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DOE/NASA CONTRACTOR
REPORT

DOE/NASA CR-150870

SOLAR HEATING AND HOT WATER SYSTEM INSTALLED AT
LISTERHILL, ALABAMA

Prepared from documents furnished by

Reynolds Metals Company
Product Development Division
Richmond, Virginia 23261

Under DOE Contract G-77-A-01-4070

Monitored by the

National Aeronautics and Space Administration
George C. Marshall Space Flight Center, Alabama 35812

For the U. S. Department of Energy

(NASA-CR-150870) SOLAR HEATING AND HOT
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U.S. Department of Energy



Solar Energy



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INTRODUCTION

- 1.0 A technical proposal for a solar space heating and potable hot water heating demonstration system at Reynolds Metals Shower and Change Facility in Listerhill, Alabama was submitted to Energy Research and Development Administration (now a part of U.S. Department of Energy) and was accepted. The solar system was designed to provide 79% of the estimated annual space heating load and 59% of the estimated annual potable hot water requirement. Back-up space heat is provided with an electric resistance heater and back-up hot water is provided with six 120 gallon electric hot water heaters.
- 2.0 The shower and change facility is similar to those widely used by industry. It has 3534 square feet of floor space and 3446 square feet of wall space. Thirty seven showers and 210 lockers are available in the facility. The building has double walls constructed of concrete blocks with styro-foam insulation between the walls.
- 3.0 The solar energy collection system consists of 80 Reynolds Metals flat plate aluminum collectors, a differential temperature controller, a pump, and a 5,000 gallon unpressurized underground steel storage tank. The solar working fluid is water that has been treated with NALCO 2755 inhibitor. All of the collectors are arranged to operate with the same pump and are installed with gravity drainage for freeze protection.

4.0 The collectors are grouped in four arrays of twenty collectors each. Three arrays are mounted on the roof and the remaining array is mounted in a field on a concrete pad behind the building. All of the collectors are facing due south at a fixed tilt angle of 45 degrees. Each collector is a double-glazed 4' x 8' x 3-5/8" panel with an effective collector area of approximately 30 square feet.

5.0 The stored solar energy can be used to provide space heat and/or potable hot water. Subject to demand and sufficient temperature differentials, space heat is provided by circulating water from the solar storage tank through a liquid-to-air heat exchanger mounted in the air duct. To heat potable water, water from the solar tank is circulated through a counterflow liquid-to-liquid heat exchanger where it heats water being circulated from the 1400 gallon potable water storage tank. The system also has the flexibility of giving priority to space heating if desired. If the temperature of the solar storage water reaches 185°F, excess heat is dumped by circulating solar water through a counterflow liquid-to-liquid heat exchanger where it heats tap water being circulated from a commercial cooling tower.

6.0 The project was initiated in September, 1977 and declared operational in April, 1978 with the completion of the acceptance tests. The installation was dedicated on Sunday, May 3, 1978.

7.0 This report describes, in considerable detail, the design, construction, start-up, acceptance testing, operation and maintenance of the solar system installed at Reynolds Metals Shower and Change Facility in Listerhill, Alabama. It is hoped this information and experience will be helpful to others who elect to use solar energy in similar applications.

SUMMARY OF PROJECT INFORMATION

1.0 General Information

- 1.1 Owner: Reynolds Metals Company
Richmond, Virginia 23261
- 1.2 Contractor: Smith General Contractors, Inc.
Florence, Alabama
- 1.3 Operational Date: April, 1978
- 1.4 Building:
 - 1.4.1 Type: One story, flat roof, no windows
 - 1.4.2 Use: Shower and Change House
 - 1.4.3 Floor Area: 3534 ft.²
 - 1.4.4 Construction: Double wall
 - 1.4.5 Wall Material: Concrete blocks
 - 1.4.6 Insulation: Styrofoam between blocks

2.0 Climatological Data

- 2.1 Latitude: 34°-39'N
- 2.2 Heating Degree Days: Yearly 3302; January 746
- 2.3 Peak Daily Insolation: 350 BTU/ft.²
- 2.4 Yearly Sunshine: 58% (Birmingham, Alabama data)

3.0 Solar Energy System

- 3.1 Application: Heating 79%; hot water 59%
- 3.2 Collector:
 - 3.2.1 Type: Flat plate, Liquid
 - 3.2.2 Glazing: Teflon inner; Tedlar outer
 - 3.2.3 Absorber Material: Aluminum Alloy 1350-0
 - 3.2.4 Absorber Coating: Siliconized Polyester Paint
 - 3.2.5 Tilt Angle: 45°
 - 3.2.6 Total Area: 2344 ft.² net
 - 3.2.7 Manufacturer: Reynolds Metals Company
Richmond, Virginia 23261
- 3.3 Storage:
 - 3.3.1 Medium: Water inhibited with NALCO 2755
 - 3.3.2 Container: Underground, unpressurized steel tank
 - 3.3.3 Capacity: 5000 gallons

4.0 Back-up System

- 4.1 Space Heat: Electrical Resistance
- 4.2 Hot Water: 6-120 gallon electric tanks

ALLOY SYSTEM COST SUMMARY

<u>Cost Element</u>	<u>Estimated Cost</u>	<u>Actual Cost</u>
o System Design	\$ 38,107	\$ 39,917
o Materials		
- Frames	\$ 2,464	\$ 1,932
- Collectors	\$ 15,920	\$ 16,385
- Tanks	\$ 8,764	\$ 8,954
- Heat Exchangers	\$ 3,709	\$ 2,952
- Controls	\$ 1,190	\$ 3,806
- Others	\$ 3,677	\$ 7,012
o Construction & Installation		
- Mechanical	\$ 29,357	\$ 31,368
- Electrical	\$ 7,955	\$ 4,857
- General	\$ 14,952	\$ 19,898
- Tanks	\$ 4,640	\$ 3,829
o Project Management	\$ 13,089	\$ 17,494
	<hr/>	<hr/>
	\$ 143,824	\$ 158,404

PROJECT CHRONOLOGICAL

- 1.0 June, 1977 - Reynolds Metals was advised that its proposal for a solar energy demonstration project had been selected for negotiation of a cooperative agreement.
- 2.0 September, 1977 - Reynolds Metals was awarded a contract which stipulated that ERDA (now a part of DOE) would pay \$71,916 or 50% of the estimated total cost.
- 3.0 September, 1977 - A final Design Review was held with government team (Planning Research Company and Marshall Space Flight Center personnel). Minor design and operation points were resolved and clarified.
- 4.0 October, 1977 - A preconstruction meeting was held with general contractor and his mechanical subcontractor to discuss construction and scheduling.
- 5.0 October, 1977 - The site preparation began. The site was partially graded and concrete foundations poured for the ground mounted collector array. Temporary roof protection and steel support foundations for roof mounted collector arrays were installed.
- 6.0 November, 1977 - The collector support stands were assembled and installed. The collectors and 5000 gallon steel storage tank were ready for installation.

- 7.0 December, 1977 - All collectors were mounted to frames. Both liquid-to-liquid heat exchangers were mounted. Three pumps were mounted and approximately 30% of the plumbing was completed. Outside plumbing was delayed by severe inclement weather. The 5000 gallon storage tank was installed and backfilled. The installation and checkout (and therefore operation) were delayed approximately one month.
- 8.0 January, 1978 - The liquid-to-air (space heat) heat exchanger was installed. The concrete pad for cooling tower was poured and the cooling tower mounted (The fan motor for cooling tower had to be returned. The manufacturer had shipped a 110V motor instead of a 440V motor). The plumbing was approximately 75% complete, but no insulating or electrical work had been completed. Both plumbing and insulating were delayed another month by severe inclement weather. Also, late delivery of the 1400 gallon potable water preheat tank had prevented the plumbing contractor from completing his inside work. The control panel had been assembled and was ready for installation. A delay on open house was requested until May to allow ample time to have the system operating properly for dedication.
- 9.0 February, 1978 - All plumbing and electrical work had been completed. The insulation was 95% complete. The site grading was 85% complete.

- 10.0 March, 1978 - Installation check-out and acceptance tests began on March 13, 1978. All acceptance tests were completed, with the exception of the heat dump test, during the week of March 20. The pump in the potable loop of the heat dump system was undersized and had to be replaced. The system was operational with the exception of the heat dump loop.
- 11.0 April, 1978 - The new pump was installed in the heat dump system and the acceptance test was completed. The system was completely operational.
- 12.0 May, 3, 1978 - The open house and the dedication ceremony of installation was held in conjunction with Sun Day. Mr. John Blomquist, President of Reynolds Metals and Mr. Dan Henry, Government Project Manager, Marshall Space Flight Center, made short presentations to a group of about 65 local VIPs and news media personnel. Later in the day, the facility was opened to the public.

SYSTEM OPERATION AND CONTROL LOGIC

(Reference RMCo Dwg. No. 45616107R and System Schematic)

- 1.0 Main Solar Loop - The main solar loop or solar energy collection system consists of 80 Reynolds collectors, a pump and a 5,000 gallon unpressurized underground steel storage tank. Water from the underground steel storage tank is circulated through the collectors where it is heated and then returned to the storage tank.
- 1.1 The solar collection loop is controlled with a differential temperature controller (LTC) which can be set for either manual or automatic operation. With the controller set on automatic, whenever the sensor located in the collector senses a temperature which is approximately 15°F greater than the sensor located in the solar storage tank, the controller (LTC) activates motor starter (LM) causing pump (LMTR) to circulate water between the collectors and the storage tank (The sensors are solid state thermistors which can provide accuracy from extended distances. The sensors are encapsulated in one-quarter inch copper tubing and are rated at temperatures of 300°F). Circulation of the solar water continues until the differential temperature between the sensors drops to 5°F or the temperature of the solar water in the tank reaches a maximum temperature of 190°F. When either one of these conditions is reached, the controller (LTC) deactivates the solar pump (LMTR). The system will resume operation when the temperature

differential reaches 15°F and/or the temperature of the solar water drops to 180°F.

1.2 Motor starter (1M) also energizes a normally open solenoid valve (1SOL) in the drain-down by-pass line of the solar supply loop (This solenoid valve allows the solar collector loop to drain down when the system is not operating, thus providing freeze protection).

1.3 The water level in the solar storage tank is controlled by a conventional liquid level sensor. A totalizing flowmeter is located in the makeup water line in order to record the quantity of uninhibited water added to the system.

2.0 Heat Dump Loop - Excess heat from the solar storage tank is dumped by circulating the solar water through a counter-flow liquid-to-liquid heat exchanger where it heats tap water being circulated from a commercial cooling tower.

2.1 The heat dump (cooling tower) loop is controlled by a thermostat (3TAS) with a capillary located in the solar water storage tank which closes when the solar water temperature reaches 185°F. Upon closing, the thermostat energizes control relay (2CR) which activates the motor starter for the cooling tower fan and motor starter (4M) which starts pumps (4MTR) and (5MTR). The pumps will continue to circulate water until the temperature of the solar water drops to approximately

175°F causing the thermostat to open and shut down the heat dump subsystem.

3.0 Space Heat Subsystem - Space heat is provided upon demand by circulating water from the solar storage tank through a liquid-to-air heat exchanger mounted in the air duct.

3.1 The space heat loop is controlled by thermostat (2TAS located in the locker room) connected in series with differential temperature controller (3TC) (The solar space heat thermostat is set approximately 2°F higher than the back-up furnace thermostat. This allows the solar heating system to activate first). When the locker room thermostat (2TAS) closes (calls for heat) and the controller (3TC) senses that the temperature of the solar water in the storage tank is 15°F or greater than the air temperature in the space heat duct, motor starter (3M) is activated. This causes pump (3MTR) to circulate solar water through the liquid-to-air heat exchanger mounted in the air duct. The system will continue to operate until the temperature differential between the solar water and air inside the duct drops to 5°F or the thermostat in the locker room opens.

3.2 The control system has a temperature limit switch (1TAS) which can be used to reserve all stored solar energy for space heating whenever the outside ambient is below a

specified temperature. The temperature limit switch (LTAS) is connected in series with the differential temperature controller (2TC) for the potable hot water subsystem, and will not allow controller (2TC) to activate until the outside ambient reaches the preset temperature. (The temperature limit switch can be bypassed by setting switch (SS1) on the control panel to HAND position. Bypassing the temperature limit switch (LTAS) allows any stored solar energy to be used for space heating and/or potable hot water subject to temperature differentials and demand).

4.0 Potable Hot Water - Water from the solar storage tank is circulated through a counter-flow liquid-to-liquid heat exchanger where it heats potable water being circulated from a 1400 gallon potable water storage tank.

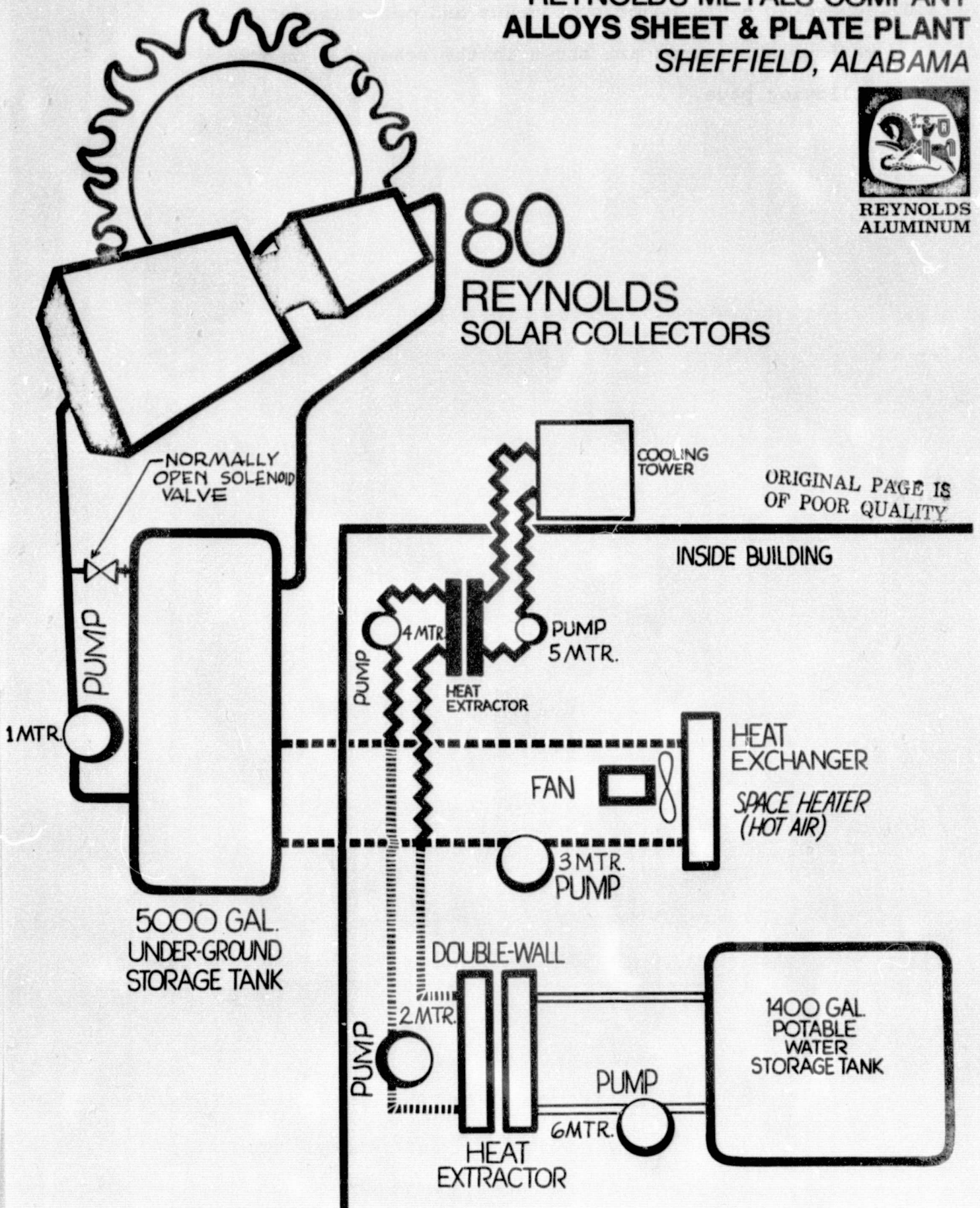
4.1 The potable hot water subsystem is controlled by a differential temperature controller (2TC). The controller has one sensor located near the top of the storage tank and the other sensor located near the bottom of the potable hot water tank. If the temperature of the water in the solar storage tank is 8°F higher than the temperature of the water in the 1400 gallon potable tank, the controller energizes control relay (1CR) which in turn activates motor starter (2M) starting pumps (2MTR and 6MTR). The system will continue to operate until the differential temperature between the solar water and potable hot water drops to 5°F.

5.0 Schematic - The major components and operation of the various subsystems are shown in the schematic on the following page.

SYSTEM SCHEMATIC
REYNOLDS METALS COMPANY
ALLOYS SHEET & PLATE PLANT
SHEFFIELD, ALABAMA



80
REYNOLDS
SOLAR COLLECTORS



SYSTEM DESIGN CHANGES FROM ORIGINAL
PROPOSAL AND CONSTRUCTION PROBLEMS

1.0 Design Changes

- 1.1 The spray pond in the heat dump system was changed to a cooling tower. The cooling tower was believed to be more practical and cost effective.
- 1.2 The dual prefabricated concrete storage tanks were changed to a single steel storage tank. Experience with a similar installation at another Reynolds Metals location indicated that a single storage tank would greatly simplify controls and reduce system down time.

2.0 Construction Problems

- 2.1 The biggest construction problem was inclement weather conditions during December and January. The contractor was able to do very little outside work during these two months.
- 2.2 Late delivery of the 1400 gallon potable water tank delayed completion of the plumbing approximately two weeks.
- 2.3 An undersized pump in the potable loop of the heat dump system delayed completion of the acceptance test plan approximately two weeks.
- 2.4 The fan motor for the cooling tower had to be returned. The manufacturer shipped a 110V motor instead of a 440V motor.

ACCEPTANCE TEST PLAN

(Reference RMCo. Dwg. No. 45616107R)

- 1.0 Introduction - In order to verify that the completed solar system meets performance requirements, the various subsystems and their respective critical components or elements will be isolated and tested. The following acceptance test plan outlines the critical subsystem components to be tested, the test objectives, test requirements and test procedures.

- 2.0 Collector Solar Loop - This loop circulates inhibited water through the collectors when heat can be gained and stores it in an underground unpressurized steel storage tank.
- 2.1 Leak Testing - Upon completion of installation, the solar loop will be isolated and hydrostatically tested at 50 psig minimum (60 psig maximum) for 15 minutes to insure that no leaks are present in system.
- 2.1.1 Install gate valves (or caps) in collector supply and return lines at unions as close to the storage tank as possible.
 - 2.1.2 Cap or valve solar supply 3/4" drain down line at union as close as possible to solenoid valve (1SOL) on storage tank.
 - 2.1.3 Close all gate valves installed in 2.1.1 and 2.1.2
 - 2.1.4 Remove air release valve from one bank of collectors on roof and insert a nipple.
 - 2.1.5 Fill system and all lines with tap water through nipple.
 - 2.1.6 Remove nipple and replace air release valve.
 - 2.1.7 Connect positive displacement pump at any convenient location.
 - 2.1.8 Pressurize system to 50 psig minimum (60 psig maximum).
 - 2.1.9 Maintain 50 psig minimum for 15 minutes and check each fitting and connection for leaks.
 - 2.1.9.1 Repair all leaks. System must maintain 50 psig for 15 minutes after all leaks have been repaired.
 - 2.1.10 Upon completion of pressure test, drain system (Test water not to be added to solar storage tank).
 - 2.1.11 Disconnect positive displacement pump and reconnect piping.
 - 2.1.12 Remove temporary gate valves or caps from supply, return and drain down lines of solar loop. Reconnect all lines to solar storage tank.

2.2 Balancing Flow Rate of Collector Banks - The objective of this test will be to balance the flow rate in the solar loop. The main solar loop consists of four collector arrays with 20 collectors in each array. Each array is fitted with a differential pressure measuring device. Flow rates will be balanced in each array and the total flow rate recorded. A by-pass valve parallel to the solar pump will be used to control the desired total flow through the collector arrays.

2.2.1 Deactivate all pumps by opening pump disconnect switches (1DISC through 6DISC).

2.2.2 Check solar loop pump (1MTR) for prime. IF PUMP NEEDS PRIMING, REFER TO SECTION 8.0 IN START-UP PROCEDURE FOR PRIMING PRACTICES.

2.2.3 Check for proper operation of normally open solenoid valve in by-passline near underground solar storage tank (Solenoid valve (1SOL) must close when power is on to pump).

2.2.4 Open all 1-1/2" valves and all florater valves in solar loop. Close 3/4" valve in pump (1MTR) by-pass.

2.2.5 Set switch of solar loop controller (1TC) on MANUAL.

2.2.6 Start solar loop pump (1MTR) by closing pump disconnect switch (1DISC).

2.2.7 Using Thrush Model 832 Florater meter and Thrush Florater balancing valve, check and/or set flow rate on ground mounted collectors (Optimum flow rate 10 to 13 gpm).

2.2.7.1 Open carrying case and place test kit in a convenient spot on test site with test kit horizontal.

2.2.7.2 With test kit balance valve closed, connect hoses to florater - Red hose upstream, high pressure - Green hose downstream, low pressure.

2.2.7.3 Open test kit balance valve.

2.2.7.4 Open high and low bleed valves alternately to purge air from system (Bleed water discharges from convenient clear plastic flexible tube).

- 2.2.7.5 When bleeding shows all air removed, close test kit balance valve and read differential pressure gauge. Refer to chart in Appendix I in Maintenance Manual for conversion to gpm and additional instructions.
- 2.2.7.6 When test is complete, open test kit balance valve and disconnect test hoses from florater.
- 2.2.7.7 Store hoses by coiling them around the test kit panel.
- 2.2.8 Check and/or set florater on each bank of roof mounted collectors using the above procedure (Optimum flow rate 10 to 13 gpm per collector bank).
- 2.2.9 Recheck flow rate on ground mounted collectors and adjust if needed.
- 2.2.10 Repeat 2.2.7, 2.2.8 and 2.2.9 until flow rates approximately equal.
- 2.2.11 If florater setting is over 50, open pump (1MTR) by-pass valve slightly.
- 2.2.12 Repeat 2.2.10 and 2.2.11 until flows are equal and at desired rate and florater is operating in lower range.
- 2.2.13 Record flow rate for each collector array.
- 2.2.14 Shut off pump (1MTR) by opening disconnect switch (1DISC).
- 2.2.15 Move switch of solar loop controller (1TC) to OFF position.
- 2.3 Collector Array and Piping Heat Collection Efficiency -
The objective of this test will be to determine the collector array and piping heat collection efficiency. This requires that the total solar insolation available to the collector array and the net heat delivered to the storage tank be measured. The procedure will be to record the solar flux while simultaneously recording the inlet and outlet water temperatures and flow rates in the collector system. This data, along with the ambient temperatures, will provide a means of comparing the actual performance to the projected design performance.

- 2.3.1 Install thermocouple in tees at inlet and outlet of one array and connect to readout.
 - 2.3.2 Install thermocouple for ambient temperature and connect to readout.
 - 2.3.3 Install pyranometer on collector frame. Pyranometer must be oriented in same direction as collectors and connected to readout.
 - 2.3.4 Deactivate all pumps by opening pump disconnect switches (1DISC through 6DISC).
 - 2.3.5 Set switch of solar loop controller (1TC) on AUTO (Temperature of collector must be 15° higher than temperature of water in solar storage tank for system to operate automatically).
 - 2.3.6 Start pump (1MTR) to solar loop by closing disconnect switch (1DISC). BE SURE PUMP IS PRIMED BEFORE ATTEMPTING TO START PUMP.
 - 2.3.7 Record solar flux while simultaneously measuring inlet and outlet water temperature and flow rates in collector system plus ambient temperature.
 - 2.3.8 Upon completion of test, shut off pump (1MTR) by opening disconnect switch (1DISC).
 - 2.3.9 Move switch of solar loop controller (1TC) to OFF position.
 - 2.3.10 Analyze and plot data.
- 2.4 Heat Loss from Storage Tank - The objective of this test will be to determine the heat losses from the storage tank. This requires that the solar water in the tank be heated to a known temperature (MINIMUM WATER TEMPERATURE 120°F, PREFERRED WATER TEMPERATURE 140° OR ABOVE). The test procedure will be to place several thermocouples at various depths within the storage tank and to record the temperature drop versus time with the solar system deactivated. The volume of water and water-to-wall surface area will be recorded.
- 2.4.1 Deactivate system by opening all pump disconnect switches (1DISC through 6DISC).

- 2.4.2 Shut off make-up water to solar storage tank.
 - 2.4.3 Install thermocouples at three levels (1 foot from bottom, midway and at 1-6 inches below water surface) and connect to readout.
 - 2.4.4 Determine water level and/or volume in solar storage tank (See tank chart in Appendix G in Maintenance Manual).
 - 2.4.5 Record temperature measurement at one hour intervals for four hours minimum.
 - 2.4.6 Calculate overall heat transfer loss through wall of tank.
- 2.5 Freeze Protection - The objective of this test is to insure that freeze protection is provided by the gravity drain system. The basic requirement is that all or virtually all of the water in the collectors and piping drain back into the storage tank when the solar pump has been deactivated.
- 2.5.1 Inspect all collectors to see that they were installed in horizontal position plus or minus 1/8".
 - 2.5.2 Inspect all hoses and piping to insure that there are no high or low places where water can be trapped during drain down. (All areas that appear low are to be disconnected to check for the presence of water after drain down.)
 - 2.5.3 Using a four-foot carpenter's level, check to see that all piping is sloped to gravity drain when system is deactivated.
 - 2.5.4 Check to see that normally open solenoid in by-pass line at tank is closed when system is activated.

3.0 Subsystem Leak Tests - The solar water side of the heat dump, space heating and hot water subsystem are to be hydrostatically tested at 50 psig minimum (60 psig maximum) for 15 minutes to insure that no leaks are present. All potable water loops are to be hydrostatically tested at 125 psig minimum (150 psig maximum) for 15 minutes without leaking.

3.1 Solar Water Side for Heat Dump, Space Heating and Hot Water Subsystem

- 3.1.1 Install gate valves or caps in solar water supply and return lines at unions as close to solar storage tank as possible (Valves or caps must be installed at a location where supply and return lines are common to all three subsystems).
 - 3.1.1.1 Close all valves installed in above step.
- 3.1.2 Fill all lines in solar water loop of each subsystem with tap water at any convenient location (Use sill cock or other suitable valve and/or fitting to facilitate hose connection for filling and attachment of positive displacement pump for pressure testing).
- 3.1.3 Vent each subsystem while filling by loosening a plug or union at the highest point of each line. Retighten plug or union after venting completed.
- 3.1.4 Connect positive displacement pump and pressurize system to 50 psig (60 psig maximum).
- 3.1.5 Maintain 50 psig for 15 minutes and check all fittings and connections for leaks.
 - 3.1.5.1 Repair all leaks (System must maintain 50 psig for 15 minutes continuous after all leaks have been repaired).
- 3.1.6 Disconnect positive displacement pump, drain system and reconnect piping (Test water not to be added to solar storage tank).
- 3.1.7 Remove temporary gate valves or caps from supply and return lines and reconnect lines to solar storage tank.

3.2 Potable Water Subsystems and Loops

- 3.2.1 All potable water subsystems and loops to be hydrostatically pressure tested at 125 psig minimum (150 psig maximum) for 15 minutes using standard plumbing practices.
- 3.2.2 Repair all leaks. (System must maintain 125 psig minimum for 15 minutes continuous after all leaks have been repaired).

4.0 Heat Dump Subsystem - The objective of this test will be to measure the rate of heat dissipation when the cooling tower is operating. The basic design requirement is that the cooling tower dump at least be 1.6×10^6 BTU in a 24-hour interval. The procedure will be similar to that used in determining storage tank loss (Section 2.4) except that the pumps to the cooling tower heat exchanger will be activated (WATER IN SOLAR STORAGE TANK MUST BE HEATED TO 120°F MINIMUM WITH 140°F OR ABOVE PREFERABLE).

- 4.0.1 Deactivate system by opening all pump disconnect switches (1DISC through 6DISC).
- 4.0.2 Shut off make-up water supply to solar storage tank.
- 4.0.3 Check to see that cooling tower is filled with water and fan is operating properly (Refer to section 9.0 of Start-up Procedure in Maintenance Manual).
- 4.0.4 Manually operate heat dump subsystem pumps.
 - 4.0.4.1 Check to see that pumps are primed (Refer to section 8.0 in Start-up Procedure in Maintenance Manual).
 - 4.0.4.2 Start pump (4MTR) in solar side and bronze circulator (5MTR) in potable water side of cooling tower heat exchanger by placing switch (SS3) in HAND position and closing disconnect switch (4DISC and 5DISC) to each pump.
- 4.0.5 Measure temperature of water in solar storage tank with thermocouple at three levels (1 foot from bottom, midway and at 1-6 inches below water surface at top of tank).
- 4.0.6 With heat dump subsystem operating, record temperature measurements of each thermocouple at one-hour intervals for four hours minimum.
- 4.0.7 Upon completion of test, shut down system by opening pump disconnect switches (4DISC and 5DISC).
- 4.0.8 Determine water level and/or volume in solar storage tank (See tank chart in Appendix G in Maintenance Manual).
- 4.0.9 Determine rate of heat dissipation.

5.0 Space Heat Subsystem - The objective of this test is to insure that design heat delivery can be achieved. The test procedure consists of measuring the liquid flow rate to the heat exchanger with a differential pressure device and measuring the temperature drop in the liquid across the heat exchanger. Transfer line heat losses will be determined by recording the temperature drop between the outlet of the storage tank and the inlet to the heat exchanger (WATER IN TANK MUST BE HEATED TO 120°F MINIMUM WITH 140°F OR ABOVE PREFERABLE).

- 5.0.1 Install thermocouples on inlet and outlet of solar side of space heat exchanger and on solar supply line at connection to solar storage tank.
- 5.0.2 Set switch of space heat solar controller (3TC) on MANUAL.
- 5.0.3 Activate pump (3MTR) for space heating system by moving switch (SS2) in control panel to HAND position and closing pump disconnect switch (3DISC) (CHECK TO SEE THAT PUMP IS PRIMED).
- 5.0.4 Shut off back-up space heating system by turning thermostat in locker room down or shut off power.
- 5.0.5 Using Thrush Model 832 Florater meter and Thrush Florater balancing valve (located at heat exchanger outlet), determine flow rate through heat exchanger at 5 to 10-minute intervals for one-hour minimum.
 - 5.0.5.1 Open carrying case and place test kit in a convenient spot on test site with test kit horizontal.
 - 5.0.5.2 With test kit balance valve closed, connect hoses to florater - Red hose upstream, high pressure - Green hose downstream, low pressure.
 - 5.0.5.3 Open test kit balance valve.
 - 5.0.5.4 Open high and low bleed valves alternately to purge air from system (Bleed water discharges from convenient clear plastic flexible tube).
 - 5.0.5.5 When bleeding shows all air removed, close test kit balance valve and read differential pressure gauge. Refer to chart in Appendix I in Maintenance Manual for conversion to gpm.

- 5.0.6 Simultaneously record temperature at inlet and outlet of heat exchanger and supply line connection to tank for each corresponding flow rate.
- 5.0.7 When test is complete, open test kit balance valve before disconnecting test hoses from florater.
 - 5.0.7.1 Store hoses by coiling them around the test panel.
- 5.0.8 Restore system to normal operating mode. Shut pump (3MTR) off by opening pump disconnect switch (3DISC).
- 5.0.9 Compute heat delivered and transfer line losses.

6.0 Hot Water Subsystem - The objective of this test is to determine if the design heat transfer rate is obtained. The test requires the measurement of the temperature drop across the heat exchanger on the solar side while simultaneously recording the flow rate via a differential pressure device (WATER IN TANK MUST BE HEATED TO 120°F MINIMUM WITH 140°F OR ABOVE PREFERABLE).

- 6.0.1 Install thermocouple on inlet and outlet of solar side of potable water heat exchanger and on supply piping outlet to underground storage tank.
- 6.0.2 Deactivate solar space heat subsystem by turning solar space heat thermostat down or off.
- 6.0.3 Turn showers on to create demand for hot water if needed.
- 6.0.4 Set switch of potable water solar controller (2TC) on MANUAL.
- 6.0.5 Activate pumps (2MTR and 6MTR) for both sides of potable hot water heat exchanger by moving switch (SS1) in control panel to HAND position and closing disconnect switches (2DISC and 6DISC). CHECK PUMP FOR PRIME - FOR PUMP PRIMING PRACTICE, REFER TO SECTION 8.0 IN START-UP PROCEDURE.
- 6.0.6 Using Thrush Model 832 Florater meter and Thrush Florater balancing valve (located at heat exchanger inlet), determine flow rate through heat exchanger at 5 to 10-minute intervals for one hour minimum.
 - 6.0.6.1 Open carrying case and place test kit in a convenient spot on test site with test kit horizontal.
 - 6.0.6.2 With test kit balance valve closed, connect hoses to florater. Red hose upstream, high pressure - Green hose downstream, low pressure.
 - 6.0.6.3 Open test kit balance valve (bottom of panel).
 - 6.0.6.4 Open high and low bleed valves alternately to purge air from system (Bleed water discharges from convenient clear plastic flexible tube).

- 6.0.6.5 When bleeding shows all air removed, close test kit balance valve and read differential pressure gauge. Refer to chart in Appendix I in Maintenance Manual for conversion to gpm.
- 6.0.7 Simultaneously record temperature at inlet and outlet of heat exchanger and supply line connection to solar storage tank for each corresponding flow rate.
- 6.0.8 When test is complete, open test kit balance valve before disconnecting test hoses from florater.
 - 6.0.8.1 Store hoses by coiling them around the test panel.
- 6.0.9 Restore system to normal operating mode. Shut pumps off by opening pump disconnect switches (2DISC and 6DISC).
- 6.0.10 Compute heat delivered and transfer line losses.

RESULTS OF ACCEPTANCE TESTS

1.0 Introduction

A series of performance tests was conducted on the solar system to demonstrate various performance requirements.

2.0 Collector Solar Loop

- 2.1 The solar loop was hydrostatically pressure tested at 50 psig. All leaks were repaired.
- 2.2 The flow rate was balanced in each collector array at approximately 11 gpm.
- 2.3 The heat collection efficiency of one collector array and its associated piping was determined. The results are shown in Tables 1, 2 and 3.
- 2.4 The heat loss from the underground storage tank was found to be negligible over an 8.5 hour period. The data is shown in Table 4.
- 2.5 All collectors and piping were inspected to ensure that they were installed with the correct slope for drainage.

3.0 Subsystem Leak Tests

- 3.1 The solar loop of the heat dump, space heating and potable hot water heating subsystems were hydrostatically pressure tested at 50 psig. All leaks were repaired.
- 3.2 All subsystem potable water loops were hydrostatically pressure tested at 125 psig. All leaks were repaired.

