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HEAT EXCHANGER CLEANING IN SUPPORT OF OCEAN THERMAL ENERGY CONV--ETC(U)
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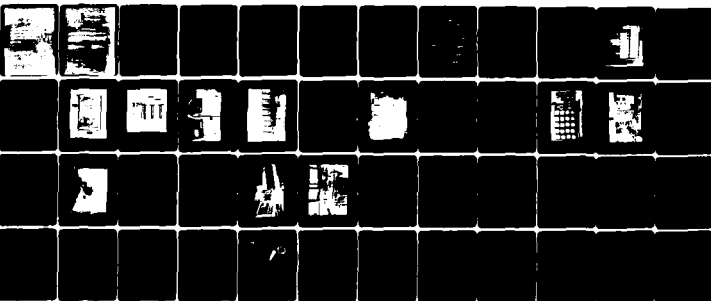
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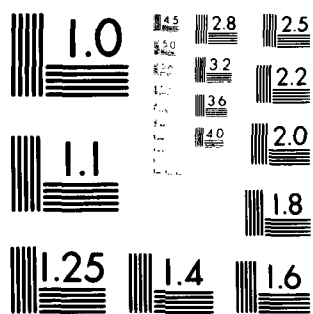
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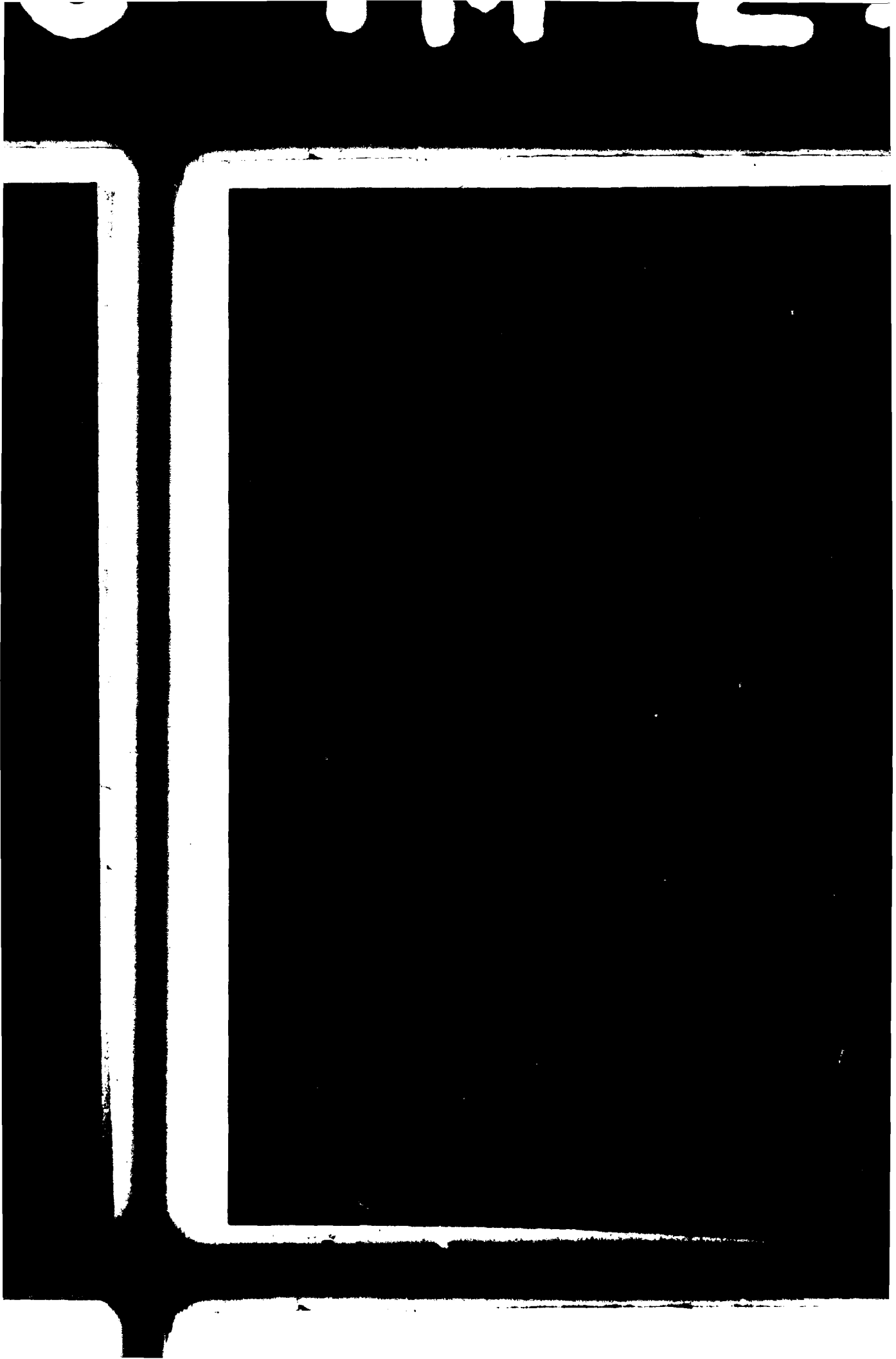


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TABLE OF CONTENTS

	<u>Page No.</u>
INTRODUCTION.	1
Background	1
Purpose.	3
ELECTRONIC SUBSYSTEMS	3
Amplifiers	3
Flowmeters	9
Temperature Measurement.	16
Heaters.	17
Brush Control.	21
Ball Control	23
Chlorination	26
APPENDIX A - AMPLIFIER CIRCUIT.	A-1
APPENDIX B - FLOWMETER MODIFICATION	B-1
APPENDIX C - HEATER CONTROL SCHEMATIC	C-1
APPENDIX D - FLOW DRIVEN BRUSHES.	D-1
APPENDIX E - RECIRCULATING SPONGE RUBBER BALL SCHEMATIC	E-1
APPENDIX F - CHLORINE PROBE DATA.	F-1
APPENDIX G - SEA WATER INSTRUCTION ADDENDUM	G-1

LIST OF ILLUSTRATIONS

<u>Figure No.</u>		<u>Page No.</u>
1	Heat Exchanger Cleaning Facility	2
2	Block Diagram - Electronic Subsystems	4
3	Amplifier Rack	5
4	Analog Panel	7
5	Amplifier Modification	8
6	Amplifier Test Jack	9
7	Amplifier Card	10
8	CRT Data Display	11
9	Flowmeter with Multiplexer	12
10	Computer to Flowmeter Control Panel	13
11	Flowmeter Card	15
12	Noise Suppression Filter for Flow Measurement	16
13	Temperature Measuring Circuit	17
14	Frontal - VARIAC Rack	18
15	Reverse - VARIAC Rack	19
16	Flow Driven Brush Control Panel	22
17	Recirculating Sponge Rubber Ball Control Panel	24
18	Interconnection of Recirculating Sponge Rubber Ball Electronics Panel to Mechanicals	25
19	Chlorination System Components	27
20	Chlorine Generator	28
21	Interconnection of Chlorine System Components	29

<u>Table No.</u>		<u>Page No.</u>
1	Amplifier Output to Computer Analog Panel	6
2	Amplifier Input Connections	9
3	Multiplexer Connections to Computer Output Bits	14
4	Interconnection of Temperature Monitor to Computer	17
5	Output Control Lines from Computer to Heater Control	20
6	Interconnection of Heater Controls to Heat Transfer Units	21
7	Flow Driven Brush Timer to Valve Connections	23

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INTRODUCTION

Ocean Thermal Energy Conversion (OTEC) is an effort to develop the energy potential of the oceans. The OTEC concept seeks to utilize the thermal difference between the warm surface waters and the cold deep waters to drive a turbine generator. Using ammonia as a working fluid, the output might be either direct electrical energy or energy-intensive chemicals (i.e., fertilizers). Since the thermal range between the ocean waters is not great, it is critical to maintain optimum performance within heat exchangers. The performance of heat exchangers will therefore decide the ultimate success or failure of OTEC.

BACKGROUND

Hardware development in support of OTEC began at David W. Taylor Naval Ship Research and Development Center (DTNSRDC) in early 1977. The countermeasures system was designed to obtain data on the heat transfer capabilities of various materials when subjected to fouling and cleaning. In October 1978, Argonne National Laboratories (ANL), technical agent for the Department of Energy (DOE) sponsor, asked the Naval Coastal Systems Center (NCSC) to assume overall responsibility for biofouling countermeasures.

NCSC was tasked to determine the performance of the following three cleaning systems for in situ removal of fouling: (1) flow driven brushes, (2) recirculating sponge rubber balls, and (3) chlorination. Each cleaning system was tested on NCSC's ammunition pier. Figure 1 shows the test system arrangement on this pier. Both aluminum and titanium pipe were used in these tests.

The flow driven brushes and recirculating sponge rubber ball systems act to exert shear forces against the pipe interior by the cleaning agent; i.e., brush or ball. These shear forces should be strong enough to prevent and/or remove fouling layers. These systems differ mainly in their cleaning agent and flow pattern; the flow driven brushes require reverse flow and the recirculating sponge rubber ball features unidirectional flow.

The chlorine system makes use of the disinfecting power of oxidizing chemicals. These systems predominate in the United States and are primarily used in sewage treatment or power generation industries.

Each system offers potential for maintaining heat exchanger efficiency while subjected to the assault of heavy biofouling. It remains to be determined which system, or combination of systems, can reduce fouling below a target level.

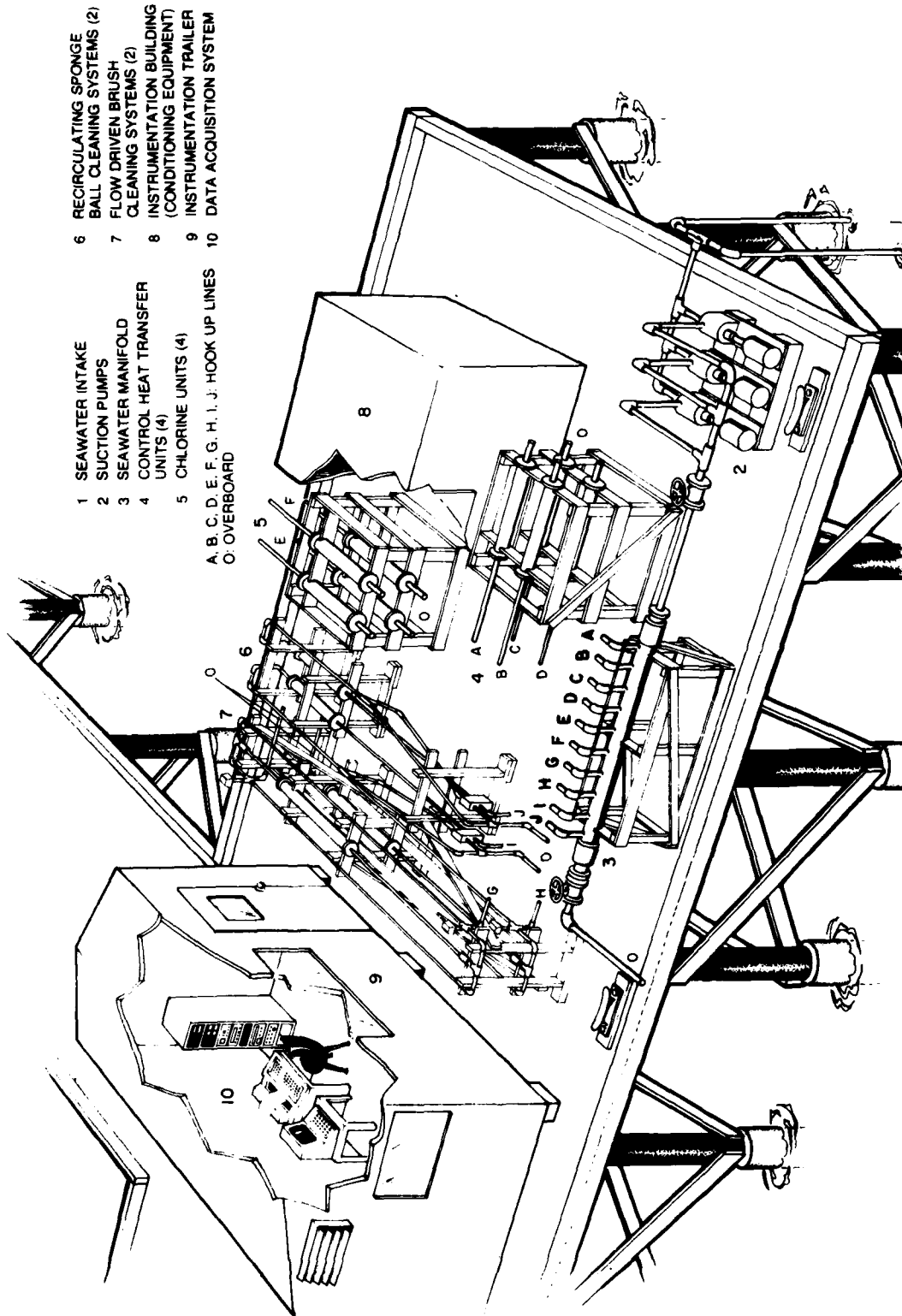


FIGURE 1. HEAT EXCHANGER CLEANING FACILITY

PURPOSE

This report documents the electronic subsystems as well as provides operation and maintenance requirements. The biofouling countermeasures system is comprised of two major subsystems, each having multiple components:

1. Electronic Subsystems

- a. Amplifiers
- b. Flowmeters
- c. Temperature Measurement
- d. Heaters
- e. Brush Control
- f. Ball Control
- g. Chlorination

2. Mechanical Subsystems

- a. Water Supply and Distribution
- b. Ball Recirculation
- c. Flow-Driven Brushes
- d. Chlorination

This report deals mainly with the electronics subsystems for control or data gathering functions. No power requirements will be discussed. For electrical requirements, refer to NCSC Technical Memorandum 297-80, Heat Exchanger Cleaning in Support of Ocean Thermal Energy Conversion (OTEC) - Mechanical Subsystems.

ELECTRONIC SUBSYSTEMS

A block diagram outlines the inter-relationship of the electronic subsystems, which will be discussed separately, and is shown in Figure 2.

AMPLIFIERS

Amplifier design was accomplished by DTNSRDC Code 2732. Output from heat transfer units (HTU) thermopiles and thermistors provides input into continuously operating low noise amplifiers. Prior to use or adjustment, all amplifiers were allowed at least 24 hours to warm up. A photograph of the amplifier rack is provided as Figure 3. Cabling from the amplifier outputs to the computer's analog input panel (front of computer) is shown in Table 1. Figure 4 provides a visual of the analog panel. Amplifier inputs are shown in Table 2. Inputs consist of two cables, each having a twisted shielded pair. Each pair was connected to a four-pin amphenol plug (female) and the amplifier rack. The shield for the thermistor cable was not connected at the plug end. Each HTU was connected to the amplifier rack by a heavy ground wire.

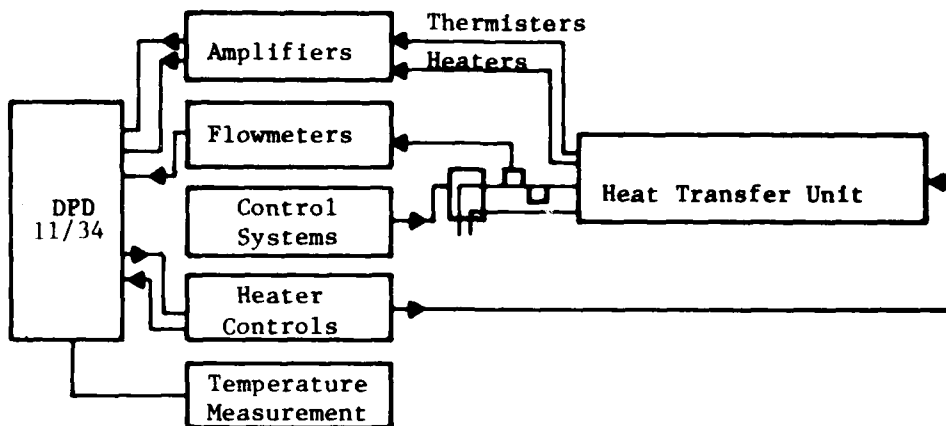


FIGURE 2. BLOCK DIAGRAM - ELECTRONIC SUBSYSTEMS

In order to facilitate offset adjustment, the amplifiers were modified to allow frontal access to range adjustments (Figure 5). A test jack was required to perform the offset adjustments. The test jack is shown in Figure 6 and requires a four-pin amphenol plug (male).

