NOAA Technical Memorandum ERL WPL-12

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
Environmental Research Laboratories

NOAA Mark VII Acoustic Echo Sounder

EDWARD J. OWENS

Wave
Propagation
Laboratory
BOULDER,
COLORADO
June 1975

NOAA

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

U.S. DEPARTMENT OF COMMERCE

ONMENTAL RESEARCH LABORATORIES

WAVE PROPAGATION LABORATORY

DEPARTMENT OF COMMERCE

UNITED STATES OF AMERICA

IMPORTANT NOTICE

Technical Memoranda are used to insure prompt dissemination of special studies which, though of interest to the scientific community, may not be ready for formal publication. Since these papers may later be published in a modified form to include more recent information or research results, abstracting, citing, or reproducing this paper in the open literature is not encouraged. Contact the author for additional information on the subject matter discussed in this Memorandum.

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

BOULDER, COLORADO

NOAA Technical Memorandum ERL WPL-12

NOAA MARK VII ACOUSTIC ECHO SOUNDER

Edward J. Owens

Wave Propagation Laboratory
Boulder, Colorado
June 1975

UNITED STATES
DEPARTMENT OF COMMERCE
Rogers C.B. Morton, Secretary

NATIONAL OCEANIC AND
ATMOSPHERIC ADMINISTRATION
Robert M. White, Administrator

Environmental Research
Laboratories
Wilmot N. Hess, Director

DISCLAIMER

The NOAA Environmental Research Laboratories do not approve, recommend, or endorse any proprietary product or proprietary material mentioned in this publication. No reference shall be made to the NOAA Environmental Research Laboratories, or to this publication furnished by the NOAA Environmental Research Laboratories, in any advertising or sales promotion which would indicate or imply that the NOAA Environmental Research Laboratories approve, recommend, or endorse any proprietary product or proprietary material mentioned herein, or which has as its purpose an intent to cause directly or indirectly the advertised product to be used or purchased because of this NOAA Environmental Research Laboratories publication.

CONTENTS

		Page
ABSTRACT		1
1.	INTRODUCTION	1
2.	GENERAL CHARACTERISTICS	1
3.	THEORY OF OPERATION	3
4.	INITIAL SETUP PROCEDURE	5
	4.1 Unpacking and Installation	5
	4.2 Final Cabling	7
5.	ADJUSTMENT AND CALIBRATION PROCEDURE	8
6.	STARTUP PROCEDURE	23
	6.1 AC Power Switches	23
	6.2 Interconnecting Cables	23
	6.3 Echo Range	23
	6.4 Ramp Gain	24
	6.5 Filter	24
	6.6 Pulse Width	24
	6.7 Receiver Delay	25
	6.8 Receiver Gain	25
	6.9 Filter Gain	25
	6.10 Gain Adjustment	26
	6.11 Transmit Frequency	26
	6.12 1000 Hz Sync Frequency	26
	6.13 Mult. Freq. Facs. Select	26
	6.14 Facsimile Recorder	27
	6.15 Start Control Unit	28
	6.16 Power Amplifier	28
	6.17 Facsimile Recorder	28
7.	SHUTDOWN PROCEDURE AND PAPER REPLACEMENT	29
8.	MAINTENANCE OF FACSIMILE RECORDER	30
	8.1 Daily Maintenance	30
	8.2 Weekly Maintenance	30
9.	SYSTEM GAIN	31
10.	COMMENTS	32
11.	REFERENCES	33
APPENDIX A	FACSIMILE RECORDER MODIFICATIONS	34
APPENDIX B	DESIGN AND OPERATION OF THE CONTROL UNIT ELECTRONICS	36
APPENDIX C	SCHEMATIC DIAGRAMS	44

CONTENTS (contd)

		Page
APPENDIX D	DESIGN AND OPERATION OF THE FACSIMILE RECORDER ELECTRONICS	60
APPENDIX E	PARTS LIST (ABBREVIATED)	61
APPENDIX F	INTERCONNECTING CABLE/CONNECTOR WIRING DIAGRAM	65
APPENDIX G	DESIGN OF ANECHOIC ABSORBING CUFF	66
APPENDIX H	RECOMMENDED SPARE PARTS LIST	69
APPENDIX I	VARIABLE SYSTEM COMPONENTS	70

NOAA MARK VII ACOUSTIC ECHO SOUNDER

Edward J. Owens

The NOAA Mark VII portable Acoustic Echo Sounder which consists of a central unit, power amplifier, facsimile recorder, and 4-ft parabolic reflector antenna and which is used to monitor atmospheric temperature structure (inversions and convective plumes) to a height of 1360 m, by measuring backscattered echoes from acoustic tone bursts, is described. The theory and operation of the system are covered in detail. Complete instructions for initial set-up, adjustment and calibration, startup, shutdown, and maintenance are given. Appendices include wiring diagrams, design and operation of electronics subsystems, modifications to system, parts lists, and schematic diagrams of circuits.

1. INTRODUCTION

The NOAA Mark VII Acoustic Echo Sounder is a portable, monostatic instrument used to monitor atmospheric temperature fluctuations by measuring backscattered echoes from acoustic tone bursts. This small but versatile research instrument can record the height and structure of temperature inversions and convective plumes in the boundary layer to an altitude of 1360 m above the antenna. The system is a unique combination of commercially available analog function modules and standard digital integrated circuits placed in sockets on printed circuit boards for simple, trouble-free operation and easy maintenance.

2. GENERAL CHARACTERISTICS

The sounder consists of four electronic components (control unit. power amplifier, facsimile recorder, and antenna preamplifier) and the antenna assembly. Operating at 117 V 60 Hz, it draws only 120 W idling power and 170 W during tone bursts. The average power consumption is about 125 W; with minor modifications, the sounder could be operated from direct current power sources such as batteries or generators. The control unit contains the major electronic sub-assemblies placed on 14 printed circuit boards and mounted in a 5.25-in relay rack mountable chassis. The facsimile recorder is a modified Ross "Straightline" depth sounder repeater using 7-in wide dry paper (see App. A). The power amplifier is a commercially available Bogen 125-W monaural audio amplifier. The antenna is a 4-ft aluminum parabolic dish modified for acoustic use. A description of the theory of design of the electronics and antenna is in Owens (1974) and Simmons et al. (1971). A remote preamp designed by J. W. Wescott of the NOAA Wave Propagation Laboratory is used to switch the transducer between transmit and receive modes automatically and to amplify the very weak acoustic echo signal. The preamplifier is placed next to the antenna with as much as 2000 ft of cable between it and the control unit.

A. Three simultaneous or independent transmitting frequencies of 2000, 2500, and 3333 Hz.

B. Pulse repetition rates of 60 (170 m), 30 (340 m), and 15 (680 m) per min or 30 (340 m), 15 (680 m), and 7.5 (1360 m) per min depending on the speed of the writing belt drive motor located in the facsimile recorder.

C. Tone-burst duration variable from 10 to 990 ms in 10 ms increments.

D. Receiver-delay variable from 10 to 990 ms in 10 ms increments.

E. Antenna preamplifier gain of 70 to 100 dB (adjustable).

F. Additional receiver gain variable from 0 to 16 dB (0, 10, 12, 14, 16).

G. Additional filtered-echo gain variable from 30 to 46 dB (30, 36, 40, 44, 46).

H. Transmit power variable up to 100 electrical watts.

I. Darkness of the facsimile record.

Other features incorporated in the sounder include:

A. A 1-min time mark placed on the facsimile record every hour by disabling the tone-burst generator while still sampling the background noise level. A push-button switch is used to set the hour mark initially to correspond with the time-of-day clock.

B. BNC connections for tape recording or monitoring the detected echo signal corresponding to echo intensity of each of the three transmitted frequencies (if multifrequency transmission is selected) or of the individual transmit frequency selected. These outputs can be the raw detected echo for direct recording or low-pass filtered for FM recording.

C. Switch-selectable facsimile recording of the individual echo intensity signal selected, or of one of the multiple frequency echo intensity signals.

D. Tape recorder output of the selected low-pass filtered detected echo mixed with a portion of the inverted transmit gate for single channel FM recording of echo returns versus range.

E. BNC connector for monitoring or tape recording the raw echo from the remote preamplifier.

F. An audio monitor speaker for listening to the gated gain-swept raw echo or the detected-echo signal.

With external signal processing equipment and a tape recorder, the intensity of scattering as a function of height can be calculated. By properly measuring the overall gain of the acoustic system and knowing the theoretical expression for acoustic scattering in a turbulent atmosphere (Monin, 1962), it is possible to use the scattering intensity to determine C_T (Neff, 1975). The same equipment can be used to extract the Doppler information contained in the received echo signal. Work is taking place at NOAA to incorporate into the MARK VII system a digital method of extracting Doppler information to determine wind velocities along the path of propagation to an altitude of 400 m. Power and space requirements have been allowed for in the control unit for easy modifications of existing systems.

3. THEORY OF OPERATION

The theory of operation of the NOAA MARK VII Acoustic Echo Sounder can be followed from the detailed schematic diagrams and explanations in Appendix B and from the block diagram (fig. C.1) and schematic diagrams (figs. C.2 through C.16). The Control Unit consists of 14 printed circuit boards (PCB's) in a 5.25-in by 19-in chassis which can be mounted in a relay rack. Front and rear panels upon which the various switches and connectors are located are hinged to allow easy access to the printed circuit boards for maintenance and calibration.

Figure C.2 shows the arrangements of 13 PCB's, numbered from left to right, installed in card holders, and removable from the front of the chassis. The FAXAMP board (PCB 14) is mounted at the left rear of the bottom plate and is removable from the back of the chassis.

The Clock Circuit (PCB 4) is the basis for all timing and transmit frequency generation. The output of a 200-kHz square-wave oscillator is counted down by various "Count-Down" circuits to yield the 20-kHz square-wave input to the transmitter circuits and the 100-kHz square-wave input to the gating circuits.

The Transmitter Circuit (PCB 7) uses three different "Divide-By" networks to produce square-wave signals of 2 kHz, 2.5 kHz, and 3.333 kHz from the 20-kHz input signal. Three feed-forward active band-pass filters shape the transmit frequencies which are then gated by the TRANSMIT GATE to form the transmitted tone burst. The tone burst is amplified and fed to the remote preamplifier automatic transmit-receive circuits through the long multiconductor cable.

The Dual Gate Circuits (PCB 6) use the 100-Hz signal from the clock as the 10 ms timing base for the thumb-wheel-switch selectable TRANSMIT and RECEIVER-DELAY control gates which in turn control the respective electronic switches in the Transmitter and Receiver circuits.

The Hour Marker Circuit (PCB 5) sends a control pulse to the TRANSMIT GATE circuit to disable it, thus deactivating the transmitted tone burst, for 1 min every hour. This places a 1-min timing mark on the facsimile record which can be synced to a time-of-day clock.

The Receiver (PCB 10) uses the RECEIVER GATE control pulse to switch the output of the remote preamplifier, i.e., the wide-band raw echo signal, through a variable-gain amplifier to the X input of an analog multiplier. A range-compensating gain ramp is fed to the Y input of the analog multiplier. The resulting signal is the gated range-compensated raw echo signal which is then band-pass filtered.

The Filters (PCB's 11, 12, and 13) are narrow, active band-pass filters, each tuned to one of the three transmit frequencies available. Their output signal is the gated, narrow-band, range-compensated echo signal.

The Detector (PCB 8) consists of three identical circuits, each composed of a variable-gain amplifier, a precision rectifier, and a low-pass filter. The output of the low-pass filter is a low frequency signal proportional to the square root of the received echo intensity.

The Facsimile Amplifier (PCB 14) amplifies the echo signal for use with a dry-paper Facsimile Recorder. The Facsimile Recorder electronics generate a short key pulse when the writing pen is positioned at the bottom of the paper. A hole is sensed by a photo-transistor which triggers a "one-shot" to produce a very short positive-going pulse used to reset the counters in the transmitter and receiver-gate circuits. (See App. D).

The Remote Preamplifier, located next to the antenna at some distance from the Control Unit, acts as an automatic switch for transmit and receive modes, and amplifies the very weak echo signal. Two diode bridges are used, one to eliminate the low-amplitude hum and correct frequency leak-through present on the long cable, and the other to voltage-limit the signal passed to the low-noise amplifier. When serving as a receiver the limiter bridge passes all echo signals through a 100:1 step-up transformer to a low-noise amplification stage. Several sections of high-pass filters eliminate the usually strong, low frequency ambient background noise. A line amplifier then passes the highly amplified signal back through the same multiconductor cable to the control unit and to the receiver circuit.

The Tape Mixer Circuit (PCB 9) mixes the output of the selected detected echo signal with an inverted portion of the TRANSMIT GATE for tape recording.

4. INITIAL SETUP PROCEDURE

4.1 Unpacking and Installation

A. Unpack the electronic components and place them in the modified short relay rack as illustrated in figure 1. [1] Use the 12 10-24 relay rack screws provided to attach the power amplifier at the bottom of the rack. [2] Mount the Control Unit. [3] Mount the Facsimile Recorder on top. Leave a 1.25 m gap between the top of the Power Amplifier and the bottom of the Control Unit to allow the front panel of the Control Unit to be opened. The rack is

Figure 1. Electronic components in modified short relay rack.

designed to sit upon a flat surface for easy access to the Facsimile Recorder. Different rack mounting hardware for the Facsimile Recorder is available upon request. However, paper replacement is easier when the Facsimile Recorder is horizontal. The packing boxes should be saved for possible future shipping.

B. Unpack the antenna, tripod transducer mount assembly, transducer, interconnecting cable, and remote preamplifier. Assemble the antenna as follows: (1) Assemble the tripod mount by attaching the adapter plate to the transducer, the rod supports to the adapter plate, and finally the rods to the rod supports. (2) Insert the tripod into the three holes provided in the parabolic reflector and attach with the hardware supplied (fig. 2). The rubber washers and grommets isolate the transducer from the reflector to prevent vibration and reverberation from entering the very sensitive transducer during the receive mode. Align the transducer at the focus of the parabolic reflector by allowing the tripod support rods to protrude through the reflector until flush with the bottom of the nut.

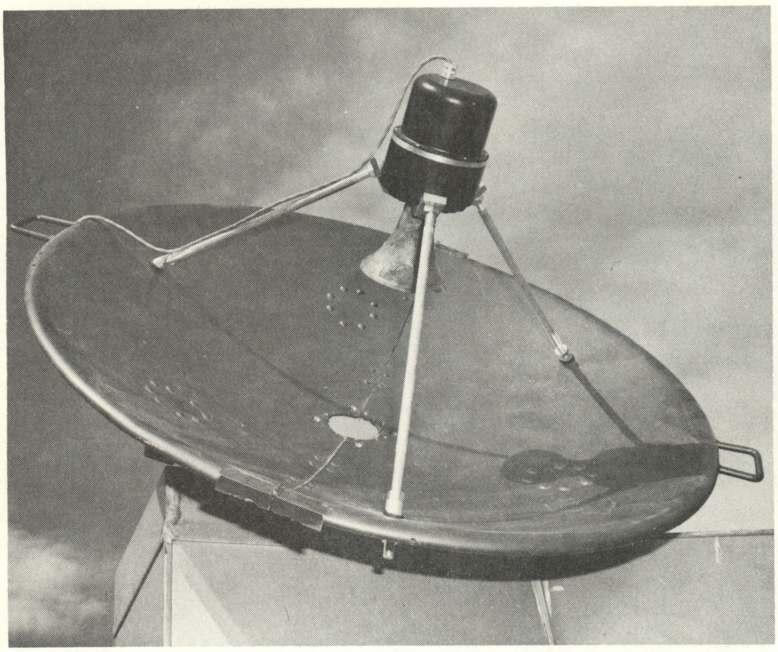


Figure 2. Parabolic reflector with tripod inserted.

(3) Attach the coupling horn to the adapter plate, insuring that the rubber washer remains in place in the recess at the mouth of the transducer, and secure until hand tight.

C. Place the antenna in a convenient low-noise location within 250-ft of the Control Unit. (Cables longer than 250 ft must be supplied by the user.) Ordering information for the wire and the connectors is in Appendix E (parts list). The wiring diagram and instructions are in Appendix F.

D. Install the anechoic absorbing cuff around the antenna assembly, running the transducer cable to the remote preamplifier through some convenient access. Cuff theory and design are in Appendix G; they are not supplied as part of the system. A typical cuff is shown in figure G.1.

E. Connect the transducer to the remote preamplifier by attaching the 3 pin connector to the appropriate socket.

F. Connect the interconnecting cable to the remote preamplifier by attaching the 20 pin connector to the appropriate socket.

G. Run the interconnecting cable from the remote preamplifier to the Control Unit. For long-term installation protect the cable from rodents and fowl and from vehicle damage by burying it, or by suspending it from fence posts.

H. A list of recommended spare parts is in Appendix H.

4.2 Final Cabling

Refer to figure 3 and attach the cabling as follows:

A. Attach a short BNC cable from the connector on the back panel of the Control Unit labeled TRIGGER PULSE to a connector on the Facsimile Recorder labeled TRIGGER PULSE.

B. Attach a short BNC cable from the connector on the back panel of the Control Unit labeled FACS OUTPUT to a connector on the Facsimile Recorder labeled FACS INPUT.

C. Attach a short BNC cable from the connector on the back panel of the Control Unit labeled TO POWER AMPLIFIER to a connector on the inside right panel of the Power Amplifier labeled INPUT.

D. Attach the short two-conductor cable with banana jacks from the banana connector located on the back panel of the Control Unit labeled FROM POWER AMPLIFIER to the banana connector located on the inside right panel of the Power Amplifier labeled OUTPUT.

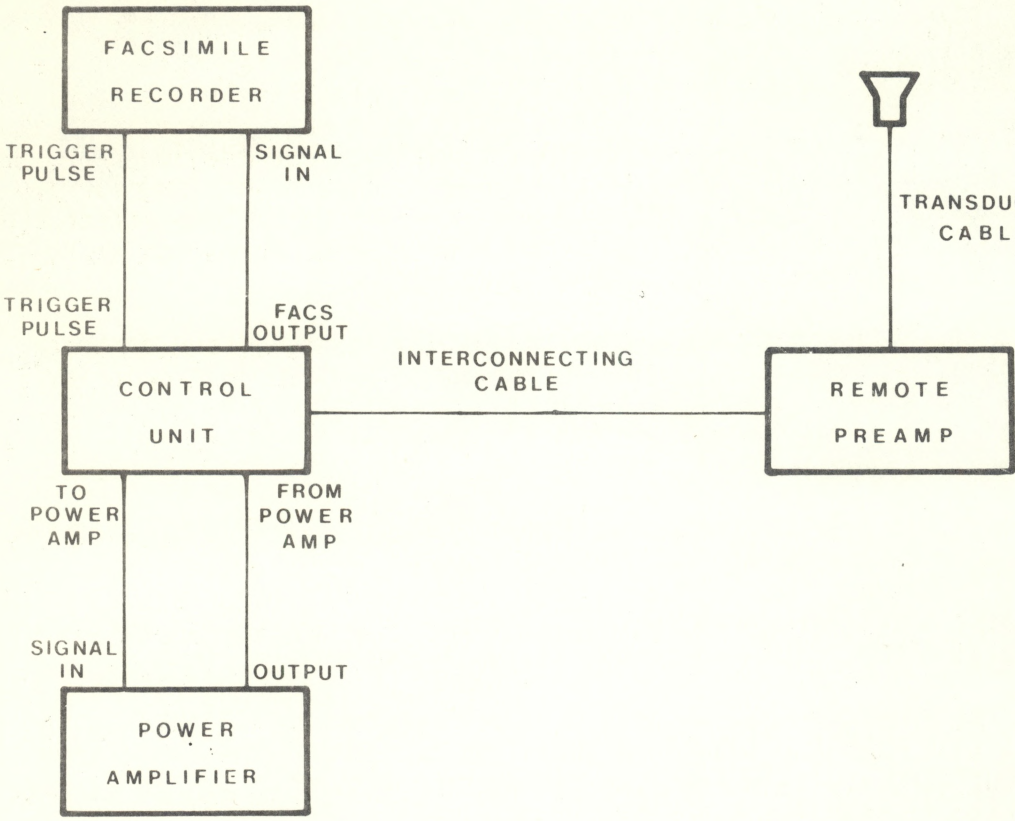


Figure 3. System wiring diagram.

