113
12/31/79

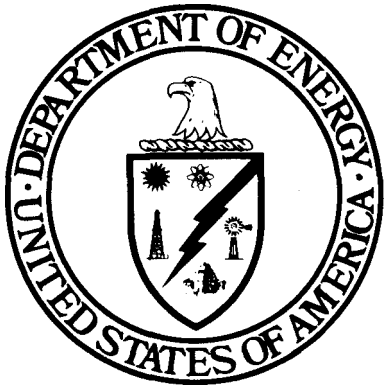
MASTER

Lh. 6015

SOLAR/1011-79/50

Solar Project Description

ALBUQUERQUE WESTERN-I MULTI-DWELLING BUILDING Albuquerque, New Mexico September 28, 1979



U.S. Department of Energy

National Solar Heating and Cooling Demonstration Program

National Solar Data Program

NOTICE

Solar/1011-79/50
Distribution Category UC-59

SOLAR PROJECT DESCRIPTION
FOR
ALBUQUERQUE WESTERN - I
MULTI-DWELLING BUILDING - ALBUQUERQUE, NEW MEXICO

Department of Housing and Urban Development

Under Contract Number

H-2372

David Moore
Solar Heating and Cooling Demonstration Program Manager

By

The Boeing Company
David Beers, Program Manager

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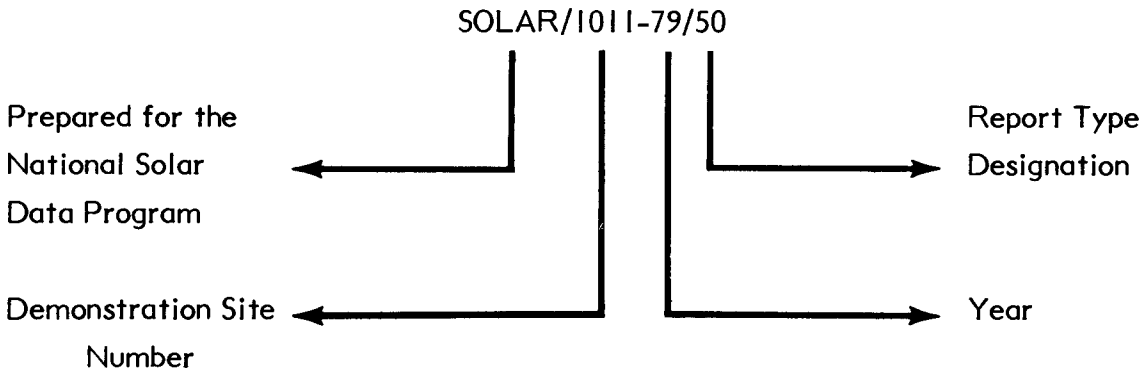
LIST OF FIGURES

NATIONAL SOLAR DATA PROGRAM REPORTS

Reports prepared for the National Solar Data Program are numbered under a specific format. For example, this report is for the Albuquerque Western - I Mulit-dwelling project site is designated as SOLAR/1011-79/50. 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 concentrating, reflector on tracking mounts
- o Freeze Protection - Drain down
- o Application - Domestic hot water
- o Storage - Water, 2000 gallon tank
- o New or Retrofit - New
- o Performance Evaluation Instrumentation - Yes
- o Site-Specific Features - Gas fired boiler auxiliary heating

The Albuquerque Western - I solar energy system (Grant H-2767) is installed in a 110 unit apartment building located in Albuquerque, New Mexico. The system is designed to provide solar energy for domestic hot water heating.

The DHW solar energy collection and storage system utilizes, 1782 square feet (gross), of south facing, tracking collectors mounted at a tilt angle of 35^{o} to horizontal.

Solar energy for heating domestic hot water is provided by circulating water from a 2000 gallon storage tank through a heat exchanger located between TSU-2 and DHW-1. Auxiliary energy for domestic hot water is provided by natural gas whenever the temperature of the domestic hot water tank falls below 140^{o} F.

The dwelling has been fully instrumented for performance evaluation since May 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. SITE AND BUILDING DESCRIPTION

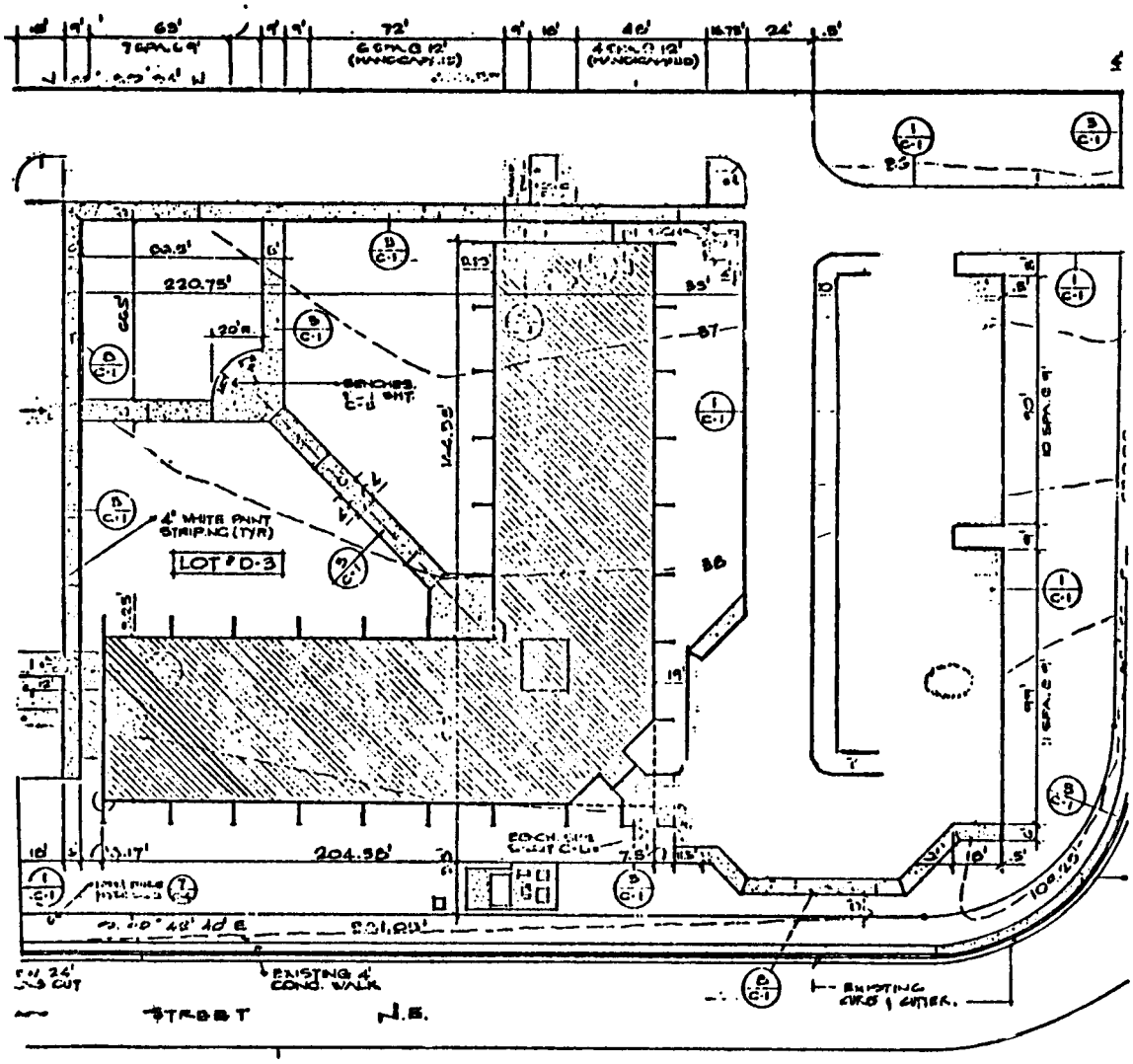


Figure III-1. Site Plan

Site Description (See Figure III-1)

- Topography - Flat
- Latitude - 35^{o}
- Longitude - 106^{o}
- Elevation - 5339 feet
- Annual degree days
  - Heating - 4292
  - Data location - Albuquerque, New Mexico
  - Data reference - Local Climatological Data Annual Summaries, Department of Commerce, National Oceanographic and Atmospheric Administration
- Average horizontal insolation (clear day)
  - January - 1853 Btu/Ft^2 day
  - July - 2250 Btu/ft^2 day
  - Data location - Albuquerque, New Mexico
  - Data reference - ASHRAE System Handbook

