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FINAL REPORT

COST EFFECTIVE SOLAR HOT WATER SYSTEM FOR ECONO-TRAVEL MOTOR HOTEL Located At BLUEFIELD, WEST VIRGINIA

Prepared For

THE DEPARTMENT OF ENERGY

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Submitted By

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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 3400 Cumberland Road, Bluefield, West 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 five (5) years instead of the 7.73 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 insolation. Additional roof reinforcements for these retrofit systems were not required. The collector supports were designed to withstand 100 miles 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 81 percent. A saving of

approximately $4,000. per year was calculated based on $.04 per KWH to give a 7.73 year payback time on the system which cost $32,300.00 to install. The cost of the system was underestimated by approximately $7,500.00.

DESIGN FEATURES

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 14 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 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 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 hotel is full. (See Figure 2) Final assembly of the solar collectors are made on the flat roofs of the 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 to blend with the color of the hotel.

INSTALLATION EXPERIENCE

Solar Systems of Virginia, Incorporated, was fortunate to have installed a similar but smaller system on a hotel addition at a 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 which is 60 inches in diameter and 187 inches tall. This building caused cost overruns which were not included in the initial cost estimate.

Problems have been small, but the system has not been completely trouble free. A small leak developed in the air vent in the mechanical room when solding material collected in the vent. The vent was replaced at a small cost. The major problem occurred when the valve between the heat exchanger and the storage tank failed to operate. The temperature in the storage tank and the piping reached a very low point during several cold days during February. The pipe between the tank and heat exchanger burst and had to be replaced. The solution to this problem will be handled by placing electrical heat tape between the pipe and insulation to prevent freezing.

All pumps, heat exchanger and the controls are operating as designed with no problems. The supplier of the heat exchanger ran a computer program to size the most cost effective unit with an approach temperature of 15° F. No problems have been encountered with the Bluefield code requirements. The use of the non-toxic proplyene glycol was sufficient for the city inspectors. Building, electrical and plumbing permits were required to install the system.

PERFORMANCE DATA

The owners of the hotels and Solar Systems of Virginia, Inc., are satisfied with the performance of the system. After initial check out of the system, the system has been trouble free. The system which went into operation on December 6, 1978, was checked for leaks on that day

and then all lines were insulated. The system has been operating satisfactorily since with only one major leaking problem. (See Page 4) The temperature of the water - 40% proplyene glycol solution out of the collectors is 100° F. to 150° F. depending on the storage tank temperature.

A comparison of the electricity used for the months of January through June shows a reduction in the KWH used as well as demand charge when comparison is made between 1978 and 1979. (See Table I) It is difficult to determine the actual savings based on only six months of operations. However, if we average out the savings for January through June in the reduction in electricity and reduction in demand charge, we will save approximately $5,000. each year. If this conservative annual savings of $6,000.00 is used, the system payback time will be 5 years based on a 10% annual increase in fuel cost and system cost of $32,000.

COST SUMMARY

The cost breakdown is shown in Table II. 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 grants installations at the same time. The overhead was estimated from operating cost during the months of September and October of 1978 as shown in Table II. Two projects were being installed during these months. This system was the only one being installed during the months of November and December.

The total estimated cost of the system was $32,300. The actual system installed cost is $39,725. which resulted in a loss of $7,425.00.

CONCLUSION

This report has presented a cost effective solar heating system at an installed cost of $32,300. The system would also be cost effective at a reasonable installed cost of $40,000.00 as shown in Figure IV. 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 peak demand charge.

