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FINAL REPORT
on the
Solar Space and Water Heating System
at
STANFORD UNIVERSITY
Central Food Services Building

DOE Contract No. EG-77-A-03-1522
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May 1980

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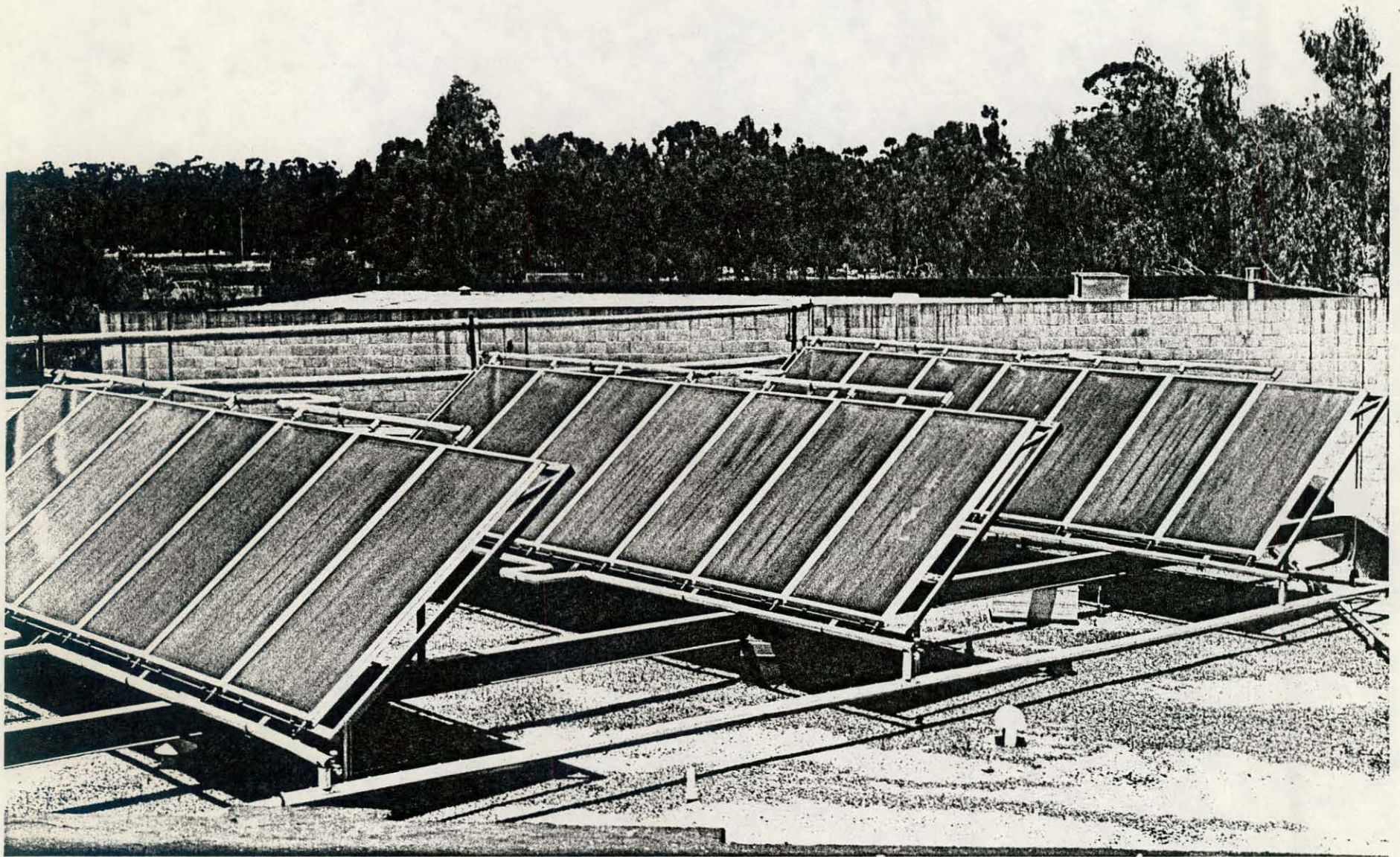
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Collectors viewed from the east.

I. SUMMARY OF RECOMMENDATIONS

- A. Large amounts of energy can be saved by the simplest measures. The savings from turning off equipment when unnecessary (sometimes completely), reducing use temperatures, and reducing hot water usage, can overshadow the savings from even the best solar system.
- B. The closed-loop drain-back system offers many advantages over other domestic hot water collector loops, including the dependability of gravity drain-back freeze protection, low maintenance, minimal costs and simplicity.
- C. By installing a loop between the solar storage tank and the backup storage tank, the backup tank can be used for solar storage (when the solar tank temperature exceeds the backup tank set temperature) during periods of high solar input and/or low loads, when storage is most needed.
- D. The FCHART computer program can be helpful not only in performing thermal and economic analyses, but also in making a cost-benefit analysis of alternate collectors on a system-by-system basis.
- E. In the closed, drain-back collector loop:
 - 1. The pump must be sized to overcome static as well as dynamic head losses.
 - 2. The sump tank should be located to minimize the height difference between the sump tank water level and the top of the collectors while still allowing for complete draining of the collectors and all plumbing exposed to freezing conditions. This will minimize static load on the pump.
 - 3. The sump tank should be located high above the pump to put as much head as possible on the suction side of the pump.
 - 4. The pump should be mounted with flow in the vertical direction to prevent air pockets from developing overnight (out of the very aerated water) in the volute of the pump.
- F. A preliminary structural analysis should be routinely included in solar feasibility studies so the impact of structural requirements can be anticipated and budgeted early when the feasibility and economics of the project are determined.

- G. Drawings and specifications should be carefully reviewed before construction, with special attention given to the side effects of design changes.
- H. On retrofit projects, carefully review as-built drawings for potential conflicts.
- I. Solar contractors should not only understand the "what" of the design, but also the "why," so they can effectively judge the consequences of changes (initiated by themselves and others) and look for opportunities of improving the system and lowering costs.
- J. Carefully read manufacturer's installation instructions.

II. SOLAR SYSTEM DESCRIPTION

A. Key Word Abstract

Application: Domestic hot water and space heating
System type: Active hydronic
Collector type: Flat plate, liquid, single-glazed
Collector manufacturer: Solar Energy Products, Inc.
Collector area: 840 square feet (aperture)
Storage capacity: 1,550 gallons, steel tanks
Building load: 203×10^6 BTU/year
BTU's produced: 142×10^6 BTU/year
Building owner: The Leland Stanford Junior University
Construction and Engineering Office
The Old Pavilion
Stanford, CA 94305
Solar system designer: Interactive Resources, Inc.
117 Park Place
Point Richmond, CA 94801
Contractor: Redwood Mechanical
1590 Tacoma Way
Redwood City, CA 94063

B. Introduction

The Stanford University Central Food Services Building is located on the Stanford campus approximately 30 miles south of San Francisco. It is a single-story building with flat roofs. It is used for food preparation and storage and includes administrative offices.

The building was previously fed by a steam main from Stanford's central steam plant located about two miles away. Over the years significant deterioration occurred in this line, resulting in wasteful heat losses. Stanford terminated steam service to the building and replaced it with a solar system and gas-fired backup.

A cost-sharing proposal for construction of the solar system was submitted to ERDA (now DOE) under Cycle 2 of the Commercial Solar Heating and Cooling Demonstration Program in November, 1976. Funding was awarded in 1977. Construction bids were received in March, 1978; construction began in June, 1978, and was completed in April, 1979.

C. Energy Conservation

Stanford University has been and continues to be concerned with energy conservation. In the Central Food Services Building, the most significant of their accomplishments has been the complete abandonment of 87 per cent

of the original heating system. Three of the original four heating coils have been shut down leaving only the offices in the administration wing to be heated. All storage and work areas are simply no longer heated. Instead of only turning down the thermostats at night, the heating system is turned off 13 to 14 hours a day. Furthermore, no heat is used on weekends. These measures save 73 per cent of the fuel used if heated for 24 hours, seven days a week.

The majority of hot water consumed in the building is used in the late afternoon to wash down the meat processing area. A pressurized spray system was installed that reduced hot water consumption from 9 to 4.5 gpm.

Energy conservation-motivated changes have resulted in at least a 60 per cent heat use reduction for the Central Food Services Building at Stanford, and possibly up to an 80 to 90 per cent reduction.

RECOMMENDATION: Large amounts of energy can be saved by the simplest measures. The savings from turning off equipment when unnecessary (sometimes completely), reducing use temperatures, and reducing hot water usage, can overshadow the savings from even the best solar system.

D. Solar System Design Philosophy

The solar system was primarily designed as a hot water heating system with space heating as a secondary function because hot water (used mainly to wash down the meat processing area) comprises an estimated 72 per cent of the building solar load. In the schematic design phase, an open loop system was planned using potable water as both the transfer fluid and storage medium. This prevented the necessity of heat exchangers which might have reduced efficiencies and increased costs.

In a response to their experiences with previous installations, designed by themselves and by others, the solar system designer, Interactive Resources, Inc., completely reevaluated the system design during the final design stages, primarily in an effort to arrive at a totally satisfactory freeze protection system. Even though the mild climate of northern California offered only an average of three or four freezes a year, none of the freeze protection systems for open loop systems (pump cycling, thermic drains, drain-out and drain-back systems using electronic valves, and combinations) were determined to be satisfactory.

An antifreeze system was then considered, but offered several disadvantages including the necessity (by code) for a double-wall heat exchanger (additional cost and reduced efficiency) and the additional maintenance costs required for replacing and closely monitoring the transfer fluid.

In an effort to combine the advantages but eliminate the difficulties of these systems, a completely revised collector loop design was developed which combined the dependability of gravity drain-back freeze protection with low maintenance, minimal costs and, of prime importance, simplicity.

This closed-loop, drain-back system uses no mechanical or electrical controls for freeze protection, eliminating potential failures and maintenance requirements. Freezes coupled with power failures and/or accidental turning off of key components do not endanger the system. The problems associated with antifreezes (e.g., cost, ease of handling, poor thermal transfer qualities, increased viscosity, potential damage to other buildings materials [some react to roofing materials], potential toxicity and required maintenance) are eliminated. If the collector array is designed to drain and its contents can be stored in a sump tank during noncollection hours, plain water can be used, increasing the thermal transfer capabilities and allowing for a more efficient and less costly single-wall heat exchanger. Simplicity of the system, especially in the controls, is a major advantage of this system.

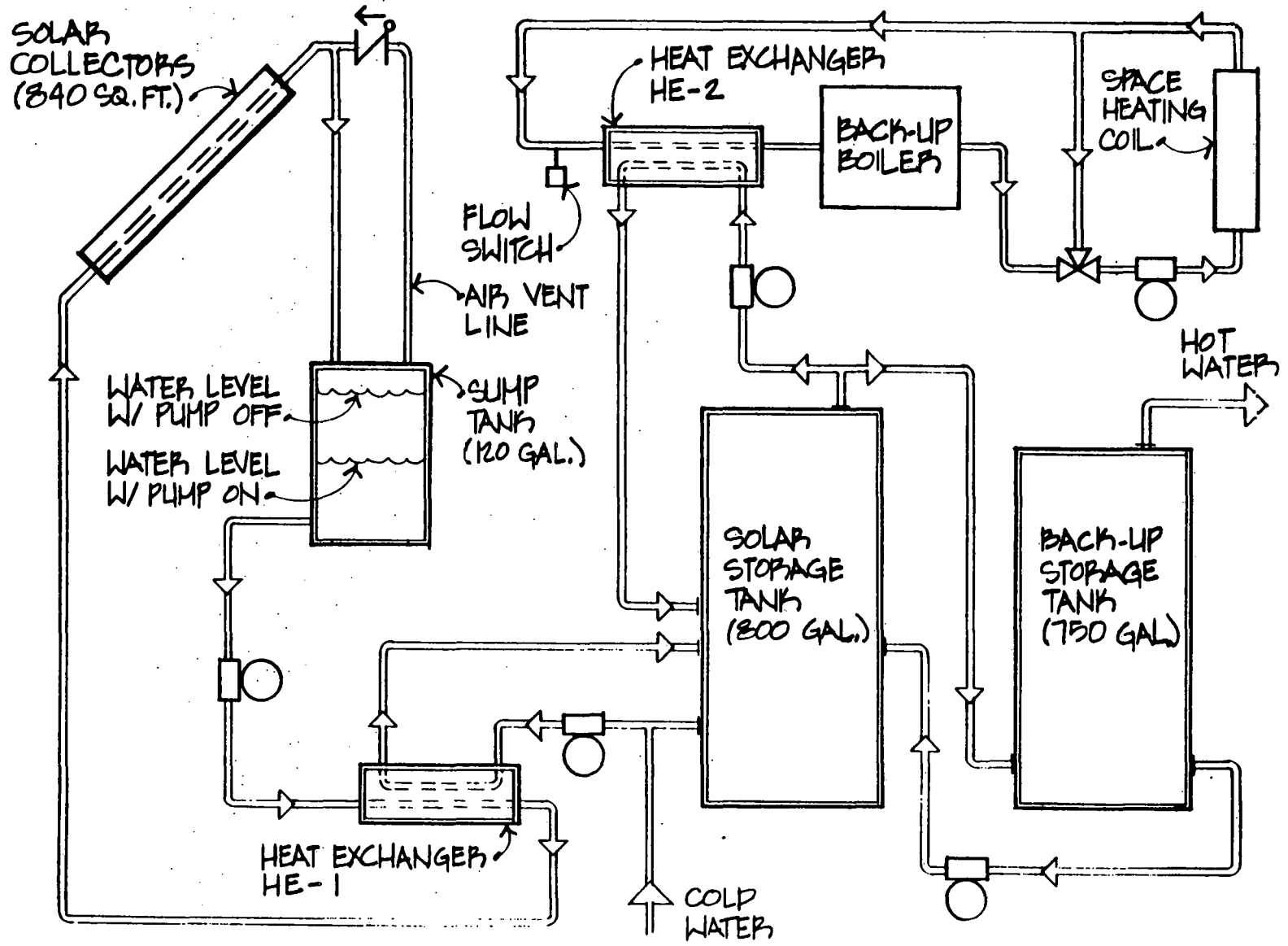
RECOMMENDATION: The closed-loop, drain-back system offers many advantages over other domestic hot water collector loops, including the dependability of gravity drain-back freeze protection, low maintenance, minimal costs and simplicity.

E. Solar System Operation Description

The solar heating system on the Central Food Services Building provides space heating and domestic hot water heating. Of the total energy supplied by the system, approximately two-thirds is used to offset the year-round domestic hot water heating load, while approximately one-third is used to offset the seasonal space heating load.

1. Collector-to-Heat Exchanger Loop

Energy in the form of heat is transferred from the solar collectors to heat exchanger HE-1 via a closed, drain-back loop. This loop includes the solar collectors, the sump tank (120 gallons), a pump, and



SOLAR SYSTEM SCHEMATIC

heat exchanger HE-1. This loop uses normal untreated tap water as the transfer medium.

The collector-to-heat exchanger loop is a closed loop containing water and air. Neither water nor air enters or exits the loop unless done so manually. With the pump off, the water level is flush with the top of the sump tank. All the piping above this level contains air.

When the pump is turned on, water is circulated from the sump tank, through the heat exchanger, up through the collectors and back to the sump tank. Air is forced from the collectors into the sump tank. The water level in the sump tank will drop to around one-quarter full.

When the pump is turned off, the weight of the water creates a suction at the top of the system. The check valve to the air vent line opens allowing air to flow from the sump tank through the air vent displacing water in the collectors and manifolds, thereby draining all the water from the collectors into the sump tank.

2. Heat Exchanger-to-Solar Storage Tank Loop

The solar storage tank contains potable water and feeds the supply side of the backup hot water storage tank. Water in this tank is circulated through heat exchanger HE-1 and returned to the tank. This completes the transfer of heat from the collectors to the solar storage tank.

The pump in the collector-to-heat exchanger loop and the pump in the heat exchanger-to-solar storage tank loop operate together. They are controlled by a differential thermostat. This controller compares the temperature in the collector with the temperature at the bottom of the solar storage tank. When the collector is 20°F warmer than the solar storage tank, the pumps are turned on. When the collector temperature drops to only 3°F warmer than the solar storage tank, the pumps are turned off.

3. Solar Space Heating Loop

Solar-heated water is stored in the solar storage tank. Water in this tank is used to pre-heat the return water in the backup space heating loop. This is done through heat exchanger HE-2.

When a differential thermostat senses that the temperature in the solar storage tank is 8°F warmer than the return water in the backup space heating loop, the solar space heating loop pump is turned on. The pump is interlocked with a flow switch in the backup heating loop. The pump will come on only if there is flow in the backup heating loop. When the storage tank temperature is only 3°F warmer than the return water in the backup heating loop, the pump is turned off. A gas-fired boiler adds heat to the backup loop, if required, but only after passing through the solar heat exchanger.

4. Tank-to-Tank Loop

The solar storage tank serves as a pre-heat tank to the backup hot water storage tank. When hot water is used in the building, it is drawn from the top of the backup hot water storage tank. Make-up water to this tank comes from the solar storage tank. Cold water make-up enters at the bottom of the solar storage tank. Backup heat is supplied to the backup storage tank by a gas-fired boiler, if required.

When the solar storage tank temperature is greater than the temperature in the backup storage tank, water is exchanged between tanks via the tank-to-tank loop. This increases the solar storage capacity during periods of high solar input and/or low loads.

When a differential thermostat senses that the solar storage tank is 10°F warmer than the backup hot water storage tank, the tank-to-tank loop pump is turned on. When the solar storage tank is only 3°F warmer, the pump is turned off.

RECOMMENDATION: By installing a loop between the solar storage tank and the backup storage tank, the backup tank can be used for solar storage (when the solar tank temperature exceeds the backup tank set temperature) during periods of high solar input and/or low loads, when storage is most needed.



Four banks of solar collectors.

III. ACCEPTANCE TEST DATA

Since the system design was based on prescriptive rather than performance standards, the acceptance testing consisted of checking the operational functioning of system controls and components.

A. Acceptance Test Plan

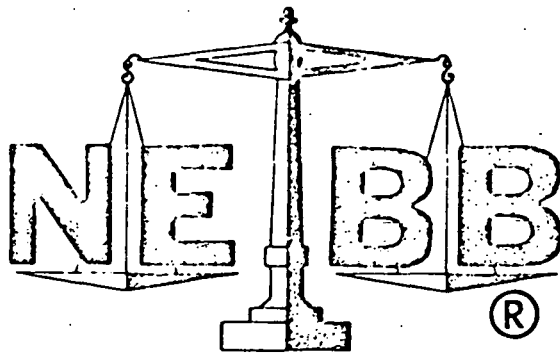
1. Hydrostatically test all equipment to 125 psi for four hours.
2. Measure water flow rates.
3. Measure amperage input to each pump.
4. Measure suction and discharge pressure of pumps.
5. Test operation of system under actual service conditions.

B. Acceptance Test Results

Hydrostatically testing the collector loop was difficult due to extreme temperature fluctuations caused by sunlight on the collectors, but tests demonstrated there were no leaks.

Flow rates, amperages and pressures are found in the attached pump test report. The collector loop pump, P-5, was found to be undersized (see the section on Problems, Solutions and Recommendations) and replaced with a large pump.

The system has been carefully watched under operational conditions. This showed that the space heating loop pump was not working as it should. Subsequent investigations showed that the flow switch was not installed properly. (See the section on Problems, Solutions and Recommendations.) A solar system operations log is included.



TEST — ADJUST — BALANCE REPORT

DATE January 22, 1979

PROJECT Central Food Services

ADDRESS Stanford University

Stanford CA

ARCHITECT Interactive Resources, Inc.

Richmond, CA

ENGINEER _____

SUBMITTED BY Thermoscope Energy Engineering Co., Inc.

ADDRESS 24 Linden Avenue

South San Francisco, CA





PUMP TEST REPORT

PROJECT Central Food Services, Stanford, CA

DATA		PUMP NO. 4	PUMP NO. 5	PUMP NO. 6	PUMP NO. 7	PUMP NO.
DESIGN	Location	Mech. Room	Mech Rm.	Mech. Rm.	Mech. Rm.	
	Service	Solar Banks	Heating	Storage-Tk	Heating	
	Manufacturer	Belle & Gossett	Belle & Gossett	Belle & Gossett	Belle & Gossett	
	Model Number	60-1½ AA	60-1½ AA	150	60-1¼ AA	
	Serial Number					
	GPM/Head	21/28	21/22	20/6	21/22	
	Req. NPSH					
	Pump RPM	1725	1725	1725	1725	
	Impeller Diam.					
	Motor Mfr./Frame	Belle & Gossett	Belle & Gossett	Belle & Gossett	Belle & Gossett	
	Motor HP/RPM	½/1725	½/1725	½/1725	½/1725	
	Volts/Phase/Hertz	115/1/60	115/1/60	115/1/60	115/1/60	
	F.L. Amps/S.F.	7.1/1.15	4.9/1.15	1.7/1.15	4.9/1.15	
	Seal Type					
ACTUAL	Pump Off-Press.					
	Valve Shut Diff.					
	Act. Impeller Diam.					
	Valve Open Diff.					
	Valve Open GPM					
	Final Dischg. Press. **	12	65.5	60	66.5	
	Final Suction Press.	Neg	55.0	.57	51.5	
	Final Δ P	12	10.5	3	15.0	
	Final GPM *		*21.5	*15 F.O.	*18 F.O.	
	Voltage $T_1-T_2, T_2-T_3, T_3-T_1$	120	120	120	120	
Amperage T_1, T_2, T_3	6.1	4.9	1.4	4.6		

REMARKS: * Measured @ Bell & Gossett circuit setters.

** Location of Gage does not include pressure prop @ 90° Elbows.

TEST DATE 12/15/78 READINGS BY Carlos Garcia

Thermoscope

energy engineering co., inc.

24 Linden Ave.

South San Francisco, Calif. 94080

(415) 952-2288

PROJECT Central Food Services

LOCATION Stanford University, Stanford CA

UNIT MARK	SYSTEM TYPE	FLOW STATION				DESIGN		INITIAL		FINAL			REMARKS
		MARK	MFGR	TYPE	SIZE	GPM	dP	dP	DSP	DSP	dP	GPM	
P-4	H.W.	SB-1	B&G	S	1	7		2.3	0			5.7	Not balanced due to low capacity.
		-2				7		.8	0			3.6	
		-3				7		.2	0			1.0	
		-4				7		0	0			0	
P-5	H.W.	P-5	B&G	S	1½	21				0	2.6	21.5	
P-6	H.W.	P-6	B&G	S	1½	20				0	1.3	15	F.O.
P-7	H.W.	P-7	B&G	S	1½	21				0	1.9	18	F.O.

SYMBOLS: CHW = Chilled Water, HW = Hot Water, CTW = Cooling Tower Water
 DSP = Degree Set Point, dP = Ft. H₂O, S = Sweat, T = Threaded

Commissary Solar System Operations Log

DATE	TIME	Weather	Heat Collector LOOP				Bldg Heat LOOP				SOLAR TANK Thermometer		Pd SUCT Press		REMARKS
			Collect X		Trans X		Return Water X		Trans X		Bot	Top	St.	Ru.	
			IN	OUT	IN	OUT	IN	OUT	IN	OUT					
			T1 Auto Status					T2 Auto Status							
5/4	7 ³⁰										60	97	6		Sump 118
	1 ⁵⁰		154	143	149	139					136	135			
5/24	7 ⁴⁰										70	150			
	2 ³⁰	clr warm	ON	174	162	160	167				158	158			
5/29		clr	OFF								142	150			
5/31	1 ³⁰	clr hot		186	177	174	182				172	172			
6/1	8 ¹⁵	cool slight drizzle	ON	98	92	87	90				75	168	3.9		Turned boiler loop pump OFF -
	12 ¹⁵	clr warm	ON	152	142	137	146				135	135	7		}
	4 ⁰⁵		OFF								166	166	13.5		
6/4		cool high drizzle	OFF								128	150	4.5			Boiler trans pump OFF
	5 ¹⁰		OFF								159	170			
6/5		cool clear	OFF								63	128	4		
6/6	7 ⁴⁰	cool clear	OFF								72	135	4		
	1 ⁴⁵		ON	175	163	160	168				157	159	10		
6/8	7 ⁴⁰	clear 70°F									64	122	4		
	12 ³⁰	clear warm	ON	156	144	138	148				136	136	7		
6/11	7 ²⁰		OFF								140	155	4		Water in sight glass - 5"
	12	clear warm	ON	170	159	158	164				155	156	9		
6/12	7 ³⁰	clear cool	OFF								74	144	4		
	1 ¹⁵	clear warm	ON	176	172	172	175				171	171	10		TIA went OFF while observing
6/13	7 ³⁵	clear cool	OFF								72	145	4		

Commissary Solar System Operations Log

RECEIVED

JUL 13 1979

Interactive Resources, Inc.

DATE	TIME	Weather	Heat Collector Loop				Bldg Heat Loop				SOLAR TANK		P4 SUCT		REMARKS		
			Collect X		Trans X		T3 Auto Status	Return Water X		Trans X		Thermometer		Press			
			IN	OUT	IN	OUT		IN	OUT	IN	OUT	Bot	Top	St.		Run	
			T1 Auto Status														
G 27	12 ⁴⁵	clr	0	151	140	134	143					133	153		6		
	28 7 ²⁵	clear cool	X									70	132		3 ⁺		
MAN 27 X	32 7		0	117	112	Reset T1 to Auto - stayed on									3	Sump 140°F. PLS - 1" H ₂ O for 2 m.	
	4 ⁴⁰		0	112	92	91	92									3 ⁻	
	10 ⁵⁰	clr sunny	0	133	125	119	126					119	119			4	
	5 ¹⁵	✓	X									155	160		7 ⁺	Sump 165°F	
	29 7 ³⁰	Sunny cool	X									63	122		3 ⁺		
MA 27 X			0														Sump 150°F
P2 X	7 ⁴⁰		0	110	89	65	90					65	122		3 ⁻	T1A stayed on when reset	
P3 D	12 ¹⁰	clr warm	0	140	130	124	133					123	123			5	
	5 ¹⁰	clr	X									155	159		8 ⁻	Sight glass - 4/8	
	2 7 ³⁰	clr cool	X									133	150		3 ⁺	Sump 165°F	
	11 4 ⁵	clr warm	0	160	151	148	154					146	145			7	
	3 7 ⁴⁵	clr cool	X									64	151		3 ⁺		
	12 6 ⁰	Sc cl	0	150	141	137	144					136	136			6	
	5 5 ¹⁰		X									150	153			7	
	5 7 ³⁰	clear cool	X									115	139		3 ⁺		
	12 7 ³⁹		X									138	138		3 ⁺	Sump 140°F	
	6 7 ³⁰	clr cool	X									64	120		3		Sump 130°F
	9 1 ²	clr warm	0	176	160	163	170					160	160			10	
	10 7 ³⁰	cl cool	X									65	115		3		Sump 108

IV. PREDICTED SYSTEM PERFORMANCE DATA

Solar performance calculations were done using a computer design program (FCHART) developed by the University of Wisconsin. FCHART is an interactive computer program used to calculate the thermal performance of solar space heating and domestic hot water heating systems. A general design procedure was developed at the University of Wisconsin from information gained from a simulation model capable for estimating the long-term thermal performance of solar heating systems based on the system design parameters, heating loads and weather. Solar and weather data for the calculations were taken from the California Solar Data Manual written by the Energy and Environmental Division of the Lawrence Berkeley Laboratory.

Stanford University
Central Food Services Building

SOLAR SYSTEM THERMAL PERFORMANCE

	<u>Space Heating Load</u> (BTU x 10 ⁶)	<u>Water Heating Load</u> (BTU x 10 ⁶)	<u>Total Load</u> (BTU x 10 ⁶)	<u>Solar Used</u> (BTU x 10 ⁶)	<u>Percentage</u> <u>Solar</u>
January	10.4	11.5	21.9	9.5	43.3
February	7.8	13.6	21.4	12.1	56.4
March	6.7	13.6	20.3	14.1	69.5
April	4.6	15.4	20.0	15.7	78.4
May	3.0	13.8	16.8	15.0	89.2
June	1.1	11.9	13.0	12.5	95.9
July*	.7	9.8	10.5	10.5	100.0
August*	.6	9.1	9.7	9.7	100.0
September*	1.0	4.8	5.8	5.8	100.0
October	2.8	11.6	14.4	12.3	85.2
November	6.2	12.7	18.9	10.3	54.6
December	<u>9.6</u>	<u>12.0</u>	<u>21.6</u>	<u>9.8</u>	<u>45.4</u>
Total	54.5	139.8	194.3	137.3	70.5

*Summer break occurs in July, August and September.

V. COLLECTOR SELECTION

The FCHART computer program allows the introduction of specific collector performance parameters (Y-intercept and slope based on independent tests) into the calculations. This performance analysis was coupled with the FCHART economic analysis to determine the best BTU-per-dollar value among selected collectors. Using collector test data together with vendor quotes, many different collectors were analyzed to compare their performance and price on this specific project with its particular weather, load and temperature characteristics. Some costs, such as varying costs for supports and manifolding, had to be estimated, and some judgments, such as quality of construction and durability, were a necessary part of the evaluation not shown in the FCHART analysis. These judgments, it turned out, reinforced the results of the computer simulation which showed the Solar Energy Products, Inc., collector producing the most BTU's per dollar.

The solar system was, therefore, designed around this collector. Several other collectors were also acceptable and actually bid (including Revere and Sunworks) but the system was installed by the low bidder with Solar Energy Products, Inc., collectors.

RECOMMENDATION: The FCHART computer program can be helpful not only in performing thermal and economic analyses, but also in making a cost-benefit analysis of alternate collectors on a system-by-system basis.

VI. BIDDING

Bids were solicited from six contractors, all of whom were experienced commercial mechanical contractors (union labor) who had done work for Stanford University before. The bids were very close with the three lowest within only a few hundred dollars of each other.

The solar space heating loop was included in the bid as a deductive alternate. In this way, the scope and cost of the project could be lowered without substantially reducing the energy saving benefits. Stanford decided, however, that the dollar savings were not substantial enough to justify dropping the space heating portion of the system, and construction proceeded on the entire system as designed.

Stanford University Central Food Services Building

SUMMARY OF CONSTRUCTION BIDS

<u>Contractor</u>	<u>Base Bid</u>	<u>Deductive Alternate For Space Heating Loop</u>
A (Redwood Mechanical - contract winner)	\$64,561	\$(2,948)
B	64,600	(4,500)
C	64,900	(5,160)
D	69,686	(3,953)
E	74,500	(3,000)
F	78,240	(5,133)

VII. COSTS

Construction costs were originally budgeted during preliminary design at \$44,250. During the final design stages, however, it became apparent that this budget could not be achieved. Some of the reasons were:

1. Substantial additional costs were required on the collector support structure because the existing roof was not able to withstand the extra load of the collectors.
2. A higher quality system was constructed than had originally been budgeted. There were additional costs in converting from an open- to a closed-loop, drain-back system (primarily in the extra cost of a sump tank, heat exchanger and pump) and higher quality components were used throughout.
3. Contractor overhead and profits were higher than anticipated.

Stanford University
Central Food Services Building

SOLAR SYSTEM PROJECT COST SUMMARY
(All costs include overhead and profit)

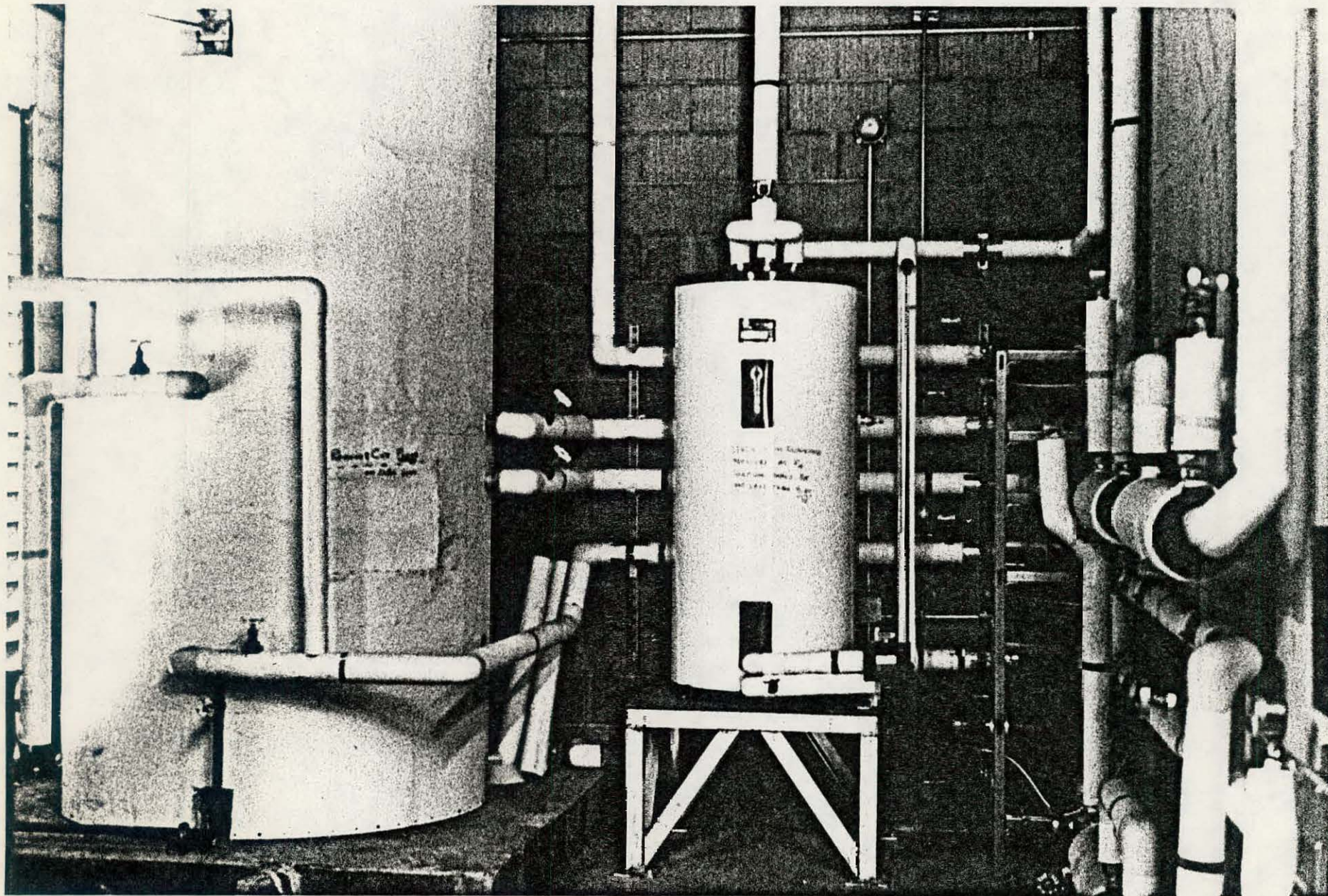
	<u>Materials</u>	<u>Labor</u>	
Collector support structure	\$12,000	\$ 2,168	
Collectors	13,841	572	
Collector manifold piping	160	1,024	
Storage tank (800 gallons)	3,500	1,680	
Storage tank insulation	200	500	
Sump tank (120 gallons)	634	650	
Pumps	1,175	850	
Heat exchangers	2,176	800	
Piping and valves	2,945	5,180	
Pipe insulation	1,000	4,760	
Controls	600	1,168	
Electrical	1,000	2,000	
Painting	1,000	1,258	
Testing and balancing		600	
Miscellaneous		<u>1,120</u>	
Subtotals	<u>40,231</u>	<u>24,330</u>	
Total base construction contract			\$64,561
Plus changes during construction:			
Storage tank relocation		\$ 997	
New collector loop pump (with new heaters and relays)		711	
Miscellaneous piping changes (pressure gauge, relief valves, etc.)		<u>535</u>	
			<u>2,243</u>
Total construction cost			\$66,804
Design costs (not nearly enough)			<u>4,500</u>
Total design and construction costs			\$71,304
Extra project costs:			
DOE reporting		\$5,000	
Misc. printing and postage		277	
Stanford's staff costs for coordinating, reviewing and inspecting the project (not nearly enough)		<u>3,000</u>	
			<u>8,277</u>
Total project cost			\$79,581

VIII. ECONOMICS

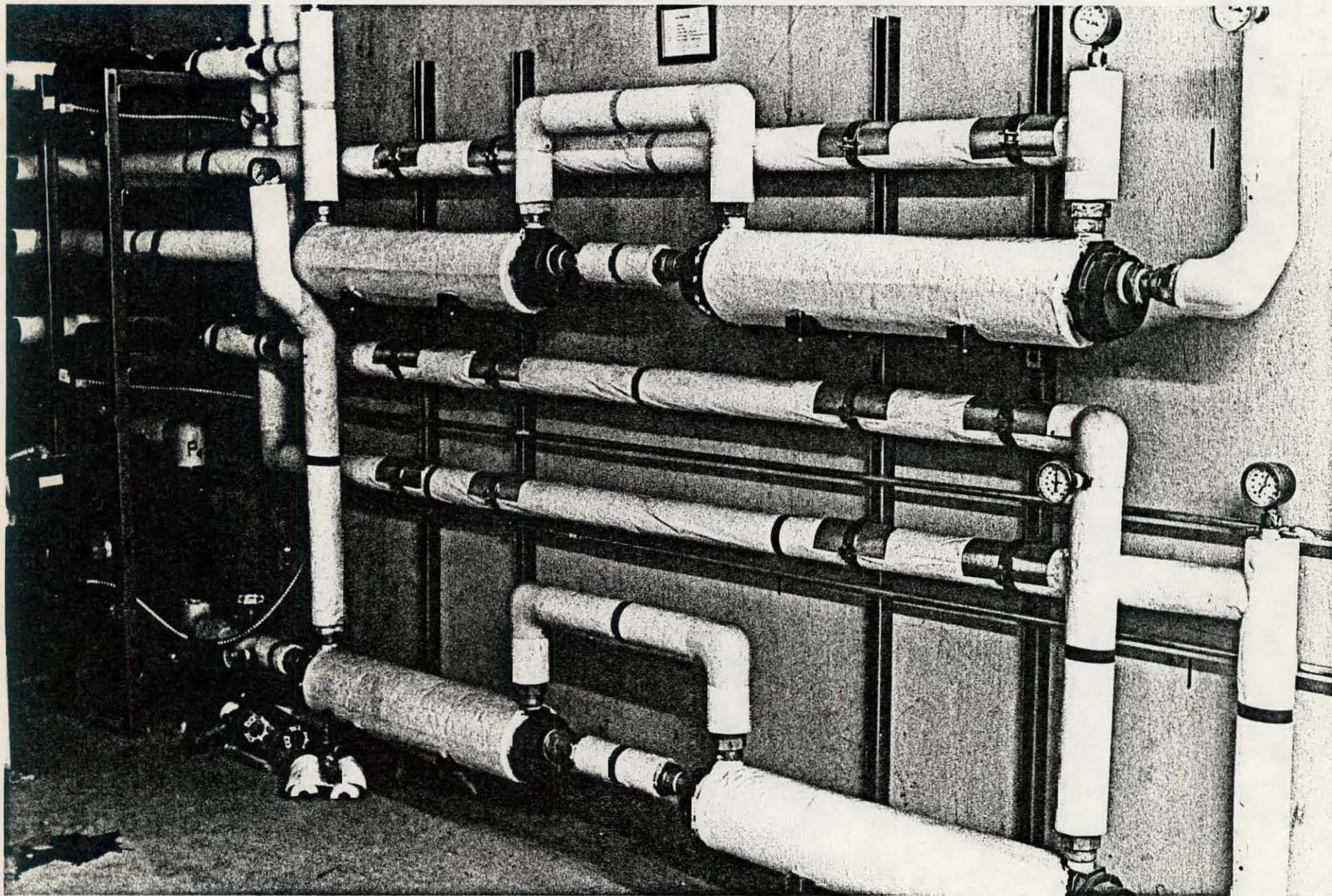
With an initial investment of \$71,304 (the costs of design and construction), and the present cost of natural gas at \$0.25 per therm, inflated at 15 per cent each year (just a reference), the undiscounted fuel savings will equal the initial investment in 22 years.

The installation of a solar system fixes the cost of energy for years to come. If the system performs at its expected level (producing 1,373 usable therms per year and, at a 65 per cent natural gas efficiency, saving 2,112 therms per year) for 20 years, the equivalent cost of the solar system is \$1.68 per therm saved. If the system should last 30 years, then the cost is \$1.12 per therm, and at 40 years, \$0.84 per therm.

By comparison, if natural gas inflates at 15 per cent a year, the 20-year average price would be \$1.27 per therm. The 30-year average price would be \$3.61 per therm.



Mechanical room: Solar storage tank on left, sump tank in center, heat exchangers on right.



Mechanical room: Heat exchangers mounted on wall.

IX. PROBLEMS, SOLUTIONS AND RECOMMENDATIONS

A. Debugging the Collector Loop

The closed, drain-back collector loop contains water and air. During noncollection hours, when the pump is off, the water in the collectors drains out and down into a sump tank located in the building. This means that when the pump comes on again, it must pump water to the top of the collectors, overcoming the force of gravity. This static head increases as the distance in height increases.

RECOMMENDATION: To minimize additional static load on the pump, the sump tank should be located to minimize the height difference between the sump tank water level and the top of the collectors while still allowing for complete draining of the collectors and all plumbing exposed to freezing conditions.

Once over the high point, water falling down the pipe creates a negative pressure at the top which sucks water coming up the pipe. The theoretical advantage of this "syphon return" over an "open drop" system is reduced pump head requirements. The pump need only be sized to overcome the static head at a very low flow. Once the "syphon return" has been established, the head loss against which the pump operates will only be flow friction losses.

The sizing of the collector loop pump was based on this concept as outlined in Bell & Gossett's Solar Design Manual. Unfortunately, this manual and the Stanford solar system both contained a basic flaw which precluded the successful execution of this concept.

Once a negative pressure is established at the top of the loop, air is sucked through the air vent line (which allows the collectors to drain when the pump is off) before water is syphoned up the pipe. A syphon return will never occur.

This problem became apparent on the Stanford solar system when it was found that the collector loop pump was delivering only half its design flow. A solenoid valve could have been installed in the air vent line to allow the syphon to occur, but this was rejected since one of the main reasons for going to this system in the first place was to eliminate the use of electronic or mechanical valves. (The system might not drain if the solenoid valve stuck in closed position.) Then it was realized that the back pressure

required to initiate the syphon was equal to the head savings once the syphon was started. The syphon return did not reduce the pump head requirements. It was necessary, therefore, to replace the original collector loop pump (1/2 HP) with a new, 3/4 HP pump.

RECOMMENDATION: The pump in the closed-loop, drain-back system must be sized to overcome static as well as dynamic head losses.

With the new pump installed, it was then discovered that there was a negative pressure on the suction side of the pump. This causes the pump to cavitate and reduces its life expectancy. The problem was believed to be due to a combination of factors: (a) The pump was only a few feet below the sump tank water level (which meant there wasn't much static head on this powerful pump to begin with); (b) there were undersized fittings to the sump tank (a standard tank in a nonstandard use) which created extra flow resistance; (c) a wye strainer before the pump which added resistance; and (d) several 90° elbows were located in the line between the sump tank and the pump. This was a necessary result of the layout and also (as discovered in The Woodlands Solar Project being constructed at the same time) because the pump had to be mounted close to the floor with flow in the vertical direction.

RECOMMENDATION: The sump tank should be located high above the pump to put as much head as possible on the suction side of the pump.

RECOMMENDATION: The pump should be mounted with flow in the vertical direction to prevent air pockets from developing over night (out of the very aerated water) in the volute of the pump.

In addition to streamlining the flow between the sump tank and the pump, the closed, drain-back loop was pressurized to put positive pressure on the suction side of the pump. A minimum (cold) pressure of 5 psi is maintained at the suction point of the pump.

This increased pressure meant the maximum (hot) pressure would come close to the set point (30 psi) of the relief valves located on each bank of collectors. The relief valves were, therefore, replaced with 70 psi valves.

B. Structural Support Problems

During detailed design it was realized that the collectors were to be mounted on a lightweight, panelized roof system (common on warehouse and storage structures such as this) which was not intended to accept additional

roof loads. A structural analysis confirmed that the addition of solar collectors on the roof would require considerably more structural work (and cost) than had originally be anticipated or budgeted. After considering numerous alternate schemes, a structural system was finally adopted which consisted of structural steel beams and trusses spanning over 20 feet and supported over the column points of the building below.

