DOE/NASA CONTRACTOR REPORT

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

U.S. Department of Energy

Solar Energy

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This work was done under the technical management of Mr. Ralph Cole, George C. Marshall Space Flight Center, Alabama 35812.

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.

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I. SYSTEM DESCRIPTION

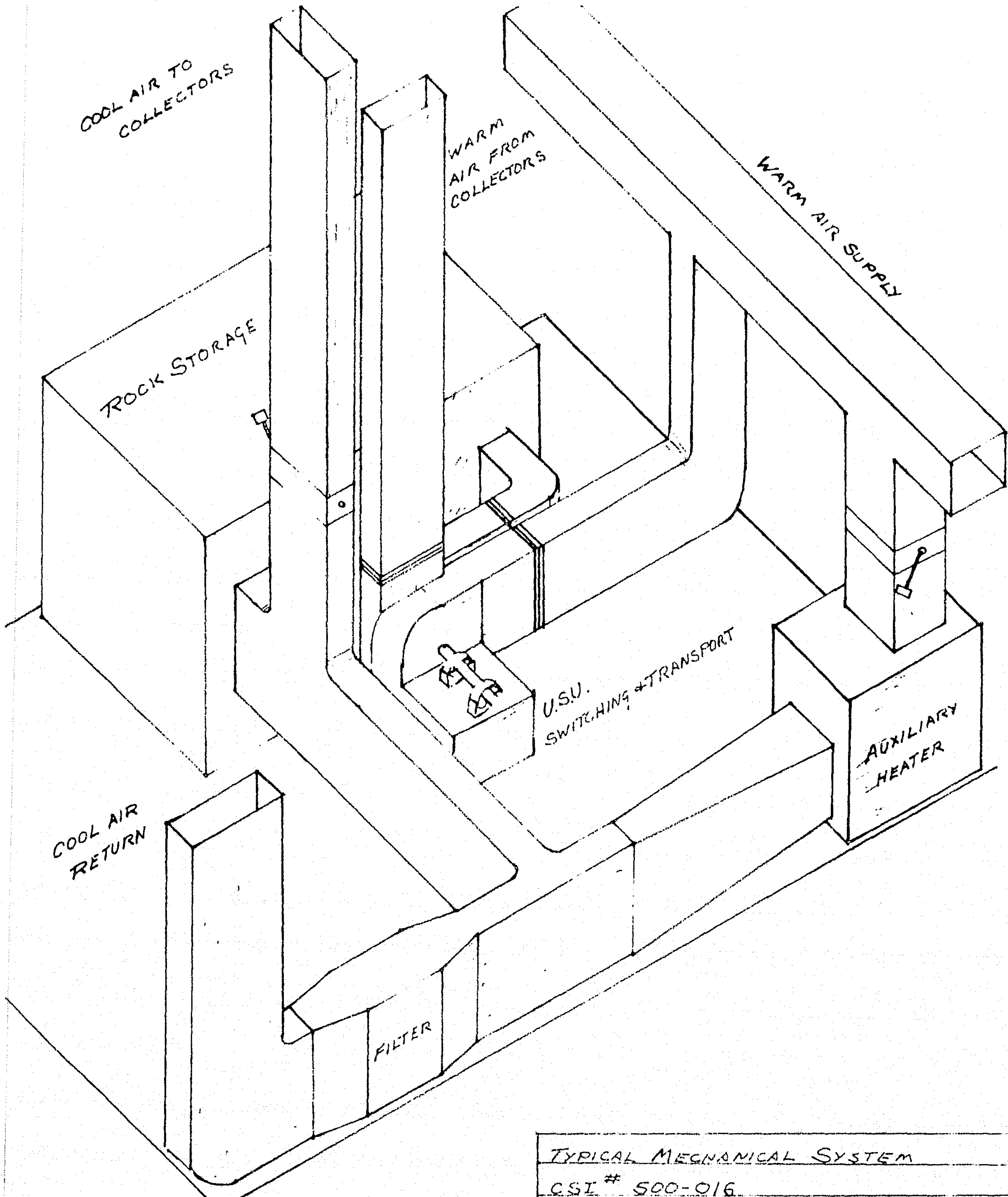
The integrated, warm air solar heating system eliminates most of the problems encountered by an architect or designer when incorporating solar heating in a construction project. The individual components are fully compatible and have been developed to work together.

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.



TYPICAL MECHANICAL SYSTEM	
CSI # 500-016	

CONTEMPORARY SYSTEMS, INC.

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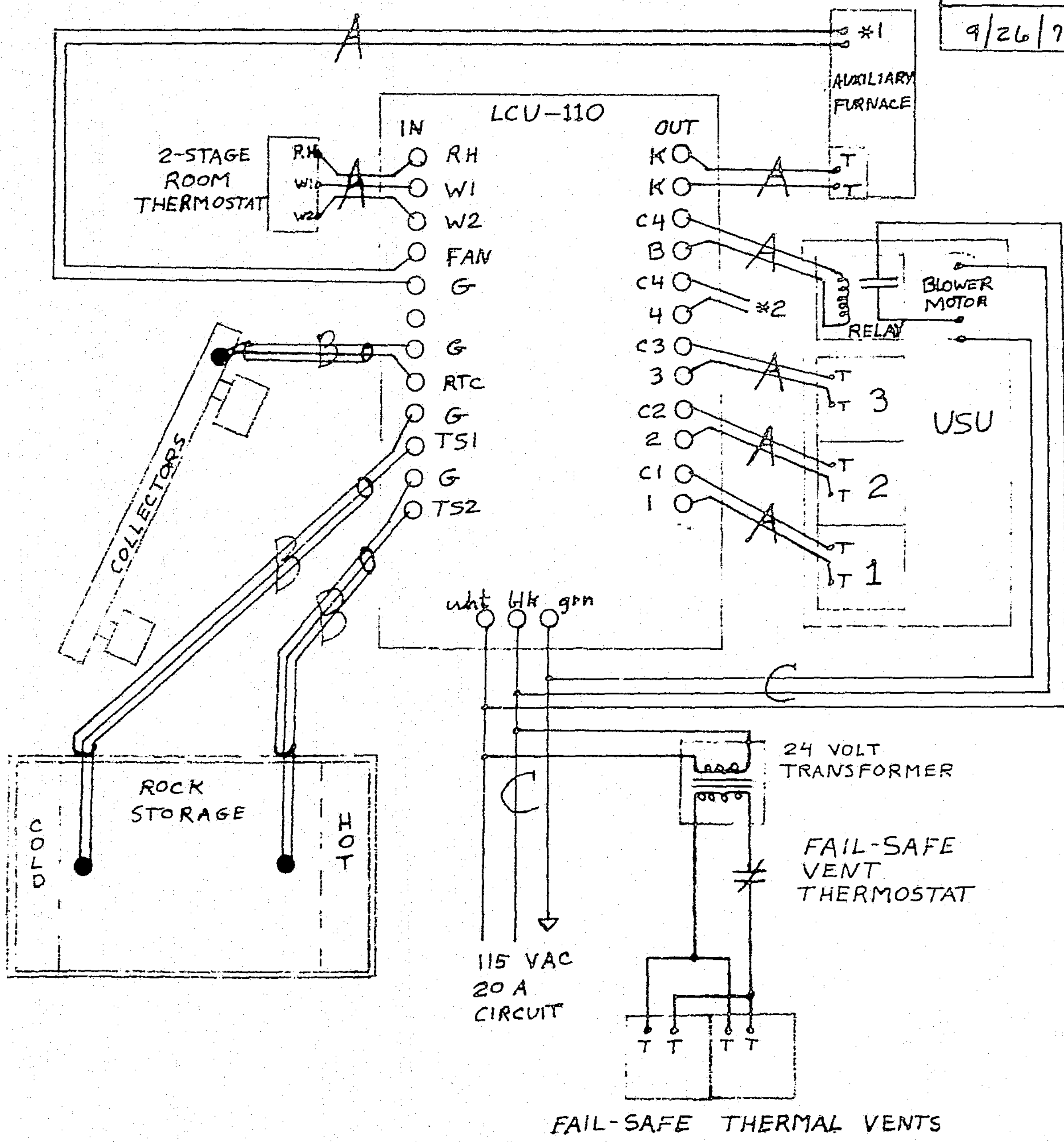
03452 • (603) 532 7972

T...ERANCES EXCEPT AS NOTED	TITLE: System Wiring	
DECIMAL ±	~~PROJECT~~ Diagram	
FUNCTIONAL ±		
ANGULAR ±		
REVISIONS 1	DRAWN BY EL	CHECKED BY
9/26/77	SCALE ∽	DRAWING # 560-001



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.

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II. SYSTEM PERFORMANCE SPECIFICATION

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

ORIGINAL PAGE IS OF POOR QUALITY

TABLE I

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RESIDENTIAL SYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY

SHEET 2 OF 6

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS		
	H	HC	HW
2.1 System Design Conditions	A	A	A
2.1.1 Equipment Capabilities	A	A	A
2.1.2 Noise or Erosion-Corrosion	A	A	A
2.1.3 Operating Conditions	A	A	A
2.1.4 Fluid Flow in Collectors	A	A	A
2.1.5 Entrapped Air	A	A	A
2.1.6 Thermal Expansion of Fluids	A	A	A
2.1.7 Pressure Drops	A	A	A
2.1.8 Condensate Removal	NA	A	NA
2.2 Mechanical Stresses	A	A	A
2.2.1 Vibration Stress Levels	A	A	A
2.2.2 Vibration from Moving Parts	A	A	A
2.2.3 Water Hammer	A	A	A
2.2.4 Vacuum Relief Protection	A	A	A
2.2.5 Thermal Changes	A	A	A
2.2.6 Flexible Joints	A	A	A
2.3 Leakage Prevention	A	A	A
2.3.1 Pressure Test: Nonpotable Fluids	A	A	A

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS		
	H	HC	HW
2.3.2 Pressure Test: Potable Water	A	A	A
2.3.3 Air Transport Systems	A	A	A
2.4 Collector Adjustment	A	A	A
2.4.1 Orientation and Tilt	A	A	A
2.4.2 Mutual Shadowing	A	A	A
2.5 Subsystem Isolation	A	A	A
2.5.1 Shutdown in Multi-family Housing	A	A	A
2.6 Heat Transfer Fluid Quality	A	A	A
2.6.1 Liquid Quality	A	A	A
2.6.2 Air Quality	A	A	A
2.6.3 Fluid Quality	A	A	A
2.6.4 Freezing Protection	A	A	A
2.7 Piping Supports	A	A	A
2.7.1 Applicable Plumbing Standards	A	A	A
2.8 Excessive Pressure and Temperature Protection	A	A	A
2.8.1 Relief Valves and Vents	A	A	A
3.1 Structural Design Basis	A	A	A
3.1.1 Applicable Standards	A	A	A

TABLE I

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REVISION ____________

DATE ____________

RESIDENTIAL SYSTEMS, INTERIM PERFORMANCE CRITERIA SUMMARY

SHEET 3 OF 6

RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEM			RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEM		
	H	HC	HW		H	HC	HW
3.1.2 Service Loads	A	A	A	3.8.2 Constraint 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 Glazing 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 Hail Resistance	A	A	A	4.5 Safety	I	I	I
3.7.1 Hail 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	[illegible]	[illegible]	A	4.6 Protection of Potable Water and Circulated Air	A	A	A

TABLE I

SPECIFICATION NO. ____________
REVISION ____________
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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		
	H	HC	HW
4.6.1 Contamination by Materials	A	A	A
4.6.2 Separation of Circulation Loops	A	A	A
4.6.3 Backflow Prevention	A	A	A
4.6.4 Growth of Fungi	A	A	A
4.7 Excessive Surface Temperatures	A	A	A
4.7.1 Protection from Heated Components	A	A	A
5.1 Effects of External Environment	A	A	A
5.1.1 Solar Degradation	A	A	A
5.1.2 Soil Corrosion	A	A	A
5.1.3 Airborne Pollutants	A	A	A
5.1.4 Dirt Retention on Cover Plate Surface	A	A	A
5.1.5 Abrasive Wear	A	A	A
5.1.6 Fluttering by Wind	A	A	A
5.2 Temperature and Pressure Resistance	A	A	A
5.2.1 Thermal Degradation	A	A	A
5.2.2 Deterioration of Heat Transfer Fluids	A	A	A
5.2.3 Thermal Cycling Stresses	A	A	A
5.2.4 Leakage	A	A	A
5.2.5 Deterioration of Gaskets and Sealants	A	A	A
5.2.6 Transmission Losses Due to Outgassing	A	A	A
5.3 Chemical Compatibility of Components	A	A	A
5.3.1 Materials/Transfer Fluid Compatibility	A	A	A
5.3.2 Corrosion of Dissimilar Materials	A	A	A
5.3.3 Corrosion by Leachable Substance	A	A	A
5.3.4 Effects of Decomposition Products	A	A	A
5.4 Components Involving Moving Parts	A	A	A
5.4.1 Wear and Fatigue	A	A	A
6.1 Accessibility for Maintenance	A	A	A
6.1.1 Access for System Maintenance	A	A	A
6.1.2 Access for System Monitoring	A	A	A
6.1.3 Draining and Filling of Liquids	A	A	A
6.1.4 Flushing of Liquids Subsystems	A	A	A
6.1.5 Filters	A	A	A
6.1.6 Potable Water Shutoff	A	A	A

TABLE I

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

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RESIDENTIAL SYSTEMS; INTERIM PERFORMANCE CRITERIA SUMMARY

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RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS H	HC	HW	RESIDENTIAL INTERIM PERFORMANCE CRITERIA PARAGRAPH	TYPE SYSTEMS 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 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 Penetration	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 curculating heating systems as ours. For example, criteria 1.2 "DHW system/subsystem performance" can not be applied to our space heating system. The following critieria 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	2.6	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)	9.1	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

Specification No. 1-NHVTC
Page Date June 1977

APPENDIX A

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 *8.5×10^6 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

ORIGINAL PAGE IS OF POOR QUALITY

Specification No. 1-NHVTC
Page Date June, 1977

ORIGINAL PAGE IS

Hot Water

50 gal/day gallons 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	20 years	lbs	
Cooling	--- years	--- lbs	---
Auxiliary Energy	20 years	200 lbs	3'x5'x5'
Storage	30 years	95,000 lbs	12'x12'x8'
Potable Water (or [illegible])	20 years	1,200 lbs	1'x2'x4'
Collector	20 years	2 lbs/ft²	717 sq. ft.
Energy Transport	25 years	260 lbs/ft	N/A
Controls	25 years	10 each	N/A
(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 obout 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.

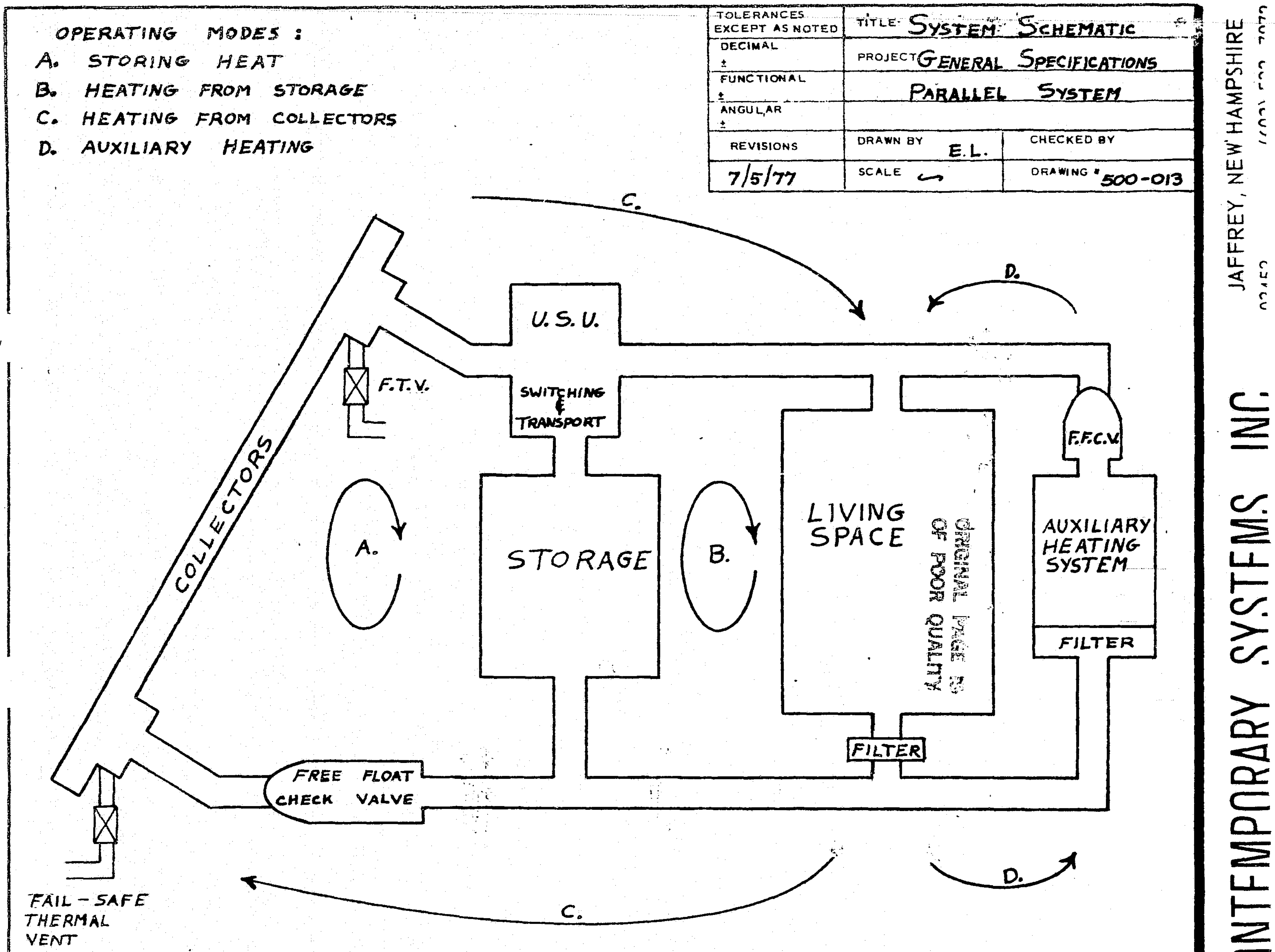
OPERATING MODES :
A. STORING HEAT
B. HEATING FROM STORAGE
C. HEATING FROM COLLECTORS
D. AUXILIARY HEATING
TOLERANCES EXCEPT AS NOTED
DECIMAL ±
FUNCTIONAL ±
ANGULAR ±
REVISIONS
7/5/77
TITLE SYSTEM SCHEMATIC
PROJECT GENERAL SPECIFICATIONS
PARALLEL SYSTEM
DRAWN BY E.L.
CHECKED BY
SCALE
DRAWING # 500-013
COLLECTORS
F.T.V.
U.S.U.
SWITCHING & TRANSPORT
STORAGE
LIVING SPACE
ORIGINAL PAGE IS OF POOR QUALITY
F.F.C.V.
AUXILIARY HEATING SYSTEM
FILTER
FILTER
FREE FLOAT CHECK VALVE
FAIL - SAFE THERMAL VENT
A.
B.
C.
C.
D.
D.
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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.

