SOLAR/1027-82/50
(DE83001068)

Solar Project Description

ENVIRONMENTAL PARTNERSHIP
UPPER FREEHOLD TOWNSHIP
Monmouth County, New Jersey
August 16, 1982

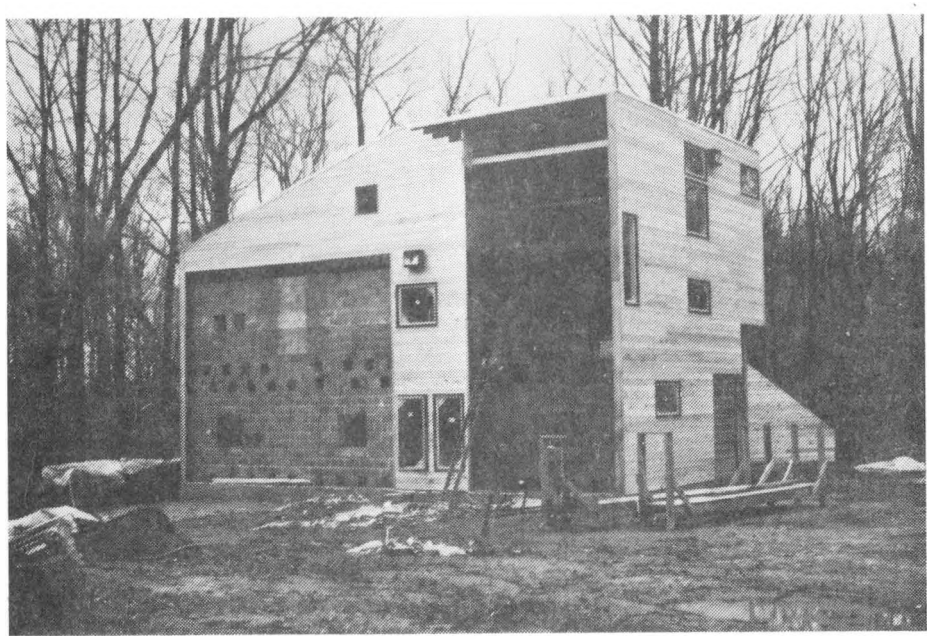
U.S. DEPARTMENT OF ENERGY

National Solar Heating and Cooling Demonstration Program

National Solar Data Program

SOLAR/1027-82/50
(DE83001068)
Distribution Category UC-59

SOLAR PROJECT DESCRIPTION
FOR
ENVIRONMENTAL PARTNERSHIP
UPPER FREEHOLD TOWNSHIP
MONMOUTH COUNTY, NEW JERSEY



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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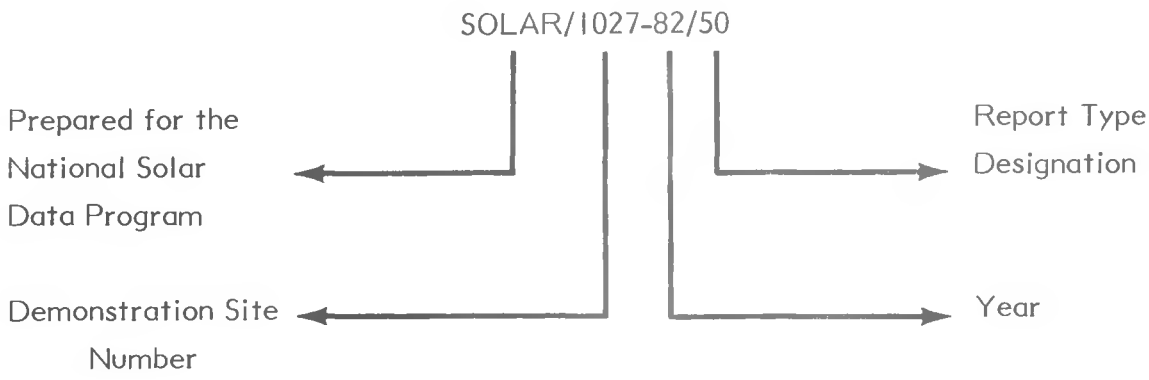
NATIONAL SOLAR DATA PROGRAM REPORTS

Reports prepared for the National Solar Data Program are numbered under a specific format. For example, this report for the Environmental Partnership project site is designated as SOLAR/1027-82/50. 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:

- Solar Project Description.
- Operational Experience.
- System Performance Evaluation.
- 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 Environmental Partnership site (Grant H-8627) is a three-story single family detached residence located in Cream Ridge, New Jersey. The solar heating system is passive and provides space heating and preheating of domestic hot water for the occupants. A wood burning heating stove and a combination wood/propane fueled furnace provide auxiliary heat. Cooling the house in summer is accomplished by opening windows, doors and exhaust dampers and operating the whole house ventilation fan until the house cools.

The following are the major solar energy descriptors:

- o Collector Types
  - Direct Gain - Window type - directly irradiated storage
  - Indirect Gain - Mass trombe wall
- o Freeze Protection -- Not required
- o Application -- Space heating and preheating domestic hot water
- o Storage -- Mass floor, mass vented trombe wall and phase change storage rods in the loft area
- o New or Retrofit -- New
- o Performance Evaluation Instrumentation -- Yes
- o Site Specific Features -- Passive system

The Environmental Partnership home contains approximately 2,050 square feet of floor area. A 540 cubic foot vented trombe wall, constructed of concrete filled concrete blocks, faces south and is glazed with 344 square feet of insulated tempered glass. The wall has both interior and exterior vents allowing both energy rejection in the summer and venting of the wall to the interior in the winter, if needed.

A sunspace of 168 square feet of south-facing insulated glass provides direct gain to the kitchen and loft areas.

The loft area has a phase change storage system composed of 32 PSI Thermal-81 phase change storage rods for auxiliary thermal storage.

Additional thermal energy is provided by a wood-burning stove located in the living space on the second floor.

A dual-fuel, propane and wood, forced air furnace provides additional heat energy distribution to the home.

A "breadbox" type hot water preheater is located in the south roof of the home. A 42 foot-square area of double glazed skylight with a concave reflector directly radiates the steel preheat tank which is coated with a selective surface.

The residence has been fully instrumented for performance evaluation since October, 1980 and the data entered 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)

Space heating of the home is provided by a passive solar heating system augmented by a wood burning stove and a wood/propane fueled forced-air furnace. A double glazed skylight, with a concave reflector, directly radiates a 66-gallon steel tank to preheat domestic hot water. A 50-gallon propane fueled domestic hot water tank heats the water to demand temperature.

Space cooling is provided by an exhaust fan in the loft area combined with opening of windows and dampers.

- Building type - Single family detached
- Latitude - 40^{o}
- Longitude - 74.5^{o}
- Altitude - 105'

HEATING DESIGN TEMPERATURES

- Outdoor - Unknown
- Indoor
  - Minimum - 62^{o} F DB
  - Maximum - 65^{o} F DB

BUILDING

- Building faces - South
- Average stories above ground - 3
- Average stories below ground - 0
- Height above grade - 27ft
- Conditioned floor area -1748 ft^2
- Roof type - Both flat and pitched (19^{o})

DESIGN HEAT LOSS/LOAD

- Heat Loss - 40,000 Btuh
- Heat gain - Unknown

- Shading
  - Heating season - 12%
  - Cooling season - 0^{o}
  - Maximum during functional season - 16%
- Appliance, lighting and equipment load - Unknown
- Average horizontal insolation
  - January - 638
  - July - 1904
- Annual degree days
  - Heating - 4911
  - Data location - NOAAH, Newark Airport, Newark, NJ
  - Data reference - Local Climatological Data Annual Summaries, Department of Commerce, National Oceanographic and Atmospheric Administration

MECHANICAL SYSTEM

- Heating
  - Solar - Direct radiation through double and triple glazed windows on mass wall and floors
  - Auxiliary - Propane/wood furnace and wood stove plus 32 phase change storage rods
  - Distribution - Forced and natural
- Cooling (Non-Solar)
  - Auxiliary - Venting the house by opening windows and dampers and activating Blower BL-2
  - Distribution - Exhausting heat from the house and air movement with Blower BL-2

DOMESTIC HOT WATER

- Daily water demand - 30 gal
- Solar - Directly radiated preheat tank (66-gal) from roof skylight
- Auxiliary - 50-gal propane fueled domestic hot water heater

GENERAL DATA

- Manufacturer - Site built
- Model name/number - None
- Type of system - Passive

SYSTEM AND COMPONENT SUMMARY

- Collector types - 1
- Circulation loops - 1
- Thermal storage units - 3
- Operational modes - 3
- Furnaces - 1
- Heating Stoves - 1
- Blowers - 2
- Dampers - 2 (types back-draft and manual)
- Sensors - 3 (integral with thermostats)
- Flow regulators - 0
- Pressure regulators - 0
- Fail safe controls - 0
- Adjustable interior sun control - 1 (manually operated venetian blinds with special surfaces)

Figure III-1. Site Plan

IV. SOLAR SYSTEM DESCRIPTION

A. General Overview

The Environmental Partnership residential solar demonstration project (Grant H-8627) is located in Upper Freehold Township, Monmouth County, Cream Ridge, New Jersey.

