SOLAR/1087-81/50
(DE81024312)

Solar Project Description

ORTIZ AND REILL DEVELOPERS, INC. (LOT 8) SINGLE FAMILY RESIDENCE Escondido, California June 18, 1981

U.S. Department of Energy

National Solar Heating and Cooling Demonstration Program

National Solar Data Program

SOLAR/1087--81/50

DE81 024312

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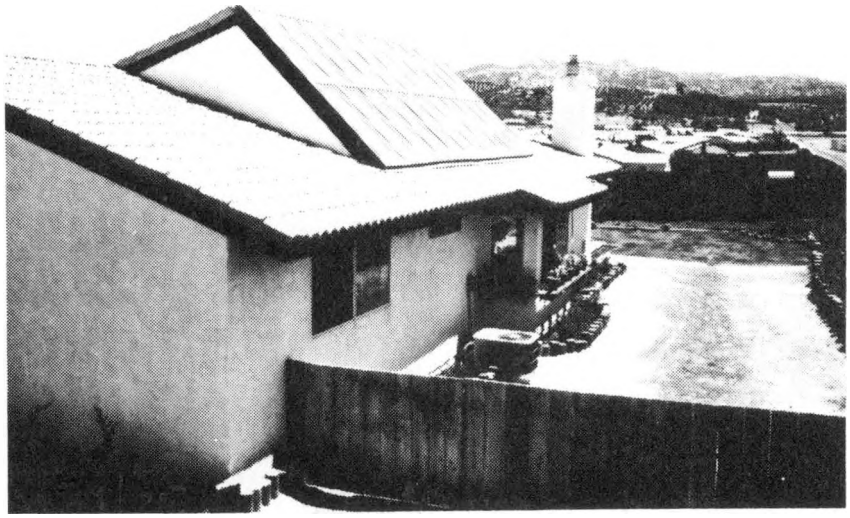
(DE81024312)
Distribution Category UC-59

SOLAR PROJECT DESCRIPTION
FOR
ORTIZ AND REILL DEVELOPERS, INC. (LOT 8)
SINGLE FAMILY RESIDENCE; ESCONDIDO, CALIFORNIA



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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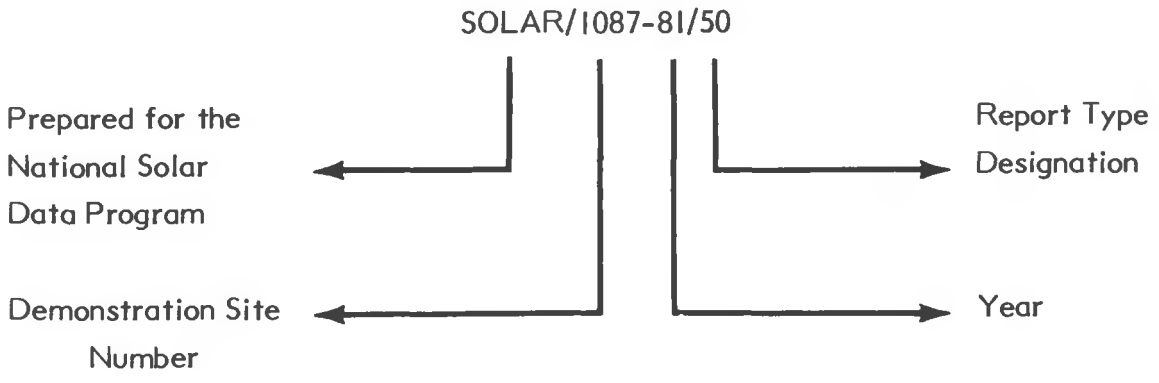
NATIONAL SOLAR DATA PROGRAM REPORTS

Reports prepared for the National Solar Data Program are numbered under a specific format. For example, this report for the Ortiz & Reill Developers, Inc. project site is designated as SOLAR/1087-81/50. 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 -- Liquid active
- o Freeze Protection -- Drain down (air bleed)
- o Application -- Space heating and DHW
- o Storage -- 750-gal tank and 66-gal tank
- o New or Retrofit -- New
- o Performance Evaluation Instrumentation -- Yes

Ortiz & Reill Developers, Inc. (Grant H-8204) House, Lot 8, is one of two instrumented single-family residences in Escondido, California. The home has approximately 1536 square feet of conditioned space. Solar energy is used for domestic-hot-water (DHW) heating and space heating. The solar energy system has an array of flat-plate collectors with a gross area of 222 square feet. The array faces 15 degrees east of south at an angle of 45 degrees to the horizontal. Water is the transfer medium that delivers solar energy from the collector array to storage for space heating and the hot water loads. Solar energy is stored in a 750-gallon tank located in the ground floor utility room. Heated city water is stored in a 66-gallon DHW tank.

When solar energy is insufficient to satisfy the space heating load, a gas furnace provides auxiliary energy for the space heating system. Similarly, an electrical heating element in the DHW tank provides auxiliary energy for DHW heating.

Energy from a hydronic fireplace radiates directly into the living space and supplements solar modes 1 and 2. The fireplace-to-storage mode activates if the fireplace is being used and the temperature difference between its water plenum and storage output is more than 9^{o} F. During operation, water is circulated from storage through the fireplace heat exchanger. The system is shown schematically in Figure IV-A-1.

The dwelling has been fully instrumented for performance evaluation since August 1978 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)

Ortiz and Reill is a single family dwelling. The solar energy system provides space heating and domestic hot water heating. Water is used as the energy collection and storage medium. Solar energy is supplied to the DHW tank through a heat exchanger which connects to the collection loop or to the storage tank. Electrical resistance coils provide auxiliary energy as required. Solar energy is supplied to the space heating system from the storage tank. A fireplace and a gas fired furnace provide auxiliary energy as required.

- Building type - Single family, detached
- Latitude - 33^{o}
- Longitude - 117^{o}
- Altitude - 660 ft

HEATING DESIGN TEMPERATURES

- Outdoor - 41^{o} F DB
- Indoor - 72^{o} F DB

BUILDING

- Building faces - South
- Average stories above ground - 1
- Average stories below ground - 0
- Height above grade - 14 ft
- Conditioned floor area - 1536 ft^2
- Roof type - Sloped with 45^{o} pitch

DESIGN HEAT LOSS/LOAD

- Heat Loss - 22,586 Btu/hr
- Heat gain - Unknown
- Shading
    - Heating season - 0
    - Cooling season - 0

UNAVAILABLE

Figure III-1. Site Plan

- Appliance, lighting and equipment load - Unknown
- Average horizontal insolation
  - January - 975.7 Btu/ft^2/day
  - July - 2186.5 Btu/ft^2/day
- Annual degree days
  - Heating - 1507
  - Data location - San Diego, CA
  - Data reference - Local Climatological Data Annual Summaries, Department of Commerce, National Oceanographic and Atmospheric Administration

MECHANICAL SYSTEM

- Heating
  - Solar - Liquid, active
  - Auxiliary - Gas furnace
  - Distribution - Air distribution system

DOMESTIC HOT WATER

- Daily water demand - 60-gal/day
- Solar - Liquid active
- Auxiliary - Gas fired DHW tank

GENERAL DATA

- Manufacturer - Southwest Energy - Tech
- Model name/number - Solruf
- Type of system - Liquid active

SYSTEM AND COMPONENT SUMMARY

- Collector types - COL-1
- Circulation loops - 5
- Thermal storage units - 2
- Operational modes - 4

- Pumps - 2
- Valves - 6
- Blowers - 1
- Dampers - 0
- Sensors - 12
- Flow regulators - 0
- Pressure regulators - 0
- Fail safe controls - 8

IV. SOLAR SYSTEM DESCRIPTION

A. General Overview

This residential solar demonstration project (Ortiz & Reill Developers, Inc., Grant H-8204) located at Escondido, California is a liquid active system utilized for space heat and DHW. A gas furnace for space heat and a gas-fired DWH are the auxiliary units for the systems.

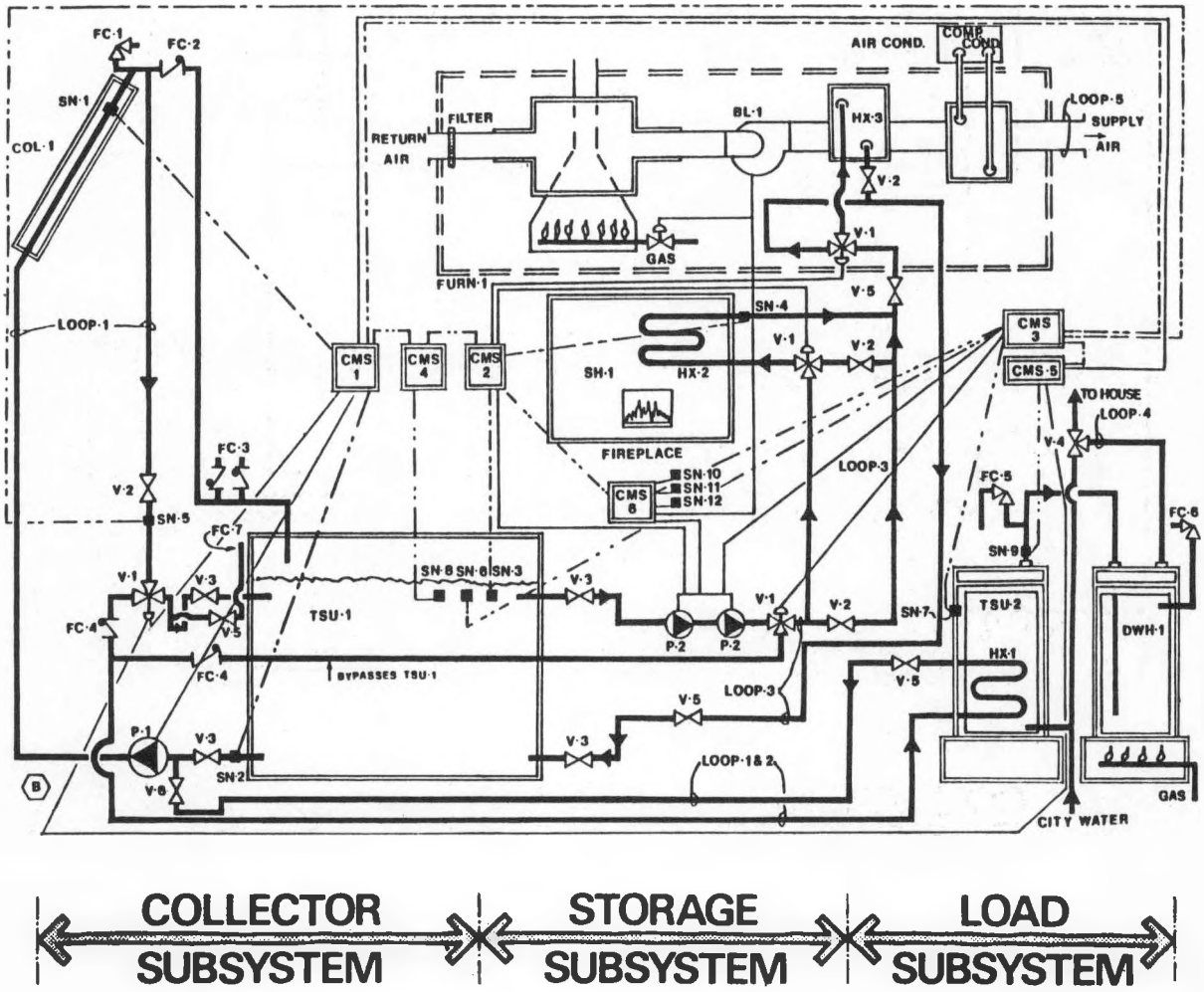


Figure IV-A-1. General Overview

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)