The cable was unplugged from the HTU and the test jack connected to the cable. To adjust the thermopile, the upper pot was turned counterclockwise to increase the offset voltage. A target offset of 100 to 200 mV was required to prevent a negative VZERO. The result of a negative VZERO is analysis error in system software; however, this analysis error does not stop overall system monitoring (a recoverable error). It should be noted that in thermopile adjustment, the bottom pot should be adjusted clockwise to increase the voltage at the computer. A target voltage of 9.999 volts is required.

A schematic of the amplifier circuit is attached as Appendix A. In general, the thermopile amplifier has a differential amplifier input, a gain of 9720, and a six-pole low-pass filter at FC = 10 Hz. For this amplifier, pin D serves as the positive input and pin B as the negative. By matching LH0044ACH differential amplifiers, offset adjustment will be maintained. If insufficient range occurs in the offset adjustment, the range may be increased by replacing the range resistor (Figure 7) with one of a higher value. The thermistor serves as a feedback element in an amplifier and also has a six-pole filter at FC = 10 Hz.

Throughout the test program, the amplifiers were very reliable. Only one failure was reported. Evidence of failure first occurred on the CRT display of active tubes. Figure 8 provides a typical CRT display. On this display, failure of the LH0044ACH amplifier is indicated by either a temperature reading of 32°C or a thermistor reading of 9.999 volts.

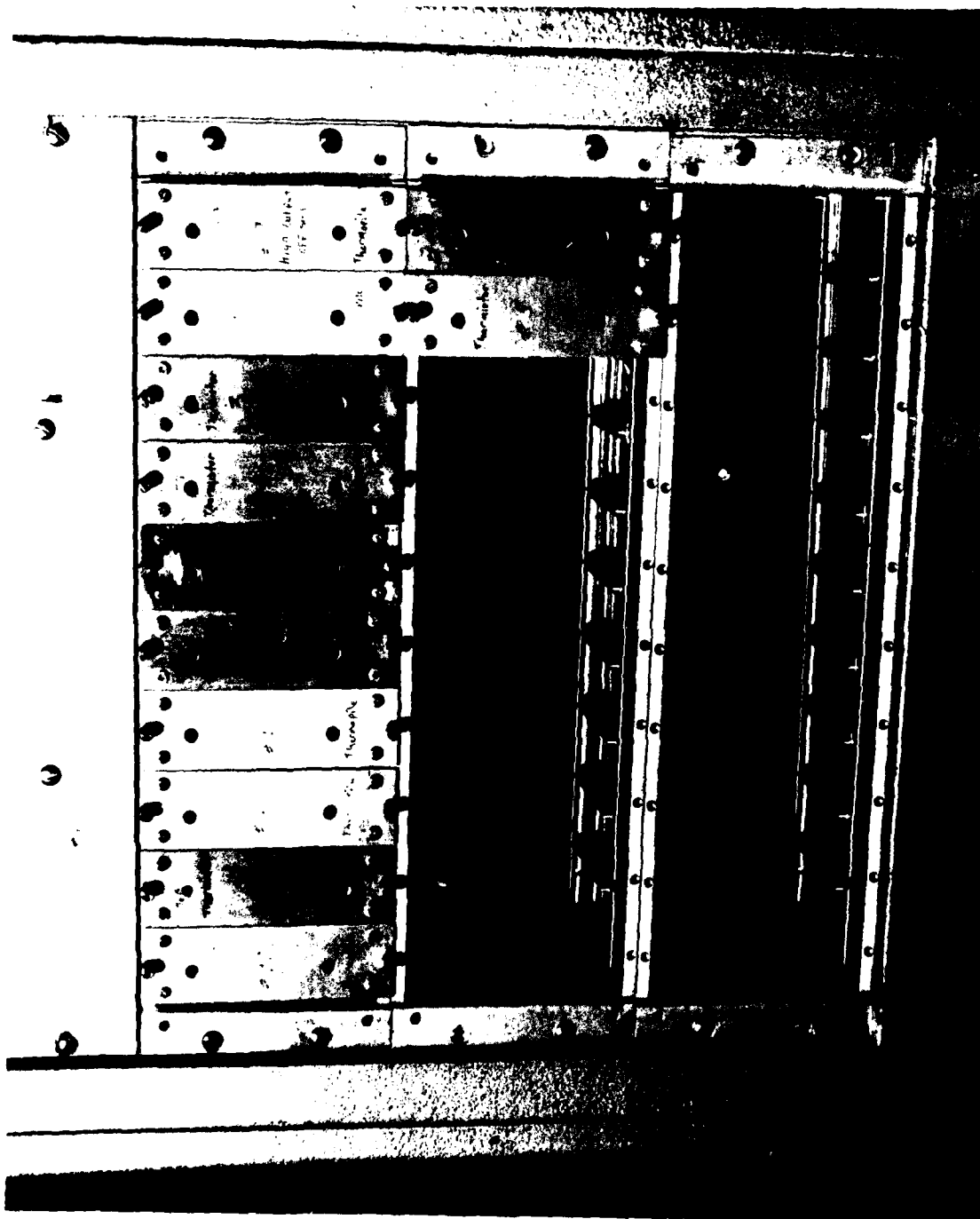


FIGURE 3. AMPLIFIER RACK

NCSC TM 296-80

TABLE 1

AMPLIFIER OUTPUT TO COMPUTER ANALOG PANEL

Amplifier No.	Pin No.	Cable Color	Terminal Strip No.	Terminal No.	Computer Function	
1	H	GRN	J9	5	GND	Shields of All Cable Pairs Connect to Pin 8 of J6-J9 or HQG
	F	BRN	J9	7	AD 01	
	M	GRN	J9	5	GND	
	N	ORG	J9	6	AD 00	
2	H	GRN	J9	5	GND	
	F	YEL	J9	10	AD 03	
	M	GRN	J9	5	GND	
	N	BLU	J9	9	AD 02	
3	H	WH	J8	5	GND	
	F	BRN	J8	7	AD 05	
	M	WH	J8	5	GND	
	N	YEL	J8	6	AD 04	
4	H	WH	J8	5	GND	
	F	BLK	J8	10	AD 07	
	M	BLK	J8	5	GND	
	N	ORG	J8	9	AD 06	
5	H	GRN	J7	5	GND	
	F	WH	J7	7	AD 11	
	M	GRN	J7	5	GND	
	N	BLK	J7	6	AD 10	
6	H	BLK	J7	5	GND	
	F	YEL	J7	10	AD 13	
	M	BLK	J7	5	GND	
	N	BRN	J7	9	AD 12	
7	H	RED	J6	5	GND	
	F	WH	J6	7	AD 15	
	M	RED	J6	5	GND	
	N	BLK	J6	6	AD 14	
8	H	WH	J6	5	GND	
	F	ORG	J6	10	AD 17	
	M	YEL	J6	5	GND	
	N	BLU	J6	9	AD 16	
9	H	RED		RTN	GND	
	F	GRN		21	AD 21	
	M	RED		RTN	GND	
	N	BLK		20	AD 20	
10	H	RED		RTN	GND	
	F	YEL		23	AD 23	
	M	BLK		RTN	GND	
	N	WH		22	AD 22	
11	H	BLU		RTN	GND	
	F	ORG		25	AD 25	
	M	BRN		RTN	GND	
	N	YEL		24	AD 24	
12	H	RED		RTN	GND	
	F	BRN		27	AD 27	
	M	BLU		RTN	GND	
	N	BLK		26	AD 26	

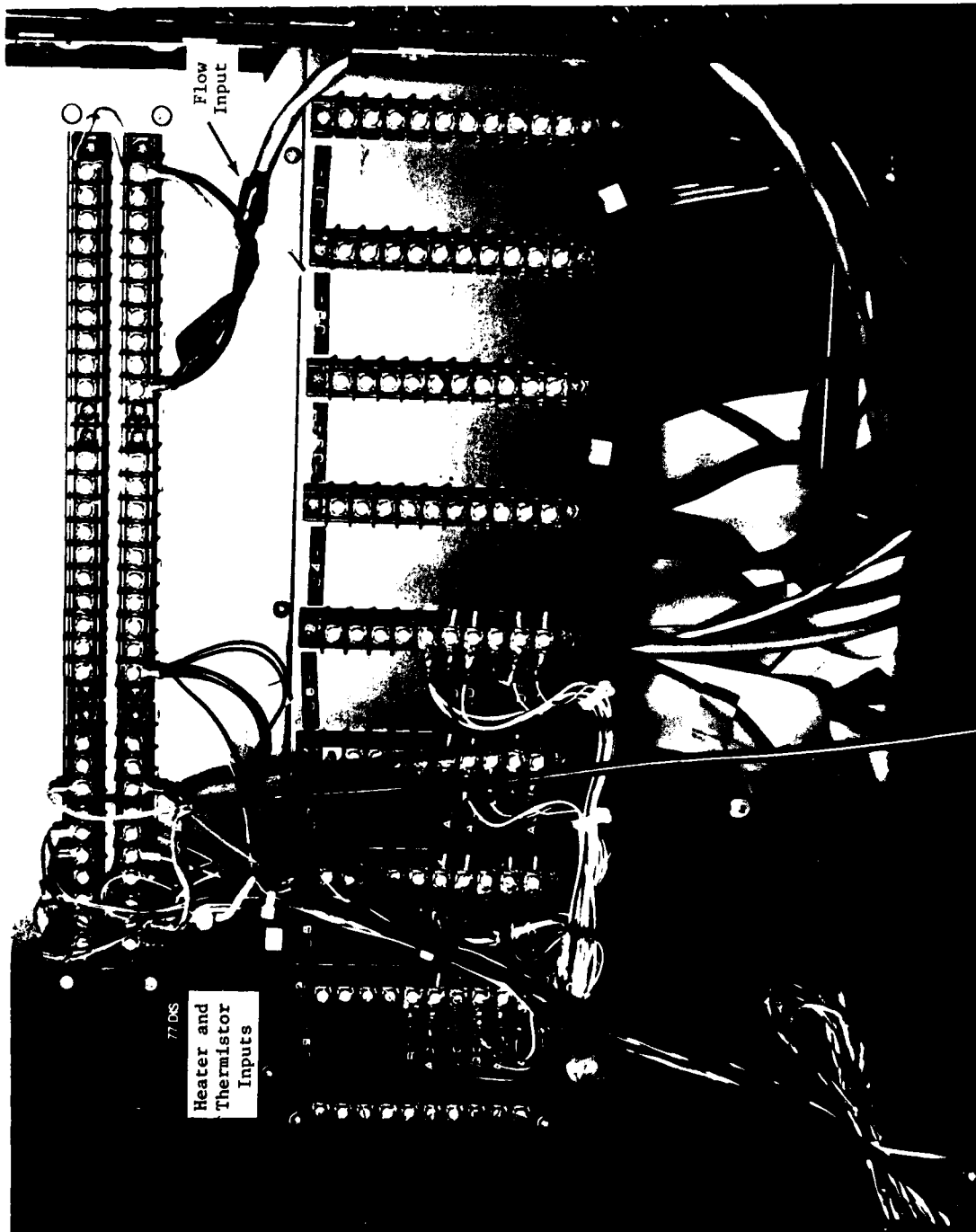


FIGURE 4. ANALOG PANEL

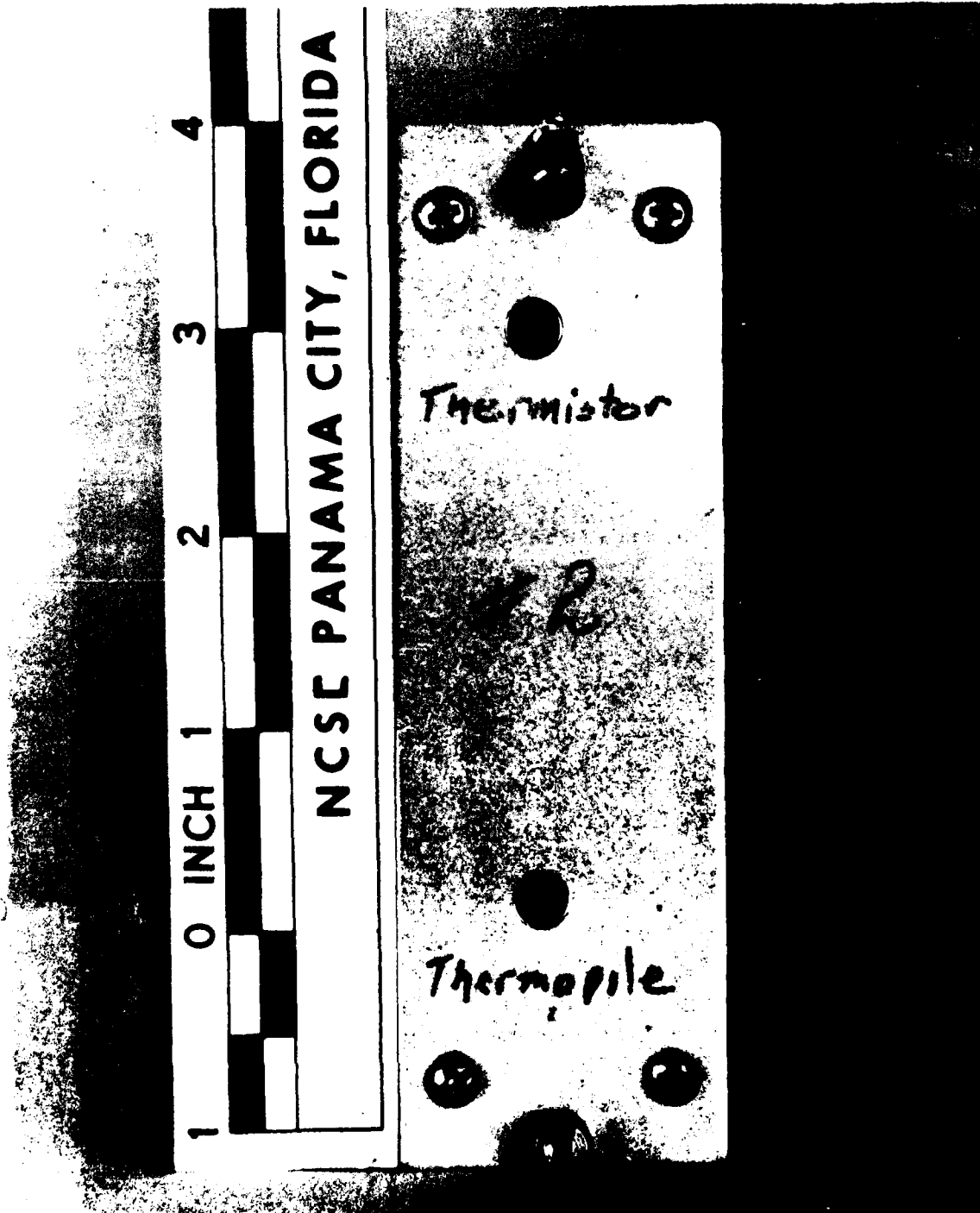


FIGURE 5. AMPLIFIER MODIFICATION

TABLE 2
AMPLIFIER INPUT CONNECTIONS

HTU Pin No.	Cable No.	Wire Color	Amplifier Pin. No.	Function
F	1	Black	B	Thermopile
B	1	White	D	
D	1	Shield	C	
C	2	Black	J	Thermistor
E	2	White	L	
-	2	Shield	K	

FLOWMETERS

The Clampitron flowmeter (Controlatron Corporation Model #242N-10) has a 10-channel capability (Figure 9). These are sonic flowmeters using parallax measurements for flow measurement. Each transducer uses two coaxial cables which may be any length under 300 feet provided the cables are matched within 10 pF impedance.

In order to minimize bubbles and stabilize flow, flowmeters should be attached in a 4 to 6 foot length of pipe. Bubbles and/or particles will increase noise at the computer. Transducers should be firmly seated as described in the manual.

