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DOE/NASA CONTRACTOR
REPORT

DR. 2812

DOE/NASA CR-161228

SOLAR HEATING SYSTEM FINAL DESIGN PACKAGE

Prepared from documents furnished by

Contemporary Systems, Inc.
68 Charlonne Street
Jaffrey, New Hampshire 03452

Under Contract NAS8-32243 with

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

For the U. S. Department of Energy

MASTER

U.S. Department of Energy

Solar Energy

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16. ABSTRACT Contemporary Systems has taken its Series V Solar Heating System and developed it to a degree acceptable by local codes and regulatory agencies. The system is composed of the Series V warm air collector, the LCU-110 logic control unit and the USU-A universal switching and transport unit. The collector was originally conceived and designed as an integrated roof/wall system and provides a dual function in the structure. The collector serves both as a solar energy conversion system and as a structural weather resistant skin. The collector can be fabricated in any length from 12 to 24 feet. This provides maximum flexibility in design and installation. The LCU-110 control unit provides totally automatic control over the operation of the system. It receives input data from sensor probes in collectors, storage and living space. The logic is designed so as to make maximum use of solar energy and minimize use of conventional energy. The USU-A transport and switching unit is a high-efficiency air-handling system equipped with gear motor valves that respond to outputs from the control system. The fan unit is designed for maximum durability and efficiency in operation, and has permanently lubricated ball bearings and excellent air-handling efficiency.			
17. KEY WORDS		18. DISTRIBUTION STATEMENT UC-59c	
		Unclassified-Unlimited WILLIAM A. BROOKSBANK, JR. Mgr, Solar Energy Applications Projects	
19. SECURITY CLASSIF. (of this report) Unclassified	20. SECURITY CLASSIF. (of this page) Unclassified	21. NO. OF PAGES 68	22. PRICE NTIS

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I. SYSTEM DESCRIPTION

The integrated, warm air solar heating system eliminates most of the problems encountered by an architect or designer when incorporating solar heating in a construction project. The individual components are fully compatible and have been developed to work together.

The Series V collectors are structural units, fastened directly to the roof or wall framing members (24" o.c). They form a fully weather-tight assembly which replaces the conventional roofing or siding. The collectors are manufactured in any length up to 24' to meet the design requirements of each installation. They are light weight -- less than two pounds per square foot -- and the insulation toward the living space is site-applied according to architectural specifications.

The Universal Switching Unit (USU) accomplishes the air circulating and switching functions. It can be equipped to operate at whatever CFM is dictated by the overall system design. Its main component is an industrial quality centrifugal fan with life lubricated ball bearings, operating at low RPM and powered by a high efficiency GE "Energy Saver" motor.

The control functions are performed by the completely automatic LCU-110 Logic Control Unit. It compares various system conditions and optimizes the use of solar energy while minimizing the use of the auxiliary heating system. The interior environment of a solar-heated house is in no way different from a conventionally heated one and requires no additional user-operated controls other than the standard room temperature thermostat. There is a manual override of the automatic functioning of the LCU Control Unit for servicing and special uses of the system.

The Fail-Safe Thermal Vents protect the collectors against overheating in summer or in the event of a power failure. They operate by thermosiphoning, and are generally connected to the inlet and outlet manifolds of the collector array.

CONTEMPORARY SYSTEMS, INC.

JAFFREY, NEW HAMPSHIRE
03452 • (603) 532 7772

TOLERANCES EXCEPT AS NOTED	TITLE: <i>System Wiring</i>	
DECIMAL	PROJECT <i>Diagram</i>	
FUNCTIONAL		
ANGULAR		
REVISIONS 1	DRAWN BY <i>EL</i>	CHECKED BY
<i>9/26/77</i>	SCALE <i>1/2"</i>	DRAWING # <i>560-001</i>

- A - Thermostat wire, class 2
- B - Shielded probe cable
- C - Class 1 wiring, compatible with codes

- *1 - to bonnetstat, sail switch or pressure switch as specified.
- *2 - to fail-safe thermal vent circuit or other as specified.

II. SYSTEM PERFORMANCE SPECIFICATION

CONTEMPORARY SYSTEMS, INC.

68 CHARLONNE STREET

JAFFREY, N. H. 03452

603-532-7972

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CONTEMPORARY SYSTEMS, INC.

68 CHARLONNE STREET

JAFFREY, N. H. 03452

603-532-7972

Date: November 8, 1977

1.0 INTRODUCTION

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

2.0 APPLICABLE DOCUMENT

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

1000-001: Leakage Specification, Control Dampers, Rev. 0
1000-002: Preliminary Collector Efficiency, Rev. 0,
Drawing #1
1000-003: CSI Installation Manual, Rev. 0
1000-004: Design Data Brochure, Rev. 0
1000-005: Quarterly Rep/Top Level Drawing List,
Oct. 20, 1977, Rev. 3

3.0 APPLICATION OF INTERIM PERFORMANCE CRITERIA BY TYPE OF SYSTEM

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

Table 1 - Residential Systems

TABLE I

SPECIFICATION NO. _____

REVISION _____

DATE _____

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
1.1 H and HC System Performance	A	A	A	1.3.1 Collector Efficiency	A	A	A
1.1.1 Heating Design Temperatures	I	I	NA	1.4 Thermal Storage	A	A	A
1.1.2 Cooling Design Temperatures	NA	I	NA	1.4.1 Storage Capacity and Rate	A	A	A
1.1.3 Relative Humidity and Water Vapor Pressure	I	I	NA	1.5 Habitability of Occupied Spaces	A	A	A
1.1.4 Solar Contribution	A	A	A	1.5.1 Heat or Humidity Transfer Effects	I	I	I
1.1.5 Operation Impairment	A	A	A	1.6 Energy Transport Efficiency	A	A	A
1.2 HW System Subsystem Performance	A	A	A	1.6.1 Thermal Losses and Electrical Power	A	A	A
1.2.1 Water Design Temperature	I	I	I	1.7 Control	A	A	A
1.2.2 Storage Design Capacity	A	A	A	1.7.1 Installation and Maintenance	A	A	A
1.2.3 Solar Contribution	A	A	A	1.7.2 Manual Adjustment	A	A	A
1.2.4 Operational Impairment	A	A	A	1.7.3 Inhabited Space Temperature	A	A	NA
1.3 Collector Performance	A	A	A	1.7.4 Hot Water Temperature	A	A	A
				1.8 Auxiliary Energy	A	A	A
				1.8.1 Design Loads	A	A	A

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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	KW		H	HC	KW
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 Expans- ion 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

TABLE I
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RESIDENTIAL SYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY								
RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEM			RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH		TYPE SYSTEM		
	M	MO	MW			M	MO	MW
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
3.2.1 Ultimate Load Combinations	A	A	A	3.9.1 Design Provisions		A	A	A
3.2.2 Ice Loads	A	A	A	4.1 Plumbing and Electrical Installation		A	A	A
3.2.3 Vehicular Loads	I	I	I	4.1.1 Plumbing Codes		A	A	A
3.2.4 Load Capacity	A	A	A	4.1.2 Electrical Codes		A	A	A
3.3 Damage Control	A	A	A	4.2 Fail-Safe Controls		A	A	A
3.3.1 Resistance to Damage	A	A	A	4.2.1 System Failure Prevention		A	A	A
3.3.2 Closing Design	A	A	A	4.2.2 Automatic Pressure Relief Valves		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 Fluids		A	A	A
3.7 Nail Resistance	A	A	A	4.5 Safety		I	I	I
3.7.1 Nail Size and Loading	A	A	A	4.5.1 Emergency Egress and Access		I	I	I
3.8 Constraint Loads	A	A	A	4.5.2 Identification and Location of Controls		A	A	A
3.8.1 Foundation Settlement	A	A	A	4.6 Protection of Potable Water and Circulated Air		A	A	A

