DOE/NASA CONTRACTOR REPORT

DOE NASA CR-150616

PRELIMINARY DESIGN PACKAGE FOR SOLAR HEATING AND HOT WATER SYSTEM

Prepared by

Wormser Scientific Corporation
88 Foxwood Road
Stamford, Connecticut 06903

Under Contract NAS8-32250 with

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

TECHNICAL REPORT STANDARD TITLE PAGE

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15. SUPPLEMENTARY NOTES

This work was done under the technical management of Valmore Fogle, Marshall Space Flight Center, Alabama.

16. ABSTRACT

This document is a collation of reports submitted by Wormser Scientific Corporation for the preliminary design review on the development of a multi-family solar heating and domestic hot water prototype system. The report contains the necessary information to evaluate the system being developed by Wormser under NASA/MSFC Contract NAS8-32250. The system consists of the following subsystems: collector, storage, transport, control and Government-furnished site data acquisition. It will be installed in Columbia, South Carolina. Some retyping and tracing of drawings have been done for legibility.

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NAS8-32250 VERIFICATION CROSS REFERENCE MATRIX

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PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
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PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
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2.1.5 Entrapped Air	1	4	4	
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PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
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PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
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PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
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3.8.2 Constraint Loads	N/A	N/A	N/A	

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PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
3.9 Pending Condition	N/A	N/A	N/A	
3.9.1 Design Provisions	N/A	N/A	N/A	
4.1 Plumbing and Electrical Insulation	1	3	3	
4.1.1 Plumbing Codes	1	3	3	
4.1.2 Electrical Codes	1	3	3	
4.2 Fail-Safe Controls	1	3	3	
4.2.1 System Failure Prevention	1	4	4	
4.2.2 Automatic Pressure Relief Valve	1	3	3	
4.3 Fire Safety	1	3	3	
4.3.1 Applicable Fire Standards	1	3	3	
4.3.2 Penetrations through Wire Rated Assemblies	1	3	3	
4.4 Toxic	N/A	N/A	N/A	Heat transfer fluids
4.4.1 Provisions of Catch Basins	N/A	N/A	N/A	Fluids are all pure water
4.4.2 Detection of Toxic & Flammable Fluids	N/A	N/A	N/A	

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PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
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4.6.2 Separation of Circulation Loops	1	3	3	
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4.6.4 Growth of Fungi	1	4	3	
4.7 Excessive Surface Temperature	3	3	3	
4.7.1 Protection from Heated Components	3	3	3	
5.1 Effects of External Environment	1	4	3	
5.1.1 Solar Degradation	1	4	3	
5.1.2 Soil Corrosion	N/A	N/A	N/A	

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PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
5.1.3 Airborne Pollutants	1	3	3	
5.1.4 Dirt Retention on Cover Plate Surface	1	1	3	
5.1.5 Abrasive Wear	1	1	3	
5.1.6 Fluttering by Wind	1	1	3	
5.2 Temperature and Pressure Resistance	1	1	3	
5.2.1 Thermal Degradation	1	1	3	
5.2.2 Deterioration of Heat Transfer Fluids	1	3	3	
5.2.3 Thermal Cycling Stresses	p	p	3	
5.2.4 Leakage	1	4	4	
5.2.5 Deterioration of Gaskets & Sealants	1	3	3	
5.2.6 Transmission Losses Due to Outgassing	1	3	3	
5.3 Chemical Compatibility of Components	1	3	3	
5.3.1 Materials/Transfer Fluid Compatibility	1	3	3	
5.3.2 Corrosion of Dissimilar Materials	1	3	3	

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PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
5.3.3 Corrosion by Leachable Substance	1	3	3	
5.3.4 Effects of Decomposition Products	1	3	3	
5.4. Components Involving Moving Parts	1	3	3	
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6.1 Accessibility for Maintenance	1	3	3	
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6.1.2 Access for System Monitoring	3	3	3	
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PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
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6.2.3 Maintenance Plan	3	3	3	
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6.3 Repair and Service Personnel	1	3	3	
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6.3.2 Maintenance of System	3	3	3	
7.1 Design	3	3	3	
7.1.1 Dwelling Design	3	3	3	
7.1.2 Mobile Home Design	N/A	N/A	N/A	
7.1.3 Site Design	3	3	3	
7.1.4 Passive Use of Solar Energy	3	3	3	
7.2 Adequate Space	1	3	3	
7.2.1 Collector Area	1	1	3	
7.2.2 Storage Area	1	3	3	
7.2.3 Utility Chases	1	3	3	

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N/A Not Applicable

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
7.3 Functioning of Dwelling Site	3	3	3	
7.3.1 Space Use	3	3	3	
7.3.2 Shading of Adjacent Structures	3	3	3	
7.3.3 Impact on Environment	3	3	3	
7.3.4 View	3	3	3	
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8.1.1 Blockage of Solar Subsystem	1	3	3	
8.1.2 Shading of Collector	2	3	3	
8.1.3 Sensor Location	1	3	3	
8.2 Mechanical & Electrical Functioning of Dwelling & Site	3	3	3	
8.2.1 Exhaust & Venting	1	3	3	
8.2.2 Utilities	1	3	3	
8.3 Mechanical & Electrical Functioning of Connections	1	3	3	

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N/A Not Applicable

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
8.3.1 Plumbing Connections	1	3	3	
8.3.2 Electrical Connections	1	3	3	
9.1 Structural Integrity	1	3	3	
9.1.1 Movement in Adjacent Structures	1	3	3	
9.2 Structural Integrity of Dwelling	1	3	3	
9.2.1 Loads	1	3	3	
9.2.2 Penetration of Structural Members	1	3	3	
9.3 Structural Connections	2	4	3	
9.3.1 Structural Connections	2	4	3	
9.3.2 Brittle Subsystem	1	3	3	
9.3.3 Strength and Stiffness	1	3	3	
10.1 Safety of Dwelling and Site	1	3	3	
10.1.1 Fire	1	3	3	
10.1.2 Accidents	1	3	3	

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PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
11.1 Durability	3	3	3	
11.1.1 Vegetation	3	3	3	
11.2 Durability & Reliability of Dwelling & Site	3	3	3	
11.2.1 Chemical Corrosion	1	3	3	
11.2.2 Heat and Moisture	1	3	3	
11.2.3 Exterior Penetrations	1	3	3	
11.3 Durability & Reliability of Connections	1	3	3	
11.3.1 Material Compatibility	1	3	3	
12.1 Maintainability of H, HC, HW Systems	1	3	3	
12.1.1 Accessibility	1	3	3	
12.1.2 Misuse	1	3	3	
12.1.3 Permanent Maintenance Accessories	1	3	3	
12.2 Maintainability of Dwelling and Site	1	3	3	
12.2.1 Accessibility	1	3	3	

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N/A Not Applicable

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
12.2.2 Ice Dams	1	3	3	
12.3 Connections	3	3	3	
12.3.1 Accessibility	3	3	3	
13.1 Visual Characteristics of Dwelling and Site	3	3	3	
13.1.1 Dwelling	3	3	3	
13.1.2 Neighborhood	3	3	3	

2. Description, Quantity and Rationale for Test Hardware

The pyramidal optics system is operating in a full scale prototype in Rehoboth, Delaware and another full scale system is under construction for a four townhouse condominium with an optical unit in each end dwelling feeding a central storage. The following components of the system will be further developed under the contract:

a. Reflective surfaces

b. Reflective panel lifting mechanism

c. Glazing details

d. Glazing support structure

e. Absorber plate

f. Absorber plate support

g. Storage systems

h. Methods of assembling components into complete system.

Test hardware for testing these assemblies will consist of mock-ups of the various components and the required instruments for qualifying the component. Following is an outline of the test hardware required.

A. DEVELOPMENT, QUALIFICATION

Quantity	Test Hardware	Rationale
	a. Reflective Surfaces	
10-20	Sample surfaces prepared by reflective film manufacturers	Samples for tests
1	Reflectometer	Instrument to measure reflectivity at various wave lengths. Reflectivity of mirror surfaces directly affects system performance
20 ft.	Structural mock-up of building interior	Samples for testing attachment methods to building interior.
10-20	Various glues, and fastening devices	System costs directly related to installation ease.
	b. Reflective Panel Lifting Mechanism	
3	Panel lifting mechanisms	Samples for testing and inspection
1	Weight set	Lifting ability test
	c. Glazing details	
5	Glazing system mockups of different configurations	Samples for tests
1	Sand bags, hose, etc.	Materials for wind loading tests
	d. Glazing Support Structure	
5	Models of support structure of glazing	Samples for testing obscuration
1	Solar exposure	For testing obscuration of various glazing support alternatives.

