DOE/NASA CONTRACTOR REPORT

DOE/NASA CR-150697

DESIGN DATA BROCHURE: SOLAR HOT AIR HEATER

Prepared by

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Under Contract NAS8-32247 with

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

For the U. S. Department of Energy

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16. ABSTRACT

This Design Data Brochure provides information on the design, installation, performance, and application of SEECO Mod-1 Solar Hot Air Heater for residential, commercial and industrial use.

The system has been installed at the Concho Indian School in El Reno, Oklahoma.

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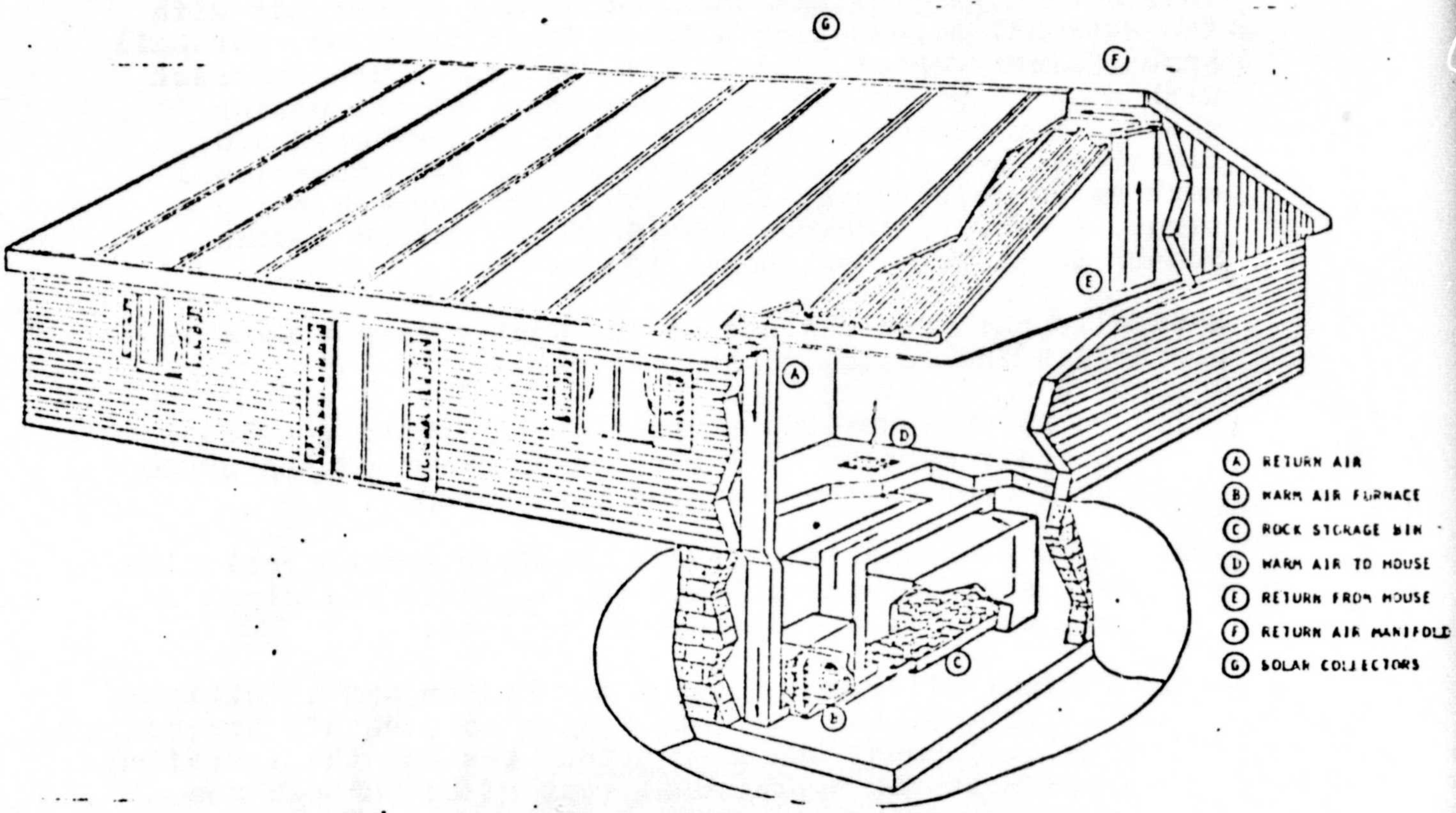

TYPICAL INSTALLATION

SOLAR HEATING SYSTEM

SINGLE FAMILY RESIDENCE

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INTRODUCTION

This system was designed by Solar Engineering & Equipment Co. Inc. in collaboration with The Binkley Company, Inc.

This design was further developed under a contract with the National Aeronautics & Space Administration, Marshall Space Flight Center, Huntsville, Alabama. The contract with NASA required further development of the design wherein two prototype systems would be developed and fabricated and ultimately installed in two operational test sites selected by NASA, the first system being a single family residence located at the Concho Indian School in El Reno, Oklahoma.

Basically the requirements of the NASA contract were to accomplish the following objectives:

1. To further develop and refine two prototype solar hot air systems utilizing the concept of the SEECO collector as the basis of the system.

2. To design and install the complete system including all storage requirements for specific buildings as selected for operational test sites.

3. To test all components of the system and to ultimately test the complete system through all stages of development and to continue testing the installed system at the operational test sites through one complete winter season and to report all test findings to NASA for further evaluation.

The specific goals of the program were:

a) To develop a solar heating collecter and system that would be economical yet durable and efficient.

b) To prove that the air-to-air system would function as well as a liquid system and thereby eleminate the problems of freezing of the transfer fluids and inherent problems in liquid collectors.

c) To design a collector in which the basic materials used in its manufacture are standard products readily available off the shelf that can be mass produced in large quantities.

d) The collector can be manufactured in any length up to 40 feet to accommodate design of any roof span to the 40 foot limitation, thereby eliminating the need for multiple manifold connections required in a series of small collector modules.

e) To prove that the collector can efficiently serve as the actual roof of a building through its structural integrity and waterproofness and thereby eliminating the cost of the roof, therefore reducing the solar system collector cost.

As this development program progressed it became apparent that the SEECO collector could provide other advantages when used in industrial and agricultural systems for proper produce drying and for industrial and institutional hot water. Several systems have been designed for lumber drying, cotton and industrial hot water for hospitals and nursing homes.

Solar Engineering & Equipment Co. Inc. extends its services to architects and engineers as well as to private individuals and companies who have an interest in solar systems utilizing the concept outlined in this brochure of employing any of the other methods wherein solar energy can provide useful and economical alternative energy sources.

S E E C O M O D - I

SOLAR HOT AIR HEATER FOR

RESIDENTIAL, COMMERCIAL and INDUSTRIAL USE

Technical Manual for Architects and Engineers

I N D E X

Fig. 1 - Cross Section - SEECO Mod I Collector

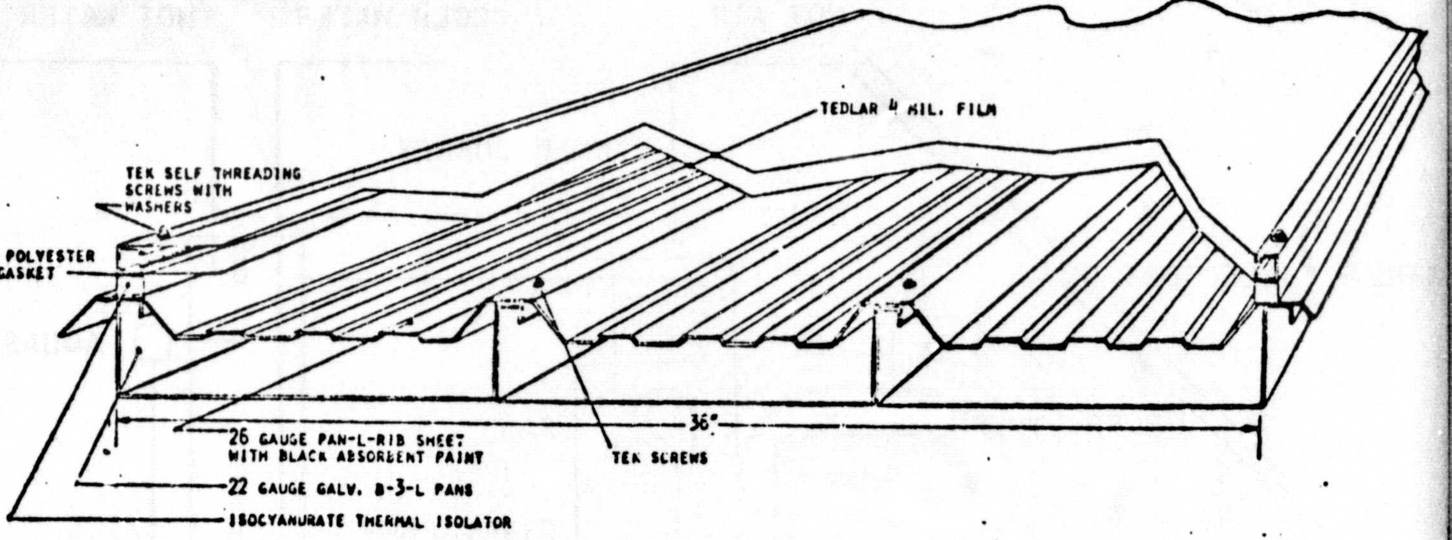


FIGURE 1 SOLAR COLLECTOR

1. System Description

The SEECO solar air heater, Mod I, is made in modules 3' wide and any length not exceeding forty feet. These modules are joined to form a collector of any chosen width in multiples of three feet. The collectors are fabricated by utilizing standard steel building wall components, as shown by the drawing (Fig. 1). Three bottom pans, each 12" wide made of galvanized steel, 22 gauge, are joined to form the three foot width. A standard 26 gauge steel sheet, painted with best grade flat black paint of a special heat resistant type, forms the absorber plate. Over this is installed the top thermal window consisting of two layers of Dupont Tedlar 4 mil thick plastic film mounted on a 3/4" x 3/4" steel frame. This window is separated from the absorber plate by a special urethane-isocyanurate thermal isolator. Forced air is passed over and under the absorber plate through air plenums at the top and bottom of the collector system, as shown on the drawing. Each module channel may be individually balanced by the use of hand dampers installed as shown. This adjustment is made after installation, at the job site, prior to closing in the hot air plenum at the roof ridge. This system of air ducts or plenums connects into the existing warm air system. This interconnection detail will vary in accordance with the conventional hot air system which will interface with the solar system. A typical installation is shown. (Fig. 3)

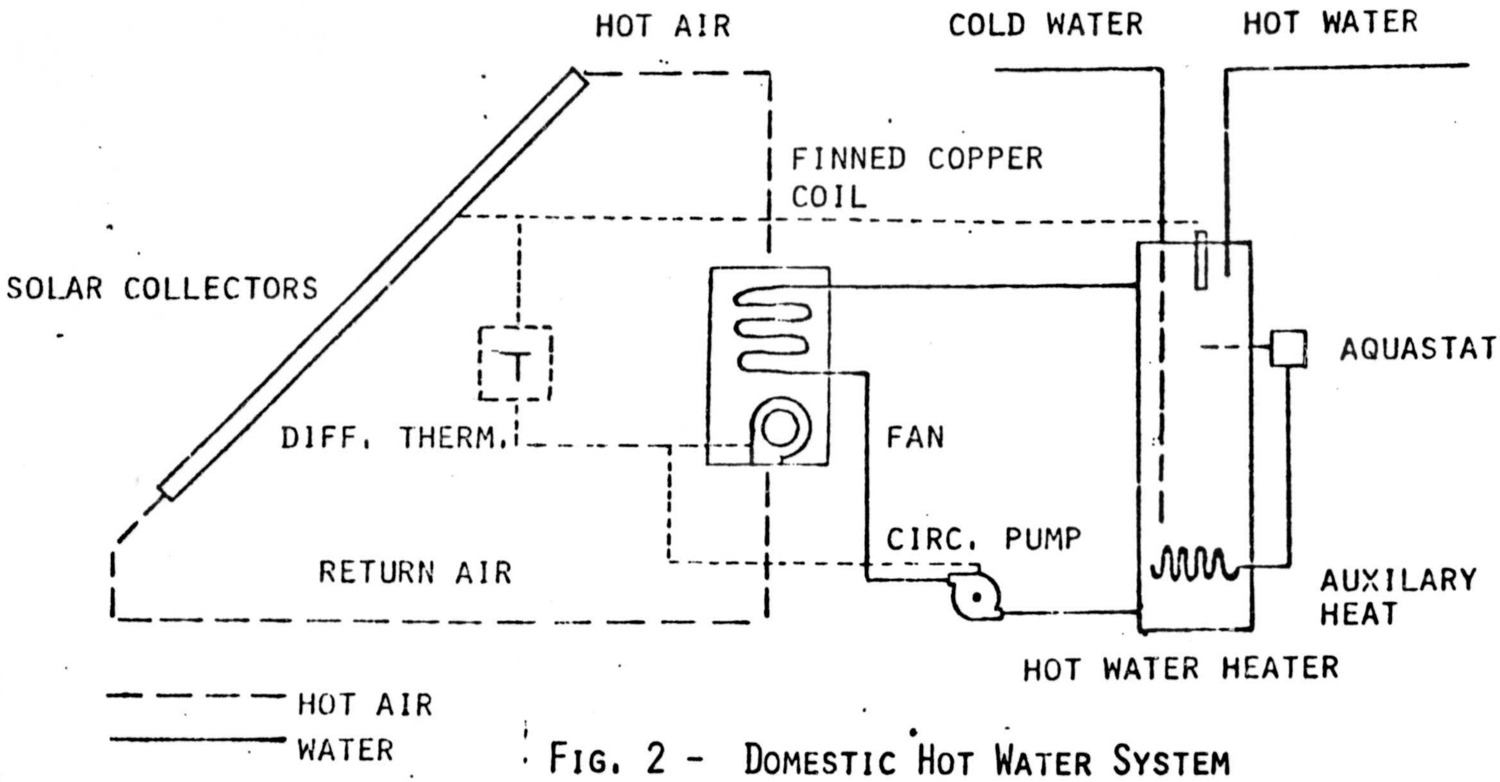


FIG. 2 - DOMESTIC HOT WATER SYSTEM

2. <u>Accessories</u>

This system may be equipped with an air to water heat exchanger to heat domestic hot water. (Fig. 2) This is an economical and efficient way to produce hot water for domestic use because there is no danger of cross pollution between antifreeze admixtures because no antifreeze is necessary and our high efficiency heat transfer coils actually are lower in price than double tube liquid heat exchangers of the same capacity. A drawing of a typical domestic hot water system shows the simplicity of the system.