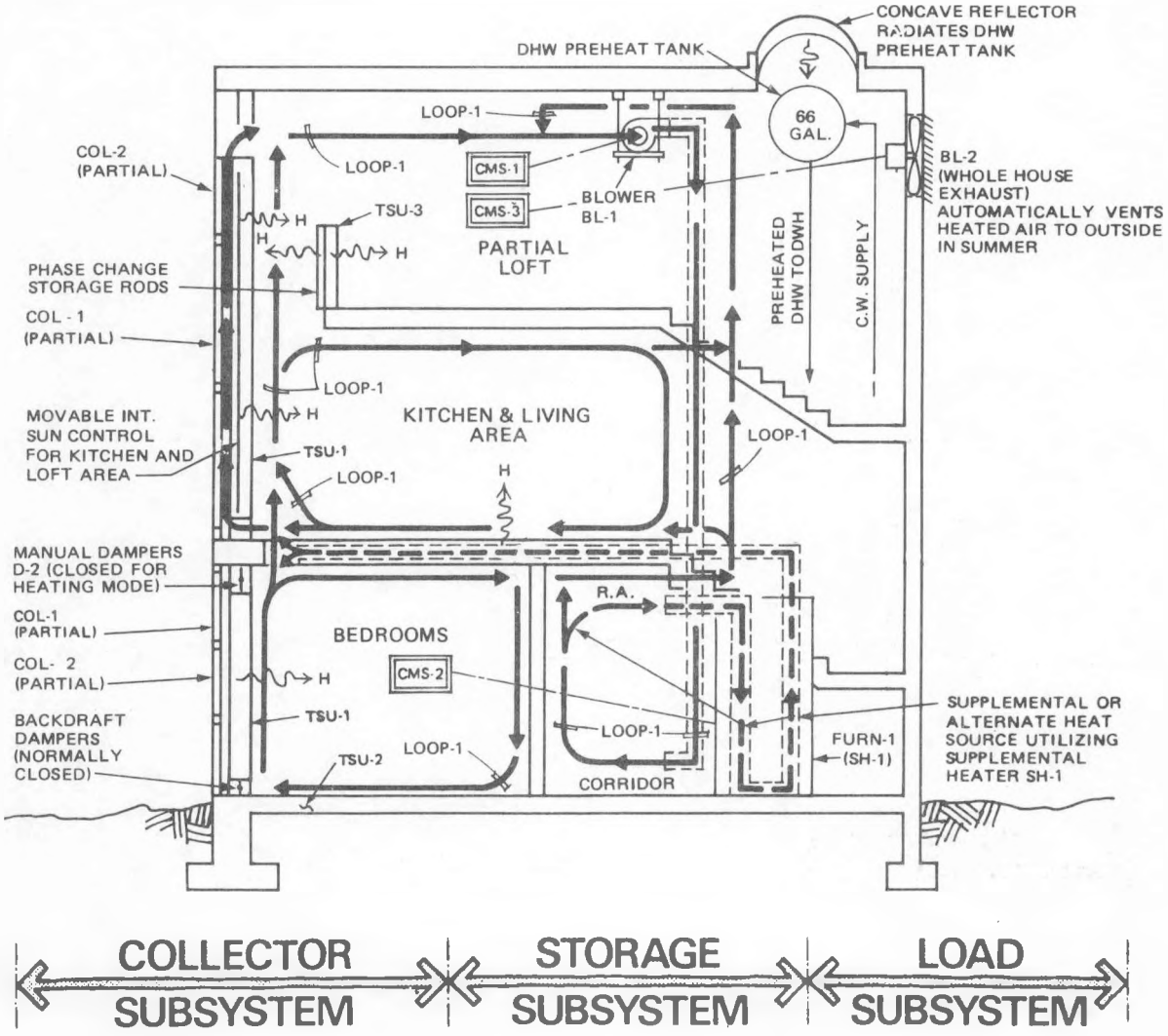


Figure IV-A-1. General Overview

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 figure IV-B-1)

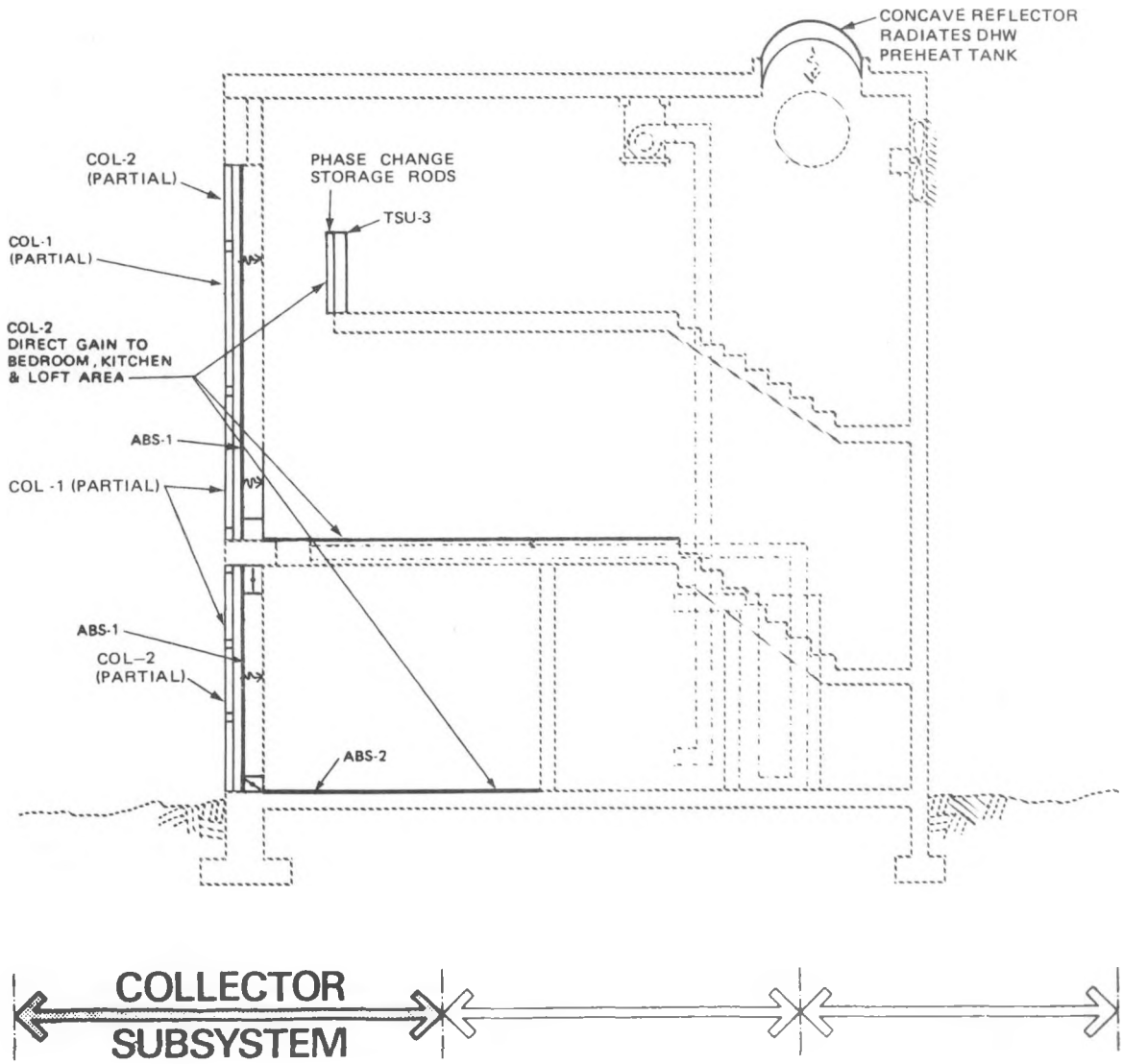


Figure IV-B-1. Collector Subsystem

There are two collector arrays. Collector (COL-1) contains a net area of 344 ft^2 of south facing insulated glass. Solar energy is absorbed and stored in a flat black painted trombe wall.Collector (COL-2) contains a net area of 168 ft^2 of south facing insulated glass providing direct gain to the kitchen floor and loft area.