The flowmeter multiplexer is connected to the computer digital output bits according to Table 3.

The computer to flowmeter control panel is seen in Figure 10. An analog output is read at the computer with a 0 to 10 volt output corresponding to 0 to 20 gpm flow.

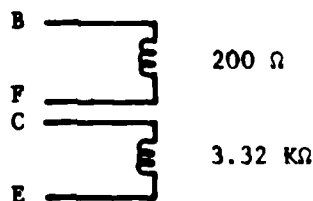


FIGURE 6. AMPLIFIER TEST JACK

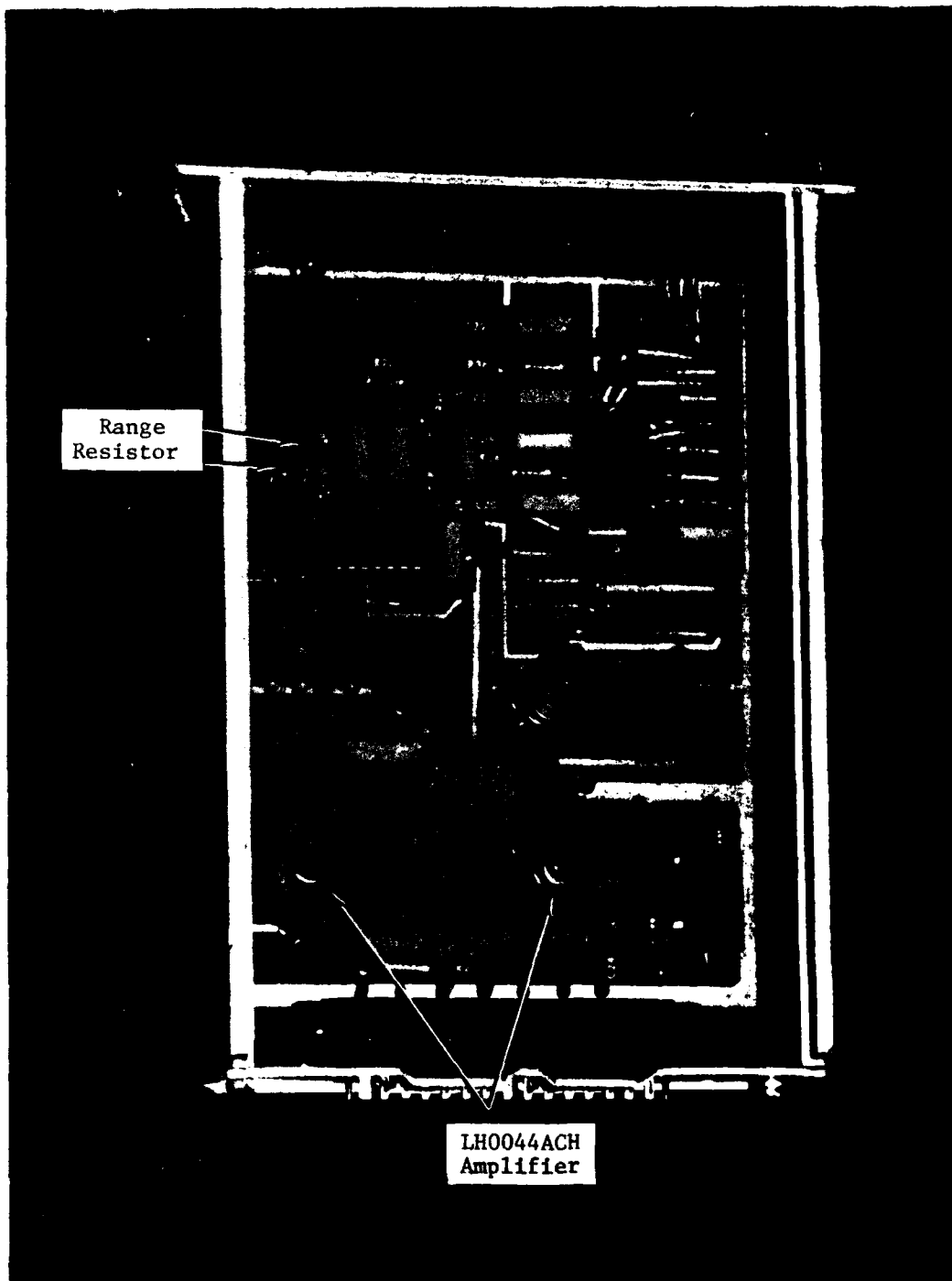


FIGURE 7. AMPLIFIER CARD

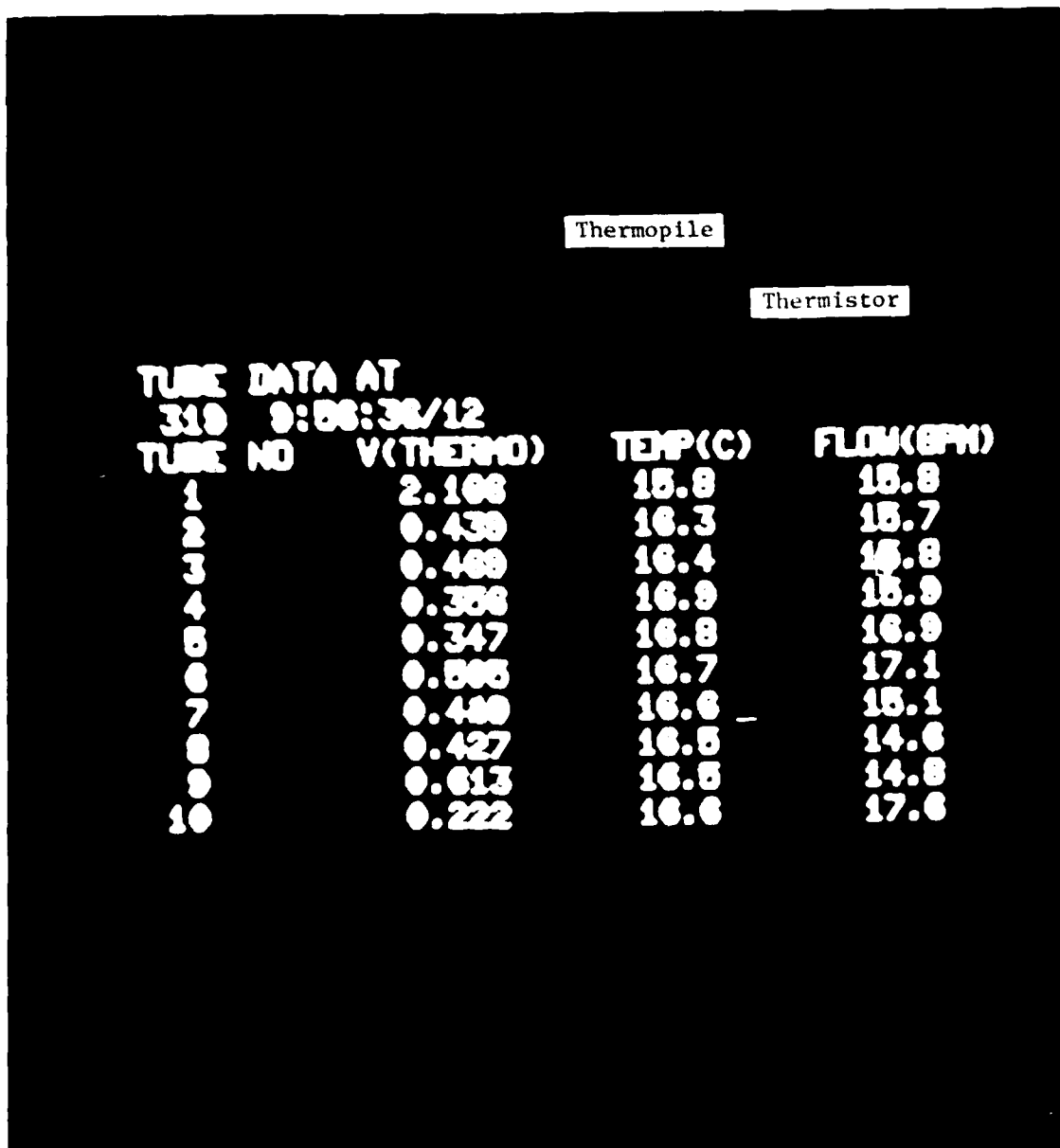


FIGURE 8. CRT DATA DISPLAY

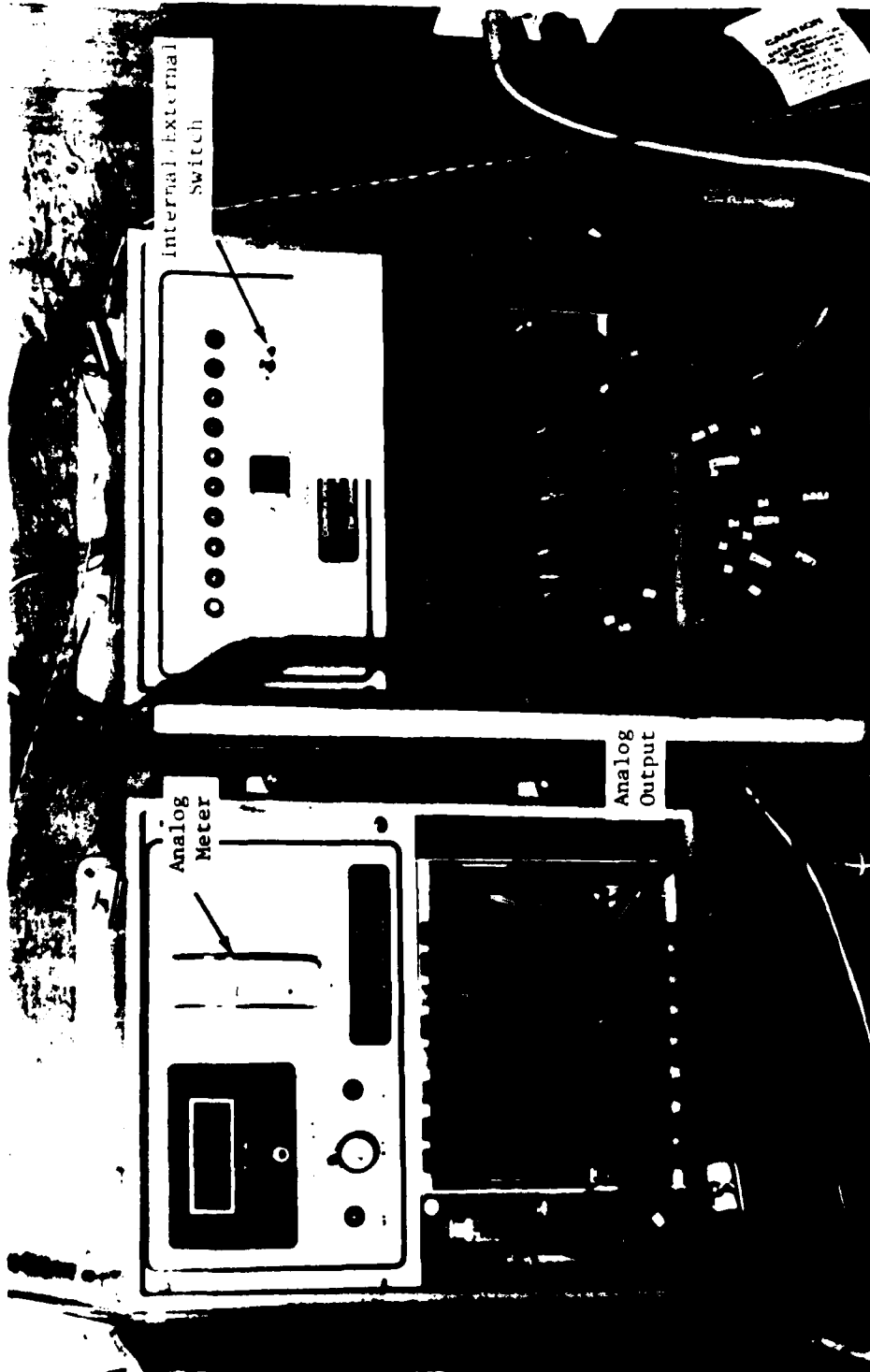


FIGURE 9. FLOWMETER WITH MULTIPLEXER

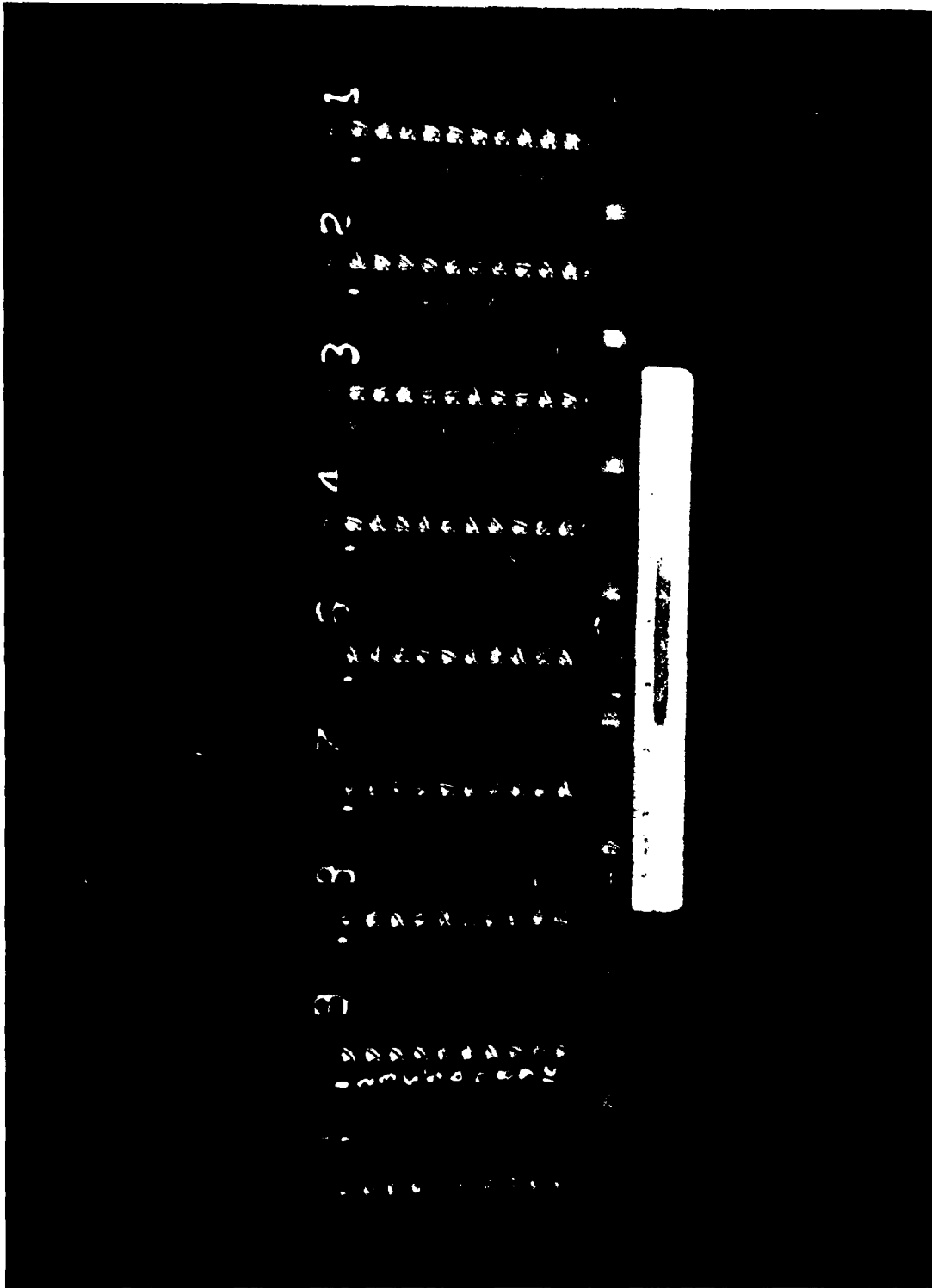


FIGURE 10. COMPUTER TO FLOWMETER CONTROL PANEL

TABLE 3

MULTIPLEXER CONNECTIONS TO COMPUTER DIGITAL OUTPUT BITS

Computer Function	Terminal Strip No.	Terminal No.	Cable Color	Flowmeter Function
OU11	2	10	Blue	Address Bit 1
OU12	2	4	Brown	Address Bit 2
OU13	2	3	Green	Address Bit 3
OU14	1	9	White	Address Bit 4
GND	2	8	Red	GND
GND	2	8	Black	GND

The multiplexer channel select is a modification of the standard unit. Appendix B is a schematic of this modification. Channel selection can be controlled manually or by the computer. An external setting of the function switch allows manual selection of channels. An internal setting of the function switch places the multiplexer under computer control.

