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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

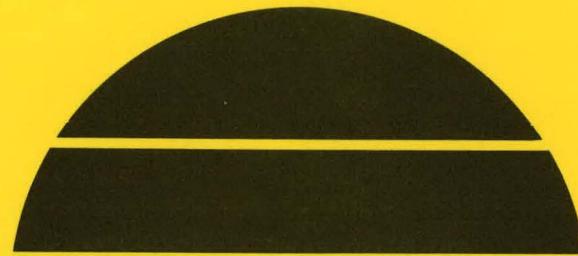
Prepared by

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2357 59th Street
St. Louis, Missouri 63110

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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TECHNICAL REPORT STANDARD TITLE PAGE

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15. SUPPLEMENTARY NOTES This work was done under the technical management of Mr. Lary Lawson, Marshall Space Flight Center, Alabama.			
16. ABSTRACT <p>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.</p> <p>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.</p>			
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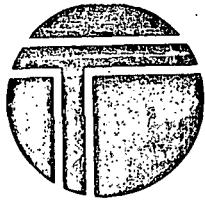
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William Tao & Associates, Inc., Consulting Engineers 2357 59th Street St. Louis, Missouri 63110 314-644-1400

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: R. S. Tang

Date: December 14, 1979

Title: Vice President

GENERAL INFORMATION

BUILDING INFORMATION

The system supplements the winter heating load for a 900 ft² 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 ft²) 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.

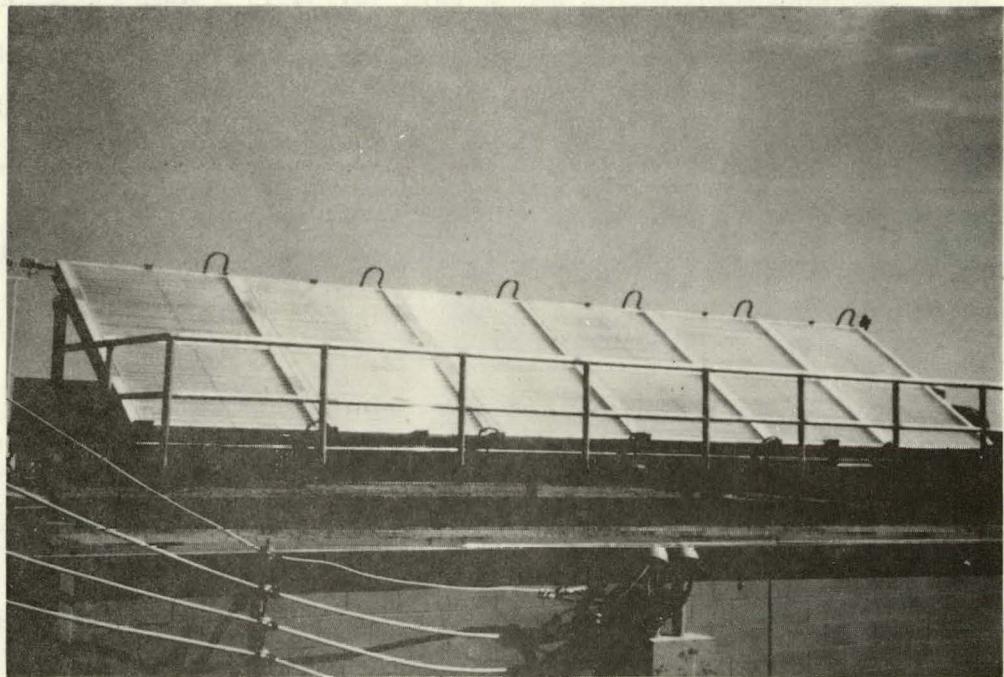
Supporting Structure: The supporting structure is welded steel construction with an observation catwalk. It is designed such that the tilt angle of the collectors can be adjusted for experimental purposes. Since the system is primarily for space heating, the collectors have been left at this tilt angle 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.

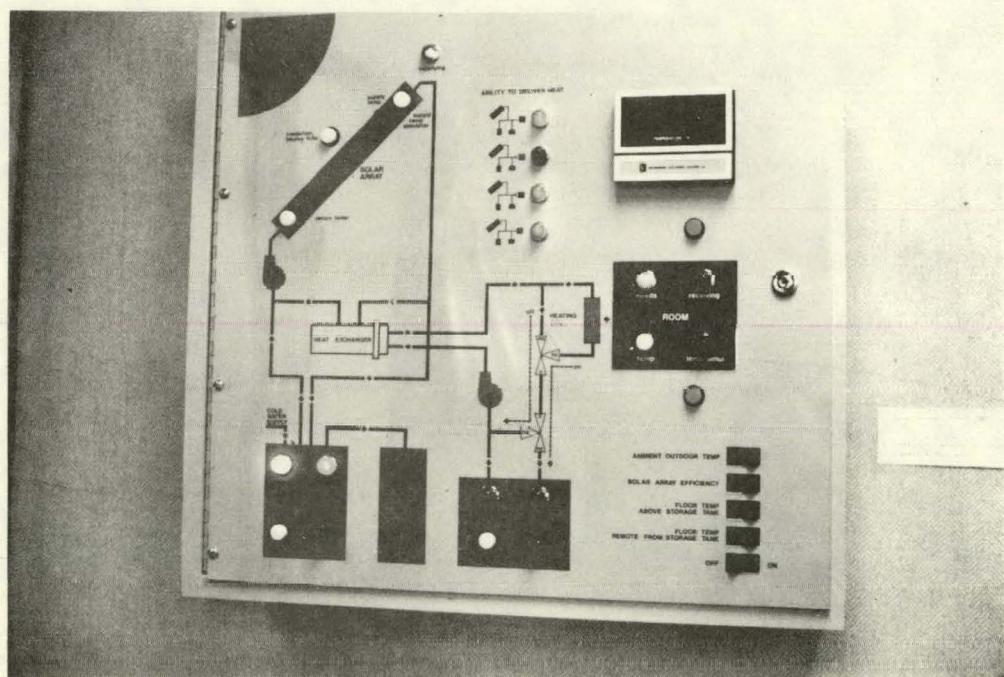
Solar Storage Tank: The storage tank is a 1000 gallon steel tank buried below the slab floor of the addition. It is insulated with rubber insulation and filled with water. The storage-to-collector area ratio is 33 lbs. H₂O/ft² of collector.

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.

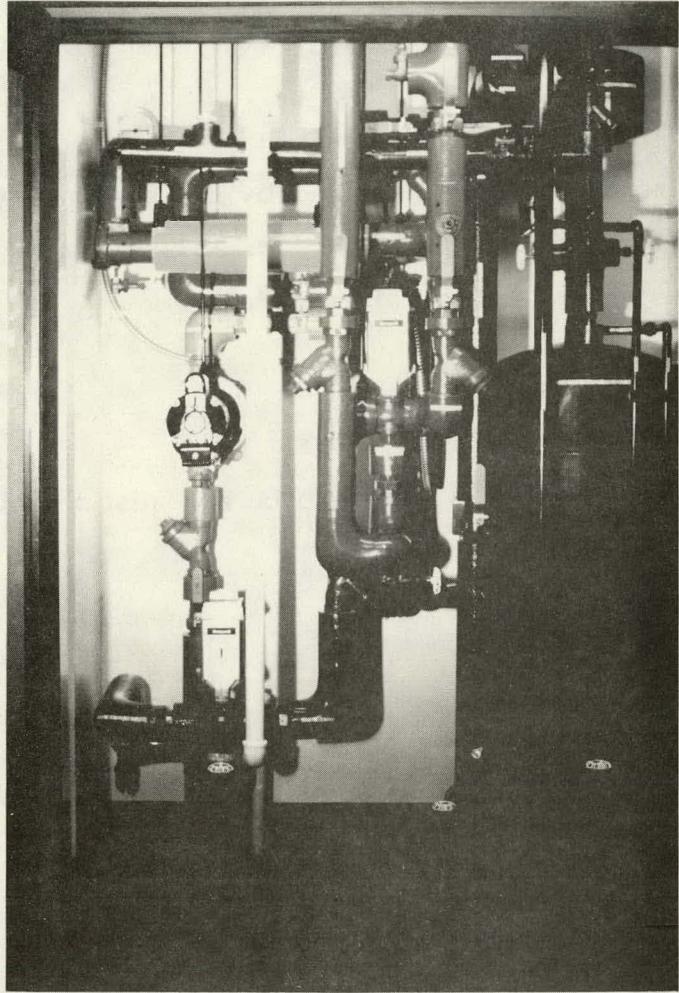
Heating Coil: A 4 row - 15 fins/in air-to-water heating coil is mounted in the return air upstream of the electric heating coil.



COLLECTOR ARRAY



DISPLAY PANEL
(NOT REQUIRED BY CONTRACT)



**SOLAR SYSTEM
MECHANICAL ROOM**

MAINTENANCE & CONSTRUCTION PROBLEMS ENCOUNTERED

CONSTRUCTION

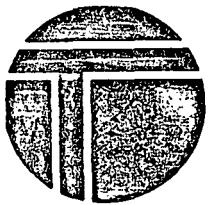
No undue construction problems were encountered during the installation of this system. Minor changes were required and implemented as indicated on the record drawings enclosed.

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

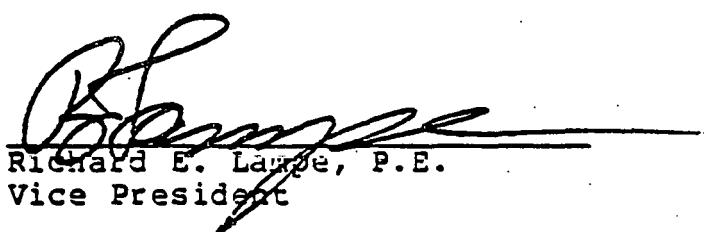
FOR JAN. 1979 - APRIL 1979

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. Lange, P.E.
Vice President

NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING

SOLAR SYSTEM MAINTENANCE

PROJECT IDENTIFICATION NO EG-77-A-01-4085	2. MAINTENANCE PERFORMED BY Wm. Tao & Associates., Inc	3. SEQUENCE NO I	4. DATE 4 20 79 MO DAY YR
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5. 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

6. 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

7. SIMILAR DOWNTIME From Jan. 15 to April 9 = 84 days

Estimated hours of solar radiation lost due to maintenance action

Hrs

8. LIST OF MAINTENANCE

Maintenance Done

Inhouse

I

C

If Contracted, Attach a copy of the Invoice.

Contracted

Replacement not complete and all costs are not yet available

Labor Category Labor Hrs Rate (\$/Hr) Labor Cost

_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

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 _G	2.8	115	1φ	
WATER PUMP P _W	7.2	116	1φ	
A/H FAN	2.6	202	1φ	
OPERATIONAL TEST				
ITEM	DOES EQUIPMENT OPERATE PROPERLY WHEN ENERGIZED?	COMMENTS	DATE	BY
P _G GLYCOL LOOP PUMP	Yes		12/11/79	GGF
P _W 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 12/14/79	BY GGF
ALL EQUIPMENT SHOWN ON THE CONSTRUCTION DOCUMENTS HAVE BEEN INSTALLED AS REQUIRED.			DATE 12/12/79	BY 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"/> P_G DISCHARGE (GLYCOL LOOP)	<input type="checkbox"/> P_W DISCHARGE (WATER LOOP)	<input type="checkbox"/> DOMESTIC WATER HEAT EXCHANGER (GLYCOL SIDE)	<input type="checkbox"/> COLLECTORS	DATE:	BY:		
COLLECTORS		1	2	3	4	5	6
CIRCUIT SETTER SIZE	1½"						
SETTING	40						
PRESSURE DROP (FT. H_2O)	3.25'						
FLOW REQUIRED (GPM)	6½						
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_G DISCHARGE (GLYCOL LOOP)	<input type="checkbox"/> DOMESTIC WATER HEAT EXCHANGER (GLYCOL SIDE)	DATE:	BY:			
<input checked="" type="checkbox"/> P_W DISCHARGE (WATER LOOP)	<input type="checkbox"/> COLLECTORS	12/12/79	GGF			
COLLECTORS	1	2	3	4	5	6
CIRCUIT SETTER SIZE	1½"					
SETTING	26					
PRESSURE DROP (FT. H_2O)	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_G DISCHARGE (GLYCOL LOOP)	<input checked="" type="checkbox"/> DOMESTIC WATER HEAT EXCHANGER (GLYCOL SIDE)	DATE:	BY:				
<input type="checkbox"/> P_W DISCHARGE (WATER LOOP)	<input type="checkbox"/> COLLECTORS	12/13/79	GGF				
COLLECTORS		1	2	3	4	5	6
CIRCUIT SETTER SIZE	1 1/2"						
SETTING	60						
PRESSURE DROP (FT. H ₂ 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_G DISCHARGE (GLYCOL LOOP)	<input type="checkbox"/> DOMESTIC WATER HEAT EXCHANGER	DATE:	BY:
<input type="checkbox"/> P_W DISCHARGE (WATER LOOP)	<input checked="" type="checkbox"/> COLLECTORS	12/13/79	GGF
COLLECTORS	1	2	3
CIRCUIT SETTER SIZE	3/4"	3/4"	3/4"
SETTING	35	30	25
PRESSURE DROP (FT. H₂O)	4.5	4.5	2.25
FLOW REQUIRED (GPM)	1.08	1.08	1.08
FLOW ACTUAL (GPM)	.75	1.0	.94
WAS ADJUSTMENT REQUIRED?	No	No	No
COMMENTS:			

CONTROL SYSTEM

General Description

The Controller/Display Panel was engineered, designed and built by William Tao & Associates' employees. It consist 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
T_S: GLYCOL LOOP TEMP. @ SUPPLY
FROM COLLECTORS

TR: ROOM TEMP. (°F)

TT: STORAGE TANK TEMP. (°F)

