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DOE/NASA CONTRACTOR REPORT

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DOE/NASA CR-150630

PRELIMINARY DESIGN PACKAGE FOR SOLAR COLLECTOR AND SOLAR PUMP

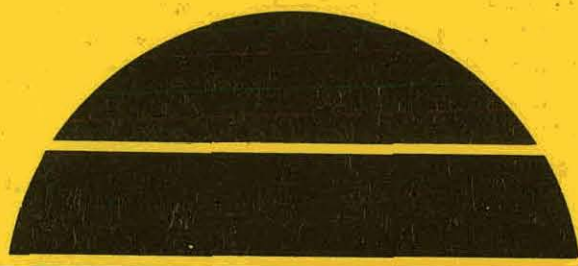
Prepared from documents furnished by

Calmac Manufacturing Corporation
150 S. Van Brunt Street
Englewood, New Jersey 07631

Under Contract NAS8-32253 with

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

For the Department of Energy



U.S. Department of Energy



Solar Energy

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16. ABSTRACT Calmac Manufacturing is developing a solar-operated pump using an existing solar collector, for use on solar heating and cooling and hot water systems. These systems are for use in single-family, multi-family, or commercial buildings. This report contains the information necessary to evaluate the preliminary design of the Calmac collector and solar-powered pump, and is a collation of the following information: preliminary design drawings, Verification Plans, Hazard Analysis, and other information valuable in defining the design of the subsystem. Renumbering of pages and some reformatting have been done in the interest of clarity.					
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			 WILLIAM A. BROOKSBANK, JR. Mgr, Solar Heating and Cooling Project Ofc		
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PART 1

Preliminary Design Review Data

Contract NAS8-32253

Project: Flat Plate Collector

CALMAC Manufacturing Corporation
150 South Van Brunt Street
Englewood, N.J. 07631

Drawings to Define Sybssystem

Contract NAS8-32253

Project: Flat Plate Collector

The following drawings are required to define the subsystem:

1. Twin tubing cross section
2. Header assembly
3. U-bend
4. Tubes for header takeoffs and U-bends
5. Standard straight Sunmat
6. Collector assembly, top view, lengthwise cross section and widthwise cross section.

See Section 3 for drawings.

Special Installation and Maintenance Tools

Contract NAS8-32253

Project: Flat Plate Collector

Part Number: SM001

Nomenclature: Stimpson Clamp Driver

Description and Use: The tool consists of a short length of 3/8" ID pipe with a 5/16" slot cut in one side, fastened to a handle. The tool slips over the EPDM tubing and is used to push Stimpson clamps over header nipples and U-bends.

Manufacturer: CALMAC Manufacturing Corporation

Justification: The best alternative using standard tools is to use a pair of pliers as a pushing tool with the clamp between its grip. Applying enough pressure to hold the clamps easily, however, damages the clamps, and the pliers tend to slip off the round shape of the clamps.

Subsystem Hazards Analysis

1. Identification and Control of Hazards. The sources of hazard in the collector subsystem are excess temperatures and pressures within the piping and tubing, and the toxicity of the ethylene glycol heat transfer fluid. The hazards are only to personnel and not to equipment or buildings -- the temperatures and pressures involved are not high enough to ignite, collapse or otherwise damage equipment or buildings. The potential hazards to personnel, however, are major as serious burns, or poisoning could result from a malfunction.

The strategy for managing excess temperatures and pressures is primarily to relieve them before they build up to an excess. The use of a temperature and pressure relief valve in the system set at 225°F and 40 PSI accomplishes this objective. In addition, to minimize the risk of burns suffered from touching the cover panel which might reach to 180°F during no flow conditions, signs will be recommended when the collector is operated in areas subjected to public traffic. The toxicity of the glycol is managed by the use of a basin to catch fluid vented from the temperature/pressure relief valve. The other source of glycol contamination -- leaking from the collector or some other part of the system -- will be managed by recommending periodic inspection of the level of glycol in the system.

2. Residual Hazards. In a properly installed system -- and it should be made clear that the relief valve and the catch basin must be installed on site -- and a properly maintained system, residual hazards are low. These hazards are comparable to hazards associated with conventional systems -- the hazard of excess build up of hot water or steam pressure in hydronic heating systems, or the risk of leaks from gas stoves.
3. Component Failure. The malfunction of a temperature/pressure relief valve will significantly increase the hazard of excess temperature and pressure. Similarly, the malfunction of piping, tubing, gaskets, fittings or valves, or improper installation will increase the hazard from the toxicity of glycol.

Contract NAS8-32253

Project: Flat Plate Collector

We recommend use of the following data at the prototype design review:

1. Drawings:
 - a. Twin tubing cross section
 - b. Header assembly
 - c. U-bend
 - d. Tubes for header takeoffs and U-bends
 - e. Standard straight SUNMAT
 - f. Collector assembly, top view, lengthwise cross section and with wise cross section.
 - g. *Dryer Tube*
 - h. *U-bend and Stimpson clamp*
2. Test data:
 - a. Collector efficiency
 - b. operating temperature and pressure limits
 - c. pressure drop through system
 - d. freeze tolerance
 - e. resistance to ponding
 - f. fail-safe performance
 - g. water potability
 - h. resistance to solar degradation of EPDM
 - i. resistance to fluttering by wind
 - j. leakage
 - k. resistance to thermal degradation
 - l. resistance to structural damage

Prototype Design Review Data (Continued)

3. Analyses:

- a. noise and corrosion
- b. structural calculations

Government-Furnished Instrumentation

Contract NAS8-32253

Project: Flat Plate Collector

No government-furnished instrumentation is required.

Design Standards and Symbology

Contract NAS8-32253

Project: Flat Plate Collector

We use design standards and symbology of the American Society of Mechanical Engineers. Symbols are published in American National Standard Graphical Symbols for Pipe Fittings, Valves and Piping.

Verification Plan

Contract NAS8-32253

Project: Flat Plate Collector

CALMAC Manufacturing Corporation
150 South Van Brunt Street
Englewood, N.J. 07631

1. Verification Matrix. See attached
2. Test Hardware. To perform tests at our location we will use the following hardware:

velometer - air velocity
 rotometer - flow rate
 potentiometer pyrometer - temperature
 pressure gauges - pressure
 pyranometer - insolation
 manometer - pressure drop

This is all basic hardware for measuring the key parameters associated with plumbing and heating devices, except for the pyranometer, which is unique to the solar field.