TABLE I

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RESIDENTIAL SYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY

SHEET 6 OF 6

APPLICATION

A - APPLICABLE TO SYSTEMS INDICATED
 I - APPLICABLE TO SYSTEM AND BUILDINGS
 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 Decom- position 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 Flutotoxicity by Used	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

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RESIDENTIAL SYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY

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APPLICATION

A - APPLICABLE TO SYSTEMS INDICATED
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TYPE SYSTEMS

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

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RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS			RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS		
	H	HC	HW		H	HC	HW
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, HW 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 Sub- system	I	I	I	12.1.3 Permanent Mainte- nance 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 Dam	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 Character- istics 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

4.1 Deviations to Residential I. P. C.

All of the not applicable deviations, NA (Dev), were criteria which do not apply to single dwelling air circulating heating systems as ours. For example, criteria 1.2 "DHW system/subsystem performance" can not be applied to our space heating system. The following criteria deviations fall into this category: 1.2, 1.7.4, 2.1.5, 2.2.3, 2.2.4, 2.3.1, 2.3.2, 2.5, 2.5.1, 2.6.4, 3.2.3, 3.3.2, 4.1.1, 4.2.2, 4.4, 4.4.1, 4.4.2, 4.6.1, 4.6.2, 4.6.3, 5.1.2, 5.2.2, 5.2.4, 6.1.3, 6.1.4, 6.1.6, 6.3.2.

Should the configuration of our system change in a way which makes any of these criteria be applicable to our system, CSI will make changes in accordance with the I. P. C.

The deviations in paragraph 1.8.1, 2.1.7, 2.7, 2.7.1 are due to criteria which apply to design of the specific house and heating system required of the architect or HVAC engineers, not to our system before installation. Here the pertinence has been changed from applicable to heating system" to "applicable to system and building, as per architect's specifications."

5.0 GOVERNMENT FURNISHED PROPERTY

The Government will furnish a Site Data Acquisition System for both installations. The requirements and composition and all deviations of these SDAS have been submitted on the proper forms to NASA

6.0 GOVERNMENT DIRECTED REQUIREMENTS

TABLE 2

IPC PARAGRAPH	PERTINENCE	IPC	PERTINENCE	IPC	PERTINENCE	IPC	PERTINENCE
1.1	A	2.5	A	4.6.3	NA (DEV)	7.3.2	I
1.1.1	I	2.6.1	A	4.6.4	A	7.3.3	I
1.1.2	NA	2.6.2	A	4.7	A	7.3.4	I
1.1.3	I	2.6.3	A	4.7.1	A	8.1	I
1.1.4	A	2.6.4	NA (DEV)	5.1	A	8.1.1	I
1.1.5	A	2.7	I (DEV)	5.1.1	A	8.1.2	I
1.2	NA (DEV)	2.7.1	I (DEV)	5.1.2	NA (DEV)	8.1.3	I
1.2.1	I	2.8	A	5.1.3	A	8.2	I
1.2.2	A	2.8.1	A	5.1.4	A	8.2.1	I
1.2.3	A	3.1	A	5.1.5	A	8.2.2	I
1.2.4	A	3.1.1	A	5.1.6	A	8.3	I
1.3	A	3.1.2	A	5.2	A	8.3.1	I
1.3.1	A	3.2	A	5.2.1	A	8.3.2	I
1.4	A	3.2.1	A	5.2.2	NA (DEV)	8.4	I
1.4.1	A	3.2.2	A	5.2.3	A	9.1.1	I
1.5	A	3.2.3	NA (DEV)	5.2.4	NA (DEV)	9.2	I
1.5.1	I	3.2.4	A	5.2.5	A	9.2.1	I
1.6	A	3.3	A	5.2.6	A	9.2.2	I
1.6.1	A	3.3.1	A	5.3	A	9.3	I
1.7	A	3.3.2	NA (DEV)	5.3.1	A	9.3.1	I
1.7.1	A	3.4	A	5.3.2	A	9.3.2	I
1.7.2	A	3.4.1	A	5.3.3	A	9.3.3	I
1.7.3	A	3.5	I	5.3.4	A	10.1	I
1.7.4	NA (DEV)	3.5.1	I	5.4	A	10.1.1	I
1.8	A	3.6	I	5.4.1	A	10.1.2	I
1.8.1	I (DEV)	3.6.1	I	6.1	A	11.1	I
2.1	A	3.7	A	6.1.1	A	11.1.1	I
2.1.1	A	3.7.1	A	6.1.2	A	11.2	I
2.1.2	A	3.8	A	6.1.3	NA (DEV)	11.2.1	I
2.1.3	A	3.8.1	A	6.1.4	NA (DEV)	11.2.2	I
2.1.4	A	3.8.2	A	6.1.5	A	11.2.3	I
2.1.5	NA (DEV)	3.9	A	6.1.6	NA (DEV)	11.3	I
2.1.6	A	3.9.1	A	6.2	A	11.3.1	I
2.1.7	I (DEV)	4.1	A	6.2.1	A	12.1	I
2.1.8	NA	4.1.1	NA (DEV)	6.2.2	A	12.1.1	I
2.2	A	4.1.2	A	6.2.3	A	12.1.2	I
2.2.1	A	4.2	A	6.2.4	A	12.1.3	I
2.2.2	A	4.2.1	A	6.3	A	12.2	I
2.2.3	NA (DEV)	4.2.2	NA (DEV)	6.3.1	A	12.2.1	I
2.2.4	NA (DEV)	4.3	A	6.3.2	NA (DEV)	12.2.2	I
2.2.5	A	4.3.1	A	7.1	I	12.3	I
2.2.6	A	4.3.2	I	7.1.1	I	12.3.1	I
2.3	A	4.4	NA (DEV)	7.1.2	I	13.1	I
2.3.1	NA (DEV)	4.4.1	NA (DEV)	7.1.3	I	13.1.1	I
2.3.2	NA (DEV)	4.4.2	NA (DEV)	7.1.4	I	13.1.2	I
2.3.3	A	4.5	I	7.2	I		
2.4	A	4.5.1	I	7.2.1	I		
2.4.1	A	4.5.2	A	7.2.2	I		
2.4.2	A	4.6	A	7.2.3	I		
2.5	NA (DEV)	4.6.1	NA (DEV)	7.3	I		
2.5.1	NA (DEV)	4.6.2	NA (DEV)	7.3.1	I		

Date: November 8, 1977

7.0 GEOGRAPHICAL AREA

Solar heating system for single family dwelling is for installation in northeastern region of the United States. The states included in the northeastern region are New Hampshire, Vermont, Maine, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania, Delaware, Ohio.

8.0 SYSTEM APPENDICE

Appendix A, System Performance Specification for
New Hampshire Vocation-Technical College House

SYSTEM PERFORMANCE SPECIFICATION

APPENDIX A

Specification No. 1-NHVT

Page Date June 1977

A SYSTEM IDENTIFICATION

This Appendix defines the performance and installation drawings for (Enter type of system), (Enter Contractor Name), System Model Number (Enter Model Number).