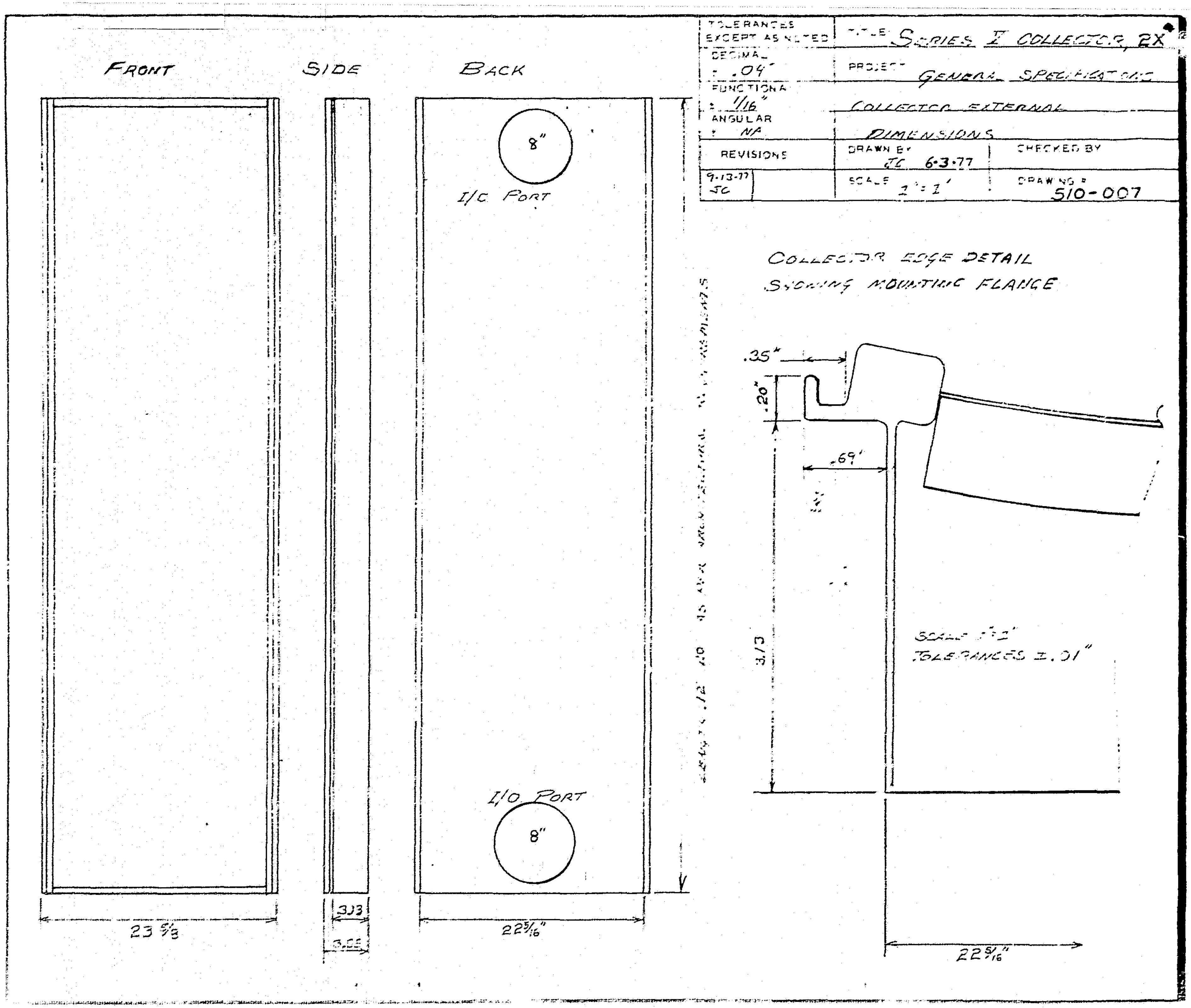
IV. SERIES V SOLAR COLLECTORS

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.



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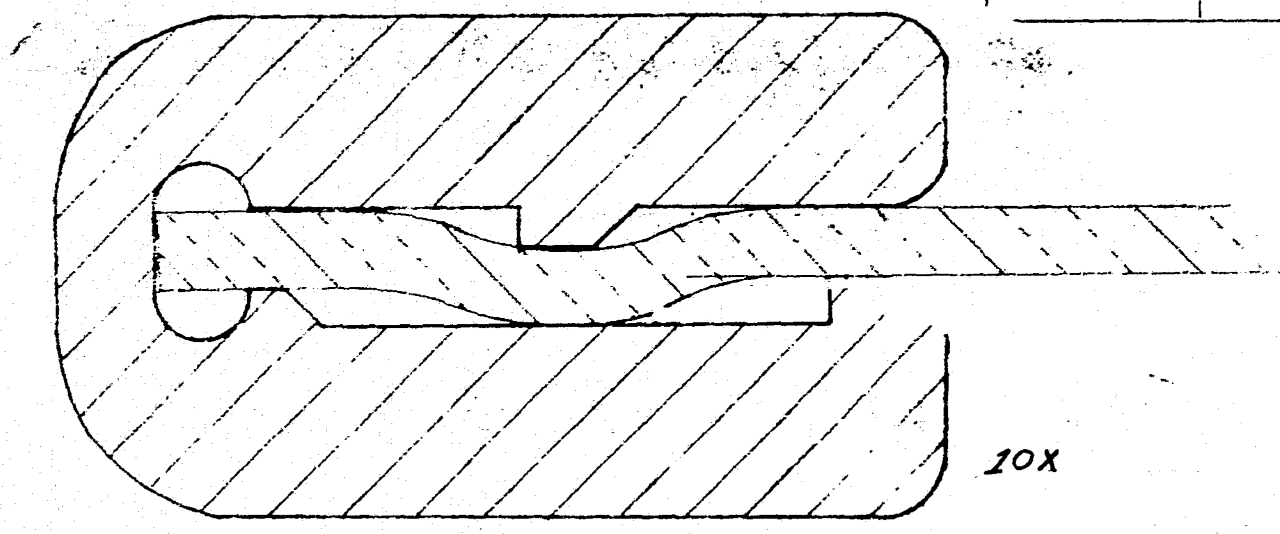
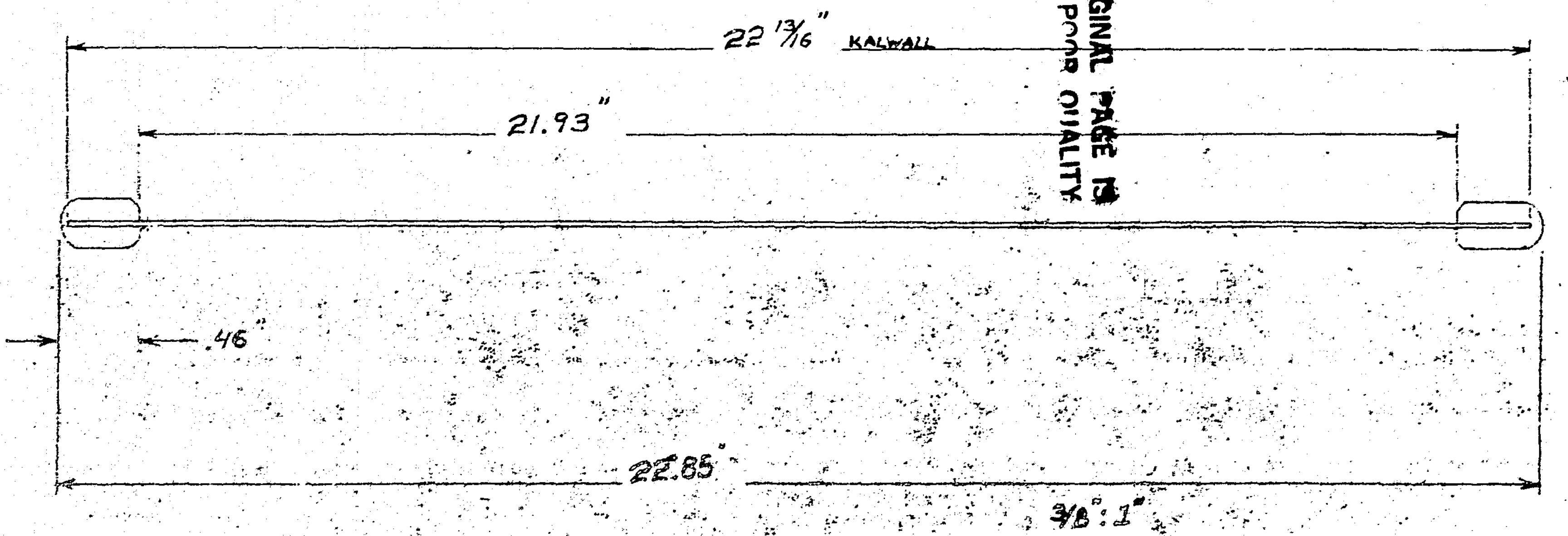
MATERIALS:

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

Extrusions: CSI#120-004 Alloy 6063-T4

TOLERANCES EXCEPT AS NOTED	TITLE: COVER ASSEMBLY	
DECIMAL ±	PROJECT SERIES II	
FUNCTIONAL ±		
ANGULAR ±		
REVISIONS	DRAWN BY JC 10-5-77	CHECKED BY
	SCALE	DRAWING # 120-008





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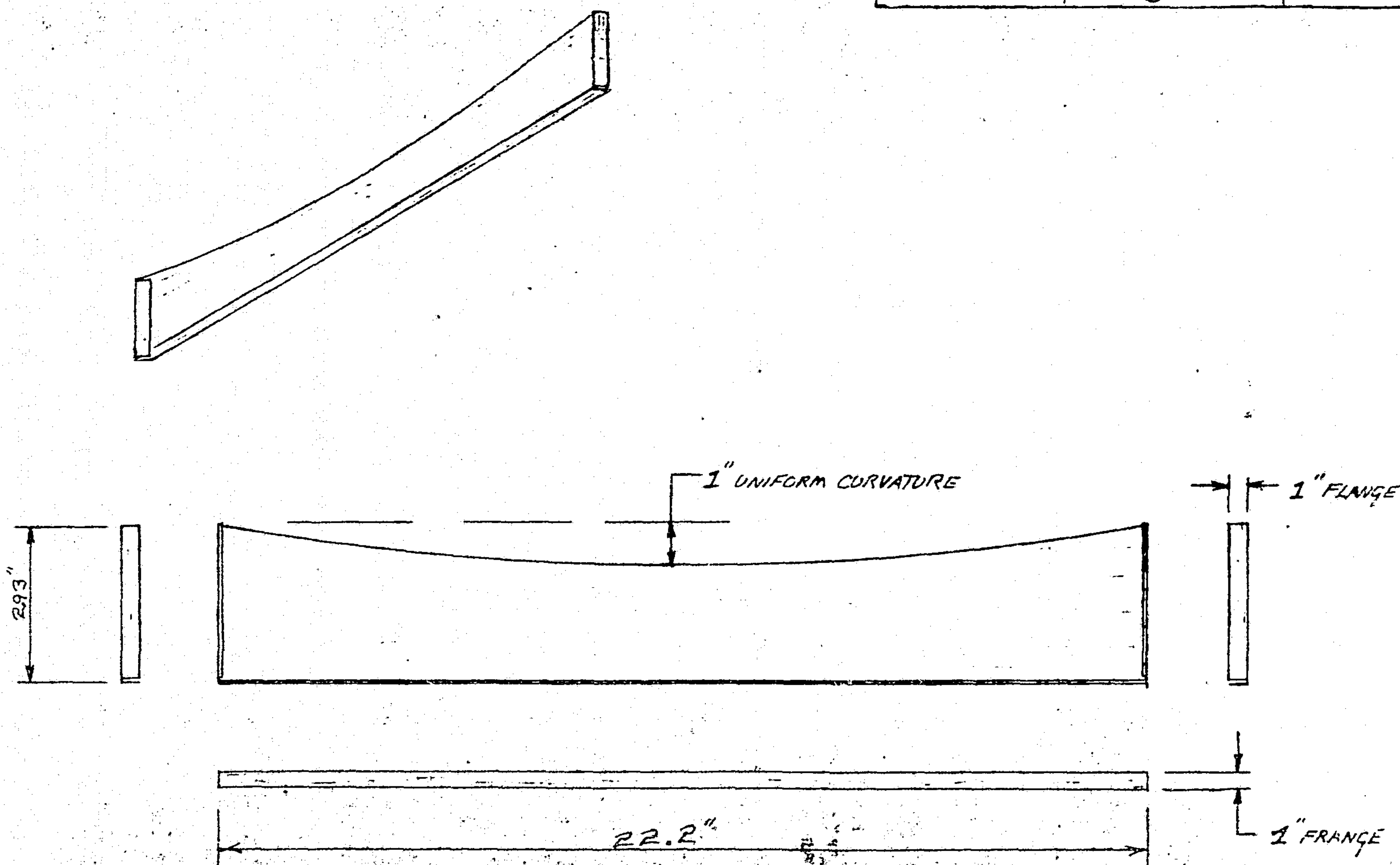
JOB:	
MATERIALS: .032" alluminum	
QUANTITY:	

TOLERANCES EXCEPT AS NOTED	TITLE: COLLECTOR END CAP	
DECIMAL ± .03"	PROJECT SERIES IV - 2X	
FUNCTIONAL ± 1/32"	PRODUCTION	
ANGULAR ± NA		
REVISIONS	DRAWN BY G.C.	CHECKED BY
	SCALE 3" = 1"	DRAWING # 130-010



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

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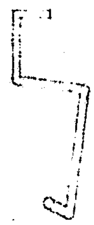
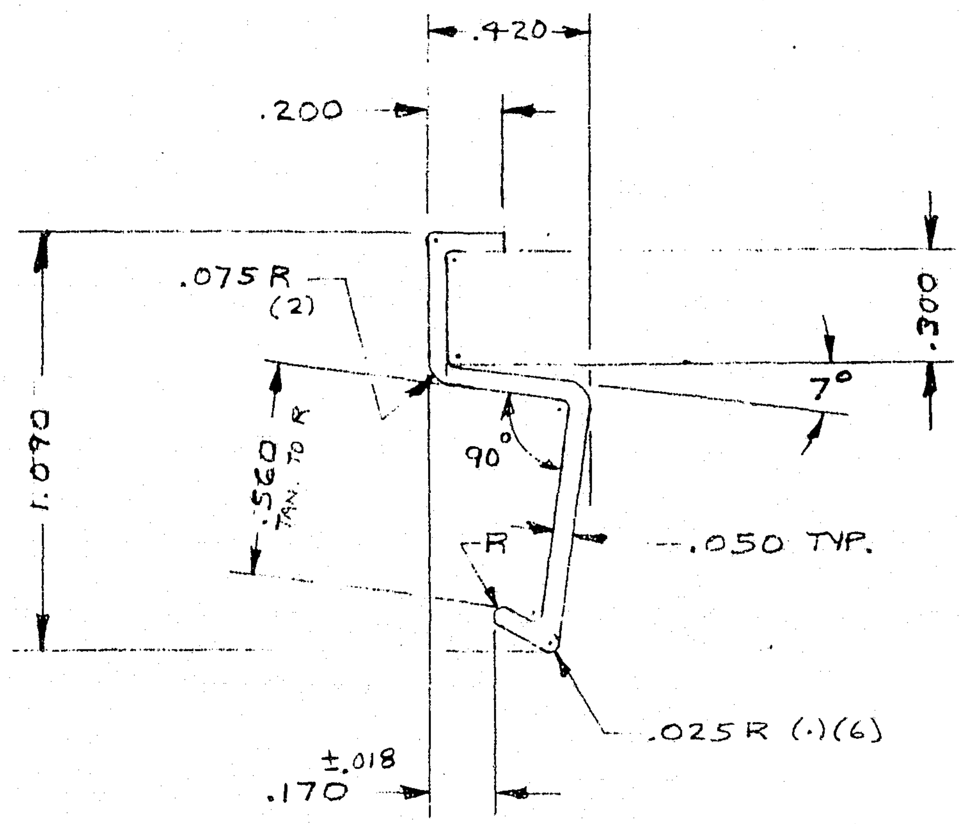
03452 (603) 532 7072

SECTION 69557





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"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

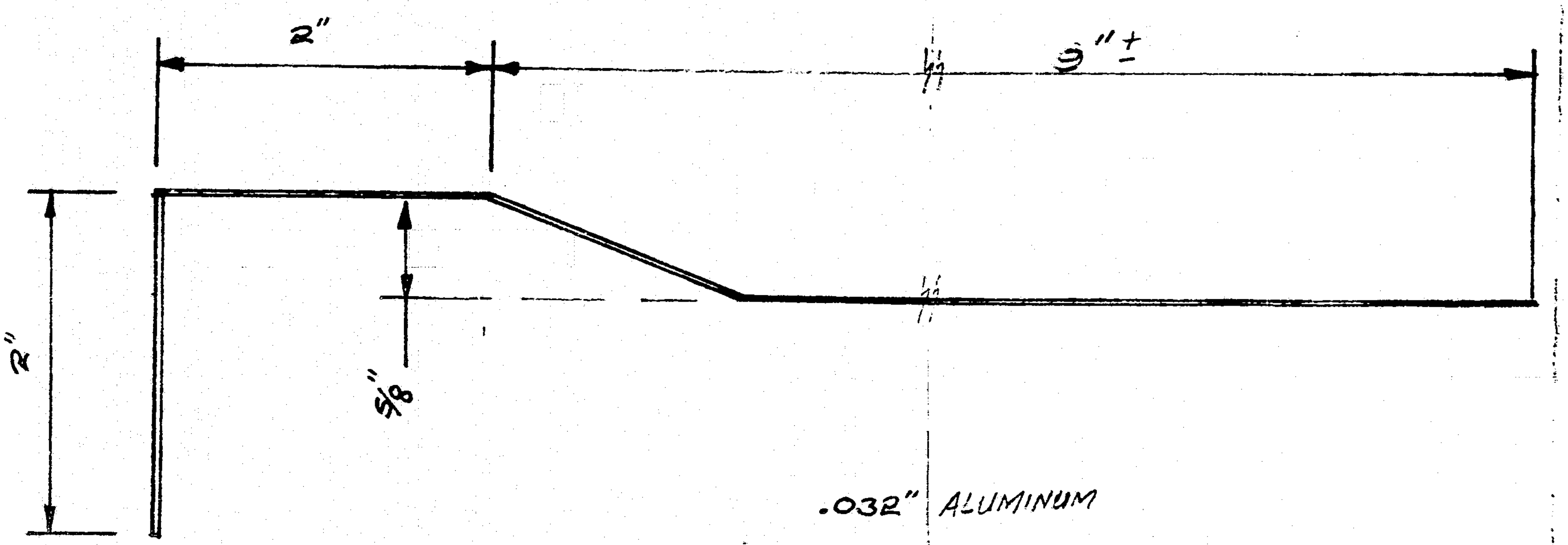
CODE	A	BT	CT	M	S		

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

BRUNING 44-122 24442-2

R 929 11 (REV. 10 75)

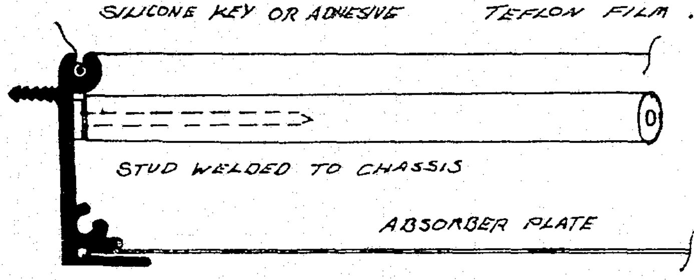
TOLERANCES EXCEPT AS NOTED	TITLE: TOP FLASHING PROFILE	
DECIMAL ±	PROJECT SERIES IV + V	
FUNCTIONAL ±	COLLECTORS	
ANGULAR ±		
REVISIONS	DRAWN BY JC	CHECKED BY
	SCALE	DRAWING # 150-006



JAFFREY, NEW HAMPSHIRE

CONTEMPORARY SYSTEMS INC.

