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FINAL TECHNICAL REPORT
ON THE SOLAR HEATING SYSTEM
AT THE OFFICE OF BURNS/PETERS ARCHITECTS
(DEPARTMENT OF ENERGY AGREEMENT EM-78-F-03-2127)

By *FC03-78CS32127*

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June 18, 1979

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GENERAL DESCRIPTION

The Burns/Peters Building, as shown in Figures 1 and 2, is a 6000 square foot office located at 8000 Pennsylvania Place NE, Albuquerque, New Mexico. The building exhibits energy conservation design practices for both space conditioning and daylighting. The building's envelope is well insulated with styrene sheathing, fiberglass batts, and double glazed windows. North facing clerestory windows and reflective surfaces on the shed ceilings provide complete daylighting in the studio lofts (Figure 3). All windows are operable to allow ventilation and cooling in the swing seasons. Space cooling is provided by six evaporative coolers which work well in Albuquerque's arid climate and reduce energy requirements to less than 25% of standard refrigerated air conditioning units. Space heating is provided by a conventional hydronic heating system with solar assistance as described below. Domestic water heating is met by 100% solar energy.

Heating Systems: Space heating is provided by a completely conventional

FIRST FLOOR PLAN

Figure 1

hydronic system consisting of six fan coil units and a central, gas-fired boiler (Figure 4). Water is circulated in a pressurized, closed loop from the boiler to the fan coil units. Then it passes through a heat exchanger before returning to the boiler. The heat exchanger uses solar heated water from the storage tank to warm the circulating water in the conventional hydronic system and reduce the load on the boiler.

The solar heating system consists of sixty concentrating, tracking solar collectors (820 net square feet) as manufactured by Albuquerque Western Solar Industries.. The collectors are mounted on the south shed roof as shown in Figures 3, 5, and 6. Water from the storage tank is the working fluid in the drain-down system. The solar heated water is stored in an 1800 gallon atmospheric tank of wood construction with a polypropelene liner and six inch fiberglass batt insulation as shown in Figure 7. Upon demand from the building thermostats, solar heated water from the storage tank is circulated through the heat exchanger to warm the water in the conventional hydronic system.

Domestic water is heated by a natural convection loop (Figure 8) between the electric water heater and the solar storage tank. A double-wall heat

Figure 2

exchanger is provided along with a high temperature cutout to prevent the electric water heater from overheating. The back-up electric resistance heating elements in the tank have been disconnected.

Temperature sensors have been installed at various locations throughout the system. These are shown on the heating system schematic of Figure 4. The sensors are wired to a display in the lobby of the building as shown in Figure 9. At the display one can dial in any of the ten sensors to see the temperature at that point in the system.

The systems were installed according to the as-built piping schematic of Figure 10. The system met Interim Performance Criteria Requirements as specified in the Interim Performance standards, number NBSIR 76-1187.

Figure 3
Building Section

Conventional Hydronic Heating System

LEGEND	
SYMBOL	DESCRIPTION
	SUPPLY & RETURN LINES
	DIRECTION OF FLOW
	GATE VALVE
	BALANCING COCK
	PUMP ISOLATOR
	CHECK VALVE
	STRAINER
	T & P TEST PLUG
	UNION
	T & P RELIEF VALVE
	WATER REGULATOR
	ATMOSPHERIC VENT
①	TEMPERATURE SAMPLE

Solar Collection and Storage System

Domestic Water Heating System

Figure 4
Heating System Schematic

TEMPERATURE SAMPLES	
①	STORAGE TANK SUPPLY TO COLLECTORS
②	COLLECTOR RETURN TO STORAGE TANK
③	STORAGE TANK SUPPLY TO HEAT EXCHANGER SHELL
④	HEAT EXCHANGER SHELL RETURN TO STORAGE TANK
⑤	FAN COIL RETURN TO HEAT EXCHANGER TUBE
⑥	HEAT EXCHANGER TUBE SUPPLY TO BOILER
⑦	FAN COIL SUPPLY FROM BOILER
⑧	HEATING COIL SUPPLY FROM WATER HEATER STORAGE
⑨	WATER HEATER SUPPLY FROM HEATING COIL
⑩	OUTSIDE AIR TEMPERATURE
TEMPERATURE RESULTS*	
②-①	= SOLAR WATER GAIN FROM COLLECTORS
③-④	= SOLAR WATER ACROSS HEAT EXCHANGER SHELL
⑥-⑤	= HEATING WATER GAIN FROM HEAT EXCHANGER TUBE
⑦-⑥	= HEATING WATER GAIN FROM GAS FIRED BOILER
⑨-⑧	= DOMESTIC WATER GAIN FROM THERMOSIPHON COIL
* SYSTEM PUMP MUST BE OPERATING

Figure 5
Solar Collectors in Park Position

Figure 6
East Bank of Solar Collectors
Tracking the Sun

Figure 7
1800 Gallon Wood Storage Tank with Piping
Connections

Figure 8
Domestic Water Storage Tank with
Piping to Double Wall Heat
Exchanger in Solar Storage Tank

Figure 9
Display Showing System Schematic
and Allowing the User to Observe
Temperature at Various Points

LEGEND	
—	SUPPLY & RETURN LINES
→	DIRECTION OF FLOW
⊗	GATE VALVE
⊕	BALANCING COCK
■	PUMP ISOLATOR
⌞	CHECK VALVE
⌞	STRAINER
⌞	T & P TEST PLUG
⌞	UNION
⌞	T & P RELIEF VALVE
⌞	WATER REGULATOR
⌞	ATMOSPHERIC VENT
①	TEMPERATURE SAMPLE

SOLAR HEATING SYSTEM

TEMPERATURE SAMPLES	
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②	COLLECTOR RETURN TO STORAGE TANK
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⑨-⑧	= DOMESTIC WATER GAIN FROM THERMOSIPHON COIL
* SYSTEM PUMP MUST BE OPERATING	

Figure 10
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MAJOR MAINTENANCE AND CONSTRUCTION PROBLEMS ENCOUNTERED

Construction of the solar heating systems went fairly smoothly. The problems encountered in construction were as follows:

1. The piping loop from the storage tank through the heat exchanger and back to the storage tank originally had problems with natural convection reverse circulation when the storage temperature was lower than the hydronic heating system return water. In these cases the boiler would end up heating the storage tank. This was solved by installing a check valve in the loop.
2. The collectors were originally installed with receiver tubes rigidly fastened to a rigid frame. This did not allow for pipe growth, so the collector attachment was modified to allow the receiver pipe to move relative to the frame.

A maintenance schedule for the solar heating system is included in Appendix B.

UPDATED SYSTEM PERFORMANCE DATA

The solar system performance can be estimated from the results of hour-by-hour computer simulations published by recognized experts. For example, the solar performance can be estimated using the method of Balcomb et al.¹ This methodology involves calculation of percent solar heating from building load and collector area. Correction factors must be applied to modify the published results for the specific conditions to be addressed. The following pages do not show the reader how to apply this method, but simply present the calculations for this particular case.