Other testing requiring hardware and expertise outside our range of experience -- the chemical testing of water for potability, for example -- will be performed by outside laboratories. Testing to certify performance will be performed by an independent laboratory.

3. Test Schedule and Location:

<u>Date</u>	<u>Test</u>	<u>Location</u>
Feb 15	Freeze tolerance of system	CALMAC factory
Mar 1-30	Potability of water run through system	Outside lab to be determined
Mar 1	Pressure drop through system	CALMAC factory
Mar 2	Leakage	" "
Mar 8	Resistance to ponding	" "
Mar 9	Resistance to structural damage	" "
Mar 15	Resistance to fluttering by wind	" "
Mar 22	Fail-safe protection	" "
Mar 29	Temperature and Pressure limits	" "
Mar 1-15	Collector efficiency	" "
Mar 15-May 15	Thermal degradation and collector efficiency	DSET, Phoenix, AZ

4. All this testing will be done during the qualification stage. We have enough experience with the operating characteristics of the collector, based on earlier models we have used, not to need testing at the development stage, and adequate data is available to verify all interim performance criteria at the development stage. Testing at the qualification stage is related primarily to durability and particularly to our use of the EPDM tubing, which, since it is manufactured especially for this application, is unique. The tests for freeze tolerance, potability, pressure drop, leakage, temperature and pressure limits, thermal degradation, and collector efficiency all stem from the use of EPDM. The need to test resistance to fluttering and ponding, on the other hand, stems from the unique structural design of the system. The fail-safe test is a precautionary measure to insure meeting safety requirements.

Testing at the acceptance stage should not be necessary, unless design changes are made following qualification testing. Our plan is to complete testing of all key areas here at our plant as early as possible in the qualification stage and then have DSET verify our findings to meet the need for certification by an independent agency.

ITEM (NAME & PART NO.)

VERIFICATION CROSS
REFERENCE MATRIX

Flat Plate Collector

1. SIMILARITY 3. INSPECTION N/A NOT APPLICABLE
2. ANALYSIS 4. TEST

VERIFICATION METHOD:

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
Subsystem Specification	1	4	4	
Interim Performance Criteria				
1.2.4	3	3	3	
1.3	3	3	3	
1.3.1	1	1	3	
1.4	3	3	3	
1.4.1	2	3	3	
2.1	3	3	3	
2.1.1	2	3	3	
2.1.2	2	3	3	
2.1.3	2/1	4	3	
2.1.4	1	1	3	
2.1.5	3	3	3	
2.1.6	3	3	3	
2.1.7	1	4	3	
2.2	3	3	3	
2.2.1	3	3	3	
2.2.2	3	3	3	
2.2.4	3	3	3	
2.2.5	3	3	3	
2.2.6	3	3	3	

ITEM (NAME & PART NO.)
Flat Plate Collector

VERIFICATION CROSS
REFERENCE MATRIX

VERIFICATION METHOD: 1. SIMILARITY 3. INSPECTION N/A NOT APPLICABLE
2. ANALYSIS 4. TEST

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
2.3	3	3	3	
2.3.1	1	4	3	
2.4	3	3	3	
2.4.1	1	1	3	
2.6.4	1	4	3	
2.8	3	3	3	
2.8.1	1	1	3	
3.1	3	3	3	
3.1.1	3	3	3	
3.1.2	2	3	3	
3.2	3	3	3	
3.2.1	2	2	3	
3.2.2	2	2	3	
3.2.4	2	2	3	
3.3	3	3	3	
3.3.1	2	4	3	
3.4	3	3	3	
3.4.1	2	2	3	
3.7				
3.7.1	2	2	3	
3.8	3	3	3	
3.8.1	2	2	3	
3.9	3	3	3	

ITEM (NAME & PART NO.)

Flat Plate Collector

VERIFICATION CROSS
REFERENCE MATRIX
 VERIFICATION METHOD: 1. SIMILARITY 3. INSPECTION N/A NOT APPLICABLE
 2. ANALYSIS 4. TEST

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
3.9.1	1	4	3	
4.1	3	3	3	
4.1.1	3	3	3	
4.2	3	3	3	
4.2.1	1	4	3	
4.2.2	3	3	3	
4.3	3	3	3	
4.3.1	1	1	3	
4.3.2	1	3	3	
4.4	3	3	3	
4.4.1	3	3	3	
4.4.2	3	3	3	
4.6	3	3	3	
4.6.1	2	4	3	
4.6.3	3	3	3	
4.6.4	2	3	3	
4.7	3	3	3	
4.7.1	2	3	3	
5.1	3	3	3	
5.1.1	1	4	3	
5.1.3	1	3	3	
5.1.4	1	3	3	
5.1.5	1	3	3	

ITEM (NAME & PART NO.)

VERIFICATION CROSS
REFERENCE MATRIX

Flat Plate Collector

VERIFICATION METHOD: 1. SIMILARITY 3. INSPECTION N/A NOT APPLICABLE
2. ANALYSIS 4. TEST

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
5.1.6	2	4	3	
5.2	3	3	3	
5.2.1	1	4	3	
5.2.2	1	1	3	
5.2.3	2	2	2	
5.2.4	1	4	3	
5.2.5	1	1	3	
5.2.6	1	1	3	
5.3	3	2	3	
5.3.1	1/2	3	3	
5.3.2	2	2	3	
5.3.3	2	2	3	
5.3.4	2	2	3	
6.1	3	3	3	
6.1.1	3	3	3	
6.1.2	3	3	3	
6.1.3	3	3	3	
6.1.4	3	3	3	
6.1.5	3	3	3	
6.2	3	3	3	
6.2.1	3	3	3	
6.2.2	3	3	3	
6.2.3	3	3	3	

ITEM (NAME & PART NO.)

