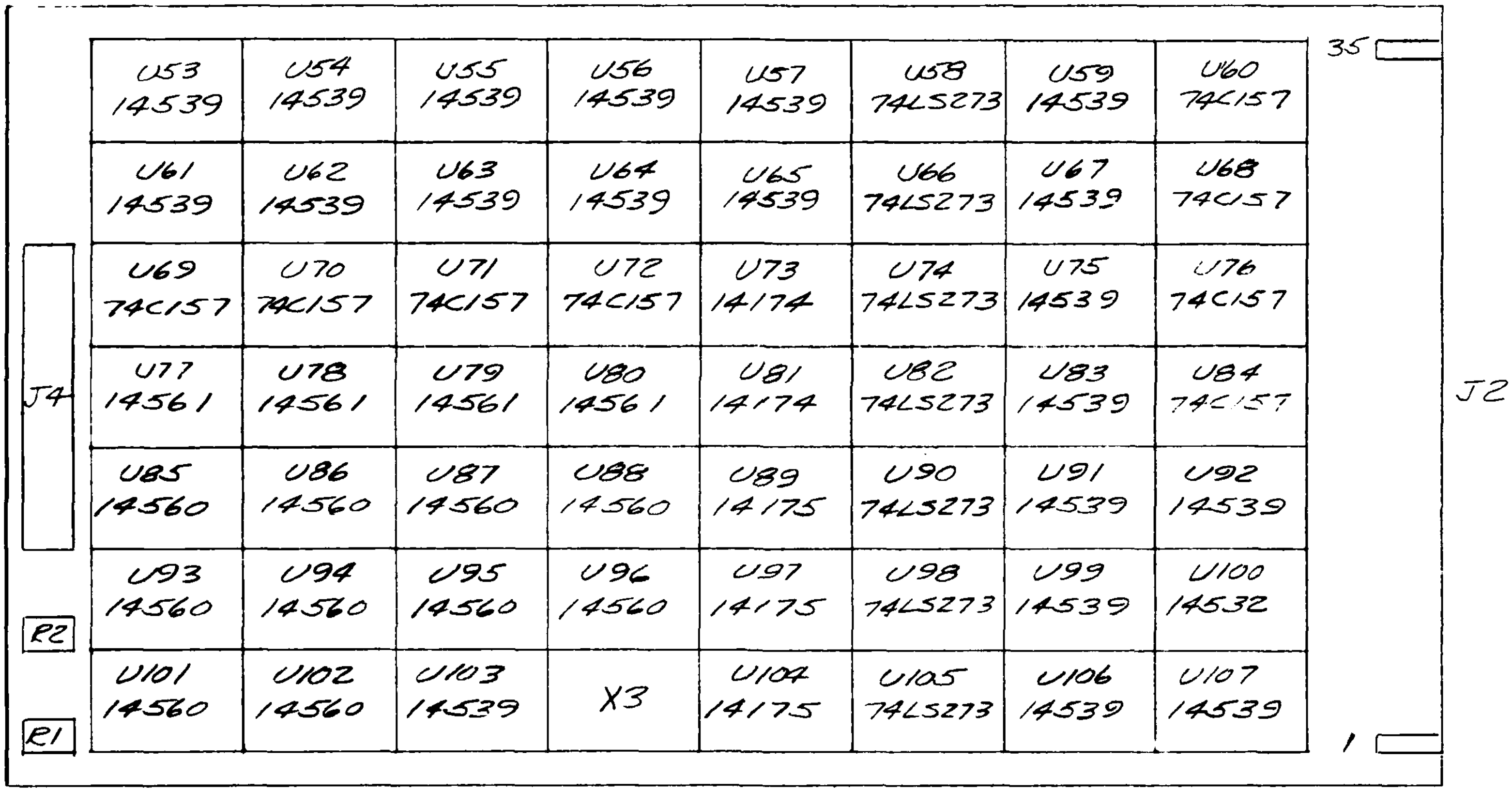

Figure B-6. Parts location, threshold det. A2.