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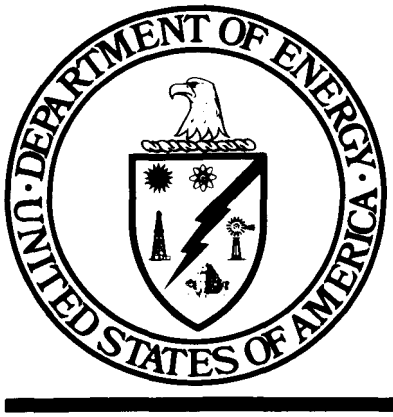
SOLAR/1084-81/50
(DE81027853)

Solar Project Description

PUBLIC SERVICE COMPANY OF NEW MEXICO (LOT 7) SINGLE FAMILY RESIDENCE Rio Rancho, New Mexico August 6, 1981



U.S. Department of Energy

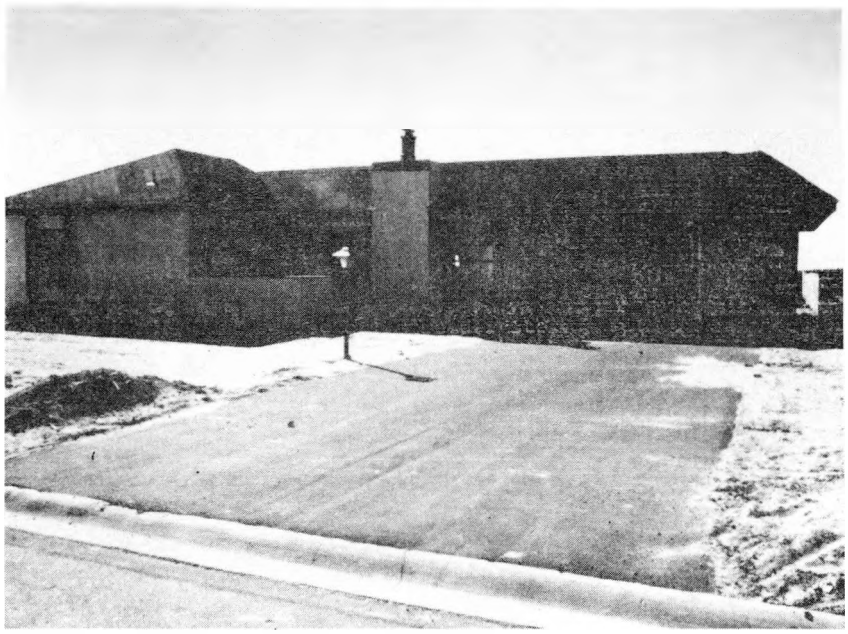
National Solar Heating and Cooling Demonstration Program

National Solar Data Program

DISCLAIMER

SOLAR/1084-81/50
(DE81027853)
Distribution Category UC-59

SOLAR PROJECT DESCRIPTION
FOR
PUBLIC SERVICE COMPANY OF NEW MEXICO (LOT 7)
SINGLE FAMILY RESIDENCE - RIO RANCHO, NEW MEXICO



Department of Housing and Urban Development

Under Contract Number

H-2372

David Moore
Solar Heating and Cooling Demonstration Program Manager

By

The Boeing Company
David Beers, Program Manager

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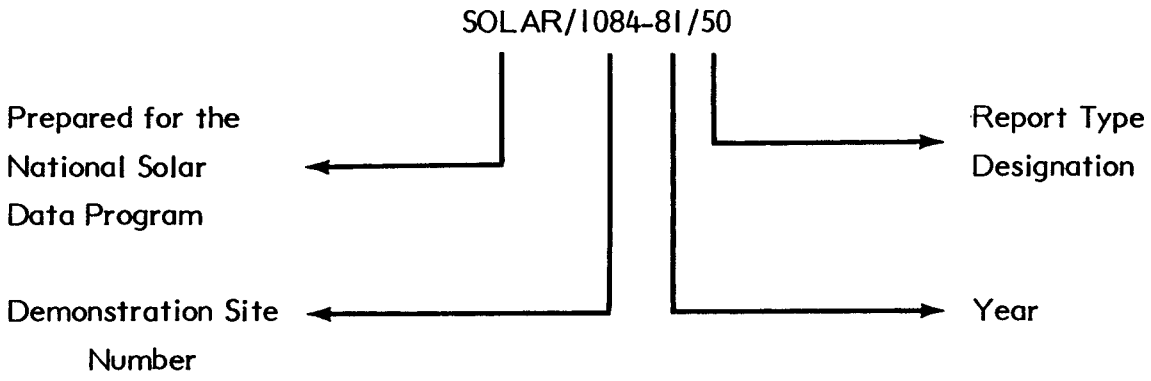
LIST OF FIGURES

NATIONAL SOLAR DATA PROGRAM REPORTS

Reports prepared for the National Solar Data Program are numbered under a specific format. For example, this report for the Public Service Company of New Mexico (Grant H-8172) project site is designated as SOLAR/1084/81/50. The elements of this designation are explained in the following illustration:



Demonstration Site Number: Each project has its own discrete number - 1000 through 1999 for residential sites and 2000 through 2999 for commercial sites.

Report Type Designation:
This number identifies the type of report, e.g.,

- Monthly Performance Reports -- designated by the numbers 01 (for January) through 12 (for December);
- Solar Energy System Performance Evaluations -- designated by the number 14;
- Solar Project Descriptions -- designated by the number 50;
- Solar Project Cost Reports -- designated by the number 60.

These reports are disseminated through the U.S. Department of Energy, Technical Information Center, P.O. Box 62, Oak Ridge, Tennessee 37830.

I. FOREWORD

The National Program for Solar Heating and Cooling is being conducted by the Department of Energy (DOE) as mandated by the Solar Heating and Cooling Demonstration Act of 1974. The Department of Housing & Urban Development is responsible to DOE for the Solar Residential Demonstration Program. The overall goal of the Federal Demonstration Program is to assist in the establishment of a viable solar industry and to achieve a substantial reduction in fossil fuel use through widespread use of solar heating and cooling applications. An analysis and synthesis of the information gathered through this program will be disseminated in site-specific reports and summary documents as products of the National Solar Data Program. These reports will cover topics such as:

- o Solar Project Description.
- o Operational Experience.
- o System Performance Evaluation.
- o Monthly Performance Reports.

Information contained herein for this Solar Project Description report has been extracted from data collected during site visits and from reference documents such as the project proposal, designer specifications, grantee submittals, manufacturer literature, photographs, specific "as-built" data and other project documentation available. The remaining reports in this series will utilize the Solar Project Description for supporting reference.

II. EXECUTIVE SUMMARY

The following are the major solar energy descriptors:

- o Collector Type -- Air flat plate collectors
- o Freeze Protection -- Not required
- o Application -- Space Heat/DHW
- o Storage -- 213 ft^3 bin (20,000 lb rocks)
- o New or Retrofit -- New
- o Performance Evaluation Instrumentation -- Yes

The Public Service Company House, Lot #7 (Grant H-8172) is one of two instrumented single-family residences in Rio Rancho, New Mexico. The home has approximately 1350 square feet of conditioned space. Solar energy is used for space heating the home and preheating domestic hot water (DHW).

The solar energy system has an array of flat-plate collectors with a gross area of 150 square feet. The array faces south at an angle of 32 degrees to the horizontal. Air is the transfer medium that delivers solar energy from the collector array to storage, space heating and domestic hot water. Solar energy is stored in a 213-cubic-foot bin, with 8-inch concrete walls and polyurethane insulation. The bin contains approximately 20,000 pounds of rock.

Preheated city water is stored in an 80-gallon preheat storage tank and supplied, on demand, to a conventional 40-gallon DHW tank. An electrical strip heater in the air distribution duct provides auxiliary energy for space heating. Similarly, an electrical heating element in the DHW tank provides auxiliary energy for water heating. The system, shown schematically in figure IV-A-1, has five modes of solar operation.

The dwelling has been fully instrumented for performance evaluation since November 1977 and the data is integrated into the National Solar Data Network.

Original cost estimates for provisioning and installation of the solar system are given in section VI of this report. However, the final solar system cost and the cost of its instrumentation are not included in this report.

III. GENERAL CHARACTERISTICS (See figure III-1. Site Plan)

The Public Service Company House, Lot 7 (Grant H-8172) is an instrumented single family residence in Rio Rancho, NM. Solar energy is utilized for both space heat and DHW.

- Building type - Single family house, detached
- Latitude - 35^{o}
- Longitude - 107^{o}
- Altitude - 5314 ft

HEATING DESIGN TEMPERATURES

- Outdoor - 15^{o} F
- Indoor - 70^{o} F

BUILDING

- Building faces - North
- Average stories above ground - 1.0
- Average stories below ground - 0
- Height above grade - 13 ft
- Conditioned floor area - 1185 ft^2
- Roof type - Flat

DESIGN HEAT LOSS/LOAD

- Heat Loss - 26,362 Btu/hr
- Heat gain - Unknown
- Shading
  - Heating season - 0
  - Cooling season - 0

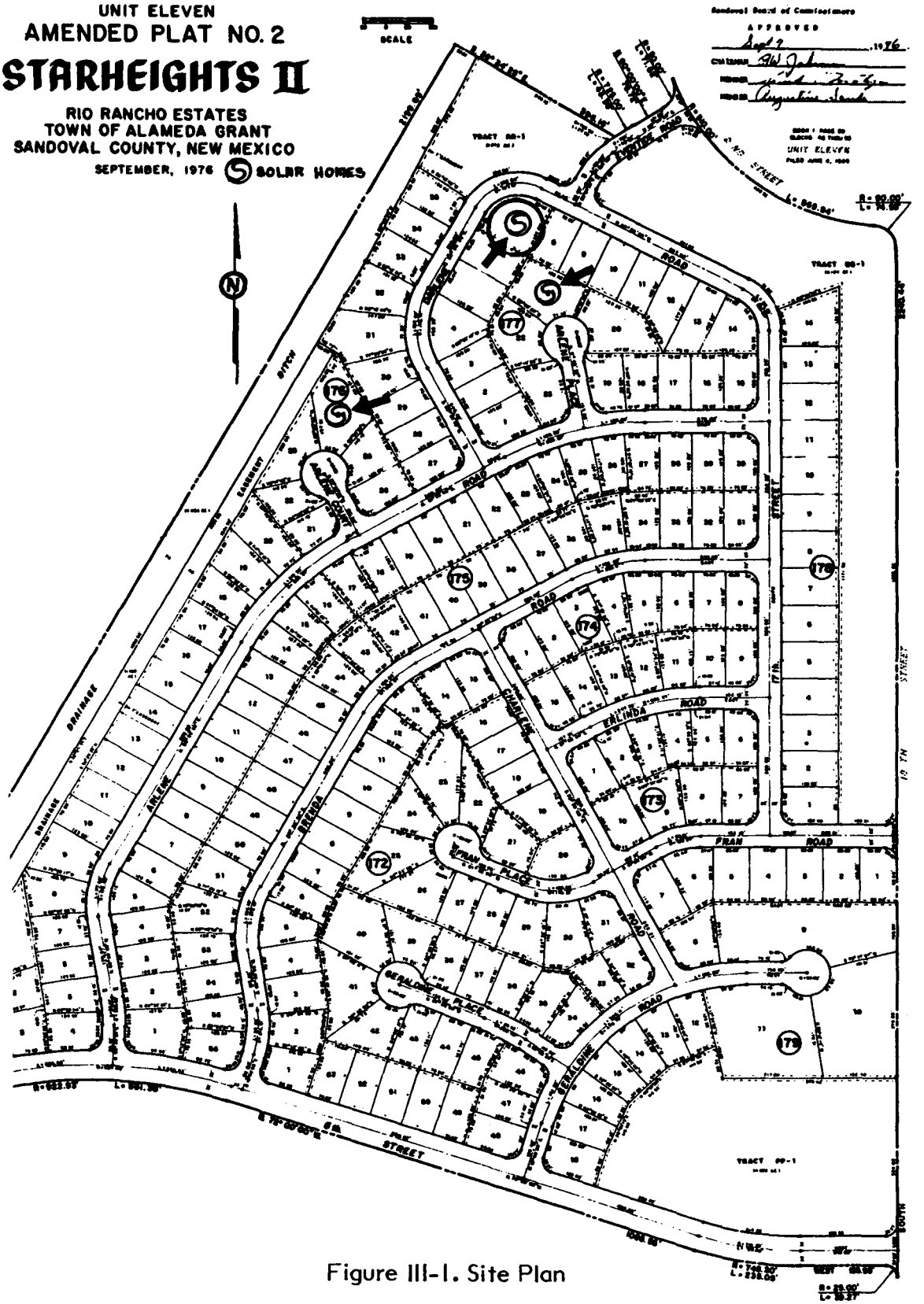


Figure III-1. Site Plan

- Appliance, lighting and equipment load - 1200 Btu/hr
- Average horizontal insolation
  - January - 1017 Btu/ft^2/day
  - July - 2489 Btu/ft^2/day
- Annual degree days
  - Heating - 4292 DD
  - Data location - Albuquerque, NM
  - Data reference - Local Climatological Data Annual Summaries, Department of Commerce, National Oceanographic and Atmospheric Administration