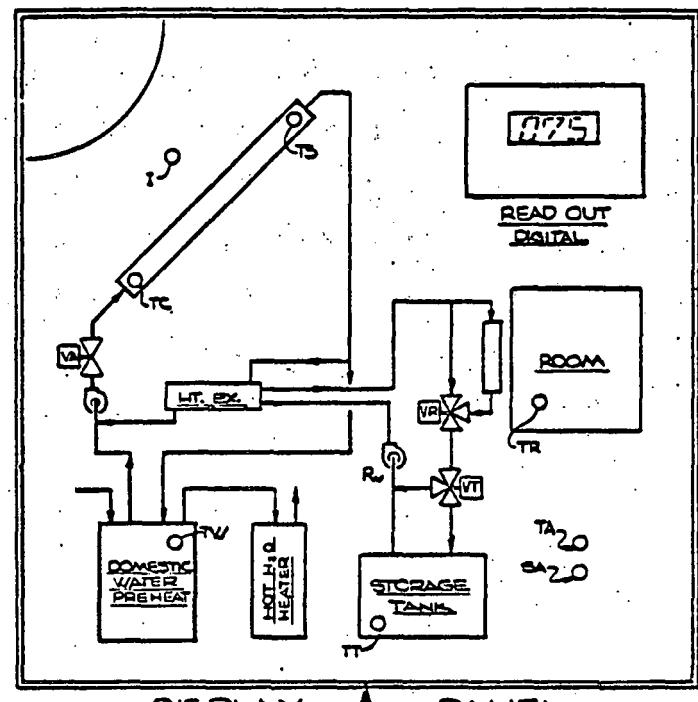
TC: GLYCOL LOOP TEMP. @
COLLECTOR INLET (°F)

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

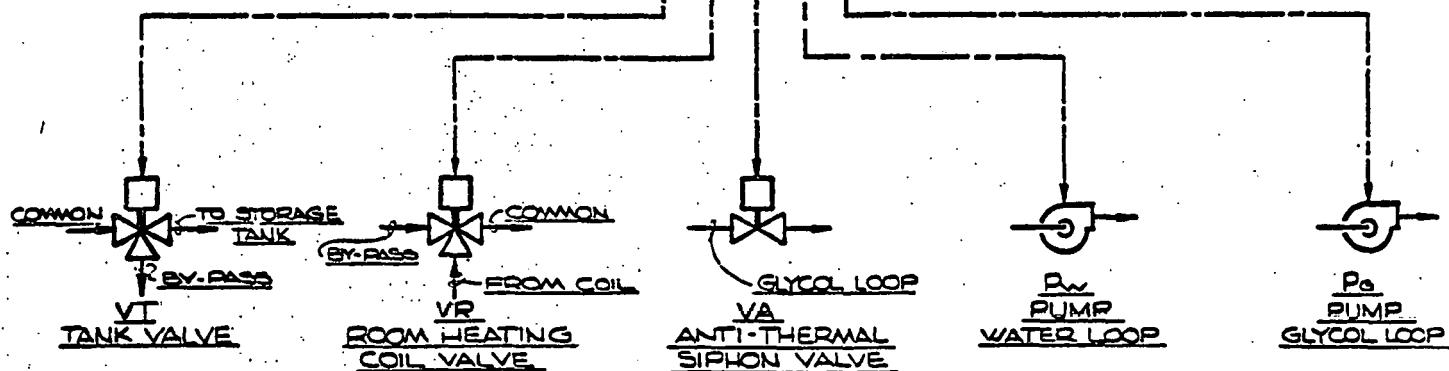
TA: AMBIENT TEMP. (°F)

OTHER SENSORS
INPUT

I: INSOLATION (BTU/H·ft²)



CONTROLLER



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 ₂ 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.	N.A.
TW	N.A.	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	OFF
VT	TO TANK	BY-PASS TANK	TO TANK	TO TANK	TO TANK	BY-PASS TANK				
VR	BY-PASS COIL	TO COIL	TO COIL	TO COIL	TO 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.ft²)

SA: Array Efficiency. This output is actually the energy being harvested from the collector array in Btu/hr. ft² 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.

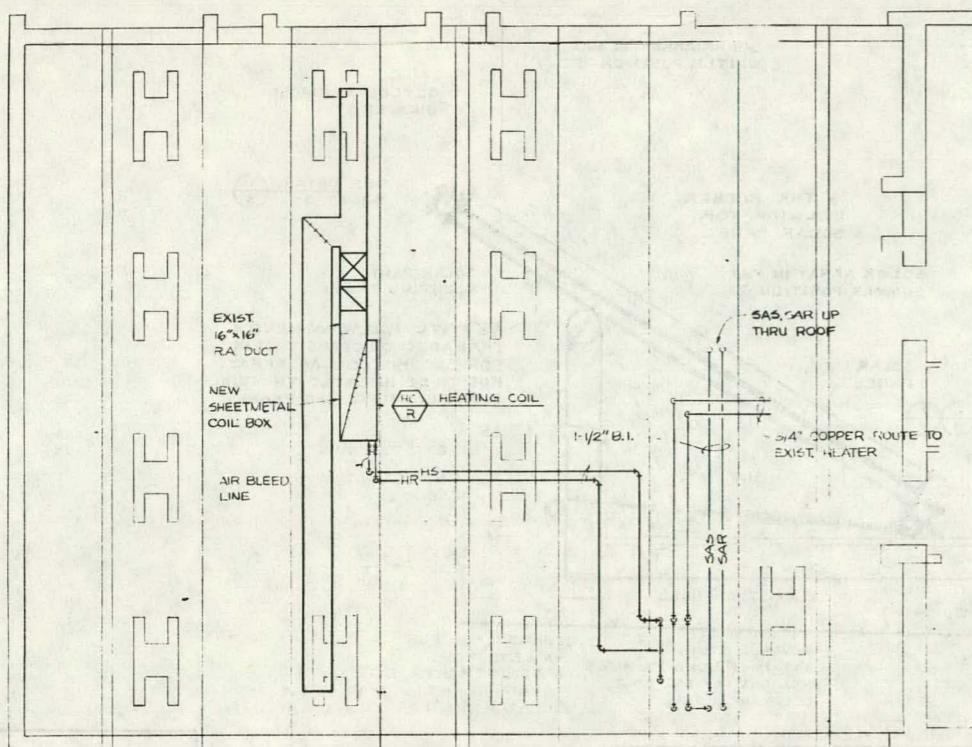
IV. System Capabilities Display

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 regardless of the systems ability to deliver such energy.

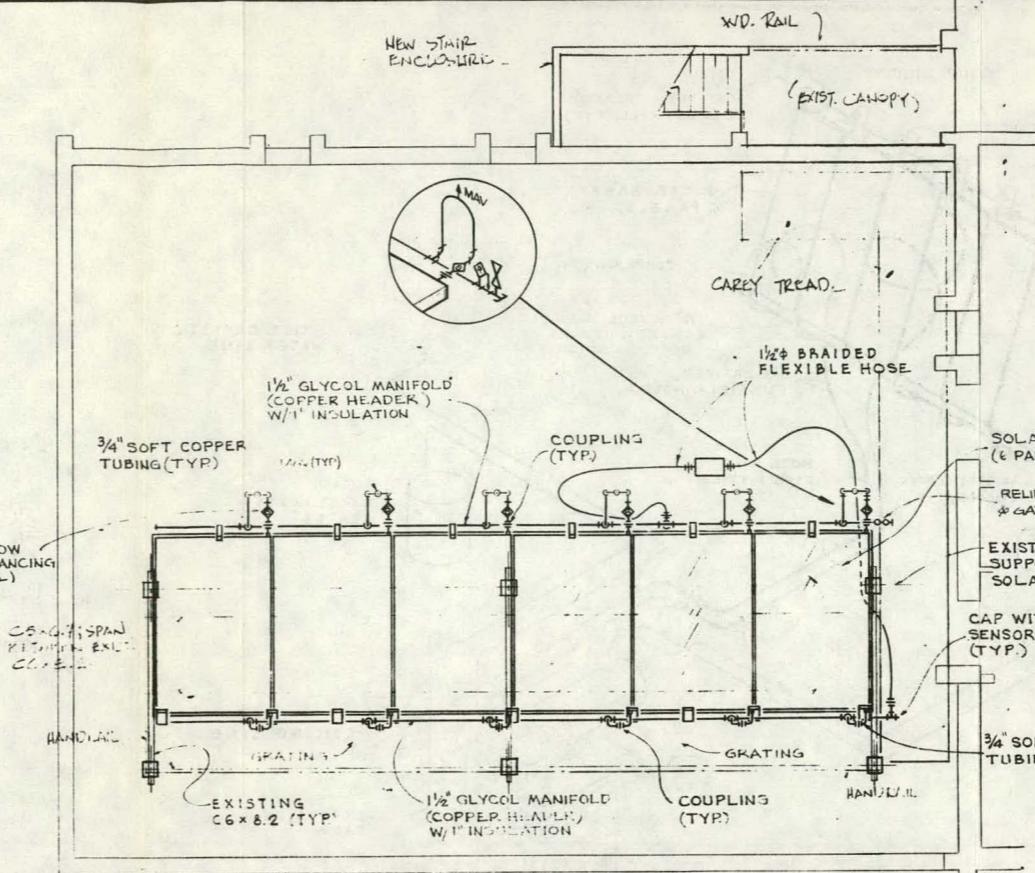
The display panel also has four red lights, each indicating a different ability of the system to deliver energy to one of the three loads. The four abilities are:

- 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.

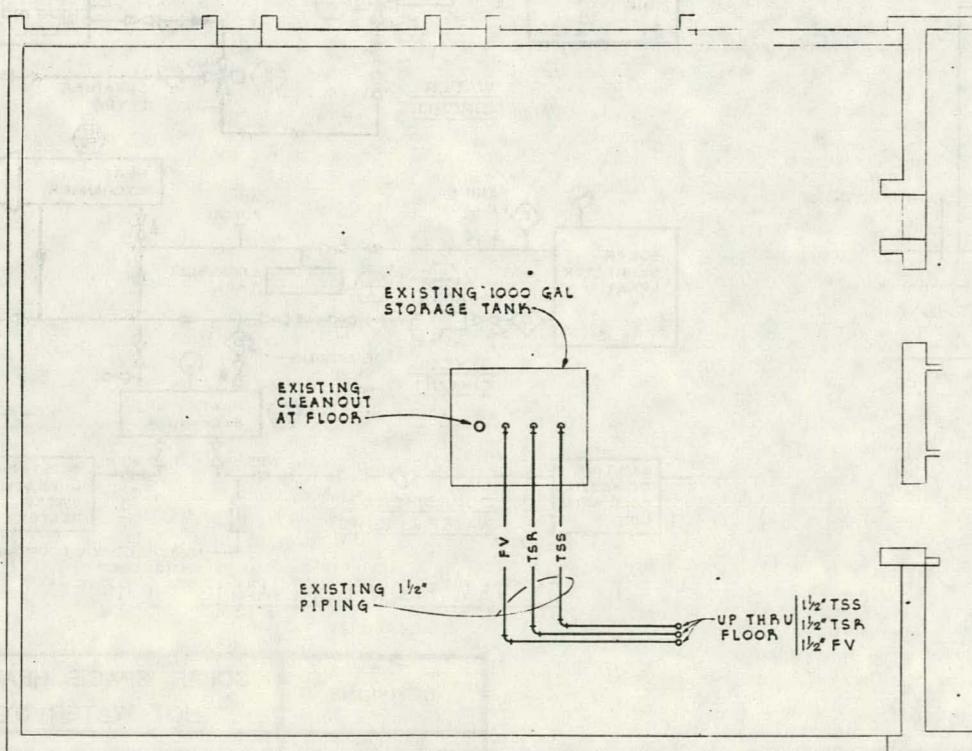
When the NEED matches the ABILITY as indicated by the white and red lights, an amber light at the appropriate load will illuminate indicating it is receiving energy. Green lights at the storage tank and the collectors illuminate to indicate that energy is being supplied from these sources.



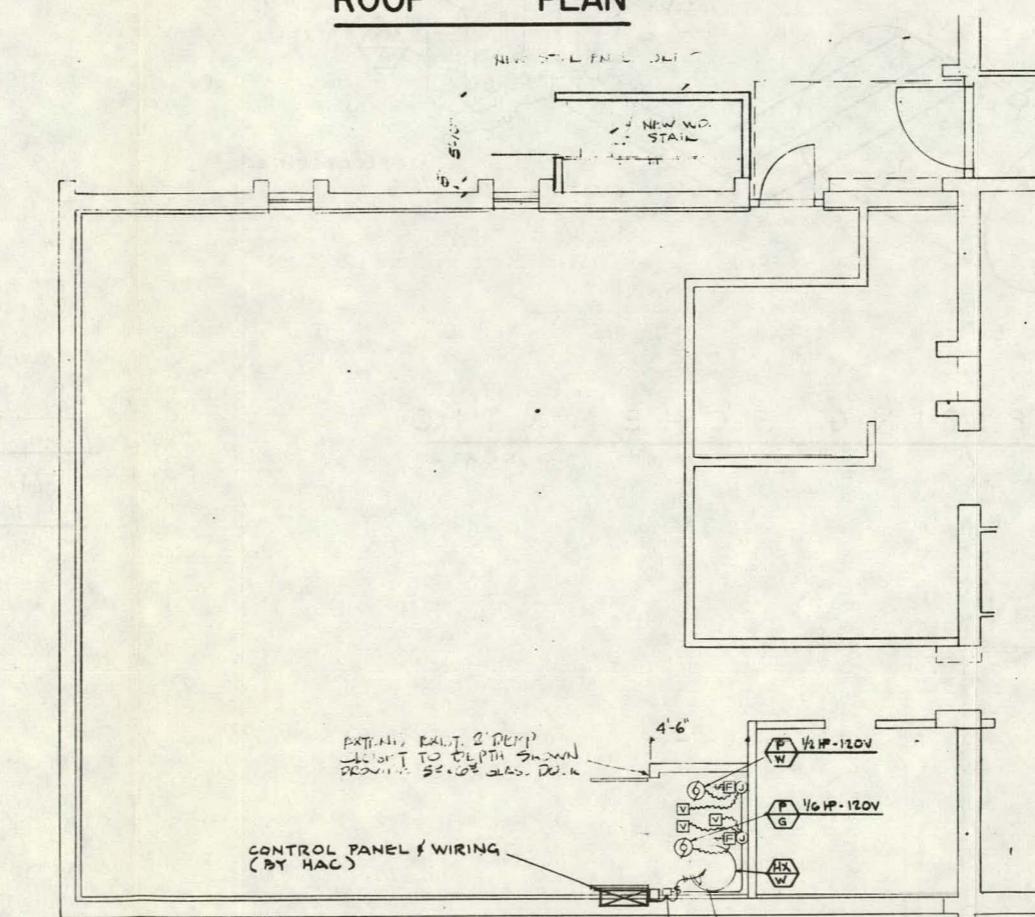
PLENUM PLAN



ROOF PLAN



UNDERFLOOR PLAN



FLOOR PLAN

SYMBOL SCHEDULE

MECHANICAL:

- GATE VALVE
- ▼ 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

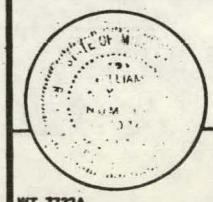
ELECTRICAL:

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

SOLAR SPACE HEATING AND HOT WATER SYSTEM.