Building Description

- Occupancy
  - Multi-family - 101 apartments
- Total area - Approximately 85,600 square feet
- Height - 4 story
- Roof slope at collector - 35^{o}
- Special features - Tracking panels

Mechanical System

- Heating
  - Solar - Liquid
  - Auxiliary - Gas-fired hot water boiler
  - Distribution - Parallel

Domestic Hot Water

- Daily water demand - 21 Gal per person/day x (113 persons)
- Thermal load - 1.58×10^6 Btu/day
- Solar - Liquid, active
- Auxiliary - Natural gas
    - Maximum recovery rate - 1400 Gal per hour

System and component summary

- Number of collector types - 1
- Number of circulation loops - 3
- Thermal storage unit(s) - 1
- Operational modes - 3
- Pumps - 3
- Valves - 2
- Sensors other than tracking control - 4
- Fail safe controls - 1

IV. SOLAR SYSTEM DESCRIPTION

A. General Overview (see figure IV-A-1)

The Albuquerque Western site (HUD Grant H-2767) is a four story, 101 unit apartment building for the elderly and the handicapped located in Albuquerque, New Mexico. Only the DHW system (System 1) is described and reported by this document.

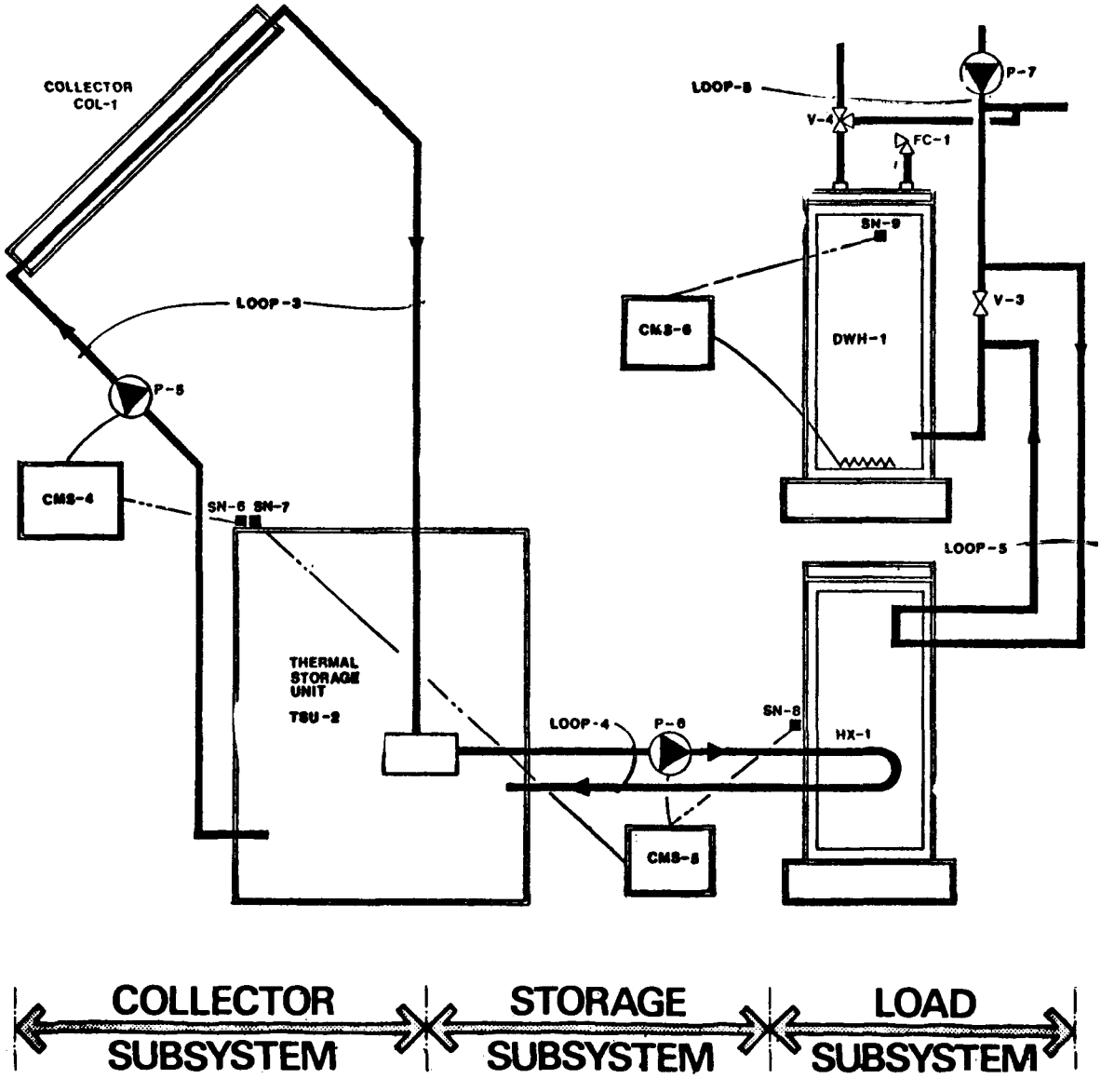


Figure IV-A-1. General Overview

The DHW solar energy collection and storage system utilizes 1782 square feet (gross) of south facing, tracking collectors mounted at a tilt angle of 35^{o} to the horizontal. Water is the energy transport medium between the collectors and storage. Energy obtained by the collectors is stored in a 2,000 gallon, water filled storage tank. When storage reaches a previously determined control temperature setting, energy is transferred from storage to the hot water subsystem via a liquid-to-liquid heat exchanger. The hot water is continuously circulated throughout the building. Auxiliary heating, as required to maintain constant DHW temperature, is accomplished by a inline, natural gas-fired boiler.