MECHANICAL SYSTEM

- Heating
  - Solar - Air flat plate collectors
  - Auxiliary - Heating strip in ducts (ERH-1)
  - Distribution - Air

DOMESTIC HOT WATER

- Daily water demand - 45 gal
- Solar - Air flat plate collectors
- Auxiliary - Electric element in DHW tank

GENERAL DATA

- Manufacturer - Solar Seven Industries
- Model name/number - Unknown
- Type of system - Air flat plate collectors

SYSTEM AND COMPONENT SUMMARY

- Collector types - 1
- Circulation loops - 5
- Thermal storage units - 2 (TSU-1, Rock bin storage and TSU-2 Preheat Tank).
- Operational modes - 6
- Pumps - 1
- Valves - 3
- Blowers - 2
- Dampers - 9
- Sensors - 5
- Flow regulators - 0
- Pressure regulators - 0
- Fail safe controls - 0

IV. SOLAR SYSTEM DESCRIPTION

A. General Overview

This residential solar demonstration project (Public Service Co., Grant H-8172) located at Rio Rancho, NM is an active air system utilized for space heat and DHW. Auxiliary units are provided for both space heat and DHW by electric heat strip in ducts and an electric element in the DHW-1.

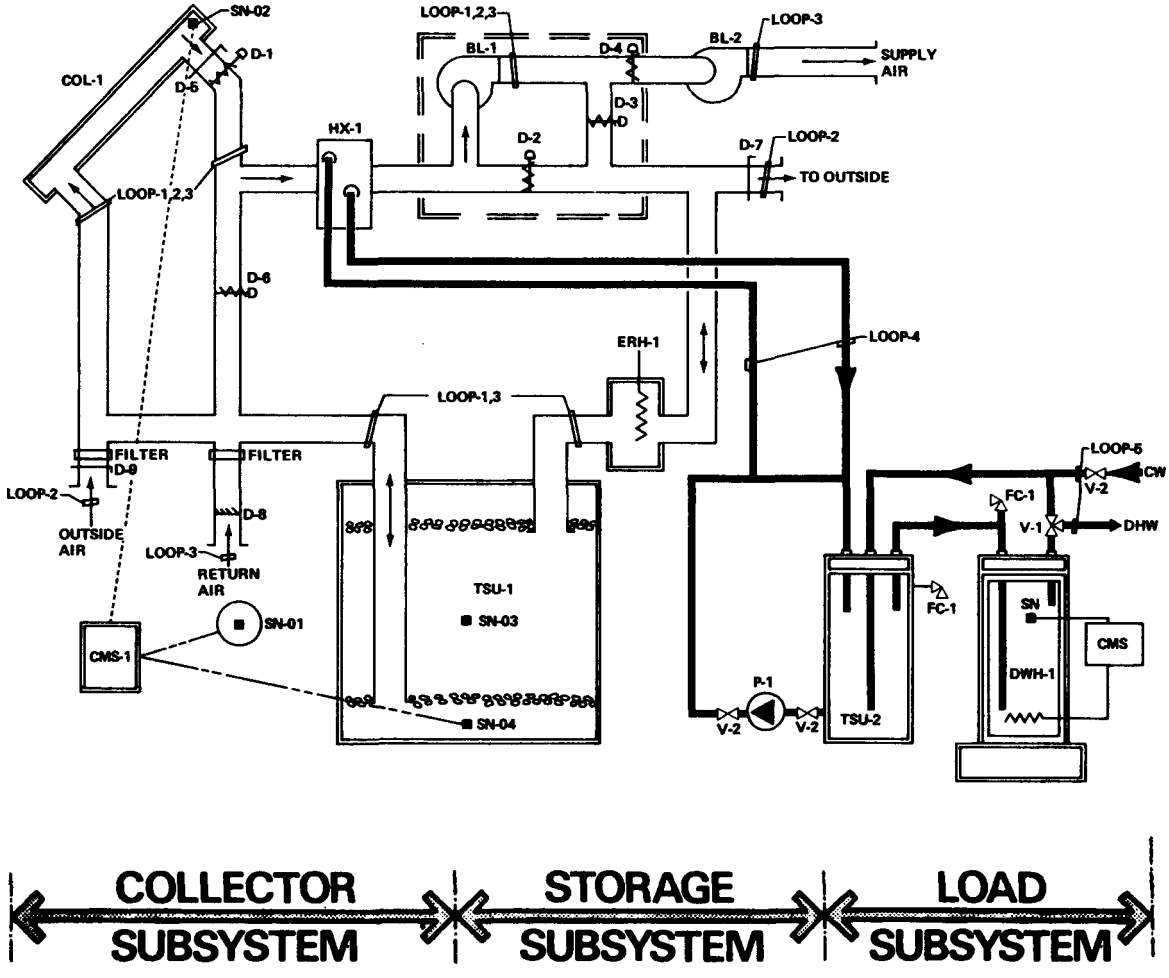


Figure IV-A-1. General Overview

Subsequent sections describe the collector, storage, energy-to-load, and auxiliary subsystem. Specific details of the operating modes and controls are described in the final section. Figure IV-A-1 is a system schematic diagram.

B. Collector Subsystem (See figures IV-B-1 and IV-B-2)

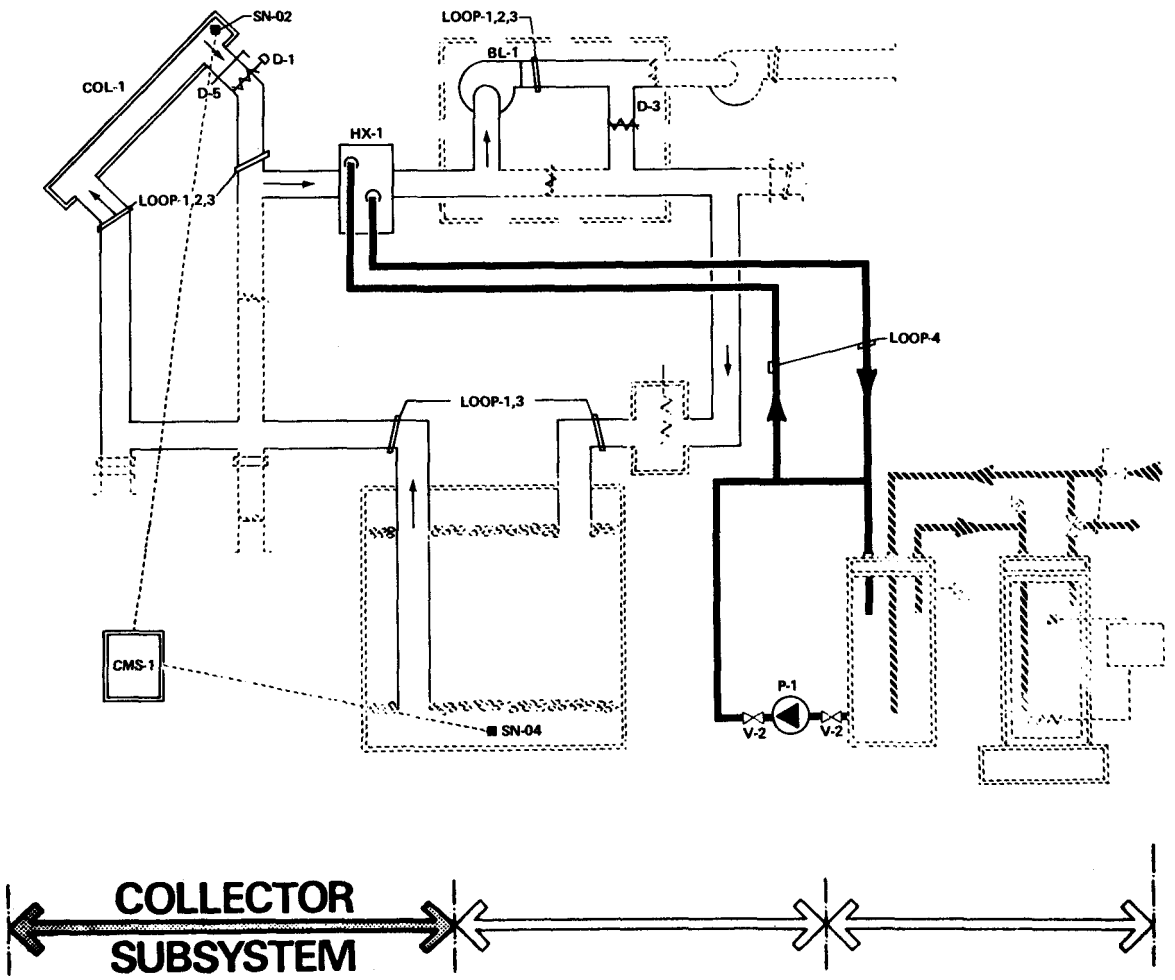


Figure IV-B-1. Collector Subsystem, Collector-to-Storage

Collector array system consists of 8 air flat plate (156 ft^2) collector panels. Freeze protection is not required. Solar heated air flows through air circulation Loop No. 1. Water is circulated through the heat exchanger for DHW preheat.

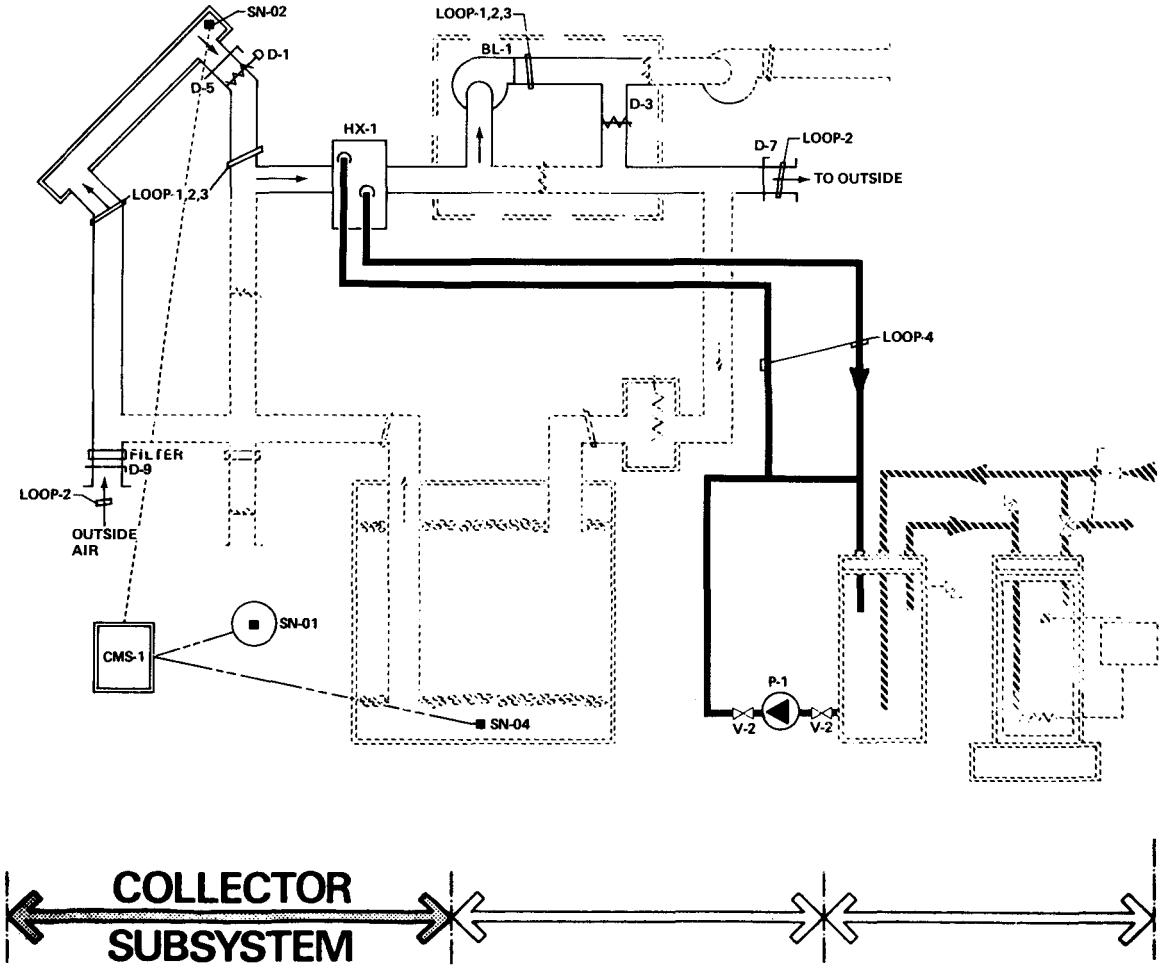


Figure IV-B-2. Collector Subsystem, Collector-to-Hot Water - Summer Mode

Solar heated air flows through air circulation Loop No. 2 when heat is not required for storage or for space heating. Water is circulated through the heat exchanger for DHW preheat.