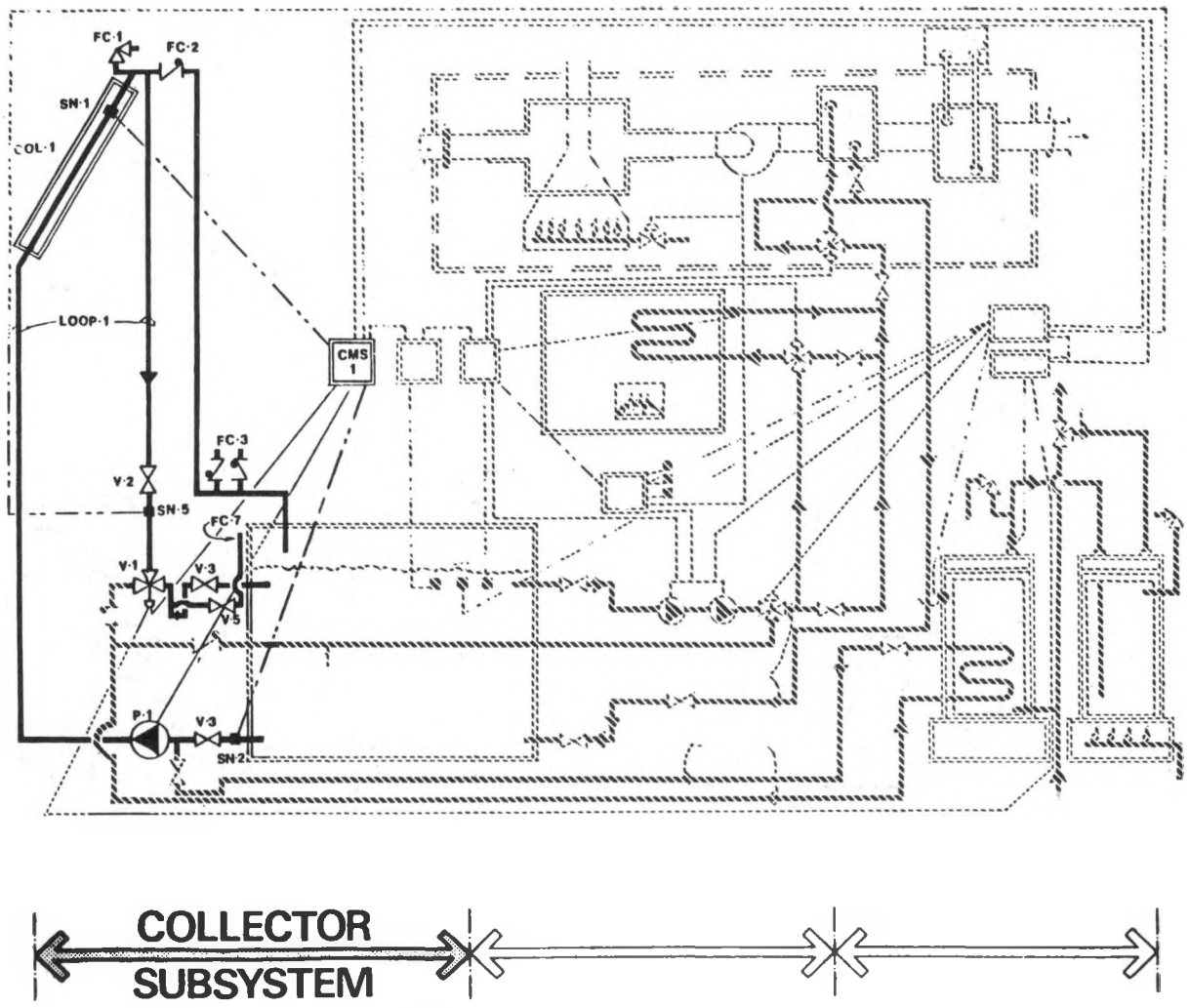


Figure IV-B-1. Collector Subsystem, Collector-to-Storage

The collector array system consists of 11 liquid flat plate (222 ft^2) collector panels. Freeze protection is by drain down (air bleed). Mode 1 circulates water from the storage tank through the collector array and back to the tank.

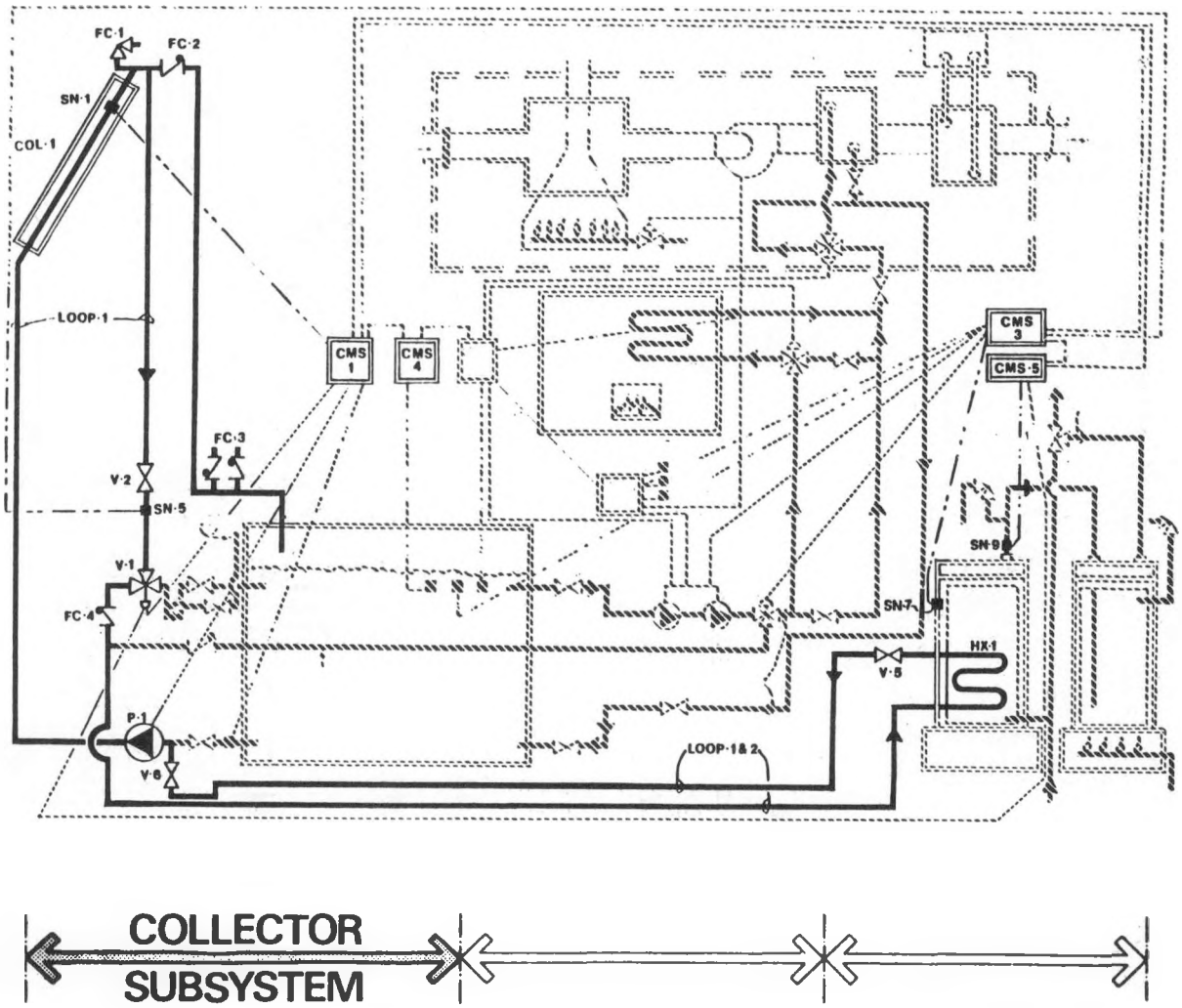
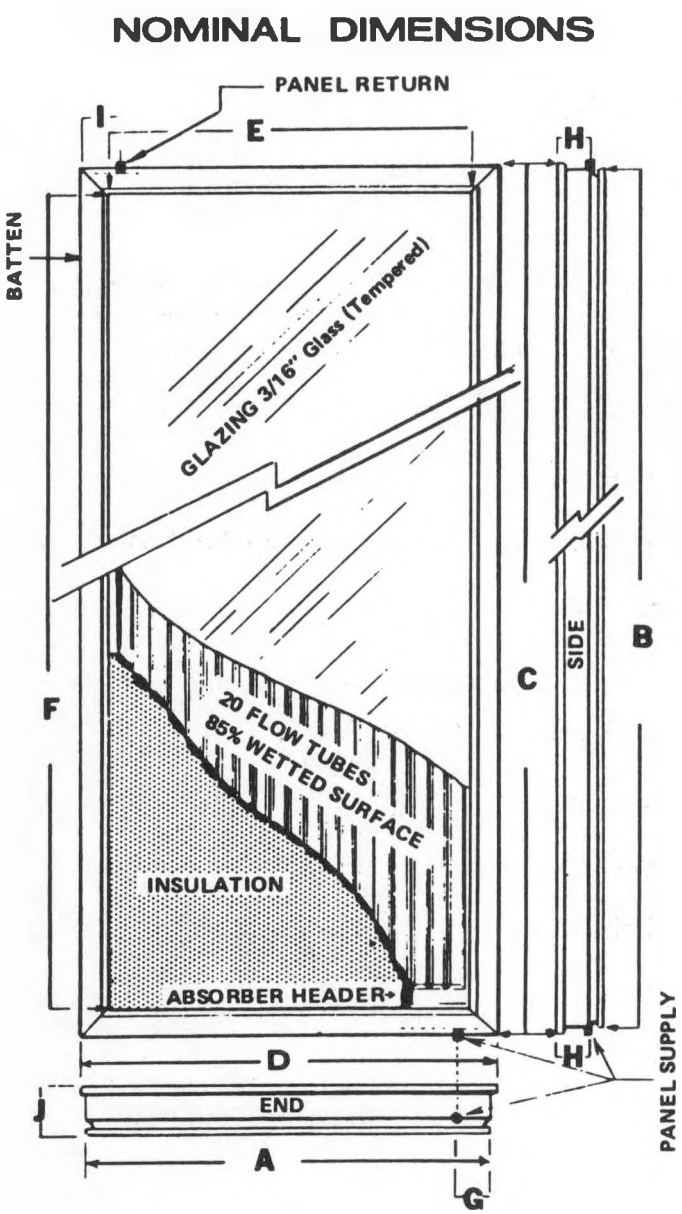


Figure IV-B-2. Collector Subsystem, Collector-to-DHW Tank

Mode 4 circulates water through the collector array to the heat exchanger in the DHW tank and back to the collectors.

