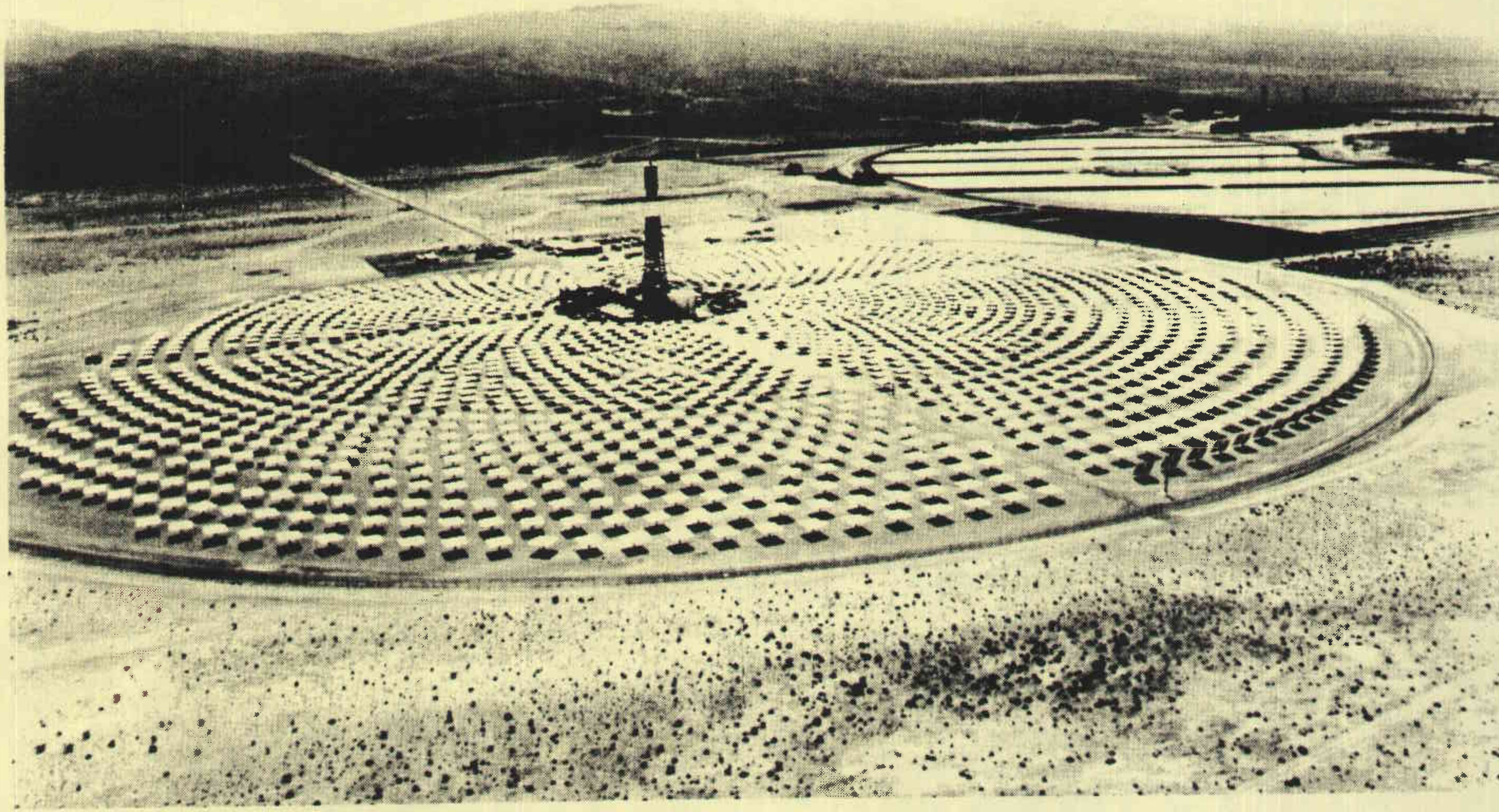
DOE/SF/10501-T13
(STMPO-602)

SOLAR 10-MWe PILOT PLANT



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SOLAR 10 MWe PILOT PLANT FACT SHEET

INTRODUCTION

By: J. J. Bartel, Sandia Labs.

This fact sheet details characteristics of the Solar 10 MWe Central Receiver Pilot Plant. The plant is a cooperative effort between the Department of Energy and the Associates - Southern California Edison Company, the Los Angeles Department of Water and Power and the California Energy Commission.

This experimental pilot plant provides new opportunities for technology improvement which will be incorporated into future commercial size plants. During the next eighteen months, the plant will fulfill its primary role of supplying technical performance data on the systems described herein and exploring the best ways to utilize solar energy.

The Department of Energy provides major funding for operation of the facility. An on-site technical staff is maintained to test the various sub-systems and analyze the performance of the components.

Principal areas of technical investigation include:

- Evaluation of mirror performance: to determine how often they must be cleaned, how much maintenance is required.

- Boiler performance: to determine the thermal losses as a function of wind velocity, ambient temperature, and operational temperature.

- Thermal storage optimization: finding the best way to charge and discharge storage and determine how long the energy can be stored.

- The effect of daily temperature cycling upon conventional power plant components.

- Environmental effects: find out if there is any effect upon the desert flora and fauna due to the plant.

Supporting the testing program are a number of computer systems which leads to another area of investigation: the interaction between man and these "new" machines. Presently, computers monitor the 1,818 heliostats and direct them according to operator-oriented commands. The 18 boiler panels are continuously monitored and similarly controlled by the computer. During the next 18 months, research and development will emphasize the automation of the individual plant systems so the heliostats, boiler, turbine and storage components will interact with each other with minimal operator assistance. The control operators will then be able to concentrate on maximizing the amount of energy delivered to the customer and minimizing the cost of electrical generation.

Considering its small size and the fact that Solar One is the first of its kind, it is not expected to be a cost effective plant. The value of this experiment is to generate knowledge which will allow cost competitive plants to be built. The application of such knowledge will not be limited to solar electric power plants; but will be applied to other solar and non-solar applications as well. Improvements in design, manufacture, operation, control and maintenance sought at this facility are relevant to a gamut of applications. Representative applications are described in the brochure "Solar Central Receiver Power Systems", available from the Solar One Visitor Center.

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SOLAR 10 MWe PILOT PLANT

I. General Statistics

A. Participants and Cost Figures:

SOLAR ONE COST FIGURES (ESTIMATED)

	PROJECT PARTICIPANTS				
	Department of Energy	Southern Calif. Edison	L.A. Dept. of Water & Power	Calif. Energy Commission	Total
Design and Construction of Solar Facilities: heliostats, tower, thermal storage, master control	$120,000,000	$	$	$	$120,000,000
Design and Construction of Non-Solar Facilities: electrical generation equipment		17,840,000	3,660,000		21,500,000
Participant Services:					
Land		250,000			250,000
Plant integration and startup: technical support and plant operating procedures		520,000	130,000		650,000
Project reviews and information dissemination		964,000	241,000	800,000	2,005,000
TOTAL DESIGN AND CONSTRUCTION COSTS	$120,000,000	$17,840,000	$ 3,660,000	$	$141,500,000
TOTAL PARTICIPANT SERVICES		1,734,000	371,000	800,000	2,905,000
TOTAL COSTS	$120,000,000	$19,574,000	$ 4,031,000	$ 800,000	$144,405,000

SOLAR ONE CAPITAL COST
(Millions)

SOLAR FACILITY	COST	PERCENT
Solar Facility Design Cost	$ 31.2	22%
Collector Field Fabrication and Construction	40.0	28%
Receiver Fabrication and Construction	23.4	17%
Thermal Storage Fabrication and Construction	12.0	8%
Plant Control System	3.0	2%
Beam Characterization System	1.0	1%
Miscellaneous Support Systems	9.4	7%
TOTAL SOLAR FACILITY DESIGN/ FABRICATION/CONSTRUCTION COST	120.00	85%
TURBINE/GENERATOR DESIGN AND CONSTRUCTION COST	21.5	15%
TOTAL PLANT COST	$141.5	100%

SOLAR ONE ANNUAL OPERATING AND MAINTENANCE BUDGET
(1983 Dollars)

	COST	PERCENT
Labor	$2,090,000	62%
Material	471,800	14%
Contract	288,800	9%
Other Miscellaneous Expenses	49,900	2%
Administration and General Overheads	469,200	13%
TOTAL O&M BUDGET	$3,369,700	100%

B. Major Construction Contractors

1.	Martin Marietta	Heliostats
2.	McDonnell Douglas	Master Control, System Design Integration
3.	Stearns-Roger	Architect/Engineering Services
4.	Rocketdyne of Rockwell Int'l.	Receiver, Thermal Storage Systems
5.	Townsend and Bottum	Construction Manager (Solar Facilities)
6.	General Electric	Turbine Generator

C. Project Schedule:

1.	Start Site Construction	September 1979
2.	Information Center Completed	July 1980
3.	Turbine Roll and Initial Operating Date	April 12, 1982
4.	Two Year Experimental Test and Evaluation Phase	1982 - 1984
5.	Three Year Power Production Phase	1984 - 1987

II. Specific Statistics:

A. Plant Rating:
1. 10 MWe for 7.8 hours - summer solstice
2. 10 MWe for 4 hours - winter solstice
3. 7 MWe for 4 hours from Thermal Storage

B. Geographic Features:
1. Minimum temperature: January 10^{o}F (-12.2^{o}C); July 73^{o}F (23^{o}C)
2. Maximum temperature: January 60^{o}F (16^{o}C); July 115^{o}F (46.1^{o}C)
3. Latitude: 34.86 degrees North
4. Longitude: 116.83 degrees West
5. Elevation: 1,946 feet above mean sea level
6. Approximately 3600-4000 hours of sunlight per year or 9.8-10.9 hours per day.

C. Size of Plant:
1. 1900 feet from north to south.
2. 2500 feet from east to west.
3. 130 acres: 72 acres for the heliostat field; 58 acres for the power plant, control and administration buildings, laydown and miscellaneous areas.

D. Power to the Grid:
1. Maximum power to the grid:
   a. 10.8 MWe (Operating Mode 1)
   b. 12.5 MWe gross; 1.7 MWe parasitic loads
2. Maximum estimated daily energy:
   a. 112 MWe/hr - June 21
   b. 48 MWe/hr - December 21
3. Annual estimated energy generation:
   a. 26,000 MWe/hr - 365 day operation

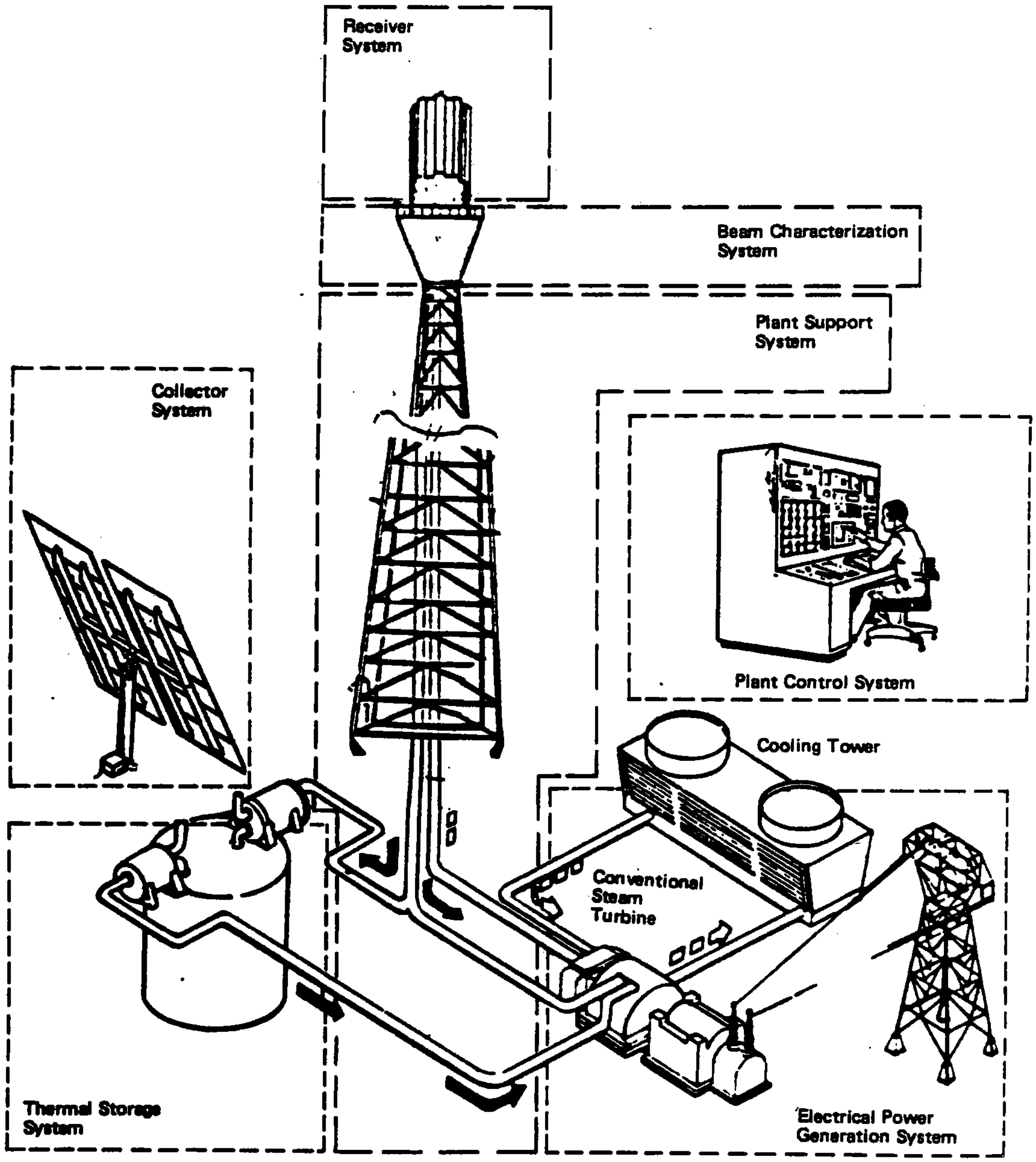
E. Gross Plant Efficiency:
1. 17.4% - Noon on June 21 - summer solstice
2. 15.4% - 2 PM on December 21 - winter solstice

F. Water Usage:
Approximately 100 acre feet of water per year for pilot plant operation and heliostat washing. Receiver makeup - 2 GPM (annual basis); cooling tower (blowdown) - 22 GPM (annual basis); and 71 GPM evaporation and drift.

G. Use of Electricity:
20% of electrical energy generated will go to the Los Angeles Department of Water and Power; 80% to the Southern California Edison Company.