SYSTEM LOAD

Walls	$U A = 0.07 \cdot 3900 = 273 \text{ BTU/hr-F}^0$
Roof	$U A = 0.05 \cdot 5000 = 250 \text{ "}$
Glass	$U A = 0.65 \cdot 450 = 292 \text{ "}$
Doors	$U A = 0.85 \cdot 84 = 71 \text{ "}$
Slab	$F P = 0.67 \cdot 290 = 194 \text{ "}$
Infiltration	$pVc_p = 0.060 \cdot$ $38000 \cdot 0.24 = 550 \text{ "}$
TOTAL	1630 BTU/hr-F^0

$$\frac{\text{Collector Area}}{\text{Load}} = 820 \text{ SF} / 1630 \frac{\text{BTU}}{\text{hr-F}^0} = 0.50 \frac{\text{SF}}{\text{BTU/hr-F}^0}$$

$$\frac{\text{Storage Mass}}{\text{Collector Area}} = 1800 \text{ gal} \cdot 8.3 \frac{\text{LBM}}{\text{gal}} \cdot 1 \frac{\text{BTU}}{\text{LBM-F}^0} \cdot \frac{1}{820 \text{ SF}_g} = 18 \frac{\text{BTU}}{\text{SF}_g\text{-F}^0}$$

¹Balcomb, Hedstrom, Moore, and Rogers, "Solar Heating Handbook for Los Alamos," Los Alamos Scientific Laboratory Report LA-5967-MS.

The following table lists characteristics of the Burns/Peters Office, characteristics of the systems modeled by Balcomb et al¹, and the appropriate correction factors which must be applied to the collector area/load ratio. Additional information may be obtained from Reference 1.

<u>Characteristic</u>	<u>Burns/Peters</u>	<u>Computer Simulation</u>	<u>Correction Factor</u>
Storage thermal mass (BTU/SF-F ⁰)	18	15	1.03
Heating Degree Days	4350	7400	1.70

Table I Load Factor Corrections

The corrected load factor for this case is

$$\begin{aligned}\frac{\text{Collector Area}}{\text{Load}} &= 0.50 \frac{\text{hr-SF-F}^0}{\text{BTU}} \cdot 1.03 \cdot 1.70 \\ &= 0.87 \frac{\text{hr-SF-F}^0}{\text{BTU}}\end{aligned}$$

This must be normalized to the building load used in the computer calculations, 12 BTU/SF_B-⁰day,

$$\frac{A}{A_B} = 0.87 \frac{\text{hr-SF-F}^0}{\text{BTU}} \cdot 12 \frac{\text{BTU}}{\text{SF}^0\text{day}} \cdot \frac{\text{day}}{24 \text{ hr}} = 0.44 \frac{\text{SF}}{\text{SF}_B}$$

From the Figure on the following page, this yields 70% active solar heating.

**Liquid/Water/Forced Air System in Los Alamos
EFFECT OF COLLECTOR ARRAY SIZE**

Figure 11 Solar Heating Fraction vs
Ratio of Collector Area to
Building Floor Area

APPENDIX A

ACCEPTANCE TEST PLAN AND RESULTS

TEST DATE: JANUARY 31, 1979

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SYSTEM DEFICIENCIES AND CORRECTIVE ACTION TAKEN	A - 6
ACCEPTANCE TEST PLAN	A - 7

DESCRIPTION OF TEST

The active solar heating system was tested in accordance with the acceptance test plan with a few minor modifications. The test procedure and results are given below. The system met the provisions of the Acceptance Test as described below.

- A. **HYDROSTATIC TEST:** This test was performed in the presence of and to the satisfaction of the Architect's representative prior to January 1, 1979. The reason for this was to complete the work on time (a great deal of work was required after the test, e.g., all pipe insulation). The piping from the mechanical room to the collectors was subjected to a hydrostatic test at 35 PSIG for a 2 hour period with no loss in pressure. It should be noted, however, that not all solar piping within the mechanical room was tested. Piping at the pumps and heat exchanger was not installed when the test was run. However, this was inspected and approved before the insulation was applied. The storage tank was also inspected and tested. The tank was set in place, filled with water, and the water level was then monitored for two days during which no drop was observed.
- B. **FLOW TEST:** A test was run to determine the flow rate through the collectors. The pressure rise across the pump was measured and this was used in conjunction with the manufacturer's pump curve (Page A-3) to determine the flow rate. The pressure rise across the pump was originally measured as $12.5 - 1.5 = 11.0$ PSIG = 25.3 feet of water at 70°F. This seemed too low, so measurements were also made for no-flow (pump discharge valve shut). In this case, the pressure rise was 27 feet. The pump curve of Page A-3 indicates that the no-flow pump head should be 38 feet (the Impeller diameter is 5-7/8"). This indicated a problem with pump operation. Subsequent investigation indicated that the pump was turning backwards. It was then rewired and tested by the architect's representative on March 12, 1979. At that time, the pump pressure rise was measured at $16.5 - 1.5 = 15$ PSIG = 34.5 feet head → 50 GPM. This is quite near the design operating condition of 35 feet and 45 GPM, so the system was left in that operating condition.
- C. **AUTOMATIC DRAINAGE:** The collector pump was shut off and the system was allowed to drain completely. The water level was then marked on the storage tank site glass. At this point the solar pump was activated and run until the water level dropped to a minimum. This level was also marked on the site glass - 1-7/8" below the original level. The pump was then shut off so the collectors and piping could drain. The piping drained and the storage tank water level rose to its original level within 10 minutes. The storage tank has inside dimensions of 7'0" by 6'0". Thus, the 1-7/8" change in water level corresponds to 49.2 gallons of water. This compares with 55.8

gallons of piping volume above the roof (820 lineal feet of 1-1/4" type M copper). Thus, approximately 10% of the piping was not filled with water. The air was probably in the return line from the top of the collectors back to the storage tank. This line will generally not fill because it is too steep. Thus, no firm conclusions can be drawn from this test. However, experience with the system indicates that there appears to be no problem with the drain down. The system has been in operation for one heating season during which the outside air temperature dropped well below 15°F on many occasions. During this period, no problems with freezing were encountered. Thus, it is apparent that the drain down system does afford adequate freeze protection.

- D. **COLLECTOR TRACKER:** The trackers were tested by manually shading one tracking sensor and causing the collectors to turn away from the sun. The shading was then removed and the collectors returned to properly tracking the sun. Thus, proper operation was demonstrated. However, a number of the collectors were found to be out of alignment with the sun. This might have been due to either high winds or slack developing in the cables. For this reason all the collectors were subsequently aligned and the cables tightened to minimize such problems in the future.

- E. DOMESTIC WATER SYSTEM: The domestic water heating system was not tested according to the original Acceptance Test Plan. At the beginning of the test, the 20 gallon domestic water heated tank was drained of hot water through one of the bathroom faucets. The breaker in the electrical circuit to the heating element was opened to cause the water to be heated only through the heat exchanger in the 1800 gallon solar storage tank. Operation of the thermosyphon between the storage tank and the domestic water heater was confirmed by observing that while the supply line from the water heater to the heat exchanger in the storage tank was cold, the line from the storage tank to the water heater was warm. The storage tank was at quite a low temperature (120°F maximum) during the test because of the constant interruption to the collection of energy, but by the end of the four hour test the hot water temperature at the tap was well above the cold water temperature. Although the temperature was not measured at the tap, it was considered adequate for the uses in the building--washing hands and showering.
- F. CONTROL SYSTEM CHECKOUT: The control systems on both the solar system and solar to conventional heating system were checked and found to be operating as designed. With sufficient sunlight available, the collectors unpark and track the sun. Approximately 6 minutes (measured as 5 min., 3 sec.) after the collectors unpark, the collector pump starts. If the light level drops below a set value (adjustable), the collector pump shuts off after approximately a 3 minute delay (measured as 3 min., 49 sec.). If the light level drops to a lower level, the collectors park. If the pump is still running, it shuts off immediately.

If the storage tank temperature is above 110°F and the building calls for heat, the storage tank/heat exchanger pump and the fan coil supply pump operate supplying solar heated water to the building. If the storage tank temperature is below 110°F and the building calls for heat, only the fan coil pump operates, and the boiler fires to provide heated water to the building.