COLLECTOR (COL-1) (See figure IV-B-3)

- Manufacturer - Solar Seven
- Model name/number - Unknown
- Type - Air
- Location - Roof
- Orientation - 0^{o} East of South
- Tilt angle - 32^{o} from horizontal
- Collector characteristics
  - Number of panels - 8
  - Total gross area of array - 156 ft^2
  - Net aperture area - 143 ft^2
  - Net absorber area - 143 ft^2
  - Weight per panel, empty - 134 lb
  - Weight per panel, full - 134 lb
  - Weight of filled array and support structure - 2000 lb
  - Panel length - 78.0 in
  - Panel width - 36.0 in
  - Frame depth - 3.0 in
  - Standoff height - 0
- Built-in collector - Yes
- Collector shading -
  - Area shaded in June - 0%
  - Area shaded in December - 0%
  - Maximum shade during functional season - 0%

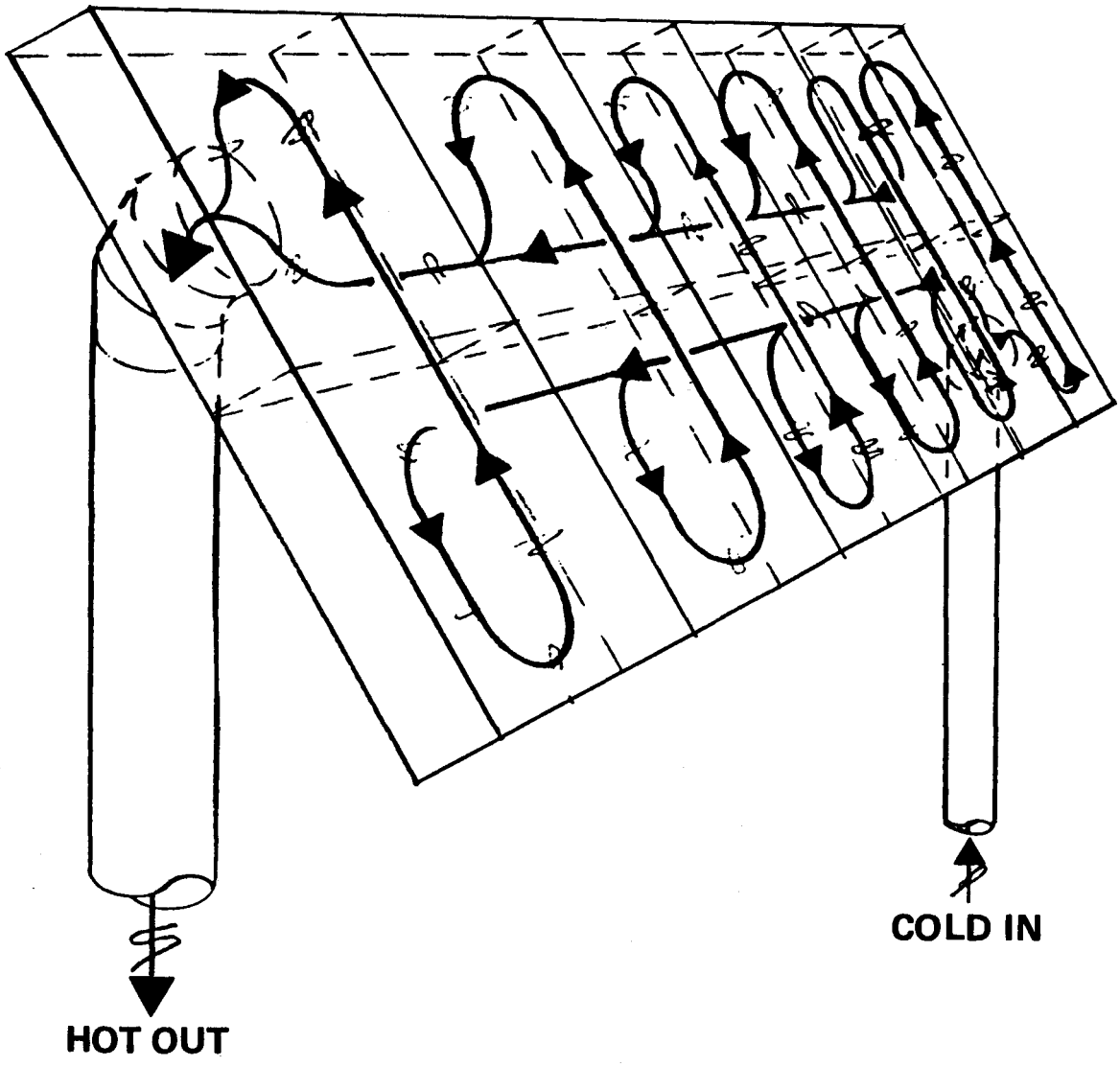


Figure IV-B-3. Solar Collector

- Cover plates
  - Number of cover plates - 2
- Cover plate No. 1
  - Location - Outer layer
  - Material - Glass, tempered
  - Thickness - 0.125 in
  - Optical properties

	(solar region)	(infrared region)
- Transmittance -	89%	
- Reflectance -		
- Emittance -		

  - Edge or surface treatment, other than coating - None
  - Coating on cover plate material - None
- Cover plate No. 2
  - Manufacturer - Solar Seven
  - Material - Glass, tempered
  - Thickness - 0.125 in
  - Optical properties

	(solar region)	(infrared region)
- Transmittance	89%	
- Reflectance		
- Emittance		

  - Edge treatment - None
  - Coating - None
- Absorber
  - Manufacturer - Solar Seven
  - Material - Steel, Galvanized

- Substrate material dimension
  - Thickness - 0.024 in
  - Length - 78 in
  - Width - 36 in
- Number of absorbers per collector - 1

- Coating
  - Manufacturer - 3M Company
  - Model name/number - Nextel "Black Velvet"
  - Coating material - Flat paint, black

	(solar region)	(infrared region)
Absorptance -	97%	
Reflectance -		
Emittance -		

- Heat transfer fluid passages
  - Location - Beneath absorber
  - Pattern - Parallel
  - Materials - Copper
  - Wall thickness - Unknown
  - Internal diameter - Unknown
  - Maximum operating conditions
    - Temperature - Unknown
    - Pressure - Unknown
  - Fluid passage bond to substrate - Integral
  - Protective coating inside fluid passage - None

- Insulation
  - Layer one - sides
    - Manufacturer - Solar Seven

- Product name/number - Unknown
- Material - Glass fiber
- Thermal resistance - Unknown

o Layer one - back
- Manufacturer - Solar Seven
- Product name/number - Unknown
- Material - Glass fiber
- Thermal resistance - Unknown

o Gaskets and sealants - No Information Available
  o Inner cover -
  o Outer cover -
  o Backing plate -
  o Penetrations -

o Frame
  o Manufacturer - Solar Seven
  o Product name/number - Unknown
  o Material - Aluminum
  o Protective coating - None
  o Standoffs used - No
  o Number of structure attach points per module to building - Continuous
  o Built-in collector - Yes

- Reflectors - None
  - Desiccant - No
  - Freeze protection - None required
  - Overheating protection - Summer air vent
- Collector performance
  - Method of evaluation - INFORMATION UNAVAILABLE
  - y intercept $F_R (\tau\alpha)_\eta$ -
  - Slope - $F_R U_L$
- Point Number 1 2 3 4
  - η = collector thermal efficiency (%) -
  - t_i or t_f = collector inlet temperature (^{o} F) -
  - t_a = ambient air temperature (^{o} F) -
  - I_t = insolation intensity Btu/hr ft^2 -
  - ASHRAE $(t_i - t_a)/I_t$ -

WHERE

- η = collector thermal efficiency
- U_L = collector heat loss factor
- F_R = collector heat removal factor
- t_a = ambient air temperature, ^{o} F
- $(\tau\alpha)$ = Transmissivity-absorptivity product at normal incidence
- t_i = collector inlet temperature, ^{o} F
- t_f = average fluid temperature, ^{o} F
- I_t = radiation (insolation) intensity on collector, Btu/hr.ft^2
  - Test flow rate - 2.0 ft^3/min
  - Heat loss coefficient - Unknown
  - Test wind speed - Unknown

- Test collector area
  - Gross - 19.5 ft^2
  - Net - 18.0 ft^2
- Fluid specific heat - 0.24 Btu/lb/^{o} F
- Test fluid medium - Air

AIR CIRCULATION LOOP NO. 1 (COL-1 TO TSU-1)

- Heating
  - Maximum design operating temperature - 120^{o} F
  - Maximum design operating pressure - 1.25 in wg
  - Heating design air flow -
    - Maximum - 800 cfm
    - Minimum - 300 cfm
- Components within circulation loop
  - Blower(s) - BL-1
  - Thermal storage unit(s) - TSU-1
  - Damper(s) - D-1, D-2, D-3, D-4, D-5 and D-6
  - Heat exchanger(s) - HX-1
  - Other(s) - Electric Resistance Heater (ERH-1)
- Ducting
  - Type - Steel, galvanized
  - Location - Above grade
  - Maximum operating temperature -
  - Thermal resistance - R-
  - Insulation - Fiberglas
  - Finish
    - Internal - Foil Laminate
    - Exterior - Galvanized

- Blower
  - Manufacturer - Lau
  - Model name/number - FGP Series
  - Type - Squirrel cage
  - Motor size - 0.17 hp; 115 V; 1 phase; 60 Hz
  - Maximum motor speed - 1000 rpm
  - Drive - Belt
  - Blower speed - Single
  - Design conditions
    - Impeller Speed - 1000 rpm

	Low Static Mode	High Static Mode
- Circulating volume	300 cfm	
- Motor operation	0.17 bhp	

- Damper - D-1, D-6
  - Manufacturer - Ruskin
  - Model name/number - MD 35
  - Function - ON/OFF
  - Type - Multilouver
  - Operation - Automatic, motorized
- Damper(s) - D-2, D-3, D-4
  - Manufacturer - Solar Seven
  - Function - Flow switching
  - Type - Multilouver
  - Operation - Automatic, motorized

- Damper - (D-5)
  - Manufacturer - Shop Built
  - Function - Flow-adjusting
  - Type - Slide gate
  - Operation - Manual
- Heat Exchanger (HX-1) AIR TO LIQUID
  - Manufacturer - Magic-Aire
  - Model name/number - HHW-2
  - Type of flow - Parallel
  - Heat exchanger design - Fin coil
  - Number of separations - Unknown

	Side One	Side Two
o Convection:	Forced	Forced
o Part of circulation loop:	1,2,3	4
o Maximum manufacturer's rated:		
- Temperature -	200° F	
- Pressure -	150 psi	
o Heat transfer area	1 ft^2	
o Rows	2	
o Fins per inch	10	
o Face area	2.4 ft^2	
o Material	Copper	Aluminum