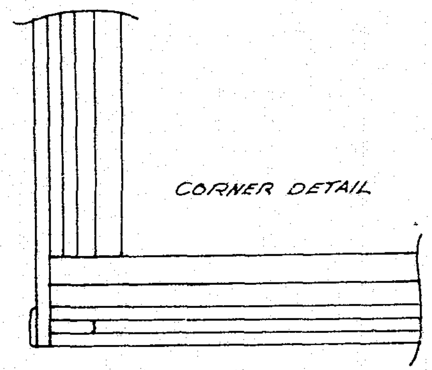
TOLERANCES EXCEPT AS NOTED	TITLE SUB CHASSIS DETAIL	
DECIMAL ±	PROJECT SERIES V COLLECTOR	
FUNCTIONAL ±		
ANGULAR ±		
REVISIONS	DRAWN BY 8-8-77 JC	CHECKED BY
	SCALE	DRAWING # 130-017

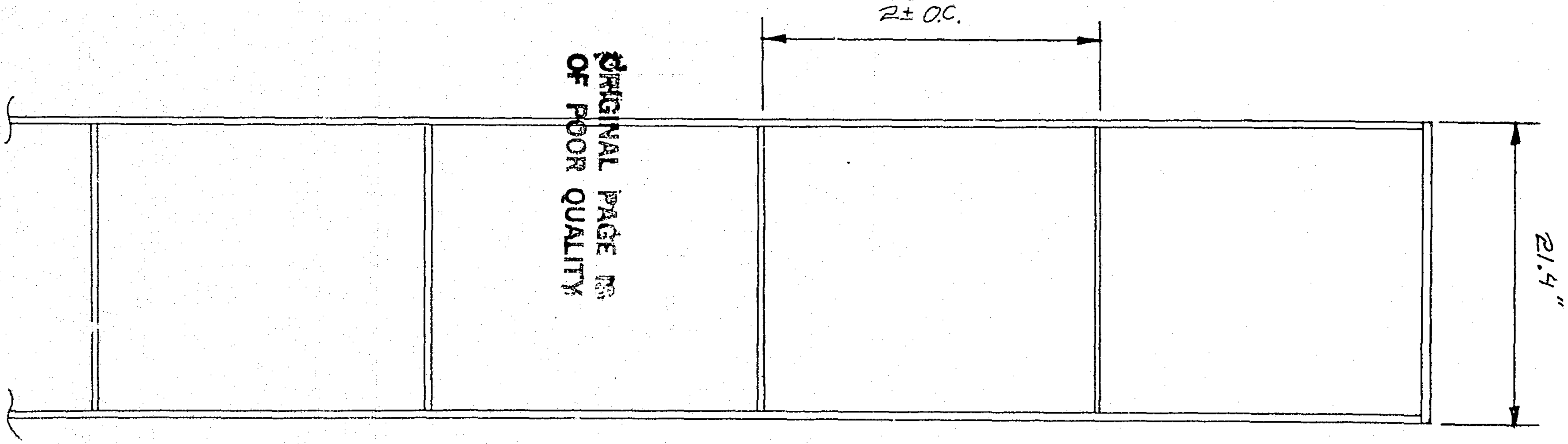


ALUMINUM TUBE: 1/4" DIA. .058" WALL 6061-T6

TUBE LENGTH:

INNER CHASSIS: CSI# 130-015

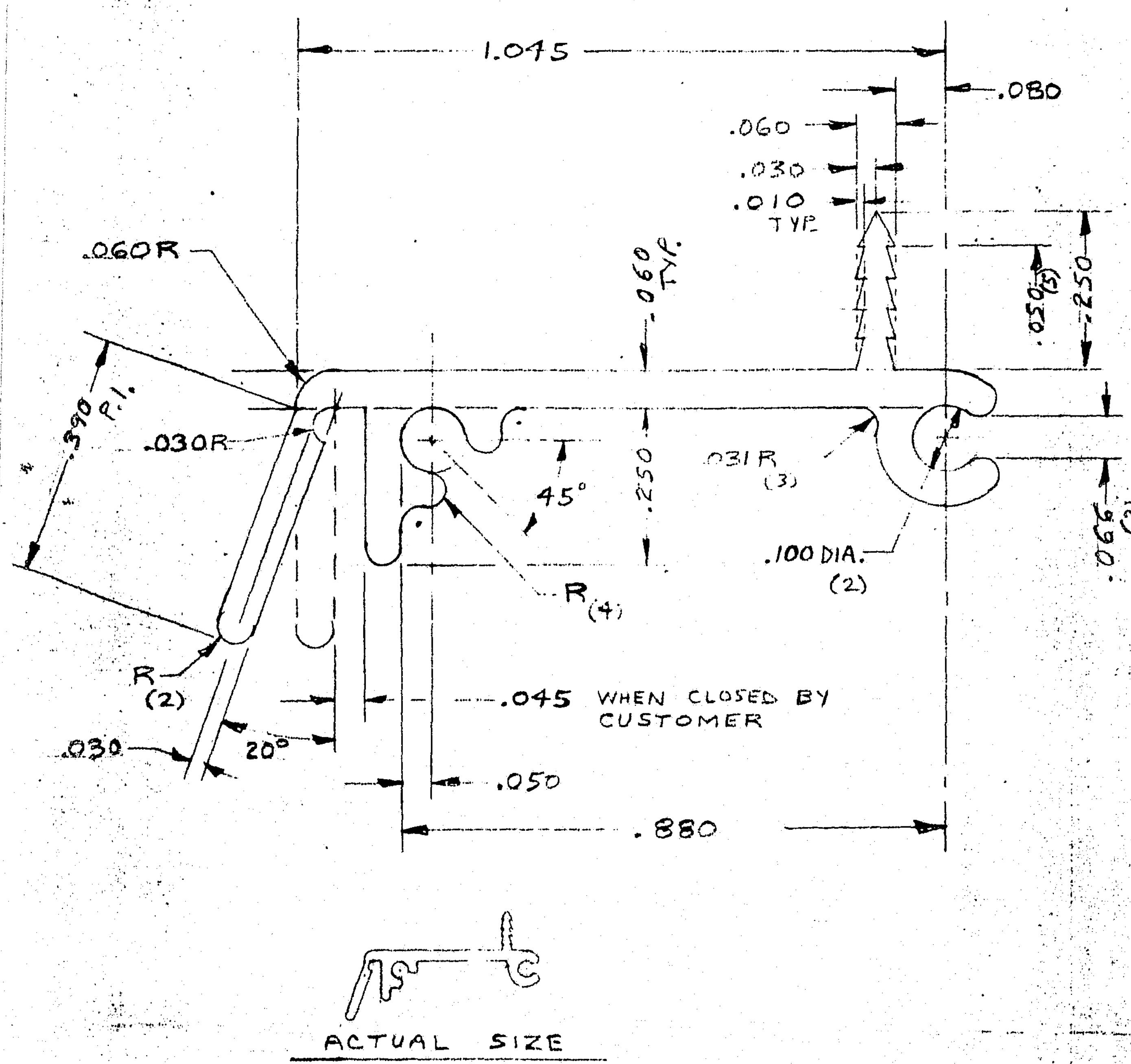




CONTEMPORARY SYSTEMS INC

JAFFREY, NEW HAMPSHIRE

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

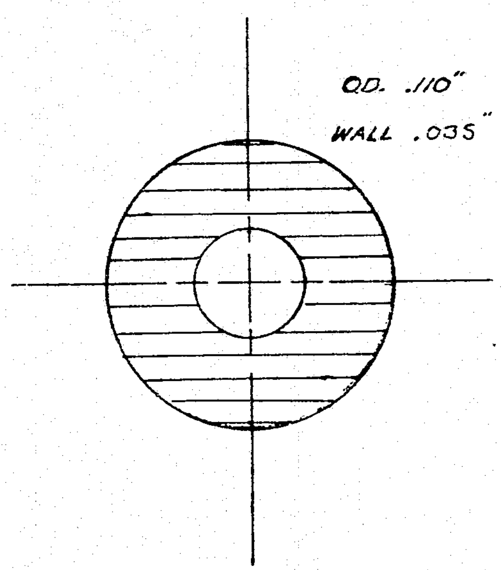
REYNOLDS STANDARD TOLERANCES FOR EXTRUDED ROD, BAR & SHAPES APPLY UNLESS SPECIFICALLY SHOWN OTHERWISE

ESTIMATED AREA	.141	SQ IN
EST WT PER FT	.169	LBS
EST PERIMETER	4.829	IN
FACTOR 29	CIRCLE DIA 1-2	1.4

CODE	A	BT	CT	M	S		

CUSTOMER	CONTEMPORARY SYSTEMS INC.
CITY STATE	JAFFREY, N.H.
CUST. NO.	130-015
END USE	SOLAR PANEL - INNER CHASSIS
SCALE	4X
DR	WEA
CK	
DATE	8-2-77
SECTION CLASSIFICATION	SOLID
ALLOY	6063-T5
OUR SECTION NO	69617
REV	
INQ NO	2775

TOLERANCES EXCEPT AS NOTED	TITLE: Silicone Key Strip.	
DECIMAL ±	PROJECT Series V Collector	
FUNCTIONAL ±		
ANGULAR ±	By: Chase/Walton Co.	
REVISIONS	DRAWN BY JC 8-8-77	CHECKED BY
	SCALE	DRAWING # 130-016



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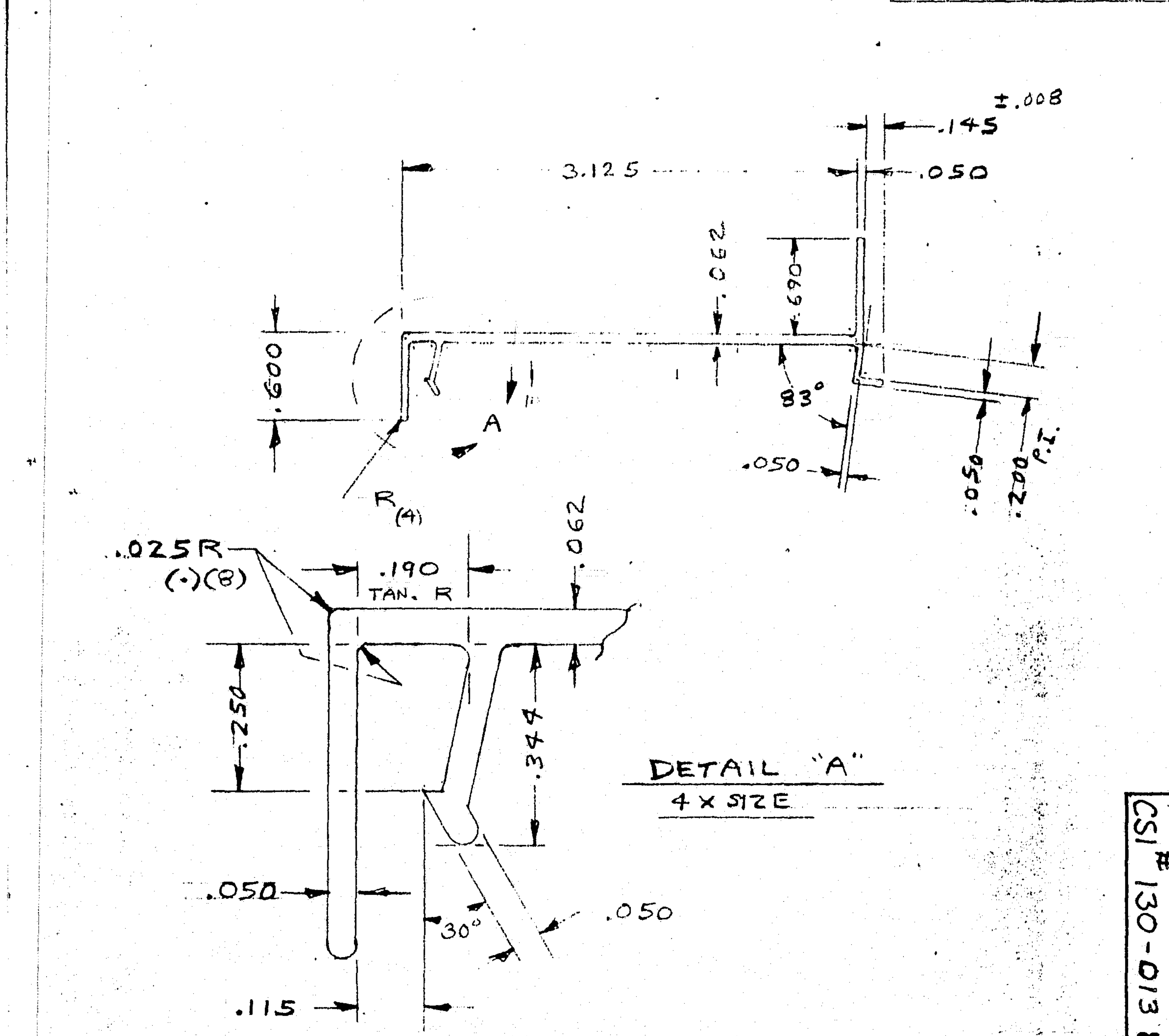
SECTION NO. 69558



"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."

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

ESTIMATED AREA	.295	SQ IN
EST. WT PER FT	.354	LBS
EST PERIMETER	10.247	IN
FACTOR 29	CIRCLE DIA 3-4	

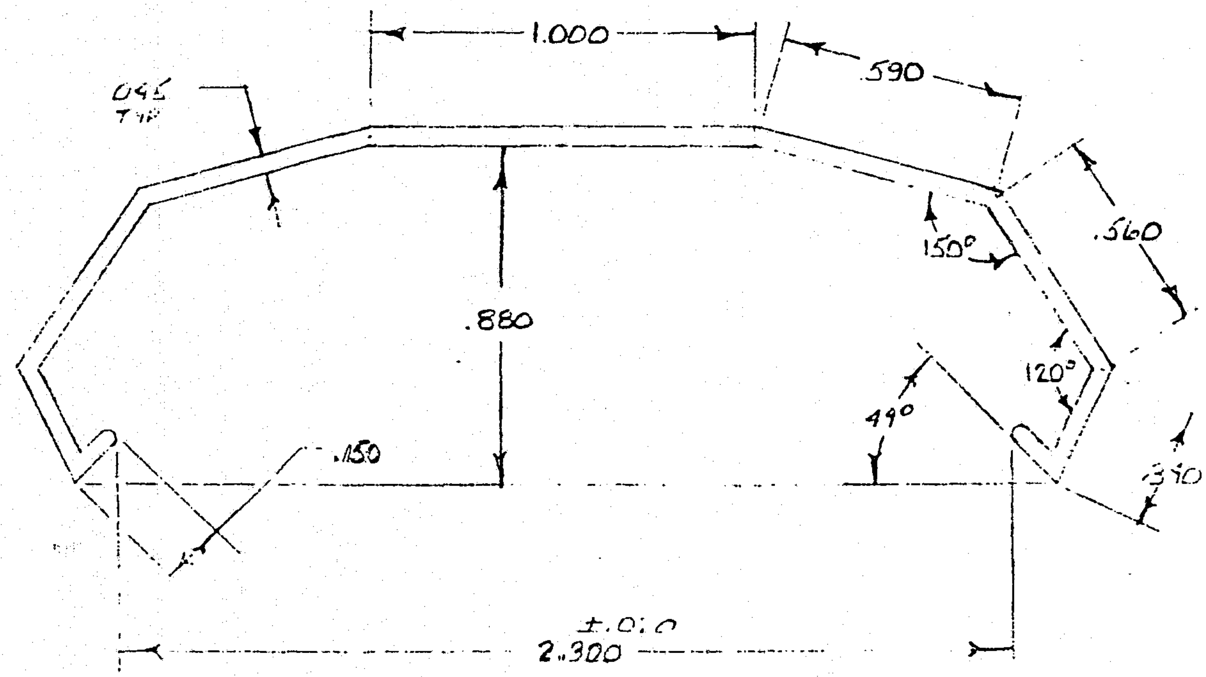
CODE	A	BT	CT	M	S		
					—		

R 529 11 (REV. 10-75)

TOLERANCES EXCEPT AS NOTED	TITLE Batten Cap	
DECIMAL ±	PROJECT Series IV + V	
FUNCTIONAL ±	Collector	
ANGULAR ±		
REVISIONS	DRAWN BY JC	CHECKED BY
	SCALE 2X	DRAWING # 150-005 PREVIOUSLY: 150-004

MATERIALS:

Extruded profile; Aluminum alloy 6063-T5



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NOTES

1. ALL UNSPECIFIED TOLERANCES TO BE ±.010

2. BREAK ALL SHARP CORNERS.

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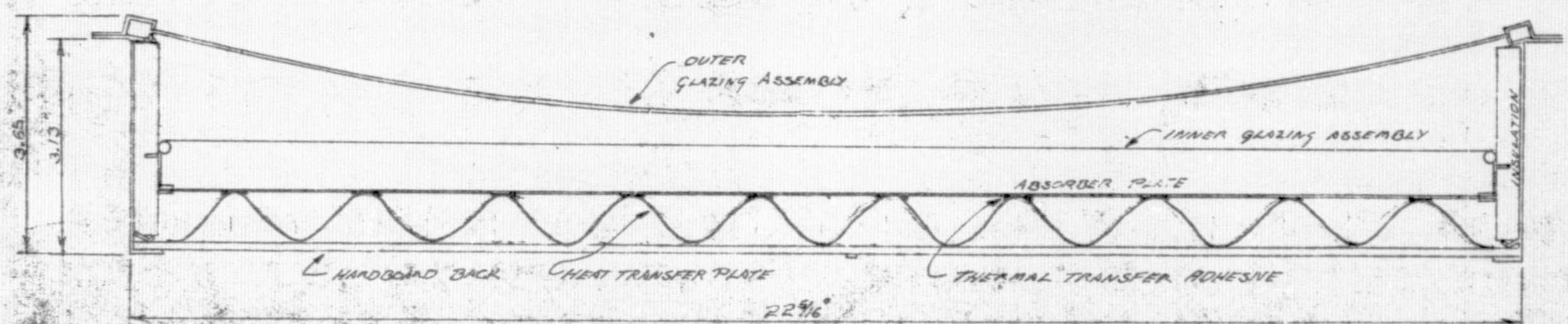
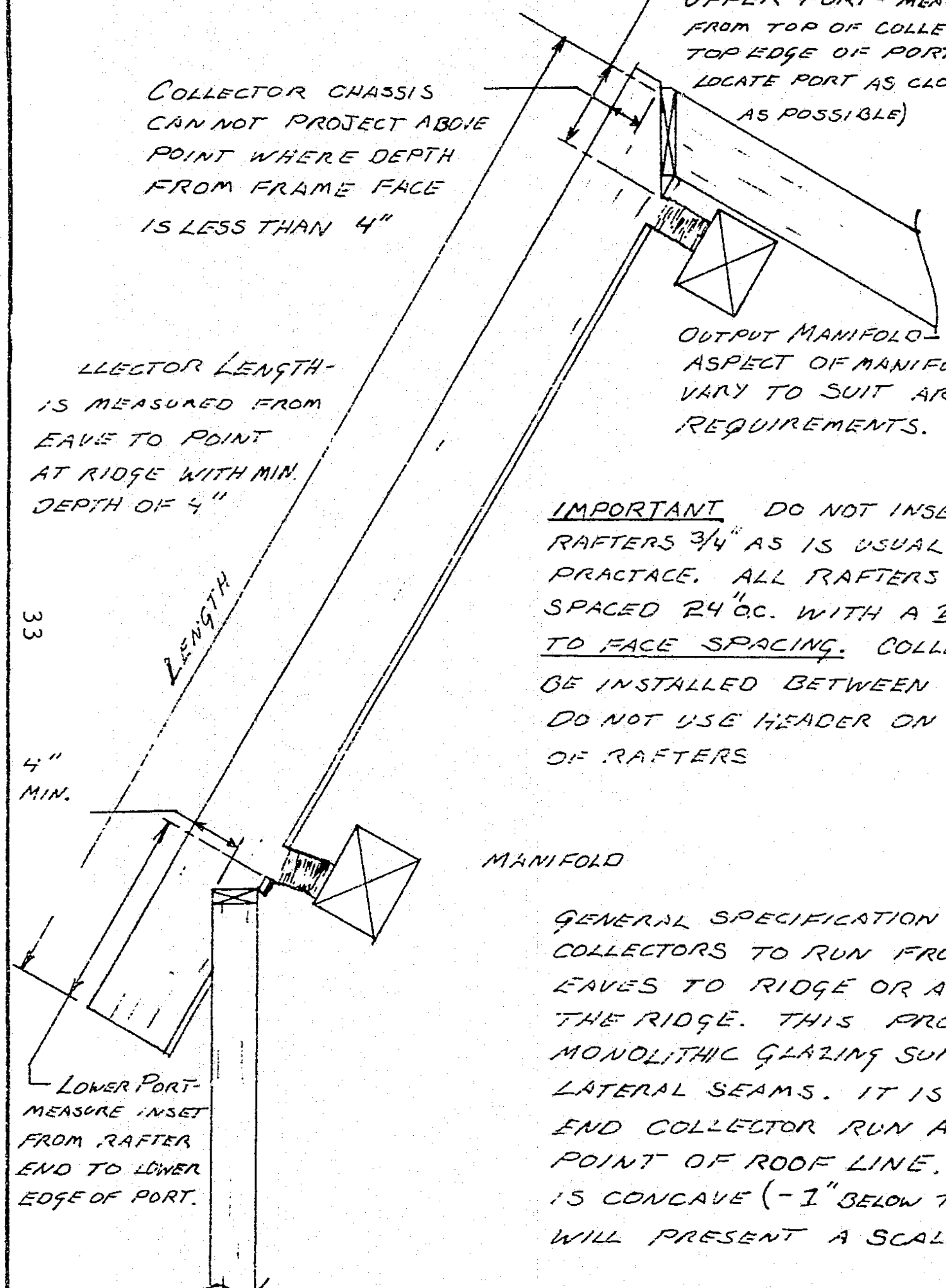
TOLERANCES EXCEPT AS NOTED	TITLE COLLECTOR SECTION		
DECIMAL	PROJECT SERIES V		
FUNCTIONAL			
ANGULAR			
REVISIONS	DRAWN BY 7-7-77 J.C.		CHECKED BY
	SCALE		DRAWING # 100-004



TOLERANCES EXCEPT AS NOTED	TITLE: SERIES IV COLLECTOR	
DECIMAL ± N.A.	PROJECT GENERAL SPECIFICATIONS	
FUNCTIONAL ± N.A.	FRAMING DETAILS, INTEGRATED	
ANGULAR ± N.A.	ROOF ARRAY	
REVISIONS	DRAWN BY J.C.	CHECKED BY
9.13.77 JC	SCALE N.A.	DRAWING # 510-002



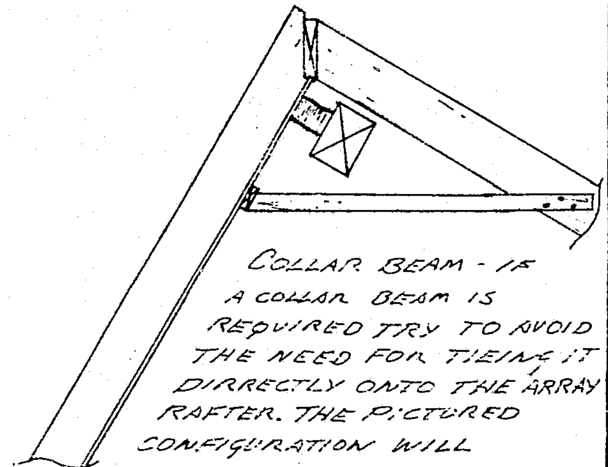
UPPER PORT - MEASURE INSET FROM TOP OF COLLECTOR TO TOP EDGE OF PORT (NOTE: LOCATE PORT AS CLOSE TO END AS POSSIBLE)

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

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

LLECTOR LENGTH - IS MEASURED FROM EAVE TO POINT AT RIDGE WITH MIN. DEPTH OF 4"

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



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

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.

LOWER PORT - MEASURE INSET FROM RAFTER END TO LOWER EDGE OF PORT.

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

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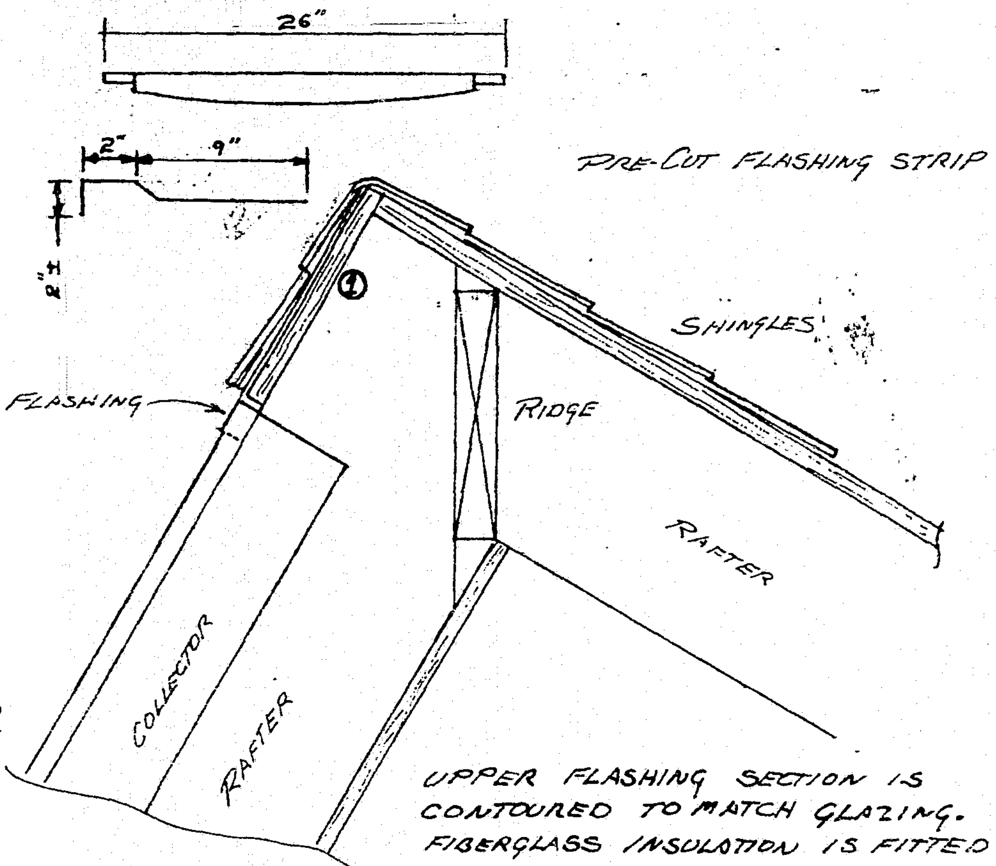
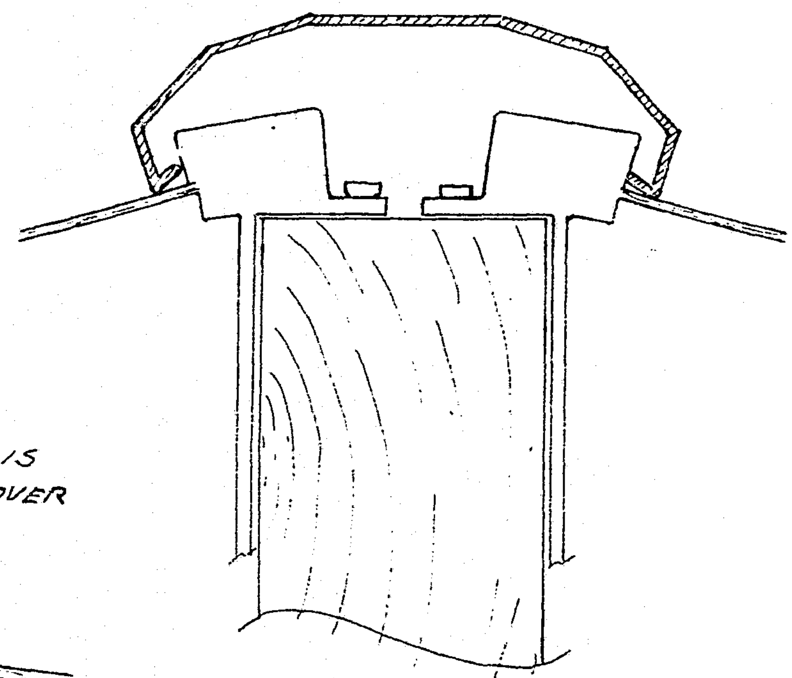
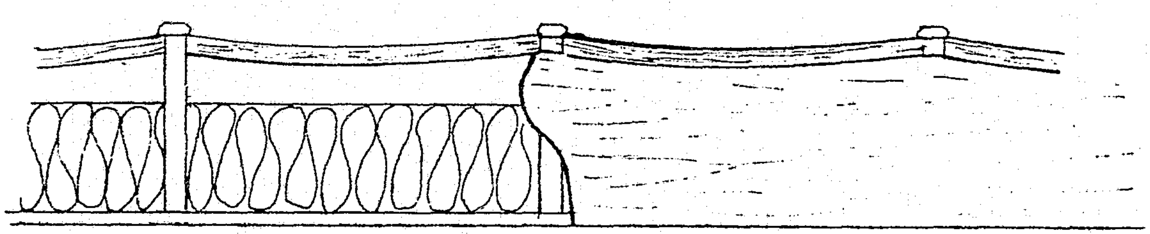
TOLERANCES EXCEPT AS NOTED	TITLE: SERIES IV COLLECTOR	
DECIMAL ±	PROJECT GENERAL SPECIFICATIONS	
FUNCTIONAL ±	FLASHING & TRIM	
ANGULAR ±		
REVISIONS	DRAWN BY J.C.	CHECKED BY
6-3-77 JC / 9-13-77 JC	SCALE	DRAWING # 510-005



UPPER FLASHING SECTION IS CONTOURED TO MATCH GLAZING. FIBERGLASS INSULATION IS FITTED UNDER FLASHING. SILICONE SEAL IS PLACED BETWEEN FIBERGLASS COVER AND FLASHING.



SNAP FIT BATTEN CAP AT COLLECTOR INTERSECTION.



LOWER FACIA 1/2" STOCK FITTED TO LOWER CONTOUR OF COLLECTOR GLAZING.

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

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V. LOGIC CONTROL UNIT (LCU-110)

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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 "forgetable 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.

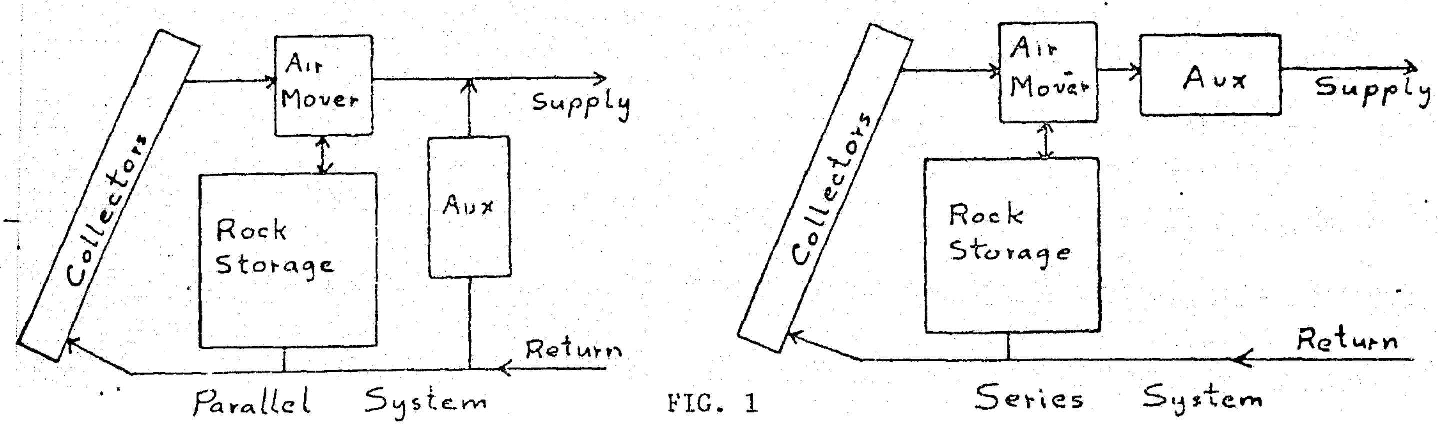

FIG. 1

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

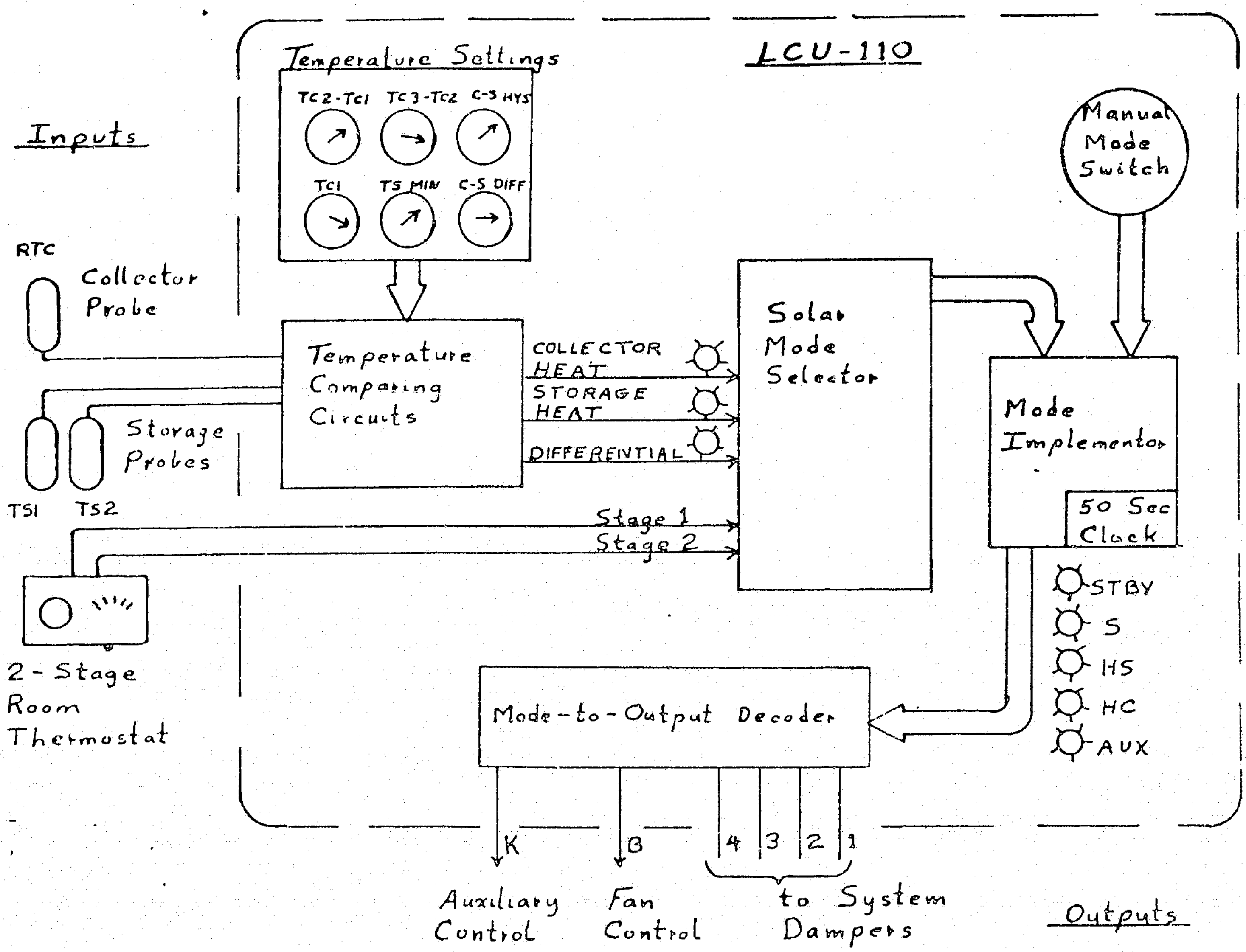

FIG. 2

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.

