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DOE/NASA CONTRACTOR REPORT

DOE/NASA CR-150619

**PRELIMINARY DESIGN PACKAGE FOR SOLAR HEATING AND
HOT WATER SYSTEM**

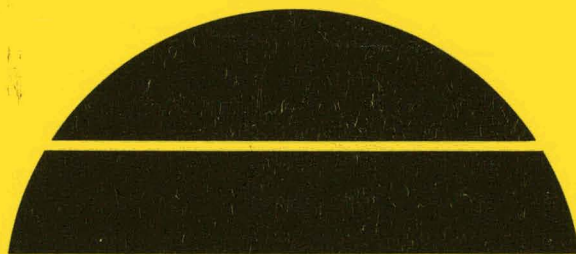
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Under Contract NAS8-32242 with

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

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Solar Energy

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1. REPORT NO. DOE/NASA CR-150619	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.	
4. TITLE AND SUBTITLE Preliminary Design Package for Solar Heating and Hot Water System		5. REPORT DATE December 1976	6. PERFORMING ORGANIZATION CODE
		8. PERFORMING ORGANIZATION REPORT #	
7. AUTHOR(S)		10. WORK UNIT, NO.	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Colt, Incorporated 71-590 San Jacinto Drive Rancho Mirage, California 92270		11. CONTRACT OR GRANT NO. NAS8-32242	
		13. TYPE OF REPORT & PERIOD COVERED Contractor Report	
12. SPONSORING AGENCY NAME AND ADDRESS National Aeronautics and Space Administration Washington, D. C. 20546		14. SPONSORING AGENCY CODE	
		15. SUPPLEMENTARY NOTES This work was done under the technical management of Mr. Mitchell Cash, George C. Marshall Space Flight Center, Alabama.	
16. ABSTRACT Colt is developing two prototype solar heating and hot water systems for use in single-family dwellings or commercial buildings. The systems are to consist of the following subsystems: collector, storage, transport, hot water, auxiliary energy, and government-furnished site data acquisition. The systems are to be installed at Yosemite, California, and Pueblo, Colorado. This report contains the necessary information to evaluate the preliminary design for Colt's solar heating and hot water system. Included in the report are Colt Interface with Proposed Instrumentation Plan, Training Program, Hazard Analysis, Preliminary Design Drawings, and other information about the progress and design of the system. This system has had major re-design after the preliminary design effort took place. For valid updated information, it is recommended that the final System/Subsystem Design Package be used.			
17. KEY WORDS		18. DISTRIBUTION STATEMENT Unclassified-Unlimited UC-59c <i>William A. Brooksbank, Jr.</i> WILLIAM A. BROOKSBANK, JR. Mgr, Solar Heating and Cooling Project Office	
19. SECURITY CLASSIF. (of this report) Unclassified	20. SECURITY CLASSIF. (of this page) Unclassified	21. NO. OF PAGES 67	22. PRICE NTIS

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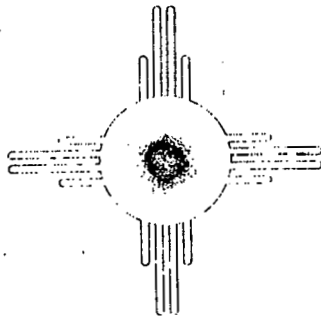
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SECTION A
COLT INTERFACE WITH THE PROPOSED
INSTRUMENTATION PLAN

COLT INC.
OF SOUTHERN CALIFORNIA
ENERGY SYSTEMS DIVISION



December 1, 1976

COLT INC. OF SOUTHERN CALIFORNIA
71-590 San Jacinto Drive
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1.0 Introduction

This document is a portion of the Proposed Instrumentation Plan (ref. SHC-1006). The intent is to provide necessary instrumentation for MSFC as specified in the S.O.W., Paragraph 4.3B. Full compliance to the proposed instrumentation plan, as specified in SHC-1006, is out of the program scope. This plan contains a system descriptive summary and a definition of the requested instrumentation. To assist in instrumentation definition, a schematic has been prepared showing instrumentation locations, line size, and flow directions. A list has been made of all required instrumentation, as specified in NASA SCH-1006, and the system operating modes have been defined.

2.0 System Descriptive Summary

The prime element of the collection system is the flat plate solar collector. It is capable of being integrated into a sloping roof or placed on a flat roof using truss supports. The collector is water tight to the outside elements and is insulated. Solar heat from the collector is carried by a transfer fluid to the thermal storage tank, where heat transfer takes place in a secondary heat exchanger, to permit thermal storage in a large, water-filled tank. The heated water is then pumped through a liquid-to-air heat exchanger to provide space heating when required. An auxiliary electric strip heater provides heat when the solar storage is not available. Domestic water passes through a hot water heat exchanger in the thermal storage tank,

prior to passing through the auxiliary electric hot water heater.

2.1 System Type

The type of system that Colt will employ, at the operational test sites, utilizes a flat plate collector with a paraffinic liquid heat transfer loop that transports paraffinic oil through a secondary heat exchanger in a water thermal storage tank.

2.2 Collector Area

The collector measures approximately 10' x 2'. Each collector absorber surface is 17.06 square feet. Each operational test site is expected to have 35 collectors providing approximately 600 square feet of absorber surface.

2.3 Collector Description

2.3.1. Absorber Surface

The absorber surface consists of two (2) flat 20-gauge steel plates formed together by seam welding, and pressure expanded to provide a flow path for the heat transfer fluid. The surface of the absorber is selectively coated with bright nickel and black chrome.

2.3.2 Collector Frame

The collector frame is uniquely fabricated from a single sheet of 20-gauge steel to support the glazing, contain the back side insulation, provide a fire retardant barrier, and house the absorber plate. The frame, in

conjunction with the glazing interface moldings, can be integrated into the roof between the joists of a building, or receive support structure for placement on a flat roof.

2.4 Thermal Storage

Each of the two (2) operational test sites will have different thermal storage tank configurations. One tank will be a 1500 gallon concrete container that will be insulated with 2" of urethane foam and will be buried in the ground. Heat transfer from the collector thermal fluid takes place in a composite flat plate heat exchanger assembly housed within the thermal storage tank.

The second tank is fabricated of steel with an integral plate coil heat exchanger forming the cylindrical shell. This tank will also be insulated with 2 inches of urethane foam. The steel tank will be placed inside the operational test site building.

2.5 Space Heating Method

Hot water will be pumped from the thermal storage tank through a liquid-to-air heat exchanger located in the heating duct. An auxiliary electric strip heater will be installed in the same heating duct to provide heat during the absence of solar heating. A squirrel cage forced draft blower will provide air circulation through the heat exchanger and the auxiliary electric strip heater.

2.6 Hot Water Sub System

Domestic water will pass through a 66 gallon hot water heater exchanger housed in the thermal storage tank. It will then pass to a 52 gallon electric water storage heater manufactured by American Appliance Manufacturing Corporation.

The electric heating element provides auxiliary heat when the water temperature drops below 125°F.

2.7 Energy Transport System

2.7.1 Blowers

Colt has specified a Dayton forced draft blower, capable of moving 1800 cfm of air across the heating coil and electric duct heater. This blower is a part of the heating duct.

2.7.2 Duct

The duct cross-section measures 31" by 21" and is fabricated of 26-gauge sheet metal, insulated with fiberglass, downstream of the heat exchangers.

2.7.3 Pumps

Colt has specified two (2) types of pumps; cast iron and stainless steel. Both are manufactured by Grundfos Pump Corporation. The cast iron pump will be used for the closed loop system in the collector loop which pumps paraffinic oil. A stainless steel pump will be used in the space heating loop which is an open system pumping water.

Pump specifications to be supplied later.

2.7.4 Piping

All piping shall be Type L copper tubing, installed with sweated copper fittings. The diameter of the piping is noted on solar system schematic piping. Length of run will be as required by the particular installation.

2.7.5 Fluid Type

Paraffinic oil (Dow Therm HP), has been selected for the system heat transfer fluid. It is low cost, noncorrosive, has a moderate viscosity, and a high flash point. In addition, it has no freezing or boiling problems, requires only a moderate pumping power, and contributes to excellent pump and valve life. The table below, Table 2.7.5-1, describes the physical properties of the paraffinic oil.

TABLE 2.7.5-1

DOW THERM HP PHYSICAL PROPERTIES

Pour Point (ASTM D-97) -----		15°F
Flash Point -----		420°F
Fire Point -----		460°F
	<u>100°F</u>	<u>200°F</u>
Thermal Conductivity (BTU/(HR)(FT ²)(°F/FT) -----	.078	.076
Viscosity (Centipoise) -----	28	4.5
Density (gm/cm ³) -----	.85	.82
Specific Heat (BTU/16°F) -----	.47	.52

2.8 Auxiliary Energy

For each operational test site, both 110 and 220 volt service will be required. All controllers will be supplied with 110 volt power with the exception of the thermostat that will be low voltage. All motor controllers will be switched by low voltage. The pumps and the forced draft blower will run on 110 volt power. The auxiliary strip heater and the auxiliary hot water heater will run on 220 volt.

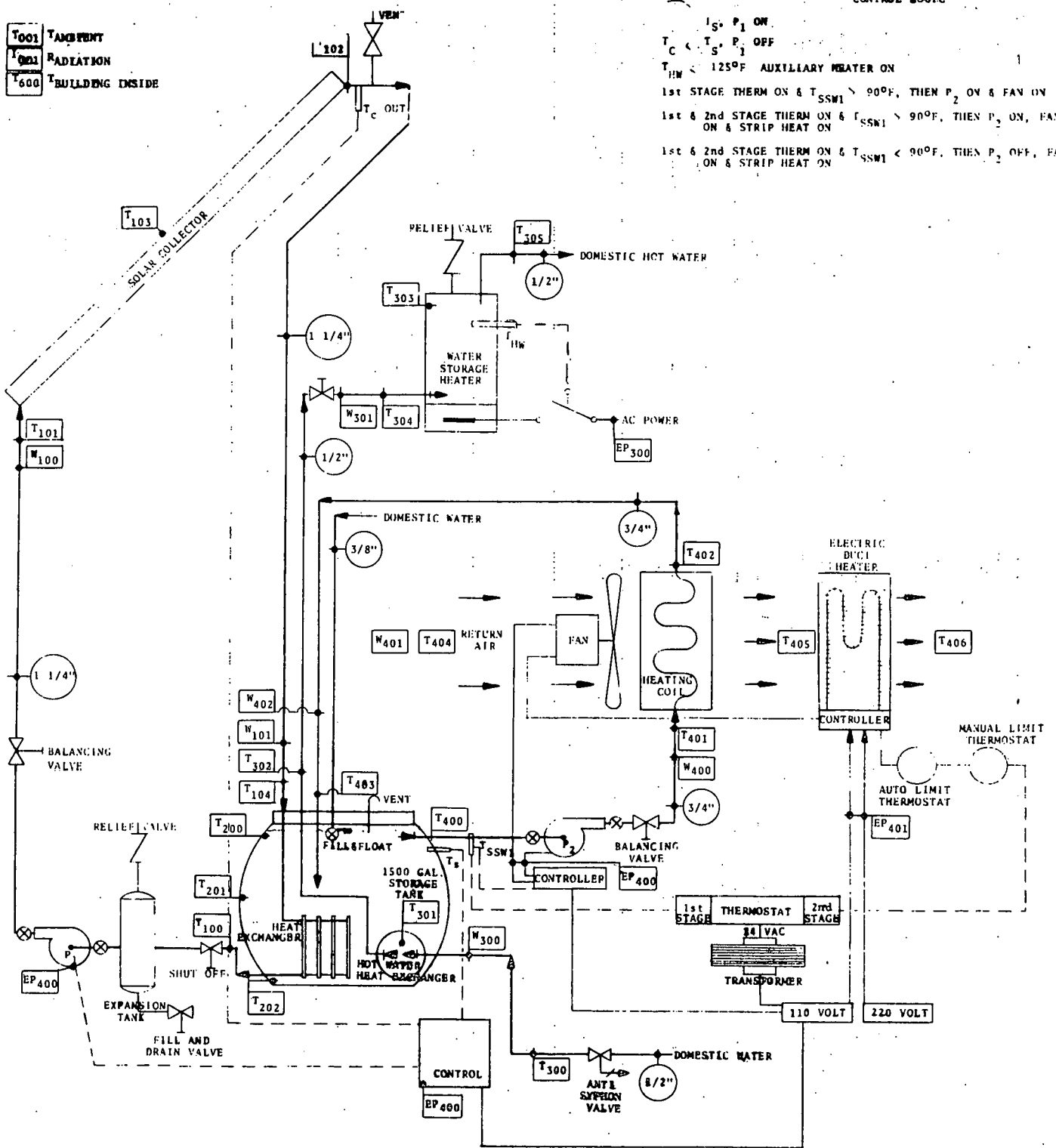
2.9 Operational Control Sequence

The Colt solar heating and hot water heating system is most easily described by the solar system schematic shown on Figure 2.9-1.