COLLECTOR (COL-1, DIRECT GAIN TO TROMBE WALL) (See figure IV-B-2)

- Manufacturer - Site built
- Model name/number - None
- Type - Triple glazed with insulating glass
- Location - South facing windows
- Orientation - South
- Tilt angle - 90^{o} from horizontal
- Collector characteristics
  - Number of panels - 24 (window type)
  - Total gross area of array - 540 ft^2
  - Net aperture area - 344 ft^2
  - Weight per panel, empty - Unknown
  - Panel length - Unknown (panels vary)
  - Panel width - Unknown (panels vary)
- Built-in collector - Yes, integral with structure
- Collector shading
  - Area shaded in June - 0%
  - Area shaded in December - 12%
  - Maximum shade during functional season - 16%
- Cover plates
  - Number of cover plates - 3
- Cover plate No. 1
  - Location - Outer glazing of south wall
  - Manufacturer - Cardinal Glass Co., Minneapolis, Minnesota
  - Material - Insulating glass (plate)
  - Thickness - 0.188 in.
  - Optical properties - Unknown

Passive System -
Collectors are site built and
integral with the residential structure

Figure IV-B-2. Solar Collector

- Edge or surface treatment - None
- Coating - None

- Cover plate No. 2
  - Manufacturer - Cardinal Glass Co., Minneapolis, Minnesota
  - Location - Middle glazing
  - Material - Insulating glass
  - Thickness - 0.125
  - Optical properties - Unknown
  - Edge treatment - None
  - Coating - None

- Cover plate No. 3
  - Location - Inner glazing of south wall
  - Material - Insulating glass
  - Thickness - 0.125 in.
  - Optical properties - Unknown
  - Edge or surface treatment - None
  - Coating - None

- Absorber (ABS-1)
  - Manufacturer - Site built
  - Material - Flat black coating on trombe wall
  - Substrate material dimensions
    - Thickness - 1 ft
    - Length - 38 ft
    - Height - 17 ft

- Coating
  - Manufacturer - RUSTOLEUM
  - Model name/number - Flat black 412

- Coating material - Alkyd enamel paint (on collector side)

- Frame
  - Manufacturer - Site built (integral part of wall structure)
  - Standoffs used - No
  - Number of structure attach points per module to building - 6
- Reflectors - None

COLLECTOR (COL-2, DIRECT GAIN TO KITCHEN & LOFT AREA)

- Manufacturer - Site built
- Type - Vertical south glazing
- Tilt angle - 90^{o} from horizontal
- Location - South wall (integral with structure)
- Orientation - South
- Collector characteristics
  - Number of window panels - 6
  - Total gross area of array - 177 ft^2
  - Net aperture area - 168 ft^2
  - Window panel sizes
    - Length - 60 in
    - Width - 60 in
- Collector shading
  - Area shaded in June - 0%
  - Area shaded in December - 12%
  - Maximum shade during functional season - 16%
- Cover plates - 2
  - Location
    - One in outer layer of double glazed window
    - One in inner layer of double glazed window

- Material - Tempered glass
- Thickness - Unknown
- Edge treatment - Unknown

- Absorber (ABS-2)
  - Manufacturer - Site built
  - Material - Dark brown uncoated ceramic floor tile over concrete substrate
  - Substrate material dimension
    - Thickness - (average) 6 in
    - Length - 48 in
    - Width - 120 in
  - Number of absorbers per collector - 1
- Frame
  - Manufacturer - Site built (integral part of wall structure)
  - Standoffs used - No
  - Built-in collector - Yes
- Reflectors - None

- Movable insulation inside building
  - Manufacturer - Levolor Lorentzen
  - Product name/number - Movable slat venetian blinds
  - Controls - Manual
  - Material - Cryotherm/w/89 bright coating
  - Color exposed to sun - Chrome in summer/flat black in winter
  - Color exposed to interior of home - Opposite of color exposed to sun above
- Collector performance - Passive system (no data)

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

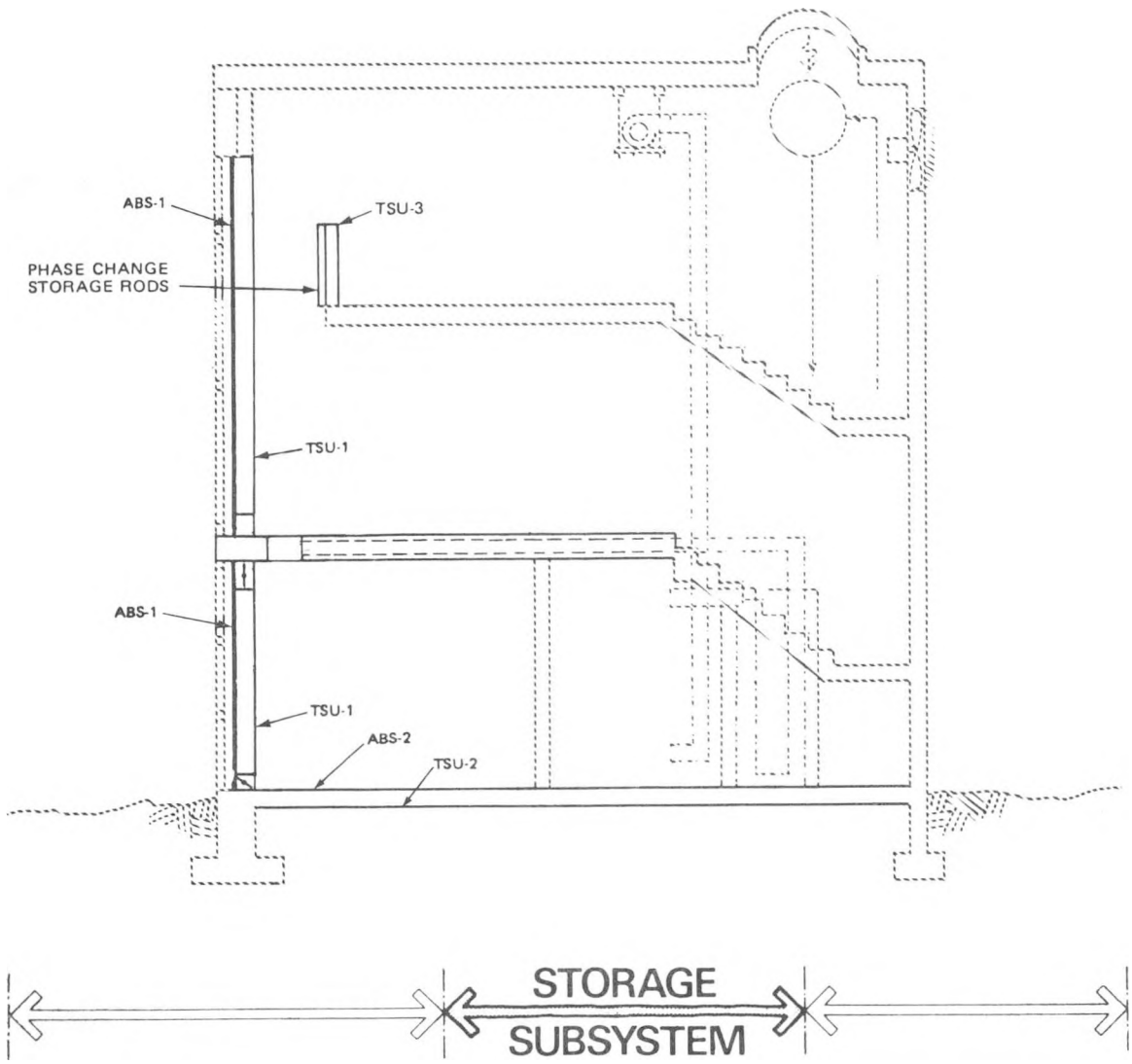


Figure IV-C-1. Storage Subsystem

Solar energy storage is provided primarily by a concrete floor and a mass trombe wall. The floor is covered with unglazed dark brown ceramic tile and the wall is painted with flat black paint on the side towards the collector. Auxiliary storage is provided by phase change rods located in the loft area.

THERMAL STORAGE UNIT (TSU-1)

- Manufacturer - Site built
- Model name/number - None
- Total storage container volume - 646 ft^3
- Dimensions of storage container
  - Length - 38 ft
  - Width - 1 ft
  - Height - 17 ft
- Storage medium
  - Medium - Concrete filled concrete block, vented mass trombe wall
  - Specific heat - 0.21 Btu/lb/^{o} F approximately
  - Density - 135 lbs/ft^3

THERMAL STORAGE UNIT (TSU-2)

- Manufacturer - Site built
- Model name/number - None
- Total storage container volume - 190 ft^3
- Dimensions of storage container
  - Length -38 ft
  - Width - 10 ft
  - Thickness - 0.5 ft
- Storage medium
  - Medium - Concrete mass floor
  - Specific heat - 0.20 Btu/lb/^{o} F approximately
  - Density - 120 lbs/ft^3
  - Location - Bedroom floor
- Energy collection - Direct gain, window type, directly radiated (COL-1 and COL-2)

- Location - South facing wall, integral with structure
- Manufacturer - PSI Energy Systems, Inc.
- Model name/number - Thermal 81 Phase Change Storage
- Total storage container volume - 11.3 ft^3
- Volume of storage medium - 11.3 ft^3
  - Height - 4.0 ft
  - Diameter - 0.33 ft
- Storage medium
  - Medium in thermal rods - Unknown
  - Specific heat - Unknown
- Location - Mounted on loft railing inside house
- Surface area - 137 ft^2
- Exterior finish - Black plastic