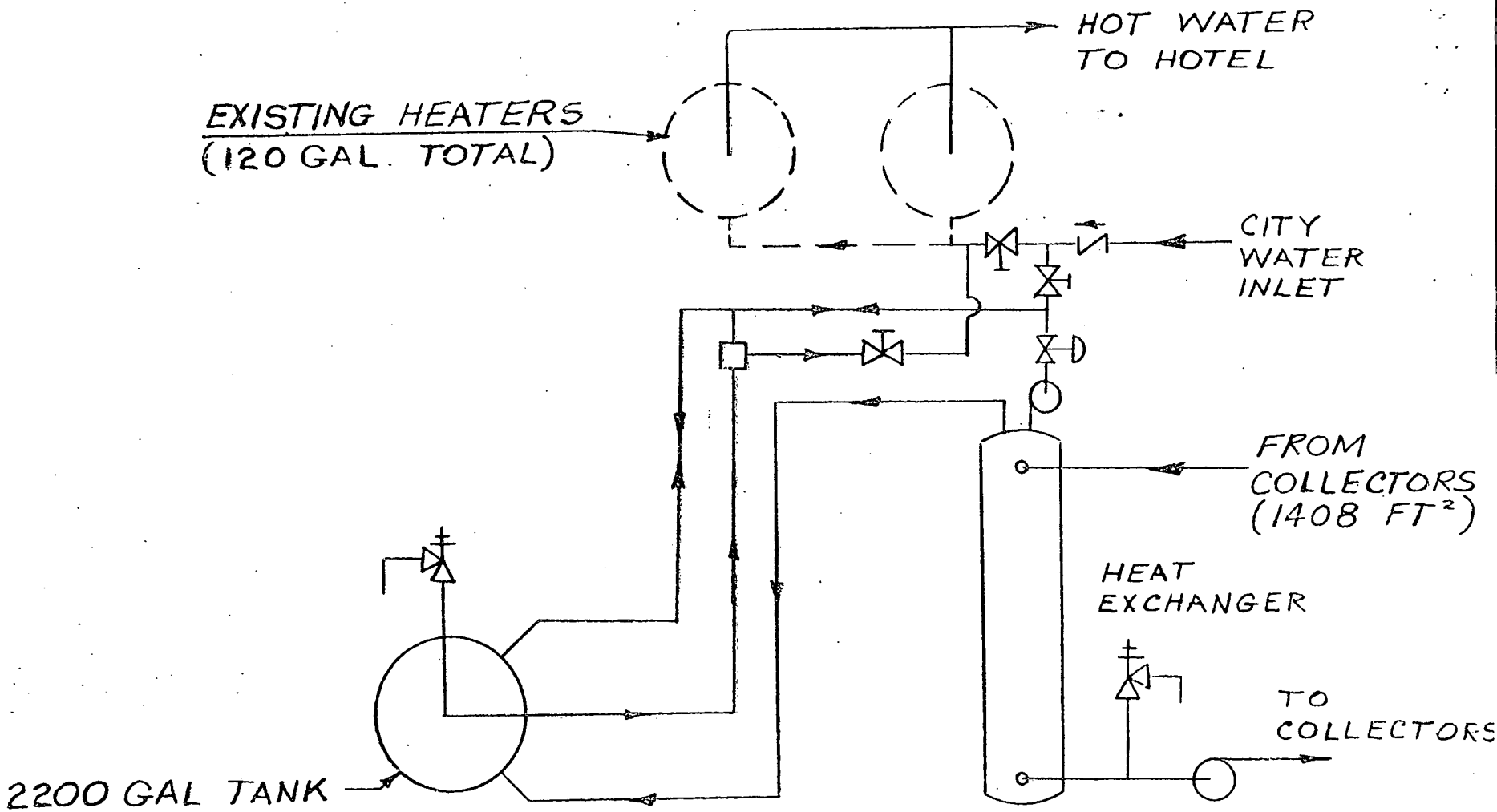

FIGURE - 1 HOTEL PIPING SCHEMATIC

(SYSTEM FOR 48 UNIT HOTEL)