Note that the polarity of the banana connectors on this cable is extremely important; the black socket should be connected to the banana jack having the indexing bump. Any other configuration might damage the Power Amplifier.

E. Insure that the Control Unit power switch, and the Power Amplifier switch, the Facsimile Recorder power switch and the Power Amplifier power switch are all in the OFF position.

F. Plug the three power cables into 117 Vac (volts alternating current) 15 amp receptacles.

5. ADJUSTMENT AND CALIBRATION PROCEDURE

The test equipment needed to adjust and calibrate the system includes an oscilloscope, a digital volt meter (DVM), a sine wave oscillator, and a frequency counter.

The overall electronic gain of the system must be known if C_T information is to be obtained from the returned echo data. Even if the absolute amplitude of the returned echo intensity is not required for a particular application, a record of the gain measurements will aid in troubleshooting the system in case of a failure. Use the log book supplied for recording the results of the gain measurements and for logging the operating times, problems, modifications, etc. Complete and accurate records are especially helpful if more than one person is responsible for operating and maintaining the system.

We urge operators to read all instructions carefully and to become familiar with the controls before attempting to operate the equipment.

The procedure for setting up and for calibrating the system follows.

A. Insure that all cables are properly connected with the power switches off. See figure 3.

B. Set the following switches on the Control Unit to the position indicated.

(1) Front Panel Switches

(a)	PULSE WIDTH	- 100
(b)	RECEIVER DELAY	- 110
(c)	FILTER SELECT	- A
(d)	RECEIVER GAIN	- A
(e)	FILTER GAIN	- A
(f)	FACS POWER/GAIN	- Counterclockwise (CCW)
(g)	FACS SELECT	- KEY
(h)	TRANSMIT POWER	- CCW
(i)	AUDIO MONITOR	- OFF
(j)	AUDIO MONITOR VOLUME	- CCW

(2) Back Panel Switches

(a)	TRANSMIT FREQUENCY	- INTERNAL
(b)	1000 Hz SYNC FREQUENCY	- INTERNAL
(c)	MULT. FREQ. FACS SELECT	- A
(d)	RAMP SELECT	- C

C. Disconnect the Antenna Cable from the socket on the back panel of the Control Unit. Replace it with the test connector supplied.

D. Set the output of the Sine Wave Oscillator for 2 kHz, 100 mV RMS as measured on the DVM. Connect it with a short BNC cable to the connector on the test plug.

E. Set the power switch of the Control Unit to the ON position.

F. ± 15V Remote Power Supply (PCB 1)

(1) Monitor Test Point (TP) RED with a DVM and adjust the variable resistor above the test point for + 15 volt direct current (Vdc) ± 5 mV.

(2) Monitor TP GREEN with a DVM and adjust the variable resistor directly below the test point for -15 Vdc ± 5 mV.

G. ± 15V Local Power Supply (PCB 2)

(1) Monitor TP RED with a DVM and adjust the variable resistor directly above the test point for + 15 Vdc ± 5 mV.

(2) Monitor TP GREEN with a DVM and adjust the variable resistor directly below the test point for -15 Vdc ± 5 mV.

H. + 5V Power Supply (PCB 3)

Monitor TP Red for + 5 Vdc.
No adjustment available.

I. Clock (PCB 4)

(1) Monitor TP BLUE with the frequency counter for 20 kHz square wave.
No adjustment available.

(2) Monitor TP ORANGE for 1000 Hz square wave. No adjustment available.

(3) Monitor TP WHITE for 100 Hz square wave. No adjustment available.

J. Hour Marker (PCB 5)

(1) Monitor TP GREEN for 30 Hz square wave as measured on the frequency meter.

(2) Monitor TP YELLOW with an oscilloscope. Push and then release the push button switch labeled HOUR MARKER on the front panel of the Control Unit. The signal will go to "LOW" (about 0 Vdc) and remain there for 1 min after button is released. When exactly 1 min has elapsed, the signal will go to "HIGH" (+3.75 Vdc) for 59 min and then the process to "LOW" and then to "HIGH" will be repeated.

K. Gate Circuits (PCB 6)

(1) Set the power switch of the Facsimile Recorder to the ON position. Set drive belt to give a 4-sec pulse repetition rate.

(2) Monitor TP ORANGE with an oscilloscope. A short positive-going pulse should occur about every 5 sec corresponding to the writing pen appearing in position at the bottom of the paper. The amplitude of the pulse should be about +3.75 V and its duration equal to the value of the PULSE WIDTH thumb-wheel switches ± 10 ms. This pulse is the TRANSMIT-GATE which appears also at a BNC on the back panel of the Control Unit for external triggering of the oscilloscope.

(3) Monitor TP Yellow with an oscilloscope. A short negative-going pulse should occur going from +3.75 Vdc to 0 Vdc. The duration of this negative pulse should be equal to the value of the RECEIVER DELAY thumb-wheel switch setting ± 10 ms.

L. Transmitter (PCB 7)

Turn the Control Unit OFF; remove PCB 7 and reinstall it using the extender board; turn the Control Unit ON.

(1) Static Adjustments. (The following adjustments zero the dc offset of the operational amplifiers and should be made only after replacement of an integrated circuit or for trouble-shooting the PCB in case of a failure. If no failures have occured, skip the Static Adjustments and continue with the Calibration.)

(a) Unplug Integrated Circuits (IC's) 4, 5, and 6.

(b) Ground IC-7 pin 2 through a 10 KΩ resistor and adjust IC-7 balance pot for zero Vdc measured at TP BLUE.

(c) Ground IC-8 pin 2 through a 10 KΩ resistor and adjust IC-8 balance pot for zero Vdc measured at TP GREEN.

(d) Ground IC-9 pin 2 through a 10 KΩ resistor and adjust IC-9 balance pot for zero Vdc measured at IC-9 pin 6 (TP WHITE).

(e) Ground IC-10 pin 3 and adjust IC-10 balance pot for zero Vdc measured at IC-10 pin 6 (TP ORANGE).

(f) Short IC-6 pin 15 to IC-6 pin 16. Ground IC-10 pin 6 (TP ORANGE) and adjust IC-11 balance pot for zero Vdc measured at IC-11 pin 6 (TP YELLOW).

(g) Turn the Control Unit OFF.

(h) Replace IC's-4, -5, and -6 in the correct sockets.

(i) Turn the Control Unit ON.

(2) Calibration.

(a) Monitor TP BLUE with an oscilloscope and a frequency meter.

1. With FILTER SELECT SWITCH set to position A, adjust R-1 for 10 V peak-to-peak (P-P) amplitude. The frequency meter should read 2 kHz.

2. With FILTER SELECT SWITCH set to position B, adjust R-2 for 10 V P-P amplitude. The frequency meter should read 2.500 kHz.

3. With FILTER SELECT SWITCH set to position C, adjust R-3 for 10 V P-P amplitude. The frequency meter should read 3.333 kHz.

(b) Monitor TP ORANGE with an oscilloscope.

1. Insure that the Facsimile Recorder is turned ON.

2. Insure that jumper J-1 on PCB 7 is installed from pin 2 of IC-11 to either pin 14 or pin 16 of IC-6 (pin 14 is a spare section of analog gate IC-6).

NOTE: The transmitted tone burst is present at TP ORANGE with a duration equal to the value of the PULSE WIDTH thumb-wheel switches of the carrier frequency selected by the FILTER SELECT SWITCH.

(c) Turn the Control Unit OFF; remove the extender board and reinstall PCB 7.

M. Receiver (PCB 10)

(1) Static Adjustment. Remove PCB 10; reinstall it using the extender board.

(a) Disconnect the BNC cable from the external Sine Wave Oscillator to the test plug; replace it with a BNC shorting cap.

(b) Remove IC-1 and short IC-1 pin 15 to IC-1 pin 16 on the PCB. Turn the Control Unit ON.

(c) Insure that jumper J-1 is installed from IC-1 pin 16 to IC-2 pin 2.

(c) Monitor IC-2 pin 6 and adjust IC-2 balance pot for zero Vdc offset.

(e) Monitor IC-3 pin 13 (TP YELLOW) and adjust R4, integrator dc offset, for zero Vdc during reset. The time duration of the reset portion of the integrator is the length of the TRANSMIT PULSE and may be too short to adjust correctly. To make this adjustment more easily, disconnect the BNC cable going to the connector labeled TRIGGER PULSE on the back panel of the Control Unit. This open circuited input causes the transmit gate to remain open ("HIGH"), thus keeping the integrator reset. Once this adjustment is made, return the cable to its original position.

(f) Monitor IC-3 pin 13 (TP YELLOW) and adjust R3, 4-sec ramp, for -10 Vdc maximum gain.

(g) Turn RAMP SELECT SWITCH located on the back panel of the Control Unit to position B and change belt drive on Facsimile Recorder for 2-sec pulse repetition rate. The drive belt should be in the middle position of the drive pully and idler pully.

(h) Adjust R-2, 2-sec ramp, for -10 Vdc maximum gain.

(i) Turn RAMP SELECT SWITCH located on the back panel of the Control Unit to position A and change belt drive on the Facsimile Recorder for 1-sec pulse repetition rate. The drive belt should be in the inner grooves of both the drive pulley and idler pulley.

(j) Adjust R-1, 1-sec ramp, for -10 Vdc maximum gain.

(k) Return RAMP SELECT SWITCH to position C and reposition drive belt to 4-sec pulse repetition rate. Disconnect the BNC cable going to TRIGGER PULSE.

(l) Monitor IC-3 pin 1 TP BLUE and adjust R-5 for zero Vdc offset.

(m) Remove the shorting cap from the test plug and reconnect the BNC cable from the external sine wave oscillator to the test plug.

(n) Replace IC-1 and remove the short from pins 15 and 16 of IC-1.

(2) Calibration.

(a) Place a shorting cap on the TRIGGER PULSE BNC on the rear panel.

(b) Monitor pin 16 of PCB 10 with an oscilloscope and adjust the amplitude of the 2-kHz sine wave signal from the external oscillator for 100 mV P-P.

(c) Monitor IC-2 pin 6 (pin 3 on PCB 10) with an oscilloscope. Enter in the log book , as in following table, the measurements taken at each setting of the RECEIVER GAIN select switch.

Receiver Gain

Receiver Gain Switch Setting	Output Voltage V_{out} (P-P)	Theoretical Gain (dB)	Calculated Gain 20 log $\frac{V_{out}}{V_{in}}$ (dB)
A		0	
B		10	
C		12	
D		14	
E		16	

(d) Monitor IC-3 pin 13, TP YELLOW, with a DVM and record the reading in the log book.

(e) Monitor IC-3 pin 1 TP BLUE with an oscilloscope and record in the log book the signal levels of each setting of the RECEIVER GAIN select switch.

Output of Receiver

Receiver Gain Switch Setting	Output Voltage V_{out} (P-P)	Calculated Gain (dB) 20 Log $\frac{V_{out}}{V_{in}}$	Gain Due To x·y Mult. (dB) 20 Log $\frac{V_{out}}{V_{in}}$
A			
B			
C			
D			
E			

(f) Turn the Control Unit OFF; remove the extender board and reinstall PCB 10. Turn Control Unit ON.

N. Filter A , 2.0 kHz (PCB 11)

(1) Adjust the external oscillator for the center frequency of the filter being tested.

(2) Monitor TP YELLOW on the filter board with an oscilloscope for the same voltages as in step (2)(e) above. Record the input voltage in the log book.

(3) Monitor TP BLUE with an oscilloscope and adjust the trimpot for zero Vdc offset by simply centering the waveform about zero reference on the oscilloscope.

(4) Monitor TP Blue with an oscilloscope and record the result in the log book as follows:

Input Voltage V_{in}(P-P)	Output Voltage V_{out}(P-P)	Loss (dB) 20 Log $\frac{V_{out}}{V_{in}}$

NOTE: Make sure that the external oscillator is turned to the center frequency of the filter being measured.

O. Filter B, 2.5 kHz (PCB 12).

(1) Adjust the external oscillator to the center frequency of the filter being tested.

(2) Repeat parts (2), (3), and (4) of N.

P. Filter C, 3.33 kHz (PCB 13).

(1) Adjust the external oscillator to the center frequency of the filter being tested.

(2) Repeat parts (2), (3), and (4) of step N.

Q. Detector (PCB 8). Turn the Control Unit OFF; remove PCB 8 and reinstall using the extender board. Unplug PCB's 11, 12, and 13.

(1) Static Adjustments.

(a) Ground pin 5 on PCB 8 using the short clip lead provided.

(b) Monitor IC-3 pin 6 with a DVM and adjust IC-3 balance pot for zero Vdc offset.

(c) Center IC-1 balance pot.

(d) Monitor IC-2 pin 6, pin 3 on PCB 8, with a DVM and adjust IC-2 balance pot for zero Vdc offset.

(e) Remove the ground from pin 5 of PCB 8 and replace it on pin 11 of PCB 8.

(f) Monitor IC-6 pin 6 with a DVM and adjust IC-6 balance pot zero Vdc offset.

(g) Center IC-4 balance pot.

(h) Monitor IC5 pin 6 (pin 9 on PCB 8) with a DVM and adjust balance pot for a zero Vdc offset.

(i) Remove the ground from pin 11 of PCB 8 and replace it on pin 18 of PCB 8.

(j) Monitor IC-9 pin 6 with a DVM and adjust IC-9 balance pot zero Vdc offset.

(k) Center IC-7 balance pot.

(l) Monitor IC-8 pin 6 (pin 19 on the PCB) with a DVM and adjust IC-7 balance pot for zero Vdc offset.

(m) Remove ground lead from pin 18 of PCB 8.

(n) Reinstall PCB's 11, 12, and 13.

(2) Calibration.

Calibration of Filter A

(a) Adjust the external oscillator for the center frequency of filter A.

(b) Set Receiver Gain switch to position A.

(c) Monitor pin 5 of PCB 8 with the oscilloscope and record reading in the log book.

(d) Monitor IC-3 pin 6 with an oscilloscope and record in the log book, as in the following table, the signal levels at each position of the FILTER GAIN select switch.

Filter Gain (Filter A)

Switch Setting	V_{out} (RMS)	V_{out} (P-P)	Calculated Gain (dB) $20 \log \frac{V_{out}}{V_{in}}$	Theoretical Gain (dB)
A				30
B				36
C				40
D				44
E				46

(e) Monitor pin 3 of PCB 8 and adjust R-1 for equal peaks.

(f) Monitor pin 3 of PCB 8 with an oscilloscope. Record in the log book as in table above the peak voltage reading at each setting of the FILTER GAIN SELECT SWITCH.

(g) Monitor pin 2 of PCB 8 with a DVM. Record in the log book as in table below the voltage readings at each position of the FILTER GAIN SELECT SWITCH.

Detector Gain

Switch Setting	V_{in} (P-P) Pin 5	Filter Gain Pin 3 (V,P-P)	Detector Loss Pin 3 Vdc	Detector Gain (dB)
A				
B				
C				
D				
E				

Calibration of Filter B

(a) Adjust the external oscillator for the center frequency of filter B.

(b) Set the Receiver Gain switch to position A.

(c) Monitor pin 11 of PCB 8 with an oscilloscope and record the reading in the log book.

(d) Monitor IC-6 pin 6, pin 13 on the PCB with an oscilloscope and record in the log book the signal levels for every setting of the FILTER GAIN SELECT SWITCH, as in calibration of filter A (Q(2)(d)).

(e) Monitor pin 9 and adjust R-2 for equal peaks.

(f) Monitor pin 9 and pin 8 of PCB 8 and record the voltages in the log book as in table following.

Filter Gain Switch Setting	V_{in}(P-P) Pin 11	Filter Gain Pin 13 (V,P-P)	Detector Loss Pin 8 Vdc	Detector Gain (dB)
A				
B				
C				
D				
E				

Calibration of Filter C

(a) Adjust the external oscillator for the center frequency of filter C.

(b) Set the Receiver Gain Switch to position A.

(c) Monitor pin 18 of PCB 8 with an oscilloscope and record the reading in log book.

(d) Monitor IC-9 pin 6, pin 19 on the PCB with an oscilloscope and record in the log book the signal levels for every setting of the FILTER GAIN SELECT SWITCH (as in (2)(d) above).

(e) Monitor pin 17 on the PCB and adjust R-3 for equal peaks.

(f) Monitor pin 16 and pin 15 of PCB 8 and record the voltages in the log book as illustrated below.

Filter Gain C

Filter Gain Switch Setting	V_{in}(P-P) Pin 18	Filter Gain Pin 19(V,P-P)	Detector Loss Pin 15 (Vdc)	Detector Gain (dB)
A				
B				
C				
D				
E				

R. Tape Mixer (PCB 9)

(1) Static Adjustments. Turn Control Unit OFF; remove and reinstall PCB 9 using the extender board.

(a) Unplug PCB 8 (DECT) and PCB 6 (DG); turn the Control Unit ON.

(b) Ground pin 3 of PCB 9.

(c) Monitor TP ORANGE with a DVM and adjust IC-1 balance pot for zero Vdc offset.

(d) Remove the ground from pin 3.

(e) Ground pin 16 on PCB 9.

(f) Monitor TP GREEN with a DVM and adjust IC-2 balance pot for zero Vdc offset.

(g) Remove the ground from pin 16 of PCB 9.

(h) Ground IC-3 pin 3.

(i) Monitor TP WHITE with a DVM and adjust IC-3 balance pot for zero Vdc offset.

(j) Remove the ground from IC-3 pin 3.

(k) Ground TP WHITE.

(l) Monitor TP BLUE and adjust IC-4 balance pot for zero Vdc offset.

(m) Remove ground from TP WHITE.

(n) Plug in PCB's 6 and 8.

(2) Calibration.

(a) Turn the Control Unit ON.

(b) Monitor pin 3 of PCB 9 with an oscilloscope and record the reading in the log book.

(c) Monitor TP ORANGE with an oscilloscope and record the reading in the log book.

(d) Monitor IC-3 pin 3 and adjust R-1 for desired output voltage. Usually this voltage will be equal to the reading at TP ORANGE. This control is used to reduce the output signal if it is normally too high for the input of the tape recorder being used.

(e) Monitor IC-3 pin 3 and adjust R-2 for the desired amplitude of the inverted TRANSMIT GATE to be recorded. The amplitude of this pulse should be near the maximum negative limit of the input of the tape recorder.

