(NASA-CR-161420) SOLAR HEATING AND HOT WATER SYSTEM INSTALLED AT SAINT LOUIS, MISSOURI Final Report (Tao (William) and Associates) 68 p HC A04/MF A01 CSCL 10A

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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

William Tao and Associates
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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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^2 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^2) 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.

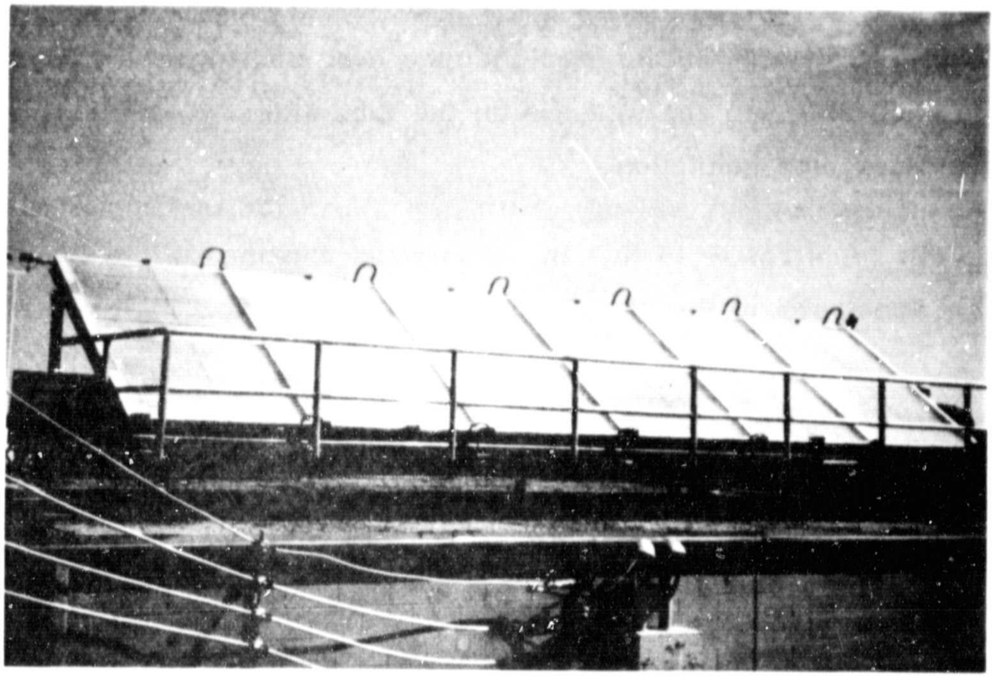
Supporting Structure: The supporting structure is welded steel construction with an observation catwalk. It is designed such that the tilt angle of the collectors can be adjusted for experimental purposes. Since the system is primarily for space heating, the collectors have been left at this tilt angle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

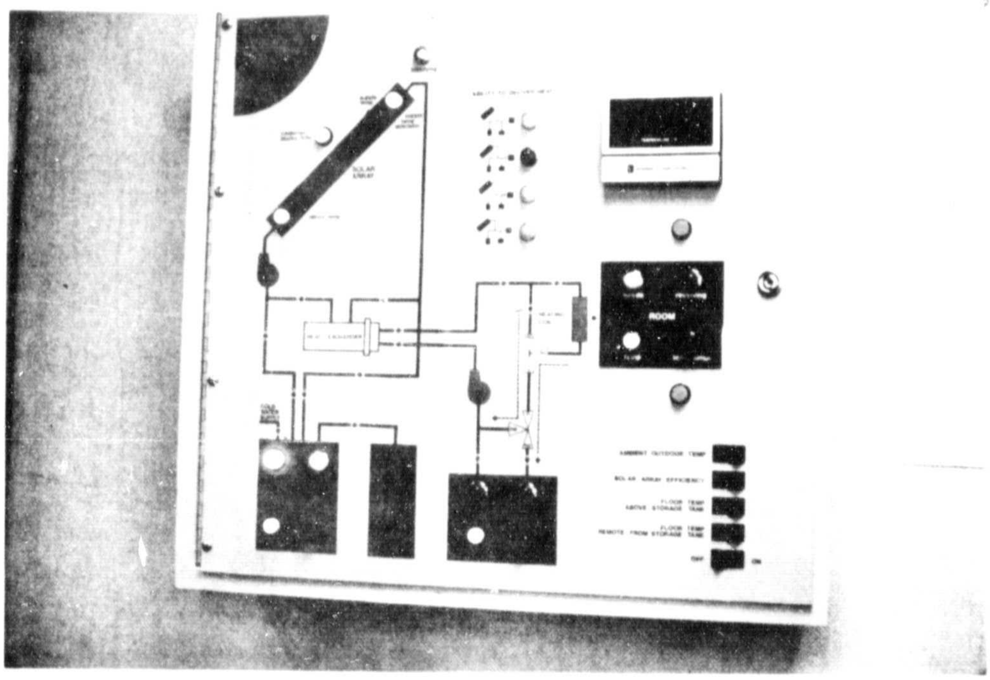
Solar Storage Tank: The storage tank is a 1000 gallon steel tank buried below the slab floor of the addition. It is insulated with rubber insulation and filled with water. The storage-to-collector area ratio is 33 lbs. H_2O/ft^2 of collector.

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.

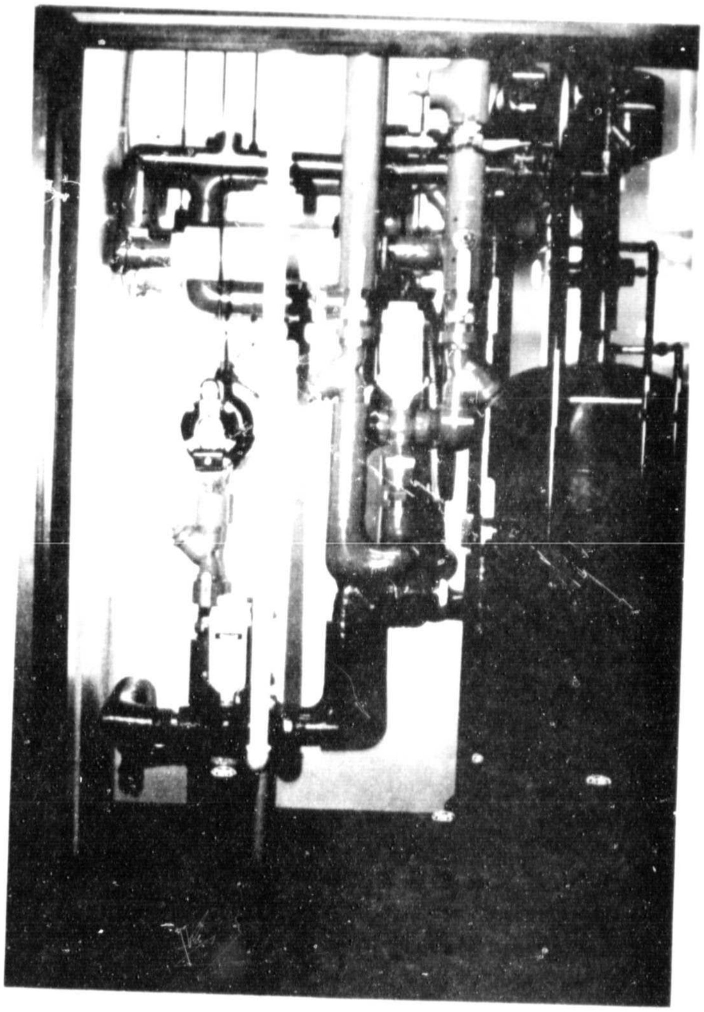
Heating Coil: A 4 row - 15 fins/in air-to-water heating coil is mounted in the return air upstream of the electric heating coil.



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

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

... REA 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	Time Required Min
Heat Exchanger Glycol-Htg. Water	HX3	R & RPL	*	
.				
.				
.				
.				
.				

TYPE OF ACTION CODES: Adjustment ADJ Repair R Replacement RPL

. 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

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

. COST 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
		×		=	
		×		=	
		×		=	

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 12/11/79	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"

☒ P_G DISCHARGE (GLYCOL LOOP) ☐ P_W DISCHARGE (WATER LOOP)		☐ DOMESTIC WATER HEAT EXCHANGER (GLYCOL SIDE) ☐ COLLECTORS				DATE: 12/12/79	BY: GGF
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"

☐ P_G DISCHARGE (GLYCOL LOOP) ☑ P_W DISCHARGE (WATER LOOP)		☐ DOMESTIC WATER HEAT EXCHANGER (GLYCOL SIDE) ☐ COLLECTORS				DATE: 12/12/79	BY: 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"

☐ P_G DISCHARGE (GLYCOL LOOP) ☐ P_W DISCHARGE (WATER LOOP)	☑ DOMESTIC WATER HEAT EXCHANGER (GLYCOL SIDE) ☐ COLLECTORS	DATE: 12/13/79	BY: GGF

COLLECTORS		1	2	3	4	5	6
CIRCUIT SETTER SIZE	1½"						
SETTING	60						
PRESSURE DROP (FT. H_2O)	.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"

☐ P_G DISCHARGE (GLYCOL LOOP) ☐ P_W DISCHARGE (WATER LOOP)		☐ DOMESTIC WATER HEAT EXCHANGER (GLYCOL SIDE) ☑ COLLECTORS				DATE: 12/13/79	BY: GGF
COLLECTORS		1	2	3	4	5	6
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_2O)		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

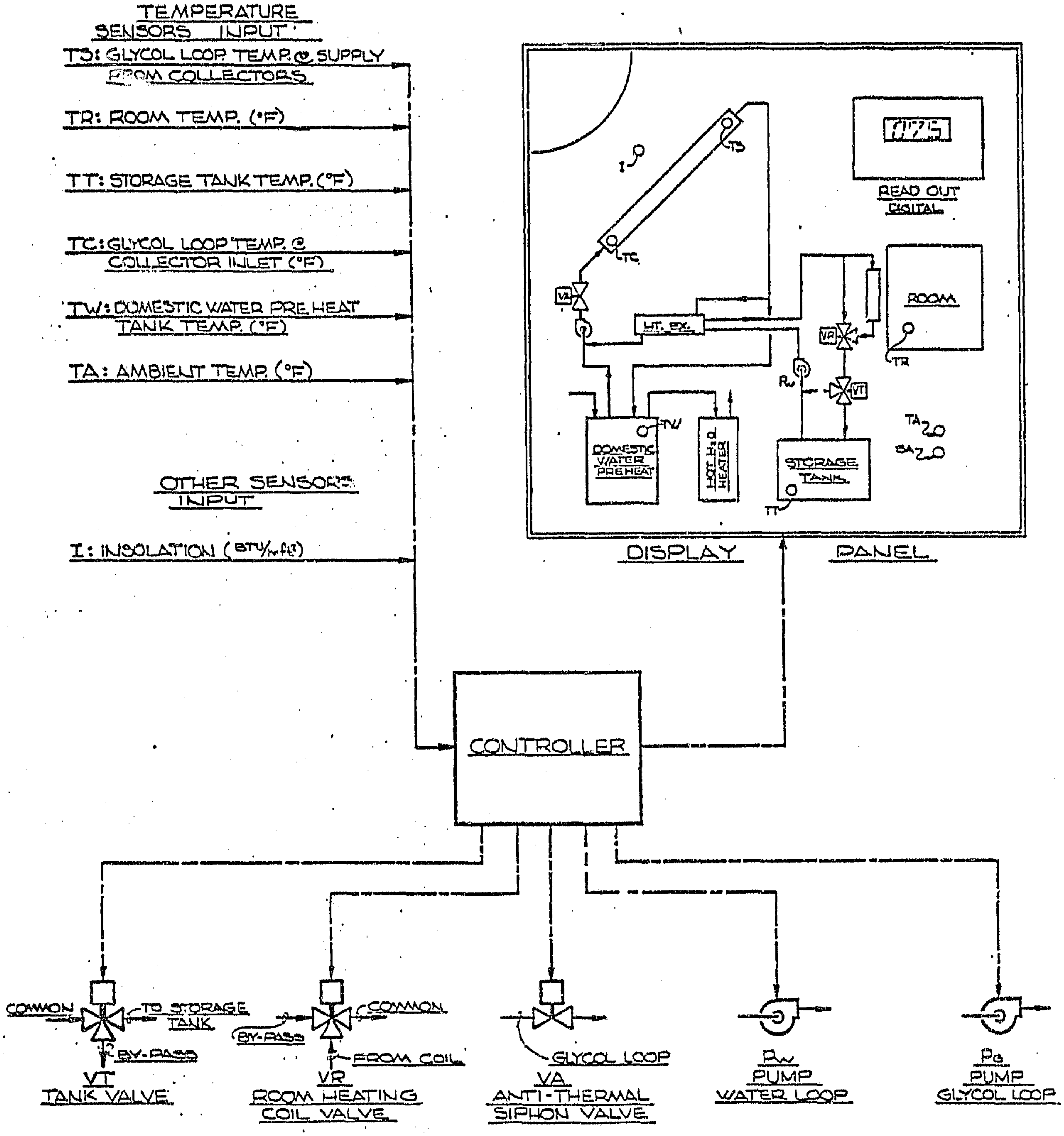
COMMENTS:

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.



