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INSTALLATION PACKAGE FOR SIMS PROTOTYPE SYSTEM 2, SOLAR HOT WATER

Prepared by

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Under Contract NAS8-32036 with

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

For U. S. Dept of Energy

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16. ABSTRACT

The International Business Machines Corporation, under NASA/MSFC Contract NAS8-32036, has developed prototype system 2 solar hot water for use in a single family dwelling.

System 2 has been installed in building No. 20, which is a single family residence on the grounds of the Veterans Administration Hospital at Togus, Maine.

The system consists of the following subsystems: collector, storage, energy transport, and control. It is a design with wide-spread application potential with only slight adjustments necessary in system size. Additional design information may be found in DOE/NASA CR 150521 "System Design Package for SIMS Prototype System 2 Solar Hot Water".

This document will provide the general guidelines which may be utilized in development of detailed installation plans and specifications. In addition, it provides instruction on operation, maintenance, and repair of System 2 solar hot water.

A small amount of retyping and reformatting has been done to publish this document, in the interest of clarity and legibility.

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INTRODUCTION

A solar energy system for supplying domestic hot water to single family residences has been designed by IBM under contract NAS8-32036 to the National Aeronautics and Space Administration's Marshall Space Flight Center. The prototype system illustrated pictorially in Figure 1-1, is an integration of currently marketed subsystems and has been built and demonstrated as part of the government's National Program for the Solar Heating and Cooling of Buildings.

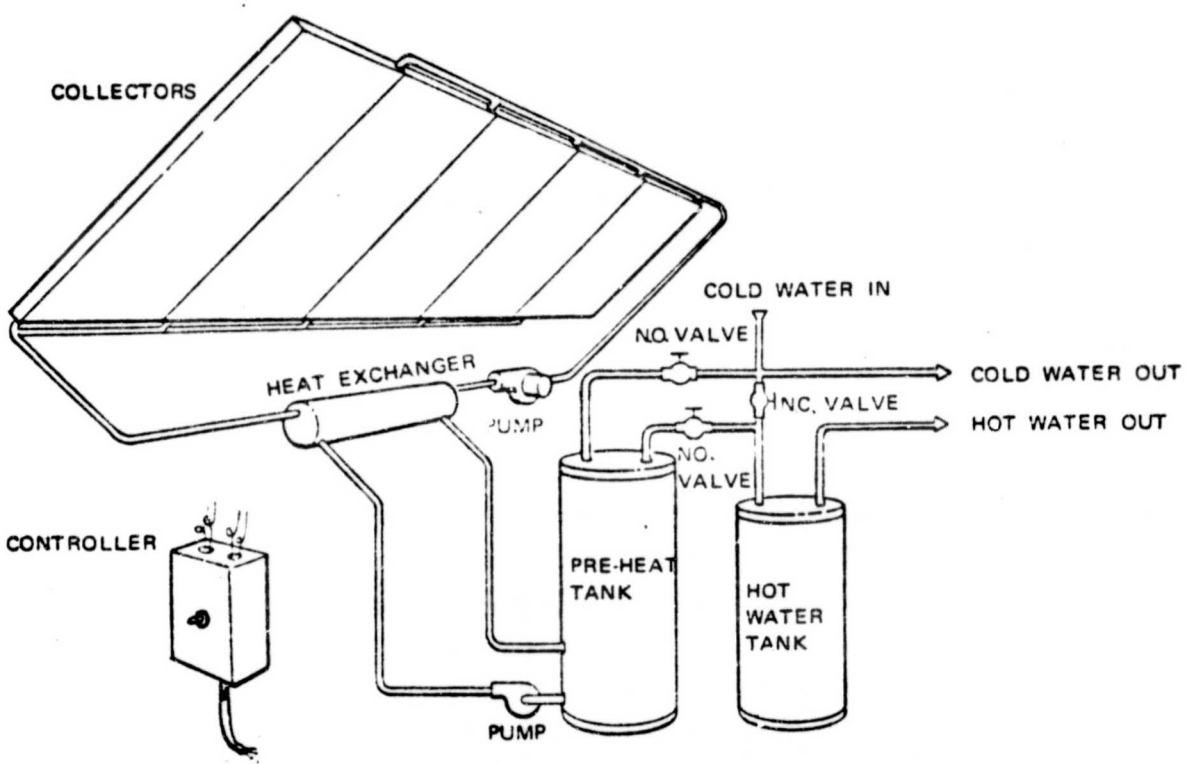


Figure 1-1. System Illustration

SYSTEM FUNCTIONAL DESCRIPTION AND OPERATION

SIMS Prototype System 2 is a liquid, closed loop, non-draining solar energy system for supplying domestic hot water to single family residences. As shown schematically in Figure 2-1, it consists of solar collectors, storage tank, pumps, heat exchanger and associated plumbing and controls. A silicone fluid circulated through the collector absorbs energy which is transferred by way of a heat exchanger to potable water stored in a preheat tank. The preheat tank, which is used to store solar energy, services a standard domestic hot water (dhw) heater tank which maintains the supply water at a preset temperature level, typically 140°F. City water replenishes that flowing from the preheat tank as water is drawn at the service outlets.

Thus solar energy is used to preheat water for the standard domestic hot water system, which is presumed to exist or be supplied separately and is not part of the solar energy system. The standard dhw system serves as the auxiliary energy source and can supply all hot water needs in the event of extended inclement weather. It is the primary functional interface with the solar energy system.