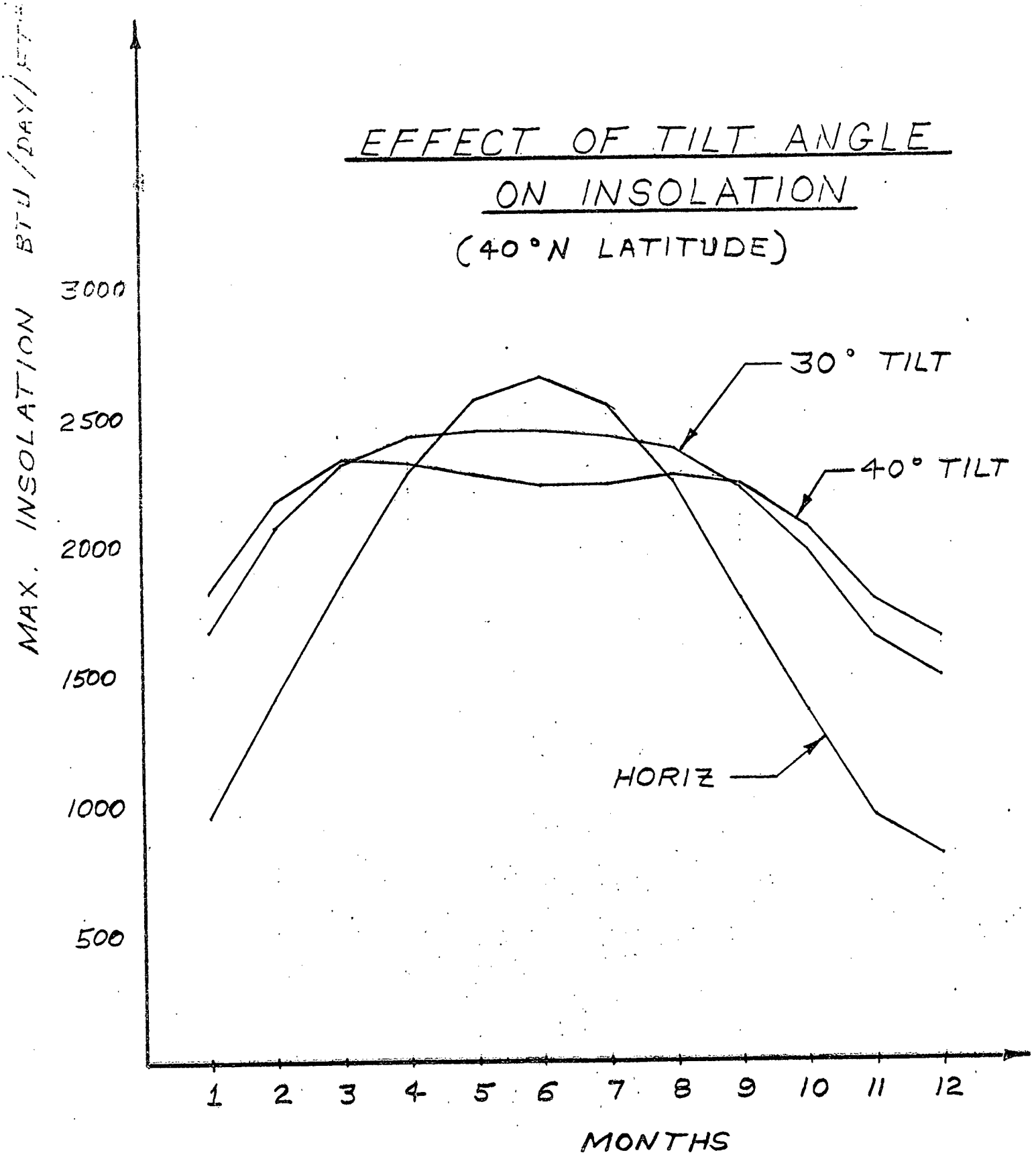

FIGURE 2 - COLLECTOR TILT

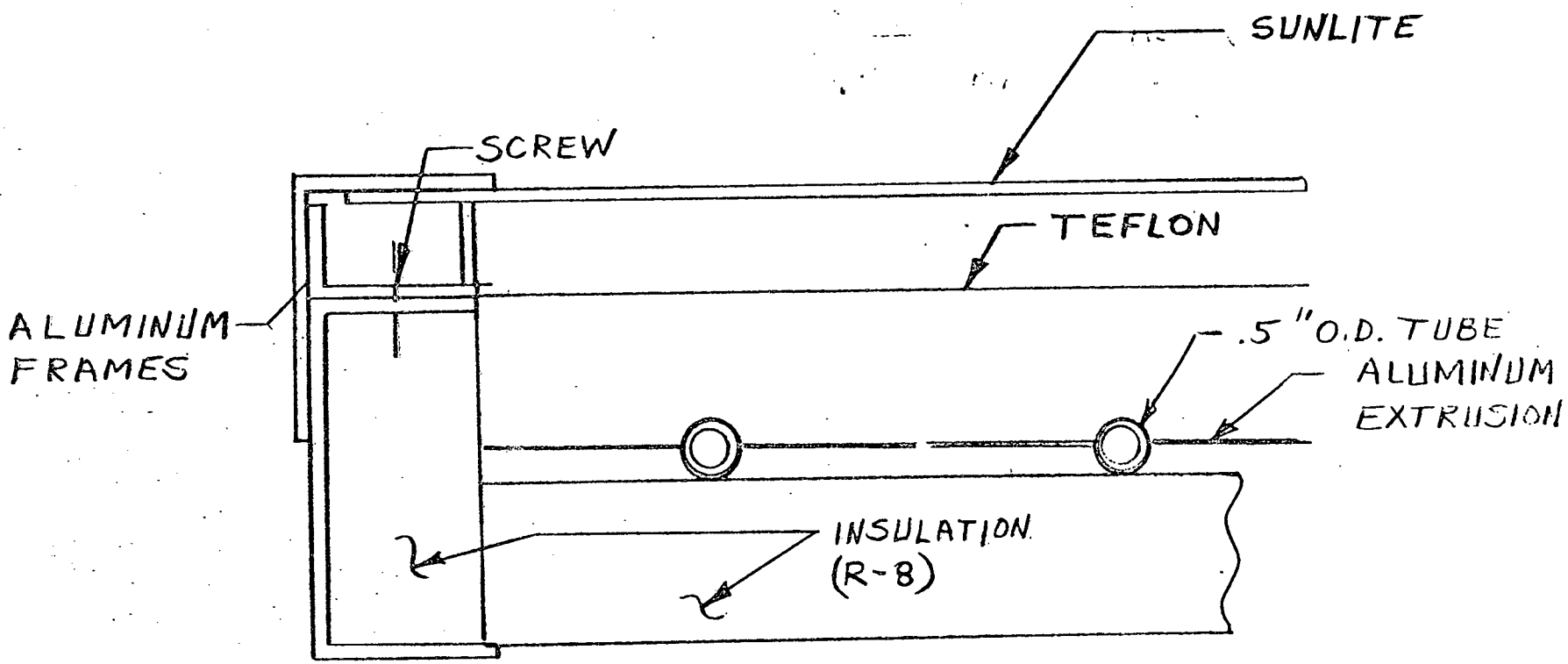

FIGURE - 3

COLLECTOR DETAILS

NO SCALE

TABLE I

BLUEFIELD SOLAR SYSTEM

PERFORMANCE DATA

	1978			1979		
MONTH	KWH USED	KW DEMAND CHARGE	ELEC. BILL	KWH USED	KW DEMAND CHARGE	ELEC. BILL
1	63600	232	$2,531.30	56880	223	$1,987.98
2	78240	224	2,995.30	83040	229	2,759.14
3	72240	209	2,767.28	63480	215	2,290.63
4	43320	193	1,839.65	34920	162	1,253.07
5	31080	157	1,355.92	25320	122	911.64
6	24600	125	918.35	22080	109.2	796.66
7	29520	112	1,036.89			
8	27480	115	962.79			
9	29040	114	1,026.47			
10	23520	109	854.94			
11	30120	128	1,081.46			
12	40920	152	1,440.00			
		1977				
12	58320	211	2,317.00			

TABLE II

COST SUMMARY FOR

BLUEFIELD, WEST VIRGINIA

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 Hours	528	
Labor Cost @ $5.50/Hr.		$ 2,900.
TOTAL COLLECTOR ARRAY		$ 6,994.

B. SUPPORTS FOR COLLECTORS:

1. MATERIALS:

Baseplate w/Flashing (Subcontract)	$ 2,500.
Wood Frames	1,303.
Nails	30.
Total Materials	$ 3,833.

B. SUPPORTS FOR COLLECTORS: (Continued)

2. LABOR:

Collector Supports = 264 Hours 264 Hours @ $5.50/Hour	$ 1,970.	
TOTAL COLLECTOR SUPPORT		$ 5,803.

C. PIPING/FITTINGS:

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