VERIFICATION CROSS
REFERENCE MATRIX

Flat Plate Collector

VERIFICATION METHOD:

- 1. SIMILARITY
- 2. ANALYSIS
- 3. INSPECTION N/A NOT APPLICABLE
- 4. TEST

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
6.2.4	3	3	3	
6.3	3	3	3	
6.3.1	3	3	3	
6.3.2	3	3	3	
11.2.1	2	2	3	
11.2.2	2	2	3	
11.3.1	1	1	3	

PART 2

Preliminary Design Review Data

Contract NAS8-32253

Project: Solar Pump

CALMAC Manufacturing Corporation
150 South Van Brunt Street
Englewood, N.J. 07631

Drawings to Define Subsystem

Contract NAS8-32253

Project: Solar Pump

The following drawings are required to define the subsystem:

1. Pump top view and cross section
2. Vapor tube

Special Installation and Maintenance Tools

Contract NAS8-32253

Project: Solar pump

No special installation and maintenance tools are required.

Subsystem Hazards Analysis

1. Identification and Control of Hazards. The sources of hazard in the pump subsystem are excess temperatures and pressures within the piping and tubing, and the toxicity of the ethylene glycol heat transfer fluid. The hazards are hazards only to personnel and not to equipment or buildings -- the temperatures and pressures involved are not high enough to ignite, collapse or otherwise, damage equipment or buildings. The potential hazards to personnel, however, are major as serious burns, or poisoning could result from a malfunction.

The strategy for managing excess temperatures and pressures is primarily to relieve them before they build up to an excess. The use of a temperature and pressure relief valve in the system set at 280°F and 28 PSI accomplishes this objective. In addition, to minimize the risk of burns suffered from touching the pump which might reach to 200°F during normal operation signs will be recommended when the pump is operated in areas subjected to public traffic. The toxicity of the glycol is managed by the use of a basin to catch fluid vented from the temperature/pressure relief valve. The other source of glycol contamination -- leaking from the pump or some other part of the system -- will be managed by recommending periodic inspection of the level of glycol in the system.

2. Residual Hazards. In a properly installed system -- and it should be made clear that the relief valve and the catch basin must be installed on site -- and a properly maintained system, residual hazards are low. These hazards are comparable to hazards associated with conventional systems -- the hazard of excess build up of hot water or steam pressure in hydronic heating systems, or the risk of leaks from gas stoves.
3. Component Failure. The malfunction of a temperature/pressure relief valve will significantly increase the hazards of excess temperature and pressure. Similarly, the malfunction of piping, tubing, gaskets, fittings or valves, or improper installation will increase the hazard from the toxicity of glycol.

Contract NAS8-32253

Project: Solar Pump

We recommend use of the following data at the prototype design review:

1. Drawings:
 - a. Pump, top view
 - b. Pump, cross section
 - c. Vapor tube
2. Test data:
 - a. Operating performance (flow rate, pressure output for various combinations of liquid temperature and steam pressure)
 - b. Thermal degradation
 - c. Fail-safe performance
 - d. Leakage
 - e. Vibration
 - f. Water potability
3. Analyses:
 - a. Noise and corrosion
 - b. Structural calculations

Design Standards and Symbology

Contract NAS8-32253

Project: Solar Pump

We use design standards and symbology of the American Society of Mechanical Engineers. Symbols are published in American National Standard Graphical Symbols for Pipe Fittings, Valves and Piping.

Government-Furnished Instrumentation

Contract NAS8-32253

Project: Solar Pump

No government-furnished instrumentation is required.

Verification Plan

Contract NAS8-32253

Project: Solar Pump

CALMAC Manufacturing Corporation
150 South Van Brunt Street
Englewood, N.J. 07631

1. Verification Matrix. See attached.
2. Test Hardware. To perform tests at our location we will use the following hardware:

rotometer - flow rate
 potentiometer pyrometer - temperature
 pressure gauges - pressure
 manometer - pressure drop

These instruments are all basic hardware for measuring the key parameter associated with plumbing and heating devices.

Other testing requiring hardware and expertise outside our range of experience -- the chemical testing of water for potability, for example -- will be performed by outside laboratories. Testing to certify performance will be performed by an independent laboratory.

3. Test Schedule and Location:

<u>Date</u>	<u>Test</u>	<u>Location</u>
Mar 1-30	Potability of water run through system	Outside lab to be determined
Mar 1-30	Thermal degradation	CALMAC factory
Mar 8	Leakage	" "
Mar 15	Vibration	" "
Mar 22	Fail-safe performance	" "
Mar 15-30	Operating performance and limits	" "
Apr 1-30	Operating performance and limits	DSET, Phoenix, AZ

4. All this testing will be done during the qualification stage. The critical problem in the case of the pump is the development of a design that will meet operating performance requirements -- pumping at specified pressures and flow rates -- not the development of designs that meet ruggedness and durability requirements. Solving this problem involves analyzing different shapes and designs of the cylinder chamber, valves, vapor tube and so forth, and does not lend itself to testing. Once the design is set and operating performance requirements met, then we can test rigorously both the pump's operating characteristics and its durability during the qualification stage. Unless design changes develop during this period we can proceed readily to certification by an outside agency (DSET) towards the end of the qualification stage.

ITEM (NAME & PART NO.)

VERIFICATION CROSS
REFERENCE MATRIX

Pump

VERIFICATION METHOD: 1. SIMILARITY 3. INSPECTION N/A NOT APPLICABLE
2. ANALYSIS 4. TEST

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
Technical Performance Requirements	2	4	3	
Interim Performance Criteria				
1.2.4	3	3	3	
2.1	3	3	3	
2.1.1	2	3	3	
2.1.2	2	3	3	
2.1.3	2	4	3	
2.1.5	3	3	3	
2.1.6	3	3	3	
2.2	3	3	3	
2.2.1	2	3	3	
2.2.2	2	4	3	
2.2.4	3	3	3	
2.2.5	2	3	3	
2.2.6	3	3	3	
2.3	3	3	3	
2.3.1	2	4	3	
2.6	3	3	3	
2.6.1	1	3	3	
2.6.3	3	3	3	
2.6.4	1	3	3	
2.7	3	3	3	

ITEM (NAME & PART NO.)

