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DOE/NASA CONTRACTOR  
REPORT

DOE NASA CR-161420

SOLAR HEATING AND HOT WATER SYSTEM INSTALLED AT  
ST. LOUIS, MISSOURI -- FINAL REPORT

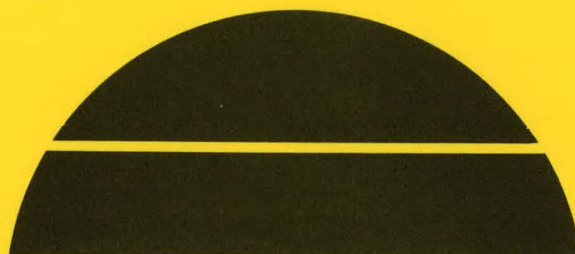
Prepared by

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Under Contract EG-77-G-01-4085

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

For the U. S. Department of Energy



**U.S. Department of Energy**



**Solar Energy**

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1. REPORT NO. DOE/NASA CR-161420		2. GOVERNMENT ACCESSION NO.		3. RECIPIENT'S CATALOG NO.	
4. TITLE AND SUBTITLE Solar Heating and Hot Water System Installed at St. Louis, Missouri - Final Report				5. REPORT DATE April 1980	
				6. PERFORMING ORGANIZATION CODE	
7. AUTHOR(S)				8. PERFORMING ORGANIZATION REPORT #	
9. PERFORMING ORGANIZATION NAME AND ADDRESS William Tao and Associates 2357 59th St. St. Louis, Missouri 63110				10. WORK UNIT NO.	
				11. CONTRACT OR GRANT NO. EG-77-G-01-4085	
12. SPONSORING AGENCY NAME AND ADDRESS National Aeronautical and Space Administration Washington D.C. 20546				13. TYPE OF REPORT & PERIOD COVERED Contractor Report	
				14. SPONSORING AGENCY CODE	
15. SUPPLEMENTARY NOTES This work was done under the technical management of Mr. Lary Lawson, Marshall Space Flight Center, Alabama.					
16. ABSTRACT  This document provides information on the solar heating and hot water system installed at the William Tao & Associates, Inc., office building in St. Louis, Missouri. The information consists of description, photos, maintenance and construction problems, final drawing, system requirements and manufacturer's component data.  The solar system was designed to provide 50 percent of the hot water requirements and 45 percent of the space heating needs for a 900 square foot office space and drafting room. The solar facility has 252 sq. ft. of glass tube concentrator collectors and a 1000 gallon steel storage tank buried below a concrete slab floor. Freeze protection is provided by a propylene glycol/water mixture in the collector loop. The collectors are roof mounted on a variable tilt array which is adjusted seasonally and is connected to the solar thermal storage tank by a tube-in-shell heat exchanger. Incoming city water is preheated through the solar energy thermal storage tank.					
17. KEY WORDS			18. DISTRIBUTION STATEMENT Unclassified-Unlimited UC-59a  <i>William A. Brooksbank Jr</i> WILLIAM A. BROOKSBANK, JR. Mgr., Solar Energy Applications Proj		
19. SECURITY CLASSIF. (of this report) Unclassified		20. SECURITY CLASSIF. (of this page) Unclassified		21. NO. OF PAGES 67	
				22. PRICE NTIS	

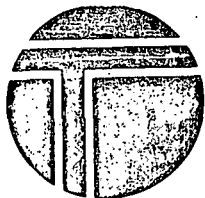
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William Tao & Associates, Inc., Consulting Engineers 2357 59th Street St. Louis, Missouri 63110 314-644-1400

### STATEMENT OF IPC CERTIFICATION

I hereby certify that the solar system herein, built under Agreement No. EG-77-A-01-4085, complies with the "Interim Performance Criteria for Commercial Solar Heating and Combined Heating/Cooling Systems and Facilities" Document No. 98M10001; Revision: Basic, Dated February 28, 1975, as applicable.

Signed: \_\_\_\_\_

Date: December 14, 1979

Title: Vice President

## GENERAL INFORMATION

### BUILDING INFORMATION

The system supplements the winter heating load for a 900 ft<sup>2</sup> addition to William Tao & Associates, Inc., office building and preheats the service hot water for the entire building. The Unitech Building is a single-story, masonry construction office building housing 90 employees engaged in consulting engineering practice.

### SYSTEM INFORMATION

Collectors: The array consists of (6) KTA Model KT4-85 collectors (252 ft<sup>2</sup>) mounted on the roof of the above-mentioned addition. They are considered a mildly concentrator type of flat-fixed collector. The absorber is a copper tube and is surrounded by two additional glass tubes. The larger glass tube is coated with a reflective surface such that solar energy is concentrated onto the smaller absorber tube. These tube assemblies are arranged horizontally in an aluminum case. An acrylic glazing covers the entire collector assembly. The collectors were installed at a tilt angle of 45 deg. facing south.

Supporting Structure: The supporting structure is welded steel construction with an observation catwalk. It is designed such that the tilt angle of the collectors can be adjusted for experimental purposes. Since the system is primarily for space heating, the collectors have been left at this tilt angle and have not been adjusted seasonally.

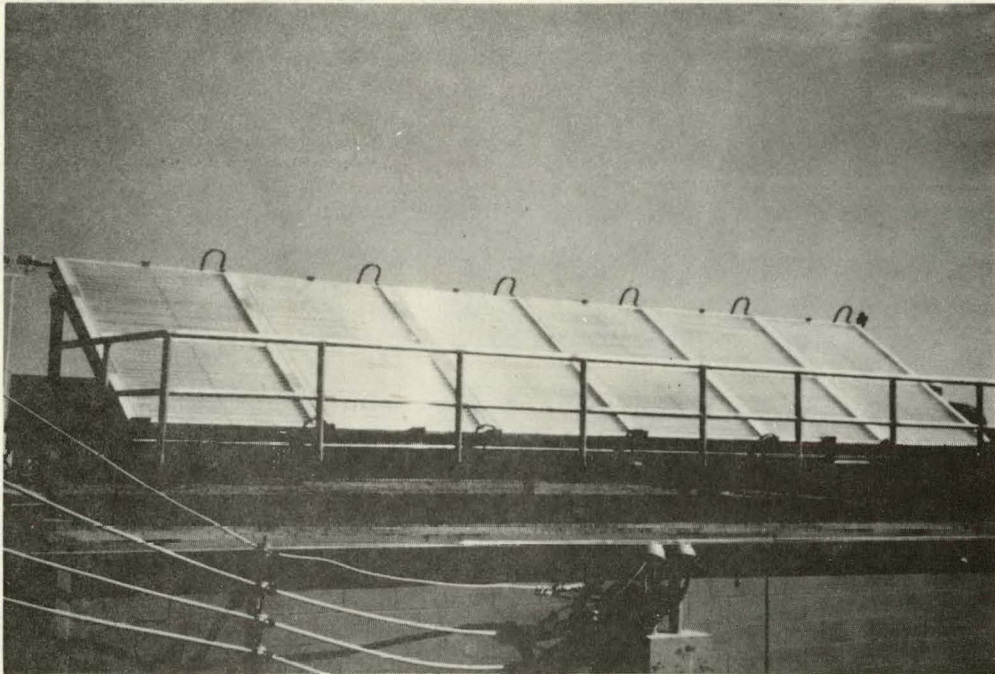
Service Hot Water Preheat Tank: City water entering the building intended for hot water use passes through the solar preheat tank. This is a glass-lined 80 gallon steel tank equipped with an externally applied plate heat exchanger. The hot solar fluid flows through the plate heat exchanger whenever the solar pump is operating. The tank is externally insulated with 1" Armaflex rubber insulation.

Solar Storage Tank: The storage tank is a 1000 gallon steel tank buried below the slab floor of the addition. It is insulated with rubber insulation and filled with water. The storage-to-collector area ratio is 33 lbs. H<sub>2</sub>O/ft<sup>2</sup> of collector.

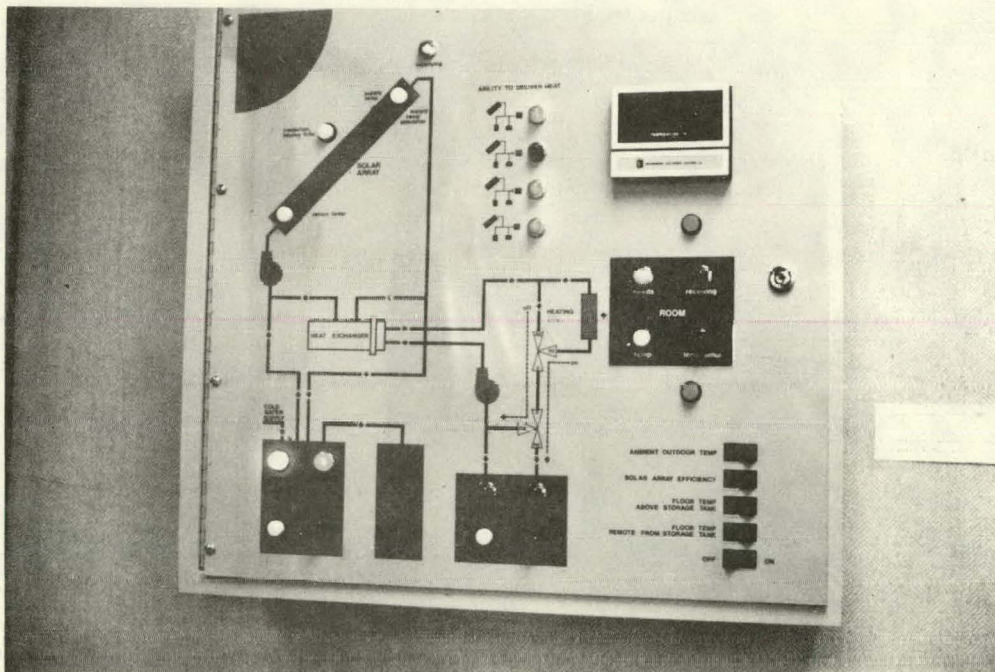
Heat Exchanger: A tube and shell heat exchanger is used to transfer thermal energy from the solar fluid to the water loop. This is a four pass Bell and Gosset Model #STH-420-4 brass straight tube heat exchanger. The solar fluid is on the shell side and the water is on the tube side. It is insulated with 1" thick fiberglass pipe insulation.

Heating Coil: A 4 row - 15 fins/in air-to-water heating coil is mounted in the return air upstream of the electric heating coil.



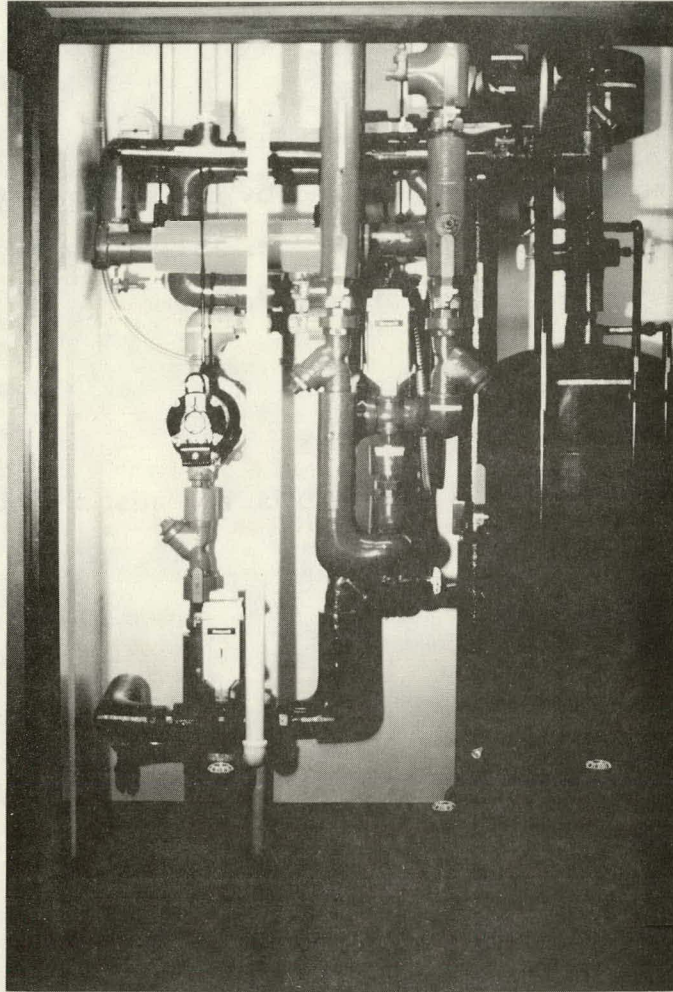


**COLLECTOR ARRAY**



**DISPLAY PANEL  
(NOT REQUIRED BY CONTRACT)**





**SOLAR SYSTEM  
MECHANICAL ROOM**

## MAINTENANCE & CONSTRUCTION PROBLEMS ENCOUNTERED

### CONSTRUCTION

No undue construction problems were encountered during the installation of this system. Minor changes were required and implemented as indicated on the record drawings enclosed.

### MAINTENANCE

There has been no regular maintenance required by the system. As reported in the attached TECHNICAL STATUS REPORT FOR Jan. 1979 - April 1979 special maintenance and revisions were required after a freezeup.

### RECOMMENDATIONS.

Freezing caused by thermal syphoning proved to be a realistic problem requiring due consideration in system designs.





William Tao & Associates, Inc., Consulting Engineers 2357 59th Street St. Louis, Missouri 63110 314-644-1400

April 23, 1979

WT 7732B (1)

TECHNICAL STATUS REPORT


FOR JAN. 1979 - APRIL 1979

Project Title: "Solar Space Heating and Hot Water System"

Agreement No: EG-77-A-01-4-85

The project status is as follows:

1. January 8, 1979 system functioning satisfactorily considering very cold and cloudy weather.
2. January 8 - cleaned 4" of snow and ice off collectors to get output.
3. January 15 - The glycol/heating water heat exchanger froze and failed. Cause has been identified as thermal syphoning. A new heat exchanger was ordered with delivery scheduled in 16 weeks. The damaged heat exchanger was sent to be repaired, if possible. (Series 50 - Solar System Maint. Report is attached)
4. January 15 - April 8 - System shut down due to lacking heat exchanger.
5. April 9 - The damage heat exchanger has been temporarily repaired and the system is operating. An electric controlled valve was inserted in the solar collector-glycol supply line to prevent thermal syphoning and the potential reoccurrence of the heat exchanger freezing. This valve opens when the glycol pump is on and closes when the pump stops.
6. The new heat exchanger, on order since January, is expected to arrive in May or June of 1979.

  
Richard E. Lampe, P.E.  
Vice President

# NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING

## SOLAR SYSTEM MAINTENANCE

1. PROJECT IDENTIFICATION NO EG-77-A-01-4085	2. MAINTENANCE PERFORMED BY Wm. Tao & Associates., Inc	3. SEQUENCE NO 1	4. DATE 4 20 79 MO DAY YR
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### 1. AREA OF MAINTENANCE - SUBSYSTEM

Collectors ☐ 1      Energy Transport ☒ 3      Thermal Storage ☐ 5      Cooling ☐ 7  
 Controls ☐ 2      Hot Water ☐ 4      Heating ☐ 6

Component/Part	Schematic Reference (See Dictionary)	Type of Action (See Codes Below)	Time Required	
			Hours	Min
Heat Exchanger Glycol-Htg. Water	HX3	R & RPL	*	

TYPE OF ACTION CODES:      Adjustment   ADJ      Repair   R      Replacement   RPL

### 2. DESCRIPTION OF MAINTENANCE ACTION

TYPE OF MAINTENANCE      Scheduled ☐ S      Unscheduled ☒ U

- A. Problem - Heat Exchanger froze and failed
- B. Cause - Thermal syphoning of collector glycol loop
- C. Service Rendered - Temporary - Repaired heat exchanger  
 (Permanent) - Will replace heat exchanger

3. SOLAR DOWNTIME      From Jan. 15 to April 9      =      84 days  
 Estimated hours of solar radiation lost due to maintenance action      Hrs

4. 1ST OF MAINTENANCE      Maintenance Done      Inhouse ☐ I  
 If Contracted, Attach a copy of the Invoice.      Contracted ☐ C

Replacement not complete and all costs are not yet available

Labor Category	Labor Hrs	Rate (\$/Hr)	Labor Cost
_____	_____ x _____	_____ = _____	_____
_____	_____ x _____	_____ = _____	_____
_____	_____ x _____	_____ = _____	_____

- A. Total Labor Cost      \_\_\_\_\_
- B. Cost of Replacement Parts for this Action      \_\_\_\_\_
- C. Cost of Materials      \_\_\_\_\_
- D. Total Cost of Maintenance      \_\_\_\_\_

ACCEPTANCE TEST DATA SHEET FOR  
FINAL REPORT AGREEMENT NO. EG-77-A-01-4085  
"SOLAR SPACE HEATING AND HOT WATER"

ANTIFREEZE				
DATE	12/10/79	BY	GARY FROESCHNER	
HYDROMETER READING	SAFE TO +5°F			
FLUID TEMPERATURE	74°F			
COMMENTS	WILL NEED TO INCREASE GLYCOL CONCENTRATION BEFORE 12/30/79			
AMPERAGE AND VOLTAGE				
DATE	12/14/79	BY	GARY FROESCHNER	
	AMPS	VOLTS	COMMENTS	
GLYCOL PUMP P <sub>G</sub>	2.8	115	1φ	
WATER PUMP P <sub>W</sub>	7.2	116	1φ	
A/H FAN	2.6	202	1φ	
OPERATIONAL TEST				
ITEM	DOES EQUIPMENT OPERATE PROPERLY WHEN ENERGIZED?	COMMENTS	DATE	BY
P <sub>G</sub> GLYCOL LOOP PUMP	YES		12/11/79	GGF
P <sub>W</sub> WATER LOOP PUMP	YES		12/11/79	GGF
CONTROL PANEL	YES		12/11/79	GGF
AUTOMATIC VALVE VT	YES		12/11/79	GGF
AUTOMATIC VALVE VR	YES		12/11/79	GGF
AUTOMATIC VALVE VA	YES		12/11/79	GGF
ELECTRIC HEATING SYSTEM	YES		12/11/79	GGF
NO INDICATIONS OF ALGAE, FUNGI, MOLD OR MILDEW HAVE BEEN OBSERVED.			DATE	BY
			12/14/79	GGF
ALL EQUIPMENT SHOWN ON THE CONSTRUCTION DOCUMENTS HAVE BEEN INSTALLED AS REQUIRED.			DATE	BY
			12/12/79	GGF
COMMENTS				



**ACCEPTANCE TEST DATA SHEET FOR  
FINAL REPORT AGREEMENT NO. EG-77-A-01-4085  
"SOLAR SPACE HEATING AND HOT WATER"**

<input checked="" type="checkbox"/> <b>P<sub>G</sub> DISCHARGE (GLYCOL LOOP)</b>		<input type="checkbox"/> <b>DOMESTIC WATER HEAT EXCHANGER (GLYCOL SIDE)</b>				<b>DATE:</b> 12/12/79	<b>BY:</b> GGF
<input type="checkbox"/> <b>P<sub>W</sub> DISCHARGE (WATER LOOP)</b>		<input type="checkbox"/> <b>COLLECTORS</b>					
<b>COLLECTORS</b>		<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>
CIRCUIT SETTER SIZE	1 1/2"						
SETTING	40						
PRESSURE DROP (FT. H <sub>2</sub> O)	3.25'						
FLOW REQUIRED (GPM)	6 1/2						
FLOW ACTUAL (GPM)	6.7						
WAS ADJUSTMENT REQUIRED?	No						

**COMMENTS:**

ACCEPTANCE TEST DATA SHEET FOR  
 FINAL REPORT AGREEMENT NO. EG-77-A-01-4085  
 "SOLAR SPACE HEATING AND HOT WATER"

<input type="checkbox"/> P <sub>G</sub> DISCHARGE (GLYCOL LOOP)		<input type="checkbox"/> DOMESTIC WATER HEAT EXCHANGER (GLYCOL SIDE)				DATE:		BY:	
<input checked="" type="checkbox"/> P <sub>W</sub> DISCHARGE (WATER LOOP)		<input type="checkbox"/> COLLECTORS				12/12/79		GGF	
COLLECTORS		1	2	3	4	5	6		
CIRCUIT SETTER SIZE	1 1/2"								
SETTING	26								
PRESSURE DROP (FT. H <sub>2</sub> O)	3.1								
FLOW REQUIRED (GPM)	12								
FLOW ACTUAL (GPM)	11.5								
WAS ADJUSTMENT REQUIRED?	No								
COMMENTS:									

**ACCEPTANCE TEST DATA SHEET FOR  
FINAL REPORT AGREEMENT NO. EG-77-A-01-4085  
"SOLAR SPACE HEATING AND HOT WATER"**

<input type="checkbox"/> P <sub>G</sub> DISCHARGE (GLYCOL LOOP)		<input checked="" type="checkbox"/> DOMESTIC WATER HEAT EXCHANGER (GLYCOL SIDE)				DATE:	BY:
<input type="checkbox"/> P <sub>W</sub> DISCHARGE (WATER LOOP)		<input type="checkbox"/> COLLECTORS				12/13/79	GGF
<b>COLLECTORS</b>		1	2	3	4	5	6
CIRCUIT SETTER SIZE	1 1/2"						
SETTING	60						
PRESSURE DROP (FT. H <sub>2</sub> O)	.25						
FLOW REQUIRED (GPM)	1.2						
FLOW ACTUAL (GPM)	1.1						
WAS ADJUSTMENT REQUIRED?	No						

COMMENTS:

**ACCEPTANCE TEST DATA SHEET FOR**  
**FINAL REPORT AGREEMENT NO. EG-77-A-01-4085**  
**"SOLAR SPACE HEATING AND HOT WATER"**

<input type="checkbox"/> P <sub>G</sub> DISCHARGE (GLYCOL LOOP) <input type="checkbox"/> P <sub>W</sub> DISCHARGE (WATER LOOP)		<input type="checkbox"/> DOMESTIC WATER HEAT EXCHANGER (GLYCOL SIDE) <input checked="" type="checkbox"/> COLLECTORS				DATE: 12/13/79	BY: GGF
<b>COLLECTORS</b>		<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>
CIRCUIT SETTER SIZE		3/4"	3/4"	3/4"	3/4"	3/4"	3/4"
SETTING		35	30	25	20	20	20
PRESSURE DROP (FT. H <sub>2</sub> O)		4.5	4.5	2.25	1.75	1.25	1.50
FLOW REQUIRED (GPM)		1.08	1.08	1.08	1.08	1.08	1.08
FLOW ACTUAL (GPM)		.75	1.0	.94	1.12	.93	1.01
WAS ADJUSTMENT REQUIRED?		No	No	No	No	No	No
<b>COMMENTS:</b>							

## CONTROL SYSTEM

### General Description

The Controller/Display Panel was engineered, designed and built by William Tao & Associates' employees. It consists of sensors, actuated controlling elements, a controller and a display panel as shown in the "Control Schematic" on the following page. The panel controls the solar system as described in the Control Sequence section and is used for demonstration purposes as described in the Displaying Capabilities section. The controller components are located within the display panel but are shown separately for clarity of function. Solid state electronics and relays are used in the controller.