COLLECTOR (COL-1)

- Manufacturer - Southwest ENER - TECH Inc.
- Model name/number - Solruf/376
- Type - Liquid flat plate
- Location - Roof
- Orientation - Fixed at 15° E of S
- Tilt angle - Fixed tilt at 45° from horizontal
- Collector characteristics
  - Number of panels - 11
  - Total gross area of array - 222 ft^2
  - Net aperture area - 189 ft^2
  - Net absorber area - 222 ft^2
  - Weight per panel, empty - 112 lb
  - Weight per panel, full - 118 lb
  - Weight of filled array and support structure - 1296 lb
  - Panel length - Approximately 80 5/16 in
  - Panel width - Approximately 38 5/16 in
  - Frame depth - Not available
  - Standoff height - 0
- Built-in collector - Surface of roof
- Collector shading -
  - Area shaded in June - 0%
  - Area shaded in December - 0%
  - Maximum shade during functional season - 0%



	M376
A. Width Frame Wall	37-3/4"
B. Length Frame Wall	79-3/4"
C. Length Cover Plate Batten	80-5/16"
D. Width Cover Plate Batten	38-5/16"
E. Width Aperture Opening	33"
F. Length Aperture Opening	75"
G. Fitting Center From Frame Wall Edge	5-1/2"
H. Fitting Center From Collector Top	3-3/8"
I. Fitting Center From Coverplate Batten Edge	5-7/8"
J. Collector Height	4-1/2"

Figure IV-B-3. Solar Collector

- Cover plates
  - Number of cover plates - 1
- Cover plate No. 1
  - Location - Outer layer
  - Manufacturer - ASG
  - Product name/number - Low iron
  - Material - Tempered glass
  - Thickness - 0.187 in
  - Optical properties

	(solar region)	(infrared region)
- Transmittance -	0.88	0.10
- Reflectance -	0.09	0.10

    - Emittance - 0.01
  - Edge or surface treatment, other than coating - Mechanical, ground
  - Coating on cover plate material - None
- Absorber
  - Manufacturer - Southwest ENER - TECH Inc.
  - Model name/number - Solruf/376
  - Material - Stainless (316)
  - Substrate material dimension
    - Thickness - N/A
    - Length - N/A
    - Width - N/A
  - Number of absorbers per collector - 1
- Coating
  - Manufacturer - Southwest ENER - TECH Inc.
  - Model name/number - None
  - Coating material - Sodium Glycomate

	(solar region)	(infrared region)
o Absorptance -	0.91	
o Reflectance -	None	

- o Emittance - 0.13
- o Method of application - Chemically plated

- o Heat transfer fluid passages
  - o Location - In absorber
  - o Pattern - Unknown
  - o Materials - Stainless (444)
  - o Wall thickness - Unknown
  - o Internal diameter - Unknown
  - o Maximum operating conditions
    - Temperature - Unknown
    - Pressure - 40 psi
  - o Fluid passage bond to substrate - Integral
  - o Protective coating inside fluid passage - None
- o Insulation
  - o Layer one - sides
    - Manufacturer - Owens Corning
    - Product name/number - Fiberglas
    - Material - Glass fiber
    - Thermal resistance - Unknown
  - o Layer one - back
    - Manufacturer - Owens-Corning
    - Product name/number - AFU
    - Material - Fiberglas
    - Thermal resistance - R-7

- Gaskets and sealants
  - Inner cover - Silicone
  - Outer cover - Unknown
  - Backing plate - Unknown
  - Penetrations - Unknown
- Frame
  - Manufacturer - Southwest ENER - TECH Inc.
  - Product name/number - Solruf/376
  - Material - Unknown
  - Protective coating - None
  - Number of structure attach points per module to building - Continuous
  - Built-in collector - Yes
- Reflectors - No
  - Desiccant - No
  - Freeze protection - Drain down (air bleed)
  - Overheating protection - No
- Collector performance
  - Method of evaluation - $\frac{t_i - t_a}{I_t}$ (ASHRAE)
  - y intercept $F_R (\tau\alpha)_\eta$ - 0.74%
  - Slope - $F_R U_L$
- Point Number

1	2	3	4

  - n = Collector thermal efficiency (η %) -
  - t_i or t_f = collector inlet temperature (^{o} F) - DATA
  - t_a = ambient air temperature (^{o} F) - UNAVAILABLE
  - 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
- I_t = radiation (insolation) intensity on collector, Btu/hr.ft^2
    - Test flow rate -
    - Heat loss coefficient
    - Test wind speed -
    - Test collector area
        - Gross - 20.2 ft^2
        - Net - 17.2 ft^2
    - Fluid specific heat - 1.00 Btu/lb/^{o}F
    - Test fluid medium - Water

LIQUID CIRCULATION LOOP NO. 1 (COL-1 TO TSU-1 OR TSU-2)

- Maximum design operating temperature - 180^{o} F
- Maximum design operating pressure - 8 psi
- Heating design liquid flow -
    - Maximum - 6.9 gpm
    - Minimum - 3.6 gpm
- Design pump speed - 2620 rpm
- Heat transfer medium -
    - Volume of liquid in loop - 662-gal

- Anticipated liquid temperatures
  - Maximum - 150°F
  - Minimum - 40°F
- Provisions for expansion - Air space in TSU-1
- Medium - Water (> 99%); Nitrate Borate (rust inhibitor, < 1%)
- Specific heat - 1.00 Btu/lb/° F
- Density - 62.4 lbs/ft^3
- Heat capacity - 62.4 Btu/ft^3/° F
- Boiling point - 212° F
- Freezing point - 32° F
- Recommended temperatures
  - Maximum - 180° F
  - Minimum - 40° F
- Toxicity - Non-potable
- pH factor - 7.0
- Chemical feeder to maintain pH factor - No
- Inhibitor - Yes, < 1% Nitrate Borate (Rust inhibitor)

- Components within circulation loops
  - Pump(s) - P-1
  - Thermal storage unit(s) - TSU-1, TSU-2
  - Heat exchanger - HX-1
  - Collector(s) - COL-1
  - Valve(s) - V-1, V-2, V-3, V-4, V-5, V-6
  - Other(s) - FC-1, FC-2, FC-3, FC-4, FC-7
- Piping
  - Rigid - Copper, Type L
  - Piping insulation - Cellular rubber (Rubatex Co.)

- Location - Above grade
- Exterior finish - Aluminum foil
- Filters - None

- Circulator pump (P-1)
  - Manufacturer - Grundfos
  - Model name/number - 25-42
  - Type - Centrifugal
  - Maximum operating conditions
    - Dynamic pressure - 6 psi
    - Temperature - 210° F
  - Material exposed to heat transfer fluid - Stainless (316)
  - Motor size - 0.05 HP; 115 V; 1 phase; 60 Hz
  - Maximum motor speed - 2620 rpm
  - Drive - Direct
  - Speed - Single
  - Pump speed - 2620 rpm
  - Circulating volume - Low head mode - 23 gpm
  - Operating head (dynamic) - High head mode - 6.06 psi
  - Motor operation - 0.05 bhp
- Heat Exchanger (HX-1)
  - Manufacturer - Ford
  - Model name/number - TC65
  - Type of flow - Parallel
  - Heat exchanger design - Tube with fins
  - Number of separations - Single
  - External exposed surface - 10 ft^2

	Side One	Side Two
o Convection:	Natural	Forced
o Located in:	TSU-2	TSU-2
o Part of circulation loop:	1	2
o Maximum manufacturer's rated:		
- Temperature -		240° F
- Pressure -	8 psi	
o Heat transfer area		9.84 ft^2
o Description		
- Length of tubing with fins -		14 ft
- Diameter of tubing -		0.875 in
- Fins		
- Thickness -	N/A	N/A
- Length -	N/A	N/A
- Diameter -	N/A	N/A
- Material	Copper	Copper

o Heating

- Design heating capacity - 17,400 Btu/hr
- Effectiveness -

	Side One	Side Two
- Design flow rate -	N/A	9 gpm
- Related pump no. -		P-1
- Liquid temperatures:		
- Entering -	Unknown	Unknown
- Leaving -	Unknown	Unknown

- Distribution Valve (V-1)
  - Manufacturer - Synchron
  - Model name/number - V 8044E10111
  - Function - Flow switching
  - Operation - Automatic, motorized
  - Type - Gate
- Distribution Valve (V-2, V-3)
  - Manufacturer - Crane
  - Model name/number - GEM 2182
  - Function - Balancing
  - Operation - Manual
  - Type - Ball
  - Pressure - 150 psi
  - Temperature - 180° F
  - Materials exposed to heat transfer fluid - Brass/Rubber
- Distribution Valve (V-4, V-5)
  - Manufacturer - Watts
  - Model name/number - 70A
  - Function - 3 way mixing/tempering
  - Operation - Manual
  - Type - Tempering
  - Pressure - 150 psi
  - Temperature - 160° F
  - Materials exposed to heat transfer fluid - Bronze/Stainless
- Distribution Valve (V-6)
  - Manufacturer - Unknown
  - Model name/number - Hose Bib

- Function - Drain/Fill
- Operation - Manual
- Type - Gate

- Fail Safe Control (FC-1)
  - Manufacturer - Cash Acme
  - Model name/number - NCLX-5 Series 2
  - Type - Pressure relief valve
- Flow Control (FC-2, FC-4)
  - Manufacturer - Unknown
  - Model name/number - NIBCO
  - Type - Check valve
- Flow Control (FC-3)
  - Manufacturer - Simons
  - Model name/number - 501
  - Type - Vacuum/Pressure relief valve
- Fail Safe Control (FC-7)
  - Manufacturer - Unknown
  - Model name/number - Unknown
  - Type "Water Hammer" arrester

CONTROL MODE SELECTOR (CMS-1, 3, 4 AND 5)

- Manufacturer - Heliotrope General
- Model name/number - Delta T, DTT80 and L400-8A
- Modes controlled
  - Collector to storage -
    - ON - (SN-1) > (SN-2) + 9^{o} F
    - OFF - (SN-1) < (SN-2) + 3^{o} F

- Collector to HW
  - ON - (SN-5) > (SN-7) + 9^{o} and (SN-9) < 120^{o} F
  - OFF - (SN-5) < (SN-7) + 5^{o} or (SN-9) $\geq$ 120^{o} F
- Sensors (SN-1, SN-2, SN-5, SN-7)
  - Manufacturer - Heliotrope
  - Model name/number - Delta T
  - Type - Temperature/thermistor
- Sensor (SN-9)
  - Manufacturer - Honeywell
  - Type - Bulb sensor

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

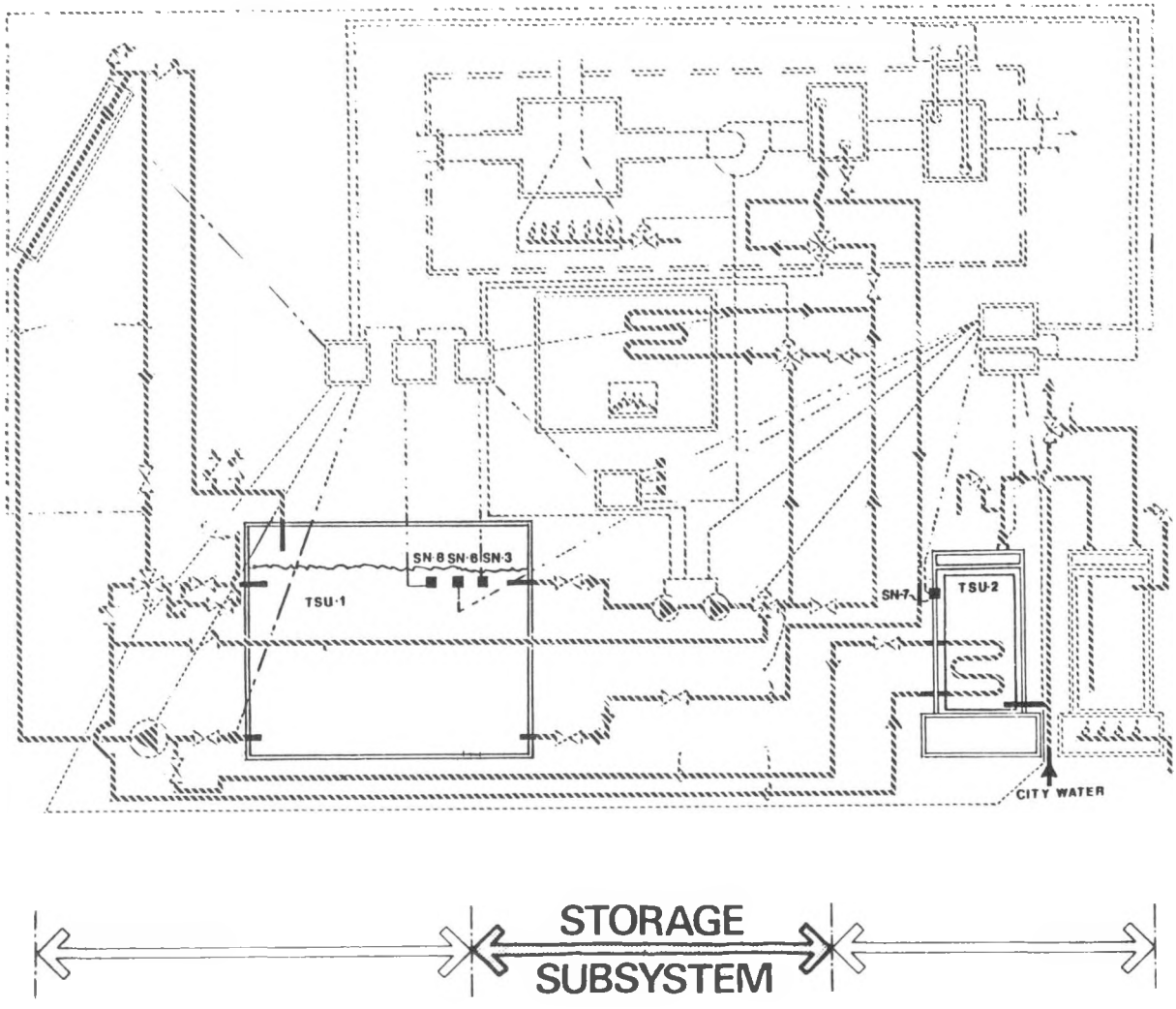


Figure IV-C-1. Storage Subsystem

Solar energy is stored in a 750-gallon tank (TSU-1). The tank dimensions are 7 ft high by 4 ft diameter. This tank is made of fiberglas reinforced plastic and has polyurethane insulation.