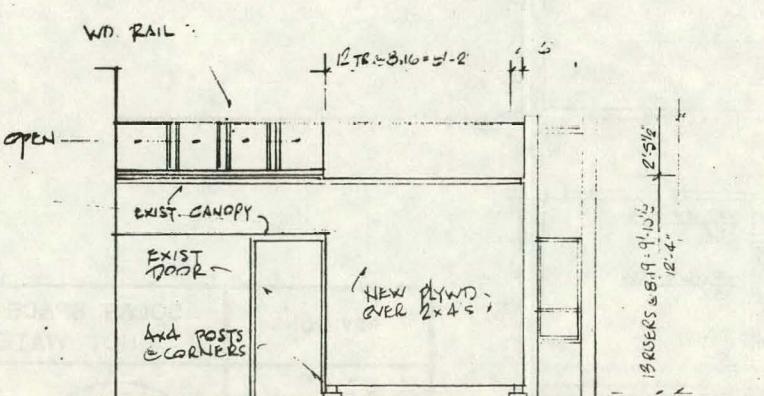
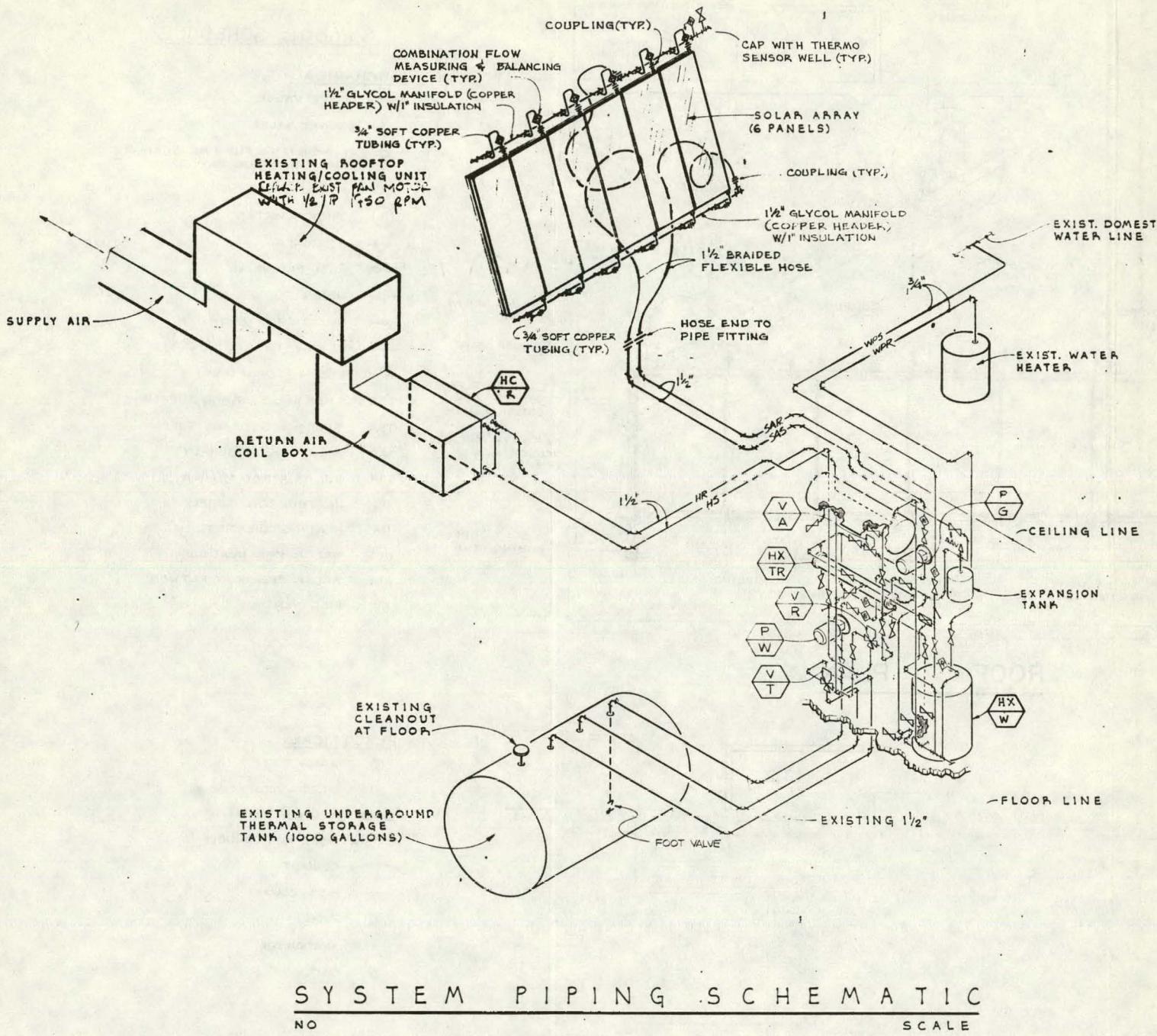
REVISIONS

DEC. 29, 1977
NOV. 7, 1979
Corrections as built

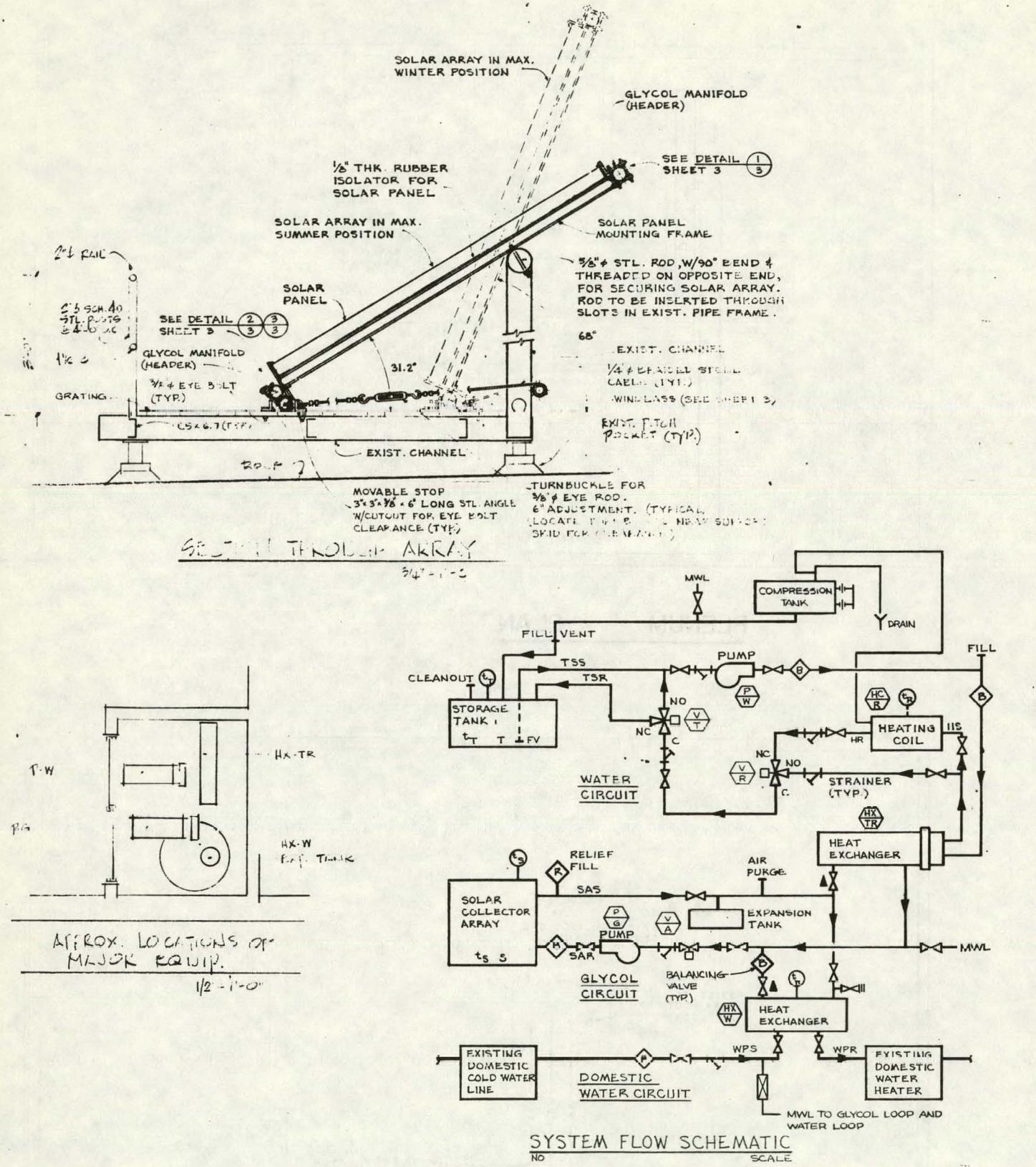


PLANS

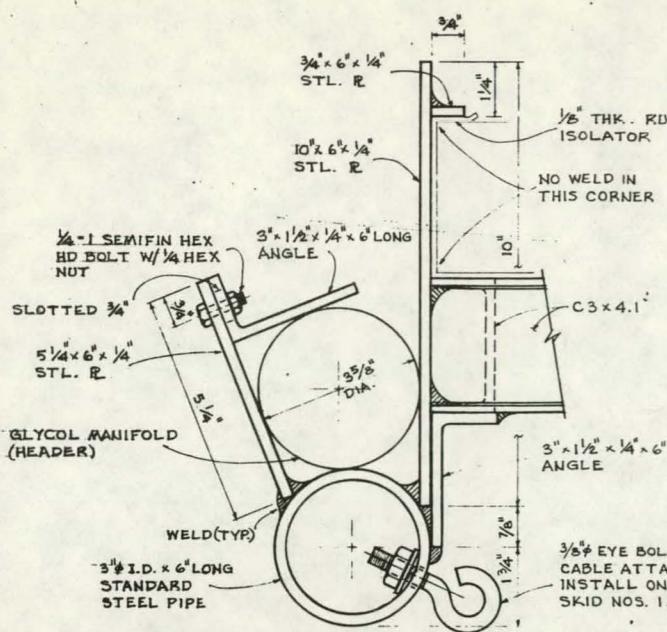
RRJ
REP &
C
BY
REL
WT 7732A



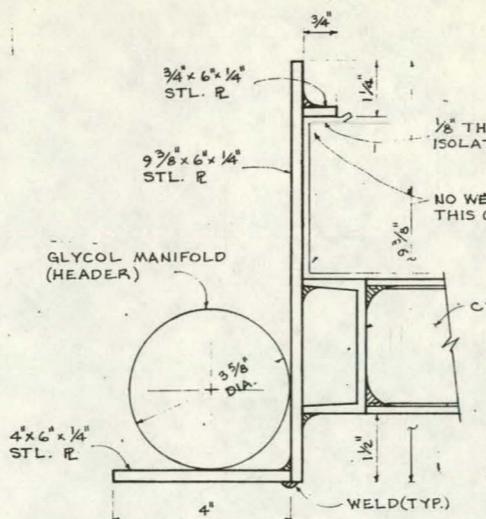
PARTIAL NORTH ELEVATION SHOWING
ENCLOSURE OF NEW STAIR
14' = 1'-0"



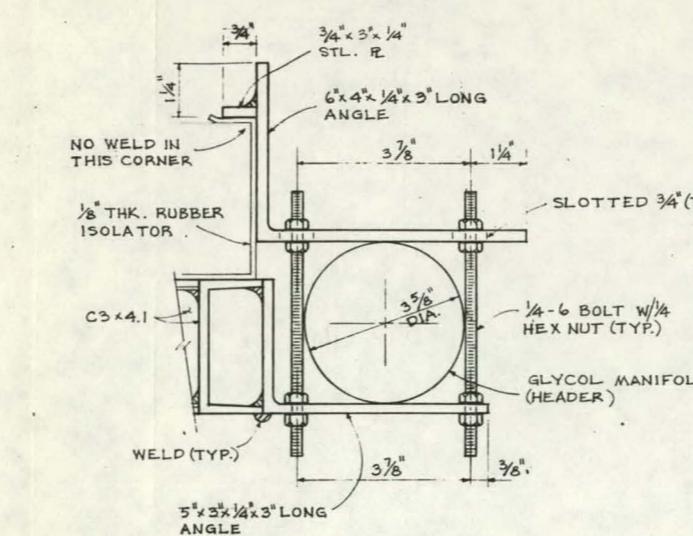
REVISIONS	SOLAR SPACE HEATING AND HOT WATER SYSTEM
DEC. 29, 1977 NOV. 7, 1979 Corrections as built	 <p>WILLIAM K. Y. TAD NUMBER E-707</p> <p>WT 7732A</p> <p>Designed By JRL Drawn By JK Checked By REL</p> 