B. Collector Subsystem (See Figure IV-B-1)

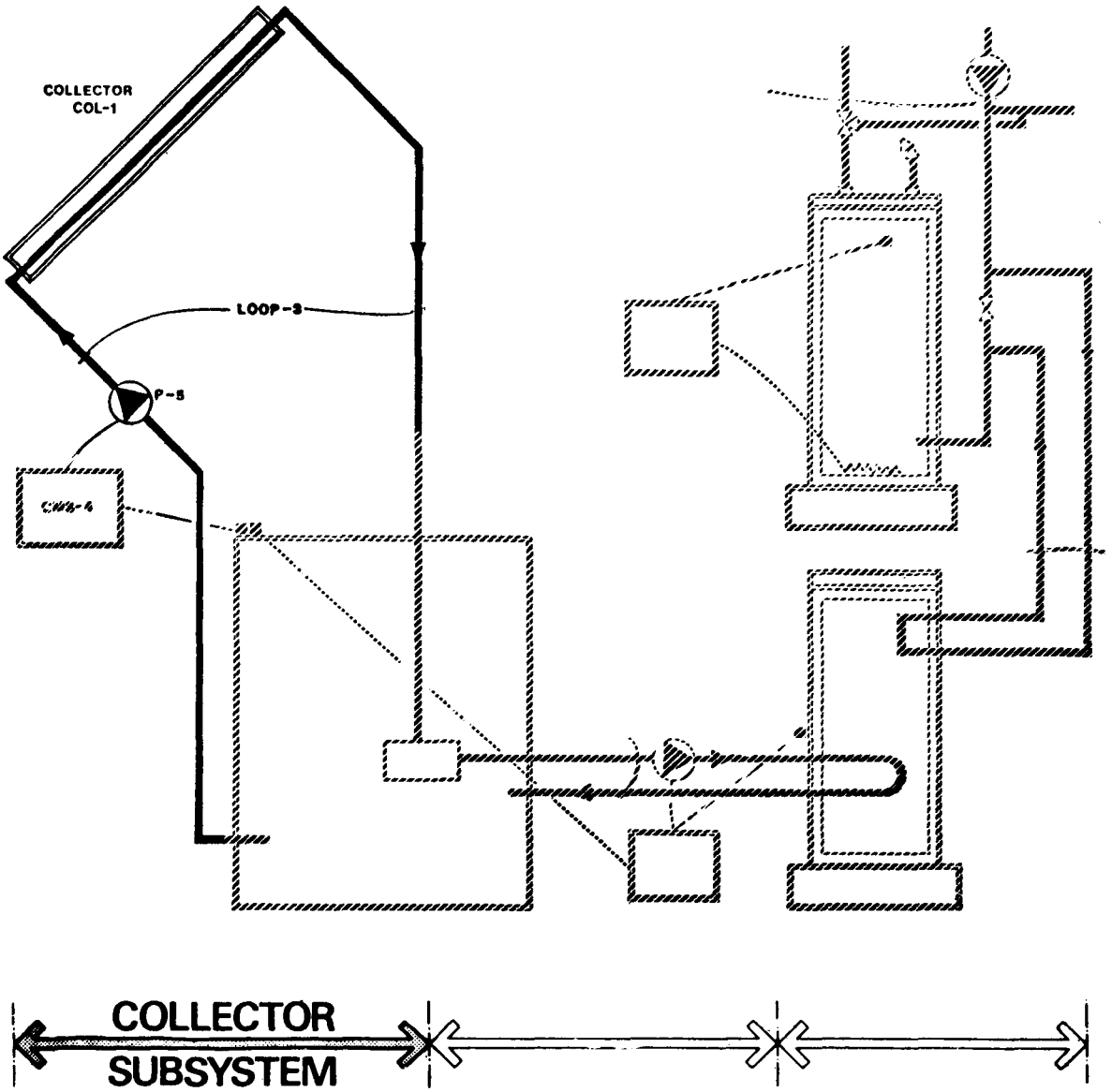


Figure IV-B-1. Collector Subsystem

Collector array system consists of 507 liquid concentrating, reflector on tracking mount with fixed absorber, panels. The DHW system employs 110 panels. A drain system is used for freeze protection.

Collector (COL-1) (See Figure IV-B-2)

- Manufacturer - Albuquerque W Solar Industries
- Model name/number - Solcan
- Type - Liquid concentrating, reflector on tracking mount with fixed absorber
- Location - Roof
- Orientation - South
- Tilt angle - 35^{o} from horizontal
- Number of collector panels - 110
- Collector
  - Total gross area of array - 1782 ft^2
  - Net aperture area - 1496 ft^2
  - Weight per panel, empty - 65 lbs
  - Weight per panel, full - 66 lbs
  - Panel length - 106.0 inches
  - Panel width - 22.0 inches
  - Standoff height - 12 inches
- Glazing (cover plate)
  - Number of cover plates - One
- Cover plate No. 1 -
  - Manufacturer - Albuquerque W Solar Industries
  - Location - Outer layer of multiple layers or single cover
  - Material - Tedlar film
  - Thickness - 0.04 inch
  - Edge or surface treatment - None
  - Coating - Tedlar film

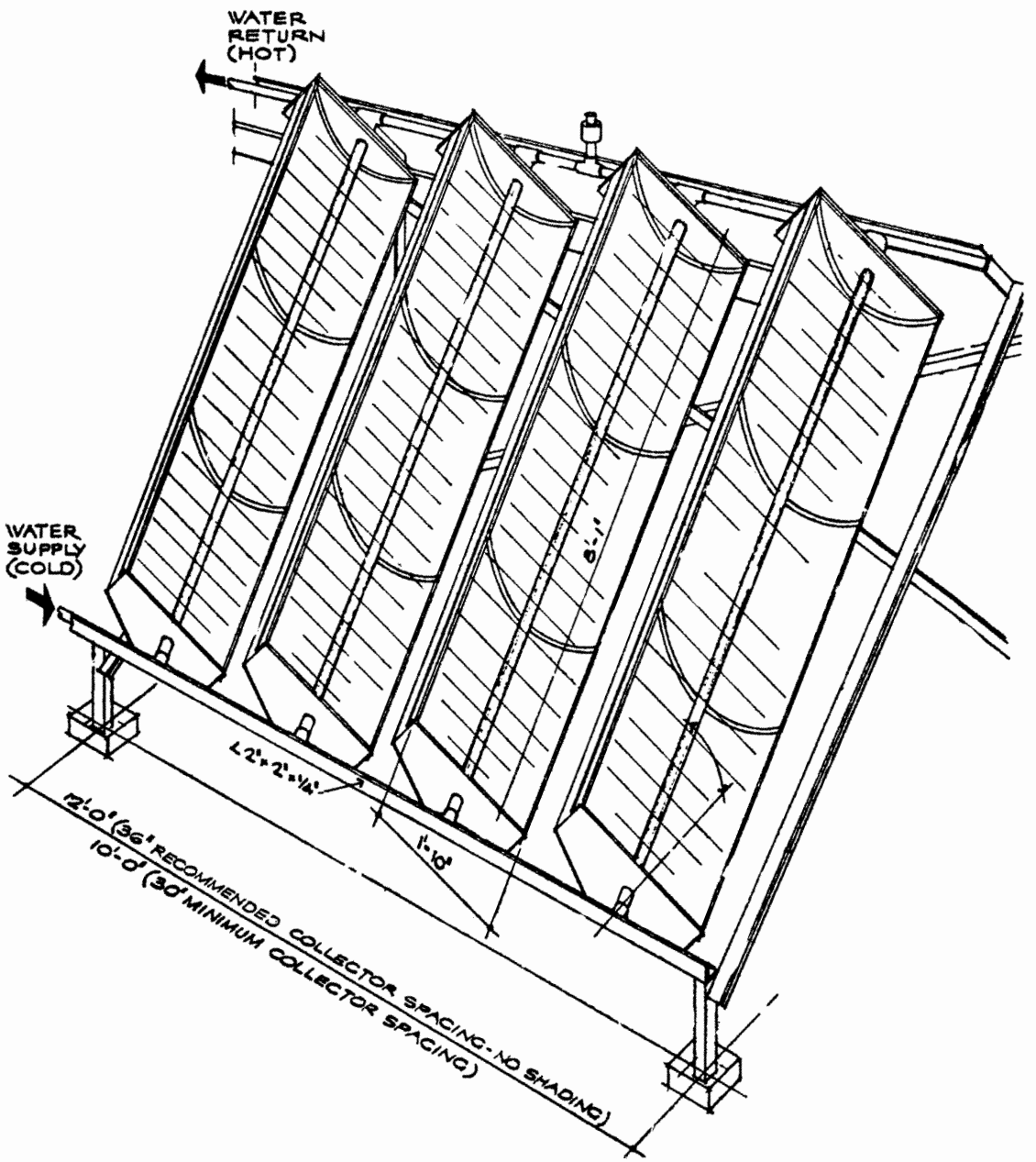


Figure IV-B-2. Solar Collector

- Optical properties (solar region) (infrared region)
  - Transmittance 91%
  - Reflectance 9%
- Absorber
  - Manufacturer - Albuquerque W Solar Industries
  - Material - Copper, Type M
  - Substrate material dimension
    - Thickness - 0.04 inch
    - Length - 106. inches
    - Width - 2.2 inches
- Coating
  - Material - Weldom Solar Black
  - Application method - Painted
  - Absorptance - 93% Solar Region
  - Emittance - 93%
- Heat transfer fluid passages
  - Location - In absorber
  - Pattern - Parallel
  - Materials - Copper, Type M
  - Wall thickness - 0.042 inch
  - Outside diameter - 2.2 inches
  - Fluid passage bond to substrate - NA
  - Protective coating inside fluid passage - None
- Insulation
- Frame
  - Manufacturer - Albuquerque W Solar Industries
  - Product Name/Number - Solcan

- Material - Steel, 26 galvanized
- Protective coating - Galvanized
- Number of structure attach points per module to building - Two
- Desiccant - None

- Reflector
  - Number of reflectors - One
  - Substrate Material - Mylar
  - Reflective coating - Aluminum, vacuum deposited
  - Physical Dimensions
    - Length - 101.0 inches
    - Width - 22.0 inches
    - Concentration factor - 10.0
  - Freeze protection - Drain - down (air bleed)
  - Overheating protection - Concentrator off-tracking device