(f) Monitor TP WHITE with an oscilloscope and adjust R-3 for the gain desired. Record the signal levels in the log book.

S. FAXAMP (PCB 14)

(1) Attach a 100 KΩ dummy load resistor to the BNC connector FACS OUTPUT on the back panel.

(2) Turn R-2 fully clockwise.

(3) Turn R-3 fully CCW.

(4) Turn the Control Unit ON.

(5) Monitor TP GREEN with an oscilloscope and adjust R-1 for zero volts Vdc offset.

(6) Turn the FACS POWER/GAIN switch ON (just beyond the click with no signal input).

(7) Monitor the output voltage across the 100 KΩ dummy load resistor with an oscilloscope and adjust R-2 CCW until the voltage reading goes to a minimum. Then back off until reading is a couple of volts above the minimum.

(8) Adjust R-3 CCW until the output does go to a minimum.

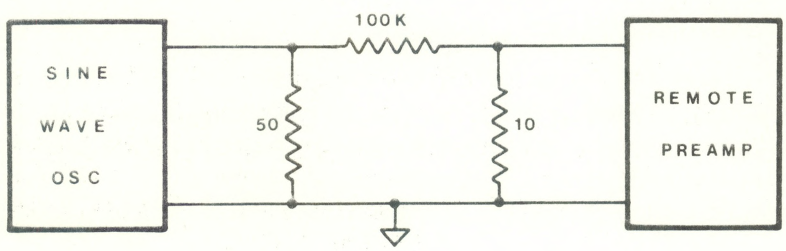
(9) Turn off the FACS AMP and remove the 100 K dummy load resistor.

(10) Reconnect the BNC cable from the Facsimile Recorder input to the Control Unit's FACS output BNC connector.

(11) Turn the Control Unit ON. Adjustments are complete.

T. Remote Preamplifier

(1) Using the special 80-dB attenuator pad that is provided, connect the output of the sine wave oscillator to the input of the remote preamp. For the input to the remote preamp, use the special BNC-to-3-pin-adapter-plug which is provided. Make sure that the attenuator is put in the circuit correctly with the proper grounding.



80-dB Attenuator Pad.

(2) Before making any measurements or adjustments, make sure that the attenuator pad is not loading the output of your Sine Wave Oscillator. Your oscillator should have listed either on the equipment or in the instruction manual the output impedance which the unit is designed to feed. The attenuator pad has a 50 Ω input resistor to match a sine wave oscillator with an output impedance of 50 Ω. If your instrument has an output impedance different from 50 Ω, the correct resistor will have to be substituted for the built-in 50 Ω resistor before any measurements can be taken. Once this modification has been completed continue with the next step.

(3) Using an oscilloscope, set the output of the Sine Wave Oscillator for 2 kHz 1V P-P. This produces the 100 μV input signal to the remote preamp.

(4) Set the toggle switch, located on the outside of the case of the Remote Preamp opposite the connectors, to the ON position. This replaces the transducer with a dummy 10 Ω load.

(5) Turn the Facsimile Recorder ON. It matters not which pulse repetition rate is selected.

(6) Turn the Control Unit ON. Set the various switches to the usual mode of operation.

(7) Monitor IC-1 pin 6 with an oscilloscope and adjust R-1 for zero Vdc offset.

(8) Short IC-2 pin 3 to ground with a short clip-wire provided.

(9) Monitor IC-2 pin 6 with an oscilloscope and adjust R-2 for zero Vdc offset.

(10) Remove the short from IC-2 pin 3 and replace on the IC-3 pin 3.

(11) Monitor IC-3 pin 6 (the output) with an oscilloscope and adjust R-3 for zero Vdc offset. Note, this adjustment may not have much control, but the offset voltage should not be greater than 10 mV in any case.

(12) Remove the short from IC-3 pin 3.

(13) Do <u>not</u> under any circumstances adjust R-4. This resistor sets the hum-null for any difference in grounds between the Remote Preamp and Control Unit and has been precision adjusted to minimize hum regardless of the length or type of cable used between Preamp and Control Unit. Tampering with R-4 will invalidate the gain calibration of the Remote Preamp.

(14) Set the internal load toggle switch to OFF.

(15) Monitor TP-5 with an oscilloscope and record in the log book the peak-to-peak voltage reading. This reading should be about 3.5 V P-P.

(16) Set the output of the Sine Wave Oscillator for 2.5 kHz at 1 V P-P.

(17) Repeat step 15.

(18) Set the output of the Sine Wave Oscillator for 3.333 kHz 1 V P-P.

(19) Repeat step 15.

(20) Turn the Control Unit OFF.

(21) Secure the Remote Preamp hinged lid and place in a convenient location next to the antenna. Attach the transducer cable and interconnecting cable. Attempt to isolate both the antenna and Remote Preamp from earth ground if excessive 60 Hz hum pickup is encountered.

6. STARTUP PROCEDURE

6.1 AC Power Switches

A. Insure that the AC power switches on the Control Unit, Power Amplifier and Facsimile Recorder are in the OFF position.

B. Insure that the FAC POWER/GAIN switch located on the front panel of the Control Unit is in the OFF position (fully CCW).

C. Insure that the Transmit Power Control is fully CCW.

6.2 Interconnecting Cables

Insure that interconnecting cables are correctly installed. Refer to section 4.2.

6.3 Echo Range

Position belt on motor pulley and idler pulley of writing belt drive motor to select echo range desired, i.e.,

A. Inner groove (closest to back plate) for 1-sec period for echo range of 550 ft (170 m).

B. Middle groove for 2-sec period for echo range of 1100 ft (340 m).

C. Outer groove for 4-sec period for echo range of 2200 ft (680 m).

Note: Model B sounder has periods of 2, 4, and 8 secs.

6.4 Ramp Gain

The RAMP GAIN switch located on the back panel of the Control Unit selects the proper 1/R gain ramp to correspond to the echo range period selected.

A. Position A for 1-sec period.

B. Position B for 2-sec period.

C. Position C for 4-sec period.

Note: Model B sounders have positions corresponding to 2, 4, and 8 secs.

6.5 Filter

Position the FILTER SELECT switch, located on the front panel of the Control Unit, to the desired transmitting frequency. The following selections are available:

A. Position A for 2 kHz.

B. Position B for 2.5 kHz.

C. Position C for 3.333 kHz.

D. Position D for simultaneous transmission of all three frequencies.

6.6 Pulse Width

Select the duration of the tone burst by positioning the thumbwheel switches located on the front panel of the Control Unit and labeled PULSE WIDTH.

6.7 Receiver Delay

Select the delay time before the receiver is activated by positioning the thumb-wheel switches located on the front panel of the Control Unit and labeled RECEIVER DELAY. The Receiver Delay must exceed the Pulse Width by at least 10 ms to insure proper operation of sensitive receiver circuits.

6.8 Receiver Gain

Select for desired wide-band receiver gain by positioning the selector switch located on the front panel of the Control Unit. Gain settings are as follows:

A. Position A for receiver gain of 0 dB.

B. Position B for receiver gain of 10 dB.

C. Position C for receiver gain of 12 dB.

D. Position D for receiver gain of 14 dB.

E. Position E for receiver gain of 16 dB.

Set to Position C initially; make further adjustments to obtain a non-saturated signal by monitoring RAW ECHO -- located on the front panel of the Control Unit adjacent to the Receiver Gain switch.

6.9 Filter Gain

Select the desired narrow band-pass filtered gain by positioning the selector switch located on the front panel of the Control Unit. Gain settings used are as follows:

A. Position A for filter gain of 30 dB.

B. Position B for filter gain of 36 dB.

C. Position C for filter gain of 40 dB.

D. Position D for filter gain of 44 dB.

E. Position E for filter gain of 46 dB.

Set to Position D initially and then make further adjustments to obtain a non-saturated signal by monitoring the Detected Echo -- located on the front panel of the Control Unit adjacent to the Filter Gain switch.

6.10 Gain Adjustment

Gain Settings in steps 6.8 and 6.9, and transmit frequency selection should be adjusted to produce a non-saturated signal (with good signal-to-noise ratio) to the tape recorder output and the Facsimile Recorder. Background noise and atmospheric conditions will affect these settings and only experience with the system will make these selections easier.

6.11 Transmit Frequency

Set the toggle switch, located on the back panel of the Control Unit and labeled TRANSMIT FREQUENCY on INTERNAL. If an external oscillator is used, set the switch on EXTERNAL, and connect the signal source to the EXTERNAL FREQUENCY INPUT BNC located directly below the switch. The input should not exceed 10 V P-P.

Note: If a frequency other than those supplied within the Control Unit is used, a suitable receiver filter must also be used and connected to the RAW ECHO BNC output located on the front panel of the Control Unit.

6.12 1000 Hz Sync Frequency

Set the toggle switch, located on the back panel of the Control Unit and labeled 1000 Hz SYNC FREQUENCY on INTERNAL. If it is desired to sync the electronics of the Control Unit to an external 1000 Hz square-wave signal source then set the switch on EXTERNAL and introduce the new reference signal into the BNC located directly below the switch. A positive going 5-V square-wave signal must be used.

6.13 Mult. Freq. Facs. Select

Position the Multiple Frequency Facsimile Recorder select switch located on the back panel of the Control Unit for the desired output to be recorded. Outputs available are as follows:

A. Position A for 2 kHz detected echo to be recorded.

B. Position B for 2.5 kHz detected echo to be recorded.

C. Position C for 3.333 kHz detected echo to be recorded.

The position of this switch must correspond to the selected transmit frequency through the FILTER SELECT SWITCH when individual frequencies are being transmitted or to the desired recording output when three simultaneous frequencies are being transmitted.

6.14 Facsimile Recorder

Always use the following steps for initial setup or when changing paper:

A. Revolve the writing belt so that no pens are positioned over the paper platen.

B. Remove used paper and tubes from the Facsimile Recorder by lifting the paper platen with the handle provided.

C. Clean the carbon residue from the machine. A vacuum cleaner is handy for this.

D. Replace worn writing pens with new ones and insure that pens which actually touch the paper are the same length. Again, revolve the writing belt so that no pens are under the paper platen.

E. Remove and clean the Plexiglas stylus guide with soap and water or alcohol and reinstall.

F. Install new roll of paper, making sure the tube is firmly seated in the roller guides.

G. Thread paper under the stylus guide and tape end onto an empty tube.

H. Install paper take-up tube in its guides and insure that it is properly seated.

I. Lower the paper platen, making sure it is firmly locked into position.

J. Turn power switch to ON position and insure proper stylus movement over paper.

The pens of the Recorder may have to be bent to insure proper contact with the paper and the high voltage bar. One of the styli may require shortening with respect to the other to reduce alternate line offset of recorded line scans. The need for this and/or the effect of stylus trimming can be observed on the recording by setting the FACS MODE switch to the key position for recording tone bursts only. Damage to pens may result if care is not taken when lifting the paper platen or when cleaning the stylus guide. Both pens should always be changed at the same time to insure proper keying of the Control Unit. A baseline adjustment is available to move the start of the recorded signal to the desired position at the bottom of the page.

6.15 Start Control Unit

A. Turn Audio Monitor volume control fully CCW and set select switch on UNFILTERED position.

B. Turn POWER switch to ON position.

C. Turn the Audio Monitor volume control CW until a rasping sound is heard. This is the background noise that the antenna is "hearing"; it is being gated and gain swept. The period and the amplitude change should, if all is working well, correspond to the writing pen appearing at the bottom of the paper in the Facsimile Recorder.

D. The portion of background noise appearing at the output of the selected receiver filter can be monitored by setting the Audio Monitor select switch on the FILTERED position. Again, swept high frequency sound should be heard when the Audio Monitor volume control is turned CW.

6.16 Power Amplifier

When the system is functioning properly, the Transmit Power Control can be adjusted to a reading of 60 V P-P as monitored on an oscilloscope at the BNC directly below the TRANSMIT POWER control knob. Echoes should now be heard from the Audio Monitor Speaker.

6.17 Facsimile Recorder

A. Turn the FACSIMILE POWER/GAIN switch CW until a click is heard. The facsimile writing amplifier is now on and the knob can now be used to adjust the gain for the desired display on the Facsimile Recorder.

B. Press and release the HOUR MARKER push button switch located on the front panel of the Control Unit and record the time of release. It is suggested that release should occur at the 59th minute of a time-of-day clock. Since the internal HOUR MARKER electronics use the 60 Hz power line frequency to generate the interrupt, no timing differences are likely to occur. An indication of power line failure would be a difference between the 59th minute of the time-of-day clock and the hour marks recorded on the Facsimile Recorder. If this happens, time marks on the record are no longer valid and the HOUR MARKER must be reset and noted.

C. As records are being produced, follow maintenance directions and recommendations in Section 8.

7. SHUTDOWN PROCEDURE AND PAPER REPLACEMENT

The shutdown procedure is as follows:

A. Turn TRANSMIT POWER control fully CCW.

B. Turn Power Amplifier OFF.

C. Turn Control Unit OFF.

D. Turn Facsimile Recorder OFF.

The system must be turned off for replacement of paper or when such conditions exist that no meaningful records are being produced. Extremely high background noise levels cannot be tolerated by either the receiver circuits or by the writing amplifier and pens. If high background noise conditions do exist, steps must be taken either to shield the antenna from the objectionable noise source or to move the antenna to a more desirable, less noisy location. Once the system is set up and operating properly, shutdown usually means just turning down the transmitted power and then turning off the power switches. No other switches need be touched. Changing the paper -- as described in item 14 above -- usually takes less than 15 min with little loss of data. A paper use rate of 7.25 in per hour makes paper replacement necessary once every 6.5 days (if running 24 hr per day) or after 156 hr of Facsimile Recorder operation.

The Control Unit requires a trigger pulse generated by the Facsimile Recorder for proper sequencing and resetting of its contours. Thus, the Facsimile Recorder must be the first component turned on and the last component turned off. No damage to the Control Unit will occur if it is inadvertently left on after the Facsimile Recorder is turned off. However, to prevent damage to both Transducer and Control Unit, turn transmitted power and Power Amplifier OFF before turning Control Unit and Facsimile Recorder off. The system must always be OFF for replacement of PCB's and components.

NOTE: Occasional false triggering of the Control Unit may occur by various means. This situation is not harmful to the system and is to be treated as an annoyance. Persistent false triggering, however, means an inoperative trigger circuit and/or noise on the control lines. Further work is being done at NOAA to eliminate this as a possible trouble area with results and/or modifications to follow if necessary.

8. MAINTENANCE OF FACSIMILE RECORDER

8.1 Daily Maintenance

A. Remove, clean, and reinstall the guide bar. Note this action on the facsimile recording by placing a pencil mark at the bottom of the record.

B. Inspect for any carbon accumulation on the writing pens and clean if necessary. Do not turn the recorder off during this operation.

8.2 Weekly Maintenance

Perform weekly maintenance while changing the paper supply in the Facsimile Recorder.

A. Pull out a few inches of paper from the supply roll and tear the record off using the guide bar as a cutting edge.

B. Roll up and remove the expended paper roll; mark the time of day and date on the blank portion of the record. Enter into the log book the time of day, date, and gain settings of the Control Unit.

C. Remove the unused portion of the supply roll from the paper platen.

D. Remove the unused portion of the recording paper from the 3/4-in center tube and discard. Install this empty tube in the takeup guides on the paper platen.

E. Vacuum the carbon and paper residue from the bottom of the recorder.

F. Remove guide bar and clean with soap and water or alcohol.

G. Place a fresh roll of paper in the supply guides of the paper platen. Pull out about 14 in of paper; position it over the platen and attach to the takeup reel with a small piece of tape.

H. Reinstall clean guide bar.

I. Inspect the two writing pens; replace them with new ones, if necessary. The new pens may require slight bending to conform to the surface of the paper platen and to produce tension sufficient to insure that the pens remain on the paper during their entire travel and that the traces induced are properly spaced.

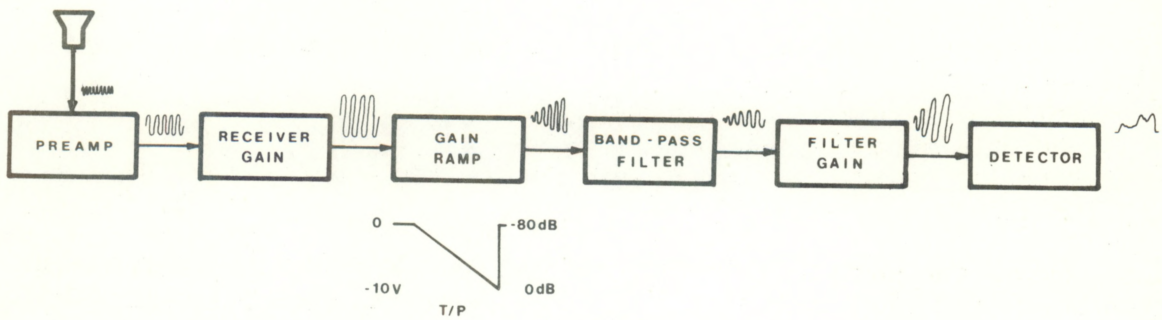
J. Align the pens so that the paper platen can be closed.

K. Close the paper platen securely and turn the power switch ON.

L. Let the recorder run for about 3 min to insure proper pen pressure and alignment and allow the takeup reel to apply proper tension to the paper. The Facsimile Recorder is now ready for another 6.5 day run.

9. SYSTEM GAIN

The total gain of the system includes the electronics gain, the transmitting antenna gain, and the receiver antenna gain. After a careful and complete calibration (the procedure is in section 5), the electronics gain is calculated as follows from the results of the individual gain measurements listed in the log book.



System Gain.

GdB = PG + RG + BPFG + FG + DG where GdB is the gain in dB, PG is the preamp gain, RG is the receiver gain, BPFG is the loss in the band pass filter, FG is the filter gain and DG is the detector gain.

For example:

Let PG = 100
RG = 14
BPFG = -9
FG = 44
DG = -3.52 .

Then

GdB = 100 + 14 - 9 + 44 - 3.52

or GdB = 145.48 .

Since $G = 20 \log \frac{V_o}{V_i}$, then $\frac{V_o}{V_i} = 10^{\frac{GdB}{20}}$.

So, $G(t) = 10^{\frac{GdB}{20}} \; t/p$

where G(t) is the voltage gain as a function of time, GdB is the gain in dB, t is time in seconds, and p is the selected period in seconds. Continuing the example

Let t = 4 sec
p = 4 sec
G = 145.48 dB .

Then $G(4 \text{ sec}) = 10^{\frac{145.48}{20}} \; \frac{4 \text{ sec}}{4 \text{ sec}} = 18{,}793{,}168.$

Thus, the voltage gain at any instant in time can be determined by the formula

$$G(t) = 10^{\frac{GdB}{20}} \; t/p.$$

The gain of the antenna, both transmitting and receiving, is still uncertain because of the immense difficulty in measuring beam patterns. A new procedure is being investigated to measure both the transmitting and receiving antenna beam patterns. B.C. Willmarth et al. (1975) have described the procedure.

A relative gain measurement, however, is available for use in determining C_T from acoustic echo signals. This calculation is the result of William Neff's (1975) work at NOAA.