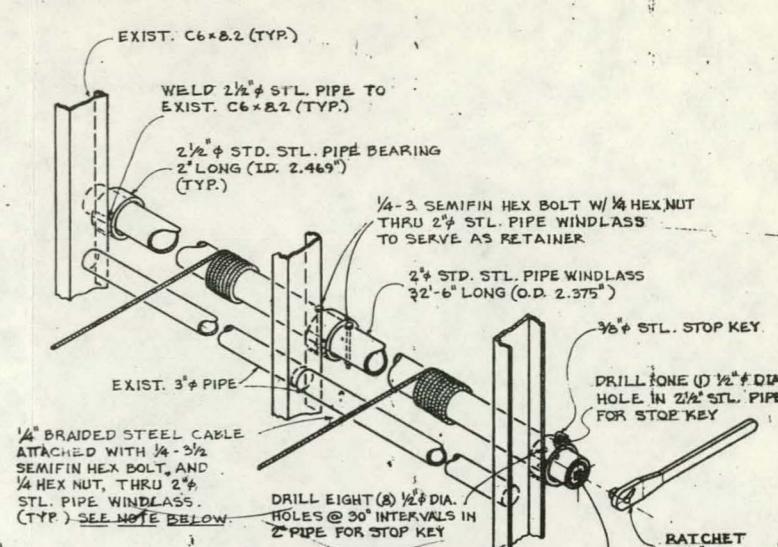
SUPPORT SKID DETAIL
HALF SCALE



SOLAR PANEL
RETENTION CLIP DETAIL
HALF SCALE



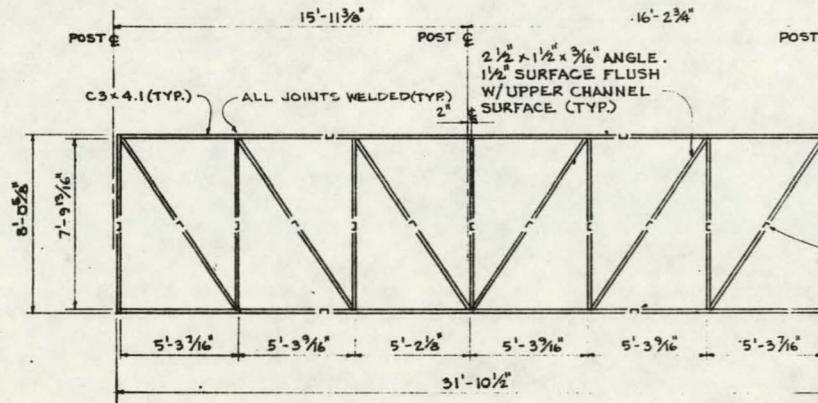
UPPER CLIP ASSEMBLY DETAIL
HALF SCALE



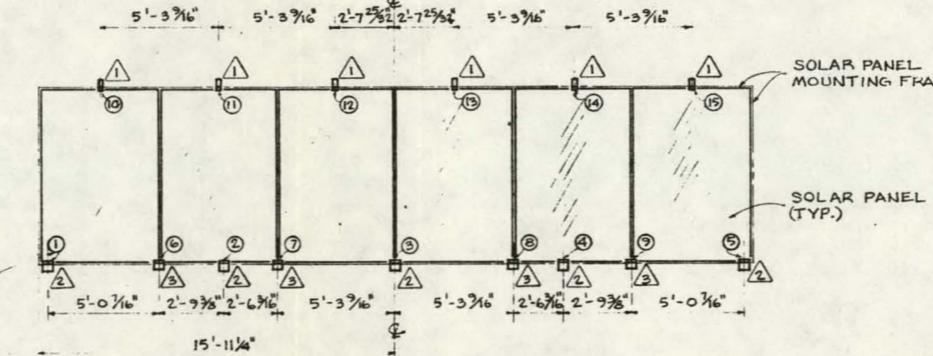
NOTE: THERE ARE THREE (3) EVENLY SPACED CABLE ATTACHMENTS TO PIPE WINDLASS. FOR DWG. CLARITY ONLY TWO CABLE ATTACHMENTS ARE SHOWN. ARRANGE CABLES TO CONNECT TO SUPPORT SKID NOS. 1, 3, & 5.

2" O.D. SOCKET W/ 1/2" DRIVE. WELD INSIDE END OF 2" STL. PIPE AS SHOWN.

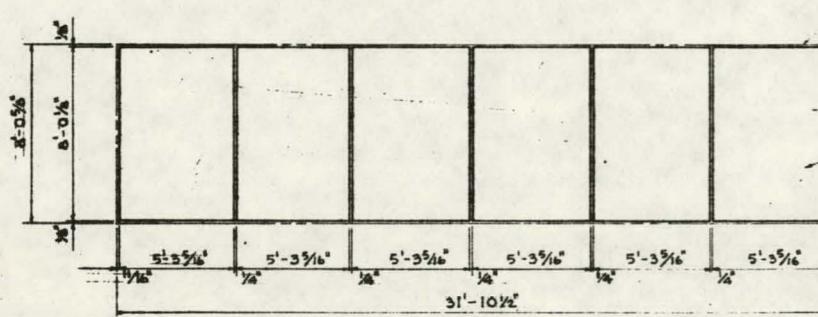
WINDLASS MOUNTING ARRANGEMENT
NO SCALE



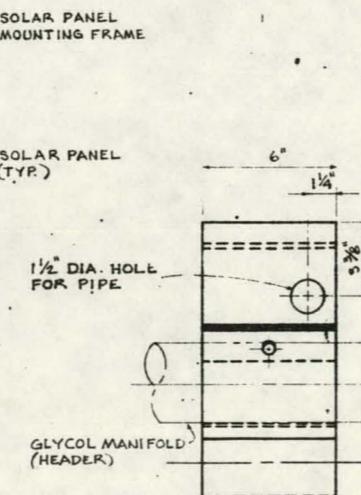
SOLAR PANEL MOUNTING FRAME
SCALE: 1/4"-1-0"



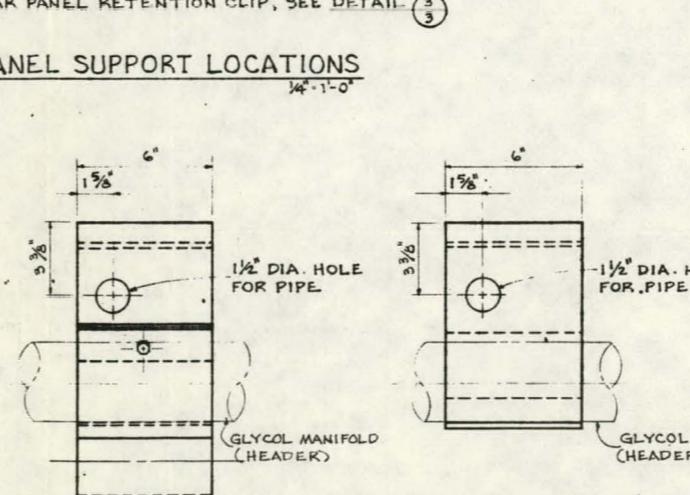
SOLAR PANEL SUPPORT LOCATIONS
SCALE: 1/4"-1-0"



SOLAR PANEL MOUNTING ARRANGEMENT
SCALE: 1/4"-1-0"



SUPPORT SKID NO. 5



SUPPORT SKID NO. 3

RETENTION CLIP NOS. 6-9

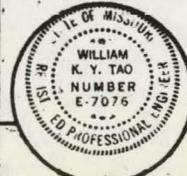
NOTE: ONLY SUPPORT SKID NOS. 3, 5 AND ALL RETENTION CLIPS HAVE HOLES AS SHOWN.

FRONT VIEW - SOLAR PANEL SUPPORTS - HOLE LOCATIONS
QUARTER SCALE

REVISIONS

DEC. 29, 1977

SOLAR SPACE HEATING AND
HOT WATER SYSTEM



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 preheats 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

1. PROJECT IDENTIFICATION NO. EG-77-A-01-4085		2. PROJECT TITLE Solar Space Heating And Hot Water System	3. DATE 12 - 30 - 77 MO DAY YR
4 DEMONSTRATION PROJECT LOCATION Name <u>William Tao & Associates, Inc.</u> Street <u>2357 59th Street</u> City <u>St. Louis</u> State <u>MO</u> Zip <u>63110</u>		9. GENERAL CHARACTERISTICS 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 for January <u>1026</u>	
5 CONTRACTOR NAME AND ADDRESS Name <u>William Tao & 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		H. Front of Building Faces (Circle One) N NE NW SE S SW E W	
PROJECT MANAGER Richard Lampe		TELEPHONE NO. (314) 644-1400	I. Design Monthly Avg. Wind Direction (Circle One) N NE NW SE S SW E W
6. A&E CONTRACTOR NAME AND ADDRESS Name <u>William Tao & 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		J. Design Monthly Avg. Wind Velocity <u>11.8</u> MPH	
PROJECT MANAGER Richard Lampe		TELEPHONE NO. (314) 644-1400	K. January Not monitored _____ BTU/FT ² Day L. July in St. Louis area _____ BTU/FT ² Day
OWNER NAME AND ADDRESS Name <u>William Tao & 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>		HEATING DESIGN TEMPERATURES M. Outdoor for 97.5% <u>8</u> °F N. Indoor <u>72</u> °F	
8. BUILDING OCCUPANCY A. Residential <input type="checkbox"/> R Commercial <input checked="" type="checkbox"/> C B. Type (See Table 1) <u> </u> Enter Code/Describe C. Category (See Table 2) <u> </u> Enter Code/Describe		COOLING DESIGN TEMPERATURE: O. Outdoor for 2.5% <u>95</u> °F P. Indoor <u>75</u> °F Q. Outdoor Dew Point <u>78</u> °F	
		DESIGN SHADED GLASS AREA R. Heating Season <u>25</u> FT ² S. Cooling Season <u>25</u> FT ²	
		10. INTEGRATION OF SOLAR SYSTEM 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

11. 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 FT²

Using Solar Energy 900 FT²

D. Exterior Wall Geometry (Total Area)

Walls 1240 FT²

Door Openings 25 FT²

Windows 25 FT²

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
4. SYSTEM GENERAL DESCRIPTION A. Air, active Function _____ (Table 5) Type(specify) _____		7. COLLECTOR SUBSYSTEM A. Number of Collector Types 1 B. Collector ID: (See Table 1) 1 KTA KT 4-85 2 _____ 3 _____ 4 _____
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) _____		If any one of these collectors is new, write in the description and complete Collector Subsystem Description form for each collector type
C. Liquid, active Function Heating Hot Water (Table 5) Type(specify) multiple Concentrators		C. Orientation X Due S (Based on True N) _____ ° E of S _____ ° W of S
D. Liquid, passive Function _____ (Table 5) Type: Thermosyphon SYPHON Evaporator EVAP Liquid Bag LIBAG Other(specify) _____		D. Tilt (Degrees from Horizontal) Fixed <input type="checkbox"/> F _____ ° Adjustable <input checked="" type="checkbox"/> A from 32° to 68°
E. Combined Systems (Describe):		E. Location Roof <input checked="" type="checkbox"/> R Wall <input type="checkbox"/> W Ground <input type="checkbox"/> G Separate Structure <input type="checkbox"/> S Other(Describe) <input type="checkbox"/>
5. SCHEMATICS OF SOLAR SYSTEM ON HAND: No <input type="checkbox"/> 0 Yes <input checked="" type="checkbox"/> 1		F. Array Characteristics Number of Panels for each Collector Type (See 7B Above) 1 6 2 _____ 3 _____ 4 _____
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.		G. Total Area of Array 252 FT ² H. Effective Array Aperture Area 216 FT ²

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

DT

Deciduous

CT

Coniferous

Trees not on Site

NDT

Deciduous

NCT

Coniferous

Other (Specify) _____

K. Freeze Protection (Table 2) _____

Other (specify) Glycol Loop

L. Overheating Protection (Table 3) _____

Other (specify) None

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

L

Liquid _____

No. of Circulation Loops 2

A

Air _____

No. of Circulation Loops _____

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

10. HOT WATER

A. Manufacturer Ruud

B. Model Name Hot Water Heater

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

Source:

D. Oil 0 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 0 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 Tons 4

N. Energy Input BTU/HR

13. AUXILIARY HEATING & COOLING

A. Heat Pump No 0 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. (KTA) KT4-85	2. PROJECT IDENTIFICATION NO. EG-77-A-01-4085	3. DATE 12 - 30 - 77 MO DAY YR
4. TYPE (See Table 1)	7. COLLECTOR PANEL CHARACTERISTICS	
5. SPECIFY (IF OTHER) Flat Plate with multiple concentrators.	A. Gross Collector Area <u>42</u> FT ²	
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>	B. Net Aperture Area <u>36</u> FT ²	
	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 110. PHYSICAL CHARACTERISTICS Length 96 IN
Width 63 IN

COVER PLATE NO	MATERIAL (SEE TABLE 3)	THICKNESS IN	TRANSMIT- TANCE %	REFLECTANCE %
C. OUTERMOST	Plastic (polyvinyl Flouride)	4 mils	73	7
D. 2				
E. 3				

11. EDGE OR SURFACE TREATMENT (SEE TABLE 4)

COVER PLATE NO.	TYPE OF TREATMENT	COATING	COATING FUNCTION	METHOD OF APPLICATION
A. 1 OUTERMOST	Outer Polished			
B. 2				
C. 3				

12. DESICCANTS

A. Desiccants Used

No 0 Yes 1B. Type Silica Gel SGAnhydrous Calcium Chloride CAOther

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 CU2O
 (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
 Fluid Passages
 (See Table 6C) ABSORBER TUBE

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			
JACK LAYER 1			

18. PHYSICAL PROPERTIES OF INSULATION

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

NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING

COLLECTOR SUBSYSTEM DESCRIPTION

(COMPLETE FOR EACH COLLECTOR TYPE)