4.0 Heat Dump Subsystem

The rate of heat dissipation through the cooling tower was found to be approximately 1.33 million BTU/24 hours (Test #1) and 2.65 million BTU/24 hours (Test #2). The data is shown in Table 5.

5.0 Space Heat Subsystem

The heat transferred through the exchanger in the air heating duct was found to be 247,840 BTU/Hr. (Test #1) and 169,589 BTU/Hr. (Test #2). The heat losses in the space heat transfer lines were found to be negligible as evidenced by comparison of the inlet temperature at heat exchanger and tank outlet (See Table 6).

6.0 Potable Hot Water

The heat transferred through the potable water heat exchanger was 50,916 BTU/Hr. Data is shown in Table 7.

7.0 Summary A comparison of actual and expected performance is shown in Table 8 and Figure 1.

TABLE 1

COLLECTOR ARRAY EFFICIENCY TEST DATA

<u>Time</u>	<u>Collector Array Inlet Temperature (°F)</u>	<u>Collector Array Outlet Temperature (°F)</u>	<u>Outside Ambient Temperature (°F)</u>	<u>Flow (gpm)</u>	<u>Pyranometer (BTU/Hr. Ft. 2)</u>
9:30 am	112	123	52	11.5	200
10:00 am	115	128.5	57	11.5	220
10:30 am	117.5	132	55.5	11.5	240
11:00 am	122	137	62	11.75	250
11:30 am	127	142	69	11.75	255
12:40 pm	137	152.5	68	11.75	260
1:00 pm	142	155	63	11.75	250
1:45 pm	148	159	69	11.75	240
2:00 pm	149.5	160	69.5	11.75	230
2:30 pm	153	160.5	66	11.75	200

Date of Test: 3-22-78

TABLE 2

**COLLECTOR ARRAY EFFICIENCY TEST
(DATA PERIOD AVERAGES)**

<u>Time</u>	<u>T_i Avg. Inlet Temperature (°F)</u>	<u>T_o Avg. Outlet Temperature (°F)</u>	<u>T_a Avg. Ambient Temperature (°F)</u>	<u>Avg. I (BTU/Hr. Ft.²)</u>	<u>Avg. Flow (gpm)</u>
9:30 am	113.5	125.75	54.5	210	11.5
10:00 am	116.25	130.25	56.25	230	11.5
10:30 am	119.75	134.5	58.75	245	11.63
11:00 am	124.5	139.5	65.5	252.5	11.75
11:30 am	132	145.25	68.5	257.5	11.75
12:40 pm	139.5	153.75	65.5	255	11.75
1:00 pm	145	157	66	245	11.75
1:45 pm	148.75	159.5	69.25	235	11.75
2:00 pm	151.25	160.25	67.75	215	11.75
2:30 pm					
TOTAL	1190.5	1305.75	572	2145	105.13
AVERAGE	132.28	145.08	63.6	238	11.68

Date of Test: 3/22/78

TABLE 3

COLLECTOR ARRAY EFFICIENCY TEST
(CALCULATED VALUES)

Time	T_p^* Avg. Plate Temperature (F)	$\frac{T_p - T_a}{I}$ (°F-Hr. Ft ² /BTU)	Q Heat Collected (BTU/Min)	Q' Heat Collected Per Ft. of Collector (BTU/Hr. Ft ²)	Collector Array Efficiency (%)
9:30 am	119.6	.310	1173.49	121.4	57.8
10:00 am	123.3	.291	1341.13	138.7	60.3
10:30 am	127.1	.279	1428.33	147.8	60.3
11:00 am	132	.263	1468.16	151.9	60.2
11:30 am	138.6	.272	1296.88	134.2	52.1
12:40 pm	146.6	.318	1394.75	144.8	56.8
1:00 pm	151	.347	1174.53	121.5	49.6
1:45 pm	149.9	.343	1052.18	108.9	46.3
2:00 pm	155.75	.409	880.90	91.1	42.4
2:30 pm					
Averages	138.7	.316	1245.4	128.8	54.1

Date of Test: 3/22/78

TABLE 4
UNDERGROUND STORAGE TANK LOSSES

<u>Time</u>	<u>Temperature 6" From Bottom of Tank (°F)</u>	<u>Temperature 48" Mid-way of Tank (°F)</u>	<u>Temperature 6" Below Top of Water Surface (°F)</u>
12:55 pm	147	147.5	146
1:55 pm	146	148	147
2:50 pm	146	148	147
3:50 pm	146	148	148
4:45 pm	146	148	149
9:30 pm	145	148	148

Date of Test: 3-21-78

TABLE 5

HEAT DISSIPATED BY COOLING TOWER

Test #1	Temp. at Top of Storage Tank (°F)	Temp. at Middle of Tank (°F)	Temp. at Bottom of Tank (°F)	Heat Removed From Lower Half of Tank (BTU/Hr.)	Heat Removed From Upper Half of Tank (BTU/Hr.)	Total Heat Removed (BTU/Hr.)
Time						
8:34 am	125	122	122			
9:34 am	124	123.5	116	22,907.5		23,428
10:34 am	124	123	113.5	39,567.5		39,567.5
11:34 am	124	121	110	43,732.5	13,015.6	56,748.1
12:34 pm	123	117	108	60,392.5	41,650	102,042.5
					TOTAL --	221,786

Average Heat Dissipated -- 55,447 BTU/
Hr.

Test #2						
10:15 am	157	157	155			
11:15 am	156.5	156.5	148	77,052	9,996	87,049
12:15 pm	156	154	143	79,135	29,988	109,123
1:15 pm	155	150	140.5	66,640	49,980	116,620
2:15 pm	155	146	136	89,548	39,984	129,532
					TOTAL --	442,324

Average Heat Dissipated -- 110,580 BTU/
Hr.

Date of Test #1: 4/26/78; Date of Test #2: 5/1/78

TABLE 6.
SPACE HEAT TEST

Test #1

<u>Time</u>	<u>Temp. of Solar Water at Inlet to Heat Exchng. (°F)</u>	<u>Temp. of Solar Water at Outlet from Heat Exchng. (°F)</u>	<u>Temp. of Solar Water Leaving Tank (°F)</u>	<u>Flow Through Heat Exchng. (gpm)</u>	<u>Average Heat Removed (BTU/Min.)</u>	<u>Total Heat Removed Through Exchng. (BTU)</u>
9:55 am	111	103	111	44.5	2965.5	44,483
10:10 am	110	102	110	44.5	2780.1	41,702
10:25 am	109	102	109	44.5	2780.1	41,702
10:40 am	108	100	108	44.5	2780.1	41,702
10:55 am	107	100	107	44.5		
TOTAL BTU/Hr. -						169,589

Test #2

8:15 am	177	166	177	44	3848.5	57,728
8:30 am	176.5	166	180	44.25	3870.3	58,055
8:45 am	176.5	166	176.5	44.5	4448.2	66,723
9:00 am	175	161.5	175.5	44.5	4355.6	65,334
9:15 am	172	162	172	44.5		
TOTAL BTU/Hr. -						247,840

Date of Test #1: 3-17-78; Date of Test #2: 3-20-78

TABLE 7

POTABLE WATER TEST

<u>Time</u>	<u>H.E. Inlet Temp. (°F)</u>	<u>H.E. Outlet Temp. (°F)</u>	<u>Flow (gpm)</u>	<u>Average (BTU/Min)</u>	<u>Total Heat Removed thru Exchanger (BTU)</u>
9:50 am	157	140.5	8	1049.6	10,496
10:00 am	156	141	8	999.6	14,994
10:15 am	156	141	8	999.6	14,994
10:30 am	156	141	8	966.3	14,494
10:45 am	155	141	8	933.0	13,994
11:00 am	155	141	8	899.6	13,495
11:15 am	155	142	8	833.0	12,495
11:30 am	155	143	8	683.1	40,984
12:30 pm	153.5	145	8		

TOTAL BTU/2.67 hrs. - 135,946

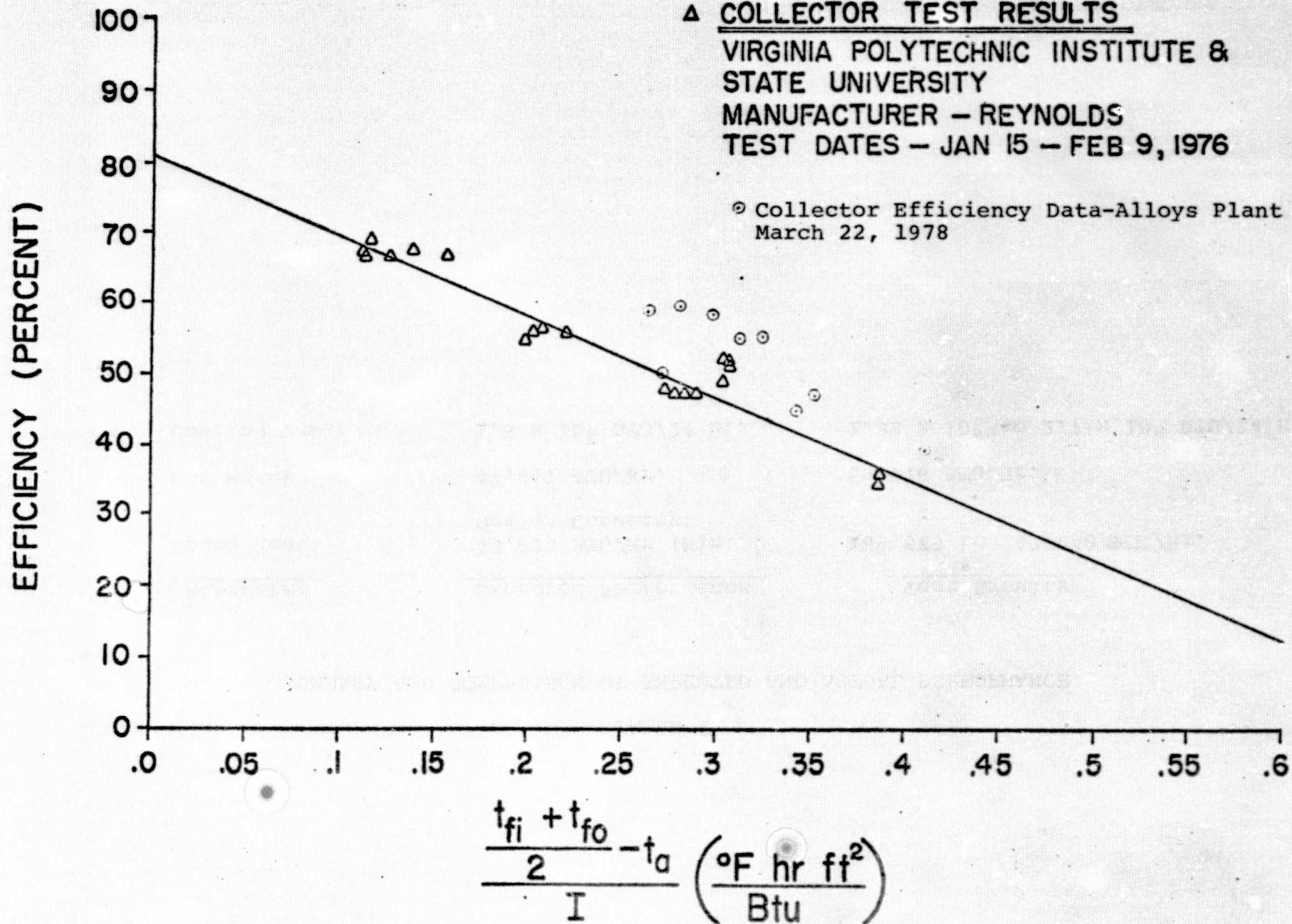
AVG. BTU/hr. - 50,916

Date of Test: 3-21-78

TABLE 8

SUMMARY AND COMPARISON OF EXPECTED AND ACTUAL PERFORMANCE

<u>Subsystem</u>	<u>Expected Performance</u>	<u>Test Results</u>
Space Heat	43,000 BTU/Hr (Min. Design Capacity)	169,589 to 247,840 BTU/Hr.
Hot Water	47,467 BTU/Hr.	50,916 BTU/Hr.
Cooling Tower	1.6×10^6 BTU/24 Hr.	1.33×10^6 to 2.7×10^6 BTU/24 Hr.



INTERIM PERFORMANCE CRITERIA

CERTIFICATION

CONTRACT NO. G-77-A-01-4070

DEMONSTRATION CONTRACTOR REYNOLDS METALS COMPANY

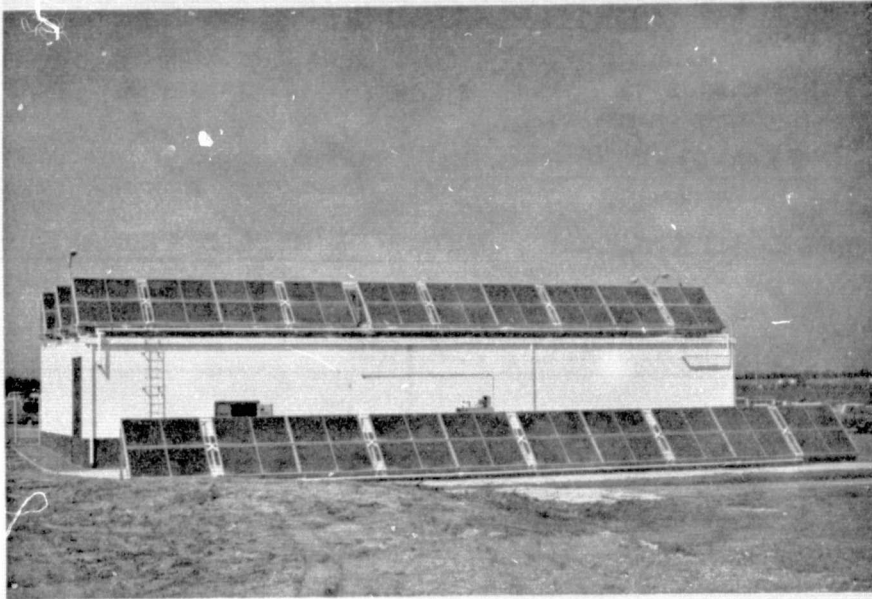
SYSTEM LOCATION LISTERHILL, ALABAMA

SYSTEM TYPE SPACE HEAT AND HOT WATER

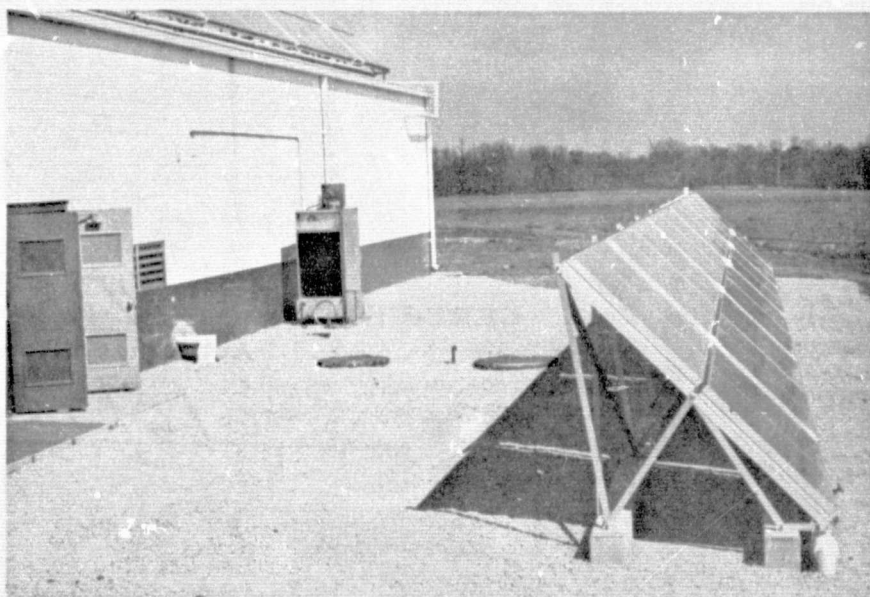
We have addressed each of the items referenced in NASA publication 98M10001 entitled "Interim Performance Criteria For Heating/Cooling Systems and Facilities" dated February 28, 1975. It is our opinion that the subject system complies with these performance criteria. Due to limitations in the state-of-the-arts, some of the criteria were evaluated on the basis of professional judgement and/or experience in lieu of quantitative analysis and test data.

CERTIFIED BY 
Authorized Representative

DATE 6/6/78

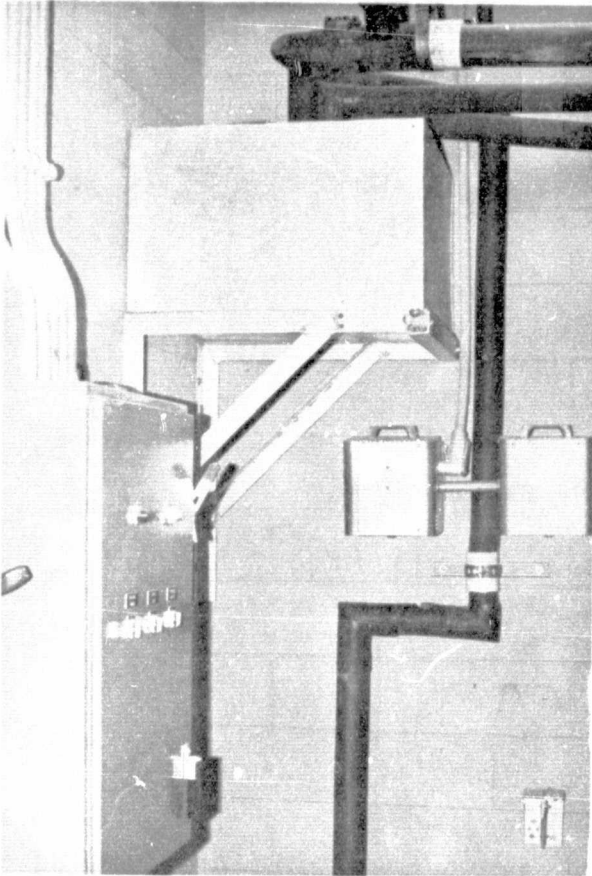


COMPLETED INSTALLATION ON
SHOWER AND CHANGE FACILITY

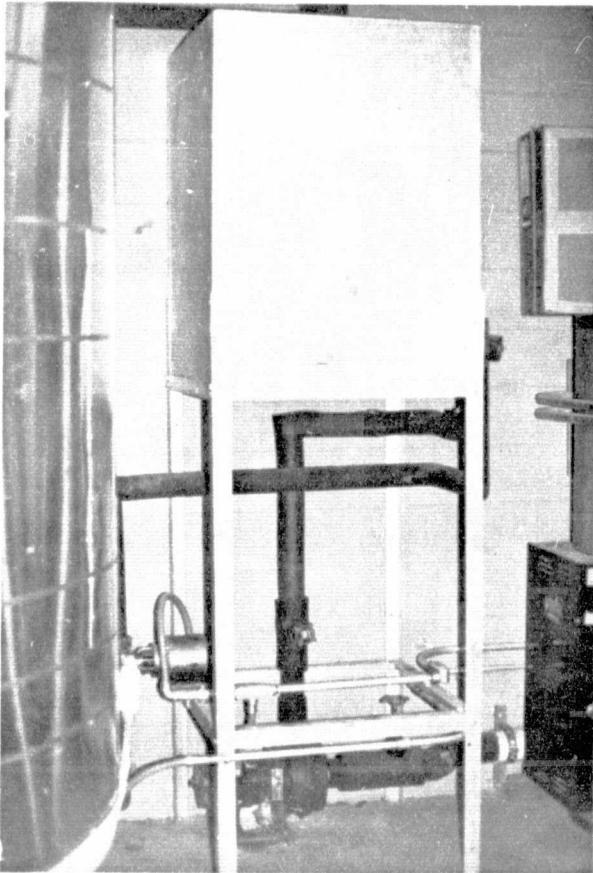


GROUND MOUNTED COLLECTOR ARRAY

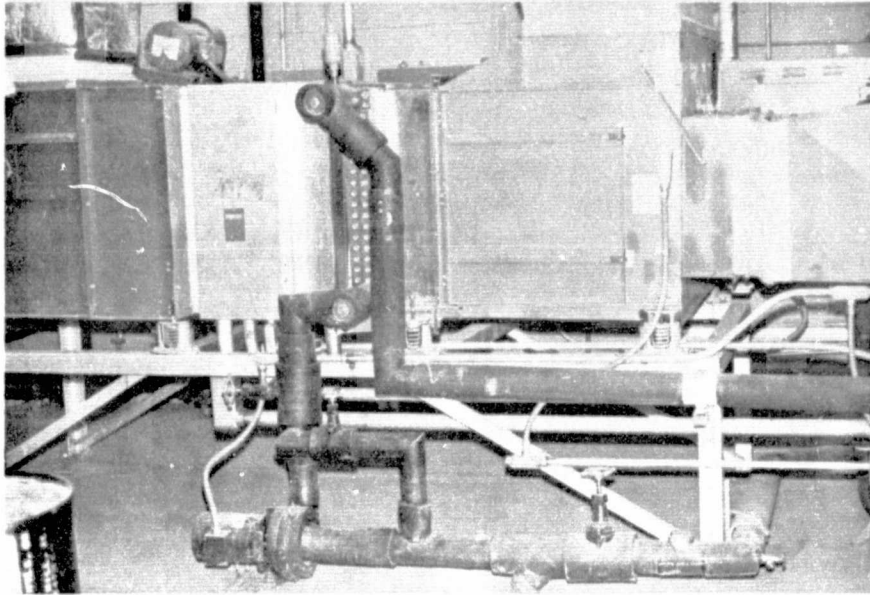
ORIGINAL PAGE 12
OF POOR QUALITY



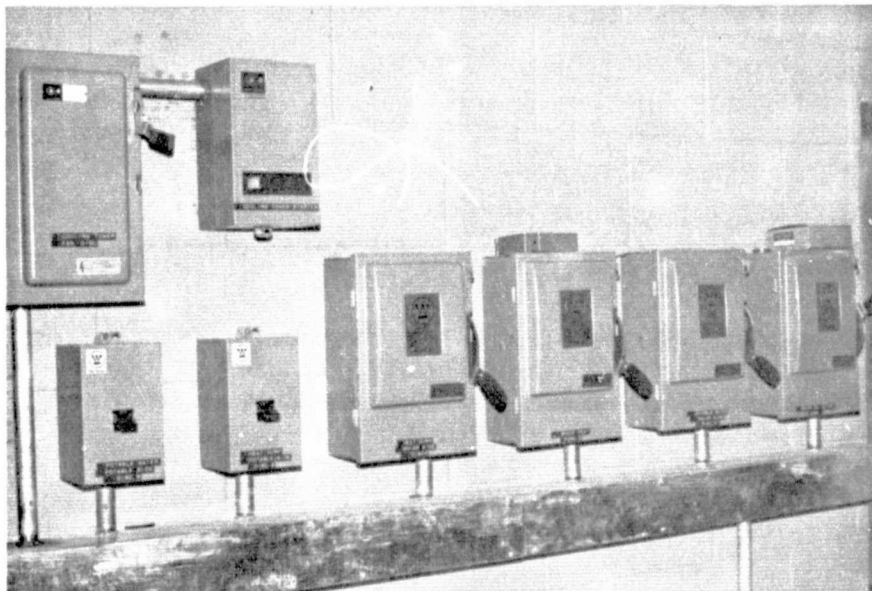
SYSTEM CONTROL PANEL AND
HEAT DUMP HEAT EXCHANGER



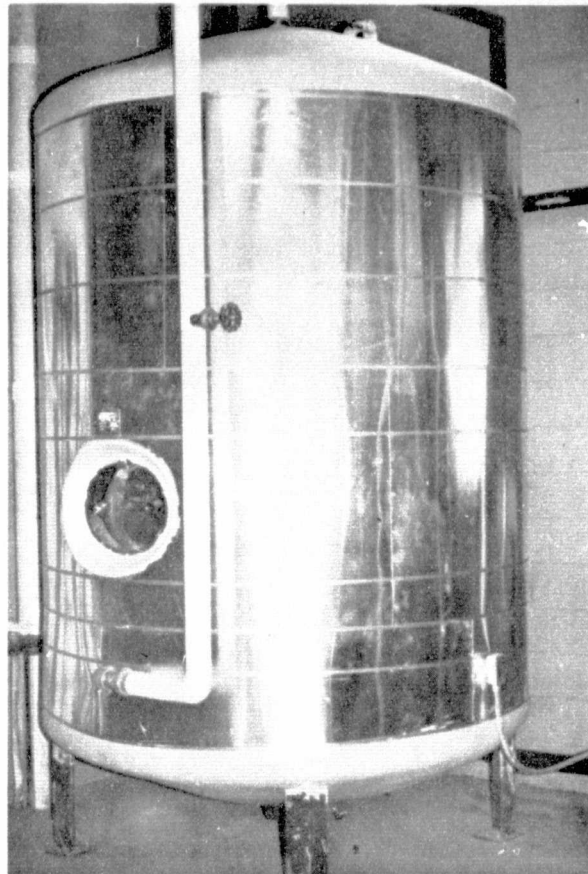
POTABLE WATER HEAT EXCHANGER



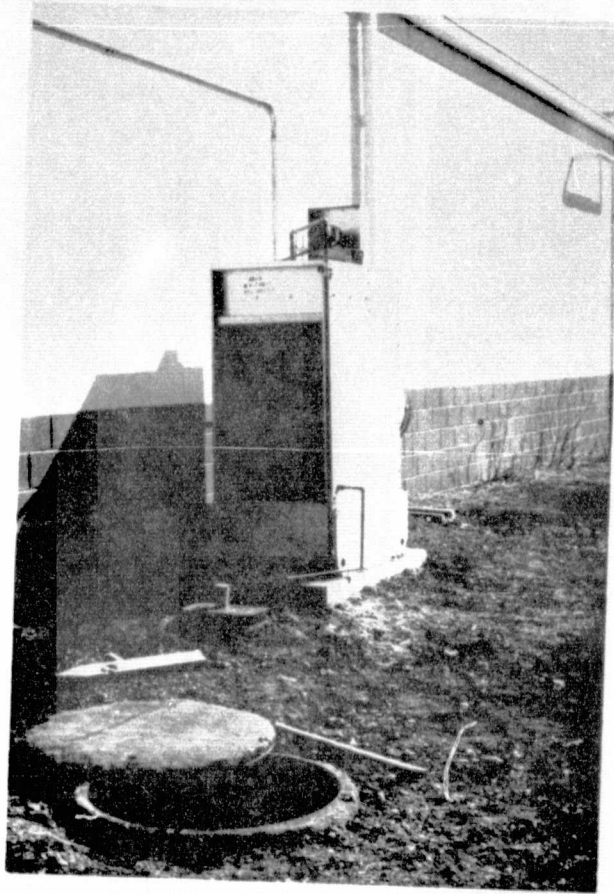
SPACE HEAT SUBSYSTEM



PUMP DISCONNECT SWITCHES



1400 GALLON POTABLE
WATER STORAGE TANK



COOLING TOWER

PART II
(MAINTENANCE MANUAL)

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START-UP PROCEDURE

(Reference RMCo Dwg. No. 45616107R)

- 1.0 Add inhibitor to solar storage water - The water in the solar storage tank will be charged initially with 4 fluid ounces of NALCO 2755 per gallon of water.
 - 1.1.1 Gloves and goggles should be worn when adding the inhibitor to the solar water.
 - 1.1.2 Determine the volume of water in solar storage tank. Refer to Appendix G.
 - 1.1.3 Add inhibitor at a rate of 4 fluid ounces per gallon of storage water.
- 2.0 Check to see that all six pump disconnect switches are open.
- 3.0 Set all controllers (1TC, 2TC, and 3TC) on OFF position and adjust cut-in set point to desired temperature differential. (Instructions for checking the operation of the controller and the sensors are shown in the Solar Commander Installation Instruction in Appendix A).
 - 3.1 Solar Collector Loop
 - 3.1.1. Set the solar collector loop controller (1TC) on a 15°F differential by aligning the white tip of the screwdriver slot (in the circular shaped potentiometer) with the white dot at the 3-o'clock position (The potentiometer is normally set on the white dot or 15°F set point).
 - 3.2 Potable Hot Water Subsystem
 - 3.2.1 Set the potable hot water controller (2TC) on an 8°F temperature differential by setting the white tip of the screwdriver slot at the 10-o'clock position.
 - 3.3 Space Heat Subsystem
 - 3.3.1 Set the space heat controller (3TC) on a 15°F temperature differential using the procedure described in Section 3.1.1.

4.0 Set the thermostats (1TAS, 2TAS, and 3TAS) to the desired temperatures.

4.0.1 Minor adjustments may be required to obtain better set point accuracy after installation. (For instructions, refer to Installation and Maintenance Instructions for Remote Bulb Temperature Controllers, Appendix B.)

4.1 Potable Water Subsystem

4.1.1 Set thermostat (1TAS) by turning dial knob to 60°F.

4.2 Space Heat Subsystem

4.2.1 Set thermostat (2TAS) by turning dial knob to 2°F higher than thermostat setting for the back-up space heating system.

4.3 Heat Dump Subsystem

4.3.1 Set thermostat (3TAS) by turning dial knob to 185°F.

5.0 Close main switch on main power control panel (This switch will usually be closed).

6.0 Close bus switch (10) on main power control panel to energize controls.

7.0 Check control panel door (A safety switch prevents the system from starting until control panel door is closed and latched).

8.0 Check all pumps for prime, and prime if needed (All pump disconnect switches should be open). PUMPS SHOULD NEVER BE STARTED OR RUN DRY (See Pump Operating and Maintenance Instructions in Appendixes C, D, and E). Circulating pumps should be oiled before running (See Appendix E).

8.1 Solar Loop Pump

8.1.1 Attached garden hose to boiler drain in supply line.

8.1.2 Close pump discharge valve.

8.1.3 Fill supply line with tap water.

- 8.1.4 Vent supply line at pump by loosening vent plug in pump. It may also be necessary to loosen union nearest tank in supply line.
- 8.1.5 Close boiler drain.
- 8.1.6 Partially open discharge valve.
- 8.1.7 Start pump by setting controller switch (1TC) on MANUAL and close pump disconnect switch (1DISC). DO NOT START SOLAR LOOP PUMP WHEN OUTSIDE TEMPERATURE IS BELOW 32°F AND SUN IS NOT SHINING.
- 8.1.8 Check flow at florater valve by removing one of the brass caps and pressing valve in with small screwdriver.
- 8.1.9 If pump not primed, repeat steps 8.1.2 through 8.1.8.
- 8.1.10 Open discharge gate valve as soon as pump reaches operating speed.
- 8.1.11 Turn water off and disconnect garden hose.
- 8.1.12 Shut pump off after priming by opening disconnect switch (DISC1). Set controller switch on OFF position.
- 8.2 Space Heat, Potable Water and Heat Dump Solar Pumps
(For additional information, refer to Appendix D).
 - 8.2.1 Attach garden hose to boiler drain in supply line (near main power panel).
 - 8.2.2 Close valves in space heat and potable water discharge lines.
 - 8.2.3 Close valve in solar supply line for heat dump pump.
 - 8.2.4 Fill supply line with tap water.
 - 8.2.5 Vent space heat and potable water pump by opening vent plug on top of each pump. Vent heat dump pump through plug in tee near pump.
 - 8.2.6 Close boiler drain.
 - 8.2.7 Partially open all pump discharge valves and open heat dump supply valve.

8.2.8 Start pumps individually on solar side of each subsystem.

8.2.8.1 Potable Hot Water Subsystem - Set switch (SS1) in control panel on HAND; set controller switch (2TC) on MANUAL; and close pump disconnect switch (2DISC).

8.2.8.2 Space Heat Subsystem - Set switch (SS2) in control panel on HAND; set controller (3TC) switch on MANUAL; and close pump disconnect switch (3DISC).

8.2.8.3 Heat Dump Subsystem - Set switch (SS3) in control panel on HAND and close pump disconnect switch (4DISC).

8.2.9 Check flow at florater valve in potable water and space heat subsystem. Check flow in heat dump subsystem by noting temperature change at pump or check valve above pump.

8.2.10 Open discharge gate valve as soon as pump reaches operating speed.

8.2.11 Shut each pump off after priming by opening respective disconnect switches. Set all controller switches on OFF position.

8.3 Circulating Pump for Potable Side of Potable Water Subsystem - (For additional information, refer to Appendix E).

8.3.1 Oil all three oil cups before starting circulator and every three months thereafter (Use S.A.E. #20 non-detergent oil).

8.3.2 Check to be sure circulating loop is filled with tap water.

8.3.3 Start circulating pump by setting switch (SS1) in control panel on HAND; set controller (2TC) switch on MANUAL; and close pump disconnect (6DISC).

8.3.4 Shut pump off by opening disconnect switch (6DISC). Set controller switch (2TC) on OFF position.

8.4 Pump for Potable Side of Cooling Tower Subsystem - (For additional information, refer to installation and operation instructions for Bell & Gossett 1535 pump in Appendix C).

- 8.4.1 Check to be sure circulating loop is filled with tap water (See section 9.0 for filling cooling tower reservoir).
- 8.4.2 Start pump by setting switch (SS3) in control panel on HAND and close pump disconnect switch (5DISC).
- 8.4.3 Shut pump off by opening disconnect switch (5DISC). Set switch SS3 in control panel on OFF.

9.0 Clean cooling tower and fill with tap water.

- 9.1.1 Wash foreign matter from fill and basin.
- 9.1.2 Fill circulating system with water.
- 9.1.3 Adjust float valve to maintain 5" of water in cold water basin.
- 9.1.4 Check bleed-off line to make sure water is being discharged during operation.
- 9.1.5 Check fan for free rotation and oil level in bearing housing (See Appendix F). Start motor and check direction of rotation. Fan must rotate clockwise when viewed from the fan discharge side. If the rotation is incorrect, change any two of the three motor leads.
- 9.1.6 Depth of water in hot water basin should be uniform. If the basin overflows, reduce the flow rate. Do not pump more water than design capacity.
- 9.1.7 **WARNING:** Do not cycle the motor so that the total of the starting time exceeds 30 seconds each hour.

10.0 Check operation of each subsystem manually.

10.1 Check Solar Collector Loop

- 10.1.1 Check solar loop pump (1MTR) for prime.
(DO NOT START SOLAR LOOP PUMP WHEN
OUTSIDE TEMPERATURE IS BELOW 32°F AND
SUN IS NOT SHINING).
- 10.1.2 Check for proper operation of normally
open solenoid valve in by-pass line
near underground solar storage tank.
Solenoid valve (1SOL) must close when
power is on to pump. (See Appendix H.)
- 10.1.3 Set switch of solar loop controller (1TC)
on MANUAL. Start solar loop pump by
closing pump disconnect switch (1DISC).
- 10.1.4 Using Thrush Model 832 Florater meter
and Thrush Florater balancing valve,
check to see if flow rate is balanced
to each collector array. If not, set
flow rate on ground mounted collectors
by adjusting Florater balancing valve
(Optimum flow 10 to 13 gpm).
 - 10.1.4.1 Open carrying case and place
test kit in a convenient spot
on test site with test kit
horizontal.
 - 10.1.4.2 With test kit balance valve
closed, connect hoses to
florater - Red hose upstream,
high pressure -- Green hose
downstream, low pressure.
 - 10.1.4.3 Open test kit balance valve.
 - 10.1.4.4 Open high and low bleed valves
alternately to purge air from
system (Bleed water discharges
from convenient clear plastic
flexible tube).
 - 10.1.4.5 When bleeding shows all air
removed, close test kit balance
valve and read differential
pressure gauge. Refer to chart
in Appendix I for conversion to
gpm and additional instructions.