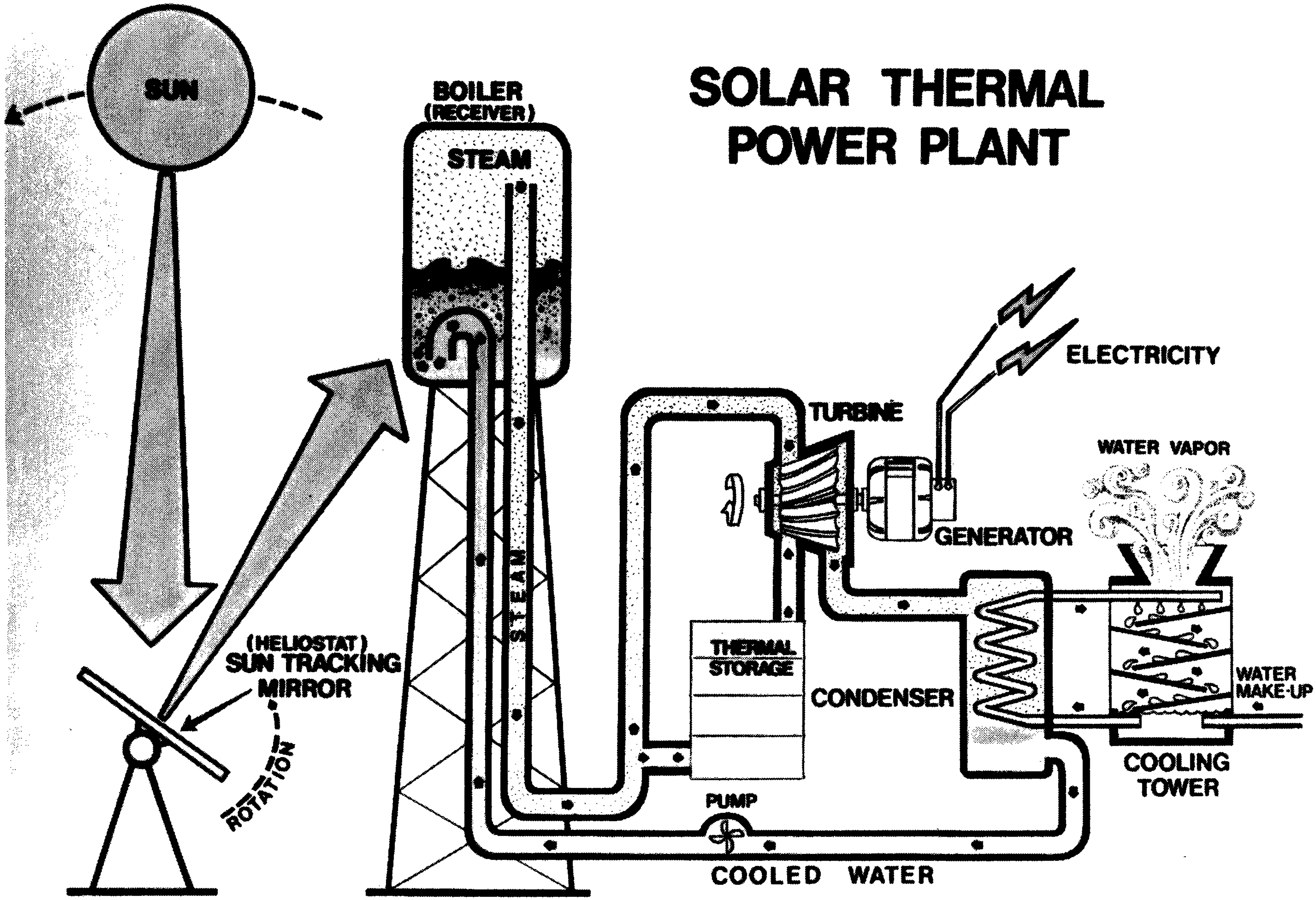
III. Operating Description:

Sunlight is reflected by the heliostats to a tower-mounted receiver/boiler which absorbs the heat and converts water to steam. The steam is directed to a conventional turbine generator which produces electrical power. During periods when excess steam is available, it is used to heat the oil in the thermal storage tank. Later, steam can be generated by heating condensate with the hot oil. After use, the steam is condensed back to water which is recycled to the receiver and converted into steam.



PILOT PLANT SYSTEM SCHEMATIC

SOLAR THERMAL POWER PLANT



HELIOSTAT

I. General Statistics:

A. Total Heliostats in Field: 1,818 (578 in south field and 1,240 in north field).
B. Heliostat Measurements: 22'6" x 22'7" consisting of 12 mirror panels each measuring 120.3 inches long by 43.3 inches wide or 3'6" by 10'.
C. Slightly Concave: Approximately 1,000 foot focal length (1/6" curvature in 10 foot length).
D. Reflective Area: 430 square feet or 39.9 square meters.
E. Heliostat Weights:
   1. Heliostat Rack Assembly — 2,546 lbs.
      (Mirror assembly, bar joists, torque tube, supports arms, mounting hardware)
   2. Drive Unit Assembly — 923 lbs.
      (Drive mechanism, support base, oil, motors/gearheads, encoders, mounting hardware)
   3. Pedestal Assembly — 601 lbs.
      (Pedestal, cover, mounting hardware)
   4. Cable and Electronics — 62 lbs.
      (Cable, heliostat control electronics, mounting hardware)
   5. Heliostat Total Weight — 4,132 lbs.
F. Heliostat Performance, Specifications and Operational Limits:
   1. Heliostat Reference Position: Mirror normally horizontal, pointing east.
   2. Stow Position: Mirrors face down normally; however, to mitigate mirror facet corrosion, heliostats are now stowed in a vertical position except when high wind conditions exist.
   3. Gimbal Rotation: Azimuth, 270° from reference; Elevation 95° from reference.
   4. Gimbal Drift: During power-off modes, the drive mechanism locks both axes.
   5. Stowage (depending on wire-walk requirements): 15 minutes from any position (270° maximum travel).
   6. Over-the-Shoulder Resolution (depending on wire-walk requirements): 10 minutes (180° maximum travel).
   7. Maximum Slew Rate: 18° per minute.
G. Cost: $15-22,000 each.
H. Reflectivity (Efficiency Rating): Average reflectance of a clean heliostat mirror exceeds 91% over an air mass 2 solar spectrum with a 1 mrad cone.
I. Life Expectancy: 30 years.
J. Cleaning Procedure: Heliostats are turned to a 45° angle during rain storms or rinsed with demineralized water.

II. Specific Statistics:

A. Mirrors: Each panel consists of a second surface (silver backing) glass mirror bonded to an aluminum honeycomb core (2½" thick). This core is bonded to a steel enclosure pan and sealed with an environmental edge seal. The heliostats are turned in a stow position (mirror surface down) when the winds exceed 45 miles per hour and during adverse weather conditions. They are capable of withstanding 50 mph winds in the vertical position and 90 mph in the stow position without structural damage.
B. Heliostat Rack Assembly: Rack consisting of four bar joists riveted to a 12 inch diameter torque tube, which is parallel to the heliostat elevation axis. Each mirror module is mounted to the bar joists in three places.

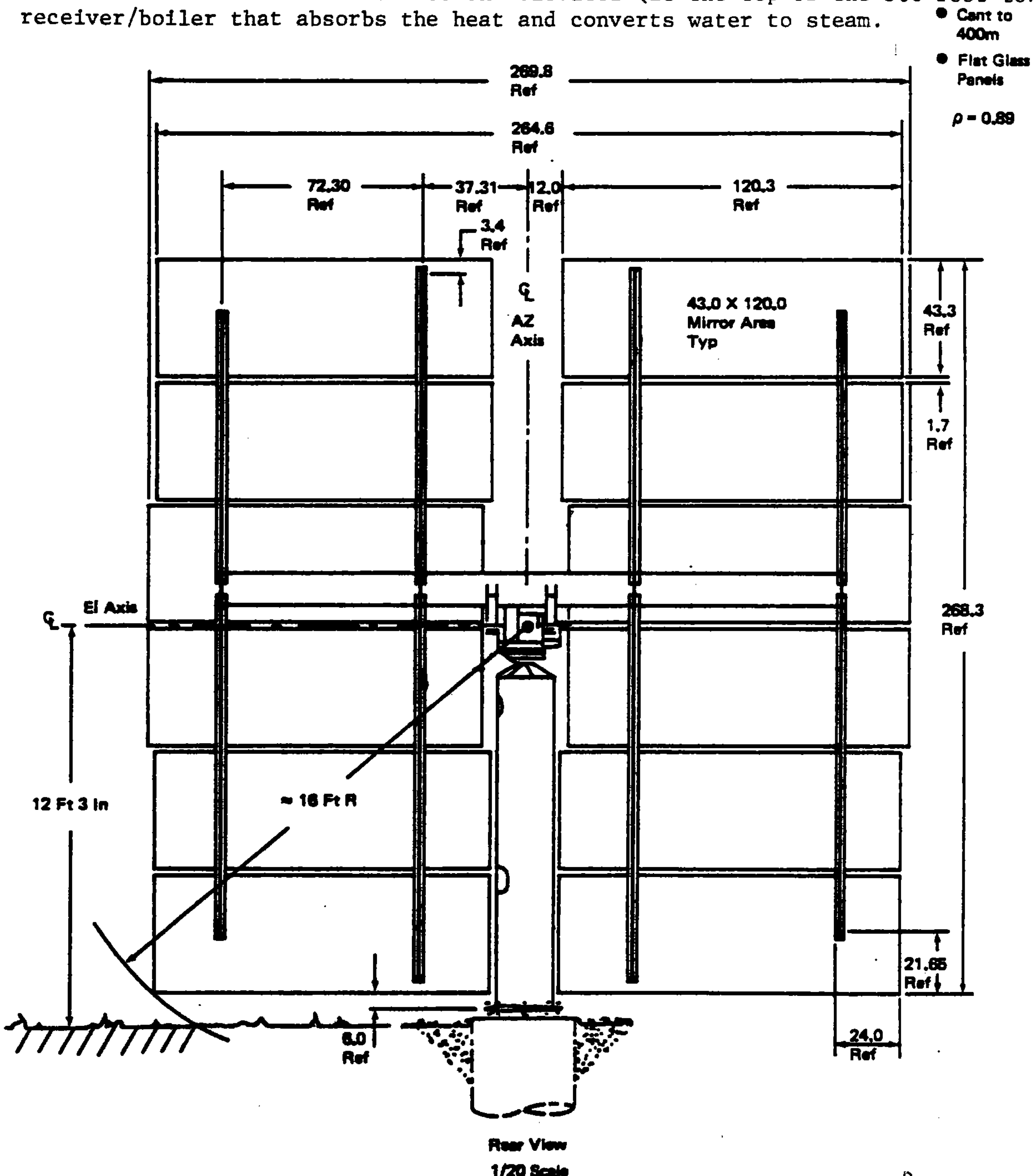
C. Drive Mechanism: Provides the driving force for positioning the heliostat azimuth and elevation axis. Each axis is driven by a DC motor (1/6 HP) and the axis position is identified by a 13-bit incremental encoder.

D. Support Pedestal: 10 feet tall and 20 inches in diameter houses the electronic controls for the heliostat. Input power is 110 volt, 60 cycles.

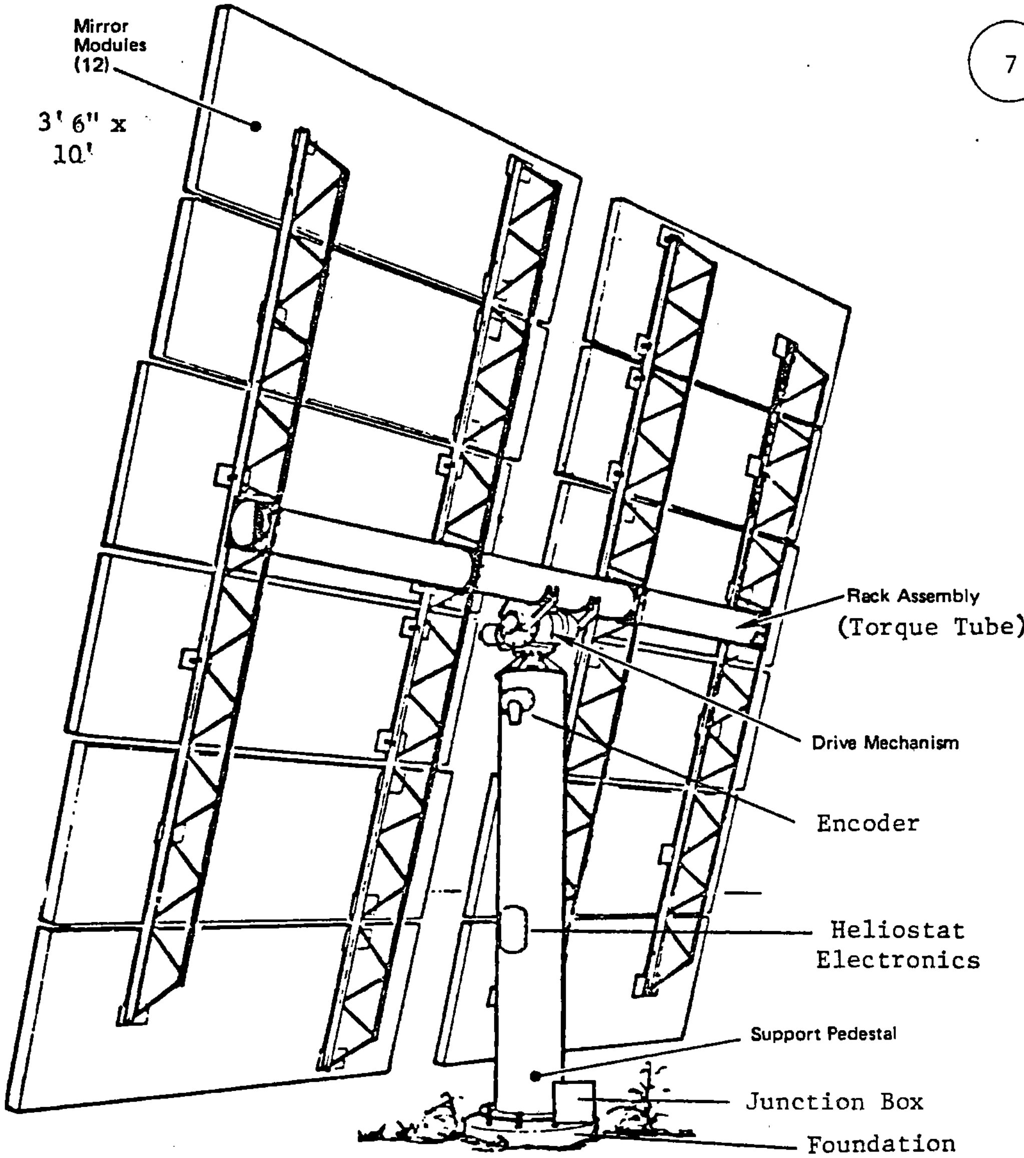
E. Foundation: 10 feet deep and 36 inches in diameter reinforced concrete with eight imbedded support bolts.

III. Operating Description:

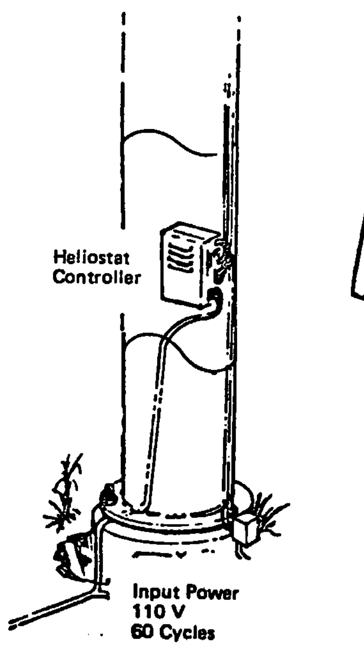
Each computer-controlled heliostat is a sun-tracking mirror. Sunlight strikes the heliostat and is reflected to the elevated (at the top of the 300 foot tower) receiver/boiler that absorbs the heat and converts water to steam.