The graphics on the front of the display panel depict the piping schematic of the solar system with all of its major components and the loads served by the system. Illuminated buttons are located on the schematic representing location of associated sensors. Depressing a button will cause it to illuminate and the sensor value to display on the digital read-out unit. Simulated values can be introduced. Adjustments and calibrations to the controller are accomplished from this panel, and the main system switch is located on the front. These and other features are discussed further in the Displaying Capabilities section.

# TEMPERATURE SENSORS INPUT

TS: GLYCOL LOOP TEMP. @ SUPPLY FROM COLLECTORS

TR: ROOM TEMP. (°F)

TT: STORAGE TANK TEMP. (°F)

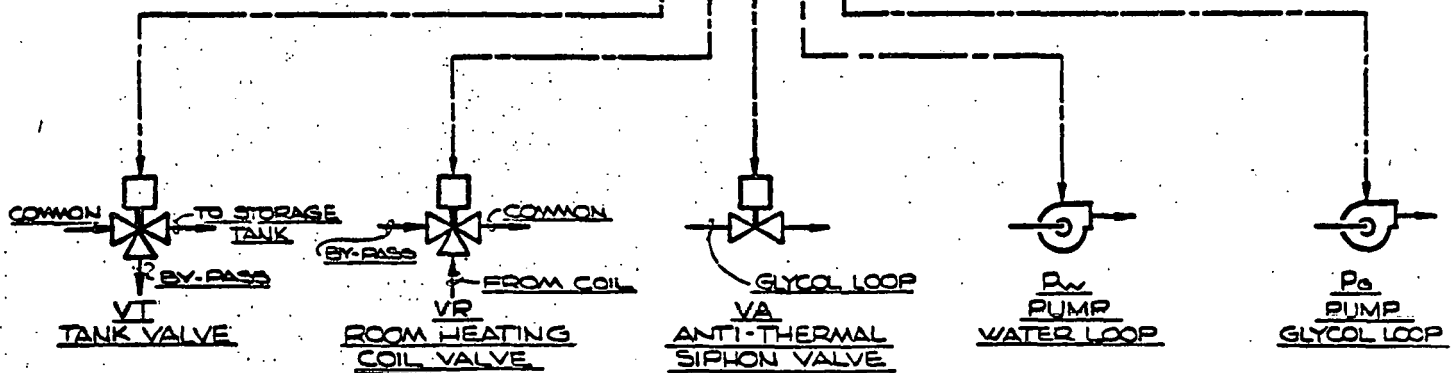
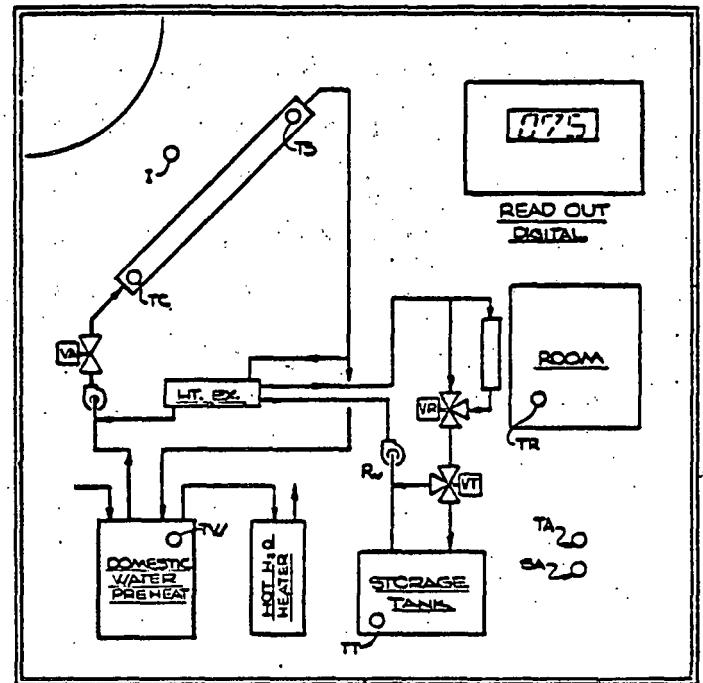
TC: GLYCOL LOOP TEMP. @ COLLECTOR INLET (°F)

TV: DOMESTIC WATER PRE HEAT TANK TEMP. (°F)

TA: AMBIENT TEMP. (°F)

## OTHER SENSORS INPUT

I: INSULATION (BTU/ft²)



## CONTROL SCHEMATIC



## CONTROL SEQUENCE

The Control Matrix on the following page shows the manner in which the system is controlled by this equipment and identifies the eight modes of system operation. The controller is manually switched to the summer or winter setting by in-house personnel at the appropriate times. The specifications located in the Appendix include a Control Sequence which the panel was intended to accomplish. Minor improvements and expansions to this sequence did occur during the development of the system as indicated by the Control Matrix.

"N.A." in the Matrix indicates that a sensor value has no effect on a particular mode of operation.

# CONTROL MATRIX

SEASON	WINTER					SUMMER		
MODE	1	2	3	4	5	1	2	3
DESCRIPTION	SOLAR CHARGING STORAGE	SOLAR SUPPORTING HEATING LOAD	SOLAR SUPPORTING HEAT LOAD & CHARGING STORAGE	STORAGE SUPPORTING HEATING LOAD	NO SOLAR SYSTEM CONTRIBUTION	SOLAR SUPPORTING DOMESTIC H <sub>2</sub> O PREHEAT	NO SOLAR SYSTEM CONTRIBUTION	SAFETY OVER-RIDE

INPUT	SENSOR VALUES	TS	> TT+5°F	> TR+5°F	> TR+5°F > TT+5°F	< TR+5°F < TT+5°F	< TT+5°F < TR+5°F	> TW+5°F	< TW+5°F	> TW
		TR	> 75°F	< 75°F	< 75°F	< 75°F	N.A.	N.A.	N.A.	N.A.
		TT	< TS-5°F	N.A.	< TR-5°F	> TR+5°F	< TR-5°F	N.A.	N.A.	N.A.
		TW	N.A.	N.A.	N.A.	N.A.	N.A.	< 140°F	< 140°F	> 140°F

OUTPUT	CONTROLLING ELEMENTS	PG	ON	ON	ON	OFF	OFF	ON	OFF	OFF
		VA	OPEN	OPEN	OPEN	CLOSED	CLOSED	OPEN	CLOSED	CLOSED
		PW	ON	ON	ON	ON	OFF	OFF	OFF	OFF
		VT	TO TANK	BY-PASS TANK	TO TANK	TO TANK	BY-PASS TANK	BY-PASS TANK	BY-PASS TANK	BY-PASS TANK
		VR	BY-PASS COIL	TO COIL	TO COIL	TO COIL	BY-PASS COIL	BY-PASS COIL	BY-PASS COIL	BY-PASS COIL

## DISPLAYING CAPABILITIES

The display panel functions can be divided into four categories.

- I. Sensor Display
- II. Simulated Sensor Display
- III. Scan Sensor Display
- IV. System Capabilities Display

### I. Sensor Display

The following values are displayed at the Digital Read-Out Unit by pressing the appropriate button. Each button will stay illuminated while its associated values are displayed until another button is depressed.

TR: The temperature of the glycol solution in the supply header from the collector array. (deg. F.)

TR: The temperature of the room. (deg. F.)

TT: The temperature of the water in the Thermal Storage Tank. (deg. F.)

TC: The temperature of the glycol solution in the return header of the collector array. (deg. F.)

TW: The temperature of the domestic water in the Preheat Tank. (deg. F.)

TA: The ambient temperature outdoors. (deg. F.)

I: Solar insolation in the plan of the collectors. (Btu/hr.ft<sup>2</sup>)

SA: Array Efficiency. This output is actually the energy being harvested from the collector array in Btu/hr. ft<sup>2</sup> as measured in the glycol loop with assumed constant flow. When insolation is divided by this number, an approximate instantaneous efficiency is obtained.

## II. Simulated Sensor Displays

The display panel can be locked into the simulate mode by pressing two orange buttons on the front of the panel simultaneously. In this mode, values for each of the controlling sensors can be dialed into the controller with rheostat located on the front of the display panel. The system will react to these values as though they were actual readings. This mode is used for demonstration and trouble shooting purposes.

## III. Scan Sensor Display

The scan mode can be energized while in the simulate or the display mode. This automatically scans the display board sending each sensor value to the read-out unit sequentially for approximately 2 seconds each. This eliminates the need to manually press each button. This mode is used for demonstration purposes and in calibrating the panel.

## IV. System Capabilities Display

The display panel has three white lights, one each associated with the room, thermal storage tank and the domestic hot water preheat tank. When these loads have need for thermal energy input, their associated light is illuminated irregardless of the systems ability to deliver such energy.

The display panel also has four red lights, each indicating a different ability of the system to deliver energy to one of the three loads. The four abilities are:

- 1) Ability to deliver energy from the collectors to the room.
- 2) Ability to deliver energy from the collectors to the storage tank.
- 3) Ability to deliver energy from the collectors to the preheat tank.
- 4) Ability to deliver energy from the storage tank to the room.

When the NEED matches the ABILITY as indicated by the white and red lights, an amber light at the appropriate load will illuminate indicating it is receiving energy. Green lights at the storage tank and the collectors illuminate to indicate that energy is being supplied from these sources.



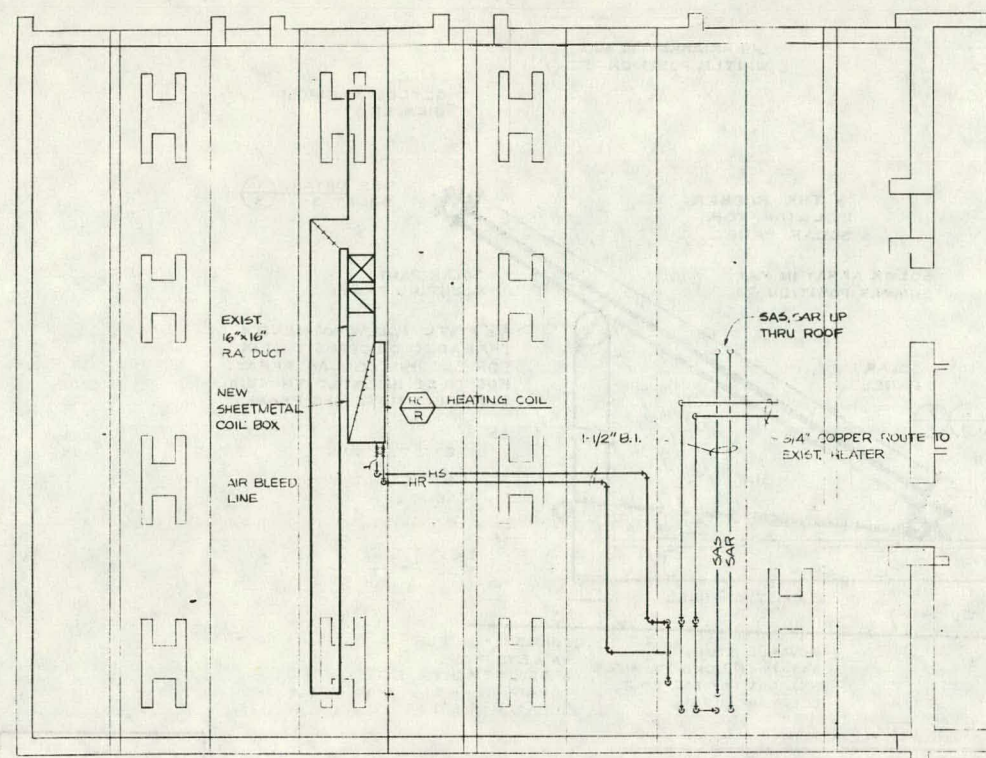
# SYMBOL SCHEDULE

## MECHANICAL:

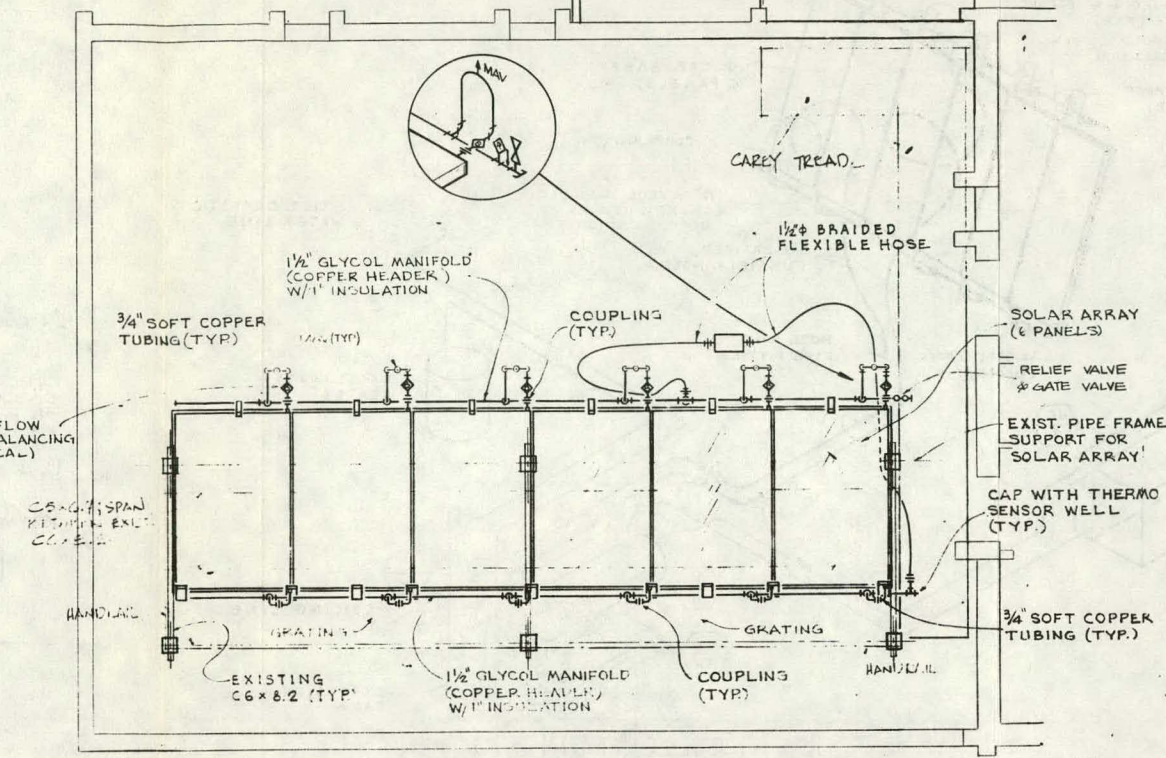
- X— GATE VALVE
- X— 3-WAY VALVE
- ◇ COMBINATION FLOW MEASURING AND BALANCING DEVICE
- ◇ RELIEF VALVE
- ⊙ THERMOMETER
- |— STRAINER
- |— HOSE END VALVE
- |— UNION
- DIRECTION OF FLOW
- ELBOW (TURNED DOWN)
- ELBOW (TURNED UP)
- TSS THERMAL STORAGE SUPPLY
- TSR THERMAL STORAGE SUPPLY
- SAS SOLAR ARRAY SUPPLY
- SAR SOLAR ARRAY-RETURN
- HS HEATING COIL SUPPLY
- HR HEATING COIL RETURN
- WPS WATER PRE-HEAT SUPPLY
- WPR WATER PRE-HEAT RETURN
- FV FILL VENT

## ELECTRICAL:

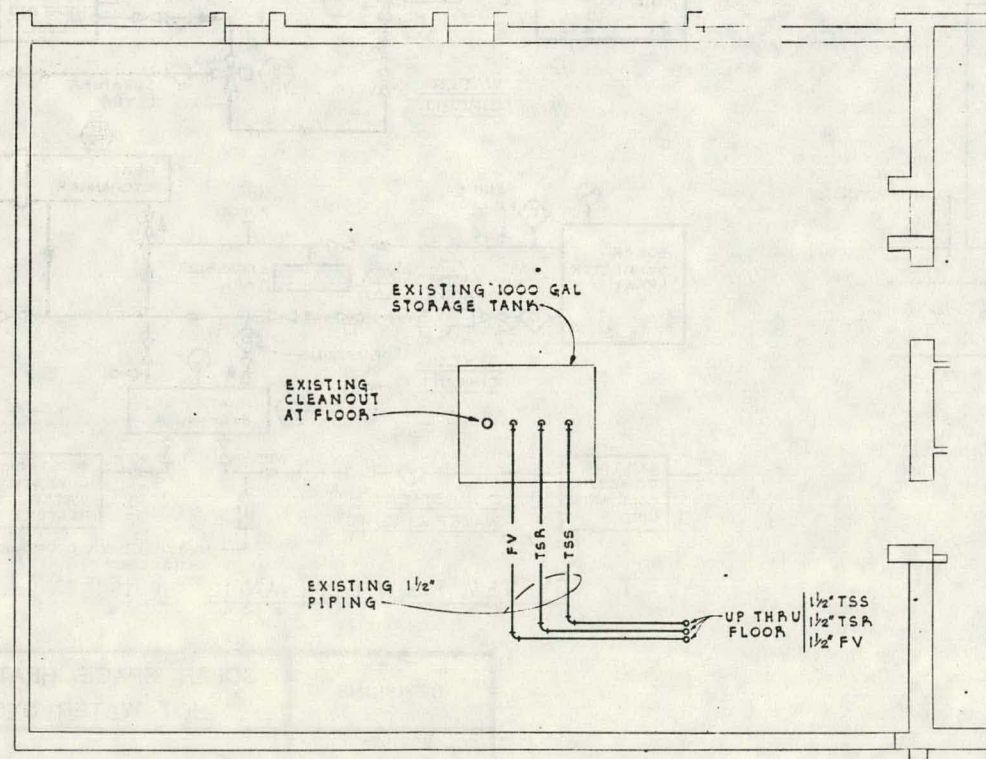
- ⊙ MOTOR
- ⊙ ELECTRIC ACTUATED VALVE
- ⊙ CONTROL PANEL
- HOME RUN CONDUIT
- CONDUIT
- FLEX CONDUIT
- ⊙ FUSE
- ⊙ JUNCTION BOX
- ⊙ SWITCH