Additional solar thermal energy, as well as city preheated water, is stored in a 66-gallon (TSU-2) preheat tank. This tank is 4.5 ft high by 2 ft diameter with cast stone interior lining and insulated with fiberglass. The container is steel, commercial quality.

THERMAL STORAGE UNIT (TSU-1)

- Manufacturer - The Fiberglas Company
- Model name/number - 750-gal
- Total storage container volume - 88 ft^3
- Volume of storage medium - 88 ft^3 (750-gal)
  - Height - 7.0 ft
  - Diameter - 4.0 ft
- Maximum rated operating conditions
  - Temperature - 180° F
  - Pressure - 8 psi
- Storage medium
  - Design heating operating temperatures
    - Maximum 150° F
    - Minimum 50° F
  - Medium - Water (>99%) Nitrate Borate (< 1%)
  - 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 manufacturers recommended use of temperature
  - Maximum - 150° F
  - Minimum - 50° F
- Toxicity - Non-potable
- pH Factor - 7.0
- Inhibitor - Yes, (< 1% Nitrate Borate) Rust inhibitor

- Container construction
  - Type - Fiberglas
  - Interior lining - None
  - Location - Garage
  - Auxiliary heaters - No
  - Insulation - Polyurethane
  - Exterior finish - Fiberglas
  - Filters - No
  - Getters - No

THERMAL STORAGE UNIT (TSU-2)

- Manufacturer - Ford
- Model name/number - TC66E
- Total storage container volume - 14 ft^3
- Volume of storage medium - (66-gal)
  - Height - 4.5 ft
  - Diameter - 2.0 ft
- Maximum rated operating conditions
  - Temperature - 180° F
  - Pressure - 175 psi
- Storage medium
  - Design heating operating temperatures
    - Maximum 150° F
    - Minimum 120° F
  - 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 manufacturers recommended use of temperature
  - Maximum - 150° F
  - Minimum - 120° F
- Toxicity - Potable
- pH Factor - 7.0
- Inhibitor - No
- Container construction -
  - Type - HR Steel commercial (13 ga top and bottom, 11 ga sides)
  - Interior lining - Stone
  - Location - Garage
  - Auxiliary heaters - No
  - Insulation - Fiberglass
  - Exterior finish - Enamel
  - Filters - No
  - Getters - No

D. Energy To Load Subsystem (See Figures IV-D-1, IV-D-2, IV-D-3 and IV-D-4)

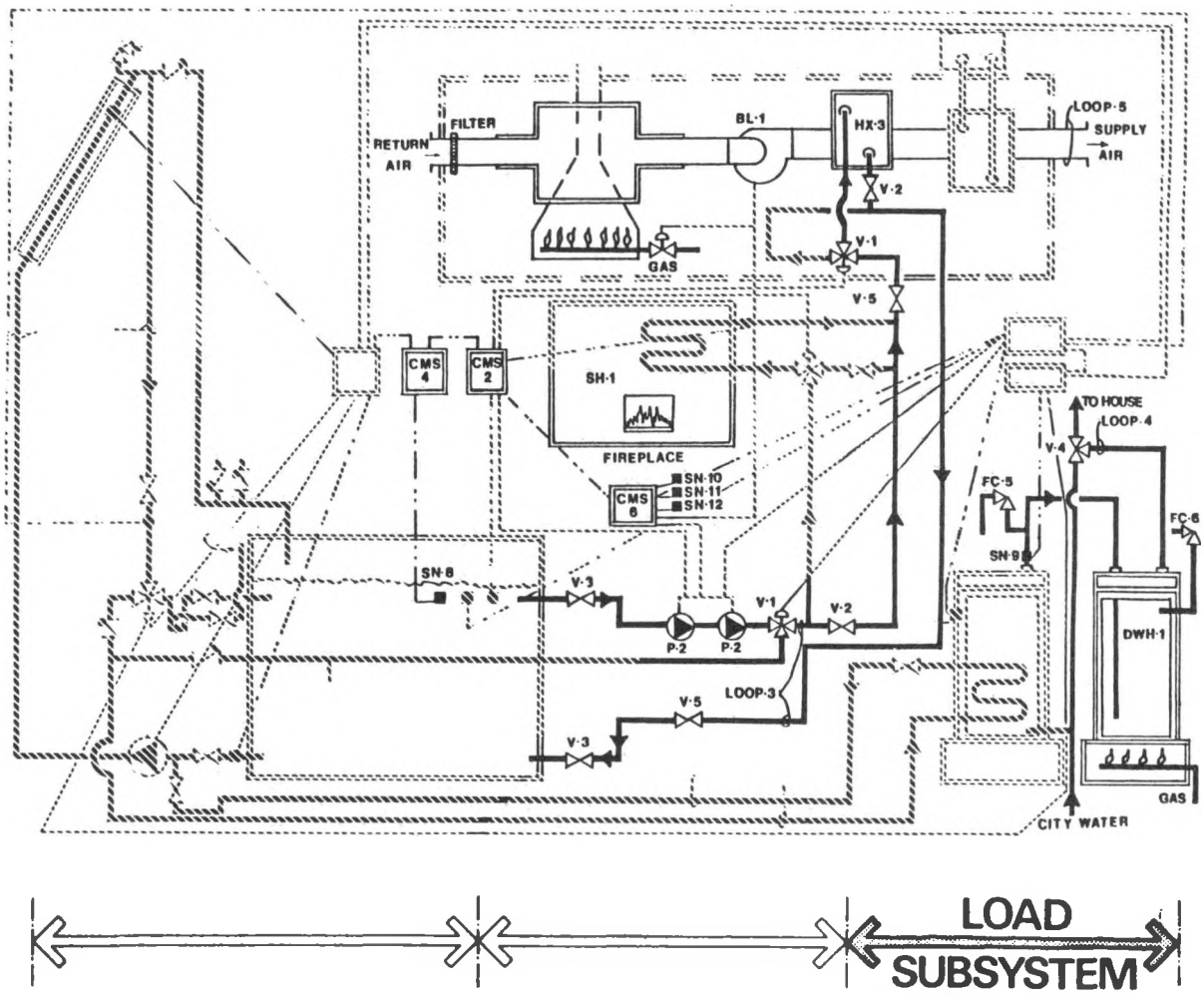


Figure IV-D-1. Energy-to-Load Subsystem, Storage-to-Space Heating

Water is the transfer medium that delivers solar energy from the collector array to storage for space heating and the hot water loads. Solar energy is stored in a 750-gallon tank located in the ground floor utility room. Heated water is circulated from storage through a heat exchanger in the air-handling unit and returned to storage. Heated city water is stored in a 66-gallon DHW tank and supplied to the DWH on demand. When solar energy is insufficient to satisfy the space heating load, a gas furnace provides auxiliary energy for the space heating system. Similarly, an electrical heating element in the DHW tank provides auxiliary energy for DHW heating. Energy from an hydronic fireplace radiates directly into the living space and supplements solar modes 1 and 2.

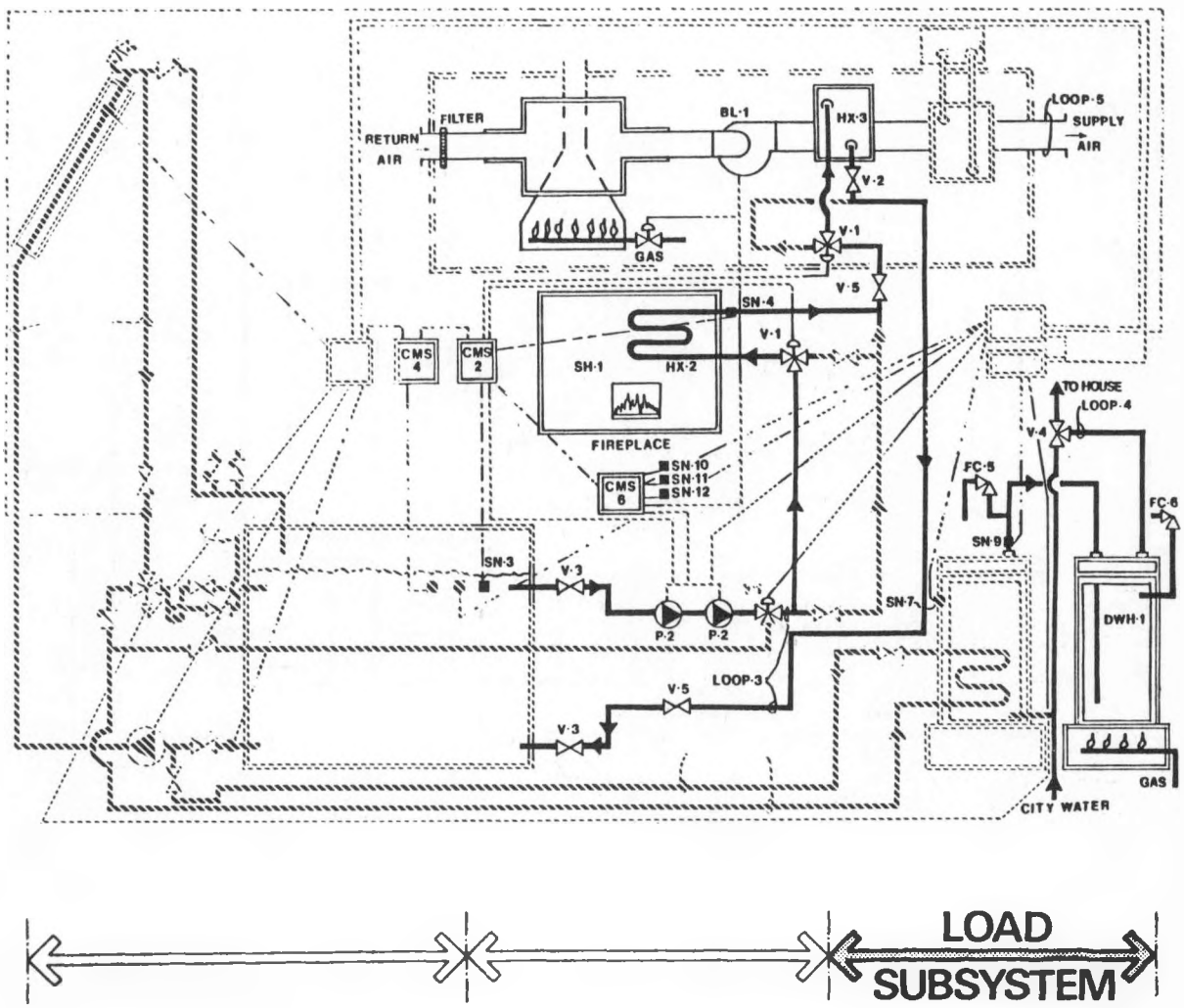


Figure IV-D-2. Energy-to-Load Subsystem, Storage-to-HX-2-to-Space Heating

The fireplace can also add energy to the water circulating from storage before it enters the air-handling unit. If the fireplace is being used and the temperature difference between its water plenum and storage output is more than 9^{o} F, valve V-1 is activated and energy is added to the water from the fireplace heat exchanger.