D. INSULATION: (PIPING)

1. Materials	$ 744.	
2. Labor 72 Hours @ $5.50	396.	
TOTAL COST		$ 1,140.

E. EQUIPMENT:

Pumps	$ 397.	
Heat Exchanger	564.	
Expansion Tank	20.	
Valves/Gauges	1,000.	
Air Vents	21.	
Air Separator	22.	
Anti-Freeze	175.	
Tempering Valve	70.	
Check Valve	50.	
Zone Valve	36.	
TOTAL COST		$ 2,355.

F. CONTROLS:

Controller w/Wire	$ 100.	
Wiring 12 Hours @ $5.50	50.	
TOTAL COST		$ 150.

G. ELECTRICAL:

Power to Pumps	$ 180.

H. TANK/INSULATION:

1. MATERIALS:

Concrete Pad	$ 184.	
Re-Bar	32.	
Tank	2,591.	
Crane	60.	
Shipping of Tank	217.	
Insulation (6" Fiberglass)	90.	
Barracade	79.	
Total Materials		$ 3,253.

2. LABOR:

40 Hours @ $5.50	$ 220.	
TOTAL TANK COST		$ 3,473.

I. TANK HOUSE:

1. MATERIALS:

Wood	$ 600.	
Nails	30.	
Paint	50.	
Total Materials		$ 680.

2. LABOR:

60 Hours @ $5.50	$ 330.	
TOTAL COST OF TANK HOUSE		$ 1,010.

TOTAL MATERIAL COST	$ 19,327.	
TOTAL LABOR COST	7,421.	
TOTAL	$ 26,758.	$26,758.

OVERHEAD

Rooms	$ 352.	
Travel	345.	
Meals	770.	
This system was the only one under construction during September, October and two systems under construction during November, December = 2500 + 2500 + 1/2 (6500 + 6500)	11,500	
Total Overhead	$12,967	$12,967
TOTAL SYSTEM COST		$39,725.