3. <u>Typical Installation Arrangements</u>

The SEECO solar collector may be used as a structural part of the roof. It can be self supporting in spans up to twenty feet and may eliminate a part of the roof in new construction. In order to minimize on field installation work, the collectors are shipped from the factory in maximum sized modules. Because of overhead clearance and road regulations, maximum widths of four modules or 12 ft. are shipped factory joined. Any length up to forty feet can be custom made to fit job requirements. These collector modules may be installed with their long axes

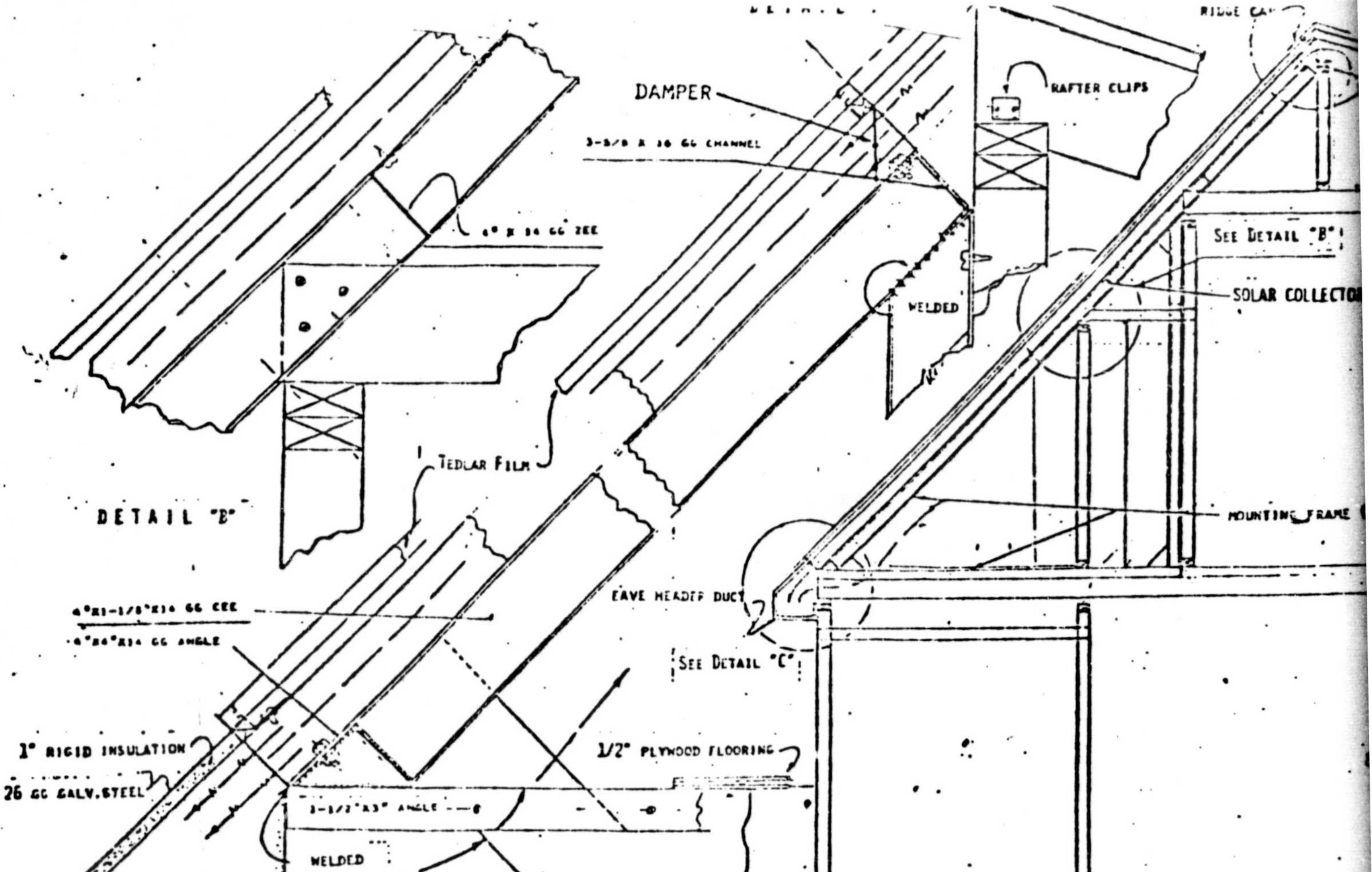


FIG. 3 - INSTALLATION DETAILS

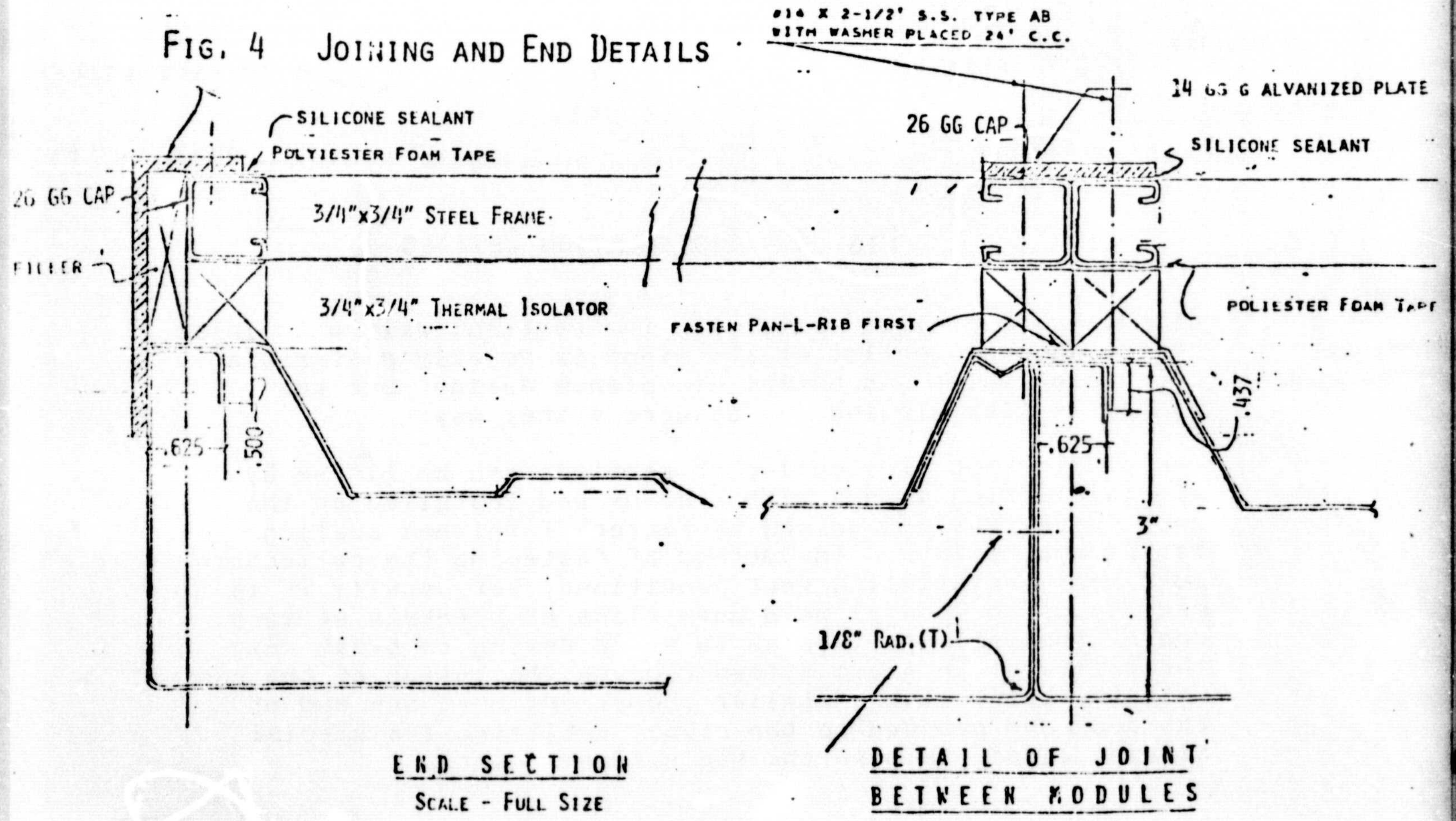
either horizontal or vertical. The vertical axis with inlet at the eave and outlet at the ridge is usually preferable because of inlet and outlet air plenum design, but the system is flexible and may be used either way.

The twelve foot wide collector sections can be lifted by special lifting slings with a crane and installed on the roof where they are joined by factory furnished sealing strips and gaskets. The method of fastening the collectors must meet the existing roof conditions, but usually it is made by using special hold down clips or brackets at each end of the collector, so as to avoid having to break down the collector to place screws through the bottom of the pan into the roof. The installer should begin at one end of the roof and proceed to the other, utilizing the special sliding ladder to make the top surface joints.

The supply and return manifolds are then connected into the conventional system. This will vary in accordance with the type of system that will be used, but interfacing ducts and control dampers are usually similar to the example shown, although exact duct locations may vary. If possible, interfacing duct work should be designed by a professional who understands the principals of air distribution and ductwork design. SEECO is always ready to assist the client in this sort of work.

When the fan(s) have been installed and are operable, full capacity air should be circulated through the system, prior to installing the bottom of the hot air supply plenum or any other obstacle to access to the adjustable dampers. It is essential that these dampers be individually adjusted for each air channel to equalize air flow across the roof. This flow velocity can be checked with a hand held velometer with a flexible tube connected nozzle. When the air circulation has been balanced the duct system should be closed and sealed and the entire system checked for air leaks, inspecting each joint where air might possibly escape. Air leaks should be sealed with the special silicone sealant furnished with the installation. The contractor should then adjust the various control damper combinations for proper operation and sequencing in accordance with the various modes. As may be seen from the typical drawings, the SEECO collector can be tailor-made to fit a required length but the width must be maintained in multiples of three feet.

FIG. 4 JOINING AND END DETAILS



END SECTION

SCALE - FULL SIZE

DETAIL OF JOINT BETWEEN MODULES

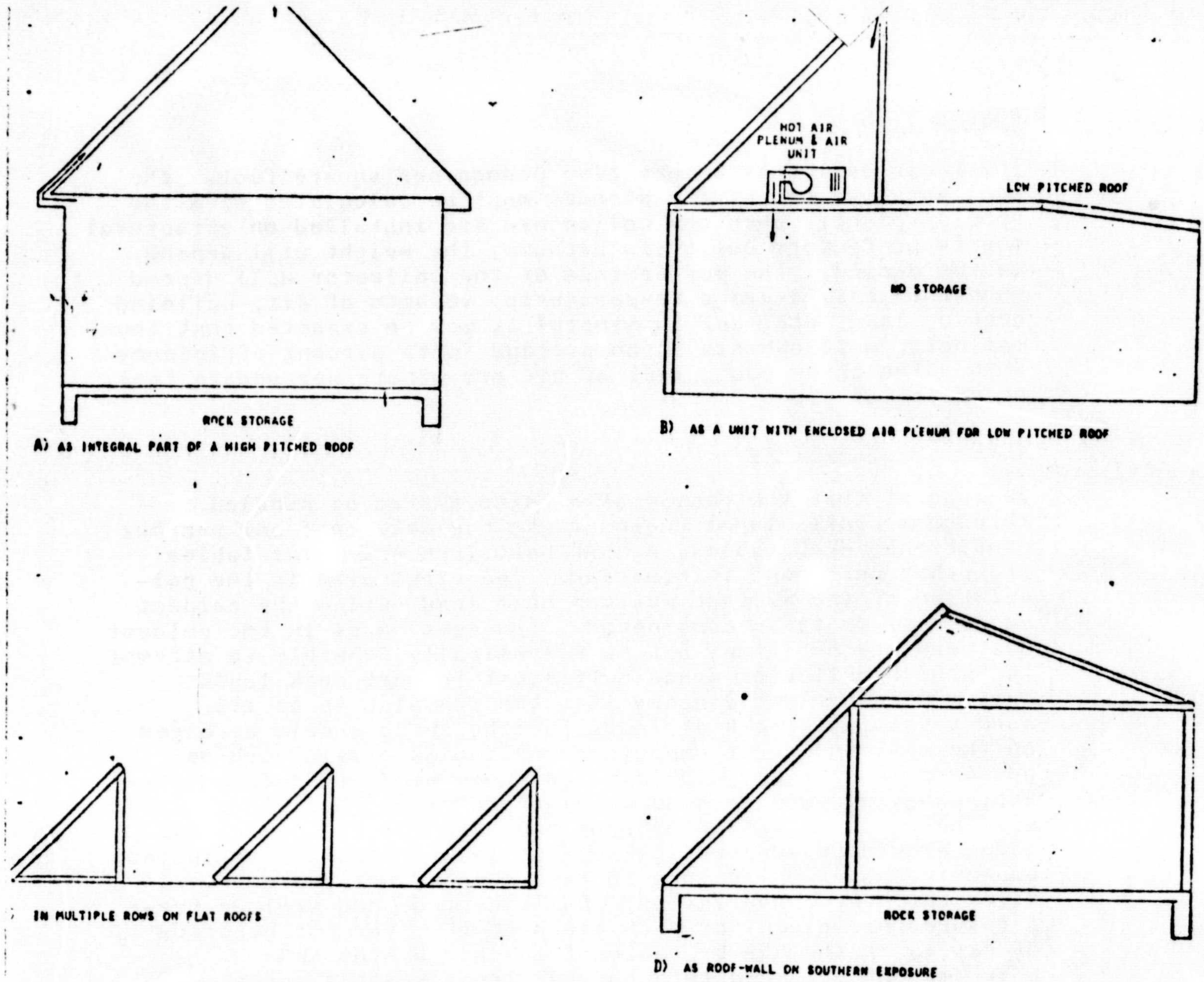


FIG. 5 - VARIOUS MOUNTING SYSTEMS

4. Unit Dimensions and Mounting Instructions

The SEECO Mod I collector can be mounted in various ways. Typical arrangements are shown on the drawing (Fig. 5). As a general rule, especially designed mounting flashings or straps are furnished by the factory and shipped with the unit. Typical strapping and hold-down flashings may be seen on the hot air plenum drawings, both ridge and eave. (Fig. 3).

The collectors may also be free standing for mounting on a flatter roof, either with especially designed mounting arrays or in factory fabricated housings which are also air plenums as shown on the typical drawings. (Fig. 5).

5. Physical Data

The basic collector weighs five pounds per square foot. The additional weight of the plenums must be calculated from the special plans. When the collectors are installed on structural mounts or factory built air plenums, the weight will depend on the design. The performance of the collector will depend upon the area, average temperatures, volumes of air, building heating load, etc. but in general it may be expected that the collector will operate at an average forty percent efficiency when using three cubic feet of air per minute per square foot of collector area.

6. Selection Procedure

We suggest that the design of a solar system be handled through a professional engineer who has data on local weather conditions, HVAC tables, ASHRAE heat loss and solar tables and other pertinent information. The first step is the calculation of the average maximum heat load during the coldest month that is to be considered. (In some cases in the coldest northern states it may not be economically feasible to attempt to furnish collector areas sufficient to meet peak loads during December and January when the sun also is at its lowest point.) The heat loads for the space should be based on the maximum use of energy conserving materials such as adequate insulation, double paned storm windows, good weather-stripping, minimum outside air introduction, etc. If possible all energy conservation methods suggested by the new ASHRAE codes should be adopted, because it is not feasible to install expensive solar collectors to heat spaces that are not maximized for heat conservation. Daily average and minimum temperatures are given for each month of the year for hundreds of cities in the USA by tables furnished by the NOAA which may be obtained through your local weather bureau. These tables also include data on solar insolation for each hour of the day, (Fig. II) and percentages of sunlight that may be expected for each month of the year. This information is readily available and any engineer who will work in solar energy should have it all in his files.