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

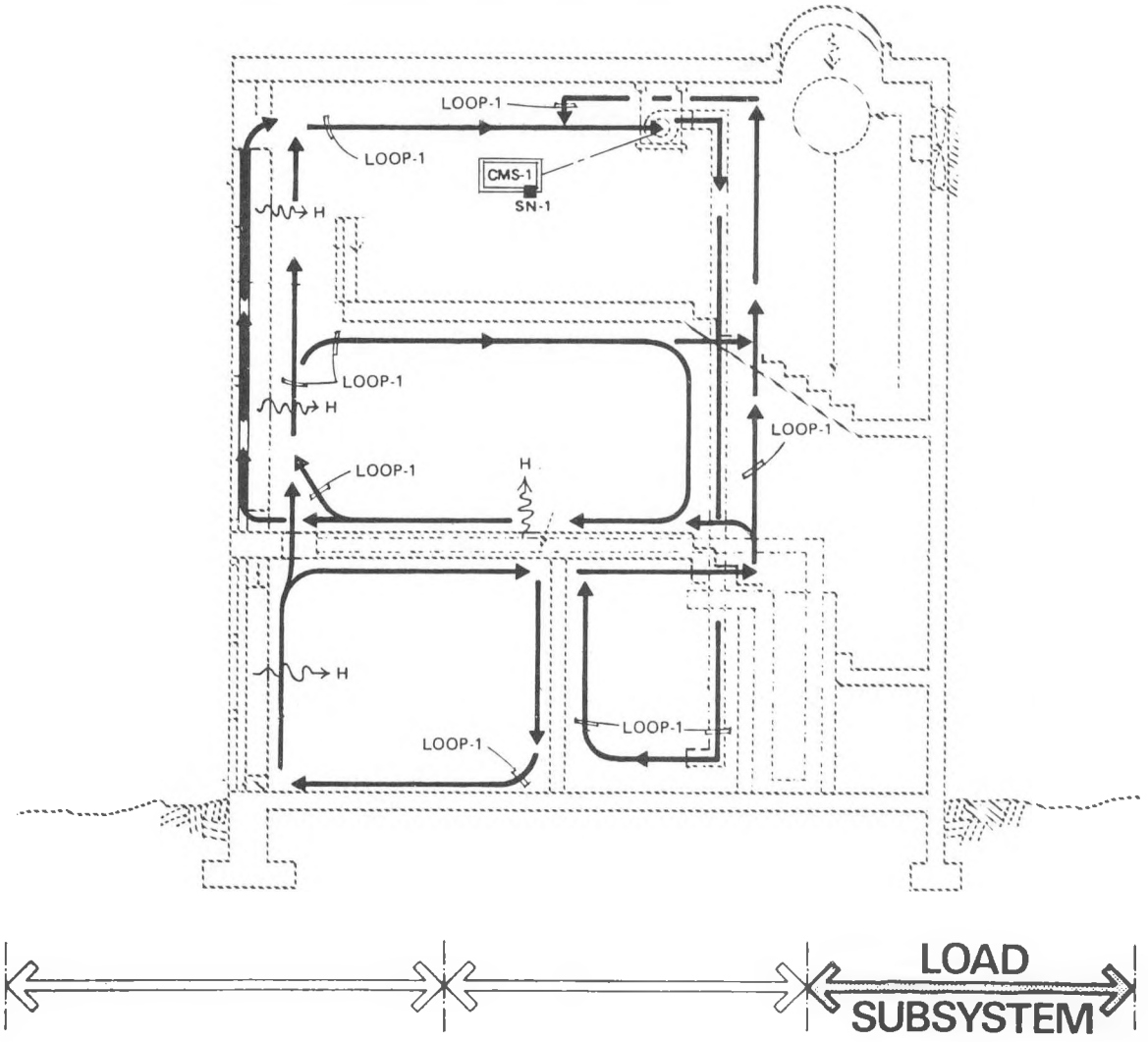


Figure IV-D-1. Energy-to-Load Subsystem, Winter Mode
(Without Use of Supplemental Heater SH-1)

Solar energy stored in the concrete floor and trombe walls radiates to adjacent areas and is then distributed to living spaces by natural convection. A small destagnation fan (Blower BL-1) automatically returns heated air from the loft area through a metal duct to the first floor stair area. The air then flows through the living spaces gaining heat from the thermal storage areas and eventually returns to the loft area by natural convection.

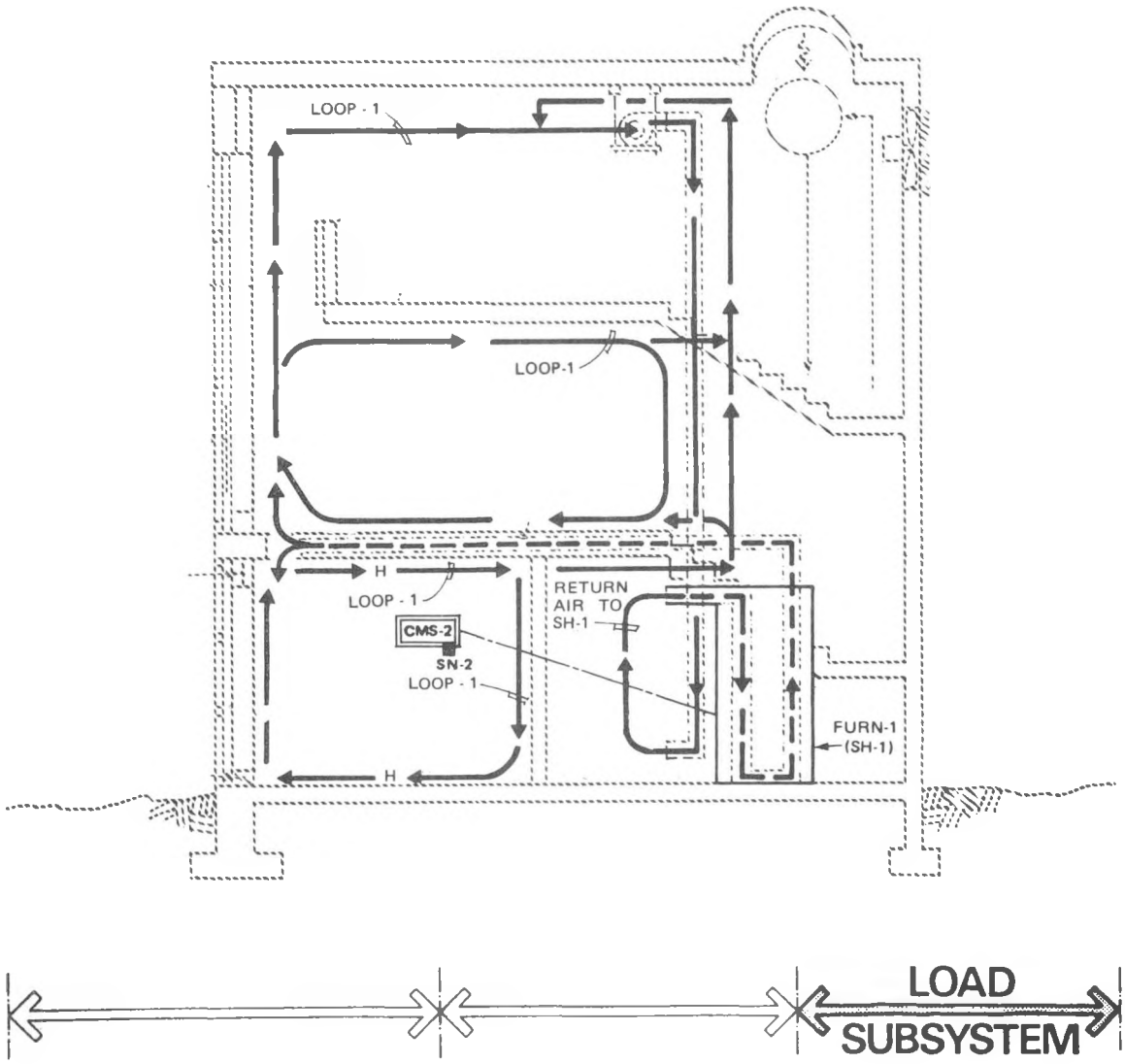


Figure IV-D-2. Energy-To-Load Subsystem-Winter Mode
(Utilizing Supplemental Heater SH-1)

Supplemental Heater (SH-1) may be used to reheat the air returned from the loft area and redistribute it to the living spaces if needed to supplement or replace solar heating.