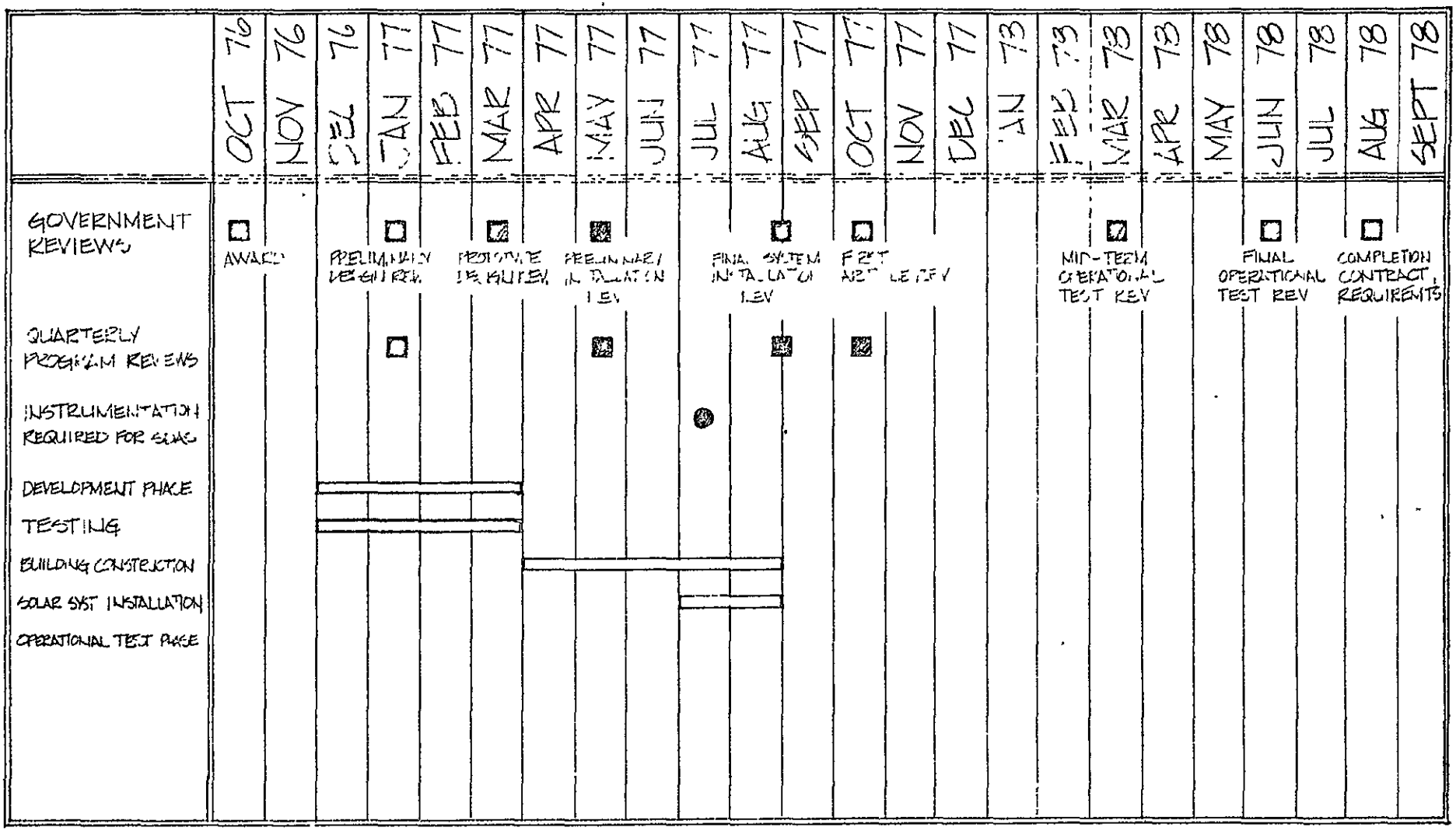
Quantity	Test Hardware	Rationale
	f. Absorber	
Several	Samples of copper absorber	Test materials for absorber configuration
1	Pump	Test materials for absorber configuration
Various	Plumbing fittings, pipe, vents	Test materials for absorber configuration
1	Flow meter	Flow measurements
2	Thermopiles	Cover sheet test
8	Thermistors	Cover sheet test instrumentation
4	Cover sheet mock-ups	Cover sheet test materials
1	Single lens reflex camera	Recording test results
	Film & processing	Recording test results
5	Absorber plate support mock-ups	Model for best support method

Test List	Estimated Time For Test
Reflectivity test on candidated films	1 week
Fastening methods tests	4 weeks
Panel lifting mechanism test	4 weeks
Glazing system test	8 weeks
Absorber configuration test	2 weeks
Absorber cover test	8 weeks
Absorber plate support mock-ups	2 weeks
Glazing support analysis	8 weeks

PROGRAM SCHEDULE

ADDITIONAL DEVELOPMENT OF PYRAMIDAL OPTICS CONCENTRATOR FOR SOLAR HEATING AND HOT WATER SYSTEM

CONTRACT NAS8-32250
WORMSER SCIENTIFIC CORPORATION
5107



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Quantity	Test Hardware	Rationale
	f. Absorber	
Several	Samples of copper absorber	Test materials for absorber configuration
1	Pump	Test materials for absorber configuration
Various	Plumbing fittings, pipe, vents	Test materials for absorber configuration
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4	Cover sheet mock-ups	Cover sheet test materials
1	Single lens reflex camera	Recording test results
	Film & processing	Recording test results
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Glazing system test	8 weeks
Absorber configuration test	2 weeks
Absorber cover test	8 weeks
Absorber plate support mock-ups	2 weeks
Glazing support analysis	8 weeks

4. Level to Which Development, Qualification and Acceptance Testing is Required and Supporting Rationale

Development, qualification and acceptance testing will be carried to a level which will assure a durable cost effective solar system that can collect and distribute energy at design levels for many years.

5. If Testing is to be by The Government, Describe Items to be Tested, Purpose, Test Requirements, Instrumentation Required and Number of Days for Testing

No government testing is anticipated as being required at this time.

Quality Assurance Plan

Different quality control procedures will be used on three different type of components, subsystems and operation involved in the project.

a. Purchased Components and Subsystems

The solar energy heating and hot water system consists of many different purchased components and subsystems ranging from common building materials such as copper pipe and insulating board, to sophisticated subsystems, such as water-to-air heat pumps and evaporative coolers. These components and subsystems will be purchased in accordance with specifications proposed by suppliers and reviewed and approved by WSC. Purchases will be made from reputable suppliers who are expected to have their own quality control organizations and who will certify the performance of their products to these specifications which will be incorporated in the purchase orders.

b. Custom Fabricated Components and Subsystems

Certain components and subsystems, such as the plexiglass window assembly and the reflective mylar laminated to support materials are being developed and specifically fabricated by subcontractors for this program as described in section 2 of the verification plan. WSC is preparing specifications and inspection procedures and will supervise testing at the subcontractor's or its own facility to assure conformance to the design specifications.

c. Installation and Assembly Procedures

WSC technical personnel will supervise the overall installation of the system and will insure that it is assembled correctly and using in general, good workmanship practice.

Assembly of subsystems of the overall system will be performed by local tradesman such as plumbers, sheet metal men and carpenters. These tradesmen will be furnished drawings and specifications of the type normally used in their respective trades, and are expected to adhere to these drawings and specifications and to perform their tasks in accordance with good, accepted workmanship subject to supervision by their respective trade supervisors and the general supervision by the construction superintendant.

Training and specific supervision will be provided by WSC technical personnel as required.

WORMSER SCIENTIFIC CORPORATION

PYRAMIDAL OPTICS SOLAR SYSTEM

PRELIMINARY SYSTEM PERFORMANCE SPECIFICATION

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1.0 Introduction

This Performance Specification establishes the requirements for the design and performance of the solar heating and hot water systems to be delivered. It designates the Interim Performance Criteria applicable to each type system and defines the deviations. The appendices specify the performance for the system.