VERIFICATION CROSS
REFERENCE MATRIX

Pump

VERIFICATION METHOD: 1. SIMILARITY 3. INSPECTION N/A NOT APPLICABLE
2. ANALYSIS 4. TEST

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
2.7.1	3	3	3	
2.8	3	3	3	
2.8.1	1	1	3	
3.1	3	3	3	
3.1.1	3	3	3	
3.1.2	2	3	3	
3.2	3	3	3	
3.2.1	2	2	3	
3.3	3	3	3	
3.3.1	2	2	3	
3.4	3	3	3	
3.4.1	2	2	3	
3.8	3	3	3	
3.8.1	2	2	3	
3.9.1	3	3	3	
4.1	3	3	3	
4.1.1	3	3	3	
4.2	3	3	3	
4.2.1	1	4	3	
4.2.2	3	3	3	
4.3	3	3	3	
4.3.1	2	1	3	
4.4	3	3	3	

ITEM (NAME & PART NO.)

Pump

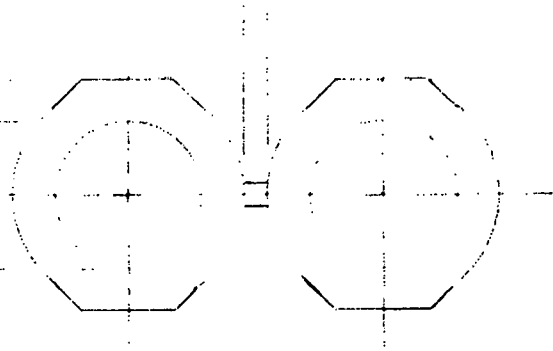
VERIFICATION CROSS
REFERENCE MATRIX
 VERIFICATION METHOD: 1. SIMILARITY 3. INSPECTION N/A NOT APPLICABLE
 2. ANALYSIS 4. TEST

PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
4.4.1	3	3	3	
4.5	3	3	3	
4.5.2	3	3	3	
4.6	3	3	3	
4.6.3	3	3	3	
4.6.4	2	3	3	
4.7	3	3	3	
4.7.1	2	3	3	
5.1	3	3	3	
5.1.1	1	3	3	
5.1.3	1	3	3	
5.2	3	3	3	
5.2.1	1	4	3	
5.2.2	1	1	3	
5.2.3	2	2	3	
5.2.4	1	4	3	
5.2.5	1	1	3	
5.3	3	3	3	
5.3.1	1/2	3	3	
5.3.2	2	2	3	
5.3.3	2	2	3	
5.3.4	2	2	3	
5.4	3	3	3	

ITEM (NAME & PART NO.)		VERIFICATION CROSS REFERENCE MATRIX		
Pump				
VERIFICATION METHOD:		1. SIMILARITY	3. INSPECTION	N/A NOT APPLICABLE
		2. ANALYSIS	4. TEST	
PERFORMANCE REQUIREMENT	VERIFICATION PHASE			REMARKS
	DEVELOPMENT	QUALIFICATION	ACCEPTANCE	
5.4.1	1	3	3	
6.1	3	3	3	
6.1.1	3	3	3	
6.1.2	3	3	3	
6.1.3	3	3	3	
6.1.4	3	3	3	
6.1.5	3	3	3	
6.2	3	3	3	
6.2.1	3	3	3	
6.2.2	3	3	3	
6.2.3	3	3	3	
6.2.4	3	3	3	
6.3	3	3	3	
6.3.1	3	3	3	
6.3.2	3	3	3	
8.3.1	3	3	3	
11.2.1	2	2	3	
11.2.2	2	2	3	
11.3.1	1	1	3	