10. COMMENTS

The NOAA MARK VII monostatic Acoustic Echo Sounder has proved to be a versatile and useful research tool in spite of several shortcomings. Digital circuit design has been used extensively to reduce the physical size and cost of the system. The amount of adjustment necessary which has increased with the greater versatility of the system, is a distinct disadvantage. Still, the system calibration and operation are not prohibitively difficult, especially after some experience is gained through setup and operation.

The Wave Propagation Laboratory is continuing it efforts to reduce the chance of operator error and system failures by simplifying the electronic circuits' design and by specifying more reliable (and less expensive) components that require no external adjustments. Users will be informed of changes to the circuits and change of parts to insure a reliable and easily operated sounder. The Wave Propagation Laboratory welcomes suggestions for changes or modifications to the electronics of the system that would increase usefulness of future systems.

11. REFERENCES

Monin, A.S (1962), Characteristics of the scattering of sound in a turbulent atmosphere, Soviet Phys - Acoustics 7(4): 370-373.

Neff, W.D. (1975), Quantitative evaluation of acoustic echoes from the planetary boundary layer, NOAA ERL WPL Tech. Rept. (to be published).

Owens, E.J. (1974), Development of a portable acoustic echo sounder, NOAA Tech. Rept. ERL 298-WPL 31.

Simmons, W.R., J.W. Wescott, and F.F. Hall, Jr. (1971), Acoustic echo sounding as related to air pollution in urban environments, NOAA Tech. Rept. ERL 216-WPL 17, pp. 40-51.

Strand, O. N. (1971), Numerical study of the gain pattern of a shielded acoustic antenna, J. Acoust. Soc. Am. 49(6), Pt. 1: 1698-1703.

Willmarth, B.C., E.H. Brown, J.T. Priestley, and D.W. Beran (1975), Beam pattern measurements for large acoustic antennas, in Proc. 16th Conf. on Radar Meteorology, Houston, Texas, American Meteorological Society, 1975.

APPENDIX A

FACSIMILE RECORDER MODIFICATIONS

Several dry paper facsimile recorders were studied before a ROSS "Straight line" depth sounder repeater was selected. This unit was found (1) to be easily modified for acoustics work, (2) to have a reasonable paper width and length, (3) to be relatively small and compact and, (4) to be inexpensive.

Upon delivery of the units the following steps were performed:

1. Remove the inner chassis including the paper platen hinge assembly and motor support bracket.

2. Drill two 3/8-in holes centered and to the right of the power plug hole and install BNC bulkhead connectors with grounding washers.

3. Strip the unit of all electronic components and wires. Save only the printed circuit board connector and the power plug bracket.

4. Remove the black paint and lettering from the face of the unit using solvent and let dry.

5. Mask and repaint the face of the unit flat black.

6. With the hinge of the cover toward the top, install from top to bottom in the existing holes a BNC bulkhead connector with ground washer, a fuse holder, a pilot light, a push-bottum spring-loaded switch, and finally a single pole single throw (SPST) toggle switch.

7. Remove the original paper drive motor and replace it with the one that you have purchased (see App. E).

8. Remove the original belt-drive motor and replace it with the one that you have purchased. Note: It may be necessary to mill out a portion of the motor bracket or remove a portion of the chassis main frame for the new motor to fit in the space.

9. Install pulleys on motor bracket if needed. Note: current Mark VII systems have a special three-position pulley arrangement to produce the three pulse-repetition rates of the unit. Simpler systems can be made for fixed speeds by carefully choosing the speed of the drive motor.

10. Loosen the tension on the supply paper roll by removing the lock washer on the large plastic roller and cutting off portions of the pulley and tension bar springs.

11. Mount the special ordered printed circuit board (item 1-L in App. E) in the existing holes using the bracket saved from the original printed circuit board.

12. Rewire the unit following the schematic in figure C.15.

13. Install the plastic pen-guide bar on the paper platen.

14. Install a second pen and holder on the writing belt.

15. Punch the two timing holes in the writing belt. Note: align the pen at the bottom of the paper and punch the hole under the photo-cell position.

16. Label the switches, BNC's, etc., as illustrated in figure A.1.

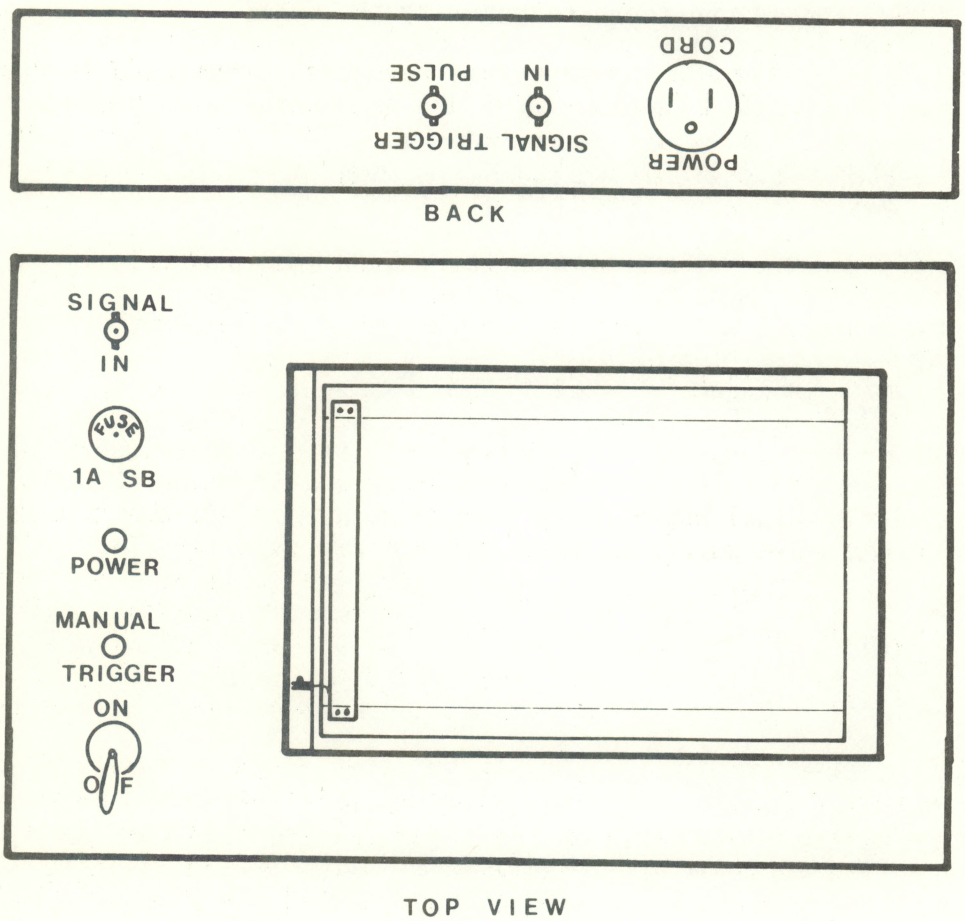


Figure A.1. Faces of the Facsimile Recorder.

APPENDIX B

DESIGN AND OPERATION OF THE CONTROL UNIT ELECTRONICS

1. PCB 4 (CLOCK CIRCUIT)

The three transmit frequencies and timing pulses are generated from the very stable 200 kHz square wave oscillator. Integrated circuit IC-1 is a 7476 dual J-K master-slave flip-flop wired as a simple divide-by-two circuit to produce 100 kHz square wave at pin 1 of the IC-2. Integrated circuits IC-2 and IC-3 are 7490 decade counters wired as simple divide-by-ten to produce a 1 kHz symmetrical square wave at TP Orange and to pin 16 of the card.

The rotary switch labeled INTERNAL, EXTERNAL, 1000 Hz SYNC FREQUENCY located on the back panel of the Control Unit selects either this internally generated signal or the externally supplied sync signal. The 1000 Hz signal is returned to the card through pin 18 through IC-4 (another 7490 decade counter), to produce the 100 Hz symmetrical square wave present at TP White and pin 22 of the PCB. This signal is the basic 10 m sec timing pulse used by the Dual Gate circuit on PCB 6.

IC-5 (7490 decade counter) produces the 20 kHz symmetrical square wave present at TP Blue and pin 21 of the PCB. This 20 kHz signal is used to generate the transmit frequencies in PCB 7.

2. PCB 5 (HOUR MARKER)

The power line frequency is halfwave rectified and triggers IC-7 (9601 nonstable multivibrator) to produce a 60 Hz pulse which is used as the clock for the hour marker. In this way the sounder's time marks agree with the local time-of-day clock even if the line frequency is in error. IC-8 (7496 flip-flop) acts as a divide-by-two to produce the 30 Hz square wave for the remaining counters. Integrated circuits IC-1 through IC-6 (7490) are connected in a counting chain whose outputs are decoded to yield positive gain pulses at 1 min (from IC-9-c pin 8) and at 1 hr (from IC-9-D pin 11).

The output at TP Yellow and pin 22 of the card is initially set "LOW" by pressing and then releasing the spring-loaded push-button switch HOUR MARKER on the front panel of the Control Unit. This action first resets integrated circuits IC-1 through IC-6 to zero and presets integrated circuit IC-8-B pin 1 "HIGH" and IC-8-B pin 10 "LOW". When the switch is released the reset signal coming in pin 3 of the PCB is removed and the counting chain can again count the 30 Hz pulses.

Once a count of 1800 (60 sec x 30 pulses per sec) is reached, both inputs to "AND" gate IC-9-A are high which toggles integrated circuit IC-8-B. This causes the signal level at pin 22 of the PCB to go and remain "HIGH" until a count of 108,000 (60 sec/min x 60 min/hr x 30 pulses/sec) is reached. The pulse from integrated circuit IC-9-D pin 11 again resets the counting chain and presets the inhibit flip-flop IC-8-B. The HOUR MARKER control signal is used by the Dual Gate circuit (PCB 6) to inhibit the transmit pulse for the first 60 sec of each hour.

3. PCB 6 (DUAL GATES)

The Dual Gate PCB consists of two nearly identical circuits used to develop the TRANSMIT and RECEIVER DELAY control pulses. These pulses are in turn used by the transmitter (PCB 7) and the receiver (PCB 10) to turn the electronic switches on and off in those circuits.

The 100 Hz square wave coming from the clock circuit is used by integrated circuits IC-1 and IC-2 (7490 decade counters). Their binary coded decimal (BCD) outputs are compared by integrated circuits IC-5 and IC-6 (74L85 4-bit magnitude comparators) with the BCD outputs of the thumb-wheel switches located on the front panel of the Control Unit. Two sets of two switches each are present -- one for the transmit pulse time duration and the other for the receiver delay time duration. Each set of switches is capable of selecting pulse lengths from 10 m sec to 990 m sec in 10 m sec increments.

The reset pulse for the dual gate card, and thus for the sounder, is generated by the facsimile recorder. The writing belt has two holes at appropriate places to illuminate a photo-electric switch when the pens are in position at the bottom of the paper. A short positive-going pulse is generated by its internal circuitry and is fed in at pin 19 of the dual gate card. This pulse both resets the counters (IC-1 and IC-2) and presets pin 16 of the inhibit flip-flop (IC-9-A) "HIGH".

The counting cycle begins and pin 2 on integrated circuit IC-10-A goes "HIGH" when the count in the counting register equals the setting of the thumb-wheel switches. Since pin 1 of integrated circuit IC-10-A has already been preset high the output of the "AND" gate also goes "HIGH" toggling flip-flop IC-9-A (7476). Pin 15 of integrated circuit IC-9-A thus goes "LOW" disabling the "AND" gate IC-10-A from passing any more pulses until the entire system has been reset by the reset pulse coming from the facsimile recorder.

The transmit pulse control signal has not yet been supplied to the transmitter however. Integrated circuit IC-10-C "ANDS" the transmit pulse with the output of the HOUR MARKER circuit to inhibit the transmit pulse for 1 min every hour. When the HOUR MARKER control signal is "HIGH" the control pulse is preset at TP Orange and pin 23 of the card. When the HOUR MARKER control signal is "LOW" the transmit pulse is absent from pin 23 which goes to the transmitter circuit.

A jumper is available on integrated circuit IC-10-C pin 9 which can connect it to + 5 Vdc to enable the circuit manually. It is recommended that the HOUR MARKER (PCB 5) be removed from the rack when this mode of operation is required.

Integrated circuit IC-9-B operates in much the same way as integrated circuit IC-9-A. The difference lies in the mode of the output control signal level which in this case remains "LOW" (to turn the electronic switch in the receiver circuit off during the transmitted tone burst) until the setting of the switches is equal to the count in integrated circuits IC-3 and IC-4. Once the flip-flop is toggled the output goes "HIGH" thus turning on the electronic switch in the receiver circuit.

4. PCB 7 (TRANSMITTER)

A 20 kHz symmetrical square is inputed to the transmitter card through pin 15. The three available transmit frequencies are generated by the three divide-by circuits whose outputs are fed to integrated circuits IC-7, IC-8, and IC-9. Integrated circuit IC-1 is wired as a divide-by-five whose output is a 4 kHz pulse train. Integrated circuit IC-4-A (7476) is wired as toggle flip-flop and is used to generate the 2 kHz symmetrical square for input to the active feed-forward narrow band-pass filter to shape the signal into a sine wave for transmission.

Integrated circuits IC-2-A and IC-2-B (7476) are two toggle flip-flops in series which divide the 20 kHz square wave by 2 each to yield an output of 5 kHz. Integrated circuit IC-5-A (7476) divides by 2 again, generating the 2.5 kHz signal which is shaped by the second integrated circuit operational amplifier filter IC-8.

Integrated circuits IC-3-A and IC-3-B (7476) act together to form a divide-by-six circuit whose output is 6.666 kHz pulse train. Toggle flip-flop IC-5-B (7476) divides by two and generates the 3.333 kHz signal for the third shaping filter. The values of the resistors used in the operational amplifier filters are given in Appendix I.

The three transmitting frequencies are fed via pins 2, 16, and 7 to the rotary switch located on the front panel of the control unit labeled FILTER SELECT. When position A or position B or position C is selected, that individual frequency is fed via pin 3 or pin 17 or pin 8 on the PCB through a capacitor to integrated circuit IC-10 which acts as a signal mixer. When the ALL position is selected all the transmitting frequencies are inputed to the mixer circuit. Variable resistors R-1, R-2, and R-3 allow the user to selectively mix equal or unequal amplitudes of each transmitting frequency to form the desired transmitting envelope. The output of pin 22 on the card is the continuous transmitting frequency selected and goes to the toggle switch located on the back panel of the Control Unit labeled INTERNAL, EXTERNAL TRANSMIT FREQUENCY. When the INTERNAL position is selected this is the signal fed to pin 21 of the PCB for developing the transmitting tone burst. If EXTERNAL is selected the user can supply his own transmitting frequency remembering that only three fixed filters are available in the internal receiver circuit.

Integrated circuit IC-6 (AD7510) is the transmitting electronic switch whose output signal is controlled by the control pulse coming from its transmitting half of the dual gate PCB. The output tone burst is available on both pin 14 and pin 16 of the electronic switch and the jumper can be moved in case a section of the switch becomes defective. Integrated circuit IC-11 is a unity gain amplifier whose output is the tone burst to be transmitted and which can be monitored on TP Yellow. Notice that the current sensitive electronic switch is placed between the operational amplifier's input resistor and its summing junction. The input resistor is of a high enough value to limit the "ON" current in the electronic switch to a safe value.

5. PCB 10 (RECEIVER)

The received echo signal is fed from the output of the remote preamplifier circuit to pin 16 of the receiver card via the long interconnecting cable. The receiver-delay control signal from the dual gate PCB turns on the receiver's electronic switch (AD7510) after the strong near field and ringing echo signals have decayed sufficiently not to harm the succeeding amplification stages. Again the electronic switch is placed between the operational amplifier (IC-2) input resistor and summing junction and again it has two available outputs selected by a jumper on the PCB. Integrated circuit IC-2 (741) is the first variable operational amplifier whose gain is selected by a rotary switch labeled RECEIVER GAIN located on the front panel of the Control Unit. The values of the five fixed resistors used with this amplifier are listed in Appendix I.

The input to pin 7 of integrated circuit IC-3 (AD532JD x·y multiplier) is now the gated, amplified raw echo signal. The other input to the multiplier (pin 13) is the gain ramp signal generated by the BURR-BROWN 4013/25 module. Wired as an integrate-and-reset generator, the module generates a lineal ramp used to vary the gain, or rather the attenuation, of the x•y multiplier. The external components, consisting of the 2μF capacitor and the three sets of variable resistor networks on pins 7, 8, and 17 of the PCB, allow the gain ramp to be accurately adjusted and changed by the rotary switch, labeled RAMP SELECT and located on the back panel of the control unit, to correspond to the drive belt selection for pulse repetition rates on the facsimile recorder. Resistors R-1, R-2, and R-3 allow the user to calibrate the ramp voltage so that an accurate attenuation-versus-time signal is supplied to the multiplier. Zero Vdc from the ramp generator is equivalent to 80 dB attenuation of the echo signal by the multiplier. A negative 10 Vdc signal from the ramp generator is equivalent to unity gain (zero attenuation) of the echo signal by the multiplier. Thus the near-in echoes are attenuated the most and as time progresses the echoes are attenuated linearly less until finally the farthest echo is not attenuated at all.

Integrated circuit IC-4 is not actually part of the receiver circuit but is used to invert the detected echo signal coming from the detector PCB and going to the writing amplifier.

6. PCB 8 (DETECTOR)

The detector consists of three identical circuits containing three operational amplifiers each, one set of which is described here. The receiver card output is the gated, amplified, gain-ramped raw echo signal and actually goes into the filter (PCB's 11, 12, and 13) before reaching the detector. The active, narrow band-pass filters used are not described in detail since they are commercially available.

The input to the detector PCB via pins 5, 11, and 18 is thus the gated, amplified, gain-ramped and filtered echo signal. Presumably only true backscatter echo signals are now present whose intensities represent the intensity of the turbulent temperature fluctuations. Integrated circuit IC-3 (741) is the second variable operational amplifier whose gain is selected by a rotary switch located on the front panel of the Control Unit labeled FILTERED GAIN. The values of the five fixed resistors are in Appendix I.

Integrated circuits IC-1 and IC-2, along with the associated electronic components, act as a "perfect" rectifier whose output on pin 6 of IC-2 is the full wave rectified (or detected) result on its input. A low pass filter consisting of a resistor and capacitor is used to generate the detected echo signal for tape recording and for presentations on the Facsimile Recorder. Since there are three independent circuits available, recordings of the detected echo signals from each of the three transmitted frequencies can be made if all three frequencies are being transmitted simultaneously.

7. PCB 9 (TAPE MIXER)

The tape mixer PCB was incorporated into the unit specifically for those users who have severe tape recorder limitations, i.e., a small number of available channels. This PCB does nothing but mix a portion of the inverted transmit pulse with the analog of the echo intensity so that both sync and intensity information can be recorded on a single tape recorder channel. The sync signal is necessary to obtain range information.

Integrated circuits IC-1 and IC-2 are identical 741 operational amplifiers whose outputs are summed at the non-inverting input of operational amplifier IC-3 (741). Resistors R-1 and R-2 are adjustable amplitude controls; resistor R-3 adjusts the overall signal gain. This versatility lends itself to different input requirements for various tape recorders. Integrated circuit IC-4 simply inverts the mixed signal again for the various signal constraints of tape recorders.