A check valve was added to the storage tank/heat exchanger piping loop following the initial checkout and operation of the system. Because the heat exchanger is on the floor of the mechanical room considerably below the level of water in the storage tank, it was discovered that with a cold storage tank and the boiler operating to supply heat to the building, the storage tank/heat exchanger piping loop would thermosyphon and actually heat the storage tank from the boiler. The check valve prevented the thermosyphoning.

- G. OPERATION: Temperatures at the locations given in Figure 4, Page 5, were taken and recorded during the day from February 22-28, 1979. These are given on the following page. Sensors 1 and 2 indicate that water temperature rises as much as 25°F through the collectors ($T_2 - T_1$). The storage tank temperature ranged from 112°F to 158°F. Storage tank water drops approximately 5°F in passing through the heat exchanger ($T_3 - T_4$). The heat exchanger raises the hydronic heating water temperature approximately 5°F ($T_6 - T_5$). The heating water supply temperature (T_7) varies from 110°F to 148 °F depending on storage tank temperature and water flow in the heating circuit. The domestic water temperature rise through the heat exchanger ($T_9 - T_8$) reaches as much as 40°F although the domestic water temperature (T_8) generally did not exceed 95°F.

JOB _____

SHEET NO. _____

OF _____

CALCULATED BY _____

DATE _____

CHECKED BY _____

DATE _____

SCALE _____

Burns/Peters, AIA, Architects-Planners

8100 Mountain Rd. NE, Suite 106
ALBUQUERQUE, NEW MEXICO 87110

BURNS/PETERS OFFICE SOLAR HEATING TEMPERATURES

DATE - 1979			WEATHER			COLLECTORS		TANK	EXC.	FAN COIL	EXC.	BOILER	DOMESTIC WATER		OUT
MONTH	DAY	TIME	CLEAR	PCLOUD	O.CAST	IN	OUT		SHELL	RETURN	TUBE	OUT	IN	OUT	AIR
						(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
FEB	22	8:40am	SNOW	X		—	—	120	116	117	118	125	125	75	31
		11:26am		X		112	120	122	115	125	125	120	120	78	42
		2:42pm		X		117	140	130	117	105	115	115	115	80	48
		4:54pm		X		—	—	135	130	125	130	127	80	120	50
FEB	23	8:40am		X		—	—	115	110	113	115	122	82	105	32
		10:32am		X		110	116	115	113	109	112	112	82	105	37
		11:48am		X		110	132	119	115	110	115	112	85	106	40
		2:58pm		X		120	130	136	130	—	—	—	85	118	46
		4:44pm		X		—	—	137	126	—	—	—	85	118	52
FEB	24	11:49am		X		110	135	118	112	107	112	112	90	105	45
FEB	25	9:30am		X		110	128	117	114	108	112	112	78	105	34
		4:40pm		X		150	150	158	150	142	150	148	90	130	60
FEB	26	8:09am	ECLIPSE			—	—	117	111	105	110	110	95	108	41
		11:21am		X		107	110	112	109	127	127	131	85	105	42
		12:42pm		X		110	136	125	122	102	110	110	90	114	50
		4:03pm		X		—	—	135	125	—	—	—	75	115	50
FEB	27	8:32am		X		—	—	115	110	105	110	110	82	102	39
		10:37am		X		—	—	115	112	106	112	112	85	105	41
		12:46pm		X		108	112	115	112	106	114	114	82	66	45
		4:41pm		X		—	—	121	116	110	116	115	74	100	44
FEB	28	8:12am		X		—	—	113	107	100	104	110	75	101	41
		10:34am		X		114	138	118	114	105	110	110	78	105	55
		11:43am		X		108	132	122	118	115	116	115	80	106	60
		2:41pm		X		125	150	135	132	118	122	119	85	115	60
		3:45pm		X		130	140	142	135	105	115	115	82	120	60

SYSTEM DEFICIENCIES AND CORRECTIVE ACTION TAKEN

A list of action items identified during the acceptance test are as follows.

1. The solar collector pump was found to put out inadequate flow. Subsequent investigation revealed that the impeller was turning backwards. The pump was rewired and tested on March 12, 1979. At this time it demonstrated proper operation.
2. Various piping lines within the mechanical room were not yet insulated. This was completed by February 28, 1979.
3. The collectors were originally installed rigidly fixed to rigid frames. In order to allow for pipe growth, spacer washers were installed to allow the pipe to move relative to the frame. This was completed by February 28, 1979.
4. A few collectors were found to be out of alignment. The alignment was checked and adjusted on all collectors by February 28, 1979.
5. The box containing the collector tracking motor, controls, and limit microswitches is tilted such that the cavities containing the microswitches could fill with snow and/or water. AWSI will evaluate covering those cavities.
6. A discrepancy between collector piping volume (55.8 gallons) and drain-down volume (49.2 gallons) turned up during the automatic drainage test. This is discussed in detail on Pages A-2 and A-3. The discrepancy has not yet been explained. However, since the system has undergone many nights with temperature well below 15°F, it appears that the system does, in fact, completely drain for freeze protection as designed.

SOLAR HEATED OFFICE BUILDING
FOR
THE BURNS/PETERS GROUP, ARCHITECTS-PLANNERS
8000 PENNSYLVANIA CIRCLE, NE
ALBUQUERQUE, NEW MEXICO 87110

SOLAR ENERGY SYSTEM ACCEPTANCE TEST PLAN

(Revised January 9, 1979)

I. GENERAL

The Owner of this Project is The Burns/Peters Group, the Engineer is Bickle Division/CM, Inc., and the Contractor is Albuquerque Western Solar Industries, Inc. The solar heating system shall be inspected by the Engineer to ensure compliance with the plans and specifications and with the 1976 Edition of the Uniform Solar Energy Code. The Contractor shall notify the Engineer in writing that the work is ready for inspection and testing. The Engineer shall advise the D.O.E. Project Manager and the Owner of the test approximately ten (10) days prior to test execution, and of the exact day and time at least two (2) days prior to the test. A time mutually acceptable to the Contractor and Engineer shall be set for the test and inspection. Participation by the D.O.E. Project Manager will be on a best effort basis. The test will not be delayed to accomodate the D.O.E. Project Manager.

It is the duty of the Contractor to assure that the work will stand the test prior to notifying the Engineer. The test shall be performed in the presence of the Engineer. If the Engineer determines that the work does not pass the test and inspection, necessary corrections shall be made and the work re-submitted for test and insepctions as described above. No part of the system shall be covered, concealed, or put into use until it has been inspected, tested, and approved by the Engineer. Any work which is concealed prior to testing shall be uncovered and tested for approval by the Engineer. Upon satisfactory completion of the test and inspection, the Engineer shall issue to the Contractor a written approval of the work performed.

II. TESTING

Testing shall be performed by the Contractor in the presence of the Engineer. All equipment, materials, and labor for the test shall be provided by the Contractor.

A. Hydrostatic Test: The entire solar heating system including piping, valves, collectors, heat exchanger and pump, but excluding the storage tank shall be subjected to a hydrostatic test at 25 psig. The test shall show no leaks or loss of pressure for a one-hour period. The storage tank shall be filled with water at atmospheric pressure for a period of 24 hours prior to inspection by the Engineer and shall withstand the test without leaking.

B. Flow Test: The water returning from the collectors to the storage tank shall be diverted to a measuring drum. The time required to fill the drum shall be measured and the flow rate determined. At the Contractor's option, instead of utilizing the measuring drum system, the Contractor may determine the flow rate by measuring the pressure rise across the pump and correlating with the pump curve. The system shall be balanced to ensure proper flow as specified on the drawings.