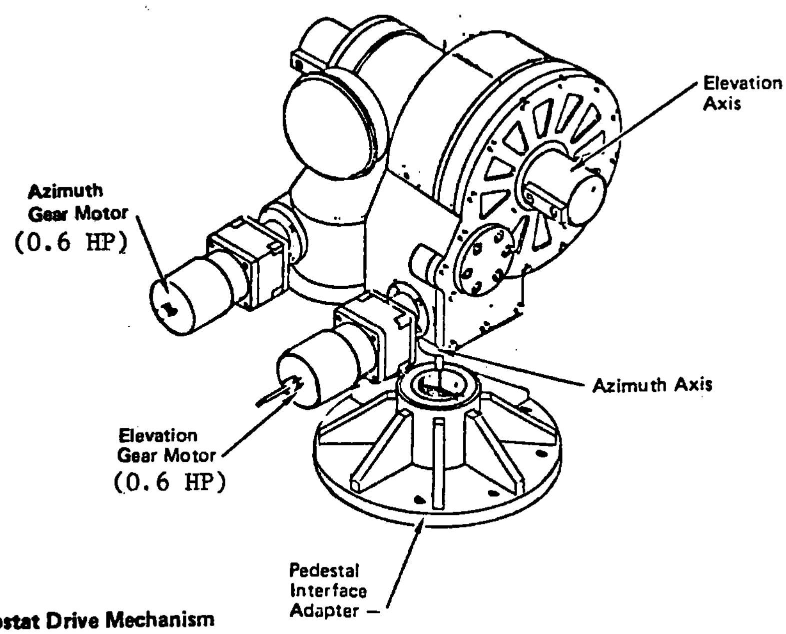
Martin Marietta Corp. Heliostat (Total Net Reflective Area 430 Ft^2)



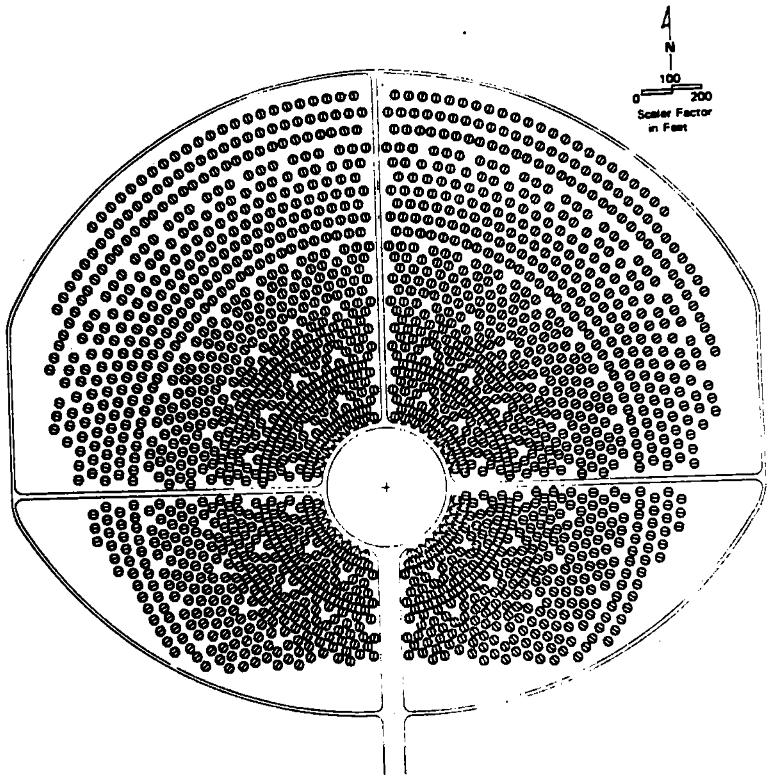
Heliostat Assembly



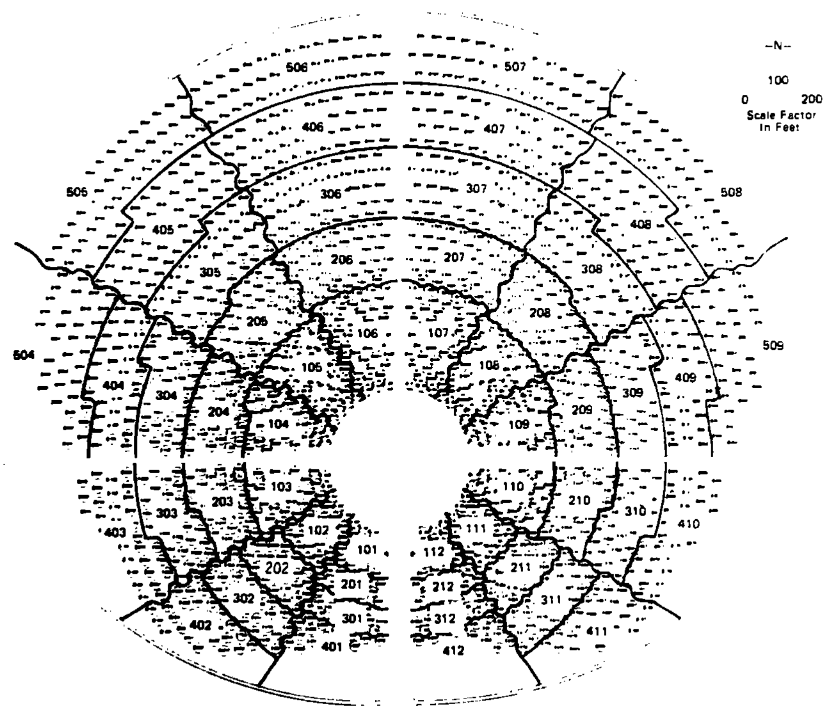
Pedestal Showing Heliostat Controller



Heliostat Drive Mechanism



Collector Field Layout



Collector Field Segmentation

RECEIVER TOWER

I. General Statistics

A. Tower:
1. Height: 298 feet (including 45 foot receiver).
2. Weight: 202 tons (not including receiver panels).
3. Material: Steel
4. Foundation: 1,500 tons of concrete buried approximately 25 feet below the surface.

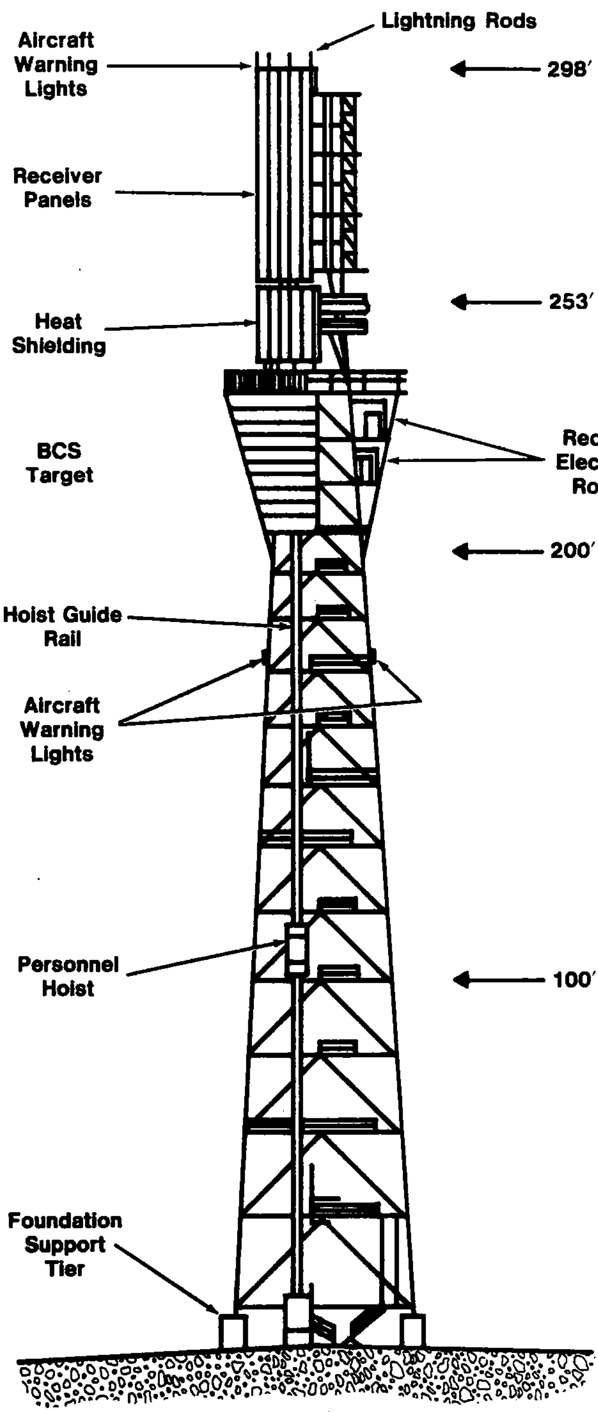
B. Receiver:
1. Dimension: 45 feet high, 23 feet in diameter.
2. Number of panels: 24 panels of 70 tubes each; 18 boiler panels and 6 pre-heater panels. The boiler panels are located on the west, north and east side of the receiver with the pre-heater panels on the south side.

II. Specific Statistics

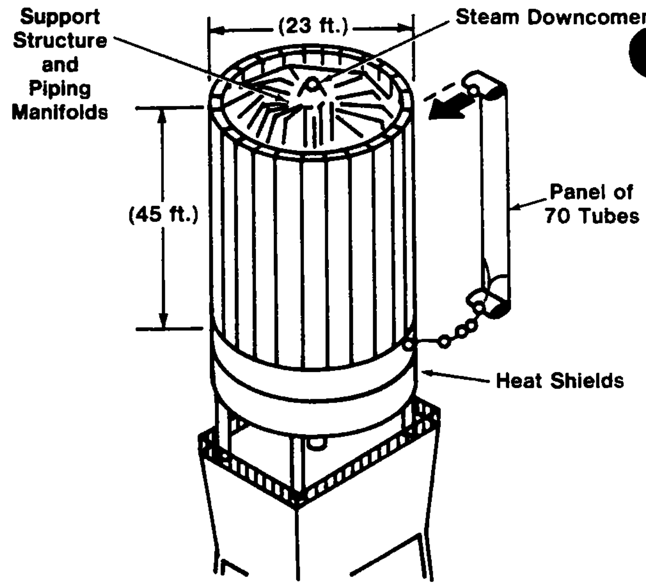
A. Receiver panels:
1. Function: Provide a vessel in which water can be converted to super-heated steam by thermal energy from the heliostat field.
2. Dimensions: Each panel is 45 feet high and 35 inches wide; comprised of seventy 1/2 inch diameter tubes (internal diameter: 0.269 inch).
3. Panel weight: 4,000 lbs.
4. Tube material: Incoloy 800; an iron, nickel, chrome alloy with a melting point of 2540-2600°F.
5. External panel coating: Pyromark paint - high absorbitivity coating.
6. Maximum operating metal temperature: 1150°F.
7. Operational thermal expansion: 5-6 inches vertically; 1 inch horizontally.
8. Life expectancy: Greater than 30 years.

B. Operational Steam:
1. Direction of flow: Vertically upward through receiver panels.
2. Temperature: 960°F.
3. Pressure: 1510-1570 psi.
(NOTE: Feedwater is extensively demineralized.)

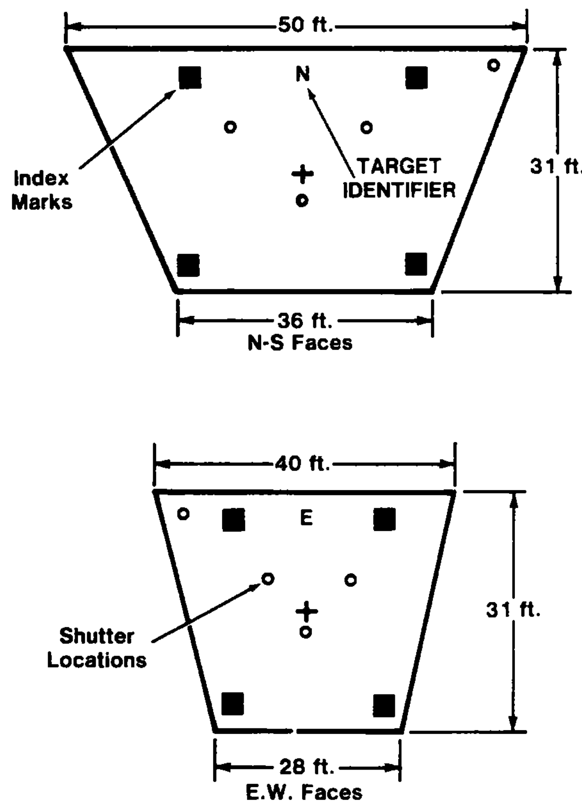
C. Beam Characterization System (BCS) Targets:
1. Function: Four targets in conjunction with four BCS field cameras and the Master Control System, perform periodic calibration and alignment of individual heliostats.
2. Dimensions: North and South targets: 31 feet high by 36-50 feet wide and the East and West targets: 31 feet high by 28-40 feet wide.
3. Panel composition: 6061-T6 aluminum.
4. External coating: Heat resistant white paint (Koppers Co., #A-1639-66) stable at 250-300°F with a lifetime greater than one year.



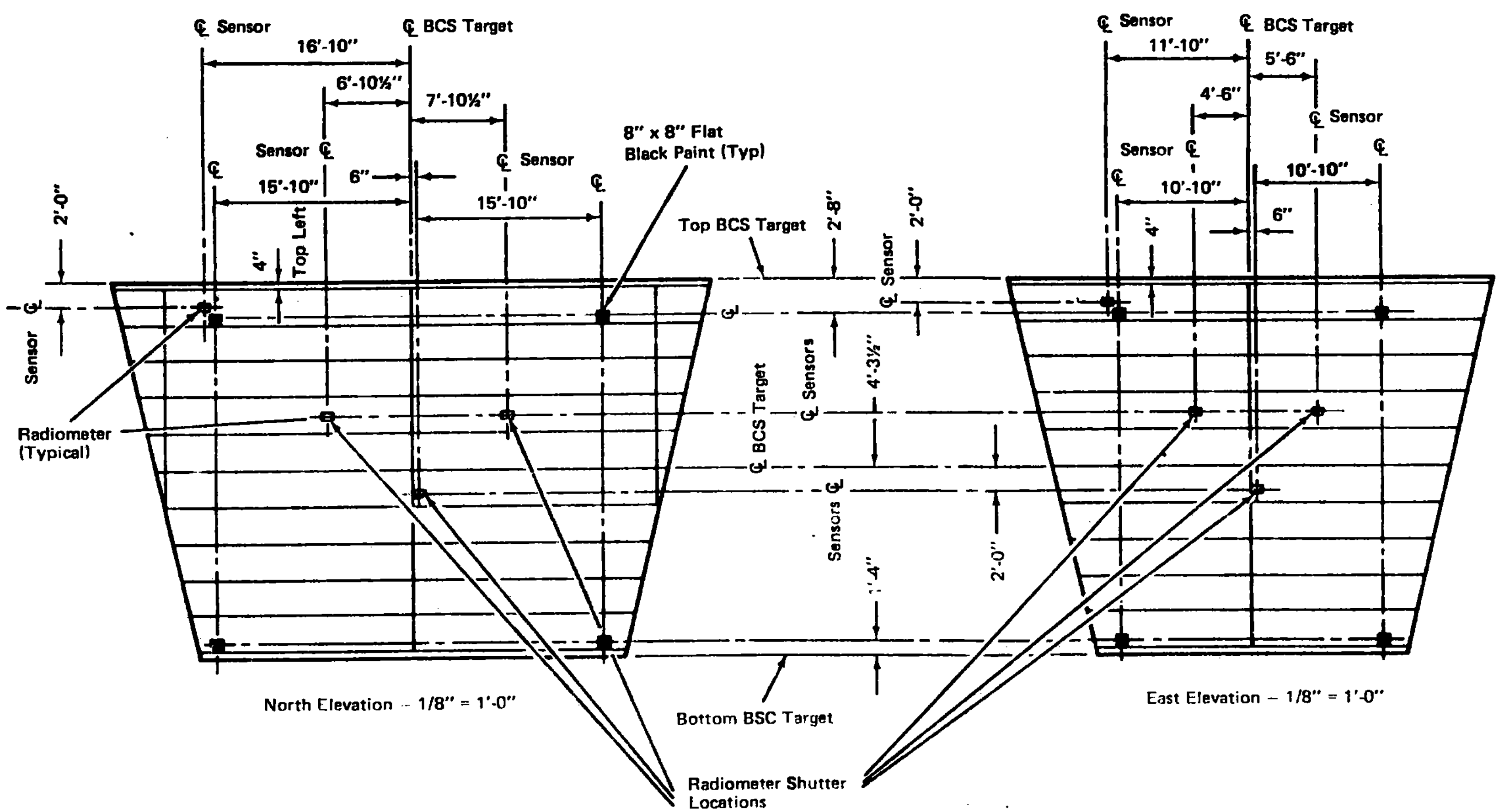
RECEIVER TOWER
(Looking East)