A-1 SYSTEM PERFORMANCE SHEETS

Site - Campus, New Hampshire Vocational-Technical College

The system shall be installed in a residence in the city of Manchester, county of Hillsboro, state of New Hampshire

Heating Capacity

The system will provide solar energy for 92+ % of the average total heating load during the heating season based on an average total heating load of $*8.5 \times 10^6$ BTU/Month and a peak heating load of 35,000 BTU/hr.

Cooling Capacity

The system will provide solar energy for 0 % of the average total cooling load during the cooling season, based on an average total cooling load of ---- BTU/Month and a peak cooling load of ---- BTU/hr.

Auxiliary Energy

The average rate of auxiliary energy used for heating shall be no greater than 4×10^6 BTU/Month of the total energy required for heating, including hot water. This shall be no greater than 6 % of the total energy required for heating. The average rate of auxiliary energy used for cooling during the cooling season shall be no greater than --- BTU/Month. This shall be no greater than --- % of the total energy required for cooling.

*7 month avg.

SYSTEM PERFORMANCE SPECIFICATION

Specification No. 1-NHVT

Page Date June, 1977

Hot Water

50 gal/day ~~volume~~ of potable (or useable) hot water shall be delivered at no less than 1.25 gal/min at temperatures no less than 130 °F. Recovery time shall be no greater than 3 hours. The average hot water heating load will be 1.1×10^6 BTU/Month of which 58 % 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 2 K.W. The maximum electrical energy required to drive the complete system shall be no greater than 2 K.W. The average yearly electrical energy required to drive the system shall be no greater than 1800 K.W.H. Water requirements for cooling condensers and/or air humidification shall be no greater than --- gal/hr.

Physical Data - Table II

The following subsystems shall have:

	Design life no less than	Weight (filled) no greater than	Installation dimensions
Heating	<u>20</u> years	<u>---</u> lbs	<u>---</u>
Cooling	<u>---</u> years	<u>---</u> lbs	<u>---</u>
Auxiliary Energy	<u>20</u> years	<u>200</u> lbs	<u>3'x5'x5'</u>
Storage	<u>30</u> years	<u>95,000</u> lbs	<u>12'x12'x8'</u>
Potable Water (or useable)	<u>20</u> years	<u>1,200</u> lbs	<u>1'x2'x4'</u>
Collector	<u>20</u> years	<u>2</u> lbs/ft ²	<u>717 sq. ft.</u>
Energy Transport	<u>25</u> years	<u>260</u> lbs/ft	<u>N/A</u>
Controls	<u>25</u> years	<u>10</u> each	<u>N/A</u>
(Other)			

III. SYSTEM OPERATION

The system has six operating modes: standby, storing heat, heating from collectors, heating from storage, auxiliary heating, and combined auxiliary heating and storing heat (see Fig. III-1). The order of priority is as follows:

1. Heating from collectors: when the room thermostat demands heat and the collectors are receiving sufficient energy to provide heated air at greater than approximately 85°F to the house.
2. Heating from storage: when the room thermostat demands heat and there is insufficient energy in the collectors but enough energy in storage to provide heated air at greater than about 85°F to the house.
3. Combined Auxiliary heating and storing heat: with heat demand and insufficient energy in collectors and storage for room heating but sufficient energy in the collectors to charge storage. In this case the auxiliary furnace provides for space heating and energy from the collectors is stored concurrently.
4. Auxiliary heating: when the house demands heat and none is available from the collectors or from storage for space heating or storing. The auxiliary furnace provides back-up heating for the house.
5. Storing Heat: with no heat demand from the house and sufficient energy in the collectors for storing.
6. Standby: with no heat demand and insufficient collector energy for storing (or a full storage).

The following points concerning system operation should also be noted:

1. In no mode is solar heat ever stored or used when its equivalent value, in auxiliary fuel dollars, would be less than the value of the electrical power needed to run the system.
2. The Fail-Safe Thermal Vents cool the collectors in warm weather when no heat is demanded or needed in storage. The collector array circulates outside air by thermosiphoning. The vents open automatically whenever temperatures exceed 165°F , due either to ambient temperature rise or power failure.

OPERATING MODES :

- A. STORING HEAT
- B. HEATING FROM STORAGE
- C. HEATING FROM COLLECTORS
- D. AUXILIARY HEATING

TOLERANCES EXCEPT AS NOTED	TITLE: SYSTEM SCHEMATIC	
DECIMAL	PROJECT: GENERAL SPECIFICATIONS	
FUNCTIONAL	PARALLEL SYSTEM	
ANGULAR		
REVISIONS	DRAWN BY E.L.	CHECKED BY
7/5/77	SCALE 1"	DRAWING # 500-013

Figure III-1

3. The air flow through storage is reversed between storing and heating from storage modes so that temperature stratification is maintained.
4. The LCU-110 solar system control accomplishes automatic control of dampers, the USU, the auxiliary furnace and the fail-safe thermal vents. It monitors collector temperature, storage temperatures (hot end and cold end) and the two-stage room thermostat. Settable system parameters include: collector-storage differential and collector and storage output sensible heat temperatures. Storage temperature may also be limited, in summer, to 100°F.
5. Free float check valves are used in the system ducts where needed to prevent unwanted thermosiphoning and backflow through the auxiliary furnace.
6. A replaceable filter must be provided in the return duct from the living space to prevent dust accumulation in the rock storage or collectors. This system must be maintained with filters being replaced every 500 hours of operation.

IV. SERIES V SOLAR COLLECTORS

The Series V warm air circulating collectors have several unique design features. They are structural units which are fastened directly to the two-inch nominal house framing members which are spaced 24" on center. They form a water-tight roof or wall assemble and replace the conventional roofing or siding. This approach reduces costs in new construction when compared to an external, add-on collector. Great architectural freedom is also gained by custom manufacturing the length of the collectors to each different installation.

The collector chassis is constructed of a specially designed extruded aluminum side rail and two-piece end caps. The complete unit is very light weight (less than two pounds per square foot) and installs quickly and easily. There is a double glazing: the outer layer is Kalwall "Sunlite Premium II" 40 mil fiberglass and the inner layer is Teflon FEP. This combination glazing design is highly efficient for admitting and trapping solar energy. It also lends a particularly attractive appearance to the collector array, and can be used to great design advantage.

The chassis sides are insulated; rear insulation is site-applied to meet individual job requirements.

One of the most interesting features of the Series V design is that it accommodates differential expanding and contracting of the glazing, maintaining the integrity of weatherseal and avoiding warpage, which is a problem with some other designs on the market. The glazing unit is easily removable from the collector chassis in case of damage.

FRONT

SIDE

BACK

LENGTH: 12" 20" AS PER ARCHITECTURAL REQUIREMENTS

TOLERANCES EXCEPT AS NOTED	TITLE: <i>SERIES I COLLECTOR, 2X</i>	
DECIMAL : .04"	PROJECT: <i>GENERAL SPECIFICATIONS</i>	
FUNCTIONAL: : 1/16"	<i>COLLECTOR EXTERNAL</i>	
ANGULAR : NA	<i>DIMENSIONS</i>	
REVISIONS	DRAWN BY <i>J.C. 6-3-77</i>	CHECKED BY
9-13-77 JC	SCALE 1" = 1'	DRAWING # <i>510-007</i>

COLLECTOR EDGE DETAIL
SHOWING MOUNTING FLANGE

CONTEMPORARY SYSTEMS, INC.