RECOMMENDATION: A preliminary structural analysis should be routinely included in solar feasibility studies so the impact of structural requirements can be anticipated and budgeted early when the feasibility and economics of the project are determined.

C. Collector Sensor Not Properly Located

When the system design was changed from an open loop to a closed, drain-back loop, the collector temperature sensor, instead of being relocated, was left in the collector manifold. In an open loop system this would have worked because water remains in all the piping overnight and the sensor, through syphoning and conduction, would have registered collector temperature rise in the morning. In the closed, drain-back loop, with no water in the pipes in the morning, the manifold and the sensor were thermally isolated from the collector and early morning temperature rise could not be registered by the controller. A new sensor was, therefore, installed directly to the back of the collector absorber plate.

RECOMMENDATION: Carefully review drawings and specifications before construction, with special attention given to the side effects of design changes.

D. Storage Tank Foundation Revised

Drilled piers were originally designed to be dug in the mechanical room to resist earthquake loads of the vertically-mounted solar storage tank. Underground electrical ducting was discovered during construction passing directly through two of the piers. This could have been avoided by careful examination of the electrical as-built drawings. Even though the electrical ducts were empty (to be used for future expansion), the storage tank was relocated to take advantage of a better location (recently freed by the removal of some unused equipment) and the tank support redesigned (to avoid further surprises). The new design consisted of a heavy, raised slab instead of piers to prevent overturning.

RECOMMENDATION: Carefully examine as-built drawings for potential conflicts on retrofit projects.

E. Sloping of the Collector Support Structure

The collector support structure was designed to slope with the roof. This allowed the collectors and piping to be mounted square with the support structure while still achieving the necessary slope for draining water out of the collectors. Without realizing the intent of the design, the contractor installed the support structure level. This not only would have hampered drainage, but increased the height of the roof support stands at the low points of the roof. The extra height increased the moment loading (created by wind) on the supports. The roof support stands were not designed to take this extra load and the contractor, therefore, had to reinstall the collector support structure as designed. The steel did not have to be refabricated.

RECOMMENDATION: The contractors should not only understand the "what" of the design, but also the "why," so they can effectively judge the consequences of changes (initiated by themselves and others) and look for opportunities of improving the system and lowering costs.

F. Flow Switch Not Installed Properly

The flow switch (which signals the solar system when there is a space heating load) was improperly installed because the piping connection was too small, preventing the paddle (which extends into the flow pipe and is displaced by flow) from moving.

RECOMMENDATION: Carefully read manufacturer's installation instructions.

G. Haze on the Inside of Collector Coverplate

Soon after installation, a noticeable haze appeared on the inside of almost every coverplate. The haze was very sparse along the flow tubes, making dark-appearing stripes. A white, chalky deposit also appeared on the inside of the glass near the outlet elbows of eight or ten collectors.

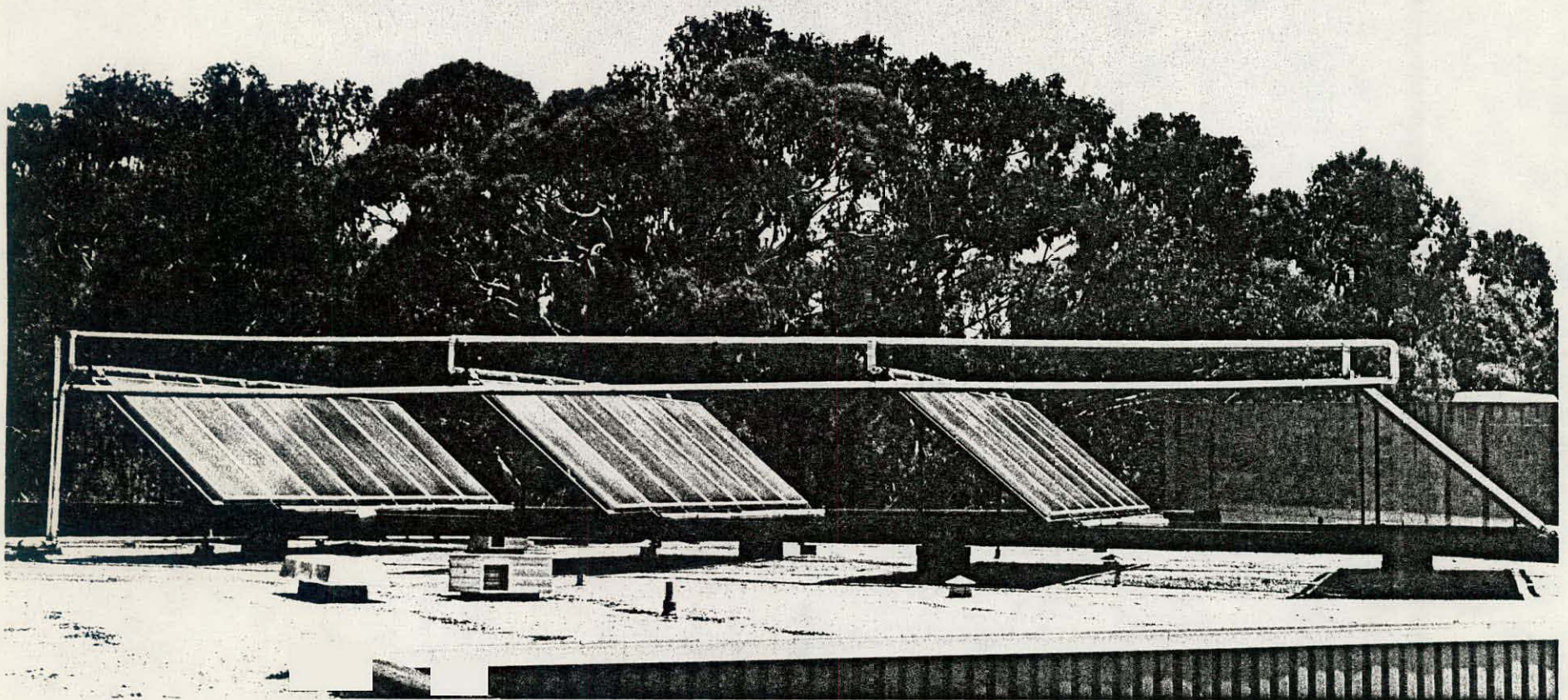
As part of its warranty coverage, the collector manufacturer, Solar Energy Products, Inc., removed the coverplates and cleaned the glass. The haze was of a greasy, or even waxy, nature. Several solvents were used,

but a grease-cutting agent proved the most successful. It was their estimate that the haze was caused by out-gassing from the Nextel absorber coating. This occurred during construction while the collectors were stagnating and was caused by the absorber plates not being properly baked out.

H. Absorber Plate Flow Tubes Touching Glass

In several collectors, the flow tubes were very close to the glass and, in some cases, even touching the glass. Solar Energy Products, Inc., thought this was caused by a lack of quality control which resulted in imbalanced forces on the asymmetric absorber plate during expansion. Solar Energy Products, Inc., has since introduced a new symmetrical absorber plate which should prevent this from occurring in the future.

Although heat losses increase when the flow tubes touch the coverplate, there has not been any apparent loss of overall system performance and, as yet, no noticeable damage such as glass breakage.



Collectors viewed from the west.

APPENDIX A

OPERATION AND MAINTENANCE MANUAL

OPERATION AND MAINTENANCE MANUAL
For the
SOLAR HOT WATER AND SPACE HEATING SYSTEM
At the
CENTRAL FOOD SERVICES BUILDING
THE LELAND STANFORD JUNIOR UNIVERSITY

12 October 1979

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I. PROJECT INFORMATION

I. PROJECT INFORMATION

A. Information Summary

Application: Domestic hot water and space heating

System type: Active hydronic

Collector type: Flat plate, liquid, single-glazed

Collector area: 840 square feet (aperture)

Storage capacity: Solar storage tank - 800 gallons
Backup storage tank - 750 gallons

B. Key Personnel

Owner: Stanford University
Facilities Engineering Office
Attn: Robert Kavinoky, Associate Manager of Construction
(415) 497-4384

Solar System Designer: Interactive Resources, Inc.
117 Park Place
Point Richmond, CA 94801
Attn: Dale Sartor, Charles Beavers
(415) 236-7435

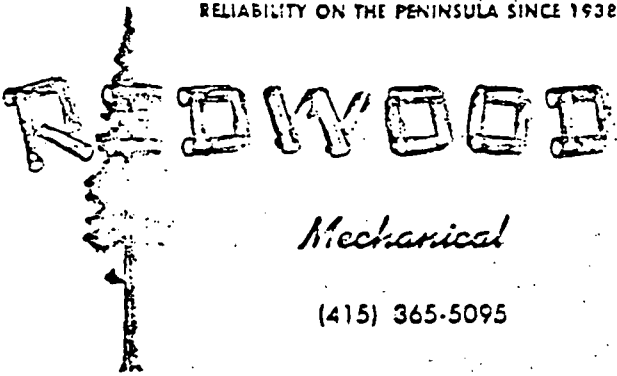
Contractor: Redwood Mechanical
1590 Tacoma Way
P. O. Box 5128
Redwood City, CA 94063
Attn: Gunnar Galsgaard
(415) 365-5095

Solar Collector Manufacturer: Solar Energy Products, Inc.
P. O. Box 3969
Santa Rosa, CA 95402
Attn: Jay C. McLaughlin
(707) 584-7161

C. Loop Identification

Red: Collector-to-heat exchanger loop
Blue: Heat exchanger-to-Solar storage tank loop
Green: Solar space heating loop
Yellow: Tank-to-tank loop

RELIABILITY ON THE PENINSULA SINCE 1938



Mechanical

(415) 365-5095

GENERAL & MECHANICAL CONTRACTORS

California License No. 53431 — E-1; C 4, 20, 36, 42, 43

1590 TACOMA WAY—P.O. BOX 5128

REDWOOD CITY, CALIFORNIA 94063

June 5, 1979

GUARANTEE

FOR

Central Food Service Building
Stanford University
Stanford, California
Stanford Project No. 1097

We hereby guarantee the labor and material to construct a Solar Hot Water and Space Heating System, per Plan and Specifications, at the Central Food Service Building located on Stanford University Campus, Stanford, California for one (1) year commencing with April 18, 1979.

We agree to repair or replace any or all such work that may prove defective in workmanship or materials. Ordinary wear and tear, unusual abuse and/or neglect are excepted.

In the event of our failure to comply with the above mentioned conditions within a reasonable time after being notified in writing, we do hereby authorize the Owner to proceed to have the defects repaired and made good at our expense and we will pay the costs and charges therefor immediately upon demand.

G. Galsgaard, Manager

II. SOLAR SYSTEM DESCRIPTION AND OPERATION

II. SOLAR SYSTEM DESCRIPTION AND OPERATION

A. Summary Description

The solar heating system on the Stanford University Food Services Building provides space heating and domestic hot water heating. Of the total energy supplied by the system, approximately two-thirds is used to offset the year round domestic hot water heating load, while approximately one-third is used to offset the seasonal space heating load.

1. Collector-to-Heat Exchanger Loop. Energy in the form of heat is transferred from the solar collectors to a heat exchanger (HE-1) via a closed, drain-back loop. This loop includes the solar collectors, the sump tank (120 gallons), pump P-4 and heat exchanger HE-1. This loop uses untreated tap water as the transfer medium.

IMPORTANT: No other transfer fluid should be used. The Interim Performance Criteria for Solar Heating and Cooling Systems in Commercial Buildings, the federal code under which this system as built, requires a double-wall heat exchanger between potable and non-potable fluids. With potable water used for drinking and washing on one side of the single-wall heat exchanger, HE-1, potable water must be used in the collector-to-heat exchanger loop.

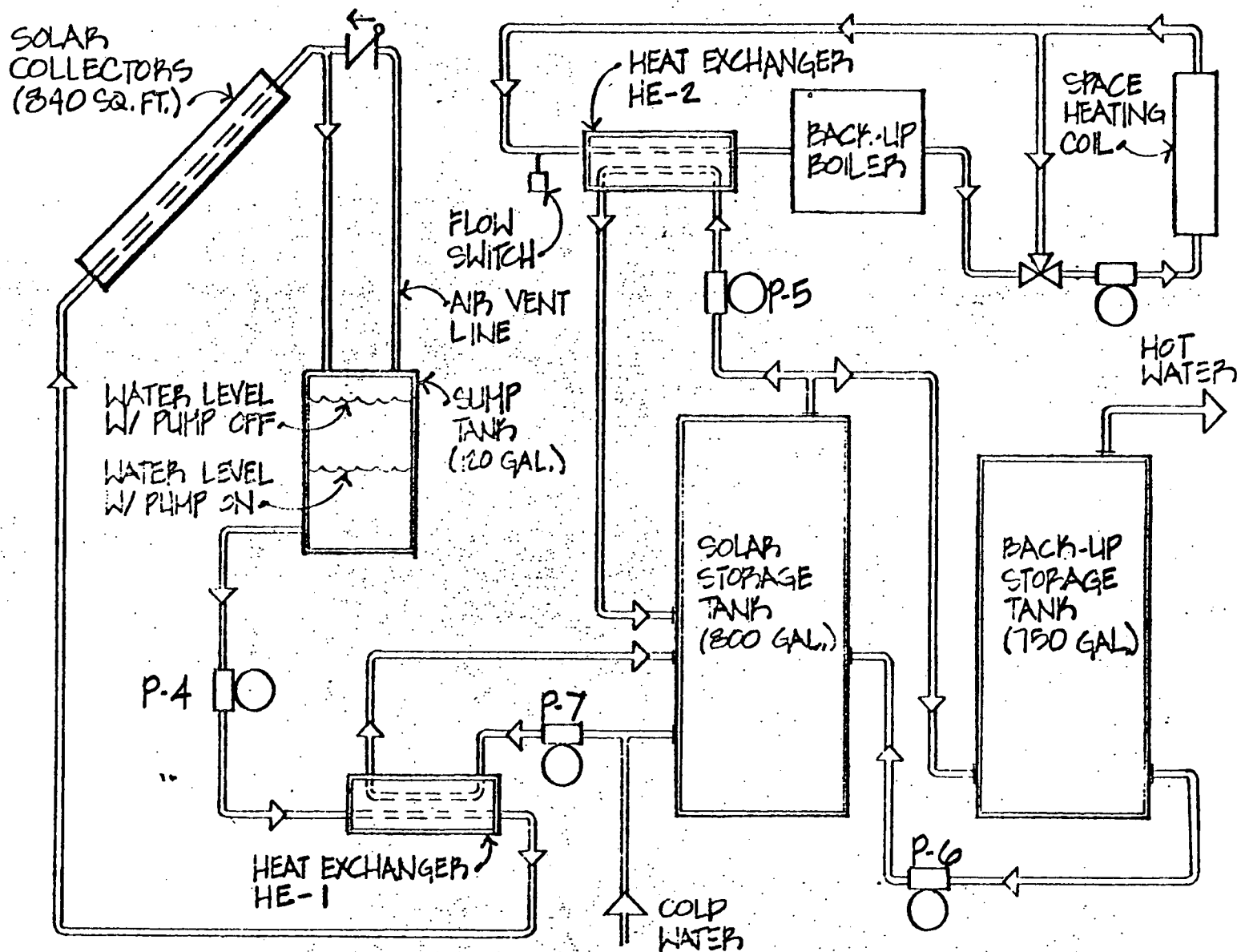
The collector-to-heat exchanger loop is a closed loop containing water and air. Neither water nor air should enter or exit the loop unless done so manually. With pump P-4 off, the water level should be flush with the top of the sump tank. All the piping above this level should contain air.

When pump P-4 is turned on, water will be circulating from the sump tank through the heat exchanger, up through the collectors and back to the sump tank. Air will be forced from the collectors into the sump tank. The water level in the sump tank should drop to around half-full. The piping in this loop holds approximately 60 gallons; the sump tank, 120 gallons.

When pump P-4 is turned off, the weight of the water creates a suction at the top of the system. The check valve to the air vent line opens allowing air to flow from the sump tank through the air vent, displacing water in the collectors and manifolds, thereby draining all the water from the collectors into the sump tank.

IMPORTANT: Water should never be allowed to remain in the collectors when the pump is off. If freezing conditions should occur, the collector piping will freeze and burst.

The collector-to-heat exchanger loop is pressurized to ensure that pump P-4 always has a positive pressure on its suction side. A minimum (cold) pressure of 5 psi should be maintained at this point.



SOLAR SYSTEM SCHEMATIC

2. Heat Exchanger-to-Solar Storage Tank Loop. The solar storage tank contains potable water and feeds the supply side of the backup hot water storage tank. Water in this tank is circulated through the heat exchanger HE-1 and returned to the tank. This completes the transfer of heat from the collectors to the solar storage tank.

Pump P-4 in the collector-to-heat exchanger loop and pump P-7 in the heat exchanger-to-solar storage tank loop operate together. They are controlled by differential thermostat T-1.

T-1 compares the temperature in the collector with the temperature at the bottom of the solar storage tank. When the collector is 20°F warmer than the solar storage tank, pumps P-4 and P-7 are turned on. When the collector temperature drops to only 3°F warmer than the solar storage tank, pumps P-4 and P-7 are turned off.

3. Solar Space Heating Loop. Solar-heated water is stored in the solar storage tank. Water in this tank is used to pre-heat the return water in the backup space heating loop. This is done through heat exchanger HE-2.

When differential thermostat T-3 senses that the temperature in the solar storage tank is 8°F warmer than the return water in the backup space heating loop, pump P-5 is turned on. The pump is interlocked with a flow-switch in the backup heating loop. Pump P-5 will come on only if there is flow in the backup heating loop. When the storage tank temperature is only 3°F warmer than the return water in the backup heating loop, pump P-5 is turned off.

IMPORTANT: The backup space heating loop should use only water as the transfer fluid, because the solar storage tank contains potable water and heat is transferred through a single-wall heat exchanger.

4. Tank-to-Tank Loop. The solar storage tank serves as a pre-heat tank to the backup hot water storage tank. When hot water is used in the building, it is drawn from the top of the backup hot water storage tank. Make-up water to this tank comes from the solar storage tank. Cold water make-up enters at the bottom of the solar storage tank.

Backup heat is supplied to the backup storage tank by the gas-fired boiler, if required.

When the solar storage tank temperature is greater than the temperature in the backup storage tank, water is exchanged between tanks via the tank-to-tank loop. This increases the solar storage capacity during periods of high solar input and/or low loads.

When differential thermostat T-2 senses that the solar storage tank is 10°F warmer than the backup hot water storage tank, pump P-6 is turned on. When the solar storage tank is only 3°F warmer, pump P-6 is turned off.

B. System Start-up

1. Add Water to the Collector-to-Heat Exchanger Loop. Open the manual air vent connected to the top of the sump tank. Open the two sight glass valves. Add water to the loop through the hose bibb at the bottom of the sump tank. Fill the system until the water level is flush with the top of the tank. Add compressed air to the air vent until the pressure gauge on the pump registers 10 psi. (Once operational, check this pressure to ensure that it doesn't drop below 5 psi with the pump on.) Close the air vent. Close the two sight glass valves (water level can only be accurately read during static conditions). Check that all gate valves are wide open and all drains and air vents are closed.
2. Convert Make-up Water from Backup Storage Tank to Solar Tank. Open gate valve which allows cold make-up water to enter the solar storage tank. Close the gate valve which brings cold make-up water directly to the backup hot water storage tank. Check that all gate valves are wide open in the storage tank-to-heat exchanger loop, the space heating loop, and the tank-to-tank loop. Drains and air vents should be closed.
3. Divert Backup Space Heating Loop Through Heat Exchanger. Open the two gate valves which allow return water in the backup loop to enter the heat exchanger HE-2. Close the bypass valve.
4. Switch Differential Thermostats to "Automatic." Switch the three differential thermostats, T-1, T-2 and T-3, to the "automatic" position.

C. System Shut-down

1. Switch Differential Thermostats to "Off." Switch the three differential thermostats, T-1, T-2 and T-3, to the "off" position.
2. Bypass Backup Space Heating Loop from Heat Exchanger HE-2. Open bypass valve. Close the two gate valves which keep return water in the backup loop from entering the heat exchanger HE-2.
3. Convert Make-up Water from Solar Tank to Backup Storage Tank. Close the gate valve at the cold water make-up to the solar storage tank. Open the gate valve at the cold water make-up to the backup storage tank. Close the two gate valves in the tank-to-tank loop that will isolate the backup tank from the solar tank and its piping.

D. Balancing Flow Through Collectors

There are five flow balancing circuit setters in the collector-to-heat exchanger loop. The circuit setter above the sump tank should be set first at 21 gpm. This will create enough back pressure to fill all the piping on the roof with water. Once filled, the reverse return piping will make balancing flow through each collector bank much easier. Each circuit setter on the four collector banks should be set for 5.25 gpm.

E. Isolating Collector Banks for Repairs

Each of the four collector banks can be isolated from the rest of the system if it should become necessary for repairs, or for other reasons, while allowing the rest of the system to operate.

Each collector bank has a gate valve at its low inlet and a circuit setter at its high outlet. Both of these should be closed. Then the drain at the bottom of the bank and the manual air vent at the top of the bank should be opened. This will ensure that there is no water trapped in the collector bank during isolation.

F. Low-level Alarm and Disconnect

The collector-to-heat exchanger loop is equipped with a low-level alarm and disconnect. It is located in the piping at the bottom of the sump tank. Should a leak develop in this loop, the water level will fall and trigger the alarm. It will automatically disconnect pumps P-4 and P-7 and sound the alarm bell on the wall, behind the sump tank.

III. PERIODIC INSPECTION AND MAINTENANCE

III. PERIODIC INSPECTION AND MAINTENANCE

The solar system should be inspected every six months to ensure that all components and systems are operating normally. If properly adhered to, the solar system will perform more efficiently and last longer. It is in future years, when fuel prices have greatly escalated, that the solar system will make its greatest economic savings.

A. Check Water Level in Collector-to-Heat Exchanger Loop

With the pumps off, and water completely drained from the collectors into the sump tank, open the two sight glass valves and observe the water level in the collector-to-heat exchanger loop. The water level should be flush with the top of the sump tank. If low, water should be added through the hose bibb at the bottom of the sump tank. Water level can only be checked during static conditions. Close sight glass valves before turning pump on.

As a cross check, depress the test switch on the low-level switch. Light "on" indicates fluid level above probe; light "off," fluid level below probe. No light could also indicate a probe with excessive scale deposits.

B. Check Pressure in Collector-to-Heat Exchanger Loop

Check loop pressure at the gauge on the suction side of pump P-4. Pressure should be around 10 psi, but should not fall below 5 psi during worst conditions, with pump on and water cold. If pressure is low, add compressed air to the vent line connected to the loop above the sump tank.

If pressure and/or water level cannot be maintained, then check for leaks. Open manual air vents at the top of each collector bank. Fill loop completely with water. Close air vents, pressurize loop and inspect for leaks. Flexible connections are the logical place to start.

C. Check Operation of Differential Thermostats

The differential thermostats should be periodically checked to see if the pumps are being activated and deactivated at the proper temperature differentials. (See Section 6 on controls for on-off settings.)

Differential thermostat T-1, which operates the solar collection loops, should be observed through a full sunny day's operation--at early morning, mid-day and late afternoon.

Differential thermostat T-2 (tank-to-tank loop) should activate pump P-6 only if the solar storage tank temperature is greater than the backup storage tank.

Differential thermostat T-3 (space heating loop) should activate pump P-5 only when the solar storage tank temperature is greater than the backup space heating loop and there is flow in the backup space heating loop. This can only really be checked during the winter season.

If the controllers are not operating according to the differential settings, the sensors can be checked by disconnecting the sensor wires from the controller and measuring the sensor resistance with an ohm meter. Temperature vs. resistance specifications are given in Section 6 on controls.

The controllers can be further tested by shorting the sensors. No resistance will give an infinitely high temperature signal to the controller. For example, on T-1 (collector loops), if the collector sensor is shorted, pumps P-4 and P-7 should go on. If the storage tank sensor is shorted, the pumps should go off.

Note on indicator lights: Indicator lights on the controllers usually show when the pumps are on and off, but not always. When the disconnect switch between a controller and pump is off, the indicator light goes on, giving a misreading. Similarly, there is a flow switch interlocked with T-3 (space heating loop). When there is no flow through the backup space heating loop, pump P-5 is prevented from coming on, regardless of the temperature differentials. This disconnection likewise turns the controller indicator light on, but not the pump.

D. Check Pump Lubrication

Pumps should be lubricated according to the service instructions in Section 7.

E. Wash Solar Collector Glazing

Every six months, the collectors should be inspected for dirt and pollutants on the glazing. Rainfall will usually keep the collectors adequately clean during the rainy season, but dirt and pollutants will build up on the glass during dry months. At a minimum, hose the collectors down with water. If dirt build-up continues, then squeegee clean.

F. Drain Sediment From Storage Tank

Open the drain valve of the 800-gallon solar storage tank. Let the water run till it flows clean. This will keep sediment from building up on the tank bottom. Every two years, the solar storage tank should be drained and the lining inspected.

G. Check Heat Exchangers

A marked increase in pressure drop and/or reduction in performance indicate cleaning is necessary. (See Section 8 on heat exchangers for pressure drop information.) Heat exchanger effectiveness at start-up was found to be between 50 and 60 per cent. If found to be substantially lower than this, recheck under different operating conditions. Instructions for cleaning the tubes is given in the maintenance instructions in Section 8.

IV. SOLAR COLLECTORS

IV. SOLAR COLLECTORS

Solar Energy Products, Inc.
West Coast Operations
P. O. Box 3969
Santa Rosa, CA 95402

Attn: Jay C. McLaughlin
(415) 584-7161

Model No. CU30-WW

Serial Numbers:

	North			South	
	A	B	C	D	
West					
1.	10204	10177	10210	10158	
2.	10207	10206	10164	10157	
3.	10208	10169	10163	10136	
4.	10203	10166	10160	10212	
5.	10202	10167	10205	10126	
6.	10209	10168	10162	10029	
7.	10159	10165	10170	10211	
East					



FEATURES: SUNFIRED™ CU30-WW SOLAR COLLECTOR

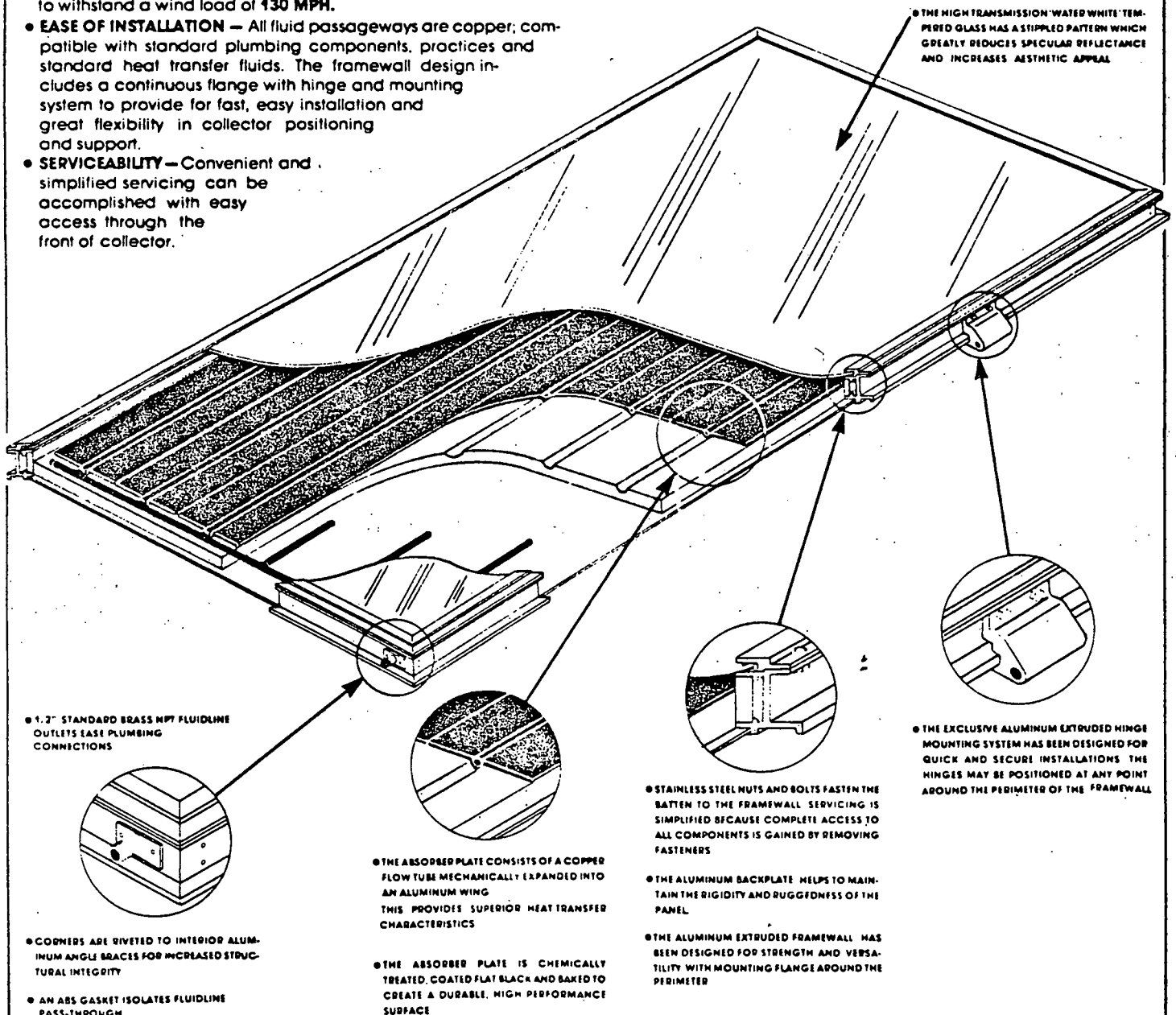
FEATURE FOR FEATURE — The Sunfired™ CU30 is carefully designed and constructed of the finest quality materials to provide dependable performance with a maximum service life expectancy.

- **PERFORMANCE** — Our advanced design absorber plate combines copper flow tubes mechanically expanded into a highly conductive aluminum extruded wing, closed cell isocyanurate insulation, high transmissivity tempered glass cover plate, and a highly absorptive durable plate coating to assure outstanding thermal performance (See Test Analysis page 5). The CU30 may be used in open or closed systems with working pressures to 150 p.s.i. and provides thermal performance stability to 300°F. An outstanding feature of the CU30 is the advanced design of the custom aluminum extruded framewall. The framewall has been designed for strength and versatility in mounting, in either saw-tooth or integrated roofing application.
- **DURABILITY** — The anodized aluminum frame, non-degrading tempered glass cover plate, water-resistant closed cell insulation and copper flow passageways all provide for design service life of 30 years, when properly operated.
- **STRUCTURAL INTEGRITY** — The CU30 series collectors are designed to withstand a wind load of 130 MPH.
- **EASE OF INSTALLATION** — All fluid passageways are copper, compatible with standard plumbing components, practices and standard heat transfer fluids. The framewall design includes a continuous flange with hinge and mounting system to provide for fast, easy installation and great flexibility in collector positioning and support.
- **SERVICEABILITY** — Convenient and simplified servicing can be accomplished with easy access through the front of collector.

- SEP's Systems have been approved for use in HUD's SOLAR DOMESTIC HOT WATER INITIATIVE by the Polytechnic Institute of New York and Florida Solar Energy Center.
- Independent testing has been conducted by Desert Sunshine Exposure Tests, Inc. in accordance with ASHRAE 93-77 testing standards.
- SEP's Systems meet the testing standards set by the American National Standards Institute (ANSI B198.1-1977).
- SEP's Sunfired™ CU30-WW solar collector has been approved by the Research Committee of IAPMO (S-1888).

LIMITED WARRANTY

The Sunfired™ CU30 Solar Collector is warranted against defects in materials and workmanship for five years from date of purchase (except for freeze damage, glass breakage and damage due to aggressive heat transfer fluid).





SPECIFICATIONS: SUNFIRED™ CU30-WW SOLAR COLLECTOR

CU30-WW

OUTSIDE DIMENSIONS:	98.5" x 48.5" x 2.57"
APERTURE AREA (sq. ft.):	29.9
GROSS FRONTAL AREA	32.67
DRY WEIGHT (lbs.):	180
COVER PLATE	
Material	Water White glass
Ughts Per Panel	(1) 85.5 lbs.
Iron Oxide Content (%)	0.01
Thickness (Inches)	3/16
Dimensions (Inches/light)	46 x 96
Solar Transmission (%)	91
Tensile Strength (psi)	6400 (tempered)
Elastic Modules (psi 10 ⁶)	10.5

COVER PLATE GASKET: Silicone gasket seal bonded to framewall and cover plate batten, UV stable

BACK PLATE

Material: 0.032 mill finish aluminum sheet
Weight: 13.0 lbs.

FRAMEWALL, BATTEN, AND MULLION

Materials: aluminum alloy extrusion: Alloy no. 6063-T5
Weight: 35 lbs.
Finish: Clear anodized

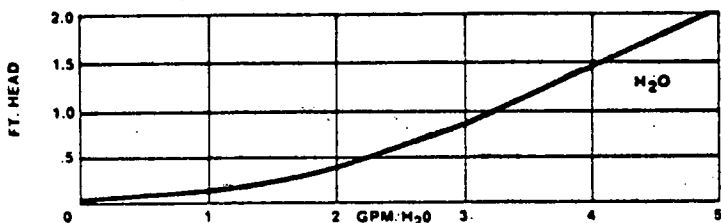
ABSORBER PLATE

Material: 0.5" I.D. - 0.026 wall copper flow tubes mechanically expanded into extruded aluminum wings for superior thermal conductivity. Flow tubes brazed to 3/4 inch copper headers unless specified otherwise. All wetted surfaces are copper or brass.

Fluid Capacity: 0.84 gallons

Flow Characteristics: 0.05ft. head at 0.75 gpm flow rate (water). Internal baffles direct flow for a uniform flow distribution. Absorber plate is designed to allow for fluid drainage when level mounted in the horizontal position. Vertically mounted collectors must be ordered specifically without internal baffles to allow collector drainage.

Pressure Drop Curve



THE ABOVE CURVE ILLUSTRATES PRESSURE DROP ACROSS THE CU30 PANEL WITH WATER AS THE TRANSFER FLUID

Surface: Assembled plate is chemically treated and coated flat black unless specified otherwise.

Solar Absorptivity: 0.98
Emmissivity: 0.89
Weight: 49 lbs.

INSULATION

Material: 1-1/8 inch isocyanurate foam board; routed to receive flow tube pattern.
Thermal Conductivity: 0.09 Btu-in./ft.²°F
Flame Spread Classification: 20
Weight: 7.0 lbs.

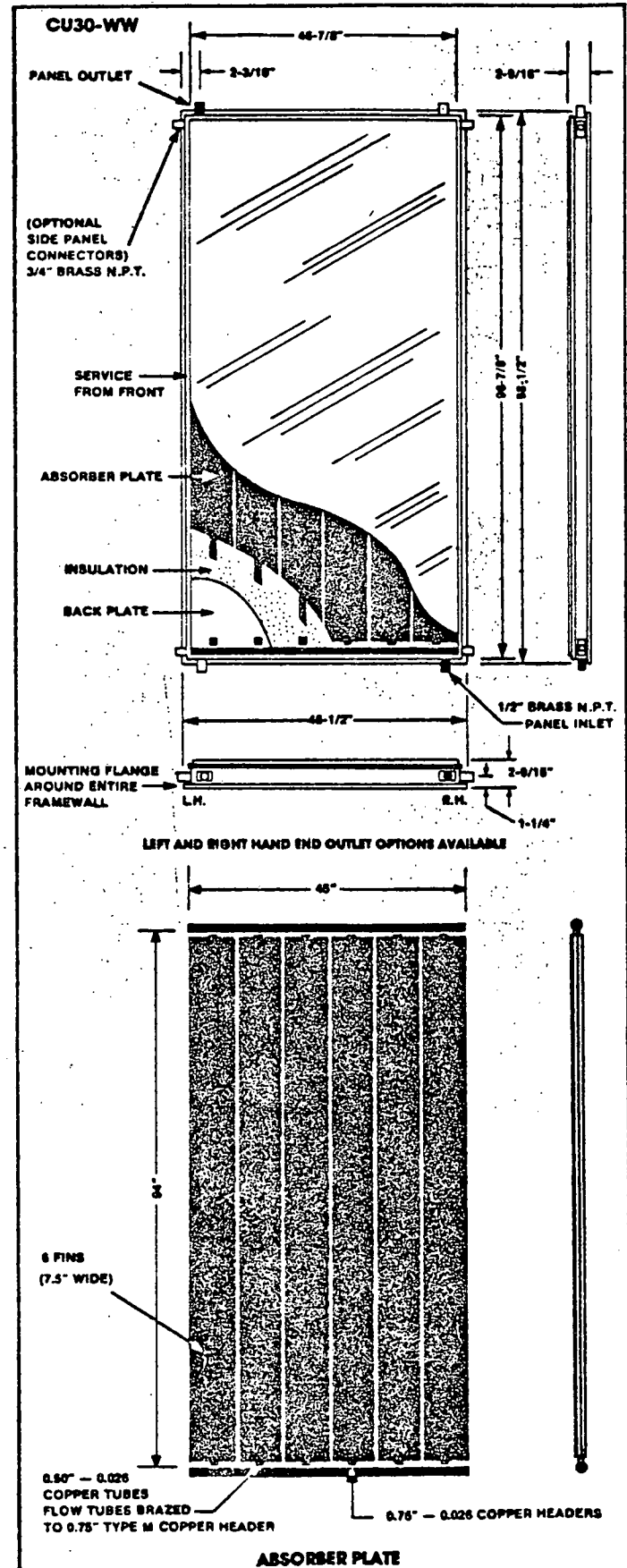
DESIGN LIFE: Material selection and design considerations allow an expected service life of thirty (30) years, when the panel is operated properly.

OPTIONS

CU30-HRM Mounting System: Aluminum extruded mill finish hinges (4) designed to mate with any section of framewall. Aluminum standoffs (2) and mounting brackets (4) suitable for fixed position or adjustable mounting (from 0° to 90°+). Weight 9.0 lbs.

CU30-SO Four 3/4" brass threaded outlets with parallel internal 1" I.D. - 0.035 wall copper headers.

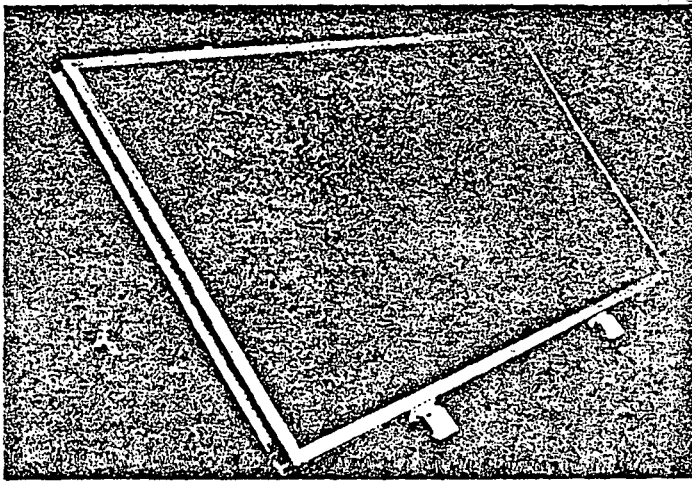
Left hand and right hand 1/2" brass NPT end outlets.





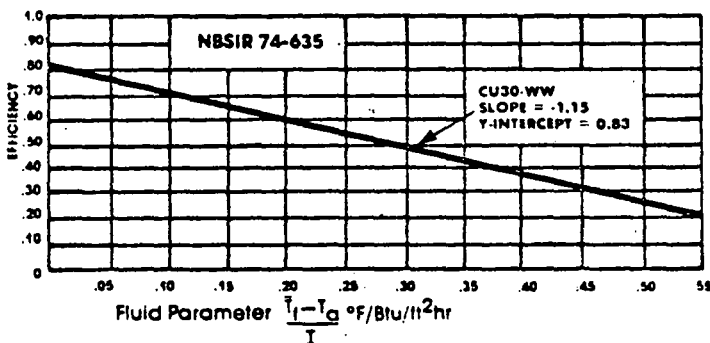
SPECIFICATIONS: SUNFIRED™ CU30-WW SOLAR COLLECTOR

CU30-WW FLAT PLATE SOLAR COLLECTOR

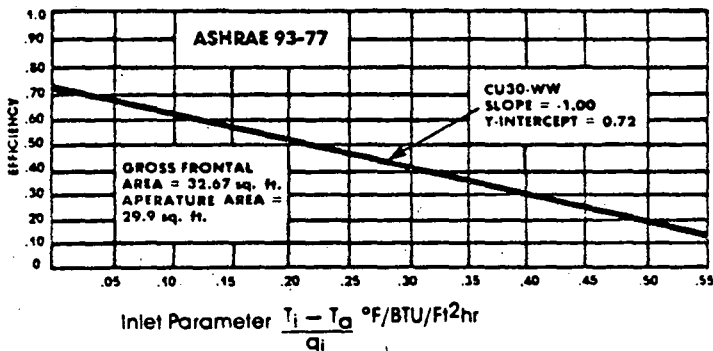


Testing performed in accordance with NBSIR 74-635, ASHRAE 93-P and ASHRAE 93-77 by Desert Sunshine Exposure Tests, Inc., Phoenix, Arizona.

APERTURE AREA—THERMAL PERFORMANCE CURVE



GROSS FRONTAL AREA — THERMAL PERFORMANCE CURVE



T_a = ambient temperature
 I = solar insolation

$\bar{T}_f = \frac{T_{in} + T_{out}}{2}$ of collector fluid

THERMAL PERFORMANCE CURVE EXPLANATION

The above thermal performance curve has been derived from tests conducted by: Desert Sunshine Exposure Tests, Inc.

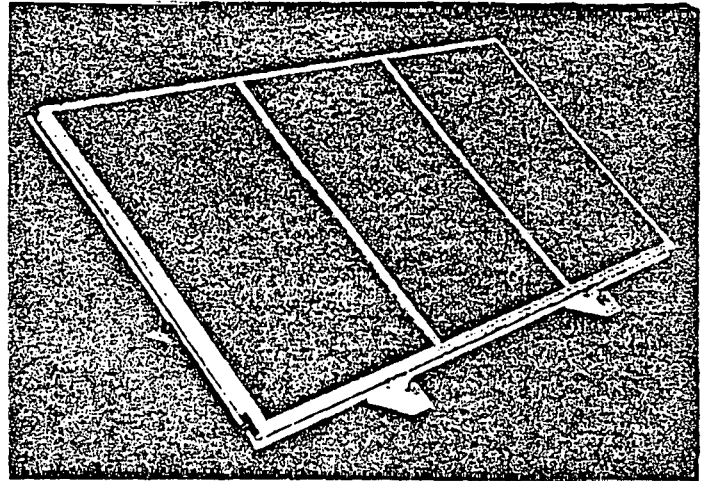
Test data available upon request

Instantaneous solar collector efficiency of the CU30 solar collector is found by operating the panel under stable conditions and monitoring inlet and outlet temperatures and the mass flow rate. The panel inlet and outlet temperatures are averaged and the ambient air temperature is subtracted from the result. This number is then divided by the incident solar radiation $Btu/hr.ft.^2$. The resulting value is plotted along the x-axis of the graph. The value to be plotted on the y-axis is the actual efficiency of the panel: output (outlet temperature minus inlet temperature $^{\circ}F$ multiplied by the flow rate $lb./hr.$) divided by input (insolation $Btu/hr.$). These values plotted at different inlet temperatures, provide an instantaneous performance curve.

THERMAL PERFORMANCE STABILITY

Thermal distortion of the solar collector during operation and periods of stagnation to temperatures of $300^{\circ}F$ will not cause significant deterioration of panel's performance.

CU30-SL FLAT PLATE SOLAR COLLECTOR



Testing performed in accordance with NBSIR 74-635 by Energy Design Associates, Inc., Gainesville, Florida.