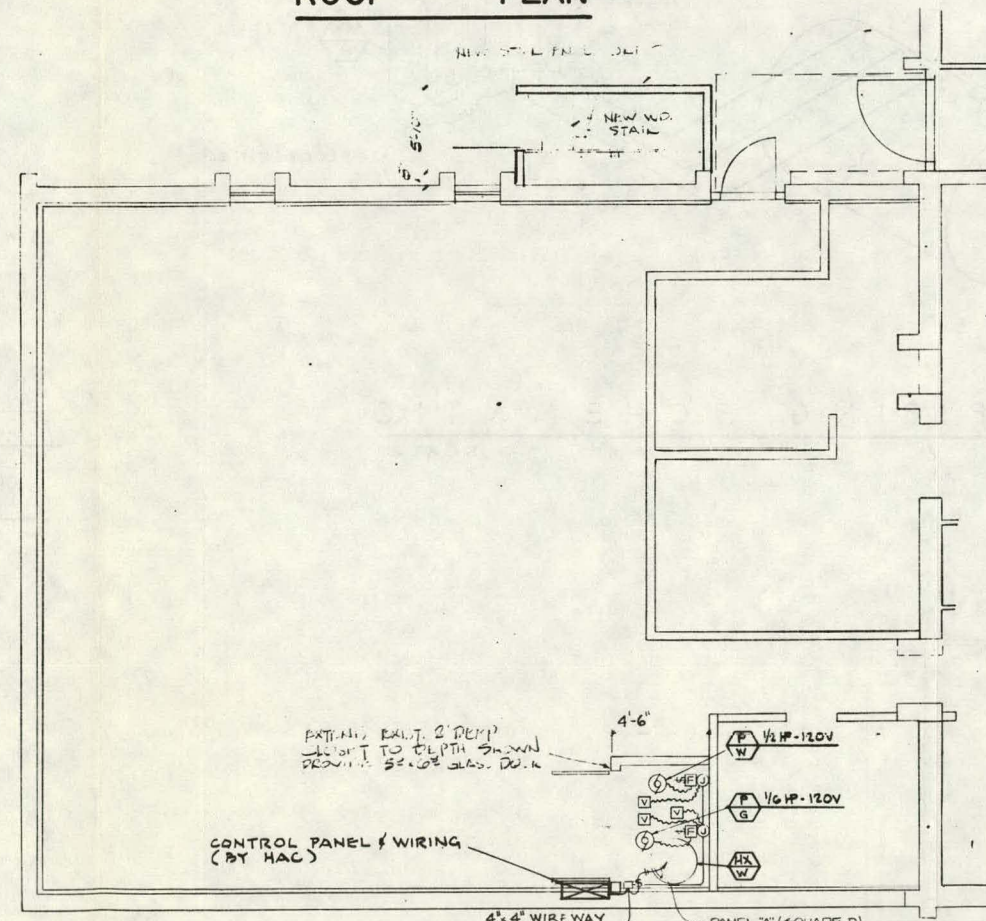
PLENUM PLAN



ROOF PLAN



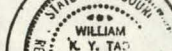

UNDERFLOOR PLAN



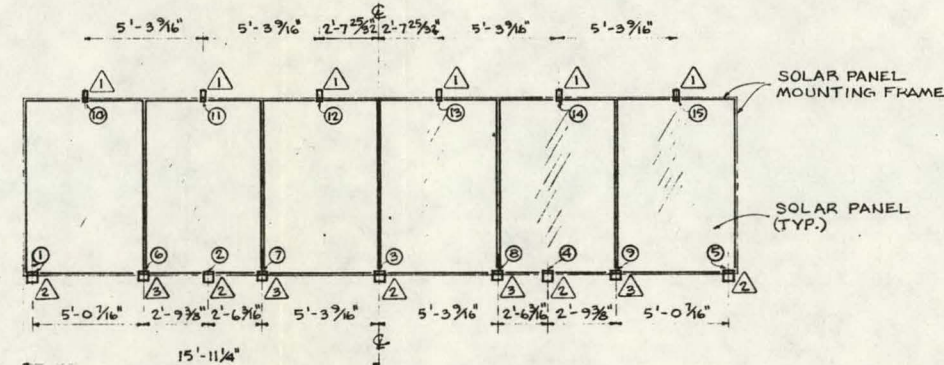
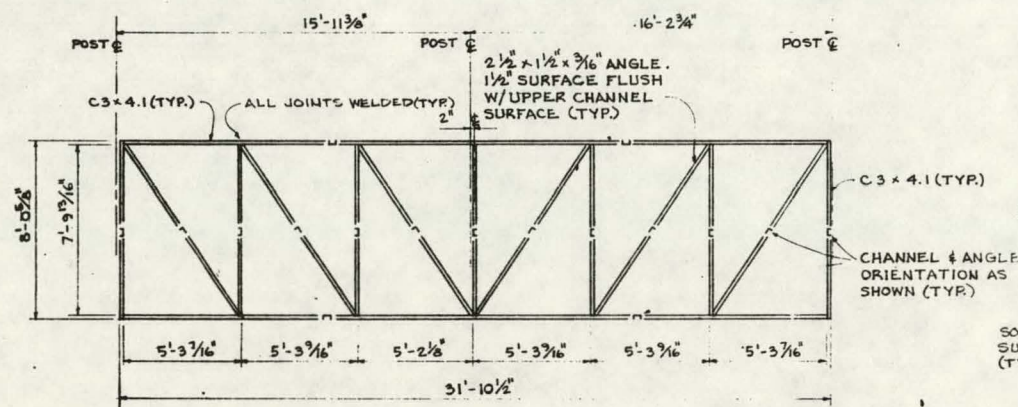
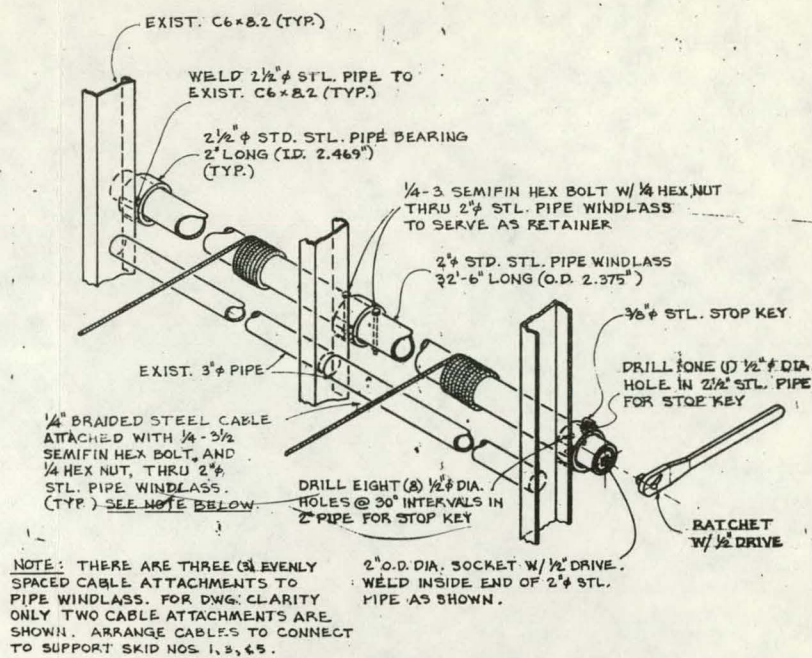
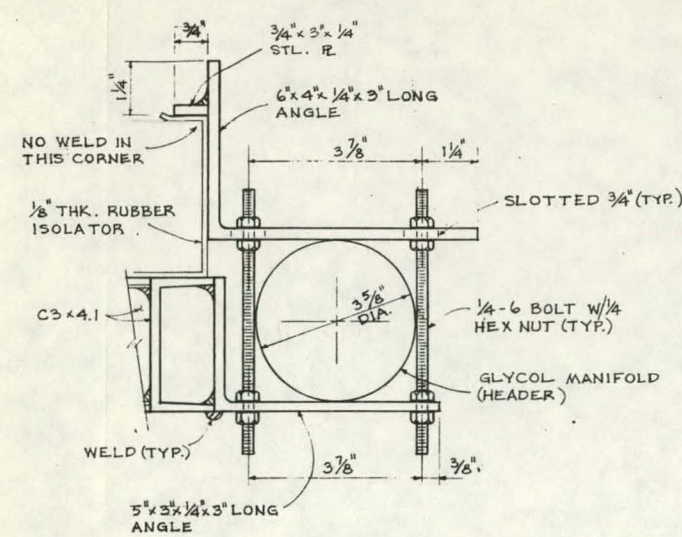
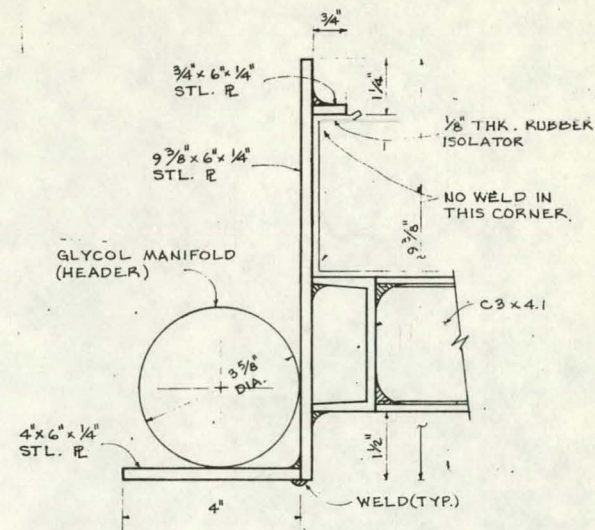
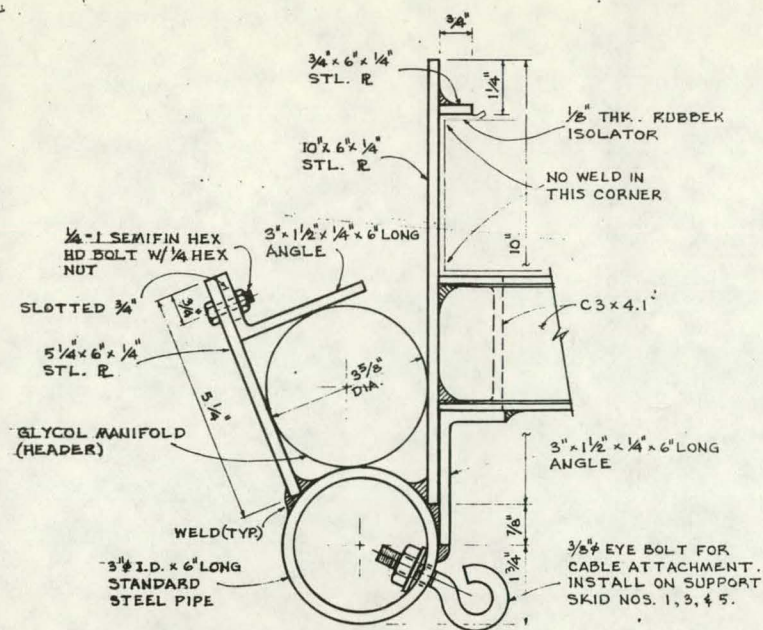
FLOOR PLAN

REVISIONS	SOLAR SPACE HEATING AND HOT WATER SYSTEM.
DEC. 29, 1977 NOV. 7, 1979 Corrections as built	PLANS
WT 7732A	1 OF 1



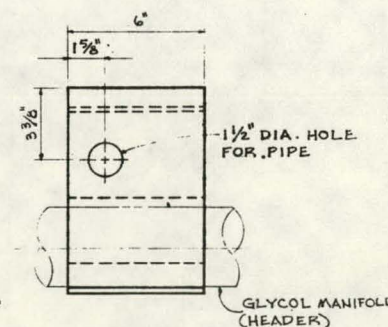
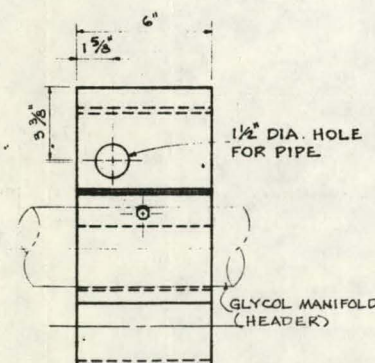
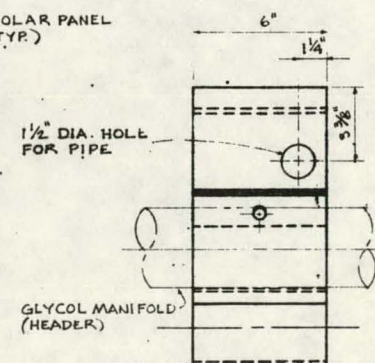
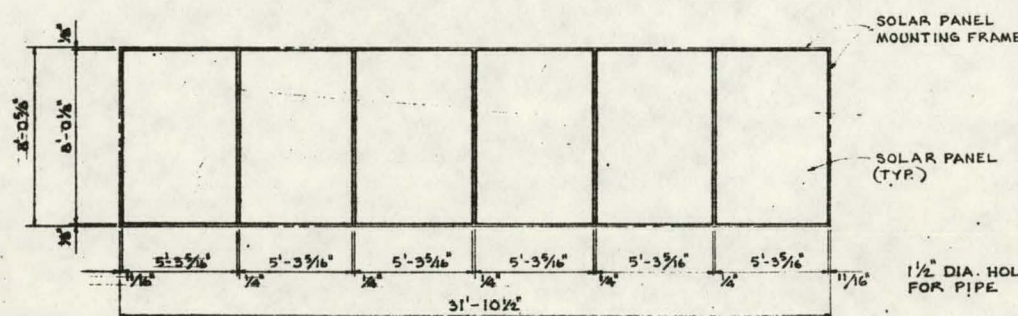
<p>REVISIONS</p>	<p>SOLAR SPACE HEATING AND HOT WATER SYSTEM</p>
<p>DEC. 29, 1977 NOV. 7, 1979 Corrections as built</p>	<p>DETAIL</p>
	<p>  </p>
	<p>       Designed By: RM        Drawn By: RM        Checked By: RM        Approved By: RM     </p>
<p>WT 7732A</p>	





NOTES:

- ① UPPER CLIP ASSEMBLY, SEE DETAIL (1/3)
- ② SUPPORT SKID, SEE DETAIL (2/3)
- ③ SOLAR PANEL RETENTION CLIP, SEE DETAIL (3/3)



NOTE: ONLY SUPPORT SKID NOS. 3, 5 AND ALL  
RETENTION CLIPS HAVE HOLES AS SHOWN.

FRONT VIEW - SOLAR PANEL SUPPORTS - HOLE LOCATIONS  
QUARTER SCALE

<p>REVISIONS</p>	<p><b>SOLAR SPACE HEATING AND HOT WATER SYSTEM</b></p>
<p>DEC. 29, 1977</p>	<p><b>DETAILS</b></p>



## SOLAR SYSTEM PERFORMANCE

This system was not instrumented per the contract, thus valid system performance evaluations are not feasible. WTA has on their own added the capability to display temperature and solar insolation, one at a time. By assuming constant fluid flow rates, approximate system efficiency can be calculated. This instrumentation was not built to monitor or record sensor readings and events on a continuous basis. It is possible to connect the control and display equipment to the in-house PDP-11 real time computer for data logging and control. However, the cost of this additional instrumentation required for performance evaluations is prohibitive to WTA.

A second complicating factor is that there are no meters installed to measure the energy used in the affected portion of the building. As mentioned in the General Description section of this report, this solar system is serving a small portion of an office building. There are a total of 6 air handlers in this building, one of which serves the same area served by the solar system. There is one electric and one gas meter for the entire building. To isolate the energy consumption of a portion of the building would require separate metering. The same problem exists with the gas domestic hot water heater in that many of the air handling units are also gas. Again separate metering would be necessary.

As professional engineering firm, William Tao & Associates, Inc., would like to access the true system performance. However, the labor and equipment cost to obtain performance information of value for this system is more than this private firm can justify. While it is obvious that certain general performance statements can be made, it is also true that such statements are highly subjective in nature and of little value as objective system performance evaluations. In this light the following is offered as a generally observed performance of the solar system.

During a typical winter full-sun day, the system will come on and contribute to the heating load usually by 10:00 a.m. By noon, the system will contribute

both to heating the space and charging the storage tank. The tank is usually charged enough that by evening it will continue to contribute to space heating from the storage tank. On many occasions the system will still be in this mode of operation the next morning. It is impossible to say that the solar system is completely carrying the heating load at any time lacking ability to know whether the electric heating coil is on. The same is true for the domestic water system.

In general, the system works since it contributes to space heating and charges the storage tank sufficiently enough to contribute during the night hours and it preheates incoming domestic water.

# APPENDIX

## APPENDIX

### CONTENTS

<u>Title</u>	<u>Page</u>
Building Description	A1
Solar System Description	B1
Collector Subsystem Description	C1
Energy Transport Subsystem Description	D1
Thermal Storage Subsystem Description	E1
Controls Subsystem Description	F1
Solar System Design Process Report	G1
Manufacturer Information	H1

# NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING

## BUILDING DESCRIPTION

Page 1 of 3

<b>1. PROJECT IDENTIFICATION NO.</b> EG-77-A-01-4085	<b>2. PROJECT TITLE</b> Solar Space Heating And Hot Water System	<b>3. DATE</b> 12 - 30 - 77 MO DAY YR
---	---	---

<b>4. DEMONSTRATION PROJECT LOCATION</b> Name <u>William Tao &amp; Associates, Inc.</u> Street <u>2357 59th Street</u> City <u>St. Louis</u> State <u>MO</u> Zip <u>63110</u>	<b>9. GENERAL CHARACTERISTICS</b> A. Latitude <u>38.7</u> °N B. Longitude <u>90.4</u> °W C. Altitude <u>500</u> Feet D. Normal Cooling Days <u>1475</u> °F Days/Yr E. Cooling Hours/Year <u>1000</u> (Per ASHRAE) F. Normal Heating Days <u>4900</u> °F Days/Yr G. Heating Degree Days <u>1026</u> for January H. Front of Building Faces (Circle One) N NE NW SE S SW <u>(E)</u> W I. Design Monthly Avg. Wind Direction (Circle One) N NE <u>(NW)</u> SE S SW E W J. Design Monthly Avg. Wind Velocity <u>11.8</u> MPH
--	--

<b>5. CONTRACTOR NAME AND ADDRESS</b> Name <u>William Tao &amp; Associates, Inc.</u> Street <u>2357 59th Street</u> City <u>St. Louis</u> State <u>MO</u> Zip <u>63110</u> Small Business No <input type="checkbox"/> 0 Yes <input checked="" type="checkbox"/> 1	<b>AVG. TOTAL HORIZONTAL SOLAR RADIATION FOR:</b> K. January <u>Not monitored</u> BTU/FT <sup>2</sup> Day L. July <u>in St. Louis area</u> BTU/FT <sup>2</sup> Day
---	--

<b>PROJECT MANAGER</b> Richard Lampe	<b>TELEPHONE NO.</b> (314) 644-1400	<b>HEATING DESIGN TEMPERATURES</b> M. Outdoor for 97.5% <u>8</u> °F N. Indoor <u>72</u> °F
---	--	--

<b>6. A&amp;E CONTRACTOR NAME AND ADDRESS</b> Name <u>William Tao &amp; Associates, Inc.</u> Street <u>2357 59th Street</u> City <u>St. Louis</u> State <u>MO</u> Zip <u>63110</u> Small Business No <input type="checkbox"/> 0 Yes <input checked="" type="checkbox"/> 1	<b>COOLING DESIGN TEMPERATURE:</b> O. Outdoor for 2.5% <u>95</u> °F P. Indoor <u>75</u> °F Q. Outdoor Dew Point <u>78</u> °F
---	---