Page 3 of 4

9. GASKETS SPECIFICATIONS TYPE. CORK CS 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					

9. SEALANTS SPECIFICATIONS

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

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

21. REFLECTORS

A. Substrate Material
(See Table 9A)Alum.

H. Width ____ IN

B. Alloy/Generic Type

not available

I. Diameter ____ IN

C. Reflective Surface
(See Table 9B)not available

J. Concentration Factor ____

D. Protective Coating
(See Table 6B)not available

22. MOUNTING FRAME

E. Shape

Flat FA. Manufacturer Field erectedCylinder C

B. Model Name _____

Parabolic Dish PD

C. Model ID _____

Parabolic Cylinder PCD. Material Used
(See Table 9A) _____

F. Length

58 INE. Protective Coating
(See Table 6B) _____

G. Thickness

1 IN

NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING

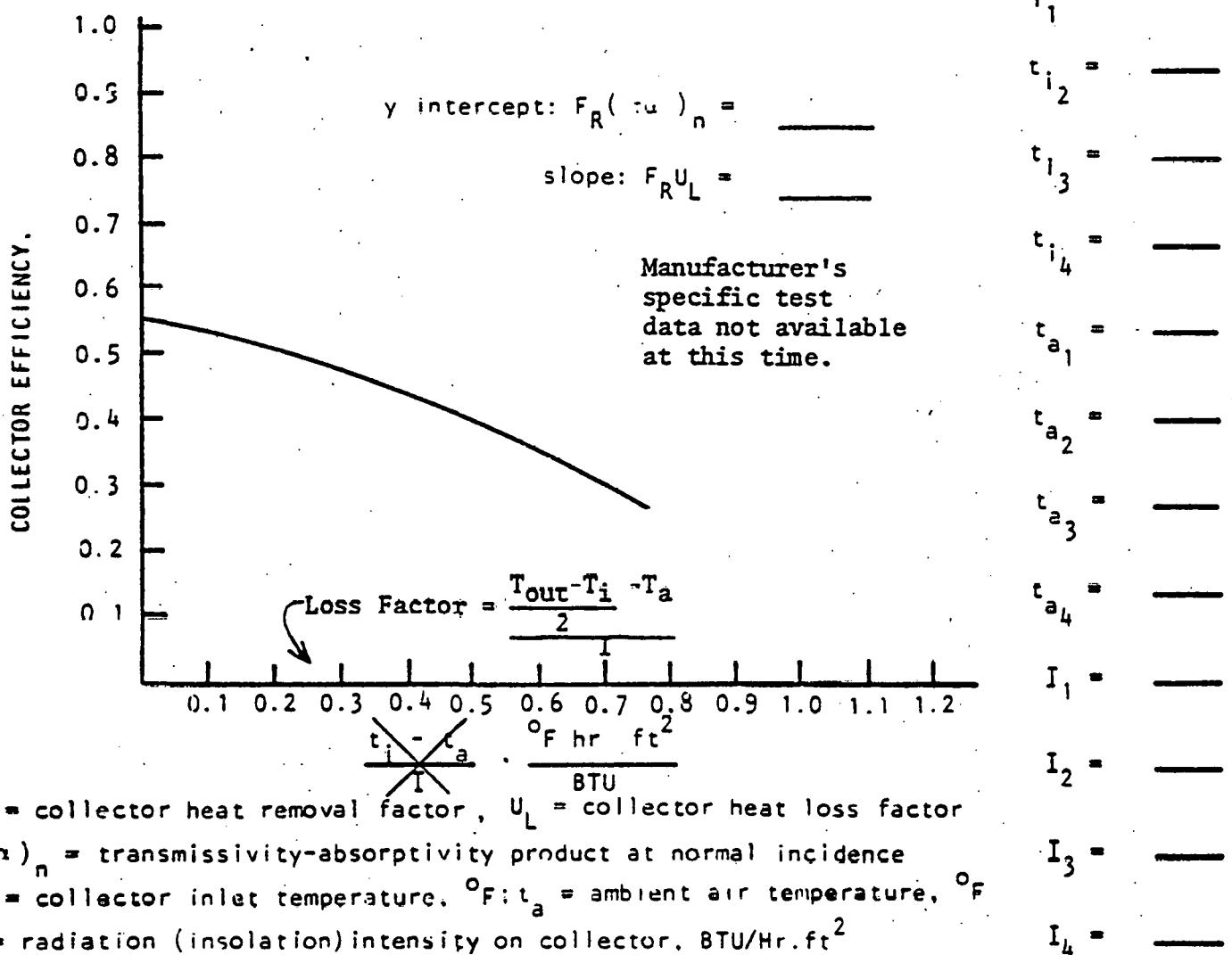
COLLECTOR SUBSYSTEM DESCRIPTION

(COMPLETE FOR EACH COLLECTOR TYPE)

Page 4 of 4

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/ft² 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.



here:

 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.ft²

A. Design Mass Flow Rate

0.03 GPM/Ft²
~~Ft³/Ft²-MIN~~
 BTU/Hr-Ft²-°F

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

B. Backside Thermal Loss

C. Edge Thermal Loss

D. Top Heat Loss

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 GPM5. NORMAL MAXIMUM DESIGN TEMPERATURE 1 °F

6. PHYSICAL PROPERTIES

A. Heat Transfer Medium (Table 1) _____

Other (specify) Water-Glycol solutionB. Composition (% of Total Volume) 60 %C. Specific Heat .86 BTU/Lb/°FD. Density 64.8 Lb/Ft³E. Viscosity Over Working Temperature Range 1.5 CentipoisesF. Boiling Point 220 °FG. Freezing Point -10 °FH. Maximum Recommended Use Temp. 300 °FI. Flash Point - °FJ. pH Factor > 7K. Chemical Feeder to Maintain pH No 0 Yes 1

L. If Yes, Manufacturer _____

M. Product Name _____

ID Number _____

N. Inhibitor No 0 Yes 1O. Generic Type Inhibited GlycolP. % of total weight 40 %Q. Potable No 0 Yes 1

7. RIGID PIPING/MANIFOLD

A. Material (Table 2A) 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 RPlastic P Metal MB. Generic Type/Alloy Soft copper

C. Reinforcement:

Glass Fiber G Fabric FMetal 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 1B. Material (Table 4) Fiberglass withOther (specify) aluminum jacketC. Thickness 1 IND. Density _____ Lb/Ft³E. Thermal Resistance .34 R VALUE

10. EXTERIOR FINISH (Table 5)

Generic Name, if any Painted

11. LOCATION

Below Grade BGAbove 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)

Page 2 of 4

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/Ft³D. 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

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			

9. DUCT INSULATION

Internal (Duct Liner)

A. Insulated No 0 Yes 1B. Material _____
(See codes below)

C. Thickness _____ IN

D. Density _____ Lb/Ft³

E. Thermal Resistance _____ R VALUE

F. Internal Finish

None 0 Neoprene 1

Other(specify) _____

External (Duct Wrap)

Insulated No 0 Yes 1G. Material _____
(See codes below)

H. Thickness _____ IN

I. Density _____ Lb/Ft³

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

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

TYPE OF BLOWERS

CENTRIFUGAL	CE	VANE-AXIAL	VA
GEAR	GE	TUBE-AXIAL	TA
PISTON	PI	ADJUSTABLE PITCH	AD
VANE	VA	SQUIRREL CAGE	SQ
OTHER(specify)		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			
1					
3					
4					

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
3	Jenkins		Fig. 546-P	FS	GL
4					

VALVES

DAMPERS

FUNCTION	TYPE	FUNCTION	TYPE
FLOW SWITCHING	FS	GLOBE	GL
ON-OFF	OF	GATE	GA
FLOW ADJUSTING	FA	BUTTERFLY	BF
DRAIN	DR	NEEDLE	NE
BLEED	BL	BALL	BA

FLOW SWITCHING	FS	FLOW SWITCHING	FS	SINGLE BLADE	SB
ON-OFF	OF	ON-OFF	OF	OPPOSED BLADE	OB
FLOW ADJUSTING	FA	FLOW ADJUSTING	FA	MULTILOUVER	ML
DRAIN	DR			MULTISHUTTER	MS
BLEED	BL			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 S Single D Double
			Enter Code	Tube Passes	Shell Passes	
1	LL	CR	SAT	2	1	S

TYPE OF EXCHANGE		TYPE OF FLOW		HX DESIGN		
Air-Air	AA	Parallel	PA	Shell & Tube (Specify number of Tube Passes Shell Passes)	SAT	Fin Coil
Air-Liquid	AL	Counter	CO	Heat Pipe	HP	Tube around Tank
Liquid-Liquid	LL	Cross	CR			Tube inside 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: $T_i=147^{\circ}\text{F}$ $T_{out}=150^{\circ}\text{F}$, 6gpm	ST		6500 Btu 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 FT³
 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 inC. Density Lb/ft³D. 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

5. 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 FT³

7. PHYSICAL PROPERTIES
 A. Specific Heat 1.0 BTU/Lb/°F
 B. Density 62.3 Lb/FT³
 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-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/FT³ of Packed Material - Lbs
 C. Heat Capacity of Packed Material - BTU/Lb/°F
 D. Flow Rate of Heat Transport - FT³/Min
 E. Pressure Drop Between Inlet & Outlet - PSI

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 - FT³

17. PHYSICAL PROPERTIES
 A. Specific Heat
 Above Transformation - BTU/Lb/°F
 Below Transformation - BTU/Lb/°F
 B. Density
 Solid Phase - Lb/FT³
 Liquid Phase - Lb/FT³
 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-Recrystallization DR
 J. Latent Heat - BTU/Lb
 K. Material for Racks & Troughs
 Plastic P Metal M
 L. Other (specify) -

PREPARED BY:

Richard R. Janis

12/29/77

E2

CONTROL SUBSYSTEM DESCRIPTION

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

$T_1 > T_2 + 5 \text{ deg. (2dj)}$
 $T_3 > 75 \text{ deg. (2dj)}$

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

$T_1 > T_3 + 5 \text{ deg. (2dj)}$
 $T_3 < 75 \text{ (adj)}$

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

$T_2 > T_3 + 5 \text{ deg. (adj)}$
 $T_1 < T_2 + 5 \text{ deg. (adj)}$
 $T_1 < T_3 + 5 \text{ deg. (adj)}$

$T_3 < 75 \text{ deg. (adj)}$

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

Page 1 of 2

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

← CSF →

Thermistor

← TMD →

Photo Cell

PH

Time

TI

TH

Timer

Solar Radiation

SP

Thermocouple

Resistance Thermometer

TC

RT

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

4. 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)	MRI56 RX SRE 155 M80065
4	CFS	SV	Bell and Gossett (Note* this single pump also both LS and CSF)	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				
7				

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		
	Automatic Draindown	AD	Electrical Overload Protection	EOP

PREPARED BY

Joseph W. Trindle

12/29/77

NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING

SOLAR SYSTEM DESIGN PROCESS REPORT

Page 1 of 2

1. PROJECT IDENTIFICATION NO EG-77-A-01-4085	2. PROJECT TITLE Solar Space Heating and Hot Water System	3. DATE 12 - 30 - 77 MO DAY YR
4. DEMONSTRATION PROJECT LOCATION: Street <u>2357 59th Street</u> City <u>St. Louis</u> State <u>MO</u> Zip <u>63110</u>	7. SOLAR SYSTEM FUNCTION (CHECK ONE)	
5. SOLAR SYSTEM DESIGN CONTRACTOR Name <u>William Tao & Associates, Inc.</u> Project Manager <u>Richard E. Lampe</u> Telephone No. <u>(314) 644-1400</u>	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
6. A & E CONTRACTOR (IF DIFFERENT FROM ABOVE) 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

C. 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.

1. 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

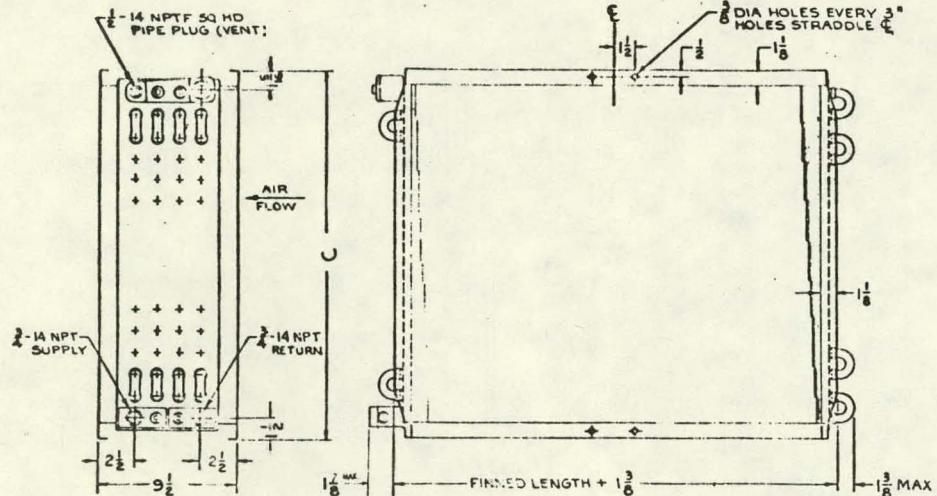
12/29/77

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.

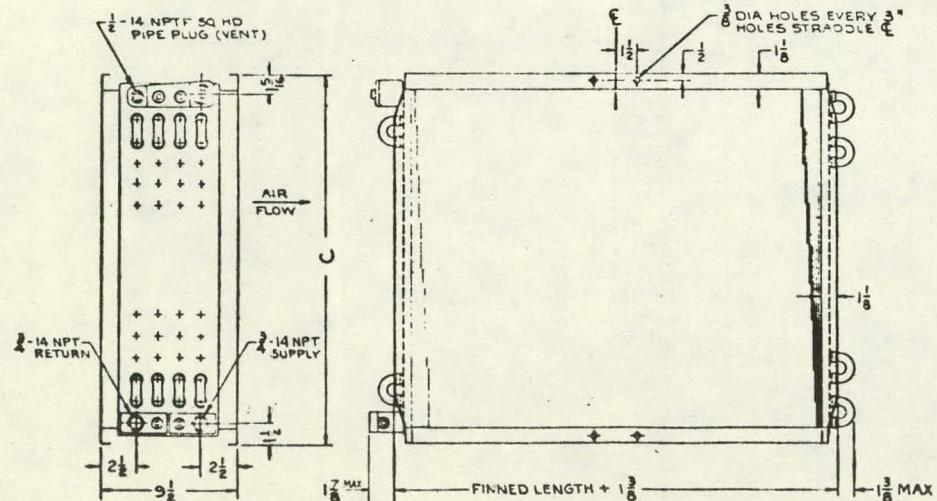
REISSUE
48
HORISBLE
0
MAX

REISSUE		48		HORISBLE		0		MAX																																					
B 2816 655								TYPE P COIL																																					
4-ROW 2-CIRCUIT								SCALE																																					
<p>ENGR BID ENGR SPCL</p> <p>THIS DRAWING IS THE PROPERTY OF THE TRANE COMPANY AND IS TO BE RETURNED UPON REQUEST. IT SHALL NOT BE COPIED OR REPRODUCED EXCEPT FOR AUTHORIZED PARTIES BY THE WRITTEN CONSENT OF THE TRANE COMPANY.</p> <p>ALL DRAWINGS ARE IN INCHES.</p> <p>1. FIRST USED ON ASSEMBLY NO. 9-21-72</p> <p>2. CHKD 10-16-72</p> <p>3. ENGR APPR</p>								THE TRANE COMPANY LA CROSSE, WISCONSIN																																					
<table border="1"> <thead> <tr> <th colspan="6">QTY REQ'D</th> <th>EXT ITEM</th> <th colspan="2">PART NAME</th> <th>MATERIAL</th> <th>DRW BLDG</th> <th>DRAWING PART OR MATERIAL NO</th> </tr> <tr> <th>EXT 6</th> <th>EXT 8</th> <th>EXT 4</th> <th>EXT 3</th> <th>EXT 2</th> <th>EXT 1</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> </tr> </thead> <tbody> <tr> <td></td> </tr> </tbody> </table>								QTY REQ'D						EXT ITEM	PART NAME		MATERIAL	DRW BLDG	DRAWING PART OR MATERIAL NO	EXT 6	EXT 8	EXT 4	EXT 3	EXT 2	EXT 1																				
QTY REQ'D						EXT ITEM	PART NAME		MATERIAL	DRW BLDG	DRAWING PART OR MATERIAL NO																																		
EXT 6	EXT 8	EXT 4	EXT 3	EXT 2	EXT 1																																								