Once we have determined the maximum amount of sunshine and solar energy which we may expect to obtain on the design day chosen, we refer to our collector efficiency chart to determine how much usable energy we may expect to receive per day from our system. A simple formula is one in which the total maximum daily heat required, including stored heat, will be divided by the BTU per square foot which we may expect to obtain from our collector, will give us the total amount of collector area required.

$$Q = \frac{\text{Total BTU}}{\text{Coll. BTU/SQFT}} = \text{Collector Sq. Ft. Area}$$

Whether we use the required amount of collector area and the calculated amount of storage volume, will depend on the highly variable trade-off against total cost that we can obtain and there is no fixed rule of thumb to determine this, as the two main variables are the amount of solar heat available and the range of outside temperature which we choose as our base. For this reason we suggest that this selection work be done by an experienced HVAC solar engineer, and his methods and choices can be studied and employed on other projects at a later date.

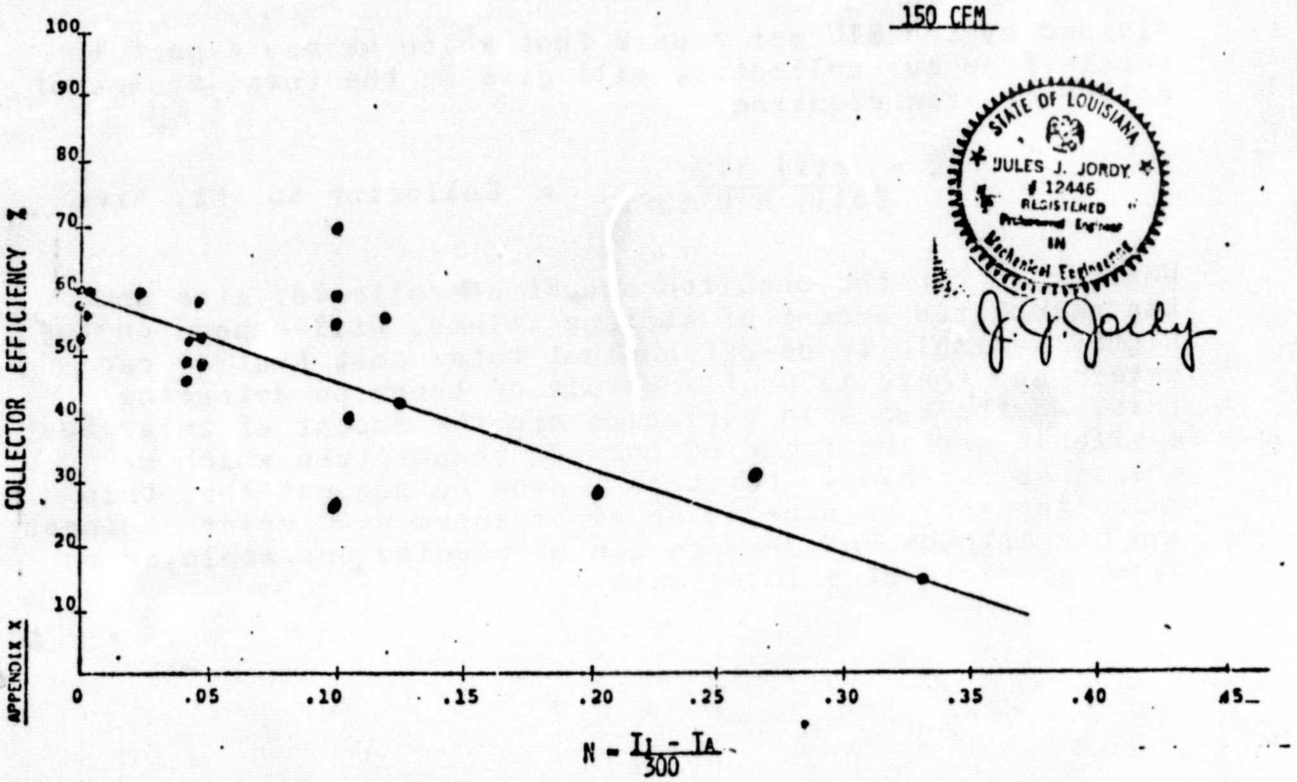


FIG. 6 - SEECO MOD I - PERFORMANCE CURVE

Collector Performance

The SEECO Mod I collector has been fully tested in accordance with approved Bureau of Standards and ASHRAE testing procedures and the curves (Fig. 6) should be an excellent guide for collector efficiency and selection under certain conditions. The efficiency chart will show how you should expect your SEECO collector to perform. Since this collector operates at peak efficiency at low operating temperatures, the thermal design is based on a twenty degree F. rise over the collector which means that the normal operating air temperature will be between 90° and 100° F. Air volume has been calculated on this basis also. On retrofit jobs the collector can be operated on other air volumes, if necessary to work in conjunction with existing hot air heating systems.

Selection Procedure

1. Calculate 24 hour heat load for building. This heat load should be based on the average daily temperature for the site, taken from NOAA climatological data, for the coldest month of the year. This will determine the temperature differential to be used in the heat load calculations. It will be important for the client to indicate the amount of heating that he will require, with particular reference to number of hours per day and specific temperatures required during the day and at night. (In our example calculation we have chosen a daytime temperature of 70 degrees for eight daylight hours at 70 degrees and 55 degrees for 16 hours - when solar heat is not available. The architect or the client should also specify the percentage of the total heat requirement that should be furnished by solar energy. For example, some system designers base their calculations on furnishing only 75% of the theoretical heat requirement and on the use of auxiliary heat at other times. It should also be noted that the sun does not shine 100% of the time and the days of effective sunlight are listed in the NOAA climatological data and the client should be made aware of this percentage, which should be taken into consideration when deciding on the amount of solar energy which will be required.

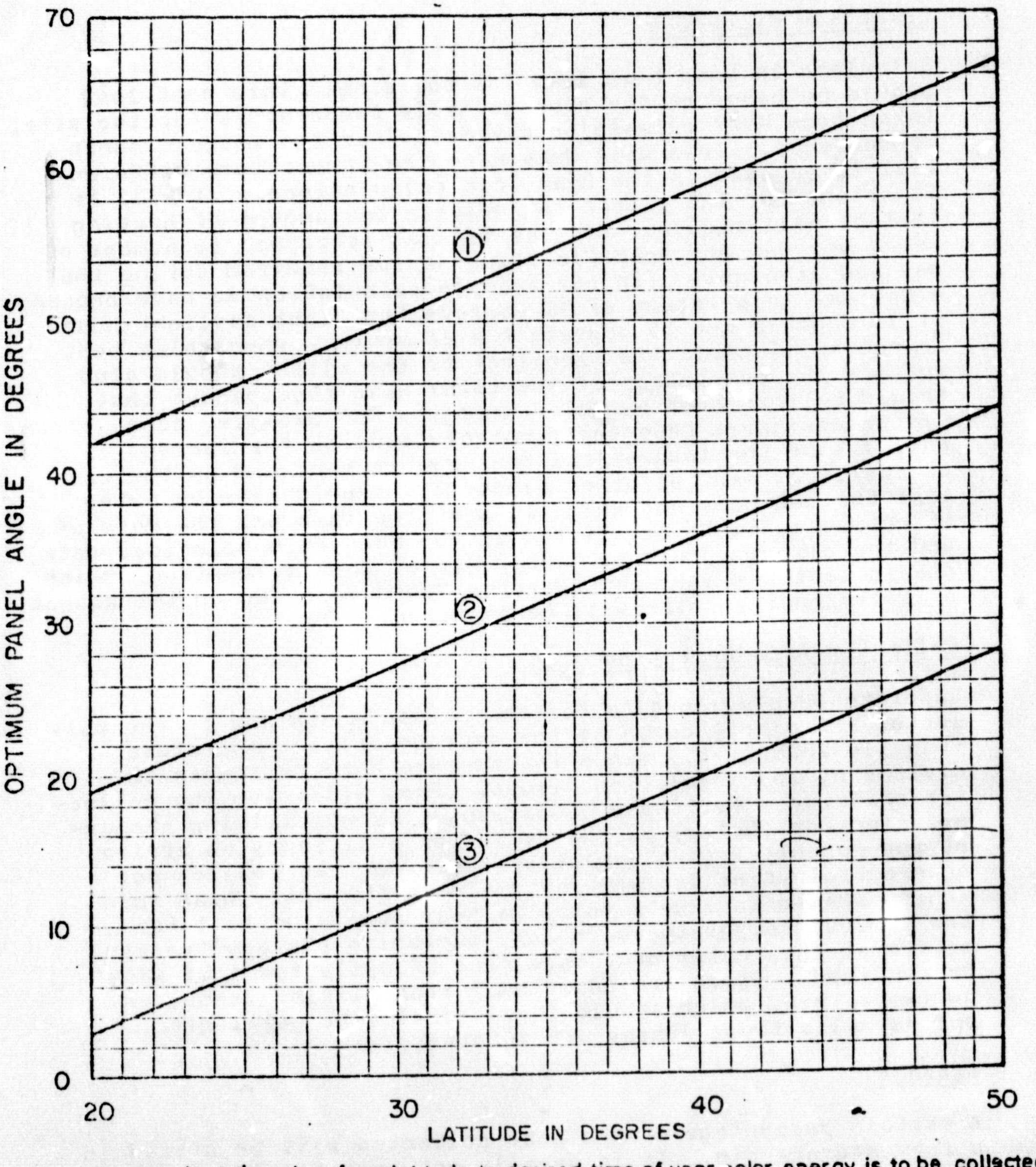
2. Collector Area Selection

Refer to insolation data for the chosen month and to the collector efficiency curve at the average inlet temperature (usually 70 deg. F.) minus the average outside temperature divided by the insolation figure. This will give the collector efficiency for those conditions. By multiplying the insolation for the day by the collector efficiency we arrive at the amount of usable heat we may expect to collect per square foot of collector. By dividing the daily heat load (which should include a total 24 hour supply of heat for the various temperatures chosen, including storage) we can arrive at the number of square feet of collector that will be required. There are additional transmission losses in ductwork, etc. which should theoretically be subtracted, but normally these losses are ignored.

Storage

A certain percentage of the heat collected will be stored in a rock storage bin. It is usually not economically feasible to store more than the heat required for the night hours. Many designers use only 75% of the night requirement. There are several ways to calculate the volume of the storage varying from rules of thumb such as one half cubic foot of rock per square foot of collector area while others base their volumes on ASHRAE data and the actual specific heat of the

RECOMMENDED PANEL INSTALLATION ANGLE FOR SOUTH FACING PANELS



To use chart, draw line from latitude to desired time of year solar energy is to be collected. Read panel angle directly left on chart.

① - For maximum winter insolation.
② - For maximum year round insolation.
③ - For maximum summer insolation.

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FIG. 7 COLLECTOR INCLINATION

rock which arrives at one cubic foot of rock per square foot of collector, but in most cases the actual amount of storage installed will depend on the space and the money available. Our example is based on ASHRAE data.

Storage

Solar air heating systems normally use a rock storage bin for storing heat collected during the day to heat the space at night. The heat collected requirement is usually the same as the daytime requirement depending upon the thermostat settings. Under normal conditions we would recommend a setting of 70 degrees F from 0700 to 0900 at night and a setting of 55 degrees from 1900 to 0700 or 50% - 50% division of heating requirement. Solar collector collecting ability should only be based on approximately 0900 to 1700 hours or a maximum of eight hours in the winter. We therefore must consider that we can use direct solar heat for only 8 hours and must store sufficient heat for 16 hours in our storage calculations. Useful storage temperatures may vary between 100 degrees F to 75 degrees F(when the thermostat is set at 55 degrees).

The calculation of actual storage volume will depend on several variables discussed under Selection Procedure. Usually, the amount of storage installed will depend on space available and costs.

There are several methods to store rocks. The storage tank may be placed outside of the house and underground, or it may be placed under the floor slab when this is on the ground and without basement. Plywood bins may be used, as shown in our typical design. (Fig. 8) These latter may be prefabricated and installed on the site. It is generally unfeasible to provide storage for more than one night, and some say that only 75% of this storage is effective. This has yet to be proved, as no exhaustive studies of rock storage have yet been made.

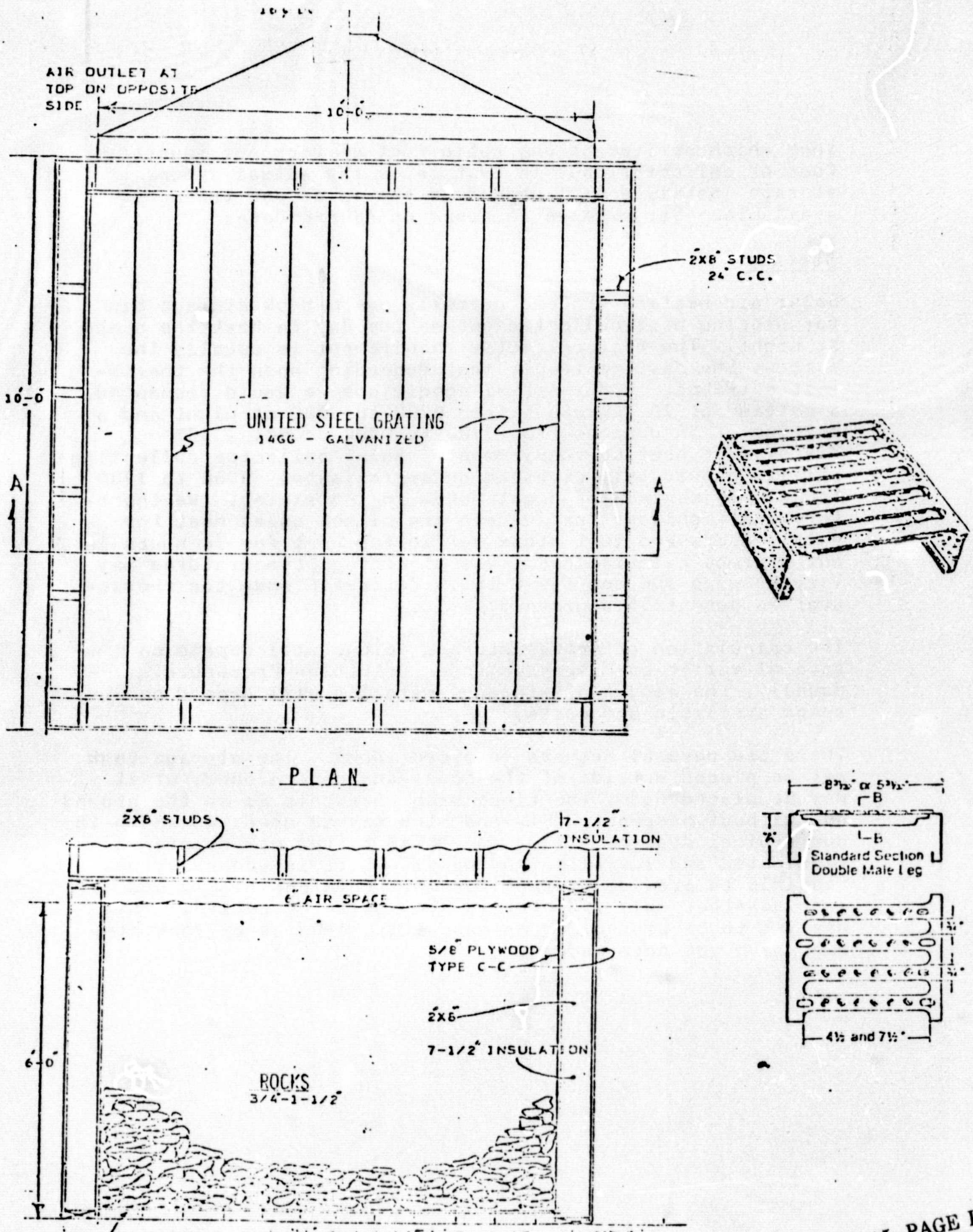
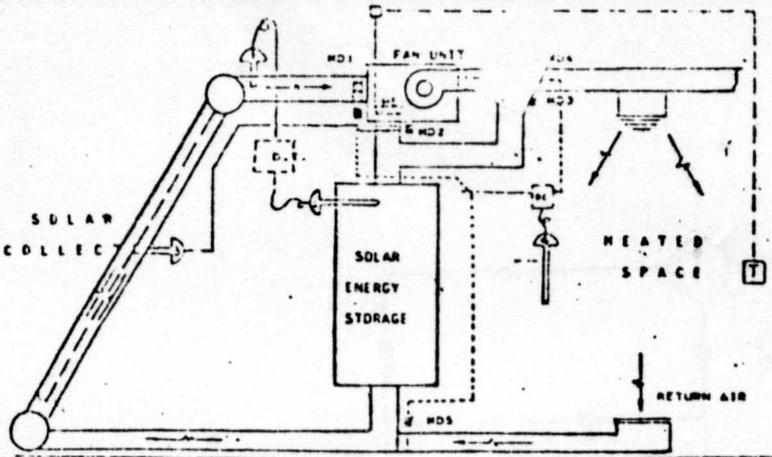


