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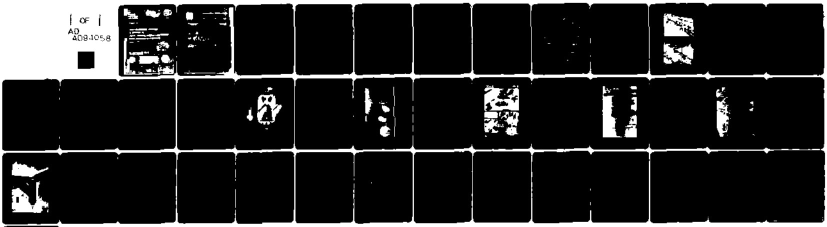

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This report describes the mechanical systems supporting biofouling countermeasures for Ocean Thermal Energy Conversion (OTEC). Described in the report are the water supply and distribution and the flow driven brush, recirculating sponge rubber ball, and chlorination systems. In addition, the maintenance procedures utilized at the NCSC test site are provided.

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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/or 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 in both aluminum and titanium pipe.

The flow driven brushes and recirculating sponge rubber ball systems 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 brush system requires 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 a potential for maintaining heat exchanger efficiency while subjected to the assault of heavy biofouling. It remains to determine which system or combination of systems can reduce fouling below a target level.

PURPOSE

This report documents the mechanical 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

MECHANICAL SUBSYSTEMS

This report deals with the mechanical subsystems as well as operation and maintenance requirements. In general, the mechanical subsystems operate independently of computer (PDP 11/34) control. Computer interaction with mechanical subsystems is solely through data gathering and not control functions. Figure 1 is a block diagram of the overall countermeasures system. The arrangement of these subsystems on NCSC's ammunition pier is shown in Figure 2. Each subsystem will be discussed.

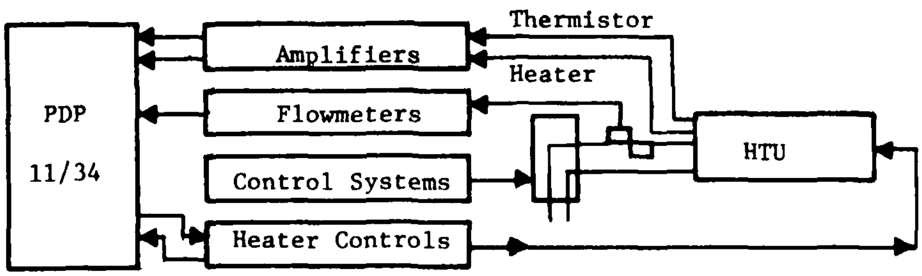


FIGURE 1. BLOCK DIAGRAM OF FOULING COUNTERMEASURES SUBSYSTEMS

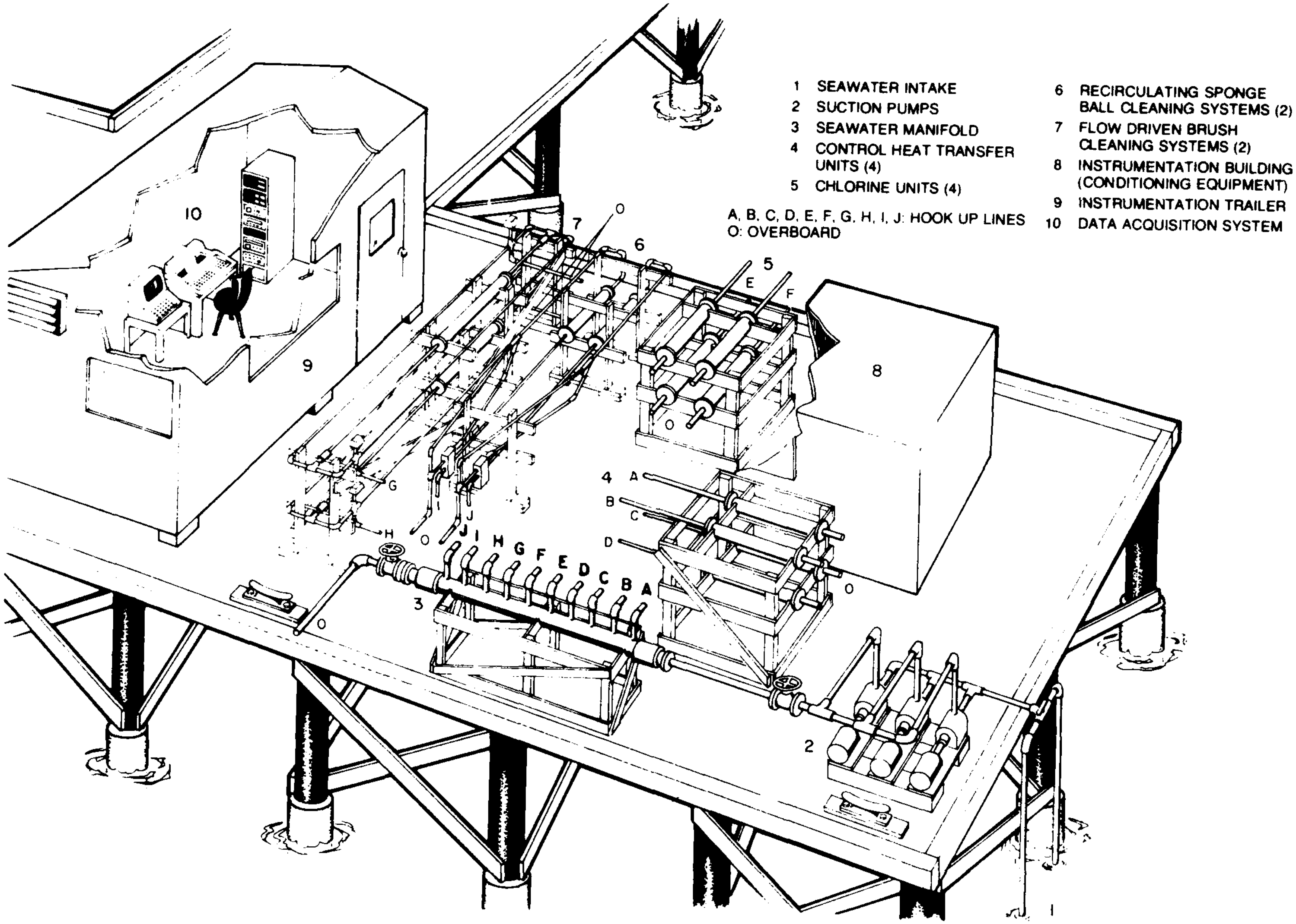


FIGURE 2. HEAT EXCHANGER CLEANING TEST FACILITY

WATER SUPPLY AND DISTRIBUTION

The major components of water supply and distribution include the strainer assembly, pumps, distribution header, filters, and power supply (Figure 3). Piping details are seen in Figure 4.

The ammunition pier extends 40 feet into St. Andrew Bay and is 7 feet above water level. Water depth at the pier is approximately 12 feet with water being drawn from a depth of 6 to 7 feet. Normally, two pumps are used when more than eight heat transfer units (HTU) are being tested. Water is fed into a 6-inch distribution header and ultimately back into the bay. Each HTU is serviced from the distribution header by flexible PVC tubing.

Strainer Assembly

The intake, or strainer assembly, consists of two flexible 4-inch pipes feeding into a single manifold. Each side is controlled separately by a 4-inch ball valve. Details on the strainer assembly are shown in Figure 5. The system operates from one side while the other is serviced.

The strainer has two potential problem areas. First, in estuarine situations there can be large amounts of detritus such as marine grasses that can clog the strainer, thus reducing the flow rate. Secondly, air leakage around the ball valve may necessitate keeping the standby intake in the water. Both problems are seen as increases in flow rate standard deviation at the computer.

Maintenance should include daily examination of strainers for clogging and cleaning of each filter on alternate weeks. Depending on the reasons for fouling or other clogging, e.g., large amounts of floating grass, more frequent cleaning may be required.

Pumps

Three Model 2C9220 Pacer pumps, manufactured by Pacer Pumps of New Holland, Pennsylvania (Appendix A), are used to draw sea water from the bay. Each 2-inch, self-priming, centrifugal pump is pedestal mounted and flexibly coupled to a 7 1/2 hp electric motor turning at 3450 rpm. All three pumps are fed from a common 4-inch manifold. However, each pump may be isolated and removed from the system by closing 2-inch PVC valves on either side of the pump. In the present system, two pumps are required when the HTU number exceeds eight units. The third pump acts as a standby and is equipped with a pressure switch that energizes the #3 pump should pressure in the lines fall below 5 psig. The third pump would, therefore, be activated due to failure of pumps #1 or #2 and would provide adequate flow to keep all HTUs wet while maintenance is performed on the damaged pumps.

Perhaps the major shortcoming concerns intermittent power fluctuations. Power outages of milliseconds are sufficient to throw electrical breakers.