8. PCB 14 (FACSIMILE RECORDER WRITING AMPLIFIER)

The Facsimile Recorder Writing Amplifier was designed to obtain the maximum electronic dynamic range compatible with the dynamic range of the dry recording paper and of the atmosphere. Since the typical dynamic range of the paper is about 36 dB and the approximate dynamic range of returned echo signals in the lower atmosphere is about 36 dB, the gain of the writing amplifier was also desired to be about 36 dB. This level of response has been achieved with this circuit, which consists of a polarity inverting low gain operational amplifier IC-1 (308) and a constant current high voltage output stage.

Operational amplifier IC-2 (308) and PHILBRICK NEXUS module 1016 (high voltage, high current booster amplifier) form the constant current amplification stage whose output voltage is offset by the output of transformer T-2 and divide-bridge B-1. The output voltage varies from +26 Vdc during idle to +70 Vdc when writing black. The booster amplifier is capable of supplying 100 mα of current into the nonuniform load. As the stylus is slowly drawn across the paper its surface contact changes because of the roughness of the clay coating and nonlinear drive of the belt pulley. This nonuniformity causes the load resistance to change radically, thus forcing a rapid response from the writing amplifier. The constant current feature of the amplifier tends to reduce the intensity discontinuities from varying load in order to draw a uniform and consistant shade of gray even when changes in temperature, humidity, stylus wear, paper speed, stylus speed, and paper roughness are experienced.

Transformer T-1 and diode bridges B-2 and B-3 form the nonregulated ± 28 Vdc power supply for the current booster (PN 1016). The output voltage as monitored on pin 15 of the PCB is a high frequency (about 3 kHz) signal of positive-going spikes whose baseline is the value of the offset voltage and whose amplitude is proportional to the amplitude of the input signal. During those brief times when the pens are actually off the paper, the output of the writing amplifier goes to + 70 Vdc because of the infinite load when there is no path to ground from the high voltage bar.

9. REMOTE PREAMPLIFIER

The Remote Preamplifier is perhaps the most important part of the echo sounder system. Its function is to switch the electronics automatically from transmit to receive modes of operation without the use of relays. Relays are inherently noisy devices whose switch closure and contact bounce cause high amplitude spurious pulses which may damage the very sensitive receiver electronics and generate false data.

Diode bridge B-1 is connected into the circuit and biased in such a way as to kill hum and low noise at the input to the transducer. Low amplitude signals (less than 0.6 V nominally) are shorted to ground through the bridge which is now conducting by being forward biased. When the tone burst occurs (60 V P-P), diode bridge B-1 is reversely biased and all but 1.2 V P-P of the tone burst signal is fed to the transducer through the pair of IN4004 back-to-back diodes.

Diode bridge B-2, acting as a limiter, is also reversely biased during the tone burst and becomes an open switch. Thus very little of the transmitted tone burst is passed through the bridge to the stepup transformer. During the receive mode of operation, the back-to-back diodes are biased off while diode bridge B-2 is biased on, passing the very weak returned echo signal (between 0.1 and 500 μV) to the 100:1 stepup transformer. The on resistance of diode bridge B-2 is kept low (about 2 ohms) so that most of the echo signal is amplified by 40 dB in the transformer.

The circuit elements, placed directly on the primary and secondary of the transformer, shape the impedance characteristics of the transformer and limit the amplified leak-through tone burst that does get through the diode limiter.

A low noise operational amplifier IC-1 (1321) adds another 30 dB of gain to the signal and is followed by three stages of high-pass filtering to attenuate frequencies below 800 Hz. Operational amplifiers IC-2 (301) and IC-3 (301) add another 10 dB gain to the signal and attenuate frequencies above 10 kHz. Operational amplifier IC-3 also acts as a line amplifier making it possible to operate the sounder on different length cables. Variable resistor R-4 is the hum-null adjustment and cancels any 60 Hz hum that may occur between the Remote Preamplifier and Control Unit grounds.

The noise figure of the Remote Preamplifier is about 2 dB; i.e., the only noise added to the thermal agitation noise of the transducer voice coil is that attributable to the a.c. resistance through diode limiter bridge B-2. Since this is about 2 ohms, and the transducer resistance is about 4 ohms, the thermal agitation noise voltage delivered to the step-up transformer is increased by a factor of $\sqrt{6\Omega/4\Omega}$, or about 2 dB. No further noise is added by subsequent circuit elements since the step-up transformer increases the transducer thermal noise voltage to a level several times higher than the equivalent input noise voltage of the first operational amplifier stage. The 2 dB degradation of an otherwise ideal noise figure is acceptable because earlier measurements have shown that acoustic background noise under extremely quiet conditions produces transducer voltages about 15 dB above thermal agitation noise, and typical acoustic echoes produce transducer voltages about 35 dB above thermal agitation noise.

APPENDIX C

SCHEMATIC DIAGRAMS

Figure		Page
C.1	NOAA MARK VII ACOUSTIC ECHO SOUNDER	45
C.2	CARD RACK	46
C.3	WIRING DIAGRAM	47
C.4	± 15 VOLT POWER SUPPLY PCB's 1 and 2	48
C.5	+ 5 VOLT POWER SUPPLY PCB 3	48
C.6	CLOCK PCB 4	49
C.7	HOUR MARKER PCB 5	50
C.8	DUAL GATE PCB 6	51
C.9	TRANSMITTER PCB 7	52
C.10	RECEIVER PCB 10	53
C.11	BAND-PASS FILTER PCB's 11, 12, and 13	54
C.12	DETECTOR	55
C.13	TAPE MIXER PCB 9	56
C.14	FACSIMILE WRITING AMPLIFIER PCB 14	57
C.15	FACSIMILE RECORDER PCB 15	58
C.16	REMOTE PREAMPLIFIER AND INTERCABLING	59

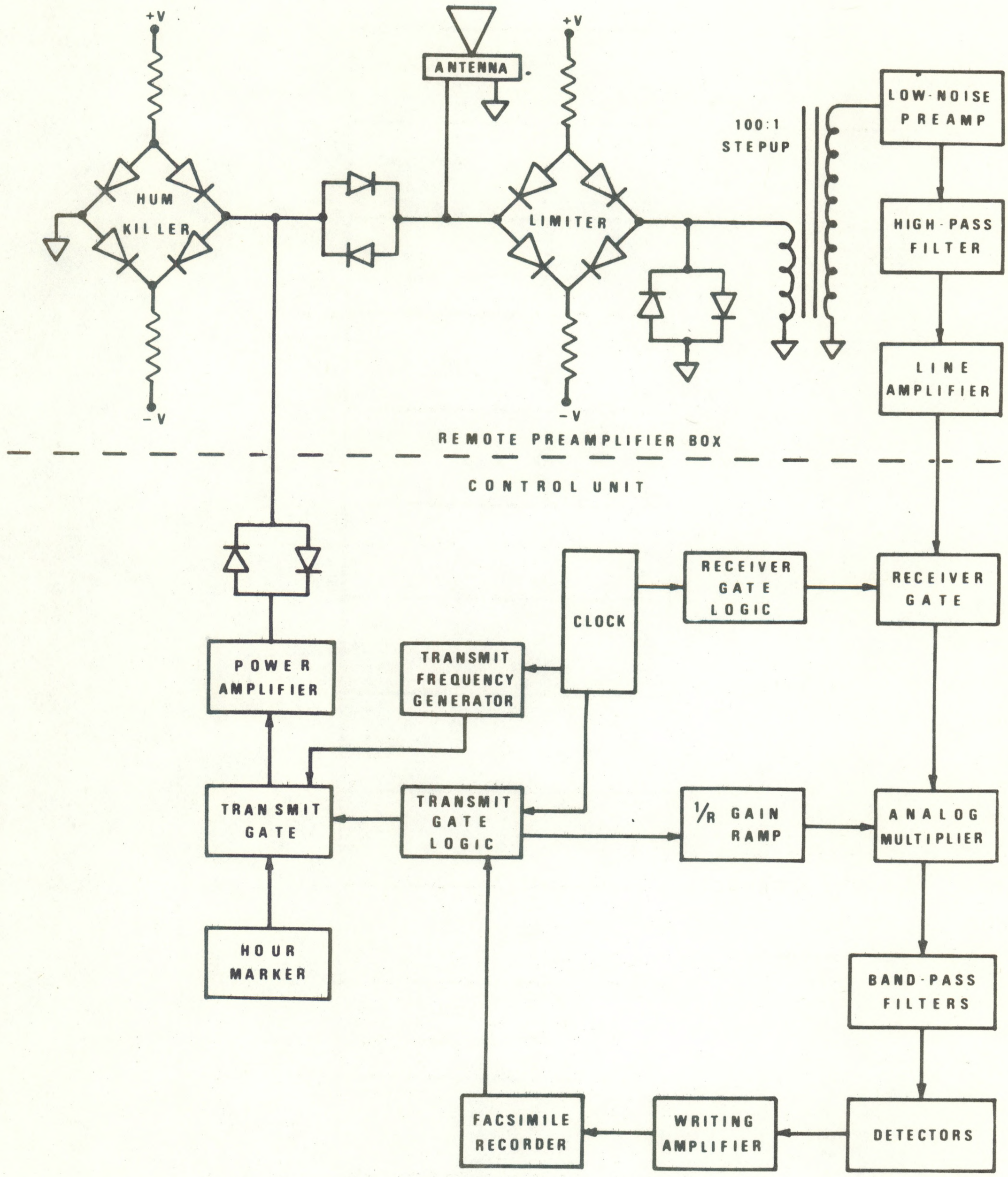


Figure C.1. NOAA Mark VII acoustic echo sounder.

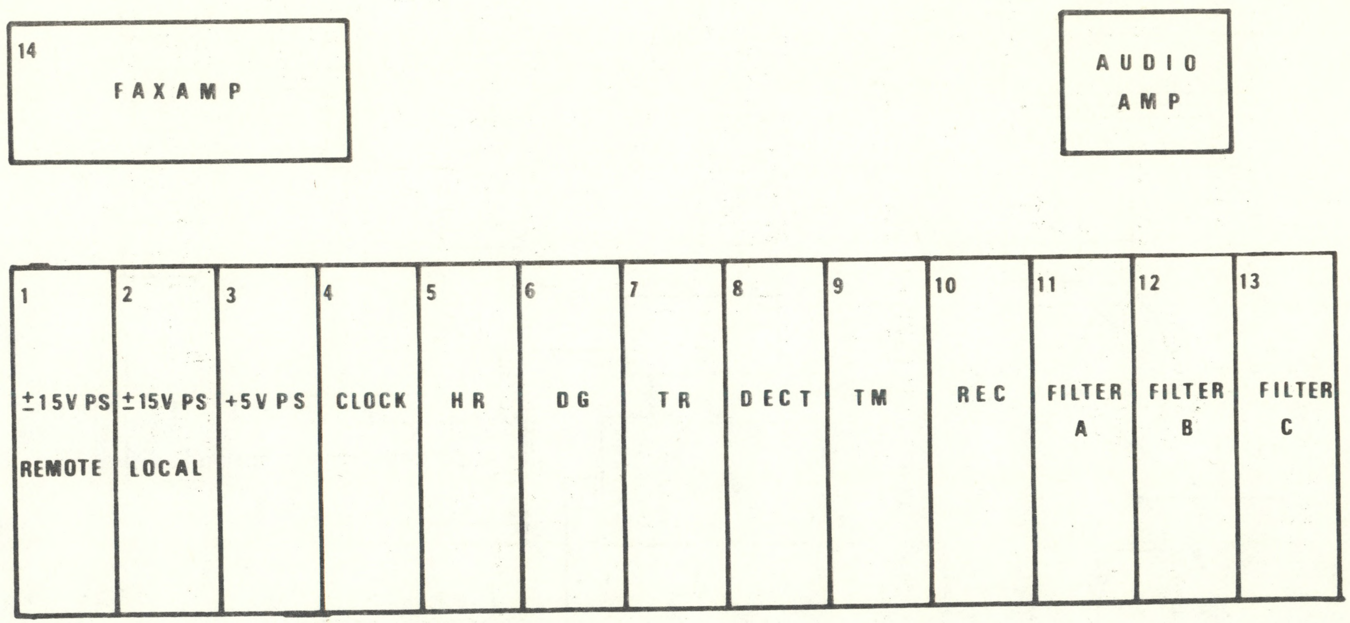


Figure C.2. Card rack.

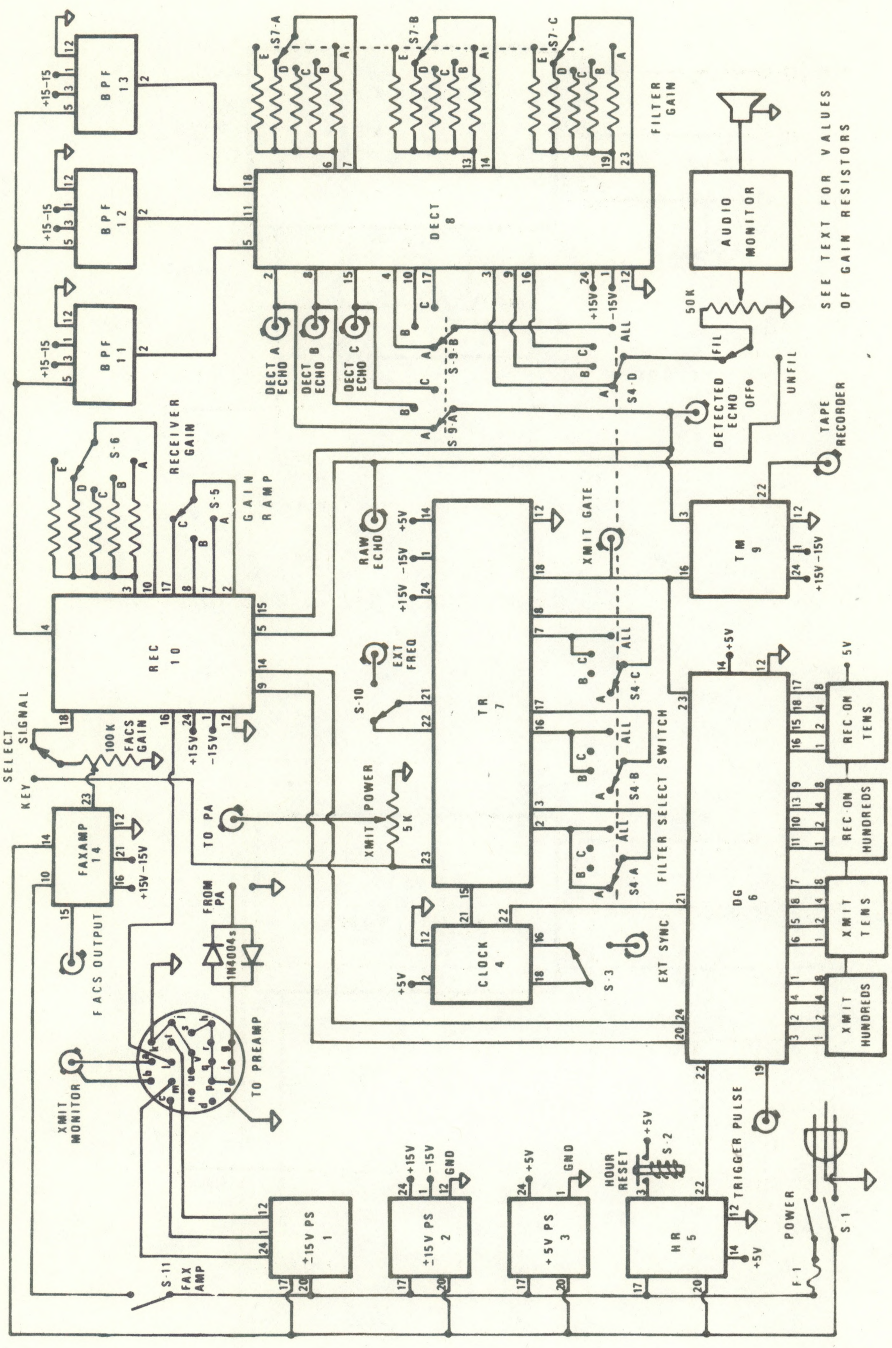


Figure C.3. Wiring diagram.