  - Heating
    - Overall heat transfer coefficient (UA) - 1600
    - Effectiveness - Unknown

	Side One	Side Two
o Design flow rate -	300 cfm	3 gpm
o Related circulator no.	BL-1	P-1
o Liquid temperatures:		
- Entering -	Unknown	Unknown
- Leaving -	Unknown	Unknown

AIR CIRCULATION LOOP NO. 2 (SUMMER VENT)

- o Heating
  - o Maximum design operating temperature - 120° F
  - o Maximum operating pressure - 1.25 in wg
  - o Heating design air flow -
    - - Maximum - 300 cfm
    - - Minimum - Unknown
- o Components within circulation loop
  - o Blower(s) - BL-1
  - o Damper(s) - D-1, D-2, D-3, D-4, D-5, D-7 and D-9
  - o Heat exchanger(s) - HX-1
- o Ducting
  - o Type - Steel, galvanized
  - o Location - Above grade
  - o Insulation - Fiberglass
  - o Finish -
    - - Internal - Foil Laminate
    - - Exterior - Galvanized
  - o Filter -
    - - Type - Fiberglass
    - - Location - RA Grille

- Damper - (D-7, D-9)
  - Manufacturer - Shop built
  - Function - ON/OFF
  - Type - Slide gate

LIQUID CIRCULATION LOOP NO. 4 (HOT WATER PREHEAT)

- Design operating temperature - 140° F
- Design operating pressure - 125 psi
- Heating
  - Design liquid flow - 3.0 gpm
  - Design pump speed - At maximum
- Heat transfer medium
  - Volume of liquid in loop - 85 gal
  - Anticipated liquid temperature -
    - Maximum - 140° F
    - Minimum - 40° F
  - Provisions for expansion - No
  - Medium - Water (100%)
  - Specific heat - 1.00 Btu/lb/° F
  - Density - 62.4 lb/ft^3
  - Heat capacity - 62.4 $Btu/ft^3/°$ F
  - Boiling point - 212° F
  - Freezing point - 32° F
  - Medium manufacturer's recommended use temperature -
    - Maximum - 140° F
    - Minimum - 40° F
  - Toxicity - Potable

- pH factor - 7.0
- Chemical feeder - No
- Inhibitor - No

- Components within circulation loop
  - Pump(s) - P-1
  - Heat exchanger(s) - HX-1
  - Thermal storage unit(s) - TSU-2
  - Valve(s) - V-2

- Piping
  - Rigid - Copper, Type M
  - Insulation - Cellular Rubber
  - Location - Above grade

- Circulator pump (P-1)
  - Manufacturer - Teel
  - Model name/number - IP-760
  - Type - Centrifugal
  - Maximum operating conditions
    - Dynamic static - 150 psi
    - Temperature - 250° F
  - Material exposed to heat transfer fluid - Bronze
  - Motor size - Unknown
  - Maximum motor speed - Unknown
  - Drive - Direct
  - Speed - Single
  - Pump speed - Single
  - Circulating volume - Low head mode - Unknown
  - Operating head (dynamic) - Low head mode - Unknown
  - Motor operation - Unknown

- Distribution Valve
  - Manufacturer - Nibco
  - Model name/number - Unknown
  - Function - ON/OFF
  - Operation - Manual
  - Type - Gate
  - Maximum manufacturer's rated operating conditions:
    - Pressure - 125 psi
    - Temperature - 180^{o} F
  - Material exposed to heat transfer fluid - Bronze

Control Mode Selector (CMS-1)

- Manufacturer - Solar Seven
- Model name/number - Unknown
- Modes controlled
  - Collector to storage
    - ON - (SN-2) > 120^{o} F and (SN-4) < 90^{o} F
    - OFF - (SN-2) < 90^{o} F or (SN-4) > 120^{o} F
  - Collector to HW, Summer Mode
    - ON - (SN-1) $\geq 70^{o}$ F and (SN-2) > 120^{o} F or (SN-2) > 120^{o} F and (SN-4) > 90^{o} F
    - OFF - (SN-1) < 70^{o} F or (SN-2) < 120^{o} F, or (SN-4) < 90^{o} F
- Sensors (SN-1), (SN-2), (SN-3) and (SN-4)
  - Manufacturer - Solar Seven
  - Model name/number - Unknown
  - Type - Temperature, thermistor

C. Storage Subsystem (See figure IV-C-1)

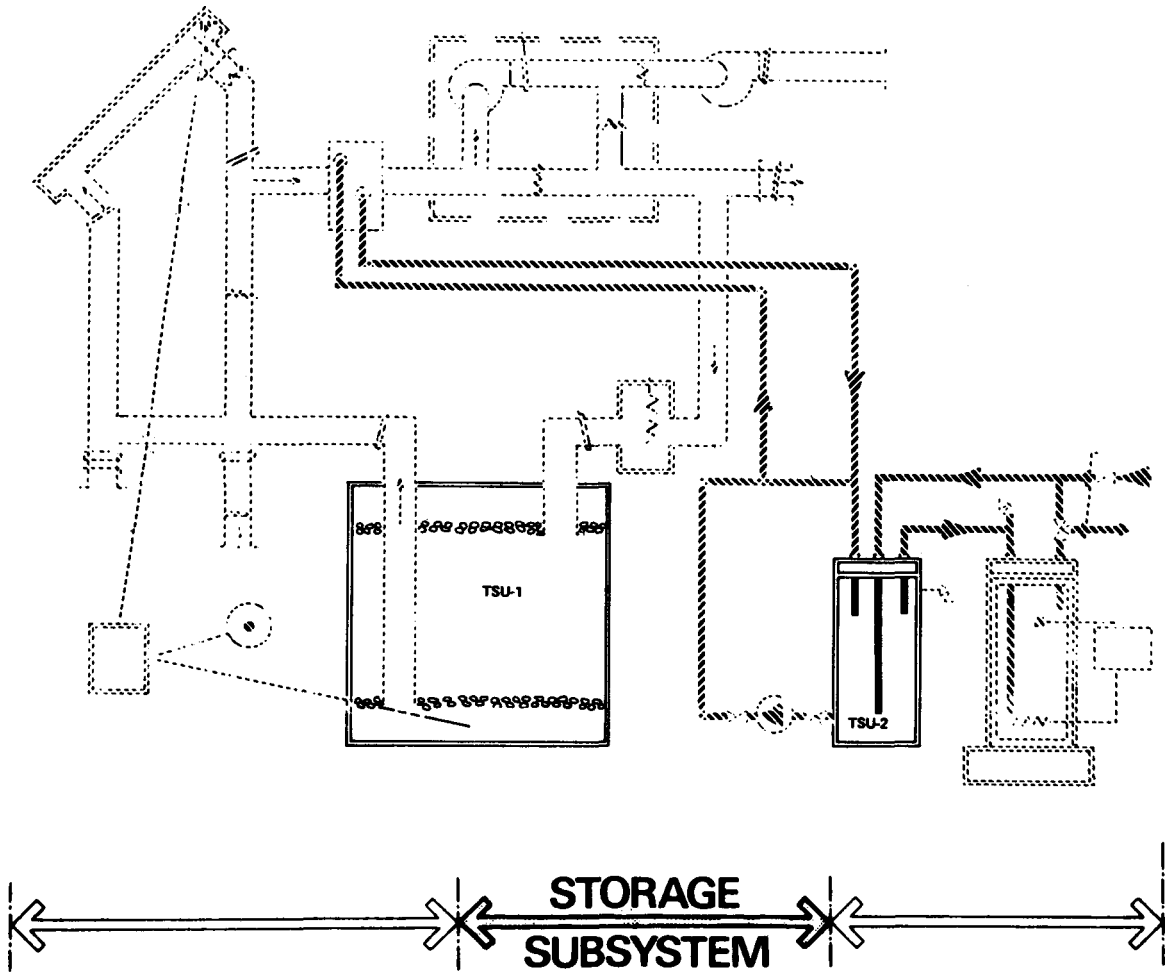


Figure IV-C-1. Storage Subsystem

Solar energy is stored in a 213 ft^3 bin (TSU-1) with 8-inch concrete walls and polyurethane insulation. This bin contains 20,000 lbs of rock.

Preheated city water is stored in an 80-gal (TSU-2) tank and its measurements are 5.3 ft high x 2.1 ft in diameter.

THERMAL STORAGE UNIT (TSU-1)

- Manufacturer - Site built
- Model name/number - Unknown
- Total storage container volume - 212.8 ft^3
- Volume of storage medium - 20,000 lbs
  - Length - 7.3 ft
  - Width - 5.3 ft
  - Height - 5.5 ft
- Maximum rated operating conditions - Not rated
- Storage medium
  - Design heating operating temperatures
    - Maximum - 120° F
    - Minimum - 90° F
  - Material - Smooth surfaced stone
  - Total weight - 20,200 lbs
  - Size - 0.75 - 1.5 in
  - Specific heat - 0.20 Btu/lb/° F
  - Density - 100 lbs/ft^3
  - Heat capacity - 25 Btu/ft^3/° F
  - Boiling point - Not applicable
  - Freezing point - Not applicable
- Medium manufacturers recommended use of temperature
  - Maximum - 120° F
  - Minimum - 90° F
- Toxicity - Not applicable
- pH Factor - Not applicable

- Container construction
  - Type - Concrete/Wood Products/Floor Tile
  - Interior lining - Gypsum board
  - Location - Below grade
  - Insulation - Fiberglass/Styrofoam
  - Exterior finish - Concrete
  - Filters - Yes
  - Getters - No

Thermal Storage Unit (TSU-2)

- Manufacturer - A. O. Smith
- Model name/number - STJ-80
- Total storage container volume - 11 ft^3
- Volume of storage medium - 80 gal
  - Height - 5.3 ft
  - Diameter - 2.1 ft
  - Maximum rated operating conditions
    - Temperature - 180° F
    - Pressure - 150 psi
  - Design operating temperatures
    - Maximum - 180° F
    - Minimum - 40° F
  - Storage Medium - 100% Water
  - Specific heat - 1.00 Btu/lb/° F
  - Density - 62.4 lb/ft^3
  - Heat capacity - 62.4 Btu/ft^3/° F
  - Manufacturer's recommended use of temperature
    - Maximum - 140° F

- Minimum - 40° F

- Toxicity - Potable
- pH factor - 7.0

- Container Construction
  - Type - Metal
  - Interior lining - Glass
  - Location - In room of building (Mech'l Room)
  - Auxiliary heaters - No
  - Insulation - Fiberglas
  - Exterior finish - Enamel