Prior to use, each transducer and its input board is zeroed. In order to zero the transducer, there must be water in the pipe with no flow. The zero pot is adjusted (Figure 11) on the appropriate input board. It should be noted that the external scale on the input board is used for flow measurement. The internal scale (Figure 11) which utilizes a factory calibration was typically 84 percent of true flow.

The analog output from the multiplexer is filtered to reduce noise. A two-pole Butterworth filter with a cutoff frequency of 0.5 kHz is used for this purpose. The schematic is shown in Figure 12.

If fault readings occur during a data analysis, the program must be halted so that adjustments can be made to flowmeter stability. Stability is adjusted using the stability pot (Figure 11) located on the individual flowmeter card. The pot should be adjusted clockwise until a fault reading appears. It should then be adjusted counterclockwise as turns of the pot are counted until the fault reading reoccurs. To ensure stability mid-range, additional adjustment clockwise one-half the value of turns is needed between successive erroneous readings.

The flowmeter system has experienced failure in two areas: (1) in the flowmeter internal power supply and (2) in the transducer seating compound. In either case, a sharp increase in flow standard deviation indicated failure. Also, it should be noted that a high flow standard deviation may mean that air is being pumped by the sea water supply pumps; i.e., bubbles, or that fouling exists in the flow measurement section of piping; i.e., reflections thus noise.



FIGURE 11. FLOWMETER CARD

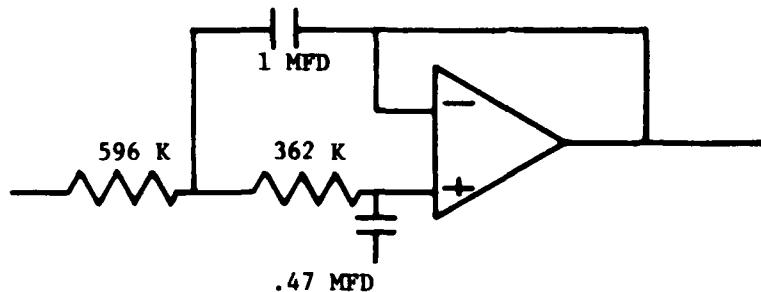


FIGURE 12. NOISE SUPPRESSION FILTER FOR FLOW MEASUREMENT

Transducer cables are extremely susceptible to cross-talk. Therefore, each set of transducer cables must be shielded from this problem. A good expedient is well grounded 1/2 inch conduit.

The temperature monitor has been extremely reliable with no failures due to electronics. With the data obtained, direct correlations of R_f versus ambient air temperature will be made.

Failure of the transducer seating compound may also be indicated by sharp deflection of the analog meter during computer switching between flow-meter channels.

TEMPERATURE MEASUREMENT

During the course of the investigation, there was some indication that certain heat transfer monitors were reacting to changes in ambient temperature. In order to address this potential problem, air temperature monitoring was initiated.

Figure 13 presents a schematic of this temperature measuring system. It utilizes a new and very accurate temperature transducer (AD 581) manufactured by Analog Devices. The sensor is a constant current regulator passing a current proportional to absolute temperature ($1 \mu\text{A}/^\circ\text{K}$). Signal conditioning converts this into degrees Celsius for display and for computer inputs.

Both ambient (outside air) temperature and inside air (electronics shack) temperature are monitored. Interconnection of the temperature monitor to the computer is provided in Table 4.

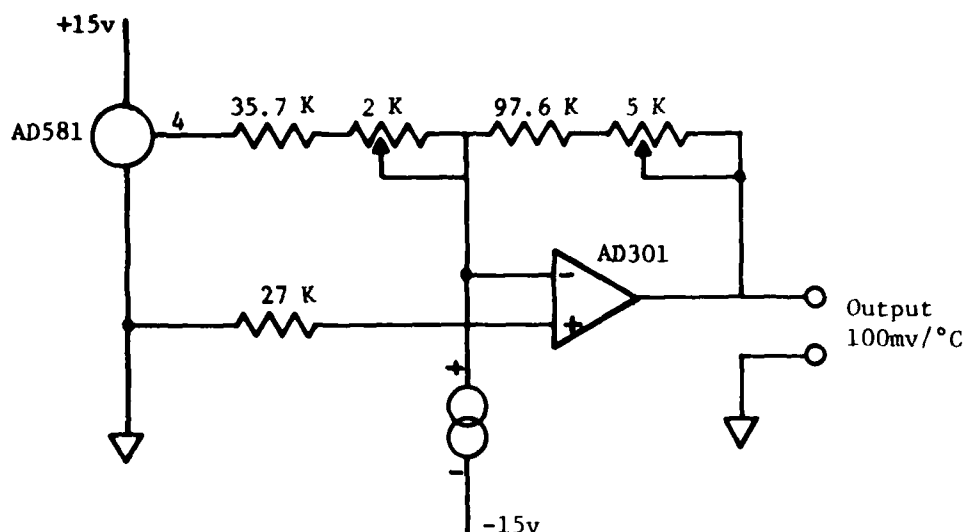


FIGURE 13. TEMPERATURE MEASURING CIRCUIT

HEATERS

Fore and aft views of the heater control (VARIAC) rack are seen as Figures 14 and 15. A detailed wiring schematic is attached as Appendix C.

Heater function is controlled by a digital on-off bit set by the computer. Table 5 provides the interconnection between the computer and heater control panel.

TABLE 4

INTERCONNECTION OF TEMPERATURE MONITOR TO COMPUTER

Monitor	Decimal Channel	OCTAL Channel
Outside Air	26	32
Inside Air	27	33

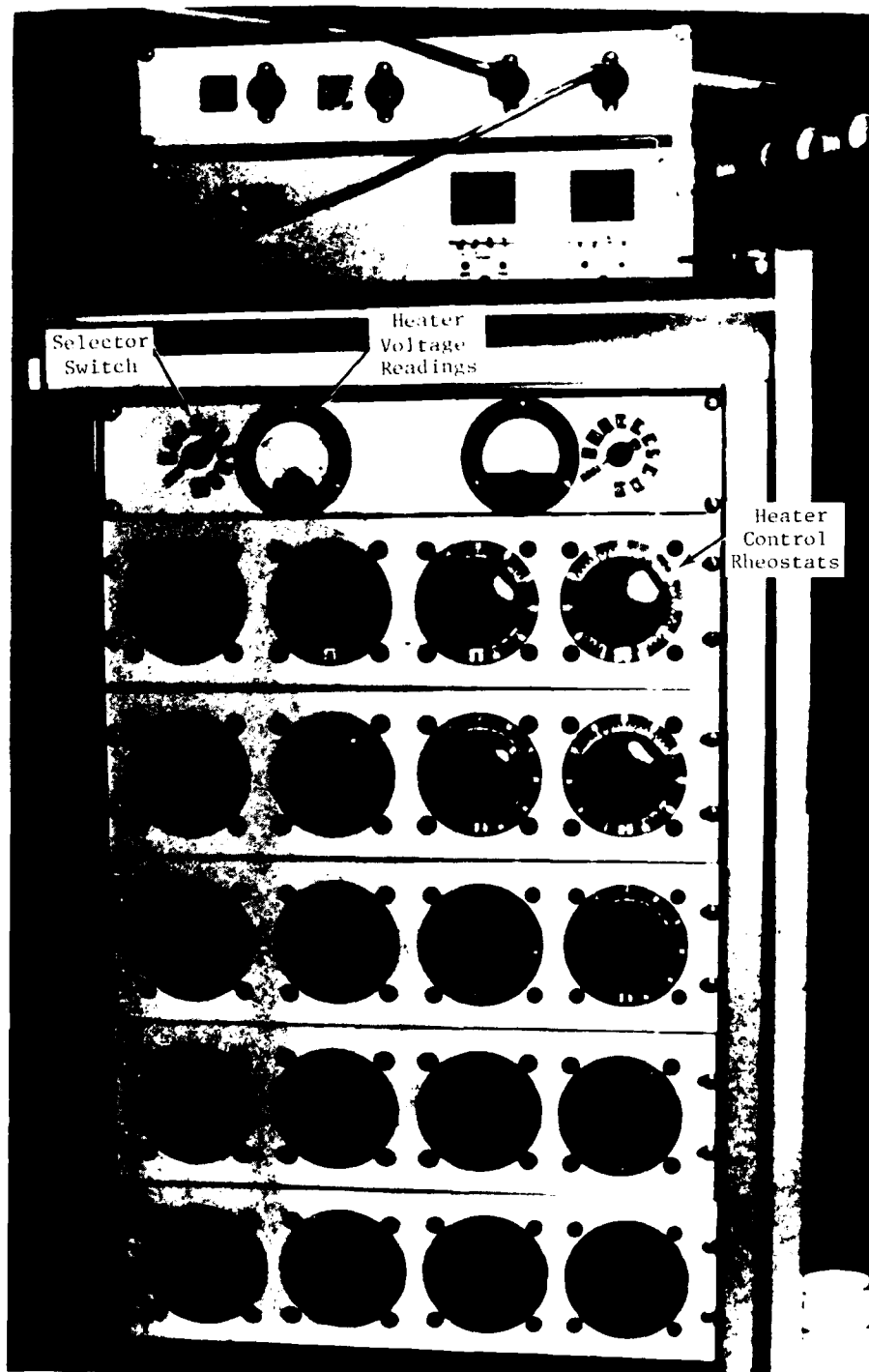


FIGURE 14. FRONTAL - VARIAC RACK

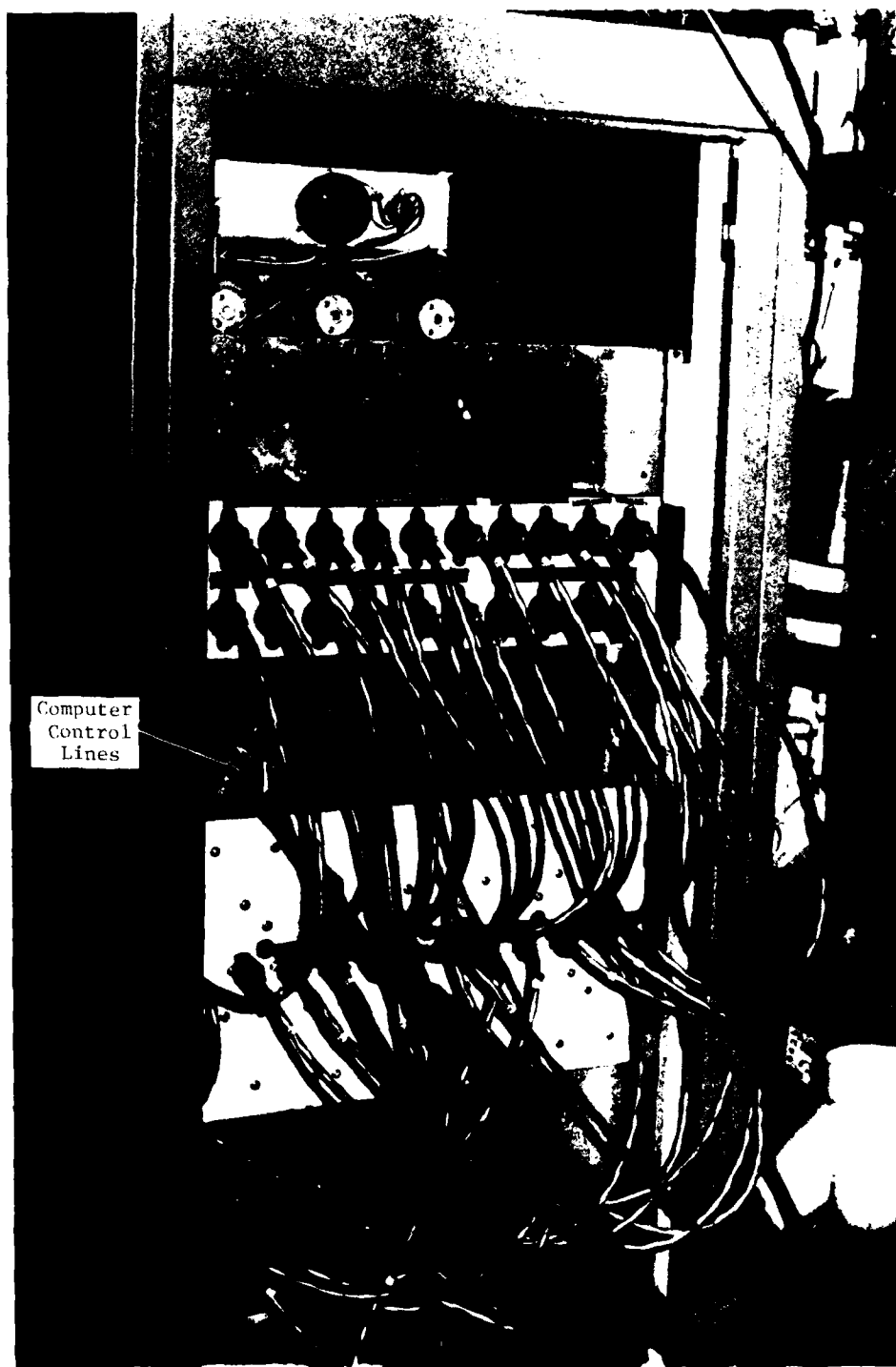


FIGURE 15. REVERSE - VARIAC RACK

TABLE 5

OUTPUT CONTROL LINES FROM COMPUTER TO HEATER CONTROL

Computer Function	Terminal Strip No.	Terminal No.	Cable Color	Rack Connector Pin	Variac No.	Monitor No.	Line Plug No.	Heater No.
OU00	4	7	Blue	A	1	1	2	2
OU01	3	6	Brown	B	2	2	2	2
OU02	3	2	Red	C	3	3	2	3
OU03	2	6	Black	D	4	4	2	4
OU04	4	8	Orange	E	5	5	2	5
OU05	3	5	Yellow	F	6	6	2	6
OU06	3	8	Green	H	7	7	2	7
OU07	2	5	White (Br)	J	8	8	2	8
OU08	2	7	White (Gry)	K	9	9	1	9
OU09	1	5	White (Bl)	L	10	10	1	10
OU10	1	8	White (Yd)	M	11	12	1	11
			Gray	N	12	12	1	12
GND	3	7	White (R)					
GND	3	7	White (Bk)	R				
GND	3	7	White (Or)	R				
GND	3	7	White	R				
GND	3	7	Purple	R				
GND	3	7	White (P)	R				
			White (Gr)					
					12	12	3	12
					13	13	3	13
					14	14	3	14
					15	15	3	15
					16	16	3	16
					17	17	3	17
					18	18	3	18
					19	19	3	19
					20	20	3	20

NOTE: Terminal strips 6-9 contain the second digital output word.
Connections on 6-9 are identical to connections on 1-4, respectively.

Connection of the heater control rack to individual heat transfer units is made through a three-pin amphenol connector in accordance with Table 6.

Once all connections have been made, each VARIAC must be set to obtain the desired temperature rise for each thermopile. This can best be accomplished through the computer after temperature stabilizes. A target thermopile range of 8.5 to 9 volts is desirable. Excessive or prolonged temperature rises should be prevented or they may seriously affect heater performance in HTUs.

TABLE 6

INTERCONNECTION OF HEATER CONTROLS TO HEAT TRANSFER UNITS

Variac Rack Output Jack	Cable Color	HTU Pin No.	Function
Key pin	Black	A	+ VDC
Center pin	Shield	-	
Parallel pin	White	C	- VDC

When an HTU is activated, the digital cable from the computer drives solid state relays through SN7406 inverter integrated circuits (IC) to turn on AC lines. AC voltage is rectified (to reduce eddy current corrosion) as inputs into HTU heater elements.