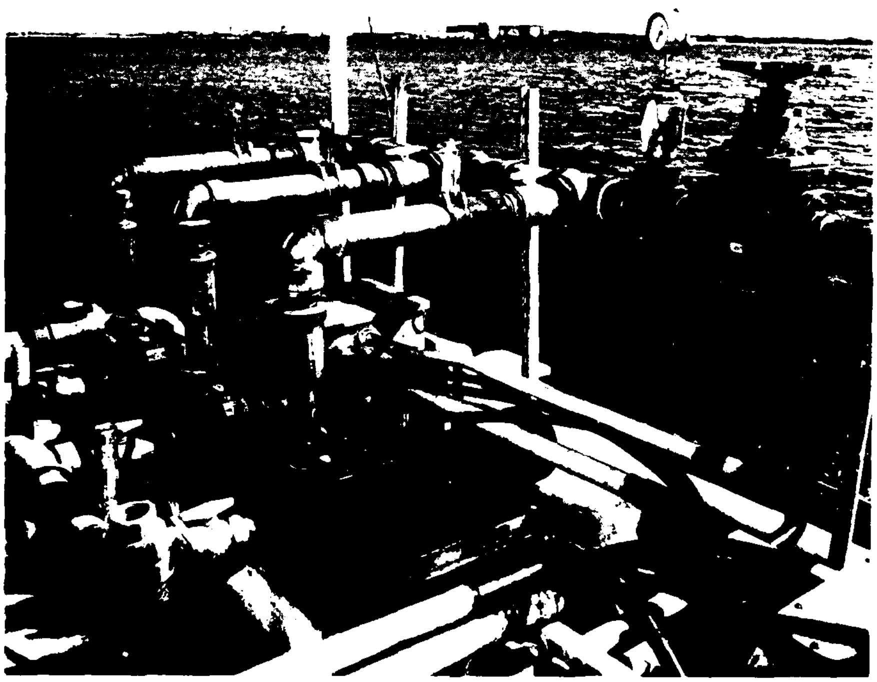
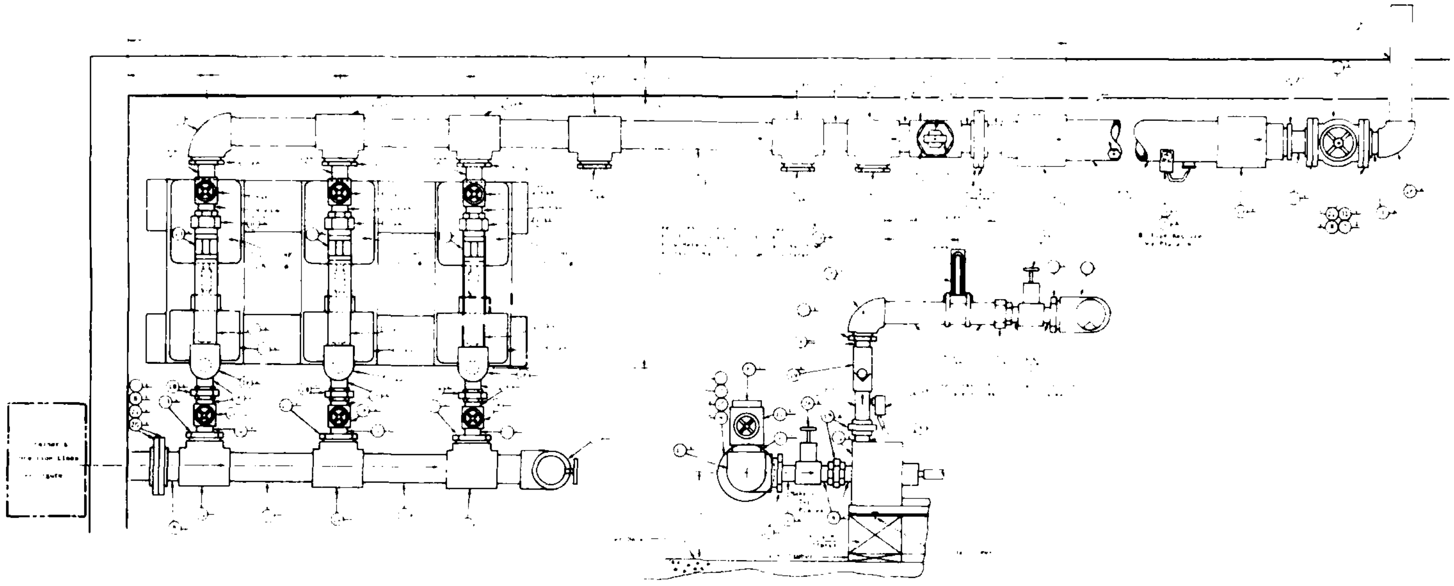


FIGURE 3. MAJOR COMPONENTS OF WATER SUPPLY AND DISTRIBUTION



1	Pipe, 6" Sch. 80, 1 Length, PVC
2	Pipe, 4" Sch. 80, 2 Lengths, PVC
3	Pipe, 3" Sch. 80, 1 Length, PVC
4	Pipe, 2" Sch. 80, 1 Length, PVC
5	Plug, Threaded 1 ¼" Sch. PVC
6	Nipple, Short, 4" Sch. 80 4" Lg., PVC
7	Stud, 5/8" - 11 UNC - 2 B, CRES
8	Hex Nut, 5/8" - 11 UNC - 2 B, CRES
9	Nipple, Short, 2" Sch. 80 2 1/2" Lg., PVC
10	Nipple, Long, 2" Sch. 80 6" Lg., PVC
11	Pump, 2" Self Priming Centrifugal Pacer No. 2C9220 7 1/2 HP 3450 RPM 230/460 V TEFC 3 ϕ, PVC
12	Gate Valve, Threaded 4", PVC
13	Flowmeter Series B No. 39083 3" Nom. Size, PVC
14	Tee, 4" Threaded Sch. 80, PVC
15	Elbow, 90° Threaded 4" Sch. 80, PVC
16	Elbow, 90° Threaded 3" Sch. 80, PVC
17	Gage, 0-75 Psi ¼" Male Pipe THD, Bronze
18	Union, Threaded 2" Sch. 80, PVC
19	Check Valve, Threaded 2" Size, PVC
20	Flange, Threaded 4" 150 Lb., PVC
21	Gasket, For 4" 150 Lb. Flange, Solid Neoprene
22	Flange, Threaded 3" 150 Lb., PVC
23	Reducing Bushing, Threaded 4.. x 2" PVC
24	Reducing Bushing, Threaded 4" x 1", PVC
25	Reducing Bushing, Threaded 3" x 2", PVC
26	Gate Valve, Threaded 2", PVC
27	Reducing Bushing, Threaded 1" x ¼", PVC
28	Reducing Bushing, 4" x 3" Socket, PVC
29	Reducing Coupling, 6" x 4" Socket, PVC
30	Reducing Coupling, 3" x 2" Threaded, PVC
32	Gasket, For 3" 150 Lb. Flange, Solid Neoprene
32	Plug, Threaded 4" Sch. 80, PVC
33	Globe Valve, Flanged 3"
34	Low Pressure Switch Augomatic Unit, Model No. A-1004-1, PVC

FIGURE 4. WATER SUPPLY PIPING

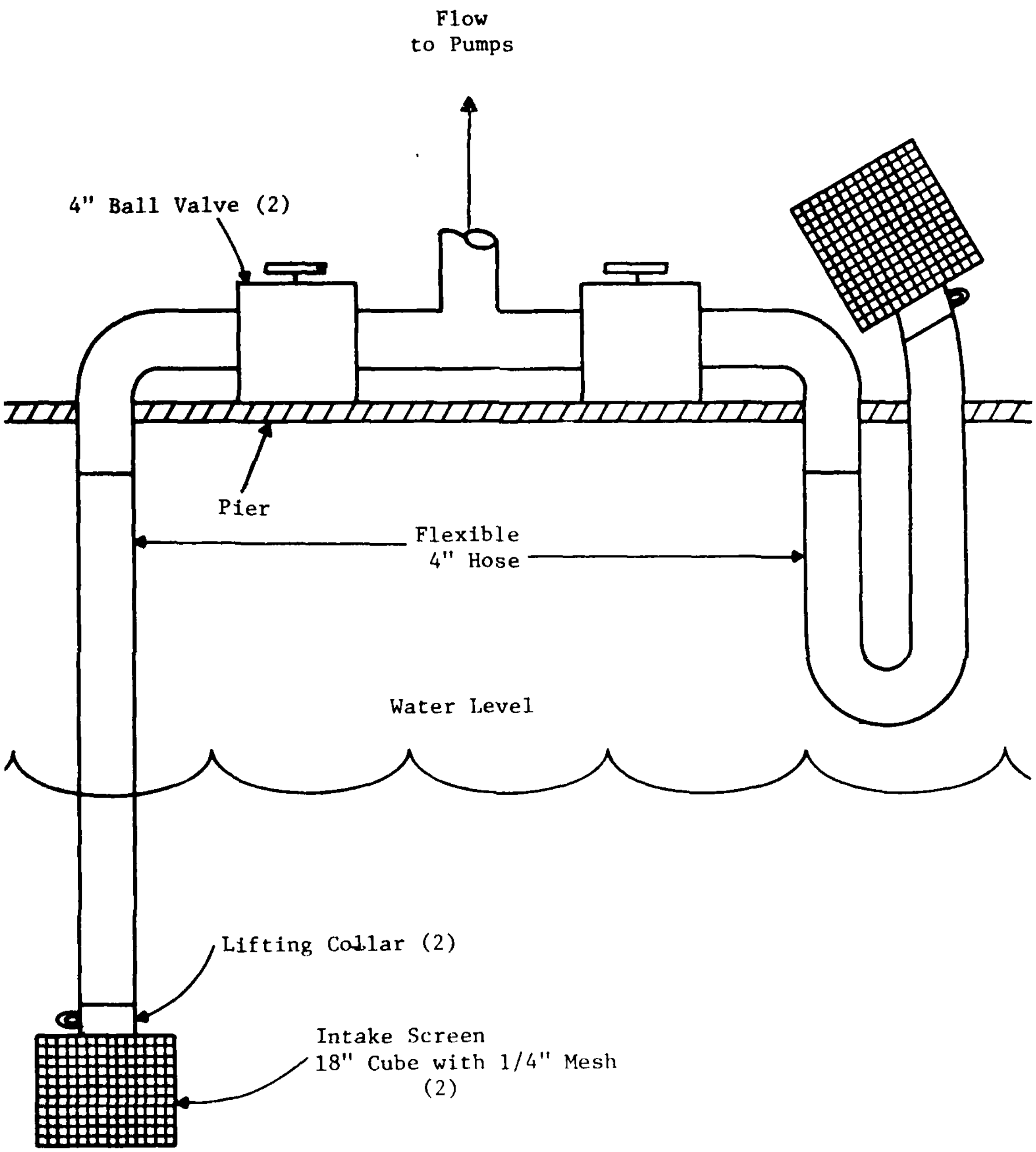


FIGURE 5. STRAINER ASSEMBLY DETAIL

Thus the pumps are protected but at the expense of ongoing experiments. Two options are available for this problem. The first involves the use of standby power. This is an admittedly expensive option and was not deemed cost effective. The second would use alarm-recording telephones to notify personnel of a power outage. This would allow personnel to restart pumps following the outage with a significant reduction in time before pumps are restarted.

The pumps have been found to be reliable provided there is both prope-- maintenance and lubrication and particularly proper motor alignment. In the past, major failures have occurred in the sealed bearing and shaft assembly. When this assembly fails, there is usually extensive damage to other pump starts; e.g., impeller, impeller housing, etc. Impending failure is determined through a change in the pump pitch sound. It is recommended that a substantial parts inventory be available at all times.

Power

Power requirements in support of water supply and distribution are significant; however, total power required for the OTEC facility is less than 100 A (250 v, 3 phase) Figure 6 is an electrical conduit and equipment diagram. Figure 7 provides details of electrical wiring.

Distribution Header

The distribution header is a 10 foot long section of 6-inch Schedule 80 PVC pipe that has been drilled and tapped for thirty 1 1/4-inch NPT holes (Figure 8). The header forms the major water reservoir feeding each HTU. Header pressure is maintained at 30 psig.

Experience with the header has indicated that at least a biannual cleaning is required to remove bivalve concentrations that occur in low velocity areas. This problem would be significant in tropical areas. Service to HTUs is provided through a 1 1/4-inch PVC ball valve into filters.

Filters

Each HTU is fitted with a filter assembly located downstream from the distribution header. Figure 9 provides detail on the filter assembly. Basically, the filter assembly consists of two identical loops: one series for filtration of the primary flow and one as a standby when servicing the primary loop is required. This ensures uninterrupted flow during an experiment.

Each strainer is a 2-inch Type 306 PVC line strainer (GF Plastics) with screens of 8-mesh and 3/32-inch diameter holes. A 2-inch strainer was required to meet flow rate requirements for testing (16 gpm). Appendix B provides further detail on the strainers.