SPECIFICATIONS SUMMARY: CU30 SUNFIRED™ SOLAR COLLECTOR

The CU30 Flat Plate solar collector panels shall be capable of absorbing solar radiation and transferring the resulting heat into a heat transfer fluid circulating through the panel. The absorber plate shall consist of a grid pattern of aluminum "fin" extrusions with copper flow tubes mechanically expanded into the fins, providing positive thermal contact of minimum 67% of tube surface. The enclosure box shall be constructed of clear anodized aluminum with the mounting flange extending around the entire perimeter of the panel. Insulation shall be 1-1/8" closed cell isocyanurate rigid foam board. The cover plate shall be tempered water white glass with transmissivity of .94. The panel fluid connections shall be thermally isolated 1/2" NPT brass nipple.

THERMAL PERFORMANCE

The panel's aperture shall be independently tested according to ASHRAE 93-77 test standards. The panels shall have a linear analysis thermal efficiency described by the equations:

$$EFF. = 0.83 - 1.15 \frac{(T_f - T_a)}{I} \quad (\text{NBSIR 74-635})$$

$$EFF. = 0.72 - 1.10 \frac{(T_{f,i} - T_a)}{q_i} \quad (\text{ASHRAE 93-77})$$

$$EFF. = 0.696 - 0.584 (IP) - 0.872 (IP)^2$$

DURABILITY

The panel shall be capable of withstanding stagnation temperatures of $300^{\circ}F$ without significant degradation. The panel shall be designed to withstand wind loads to 130 mph, when properly mounted. The absorber plate shall be designed to allow fluid drainage for freeze protection and shall be capable of withstanding working pressures of 150 psi. The panels shall have a design service life of 30 years.

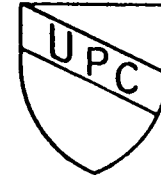
SERVICEABILITY

The glass cover plate shall be removable from the front of the panel with simple hand tools. The absorber plate and other components shall then be removable through the front of the panel.



INTERNATIONAL ASSOCIATION OF PLUMBING AND MECHANICAL OFFICIALS

A NON-PROFIT CORPORATION



Accepted November, 1977

Application number S-14364

Void after November, 1978

File number S-1888

RECOMMENDATION OF THE PLUMBING RESEARCH COMMITTEE

The product described herein has been reviewed, tested and recommended for acceptance by the Research Committee of the International Association of Plumbing and Mechanical Officials as meeting the requirements of the UNIFORM PLUMBING CODE. This recommendation is subject to the conditions set forth in the characteristics below and is not to be construed as assurance or guarantee by the Association of product acceptance by local jurisdictions or authorities using the UNIFORM PLUMBING CODE or otherwise affiliated with the Association.

Product trade name Solar Collectors Model No. CU30WW

Characteristics: Flat-plate solar collectors for swimming pool, space or domestic hot water heating applications (for residential, commercial and industrial uses). To be installed in accordance with the manufacturer's instructions and recommendations and the Uniform Solar Energy Code.

Dimensions (length x width x thickness) are: 8'2.5" x 4'0.5" x 2.57". The total collector area is 33.2 square feet (approximately) and the aperture area is 30.1 square feet (approximately). Frame construction is aluminum alloy (alloy no. 6063-T5) extrusion clear anodized. The absorption surface plate is made of extruded aluminum. The water-ways are made of copper

Applicant Solar Energy Products, Inc.
Address 1208 N.W. 8th Ave. City Gainesville State FL 32601

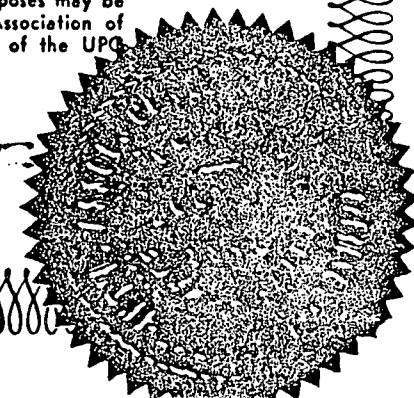
This recommendation is for the period indicated herein and is void after date shown above. Any change in material, marking or design without having first obtained the approval of the Research Committee or evidence of inferior workmanship or failure to follow an equitable service policy may be deemed as sufficient cause for revocation of this recommendation.

Reproduction of or reference to this form for advertising purposes may be made only by specific written permission of International Association of Plumbing and Mechanical Officials. This authorizes the use of the UPC shield on products covered by this certificate.

Allen R. McQuinn
CHAIRMAN, RESEARCH COMMITTEE

Neil C. Moore
EXECUTIVE DIRECTOR

Sponsors of UNIFORM MECHANICAL CODES





INTERNATIONAL ASSOCIATION OF PLUMBING AND MECHANICAL OFFICIALS

A NON-PROFIT CORPORATION



Accepted November, 1977

Application number S-14364

Void after November, 1978

File number S-1888

RECOMMENDATION OF THE PLUMBING RESEARCH COMMITTEE ATTACHMENT TO LISTING CERTIFICATE

Product trade name Solar Collectors

tubing, type M, 0.5" I.D. The inlet and outlet headers are made of copper tubing, type M, 0.75" O.D. Insulation is isocyanurate foam, 1.125" thickness. Selective paint is flat black, rust inhibitive, high temperature. Glazing - tempered glass, single, 0.188". Weight - 190 lbs (dry), 200 lbs (wet). The cover plate gasket is silicone gasket seal bonded to frame wall and cover plate batten, UV stable. The back plate is 0.032 mil finish aluminum sheet. All wetted surfaces are copper or brass. Two (2) drain holes, 0.25" in diameter, are located at the low points of the panels. Flow characteristics: 0.05 foot head at 0.75 gpm flow rate, maximum design flow rate is 5 gpm.

Sponsors of UNIFORM MECHANICAL CODES

EDWARD B. O'KELLEY, P.E.
CONSULTING STRUCTURAL ENGINEER

904 SOUTH MAIN STREET
GAINESVILLE, FLORIDA 32601

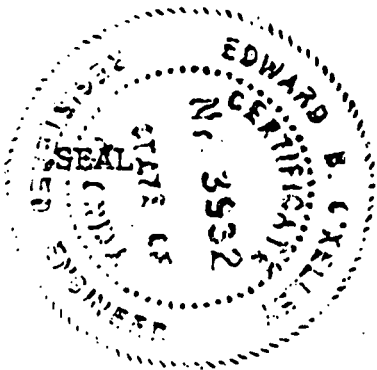
TELEPHONE
904-372-7358

STRUCTURAL CERTIFICATION

Solar Energy Products, Inc.
1208 N. W. 8th Avenue
Gainesville, Florida 32601

Collector Model Number: Cu 30 WW

The undersigned, an engineer registered in the State of Florida does certify that, having used generally accepted procedures, he has determined that the wind load that may be sustained by the solar collector identified in the heading above without damage to the cover plate material* or its mounting is at least 42.5 lb/ft².



Signed Edward B. O'Kelley, Jr. Date: Dec. 16, 1977
Typed Name: Edward B. O'Kelley, Jr.
Registration No. Florida 3932

* The structural behavior of glass is such that the risk of breakage must be handled statistically. Risk can be reduced to an insignificant level, but it cannot be eliminated. For this reason, glass is not guaranteed against breakage. Predicted breakage for these stated installation conditions is estimated as 15 out of 1,000, exclusive of breakage caused by flying objects.

JOHN E. BROWN & ASSOCIATES INC.
ARCHITECTS — ENGINEERS

2 9 0 2 M c B R I D E L A N E
S A N T A R O S A , C A L I F . 9 5 4 0 1
T E L E P H O N E (7 0 7) 5 4 6 - 1 5 3 3

May 2, 1978

Mr. Jay C. McLaughlin, Vice-President
Solar Energy Products, Inc.
P.O. Box 3969
Santa Rosa, California 95402

Dear Mr. McLaughlin:

In receipt of your request of February 22, 1978, we analyzed your Solar Collector Panel CU30-WW with Mounting Assembly CU30-HRM. Our structural analysis was based on the assumption that the system is assembled and mounted according to the manufacturer's instructions and specifications, contained in Manual 13.25/Sb-1, with components and details as shown on attached Drawings #101-108, dated November 22, 1977. It was further assumed that all aluminum members have a yield point of 15,000 psi or more; all connector bolts used are 3/8" in diameter or greater; and that the assemblies are located at a height not exceeding 30' from the ground.

The structural analysis is shown on computation sheets C.1 thru C.7, dated March 1978, attached to this letter.

The analysis is based on the requirements for resistance against wind and seismic forces defined in the following building codes:

Uniform Building Code, 1976 edition
Title 24, Building Regulations, California Administrative Code
Title 21, California Administrative Code (Schools)
Title 22, California Administrative Code (Hospitals)

We found that the controlling force for the purpose of our analysis was a wind force of 20 lbs. per square foot, in addition to the dead loads of the structure. In our analysis, we found the following three areas of compliance with the codes:

- 1) When the unit is mounted horizontally, as shown in the top portion of Drawing #108, and when it has 2 standoff supports in any location, the assembly meets the requirements of the codes stated above.
- 2) When mounted horizontally, and when the 2 standoff supports are symmetrically located with respect to the center point and are at least 3'-8" apart, but not more than 4'-10" apart, the assembly is capable of resisting a wind force of 130 mph, equalling a horizontal force of 42.5 lbs. per square foot.
- 3) When the assembly is mounted vertically, as shown in the lower half of Drawing #108, additional bracing is required for the standoff and, under these conditions, special details need be provided.

Sincerely,

John E. Brown

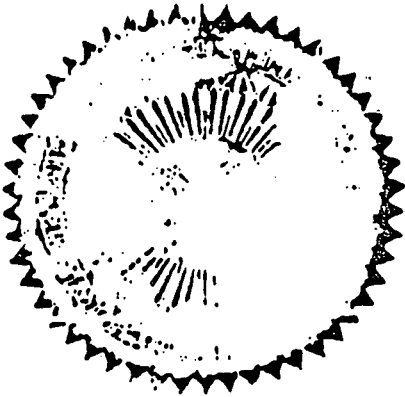
John E. Brown
Structural Engineer

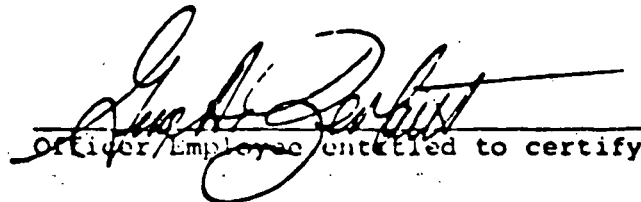
CERTIFICATION OF SOLAR DEVICE PERFORMANCE TEST

DSET does not certify the product described herein, or the performance thereof, or the suitability of the product for any purposes whatever. DSET certifies only that the foregoing test procedures were followed and that the referenced test report is the result of said tests.

Certified and Sworn to by

DESERT SUNSHINE EXPOSURE TESTS, INC.





Officer/Employee entitled to certify

Gene A. Zerlaut, Technical Director
Typed Name and Title

July 7, 1977

Date



Solar Energy Products, Inc.

P.O. Box 3969 • Santa Rosa, California 95402
Supplier of Solar Energy Equipment
(707) 526-3541

We Lost Anything Under the Sun

BOX 185 • BLACK CANYON STAGE
PHOENIX, ARIZONA 85020
(602)465-7525



TAWA
THE SUN KACHINA

January 27, 1977

Mr. Dudley Slocum
President
GULF THERMAL CORPORATION
2215 Industrial Blvd.
P. O. Box 13124 Airgate Br.
Sarasota, Florida 33578



Solar Energy Products, Inc

1208 N.W. 8th Ave. • Gainesville, Florida 3260
Supplier of Solar Energy Equipment

(904) 377-6527

Dear Mr. Slocum:

The following report gives the basic results of performance tests conducted on the Gulf Thermal Corporation Model CUS collector.

Testing was performed in accordance with the ASHRAE 93-P proposed method and DSET Specification 75SE2 utilizing an alt-azimuth sun-tracking (ENI) mount. The general test rationale and procedures employed are described in the DSET Specification appended to this report. The specification should also be referred to for instrumentation used and exceptions to the ASHRAE 93-P procedures.

It should be noted that pressure drop data as presented were measured with standard pressure gauges and are not considered highly accurate. Therefore, caution is advised in forming conclusions based on these data. Highly accurate pressure transducers are due to be installed in the test facility; however, due to schedule commitments, it was required that testing proceed prior to their installation.

The ASHRAE 93-P method is composed of four parts: (1) Preconditioning, (2) Determination of the collector's time constant, (3) Instantaneous efficiency performance test, and (4) Determination of the incident angle modifier for the collector.

Each of these topics will be addressed separately and test data and results are presented at the end of the report.

1. Preconditioning

Prior to the thermal performance tests the collector was placed at a 45° south facing angle and exposed to the sun in a non-operational, stagnation mode. The collector was initially

filled with water, the inlet sealed, and the water was allowed to evaporate over a three-day period during which the cumulative daily insolation was equal to or greater than 1500 BTU/FT².

At the end of the stagnation period the collector was visually inspected. No discernible damage or changes were noted.

2. Collector Time Constant

Testing of the collector to determine its time constant, i.e., the time required for the outlet fluid temperature to attain 63.2 percent of its steady state value, was performed on the ENI mount by turning the collector out of the sun to provide the necessary step change in insolation (ASHRAE 93-P, Section 8.3.1, Method (1)).

The data obtained, as given in the table attached, resulted in a value of 3 min. 50 sec. for the time constant of the collector.

As one-half of the collector's time constant is less than 5 minutes, the subsequent performance test data were integrated over 5-minute time periods.

3. Instantaneous Efficiency Performance Test

The instantaneous efficiency test was performed utilizing an alt-azimuth sun-tracking (ENI) mount which maintained the collector at normal incidence to the sun throughout the test period. The test was conducted at an average flow rate of 409.28 lb/hr (0.818 gpm) while the inlet fluid temperature was varied. The inlet fluid temperature was varied from around ambient temperature to about 205°F to provide as wide a range of operating conditions as possible.

Data obtained from this test and relevant calculated values are given in the attached tables. Please note that where integrated values have been reported, the mean value for the integral is given in parentheses.

Following the data tables are two graphs presenting the efficiency data as a function of the inlet parameter, $(T_i - T_a)/q_i$ (which describes the conditions under which the collector was operated).

In the case of the first graph, the data were analyzed using a 2nd order least squares polynomial which resulted in the following efficiency equation as a function of the inlet parameter.

$$\eta = 0.760 - 0.639 \left[\frac{T_i - T_a}{q_i} \right] - 0.951 \left[\frac{T_i - T_a}{q_i} \right]^2 \quad (1)$$

In the case of the second graph, the data were analyzed with a 1st order least squares regression, at the client's request. The analysis resulted in the following linear equation for the efficiency of the collector in terms of the inlet parameter.

$$\eta = 0.787 - 1.097 \left[\frac{T_i - T_a}{q_i} \right] \quad (2)$$

As the ASHRAE method requires 2nd order polynomial analysis, subsequent discussion and presentation of the test results are based upon the non-linear 2nd order analysis as given in equation (1).

At an inlet parameter of zero, i.e., no heat loss to ambient relative to the inlet temperature, equation (1) yielded a value of 0.760 (76.0%) for the optical efficiency factor. The optical efficiency factor, $F_{R\alpha\tau}$, is the product of the heat removal factor (F_R), the receiver absorptivity (α) and the transmissivity (τ) of the cover system.

Differentiation of the efficiency equation with respect to the inlet parameter resulted in the following expression that describes the overall heat losses from the collector, $F_R U_L$, where U_L is the overall heat loss coefficient.

$$\frac{d\eta}{d \left[\frac{T_i - T_a}{q_i} \right]} = F_R U_L = -0.639 - 1.902 \left[\frac{T_i - T_a}{q_i} \right]$$

Since the overall heat loss is a function of the thermal conditions under which the collector is operated, as described by the inlet parameter, the differential was evaluated at three different parameters to give some indication of the heat losses experienced by the collector. The resultant values are given below.

<u>Inlet Parameter*</u>	<u>F_RU_L**</u>
0.05	-0.734
0.25	-1.115
0.45	-1.495

*°F/BTU/FT².hr

**BTU/FT².hr/°F

As the above values demonstrate, the heat losses increase with increasing operating temperatures.

As you will note, the ASHRAE method requires that the efficiency of the collector be expressed in terms of the inlet fluid temperature whereas in the NBS method the average fluid temperature is utilized and results are expressed in terms of the fluid parameter, $(\bar{T}_f - T_a)/q_i$. Consequently, performance curves based on different parameters are not readily comparable. However, the data tables contain all of the data necessary to generate performance curves based upon any of the various parameters for which measurements exist.

In this respect, we have provided two additional graphs of efficiency as a function of the fluid parameter, one with a non-linear (2nd order) analysis, the other with a linear analysis. The analysis resulted in the equations below.

$$\eta = 0.779 - 0.572 \left[\frac{\bar{T}_f - T_a}{q_i} \right] - 1.120 \left[\frac{\bar{T}_f - T_a}{q_i} \right]^2 \quad (\text{non-linear})$$

$$\eta = 0.825 - 1.154 \left[\frac{\bar{T}_f - T_a}{q_i} \right] \quad (\text{linear})$$

These equations and the curves presented in the graphs should provide a means of comparison to the previous tests you have that were performed to the NBS method.

4. Incident Angle Modifier

In order to predict collector performance over a wide range of conditions, tests were conducted to determine the incident angle modifier, K_{at} , for the collector. The incident angle modifier is used to modify the performance curve (determined at normal incidence) to account for changes in performance as a function of the sun's incident angle and is defined by the general equation:

$$K_{at} = 1 + b_o \left[\frac{1}{\cos \theta} - 1 \right]$$

The collector was tested by adjusting the ENI mount so that the collector was at incident angles of 45°, 60° and 75°. Data were taken in each of the incident angle positions and the appropriate efficiency values were computed (ASHRAE 93-P, Section 8.3.3, Method (1)).

The efficiency data so obtained were plotted on the performance graph and an extrapolation was made to the ordinate by assuming the same slope as the performance curve.

Mr. Dudley Slocum
January 27, 1977
Page Five

The intercept values, η_0 , for each incident angle condition thus obtained are given below along with the resultant values for K_{at} .

Incident Angle, θ :	<u>45°</u>	<u>45°</u>	<u>60°</u>	<u>60°</u>	<u>75°</u>	<u>75°</u>
η_0 :	0.762	0.747	0.704	0.711	0.441	0.439
K_{at} :	1.003	0.993	0.926	0.936	0.580	0.578

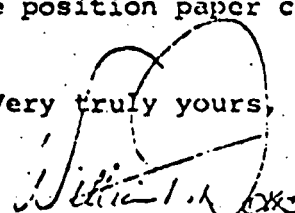
The data for K_{at} as a function of $\frac{1}{\cos\theta} - 1$, as presented in a graph attached, were analyzed using a least squares linear regression in order to determine the value of b in the general equation. This yielded the following incident angle modifier equation for the collector:

$$K_{at} = 1 - 0.174 \left[\frac{1}{\cos\theta} - 1 \right]$$

The ASHRAE 93-P test is quite comprehensive and valuable in the amount of information it can provide about the collector's operating characteristics. DSET has prepared a position paper (enclosed) for the exclusive use of its clients which presents methods by which the test results can be used to generate various information about the collector.

The methods and procedures presented in the position paper, for the most part, have not been extensively field tested. We, therefore, solicit any comments you may have regarding the position paper consistent with your experiences in the field.

Very truly yours,


William T. Dokos
Research Engineer

WTD:lf

Enclosures

SYMBOLS/DEFINITIONS

α	Absorptance of receiver/absorber
τ	Transmittance of cover
F'	Collector plate efficiency factor
F_R	Collector plate heat-removal efficiency
U_L	Overall heat loss coefficient
t	Local solar time
\dot{m}	Mass flow rate
T_i	Inlet fluid temperature
T_o	Outlet fluid temperature
T_p	Plate temperature
T_a	Ambient air temperature
C_p	Heat capacity
q_i	Insolation (incoming solar radiation)
P_{in}	Inlet pressure
ΔP	Pressure drop
ΔT	Fluid temperature differential ($T_o - T_i$)
\bar{T}_f	Average fluid temperature
\bar{T}_p	Average plate temperature
$\bar{T}_f - T_a$	Average fluid temperature differential over ambient
$\bar{T}_p - T_a$	Average plate temperature differential over ambient
$(\bar{T}_f - T_a)/q_i$	Fluid parameter
$(\bar{T}_p - T_a)/q_i$	Plate parameter
n_{q_i}	Collector output
n	Efficiency
— (Superscript)	Average values

GULF THERMAL CORPORATION
 DSET No. 170065/77S0109A

Collector Time Constant

Date: January 9, 1977

Wind: 360 fpm

Solar Time	°C		$\frac{T_o - T_i}{T_{o,int} - T_{in}}$
	T_o	T_i	
13:56:00	24.6	12.6	1.000
- - - - Collector Taken Out of Sun - - - -			
13:56:30	25.1	12.6	1.042
13:56:50	24.4	12.6	0.983
13:57:10	23.5	12.7	0.902
13:57:30	22.2	12.6	0.800
13:57:50	21.1	12.5	0.711
13:58:10	20.2	12.6	0.633
13:58:30	19.3	12.6	0.558
13:58:50	18.5	12.5	0.496
13:59:10	17.9	12.5	0.446
13:59:30	17.4	12.5	0.405
13:59:50	16.9	12.4	0.369
14:00:10	16.5	12.4	0.336
14:00:30	16.1	12.4	0.303



DESERT SUNSHINE EXPOSURE TESTS, INC.

Box 185, Black Canyon Stage
Phoenix, Arizona 85020

COMPANY: GULF THERMAL CORPORATION
REFERENCE NO.: 10/20/76 Slocum
DSET NO.: 17006S
REPORT NO.: 77S0109A

DATE: January 9, 1977
COLLECTOR: CUS, GP 17006S
GLAZING: Single Glass
APERTURE AREA: 29.9 ft²

TEST METHOD: DSET 75SF2.7 (ASHRAE 93-P/ENI)

t, solar	1222	1229	1245	1252	1402
m̄ (lb/hr)	372.5	369.9	368.8	368.3	373.3
∫T _i (°F)	(204.7) 3070.7	(204.6) 3069.1	(204.4) 3066.1	(204.3) 3064.8	(162.2) 2433.4
∫T _o (°F)	(211.6) 3174.0	(211.5) 3172.3	(211.5) 3172.4	(211.5) 3172.1	(172.9) 2593.7
T _p (°F)	-	-	-	-	-
T _p (°F)	-	-	-	-	-
T _p (°F)	-	-	-	-	-
∫T _a (°F)	(46.2) 693.3	(46.8) 701.6	(46.8) 702.1	(47.3) 708.9	(48.5) 727.1
Wind Velocity	N 7	E 7	NE 8	N 4	N 8
Air Over Collector (fpm)	410	200	480	470	400
C _p (BTU/lb.°F)	1.00637	1.00635	1.00635	1.00632	1.00148
∫q _i (BTU/FT ² .hr)	(338.9) 5083.2	(339.0) 5084.6	(337.9) 5069.1	(337.9) 5068.0	(324.9) 4873.5
q _i , % Diffuse	5.5	5.5	5.5	5.6	5.8
Tilt Angle	54.4	54.6	55.1	55.4	61.1
Incidence Angle	0°	0°	0°	0°	0°
Azimuth Angle	-5.1	-7.1	-11.6	-13.5	-31.4
P _{in} (psi)	13.3	13.3	13.2	13.2	13.8
ΔP (psi)	3.2	3.2	3.2	3.2	3.3
∫ΔT (°F)	(6.9) 103.2	(6.9) 103.1	(7.1) 106.3	(7.2) 107.3	(10.7) 160.3
T _f (°F)	208.2	208.0	208.0	207.9	167.6
T _p (°F)	-	-	-	-	-
T _f -T _a (°F)	161.9	161.3	161.1	160.6	119.1
T _p -T _a (°F)	-	-	-	-	-
T _i -T _a (°F)	158.5	157.8	157.6	157.0	113.7
(T _f -T _a)/q _i *	0.478	0.476	0.477	0.475	0.367
(T _i -T _a)/q _i *	0.468	0.466	0.466	0.465	0.350
(T _p -T _a)/q _i *	-	-	-	-	-
η _{q_i**}	-	-	-	-	-
Efficiency, η	0.255	0.252	0.260	0.262	0.411



DESERT SUNSHINE EXPOSURE TESTS, INC.

Box 185, Black Canyon Stage
Phoenix, Arizona 85020

COMPANY: GULF THERMAL CORPORATION
REFERENCE NO.: 10/20/76 Slocum
DSET NO.: 17006S
REPORT NO.: 77S0109A

DATE: January 9, 1977
COLLECTOR: CUS, GP 17006S
GLAZING: Single Glass₂
APERTURE AREA: 29.9 ft²

TEST METHOD: DSET 75SE2.7 (ASHRAE 93-P/ENI)

t, solar	1409	1425	1432	1507	1514
ṁ (lb/hr)	370.6	370.1	368.5	370.2	377.7
∫T _i (°F)	(162.1) 2432.0	(161.9) 2428.0	(161.5) 2422.8	(54.5) 817.9	(54.5) 817.7
∫T _o (°F)	(172.9) 2593.4	(172.6) 2588.4	(172.2) 2582.6	(72.4) 1086.0	(72.0) 1079.7
T _p (°F)	-	-	-	-	-
T _p (°F)	-	-	-	-	-
T _p (°F)	-	-	-	-	-
∫T _a (°F)	(48.5) 727.8	(48.7) 730.8	(48.9) 733.6	(49.8) 747.2	(49.7) 745.2
Wind Velocity	NE 6	N 8	N 10	N 8	E 5
Air Over Collector (fpm)	490	500	610	820	160
C _p (BTU/lb.°F)	1.00148	1.00145	1.00141	0.99924	0.99925
∫q _i (BTU/FT ² .hr)	(322.9) 4844.2	(320.0) 4800.4	(317.6) 4764.0	(294.1) 4410.9	(288.9) 4332.8
q _i , % Diffuse	5.8	5.7	5.8	5.3	5.3
Tilt Angle	61.9	62.9	63.7	69.7	70.7
Incidence Angle	0°	0°	0°	0°	0°
Azimuth Angle	-33.0	-34.8	-36.3	-45.0	-46.3
P _{in} (psi)	13.8	13.8	13.8	14.3	14.0
AP (psi)	3.5	3.5	3.5	3.6	3.6
∫ΔT (°F)	(10.8) 161.4	(10.7) 160.5	(10.6) 159.7	(17.9) 268.1	(17.5) 262.0
T _f (°F)	167.5	167.2	166.8	63.5	63.2
T _p (°F)	-	-	-	-	-
T _f -T _a (°F)	119.0	118.5	117.9	13.6	13.6
T _p -T _a (°F)	-	-	-	-	-
T _i -T _a (°F)	113.6	113.6	112.6	4.7	4.8
(T _f -T _a)/q _i *	0.368	0.370	0.371	0.046	0.047
(T _i -T _a)/q _i *	0.352	0.355	0.355	0.016	0.017
(T _p -T _a)/q _i *	-	-	-	-	-
n _{q_i**}	-	-	-	-	-
Efficiency, η	0.413	0.414	0.414	0.752	0.763



DESERT SUNSHINE EXPOSURE TESTS, INC.

Box 185, Black Canyon Stage
Phoenix, Arizona 85020

COMPANY: GULF THERMAL CORPORATION
REFERENCE NO.: 10/20/76 Slocum
DSET NO.: 17006S
REPORT NO.: 77S0109A

DATE: January 9, 1977
COLLECTOR: CUS, GF 17006S
GLAZING: Single Glass₂
APERTURE AREA: 29.9 ft²

TEST METHOD: DSET 75SE2.7 (ASHRAE 93-P/ENI)

t, solar	1530	1537		
m̄ (lb/hr)	376.0	373.4		
∫ T _i (°F)	(54.4) 816.1	(54.4) 815.3		
∫ T _o (°F)	(70.7) 1059.9	(70.3) 1053.9		
T _p (°F)	-	-		
T _p (°F)	-	-		
T _p (°F)	-	-		
∫ T _a (°F)	(49.7) 744.8	(49.4) 741.4		
Wind Velocity	NE 6	N 5		
Air Over Collector (fpm)	200	90		
C _p (BTU/lb.°F)	0.99933	0.99937		
∫ q _i (BTU/FT ² .hr)	(275.3) 4130.1	(268.1) 4021.7		
q _i , % Diffuse	5.0	5.0		
Tilt Angle	73.2	74.4		
Incidence Angle	0°	0°		
Azimuth Angle	-49.2	-50.4		
P _{in} (psi)	14.8	14.8		
ΔP (psi)	3.7	3.8		
∫ ΔT (°F)	(16.2) 243.7	(15.9) 238.6		
T _f (°F)	62.5	62.3		
T _p (°F)	-	-		
T _f -T _a (°F)	12.9	12.9		
T _p -T _a (°F)	-	-		
T _i -T _a (°F)	4.7	4.0		
(T _f -T _a)/q _i *	0.047	0.048		
(T _i -T _a)/q _i *	0.017	0.015		
(T _p -T _a)/q _i *	-	-		
η _{q_i} **	-	-		
Efficiency, η	0.742	0.740		



DESERT SUNSHINE EXPOSURE TESTS, INC.

Box 185, Black Canyon Stage
Phoenix, Arizona 85020

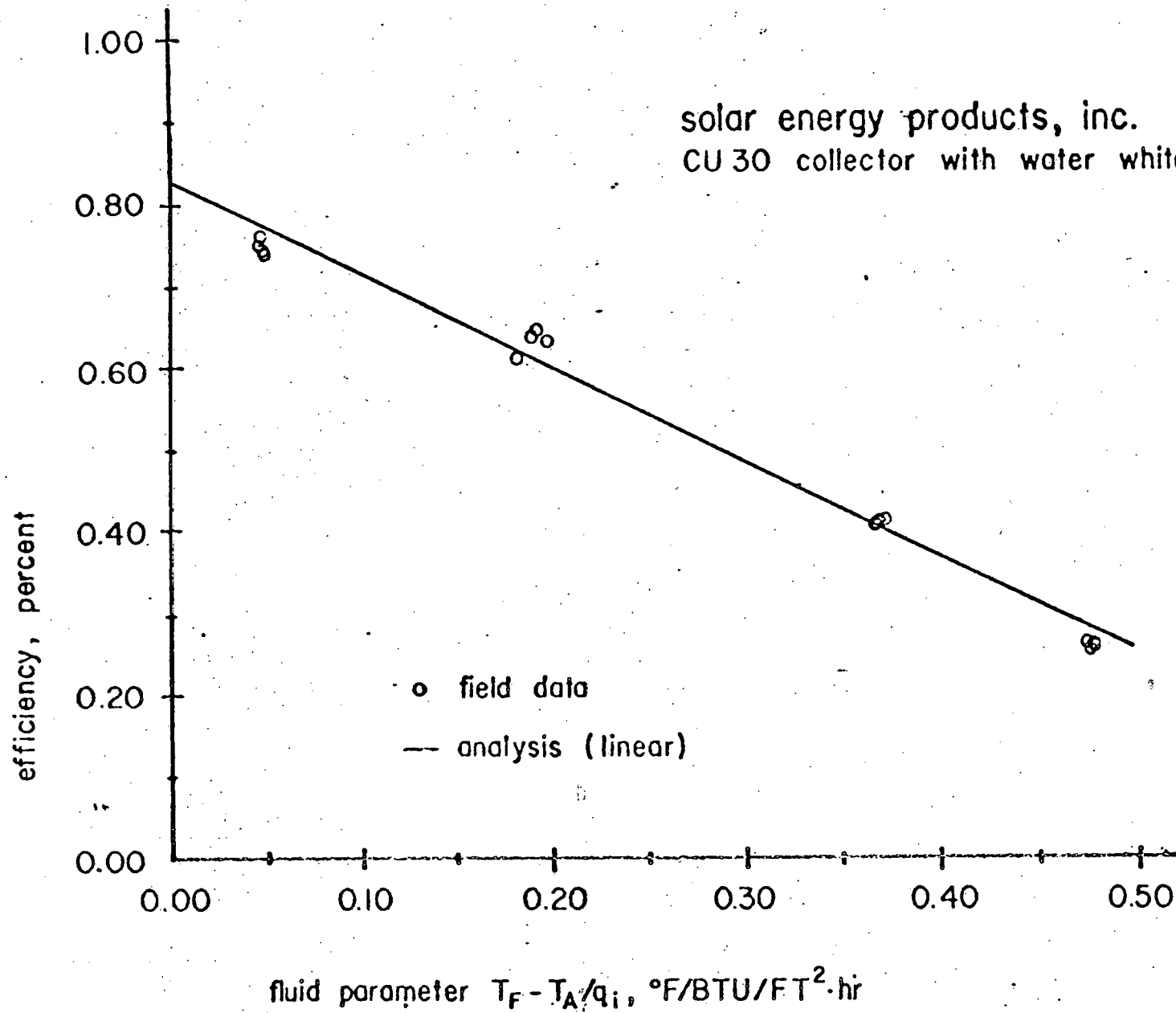
COMPANY: GULF THERMAL CORPORATION
REFERENCE NO.: 10/20/76 Slocum
DSET NO.: 17006S
REPORT NO.: 7750109A

DATE: January 10, 1977
COLLECTOR: CUS, GP 17006S
GLAZING: Single Glass₂
APERTURE AREA: 29.9 ft²

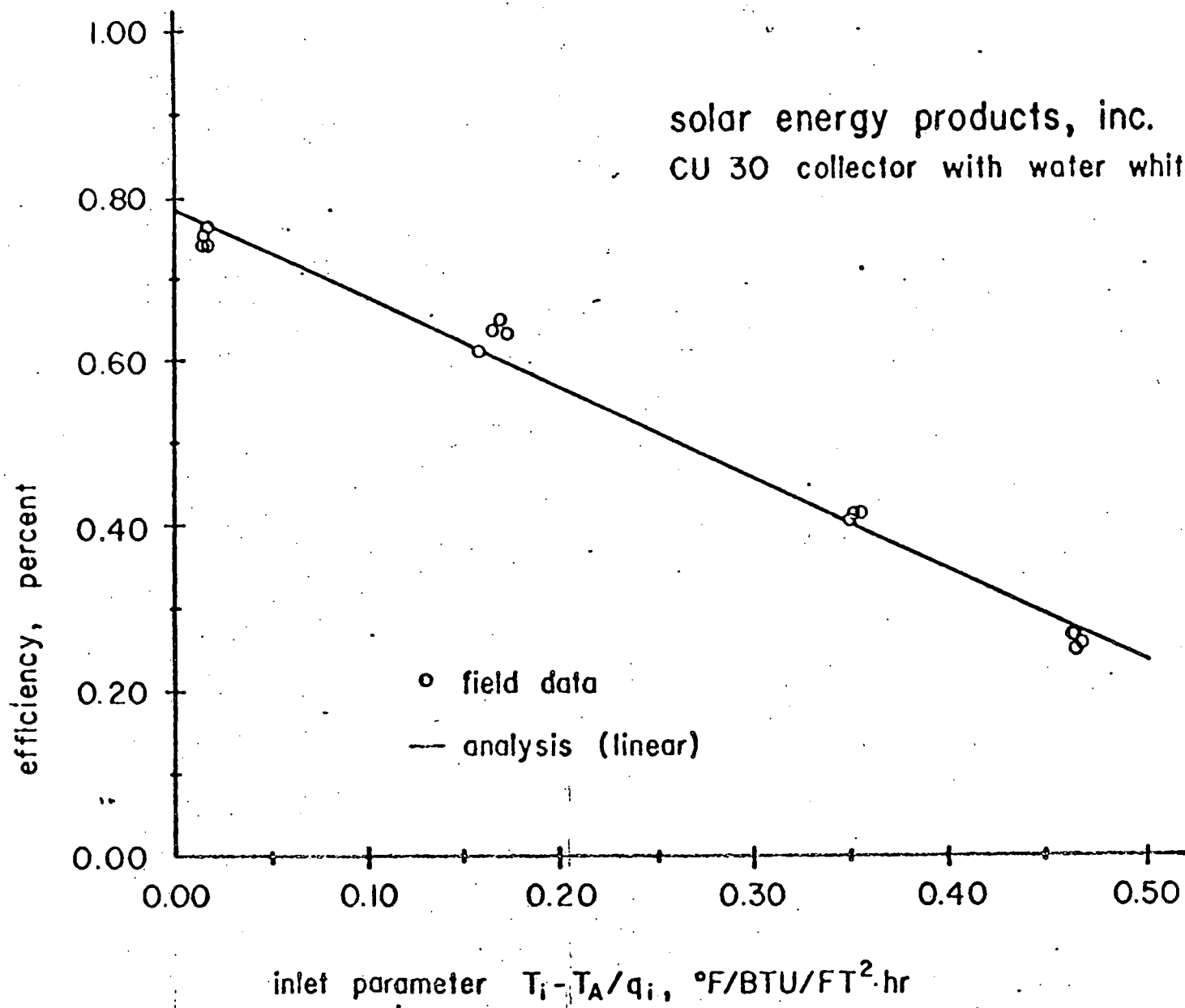
TEST METHOD: DSET 75SER.7 (ASHRAE 93-P/ENI)

t, solar	1147	1247	1254	1310	
m (lb/hr)	375.6	375.0	373.5	373.0	
$\int T_i$ (°F)	(108.6) 1629.7	(108.3) 1623.8	(108.2) 1623.4	(108.3) 1625.2	
$\int T_o$ (°F)	(125.0) 1890.4	(125.3) 1879.0	(124.2) 1863.3	(125.2) 1878.1	
T _p (°F)	-	-	-	-	
T _p (°F)	-	-	-	-	
T _p (°F)	-	-	-	-	
$\int T_a$ (°F)	(52.2) 782.8	(52.6) 789.1	(53.4) 801.4	(54.2) 813.7	
Wind Velocity	0	S 5	S 3	S 2	
Air Over Collector (fpm)	0	310	220	0	
C _p (BTU/lb.°F)	0.99838	0.99836	0.99834	0.99836	
$\int q_i$ (BTU/FT ² .hr)	(342.7) 5140.7	(330.1) 4952.1	(316.0) 4740.4	(343.5) 5151.9	
q _j , % Diffuse	12.7	10.7	11.1	8.5	
Tilt Angle	54.3	55.1	55.4	56.0	
Incidence Angle	0°	0°	0°	0°	
Azimuth Angle	4.9	-12.2	-14.1	-17.1	
P _{in} (psi)	14.3	14.0	14.2	14.0	
ΔP (psi)	3.1	3.2	3.4	3.3	
$\int \Delta T$ (°F)	(17.4) 260.7	(17.0) 255.2	(16.0) 239.8	(16.9) 252.9	
T _f (°F)	117.3	116.8	116.2	116.8	
T _p (°F)	-	-	-	-	
T _f -T _a (°F)	65.1	64.2	62.8	62.5	
T _p -T _a (°F)	-	-	-	-	
T _i -T _a (°F)	56.4	55.7	54.8	54.1	
(T _f -T _a)/q _i *	0.190	0.194	0.199	0.182	
(T _i -T _a)/q _i *	0.165	0.169	0.173	0.157	
(T _p -T _a)/q _i *	-	-	-	-	
η _{q_i} **	-	-	-	-	
Efficiency, η	0.636	0.645	0.631	0.611	

solar energy products, inc.
CU 30 collector with water white glass



solar energy products, inc.
CU 30 collector with water white glass



V. STORAGE TANKS

V. STORAGE TANKS

A. Solar storage tank:

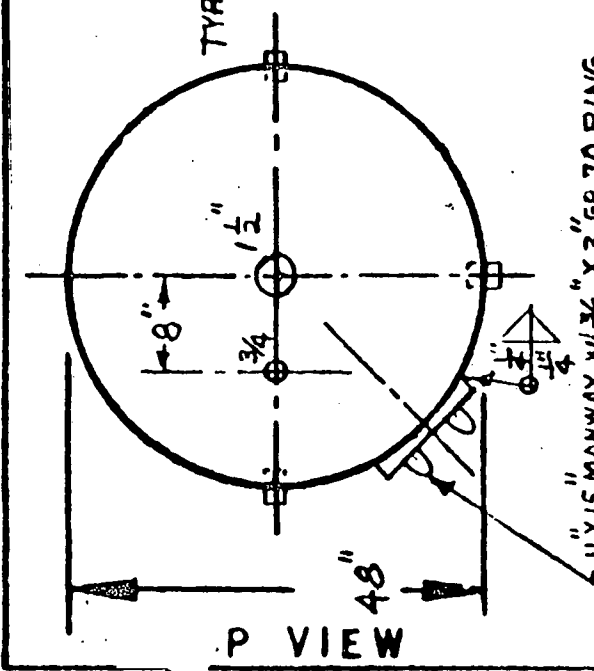
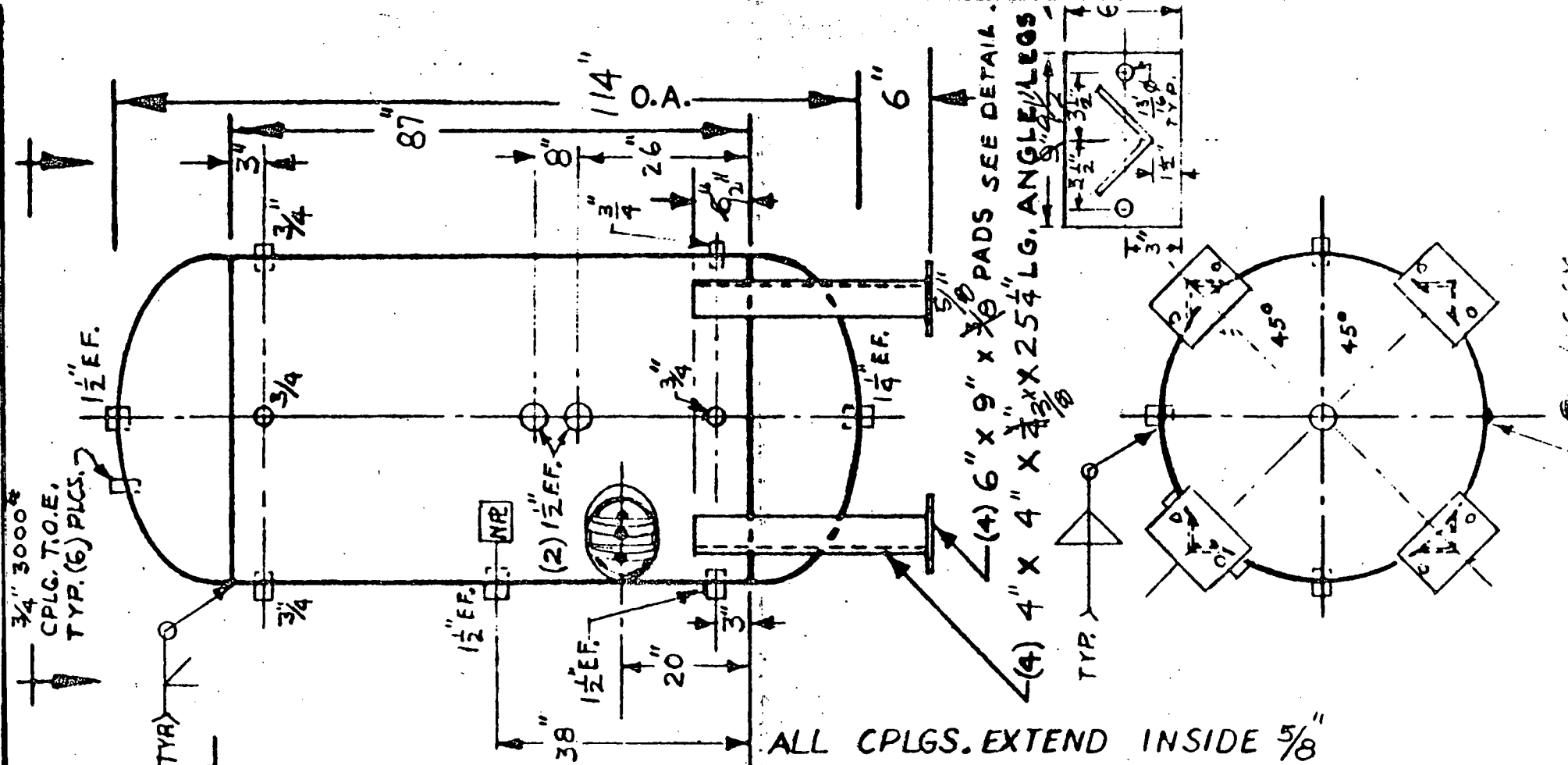
Roy E. Hanson, Jr., Mfg.
1924 Compton Ave.
Los Angeles, CA 90011

800 gallons
Steel with cement lining

B. Sump tank:

Rheem
Model No. 668-120-T

120 gallons
Steel with glass lining
Storage only (no heating elements)



SHOP DATA	
HEAD .250" SA455 38DR X 6.5 KR.	
R.T. - NO	
SHELL .250" SA455 (R)	
W.P. 125 PSI ASME	
GALLONS 800	WT 1300 ⁺ PROX.
SERIAL NO. _____	
ROY E. HANSON JR. MFG.	
1924 COMPTON AVE.	
LOS ANGELES CALIF 90011	

SK-9397	DATE-6-9-78
FOR CALIFORNIA HYDRONICS	
VERT. WATER TANK.	
INSIDE CEMENT LINED	
BY OTHERS AT JOBSITE	
OUTSIDE PRIMER.	
788.	