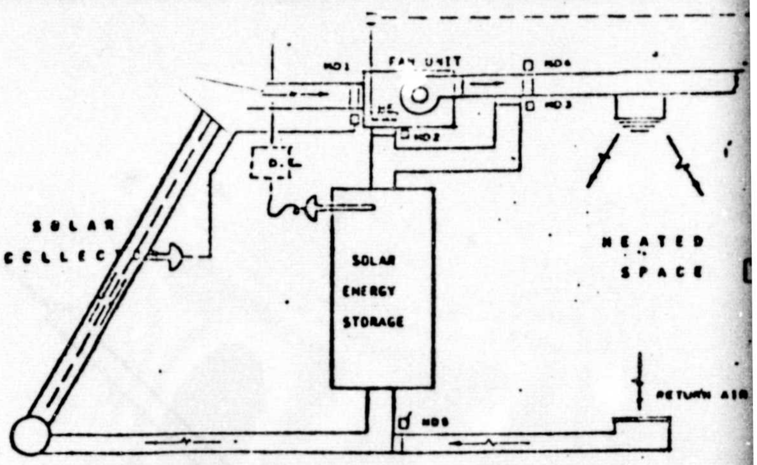
FIG. 8 TYPICAL ROCK STORAGE BIN



MODE NO. 1 - STORAGE CYCLE

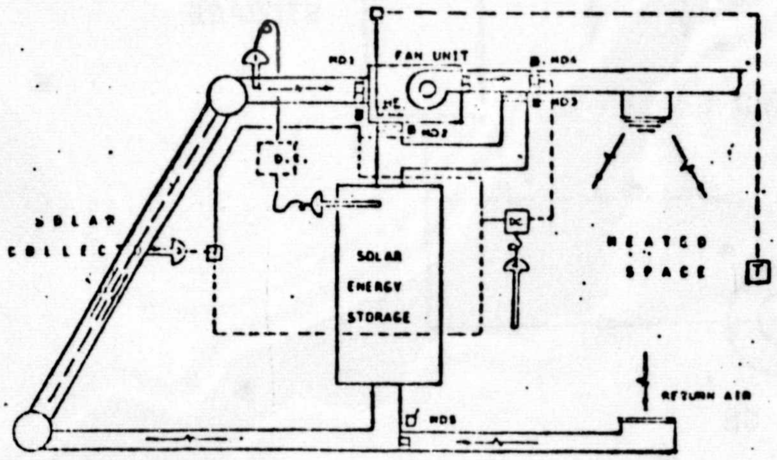
WHEN BUILDING TEMPERATURE IS SATISFIED SENSOR 4 ACTUATES RELAYS OPEN MD-1 AND CLOSE MD-2 AND SIMULTANEOUSLY TO CLOSE MD-5, CLOSE MD-4 AND OPEN MD-3. ALL DAMPER SETS, EXCLUDING MD-5, MAY BE INTERLINKED AND SPRING LOADED TO A NORMAL POSITION WHICH IS CHANGED BY MOTORIZED ACTION.

NOTE THAT STORAGE CYCLES MAY BE INTERMITTENT WITH HEATING CYCLES.



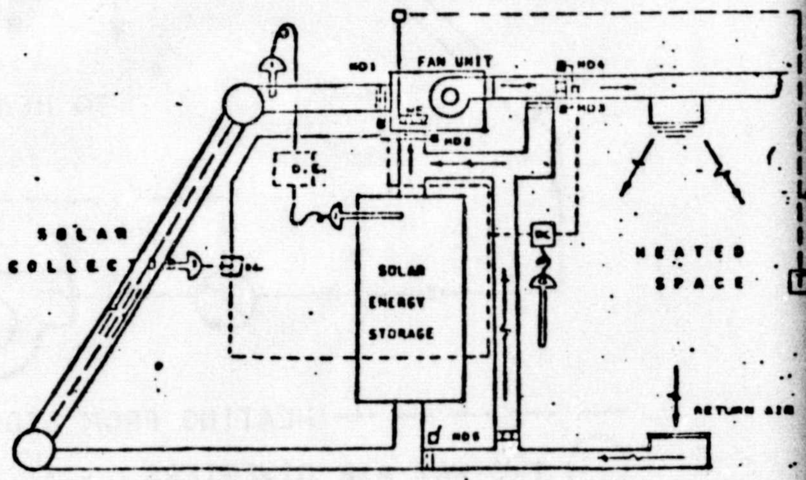
MODE NO. 4 - AUXILIARY HEAT

IN ALL OTHER MODES, WHEN SPACE THERMOSTAT T CALLS FOR ADDITIONAL HEAT IT ACTUATES AUXILIARY HEAT SOURCE HE TO FURNISH ADDITIONAL HEAT TO THE BUILDING. OTHER CONTROLS CONTINUE TO OPERATE IN ACCORDANCE WITH THE MODE IN EFFECT.



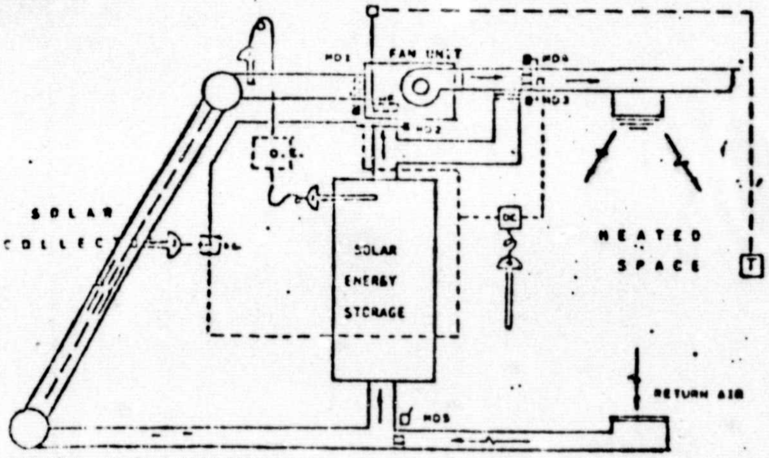
MODE NO. 2 - SOLAR HEATING CYCLE

WHEN SENSOR 3 INDICATES THAT SOLAR HEAT IS AVAILABLE IT ACTIVATES CIRCUIT TO SENSOR 4 WHICH WILL ACTIVATE DAMPER CIRCUIT AND OPEN MD-1, CLOSE MD-2, CLOSE MD-3, OPEN MD-4 AND OPEN MD-5, WHICH WILL ALLOW CIRCULATION OF SOLAR HEATED AIR THROUGH HEATED SPACE. THIS OPERATION MAY BE INTERMITTENT AS CONTROLLED BY SENSOR-4. THERMOSTAT T WILL ACTIVATE AUXILIARY HEATING SOURCE WHEN SOLAR HEAT IS NOT SUFFICIENT.



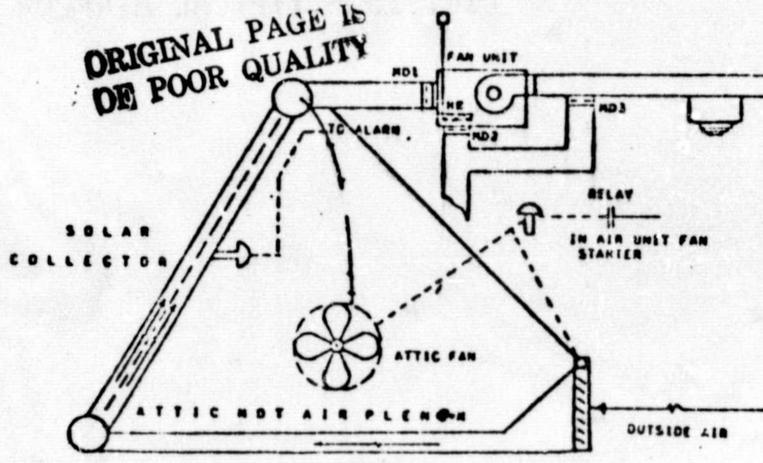
MODE NO. 5 - CONVENTIONAL SYSTEM

DAMPER MD-1 CLOSES INLET FROM SOLAR COLLECTOR. DAMPER MD-5 CLOSES RETURN TO COLLECTOR AND OPENS BYPASS DAMPER. MD-2 IS OPEN TO PERMIT RETURN TO CONVENTIONAL AIR UNIT. CONVENTIONAL SYSTEM IS THEN CONTROLLED BY ITS OWN SYSTEM.



MODE NO. 3 - HEATING FROM STORAGE

WHEN SENSOR 3 INDICATES THAT SOLAR HEAT IS NOT AVAILABLE IT CLOSES MD-1 AND OPENS MD-2. IF SENSOR 4 INDICATES THAT SPACE HEAT IS REQUIRED IT OPENS MD-4 AND CLOSES MD-3 AND OPENS MD-5. HEAT FROM STORAGE IS THEN CIRCULATED. IF NO SPACE HEAT IS REQUIRED MD-4 IS CLOSED AND FAN IS STOPPED.



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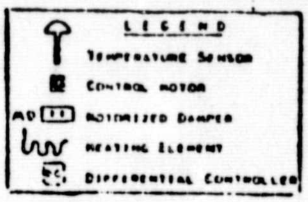
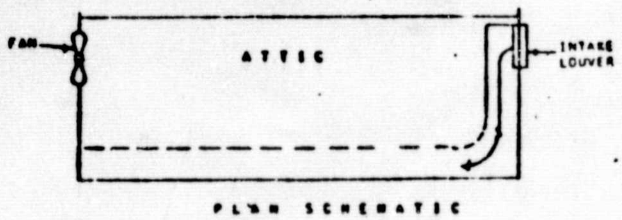
MODE NO. 6 - SUMMER VENTILATION

TO PREVENT STAGNATION AND OVERHEATING OF COLLECTOR IN SUMMER. A RELAY IN STARTER AIR UNIT WILL CLOSE WHEN FAN IS STOPPED. IF AMBIENT AIR SENSOR INDICATES A TEMPERATURE ABOVE A HIGH LIMIT IT CLOSES CIRCUIT AND STARTS ATTIC FAN AFTER OPENING INLET AIR SHUTTER. AN ALARM CIRCUIT SOUNDING AN AUDIBLE SIGNAL MAY BE INCORPORATED INTO THIS CIRCUIT IF DESIRED.





PLAN SCHEMATIC

FIG. 9 - CONTROL SYSTEM

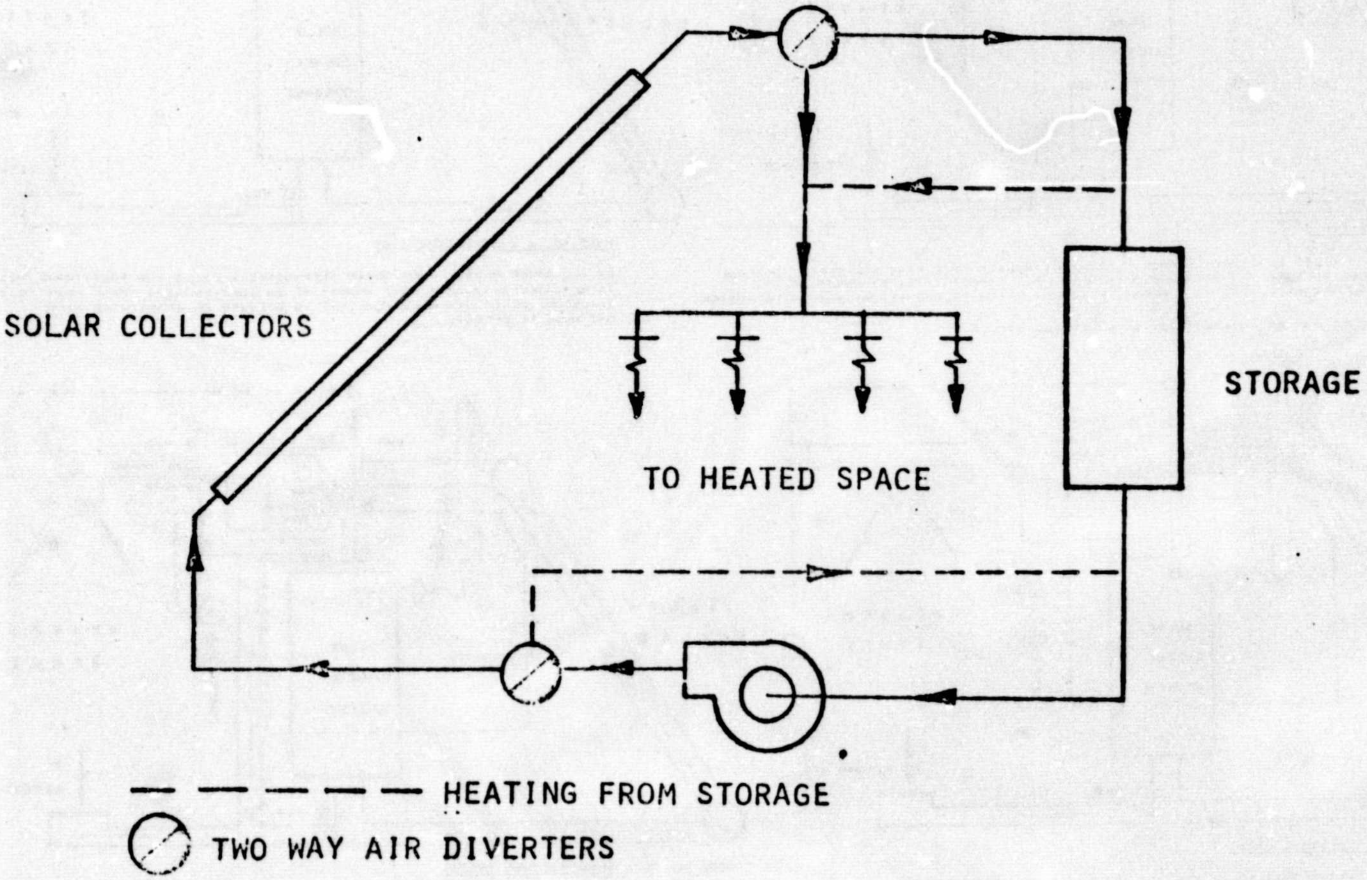


FIG. 10 - TYPICAL AIRFLOW DIAGRAM

9. <u>Guide Specification</u>

The solar collector system shall be of the air heater type. The system shall be designed to produce not less than ______ BTU per day when operating at a median temp. of ______ °F during the month of ______________ with a total daily solar insolation of __________ BTU/HR/Sq.Ft. of net collector area, as determined from the ASHRAE or NOAA climatological data. Latitude is ____________.