Control of pump P-1, which pumps the heat transfer fluid through the collector and the thermal storage tank, is accomplished by a differential temperature controller. This control measures the exit water temperature of the collector and compares this temperature to that of the water in the storage tank. When the heat transfer fluid leaving the collector is approximately 8°F greater than the thermal storage tank temperature, pump P-1 is turned on. When the heat transfer fluid temperature decreases and approaches the thermal storage tank temperature, pump P-1 is turned off. Control system stability is achieved by the correct temperature switch points to prevent thermal cycling. Depending on the system size, switching stability is generally achieved with a temperature delta

T₀₀₁ T AMBIENT
 T₀₀₁ RADIATION
 T₆₀₀ T BUILDING INSIDE

I₅ P₁ ON
 T_C < T_S P₁ OFF
 T_{HW} < 125°F AUXILIARY HEATER ON
 1st STAGE THERM ON & T_{SSW1} > 90°F, THEN P₂ ON & FAN ON
 1st & 2nd STAGE THERM ON & T_{SSW1} > 90°F, THEN P₂ ON, FAN ON & STRIP HEAT ON
 1st & 2nd STAGE THERM ON & T_{SSW1} < 90°F, THEN P₂ OFF, FAN ON & STRIP HEAT ON



DEFINITIONS

- T_S - STORAGE
- T_{SSW1} - SWITCH STORAGE TANK
- T_{C OUT} - T COLLECTOR OUT
- 24VAC - 24 VOLTS - AC
- T_R - T ROOM

WHEELER	11/21/76	
12/1/76	11/20/76	
OPERATIONAL TEST FILE INSTRUMENTATION LOG # 102		

FIGURE 2.9-1 SYSTEM SCHEMATIC

setting of approximately eight (8) degrees.

Pump P-2, supplying hot water to the space heating heat exchanger, is turned on simultaneously with the air circulating blower by the first stage of the room thermostat. Should insufficient solar heat be available, the second stage thermostat will turn on the auxiliary electric strip heater. With the auxiliary heater on, air will continue to be preheated by the solar heat exchanger with pump P-2 on, as long as the solar hot water is above 90°F.

Pump P-2 will cut off when the hot water drops below 90°F. At any time the auxiliary electric heater is on, the forced draft blower will also be on.

2.10 Coefficient of Performance

To be supplied later.

3.0 Instrumentation Definition

3.1 Instrumentation Locations

Figure 2.9-1, the System Schematic, shows the location of the instrumentation to be used on the operational test system and all piping sizes.

3.2 Instrumentation Parts Schedule

Table 3.2-1 lists the instrumentation to be used in the operational test systems. This list is correlated to the System Schematic and the requirements of NASA SCH-1006.

TABLE 3.2-1
INSTRUMENTATION LIST

SYMBOL	DESCRIPTION	RANGE	MFGR.	PART NO.
W100	Collector Flow	0°-20GPM	Ramapo	MKV-1 1/4
T100	Collector/Storage Out	30°-200°F	Minco	553-F203
T101	Collector In	30°-220°F	Minco	553-F203
T102	Collector Out	30°-220°F	Minco	553-F203
T103	Collector Surface	-40°-450°F	Minco	S34A
T104	Collector/Storage In	30°-220°F	Minco	553-F203
W101	Storage Flow	0°-20GPM	Ramapo	MKV-1 1/4
T200	Storage Upper	30°-220°F	Minco	553-F203
T201	Storage Middle	30°-220°F	Minco	553-F203
T202	Storage Lower	30°-220°F	Minco	553-F203
T300	Domestic Water/In Storage	30°-100°	Minco	553-F203
T301	Domestic Hot Water Out	30°-220°	Minco	553-F203
T302	Domestic Water/Out Storage	30°-220°	Minco	553-F203
T303	Auxiliary Hot Water Storage	30°-220°	Minco	553-F203
T304	Domestic Water/In W.S.H.	30°-220°	Minco	553-F203
T305	Domestic Water/Out W.S.H.	30°-220°	Minco	553-F203
W300	Domestic Water Flow/ Storage In	0-20GPM	Ramapo	MKV-1/2
W301	Domestic Water Flow/ W.S.H. Out	0-20GPM	Ramapo	MKV-1/2
EP300	Elect. Power W.S.H.	54 KWH	Ohio Semitronics	PC5-XY
T400	Heat Storage/Out	30°-220°	Minco	553-F203

TABLE 3.2-1
INSTRUMENTATION LIST
(continued)

SYMBOL	DESCRIPTION	RANGE	MFGR.	PART NO.
T401	Heat Coil In	30°-220°	Minco	553-F203
T402	Heat Coil Out	30°-220°	Minco	553-F203
T403	Heat/Storage In	30°-220°	Minco	553-F203
T404	Air - Heat Coil In	30°-220°	Minco	553-F132
T405	Air - Heat Coil Out	30°-150°F	Minco	553-F132
T406	Air - Heat Duct Out	30°-150°F	Minco	553-F132
EP400	Elect. Power Control, P. and P ₂	.3 KWH	Ohio Semitronics	PC5-XY
EP401	Elect. Power - Duct Heater	15 KWH	Ohio Semitronics	PC5-XX
W400	Heat Coil Flow/In	0°-20GPM	Ramapo	MKV 3/4
W401	Duct Flow	0-2000 CFM	Dietrich Std/ Type	74/157A
W402	Heat Coil Flow/Out	0-20GPM	Robinson-Halpern Ramapo	MKV 3/4
T001	T Ambient	-40-150°	Minco	553-F132
T001	Total Radiation	Total	Eppley	8-48
T600	Building Inside	-40-150°	Minco	553-F132

3.3 Operating Modes

The operating modes are described in Paragraph 2.9, and shown on the System Schematic, Figure 2.9-1, in abbreviated form. The flow directions are also shown on the System Schematic.

SECTION B
QUALITY ASSURANCE PLAN

CONTRACT NAS8-32242

COLT INC.
OF SOUTHERN CALIFORNIA
ENERGY SYSTEMS DIVISION



NOVEMBER 24, 1976

COLT, INC. OF SOUTHERN CALIFORNIA
71-590 San Jacinto Drive
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1.0 Introduction

The approach that Colt has taken to Quality Assurance is to provide an organization that effectively has a voice in all matters concerning Quality. Through Quality Assurance, a higher degree of reliability will be achieved, and the ability of the various components in the system to meet the system design and system specifications will be realistically approached. Quality Assurance will not end with hardware; it will also be involved in all documentation that is transmitted to the customer. It is the responsibility of Quality Assurance to insure that a common thread exists between hardware, documentation, and the control functions of Quality as they relate to configuration management.

2.0 Administration Management

Administration and management of the Quality Assurance function will be the responsibility of the Quality Assurance Manager assigned to the NASA Solar Heating and Hot Water Heating project. The Quality Assurance Manager will report directly to the President of Colt, Inc. regarding all functions and responsibilities that pertain to Quality Assurance on the NASA Solar Heating and Hot Water Heating Program. The Quality Assurance Manager for the NASA program will be Mr. Chuck Barsamian, who has been assigned the responsibility for Quality, Reliability and Safety. As Quality Assurance Manager, Mr. Barsamian will have the responsibility to insure that all Quality contractual requirements are properly planned,

documented, coordinated, and implemented. He will serve as the central contact for all Quality Assurance liaison within the Solar Program.

3.0 Inspection and Test

The Inspection system for the Solar Program will insure that all articles and materials that have been fabricated and procured will be inspected and/or tested to insure conformance to specification and/or procurement requirements. The inspections will occur as required during receiving, processing, fabrication, assembly, test and/or delivery of hardware, as may be appropriate.

All components received from outside vendors will be checked through Quality Assurance to insure that the parts comply to the terms of the purchase order. Materials and components that are procured against a specification will be checked for compliance to that specification upon receiving. An inspection and receiving plan will be formulated that will include the following:

- Vendor Name
- Part Number
- Part Name
- Applicable Drawing or Specification
- Applicable Revision
- Inspection to be Performed
- Name of Inspector

A Quality Assurance plan will be prepared covering the processing, fabrication, and assembly operations. Typical Quality Assurance checks that will be implemented into this plan

include such things as:

- Assembly and pretest
- Collector glazing and sealing
- Collector installation into the roof
- Flushing and purging of lines
- Cleaning and installation of vessels and tanks
- Storage tank foaming
- Installation of all major equipment
- System filling and venting
- Protection of flow meters during system filling
- Instrumentation check out

A check-off list of steps and functions to be witnessed will be prepared, and Quality Assurance sign-off will be required. Test conduction will be checked by Quality Assurance. The primary concern of test surveillance will involve the tests set up, determination that proper instrumentation is being obtained for testing, and that instrument calibrations are in date. The following specific responsibilities relating to the test effort will be signed and stamped off by Quality Assurance:

Test and Test Support

- Leak and hydrostatic testing
- Calibration of water level device
- Verification of instrumentation calibration
- Pretest verification of instrumentation operability
- Verification of test data
- Controls check out
- Post test conditions

All documentation that forms a part of the acceptance data package will be reviewed by Quality Assurance to insure all contractual items are present and in order prior to shipment of deliverable systems.

4.0 Controls

Quality Assurance will implement several forms of controls for

the handling, packaging, and storage of test equipment as compared to deliverable end items. These controls will segregate test equipment from deliverable end items. The storage will involve tagging of all equipment as to its particular dash number and to separate test from deliverable equipment as it relates to configuration management. Hardware that has been scrapped or damaged will be segregated in a separate area. All hardware, regardless of test, and whether deliverable or defective, will be stored inside to prevent both damage and deterioration. All hardware that can be confused because of design changes will be clearly marked with appropriate dash numbers. Substitution of hardware will not be permitted unless within full compliance of the configuration management program. Processes that require uniform Quality Assurance, such as plating, will require certification from the vendor performing the plating operation. Welds, heat treating, soldering, special passivations, etc., are not considered to be design critical to the present design. However, should any such process appear to present a quality problem, certification as to its performance will be immediately implemented into the fabrication process.

Quality Assurance sign-off will be required for the release of all drawings, and, at this time, the drawing will be reviewed pertaining to critical processes or inspections requiring quality inspection or certification.

5.0 Metrology

Quality Assurance will maintain a metrology system for control of the measurement process to insure quality conformance. This system will insure that transducers, flow meters, resistance temperature sensors and weather gathering components are within the calibration standards recommended by the manufacturers. Performance specifications of the instrumentation selected will be reviewed by Quality and compared to the present status of all instrumentation.