2.0 Applicable Documents

2.1 Government Documents

Interim Performance Criteria for Solar Heating and Combined Heating/Cooling Systems and Dwellings, January 1, 1975.
U.S. Department of Housing and Urban Development.

2.2 Contractor Documents

2.2.1 Solar Heating and Hot Water System Using Reflective Pyramid Optical Condensing System
WSC response to POA-DSE-75-1 dated October 30, 1975

2.2.2 Technical Proposal -P107
Additional Development of Pyramidal Optics Concentrator Solar Heating and Hot Water System in response to RFP-AP32-75-406

2.2.3 Technical Proposal-P107-1
Additions and Clarifications to P107

2.3 Other Documents

(If any)

3.0 Application of Interim Performance Criteria

The application of each paragraph of the Interim Performance Criteria to each type system is provided in the following table.

Table I-Residential Systems

TABLE I
CONTINUATION SHEET

SPECIFICATION NO. _____
REVISION _____
DATE _____

RESIDENTIAL SYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY

SHEET 2 OF 6

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS			RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS		
	H	HC	HW		H	HC	HW
2.1 System Design Conditions	A	A	A	2.3.2 Pressure Test: Potable Water	A	A	A
2.1.1 Equipment Capabilities	A	A	A	2.3.3 Air Transport Systems	A	A	A
2.1.2 Noise or Erosion-Corrosion	A	A	A	2.4 Collector Adjustment	A	A	A
2.1.3 Operating Conditions	A	A	A	2.4.1 Orientation and Tilt	A	A	A
2.1.4 Fluid Flow in Collectors	A	A	A	2.4.2 Mutual Shadowing	A	A	A
2.1.5 Entrapped Air	A	A	A	2.5 Subsystem Isolation	A	A	A
2.1.6 Thermal Expansion of Fluids	A	A	A	2.5.1 Shutdown in Multi-family Housing	A	A	A
2.1.7 Pressure Drops	A	A	A	2.6 Heat Transfer Fluid Quality	A	A	A
2.1.8 Condensate Removal	NA	A	NA	2.6.1 Liquid Quality	A	A	A
2.2 Mechanical Stresses	A	A	A	2.6.2 Air Quality	A	A	A
2.2.1 Vibration Stress Levels	A	A	A	2.6.3 Fluid Quality	A	A	A
2.2.2 Vibration from Moving Parts	A	A	A	2.6.4 Freezing Protection	A	A	A
2.2.3 Water Hammer	A	A	A	2.7 Piping Supports	A	A	A
2.2.4 Vacuum Relief Protection	A	A	A	2.7.1 Applicable Plumbing Standards	A	A	A
2.2.5 Thermal Changes	A	A	A	2.8 Excessive Pressure and Temperature Protection	A	A	A
2.2.6 Flexible Joints	A	A	A	2.8.1 Relief Valves and Vents	A	A	A
2.3 Leakage Prevention	A	A	A	3.1 Structural Design Basis	A	A	A
2.3.1 Pressure Test: Nonpotable Fluids	A	A	A	3.1.1 Applicable Standards	A	A	A

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TABLE I
CONTINUATION SHEET

SPECIFICATION NO. _____
REVISION _____
DATE _____

RESIDENTIAL SYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS			RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS		
	H	HS	HJ		H	HS	HJ
3.1.2 Service Loads	A	A	A	3.8.2 Constrain Loads	A	A	A
3.2 Failure Loads and Load Capacity	A	A	A	3.9 Ponding Condition	A	A	A
				3.9.1 Design Provisions	A	A	A
3.2.1 Ultimate Load Combinations	A	A	A	4.1 Plumbing and Electrical Installation	A	A	A
3.2.2 Ice Loads	A	A	A				
				4.1.1 Plumbing Codes	A	A	A
3.2.3 Vehicular Loads	I	I	I	4.1.2 Electrical Codes	A	A	A
3.2.4 Load Capacity	A	A	A				
				4.2 Fail-Safe Controls	A	A	A
3.3 Damage Control	A	A	A	4.2.1 System Failure Prevention	A	A	A
3.3.1 Resistance to Damage	A	A	A				
				4.2.2 Automatic Pressure Relief Valves	A	A	A
3.3.2 Glazing Design	A	A	A				
3.4 Cyclic Loads	A	A	A	4.3 Fire Safety	A	A	A
3.4.1 Deflection Limitations	A	A	A	4.3.1 Applicable Fire Standards	A	A	A
3.5 Cutting of Structural Elements	I	I	I	4.3.2 Penetrations through Fire Rated Assemblies	I	I	I
3.5.1 Design Provisions	I	I	I	4.4 Toxic	A	A	A
3.6 Creep and Residual Deflection	I	I	I	4.4.1 Provisions of Catch Basins	A	A	A
3.6.1 Deflection Limitations	I	I	I	4.4.2 Detection of Toxic and Flammable Vapors	A	A	A
				4.5 Safety	I	I	I
3.7 Hail Resistance	A	A	A				
				4.5.1 Emergency Egress and Access	I	I	I
3.7.1 Hail Size and Loading	A	A	A				
				4.5.2 Identification and Location of Controls	A	A	A
3.8 Constraint Loads	A	A	A				
				4.6 Protection of Potable Water and Circulated Air	A	A	A
3.8.1 Foundation Settlement	A	A	A				

SPECIFICATION NO. _____
REVISION _____
DATE _____

TABLE I

RESIDENTIAL SYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY

APPLICATION

A – APPLICABLE TO SYSTEMS INDICATED
I – APPLICABLE TO SYSTEM AND BUILDING
NA – NOT APPLICABLE

TYPE SYSTEMS

H – HEATING
HC – HEATING AND COOLING
HW – HOT WATER

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS			RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS		
	H	HC	HW		H	HC	HW
4.6.1 Contamination by Materials	A	A	A	5.2.4 Leakage	A	A	A
4.6.2 Separation of Circulation Loops	A	A	A	5.2.5 Deterioration of Gaskets and Sealants	A	A	A
4.6.3 Backflow Prevention	A	A	A	5.2.6 Transmission Losses Due to Outgassing	A	A	A
4.6.4 Growth of Fungi	A	A	A	5.3 Chemical Compatibility of Components	A	A	A
4.7 Excessive Surface Temperatures	A	A	A	5.3.1 Materials/Transfer Fluid Compatibility	A	A	A
4.7.1 Protection from Heated Components	A	A	A	5.3.2 Corrosion of Dissimilar Materials	A	A	A
5.1 Effects of External Environment	A	A	A	5.3.3 Corrosion by Leachable Substance	A	A	A
5.1.1 Solar Degradation	A	A	A	5.3.4 Effects of Decomposition Products	A	A	A
5.1.2 Soil Corrosion	A	A	A	5.4 Components Involving Moving Parts	A	A	A
5.1.3 Airborne Pollutants	A	A	A	5.4.1 Wear and Fatigue	A	A	A
5.1.4 Dirt Retention on Cover Plate Surface	A	A	A	6.1 Accessibility for Maintenance	A	A	A
5.1.5 Abrasive Wear	A	A	A	6.1.1 Access for System Maintenance	A	A	A
5.1.6 Fluttering by Wind	A	A	A	6.1.2 Access for System Monitoring	A	A	A
5.2 Temperature and Pressure Resistance	A	A	A	6.1.3 Draining and Filling of Liquids	A	A	A
5.2.1 Thermal Degradation	A	A	A	6.1.4 Flushing of Liquids Subsystems	A	A	A
5.2.2 Deterioration of Heat Transfer Fluids	A	A	A	6.1.5 Filters	A	A	A
5.2.3 Thermal Cycling Stresses	A	A	A	6.1.6 Potable Water Shutoff	A	A	A

TABLE I

SPECIFICATION NO. _____
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RESIDENTIAL SYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY