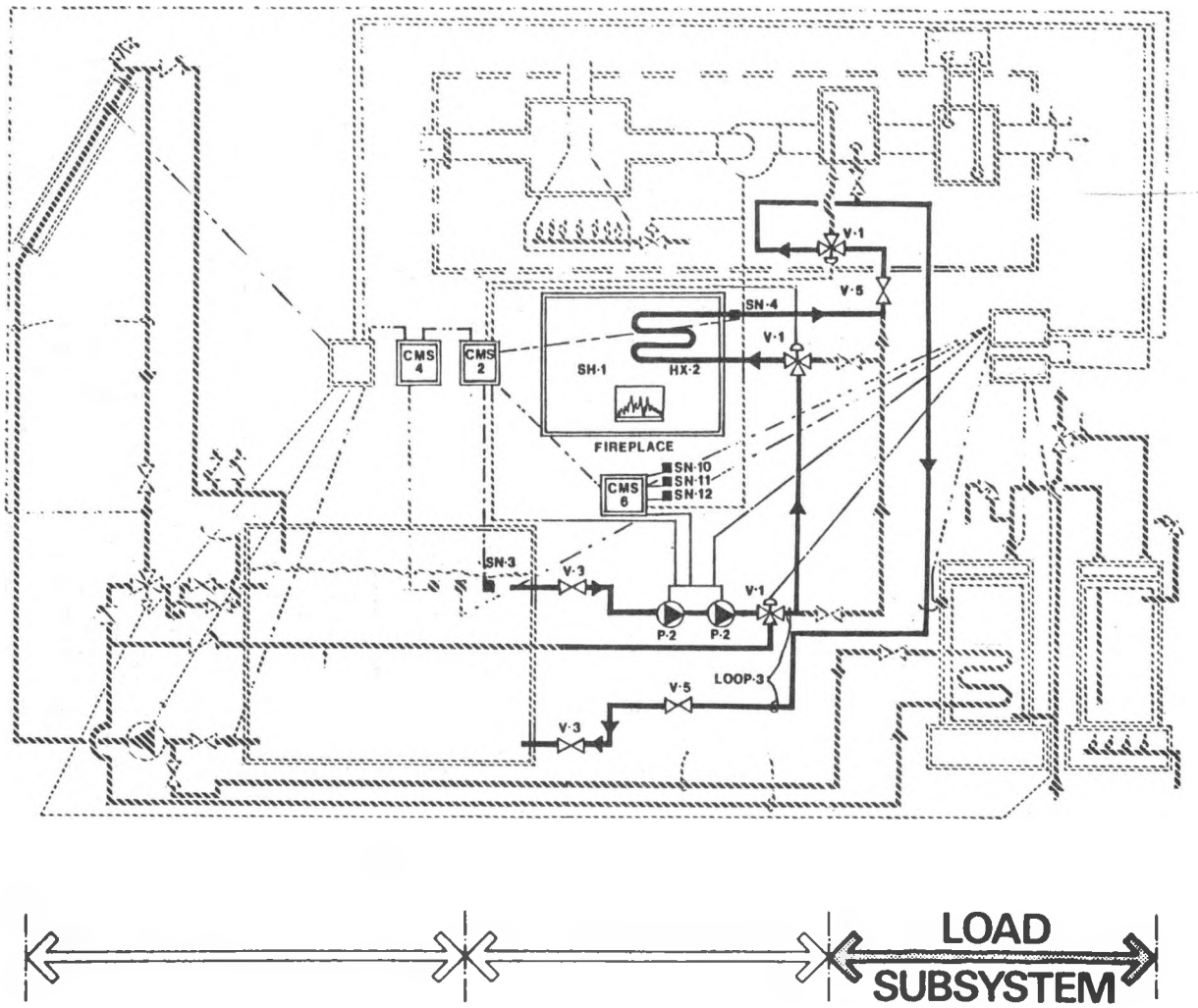


Figure IV-D-3. Energy-to-Load Subsystem, HX-2-to-Storage

The fireplace-to-storage mode activates if the fireplace is being used, the temperature difference between its water plenum and storage output is more than 9^{o} F, and there is no demand for space heating. During operation, water is circulated from storage through the fireplace heat exchanger.

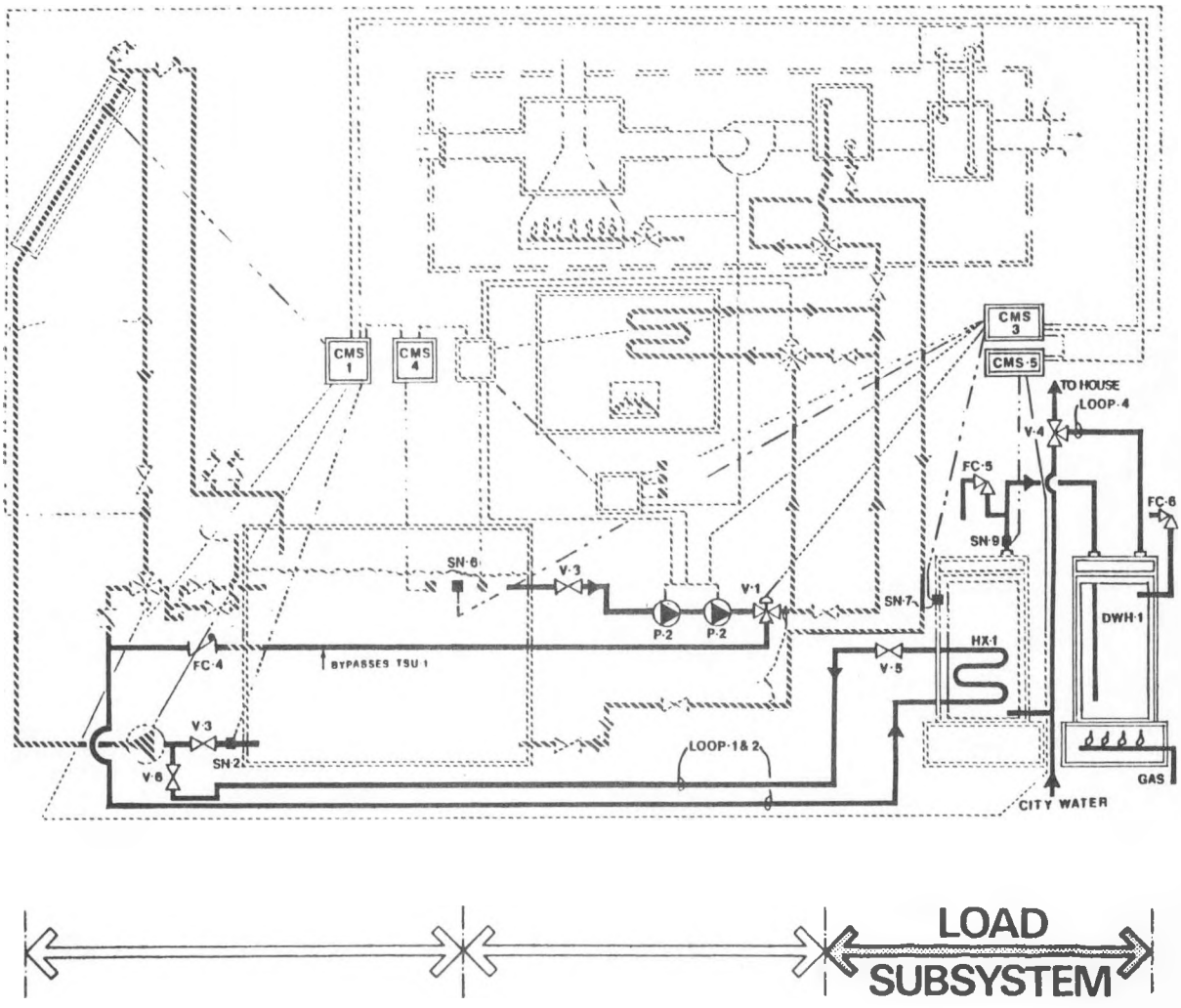


Figure IV-D-4. Energy-to-Load Subsystem, Storage-to-DHW

Incoming city water enters the DHW tank, where it is heated by water circulating from storage through a heat exchanger in the tank.

LIQUID CIRCULATION LOOP NO. 2 (TSU-1 TO HX-1)

- Design operating temperature - 180° F
- Design operating pressure - 8 psi
- Heating
  - Design liquid flow - 5.4 gpm
  - Design pump speed - 2620 rpm
- Heat transfer medium
  - Volume of liquid in loop - 651 gal
  - Anticipated liquid temperature
    - Maximum - 150°F
    - Minimum 90° F
  - Provisions for expansion - Air space in TSU-1
  - Medium - Water (99%); Rust inhibitor (1%)
  - 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 - 180° F
    - Minimum - 90° F
  - Toxicity - Non-potable
  - pH factor - 7.0
  - Chemical feeder - No
  - Inhibitor - Yes (1% Nitrate Borate)

- Components within circulation loop
  - Pump(s) - P-2
  - Heat exchanger(s) - HX-1
  - Thermal storage unit(s) - TSU-1, TSU-2
  - Valve(s) - V-1, V-3, V-5, V-6
  - Other(s) - FC-4
- Piping
  - Rigid - Copper, Type L
  - Insulation - Cellular rubber (Rubatex)
  - Location - Above grade

LIQUID CIRCULATION LOOP NO. 3 (TSU-1 TO HX-3, OR TO HX-2 AND HX-3, OR HX-2 TO TSU-1)

- Design maximum operation temperature - 180° F
- Design maximum operation pressure - 8 psi
- Heating
  - Design liquid flow - 6.1 gpm
  - Design pump speed - 2620 rpm
- Heat transfer medium
  - Volume of liquid in loop - 652 gal
  - Anticipated liquid temperatures
    - Maximum - 150° F
    - Minimum - 120° F
  - Provisions for expansion - Air space in TSU-1
  - Medium - Water (>99%) Nitrate Borate (<1%)
  - Specific heat - 1.00 Btu/lb/° F
  - Density - 62.4 lbs/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 - 180° F
  - Minimum - 120° F
- Toxicity - Non-potable
- pH factor - 7.0
- Chemical feeder to maintain pH factor - No
- Inhibitor - Yes, Nitrate Borate (1%)

- Components within circulation loop
  - Pump - P-2
  - Heat exchanger(s) - HX-2, HX-3
  - Thermal storage unit(s) - TSU-1
  - Valve(s) - V-1, V-2, V-3, V-5
- Piping
  - Rigid - Copper, Type L
  - Insulation - Cellular rubber (Rubatex)
  - Location - Above grade
- Heat Exchanger (HX-2)
  - Manufacturer - Southwest ENER - TECH Inc.
  - Model name/number - Fireplace heat exchanger M1820
  - Type of flow - Parallel
  - Heat exchanger design - Tube in plate
  - Number of separations - Unknown

	Air Side	Liquid Side
o Convection	Natural	Forced
o Located in:	Fireplace	Fireplace