General features or characteristics of the system design are:

- Single family residence application
- Continental U.S. location
- Liquid flat plate collectors
- Silicone heat transfer fluid (non-toxic)
- Fail-safe double wall heat exchanger
- Automatic operation

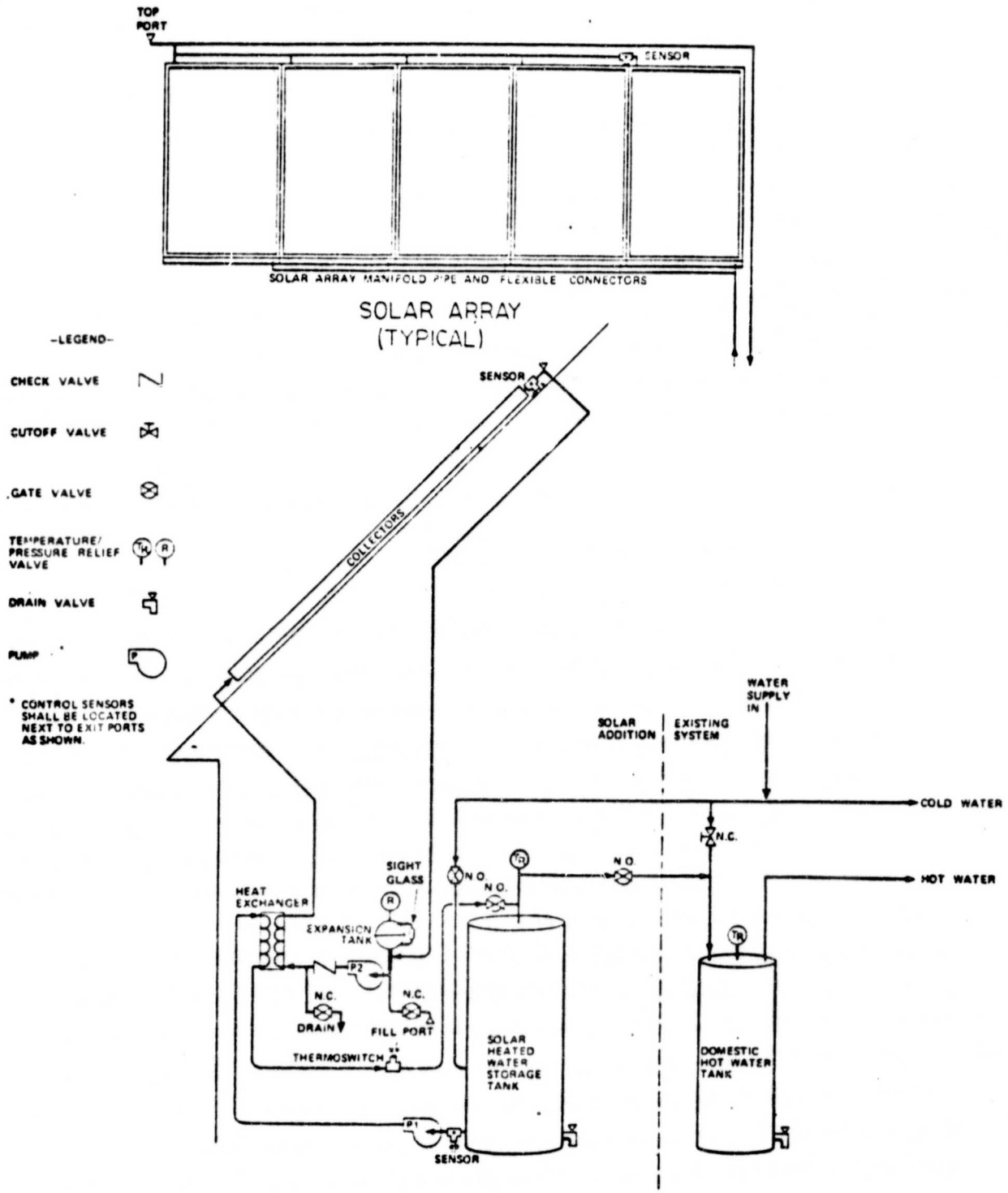


Figure 2-1. System 2 Functional Schematic

- Conventional auxiliary energy dhw system
- Over-temperature protection
- Freeze protected

The baseline system accommodates nominal domestic hot water requirements of 50 to 120 gallons per day at 140°F. This range is sufficient to cover the predominance of American households. The system can be scaled up or down, however, for a wide range of hot water requirements for single family, multi-family, or light commercial application without significant change to the design concept.

INSTALLATION

The intent of this section is to provide the architect or engineer with general guidelines which may be utilized in development of detailed installation plans and specifications. In the event of conflict between this data and local codes or standards, the code or standard shall take precedence.

GENERAL

The solar energy system can be installed as part of new construction or integrated into existing facilities. With few exceptions, the system consists of hardware available through local sources and common to the building construction trades.