SOLARAIDE

Specify Rheem* Electric Solaraide for Solar-Heated Water Storage

Why Solaraide? Several good reasons. First, Rheem gives you a choice. (1) a storage tank specially equipped for installation with a Solar System. (2) or an electric storage water heater with a single element that "aides" the sun to provide sufficient hot water. The element assists the system only when the solar energy cannot maintain the desired temperature or during periods of peak demand for hot water. (3) both the single element electric and storage model series feature a raised solar panel outlet that helps prevent scale and sediment from entering and circulating through the solar collector cells. And finally, Rheem Solaraide is available in three capacities — 66, 82 and 120 gallon models — sized for the average-to-large family.

- (1) NO EXCEPTIONS TAKEN
- (2) FURNISH AS CORRECTED
- (3) SUBMIT SPECIFIC ITEM
- (4) REVISE AND RESUBMIT
- (5) REJECTED

Review is only for general conformance with the design concept of the project and general compliance with the information included in the Contract Documents. Markings or comments made during this review do not relieve the Contractor of his responsibility to comply with the requirements of the drawings and specifications. Contractor is responsible for: details and accuracy; correlating and dimensions, quantities and job site conditions; choice of communication processes and techniques of construction; coordination of his work with that of other trades; and performing in a safe and satisfactory manner.

INTERACTIVE RESOURCES, INC.
Architects, Engineers, Planners

6-28-78 By *[Signature]*
Storage Tank Model

2 SERIES: Rheem Solaraide Storage Tank and Electric Storage Water Heater... especially designed to be completely compatible with direct solar heating systems.

Both series are available in 66, 82 and 120 gallon capacities.

Raised 7" from the bottom, the outlet to the solar collector cells helps prevent scale and sediment from entering and circulating through the solar system.

Electric Storage Water heater

*A registered trademark.

Value and Performance

SOLARAIDE

for solar-heated water storage . . .
and electric storage water heaters

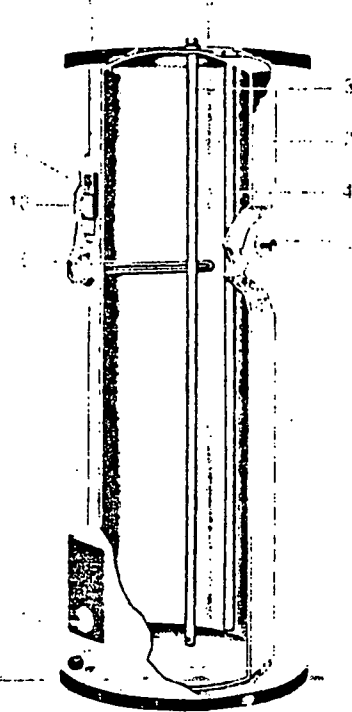
CONSTRUCTION FEATURES

All Models - 66, 82 and 120 gallon capacities.

1. Collector Feed is located 7" above the bottom to help prevent scale or sediment from entering solar collector system.
2. Fiberglass Insulation completely surrounds glasslined tank,* keeps water hot and conserves energy. New full wrap around jacket for improved appearance.
3. Cold Water Inlet brings cold water to tank bottom to prevent mixing with already heated water.
4. Anode Rod protects inner tank. Additional opening in top pan for easy access to anode rod.
5. Cold Water Inlet, Hot Water Outlet, Relief Valve and Anode Rod are at top of tank for easy access and fast, economical installation.
6. Side Return Opening. Located 41" from the bottom of the heater to allow for convenient installation with a gravity feed type of system.

Electric Models - 66, 82 and 120 gallon capacities.

7. Bottom pan is secured by a special lug on tank bottom eliminating need for sheet metal screws. The lug serves as a ground and also locks tank to pan to prevent "floating action."
8. Improved Electrical Junction Box (for 1/2" and 3/4" conduit) placed above heating element for easy installation. No spot welds used.
Direct Immersion Heating Element** is completely immersed - all the heat goes into the water.
10. Automatic Temperature Control Thermostat keeps stored water at desired temperature.
11. High Temperature Limit automatically and safely cuts off power in event desired temperature is exceeded.



RHEEMGLAS TANK Rheem water heater tanks are made with exacting care. The tank surface is coated with an exclusive porcelain formula called Rheemglas and fused to the solid steel shell at 1600°. The result is a smooth, tough, glasslike lining. Tank is designed and tested to withstand 300 PSI hydrostatic test pressure for working pressure of 150 PSI U.L. Standard.

**DIRECT IMMERSION HEATING ELEMENT Nickel Chromium heating coil imbedded in magnesium oxide and sealed in a tinned-copper tube. Although in direct contact with water, the ends are sealed to prevent entrance of moisture. Elements are changed, should the need arise, by screwing into special tank flanges.

NOTE: Unless otherwise specified standard 240 volt AC will be furnished. 120 volt, 208 volt, 277 volt and 480 volt AC supplied on special order. No extra cost (units are shipped with a 4500 watt element). If heating elements of different wattages than those shown are demanded by zone requirements they must be specifically requested.

Model No.	Capacity		Max. UL Listed Wattage	Unit Dimensions				Shipping Weight	
	Gal.	Liters		"H"		"D"		Lbs.	Kgms.
668-66-I	66	250	6000	59 3/4"	150.5	24 3/4"	61.6	221	100
668-82-I	82	310	6000	60 3/4"	153.4	26 3/4"	66.7	248	113
668-120-I	120	454	6000	62 5/16"	158.3	28 3/4"	71.8	399	181
668-66-T	66	250	STORAGE ONLY	59 3/4"	150.5	24 3/4"	61.6	221	100
668-82-T	82	310	STORAGE ONLY	60 3/4"	153.4	26 3/4"	66.7	248	113
120-T	120	454	STORAGE ONLY	62 5/16"	158.3	28 3/4"	71.8	399	181

LIMITED WARRANTY

GENERAL. Manufacturer RHEEM MANUFACTURING COMPANY, will furnish a replacement water heater in the event of tank failure, and will furnish a replacement for any other part, which fails in normal use and service within the applicable periods specified below, in accordance with the terms of this warranty. The RHEEM replacement will be warranted for only the unexpired portion of the original warranty.

THE TANK. If the tank fails within FIVE (5) years after original installation and operation RHEEM will furnish a replacement water heater. However, if the water heater is installed in other than a single family dwelling, this tank warranty is limited to ONE (1) year from date of original installation and operation.

ANY OTHER PART. If any other part fails within ONE (1) year after original installation and operation, RHEEM will furnish a replacement part.

THIS WARRANTY WILL NOT APPLY: a) to defects or malfunctions resulting from failure to properly install, operate or maintain the unit in accordance with the printed instructions provided b) to damage from abuse, accident, fire, flood and the like c) IN THE EVENT TANK FAILURE OCCURS: DUE TO THE WATER HEATER BEING OPERATED AT WATER TEMPERATURES EXCEEDING MAXIMUM SETTING OF THE OPERATING AND/OR HIGH LIMIT CONTROL, OR THE WATER HEATER IS NOT SUPPLIED WITH POTABLE WATER, FREE TO CIRCULATE AT ALL TIMES THE TANK MUST BE FREE OF DAMAGING SCALE DEPOSITS AND NOT SUBJECT TO PRESSURES OR FIRING RATES GREATER THAN THOSE SHOWN ON THE RATING PLATE WHICH MUST NOT BE ALTERED, OBTAINED OR REMOVED d) for units which are not installed in the United States of America, and in accordance with applicable local codes, ordinances, and good trade practices e) if the unit is moved from its original installation location.

SERVICE LABOR RESPONSIBILITY: This Warranty does not cover any labor expenses for service, removal or re-installation. All such expenses are your responsibility.

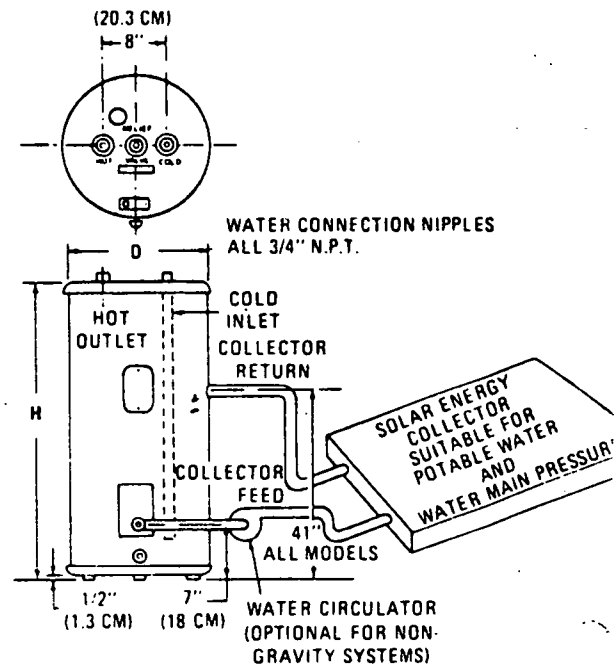
SHIPPING COSTS. RHEEM will pay the transportation costs for the replacement to a convenient delivery point selected by us near the place of installation, such as a local RHEEM water heater distributor. You must pay any local cartage including the cost of returning the replaced item to our local distributor.

HOW TO MAKE CLAIM. Any claim for warranty service should be made to your contractor or dealer from whom the water heater was purchased. If this cannot be done, simply contact any other local contractor handling RHEEM water heater products, or our factory branch.

In most cases, your contractor should be able to promptly take the necessary corrective action, and thereafter, notify RHEEM of the in-warranty claim. HOWEVER, ANY REPLACEMENTS ARE MADE SUBJECT TO VALIDATION BY RHEEM OF IN-WARRANTY COVERAGE. The item to be replaced must be made available in exchange for the replacement.

MISCELLANEOUS. No one is authorized to make any other warranties on our behalf. ANY IMPLIED WARRANTIES, INCLUDING MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, SHALL NOT, EXTEND BEYOND THE APPLICABLE WARRANTY PERIODS SPECIFIED ABOVE. RHEEM'S SOLE LIABILITY WITH RESPECT TO ANY DEFECT SHALL BE AS SET FORTH IN THIS WARRANTY AND ANY CLAIMS FOR INCIDENTAL OR CONSEQUENTIAL DAMAGE FROM WATER LEAKAGE ARE EXCLUDED. Some states do not allow limitations on how long an implied warranty lasts, or for the exclusion of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific rights, and you may also have other rights which vary from state to state.



RHEEM WATER HEATER DIVISION
CITY INVESTING COMPANY
7600 S. Kedzie Avenue/Chicago, Illinois 60652

Rheem also makes Environmental Control Products, Residential and Air Conditioning Equipment, Commercial and Industrial Heating - Cooling and Air Treatment Products.



VI. CONTROLS

VI. CONTROLS

- A. Differential thermostats: Rho Sigma
Model No. 502-S
Solid state, linear circuitry, fixed flow

<u>Differential thermostat</u>	<u>Pumps Controlled</u>	<u>T on</u>	<u>T off</u>
T-1	P-4 and P-7 (solar collection loops)	20°F	3°F
T-2	P-6 (tank-to-tank loop)	10°F	3°F
T-3	P-5 (space heating loop)	8°F	3°F

Collector sensor: Rho Sigma STH (mounted directly to a collector absorber plate from the back).

Storage tank sensors: Rho Sigma SP.

- B. Low-level switch: McDonnell & Miller, Model No. 902-M.

When the water level drops below the level of this switch, pumps P-4 and P-7 are disconnected and the alarm bell mounted above the sump tank is activated. The switch will automatically reset after momentary power interruptions, but must be manually reset after a fall in water level or an extended power failure.

- C. Flow switch: McDonnell FS4-3.

This switch prevents pump P-5 from activating until it senses that there is flow in the backup space heating loop.

SOLAR CONTROLS AND INSTRUMENTATION

RHO SIGMA
PSI
INCORPORATED

11922 VALERIO STREET, N. HOLLYWOOD, CA 91605. (213) 982-6800

Control Systems

For regulation of liquid and air flows in solar systems designed for heating and cooling. UL Listed.

Sensors

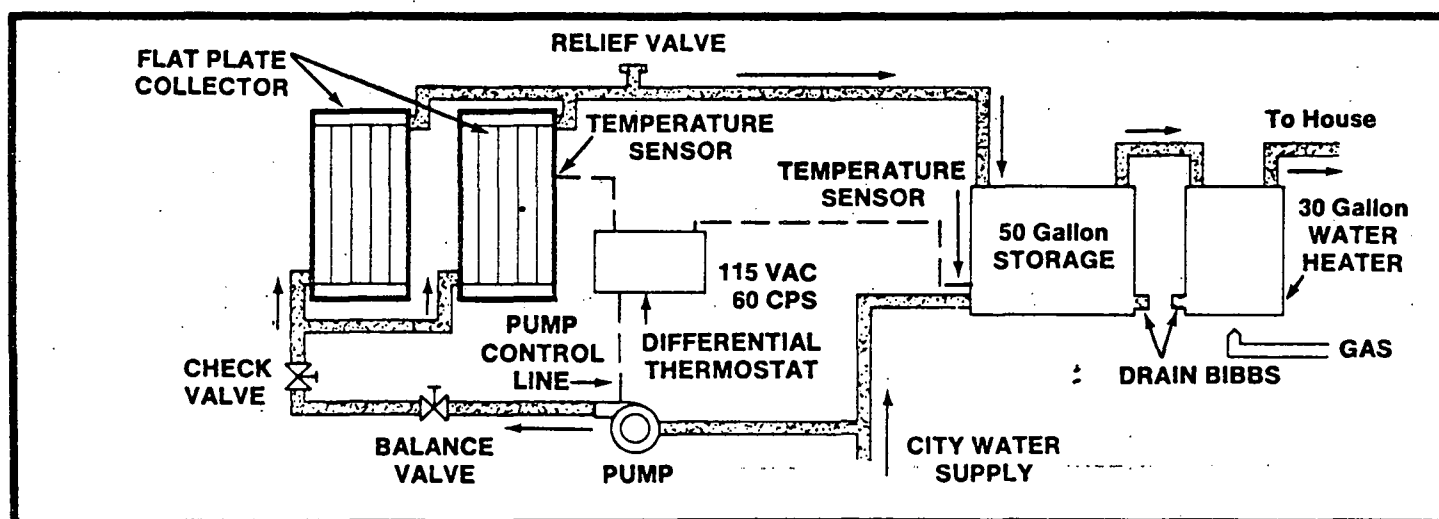
Compatible with standard plumbing fittings. Designed to withstand solar collector stagnation temperature. Designed for easy installation.

Instrumentation

Microprocessor for advanced systems monitoring and data reduction. Ideal for engineering studies of complex systems.

Pumps and valves

Valves designed specifically for solar applications. Pumps ideally suited for domestic water applications.



TYPICAL APPLICATION OF RHO SIGMA CONTROLS AND SENSORS

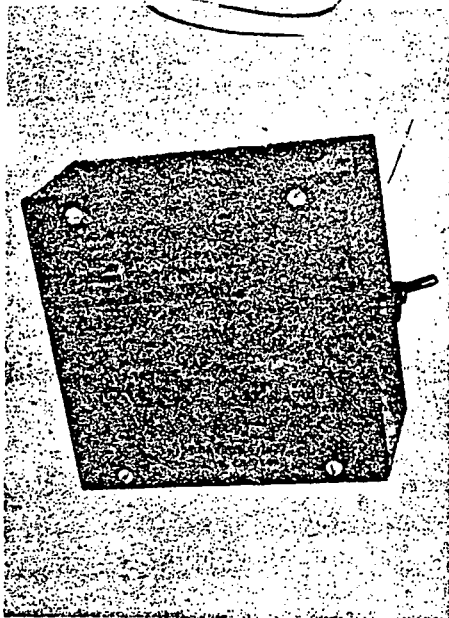
The objective of the system is to heat water using solar energy as the primary source. The variable and diffuse nature of solar energy mandates the use of a new kind of pump control to accomplish the task. The minimum requirement of the control is to sense conditions when the temperature difference between the solar collector and solar storage tank is sufficient to justify pump operation. An adequate temperature dead band should be incorporated into

the design to prevent harmful cycling of the pump in the mornings and evenings. Other requirements of the solar control may be:

- high limit turn-off to limit the temperature of the storage tank and
- anti-freeze protection circuit to protect the solar collector from freeze damage.

Refer to back page for further discussion.

RS 500



Proportional Solar Control

Input: 120 VAC

Output: 120 VAC, 6 amps

RS 500P-1HL

All solid state electronic circuitry varies speed as a function of the ΔT to achieve maximum efficiency in energy transfer.

Minimum flow

Full flow

$\Delta T = 3^\circ \pm 1^\circ F$

$\Delta T = 12^\circ \pm 1^\circ F$

Power delivered to pump is at full voltage and zero crossover, thus assuring full torque at low speed and absence of line noise. Design eliminates motor speed hysteresis and assures smoothly variable motor speed control. Compatible with permanent-capacitor and shaded-pole motors.

Standard features:

- pulsing indicator light indicates pump speed.
- switch meets local electrical code requirements for pump power disconnect switch when control is located within 6 feet of pump.
- high temperature turn-off to limit upper temperature of storage tank. (140°F standard)
- low temperature turn-on circuit turns on pump at specified low temperature to protect solar collectors from freeze damage. (37°F standard)

RS 500P-1H/L-2L/H

This versatile control has two 6-amp outputs providing great design freedom. The first output provides proportional control with optional high and low temperature override circuits identical to the RS 500P-1HL. The second output is normally configured to break the 110 VAC power to drain valves on the approach of freezing conditions. But the second output can also be configured to customer specifications to control a second pump or numerous other valve configurations including 24 VAC power. Additional flexibility is provided through various interlocks between the two outputs. Other options include power delivery through the second output to activate various cooling mechanisms on over-temperature signals from either the collector or the storage sensors. Contact our application engineers for details on these configurations and pump compatibility.

RS 104



Differential Thermostat with collector freeze-protection circuit.

Input: 120 VAC

Output: 2 independent relays; all contacts rated at 10 amps in standard and optional configurations.

In standard configuration, relays change state under the following conditions:

Relay A contacts make when:

$$\Delta T_{on} = T(\text{collector}) - T(\text{storage}) > 20^\circ \pm 3^\circ F$$

Relay A contacts break when:

$$\Delta T_{off} = T(\text{collector}) - T(\text{storage}) < 3^\circ \pm 1^\circ F$$

Relay B contacts make when:

$$T_{on} = T(\text{collector}) = 37^\circ \pm 1^\circ F$$

Relay B contacts break when:

$$T_{off} = T(\text{collector}) = 41^\circ \pm 1^\circ F$$

In optional configurations,

- 2PDT and 3PDT relays may be specified (contacts rated at 10 amps).
- Relay B may be controlled by the storage temperature; and
- the temperatures specified above for Relay B may be factory adjusted to customer specifications.

The RS 104 in its standard configuration energizes the pump when the collector is hot enough to heat the water in storage. Relay B can protect the collector from freeze-damage by turning the pump on, thus recirculating water, or can be used to open drain valves to empty the solar collectors.

In its optional configurations, great design freedom is available. For example, the SK version of the RS 104 can a) energize the pump to transfer energy from the collectors to the storage and, b) switch space heating systems to auxiliary energy sources when sufficient solar energy is not available in the solar storage to meet the demands of the room thermostat.

The following pumps have been tested and found to perform well with the RS 500:

Taco 007.

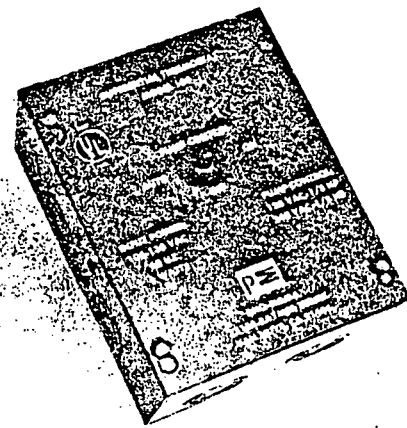
All Grundfos models.

March 821BR and 809.

Teel 1P761 and 1P760.

Sunstrand LA4302.

RS 106



Differential Thermostat

Input: 120 VAC

Standard Output:

SPDT Relay rated at 10 amps.

1/2 hp at 120 VAC

1/2 hp at 240 VAC

Switch with manual ON-OFF-AUTO positions.

Relay contacts make when

$$\Delta T_{on} = T(\text{collector}) - T(\text{storage}) > 20^\circ \pm 3^\circ F$$

Relay contacts break when

$$\Delta T_{off} = T(\text{collector}) - T(\text{storage}) < 3^\circ \pm 1^\circ F$$

Housed in standard NEMA box to assure compatibility with standard electrical trade hardware.

Wiring connections made by standard electrical trade procedures.

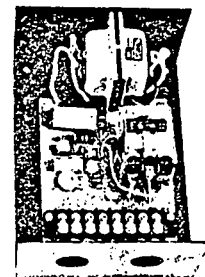
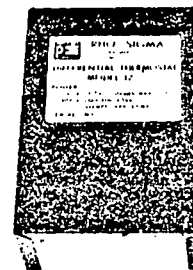
Optional outputs:

2PDT relay, 10 amp per contact.

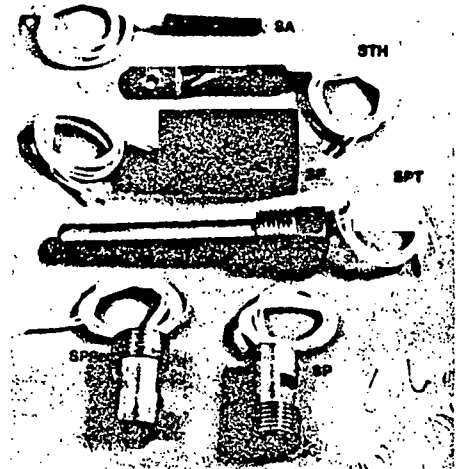
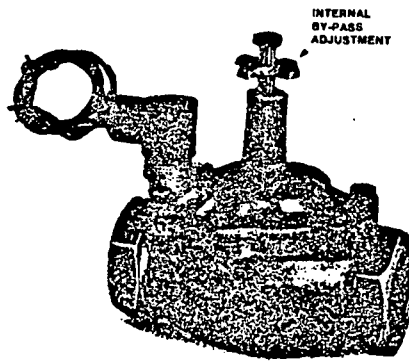
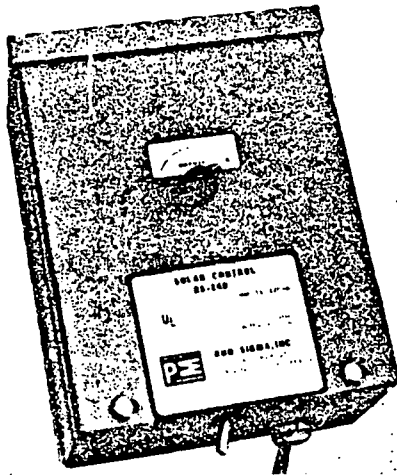
3PDT relay, 10 amp per contact.

Factory adjustment of T on and T off can be made to customer specifications.

RS 12



Provides differential control identical to the RS 106. Relay switches 120 VAC at 10 amps directly to the pumps.



Swimming Pool Solar Control.

Input: 220 VAC standard, 120 VAC (optional)

Output: 24 VAC at 35 VA

Thermostatic setting to prevent pool over heating (adjustable: 56°F-120°F).

Turns on solar heater when solar collectors are 6°F hotter than pool temperature when pool temperature is below thermostatic setting. When pool temperature is above the thermostatic setting, then water by-passes the solar collectors.

Easily wired into pump timers so that the control unit functions only when the pump is operating. Rain tight enclosure.

Easy retrofit installation into existing pool filtration systems.

Optional configurations available for normally open valves and 24 VDC solenoids.

Configurations available for direct switching of an auxiliary pump.

Material: Brass

Port Diameters: 1½" and 2"

Low voltage solenoid

Pressure drop: 1 psi and 40 gpm (1½" valve)

Internal Bypass: Valve modified to Rho Sigma's specifications. Unique adjustment on stem enables installer to conveniently limit the amount of valve closure. Thus, high back-pressure (developed within the collector array) on the pump may be relieved through the internal by-pass of the valve. Internal bypass also provides a drain-down path for the collector supply line when the pump turns off.

Specify either normally open or normally closed valve configuration.

Positive opening assured by connection to suction side of pump.

All Rho Sigma sensors are electrically identical and interchangeable and are designed to withstand stagnation temperatures of solar collectors. Two and only two sensors are required with each differential thermostat.

The SA Sensor is the temperature sensing element encased in epoxy.

The ST Sensor has a copper housing with a hole punched in it for bolting directly to the collector plate or suspending inside air ducts. Alternatively, a radiator hose pipe clamp may be used to secure the rugged sensor to the surface of a pipe. Or it may be slipped inside the insulation of the storage tank.

The SF Sensor is a 1"x1"x2", sand-blasted and black-anodized aluminum sensor designed for use with unglazed solar collectors or in high flow rate, low delta-T systems. The screw provided with the sensor may be used to mount the sensor near the collector where it will sense the temperature and availability of solar energy at the collector. Designed primarily for all use with the RS 240.

The SPT-XX Sensor has a probe at the end of its ½" pipe threads. The temperature-sensing element is at the tip of the all brass sensor. It is designed primarily for insertion into tanks to obtain the most accurate measurement of the fluid or air temperature inside. Standard probe lengths are 1½", 3", 4½", 6", 12", and 24".

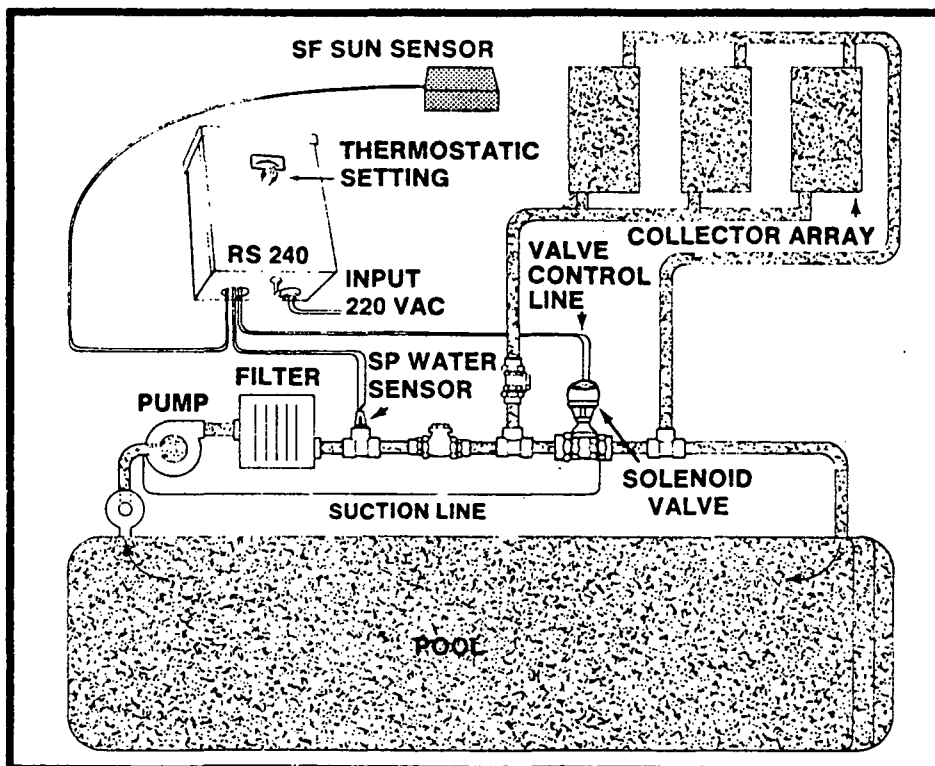
The SP Sensor is epoxied into a rugged brass housing with standard ½" pipe threads for easy installation into standard plumbing fixtures.

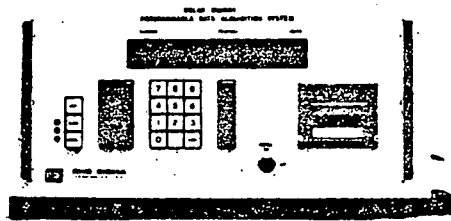
The SPR Sensor may be screwed into the end of a pipe which may be inserted into the top of a deep tank. Wires run inside of the pipe to the control. Provides accurate sensing of temperature at the bottom of deep tanks.

Dual Thermistors may be specified in any housings. One thermistor provides control signals; the other thermistor may provide signals for instrumentation or a second solar control, (e.g., Model SP-2).

Sensors will provide strong signals even when separated from the controller by 200 feet.

TYPICAL POOL INSTALLATION





The RS 5080 is a data collection and data processing system. It accepts inputs from a wide range of sensors (temperatures, flows, pyranometers, etc.) Sensors are sampled at a predetermined frequency ranging from every 2 seconds upward. Frequency depends on resolution desired and total number of sensors involved.

Basic equations of the form:

$Q = C_p \int \dot{m} (T_2 - T_1) dt$ are solved for collectors, storage tanks and back-up energy sources. Collector efficiency is determined as:

$$\xi = \frac{Q_c}{H}, \quad H = \text{insolation and } Q_c = \text{BTU's added to flow}$$

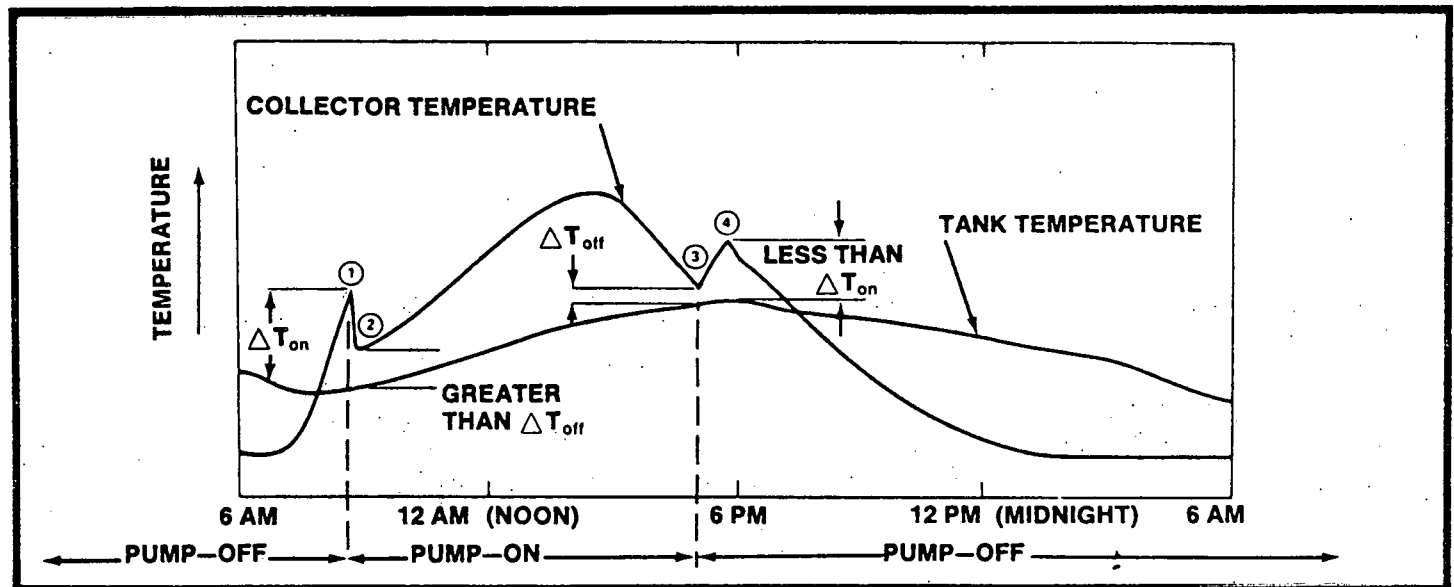
stream through collector. Both instantaneous and long term average efficiencies are calculated by the microprocessor. The 5080 also determines the % of the total load which is supplied by solar system:

$$\xi_{\text{solar}} = \frac{Q_{\text{solar}}}{Q_{\text{solar}} + Q_{\text{back-up}}}$$

All data is printed out by the included printer on demand and/or at preset intervals. Results of total system performance are integrated over each 24 hours of operation and also printed as a running total.

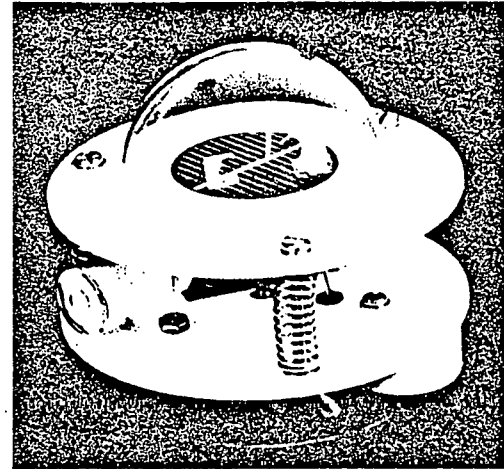
TYPICAL OPERATING CYCLE FOR A SOLAR HEATING SYSTEM

Figure 1 indicates a representative example of the sequence of events in a normal daily solar heating/hot water cycle under the control of the Differential Thermostat.



As shown in Figure 1, the pump is initially off. As the sun rises the collector temperature rises sharply above the tank temperature. This is shown as ΔT_{on} . This ΔT turns the pump on. The cooler tank water carries off the heat in the collector and causes the initial drop to the point marked 2. If the ΔT at point 2 is greater than the ΔT_{off} , then the pump continues to operate.

As evening approaches, the collector temperature moves below the ΔT_{off} threshold at the point marked 3. The pump is turned off and due to the stagnation condition (i.e., the sun is heating the collector but the pump is not on) the temperature in the collector rises as shown at point 4. If ΔT_{on} is set sufficiently greater than ΔT_{off} , the pump will



The RS 1008 is a photovoltaic pyranometer with the following specifications:

- instantaneous response,
- output approximately 500MV at 1 KW/square meter solar input,
- cosine response close to thermopile pyranometers.
- temperature compensated to maintain pyranometer within -2.2% at 0°C (datum point = 30°C) and 1.0.8% at 60°C (datum point = 30°C).
- accuracy within 4% of a Class I instrument.

Mounting screw-hole is compatible with camera tripods. Dessicant bottle prevents condensation in dome.

remain off. The adjustments of the threshold and hysteresis settings in the Differential Thermostat are preset at the factory.

The hysteresis circuit is a special feature of the Differential Thermostat which prevents the pump from being unnecessarily turned on and off immediately following an initial pump turn-on or turn-off event. Without this circuit feature, the sharp peaks of temperature rise shown at points 1 and 4 would cause the pump to repeatedly switch on and off, causing unnecessary wear on the pump, pump motor, and relay contacts controlling pump operation, as well as reduced efficiency in transferring heat energy from the collector to the storage tank.



RHO SIGMA

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DIFFERENTIAL THERMOSTAT APPLICATION NOTES

INTRODUCTION

The Differential Thermostat is designed to provide control functions for homes or other buildings employing solar heating and hot water systems. With the advent of solar heating and hot water systems, a new form of thermostat is required. The following discussion gives a brief description of the operation of a differential thermostat as compared to that of the thermostat used in conventional heating systems and/or hot water systems.

In the conventional house the thermostat is set at the desired room temperature, typically 70 degrees for heating and 140 degrees for hot water. When either temperature is below this setting the heating system is turned on. When the temperature rises above this setting the heating system is turned off. This cycle is repeated throughout the day and night always with reference to the 70 degree (or 140 degree) reference point setting.

Since the heat source in a conventional heating system always provides heat at a temperature substantially higher than desired temperature, the specific temperature of the burner output need not be known. Thus, the thermostat in a conventional system is required to sense only one temperature — room (or hot water) temperature — to perform the necessary control function. As will be shown, a single temperature measurement is not adequate for a solar heating system.

The basic solar system used in many installations includes a flatplate collector on the roof of the building supplying water to a storage tank, and a pump to recirculate water from the bottom of a storage tank back up to the collector. During most of the daylight hours, the sun's radiation incident on the collector will cause the temperature of the water at the collector to be higher than that at the storage tank. Under these conditions, the pumping and recirculating action achieves the desired objective of transferring heat energy into the storage tank for subsequent use in building or water heating.

At night, however, or under overcast daytime conditions, the collector water temperature will tend to fall below the storage tank water temperature. Continued pumping and recirculation under these conditions would be self-defeating; since heat energy would be removed from, not added to, the storage tank.

The pump could of course be manually turned on when it appears that the collector is capable of supplying heat energy to the storage tank and manually turned off when it is not. But this would be inefficient if the collector temperature and storage tank temperature are not accurately known and compared, and would also be burdensome and inconvenient to the user of a solar heating system. A much more effective solution is to employ the Rho Sigma Differential Thermostat to automatically sense and compare the collector and storage tank temperatures, and to control the daily on-off cycling of the pump in the optimum manner.

TYPICAL OPERATING CYCLE FOR A SOLAR HEATING SYSTEM

Figure 1 indicates a representative example of the sequence of events in a normal daily solar heating/hot water cycle under the control of the Differential Thermostat. The terms ΔT_{off} and ΔT_{on} which appear in the figure are defined as follows:

ΔT_{off} = temperature difference between collector exit water temperature and storage tank water temperature sufficient to turn pump off.

ΔT_{on} = temperature difference between collector exit water temperature and storage tank water temperature sufficient to turn pump on.

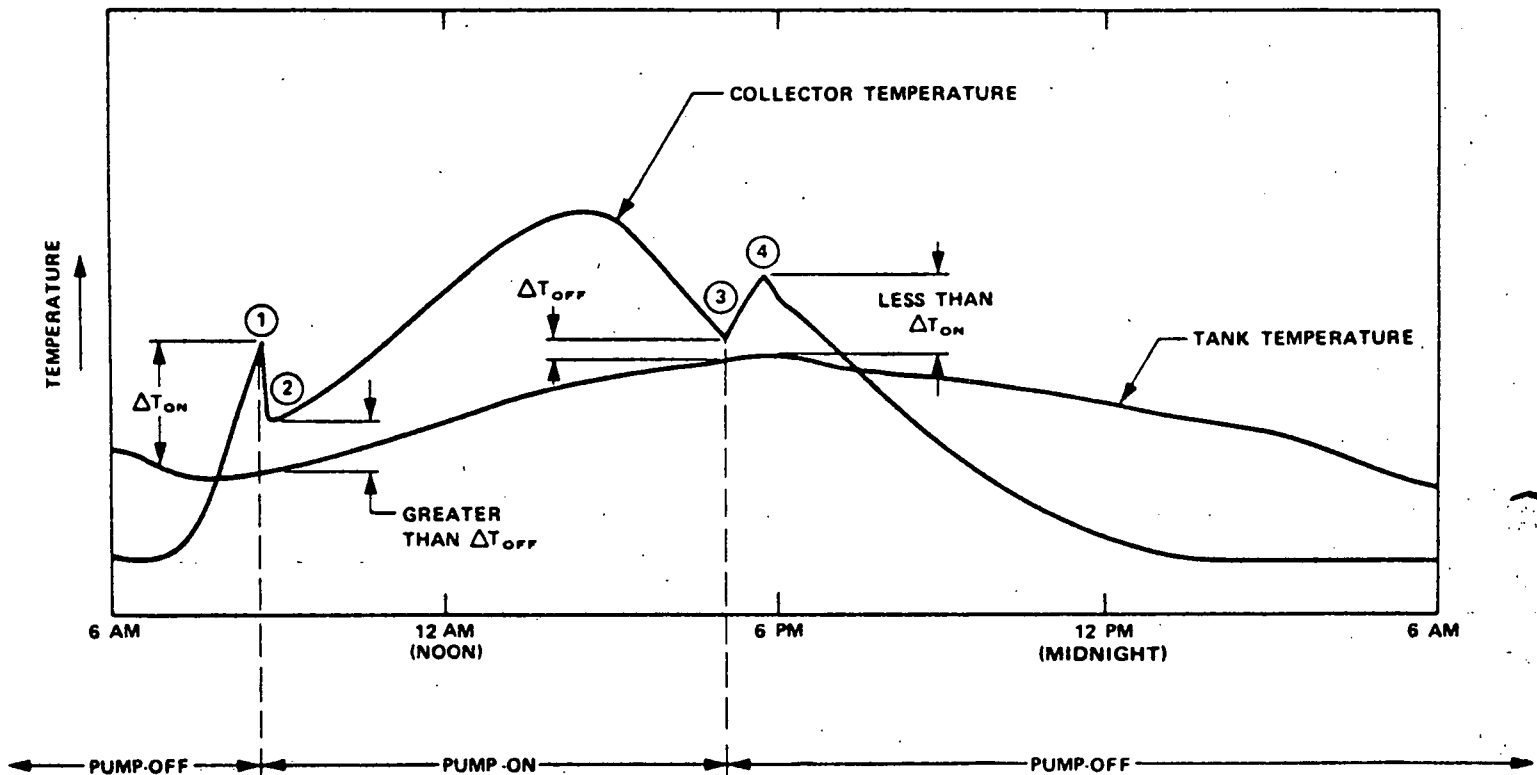


FIGURE 1 - PUMP CYCLING UNDER CONTROL OF THE DIFFERENTIAL THERMOSTAT

As shown in Figure 1, the pump is initially off. As the sun rises the collector temperature rises sharply above the tank temperature. This is shown as ΔT_{on} . This ΔT turns the pump on. The cooler tank water carries off the heat in the collector and causes the initial drop to the point marked 2. The ΔT at point 2 is however greater than the ΔT_{off} and the pump continues to operate.

As evening approaches, the collector temperature moves below the ΔT_{off} threshold at the point marked 3. The pump is turned off and due to the stagnation condition (i.e., the sun is heating the collector but the pump is not on) the temperature in the collector rises as shown at point 4. If ΔT_{on} is set sufficiently greater than ΔT_{off} , the pump will remain off. The adjustments of the threshold and hysteresis settings in the Differential Thermostat are correctly preset at the factory.

The hysteresis circuit is a special feature of the Differential Thermostat which prevents the pump from being unnecessarily turned on and off immediately following an initial pump turn-on or turn-off event. Without this circuit feature, the sharp peaks of temperature rise shown at points 1 and 4 would cause the pump to repeatedly switch on and off, causing unnecessary wear on the pump, pump motor, and relay contacts controlling pump operation, as well as reduced efficiency in transferring heat energy from the collector to the storage tank.

SOLAR HOT WATER SYSTEM APPLICATION OF DIFFERENTIAL THERMOSTAT

Figure 2 shows a typical solar hot water system installation. The 50 gal. storage tank operates as a pre-heat system for the conventional 30 gal. gas (or electric) system. With 40 to 50 square feet of collector area this system will supply 60%, or more, of the hot water needed for a family of four under most insolation (sun) conditions. During extended periods of cloud conditions, the 30 gal. gas water system functions as augmentation. During clear sunny days, even under low ambient temperature conditions, the storage tank water can rise to very high temperatures. To prevent scalding, it is suggested that a "high set" thermostat be used in the storage tank as shown. This thermostat should be set in the range of 160°F and connected in series with the pump motor. This will prevent the storage tank water from rising above this temperature. Without the "high set" thermostat, tank temperatures could exceed 180°F on clear sunny days. (For heating systems this "high set" thermostat would not be required.)

The Differential Thermostat can be installed at any convenient indoor location. (Ruggedized, weather-proof models can be furnished when outdoor installation is required.) Thermistor Sensor #1 is inserted in the collector exit water line as shown. A pair of wires run from this sensor to the Differential Thermostat. Similarly, at the exit line from the storage tank, a pair of wires from Thermistor Sensor #2 connect to the Differential Thermostat. Action of the Thermostat operates a set of relay contacts for controlling the pump motor. If desired, the pump motor control lines can be placed in series with the high set thermostat to prevent the pump from operating when the upper tank temperature is reached.