JAFFREY, NEW HAMPSHIRE

03452

(603) 532-7972

MATERI ::

Kalwall: 22-13/16 inches wide .40" Premium grade or equivalent

Extrusions: CSI#120-004 Alloy 6063-T4

TOLERANCES
EXCEPT AS NOTED

DECIMAL

FUNCTIONAL

ANGULAR

REVISIONS

TITLE: COVER ASSEMBLY

PROJECT SERIES II

DRAWN BY
JTC 10-5-77

SCALE

CHECKED BY

DRAWING # 120-008

10X

3/8":1"

JOB.

MATERIALS:

.032" aluminum

QUANTITY:

TOLERANCES
EXCEPT AS NOTED

DECIMAL

± .03"

FUNCTIONAL

± 1/32"

ANGULAR

± NA

REVISIONS

TITLE

COLLECTOR END CAP

PROJECT

SERIES IV - 2X

PRODUCTION

DRAWN BY

JTC

CHECKED BY

SCALE

3" = 1"

DRAWING #

130-010

NOTE: 7

END CAP TO BE USED ONLY WITH CSI EXTRUSION #130-009

CONTEMPORARY SYSTEMS, INC.

JAFFREY, NEW HAMPSHIRE

03450

(603) 532 7072

ACTUAL SIZE

"This drawing represents an interpretation by Reynolds Metals Company of the section requested by its customer. Reynolds will manufacture extrusions in accordance with this section drawing, customer should thoroughly check this section drawing against its own design criteria. Reynolds Metals Company makes no warranty of fitness for a particular purpose with regard to extrusions produced pursuant to this drawing, its only warranty being that set forth in its sales order acknowledgment form."

REVISIONS

CONTEMPORARY SYSTEMS, INC.

REYNOLDS STANDARD TOLERANCES FOR EXTRUDED ROD, BAR & SHAPES APPLY UNLESS SPECIFICALLY SHOWN OTHERWISE.

ESTIMATED AREA	.081	SQ IN
EST. WT PER FT.	.097	LBS
EST PERIMETER	3.325	IN
FACTOR	34	CIRCLE DIA. 1-2
CODE	A	BT CT M S

CITY	STATE	JAFFREY, N.H.	CUST. NO.	130-009-A
IND. USE	SCALE	2X	DR	WEA
CK	DATE	6-29-77	SECTION CLASSIFICATION	ALLOY
SOLID	6063-T6	OUR SECTION NO.	69557	REV
INO NO.	2746			

TOLERANCES EXCEPT AS NOTED	TITLE: <i>TOP FLASHING PROFILE</i>	
DECIMAL ±	PROJECT <i>SERIES IV + V</i>	
FUNCTIONAL ±	<i>COLLECTORS</i>	
ANGULAR ±		
REVISIONS	DRAWN BY <i>JC</i>	CHECKED BY
	SCALE	DRAWING # <i>150-006</i>

TOLERANCES EXCEPT AS NOTED	TITLE: <i>SUB CHASSIS DET.</i>	
DECIMAL	PROJECT: <i>SERIES I COLLECTOR</i>	
FUNCTIONAL		
ANGULAR		
REVISIONS	DRAWN BY <i>8-8-77 JC</i>	CHECKED BY
	SCALE	DRAWING # <i>130-017</i>

ALUMINUM TUBE: 1/4" DIA. .058" WALL 6061-T6
 TUBE LENGTH:
 INNER CHASSIS: CSI # 130-015

"This drawing represents an interpretation by Reynolds Metals Company of the section requested by its customer. Reynolds will manufacture extrusions in accordance with this section drawing, customer should thoroughly check this section drawing against its own design criteria. Reynolds Metals Company makes no warranty of fitness for a particular purpose with regard to extrusions produced pursuant to this drawing, its only warranty being that set forth in its sales order acknowledgment form."

REVISIONS		CUSTOMER	
		CONTEMPORARY SYSTEMS INC.	
		CITY	CUST. NO.
		STATE	130-015
		SOLAR PANEL - INNER CHASSIS	
		SCALE	DR
		4X	WEA
		CK	DATE
			8-2-77
REYNOLDS STANDARD TOLERANCES FOR EXTRUDED ROD, BAR & SHAPES APPLY UNLESS SPECIFICALLY SHOWN OTHERWISE		SECTION CLASSIFICATION	
ESTIMATED AREA .141 SQ IN		SOLID	
EST WT PER FT .169 LBS		ALLOY	
EST PERIMETER 4.829 IN		6063-T5	
FACTOR 29 CIRCLE DIA 1-2 1.4		OUR SECTION NO	
CODE		69617	
A BT CT M S		REV	
		INO NO	
		2775

TOLERANCES EXCEPT AS NOTED	TITLE: <i>SILICONE KEY STRIP</i>	
DECIMAL	PROJECT <i>SERIES II COLLECTOR</i>	
±		
FUNCTIONAL		
±		
ANGULAR	<i>BY: CHASE/WALTON CO.</i>	
±		
REVISIONS	DRAWN BY <i>JTC 8-8-77</i>	CHECKED BY
	SCALE	DRAWING # <i>130-016</i>

MATERIALS:

Extruded profile; Aluminum alloy 6063-T5

TOLERANCES EXCEPT AS NOTED	TITLE: <i>BOTTEN CAP</i>	
DECIMAL	PROJECT: <i>SERIES II+V</i>	
FUNCTIONAL	<i>COLLECTOR</i>	
ANGULAR		
REVISIONS	DRAWN BY <i>JC</i>	CHECKED BY
	SCALE <i>RX</i>	DRAWING # <i>150-005</i> <i>PREVIOUS: 150-004</i>

NOTES

1. ALL UNSPECIFIED TOLERANCES TO BE $\pm .010$
2. BREAK ALL SHARP CORNERS.

TOLERANCES EXCEPT AS NOTED	TITLE <i>COLLECTOR SECTION</i>	
DECIMAL	PROJECT <i>SERIES V</i>	
FUNCTIONAL		
ANGULAR		
REVISIONS	DRAWN BY <i>T-T-TT J.C.</i>	CHECKED BY
	SCALE	DRAWING # <i>100-004</i>

TOLERANCES
EXCEPT AS NOTED

DECIMAL

± NA

FUNCTIONAL

± NA

ANGULAR

± NA

REVISIONS

9.13.77
JL

TITLE: *SERIES IV COLLECTOR*

PROJECT *GENERAL SPECIFICATIONS*

FRAMING DETAILS, INTEGRATED

ROOF ARRAY

DRAWN BY *J.C.*

CHECKED BY

SCALE *NA.*

DRAWING #
510-002

COLLECTOR CHASSIS
CANNOT PROJECT ABOVE
POINT WHERE DEPTH
FROM FRAME FACE
IS LESS THAN 4"

UPPER PORT - MEASURE INSET
FROM TOP OF COLLECTOR TO
TOP EDGE OF PORT (NOTE:
LOCATE PORT AS CLOSE TO END
AS POSSIBLE)

OUTPUT MANIFOLD -
ASPECT OF MANIFOLD MAY
VARY TO SUIT ARCHITECTURAL
REQUIREMENTS.