D. Energy To Load Subsystem (See figures IV-D-1 and IV-D-2)

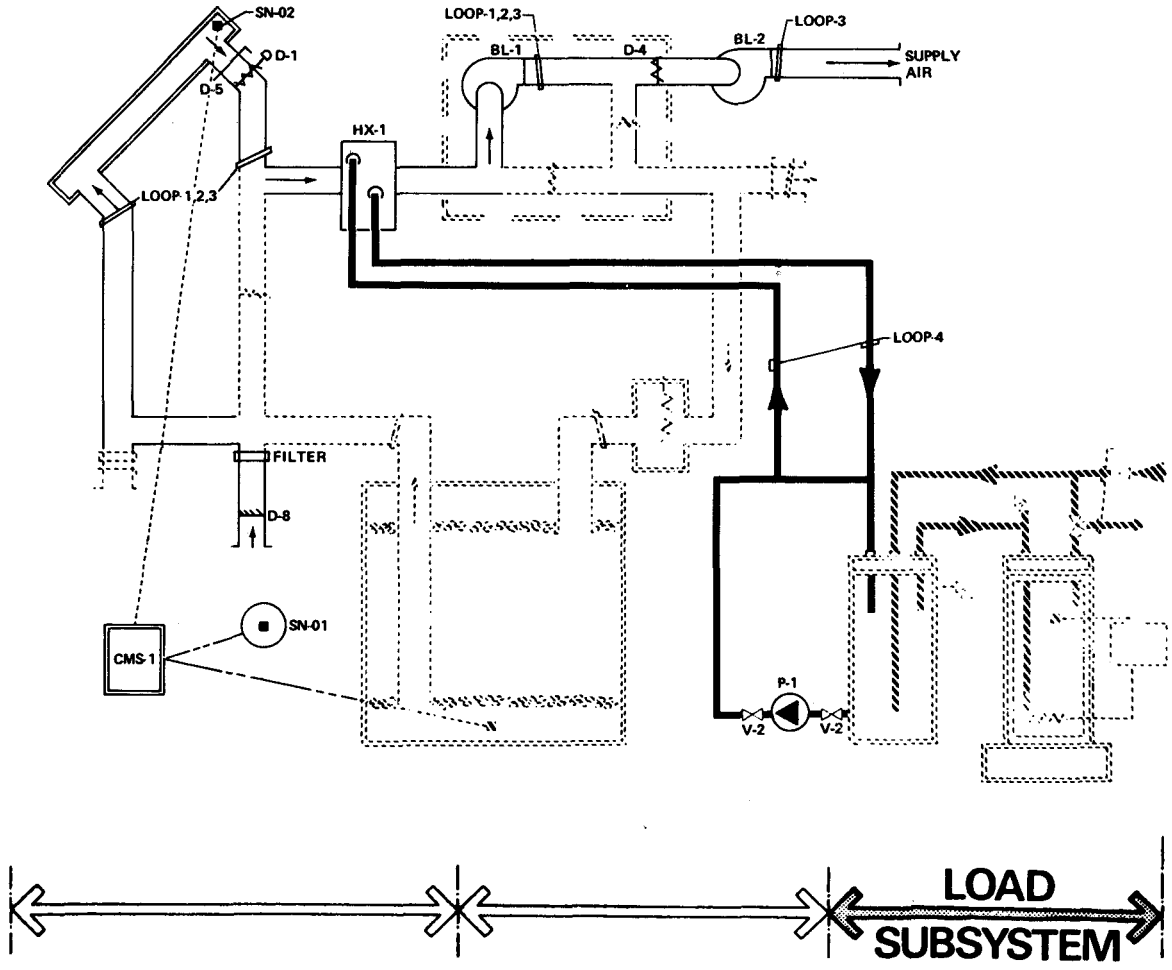


Figure IV-D-1. Energy-to-Load Subsystem, Collector-to-Space

Solar heated air flows through air circulation loop no. 3. Water is circulated through the heat exchanger for DHW preheat.

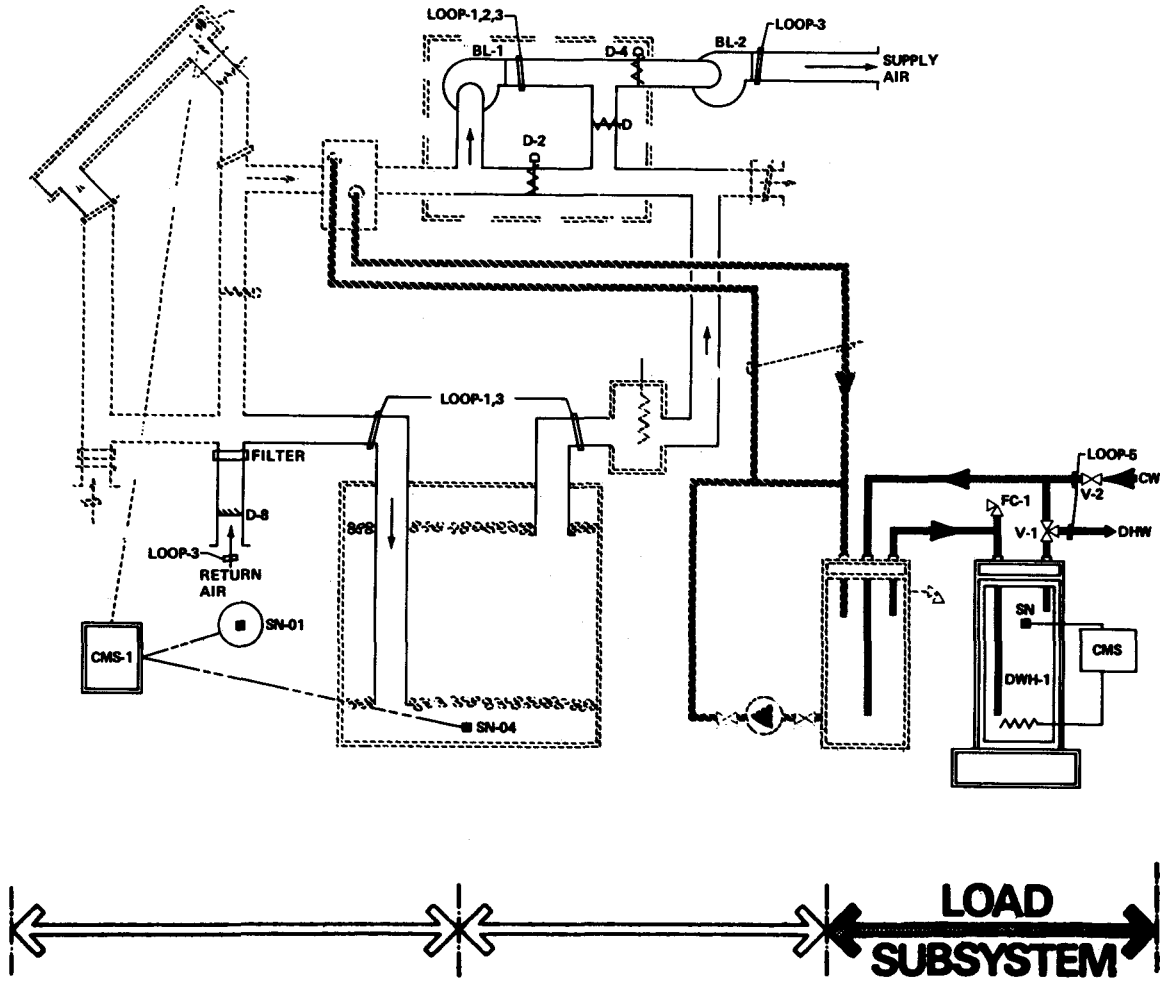


Figure IV-D-2. Energy-to-Load Subsystem, Storage-to-Space

Solar energy stored in the TSU-1 is used to meet the space heating demands by circulating it through heating ducts in the air distribution system. Auxiliary space heating, supplementing this source, is provided by an electrical resistance heater (ERH-1) installed in the ductwork.

Solar heated city water is stored in a preheat 80-gal tank (TSU-2) and supplied, on demand, to a conventional 40-gal DHW tank. When solar energy is insufficient, an electrical element in DWH-1 provides auxiliary energy for water heating.

AIR CIRCULATION LOOP NO. 3 (COL-1 TO SPACE)

- Heating
  - Maximum design operating temperature - 120° F
  - Maximum operating pressure - 1.25 in wg
  - Heating design air flow
    - Maximum - 800 cfm
    - Minimum - 300 cfm
- Components within circulation loop
  - Blower(s) - BL-1, BL-2
  - Damper(s) - D-1, D-2, D-3, D-4, D-6, D-8
  - Heat exchanger(s) - HX-1
  - Filter - D-5
- Ducting
  - Type - Steel, galvanized
  - Location - Above grade and below grade inside TSU-1
  - Maximum operating temperature - 120° F
  - Thermal resistance - R-Unknown
  - Insulation - Fiberglas
  - Finish
    - Internal - Foil laminate
    - Exterior - Galvanized
  - Filter
    - Location - At F.A. intake
    - Type - Fiberglas
- Blower (BL-2)
  - Manufacturer - Dayton
  - Model name/number - 2C987

- o Type - Squirrel cage
- o Motor size - 0.33 hp; 115 V; 1 phase; 60 Hz
- o Maximum motor speed - 1725 rpm
- o Drive - Belt
- o Blower speed - Single
- o Design conditions
  - Impeller Speed - 1725 rpm

	Low Static Mode	High Static Mode
- Circulating volume	800 cfm	
- Motor operation	0.33 bhp	

LIQUID CIRCULATION LOOP NO. 5 (DOMESTIC HOT WATER)

- o Design maximum operation temperature - 140° F
- o Design maximum operation pressure - 60 psi, city pressure
- o Heat transfer medium
  - o Volume of liquid in loop - 125 gal (open ended)
  - o Anticipated liquid temperatures
    - Maximum - 140° F
    - Minimum - 40° F
  - o Provisions for expansion - PRV on DWH-1
  - o Medium - Water (100%)
  - o Specific heat - 1.00 Btu/lb/° F
  - o Density - 62.4 lb/ft^3
  - o Heat capacity - 62.4 $Btu/ft^3/°$ F
  - o Boiling point - 212° F
  - o Freezing point - 32° F

- Medium manufacturer's recommended use temperature -
  - Maximum - 140° F
  - Minimum - 40° F
- Toxicity - Potable
- pH factor - 7.0
- Chemical feeder to maintain pH factor - No
- Inhibitor - No

- Components within circulation loop
  - Domestic water heater(s) - DWH-1
  - Thermal storage unit(s) - TSU-2

- Piping
  - Rigid - Copper, Type M
  - Interior coating - Unknown
  - Insulation - Cellular Rubber
  - Location - Above grade
  - Filters - No
  - Getters - No

- Distribution Valve (V-1)
  - Manufacturer - Nibco
  - Model name/number N170
  - Function - 3-way, mixing
  - Operation- Manual
  - Type - Gate
  - Maximum manufacturer's rated operating conditions:
    - Temperature - 180° F
    - Pressure - 150 psi
  - Material exposed to heat transfer fluid - Bronze

- Fail Safe Control (FC-1)
  - Manufacturer - Nibco
  - Product name/number - Unknown
  - Type - Pressure/Relief Valve

Control Mode Selector (CMS-1)

- Manufacturer - Solar Seven
- Model name/number - Unknown
- Modes controlled
  - Collector to space
    - ON - (SN-1) < 70^{o} F and (SN-2) > 120^{o} F
    - OFF - (SN-1) > 70^{o} F or (SN-2) < 90^{o} F
  - Storage to space
    - ON - (SN-1) < 70^{o} F and (SN-4) > 90^{o} F
    - OFF - (SN-1) > 70^{o} F or (SN-4) < 90^{o} F
- Sensors (SN-1), (SN-2), (SN-3) and (SN-4)
  - Manufacturer - Solar Seven
  - Model name/number - Unknown
  - Type - Temperature, thermistor

E. Auxiliary Subsystems (See figure IV-E-1)

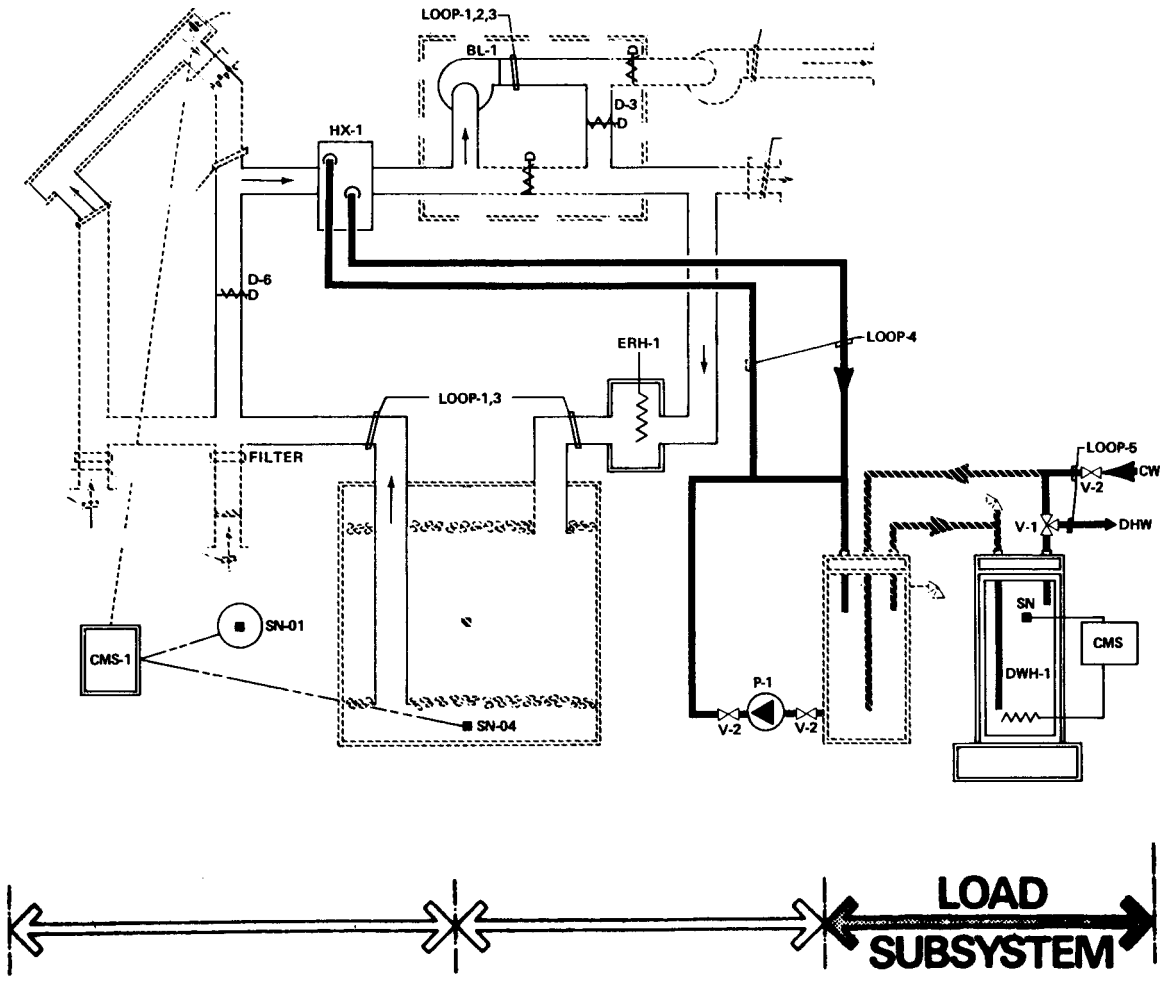


Figure IV-E-1. Auxiliary Subsystem

The auxiliary subsystems, DWH-1 and ERH-1 mentioned in the foregoing Energy to Load Subsystem have been grouped in this section for descriptive purposes.