SHEET 1 OF 6

APPLICATION

A – APPLICABLE TO SYSTEMS INDICATED
I – APPLICABLE TO SYSTEM AND BUILDING
NA – NOT APPLICABLE

TYPE SYSTEMS

H – HEATING
HC – HEATING AND COOLING
HW – HOT WATER

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS			RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS		
	H	HC	HW		H	HC	HW
6.2 Installation, Operation and Maintenance Manual	A	A	A	7.3.1 Space Use	X	X	X
				7.3.2 Shading of Adjacent Structures	X	X	X
6.2.1 Installation Instructions	A	A	A	7.3.3 Impact on Environment	X	X	X
6.2.2 Maintenance and Operation Instructions	A	A	A	7.3.4 View	X	X	X
				8.1 Interference with Mechanical Operation	X	X	X
6.2.3 Maintenance Plan	A	A	A	8.1.1 Blockage of Solar Subsystem	X	X	X
6.2.4 Replacement Parts	A	A	A	8.1.2 Shading of Collector	X	X	X
6.3 Repair and Service Personnel	A	A	A	8.1.3 Sensor Location	X	X	X
6.3.1 Maintenance of H and HC Systems	A	A	A	8.2 Mechanical and Electrical Functioning of Dwelling and Site	X	X	X
6.3.2 Maintenance of HW System	A	A	A				
7.1 Design	X	X	X	8.2.1 Exhaust and Venting	X	X	X
7.1.1 Dwelling Design	X	X	X	8.2.2 Utilities	X	X	X
7.1.2 Mobile Home Design	X	X	X	8.3 Mechanical and Electrical Functioning of Connections	X	X	X
7.1.3 Site Design	X	X	X				
7.1.4 Passive Use of Solar Energy	X	X	X	8.3.1 Plumbing Connections	X	X	X
7.2 Adequate Space	X	X	X	8.3.2 Electrical Connections	X	X	X
7.2.1 Collector Area	X	X	X	9.1 Structural Integrity	X	X	X
7.2.2 Storage Area	X	X	X				
7.2.3 Utility Chases	X	X	X	9.1.1 Movement in Adjacent Structures	X	X	X
7.3 Functioning of Dwelling Site	X	X	X	9.2 Structural Integrity of Dwelling	X	X	X

TABLE I
CONTINUATION SHEET

SPECIFICATION NO. _____
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RESIDENTIAL SYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY

SHEET 6 OF 6

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	HVAC SYSTEMS H	HC	HV	RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	HVAC SYSTEMS H	HC	HV
9.2.1 Loads	I	I	I	11.3.1 Material Compatibility	A	A	A
9.2.2 Penetration of Structural Members	I	I	I	12.1 Maintainability of H, HC, HV Systems	I	I	I
9.3 Structural Connections	I	I	I	12.1.1 Accessibility	I	I	I
9.3.1 Structural Connections	I	I	I	12.1.2 Misuse	I	I	I
9.3.2 Brittle Subsystem	I	I	I	12.1.3 Permanent Maintenance Accessories	I	I	I
9.3.3 Strength and Stiffness	I	I	I	12.2 Maintainability of Dwelling and Site	I	I	I
10.1 Safety of Dwelling and Site	I	I	I	12.2.1 Accessibility	I	I	I
10.1.1 Fire	I	I	I	12.2.2 Ice Dams	I	I	I
10.1.2 Accidents	I	I	I	12.3 Connections	I	I	I
11.1 Durability	I	I	I	12.3.1 Accessibility	I	I	I
11.1.1 Vegetation	I	I	I	13.1 Visual Characteristics of Dwelling and Site	I	I	I
11.2 Durability and Reliability of Dwelling and Site	I	I	I	13.1.1 Dwelling	I	I	I
11.2.1 Chemical Corrosion	A	A	A	13.1.2 Neighborhood	I	I	I
11.2.2 Heat and Moisture	I	I	I				
11.2.3 Exterior Penetrations	I	I	I				
11.3 Durability and Reliability of Connections	A	A	A				

4.0 Deviations From Interim Performance Criteria

Comment on 4.6.2 Separation of Circulation Loops. The proposed system has the domestic hot water preheat coil submerged in the main thermal storage tank. This unpressurized tank contains only pure water. In the unlikely event of a leak in the heat exchange coil, flow would be down the pressure gradient from the domestic water line to the tank. We believe this arrangement poses no contamination hazard. No deviations from the IPC are proposed.

5.0 Government Furnished Property

Government furnished property will be limited to the monitoring system including the sensors, junction box, site data aquisition subsystem, and SDAS telephone interface.

6.0 Government Directed Requirements

No specific system performance requirements have been directed by the contracting officer.

7.0 Geographical Area

Solar heating and hot water for multiple family dwellings are for instllation in the Yacht Cove development in South Carolina of the United States.

8.0 System Appendix A

Appendix A-Heating and Hot Water System for Multiple Family Residence. Model number S107

A. System Identification

This appendix defines the performance for solar heating and hot water system model S107.

A1. System Performance Sheets

Site

The system shall be installed in a multi-family dwelling in the city of Columbia, state of South Carolina.

Heating Capacity

The system will provide solar energy for 50% of the average total heating load during the heating season based on an average total heating load of 19×10^6BTU/month and a peak heating load of 95,200 BTU/hr.

Auxiliary Energy

The average rate of auxiliary energy used for heating shall be no greater than 7×10^6BTU/month including hot water. This shall be no greater than 50% of the total energy required for heating.

Hot Water

50 gallons of potable (or useable) hot water shall be delivered at no less than 20 gal/min at temperatures no less than 120°F. Recovery time shall be no greater than 2 hours. The average hot water heating load will be 3.06×10^6BTU/month of which 25% is provided by auxiliary energy.

Operating Requirements

The maximum electrical energy required to drive the solar portion of the system at its rated capacity shall be no greater than 1.0 KW. The maximum electrical energy required to drive the complete system shall be no greater than 53 KW. The average yearly electrical energy required to drive the system shall be no greater than 24,000 KWH.

Physical Data - Table II

The following subsystems shall have:

	Design life no less than	Weight (filled) no greater than	Installation Dimensions
Heating	15 years	1200 lbs.	24"x24"x30"
Cooling	N/A	N/A	N/A
Auxiliary Energy	15 years	400 lbs.	28"x28"x12"
Storage	20 years	60,000 lbs.	
Potable Water (or useable)	20 years	2,000 lbs.	5'x3' diameter
Collector	25 years	6 lbs/ft.	
Energy Transport	25 years	2 lbs/ft	N/A
Controls	15 years	60 each	N/A
(other)			

Sheet A-3

The existing system consist of the following:

1. 240 sq. ft. (total area) of the collector described in the proposal with an efficiency of 45% under the following conditions as described in addendum to the proposal. Two 505 sq. ft. window apertures in the outer wings of a four townhouse complex.

2. 2,500 gallons of storage capacity in a two compartment concrete tank. The insulation is polyurethane and styrene.

3. A control system as described in the propsoal.

4. A transport system with 600 feet of 1" inch diameter pipe, covered with 3/4" inches of Armaflex insulation. The mass flow is 10 gpm to each collector assembly. Two each.

5. The solar insolation at the existing location that the existing system is rated against is avg. 1200 BTU/ft/day.

6. DHW heat exchanger in the storage tank has a capacity of 40 gallons.

7. DHW storage tanks are 100 gallons each.

8. DHW has electric auxiliary heat.

Special Handling, Installation and Maintenance Tools List

Installation and maintenance of the pyramidal optics solar system requires the use of only familiar carpenter and HVAC tools common to the trades. No special tools are required.

Systems Hazard Analysis

The pyramidal optics solar collecting system is a very safe system employing plain water as a heat transfer fluid and operating at low temperatures. Many of the components which might have hazardous operating characteristics such as high pressure, high voltage, high RPM, are standard off-the-shelf items such as heat pumps, water pumps, etc. and have been used many years and have been proven to be safe.

Non-standard components are still under development and their properties as potential sources of hazard will require further examination when the development is completed.

Training Program for Local Tradesmen

The fabrication of the pyramidal optics system requires, for the most part, a series of conventional construction procedures such as carpentry, plumbing and sheet metal work. Assembly of a small part of the system is novel and unique to the system. This portion of the construction will be carefully documented in drawings and will be fully supervised by knowledgeable personnel.

Identification of Symbology

The graphic conventions used on the drawings will be as shown in ASHRAE Handbook of Fundamentals, 1972, Chapter 28, "Abbreviations and Symbols" and Architectural Graphic Standards Ramsey and Sleeper, Pg. 630-631, 1970 ED.