	Air Side	Liquid Side
o Part of circulation loop:	3	3
o Maximum manufacturer's rated:		
- Temperature -	250° F	212° F
- Pressure -	100 psig	100 psig
o Heat transfer area	2.5 ft^2	
- Thickness	5/8 in	
- Length	20 in	
- Width	18 in	
o Material	439 Stainless	439 Stainless

o Heating

- Design heating capacity - 60,000 Btu/hr
- Effectiveness - 75%

o Design flow rate -

	Air Side	Liquid Side
- Related circulator no. -	BL-1	P-2

o Heat Exchanger (HX-3)

o Manufacturer - Magic Aire

o Model name/number - VHW4

o Type of flow - Vertical

o Heat exchanger design - Fin coil

	Air Side	Liquid Side
o Convection:	Forced	Forced
o Part of circulation loop:	4	4
o Maximum manufacturer's rated:		
- Temperature -		200° F
- Pressure -		1750 psi

	Air Side	Liquid Side
o Heat transfer area		
o Rows	2	
o Fins per inch	10	
o Face area	2.41 ft^2	
o Material	Aluminum	Copper

o Heating

- Design heating capacity - 79,000 Btu/hr
- Effectiveness - Unknown

	Air Side	Liquid Side
o Design flow quantity	1200 cfm	5 gpm
o Related circulator no. -	BL-1	P-2
o Liquid temperatures:		
- Entering -	60^{o} F DB	180^{o} F DB
- Leaving -	112^{o} F DB	170^{o} F DB

LIQUID CIRCULATION LOOP NO. 4 (TSU-2 TO DWH-1 TO HOUSE DEMAND)

- o Maximum design operating temperature - 150^{o} F
- o Maximum design operating pressure - 150 psi
- o Heating
  - o Design liquid flow - 6.1 gpm
  - o Design pump speed - 2620 rpm
- o Heat transfer medium
  - o Volume of liquid in loop - 33 gal
  - o Anticipated liquid temperatures
    - Maximum - 140^{o} F
    - Minimum - 115^{o} F

- Provision for expansion - Open loop to city water
- Medium - Water (100%)
- Specific heat - 1.00 Btu/lb/^{o} F
- Density - 62.4 lb/ft^{3}
- Heat capacity - 62.4 Btu/ft^{3}/^{o} F
- Boiling point - 212^{o} F
- Freezing point - 32^{o} F
- Medium manufacturer's recommended use temperature
  - Maximum - 140^{o} F
  - Minimum - 115^{o} 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
  - Heat exchanger(s) - HX-1
  - Thermal storage unit(s) - TSU-2
  - Valve(s) - V-4
  - Other(s) - FC-5
- Piping
  - Rigid - Copper, Type L
  - Insulation Type - Glass foam/Cellular rubber
  - Location - Above grade

AIR CIRCULATION LOOP NO. 5 (Space Heat)

- Heating
  - Maximum design operating temperature - 100^{o} F
  - Maximum design operating pressure - 0.5 in wg

- Heating design air flow
  - Maximum 1000 cfm
  - Minimum 986 cfm

- Components within circulation loop
  - Blower(s) - BL-1
  - Furnace(s) - FURN-1
  - Heat exchanger(s) - HX-3
  - Other(s) -

- Ducting
  - Type - Aluminum
  - Location - Attic
  - Maximum operating temperataure - 100° F
  - Thermal resistance - Unknown
  - Insulation - Fiberglas
  - Filter - Fibrous (Duralast)

- Blower
  - Manufacturer - Day and Night
  - Model name/number - Futura, 80U36, Series 19A
  - Type - Squirrel cage
  - Motor size - 0.33 HP; 115 V; 1 phase; 60 Hz
  - Motor speed - 1210 rpm
  - Blower speed - 4 speed
  - Design conditions

	Low Static Mode	High Static Mode
- Circulating volume	850cfm	920 cfm
- Motor operation	0.3 bhp	0.3 bhp

- At high speed
  - Impeller speed - 1210 rpm

	Low Static Mode	High Static Mode
- Circulating volume	1140 cfm	1300 cfm
- External static pressure	0.6 in wg	0.2 in wg
- Motor operation	0.3 bhp	0.3 bhp

CONTROL MODE SELECTOR (CMS - 2, 4 AND 6)

- CMS - 4
  - Manufacturer - Penn
  - Model name/number - A19AAF-12 Aquastat
- CMS - 2 and 6
  - Manufacturer - Heliotrope General
  - Model name/number - Delta T DTT 80 and T872C1 004
- CMS - 4 is wired in conjunction with CMS - 2 and 6
- Modes Controlled
  - Storage-to-Space
    - ON - (SN-10) < 70^{o} F (set PT.) and (SN-8) > 90^{o} F
    - OFF - (SN-10) > 72^{o} F (set PT.) or (SN-8)< 90^{o} F
  - Storage-to-Auxiliary-to-Space
    - ON - (SN-4) > (SN-3) + 9^{o} F and (SN-10) < 70^{o} F (set PT.)
    - OFF - (SN-4) < (SN-3) + 3^{o} F or (SN-10) > 68^{o} F (set PT.)
  - Auxiliary-to-Storage
    - ON - (SN-4) > (SN-3) + 9^{o} F
    - OFF - (SN-4) < (SN-3) + 3^{o} F
  - Furnace Auxiliary
    - ON - (SN-11) < 68^{o} F (set PT.)
    - OFF - (SN-11) > 72^{o} F (set PT.)

- Sensors (SN-3, SN-4)
  - Manufacturer - Heliotrope General
  - Model name/number - Unknown
  - Type - Temperature, thermistor
- Sensor (SN-08)
  - Manufacturer - Penn
  - Model name/number - Aquastat, A19AAF-12
  - Type - Bulb sensor
- Sensor (SN-10, SN-11)
  - Manufacturer - Honeywell
  - Model name/number - Unknown
  - Type - Integral with thermostat

CONTROL MODE SELECTOR (CMS - 1, 3, 4 AND 5)

- Modes controlled
  - Storage-to-HW
    - ON - (SN-6) > (SN-7) + 9^{o} F and (SN-9) < 120^{o} F and (SN-8) $\geq 90^{o}$ F
    - OFF - (SN-6) < (SN-7) + 3^{o} F or (SN-9) > 120^{o} F or (SN-8) < 90^{o} F
- Sensors (SN-6, SN-7)
  - Manufacturer - Helitrope
  - Model name/number - Delta T
  - Type - Temperature/thermistor
- Sensors (SN-8, SN-9)
  - Previously described

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

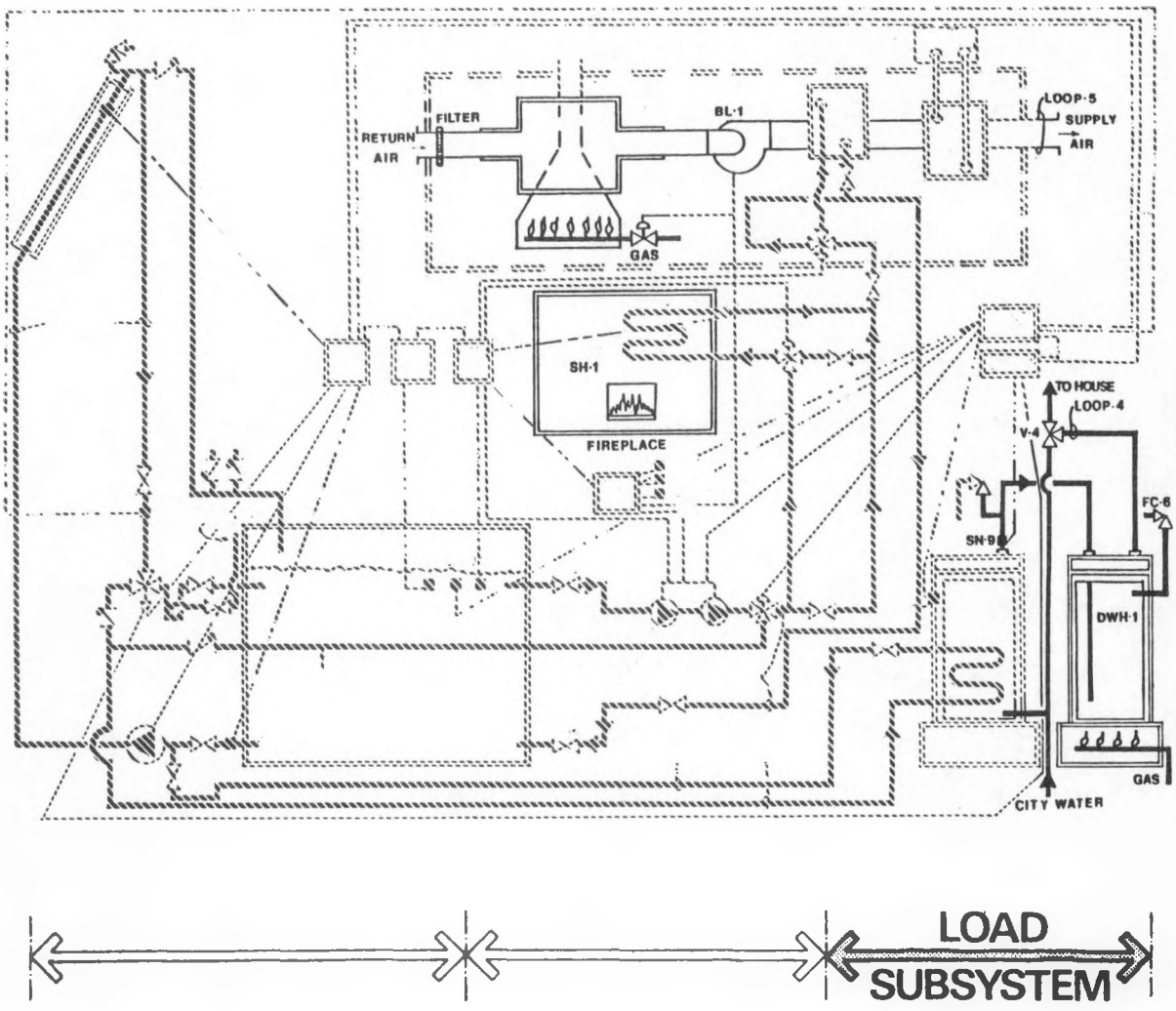


Figure IV-E-1. Auxiliary-to-Load Subsystem

The auxiliary subsystems, DWH-1, FURN-1 and SH-1 mentioned in the foregoing Energy to Load Subsystem have been grouped in this section for descriptive purposes, their function and purpose have been previously described.