Connectors are provided on the Differential Thermostat for the 120 VAC, 60 cycle, required to operate the unit as well as for the two sensor inputs and the pump motor control lines.

Figure 3 illustrates the physical configuration of the Differential Thermostat. Refer to the specification sheet for this unit for additional technical and performance information.

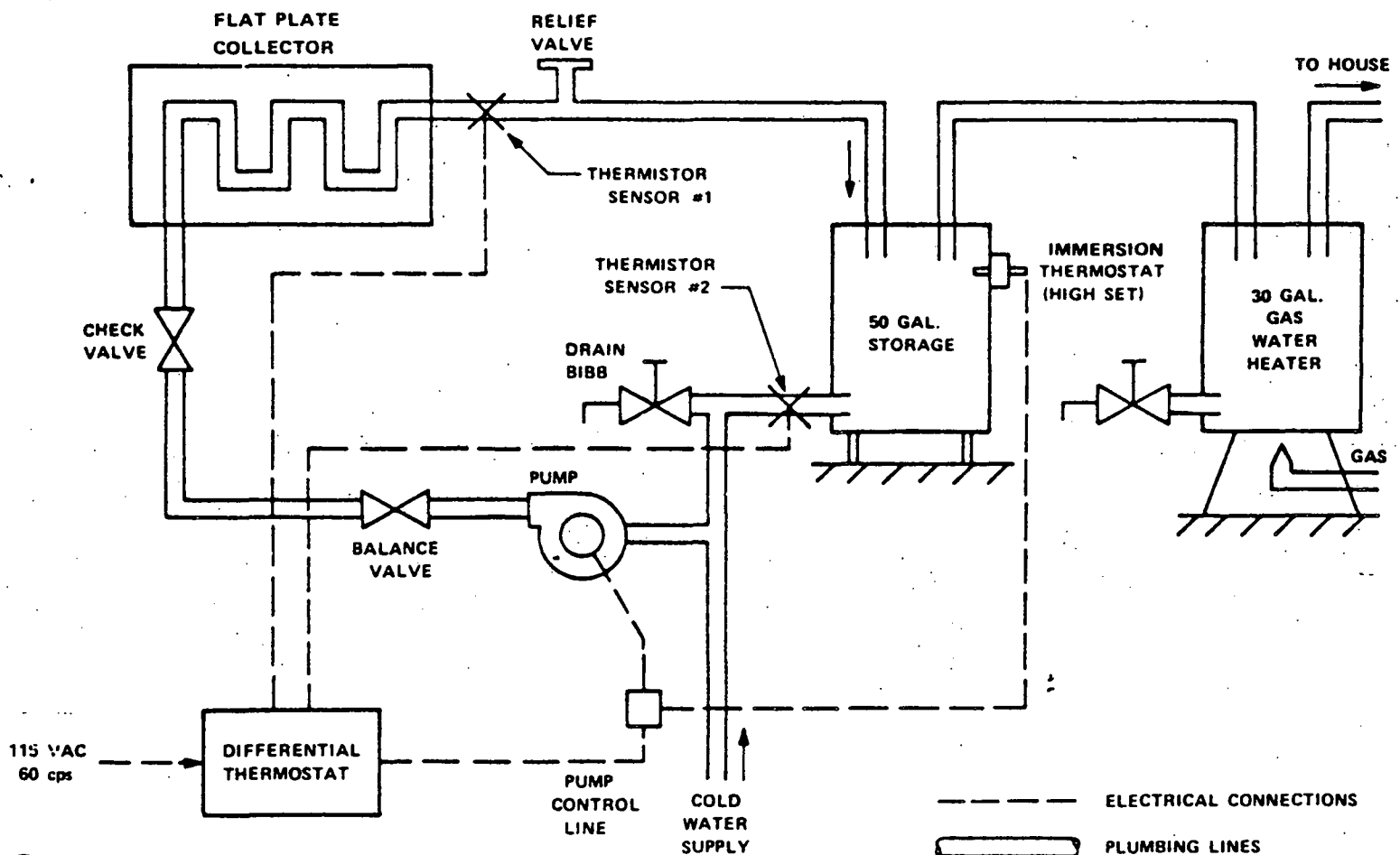
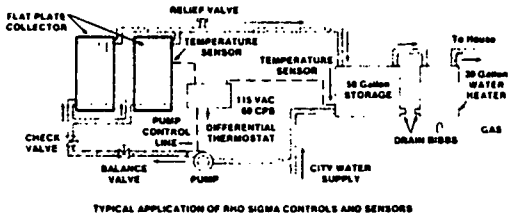


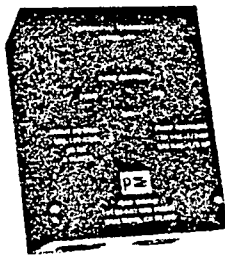
FIGURE 2 - TYPICAL SOLAR HOT WATER SYSTEM INSTALLATION



SOLAR CONTROLS & INSTRUMENTATION

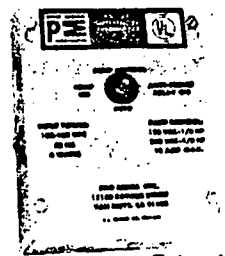


Rho Sigma's manufacturing and engineering departments are devoted exclusively to the development and manufacture of solar energy controls and instruments. Our standard product line, partially described on this page, provides the widest control capability currently available to the solar energy industry. Our engineering efforts are directed toward system designs submitted by engineering and manufacturing firms as well as systems conceived in-house. These efforts have led to the expansion of our solar control capability to encompass solar systems incorporating heat pumps, air conditioning and other equipment. The company has also developed a line of instruments to meet the unique needs of the solar energy industry. Rho Sigma welcomes the opportunity to work with you on advanced solar control problems. We believe that the new controls which we are building today will become the standard control designs of tomorrow. Contact our engineering department.



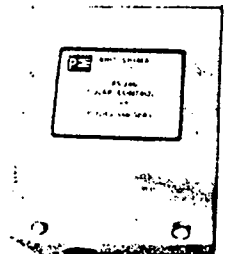
SPACE HEATING RS106
 Input: 120 VAC
 Output: SPDT
 1/3 hp @ 120 VAC
 1/2 hp @ 240 VAC
 Available Outputs:
 2 PDT @ 10 amps
 3 PDT @ 10 amps
 Relay energizes when:

$\Delta T_{on} = T_{(collector)} - T_{(storage)} > 20^{\circ}F.$
 Relay de-energizes when:
 $\Delta T_{off} = T_{(collector)} - T_{(storage)} < 3^{\circ}F.$
 Adequate room in high-voltage compartment to accommodate a booster relay.

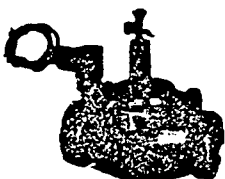


SPACE HEATING RS104
 Input: 120 VAC
 Output: 2 relays SPDT
 1/3 hp @ 120 VAC
 1/2 hp @ 240 VAC
 Available Outputs:
 2 PDT @ 10 amps
 3 PDT @ 10 amps

Relay A is identical to the RS106.
 Relay B energizes when:
 $T_{(collector)} = 37^{\circ} \pm 1^{\circ}F.$
 Relay B de-energizes when:
 $T_{(collector)} = 41^{\circ} \pm 1^{\circ}F.$



POOLS & SPAS RS260
 Input: 120 VAC
 240 VAC optional
 Output: 24 VAC @ 35 VAC
 Designed to control NO and NC valves installed in pool filter system.
 Switch and high-limit control to prevent pool overheating.



RS950
 Brass valve (1 1/2" or 2") built to Rho Sigma specifications to allow for adjustable internal by-pass to reduce back pressure on filter pump.

DOMESTIC WATER RS500-1 Series

Input: 120 VAC
 Output: 120 VAC @ 6 amps
 Designed for permanent capacitor and shaded-pole circulator pumps.



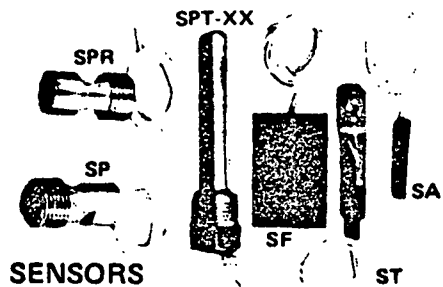
Increases solar energy collection efficiency by modulating system flow in proportion to temperature differential between collector and storage. High-

temperature circuit can turn pump off when tank approaches excessive temperatures. Low-temperature circuit can turn pump on when collector approaches freezing temperatures.

RS500-2 Series -- Dual Output

Input: 120 VAC
 Output A: Identical to RS500-1 Series
 Output B: 120 VAC @ 3 amps

Dual output control with first output identical to RS500-1 Series. Second output adds another dimension of versatility. It can control valves to drain the system when freezing conditions approach and can be interlocked with first output to inhibit pump operation when drain valves dump collector, and can turn on a second pump in a heat exchange system. High-temperature and low-temperature circuits can override other signals to the second output and make or break the power out of it.



SENSORS

Two and only two sensors are required with each differential thermostat. The SA Sensor is the temperature sensing element encased in epoxy. The ST Sensor has a copper housing with a hole punched in it for bolting directly to the collector plate. A radiator hose pipe clamp may be used to secure the rugged sensor to the surface of a pipe.

The SF Sensor is an anodized sensor designed for use with unglazed solar collectors or in low ΔT systems, and for use with the RS260.

The SPT-XX Sensor has 1/2" pipe threads. Standard probe lengths are 1 1/2", 4 1/2", 6", 12" and 24".

The SP Sensor has standard 1/2" pipe threads for easy installation into standard plumbing fixtures.

The SPR Sensor may be screwed into the end of a pipe which may be inserted into the top of a deep tank. Provides accurate sensing of temperature at the bottom of deep tanks.

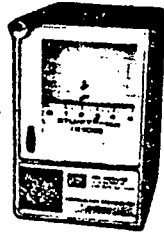
Dual Thermistors may be specified in any housing.



RS5080
 Microprocessor for on-site data acquisition of all energy-related system parameters.

RS1009, RS1008

Photovoltaic pyranometer with single track recorder calibrated to it for measurement of solar energy in engineering units.



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RHO SIGMA

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RHO SIGMA'S LINEARIZATION

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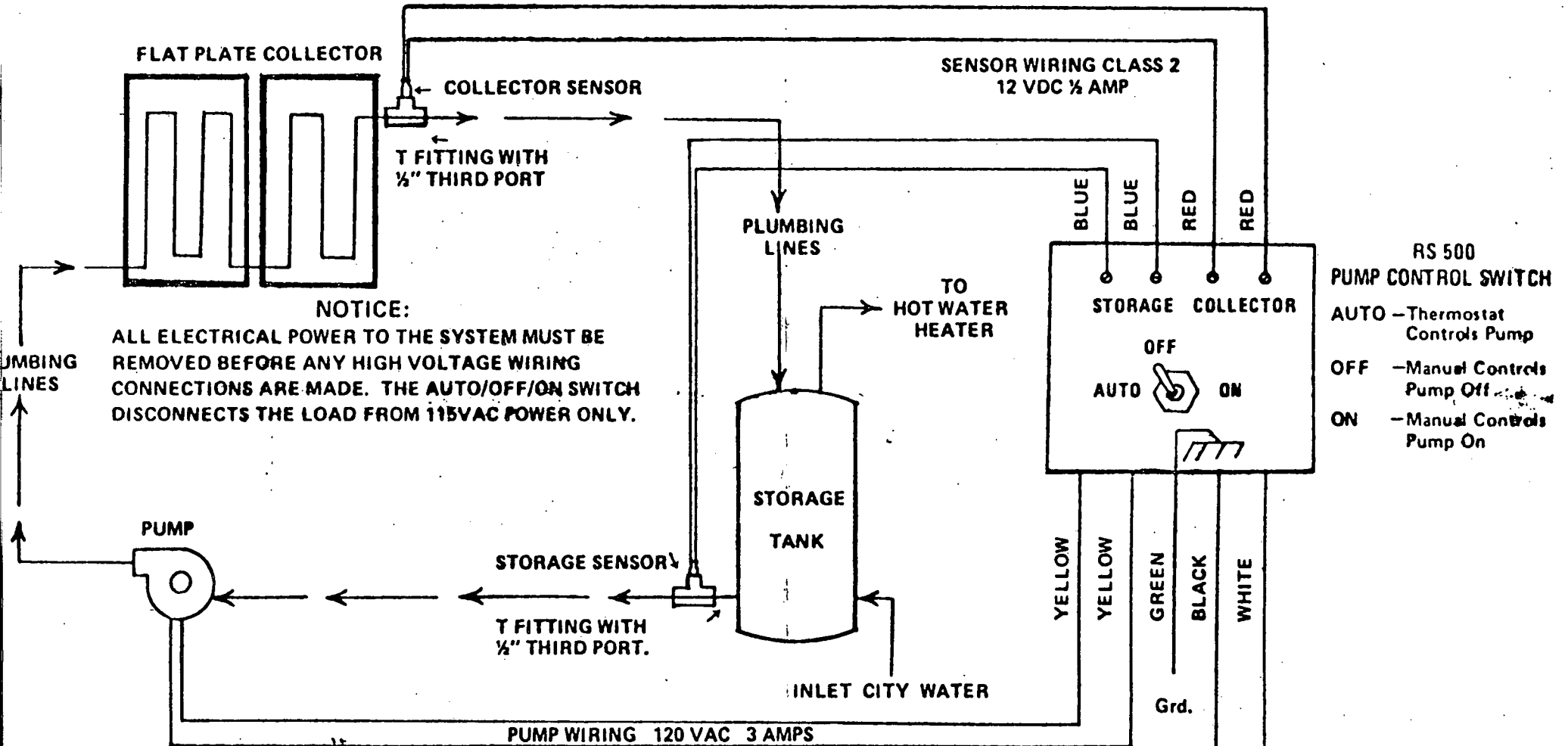
REDWOOD MECHANICAL

Electronic linearization of the sensor signal is accomplished by an entire matrix (over 20 components) incorporated on our printed circuit board. This function eliminates the natural tendency for drift that occurs at high and low temperature exposures to either sensor. The control accepts the conventional signal from the sensors and "corrects" or compensates for temperature extreme error. This is accomplished within the RS 500 & RS 360 controls, on redesigned printed circuit boards. Linearity circuitry cannot be added to early control models. The attached charts show linearity at work in a Rho Sigma control.



DIFFERENTIAL THERMOSTAT INSTALLATION DRAWING

RS 500-1 SINGLE OUTPUT (Rev. A)



RS 500 PUMP CONTROL SWITCH

AUTO - Thermostat Controls Pump

OFF - Manual Controls Pump Off

ON - Manual Controls Pump On

PUMP MOTORS (YELLOW OUTPUT)		
500 P PROPORTIONAL	1/10 HP	SHADED POLE OR PERMANENT CAPACITOR
500S ON / OFF	1/10 HP	ANY

LIGHT INDICATOR	
PUMP	LIGHT
OFF	OFF
PROPORTIONAL SPEED	PULSING ON
ON	ON

WARNING:
ALL FIELD WIRING MUST BE RATED AT 90°C MIN.



**TEMPERATURE vs. RESISTANCE
SPECIFICATIONS**

**RHO SIGMA
SENSORS**

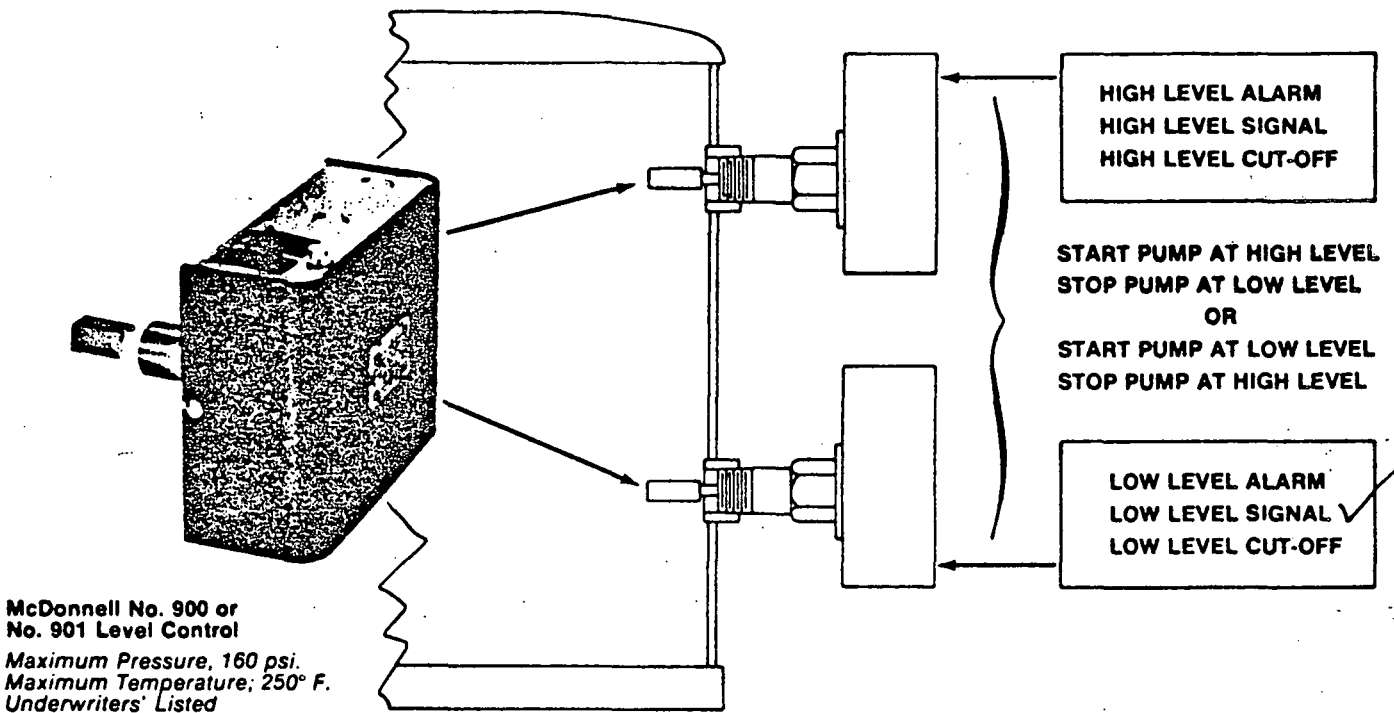
°F	°C	RESIST. EQUIV.	°F	°C	RESIST. EQUIV.	°F	°C	RESIST. EQUIV.
32	0.0	32654.	106	41.1	5093.	180	82.2	1170.
34	1.1	30859.	108	42.2	4873.	182	83.3	1129.
36	2.2	29174.	110	43.3	4663.	184	84.4	1090.
38	3.3	27592.	112	44.4	4464.	186	85.6	1053.
40	4.4	26105.	114	45.6	4274.	188	86.7	1017.
42	5.6	24709.	116	46.7	4093.	190	87.8	982.
44	6.7	23395.	118	47.8	3921.	192	88.9	949.
46	7.8	22160.	120	48.9	3758.	194	90.0	917.
48	8.9	20998.	122	50.0	3602.	196	91.1	886.
50	10.0	19903.	124	51.1	3453.	198	92.2	857.
52	11.1	18873.	126	52.2	3312.	200	93.3	828.
54	12.2	17903.	128	53.3	3177.	202	94.4	801.
56	13.3	16988.	130	54.4	3048.	204	95.6	775.
58	14.4	16126.	132	55.6	2925.	206	96.7	749.
60	15.6	15313.	134	56.7	2808.	208	97.8	725.
62	16.7	14546.	136	57.8	2697.	210	98.9	702.
64	17.8	13822.	138	58.9	2590.	212	100.0	679.
66	18.9	13139.	140	60.0	2488.	214	101.1	658.
68	20.0	12493.	142	61.1	2391.	216	102.2	637.
70	21.1	11883.	144	62.2	2298.	218	103.3	617.
72	22.2	11307.	146	63.3	2209.	220	104.4	597.
74	23.3	10762.	148	64.4	2124.	222	105.6	579.
76	24.4	10247.	150	65.6	2043.	224	106.7	561.
78	25.6	9760.	152	66.7	1966.	226	107.8	543.
80	26.7	9298.	154	67.8	1891.	228	108.9	527.
82	27.8	8862.	156	68.9	1820.	230	110.0	511.
84	28.9	8448.	158	70.0	1753.	232	111.1	495.
86	30.0	8056.	160	71.1	1688.	234	112.2	480.
88	31.1	7685.	162	72.2	1625.	236	113.3	466.
90	32.2	7333.	164	73.3	1566.	238	114.4	452.
92	33.3	6999.	166	74.4	1509.	240	115.6	438.
94	34.4	6683.	168	75.6	1454.	242	116.7	425.
96	35.6	6382.	170	76.7	1402.	244	117.8	413.
98	36.7	6097.	172	77.8	1351.	246	118.9	401.
100	37.8	5827.	174	78.9	1303.	248	120.0	389.
102	38.9	5570.	176	80.0	1257.	250	121.1	378.
104	40.0	5328.	178	81.1	1213.			

Accuracy of sensors is $\pm 4^{\circ}\text{C}$ over range of $0^{\circ}\text{--}70^{\circ}\text{C}$. Maximum operating temperature is 177°C (350°F). Sensors having tighter tolerances are available.

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INDUSTRIAL APPLICATIONS

McDonnell 900 Series Probe Controls



McDonnell Control for Tanks and Pressure Vessels up to 160 psi.

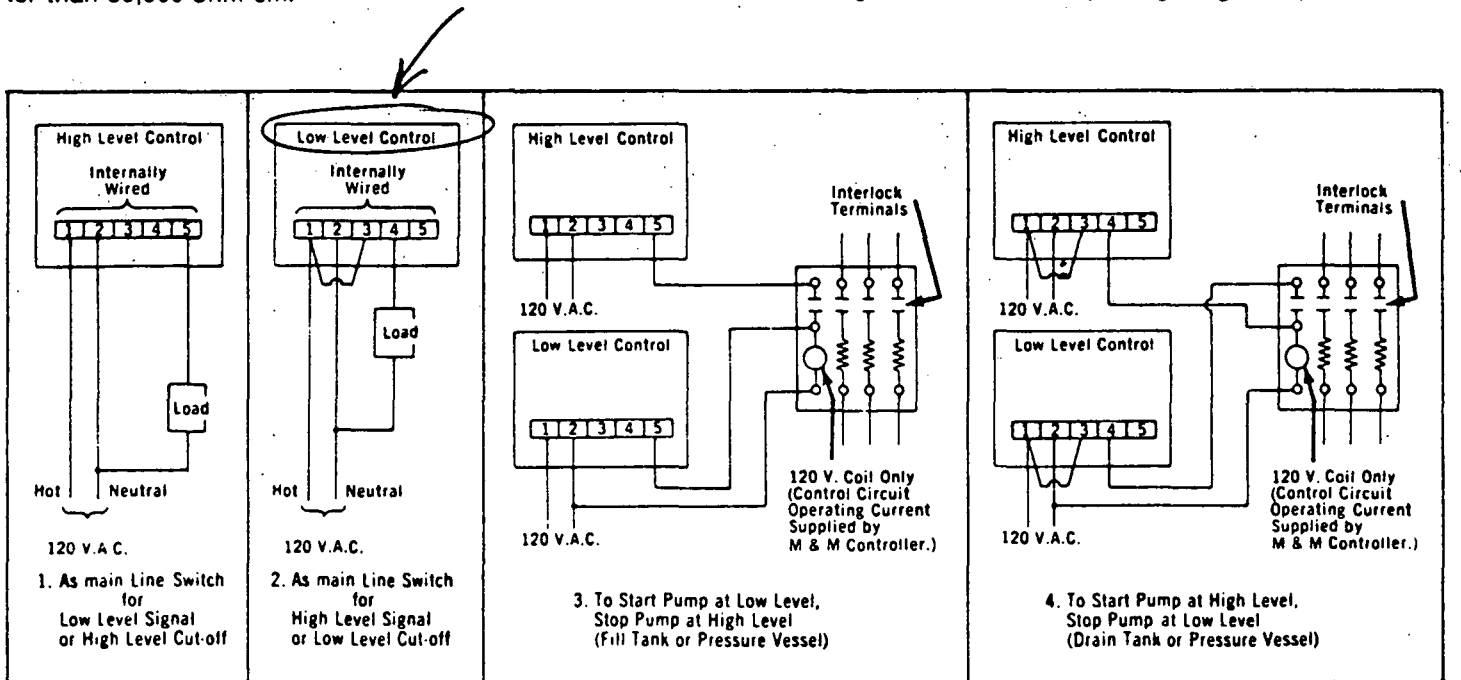
For tanks or pressure vessels up to 160 psi., any of the essential functions listed above—either singly or in combination—can be accomplished by use of the McDonnell 900 Series Level Controls.

Whether the desired operation is to ring an alarm, turn indicating lights on or off at a remote control panel, start and/or stop feed or drain pumps, or energize an electric valve . . . it can be done automatically.

McDonnell 900 Series Controls will operate in ordinary tap water or other compatible liquids with a resistance no greater than 50,000 ohm-cm.

Typical Example: A water storage tank installed in an industrial plant. A high level alarm (Wiring Diagram 2) is utilized to indicate a flooding condition, and a low level alarm (Wiring Diagram 1) is utilized to indicate a below normal level condition. These situations could occur from a sticking or leaking fill valve, or an inoperative pump.

Typical Example: A small storage tank from which liquid is drawn for a manufacturing process. To maintain an adequate level at all times, a solenoid valve (or pump) is turned on at a predetermined low level, and remains on until a predetermined high level is reached (Wiring Diagram 3).



INSTALLATION INSTRUCTIONS—McDonnell 900 Series Probe Controls

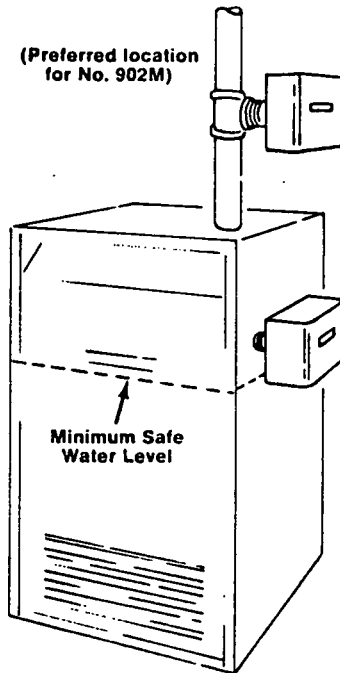
Model Number	Automatic Reset	Manual Reset*	Test Light	Retard Circuit
900	X		X	
900M		X	X	
901	X			
901M		X		
902M		X	X	X

*Manual Reset Feature Pat. 3,834,357.

Note: Momentary power interruptions will cause No. 900M and No. 901M to break circuit; manual reset button must be pushed to restore operation. If objectionable, use Automatic Reset No. 900 or No. 901, or Manual Reset No. 902M which has special retard circuit.

Can be used as Low Water Cut-offs on Hot Water Boilers or as Liquid Level Controls to maintain or sense levels in Tanks

(Preferred location for No. 902M)



LOCATION ON HOT WATER BOILERS

The 900 Series may be installed in the boiler above the lowest safe water level established by the boiler manufacturer. Some manufacturers provide a suitable opening in the side of the boiler.

If necessary, the cut-off may be installed in a 1 1/4 inch or larger Tee in the vertical riser above the boiler. Caution: If installed above the boiler, make sure the system is properly designed and fitted with vents to prevent air binding which could break the control circuit.

BOILER OR TANK WATER

Control will function satisfactorily in ordinary tap water as supplied by practically all public water systems. Specific resistance of boiler or tank water can be verified by the test button; if lamp lights, the circuit is complete through water to ground. Demineralized or distilled water with a specific resistance greater than 50,000 ohm-cm. may require the addition of boiler compound.

HORIZONTAL MOUNTING

When the 900 Series is installed with electrode assembly in horizontal position, the flat surface of the "U" shaped probe should be in the vertical position. Factory-assembled unit is in correct position when test and reset buttons are either at top or at bottom.

VERTICAL MOUNTING

The 900 Series can be installed in a top opening of the boiler or tank.

ELECTRICAL AND OPERATIONAL

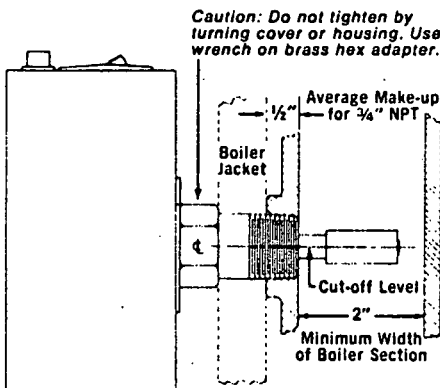
Wire per instructions, fill system and energize electrical circuits. For controls with manual reset, depress Reset Switch to start burner.

FLUID LEVEL TEST

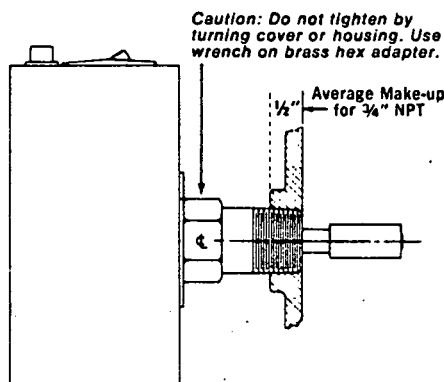
For controls with Reset and Test Switches, first depress the Reset Switch. For all controls with Test Switch, depress the Test Switch and note lamp. Normally, light "ON" indicates fluid level above probe, light "OFF," fluid level below probe. No light could also indicate a probe with excessive scale deposits. For controls without Test Switch, drain until level is below the probe. Burner circuit will open and alarm circuit, if connected, will close.

GROUNDING PROBE TEST

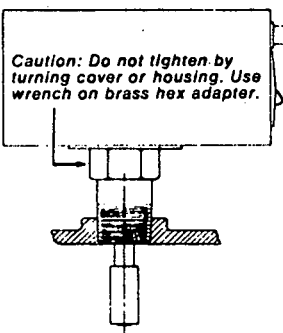
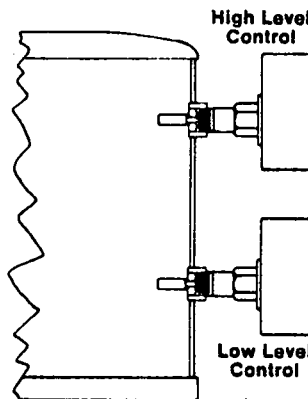
With the liquid level below the probe, depress the Test Switch. A light "ON" could indicate a grounded probe. For controls without a Switch and with liquid level below the probe, a closed burner circuit could indicate a grounded probe: Replace the grounded probe.



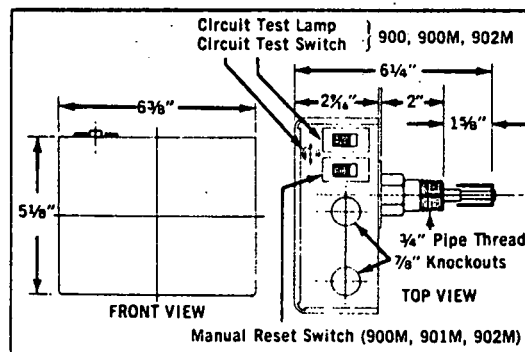
INSTALLATION ON HOT WATER BOILERS



INSTALLATION ON TANKS—For High and/or Low Level Control (See Reverse Side for Wiring)



VERTICAL INSTALLATION



WIRING INSTRUCTIONS—McDonnell 900 Series Probe Controls



OPERATING DUTY

Maximum Pressure—160 psi.
Maximum Temperature—250° F.

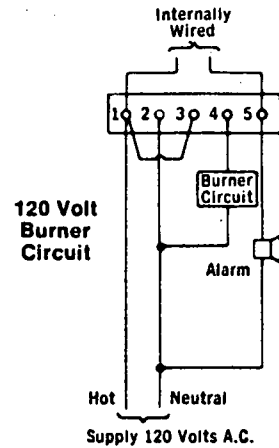
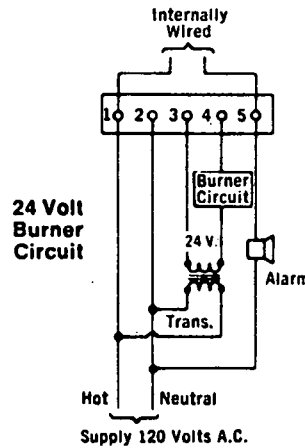


ELECTRICAL RATINGS IN AMPERES

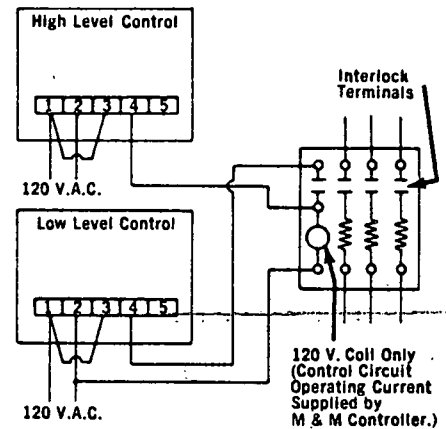
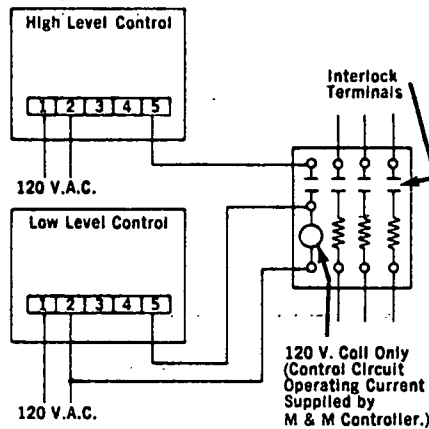
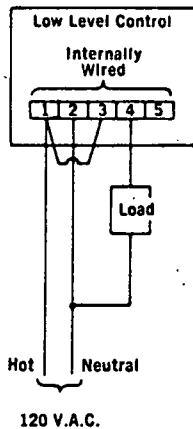
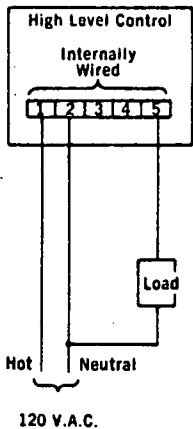
Motor Duty:	120 V.A.C.	240 V.A.C.
Full Load	5.8	2.9
Locked Rotor	34.8	17.4
Pilot Duty:	125 VA 120-240 V.A.C.	

IMPORTANT Terminals No. 1 and No. 2 must always be wired to 120 volts 60 Hz. Terminals No. 3 and No. 4 are isolated contacts, and may be wired for 24 volts, 120 volts or 240 volts.

APPLICATIONS ON HOT WATER BOILERS



APPLICATIONS ON TANKS AND PRESSURE VESSELS



1. As main Line Switch for Low Level Signal or High Level Cut-off

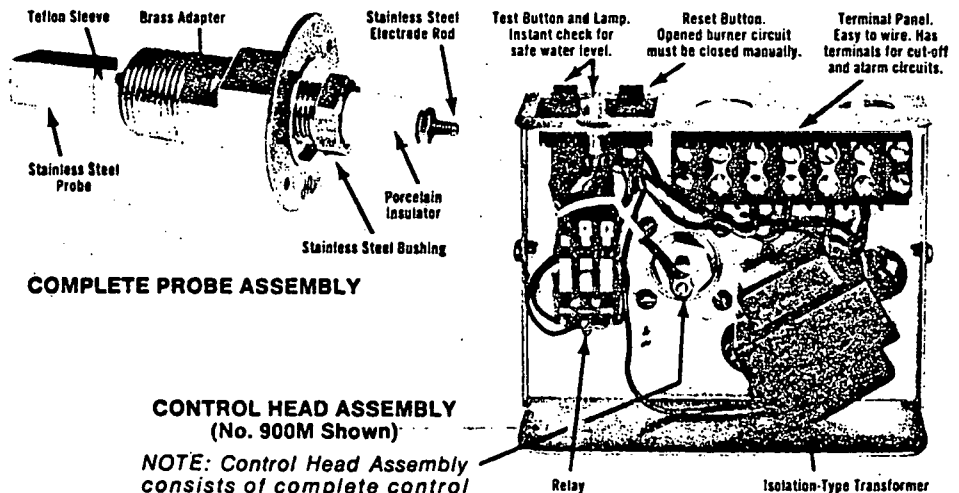
2. As main Line Switch for High Level Signal or Low Level Cut-off

3. To Start Pump at Low Level, Stop Pump at High Level (Fill Tank or Pressure Vessel)

4. To Start Pump at High Level, Stop Pump at Low Level (Drain Tank or Pressure Vessel)

REPLACEMENT PARTS McDonnell 900 Series

Model Number	Control Head Assembly	Complete Probe Assembly
900	353019	353025 (All Models)
900M	353020	
901	353021	
901M	353022	
902M	353023	



COMPLETE PROBE ASSEMBLY

CONTROL HEAD ASSEMBLY
(No. 900M Shown)

NOTE: Control Head Assembly consists of complete control less Complete Probe Assembly.

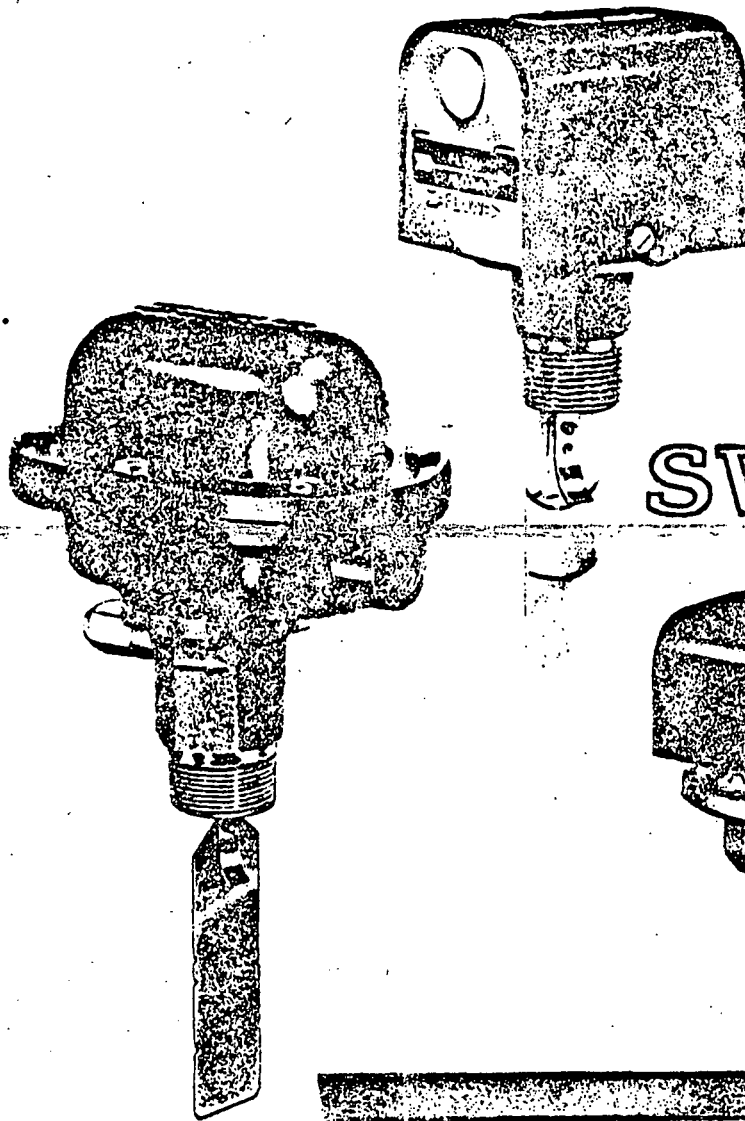
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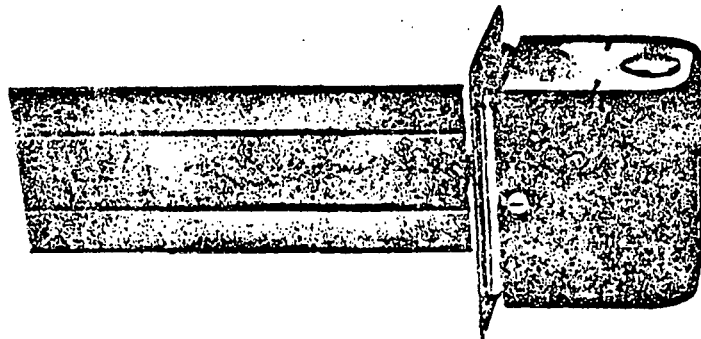
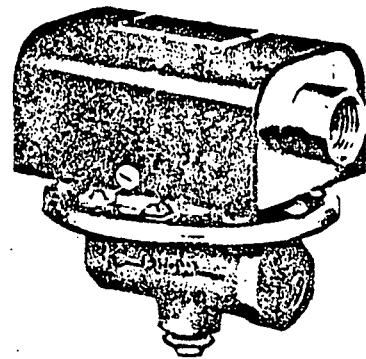


INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

MCDONNELL



FLOW SWITCHES



MCDONNELL & MILLER

3500 N. Spaulding Avenue, Chicago, Illinois 60618
Tel. 312/267-1695 Fax 312/25-3376

MCDONNELL FLOW SWITCHES

Versatile controls actuated by liquid or air flow

Widely used as automatic controllers or safety devices

The flow of liquids in pipelines and air in ducts plays an important role in industry and commerce. Under most circumstances it is essential to know whether or not there is a flow in a pipeline or duct, and to act upon that knowledge. This is the reason for, and the function of, McDonnell Flow Switches.

It started with steam locomotives

The steam locomotive, which has just about disappeared from our railroads, was a creature of enormous thirst. For the efficient generation of steam it demanded treated water—that is, water with a chemical compound added to it. That's when the first McDonnell Flow Switch was developed. When water was supplied to the locomotive tender, the flow switch actuated a feed pump to add the necessary chemical compound to the water.

Today, it goes wherever there's flow

Since that time, a complete line of McDonnell Flow Switches has been developed for a wide range of applications, including:

- Air Conditioning Systems
- Hot Water Space Heating Systems
- Hot Water Supply Systems
- Pump Systems
- Water Cooled Equipment
- Blending or Additive Systems
- Liquid Transfer Systems
- Fire Sprinkler Systems
- Water Treatment Systems
- Duct Type Heating Systems
- Exhaust Systems
- Make-Up Air Systems

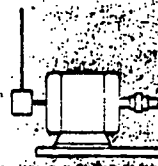
The various models in the McDonnell line of flow switches are illustrated and described on the following pages.

TABLE OF CONTENTS	
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Introduction and General Applications	2
Basic Uses of McDonnell Flow Switches	2
How to Select McDonnell Liquid Flow Switches	3
Electrical Ratings and Switch Schematics	3
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Extra Sensitive Flow Switches for Low Flow Rates— No. FS1 and FS6 Series	6-7
Flow Switch Models for Heavy Duty Applications Including Standard, Explosion-Proof and Vapor-Proof Models — FS7 Series, FS7-4 Series, FS7-L Series	8-10
Flow Switch Models for Heavy Duty Applications Double-Pole Double-Throw Operation — FS7-D Series	10
Flow Actuated Pneumatic Control — No. FS7-A	10
Water Flow Indicators for Sprinkler System Branch Piping—No. FS4-3F and No. FS7-4F	11
General Engineering Data for Flow Switches: Table for Flow Velocities in Pipe; Correction for Specific Gravity; Pressure Drop Table	12
How to Select McDonnell Air Flow Switches	13
Air Flow Switch Models for Low, Medium and Higher Velocities	14-15

THESE ARE SOME OF THE BASIC USES OF MCDONNELL FLOW SWITCHES



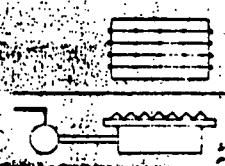
Signal Devices—In this era of automation, knowledge of flow, or no-flow, is important. A flow switch can provide a visual or audible report from any location, either nearby or remote.



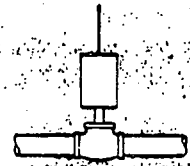
Motors—The operation of pumps, compressors and similar apparatus frequently depends upon fluid flow in a pipeline. A flow switch provides a dependable way to control such motors or other prime movers, or to add greater safety.