Should the calibrations be out of specification value, or out of date, the test equipment involved will be recalibrated.

6.0 Nonconformance

Nonconformance of hardware involving components or systems that are deliverable items involving performance shall be subject to Material Review Board action. Hardware judged to be nonconforming to drawings and/or specifications shall require Material Review Board action. The Material Review Board will consist of the Program Manager, Project Engineer, and Director of Quality Assurance. The recommendations of the Material Review Board will be submitted to MSFC who will have final approval or disapproval pertaining to the Material Review Board recommendations.

The cause of each discrepancy will be traced to the source. Affirmative action will be taken in each instance to insure that the discrepancy is not repeated. Should the discrepancy involve

a manufacturing process, a design tolerance, or a performance criteria that cannot be brought into the current specification or drawing limitations, a change in specifications and/or drawing will be initiated and approval coordinated with MSFC.

7.0 Records

Permanent records will be maintained by Quality Assurance of all inspections and tests during the program. Quality Assurance will also be responsible for preparation of the Acceptance Data Package and maintaining a copy of the Acceptance Data Package in the Colt files. All deviations to specifications and drawings, including those requiring and those not requiring approval by MSFC, will be maintained in the Quality Assurance files.

Colt will use Quality Assurance as a control function to insure that the Configuration Management system is completely implemented into the drawing and specification system for deliverable hardware. To facilitate this control procedure, Quality Assurance will maintain a complete set of drawings and specifications representing the latest configuration.

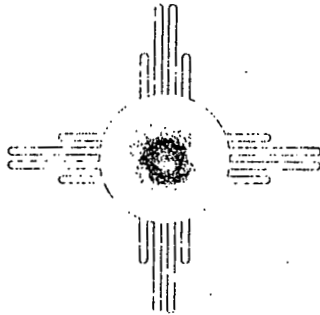
8.0 Procedures

In-house procedures will be written defining the criteria for Quality acceptance, or rejection, of all hardware and tests as specified in Paragraph 3.0. For example, Quality assurance will be present at the initiation and completion of each test to determine such things as calibration dates of instrumentation, that sufficient data is being obtained for the test, that pretest

check-off lists were used, that preparatory conditions defined in the test plan have been accounted for, and that the test results are indicative of the test performed. Quality Assurance shall review all test reports and shall sign each test report, attesting to its accuracy.

SECTION C
SPECIAL HANDLING
INSTALLATION & MAINTENANCE
TOOLS LIST

COLT INC.
OF SOUTHERN CALIFORNIA
ENERGY SYSTEMS DIVISION



November 24, 1976

COLT INC. OF SOUTHERN CALIFORNIA
71-590 San Jacinto Drive
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SPECIAL INSTALLATION AND MAINTENANCE TOOLS

Part Number NAS00119-C16

Nomenclature - Alignment Tool

Description and Use:

This specially made tool will align three (3) collectors at once to insure that exterior roof seals interface correctly. The tool, 6'0" long and 6" wide, will be fabricated from 20 gauge cold rolled sheet stock.

The function of this tool is as follows:

To locate the collector housings in proper relation to the supporting roof joists which in turn will provide alignment of the collector/roof seals.

Identification of Manufacturer:

Fabrication can be accomplished by a local sheet metal fabricator.

Reason for Equipment:

The installation is accomplished with better alignment accuracy requiring less skill.

SPECIAL INSTALLATION AND MAINTENANCE TOOLS

Part Number NAS00119-C17

Nomenclature - Crimping Tool

Description and Use:

A low cost, simple approach is required to secure the interior collector cap, which holds the glass in place, to the collector shell. This tool is required only for initial collector buildup or to replace the collector glazing. An off-the-shelf metal cutter will be modified by making the jaws into a crimper rather than a cutter.

Identification of Manufacturer:

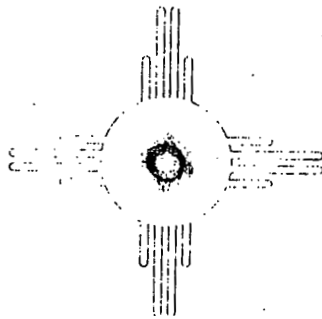
Modification by Colt of an off-the-shelf metal cutter, available through McMaster-Carr.

Reason for Equipment:

This tool will expedite production time and eliminate the cost of alternatives such as sheet metal screws.

SECTION D
SYSTEMS HAZARD ANALYSIS

COLT INC.
OF SOUTHERN CALIFORNIA
ENERGY SYSTEMS DIVISION



November 30, 1976

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1.0 Introduction

This document is an analysis of hazardous conditions that may exist in the solar hot water and space heating systems. This analysis identifies extreme conditions and discusses their potential hazard. The hazards have been evaluated for all major aspects of the system, including personnel, equipment, and structure.

2.0 Approach

This analysis identifies hazards that may be detrimental to personnel, equipment, and the structure. A classification has been established as to whether the hazard level is Major, Minor, or None. Residual hazards have been examined and identified, such as hardware failures that may cause further contribution to a hazard.

2.1 Hazard Identification

The objective in analyzing the hazards to personnel, equipment, and structure is to first identify the hazard; secondly, subjectively classify the hazard risk; and third, discuss what corrective action or method of controlling the hazard is required.

2.1.1 Hazard to Personnel

There is concern for the elimination of all hazards. Of primary concern is the elimination of hazards to personnel. Possible hazards to personnel have been defined as: the

contamination of the domestic hot water, glass breakage, hot water exceeding 160°, and the release of the collector thermal loop relief valve.

2.1.1.1 Domestic Hot Water Contamination

A prime concern for any solar system using a heat transfer fluid other than water, is the possibility of the fluid entering and contaminating the domestic hot water system. Colt has chosen paraffinic oil as the heat transfer fluid for its solar system. Paraffinic oil is a non-toxic, non-nutritive fluid that performs well in the solar collection system.

The Colt solar system has three assurances that this contamination will not occur:

1. The paraffinic oil is in a closed loop configuration from the collector array to the heat exchanger and back to the collectors. This loop will have been hydrostatically tested to 100 psi prior to filling with paraffinic oil.
2. The possibility of contamination is further minimized by the fact that if a paraffinic oil leak occurred in the storage tank, the oil would float harmlessly on top of the storage water.
3. The possibility of paraffinic oil leaking from the thermal storage water to the domestic water lines or hot water heat exchanger tank is virtually nonexistent,

because (1) the domestic water is separated from the paraffinic oil by a second boundary, and (2) the domestic water is at a greater pressure than the atmospheric pressure of the storage water.

Possible Hazard - None

2.1.1.2 Glass Breakage

The glazing specified for the solar collector is 1/8" tempered glass. In the event of glass breakage, no hazard is expected because of the way the tempered glass breaks into small harmless pieces. This is not true of normal strength glass, which could be very hazardous by breaking into large, jagged sheets. In the event of a hailstorm, no damage is foreseeable. Tests conducted at LASL during the last three years have experienced hailstones of 2" in diameter, and no damage to collector glazing has occurred.

Possible Hazard - None

2.1.1.3 Extreme Hot Water Temperature

A hazardous condition to personnel may exist if the domestic hot water temperature exceeds 160°. If this condition exists after the solar system is adjusted, Colt will install a mixing valve to mix cold water with the excessively hot water prior to domestic use.

Possible Hazard - None

2.1.1.4 Release of Relief Valve

There exists the possibility of a hazard to personnel, if the relief valve in the collector thermal loop is opened and hot paraffinic oil is ejected into the air and possibly onto personnel. To alleviate this possible hazard, piping has been designed to discharge the paraffinic oil into a gravel catch basin in the event of a discharge through the relief valve.

Possible Hazard - None

2.1.2 Hazards to Equipment

Hazards to equipment are those hazards which are judged to cause equipment failures and/or destruction of equipment. Possible hazards to equipment are generally categorized as resulting from overpressure or overstressing of components. An additional possibility exists and that is the presence of fungi in the thermal storage water.

2.1.2.1 Overpressure, Overstressing and Leakage

All pressure vessels will be subjected to component part testing at the manufacturer, to a pressure of 2.5 times M.E.O.P. After the solar system is installed, another hydrostatic test will be performed on all piping and pressure vessels to insure that the system piping and joints will withstand a pressure of 2.0 times M.E.O.P. This test virtually eliminates any failure in any part of the fluid system.

Possible Hazard - None

2.1.2.2 Fungi in Storage Water

A warm, moist climate is conducive to the propagation of fungi and algae. Since the hot storage water temperature is expected to be between 160° and 200°, it is highly unlikely that any type of organism can sustain life at these temperatures. During verification testing, the thermal storage tank will be inspected, and if fungi or algae is detected, elimination will be accomplished using chemicals familiar to the pool industry.

Possible Hazard - None

2.1.2.3 Collector Thermal Expansion

Previous testing has shown that collector temperatures can go as high as 400°F. From ambient to 400°F, the collectors will expand approximately 0.1" in the lateral direction and .030" in the transverse direction. This expansion has been allowed for in the design of the collector, and no problems are expected.

Possible Hazard - None

2.1.2.4 Thermal Storage Tank Venting

A 3/4" vent has been designed into the lid of the storage tank. This vent will allow for the removal of excess water and air pressures in the storage tank. If the storage tank cools, the vent will allow for fresh air to be taken in, eliminating the possibility of tank collapse.

If the float valve inside the thermal storage tank malfunctions, excess water will flow out the vent. Because the vent is sized as 3/4" and the fill at 3/8", overpressure is not expected to be a problem.

Possible Hazard - None

2.1.2.5 Collector Explosion/Implosion

A possibility of collector explosion or implosion exists if venting is not allowed for. Three (3) one-quarter (1/4) inch holes have been designed at the bottom of each solar collector frame. During heat up, these holes vent off pressure between the glazing and collector plate, eliminating the possibility of collector explosion. At the end of the heating day, the holes admit air to the space between the glazing and absorber glass, maintaining the space at atmospheric pressure, to eliminate the possibility of collector implosion. The holes serve a second purpose in that they also drain any condensate forming on the underside of the glazing.

Possible Hazard - None

2.1.3 Hazard to Structure

Two possible hazards could present problems to the structure: (1) excess collector weight on the roof of an existing structure, and (2) the leakage of water tight seals.

2.1.3.1 Excess Weight on Roof

In retrofitting an existing structure to a solar collection

system, there exists a possibility that the structure will not support the weight on the roof. A collector array weighs approximately seven (7) pounds per square foot. Prior to installation of a collector array on the roof, an assessment will be made to determine the load-carrying capacity of the roof of the structure to be retrofitted. If required, the load-carrying capability of the roof structure will be increased.

Possible Hazard - None

2.1.3.2 Leakage of Weather Tight Seals

The possibility of leakage around weather tight seals is minimal because the normal state-of-the-art roofing and flashing practices will be employed. All seals that must move to provide thermal expansion use proven collector installation techniques.

Possible Hazard - None

2.2 Residual Hazards

There are no residual hazards in the Colt solar system.

2.3 Hardware Failures that Contribute to a Hazard

The solar system has been engineered so that any component failure in the solar system will not create a hazard.

Possible Hazard - None

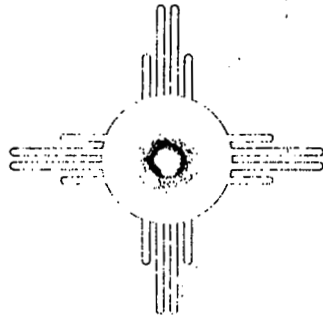
3.0 Conclusion

The Colt solar system does not present a hazard to personnel, equipment, or structure.