INSTALLATION CONSIDERATIONS

A. COLLECTORS

The collectors are ganged via a supply and return header to form either a roof or ground mounted array. For a maximum efficiency, the collector array should be mounted facing due south, although a variance of $\pm 20^{\circ}$ will not greatly affect system performance. The array must also be tilted from the horizontal at an angle approximating the local latitude. A variance in tilt angle about this optimum of $\pm 10^{\circ}$ will not significantly affect long-term system performance. As shading will significantly decrease performance, the array must be installed in an area free of shadows from trees or adjacent structures. Although not required, the construction of a weather-tight enclosure for the collector array (similar to that noted in Figure 5-1) will provide protection to the supply and return piping, structural support for the collectors and be aesthetically acceptable to home owner. This enclosure can be attached directly to the roof sheathing for those installations

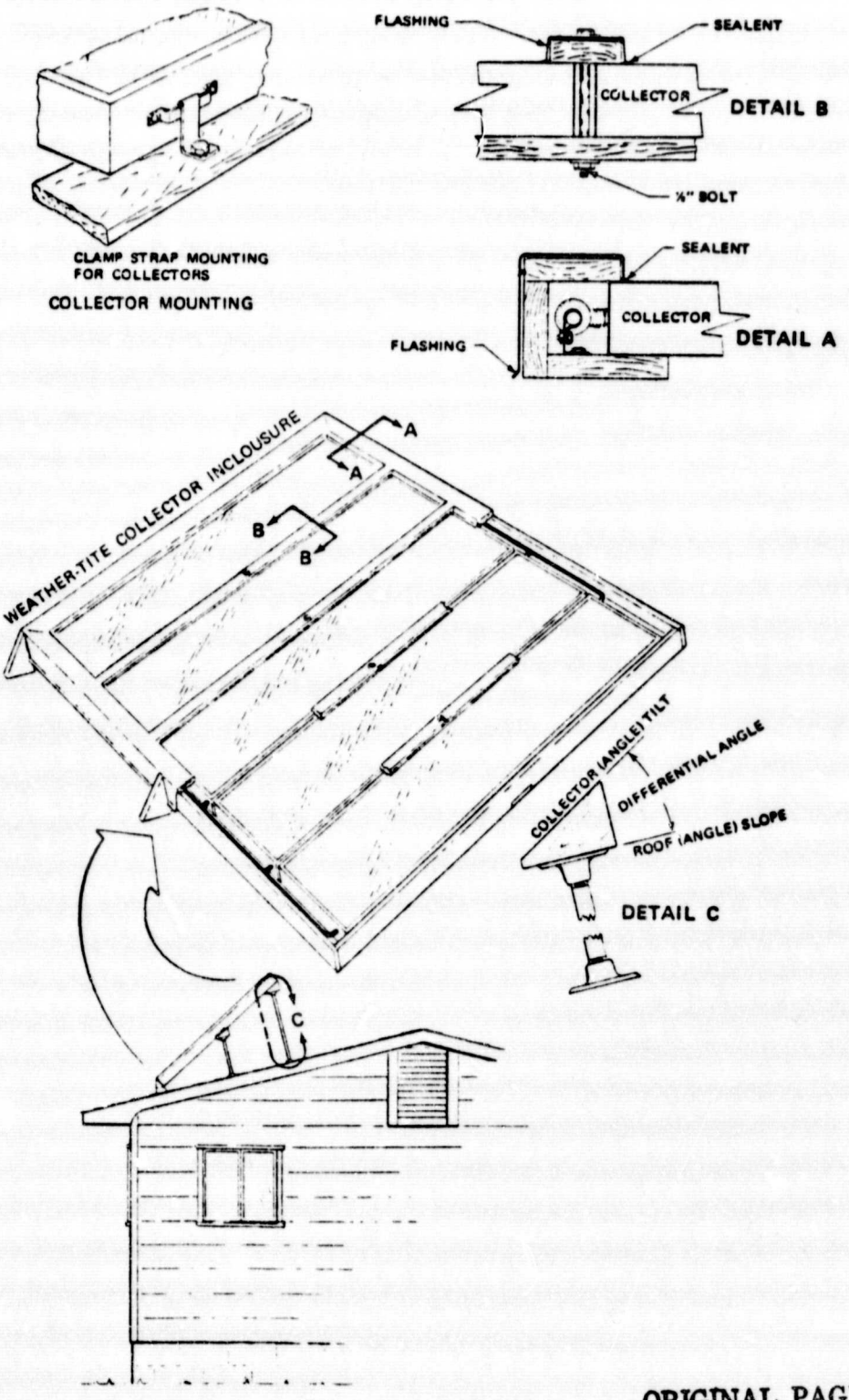


Figure 3-1. Typical Collector Array Installation Using Weather-Tight Enclosure

where the slope is compatible with the necessary tilt angle. In such installations, care should be taken to install proper flashing around the framing and to provide proper clearance around and between the collectors (minimum of 5" on perimeter and 1/4" to 1/2" between collectors).

This method of framing can also be utilized for locations where the roof slope is less than the required tilt angle by the addition of standoff's which will elevate the array to the proper angle.

Alternate methods of framing may also be utilized (Figure 5-2). In all cases care should be exercised to insure proper pipe insulation, protection around roof penetrations, and to select materials in accordance with good construction practice.

If preferred by the owner, or necessary by the orientation of the building, the collector array may be ground mounted on an "A" frame structure properly constructed.

The collector array may also be mounted on an exposed framing. However, in this type installation, it is recommended that the remaining elements of the system be located within the facility.

All ground-mounted arrays must be designed to protect the collectors from snow drifts, water and other site conditions which could impact the collector performance.

B. INSULATION

All piping, fittings tanks, pumps and heat exchanger shall be insulated with appropriate material. The insulating material, binders, jackets, etc., shall be UL listed and labeled. All above material, binders, jackets, etc., shall also have a flame spread rating of 25 or less and smoke development rating and fuel contribution rating of 50 or less when tested in accordance with ASTM E84.