<b>7. OWNER NAME AND ADDRESS</b> Name <u>William Tao &amp; Associates, Inc.</u> Street <u>2357 59th Street</u> City <u>St. Louis</u> State <u>MO</u> Zip <u>63110</u> Telephone No. <u>(314) 644-1400</u>	<b>DESIGN SHADED GLASS AREA</b> R. Heating Season <u>25</u> FT <sup>2</sup> S. Cooling Season <u>25</u> FT <sup>2</sup>
---	---

<b>8. BUILDING OCCUPANCY</b> A. Residential <input type="checkbox"/> R Commercial <input checked="" type="checkbox"/> C B. Type (See Table 1) <u>b</u> Enter Code/Describe C. Category (See Table 2) <u>b</u> Enter Code/Describe	<b>10. INTEGRATION OF SOLAR SYSTEM</b> Concurrently with Bldg Design <input type="checkbox"/> ND Occurred After Bldg was Designed <input checked="" type="checkbox"/> AD Retrofit into an Existing Bldg <input type="checkbox"/> RF
--	--

# NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING

## BUILDING DESCRIPTION

Page 2 of 3

### REGULATORY CODES

State ☐ ST Local ☐ LO

Other(specify) \_\_\_\_\_

Name of State or Local Code/  
Regulation \_\_\_\_\_ Edition \_\_\_\_\_

Building \_\_\_\_\_ Year \_\_\_\_\_

Mechanical \_\_\_\_\_ Year \_\_\_\_\_

Electrical \_\_\_\_\_ Year \_\_\_\_\_

Plumbing \_\_\_\_\_ Year \_\_\_\_\_

Other(specify) \_\_\_\_\_

Model Codes which are the basis for  
Regulation (Use abbreviations in Table 3)

Edition(year)

Building BOCA 1977

Mechanical BOCA 1977

Electrical NEC 1978

Plumbing BOCA 1977

Other(specify) \_\_\_\_\_

### 12. A. Number of Stories

Above Ground AG 1

Below Ground BG 0

B. Total Height Above Ground 13 FT

### C. Conditioned Floor Area

Total 1200 FT<sup>2</sup>

Using Solar Energy 900 FT<sup>2</sup>

### D. Exterior Wall Geometry (Total Area)

Walls 1240 FT<sup>2</sup>

Door Openings 25 FT<sup>2</sup>

Windows 25 FT<sup>2</sup>

### E. Roof

Flat ☐ FL

Sloped ☒ SL Pitch Angle 1.3 °

F. Attic: Ventilated No ☒ 0 Yes ☐ 1

G. Crawl Space: Vented No ☒ 0 Yes ☐ 1

### 13. BUILDING VENTILATION RATES

Mechanical, heating 10 Changes/hr

Mechanical, cooling 10 Changes/hr

Natural, heating 1/2 Changes/hr

Natural, cooling 1/2 Changes/hr

### 14. INTERNAL HEAT RELEASE (MAXIMUM LOAD)

Occupants 15,000 BTU/hr

Lighting 8,100 BTU/hr

Appliance &  
Equipment 5,900 BTU/hr

### 15. HVAC SYSTEM OPERATION CHARACTERISTICS

A. Number of Zones 1

B. Type: Perimeter ☐ P Interior ☒ I

Other(Specify) \_\_\_\_\_

C. System Designation \_\_\_\_\_ (See Table 4)

D. Principle of Operation (Check One)

Heating-Cooling-Off ☒ HCO

Air Volume Variation ☐ AVV

Air Mixing Control ☐ AMC

Temperature Variation ☐ TVA

Other(specify) \_\_\_\_\_

E. Heat Dissipating Devices (Check One)

Evaporative Condenser ☐ EC

Air-Cooled Condenser ☒ AC

Cooling Tower ☐ CT

Other(specify) \_\_\_\_\_

F. Energy Conservation and Recovery

Devices \_\_\_\_\_ (See Table 5)

G. System Operating Temperature Set Points

Heating: \_\_\_\_\_ Cooling: \_\_\_\_\_

Day 72 °F 9 hrs/day 75 °F 9 hrs/day

Night 65 °F 15 hrs/day 85 °F 15 hrs/day

Weekend 65 °F 24 hrs/day 85 °F 24 hrs/day



# NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING BUILDING DESCRIPTION

Page 3 of 3

## 1. DESIGN LOAD AND SYSTEM PERFORMANCE SUMMARY

Month	Total Load (MBtu)			Energy Supplied By (MBtu)		Solar System Energy Usage (Kwh)
	Hot Water	Heating	Cooling	Solar System	Auxiliary System	
JANUARY	920	6,200		1,809	4,810	38
FEBRUARY	950	4,320		2,385	2,670	38
MARCH	920	3,120		2,816	1,000	38
APRIL	840	1,090		1,800	-0-	38
MAY	760	330		960	-0-	-0-
JUNE	660	10		-0-	94	-0-
JULY	590	-0-		-0-	84	-0-
AUGUST	570	-0-		-0-	81	-0-
SEPTEMBER	590	200		660	-0-	38
OCTOBER	660	660		1,190	-0-	38
NOVEMBER	760	2,680		2,030	1,280	38
DECEMBER	840	5,710		1,830	4,580	38

### 17. TYPE OF PREDICTIVE MODEL USED

Performance Calculations ☒ PC  
 Steady State ☐ SS  
 Transient ☐ TR  
 Analytic model designation \_\_\_\_\_

### 18. SIMULATION TIME PERIOD

Hourly ☐ H  
 Daily ☐ D  
 Monthly ☒ M  
 Other (specify) \_\_\_\_\_

PREPARED BY:

Richard R. Janis

12/29/77

# NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING

## SOLAR SYSTEM DESCRIPTION

Page 1 of 3

1. PROJECT IDENTIFICATION NO. EG-77-A-01-4085	2. PROJECT TITLE Solar Space Heating & Hot Water System	3. DATE 12 - 30 - 77 MO DAY YR
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### 4. SYSTEM GENERAL DESCRIPTION

A. Air, active  
Function \_\_\_\_\_ (Table 5)  
Type(specify) \_\_\_\_\_

B. Air, passive  
Function \_\_\_\_\_ (Table 5)  
Type: Window type \_\_\_\_\_ WIN  
Storage, Direct Irrad \_\_\_\_\_ DI  
Storage, Indir Heated \_\_\_\_\_ IH  
Storage, Combined \_\_\_\_\_ BO  
Air Plenum \_\_\_\_\_ PLENUM  
Other(specify) \_\_\_\_\_

C. Liquid, active  
Function Heating Hot Water (Table 5)  
Type(specify) multiple concentrator

D. Liquid, passive  
Function \_\_\_\_\_ (Table 5)  
Type: Thermosyphon \_\_\_\_\_ SYPHON  
Evaporator \_\_\_\_\_ EVAP  
Liquid Bag \_\_\_\_\_ LIBAG  
Other(specify) \_\_\_\_\_

E. Combined Systems (Describe): \_\_\_\_\_

### 7. COLLECTOR SUBSYSTEM

A. Number of Collector Types 1  
B. Collector ID: (See Table 1)  
1 KTA KT 4-85  
2 \_\_\_\_\_  
3 \_\_\_\_\_  
4 \_\_\_\_\_

If any one of these collectors is new, write in the description and complete Collector Subsystem Description form for each collector type

C. Orientation X Due S  
(Based on True N) \_\_\_\_\_ ° E of S  
\_\_\_\_\_ ° W of S

D. Tilt (Degrees from Horizontal)  
Fixed ☐ F \_\_\_\_\_ °  
Adjustable ☒ A from 32 ° to 68 °

E. Location  
Roof ☒ R  
Wall ☐ W  
Ground ☐ G  
Separate Structure ☐ S  
Other(Describe) ☐ \_\_\_\_\_

### 5. SCHEMATICS OF SOLAR SYSTEM ON HAND:

No ☐ 0 Yes ☒ 1

### 6. SYSTEM DESIGNER/MANUFACTURER

A. Name William Tao & Associates, Inc.  
B. Address 2357 59th Street  
C. City St. Louis State MO Zip 63110  
D. Telephone No. ( 314 ) 644-1400  
E. Model Name Custom design  
F. Model No. \_\_\_\_\_

### F. Array Characteristics

Number of Panels for each  
Collector Type (See 7B Above) 1 6  
2 \_\_\_\_\_  
3 \_\_\_\_\_  
4 \_\_\_\_\_

G. Total Area of Array 252 FT<sup>2</sup>

H. Effective Array  
Aperture Area 216 FT<sup>2</sup>

# NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING

## SOLAR SYSTEM DESCRIPTION

Page 2 Of 3

### COLLECTOR SUBSYSTEM (CONTINUED)

#### I. Collector Array Shading

Area shaded between 10 am and 2pm Solar Time

On June 21 0 % of Aperture

On Dec 22 0 % of Aperture

Maximum shade during Functional Season 0 % of Aperture

#### J. Cause of Shading

Building Itself ☐ B

Adjacent Building ☐ ADJ

Trees on Building Site

Deciduous ☐ DT

Coniferous ☐ CT

Trees not on Site

Deciduous ☐ NDT

Coniferous ☐ NCT

Other (Specify) \_\_\_\_\_

#### K. Freeze Protection (Table 2) \_\_\_\_\_

Other(specify) Glycol Loop

#### L. Overheating Protection (Table 3) \_\_\_\_\_

Other(specify) Shading

Please supply the following information, if these are not an integral part of Collector subsystem

#### M. Mounting frame manufacturer

Name Field erected

Model Name \_\_\_\_\_

Model No. \_\_\_\_\_

Material (Table 4A) \_\_\_\_\_

Protective Coating (Table 4C) \_\_\_\_\_

Standoff Used No ☐ 0 Yes ☒ 1

Standoff Height 12 In

No. of Attachment Points 6

### 7. COLLECTOR SUBSYSTEM (CONTINUED)

#### N. Reflector

Substrate Material (Table 4A) Glass

Reflective Surface (Table 4B) \_\_\_\_\_

Protective Coating (Table 4C) \_\_\_\_\_

Shape (Table 4D) \_\_\_\_\_

Concentration Factor \_\_\_\_\_

Length \_\_\_\_\_ In

Width \_\_\_\_\_ In

Diameter \_\_\_\_\_ In

Thickness \_\_\_\_\_ In

### 8. THERMAL STORAGE

Number of Storage Units 1

(Please complete Thermal Storage Subsystem Description form for each unit)

### 9. ENERGY TRANSPORT

Liquid ☒ L

No. of Circulation Loops 2

Air ☐ A

No. of Circulation Loops \_\_\_\_\_

(Please complete detailed Energy Transport Subsystem description form for each circulation loop)

### 10. HOT WATER

A. Manufacturer Rund

B. Model Name Hot Water Heater

C. Model No. RP-50-42 (gas)

Source:

D. Oil ☐ O Gas ☒ G Electric ☐ E

E. Tank 50 Gal

F. Delivered at 1 Gal/Min

G. Inlet Temp \_\_\_\_\_ °F

H. Outlet Temp 140 °F

I. Minimum recovery time 42 GAL/Hr

J. Energy Input 35,000 BTU/Hr

K. Energy Output 24,500 BTU/Hr

NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING  
SOLAR SYSTEM DESCRIPTION

Page 3 of 3

11. SPACE HEATING

SOLAR SYSTEM

A. Total Heating Capacity 34,200 BTU/HR  
B. Air Flow Entering at 1,600 CFM  
C. Dry Bulb Temp 75 °F  
D. Relative Humidity 0 %

AUXILIARY SYSTEM

E. Furnace ☐ F Resistance ☒ R Boiler ☐ B Heater  
F. Oil ☐ O Gas ☐ G Electric ☒ E  
G. Manufacturer Trane  
H. Model Name Package Rooftop Unit  
I. Model No. SAHA-40  
J. Energy Input 35,500 BTU/HR  
K. Energy Output 34,200 BTU/HR

12. SPACE COOLING

SOLAR SYSTEM

A. Total Capacity \_\_\_\_\_ BTU/HR  
B. Sensible Capacity \_\_\_\_\_ BTU/HR  
C. Inlet Air Flow \_\_\_\_\_ CFM  
D. Dry Bulb \_\_\_\_\_ °F  
E. Wet Bulb \_\_\_\_\_ °F

AUXILIARY SYSTEM

F. Air Conditioners No ☐ O Yes ☒ 1  
G. Manufacturer Trane  
H. Model Name Package Rooftop Unit  
I. Model No. SAHA-40  
J. Type (Check One):  
Vapor Compression ☒ VC  
Rankine Cycle ☐ RC  
Sterling Cycle ☐ SC  
Absorption ☐ AA  
Desiccant ☐ DE

12. Continued

K. COP \_\_\_\_\_  
L. Oil ☐ O Gas ☐ G Electric ☒ E  
M. Total Capacity 4 Tons  
N. Energy Input \_\_\_\_\_ BTU/HR

13. AUXILIARY HEATING & COOLING

A. Heat Pump No ☒ O Yes ☐ 1  
B. Manufacturer \_\_\_\_\_  
C. Model Name \_\_\_\_\_  
D. Model No. \_\_\_\_\_  
E. Type:  
Air to Air ☐ AA  
Air to Liquid ☐ AL  
Liquid to Liquid ☐ LL  
F. COP \_\_\_\_\_  
G. Heating  
Useful Thermal Output \_\_\_\_\_ kW  
Electrical Input \_\_\_\_\_ kW  
H. Cooling  
Useful Thermal Output \_\_\_\_\_ kW  
Electrical Input \_\_\_\_\_ kW

14. DEHUMIDIFIER

Manufacturer \_\_\_\_\_  
Model Name \_\_\_\_\_  
Model No. \_\_\_\_\_  
Capacity \_\_\_\_\_ Lb. Water Vapor Per Hour

15. CONTROLS & SAFETY DEVICES

(Please complete the Controls & Safety Devices Subsystem description form)

PREPARED BY:

Richard R. Janis 12/29/77

# NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING

## COLLECTOR SUBSYSTEM DESCRIPTION

(COMPLETE FOR EACH COLLECTOR TYPE)

NOTE: Some items not applicable to KTA Collector due to unique design.

Page 1 of 4

1. COLLECTOR IDENTIFICATION NO. <u>(KTA) KT4-85</u>	2. PROJECT IDENTIFICATION NO. <u>EG-77-A-01-4085</u>	3. DATE <u>12</u> - <u>30</u> - <u>77</u> MO DAY YR
--	---	---

4. TYPE (See Table 1) _____  5. SPECIFY (IF OTHER) <u>Flat Plate with multiple concentrators.</u>  6. IDENTIFICATION Manufacturer <u>KTA Corporation</u> Address <u>12300 Washington Ave.</u> City <u>Rockville</u> State <u>Maryland</u> Zip <u>20852</u> Model ID <u>KT4-85</u> Model Name <u>KTA Solar Collector</u> Telephone No. <u>(301) 468-2066</u>	7. COLLECTOR PANEL CHARACTERISTICS A. Gross Collector Area <u>42</u> FT <sup>2</sup> B. Net Aperture Area <u>36</u> FT <sup>2</sup> C. Empty Weight <u>1000</u> Lbs D. Full Weight <u>1130</u> Lbs E. Length <u>96</u> In F. Width <u>63</u> In G. Depth <u>3-1/4</u> In  8. PASSIVE COLLECTOR HEAT TRANSFER CONTROL _____ (See Table 2)
---	--

COVER PLATES	9. NUMBER OF COVER PLATES <u>1</u>	10. PHYSICAL CHARACTERISTICS Length <u>96</u> IN Width <u>63</u> IN
--------------	------------------------------------	---

COVER PLATE NO	MATERIAL (SEE TABLE 3)	THICKNESS IN	TRANSMITTANCE %	REFLECTANCE %
C. <u>1</u> OUTERMOST	<u>Plastic (polyvinyl Fluoride)</u>	<u>4 mils</u>	<u>83</u>	<u>7</u>
D. <u>2</u>				
E. <u>3</u>				

11. EDGE OR SURFACE TREATMENT (SEE TABLE 4)				
COVER PLATE NO.	TYPE OF TREATMENT	COATING	COATING FUNCTION	METHOD OF APPLICATION
A. <u>1</u> OUTERMOST	<u>Double Polished</u>			
B. <u>2</u>				
C. <u>3</u>				

12. DESICCANTS	
A. Desiccants Used B. Type <u>Silica Gel</u> <input type="checkbox"/> SG <u>Anhydrous Calcium Chloride</u> <input type="checkbox"/> CA <u>Other</u> <input type="checkbox"/>	No <input checked="" type="checkbox"/> 0 Yes <input type="checkbox"/> 1 If other, specify _____

NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING  
COLLECTOR SUBSYSTEM DESCRIPTION  
(COMPLETE FOR EACH COLLECTOR TYPE)

Page 2 of 4

**ABSORBER**

**13. IDENTIFICATION**

A. Manufacturer KTA Corporation  
B. Model Name KTA Solar Collector  
C. Model No. KT4-85

**4. PHYSICAL PROPERTIES**

A. Substrate Material Copper  
(SEE TABLE 5A)  
B. Alloy Designation                       
Generic Type  
C. Thickness                      IN  
D. Coating CU<sub>2</sub>O  
(See Table 5B)  
E. Method of Application                       
(SEE TABLE 5C)  
F. Absorptance                       
G. Reflectance                     

**15. HEAT TRANSFER FLUID PASSAGE CHARACTERISTICS**

A. Material Copper  
(See Table 5A)  
B. Alloy Designation/  
Generic Type                       
C. Wall Thickness                      IN  
D. Bond to Substrate                       
(See Table 6A)  
E. Protective Coating                       
(See Table 6B)  
F. Location of absorber tube  
Fluid Passages  
(See Table 6C)

**INSULATION**  
**16. NUMBER OF LAYERS**

Sides                       
Back 1

**INSULATION**

**17. INSULATION MANUFACTURER & PRODUCT ID** High Temp. Polyurethane by KTA.

LOCATION		MANUFACTURER	PRODUCT NAME	IDENTIFICATION NO
SIDES	LAYER 1			
	LAYER 2			
JACK	LAYER 1			
	LAYER 2			

**18. PHYSICAL PROPERTIES OF INSULATION**

LOCATION		MATERIAL(SEE TABLE 7)	THICKNESS IN	DENSITY LB/FT <sup>3</sup>	R VALUE
SIDES	LAYER 1				
	LAYER 2				
BACK	LAYER 1	Polyurethane	1"		5.70
	LAYER 2				

# NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING

## COLLECTOR SUBSYSTEM DESCRIPTION

(COMPLETE FOR EACH COLLECTOR TYPE)

Page 3 of 4

### 9. GASKETS SPECIFICATIONS TYPE. CORK CO RUBBER RU PLASTIC PL OTHER (Specify)

LOCATION	TYPE	GENERIC NAME	MANUFACTURER	NAME	ID NO
A. Inner Cover Plate					
B. Outer Cover Plate					
C. Backing Plate					
D. Piping Penetration					
E. Frame Joint					

### 10. SEALANTS SPECIFICATIONS

LOCATION	TYPE (See Table 8)	MANUFACTURER	NAME	ID NO
A. Inner Cover Plate	<i>Hermatic</i>	<i>by KTA</i>		
B. Outer Cover Plate				
C. Backing Plate				
D. Piping Penetration				
E. Frame Joint				

### 11. MOUNTING FRAME & REFLECTOR (Please supply information in this block if these are integral parts of the Collector Subsystem)

#### 21. REFLECTORS

- A. Substrate Material Glass  
(See Table 9A)
- B. Alloy/Generic Type \_\_\_\_\_
- C. Reflective Surface not available  
(See Table 9B)
- D. Protective Coating \_\_\_\_\_  
(See Table 6B)
- E. Shape
- Flat ☐ F
- Cylinder ☒ C
- Parabolic Dish ☐ PD
- Parabolic Cylinder ☐ PC
- F. Length 58 IN
- G. Thickness \_\_\_\_\_ IN

- H. Width \_\_\_\_\_ IN
- I. Diameter \_\_\_\_\_ IN
- J. Concentration Factor \_\_\_\_\_

#### 22. MOUNTING FRAME

- A. Manufacturer Field erected
- B. Model Name \_\_\_\_\_
- C. Model ID \_\_\_\_\_
- D. Material Used \_\_\_\_\_  
(See Table 9A)
- E. Protective Coating \_\_\_\_\_  
(See Table 6B)

# NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING

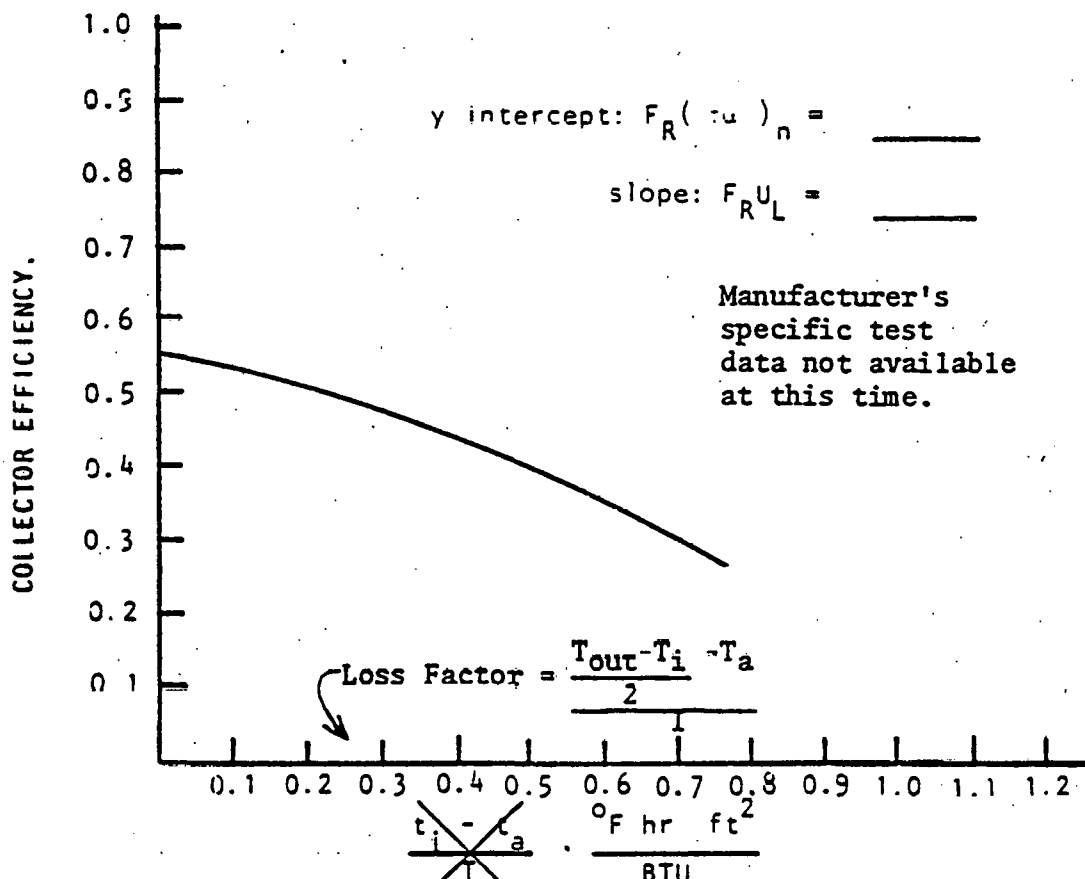
## COLLECTOR SUBSYSTEM DESCRIPTION

(COMPLETE FOR EACH COLLECTOR TYPE)

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### 3. COLLECTOR PERFORMANCE

This information should be provided by the manufacturer using the slope intercept method, as per NBSIR 74-635, providing a minimum of four points over the inlet temperature range of 100-180°F, and insolation range of 150-300 BTU/ft<sup>2</sup> hr. at design flow rate. A plot of the thermal efficiency versus the difference in temperature and ambient divided by the incident insolation for the range of exposure conditions will provide the basic thermal performance at near normal incident angles. See Appendix A, Intermediate Minimum Property Standards for Solar Heating and Domestic Hot Water Systems, NBS.



$t_{i1} =$  \_\_\_\_\_

$t_{i2} =$  \_\_\_\_\_

$t_{i3} =$  \_\_\_\_\_

$t_{i4} =$  \_\_\_\_\_

$t_{a1} =$  \_\_\_\_\_

$t_{a2} =$  \_\_\_\_\_

$t_{a3} =$  \_\_\_\_\_

$t_{a4} =$  \_\_\_\_\_

$I_1 =$  \_\_\_\_\_

$I_2 =$  \_\_\_\_\_

$I_3 =$  \_\_\_\_\_

$I_4 =$  \_\_\_\_\_

where:

$F_R$  = collector heat removal factor,  $U_L$  = collector heat loss factor  
 $(\tau\alpha)_n$  = transmissivity-absorptivity product at normal incidence  
 $t_i$  = collector inlet temperature, °F;  $t_a$  = ambient air temperature, °F  
 $I$  = radiation (insolation) intensity on collector, BTU/Hr.ft<sup>2</sup>

A. Design Mass Flow Rate

0.03  $\frac{Lb}{Hr \cdot Ft^2}$   
 $\frac{GPM}{Ft^2 \cdot MIN}$   
 $\frac{BTU}{Hr \cdot Ft^2 \cdot ^\circ F}$

B. Backside Thermal Loss

\_\_\_\_\_

C. Edge Thermal Loss

\_\_\_\_\_

D. Top Heat Loss

\_\_\_\_\_

E. Design Wind Speed

\_\_\_\_\_ MPH

F. Thermal Response Time Constant

\_\_\_\_\_ MIN

G. Spectral Response

\_\_\_\_\_ um

H. Angle Modifier (Check one)

45° ☐ 1 60° ☐ 2 75° ☐ 3

PREPARED BY:

Richard R. Janis

12/29/77



# NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING

## ENERGY TRANSPORT SUBSYSTEM DESCRIPTION

(COMPLETE FOR EACH CIRCULATION LOOP)

PROJECT ID  
G-77-A-01-4085

Page 1 of 4

1. TYPE OF ENERGY TRANSPORT Liquid ☒ L Air ☐ A  
(If Air, skip Page 1 and begin on Page 2)
2. NUMBER OF CIRCULATION LOOPS  
(Energy Transport Subsystem Description must be completed for each circulation loop separately)
3. CIRCULATION LOOP NO Glycol Loop

### ENERGY TRANSPORT (LIQUID)

4. FLOW RATE 8 GPM

5. NORMAL MAXIMUM DESIGN TEMPERATURE 1 °F

### 6. PHYSICAL PROPERTIES

- A. Heat Transfer Medium (Table 1) \_\_\_\_\_  
Other (specify) Water-Glycol solution
- B. Composition (% of Total Volume) 60 %
- C. Specific Heat .86 BTU/Lb/°F
- D. Density 64.8 Lb/Ft<sup>3</sup>
- E. Viscosity Over Working Temperature Range 1.5 Centipoises
- F. Boiling Point 220 °F
- G. Freezing Point -10 °F
- H. Maximum Recommended Use Temp. 300 °F
- I. Flash Point - °F
- J. pH Factor > 7
- K. Chemical Feeder to Maintain pH No ☒ 0 Yes ☐ 1
- L. If Yes, Manufacturer \_\_\_\_\_
- M. Product Name \_\_\_\_\_  
ID Number \_\_\_\_\_
- N. Inhibitor No ☐ 0 Yes ☒ 1
- O. Generic Type Inhibited Glycol
- P. % of total weight 40 %
- Q. Potable No ☒ 0 Yes ☐ 1

### 7. RIGID PIPING/MANIFOLD

- A. Material (Table 2A) 3-1/2" 40 S Steel
- B. Generic Type/Alloy Designation \_\_\_\_\_
- C. Protective Coating Interior (Table 2B) \_\_\_\_\_

### 7. RIGID PIPING/MANIFOLD (Continued)

D. Generic Type, if Plastic Interior Coating \_\_\_\_\_

### 8. FLEXIBLE COUPLINGS

- A. Material: Rubber ☐ R Plastic ☐ P Metal ☒ M
- B. Generic Type/Alloy Soft copper
- C. Reinforcement: Glass Fiber ☐ G Fabric ☐ F Metal Wire ☐ M None ☒ 0
- D. Generic Name, if any \_\_\_\_\_
- E. Thickness \_\_\_\_\_ IN
- F. Pressure Rating 125 PSI
- G. Connections (Table 3) \_\_\_\_\_
- H. Generic Name, if any \_\_\_\_\_

### 9. PIPING INSULATION

- A. Insulated No ☐ 0 Yes ☒ 1
- B. Material (Table 4) Fiberglass with  
Other (specify) aluminum jacket
- C. Thickness 1 IN
- D. Density \_\_\_\_\_ Lb/Ft<sup>3</sup>
- E. Thermal Resistance .34 R VALUE

### 10. EXTERIOR FINISH (Table 5)

Generic Name, if any Acrylic Paint

### 11. LOCATION

- Below Grade ☐ BG
- Above Grade ☒ AG

### 12. JOINTS (Table 6)

### 13. NUMBER OF PUMPS

1

# NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING

## ENERGY TRANSPORT SUBSYSTEM DESCRIPTION

(COMPLETE FOR EACH CIRCULATION LOOP)

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### ENERGY TRANSPORT AIR

4. FLOW RATE \_\_\_\_\_ CFM
5. NORMAL MAXIMUM DESIGN TEMPERATURE \_\_\_\_\_ °F
6. PHYSICAL PROPERTIES not applicable
7. RIGID DUCTING
- A. Material \_\_\_\_\_  
(See codes below)
- B. Generic Type \_\_\_\_\_  
Alloy Designation \_\_\_\_\_
- C. If jacketed glass fiber, density \_\_\_\_\_ Lb/Ft<sup>3</sup>
- D. Thickness of ducting material \_\_\_\_\_ IN
8. FLEXIBLE DUCTING.
- A. Material \_\_\_\_\_  
(See codes below)
- B. Generic Type \_\_\_\_\_

### DUCTING MATERIAL

- RIGID
- |                      |         |
|----------------------|---------|
| ALUMINUM             | AL      |
| STEEL                | ST      |
| PLASTIC              | PL      |
| JACKETED GLASS FIBER | JF      |
| ASBESTOS CEMENT      | AC      |
| OTHER                | Specify |
- FLEXIBLE (wire reinforced)
- |                      |         |
|----------------------|---------|
| JACKETED GLASS FIBER | JFB     |
| PLASTIC              | PLA     |
| RUBBER               | RUB     |
| OTHER                | Specify |

### 9. DUCT INSULATION

- Internal (Duct Liner)
- A. Insulated No ☐ 0 Yes ☐ 1
- B. Material \_\_\_\_\_  
(See codes below)
- C. Thickness \_\_\_\_\_ IN
- D. Density \_\_\_\_\_ Lb/Ft<sup>3</sup>
- E. Thermal Resistance \_\_\_\_\_ R VALUE
- F. Internal Finish
- None ☐ 0 Neoprene ☐ 1
- Other (specify) \_\_\_\_\_
- External (Duct Wrap)
- Insulated No ☐ 0 Yes ☐ 1
- G. Material \_\_\_\_\_  
(See codes below)
- H. Thickness \_\_\_\_\_ IN
- I. Density \_\_\_\_\_ Lb/Ft<sup>3</sup>
- J. Thermal Resistance \_\_\_\_\_ R VALUE

### 10. FINISH

- A. Exterior (Table 5) \_\_\_\_\_
- B. Generic Name \_\_\_\_\_

### 11. LOCATION (Table 7)

### 12. JOINTS (Table 6)

### 13. NUMBER OF BLOWERS

### INSULATION MATERIAL

- |                   |         |
|-------------------|---------|
| GLASS FIBER       | GW      |
| CALCIUM SILICATE  | CS      |
| MINERAL FIBER     | MW      |
| CELLULAR RUBBER   | CR      |
| POLYURETHANE FOAM | PF      |
| OTHER             | Specify |

### 14. PUMP/BLOWER IDENTIFICATION Pump ☒ P Blower ☐ B

No.	Manufacturer	Product Name	Product No
1	Bell & Gossett	Pump	1-1/4 HV
2			
3			
4			
5			

**NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING**  
**ENERGY TRANSPORT SUBSYSTEM DESCRIPTION**  
 (COMPLETE FOR EACH CIRCULATION LOOP)

Page 3 of 4

**5. A. PUMP/BLOWER CHARACTERISTICS (Use abbreviations given below)**

No	Type	Capacity CFM/GPM	Motor Operating Horsepower HP	Operating Pressure PSI	Filtered Y or N
	CE	12	1/6	125	N
					N
3					
4					

**TYPE OF PUMPS**

CENTRIFUGAL ☒ CE  
 GEAR ☐ GE  
 PISTON ☐ PI  
 VANE ☐ VA  
 OTHER(specify) \_\_\_\_\_

**TYPE OF BLOWERS**

VANE-AXIAL ☐ VA  
 TUBE-AXIAL ☐ TA  
 ADJUSTABLE PITCH ☐ AD  
 SQUIRREL CAGE ☐ SQ  
 OTHER(specify) \_\_\_\_\_

**5. B. PUMPS CHARACTERISTICS (PUMPS ONLY) (Use abbreviations given below)**

No	Maximum Operating Temp °F	Material Exposed To Fluid	Generic Name Alloy Designation	Getters Y or N	Generic Name Getters
	250	Bronze			
3					

Material exposed to fluid: Brass ☐ BR Steel ☐ ST Plastic ☐ PL Other(specify) Bronze

**16. VALVES (FOR PUMPS)/DAMPERS (FOR BLOWERS) (use abbreviations given below)**

No	Manufacturer	Product Name	Product No	Function	Type
1	Bell & Gossett	Circuit Setter		FA	BA
2	Jenkins		Fig. 47-U	OF	GA
	Jenkins		Fig. 546-P	FS	GL
4					

**VALVES**

**DAMPERS**

FUNCTION				TYPE			
FLOW SWITCHING	FS	GLOBE	GL	FLOW SWITCHING	FS	SINGLE BLADE	SB
ON-OFF	OF	GATE	GA	ON-OFF	OF	OPPOSED BLADE	OB
FLOW ADJUSTING	FA	BUTTERFLY	BF	FLOW ADJUSTING	FA	MULTILOUVER	ML
DRAIN	DR	NEEDLE	NE			MULTISHUTTER	MS
SEED	BL	BALL	BA			SPLITTER	SP

NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING  
ENERGY TRANSPORT SUBSYSTEM DESCRIPTION  
(COMPLETE FOR EACH CIRCULATION LOOP)

Page 4 of 4

**7. HEAT EXCHANGERS**

**A. NUMBER OF HEAT EXCHANGERS**    1

**B. HEAT EXCHANGER(HX) CHARACTERISTICS (Use abbreviations given below)**

NO	Type of Exchange	Type of Flow	HX Design			No. of Walls	
			Enter Code	Tube Passes	Shell Passes	Single	Double
1	LL	CR	SAT	2	1	S	

TYPE OF EXCHANGE		TYPE OF FLOW		HX DESIGN			
Air-Air	AA	Parallel	PA	Shell & Tube	SAT	Fin Coil	FIN
Air-Liquid	AL	Counter	CO	(Specify number		Tube around	
Liquid-Liquid	LL	Cross	CR	of Tube Passes		Tank	TAT
				Shell Passes)		Tube inside	
				Heat Pipe	HP	Tank	TIT

**C. HEAT EXCHANGE SPECIFICATIONS (Use abbreviations given below)**

X NO	Effectiveness		Material	Alloy Designation	Overall Heat Transfer Coefficient
	z	Specify Flow Conditions			
1	66	Warm Side: $T_i=156^{\circ}\text{F}$ $T_{out}=153^{\circ}\text{F}$ , 12gpm Cool Side: $T_i=147^{\circ}\text{F}$ $T_{out}=15^{\circ}\text{F}$ , 6gpm	ST		6500 $\frac{\text{Btu}}{\text{h}^{\circ}\text{F}}$
2					
3					
4					
5					

**MATERIAL:**      Copper    CU    Aluminum    AL    Steel    ST    Other    Describe

**PREPARED BY:**

Richard R. Janis      12/29/77

# NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING

## THERMAL STORAGE SUBSYSTEM DESCRIPTION

(COMPLETE FOR EACH STORAGE UNIT)

Page 1 of 2

PROJECT ID  
EG-77-A-01-4085

1. NUMBER OF STORAGE UNITS 1

2. STORAGE CONTAINER UNIT NO. 1

3. TOTAL STORAGE UNIT VOLUME 134 FT<sup>3</sup>

4. HEAT CAPACITY 730 MBTU'S

5. MAXIMUM NORMAL DESIGN TEMP 160 °F

6. MINIMUM TEMPERATURE 65 °F  
(If used for cold storage)

### 7. FILTERS

A. Inlet ☐ 1 Outlet ☐ 0 None ☒ N

B. Manufacturer \_\_\_\_\_

C. Product ID \_\_\_\_\_

### 8. AUXILIARY HEATERS

A. Number of \_\_\_\_\_

B. Manufacturer \_\_\_\_\_

C. Model \_\_\_\_\_

D. Capacity \_\_\_\_\_ kW

### 9. DIMENSIONS

A. Length 6' FT

B. Width \_\_\_\_\_ FT

C. Height \_\_\_\_\_ FT

D. Diameter 5'-4" FT  
(If cylindrical)

### 10. CONTAINER MATERIAL (Check one)

A. Concrete ☐ CC

Cinder Block (Reinforced) ☐ CB

Steel ☒ ST

Aluminum ☐ AL

Wood ☐ WD

Plastic ☐ PL

Glass Fiber ☐ GR

Reinforced Plastic ☐

Other \_\_\_\_\_

B. Generic Type Water Tank

### 11. CONTAINER LINING (Check one)

Epoxy Compound ☐ EP

Neoprene ☐ NE

Hypalon ☐ HY

Porcelain Enamel ☐ PE

Butyl Rubber ☐ BR

Glass ☐ GL

Stone ☐ SN

Other None

### 12. TANK/CONTAINER LOCATION

A. Above Ground ☐ AG

Below Ground ☒ BG

B. Specify (Table 1) \_\_\_\_\_

### 13. INSULATION

Material (Check one)

A. Glass Wool ☐ GW

Calcium Silicate ☐ CS

Mineral Wool ☐ MW

Cellular Rubber ☐ CR

Polyurethane Foam ☐ PF

Styrofoam ☐ SF

Reflective Foil ☐ RF

None ☐ NO

Other Expanded closed cell elastomer

B. Thickness - in

C. Density - Lb/Ft<sup>3</sup>

D. Thermal Resistance 0.22 (R Value)

### 14. EXTERIOR FINISH (Moisture Barrier)

A. None ☐ NO

Asphalt ☒ AS

Asphalt & Felt ☐ AF

Metal Cladding ☐ MC

Plastic Coating ☐ PC

Paint ☐ PT

Cementitious Material ☐ CM

Other \_\_\_\_\_

B. Generic Name \_\_\_\_\_



NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING  
THERMAL STORAGE SUBSYSTEM DESCRIPTION  
(COMPLETE FOR EACH STORAGE UNIT)

Page 2 of 2

STORAGE MEDIUM-SENSIBLE HEAT LIQUID

15. SENSIBLE HEAT LIQUID ☒ SL

6. TYPE

A. Name (Table 2A) Water  
B. Commercial ID -  
C. Composition (% Of Total Volume) 100 %  
D. Inhibitor Type TDB  
E. % Total Weight - %  
F. Total Volume 135 FT<sup>3</sup>

7. PHYSICAL PROPERTIES

A. Specific Heat 1.0 BTU/Lb/°F  
B. Density 62.3 Lb/FT<sup>3</sup>  
C. Viscosity 1.0 Centipoises  
D. Boiling Point 212 °F  
E. Freezing Point 32 °F  
F. Flash Point - °F  
G. Maximum Recommended Use Temperature 200 °F  
H. Potable No ☐ 0 Yes ☒ 1  
I. pH Factor -

STORAGE MEDIUM- LATENT HEAT

15. LATENT HEAT ☐ LH

16. TYPE

A. Material  
Salt Hydrates ☐ SH  
Eutectic Mixtures ☐ EU  
Paraffin ☐ PA  
B. Type (Table 2C) -  
C. Additives  
Nucleating Agents ☐ N  
Thickening Agents ☐ T