Collector absorption plates shall be made of 26 gauge steel with a black surface which shall have an absorption capability of not less than 90% with equal emissivity.

Collector case shall be 22 gauge galvanized steel. Cover window shall be two sheets of TEDLAR 4 mil thick special solar plastic film glued to steel frame with Monsanto GELVA or equal special adhesive. After glueing TEDLAR shall be shrunk on frame to drum tightness. Cover window shall be fastened to collector frame with self threading chromium plated TEK screws over a special polyester sponge type sealing gasket.

Collecting system shall include capacity to warm __________ gals. per day of domestic hot water from ______ degrees F to ________ degrees F through a copper tube air to water heat exchanger with aluminum fins. Solar contractor shall furnish heat exchanger, separate fan, and circulating pump, with a differential control thermostat in a separate self contained package which will attach to the existing conventional hot water system.

Heat load of space and interface design should be done by a registered professional engineer with experience in both HVAC and Solar design.

EXAMPLE

Three bedroom house at Ashland, MA.   Lat. = 45^o N

Floor area = 1300 sq. ft. Roof slope = 35^o

Refer to NOAA Climatological Data

Insolation, 21 Jan. - 1632 BTU/DAY/SqFt. (interpolated)
Average Min. Temp. = 30^oF

24 Hr. Heat Loss = 352,660 BTU
Night Loss (storage load) = 193,640 BTU
Average collector efficiency = 40% (See Fig.)

Collector Area Required

$$\frac{352,600 \text{ BTU/DAY}}{40\% \text{ Eff} \times 1632 \text{ BTU/sq ft}} = 540 \text{ sq. ft.}$$

Storage (night load only)

Temp. Diff. (night) = 75 - 55 = 20^oF

Rock Temp. range = $90^o - 70^o = 20^o$

Weight of crushed rock = 100 lbs./cu ft.

Specific Heat = .C2 BTU/^{o}F/LB = 20 BTU/CU FT.
= 20 BTU x 20^oF = 400 BTU/CU FT.

$$\text{Volume} = \frac{193,600}{400} = 484 \text{ cu. ft.}$$

Domestic Hot Water

4 Occupants at 15 gal. = 60 gal./day

60 x 8.33 = 500 lbs/day

Water in = 50^oF Out = 140^oF T.D. 90^o

500 lbs. x 90 T.D. = 45,000 BTU/day

$$\frac{45,000}{40\% \times 1632} = 69 \text{ sq. ft. of collector}$$

TABLE A1

Meteorological Data For The Current Year

Station: MADISON, WISCONSIN TRUAX FIELD Standard time used: CENTRAL Latitude: 43° 08' N Longitude: 89° 20' W Elevation (ground): 858 feet Year: 1979

Month	Temperature °F Averages: Daily maximum	Daily minimum	Monthly	Extremes: Highest	Date	Lowest	Date	Degree days Base 65 °F: Heating	Cooling	Precipitation in inches, Water equivalent: Total	Greatest in 24 hrs.	Date	Snow, Ice pellets: Total	Greatest in 24 hrs.	Date
JAN	30.9	12.9	21.9	53	10	-5	29	1329	0	0.98	0.34	9-10	3.2	1.8	2-3
FEB	29.9	12.9	21.3	47	21	-14	7	1222	0	1.54	0.47	17	20.9	5.6	23-24
MAR	36.0	14.2	25.1	51	31	-8	9	1195	0	3.09	0.93	21-22	10.0	4.7	6-7
APR	51.7	30.2	41.0	70	23	12	4	714	0	4.19	2.83	27-28	5.9	4.9	8
MAY	75.5	49.9	62.5	93	19	34	13	190	81	4.57	1.56	30	0.0	0.0	
JUN	80.9	57.5	69.2	93	20	41	8	43	176	4.30	1.09	14-15	0.0	0.0	
JUL	84.2	60.6	72.4	93	18	45	12	18	236	6.07	3.89	3	0.0	0.0	
AUG	81.7	59.5	70.6	93	23	44	7	11	190	5.25	1.07	28-29	0.0	0.0	
SEP	69.6	45.3	57.5	85	10	25	26	239	18	0.94	0.46	17-19	0.0	0.0	
OCT	67.1	37.7	52.2	90	13	23	27	412	21	0.64	0.34	24	0.0	0.0	
NOV	52.2	31.5	41.9	70	4	5	25	697	0	2.79	0.83	2-3	5.5	3.0	26-27
DEC	39.1	17.0	25.5	57	14	-3	10	1217	0	0.29	0.11	14	2.5	1.5	11
YEAR	57.7	35.9	46.8	93	AUG 23	-14	FEB 9	7235	742	34.59	3.89	JUL 3	50.3	5.6	FEB 23-24

Month	Relative humidity, pct. Hour 00 (Local time)	Hour 06	Hour 12	Hour 18	Wind Resultant: Direction	Speed m.p.h.	Average speed m.p.h.	Fastest mile: Speed m.p.h.	Direction	Date	Percent of possible sunshine	Average sky cover, tenths, sunrise to sunset	Number of days, Sunrise to sunset: Clear	Partly cloudy	Cloudy	Precipitation .01 inch or more	Snow, Ice pellets 1.0 inch or more	Thunderstorms	Heavy fog, visibility ¼ mile or less	Temperature °F Maximum: 90° and above (b)	32° and below	Minimum: 32° and below	0° and below	Average station pressure mb. Elev. 866 feet m.s.l.
JAN	92	86	79	77	25	4.6	9.8	44	SW	11	27	8.2	4	3	24	12	2	1	3	0	15	30	6	987.7
FEB	82	84	66	72	31	2.9	9.9	36	W	25	37	7.6	5	5	18	13	6	1	1	0	14	29	8	984.1
MAR	93	85	65	70	32	1.1	9.2	35	E	27	55	7.1	5	9	17	14	3	3	4	0	12	26	6	983.6
APR	82	83	57	61	07	2.4	9.4	26	SW	29	45	7.3	5	7	18	11	1	3	3	0	1	19	0	986.3
MAY	75	78	50	51	20	1.2	8.3	38	SW	19	63	6.9	4	13	14	12	0	6	0	3	0	0	0	982.6
JUN	79	80	56	58	19	2.7	8.9	42	W	13	57	5.8	4	12	14	19	0	12	1	6	0	0	0	982.4
JUL	78	79	50	53	25	3.6	7.9	25	NE	3	75	4.3	13	13	5	7	0	6	1	8	0	0	0	989.7
AUG	80	83	57	61	19	1.3	7.5	31	SE	1	47	7.0	5	9	17	10	0	12	3	5	0	0	0	985.9
SEP	84	88	54	53	25	2.4	7.9	22	NW	23	54	5.8	9	9	12	7	0	1	0	0	0	2	0	987.5
OCT	79	84	47	50	21	4.3	9.4	30	SW	24	67	4.5	13	6	12	3	0	2	0	1	0	10	0	985.1
NOV	86	89	72	78	22	3.1	10.2	42	SW	29	37	7.1	9	2	19	12	4	2	7	0	4	15	0	983.7
DEC	86	87	76	82	30	2.0	9.7	34	SW	14	24	8.2	3	4	24	6	1	0	1	0	10	29	2	987.8
YEAR	81	84	60	66	24	1.7	8.9	44	SW	JAN 11	51	6.7	79	92	194	130	17	49	24	23	64	159	20	984.[illegible]

Normals, Means, And Extremes

Month	Temperatures °F Normal: Daily maximum	Daily minimum	Monthly	Extremes: Record highest	Year	Record lowest	Year	Normal Degree days Base 65 °F: Heating	Cooling	Precipitation in inches, Water equivalent: Normal	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Snow, Ice pellets: Maximum monthly	Year	Maximum in 24 hrs.	Year
(a)				16		16					35		35		27		27		27	
J	25.6	8.2	16.9	56	1967	-30	1953	1494	0	1.25	2.45	1974	0.19	1961	1.27	1960	21.7	1971	11.4	1971
F	29.5	11.1	20.3	56	1957	-23	1965	1252	0	0.95	2.77	1953	0.09	1959	1.35	1953	20.9	1973	10.3	1950
M	39.2	21.2	30.2	78	1967	-27	1962	1079	0	1.93	5.06	1973	0.38	1958	2.27	1973	25.6	1959	13.6	1971
A	56.0	34.6	45.3	87	1962	9	1972	591	0	2.56	7.11	1973	0.76	1946	2.93	1975	17.4	1973	12.9	1973
M	67.3	44.5	55.0	93	1975	20	1966	297	18	3.41	6.26	1960	0.95	1971	3.56	1966	0.7	1966	0.7	1966
J	76.9	55.5	65.8	95	1971	31	1972	72	76	4.33	8.15	1963	0.81	1973	3.67	1943	0.0		0.0	
J	81.4	58.8	70.1	98	1955	36	1967	16	172	3.81	10.73	1950	1.38	[illegible]	5.25	1950	0.0		0.0	
A	80.0	57.3	68.7	95	1964	39	1965	37	154	3.05	7.47	1972	0.70	1964	2.90	1965	0.0		0.0	
S	71.2	48.5	59.7	90	1973	25	1974	173	14	3.36	9.51	1961	0.49	1952	3.57	1961	T	1955	T	1955
O	60.5	38.3	49.9	90	1975	15	1972	474	6	2.16	5.55	1959	0.05	1952	2.01	1960	0.7	1967	0.7	1967
N	43.0	26.4	34.7	76	1964	1	1964	909	0	1.87	3.94	1961	0.34	1952	2.32	1971	8.9	1954	6.8	1954
D	29.8	14.0	21.9	62	1970	-22	1962	1336	0	1.47	3.04	1971	0.25	1960	1.65	1971	20.8	1970	16.0	1970
YR	55.0	34.8	44.9	98	JUL 1955	-30	JAN 1953	7730	460	30.25	10.93	JUL 1950	0.06	OCT 1952	5.25	JUL 1950	25.4	MAR 1959	16.0	DEC 1970

Month	Relative humidity pct. Hour 00 (Local time)	Hour 06	Hour 12	Hour 18	Wind: Mean speed m.p.h.	Prevailing direction	Fastest mile: Speed m.p.h.	Direction	Year	Pct. of possible sunshine	Mean sky cover, tenths, sunrise to sunset	Mean number of days, Sunrise to sunset: Clear	Partly cloudy	Cloudy	Precipitation .01 inch or more	Snow, Ice pellets 1.0 inch or more	Thunderstorms	Heavy fog, visibility ¼ mile or less	Temperatures °F Max.: 90° and above (b)	32° and below	Min.: 32° and below	0° and below	Average station pressure mb. Elev. 866 feet m.s.l.
(a)	16	15	15	16	27	14	29	29		27	27	29	29	29	27	27	27	27	16	14	14	16	3
J	77	73	69	73	10.5	WNW	58	S	1967	48	6.9	8	6	17	10	2	*	3	0	20	31	11	986.9
F	77	77	64	67	10.6	WNW	57	W	1948	52	6.8	7	6	15	8	2	*	2	0	16	25	7	985.7
M	76	81	64	67	11.3	NW	70	SW	1956	56	6.9	6	8	17	11	3	2	3	0	7	27	2	983.0
A	76	81	59	57	11.5	NW	73	SW	1967	52	6.8	6	8	16	11	1	4	1	0	*	15	0	983.1
M	77	80	55	55	10.4	S	77	SW	1950	58	6.5	7	9	15	12	0	6	1	*	0	4	0	980.7
J	81	83	57	57	9.2	S	57	W	1947	64	6.1	7	10	13	11	0	7	1	5	0	*	0	981.3
J	85	86	57	55	8.7	S	72	NW	1951	69	5.6	9	12	10	9	0	7	1	4	0	0	0	984.1
A	87	90	57	57	8.1	S	67	W	1955	68	5.6	10	11	10	9	0	6	2	3	0	0	0	985.6
S	85	92	61	69	8.8	S	52	[illegible]	1959	62	5.7	10	8	12	9	0	4	1	1	0	1	0	[illegible]
O	81	86	57	67	9.6	S	73	SW	1951	57	5.7	10	8	13	9	0	2	2	*	*	9	0	[illegible]
N	83	85	68	75	10.9	S	56	SE	1947	40	7.2	5	6	18	9	1	1	2	0	3	21	0	[illegible]
D	82	83	73	78	10.2	W	65	SW	1949	39	7.2	6	6	19	10	3	*	3	0	18	27	6	[illegible]
YR	81	84	62	66	9.9	S	77	SW	MAY 1950	57	6.4	92	98	175	117	12	41	22	11	65	163	29	986.3

Means and extremes above are from existing and comparable exposures. Annual extremes have been exceeded at other sites in the locality as follows: Highest temperature 107 in July 1936; lowest temperature -37 in January 1951; minimum monthly precipitation T in October 1889 and earlier; maximum precipitation in 24 hours 5.31 in September 1941; maximum monthly snowfall 31.8 in January 1929.

(a) Length of record, years, through the current year unless otherwise noted, based on January data.
(b) 70° and above at Alaskan stations.
* Less than one half.
T Trace.

NORMALS - Based on record for the 1941-1970 period.
DATE OF AN EXTREME - The most recent in cases of multiple occurrence.
PREVAILING WIND DIRECTION - Record through 1963.
WIND DIRECTION - Numerals indicate tens of degrees clockwise from true north. 00 indicates calm.
FASTEST MILE WIND - Speed is fastest observed 1-minute value when the direction is in tens of degrees.