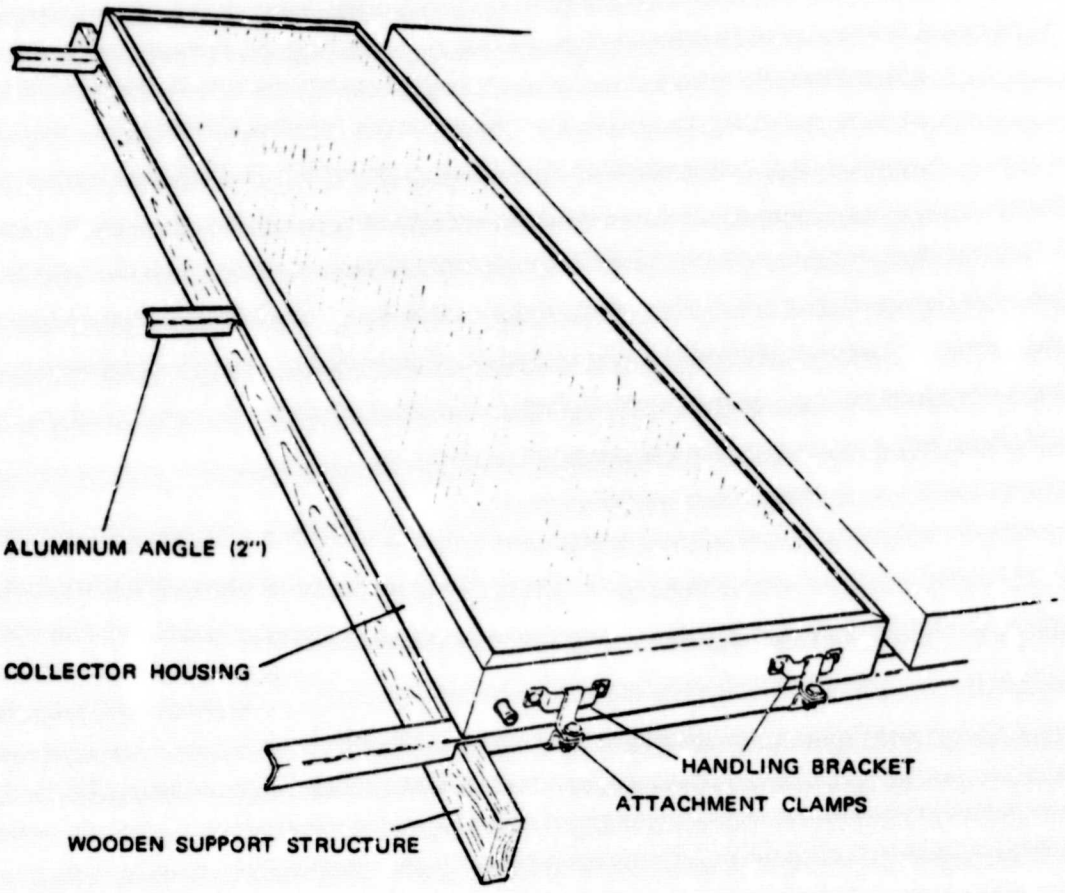


Figure 5-2. Alternate Collector Framing Method

All piping and pumps shall be insulated with a minimum "R" value of 5. Tanks and heat exchanger shall be insulated with a minimum "R" value of 11.

Insulation on fittings shall be applied in such a manner as to allow for removal of these fittings without disturbing the adjacent insulation.

No wheat paste, mold breeding, or mold sustaining organic insulating materials shall be used.

C. PIPING, FITTINGS AND PUMPS

Type "L" copper tubing (1" for the collector silicone fluid loop and 3/4" for the water preheat tank loop) shall be installed with minimum bends and a maximum length of 50 feet for each loop. High temperature solder (95% tin, 5% silver) shall be used on all sweat fittings in the collector (silicone fluid) loop. Sweat fittings in the water loop should be soldered with 50% tin and 50% lead. A mild solder flux should be used prior to the soldering operation. To minimize potential for leakage of the silicone fluid, the use of compression and/or flare fittings should be avoided, and threaded fittings minimized.

Teflon tape and teflon pipe dope must be used on all threaded connections. To eliminate potential leaks due to thermal expansion, flexible couplings, as manufactured by Hydro-Flex, or equal, shall be used to connect the collectors to the supply and return headers.

Fittings shall be installed which will provide for the filling and draining of collector (silicone loop). The circulating pump shall be capable of being replaced without the need for draining the entire loop. Fittings shall be installed in the preheat tank (water) loop which will allow for segregation of the solar energy system from the conventional domestic hot water tank without interruption in the supply of hot water to the residence.

Pipe hangers and supports shall be installed in accordance with local code requirements. Insulating couplings or a dielectric flanged union shall be used between connections of dissimilar metals.

D. HEAT EXCHANGER

To ensure satisfaction of code requirements and prevent possible contamination of the domestic hot water supply, a double wall heat exchanger must be utilized. This exchanger should be installed in a well insulated or heated area not subject to feezing temperatures.

E. TANKS

The solar storage or preheat tank must have connections to facilitate the supply and return lines to the water side of the heat exchanger. In cases where only one connection is available, it will be necessary to modify the tank drain fitting to provide for a connection to the solar water loop while retaining the capability for draining the storage tank. The preheat tank should be installed in a well insulated or heated area not subject to freezing temperatures.