- 10.1.4.6 When test is complete, open test kit balance valve and disconnect test hoses from florater.
- 10.1.4.7 Store hoses by coiling them around the test kit panel.
- 10.1.5 Check and/or set florater on each bank of roof mounted collectors using the above procedure. (Optimum flow 10 to 13 gpm per collector array.)
- 10.1.6 Recheck flow on ground mounted collectors and adjust if needed.
- 10.1.7 Repeat 10.1.4, 10.1.5, 10.1.6 until flows approximately equal.
- 10.1.8 If florater setting over 50, open pump (1MTR) by-pass valve slightly.
- 10.1.9 Repeat 10.1.7 and 10.1.8 until flows are equal and at desired rate and florater is operating in lower range.
- 10.1.10 Shut off pump by opening disconnect switch (1DISC).
- 10.1.11 Move switch of solar loop controller (1TC) to OFF position.
- 10.2 Check Potable Hot Water Subsystem
 - 10.2.1 Set controller (2TC) switch on MANUAL.
 - 10.2.2 Set switch (SS1) in control panel on HAND position and close pump disconnect switches (2DISC and 6DISC). CHECK PUMPS FOR PRIME BEFORE ATTEMPTING TO START PUMPS.
 - 10.2.3 If pumps fail to run, refer to troubleshooting section.
 - 10.2.4 To shut off system, open pump disconnect switches (2DISC and 6DISC) and place controller (2TC) switch on OFF position.
- 10.3 Check Space Heat Subsystem
 - 10.3.1 Set controller (3TC) switch on MANUAL.
 - 10.3.2 Shut off back-up space heating system if weather permits.

- 10.3.3 Set switch (SS2) in control panel on HAND position and close pump disconnect switch (3DISC). CHECK PUMP FOR PRIME BEFORE ATTEMPTING TO START PUMP.
- 10.3.4 If pump does not run, refer to troubleshooting section.
- 10.3.5 To shut off system, open pump disconnect switch (3DISC) and place controller (3TC) switch on OFF position.

10.4 Check Heat Dump Subsystem - DO NOT OPERATE COOLING TOWER LOOP PUMP WHEN OUTSIDE TEMPERATURE IS BELOW 32°F.

- 10.4.1 Check to see that cooling tower is filled with water and operating properly (See Section 9.0).
- 10.4.2 Set switch (SS3) in control panel on HAND position and close pump disconnect switches (4DISC and 5DISC). CHECK PUMPS FOR PRIME BEFORE ATTEMPTING TO START PUMPS.
- 10.4.3 If pumps do not run, refer to troubleshooting section.
- 10.4.4 Shut off system by opening disconnect switches (4DISC and 5DISC) on respective pumps.

11.0 Operate each subsystem individually on automatic mode.

11.1 Solar Collector Loop

- 11.1.1 Set controller (1TC) on AUTOMATIC position (For pumps to operate automatically, temperature of collector must be 15°F higher than temperature of solar water).
- 11.1.2 Close pump disconnect switch (1DISC).
- 11.1.3 If system fails to operate, refer to troubleshooting section.
- 11.1.4 Shut system off by opening pump disconnect switch (1DISC) and setting controller (1TC) on OFF position.

11.2 Potable Hot Water Subsystem

- 11.2.1 Turn thermostat (1TAS) down as low as possible.
- 11.2.2 Set switch (SS1) in control panel and on controller (2TC) on AUTOMATIC position (Temperature of solar water must be 15°F higher than temperature of potable water, and ambient temperature must be above setting of thermostat (1TAS) for pumps to operate automatically).
- 11.2.3 Close pump disconnect switches (2DISC and 6DISC).
- 11.2.4 If system fails to operate, refer to troubleshooting section.
- 11.2.5 Shut system off by opening pump disconnect switches (2DISC and 6DISC) and setting ambient thermostat (1TAS) on 60°F.

11.3 Space Heating Subsystem

- 11.3.1 Increase thermostat (2TAS) setting (in locker room) until system calls for heat.
- 11.3.2 Set switch (SS2) in control panel and on controller (3TC) on AUTOMATIC position.
- 11.3.3 Shut off back-up space heating if weather conditions permit.
- 11.3.4 Close pump disconnect switch (3DISC).
- 11.3.5 If system fails to operate, refer to troubleshooting section.
- 11.3.6 Shut off pump by opening pump disconnect switch (3DISC).
- 11.3.7 Restore system to normal operating condition.

11.4 Heat Dump Subsystem

- 11.4.1 Set switch (SS3) in control panel on AUTOMATIC position.
- 11.4.2 Turn thermostat (3TAS) down as low as possible.

- 11.4.3 Close pump disconnect switches (4DISC and 5DISC).
- 11.4.4 If system fails to operate, check to be sure that thermostat (3TAS) setting is lower than temperature of solar water. Also, refer to troubleshooting section.
- 11.4.5 Shut system off by opening pump disconnect switches (4DISC and 5DISC) and reset thermostat (3TAS) at 185°F.

12.0 Set system up for automatic operation.

- 12.1 Set all switches (SS1, SS2, and SS3) in control panel on AUTOMATIC.
- 12.2 Set all controllers (1TC, 2TC, and 3TC) on AUTOMATIC.
- 12.3 Set all thermostats (1TAS, 2TAS, and 3TAS) in accordance with Section 4.0.
- 12.4 Close all pump disconnect switches.

OPERATING AND MAINTENANCE INSTRUCTIONS

1.0 Inhibitor - Both periodic and annual additions of the NALCO 2755 inhibitor are required to the solar storage water (Refer to section 1.0 of Start-up Procedure for initial charge of inhibitor).

1.1 Handling Inhibitor

1.1.1 Gloves and goggles should be worn when adding the inhibitor to the solar water.

1.2 Monitoring

1.2.1 Read make-up water meter monthly and add 4 fluid ounces of NALCO inhibitor for each gallon of tap water added to system (Refer to section 1.1 for handling precautions).

1.2.2 Check pH once a month with Litmus paper or a pH probe. pH should be maintained between 10.0 and 10.5. If pH falls outside of this range, a sample should be taken and forwarded to MRD for analysis (See section 1.2.3).

1.2.3 Take a 150 to 200 ml sample from solar storage tank every six months and forward to Reynolds Metallurgical Research, Corrosion Laboratory, in Richmond, Virginia for pH, resistivity and concentration analysis (Solar water should be thoroughly mixed before sampling).

1.2.4 Solar storage water is to be recharged annually with 2 fluid ounces of NALCO 2755 inhibitor per gallon of solar water. (Existing solar water does not have to be drained.)

2.0 Pumps

2.1 Centrifugal - Refer to Appendix C and Appendix D.

2.2 Circulator - Oil all three cups with SAE 20 non-detergent oil before starting pump initially and every 3 months thereafter. For additional instructions, refer to Appendix E.

3.0 Strainers

3.1 All cast iron Y-type strainers are to be cleaned monthly for the first six months and every three months thereafter.

4.0 Collector Repair

4.1 Outside Glazing

- 4.1.1 Small breaks or punctures may be repaired by covering the damaged area with a patch of the glazing material and bonding with a RTV silicon sealant or with Scotch pressure sensitive adhesive transfer tape (No. 465).
- 4.1.2 The entire outside glazing may be replaced.
 - 4.1.2.1 Remove bottom circumferential row of screws (two in each corner and one midway of top and bottom angle) from angle cover.
 - 4.1.2.2 Remove angle cover from top of collector.
 - 4.1.2.3 Remove old glazing and sealing residue from rectangular glazing frame.
 - 4.1.2.4 Apply Scotch pressure sensitive adhesive transfer tape (No. 465) around the entire perimeter of the glazing frame.
 - 4.1.2.5 Stretch glazing material over the rectangular glazing frame as tight as possible, smoothing out all wrinkles and air pockets while securing glazing to tape (The 4 mil Tedlar* glazing material may be purchased from most duPont plastic distributors).
 - 4.1.2.6 Apply a small bead of RTV silicon sealant around the perimeter of the angle frame cover.
 - 4.1.2.7 Replace angle frame cover over glazing and secure with screws removed in 4.1.2.1

4.2 Inner Glazing

- 4.2.1 Damaged inner glazing can be replaced using the procedure described in section 4.1.2 with the exception that the glazing is applied to the bottom of the rectangular glazing frame. The inner glazing is a duPont 1 mil FEP Teflon* 100A material and can be purchased from most duPont plastic distributors.

* duPont registered trademark.

4.3 Back of Collector

4.3.1 Punctures and tears in the back of the collector can be repaired with Reynolok* Patching Tape.

4.3.1.1 Clean area to be patched with mineral spirits, Varsol, alcohol or naptha.

4.3.1.2 Fill puncture with butyl caulking if needed.

4.3.1.3 Remove paper backing from patching tape and apply tape over damaged area, smoothing out wrinkles and air pockets to insure good adhesion.

5.0 Cooling Tower

5.1 Maintenance Instructions

5.1.1 Lubricate motor periodically and at start and end of each season.

5.1.2 Keep oil cups full to insure proper oil level in bearing housing (Use SAE 20 mineral oil).

5.1.3 Check belt tension every two to three weeks during peak operation season.

5.1.4 Check the bleed-off for continuous water discharge.

5.1.5 Drain and clean cold water basin and suction screen periodically.

5.1.6 Check float valve periodically for proper operation and maintenance of water level.

5.2 Seasonal Shutdown - Between October 1 and May 1, the cooling tower is to be shut down and drained to prevent damage from freezing.

5.2.1 Close stop and waste valve in supply line and open vent.

5.2.2 Open all valves in plastic vault at foot of tower.

5.2.3 Drain tower basin and leave the basin drain open.

5.2.4 Remove and store belts in a cool, dark, dry place. Clean and coat sheave grooves with rust preventive.

*Reynolds registered trademark

5.2.4 At shutdown, operate tower until oil in bearing housing is warm; drain and refill with SAE 20 mineral oil.

5.2.5 Lubricate fan motor.

5.3 Seasonal Start-up

5.3.1 Remove rust preventive from sheaves and replace belt (Refer to page 4 of Appendix F for belt installation and tensioning instructions).

5.3.2 Check to see that fan is free to rotate before starting motor. Check fan for proper rotation (clockwise when viewed from fan discharge side). Lubricate fan motor.

5.3.3 Operate tower until warm drain bearing housing and refill with SAE 20 mineral oil.

5.3.4 Clean and wash foreign matter from fill and basins.

5.3.5 Fill circulating system with tap water.

5.3.6 Start pump and adjust float valve to maintain 5" of water in cold water basin.

5.3.7 Check bleed-off line to make sure water is being discharged during operation.

5.3.8 Check depth of water in hot water basin. If basin overflows, reduce flow rate.

TROUBLE SHOOTING

(Reference RMCo. Dwg. No. 45616107R)

1.0 Power

1.1 Control Panel

PROBLEM: THERE IS NO POWER TO PANEL

POSSIBLE CAUSE

- (a) Open bus switch (10) on main control panel
- (b) Blown fuse (13FU)

REMEDY

- (a) Close switch.
- (b) Replace fuse. If fuse blows again, have an electrician check electrical circuit.

1.2 Solenoid Valve

PROBLEM: SOLENOID VALVE (1SOL) DOES NOT CLOSE WHEN PUMP (1MTR) IS ENERGIZED

POSSIBLE CAUSE

- (a) Malfunctioning starter (1M)
- (b) Coil burned out

REMEDY

- (a) Check starter reset
- (b) Check electrical continuity and replace coil if needed.

2.0 Pumps

2.1 Solar Collector Loop Pump

PROBLEM: PUMP (1MTR) WILL NOT RUN

POSSIBLE CAUSE

- (a) Open or faulty disconnect switch (1DISC)
- (b) Blown fuse (1FU, 2FU, or 3FU)

REMEDY

- (a) Check disconnect switch.
- (b) Replace fuses. If fuse blows again, have an electrician check electrical circuit.

- (c) Heater overload in starter (1M)
- (d) Open circuit in motor starter
- (e) Temperature differential between collector and solar water in storage tank is less than cut-in differential setting on solar controller (1TC)
- (f) Malfunctioning solar controller (1TC)
- (g) Malfunction of controller (1TC) sensors
- (h) Temperature of water in solar storage tank may be above 190°F
- (c) Wait a few minutes and reset. If motor still inoperable, check for electrical continuity with ohmmeter.
- (d) Check for loose connection and dirty or burned contacts. Check for electrical continuity with ohmmeter (Replace defective parts).
- (e) Check to see that controller is on and set in accordance with Section 3.1 of Start-up Procedure. Then wait for temperature of collector to increase or temperature of solar water to decrease.
- (f) Check automatic operation of module in accordance with Section A.6 of Solar Controller Installation Instructions in Appendix A.
- (g) Check sensors in collector and solar storage tank in accordance with Section B.1 of Solar Controller Instructions in Appendix A.
- (h) Check temperature of water in solar storage tank. If above 190°F wait for solar water to cool.

PROBLEM: PUMP (1MTR) RUNS CONTINUOUSLY

POSSIBLE CAUSE

REMEDY

- | | |
|---|--|
| (a) Controller (1TC)
set improperly | (a) Check controller for proper setting (Pump will run continuously on MANUAL). |
| (b) Malfunction of controller (1TC) sensors | (b) Check sensor in solar collector and solar storage tank in accordance with Section A.6 of Solar Controller Installation Instructions in Appendix A. |

2.2 Potable Water

PROBLEM: PUMPS (2MTR AND 6MTR) WILL NOT RUN

POSSIBLE CAUSE

REMEDY

- | | |
|---|--|
| (a) Open or faulty disconnect switch (2DISC and 6DISC) | (a) Check disconnect switch. |
| (b) Blown fuse (4FU, 5FU, 6FU, or 15FU) | (b) Replace blown fuses. If fuse blows again, have electrician check circuit. |
| (c) Heater overload in starter (2M) | (c) Wait a few minutes and reset. If motor still inoperable, check for electrical continuity with ohmmeter. |
| (d) Heater overload in starter (6MS) | (d) Replace heater coils for overload relay if needed. |
| (e) Temperature differential between solar water in storage tank and potable water in 1400 gallon tank is less than cut-in differential setting on solar controller (2TC) | (e) Check to see that controller is on and set in accordance with Section 3.2 of Start-up Procedure. Then wait for temperature of solar water in storage tank to increase or temperature of potable water storage to decrease. |

- | | |
|---|--|
| <p>(f) Malfunctioning solar controller (2TC)</p> <p>(g) Malfunction of controller (2TC) sensors</p> <p>(h) Outside air temperature is below limit setting on thermostat (1TAS)</p> <p>(i) Thermostat switch (1TAS) not operating properly</p> | <p>(f) Check automatic operation of module in accordance with Section A.6 of Solar Controller Installation Instructions in Appendix A.</p> <p>(g) Check sensors in accordance with Section B.1 of Solar Controller Installation Instructions in Appendix A.</p> <p>(h) If thermostat is set in accordance with Section 4.1 of Start-up Procedure, wait for ambient temperature to rise above thermostat limit setting.</p> <p>(i) Refer to Appendix B.</p> |
|---|--|

PROBLEM: PUMPS (2MTR AND 6MTR) RUN CONTINUOUSLY

POSSIBLE CAUSE

- (a) Controller (2TC) set improperly
- (b) Malfunctioning of controller (2TC) sensor

REMEDY

- (a) Check switch for proper setting (Pump will run continuously on MANUAL).
- (b) Check sensors in potable water tank and solar storage tanks in accordance with Section B.1 of Solar Controller Installation Instructions in Appendix A.

2.3 Space Heating

PROBLEM: PUMP (3MTR) WILL NOT RUN

POSSIBLE CAUSE

REMEDY

- | | |
|---|---|
| (a) Open or faulty disconnect switch (3DISC) | (a) Check disconnect switch. |
| (b) Blown fuse (7FU, 8FU, or 9FU) | (b) Replace blown fuses. If fuse blows again, have electrician check circuit. |
| (c) Heater overload in starter (3M) | (c) Wait a few minutes and reset. If motor still inoperable, check for electrical continuity with ohmmeter. |
| (d) Open circuit in motor starter (3M) | (d) Check for loose connection and dirty or burned contacts. Check for electrical continuity with ohmmeter (Replace defective parts). |
| (e) Temperature differential between solar water in tank and heat duct is less than cut-in differential setting on solar controller (3TC) | (e) Check to see that solar controller is on and set in accordance with Section 3.3 of start-up procedure. Then wait until solar water heats up or temperature in air duct decreases. |
| (f) Malfunctioning solar controller (3TC) | (f) Check automatic operation of module in accordance with Section A.6 of Solar Controller in the Installation Instructions in Appendix A. |
| (g) Malfunction of controller (3TC) sensors | (g) Check sensors in air duct and in solar storage tank in accordance with Section B.1 of Solar Controller Installation Instructions in Appendix A. |

(h) Temperature in locker room above thermostat (2TAS) setting.

(h) Check to see that thermostat in locker room is set in accordance with Section 4.2 of Start-up Procedure.

(i) Thermostat switch (2TAS) not operating properly

(i) Refer to Appendix B.

PROBLEM: PUMP (3MTR) RUNS CONTINUOUSLY

POSSIBLE CAUSE

REMEDY

(a) Controller (3TC) switch set improperly

(a) Check controller for proper setting (Pump will run continuously on MANUAL).

(b) Malfunctioning of controller (3TC) sensor

(b) Check sensor in air duct and solar storage tank in accordance with section B.1 of solar controller installation instructions in Appendix A.

2.4 Heat Dump Loop

PROBLEM: PUMPS (4MTR AND 5MTR) WILL NOT RUN

POSSIBLE CAUSE

REMEDY

(a) Open or faulty disconnect switch (4DISC and 5DISC)

(a) Check disconnect switches.

(b) Blown fuse (10FU, 11FU, 12FU, or 14FU)

(b) Replace blown fuse. If fuse blows again, have electrician check circuits.

(c) Heater overload in starter (4M)

(c) Wait a few minutes and reset. If motor still inoperable check for electrical continuity with ohmmeter.

- | | |
|---|---|
| <p>(d) Heater overload in starter (5MS)</p> <p>(e) Temperature of water in storage tank below limit setting on thermostat (3TAS)</p> <p>(f) Thermostat switch (3TAS) not operating properly</p> | <p>(d) Replace heater coils for overload relay if needed.</p> <p>(e) Pump will not operate unless temperature of solar water exceeds limit setting on thermostat. Check to see that thermostat is set in accordance with Section 4.3 of Start-up Procedure.</p> <p>(f) Refer to Appendix B.</p> |
|---|---|

PROBLEM: PUMPS (4MTR and 5MTR) RUN CONTINUOUSLY

POSSIBLE CAUSE

- (a) Thermostat (3TAS) set improperly or malfunctioning

REMEDY

- (a) Check thermostat setting in accordance with Section 4.3 of Start-up Procedure. Refer to Appendix B.

PRODUCT LITERATURE FOR SYSTEM COMPONENTS

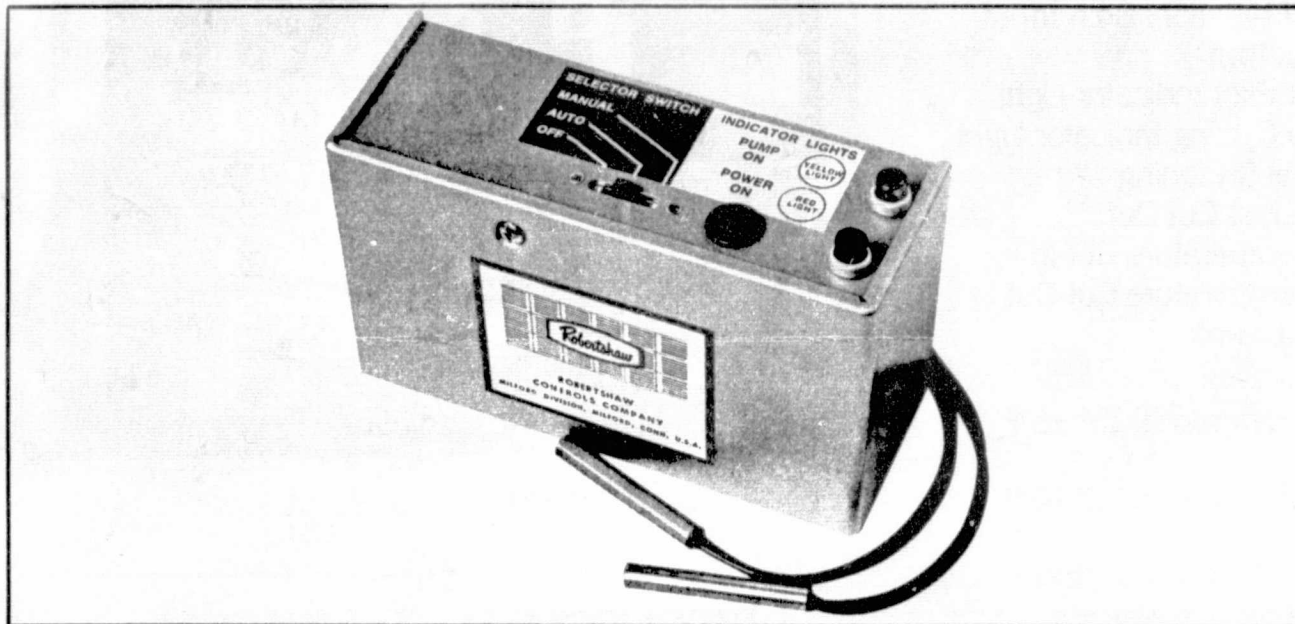
APPENDIX A

SOLAR COMMANDER AND SENSORS

Robertshaw

THE SD-10

PRODUCT INFORMATION BULLETIN



Provides sensitive temperature response and solid state switching to effectively operate a circulating pump in a liquid filled solar heat storage system.

Solid State Thermistor Sensors, of special design, are utilized to accurately signal temperature differential to the control circuit from the solar collector and the storage tank with maximum accuracy from extended distances up to several thousand feet if necessary.

The Solar Commander provides pump circulation cut-in any time the collector panel temperature is 15° higher than the storage tank. Temperature differentials of 5° or less between these points will signal the solar commander to turn the circulating pump off. The pump switch action is accomplished with solid

state components, capable of handling loads up to 3.8 amp inductive, eliminating the need for any moving parts in the controller circuit. The Solar Commander cut-in temperature can be an adjustable option between 8° and 20°F.

The Solar Commander circuit incorporates electrical isolation protection for both input and output signal. The entire electrical circuit is protected by space age encapsulation.

The Solar Commander comes equipped with an easy access terminal strip for the low voltage sensor circuit and line leads hook-up. The case-frame is equipped with line lead conduit adapter access. The Solar Commander sensors are conveniently encapsulated in 1/4" copper tubing and come with 12" lead lengths.

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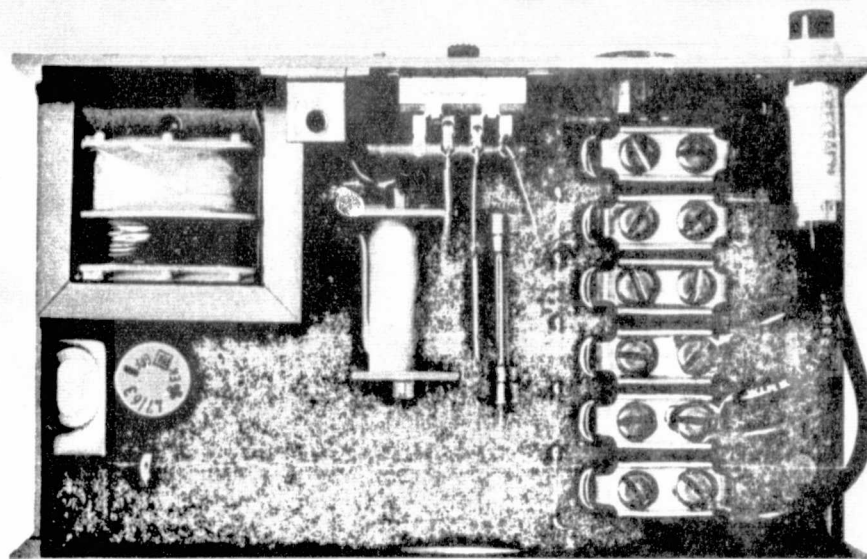
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DESIGN SECTION

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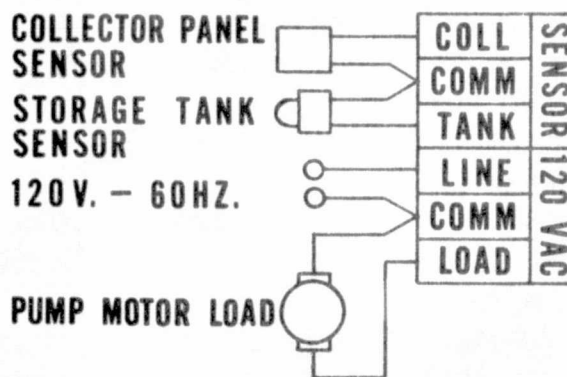
Solid State Pump Switching
 Thermistor Sensors
 Encapsulated Circuit
 Fixed or Adjustable Pump
 Cut-In Differential
 Circuit Isolation, Both Input
 and Output
 Power Pilot Indicator Light
 Pump Cycling Indicator Light
 Manual Switching
 High Limit Cut-Out
 Low Temperature Cut-In
 Low Temperature Cut-Out
 UL Approval



Cut-in differential $15^{\circ} \pm 5^{\circ}\text{F}$
 (fixed)
 Cut-out differential $5^{\circ} \pm 3^{\circ}\text{F}$
 (fixed)
 Thermistor Sensors 300°F
 rated (interchangeable)
 Available without case-frame
 and cover

Adjustable cut-in differential
 (8° to 20°F)
 Recycling upper limit
 (190°F)
 Positive off lower limit (90°F)
 Power Pilot Indicator Light
 Pump Cycling Indicator Light
 Three position manual
 switch (On-Off-Auto)
 Two position manual switch
 (Off-Auto)
 High Temperature Sensors
 (400°F)

DIFFERENTIAL THERMOSTAT SOLAR HEAT CONTROL SD-10



Input 80 to 130 volts, 60
 cycles Hz
 Load — 3.8 amp inductive full
 load amperes 29 amp locked
 rotor
 Thermistor Linearity —
 included in control tolerance
 between 65° and 190°

Robertshaw
 Controls Company

Temperature Controls Marketing Group
 Long Beach, California 90805

SOLAR COMMANDER INSTALLATION INSTRUCTIONS

- A. Module instructions apply to that with lights, selector switch, CI and CO diff., high limit cut-out and freeze protection.
1. Remove the cover and read the label instructions and wiring diagram.
 2. Mounting of the control can be made thru the holes in the back of the case. The control is not position sensitive and may be mounted in any plane. Each case has an outlet for high voltage leads accepting 1/2" conduit fittings.
 3. All power to the control should be removed prior to wiring. Power supply to terminal is marked "LINE".
 4. Connect motor leads to terminals "LOAD and COMMON". The full load ampere rating of the motor must not exceed 3.8 amps @120VAC, 50/60 Hertz (1.9A @240VAC). The control should be used in ambients not exceeding 150°F.
 5. Units supplied with the three (3) position selector switch should have the switch in the "off" position prior to closing of power disconnect. With power applied motor will not run. If optional lights are included, the red light will be on indicating power to the control. Moving the selector switch to "Manual" will permit the motor and pump to run. The motor will run continuously regardless of sensor condition. With light option, the amber light will be on. Moving the selector switch to "OFF" will turn off the motor and amber light.
 6. Checking the automatic operation of the module, prior to connecting the sensors, can be made as follows on all models:
 - a. By jumping the sensor terminals "COLLECTOR" to sensor "COMMON" will permit the motor to operate once the selector switch is moved from the "OFF" to "AUTO" position, checking the cut-in circuit of the module. Remove jumper.
 - b. With the "TANK" to "COMMON" jumpered and "COLLECTOR" to sensor "COMMON" opened; when moving the selector switch from "OFF" to "AUTO" the motor will not run. This checks the differential cut-out portion of the module.

Units without a selector switch can be checked similarly to above except by removal and re-applying the supply voltage. These units are always automatic and can never run constantly.
- B. Sensor instructions apply to both 300°F and 400°F sensors. The sensors as manufactured are for clamp mounting to their respective sensing surfaces by means of the tubing clip supplied with each sensor. These units must not be immersed into the fluid transfer medium unless installed in a sensor well.
1. Checking the sensor can easily be made by means of a Multimeter or digital ohmmeter. The color of the leads from the sensor denote the maximum panel temperature - 300°F for white and 400°F for red. The white 300°F sensor is always used in the storage tank, while the red or white may be used at the collector, depending on maximum temperatures encountered. Excessive time and temperature above the sensor rating will degrade the sensor shifting its

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calibration.

Temperature/resistance values are the same for both 300°F and 400°F Robertshaw type "SS" sensors. Approximate checking resistances run:

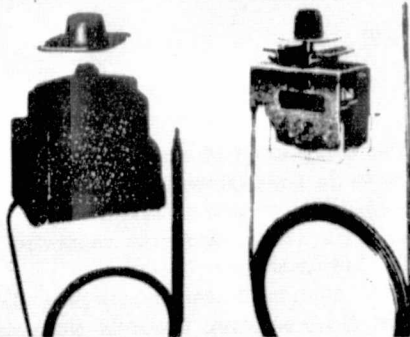
Temperature		Resistance
°F	°C	ohms
32°	0°	105,000
77°	25°	30,000
122°	50°	10,000
212°	100°	1,700

These values are to be used as a guide to the operating of the control and not as a calibration check.

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APPENDIX B

REMOTE BULB TEMPERATURE CONTROLLERS



Remote Bulb Temperature Controllers

55 SERIES

INSTALLATION & MAINTENANCE INSTRUCTIONS

IM-55

OPERATION

Temperature variations sensed by the liquid - filled bulb are hydraulically transmitted through the capillary to a stainless steel diaphragm capsule. The capsule operates a lever to actuate one or two snap - action switches.

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PART I - INSTALLATION

1. Mount the controller in any position. Locate the controller where shock and vibration are minimal. See Fig. 1, mounting dimensions.
 - a. Panel Mounting (Types E55S and E55AS). Drill panel as shown in figure 1. Mount to panel using two holes on top bracket.
 - b. Surface Mounting (Types E55 and E55A). Mount using two enclosure mounting holes as shown in figure 1.
2. Install Bulb and Capillary
 - a. Fully immerse the bulb and 6" capillary in the control zone. For best results it is generally desirable to place the bulb close to (but not touching) the heating or cooling source in order to sense temperature fluctuations quickly.
 - b. Place the remaining capillary adjacent to the control head so that it will sense the same ambient temperatures.
 - c. Factory calibration, unless specified otherwise, allows for 6" capillary tube in the control zone. If longer lengths are required recalibration may be necessary, in which case follow procedures outlined in Part II.
 - d. "C" style bulbs can be coiled or shaped to fit the installation. Avoid sharp bends and coils smaller than 2" radius. Do not bend "B" style bulbs.
 - e. Avoid bending or coiling the capillary tube smaller than $\frac{1}{4}$ " radius. Exercise caution when making bends near the capillary ends.
 - f. If a separable well or union connector is used follow separate instructions included.
3. Make Wiring Connections

Wire directly to switch terminals according to particular requirements of the application. See figure 2. For dual switch Types E55A and E55AS, if switches are to be set apart, connect wiring so that switch No.2 will function at the higher temperature.
4. Adjust Switch Settings for dual switch types, switches are factory set to actuate together within 5% of range (switch No.2 set on dial) but may be set to actuate up to 100% of scale range apart. Either switch may be set to agree with the dial. See Part II, paragraphs (3 or 4) for instructions.
5. Start - Up Process

Turn dial knob to the desired temperature setting. Controller is ready for operation. Minor adjustments might be necessary to obtaining better setpoint accuracy after installing the unit in a particular process. See Part II for instructions.



UNITED ELECTRIC CONTROLS COMPANY

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PART II: ADJUSTMENTS (See figure 2)

1. General — Read before making adjustments.

Calibrating Bath — Place the sensing bulb and the amount of capillary to be exposed to process temperatures into the bath, preferably circulating liquid. Bath temperature should be where the greatest setting accuracy is desired or approximately mid-range.

Test Thermometer — Use an accurate one such as a thermocouple with its probe located next to the sensing bulb.

Stabilization — Before making adjustments allow 5 minutes for the thermal system to adjust to the bath temperature. If controlling a process, make sure the process has stabilized, i.e., successive ON - OFF cycles repeat.

Set Point Reference — Connect test lights to the terminals to indicate switch operation.

2. Adjusting Single Switch Types E55 and E55S

Set point adjustment is made by rotating the knob and dial to the desired temperature setting. Controls are factory calibrated, and do not normally require recalibration in the field. However, should this become necessary, follow paragraph 3, steps a through e (below).

3. Adjusting Dual Switch Types E55A and E55AS No.2 Switch to Dial

E55 Series Controllers are standardly supplied with the No.2 (higher temperature) switch set to the dial. To adjust switch settings for these controllers, proceed as follows.

- a. First, follow paragraph 1 of this section entitled "General."
- b. Set the dial to the same temperature as the test bath.
- c. Loosen knob set screw and remove dial, taking care not to rotate the shaft. (Note: Shaft has calibrated flat for easy knob and dial replacement).
- d. Using a 1/16" allen head wrench, turn zero adjustment (A) until switch No.2 actuates. (Counter clockwise for higher setting.)
- e. Replace dial on shaft.
- f. Turn dial to a higher setting, equal to temperature differential (°F) desired between switches No. 1 and No. 2.
- g. Remove knob and dial for access to the No.1 switch adjustment screw.
- h. Using a small screw driver turn in or out the No.1 switch adjustment screw until the No.1 switch actuates.
- i. Replace dial, tighten dial set screw to calibrated flat. Controller is ready for operation.

4. Adjusting Dual Switch Types E55A and E55AS, No.1 Switch to Dial

If your controller has been specifically furnished with the No.1 (lower temperature) switch set to the dial, proceed as follows to readjust switch settings:

- a. First follow paragraph 3 (above) steps a through h.
- b. Having completed step h from paragraph 3, replace knob and dial.
- c. Reset dial to the same setting as the bath temperature.
- d. Remove knob and dial, and using a 1/16" allen head wrench, turn zero adjustment screw slowly in a counterclockwise direction until the No.1 switch transfers.
- e. Replace dial, and adjust to desired setpoint. Controller is ready for operation.