C. Automatic Drainage: The lengths and sizes of all piping from the control valve to the collectors and back to storage and of the drain line shall be measured by the Contractor and reported to the Engineer. The Contractor shall also report the change in tank water level which occurs when the pump is shut off and the system has drained completely. If it is determined that the system has not drained, the Contractor shall make any required adjustments and rerun the test until the Engineer's approval is granted.

D. Collector Tracker: The tracker shall be installed and operated until the slack is worked out of the cables. The collectors shall then be aligned for test and inspection. For the test, the tracking system shall then be caused to turn away from the sun by shading one of the two sun-finder eyes. The eye shall be uncovered and the system allowed to return to normal tracking. Each collector shall be visually inspected by the Engineer to insure that all collectors are aligned with the sun. The standard AWSI "equal light band" method will be used to determine alignment. The Contractor shall make any adjustments required by the Engineer.

E. Domestic Water System: With the solar storage tank charged to a minimum temperature of 150°F, switch the water heater electrical breaker off and drain all the hot water from the water heater tank. Wait four hours and draw 30 gallons of water from the water heater tank. Measure the temperature of the water drawn to insure a minimum temperature of 100°F. Reset the electrical breaker.

III. SYSTEM CONTROL CHECK-OUT

On a clear, sunny day, perform the following procedures to check out the electronic control system:

A. Initialization:

1. Power switch off (on top of control box)
2. Collectors parked
3. Pump circuit switches on
4. Selector switch on "AUTO"
5. Summer switch on "WINTER"

B. Collector Electrical Check:

1. Power switch on

2. Check for LED lit on unpark section
3. Make visual inspection for unparked collectors
4. Hold hand over post eye
 - (a) check for immediate collector parking
 - (b) check for unlit LED on unpark section
5. Turn power switch to off

C. Pump Electrical Check

1. Turn power switch on
2. Check for lit LED on collector pump section
3. Anticipate approximately a six minute delay until the collector pump starts
4. Turn collector pump potentiometer until LED goes off
 - (a) anticipate approximately a three minute delay before pump stops
 - (b) reset collector pump potentiometer back to calibrated setting
5. Repeat steps Section C, Subparts 1 through 3
 - (a) hold hand over post eye
 - (b) expect immediate parking of collectors and collector pump shut down

D. Conventional Heating System and Solar Interface Check:

1. Disconnect tank thermistor
2. Insert resistive value corresponding to 180°F in tank
3. Turn building thermostat up to call for heat
 - (a) heat exchanger pump should operate along with appropriate fan coil and boiler circulating pump

- (b) boiler should not operate
- 4. Insert resistive value corresponding to 100°F in tank
- 5. Turn building thermostat up to call for heat
 - (a) boiler should fire and boiler pump should start circulating water
 - (b) solar heat exchanger pump should not operate

E. Final:

- 1. If any test fails, correct the defective component
- 2. Once all tests are positive, the control system is operative.

IV. OPERATION

The entire solar heating system shall be subjected to a 72-hour minimum operational test. The Contractor shall readjust control set points to demonstrate system performance to the Engineer and Owner. The Contractor shall reset all controls to the factory determined "normal" set conditions. The Owner shall record thermometer readings once every four (4) hours of the storage tank, the collector supply line, the collector return line, and outside temperature. All recorded temperatures shall be submitted to the D.O.E. Project Manager.

The system shall be constantly monitored by the Owner throughout the operational test to insure all components respond as designed. If any part of the system fails to perform as designed, the Contractor shall correct the defective component and this entire operational test shall be repeated until the system operates successfully.

APPENDIX B
OPERATION AND MAINTENANCE MANUAL

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OPERATION AND MAINTENANCE

Operation and maintenance of the solar system can be broken into three main activities: Initial Start-Up in Fall, Winter Maintenance, and Spring Shutdown.

I. FALL START-UP:

1. Lubricate pump and motor (see Page B-5)
2. Refill storage tank to level shown on sight glass.
3. Check for piping leaks. Repair as necessary.
4. Check for deteriorated insulation. Replace as necessary.
5. Check collectors for proper alignment. Adjust as necessary.
6. Check collectors for frayed cables. Replace as necessary.
7. Check condition of Tedlar dust covers. Replace as necessary.
8. In low voltage side of active solar system control box, switch summer-winter switch to WINTER position.
9. Confirm that
 - a. The collectors track
 - b. The solar pump operates
 - c. The collectors drain

II. WINTER MAINTENANCE:

1. Lubricate pump and motor (see Page B-5) after three months of operation.
2. Refill storage tank to proper level after three months of operation.
3. Repair piping leaks, deteriorated insulation, and damaged Tedlar collector covers as necessary.

III. SPRING SHUTDOWN:

1. In low voltage side of active solar system control box, place the summer-winter switch in the SUMMER position.

NORMAL SYSTEM OPERATING SEQUENCE

Solar Collection System: The solar collection system is controlled by a light sensor, L1, and the storage tank temperature sensor, T3 (see Figure 1, Page B-4). When adequate light level is perceived, the solar collector trackers (T1 and T2) allow the collectors to begin to follow the sun. If the light level increases beyond some threshold, the solar pump, P1, will come on to circulate fluid and collect heat. The pump and trackers will continue to operate until the light sensor drops below some threshold or until the storage tank temperature exceeds the high limit (e.g. 195°F). An operating mode table for the solar collection system is given below.

<u>SOLAR COLLECTION SYSTEM</u>			
<u>Light Sensor (L₁)</u>	<u>Tank Temp Sensor (T₃)</u>	<u>Trackers (T₁ & T₂)</u>	<u>Pump* (P₁)</u>
High	> 195	-	-
High	< 195	+	+
Med	> 195	-	-
Med	< 195	+	-
Low	> 195	-	-
Low	< 195	-	-

*Pump has 6 minute delay before starting and 3 minute delay before shutting off.

Hydronic Heating System: The hydronic heating pump, P3, is controlled by the room air thermostats, T4. On a call for heat, the pump is activated and it circulates water through the boiler and to the fan coil units throughout the building. The boiler fires as necessary to maintain a constant leaving water temperature (e.g., 120°F). The boiler will fire anytime the hydronic heating is operating and the supply water temperature is less than 120°F. The heat exchanger pump, P2, is controlled by the room air thermostats and the storage tank temperature sensor. If the room air thermostats call for heat and the storage tank temperature sensor is greater than the low limit (e.g., 120°F), the heat exchanger pump will be activated. This will circulate water from the solar storage tank through the heat exchanger and back to the tank. This will provide either preheating or total heating of the circulating water. If the heat exchanger is able to raise the hydronic heating system water to above 120°F, the boiler will not fire and the building will be heated by 100% solar energy. If the hydronic heating water leaving the heat exchanger is less than 120°F, the solar will provide only a fraction of the building load with the remainder being made up by the boiler. An operating mode table for the hydronic heating system is given below.

<u>HYDRONIC HEATING SYSTEM*</u>			
<u>Room T-stats (T₄)</u>	<u>Tank Temp Sensor (T₃)</u>	<u>Heat Exchanger Pump (P₂)</u>	<u>Hydronic Heating Pump (P₃)</u>
+	> 120	+	+
+	< 120	-	+
-	> 120	-	-
-	< 120	-	-

* Boiler fires as necessary to maintain 120°F supply water temperature when hydronic heating pump (P₃) is operating.

FIGURE B1

BURN'S / PETERS

CONTROL SCHEMATIC

Normal Temperatures and Flow Rates

Under most operating conditions when water is circulating, the temperatures and flow rates in the systems should fall within the following ranges or near the following setpoints. See piping schematic on the following page for the locations of temperature sensors.