These units are highly reliable requiring no maintenance. Prevention of heater deterioration due to flow is accomplished by a pressure switch (Model S-1004-1, Fluid Services, Inc.) on the sea water distribution header. This switch is wired back to the 5-volt power supply on the solid state relays and disconnects all heaters during pump failures.

BRUSH CONTROL

Brush control is provided by a timing element set with binary switches located on the front panel (Figure 16). A normal cycle begins with reverse flow driving the brush to one end of the HTU and ends with normal flow returning the brush back to its starting point. The mechanical counter will count once per valve cycle. Valve cycling can be initiated immediately by flipping all binary switches down and immediately returning them to their original condition.

Interconnection between the timer and valves are shown in Table 7. Since valves must reverse flow by operating in opposite directions, the connection of the open (forward) and close (reverse) wires must be reversed on the second valve.

In the circuit (Appendix D), the first IC forms the oscillator and an eight-stage divider. Outputs from the second eight-stage divider are ganged together by front panel switches to the reset. After the correct count, the reset pulse turns on the reverse flip-flop and relay, causing the valves to reverse position slowly. After approximately 15 seconds, a pulse from IC #1

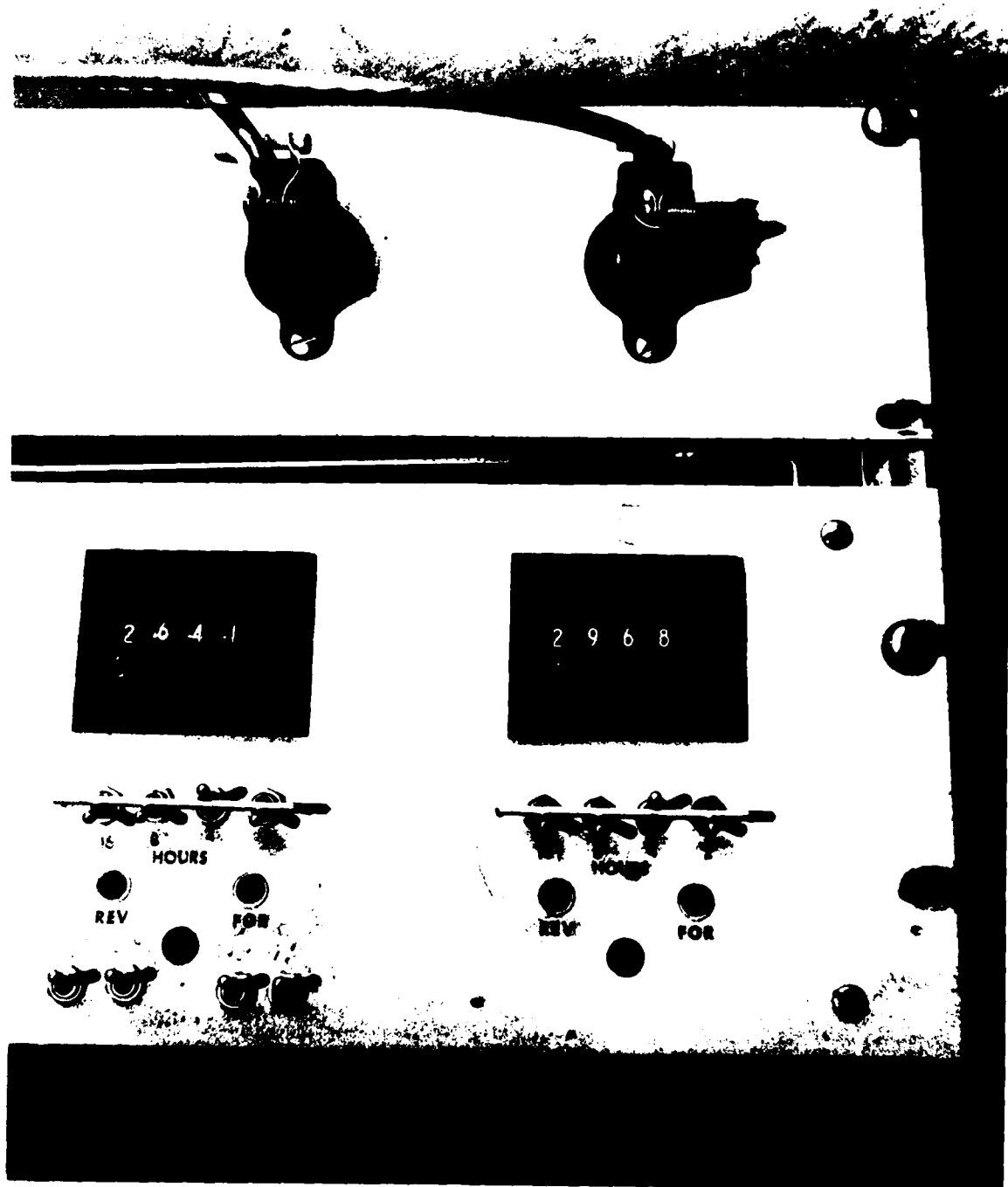


FIGURE 16. FLOW DRIVEN BRUSH CONTROL PANEL

TABLE 7

FLOW DRIVEN BRUSH TIMER TO VALVE CONNECTIONS

Timer Pin No.	Cable Color	Valve Terminal No.	Function
1	Black (GND)	N	Return
2		-	
3	Green	1	
4	White	2	
5	Red	-	
6	Black	-	

turns the reverse output off and the forward on. This returns both valves to the forward flow position. The reset pulse also increases the counter. Front panel LEDs indicate the position of relays with the blinking of the red indicating a timing operation.

Only one incidence of failure has occurred in the brush system. The limit switch within a motorized valve corroded such that no contact was made. The valve would reverse flow but not return to the normal flow position. Preventive maintenance on these sealed valves is mandatory.

BALL CONTROL

The ball control panel is shown in Figure 17 with an electrical schematic attached as Appendix E. In general, ball movement is initiated by a triggering pulse from the 555 timer. This pulse drives the DC motor to the release position. As the ball passes the optical sensor, the DC motor is reset to the catch position, counter is incremented, and the timer is reset. The ball, meanwhile, passes through the HTU and is diverted into the catch loop by a strainer. An entire cycle requires 5 to 10 seconds.

System failure is indicated by the DC motor remaining in the release position. Experience indicates this is probably due to an inoperative optical sensor. Otherwise, system electronics have been very reliable with minimal problems encountered to date.

Figure 18 is the interconnection diagram between the electronics panel and mechanical systems. Timer frequency is set to 18 Hz at pin 3 by adjusting R3 (Appendix E). Cycle position 5 will be 15 minutes for this frequency. For each position counterclockwise, cycle interval will be reduced by one half.

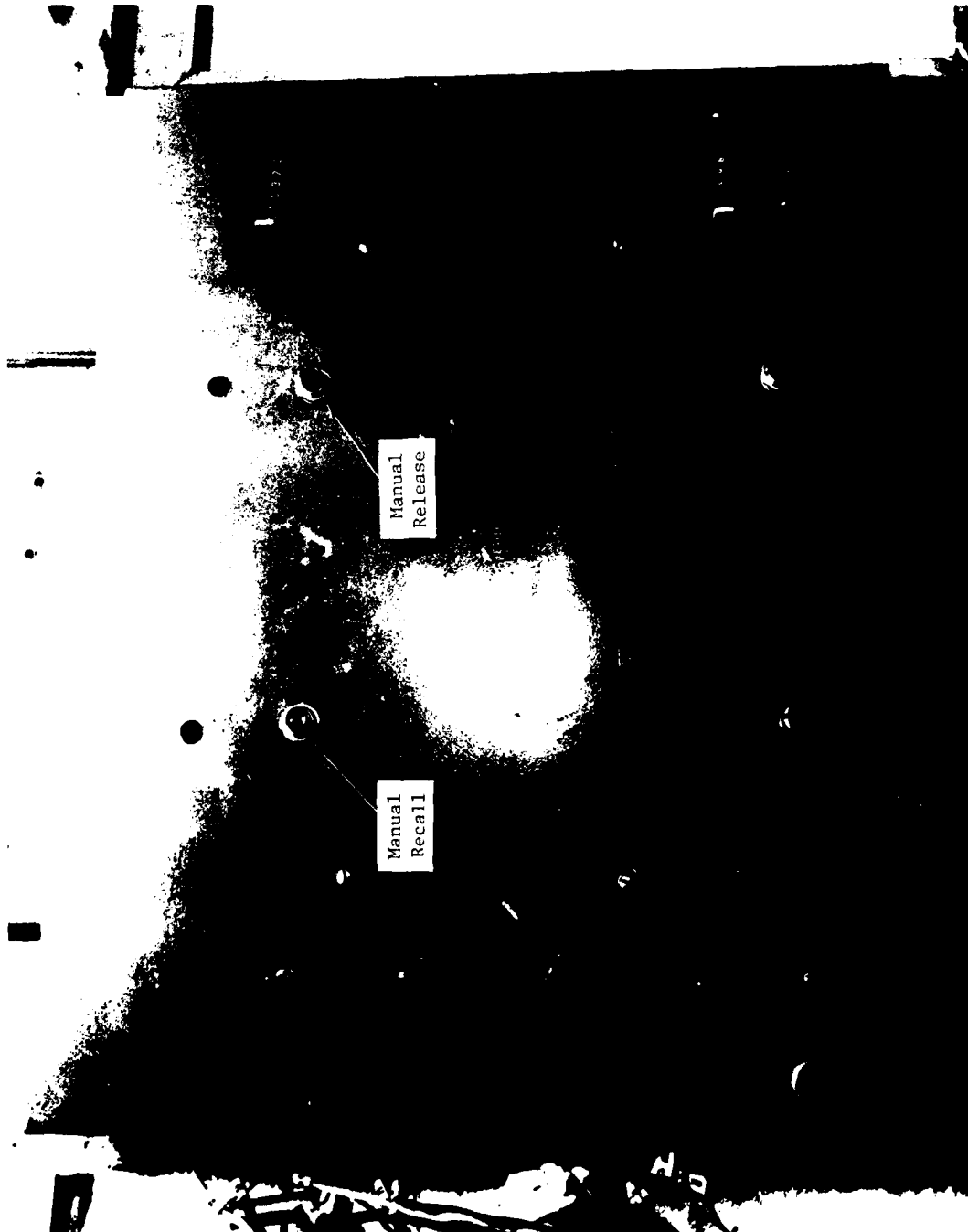


FIGURE 17. AMERTAP BALL CONTROL PANEL

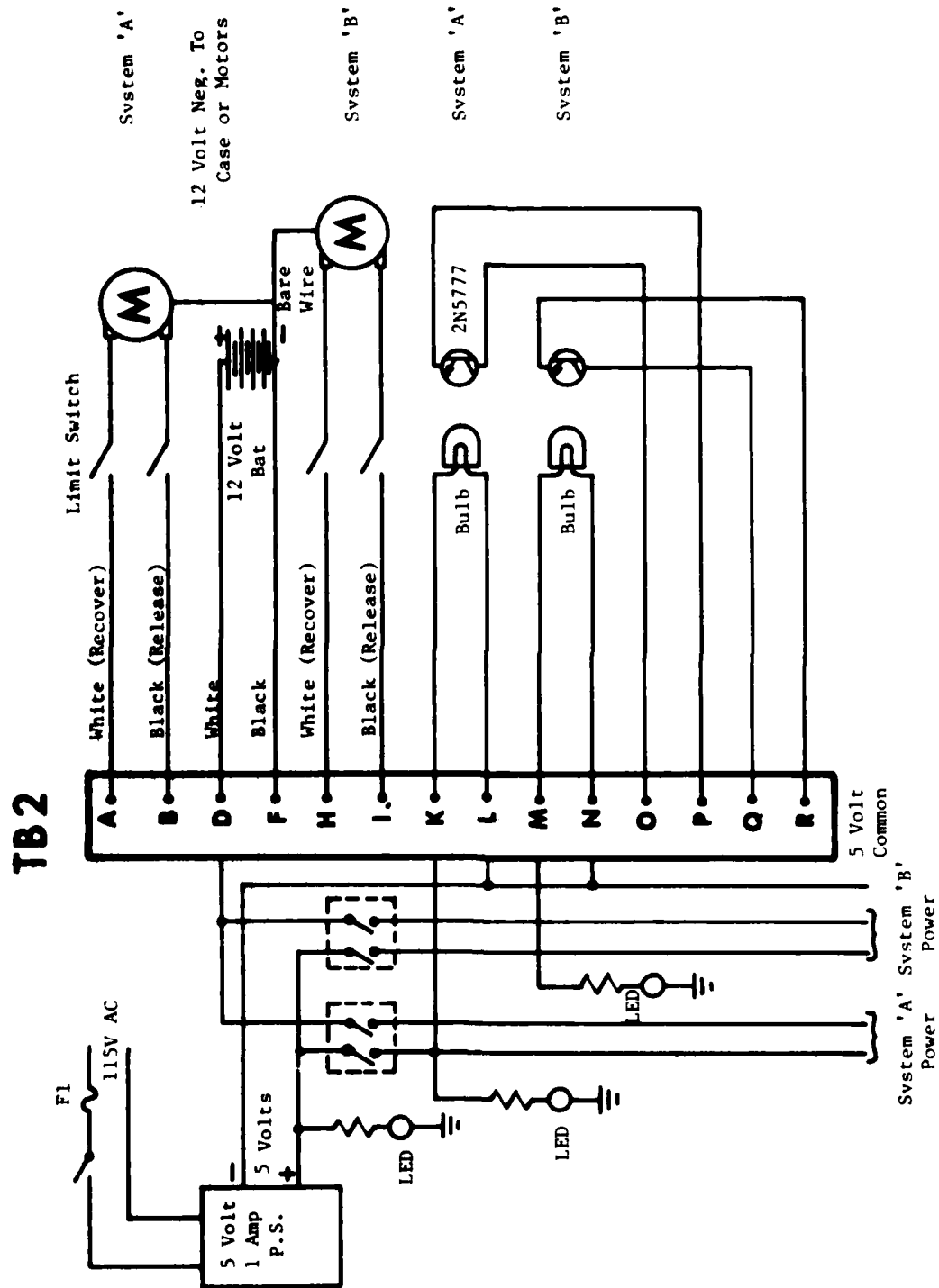


FIGURE 18. INTERCONNECTION OF RECIRCULATION SPONGE RUBBER BALL ELECTRONICS PANEL TO MECHANICALS

Daily maintenance consists of (1) cycling of the system to ensure proper operation of limit switches, DC motor, optical sensors, and electronics; (2) spraying the DC motor with a lubricant; and (3) ensuring unrestricted ball movement.

CHLORINATION

The chlorine system was originally designed to provide continuous chlorine addition into two HTU loops. Chlorine control would be through signal conditioning between the chlorine monitor and chlorine generator. Although design deficiencies, i.e., inadequate flow for two loops, have prevented utilization of the chlorine system in this manner, electrical connections have been maintained that would, using a larger power supply, allow injection of high chlorine dosages as a side stream. However, usefulness of this option to OTEC is questionable for tests on a small scale.

Figures 19 and 20 show the major components of the chlorine system. These include power supply, signal transmitter, proportion controller, chlorine analyzer (Figure 19), and chlorine generator (Figure 20). An important consideration is that this system is independent of computer control and monitoring. Interconnection between the various components is documented by Figure 21. Figure 21(a) provides interconnections for continuous chlorination while Figure 21(b) is for intermittent chlorination. Appendix F provides further data on the chlorine analyzer.

For the Panama City test site, chlorine addition has been limited to intermittent dosing. The dosage regime is variable but, in general, consists of chlorine addition for 15 minutes daily. Experience indicates that the power supply requirements for a particular chlorine dosage are a relatively narrow range of voltages. Chlorine concentration is monitored by the DPD techniques. LaMotte Chemicals water test kit (Model LP-MW, Code 6819) is a handy, simple technique for this determination.