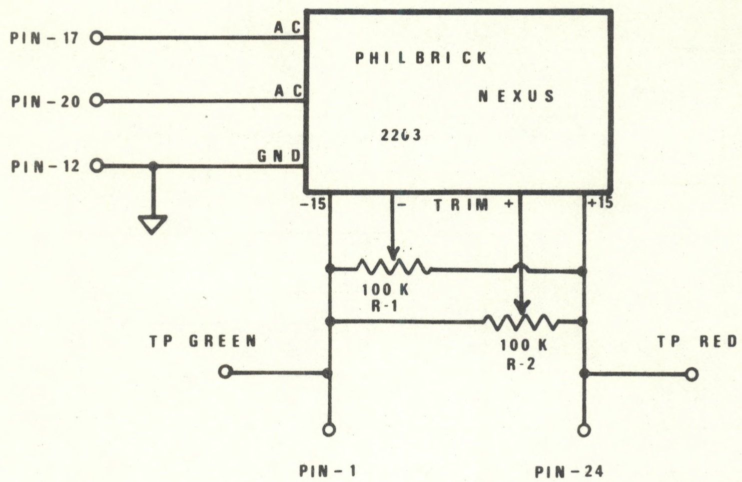


Figure C.4. ± 15-V *power supply PCB's 1 and 2.*

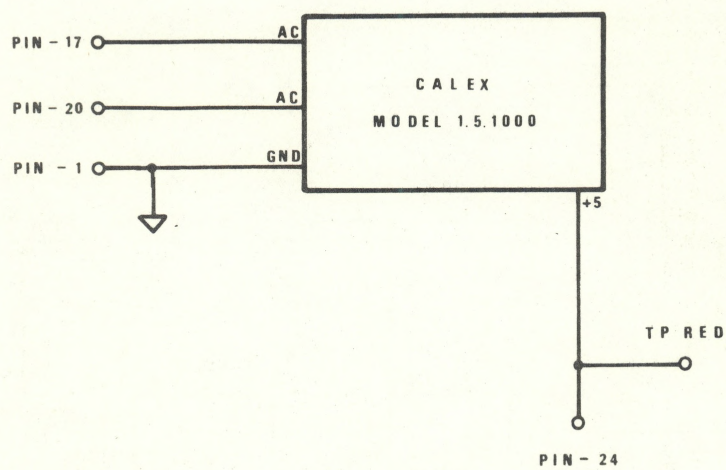


Figure C.5. + 5-V *power supply PCB 3.*

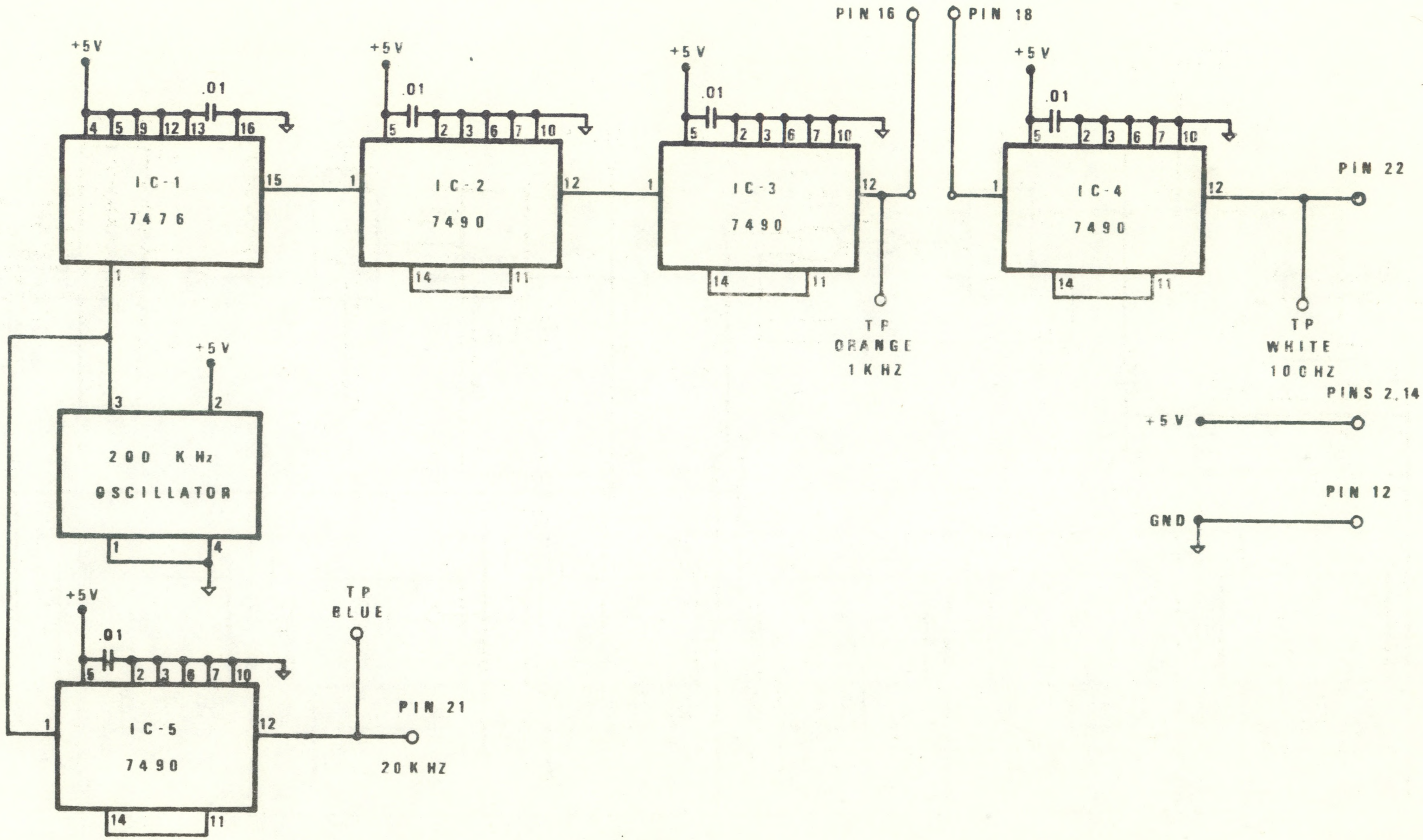


Figure C.6. Clock PCB 4.

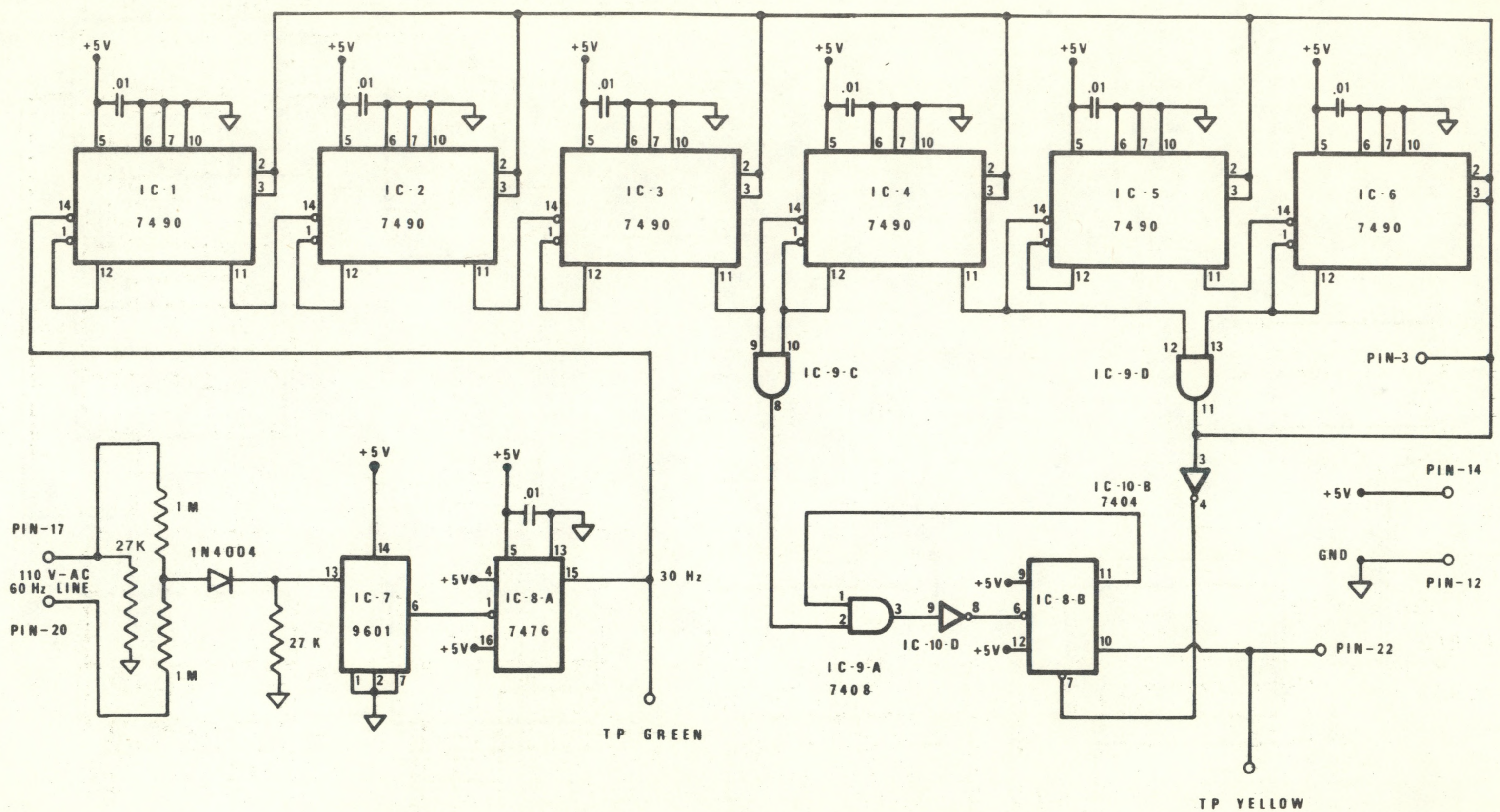


Figure C.7. Hour marker PCB 5.

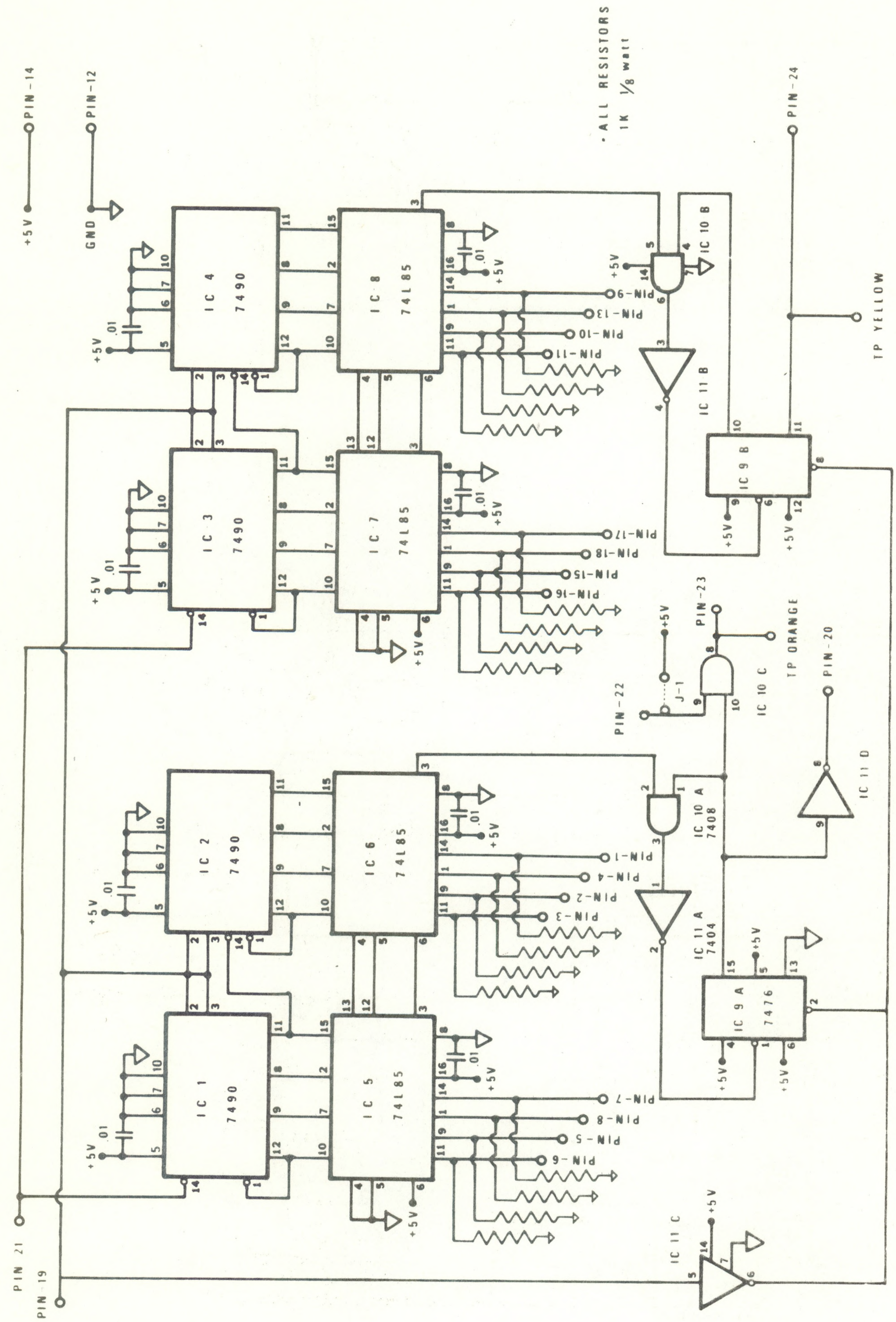


Figure C.8. Dual gate PCB 6.

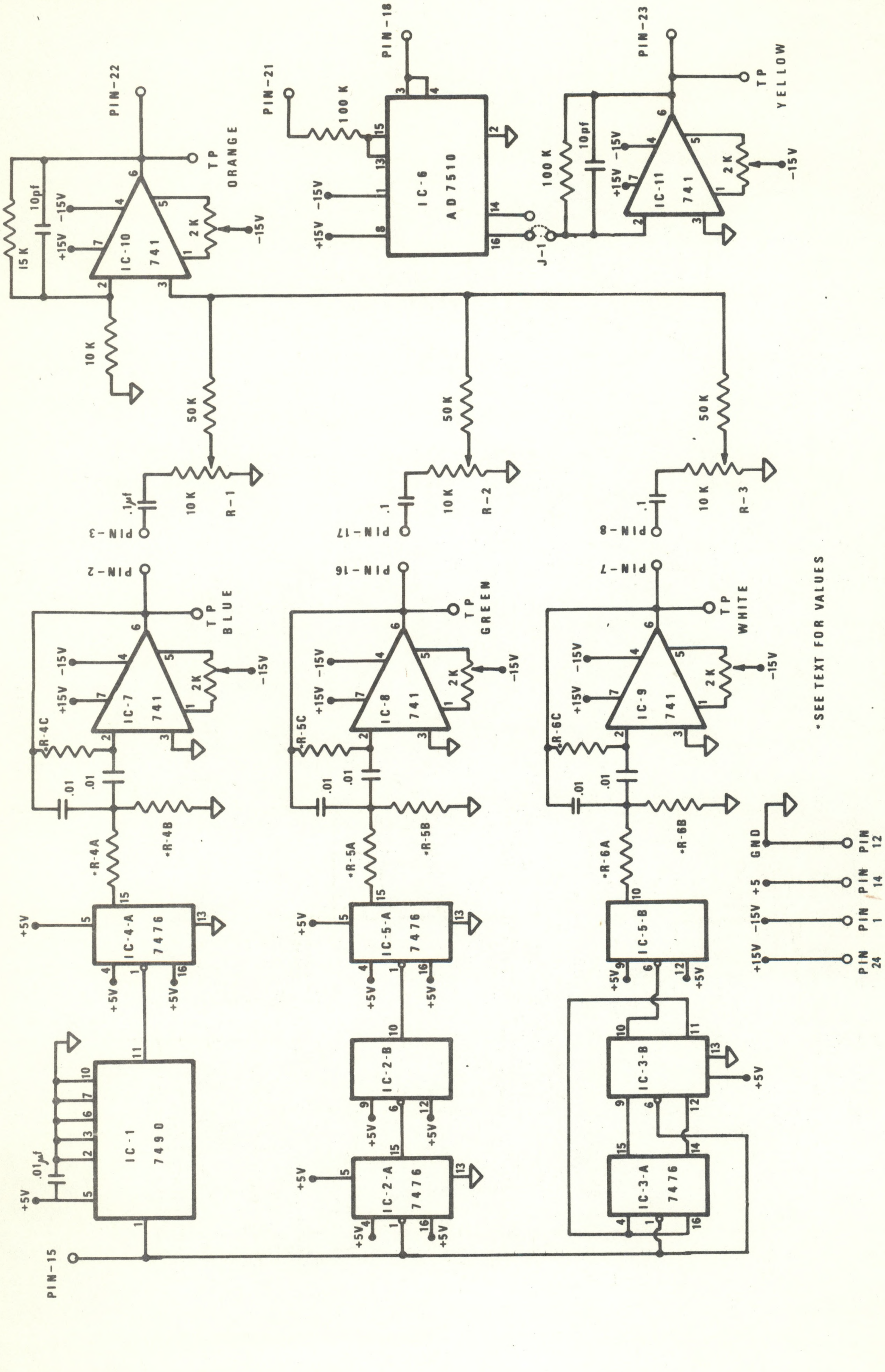


Figure C.9. Transmitter PCB 7.

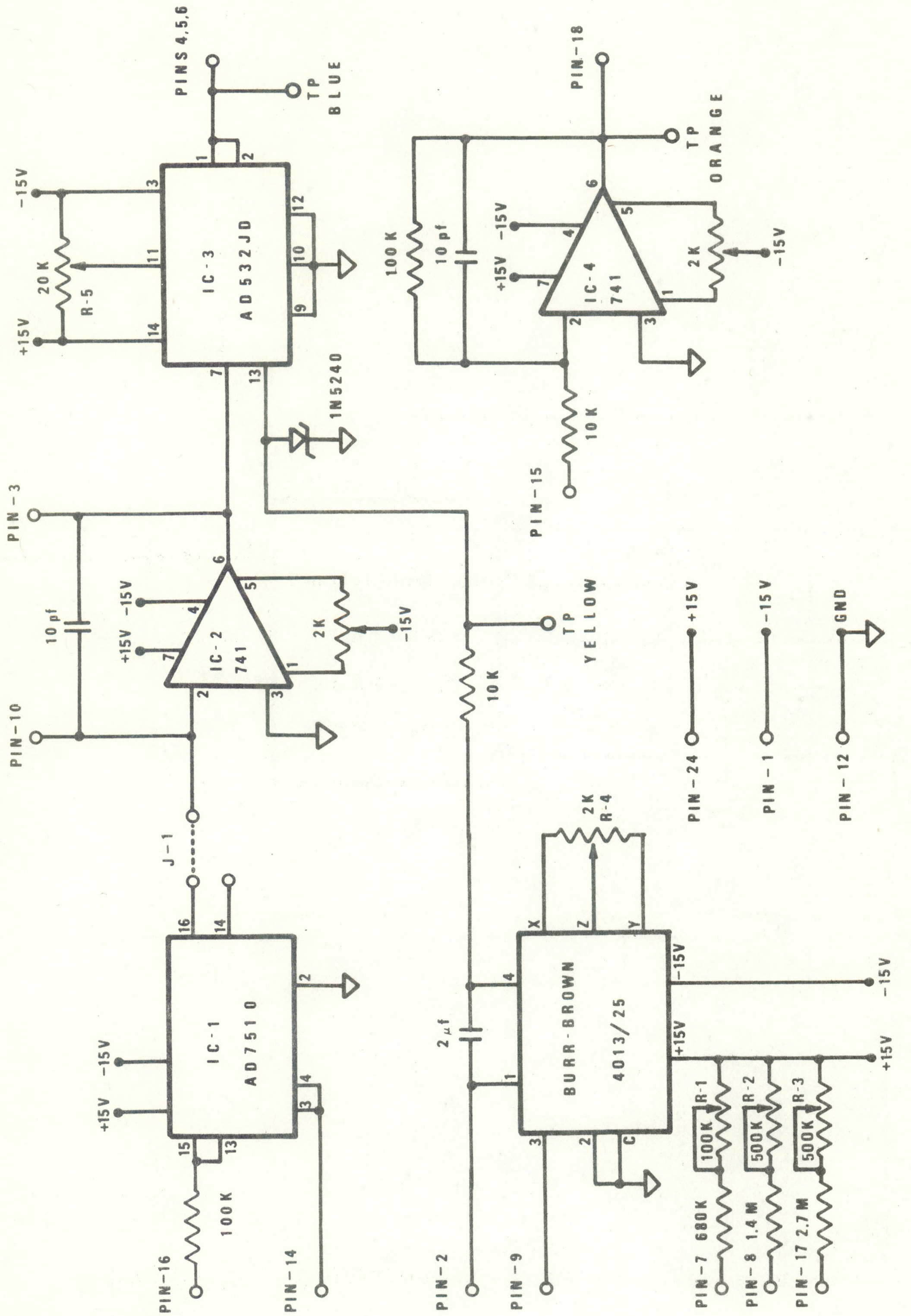


Figure C.10. Receiver PCB 10.