Drawings List Required for System Identification

1. General Component Schematic
2. Ray Diagram
3. Piping Schematic (with collector, distribution, DHW loops)
4. Control Schematic
5. Pyramidal Condenser Sections, Plans, Elevations
6. Skylight Structural Support
7. Skylight Glazing Detail
8. Reflective Material Section
9. Reflective Moving Flap Frame Structure
10. Flap Lifting Mechanism
11. Absorber Plate

12. Absorber Plate Support and Absorber Cover

13. Absorber Piping and Venting

14. Storage Tank Sections, Plans, Elevations

15. Direct Solar Coil (water-to-air) Description

16. Backup Electric Coil (duct heater) Description

17. Heat Pump Description

18. Domestic Hot Water Tank

19. Pumps, Valves, Vents, Expansion Tanks, Level Gauges, Description

Description and Rationale for Proposed Special Handling, Installation and Maintenance Tools

No special tools are required.

List of Data We Recommend for Accomplishing Prototype Design Review

1. Prototype system drawings

2. Accumulated test results to date

3. Spare parts list

4. System performance specification

5. Procurement specifications

6. Verification status summary

7. Installation operation and maintenance manuals

8. System installation drawings

Proposed SDAS Delivery Schedule

The SDAS should be delivered and installed during the final phases of construction. Construction will begin approximately 4/1/77 and terminate about 9/1/77. The SDAS should be delivered and installed during the week ending 8/21/77, if construction is proceeding on schedule.

Top Level System Drawings and/or Schematics That Describe System

See drawings.

CONTROL LOGIC DESCRIPTION

SEQUENCE OF OPERATIONS:

Heating Mode:

On call for heating and the temperature of the storage water is above 80°F (4TAS), thermostat 5TAS terminals W1 and RH will be energized, thus energizing solenoid V_1 (normally closed) and solar water circulating pump P-6 and energizing the blower motor.

If space temperature continues to drop at 5TAS, terminal W_2 will also become energized, thus energizing one half of the electric duct heater. As thermostat becomes satisfied the duct heater will drop out then the circulating pump and blower motor will drop out and de-energize the water coil solenoid V_1 .

If the temperature of the storage water drops below 80°F (but above 50°F) 4TAS will open, de-energizing solenoid V_1 and energizing solenoid V_2 and contacts across terminals R and Y of the heat pump turning the heat pump on.

Should the temperature of the storage water (3TAS) go below 50°F the heat pump will shut off the solenoid valve V_2 will de-energize and the P-6 pump will de-energize. The heat pump cross over relay will then energize the air-to-air outdoor evaporator and the heat pump placing the heat pump into its air-to-air mode of operation. The heat pump will remain in this mode as long as the outdoor temperature is above 40°F.

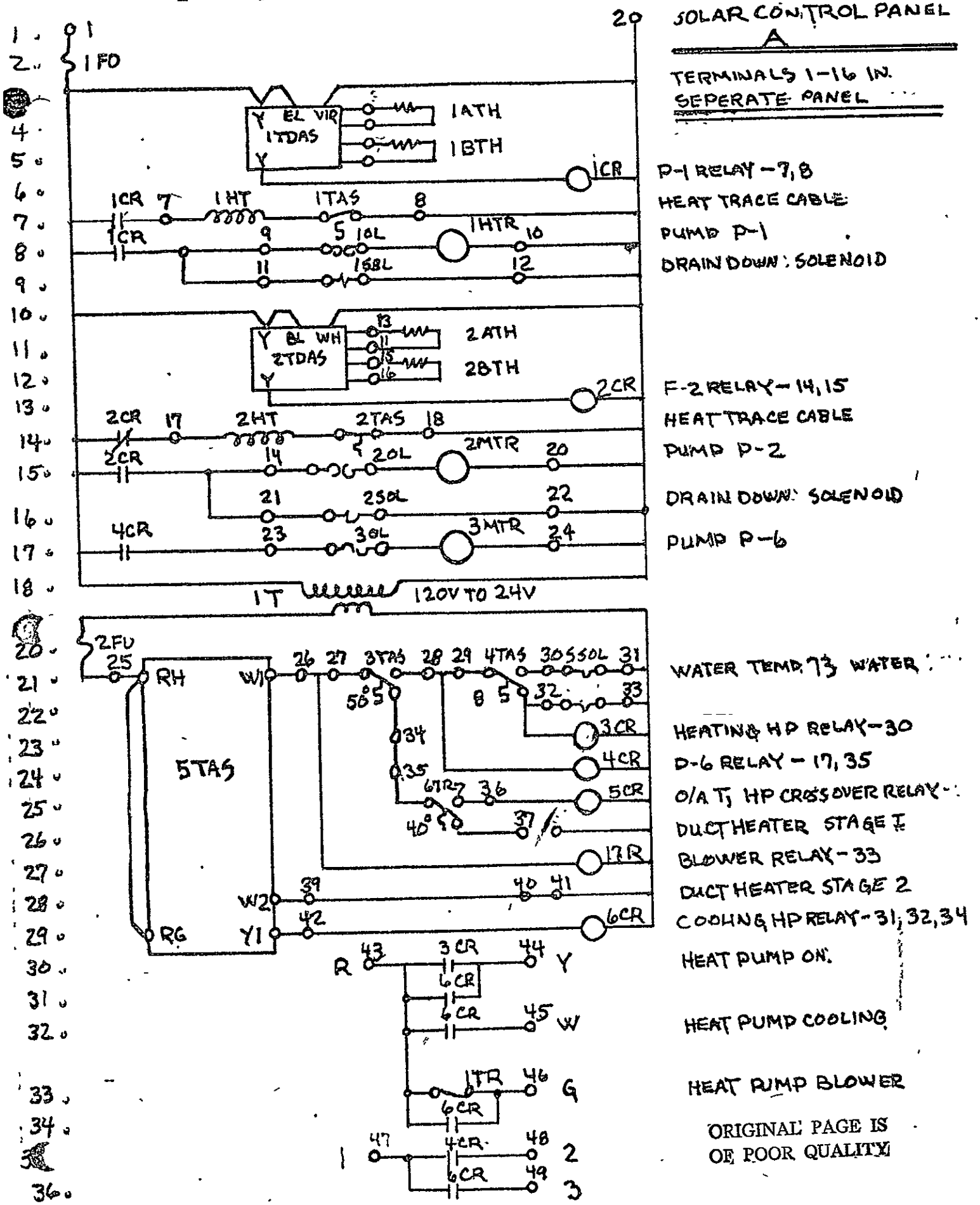
As the outdoor temperature drops below 40°F the second stage of the duct heater will become energized should the space temperature continue to call for heat.

The blower relay #1TR has a time delay on it to prevent the heat pump blower from energizing until after the set time period.

Cooling Mode:

On call for cooling thermostat 5TAS terminals Y_1 and RC will be energized thus energizing the heat pump and outdoor condenser to start in the cooling mode.

As the thermostat becomes satisfied the heat pump and the outdoor condenser will shut down and also the blower motor will drop out.