FIG. 11 - TYPICAL CLIMATOLOGICAL DATA

OKLAHOMA CITY, OKLAHOMA

TABLE A2 ... SOLAR POSITION AND INSOLATION VALUES FOR 32 DEGREES NORTH LATITUDE

DATE	SOLAR TIME AM	SOLAR TIME PM	SOLAR POSITION ALT	SOLAR POSITION AZM	BTUH/SQ. FT. TOTAL INSOLATION ON SURFACES NORMAL	HORIZ.	SOUTH FACING SURFACE ANGLE WITH HORIZ. 22	32	42	52	90
JAN 21	7	5	1.4	65.2	1	0	0	0	0	1	1
	8	4	12.5	56.5	203	56	93	106	116	123	115
	9	3	22.5	46.0	269	118	175	193	206	212	181
	10	2	30.6	33.1	295	167	215	256	269	274	221
	11	1	36.1	17.5	306	198	273	295	308	312	245
	12		38.0	0.0	310	209	295	306	321	324	253
	SURFACE DAILY TOTALS				2458	1288	1839	2005	2118	2166	1779
FEB 21	7	5	7.1	73.5	121	22	34	37	40	42	38
	8	4	19.0	64.4	247	95	127	136	140	141	108
	9	3	29.9	53.4	288	161	206	217	222	220	158
	10	2	39.1	39.4	306	212	266	278	283	279	193
	11	1	45.6	21.4	315	244	304	317	321	315	214
	12		48.0	0.0	317	255	316	330	334	328	222
	SURFACE DAILY TOTALS				2672	1724	2188	2300	2345	2322	1644
MAR 21	7	5	12.7	81.9	185	54	60	60	59	56	32
	8	4	25.1	73.0	260	129	146	147	144	137	78
	9	3	36.8	62.1	290	194	222	224	220	209	119
	10	2	47.3	47.5	304	245	290	283	278	265	150
	11	1	55.0	26.8	311	277	317	321	315	300	170
	12		58.0	0.0	313	287	329	333	327	312	177
	SURFACE DAILY TOTALS				3012	2084	2378	2403	2358	2246	1276
APR 21	6	6	6.1	99.9	66	14	9	6	6	5	3
	7	5	18.8	92.2	206	86	78	71	62	51	10
	8	4	31.5	84.0	255	158	156	148	136	120	35
	9	3	43.9	74.2	278	220	225	217	203	183	68
	10	2	55.7	60.3	290	267	279	272	256	234	95
	11	1	65.4	37.5	295	297	313	306	290	265	112
	12		69.6	0.0	297	307	325	318	301	276	119
	SURFACE DAILY TOTALS				3076	2390	2444	2356	2206	1994	764
MAY 21	6	6	10.4	107.2	119	36	21	13	13	12	7
	7	5	22.8	100.1	211	107	88	75	60	44	13
	8	4	35.4	92.9	250	175	159	145	127	105	15
	9	3	48.1	84.7	269	233	223	209	188	163	33
	10	2	60.6	73.3	280	277	273	259	237	208	56
	11	1	72.0	51.9	285	305	305	290	268	237	72
	12		78.0	0.0	286	315	315	301	278	247	77
	SURFACE DAILY TOTALS				3112	2582	2454	2284	2064	1788	469
JUN 21	6	6	12.2	110.2	131	45	26	16	15	14	4
	7	5	24.3	103.4	210	115	91	75	59	41	14
	8	4	36.9	96.8	245	180	159	143	122	99	16
	9	3	49.6	89.4	264	236	221	204	181	153	19
	10	2	62.2	79.7	274	279	268	251	227	197	41
	11	1	74.2	60.9	279	306	299	282	257	224	56
	12		81.5	0.0	280	315	309	292	267	234	60
	SURFACE DAILY TOTALS				3084	2634	2436	2234	1990	1690	370
JUL 21	6	6	10.7	107.7	113	37	22	14	13	12	8
	7	5	23.1	100.6	203	107	87	75	60	44	14
	8	4	35.7	93.6	241	174	158	143	125	104	16
	9	3	48.4	85.5	261	231	220	205	185	159	31
	10	2	60.9	74.3	271	274	269	254	232	204	54
	11	1	72.4	53.3	277	302	300	285	262	232	69
	12		78.6	0.0	279	311	310	296	273	242	74
	SURFACE DAILY TOTALS.				3012	2558	2422	2250	2030	1754	458
AUG 21	6	6	6.5	100.5	59	14	9	7	6	6	4
	7	5	19.1	92.8	190	85	77	69	60	50	12
	8	4	31.8	84.7	240	156	152	144	132	116	33
	9	3	44.3	75.0	263	216	220	212	197	178	65
	10	2	56.1	61.3	276	262	272	264	249	226	91
	11	1	66.0	38.4	282	292	305	298	281	257	107
	12		70.3	0.0	284	302	317	309	292	268	113
	SURFACE DAILY TOTALS				2902	2352	2388	2296	2144	1934	736
SEP 21	7	5	12.7	81.9	163	51	56	56	55	52	30
	8	4	25.1	73.0	240	124	140	141	138	131	75
	9	3	36.8	62.1	272	188	213	215	211	201	134
	10	2	47.3	47.5	287	237	270	273	268	255	145
	11	1	55.0	25.8	294	268	306	309	303	289	164
	12		59.0	0.0	296	278	318	321	315	300	171
	SURFACE DAILY TOTALS				2568	2014	2288	2308	2264	2154	1226
OCT 21	7	5	6.8	73.1	99	19	29	32	34	36	37
	8	4	18.7	64.0	229	90	120	128	133	134	104
	9	3	29.5	53.0	273	155	198	208	213	212	153
	10	2	38.7	39.1	293	204	257	263	273	270	185
	11	1	45.1	21.1	302	235	294	307	311	306	209
	12		47.5	0.0	304	247	306	320	324	318	217
	SURFACE DAILY TOTALS				2696	1654	2100	2208	2252	2232	[illegible]
NOV 21	7	5	1.5	65.4	2	0	0	0	1	1	1
	8	4	12.7	56.6	196	55	91	104	113	119	111
	9	3	22.6	46.1	263	118	173	190	202	208	176
	10	2	30.8	33.2	280	165	233	252	265	270	217
	11	1	36.2	17.6	301	197	270	291	303	[illegible]	[illegible]
	12		38.2	0.0	304	207	282	304	316	[illegible]	[illegible]
	SURFACE DAILY TOTALS				2406	1280	1816	1980	2084	[illegible]	[illegible]
DEC 21	8	4	10.3	53.8	176	41	77	90	101	108	[illegible]
	9	3	19.8	43.6	257	102	161	180	195	204	183
	10	2	27.6	31.2	288	150	221	244	259	267	225
	11	1	32.7	16.4	301	180	258	282	298	305	251
	12		34.6	0.0	304	190	271	295	311	318	259
	SURFACE DAILY TOTALS				2348	1136	1704	1888	2016	2086	1794

NOTE:
1) BASED ON DATA IN TABLE 1, pp 387 in 1972 ASHRAE HANDBOOK OF FUNDAMENTALS: 0% GROUND REFLECTANCE; 1.0 CLEARNESS FACTOR.
2) SEE FIG. 4, pp 394 in 1972 ASHRAE HANDBOOK OF FUNDAMENTALS FOR TYPICAL REGIONAL CLEARNESS FACTORS.
3) GROUND REFLECTION NOT INCLUDED ON NORMAL OR HORIZONTAL SURFACES.

TABLE A3 ... SOLAR POSITION AND INSOLATION VALUES FOR 40 DEGREES NORTH LATITUDE

DATE	SOLAR TIME		SOLAR POSITION		BTUH/SQ. FT. TOTAL INSOLATION ON SURFACES						
							SOUTH FACING SURFACE ANGLE WITH HORIZ.				
	AM	PM	ALT	AZM	NORMAL	HORIZ.	30	40	50	60	90
JAN 21	8	4	8.1	55.3	142	28	65	74	81	85	84
	9	3	16.8	44.0	239	83	155	171	182	187	171
	10	2	23.8	30.9	274	127	218	237	249	254	223
	11	1	28.4	16.0	289	154	257	277	290	293	253
	12		30.0	0.0	294	164	270	291	303	306	263
	SURFACE DAILY TOTALS				2182	948	1660	1810	1906	1944	1726
FEB 21	7	5	4.3	72.7	69	10	19	21	23	24	22
	8	4	15.4	62.2	224	73	114	122	126	127	107
	9	3	25.0	50.2	274	132	195	205	209	208	167
	10	2	32.8	35.9	295	178	256	267	271	267	210
	11	1	38.1	18.9	305	206	293	306	310	304	236
	12		40.0	0.0	308	216	306	319	323	317	245
	SURFACE DAILY TOTALS				2640	1414	2060	2152	2202	2176	1730
MAR 21	7	5	11.4	80.2	171	46	55	55	54	51	35
	8	4	22.5	69.6	250	114	140	141	138	131	89
	9	3	32.8	57.3	282	173	215	217	213	202	138
	10	2	41.6	41.9	297	218	273	276	271	258	176
	11	1	47.7	22.6	305	247	310	313	307	293	200
	12		50.0	0.0	307	257	322	326	320	305	208
	SURFACE DAILY TOTALS				2916	1852	2308	2330	2284	2174	1484
APR 21	6	6	7.4	98.9	89	20	11	8	7	7	4
	7	5	18.9	89.5	206	87	77	70	61	50	12
	8	4	30.3	79.3	252	152	153	145	133	117	53
	9	3	41.3	67.2	274	207	221	213	199	179	93
	10	2	51.2	51.4	286	250	275	267	252	229	126
	11	1	58.7	29.2	292	277	308	301	285	260	147
	12		61.6	0.0	293	287	320	313	296	271	154
	SURFACE DAILY TOTALS				3092	2274	2412	2320	2168	1956	1022
MAY 21	5	7	1.9	114.7	1	0	0	0	0	0	0
	6	6	12.7	105.6	144	49	25	15	14	13	9
	7	5	24.0	96.6	216	214	89	76	60	44	13
	8	4	35.4	87.2	250	175	158	144	125	104	25
	9	3	46.8	76.0	267	227	221	206	186	160	60
	10	2	57.5	60.9	277	267	270	255	233	205	89
	11	1	66.2	37.1	283	293	301	287	264	234	108
	12		70.0	0.0	284	301	312	297	274	243	114
	SURFACE DAILY TOTALS				3160	2552	2642	2264	2040	1760	724
JUN 21	5	7	4.2	117.3	22	4	3	3	2	2	1
	6	6	14.8	108.4	155	60	30	18	17	16	10
	7	5	26.0	99.7	216	123	92	77	59	41	14
	8	4	37.4	90.7	246	182	159	142	121	97	16
	9	3	48.8	80.2	263	233	219	202	179	151	47
	10	2	59.8	65.8	272	272	266	248	224	194	74
	11	1	69.2	41.9	277	296	296	278	253	221	92
	12		73.5	0.0	279	304	306	289	263	230	98
	SURFACE DAILY TOTALS				3180	2648	2434	2224	1974	1670	610
JUL 21	5	7	2.3	115.2	2	0	0	0	0	0	0
	6	6	13.1	106.1	138	50	26	17	15	14	9
	7	5	24.3	97.2	208	114	89	75	60	44	14
	8	4	35.8	87.8	241	174	157	142	124	102	24
	9	3	47.2	76.7	259	225	218	203	182	157	58
	10	2	57.9	61.7	269	265	266	251	229	200	86
	11	1	66.7	37.9	275	290	296	281	258	228	104
	12		70.6	0.0	276	298	307	292	269	238	111
	SURFACE DAILY TOTALS				3062	2534	2409	2230	2006	1728	702
AUG 21	6	6	7.9	99.5	81	21	12	9	8	7	5
	7	5	19.3	90.0	191	87	76	69	60	49	17
	8	4	30.7	79.9	237	150	150	141	129	113	50
	9	3	41.8	67.9	260	205	216	207	193	173	83
	10	2	51.7	52.1	272	246	267	259	244	221	120
	11	1	59.3	29.7	278	273	300	292	276	257	140
	12		62.3	0.0	280	282	311	303	287	267	147
	SURFACE DAILY TOTALS				2916	2244	2354	2258	2104	1894	978
SEP 21	7	5	11.4	80.2	149	43	51	51	49	47	32
	8	4	22.5	69.6	239	109	133	134	131	124	84
	9	3	32.8	57.3	263	167	206	208	203	193	132
	10	2	41.6	41.9	280	211	262	265	260	247	168
	11	1	47.7	22.6	287	239	298	301	295	281	192
	12		50.0	0.0	290	249	310	313	307	292	200
	SURFACE DAILY TOTALS				2708	1788	2210	2228	2182	2074	1416
OCT 21	7	5	4.5	72.3	48	7	14	15	[illegible]	[illegible]	[illegible]
	8	4	15.0	61.9	204	68	106	113	117	118	100
	9	3	24.5	49.8	257	125	185	195	200	198	160
	10	2	32.4	35.6	280	170	245	257	261	257	203
	11	1	37.6	18.7	291	199	283	295	299	294	229
	12		39.5	0.0	294	208	295	308	312	306	238
	SURFACE DAILY TOTALS				2454	1348	1962	2060	2098	2074	[illegible]
NOV 21	8	4	8.2	55.4	136	28	63	72	78	82	81
	9	3	17.0	44.1	232	82	152	167	178	183	167
	10	2	24.0	31.0	268	126	215	233	245	249	219
	11	1	28.6	16.1	283	153	254	273	285	288	248
	12		30.2	0.0	288	163	267	287	298	301	258
	SURFACE DAILY TOTALS				2128	942	1636	1778	1870	1906	1726
DEC	8	4	5.5	53.0	89	14	39	45	50	54	56
	9	3	14.0	41.9	217	65	135	152	164	171	163
	10	2	20.7	29.4	251	107	200	221	235	242	221
	11	1	25.0	15.2	280	134	239	252	276	283	257
	12		26.6	0.0	285	143	253	275	290	296	263
	SURFACE DAILY TOTALS				1978	782	1480	1634	1740	1796	1646

1 BTUH/SQ. FT. = 3.152 W/m^2

NOTE:
1) BASED ON DATA IN TABLE 1, P. 387 IN REF. [3]; 0% GROUND REFLECTANCE; 1.0 CLEARNESS FACTOR.
2) SEE FIG. 4, P. 394 IN [3] FOR TYPICAL REGIONAL CLEARNESS FACTORS.
3) GROUND REFLECTION NOT INCLUDED ON NORMAL OR HORIZONTAL SURFACES.

