COO-4661-1

FINAL REPORT

Cost Effective Solar Hot Water System For ECONO-TRAVEL MOTOR HOTEL

Located At

WOODBRIDGE, VA.

Prepared For

THE DEPARTMENT OF ENERGY

GRANT NO. EM-78-G-02-4661

Submitted By

Allen Management Company

Prepared By

SOLAR SYSTEMS OF VIRGINIA, INC.
Hampton, Va.

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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 13317 Gordon Boulevard, Woodbridge, Virginia. The description of the system along with the final breakdown, performance data and payback time are given. The payback time for the installed system will be approximately four (4) years instead of the 7.2 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 1536 square feet of collector area will supply heat to the 2400 gallon preheat tanks. Additional roof reinforcements for

these retrofit systems were not required. The collector supports were designed to withstand 100 miles per hour (25psf) wind loads and a 20 psf dead load. The desired percentage of hot water heating for use in the rooms and laundry was 71 percent. A savings of approximately $4,482.00 per year was calculated based on $.04 per KWH to give a 7.2 year payback time on the system which cost $32,300.00 to install. The cost of the system was underestimated by approximately $6,000.00.

DESIGN FEATURES

The system is broken down into two (2) separate systems since the 60 unit hotel is located in two separate buildings. One containing the standard 48 unit Econo-Travel Motor Hotel and the other is a 12 unit two level detached building. The solar system for the 12 unit building which does not contain a laundry was sized for 15 gallons of 130°F hot water use per day. This volume is the amount measured at the 24 unit addition located in Hampton, Virginia. A volume of approximately 30 gallons was measured at the same site after a laundry was installed. This volume is used to size all systems under the DOE grant program.

The large 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 60" diameter and 16 foot tall tank. This vertical tank is used to obtain as much stratification as possible which increases the efficiency of the system. A third pipe from the top of the tank to the backup heater also increases the efficiency. If the same pipe were used to supply hot water to the backup heater as well as to the heat exchanger, early morning lower temperture 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 SSV, 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% 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 motels to reduce the amount of framing materials and perimeter of the collectors. One collector on the roof is eight feet high and 32 or 48 feet long. The non-selective aluminum absorber plate consists of a tube-double fin extruded shape

formed in a serpentine pattern. The plates are fabricated in 4 by 8 foot panels for ease of handling. The backside of the collector is supported on 5/8 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 one 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.

The small system is very similar to the large one but contains only 128 square feet of collector area and 200 gallons of preheat hot water storage. The collectors are identical to the ones used in the other system. The preheat tank (30 inches in diameter and 60 inches tall) was placed in the mechanical room near the two (2) electrical backup heaters. The system design and operation is identical to the large system.

INSTALLATION EXPERIENCE

Solar Systems of Virginia, Incorporated, was fortunate to have installed a similar but smaller system on a hotel addition at the Hampton site in August 1977. A detail 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 an enclosure around the storage tank. This building caused cost overruns which were not included in the initial cost estimate.

The major problem encountered during the installation of the retrofit system was the condition of the roof. The prototype system at Hampton, Virginia was on a building with a new roof but the existing roofs were far from being new. Rain water stayed on the roof of the 48 unit building during the entire installation of the collectors which caused delay and additional time to get the work completed. A contract was signed on January 2, 1978 to have the baseplate installed which is normally a one week effort. The contractor completed the job on May 16, 1978.

All pumps, heat exchanger and the controls are operating as designed. The controls have caused minor problems at this site when the lighting ran into the building. The differential temperature controller in the large system along with five air conditioning units were damaged. The damaged controller was discovered when the hotel ran out of hot water after two nights and one and half days of cloudy weather. This gave an indication of the number of days of storage of solar hot water during the summer.

The supplier of the heat exchanger ran a computer program

to size the most cost effective unit 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. No problems have been encountered with the Woodbridge code requirements. The use of the non-toxic proplyene glycol was sufficient for the city inspectors. Building and plumbing permits were required to install the system.

PERFORMANCE DATA

The owners of the hotel and Solar Systems of Virginia are satisfied with the performance of the systems. After initial checkout of the systems, the systems went into operation on June 17, 1978. The system was checked for leaks and then all lines were insulated. The temperature of the water/40% proplyene glycol solution out of the collectors is 100°F 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 July. A comparison to last July (1977) indicates a savings of approximately $1,300. A reduction in KWH used of approximately 30,000 KWH and a reduction in peak demand by 60 KW. The results are not consistant which makes it difficult to determine the annual savings of the system. The payback time is impossible to determine until more months of operare 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 System of Va, Inc. had five (5) grants installations at the same time. The overhead was estimated from operating cost during the months of January thru June of 1978 as shown in Table III. Two projects were being installed during these months.