IMPORTANT DO NOT INSET END
RAFTERS $3/4"$ AS IS USUAL FRAMING
PRACTICE. ALL RAFTERS MUST BE
SPACED 24" OC. WITH A 22 1/2" FACE
TO FACE SPACING. COLLECTORS WILL
BE INSTALLED BETWEEN RAFTERS
DO NOT USE HEADER ON LOWER END
OF RAFTERS

MANIFOLD

GENERAL SPECIFICATION CALLS FOR ALL
COLLECTORS TO RUN FROM LOW POINT ON
EAVES TO RIDGE OR A POINT JUST BELOW
THE RIDGE. THIS PROVIDES A
MONOLITHIC GLAZING SURFACE WITH NO
LATERAL SEAMS. IT IS INADVISABLE TO
END COLLECTOR RUN ABOVE THE LOWEST
POINT OF ROOF LINE. COLLECTOR GLAZING
IS CONCAVE (-1" BELOW TOP EDGE OF RAFTER) AND
WILL PRESENT A SCALLOPED FACIA.

NOTE: ALWAYS LOCATE PORTS AS CLOSE
TO ENDS AS POSSIBLE.

COLLAR BEAM - IF
A COLLAR BEAM IS
REQUIRED TRY TO AVOID
THE NEED FOR TIEING IT
DIRECTLY ONTO THE ARRAY
RAFTER. THE PICTURED
CONFIGURATION WILL
SIMPLIFY CONSTRUCTION.

TOLERANCES EXCEPT AS NOTED	TITLE: <i>SERIES III COLLECTOR</i>	
DECIMAL	PROJECT: <i>GENERAL SPECIFICATIONS</i>	
FUNCTIONAL	<i>FLASHING & TRIM</i>	
ANGULAR		
REVISIONS	DRAWN BY <i>JL.</i>	CHECKED BY
6-3-77 <i>JL</i>	9-13-77 <i>JL</i>	SCALE
		DRAWING # <i>510-005</i>

② TWO PIECES OF 5/8" SHEATHING USED AT COLLECTOR HEAD TO BRING ELEVATION OF ROOFING EQUAL WITH BATTEN CAPS.

V. LOGIC CONTROL UNIT (LCU-110)

INTRODUCTION

The LCU-110 Solar Controller is designed to control air-circulating space heating solar energy systems. It monitors temperatures in the collectors and in storage and responds to demands for heating from the room thermostat. System dampers and fans are controlled in a manner which maximizes use of solar energy and calls upon the auxiliary (back-up) heating system only when there is no solar or stored solar energy available. It also provides the homeowner with a display of the solar system's operating mode and the solar energy available. It simplifies solar system servicing and start-up with its manual operating capability, and its logic (decision-making) circuitry can be tailored to virtually any system arrangement.

The LCU-110 operates the whole heating system automatically 99% of the time, becoming a "forgettable intermediary" between the thermostat and the back-up heating system, making use of solar energy whenever available. Attractive and of rugged construction, the LCU-110 Solar Controller offers these advantages:

- lower control costs: the LCU-110 costs less than designing and installing a customized control system of relays, differential thermostats and temperature controllers
- simplified air transport system: use of the LCU-110 allows moving air between collectors, storage and living space with one fan and less ducting than otherwise; when used in conjunction with the CSI Solar Air Mover (USU) it greatly reduces air transport system installed costs and complexity
- ease of operation: the display and automatic/manual controls make any solar system easier to understand, operate and maintain

This manual provides information on the installation, operation and maintenance of the LCU-110. Part 1 explains the operation and function of the controller. This section should be read by installers, system maintainers and solar homeowners. Part 2 is written for the installer (electrician or other qualified person). Part 3 is directed toward those servicing or troubleshooting the solar system and the LCU-110. The Appendix contains specifications, circuit diagrams, warranty information and any information specific to the installation for which this manual was supplied.

Two versions of the LCU-110 are available: Series Logic for systems with the auxiliary heater between the solar system and the living space, and Parallel Logic for auxiliary systems in parallel with the solar. This manual was written for the more common parallel configuration but when the Series version differs significantly, the text is so noted. Other arrangements of solar and auxiliary systems can be controlled by custom tailoring the LCU-110.

FIG. 1

THEORY OF OPERATION

The operation of the LCU-110 controller is illustrated in the block diagram below (fig. 2). The Temperature Comparing Circuits compare system input temperatures with the temperature settings of the controller, and three signals are generated:

COLLECTOR HEAT tells us whether the collectors are converting solar energy at a rate great enough to heat the living space

STORAGE HEAT defines whether the rock storage bin is hot enough to use stored heat

DIFFERENTIAL indicates that the collectors are hot enough and the storage bin cool enough to warrant storing solar energy

The Solar Mode Selector looks at these three signals and at the room thermostat's request for heat and determines what mode the solar system

FIG. 2 37

should operate in to make best use of available solar energy. It outputs this requested mode to the Mode Implementor (if the LCU-110 is being operated manually, the Mode Implementor takes the mode indicated by the Manual Mode Switch). The Mode Implementor maintains the current operating mode and does the work necessary to change the system from one mode to another, such as shutting down the fan to allow dampers to change or waiting for the auxiliary heater to cool down at the end of a cycle. It may take two or more fifty second intervals to accomplish this.

The Mode Implementor provides the current mode to the Mode-to-Output Decoder which controls the proper damper, fan and auxiliary heater control outputs needed to operate the solar system in each mode.

SYSTEM TEMPERATURE SETTINGS

Three RTD temperature probes sense collector output air temperature (RTC), hot side storage temperature (TS2) and cold side storage temperature (TS1). These temperatures are compared with the settings of the six dials (potentiometers) on the main circuit board inside the LCU-110.

FIG. 3

These settings are the turn-on and turn-off temperatures for the three signals to the logic or decision making circuitry: COLLECTOR HEAT, STORAGE HEAT and DIFFERENTIAL. TC3-TC2, TC2-TC1 and TC1 are settings which determine if air coming from the collectors is hot enough to deliver to the living space to heat it properly. This temperature is dependent upon the air's velocity and moisture content. A

minimum of 85°F (29°C) is common. As the collectors warm up their temperature must rise above the turn-on threshold TC2 before COLLECTOR HEAT is "on", and heating from the collectors is allowed. As air begins circulating through the collectors their temperature will decrease somewhat, stabilizing between TC2 and TC1 for a period of time. If the solar input is insufficient and the collector temperature falls below TC1, COLLECTOR HEAT goes "off" and heating from the collectors is not allowed. In this controller TC1 and TC2-TC1 (i.e. the difference between TC2 and TC1) are adjustable.

This turn-on and turn-off difference is commonly called system hysteresis and prevents the system from cycling on and off too frequently. Figure 4 shows this hysteresis provision graphically.

NOTE: Series Systems have an additional setting - TC3-TC2 - and have two levels of Collector Heat.

FIG. 4

C-S DIFF and C-S HYS are settings which determine if air coming from the collectors is hot enough to put energy into storage. The collectors must be hotter than the cold side of storage by an amount equal to C-S DIFF plus C-S HYS before the DIFFERENTIAL is turned "on" and storing heat is allowed. Should this difference fall below C-S DIFF then DIFFERENTIAL will be turned off and storing heat will no longer be allowed. This process is illustrated below:

FIG. 5

TS MIN is a temperature setting which determines when the rock storage bin is hot enough to allow space heating from storage. When the hot side of storage rises to a temperature equal to the TS MIN setting plus 5°F, STORAGE HEAT is turned "on" and heating from storage is allowed. When the hot side storage temperature falls below TS MIN then STORAGE HEAT is turned "off" and heating from storage is no longer allowed. The Storage Heat hysteresis is internally set to 5°F.