The ERH-1 strip heater can be activated when off-peak electrical power rates are available to store energy in the rock storage or preheat water tank.

The DWH-1 heating element activates as necessary to provide hot water.

AUXILIARY LOADS

- Domestic Water Heater (DWH-1)
  - Manufacturer - Jet Glass
  - Model - L-4055-D
  - Energy source - Electric
  - Tank size - 40-gal
  - Energy input - Unknown
  - Energy output - Unknown
  - Maximum pressure rating - 300 psi
  - Maximum temperature rating - Unknown
  - Design operating pressure - 150 psi
  - Heating stages - 2
  - Maximum recovery rate - 40 gal/hr
  - Yearly average inlet temperature - 50^{o} F
  - Design output temperature - 140^{o} F
  - Thermal resistance - R-11
  - Standby heat loss - 0.6%/hr
  - Corrosion protection anodes - No
  - Burner ignition method - Electric
  - Flue vent - No
- Electric Resistance Heater (ERH-1)
  - Manufacturer - Brasch
  - Model name/number - Stock slip-in
  - Energy source - Electric
  - Electrical input - 15.0 KW; 240 V; 1 phase; 60 Hz
  - Number of stages - 2
  - Type - Duct heater, (Related Blower BL-1)

F. Modes of Operation (See figure IV-F-1)

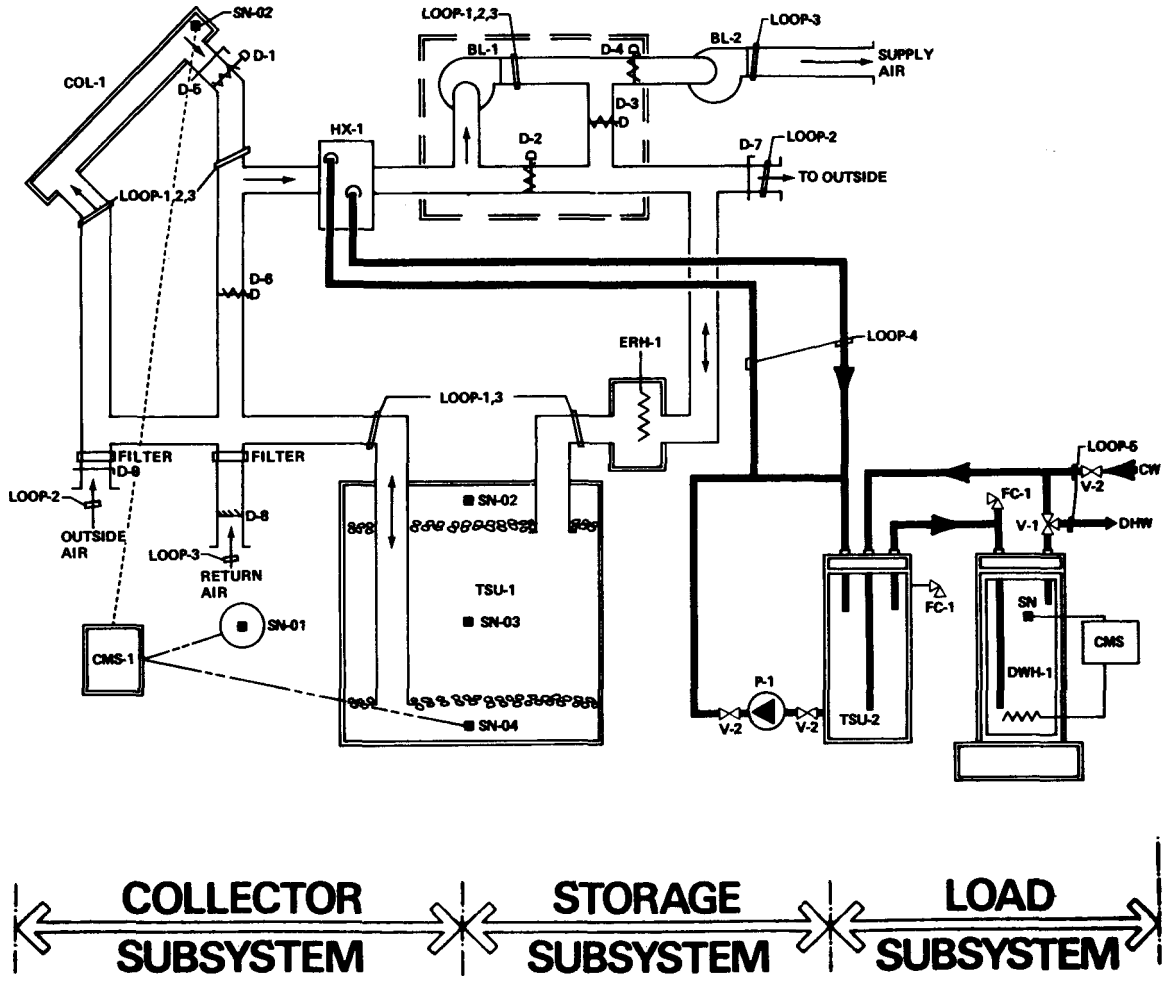


Figure IV-F-1. Controls Diagram

The Public Service Company solar system is shown on figure IV-F-1. The system consists of the following four subsystems: a) collector; b) storage; c) load (space heat/DHW) and d) auxiliary load subsystems.

Operation of the solar system and the auxiliary subsystems may involve one or more of the five modes of operations described below.

Mode 1 - Collector-to-Space Heating:

This mode activates when thermal energy for space heating is requested by the room thermostat and the collector loop of the solar energy system has been activated by a control sensor located on the output side of the collector air duct. This control is set to activate above 120° F. The heated air is circulated from the collector to the conditioned space by simultaneous operation of blowers BL-1 and BL-2. In this loop the DHW is also preheated through an air-to-liquid heat exchanger. If the space heating requirement is satisfied, the collected solar energy will then be directed to storage, as described under mode 4. The collector loop is deactivated when the temperature on the collector control sensor decreases to below 90° F.

Mode 2 - Storage-to-Space Heating:

This mode activates when energy is not available from the collector loop (nighttime and cloudy days). The system provides thermal energy from storage to the conditioned space. Blowers BL-1 and BL-2 circulate the air through rock storage and to the conditioned space. If stored energy cannot satisfy the load requirements, then the auxiliary strip heater is activated.

Mode 3 - Auxiliary Energy-to-Storage:

This mode can be activated when off-peak electrical power rates are available. This mode stores thermal energy produced by the auxiliary electrical heating element. Blower BL-1 circulates air through storage, past the DHW heat exchanger and the strip heaters.

Mode 4 - Collector-to-Storage:

This mode activates when the collector loop is operating under the control conditions described under mode 1, but no space heating load exists. Blower BL-1 provides air circulation for solar energy collection and transport to rock storage and also DHW preheating.

Mode 5 - Summer Mode, Collector-to-Vent:

This mode can be activated during periods when DHW preheating is required and space heating is not. A manual damper must be removed to open an outside vent. Outside air is heated by the solar collector. It is then circulated through the heat exchanger for the DHW preheat and out through the summer vent by operating Blower BL-1.

V. PERFORMANCE EVALUATION INSTRUMENTATION

A. The National Solar Data Network

The National Solar Data Network (see figure V-A-1) has been developed for the Department of Energy to process data collected from specific residential demonstration sites which were selected for thermal performance evaluation. The data flow in the Network includes monthly and seasonal system performance reports describing the thermal performance of the solar energy system and subsystems.

The performance evaluation instrumentation at each selected demonstration site is part of a comprehensive data collection system that allows for valid analyses of the solar system performance. Collected data are both applicable and practical in calculating thermal performance factors that describe the behavior of the solar system (see NBSIR 76-1137), National Bureau of Standards. Additional instrumentation may also be included as a result of site-specific requirements. Typically, the instrumentation includes sensors that monitor the following:

- Total insolation in the plane of the collector array
- Ambient temperature
- Collector subsystem flow rate and temperatures
- Storage inlet flow rate and temperatures
- Storage outlet flow rate and temperatures
- Storage temperature
- Storage-to-load subsystem flow rate and temperatures
- Auxiliary fuel flow rates

Site data are recorded automatically at prescribed intervals by the Site Data Acquisition System (SDAS). The recorded data are transmitted daily to the Communications Processor in the Central Data Processing System (CDPS). The communications link between every SDAS and the CDPS consists of voice-grade telephone lines and telephone data couplers. A reading is transmitted from the SDAS internal timer with every data sample to ensure that the data are time-tagged correctly.