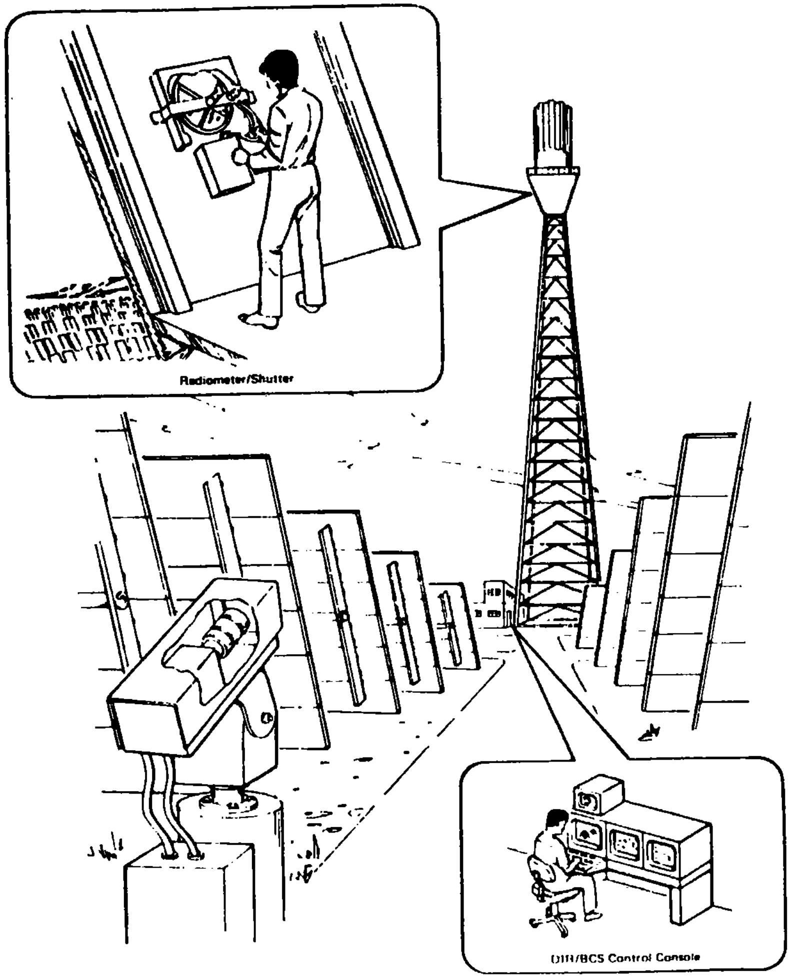
Receiver Unit
(Boiler)



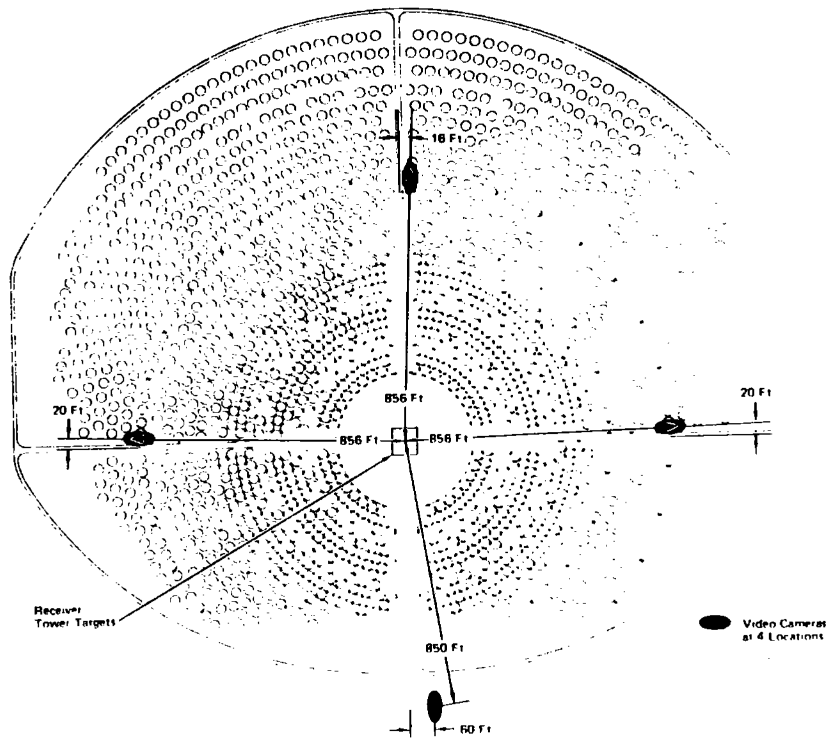
BCS TARGETS



Radiometer and Radiometer Shutter Orientation



Digital Image Radiometer
Beam Characterization System



BCS Camera Orientation

THERMAL STORAGE

I. General Statistics:

A. Tank Dimensions:

1. The steel tank is 45 feet deep (at outside edge), 65 feet in diameter, with a volume of 149,288 cubic feet. The circumference of 204 feet will expand three inches when the system is fully heated.
2. Walls are 1/4 inch to 1 1/8 inch steel with 12 inches of insulation.
3. Roof is steel plus 2 feet of insulation and aluminum cladding.

B. Contents:

1. 4,532 tons of crushed granite from San Bernardino County.
2. 2,266 tons of sand from the Monterey Bay area.
3. 239,600 gallons of Caloria HT-43 oil manufactured by Exxon.

II. Specific Statistics:

A. Caloria HT-43 Oil:

1. A petroleum oil about the consistency of mineral oil when cold.
2. Decomposes at a rate of 48 lb/hr at 580^{o}F, producing non-condensible waste gases, such as methane, ethane and hydrogen.

B. Temperatures:

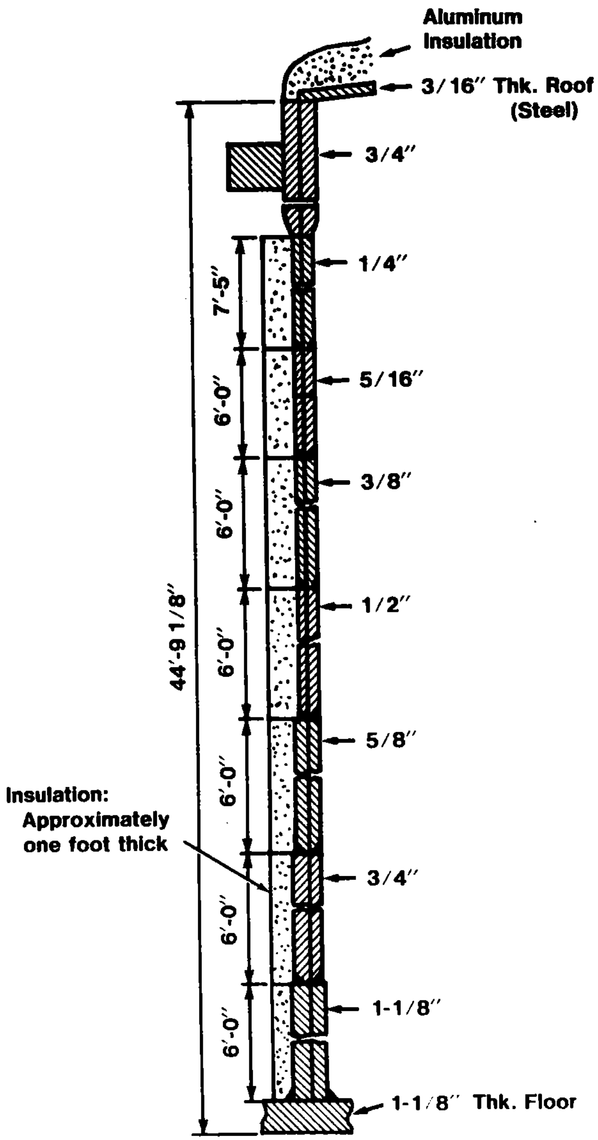
1. During the charging and extraction processes, the system fluid flows through the rock at a temperature range from 435 to 580^{o}F.
2. A de-superheater lowers the input steam temperature from 960 to 600^{o}F before the steam goes into the charging heat transfer system.
3. Steam from thermal storage goes into the turbine at 525^{o}F (380 psia).

C. Charging/Discharging Rates:

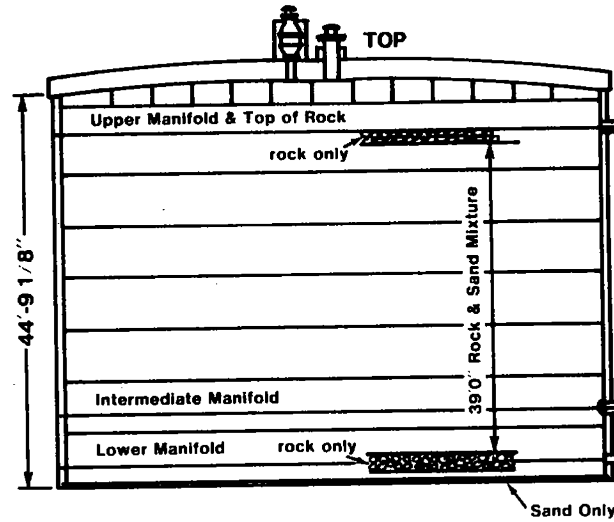
1. Charging rate: To 6.6 MWe for 4.2 hours.
2. Discharging rate: To 7 MWe for 4 hours.

III. Operating Description:

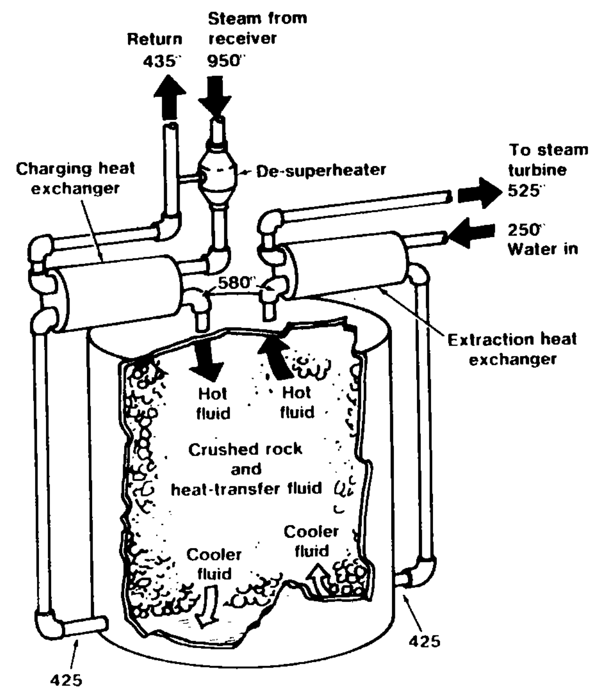
The thermal storage unit is a vertical cylindrical tank filled with a sand/rock mixture through which caloria oil passes. Hot caloria is introduced at the top and passes downward through the tank. As the oil flows through the rock and sand mixture, it transfers its heat to the rock and sand and is cooled to the low temperature of 535^{o}F. The process is repeated until the thermal storage unit is fully charged. The thermal storage unit is designed to store thermal energy by condensing receiver generated steam. It can also serve as a source of thermal energy for a simultaneous steam generation while the receiver is in operation. An ullage maintenance unit (UMU) flares decomposition gases such as methane, ethane, and hydrogen. Heavier hydrocarbon compounds withdrawn from the thermal storage unit in a gaseous state are condensed in the interconnecting piping leading to the UMU. The condensed hydrocarbons drain into the heptane tank for re-use to pressurize the thermal storage unit.



TANK WALL DETAIL



TANK DETAIL



TEMPERATURE DETAIL

TURBINE GENERATOR

I. General Statistics

A. Manufacturer: General Electric

B. Equipment cost: $2,120,372.28

C. Weight: 214,280 lbs. or 107.14 tons

D. Turbine generator length: 36'9.94"

E. Turbine width: 14'

F. Generator width: 7'8"

G. Maximum gross output: 12.8 MWe

II. Specific Statistics

A. Rated generator capacity: 13.8 KV (14.23 MVA), grounded wyeconnected, 3 phase, 60 Hz. The short circuit ratio of the generator at maximum output is 0.58 or greater. Operates at power factors of 0.90 lagging to 0.95 leading without exceeding the guaranteed temperature rise.

B. Electrical power devices required for operation and control of turbine:

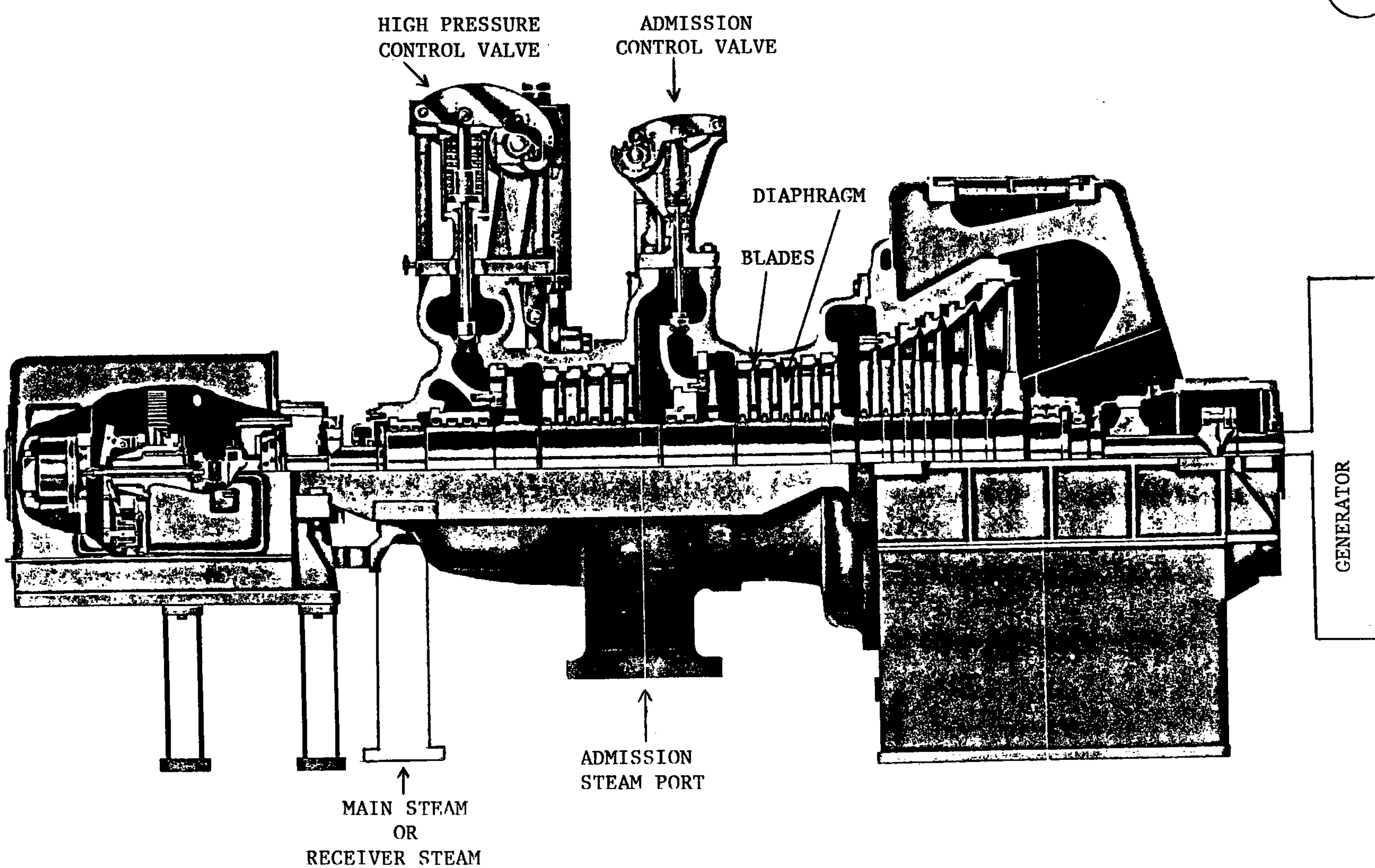
1. AC bearing oil pump (2)
2. DC emergency bearing oil pump
3. DC starter for emergency oil pump
4. Vapor extractor
5. Turning gear
6. Gland exhauster pump
7. Hydraulic fluid pump (2)
8. Filter motor
9. Hydraulic fluid heaters
10. Motor valve operators
11. Speed-load control motor

C. During normal operation, the plant generator, auxiliary transformer, and 33kv lines are interconnected thereby allowing the generator output to accommodate the plant auxiliary electrical load plus provide a net power production to the grid.