- Collector performance
  - Method of evaluation - ASHARE
  - y intercept - $F_r(ta)_n$
  - Slope - $F_R U_L$
  - Point Number 1 2 3 4
  - n = Collector thermal efficiency (%) - Not Available
  - t_i = collector inlet temperature (^oF) - Not Available
  - t_a = ambient air temperature (^oF) - Not Available
  - I_t = insolation intensity Btu/hr ft^2 - Not Available
  - ASHRAE $(t_i-t_a)/I_t$ - Not Available
  - Fluid specific heat -
  - Test fluid medium - Water

Liquid Circulation Loop No. 3 (COL-1 to TSU-2)

- Maximum design operating temperature - 180o F
- Heating design liquid flow - 65 gpm
- Heat transfer medium - Water, 100%
  - Specific heat - 1.00 Btu/lb/^{o} F
  - Density - 63 lb/ft^{3}
  - Boiling point - 212^{o} F
  - Freezing point - 32^{o} F
  - Maximum recommended use temperature - 180^{o} F
  - Toxicity - Potable
  - Chemical feeder to maintain pH factor - No
  - Inhibitor - No
- Circulator pump (P-5)
  - Manufacturer - Armstrong
  - Model Name/Number - 1 3/4 Base mounted
  - Type - Centrifugal
  - Maximum operating conditions
    - Temperature - 200^{o} F
  - Material exposed to heat transfer fluid - Bronze
  - Maximum motor speed - 1750 rpm
  - Drive - Direct
  - Speed - Single
  - Pump speed - 1750 rpm
  - Circulating volume - Low head mode - 75 gpm @ 100 ft head
  - Operating head (dynamic) - Low head mode - 75 gpm

- Piping
  - Rigid - Copper
  - Location - Above grade
  - Filters - No

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

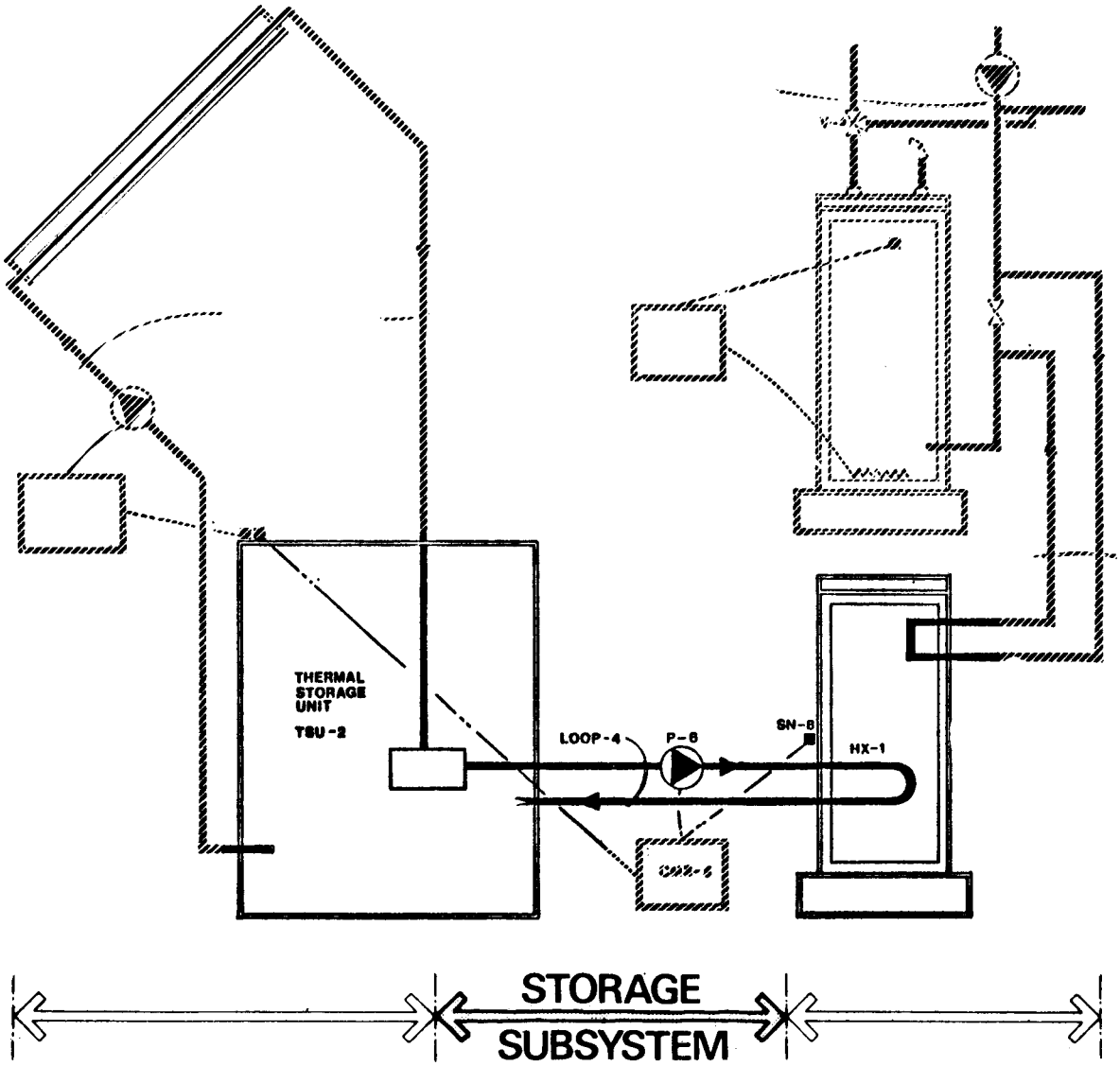


Figure IV-C-1. Storage Subsystem

Solar energy storage is provided by a 2000 gallon underground storage tank. This tank is made of wood with a Hypalon Barrier. It measures 6.6 feet in height, 5.5 feet in width, 11 feet in length. The collector pump (P-5) circulates water through storage. Two pipes installed within the storage tank are designed to supply and return liquid in the tank. A discharge pump (P-6) circulates water from storage through the heat exchanger and back to the storage tank. The heat exchanger is a separate entity and has dual purpose. One for keeping water hot is TSU-2 and to furnish hot water to DHW-1.

Thermal Storage Unit (TSU-2)

- Container - Wood with Hyopalon Barrier
  - Total storage volume - 399 cu ft
    - Length - 11 feet
    - Width - 5.5 ft
    - Height - 6.6 ft
- Storage medium
  - Heating design temperature - 165° F
  - Medium - Water, 100%
  - Specific heat - 1.000 Btu/lb/°F
  - Density - 63 lb/ft^3
  - Boiling point - 212° F
  - Freezing point - 32° F
  - Recommended medium temperature - 165° F
  - Toxicity - Potable
  - pH Factor - 7
  - Inhibitor - No
- Container construction
  - Type - Wood with Hypolan Barrier
  - Location - Mech room
  - Auxiliary heaters - None
  - Insulation - Fiber glass
    - Thermal resistance - R-20
  - Exterior finish - Wood
  - Interior lining - Hypalan
  - Filters - None

Liquid Circulation Loop No. 4 (TSU-2 to Heat Exchanger HX-1)

- Design operating temperature - 185° F
- Design liquid flow - 60 gpm
- Heat transfer medium
  - Medium - 100% Water
  - Specific heat - 1.00 Btu/lb/°F
  - Density - 63 lb/ft^3
  - Boiling point - 212° F
  - Freezing point - 32° F
  - Maximum recommended use temperature - 165° F
  - Toxicity - Potable
  - pH factor - 7
  - Chemical feeder - No
  - Inhibitor - No
  - Piping
    - Rigid - Copper
    - Insulation - Mineral fiber
    - Thermal Resistance - R-4.5
    - Exterior finish - Cement cloth coated fabric
    - Finish and insulation joint type - Tape and mastic
    - Interior coating - None
    - Location - Above grade
- Circulator pump (P-6), TSU-2-to-HX-1
  - Manufacturer - Armstrong
  - Model Name/Number - 1 1/2D4280 Series
  - Type -Centrifugal

- Maximum operating conditions
  - Temperature - 195° F
- Material exposed to heat transfer fluid - Bronze
- Motor size - 0.75 hp
- Maximum motor speed - 1750 rpm
- Drive - Direct
- Speed - Single
- Pump speed - 1750 rpm
- Circulating volume - Low head mode - 60 gpm 20 ft head
- Motor operation - 0.75b hp