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 CONTRIBU-TION	SOLAR SUPPORTING DOMESTIC H_2O PREHEAT	NO SOLAR SYSTEM CONTRIBU-TION	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. ($Btu/hr.ft^2$)

SA: Array Efficiency. This output is actually the energy being harvested from the collector array in Btu/hr. ft^2 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:

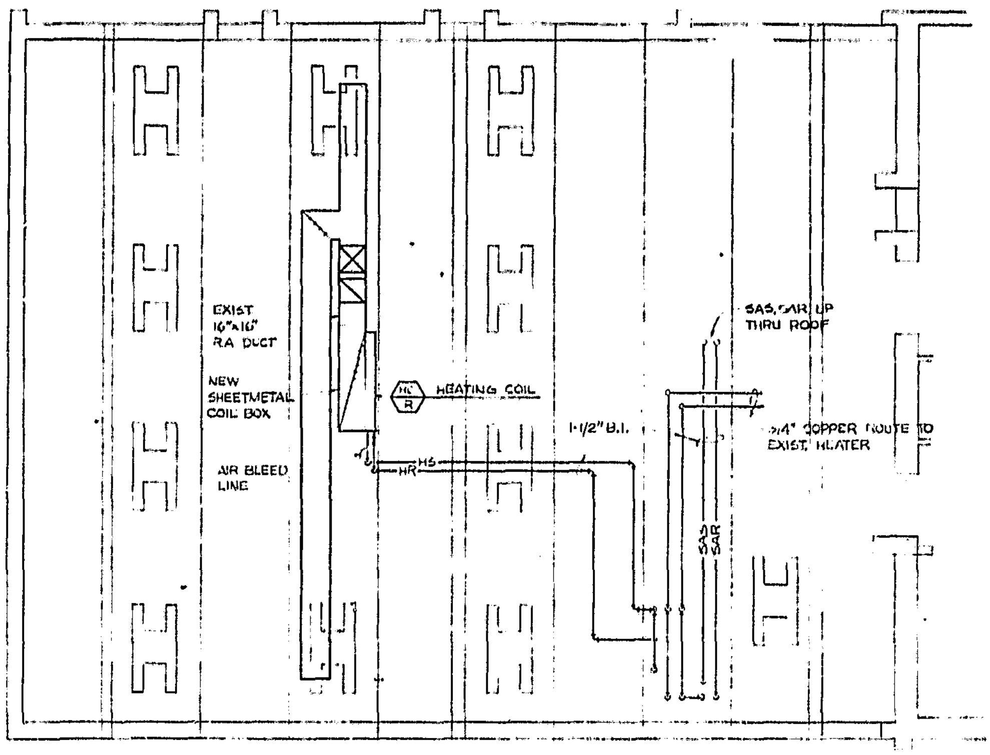
1) Ability to deliver energy from the collectors to the room.

2) Ability to deliver energy from the collectors to the storage tank.

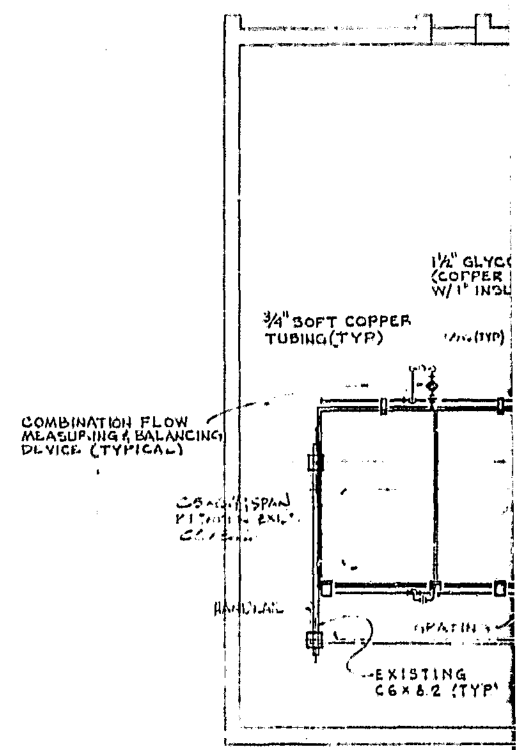
3) Ability to deliver energy from the collectors to the preheat tank.

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.



PLENUM PLAN



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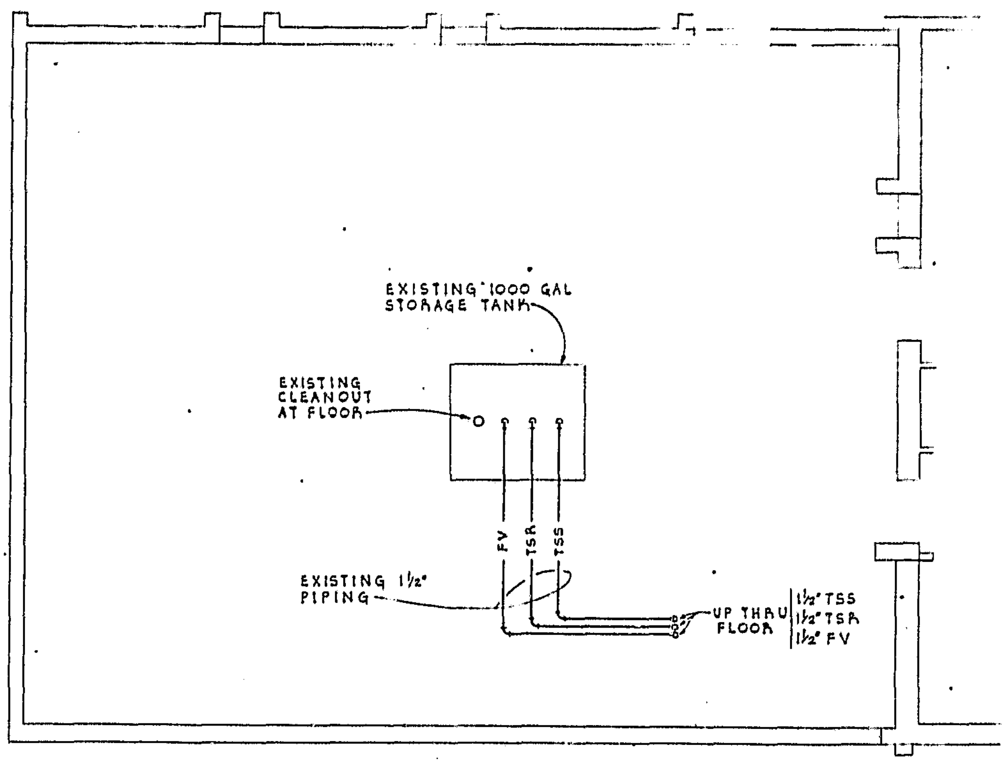
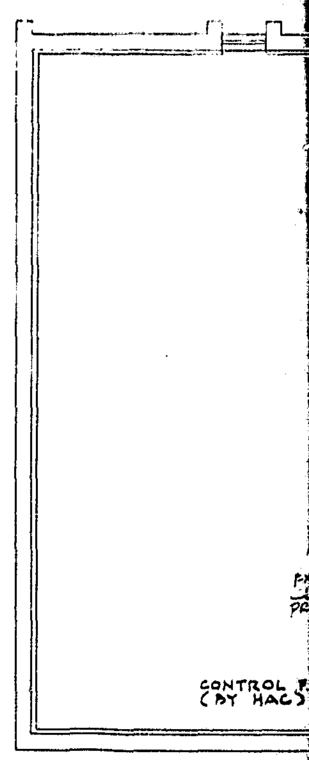
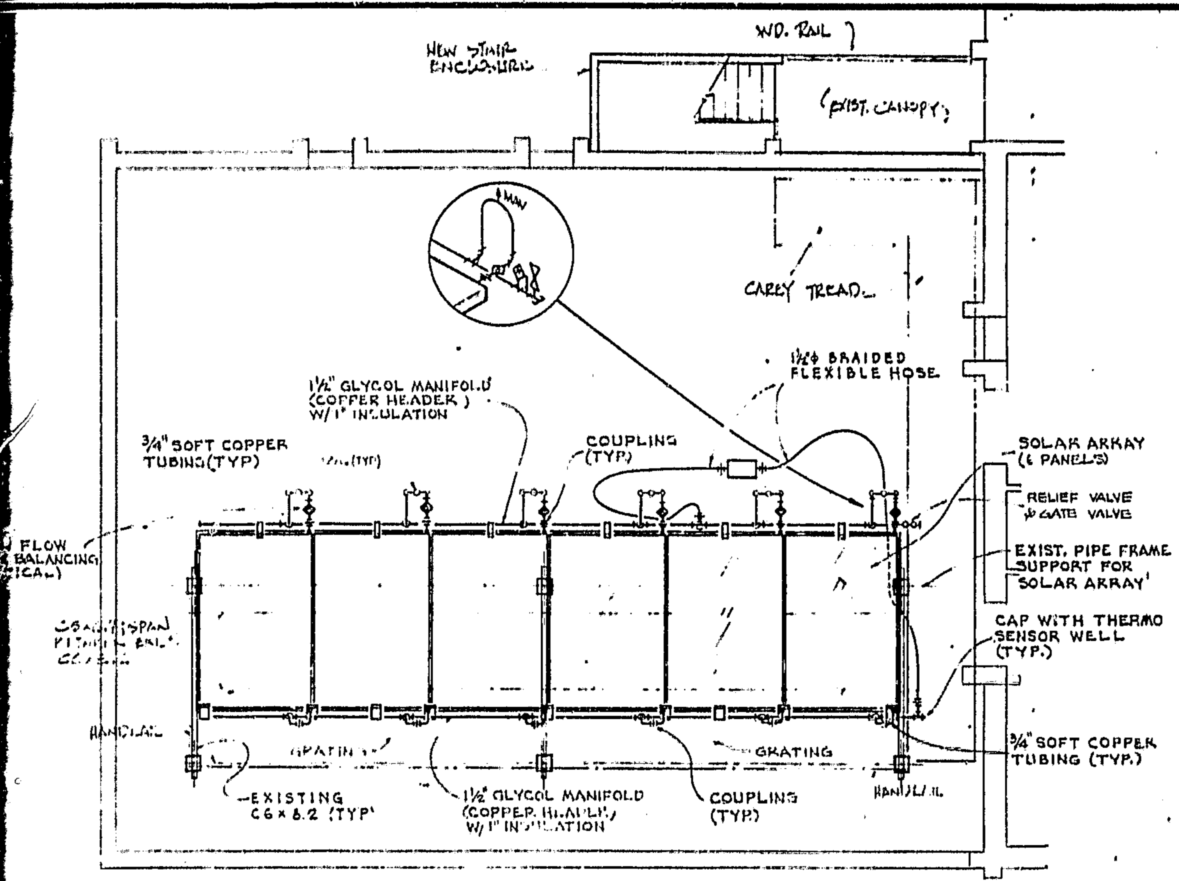


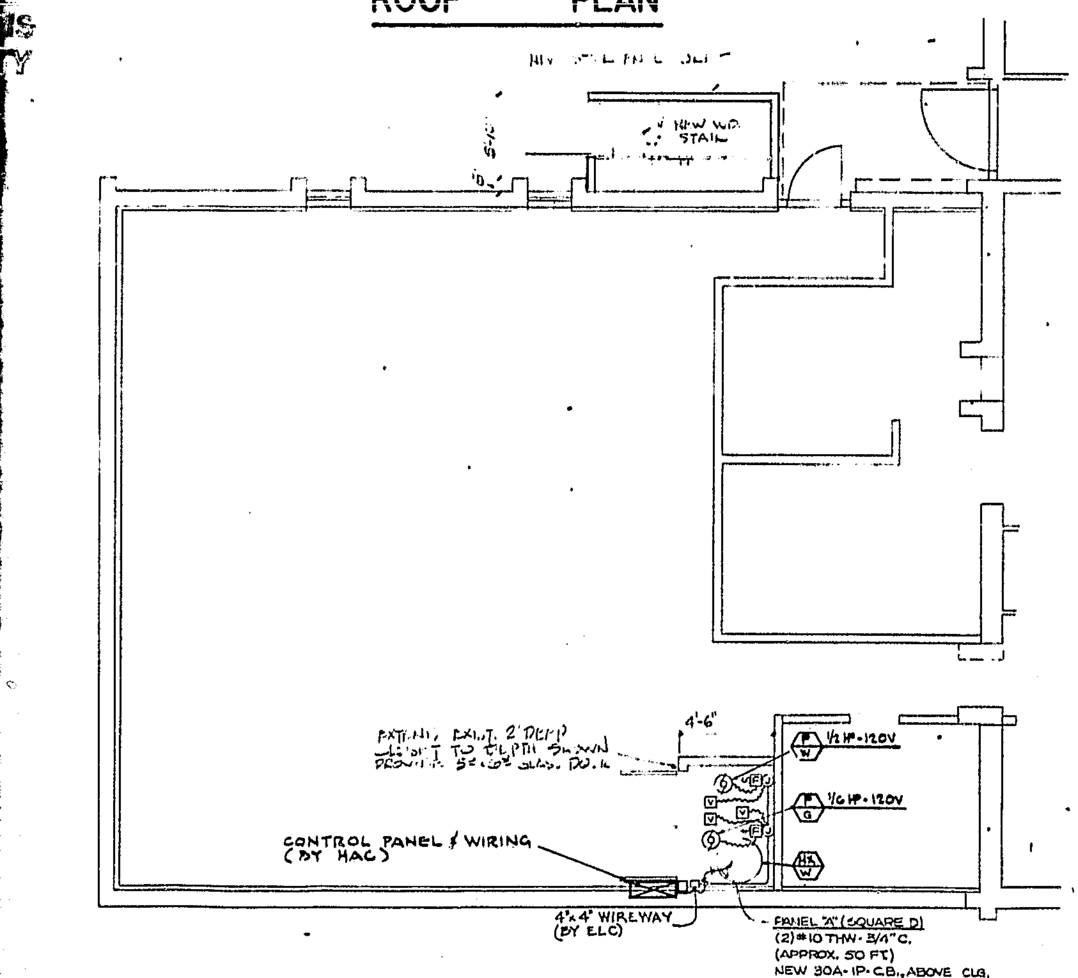


UNDERFLOOR PLAN

FOLDOUT FRAME



ROOF 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:

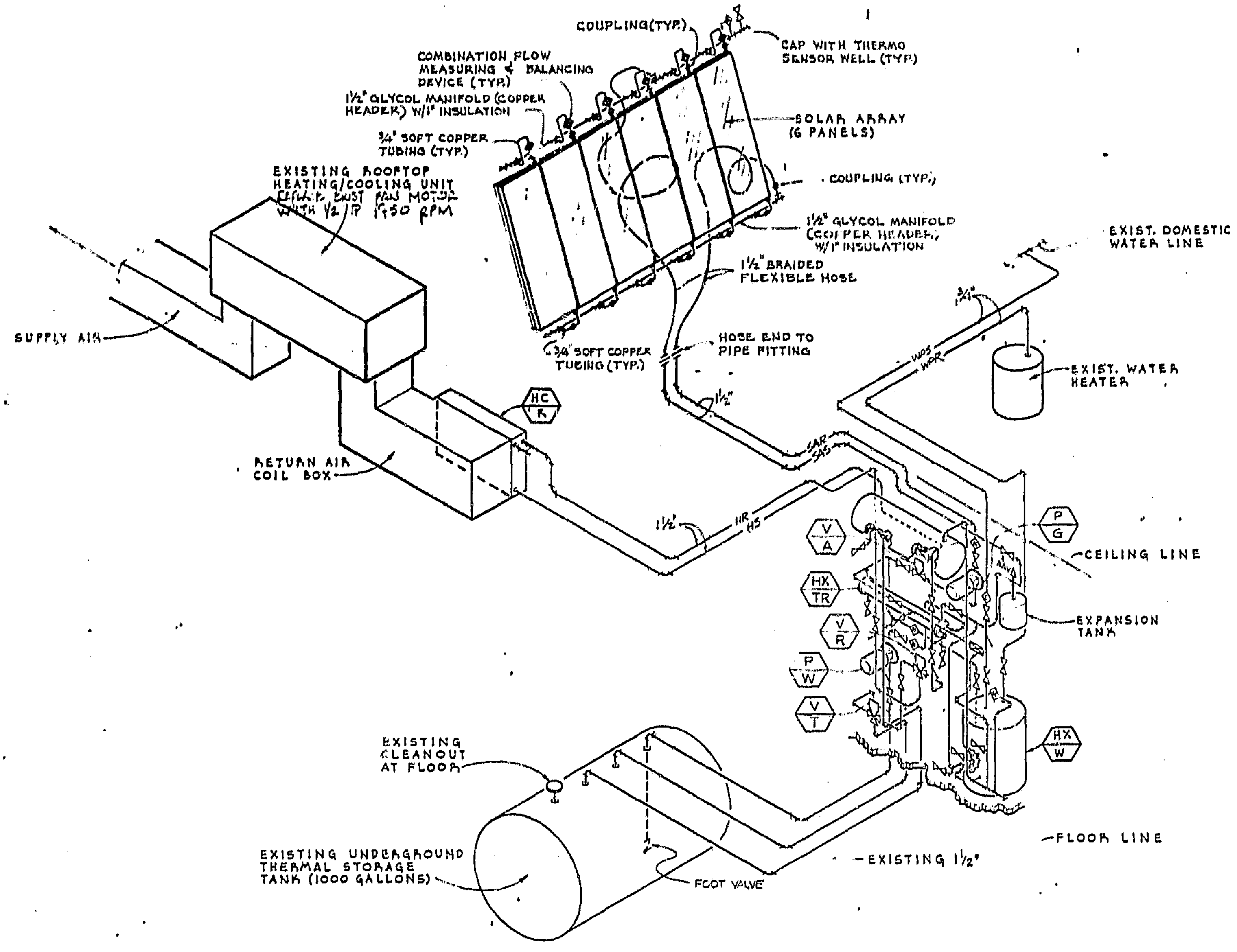
- MOTOR
- ELECTRIC ACTUATED VALVE
- CONTROL PANEL
- HOME RUN CONDUIT
- CONDUIT
- FLEX CONDUIT
- FUSE
- JUNCTION BOX
- SWITCH

FOLDOUT FRAME 2

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

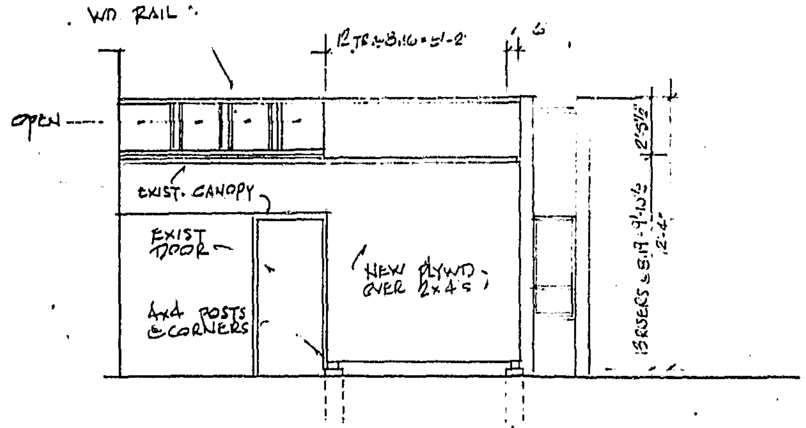
WT 7732A

RRJ
REL



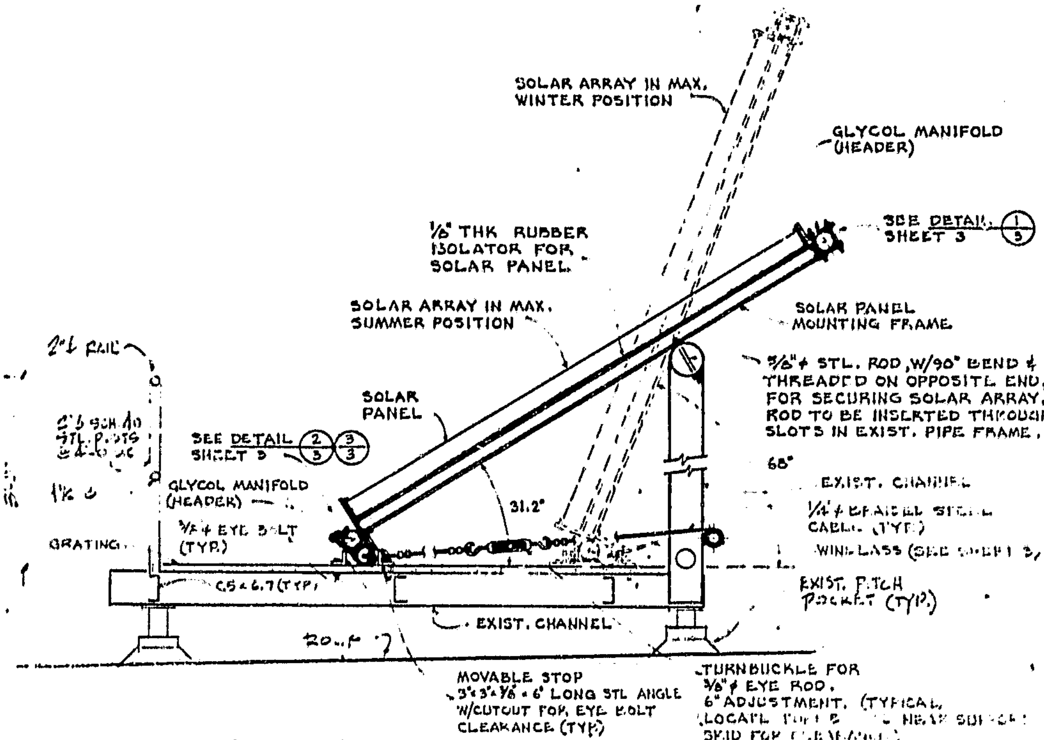
SYSTEM PIPING SCHEMATIC

NO SCALE

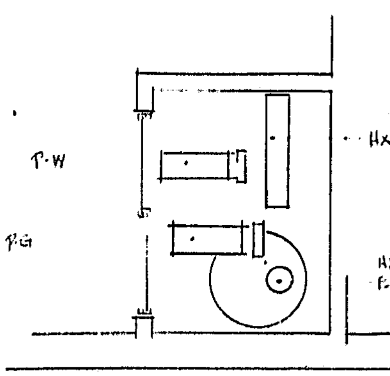


PARTIAL NORTH ELEVATION SHOWING ENCLOSURE OF NEW STAIR

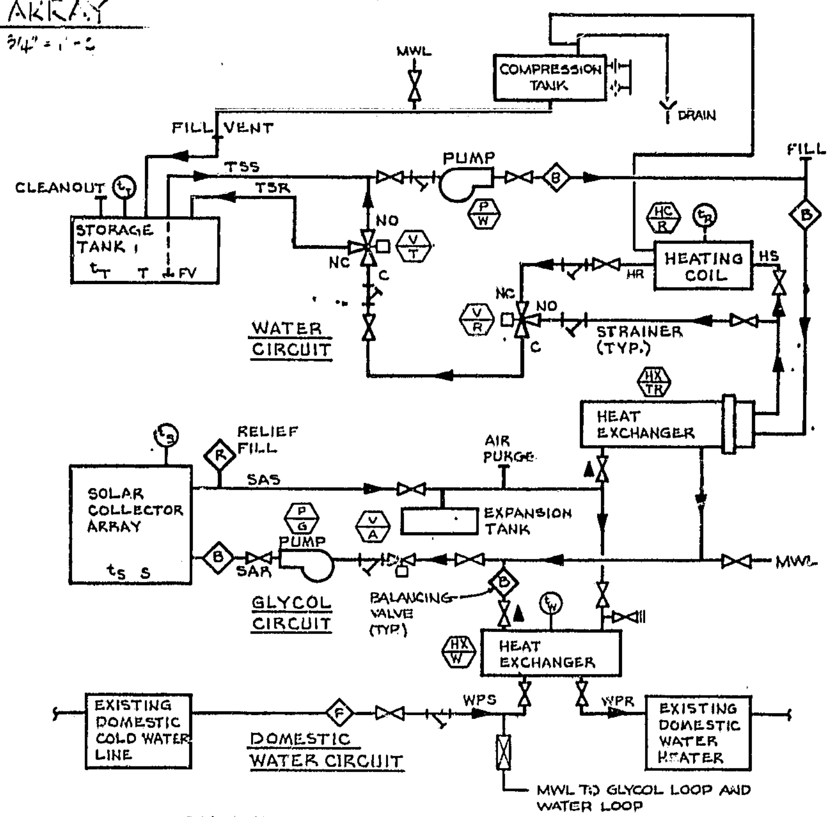
1/4" = 1'-0"



SECTION THROUGH ARRAY
3/4" = 1'-0"



APPROX. LOCATIONS OF MAJOR EQUIP.
1/2" = 1'-0"

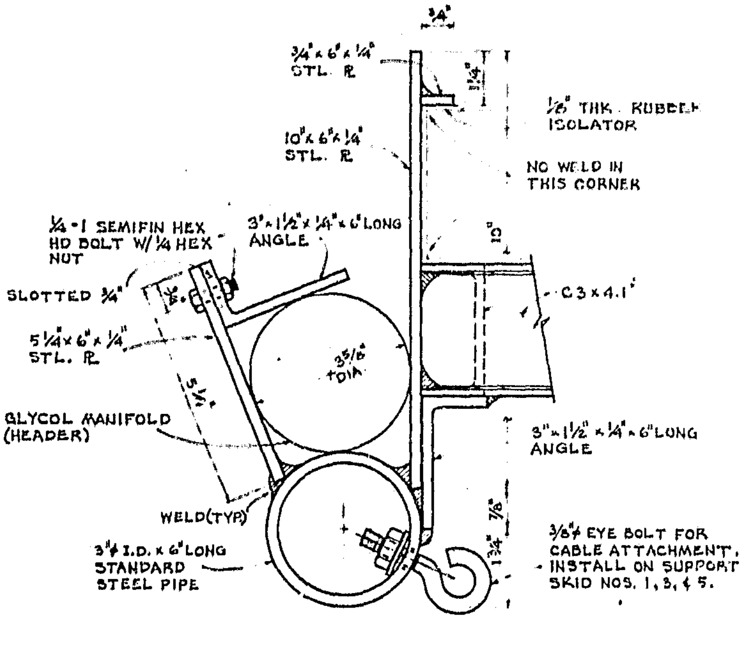


SYSTEM FLOW SCHEMATIC
NO SCALE

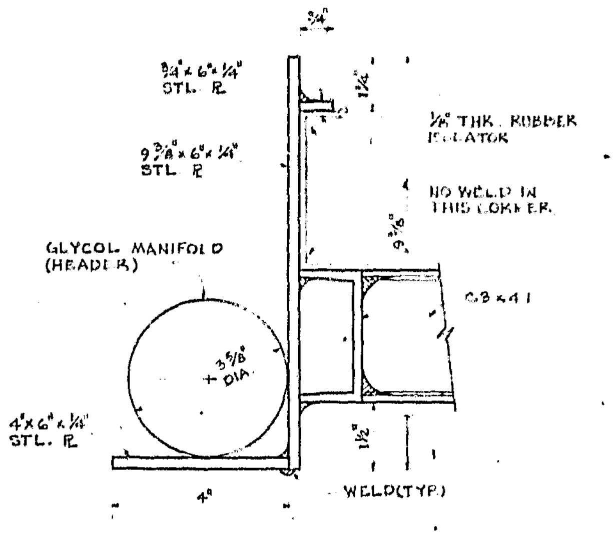
REVISIONS	SOLAR SPACE HEATING AND HOT WATER SYSTEM
DEC. 29, 1977 NOV. 7, 1979 Corrections as built	STATE OF MISSOURI WILLIAM K. Y. TAO NUMBER E-707 REGISTERED ENGINEER DETAILS