D. Back-up power: Prior to turbine startup, power can be drawn directly from the grid as required to supply the plant startup auxiliary load. The 125 volt DC system is a battery powered system designed to provide reliable power to critical components (turbine DC lube oil pump and solenoid operators on control and isolation valves) which must be maintained in an operational status even when the primary AC power is lost. The unit is rated and guaranteed at 12.8 MWe gross electrical output at a 2.5 inch Hg condenser back pressure at a throttle steam inlet condition of 960°F, 1465 psia, and flow-rate of 112,140 lb/hr (Mode 1 operation). It operates at a synchronous speed of 3600 rpm and is directly coupled to a 13.8 KV generator. The unit is configured with four steam extraction ports for feedwater heating. The unit is also guaranteed to produce 8.0 MWe gross at a 2.5 inch Hg condenser back pressure at an admission steam inlet condition of 525°F, 385 psia and flow-rate of 105,000 lb/hr (Mode 6 operation).

III. Operating Description

The steam turbine is an automatic admission, single flow, extraction, condensing unit capable of accepting steam through the main control valves, through the admission control valves or through both inlets simultaneously under the operating conditions (Modes) defined for the plant. The turbine is comprised of a rotational shaft on which stages of blades are attached and contained in a high pressure casing. Incoming steam passes through these blade discs and forces the shaft to rotate. Turbine exhaust steam is routed through a condenser, where it is condensed and pumped back to the receiver to be recycled into steam. The turbine shaft is connected to the generator which is a rotating magnet within a coil. The rotating magnet induces electricity in the coil. The electricity that is generated is connected to the electrical grid for distribution.



GENERAL ELECTRIC

MASTER CONTROL BUILDING

I. General Description of Rooms

A. First Floor:

1. Machine Room: Contains the elevator apparatus, hydraulic pumps.
2. Laydown Area: Disassembly area.
3. Chemistry Laboratory: Used in analyzing the quality of feedwater.
4. Control Termination Room: Contains computer equipment for the plant controls.
5. 480 Volt Switchgear Room: Contains electrical equipment used in operating motors and other electrical equipment (air compressors, pumps, valves, etc.).
6. Battery Room: Contains batteries for the emergency control equipment (the ultimate backup in case of power failure).
7. Shop Area: Contains spare parts for maintenance and repair of plant equipment.
8. Telecommunications: Switchboards for automatic telephone system.
9. Instrument Room: A repair room for the plant instruments.

B. Second Floor:

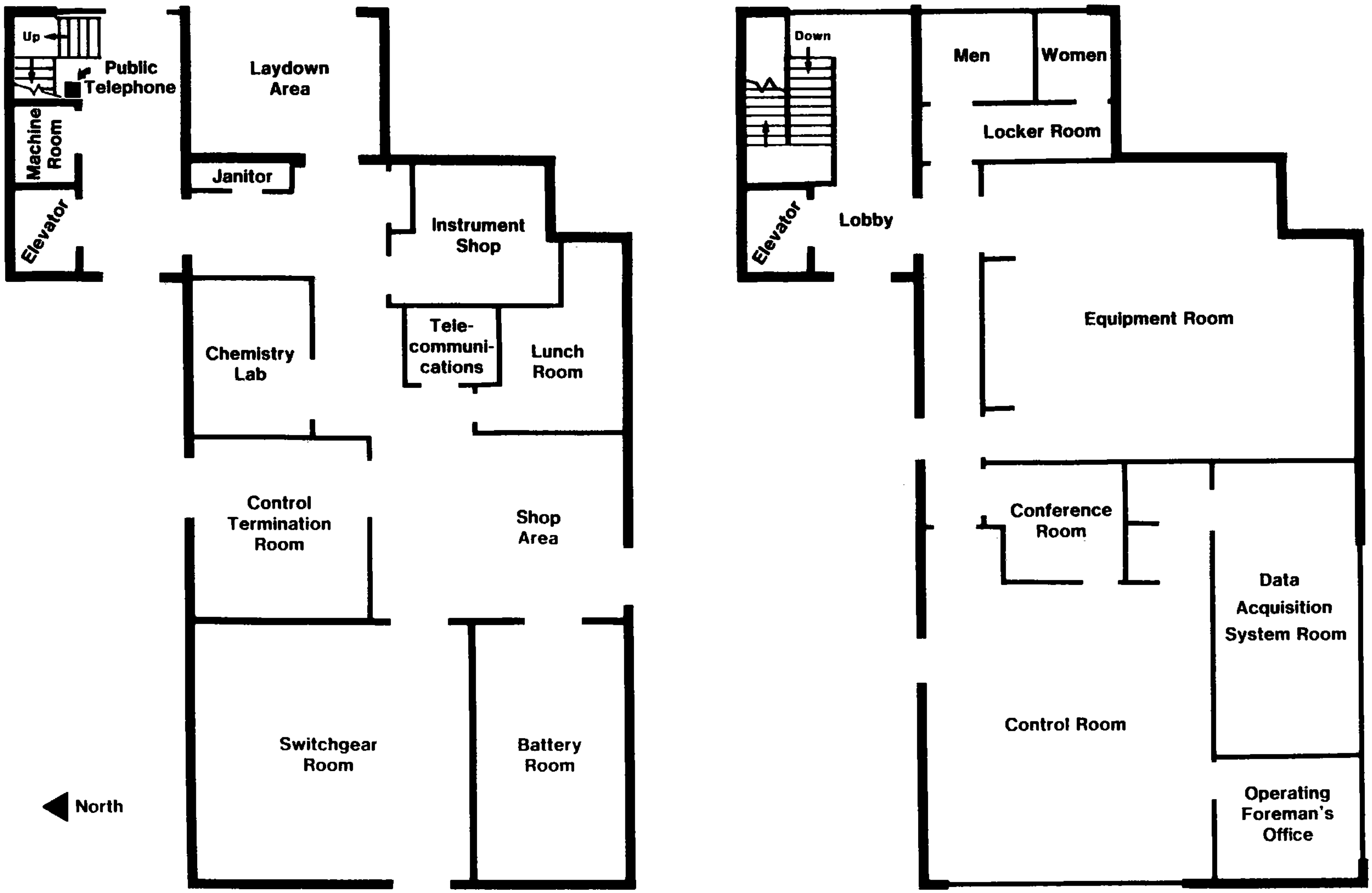
1. Equipment Room: The four computer systems and their hardware are installed in this room.
2. Conference Room: For visitors and conferences containing windows looking into the Equipment Room and the Control Room.
3. Control Room: The control operators are stationed in this room with computer terminals to operate the plant.
4. Operating Foreman's Office: For the designated chief operator of the plant.
5. Data Acquisition System Room: Project participants, DOE and other contractors, can receive operational information on the plant from computer terminals installed in this room.

II. Specific Description of Computer System

A. There are four MODCOMP (Modular Computer Company) computers installed at the plant. Two control the heliostats, one controls the plant, the other monitors the plant.

1. Beckman Instruments provided the System Distributed Process Controlliers and corresponding peripheral equipment.
2. McDonnell Douglas is the control system integrating contractor and together with the Southern California Edison Company provided the control logic (equations) to tell the computer how to run the pumps, valves, etc. (the plant excluding the heliostats).
3. Martin Marietta provided the control logic to run the heliostats.

CONTROL BUILDING LAYOUT



FIRST FLOOR PLAN

SECOND FLOOR PLAN

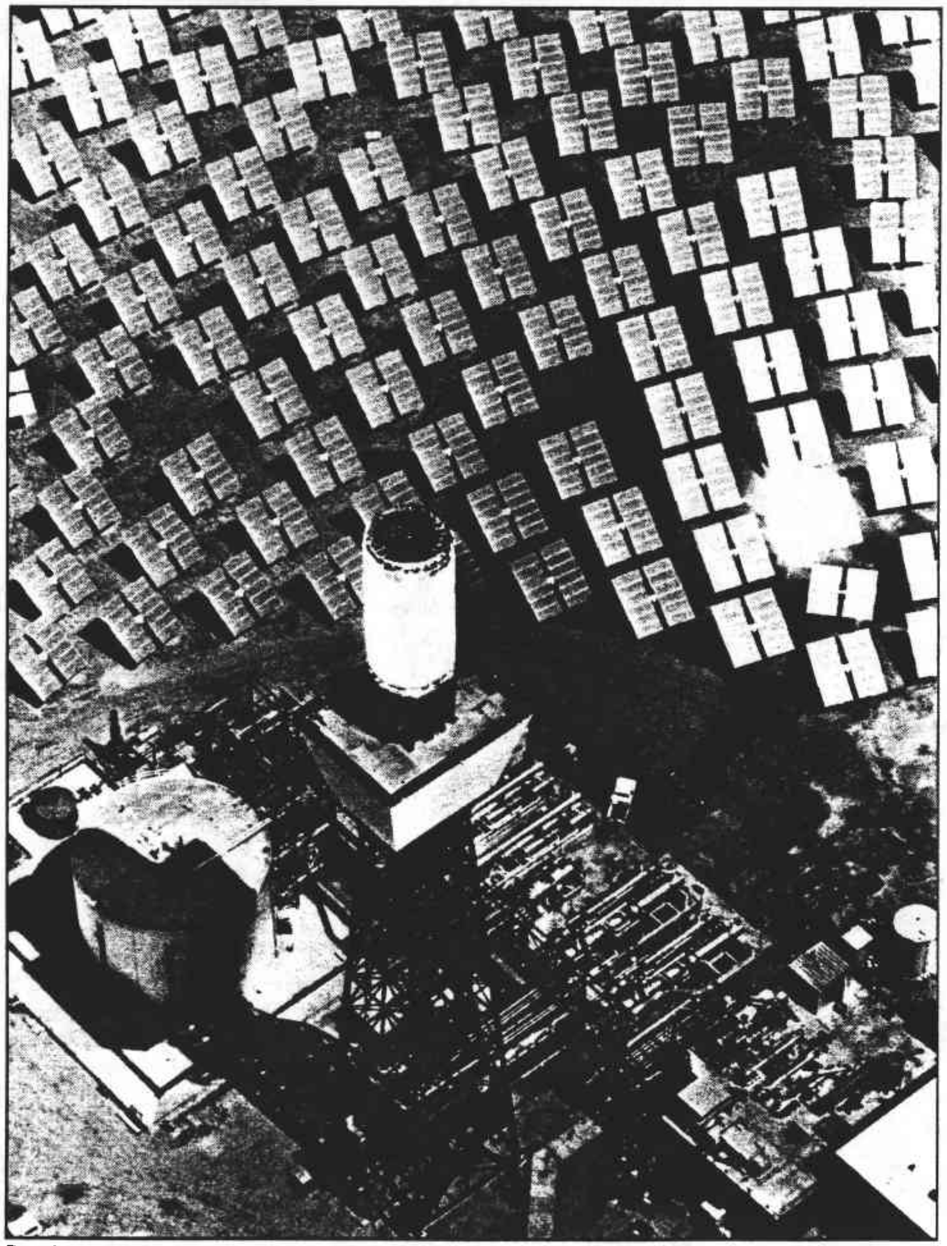
Solar One Start-up

On April 12, 1982, at 3:09 p.m., the Solar One turbine/generator was synchronized to the SCE system for the first time, marking the dawning of a new age of electrical power generation. Since that time, over 828,000 kWh have been generated. On May 19, 1982, just five weeks after turbine roll, Solar One produced 56,600 kWh for a new daily record.

Start-up of the plant has been characterized by the lack of significant problems and a successful demonstration of the control system. The computer control systems have operated much better than expected and equipment failure has been minimal. Major problems during start-up have included cloudy weather and water chemistry. The receiver (a once-through boiler) has stringent water chemistry requirements (*e.g.*, 10 ppb iron, 2 ppb sodium, 2 ppb choride, etc.). This, coupled with extensive complicated piping systems and delays caused by weather, has made water clean-up difficult.

Since turbine roll, receiver steam tests have continued in parallel with power generation and commissioning of the thermal storage system (TSS) and the beam characterization system (BCS).

Test schedules have been worked out so power production is "piggy backed" on receiver steam testing. TSS activation was delayed because a leak in the tank floor was discovered. The leak was caused by a defect in the floor plate when it was manufactured. The leak was repaired and the TSS has been fully charged to 575°F and a thermocline is now evident. The thermocline (sharp break in oil temperature) occurs over approximately a five-foot height difference within the tank. On August 24, 1982, steam generated from the TSS rolled the turbine to 3.4 MW while synchronized to the grid.



Receiver glows brilliantly atop the 300-foot tower from sunlight reflected by hundreds of heliostats shown as test operations began early in April. Ground facilities, left to right, include the thermal storage tank (in shadow of tower), thermal storage system heat exchangers (behind and to right of tower), turbine-generator deck and the control building (lower right).

In mid-July, the Department of Energy (DOE) authorized weekend power production. SCE operators, under the observation of DOE, Sandia, and McDonnell Douglas operated the turbine/generator on weekends to generate electricity. On the third weekend of operation, a new record of 60,738 kWh was generated over 8-½ hours of operation.

The BCS, which serves as an aid for identifying heliostats that need maintenance, has been placed in operation. This system allows operators to check individual heliostat focus, aim point, and power across the beam automatically. The computer software will move heliostats that may block the beam of the mirrors being examined. Therefore, the heliostat being checked has an unobstructed view of the BCS target located just below the receiver on the tower.

Receiver steam tests are essentially completed, however evaluation of the tests remain. These tests have demonstrated the receiver control system's capability over a wide range of operation up to rated conditions of 960°F and 1465 psi. Normal operation of a power generation boiler is similar to piloting a large ship where the control system's response is generally very slow. The Solar One receiver consists of 24 individual boiler panels that can respond very quickly and operation is more like driving a "Ferarri".

Instead of the traditional power plant control system that utilizes meters, gauges, and switches, the Solar One computer control system utilizes a CRT console and keyboard. Operators can "call up" displays that show live on-line schematic diagrams of the plant's systems. The operators can simply use a light pen to identify valves and circuit breakers and operate them from the control console keyboard. In addition, the system has the flexibility to plot component information (*e.g.*, pressures, flows, temperatures, etc.) which serves as an aid to the operators.

Operator acceptance of the new computer system has been very positive. The training program, conducted by McDonnell Douglas utilizing a simulation

(Continued on page 6)

PREPARED BY RESEARCH & DEVELOPMENT AND THE CORPORATE COMMUNICATIONS DEPARTMENT.
SOUTHERN CALIFORNIA EDISON COMPANY, ROOM 492, GENERAL OFFICE, ROSEMEAD.

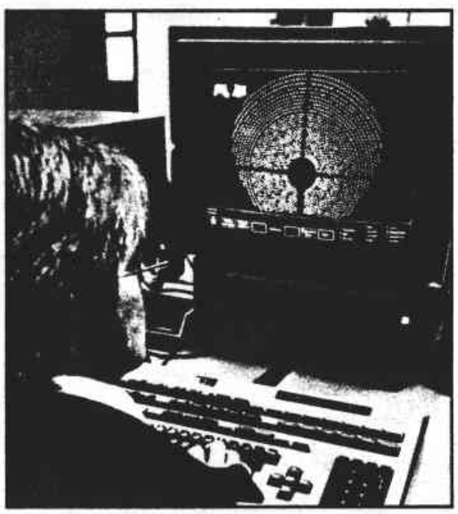
Solar One, cont'd.

laboratory, was very successful. Operators were able to understand system control functions and contribute from the very beginning of the start-up period. This demonstration of competence led to the early implementation of weekend operation.

The collector system, consisting of 1,818 heliostats, has operated without major problems. Because of a lack of funds, heliostat maintenance, including washing, was deferred. In late July, however, the reflectivity of heliostats had degraded to a point where a wash program was required. A random sample of heliostat reflectivity indicated that the original (clean) 91% reflectivity had degraded to approximately 72%. An experimental wash program was instituted using an existing SCE substation insulator wash truck in an attempt to upgrade the power level of the collector field. SCE operators developed a technique using pressurized demineralized water to rinse off the heliostats and brought the reflectivity back up to a high level. Approximately one minute is required to wash a heliostat.