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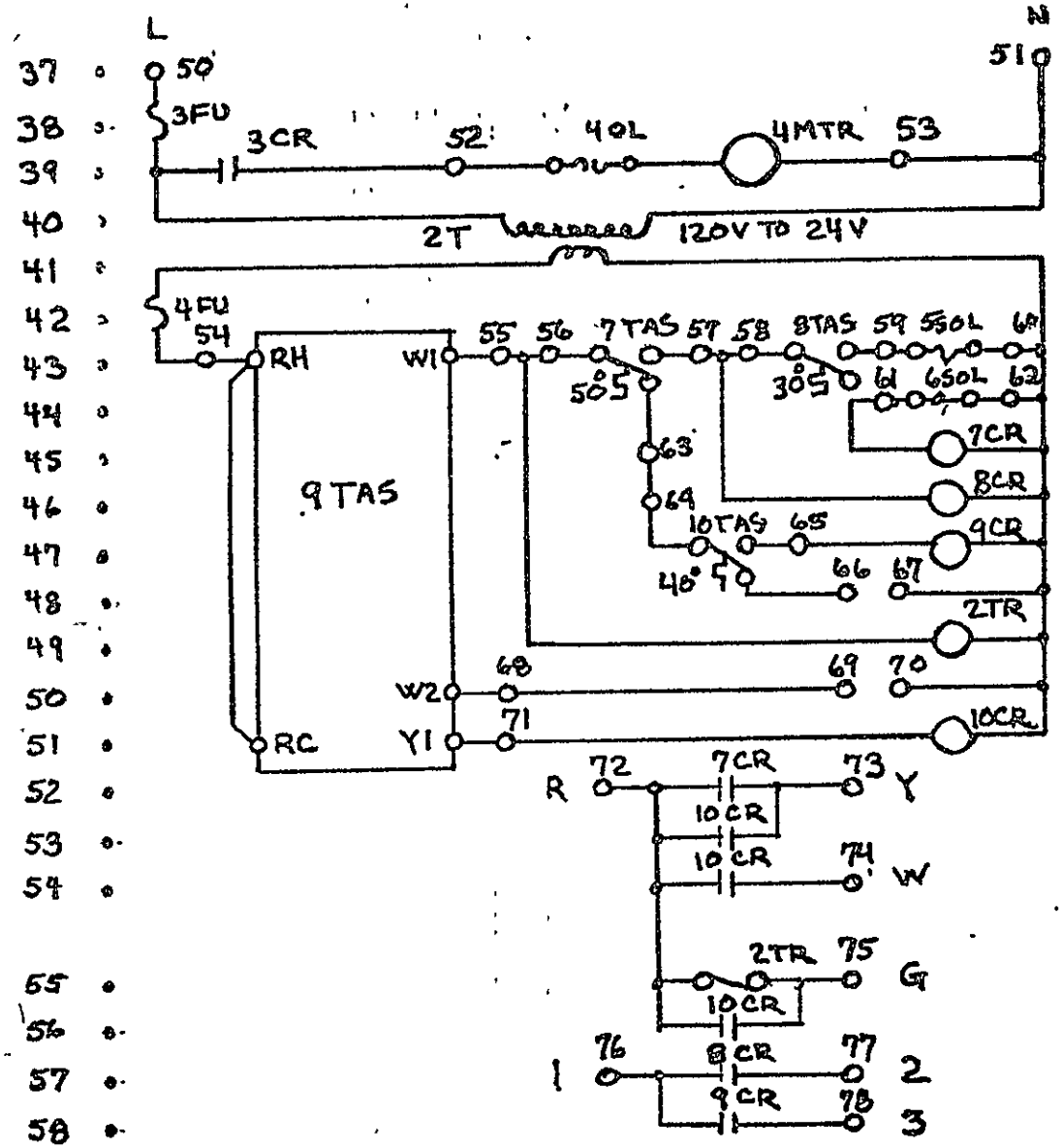
CONTROL PANEL #1 — HEAT PUMP #1 TERMINALS 17-3



PUMP P-5

WATER TEMP. T'S WATER SOL'S

HEATING HP RELAY - 52

P-5 RELAY - 39, 57

O/A T, HP CROSSOVER RELAY - 58

DUCT HEATER STAGE I

BLOWER RELAY - 55

DUCT HEATER STAGE 2

COOLING HP RELAY - 53, 54, 56

HEAT PUMP ON

HEAT PUMP COOLING

HEAT PUMP BLOWER

CONTROL PANEL #2 - HEAT PUMP #2

Proposed Instrumentation Plan (SHC-1006) (If complete at time of submission)

To be submitted at the Preliminary Design Review.

Description of Proposed Changes from System Described In Proposal

The system will be fabricated as described in the proposal with the exception of the components undergoing development as described in section 2 of the Development Plan.

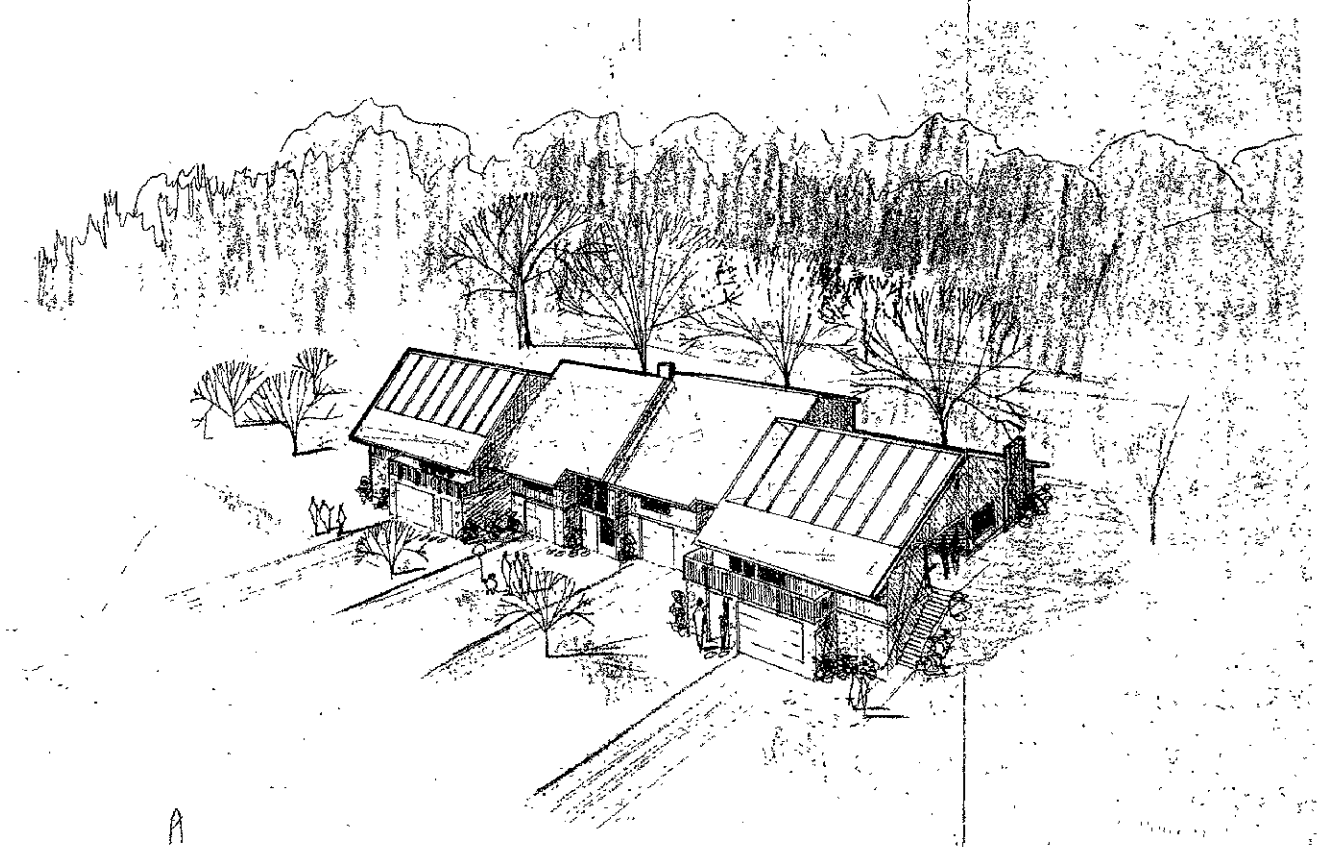
List of Component Materials to be Used in the Collector and the Component Materials in Other Subsystems That Are in Contact With the Transfer Fluid