WT 7732A

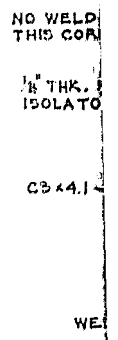
FOLDOUT FRAME 2



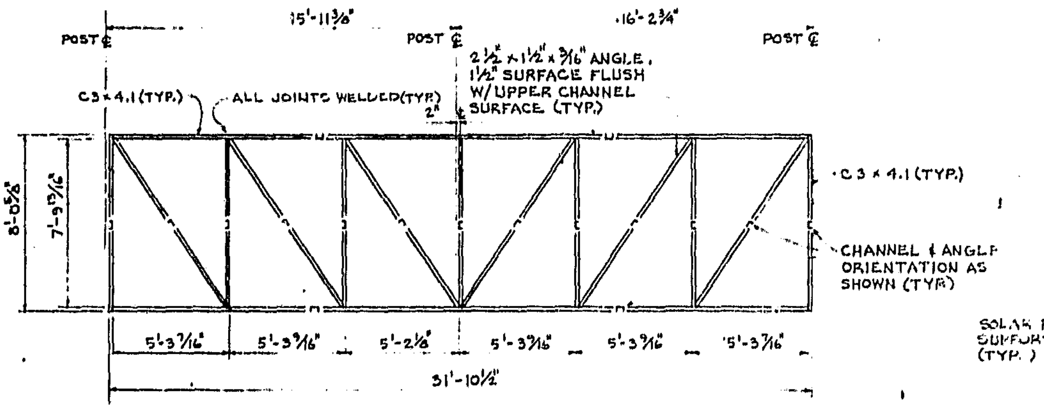
SUPPORT SKID DETAIL (2/3)
HALF SCALE



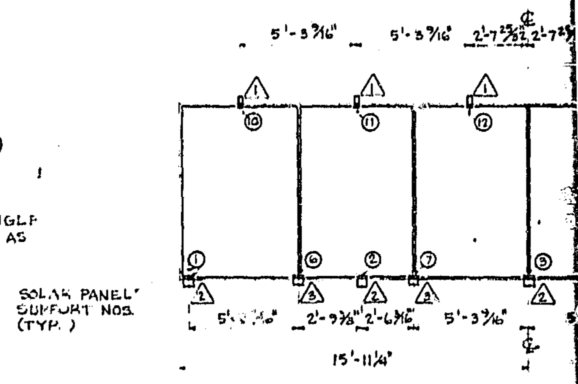
SOLAR PANEL
RETENTION CLIP DETAIL (3/3)
HALF SCALE



UPP
HALF

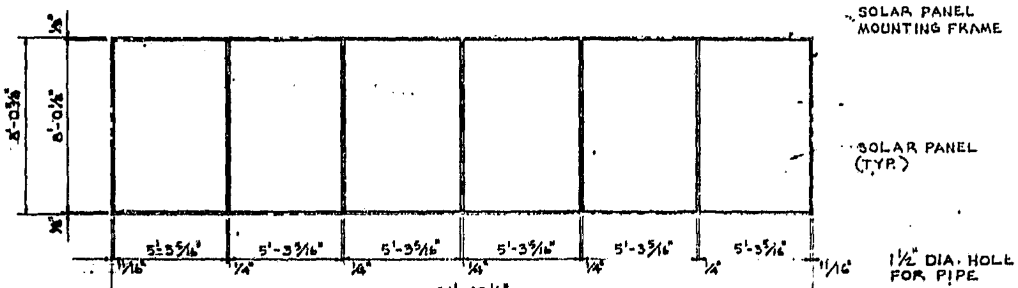


SOLAR PANEL MOUNTING FRAME
SCALE: 1/4" = 1'-0"

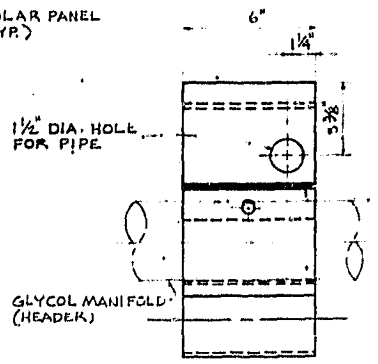


NOTES:
1. UPPER CLIP ASSEMBLY, S
2. SUPPORT SKID, SEE DET
3. SOLAR PANEL RETENTIO

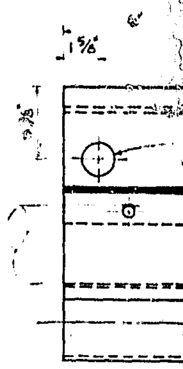
SOLAR PANEL SUPPORT
SCALE:



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



SUPPORT SKID NO. 5

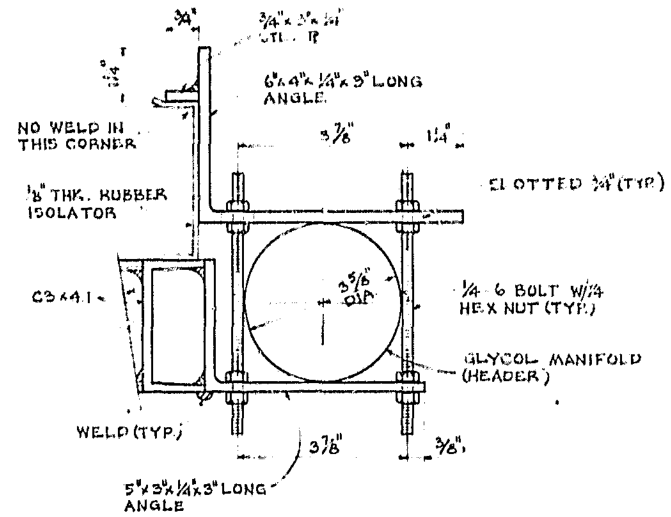


SUPPORT SK

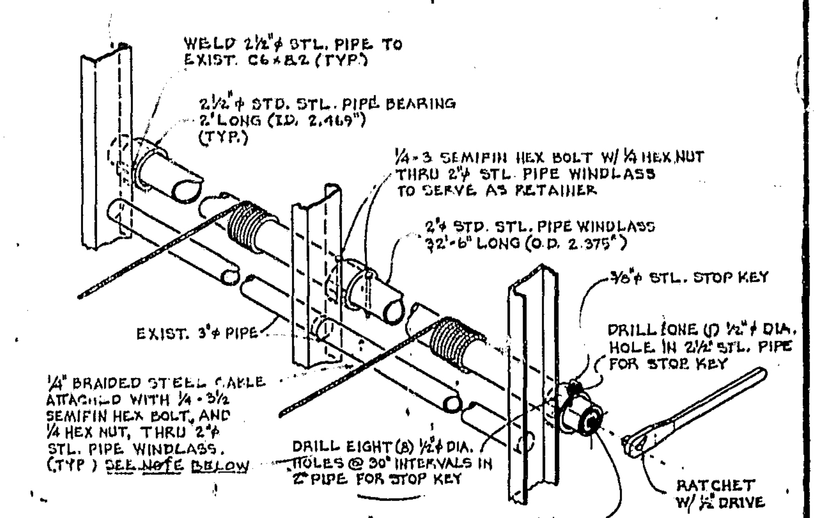
NOTE: ONLY SUPPORT SKID NO
RETENTION CLIPS HAV

FRONT VIEW - SOLAR PANE
QUARTER SCALE

FOLDOUT FRAME

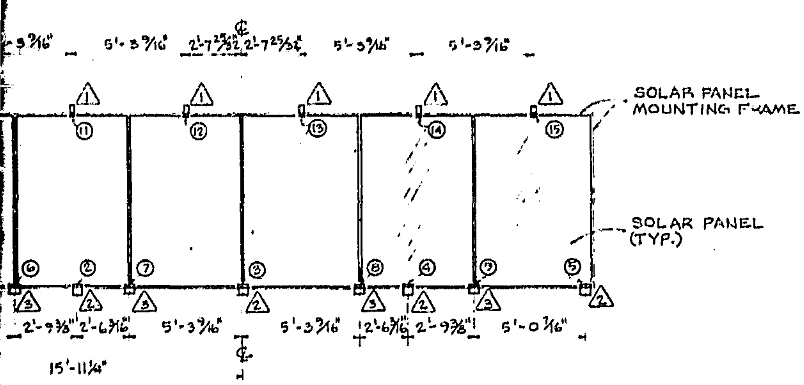


UPPER CLIP ASSEMBLY DETAIL (1/3)
HALF SCALE



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.

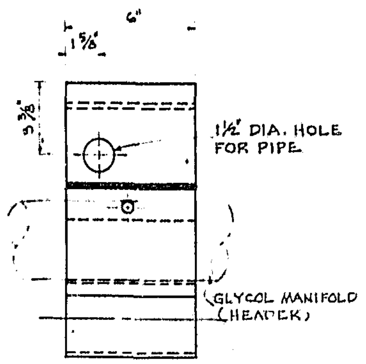
WINDLASS MOUNTING ARRANGEMENT
NO SCALE



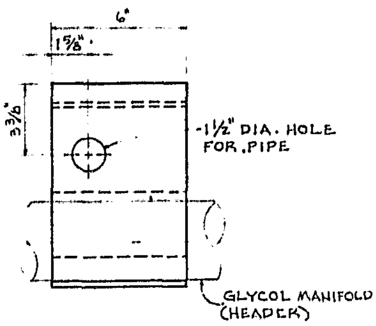
NOTES:

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

OLAR PANEL SUPPORT LOCATIONS
CALE: 1/4"=1'-0"



SUPPORT SKID NO. 3



RETENTION CLIP NOS. 6-9

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

NT VIEW - SOLAR PANEL SUPPORTS - HOLE LOCATIONS
TER SCALE

FOLDOUT FRAME 2

REVISIONS	SOLAR SPACE HEATING AND HOT WATER SYSTEM
DEC. 29, 1977	WILLIAM K. Y. TAO NUMBER E-7076 PROFESSIONAL ENGINEER — DETAILS

WT 7732A

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

NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING

BUILDING DESCRIPTION

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

4 DEMONSTRATION PROJECT LOCATION

Name William Tao & Associates, Inc.
Street 2357 59th Street
City St. Louis State MO Zip 63110

5 CONTRACTOR NAME AND ADDRESS

Name William Tao & Associates, Inc.
Street 2357 59th Street
City St. Louis State MO Zip 63110
Small Business No ☐ 0 Yes ☒ 1

PROJECT MANAGER	TELEPHONE NO.
Richard Lampe	(314) 644-1400

6. A&E CONTRACTOR NAME AND ADDRESS

Name William Tao & Associates, Inc.
Street 2357 59th Street
City St. Louis State MO Zip 63110
Small Business No ☐ 0 Yes ☒ 1

PROJECT MANAGER	TELEPHONE NO.
Richard Lampe	(314) 644-1400

7 OWNER NAME AND ADDRESS

Name William Tao & Associates, Inc.
Street 2357 59th Street
City St. Louis State MO Zip 63110
Telephone No. (314) 644-1400

8 BUILDING OCCUPANCY

A. Residential ☐ R Commercial ☒ C
B. Type (See Table 1) 5 Enter Code/Describe
C. Category (See Table 2) 5 Enter Code/Describe

9. GENERAL CHARACTERISTICS

A. Latitude 38.7 °N
B. Longitude 90.4 °W
C. Altitude 500 Feet

D. Normal Cooling Days 1475 °F Days/Yr
E. Cooling Hours/Year 1000 (Per ASHRAE)
F. Normal Heating Days 4900 °F Days/Yr
G. Heating Degree Days for January 1026

H. Front of Building Faces (Circle One) N NE NW SE S SW E W — E

I. Design Monthly Avg. Wind Direction (Circle One) N NE NW SE S SW E W — NW

J. Design Monthly Avg. Wind Velocity 11.8 MPH

AVG. TOTAL HORIZONTAL SOLAR RADIATION FOR:
K. January Not monitored in St. Louis area ____ BTU/FT² Day
L. July ____ BTU/FT² Day

HEATING DESIGN TEMPERATURES
M. Outdoor for 97.5% 8 °F
N. Indoor 72 °F

COOLING DESIGN TEMPERATURE:
O. Outdoor for 2.5% 95 °F
P. Indoor 75 °F
Q. Outdoor Dew Point 78 °F

DESIGN SHADED GLASS AREA
R. Heating Season 25 FT²
S. Cooling Season 25 FT²

10. INTEGRATION OF SOLAR SYSTEM

Concurrently with Bldg Design ☐ ND
Occurred After Bldg was Designed ☒ AD
Retrofit into an Existing Bldg ☐ RF ____*

*Original building completed in (year

NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING

BUILDING DESCRIPTION

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
Electical	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^2

Using Solar Energy 900 FT^2

D. Exterior Wall Geometry (Total Area)

Walls 1240 FT^2

Door Openings 25 FT^2

Windows 25 FT^2

E. Roof

Flat [ ] FL

Sloped [X] SL Pitch Angle 1.3 °

F. Attic: Ventilated No [X] 0 Yes [ ] 1

G. Crawl Space: Vented No [X] 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 [X] I

Other(Specify)__________

C. System Designation _____ (See Table 4)

D. Principle of Operation (Check One)

Heating-Cooling-Off [X] 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 [X] AC

Cooling Tower [ ] CT

Other(specify)__________

F. Energy Conservation and Recovery Devices [illegible] (See Table 5)

G. System Operating Temperature Set Points

	Heating: °F	hrs/day	Cooling: °F	hrs/day
Day	72	9	75	9
Night	65	15	85	15
Weekend	65	24	85	24

NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING

BUILDING DESCRIPTION

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

1⁻. TYPE OF PREDICTIVE MODEL USED

- Performance Calculations [X] PC
- Steady State [ ] SS
- Transient [ ] TR
- Analytic model designation ______

18. SIMULATION TIME PERIOD

- Hourly [ ] H
- Daily [ ] D
- Monthly [X] M
- Other (specify) ______

PREPARED BY:

Richard R. Janis 12/29/77

NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING

SOLAR SYSTEM DESCRIPTION

ORIGINAL PAGE IS OF POOR QUALITY

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

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 Concentrators*
   D. Liquid, passive
      Function ______ (Table 5)
      Type: Thermosyphon ____ SYPHON
         Evaporator ____ EVAP
         Liquid Bag ____ LIBAG
         Other (specify) ______
   E. Combined Systems (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. ______

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 thes collectors is new, write in the description and complete Collector Subsystem Description form for each collector type

   C. Orientation (Based on True N)
      X Due S
      ____ °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
      Seperate Structure ☐ S
      Other (Describe) ☐

   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^2
   H. Effective Array Aperture Area 216 FT^2

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) [illegible] 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 Ruud

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

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 Heater ☒ R Boiler ☐ B

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 4 Tons

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 DEVISES

(Please complete the Controls & Safety Devises 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.

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

4. TYPE (See Table 1) ______

5. SPECIFY (IF OTHER) Flat Plate with multiple concentrators.

6. IDENTIFICATION

Manufacturer KTA Corporation

Address 12300 Washington Ave.