The total estimated cost of the system was $32,370.. The actual system installed cost is $41,542.00 which resulted in a loss of $5,848.70.

CONCLUSION

This report has presented a cost effective solar heating system at an installed cost of $32,300. 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.

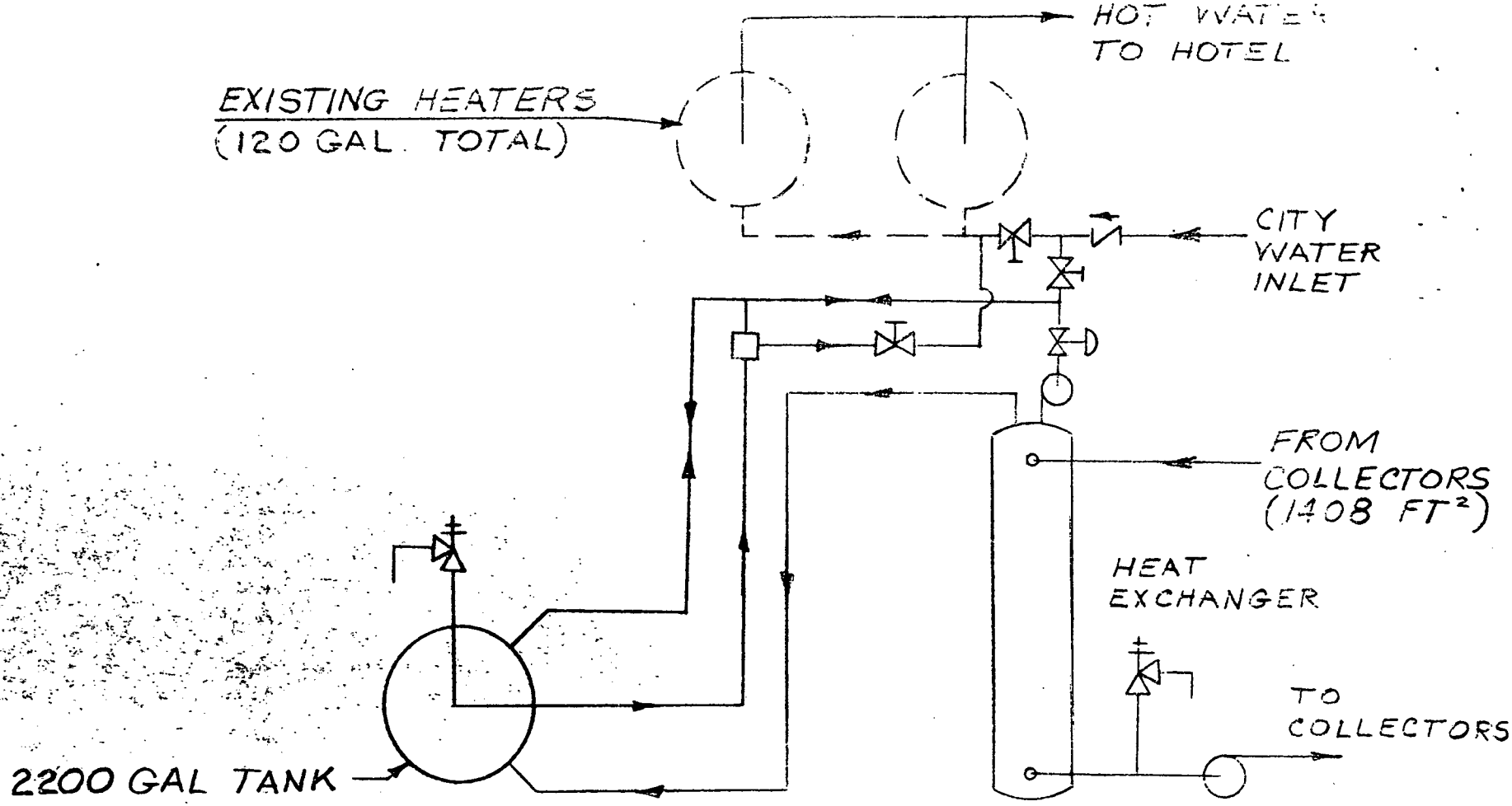

FIGURE - 1 HOTEL PIPING SCHEMATIC

(SYSTEM FOR 48 UNIT HOTEL)