D. Generic Name -  
E. % By Volume - %  
F. Total Volume - FT<sup>3</sup>

17. PHYSICAL PROPERTIES

A. Specific Heat  
Above Transformation - BTU/Lb/°F  
Below Transformation - BTU/Lb/°F  
B. Density  
Solid Phase - Lb/FT<sup>3</sup>  
Liquid Phase - Lb/FT<sup>3</sup>  
C. Viscosity (Liquid Phase) - Centipoises  
D. Boiling Point - °F  
E. Transformation Temp - °F  
F. Flash Point - °F  
G. Maximum Recommended Use Temperature - °F  
H. Potable No ☐ 0 Yes ☐ 1  
I. Type of Transformation  
Solid-Solid ☐ SS  
Solid-Liquid ☐ SL  
Dissolution-Recrystal ☐ DR  
J. Latent Heat - BTU/Lb  
K. Material for Racks & Troughs  
Plastic ☐ P Metal ☐ M  
L. Other (specify) -

STORAGE MEDIUM-SENSIBLE HEAT SOLID

5. SENSIBLE HEAT SOLID ☐ SS

16. TYPE (Table 2B)

A. Material -  
B. Size Range -  
C. Total Weight - Lbs

17. PHYSICAL PROPERTIES

A. Specific Heat - BTU/Lb/°F  
B. Weight/FT<sup>3</sup> of Packed Material - Lbs  
C. Heat Capacity of Packed Material - BTU/Lb/°F  
D. Flow Rate of Heat Transport - FT<sup>3</sup>/Min  
E. Pressure Drop Between Inlet & Outlet - PSI

PREPARED BY:

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12/29/77

# CONTROL SUBSYSTEM DESCRIPTION

## CONTROL SEQUENCE

A. System shall operate in four distinct winter modes defined by the following temperature relationships as sensed at locations shown on drawings:

### W1. Storage/collection mode

T1 > T2 + 5 deg. (2dj)  
T3 > 75 deg. (2dj)

#### Component

#### Operational mode

P1

on

P2

on

V1

open through ports C, B (port A closed)

V2

open

V3

open through ports C, B (port A closed)

### Use/collection mode

T1 > T3 + 5 deg. (2dj)  
T3 < 75 (adj)

#### Component

#### Operational mode

P1

on

P2

on

V1

Open through ports A, C (port B closed)

V2

Closed

V3

Open through ports A, B (port C closed)

### Use/no-collection mode

T2 > T3 + 5 deg. (adj)  
T1 < T2 + 5 deg. (adj)  
T1 < T3 + 5 deg. (adj)

T3 < 75 deg. (adj)

#### Component

#### Operational mode

P1

on

P2

off

V1

Open through ports B, C (port A closed)

V2

Open

V3

Open through ports A, B (port C closed)

Component

Operational mode

P1

off (manual)

P2

off

V1

manually de-energized (normal position)

V2

manually de-energized (normal position)

V3

manually de-energized (normal position)

S3. Safety override mode

T1 > T4 + 5 deg. (adj)

T4 > 140 deg. (adj)

Component

Operational mode

P1

off (manual)

P2

off

V1

manually de-energized (normal position)

V2

manually de-energized (normal position)

V3

manually de-energized (normal position)

No-use/no-collection mode

T1 < T2 + 5 deg. (adj)

T1 < T3 + 5 deg. (adj)

T3 > 75 deg. (adj)

Component

Operational mode

P1

off

P2

off

V1

Open through ports B, C (port A closed)

V2

Open

V3

Open through ports A, B (port C closed)

B. System shall operate in 3 distinct summer modes defined by the following temperature relationships as sensed at locations shown on drawings.

S1. Collection mode

T1 > T4 + 5 deg. (adj)

T4 < 140 deg. (adj)

Component

Operational mode

P1

off (manual)

P2

on

V1

manually de-energized (normal position)

V2

manually de-energized (normal position)

V3

manually de-energized (normal position)

S2. Non-collection mode

T1 < T4 + 5 deg. (adj)

T4 < 140 deg. (adj)

# NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING CONTROLS SUBSYSTEM DESCRIPTION

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PROJECT ID  
EG-77-A-01-4085

## 1. CONTROL LOGIC SELECTOR UNIT

### A. Load Supply Mode (LS)

Manufacturer Built in house  
Model Name \_\_\_\_\_  
Model No \_\_\_\_\_

### B. Collector/Storage Flow Control (CSF)

Manufacturer Built in house  
Model Name \_\_\_\_\_  
Model No \_\_\_\_\_

### C. Tracking Mount Drive Control (TMD)

Manufacturer None  
Model Name \_\_\_\_\_  
Model No \_\_\_\_\_

## 2. CONTROL SET POINTS

A. Collector to Storage Temperature Difference 5 adj. °F

Thermostat setting for:

B. Aux DHW Heating 140 adj. °F

C. Aux Space Heating 65 adj. °F

D. Aux Space Cooling N/A °F

E. Storage Heater N/A °F

F. Solar space heating 75 adj. °F

G. \_\_\_\_\_ °F

H. \_\_\_\_\_ °F

I. \_\_\_\_\_ °F

## 3. SENSOR SPECIFICATIONS (USE CONTROL LOGIC CODES GIVEN IN ITEM 1)

NO	CONTROL LOGIC	TYPE	MANUFACTURER	PRODUCT NAME	PRODUCT NO
	LS	TE	Honeywell	RT	C-773A
	CSF	SR	Science Associates Inc.	Pyranometer	615
3					
6					

### TYPE OF SENSORS CODES

← LS → Temperature TE Time TI Solar Radiation SR	← CSF → Thermistor TH Thermocouple TC Resistance Thermometer RT	← TMD → Photo Cell PH Timer
---	--	-----------------------------------

## 4. ACTUATING DEVICES (USE CONTROL LOGIC CODES GIVEN IN ITEM 1)

NO	CONTROL LOGIC	TYPE	MANUFACTURER	PRODUCT NAME	PRODUCT NO
	LS	SV	Honeywell	Motor actuated 3-way valve	M644A 1016
2	CSF	SV	Honeywell	Motor actuated 3-way valve	M644A 1016

### TYPE OF ACTUATING DEVICES CODES

Servomotor - SV

Relay - RE

Solenoid - SL

# NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING

## CONTROLS SUBSYSTEM DESCRIPTION

Page 2 of 2

### 1. ACTUATING DEVICES (CONTINUED) (USE CONTROL LOGIC CODES GIVEN IN ITEM 1)

NO	CONTROL LOGIC	TYPE	MANUFACTURER	PRODUCT NAME	PRODUCT NO
	LS	SV	Bell and Gossett (Note* this single pump both LS and CSF)	Pump (Water)	MR156 BX SRE 155 M80065
4	CFS	SV	Bell and Gossett	Pump (Water)	172540 797561 JU
5	LS	SV	Bell and Gossett (Note* this single pump also both LS and CSF)	Pump (Glycol)	102210 FU Series HV
	CSF	SV		Pump (Glycol)	102210 FU Series HV

### 5. ENERGY TRANSPORT OPERATION REGULATORS: Type Code - Pressure Reg (PR) Temperature Reg (TR)

1	TYPE	MANUFACTURER	PRODUCT NAME	PRODUCT NO
1		Included in Item 4: Related controls built in-house.		
2				
3				
4				
5				
6				

### 6. SUBSYSTEM FAIL-SAFE CONTROLS (USE CODES BELOW FOR TYPE OF CONTROLS)

1	TYPE	MANUFACTURER	PRODUCT NAME	PRODUCT NO
1		Included in Item 4: Related controls built in-house.		
2				
3				
4				
5				
6				

TYPE CODES	Pressure Relief Valve	PRV	Water Hammer Arresters	WHA
	Temperature Relief Valve	TRV	Automatic Backfill Valve	ABV
	Vacuum Relief Valve	VRV	Backflow Preventer	BFP
	Check Valve	CHV	Electrical Overload Protection	EOP
	Automatic Draindown	AD		

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12/29/77



# NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING

## SOLAR SYSTEM DESIGN PROCESS REPORT

Page 1 of 2

<b>1. PROJECT IDENTIFICATION NO</b> EG-77-A-01-4085	<b>2. PROJECT TITLE</b> Solar Space Heating and Hot Water System	<b>3. DATE</b> 12 - 30 - 77 MO DAY YR
<b>4. DEMONSTRATION PROJECT LOCATION:</b> Street <u>2357 59th Street</u> City <u>St. Louis</u> State <u>MO</u> Zip <u>63110</u>		<b>7. SOLAR SYSTEM FUNCTION (CHECK ONE)</b>  Hot Water (Domestic or Service) <input type="checkbox"/> HW Space Heating <input type="checkbox"/> H Space Cooling <input type="checkbox"/> C Heating & Cooling <input type="checkbox"/> HC Heating & Hot Water <input checked="" type="checkbox"/> HHW Cooling & Hot Water <input type="checkbox"/> CHW Heating, Cooling & Hot Water <input type="checkbox"/> HCHW
<b>5. SOLAR SYSTEM DESIGN CONTRACTOR</b> Name <u>William Tao &amp; Associates, Inc.</u> Project Manager <u>Richard E. Lampe</u> Telephone No. <u>(314) 644-1400</u>		
<b>6. A &amp; E CONTRACTOR (IF DIFFERENT FROM ABOVE)</b> Name _____ Project Manager _____ Telephone No. ( ) _____		

**8. DESCRIBE BRIEFLY THE METHODOLOGY AND STANDARDS USED TO DEVELOP THE DESIGN CRITERIA FOR THE SCHEMATIC DESIGN PHASE. IDENTIFY THE EFFECTS OF REGULATORY CONSTRAINTS, ENERGY CONSERVATION CONSIDERATIONS AND OTHER UNIQUE FACTORS AS APPROPRIATE.**

Heat loads were developed using HCC III computer program.  
 Solar design analysis was performed using a modified Duffie-Beckmann method.  
 Building design conforms with local codes and complies with ASHRAE 90-75.  
 IPC was used as guideline for Solar system design.

# NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING

## SOLAR SYSTEM DESIGN PROCESS REPORT

Page 2 of 2

9. A. BRIEFLY DESCRIBE ANY SYSTEM JUSTIFICATION AND TRADE-OFF STUDIES UNDERTAKEN IN THE SCHEMATIC DESIGN PHASE AND/OR THE DESIGN DEVELOPMENT PHASE

None

- B. IDENTIFY GOVERNING CODE \_\_\_\_\_

10. PROBLEMS & SOLUTIONS (DESCRIBE THOSE PROBLEMS ENCOUNTERED DURING DESIGN AND INTEGRATION OF SOLAR SYSTEM ESPECIALLY IN THE FOLLOWING AREAS: PERFORMANCE STANDARDS, BUILDING CODES, LAND USE, ZONING, SUN ACCESS, INSURANCE, AESTHETICS. ALSO DESCRIBE HOW THESE WERE ALLEVIATED)

Reviewers required use of double wall heat exchanger not initially proposed in system designs.

11. SYSTEM SAVINGS & PAYBACK PERIOD (ATTACH WORKSHEETS OF COMPUTATIONS)

A. Estimated cost of Solar System & Auxiliary System	(A) \$ 38,000
B. Estimated cost of Conventional Energy System	(B) \$ 30,000
C. Incremental cost of Solar System (C) = (A) - (B)	(C) \$ 8,000
D. Estimated cost of Solar System Operation (including Auxiliary Energy)	(D) \$ 420 /YEAR
E. Estimated cost of Conventional System Operation	(E) \$ 620 /YEAR
F. Energy cost savings (F) = (E) - (D)	(F) \$ 200 /YEAR
G. Simple Payback Period (C)/(F)	(G) 40 YEARS

PREPARED BY:

Richard E. Lampe

12/29/77

Bell and Gossett information on centrifugal pumps have been deleted due to copyright. For information on pumps and parts contact Bell and Gossett, 8200 North Austin Avenue, Morton Grove, Illinois 60053.

Bell and Gossett information on heat exchangers have been deleted due to copyright. For information on heat exchangers contact Bell and Gossett, 8200 North Austin Avenue, Morton Grove, Illinois 60053.

REISSUE		
DATE	BY	REVISION
1	D	

STD ENGR SPEC

SIMILAR TO

OR WINDER  
5-21-T2

THIS DRAWING IS THE PROPERTY  
OF THE TRANE COMPANY AND IS  
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TYPE P COIL

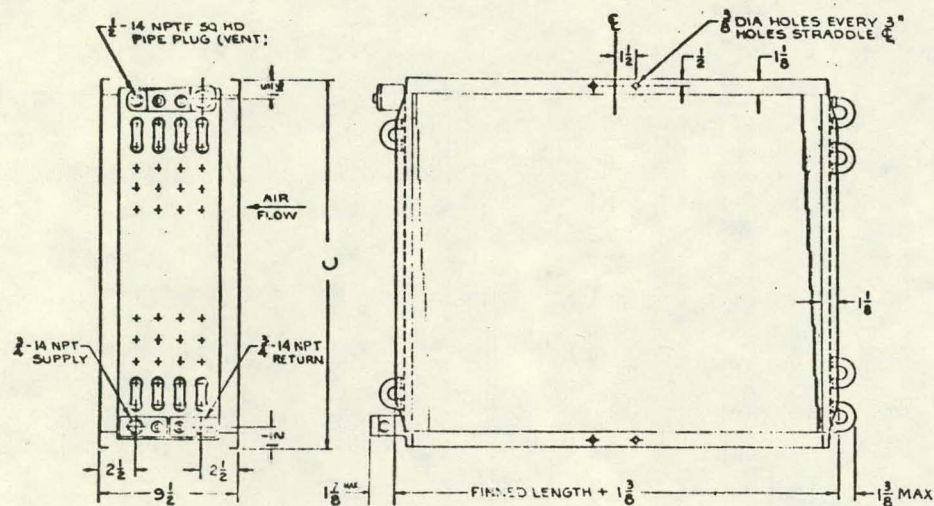
4-ROW 2-CIRCUIT

SCALE

QTY REQ'D					
EXT	EXT	EXT	EXT	EXT	EXT
1	2	3	4	5	6

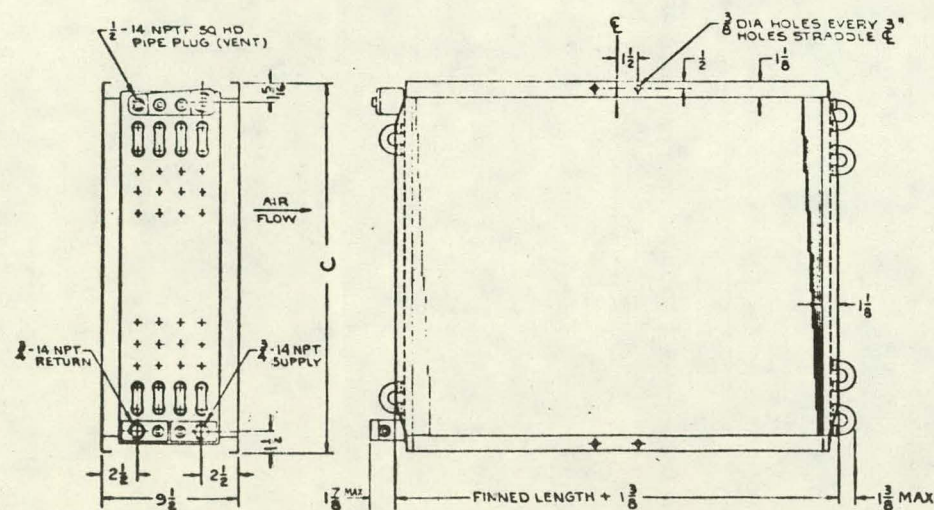
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1			

DRG SIZE	DRAWING PART OR MATERIAL NO



HORIZ AIR FLOW RH SUPPLY

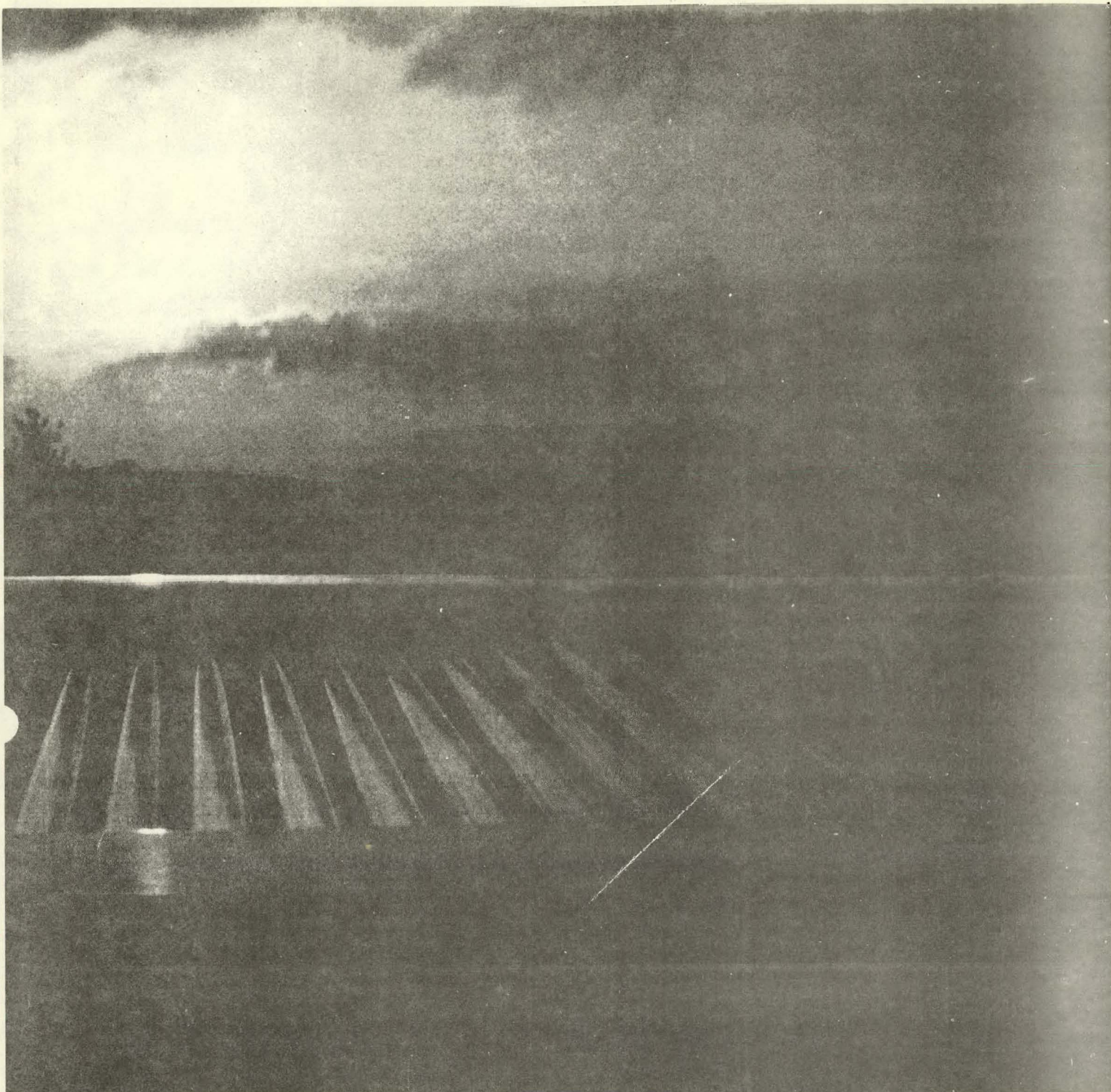
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18	19 1/2	
24	25 1/2	
30	31 1/2	



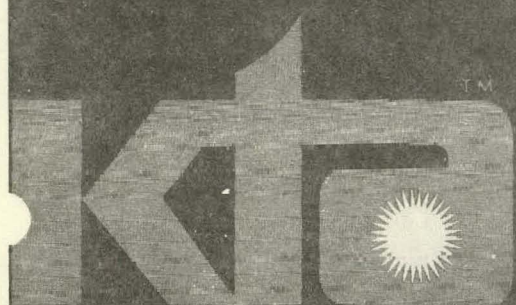
HORIZ AIR FLOW LH SUPPLY

B 2816-0655





Solar products and energy systems manufactured by:



**PRODUCTS DIVISION**



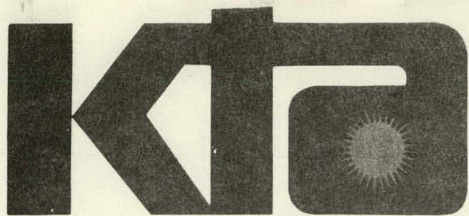
**NPD**

**ENERGY SYSTEMS, INC.**

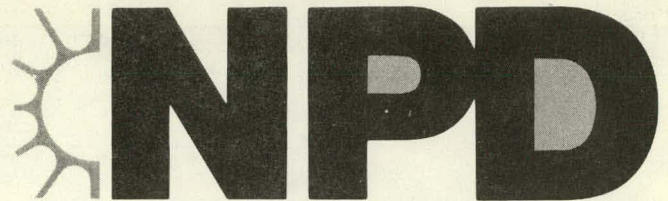
A Subsidiary of  
National Patent Development Corporation

H4





**PRODUCTS DIVISION**



**ENERGY SYSTEMS, INC.**

## Understanding the need, accepting the challenge



*(Left to right)*

**Ted Knapp**, *director of marketing*  
KTA Products Division

**Dr. William E. Tragert**, *director of operations*  
KTA Products Division

**Richard A. Lefebvre**, *president*  
NPD Energy Systems, Inc.

KTA Products Division is the manufacturing and national marketing arm of NPD Energy Systems, Inc.