City Rockville State Maryland Zip 20852

Model ID KT4-85

Model Name KTA Solar Collector

Telephone No. (301) 468-2066

7. COLLECTOR PANEL CHARACTERISTICS

A. Gross Collector Area 42 FT^2

B. Net Aperture Area 36 FT^2

C. Empty Weight 1000 Lbs

D. Full Weight 1130 Lbs

E. Length 96 In

F. Width 63 In

G. Depth 3-1/4 In

8. PASSIVE COLLECTOR HEAT TRANSFER CONTROL (See Table 2) ______

COVER PLATES

9. NUMBER OF COVER PLATES 1

10. PHYSICAL CHARACTERISTICS Length 96 IN Width 63 IN

COVER PLATE NO	MATERIAL (SEE TABLE 3)	THICKNESS IN	TRANSMITTANCE %	REFLECTANCE %
C. 1 OUTERMOST	Plastic (polyvinyl Flouride)	4 mils	93	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	Die Polished			
B. 2				
C. 3				

12. DESICCANTS

A. Desiccants Used No [X] 0 Yes [ ] 1

B. Type Silica Gel [ ] SG Anhydrous Calcium Chloride [ ] CA Other [ ]

If other, specify ______

NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING

COLLECTOR SUBSYSTEM DESCRIPTION

(COMPLETE FOR EACH COLLECTOR TYPE)

ABSORBER

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

4. PHYSICAL PROPERTIES
    - A. Substrate Material (SEE TABLE 5A): Copper
    - B. Alloy Designation Generic Type: ______
    - C. Thickness ______ IN
    - D. Coating (See Table 5B): Cu_2O
    - E. Method of Application (SEE TABLE 5C): ______
    - F. Absorptance ______ %
    - G. Reflectance ______ %

15. HEAT TRANSFER FLUID PASSAGE CHARACTERISTICS
    - A. Material (See Table 5A): Copper
    - 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			
	LAYER 2			
BACK	LAYER 1			
	LAYER 2			

18. PHYSICAL PROPERTIES OF INSULATION

LOCATION		MATERIAL (SEE TABLE 7)	THICKNESS IN	DENSITY LB/FT^3	R VALUE
SIDES	LAYER 1				
	LAYER 2				
BACK	LAYER 1	Polyurethane	1"		[illegible]
	LAYER 2				

NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING

COLLECTOR SUBSYSTEM DESCRIPTION

(COMPLETE FOR EACH COLLECTOR TYPE)

.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					

0. SEALANTS SPECIFICATIONS

LOCATION	TYPE (See Table 8)	MANUFACTURER	NAME	ID NO
A. Inner Cover Plate	Hermatic	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) Glass
    - B. Alloy/Generic Type ______
    - C. Reflective Surface (See Table 9B) not available
    - D Protective Coating (See Table 6B) ______
    - E. Shape
        - Flat [ ] F
        - Cylinder [X] 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) ______

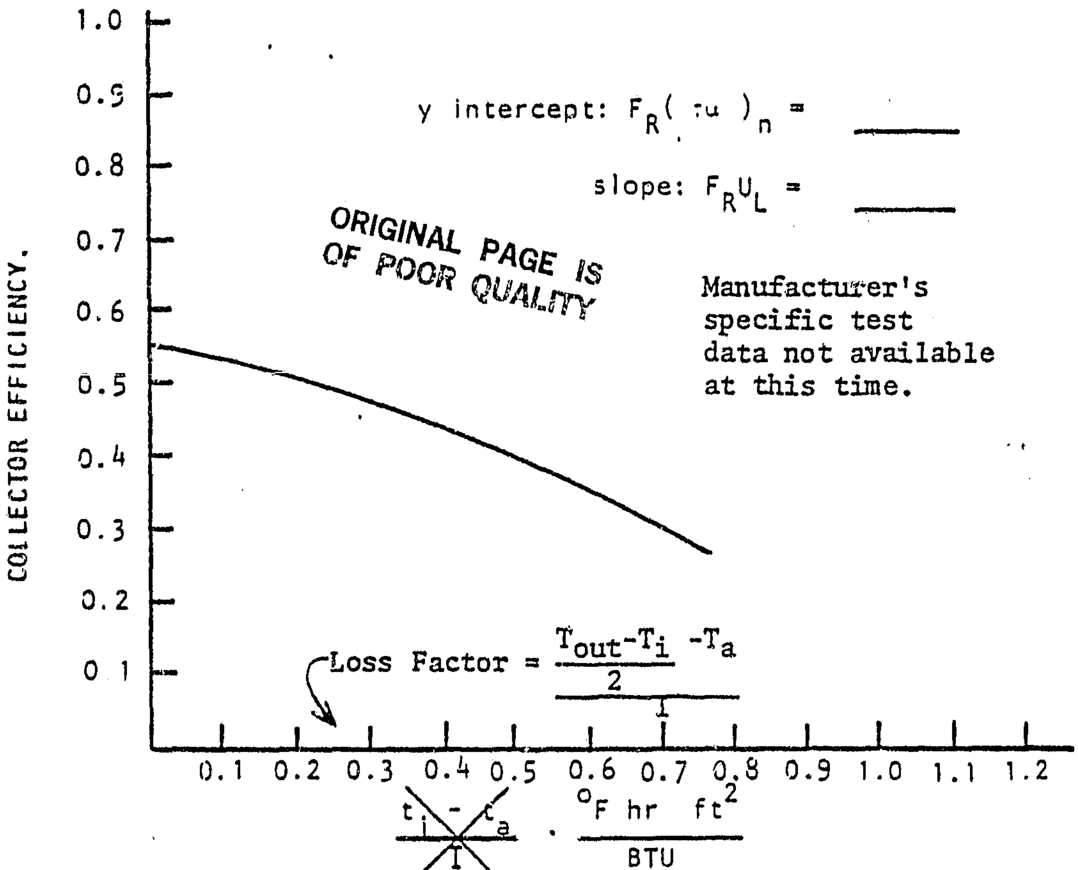
NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING

COLLECTOR SUBSYSTEM DESCRIPTION

(COMPLETE FOR EACH COLLECTOR TYPE)

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 efficience 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 Mimimum Property Standands for Solar Heating and Domestic Hot Water Systems, NBS.



t_{i_1} = ____

t_{i_2} = ____

t_{i_3} = ____

t_{i_4} = ____

t_{a_1} = ____

t_{a_2} = ____

t_{a_3} = ____

t_{a_4} = ____

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.ft²

A. Design Mass Flow Rate .03 ~~Lb/Hr-Ft²~~ GPM/Ft² Ft³/Ft²-MIN

B. Backside Thermal Loss ____ BTU/Hr-Ft²-°F

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

1. TYPE OF ENERGY TRANSPORT — Liquid [X] 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^3
   - 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 [X] 0 — Yes [ ] 1
   - L. If Yes, Manufacturer ______
   - M. Product Name ______
     ID Number ______
   - N. Inhibitor — No [ ] 0 — Yes [X] 1
   - O. Generic Type Inhibited Glycol
   - P. % of total weight 40 %
   - Q. Potable — No [X] 0 — Yes [ ] 1

7. RIGID PIPING/MANIFOLD
   - A. Material (Table 2A) [illegible]
   - 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 [X] M
   - B. Generic Type/Alloy Soft copper
   - C. Reinforcement: Glass Fiber [ ] G — Fabric [ ] F — Metal Wire [ ] M — None [X] 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 [X] 1
   - B. Material (Table 4) Fiberglass with
     Other (specify) aluminum jacket
   - C. Thickness 1 IN
   - D. Density ______ Lb/Ft^3
   - E. Thermal Resistance .34 R VALUE

10. EXTERIOR FINISH (Table 5)
    Generic Name, if any [illegible]

11. LOCATION
    - Below Grade [ ] BG
    - Above Grade [X] 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)

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/Ft3
   D. Thickness of ducting material ______ IN
8. FLEXIBLE DUCTING.
   A. Material ______ (See codes below)
   B. Generic Type ______

9. DUCT INSULATION
   Internal (Duct Liner)
   A. Insulated No ☐0 Yes ☐1
   B. 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 ☐1
   G. 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 ______

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

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)

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
1	CE	12	1/6	125	N
2					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			
2					
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	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
BLEED	BL	BALL	BA			SPLITTER	SP

NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING

ENERGY TRANSPORT SUBSYSTEM DESCRIPTION

(COMPLETE FOR EACH CIRCULATION LOOP)

7. HEAT EXCHANGERS

A. NUMBER OF HEAT EXCHANGERS 1

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

HX NO	Type of Exchange	Type of Flow	HX Design: Enter Code	HX Design: Tube Passes	HX Design: Shell Passes	No. of Walls S Single D Double
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	FIN
Air-Liquid	AL	Counter	CO	Heat Pipe	HP	Tube around Tank	TAT
Liquid-Liquid	LL	Cross	CR			Tube inside Tank	TIT

ORIGINAL PAGE IS OF POOR QUALITY

C. HEAT EXCHANGE SPECIFICATIONS (Use abbreviations given below)

HX NO	Effectiveness: %	Effectiveness: Specify Flow Conditions	Material	Alloy Designation	Overall Heat Transfer Coefficient
1	66	Warm Side: $T_i=156^oF$ $T_{out}=153^oF$, 12gpm Cool Side: $T_i=147^oF$ $T_{out}=15^oF$, 6gpm	ST		$6500\ \frac{Btu}{h-^oF}$
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)

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^3
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 ☐ I Outlet ☐ O 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 Reinforced Plastic ☐ GR
    - 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^3
    - 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)

TORAGE MEDIUM-SENSIBLE HEAT LIQUID

15. SENSIBLE HEAT LIQUID [X] 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^3

7. PHYSICAL PROPERTIES
   - A. Specific Heat 1.0 BTU/Lb/°F
   - B. Density 62.3 Lb/FT^3
   - 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 [X] 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/FT^3 of Packed Material ____ Lbs
   - C. Heat Capacity of Packed Material ____ BTU/Lb/°F
   - D. Flow Rate of Heat Transport ____ FT^3/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 ____ FT^3

17. PHYSICAL PROPERTIES
   - A. Specific Heat
     - Above Transformation ____ BTU/Lb/°F
     - Below Transformation ____ BTU/Lb/°F
   - B. Density
     - Solid Phase ____ Lb/FT^3
     - Liquid Phase ____ Lb/FT^3
   - 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) ____

PREPARED BY:

Richard R. Janis 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)   T3 < 75 deg. (adj)
T1 < T2 + 5 deg. (adj)
T1 < T3 + 5 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

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		CSF		TMD	
Temperature	TE	Thermistor	TH	Photo Cell	PH
Time	TI	Thermocouple	TC	Timer	
Solar Radiation	SR	Resistance Thermometer	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

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 (Water)	MR156 RX SRE 155 M80065
4	CFS	SV	Bell and Gossett pump both LS and CSF)	Pump (Water)	172540 797561 JU
5	LS	SV	Bell and Gossett (Note* this single	Pump (Glycol)	102210 FU Series HV
	CSF	SV	pump also both LS and CSF)	Pump (Glycol)	102210 FU Series HV

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

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

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

NO	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		

PREPARED BY:

Joseph W. Trindle 12/29/77

NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING

SOLAR SYSTEM DESIGN PROCESS REPORT

1. PROJECT IDENTIFICATION NO	2. PROJECT TITLE	3. DATE
EG-77-A-01-4085	Solar Space Heating and Hot Water System	12 - 30 - 77 (MO DAY YR)

4. DEMONSTRATION PROJECT LOCATION:

Street 2357 59th Street

City St. Louis State MO Zip 63110

5. SOLAR SYSTEM DESIGN CONTRACTOR

Name William Tao & Associates, Inc.

Project Manager Richard E. Lampe

Telephone No. (314) 644-1400

6. A & E CONTRACTOR (IF DIFFERENT FROM ABOVE)

Name ______

Project Manager ______

Telephone No. ( ) ______

7. SOLAR SYSTEM FUNCTION (CHECK ONE)

Hot Water (Domestic or Service)	☐	HW
Space Heating	☐	H
Space Cooling	☐	C
Heating & Cooling	☐	HC
Heating & Hot Water	☒	HHW
Cooling & Hot Water	☐	CHW
Heating, Cooling & Hot Water	☐	HCHW

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

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.

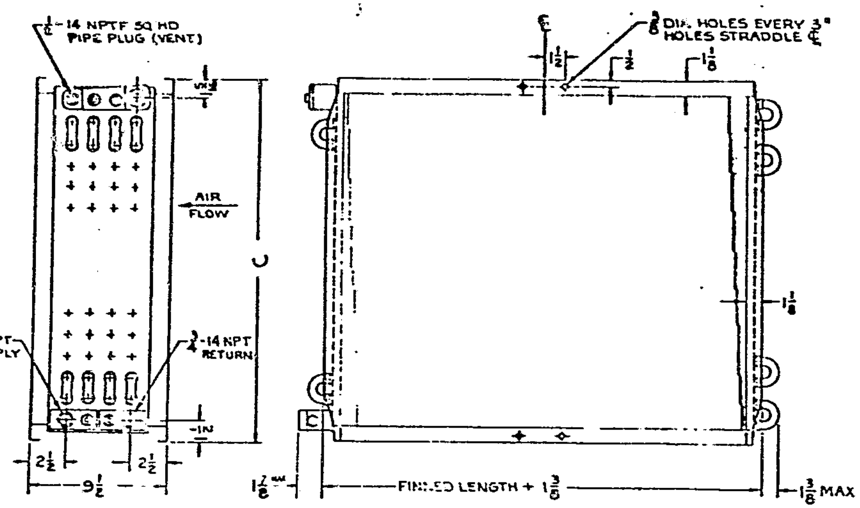
Bell and Gossett information on heat exchangers have been deleted due to copyright. For information on heat exchangers contact Bell and Gossett, 8200 North Austin Avenue, Morton Grove, Illinois 60053.