Normally, heliostats are *awakened* prior to sunrise and moved from the stow position (mirror face down) to the standby position adjacent to the receiver. The ball of sunlight moves from the focal point below ground level to the standby position in about six minutes. A series of ground and air beam safety tests have been conducted to verify the safety criteria in effect at the plant. Preliminary results have indicated that light intensity approximating 28 suns is present at ground level during a short period when the heliostats are making a transition from stow. Measurements have also been made to determine the level of intensity of the receiver when it is reflecting sunlight. Although the receiver appears to be glowing brightly, the level of reflected light is considerably less than the brightness of the sun when the receiver is operating at its maximum rating.

A spectacular display of light is evident when dust or moisture in the air is lit by hundreds of heliostats at Solar One. The world's largest solar-powered electrical generating station began "startup" tests early this spring and recently generated its first electric power. Each morning, heliostats reflecting the sun's rays are first focused on "stand-by" points, and then moved onto the receiver to create steam to operate the turbine-generator below.

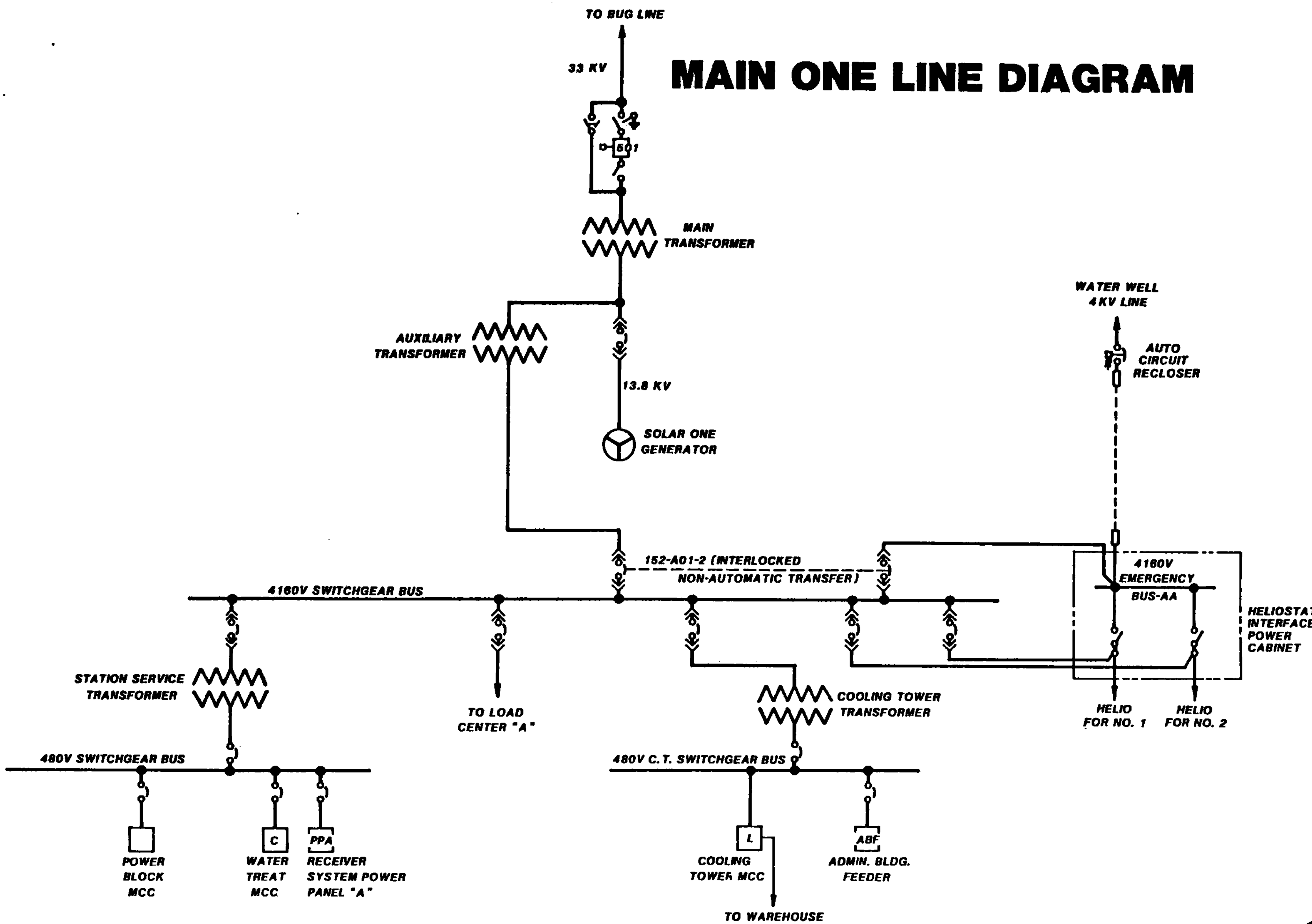


Solar One's 1,818 heliostats, which continuously track the sun, are automatically controlled by a computer. Edison operators, working in conjunction with government personnel from the San Francisco Operations Office of the Department of Energy and Sandia Laboratories, Livermore, California, will conduct extensive test operations over the next several months.

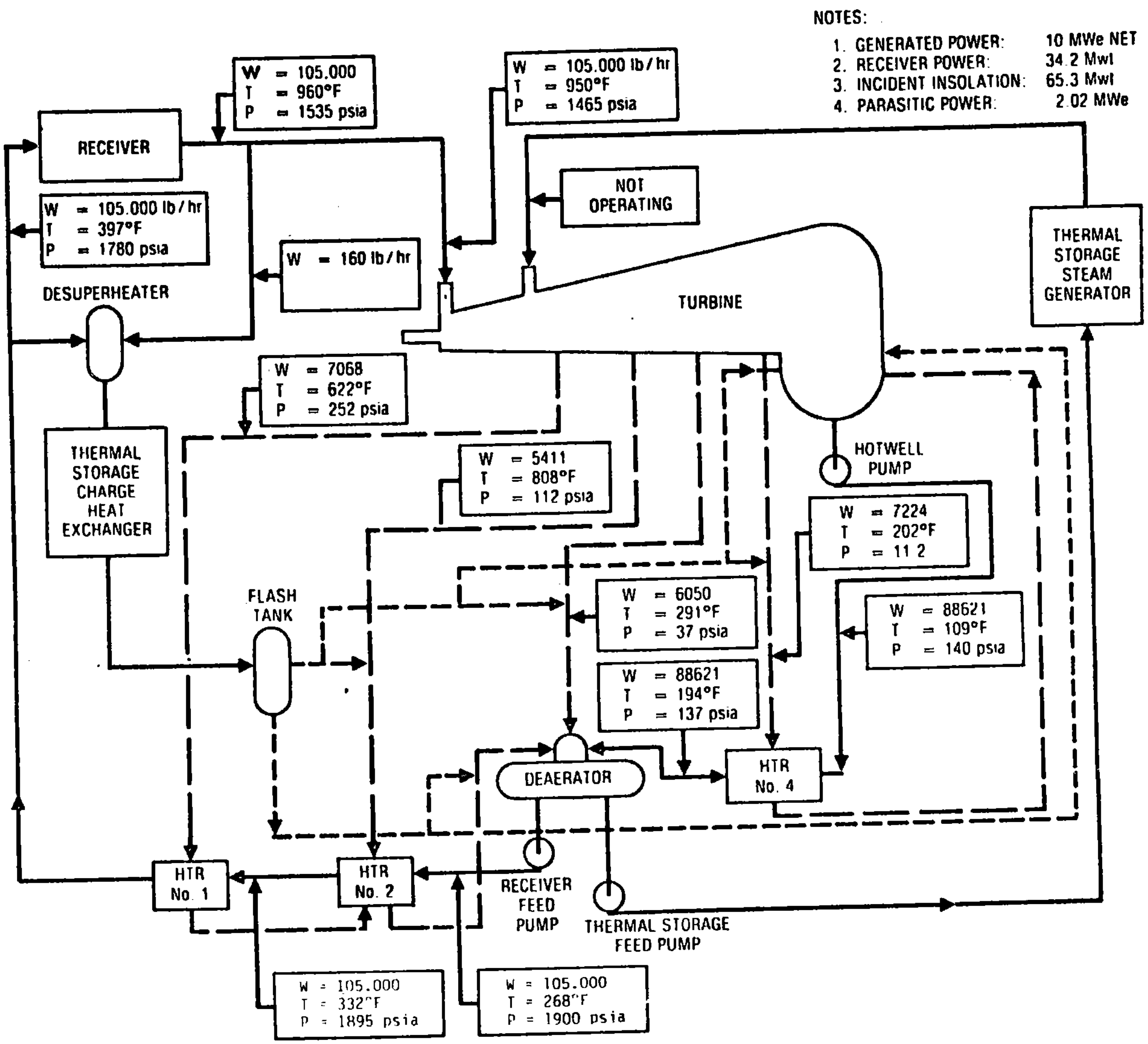
Three major equipment failures have occurred and can be attributed to the unique operational requirements of the plant. In a normal power plant, systems are turned on and run for extensive periods of time to maximize kWh output and to minimize thermal cycling of equipment. At Solar One, systems are started up and shut down everyday which places extreme thermal stresses on equipment. This has resulted in warpage of receiver boiler panel #5, failure of the main steam drag valve, and has caused numerous leaks in the receiver and thermal storage systems. Start-up procedures and equipment have been modified to minimize the thermal stress. Additionally, consideration is being given to operate the TSS at low levels all night to keep systems at near-normal temperatures ready for resumed full operation at sunrise.

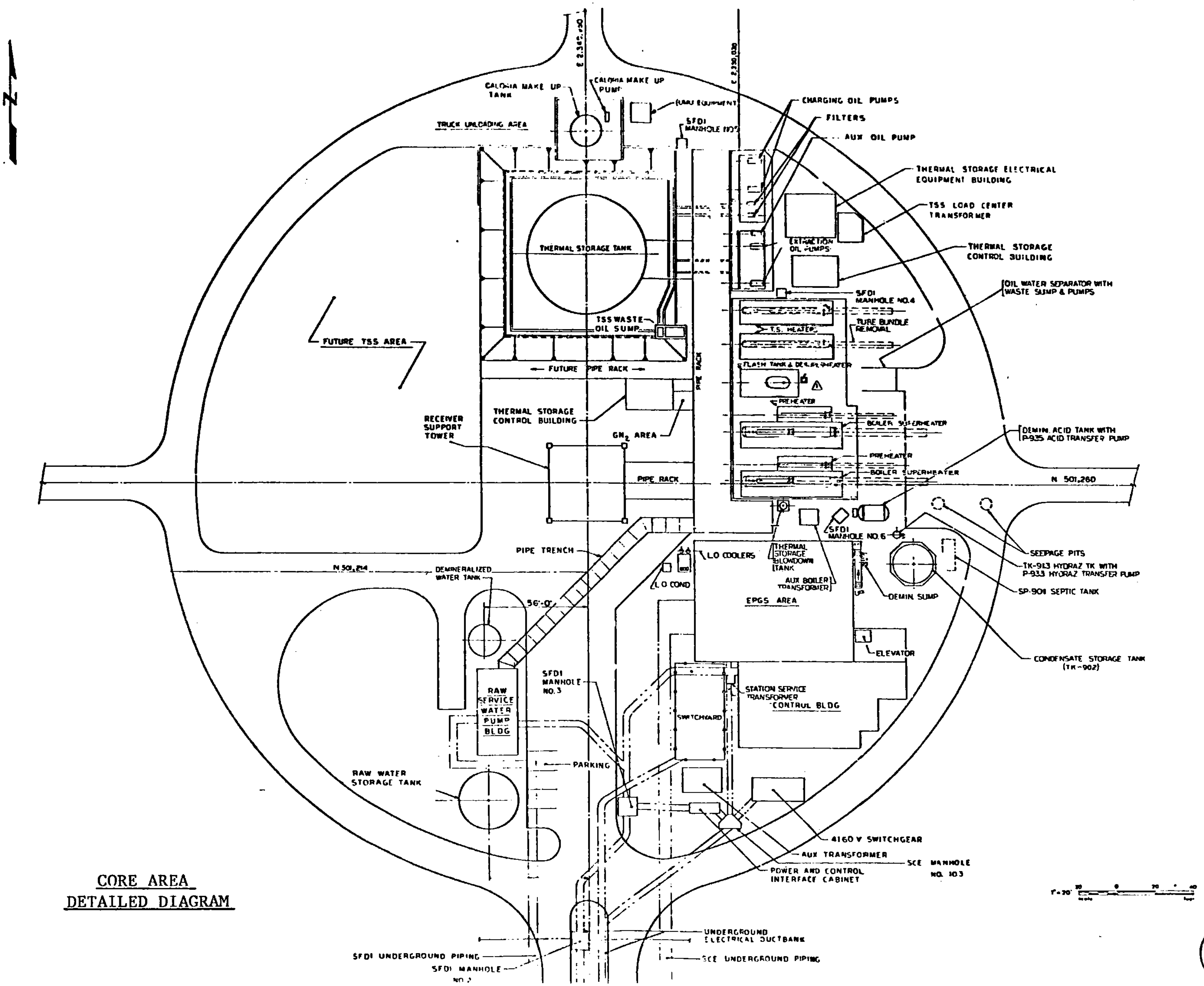
The five-year test program is well underway and the pilot plant has demonstrated that the central receiver concept works as expected. The first two years of the test program will be devoted to design verification of the individual systems and components and demonstration of the various modes of operation. Additionally, controls will be updated so the plant can be operated with a minimum operating staff and the collector system will be integrated into the overall control system. The last three years of the program will maximize kWh output and demonstrate plant reliability.