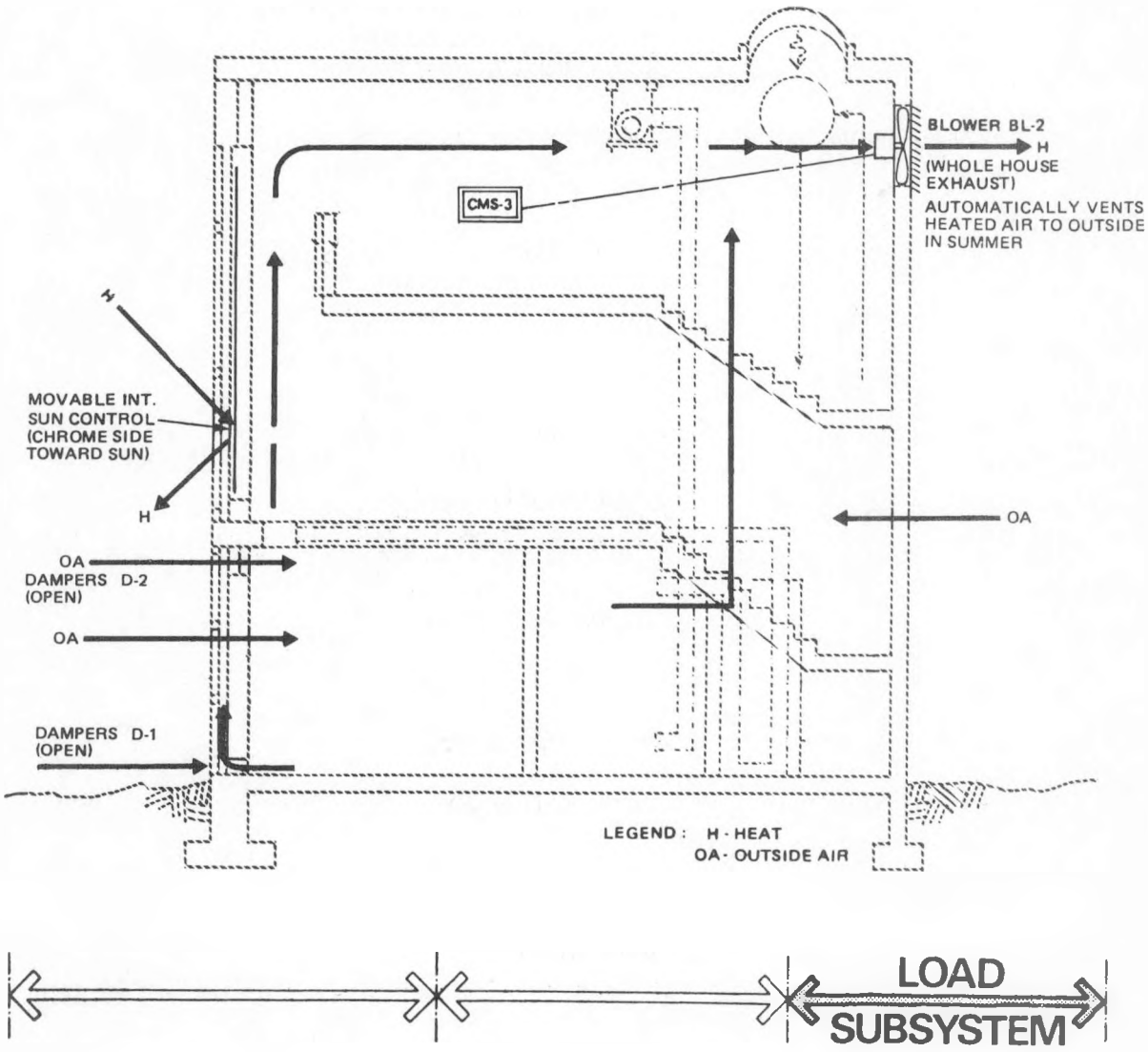


Figure IV-D-3. Energy-to-Load Subsystem, Summer Cooling Mode

Summer mode cooling is achieved by manually opening the house doors, windows and dampers D-2, and exhausting air from the home with Blower BL-2 located in the outside wall of the loft area. During the summer sun hours the chrome side of the movable slat venetian blinds would normally be exposed to the sun.

AIR CIRCULATION LOOP NO. 1

- Heating
  - Maximum design operating temperature - 120° F
  - Heating design air flow - 150 cfm
- Components within circulation loop
  - Collector(s) - COL-1, COL-2
  - Thermal Storage Unit(s) - TSU-1, TSU-2, TSU-3
  - Blower(s) - BL-1
  - Damper(s) - D-1, D-2
  - Furnace(s) - FURN-1 (SH-1)
- Blower BL-1 (destagnation fan in loft area)
  - Manufacturer - Dayton Electric Mfg. Co.
  - Model name/number - 4C446
  - Type - Squirrel cage
  - Drive - Direct (1/25 hp, 115V, 60Hz)
  - Motor speed - 3160 rpm @ free air
- Damper D-1
  - Manufacturer - Custom built
  - Function - Back draft
  - Operation - Automatic, non-motorized
  - Type - Single blade
  - Blade edges - No gasket or seal
- Damper D-2
  - Manufacturer - Custom built
  - Function - Flow switching
  - Operation - Manual
  - Type - Single blade

- Blade edge - No gasket or seal
- Blade/Frame contact - No gasket/seal

- Ducting
  - Type - Rigid steel, galvanized
  - Location - Inside building, above grade
  - Maximum operating temperature - 120° F
  - Insulation - None
  - Size - 6"
  - Exterior finish - Exposed metal

CONTROL MODE SELECTOR (CMS-1)

- Manufacturer - Honeywell
- Model name/number - Thermostat
- Modes controlled
  - Loft air to first floor
    - ON - (SN-1) > set point
    - Off - (SN-1) < set point
- Sensor (SN-1)
  - Type - Temperature, thermocouple

CONTROL MODE SELECTOR (CMS-2)

- Manufacturer - Johnson Controls
- Model name/number - Thermostat
- Modes controlled
  - Furnace heated air to living spaces
    - ON - (SN-2) < set point (80-85° F)*
    - Off - (SN-2) ≥ set point
      * Depends upon owner's desires
- Sensor (SN-2)

- Type - Temperature, thermocouple

CONTROL MODE SELECTOR (CMS-3)

- Manufacturer - Honeywell
- Model name/number - Thermostat

- Modes controlled
  - Living spaces cooling
    - On - (SN-3) > set point
    - Off - (SN-3) < set point
- Sensor (SN-3)
  - Type - Temperature, thermocouple

