C00-4664-1

FINAL REPORT

COST EFFECTIVE SOLAR HOT WATER SYSTEM FOR ECONO-TRAVEL MOTOR HOTEL

Located at

RICHMOND, VIRGINIA

Prepared for

THE DEPARTMENT OF ENERGY

Grant No. EM-78-G-02-4664

Submitted by

ALLEN MANAGEMENT COMPANY

Prepared by

SOLAR SYSTEMS OF VIRGINIA, INC.

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REB

DISCLAIMER

SUMMARY

This paper gives the final report of a cost effective solar hot water heating system installed on the Econo-Travel Motor Hotel at 5408 Williamsburg Road, Richmond, Virginia. The description of the system is given along with the final cost breakdown, expected performance data and expected payback time for the installed system is estimated to be approximately five (5) years instead of the 6.65 years estimated for the proposal. The additional savings is due to the reduction in the peak demand charge since the electric hot water heaters are not required to operate at the same time each morning as the dryers used for the laundry. As called for in the proposal to DOE, the success of the system will be determined by the reduction in the utility cost and reduced use of our fossil fuels. The results shown in the hotel's monthly electricity bills indicate that this goal has been accomplished.

INTRODUCTION

This final report gives the initial performance data of the solar hot water heating system now in operation and installed with a Grant under DOE's Hotel/Motel Solar Demonstration Program dated May 12, 1977. The hotel has two levels with flat roofs which make for ease of proper orientation of collectors to obtain maximum insulation. A total of 1,024 square feet of collector area will supply heat to the 1500 gallon preheat tanks.

Additional roof reinforcements for these retrofit systems were not required. The collector supports were designed to withstand 100 mile per hour (25 PSF) wind loads and a 20 PSF dead load. The desired percentage of hot water heating for use in the rooms and laundry was 68 percent. A savings of approximately $3,586.00 per year was calculated based on $.04 per KWH to give a 6.65 year payback time on the system which cost $23,856.00 to install. The cost of the system was under-estimated by approximately $6,000.00.

DESIGN FEATURES

The system is designed to supply hot water to the 48 unit hotel located in one (1) building. The system is designed to preheat and store the domestic hot water in a separate tank before it enters the electric hot water heaters. The water enters this tank at the bottom before it flows from the top of the tank and then to the backup electric heaters. While heat is being collected, a water pump forces the water from the bottom of the tank to the tube side of the shell and tube heat exchangers before it is pumped to the side near the top of the 54 inch diameter and 14 feet tall tank. This vertical tank is used to obtain as much stratification as possible which increases the efficiencey of the system. A third pipe from the top of the tank to the backup heater also increases the efficience. If the same pipe were used to supply hot water to the backup heater as well as to the heat exchanger, early morning lower temperature water would be coming out of the heat exchanger than from the

hot water stored at the top of the tank. Although this operational feature resulted in a higher installed cost for Solar Systems of Va., Inc., the additional savings was believed to justify the cost. (See Figure 1)

Another pump is placed on the shell side of the heat exchanger to force water through the collectors and then back to the heat exchanger. The heat is transferred from the solar fluid to the domestic water at this heat exchanger. The solar fluid is water and 40 percent proplyene glycol solution which flows through the collector tubes (.5 inch O.D. with .035 inch wall thickness). The collectors facing due South are tilted at 30 degrees to obtain maximum insolation during the summer months when the motels are full. (See Figure 2) Final assembly of the solar collectors are made on the flat roofs of the motel to reduce the amount of framing materials and perimeter of the collectors. Two (2) collectors on the roof are eight feet high and forty-eight feet long while one collector is eight feet by thirty-two feet. The non-selective aluminum absorber plate consists of a tube-double finned extruded shape formed in a serpentine pattern. The plates are fabricated in four foot by 8 foot panels for ease of handling. The backside of the collector is supported on 5/8 of an inch exterior grade plywood with 6 mil polyethylene used to seal the backside of the collector. The topside of the collector is double glazed with premium grade .040 inch Sun-lite as the outer surface and 1 mil teflon film as the second cover. (See Figure 3)

The tank insulation is six inches of fiberglass with exterior aluminum foil attached to prevent moisture in the insulation. The insulated tank is then enclosed in a building with exterior paneling painted to blend with the color of the hotel.