WEB .025 ± .010 WIDE x .025 ± .005 THICK

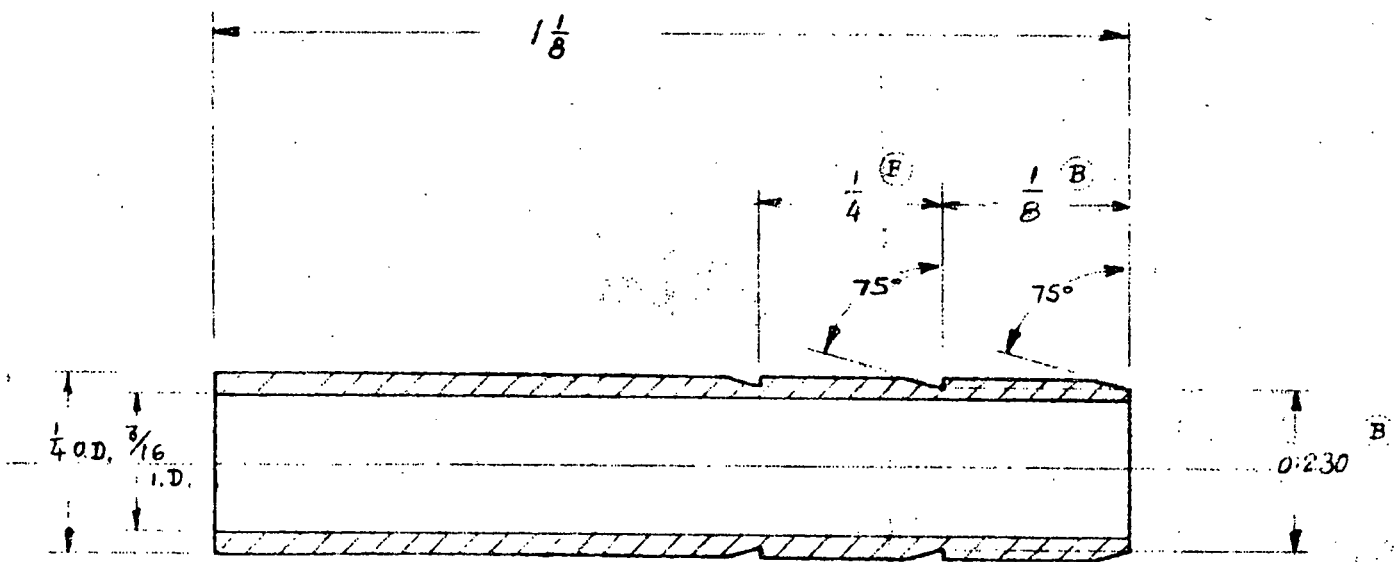
WALL = .062 ± .010
 I.D. = .203 ± .010



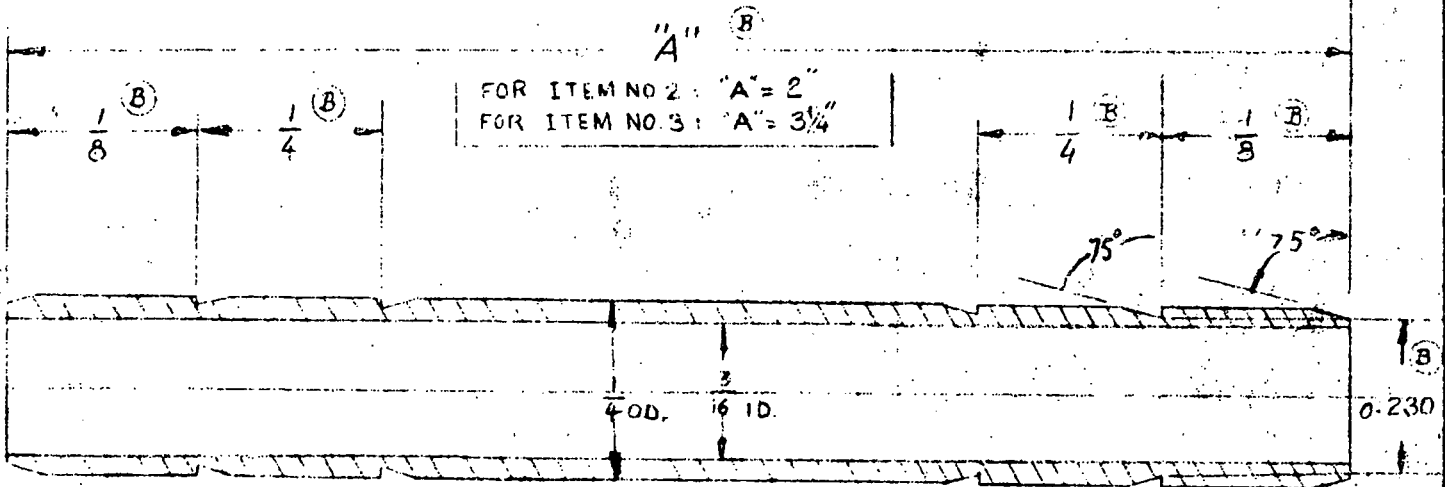
Rev By	Date	Revisions
DRN.	12-13-75	
CHK	<i>WJA</i>	
PROJ. SOL. ENERGY		
SCALE 4 = 1		

TOLERANCES: FRACTIONAL, ± 1/64; DECIMALS, ± .005; ANGLES, ± 1/2°	
TITLE TWIN TUBING - CROSS SECTION	Tool No.
MATERIAL 80-85 DUROMETER EPDM	Blank Size

CALMAC MFG. CORP.
 Englewood, N.J.
A-130P-A



ITEM 1



ITEMS NO 2 & 3

Rev	By	Date	Revisions
3			ADDED ITEM NO. 3
B	h	1-24-74	1/8 WAS 1/4; 1/4 WAS 3/8; .230 WAS .230
A	h	9/13-71	CHANGED UNDERCUTS
DRN. 12-23-70			CALMAC MFG. CORP Englewood, N.J.
CHK. <i>h</i>			
PROJ. 590-591			
SCALE			

TOLERANCES FRACTIONAL, $\pm 1/64$; DECIMALS, $\pm .005$; ANGLES, $\pm 1/2^\circ$

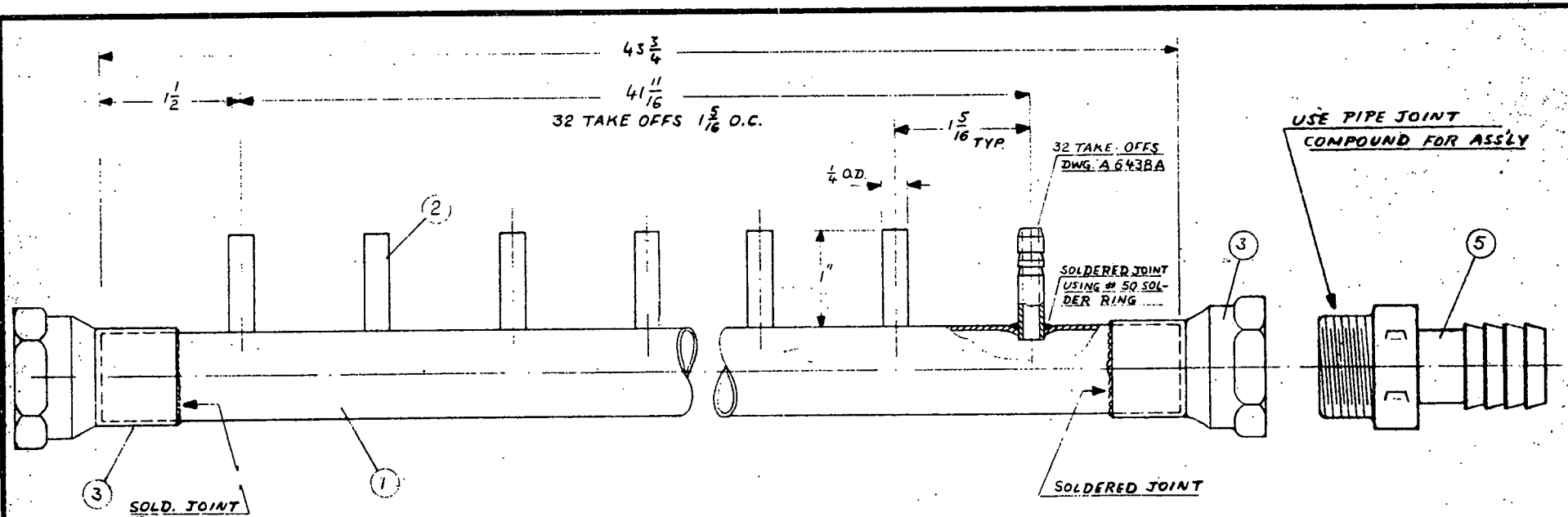
TITLE S. B. - A. S. E. TAKE-OFF TUB FOR U-BEND

MATERIAL COPPER 1/4" O.D.