Temperature Sensor	Description	Minimum	Maximum
1	Storage tank supply to collectors	110F	195F
2	Collector return to storage tank ($T_2 \geq T_1$)	115F	200F
3	Storage tank	110F	195F
4	Return from heat exchanger to storage tank ($T_4 \leq T_3$)	120F	190F
5	Fan coil return to heat exchanger	100F	150F
6	Heat exchanger supply to boiler ($T_6 \geq T_5$)	100F	160F
7	Supply from boiler to fan coil units($T_7 \geq T_6$)	120F	160F
8	Supply from domestic water heater to heat exchanger	65F	140F
9	Return from heat exchanger to domestic water heater ($T_9 > T_8$)	75F	150F
	Solar Pump	45 GPM setpoint	
	Heat Exchanger Pump	25 GPM setpoint	
	Hydronic Heating Pump	30 GPM setpoint	

LEGEND	
—	SUPPLY & RETURN LINES
→	DIRECTION OF FLOW
⊗	GATE VALVE
⊕	BALANCING COCK
⊞	PUMP ISOLATOR
⊞	CHECK VALVE
⊞	STRAINER
⊞	T & P TEST PLUG
⊞	UNION
⊞	T & P RELIEF VALVE
⊞	WATER REGULATOR
⊞	ATMOSPHERIC VENT
①	TEMPERATURE SAMPLE

TEMPERATURE SAMPLES	
①	STORAGE TANK SUPPLY TO COLLECTORS
②	COLLECTOR RETURN TO STORAGE TANK
③	STORAGE TANK SUPPLY TO HEAT EXCHANGER SHELL
④	HEAT EXCHANGER SHELL RETURN TO STORAGE TANK
⑤	FAN COIL RETURN TO HEAT EXCHANGER TUBE
⑥	HEAT EXCHANGER TUBE SUPPLY TO BOILER
⑦	FAN COIL SUPPLY FROM BOILER
⑧	HEATING COIL SUPPLY FROM WATER HEATER STORAGE
⑨	WATER HEATER SUPPLY FROM HEATING COIL
⑩	OUTSIDE AIR TEMPERATURE
TEMPERATURE RESULTS *	
②-①	= SOLAR WATER GAIN FROM COLLECTORS
③-④	= SOLAR WATER ACROSS HEAT EXCHANGER SHELL
⑥-⑤	= HEATING WATER GAIN FROM HEAT EXCHANGER TUBE
⑦-⑥	= HEATING WATER GAIN FROM GAS FIRED BOILER
⑨-⑧	= DOMESTIC WATER GAIN FROM THERMOSIPHON COIL
* SYSTEM PUMP MUST BE OPERATING	

Figure B2
Piping Schematic

BELL & GOSSETT

SERIES 1522

UNI-BUILT CENTRIFUGAL PUMPS

INSTALLATION & OPERATION INSTRUCTIONS

LOCATION

The pump should be placed as near as possible to the source of supply, particularly when operating with a suction-lift, and located to permit installation with the fewest possible number of bends or elbows in the suction pipe. The maximum suction-lift should not exceed 15 feet, including friction losses.

FOUNDATION

The Series 1522 pump, being mounted on its motor, needs no special foundation. However, it is well to provide a solid concrete base.

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

Be careful that the pump and motor are not sprung out of alignment by the weight of the piping. The pipes should be supported by suitable hangers and not by the pump. After all piping has been attached, be sure that the shaft turns freely. 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. Where there is suction-lift, horizontal runs of suction piping should slope downward from the pump toward the suction well but never upward.

Install a Square Head valve and 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 backflow that might occur due to the action of water hammer. Install a foot-valve on the bottom of the suction-pipe to keep pump primed.

PRIMING

DO NOT RUN PUMP DRY. Before starting, these pumps must be filled with water and the air removed from the casing by unscrewing the plug in top of the volute shell. 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. Once the casing and suction pipe have been primed, a small by-pass around the check valve in the discharge line may be used to keep the pump full of water and thus compensate for leakage through the foot-valve.

When the pump is primed from an independent source, a 1/4

inch pipe line controlled by a valve may be connected to one of the side plugs on the volute shell.

Do not attempt to prime a pump while it is running by letting water into it through its discharge pipe. This is an unsatisfactory method that could damage the pump or motor or possibly blow out a fuse.

To facilitate priming and draining, plugs in top and bottom of volute casing may be replaced by 1/4 inch cocks or valves.

LUBRICATION INSTRUCTIONS

All new Bell & Gossett series 1522 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 until oil flows from the overflow hole on the side of the bearing bracket. Relubricate as necessary to maintain this level.
2. Sleeve Bearing Motor—lubricate the two motor oil-cups per motor lubrication tag at least once every four months. Use ten to twelve drops in each oil-cup.
3. Ball Bearing Motor—Relubricate every 6 months to 2 years depending on operating conditions with a good grade soda-soap grease.

To prevent overgreasing of ball-bearings, remove pipe-plugs under bearing-housing of motor and allow old grease to be forced out.

HOW TO SERVICE YOUR 1522 CENTRIFUGAL PUMP

An exclusive feature of the B & G Series 1522 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. Close valve leading to supply-side of pump (If no valve has been installed, it may be necessary to drain the system).
2. Detach bearing-frame assembly from pump volute by removing eight cap-screws from center body-flange.
3. Remove impeller from pump-shaft (First turning impeller-nut counter clockwise).
4. 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.
5. 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.
6. Replace impeller on shaft making certain that impeller-nut

(Continued on next page)

is firmly tightened. The pump and bracket can then be re-assembled 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.

OPERATING THE PUMP

1. Be sure to operate the pump in the proper direction. All B & G Centrifugal pumps run clockwise when looking at the pump from the motor end. All pumps are provided with arrows showing direction of rotation.

2. Liquids having a temperature near the vaporization point cannot be raised by suction. There must be a positive suction-head depending upon the operating temperature and pressure at the suction outlet of the pump. When pumping liquids having a viscosity appreciably different from water, a positive suction-head is required.

3. When there is danger of freezing, remove drain plug at top and bottom of volute shell and drain completely.

4. Keep pump and motor bearings lubricated.

5. Do not disassemble pump unless absolutely necessary as impeller has been accurately adjusted and tested before leaving factory.

6. Pump shaft should always turn freely by hand.

7. Ask for information or help if trouble is experienced that cannot be rectified since this pump is guaranteed to operate as recommended.

8. 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.

9. The motor should be protected against overload and undervoltage. Control devices for this purpose can be obtained at a very low cost. They are inexpensive insurance.

SERIES 1522 UNI-BUILT CENTRIFUGAL PUMPS

MOTOR LUBRICATION

\$14700

SLEEVE BEARING MOTOR

LUBRICATE AT INSTALLATION OR START OF EACH
HEATING SEASON. FOR CONTINUOUS SERVICE
LUBRICATE EVERY 6 MONTHS WITH SAE #20 OIL
USE APPROX. 1/8 OZ. DO NOT OVER OIL

BALL BEARING MOTOR

RELUBRICATE BOTH BEARINGS WITH A PREMIUM
GRADE MULTI-PURPOSE LITHIUM BASE GREASE AT
LEAST ONCE A YEAR.

ITT BELL & GOSSETT
MORTON GROVE, ILLINOIS U.S.A.

BELL & GOSSETT

SUBMITTALC-135
REVISION 4

Type "HTWU" ASME High Temperature Heat Exchangers "U" Tube Design

JOB _____	B & G REPRESENTATIVE _____	
UNIT TAG NO. _____	ORDER NO. _____	DATE _____
ENGINEER _____	SUBMITTED BY _____	DATE _____
CONTRACTOR _____	APPROVED BY _____	DATE _____

DESCRIPTION

B&G "HTWU" Heat Exchangers are of the shell and tube type. The tube bundle is of "U" bend construction with tube ends expanded into a stationary tube sheet. This construction permits ample expansion or contraction for wide temperature variations. A fluid entering the shell is heated by high temperature water circulated through the tubes. Unit is designed for pumped circulation through both shell and tube side.