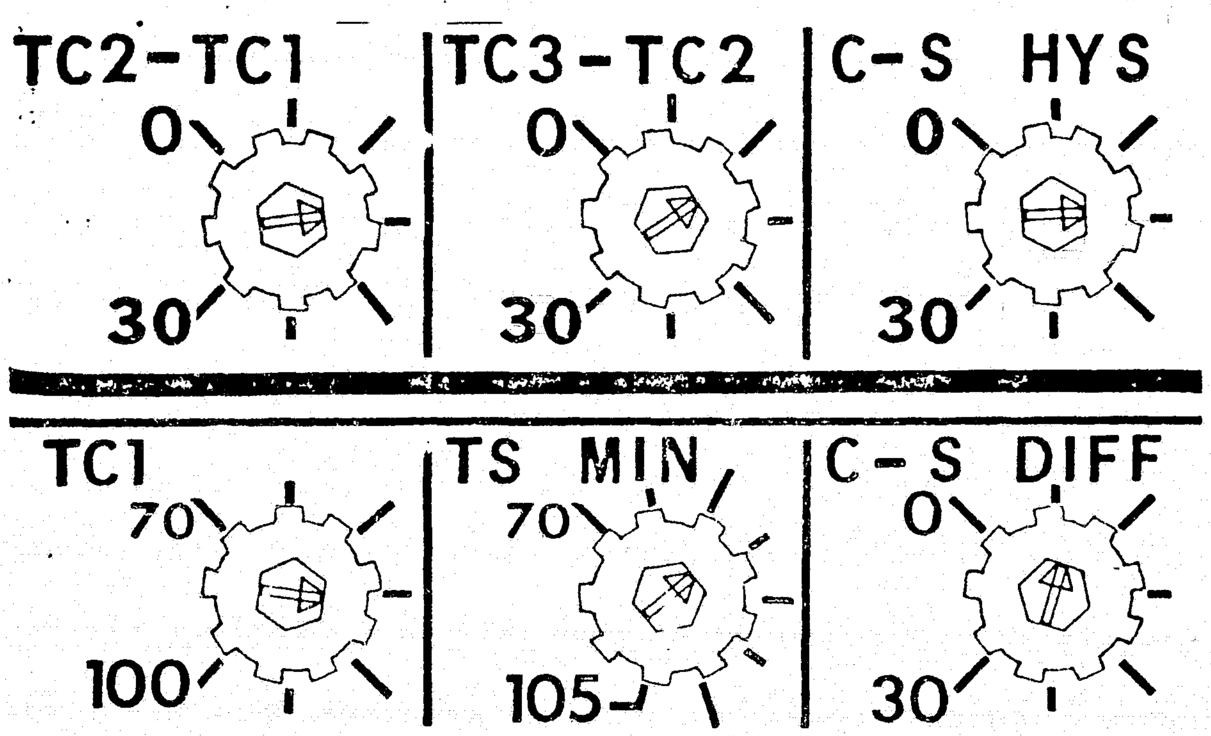

FIG. 3

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.

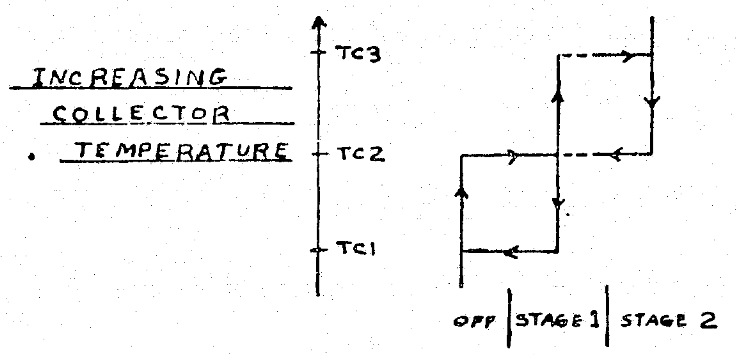

FIG. 4

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:

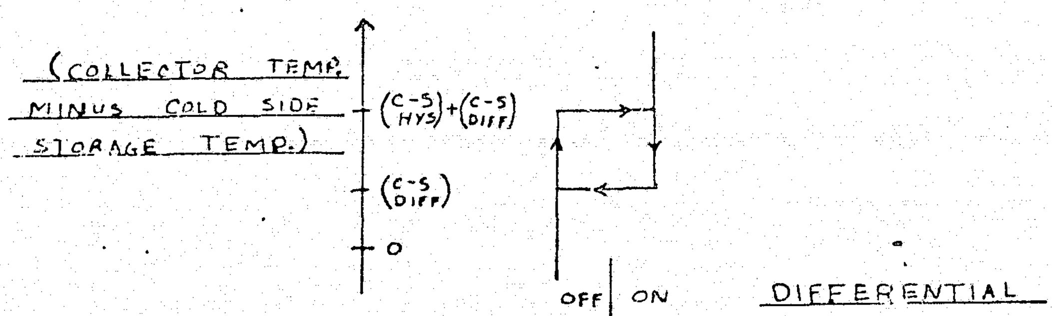

FIG. 5

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^{o}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^{o} F.

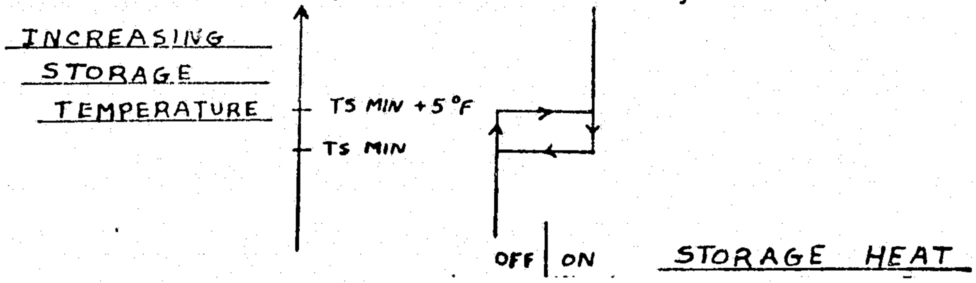

FIG. 6

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

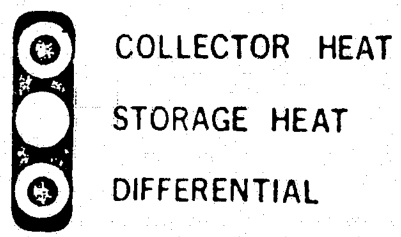

FIG. 7

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.*

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OF POOR QUALITY

SYSTEM FUNCTIONS

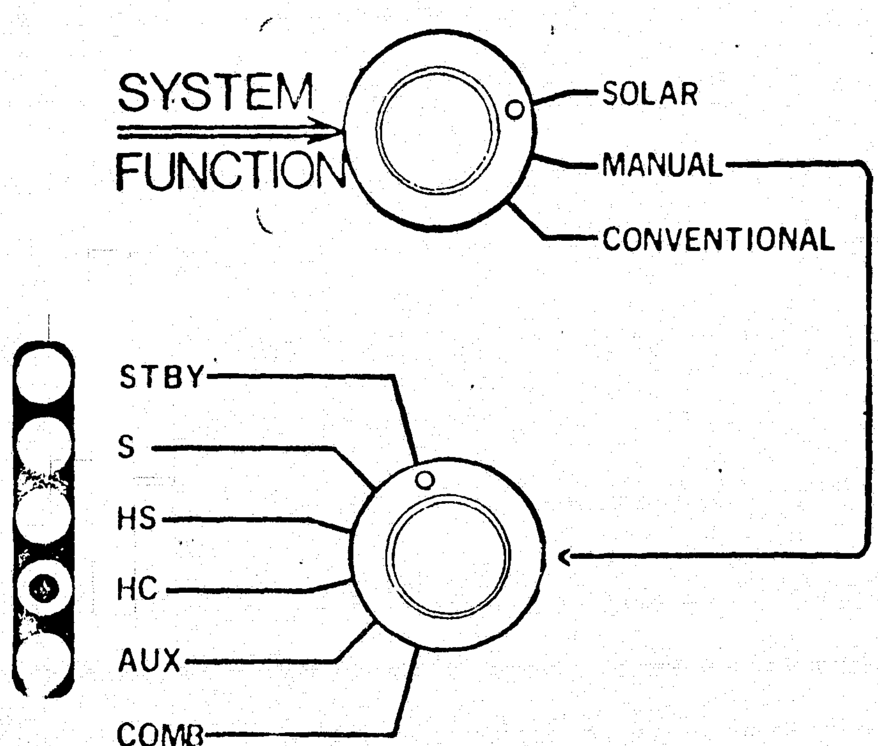


FIG. 8

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.

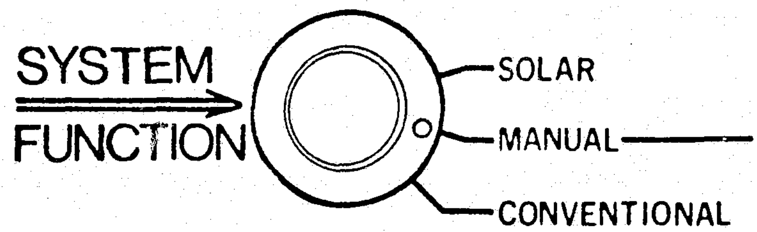


FIG. 9

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.

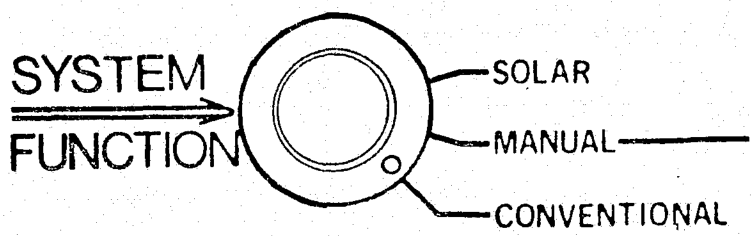


FIG. 10

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.

SUMMER LIMIT SWITCH

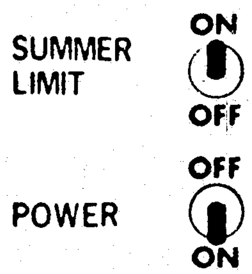


FIG. 11

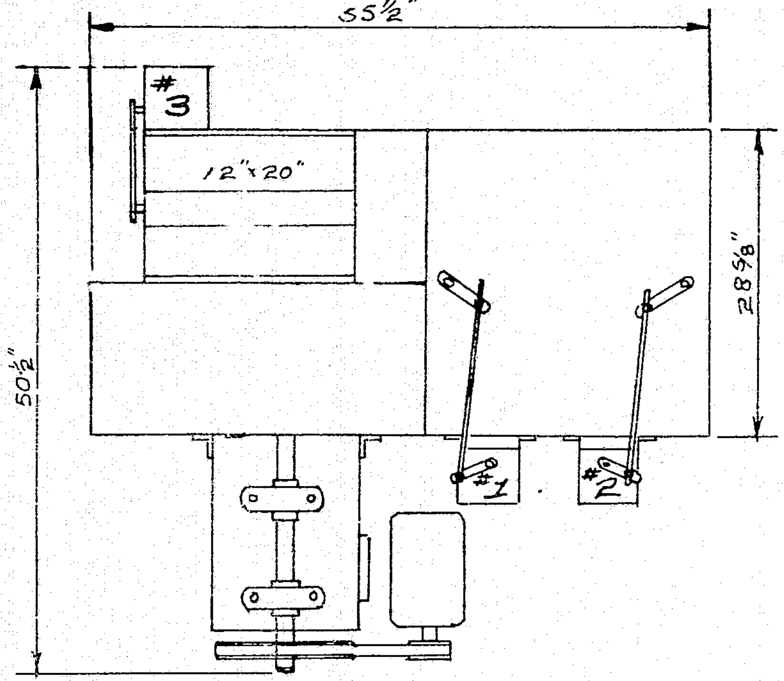
The Summer Limit Switch sets a maximum temperature of $100^{o}F$ for the storage bin. In the summer months the collectors are able to store most of the available solar energy because little space heating is demanded. Heat leaking from a hot storage bin is undesirable in the summer and this limiting prevents 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.

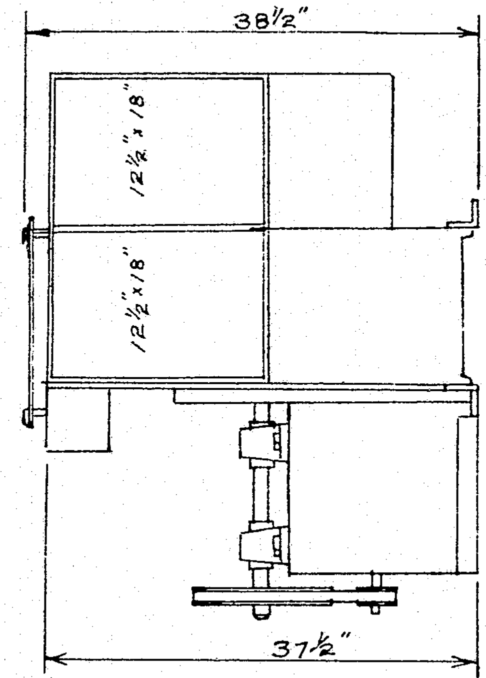
VI. UNIVERSAL SWITCHING UNIT (USU)

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 premiun 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 filmblade wipers. Damper motor; Honeywell M836-A 24 VAC. Linkage; cold rolled steel stamped pcs.

TOLERANCES EXCEPT AS NOTED	TITLE: USU-A DIMENSIONS	
DECIMAL ±	PROJECT GENERAL SPECIFICATIONS	
FUNCTIONAL ± 3/8"		
ANGULAR ±		
REVISIONS	DRAWN BY J.C. 4-4-77	CHECKED BY
		DRAWING # 520-001



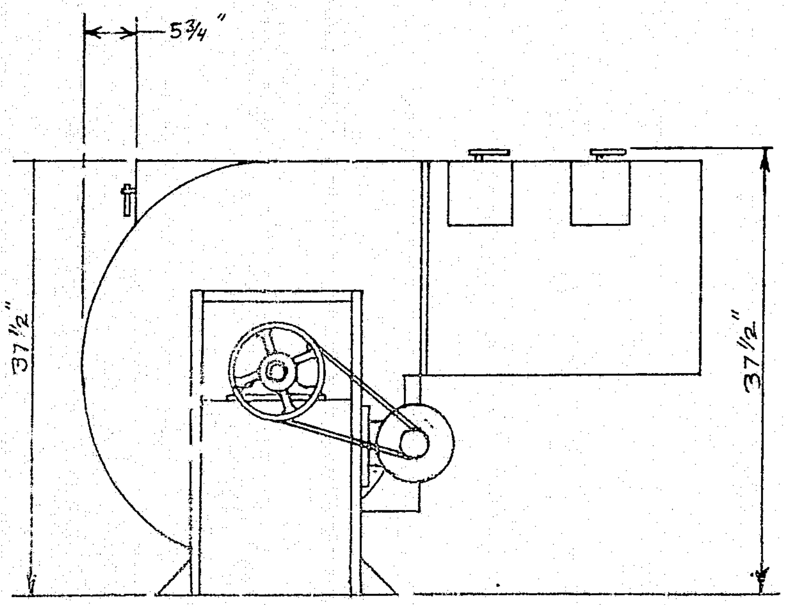


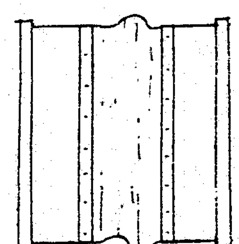
Unit may be broken down into two components for installation thru 32" min. passage door.

Fan Unit
34"Wx30$\frac{1}{2}$"Dx36$\frac{1}{2}$"H

Switching Unit
36$\frac{1}{2}$"Wx52"Dx30$\frac{1}{2}$"H

Assembled Unit
50$\frac{1}{2}$"Wx55$\frac{1}{2}$"Dx38$\frac{1}{2}$"H





Output from USU is 12½"x 18"
Output boot can taper to accomodate any duct size.
Flexible coupeling assures quite operation.

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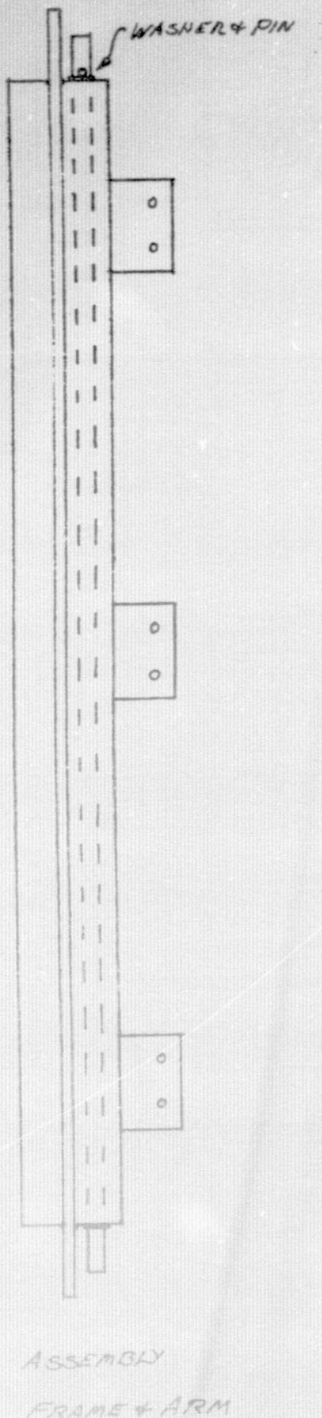
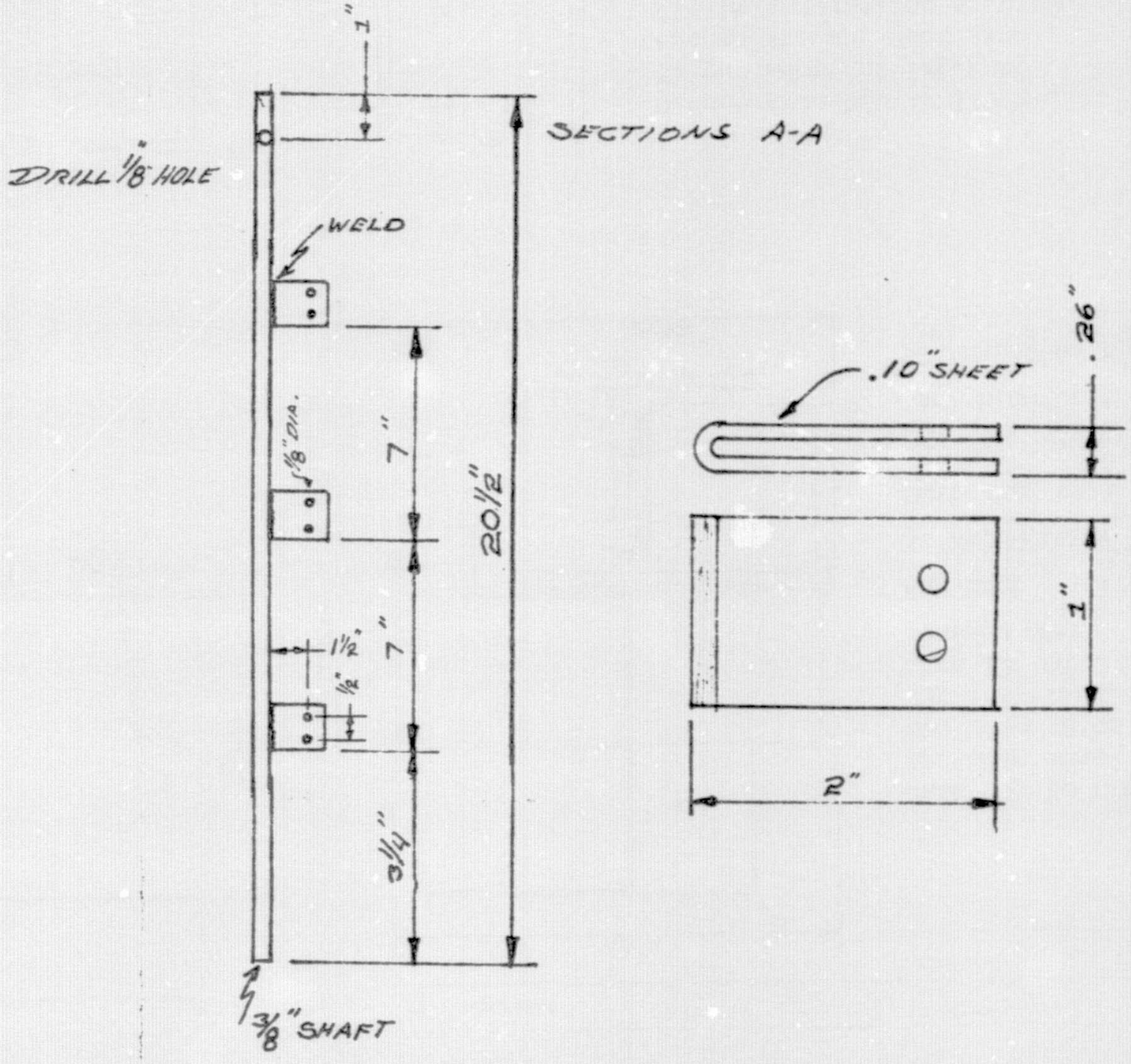
TOLERANCES EXCEPT AS NOTED	TITLE: DAMPER ARM	
DECIMAL ±	PROJECT USU-A	
FUNCTIONAL ±		
ANGULAR ±		
REVISIONS	DRAWN BY JC	CHECKED BY
	SCALE NTS	DRAWING # 200-017