Tool No.

Blank Size

A-6438B



NOTE:

- EACH SUBMAT REQUIRES TWO SUB HEADERS OF THIS DESIGN ONE SUPPLY AND ONE RETURN.
- ON ONE END OF THE SUB HEADER HOSE ADAPTER IS INSTALLED FOR RUBBER HOSE CONN. ON THE OTHER END A STEEL PLUG IS INSTALLED FOR CLEAROUT (NOT SHOWN)

ITEM	QTY.	MATERIAL
5	1	HQ. E ADAPTER 3/4 MPT X INSERT PVC
4	1	3/4 THREADED PLUG (NOT SHOWN) STEEL
3	2	ADAPTER 3/4 SLEPT COPPER
2	32	COPPER TUBING TYPE L HARD, 1/4 DIA, 1 1/8 LG
1	1	COPPER TUBING TYPE L HARD, 3/4 DIA X 4 3/4 LG

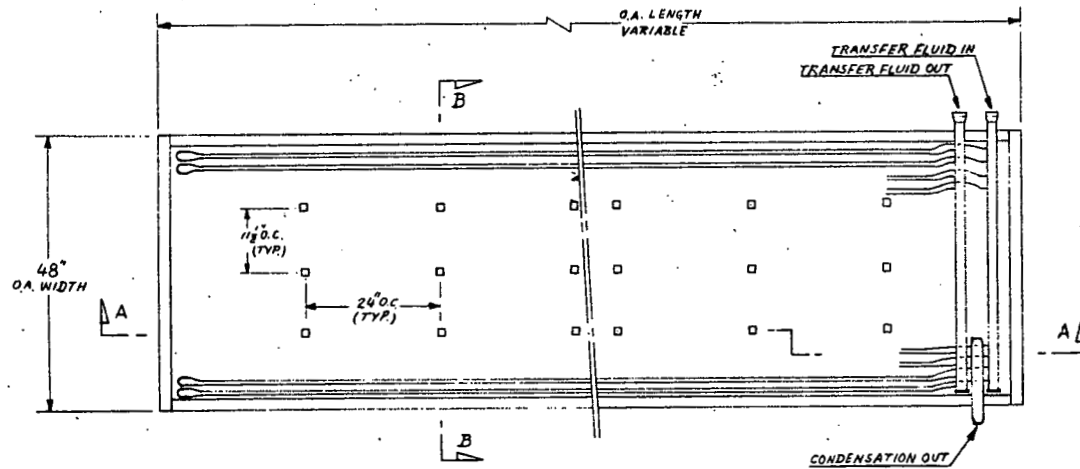
BILL OF MATERIAL

DO NOT SCALE THIS DRAWING.
 TOLERANCES UNLESS OTHERWISE NOTED
 FRACTIONAL - 1/64 DECIMAL = .005 ANGULAR = 1/2°
 NAME: SUBHEADER ASS'LY (NEW DESIGN)
 MATERIAL: AS SPEC.

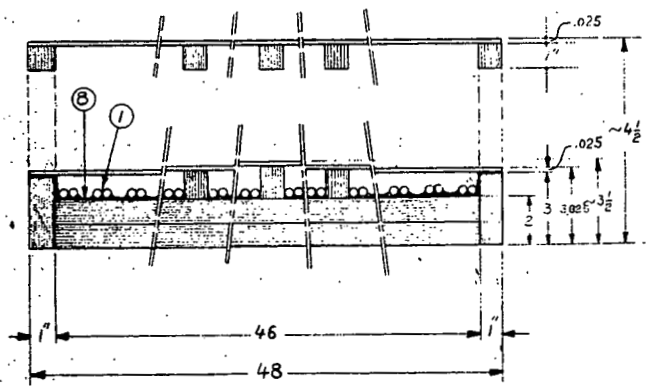
REV.	BY	DATE	Revisions

DRN: 11-20-75
 CHK: [Signature]
 APP: [Signature]
 PROJ. STANDARD
 SCALE FULL

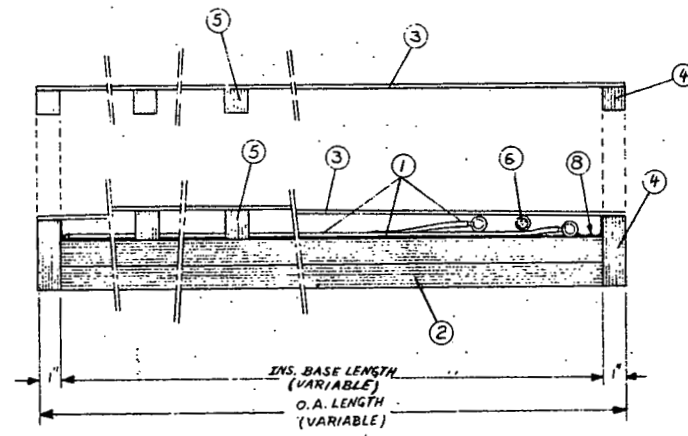
CALMAC MFG. CORP.
 Englewood, N.J.
B-ST-243



TOP VIEW
SCALE: NONE



SECTION-BB
SCALE: 1/4" = 1"



SECTION-AA
SCALE: 1/4" = 1"