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

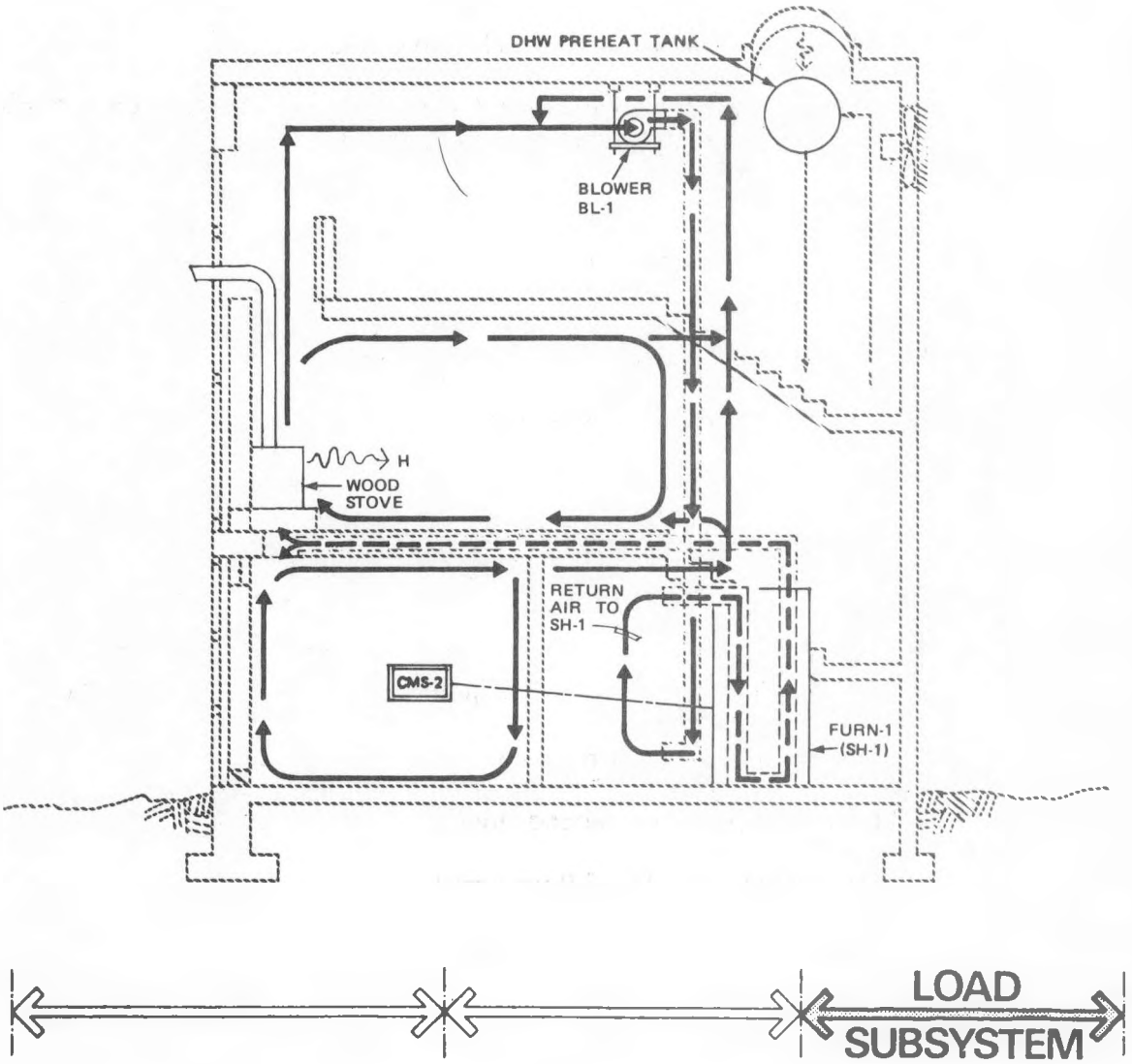


Figure IV-E-1. Auxiliary Subsystem

The auxiliary subsystems; wood burning stove; supplemental heater (SH-1), a dual fueled (wood and propane) forced air furnace, and a domestic hot water preheat tank noted in the foregoing Energy to Load Subsystem have been grouped in this section for descriptive purposes, their functions and purposes have been previously described.

AUXILIARY LOADS

- Supplemental Heater (SH-1)
  - Manufacturer - Yukon Industries
  - Product name/number - Model LWO 100
  - Type - Dual fuel two-stage furnace. Burns wood, when available, in first stage and propane in second stage
  - Capacity

    - Input - 125,000 Btuh
    - Output - 100,000 Btuh

  - Distribution - Forced (by furnace blower)
  - Blower motor size - 0.33 Hp
  - Drive - Belt driven
  - Blower speed - Multiple (2-speeds)

	Low speed	High speed
Capacity	800 cfm	1400 cfm

  - Motor operation - Unknown
- Wood burning stove (on second floor)
  - Manufacturer - RAIS (Denmark)
  - Location - Sits against trombe wall
- Domestic hot water tank
  - Manufacturer - Unknown
  - Fuel - Propane
  - Capacity - 50 gallons (This tank is supplied from a 66-gallon domestic hot water preheat tank which is directly radiated by a 42 ft^2 double glazed skylight in the building roof.)

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

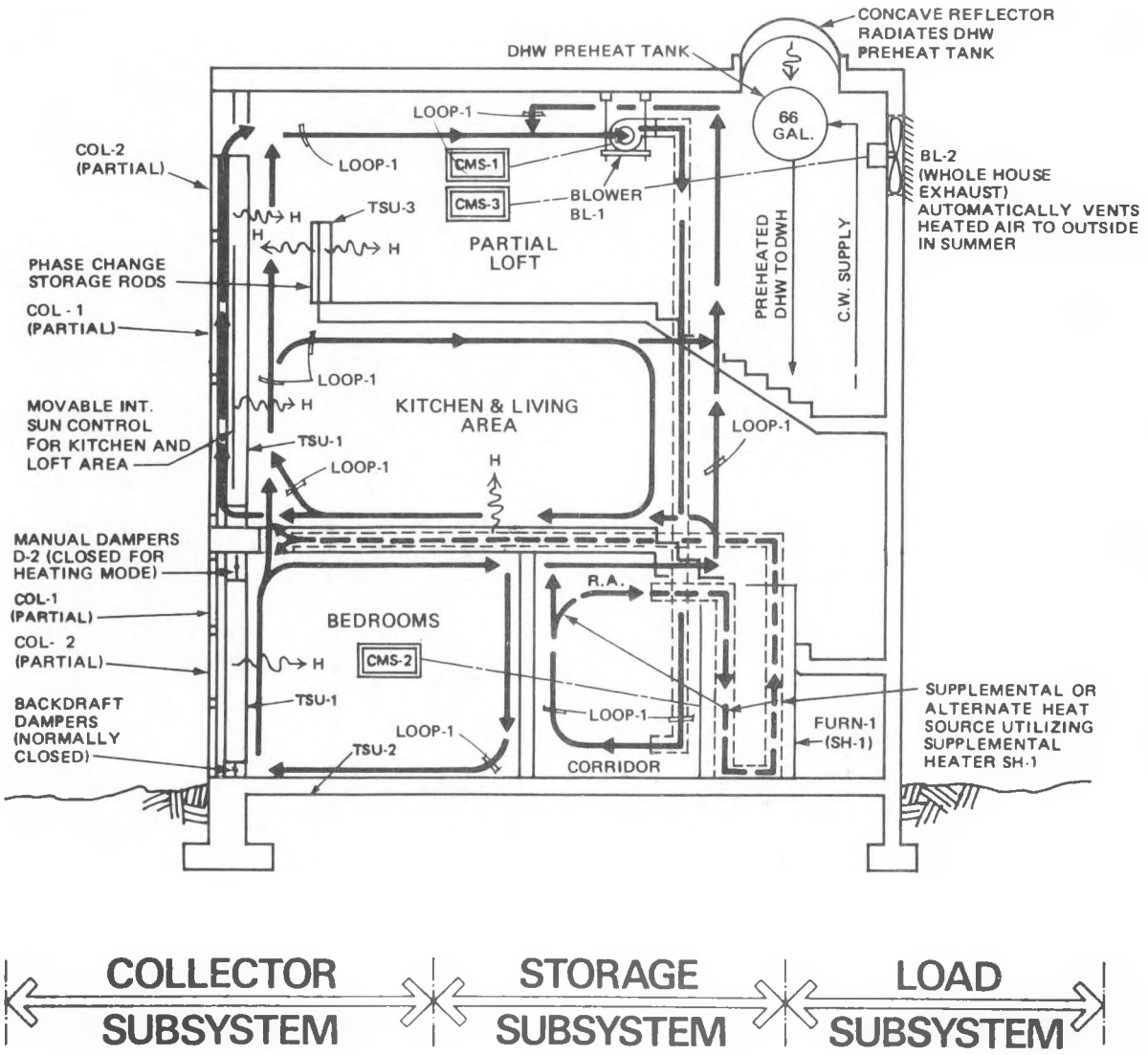


Figure IV-F-1. Controls Diagram

The Environmental Partnership solar system is shown on Figure IV-F-1. The system consists of the following four subsystems: a) collector; b) storage; c) load; and d) auxiliary load subsystems.

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

Mode 1 - Collector-to-Storage

This mode automatically activates during periods of adequate insolation. Incident solar thermal energy enters the home through approximately 554 square feet of vertical south facing windows. Solar heat radiates the mass trombe wall and floors storing heat.

Mode 2 - Storage-to-Space Heating

Solar heated air from storage in the mass trombe walls and the floors rises creating a flow of heat up through the house to the loft area. Solar thermal energy is also gained from phase change storage in the loft area. A destagnation blower (BL-1) automatically returns the air to the first floor stairs area when the temperature in the loft area reaches the control thermostat setting. Air returns to the loft by convection bringing heat to the living spaces.

Mode 3 - Auxiliary-to-Space Heating

During periods of inadequate solar insolation the Supplemental Heater (SH-1) provides heat to the living spaces.

Mode 4 - Energy-to-Load - Summer Cooling

Summer cooling is realized by manually opening doors, windows and dampers D-2, and exhausting heat from the house with Blower (BL-2) located in the outside wall of the loft area. During hours of summer sun the chrome side of the movable slat venetian blinds should be exposed to the sun.

Mode 5 - Domestic Hot Water

A domestic hot water preheat tank (66 gal) is directly radiated by a 42 ft^2 double glazed skylight located in the roof of the home. A 50-gallon propane fueled domestic hot water heater heats the water to demand temperature. Upon demand for hot water in the home, water from the preheat tank flows into the DHW tank.

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.