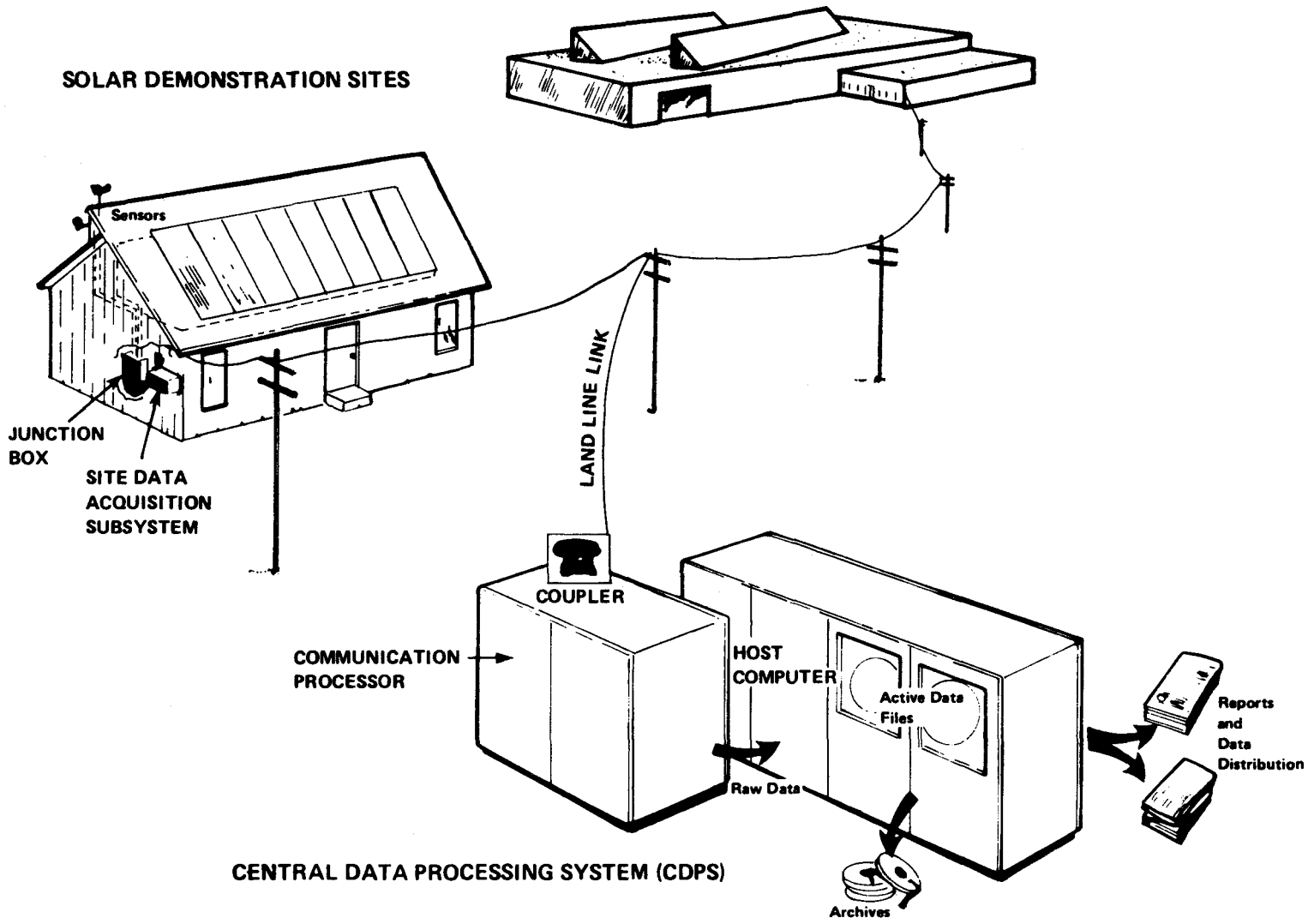


Figure V-A-1. The National Solar Data Network

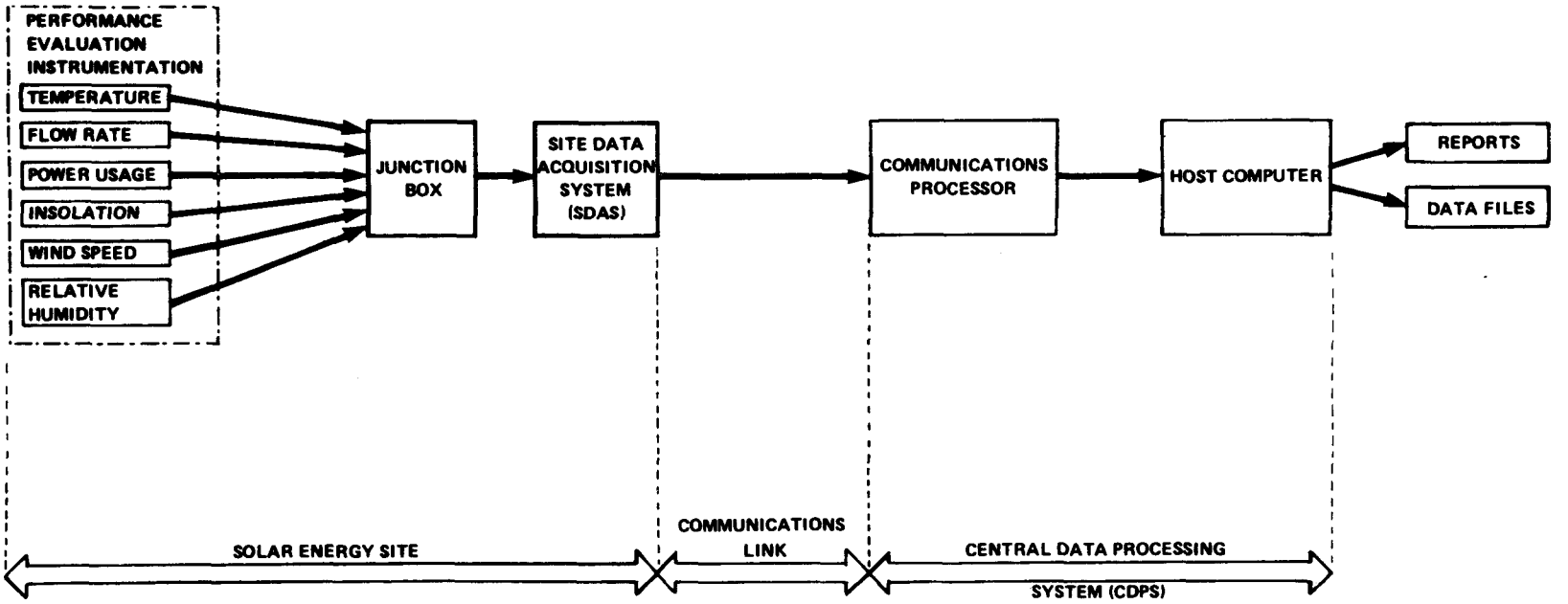


Figure V-A-2. Data Flow Path for the National Solar Data Network

The Communications Processor scans the receiving data to identify any apparent transmission errors and verifies correct site contact by checking the address code transmitted by the SDAS. Data is stored temporarily in the Communications Processor and processed by the Host Computer. The processing includes measurement checking to ensure that the data are reasonable; that is, that they are not beyond the known instrument limits and that they are not erratic. Data which appear questionable are discarded and are not used in the solar system performance analyses.

Appropriate equations were formulated and programmed to define desired performance factors for the solar energy systems at each selected demonstration site. A performance factor is a number that describes either the efficiency or the quantity of energy lost, gained, or converted by a solar energy system or by a component. All valid data are processed using these performance factor equations to generate hourly performance factors. Hourly performance factors are integrated into daily and monthly performance factors. These hourly, daily, and monthly performance factors are stored in data files in the CDPS. These data files also include measurement data, expressed in engineering units; numerical and architectual site identification; and specific site data used in generating the performance factors.

B. On-Site Instrumentation

The on-site instrumentation includes sensors to monitor the various parameters of the solar energy system, a junction box, and a Site Data Acquisition System that stores and transmits data to the Host Computer (see figures V-A-1 and V-A-2). Specific information for temperature, flow, power and miscellaneous sensors are presented in tabular form. Sensor locations are shown in figure V-B-1.

SENSOR	DESCRIPTION OF MEASUREMENT	MODEL NO.
I-001	T1001 Insolation	Eppley PSP
T-001	Outside ambient Temperature	S53P-60 IS4
T-100	Temperature, collector inlet (RA)	S57P-100
TD-100L	Temperature, collector, low	
TD-100H	Temperature, collector, high	S53P-100
W-100	Flow, collector	430DC
W-400	Flow, storage	430DC
T-400	Temperature, house return air	S57P-100
TD-400L	Temperature, house, low	
TD-400H	Temperature, house, high	S53P-100
T-200	Temperature, storage inlet (RA)	S57P-100
TD-200L	Temperature, storage, low	
TD-200H	Temperature, storage, high	S57P-100
TD-401L	Temperature, electric heater, low	
TD-401H	Temperature, electric heater, high	S57P-100
T-401	Temperature, electric heater	
T-201	Temperature, rock storage	S53P-60
T-202	Temperature, rock storage	S53P-60
T-203	Temperature, rock storage	S53P-60
T-204	Temperature, rock storage	S53P-60
T-205	Temperature, rock storage	S53P-60
T-206	Temperature, rock storage	S53P-60
T-300	Temperature, HW preheat supply	S57P-100
TD-300H	Temperature, HW preheat, high	
TD-300L	Temperature, HW preheat, low	S53P-100
EP-400	Power, AHU blower	PC5-10
EP-401	Power, F-2 blower	PC5-10
EP-402	Power, electric strip heaters (1 pass)	PC5-32
W-300	Flow, cold water supply to DHW system	MK V 3/4,.7-7
T-301	Temperature, cold water supply	S57P-60
TD-301L	Temperature, preheat, low	
TD-301H	Temperature, preheat, high	S57P-60
TD-302L	Temperature, water heater, low	
TD-302H	Temperature, water heater, high	S53P-60

SENSOR	DESCRIPTION OF MEASUREMENT	MODEL NO.
T-303	Temperature, preheat liner	S32B
T-304	Temperature, water heater liner	S32B
W-301	Flow, preheat HX	MK V 3/4,.7-7
T-305	Temperature, HX inlet	S57P-60
TD-305L	Temperature, HX, low	
TD-305H	Temperature, HX, high	S53P-60
EP-300	Power, HX pump	PC5-106
EP-301	Power, water heater (4 passes)	PC5-29
T-600	Temperature, house ambient	S53P-28
S-300	Flow Switch, summer vent	2A

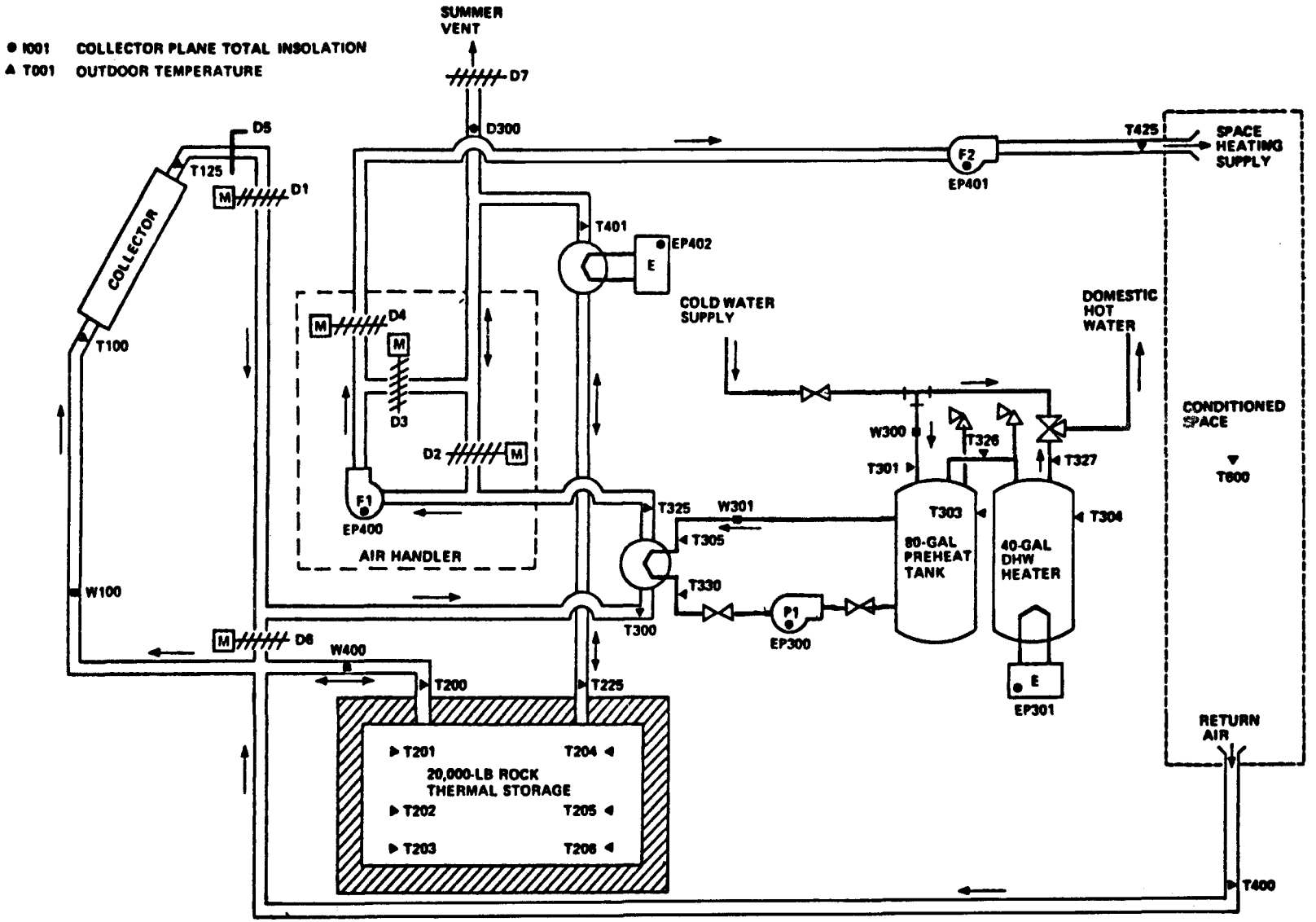


Figure V-B-1. Sensor and Control Diagram

VI. COST DATA

A. General

The following cost data depicts only solar energy portion of the construction costs. Costs of instrumentation is not included since it is not part of the construction effort.