- Heat Exchanger (HX-1)
  - Manufacturer - Sims
  - Model name/number - SE-1064
  - Type of flow - Counter
  - Heat exchanger design - Shell & tube
    - Number of passes - 4 each
  - External exposed surface - 78.5 ft
  - Maximum manufacturer's rated
    - Temperature - 200° F
    - Pressure - 300 psi
  - Material - Copper
  - Related pump - P-6

D. Energy To Load Subsystem (See Figure IV-D-1)

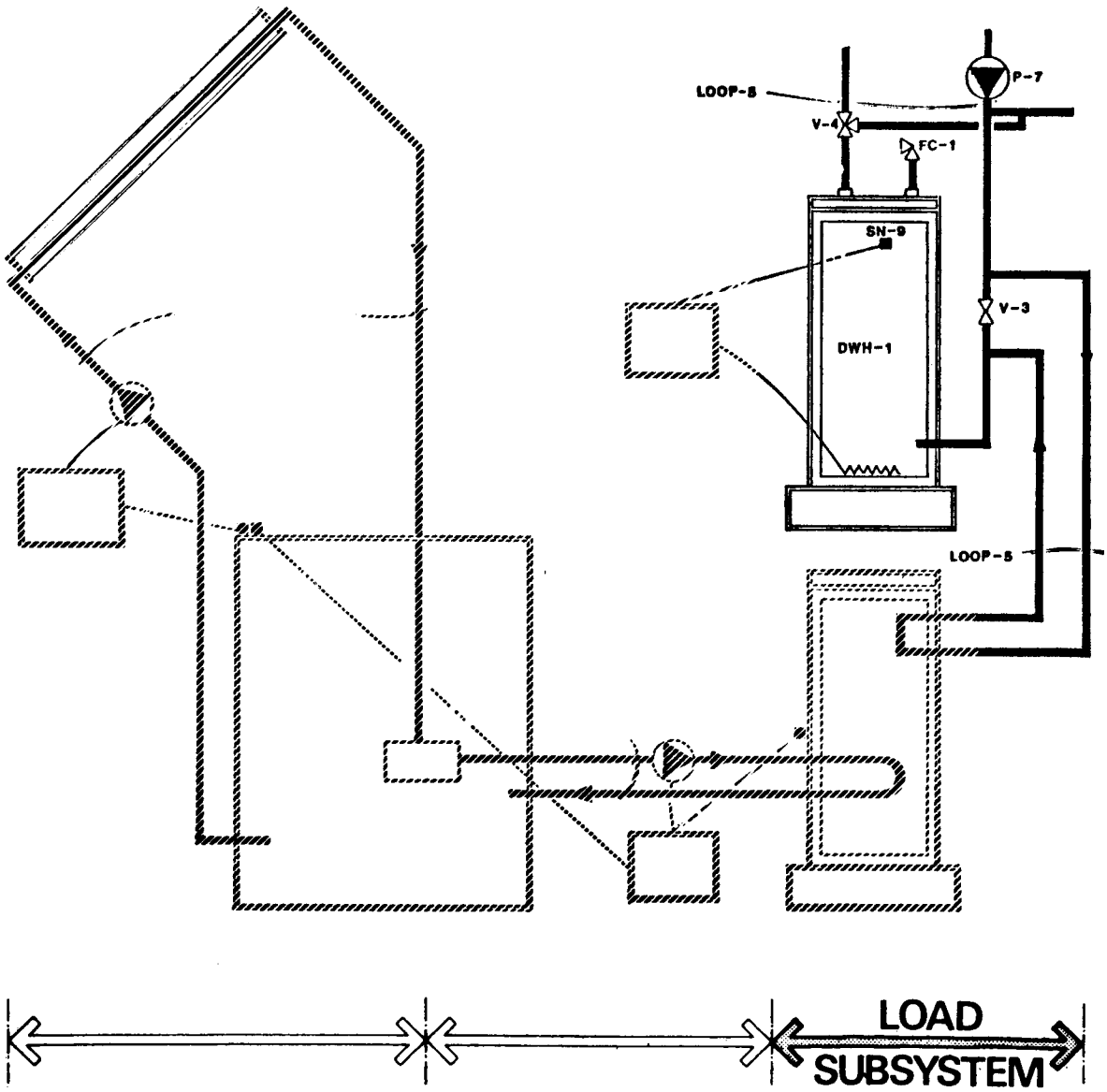


Figure IV-D-1. Energy-to-Load Subsystem

Solar energy stored in the 2000 gallon storage tank is used to meet demands of domestic hot water. The solar preheated water is pumped from TSU-2 through the heat exchanger to DWH-1. Whenever solar heated water drops below preset temperature, the automatic gas-fired DWH will heat water to required temperature.

Liquid Circulation Loop No. 5 (CWS to Hot Water Demand)

- Design liquid flow - 60 gpm
- Heat transfer medium
  - Medium - 100% water
  - Specific heat - 1.00 Btu/lb/^{o}F
  - Density - 63 lb/ft^{3}
  - Boiling point - 212^{o} F
  - Freezing point - 32^{o} F
  - Maximum recommended use temperature - 140^{o} F
  - Toxicity - Potable
  - Chemical feeder to maintain pH factor - No
  - Inhibitor - No
- Piping
  - Rigid - Copper
  - Location - Above grade
  - Exterior finish - Cement cloth coated fabric/tape and mastic
  - Insulation - Mineral fiber
- Circulator pump (P-7), HX-1 to DHW-1
  - Manufacturer - Armstronng
  - Model Name/Number - 1 1/2 D 4280 Series
  - Type - Centrifugal
  - Maximum operating conditions
    - Temperature - 195^{o} F
  - Material exposed to heat transfer fluid - Bronze
  - Motor size - 0.75 hp
  - Maximum motor speed - 1750 rpm
  - Drive - Direct

- Speed - Single
- Pump speed - 1750 rpm
- Circulating volume - Low head mode - 60 gpm/20 ft head
- Motor operation - 0.75b hp

- Distribution Valve (V-3)
  - Function - On-Off
  - Operation - Manual
  - Type - Gate
- Distribution Valve (V-4)
  - Function - Temperature
  - Operation - Automatic
  - Type - Ball
- Flow Control (FC-1)
  - Type - Temperature and pressure relief