FIG. 6

TC1 and TS MIN are commonly set at the same temperature. Also, TC2-TC1 is commonly set equal to C-S HYS.

TEMPERATURE COMPARING CIRCUITS

FIG. 7

The temperature comparing circuits (see fig. 2) compare system temperatures to the settings on the main circuit board inside the LCU-110 and generate the three signals: COLLECTOR HEAT, STORAGE HEAT, DIFFERENTIAL.

The room thermostat provides two more signals: stage one and stage two call for heat.

NOTE: Series Systems have two additional signals: auxiliary heater call for system fan and collector heat stage two.

SOLAR MODE SELECTOR

The Solar Mode Selector circuitry monitors these five (or seven) signals and determines which mode the solar system should be operating in. A mode priority is built into this circuit to make maximum use of solar energy. If no heat is demanded by the room thermostat the system will store heat (S mode) whenever the DIFFERENTIAL is "on". If the

room thermostat is at stage one then:

- if COLLECTOR HEAT is on the system will heat from collectors, HC
- if COLLECTOR HEAT is off but STORAGE HEAT is on then the system will heat from storage, HS
- if neither COLLECTOR HEAT nor STORAGE HEAT is on then the system will call upon the auxiliary (back-up) heating system for heat, AUX

Whenever the room thermostat is at stage two the system will heat from auxiliary (AUX mode). S and AUX modes are allowed simultaneously.

NOTE: Series Systems will heat from collectors (HC mode) when COLLECTOR HEAT is at stage 2 and will heat from collectors with auxiliary make-up heat (HC and AUX modes simultaneously) when COLLECTOR HEAT is at stage 1. Also, the circulation path for AUX mode is through storage, so AUX mode becomes AUX and HS.

SYSTEM FUNCTIONS

FIG. 8

SOLAR When the System Function Switch (on the front of the LCU-110) is set to SOLAR the LCU-110 operates the whole system automatically. The Solar Mode Selector picks the proper mode and passes this information to the Mode Implementor circuitry (see fig. 2). The Mode

Implementor holds the current mode and displays it on the lights on the front of the LCU-110. If a change is needed the Mode Implementor may take fifty seconds or longer to shift mode. It will shut the fan down to change dampers and may wait for the auxiliary heater to cool down. The Mode-to-Output Decoding circuitry switches the proper 24 VAC output circuits for each mode.

FIG. 9

MANUAL When the System Function Switch is set to **MANUAL** the mode selector switch below it is activated. The temperature sensor and room thermostat inputs are ignored and the Mode Implementor takes the desired mode from the manual mode selector switch (see fig. 2). Again, changing modes manually may take fifty seconds or longer. Manual solar system operation is intended for servicing and start up. If a freezing rain leaves the collectors glazed and prevents collecting available solar energy, manual operation also allows the ice to be melted off using the S mode for a short period of time.

FIG. 10

CONVENTIONAL When the System Function Switch is in this position, the solar system is locked out and space heating is done by the auxiliary system only. This function allows for space heating while the solar system, or the LCU-110, is being serviced. The two circuit cards inside the controller may be replaced or mailed to the factory for repair with the System Function Switch left in this position, but **CAUTION**- the control is electrically live until power is disconnected and lethal voltages may be present when removing circuit cards. Servicing should be left to qualified personnel.

NOTE: Series Systems, when in **CONVENTIONAL** mode, set up the dampers in HS mode, the auxiliary heater controls the system fan, and the LCU-110 **POWER** switch must be left **ON**. If the system fan is to be serviced, the LCU-110 should be shut off and power to the fan motor disconnected.

SUNMER LIMIT SWITCH

FIG. 11

The Summer Limit Switch sets a maximum temperature of 100°F for the storage bin. In the summer months the collectors are able to store most of the available solar energy because little space heating is demanded. Heat leaking from a hot storage bin is undesirable in the summer and this limiting prevents it from occurring. The Summer Limit Switch should be set ON at the end of the heating season and OFF when it begins again in the fall.

VI. UNIVERSAL SWITCHING UNIT (USU)

The switching system incorporates the centrifugal fan and motorized air valves into one component. This minimizes specialized on site assembly labor and assures high quality standards. Electrical outputs from the system control unit (LCU-110) open or close specific air valves and start or stop the fan, thereby controlling the flow of air through different sections of the transport system. The air circulating device, powered by a special energy-saving motor, is of premium quality and consumes less power than other fans moving the same amount of air.

MATERIALS: Fan; Cold rolled steel chassis w/ rust preventive paint
Valve box; 24 Gauge galvanized steel chassis, nylon bearings, cold
rolled shaft, PVF film blade wipers. Damper motor; Honeywell M836-A
24 VAC. Linkage; cold rolled steel stamped pcs.

TOLERANCES EXCEPT AS NOTED	TITLE: <i>USU-A DIMENSION</i>	
DECIMAL	PROJECT: <i>GENERAL SPECIFICATIONS</i>	
FUNCTIONAL		
ANGULAR		
REVISIONS	DRAWN BY: <i>J.C.</i>	CHECKED BY:

DRAWING # *520-001*

Unit may be broken down into two components for installation thru 32" min. passage door.

Fan Unit
34" W x 30 1/2" D x 36 1/2" H
Switching Unit
36 1/2" W x 52" D x 30 1/2" H
Assembled Unit
50 1/2" W x 55 1/2" D x 38 1/2" H

Output from USU is 12 1/2" x 18"
Output boot can taper to accommodate any duct size.
Flexible coupling assures quite operation.

ASSEMBLY
FRAME & ARM

DRILL $\frac{1}{8}$ " HOLE

SECTIONS A-A

TOLERANCES EXCEPT AS NOTED	TITLE: <i>DAMPER ARM</i>	
DECIMAL	PROJECT <i>USU-A</i>	
+		
FUNCTIONAL		
+		
ANGULAR		
+		
REVISIONS	DRAWN BY <i>JC</i>	CHECKED BY
	SCALE <i>NTS</i>	DRAWING # <i>200-017</i>

7/16" DIA. - LOCATE ON CENTER LINE OF 5/8 TUBING
CENTER HOLE IN FLANGE.

NOTE: CORNERS
MUST BE SQUARE.

1/2 x 1/2 x 7/16 TEE

OUTPUT END
TEE ALL 4
SIDES

INPUT END
TEE 3 SIDES

SECTIONS A-A

TOLERANCES EXCEPT AS NOTED	TITLE
DECIMAL	USU FRAME
FUNCTIONAL	PROJECT
ANGULAR	USU-A
REVISIONS	DRAWN BY JTC
	CHECKED BY
	SCALE NTS
	DRAWING # 200-019

TOLERANCES EXCEPT AS NOTED	TITLE: <i>CHASSIS ASSEMBLY</i>	
DECIMAL ±	PROJECT <i>USU-A</i>	
FUNCTIONAL ±		
ANGULAR ±		
REVISIONS	DRAWN BY <i>JC</i>	CHECKED BY
	SCALE <i>1/2" = 1'</i>	DRAWING # <i>200-021</i>

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RUN LINE OF ADHESIVE AROUND ENTIRE PERIMETER
WHERE SHEET METAL CONTACTS FRAME - RIVET 4" O.C.
ON ALL SIDES.