F. SYSTEM CONTROL

Control of the solar energy system is accomplished through the installation of a commercially available controller unit. The unit should be mounted in the same area as the water storage tank. The unit receives electrical service from a separate 120 VAC 60 Hz disconnect switch. This service provides for operation of the circulating pumps and control devices. Sensor wiring shall be 18 gauge twisted pair connected to the pigtails of the installed sensors using conventional wire nuts. All control wiring shall be run in solid conduit.

MISCELLANEOUS

A. MAINTENANCE AND REPAIR

Components of the solar energy system should be located for ease of maintenance and repair.

B. IDENTIFICATION

Main shutoff valves and power disconnect switches shall be located in such a manner as to be easily accessible and conspicuously identifiable in the event of an emergency.

C. INSTALLATION INSTRUCTIONS

Documentation shall be developed which will describe the interconnecting requirements of the components installed and their interface with the building and site. This documentation, including the "as-built" drawings may be used together with the Operating, Maintenance, and Repair instructions.

OPERATION, MAINTENANCE AND REPAIR

GENERAL

Prior to acceptance of the system installation from the installation contractor, the following tests will be performed:

- Pneumatic test of the collector subsystem (silicone fluid) to 75 PSI, which pressure is in excess of twice the normal operating pressure.

- Hydrostatic test of the solar heated water storage subsystem in accordance with local code.

- Testing of operating controls to insure program sequence of operation.

- On-site and computer checkout of data acquisition sensor installation to insure proper installation and operation.

- Operational test of solar energy system to insure proper installation and sequence of operation in accordance with the design requirements.

Upon satisfactory completion of acceptance tests, the system should function with minimum maintenance.

SYSTEM OPERATION

A. Shutdown

Should it be necessary to shut down the solar energy system, all that is required is to move the switch on the Rho Sigma controller to the "OFF" position. For added safety reasons, it is recommended that the Power Disconnect switches to the circulating pumps and the controller be placed in the "OFF" position.

B. Startup

The solar energy system can be operated in either automatic or manual modes. Prior to operating in either mode, a check should be made to insure that all valves are in the proper position (open or closed), and that the Power Disconnect switches to the circulating pumps (P1 & P2) are in the "ON" position. The Power Disconnect switch to the "Controller" should also be in the "ON" position. After completing the above check, the system can be placed in the Automatic Operation mode by moving the switch on the Rho Sigma Controller unit to the "AUTO" position. The solar energy system can also be operated in the manual mode by placing the switch on the Rho Sigma Controller unit to the "ON" position. However, as this will result in continuous operation of the circulating pumps (P1 and P2), this mode of operation is not recommended except for maintenance and checkout of the system.

This system has also been equipped with a freeze protection (thermoswitch) device which will shut the system down if the temperature of the water in the water side of the heat exchanger drops below 40 F. This shut down is accomplished by removing power to the "Controller" which drops power to the circulating pumps P1 and P2. As the temperature of the water rises above 45 F, the system is automatically placed back in operation.

PREVENTATIVE MAINTENANCE

Although the system is designed for maximum reliability, it is recommended that periodic inspections be made (once per month) of the installation to insure continued safe operation of the system. Fittings and pipe insulation should be inspected for traces of silicone oil and/or water stains. Once per quarter the system should be switched to manual operation to check the operation of the pumps and continued flexibility of the controller unit. Other than replacement of the packing on valves and the circulating pump, the system should be maintenance free.

REPAIR

- All repair work should be accomplished by qualified personnel.
- Prior to the start of any repair the system must be shut down in accordance with the SHUT DOWN procedure outlined in SYSTEM OPERATION section of the brochure.

A. Collector Subsystem (Silicone Fluid Loop)

In the event of a leak or replacement of defective element in the silicone fluid loop it will be necessary to drain the fluid from the subsystem (except for the collector pump which is equipped with isolation valves) by opening the top port on the high point of the loop and the drain valve located on the low side of the loop. The silicone fluid should be recovered by draining into clean five-gallon containers as the fluid will be reused upon completion of repair. CAUTION: Drain only when system is cool.

Upon completion of repair, it is necessary to pneumatically test the subsystem loop (at 75 psi) to insure continued safe operation of the system.

The collector loop can then be recharged by pumping the silicone fluid into the system through the fill port connection with the top port on the top of the system open. The collector circulating pump should be run briefly after filling to remove any trapped air; then add additional fluid, if necessary, and close the fill and top ports tightly.

B. Solar Heated Water Storage Subsystem (Water Loop)

To repair a leak or faulty component of the water storage subsystem, the following procedure should be followed:

(1) Shut system down in accordance with procedure outlined in the System Operation Section.

(2) Close water supply valve to water storage tank and the valve between the water preheat tank and the domestic hot water tank.

(3) Open cold water supply valve to domestic hot water tank to provide for continued operation of the conventional domestic hot water supply system.

(4) Drain the solar heated water storage loop by opening the drain valve on the bottom of the water preheat tank.

(5) Replacement of the circulating pump can be accomplished without draining the loop; simply close the isolation valves located in the flange on each side of the pump, disconnect the pump and replace with a new unit.