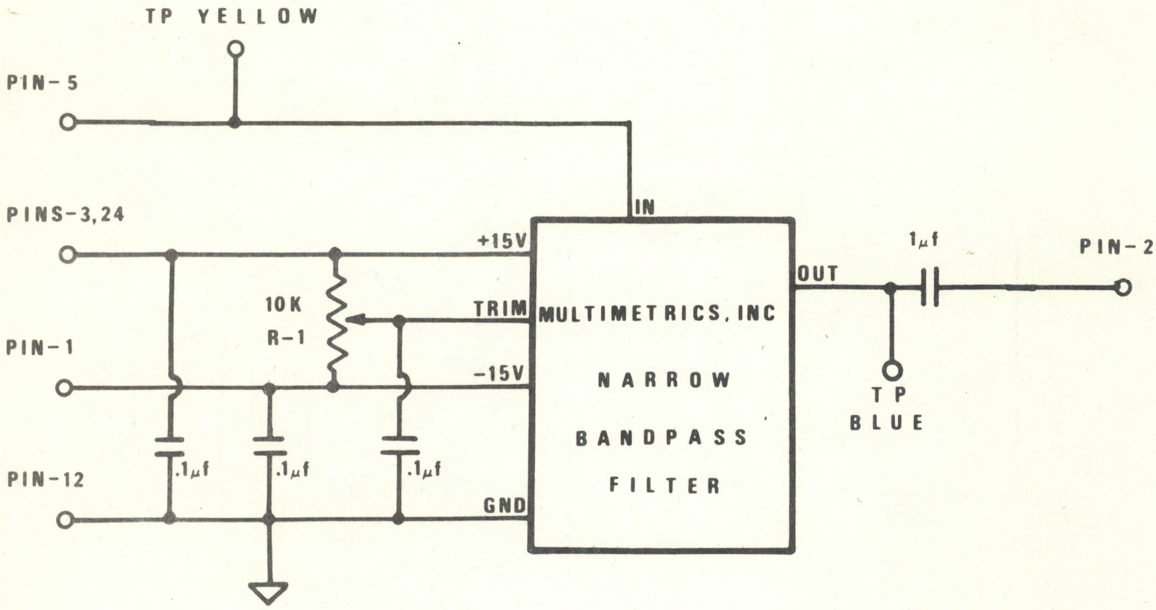


Figure C.11. Band-pass filter PCB's 11, 12, and 13.

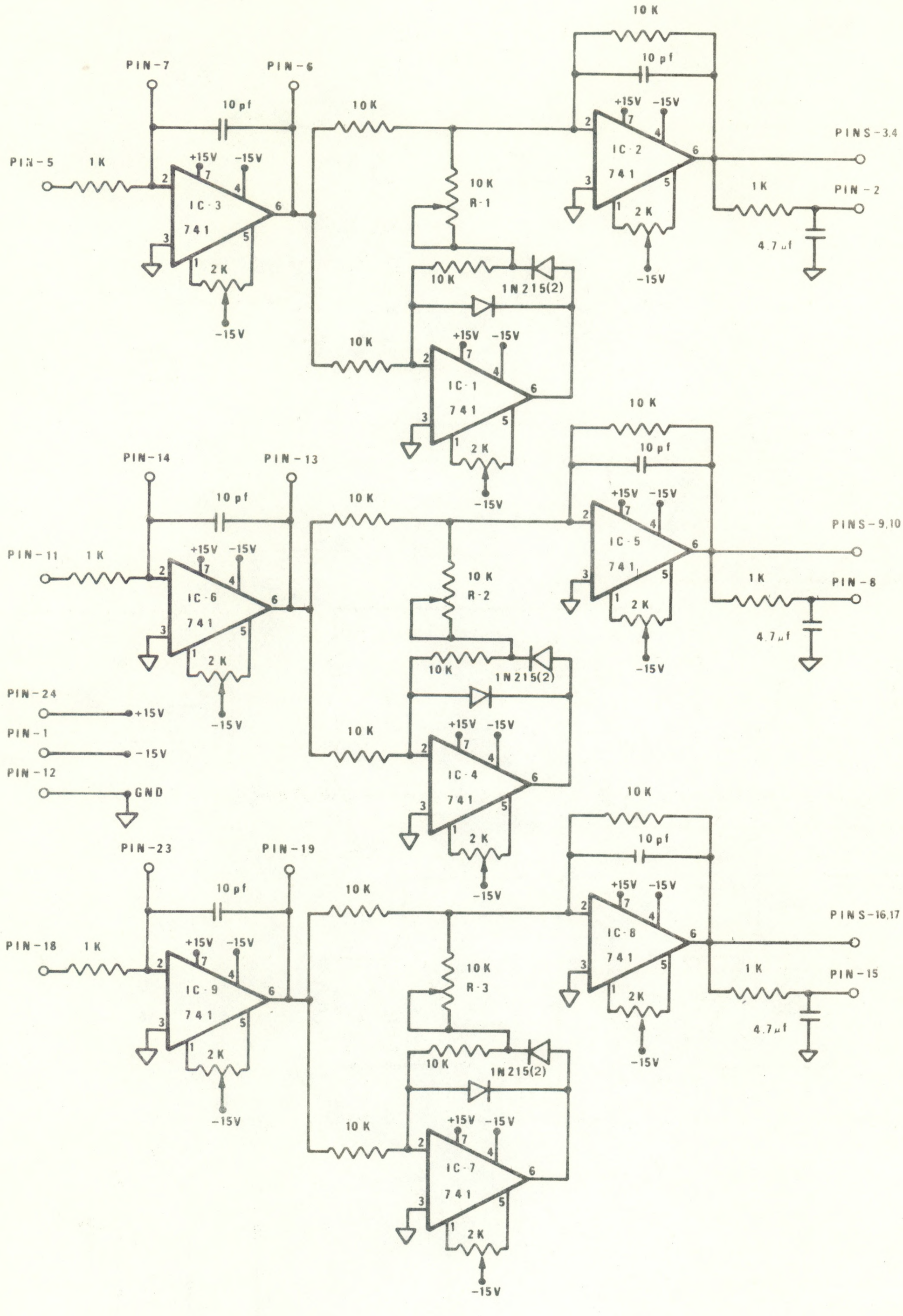


Figure C.12. Detector PCB 8.

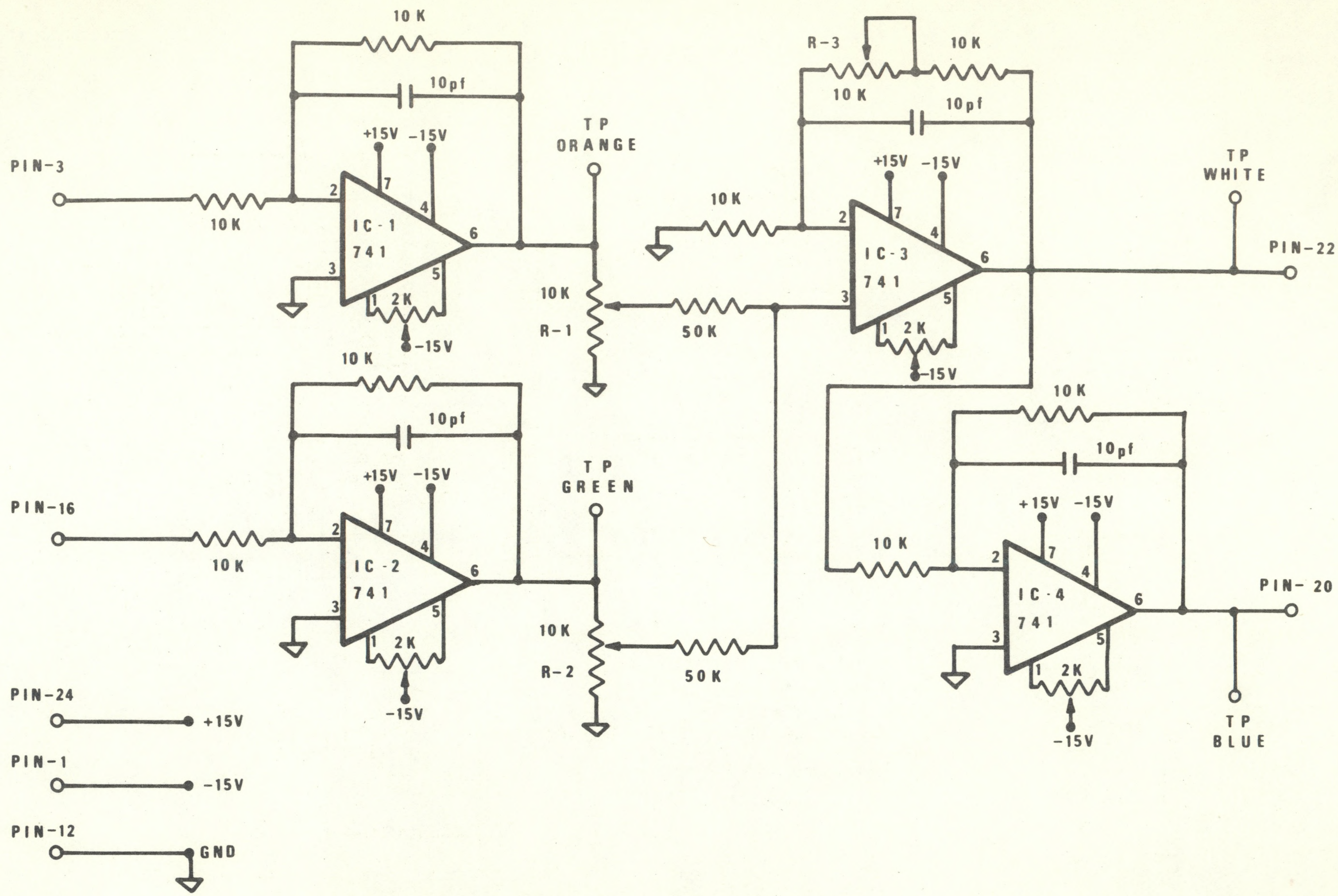


Figure C.13. Tape mixer PCB 9.

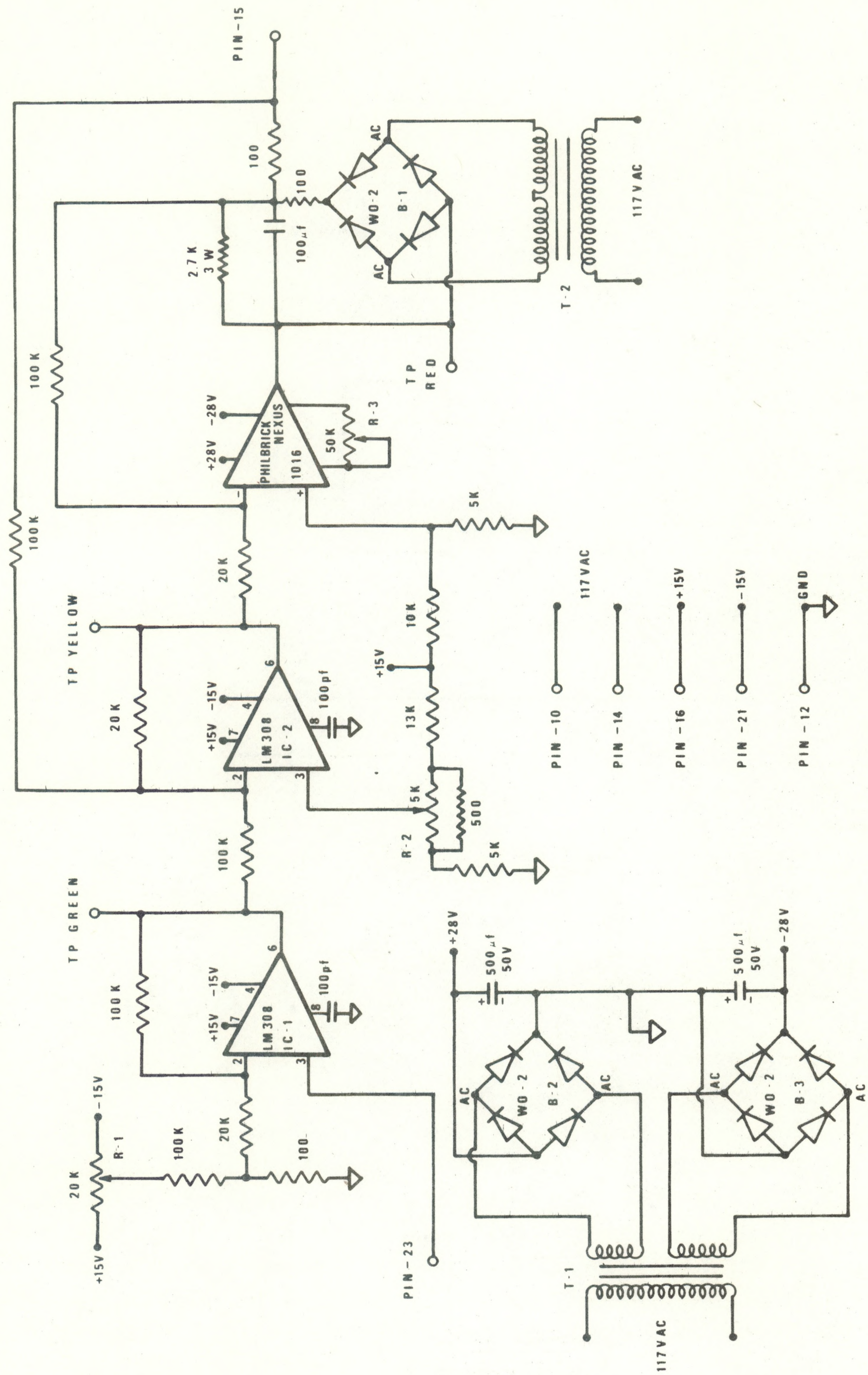


Figure C.14. Facsimile writing amplifier PCB 14.

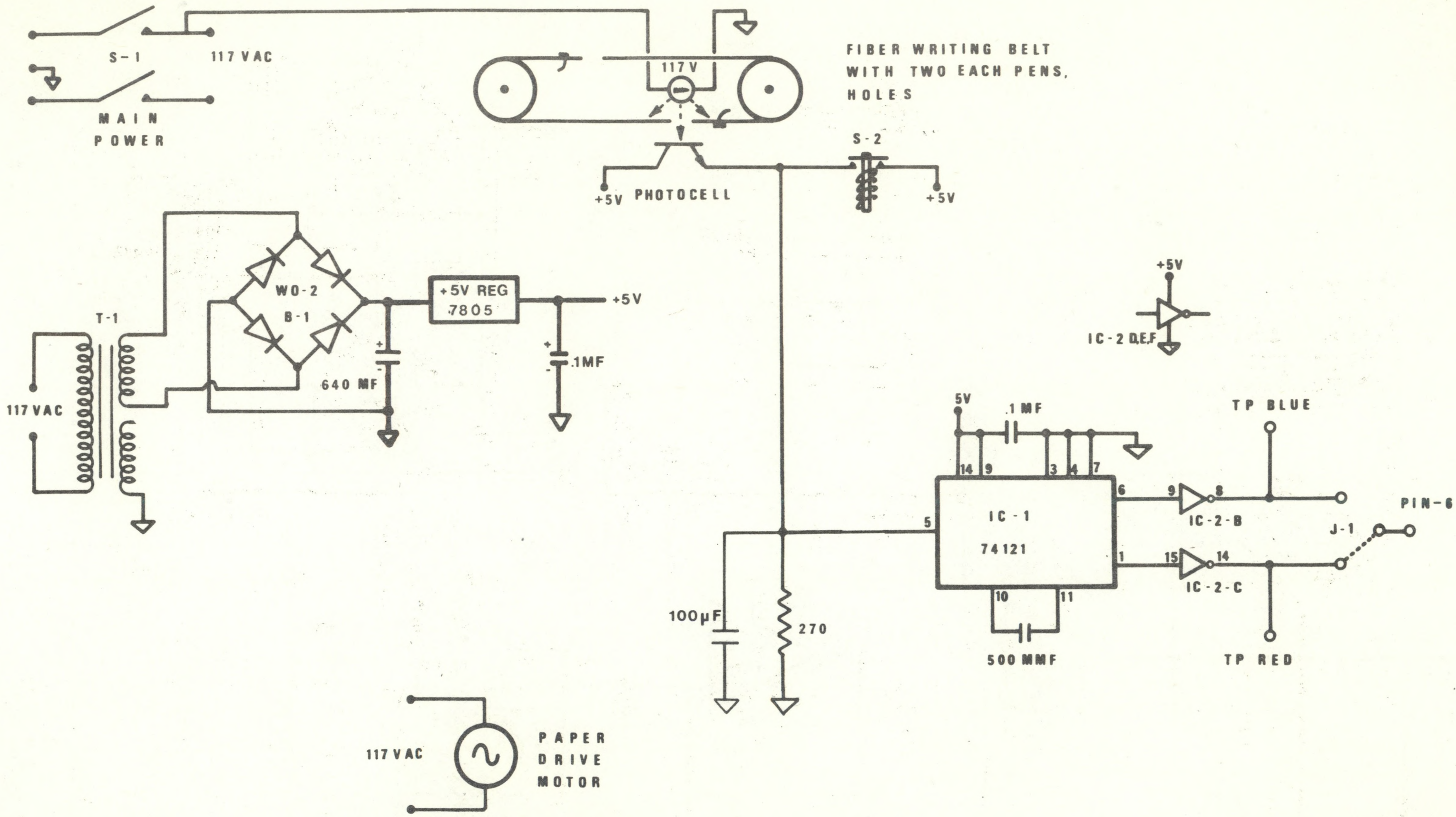


Figure C.15. *Facsimile recorder PCB 15.*

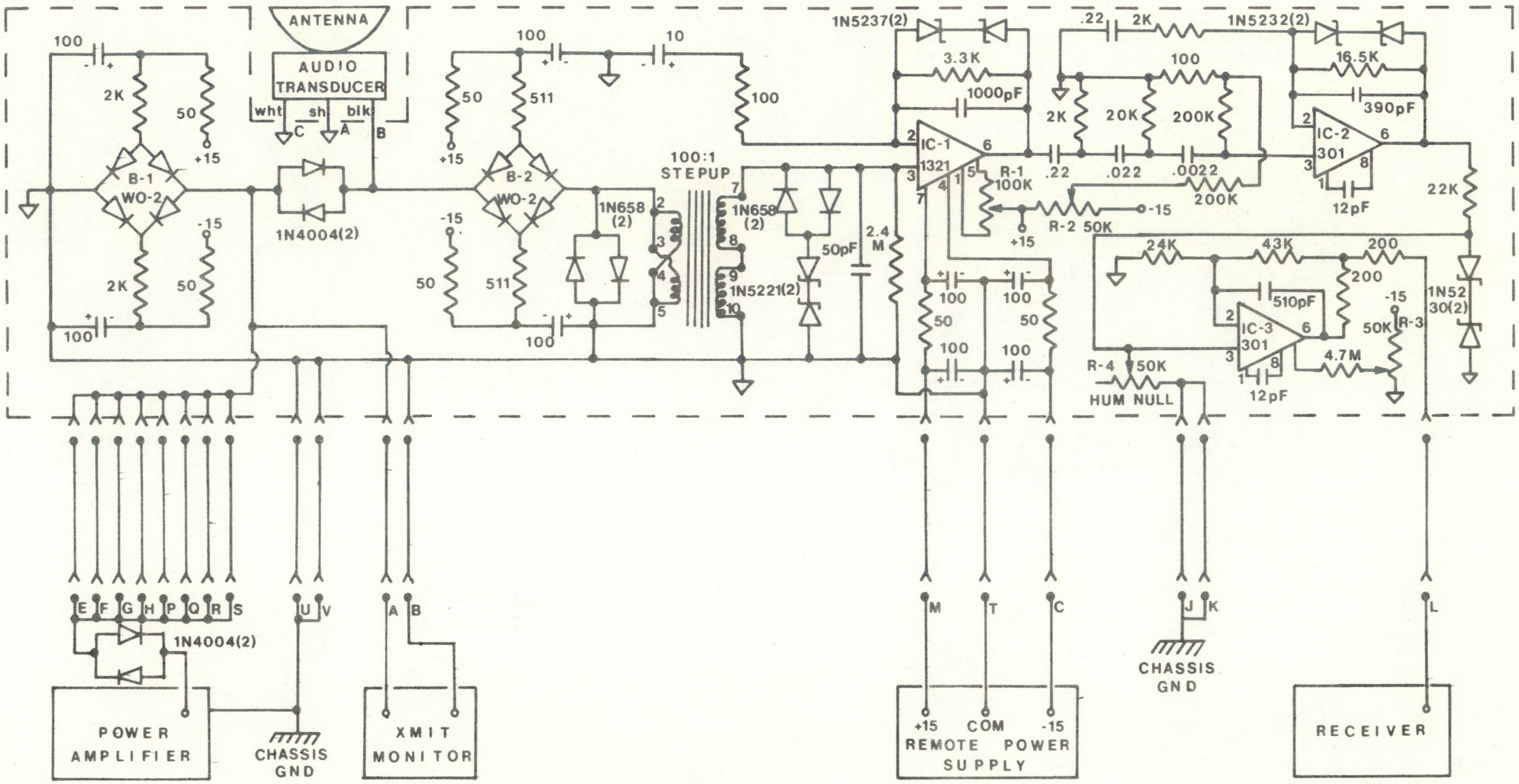


Figure C.16. Remote preamplifier and intercabling.