PROTECT

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SLOT DETAIL

TOLERANCES EXCEPT AS NOTED	TITLE: <i>VALVE BOX RECEIVER</i>	
DECIMAL ±	PROJECT <i>USU-A</i>	
FUNCTIONAL ±		
ANGULAR ±		
REVISIONS	DRAWN BY <i>JC</i>	CHECKED BY
	SCALE	DRAWING # <i>200-016</i>

PLACE 8"x8" ACCESS DOOR
ON SIDE () CENTER
OPPOSITE CUT OUT
10 1/8" R. CUT OUT TO GO
ON SIDE ().
24 GA. GALVANIZED
SCALE 1"=1'

1 PIECE / ASSY.

OPEN BOTH ENDS

DUCT SECTION 24 GA. GALVANIZED
24" LONG
1 1/2" = 1'
DO NOT CREASE SIDES OR PROVIDE
SMALL END.

QUANT:

TOLERANCES EXCEPT AS NOTED	TITLE: <i>DAMPEN BLADE</i>	
DECIMAL ±	PROJECT <i>USU-A</i>	
FUNCTIONAL ±		
ANGULAR ±		
REVISIONS	DRAWN BY <i>JC</i>	CHECKED BY
	SCALE <i>3":1'</i>	DRAWING # <i>200-020</i>

24 GA GAL. STEEL

TOLERANCES EXCEPT AS NOTED	TITLE: <u>VENT, SHEET METAL</u>	
DECIMAL ±	PROJECT <u>VENT SYSTEM</u>	
FUNCTIONAL ±		
ANGULAR ±		
REVISIONS	DRAWN BY <u>JK.</u>	CHECKED BY
	SCALE <u>2" = 1'</u>	DRAWING # <u>P30-004</u>

JOB:
UNITS:
MATERIAL:

TOLERANCES EXCEPT AS NOTED	TITLE: <i>CHASSIS FRAME</i>	
DECIMAL ±	PROJECT <i>F.F.C.V.</i>	
FUNCTIONAL ±		
ANGULAR ±		
REVISIONS	DRAWN BY <i>JC</i>	CHECKED BY
	SCALE	DRAWING # <i>210-005</i>

REINFORCE CORNERS ON EXTERIOR WITH 3/16" ANGLE WELDED TO FRAME.

16 GA STEEL BRACKET
WELDED TO FRAME

TOLERANCES EXCEPT AS NOTED	TITLE: <u>DRIVE COVER</u>	
DECIMAL ±	PROJECT <u>USU-A</u>	
FUNCTIONAL ±		
ANGULAR ±		
REVISIONS	DRAWN BY <u>JL</u>	CHECKED BY
	SCALE	DRAWING # <u>200-022</u>

TOLERANCES EXCEPT AS NOTED	TITLE: <i>COVER MESH</i>	
DECIMAL ±	PROJECT <i>USU-A</i>	
FUNCTIONAL ±		
ANGULAR ±		
REVISIONS	DRAWN BY <i>J.C.</i>	CHECKED BY
	SCALE	DRAWING # <i>200-023</i>

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CUT SHEET TO FIT INSIDE DRIVE
COVER. WELD TO FACE ON ALL EDGES.

TOLERANCES
EXCEPT AS NOTED

DECIMAL

±

FUNCTIONAL

±

ANGULAR

±

REVISIONS

TITLE: *SHAFT COVER*

PROJECT *USU-A*

DRAWN BY *J.C.*

CHECKED BY

SCALE

DRAWING # *200-024*

TOLERANCES EXCEPT AS NOTED	TITLE: <i>ASSEMBLY DRAWING</i>	
DECIMAL ±	PROJECT <i>VENT VALVE</i>	
FUNCTIONAL ±	<i>FAIL SAFE</i>	
ANGULAR ±		
REVISIONS	DRAWN BY <i>JC 7-6-77</i>	CHECKED BY
	SCALE <i>4"=1'</i>	DRAWING # <i>230-003</i>

VII. TRANSPORT SYSTEM

1. Collector Manifolding

The collector manifolding will generally be fabricated of a rectangular or square duct of approximately one-half the cross-section area of the solar ducting. The manifold will interconnect to the 8" round takeoff collars on the collector 1/0 ports. All of the cold ports of the array will be connected in parallel as will all of the warm ports. A flexible 8" duct will connect the collector takeoff collar to the manifold takeoff collar. The manifold takeoff collar on either hot or cold side will have an adjustable locking volume damper for system balancing. See Figure VIII-1. It is of special importance to make all interconnections air tight and to insulate all ducting in accordance with the enclosed table CSI #240-001.

2. Fail-Safe Vents

A sufficient number of fail-safe thermal vent valves and ports must be provided so that the system can thermosiphon enough air to cool it below damaging temperatures. Thermal vent ports are used in pairs, an intake to the collector cold manifold and an exhaust from the collector hot manifold. There are two criteria for determining the number of ports needed and their spacing:

- 1) A pair of ports must be provided for every 350 ft² of active collector area.
- 2) Ports should be provided for every 24 linear feet of collector manifold.

The vent port is generally fitted to the gable end panel of the house via a 10" insulated flexible ducting. Reference CSI Drawing #530-001.

3. USU Motor Sizing

The USU should be ordered with the proper electric motor, sized to run the fan at the proper CFM as follows:

<u>Active Collector Area</u>	<u>Motor</u>
100-250 ft ²	1/3 HP
250-350 "	1/2 HP
350-600 "	3/4 HP

4. Duct Sizing

The inside dimensions of the solar system's interconnecting ducting are chosen by one criterion: linear air velocity in the ducts must not be greater than 1000 ft/min. Calculate the duct's inside dimensions (HxW) by:

- a) Calculate the system's air flow. Multiply the active area of the collector array by 3 to obtain system CFM (cubic feet per minute):

$$(\text{Active area}) \quad \frac{3 \text{ CFM}}{\text{ft}^2} = \text{system CFM}$$

- b) Calculate the duct's minimum inside area (HxW) min. by dividing the system CFM by 1000:

$$\text{duct inside area ft}^2 \geq \frac{\text{system CFM}}{1000 \text{ ft. /min.}}$$

- c) Choose duct inside dimensions H and W (in ft.) to be compatible with the building design and:

$$H \times W \geq \text{duct minimum inside area}$$

- d) Duct outside dimensions will depend on the required duct insulation. Consult the duct insulation requirements in the general specifications. CSI #240-001.

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WARM
MANIFOLD

COOL
MANIFOLD

TOLERANCES EXCEPT AS NOTED	TITLE: COLLECTOR MANIFOLD	
DECIMAL	PROJECT: COLLECTOR/MANIFOLD	
FUNCTIONAL	INTERCONNECT	
ANGULAR		
REVISIONS	DRAWN BY: JCA	CHECKED BY:
	SCALE:	DRAWING # 570-001

Figure VIII-1

09

TOLERANCES EXCEPT AS NOTED	TITLE: <i>THERMAL VENTING DEVICE</i>	
DECIMAL ±	PROJECT <i>GENERAL SPECIFICATIONS</i>	
FUNCTIONAL ±		
ANGULAR ±		
REVISIONS	DRAWN BY <i>JL</i>	CHECKED BY
	SCALE <i>NTS</i>	DRAWING # <i>530-001</i>

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MATERIALS: h; 1/2-18 expanded metal hot rolled steel.
frame; 5/8 x5/8 x 1/8" hot rolled steel angle.