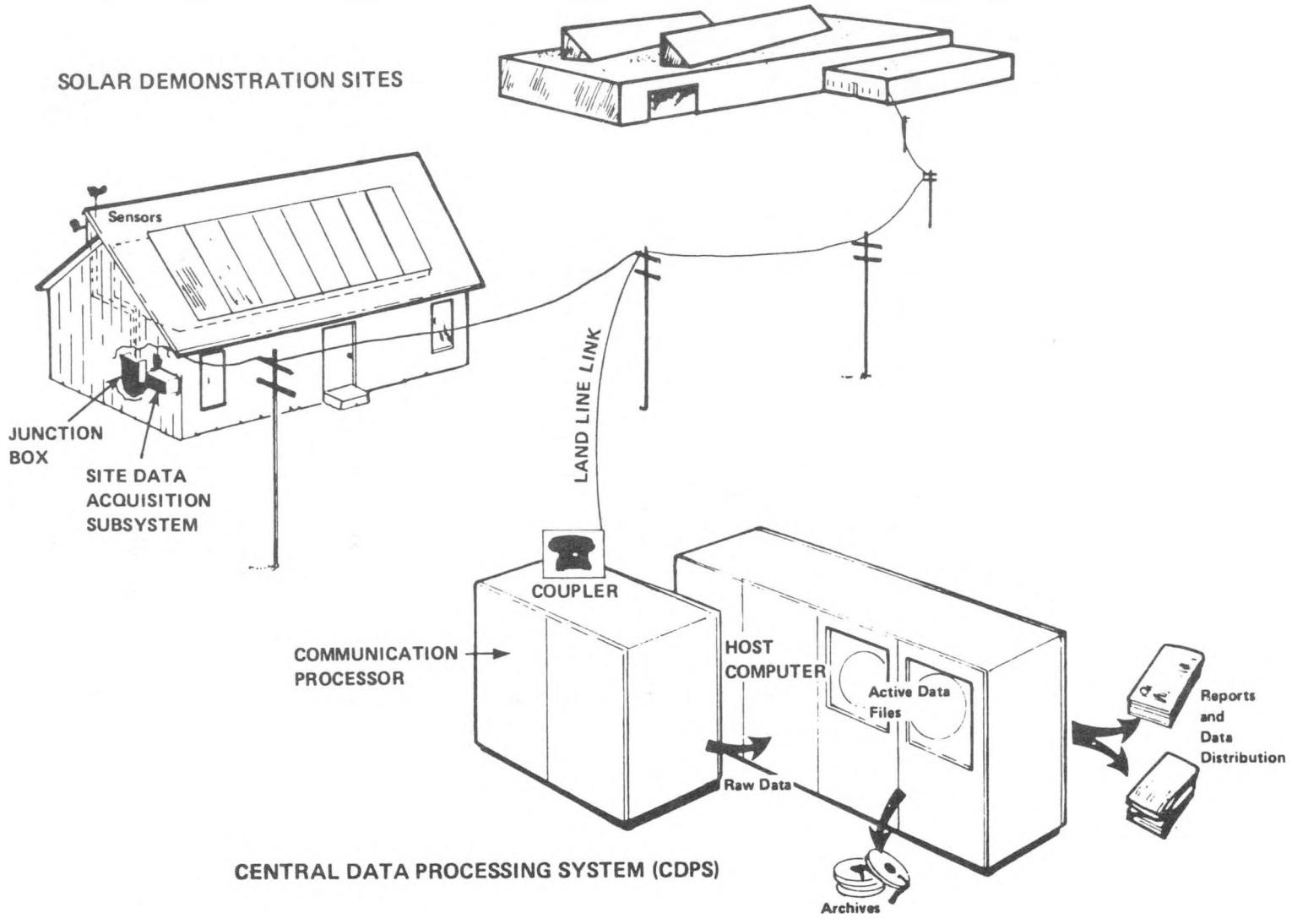


Figure V-A-1. The National Solar Data Network

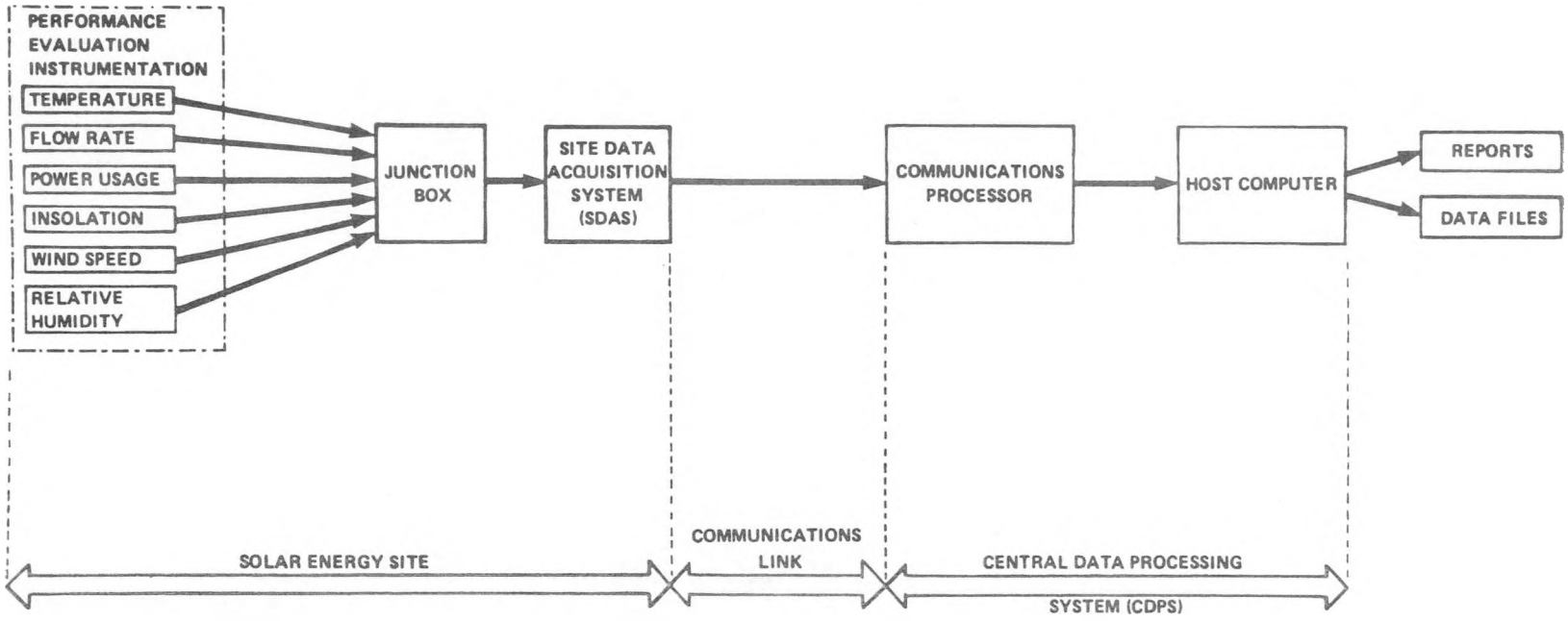


Figure V-A-2. Data Flow Path for the National Solar Data Network

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 architectural 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.
I001	Total insolation, Trombe Wall	PSP
I002	Total insolation, Roof	PSP
T001	Temperature, Outside ambient	S53P60
WD001	Wind direction	W102-P-DC-360
WV001	Wind velocity	W102-P-DC-360
T100	Air temperature, Top of Trombe Wall-Living Room	S57P60
T101	Air temperature, Bottom Trombe Wall-Living Room	S57P60
T200	Temperature, South Side of Wall-Bedroom 1	S53P28
T201	Temperature, North Side of Wall-Bedroom 1	S53P28
T202	Temperature, South Side of Wall-Bedroom 2	S53P28
T203	Temperature, North Side of Wall-Bedroom 2	S53P28
T204	Temperature of South Side of Wall-West Living Room	S53P28
T205	Temperature of North Side of Wall-West Living Room	S53P28
T206	Temperature of South Side of Wall-East Living Room	S53P28
T207	Temperature of North Side of Wall-East Living Room	S53P28
T212	3rd Floor Heat Storage Rod, Bottom/Front	S32B
T213	3rd Floor Heat Storage Rod, Bottom/Rear	S32B
T214	3rd Floor Heat Storage Rod, Top/Rear	S32B
T215	3rd Floor Heat Storage Rod, Top/Front	S32B
W300	Flow, Cold Water Supply to DHW Preheat Tank	Hersey 430
T300	Temperature, Cold Water Supply	S57P60
T301	DHW Preheat Outlet Temperature	S57P100
T302	DHW Preheat Tank Outer Surface Temperature	S32B
T303	Temperature, Water Inlet to DHWH Tank	S57P60
T304	Temperature, Water Outlet from DHWH	S57P100
T305	Temperature, Outer Surface DHWH Tank	S32B
F300	Flow, Propane to DHWH	AC-175
EP400	Electrical Power Consumption, Furnace Blower	PC5-10F
F400	Flow, Propane to Furnace	AC-175