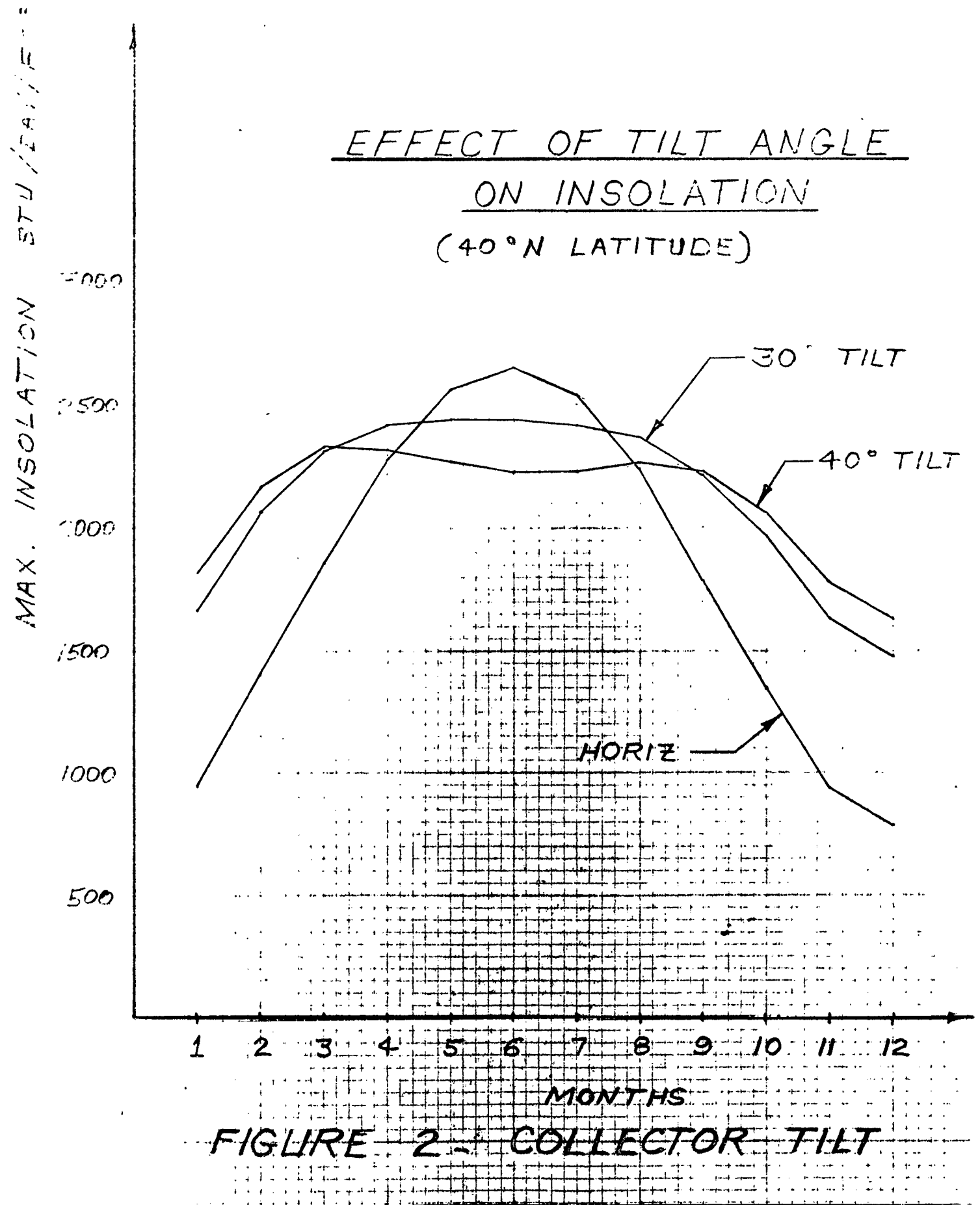

FIGURE 2 - COLLECTOR TILT

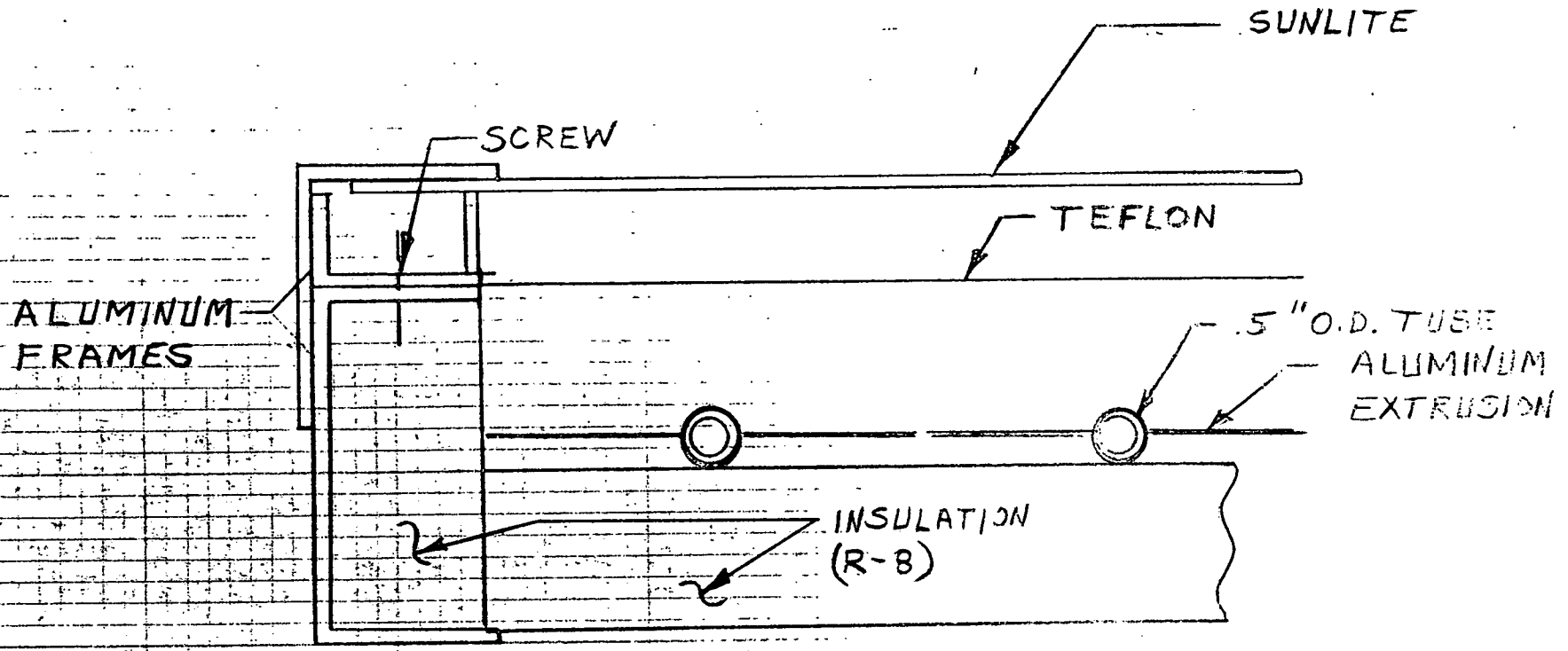

FIGURE - 3

COLLECTOR DETAILS

NO SCALE

WOODBRIDGE SOLAR SYSTEM

PERFORMANCE DATA

TABLE 1

	1977			1978		
MONTHS	KWH USED	DEMAND CHARGE KW	TOTAL COST	KWH USED	KW DEMAND CHARGE	TOTAL COST
JANUARY	N/A	N/A	N/A	87350	228	$ 3,881
FEBRUARY	N/A	N/A	N/A	91380	260	4,270
MARCH	N/A	N/A	N/A	82340	254	4,035
APRIL	N/A	N/A	N/A	41530	178	2,214
MAY	38070	164	$ 2,571	35360	145	1,845
JUNE	44780	166	2,459	38200	130	2,188
JULY	65590	173	3,321	34360	113	2,075*
AUGUST	61490	166	3,097	46060	120	2,536
SEPTEMBER	48220	166	2,675	42520	120	2,442
OCTOBER	41152	149	1,989	28960	136	1,574
NOVEMBER	44610	181	2,246			
DECEMBER	60660	200	2,812			