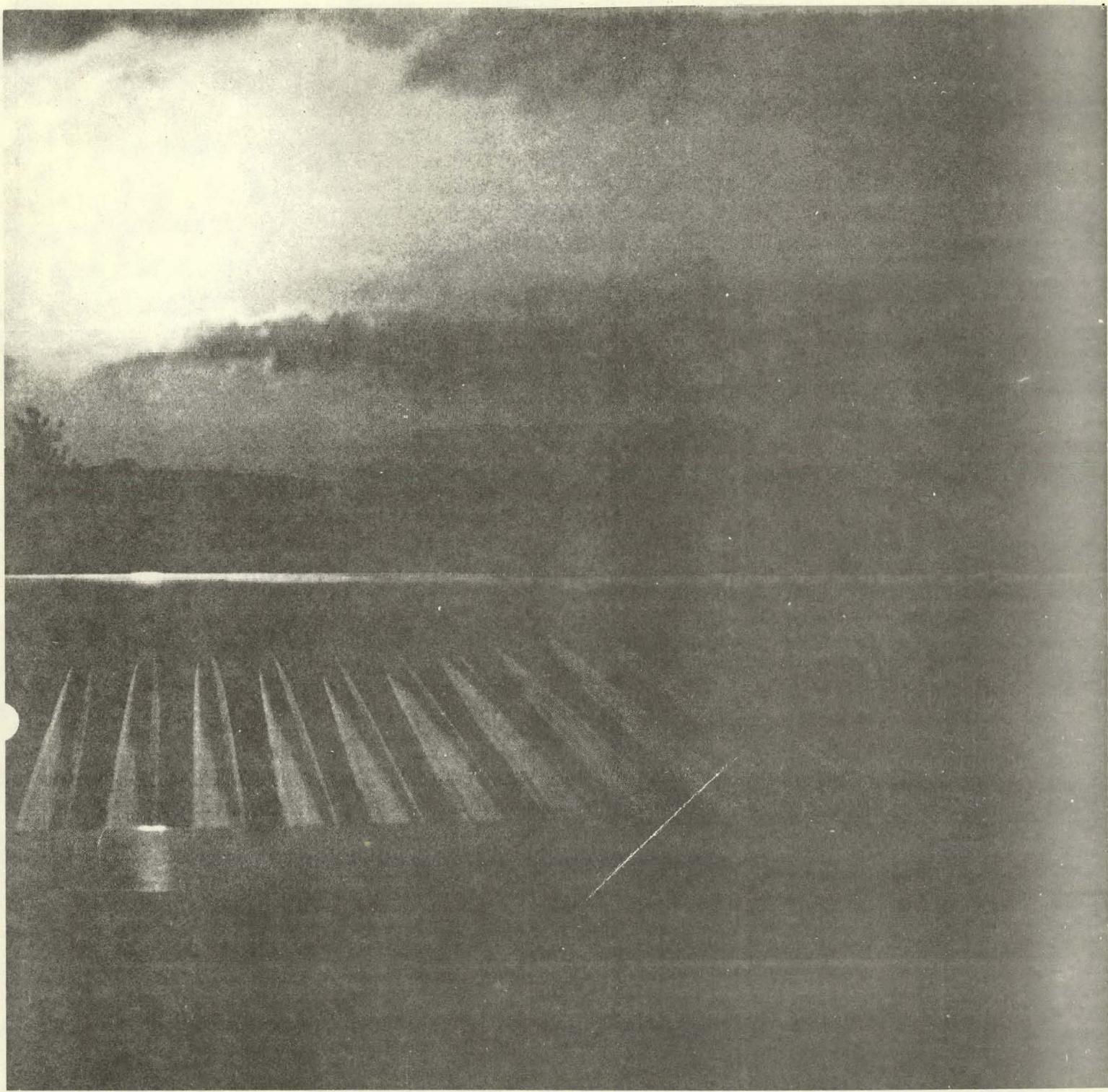
HORIZ AIR FLOW RH SUPPLY

FINNED WIDTH	C	ORDER NO
12	$13\frac{1}{2}$	
18	$19\frac{1}{2}$	812
24	$25\frac{1}{2}$	0305
30	$31\frac{1}{2}$	

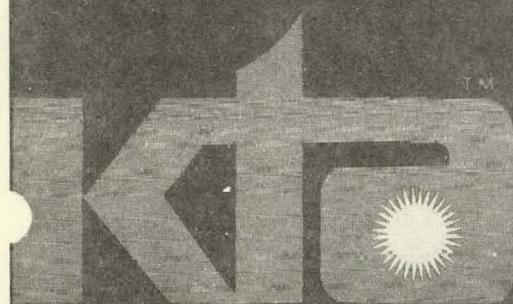


HORIZ AIR FLOW LH SUPPLY

B 2816-0655



Solar products and energy systems manufactured by:



PRODUCTS DIVISION



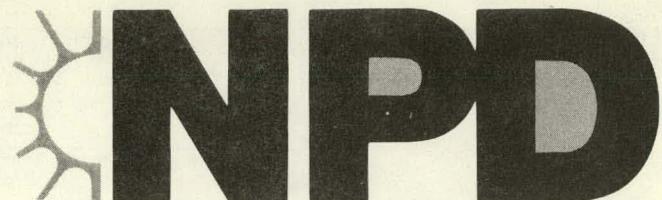
ENERGY SYSTEMS, INC.

H4

A Subsidiary of
National Patent Development Corporation



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.

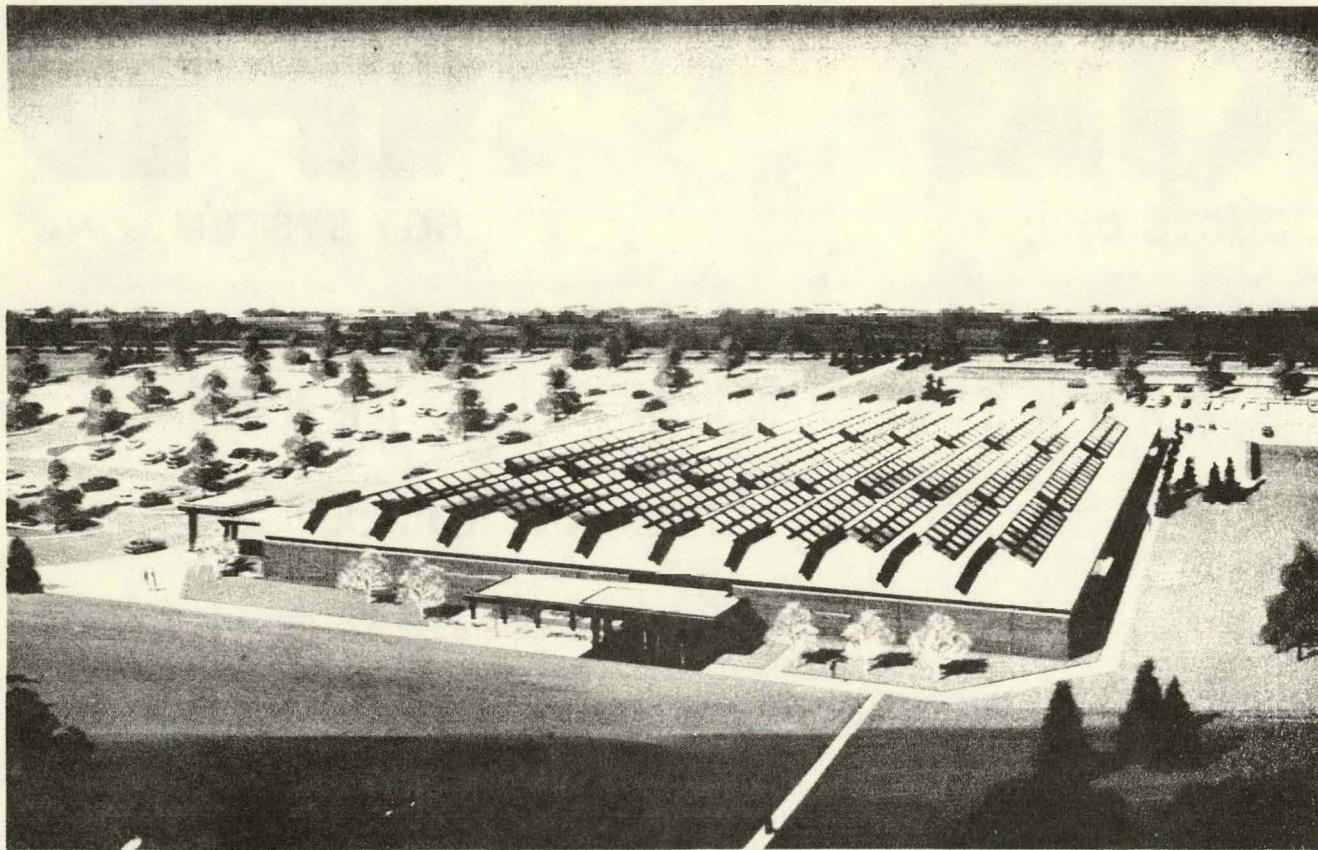
We manufacture solar collectors, environmental control systems for computer rooms, research facilities, hospitals, and schools in new construction and renovation.

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

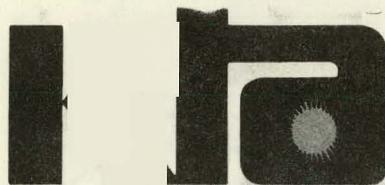
CONSULTING ENGINEERS/SOLAR, HVAC: Bridgers & Paxton
Albuquerque, New Mexico

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

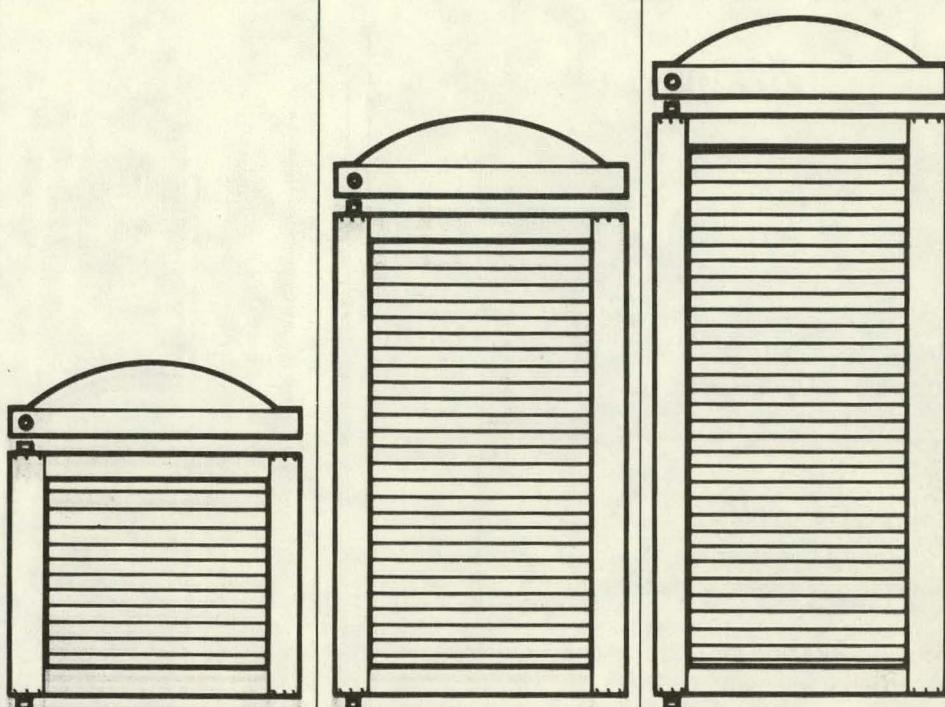
MECHANICAL CONTRACTOR/SOLAR: Arey, Inc.
Chevy Chase, Maryland

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



Aperture area:
(metric)

KT5-45

17.8 ft²
1.7 m²

KT5-85

35.6 ft²
3.3 m²

KT5-125

53.4 ft²
5.0 m²

Case size:
(metric)

43 $\frac{3}{4}$ " x 63 $\frac{1}{4}$ " x 7 $\frac{5}{8}$ "
111.13 cm x 160.8 cm

87 $\frac{1}{2}$ " x 63 $\frac{1}{4}$ " x 7 $\frac{5}{8}$ "
222.25 cm x 160.8 cm

131 $\frac{1}{4}$ " x 63 $\frac{1}{4}$ " x 7 $\frac{5}{8}$ "
333.5 cm x 160.8 cm

Weight:
(metric)

75 lbs
34.1 kg

150 lbs
68.2 kg

225 lbs
102.3 kg

All connections $\frac{7}{8}$ " O.D. Copper •

FEATURES OF KTA™ TUBULAR COLLECTORS

The heart of the KTA™ 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™ tubular design allows field replacement of individual elements.

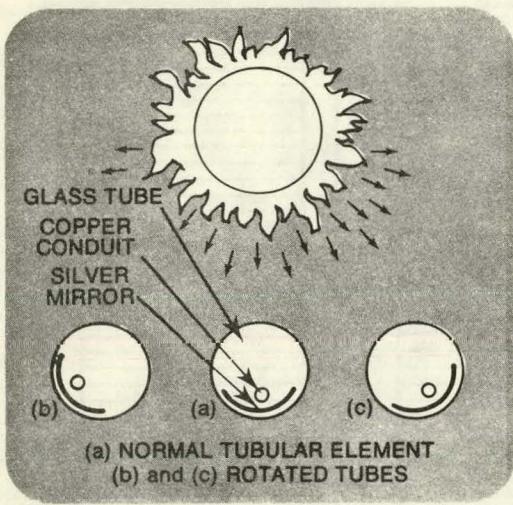
Incorporated into the KTA™ design features are:

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



tubular elements

ROTATION



(a) NORMAL TUBULAR ELEMENT
(b) and (c) ROTATED TUBES

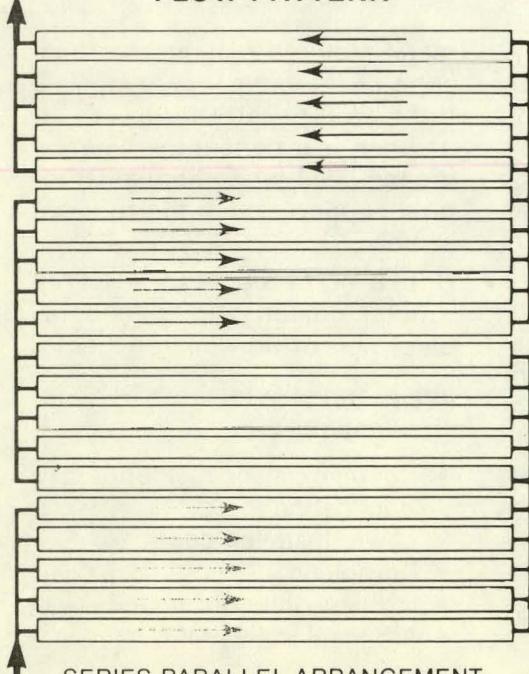
During the brazing process, these tubular concentrating elements can be "rotated" to any angle within 30° of perpendicular.