Total System Hazard - None

SECTION E
PRELIMINARY TRAINING PROGRAM

COLT INC.
OF SOUTHERN CALIFORNIA
ENERGY SYSTEMS DIVISION



December 1, 1976

COLT INC. OF SOUTHERN CALIFORNIA
71-590 San Jacinto Drive
Rancho Mirage, California 92270

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4.4 System Check-out Procedures	E- 4
4.5 System Operations	E- 4
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1.0 Introduction

It is the purpose of the training program to identify the skill level required, and the training program syllabus to be implemented, with tradesmen local to the operational test site. The training program will assume that the installation contractor professes certain skills necessary for a contractor involved with installation and service of heating systems. Those requirements are defined in this training program. Special training which would not necessarily be a part of any heating contractor's background, that is typical to systems such as Colt's, will be covered in a training program conducted by Colt in the locale of the operational test site.

2.0 Contractor Prerequisite

The contractor installing the solar system should be skilled, experienced, and trained in all the primary disciplines of heating and ventilation.

1. The contractor shall have experience in the theory and practice of heating, ventilation, basic air distribution, heat loads, and heating equipment fundamentals. This background should include the ability to follow system schematics; to trouble shoot from the schematics; and also understand manufacturer's catalogs, charts, specifications, and special instructions.
2. The contractor should have a basic understanding of alternating current, motor control, thermostats, and

and low voltage wiring. The various control devices used for heating and hot water systems should, therefore, be understood by the contractor. Types of tools for both service and installation of control equipment should be first-hand knowledge of the contractor.

3. The contractor should understand the design and layout of air distribution systems as they apply to space heating. He should have an understanding of the terminology involved with air distribution systems as it applies to friction calculations, duct velocity, static pressure, and the various techniques used for balancing air distribution systems.
4. The contractor should have knowledge of general sheet metal fabrication, knowing the characteristics of materials commonly used in sheet metal work. He should understand the basic principles involved in sheet metal pattern development. He should have experience in laying out, cutting, forming, and joining material as required in light metal fabrication.
5. The contractors should have experience in the installation of piping systems involving the sweating of solder in copper fittings. He should know how to properly clean, solder, and test all piping systems.
6. The contractor should be experienced in the application

of various insulation materials on piping systems. This experience should include the insulation techniques on corners, valves, and other perturbances that may be in a solar system.

7. The contractor should have the experience in filling fluid systems that require exacting quantities of fluid and the purging of intrained air.
8. The contractor should have a general understanding of heat transfer and the relative value of different forms of insulation. This should include a working knowledge of a variety of installation techniques of insulation in/on air distribution ducts.

3.0 Special Equipment

There is no special equipment that is not provided by Colt for the installation of the solar heating and hot water heating system.

4.0 Colt Training Program

The Colt training program provides the installing contractor with a detailed description of the system, instruction in subsystem installation techniques, an explanation of the site data acquisition system, training in check-out procedures, instruction in conducting routine operations of the system, and training in system trouble shooting. For the contractor exhibiting the previously defined skills and prerequisites,

and upon completion of the Colt training program, the installation and operation of the solar heating and hot water heating system will be without difficulty. The installation will be as routine and straight forward as any conventional heating system.

4.1 System Description

To be supplied later.

4.2 Installation Techniques

To be supplied later.

4.3 Site Data Acquisition System and Instrumentation

To be supplied later.

4.4 System Check-out Procedures

To be supplied later.

4.5 System Operations

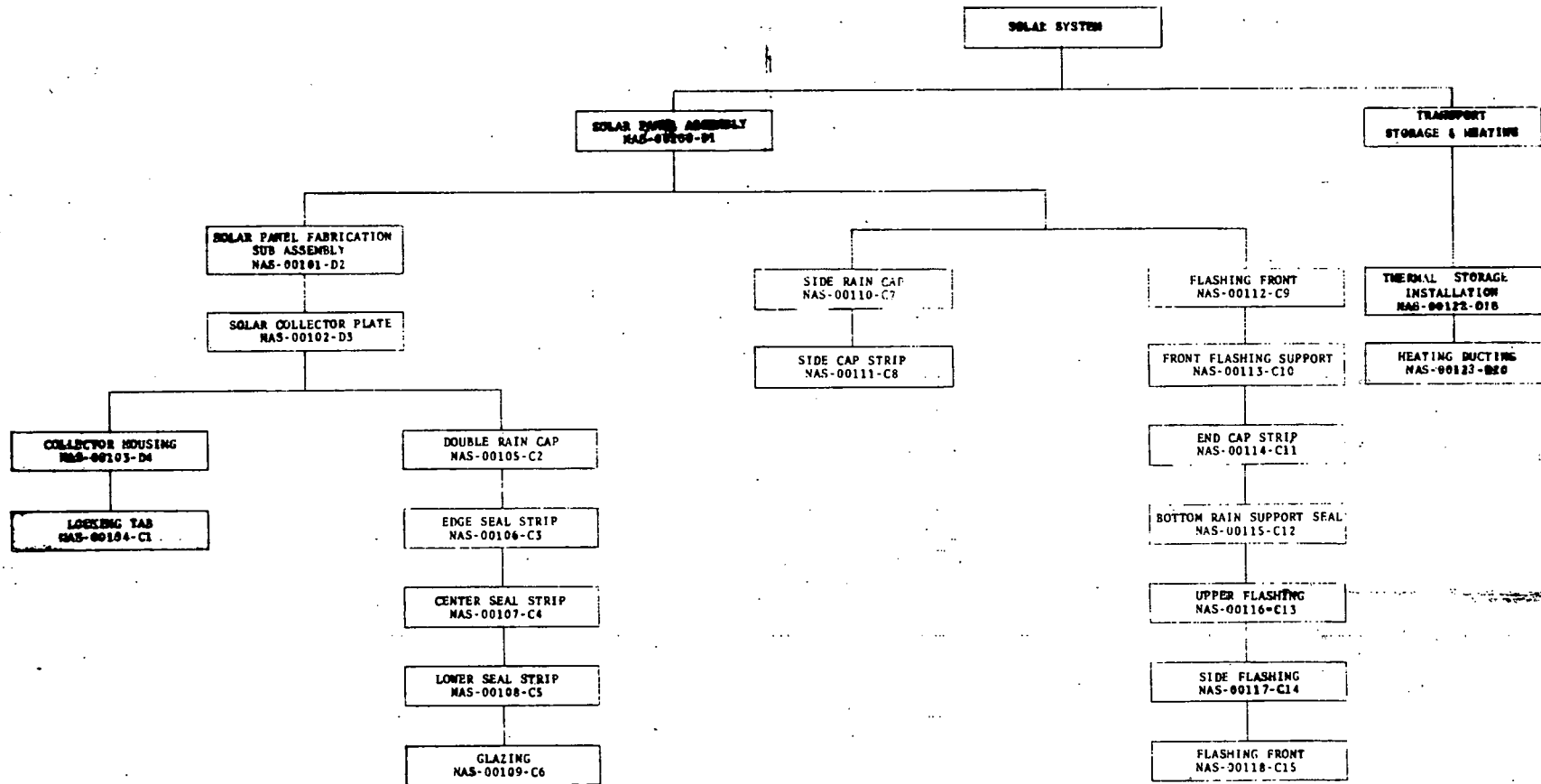
To be supplied later.

4.6 System Trouble Shooting

To be supplied later.

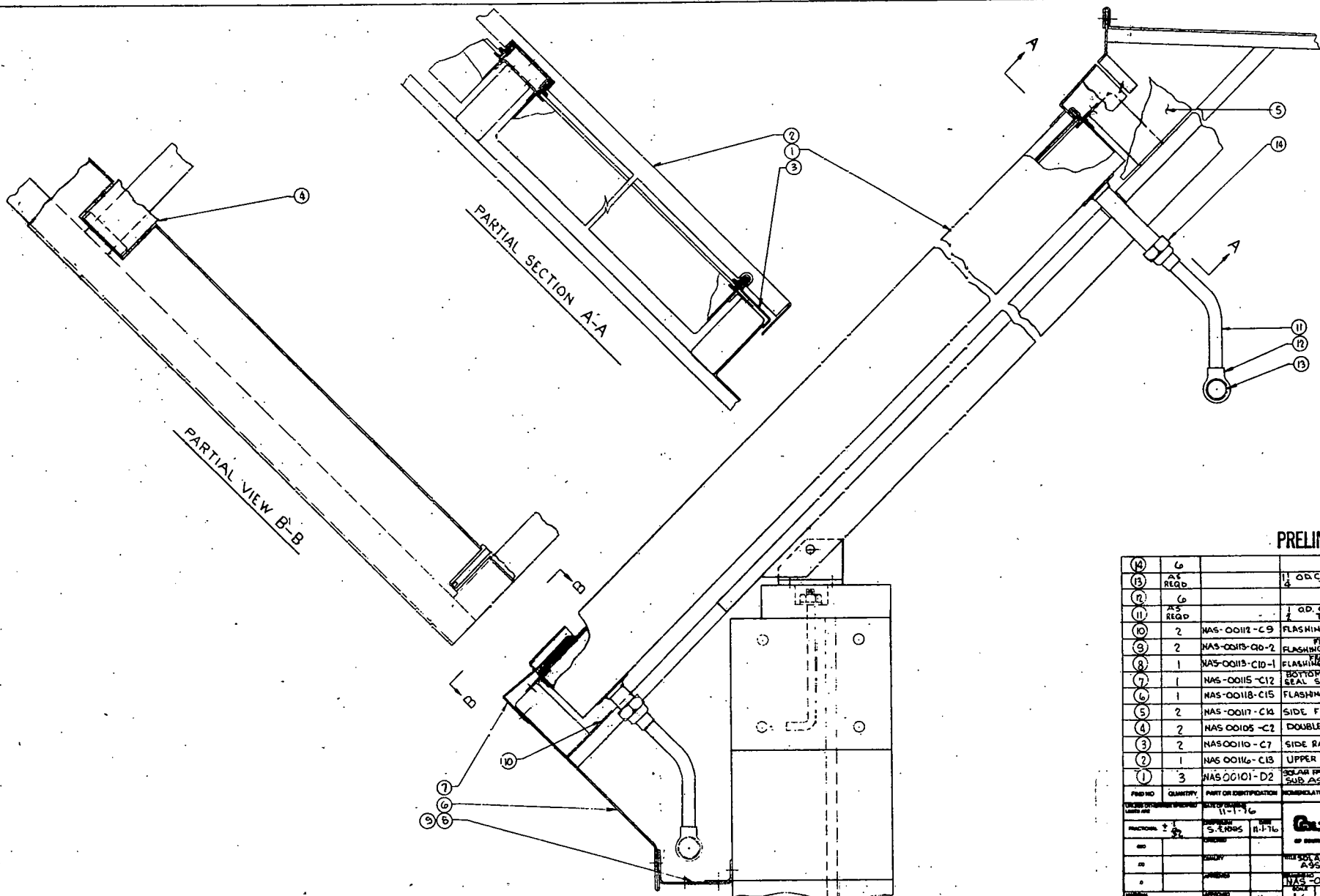
The details of the Colt training program will be formulated and written during the installation and system testing of the Verification and Development Test equipment being installed in the Colt test facility.