POSSIBLE MANIFOLD CONFIGURATIONS

TOLERANCES EXCEPT AS NOTED	TITLE: STORAGE MANIFOLD SYSTEM	
DECIMAL	PROJECT GENERAL SPECIFICATIONS	
FUNCTIONAL		
ANGULAR		
REVISIONS	DRAWN BY 4-27-77 JC	CHECKED BY
	SCALE N.T.S.	DRAWING # 540-003

1. Storage manifold module size is 4'W x 3'H.
2. The expanded mesh screen is attached to a welded metal frame. The mesh extends six inches on the left and right ends.
3. Modules may be stacked or placed side by side as illustrated.
4. Mesh is wired together where modules meet.
5. The basic storage bin is fabricated to the width of the single or double module. Insulation and plywood sheathing is fitted to the inside of the bin as per specifications.
6. The module is fitted into the bin as illustrated using excess side mesh to fit to the bin walls. Mesh is tacked to plywood with wire staples.
7. After all manifold modules are fitted and secured the bin is filled to the top of the module with the specified type of stone. Note that the stone may settle up to one inch per foot of depth within the first two weeks.

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DUCTING/ MANIFOLDING INSULATION REQUIREMENTS

1) Manifolding:

A. Hot manifold; assume output temperature of 120°F.

<u>Average temp. surrounding manifold</u>	<u>Suggested manifold insulation</u>	<u>Tolerance</u>
0° F.	R-10	Loss must not exceed 0.7% of total system output; verify loss is within this spec.
20°	R-8	
40°	R-6	
60°	R-4	

B. Cold manifold; assume input temperature of 65°F.

0°	R-8	Loss must not exceed 0.7% of total system output; verify loss is within this spec.
20°	R-6	
40°	R-4	
60°	R-2	

2) Ducting, exterior to heated living space:

A. Hot ducting; assume output temperature of 120°F.

0°	R-12	Loss must not exceed 1.0% of total system output; verify loss is within this spec.
20°	R-10	
40°	R-8	
60°	R-6	

B. Cold Ducting; assume input temperature of 65°F.

0°	R-6	Loss must not exceed 0.7% of total system output; verify loss is within this spec.
20°	R-5	
40°	R-4	
60°	R-3	

3) Ducting; inside heated space:

A. Hot ducting; assume air temperature of 120°F.

40°	R-5	Loss must not exceed 6% of total system output; verify loss is within this spec.
50°	R-4	
60°	R-4	
70°	R-3	

B. Cold ducting; assume air temperature of 65°F.

40°	R-3	Loss must not exceed 2% of total system output; verify loss is within this spec.
50°	R-3	
60°	-	
70°	-	

CSI # - 240-001

VIII STORAGE DESIGN

1. Storage Sizing

The storage sizing for system configurations will require one cubic foot of rock for each square foot of active collector area. For example, a house with a normalized load of 6 $\frac{\text{BTU/DD}}{\text{ft}^2}$ in a 7000 degree day climate will have

a collector to house area ratio of (.24). This means that a 1,600 ft^2 house would require (.24) (1,600) = 384 ft^2 of active collector area. This would require 384+ cubic feet of rock storage.

2. Storage Bin Shape

The shape of the storage bin is determined primarily by the face velocity of air through stone:

- a) Calculate the total air volume/min. (in CFM):

$$\frac{3 \text{ ft}^3 / \text{min.}}{\text{ft}^2 \text{ collector}} \times \text{collector active area} = \text{volume/min.}$$

- b) Multiply the volume/min. by 25, a desirable face velocity, to determine the cross sectional area of the storage (Height x Width) perpendicular to the air flow:

$$\text{Volume/min.} \times 25 = \text{Cross Sectional Area of Storage (HxW)}$$

This figure for HxW can be allowed to vary $\pm 20\%$ and still assure good flow distribution without unnecessarily high pressure drops through the storage system. The final determination of Height and Width depends on the additional parameters explained in Figure VII-1.

3. Stone Selection

The stone specification requires a washed and screened stone in a size range from 1 to 1 1/2" average diameter. This stone is generally in the form of "trap rock" in the New England area and is used for septic system fields or foundation drainage and is usually readily available.

The sizing is important since it affects the storage pressure drop. See Table VII-1 for evaluation of pressure drop.

Path Length (L)	Face Velocity		
	20	25	30
6	--	.14	.20
8	.08	.18	.27
10	.11	.23	.33
12	.15	.28	.40

Table VII-1

Pressure Drop Across Storage

Notes:

- 1) Pressure drop is in inches of water.
- 2) Add .10" to calculated value to account for storage manifold losses.

Figure VII-1
Storage Bin Configuration

- A. $H \times W$ = Cross-sectional area perpendicular to air flow.
- B. The ratio of $W:H$ should be no greater than 3 nor less than .3.
- C. The ratio of $\frac{L:W+H}{2}$ should be no greater than 2 nor less than 1.
- D. L should be between 6 and 12 feet.

Note: L , W , H are inside dimensions occupied by stone. Allow additional size for manifolds, insulation and cap.

TOLERANCES EXCEPT AS NOTED	TITLE: Storage Bin, Top View	
DECIMAL ±	PROJECT General Specifications	
FUNCTIONAL ±		
ANGULAR ±	540-001	4-12-77
REVISIONS	DRAWN BY JC	CHECKED BY
6-6-77 FOAM	SCALE 3/8:1'	DRAWING # 540-001

1. Storage bin walls that are common to the exterior of the structure must have foam insulation.
2. Foam insulation must be kept from direct contact with stone bed by plywood spacer on side walls.
3. Manifolds are factory manufactured units used to insure free air flow over entire face area.
4. Storage bin walls that are common to the interior of the structure must have 2" insulation.
5. Foundation must be water proof. Leakage of water into the warm storage system may cause a health hazard. This applies to the foundation slab as well.
6. The effective bed length of the storage system is the distance between inside manifold faces.

TOLERANCES EXCEPT AS NOTED	TITLE: <i>ROCK STORAGE SECTION</i>	
DECIMAL	PROJECT: <i>GENERAL SPECIFICATIONS</i>	
±		
FUNCTIONAL		
±		
ANGULAR		
±		
REVISIONS	DRAWN BY <i>J.C.</i>	CHECKED BY
<i>7-5-77</i> <i>J.C.</i> <i>AGU.</i>	SCALE <i>NTS</i>	DRAWING # <i>540-002</i>

ROCK BED INSULATION SPECIFICATION

Storage walls common to areas whose temperatures are:

Above 50°F	Ins	Wall	Total
------------	-----	------	-------

Top	R7.5	1.75	9.25
Perimeter	R7.5	1.75	9.25

Above 30°F

Top	R11	"	12.75
Perimeter	R11	"	12.75

Above 0°F

Top	R15	"	16.75
Perimeter	R15	"	16.75

Above -30°F

Top	R19	"	20.75
Perimeter	R19	"	20.75

Suggested Insulation type;
Isocyanurate Foam, foil faced
Celotex Thermax TF-600 or 610
@ R-8 per inch.

BOTTOM INSULATION: is suggested in most installations, R3 to R6 is generally satisfactory. Additional insulation may be required if much ground water movement is present.

WATER PROOFING: The entire bin must be water and damp proofed. Dampness in contact with the warm stones may prove to be a health hazard.

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