INSTALLATION EXPERIENCE

Solar Systems of Virginia, Inc., was fortunate to have installed a similar but smaller system on a hotel addition at the Hampton site in August 1977. A detailed drawing of this system and the collector assembly was made to plan the installation. Many discussions were made with the technician to make the field installation easier. A problem encountered with the retrofit system that did not exist with the prototype system was the cost and time required to build and enclosure around the storage tank. This building caused cost over-runs which were not included in the initial cost estimate.

The major problems encountered during the installation of the retrofit system was the location of the tank. The tanks were located at the side of the hotel at the other locations but the tank had to be re-located at the rear of the building in Richmond because of its interference with future expansion of the hotel. The lines from the tank to the mechanical rooms were much longer due to the location of the tank. This will reduce the efficiency of the solar system. The loss in efficiency is difficult to determine.

All pumps, heat exchangers and the controls are operating

as designed. The supplier of the heat exchangers ran a computer program to size the most cost effective units with an approach temperature of 15° F. The threaded connections on the tank have presented problems because the threads were not properly cleaned after galvanizing or damaged during handling. The use of the non-toxic proplyene glycol was not sufficient for the city inspectors. Mechanical, electrical plumbing permits were required to install the system. The inspectors required a double walled heat exchanger. This will also reduce the efficiency of the solar system. The loss in efficiency is difficult to determine without proper instrumentation.

PERFORMANCE DATA

The owners of the hotel and Solar Systems of Virginia are satisfied with the performance of the system. After initial check out of the system, the system went into operation on May 28, 1979. The system was checked for leaks and all lines were insulated. The temperature of the water and 40 percent proplyene glycol solution out of the collectors is 100° to 170° F depending on the storage tank temperature. The pressure drop through the entire collector piping system is 15 PSI.

The performance data is shown in Table I. The first electricity bill to reflect the reduction in total cost is June. A comparison to last June (1978) indicates a savings of approximately $261.00. A reduction in KHW used of approx-

imately 5,000 KWH, which results to approximately $3,000. year. The payback time is impossible to determine until more months of ooeration are recorded.

COST SUMMARY

The cost comparison is shown in Table II. The estimated cost is the same as shown in the cost proposal of the grant application. The overhead and labor was very difficult to determine since detailed cost records were not kept during the installation of the solar system. Solar Systems of Virginia Inc. had five (5) grants installations at the same time. The overhead was estimated from operating cost during the months of February thur June 1979 as shown in Table III.

The total estimated cost of the system was $23,856. The actual system installed cost is $27,201.00 which resulted in a loss of $6,000.00.

CONCLUSION

This report has presented a cost effective solar heating system at an installed cost of $23,856. This is accomplished by (1) collector design to match the hot water needs, (2) system sized to meet the hot water needs during the summer months, and (3) maximum system performance when the system reduces the peake demand charge.

RICHMOND SOLAR SYSTEM

PERFORMANCE DATA

TABLE 1

	1978			1979		
MONTHS	KWH USED	DEMAND CHARGE KW	TOTAL COST	KWH USED	DEMAND CHARGE KW	TOTAL COST
JANUARY	43100	132	$1,925.94	58500	134	$2,446.56
FEBRUARY	47100	146	2,142.62	59700	176	2,464.90
MARCH	34900	129	1,673.75	35300	12	1,536.02
APRIL	25700	113	1,291.27	29300	86	1,271.55
MAY	29800	89	1,504.13	27700	85	1,362.18*
JUNE	34700	101	1,811.67	29800	112	1,550.89
JULY	36800	103	1,894.71	32080	93	1,585.10
AUGUST	41200	110	2,086.50	33200	91	1,595.04
SEPTEMBER	29000	105	1,452.03			
OCTOBER	23800	83	1,187.81			
NOVEMBER	35000	113	1,547.67			
DECEMBER	46900	132	2,086.99			