SECTION F
PRELIMINARY DESIGN DRAWINGS



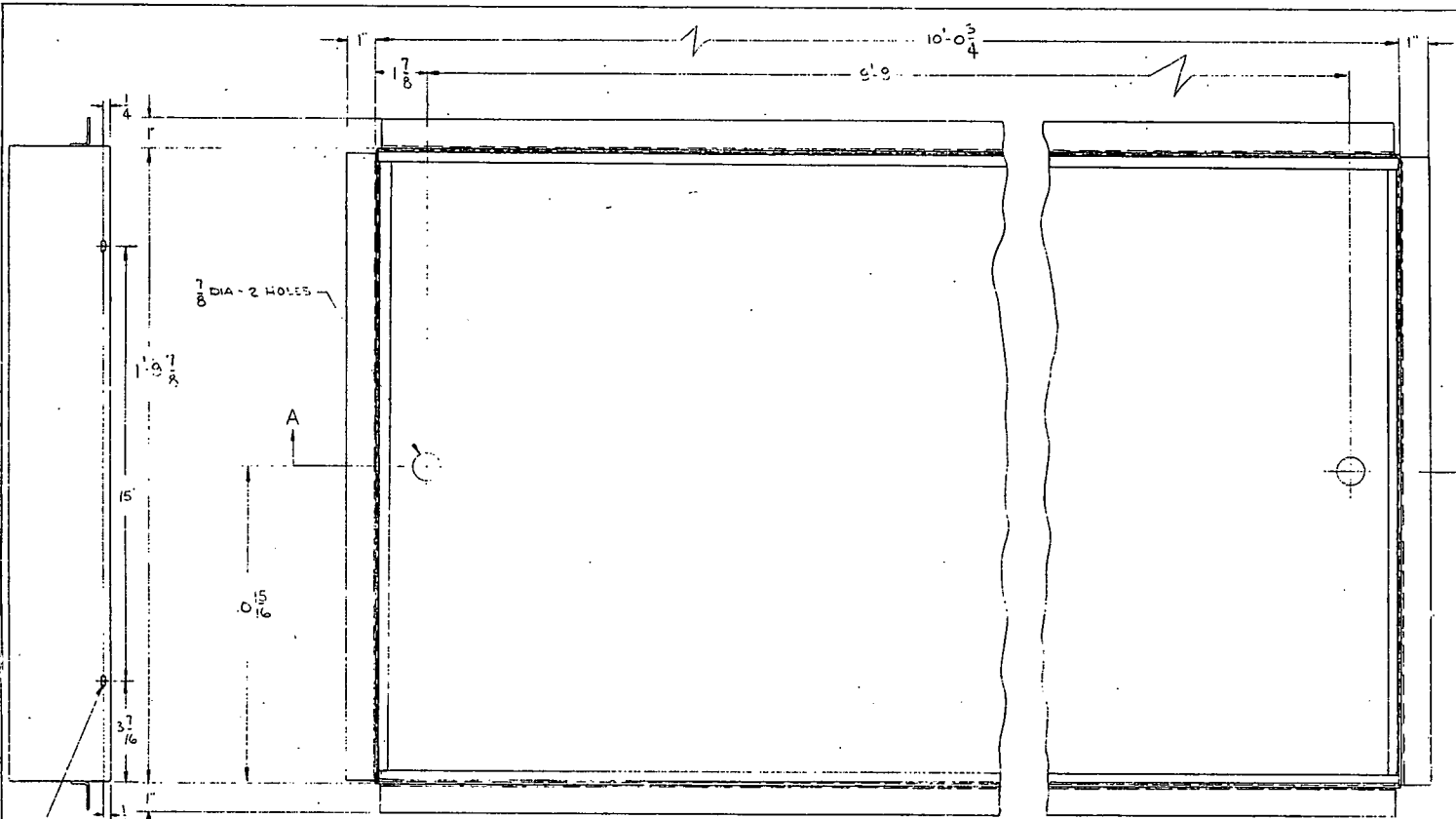
PRELIMINARY

DATE OF REVISION		 GALT INC. 1700 WINGTREE WINGTREE		
DESIGNED BY	DATE			
CHECKED BY				
QUALITY				
APPROVED				
APPROVED		DATE	BY	CHECK

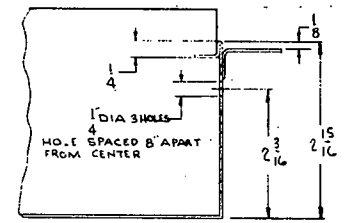


PRELIMINARY

14	6			
13	AS REQD		1	O.D. COPPER TUBING
12	6			
11	AS REQD		1	O.D. COPPER TUBING
10	2	NAS-0012-C9	FLASHING FRONT	
9	2	NAS-0013-QD-2	FLASHING SUPPORT	
8	1	NAS-0013-C10-1	FLASHING SUPPORT	
7	1	NAS-0015-C12	SEAL SUPPORT	
6	1	NAS-0018-C15	FLASHING FRONT	
5	2	NAS-0017-C14	SIDE FLASHING	
4	2	NAS-0016-C2	DOUBLE RAIN CAP	
3	2	NAS-0010-C7	SIDE RAIN CAP	
2	1	NAS-0016-C13	UPPER FLASHING	
1	3	NAS-00101-D2	SOLAR PANEL EMB. SUB ASSEMBLY	
PNB NO	QUANTITY	PART OR IDENTIFICATION	NOMENCLATURE DESCRIPTION	
UNLESS OTHERWISE SPECIFIED		SIZE OF BOLTS	1/2-13	
FRACTIONAL	1/2	S. ENDS	R-176	GALT INC. OF BOSTON, MASSACHUSETTS
NO				
NO				SOLAR PANEL ASSEMBLY
NO				NAS-00100-D1
NO				1/2 D 1

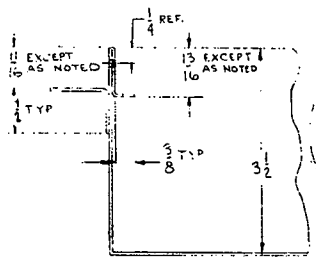


- NOTES:
1. BREAK SHARP EDGES.
 2. 20 GA. (.035 IN.) C.R. SHEET STEEL (ARMCO I.E. ZINC GRIP, PAINT GRIP) OR EQUIVALENT. CLEAN, DEGREASE AND PRIME SPRAY WITH PPG INHIBITIVE EPOXY PRIMER, UC-40485, APPROX. 2 MIL DRY THICKNESS, FLASH SOLVENTS FOR APPROX. 10 MIN. BAKE APPROX. 10 MIN. @ 400°F, COOL, SPRAY WITH LOW GLOSS DURACRON SUPER 600 TO OBTAIN APPROX. 1.0 MIL DRY FILM, FLASH SOLVENTS MINIMUM OF 10 MIN. BAKE APPROX. 10 MINUTES @ 400°F.

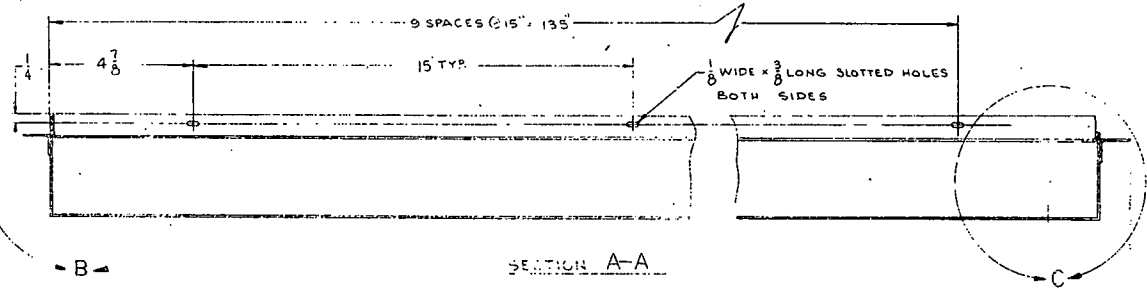


VIEW C (LOWER END)
SCALE: FULL SIZE

1/8" WIDE x 3/8" LONG SLOTTED HOLES THIS SIDE ONLY



VIEW B (UPPER END)
SCALE: FULL SIZE

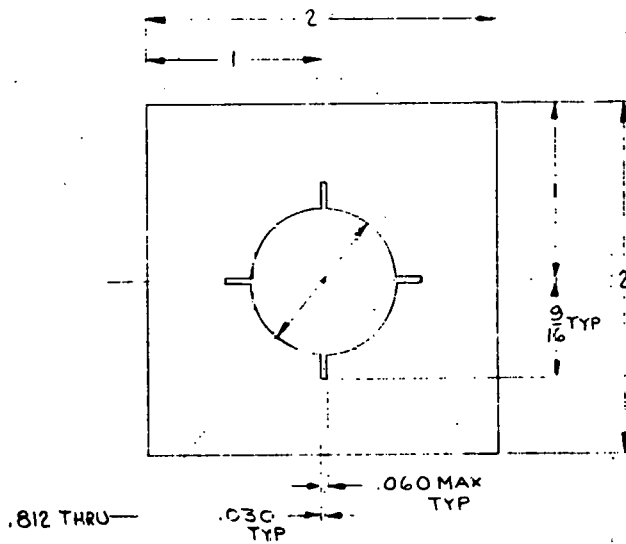


SECTION A-A

PRELIMINARY


FIG. NO.	QUANTITY	PART OR IDENTIFICATION	ABBREVIATURE DESCRIPTION
FRONT VIEW	1	COLLECTOR HOUSING	
FRONT VIEW	32	S. ENNIS 11-176	GALT INC. OF MEMPHIS, TENNESSEE
000		SCREW	
00		SPRING	
0		SCREW	
0		SCREW	
INTERNAL AS NOTED		SCREW	

NAS-00103-DA
D I

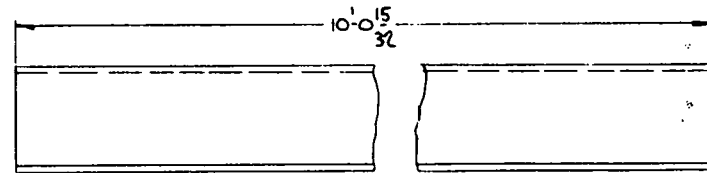
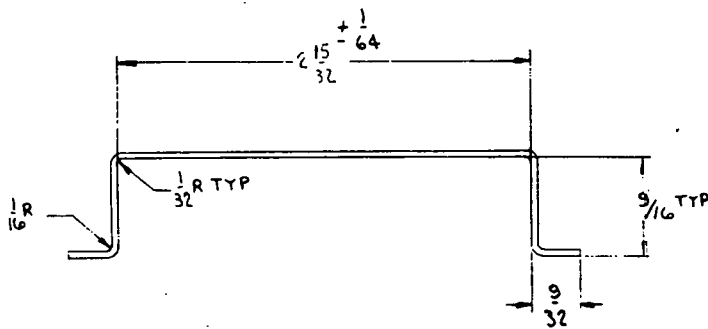


MAT'L - 28GA. (.015 IN.) C.R. SHEET STEEL
 (ARMCO I.F. ZINC GRIP, PAINT GRIP)
 OR EQUIVALENT. CLEAN, DEGREASE
 AND PRIME WITH GOOD QUALITY
 PRIMER & FINISH SPRAY WITH WHITE PAINT

PRELIMINARY

FIG. NO.	QUANTITY	PART OR IDENTIFICATION	NOMENCLATURE DESCRIPTION	
FRAC. OF PARTS SPECIFIED LISTED ARE		DATE OF DESIGN 11-1-76	 OF BUSINESS SERVICES	
FRACTIONAL + 1 - 32		DESIGNED BY S. ENNIS		DATE 11-1-76
DEC.		CHECKED		
RD.		APPROVED		
0		REVISION		
MATERIAL AS NOTED		FINISHED	PART NO. NAS-00104-01 2/1 C 1	

F-6



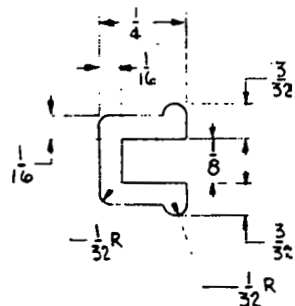
2. MATERIAL-20 GA. (.035 IN.) C.R. SHEET STEEL (ARMCO I.F. ZINC GRIP, PAINT GRIP) OR EQUIVALENT. CLEAN DEGREASE AND PRIME SPRAY WITH PPG INHIBITIVE EPOXY PRIMER, UC-40485, APPROX. 2 MIL DRY THICKNESS, FLASH SOLVENTS FOR APPROX. 10 MINUTES, BAKE APPROX. 10 MIN. @ 400°F. COOL, SPRAY WITH LOW GLOSS DURACRON SUPER 600 TO OBTAIN APPROX. 1.0 MIL DRY FILM, FLASH SOLVENTS MINIMUM OF 10 MINUTES, BAKE APPROX. 10 MIN. @ 400°F.