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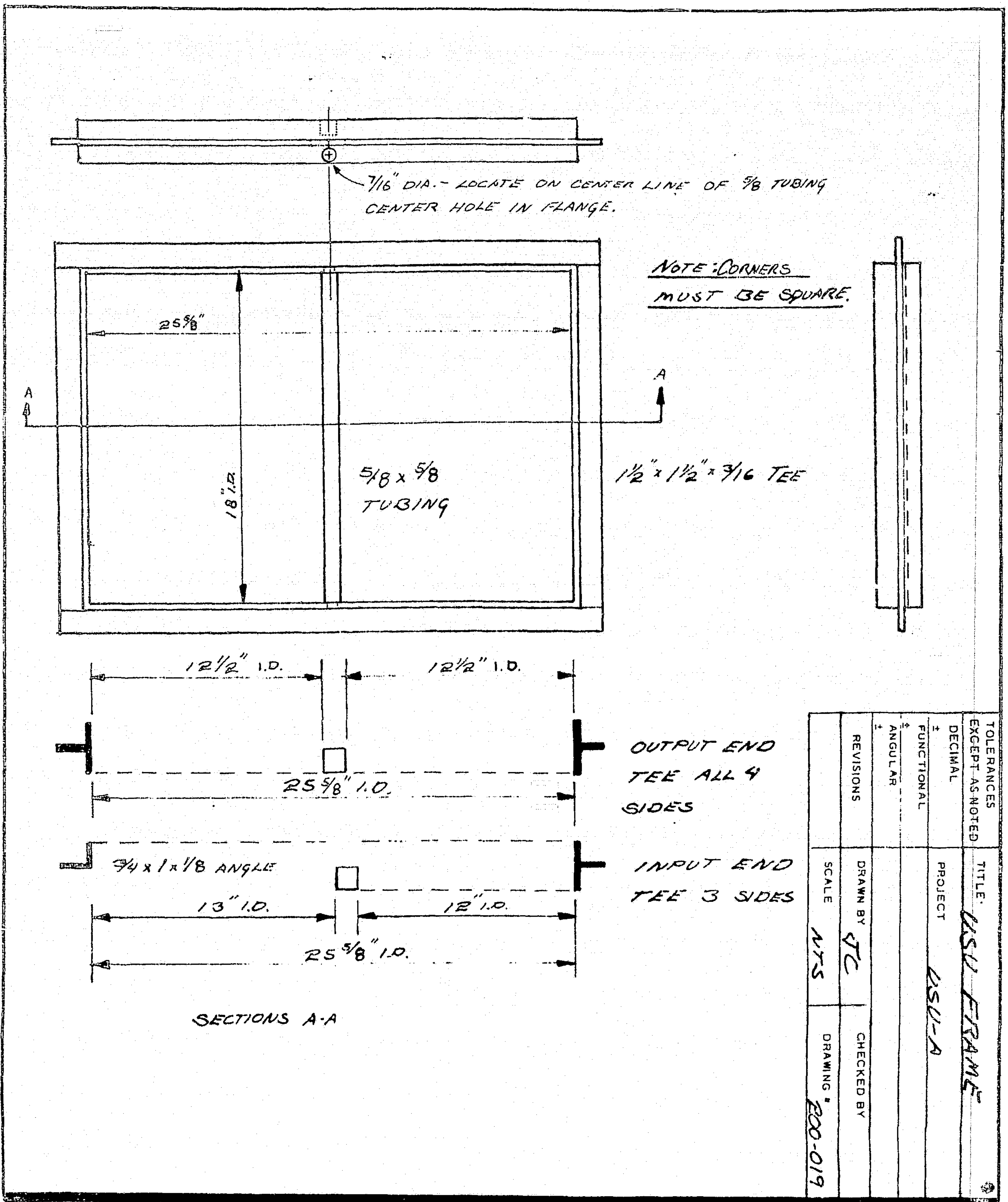

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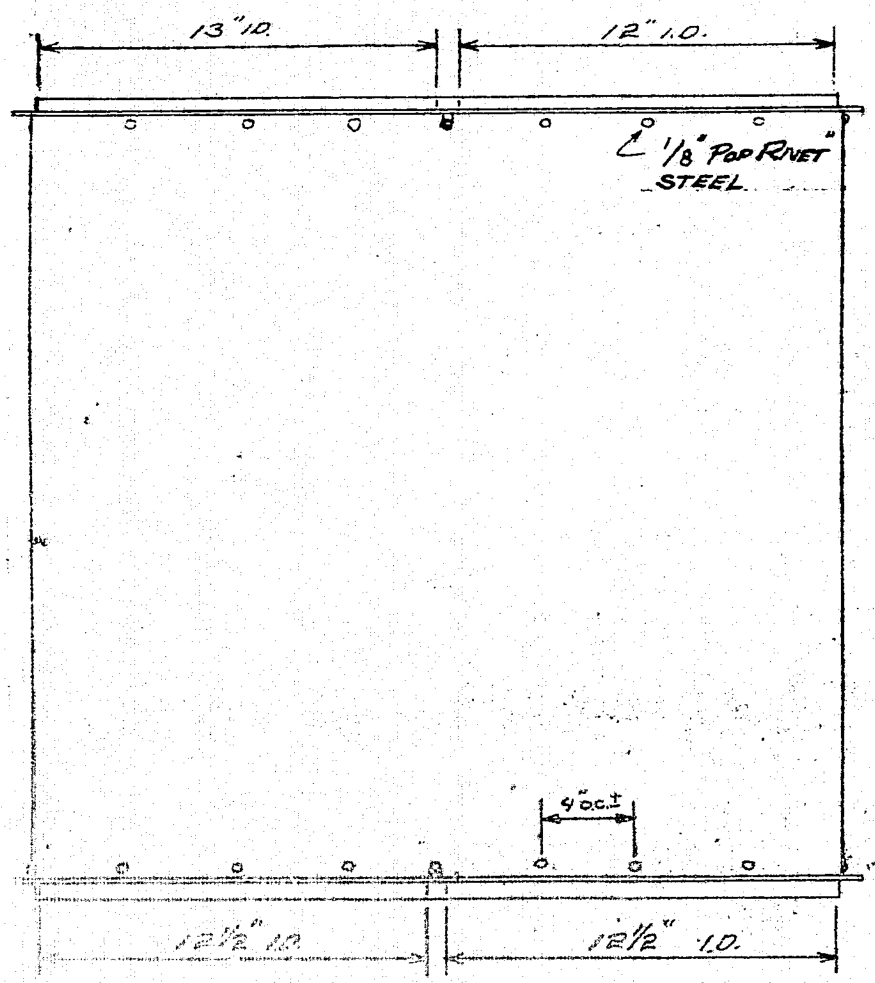
TOLERANCES EXCEPT AS NOTED	TITLE: CHASSIS ASSEMBLY	
DECIMAL ±	PROJECT USU-A	
FUNCTIONAL ±		
ANGULAR ±		
REVISIONS	DRAWN BY JC	CHECKED BY
	SCALE 1/2":1'	DRAWING # 200-021



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

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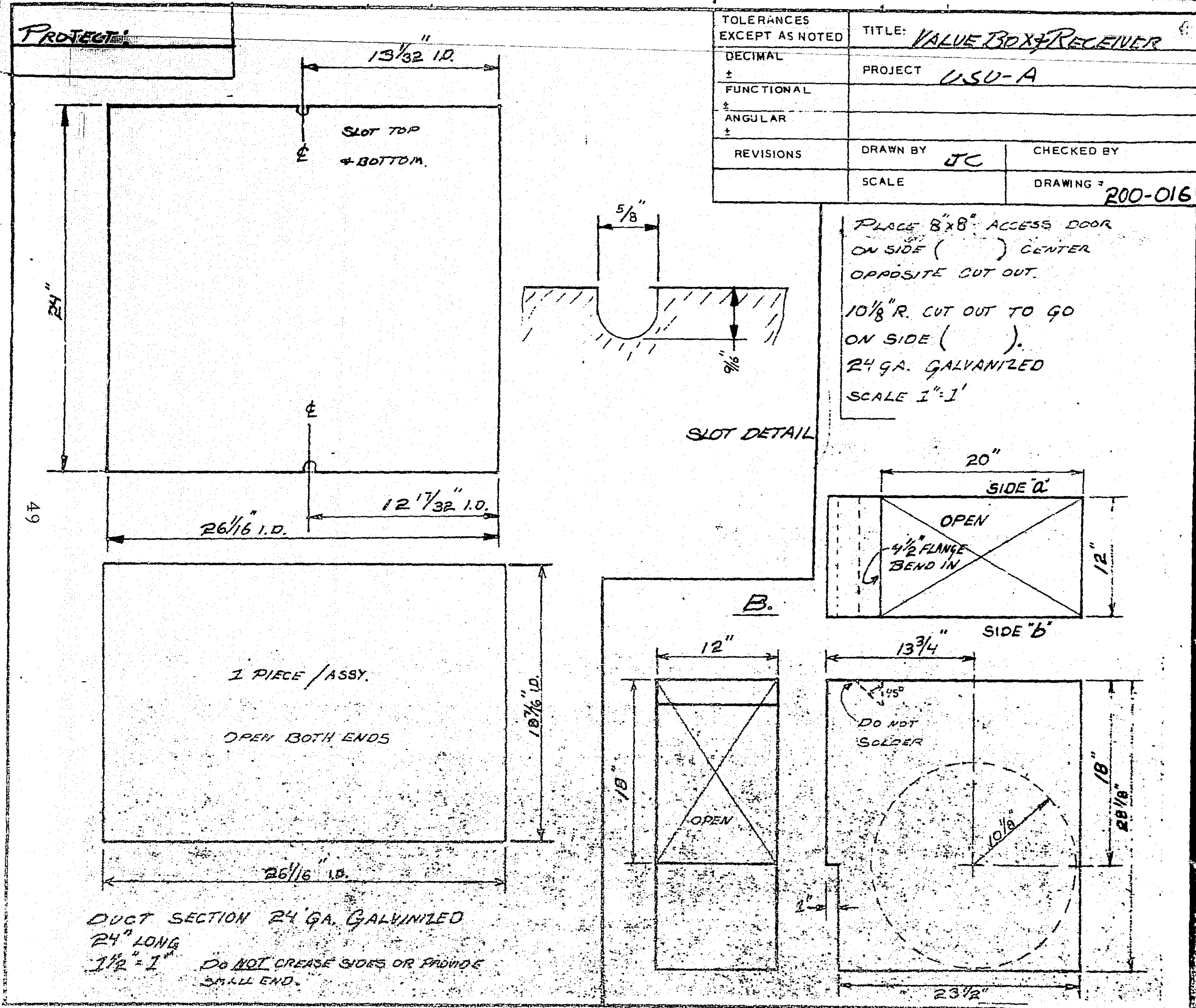

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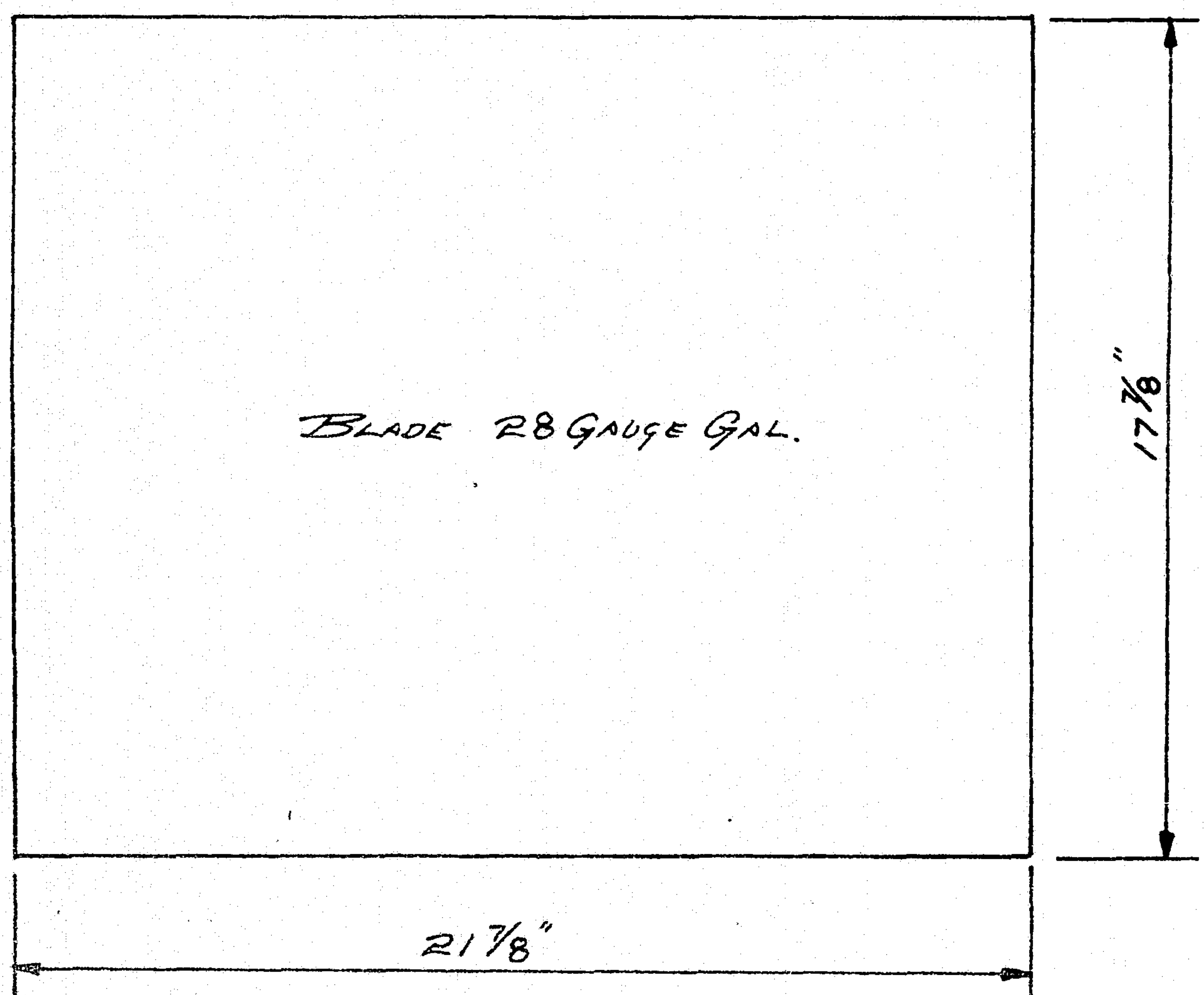
JOB:	
QUANT:	

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



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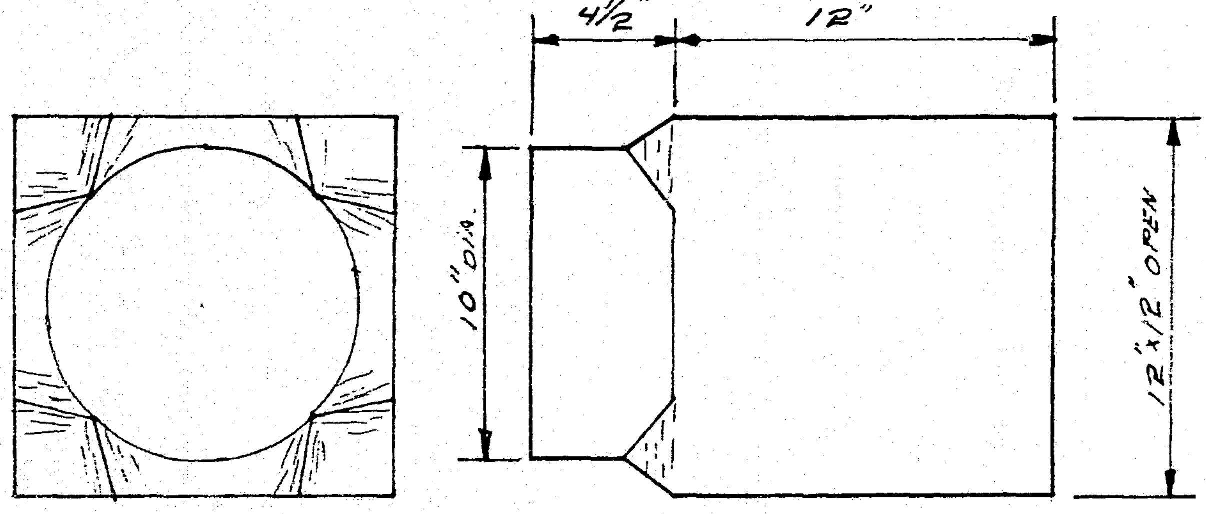
TOLERANCES EXCEPT AS NOTED	TITLE: VENT, SHEET METAL DW	
DECIMAL ±	PROJECT VENT SYSTEM.	
FUNCTIONAL ±		
ANGULAR ±		
REVISIONS	DRAWN BY JC.	CHECKED BY
	SCALE 2":1'	DRAWING # 230-004



24GA GAL. STEEL

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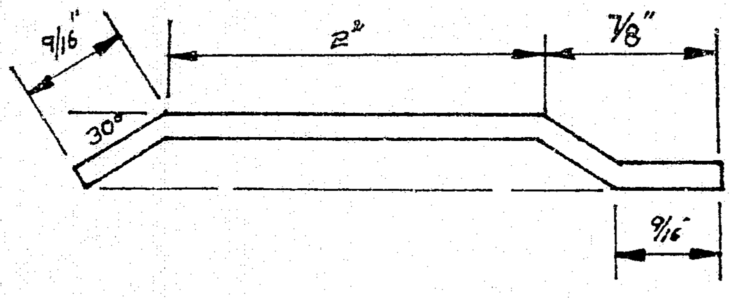
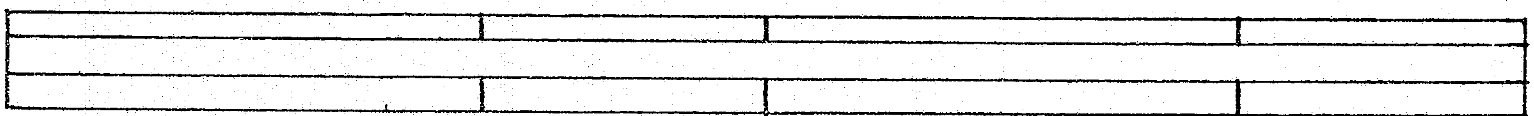
JOB:

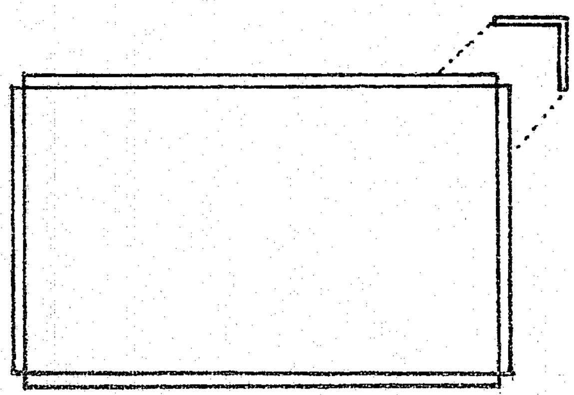
UNITS:

MATERIAL:

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







REINFORCE CORNERS ON EXTERIOR WITH 7/16" ANGLE WELDED TO FRAME.