We manufacture solar collectors, environmental control systems for computer rooms, research facilities, hospitals, and schools in new construction and renovation.

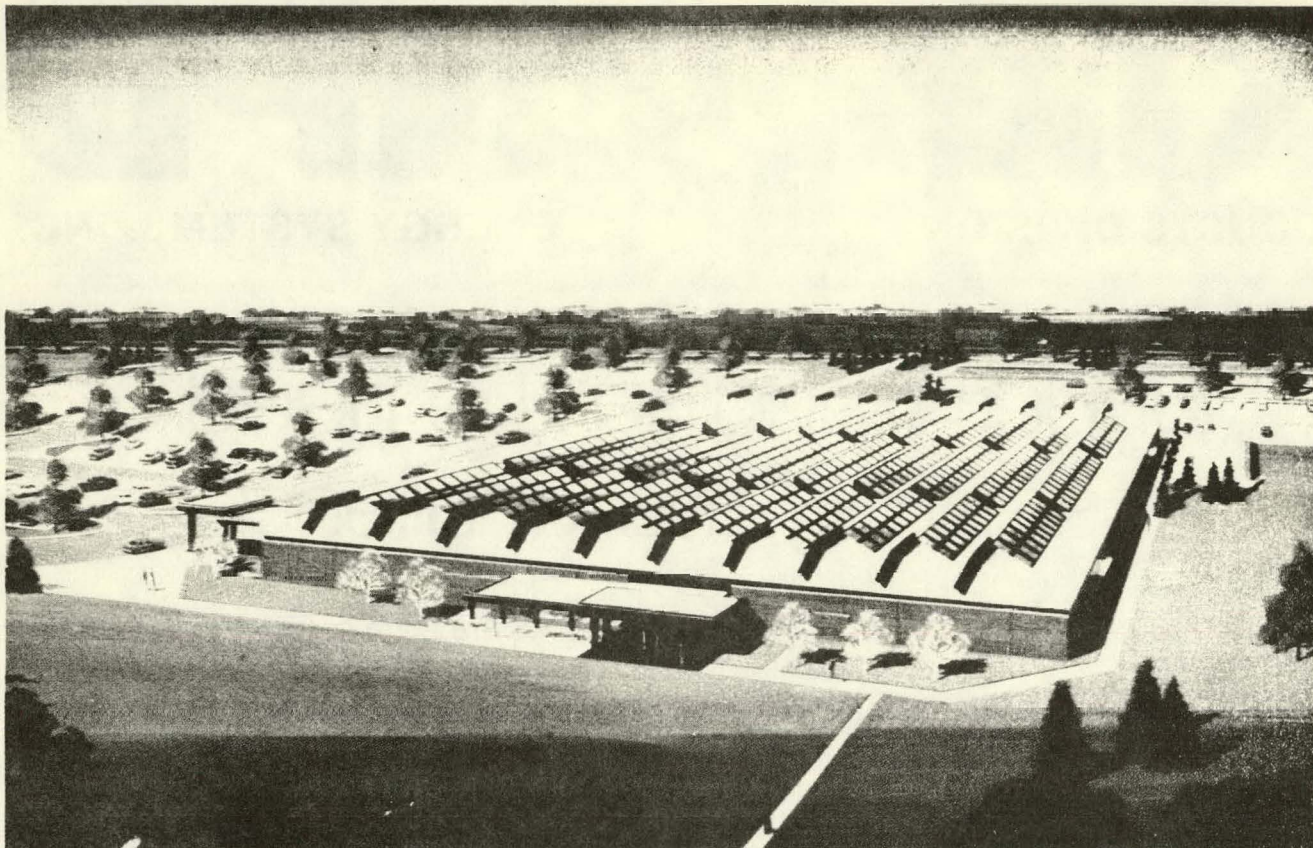
Our nationwide network of highly-skilled engineering-oriented sales representatives serve the broad market for KTA-NPD Energy Systems, Inc. product applications.

Our representatives are long-experienced in working closely with architects, consulting engineers, and facilities managers.

The KTA-NPD Energy Systems, Inc. management team collectively have acquired more than 100 years of experience, providing innovation and leadership in manufacturing, marketing, and energy-efficient product development.

One example of this innovative leadership is the application of our solar collectors at Bolling Air Force Base on the next page.





# Bolling Air Force Base goes solar

**OWNER:** Army and Air Force Exchange Service  
Dallas, Texas

**ARCHITECT:** MOV, Inc.  
Arlington, Virginia

**CONSULTING ENGINEERS/SOLAR, HVAC:** Bridgers & Paxton  
Albuquerque, New Mexico

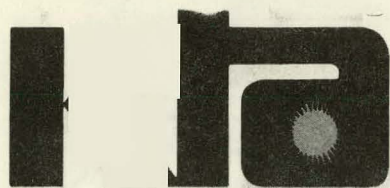
**STRUCTURAL ENGINEERS/SOLAR:** Abiouness, Cross & Bradshaw, Inc.  
Norfolk, Virginia

**MECHANICAL CONTRACTOR/SOLAR:** Arey, Inc.  
Chevy Chase, Maryland

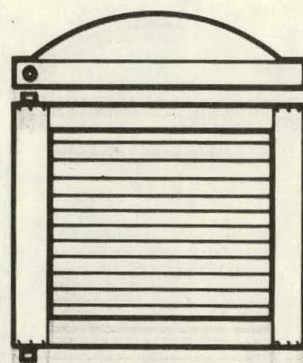
**SOLAR COLLECTOR MANUFACTURER:** KTA-NPD Energy Systems, Inc.  
Rockville, Maryland

**APPLICATION:** New shopping facility at Bolling Air Force Base, Washington, D.C., will be provided with 18,000 sq. ft. of KTA™-NPD tubular concentrating solar collectors for domestic hot water, and comfort heating and cooling.





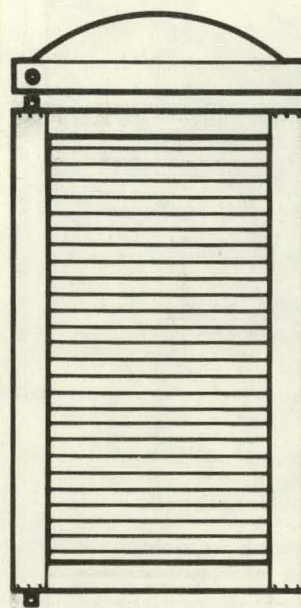
# solar collectors



**KT5-45**

17.8 ft<sup>2</sup>

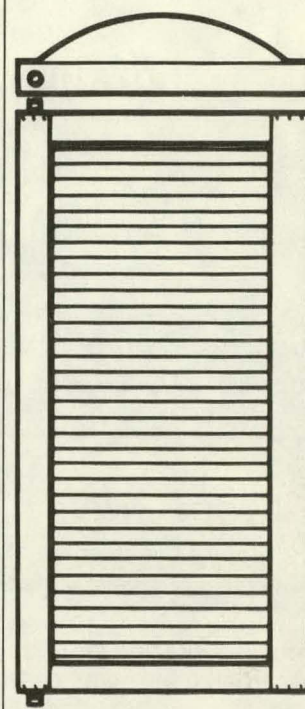
1.7 m<sup>2</sup>



**KT5-85**

35.6 ft<sup>2</sup>

3.3 m<sup>2</sup>



**KT5-125**

53.4 ft<sup>2</sup>

5.0 m<sup>2</sup>

**Aperture area:**  
(metric)

**Case size:**  
(metric)

**Weight:**  
(metric)

43<sup>3</sup>/<sub>4</sub>" × 63<sup>1</sup>/<sub>4</sub>" × 7<sup>5</sup>/<sub>8</sub>"  
111.13 cm × 160.8 cm

87<sup>1</sup>/<sub>2</sub>" × 63<sup>1</sup>/<sub>4</sub>" × 7<sup>5</sup>/<sub>8</sub>"  
222.25 cm × 160.8 cm

131<sup>1</sup>/<sub>4</sub>" × 63<sup>1</sup>/<sub>4</sub>" × 7<sup>5</sup>/<sub>8</sub>"  
333.5 cm × 160.8 cm

75 lbs  
34.1 kg

150 lbs  
68.2 kg

225 lbs  
102.3 kg

All connections 3/8" O.D. Copper •

## FEATURES OF KTA<sup>™</sup> TUBULAR COLLECTORS

The heart of the KTA<sup>™</sup> solar collector system is the tubular concentrating element, each of which, when in a parallel array, collect and concentrate solar radiation to heat the working fluid

Each tubular element is reflectorized along its bottom half with highly specular silver to form a semi-cylindrical mirror, which gives a concentration factor of about 3 on the copper absorber tube. This copper fluid passage is coated with Black Chrome, a selective coating noted for its high

absorptivity and low emissivity, and optically positioned inside the tube for maximum collection. Tubular concentrating elements, when assembled together within an aluminum case, afford the user some distinct advantages over other collectors. Each of the tubes can be rotated at the factory in either direction from horizontal to accommodate non-optimum roof slopes or to allow for vertical mounting. Thus, in many cases, the expense of constructing a framing super-structure on the roof is eliminated.

Such a tubular array is also lightweight, reducing absorber material, because the only absorbing

metal required rests in the focal zone of the optical system. This light weight often results in another cost benefit by minimizing the need for additional structural support within the roof assembly.

Unlike many collectors, KTA<sup>™</sup> tubular design allows field replacement of individual elements.

Incorporated into the KTA<sup>™</sup> design features are:

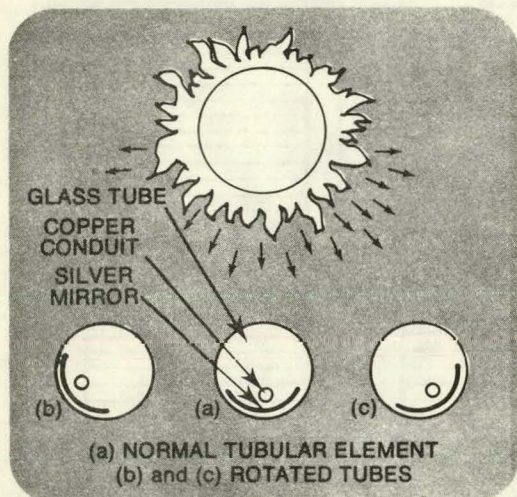
- Commercial or residential application
- Lower installed cost
- Durability
- Industry standard tested
- Application flexibility





# tubular elements

## ROTATION



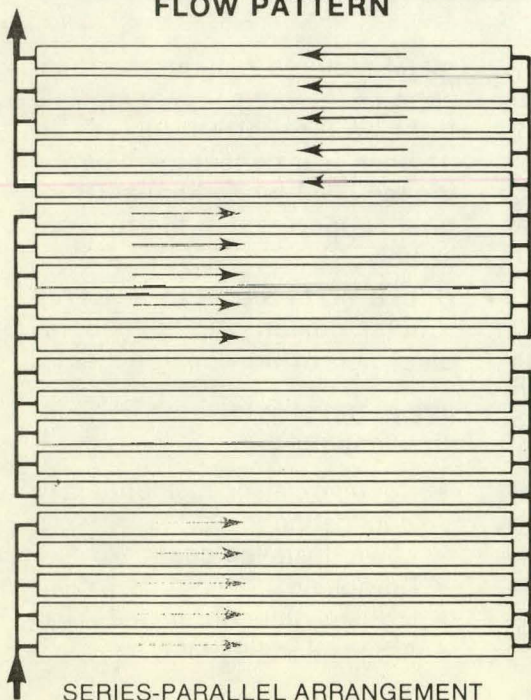
During the brazing process, these tubular concentrating elements can be "rotated" to any angle within 30° of perpendicular.

Tubes can be rotated in this fashion to match most roof slopes.

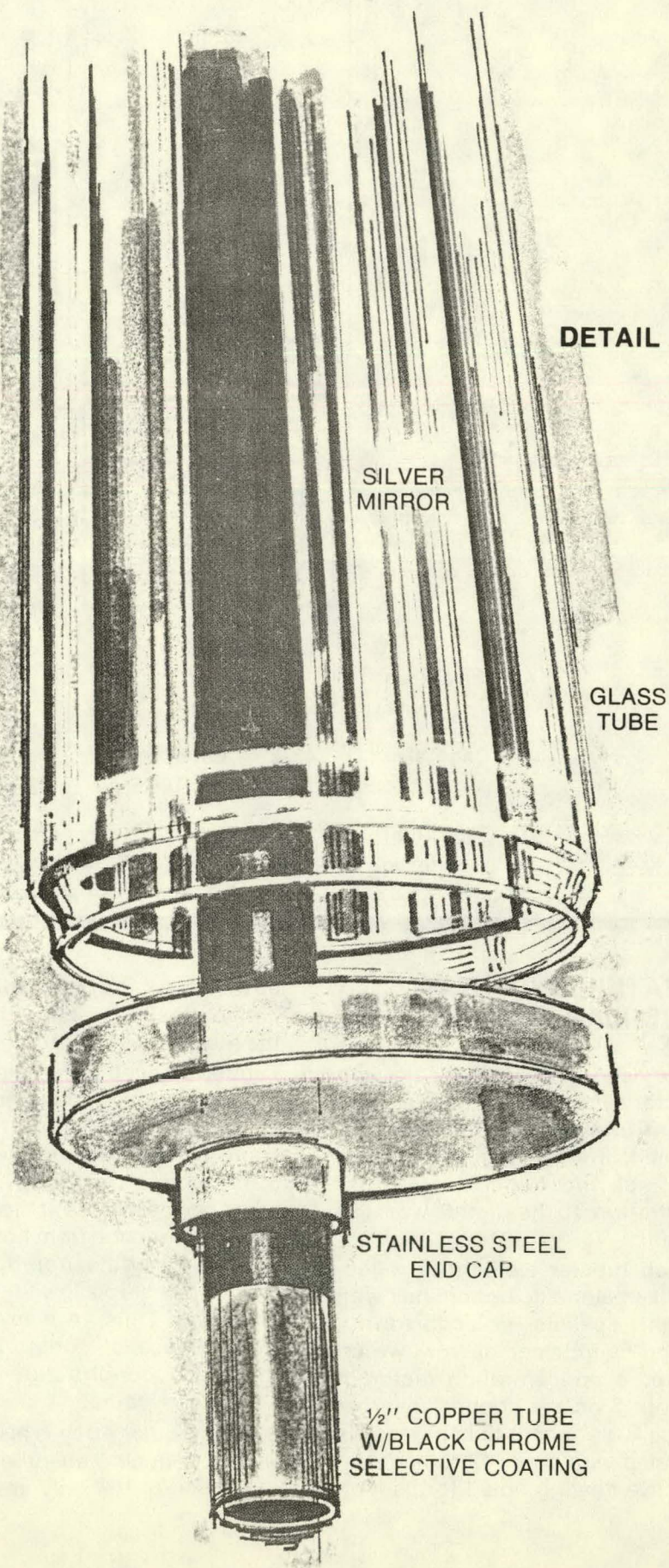
Allows flexibility for architects in design and, in many cases, eliminates the need for heavy, bulky, and expensive framing structures needed to bring collectors to optimum tilt.

Rotation will, for some applications, enable collectors to be mounted vertically on a south-facing wall.

## FLOW PATTERN



## DETAIL

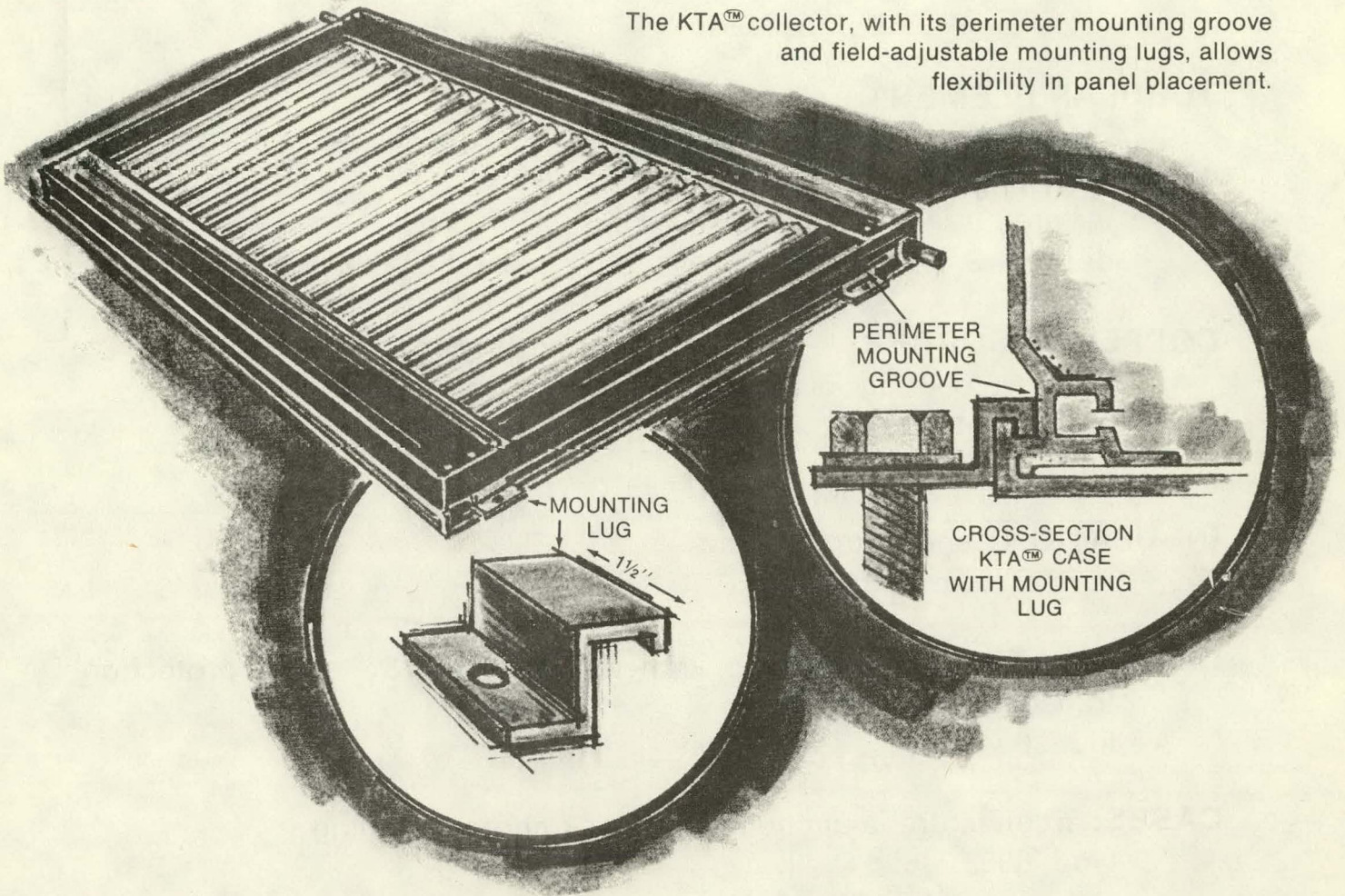




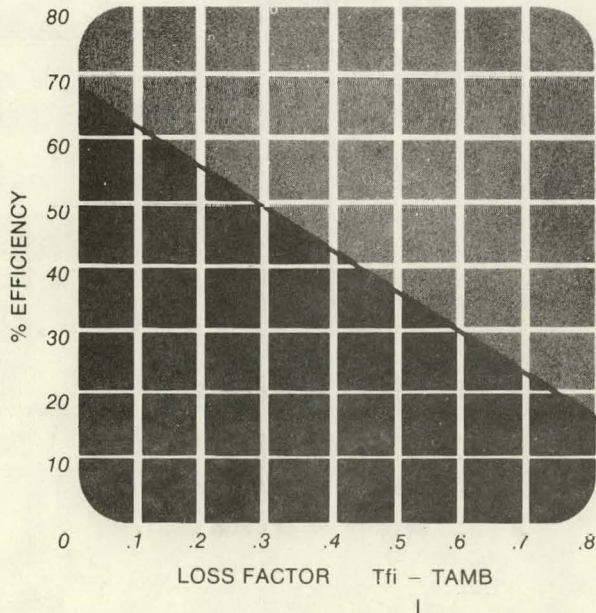


# performance

The KTA™ collector, with its perimeter mounting groove and field-adjustable mounting lugs, allows flexibility in panel placement.