1. BREAK SHARP EDGES.

NOTES:

PRELIMINARY

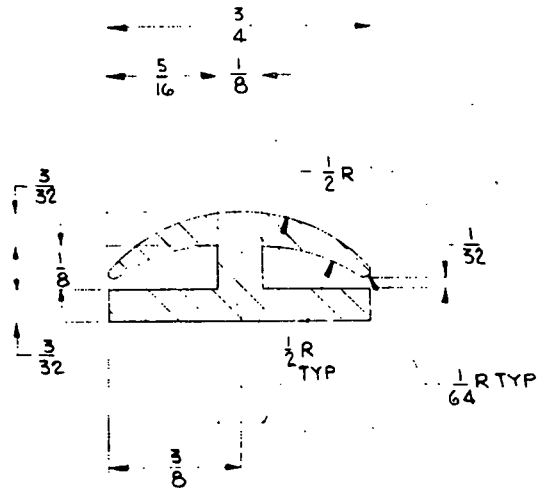
PRG NO	QUANTITY	PART OR IDENTIFICATION	REVOLUTIONARY DESIG/PROJ
UNLESS OTHERWISE SPECIFIED UNITS ARE		11-5-76	 GALT INC. OF CHICAGO, ILLINOIS
PROCESSED ± 1/32		S. ERNIS 11-5-76	
QTY			DOUBLE RAIN CAP
QTY			NAS-00105-C2
AS NOTED			2/1 C 1



MAT'L: SILICONE, BLACK, HARNESS-SHORE A-50
 BAKE FOR 2 HOURS MINIMUM AT 400° F
 END. PRODUCT TO BE STRAIGHT IN FREE STATE CONDITION
 PART TO BE SHIPPED IN LOOSE 50' COILS

PRELIMINARY

FRND NO	QUANTITY	PART OR IDENTIFICATION	NOMENCLATURE DESCRIPTION
UNLESS OTHERWISE SPECIFIED LIMITS ARE		DATE OF ORIGIN	GLT INC. OF SOUTHERN CALIFORNIA
FRACTIONAL		DATE	
000		CHECKED	
00		QUALITY	TYPE EDGE SEAL STRIP
0		APPROVED	DRAWING NO. NAS-00106-C3
MATERIAL		APPROVED	SCALE 4/1 C 1
AS NOTED			

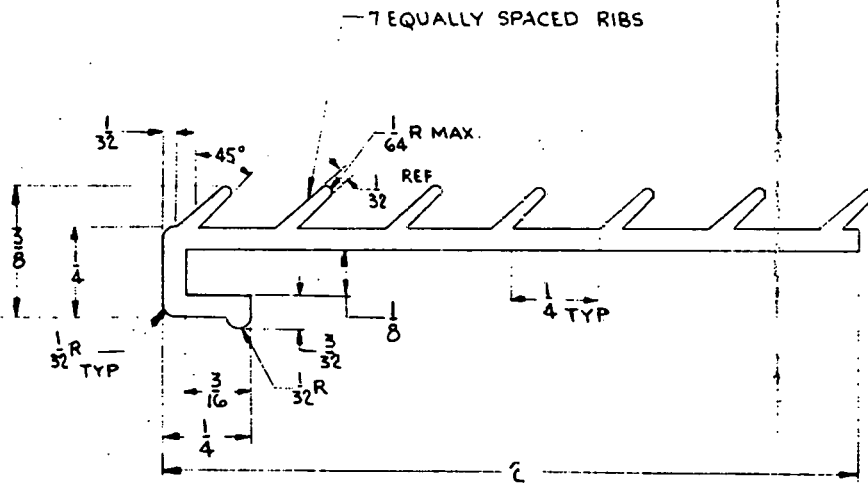


F-9

MAT'L: SILICONE, BLACK, HARDNESS-SHORE A-50
 BAKE FOR 2 HOURS MINIMUM AT 400° F.
 END PRODUCT TO BE STRAIGHT IN FREE STATE COND.
 PART TO BE SHIPPED IN LOOSE 50' COILS

PRELIMINARY

FIND NO	QUANTITY	PART OR IDENTIFICATION	NOMENCLATURE DESCRIPTION
UNLESS OTHERWISE SPECIFIED LIMITS ARE		DATE OF DRAWING 11-1-76	 GALT INC. OF CHICAGO, ILLINOIS
FRACTIONAL $\pm \frac{1}{32}$		DESIGNED BY S. ENNIS	
000		DATE 11-1-76	 GALT INC. OF CHICAGO, ILLINOIS
.00		CHECKED	 GALT INC. OF CHICAGO, ILLINOIS
0		APPROVED	 GALT INC. OF CHICAGO, ILLINOIS
DATE		APPROVED	 GALT INC. OF CHICAGO, ILLINOIS
AS NOTED			 GALT INC. OF CHICAGO, ILLINOIS

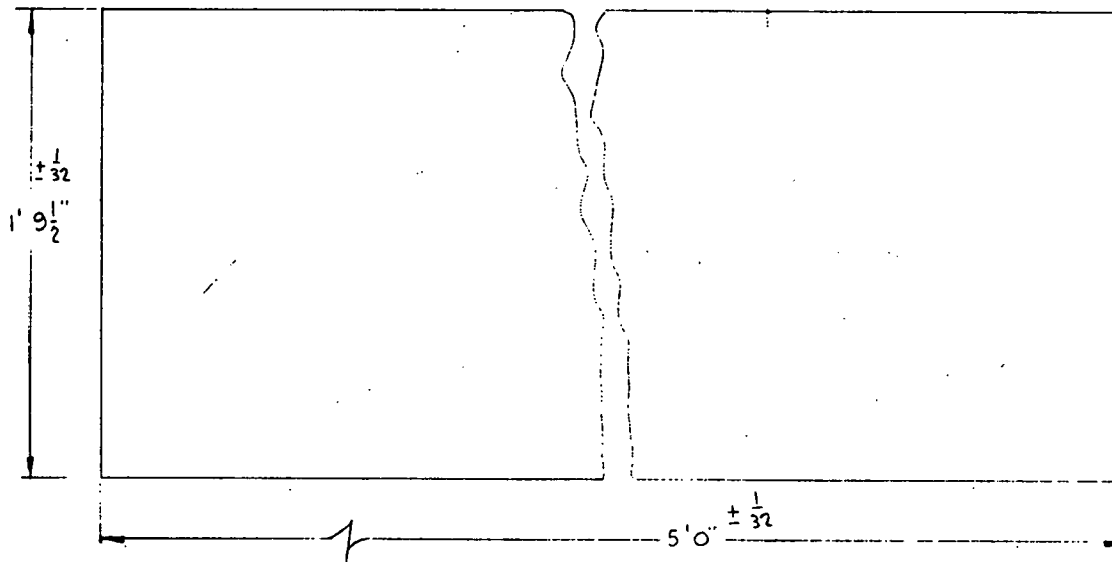


MAT'L-SILICONE, BLACK, HARDNESS-SHORE A-50
 BAKE FOR 2 HOURS MINIMUM AT 400° F.
 END PRODUCT TO BE STRAIGHT IN FREE STATE CONDITION
 PART TO BE SHIPPED IN LOOSE 50' COILS

PRELIMINARY

PNR NO	QUANTITY	PART OR IDENTIFICATION	NOMENCLATURE DESCRIPTION
UNLESS OTHERWISE SPECIFIED LIMITS ARE		DATE OF DESIGN	
FRACTIONAL	32	DESIGNER S. ENNIS	DATE 11-17-76
000		CHECKED	
00		QUALITY	NO LOWER SEAL STRIP
0		APPROVED	NAS-00108-GS
AS NOTED		APPROVED	41 C 1


GALT INC.
 OF DENVER, COLORADO

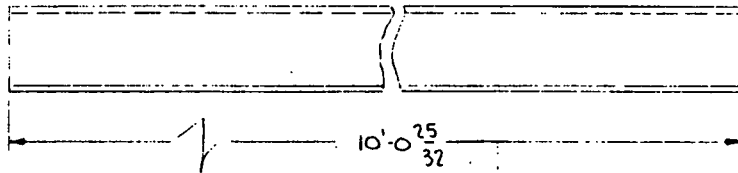
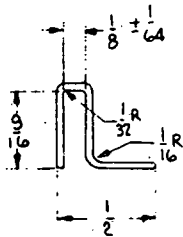


NOTES:

1. MATERIAL: $\frac{1}{8}$ THICK LOW IRON TEMPERED GLASS.
2. TRANSMISSIVITY: 400-700 MILLIMICRONS 91.5%
1050 MILLIMICRONS 87.2%
3. INDEX OF REFRACTION: 1.516
4. COEFFICIENT OF EXPANSION: 92.2×10^{-7}

PRELIMINARY

FIND NO	QUANTITY	PART OR IDENTIFICATION	NOMENCLATURE DESCRIPTION
UNLESS OTHERWISE SPECIFIED LIMITS ARE		DATE OF CHANGE 11-1-76	 OF BUSINESS EQUIPMENT
FRACTIONAL $\pm \frac{1}{32}$		APPROVED BY S. ENNIS 11-1-76	
000		DESIGNED BY	GLAZING
00		DATE	
0		APPROVED BY	NAS-00109-C6
REWORK AS NOTED		APPROVED BY	1/4 C 1



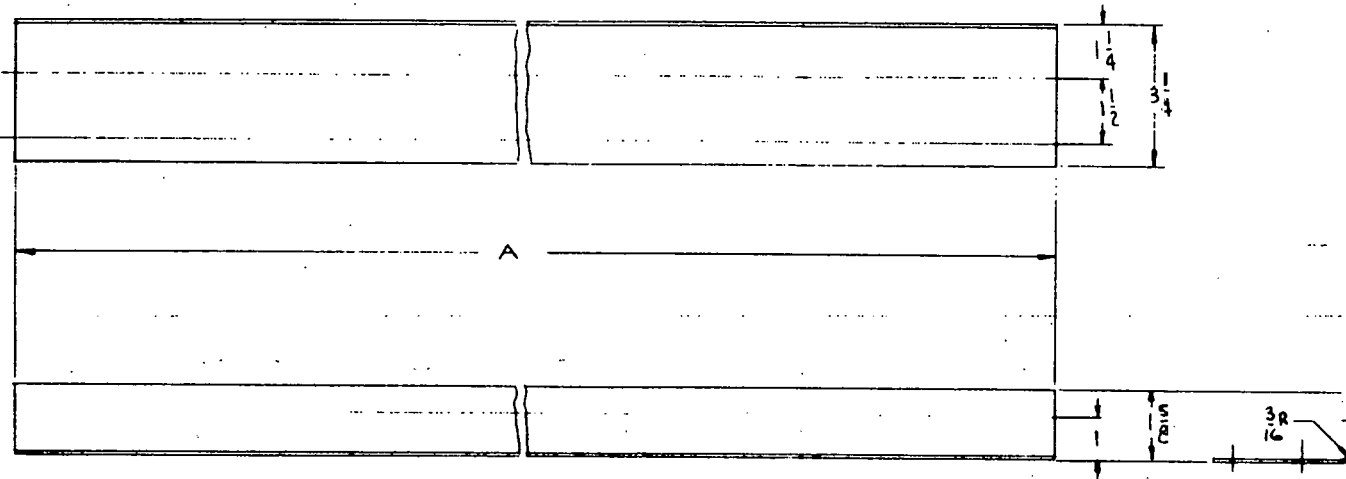
2. MATERIAL - 20 GA. (.035 IN.) C.R. SHEET STEEL (ARMCO I.F. ZINC GRIP, PAINT GRIP) OR EQUIVALENT. CLEAN, DEGREASE & PRIME, SPRAY WITH P.P.G. INHIBITIVE EPOXY PRIMER, UC-40485, APPROX. .2 MIL DRY THICKNESS, FLASH SOLVENTS FOR APPROX. 10 MIN. BAKE APPROX. 10 MIN. @ 400°F, COOL, SPRAY WITH LOW GLOSS DARACRON SUPER 600 TO OBTAIN APPROX. 1.0 MIL DRY FILM, FLASH SOLVENTS MIN. OF 10 MINUTES, BAKE APPROX. 10 MIN. @ 400°F.