TABLE A4 ... SOLAR POSITION AND INSOLATION VALUES FOR 48 DEGREES NORTH LATITUDE

DATE	SOLAR TIME AM	SOLAR TIME PM	SOLAR POSITION ALT	SOLAR POSITION AZM	BTUH/SQ. FT. TOTAL INSOLATION ON SURFACES NORMAL	HORIZ.	SOUTH FACING SURFACE ANGLE WITH HORIZ. 38	48	58	68	90
JAN 21	8	4	3.5	54.6	37	6	17	19	21	22	22
	9	3	11.0	42.6	185	46	120	132	149	145	199
	10	2	16.9	29.0	239	83	190	206	216	220	206
	11	1	20.7	15.1	261	107	231	243	250	263	243
	12		22.0	0.0	267	115	245	264	275	278	255
	SURFACE DAILY TOTALS				1710	596	1360	1478	1550	1578	1478
FEB 21	7	5	2.4	72.2	12	1	3	4	4	4	4
	8	4	11.6	60.5	188	49	95	102	105	106	96
	9	3	19.7	47.7	251	100	178	187	191	190	167
	10	2	26.2	33.3	278	139	240	251	255	251	217
	11	1	30.5	17.2	290	165	278	290	294	288	247
	12		32.0	0.0	293	173	291	304	307	301	258
	SURFACE DAILY TOTALS				2330	1080	1880	1972	2024	1978	1720
MAR 21	7	5	10.0	78.7	153	37	49	49	47	45	35
	8	4	19.5	66.8	236	96	131	132	129	122	96
	9	3	28.2	53.4	270	147	205	207	203	193	152
	10	2	35.4	37.8	287	187	263	266	261	248	195
	11	1	40.3	19.8	295	212	300	303	297	283	223
	12		42.0	0.0	298	220	312	315	309	294	232
	SURFACE DAILY TOTALS				2780	1578	2208	2228	2182	2074	1632
APR 21	6	6	8.6	97.8	108	27	13	9	8	7	5
	7	5	18.6	85.7	205	85	76	69	59	48	21
	8	4	28.5	74.9	247	142	149	141	129	113	69
	9	3	37.8	61.2	268	191	216	208	194	174	115
	10	2	45.8	44.6	280	228	268	260	245	223	152
	11	1	51.5	24.0	286	252	301	294	278	254	177
	12		53.5	0.0	288	260	313	305	289	264	185
	SURFACE DAILY TOTALS				3076	2106	2358	2266	2114	1902	1262
MAY 21	5	7	5.2	114.3	41	9	4	4	4	3	2
	6	6	14.7	103.7	162	61	27	16	15	13	10
	7	5	24.6	93.0	219	118	89	75	50	43	13
	8	4	34.7	81.6	248	171	156	142	123	101	45
	9	3	44.3	68.3	264	217	217	202	182	156	86
	10	2	53.0	51.3	274	252	265	251	229	200	120
	11	1	59.5	28.6	279	274	296	281	258	228	141
	12		62.0	0.0	280	281	306	292	269	238	149
	SURFACE DAILY TOTALS				3254	2482	2418	2234	2010	1728	982
JUN 21	5	7	7.9	116.5	77	21	9	9	8	7	5
	6	6	17.2	106.2	172	74	33	19	18	16	12
	7	5	27.0	95.8	220	129	[illegible]	77	59	39	15
	8	4	37.1	84.6	246	181	157	140	119	95	35
	9	3	46.9	71.6	261	225	216	196	175	147	74
	10	2	55.8	54.8	269	259	262	244	220	183	105
	11	1	62.7	31.2	274	280	291	273	248	216	126
	12		65.5	0.0	275	287	301	283	258	225	133
	SURFACE DAILY TOTALS				3312	2626	2420	2204	1950	1644	874
JUL 21	5	7	5.7	114.7	43	10	5	5	4	4	3
	6	6	15.2	104.1	156	62	28	18	16	15	11
	7	5	25.1	93.5	211	118	89	75	59	42	14
	8	4	35.1	82.1	240	171	159	140	121	99	43
	9	3	44.8	68.8	256	215	214	193	178	155	83
	10	2	53.5	51.9	265	250	261	246	224	195	115
	11	1	60.1	29.0	271	272	291	276	753	223	137
	12		62.6	0.0	272	279	301	286	263	232	144
	SURFACE DAILY TOTALS				3158	2474	2386	2200	1974	1694	956
AUG 21	6	6	9.1	98.3	99	28	14	10	9	8	6
	7	5	19.1	87.2	190	85	75	67	58	47	20
	8	4	29.0	75.4	232	141	145	137	125	109	65
	9	3	38.4	61.8	254	189	210	201	187	168	110
	10	2	46.4	45.1	266	225	260	252	237	214	146
	11	1	52.2	24.3	272	248	293	285	268	244	169
	12		54.3	0.0	274	256	304	295	279	255	177
	SURFACE DAILY TOTALS				2808	2086	2300	2200	2046	1836	1208
SEP 21	7	5	10.0	78.7	131	35	44	44	43	40	31
	8	4	19.5	65.8	215	92	124	124	121	115	90
	9	3	28.2	53.4	251	142	195	197	193	183	143
	10	2	35.4	37.8	269	181	251	254	248	236	185
	11	1	40.3	19.8	278	205	287	283	284	269	212
	12		42.0	0.0	280	213	293	302	295	281	221
	SURFACE DAILY TOTALS				2568	1522	2102	2118	2070	1966	1546
OCT 21	7	5	2.0	71.9	4	0	1	1	1	1	1
	8	4	11.2	60.2	165	44	85	91	95	95	87
	9	3	19.3	47.4	233	94	167	176	180	178	157
	10	2	25.7	33.1	262	133	228	239	242	239	207
	11	1	30.0	17.1	274	157	266	277	281	275	237
	12		31.5	0.0	278	166	279	291	294	288	247
	SURFACE DAILY TOTALS				2154	1022	1774	1860	1890	1856	1626
NOV 21	8	4	3.6	54.7	36	5	17	19	21	22	22
	9	3	11.2	42.7	179	46	117	129	137	141	135
	10	2	17.1	29.5	233	83	186	202	212	215	201
	11	1	20.9	15.1	255	107	227	245	255	258	238
	12		22.2	0.0	261	115	241	259	270	272	250
	SURFACE DAILY TOTALS				1668	536	1336	1448	1518	1544	1442
DEC 21	9	3	8.0	40.9	140	27	87	98	105	110	103
	10	2	13.6	28.2	214	63	164	180	192	197	190
	11	1	17.3	14.4	242	86	207	226	239	244	231
	12		18.5	0.0	250	94	222	241	254	260	244
	SURFACE DAILY TOTALS				1444	446	1136	1250	1326	1364	1304

NOTE:

1) BASED ON DATA IN TABLE 1, pp 387 in 1972 ASHRAE HANDBOOK OF FUNDAMENTALS. 0% GROUND REFLECTANCE; 1.0 CLEARNESS FACTOR.
2) SEE FIG. 4, pp 394 in 1972 ASHRAE HANDBOOK OF FUNDAMENTALS FOR TYPICAL REGIONAL CLEARNESS FACTORS.
3) GROUND REFLECTION NOT INCLUDED ON NORMAL OR HORIZONTAL SURFACES.

MEAN PERCENTAGE OF USABLE SUNSHINE FOR SELECTED LOCATIONS

State and Station	YRS	J	F	M	A	M	J	J	A	S	O	N	D	ANN
Ala., Birmingham	56	43	49	56	63	66	67	62	65	66	67	58	44	59
Montgomery	49	51	53	61	69	73	72	66	69	69	71	64	48	64
Alaska, Anchorage	19	39	46	56	58	50	51	45	39	35	32	33	29	45
Fairbanks	20	34	50	61	68	55	53	45	35	31	28	38	29	44
Juneau	14	30	32	39	37	34	35	28	30	25	18	21	18	30
Nome	29	44	45	48	53	51	48	32	26	34	35	36	30	41
Ariz., Phoenix	64	76	79	83	88	93	94	84	84	89	88	84	77	85
Yuma	52	83	87	91	94	97	99	92	91	93	93	90	83	91
Ark., Little Rock	66	44	53	57	62	67	72	71	73	71	74	58	47	62
Calif., Eureka	49	40	44	50	53	54	56	52	46	52	48	42	39	49
Fresno	55	46	63	72	83	89	94	97	97	93	87	73	47	78
Los Angeles	63	70	69	70	67	68	69	80	81	80	76	79	72	73
Red Bluff	39	50	60	65	75	79	86	95	94	89	77	64	50	75
Sacramento	48	44	57	67	76	82	90	96	95	92	82	65	44	77
San Diego	68	68	67	68	66	60	60	67	70	70	70	76	71	68
San Francisco	64	53	57	63	69	70	75	68	63	70	70	62	54	66
Colo., Denver	64	67	67	65	63	61	69	68	68	71	71	67	65	67
Grand Junction	57	58	62	64	67	71	79	76	72	77	74	67	58	69
Conn., Hartford	48	46	55	56	54	57	60	62	60	57	55	46	46	56
D.C., Washington	65	46	53	56	57	61	64	64	62	62	61	54	47	58
Fla., Apalachicola	26	59	62	62	71	77	70	64	63	62	74	66	53	65
Jacksonville	60	58	59	66	71	71	63	62	63	58	58	61	53	62
Key West	45	68	75	78	78	76	70	69	71	65	65	69	66	71
Miami Beach	48	66	72	73	73	68	62	65	67	62	62	65	65	67
Tampa	63	63	67	71	74	75	66	61	64	64	67	67	61	68
Ga., Atlanta	65	48	53	57	65	68	68	62	63	65	67	60	47	60
Hawaii, Hilo	9	48	42	41	34	31	41	44	38	42	41	34	36	39
Honolulu	53	62	64	60	62	64	66	67	70	70	68	63	60	65
Lihue	9	48	48	48	46	51	60	58	59	67	58	51	49	54
Idaho, Boise	20	40	48	59	67	68	75	89*	86	81	66	46	37	66
Pocatello	21	37	47	58	64	66	72	82	81	78	66	48	36	64
Ill., Cairo	30	46	53	59	65	71	77	82	79	75	73	56	46	65
Chicago	66	44	49	53	56	63	69	73	70	64	61	47	41	59
Springfield	59	47	51	54	58	64	69	76	72	73	64	53	45	60
Ind., Evansville	48	42	49	55	61	67	73	78	76	73	67	52	42	64
Fort Wayne	48	38	44	51	55	62	69	74	69	64	58	41	38	57
Indianapolis	63	41	47	49	55	62	68	74	70	68	64	48	39	59
Iowa, Des Moines	66	56	56	56	59	62	66	75	70	64	64	53	48	62
Dubuque	54	48	52	52	58	60	63	73	67	61	55	44	40	57
Sioux City	52	55	58	58	59	63	67	75	72	67	65	53	50	63
Kans., Concordia	52	60	60	62	63	65	73	79	76	72	70	64	58	67
Dodge City	70	67	66	68	68	68	74	78	78	76	75	70	67	71
Wichita	46	61	63	64	64	66	73	80	77	73	69	67	59	69
Ky., [illegible]ville	59	41	47	52	57	64	68	72	69	68	64	51	39	59
La., New Orleans	69	49	50	57	63	66	64	58	60	64	70	60	46	59
Shreveport	18	48	54	58	60	69	78	79	80	79	77	65	60	69
Maine, Eastport	58	45	51	52	52	51	53	55	57	53	50	37	40	50
Mass., Boston	67	47	56	57	56	59	62	64	63	61	58	48	48	57
Mich., Alpena	45	29	43	52	56	59	64	70	64	52	44	24	22	51
Detroit	69	34	42	48	52	58	65	69	66	61	54	35	29	53
Grand Rapids	56	26	37	48	54	60	66	72	67	58	50	31	22	49
Marquette	55	31	49	47	52	[illegible]	56	63	57	47	38	24	24	47
Sau. St. Marie	60	28	44	50	54	54	59	63	58	45	36	21	22	47
Minn., Duluth	49	47	55	60	58	58	60	68	63	53	47	[illegible]	40	55
Minneapolis	45	49	54	55	57	60	64	72	69	60	54	40	40	56
Miss., Vicksburg	66	46	50	57	64	60	73	69	72	74	71	60	45	64
Mo., Kansas City	69	55	57	59	60	64	70	76	73	70	67	59	52	65
St. Louis	68	48	49	56	59	64	68	72	68	67	65	54	44	61
Springfield	45	48	54	57	60	63	69	77	72	71	65	58	48	63
Mont., Havre	55	49	58	61	63	63	65	78	75	64	57	48	46	62
Helena	65	46	55	58	60	59	63	77	74	63	57	48	43	60
Kalispell	50	28	40	49	57	58	60	77	73	61	50	28	20	53
Nebr., Lincoln	55	57	59	60	60	63	69	76	71	67	66	59	55	64
North Platte	53	63	63	64	62	64	72	78	74	72	70	62	58	68

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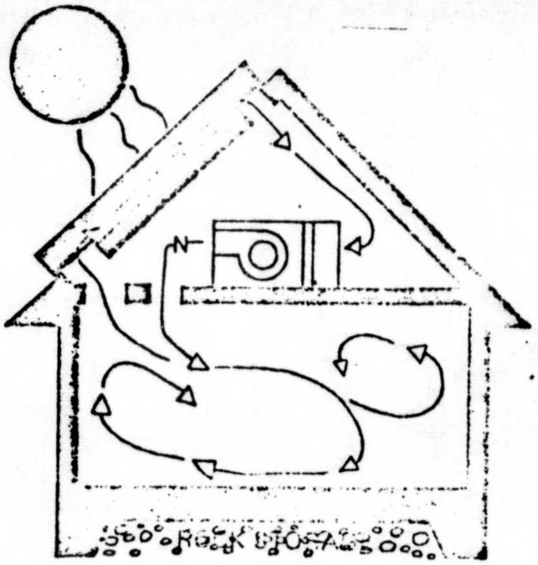
MEAN PERCENTAGE OF POSSIBLE SUNSHINE FOR SELECTED LOCATIONS