* SYSTEM WENT INTO OPERATION ON MAY 28, 1979

TABLE II

COST COMPARISON

	ESTIMATED	ACTUAL
TERIALS:		
Collectors	$ 3,700	$ 4,036
Tank Foundation	2,500	2,609.
Pumps	500	880
Heat Exchanger	1,300	1,302
Controller	50	50
Insulation	400	932
Wood	200	1,483
Miscellaneous	1,000	2,446
Sub Total	$ 9,650	$ 13,738
10% O.H.	965	
LABOR:		
Collector Installation	2,400	2,226
Collector Supports	2,400	1,391
Pipe Installation	3,600	1,092
Sub Total	$ 8,400	$ 4,709
10% O.H.	840	
GENERAL EXPENSE:	1,972	8,754
TOTAL COST	21,687	
PROFIT	2,169	
TOTAL	23,856	27,201

SOLAR SYSTEMS OF VIRGINIA, INC.

TABLE III

COST SUMMARY FOR
RICHMOND, PROJECT

A. COLLECTOR ARRAY:

1. MATERIALS:

Panel Extrusion	$ 580.
Paint and Primer	30.
Insulation	262.
Teflon	500.
Aluminum Teflon Frames	190.
Aluminum Perimeter Frames	183.
Aluminum Angles	150.
Silicone Caulking	80.
Screws/Rubber Hose/Clamps	144.
Sun-lite Glazing	645.
Aluminum Flat Bar	92.
TOTAL MATERIALS	$ 2,756.

2. LABOR:

Panel Fabrication	98	Hours
Teflon Frames	76	"
Collector Frames	30	"
Roof Assembly	220	"
TOTAL HOURS	424	
LABOR COST @ $5.25/ hour		$ 2,226.

TOTAL COLLECTOR ARRAY $ 4,982.

B. SUPPORTS FOR COLLECTORS:

1. MATERIALS:

Baseplates	$ 112.	
Wood Frames	989.	
Roofing Cement	159.	
Nails	20.	
TOTAL MATERIALS	$ 1,280.	

2. COLLECTOR SUPPORTS:

LABOR:

265 Hours @ $5.25/hour

TOTAL LABOR	$ 1,391.	
TOTAL COLLECTOR SUPPORT		$ 2,671.

C. PIPING/MATERIALS:

1. MATERIALS	$ 3,359.	
2. LABOR: 208 Hours @ $5.25/hour	$ 1,092.	
TOTAL COST		$ 4,451.

D. INSULATION:

1. MATERIALS	$ 832.	
2. LABOR: 80 Hours @ $5.25/hour	$ 420.	
TOTAL COST		$ 1,252.

E. EQUIPMENT:

Pumps	$ 880.
Heat Exchangers	1,302.
Valves/Gauges	617.
Air Vents	25.
Expansion Tanks	56.

Equipment - Continued

Air Separators	$ 37.	
Anti-Freeze	80.	
Tempering Valve	69.	
Check Valves	17.	
Zone Valves	36.	
Miscellaneous	41.	
TOTAL COST	$ 3,160.	$ 3,160.

F. CONTROLS:

1. Controllers W/wire	$ 50.	
2. Wiring - 6 Hours @ $6./hr.	36.	
TOTAL COST		86.

G. ELECTRICAL:

1. Relays, etc.	$ 100.	
2. Wiring - 45 Hours @ $6./hr.	270.	
TOTAL COST		370.

H. TANK/INSULATION:

1. MATERIALS:

Concrete	$ 290.
Tank	2,016.
Crane	189.
Insulation	100.
Barracade	14.
TOTAL COST	$ 2,609.

2. LABOR:

96 Hours @ $5.25	$ 504.	
TOTAL COST FOR TANK		3,113.

I. TANK HOUSE:

1. MATERIALS:

Wood	$ 494.	
Nails	30.	
Paint	67.	
TOTAL MATERIAL	$ 591.	