1 Fusible Disconn. Switch
2 Fusetrons 100 A, 250 V
3 1-1/2" Conduit, Rigid
4 Wire, #1 THWN Copper
5 25 Amp, 250 V, Fusetron
6 Combination Motor Starter for 7-1/2 HP Motor, NEMA Size 1 250 V, 3 ϕ, 3 Pole with 250/115 V Control XFMR. Start-Stop Push Buttons, Pilot Light, 3 O.L. Hours, NEMA 12 Encl.
7 Junction Box, 4 x 6 x 8, Hinged Cover
8 Machine Tool Relay, 115 V Coil, 2 NO, 2 NC
9 Enclosure, Hoffman
10 3/4" Conduit, Rigid
11 Wire, #14 THWN
12 1" Conduit, Rigid
13 Wire, #10 THWN Copper
14 1-1/2" Sealite, Flex Conduit
15 Wire, #2 THWN Copper
16 1-1/2" Flex Conduit
17 3/4" Condulet Box
18 1" Condulet Box
19 1/2" Sealite, Flex Conduit
20 Wire, #10 THWN Copper

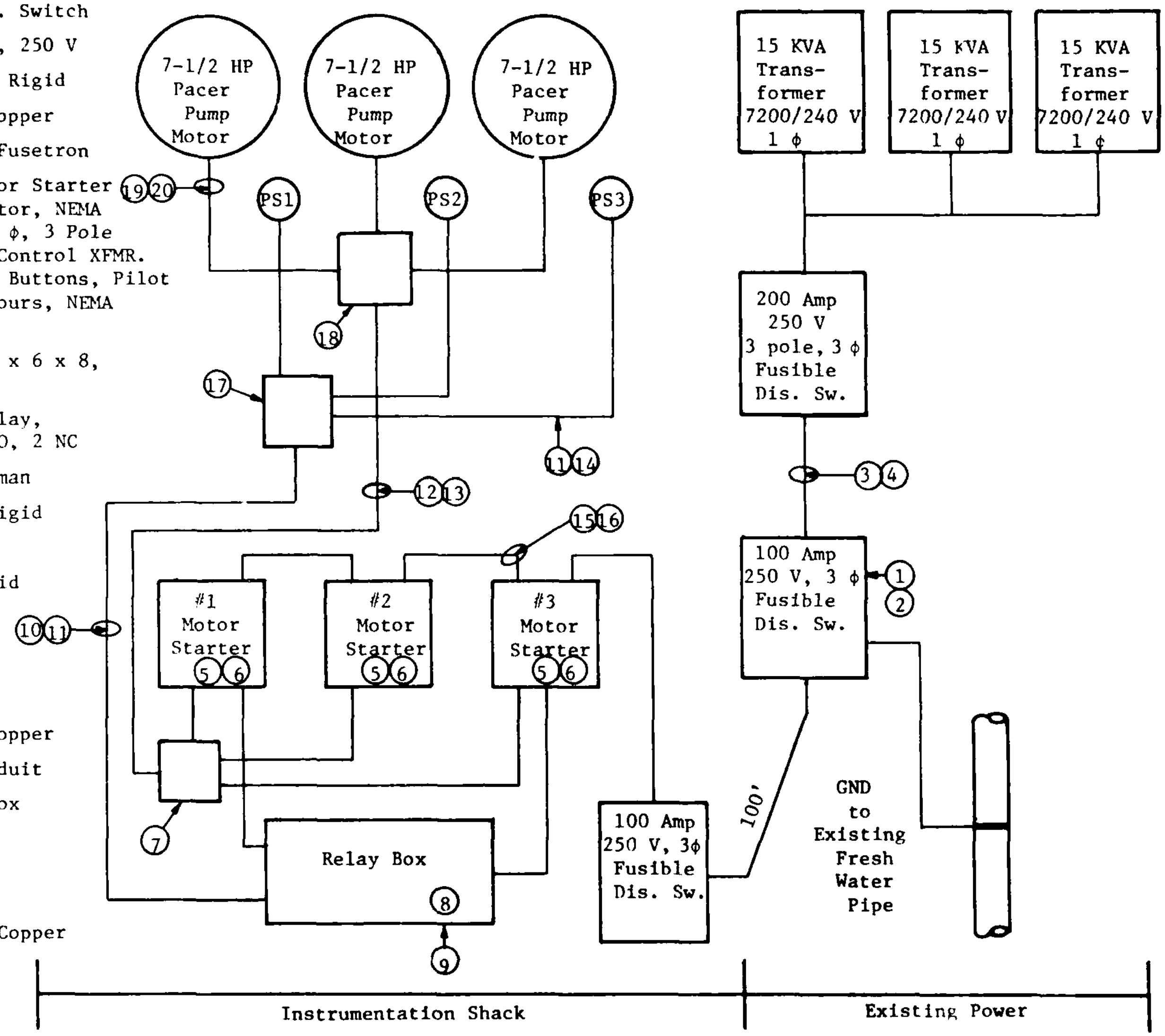


FIGURE 6. ELECTRICAL CONDUIT AND EQUIPMENT DIAGRAM

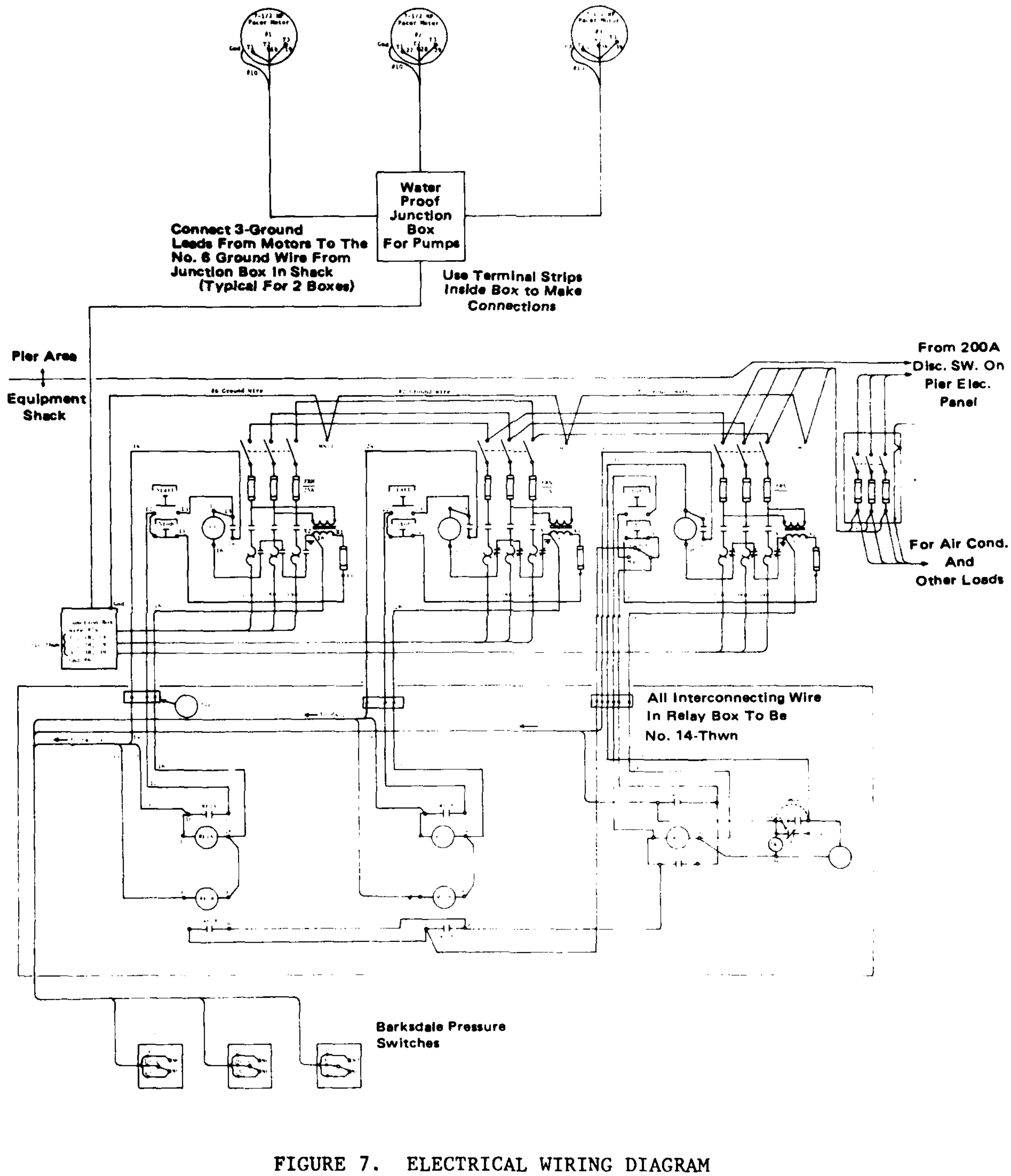


FIGURE 7. ELECTRICAL WIRING DIAGRAM

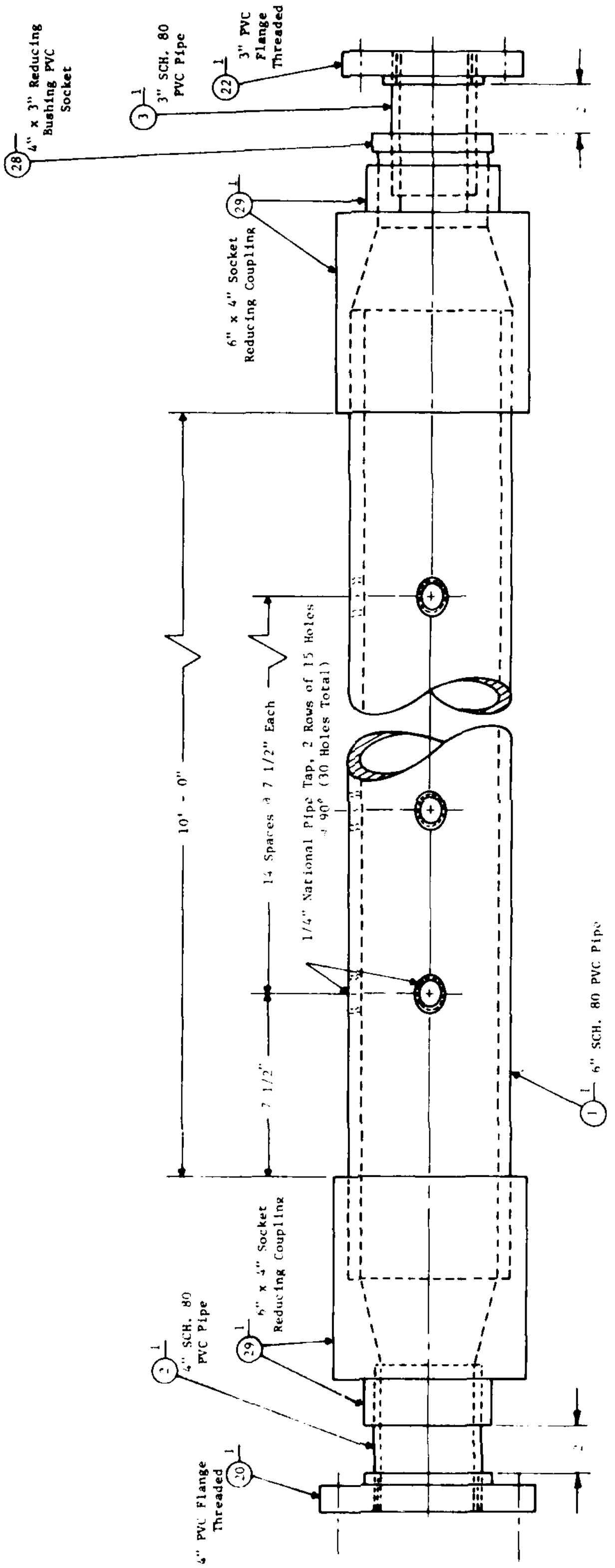


FIGURE 8. DISTRIBUTION HEADER DETAIL

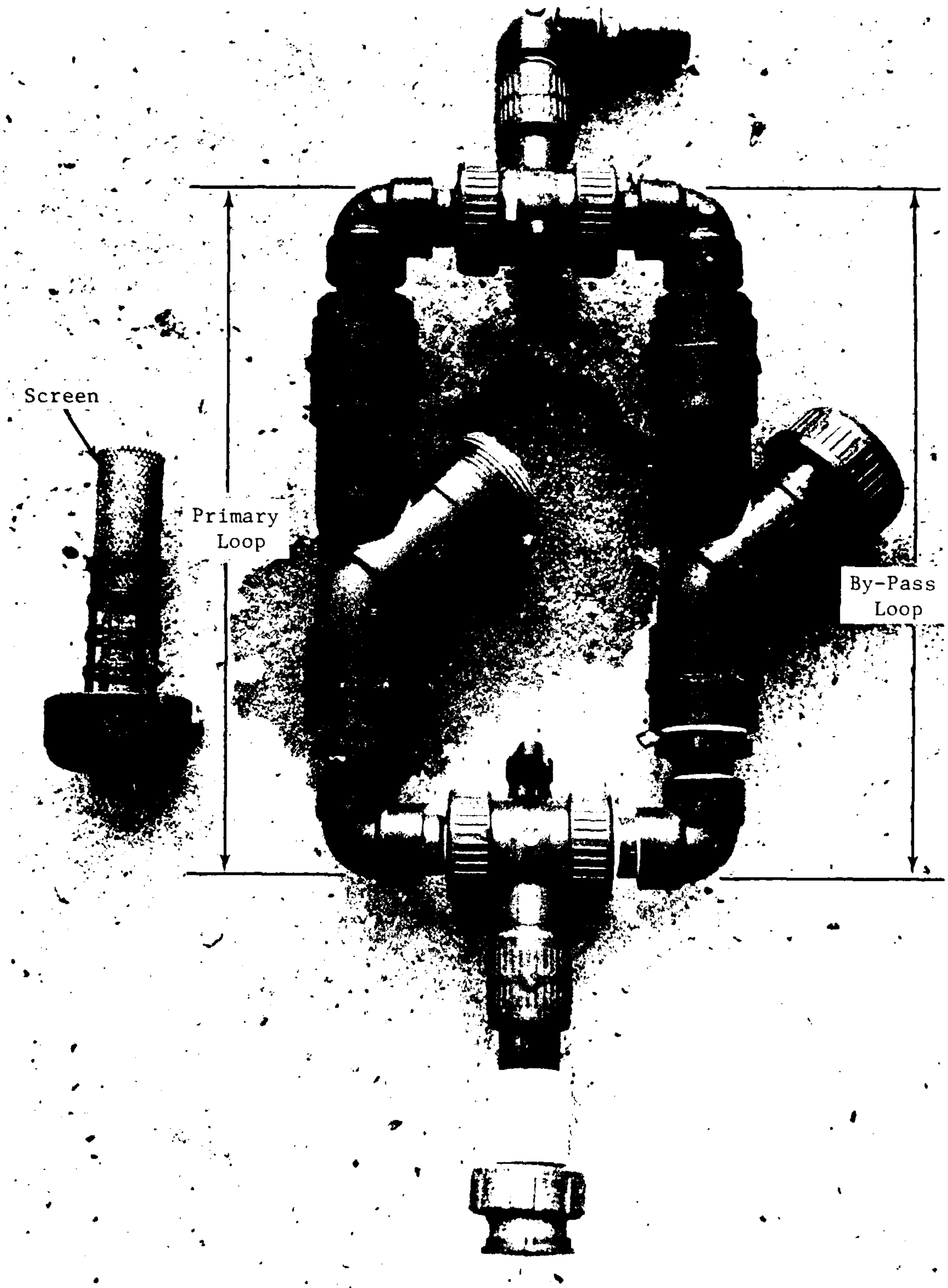


FIGURE 9. FILTER ASSEMBLY

FLOW DRIVEN BRUSH SYSTEM

The flow driven brush system is designed to use flow driven brushes to prevent and remove biofouling from heat exchangers. Figure 10 is a schematic of this test system; an engineering drawing is in Appendix C.

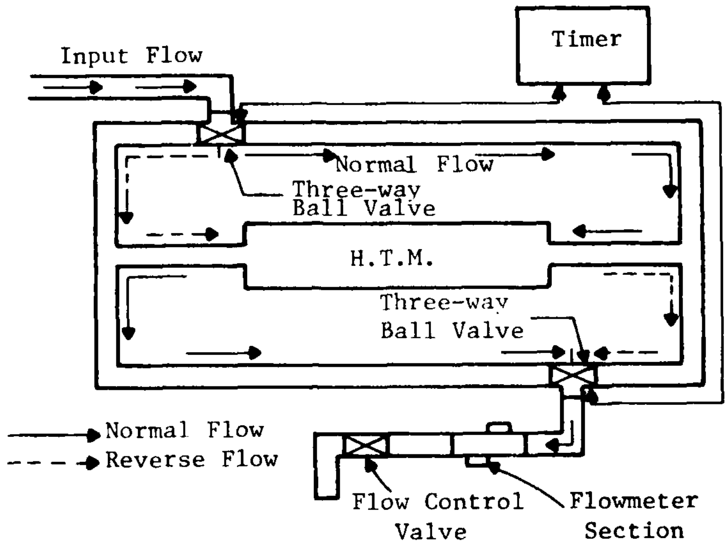


FIGURE 10. FLOW-DRIVEN BRUSH CLEANING SYSTEM

For testing, each HTU is supplied with a brush slightly larger than the diameter of the HTU pipe. Cleaning cycle initiation begins with a timer pulse to electrically operated ball valves. The valves rotate to reverse flow thus sending the shuttle (brush) from its normal position downstream to the opposite end where it remains for approximately 15 to 20 seconds. The valves then cycle again, sending the brush back to its downstream position. A single cleaning cycle therefore consists of flow reversal followed by normal flow.

Two brushes are available for test (Figure 11). Brush parameters considered in the tests include brush composition, bristle length, bristle stiffness, bristle pitch, bristle diameter, number of bristles, brush movement (spiraling), and brushing interval. The brushes pictured in Figure 11 represent the commercially recommended brush for 1-inch pipe and an experimental brush of different composition.

Few modifications have been made to the system as supplied by DTNSRDC. The major modification has been to replace the shuttle catcher housing with a new design that significantly reduces low velocity flow rate areas (Figure 12). Figure 13 shows the installed unit.