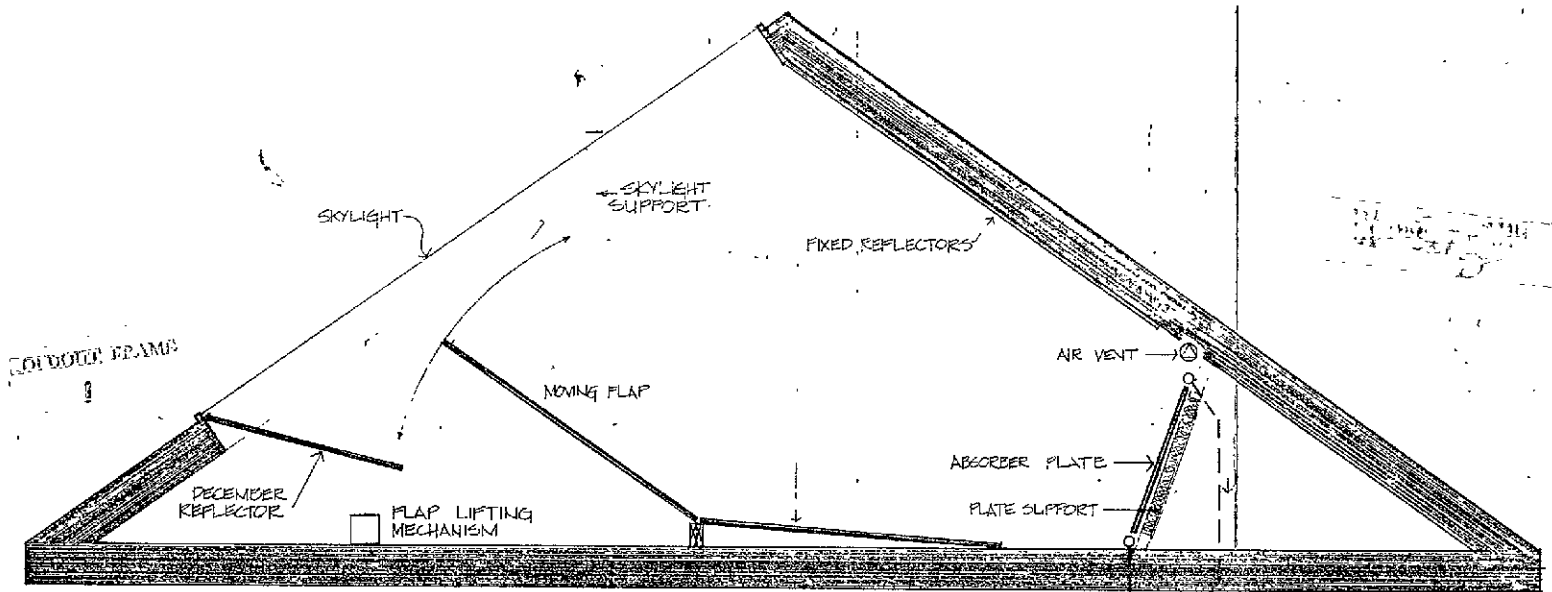
Components to be used in the pyramidal optics collector (subject to developmental improvements):

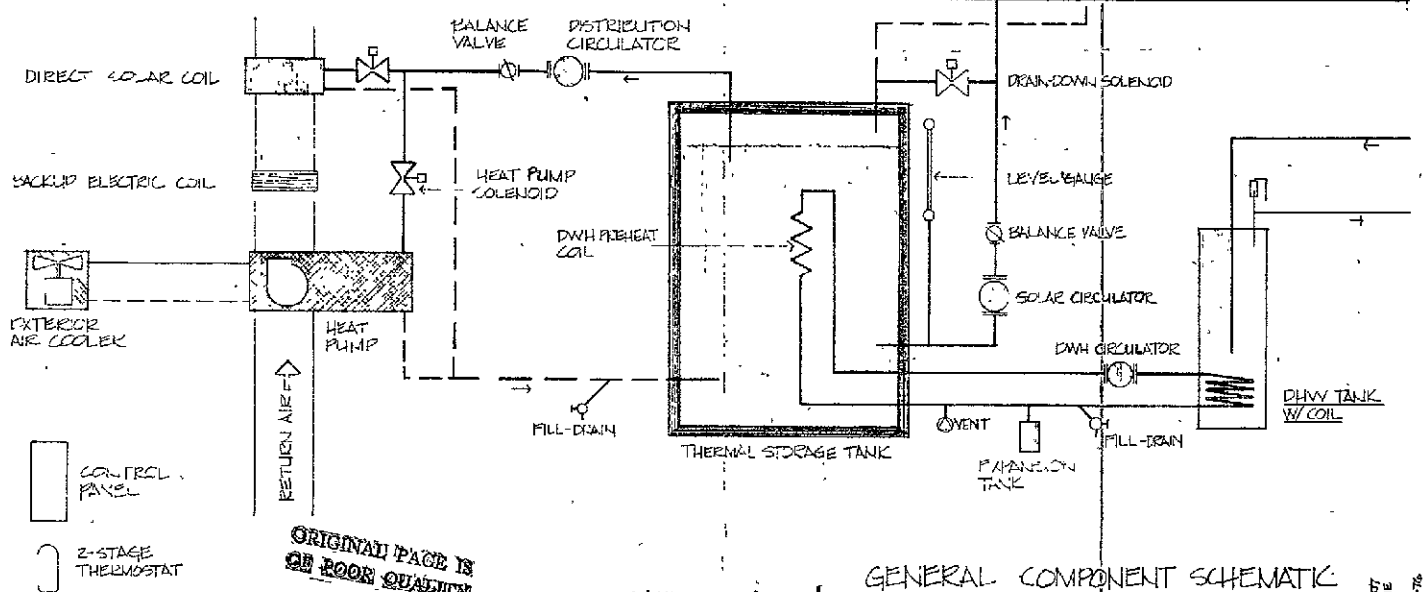
1. Copper absorber sheet
2. Absorber blacking of "black chrome"
3. Wood support structure
4. Rigid and batt insulation
5. Copper piping
6. Pipe insulation

Component materials in other subsystems in contact with heat transfer fluid (subject to developmental improvements):

1. Copper pipe, valves, fittings
2. Concrete or fiberglass storage tank


A
B





GENERAL COMPONENT SCHEMATIC

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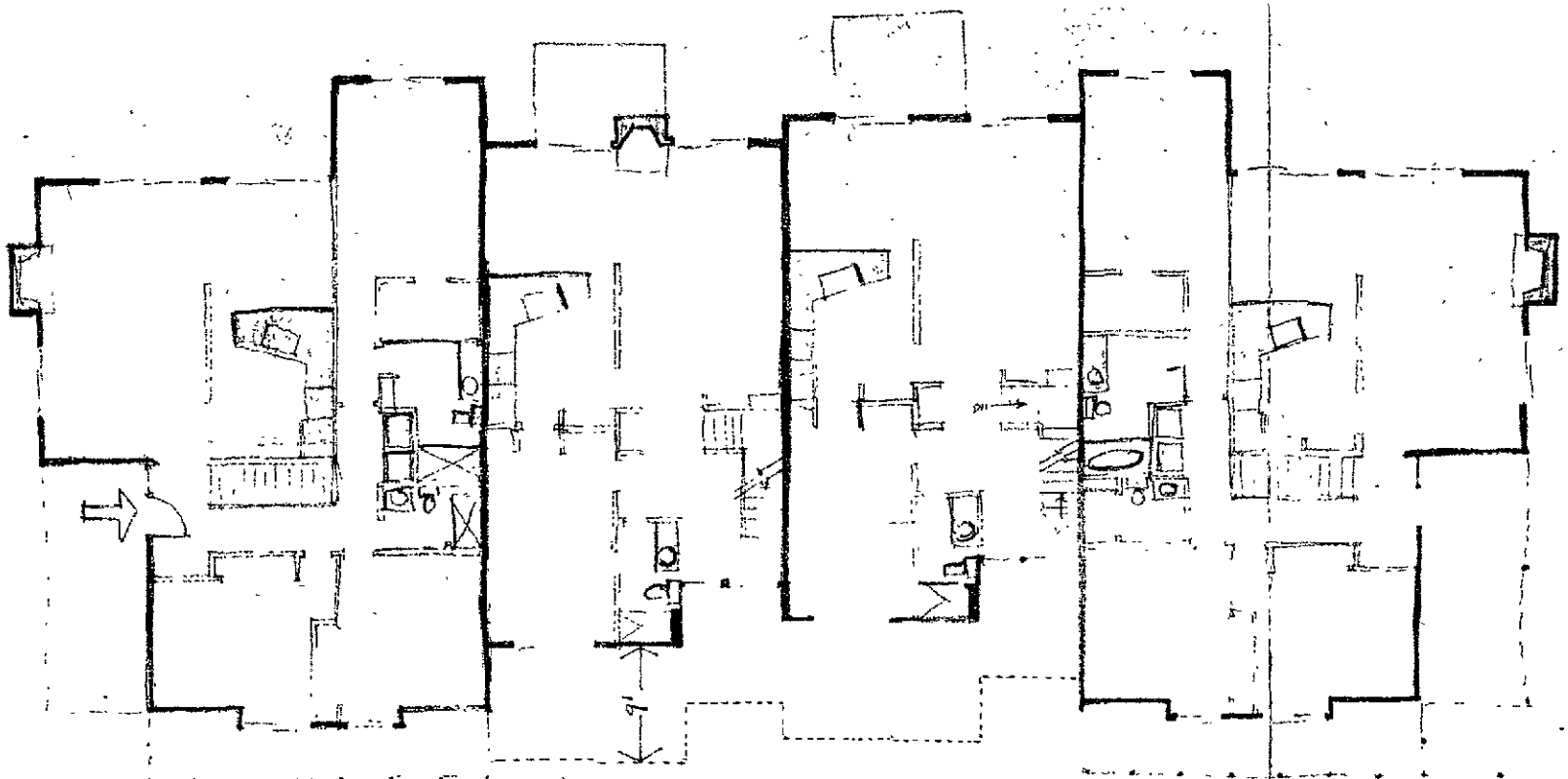