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.

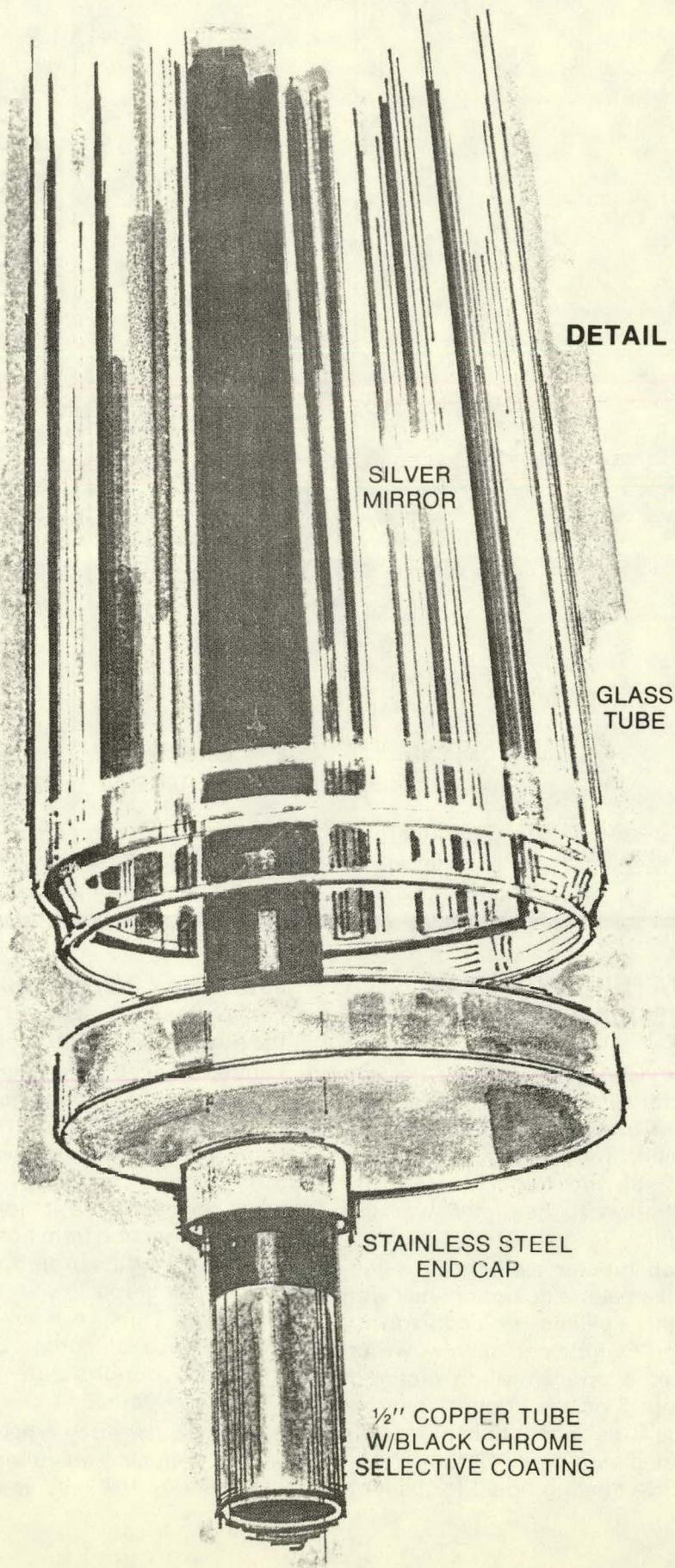
Rotation will, for some applications, enable collectors to be mounted vertically on a south-facing wall.

FLOW PATTERN



SERIES-PARALLEL ARRANGEMENT

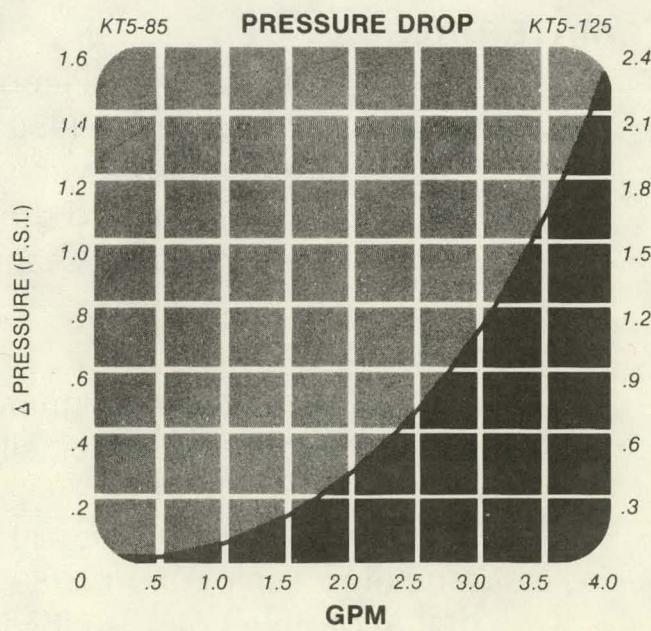
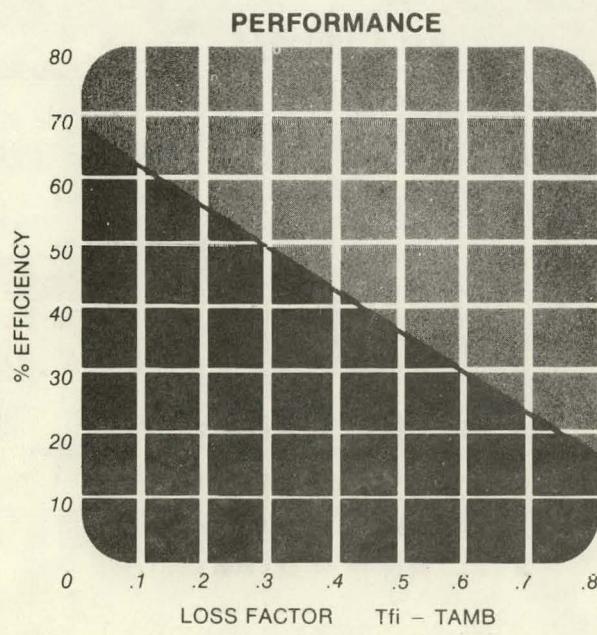
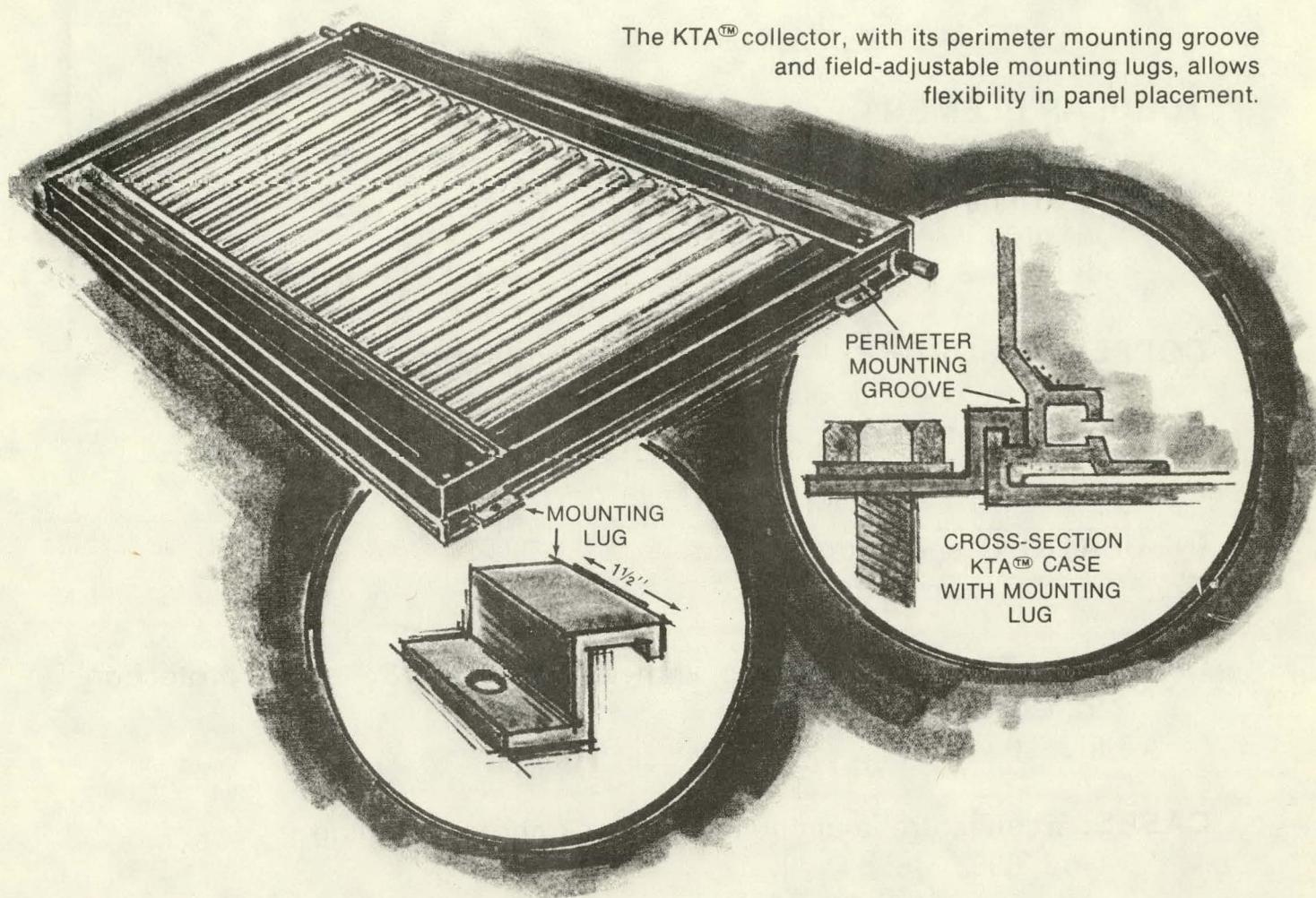
DETAIL





performance

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



& 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: 1/2" O.D. M-type hard drawn copper tube

selective coating: black chrome
absorptivity: 95%
emissivity: 7%

INSULATION: isocyanurate foam

temperature range: 350° F

COVERPLATE: 1/8" 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: 3/4" M-type hard drawn copper
lap joint collar seams

DESIGN DATA

Flow Rates: .0125 — .04 gpm/ft² recommended

Fluids: water, water/glycol, silicone oil

Acceptance Angle: 45°

Maximum Rotation Angle: 30°

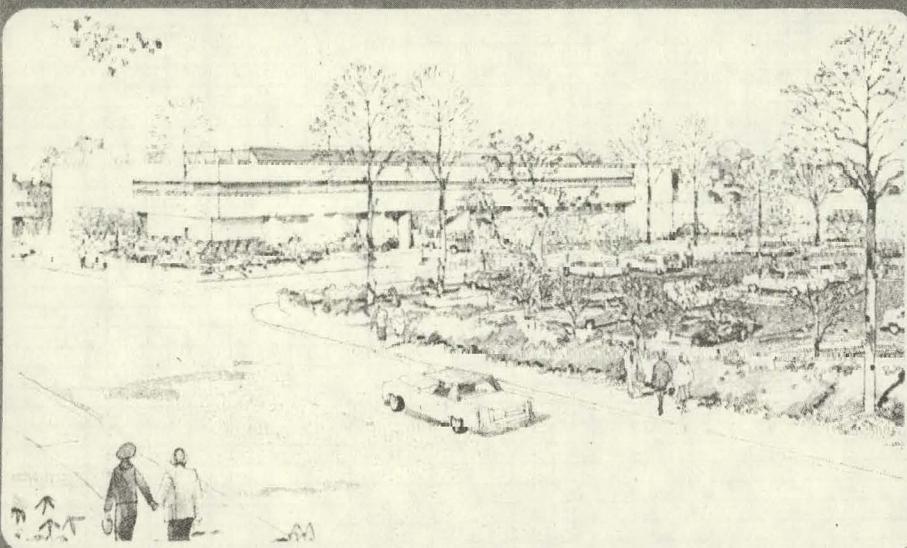
Stagnation Temperature: 350° F

Total Allowable Load: 90 lbs/ft²

Design Load: 40 lbs/ft²

Weight: 4.5 lbs/ft²

KIC solar installations



Owner:

Lindsay Cadillac, Alexandria, Virginia

Architects:

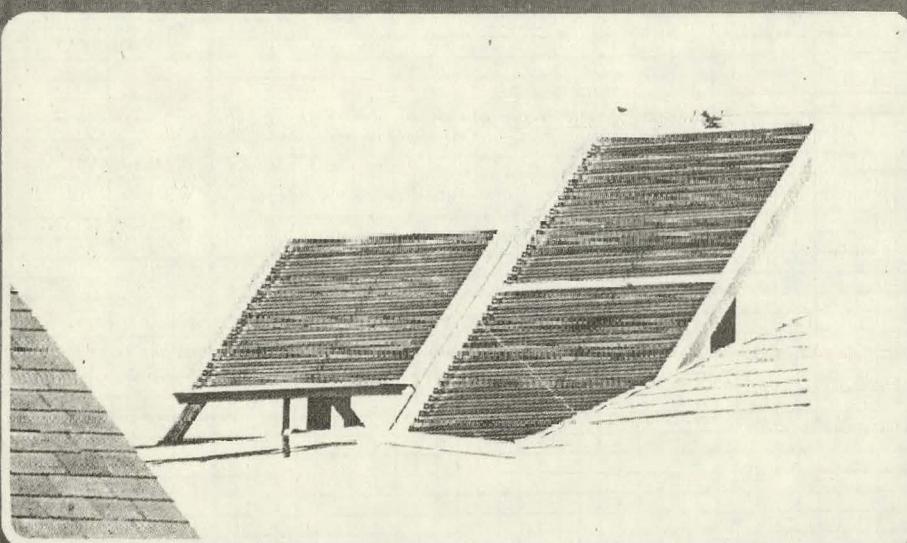
Architects Group Practice,
Alexandria, Virginia

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,
Sausalito, California

Demonstration Project:
Pacific Gas & Electric



Owner & Architect:

Capitol Courts, Inc.