Alarms—Where flow failure is critical, or where a flow occurs in an emergency line—as in a fire sprinkler system—a flow switch can warn of trouble and pinpoint its exact location.



Heating Units—The widespread use of water heaters and duct heaters ranges from commercial processing to personal comfort. A flow switch in pipe or duct can start the heating unit to speedy recovery, or stop it if flow fails.



Metering Devices—Many liquids are improved or altered between their source and point of use—chlorination of domestic water, for example. A flow switch can start and stop the additive equipment as flow dictates.

How to Select/McDONNELL LIQUID FLOW SWITCHES

The following discussion of the various factors to be considered will serve as a guide in selecting the proper McDonnell Flow Switch.

1. What function will the flow switch perform?

McDonnell Flow Switches are equipped with single-pole double-throw switches, except for FS7-D Series (DPDT operation) and No. FS7-A (Pneumatic). They can make or break an electrical circuit when flow starts or when flow stops, and can be used, for example, to:

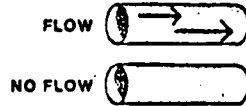
- Actuate a signal when flow stops;
- Start a motor with flow;
- Shut off an alarm when flow is adequate;
- Stop a motor with no flow.

2. Size of pipe?

McDonnell Flow Switches are being used on pipe sizes 1/2" through 16". Depending upon circumstances they can be used on pipe up to 36".

3. How much flow is present?

The flow rate at which the flow switch is to respond should be determined next. McDonnell Flow Switches are actuated (make or break) with an increase in flow, and will reverse switch position (break or make) with a decrease in flow. Throughout this booklet the term "Flow" represents the actual movement (velocity) of liquid within a pipe sufficient to actuate the switch. The term "No-Flow" represents a decrease in velocity, or a total flow stoppage, which will permit the switch to reverse back to the original position. *Important:* In operation the switch must be actuated by "Flow" before it can be reversed again by "No-Flow."



For example, the partial table below indicates the minimum flow rate required to actuate the McDonnell No. FS1. (1) There must be at least .41 gpm "Flow" before the flow switch will be actuated; the flow rate may of course be higher. (2) Should flow then drop to .24 gpm "No-Flow," or lower, the switch will reverse position. Note: The values shown in this table are factory settings; all McDonnell Flow Switches can be easily adjusted to require a higher actuating "Flow," or "No-Flow."

Required Flow Rates No. FS1
(Factory setting; Minimum adjustment)

"Flow"	0.41 gpm (or 0.43 fps) Velocity
"No-Flow"	0.24 gpm (or 0.25 fps) Velocity

Complete flow rate tables in gallons per minute (gpm) and in feet per second (fps) for each model are included in the product data. Flow rates shown are averages which may vary $\pm 10\%$ from tabulated values.

4. Maximum liquid pressure in pipe?

The maximum pipeline pressure should be considered when selecting a particular model. Different flow switch models can accommodate a range of pipeline pressures up to 1000 psi.

5. Maximum temperature?

Determine the liquid and ambient atmospheric temperatures when selecting the flow switch model. Various McDonnell Flow Switches can be used at temperatures from 32° F. up to 300° F. If temperatures are lower than 32° F., please write factory.

6. Type of liquid?

McDonnell Flow Switch models have wetted parts of brass, Monel or stainless steel. Depending on the particular model they may be used with water, certain light viscous fluids, some oils, some caustic solutions and other fluids.

7. Atmosphere surrounding flow switch?

It should be determined if the location will be subject to high humidity, weather conditions or explosive atmospheres. Standard, vapor-proof and explosion-proof flow switch models are available.

8. Installation?

It is recommended that all models be installed upright in a horizontal run of pipe and that any valves, elbows, orifices or other restrictions be removed at least five pipe diameters from either side of the flow switch. Specific installation instructions are provided with each control.

For information regarding particular applications or conditions please call or write your McDonnell representative or the factory.

ELECTRICAL RATINGS

(Underwriters Listed)

Except for Pneumatic Control on page 10 all liquid flow switches in this booklet have same type single-pole double-throw switch. FS7-D Series on page 10 has two switches. Electrical ratings for all models:

	Ampere Rating	
Motor Duty	115 V.A.C.	230 V.A.C.
Full Load	7.4 Amps.	3.7 Amps.
Locked Rotor	44.4 Amps.	22.2 Amps.
	115 V.D.C.	230 V.D.C.
	0.3 Amps.	0.15 Amps.

Pilot Duty: A.C. 125 V.A., 115-230 V.

SWITCH OPERATION SCHEMATICS

In the tables of flow rates given in this booklet for liquid flow switches the word "Flow" means that the switch will close one circuit, and open the other, when the flow rate is increased to the gpm shown. (See schematic "Flow.")

The words "No-Flow" mean the switch will reverse position—will open the first circuit and close the second—when the flow rate is decreased to the gpm shown. (See schematic "No-Flow.")

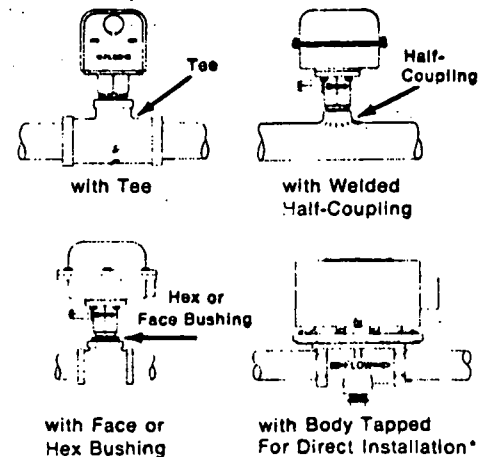


FLOW



NO FLOW

TYPICAL INSTALLATIONS



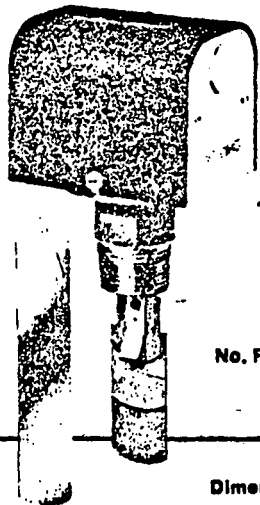
*No. FS1, FS4-3T Series and FS6 Series.

LIQUID FLOW SWITCHES

General Purpose Models

The flow switches described on these pages are used primarily as automatic controls or safety devices in air conditioning, heating and water systems and also in processing work. They include the No. FS4-3 standard model, the FS4-3T Series which are actuated by lower flow rates, and the No. FS8V which offers vapor-proof construction.

MCDONNELL No. FS4-3 FLOW SWITCH

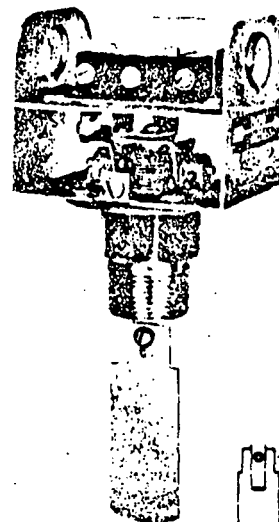
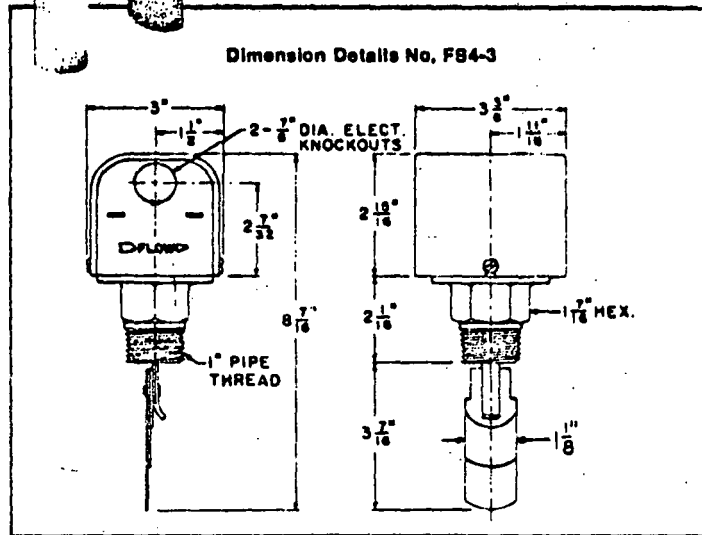


No. FS4-3

- Underwriters' Laboratories Listed
- Maximum pressure, 150 psi.
- Maximum temperature, 300° F.
- Shipping weight, 3 lbs.

The No. FS4-3 is a compact, moderately-priced flow switch for service on water lines principally. It has a single-pole double-throw switch, can be wired to make one circuit, break a second circuit when flow starts or stops. All parts in contact with liquid in pipe are of brass and Monel. The No. FS4-3 is installed in tee or welded fitting in horizontal pipe. Note outstanding design features pointed out below. For electrical ratings and switch schematics see page 3.

NOTE: McDonnell No. FS4 Flow Switch is also available with single-pole single-throw millivolt switches for self-generating control systems. Order No. FS4-MV (completes circuit with flow) or No. FS4R-MV (breaks circuit with flow).



Easy Wiring—Cover completely removable. No cramped quarters, no danger of kinked wires interfering with operation.

Two Knockouts—Connect conduit at either side of housing.

Switch—Single-pole double-throw. Compact in size. Powerful snap action assures dependable operation.

Knife-Edged Bearings—Of hardened stainless steel to minimize friction.

Adjusting Screw—Provides simple way to adjust sensitivity to flow.

Packless—Heavy duty Monel siphon seals switch assembly from line.

3-in-1 Paddle—Segmented Monel paddle quickly adaptable for 1" to 3" pipe. Extended Monel paddle also included for larger pipe sizes.



FLOW RATES REQUIRED TO ACTUATE NO. FS4-3 FLOW SWITCHES

Flow rates in gallons per minute (GPM) shown in black. Velocity in feet per second (FPS) shown in color.

Pipe Size in Which Flow Switch Installed			1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	4"	5"	6"
Factory or Minimum Adjustment	Flow	GPM	6.00	9.80	12.7	18.8	24.3	30.0	39.7	58.7	79.2
		FPS	2.24	2.11	2.00	1.80	1.63	1.30	1.00	0.94	0.88
	No Flow	GPM	3.60	5.60	7.00	9.40	11.6	12.0	19.8	29.3	39.6
		FPS	1.34	1.21	1.10	0.90	0.78	0.52	0.50	0.47	0.44
Maximum Adjustment	Flow	GPM	10.2	16.8	23.0	32.8	42.4	52.1	73.5	115.0	166.0
		FPS	3.91	3.62	3.62	3.14	2.74	2.26	1.86	1.85	1.84
	No Flow	GPM	9.20	15.0	19.5	24.0	37.5	46.1	64.2	92.0	123.0
		FPS	3.43	3.23	3.07	2.29	2.51	2.00	1.62	1.48	1.37

Flow rates are averages which may vary ± 10% from tabulated values.

*Equipped with extended paddle trimmed to pipe size.

General Engineering Data

TABLE OF FLOW VELOCITIES

... pipe in equivalent gallons per minute (GPM)

Flow In Ft./Sec (FPS)	Pipe Size											
	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	3 1/2"	4"	5"	6"
.2	.19	.33	.54	.94	1.27	2.1	3.0	4.8	6.2	7.9	12.5	18.0
.4	.38	.66	1.08	1.88	2.54	4.2	6.0	9.6	12.4	15.8	25.0	36.0
.6	.57	.99	1.62	2.92	3.81	6.2	8.9	13.4	18.6	23.7	37.5	54.0
.8	.76	1.32	2.16	3.76	5.08	8.3	11.9	19.2	24.8	31.6	50.0	72.0
1.0	.95	1.66	2.70	4.70	6.30	10.5	14.9	23.0	30.8	39.7	65.4	90.0
1.5	1.42	2.50	4.05	7.10	9.48	15.8	22.4	34.5	46.2	59.6	98.1	135
2.0	1.89	3.32	5.40	9.40	12.6	21.0	29.8	46.0	61.6	79.4	131	180
2.5	2.37	4.16	6.75	11.8	15.8	26.3	37.3	57.5	77.0	99.3	164	225
3.0	2.84	4.94	8.10	14.1	19.0	31.5	44.7	69.0	92.4	119	196	270
3.5	3.31	5.82	9.45	16.5	22.1	36.8	52.2	80.5	108	139	229	315
4.0	3.78	6.65	10.8	18.8	25.3	42.0	59.6	92.0	123	159	262	360
4.5	4.26	7.48	12.2	21.2	28.4	47.3	67.1	104	139	179	294	405
5.0	4.74	8.32	13.5	23.5	31.6	52.5	74.5	115	154	199	327	450
6.0	5.68	9.99	16.2	28.2	37.9	63.0	89.4	138	185	238	392	540
7.0	6.62	11.6	18.9	32.9	44.2	73.5	104	161	216	278	458	630
8.0	7.56	13.3	21.6	37.6	50.5	84.0	119	184	246	318	523	720
9.0	8.52	15.0	24.3	42.3	56.8	94.5	134	207	277	357	589	810
10.0	9.48	16.6	27.0	47.0	63.0	105	149	230	308	397	654	900

CORRECTION FOR SPECIFIC GRAVITY

The tables of flow rates required to actuate McDonnell Flow Switches are based on water with a specific gravity of 1.00. Shown below are the approximate flow rate correction factors for fluids with other specific gravities.

Specific Gravity of Fluid	Correction Factor (Multiplier)	Specific Gravity of Fluid	Correction Factor (Multiplier)
1.40	0.84	0.95	1.02
1.35	0.86	0.90	1.05
1.30	0.88	0.85	1.08
1.25	0.90	0.80	1.12
1.20	0.91	0.75	1.15
1.15	0.93	0.70	1.19
1.10	0.95	0.65	1.24
1.05	0.97	0.60	1.29
1.00	1.00	0.55	1.35
		0.50	1.41

Example:

Determine whether No. FS7-SE Flow Switch will be actuated by a flow of 60 gpm of gasoline (Specific Gravity 0.75) in a 3" pipeline.

Water cut-in flow rate for No. FS7-SE in 3" pipe (see table page 9) is 46.1 gpm.

46.1×1.15 (Correction Factor) = 53.02 gpm.

This 53.02 gpm cut-in point is less than 60 gpm flow rate; therefore No. FS7-SE is acceptable.

PRESSURE DROP (PSI)

Pipe Size	Flow Switch Model	Flow Rate (GPM)															
		.2	.5	1.0	2.0	4.0	8.0	10.0	15.0	20.0	25.0	30.0	50.0	75.0	100.0	150.0	200.0
1/2"	No. FS1	.28	.32	.47	.72	2.74	9.74	14.4									
3/4 & 1"	FS6 Series	.01	.02	.03	.04	.38	1.44	2.18	4.88	7.94	12.3						
3/4"	FS4-3T1-3/4 FS4-3T2-3/4			.01	.04	.14	.50	.78									
3/4"	FS4-3T3-3/4			.03	.10	.32	.94	1.33									
1"	FS4-3T1-1 FS4-3T2-1			.01	.02	.08	.23	.33									
1"	FS4-3T3-1			.03	.07	.21	.61	.85									
1"	FS4-3 FS4-3F					.15	.32	.54	1.26	2.20							
1"	FS6-V			.01	.05	.20	.33	.74	1.30								
3"	FS4-3									.01	.01	.02	.05	.10	.18	.40	.79
3"	FS6-V									.01	.01	.02	.06	.10	.13	.17	.19
1 1/4"	FS7 Series FS7-4 Series					.03	.08	.17	.39	.72							
2"	FS7 Series FS7-4 Series						.02	.02	.04	.09	.13	.19	.51	.90			
4"	FS7 Series FS7-4 Series												.01	.02	.03	.05	.06
6"	FS7 Series FS7-4 Series													.01	.01	.02	.02

FORMULA FOR LARGER PIPE, HIGHER VELOCITIES

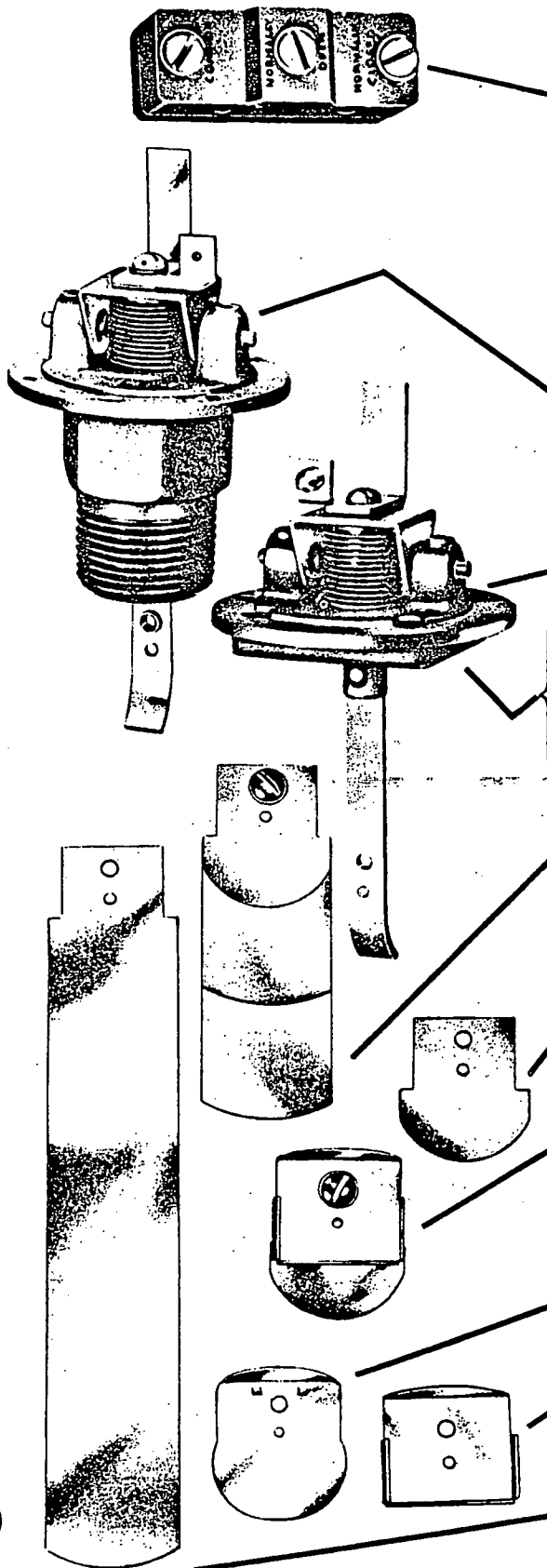
- Velocity in ft. per sec. (FPS) = $\frac{\text{GPM} \times 0.321}{\text{Pipe Area in sq. in.}}$
Example: With a flow of 1200 GPM through an 8" pipe, determine velocity.
Velocity = $\frac{1200 \times 0.321}{50.0}$ or 7.7 ft. per sec.
- GPM = $\frac{\text{Velocity in ft. per sec.} \times \text{Pipe Area sq. in.}}{0.321}$
Example: With a flow of 6.5 ft. per sec. through a 10" pipe, determine GPM.
GPM = $\frac{6.5 \times 78.9}{0.321}$ or 1600 GPM.

Standard Pipe Size	Area
8"	50.0
10"	78.9
12"	113.1
14"	138.0
16"	183.0

NEMA ENCLOSURES The following is a list of the general types of NEMA enclosures, along with the McDonnell Flow Switches which conform.

NEMA Enclosure	McDonnell Flow Switches
Type 1—General Purpose	All Models
Type 2—Drip Tight	Nos. FS7-V, FS7-SV, FS7-4V, FS7-VL, FS8V
Type 3—Weather Resistant	Nos. FS7-V, FS7-SV, FS7-4V, FS7-VL, FS8V
Type 5—Dust Tight	Nos. FS7-V, FS7-SV, FS7-4V, FS7-VL, FS8V
Type 7—Hazardous Location	Nos. FS7-E, FS7-SE, FS7-4E, FS7-EL
Type 9—Hazardous Location	Nos. FS7-E, FS7-SE, FS7-4E, FS7-EL
Type 12—Industrial Use	Nos. FS7-V, FS7-SV, FS7-4V, FS7-VL, FS8V

Replacement Parts and Assemblies McDonnell FS4 Series Flow Switches



PART NO.	DESCRIPTION
*FS4-33 (Illustrated)	Electrical Switch -- Single pole, double throw. For FS4-3 and FS4-3T models.
*612 or 612-MV... (Not illustrated)	Electrical Switch—single pole, single throw. (MV means millivolt service) For No. FS4 or FS4-MV—Completes circuit with flow.....
*612R or 612R-MV (Not illustrated)	Electrical Switch—single pole, single throw. (MV means millivolt service) For No. FS4R or FS4R-MV—Breaks circuit with flow.....
SAFS4-1R..... (Illustrated)	Bellows Base Assembly for No. FS4 and FS4-MV.....
SAFS4-1..... (Not illustrated)	Bellows Base Assembly for No. FS4-3, FS4R and FS4R-MV.....
SAFS4-T-36R.....	Bellows Base Assembly for FS4-3T models. (Furnished with both gaskets listed below)
FS4-T-37.....	Gasket for No. SAFS4-T-36R Assembly. Fits older "T" models marked on name plate for 100 PSI Maximum Working Pressure.
or FS4-T-41.....	Sealing Ring Gasket for No. SAFS4-T-36R Assembly. Fits later "T" models marked for 150 PSI Maximum Working Pressure.....
SAFS4-15.....	Paddle Assembly for FS4-3, FS4 and FS4R. (Consists of FS4-15 Paddle (for 1 inch tee), FS4-16 Paddle (for 2 inch tee), FS4-17 Paddle (for 3 inch tee), S-21 Screw, 47-67 Lock Washer and C-35 Holding Nut.....
FS4-15.....	Paddle for FS4-3T1 models.....
SAFS4-25.....	Cupped Paddle Assembly for FS4-3T2 models. Can also be used on FS4-3, FS4 and FS4R models for greater sensitivity. Consists of No. FS4-15 Paddle and No. FS4-25 Cupped Paddle.....
FS4-T-40.....	Paddle for No. FS4-3T3, 1" and FS4-3T3-3/4".....
FS4-25.....	Cupped Paddle only, for use with FS4-15 Paddle to field convert to SAFS4-25.....
FS4-37.....	6 inch paddle, for large pipe. Used with FS4-3, FS4 and FS4R.....

*No. FS4-33 Switch is not interchangeable with 612 Series Switches.

McDONNELL & MILLER, Inc., 3500 N. Spaulding Avenue, Chicago, Ill. 60618



VII. PUMPS

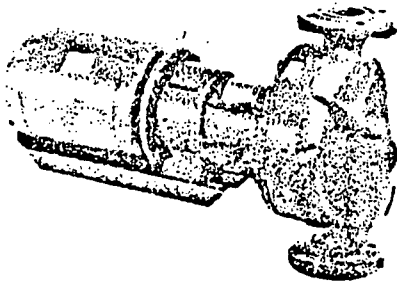
VII. PUMPS

- A. Pump P-4: Bell & Gossett, Series 60, 1½"A, 6-3/8" dia. impeller.
Baldor Motor Serial No. 1078, Model VWL 1307, 3/4 HP,
115-208/230 volts.
- B. Pumps P-5 and P-7: Bell & Gossett, Series 60, 1½"AA, 5" dia. impeller,
Identification No. 97185 BV, Model MRH 24 JX, ¼ HP,
115 volts.
- C. Pump P-6: Bell & Gossett, Series 100, 1/12 HP, 115 volts.
- D. Installation, operation and service instructions:

BELL & GOSSETT

SUBMITTAL

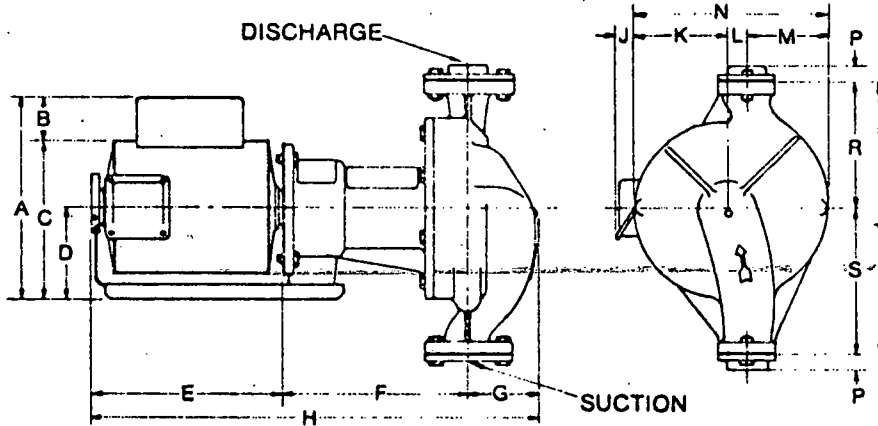
B-131.2
REVISION 6



1/2 A Series "60" Centrifugal Pumps In-Line Mounted

JOB <u>Stanford Food Commissary Bldg.</u>		B & G REPRESENTATIVE <u>California Hydronics</u>
UNIT TAG NO. <u>P-4</u>		ORDER NO. _____ DATE _____
ENGINEER <u>Interactive Resources, Inc.</u>		SUBMITTED BY _____ DATE _____
CONTRACTOR <u>Redwood Mechanical</u>		APPROVED BY _____ DATE _____

DIMENSIONS



PUMP SIZE	SUCTION AND DISCHARGE SIZE—INCHES NPT	PUMP DIMENSIONS—INCHES									
		F	G	K	L	M	N	P	R	S	T
1 1/2 A	1 1/2	9 3/4	3 3/4	4 3/4	1	3 3/4	9 1/2	3/4	6 1/2	7	13 1/2

ALL MOTORS 1750 RPM

MOTOR SIZE		MOTOR DIMENSIONS—INCHES						
H.P.	PHASE	A	B	C	D	E	H	J
1/2	1	9 1/2	2 1/2	7 3/4	4 3/4	11 1/2	24 1/2	—
1/2	3	7 3/4	—	7 3/4	4 3/4	11	24	—
3/4	1	9 1/2	2 1/2	7 3/4	4 3/4	12	25	—
3/4	3	7 3/4	—	7 3/4	4 3/4	11 1/2	24 1/2	—
1	1	10 3/8	2 1/2	8 3/8	4 3/4	9 3/4	22 3/4	3/8
1	3	8 3/8	—	8 3/8	4 3/4	10	23	3/8
1 1/2	1	10 3/8	2 1/2	8 3/8	4 3/4	10 3/4	23 3/4	3/8
1 1/2	3	8 3/8	—	8 3/8	4 3/4	10 3/4	23 3/4	3/8

Companion Flanges furnished for Suction and Discharge

6-3/8" dia. impeller

SPECIAL INFORMATION REQUIRED

20 GPM 45 FT.

MATERIALS OF CONSTRUCTION:

BRONZE FITTED ALL IRON ALL BRONZE

ELECTRICAL DATA: 3/4 HP

115-230 VOLTS 60 CY. 1 PH.

MOTOR ENCL. DRIP-PROOF

SPEC. CONSTR. _____

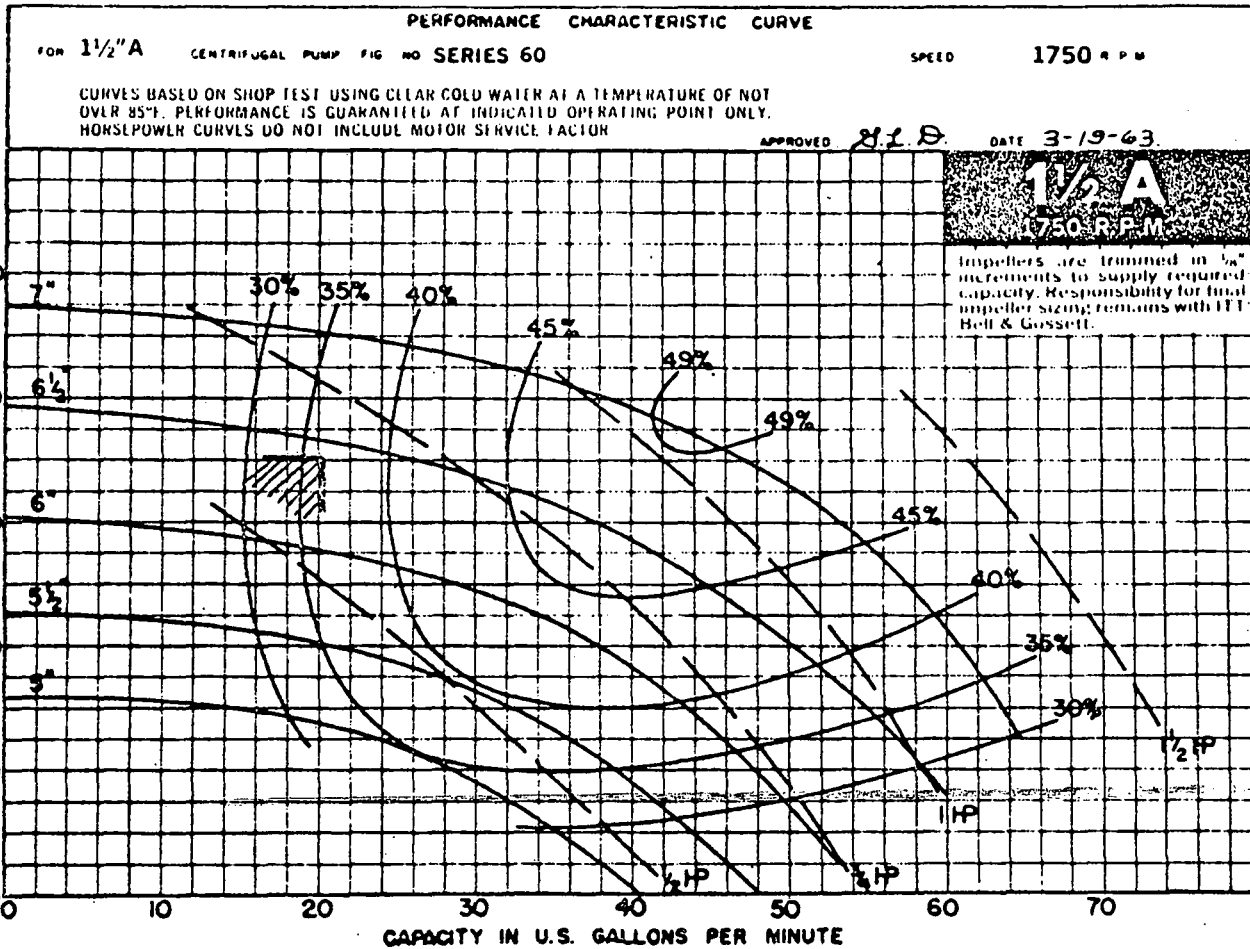
APPROXIMATE WEIGHT _____ LBS.

MAXIMUM WORKING PRESSURE 175 PSI

SEE PERFORMANCE CURVE ON REVERSE SIDE

BELL & GOSSETT IIT
FLUID HANDLING DIVISION

SERIES "60" PERFORMANCE CURVES



BELL & GOSSETT

8200 N. AUSTIN AVE. - MORTON GROVE, ILL. 60053

 INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION



BELL & GOSSETT
PRODUCTS

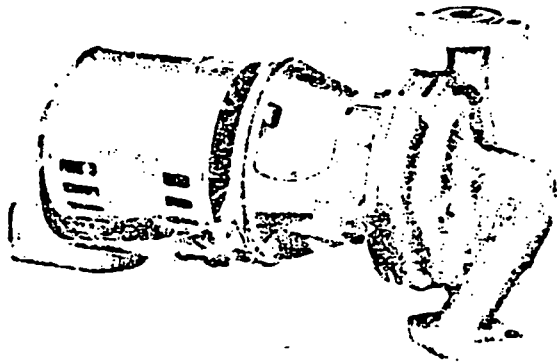
CENTRIFUGAL PUMPS

SUBMITTAL **B-131.1**

REVISION 2

In-Line Mounted Centrifugal Pumps
SERIES "60"

1 1/4 AA



JOB Stanford University Food Services Bldg.

UNIT TAG NO. P-5 & P-7

ENGINEER Interactive Resources

CONTRACTOR Redwood Mechanical Calif. Hydronics

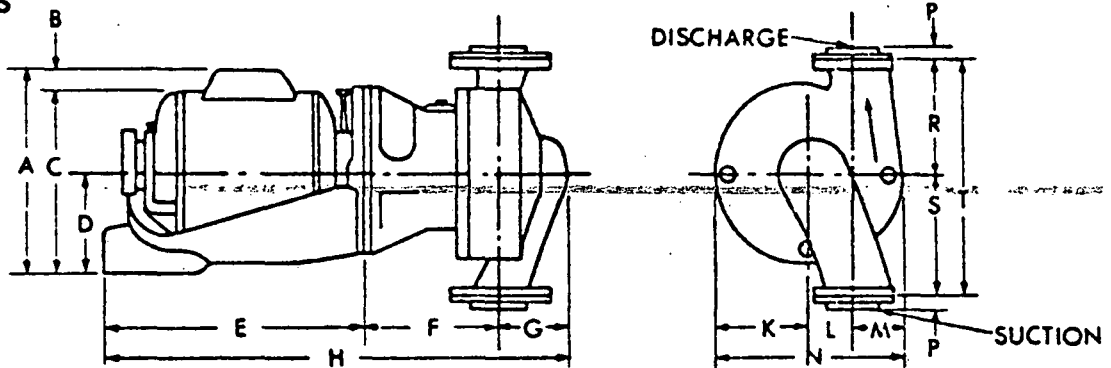
B & G REPRESENTATIVE _____

ORDER NO. _____ DATE _____

SUBMITTED BY _____ DATE _____

APPROVED BY _____ DATE _____

DIMENSIONS



Companion Flanges furnished for Suction and Discharge

PUMP SIZE	SUCTION AND DISCHARGE SIZE—INCHES NPT	PUMP DIMENSIONS—INCHES									
		F	G	K	L	M	N	P	R	S	T
1 1/4 AA	1 1/4	5 1/4	3 3/4	3 3/4	1 1/2	2 1/2	7 1/2	3/4	5	6	11

ALL MOTORS 1750 RPM

MOTOR SIZE		MOTOR DIMENSIONS—INCHES					
H.P.	PHASE	A	B	C	D	E	H
1/4	1	7 3/4	—	7 3/4	4 3/4	10	19 1/4
1/4	3	7 3/4	—	7 3/4	4 3/4	9 3/4	19
1/2	1	9 1/2	2 1/4	7 3/4	4 3/4	11	20 1/4
1/2	3	7 3/4	—	7 3/4	4 3/4	11	20 1/4
1/2	1	9 1/2	2 1/4	7 3/4	4 3/4	11 1/2	20 3/4
1/2	3	7 3/4	—	7 3/4	4 3/4	11	20 1/4

5" imp

SPECIAL INFORMATION REQUIRED

21 GPM 22 FT.

MATERIALS OF CONSTRUCTION:

BRONZE FITTED ALL IRON ALL BRONZE

ELECTRICAL DATA: 1/3 HP
115 VOLTS 60 CY. 1 PH.

MOTOR ENCL. drip proof

SPEC. CONSTR. _____

MAXIMUM WORKING PRESSURE 175 PSI

SEE PERFORMANCE CURVE ON REVERSE SIDE

BELL & GOSSETT MORTON GROVE, ILL. 60053 **ITT**

Fluid Handling Division, International Telephone and Telegraph Corporation

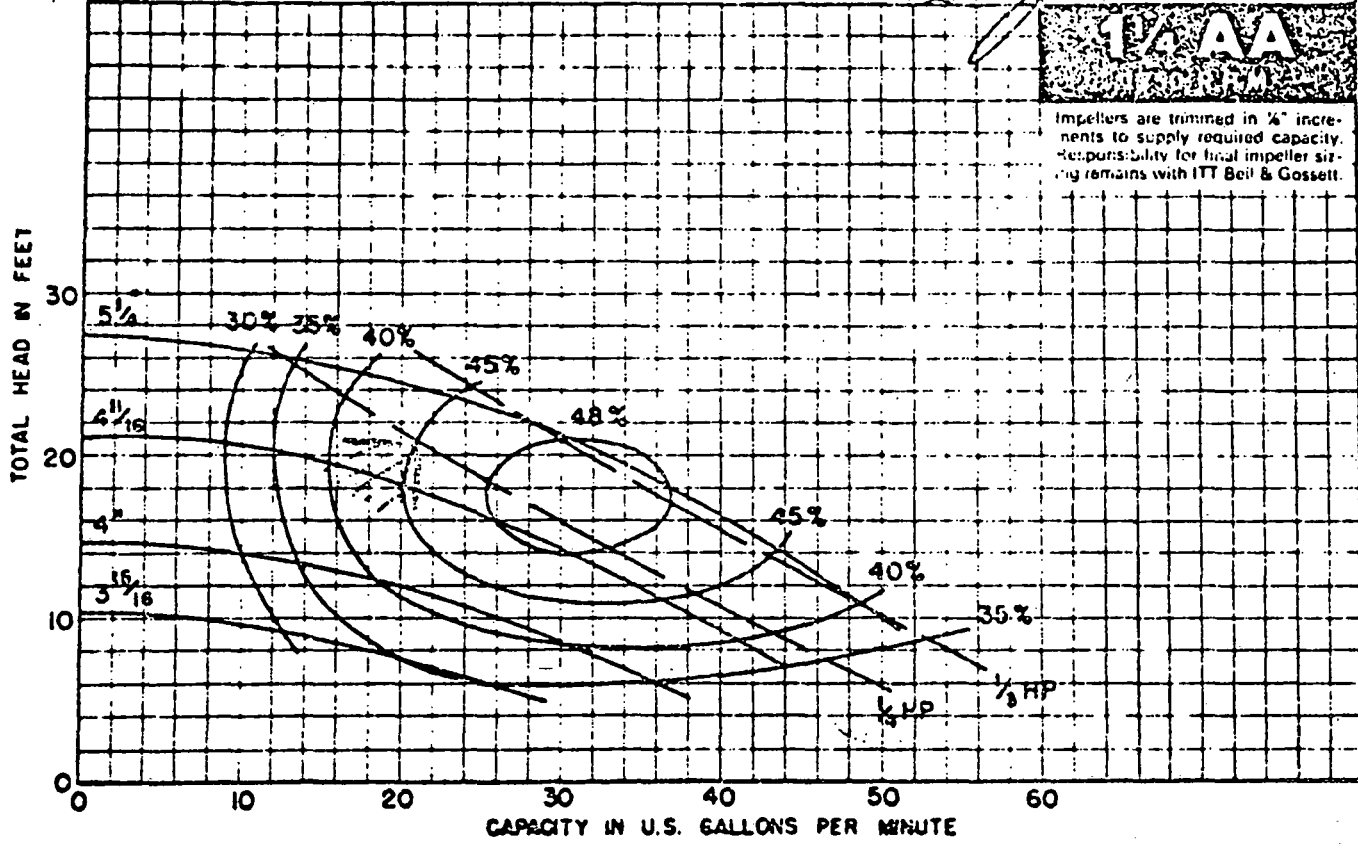
SERIES "60" PERFORMANCE CURVES

PERFORMANCE CHARACTERISTIC CURVE
 FOR 1 1/4" AA CENTRIFUGAL PUMP FIG. NO. SERIES 60
 CAPACITY G.P.M.
 HEAD FEET
 SPEED 1750 R.P.M.
 CURVES BASED ON SHOP TEST USING CLEAR COLD WATER AT A TEMPERATURE OF NOT OVER 85 F. PERFORMANCE IS GUARANTEED AT INDICATED OPERATING POINT ONLY. HORSEPOWER CURVES DO NOT INCLUDE MOTOR SERVICE FACTOR.

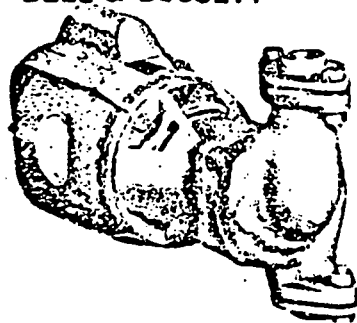
APPROVED: *[Signature]* DATE 6-15-61



Impellers are trimmed in 1/8" increments to supply required capacity. Responsibility for final impeller sizing remains with ITT Bell & Gossett.



BELL & GOSSETT



SUBMITTAL

A-120
REVISION 10

Iron & Bronze* Booster Pump

JOB	Stanford University Food Services Bldg.	B & G REPRESENTATIVE	Calif. Hydronics
UNIT TAG NO.	P-6	ORDER NO.	DATE
ENGINEER	Interactive Resources	SUBMITTED BY	DATE
CONTRACTOR	Redwood Mechanical	APPROVED BY	DATE

*Where Service Water Is Pumped, Use A Bronze Booster Pump

OPERATING DATA Capacity: 20 GPM at 6" TDH

Maximum Working Pressure 125 PSI
 Maximum Operating Temperature
 Standard Seal: 225°F. continuous • 250°F. intermittent on closed systems using modulated temperature control, proper pump location and system pressurization.
 Special Seals: 250°F. continuous consult your local wholesaler, B&G representative or the factory).
 Maximum Motor RPM 1750

CONSTRUCTION MATERIALS

Booster Body.. Cast Iron or Bronze
 Impeller:
 Pump Model No. Iron Body Bronze Body
 Series 100 — Polypropylene or Brass —
 SC-75 — Brass —
 Series HV & 2" Phenolic Phenolic
 Series PR, 2 1/2" LD3, Steel, Cadmium Brass
 HD3, PD35 & PD37 Plated
 PD38 & PD40 Cast Iron Brass
 Shaft..... Carbon Steel
 Seal..... Mechanical, Carbon on Ceramic
 Pump Bearings.. Bronze, Sleeve, Oil Lubricated
 Coupler... All Booster Pumps except PD38 and PD40 Flexible, Spring-loaded type PD38 and PD40... Flexible
 Motor.... Vibrationless oil lubricated sleeve bearing motor approved by CSA and recognized under the Component Program of Underwriters' Laboratories, Inc.
 Motor Bearings.. Bronze, Sleeve, Oil Lubricated

SCHEDULE

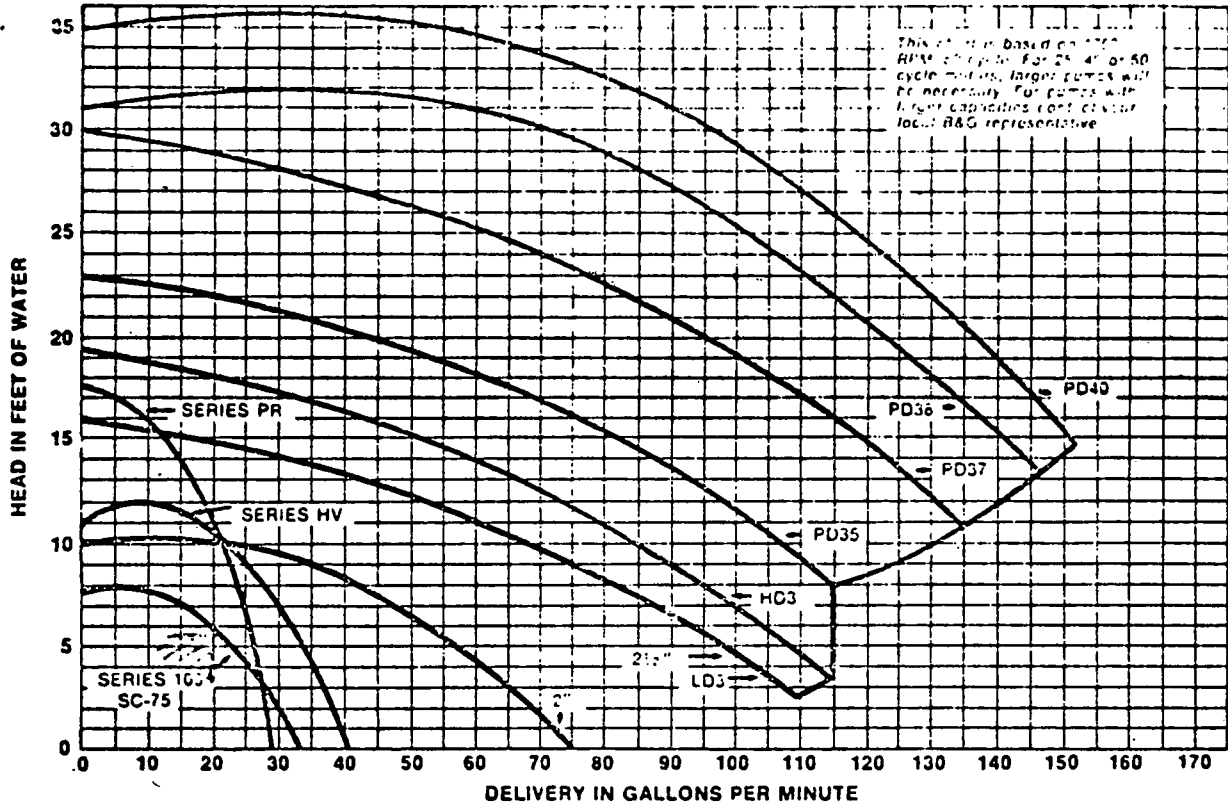
MODEL NO.	FLANGE SIZE—NPT INCHES (specify size)	**STANDARD 60 CYCLE MOTOR CHARACTERISTICS (special motors available on request)			TAGGING INFORMATION	QUANTITY		
		HP	φ	VOLTAGE				
→ SERIES 100	3/4, 1, 1 1/4 & 1 1/2	1/12	1	115—WITH BUILT-IN OVERLOAD PROTECTION	P-6			
SC-75	SWEAT							
SERIES PR	3/4, 1, 1 1/4 & 1 1/2	1/6						
SERIES HV	1, 1 1/4 & 1 1/2							
2	2	1/4						
2 1/2	2 1/2							
LD3	3	1/3						
HD3		1/2				3	208-230/460	
PD35-S		3/4				1	115/230	
PD35-T***						3	208-230/460	
PD37-S		1				1	115/230	
PD37-T***						3	208 or 230/460	
PD38-S		1 1/2	1	115/230				
PD38-T***			3	208 or 230/460				
PD40-S								
PD40-T***								

**Motors with special electrical characteristics are available on request at additional cost. Refer to motor data sheet HS-615 or contact your local Bell & Gossett Representative for details.
 ***External overload must be provided.