PART III: PARTS REPLACEMENT (See figure 2)

1. SWITCH REPLACEMENTS

To replace switches proceed as follows:

IMPORTANT: Disconnect electrical supply so that switch contacts and terminals are not live.

- a. For enclosed types, remove adjustment cover, knob and dial; then remove two (2) flat head screws to dismount control body from enclosure. Remove the large rectangular cover plate and rubber gasket from the bottom of the enclosure, and disconnect wiring from the switch terminals.
- b. For skeleton and enclosed types, follow instructions c. through g.
- c. Remove the 2 switch mounting screws; remove the switch or switches.
- d. Insert the new switch (es) and tighten screws.
- e. Recalibrate setting (s). See Part II, Adjustments
- f. Rewire the new switches and place unit back in its enclosure.
- g. Reconnect electrical supply.

2. THERMAL ASSEMBLY REPLACEMENT

IMPORTANT: Disconnect Electrical Supply so that switch contact and terminals are not live.

- a. For enclosed types, remove adjustment cover, knob and dial; then remove two (2) flat head screws to dismount control body from enclosure. Remove the large rectangular cover plate and rubber gasket from the bottom of the enclosure, and disconnect wiring from the switch terminals.
- b. Remove switch mounting screws. Remove switches and insulators.
- c. Disengage actuating lever extension spring and remove lever.
- d. Remove clamp that secures capillary (located on inside of mounting bracket).
- e. Pull the diaphragm down and away from the adjusting screw stem. Do not allow bi-metal washers to slide off diaphragm assembly. (NOTE: Some units will not have bi-metal washers).
- f. Using old diaphragm assembly as a pattern, coil the small

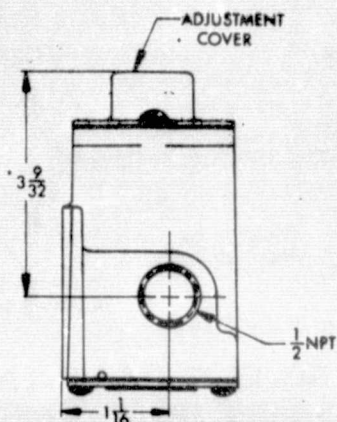
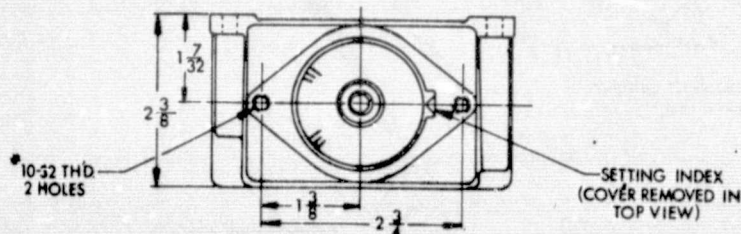
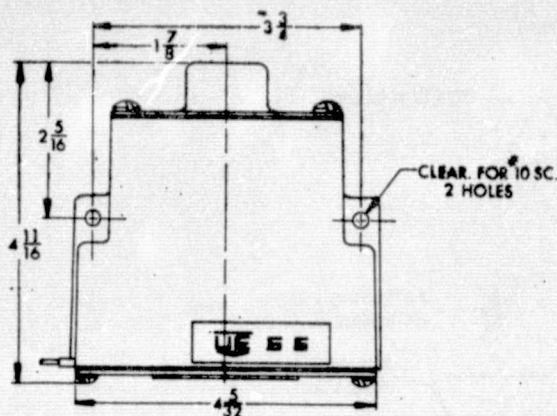
- length of copper capillary on the new assembly in the same manner.
- Transfer the bi-metal washers to the new diaphragm assembly. Be sure that the stamped "O's" on the concave surfaces of the washers are on the inside, adjacent to each other.
 - Slide new assembly fully into adjusting shaft. Hold in place while securing with mounting clamp.
 - Install flipper plate so that bumped radius in center of plate is resting on center of diaphragm.
 - Hold flipper plate in place, and using small screw driver or narrow pliers engage loose end of extension spring to the tab

on bracket.

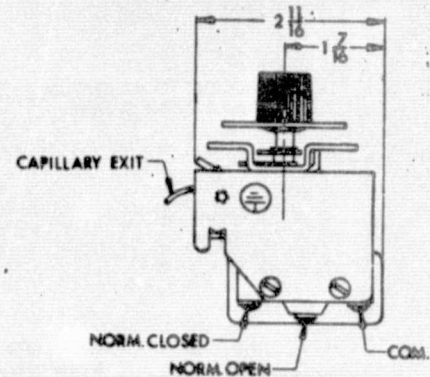
- Align switches with mounting holes in bracket. (NOTE: Switch plunger(s) should be furthest away from the end of flipper plate that is anchored by the extension spring.)
- For enclosed types, slide skeleton unit into enclosure, orienting unit so that adjustment for the second switch is aligned with the opening provided. Secure unit with the (2) flat head screws. Bend capillary into slot on conduit end of enclosure & secure with rubber gasket and cover plate.
- To recalibrate control, refer to PART II, ADJUSTMENTS.

FIGURE 1 MOUNTING DIMENSIONS

ENCLOSED TYPES



SKELETON TYPES



MOUNTING CUT-OUT

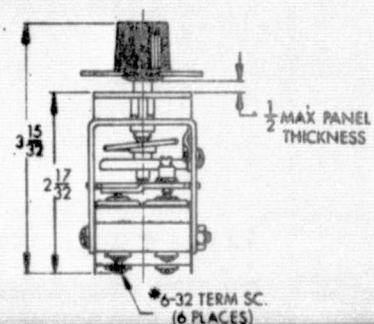
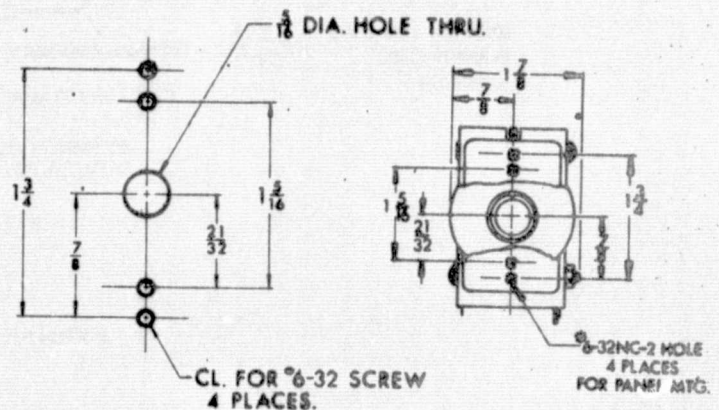
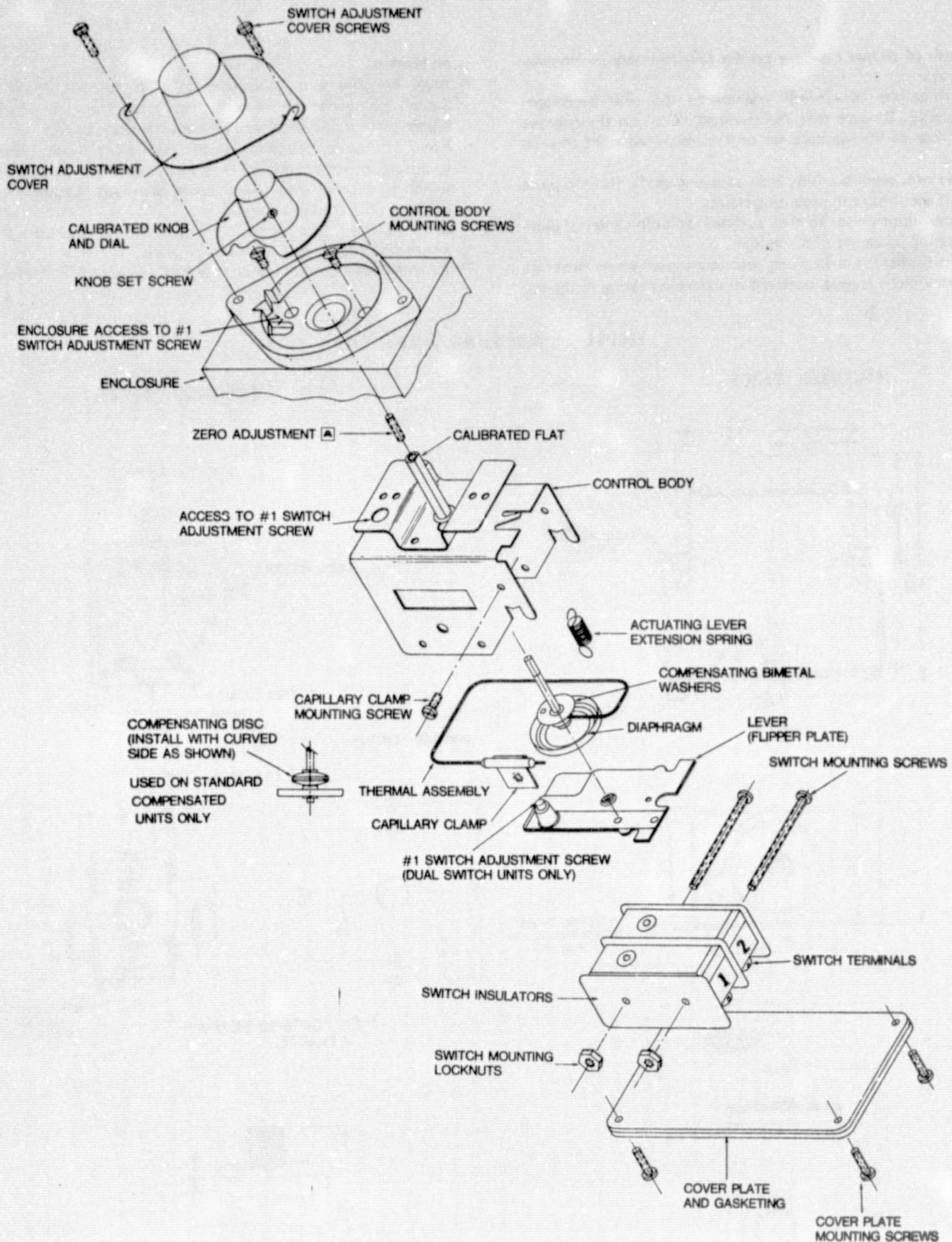


FIGURE 2 GENERAL LAYOUT

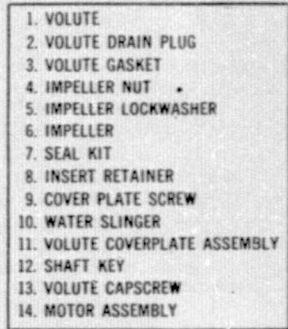
EXPLODED VIEW


UNITED ELECTRIC CONTROLS COMPANY

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APPENDIX C

BELL AND GOSSETT 1535 PUMP



ITT Fluid Handling Division, International Telephone and Telegraph Corporation, warrants that all BELL & GOSSETT products furnished by it for a period of one year after date of shipment from its factory to be free from defects in material and workmanship, subject only to the following:

1. Manufacturer's liability under this warranty, land under any other warranty express or implied, statutory or otherwise, is limited to repair or, at Manufacturer's option, replacement of all parts which are shown to have been defective when shipped, and then only if Manufacturer is notified of such within such warranty period and such defective parts are promptly delivered to its factory at 8200 N. Austin Avenue, Morton Grove, Illinois, transportation charges prepaid. Manufacturer's liability hereunder shall not be enforceable until such equipment has been fully paid for. Except to the extent expressly assumed herein, Manufacturer's liability for incident, loss and consequential damages is hereby excluded to the full extent permitted by applicable law. Manufacturer's liability as stated herein cannot be altered or enlarged except by a writing signed by an officer of Manufacturer.
2. Replacement parts will be invoiced in the regular way with invoices subject to adjust-ent after the parts claimed defective are examined at our factory. ITI Field Handling Division reserves the right to make such changes in details of design, construction of product arrangement as shall, in its judgment, constitute an improvement over former practice.

BELL & GOSSETT MORTON GROVE, ILL. 60053 **ITT**
Fluid Handling Division, International Telephone and Telegraph Corporation

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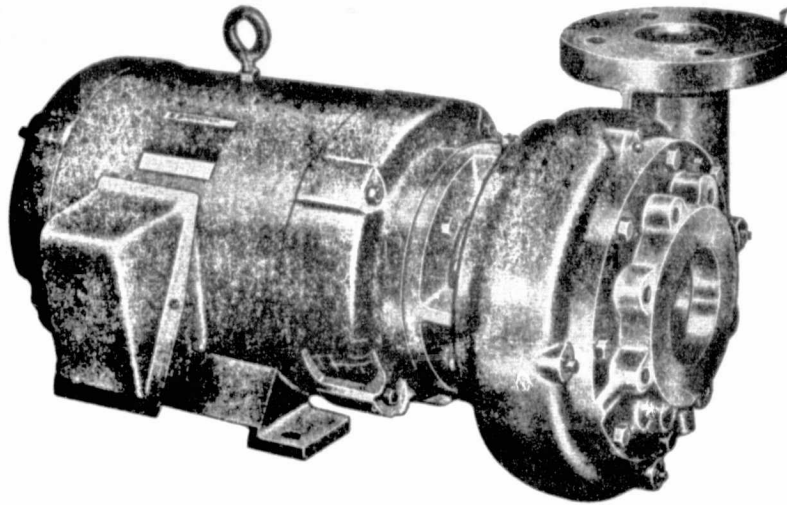
APPENDIX D

THRUSH CENTRIFUGAL PUMPS

THRUSH

Operating & Maintenance Instructions for

PC_{2g} CLOSE COUPLED END SUCTION CENTRIFUGAL PUMPS



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Your Thrush End Suction Centrifugal Pump has been carefully assembled and factory tested to provide years of trouble-free service. In order to insure the service intended, the following information is provided to enable proper installation, operation and maintenance of this product.

Disassembly	4
Discharge Piping	3
Flooded Suction Priming	3
Foundation	2
Grouting, if base plate is used	2
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Location	2
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Mechanical Seals	7
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THRUSH Products, Inc.

P.O. Box 228 • Peru, Indiana 46970 • (317) 472-3351

Serving the world since 1921



INSTALLATION

LOCATION

The pump should be located as close to the liquid source as possible so that the suction line can be short and direct. It should be located in a clean, open area, where it is easily accessible for inspection, lubrication and repair. Pumps installed in dark, dirty areas or in cramped locations are often neglected which can result in premature failure of both the pump and the driver.

Adequate provisions should be made for electrical wiring to the pump motor. A switch and overload protection should be installed near the pump unless it is impractical. The electrical conduit should be positioned in such a way as to preclude the possibility of moisture entering the conduit or the motor and causing short circuits.

FOUNDATION

The foundation must be sufficiently rigid to absorb any vibration and stress encountered during pump operation. A raised foundation of concrete is preferable for most floor mounted pumps. The raised foundation assures a satisfactory base, protects against flooding, simplifies moisture drainage and facilitates keeping the area clean.

The pump should be firmly bolted to the foundation, whether it is a raised concrete base, steelwork wall, or structural member. The mounting bolts or studs should be accurately located per the applicable Thrush dimension sheet. Foundation bolts should be enclosed by a sleeve 2 to 4 diameters larger than the bolt to allow movement for proper alignment with the pump mounting holes. Refer to figure 1. If the pump is to be mounted on steelwork or other structure, adequate support should be provided to prevent distortion of the base plate or the structure, which could produce excessive strain on the pump casing and piping and seriously affect alignment of the pump and driver.

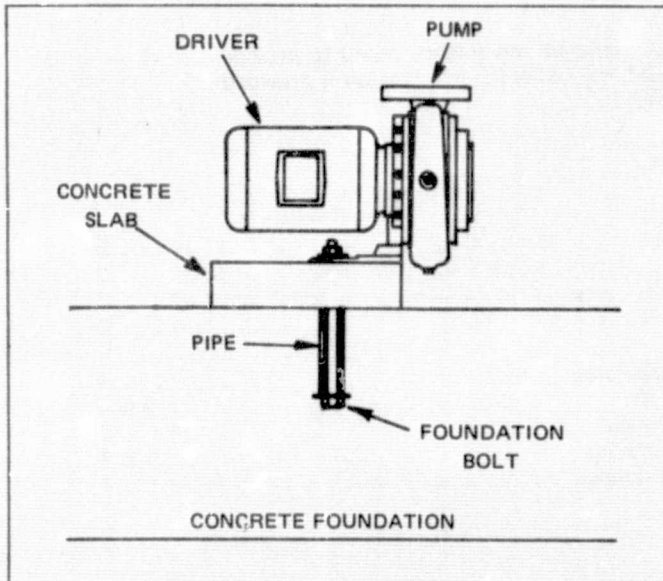


FIGURE 1. FOUNDATION FOR CLOSE-COUPLED PUMPS

MOUNTING

The pump unit should be set on the foundation, being careful not to damage the threads on the foundation bolts. Shims should be inserted and the pump leveled. A spirit level should be used on the faces of the suction and discharge flanges. If the pump has threaded nozzles, a short piece of pipe inserted in the nozzles will serve as a smooth surface for a leveling reference point. The shims should be adjusted until the pump is leveled horizontally and vertically. Tighten the foundation bolts finger tight.

GROUTING, IF BASE PLATE IS USED

Grouting the base plate prevents lateral movement of the base plate and improves the vibration absorbing characteristics of the foundation by increasing its mass. A wooden dam should be constructed around the base plate to contain the grout while it is being poured. The entire base plate should be filled with grout, allow 48 to 72 hours for grout to dry. After grout is thoroughly dried, firmly tighten foundation bolts.

PIPING

The piping practices you follow will directly affect the efficiency and power consumption of your pump. Pay particular attention to the seemingly insignificant details involved in piping for they make the difference between a good and bad installation. BOTH THE SUCTION AND THE DISCHARGE PIPING SHOULD BE INDEPENDENTLY SUPPORTED NEAR THE PUMP. LIBERAL USE OF PIPE HANGERS AND SUPPORT BLOCKS WILL PREVENT EXCESSIVE STRAIN ON THE PUMP CASING AND ON THE PIPE JOINTS. The suction diameter should be at least the same diameter as the suction nozzle on the pump and preferably larger. Use of a smaller diameter pipe will result in loss of head due to friction. All joints must be tight to maintain prime on the pump.

SUCTION PIPING

Long radius elbows should be used in place of standard elbows wherever possible, because of their superior flow characteristics. Elbows should not be used at suction nozzle, but if it is unavoidable, long radius elbows should be used. Elbows installed in any position at the suction nozzle have a tendency to distribute the liquid unevenly in the impeller eye and may cause a reduction in capacity, create an undesirable thrust condition, or create noisy operation. Eccentric reducers should be installed directly at the suction nozzle, with the taper at the bottom to prevent air pockets from forming. Straight taper reducers should never be used in a horizontal suction line because of the air pocket that is formed at the leg of the reducer and the pipe. Refer to figure 2.

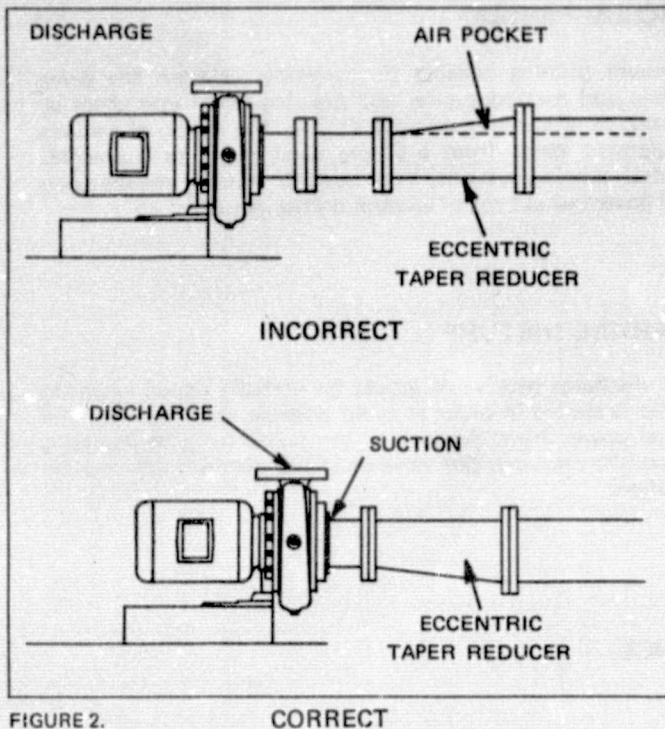


FIGURE 2. CORRECT

DISCHARGE PIPING

The discharge pipe diameter should be the same as, or larger than, the discharge nozzle diameter. The size of the discharge pipe to be used is dependent upon its application.

Long radius elbows should be used in the discharge piping as well as in the suction piping to prevent excessive head loss due to friction. Whenever possible, elbows should not be installed directly at the discharge nozzle as the turbulence created by the elbow will affect pressure gauge readings.

An increaser should be installed at the discharge nozzle if larger diameter discharge piping is used. Straight taper increasers and/or reducers are satisfactory in discharge applications.

Expansion joints are used primarily to prevent the transmission of piping strain, caused by thermal expansion and contraction, piping misalignment, pressure changes, or other causes, to the pump casing. They are also used to suppress any noise that may be transmitted through the piping. It is recommended that the flexible metal type of expansion joint be used, because rubber expansion joints, while costing less, have a tendency to deteriorate, making frequent replacement necessary.

PROPER PIPING ALIGNMENT IS ESSENTIAL BEFORE CONNECTION IS MADE. PIPING ALIGNMENT SHOULD NEVER BE ACHIEVED BY FORCE, THIS COULD PRODUCE STRAIN ON THE PIPING AND THE PUMP CASING. PROPER SUPPORTS SHOULD BE INSTALLED FOR THE PIPING TO KEEP ITS WEIGHT OFF THE PUMP CASING.

OPERATION

NOTE: CENTRIFUGAL PUMPS SHOULD NEVER BE STARTED OR RUN DRY. OPERATING A PUMP DRY WILL CAUSE SCORING OF THE MECHANICAL SEAL, RESULTING IN PREMATURE SEAL FAILURE. TO PREVENT THE PUMP FROM BEING RUN DRY, IT SHOULD BE PRIMED BEFORE STARTING.

PRIMING THE PUMP

Your pump will not operate satisfactorily until it is primed. All air must be expelled from the suction piping and pump casing and replaced by the liquid to be pumped. There are several methods of priming pumps. The one you select will depend on your specific requirements.

FLOODED SUCTION PRIMING

This method of priming a pump is relatively simple. Fig. 3.

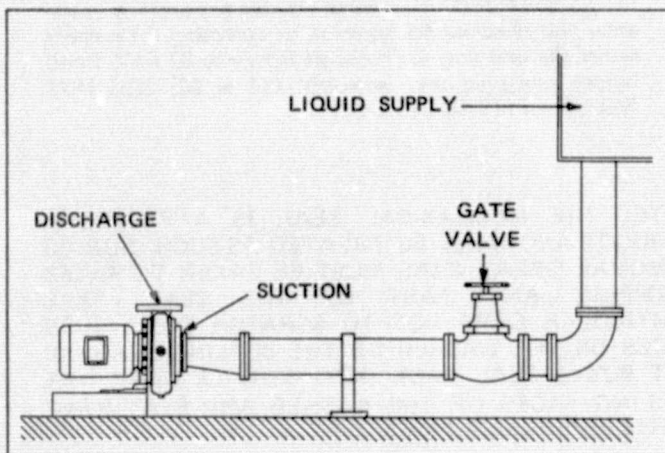


FIGURE 3. FLOODED SUCTION PRIMING

The liquid source is located above the pump and all that is necessary to prime the pump is to open the air vent valve or plug in the pump casing and to crack the gate valve in the suction line. The suction line and pump should be filled slowly until a steady stream of liquid is observed flowing from the air vent. After the pump is operating it is recommended that the air vent valve or plug be opened again to insure that all air has been expelled from the pump casing.

SUCTION LIFT

A foot valve should be used for priming on suction lift applications, Fig. 4. The foot valve located at the bottom end or foot of the suction piping, functions as a check valve which allows flow in one direction only, toward the pump. Otherwise, all the liquid may drain from the pump and suction piping back into the sump after shutdown.

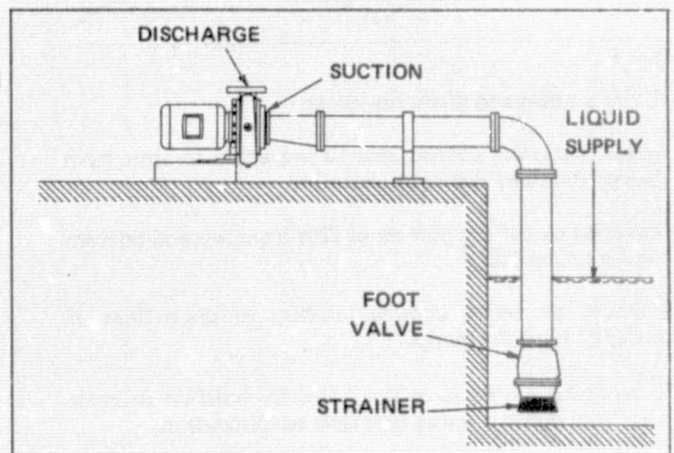


FIGURE 4. PRIMING WITH A FOOT VALVE

Initial priming is accomplished by completely filling the suction piping and pump casing with the liquid to be pumped. This can be done by removing the air vent valve or plug at the top of the pump casing, and inserting a pipe nipple in the orifice with an appropriate increaser to accommodate a hose connection. A priming line can also be inserted in the discharge piping between the check valve and the pump, or the priming can be done with a bucket and funnel. The important thing is to completely fill the suction pipe and pump casing with liquid.

When the pump is started, the vacuum created by pumping the priming fluid, combined with atmospheric pressure in the liquid well, forces liquid into the suction piping, thus opening the valve and keeping it open until the pump is shut down. When the pump is shut down, the liquid being pumped reverses its flow causing the valve to close. The liquid is now trapped in the suction piping and pump casing, thus maintaining a prime on the pump.

VACUUM PRIMING

Vacuum priming consists of removing air from the pump casing and suction piping and drawing liquid into them by means of a vacuum creating device. The types of vacuum equipment range from a simple hand pump to a complex central priming systems. Your specific priming requirements will govern what type of vacuum primer you use.

STARTING THE PUMP

The discharge gate valve should be partially closed when the pump is started in order to avoid possible water hammer and initial power draw. As soon as the pump is up to operating speed, the discharge gate valve should be opened to the desired position.

MAINTENANCE

It is doubtful that your Thrush pump will ever require complete disassembly, generally only certain components need be disassembled to accomplish inspection or repair.

DISASSEMBLY

Since your Thrush PC2g pump is of back pull out design, it is unnecessary to disconnect the piping or casing for service. All service and maintenance can be performed by disconnecting the electric service and removing the bracket-motor assembly from the casing.

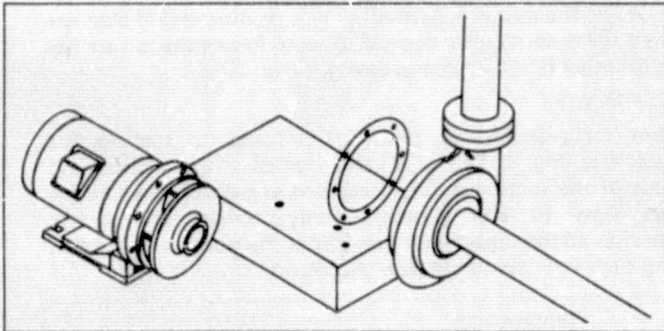


FIGURE 5.

1. Close suction and discharge valves.
2. Break electrical connections to prevent drive unit from being energized during disassembly.
3. Unscrew two of the pipe plugs (29) from top and bottom of the casing (28).
4. Remove all relief, cooling, flushing or drain lines, if present, from the pump.
5. Disconnect wiring to motor, unscrew hold down bolts that hold down support foot (24) to foundation.

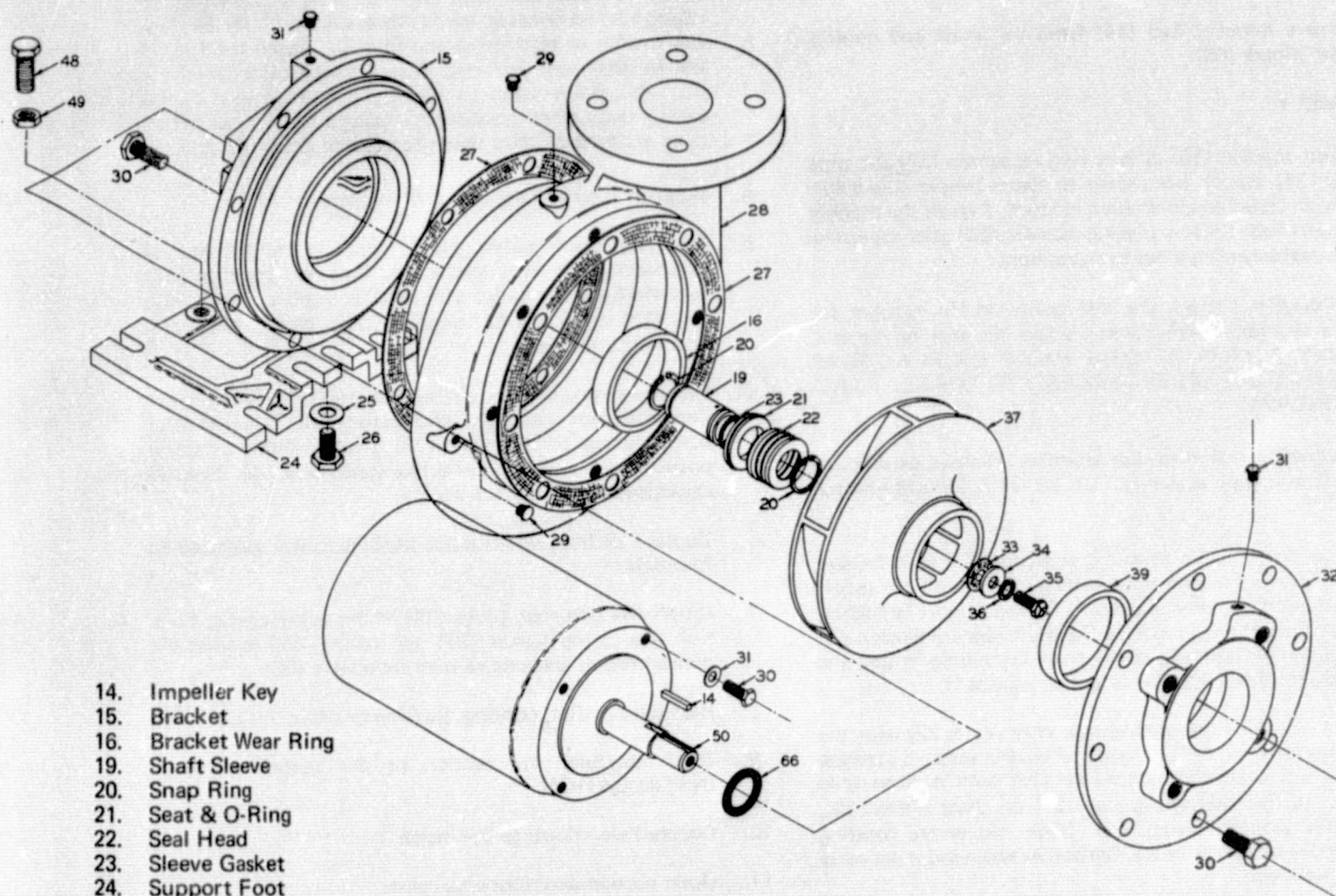
6. Remove capscrews (30) from bracket (15) and pull motor-bracket assembly from casing (28). Remove casing gasket (27).
7. Unscrew impeller screw (35) and remove washer (34), taking care not to damage gaskets (33 & 36).
8. Slide impeller (37) and impeller key (14) from the shaft, again taking care not to damage sleeve gasket (23) located behind impeller. Remove sleeve gasket (23).
9. Suction head wear ring (39) is pressed into suction head (32) with an interference fit and must be removed with a puller if replacement is necessary.
10. If replacing seal cartridge assembly (19, 20, 21 & 22) slide seal assembly off the shaft.
- 10A. If replacing mechanical seal only (21 & 22) slide seal assembly off the shaft (19, 20, 21 & 22). Remove snap ring (20) at spring end. Remove spring and seal head (22). The rubber in seal head (22) may be partially adhered to shaft sleeve (19). Remove seat and o-ring (21). The sleeve should be carefully cleaned to remove any residue in seal area, and checked for abrasion or corrosion. The sleeve under the seal may be polished lightly to 32 RMS finish before replacing seal assembly (21 & 22) (DO NOT REUSE A PITTED SLEEVE)

NOTE: THE MECHANICAL SEAL IS A PRECISION PRODUCT AND MUST BE TREATED AS SUCH. DURING REMOVAL GREAT CARE MUST BE TAKEN TO AVOID DROPPING ANY PART OF THE SEAL. TAKE PARTICULAR CARE NOT TO SCRATCH THE LAPPED FACES ON THE WASHER OR THE SEALING SEAT. DO NOT PUT A SEAL BACK INTO SERVICE UNTIL THE SEALING FACES OF THE WASHER AND SEAT HAVE BEEN LAPPED OR REPLACED.

PC₂₀ SERIES PUMPS

PARTS LIST

ORIGINAL PAGE 15
OF POOR QUALITY



- 14. Impeller Key
- 15. Bracket
- 16. Bracket Wear Ring
- 19. Shaft Sleeve
- 20. Snap Ring
- 21. Seat & O-Ring
- 22. Seal Head
- 23. Sleeve Gasket
- 24. Support Foot
- 25. Washer
- 26. Capscrew
- 27. Casing Gasket
- 28. Casing
- 29. Pipe Plug
- 30. Capscrew
- 31. Pipe Plug
- 32. Suction Head
- 33. Imp. Washer Gasket
- 34. Imp. Washer
- 35. Imp. Bolt
- 36. Imp. Bolt Gasket
- 37. Impeller
- 39. Suction Head Wear Ring
- 48. Jack Bolt
- 49. Lock Nut
- 50. Motor
- 66. Water Slinger

BOLD FACE NUMBERS INDICATE RECOMMENDED SPARE PARTS.

FIGURE 6. PUMP AND POWER FRAME, EXPLODED VIEW

11. The seal cavity of the bracket (15) should be cleaned of all residue. Make sure that the 1/32 inch radius in the seal seat cavity is not damaged during disassembly since a sharp edge can easily cut the "O" Ring during re-assembly.
12. Remove capscrews (26) and washers (25) to take off support foot (24).
13. Unscrew capscrews (30) and pipe plug (31) to remove bracket (15) from motor.
14. Remove impeller key (14) from the shaft and remove water slinger (66).