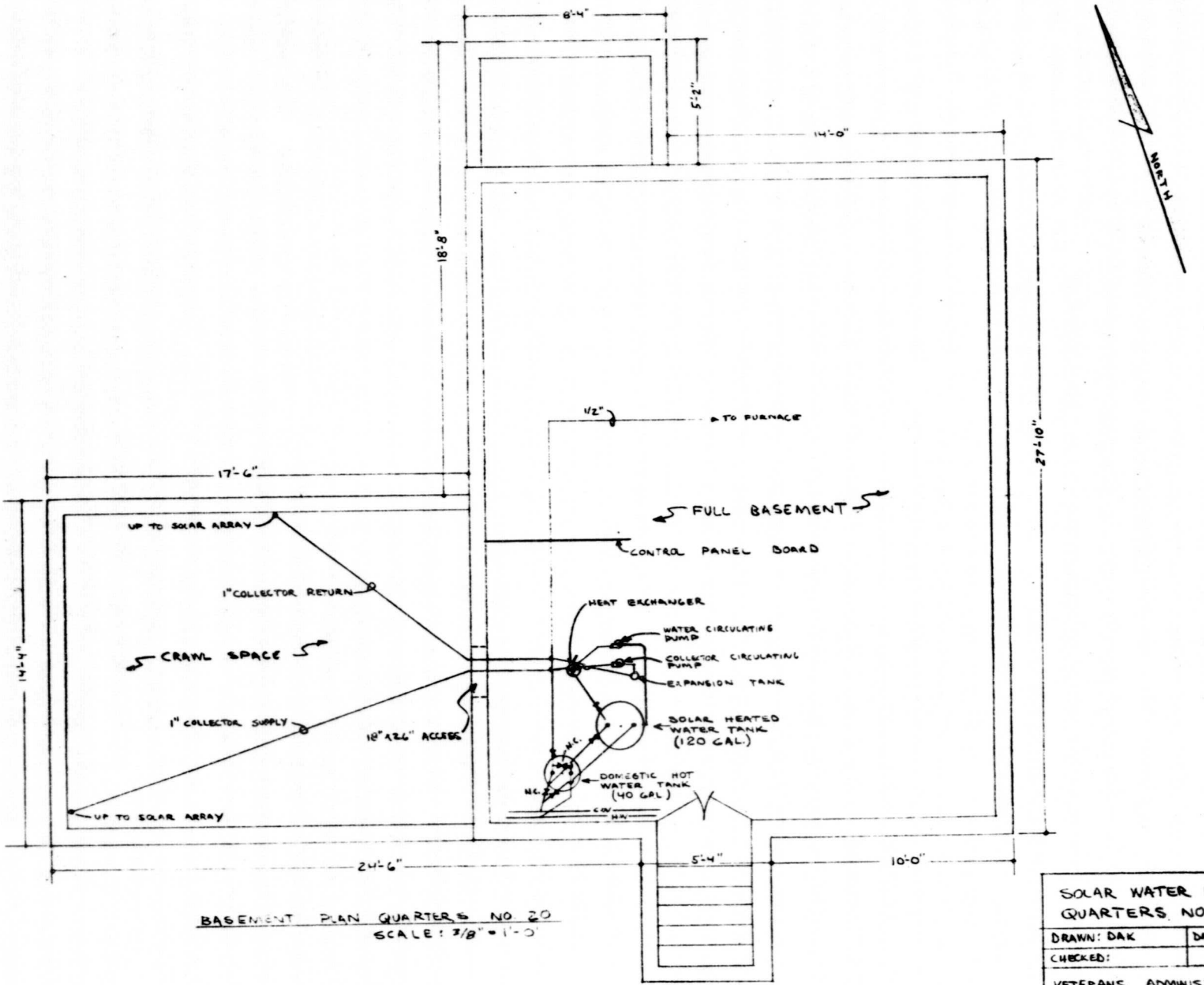
(6) Upon completion of repair the subsystem can be recharged by closing the drain valve, opening the water supply valve to the preheat storage tank and the domestic hot water tank, and closing the supply valve to the domestic hot water tank. To purge the subsystem of air, it will be necessary to open a hot water tap within the residence.

APPENDIX

DRAWINGS

SOLAR WATER HEATER QUARTERS NO. 20

V. A. SKETCH NO. 77-48 Pages 17, 18 & 19



BASEMENT PLAN QUARTERS NO 20
SCALE: 3/8" = 1'-0"

SOLAR WATER HEATER
QUARTERS NO. 20

DRAWN: DAK	DATE: 12-5-77
CHECKED:	