BELL & GOSSETT **FLUID HANDLING DIVISION**

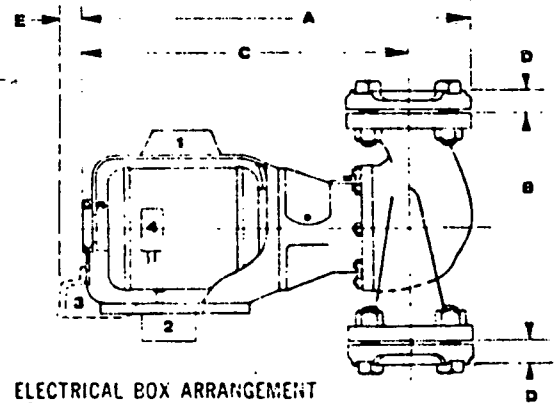
IRON AND BRONZE BOOSTER PUMP

Performance characteristics are based on using 1 1/2" or 1 1/4" flanges. When using 2" or 1" flanges performance will be slightly reduced.



DIMENSIONS & WEIGHTS

MODEL NO.	FLANGE SIZE NPT INCHES (specify size)	DIMENSIONS IN INCHES (open drip-proof)					APPROX. SHPG. WT. LBS.		
		A	B	C	D	E	IRON BODY	BRONZE	
SERIES 100	3/4	15	6 3/4	12 3/4	9/16	—	21	21	
	1 & 1/4				1/2	—			
	1 1/2				—	—			
SC-75	SWEAT		7 3/8					20	
SERIES PR	3/4	16 3/4	8 1/2	13 3/4	9/16	—	35	37	
	1 & 1/4				1/2	—			
SERIES HV	1	10 3/4	8 1/2	13 3/4	3/8	—	23	30	
	1 1/4 & 1 1/2				3/8	—			
2	2	17 3/4	10	14 3/4	1 1/16	—	40	42	
2 1/2	2 1/2				—	—	—	52	62
LD3	—				—	—	—	—	55	60
HD3	—	18 3/4	—	15 3/8	1 1/16	—	60	65	
PD35-S	—	20 3/4	12	17 3/4	1 1/4	—	78	83	
PD35-T	—	20 3/4					75	80	
PD37-S	—	21 1/4					85	90	
PD37-T	—	20 3/4					82	87	
PD38-S	—	24					128	138	
PD38-T	—	24 3/4	14 1/2	19 1/4	1 1/4	—	125	135	
PD40-S	—	24 3/4	—	20 1/4	—	—	130	140	
PD40-T	—	25 3/4	—	20 3/4	—	—	127	137	



ELECTRICAL BOX ARRANGEMENT FOR BOOSTER PUMPS WITH BELL & GOSSETT MANUFACTURED MOTORS

Model Number	1	2	3	4
Series 100 and SC-75	All Standard	Other 1Ø	3Ø	—
Series HV and 2"	115 Volt 1Ø Only			
Series PR	—	1Ø	—	—
2 1/2", LD3 and HD3				
PD35 and PD37					All
PD38 and PD40	—	—	All	—

TYPICAL SPECIFICATION

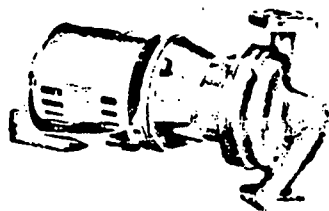
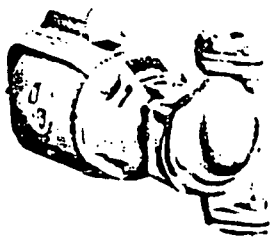
The Contractor shall furnish and install In-The-Line Pumps as illustrated on the plans and in accordance with the following specifications:

- The pumps shall be of the horizontal, oil-lubricated type, specifically designed and guaranteed for quiet operation. Suitable for 125 PSI working pressure.
- The pumps shall have a ground and polished steel shaft with integral thrust collar. The shaft shall be supported by two horizontal sleeve bearings designed to circulate oil. The pumps are to be equipped with a mechanical seal with carbon seal face rotating against a ceramic seat. The motor shall be non-overloading at any point on pump curve.
- The motor shall be of the open, drip-proof, sleeve-bearing, quiet-operating, rubber-mounted construction. Motors shall have built-in thermal overload protectors. (Exception—PD models with 3-phase motors see paragraph 4.)

- For PD models with 3-phase motors, add the following: The Contractor shall furnish and install a magnetic starter for each booster pump, with at least two thermal overload protectors. The starter shall be equipped with manual reset buttons.

The pump shall be Bell & Gossett Model No. _____ or approved equal with a capacity of _____ GPM at _____ Ft. head when directly driven through a self-aligning flexible coupling by an oil-lubricated motor, _____ volts _____ cycle phase(s).

BELL & GOSSETT



INSTRUCTION SHEET

S16946

REVISION 4

Also replaces
Instruction Manual S17630

BOOSTER AND SERIES "60" IN-LINE CENTRIFUGAL PUMPS INSTALLATION, OPERATION AND SERVICE INSTRUCTIONS

INSTALLATION INSTRUCTIONS

LOCATION

If the pump is not installed on a closed system it should be placed as near as possible to the source of supply, and located to permit installation with the fewest possible number of bends or elbows in the suction pipe.

ALIGNMENT

The compact construction of this pump makes it very unlikely that any misalignment of parts will occur, but a check should be made before putting the pump in service by turning the shaft by hand to determine that there is no binding.

PIPING

It is important that air be kept out of the system. On an open system always place the end of the suction pipe at least 3 feet below the surface of the water in the suction well to prevent air from being drawn into the pump. Avoid air pockets in the suction line and make sure that each section of the suction pipe is absolutely air tight.

Install a square head valve and a check valve in the discharge pipe close to the pump. The check valve should be between the square head valve and the pump discharge nozzle. The square head valve can be used to control the capacity of the pump or to shut off the discharge line while repairs are being made. The function of the check is to protect the pump casing from breakage that might occur due to the action of water hammer.

A 10-32 NF eye bolt has been included with the larger pump packages, use of which is optional, to enable supporting the bearing bracket from above the pump when the piping is not able to provide the necessary support.

Do not support under motor, misalignment will occur.

SYSTEM PREPARATION

Prior to pump start up, the system should be cleaned with a trisodium phosphate solution, flushed and drained. Then refilled with clean liquid. The PH should be maintained between 7 and 8.

PRIMING

DO NOT RUN PUMP DRY. Before starting, these pumps must be filled with water. After the pump has been filled, turn the shaft a few times by hand to allow all air to escape and if necessary add more water. The square head valve in the discharge should be kept closed until the pump is running at full speed and then gradually opened.

LUBRICATION

All new Bell & Gossett Boosters and Series "60" In-line centrifugal pumps are test run at the factory, but must be lubricated before being placed in operation.

Lubricate as follows:

1. Pump Bearings—Fill the bearing frame per oiling instruction tag with SAE #20 oil until oil flows from the overflow hole on the side of the bearing bracket. PD38, PD40 and Series 60 "A" size pumps are to be lubricated until oil level is up to the side hole. Relubricate as necessary to maintain this level.
2. Sleeve Bearing Motor—Lubricate thru the two motor oil cups per motor lubrication tag once every four months. Use ten to fifteen drops in each oil cup if required.
3. Ball Bearing Motor—Relubricate every six months to two years depending on operating conditions with a good soda-soap or lithium base grease.

NOTE: Over-oiling can cause deterioration of the motor mounts which in turn causes excessive coupler wear from misalignment.

OPERATING INSTRUCTIONS

1. Be sure to operate the pump in the proper direction. All PD and Series 60 run clockwise when looking at the pump from the motor end. All boosters run counterclockwise when looking at the pump from the motor end. All pumps are provided with arrows showing direction of rotation.
2. Keep pump and motor bearings lubricated.
3. Do not disassemble pump unless absolutely necessary as impeller has been accurately adjusted and tested before leaving factory.
4. Pump shaft should always turn freely by hand.
5. Ask for information or help if trouble is experienced that cannot be rectified since this pump is guaranteed to operate as recommended.
6. If pumps are to be idle for a very long period of time the interior of the volute should be cleaned and oiled. This prevents parts from rusting together and assures a longer period of satisfactory operation.
7. The motor should be protected against overload and under-voltage. Control devices for this purpose can be obtained at a very low cost. They are inexpensive insurance.

(OVER)

BELL & GOSSETT **ITT**
FLUID HANDLING DIVISION

SERVICE INSTRUCTIONS

An exclusive feature of the B & G Booster & Series "60" pumps is the availability of complete bearing bracket assemblies as replacements.

In those cases where it may be necessary only to replace the seal assembly the following instructions apply:

1. Turn off current to motor.
2. Close valves on both sides of pump (If no valves have been installed, it may be necessary to drain the system).
3. Detach bearing-frame assembly from pump volute by removing eight cap-screws from center body-flange.
4. Remove impeller from pump-shaft (First turning impeller-nut counter clockwise).
5. Lift off seal-spring — then place screwdriver point under top compression ring of seal and pry off. Seal can then be removed by pulling upward.
6. Be sure that the shaft is thoroughly cleaned then lubricate with a thin film of oil or water and push the replacement seal on as far as possible by hand. Next, using a screwdriver press down firmly all around the outer edge of the top compression ring until the seal is tight against the face of the remite insert. If end play is present push the seal on tighter.
7. Replace impeller on shaft making certain that impeller-nut is firmly tightened. The pump and bracket can then be reassembled into pump volute and placed in service.

HOW TO REPLACE THE COUPLER ASSEMBLY

- A — Turn off current to motor.
- B — Remove bearing bracket cover.
- C — Loosen coupler half from pump shaft by turning Allen set screw counter-clockwise.
- D — Remove four cap screws that connect motor bracket to pump bracket and slide motor away from bracket. If coupler sticks on pump, insert screwdriver between rear bearing and coupler half, exerting pressure outward. Loosen set screw on motor coupling half and remove coupling.
- E — Install new coupler, slipping one coupling half on motor shaft first and tighten set screw. Slip other coupling half on pump shaft, tighten set screw and bolt motor bracket to pump bracket. Replace bearing bracket cover.

CAUTION:

Do not attempt to replace individual coupler springs. If coupler arms are worn or springs are broken, always replace entire coupler assembly.

HOW TO REPLACE THE RING MOTOR MOUNTINGS

- A— Turn off current to motor.
- B— Disconnect motor leads.

C— Remove coupler from motor shaft.

D— Loosen rear clamp on motor using screwdriver to pry off clamp motor can then be lifted out of bracket.

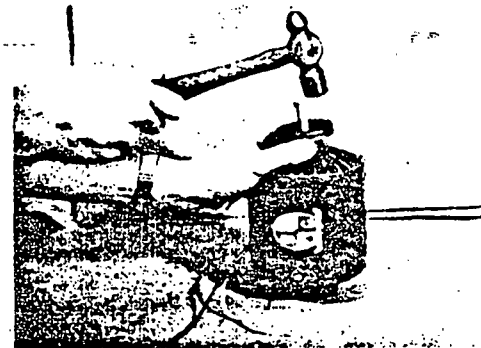
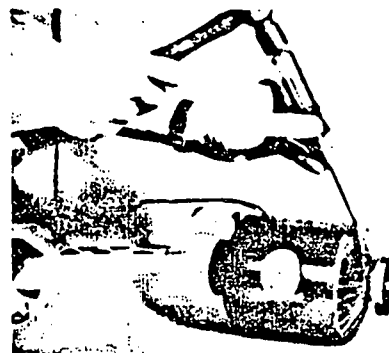
E— Place screwdriver between front mounting and end-bell of motor and strike firmly with a hammer on handle of screwdriver, forcing inner ring of motor mounting off the boss of end-bell. (Figure 1)

F— To install motor mounts, hold mounting firmly against boss of end-bell and tap inner ring lightly until mounting has started. Continue to tap around the inner ring (compression ring) until mounting is flush with end of boss. (Figure 2) Repeat procedure with rear mount, however, do not rest motor on end of shaft when applying this unit.

G— Replace motor in bracket with oil well spouts up and tighten clamp.

H— Reconnect coupler and turn shaft by hand to make sure it is free.

I— Reconnect motor leads and turn current back on.

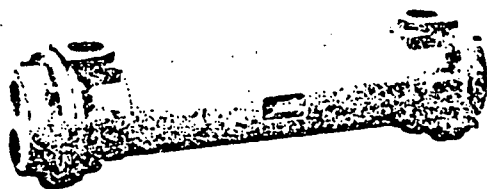


VIII. HEAT EXCHANGERS

VIII. HEAT EXCHANGERS

- A. Heat exchangers HE-1 and HE-2: Bell & Gossett, Type STH, Model No. 530-1, one pass.

- B. Installation, operation and maintenance instructions:



Type STH Heat Exchangers

JOB	Stanford University Food Services Bldg.	B & G REPRESENTATIVE	Calif. Hydronics Corp.
UNIT TAG NO.	HE-1	ORDER NO.	DATE
ENGINEER	Interactive Resources	SUBMITTED BY	DATE
CONTRACTOR	Redwood Mechanical	APPROVED BY	DATE

DESCRIPTION

B&G type 'STH' Heat Exchangers are of the shell and tube type with non-removable tube bundles. Copper shell, brass baffles and copper tie rods supply total nonferrous contact on the shell side. Replaceable zinc plug in the head provides anodic protection on the tube side.

Note: 2 units operating in series

OPERATING DATA

DUTY:

1. Exchanger Model Number 530-1

Service Cooler Heater

	TUBE SIDE	SHELL SIDE
2. Fluid Circulated .. water both sides		
3. Total Flow Expressed in GPM, GPH, CFM, CFH, lbs./min, or lbs./hr.	21 GPM	21 GPM
4. Specific Gravity		
5. Specific Heat		
6. Latent Heat		
7. Viscosity Expressed in Proper Units and Temperature such as centipoises @ °F		
8. Temperature In/Out	110/95°F	85/100°F
9. Transfer BTU/hr.	105,000	105,000
10. Thermal Conductivity		
11. Maximum Operating Temperature of Unit		
12. Pressure Drop (Maximum) total for both	1.0	16.0
13. Fouling Factor or Percentage of Additional Surface		.001

APPROVALS



Type STH Heat Exchangers

JOB	Stanford University Food Services Bldg.	B & G REPRESENTATIVE	Calif. Hydronics Corp.
UNIT TAG NO.	HE-2	ORDER NO.	DATE
ENGINEER	Interactive Resources	SUBMITTED BY	DATE
CONTRACTOR	Redwood Mechanical	APPROVED BY	DATE

DESCRIPTION

B&G type 'STH' Heat Exchangers are of the shell and tube type with non-removable tube bundles. Copper shell, brass baffles and copper tie rods supply total nonferrous contact on the shell side. Replaceable zinc plug in the head provides anodic protection on the tube side.

SEE 113

OPERATING DATA

Note: 2 units operating in parallel

DUTY:

1. Exchanger Model Number 530-1

Service Cooler Heater

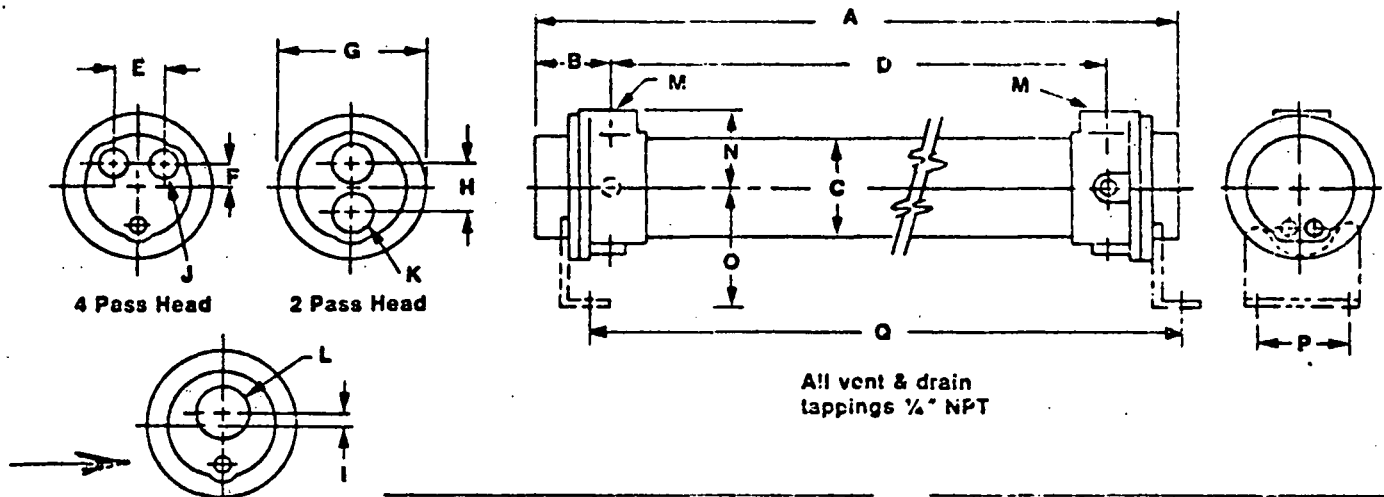
	TUBE SIDE	SHELL SIDE
2. Fluid Circulated	<u>water both sides</u>	
3. Total Flow Expressed in GPM, GPH, CFM, CFH, lbs./min. or lbs./hr.	<u>21 GPM</u>	<u>21 GPM</u>
4. Specific Gravity		
5. Specific Heat		
6. Latent Heat		
7. Viscosity Expressed in Proper Units and Temperature such as centipoises @ °F.		
8. Temperature In/Out	<u>135/123°F</u>	<u>113/125°F</u>
9. Transfer BTU/hr.	<u>126,000</u>	<u>126,000</u>
10. Thermal Conductivity		
11. Maximum Operating Temperature of Unit		
12. Pressure Drop (Maximum) <u>total for both</u>	<u>1.0</u>	<u>16.0</u>
13. Fouling Factor or Percentage of Additional Surface		<u>.001</u>

APPROVALS

OPPOSITE SIDE ← →

TYPE STH HEAT EXCHANGERS

DIMENSIONS



	Tubeside	Shellside
Design Press.	150 PSI	225 PSI
Test Press.	200 PSI	300 PSI
Design Temp.	300°F	300°F

Material Specifications	
Heads-Cast Iron	Shell-Copper
Tubesheets-Brass	Shell Ends-Brass
Tubes-STH300&400 Series 1/4 in. copper	
STH500&600 Series 3/8 in. copper	

MODEL	AREA sq. ft.	1 Pass		2 Pass		4 Pass		C in.	D in.	E in.	F in.	G in.	H in.	I in.	J NPT	K NPT	L NPT	M NPT	N in.	O in.	P in.	Q** in.	Approx. Wt.
		A in.	B in.	A in.	B in.	A in.	B in.																
STH-310-°	4.2	17%		17%		17%			13													15 3/4	16
STH-315-°	5.9	23%	2%	23%	2%	23%	2%	3 1/2	19	1%	3/8	4 1/2	1%	1/8	3/8	1	1 1/2	1	2 1/2	2%	3%	21 3/4	19
STH-320-°	7.6	29%		29%		29%			25													27 3/4	22
STH-410-°	7.2	17%		17%		17%			12 3/4													15 3/4	22
STH-415-°	10.0	23%	2%	23%	2%	23%	2%	3 3/4	18 3/4	1 1/2%	3/8	5 1/2	1 1/2%	1/8	1	1	2	1 1/2	3	3%	3	21 3/4	32
STH-420-°	12.9	29%		29%		29%			24 3/4													27 3/4	46
STH-515-°	13.0	24%		24%		23%			18 3/4													21 3/4	50
STH-520-°	16.7	30%	3%	30%	3%	29%	2%	5%	24 3/4	2%	1%	6%	2%	1/8	1	1 1/2	2 1/2	1 1/2	3 1/2	4%	3%	27 3/4	56
STH-530-°	24.0	42%		42%		41%			36 3/4													39 3/4	68
STH-620-°	28.2	31 1/2%		30 1/2%		30%			24													27 3/4	74
STH-630-°	40.8	43%		42%		42%			36													39 3/4	93
STH-640-°	53.4	55 1/2%	3%	54%	3%	54%	3%	6%	49	2%	1%	7%	3%	3/8	1 1/2	2	3	2	4 1/2	4%	3	51 3/4	112
STH-650-°	66.0	67 1/2%		66 1/2%		66%			60													63 3/4	131

*No. of passes, either 1, 2 or 4.
 **Dimension for this arrangement only
 Note: Dimensions subject to change without notice

INSTRUCTIONS FOR B&G HEAT EXCHANGER

INSTALLATION

1. Provide sufficient clearance at the end of the front head of unit to permit removal of tube bundle from shell. At the rear head end of straight-tube units, a space of 3 or 4 feet should be provided to permit the removal of the rear head.
2. Provide valves and by-passes in the piping system so that both the shell and tube sides may be by-passed to permit cutting out the unit for inspection or repairs.
3. Provide thermometer wells and pressure gauge connection in all piping to and from the unit and located as near the unit as possible.
4. Provide convenient means for frequent cleaning the unit as suggested under "Maintenance."
5. Provide necessary air vent cocks for unit so it can be purged to prevent or relieve vapor binding of either the tube or the shell sides.
6. Foundations must be adequate so that exchangers will not settle and cause piping strains. Foundation bolts should be set to allow for setting inaccuracies. In concrete footings, pipe sleeves at least one size larger than bolt diameter slipped over the bolt and cast in place are best for this purpose, as they allow the bolt center to be adjusted after the foundation has set.
7. Loosen foundation bolts at one end of unit to allow free expansion of shells. Oval holes in foundation brackets are provided for this purpose.
8. Set exchangers level and square so that pipe connections may be made without forcing.
9. Inspect all openings in exchanger for foreign material. Remove all wooden plugs and shipping pads just before installing. Do not expose units to the elements with pads or other covers removed from nozzles since rain water may enter the unit and cause severe damage due to freezing.
10. Be sure entire system is clean before starting operation to prevent plugging of tubes with sand or refuse.
11. Drain connections should not be piped to a common closed manifold.
12. Steam hammer can cause serious damage to the tubes of any heat exchanger. A careful consideration of the following points before an installation is made can prevent costly repairs which may be caused by steam hammer.
 - a. A vacuum breaker and/or vent, should be used in accordance with the type of steam system installed.
 - b. The proper trap for the steam system installed should be used.
 - c. The trap and the condensate return line to the trap should be properly sized for the total capacity of the convertor.
 - d. The trap should be sized for the pressure at the trap, not the inlet pressure to the steam controller.

OPERATION

1. When placing a unit in operation, open the vent connections and start to circulate the cold medium only. Be sure that the passages in the exchanger are filled with the cold fluid before closing the vents. The hot medium should then be introduced gradually until all passages are filled with liquid, close vents and slowly bring the unit up to temperature.
2. Start operation gradually. Do not admit hot fluid to the unit suddenly when empty or cold. Do not shock unit with cold fluid when unit is hot.
3. In shutting down, flow of hot medium should be shut off first. If it is necessary to stop circulation of cooling medium, the circulation of hot medium should also be stopped by by-passing or otherwise.
4. Do not operate equipment under conditions in excess of those specified on name plate.
5. Drain all fluids when shutting down to eliminate possibility of freezing and corrosion. To guard against water hammer, condensate should be drained from steam heaters and similar apparatus both when starting up and when shutting down.
6. In all installations there should be no pulsations of fluids, since this causes vibration and strain with resulting leaks.
7. All gasketed joints should be checked after starting, for leaks and tightened if necessary.

MAINTENANCE

1. Do not open heads until all pressure is off equipment and the unit drained.
2. Do not blow out heat exchangers with air when fluids normally handled are of an inflammable nature.
3. Provide convenient means for frequently cleaning heat exchangers suggested below:
 - a. Circulating hot wash oil or light distillate through tubes or shell at good velocity will effectually remove sludge or other similar soft deposits.
 - b. Soft salt deposits may be washed out by circulating hot fresh water.
 - c. Some cleaning compounds on the market, such as "Oakite" may be used to advantage for removing sludge or coke, provided hot wash oil or water, as described above, does not give satisfactory results.
 - d. If none of the above described methods are effective for the removal of hard scale or coke a mechanical means may be used.
4. To clean or inspect inside of tubes, remove channel cover and rear head. On exchangers having bonnet type heads (without channel cover) piping must be disconnected and both heads removed.
5. Do not attempt to clean tubes by blowing steam through individual tubes. This overheats the tube and results in tube expansion strains and sometimes leaking tubes.
6. Frequently and at regular intervals, observe interior and exterior condition of all tubes and keep them clean. Neglect in keeping all tubes clean may result in complete stoppage of flow through some tubes, with consequent overheating of these tubes as compared to surrounding tubes resulting in severe expansion strains and leaking tube joints. Frequent cleaning should be according to scale build-up. Be sure to clean tubes during Spring before the arrival of warm summer-time cooling water.
7. Exchangers subject to fouling or scaling should be cleaned periodically. A light sludge or scale coating on the tube greatly reduces its effectiveness. A marked increase in pressure drop and/or reduction in performance usually indicates cleaning is necessary, if the unit has been checked for air or vapor binding and this has been found not to be the cause. Since the difficulty of cleaning increases rapidly as the scale thickens or deposits increase, the interval between cleanings should not be excessive.
8. When removing tube bundles from exchangers for inspection or cleaning, care should be exercised that they are not damaged by improper handling. Do not handle tube bundles with hooks or other tools which could damage tubes. Tube bundles are often of great weight, yet the tubes are small and of relatively thin metal. If the tube bundle has been in service for a considerable length of time without being removed it may be necessary to use a hydraulic jack on the rear tube sheet to get it started. A good sized steel bearing plate should be inserted between jack and tube sheet and the tube ends protected by means of a filler board. In cleaning a tube bundle, tubes should not be hammered on with a metallic tool and in case it is necessary to use scrapers, care should be exercised that the scraper is not sharp enough to cut the metal of the tube.

IX. VALVES

IX. VALVES

- A. Relief valves: Bell & Gossett Model No. 480-75
- B. Circuit setters: Bell & Gossett Model Nos. CB-1 and CB-1½
- C. Gate vales: Red-White/Toyo Model No. 206
- D. Check valves: Red-White/Toyo Model No. 236
- E. Test plugs: Peterson Equipment Company, Inc.
"Pete's Plug," Nordel with brass core and body

BELL & GOSSETT

SUBMITTAL

A-434
REVISION 2



RELIEF VALVES — ASME

Valves and Fittings

JOB	Stanford Univesity Food Services Bldg.	B & G REPRESENTATIVE	Calif. Hydronics Corp
UNIT TAG NO.	solar panel & H/W tank	ORDER NO.	DATE
ENGINEER	Interactive Resources	SUBMITTED BY	DATE
CONTRACTOR	Redwood Mechanical	APPROVED BY	DATE

DESCRIPTION

B&G Relief Valves are designed to protect the heating system against high pressure conditions. During an emergency, a B&G diaphragm-operated valve has exceptionally strong opening power. These valves are built to A.S.M.E. requirements—tested by National Board and labeled with A.S.M.E.

symbol. They are offered in a wide range of capacities to permit close matching of Relief Valve capacity to the boiler load.

CONSTRUCTION

All internal working parts in B&G Relief Valves are made of brass or specially compounded rubber. Body is iron.

SCHEDULE

MODEL NUMBER	SIZE TAPPINGS	VALVE SETTING	TAGGING INFORMATION	QUANTITY ORDERED
480-15	¾ x 1	15		
480-30		30		
480-36		36		
480-45		45		
480-50		50		
480-75		75		
480-100		100		
480-125	125			
750-15	1 x 1½	15		
750-30		30		
750-36		36		
750-45		45		
750-50		50		
750-75		75		
750-100		100		
750-125	125			
1050-15	1½ x 1¼	15		

MODEL NUMBER	SIZE TAPPINGS	VALVE SETTING	TAGGING INFORMATION	QUANTITY ORDERED
1050-30	1¼ x 1¼	30		
1050-36		36		
1050-45		45		
1050-50		50		
1050-75		75		
1050-100		100		
1050-125		125		
3300-15	1½ x 2	15		
3300-30		30		
3300-36		36		
3300-45		45		
3300-50		50		
4100-15	2 x 2	15		
4100-30		30		
4100-36		36		
4100-45		45		
4100-50		50		

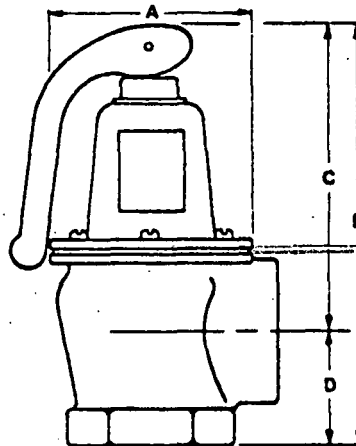
BELL & GOSSETT ITT
FLUID HANDLING DIVISION

RELIEF VALVES—ASME (Valves and Fittings)

PERFORMANCE CHARACTERISTICS

MAX. WORKING PRESSURE—125 P.S.I.G. MAX. OPERATING TEMPERATURE—250 F.

VALVE SETTING	RELIEF VALVE MODEL NUMBER AND CAPACITY IN BTU PER HOUR				
15 Lbs.	No. 480-15 300,000	No. 750-15 500,000	No. 1050-15 650,000	No. 3300-15 2,000,000	No. 4100-15 2,500,000
30 Lbs. Standard Setting	No. 480 480,000	No. 750 750,000	No. 1050 1,050,000	No. 3300 3,300,000	No. 4100 4,100,000
36 Lbs.	No. 480-36 540,000	No. 750-36 830,000	No. 1050-36 1,200,000	No. 3300-36 3,800,000	No. 4100-36 4,600,000
45 Lbs.	No. 480-45 640,000	No. 750-45 1,000,000	No. 1050-45 1,350,000	No. 3300-45 4,500,000	No. 4100-45 5,550,000
50 Lbs.	No. 480-50 700,000	No. 750-50 1,100,000	No. 1050-50 1,440,000	No. 3300-50 4,900,000	No. 4100-50 6,050,000
75 Lbs.	No. 480-75 980,000	No. 750-75 1,500,000	No. 1050-75 2,020,000		
100 Lbs.	No. 480-100 1,250,000	No. 750-100 1,900,000	No. 1050-100 2,565,000		
125 Lbs.	No. 480-125 1,540,000	No. 750-125 2,200,000	No. 1050-125 3,015,000		



DIMENSIONS & WEIGHTS

MODEL NUMBER	DIMENSIONS—INCHES				VALVE TAPPINGS		APPROX. SHIPPING WEIGHT—LBS. EACH
	A	B	C	D	INLET	OUTLET	
480	3½	6¾	4⅞	1½	¾	1	4
750		7¾	5⅞	2	1	1¼	5
1050		1¼	1¼	5			
3300	6	11	7	3¼	1½	2	18
4100					2		

TYPICAL SPECIFICATION

Furnish and install as shown on plans a diaphragm operated Relief Valve, ASME labeled for relieving pressure of _____ psig with a rating of _____ Btu/hr. The fluid should not discharge into the spring chamber. The valve should have a low blow-down differential. The valve seat and all-moving parts exposed to the fluid to be of non-ferrous material.

Manufacturer ITT Bell & Gossett No. _____.

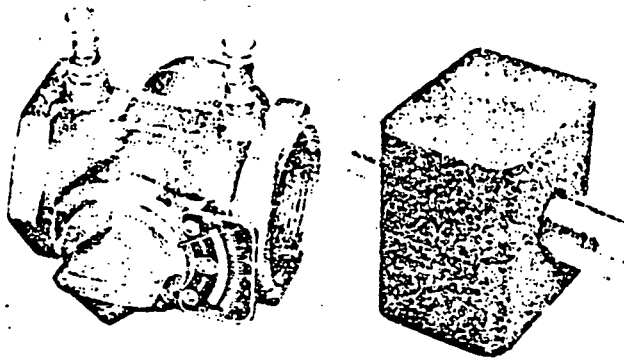
ASME Relief Valve set at _____ psig, rated at _____ Btu/hr.

BELL & GOSSETT **ITT**
INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

BELL & GOSSETT

SUBMITTAL

A-551
REVISION 3



Engineered Products
Circuit Setter®
Balance Valves
with NPT, Flanged and Solder Connections

NPT SHOWN

JOB	Stanford University Food Services Bldg.	B & G REPRESENTATIVE	Calif. Hydronics
ENGINEER	Interactive Resources	ORDER NO	DATE
CONTRACTOR	Redwood Mechanical	SUBMITTED BY	DATE
		APPROVED BY	DATE

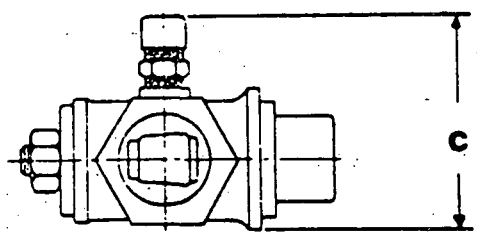
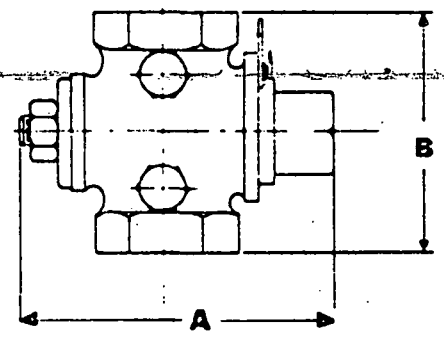
OPERATING DATA

MAXIMUM WORKING PRESSURE 125 PSIG.

MAXIMUM OPERATING TEMPERATURE 250°F.

DIMENSIONS AND WEIGHTS

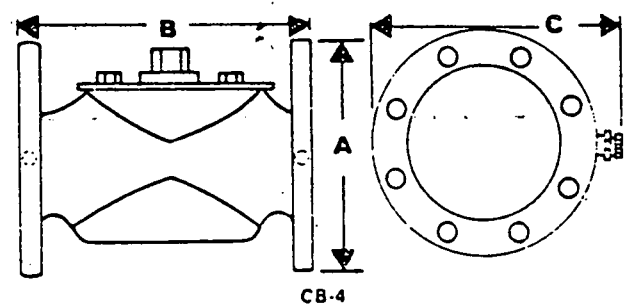
Model No.	DIMENSIONS IN INCHES								Weight In Lbs.
	Size		A		B		C		
			Normal	Insul	Normal	Insul	Normal	Insul	
CB-1/2	1/2	NPT	2 3/4	4	2 1/2	4 1/4	2 1/4	4 1/4	3/4
CB-3/4	3/4		2 1/2	4	2 1/2	4 1/4	2 3/8	4 1/4	1
CB-1	1		3 1/2	5 1/2	2 1/2	3 3/4	2 3/8	4 3/4	1 1/2
CB-1 1/4	1 1/4		3 3/4	6	3	4 1/4	2 3/8	4 3/4	2
CB-1 1/2	1 1/2		4 3/4	6 1/2	3 3/4	4 1/2	3 1/8	6	3 1/2
CB-2	2		5 1/2	7	4 1/4	4 1/2	3 1/8	6	5 1/2
CB-2 1/2	2 1/2		7 1/2	9	5 1/2	5 1/2	4 1/2	7	16
CB-3	3		8	9	6 1/2	7	5 1/8	7	20
CB-4	4	FLG	9	9 1/2	8	8	10 1/8	10 1/8	52



CB-1/2 THRU CB-3

SCHEDULE

Model No.	Tagging Information	Quantity
CB- 1/2		
CB- 3/4		
CB-1		
CB-1 1/4		
CB 1 1/2		
CB-2		
CB-2 1/2		
CB-3		
CB-4		



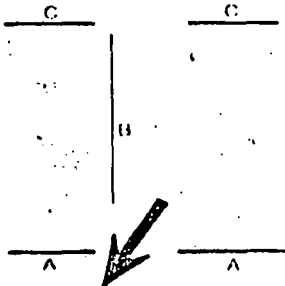
CB-4

BELL & GOSSETT **ITTT**
FLUID HANDLING DIVISION

RED-WHITE/TOYO ⁶⁰ Bronze gate valves

RED-WHITE'S 206 and 207 GATE VALVES are highly recommended as the best buy for commercial and residential jobs. Second-to-none precision machining and shell molded casting produce these high quality gate valves. Their easy grip hand wheel assures smooth torque. Screwed in bonnets for 1", 1 1/2", 2", 3" and 4". Available in 9 sizes from 3/8" to 4". Constructed of 85-5-5-5 Bronze, ASTM B62. Stem material of Dura Stem.

Working pressure non-shock (PSI)
Saturated steam 125
Cold water, oil, gas 200
Hydrostatic test pressure (PSI)
Shell 300
Seat 125



1/2" 1/4" 1/8"

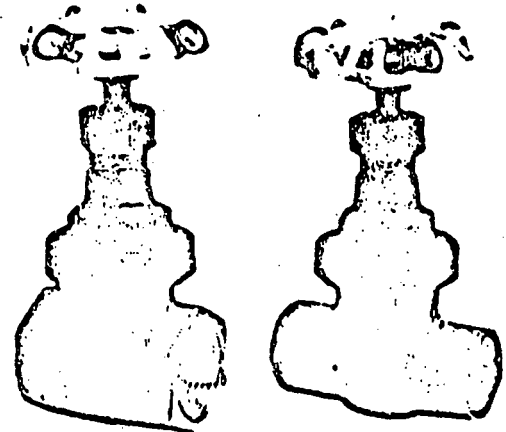


Figure #206 125# W.S.P., 200# W.O.G., NON RISING STEM, SOLID WEDGE DISC, SCREWED ENDS

Size	3/8"	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	4"
A	1 1/8"	1 1/2"	2 1/16"	2 3/8"	3 1/8"	3 3/8"	4 1/8"	4 3/8"	5 1/8"	6 1/8"
B	3 3/16"	3 1/2"	3 1/8"	4 1/8"	5 1/8"	5 3/8"	6 1/8"	6 3/8"	7 1/8"	8 1/8"
C	1 1/4"	1 1/2"	2 1/16"	2 1/8"	2 3/8"	3 1/8"	3 3/8"	4 1/8"	4 3/8"	5 1/8"

Figure #207 125# W.S.P., 200# W.O.G., NON RISING STEM, SOLID WEDGE DISC, SOLID ENDS*

Size	3/8"	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	4"
A	1 1/8"	1 1/2"	2 1/16"	2 3/8"	3 1/8"	3 3/8"	4 1/8"	4 3/8"	5 1/8"	6 1/8"
B	3 3/16"	3 1/2"	3 1/8"	4 1/8"	5 1/8"	5 3/8"	6 1/8"	6 3/8"	7 1/8"	8 1/8"
C	1 1/4"	1 1/2"	2 1/16"	2 1/8"	2 3/8"	3 1/8"	3 3/8"	4 1/8"	4 3/8"	5 1/8"

RED-WHITE'S 208 GATE VALVE is specially constructed for continuous service in either open or fully closed position for steam, water, oil or gas. Satisfactorily handles viscous materials where entrapment is undesirable. Allows free flow with minimum pressure drop. Well-proportioned reinforced body design prevents distortion from pipeline strains and vibrations. Equipped with a deep stuffing box filled with high grade molded graphite impregnated asbestos packing and a gland follower. Position of stem indicates whether valve is open or closed. Stem threads are fully protected from fluids by the backseating, when the valve is fully open, prolonging service life. Stem and disc wing guides provide tight seat and sure-seat. Can be installed in any position. Can be repacked under pressure when wide open. Available in 9 sizes from 3/8" to 3". Constructed of 85-5-5-5 Bronze, ASTM B62. Stem material of ASTM B62. Complies with Federal Specification WW-V-54, Type II, Class A, Style I.

Working pressure non-shock (PSI)
Saturated steam 125
Cold water, oil, gas 200
Hydrostatic test pressure (PSI)
Shell 300
Seat 125

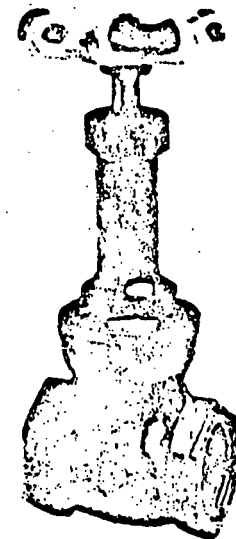
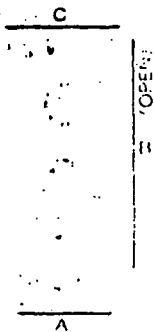


Figure #208 125# W.S.P., 200# W.O.G., RISING STEM, SOLID WEDGE DISC, SCREWED ENDS

Size	3/8"	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"
A	1 1/8"	2"	2 3/16"	2 3/8"	2 3/4"	3 1/8"	3 1/2"	4 1/8"	5 1/8"
B	4 1/8"	5 1/4"	6 1/8"	7 1/8"	8 1/8"	10 1/8"	12 1/8"	14 1/8"	17 1/8"
C	1 1/4"	2 3/8"	2 3/8"	2 1/8"	3 1/8"	3 3/8"	4 1/8"	4 3/8"	5 1/8"

*Working steam pressure rating of all solder end (CXC) valves applies to the valve bodies. These valves SHOULD NOT be used in service where the temperature of the fluids handled is higher than the point at which THE SOLDER MAY SOFTEN.

RED-WHITE/ TOYO ^{6d} Bronze check valves

RED WHITE'S 236 and 237 Y PATTERN SWING CHECK VALVE'S are used with gate valves to prevent back-flow in commercial and industrial steam, water, oil or gas lines. Can be easily installed and functions properly in either the vertical or horizontal position. 236 available in 10 sizes from 1/4" to 3", 237 available in 9 sizes from 1/2" to 3". Constructed of 85-5-5 Bronze, ASTM B62. 236 complies with Federal Specification WWV 51, Type IV, Class A, End connection 1 and 237 with WWV 51, Type IV, Class A, End connection 3. Solder ends in all sizes; comply with ANSI B16.33, Cast Brass Solder Joint Filings.