Standard "HTWU" Heat Exchangers are constructed according to A.S.M.E. requirements for pressures and temperature noted in table on the rear. A Manufacturers' Data Report for Pressure Vessels, Form No. U-1 as required by the provisions of the A.S.M.E. Code Rules is furnished with each unit.

This form is signed by a qualified inspector, holding a National Board Commission, and who is employed by an authorized inspection agency, certifying that construction conforms to the latest A.S.M.E. Code for pressure vessels. The A.S.M.E. "U" symbol is stamped on each vessel.

RECOMMENDED "HTWU" HEAT EXCHANGER

MODEL NO. _____

HEATING SURFACE (SQ. FT.) _____

OPERATING DATA

	Tube Side		Shell Side	
Type of Fluid	_____	_____	_____	_____
	Sp. Ht. _____	Sp. Gr. _____	Sp. Ht. _____	Sp. Gr. _____
Flow Rate	_____		_____	
BTU/HR. Transfer	_____		_____	
Inlet Temperature	_____ °F.		_____ °F.	
Outlet Temperature	_____ °F.		_____ °F.	
Coefficient (h)	_____		_____	
Fouling Factor	_____		_____	
Overall Heat Transfer "U"	_____		_____	
Corrected Log Mean Temp. Difference	_____		_____	
Recommended "HTWU" Heat Exchanger	_____		Area in Sq. Ft. _____	
Pressure Drops	_____		_____	

BELL & GOSSETT ITT
FLUID HANDLING DIVISION

TYPE "HTWU" ASME HIGH TEMPERATURE HEAT EXCHANGERS ("U" Tube Design)

TWO PASS HEAD

FOUR PASS HEAD

SIX PASS HEAD

*All 14" dia., and larger, units have Fabricated Steel Heads with 300# ANSI Flanges. These are all "Q", or special, units. Consult factory for dimensions, etc.

DIMENSIONS

Note: Support legs furnished only if specified on order.

CATALOG NUMBER	STD. B.S.	SQ. FT. OF H.S.			DIMENSIONS IN INCHES														
		2P	4P	6P	A	B	C	D	E	F	G	H	J	K	L	M	N	P	S
HTWU-43..	4	4.1	4.1	—	40%	7 1/4	29	6 1/8	4 1/2	2 1/2	2 1/4	—	2 1/2 NPT	1 1/4 NPT	1 NPT	—	1	—	3/4 NPT
HTWU-44..	4	5.7	5.7	—	52%	7 1/4	41	6 1/8	4 1/2	2 1/2	2 1/4	—	2 1/2 NPT	1 1/4 NPT	1 NPT	—	1	—	3/4 NPT
HTWU-45..	4	7.2	7.2	—	64%	7 1/4	52 1/2	6 1/8	4 1/2	2 1/2	2 1/4	—	2 1/2 NPT	1 1/4 NPT	1 NPT	—	1	—	3/4 NPT
HTWU-46..	4	8.8	8.8	—	76%	7 1/4	64 1/2	6 1/8	4 1/2	2 1/2	2 1/4	—	2 1/2 NPT	1 1/4 NPT	1 NPT	—	1	—	3/4 NPT
HTWU-47..	4	10.4	10.4	—	88%	7 1/4	76 1/2	6 1/8	4 1/2	2 1/2	2 1/4	—	2 1/2 NPT	1 1/4 NPT	1 NPT	—	1	—	3/4 NPT
HTWU-63..	3	12.7	12.7	9.6	40%	10 1/2	26 1/2	8	6 1/8	3 3/4	3 3/16	4 1/16	3 NPT	2 NPT	1 1/2 NPT	1 1/4 NPT	1 3/8	2 3/8	3/4 NPT
HTWU-64..	3	17.4	17.4	13.1	52%	10 1/2	38 1/2	8	6 1/8	3 3/4	3 3/16	4 1/16	3 NPT	2 NPT	1 1/2 NPT	1 1/4 NPT	1 3/8	2 3/8	3/4 NPT
HTWU-65..	3	22.1	22.1	16.7	64%	10 1/2	50 1/2	8	6 1/8	3 3/4	3 3/16	4 1/16	3 NPT	2 NPT	1 1/2 NPT	1 1/4 NPT	1 3/8	2 3/8	3/4 NPT
HTWU-66..	3	26.8	26.8	20.2	76%	10 1/2	61 1/4	8 1/2	6 1/8	3 3/4	3 3/16	4 1/16	4 FLG	2 NPT	1 1/2 NPT	1 1/4 NPT	1 3/8	2 3/8	3/4 NPT
HTWU-67..	3	31.5	31.5	23.8	88%	10 1/2	73 1/4	8 1/2	6 1/8	3 3/4	3 3/16	4 1/16	4 FLG	2 NPT	1 1/2 NPT	1 1/4 NPT	1 3/8	2 3/8	3/4 NPT
HTWU-68..	3	36.2	36.2	27.3	100%	10 1/2	85 1/4	8 1/2	6 1/8	3 3/4	3 3/16	4 1/16	4 FLG	2 NPT	1 1/2 NPT	1 1/4 NPT	1 3/8	2 3/8	3/4 NPT
HTWU-84..	4	32	32	26	53%	12 1/2	36 1/4	9 1/8	8 1/8	5	4	5 1/16	4 FLG	3 NPT	2 NPT	2 NPT	2	3	1 NPT
HTWU-85..	4	41	41	33	65%	12 1/2	48 1/4	9 1/8	8 1/8	5	4	5 1/16	4 FLG	3 NPT	2 NPT	2 NPT	2	3	1 NPT
HTWU-86..	4	49	49	41	77%	12 1/2	60 1/4	9 1/8	8 1/8	5	4	5 1/16	4 FLG	3 NPT	2 NPT	2 NPT	2	3	1 NPT
HTWU-87..	4	58	58	48	89%	12 1/2	72 1/4	9 1/8	8 1/8	5	4	5 1/16	4 FLG	3 NPT	2 NPT	2 NPT	2	3	1 NPT
HTWU-88..	4	67	67	55	101%	12 1/2	84 1/4	9 1/8	8 1/8	5	4	5 1/16	4 FLG	3 NPT	2 NPT	2 NPT	2	3	1 NPT
HTWU-89..	4	75	75	62	113%	12 1/2	96 1/4	9 1/8	8 1/8	5	4	5 1/16	4 FLG	3 NPT	2 NPT	2 NPT	2	3	1 NPT
HTWU-104..	5	56	53	45	53%	14%	35%	10%	10%	6%	4%	6%	4 FLG	3 NPT	3 NPT	2 1/2 NPT	2%	3 13/16	1 1/2 NPT
HTWU-105..	5	71	68	56	65%	14%	47%	10%	10%	6%	4%	6%	4 FLG	3 NPT	3 NPT	2 1/2 NPT	2%	3 13/16	1 1/2 NPT
HTWU-106..	5	86	82	68	77%	14%	57%	11%	10%	6%	4%	6%	6 FLG	3 NPT	3 NPT	2 1/2 NPT	2%	3 13/16	1 1/2 NPT
HTWU-107..	5	101	96	80	89%	14%	69%	11%	10%	6%	4%	6%	6 FLG	3 NPT	3 NPT	2 1/2 NPT	2%	3 13/16	1 1/2 NPT
HTWU-108..	5	116	110	92	101%	14%	81%	11%	10%	6%	4%	6%	6 FLG	3 NPT	3 NPT	2 1/2 NPT	2%	3 13/16	1 1/2 NPT
HTWU-109..	5	131	124	104	113%	14%	93%	11%	10%	6%	4%	6%	6 FLG	3 NPT	3 NPT	2 1/2 NPT	2%	3 13/16	1 1/2 NPT
HTWU-124..	4	83	78	68	54	16%	32 1/2	12%	12%	8%	5%	7 13/16	6 FLG	3 NPT	3 NPT	3 NPT	2%	4 1/2	2 NPT
HTWU-125..	4	104	98	85	66	16%	44 1/2	12%	12%	8%	5%	7 13/16	6 FLG	3 NPT	3 NPT	3 NPT	2%	4 1/2	2 NPT
HTWU-126..	4	126	119	103	78	16%	56 1/2	12%	12%	8%	5%	7 13/16	6 FLG	3 NPT	3 NPT	3 NPT	2%	4 1/2	2 NPT
HTWU-127..	4	148	139	121	90	16%	66%	13%	12%	8%	5%	7 13/16	8 FLG	3 NPT	3 NPT	3 NPT	2%	4 1/2	2 NPT
HTWU-128..	4	169	160	139	102	16%	78%	13%	12%	8%	5%	7 13/16	8 FLG	3 NPT	3 NPT	3 NPT	2%	4 1/2	2 NPT
HTWU-129..	4	191	180	156	114	16%	90%	13%	12%	8%	5%	7 13/16	8 FLG	3 NPT	3 NPT	3 NPT	2%	4 1/2	2 NPT
HTWU-1210	4	213	200	174	126	16%	102%	13%	12%	8%	5%	7 13/16	8 FLG	3 NPT	3 NPT	3 NPT	2%	4 1/2	2 NPT