MAIN ONE LINE DIAGRAM



STEAM FLOW DIAGRAM

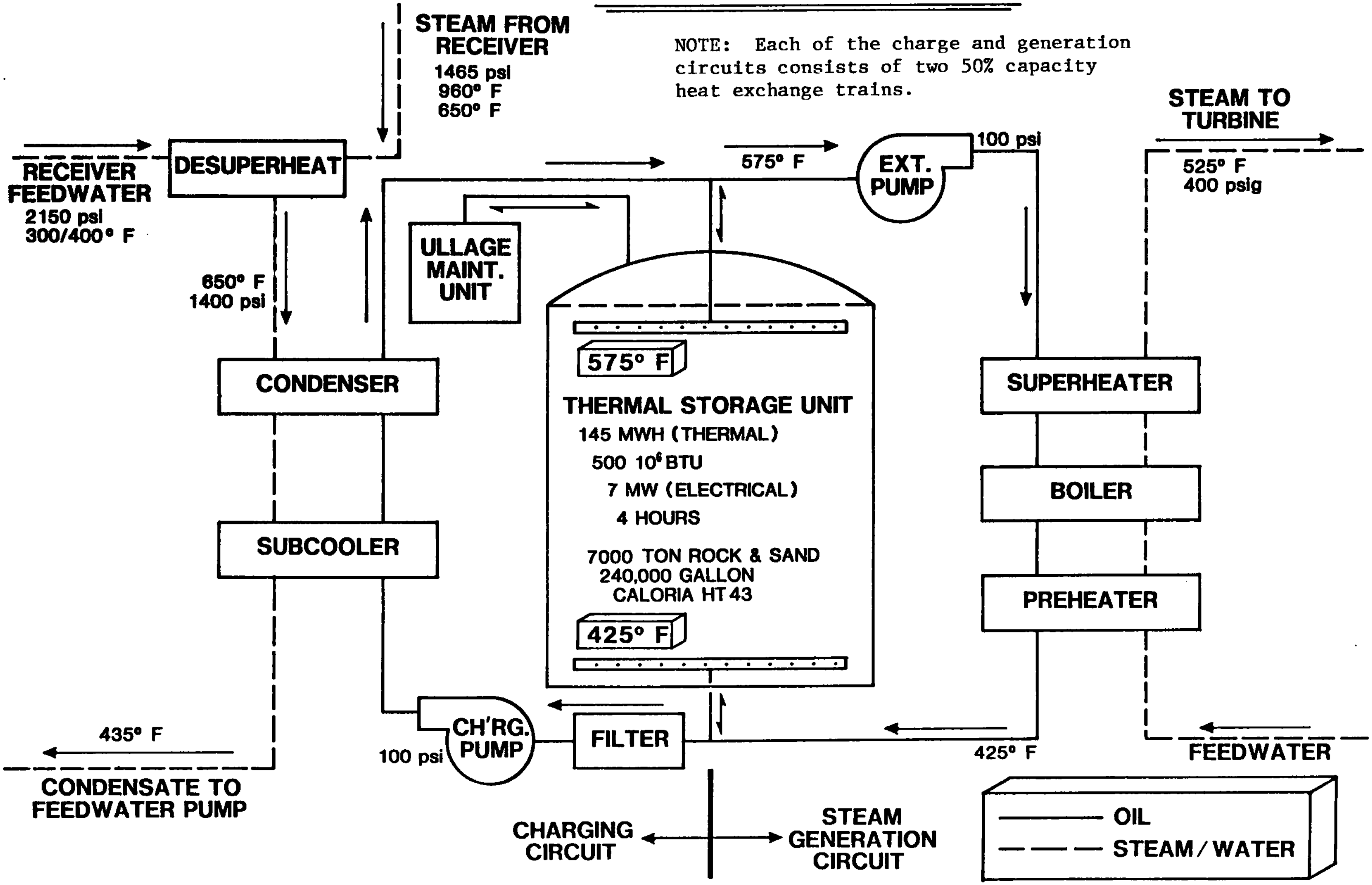




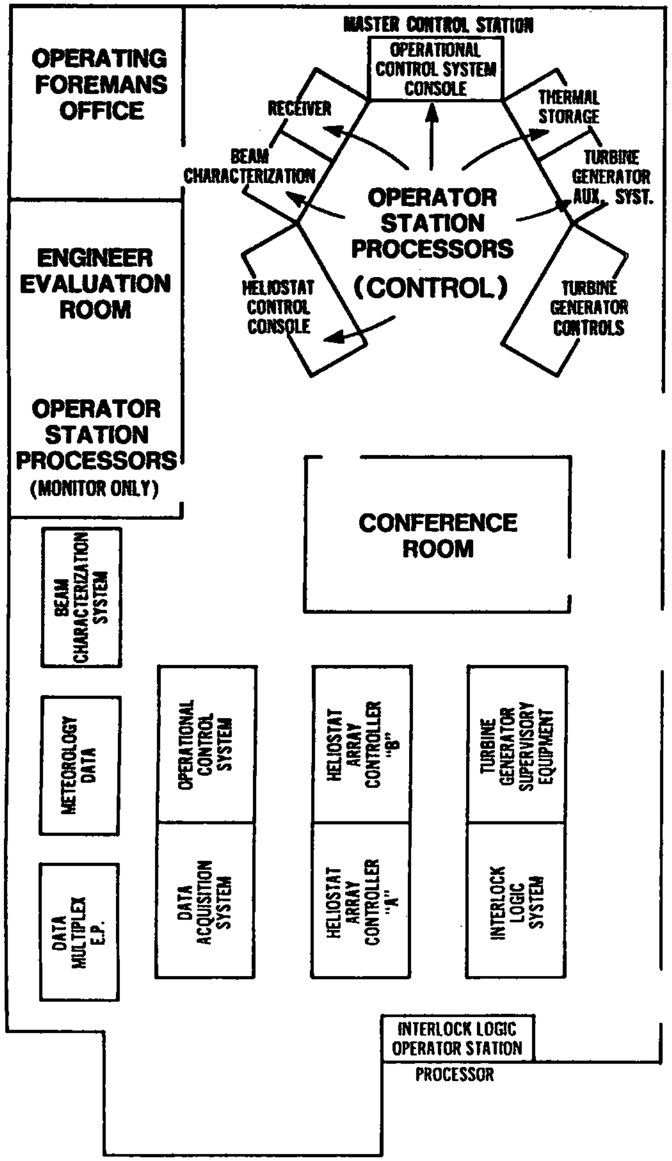
CORE AREA
DETAILED DIAGRAM

THERMAL STORAGE SYSTEM

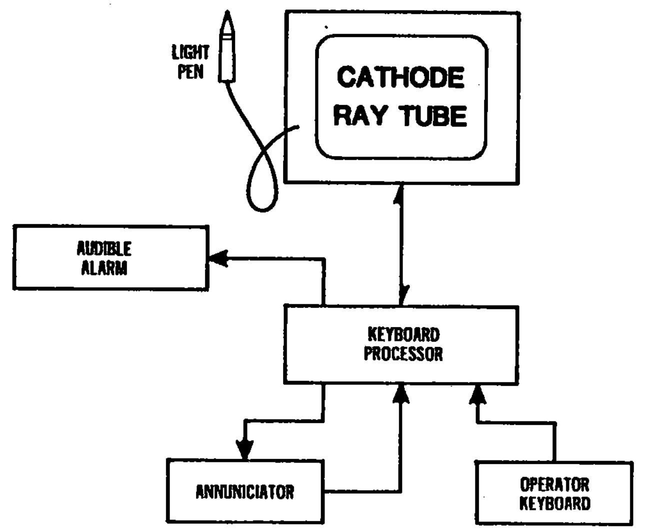
NOTE: Each of the charge and generation circuits consists of two 50% capacity heat exchange trains.



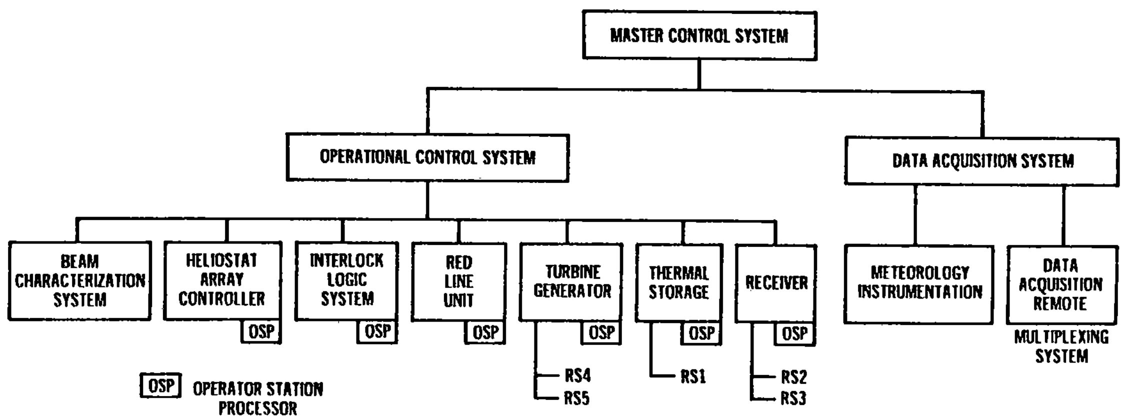
SOLAR ONE GENERATING STATION



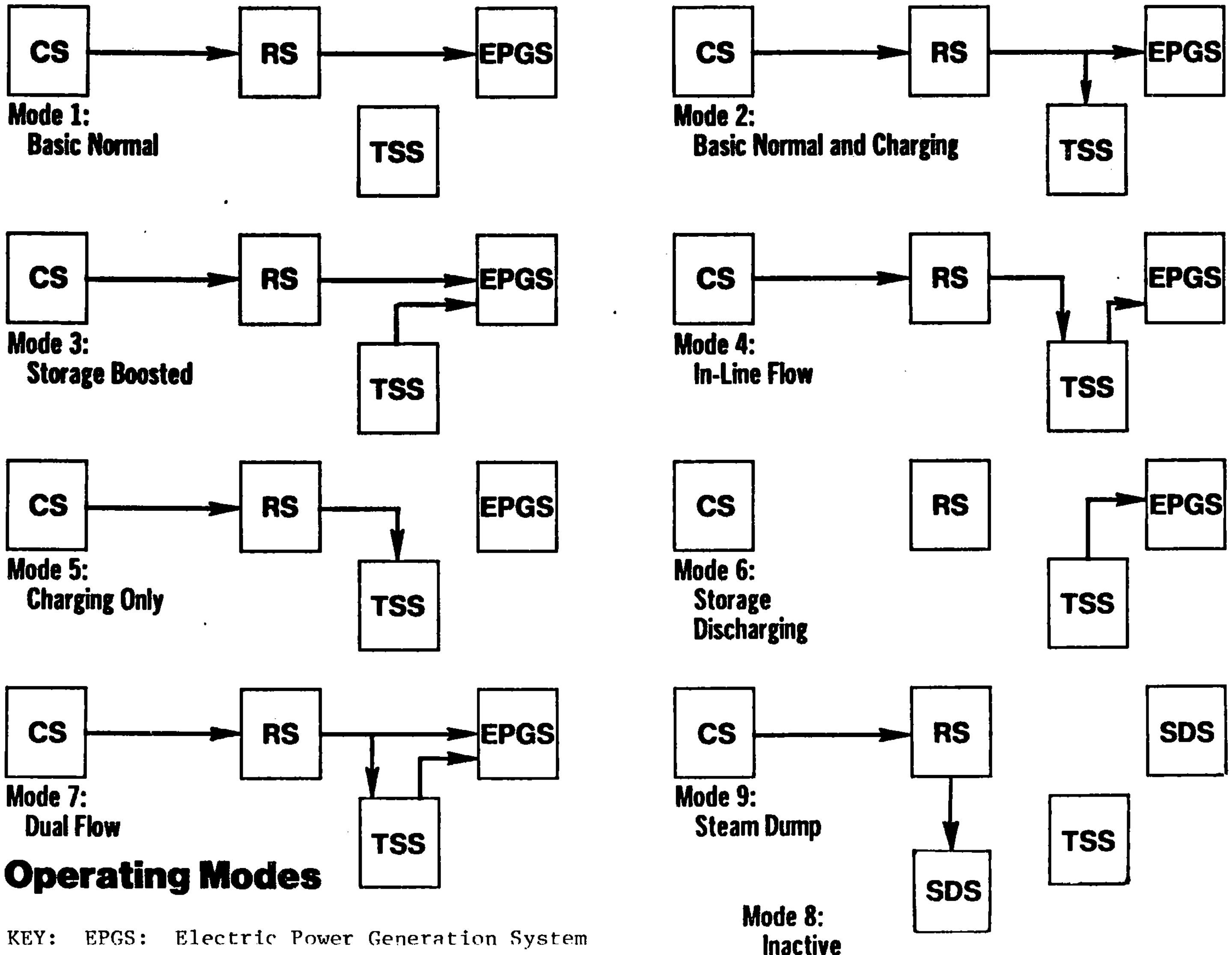
MASTER CONTROL SYSTEM PHYSICAL LAYOUT



TYPICAL OPERATOR STATION PROCESSOR



MASTER CONTROL SYSTEM HIERARCHY



Operating Modes

KEY: EPGS: Electric Power Generation System
TSS: Thermal Storage System
SDS: Steam Dump System
CS: Collector System
RS: Receiver System

DOE F 1325.8
(7-79)

U.S. DEPARTMENT OF ENERGY

memorandum

DATE OCT 2 1 1983

REPLY TO ATTN OF S. D. Elliott, Jr., Director, DOE Site Office, Daggett, CA

SUBJECT Submission of Three Reports under Cooperative Agreement DE-FC03-77SF10501 for Patent Clearance, DOE/SAN Mail & Records and DOE/TIC Distribution

TO Don Holz, Technical Information Coordinator, DOE/SAN (ISEA)
Roger Gaither, DOE/SAN (OPC)
DOE/SAN Mail File & Records (ISEA)
DOE/TIC - Document Control

Attached are three copies each of three reports prepared by Southern California Edison Company under the Subject Cooperative Agreement:

- DOE/SF/10501-TR01 (STMPO-091) - Wildlife Interactions...Spring 1982
- DOE/SF/10501-TR02 (STMPO-603) - Wildlife Interactions...Fall 1982
- DOE/SF/10501-~~FS01~~ 303 (STMPO-602) - Fact Sheet: Solar 10-MWe Pilot Plant (Rev. 2)

One copy of each report, accompanied by SAN Form 70, is for processing by OPC; following patent clearance, this copy is to be deposited in Mail & Records in the contract file for Cooperative Agreement DE-FC03-77SF10501.

Two copies of each report, accompanied by DOE Form RA-426, are to be forwarded to TIC for routine announcement and distribution to Subject List UC-62 under the indicated Report Number DOE/SF/10501-XXxx. (The report number suffix identifies the various classes of documents generated under this Cooperative Agreement and the serial document number in each class, viz: (OMxx = Operation & Maintenance Report; VC = Visitor's Center Report; TR = Topical Report; FS = Fact Sheet; etc.) The Secondary Report Number (STMPO-xxx) identifies the report in a serial sequence among all reports produced over the life of the 10-MWe Pilot Plant Project, as well as selected background reports; this STMPO-xxx designation will be used as the primary Report Number for reports generated by the DOE Project Office. A Bibliography of STMPO reports 001 through -555 is in final preparation and will be provided to ISEA and TIC for reference when it becomes available at the end of 1983. An update to the Bibliography will be issued at the end of 1984, covering Reports STMPO-600 and subsequent issues.

Please call on me at the Site Office, P.O. Box 366, Daggett, CA 92327 ((619) 254-2672) for any clarification or further information you may require.

S. D. Elliott, Jr., Director,
DOE Project Office, Barstow

cc: Sunny Cherian, DOE/HQ (CE-314)
Bob Hughey, DOE/SAN (FGS)
Paul Skvarna, SCE R&D
Duncan Tanner, SNLL 8452
Mary Soderstrum (Burns & McDonnell)

DEPARTMENT OF ENERGY
SAN FRANCISCO OPERATIONS OFFICE

CONTRACTOR REQUEST FOR PATENT CLEARANCE
FOR RELEASE OF UNCLASSIFIED DOCUMENT

Prime Contract No.	DE-FC03-77SF10501
Subcontract No.	
Report No.	DOE/SF/10501-FS01 (STMPO-602)
Date of Report	May, 1983
Name & Phone No. of DOE Technical Representative	S. D. Elliott, Jr. (619) 254-2672

TO: (1) Roger S. Gaither, Asst. Chief for Prosecution
Office of Patent Counsel/Livermore Office
P.O. Box 808, L-376
Livermore, California 94550

(2) DOE/SAN Mail & Records; File SF10501

FROM: 10-MWe Central Receiver Solar Thermal Pilot
'Plant Project Office
Post Office Box 366
Daggett, CA 92327

1. Document Title:
FACT SHEET: SOLAR 10-MWe PILOT PLANT (26 pp.); rev. 2, May, 1982; prepared by: Solar One Visitor Center

2. Type of Document: ☐ Technical Report, ☐ Conference Paper, ☐ Journal Article, ☐ Abstract or Summary, ☐ Copy of Oral Presentation, XX Other (please specify): Visitor Information Summary

3. In order to meet a publication schedule or submission deadline, patent clearance by (routine) would be desired.

SENDER IS TO CHECK BOX #4 OR #5 BELOW.

XX 4. I have reviewed (or have had reviewed by technically knowledgeable personnel) this document for possible inventive subject matter (Subject Inventions) and that no inventions or discoveries (Subject Inventions) are deemed to be disclosed in this document except as stated below:

a. Attention should be directed to pages ________ of this document.

b. This document describes matter relating to an invention:

i. Contractor Invention Docket No. ________.
ii. A disclosure of the invention was submitted to DOE on ________ (date)
iii. A disclosure of the invention will be submitted shortly ________ (approximate date)
iv. A waiver of DOE's patent rights to the contractor:
☐ has been granted, ☐ has been applied for; or ☐ will be applied for ________ (date)

☐ 5. This document is being submitted, but no review has been made of this document for possible inventive subject matter.

6. Remarks: (Please return Sender's Copy to DOE Tech. Rep. at above address)

Reviewing/Submitting Official: Name (Print/Type) Paul E. Skvarna
Title SCE R&D Site Manager
Signature ________ Date Oct. 20, 1983

TO: INITIATOR OF REQUEST

FROM: ASSISTANT CHIEF FOR PROSECUTION
Office of Patent Counsel/Livermore Office

☐ No patent objection to above-identified release.

☐ Please defer release until advised by this office.