There is no daily maintenance for this equipment. However, there is a daily operational requirement. The power supply should be set for a voltage resulting in a desired chlorine concentration. The power supply is then turned on. A chlorinated water sample is taken approximately 1 minute later (allows power supply to stabilize). Chlorine concentration is determined using the DPD technique. Power supply voltage is fine adjusted and chlorine addition continues for 15 minutes total time.

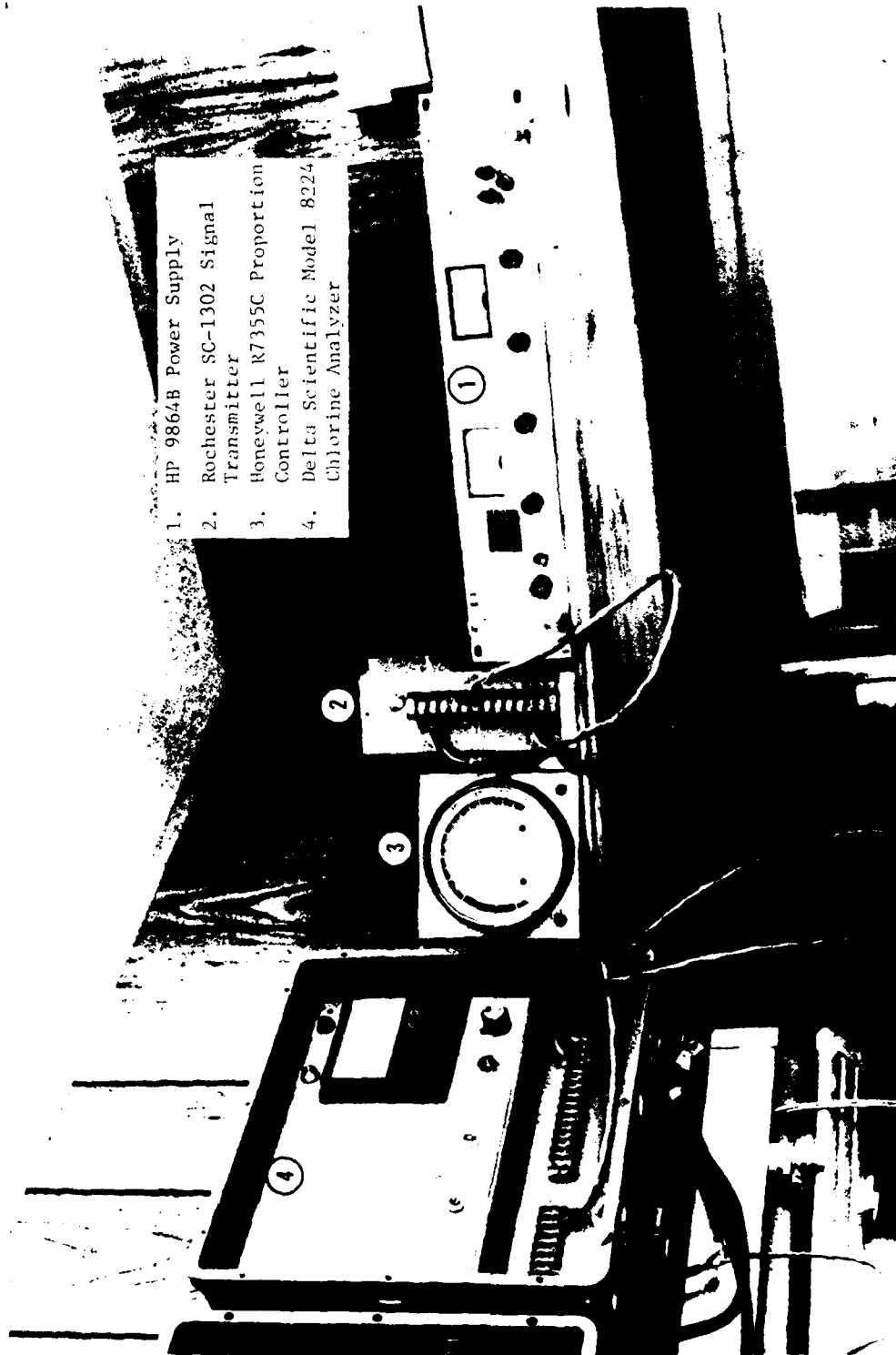


FIGURE 19. CHLORINATION SYSTEM COMPONENTS

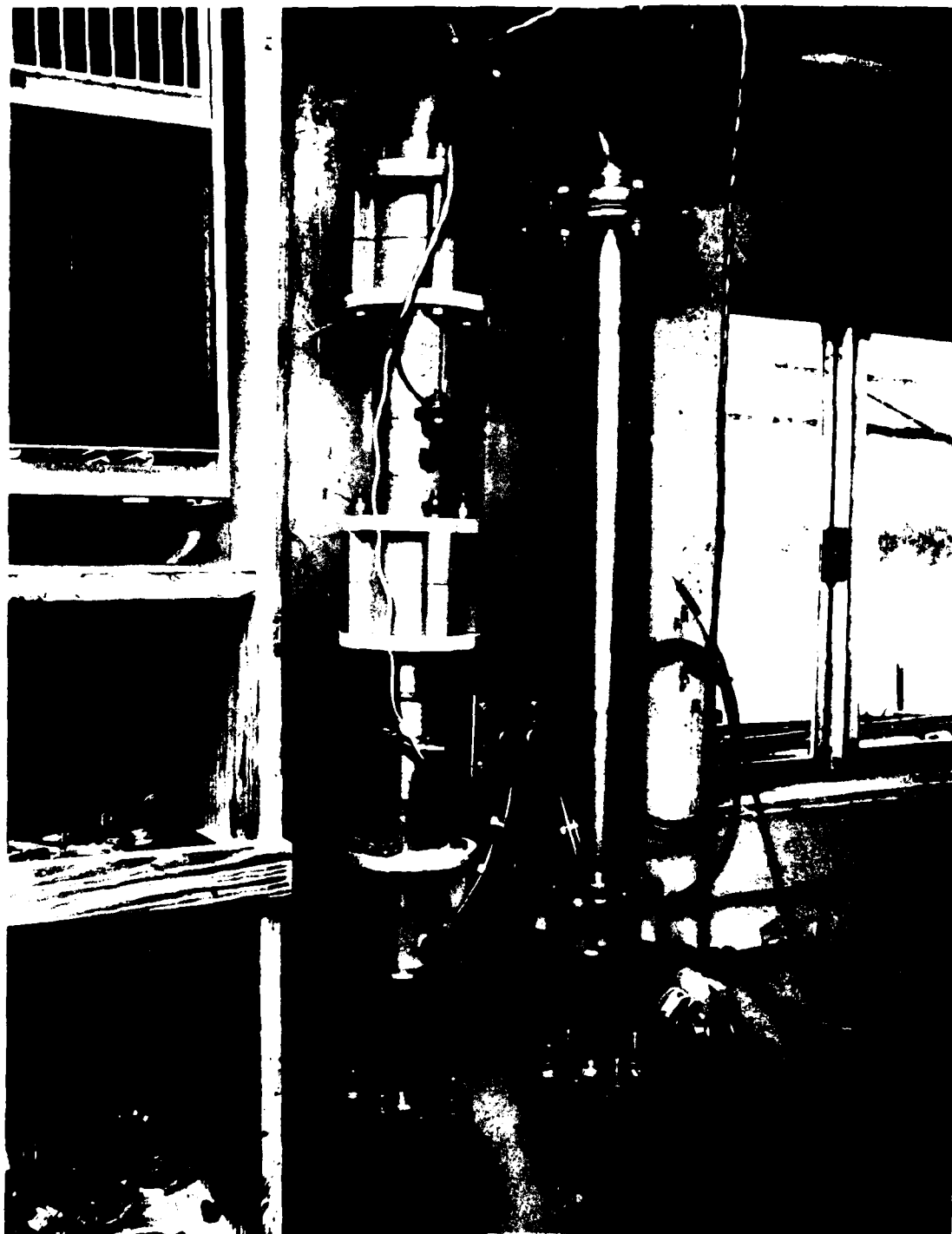
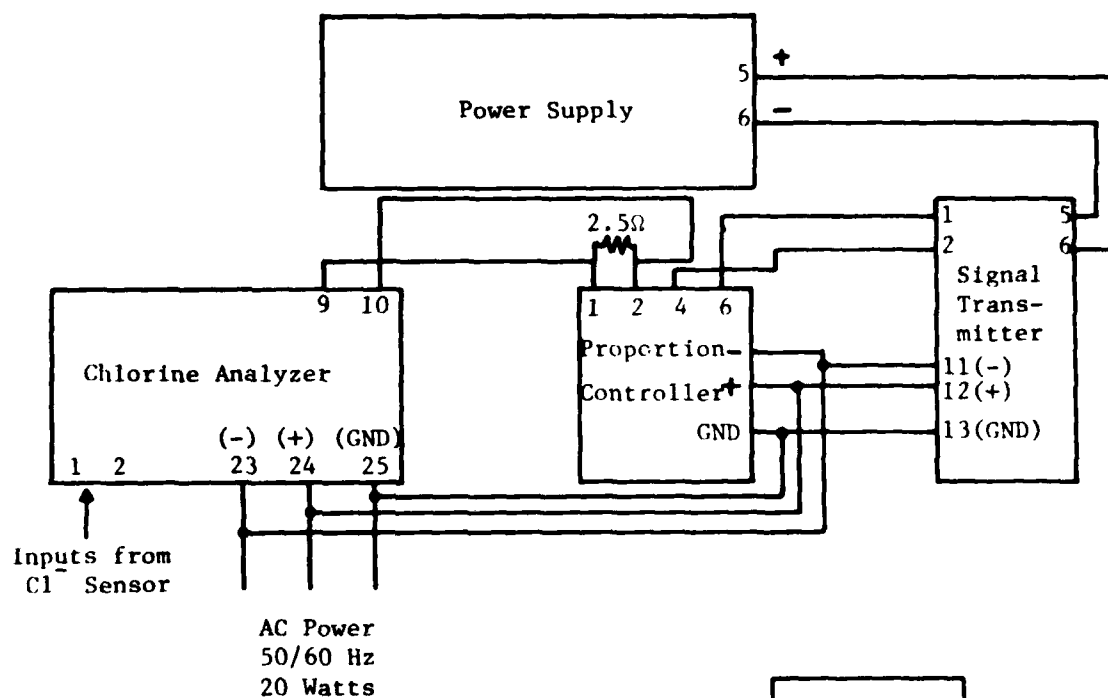


FIGURE 20. CHLORINE GENERATOR

(a) Continuous Chlorination



(b) Intermittent Chlorination

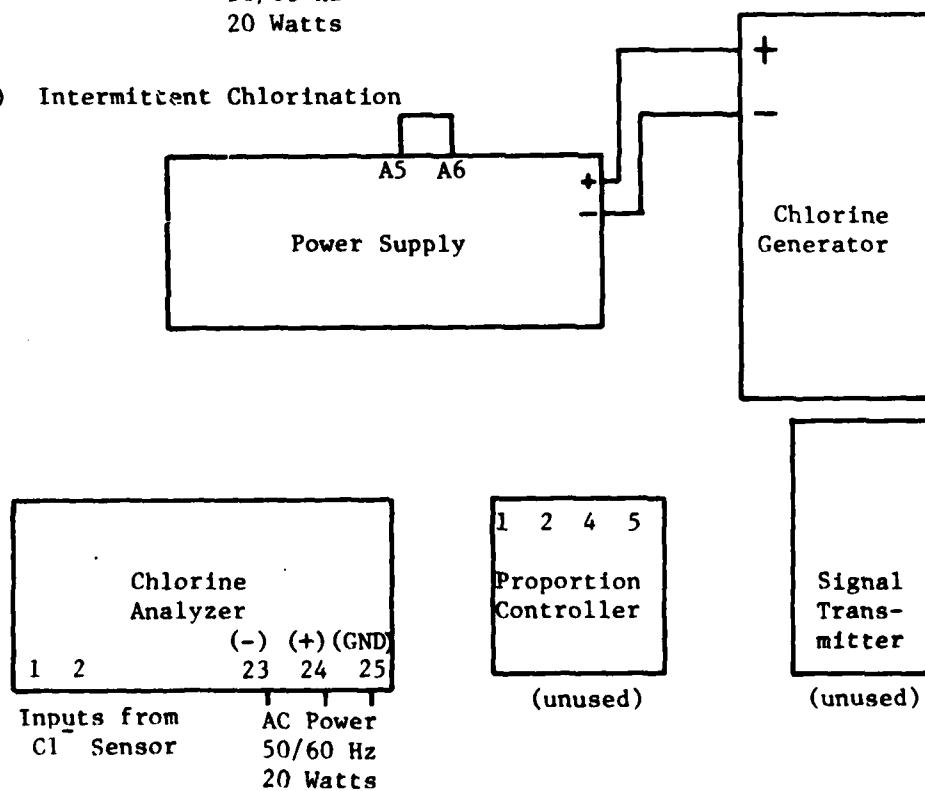


FIGURE 21. INTERCONNECTION OF CHLORINE SYSTEM COMPONENTS

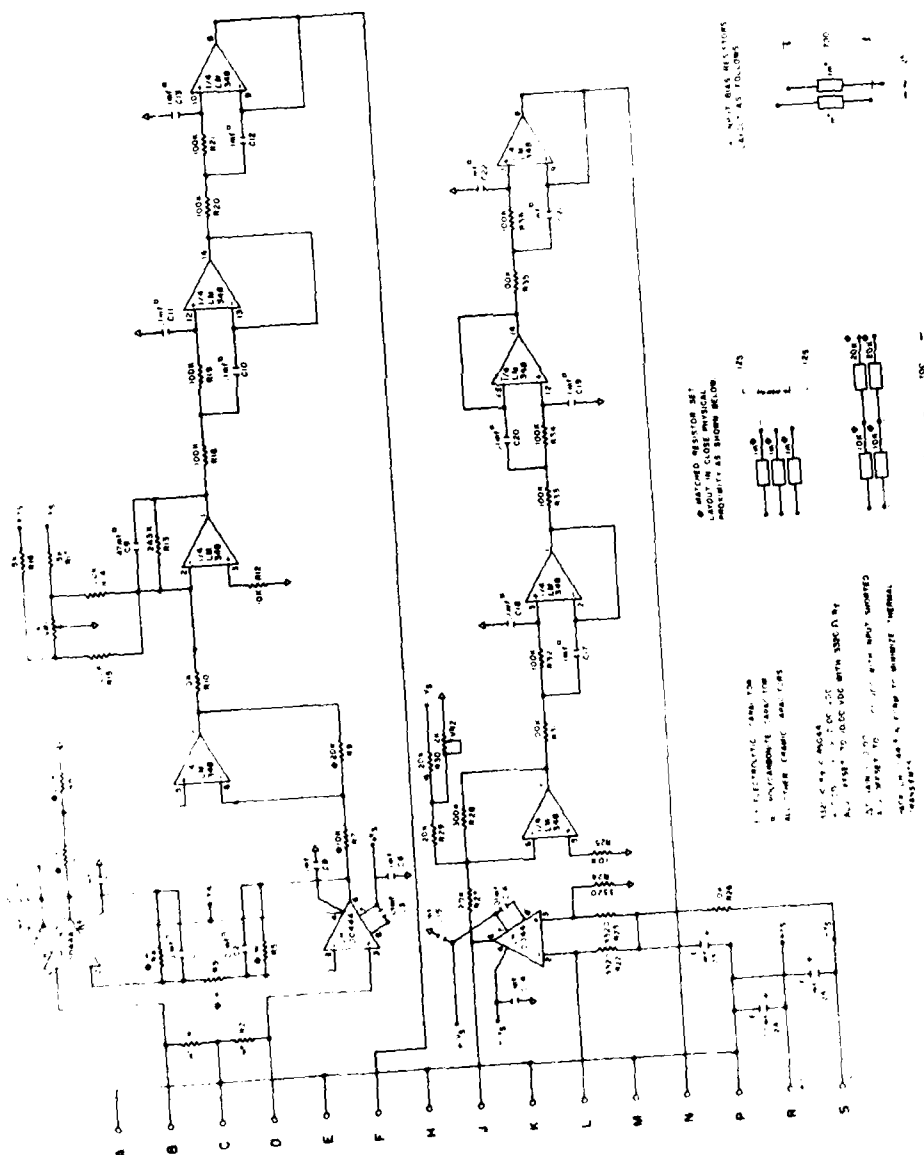
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APPENDIX A
AMPLIFIER CIRCUIT

CAPACITORS
CONDUCTORS

1011 - 1011
1011 - 1011

DATE: 5-14-68
BY: J. A. B. L.
TO: J. A. B. L.
SUBJECT: J. A. B. L.
RE: J. A. B. L.