REASSEMBLY

1. Mount bracket (15) by screwing capscrews (30) and pipe plug (31) evenly into motor to assure proper alignment. Turn all capscrews in an even amount. Attach the bracket support foot (24) by placing washers (25) over capscrews (26) and screwing them into position.
2. Thoroughly inspect the seal cavity in the bracket for burrs or nicks which could damage the seat of the seal. APPLY A FILM OF SOAP PASTE OR FLAX SOAP (DO NOT USE OIL OR GREASE) TO THE SEAT AND O-RING (21).

If replacing seal cartridge assembly, remove card board spacer and slide assembly (19, 20, 21 & 22) onto motor shaft (50).

If it is not possible to insert seal assembly with fingers, press into place a piece of tubing having end cut square and matching sleeve diameter. Tubing should be slightly larger than the diameter of the shaft. Spring tension will probably prevent the sleeve from remaining in position axially until the impeller is locked against it.

- 2A. When replacing mechanical seal only (21 & 22) wipe the sealing faces of the seat and seal washer clean. Lubricate these surfaces and shaft sleeve (19) with a clean soap solution. Put seat and o-ring (21) on shaft sleeve (19), smooth side to pump end. Slide the entire rotating assembly onto the sleeve. Carbon in seal head must mate with seal seat.

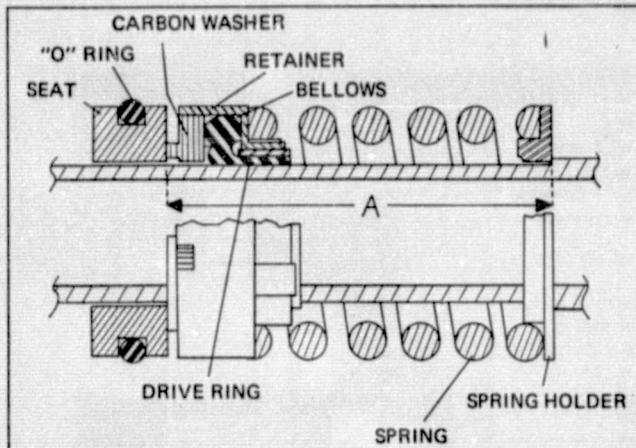
Replace snap ring (20). The shaft sleeve with the seal rotating assembly on it may now be replaced onto the pump shaft. Spring tension will probably prevent the sleeve from remaining in position axially until the impeller is locked against it.

3. Press suction head wear ring (39) in suction head if change is necessary. Rings should not be hammered into place. Use a press, or clamp the parts in a bench vise, using wooden blocks to protect the rings. It may be necessary to pin or dowel the rings after assembly if the insert or casing has had rings replaced before, since each reassembly can stretch or tear metal and thereby loosen the fits. If the facilities are available, it is good practice to take a very light finish cut or to ream the inside diameter of the casing rings after pressing to restore roundness. When rings are pressed, they may get squeezed out of shape.
 4. Replace bracket wear ring (16) in bracket (15).
 5. Carefully place sleeve gasket (23) on motor end of impeller. Assemble impeller key (14) and impeller (37) to shaft. Secure impeller with impeller washer gasket (33), impeller washer (34), impeller bolt gasket (36) and impeller bolt (35).
 6. Replace casing gasket (27) on bracket (15). Slide entire motor-bracket assembly into casing (28) being careful not to damage casing gasket (27). With assembly properly positioned in casing (28) replace capscrews (30). Turn all capscrews in and tighten evenly.
- Replace all hold down bolts securing motor assembly to foundation.
7. Install the two pipe plugs (29) in the pump casing. Position the casing gasket (27) and casing (28) against the pump bracket and secure with capscrews (30).
 8. Replace all relief, cooling, flushing or drain lines.
 9. Read carefully the section of the manual titled — INSTALLATION.
 10. Connect electricity to the motor.
 11. Open suction and discharge valves.

SERVICE

Your Thrush pump requires no maintenance other than periodic inspection, occasional cleaning and lubrication of bearings. The intent of inspection is to prevent breakdown, thus obtaining optimum service life. The liquid end of the pump is lubricated by the fluid being pumped and therefore does not require periodic lubrication. The motor, however, may require lubrication, in which case, the motor manufacturer's recommendation should be followed.

MECHANICAL SEALS



DESCRIPTION	MATERIAL
Seat	Ni Resist
'O' Ring	EPT Elastomer
Washer	Carbon
Retainer	303 Ststl
Bellows	EPT Elastomer
Drive Ring	303 Ststl
Spring	303 Ststl
Spring Holder	303 Ststl
SEAL KITS	
PC2g 1 1/4"	For Motor Frame No. 143JM thru 215JM
PC2g 1 5/8"	For Motor Frame No. 254JM thru 256JM

TROUBLESHOOTING HOT WATER
SEAL PROBLEMS

TROUBLE	POSSIBLE CAUSE	REMEDY
Cracked or broken stationary seat (Ceramic)	Seal ran dry and heated up. When liquid reached seal faces it was cooler, causing thermal cracks	Check to insure seal chamber is full of liquid before starting pump. On high temperature application insure proper flushing at seal faces
Seat scored or grooved (Ni-Resist)	Lack of Lubrication	
Carbon washer scored and grooved	Dirty system Treatment level & temperature higher than anticipated	Have system cleaned and flushed. Upgrade seal seat matl. Install solids separator or filter in flush line Check against chart and prescribe proper seal materials or lower treatment levels
Carbon washer worn unevenly	Seal improperly installed	Check installation inst. for proper assembly
Flexible bellows hard & brittle	Temperature too high	Check against chart for proper materials
EPT bellows soft & sticky; appears to be dissolving	Seal assembled with petroleum base product as lubricant System contains soluble oil	Install new seal using soap solution as lubricant Clean and flush system, or consult factory for recommendation
Retainer drive tabs badly worn or broken	Vibration or coupling misalignment Periodic loss of lubrication at seal faces	Realign pump & motor Insure proper flushing at seal faces.
Flexible bellows ruptured	Pressure too high Coupling misalignment Temperature too high	See spec sheets for max. pressure rating. Realign pump & motor Check chart and prescribe proper seal

TROUBLESHOOTING

TROUBLE: 1. Pump fails to prime or loses its prime

PROBABLE CAUSE	REMEDY
a. Air leaks in suction lines	a. Clean and tighten all suction connections; relocate suction inlet in liquid source.
b. Suction strainer is clogged	b. Remove dirt, leaves or other materials from strainer.
c. Suction lift is too high	c. Re-evaluate pump requirements and correct suction conditions accordingly.
d. Defective priming valve	d. Replace valve.
e. Defective packing or seal	e. Replace packing or seal.

TROUBLE: 2. No discharge from pump

PROBABLE CAUSE	REMEDY
a. Pump is not properly primed	a. Reprime the pump; refer to priming troubles and remedies.
b. Total head is too high	b. Re-evaluate head calculations; measure elevation differences between pump and liquid source, and pump and discharge point.
c. Driver is not operating at rated speed	c. Check voltage of electric motor; check steam pressure of steam turbine; check engine R.P.M.'s. Refer to applicable maintenance manuals for possible troubles and corrective action.
d. Impeller or discharge line is clogged	d. Back flush pump to clear obstruction; disassemble pump and/or piping and remove obstruction.
e. Wrong direction of rotation	e. Check wiring against diagram on motor name plate and in controller; reverse any two power leads on a three-phase motor; replace a single phase motor.
f. Pump is vapor bound	f. Provide additional pressure on liquid being pumped by elevating liquid source or pressurizing the supply tank.

TROUBLE: 3. Pump does not deliver rated capacity

PROBABLE CAUSE	REMEDY
a. Pump is not properly primed	a. See 2.a. above.
b. Suction lift is too high	b. See 1.c. above.
c. Excessive air in liquid	c. See 1.a. above.
d. Air leakage through stuffing box	d. See 1.e. above.
e. Driver is not operating at rated speed	e. See 2.c. above.
f. Impeller is clogged	f. See 2.d. above.
g. Wearing rings are worn	g. Replace wearing rings.
h. Impeller is damaged	h. Replace impeller.
i. Pump is vapor bound	i. See 2.f. above.

TROUBLE: 4. Insufficient pressure

PROBABLE CAUSE	REMEDY
a. Excessive air in liquid	a. See 3.c. above.
b. Drive is not operating at rated speed	b. See 2.c. above.
c. Wrong direction or rotation	c. See 2.e. above.
d. Total head is too high	d. See 2.b. above.
e. Wearing rings are worn	e. See 3.g. above.
f. Impeller is damaged	f. See 3.h. above.
g. Casing gasket is defective allowing internal leakage	g. Replace casing gasket.
h. Liquid is vaporizing	h. See 2.f. above.

TROUBLE: 5. Pump starts then stops pumping

PROBABLE CAUSE	REMEDY
a. Air leaks in suction line	a. See 1.a.
b. Air pocket in suction line	b. Reprime the pump; eliminate air pocket conditions.
c. Water seal line is plugged	c. Remove obstruction from water line.
d. Excessive air in liquid	d. See 1.a.
e. Suction lift too high	e. See 1.c.
f. Defective packing or seal	f. See 1.e.
g. Pump is vapor bound	g. See 2.f.

TROUBLE: 6. Excessive power consumption

PROBABLE CAUSE	REMEDY
a. Speed is too high	a. Internal electric motor wiring is incorrect; replace motor; refer to applicable driver maintenance manuals for possible troubles and corrective action.
b. Wrong direction of rotation	b. See 2.e.
c. Total head is too high	c. See 2.b.
d. Total head is too low	d. Re-evaluate head conditions; correct as required.
e. Impeller is clogged	e. See 2.d.
f. Impeller is binding	f. Relieve strain on casing; adjust impeller clearance.
g. Motor shaft is bent or worn	g. Replace motor shaft.
h. Driver and pump are misaligned	h. Realign driver with pump.
i. Power frame shaft is bent	i. Replace shaft.
j. Wearing rings are worn	j. See 3.g.
k. Packing is incorrectly installed	k. Install packings correctly; replace if necessary.

TROUBLE: 7. Pump is noisy or has excessive vibration

PROBABLE CAUSE	REMEDY
a. Magnetic hum	a. Consult motor manufacturer.
b. Motor bearings are worn	b. Replace bearings.
c. Foreign material in impeller	c. Remove foreign material.
d. Impeller is binding	d. See 6.f. above.
e. Motor shaft is bent or worn	e. See 6.g. above.
f. Driver and pump are misaligned	f. See 6.h. above.
g. Power frame shaft is bent	g. See 6.i. above.
h. Foundation is not rigid	h. Strengthen foundation; change method of mounting pump unit.
i. Worn bearing in power frame	i. Replace bearing.
j. Impeller is damaged	j. See 3.h.
k. Lack of lubrication in power frame	k. Lubricate power frame bearings; replace bearings if damaged.
l. Pump is not properly leveled	l. Check levelness of pump.
m. Piping is not supported	m. Provide support for suction and discharge piping.
n. Pump is cavitating	n. Re-evaluate pump application.



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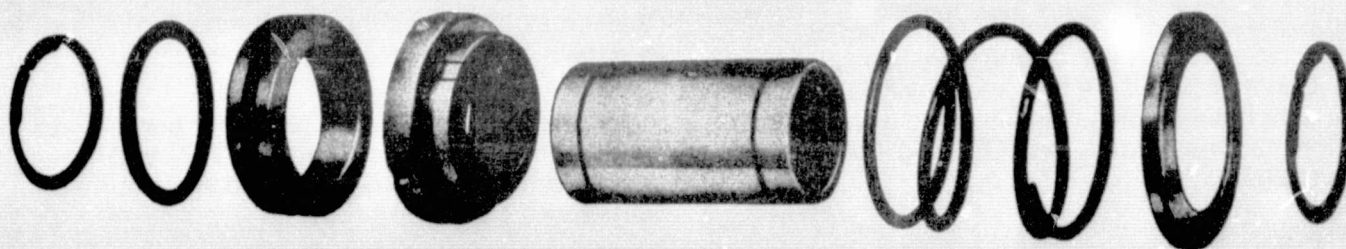
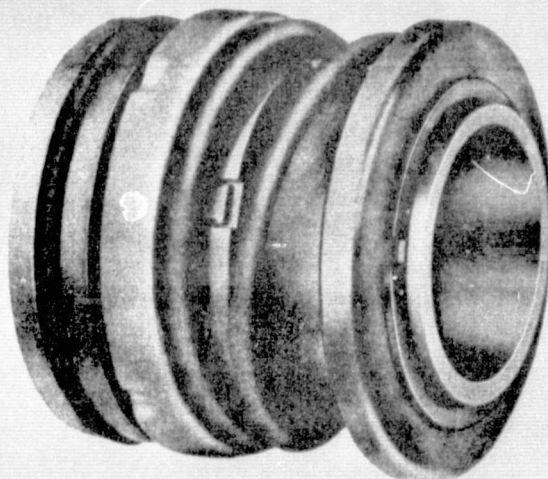


THRUSH

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Installation Instructions for

PF_{2g} & PC_{2g} CENTRIFUGAL PUMPS CARTRIDGE MECHANICAL SEALS



Thrush PF_{2g} and PC_{2g} Pumps are of the back pullout design. Therefore, it is unnecessary to disconnect the piping or casing for service. All service and maintenance on PF_{2g} pumps can be performed by disconnecting the coupling and removing the power frame assembly from the casing (Fig. 1). On PC_{2g} pumps service can be performed by disconnecting motor wiring and removing motor assembly from casing (Fig. 2).

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PF _{2g} Parts List	3
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DISASSEMBLY

1. Close suction and discharge valves.
2. Break electrical connections to prevent drive unit from being energized during disassembly.
3. Unscrew two of the pipe plugs (29) from top and bottom of the casing (28).
4. Remove all relief, cooling, flushing or drain lines, if present, from the pump.
5. (PF_{2g}) Disconnect the flexible coupling from between the pump and motor. Unscrew the hold down bolts that hold support foot (24) and bearing frame (10) to base.
- 5A. (PC_{2g}) Disconnect wiring to motor. Unscrew hold down bolts that hold support foot (24) to foundation.
6. Remove capscrews (30) from bracket (15) and pull (frame assembly — PF_{2g}) or (motor assembly — PC_{2g}) from casing (28). Remove casing gasket (27).
7. Unscrew impeller bolt (35) and remove imp. washer (34), taking care not to damage gaskets (33 & 36).
8. Slide impeller (37) and impeller key (14) from the shaft, again taking care not to damage sleeve gasket (23) located behind impeller. Remove sleeve gasket (23).
9. Remove seal cartridge assembly (19, 20, 21 & 22) from shaft (12).
10. The seal cavity of the bracket (15) should be cleaned of all residue. Make sure that the 1/32 inch radius in the seal seat cavity is not damaged during disassembly since a sharp edge can easily cut the "O" Ring during reassembly.

REASSEMBLY

1. Thoroughly inspect the seal cavity in the bracket for burrs or nicks which could damage the seat of the seal. **Apply a film of soap paste or flax soap (do not use oil or grease) to "O" Ring of the seal seat (21).**
2. Remove card board spacer and slide cartridge assembly (19, 20, 21 & 22) onto shaft (12). Making sure "O" Ring on seat (21) is properly seated in bracket (15). If it is not possible to insert seal assembly with fingers, press into place a piece of tubing having end cut square and matching sleeve diameter. Tubing should be slightly larger than the diameter of the shaft. Spring tension will probably prevent the sleeve from remaining in position axially until the impeller is locked against it.
3. Carefully place sleeve gasket (23) on motor end of impeller. Assemble impeller key (14) and impeller (37) to shaft. Secure impeller with impeller washer gasket (33), impeller washer (34), impeller bolt gasket (36), and impeller bolt (35).
4. Replace casing gasket (27) on bracket (15). Slide entire (frame assembly — PF_{2g}) (motor assembly — PC_{2g}) into casing (28) being careful not to damage casing gasket (27). With assembly properly positioned in casing (28) replace capscrews (30). Turn all capscrews in and tighten evenly.

Replace all hold down bolts securing pump assembly to base or motor assembly to foundation.
5. Install the two pipe plugs (29) in the pump casing. Position the casing gasket (27) and casing (28) against the pump bracket and secure with capscrews (30).
6. Replace all relief, cooling, flushing or drain lines.
7. Read carefully the section of the manual titled INSTALLATION, especially those paragraphs referring to pump and coupling alignment.
8. Connect electricity to the motor.
9. Open suction and discharge valves.

NOTE: The mechanical seal is a precision product and must be treated as such. During installation great care must be taken to avoid dropping any part of the seal. Take particular care not to scratch the lapped faces on the washer or the sealing seat. Do not put a seal back into service until the sealing faces of the washer and seat have been lapped or replaced.

PF_{2g} SERIES PUMPS PARTS LIST

Figure 1

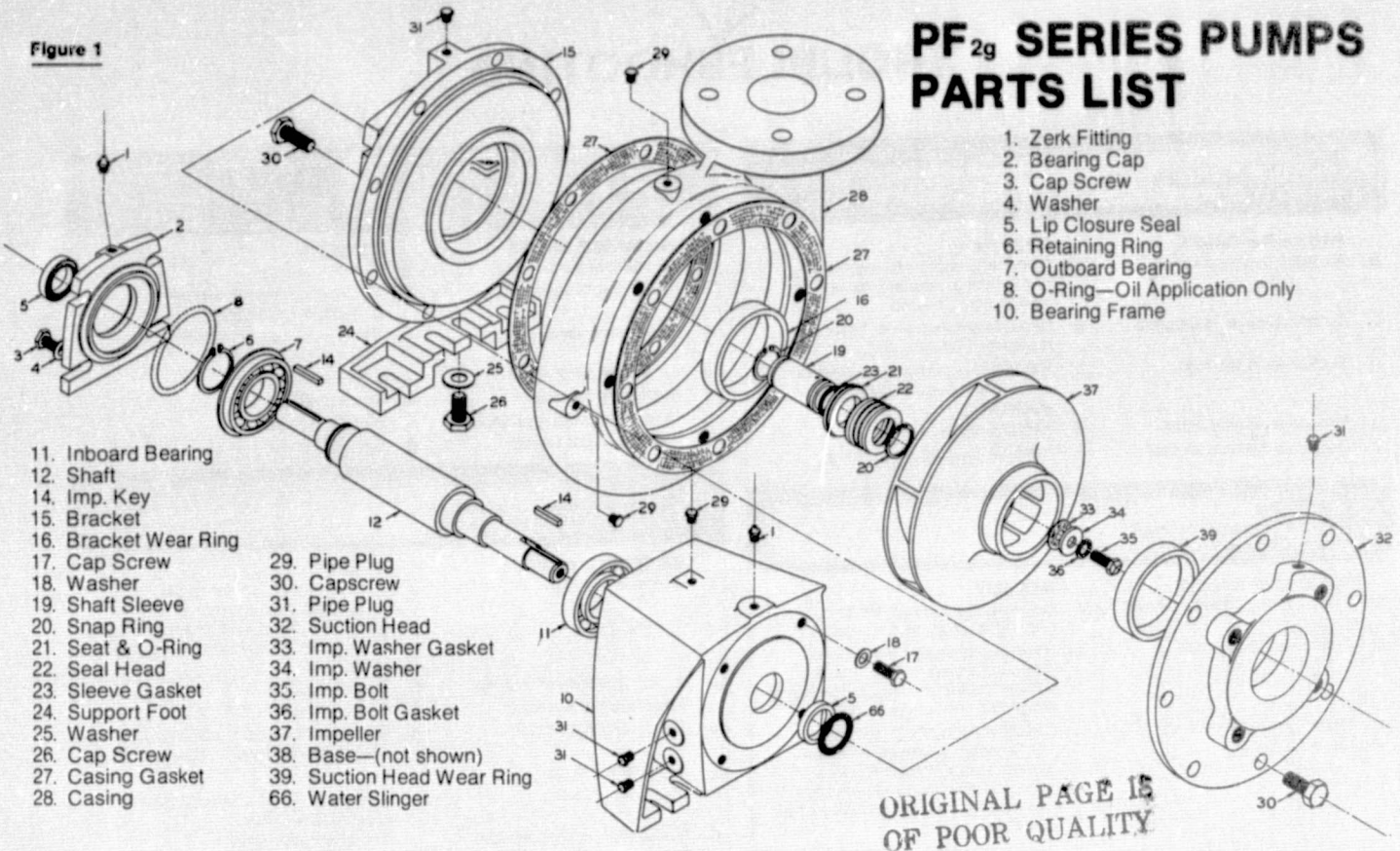
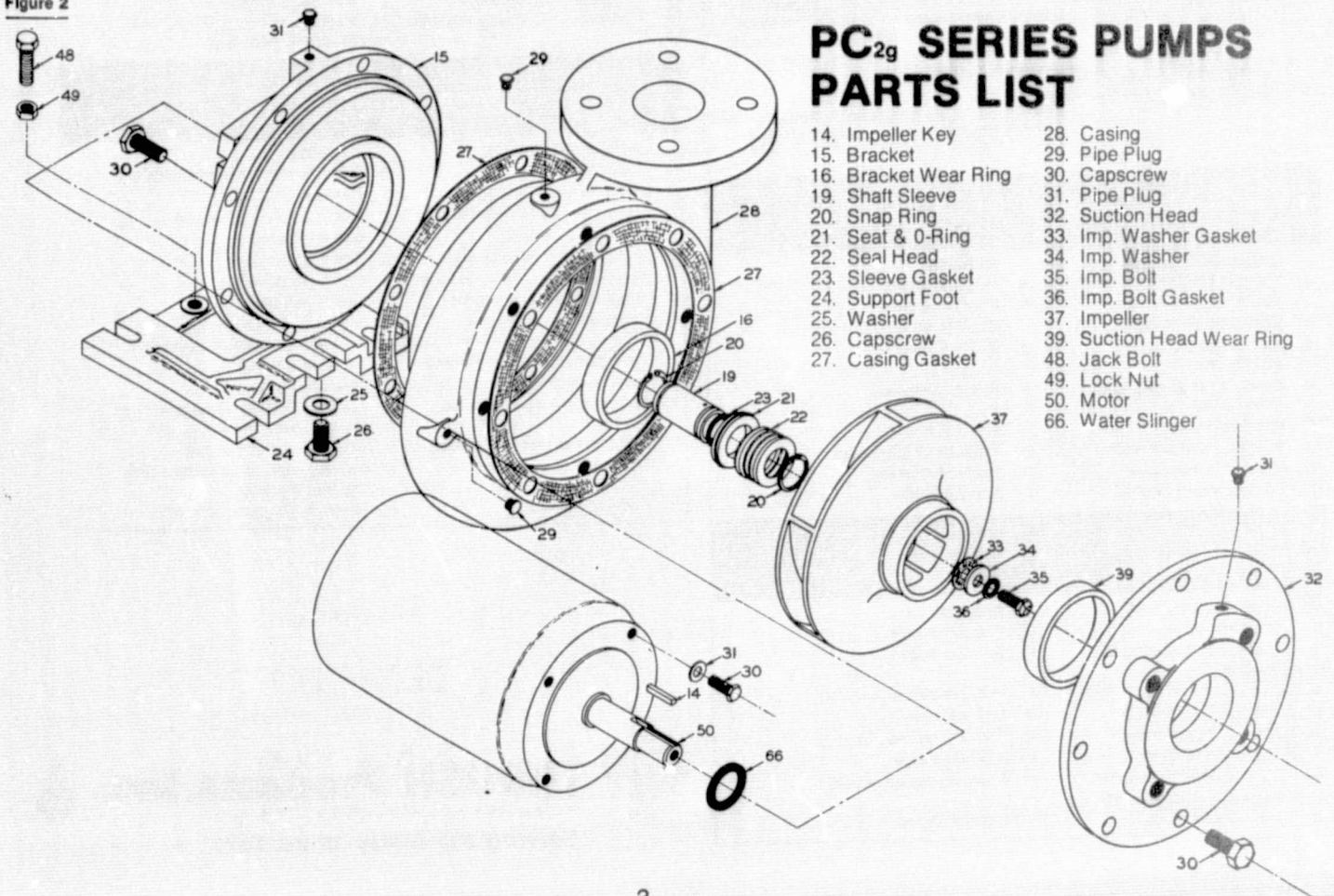


Figure 2

PC_{2g} SERIES PUMPS PARTS LIST



TROUBLESHOOTING

TROUBLE:

1. Pump fails to prime or loses its prime

PROBABLE CAUSE

- a. Air leaks in suction lines
- b. Suction strainer is clogged
- c. Suction lift is too high
- d. Defective priming valve
- e. Defective packing or seal

REMEDY

- a. Clean and tighten all suction connections; relocate suction inlet in liquid source.
- b. Remove dirt, leaves or other materials from strainer.
- c. Re-evaluate pump requirements and correct suction conditions accordingly.
- d. Replace valve.
- e. Replace packing or seal.

TROUBLE:

2. No discharge from pump

PROBABLE CAUSE

- a. Pump is not properly primed
- b. Total head is too high
- c. Driver is not operating at rated speed
- d. Impeller or discharge line is clogged
- e. Wrong direction of rotation
- f. Pump is vapor bound

REMEDY

- a. Reprime the pump; refer to priming troubles and remedies.
- b. Re-evaluate head calculations; measure elevation differences between pump and liquid source, and pump and discharge point.
- c. Check voltage of electric motor, check steam pressure of steam turbine; check engine R.P.M.'s. Refer to applicable maintenance manuals for possible troubles and corrective action.
- d. Back flush pump to clear obstruction; disassemble pump and/or piping and remove obstruction.
- e. Check wiring against diagram on motor name plate and in controller; reverse any two power leads on a three-phase motor; replace a single phase motor.
- f. Provide additional pressure on liquid being pumped by elevating liquid source or pressurizing the supply tank.

TROUBLE:

3. Pump does not deliver rated capacity

PROBABLE CAUSE

- a. Pump is not properly primed
- b. Suction lift is too high
- c. Excessive air in liquid
- d. Air leakage through stuffing box
- e. Driver is not operating at rated speed
- f. Impeller is clogged
- g. Wearing rings are worn
- h. Impeller is damaged
- i. Pump is vapor bound

REMEDY

- a. See 2.a. above.
- b. See 1.c. above.
- c. See 1.a. above.
- d. See 1.e. above
- e. See 2.c. above.
- f. See 2.d. above.
- g. Replace wearing rings.
- h. Replace impeller.
- i. See 2.f. above.

TROUBLE:

4. Insufficient pressure

PROBABLE CAUSE

- a. Excessive air in liquid
- b. Drive is not operating at rated speed
- c. Wrong direction or rotation
- d. Total head is too high
- e. Wearing rings are worn
- f. Impeller is damaged
- g. Casing gasket is defective allowing internal leakage
- h. Liquid is vaporizing

REMEDY

- a. See 3.c. above.
- b. See 2.c. above.
- c. See 2.e. above.
- d. See 2.b. above.
- e. See 3.g. above.
- f. See 3.h. above.
- g. Replace casing gasket.
- h. See 2.f. above.

TROUBLE:

5. Pump starts then stops pumping

PROBABLE CAUSE

- a. Air leaks in suction line
- b. Air pocket in suction line
- c. Water seal line is plugged
- d. Excessive air in liquid
- e. Suction lift too high
- f. Defective packing or seal
- g. Pump is vapor bound

REMEDY

- a. See 1.a. above.
- b. Reprime the pump; eliminate air pocket conditions.
- c. Remove obstruction from water line.
- d. See 1.a. above.
- e. See 1.c. above.
- f. See 1.e. above.
- g. See 2.f. above.

TROUBLE:

6. Excessive power consumption

PROBABLE CAUSE

- a. Speed is too high
- b. Wrong direction of rotation
- c. Total head is too high
- d. Total head is too low
- e. Impeller is clogged
- f. Impeller is binding
- g. Motor shaft is bent or worn
- h. Driver and pump are misaligned
- i. Power frame shaft is bent
- j. Wearing rings are worn
- k. Packing is incorrectly installed

REMEDY

- a. Internal electric motor wiring is incorrect; replace motor; refer to applicable driver maintenance manuals for possible troubles and corrective action.
- b. See 2.e. above.
- c. See 2.b. above.
- d. Re-evaluate head conditions; correct as required.
- e. See 2.d. above.
- f. Relieve strain on casing; adjust impeller clearance.
- g. Replace motor shaft.
- h. Realign driver with pump.
- i. Replace shaft.
- j. See 3.g. above.
- k. Install packings correctly; replace if necessary.

TROUBLE:

7. Pump is noisy or has excessive vibration

PROBABLE CAUSE

- a. Magnetic hum
- b. Motor bearings are worn
- c. Foreign material in impeller
- d. Impeller is binding
- e. Motor shaft is bent or worn
- f. Driver and pump are misaligned
- g. Power frame shaft is bent
- h. Foundation is not rigid
- i. Worn bearing in power frame
- j. Impeller is damaged
- k. Lack of lubrication in power frame
- l. Pump is not properly leveled
- m. Piping is not supported
- n. Pump is cavitating

REMEDY

- a. Consult motor manufacturer.
- b. Replace bearings.
- c. Remove foreign material.
- d. See 6.f. above.
- e. See 6.g. above.
- f. See 6.h. above.
- g. See 6.i. above.
- h. Strengthen foundation; change method of mounting pump unit.
- i. Replace bearing.
- j. See 3.h. above.
- k. Lubricate power frame bearings; replace bearings if damaged.
- l. Check levelness of pump.
- m. Provide support for suction and discharge piping.
- n. Re-evaluate pump application.

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THRUSH BULLETIN

THRUSH Products, Inc., Peru, Indiana 46970

FIELD PUMP TESTING

Subject: Establishing Pump Capacity from a Pump Performance Curve.

Frequently it is necessary to perform a field pump test to substantiate the operating conditions of a particular pump. A complete pump test requires head, capacity and horsepower measurements; however, in most instances the equipment necessary to perform the required test is not available. Therefore, it is necessary to obtain as much data as possible with the equipment at hand.

The operating capacity of a pump can be established in the field by measuring the total dynamic head at the operating point and comparing it to the manufacturers pump performance curve. This test requires a minimum of equipment, as all that is necessary is a suction gauge, a discharge gauge and a performance curve. Catalog curves are based on laboratory tests and reference pump pressure to (feet of water) at 60° F. Therefore, in order to obtain correct capacity it is necessary to convert all pressure readings to feet of water and determine the total pump head, or (total dynamic head). T.D.H.

T.D.H. is the resultant of all the pressure energy generated by the pump, and is computed as follows:

(A) $TDH = H_d - H_s + G_d$ (for positive suction head)

(B) $TDH = H_d + H_s + G_d$ (for negative suction head)

TDH = Total dynamic head in feet

H_d = Discharge head in feet

H_s = Suction head in feet

G_d = Gauge distance in feet

The necessary factors to convert pounds per square inch (P.S.I.) or inches of mercury (In hg) to feet of water are:

Feet of Water = $\frac{P.S.I. \times 2.31}{S.G.}$

Table 2 S.G.

Feet of Water = $\frac{In/hg \times 1.13}{S.G.}$

Table 3

P.S.I. = Pounds Per Square Inch

In/hg = Inches of Mercury

S.G. = Specific Gravity

The proper procedure to establish capacity (GPM) of a pump from the TDH with performance curve is: (Ref. Fig. 1)

1. Read & record the suction & discharge Gauge readings.
2. Establish liquid specific gravity (Table 1 for water)
3. Convert all gauge readings to feet where necessary (Table 2 & 3)
4. Compute T.D.H.
5. Compare TDH with appropriate performance curve to establish flow in GPM.

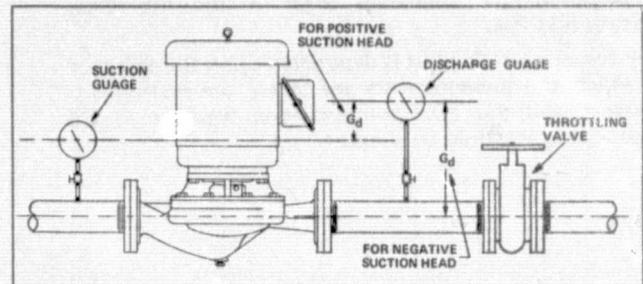


Figure 1.

EXAMPLES:

1. 2TV - 1 1/2 In-Line Pump for 80 GPM @ 44 TDH with 6 3/4" impeller diameter.

Check no flow head first to verify correct impeller diameter installed in pump.

No Flow TDH (shut-off head).

Discharge Gauge Reading = 75.8 psi

Suction Gauge Reading = 55 psi

Gauge Dist = .6 inches

Operating Temp. 180°F. = (S.G. = .972 from Table)

Suction head feet $\frac{55 \times 2.31}{.972} = 130.5$ feet

Discharge head feet $\frac{74.5 \times 2.31}{.972} = 180$ feet

$H_d - H_s + G_d = TDH$

$= 180 - 130.5 + .5 = 50$ feet

A check of the performance curve (Fig. 2) indicates a 6 3/4" impeller diameter will develop 50 feet TDH @ no flow, therefore, it is confirmed that the correct impeller diameter has been installed in the pump.

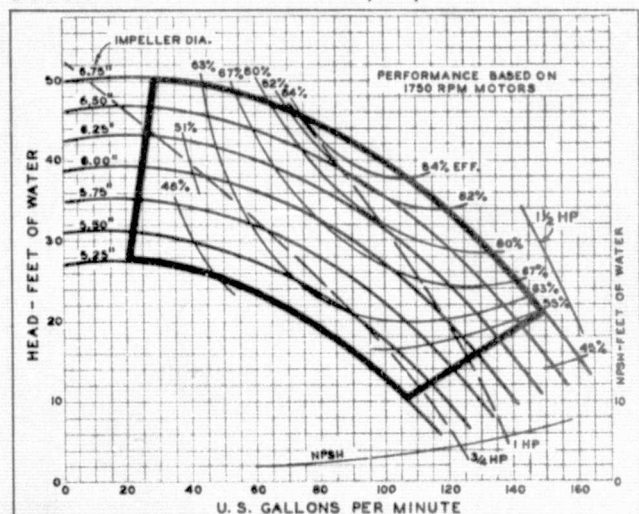


Figure 2.

II Establishing Pump Capacity

Discharge Gauge Reading 74.2 PSI

Suction Gauge Reading 54 psi

Gauge Distance .6 in.

$$\text{Suction head feet } \frac{54 \times 2.31}{.972} = 128.2$$

$$\text{Discharge head feet } \frac{74.2 \times 2.31}{.972} = 171.7$$

$$H_d - H_s + G_d = \text{TDH}$$

$$171.7 - 128.2 + .5 = 44 \text{ TDH}$$

Referring to the performance curve, 6 3/4 impeller diameter, follow the curve to 44 feet, read directly below on the gallons per minimum scale to find the pump capacity is 80 GPM.

The accuracy of this test is dependent upon the accuracy with which the measurements are taken, the instruments themselves, and the TDH computations, therefore, $\pm 5\%$ over all accuracy should be allowed.