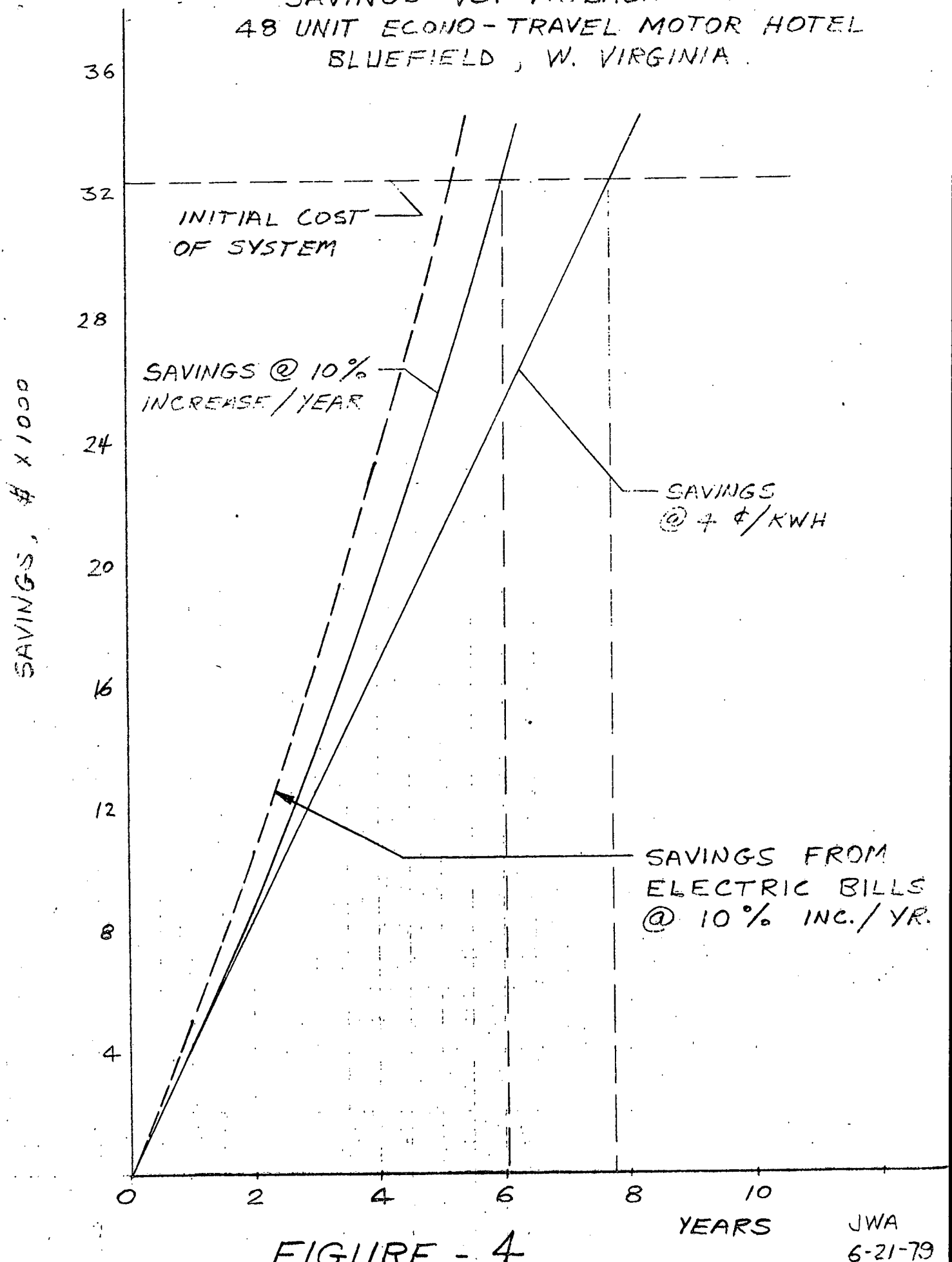
SAVINGS VS. PAYBACK TIME
48 UNIT ECONO-TRAVEL MOTOR HOTEL
BLUEFIELD, W. VIRGINIA
SAVINGS, $ X 1000
36
32
28
24
20
16
12
8
4
0
2
4
6
8
10
YEARS
INITIAL COST OF SYSTEM
SAVINGS @ 10% INCREASE/YEAR
SAVINGS @ 4 ¢/KWH
SAVINGS FROM ELECTRIC BILLS @ 10% INC./YR.
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FIGURE - 4