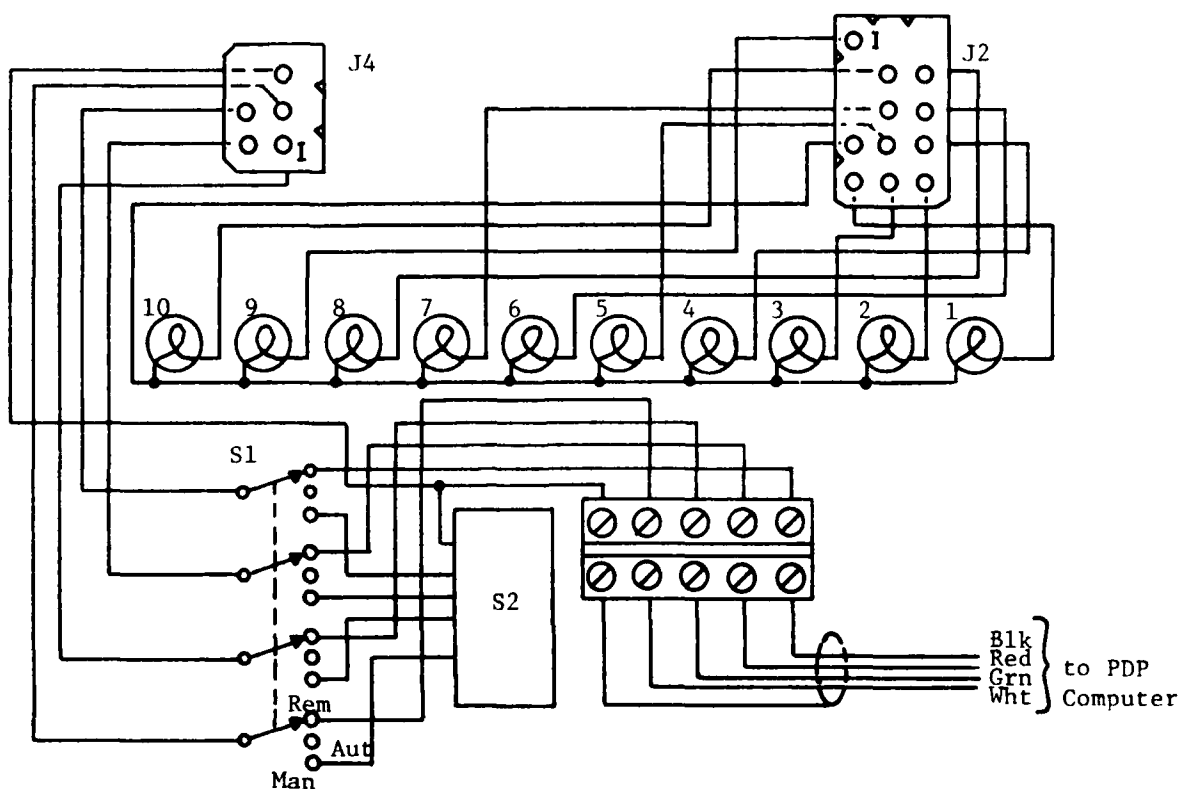


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APPENDIX B

FLOWMETER MODIFICATION

CONTROLOTRON FLOWMETER CHANNEL SELECTOR
INTERCONNECTION DIAGRAM



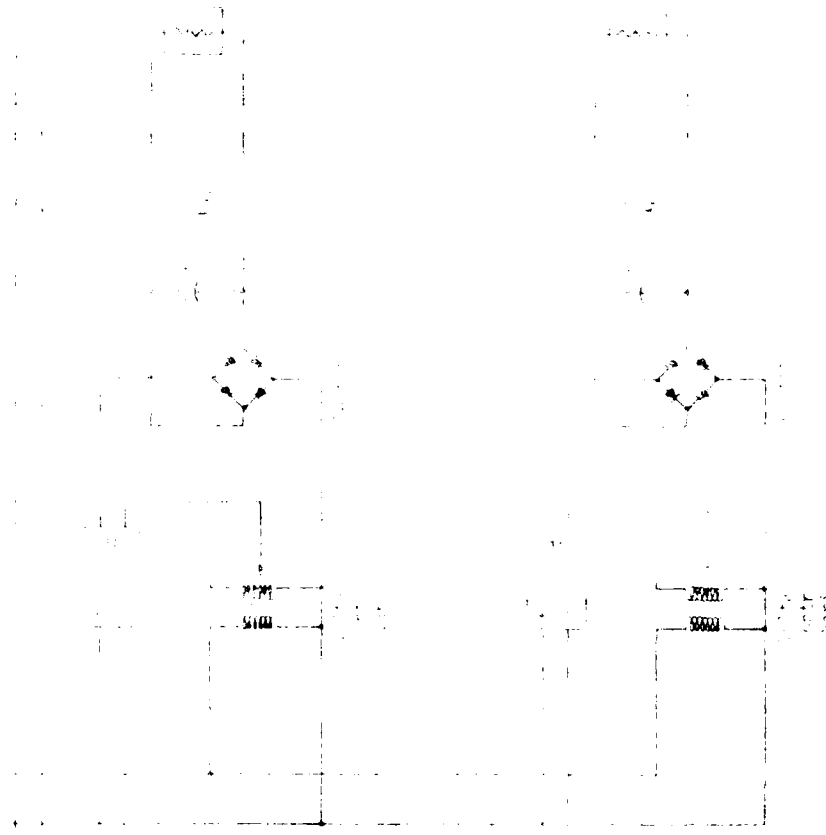
- J2 Channel Indicator Connector 242-10
- J4 Channel Selector Switch Connector 242-10
- Lamps 1-10 Channel Indicator Lamps
- S1 Remote/Manual Switch On-Off-ON
- S2 Channel Select Thumbwheel Switch Digitran Co., Mod. 8-0-330

The flowmeter modification changed from manual to computer directed stepping between flowmeter channels; therefore, allowing unsupervised continuous collection of cooling curve data.

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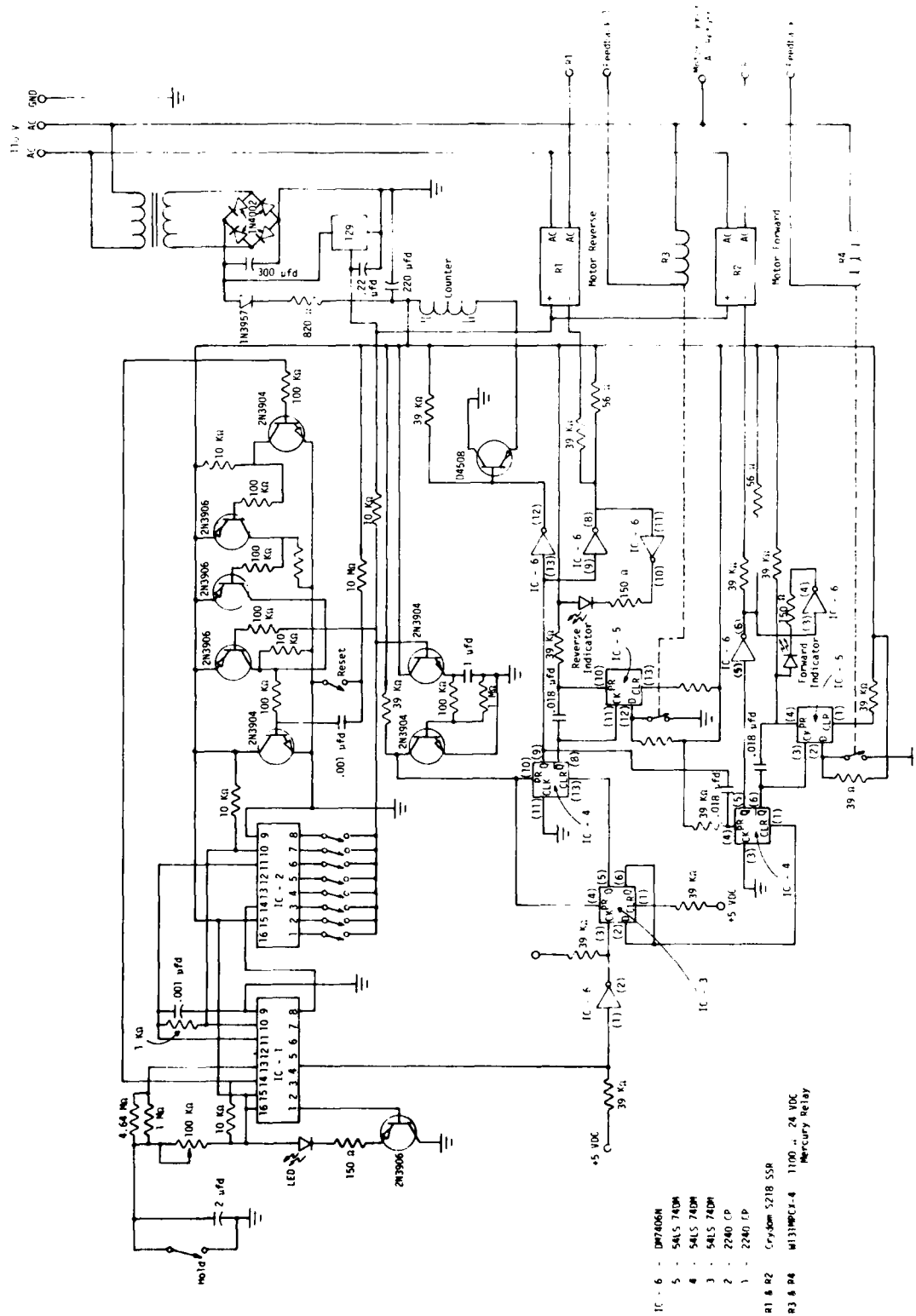
APPENDIX C
HEATER CONTROL SCHEMATIC

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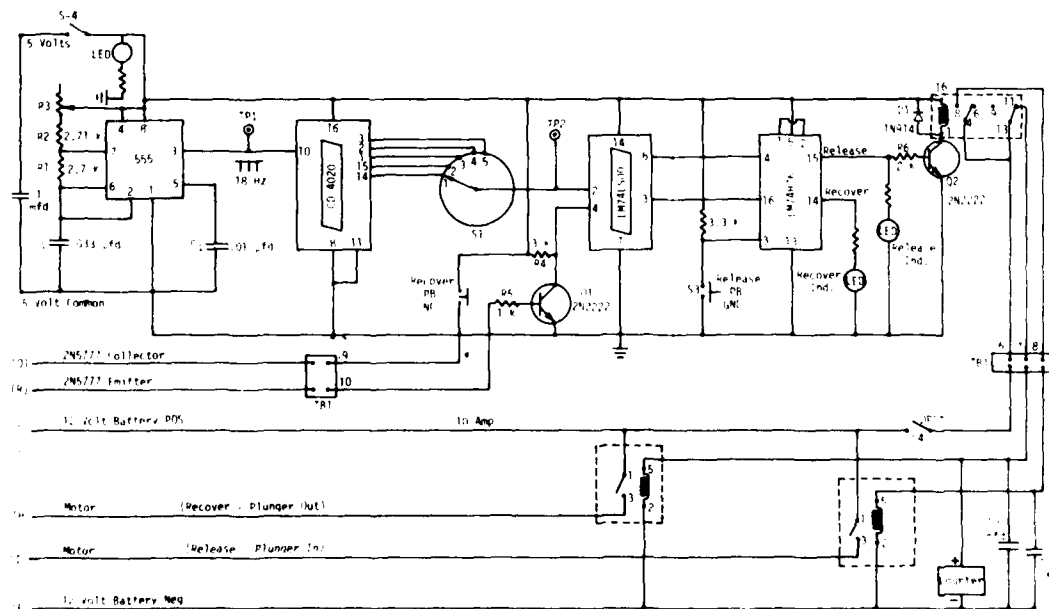
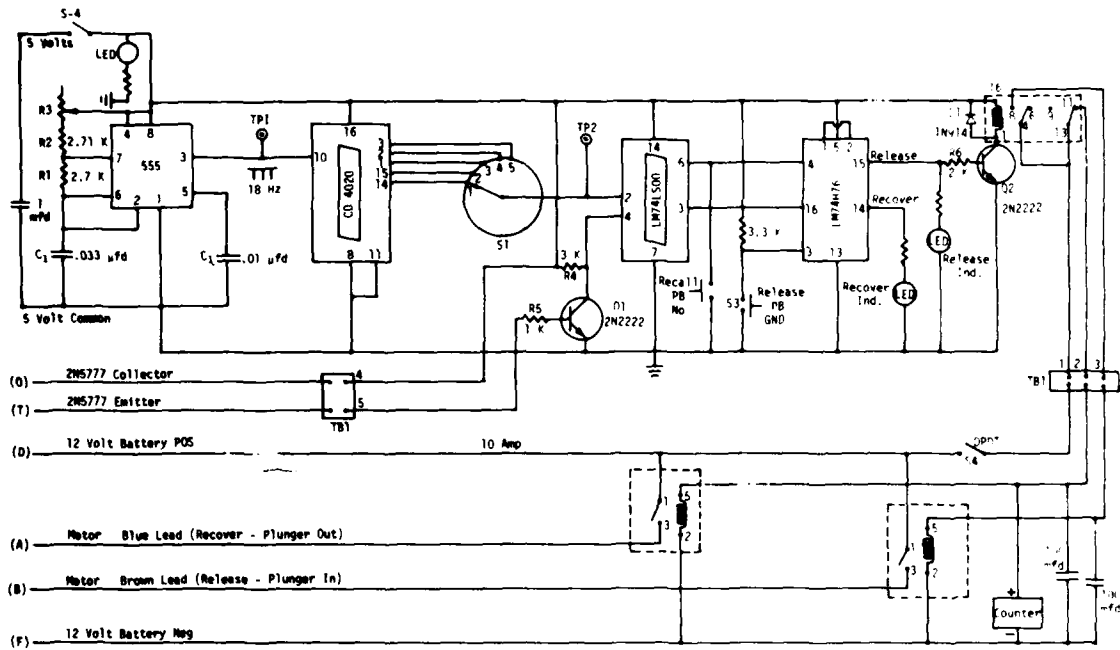
APPENDIX D
FLOW DRIVEN BRUSHES SCHEMATIC



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APPENDIX E
RECIRCULATING SPONGE RUBBER BALL SCHEMATIC

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APPENDIX F
CHLORINE PROBE DATA



Data Sheet **DS-82124** 2/76
FREE CHLORINE SENSOR

Model 82124
FREE CHLORINE SENSOR

APPLICATIONS

For measurement of Free Chlorine in aqueous solutions for monitoring, transmitting, recording and control systems. Principle uses are in water and waste treatment, industrial & utility process and cooling waters, swimming pools, and effluent monitoring.

To be used in conjunction with series 8324 and 8224 Chlorine Transmitters in, respectively, weatherproof NEMA 4 enclosure or compact control panel case. See Data Sheets DS-8324 and DS-8224.

Sensor Model 82124 is for Free Chlorine. (For sensor for Combined Available Chlorine see Data Sheet DS-82125.)