Table 1
Properties of Water

Temp. °F	S.G.
60	1.000
70	.999
80	.998
90	.996
100	.994
120	.990
140	.985
160	.979
180	.972
200	.965
212	.959
220	.957
240	.948
260	.939
280	.929
300	.919
320	.909

Table 2

Table for Converting
Pressure, Lb per Sq In. to Feet (Head) of Water.
 $\text{ft} = 2.31 \times \text{lb/sq in.}$

Pressure Pounds Per Square Inch	Feet Head	Pressure Pounds Per Square Inch	Feet Head	Pressure Pounds Per Square Inch	Feet Head	Pressure Pounds Per Square Inch	Feet Head	Pressure Pounds Per Square Inch	Feet Head	Pressure Pounds Per Square Inch	Feet Head	Pressure Pounds Per Square Inch	Feet Head
1	2.31	53	122.43	105	242.55	157	362.67	209	482.79	261	602.91		
2	4.62	54	124.74	106	244.86	158	364.98	210	485.10	262	605.22		
3	6.93	55	127.05	107	247.17	159	367.29	211	487.41	263	607.53		
4	9.23	56	129.36	108	249.48	160	369.60	212	489.72	264	609.84		
5	11.55	57	131.67	109	251.79	161	371.91	213	492.03	265	612.15		
6	13.86	58	133.98	110	254.10	162	374.22	214	494.34	266	614.46		
7	16.17	59	136.29	111	256.41	163	376.53	215	496.65	267	616.77		
8	18.48	60	138.60	112	258.72	164	378.84	216	498.96	268	619.08		
9	20.79	61	140.91	113	261.03	165	381.15	217	501.27	269	621.39		
10	23.10	62	143.22	114	263.34	166	383.46	218	503.58	270	623.70		
11	25.41	63	145.53	115	265.65	167	385.77	219	505.89	271	626.01		
12	27.72	64	147.84	116	267.96	168	388.08	220	508.20	272	628.32		
13	30.03	65	150.15	117	270.27	169	390.39	221	510.51	273	630.63		
14	32.34	66	152.46	118	272.58	170	392.70	222	512.82	274	632.94		
15	34.65	67	154.77	119	274.89	171	395.01	223	515.13	275	635.25		
16	36.96	68	157.08	120	277.20	172	397.32	224	517.44	276	637.56		
17	39.27	69	159.39	121	279.51	173	399.63	225	519.75	277	639.87		
18	41.58	70	161.70	122	281.82	174	401.94	226	522.06	278	642.18		
19	43.89	71	164.01	123	284.13	175	404.25	227	524.37	279	644.49		
20	46.20	72	166.32	124	286.44	176	406.56	228	526.68	280	646.80		
21	48.51	73	168.63	125	288.75	177	408.87	229	528.99	281	649.11		
22	50.82	74	170.94	126	291.06	178	411.18	230	531.30	282	651.42		
23	53.13	75	173.25	127	293.37	179	413.49	231	533.61	283	653.73		
24	55.44	76	175.56	128	295.68	180	415.80	232	535.92	284	656.04		
25	57.75	77	177.87	129	297.99	181	418.11	233	538.23	285	658.35		
26	60.06	78	180.18	130	300.30	182	420.42	234	540.54	286	660.66		
27	62.37	79	182.49	131	302.61	183	422.73	235	542.85	287	662.97		
28	64.68	80	184.80	132	304.92	184	425.04	236	545.16	288	665.28		
29	66.99	81	187.11	133	307.23	185	427.35	237	547.47	289	667.59		
30	69.30	82	189.42	134	309.54	186	429.66	238	549.78	290	669.90		
31	71.61	83	191.73	135	311.85	187	431.97	239	552.09	291	672.21		
32	73.92	84	194.04	136	314.16	188	434.28	240	554.40	292	674.52		
33	76.23	85	196.35	137	316.47	189	436.59	241	556.71	293	676.83		
34	78.54	86	198.66	138	318.78	190	438.90	242	559.02	294	679.14		
35	80.85	87	200.97	139	321.09	191	441.21	243	561.33	295	681.45		
36	83.16	88	203.28	140	323.40	192	443.52	244	563.64	296	683.76		
37	85.47	89	205.59	141	325.71	193	445.83	245	565.95	297	686.07		
38	87.78	90	207.90	142	328.02	194	448.14	246	568.26	298	688.38		
39	90.09	91	210.21	143	330.33	195	450.45	247	570.57	299	690.69		
40	92.40	92	212.52	144	332.64	196	452.76	248	572.88	300	693.00		
41	94.71	93	214.83	145	334.95	197	455.07	249	575.19				
42	97.02	94	217.14	146	337.26	198	457.38	250	577.50				
43	99.33	95	219.45	147	339.57	199	459.69	251	579.81				
44	101.64	96	221.76	148	341.88	200	462.00	252	582.12				
45	103.95	97	224.07	149	344.19	201	464.31	253	584.43				
46	106.26	98	226.38	150	346.50	202	466.62	254	586.74				
47	108.57	99	228.69	151	348.81	203	468.93	255	589.05				
48	110.88	100	231.00	152	351.12	204	471.24	256	591.36				
49	113.19	101	233.31	153	353.43	205	473.55	257	593.67				
50	115.50	102	235.62	154	355.74	206	475.86	258	595.98				
51	117.81	103	237.93	155	358.05	207	478.17	259	598.29				
52	120.12	104	240.24	156	360.36	208	480.48	260	600.60				

Table 3

Table for Converting
Inches of Mercury to Feet of Water
 $\text{ft} = 1.133 \times \text{in hg}$
Inches of Mercury in Tenths

	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1	1.133	1.246	1.359	1.473	1.586	1.699	1.813	1.925	2.039	2.153
2	2.266	2.38	2.492	2.605	2.72	2.833	2.946	3.06	3.172	3.286
3	3.399	3.512	3.625	3.74	3.85	3.965	4.08	4.19	4.3	4.42
4	4.532	4.645	4.76	4.87	4.985	5.1	5.21	5.325	5.44	5.55
5	5.665	5.78	5.89	6.00	6.12	6.23	6.344	6.46	6.57	6.684
6	6.798	6.91	7.024	7.138	7.25	7.364	7.48	7.6	7.7	7.817
7	7.931	8.044	8.157	8.27	8.384	8.497	8.61	8.72	8.84	8.95
8	9.064	9.177	9.29	9.40	9.517	9.63	9.74	9.857	9.97	10.088
9	10.197	10.31	10.42	10.536	10.65	10.76	10.87	10.99	11.10	11.216
10	11.33	11.443	11.556	11.67	11.78	11.896	12.01	12.123	12.236	12.35
11	12.46	12.576	12.69	12.80	12.91	13.03	13.142	13.256	13.37	13.483
12	13.596	13.71	13.82	13.935	14.05	14.162	14.275	14.39	14.50	14.615
13	14.73	14.84	14.95	15.07	15.18	15.295	15.408	15.522	15.635	15.748
14	15.86	15.975	16.088	16.20	16.315	16.428	16.54	16.655	16.77	16.88
15	16.99	17.108	17.22	17.335	17.49	17.561	17.674	17.788	17.9	18.014
16	18.13	18.24	18.354	18.467	18.58	18.694	18.807	18.92	19.034	19.147
17	19.26	19.37	19.487	19.6	19.714	19.827	19.94	20.05	20.167	20.28
18	20.39	20.51	20.62	20.73	20.847	20.96	21.07	21.187	21.30	21.41
19	21.53	21.64	21.753	21.866	21.98	22.09	22.2	22.317	22.43	22.543
20	22.66	22.77	22.883	22.996	23.11	23.223	23.336	23.45	23.563	23.676
21	23.79	23.90	24.01	24.129	24.243	24.356	24.47	24.583	24.696	24.81
22	24.926	25.04	25.152	25.265	25.38	25.5	25.6	25.72	25.83	25.945
23	26.06	26.17	26.28	26.398	26.5	26.62	26.74	26.85	26.965	27.078
24	27.2	27.305	27.418	27.53	27.645	27.76	27.87	27.935	28.098	28.21
25	28.325	28.438	28.55	28.66	28.78	28.89	29	29.118	29.23	29.344
26	29.46	29.572	29.685	29.798	29.91	30.025	30.138	30.25	30.365	30.478
27	30.6	30.705	30.82	30.93	31.04	31.16	31.27	31.385	31.498	31.61
28	31.7	31.84	31.95	32.06	32.18	32.29	32.4	32.52	32.63	32.744
29	32.86	32.96	33.07	33.18	33.3	33.413	33.526	33.64	33.753	33.866
30	33.99									

ORIGINAL PAGE 18
OF POOR QUALITY



THRUSH Products, Inc.
P.O. Box 228 • Peru, Indiana 46970 • (317) 473-5591

Serving the world since 1921



Litho in U.S.A.

APPENDIX E

THRUSH CIRCULATING PUMPS

C-2

E-1
SECTION 1200

C-2

Form R-1276
Supersedes Form R-1274

INSTRUCTIONS

MODEL R & RB

THRUSH CIRCULATORS

REPLACEMENT FOR IRON AND BRONZE

B&G 100 Series
Taco UN 110 Series
Armstrong S-25 Series

Model R or RB THRUSH CIRCULATOR capacities are comparable to the above Series.

Body length (A) Figure 1, is identical with the Models listed above; therefore, piping does not have to be changed to install THRUSH MODEL R OR RB CIRCULATORS.

INSTALLATION

Simply disconnect the wiring to the original Circulator and remove the four flange bolts holding the Circulator in the pipe line. Pull the original Circulator out of the line and insert the new Model R or RB, with its new flange gaskets, into the line. Bolt the Model R or RB firmly into position with the original flanges, nuts and bolts. The 2 bolt competitor's flanges are the same as the Model R or RB so the original flanges do not have to be removed.

Oil all 3 oil cups before starting and every 3 months thereafter. Use S.A.E. #20 non-detergent oil for motor, and #30 non-detergent oil for bracket. For high temperature or continuous operation, more frequent oiling will be necessary. Also make sure system pressure is 12 lbs. or more before starting circulator.

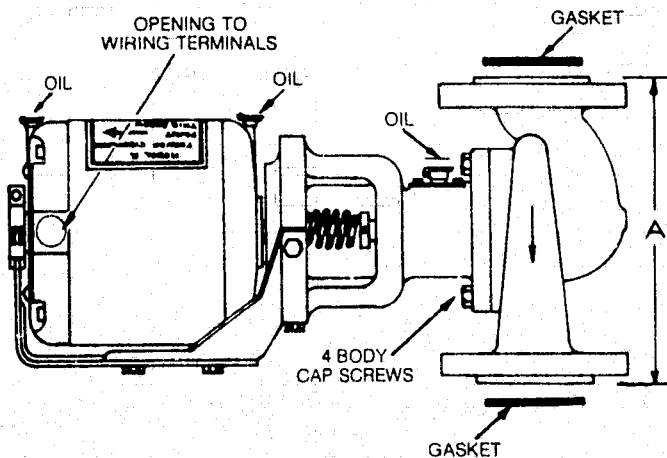


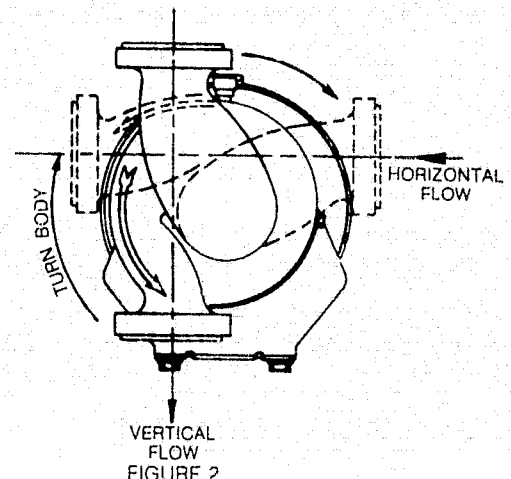
FIGURE 1

FOR HORIZONTAL FLOW

Model R or RB Circulators are shipped from factory with body mounted for downward flow as shown in Figure 1. If Circulator body is to be placed in a horizontal pipe, remove 4 body Cap Screws and turn the Circulator body only to right or left (figure 2) depending on direction of horizontal flow. **DO NOT TURN MOTOR OR BRACKET ASSEMBLY.** All 3 oil cups must always be UP as shown in Figure 1. If Circulator is to pump upward in a vertical pipe line, remove 4 Body Cap Screws and turn the Circulator body only 180°. Model R or RB may be installed in a vertical line to pump up or down and may be installed in a horizontal pipe line to pump left or right by turning the Circulator body as required. Motor and Bracket Assembly oil cups must always be UP as shown in Figure 1.

WIRING

Model R or RB Circulator motors have openings for BX connector and 2 wiring posts under terminal cover. Be sure 2 lead wires are securely fastened under terminal nuts. **DO NOT CONNECT SOLID CONDUIT TO CIRCULATOR MOTOR.** Use 18" of flexible between end of conduit and motor. Motor is built for 115v, 60c, 1 phase current.



THRUSH Products, Inc.

P.O. Box 228 • Peru, Indiana 46970

APPENDIX F

STEEL AQUATOWERS



MANUAL

*Installation, Operation
and
Maintenance Instructions*

●
SERIES 4600
STEEL AQUATOWERS

SEPTEMBER, 1975

OM-4600C

5800 Foxridge Drive — Mission, Kansas 66202

INSTALLATION, OPERATION, MAINTENANCE, DISASSEMBLY — STEEL AQUATOWERS

~~PRECEDING PAGE BLANK NOT REPRODUCED~~

Installation, Operation and Maintenance Instructions

SERIES 4600

STEEL AQUATOWERS

TOWER LOCATION

Locate so prevailing wind will blow into the louvered face. Direct fan discharge away from building surfaces to eliminate the possibility of discoloration. Locate so there is free flow of air to and from the tower. Allow clearance on all sides for maintenance. Anchor in a level position to a stable foundation.

INDOOR INSTALLATION

A duct is required from the tower air discharge to the outside. In some cases it may also be desirable to install an inlet air duct. If ducts are used, the total draft loss should not exceed .10" water pressure. Draft losses can be minimized by:

- a. Using 20% oversize ducts.
- b. Avoiding sharp turns or abrupt changes in size.
- c. Keeping duct length to a minimum.
- d. Increasing the area of screened or louvered opening so the net free area is at least 20% greater than the tower discharge opening area.

Ducts should be attached to the tower using rubber or canvas connections. Access openings for servicing the mechanical equipment must be provided if air discharge ducts are installed. If the duct discharges into the prevailing wind, it may be necessary to install a windbreak or an elbow to serve as a deflector. Ducts installed on towers with year around usage should be water tight and insulated to prevent condensation.

TOWER INSTALLATION

The tower is shipped complete with the motor in a carton and miscellaneous parts package within the tower. Anchor tower by bolting a clip to the foundation and basin sides or through slots in legs using 3/8" or larger bolts.

PIPING TO TOWER (Summer Temperature Conditions)

1. Use pipes of sufficient size to provide minimum friction loss.
2. Connect Float Valve to make-up water supply.
3. Install bleed-off line. Bleed-off is the continuous wasting of a small amount of water during operation which retards scale and corrosion. A bleed-off line can be installed at any point in the system, however, the best point is in the hot water line near the top of the tower so water will be removed when the pump is operating. A copper tube, pinched down or with a pet cock can be used.

PIPING TO TOWER (Winter Freezing Conditions)

1. Where operating conditions require tower use during freezing weather, it is recommended that the towers be installed for "dry basin" operation. See Figure 1.
2. Provide an inside open-type storage tank with a capacity of four times the cooling tower GPM.
3. Connect tower suction to storage tank.
4. Install make-up water, bleed-off, overflow and drain lines on tank.
5. Insulate and heat water lines exposed to freezing temperatures.

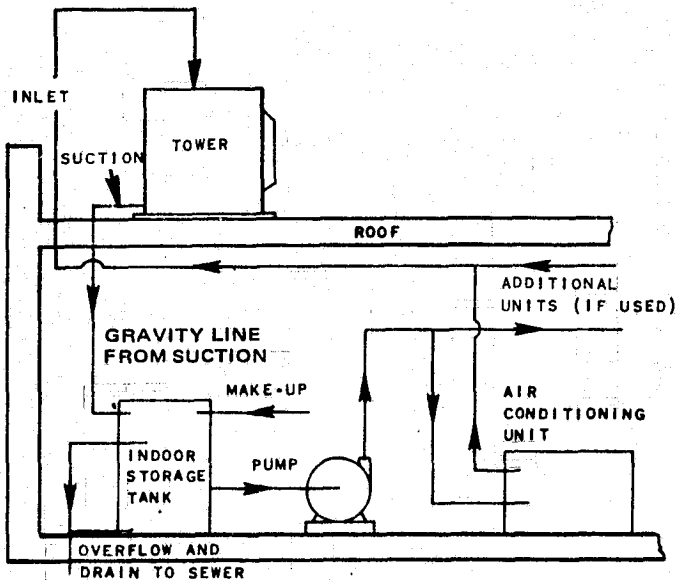


FIGURE 1. Flow Diagram for a Cooling Tower with Indoor Storage Tank. (Piping Is Arranged So That Tower Basin Will Drain When Pump Is Shut Off.)

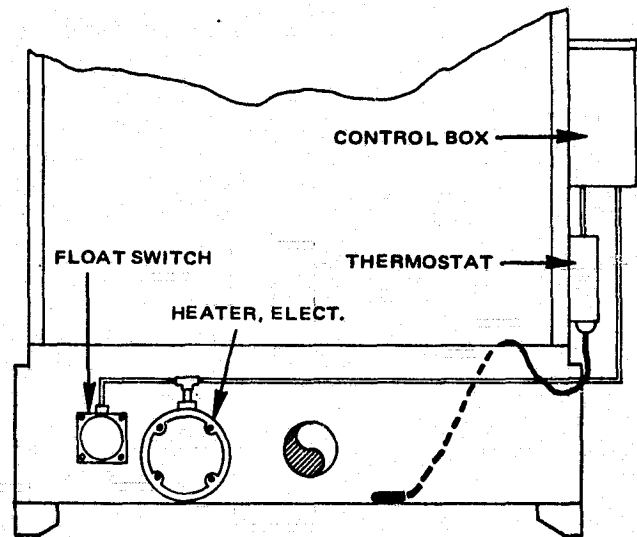


FIGURE 2. Electric heater systems are available as optional equipment to prevent freezing the cold water basin when it cannot be drained.

ORIGINAL PAGE 18
OF POOR QUALITY

MECHANICAL EQUIPMENT INSTALLATION

MOTOR, SHEAVE AND V-BELT INSTALLATION

1. Check the motor name plate to be sure its voltage, phase and frequency ratings are the same as the power supply.
2. Check to insure that fan is tightly secured to bearing housing shaft and free to rotate and that bearing housing is secure to support.
3. Install all thread belt tension adjusting bolts in motor base cradle, see Detail A. Install lock washers and nuts, fastening adjusting bolts to motor base cradle. Run galvanized nuts about halfway down on bolts. Insert bolts through slots in motor base, install lock washers and run top nuts down, locking base in place. Bolt motor to motor base.
4. Install motor sheave and align it with fan sheave. A plumb line will be helpful in aligning sheaves. See Detail "B".
5. Install V-belt and adjust tension by means of belt tension adjusting bolts. A correctly tensioned belt does not slip when the fan is started; and, when running, the "tight" side is straight between sheaves. The "slack" side will have a slight bow. Correct tension can only be determined by trial runs at successively higher tensions until slipping has stopped.

A small further increase in tension should be made to account for normal belt stretch. Avoid over tensioning. Too much tension reduces bearing and belt life.

New belts must be retensioned after 8 to 12 hours operation since new belts stretch at a higher rate and "seat" into sheave grooves.

6. Connect motor to power supply using wiring, switching, short circuit protection and overload protection in accordance with the National Electric Code and local requirements. Failure to wire the motor correctly will void its warranty. The overload protection for Motors must be part of the control system, see Diagram "C".
7. Sleeve bearing motors are usually shipped without oil and must be oiled before operating. Ball bearing motors are lubricated for the initial operation by the manufacturer.
8. Install belt guard using sheet metal screws. See Figure 3 (page 8).

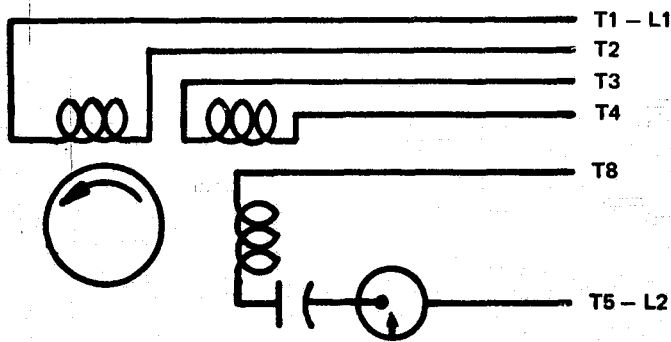
INSTALLATION OF OPTIONAL EQUIPMENT

AIR INLET SCREEN

Install hardware used to attach air inlet screen to side casing sheets. Set screen in position and install with wing nuts.

HOT WATER BASIN COVER

Install "S" strips at hot water basin sides. Remove from splash box cover those sheet metal screws indicated on installation drawing. Position basin cover segments and reinstall sheet metal screws.



Without Thermal Overload (Integral HP)

HIGH VOLTAGE

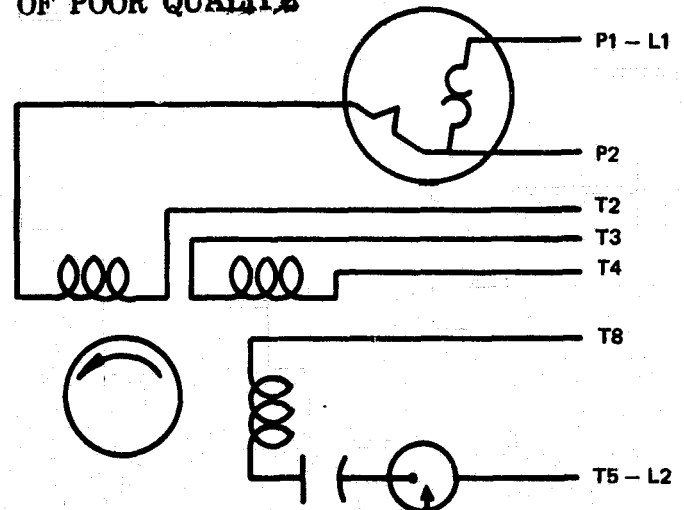
1. Connect T1 and L1 and insulate.
2. Connect T2, T3 and T8 and insulate.
3. Connect T4 and T5 and insulate.

LOW VOLTAGE

1. Connect T1, T3, T8 and L1 and insulate.
2. Connect T2, T4, T5 and L2 and insulate.

NOTE: Colors may be substituted for numbers as follows:

T1 - Blue	T5 - Black
T2 - White	T8 - Red
T3 - Green	P1 - No Color Assigned
T4 - Yellow	P2 - Brown



With Thermal Overload (Fractional HP)

HIGH VOLTAGE

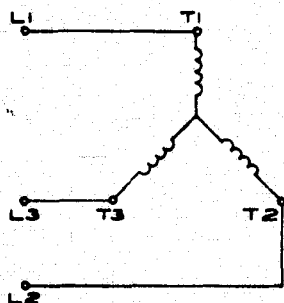
1. Insulate P2.
2. Connect T2, T3 and T8 and insulate.
3. Connect T4, T5 and L2 and insulate.
4. Connect P1 and L1 and insulate.

LOW VOLTAGE

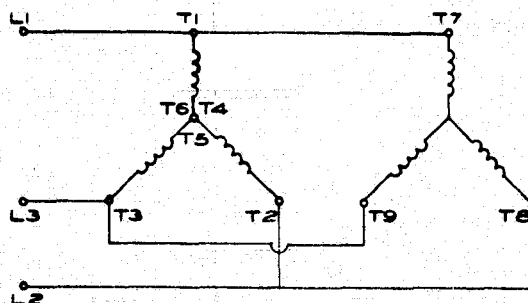
1. Connect P1 and L1 and insulate.
2. Connect P2 and T3 and insulate.
3. Connect T1 and T8 and insulate.
4. Connect T2, T4 and T5 and insulate.

To reverse rotation, interchange leads T5 and T8.

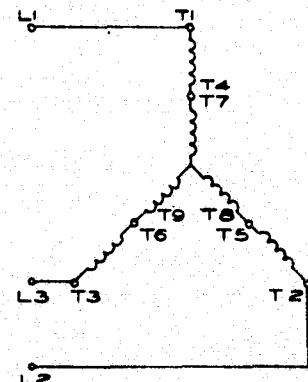
WIRING DIAGRAM CAPACITOR START MOTORS, REVERSIBLE, DOUBLE VOLTAGE



200 VOLT

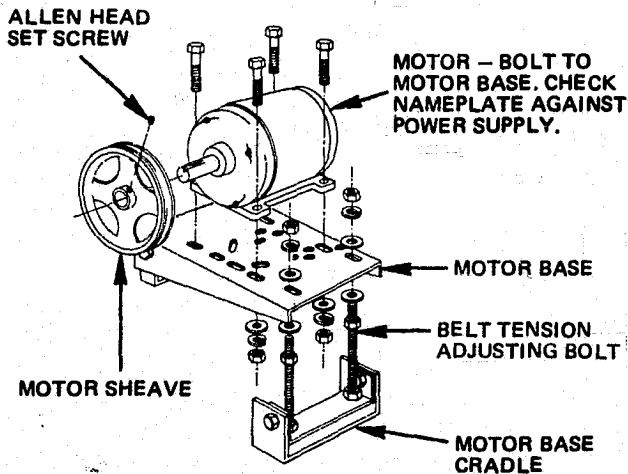


230 VOLT

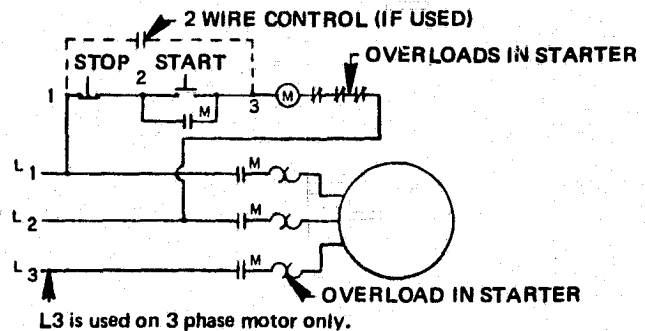
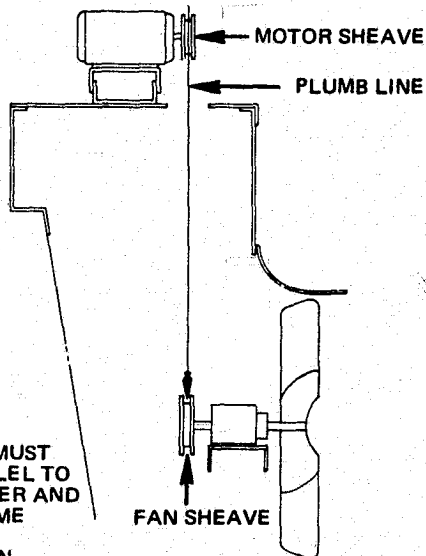


460 VOLT

WIRING DIAGRAM 3 PHASE MOTORS



DETAIL "A"

Showing Overload in Starter
DIAGRAM "C"

DETAIL "B"

OPERATION INSTRUCTIONS

1. Wash foreign matter from fill and basin.
2. Fill circulating system with water.
3. Start pump and adjust float valve to maintain 4" (5" on models 4619 thru 4625 and 8" on models 4627 thru 4633) of water in cold water basin.
4. Check bleed-off line to make sure water is being discharged during operation.
5. Check fan for free rotation and oil level in Bearing Housing (see maintenance instructions). Start motor and check direction of rotation. Fan must rotate clockwise when viewed from the fan discharge side. If the rotation

is incorrect, change any two of the three motor leads for a three-phase motor or interchange the connections of either the main or starter windings for single-phase capacitor start motor.

6. Depth of water in hot water basin should be uniform. If the basin overflows, reduce the flow rate. Do not pump more water than design capacity.
7. Do not cycle the motor so that the total of the starting times exceeds 30 seconds each hour.

MAINTENANCE INSTRUCTIONS

MOTOR LUBRICATION

Lubricate the motor according to the motor manufacturer's instructions shipped with the motor. Motor should be relubricated at the start and end of each operating season.

FAN BEARING LUBRICATION

Lubricate bearing housings with SAE 20 mineral oil.

Oil cups should be kept full to insure proper oil level in bearing housings.

BELT TENSION

Check belt tension every two to three weeks during peak operating season. Refer to page 4, item 5.

BLEED-OFF

Check the bleed-off for continuous water discharge.

BASIN AND SUCTION SCREEN

Drain and clean cold water basin and suction screen periodically.

FLOAT VALVE

Check float valve periodically for proper operation and maintenance of water level.

GENERAL

The following tables show the proper amount of bleed-off.

COOLING RANGE DEGREES F	PERCENT BLEED-OFF OF TOTAL GPM
6	.15
7-1/2	.22
10	.33
15	.54
20	.75

CHEMICAL TREATMENT

The dissolved solids in the circulating water are concentrated by evaporation and must be limited by bleed-off of some of the water. Chemical treatment is not normally required if adequate bleed-off is maintained.

Algae and slime may occur and can be controlled by careful application of proper chemicals. Improper application of concentrated water treating chemicals may damage parts of the system. If scale or algae and slime accumulate, obtain the services of a competent water treating consultant.

WATER DISCOLORATION

Discoloration of water may occur when a cooling tower is placed in operation. This discoloration is not harmful and will normally disappear after several weeks of operation. Application of a common bleach solution or increased bleed-off will alleviate this condition.

FOAMING

Foaming may occur when the concentration of dissolved solids in the circulating water is high. Increasing the bleed-off rate or application of commercial foam depressants will alleviate the problem. Foam depressants slightly alter the physical properties of the circulating water and may affect the tower operating characteristics. Dosages should not exceed manufacturer's recommended amounts. Trial of several brands may be necessary to achieve optimum foam control and tower operation.

SEASONAL SHUTDOWN INSTRUCTIONS

BASIN AND FRAME

Drain the tower basins and all exposed piping. Leave the basin drain open. Water may be left in cold water basin if tower is located in a non-freezing area.

During shutdown, clean the tower and make any necessary repairs. Apply protective coating as required to all metal parts. Particular attention should be given to bearing supports.

MECHANICAL EQUIPMENT

V-BELTS AND SHEAVES

1. At shutdown, remove and store belts in a cool, dark, dry room. Clean and coat sheave grooves with rust pre-

ventive, lacquer, or paint.

2. Before putting belts back on sheaves, remove rust preventive. Replace belts with excessive wear.
3. When putting tower back into service refer to "Mechanical Equipment Installation" page 4 for belt installation and tensioning instructions.

BEARING HOUSING, Oil Lubricated Type

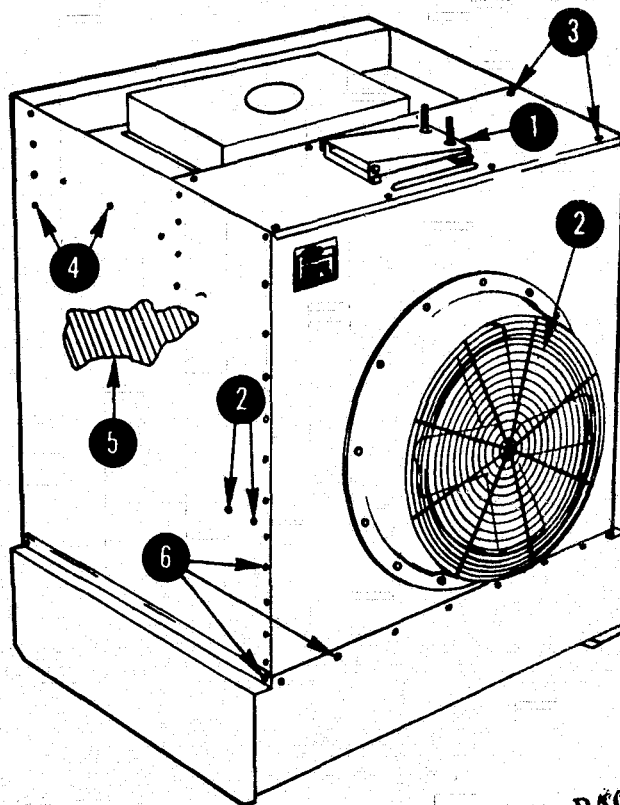
1. At shutdown, operate until oil is warm; drain and refill. Use SAE 20 mineral oil.
2. Each month, drain water condensate at the drain plug. Check oil level and add oil if necessary.
3. At start-up, operate until oil is warm; drain and refill.

ELECTRIC MOTORS

Do not start motor without determining that fan is free to rotate.

Refer to motor manufacturer's recommendations for lubrication and maintenance instructions.

If shutdown period is longer than seasonal, contact The Marley sales office or representative in your area for additional information. Always refer to tower serial number when writing for information or ordering parts. The serial number is stamped on the tower name plate.



ORIGINAL PAGE 18
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DISASSEMBLY AND REASSEMBLY INSTRUCTIONS

Never disassemble the Aquatower more than necessary; for example, if removal of the motor base is sufficient to get the tower to the installation site, remove only that part. When disassembling, remember how each part is screwed, bolted and set in place; fasten screws and bolts for each part with each section. Be careful not to mar galvanized coating.

DISASSEMBLY — 4619 thru 4633 (sequence is similar for 4613 thru 4617)

1. Remove motor base.
2. Remove fan guard, fan and all hardware attaching bearing housing support channel to casing sheets.
3. Remove screws attaching top sheet, then remove sheet.
4. Remove screws attaching distribution basin then remove basin.

5. Remove fill.

6. Remove screws from collection basin and side casing sheets at fan sheet. Remove side casing sheets and fan sheet with fan cylinder attached.

REASSEMBLY

Reassembly of the Aquatower is the reverse of the steps noted above.

The following precautions are important:

1. Fill must be installed level to assure full tower performance.
2. Bolts which use rubber sealing washers under head should be tightened securely to prevent leaks.
3. Be sure mechanical equipment is installed correctly and fan rotates freely.