VETERANS ADMINISTRATION CENTER
TOGUS MAINE

V.A. SKETCH NO. 77-48 SH. 1 OF 3

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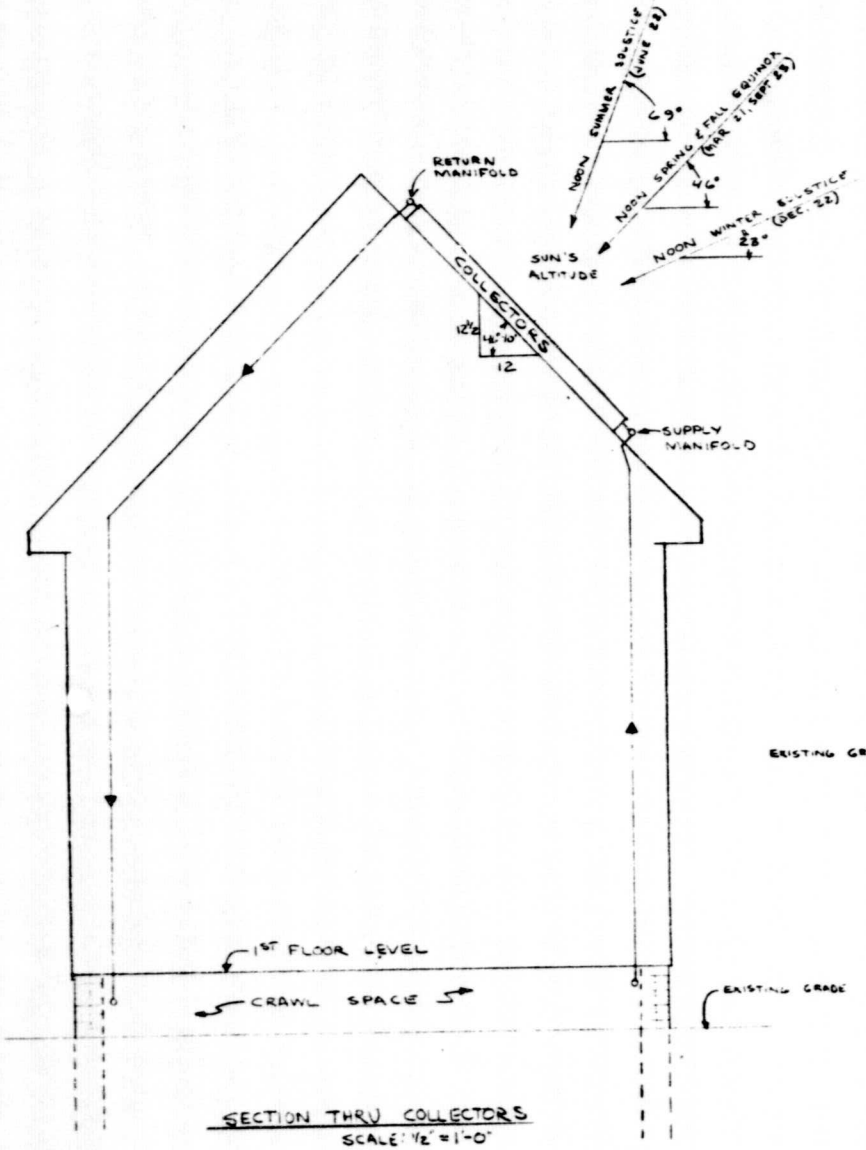
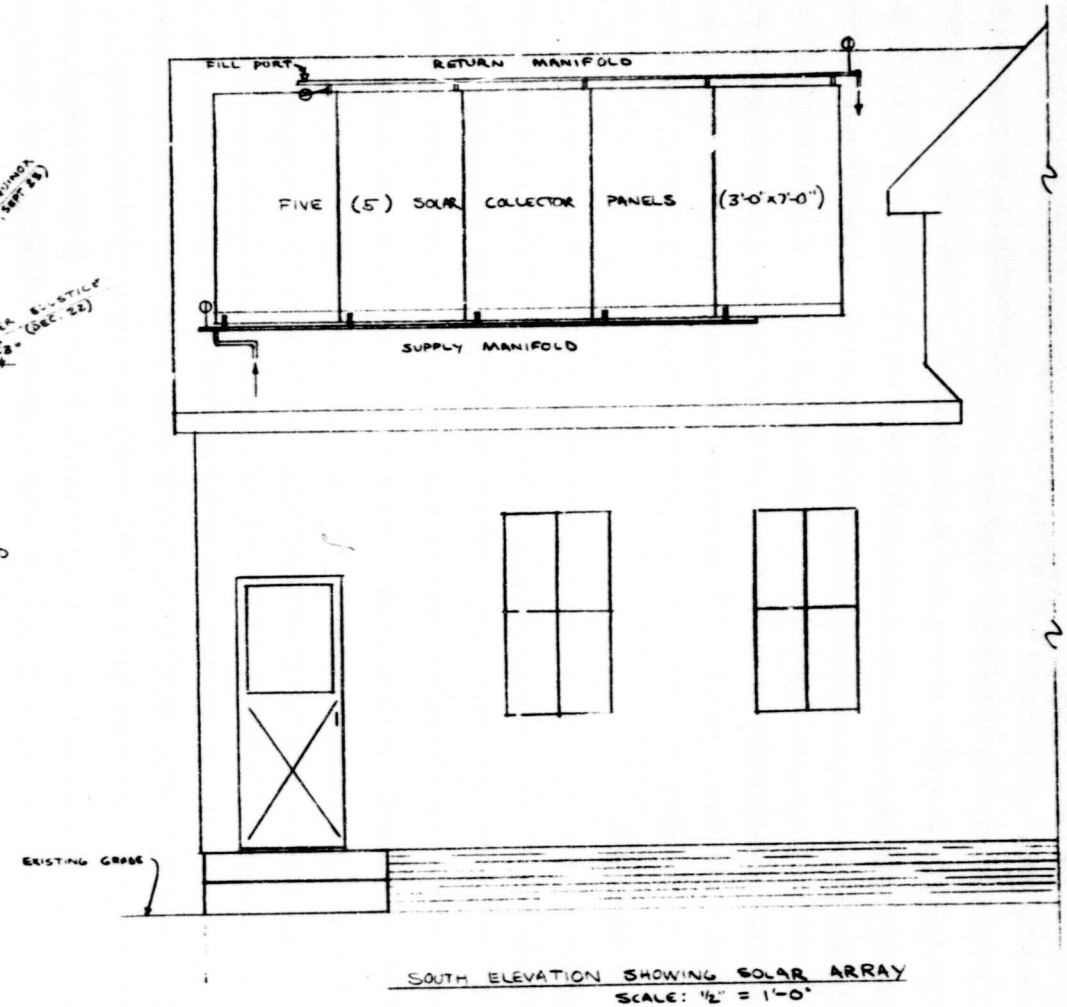