2. LABOR:

100 Hours @ $5.25	525.	
TOTAL COST FOR HOUSE		$ 1,116.
TOTAL MATERIALS COST		$ 14,737.
TOTAL LABOR COST		6,464.
TOTAL		$ 21,201.

OVERHEAD:

For the months of installation during the work on the Richmond system.

Overhead	$ 6,000.
Administrative (Permits, Gen. Contracts, etc.)	2,754.
TOTAL COST	$ 27,201.

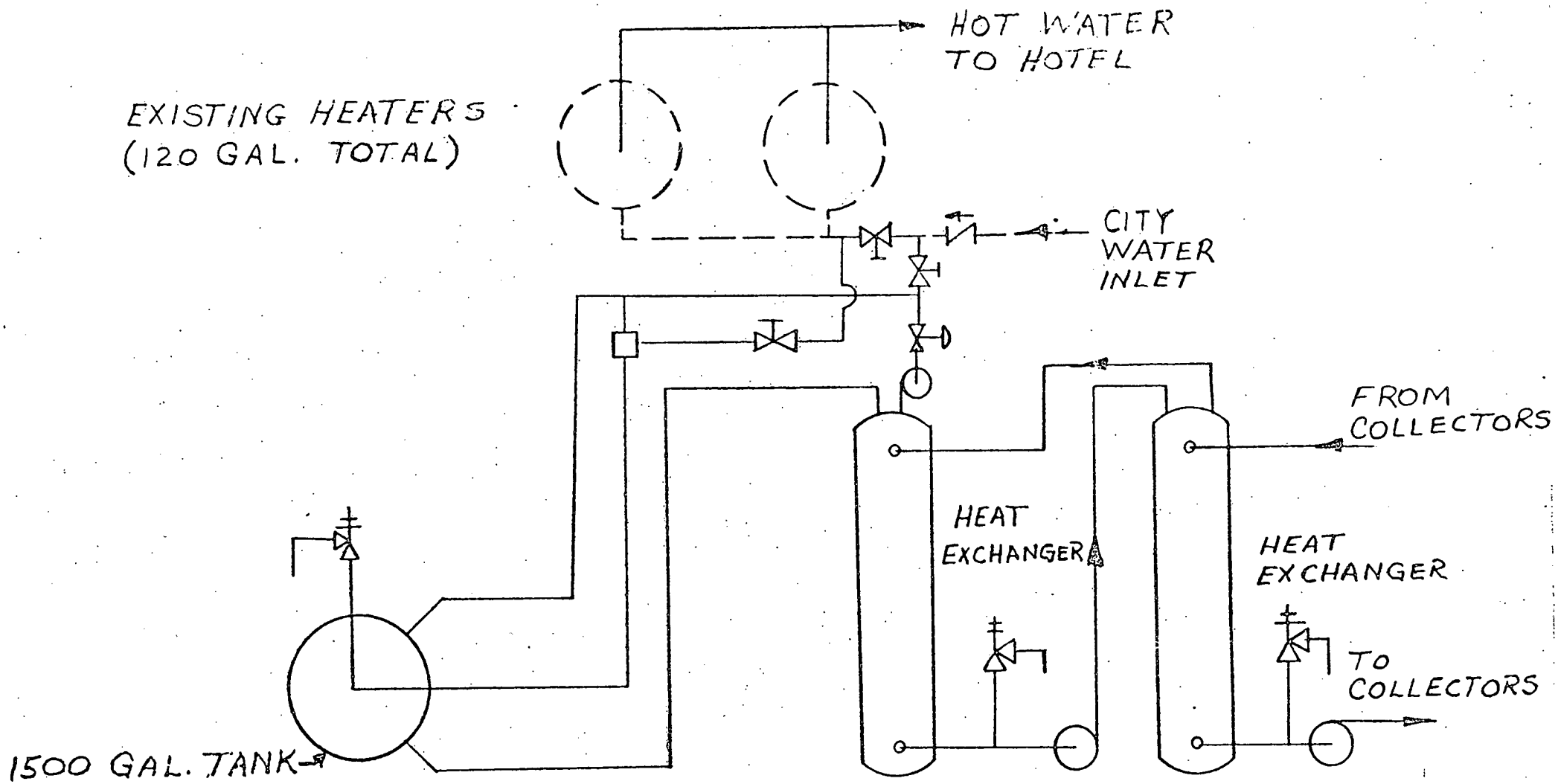

FIGURE-1 HOTEL PIPING SCHEMATIC

(SYSTEM FOR 48 UNIT HOTEL)