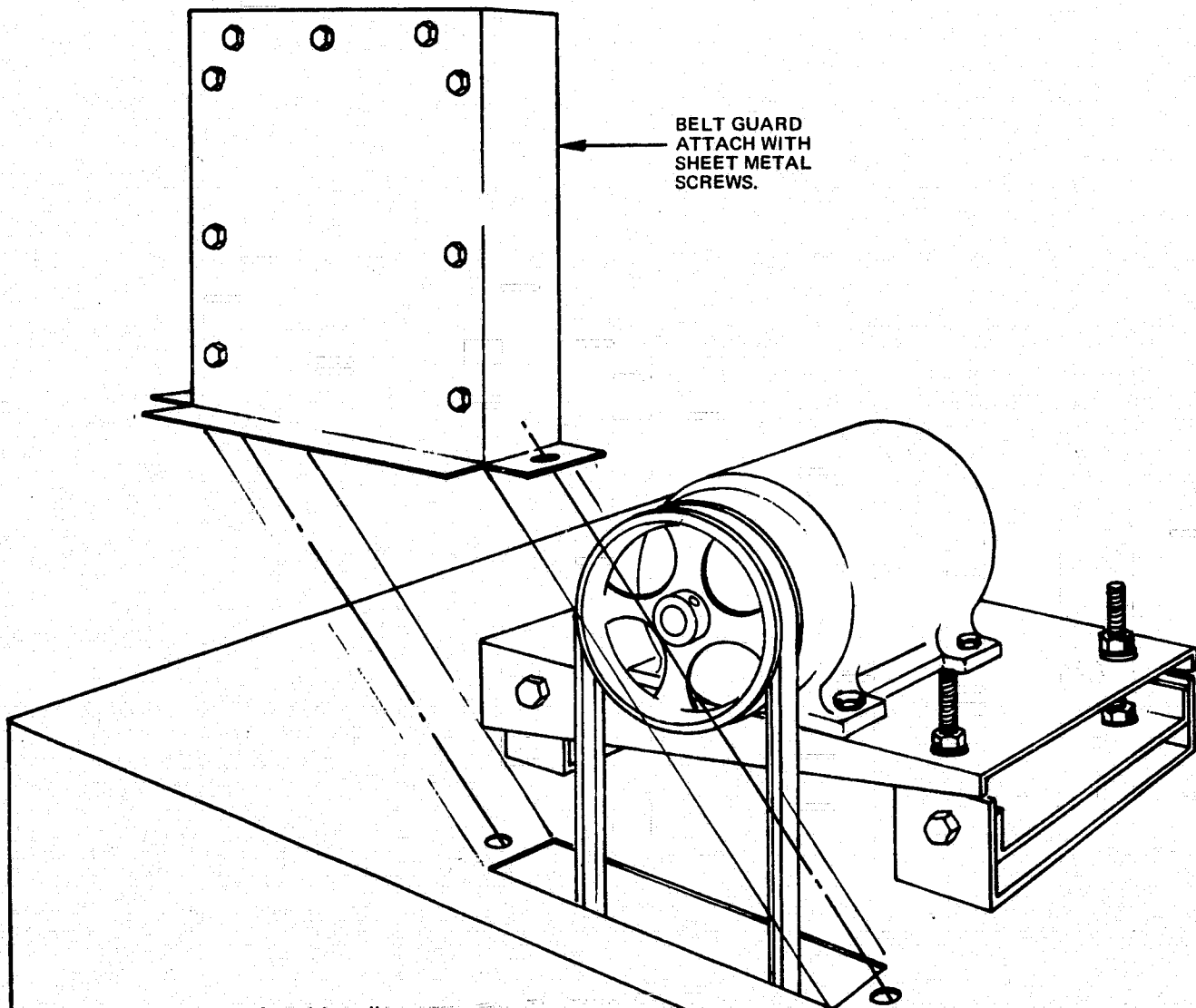


FIGURE 3. Belt Guard Install

APPENDIX G

STORAGE TANK GAUGE CHART

GENERAL STEEL TANK CO.

4000 EIGHTH AVENUE, NORTH
BIRMINGHAM, ALABAMA

GAUGE CHART

FOR

TANK 96" DIA. X 13'-5½" LONG

LEVEL	GALLONS	LEVEL	GALLONS	LEVEL	GALLONS	LEVEL	GALLONS
1"	9	25"	1048	49"	2597	73"	4128
2"	26	26"	1107	50"	2664	74"	4185
3"	47	27"	1167	51"	2731	75"	4241
4"	72	28"	1228	52"	2798	76"	4296
5"	101	29"	1289	53"	2865	77"	4350
6"	132	30"	1351	54"	2931	78"	4403
7"	165	31"	1414	55"	2998	79"	4455
8"	201	32"	1477	56"	3064	80"	4506
9"	240	33"	1540	57"	3130	81"	4555
10"	280	34"	1604	58"	3196	82"	4603
11"	322	35"	1669	59"	3262	83"	4650
12"	365	36"	1733	60"	3327	84"	4695
13"	410	37"	1798	61"	3391	85"	4738
14"	457	38"	1864	62"	3456	86"	4780
15"	505	39"	1930	63"	3520	87"	4820
16"	554	40"	1996	64"	3583	88"	4859
17"	605	41"	2062	65"	3646	89"	4895
18"	657	42"	2129	66"	3709	90"	4928
19"	710	43"	2195	67"	3771	91"	4959
20"	764	44"	2262	68"	3832	92"	4988
21"	819	45"	2329	69"	3893	93"	5013
22"	875	46"	2396	70"	3953	94"	5034
23"	932	47"	2463	71"	4012	95"	5051
24"	989	48"	2530	72"	4071	96"	5060

APPENDIX H

SOLENOID VALVE

SOLENOID VALVE COIL DATA

H-1

COILS

ASCO®

Form No. V-5192 AR4

COIL CLASSIFICATION

COIL TYPE	GRADE OF INSULATION	AMBIENT TEMP. (NOTE 1)	APPLICATION CONDITIONS (NOTE 2)
Class A	A	77° F	For normal pressure or ambient temperatures (For molded coils see Note 3)
Class F (FT) High Temp.	F	187° F	For high ambient or fluid temperatures (Notes 3 & 5)
Class F (FB) Intermediate Power	F	122° F	For higher valve pressure ratings, high ambient or fluid temperatures (Note 3)
Class F (FF) High Power	F	77° F	For higher valve pressure ratings at normal ambient temperatures (Note 3)
Class H (HT) High Temp.	H	212° F	For Higher ambient or fluid temperatures than Class F (Notes 4 & 5)
Class H (HB) Intermediate Power	H	187° F	For higher valve pressure ratings, plus higher ambient or fluid temperatures than Class F (Note 4)
Class H (HP) High Power	H	77° F	For higher valve pressure ratings than Class F, at normal ambient temperatures (Note 4)

NOTES: 1. This is the maximum ambient temperature for continuous duty. Coils rated for ambient temperatures of 77° F may be employed in areas where ambient temperatures reach 104° F occasionally.
2. The maximum fluid temperature will vary between solenoids and valve types, refer to catalog listings for maximum temperature limitations.
3. Molded coils are moisture proof and fungus proof.
4. Coils are fungus proof and radiation resistant.
5. Suitable for 24, 120, 240, 480 volts, A-C 60 HZ (or 50 HZ in 110 volt multiples)

Fig. 1

ACCESSORIES

Please send information on the following:

- ☐ STRAINERS
☐ SPEED CONTROL VALVES

Maintenance Instructions for ASCO valves will be gladly furnished. To request copies, specify the valve catalog number.

STRAINERS

Remove dirt and pipe scale from the line to reduce friction and provide longer life for equipment.



SPEED CONTROL VALVES

For controlling cylinder piston speeds. Used with ASCO 3 and 4 way solenoid valves.



Fig. 4

CONTINUOUS DUTY RATING

VOLTAGE RATING A-C	NORMAL OPERATING RANGE	VOLTAGE RATING D-C	NORMAL OPERATING RANGE
24	22-24	8	5.1 - 6.3
120	110-120	12	10.2 - 12.6
240	220-240	24	20 - 25
480	440-480	120	102 - 126

All ASCO valves are tested to operate at 15% under the nominal voltage and are capable of operating for short periods at 10% over the nominal voltage. For wider voltage ranges than shown above, a different coil must be used.

Fig. 3

INSTRUCTIONS FOR REPLACING COIL

Turn off electric power supply and line pressure to the valve. Disconnect the coil lead wires. Remove the solenoid cover. Disassemble and reassemble in order shown in Fig. 2.

NOTE: The solenoid must be fully reassembled as the housing is part of and completes the magnetic circuit.

NOTE: To change from Alternating Current (A-C) to direct Current (D-C) or reverse, it is necessary to change the complete solenoid.

EXPLODED VIEWS

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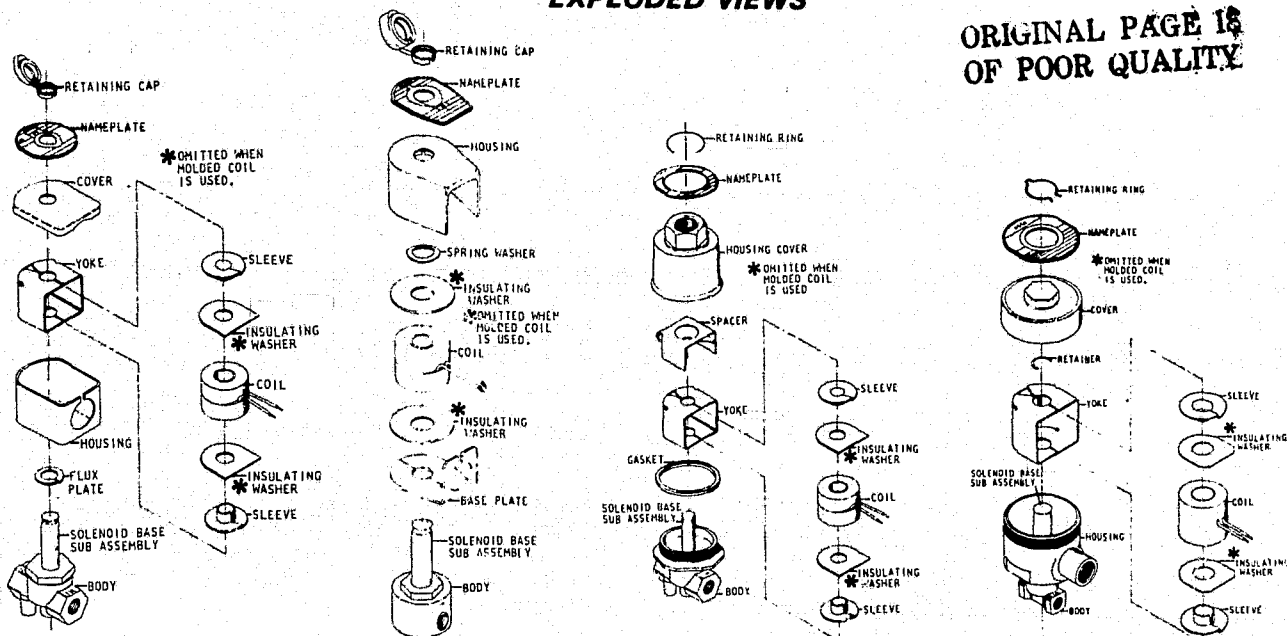


Fig. 2

ASCO®

ASCO Valves

Automatic Switch Co. FLORHAM PARK, NEW JERSEY FORM NO. V-5192 AR4

PRINTED IN U.S.A.

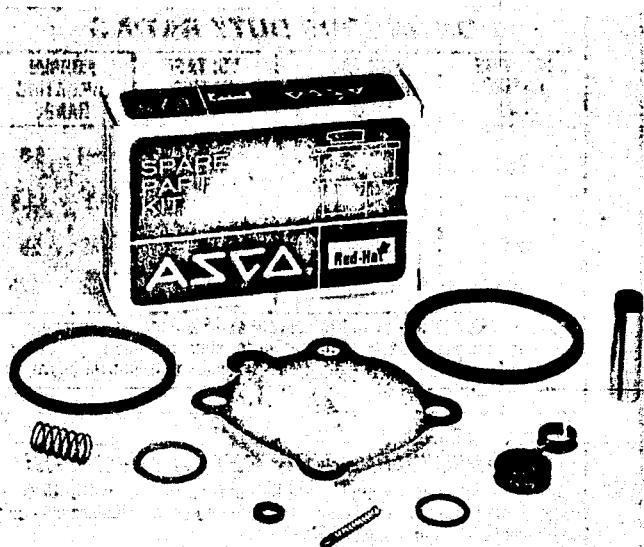
1974

SPARE PARTS KITS REPLACEMENT COILS AND ACCESSORIES FOR ASCO SOLENOID VALVES

H-2

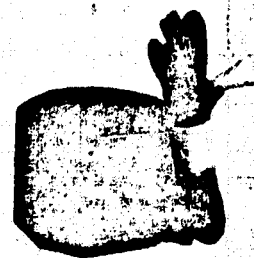
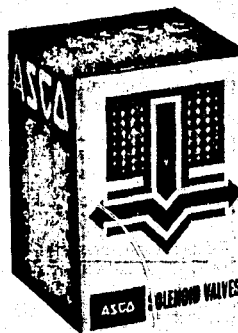
**KITS
AND
COILS**

Form No. V - 5192 AR4



SPARE PARTS KITS

Kits contain all necessary internal operating parts with gaskets, "O" rings, etc.



REPLACEMENT COILS

Coil types available are listed under coil classification Figure 1 (over)

**FOR KIT OR COIL NUMBER REFER TO VALVE CATALOG
OR SUPPLY VALVE CATALOG NUMBER, SERIAL NUMBER AND VOLTAGE
FOR CONVENIENCE, USE THE HANDY ORDER BLANK BELOW**



ASCO Valves

Automatic Switch Co. FLORHAM PARK, NEW JERSEY

To: AUTOMATIC SWITCH CO.

**DISTRICT OFFICE, SALES REPRESENTATIVE
OR ASCO AUTHORIZED STOCKING
DISTRIBUTOR**

For the address of the office nearest you, refer to the white pages of your telephone directory under ASCO or Automatic Switch Co.

AUTOMATIC SWITCH CO. Florham Park, N. J. 07932

NAME _____

STREET ADDRESS _____

CITY _____ STATE _____

SHIP VIA _____

SIGNED _____

ORDER BLANK

DATE: _____ ORDER NUMBER _____

PLEASE SEND THE FOLLOWING:

QUANTITY	SPARE PARTS KIT	REPLACEMENT COIL

ACCESSORIES

VALVE CATALOG NO. _____

SERIAL NO. _____

VOLTAGE _____



ASCO Valves

Automatic Switch Co. FLORHAM PARK, NEW JERSEY

FORM NO. V - 5192 AR4

PRINTED IN U.S.A.

1974

H-3

Pages H-3 through H-6 have been deleted because of 1977 copyright restrictions. For information on solenoid valves, bulletins 8201 and 8211, contact Automatic Switch Company, Florham Park, New Jersey 07932.

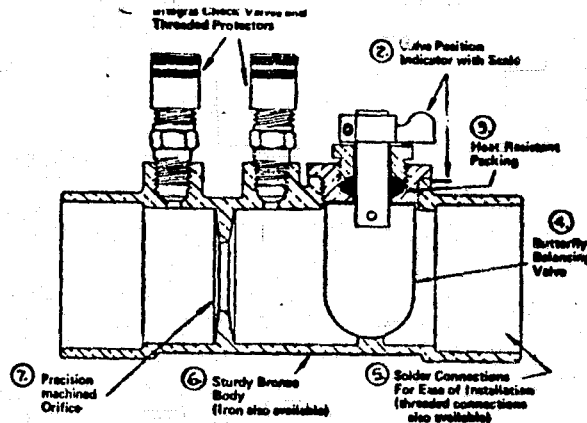
APPENDIX I

FLORATER BALANCING VALVE CHART

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OF POOR QUALITY

Features

1. Gauge Connections with integral check valves and threaded protectors
2. Valve position indicator with scale
3. Heat resistant packing
4. Butterfly balancing valve
5. Solder connections for ease of installation (threaded connections also available)
6. Sturdy bronze body (Iron body also available)
7. Precision machined orifice

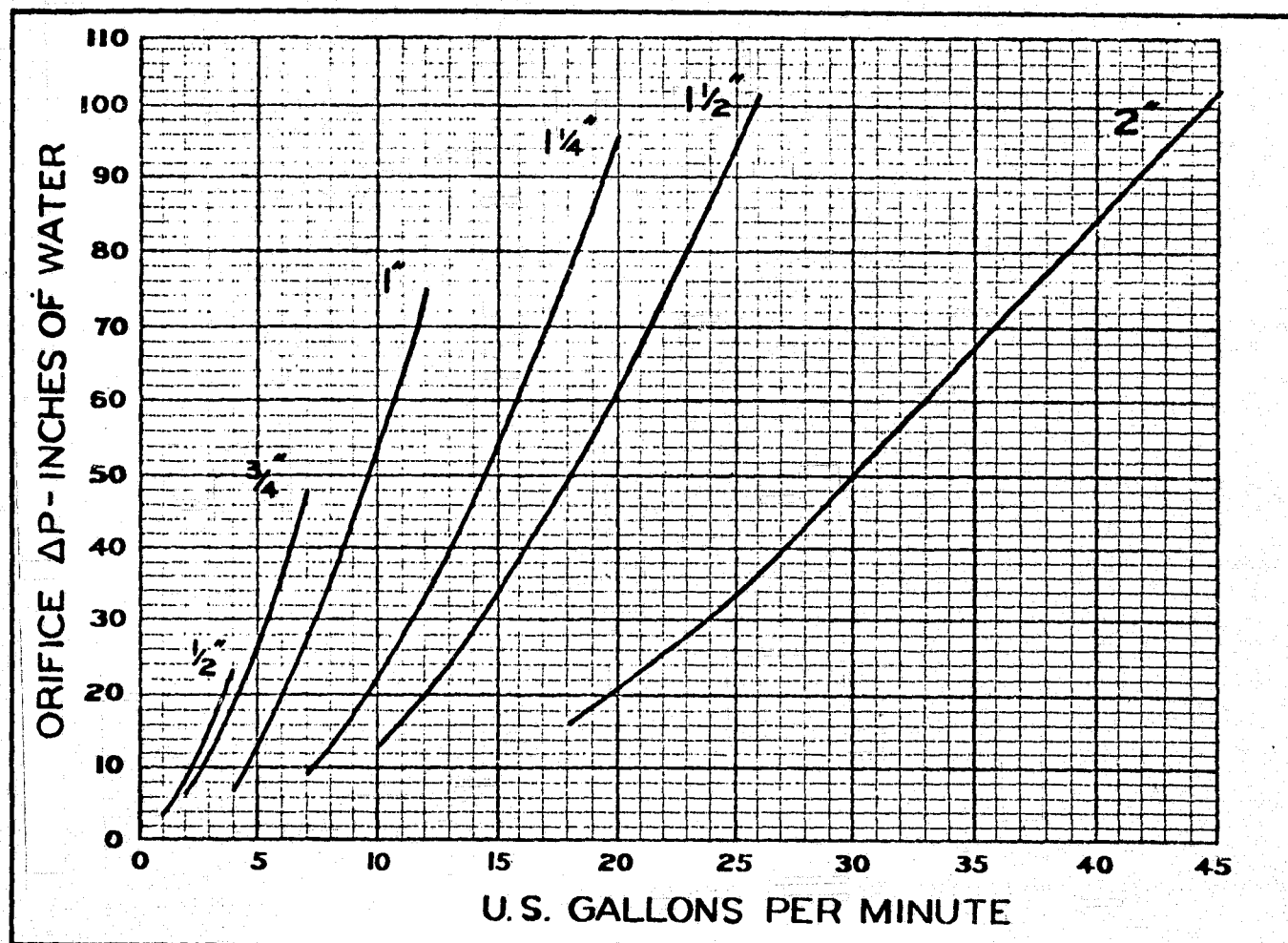


How to Size the Florater

The Florater is sized to the GPM required for the design loop. (Example) 7 GPM is required for a system loop. Locate 7 GPM on the horizontal scale of the chart. Trace 7 GPM up the vertical scale of the chart. Find that 7 GPM will intersect with 1-1/4" Florater and 1" Florater.

How to Adjust the Florater

To set the Florater for the proper GPM required use a differential pressure gauge. Assume a 1" valve is to be used as in the example at left. A 1" valve at 7 GPM requires a meter reading of 27" of water indicated on left vertical scale. Adjust the Florater Balancing valve until 27" of water differential pressure is indicated on the gauge. Record or mark the Florater scale setting for easy reference or readjustment.



THRUSH Products, Inc.

P. O. Box 228 • Peru, Indiana 46970



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MID-WEST MODEL 832 FLOW TEST KIT

Basic Operating Instructions

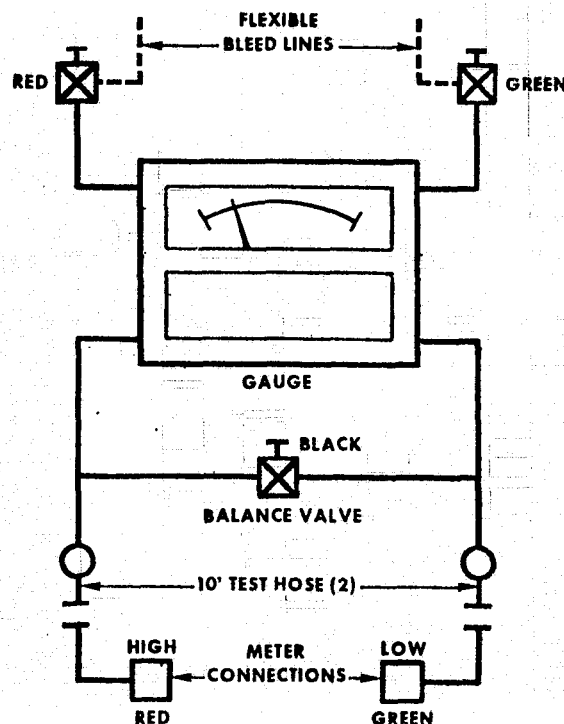
1. Open carrying case and sit in a convenient spot on test site with test kit horizontal.
2. With balance valve closed, connect hoses to meter — Red hose upstream, High Pressure — Green hose downstream — Low Pressure.
3. Open balance valve (bottom of panel).
4. Open high and low bleed valves alternately to purge air from system. (Bleed water discharges from convenient clear plastic flexible tube.)
5. When bleeding shows all air removed — close Balance Valve and read Differential Pressure Gauge. Refer to chart for conversion to GPM.
6. When test is complete — open balance valve before disconnecting Test Hoses from meter.
7. Hoses are stored by coiling them around the test panel.

NOTE: The Model 832 Test Kit is equipped with screens in the inlet hoses. If the gauge responds slowly when the balance valve is closed, the screens may be partially plugged.

To flush out and clean the screens and restore normal operation:

Open the *Balance Valve*. With the high and low pressure hoses connected to the flow meter (or other source of pressure), alternately disconnect the high, and then the low pressure hoses, and flush out each hose until the flow is clear. Approximately 30 seconds for each hose should be adequate.

Schematic Diagram



APPENDIX J

AIR RELEASE VALVE

Air Release Valves

ORIGINAL PAGE 18
OF POOR QUALITY

Anderson Air Release Valves (air traps or air vents) automatically and continuously vent air and other gases from liquids as fast as they accumulate. They are built for pressures up to 500 pounds. Installed at the high point of liquid handling piping systems, the valves eliminate spitting and splashing action from water faucets in domestic hot and cold water systems; prevent air binding and improve circulation in hot water heating systems; result in more effective circulation of water and better cooling in chilled water cooling and air conditioning systems. On industrial or municipal pipelines such as water mains, water filters, oil lines, brine lines, etc., these vents release air which restricts the flow of liquid.

OPERATION

Anderson Air Release Valves have the inlet at the bottom for connecting to the high points in piping systems which are the natural air pockets. The outlet for release of air is at the top. When the system contains no air, the liquid raises the float, closing the valve firmly against the seat. An accumulation of air or gas in the system lowers the liquid level causing the float to drop, opening the valve and releasing the air or gas.

APPLICATIONS

Anderson Air Release Valves vent air from domestic hot and cold water systems — in apartment, institutional, office and other multi-story buildings. Other applications include hot water heating systems, chilled water cooling and air conditioning systems and industrial and municipal pipelines.

FEATURES

UNIQUE DESIGN — Head and body are designed for quick dismantling for servicing at anytime.

LONG, MAINTENANCE-FREE, LEAK-PROOF SERVICE — Special cast metal housing assures top performance.

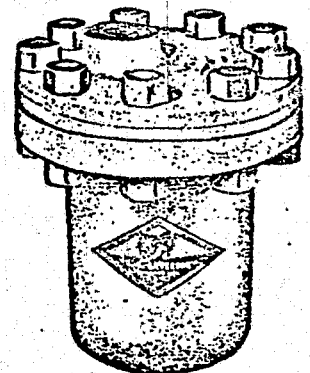
PRESSURES — Anderson manufactures two principle types of Air Release Valves: (1) No. 69 for pressures up to 100 P.S.I., No. 70 for pressures up to 150 P.S.I., Nos. 72, 73 and 74 for pressures up to 250 P.S.I. All have Cast Iron Bodies. (2) No. 213 for high pressures up to 500 P.S.I. in $\frac{1}{2}$ " or $\frac{3}{4}$ " sizes. Cast steel body.



Nos. 69 and 70A



Nos. 72A, 73A and 74

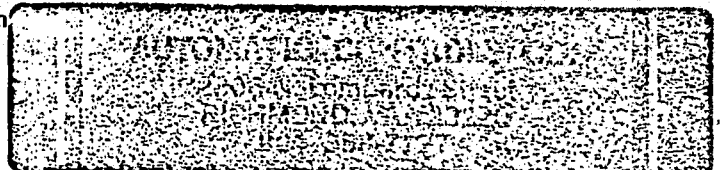


Nos. 213, 214 and 216

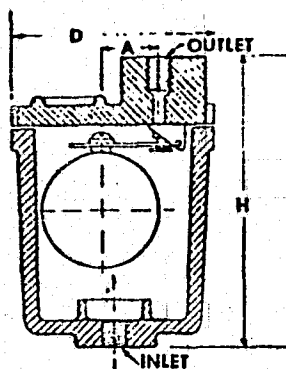
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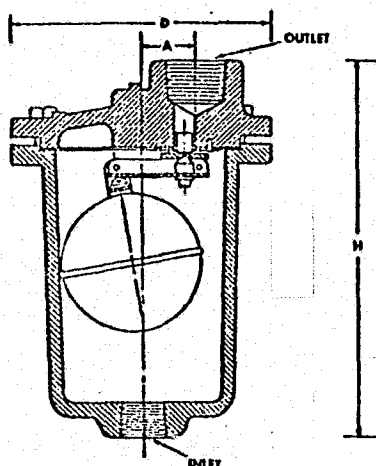
MACHINERY DESIGN



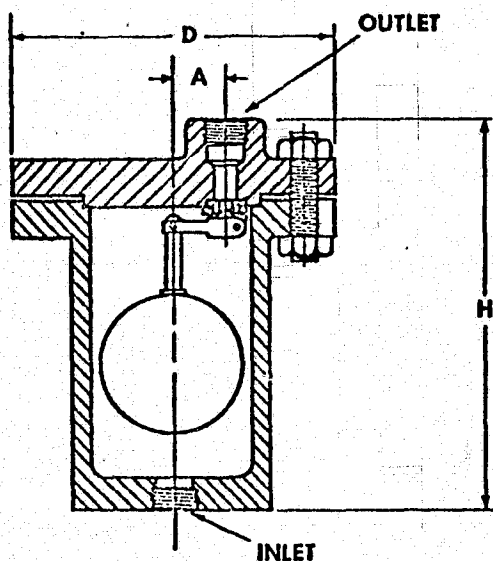
Air Release Valves



No. 69



Nos. 70A, 72A, 73A, and 74



Nos. 213, 214, and 216

MATERIALS

Rugged Cast Metal housing, stainless steel or non-corrosive internal.

SPECIFICATIONS								
Size Number of Valve	69	70A	72A	73A	74	213	214	216
Size Pipe Connections (inlet)	½"	½" or ¾"	½" or ¾"	1" or 1½"	1½" or 2"	½" or ¾"	1" or 1½"	1½" or 2"
Size Pipe Connections (outlet)	¾"	½"	½"	¾"	1"	¾" or 1"	1" or 1½"	1½" or 2"
Shipping Weight, lbs.	4	7	10	34	58	38	60	150
Maximum Pressure PSI	100	150	250	250	250	600	600	1000

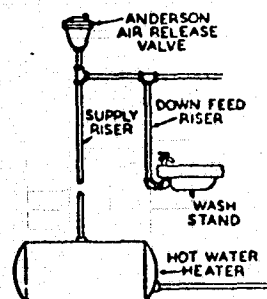
Operating Pressure	CAPACITY CU. FT. FREE AIR PER MINUTE							
10	5.2	11.0	21.0	25.0	136			
20	7.5	15.5	30.0	40.0	193			
30	10.0*	20.0*	39.5*	55.0	252*			
50	5.7	9.2	15.0	75.0*	130			
75	7.8	10.8	20.5	80.0	180*			
100	10.0	12.2	25.0*	100.0*	164*	58.0	105.0	250.0
125		13.5	30.0	100.0	125			
150		14.7*	33.5*	125.0*	147	37.0	85.0	320.0
200			25.0	85.0	195*	48.0	110.0	290.0
250			28.0	115.0	168	55.0	65.0	210.0
300						65.0	80.0	190.0
400						50.0	90.0	190.0
500						60.0	100.0	220.0
600						55.0	70.0	180.0
700								200.0
1000								200.0

DIMENSIONS			
Trap Size	A	D	H
69	¾"	3¾"	5½"
70	1"	5"	6¾"
72	1¾"	5½"	8¾"
73	1¾"	8¾"	12"
74	2¾"	9¾"	14"
213	1½"	7¾"	9¾"
214	1½"	9"	11"
216	2½"	12¾"	11¾"

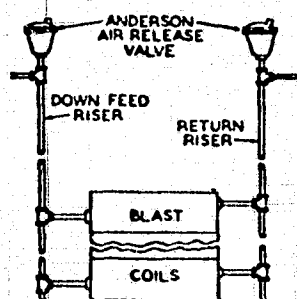
*Denotes capacity with larger orifice available at this pressure.

Note: Pipe sizes shown in heavy type are standard and traps will be shipped tapped standard unless otherwise specified. Pipe sizes shown in light type furnished at no additional cost but only from Cleveland stock.

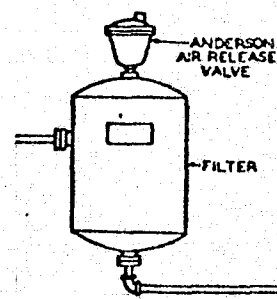
INSTALLATIONS



Venting air from hot water service lines in multi-story building.



Venting air from hot water heating or chilled water cooling coils.



Venting air from filter tanks and other process equipment.

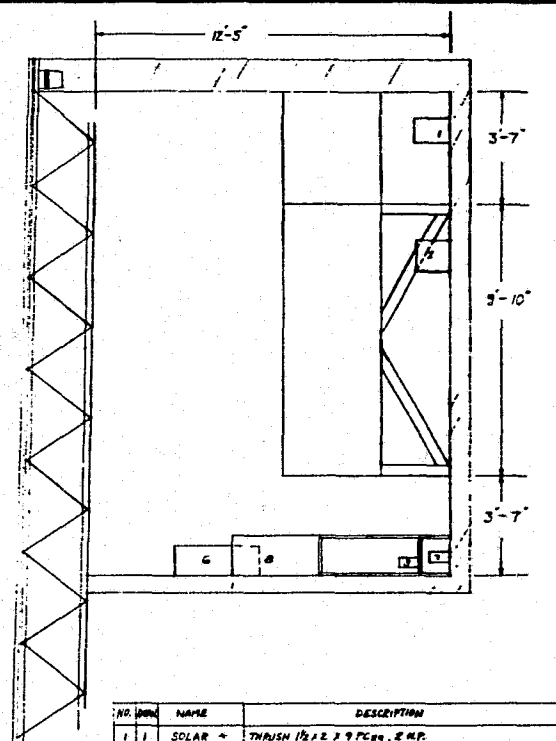
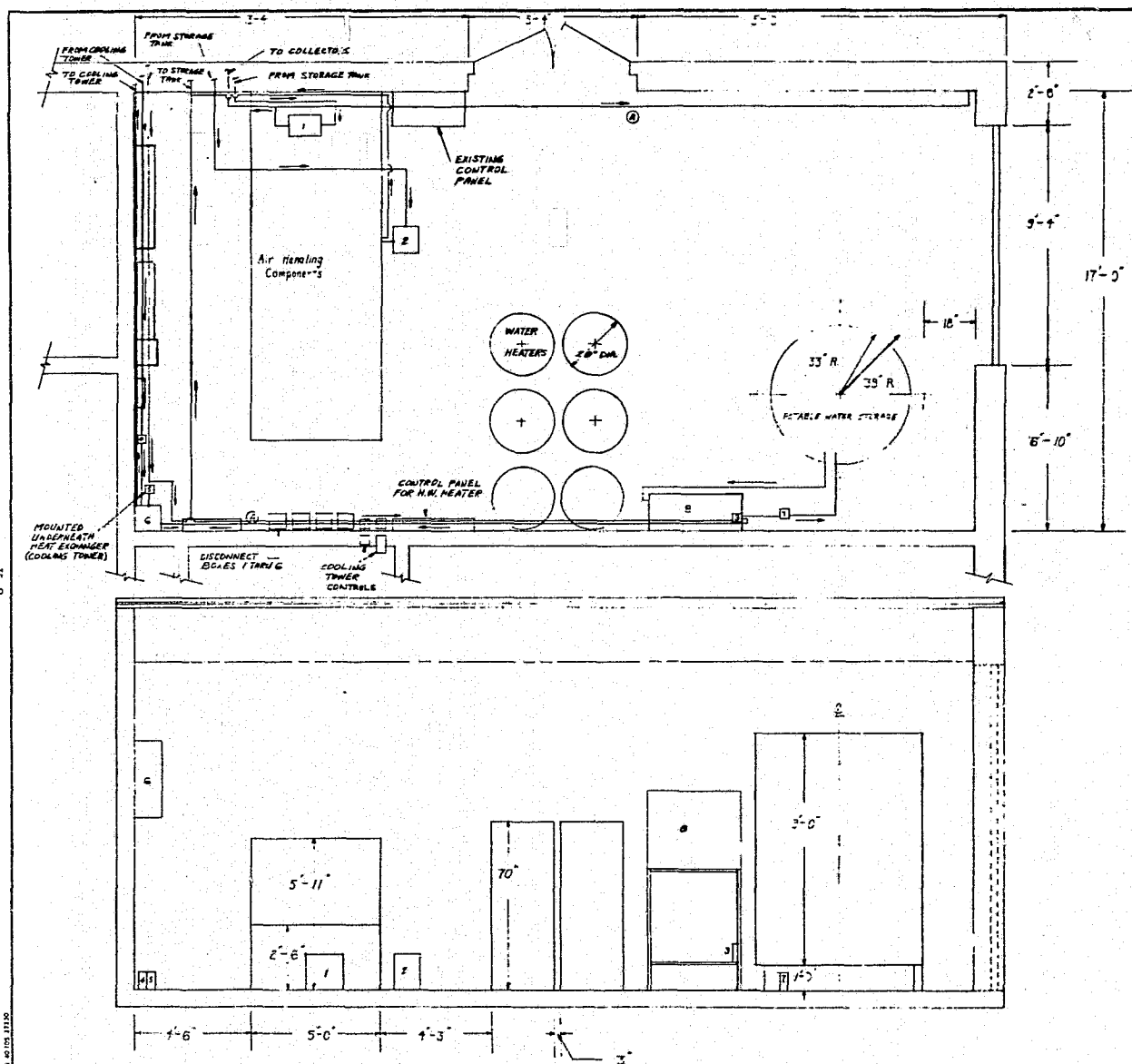
APPENDIX K

LIST OF AS-BUILT DRAWINGS

LIST OF AS-BUILT DRAWINGS

<u>Drawing No.</u>	<u>Title</u>
45615881-B	Mechanical Room Equipment Location
45615882-F	Piping Diagram for Potable Water Heater and Heat Dump Circuits
45615883-F	Piping Schematic - Heating Loop
45615884-F	Piping Diagram from Tanks to Solar Panels
45615885-C	Piping Diagram - Solar Collector System
45615888-D	Location and Piping Diagram for Ground Mounted Collectors & Returns
45616107-R	Electrical Schematic Diagram
45616109-B	Solar Storage Tank - Steel
A245-D1-1-C	Solar Collector Supports
A245-D1-2-B	Framing Details A through D
A245-P1-Z-D	Typical Connection Details

K-2



NO.	NAME	DESCRIPTION
1	SOLAR *	THRU 1 1/2" x 7" PCsg, 2 M.P.
2	SPACE HEAT *	THRU 1 1/2" x 7" PCsg, 3/4 M.P.
3	POTABLE *	THRU 1 1/2" x 7" PCsg, 3/4 M.P.
4	CIRCULATOR *	BELL & GOSSETT - 3/8" I.D. CENTRIFUGAL PUMP - SERIES 1635 1/2" V.D. M.P.
5	HEAT CLUMP *	THRU 1 1/2" x 7" PCsg, 3/4 M.P.
6	COOLING TOWER HEAT EXCHANGER	
7	POTABLE CIRCULATOR	THRU 3/8" CIRCULATOR WITH 1/2" M.P. - BRONZE BODY
8	POTABLE WATER HEAT EXCHANGER	

* THESE TYPES CIRCULATE SOLAR WATER ONLY.