ALL UNITS ASME CONSTRUCTED AND STAMPED FOR: 400 PSI W.P.—(TUBE)—800 PSI TEST
150 PSI W.P.—(SHELL)—300 PSI TEST
400°F. DESIGN TEMPERATURE —SHELL & TUBE

DESIGN PRESSURES

Standard Working Pressures

Shell Diameter	Tube	Shell
4"	400	150
6"	400	150
8"	400	150
10"	400	150
12"	400	150

MATERIALS

Furnished in Standard Units

Parts	Materials
Shell	Steel
Head	Nodular Cast Iron
Tubes 3/4" O.D.	90-10 Cupro Nickel
Tube Sheet	Steel
Baffles	Steel
Nuts & Bolts	Steel
Gaskets	Spiral Wound #304 S.S.

BELL & GOSSETT

ITT

8200 N. AUSTIN AVE. • MORTON GROVE, ILL. 60053
INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

Tracking Components

Tracking drive system is comprised of a gearhead motor driving a chain drive to the collectors, which in turn pivot about a receiver pipe. Electronics in drive system are solid state. Sensor unit is mounted on a master collector to keep the collectors aligned with the sun.

The SOLCAN Solar Heating System is dependable and within the practical price-range of the average homeowner.

FOR FURTHER INFORMATION ON THE

SOLCAN

MODEL WM100

SOLAR HEATING SYSTEM

WRITE:

ALBUQUERQUE WESTERN SOLAR INDUSTRIES

612 Comanche NE

Albuquerque, New Mexico 87107

(505) 344-7224

SUBMITTAL APPROVED

COLLECTOR, TRACKER, AND CONTROL BOX

APPROVED. ~~CONTROL WIRING DIAGRAM~~

~~AND SUPPORT STRUCTURE~~

1/2" x 1/8" STEEL DRIVE BAR AND 1/8" DIA WIRE CABLE RETURN CONNECTED TO DRIVE MOTOR ACTIVATED BY SUN FINDER TO AUTOMATICALLY TRACK THE SUN AND FOCUS SOLAR RAYS ALONG THE COLLECTING PIPE. SHEET METAL COLLECTOR BODY ROTATES ABOUT COLLECTING PIPE.

WATER RETURN (HOT)

SPRING METAL RIB BONDED TO MYLAR PRODUCES REFLECTOR SHAPE.

VENT WITH CHECK VALVE ALLOWS SYSTEM TO DRAIN WHEN INACTIVE.

END SPRINGS HOLD MYLAR REFLECTOR TAUT.

- ① 4 MIL TEDLAR PROTECTIVE COVER.
- ② 1 1/2" RIGID COPPER PIPE COATED WITH PAINT OR SELECTIVE SURFACE
- ③ 5 MIL METALIZED MYLAR REFLECTOR
- ④ 28 GAUGE GALVANIZED SHEET METAL COLLECTOR BODY.

SECTION C

SECTION A

TEDLAR COVER TENSION CLIP CONTINUOUS

DETAIL B

BY OTHERS SOLCAN COLLECTOR 18'-4

SECTION C

NOTES:

COLLECTOR ARRAY SHOULD FACE DUE SOUTH AND BE UNSHADED FOR MAX OPERATION EFFICIENCY. ALL SUPPLY AND RETURN HEADERS TO BE RIGID COPPER PIPE WRAPPED WITH HIGH TEMPERATURE INSULATION.

PAINT STEEL COLLECTOR SUPPORT FRAME. SLOPE HEADERS AS REQUIRED TO GRAVITY DRAIN SYSTEM WHEN INACTIVE TO PREVENT FREEZING.

SET ALL ROOF PENETRATIONS

ANGLE VARIES DEPENDING UPON SPECIFIED USE AND LATITUDE OF INSTALLATION.

WATER SUPPLY (COOL)

SOLCAN SOLAR COLLECTORS
MANUFACTURED BY:
ALBUQUERQUE WESTERN SOLAR INDUSTRIES, INC.

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INSTRUCTIONS FOR SUNFINDER

INSTALLATION OF PHOTO CELL SENSOR

The photo cell sensor (black semi-circular sheet metal device with two photo cells and 20 ft. of attached cable) is fastened to the bench provided for that purpose on the master collector. The master collector should be the middle collector in a row. Two sheet metal screws are used for attachment to the bench. The orientation of the photo cell sensor must be made as follows:

It is advisable to park the collector bank towards the East for the 45 degree collector installation and to the South for the horizontal collector installation. The photo cell sensor is placed on the bench so that the side with the cable on it is away from the park direction (cable on West side for 45 degree and North side for horizontal collector

installation). The cable from the photo cell sensor is directed to the sunfinder electronic module and introduced into the low voltage section through the $\frac{1}{8}$ inch hole provided for that purpose. The end of the cable is stripped revealing a stranded bare ground wire, a red wire and another wire. The ground wire is fastened to the six-terminal barrier strip at the point labeled GD. The red wire is temporarily fastened to the terminal marked TEST and the third wire is fastened to the terminal next to the ground wire.

The next section describes the installation and adjustment of the electronic module.

ELECTRONIC MODULE

Remove the cover from the module. The module is fastened to the inside of the drive unit box by a $\frac{1}{2}$ inch conduit connector through the $\frac{1}{8}$ inch hole in the back of the module and a matching $\frac{1}{8}$ inch hole in the side of the drive unit box. The drive motor is connected to the quick disconnect terminals on the small P.C. board on the right. Observe the color code marked on the board. The 110 volt, 60HZ power line is connected to the two terminals marked L and the green ground or bond wire is connected to the terminal marked GD. Provisions should be made for a temporary hook-up to the 110 volt line, so that the unit can be plugged and unplugged during the alignment procedure. Two limit switches are provided on the drive unit

box. One terminal from a switch is connected into one of the terminals on the upper right hand corner labeled SW, and the other terminal is connected to the terminal labeled SW, CCW or CW. The switch which is to *STOP CLOCKWISE* rotation of the motor when viewing from the motor shaft end, must be plugged into the CW switch and the switch used to *STOP COUNTER CLOCKWISE* rotation of the motor is plugged into the switch terminal labeled CCW. Notice that the terminals are either male or female to prevent error if the unit has to be replaced and the wires reconnected. The module is now ready for alignment procedure.