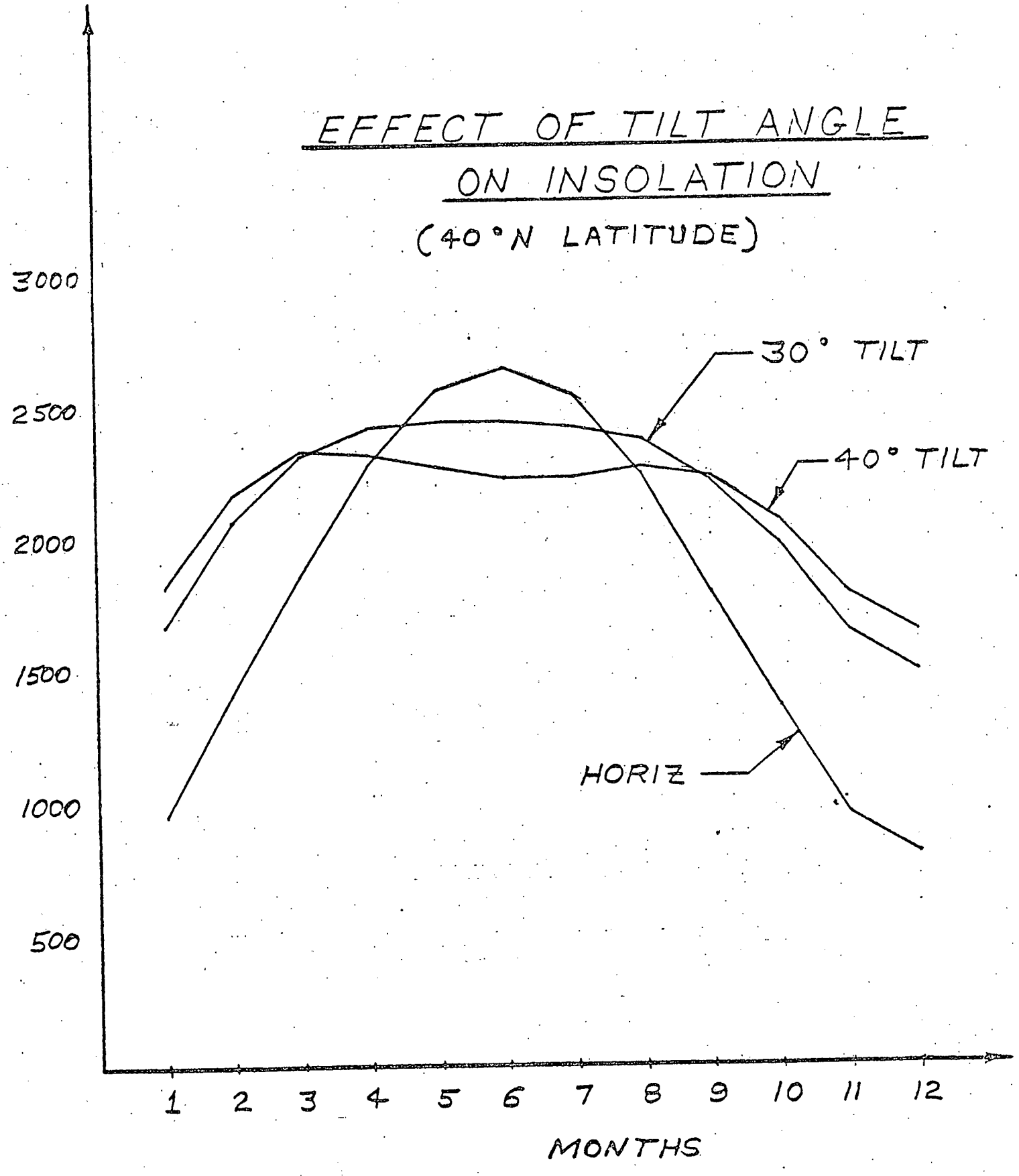

FIGURE 2 - COLLECTOR TILT