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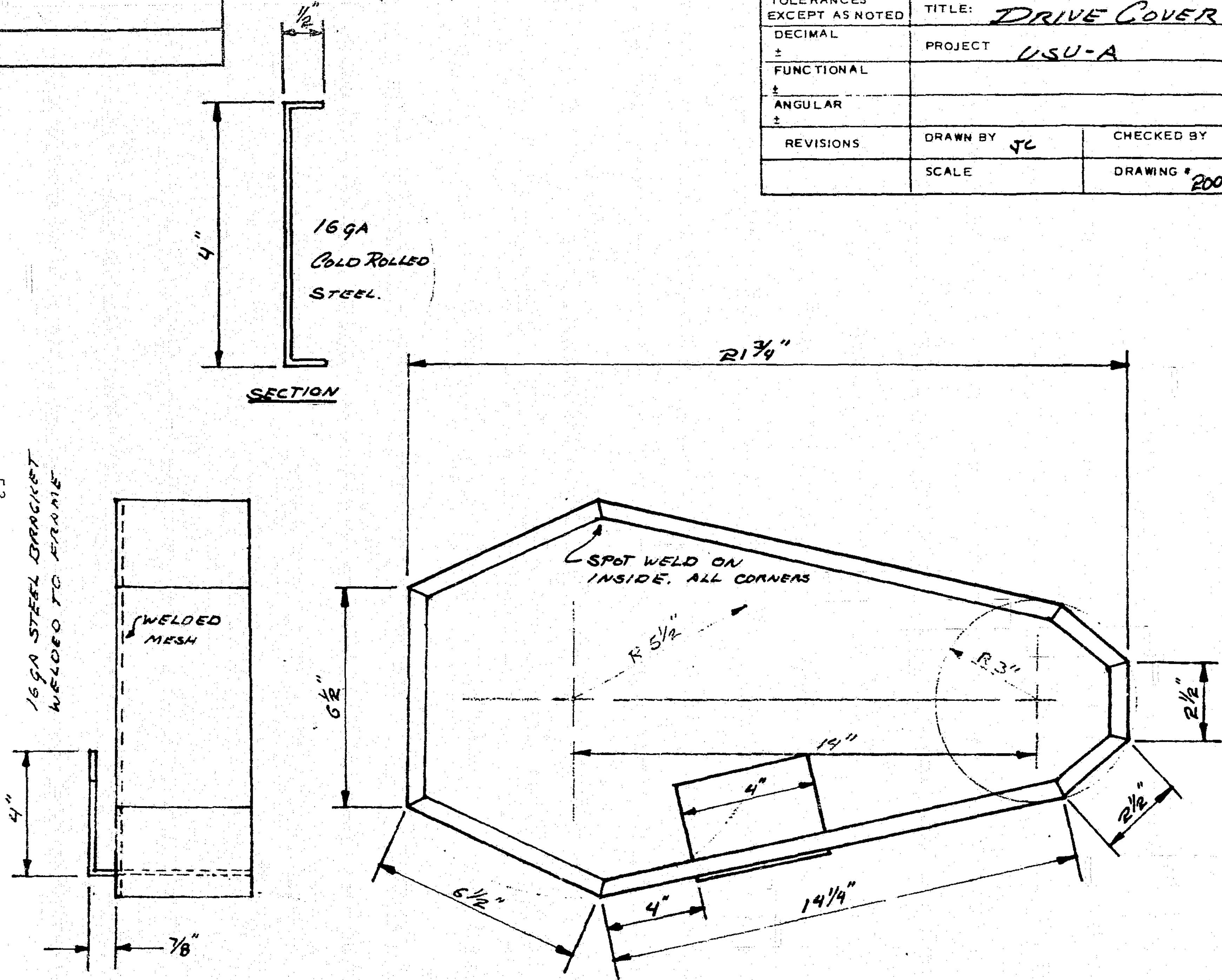
TOLERANCES EXCEPT AS NOTED	TITLE: DRIVE COVER	
DECIMAL ±	PROJECT USU-A	
FUNCTIONAL ±		
ANGULAR ±		
REVISIONS	DRAWN BY JC	CHECKED BY
	SCALE	DRAWING # 200-022



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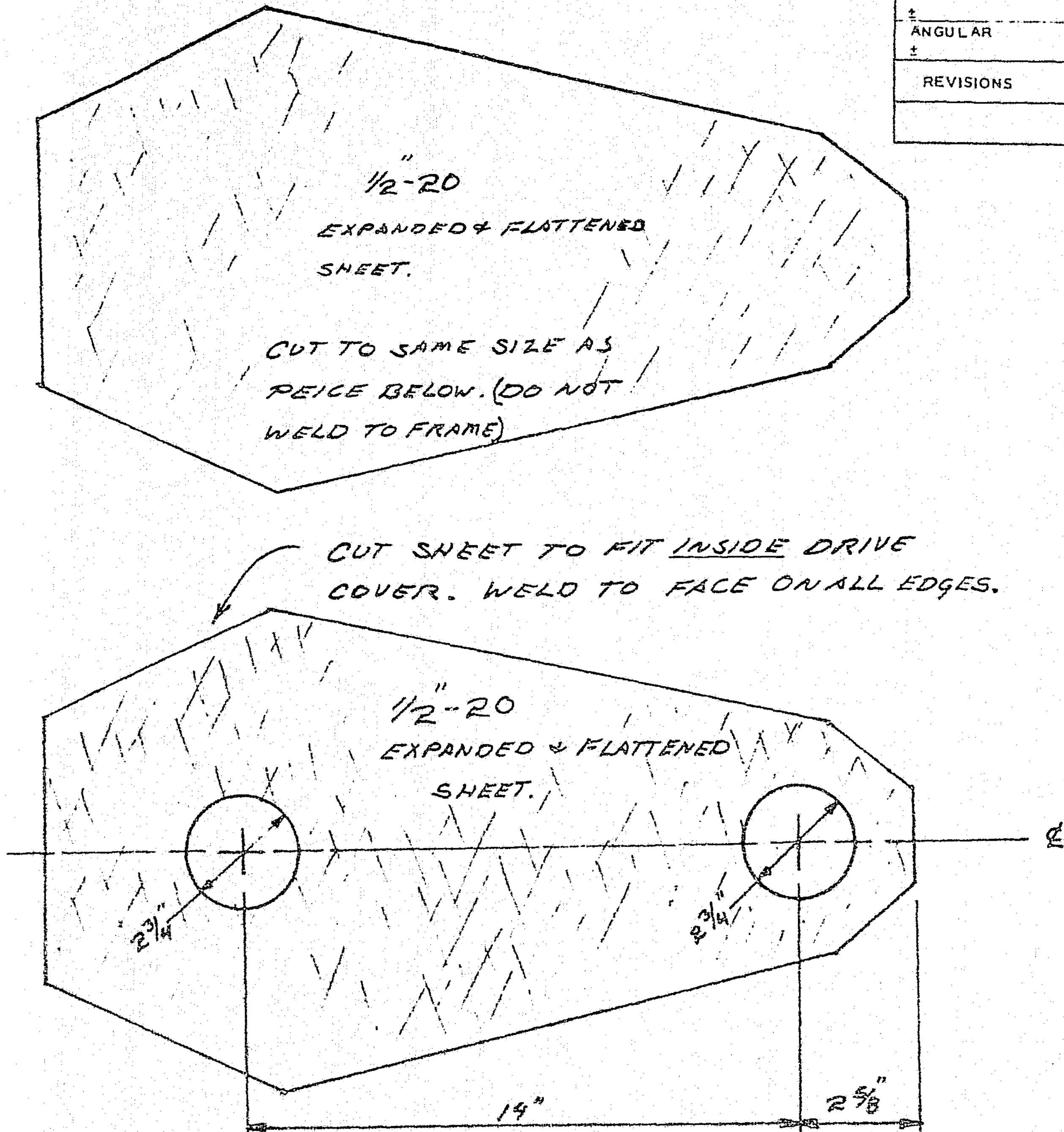
TOLERANCES EXCEPT AS NOTED	TITLE: COVER MESH	
DECIMAL ±	PROJECT USU-A	
FUNCTIONAL ±		
ANGULAR ±		
REVISIONS	DRAWN BY J.C.	CHECKED BY
	SCALE	DRAWING # 200-023



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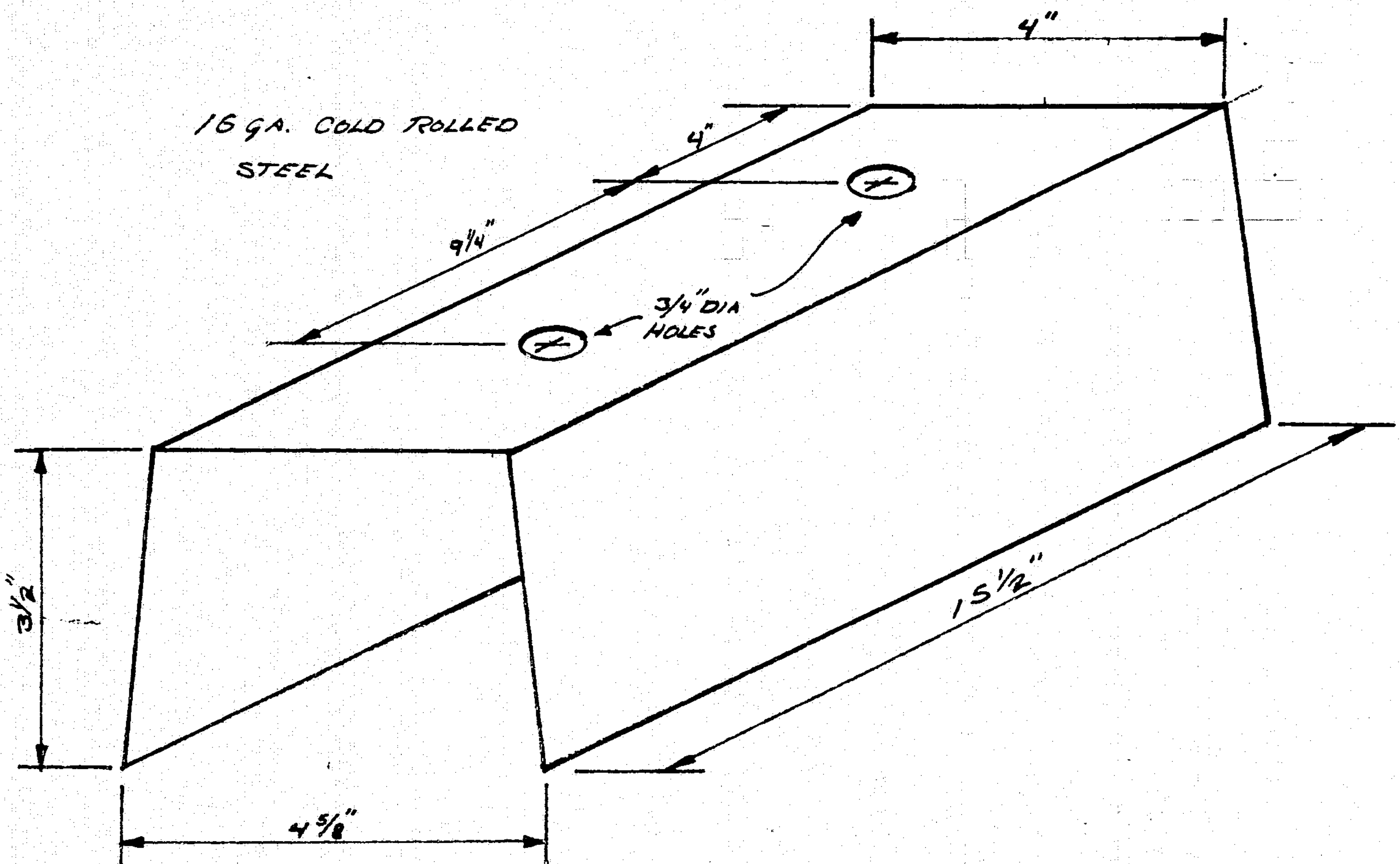
TOLERANCES EXCEPT AS NOTED	TITLE: SHAFT COVER		
DECIMAL ±	PROJECT USU-A		
FUNCTIONAL ±			
ANGULAR ±			
REVISIONS	DRAWN BY J.C.	CHECKED BY	
	SCALE	DRAWING # 200-024	



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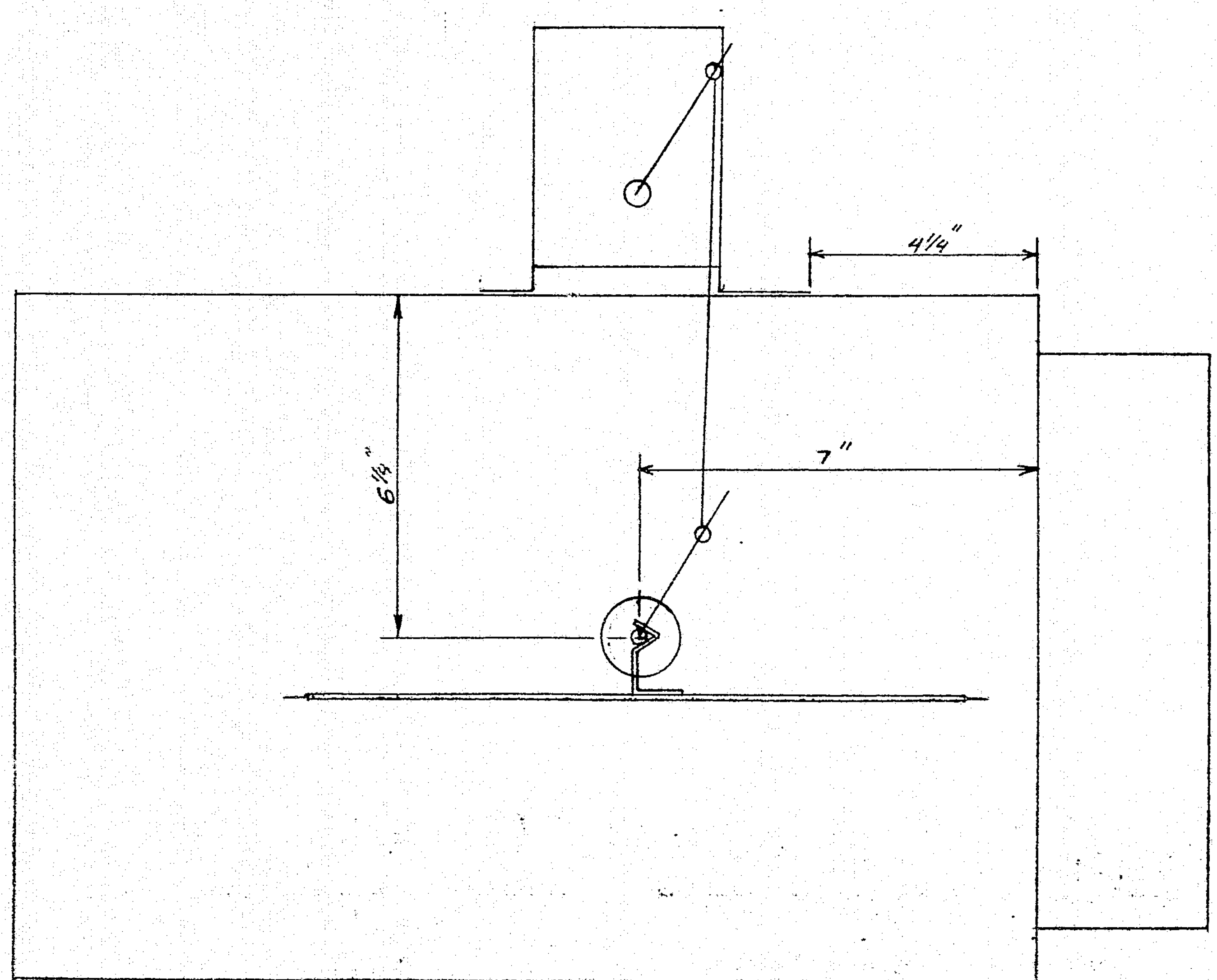
TOLERANCES EXCEPT AS NOTED	TITLE: ASSEMBLY DRAWING	
DECIMAL ±	PROJECT VENT VALVE	
FUNCTIONAL ±	FAIL SAFE	
ANGULAR ±		
REVISIONS	DRAWN BY JC 7-6-77	CHECKED BY
	SCALE 4":1'	DRAWING # 230-003



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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 I/O 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 ft^2 of active collector area.

2) Ports should be provided for every 24 linear feet of collector mainfold.

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:

Active Collector Area	Motor
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 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:

HxW$\geq$ 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.