Working pressure non-shock (PSI)

Saturated steam 125
Cold water, oil, gas 200

Hydrostatic test pressure (PSI)

Shell 300
Seat 225 to 115

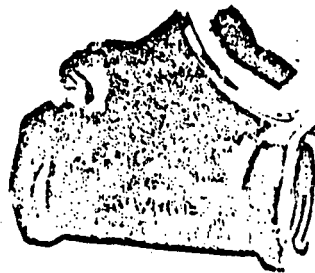
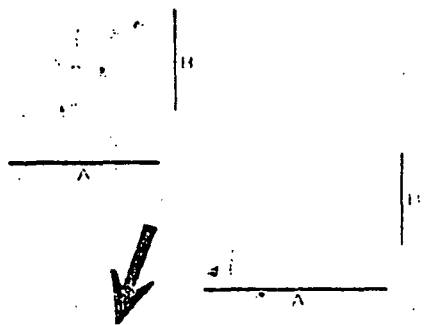


Figure #236 125# W.S.P. 200# W.O.G. Y PATTERN BODY, SWING CHECK, BRONZE DISC, SCREWED ENDS

Size	1/4"	3/8"	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"
A	1 1/16"	1 1/8"	1 3/16"	1 1/2"	1 3/4"	1 7/8"	2 1/16"	2 1/8"	2 3/8"	2 7/8"
B	1 1/8"	1 1/4"	1 5/8"	1 3/4"	1 7/8"	2 1/8"	2 1/4"	2 3/4"	3 1/8"	3 3/4"

Figure #237 125# W.S.P. 200# W.O.G. Y PATTERN BODY, SWING CHECK, BRONZE DISC, SOLDERED ENDS

Size	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"
A	2 3/16"	2 1/2"	2 3/4"	3 1/4"	3 1/2"	3 7/8"	4 1/8"	4 3/4"
B	1 1/8"	1 1/4"	1 1/2"	1 7/8"	2 1/8"	2 1/4"	2 3/4"	3 1/4"

RED-WHITE'S 238 HEAVY-DUTY Y PATTERN SWING CHECK VALVE is used to prevent back-flow on industrial steam, water, oil and gas lines. Installs easily to operate horizontally or vertically. Designed for minimum pressure change when opening or closing. Available in 9 sizes from 3/8" to 3". Body, disc and cap constructed of 85-5-5 Bronze, ASTM B62.

Working pressure non-shock (PSI)

Saturated steam 150
Cold water, oil, gas 300

Hydrostatic test pressure (PSI)

Shell 450
Seat 325 to 125

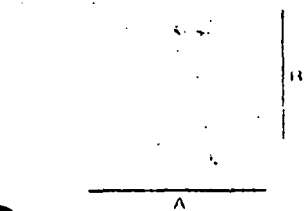


Figure #238 150# W.S.P. 300# W.O.G. SWING CHECK, BRONZE DISC, SCREWED ENDS

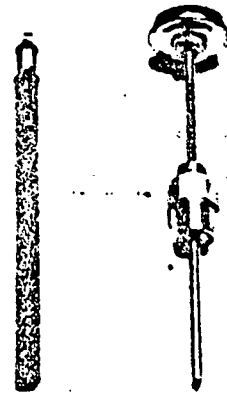
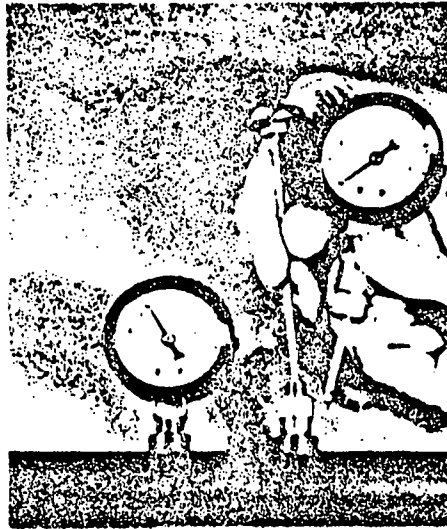
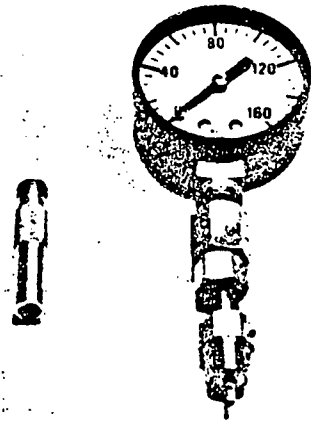
Size	3/8"	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"
A	2 1/8"	2 1/4"	2 3/8"	2 3/4"	3 1/8"	3 1/4"	3 3/8"	3 7/8"	4 1/2"
B	1 1/4"	1 1/2"	1 3/4"	1 7/8"	2 1/8"	2 1/4"	2 3/4"	3 1/8"	3 3/4"

PETE'S PLUG

PRESSURE OR TEMPERATURE TEST PLUG

ORDER FROM YOUR LOCAL REPRESENTATIVE'S STOCK

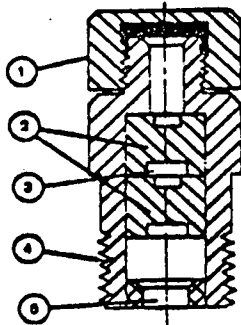
CALIFORNIA HYDRONICS CORPORATION
350 HATCH DRIVE
FOSTER CITY, CALIFORNIA 94404
PHONE (415) 341-6100



PRESSURE TEST

PRESSURE or TEMPERATURE TEST

TEMPERATURE TEST



PATENT NO. 3797317

1. Cap & Gasket Prevents Unauthorized Tampering
2. Two Neoprene, Nordel or Viton Self Closing Valves
3. Valve Pocket for Added Pressure Protection
4. $\frac{1}{4}$ " N.P.T. or $\frac{1}{2}$ " N.P.T.
5. Valve Retainer

PETE'S PLUG will allow you to take pressure or temperature readings — quickly — and eliminate the need for leaving costly gauges or temperature recorders on the line. Can be used on various applications of gas, air, water or chemicals to 1000 PSI and temperatures of -40 to 350°F . Available in any combination of valve core and valve body of Neoprene or Nordel with Brass, or 316

SS. Recommended maximum temperature ratings of Neoprene is 200°F , Nordel is 275°F .

The pressure gauge adapter has a $\frac{1}{8}$ Dia. probe of 304 stainless steel with union nut. The large probe prevents bending or breaking and is less likely to become clogged with foreign material, and operates in either the $\frac{1}{4}$ " or $\frac{1}{2}$ " N.P.T. test plug.



PETERSON EQUIPMENT COMPANY, INC.

P. O. Box 217

Richardson, Texas 75080

Phone 214/234-2356

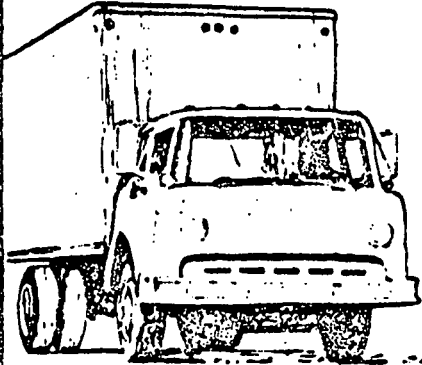
X. FLEXIBLE HOSES

X. FLEXIBLE HOSES

Stratoflex Silicone Hose, Part No.s 4241 and 4244.

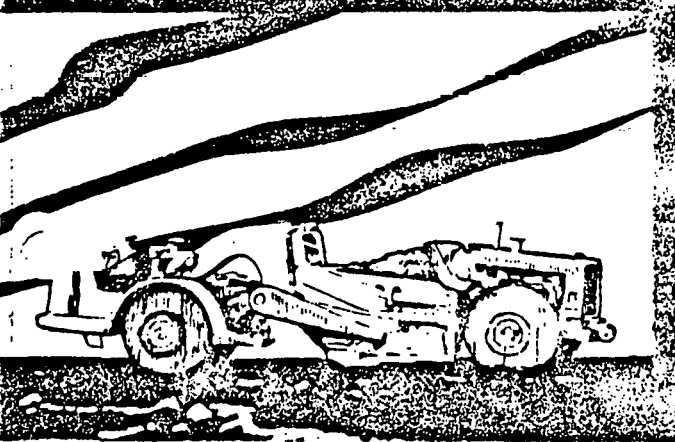
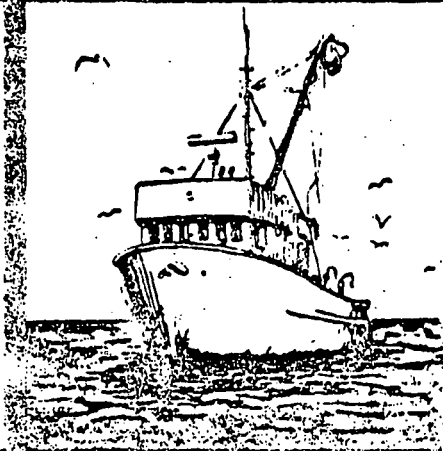
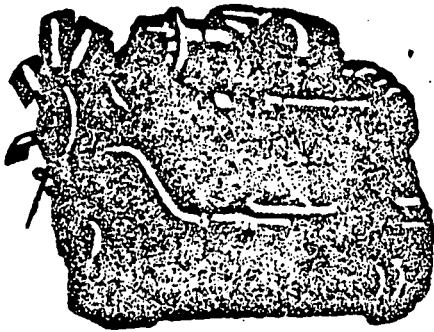
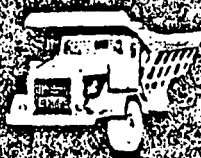
Use hose clamps only with extended tangs or shoes. Do not use wire-type clamps.

STRATOFLEX



STRATOSIL[®] SILICONE HOSE

DIESEL COOLANT
AND
HEATER HOSE



REDUCE MAINTENANCE COSTS

Stratosil hose offers the trucking industry product improvement and cost reduction. This relatively new Silicone hose actually eliminates "nonscheduled" maintenance resulting from early or "premature" failure of coolant or heater lines.



Certainly, the price of hose is an important cost consideration to the fleet operator. However, compounded expenses related to frequent downtime, the possibility of engine repair from overheats, and the loss of equipment utilization are far greater cost considerations that have plagued the trucker for years. Stratosil hose does initially cost more compared to conventional hose when specified on original equipment or when replaced in the field. However, the design objective and primary advantage of Stratosil hose is to reduce (if not eliminate) hose failure during scheduled equipment operation.

PERFORMANCE

Stratosil silicone hose is resistant to a wide variety of chemicals, oxidizing agents, acids, bases, and solvents. The hose also has excellent resistance to lubricating oils with low amine points. Charring or flaking-off after exposure to heat and different types of cooling system chemicals is negligible.

Stratosil is designed with high-performance and high-quality properties, making it an excellent hose for diesel and gas engine coolant applications. Stratosil is designed to function at low or high temperatures and under severe service conditions.

STRATOSIL COOLANT AND HEATER HOSE

4241 HOSE	\$ PART NO.	HOSE SIZE	HOSE I.D.	HOSE O.D.	MIN. BURST PRESS.	MAX. WORKING PRESS.	APPROX. WT. LBS./IN.
	4241-6	- 6	$\frac{3}{8}$	.66	350	50	.010
	4241-8	- 8	$\frac{1}{2}$	.80	325	50	.014
	4241-10	-10	$\frac{5}{8}$	.97	300	50	.019
	4241-12	-12	$\frac{7}{8}$	1.13	250	50	.025
	4241-16	-16	1	1.42	200	50	.034
<p>CONSTRUCTION: Polysiloxane (silicone) rubber inner tube, reinforced with one open fabric braid, covered with silicone rubber bonded to the braid and inner tube.</p> <p>IDENTIFICATION: Green cover, Stratosil name and part number.</p> <p>APPLICATION: Low pressure service for cooling and heater hose. Resistant to radiator coolants, steam, aging, mildew, and most wash-down fluids. Limited resistance to diesel fuel, petroleum-base oils, and solvents.</p> <p>TEMPERATURES: 65 to +350 F. (continuous service). For information on temperatures exceeding the rated limits, consult Stratosil Engineering Dept.</p> <p>SPECIAL: For use with clamps to form and bleed hose ends.</p>							
4243 HOSE	\$ PART NO.	HOSE SIZE	HOSE I.D.	HOSE O.D.	MIN. BURST PRESS.	MAX. WORKING PRESS.	APPROX. WT. LBS./IN.
	4243-6	- 6	$\frac{5}{16}$	.62	300	50	.009
	4243-8	- 8	$\frac{11}{32}$	.74	300	50	.012
	4243-10	-10	$\frac{1}{2}$	.83	225	50	.014
	4243-12	-12	$\frac{9}{16}$	.96	225	50	.017
	4243-16	-16	$\frac{7}{8}$	1.21	200	50	.023
	4243-20	-20	1 $\frac{1}{8}$	1.49	175	50	.030
<p>CONSTRUCTION: Polysiloxane (silicone) rubber inner tube, reinforced with three or more plies of woven polyester fabric impregnated with silicone rubber, and covered with a wrapped layer of silicone rubber bonded to the reinforcement.</p> <p>IDENTIFICATION: Green cover, Stratosil name and part number.</p> <p>APPLICATION: Low pressure service for heater hose. Resistant to radiator coolants, steam, aging, mildew, and most wash-down fluids. Limited resistance to diesel fuel, petroleum base oils and solvents.</p> <p>TEMPERATURES: 65 to +350 F. (continuous service). For information on temperatures exceeding the rated limits, consult Stratosil Engineering Dept.</p> <p>SPECIAL: The hose is constructed to SAE J1400 Type B equipment dimensions.</p>							

PART NO.	HOSE SIZE	HOSE I.D.	HOSE O.D.	MIN. BURST PRESS.	MAX. WORKING PRESS.	APPROX. WT. LBS./IN.	4244 HOSE
4244-6	6	3/8	.76	340	50	.014	
4244-8	8	1/2	.89	340	50	.021	
4244-10	10	5/8	1.02	340	50	.025	
4244-12	12	3/4	1.14	340	50	.029	
4244-14	14	7/8	1.26	340	50	.032	
4244-16	16	1	1.39	300	50	.036	
4244-18	18	1 1/8	1.51	300	50	.039	
4244-20	20	1 1/4	1.64	280	50	.042	
4244-22	22	1 1/2	1.76	280	50	.046	
4244-24	24	1 3/4	1.89	280	50	.050	
4244-28	28	1 7/8	2.14	260	50	.057	
4244-32	32	2	2.39	240	50	.065	
4244-36	36	2 1/4	2.64	240	50	.071	
4244-38	38	2 3/8	2.77	200	50	.074	
4244-40	40	2 1/2	2.89	200	50	.078	
4244-44	44	2 3/4	3.14	160	50	.085	
4244-48	48	3	3.39	160	50	.093	
4244-52	52	3 1/4	3.64	140	50	.107	
4244-56	56	3 1/2	3.89	140	50	.107	
4244-64	64	4	4.39	120	50	.121	



CONSTRUCTION: Polyethylene (silicone) rubber inner tube, reinforced with three layers of woven polyester fabric impregnated with silicone rubber, and covered with a wrapped layer of silicone rubber bonded to the reinforcement.

IDENTIFICATION: Green color, Stratoflex name and part number.

APPLICATION: Low pressure service for coolant and heater hose. Resistant to radiator coolant, steam, oil, grease, and most wash fluids. Limited resistance to fuels, petroleum products, and solvents.

TEMPERATURES: -40 to +200 F continuous service. For information on temperature limits exceeding 200 F, consult Stratoflex Engineering Dept.

NOTE: All hose use with clamps to formed and beaded male ends.

Stratosil silicone coolant and heater hose equals or exceeds the relevant performance values specified in RCCC Recommended Practice 303, SAE J20e and Federal Specification ZZ-H-428.

4241 Hose — SAE J20e Part III (SAE 20R3); ZZ-H-428 Type VI

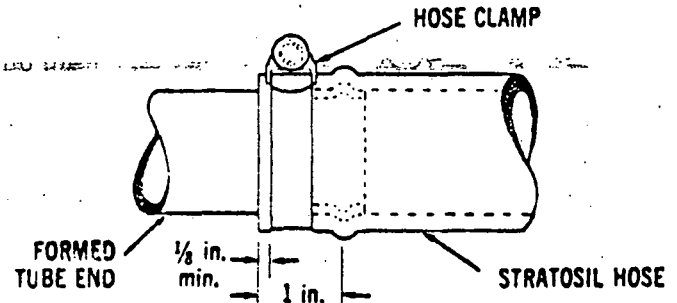
4243 Hose — RCCC RP303 Class II Type E

4244 Hose — RCCC RP303 Class I; SAE J20e Part I (SAE 20R1); ZZ-H-428 Type I

HOW TO INSTALL STRATOSIL 4241 AND 4244 HOSE

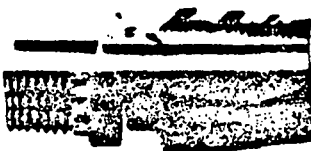
Cut hose to the desired length with a knife, push onto the formed tube end and secure with a clamp.

1. Extended tang hose clamps, or clamps with a shoe are recommended.
2. Do not use wire type clamps.
3. Hose clamps should be located as illustrated.
4. Clamping pressures — hose 1 1/2 inches and less in size, tighten to a torque of 35-40 inch pounds. Larger sizes, tighten to a torque of 45-50 inch pounds.

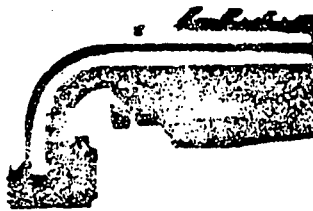


STRATOFLEX 213-TYPE HOSE FITTINGS FOR STRATOSIL 4243 HOSE

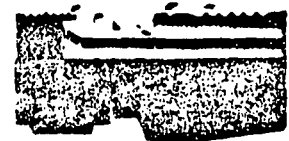
Stratosil 4243 Tube I.D. coolant hose is an extension of the 213 hose and fitting family. Designed to use 213-type fittings, this hose will enable fleet operators to convert to silicone coolant hose without having to maintain a separate inventory of fittings.



PIPE MALE



90 SAE 37 FLARE SWIVEL
90 SAE 45 FLARE SWIVEL
90 SF 30 FLARE SWIVEL

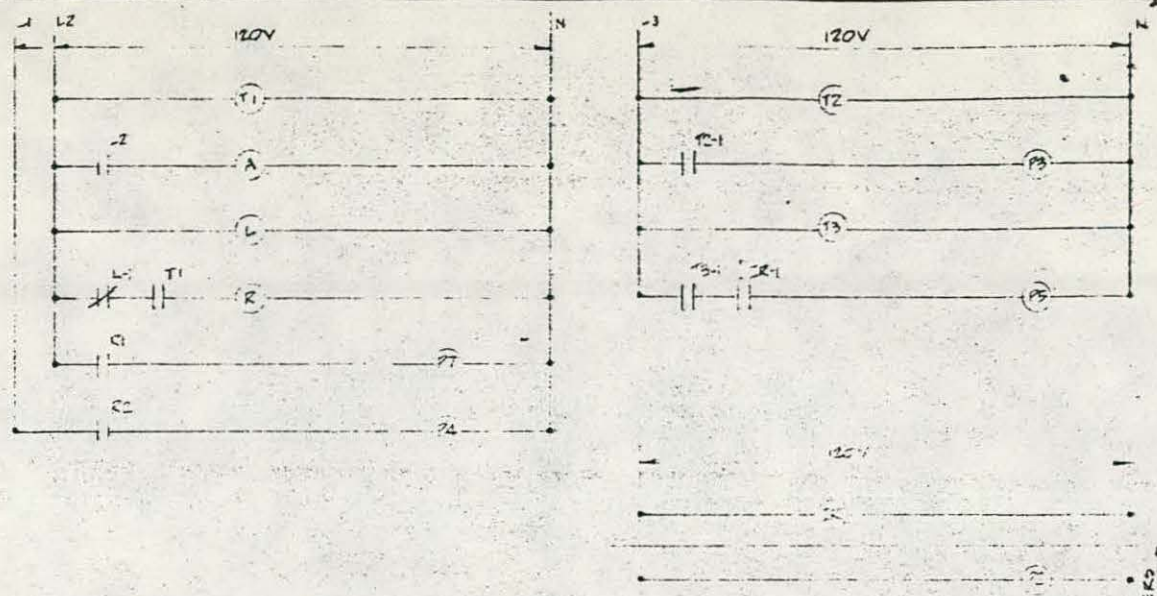


SAE 37 FLARE SWIVEL
SAE 45 FLARE SWIVEL
SF 30 FLARE SWIVEL

NOTE:

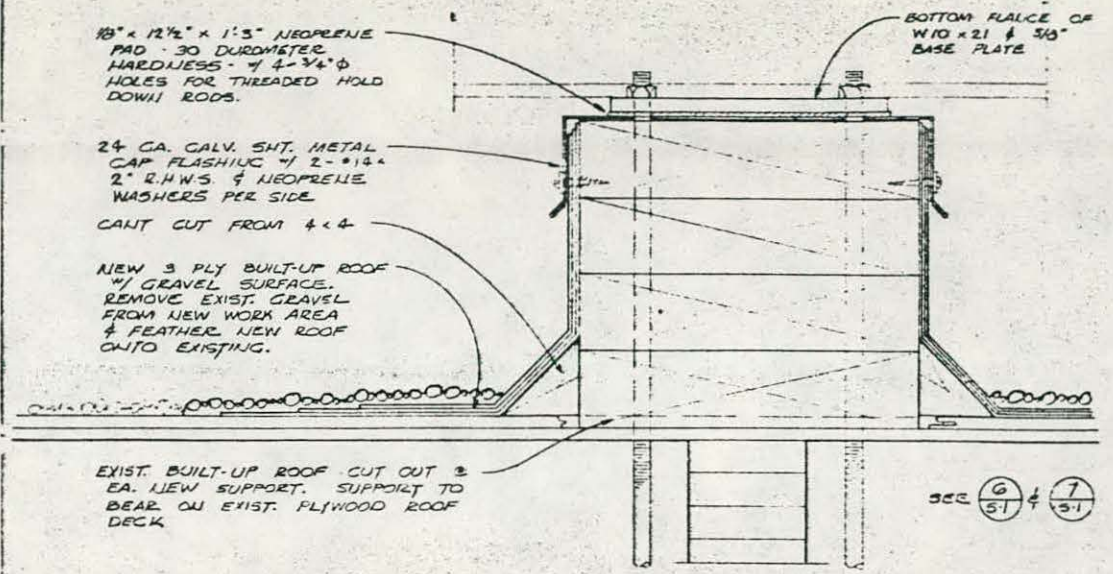
APPENDIX B

AS-BUILT DRAWINGS

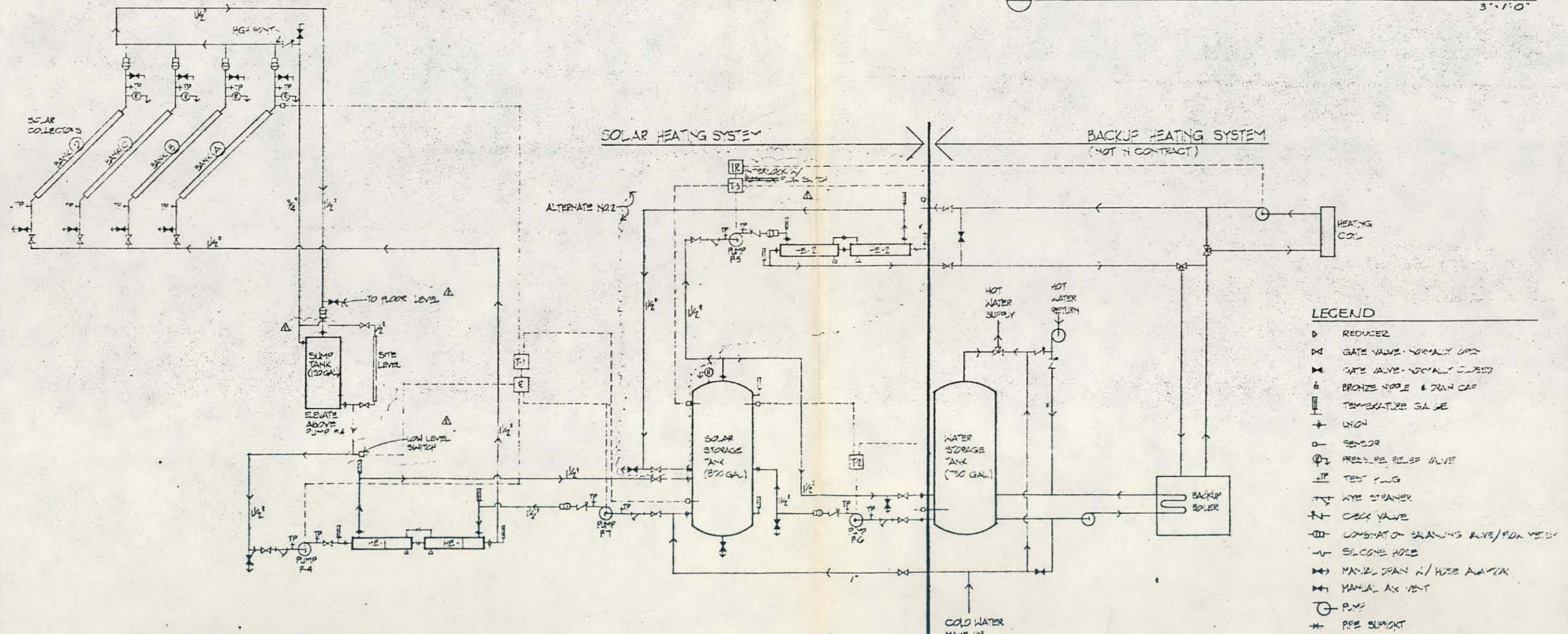


- LEGEND**
- (R) RELAY - 120V CO. - 2 NO. CONTACTS NEMA 1 ENCL.
 - (A) ALARM BELL - 120V.
 - (L) LEVEL CONTROL COMPLETE WITH PROBE ASSY - ONE MAKE ONE BREAK MANUAL RESET - MCDONNELL #902-M
 - (P) PUMP
 - (IR) INTERLOCK RELAY - 120V
 - (T) DIFFERENTIAL THERMOSTAT

① CONTROL DIAGRAM



② SOLAR TRUSS SUPPORT



- ③ SOLAR SYSTEM SCHEMATIC
- ① AT ALL LOW POINTS OF SYSTEM PROVIDE MANUAL DRAIN
 - ② AT ALL HIGH POINTS OF SYSTEM PROVIDE MANUAL VENT

- LEGEND**
- ▷ REDUCER
 - ⊗ GATE VALVE - NORMALLY OPEN
 - ⊗ GATE VALVE - NORMALLY CLOSED
 - ⊕ BRONZE NOBLE & DRAM CAP
 - ⊕ TEMPERATURE GAUGE
 - ⊕ UNION
 - ⊕ SENSOR
 - ⊕ PRESSURE RELIEF VALVE
 - ⊕ TEST TAP
 - ⊕ WYE STRAINER
 - ⊕ CHECK VALVE
 - ⊕ COMBINATION SHANNING RIVE/FLOW VALVE
 - ⊕ SILICONE HOSE
 - ⊕ MANUAL DRAIN W/ HUBS AND TAP
 - ⊕ MANUAL AIR VENT
 - ⊕ PUMP
 - ⊕ DIFFERENTIAL THERMOSTAT
 - ⊕ PUMP RELAY (STARTER)
 - ⊕ INTERLOCK RELAY

REVISIONS BY DATE

AD-BUILT 12/2/78

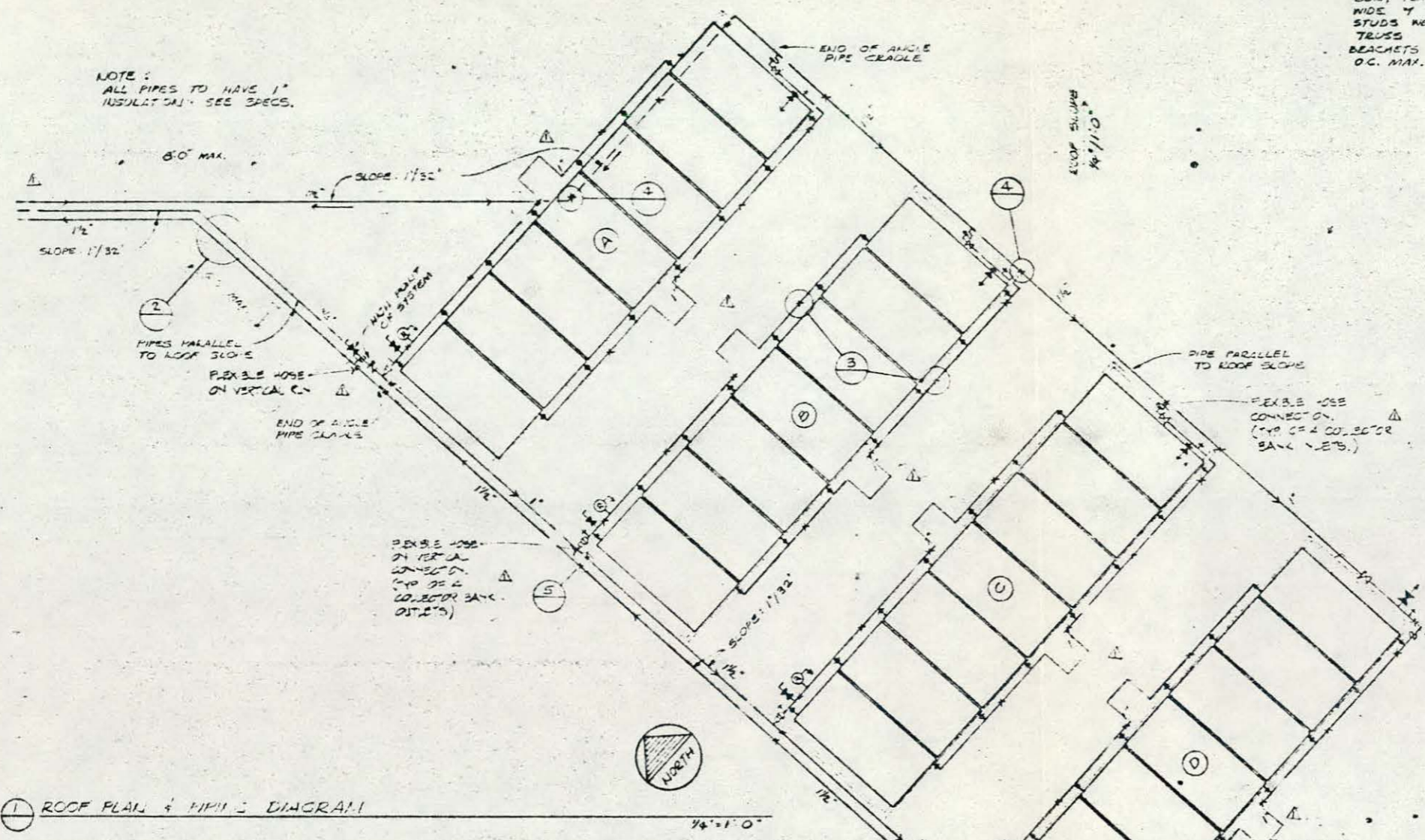
SOLAR HOT WATER AND SPACE HEATING SYSTEM
CENTRAL FOOD SERVICES BUILDING
STANFORD UNIVERSITY
SERVA ST. & PAMPAS LANE, STANFORD, CALIFORNIA

Interactive Resources, Inc.
computer professional services group
17 Oak Grove
Menlo Park, CA 94025

DATE 3-6-78
SCALE AS NOTED
DRAWN C.B.
JOB 7625
SHEET M-1

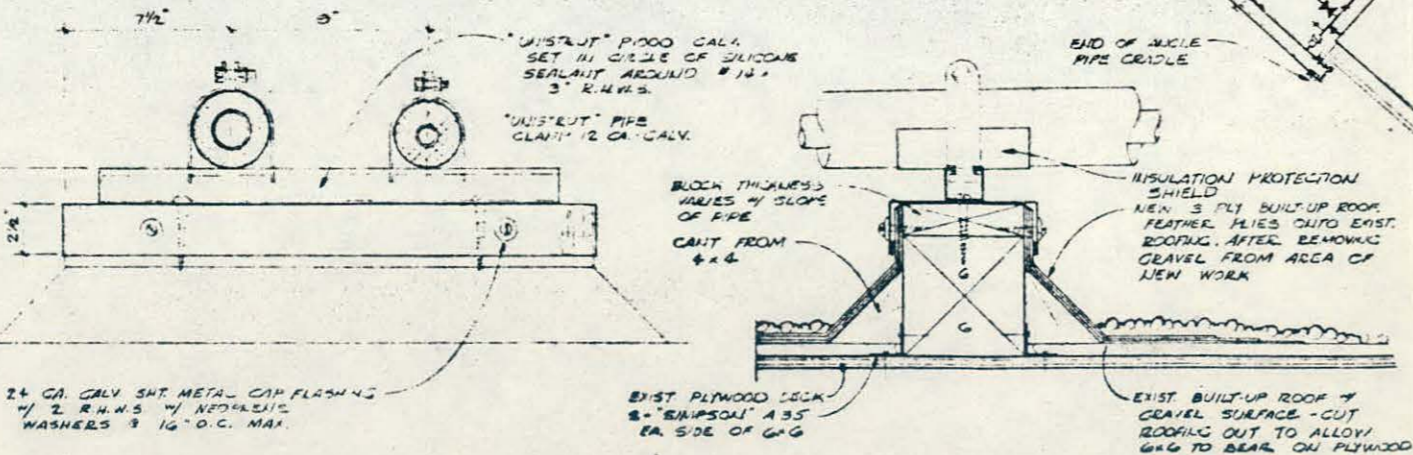
7
A

NOTE:
ALL PIPES TO HAVE 1" INSULATION - SEE SPECS.



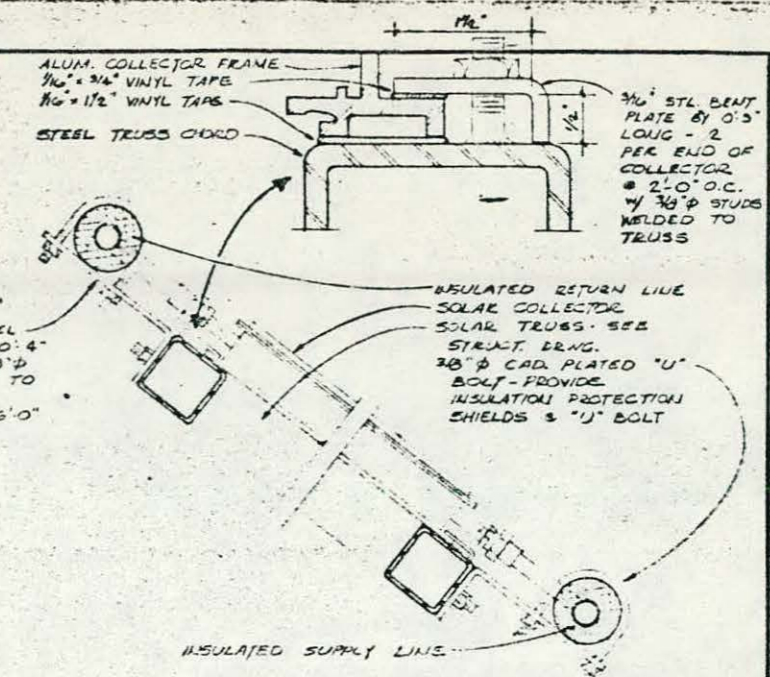
1 ROOF PLAN & PIPE DIAGRAM

1/4" = 1'-0"



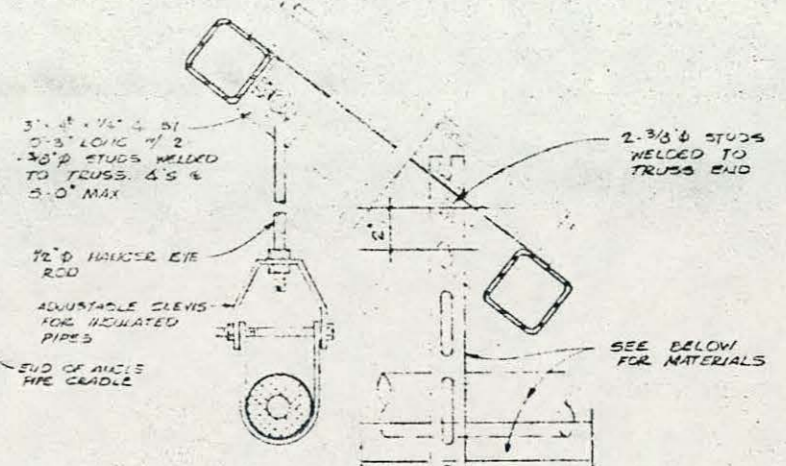
2 SUPPORT SYSTEM FOR PIPES ON ROOF

3/4" = 1'-0"



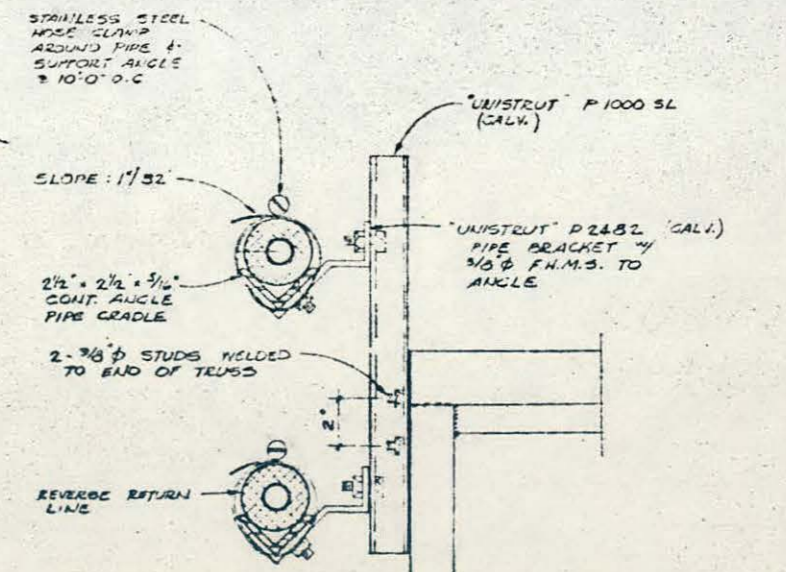
3 SUPPORT SYSTEM FOR SUPPLY & RETURN LINES

3/4" = 1'-0"



4 SUPPORT SYSTEM FOR SUPPLY LINES

3/4" = 1'-0"



5 SUPPORT SYSTEM FOR RETURN LINES

3/4" = 1'-0"

REVISIONS	BY
1	...
2	...

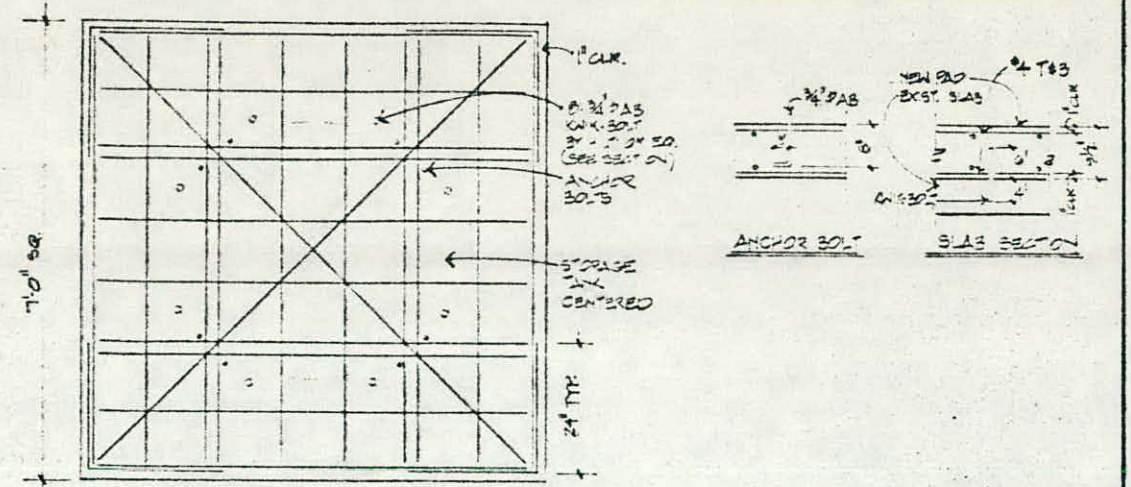
SOLAR HOT WATER AND SPACE HEATING SYSTEM
CENTRAL FOOD SERVICES BUILDING
STANFORD UNIVERSITY
SERRA ST. & DAWSON LANE, STANFORD, CALIFORNIA



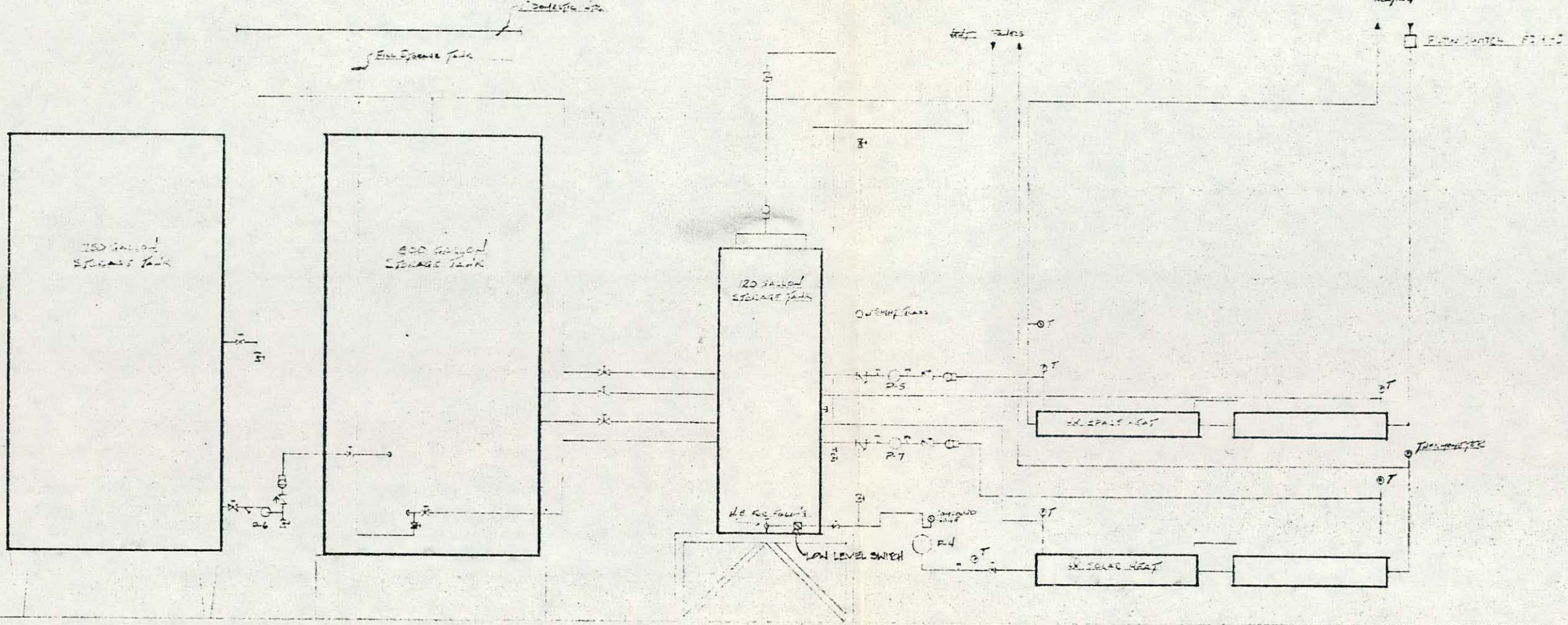
Interactive Resources, Inc.
computer produced services group
10000 W. 15th Ave. Suite 100
Boulder, CO 80501

DATE	13-6-70
SCALE	AS NOTED
DRAWN	C.T.
JOB	176-2.5
SHEET	M 2

ALL CONCRETE SLABS
#4 TOP & BOTTOM
EXCEPT PANELS
#5 BOTTOM ONLY



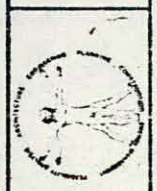
① STORAGE TANK PAD



② EQUIPMENT ELEVATION

REVISIONS	BY

SOLAR HOT WATER AND SPACE HEATING SYSTEM
CENTRAL CO SERVICES BUILDING
TAMKOR UNIVERSITY



Interactive Resources, Inc.
comprehensive professional services group
117 park place
telephone (415) 238-7435
port terminal on
94901

DATE	
SCALE	
DRAWN	
JOB	
DRAWING	

M-4