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

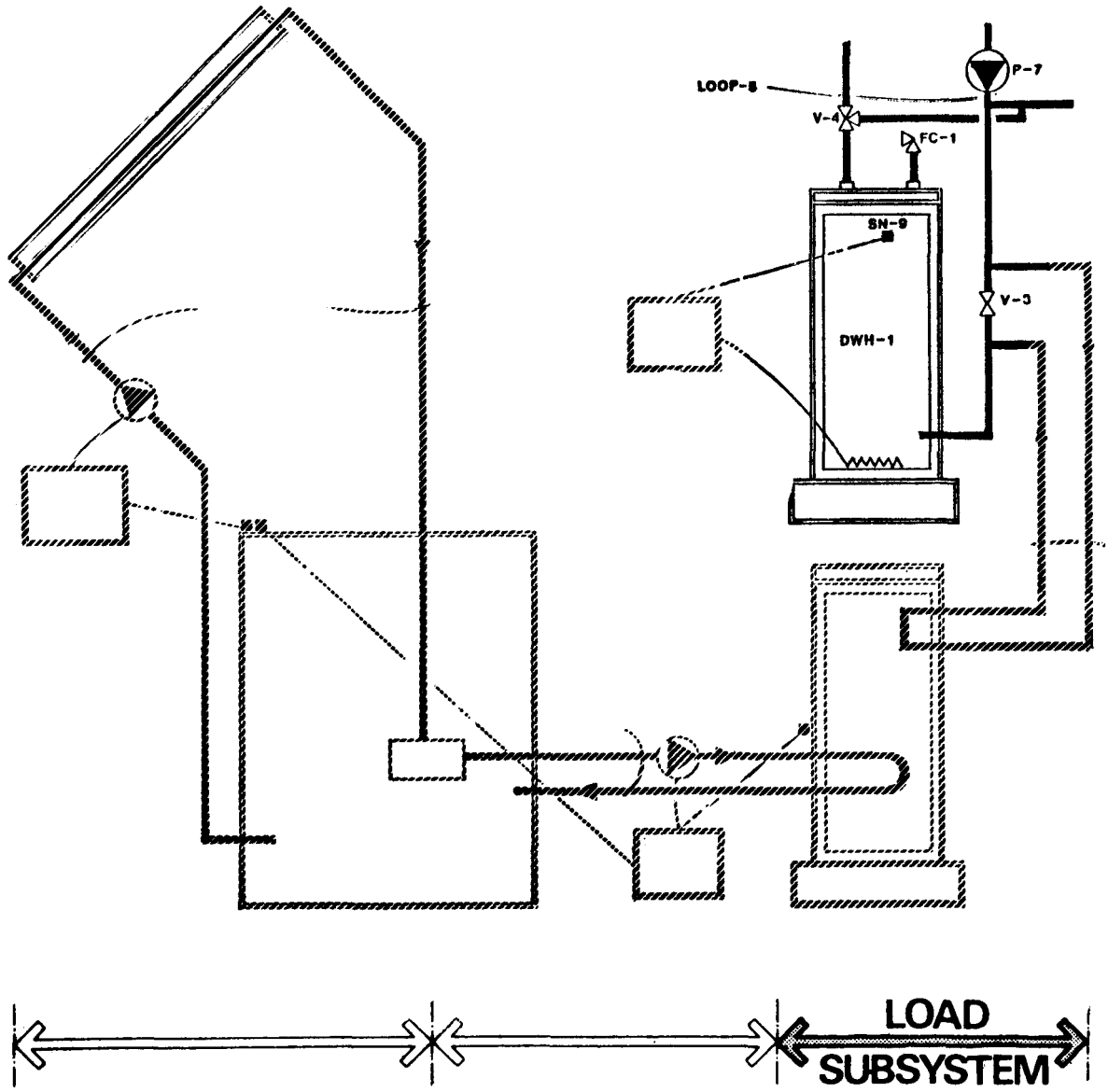


Figure IV-E-1. Auxiliary-to-Load Subsystem

The auxiliary subsystem, domestic hot water tank mentioned in the foregoing Energy to Load Subsystem is in this section for descriptive purposes, the function and purpose have been previously described.

Auxiliary Loads (DHW)

- Domestic Water Heater (DWH-1)
  - Manufacturer - Raypack
  - Model - 945 TIP
  - Energy source - Natural gas
  - Tank size - Volume - instantaneous heater
  - Energy input - 945000 Btu/hr
  - Energy output - 756000 Btu/hr
  - Maximum temperature rating - 170° F
  - Heating stages - Single
  - Maximum recovery rate - 1400 gal per hour
  - Yearly average inlet temperature - 60° F
  - Design output temperature - 125° F
  - Corrosion protection anodes - No
  - Burner ignition method - Pilot
  - Flue vent - No
- Control Mode Selector (CMS-6)
  - Modes controlled - Auxiliary to HW demand
- Sensor (SN-9)
  - Type - Thermostat

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

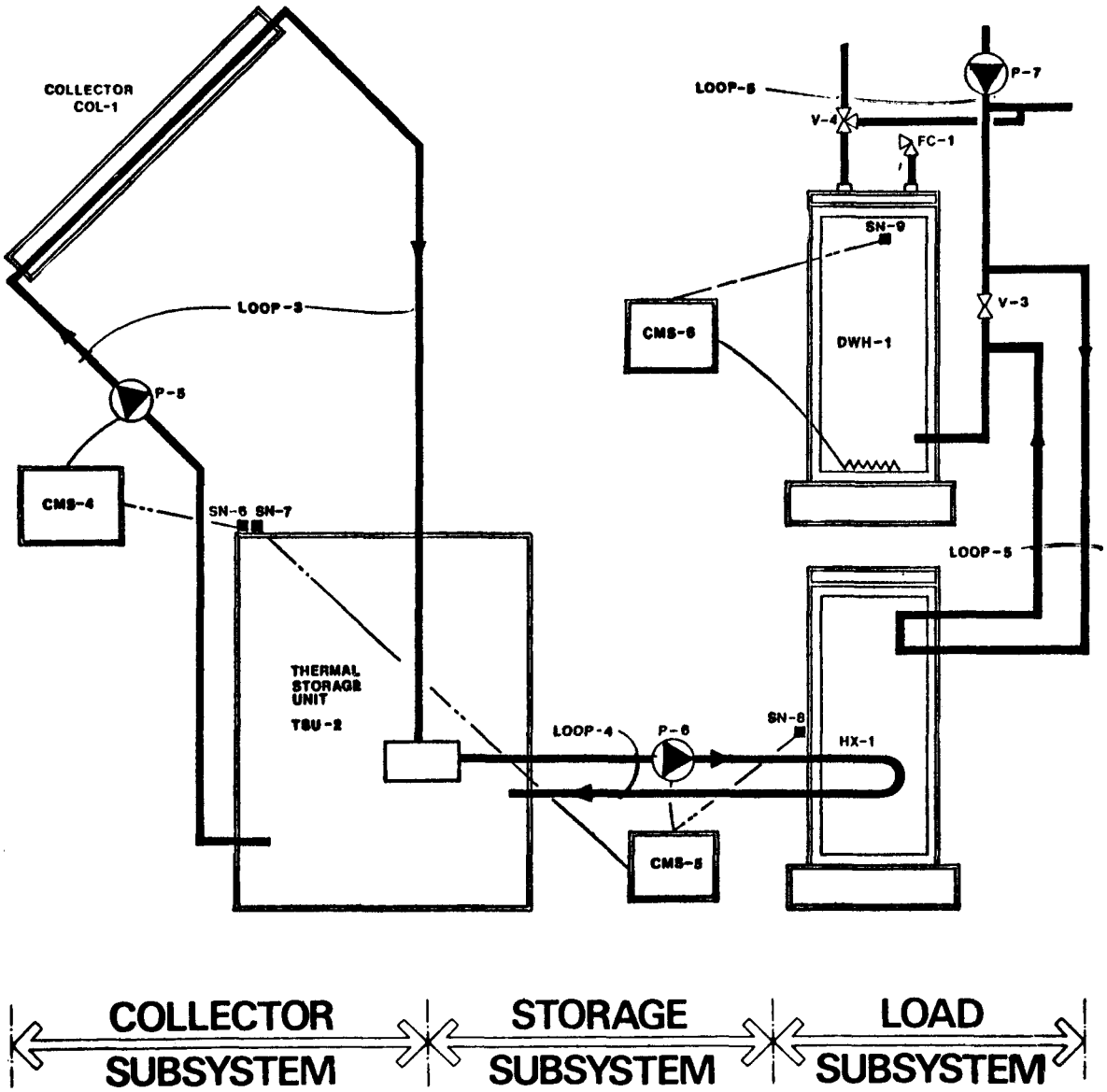


Figure IV-F-1. Controls Diagram

The Albuquerque Western - I solar system is shown on Figure IV-F-1. The system consists of the following four subsystems: a) Collector subsystem, b) storage subsystem, c) load subsystem and d) auxiliary loads subsystem. Auxiliary subsystem is a domestic hot water unit which utilizes storage water, in conjunction with the cooler exchanger. The predicted yearly domestic hot water load is 588.0

million Btu. The solar energy system is predicted to supply 68 percent of the yearly domestic hot water load. The hot water system has three modes of operation and are described below.

Mode 1 - Collector-to-Storage

This mode is activated when the collector-to-storage pump is turned on. Power to the pump is controlled by whether adequate insolation is available based on a minimum insolation intensity.

Mode 2 - Storage-to-HW Subsystem

This mode is activated whenever the storage-to-heat exchanger pump is on. Power to the pump is controlled by whether storage is at or above a pre-determined temperature level.

Mode 3 - Auxiliary Hot Water Heating

This mode is activated whenever the natural gas-fired boiler is required to "top-out" the continuously circulating hot water to obtain a preset supply water temperature level (usually 140^{o} F). This will occur whenever the pre-set temperature is above what the solar energy storage system can satisfy.

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 sutomatically 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.