AUXILIARY LOADS

- Domestic Water Heater (DWH-1)
  - Manufacturer - American Appliance
  - Model - 30-gal energy saver
  - Energy source - Natural gas
  - Tank size - 30-gal
  - Energy input - 33,000 Btu/hr
  - Energy output - 27,000 Btu/hr
  - Maximum pressure rating - 300 psi
  - Maximum temperature rating - 140° F
  - Design operating pressure - 150 psi
  - Heating stages - Single
  - Maximum recovery rate - 28-gal/hr
  - Yearly average inlet temperature - 60° F
  - Design output temperature - 140° F
  - Thermal resistance - R-4
  - Standby heat loss -4.6%/hr
  - Corrosion protection anodes - Yes, magnesium
  - Burner ignition method - Gas pilot
  - Flue vent - Yes
- Furnace (FURN-1)
  - Manufacturer - Day and Night
  - Model name/number - Futura 80U36 Series 19A (Incl BL-1)
  - Energy source - Natural gas
  - Energy input - 80,000 Btu/hr
  - Energy output - 64,000 Btu/hr

- Burner ignition method - Pilot
- Flue vent - No

- Supplemental Heater (SH-1)
  - Manufacturer - Southwest ENER - TECH Inc.
  - Product name/number - Fireplace Heat Exchanger
  - Energy source - Wood
  - Description - 20 in x 18 in Stainless

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

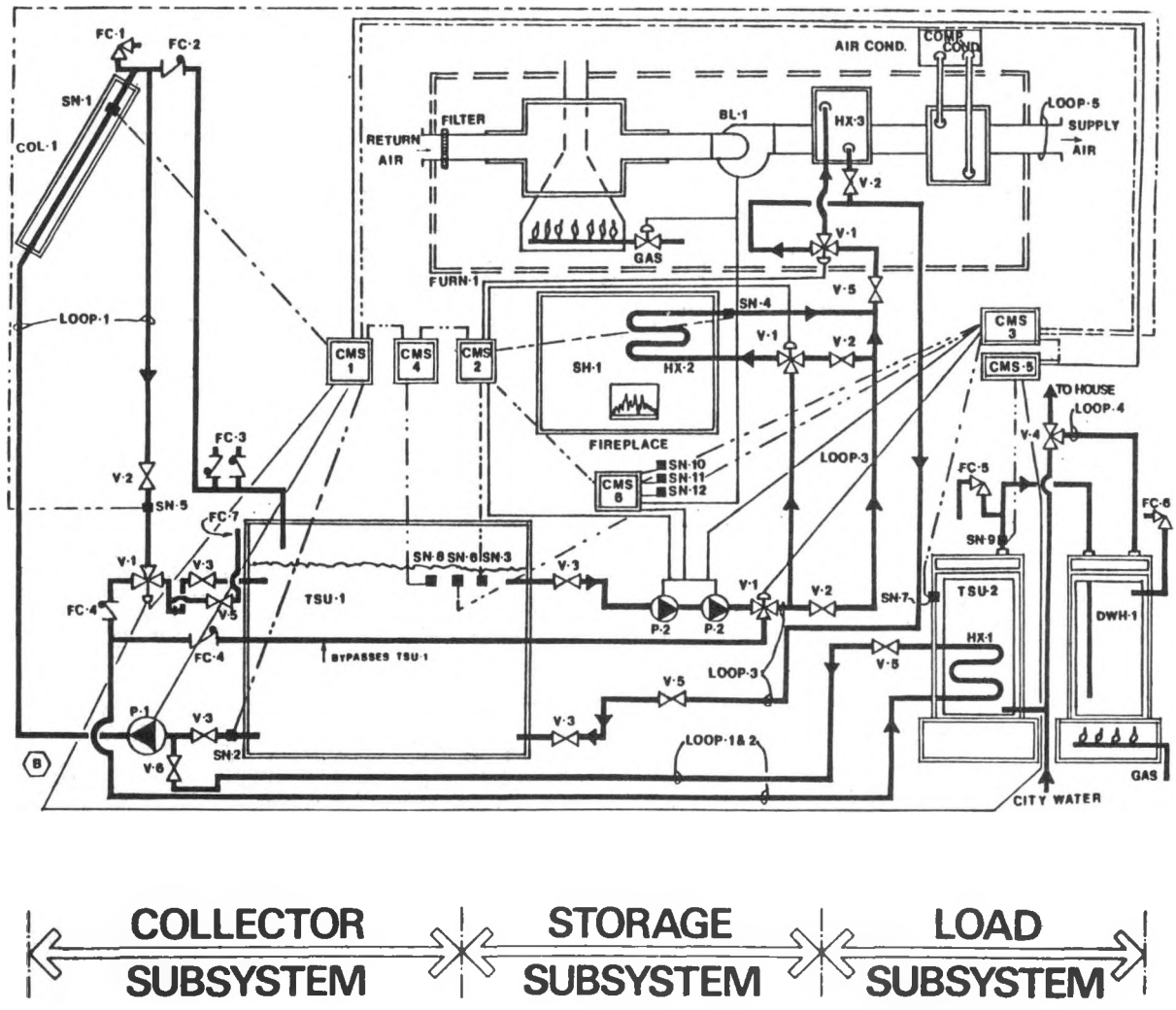


Figure IV-F-1. Controls Diagram

The Ortiz and Reill Developers (Lot 8) solar system is shown on Figure IV-F-1. The system consists of the following four subsystems: a) Collector, b) storage, c) load (DWH-1) and FURN-1 and d) auxiliary load subsystems.

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

Mode 1 - Collector-to-Storage:

This mode activates when the temperature at the outlet of the collector array exceeds the temperature at the bottom of the storage tank by more than 9^{o} F. Water is circulated from the tank through the collectors until the temperature difference is less than 3^{o} F.

Mode 2 - Storage-to-Space Heating:

This mode activates when the manually preset thermostat located in the heated space indicates a demand for space heating. Heated water is circulated from storage through a heat exchanger in the air-handling unit and returned to storage. If the demand cannot be satisfied by energy from storage, the gas furnace is activated to provide auxiliary heat. The fireplace can also add energy to the water circulating from storage before it enters the air-handling unit. If the fireplace is being used and the temperature difference between its water plenum and storage output is more than 9^{o} F, valve V-1 is activated and energy is added to the water from the fireplace heat exchanger.

Mode 3 - Storage-to-DHW:

This mode activates when there is a temperature difference exceeding a preset differential between storage and the DHW tank and there is no demand for space heating. Incoming city water enters the DHW tank, where it is heated by water circulating from storage through a heat exchanger in the tank.

Mode 4 - Collector-to-DHW:

This mode activates when the temperature in the DHW tank falls below 120^{o} F and the collector output temperature exceeds the DHW tank temperature. Water circulates through the heat exchanger in the DHW tank and returns to the collectors.

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.