ORDERING INFORMATION

Free Chlorine Sensor

Model 82124-

IV	V	VII
	4	

IV - Application

- 2 = Submersion Type
- 3 = Flow through type
- 5 = Submersion type, built-in adaptor for 3/4" N.P.T. pipe
- 7 = Other (Special), specify

V - Cable Length

- 2 = 50 ft. (Std.)
- 7 = Other (Special), specify

VII - Sensor Cable Termination

- 3 = Spade Lugs (Std.)
- 4 = Soldered wire
- 7 = Other (Special), specify

OUTSTANDING FEATURES

- Responds to various chlorine species in direct proportion to their efficiency as disinfectants. For details, see Tech. Info. Reprint No. 24 "Chlorine Measurements by Membrane Probe".
- Sensor can be located up to 1000 ft. from Chlorine Transmitter; eliminates need to pump sample from test site.
- No reagents, no sample pumps to foul, no interference from ferrous, manganese, or nitrite ions.
- Automatic continuous temperature compensation from 0 to +50°C.
- Automatic pressure compensation for up to 300 ft. submergence, and to 150 psig.
- Accessories available for different mounting methods, submergence and flow-thru applications.
- Cleaner-agitator accessory available for dirty or still water use.
- Membrane replacement by screw-on cap is quick, eliminates need for recalibration.
- Hi-volume electrolyte chamber for months of operation without need for refill.
- Virtually unbreakable. Constructed of all corrosion-resistant wetted parts.

ACCESSORIES

- 824240 Replacement Membrane Kit
- 815240-20001 Flow-thru Cell
- 812100 Cleaner/Agitator with 50 ft. cable and Power Converter for 115v/60Hz input power, 6v DC output for Cleaner/Agitator.
- 825100 Service Kit for 812100
- 813100 Handrail Mounting System
- 814240 Weatherproof Junction Box

SPECIFICATIONS

PHYSICAL DATA

Material: Sensor: grey PVC. Cathode: Gold.
Anode: Silver. Membrane: gas-permeable.
Size: 15.9 x 6.0 cm (6-1/4" x 2-3/8")
Cable: 15.2 m (50 ft.) Std. 4/c. 160" Dia.
Ambient Temperature: 0 to 50°C.
Pressure: 92 m (300 ft.) submergence or 732 kg/m (150 psig).
Mounting: Handrail for direct submergence.
Surface for flow-thru. See Accessories.
Weight: Net: 4 lb., Shipping 6 lb.

OPERATING DATA

Power Required: Powered from transmitter
Range: 0-20 ppm. See Transmitter Data
Req'd Sample Flow: 1 ft./sec.
Accuracy: ±3% Full Scale
Stability: ±1% for 30 Days
Electrolyte: Buffered KC1. Sensor Capacity: 75 ml.
Consumption: Approx. 6-9 mos.

SUGGESTED TYPICAL SPECIFICATIONS

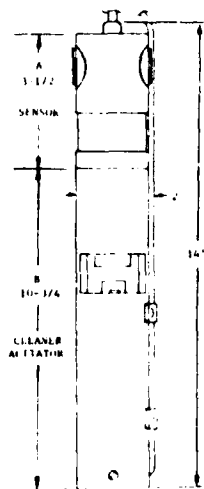
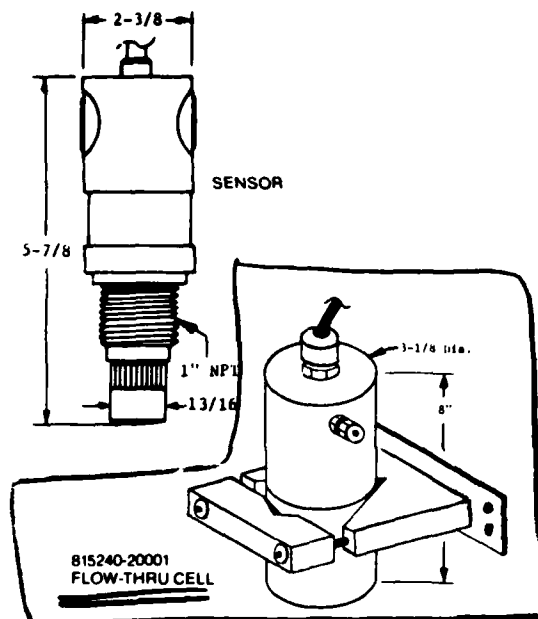
FREE CHLORINE SENSOR shall be polarographic type with gold cathode, silver anode, automatic compensation thermistor for 0-50°C range, and 2 glands for automatic pressure compensation to 150 psig. Electrolyte reservoir shall be 75 ml. Membrane change shall be by screw-cap. Calibration stability shall be ±1% for 30 days. Sensor shall be Delta Scientific Model 82124.

A CLEANER-AGITATOR ATTACHMENT shall be supplied with each sensor. Agitator motion shall be by paddle oscillation, not rotational, to avoid trapping foreign matter and shall generate minimum of 1 ft/sec sample flow. Power shall be by 6vDC from accompanying 110v 60 Hz converter. Shall be Delta No. 812100.

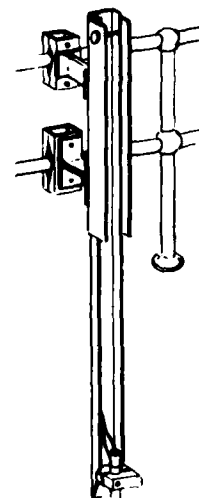
WARRANTY

All Delta equipment is warranted to be free from defects in workmanship and material, under normal use and service, for 12 months, as outlined in detailed warranty available on request

REPRESENTED IN YOUR AREA BY



A-SENSOR
B-CLEANER/AGITATOR
812100



813100 HANDRAIL
MOUNTING SYSTEM

DS-82124 2/76

Specifications subject to change without notice
Printed in USA

DELTA Scientific Corp.,

LINDENHURST, N.Y. 11757

PHONE: (516) 884-4422

TELEX: 96-7754

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APPENDIX G

SEA WATER INSTRUCTION ADDENDUM

APPENDIX G

SEAWATER INSTRUCTION ADDENDUM

CHLORINE

What the Probe Will Measure

When used in chlorinated seawater, the #821243 Free Chlorine Sensor will monitor the disinfection strength present. The probe will respond to the various Halogen species in proportion to their efficiency as disinfectants. The sensor responds to HOCl and any HOBr and HOI which may be formed. The sensor does not respond to OCl^- or any OBr^- or OI^- which is formed.

Since the reading obtained is disinfection strength, the signal can be used to control the chlorinator precisely and provide optimum disinfection while preventing overchlorination.

On the following page is a graph of the Halogen dissociation curves with respect to pH.

The Sensor Measures: HOCl , HOBr , HOI

The Sensor Does Not Measure: OCl^- , OBr^- , OI^-

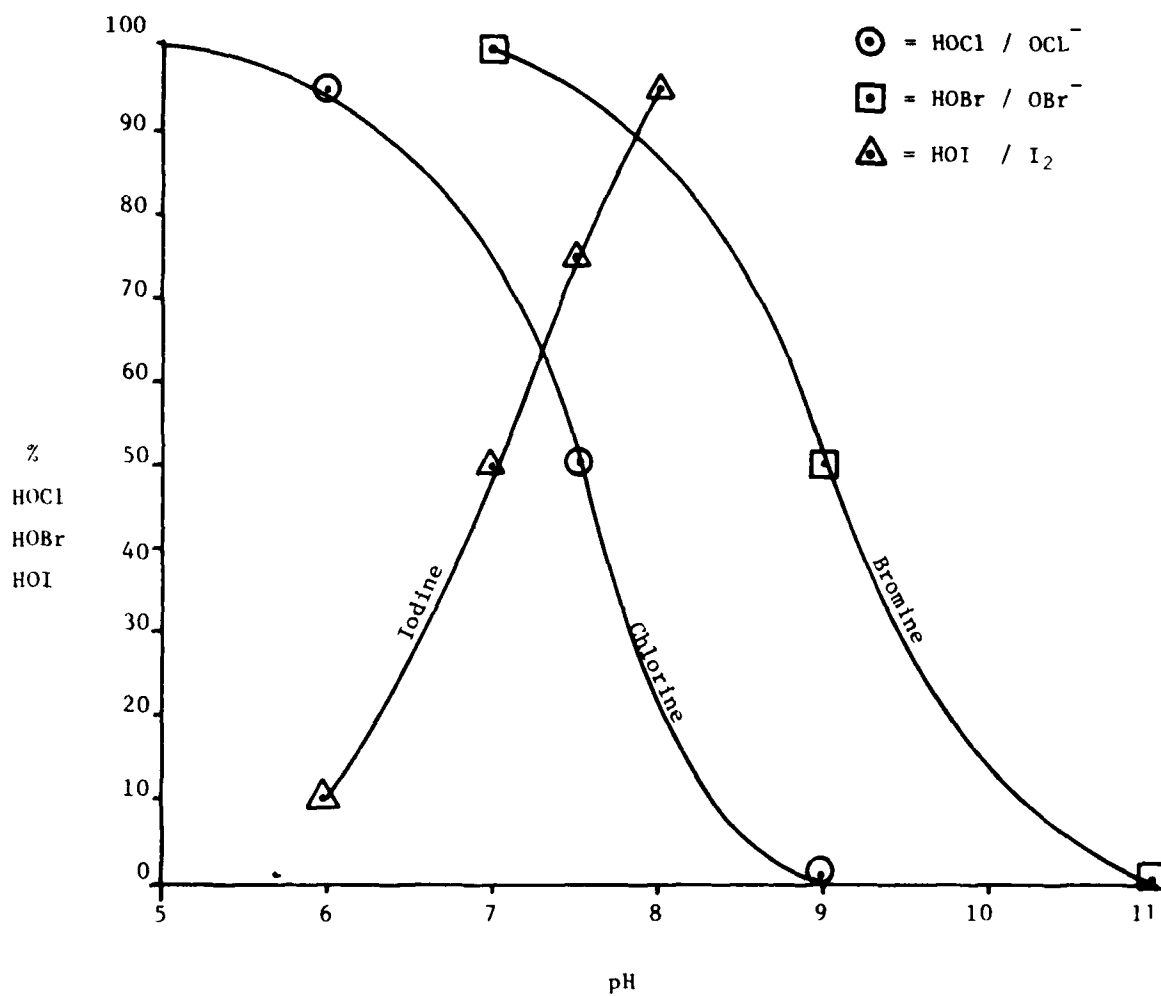


FIGURE G-1. SEAWATER HALOGEN DISSOCIATION

Probe Mounting Consideration

The following considerations must be satisfied in order for the system to operate satisfactorily:

1. Sufficient flow - The sample flow past the tip of the probe must be at least one foot per second. Too low a flow rate will give erratic readings. Too high a flow rate could cause a vortex or an air space to form at the probe tip.
2. Submergence - The entire probe must be submerged so that the pressure compensation glands on the top of the probe function properly.
3. The probe must be mounted vertically so that the membrane faces downward.
4. The membrane must be clean, free of holes and tightly fitted against the gold surface.

Calibration

The system should be calibrated at a pH of 5.0 so that only hypochlorous acid exists during the calibration procedure. When the probe is then placed in the chlorinated seawater, the reading obtained will be the hypochlorous acid equivalent. Since hypochlorous acid is the best disinfectant, it is important to know the hypochlorous acid equivalent present in the chlorinated seawater. This reading will be disinfection strength.

The method used to determine the concentration of chlorine during calibration should be either the potassium iodide titration, the snort method for free chlorine, the D.P.D. titration or the Amperometric titration. A copy of each of these test procedures from standard methods is attached to this addendum.

Materials

1. De-Ionized or Distilled Water
2. Dilute Chlorox: Dilute Standard Chlorox 1 to 10
3. pH 5 Acetate Buffer: 57 ml Acetic Acid (CONC)
164 (g) Sodium acetate
Dilute to 1 Liter
4. 500 ml Beaker
5. Magnetic Stirrer
6. Ring Stand & Clamp

Procedure

1. Allow the unit to warm up at least one half hour before calibration with the probe attached to the transmitter. Soak the probe in water during this warm up time.

2. After the system has warmed up, set the range switch to the zero position and set the needle to zero with the amplifier balance control. Set the range switch to the 0-1 position.

3. Place the probe into distilled or de-ionized chlorine free water on a magnetic stirrer with the probe about 1/2 inch above the spinning magnet. After a steady near zero reading has been obtained, set the reading to zero with the probe zero control.

4. Add one cc of pH 5 buffer to this zero water.

5. Add the dilute Chlorox solution one drop at a time until a reading of 1-2 ppm on the meter is obtained.

6. Withdraw a portion of this chlorinated sample and determine its chlorine concentration with one of the test methods.

7. Set the meter to read the value obtained (by the test method) with the calibrate control.

When the system is calibrated in this manner, the reading obtained when the probe is placed into the chlorinated sea water is disinfection strength.

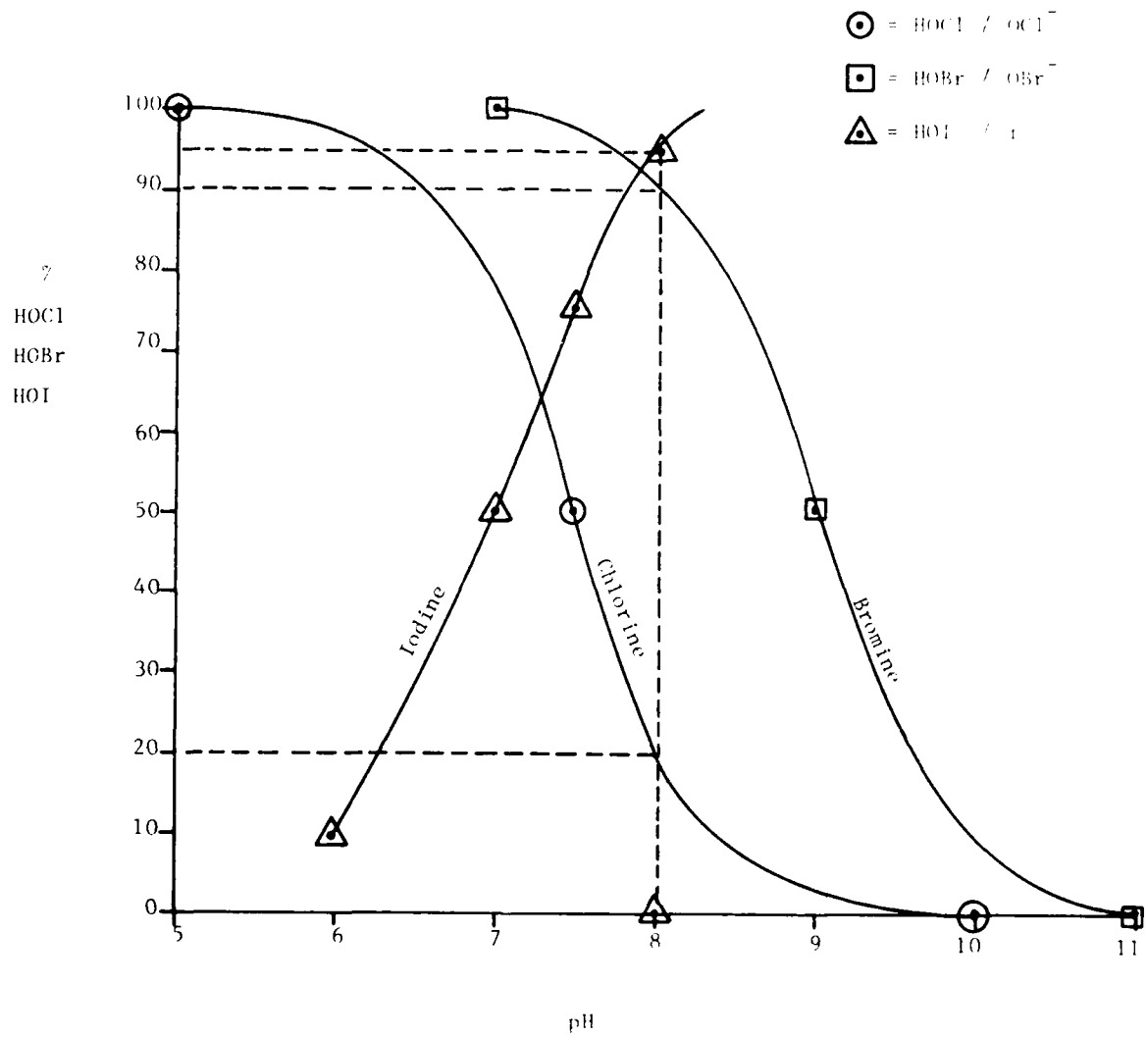


FIGURE G-2. SEAWATER HYPOCHLORITE GENERATION