THE TRANE COMPANY LA CROSSE, WISCONSIN	B 2816 .655
	TYPE P COIL
	4-ROW 2-CIRCUIT
DR WINDER 9-21-72	CHKD STARKE 10-16-72
ENGR APPR	SCALE

REISSUE — REVISION BY — DATE

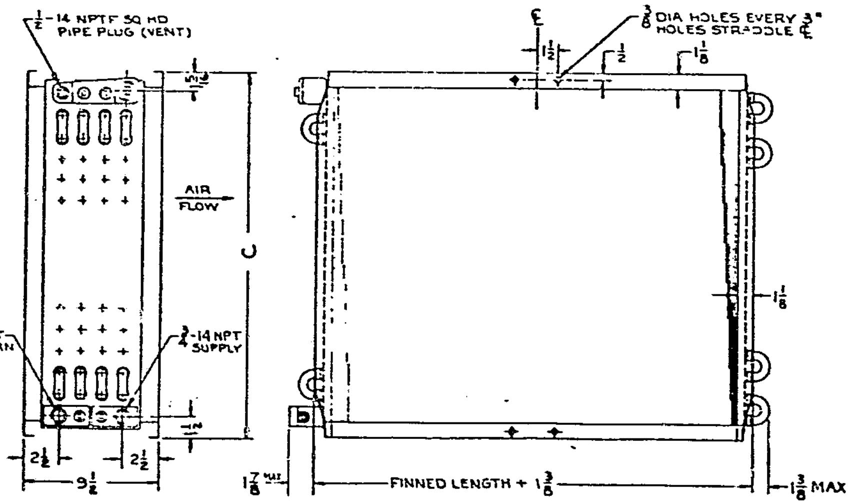
SIMILAR TO — FIRST USED ON ASSY NO — QTY REQ D — EXT — ITEM — PART NAME — MATERIAL — DRG SIZE — DRAWING PART OR MATERIAL NO

HORIZ AIR FLOW R H SUPPLY

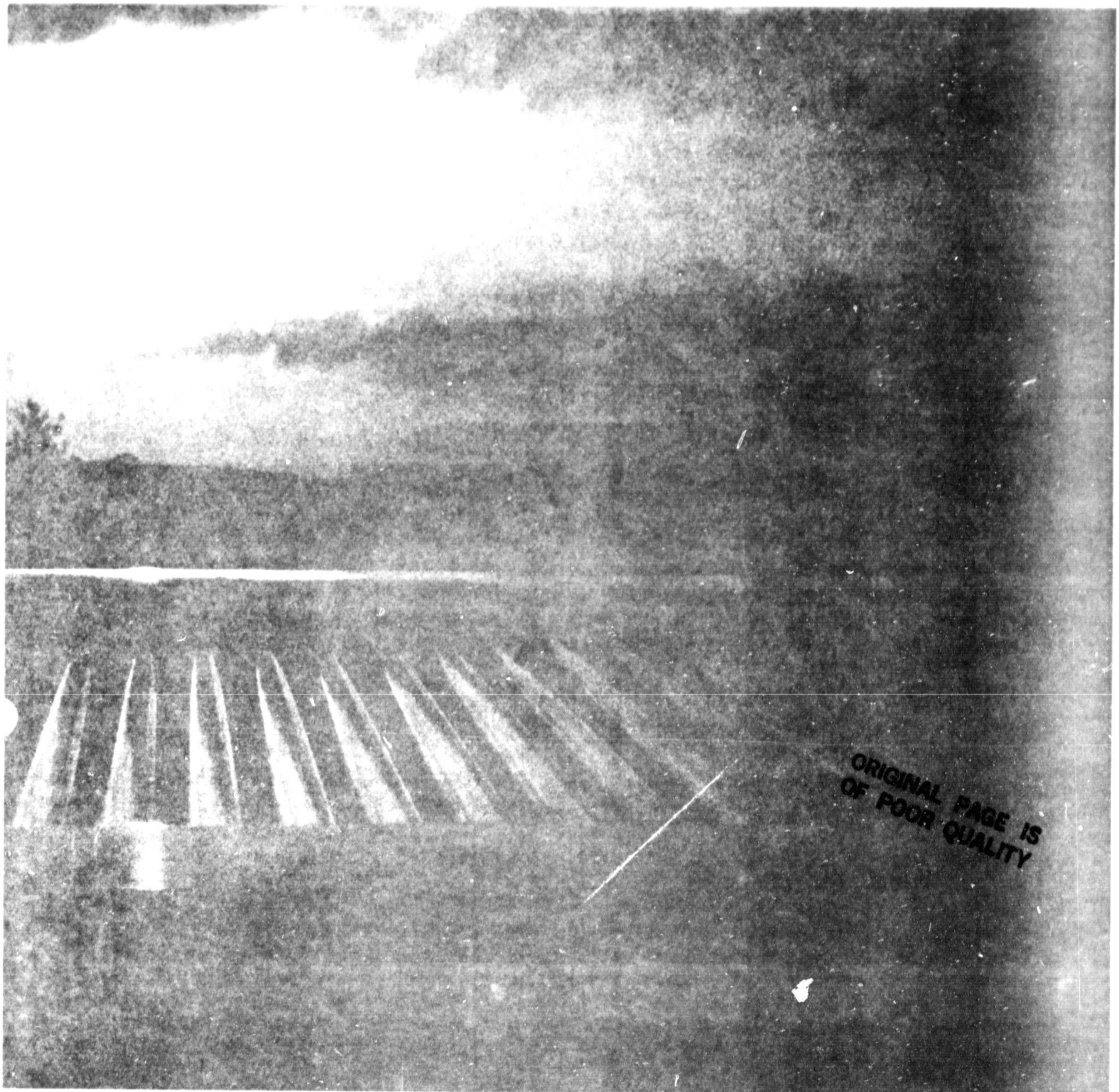


FINNED WIDTH	C	ORDER NO
12	$13\frac{1}{2}$	812 / 0305
18	$19\frac{1}{2}$	
24	$25\frac{1}{2}$	
30	$31\frac{1}{2}$	

HORIZ AIR FLOW L H SUPPLY



B 2816 .655



KTA PRODUCTS DIVISION

NPD 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.

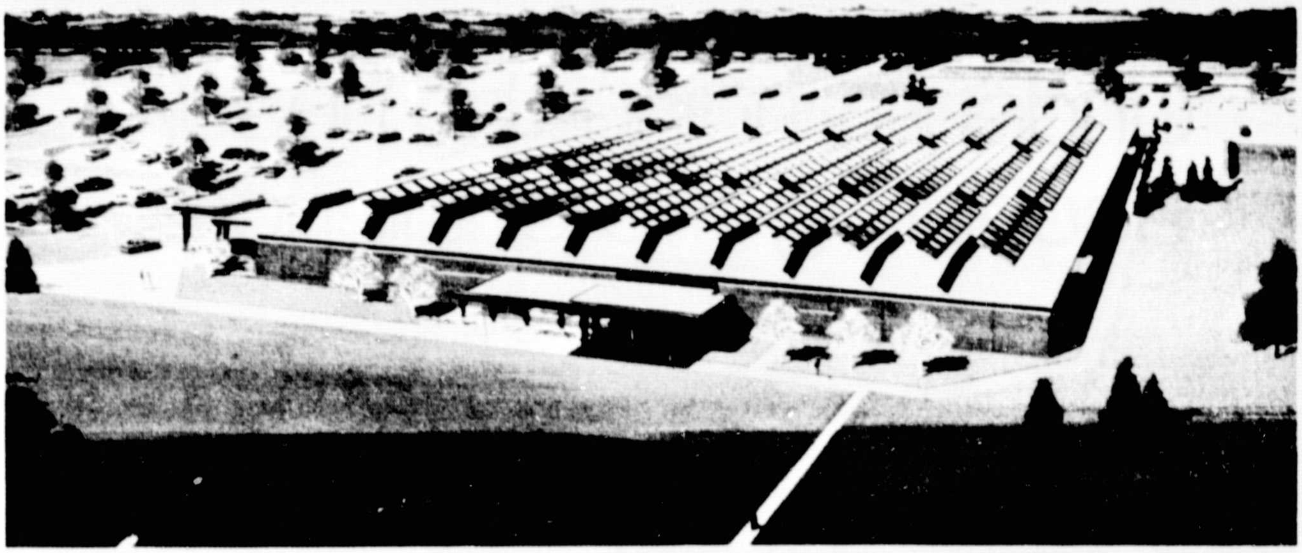
We manufacture solar collectors, environmental control systems for computer rooms, research facilities, hospitals, and schools in new construction and renovation.

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

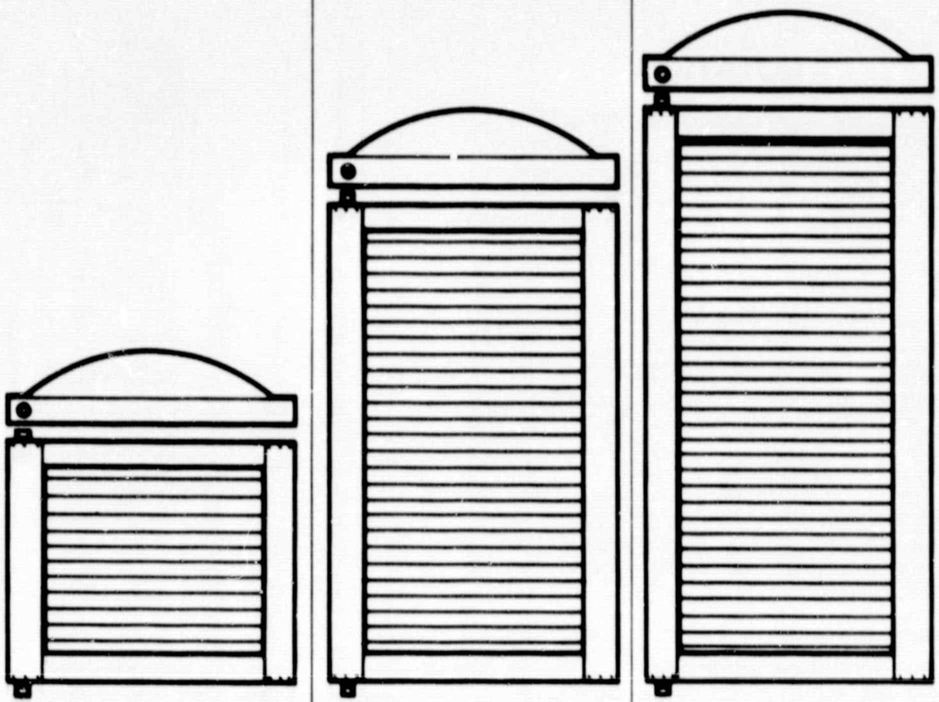
STRUCTURAL ENGINEERS/SOLAR: Abiouness, Cross & Bradshaw, Inc.
Norfolk, Virginia

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.

KTA solar collectors



	KT5-45	KT5-85	KT5-125
Aperture area:	17.8 ft²	35.6 ft²	53.4 ft²
(metric)	1.7 m²	3.3 m²	5.0 m²
Case size:	43¾″ × 63¼″ × 7⅝″	87½″ × 63¼″ × 7⅝″	131¼″ × 63¼″ × 7⅝″
(metric)	111.13 cm × 160.8 cm	222.25 cm × 160.8 cm	333.5 cm × 160.8 cm
Weight:	75 lbs	150 lbs	225 lbs
(metric)	34.1 kg	68.2 kg	102.3 kg

All connections ⅞″ 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.

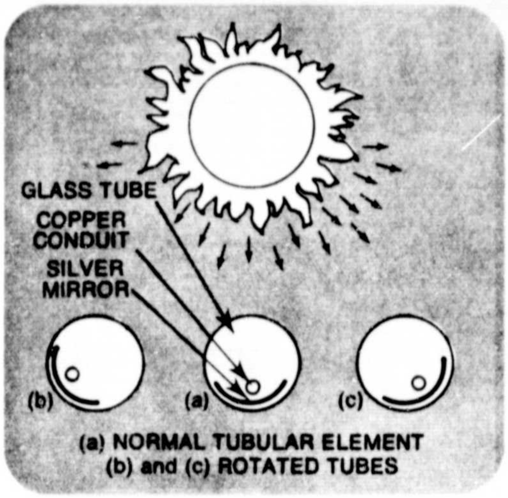
Unlike many collectors, KTA™ tubular design allows field replacement of individual elements.

Incorporated into the KTA™ design features are:

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

kta tubular elements

ROTATION



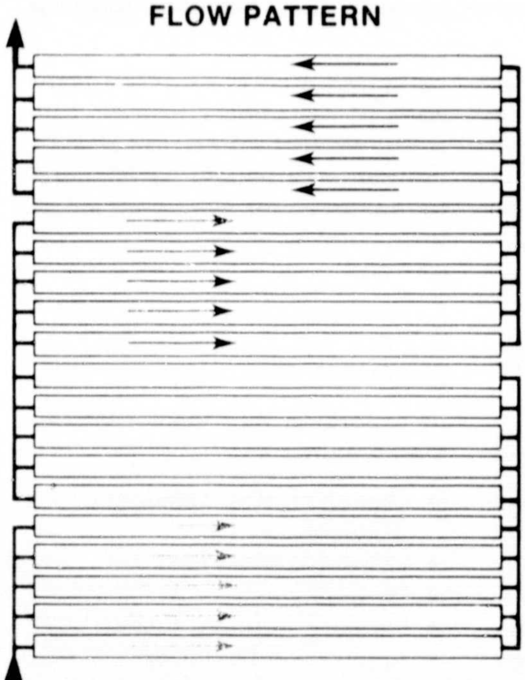
During the brazing process, these tubular concentrating elements can be "rotated" to any angle within 30° of perpendicular.

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.