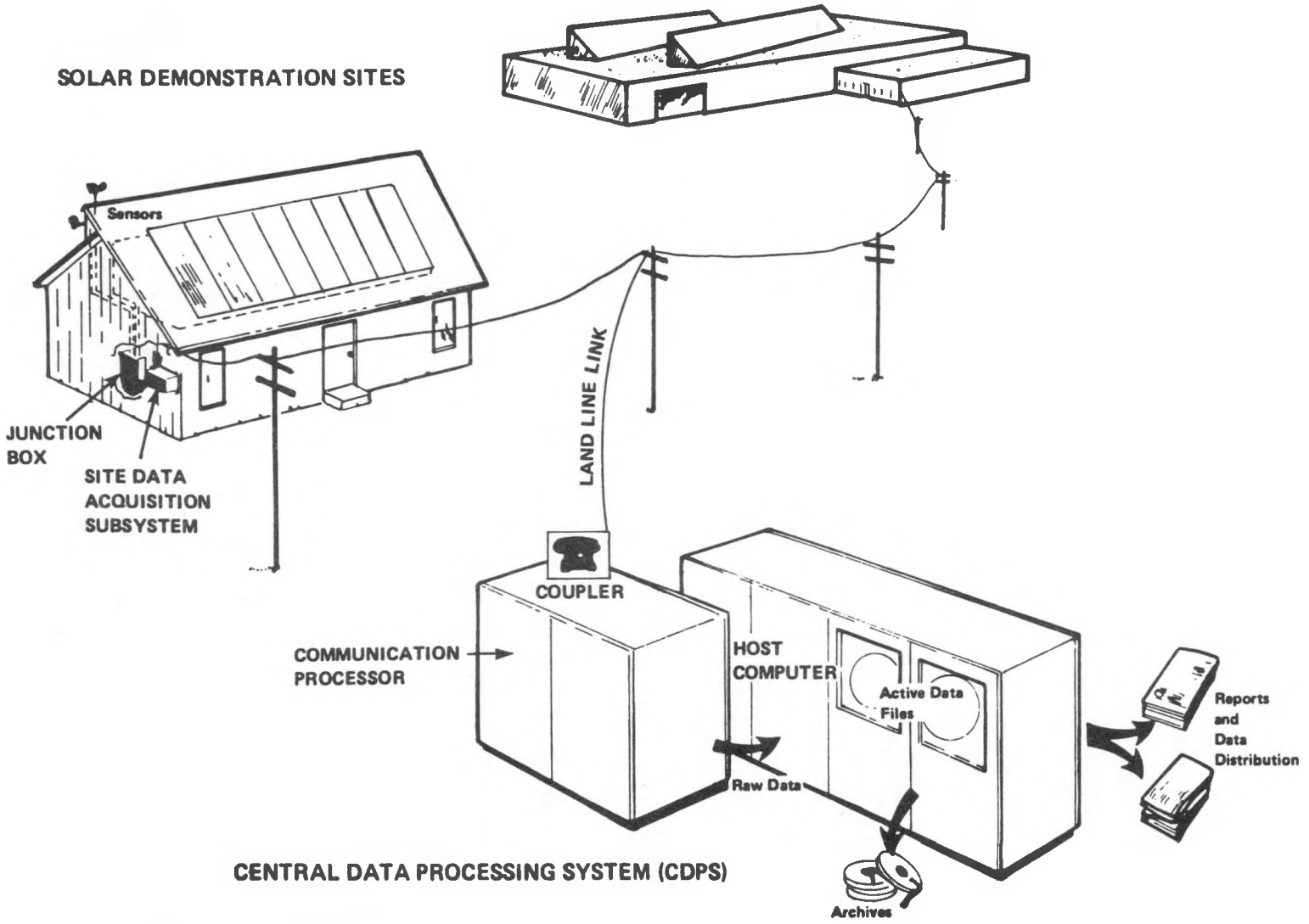


Figure V-A-1. The National Solar Data Network

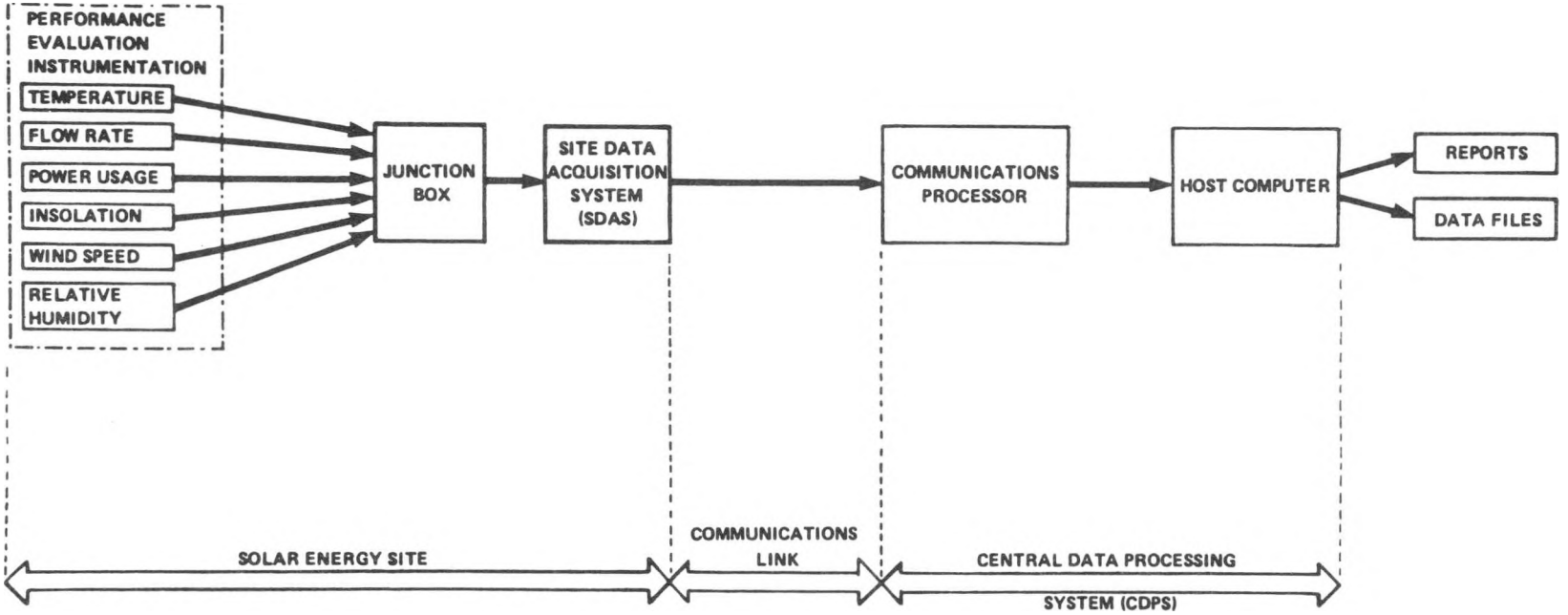


Figure V-A-2. Data Flow Path for the National Solar Data Network

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 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 figure 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.
T-001	Temperature - Outside Ambient	S53P-60
I-001	Total Insolation	Eppley PSP
T-100	Temperature - Collector Inlet	S57P-60
TD-100L	Temperature - Across Collector, Low	
TD-100H	Temperature - Across Collector, High	S53P-60
W-100	Flow - Collector Loop	MK V I, I-10
T-200	Temperature - Storage Tank Inlet	S57P-60
TD-200H	Temperature - Across Storage Tank, High	
TD-200L	Temperature - Across Storage Tank, Low	S53P-60
EP-100	Power - Collector Loop Pump	PC5-I
T-201	Temperature - Storage Tank, Bottom	S53P-846
T-202	Temperature - Storage Tank, Middle	S53P-546
T-203	Temperature - Storage Tank, Top	S53P-276
T-204	Temperature - Outside of Storage Tank	S32B
T-301	Temperature - Inlet to DHW Tank HX	S57P-60
TD-301H	Temperature - Across DHW Tank HX, High	
TD-301L	Temperature - Across DHW Tank HX, Low	S53P-60
T-300	Temperature - Cold Water Supply	S57P-60
TD-300L	Temperature - Across DHW Tank, Low	
TD-300H	Temperature - Across DHW Tank, High	S53P-60
W-300	Flow - Cold Water Supply	MK V 3/4, .7-7
EP-300	Power - DHW Water (four passes) 2	PC5-29
T-400	Temperature - Storage Tank Outlet	S57P-60
TD-400H	Temperature - Across Storage Tank, High	
TD-400L	Temperature - Across Storage Tank, Low	S53P-60
W-400	Flow - Space Heating Loop, Water	MK V I, I-10
T-401	Temperature - Fireplace Inlet	S57P-60
TD-401L	Temperature - Across Fireplace, Low	
TD-401H	Temperature - Across Fireplace, High	S53P-60
T-402	Temperature - Water Heat Coil, Inlet	S57P-60
TD-402H	Temperature - Across Heat Coil, High	
TD-402L	Temperature - Across Heat Coil, Low	S53P-60
EP-200	Power - Space Heating Pump	PC5-I

SENSOR	DESCRIPTION OF MEASUREMENT	MODEL NO.
EP-400	Power - Furnace Blower	PC5-19
F-400	Fuel Flow - Gas Meter	AC-175
T-403	Temperature - Return Air	S57P-100
TD-403L	Temperature - Across Furnace, Low	
TD-403H	Temperature - Across Furnace, High	S57P-100
TD-404L	Temperature - Across Water Coil, Low	
TD-404H	Temperature - Across Water Coil, High	S57P-100
TD-405H	Temperature - Across A/C Unit, High	
TD-405L	Temperature - Across A/C Unit, Low	S53P-100
EP-401	Power - A/C Unit 2	PC5-29
W-401	Flow - Space Heating Loop, Air	Kurz 430-DC
S-400	Switch - "On" through Fireplace	W88ACPX-3
S-401	Switch - "On" through Coil	W88ACPX-3
S-402	Switch - "On" through Storage Tank	W88ACPX-3
S-200	Switch - "On" through DHW Tank	W88ACPX-3
T-600	Temperature - Heated Air Space	S53P-28
T-301	Temperature - Outside of DHW Tank	S32B
S-403	Switch - "On" through DHW Tank	W88ACPX-3
W-301	Flow - Storage Tank to DHW Tank	MK V I, I-10

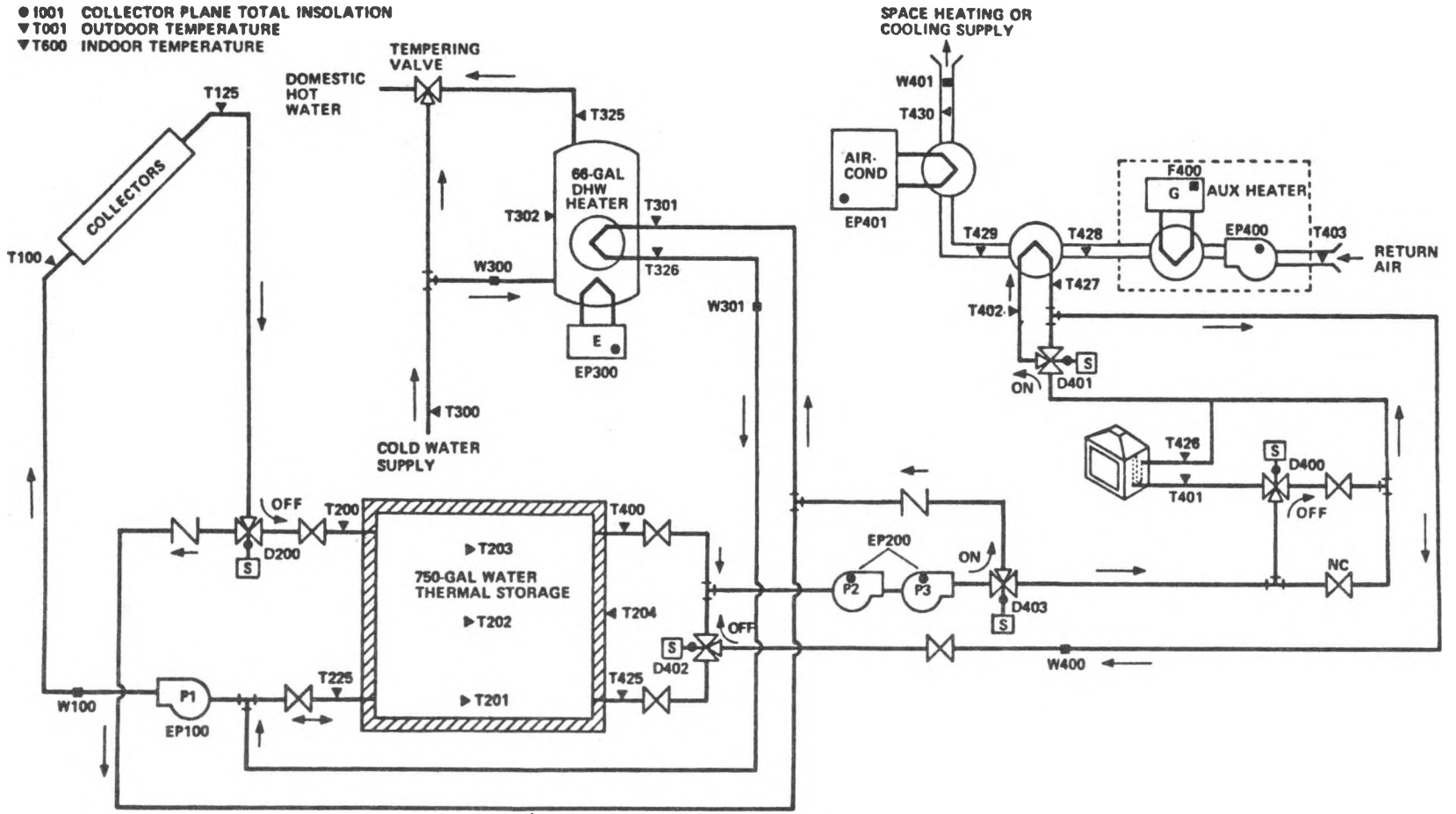


Figure V-B-1. Sensor and Control Diagram

VI. COST DATA

A. · General

The following cost data depicts only the 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	$1,800	$
Energy Storage	750	
Distribution and Controls	1,950	
Installation	8,500	
Other		
Total	$13,000	

C. Construction Period: June 1977 through May 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° F to 60° 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.

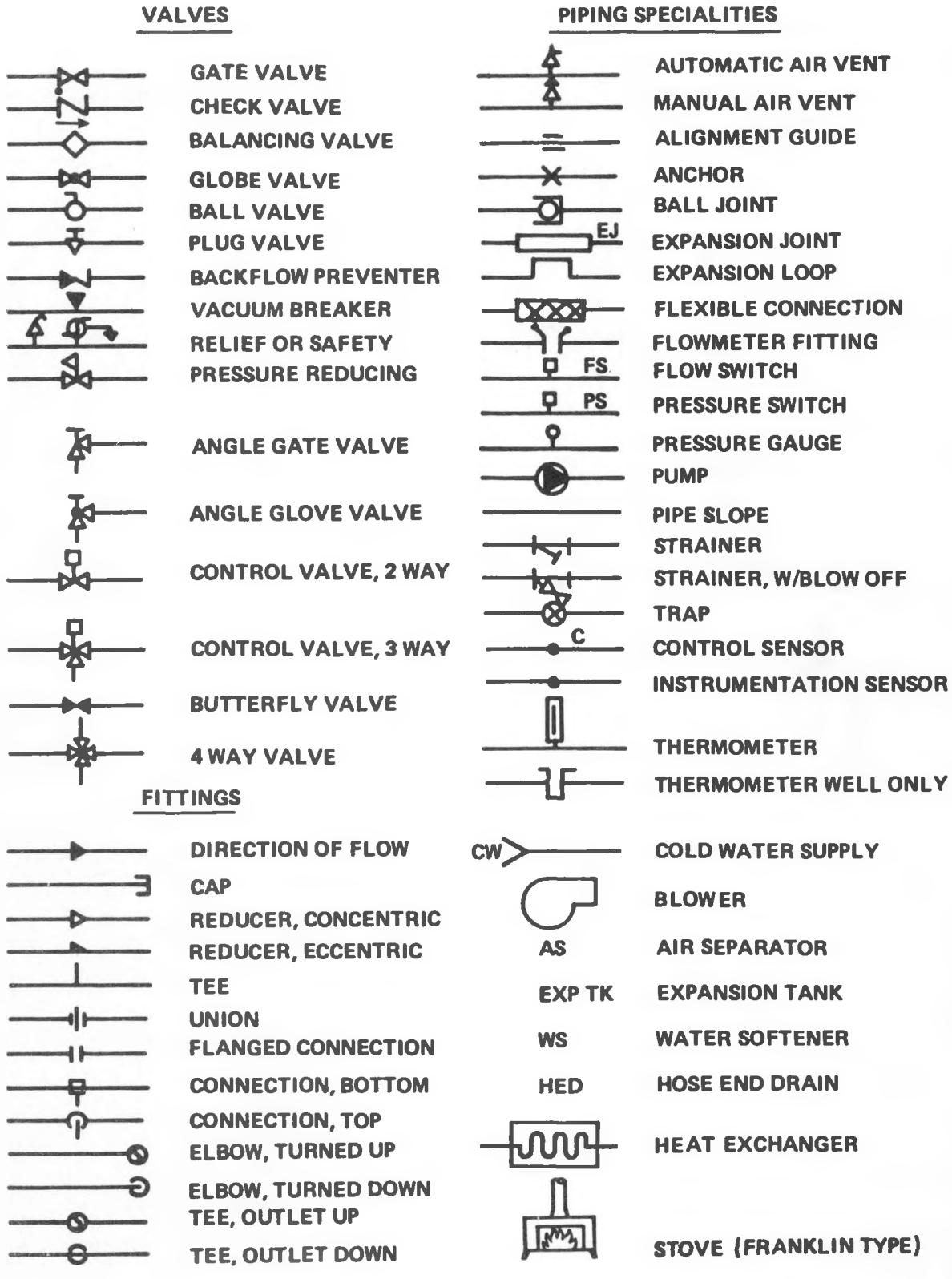
TON OF REFRIGERATION - A unit of refrigeration which is equivalent to 12,000 Btu/hr.

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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