1. BREAK SHARP EDGES

NOTES:

PRELIMINARY

FIG. NO.	QUANTITY	PART IDENTIFICATION	NOMENCLATURE DESCRIPTION
DATE OF ORDER LIMITS ARE		DATE OF ORDER 11-1-76	 GULF INC. OF CORPUS CHRISTI, TEXAS
FRACTIONAL + 32		DESIGNER S. ENNIS CHECKED	
.000		DATE 11-1-76	TITLE SIDE CAP STRIP
.00		QUALITY	PROJECT NO. NAS-00111-CA
0		APPROVED	SCALE 2/1 C 1
EST. REQD. AS NOTED		APPROVED	



2. MATERIAL - 26 GA. (.022 IN) C.R. SHEET STEEL (ARMCO I.F. ZINC GRIP, PAINT GRIP) OR EQUIVALENT. CLEAN, DEGREASE AND PRIME SPRAY WITH P.P.G. INHIBITIVE EPOXY PRIMER, UC-40485, APPROX. 2 MIL DRY THICKNESS, FLASH SOLVENTS, FOR APPROX. 10 MINUTES, BAKE APPROX. 10 MIN. @ 400° F. COOL, SPRAY WITH LOW GLASS DURACRON SUPER 600 TC OBTAIN APPROX. 1.0 MIL DRY FILM, FLASH SOLVENTS MIN. OF 10 MINUTES, BAKE APPROX. 10 MINUTES @ 400° F.

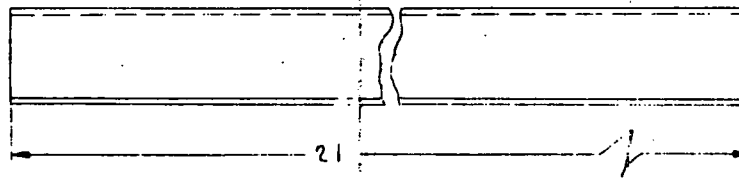
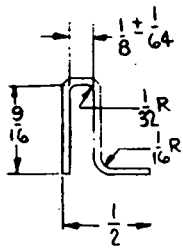
1. BREAK SHARP EDGES.

NOTES:

PART No.	QTY	LENGTH A
-1	1	6'-1 1/2"
-2	2	9'-4"

PRELIMINARY

ITEM NO.	QTY	PART OR DESCRIPTION	REVISIONS
		H-10-76	
		S. ENNIS H-10-76	



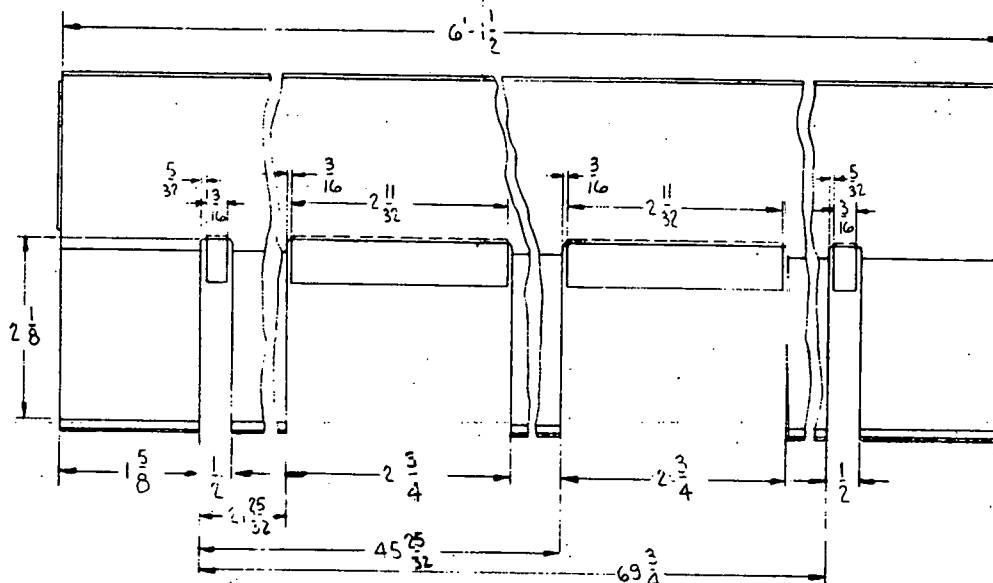
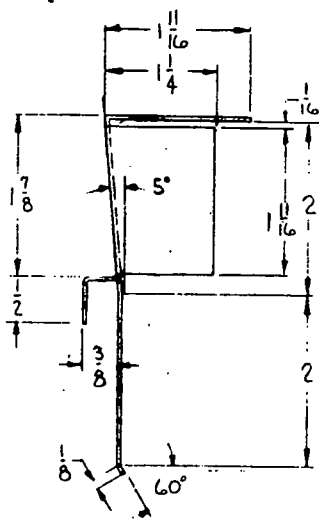
2. MATERIAL - 20 GA. (.035 IN.) C. R. SHEET STEEL (ARMCO I.F. ZINC GRIP, PAINT GRIP) OR EQUIVALENT. CLEAN, DEGREASE AND PRIME SPRAY WITH PPG INHIBITIVE EPOXY PRIMER, UC-40485, APPROX. .2 MIL DRY THICKNESS, FLASH SOLVENTS FOR APPROX. 10 MIN. BAKE APPROX. 10 MIN. @ 400°F, COOL, SPRAY WITH LOW GLOSS DURACRON SUPER 600 TO OBTAIN APPROX. 1.0 MIL DRY FILM, FLASH SOLVENTS MINIMUM OF 10 MIN., BAKE APPROX. 10 MIN @ 400°F.

1. BREAK SHARP EDGES

NOTES:

PRELIMINARY

FRG/NC	QUANTITY	PART OR IDENTIFICATION	NOMENCLATURE DESCRIPTION
UNLESS OTHERWISE SPECIFIED LIMITS ARE		DATE OF DRAFTING 11-1-76	OLT INC. OF BOSTON COMPANY
FRACTIONAL $\frac{+1}{32}$		DRAWN BY S. ENNIS	
DRG		DATE 11-1-76	
CC		CHECKED	
#		QUALITY	TITLE END CAP STRIP
MATERIAL AS NOTED		APPROVED	REVISED TO NAS-00114-C11
		APPROVED	SCALE 2/1
			SIZE C
			DRY 1



2. MATERIAL - 26 GA. (.022 IN.) C.R. SHEET STEEL (ARMCO I.F. ZINC GRIP, PAINT GRIP) OR EQUIVALENT. CLEAN, DEGREASE AND PRIME SPRAY WITH P.P.G. INHIBITIVE EPOXY PRIMER, UC-40485, APPROX. 2 MIL DRY THICKNESS, FLASH SOLVENTS FOR APPROX. 10 MIN., BAKE APPROX. 10 MIN. @ 400°F., COOL, SPRAY WITH LOW GLASS DURACROW SUPER 600 TO OBTAIN APPROX. 1.0 MIL DRY FILM, FLASH SOLVENTS MIN. OF 10 MINUTES, BAKE APPROX. 10 MINUTES @ 400°F.

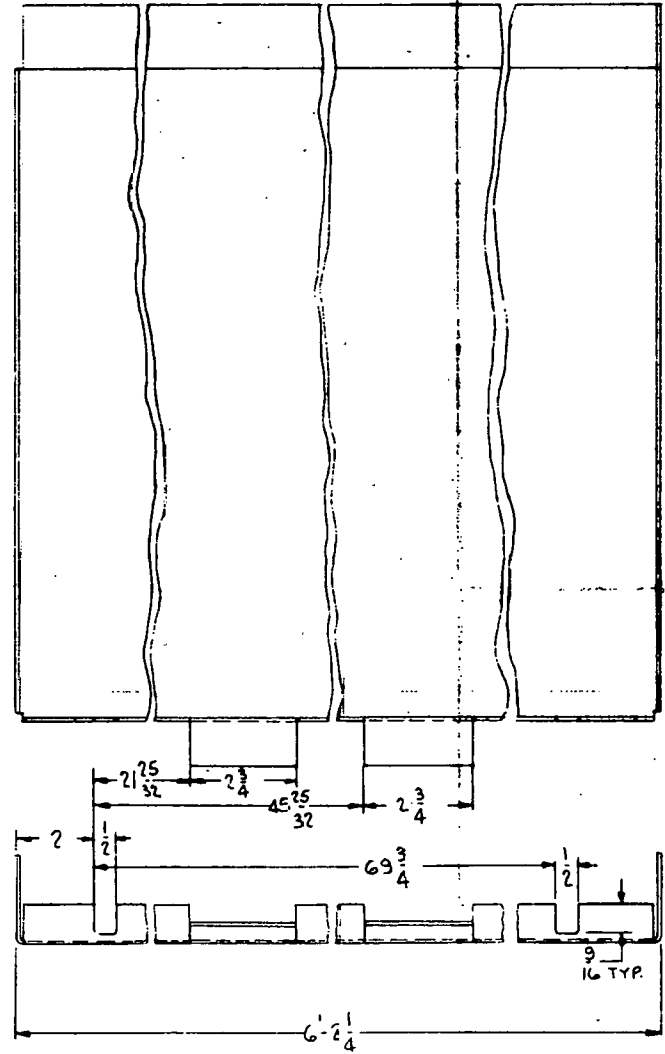
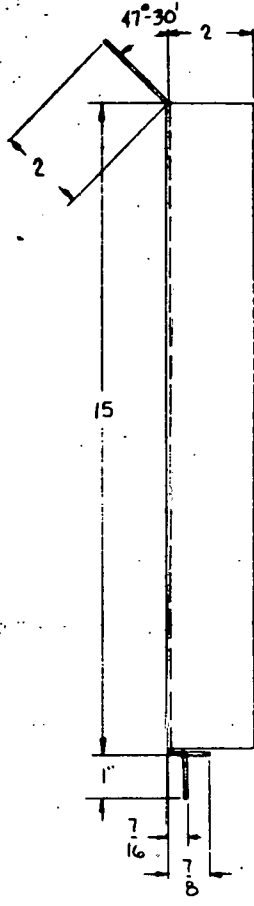
1. BREAK SHARP EDGES.