B. Construction Grant Funds

Solar Subsystem	Applicants Request	Construction Grant
Collectors	$1825	$
Energy Storage	1200	
Distribution and Controls	2700	
Installation	800	
Other		
Total	$6525	

C. Construction Period: September 1977 through June 1978

VII. APPENDIX

A. Glossary

ABSORBER PLATE - The surface in a flat plate collector that absorbs incident solar radiation and transfers the absorbed energy to a heat transfer fluid.
ABSORPTANCE - The ratio of absorbed radiation by a surface to the total incident radiation on that surface.
ABSORPTION SUBSYSTEM - The mechanical equipment that conditions indoor air by an absorption process.
ACTIVE SOLAR SYSTEM - An integrated solar energy system, consisting of collector, storage, solar energy-to-load subsystems, that can condition indoor air or preheat domestic hot water in a controlled manner.
AIR-BASED SOLAR COLLECTOR SYSTEM - A solar energy system in which air is the heat transfer fluid.
AIR CONDITIONING - The process of treating indoor air by controlling the temperature, humidity, and distribution to specified comfort settings as set by the occupants in the conditioned space.
AMBIENT AIR - A term for outdoor air, and may be brought into a building to be conditioned or circulated.
ANTI-FREEZE FREEZE PROTECTION SYSTEM - A freeze protection system that uses additives or solutions to the heat transfer medium, which depresses its freezing point sufficiently to prevent possible water freeze in the solar collectors and the exterior piping.
AUXILIARY ENERGY SUBSYSTEM - The equipment, utilizing conventional energy sources, used to supplement the output provided by a solar energy system and used to provide a full backup system when the solar system is inoperable.
BACKFLOW - The reversal of flow in a distribution system.
BACKFLOW PREVENTOR - A device or means to stop backflow.
BEAM RADIATION - Solar radiation which is not scattered and may be concentrated.
BRITISH THERMAL UNIT (Btu) - A unit of energy that is required to heat one pound of water from 59^{o} F to 60^{o} F.
BUILDING ENVELOPE - The exterior surface of a building that encloses the conditioned space.

CLIMATE - The prevailing or average weather conditions of a specific geographic region as described by temperature and other meteorological data.

COLLECTOR MANIFOLD - The piping that connects the absorber tubes in a collector plate.

COLLECTOR PLATE - A term used for an absorber plate.

COLLECTOR SUBSYSTEM - The assembly that absorbes solar radiation and transfers the absorbed thermal energy to a heat transfer fluid.

COMBINED COLLECTORS - An assembly that both collects solar radiation and stores the thermal energy in the same unit.

CONCENTRATING SOLAR COLLECTOR - A solar collector which focuses beam radiation onto an absorber in order to obtain higher energy fluxes than can normally be achieved by flat plate solar collectors.

CONCENTRATOR - A reflective surface or refracting lens used in directing insolation onto an absorber.

CONDITIONED SPACE - The space in a building where the air is conditioned by heating or cooling.

CONTROL SUBSYSTEM - The assembly of electric, pneumatic, and hydraulic actuated sensing devices used in regulating the solar energy system and the auxiliary energy subsystems.

COOLING TOWER - A heat exchanger that transfers waste heat from an absorption cooling system to ambient air.

DIFFUSE RADIATION - Solar radiation which is scattered by air molecules, dust, or other substances suspended in the air.

DRAIN-DOWN FREEZE PROTECTION SYSTEM - A freeze protection system that prevents potential water freeze-up within the collector and exterior piping by automatically draining and replacing the water with a non-freezing medium such as air, nitrogen, etc.

DUCT HEATING COIL - A liquid-to-air heat exchanger in the duct distribution system used to heat air by passing a hot fluid through a coil in the air system.

EQUIVALENT FULL LOAD COOLING HOURS - The seasonal cooling load for a building described as the total number of hours that the air conditioning system will operate under full load conditions to meet the required cooling load.

EMITTANCE - The ratio of energy radiated by a body to the energy radiated by a black body at the same temperature.

EXPANSION TANK - A tank which will permit water to expand whenever it is heated to prevent excessive pressures on the other system components.

FIXED COLLECTOR - A solar collector that is permanently oriented towards the sun and cannot track the sun nor be adjusted for seasonal variations.

FLAT PLATE COLLECTOR - A basic heat collection device used in solar heating systems, which consists of an absorber plate, with insulated bottom and sides, and covered by one or more transparent covers. There are no concentrators or focusing aids in a flat plate collector.

FOCUSING COLLECTOR - A solar collector using a parabolic mirror, fresnel lens, or other type of focusing device to concentrate solar radiation onto an absorber.

FRESNEL COLLECTOR - A concentrating solar collector which uses a fresnel lens to focus beam radiation onto an absorber.

GLAZING - The transparent cover(s) on a solar collector used to reduce the energy losses from the top of the collector.

HEAT TRANSFER FLUID - The fluid that transfers solar energy from the solar collector to the storage subsystem or to the load.

INCIDENCE ANGLE - The angle in which the insolation strikes a surface and the normal for that surface.

INSOLATION - The total amount of solar radiation on a surface in a given unit of time.

LAMINATED GLASS - A glazing consisting of multiple glass sheets bonded together by intervening layer or layers of plastic.

LANGLEY - The standard unit of insolation defined as 1 langley = 1 cal/cm^2, (1 Langley = 3.69 Btu/ft^2).

LIQUID-BASED SOLAR COLLECTOR SYSTEM - A solar energy system in which either water or an antifreeze solution is the heat transfer fluid.

LOAD - The total space conditioning or domestic water heating requirements that are supplied by both the solar energy system and the auxiliary energy subsystem.

NOCTURNAL RADIATION - The loss of thermal energy by the solar collectors to the sky at night.

NO-FLOW CONDITION - The condition obtained when the heat transfer fluid is not flowing through the collector array due to a shutdown or a malfunction.

OPAQUE - A surface that is not transparent, thus solar radiation is either reflected or absorbed.

OUTGASSING - The emission of gases by materials and components, usually during exposure to elevated temperature, or reduced pressure.

PACKAGE AIR-CONDITIONING UNIT - A factory-made assembly consisting of an indoor coil, a compressor, an outdoor coil, and other components needed for space cooling operations. This unit may also include additional components to heat the condition space.

PARABOLIC FOCUSING COLLECTOR - A concentrating collector which focuses beam radiation by a parabolic reflector.

PASSIVE SOLAR SYSTEM - An integrated solar energy system that can provide for space heating needs without the use of any other energy source other than the sun.

REFLECTANCE - The ratio of radiation reflected by a surface to the total incident radiation on the surface.

REFLECTED RADIATION - Insolation which is reflected from a surface, such as the ground, and is incident on the solar collector.

ROCK BED - A storage tank using uniform-sized rocks to store solar energy in air-based solar collector systems.

SELECTIVE SURFACE - A surface which has a high absorptance for solar radiation and a low emittance for thermal radiation.

SOLAR CONDITIONED SPACE - The area in a building that depends on solar energy to provide for a fraction of the heating and cooling needs.

SOLAR HEATING SYSTEM - An integrated assembly of collector, storage, solar energy-to-load, and control subsystems required to convert solar energy into thermal energy for space heating requirements, as well as the addition of an auxiliary backup system.

SOLAR RETROFIT - The addition of a solar energy system to an existing structure.

STORAGE SUBSYSTEM - The components used to store solar energy so that the stored energy can be used for heating, cooling, or heating water during periods of low insolation.

STRATIFICATION - The horizontal layering in a medium due to temperature differentials, commonly noticed in storage tanks filled with water.

THERMOSTAT - A temperature sensing device which controls the heating and cooling systems for space conditioning or the hot water heater.

TILT ANGLE FROM HORIZONTAL - Angle between the horizontal plane and the plane of collector.

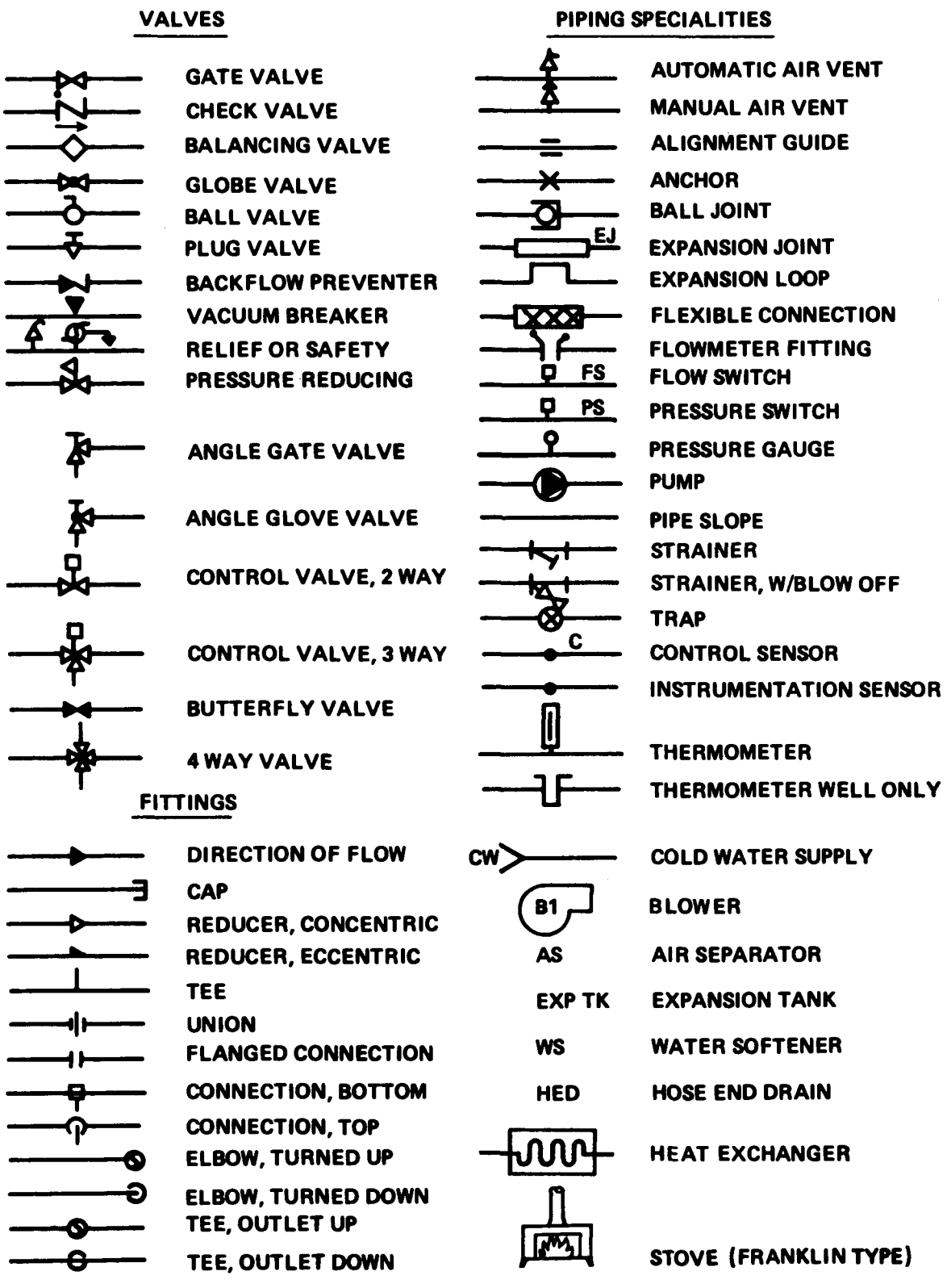
TON OF REFRIGERATION - A unit of refrigeration which is equivalent to 12,000 Btu/hr.

TRACKING COLLECTOR - A set of solar energy tracking collectors that automatically move in order to constantly aim towards the sun.

VAPOR BARRIER - A material which is used to reduce the transmission of water vapor.

ZONE - A portion of a conditioned space which use a common control because of their similar heating and cooling requirements.

B. Legend For Solar System Schematics



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