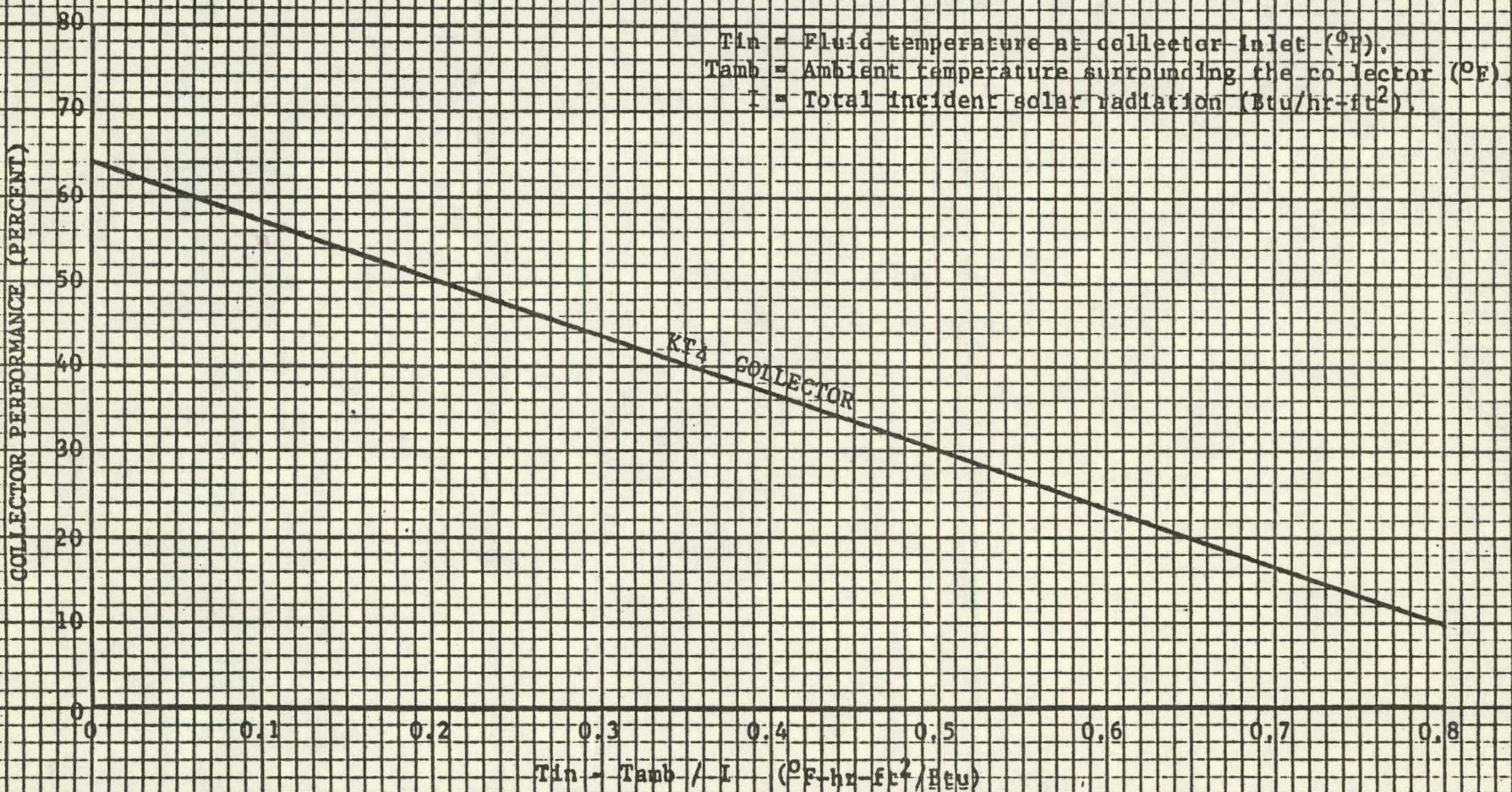
Carson City, Nevada

Engineer & Mechanical Contractor:
Vann Engineering, Sparks, Nevada

KTA Products Division

COLLECTOR PERFORMANCE

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



730601

SUBMITTAL

KTA SOLAR COLLECTOR

MODEL NO.

KT4-85

QUANTITY

6

ROTATION

NONE

CONNECTION

RIGHT HANDFRAME FINISH MILLCOVERPLATE 1/8" UVA PLEXIGLAS

OPERATIONAL FLUID

APPLICATION

REMARKS

REFERENCE NO. WT 7732APROJECT ERDA SOLAR DEMONSTRATION PROJECT

PURCHASE ORDER NO.

LOCATION ST. LOUIS, MISSOURIDATE 20 OCTOBER 1977CUSTOMER WM. TAO & ASSOCIATESSHIP TO WTASTREET 2357 59TH STREETATTN: RICHARD E. LAMPE, P.E.CITY ST. LOUISSTATE MOZIP 63110

MARK

ARCHITECT

ENGINEER



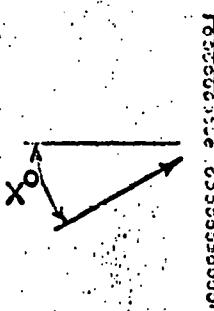
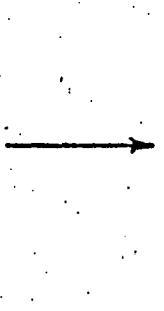
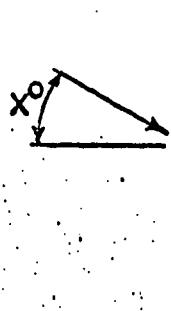
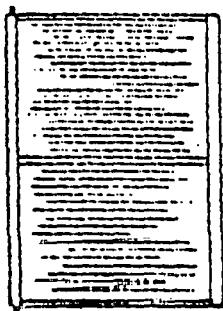
CORPORATION

12300 Washington Avenue

Rockville, Maryland 20852

COLLECTOR ROTATION NOMENCLATURE

LEFT HAND CONNECTION



UP

ROTATION

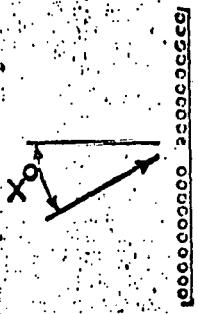
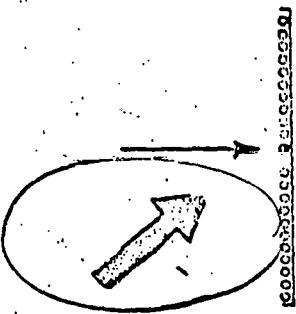
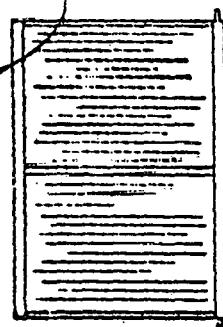
NO

ROTATION

DOWN

ROTATION

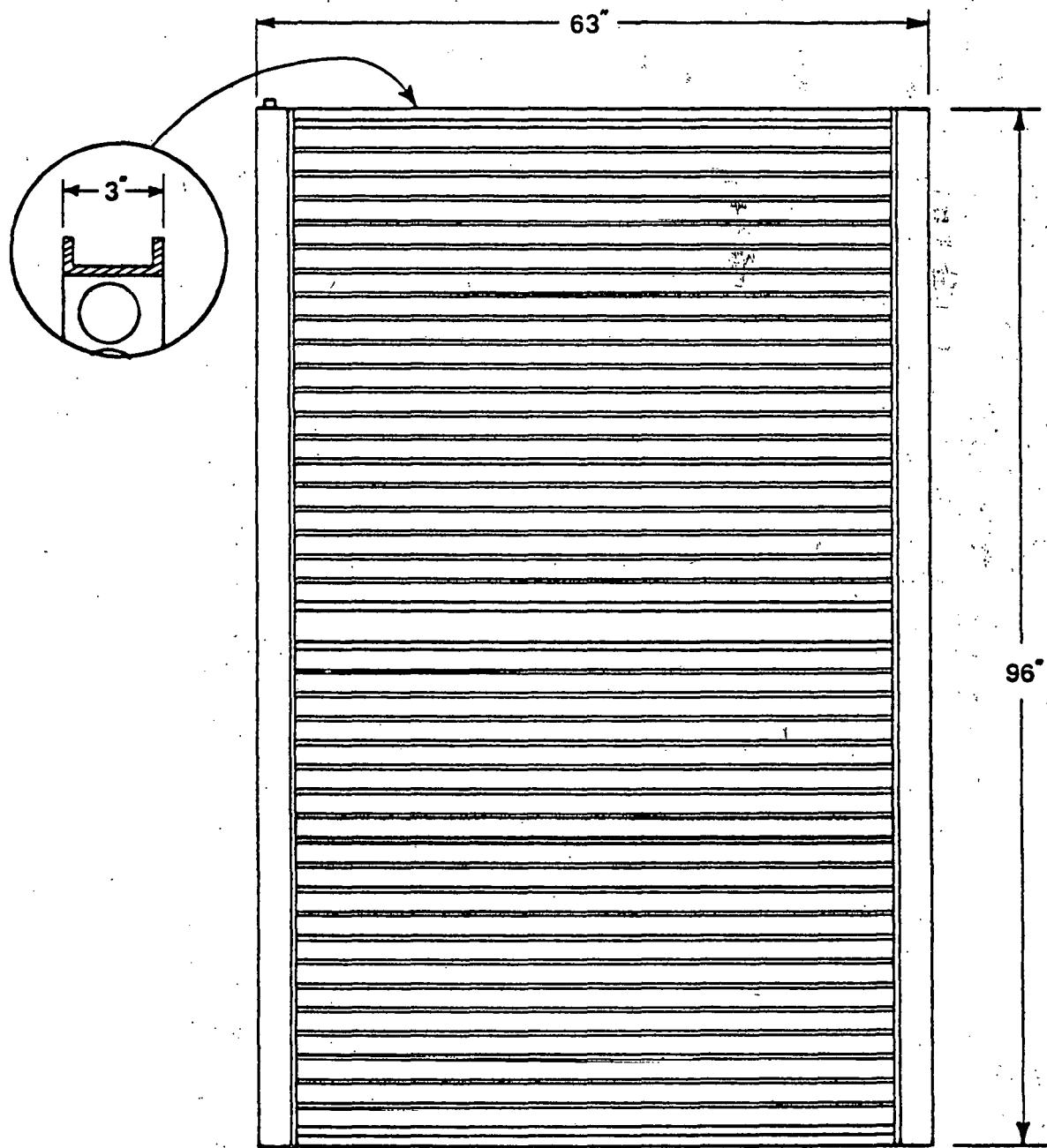
RIGHT HAND CONNECTION



Rotation available in 5° increments
Maximum rotation 30°

5-102

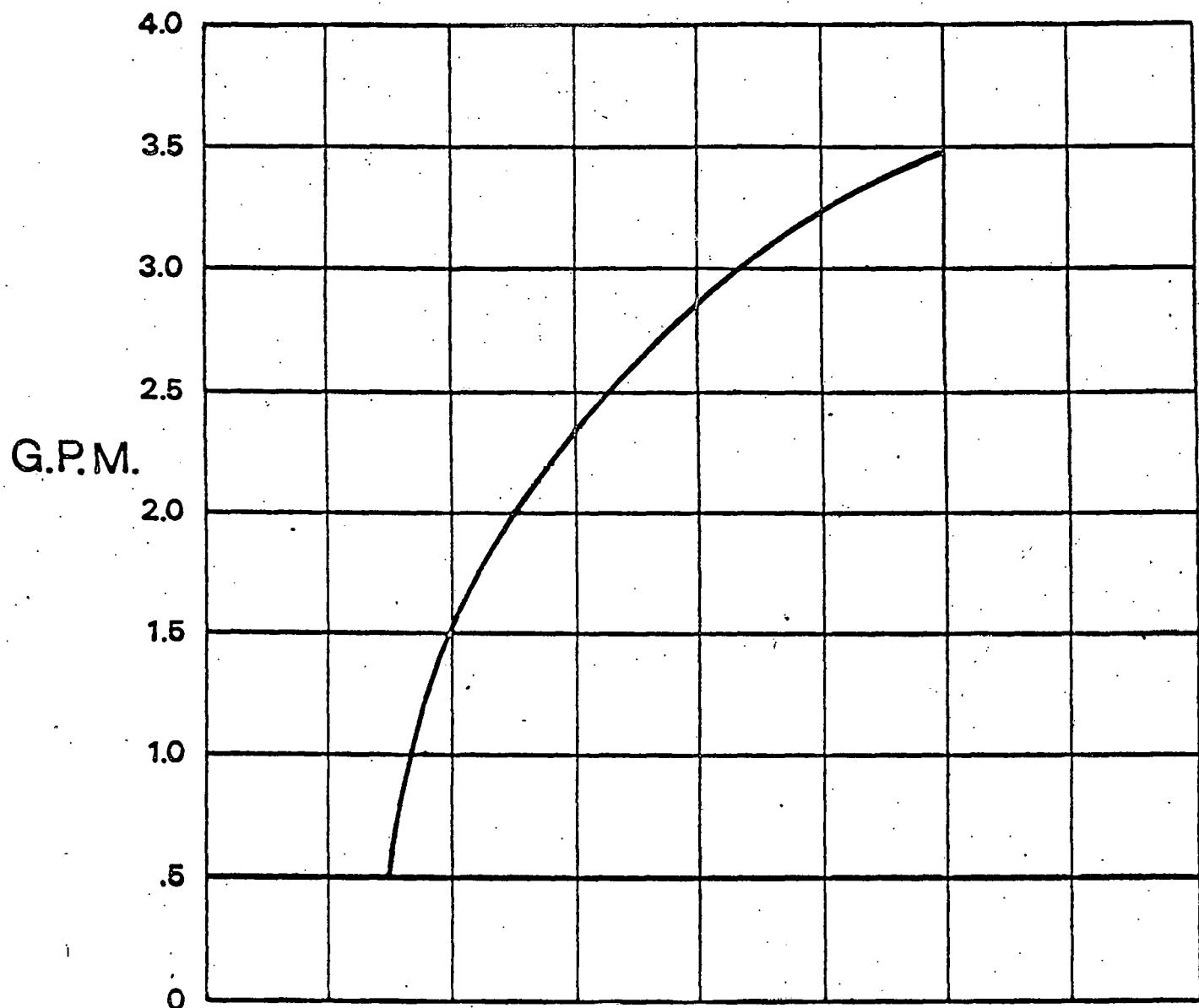
KT4-85



APERTURE: 36 sq. ft.

CONNECTIONS: 7/8" O.D. COPPER

5-202



PRESSURE DROP (P.S.I.)

NOTE: RECOMMENDED OPERATION IS BETWEEN
.02 AND .04 GPM PER FT² COLLECTOR

Kia
CORPORATION
12300 Washington Avenue
Rockville, Maryland 20852

Telephone (301) 468-2066