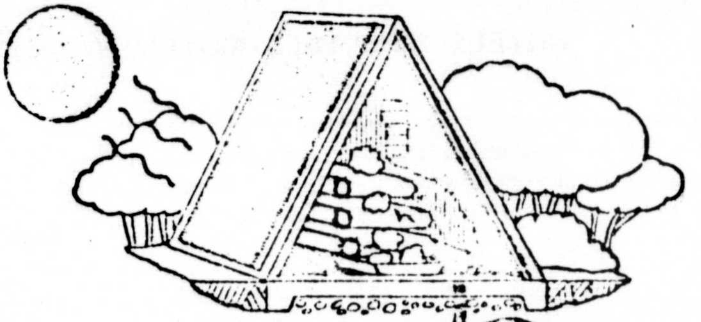
State and Station	YRS	J	F	M	A	M	J	J	A	S	O	N	D	ANN
Nevada, Ely	21	61	64	68	65	67	79	79	81	81	73	67	62	72
Las Vegas	19	74	77	78	82	85	91	84	85	92	84	83	75	82
Reno	51	59	64	69	75	77	82	90	89	86	76	68	56	76
Winnemucca	53	52	60	64	70	76	83	90	90	86	75	62	53	74
N.H., Concord	44	48	53	55	53	51	56	57	58	55	50	43	43	52
N.J., Atlantic City	62	51	57	58	59	62	65	67	66	64	54	58	52	60
N.M., Albuquerque	28	70	72	72	76	79	84	76	75	81	80	79	70	76
Roswell	47	69	72	75	77	76	80	76	75	74	74	74	69	74
N.Y., Albany	63	43	51	53	53	57	62	63	61	58	54	39	38	53
Binghamton	63	31	39	41	44	50	56	54	52	47	43	29	26	44
Buffalo	49	32	41	49	51	59	67	70	67	60	51	31	28	53
Canton	43	37	47	50	48	54	61	63	61	54	45	30	31	49
New York City	83	49	56	57	59	62	65	66	64	64	61	53	50	59
Syracuse	49	31	38	45	50	58	64	67	63	56	47	29	26	50
N.C., Asheville	57	48	53	56	61	64	63	59	59	62	64	59	48	58
Raleigh	61	50	56	59	64	67	65	62	62	63	64	62	52	61
N. Dak., Bismark	65	52	58	56	57	58	61	73	69	62	59	49	48	59
Devils Lake	55	54	60	59	60	59	62	71	67	59	56	44	45	58
Fargo	39	47	55	56	58	62	63	73	69	60	57	39	46	59
Williston	43	51	59	60	63	66	66	78	75	65	60	48	48	63
Ohio, Cincinnati	44	41	46	52	56	62	69	72	68	68	60	46	39	57
Cleveland	65	29	36	45	52	61	67	71	68	62	54	32	26	50
Columbus	65	36	44	49	54	63	68	71	68	66	60	44	35	55
Ok., Oklahoma City	62	57	69	63	64	65	74	78	78	74	68	64	57	68
Oregon, Baker	46	41	49	56	61	63	67	83	81	74	62	46	37	60
Portland	69	27	34	41	49	52	55	70	65	55	42	28	23	48
Roseburg	29	24	32	40	51	57	59	79	77	68	42	28	18	51
Pa., Harrisburg	60	43	52	55	57	61	65	68	63	62	58	47	43	57
Philadelphia	66	45	56	57	59	61	62	64	61	62	61	53	49	57
Pittsburgh	63	32	39	45	50	57	62	64	61	62	54	39	30	51
R.I., Block Island	48	45	54	47	56	58	60	62	62	60	59	50	44	56
S.C., Charleston	61	58	60	65	72	73	70	66	68	67	68	68	57	66
Columbia	55	53	57	62	68	69	68	63	65	64	68	64	51	63
S. Dak., Huron	62	55	62	60	62	65	68	76	72	66	61	52	49	63
Rapid City	53	58	62	63	62	61	66	73	73	69	66	58	54	64
Tenn., Knoxville	62	42	49	53	59	64	66	64	59	54	64	53	41	57
Memphis	55	44	51	57	64	68	74	73	74	70	69	58	45	64
Nashville	63	42	47	54	60	65	69	69	68	69	65	55	42	59
Tx., Abilene	14	64	68	73	66	73	86	83	85	73	71	72	66	73
Amarillo	54	71	71	75	75	75	82	81	81	79	76	76	70	76
Austin	33	46	50	57	60	62	72	76	79	70	70	57	49	63
Brownsville	37	44	49	51	57	65	73	78	78	67	70	54	44	61
Del Rio	36	53	55	61	63	60	66	75	80	69	66	58	52	63
El Paso	53	74	77	81	85	87	87	78	78	80	82	80	73	80
Fort Worth	33	56	57	65	66	67	73	78	78	74	70	63	58	68
Galveston	66	50	50	55	61	69	78	72	71	70	74	62	49	63
San Antonio	57	48	51	56	58	60	69	74	75	69	67	55	49	62
Utah, Salt Lake City	22	48	53	61	68	73	78	82	82	84	73	56	49	69
Vt., Burlington	54	34	43	48	47	53	59	62	59	51	43	25	24	46
Va., Norfolk	60	50	57	60	62	67	66	66	66	63	64	60	51	62
Richmond	56	49	55	59	63	67	66	65	62	63	64	58	50	61
Wash., North Head	44	28	37	42	48	48	48	50	46	48	41	31	27	41
Seattle	26	27	34	42	48	53	48	62	56	53	36	28	24	45
Spokane	62	26	41	53	63	64	68	82	79	68	53	28	22	58
Tatoosh Island	49	26	36	39	45	47	46	48	44	47	38	26	23	40
Walla Walla	44	24	35	52	63	67	72	86	84	72	59	33	20	60
Yakima	18	34	49	62	70	62	74	86	86	74	61	38	29	65
W. Va., Elkins	55	33	37	42	47	55	55	56	53	55	51	41	33	48
Parkersburg	62	30	36	42	49	56	60	[illegible]	60	60	53	37	29	48
Wisc., Green Bay	57	44	51	55	56	58	64	70	65	58	52	40	40	55
Madison	59	44	49	52	53	58	64	70	66	60	56	41	38	56
Milwaukee	59	44	48	53	56	60	65	63	67	62	56	44	39	57
Wyo., Cheyenne	63	65	66	64	61	59	68	70	68	69	69	65	63	66
Lander	57	66	70	72	66	65	74	76	75	72	67	61	62	69
Sheridan	52	56	61	62	61	61	67	76	74	67	60	53	52	64
Yellowstone Park	35	39	51	55	57	56	63	73	71	65	57	45	38	56
P. Rico, San Juan	57	64	69	71	66	59	61	65	67	61	63	63	65	66

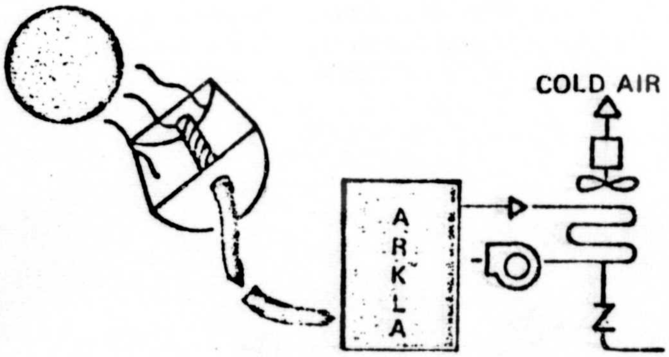
INDUSTRIAL AGRICULTURAL



HEATING

HOT AIR CAN BE INTRODUCED INTO ANY CONVENTIONAL FORCED HOT AIR HEATING SYSTEM

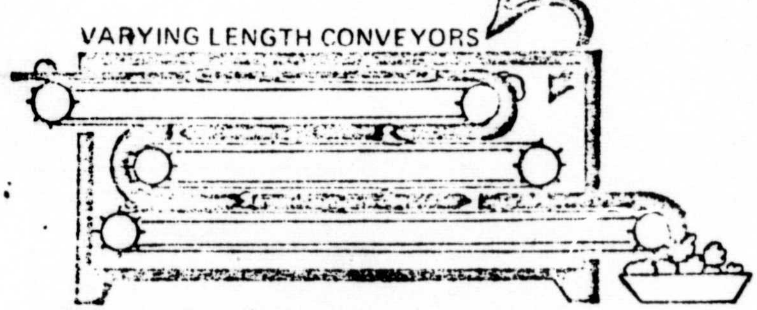




ARKLA WATER CHILLER

COOLING

SEECO IS A DISTRIBUTOR FOR THE FAMOUS ARKLA ABSORBTION CHILLER. EFFICIENT LOW COST CONCENTRATING COLLECTORS FURNISH HI-TEMP WATER TO THE UNIT WHICH PRODUCES LOW-TEMP WATER FOR COOLING AIR IN THE CONVENTIONAL FORCED AIR CONDITIONING SYSTEM



HEAVILY INSULATED SEECO STEEL SOLAR DRYING BUILDINGS DIVIDE THE COST OF COLLECTOR AND BUILDING TO GIVE THE VERY LOWEST TOTAL COST OF EFFECTIVE UTILIZATION OF SOLAR ENERGY.

COTTON MAY BE EFFECTIVELY DRIED IN SEVERAL WAYS, INCLUDING A COMBINATION OF SOLAR AND LINT BURNING INCENERATORS

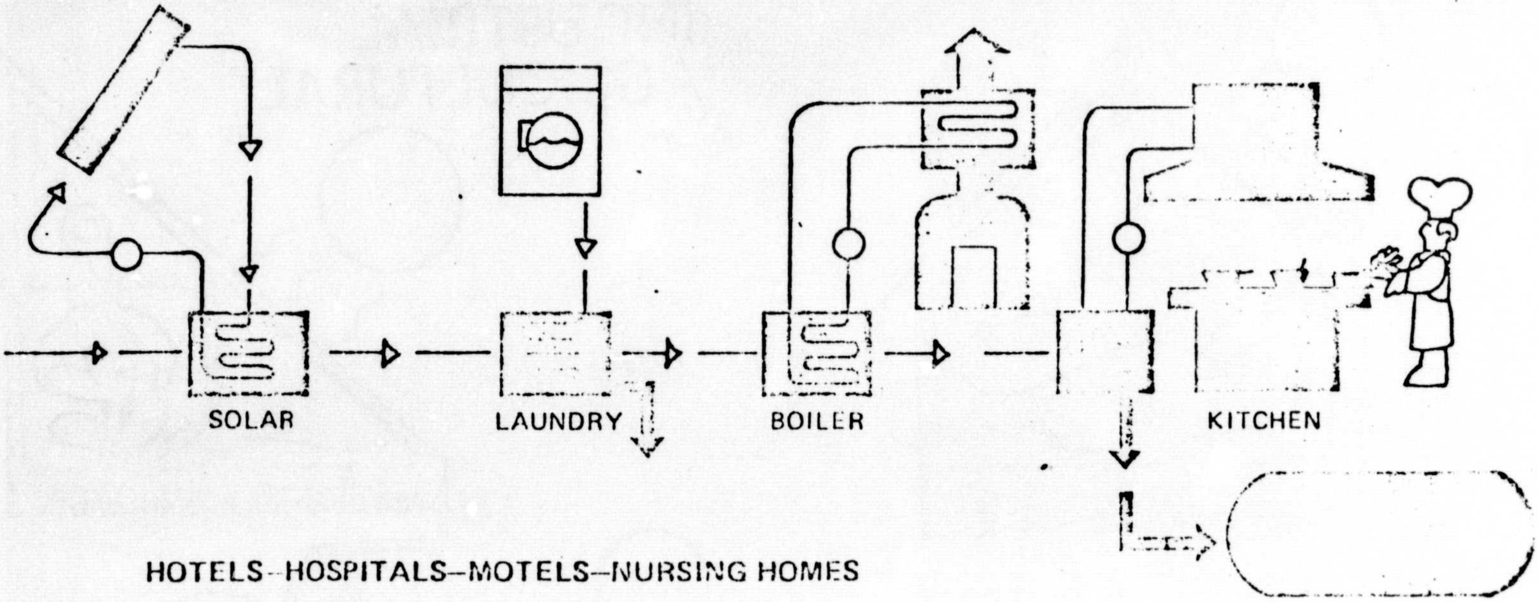
LUMBER SOLAR ENERGY IN A SEECO KILN CAN EFFECTIVELY DRY ALL TYPES OF LUMBER

PEANUTS ARE IDEALLY ADAPTED TO SOLAR DRYING SINCE THEY REQUIRE ONLY LOW TEMPERATURE AIR

CORN
GRAINS
BEANS
RICE
ALFALFA

SEECO HAS DEVELOPED EFFECTIVE SYSTEMS TO DRY THEM ALL

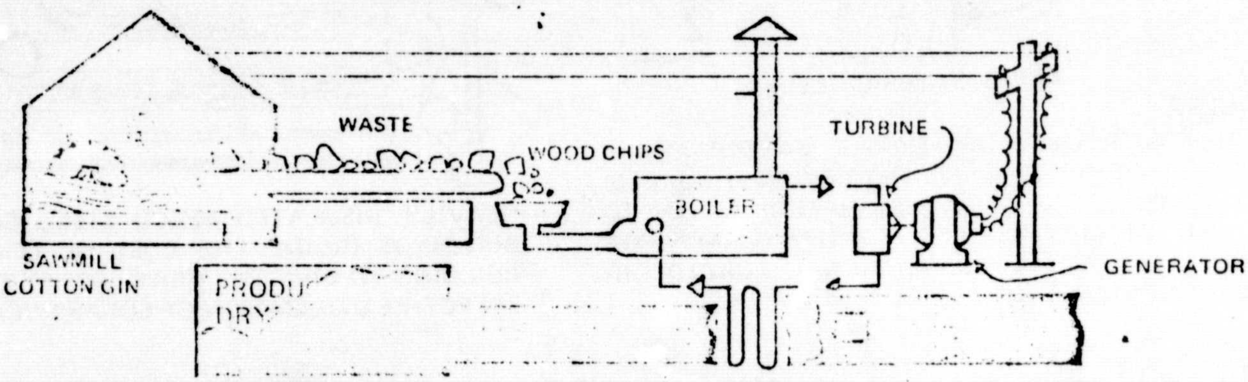
ENERGY CONSERVATION



HOTELS--HOSPITALS--MOTELS--NURSING HOMES

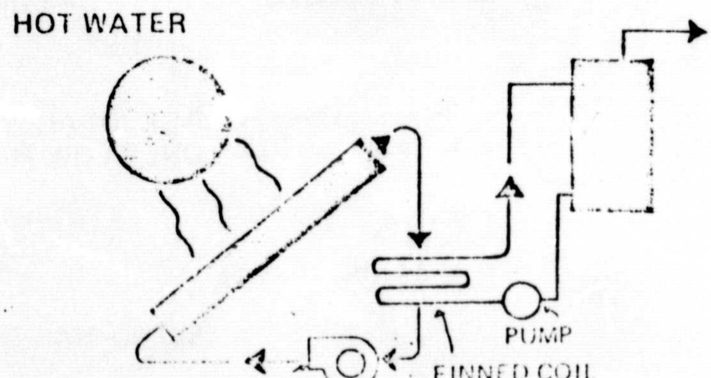
Vast quantities of energy may be reclaimed from the wasted heat from laundry washers, boiler stacks, kitchen range hoods, hot exhaust air, through a series of heat exchanging devices, starting with solar heated inlet air, to be utilized for comfort heating, process water heating, etc. in hotels and motels, fast food shops, hospitals, nursing homes, laundries canning and packing plants and in a variety of industries. SEECO can offer professional engineering and contracting service in the form of a turn-key installation contract.

TOTAL ENERGY



Complete utilization of waste products from cotton gins, sawmills, planing mills, peanut shells, corn husks, etc. will furnish energy to fire special boilers to produce steam which will drive a turbine to turn a generator which will furnish electricity. The exhaust heat from the turbine will be used to produce heat to dry the product and the electricity will power the fans, pumps, saws, etc. in the mill. SEECO has done considerable research in this field and has designed small prototype plants which show clearly that there are many industries which can be 100% self-sustaining.

Industrial & Domestic Heating & Cooling



HEATING

FOR ANY USE – RESIDENTIAL, COMMERCIAL OR INDUSTRIAL CAN BE GENERATED BY THE SEECO HOT AIR COLLECTOR WITHOUT THE USE OF ANTI-FREEZE SOLUTIONS, AT HIGHER EFFICIENCY AND LOWER COST THAN LIQUID COLLECTORS

☆ U.S. GOVERNMENT PRINTING OFFICE 1978–740-193/435 REGION NO. 4