FIGURE 11. BRUSHES AVAILABLE FOR TEST

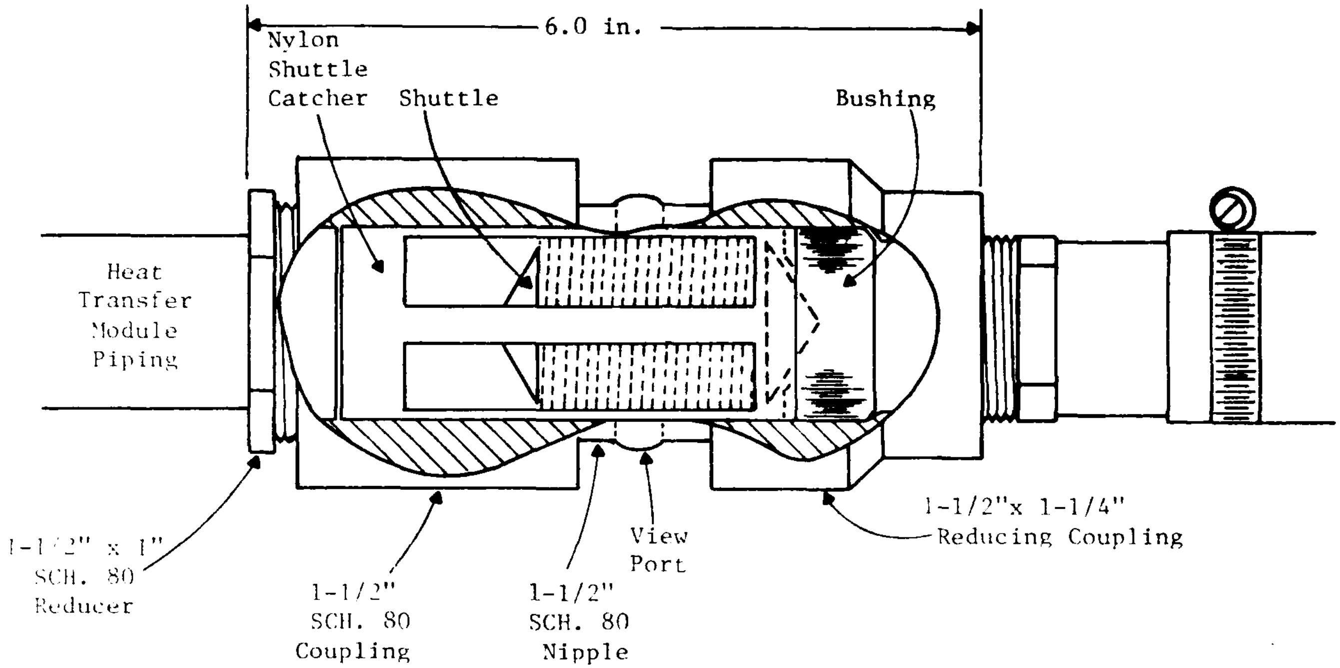


FIGURE 12. FLOW DRIVEN BRUSH CATCHER HOUSING MODIFICATION

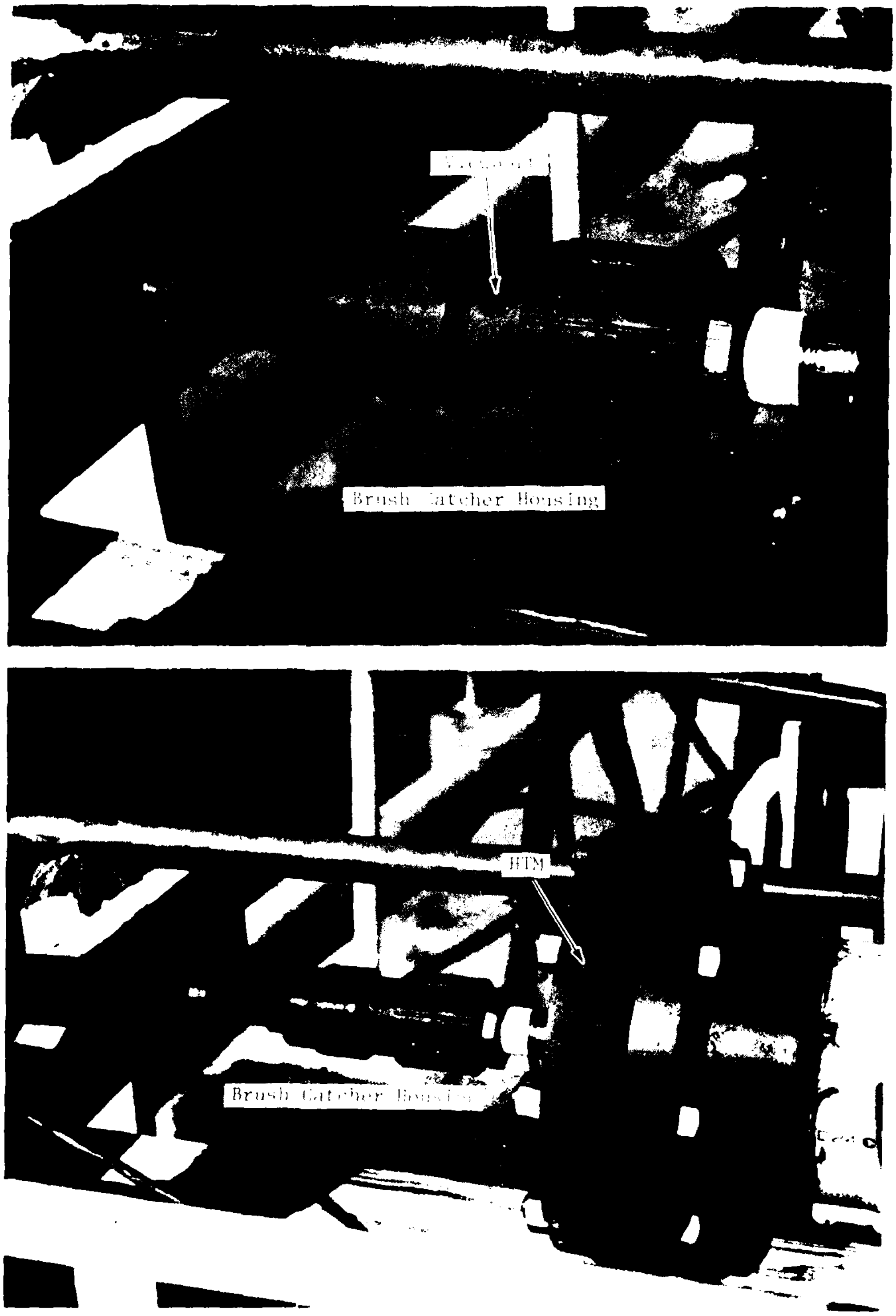


FIGURE 13. HOUSING MODIFICATION INSTALLATION

The flow driven brush system has been very reliable with the only failures attributed to limit switches within the electrically operated valves. This failure is evidenced by irregular movement of the valve handle during normal cycling and involves simple replacement.

RECIRCULATING SPONGE RUBBER BALLS

The recirculating sponge rubber system is a locally designed system featuring unidirectional flow of the sponge rubber ball. Figure 14 is a general schematic of the test system. Appendix D is an engineering drawing of this system.

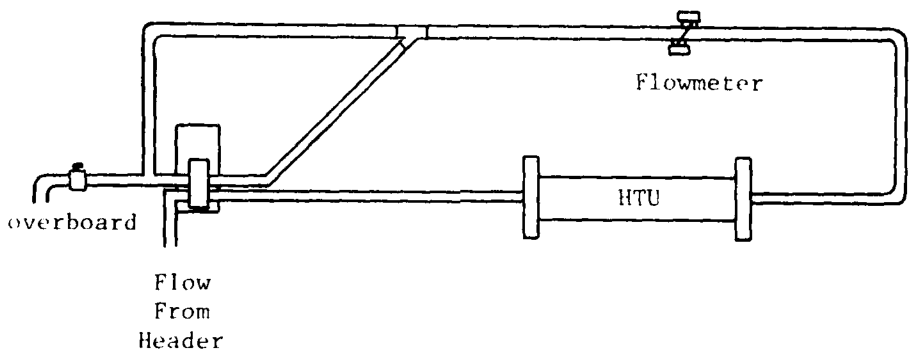


FIGURE 14. RECIRCULATING SPONGE RUBBER BALL SYSTEM SCHEMATIC

In general, the system operates when the timer pulse activates relays causing the plunger to move to the release position. In this position, the ball is driven into the incoming flow where it immediately passes an optical sensor. Passing this sensor causes (1) the timer to be reset, (2) the dc motor to return to the catch or starting position, and (3) the counter to be incremented. The ball continues through the HTU and flowmeter sections until it encounters the strainer (Appendix D). The strainer diverts the ball into the catch loop where it remains until the next cleaning cycle. Thus, a cleaning cycle involves unidirectional flow with a single ball passage.

The recirculating sponge rubber ball system consists of dc motor, limit switches, catcher housing, strainer, and optical sensor mount. Major components are shown in Figure 15 as they are mounted in the active test system.

FIGURE 15. AMERTAP SYSTEM COMPONENTS

Figure 11 shows a typical ball used in testing. These are commercially available balls recommended by the manufacturer. Ball parameters subject to test include ball diameter, ball stiffness, ball composition, ball abrasiveness, and cycle interval. Present testing focuses on ball diameter and stiffness as well as cycle interval.

The present system features high system reliability. System failure, indicated by the catcher remaining in the release position, has been limited to failures associated with the optical sensor. Maintenance of the system is minimal, involving a daily spraying of the dc motor and attaching hardware with a lubricant that displaces water and reduces corrosion.

CHLORINATION

Testing of the chlorine system has been constrained to the testing of intermittent chlorination due to limited flow of chlorine. Pipe size within the chlorine generator limits total flow to 20 to 25 gpm. This provides insufficient flow to service both the aluminum and titanium loops.

The present system, therefore, is designed to allow chlorination of both loops from the single generator. Figure 16 provides a general schematic of this system while Appendix E is an engineering drawing. The actual assembly is seen in Figure 17. The following is a list of typical operation procedures:

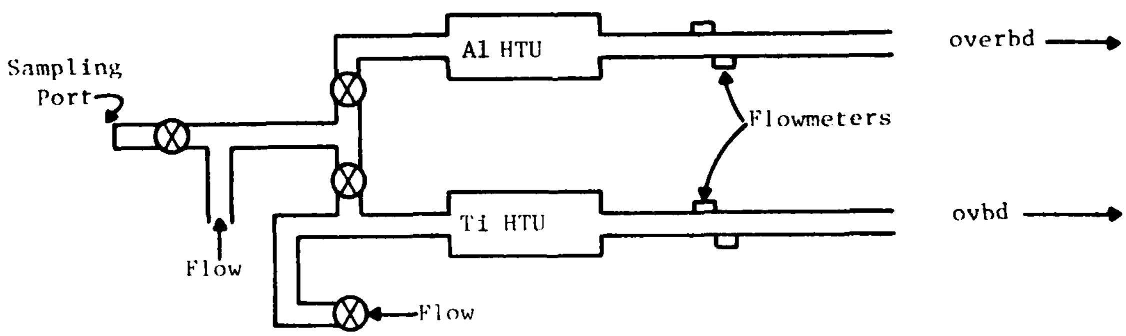


FIGURE 16. CHLORINATION SYSTEM SCHEMATIC

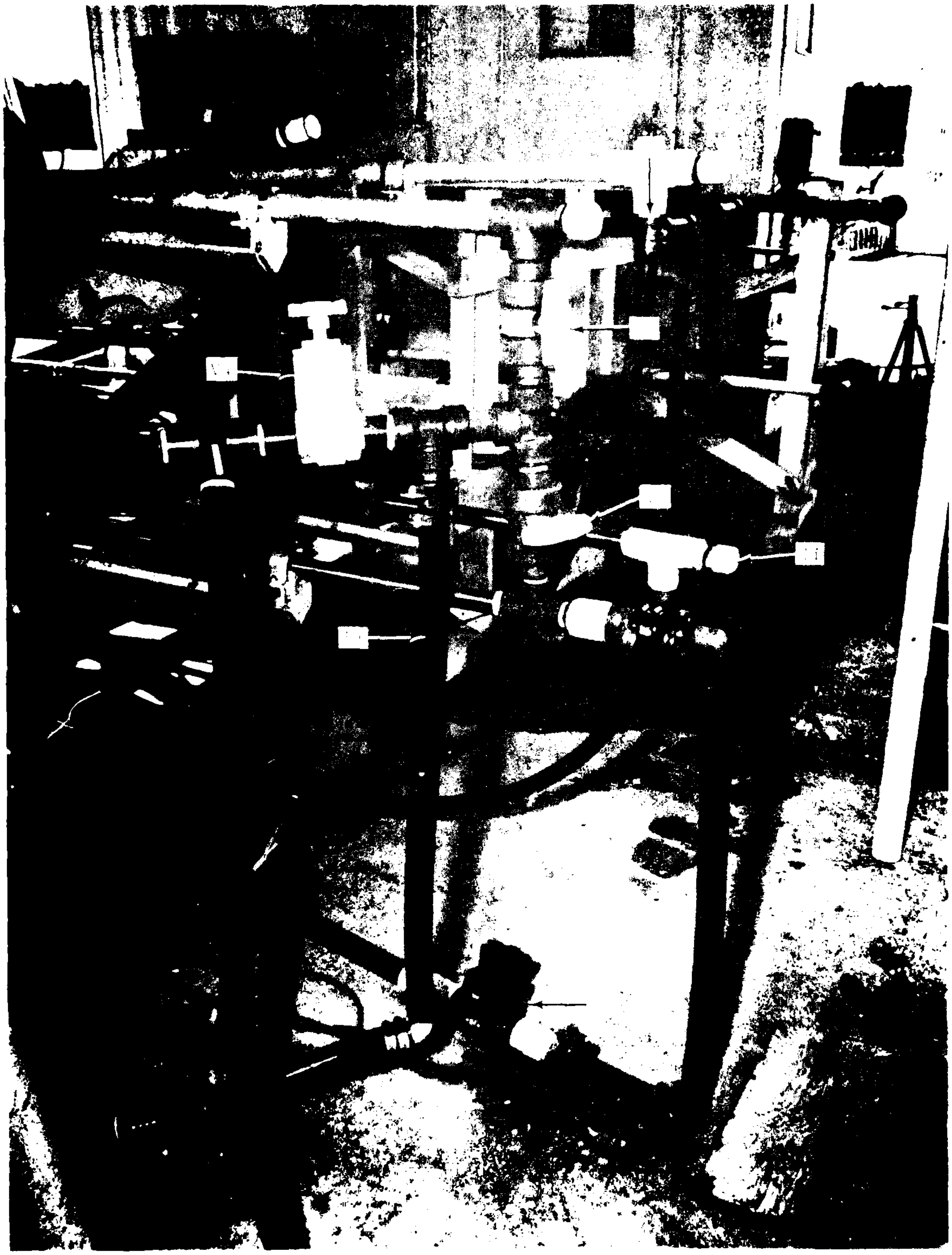


FIGURE 17. CHLORINE ASSEMBLY (T)

1. During normal operation, flow from the chlorine generator enters the "T" via F1. V2 is closed and V1 is open, thus allowing flow through the Al HTU. The Ti HTU is serviced through a separate line (F2) off the header controlled by V3.