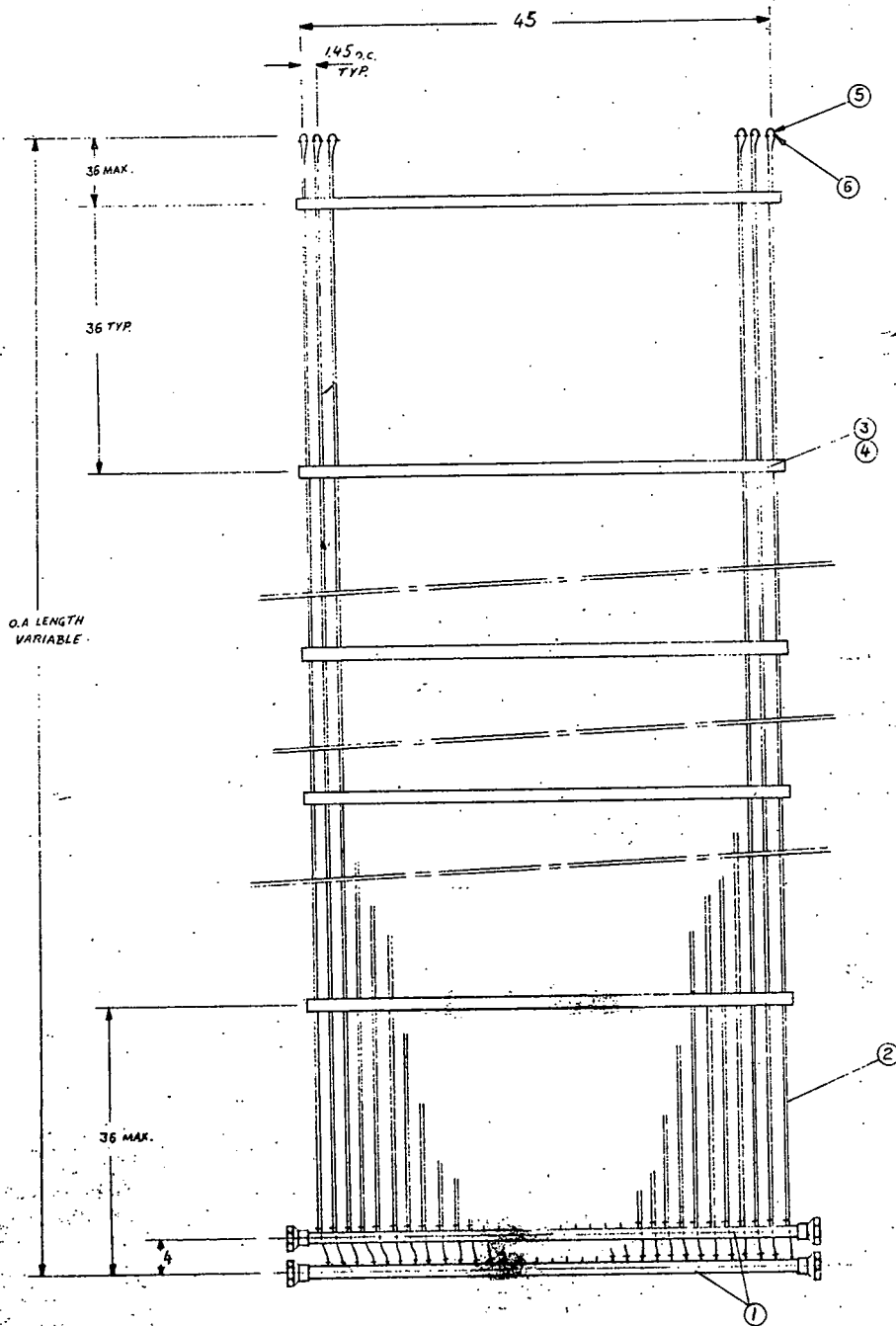
NOTE:

- SECOND LAYER OF ITEM 3, KALWALL COVER PANEL IS OPTIONAL.
- RUBBER ADHESIVE # 1300 IS USED TO JOIN INSULATION PERIMETER TO BASE AND FOR JOINT BETWEEN INSL. PERIMETER AND COVER PANEL (KALWALL) AND SPACER BLOCKS AND COVER PANEL

- INSULATION ADHESIVE #4230 IS USED TO JOIN INSULATION BASE TO INSTALLATION SURFACE, TWO LAYERS OF INSL. BASE TOGETHER, SUMMAT TO INSULATION BASE AND TO FILL THE SPACES BETWEEN SUMMAT TUBS. IT IS USED TO WATER PROOF ALL AROUND OUTSIDE

BILL OF MATERIAL	
QTY.	MATERIAL
1	SUMMAT ASS'Y, COMPL. WITH HDRS & U-BENDS
2	INSULATION BASE - 2, FT THK. INS. BDS. # 703 WITH 5 MIL THK. AL. FOIL FACING, ONE SIDE.
3	COVER PANEL, KALWALL SUNLITE PREMIUM, .025 THK.
4	SET INSULATION PERIMETER, MATERIAL AS ITEM 2
5	SET INSUL. SPACER BLOCKS, MATERIAL AS ITEM 2
6	DESICCANT DRYER TUBE
7	RUBBER ADHESIVE, 3M'S # 1300
8	INSULATION ADHESIVE, 3M'S # 4230

TOLERANCES: FRACTIONAL, 1/16"; DECIMALS, 2.000; ANGLES, 1/16"		DRN. 12-29-76	CALMAC MFG. CORP. Englewood, N. J.
TITLE SUMMAT SOLAR COLLECTOR ASS'Y		CHK. <i>ly</i>	
MATERIAL	AS SPEC.	PROJ. SOL. EN'G'Y	SCALE GIVEN
		C-155P	



BILL OF MATERIAL		
ITEM	QTY.	MATERIAL
1	2	COPPER HEADER ASS'LY. WITH ADAPTERS & 32 NIPPLES
2	*	EPDM TWIN TUBING $\frac{1}{4}$ " I.D. $\frac{3}{8}$ " O.D. (BLACK)
3	*	FLEXIBLE VINYL SPACER STRIP, .030" X 1" X .49"
4	*	RIGID VINYL SPACER STRIP, .040" X 1" X .49"
5	32	COPPER U-BEND, FROM $\frac{1}{4}$ " O.D. .032" WALL COPPER TUB.
6	128	STIMPSON BUTTON CLAMP, # A2098 (COPPER)

* QUANTITY VARIOUS AS PER SPECIFIED LENGTH OF THE SUNMAT

TOLERANCES: FRACTIONAL & 1/16" DECIMALS & .001" ANGLES & 1/16"		DRN. 12-29-76	CALMAC MFG. CORP.
TITLE "SUNMAT" ASS'LY.	Tool No.	CHK. <i>[Signature]</i>	Englewood, N. J.
MATERIAL AS. SPEC.	Blank Size	PROJ. SOL. EN'G.	C-156P
		SCALE NONE	

EPDM TUBING

STIMPSON CLAMP, # A2098

COPPER U-BEND (STD.)