NOTES:

PRELIMINARY

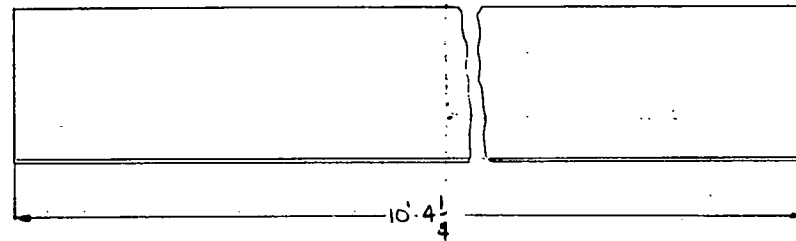
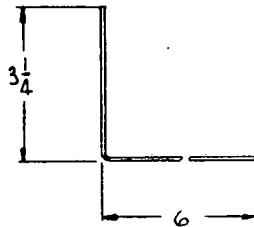
FIG NO	QUANTITY	PART OR IDENTIFICATION	SYMBOLATURE DESCRIPTION
FRONT VIEW	1	DATE OF ISSUE 11-1-76	
QUANTITY	32	DATE 11-1-76	
ADD			
DO			
APPROVED			
REVISIONS			
215 NOTED			

81-18



PRELIMINARY

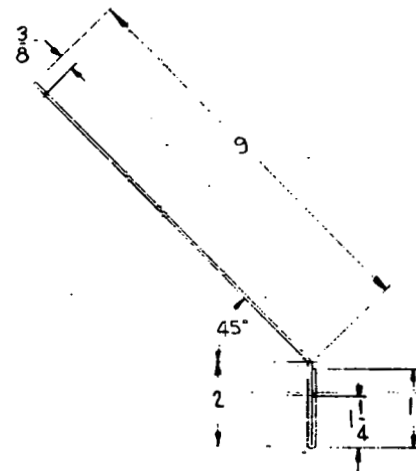
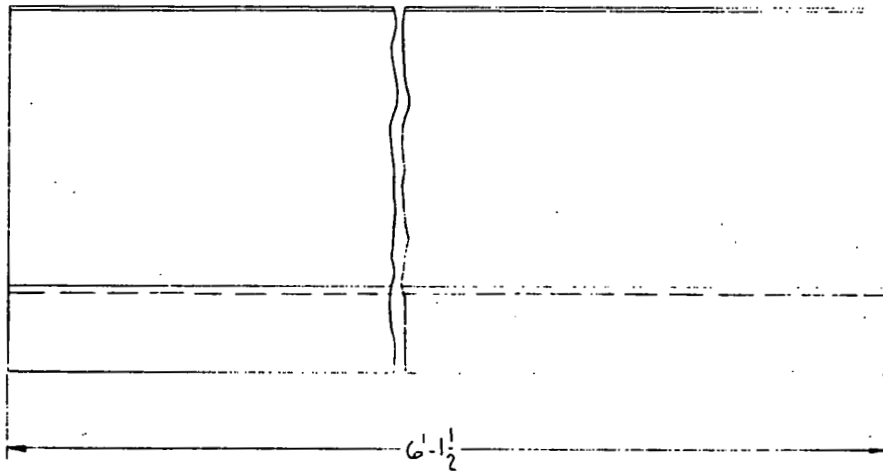
FIND NO	QUANTITY	PART OR IDENTIFICATION	NOMENCLATURE DESCRIPTION
UNLESS OTHERWISE SPECIFIED LEAVE AS IS		DATE OF DRAWING 11-11-76	
FRACTIONAL $\frac{1}{32}$		DRAWN BY S. ENNS DATE 11-11-76	
000		QUANTITY	THIS UPPER
00		APPROVED	FLASHING
0		APPROVED	NAS-00116-C13
MATERIAL AS NOTED		APPROVED	1/2 C 1



PRELIMINARY

PIN NO	QUANTITY	PART OR IDENTIFICATION	NOMENCLATURE DESCRIPTION
UNLESS OTHERWISE SPECIFIED UNITS ARE		DATE OF DESIGN 11-10-76	 GALT INC. OF BOSTON, MASSACHUSETTS
FRACTIONAL ± 1/32		DESIGNER S. ENNIS	
100		QUANTITY	DESCRIPTION SIDE FLASHING
50		APPROVED	NAS-00117-C14
0		APPROVED	1/2 C 1

F-20



2. MATERIAL- 26 GA. (.022 IN.) C.R. SHEET STEEL (ARMCO I.F. ZINC GRIP PAINT GRIP) OR EQUIVALENT. CLEAN, DEGREASE AND PRIME SPRAY WITH P.P.G. INHIBITIVE EPOXY PRIMER, UC-40485, APPROX. .2 MIL DRY THICKNESS, FLASH SOLVENTS FOR APPROX. 10 MIN., BAKE APPROX. 10 MIN. @ 400°F. COOL, SPRAY WITH LOW GLASS DURACRON SUPER 600 TO OBTAIN APPROX. 1.0 MIL DRY FILM, FLASH SOLVENTS MIN. OF 10 MINUTES, BAKE APPROX. 10 MINUTES @ 400°F.

1. BREAK SHARP EDGES.

NOTES:

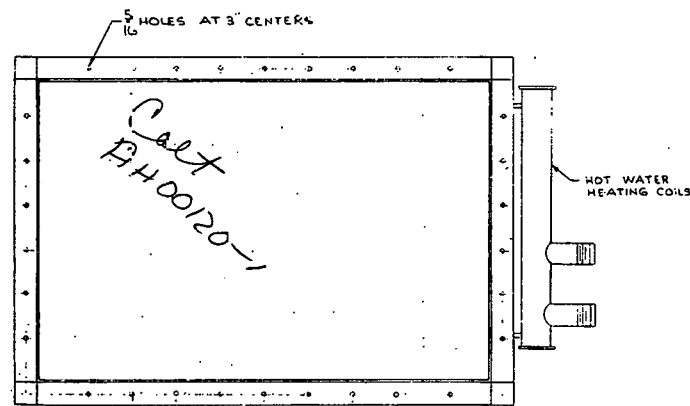
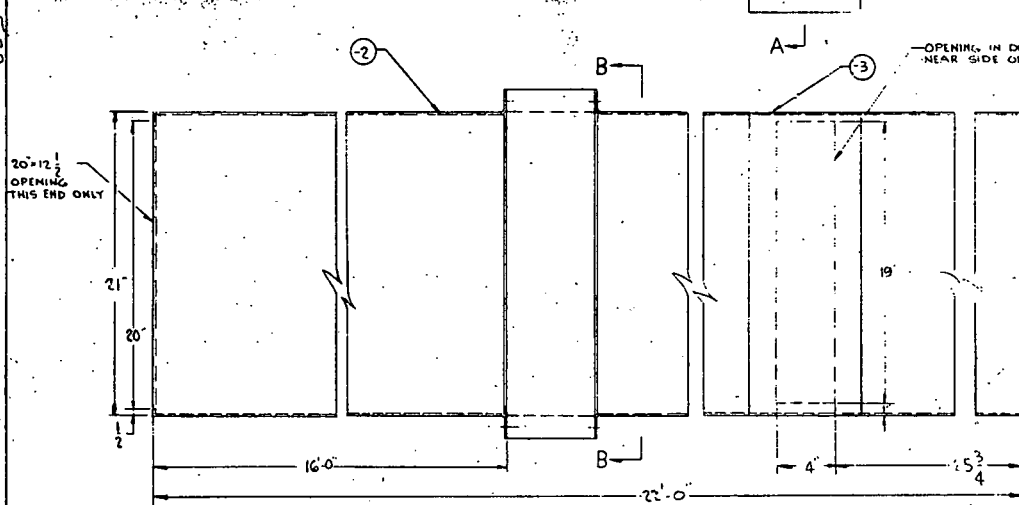
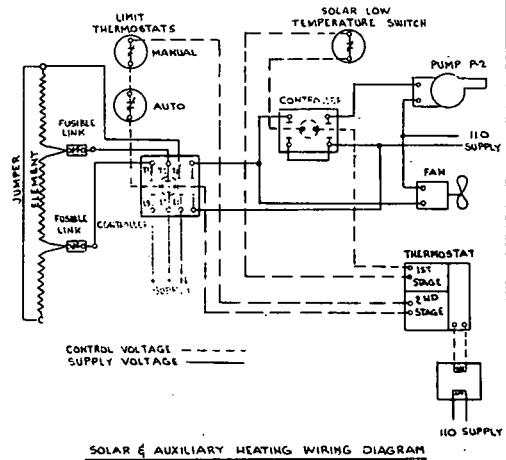
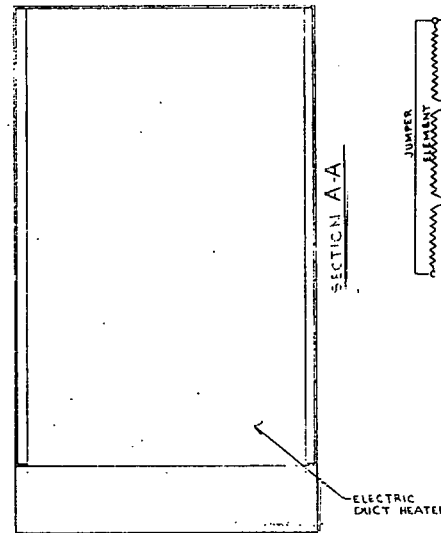
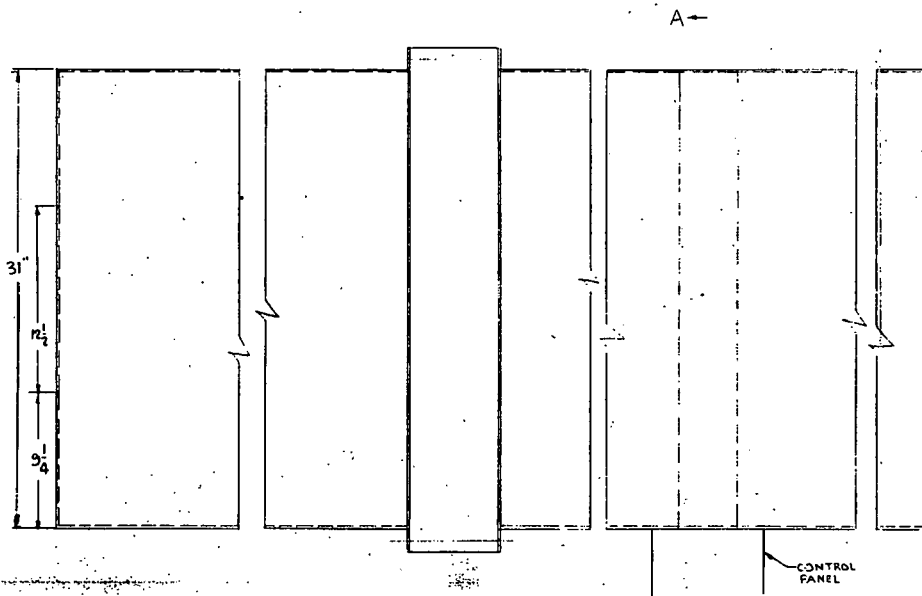
PRELIMINARY

PRD NO	QUANTITY	PART OR IDENTIFICATION	APPROXIMATE DESCRIPTION
LIMITS ARE		11-10-76	
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AS			
AS NOTED			

QLT INC.
OF MEMPHIS, TENNESSEE

FLASHING FRONT
HAS-00118-C15

1/2 C 1



PRELIMINARY

REV NO	QUANTITY	PART OR IDENTIFICATION	NOMENCLATURE DESCRIPTION
1	1	11-24-76	HEATING DUCTING
2	32	5 EN 15 11-24-76	HEATING DUCTING
3			HEATING DUCTING
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Call
FH 00120-1