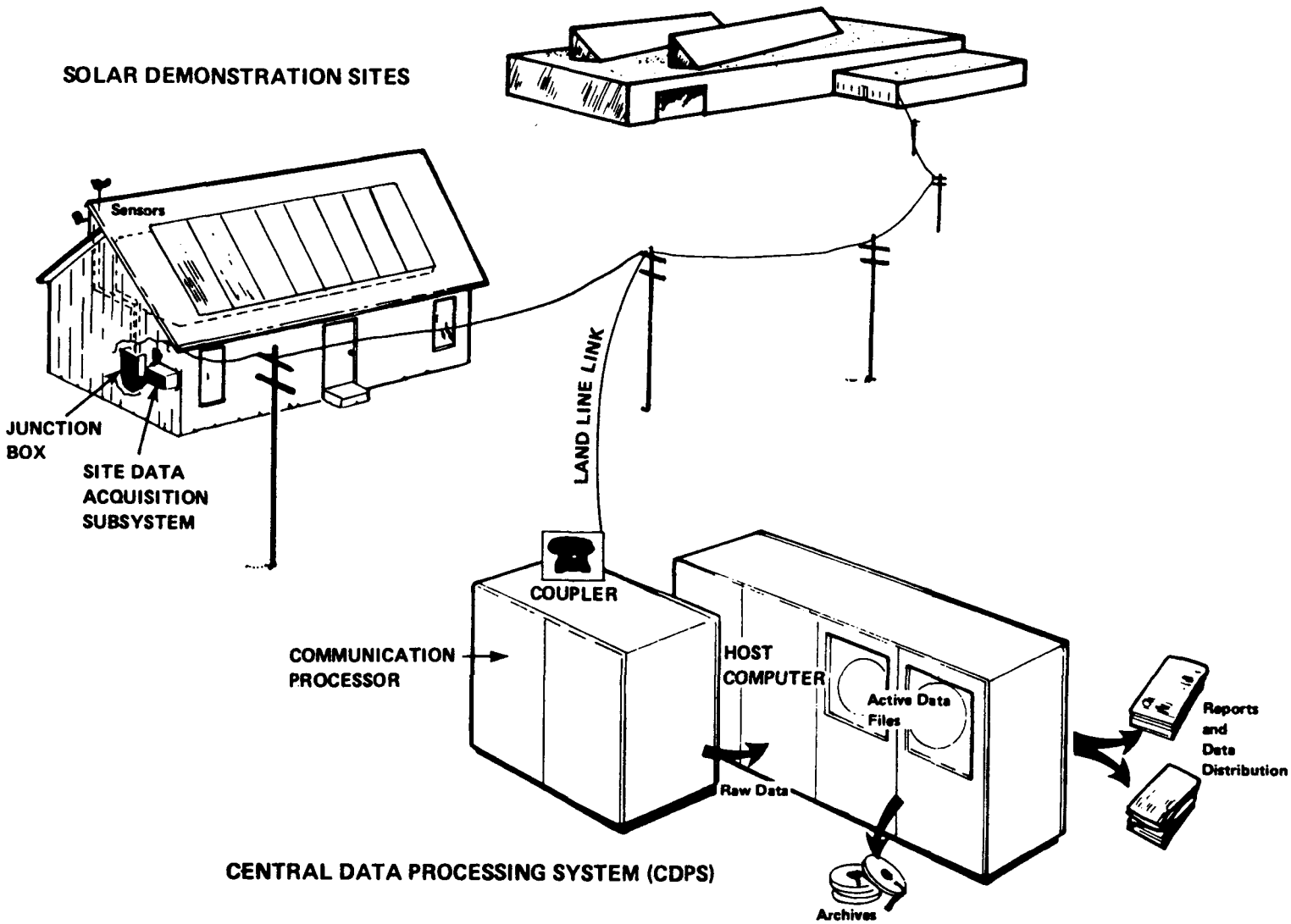


Figure V-A-1. The National Solar Data Network

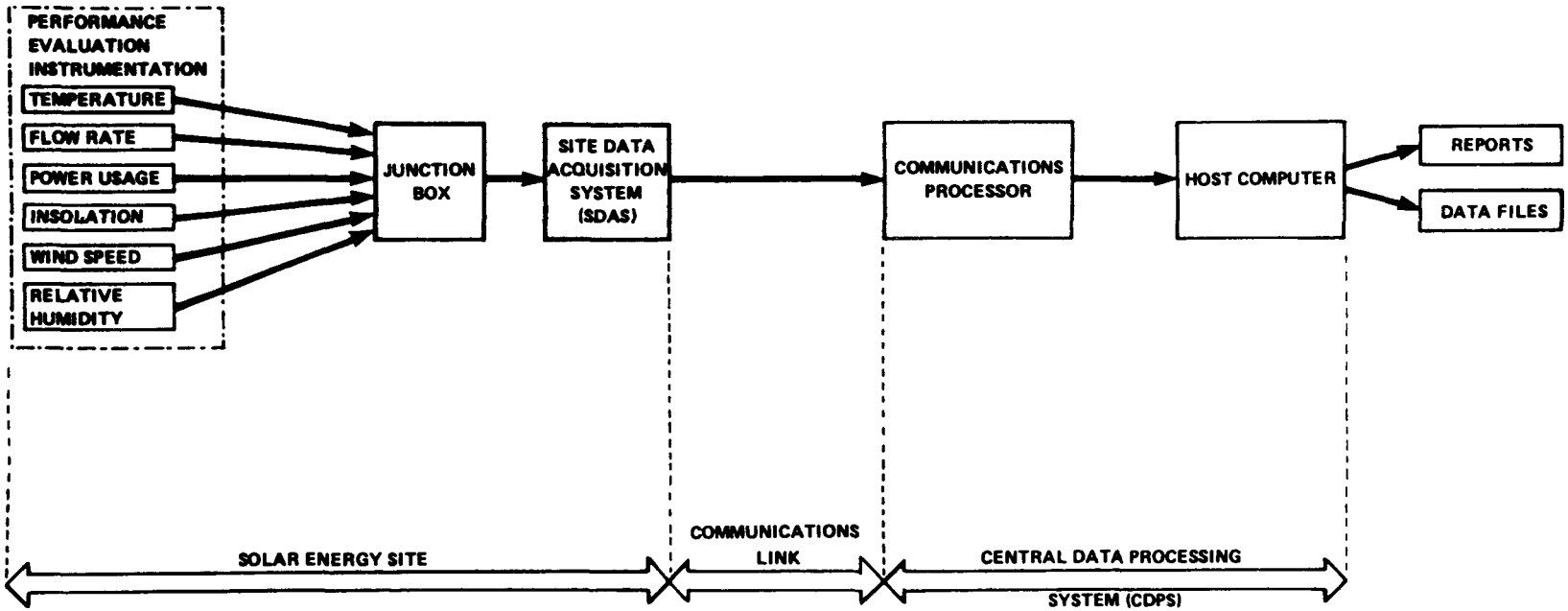


Figure V-A-2. Data Flow Path for the National Solar Data Network

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 preformance 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 vaid 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 textual 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.