APPENDIX D

DESIGN AND OPERATION OF THE FACSIMILE RECORDER ELECTRONICS

The Facsimile Recorder electronics are mounted on a printed circuit board located under the paper platen. Their purpose is to generate a very narrow positive-going reset pulse to be used by the Control Unit. The electromechanical unit consists of a photo-transistor used as a switch, a 6-W light bulb, and two holes placed in proper locations on the fiber writing belt. As the writing belt is being driven by its synchronous motor and the variable position speed pulleys, the holes pass in front of the photo-cell allowing it to be illuminated by the light bulb. The photo-cell switches ON creating a positive-going voltage to the input of IC-1 (74121) monolithic multivibrator) regulated by a 270 Ω resistor and 100 μF capacitor. The latter components keep the input to IC-1 from false triggering. The output of IC-1 is fed through IC-2 (7404 hex inverter) which inverts the pulse and acts as a buffer. Both positive and negative pulses are available by means of a jumper on the board for different applications.

A simple + 5 Vdc power supply, also located on this printed circuit board, consists of a transformer, diode bridge, regulator, and two capacitators. A manual reset push-button switch is located on the top panel for testing the operation of the unit. The main power switch, also located on the top panel, switches the 110 V 60 Hz a.c. to the writing belt motor, the paper drive motor, the power supply, and the 6-W lamp.

Two BNC cables connect the Facsimile Recorder to the Control Unit. One labeled SIGNAL IN connects the output of the writing amplifier to the high voltage writing bar. The other BNC labeled TRIGGER PULSE sends the reset trigger pulse to the Control Unit.

APPENDIX E

PARTS LIST (ABBREVIATED)

The following table of component parts includes only those items unique to this system and not readily available. Components such as resistors, capacitors, etc., may be purchased from local electronic supply houses after referring to the various detailed schematic diagrams for correct values. All resistors used are 1/2 W and have 1 percent tolerance except where noted.

Part Description	Manufacturer	Est. Cost
1. Printed Circuit Boards	Astro Engineering 2655 Pearl Street Boulder, Colo.	
A. ±15V P.S.(2262-1)	"	$ 12.00
B. +5V P.S.(2262-1 MOD)	"	12.00
C. Clock (2262-3A)	"	12.00
D. HR (2262-5A)	"	12.00
E. DG (2262-4A)	"	12.00
F. TR (92262-7A)	"	12.00
G. Dect (2471-A)	"	12.00
H. TM (2852)	"	12.00
I. REC (2262-6A)	"	12.00
J. FILTER (2262-2)	"	12.00
K. FAXAMP (2536)	"	12.00
L. KEY CARD (2798-1A)	"	12.00
M. PREAMP (1246-1-1C)	"	12.00
2. ±15V, 100 ma Power Supply Model 2203	Teledyne Philbrick Local Rep.	57.00
3. +5V, 1a Power Supply Model 1.5.1000	Calex P.O. Box 555 Alamo, Calif 94507	49.00
4. Precision frequency sources Model Y283-3A-G71	Greenray Industries Mechanicsburg, Pa.	172.70
5. Integrated Circuit 7490 Decode counter	Any local supply	.50
6. Integrated circuit 7476 Dual J.K. flip/flop	"	.60

7. Integrated circuit 7404 Hex Inverter	"	$ .50
8. Integrated circuit 7408 Quad Two Input Add Gate	"	.50
9. Integrated circuit 9601 monostable one shot multivibrator	"	.80
10. Integrated Circuit 74L85 4-bit comparator	"	6.82
11. Integrated circuit 74121 Monostable multivibrator	"	1.00
12. Integrated circuit Electronic switch AD7510KD	Analog Devices	15.00
13. Integrated circuit x·y multiplier AD532JD	Analog Devices	26.00
14. Operational amplifier 741	Any local supply	.60
15. Operationa amplifier 1016	Teledyne Philbrick	70.00
16. Operational amplifier 132101	Burr-Brown	15.75
17. Operational amplifier LM308	Any local supply	.75
18. Sample/Hold switched integrator model 4013/25	Burr-Brown	199.00
19. Bogen Model MT125 Booster amplifier	Any local supply	270.00
20. CROWN DC 300 A Power amplifier	"	685.00
21. ROSS Fisherman Straight-line Recorder (not modified)	Ross Laboratories 3138 Fairview Avenue Seattle, Wash. 98102	670.00

22. Stylus for straight line	Ross Laboratories	$ 3.75
23. Writing Belt for straight-line (not modified)	"	10.00
24. Dry recording paper for straight-line	Fitchburg CPI P.O. Box 1106 Scranton, Pa. 18501	4.38 (in lots of 100)
25. Synchronous motor Crammer No. 117P 1/20 RPM	Any local supply	12.30
26. Synchronous motor Bodine 760 60 RPM	"	40.90
27. Synchronous motor Bodine 760 30 RPM	"	42.70
28. Pamotor pentaflow fan 8500P	"	22.00
29. Multi-conductor shielded cable Belden type 8774	"	500.00/1000 ft
30. Altec Lansing 290E 4-ohm 100-W driver	"	288.00
31. Diaphragm and 4-ohm voice coil replacement for 290-E	"	48.00
32. Transformer VTC type HA-103A	"	27.00
33. Transformer 18-V secondary 8174-002	"	4.88
34. Thumb-wheel switch Interswitch LB731	"	4.40
35. Connector, cable MS-3106E 28-16S	"	9.89
36. Connector, Bulkhead MS-3102E28-16P		
37. Connector, cable MS 3106E16S-5S	"	2.50

38. Connector, bulkhead MS3102E 16S-5P	Any local supply	$ 1.50
39. Lamp - 6-W type 6S6	"	.25
40. Photo diode, FPT 100	"	3.00
41. Diode bridge type W02	"	1.40
42. Regulator +5V LM 340T-5.0 7805	"	2.00
43. Audio amplifier module, 1W CALECTRO UA-016	"	8.75

APPENDIX F

INTERCONNECTING CABLE/CONNECTOR WIRING DIAGRAM

BELDEN TYPE 8774 WIRE PAIR	MS3106E28-16S CONNECTOR PINS	
YELLOW-BLACK	YELLOW to A	BLACK to B
BLUE-BLACK	BLUE to M	BLACK to C
GREEN-BLACK	GREEN to D	BLACK to N
WHITE-BLACK	WHITE to E	BLACK to P
GREEN-RED	GREEN to F	RED to G
RED-WHITE	RED to H	WHITE to S
ORANGE-BLACK	ORANGE to T	BLACK to J
BROWN-BLACK	BROWN to K	BLACK to L
RED-BLACK	RED to Q	BLACK to R

1. Tie u and v together and to all 9 shield drain wires from the wire pairs.
2. Use waterproof bell-housing boots and seal with RTV or other sealer.

APPENDIX G

DESIGN OF ANECHOIC ABSORBING CUFF

The anechoic absorbing cuff or shield (fig. G.1), although not actually part of the MARK VII system, has proved to be a satisfactory method of increasing sounder performance in noisy environments. It is best to locate the antenna sufficiently far from noise sources. Cuffs can, however, make echo sounding possible in noisy environments where signal-to-noise ratios are small.

Cuff design is still a process based on years of trial and error construction. Several mechanical considerations are listed here to aid in developing your own design; some theoretical considerations are in Strand (1971). Figure G.2. is a sketch of a simple plywood cuff being used at the South Pole station.

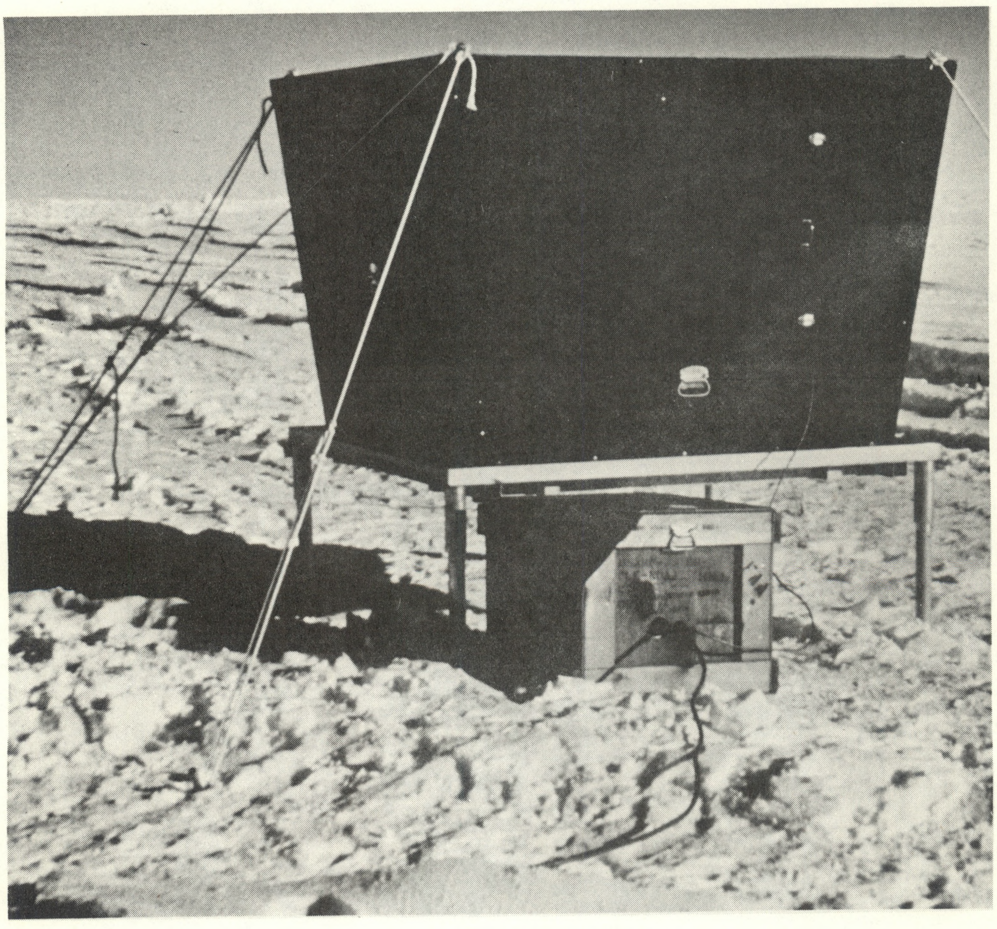
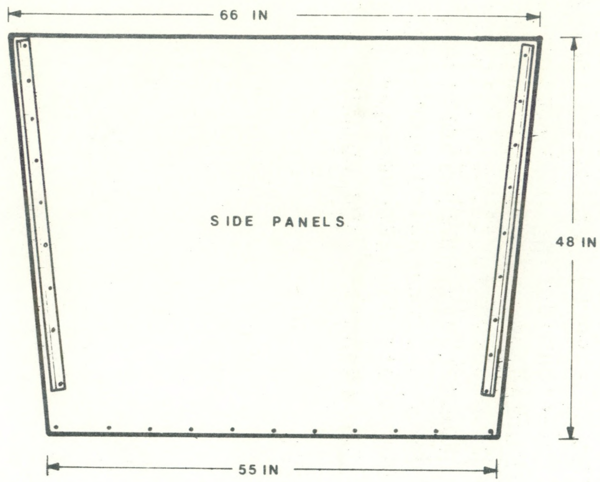


Figure G.1 A typical cuff.



MATERIALS:

a. 4 pieces $5/8$ IN EXT PLYWOOD CUT 48x66x55x48 IN

b. 2 " " " " " 48x48 IN

2 " " " " " 48x7 IN

2 " " " " " 55x8 IN

c. 4 " $1\frac{1}{2} \times 1\frac{1}{2} \times \frac{1}{8}$ IN ANGLE ALUM CUT 40 IN

d. 4 " " " " " 54 IN

e. ASSORTED HARDWARE

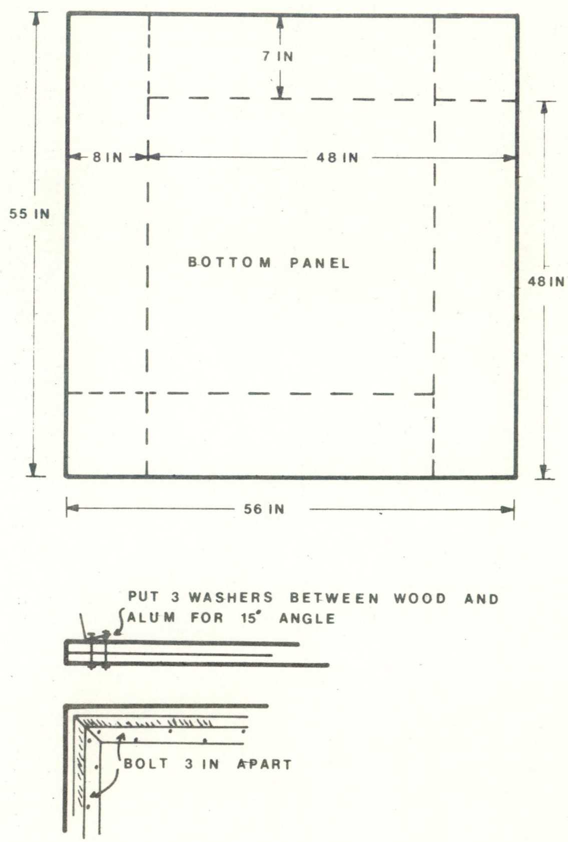


Figure G.2. Design of simple plywood cuff being used at South Pole station.

The outside walls of the cuff can be made of plywood, sheet metal, fiberglass panels, etc. The main consideration is the rigid sound deadening quality of the material used. Plywood sheets 5/8-in thick or greater are very satisfactory. They are relatively inexpensive, readily available, easy to work with, and of convenient size.

The bottom of a typical cuff is a double thickness plywood panel cut, overlapped, glued, and bolted together to form a square about 10 in wider than the diameter of the parabolic dish being used. Angle aluminum is bolted to the panel along the four top sides 5/8-in from the edge. Washers are used between the wood and the metal when bolting the aluminum down to create an angle of about 15° off vertical, tilting outward. The cuff walls are cut to flare out slightly when bolted together. The top of the cuff should be about 10 in wider than the bottom. Two of the side panels have angle aluminum bolted 5/8-in in from both sides along the edge. Open cell foam panels are glued to the entire inner surface of the plywood between the angle aluminum and on the bottom panel. Five-inch thick open cell mattress foam works well if special acoustic foam cannot be obtained. The other two side panels are cut, lined with foam, and bolted to the angle aluminum in the side panels forming the rigid cuff. The cuff is then bolted to the bottom panel through the angle aluminum.

General mechanical considerations should include (1) thick, rigid exterior walls, (2) double thick bottom panel, (3) 3 to 5 in of foam on all five panels, (4) slightly flared sides, (5) 4 to 8 ft height, (6) trap door access to the transducer, (7) easy assembly and disassembly, and (8) a removable lid to protect the foam during heavy rain. The entire cuff structure can also be mounted on a two-wheel trailer for towing to remote sites. Care should be taken to tie down the structure in case of high wind conditions. In some very noisy locations, greater noise reduction can be achieved by burying the entire cuff structure with only 6 in of the top of the cuff protruding above ground level. The excavation is then back filled to create a fixed antenna position.

APPENDIX H

RECOMMENDED SPARE PARTS LIST

	PART DESCRIPTION	RECOMMENDED QUANTITY
1.	Model 2203, ± 15 V P.S.	2
2.	Model 1.5.1000, + 5 V P.S.	1
3.	Oscillator 200 kHz	1
4.	7490	10
5.	7476	6
6.	7404	6
7.	7408	6
8.	9601	4
9.	74L85	10
10.	74121	4
11.	AD 7510 KD	2
12.	AD 532 JD	2
13.	1016 op amp	1
14.	132101 op amp	1
15.	LM 308 op amp	2
16.	4013/25 integrator	1
17.	Stylus	20
18.	Dry recording paper	10 rolls
19.	Voice coil replacement	1
20.	Lamp 6S6	1
21.	Photo diode	1
22.	+ 5-V regulator LM 340T	1

APPENDIX I

VARIABLE SYSTEM COMPONENTS

There are two models of the MARK VII system being produced. The major difference is in the range of selectable pulse repetition ratios available. For systems requiring low range information, Model A operates at 1, 2, and 4 sec periods. For greater height ranges, Model B operates at 2, 4, and 8 sec periods, yielding data to a maximum of 1360 m. Since the pulse repetition rate is dependent upon the speed of the writing belt (the holes in the writing belt are used to turn on the photo-transistor and trigger the system), the writing belt drive motor need only be changed to create the two different sets of pulse rates. A motor change and a change in the resistor values for the gain ramp generator are needed to develop the linear unity gain ramp per selected period.

The following tables give the component specifications for the different models. Also included are the gain resistor values for the RECEIVER GAIN switch and the FILTERED GAIN switch. Finally the resistor values for the active band-pass filters used in the TR card to shape the square-wave transmitting frequencies are listed.

Motor and Resistor Values

		Gain Ramp Values		Component Values	
MODEL	Writing Belt Drive Motor	Switch Position	Pulse Rep. Rate(Sec)	Fixed Resistor Value	Variable Resistor Value
A	Bodine synchronous motor No. 772, 60 RPM	A	1	680 K	100 K
		B	2	1.4 M	500 K
		C	4	2.7 M	500 K
B	Bodine synchronous motor No. 760, 30 RPM	A	2	1.4 M	500 K
		B	4	2.7 M	500 K
		C	8	5.1 M	1 M

Receiver Gain Resistor Values

Switch Position	Resistor Value	Gain (dB)
A	100 K	0
B	316 K	10
C	398 K	12
D	499 K	14
E	631 K	16

Filter Gain Resistor Values

Switch Position	Resistor Value	Gain (dB)
A	31.6 K	30
B	63.4 K	36
C	100 K	40
D	158 K	44
E	200 K	46

TR Band-Pass Filter Resistor Values

Frequency	Calculated Resistor Values
2 kHz	R-4A = 79.6 K R-4B = 418 R-4C = 159 K
2.5 kHz	R-5A = 63.7 K R-5B = 335 R-5C = 127 K
3.333 kHz	R-6A = 47.75 K R-6B = 251 R-6C = 96 K

USCOMM - ERL