SENSOR	DESCRIPTION OF MEASUREMENT	MODEL NO.
W400	Return Air to Furnace	Kurz 430DC
T402	Temperature, Return Air to Furnace	S57P100
T403	Ambient Temperature, Work Room	S53P28
T404	Ambient Temperature, Bedroom 1	S53P28
T405	Ambient Temperature, Bedroom 2	S53P28
T406	Ambient Temperature, Living room (West end, North wall)	S53P28
T407	Ambient Temperature, Living Room (East end, North wall)	S53P28
T408	Ambient Temperature, Kitchen	S53P28
T409	Ambient Temperature, Foyer	S53P28
T410	Ambient Temperature, Loft	S53P28
T411	Ambient Temperature, SDAS Room	S53P28
T412	Ambient Temperature, Loft (DHW Preheat Room)	S53P28
T413	Ambient Temperature, 1st Floor Bathroom	S53P28
T414	Ambient Temperature, 2nd Floor Bathroom	S53P28
T415	Temperature, Living Room Wood Burning Stove	S57P60
T416	Temperature, Bedroom 1 Floor Slab	S57P60
T417	Temperature, Under Floor Slab Bedroom 1	S57P60
T419	Temperature, Furnace Air to House	S57P100
RH400	Humidity of House	HM14U
T420	Temperature, Inside Surface of North Wall	S57P60
T421	Temperature, Outside Surface of North Wall	S57P60
T422	Temperature, Inside Surface of East Wall	S57P60
T423	Temperature, Outside Surface of East Wall	S57P60
T424	Temperature, Inside Surface of West Wall	S57P60
T425	Temperature, Outside Surface of West Wall	S57P60
T426	Temperature, Inside Surface, Living Room Ceiling	S57P60
T427	Temperature, Outside Surface, Living Room Ceiling	S57P60
T428	Temperature, Destagnation Duct Inlet	S57P60
T429	Temperature, Destagnation Duct Outlet	S57P60
F401	Flow, Propane to Clothes Dryer	AC175
D409	Night Curtain Position Indicator, Solarium	Archer 275-495

SENSOR	DESCRIPTION OF MEASUREMENT	MODEL NO.
EP402	Power Consumption, Destagnation Fan	PC5-103F
EP500	Power Consumption, Summer Cooling Fan	PC5-10F
EP600	Total House, Power Consumption	PC5-70F
T430	Ambient Temperature, Furnace Room	S57P60
RH001	Relative Humidity, Outdoors	HM-14u IS2
I003	Insolation, Trombe Wall	EPPLEY PSP

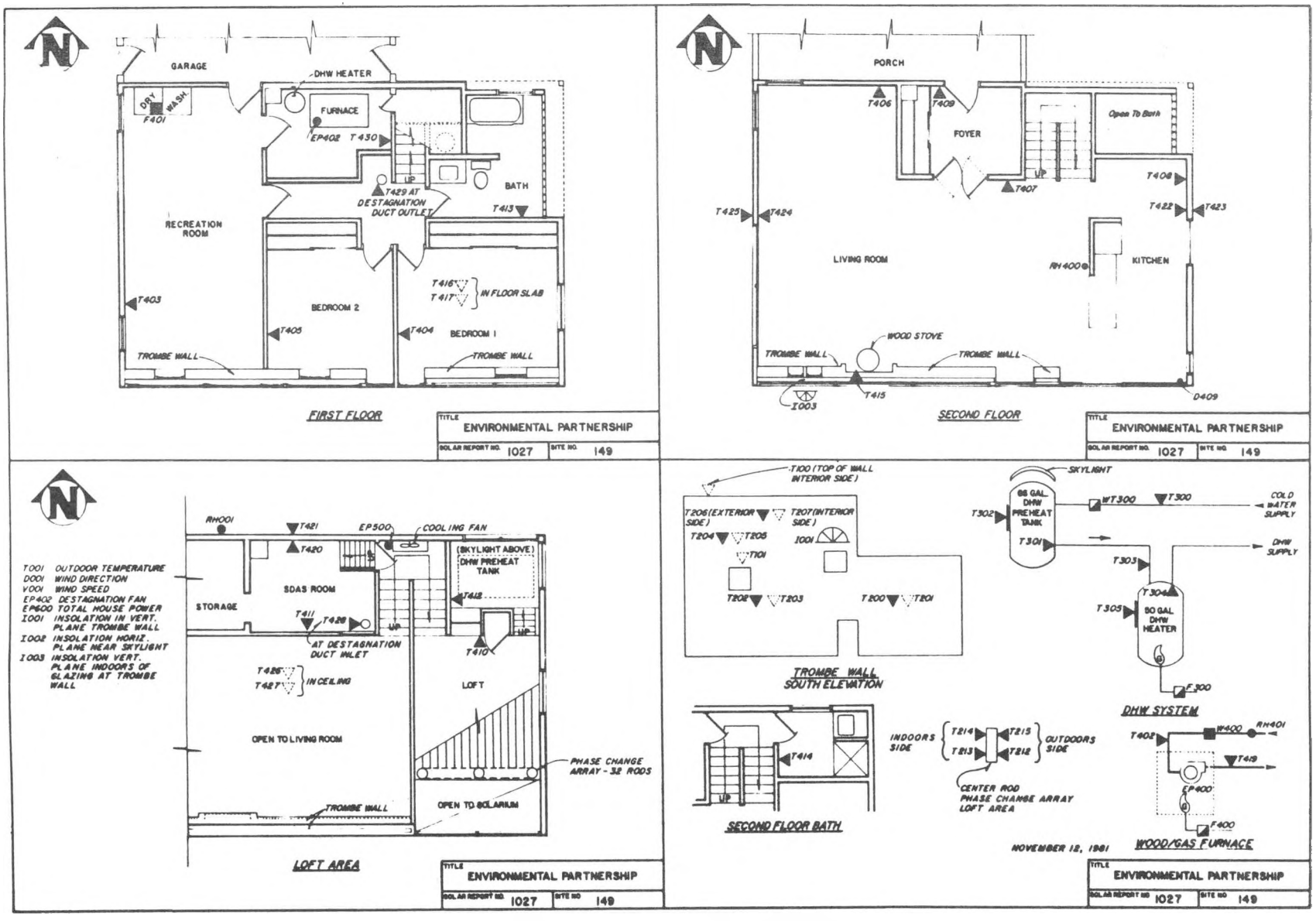


Figure V-B-1. Sensor and Control Diagram

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. Grant Funds

Solar Subsystem

Collectors	
Energy Storage	
Distribution and Controls	
Installation	
Other - Solar System Design	$5,000
Instrumentation Design	$ 800
Instrumentation Installation	$5,895
Total - Grant Funds	$11,695

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.

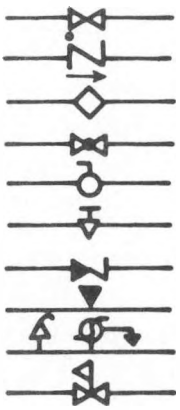
TRACKING COLLECTOR - A set of solar energy tracking collectors that automatically move in order to constantly aim towards the sun.

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.

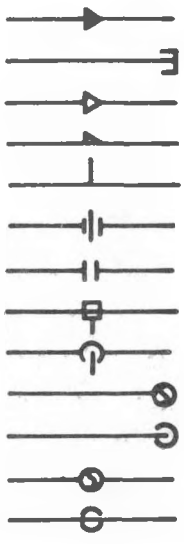
B. Legend For Solar System Schematics

VALVES



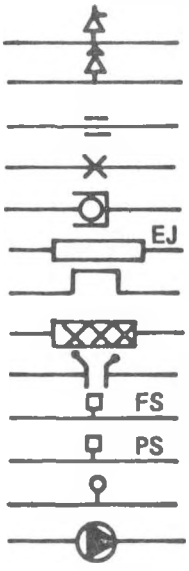
GATE VALVE
CHECK VALVE
BALANCING VALVE
GLOBE VALVE
BALL VALVE
PLUG VALVE
BACKFLOW PREVENTER
VACUUM BREAKER
RELIEF OR SAFETY
PRESSURE REDUCING
ANGLE GATE VALVE
ANGLE GLOBE VALVE
CONTROL VALVE, 2 WAY
CONTROL VALVE, 3 WAY
BUTTERFLY VALVE
4 WAY VALVE

FITTINGS



DIRECTION OF FLOW
CAP
REDUCER, CONCENTRIC
REDUCER, ECCENTRIC
TEE
UNION
FLANGED CONNECTION
CONNECTION, BOTTOM
CONNECTION, TOP
ELBOW, TURNED UP
ELBOW, TURNED DOWN
TEE, OUTLET UP
TEE, OUTLET DOWN

PIPING SPECIALITIES



AUTOMATIC AIR VENT
MANUAL AIR VENT
ALIGNMENT GUIDE
ANCHOR
BALL JOINT
EXPANSION JOINT
EXPANSION LOOP
FLEXIBLE CONNECTION
FLOWMETER FITTING
FLOW SWITCH
PRESSURE SWITCH
PRESSURE GAUGE
PUMP
PIPE SLOPE/FOOT (NOTED)
STRAINER
STRAINER, W/BLOW OFF
TRAP
CONTROL SENSOR
INSTRUMENTATION SENSOR
THERMOMETER
THERMOMETER WELL ONLY

COLD WATER SUPPLY
BLOWER
AS — AIR SEPARATOR
EXP TK — EXPANSION TANK
WS — WATER SOFTENER
HED — HOSE END DRAIN
HEAT EXCHANGER
STOVE (FRANKLIN TYPE)

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