2. To initiate chlorination, valves V1 and V3 are closed; valve V2 is opened. Flow from the generator is passing through the Ti HTU. The chlorine generator is turned on. Valve V4 is cracked and a chlorine sample taken. A chlorine determination is made using the DPD test kit. The generator voltage is adjusted as required. A second chlorine sample must be taken to check target dosage. Then V4 is closed.

3. Once the proper dosage interval has passed (15 minutes), V2 is closed. Valves V1 and V3 are then opened. This will flush chlorine out of the Ti unit while returning flow from the generator to the Al HTU. While checking chlorine concentration as before, the operator must dose as required.

4. Generator power supply must be shut off. Chlorine concentration can be monitored using the Delta Scientific Model 8324 Automatic Analyzer with Model 82124 free chlorine probes that have been placed in the system using flow cells (Figure 18) designed by Delta Scientific. Probes are located downstream of the generator and downstream from each loop.

Although automatic control of chlorine using free chlorine probes was a task objective, little data exist for the use of these probes in sea water. It appears that many interferences exist in sea water. This is borne out by poor correlation between chemical and analyzer readings.

The present system requires no maintenance. However, use of chlorine probes makes it imperative that the following operating parameters be checked at least weekly: (1) zero - has not shifted; (2) stability - meter reading not erratic; (3) membrane - not damaged; and (4) electrolyte - adequate amounts, not crystallized. Potential problems are covered in a manual supplied with the instrument.

OTEC MAINTENANCE PROCEDURES

DAILY

The following maintenance procedures will be performed at the OTEC site as soon as practical each day:

1. The test equipment must be checked visually for any signs of trouble such as severe plumbing leaks, and exceptionally noisy or hot Pacer pump bearings. The necessary corrective action should be taken.

2. The operator must inspect #1 and #2 Pacer pumps to see that they are running. If #3 Pacer pump is running, it is an indication that a

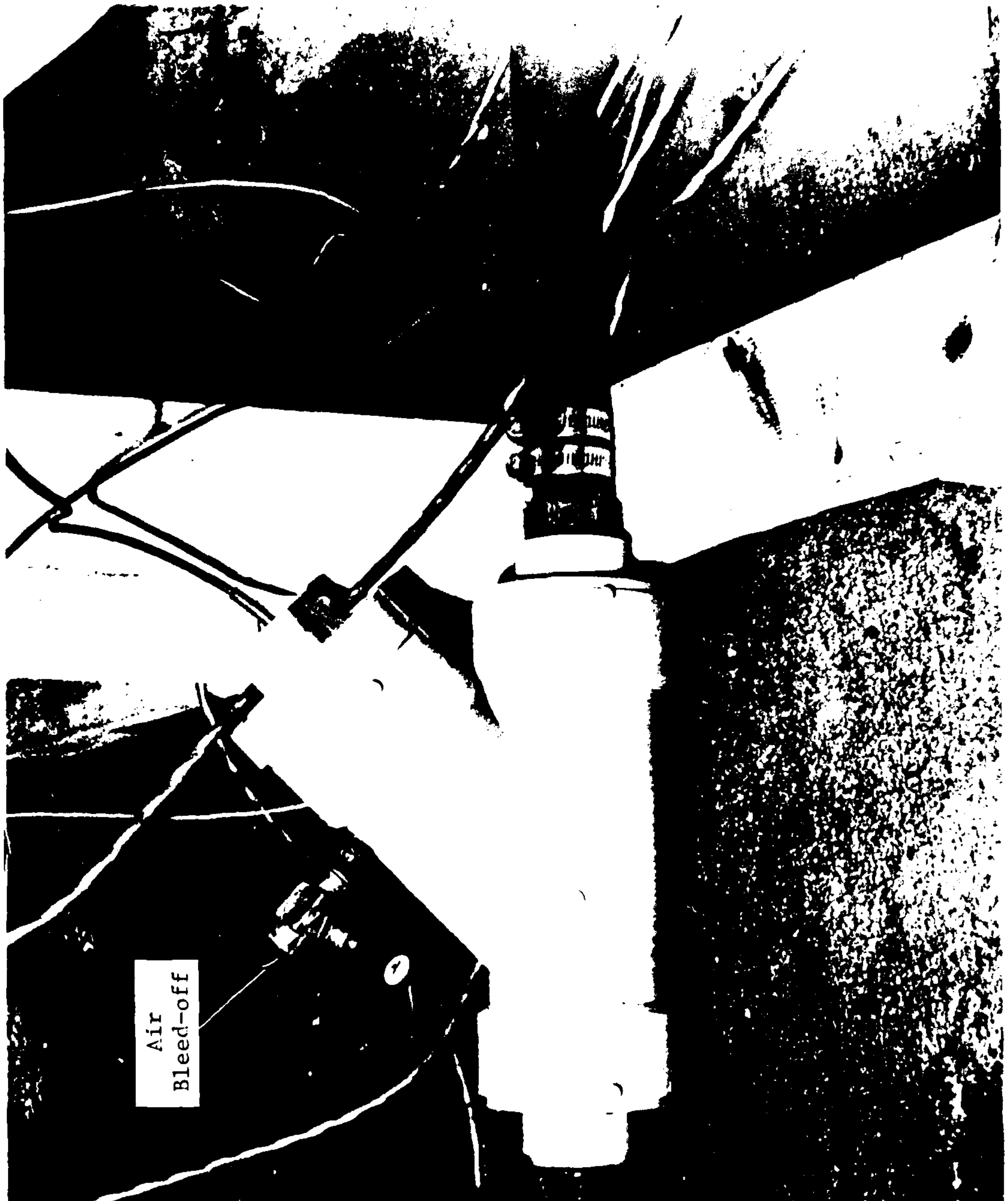


FIGURE 18. FLOW CELLS

a pressure drop has occurred at some time, causing it to come on automatically. Proper corrective measures must be taken as necessary. Pumps #1 and #2 should be able to maintain a 30 psi header pressure with eight tubes on-line. A single pump should be able to maintain a 30 psi header pressure with six tubes on-line.

3. The intake screen should be pulled up to the water surface, ensuring that it does not come clear of the water. It should be moved vigorously up and down to wash clear any grass or floating debris that has become attached. Once clean, it should fall back to the 7-foot submerged position.

4. The flow to buses 1 and 2 should be shut down by closing their valves at the header. The PVC end plugs must then be removed and the interior of each tube cleaned by passing a brush through each one several times and flushing with fresh water. End plugs should be replaced and #1 and #2 header valves opened to resume flow through each tube. Flows should then be reset.

5. The brushes in flow driven brush tubes 5 and 6 should be cycled using the switches on each counter/control box. The operator must ensure a complete brush cycle in each tube.

6. The sponge balls should be cycled in recirculating sponge rubber ball tubes 7 and 8 using the switches on each counter/control box. The operator must ensure a complete ball cycle in each tube and observe for the release position. If the catcher is in the release position, i.e., plunger down, then an electronic problem exists.

7. A visual check of the Clampitron flowmeter unit located in the computer trailer is made to ensure sea water flow of 16 gpm. The flow must be adjusted as necessary by opening or closing the exit valve for each tube. A remote cord is located near all exit valves to facilitate flow adjustment using a Simpson or equivalent VOM meter (1 VDC = 2 gpm).

8. WD-40 or an equivalent lubricant should be sprayed liberally on all Pacer pump bearing shafts and couplings as well as recirculating sponge rubber ball mechanicals.

9. At 1000 hours (i.e., 10 AM) an intermittent chlorination test must be run on tubes 9 and 10. The operator must chlorinate sea water flow in tubes 9 and 10 at the required dosage for 15 minutes daily, taking care to chlorinate tube 10 first.

10. As required, in-line filters must be cleaned without disrupting flow. Any grass and debris should be removed from screens.

11. The computer must be checked for:

a. Adequate paper in printer
b. Jammed printer
c. Adequate data files remaining on storage disk
d. Dropped tubes
e. Tube Rfs

12. The operator must ensure that the air conditioners in the computer trailer and the electrical shack are working properly. If not, he should report conditions to the project leader.

13. The LSTDSK (list disk) for the previous day must be run to obtain mean daily Rf. A report of the average daily fouling resistance should be made to the task leader.

14. After maintenance has been completed, the OTEC computer program must be restarted. All tubes must remain on-line during the heat/cool cycle. If not, the problem (VARIAC voltage, flow, etc.) must be corrected and the program restarted.

15. A log including problems, corrective actions, operating conditions, flow driven brush/recirculating sponge rubber ball cycle counts, and events must be kept on a day-to-day basis.

WEEKLY

The following actions should be performed on a weekly basis:

1. The chlorine analyzer probes must be inspected for damage to membranes, electrolyte, zero, and stability and corrected as required.

2. Flow zeroes on tubes must be checked and adjusted on individual flowmeter cards.

3. Flowmeter sections must be cleaned with a stiff brush to reduce noise due to reflections off of soft fouling.

MONTHLY

There is only one requirement for monthly maintenance. This concerns a detailed check of flow accuracy for all tubes. Techniques for flow accuracy check are set forth in a separate report.

APPENDIX A

DETAILS ON PACER PUMPS

OTEC PUMPS

DATA:

Pacer Pump Assembly:

Pump

Number of Pumps: 3

1 pump runs continually during test period (depending on HTUs being tested)

electric motor driven, pedestal mounted pump

Model Number: 208320-706

Code Number: P2882

Option: 016

Price: $300.00/pump

Company Address: Pacer Pumps
7 Peters Road
P. O. Box 135-A
New Holland, Pennsylvania 17557
(717) 656-2161

Motor

Number of Motors: 1 per pump

Electric Motor

Catalog Number: M3616T

Specification: 36A01-193

Frame Number: 184T (Ser. No. 277)

Horse Power: 7.5

Volts: 208/230/460 A.C.