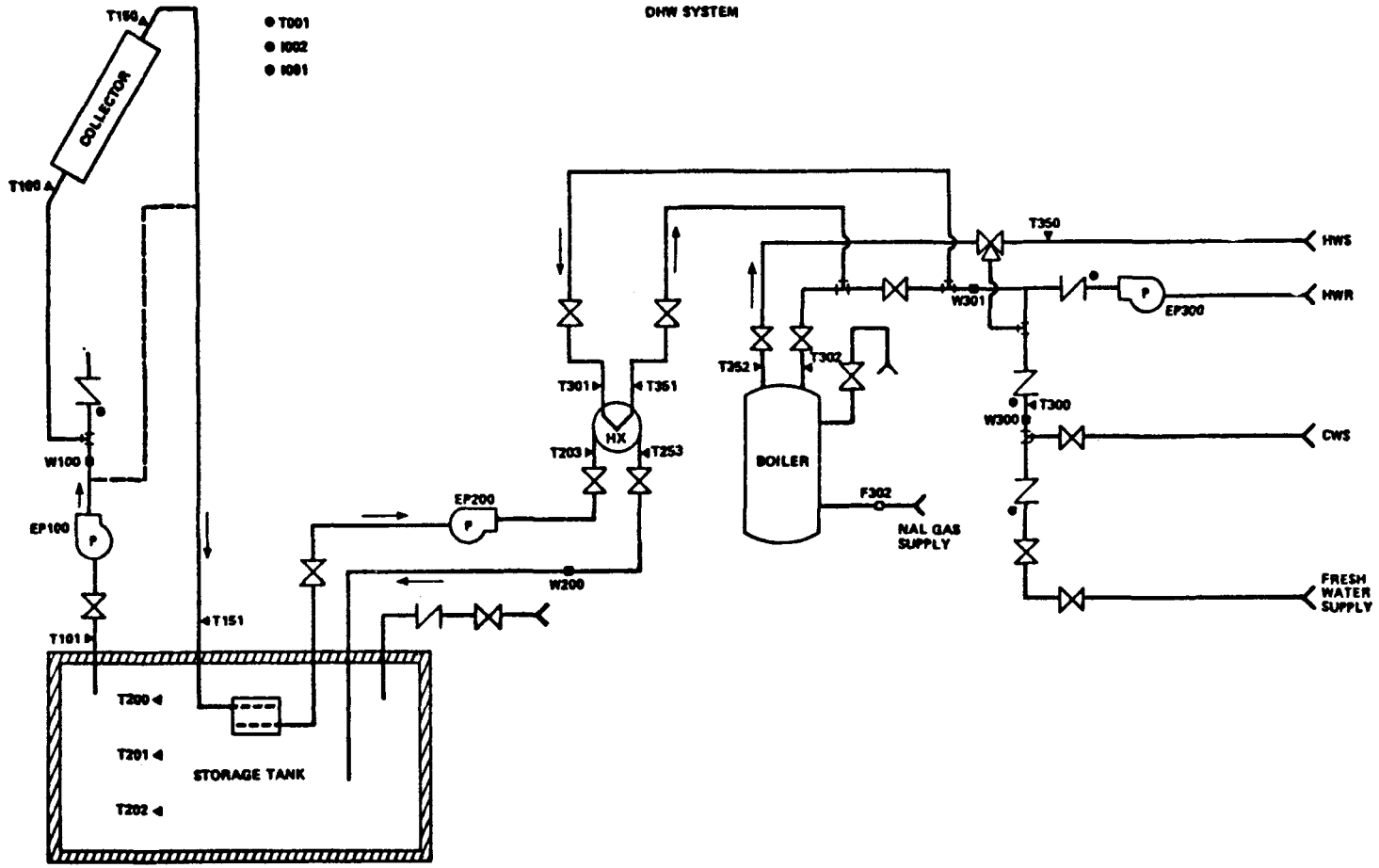


Figure V-B-1. Sensor and Control Diagram

SENSOR	DESCRIPTION OF MEASUREMENT	MODEL NO.
T001	Temperature, outside ambient	S53P-60
T100	Temperature, collector inlet	S57P-60
T150	Temperature, collector outlet	S53P-60
W100	Flow, collector loop	MKV-1 1/4-30
EP100	Power,collector pump	PC5-10
T101	Temperature, storage inlet	S57P-60
T151	Temperature, storage outlet	S53P-60
T200	Temperature, storage tank, upper	S53P-160
T201	Temperature, storage tank, middle	S53P-320
T202	Temperature, storage tank, bottom	S53P-480
T203	Temperature, heat ex. inlet	S57P-60
T253	Temperature, heat ex. outlet	S53P-60
W200	Flow, heat ex. to storage tank	MKV-2, 8-80 GPM
EP200	Power, DHW heat ex. pump	PC5-5
W300	Flow, preheat loop	FloScan 300-3
W301	Flow, cold water makeup	Hersey 430
EP300	Power, preheat loop pump and controls	PC5-1
T300	Temperature, outlet preheat tank to storage	S57P-60
T350	Temperature, inlet to preheat tank	S53P-60
T301	Temperature, cold water inlet	S57P-60
T351	Temperature, DHW supply	S53P-60
T302	Temperature, DHW boiler inlet	S57P-60
T352	Temperature, DHW boiler outlet	S53P-60
F302	Flow, gas to DHW boiler	A.M. AL-800
T002	Insolation, fixed position	Eppley PSP

VI. COST DATA

A. General

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

B. Construction Grant Funds

Solar Subsystem	Applicants Request	Construction Grant
Collectors		
Energy Storage		
Distribution and Controls		
Installation		
Other		
Total		$100,000.

C. Construction Period: January 1, 1977 through November 15, 1977

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.

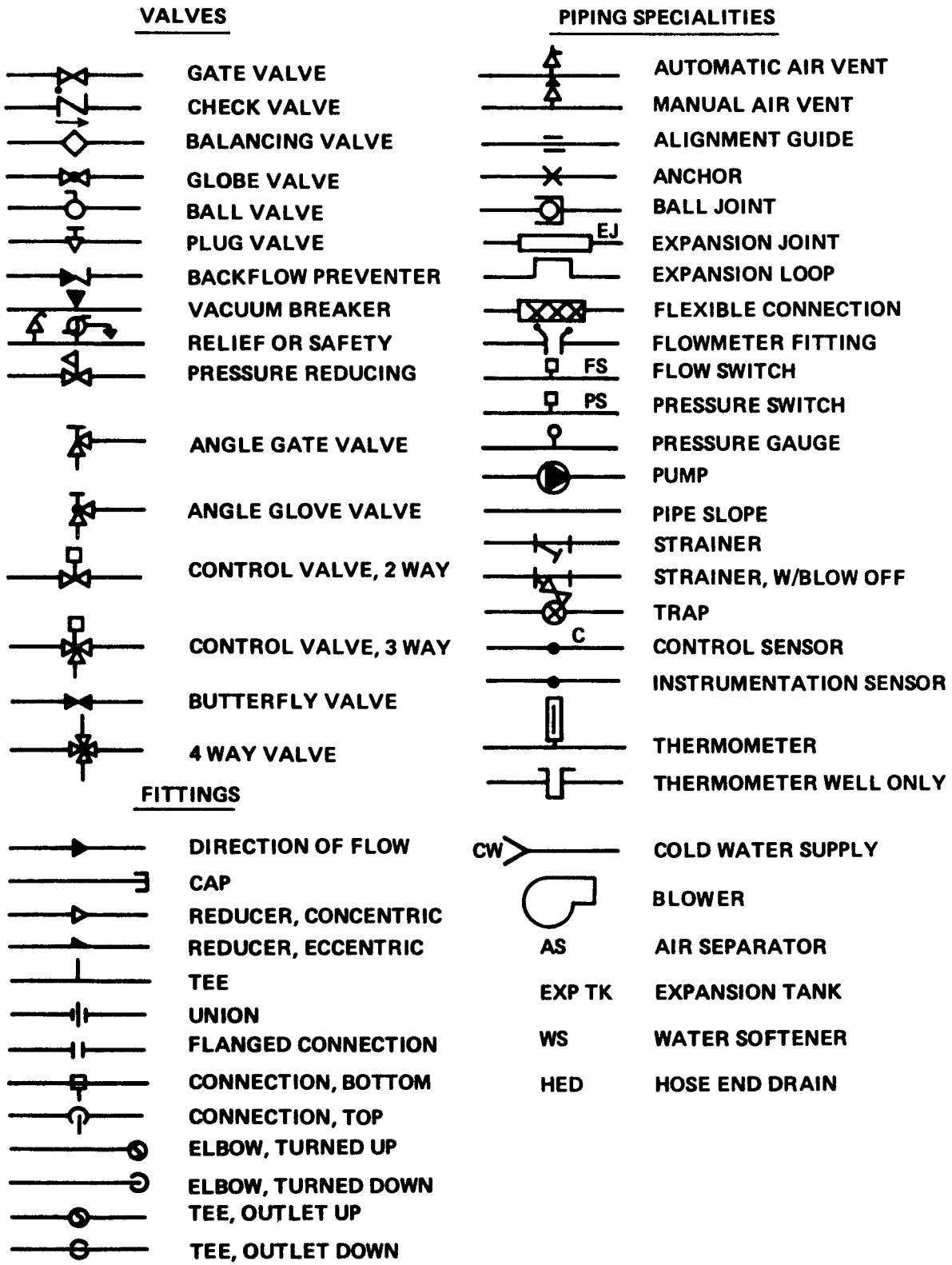
TON OF REFRIGERATION - A unit of refrigeration which is equivalent to 12,000 Btu/hr.

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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