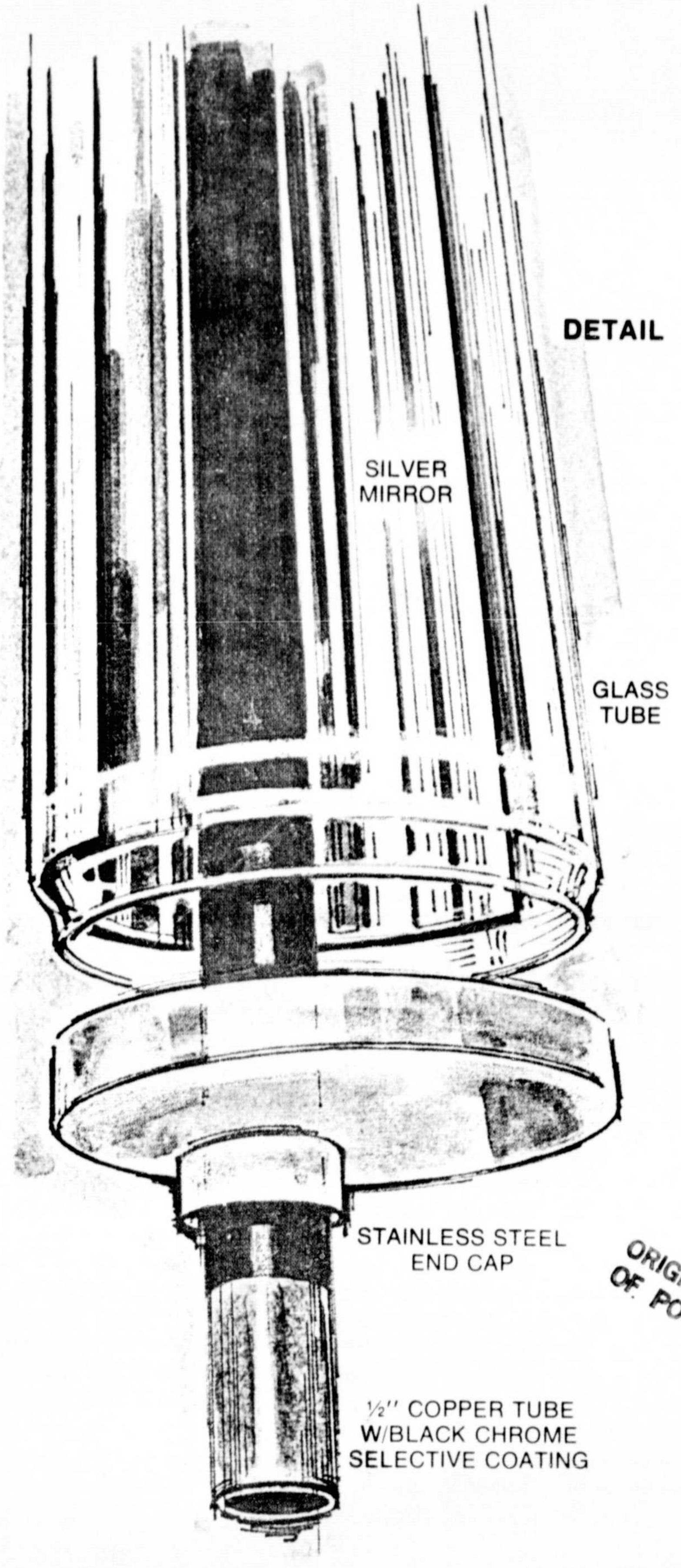
Rotation will, for some applications, enable collectors to be mounted vertically on a south-facing wall.

FLOW PATTERN



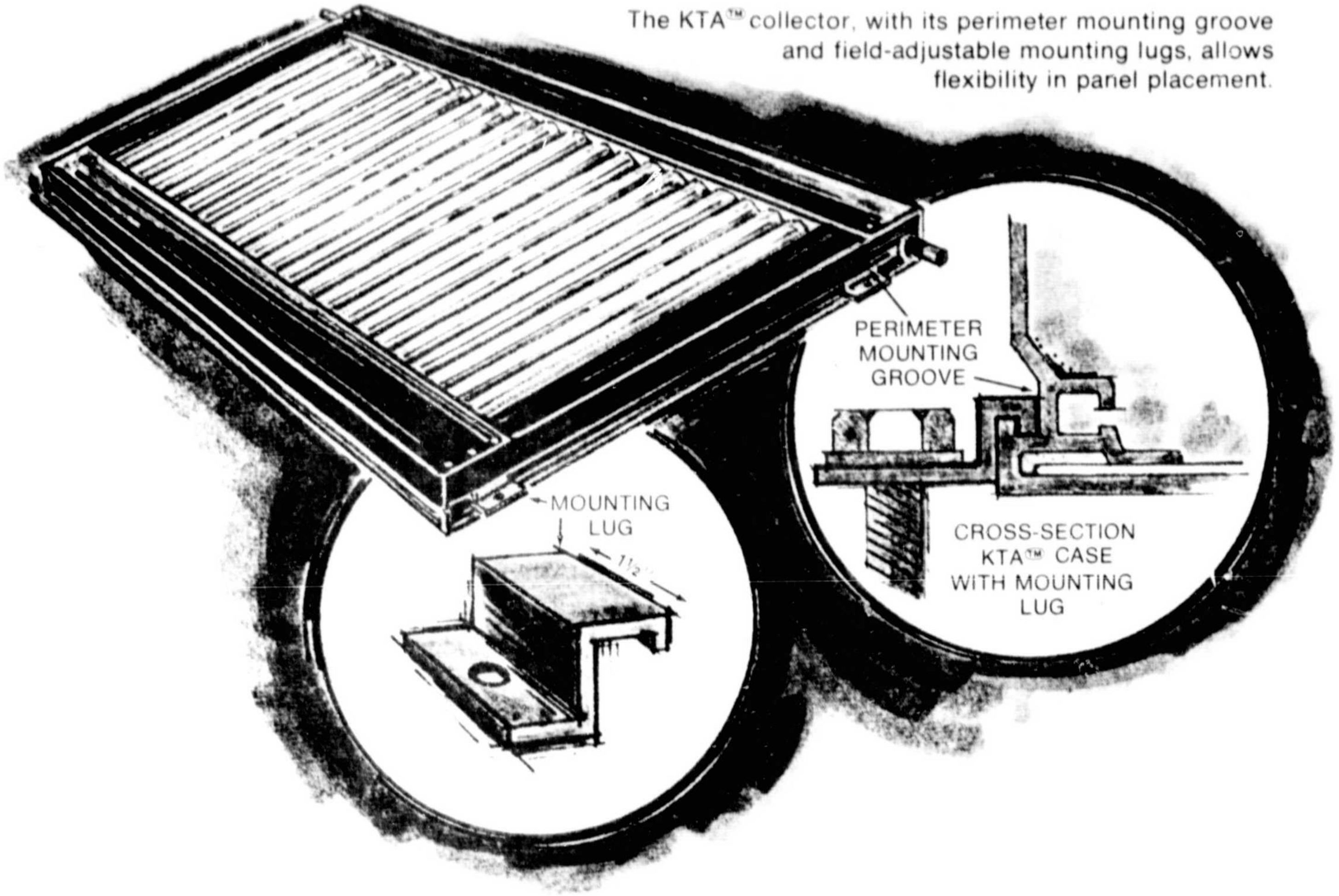
SERIES-PARALLEL ARRANGEMENT

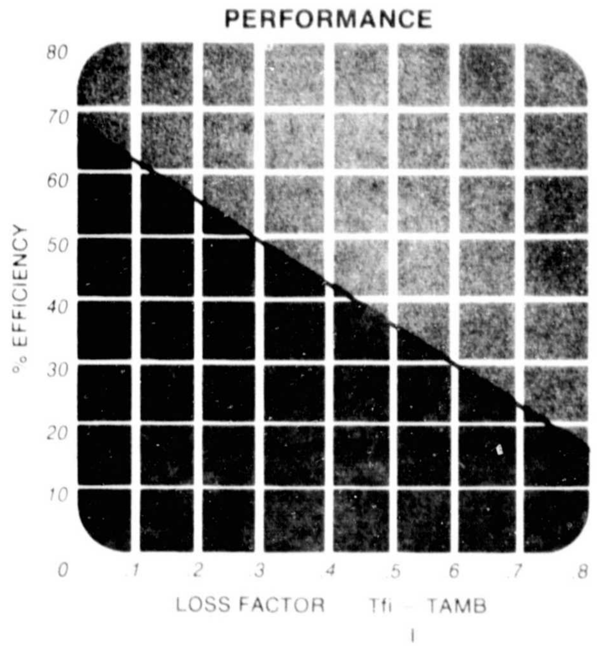
DETAIL

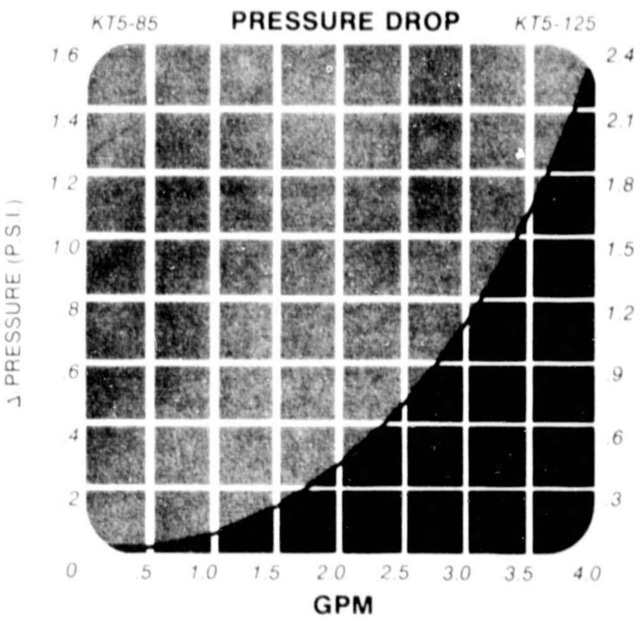


kta™ performance

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: 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^2 recommended
Fluids: water, water/glycol, silicone oil
Acceptance Angle: 45°
Maximum Rotation Angle: 30°
Stagnation Temperature: 350° F
Total Allowable Load: 90 lbs/ft^2
Design Load: 40 lbs/ft^2
Weight: 4.5 lbs/ft^2

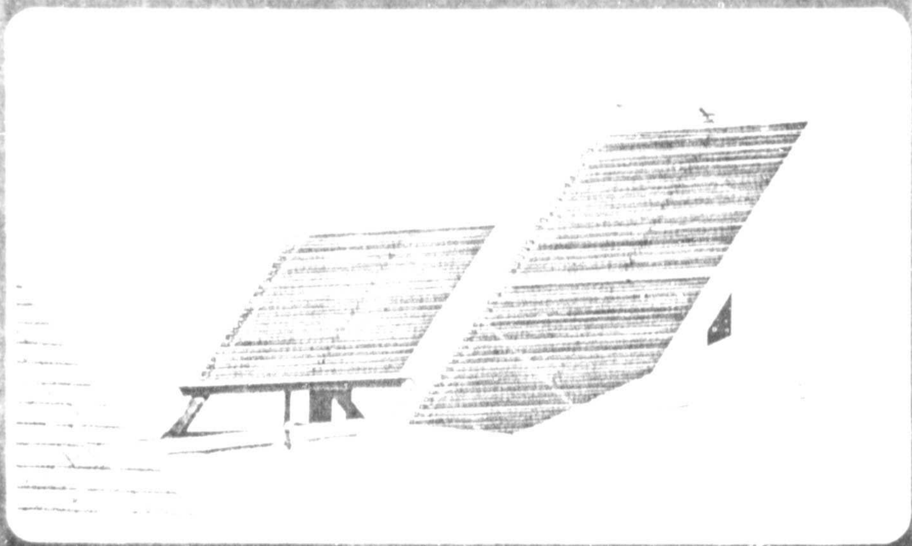
KTA solar installations

Owner:
Lindsay Cadillac, Alexandria, Virginia

Architects:
Architects Group Practice,
Alexandria, Virginia

Engineer:
Glassman & LeReche,
Falls Church, Virginia

Mechanical Contractor:
Calvert-Jones, Alexandria, Virginia



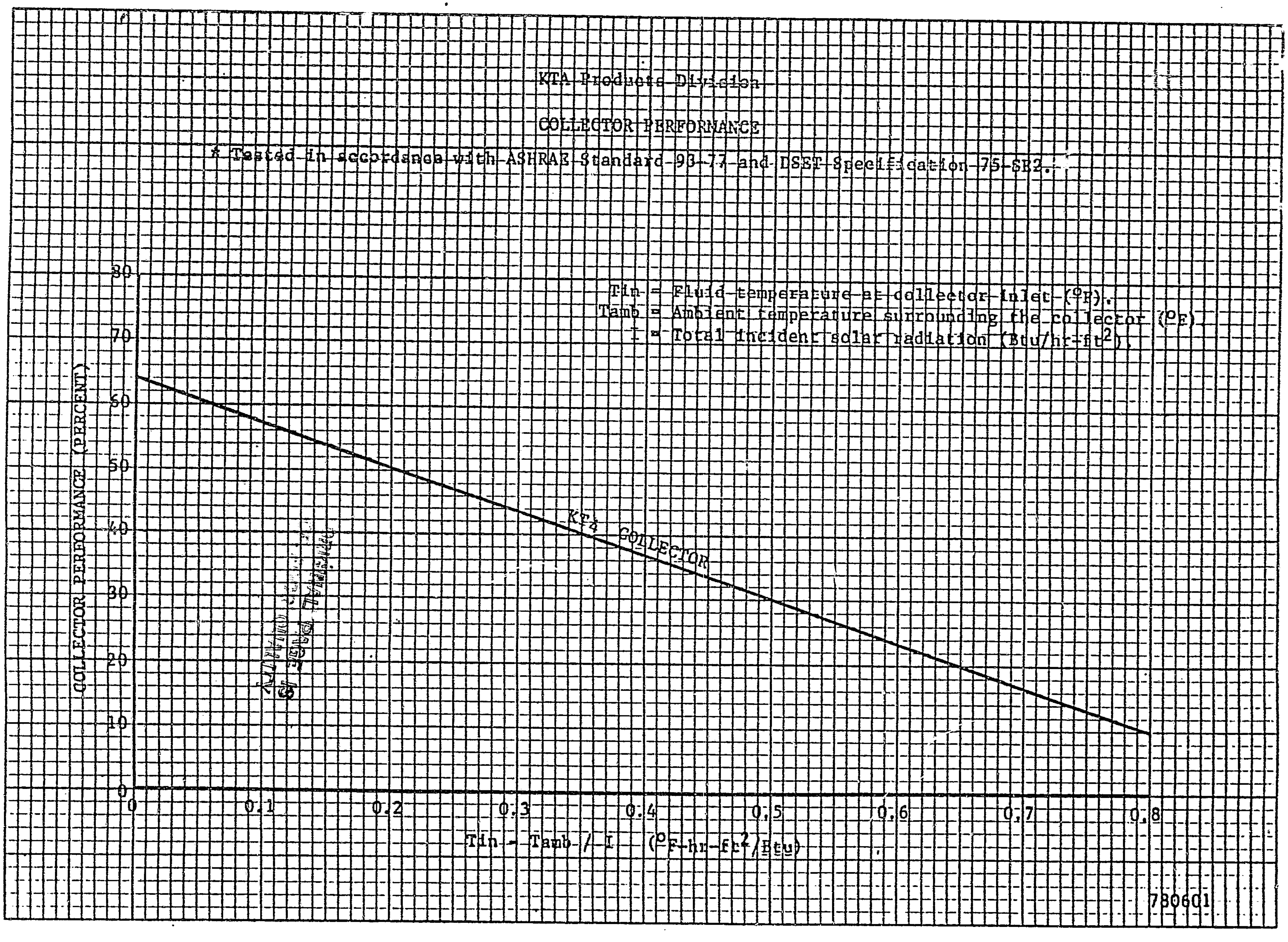
Owner:
Marina District Resident,
San Francisco, California

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-SR2.
Tin = Fluid temperature at collector inlet (°F).
Tamb = Ambient temperature surrounding the collector (°F).
I = Total incident solar radiation (Btu/hr-ft²).
KT4 COLLECTOR
COLLECTOR PERFORMANCE (PERCENT)
80
70
60
50
40
30
20
10
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Tin - Tamb / I (°F-hr-ft²/Btu)
780601

K.J.