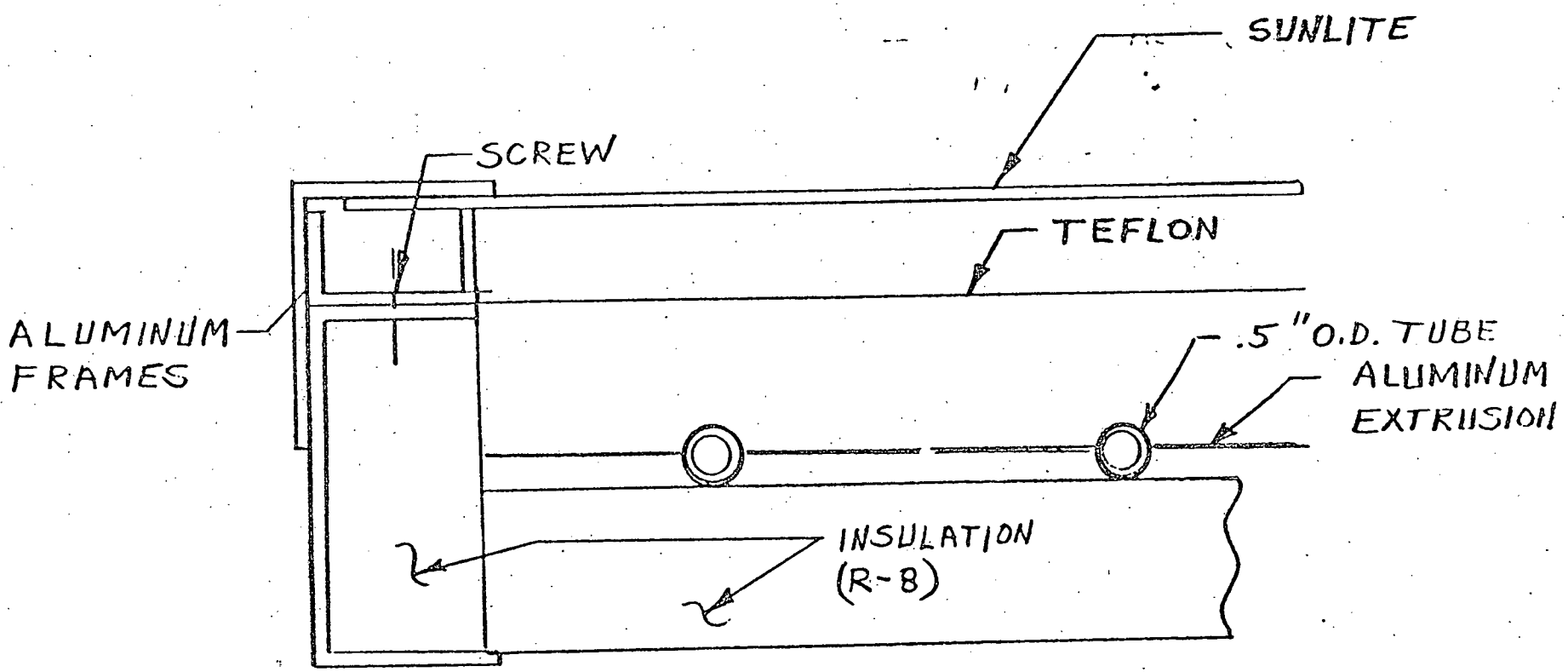

FIGURE - 3

COLLECTOR DETAILS

NO SCALE