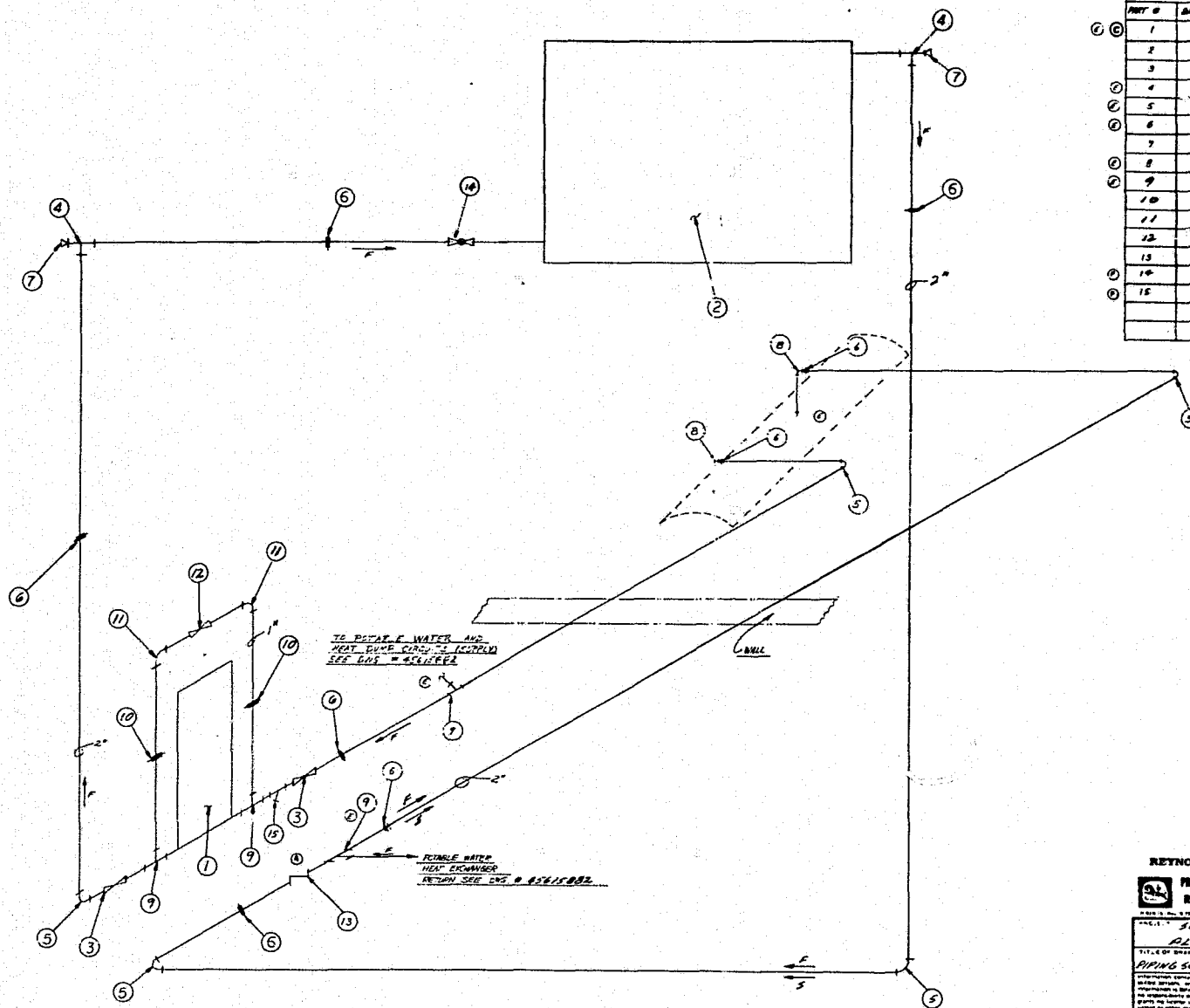
REYNOLDS METALS COMPANY



PRODUCT DEVELOPMENT DIVISION
RICHMOND, VA. 23261

PROJECT: SOLAR ENERGY - ALLOYS TITLE OF DRAWING: MILK ROOM EQUIPMENT LAYOUT		REVISION NO. 1 DATE: 12-23-77	
INFORMATION CONTAINED HEREIN IS UNCLASSIFIED EXCEPT WHERE SHOWN OTHERWISE. IT IS THE PROPERTY OF REYNOLDS METALS COMPANY AND IS NOT TO BE REPRODUCED OR TRANSMITTED IN ANY FORM OR BY ANY MEANS, ELECTRONIC OR MECHANICAL, INCLUDING PHOTOCOPYING, RECORDING, OR BY ANY INFORMATION STORAGE AND RETRIEVAL SYSTEM.		DRAWN BY: W. J. B. CHECKED BY: W. J. B. DATE: 12-23-77	





BOL OF MATERIAL		
PART #	QUANTITY	DESCRIPTION
1	1	PUMP - 1/2 HP 1/2" x 7/8" x 2 1/2", 1/2" (1/2" x 1/2")
2	1	VALVE TO BE INSTALLED
3	2	TEE - 2" B.I.
4	2	TEE - 2" B.I.
5	4	ELBOW - 2" B.I.
6	7	PIPE - 2" B.I.
7	2	PIPE - 2" B.I.
8	2	STREET ELBOW - 2" B.I.
9	4	TEE - 2" x 1/2" x 1/2" B.I.
10	2	UNION - 1" B.I.
11	2	ELBOW - 1" B.I.
12	1	GATE VALVE - 1" B.I.
13	1	CHECK VALVE - 2" B.I.
14	1	THROUGH - 2" FLOATER VALVE, CAST IRON
15	1	V-STRAINER - 2" B.I.

FURNISHED BY BIDD

1. ALL LINE UNLESS OTHERWISE SPECIFIED TO BE ASTM A106, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 803, 804, 805, 806, 807, 808, 809, 810, 811, 812, 813, 814, 815, 816, 817, 818, 819, 820, 821, 822, 823, 824, 825, 826, 827, 828, 829, 830, 831, 832, 833, 834, 835, 836, 837, 838, 839, 840, 841, 842, 843, 844, 845, 846, 847, 848, 849, 850, 851, 852, 853, 854, 855, 856, 857, 858, 859, 860, 861, 862, 863, 864, 865, 866, 867, 868, 869, 870, 871, 872, 873, 874, 875, 876, 877, 878, 879, 880, 881, 882, 883, 884, 885, 886, 887, 888, 889, 890, 891, 892, 893, 894, 895, 896, 897, 898, 899, 900, 901, 902, 903, 904, 905, 906, 907, 908, 909, 910, 911, 912, 913, 914, 915, 916, 917, 918, 919, 920, 921, 922, 923, 924, 925, 926, 927, 928, 929, 930, 931, 932, 933, 934, 935, 936, 937, 938, 939, 940, 941, 942, 943, 944, 945, 946, 947, 948, 949, 950, 951, 952, 953, 954, 955, 956, 957, 958, 959, 960, 961, 962, 963, 964, 965, 966, 967, 968, 969, 970, 971, 972, 973, 974, 975, 976, 977, 978, 979, 980, 981, 982, 983, 984, 985, 986, 987, 988, 989, 990, 991, 992, 993, 994, 995, 996, 997, 998, 999, 1000.

REYNOLDS METALS COMPANY

PRODUCT DEVELOPMENT DIVISION
RICHMOND, VA. 23261



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1	PARTIAL MATERIALS	LB 14-20-70
2	AS NOTED	PH 14-20-70
3	ALL NOTES REPEATED	PH 14-20-70
4	WAS PUMP THROU B.I.	PS 14-20-70
5	NOTE 6 REPEATED	PS 14-20-70
6	ADD CHECK VALVE	PH 14-20-70
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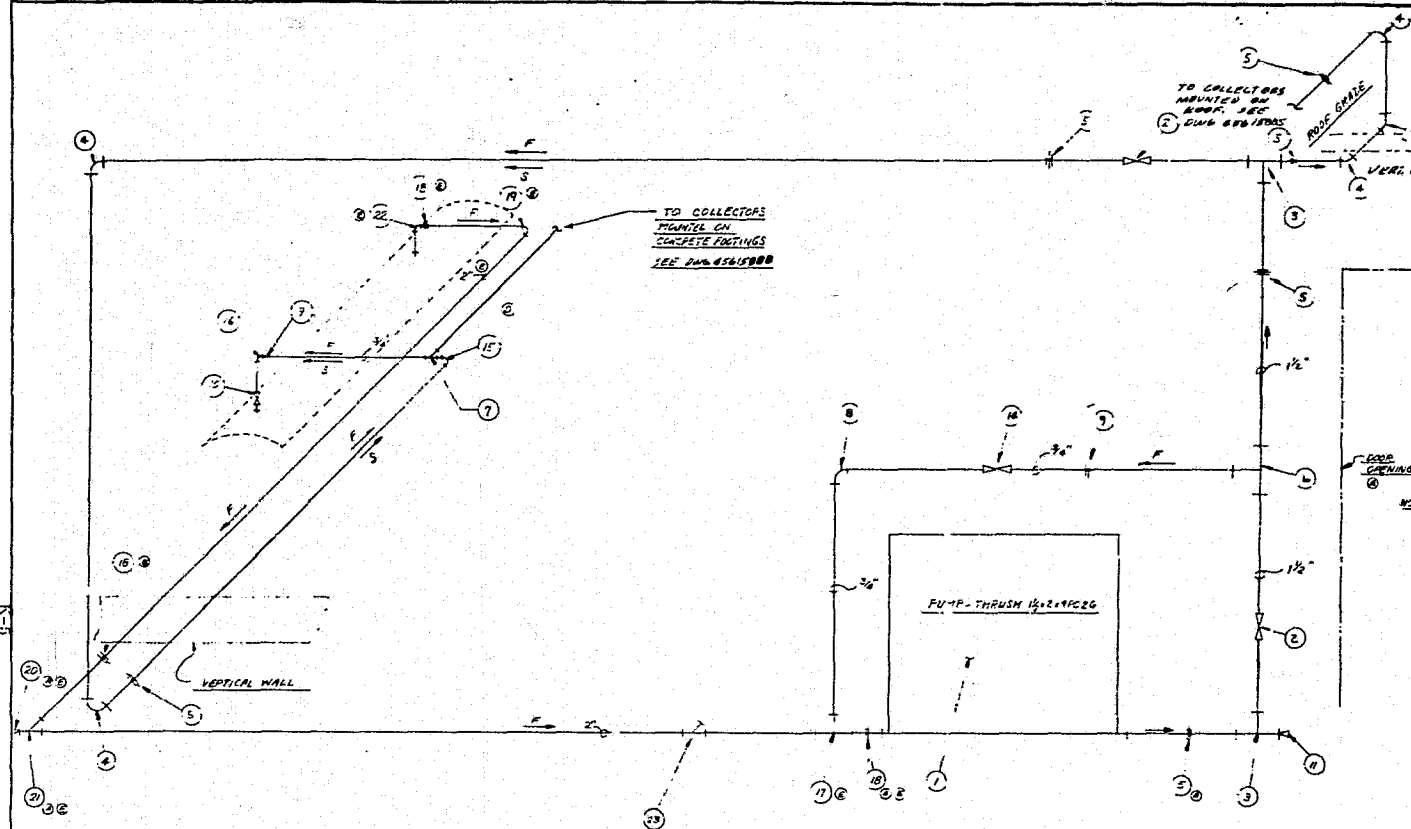
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K-15

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ORIGINAL PAGE IS
OF POOR QUALITY



BILL OF MATERIAL		
QTY.	QTY.	DESCRIPTION
1	1	PUMP - THRU 12" x 12" x 12" (OR EQUIV)
2	2	GATE VALVE - 1 1/2" B.I.
3	2	TEE - 1 1/2" B.I.
4	5	90° ELBOW - 1 1/2" B.I.
5	5	UNION - 1 1/2" B.I.
6	1	TEE - 1 1/2" x 1 1/2" x 3/4" B.I.
7	2	TEE - 1 1/2" x 3/4" x 1 1/2" B.I.
8	1	90° ELBOW - 3/4" B.I.
9	2	UNION - 3/4" B.I.
10	1	SCLENDID VALVE - 3/4" S.S.
11	1	PLUG - 1 1/2" B.I.
12		1 1/2" BLACK IRON PIPE
13		3/4" BLACK IRON PIPE
14	1	GATE VALVE - 3/4" B.I.
15	1	90° STREET ELBOW 1 1/2" B.I.
16	1	90° STREET ELBOW 3/4" B.I.

* FURNISHED BY RMC

- NOTES: 1. ALL UNITS UNLESS OTHERWISE SPECIFIED TO BE ASTM A106 OR A234.
2. ALL FITTINGS UNLESS OTHERWISE SPECIFIED TO BE ASTM A106 OR A234.
3. ALL CONNECTIONS TO STORAGE TANK TO BE MADE TO FITTINGS INSTALLED IN STEEL TANK.
4. F indicates direction of flow, S indicates direction of slope. SLOPE TO BE MINIMUM OF 1" IN 30' MINIMUM.
5. ALL HORIZONTAL RUNS OF PIPING TO BE SUPPORTED WITH A MAXIMUM SPAN OF 8'-0".
6. UNIONS AND OTHER FITTINGS MAY BE ADDED, DELETED TO BE CONSIDERED AS GOOD PIPING PRACTICE.
7. ALL VALVES UNLESS OTHERWISE SPECIFIED TO BE JENSON # 40A, THREADED, 250# ALL WITH 1" GATE VALVE, OR APPROVED EQUIV.
8. PUMP TO BE SUPPORTED BY FLASK STANDS EACH NO MORE THAN 3" FROM FLANGE. SEE ENCLOSED COPY OF SKETCH PUMP THROUGH CATALOGUE FOR DETAILS.
9. CONTRACTOR TO FURNISH AND INSTALL ALL PLUMBING - CONTRACTOR TO INSTALL PUMP FURNISHED BY REYNOLDS METALS CO.
10. NOTE: TWO 1/4" DIA. NAILS TO BE SPACED AND RESURFACED.
11. NOTE: ALL METALS TO BE GALVANIZED.

REYNOLDS METALS COMPANY

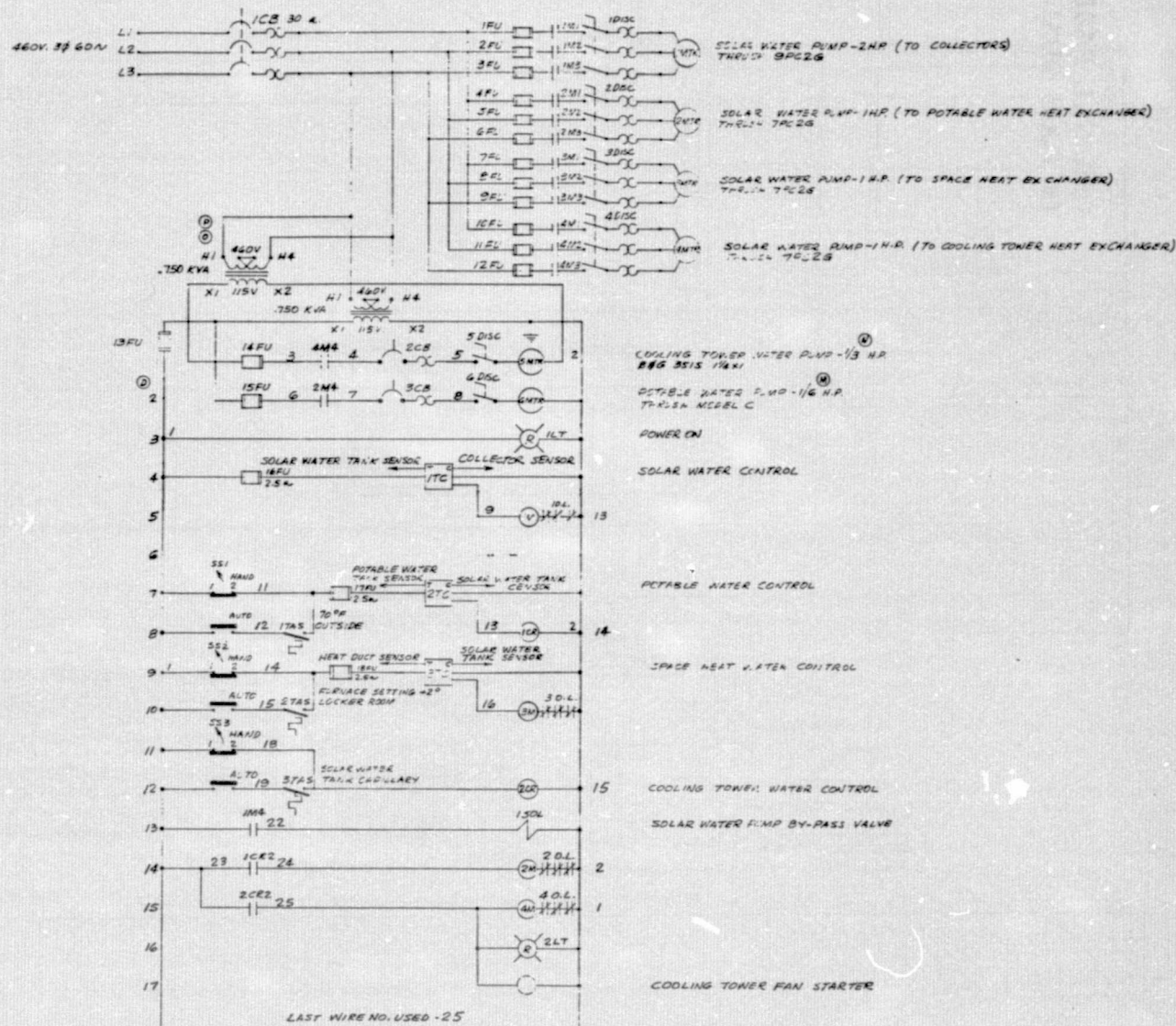
PRODUCT DEVELOPMENT DEPARTMENT
RICHMOND, VA 23261

SOLAR ENERGY ALLOYS

TANKS TO SOLAR PANELS

QTY.	QTY.	DESCRIPTION
1	1	1" STAINLESS - 2" B.I.
2	1	90° STREET ELBOW - 2" B.I.
3	1	TEE - 2" B.I.
4	1	FLVS - 2" B.I.
5	1	90° ELBOW - 2" B.I.
6	3	UNION - 2" B.I.
7	1	TEE - 2" x 2" x 3/4" B.I.

BILL OF MATERIAL

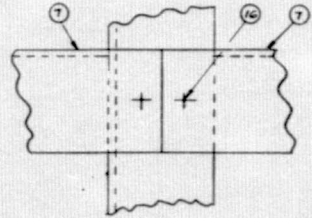
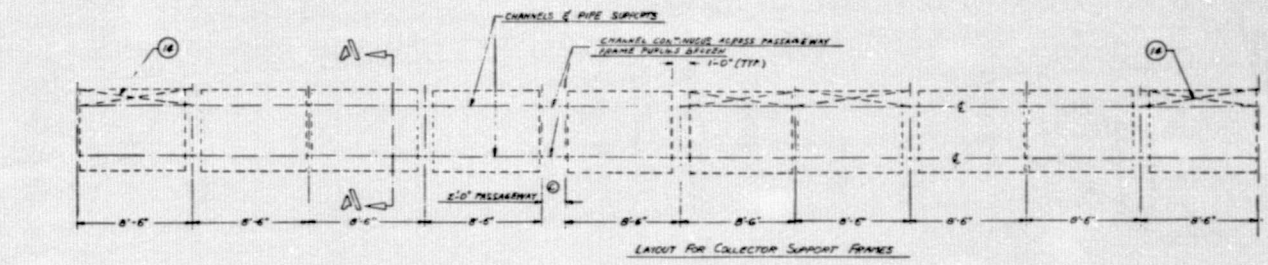


R	DRY GUARD BEARING BY 4/8/78
Q	TDR REMOVED BY 4/8/78
P	XPTR CHG CHANGED BY 4/8/78
O	TRANSFORMER ADDED BY 4/8/78
N	WAS 1/2 HP BY 4/8/78
M	WAS 1/2 HP BY 4/8/78
L	PPU ADDED BY 4/8/78
K	1/2 HP 1/2 HP BY 4/8/78
J	4TR ADDED BY 4/8/78
I	4TR REMOVED BY 4/8/78
H	4TR ADDED BY 4/8/78
G	3DG ADDED BY 4/8/78
F	13DL MOVED FOLLOWER BY 4/8/78
E	17TR 17TR 17TR BY 4/8/78
D	17TR 17TR 17TR BY 4/8/78
C	DRY GUARD BEARING BY 4/8/78
B	GENERAL REVISION BY 4/8/78
A	6.0V 1/2 HP 1/2 HP BY 4/8/78

REYNOLDS METALS COMPANY

PRODUCT DEVELOPMENT DIVISION
RICHMOND, VA. 23261

DATE	BY	REVISION	DATE	BY	REVISION
10/1/78	ALLOY	1	10/1/78	ALLOY	1
10/1/78	ALLOY	2	10/1/78	ALLOY	2
10/1/78	ALLOY	3	10/1/78	ALLOY	3
10/1/78	ALLOY	4	10/1/78	ALLOY	4
10/1/78	ALLOY	5	10/1/78	ALLOY	5
10/1/78	ALLOY	6	10/1/78	ALLOY	6
10/1/78	ALLOY	7	10/1/78	ALLOY	7
10/1/78	ALLOY	8	10/1/78	ALLOY	8
10/1/78	ALLOY	9	10/1/78	ALLOY	9
10/1/78	ALLOY	10	10/1/78	ALLOY	10
10/1/78	ALLOY	11	10/1/78	ALLOY	11
10/1/78	ALLOY	12	10/1/78	ALLOY	12
10/1/78	ALLOY	13	10/1/78	ALLOY	13
10/1/78	ALLOY	14	10/1/78	ALLOY	14
10/1/78	ALLOY	15	10/1/78	ALLOY	15
10/1/78	ALLOY	16	10/1/78	ALLOY	16
10/1/78	ALLOY	17	10/1/78	ALLOY	17
10/1/78	ALLOY	18	10/1/78	ALLOY	18
10/1/78	ALLOY	19	10/1/78	ALLOY	19
10/1/78	ALLOY	20	10/1/78	ALLOY	20
10/1/78	ALLOY	21	10/1/78	ALLOY	21
10/1/78	ALLOY	22	10/1/78	ALLOY	22
10/1/78	ALLOY	23	10/1/78	ALLOY	23
10/1/78	ALLOY	24	10/1/78	ALLOY	24
10/1/78	ALLOY	25	10/1/78	ALLOY	25



LOAD APPLIED TO STRUCTURE (REACTIONS)

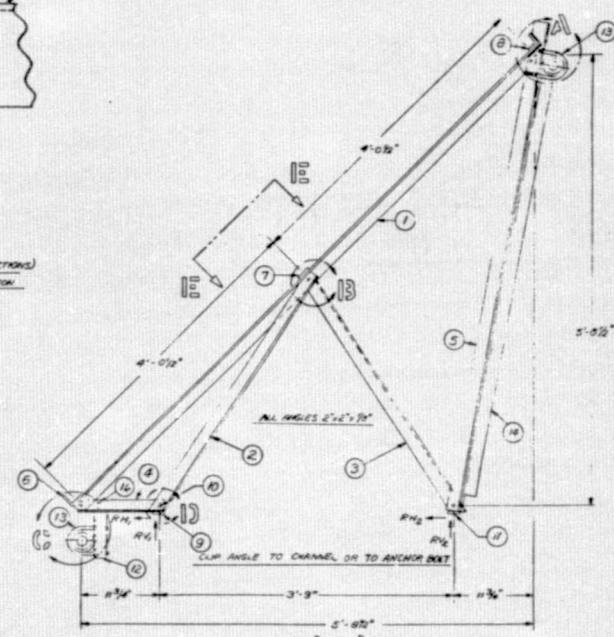
LIVE LOAD & DEAD LOAD

$R_{L1} = +103\#$
 $R_{L2} = +600\#$
 $R_{L3} = +103\#$
 $R_{L4} = +636\#$

WIND LOAD SECTION

$R_{W1} = -674\#$
 $R_{W2} = +246\#$
 $R_{W3} = -270\#$
 $R_{W4} = -192\#$

= INDICATES IN DIRECTION OF JOINTS



SECTION A-A
 $1/8" = 1'-0"$
 NOTE: FOR DETAILS A, B, C, D SEE DWS # A245-D1-2

BILL OF MATERIAL FOR 47 FRAMES 6' LONG.

ITEM NO.	NAME	MATERIAL	SIZE	UNIT WT.	TOT. WT.
1	47 TOP CHORD	6061-T6	2" x 1/2"	58#/FT	2746#
2	47 INTERIOR WEB	6061-T6	2" x 1/2"	58#/FT	2746#
3	47 INTERIOR WEB	6061-T6	2" x 1/2"	58#/FT	2746#
4	47 SKEL	6061-T6	1" x 1/2"	38#/FT	1814#
5	47 BACK WEB	6061-T6	2" x 1/2"	58#/FT	2746#
6	20 PARLIN	6061-T6	1" x 1/2"	38#/FT	1814#
7	20 PARLIN WITH 1" CLIP IN PL WIDE	6061-T6	1" x 1/2"	38#/FT	1814#
8	20 PARLIN	6061-T6	1" x 1/2"	38#/FT	1814#
9	94 TOP ANGLE SUPPORT	6061-T6	1" x 1/2"	38#/FT	1814#
10	249 BOLT-FRAME CONN.	SAE 304 STAINLESS STEEL	1/2" x 3"		
11	14 BASE ATTACHMENT	SAE 304 STAINLESS STEEL	1/2" x 1/2"		
12	47 PIPE SUPPORT	6061-T6	1" x 1/2"	38#/FT	1814#
13	14 PLATE-4" x 1/2" x 1/2"	SAE 304 STAINLESS STEEL	4" x 1/2" x 1/2"		
14	12 LATERAL BRACE	6061-T6	1" x 1/2"	38#/FT	1814#
15	470 PLATE-1/2" x 1/2" x 1/2"	SAE 304 STAINLESS STEEL	1/2" x 1/2" x 1/2"		
16	6 STAY RODS-1/2" x 1/2" x 1/2"	SAE 304 STAINLESS STEEL	1/2" x 1/2" x 1/2"		

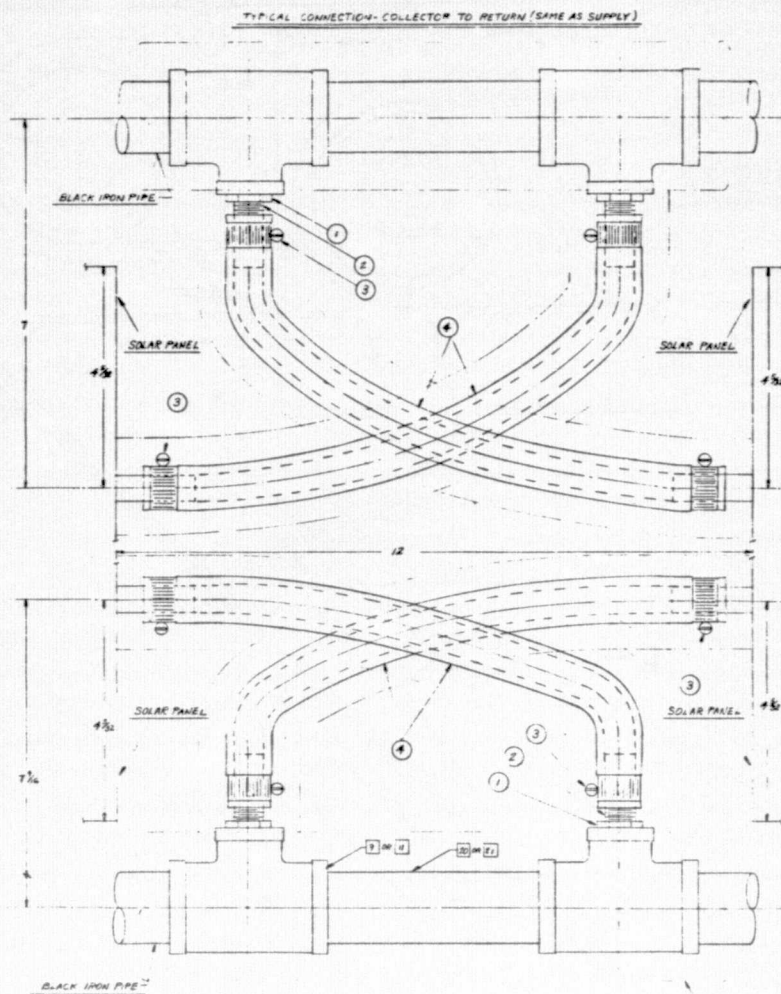
NOTE: SEE DETAILS A, B, C, D ON DWS # A245-D1-2
 INCLUDE AS INDICATED, IF CENTER POINT
 OR PERMANENT MAINTENANCE AREA.

NOTE: THIS BILL OF MATERIAL INCLUDES
 1. FRAMES FOR GROUND MOUNTING.

NOTE: ALL MATERIALS FURNISHED BY R.M.C.

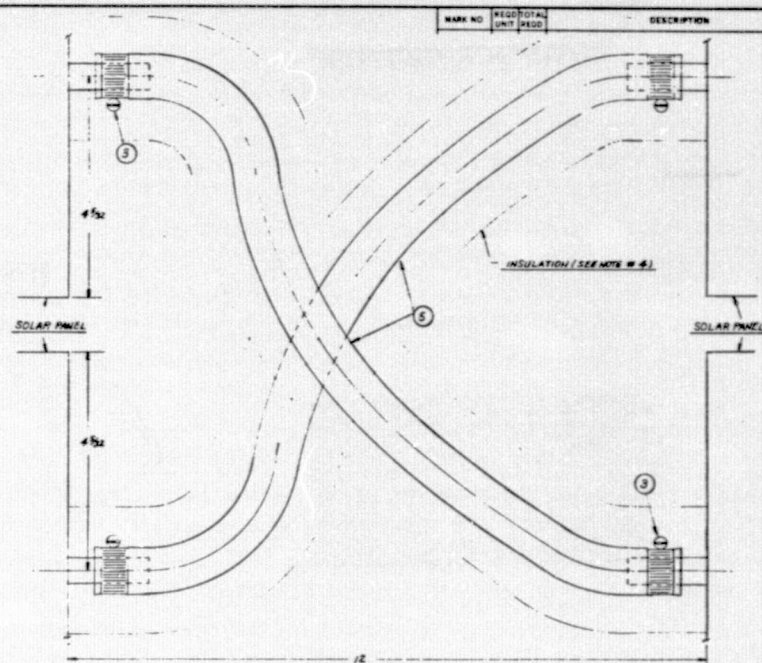
APPROXIMATE TOTAL WEIGHT - 1433.00 LBS.

REFERENCE PLANS



TYPICAL CONNECTION - SUPPLY TO COLLECTOR

NOTE: PARTS NOT DESIGNATED BY NUMBERS INCLUDED IN BILL
OF MATERIAL ON RMC DWG NO. 4561555-B



TYPICAL CONNECTION BETWEEN COLLECTORS

BILL OF MATERIAL (# COLLECTORS)						
ITEM QTY	NAME	DESCRIPTION	MATERIAL	MATERIAL SIZE	UNIT WT	TOT WT
1	4	BUSHING	72 A 76	B. I.		
2	14	NIPPLE	76	B. I.	1 1/2 LONG	
3	12	CLAMP	MADBAR	S. STEEL		
4	4	NOSE	MANUAL BC-5C	FLANGE	1/2 ID x 1 1/2 LG.	
5	2	NOSE	MANUAL BC-7A BC-DBO	FLX NOSE	7/8 ID x 1 1/2 LG.	

☐ NOS. SHOWN THIS LISTED IN B.C.M. ON CARD. #8615885-C

① SEE NOTE # 2

- NOTES:
1. REYNOLDS ALUMINUM SOLAR COLLECTORS TO BE SPECIFIED WITH MAXIMUM 1/2 IN INCH INLET & OUTLET OUTSIDE OF FRAME ENDS TO BE MAXIMIZED MINIMUM 1 INCH.
 2. FAST NO. 4 TO HAVE THREADS ON ONE END ONLY. MAKE TWO FEET 3 INCH NIPPLE.
 3. ALL PARTS SHOWN ON B.O.M. ON THIS DRAW. FURNISHES BY ALUMINUM PIPE CONTRACTOR TO INSTALL. ASSEMBLIES SEPARATE NOSES TO COLLECTORS AND INSULATE ALL LINES.
 4. ALL LINES & FITTINGS ABOVE GRADE UNLESS OTHERWISE SPECIFIED TO BE INSULATED BY THIS APPPLIER. RUBBER GASKET GEL PIPE INSULATION OR APPROVED EQUIV. INSULATION MAY BE APPLIED EITHER BY SPLICING OR DURING PLUMBING ASSEMBLY OR BY CUTTING AND REPAIRING. ALL JOINTS AND SPLITS TO BE CONNECTED BY APPLYING ARMISTECH 550 RUBBER GASKET OR APPROVED EQUIV. ALL INSULATION EXPOSED OUTSIDE TO BE COATED WITH ARMISTECH APPAPLEX FLUOR. OR APPROVED EQUIV.
- REFERENCE PLANS

[illegible]