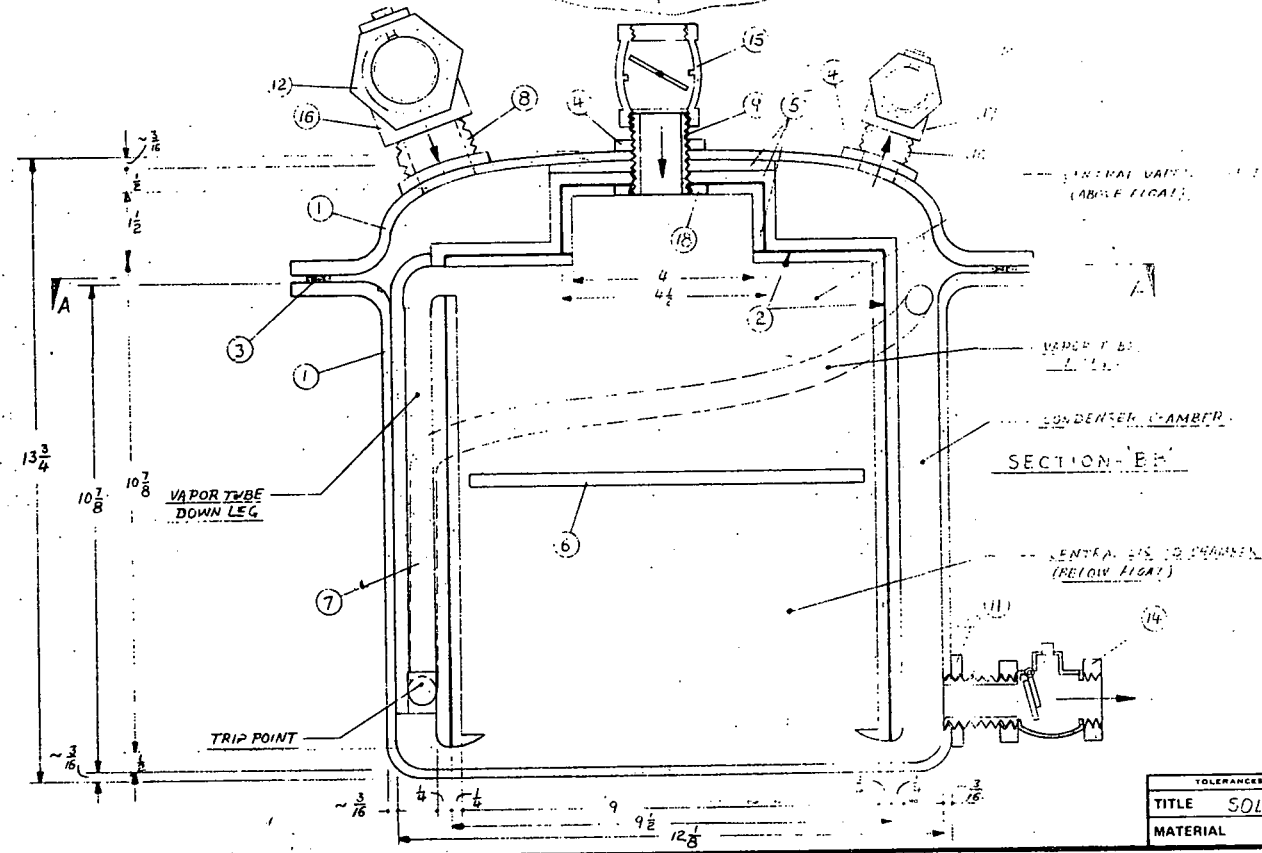
DO NOT SCALE THIS DRAWING.			REV.	BY	DATE	Revisions
TOLERANCES UNLESS OTHERWISE NOTED			DRN.	h	12-29-76	CALMAC MFG. CORP. Englewood, N.J.
FRACTIONAL : 1/64 DECIMAL - .005 ANGULAR - 1/2°			CHK.	h		
NAME: ASSEMBLY DETAIL, SUTIMAT			APP.			
MATERIAL:			PROJ. SOL. ENGR			B-157P
			SCALE	2:1		

BILL OF MATERIAL

ITEM	QTY	MATERIAL
1	1	22-15 PRESSURE COOKER, MIRRO-MATIC DELUXE TYPE, PT. NO M. 6628, AL. ALLOY CONSTRUCTION
2	1	METAL CONTAINER, #304 SS
3	1	PRESS COOKER GASKET
4	4	AL BOSS (WELD TO COOKER)
5	1	SET CORK INSULATION, 1/4" THK
6	1	CORK FLOAT, 3/4" THK, 8 1/2" DIA
7	1	1/2" ID COPPER TUBE ASS'LY
8	1	1 1/2" X CLOSE NIPPLE (GALV)
9	1	1" X NIPPLE (GALV)
10	1	1" X CLOSE NIPPLE (GALV)
11	1	3/4" X CLOSE NIPPLE (GALV)
12	2	1/8" CHECK VALVE (FOR RETURN LIQUID TO PUMP)
13	1	1" CHECK VALVE (FOR SUPPLY LIQUID FROM PUMP)
14	1	3/4" DIAPHRAGM VALVE (FOR MAKEUP LIQUID TO SOL. COLL.)
15	1	1" VALVE (FOR STEAM FROM SOL. COLL.)
16	1	1" VALVE (FOR STEAM FROM SOL. COLL.)
17	1	1" VALVE (FOR STEAM FROM SOL. COLL.)
18	1	1" VALVE (FOR STEAM FROM SOL. COLL.)
19	1	1" VALVE (FOR STEAM FROM SOL. COLL.)
20	1	1" VALVE (FOR STEAM FROM SOL. COLL.)

ACTUAL LOCATION OF VALVE, ITEM 15

SECTION-AA



TOLERANCES: FRACTIONAL ± 1/64; DECIMALS ± .005; ANGLES ± 1/16"

TITLE	SOLAR PUMP	Tool No.	
MATERIAL	AS SPEC.	Blank Size	

Rev	By	Date	Revisions

DRN. 12-30-76	CALMAC MFG. CORP. Englewood, N. J.
CHK. 1/1/77	
PROJ. SOL. ENGY	
SCALE HALF	C158P