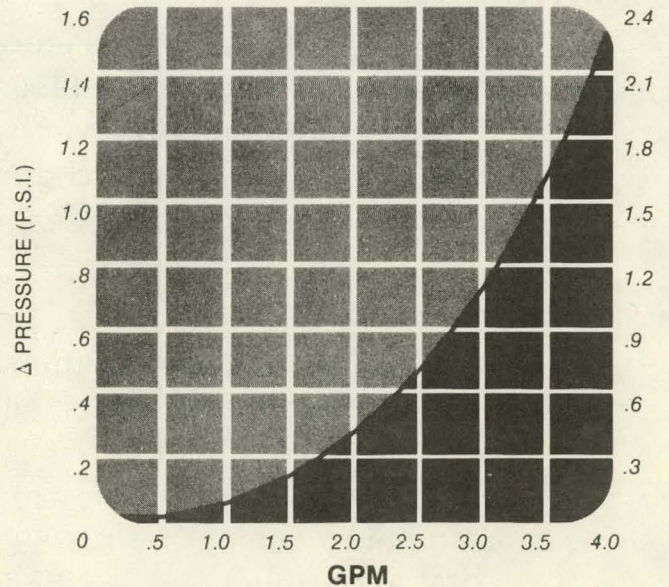
## PERFORMANCE



KT5-85

## PRESSURE DROP

KT5-125





# & specifications

● **TUBULAR ELEMENTS:** 008 soda-lime glass

solar spectrum transmissivity: 92%

solar spectrum reflectivity: 4%

infrared transmissivity: 1.6% @ 5m

density: 2.7cm/cc

● **COPPER ABSORBER:** ½" O.D. M-type hard drawn copper tube

selective coating: black chrome

absorptivity: 95%

emissivity: 7%

● **INSULATION:** isocyanurate foam

temperature range: 350° F

● **COVERPLATE:** ⅛" UVA acrylic, arched for strength & element protection

transmissivity: 92% visible

life: 20 years +

● **CASES:** architectural aluminum with black chrome coating

type: 6063 T-5

● **MATERIALS**

Sealants: GE type 108 silicone epoxy

Gaskets: hi-temperature (450°) silicone

O-rings: hi-temperature viton

Headers: ¾" M-type hard drawn copper  
lap joint collar seams

● **DESIGN DATA**

Flow Rates: .0125 — .04 gpm/ft<sup>2</sup> recommended

Fluids: water, water/glycol, silicone oil

Acceptance Angle: 45°

Maximum Rotation Angle: 30°

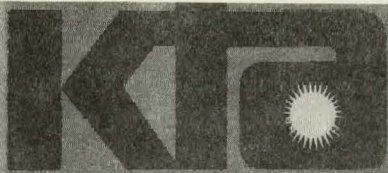
Stagnation Temperature: 350° F

Total Allowable Load: 90 lbs/ft<sup>2</sup>

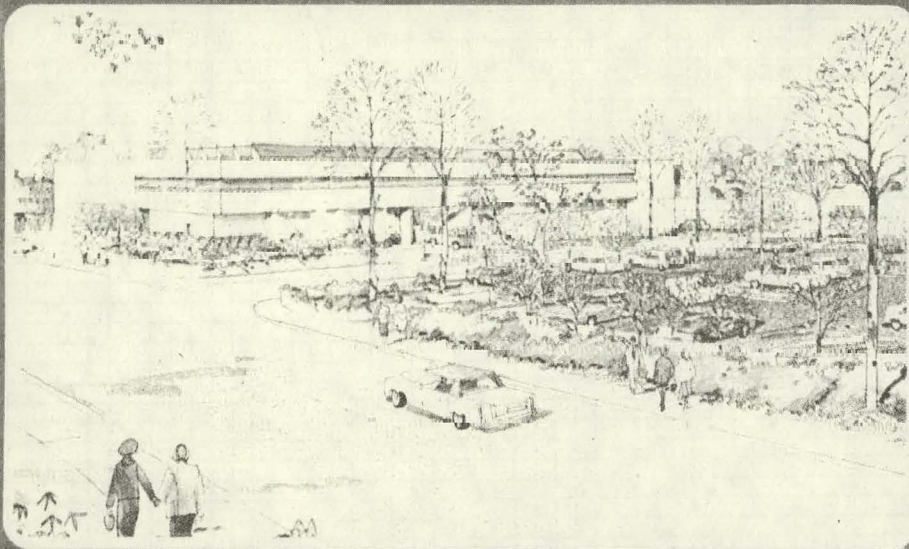
Design Load: 40 lbs/ft<sup>2</sup>

Weight: 4.5 lbs/ft<sup>2</sup>





# solar installations



**Owner:**

Lindsay Cadillac, Alexandria, Virginia

**Architects:**

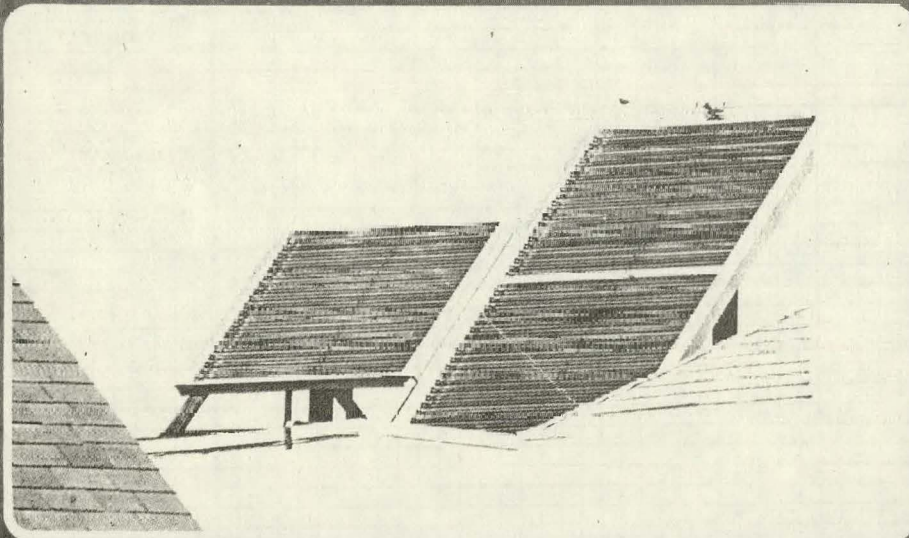
Architects Group Practice,  
Alexandria, Virginia

**Engineer:**

Glassman & LeReche,  
Falls Church, Virginia

**Mechanical Contractor:**

Calvert-Jones, Alexandria, Virginia



**Owner:**

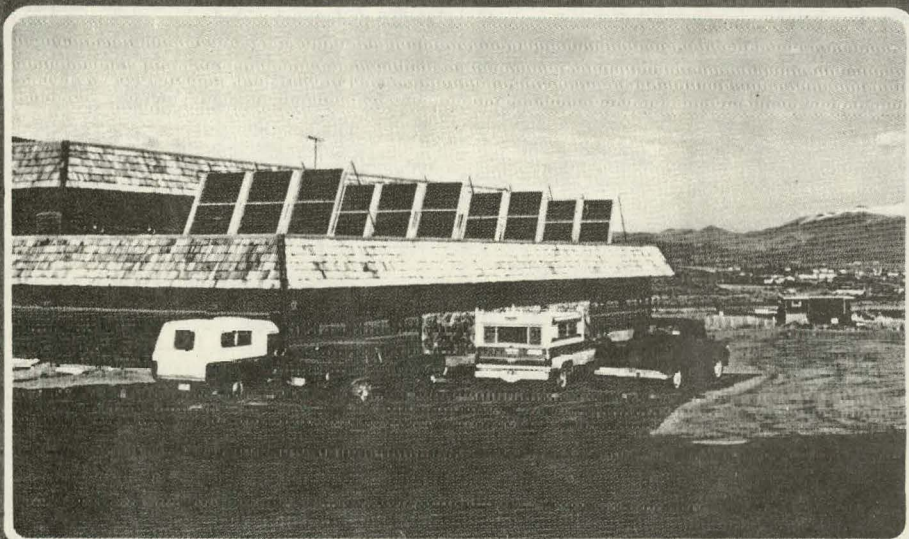
Marina District Resident,  
San Francisco, California

**Engineer & Mechanical Contractor:**

The Solar Collector,  
Gausalito, California

**Demonstration Project:**

Pacific Gas & Electric



**Owner & Architect:**

Capitol Courts, Inc.,  
Carson City, Nevada

**Engineer & Mechanical Contractor:**

Vann Engineering, Sparks, Nevada

KIA Products Division

A subsidiary of National Panasonic Corporation

1835 Reservoir Boulevard • Rockville, MD 20850 • phone (301) 761-1000



KTA Products Division

COLLECTOR PERFORMANCE

\* Tested in accordance with ASHRAE Standard 93-77 and DSET Specification 75-SB2.

$T_{in}$  = Fluid temperature at collector inlet ( $^{\circ}\text{F}$ ).  
 $T_{amb}$  = Ambient temperature surrounding the collector ( $^{\circ}\text{F}$ ).  
 $I$  = Total incident solar radiation ( $\text{Btu/hr-ft}^2$ ).

COLLECTOR PERFORMANCE (PERCENT)

$KT_1$  COLLECTOR

$T_{in} - T_{amb} / I$  ( $^{\circ}\text{F-hr-ft}^2/\text{Btu}$ )

780601



*Handwritten signature/initials*

SUBMITTAL  
KTA SOLAR COLLECTOR

MODEL NO.	QUANTITY	ROTATION	CONNECTION
KT4-85	6	NONE	RIGHT HAND
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

FRAME FINISH MILL COVERPLATE 1/8" UVA PLEXIGLAS  
OPERATIONAL FLUID \_\_\_\_\_ APPLICATION \_\_\_\_\_

REMARKS

REFERENCE NO. WT 7732A

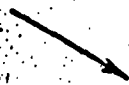
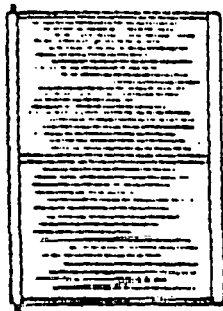
PROJECT <u>ERDA SOLAR DEMONSTRATION PROJECT</u>		PURCHASE ORDER NO.
LOCATION <u>ST. LOUIS, MISSOURI</u>		DATE <u>20 OCTOBER 1977</u>
CUSTOMER <u>WM. TAO &amp; ASSOCIATES</u>	SHIP TO <u>WTA</u>	
STREET <u>2357 59TH STREET</u>	ATTN: <u>RICHARD E. LAMPE, P.E.</u>	
CITY <u>ST. LOUIS</u>	STATE <u>MO</u>	MARK
	ZIP <u>63110</u>	

ARCHITECT	ENGINEER
_____	_____
_____	_____
_____	_____

**KTA** CORPORATION  
12300 Washington Avenue  
Rockville, Maryland 20852

# COLLECTOR ROTATION NOMENCLATURE

## LEFT HAND CONNECTION



UP



ROTATION



NO



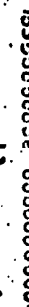
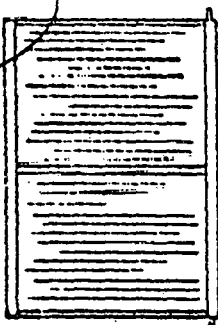
ROTATION



DOWN

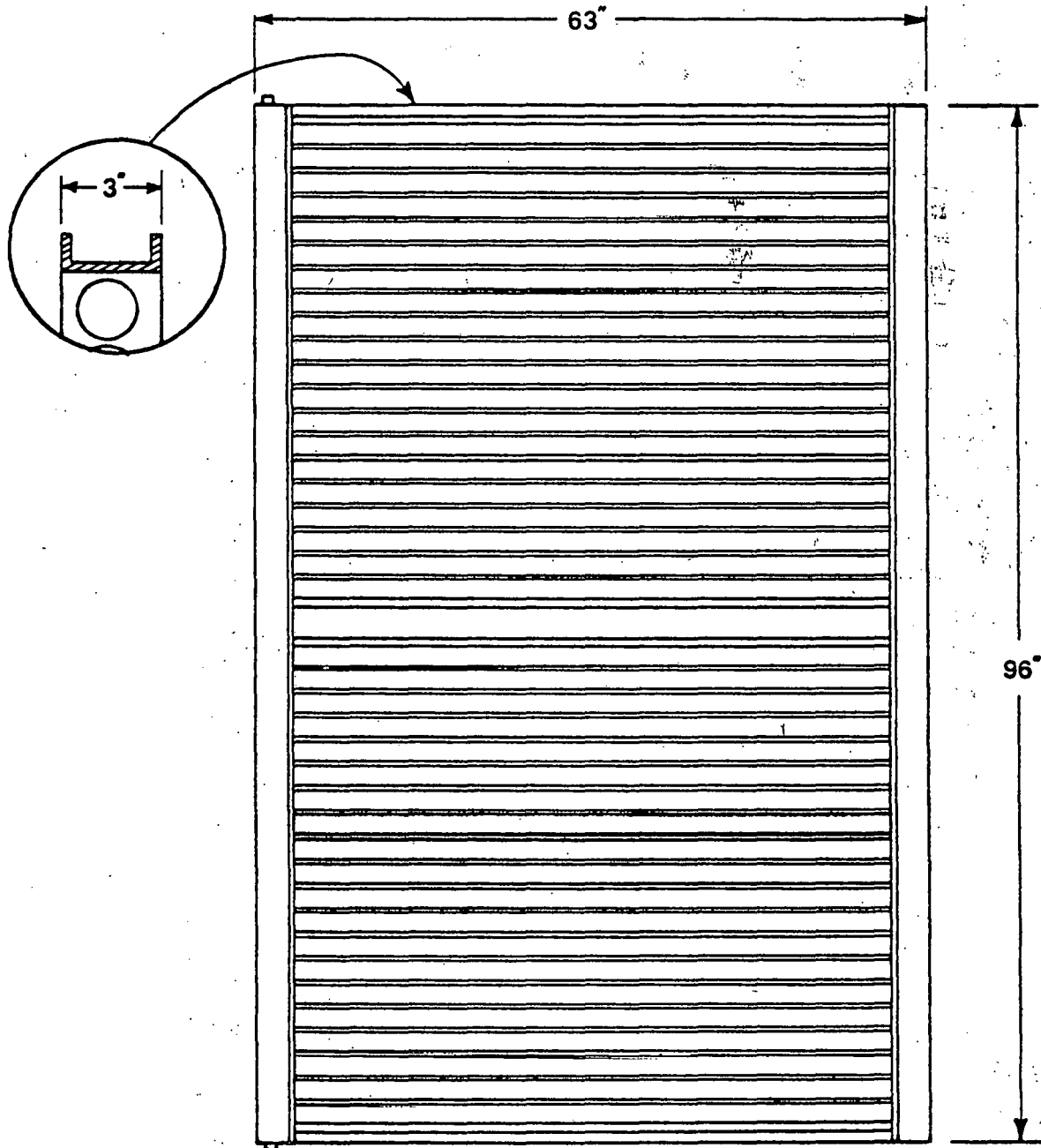
ROTATION

## RIGHT HAND CONNECTION



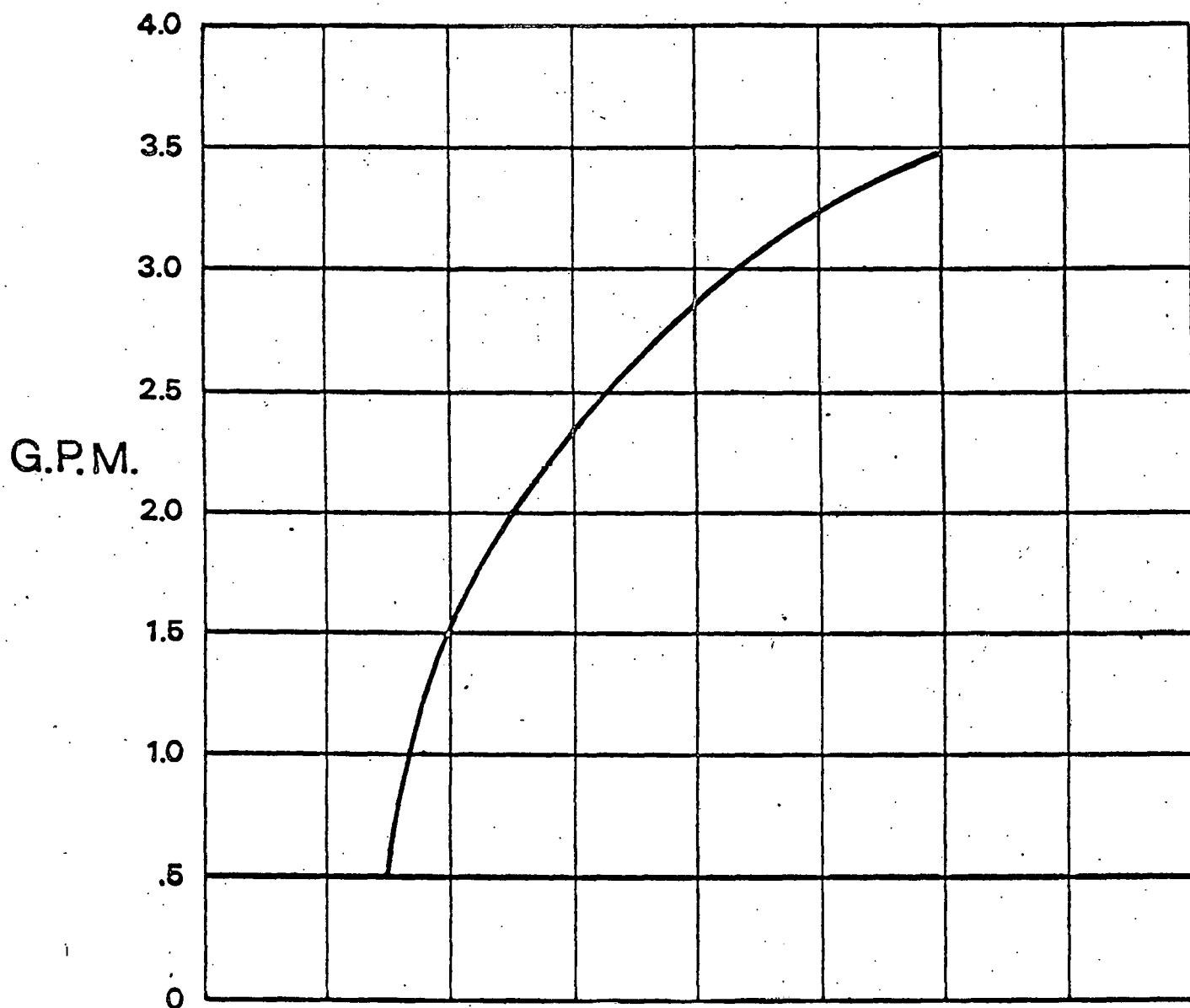
Rotation available in 5° increments  
Maximum rotation 30°

KT4-85



APERTURE : 36 sq. ft.

CONNECTIONS : 7/8" O.D. COPPER



KT4-45	0.08	0.16	0.24	0.32	0.4	0.48
KT4-85	0.16	0.32	0.48	0.64	0.8	0.96

## PRESSURE DROP (P.S.I.)

NOTE: RECOMMENDED OPERATION IS BETWEEN  
.02 AND .04 GPM PER FT<sup>2</sup> COLLECTOR