*SOLAR SYSTEM INSTALLED

TABLE II

COST COMPARISON

	ESTIMATED	ACTUAL
MATERIALS:		
Collectors	5,180	7,042
Tanks/Foundation	3,250	4,067
Pumps	750	658
Heat Exchanger	1,950	866
Controller	50	100
Insulation	600	640
Wood for Support	300	957
Miscellaneous	1,000	7,803
Sub-Total	13,080	22,133
10% Overhead	1,300	
LABOR:		
Collector Installation	3,200	2,900
Collector Supports	3,200	1,970
Pipe Installaion	4,800	2,695
Sub-Total	11,200	7,565
10% Overhead	1,120	
Sub-Total	26,700	29,698
GENERAL EXPENSE:	2,670	11,844
TOTAL COST	29,370	
PROFIT	3,000	
TOTAL	32,370	41,542

SOLAR SYSTEMS OF VA., INC.

TABLE III

COST SUMMARY FOR
WOODBRIDGE PROJECT

A.	COLLECTOR ARRAY:		
	1. MATERIALS:		
	Panel Extrusion		$ 870
	Paint & Primer		45
	Insulation		533
	Teflon		750
	Aluminum Teflon Frames		285
	Aluminum Perimeter Frames		273
	Aluminum Angles		225
	Silicone Caulking		120
	Screws		165
	Sun-lite Glazing		768
	Aluminum Flat Bar		60
	TOTAL MATERIALS		$ 4,094
	2. LABOR:		
	Panel Fabrication	120 hours	
	Teflon Frames	180 "	
	Collector Frames	48 "	
	Roof Assembly	180 "	
	TOTAL	528 hours	
	Labor Cost @ $5.50/hr.		$ 2,900
	TOTAL COLLECTOR ARRAY		$ 6,994
B.	SUPPORTS FOR COLLECTORS:		
	1. MATERIALS:		
	Baseplate w/copper cover (Subcontract)		$ 2,918
	Wood Frames		957
	Nails		30
	TOTAL MATERIALS		$ 3,905

B. SUPPORTS FOR COLLECTORS: Continued

2. LABOR:

Collector Supports = 264 Hours

264 hrs. @ $5.50/hr.	$	1,970
TOTAL LABOR	$	1,970
TOTAL COLLECTOR SUPPORT	$	5,875

C. PIPING/FITTINGS:

Materials	$	4,268
Labor - 250hrs. @ $5.50		1,375
TOTAL COST	$	7,661

D. INSULATION:

Materials	$	640
Labor - 72 hrs. @ $5.50		396
TOTAL COST	$	1,036

E. EQUIPMENT:

Pumps	$	658
Heat Exchangers		866
Expansion Tanks		40
Valves/Gauges		1,500
Air Vents		42
Air Separators		44
Anti-Freeze		135
Tempering Valves		140
Check Valves		100
Zone Valves		72
TOTAL COST	$	4,097

F. CONTROLS:

Controllers w/wire	$	100
Wiring - 12 hrs @ $5.50		66
	$	166

G. ELECTRICAL:

Breakers, Relays, etc.	$	200

G. Electrical: Continued		200
Wiring - 48hrs. @ $5.50		$ 264
	TOTAL COST	$ 464

H. TANK/INSULATION:

1. MATERIALS

Concrete	$ 135
Re-Bar	50
Tanks	3,570
Crane	150
Insulation (6" Fiberglass)	150
Barracade	12
TOTAL COST	$ 4,067

2. LABOR:

48 hours @ $5.50	$ 264
TOTAL COST FOR TANK	$ 4,331

I. TANK HOUSE:

1. MATERIALS

Wood	$ 1,177
Nails	30
Paint	55
TOTAL MATERIAL	$ 1,262

2. LABOR

60 hours @ $5.50	$ 330
TOTAL COST FOR HOUSE	$ 1,922

TOTAL MATERIAL COST	$ 26,526
TOTAL LABOR COST	9,913
TOTAL	$ 36,439

OVERHEAD

Two (2) projects were worked during January, February and March. Tanke 1/2 of total overhead as part of Woodbridge Project.

January	$ 5,500.30
February	4,196.61
March	6,758.49
Total	$ 12,755.40
1/2 for Woodbridge	6,377.70
1/2 Expense for April, May, & June	2,466.00
Administrative (Eng., Permits, etc.)	3,000.00
TOTAL OVERHEAD	$ 11,843.70
TOTAL COST	$ 41,872.00