R.P.M.: 3450

Amperage: 20.5 - 19.4/5.7

Service Factor: 1.0

Phase: 3

Company: Baldor Industrial Motor (Procured through Pacer Pumps)

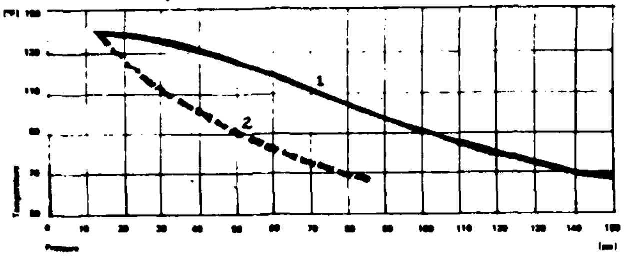
Price: $275.00/motor

APPENDIX B

STRAINER DETAIL

LINE STRAINER ENGINEERING DATA

Pressure/Temperature Characteristics



Conveyance of non-dangerous[1] and dangerous[2] fluids

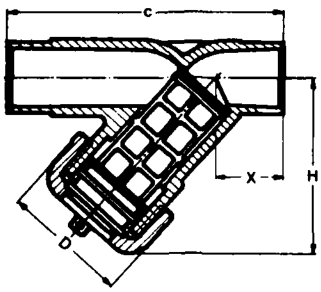
C_v Values

Nominal Size (IPS)	*C_v	k_v
½	2.45	35
¾	4.48	64
1	6.30	90
1¼	10.78	154
1½	15.75	225
2	25.90	370
3	—	—

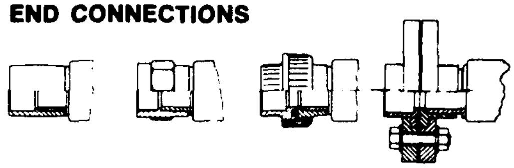
C_v = U.S. Gallons Per Minute @ 1 PSI Pressure Drop.
k_v = Liters Per Minute @ 1 BAR Pressure Drop.

TECHNICAL DATA Dimensions and Weights

All dimensions are in inches, unless otherwise noted



END CONNECTIONS



Female Socket   Female Thread   Union   Flange

Nominal Size (IPS)	½"	¾"	1"	1¼"	1½"	2"	3"
C	5.62	6.30	6.83	7.40	8.07	8.86	12.23
D	1.89	2.13	2.44	2.80	1.47	4.06	4.72
H	2.56	3.00	3.56	4.13	4.88	5.81	8.06
X	1.34	1.70	1.72	1.83	2.05	2.36	3.84
Approx. Weight each (lbs.)	.24	.37	.56	.84	1.40	2.21	5.66

For a guide to the suitability of these valves in your application, please consult the +GF+ Chemical Resistance Handbook

SAMPLE SPECIFICATION

All thermoplastic Line Strainers are to be made of transparent PVC and have screens with____mesh and ___diameter holes (specify 8 mesh 3/32", 12 mesh 1/16", 20 mesh 1/32" or 30 mesh 1/64") and have EPDM O-ring seals, as manufactured by Plastic Systems, Inc., 926 South Lyon Street, Santa Ana, Ca. 92705. Telephone (714) 558-8226.

WARRANTY

Seller's products are carefully inspected for manufacturing defects, however, it is not always possible to detect hidden defects. Said products are warranted only to the extent that Seller will replace without charge, products proved to have manufacturing defects within 6 months of the date of delivery thereof and provided Seller has been given an opportunity to inspect the product alleged to be defective and the installation or use thereof. NO WARRANTY IS INCLUDED AGAINST ANY EXPENSE FOR REMOVAL, REINSTALLATION OR OTHER CONSEQUENTIAL DAMAGES ARISING FROM ANY DEFECT. THE WARRANTIES SET OUT ABOVE ARE THE ONLY WARRANTIES, MADE BY SELLER AND ARE EXPRESSLY IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING THE WARRANTIES OF MERCHANTIBILITY AND FITNESS FOR A PARTICULAR PURPOSE

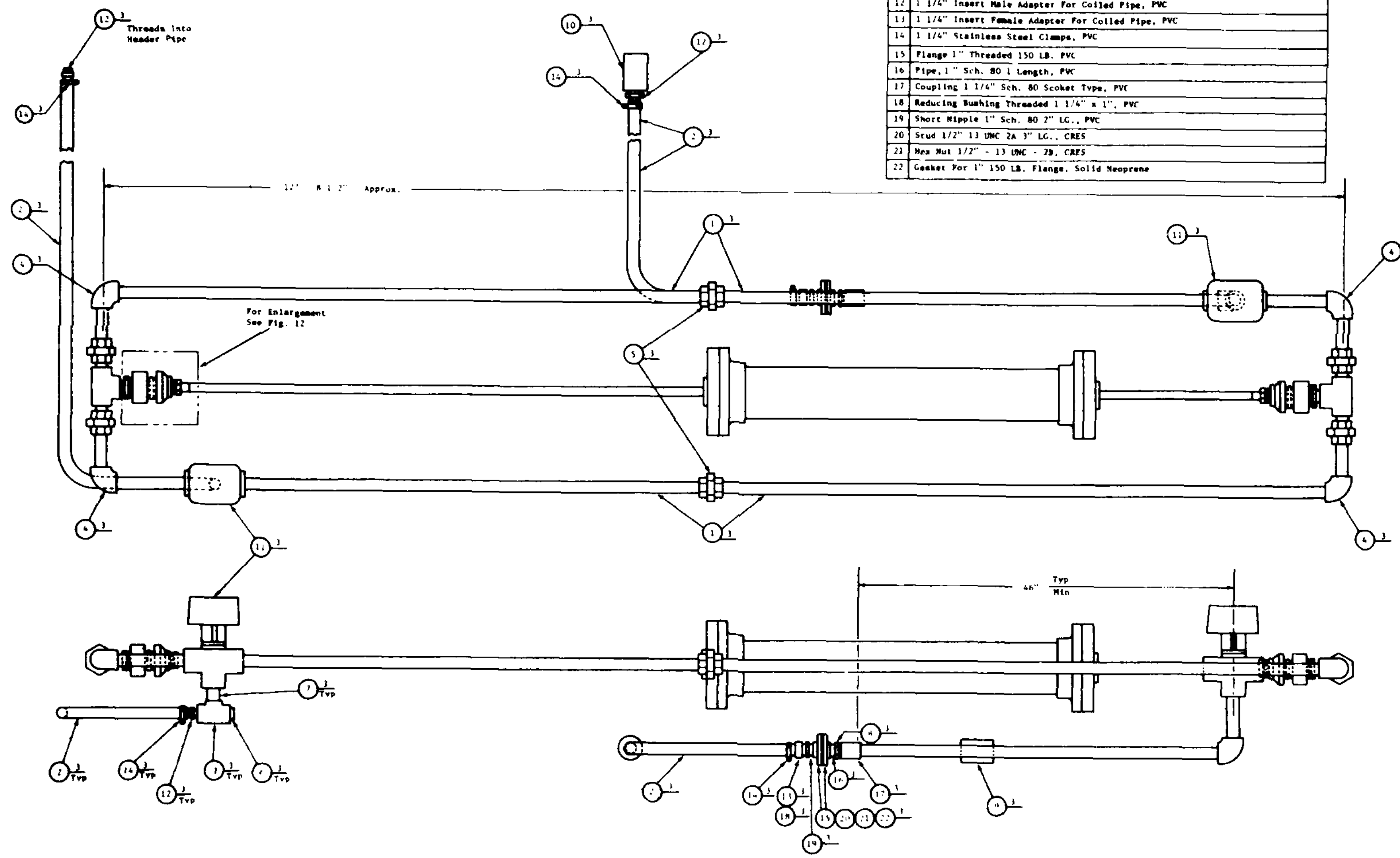
[1]TRADEMARKS OF THE E. I. DUPONT COMPANY

+GF+ PLASTIC SYSTEMS, INC.
926 S. Lyon St., Santa Ana, Ca. 92705
Telephone (714) 558-8226 Telex 68-5516
For technical assistance, dial toll free (800) 854-3773