SHEET 1 OF 1

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 ERDA SOLAR DEMONSTRATION PROJECT PURCHASE ORDER NO.

LOCATION ST. LOUIS, MISSOURI DATE 20 OCTOBER 1977

CUSTOMER WM. TAO & ASSOCIATES. SHIP TO WTA

STREET 2357 59TH STREET ATTN: RICHARD E. LAMPE, P.E.

CITY ST. LOUIS STATE MO

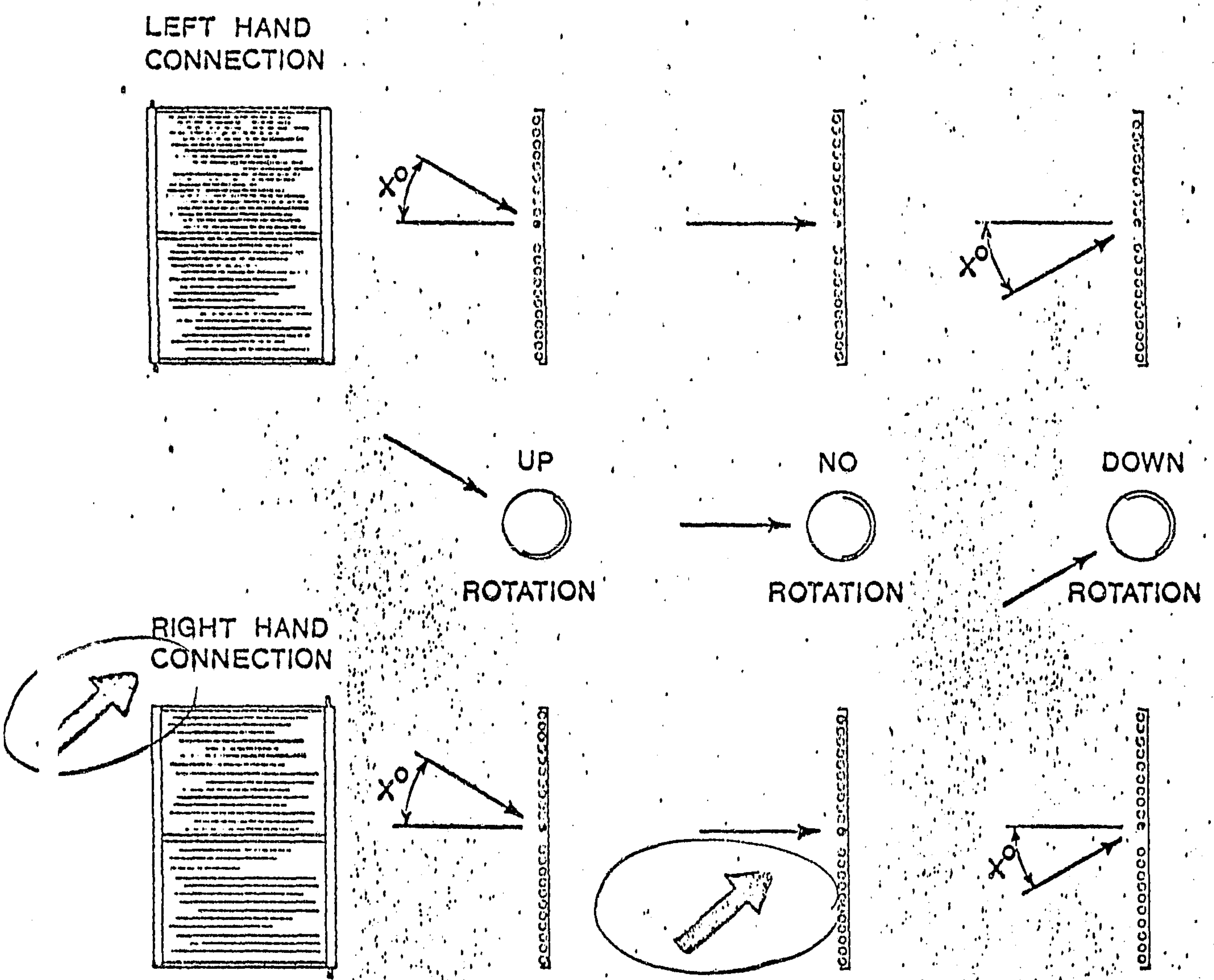
ZIP 63110 MARK

ARCHITECT

ENGINEER

KTA CORPORATION
12300 Washington Avenue
Rockville, Maryland 20852.

COLLECTOR ROTATION NOMENCLATURE



Rotation available in 5° increments
Maximum rotation 30°

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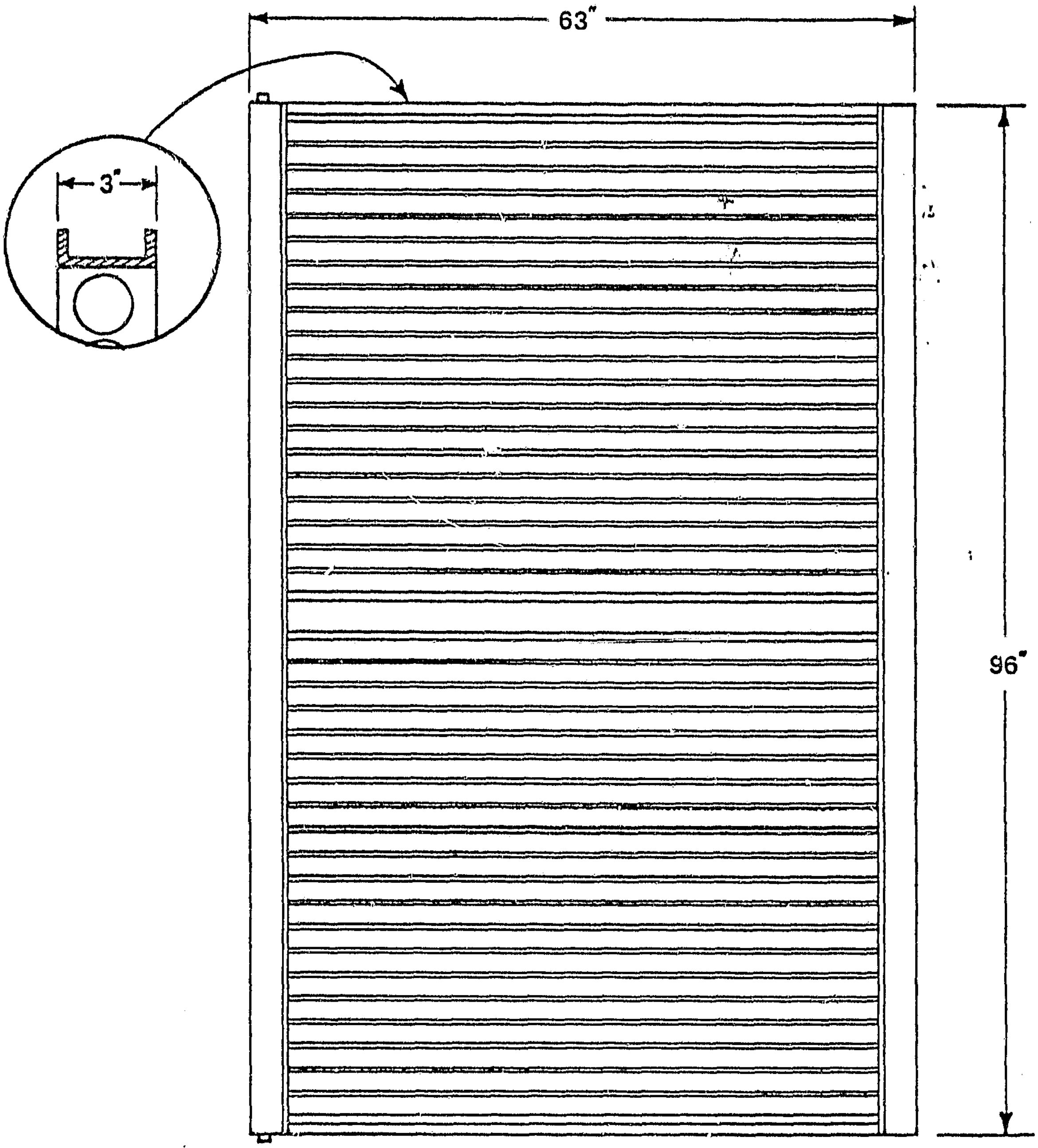
OF POOR QUALITY

CORPORATION

KT4-85

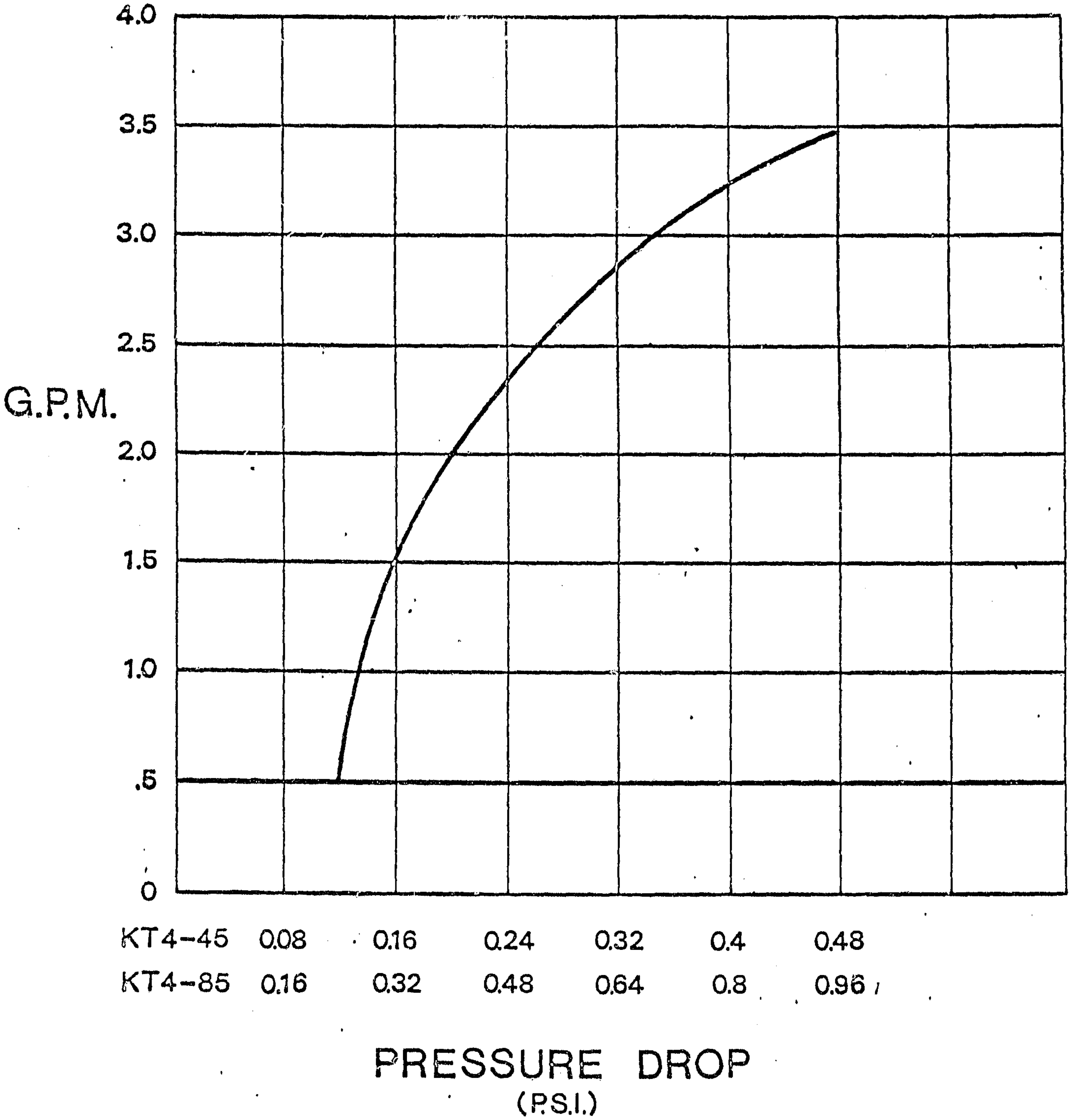


APERTURE : 36 sq. ft.

CONNECTIONS : 7/8" O.D. COPPER

KTA CORPORATION
12300 Washington Avenue
Rockville, Maryland 20852

5-202



NOTE: RECOMMENDED OPERATION IS BETWEEN .02 AND .04 GPM PER FT^2 COLLECTOR

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Rockville, Maryland 20852

Telephone (301) 468-2066

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