SECTION THRU COLLECTORS
SCALE: ½" = 1'-0"



SOUTH ELEVATION SHOWING SOLAR ARRAY
SCALE: ½" = 1'-0"

COLLECTOR ORIENTATION DATA

TILT ANGLE = 46°-10'
LATITUDE = 44°-17' (FROM USGS MAP)
ORIENTATION APPROX. 15° WEST OF SOUTH (BASED ON USGS MAP TRUE NORTH)

SOLAR WATER HEATER QUARTERS NO. 20	
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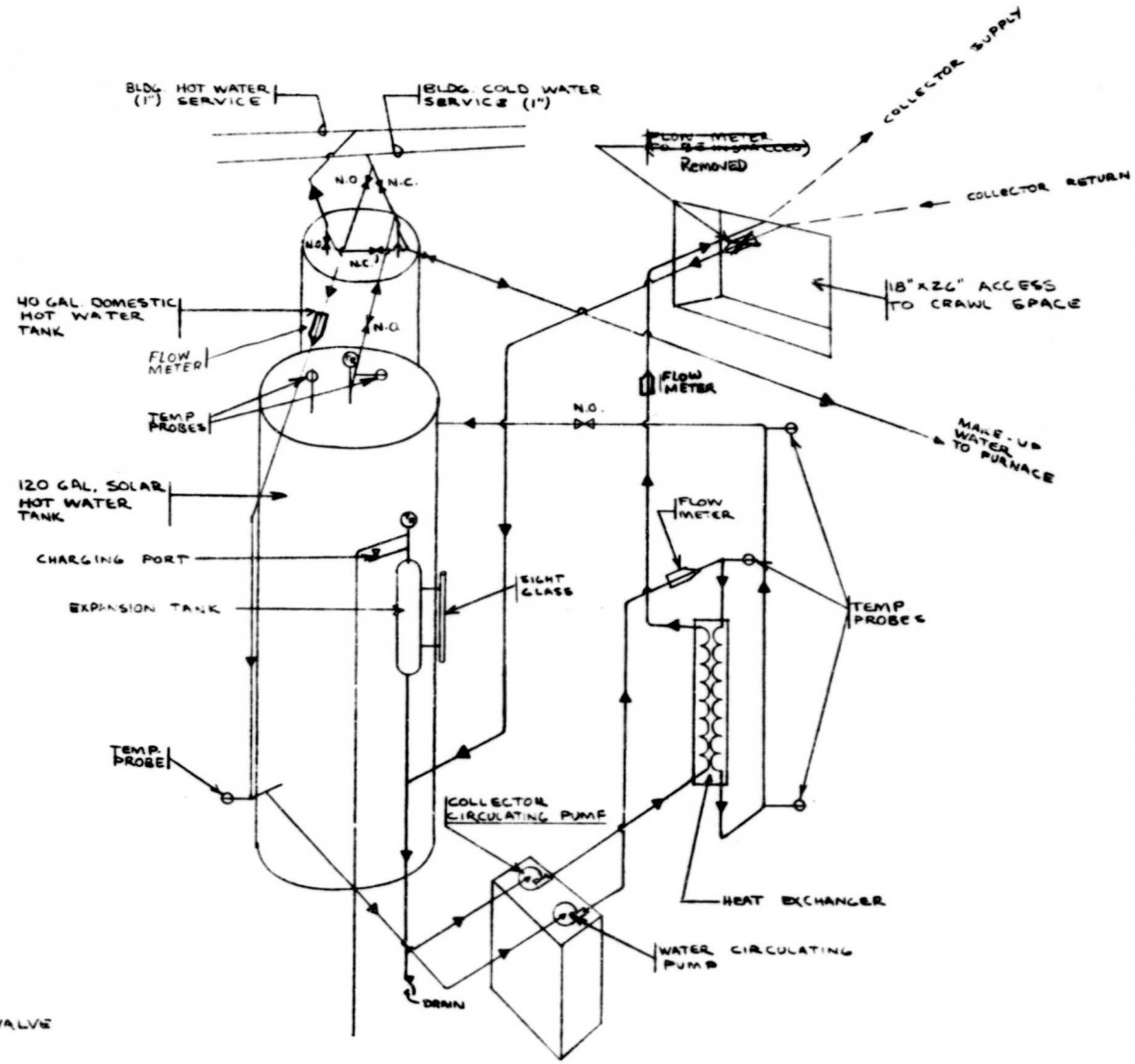
VETERANS ADMINISTRATION CENTER TOGUS MAINE	
V.A. SKETCH NO. 77-48 SH. 2 OF 2	



LEGEND

- TEMPERATURE PRESSURE RELIEF VALVE
- PUMP
- GATE VALVE
- DRAIN VALVE
- CHECK VALVE
- FLOW DIRECTION ARROW
- FLOW METER
- SENSOR
- TEMP. PROBE
- CHARGING PORT

BASEMENT PLUMBING SCHEMATIC

N.T.S.

NOTE: WATER TANKS ARE COVERED WITH 4" FIBERGLASS INSULATION. PIPING IS COVERED WITH 2" FIBERGLASS INSULATION.

SOLAR WATER HEATER QUARTERS NO. 20	
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VETERANS ADMINISTRATION CENTER TOGUS MAINE	
V.A. SKETCH NO. 77-48 SH 3 OF 3	