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

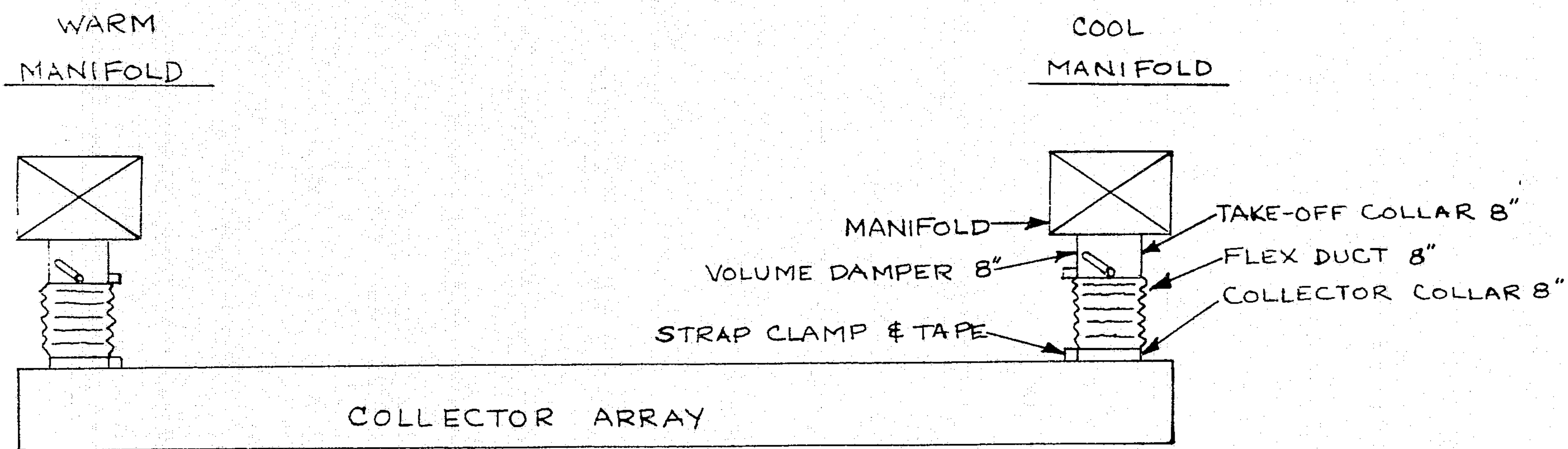

Figure VIII-1

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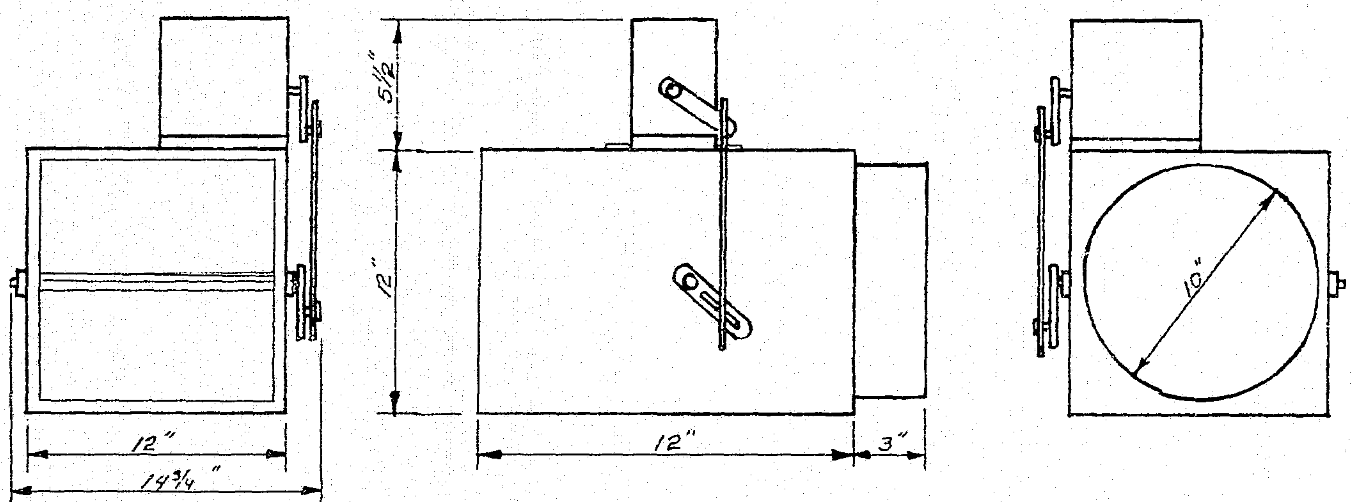
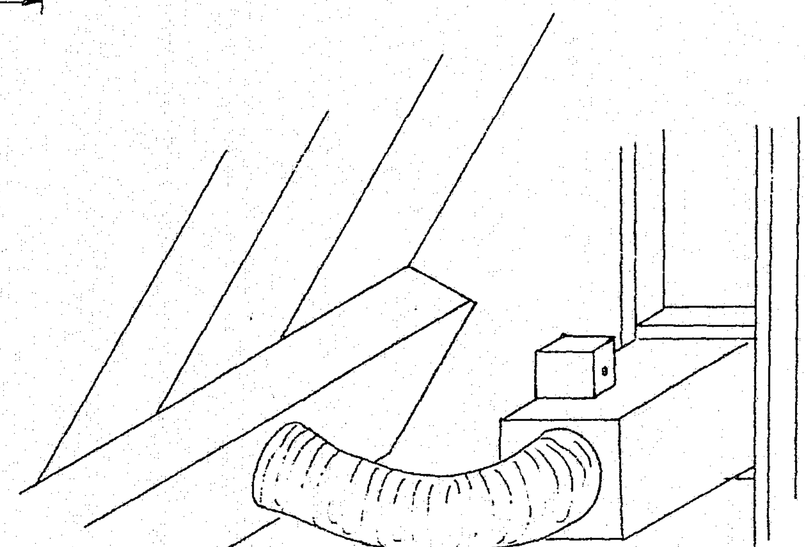
TOLERANCES EXCEPT AS NOTED	TITLE- THERMAL VENTING DEVICE	
DECIMAL ±	PROJECT GENERAL SPECIFICATIONS	
FUNCTIONAL ±		
ANGULAR ±		
REVISIONS	DRAWN BY JC.	CHECKED BY
	SCALE NTS	DRAWING # 530-001

60





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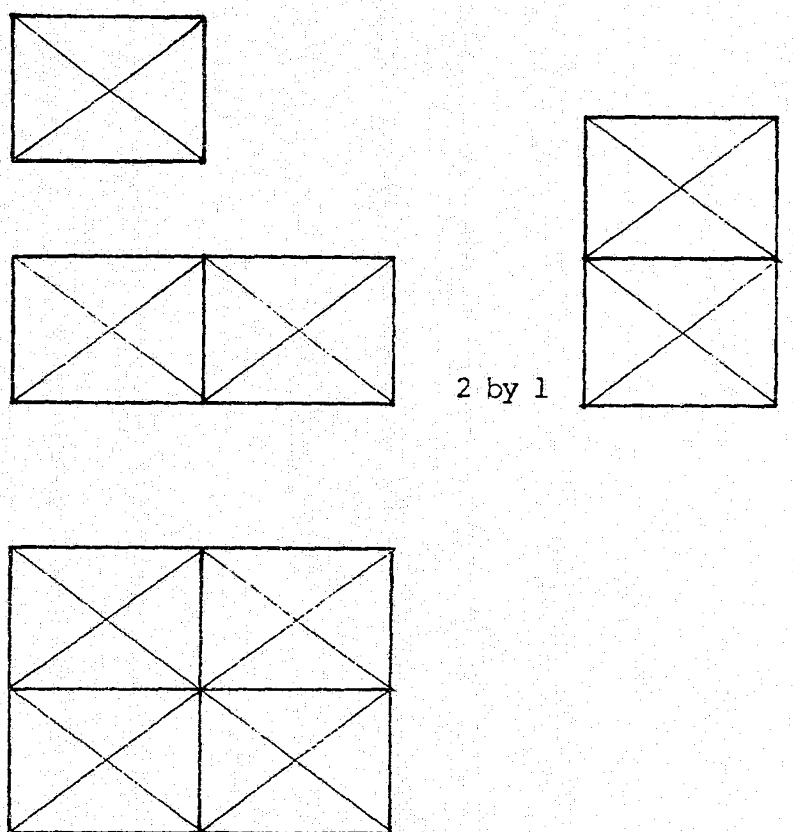
MATERIALS: Mesh; 1/2-18 expanded metal hot rolled steel.
Frame; 5/8 x5/8 x 1/8" hot rolled steel angle.

POSSIBLE MANIFOLD CONFIGURATIONS



1 by 1

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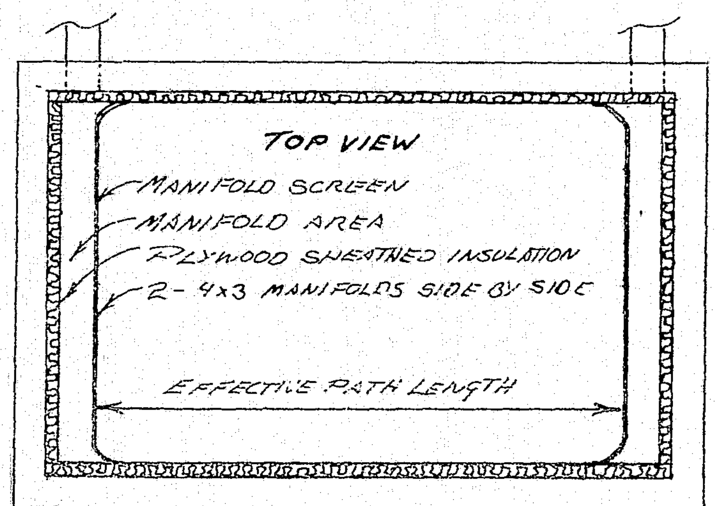

TOLERANCES EXCEPT AS NOTED	TITLE: STORAGE MANIFOLD SYSTEM	
DECIMAL ±	PROJECT GENERAL SPECIFICATIONS	
FUNCTIONAL ±		
ANGULAR ±		
REVISIONS	DRAWN BY 4-27-77 JC	CHECKED BY
	SCALE NTS.	DRAWING # 540-003

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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CSI #-240-001

DUCTING/ MANIFOLDING INSULATION REQUIREMENTS

1) Manifolding:

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

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

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

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

2) Ducting, exterior to heated living space:

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

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

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

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

3) Ducting; inside heated space:

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

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

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

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

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 $\frac{BTU/DD}{ft^2}$ 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$\pm$ 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):

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

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:

Volume/min. x 25 = 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.

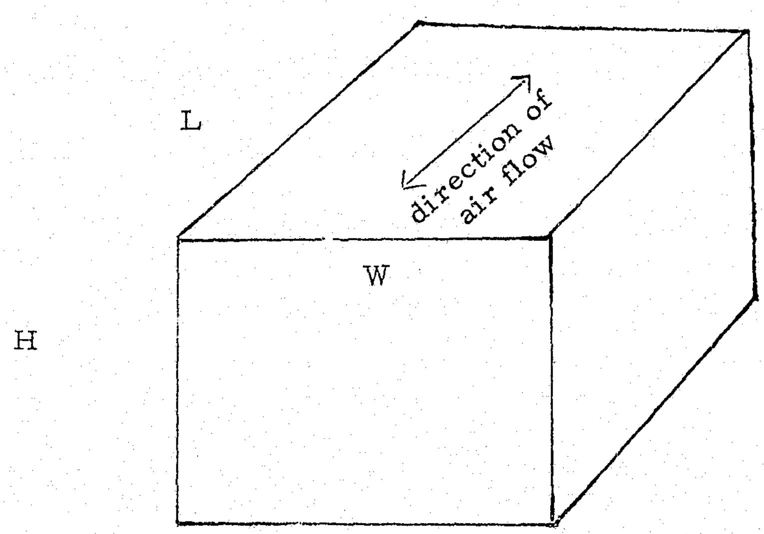


Figure VII-1
Storage Bin Configuration

A. HxW = Cross-sectional area perpendicular to air flow.

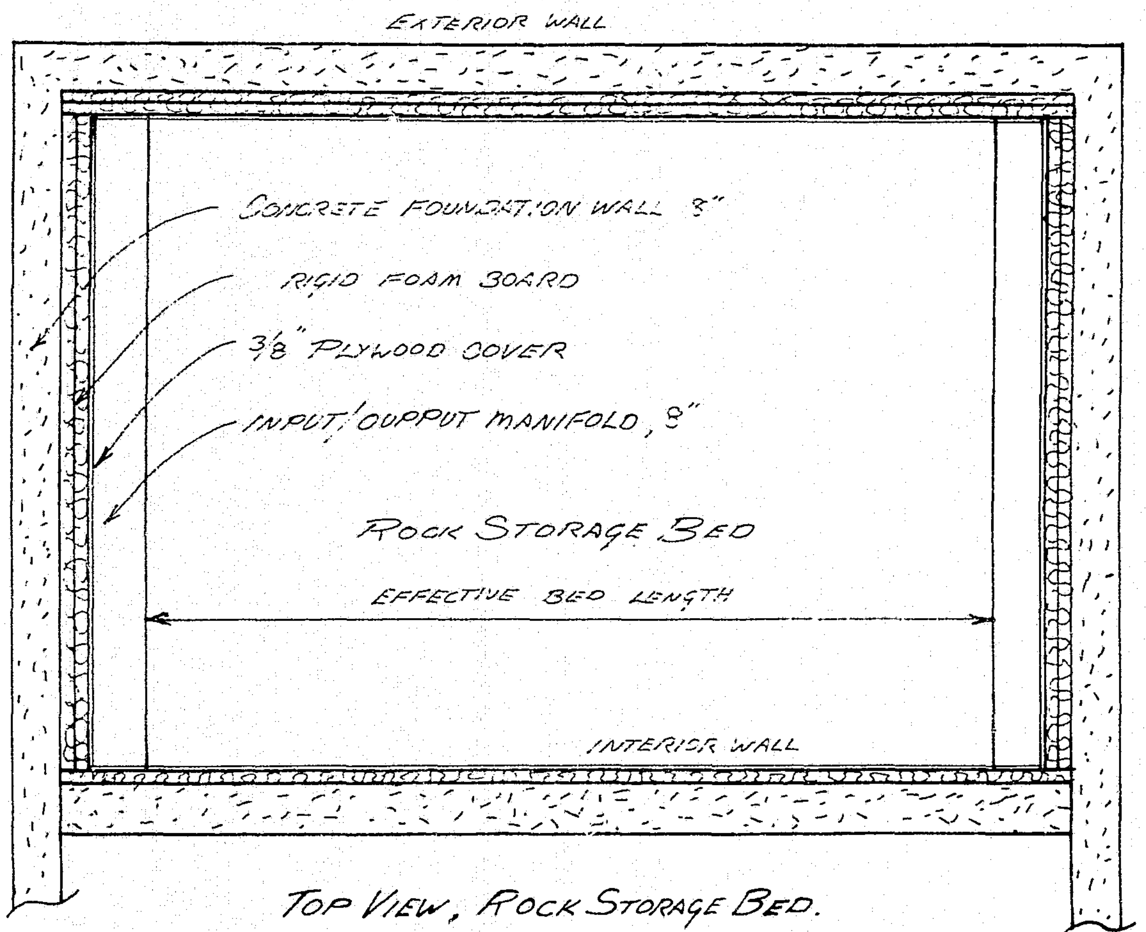
B. The ratio of W:H should be no greater than 3 nor less than .3.

C. The ratio of $L:\frac{W+H}{2}$ 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



TOP VIEW, ROCK STORAGE BED.

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 spaceron side walls.
3. Manifolds are factory manufcatured 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 applys to the foundation slab as well.
6. The effective bed length of the storage system is the distance between inside manifold faces.

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TOLERANCES EXCEPT AS NOTED	TITLE: ROCK STORAGE SECTION	
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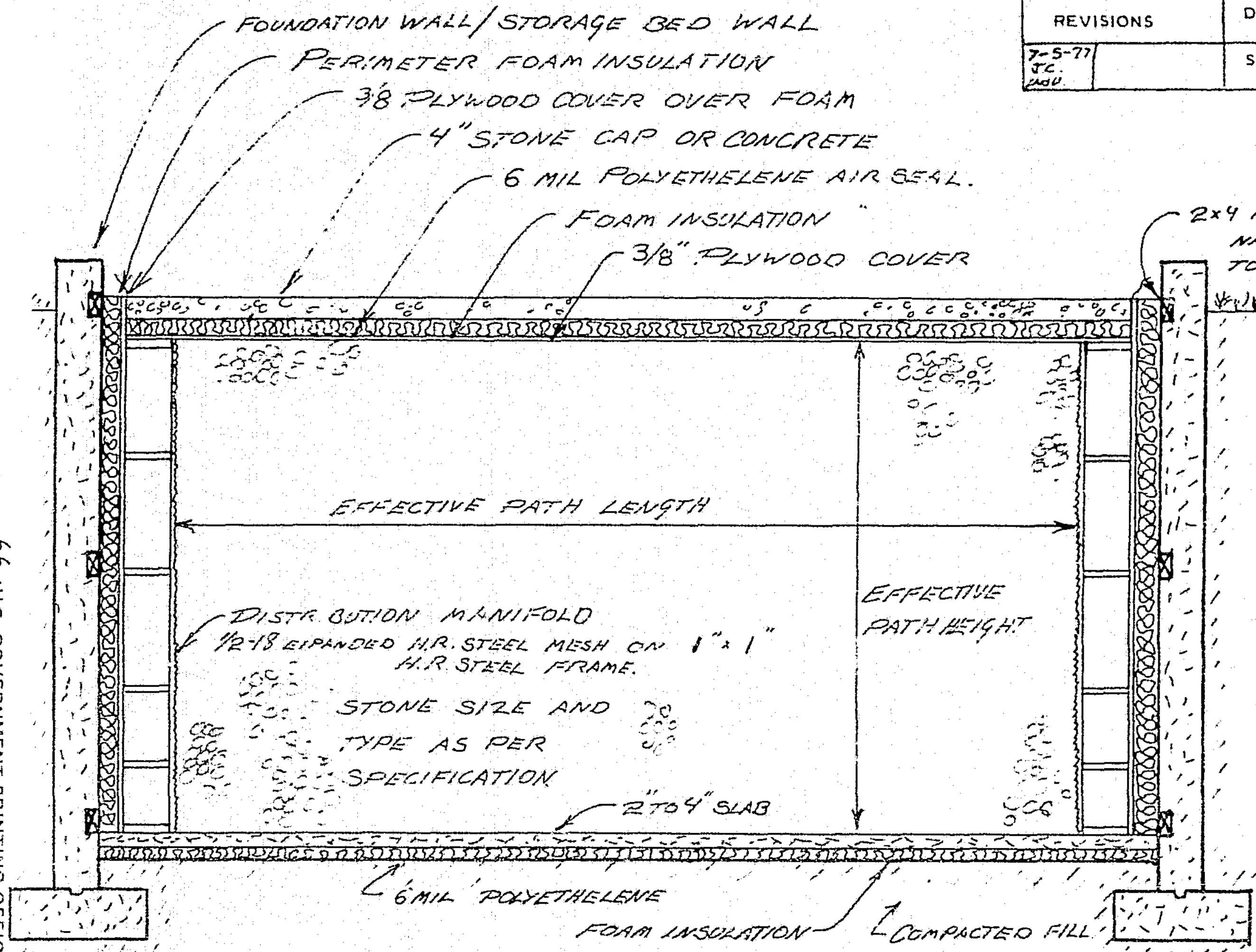
FUNCTIONAL ±		
ANGULAR ±		
REVISIONS	DRAWN BY J.C.	CHECKED BY
7-5-77 J.C.	SCALE NTS	DRAWING # 540-002



ROCK BED INSULATION SPECIFICATION

Storage walls common to areas whose temperatures are:

Above 60°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
Peremeter	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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