ALIGNMENT PROCEDURE

Temporarily move the red wire of the photo cell sensor cable TEST terminal and plug the unit into the 110 volt line. The collector bank should move towards the park position. If not, disconnect the unit from the 110 volt line and reverse the two wires on the extreme left, re-plug the unit into the 110 volt line and check for park operation. When the unit will park in the right direction, reattach the red wire to the TEST terminal. Under these conditions the collectors should orientate themselves toward the sun. When the collectors stop, the shadows cast by the photo cell sensor unit onto the photo cells

should divide each cell in half. If not, adjust the potentiometer setting until the shadows fall on the center of the photo cells.

The photo cell sensor must be aligned on the bench so that it is parallel to the collector pipe. Next, turn the adjusting screw on the bench until the shadow of the pipe of the master collector, which is cast on the end of the parabolic reflector, is centered over the center of the reflector. The shadow should be centered over the spring hole at the end of the reflector. This completes the alignment procedure.

FINAL PROCEDURE

The unit is unplugged from the 110 volt line. The red wire is moved from TEST to the RED terminal. The sunfinder relay wires from the control box are attached to the two terminals marked CONTR. BOX. The permanent line wires from the control box are connected to the L and GD terminals on the right

hand board. If a control box is not used, park and unpark action can be controlled with a switched 6 volt direct current (not alternating current) using the CONTR. BOX terminals. Another method is to attach switch points via wires across the terminals marked TEST and RED.

INSTRUCTIONS FOR CONTROL BOX

Before the control box can be connected, several other tasks must be done first, as follows:

PHOTOCELL

The ½ inch conduit with the photo cell at the end should be mounted on the roof of the house or any place near where the control box is installed. The support should be mounted with the bottom part vertical and with the photo cell facing south. It

must be mounted where it will never be shadowed at any part of the day or any season of the year or improper operation will result. Two low voltage lines should be run from the cable in the conduit to the control box.

TEMPERATURE SENSOR

The 4" long, 3000 ohm (@ 25° C., includes wire nuts for electrical hookup and silicone fiberglass tape for surface mounting, with Electronic Thermometer. The sensor is a thermistor, a device which changes to resistance with change in

temperature. The thermistor should be lowered into the storage tank to a depth where it is midway between the bottom of the tank and the normal water level.

COLLECTOR PUMP RELAY

The collector pump relay is a single-pole-single-throw relay (Dayton 5x849). It should be mounted near the collector pump. The high side of the collector pump line should run through the

relay points. The relay coil is connected through low voltage wires back to the control box.

HOUSE PUMP RELAY

The house pump relay is a double-pole-double-throw relay (Dayton 5x846). It should be mounted near the house pump. The relay coil should be connected by low voltage line back to the control box. One of the poles of the relay is connected to the

high side of the house pump motor line. The other pole is connected through 600V insulation wire back to the furnace where it is used to by-pass the furnace fan switch, so that the furnace fan will run when the house pump is running.

CONNECTING THE CONTROL BOX

The front cover of the control box is removed and the inside cover is also removed which hides the 110 volt section of the box. Three mounting holes on the back of the box are exposed and should be used for mounting the box to a wall (furnace room, pumping room, etc.). The various lines from the various relay and sensor should now be connected to the terminals in the box as given on the inside of the front cover. The instruction there is repeated here.

1. Furnace
2. House thermostat
3. House pump relay
4. Collector pump relay
- 5 & 6. Temperature sensor on tank
- 7 & 8. Photo cell on roof
- 9 & 10. Sunfinder Relay
- 24 volt transformer to collector & house pump relays.

White & black wires pair is common

Red wire, High side of line

Power to Sunfinder from White & black pair & yellow wire high side switched.

Terminal 1 goes to the furnace side of the house thermostat line and Terminal 2 goes to the thermostat side. For single stage thermostats, either line can be interrupted. For multi-stage

thermostats, only break into the line from the furnace to the common terminal on the thermostat.

Terminal 3 is connected to one line from the house pump relay coil. The other line from the coil is connected to the unused terminal on the 24 volt transformer on the outside of the control box.

Terminal 4 is connected to one line from the collector pump relay coil. The other line from the coil is connected to the same terminal on the outside transformer as the house pump line above.

Terminals 5 & 6 are connected to the lines from the temperature sensor in the storage tank.

Terminals 7 & 8 are connected to the lines from the photo cell on the roof.

Terminals 9 & 10 are connected to the lines from the sunfinder terminals labeled CONTRO. BOX.

The 110 volt 60HZ. power line is connected to the white-black pair which is common, and to the red wire which is the high side.

The 110 volt 60HZ power line to the sunfinder module is connected to the white-black pair which is common, and to the yellow wire which is high side and switched.

ADJUSTMENT OF CONTROL BOX SETTINGS

The control box does four basic tasks.

1. Parks and un parks collectors at low outside light levels.
2. Turns on or shuts off collector pump so that the water circulating through the collectors is always collecting and not losing heat. There is a built-in 5 to 10-minute delay on the shut-off of the collector pump when the light level goes too low.
3. Turns off collector pump when water temperature in the storage tank reaches 190 to 195 degrees F.

4. When the temperature of the water in the storage tank gets too low (100 degrees F.) the control box will use the furnace to heat the house until the water temperature is increased by the collectors.

The proper adjustments have been made at the factory. However, if changes in the setting are required, the following procedure should be followed.

ELECTRICAL

- A THE THERMISTOR WILL BE INSTALLED ON SIDE ON SIDE OF STORAGE TANK. THE 18-2 LEADS FROM IT ARE CONNECTED TO ⑬ YELLOW & ⑭ PURPLE POLARITY IS NOT IMPORTANT.
- B THE PHOTOCELL IS MOUNTED ON A POST ON THE ROOF. THE 18-2 LEADS FROM THE PHOTOCELL ARE CONNECTED TO ⑮ YELLOW & ⑯ RED. MAKE SURE THE PHOTOCELL IS CONNECTED TO THE 18-2 PAIR ON THE ROOF. POLARITY IS NOT IMPORTANT.
- C LEADS ② WHITE & ① BLUE ARE CONNECTED IN SERIES WITH THE THERMOSTAT & FURNACE. THIS IS AN 18-2 PAIR. POLARITY IS NOT IMPORTANT. SEE FIGURE # 2.
- D THE PAIR OF 18-2 WIRES LABELED SUNFINDER ARE CONNECTED TO ⑦ YELLOW & ⑩ BROWN. ON THE ROOF AT THE SUNFINDER INSTALLATION THIS PAIR IS HOOKED TO THE SUNFINDER CONTROL UNIT. IN THE LOW VOLTAGE SIDE OF THE SUNFINDER CONTROL ASSEMBLY IS A BARRIER STRIP. THE TWO LEADS ARE HOOKED TO THE TERMINALS MARKED CONTROL. POLARITY IS NOT IMPORTANT.

ATTENTION: ALTHOUGH A LICENSED ELECTRICIAN IS NOT REQUIRED TO WIRE THIS PHASE OF THE SYSTEM IT IS RECOMMENDED. REMEMBER YOU ARE DEALING WITH SENSITIVE LOW VOLTAGE CIRCUITS. SO PLEASE BE CAREFUL.