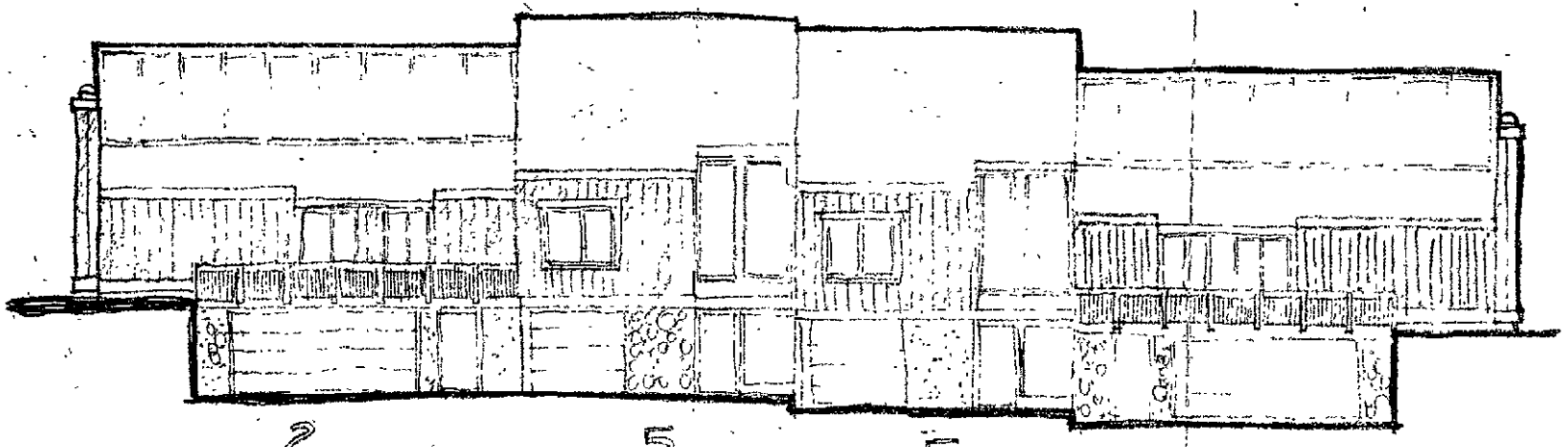
FIRST FLOOR PLAN

1/8" = 1'-0"

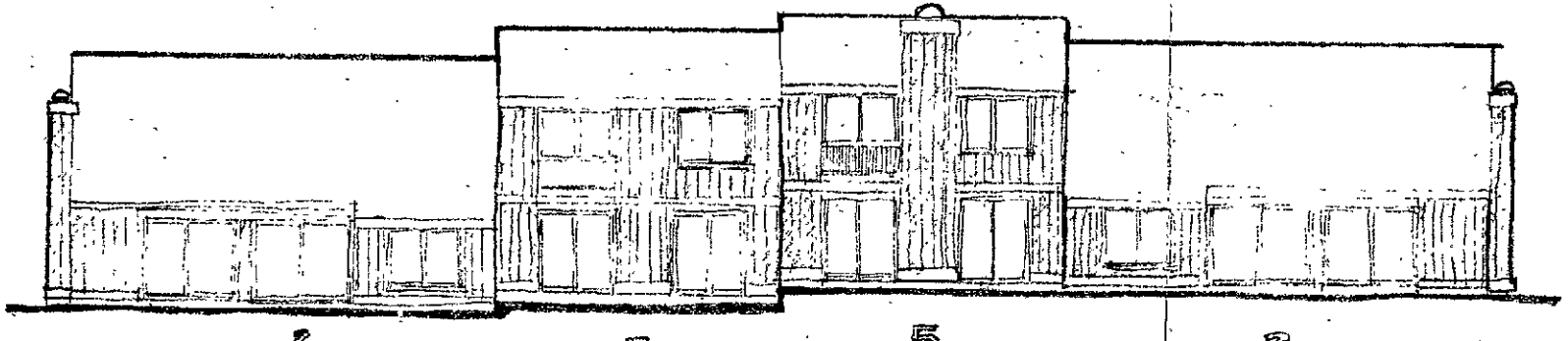
SOUTH

A

B



SOUTH (FRONT) ELEVATION
(UPHILL)



NORTH (REAR) ELEVATION
(UPHILL)

A

B

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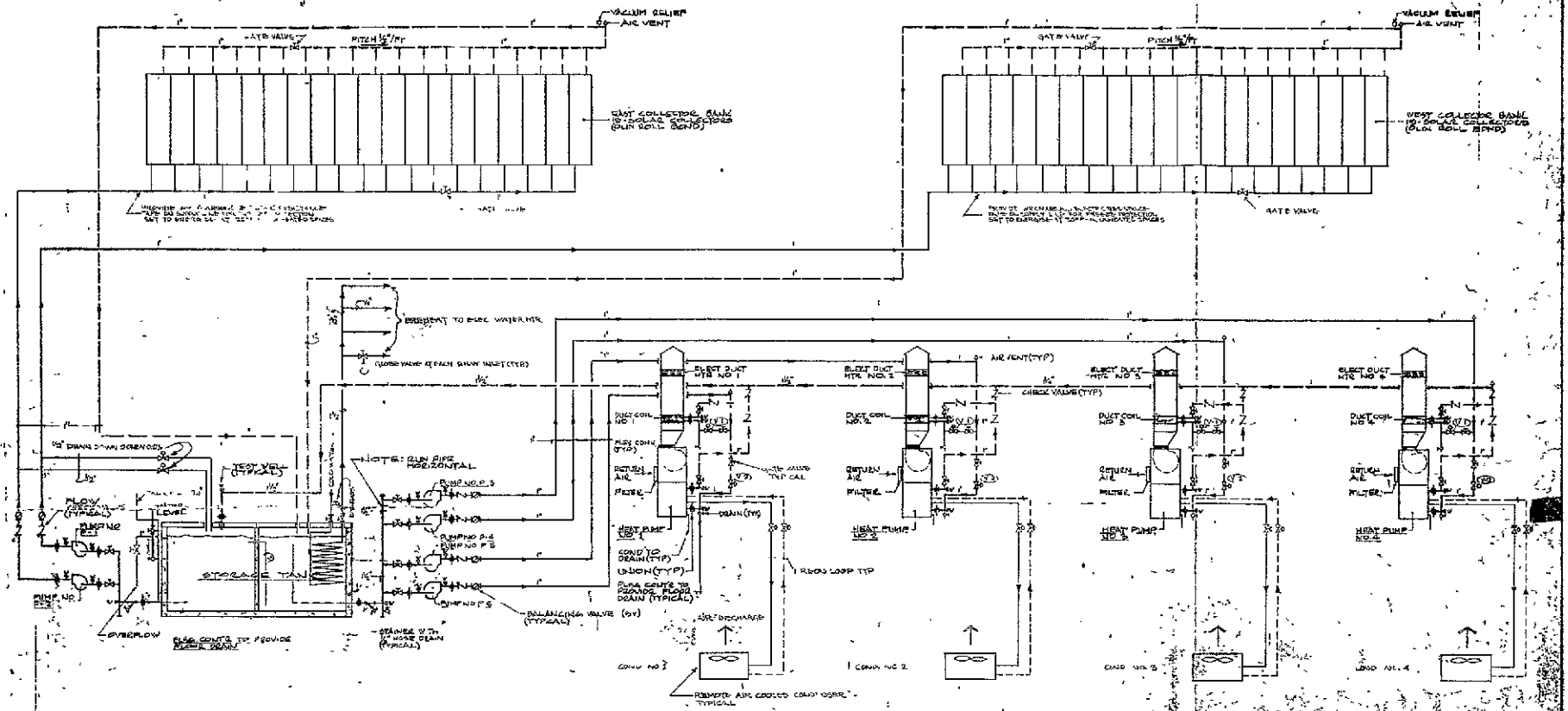

SOLAR ASSISTED WATER TO AIR HEAT PUMP SYSTEM WITH REMOTE AIR CONDENSER FOR COOLING

FLOW DIAGRAM

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