APPENDIX C

FLOW DRIVEN BRUSH SYSTEM

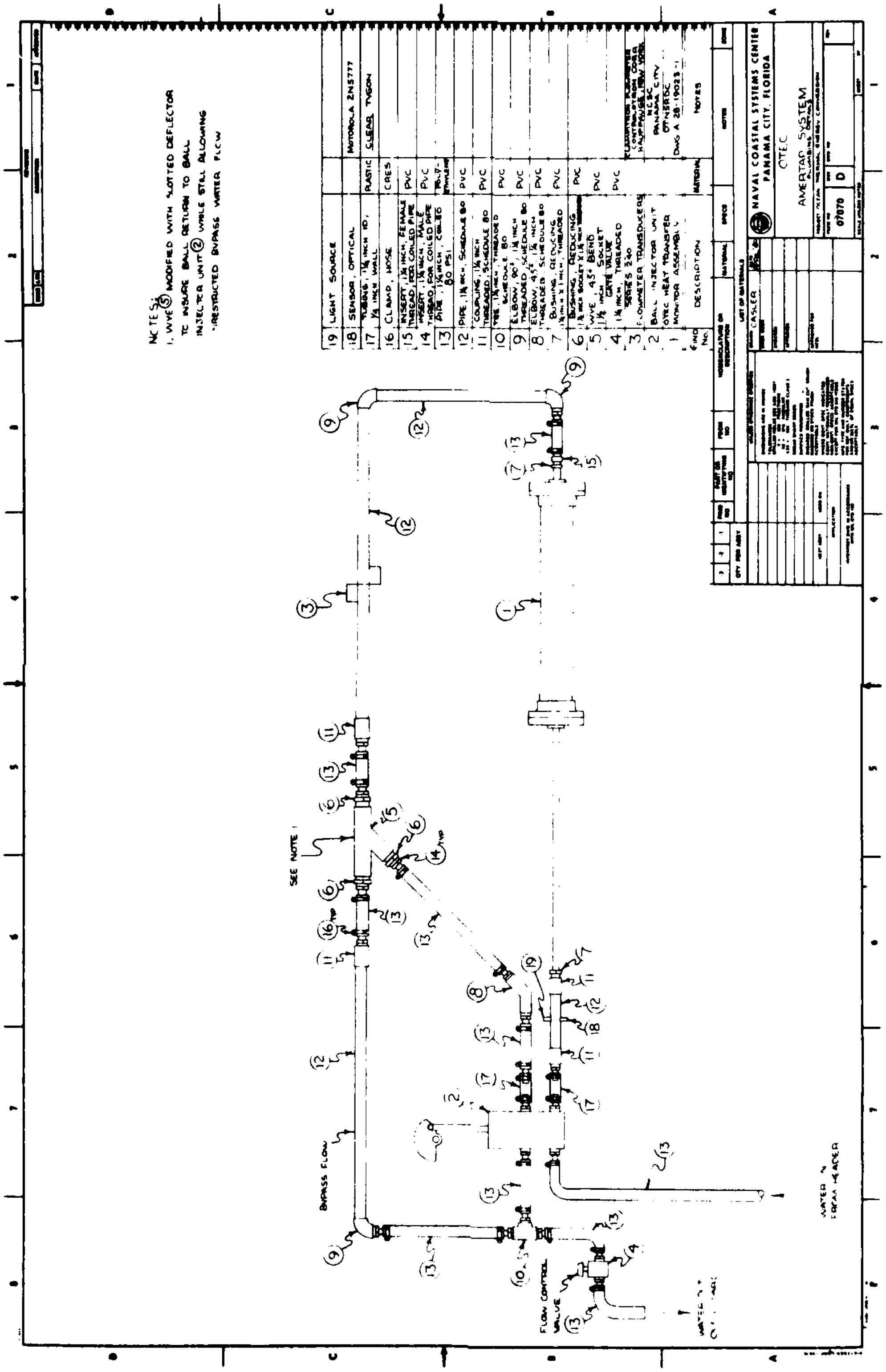
1	Pipe, 1 1/4" Sch 80 3 Lengths, PVC
2	Pipe, 1 1/4" Coiled 80 Psi, Ultra High Molecular Weight 1406, Polyethylene
3	Tee, 1 1/4" Sch 80 Threaded, PVC
4	Elbow, 90° 1 1/4" Sch 80 Scoket, PVC
5	Union, 1 1/4" Sch. 80 Scoket, PVC
6	Plug 1 1/4" Sch 80 Threaded, PVC
7	Short Nipple 1 1/4" Sch 80 x 2 1/2" Long, PVC
8	Reducing Bushing 1 1/4" x 1" Scoket, PVC
9	Flow Meter Fits Over 1 1/4" Sch 80 P.V.C. Pipe
10	1 1/4" Flow Regulating Valve Threaded End, PVC
11	1 1/4" Angle Valve 2 Position 3 Connection Electric Operated George Fisher # 150.132, Type 130,PVC
12	1 1/4" Insert Male Adapter For Coiled Pipe, PVC
13	1 1/4" Insert Female Adapter For Coiled Pipe, PVC
14	1 1/4" Stainless Steel Clamps, PVC
15	Flange 1" Threaded 150 LB. PVC
16	Pipe, 1" Sch. 80 1 Length, PVC
17	Coupling 1 1/4" Sch. 80 Scoket Type, PVC
18	Reducing Bushing Threaded 1 1/4" x 1", PVC
19	Short Nipple 1" Sch. 80 2" LG., PVC
20	Stud 1/2" 13 UNC 2A 3" LG., CRES
21	Hex Nut 1/2" - 13 UNC - 2B, CRES
22	Gasket For 1" 150 LB. Flange, Solid Neoprene



PIPING SYSTEM FOR FLOW DRIVEN BRUSHES

APPENDIX D

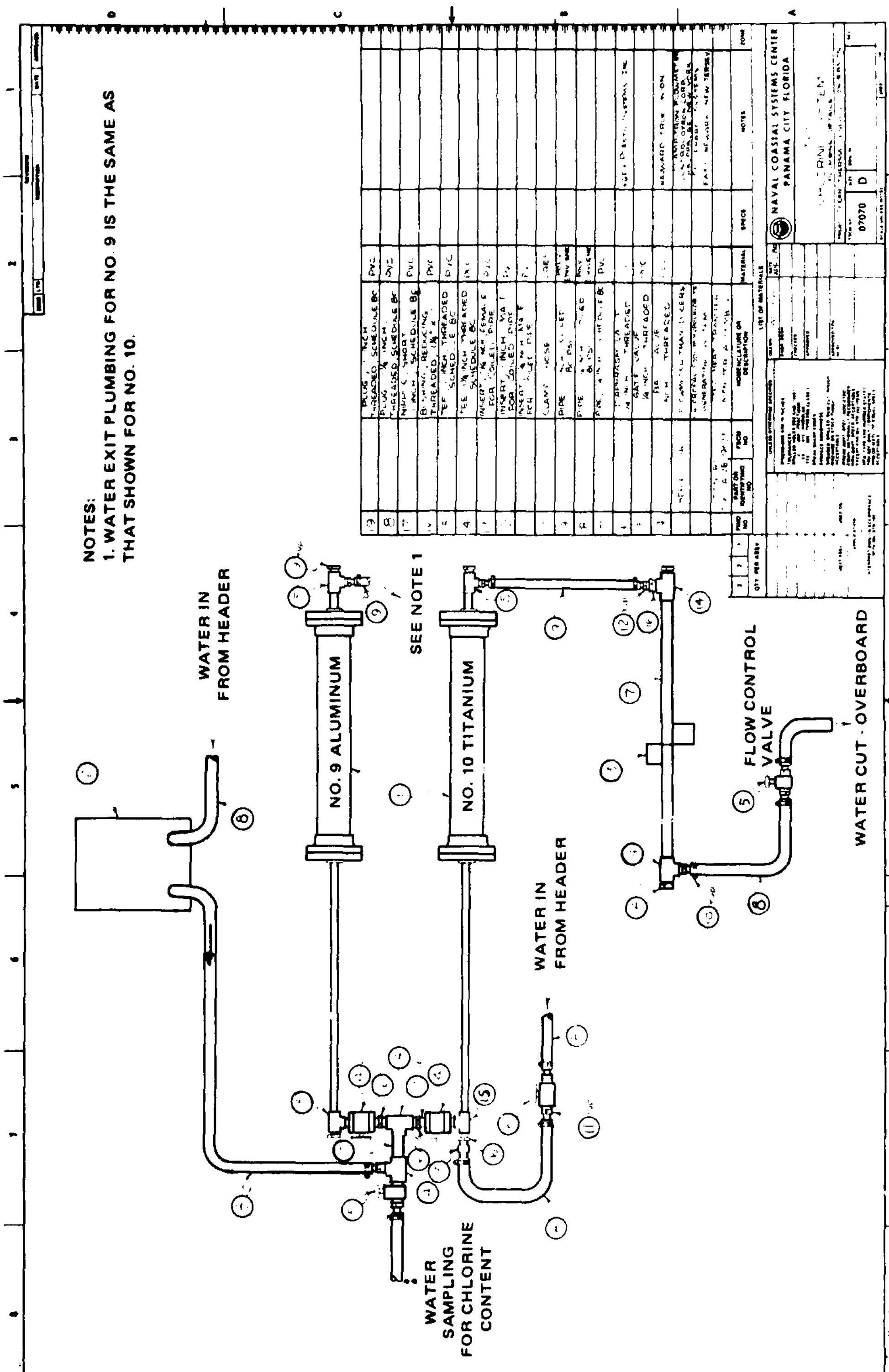
RECIRCULATING SPONGE RUBBER BALL SYSTEM



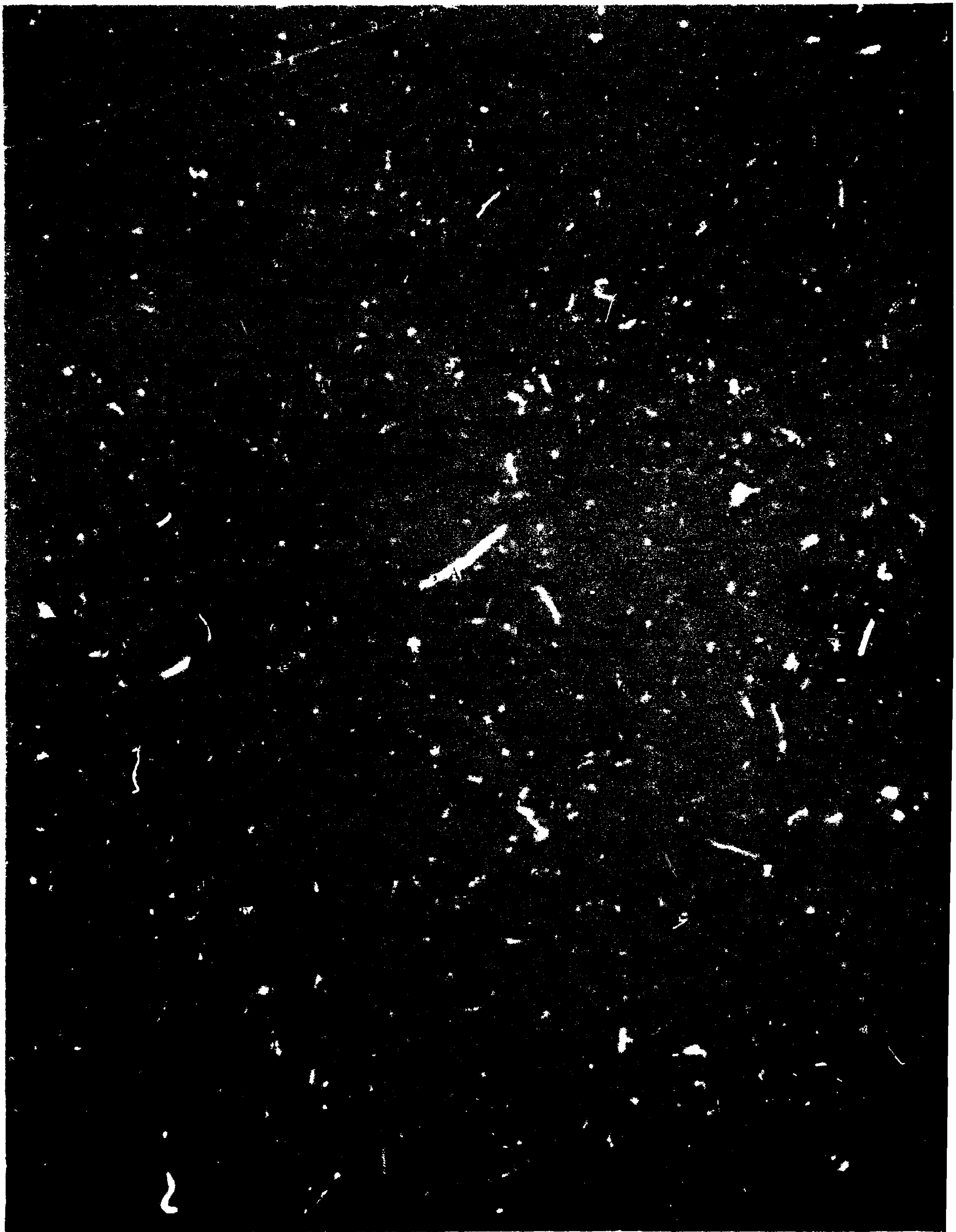
PIPING SYSTEM FOR RECIRCULATING SPONGE RUBBER BALL SYSTEM

APPENDIX E

CHLORINATION SYSTEM



PIPING SYSTEM FOR INTERMITTENT CHLORINE DOSING ON ALUMINUM AND TITANIUM TUBES



DATE
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