Signed ________ Date Mailed ________

DOE Form RA-426
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U.S. DEPARTMENT OF ENERGY

OMB NO. 038-R0190

DOE AND MAJOR CONTRACTOR RECOMMENDATIONS FOR ANNOUNCEMENT AND DISTRIBUTION OF DOCUMENTS

See Instructions on Reverse Side

1. DOE Report No. DOE/SF/10501-FS01
2. Contract No. DE-FC03-77SF10501
3. Subject Category No. UC-62
4. Title
FACT SHEET: SOLAR 10-MWe PILOT PLANT
5. Type of Document ("x" one)
[X] a. Scientific and technical report (PROJECT SUMMARY FOR TECHNICAL VISITORS)
☐ b. Conference paper: Title of conference ______
Date of conference ______
Exact location of conference ______ Sponsoring organization ______
☐ c. Other (specify planning, educational, impact, market, social, economic, thesis, translations, journal article manuscript, etc.)
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☐ b. Copies being transmitted for special distribution per attached complete address list.
☐ c. Two completely legible, reproducible copies being transmitted to DOE–TIC. (Classified documents, see instructions)
☐ d. Twenty-seven copies being transmitted to DOE–TIC for TIC processing and NTIS sales.
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Make available only ☐ b. To U.S. Government agencies and their contractors. ☐ c. within DOE and to DOE contractors.
☐ d. within DOE. ☐ e. to those listed in item 13 below.
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☐ a. Preliminary information. ☐ b. Prepared primarily for internal use. ☐ c. Other (Explain)
10. Patent, Copyright and Proprietary Information
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Has an invention disclosure been submitted to DOE covering any aspect of this information product? [X] No ☐ Yes
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[X] b. Document has been sent to responsible DOE patent group for clearance. DOE/SAN OPC
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14. Submitted by (Name and Position) (Please print or type)
S. D. Elliott, Jr., Director
Organization
DOE Solar One Site Office, P.O. Box 366, Daggett, CA 92327; ph. (619) 254-2672
Signature [signature] Date 21 October, 1983

DEPARTMENT OF ENERGY
SAN FRANCISCO OPERATIONS OFFICE

CONTRACTOR REQUEST FOR PATENT CLEARANCE
FOR RELEASE OF UNCLASSIFIED DOCUMENT

Prime Contract No.	DE/FC03-77SF10501
Subcontract No.	
Report No.	DOE/SF/10501-FS01 (STMPO-602)
Date of Report	May, 1983
Name & Phone No. of DOE Technical Representative	S. D. Elliott, Jr. (619) 254-2672

TO: (1) Roger S. Gaither, Asst. Chief for Prosecution
Office of Patent Counsel/Livermore Office
P.O. Box 808, L-376
Livermore, California 94550

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Reviewing/Submitting Official: Name (Print/Type) Paul E. Skvarna
Title SCE R&D Site Manager
Signature *Paul E. Skvarna* Date Oct. 20, 1983

TO: INITIATOR OF REQUEST

FROM: ASSISTANT CHIEF FOR PROSECUTION
Office of Patent Counsel/Livermore Office

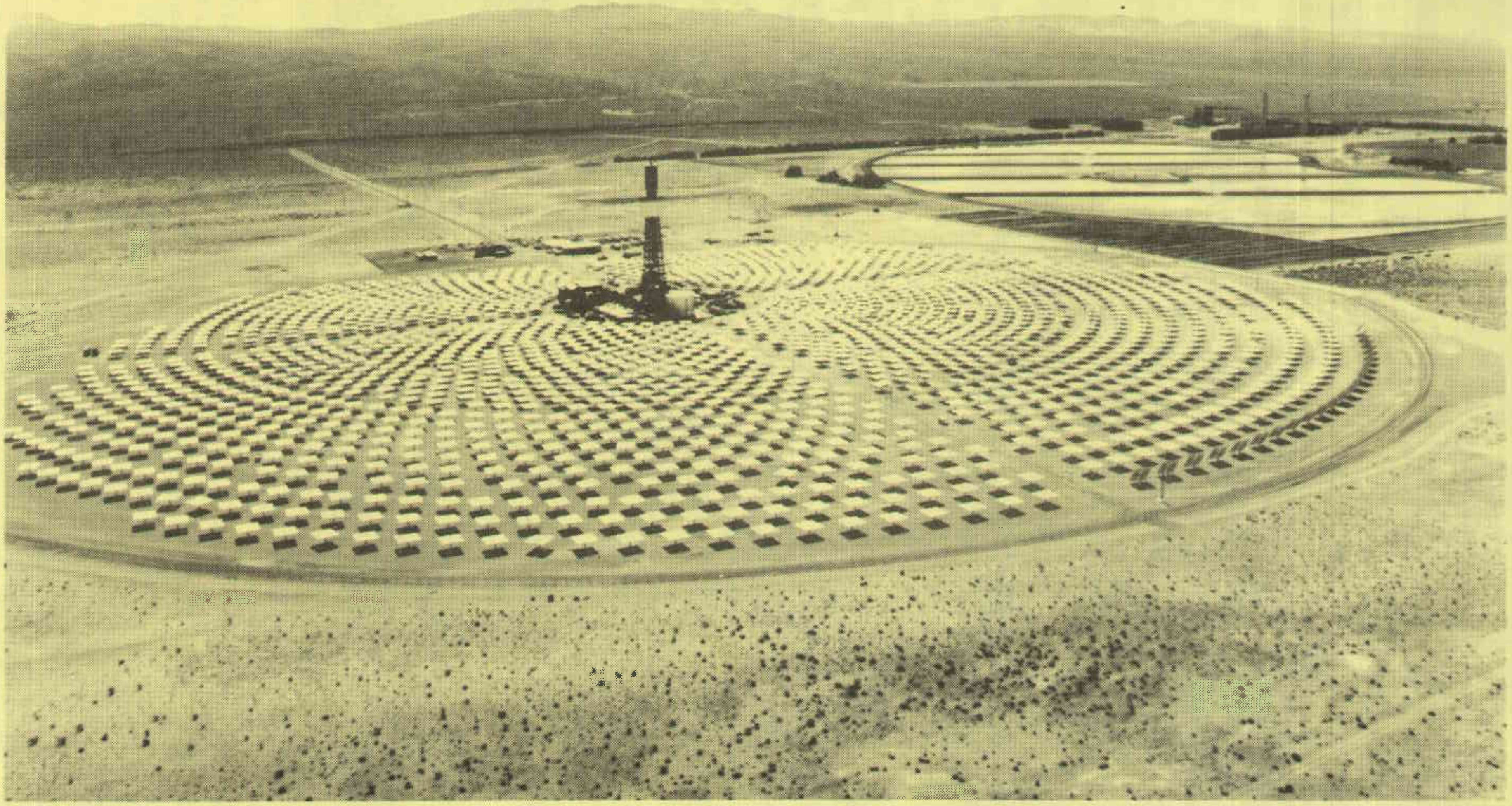
☒ No patent objection to above-identified release.

☐ Please defer release until advised by this office.

Signed *Harold M. Dixon* Date Mailed 11/4/83

COPY FOR CONTRACTOR'S (SENDER'S) FILES AFTER OPC RELEASE

SOLAR 10-MWe PILOT PLANT



DOE FILE COPY

Prepared by: Solar One Visitor Center,
P. O. Box 325, Daggett, California 92327
Phone: 714-254-2810

Revision No. 1 dated May, 1982

TABLE OF CONTENTS

SOLAR 10 MWe PILOT PLANT

I. General Statistics

A. Participants and Cost Figures:

SOLAR ONE COST FIGURES (ESTIMATED)

Item	Department of Energy	Southern Calif. Edison	L.A. Dept. of Water & Power	Calif. Energy Commission	Total
Construction of Solar Portion: heliostats, tower, thermal storage, master control	$120,000,000	$	$	$	$120,000,000
Construction of Non-Solar Portion: electrical generation equipment		17,840,000	3,660,000		21,500,000
Participant Services:					
Land		250,000			250,000
Plant integration and startup; technical support and plant operating procedures		520,000	130,000		650,000
Project reviews and information dissemination		964,000	241,000	800,000	2,005,000
TOTAL CONSTRUCTION COSTS	$120,000,000	$ 17,840,000	$ 3,660,000	$	$141,500,000
TOTAL PARTICIPANT SERVICES		1,734,000	371,000	800,000	2,905,000
TOTAL COSTS	$120,000,000	$ 19,574,000	$ 4,031,000	$ 800,000	$144,405,000

(NOTE: Operation and Maintenance cost figures are now being calculated and negotiated and will be available at a later date.)

B. Major Contractors:

1. Martin Marietta — Heliostats
2. McDonnell Douglas — Master Control, System Design Integration
3. Stearns-Roger — A/E Services
4. Rocketdyne of Rockwell Int'l. — Receiver, Thermal Storage
5. Townsend and Bottum — Construction Manager
6. General Electric — Turbine Generator

C. Project Schedule:

1. Start Site Construction — September 1979
2. Information Center Completed — July 1980
3. Turbine Roll and Initial Operating Date — April 12, 1982
4. Two Year Experimental Test Phase — 1982 - 1984
5. Three Year Power Production Phase — 1984 - 1987

II. Specific Statistics:

A. Plant Rating:

1. 10 MWe for 7.8 hours - summer solstice
2. 10 MWe for 4 hours - winter solstice
3. 7 MWe for 4 hours from Thermal Storage

B. Geographic Features:

1. Minimum temperature: January - 10°F (-12.2°C); July - 73°F (23°C)
2. Maximum temperature: January - 60°F (16°C); July - 115°F (46.1°C)
3. Latitude: 34.86 degrees North
4. Longitude: 116.83 degrees West
5. Elevation: 1946 feet above mean sea level
6. Approximately 3600-4000 hours of sunlight per year or 9.8-10.9 hours per day.

C. Size of Plant:
1. 1900 feet from north to south.
2. 2500 feet from east to west.
3. 130 acres: 72 acres for the heliostat field; 58 acres for the power plant, control and administration buildings, construction laydown area and miscellaneous smaller areas.

D. Power to the Grid:
1. Maximum power to the grid:
   a. 10.8 MWe (Operating Mode 1)
   b. 12.5 MWe gross; 1.7 MWe parasitic
2. Maximum estimated daily energy:
   a. 112 MWe/hr - June 21
   b. 48 MWe/hr - December 21
3. Annual estimated energy generation:
   a. 26,000 MWe/hr - 365 day operation

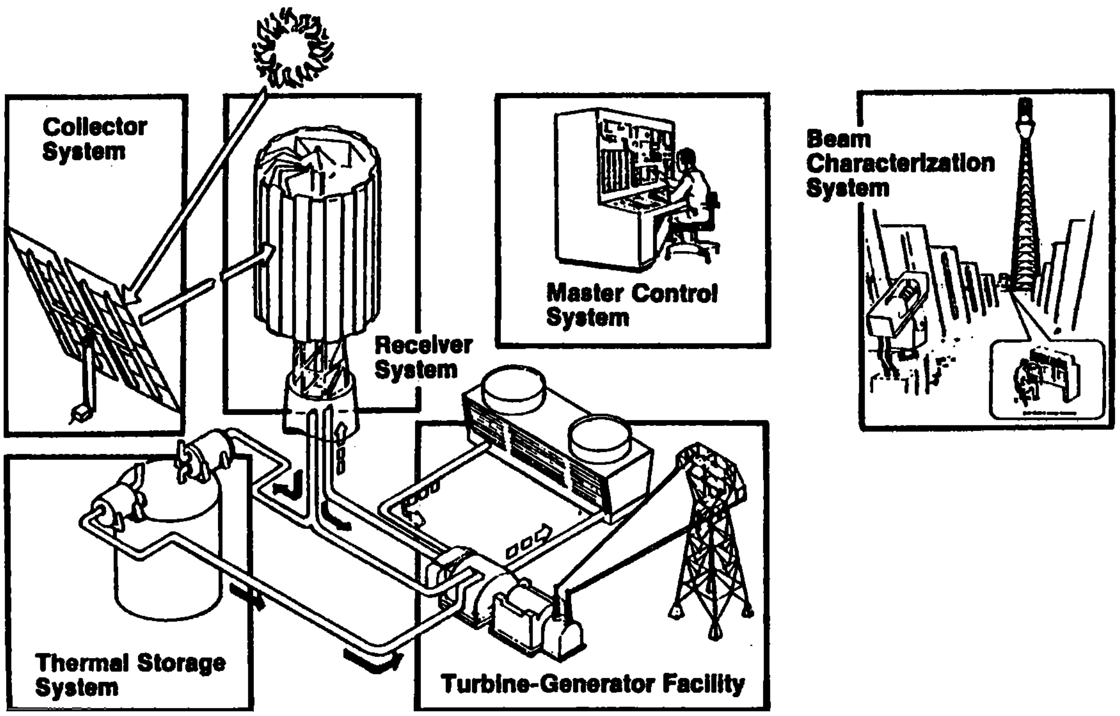
E. Gross Plant Efficiency:
1. 17.4% - Noon on June 21
2. 15.4% - 2 PM on December 21.

F. Water Usage: Approximately 220 acre feet of water per year for pilot plant operation and heliostat washing. Annual receiver makeup - 2 GPM; cooling tower - 22 GPM blowdown and 71 GPM evaporation.

G. Use of Electricity: 20% of electrical energy will go to the Los Angeles Department of Water and Power with 80% to Southern California Edison.

III. Operating Description:

Sunlight strikes the heliostat field and is reflected on a tower-mounted receiver/boiler which absorbs the heat and converts water to steam. The steam is directed to a conventional turbine generator which produces electrical power. During periods when excess steam is available, it is routed to the thermal storage tank and later extracted during periods when sufficient sunlight is not available. After use, the steam is condensed back to water so that it can be recycled to the tower to be reconverted back to steam.



HELIOSTAT

I. General Statistics

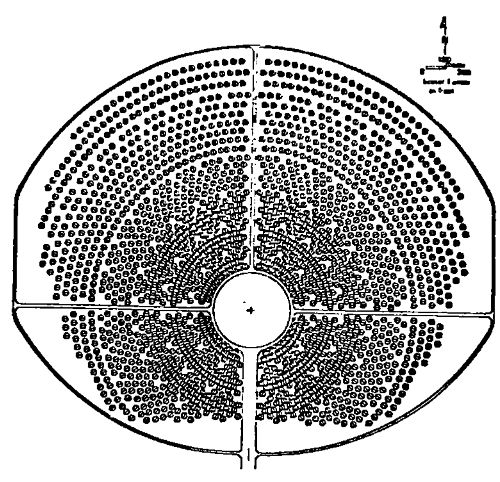
A. Total heliostats in field: 1,818 (578 in south field and 1,240 in north field). See drawing below.
B. Heliostat measurements: 22'6" X 22'7" consisting of 12 mirror panels each measuring 120.3 inches long by 43.3 inches wide or 3'6" X 10'.
C. Slightly concave: Approximately 1,000 foot focal length (1/6" curvature in 10 foot length).
D. Reflective area: 430 square feet or 39.9 square meters.
E. Weight total: 4,132 total lbs. or 2,546 lbs. for the rack assembly, 923 lbs. for the drive mechanism, 601 lbs. for the support pedestal and 62 lbs. for the cable and electronics.
F. Global rotation: Azimuth ± 270° and Elevation ± 95°.
G. Cost: $15,000 each (approximately).
H. Efficiency rating: 90%.
I. Life expectancy: 30 years.
J. Cleaning procedure: Heliostats are turned to a 45° angle during rain storms.

II. Specific Statistics

A. Mirrors: Each panel consists of a second surface (silver backing) glass mirror bonded to an aluminum honeycomb core (2½" thick). This core is bonded to a steel enclosure pan and sealed with an environmental edge seal. The heliostats are turned in a stow position (or mirror surface down) when the winds exceed 36 mph and during adverse weather conditions. They are capable of withstanding 50 mph winds in the vertical position and 90 mph in the stow position without structural damage.
B. Heliostat Rack Assembly: Rack consisting of four bar joists riveted to a 12 inch diameter torque tube, which is parallel to the heliostat elevation axis. Each mirror module is mounted to the bar joists in three places.
C. Drive Mechanism: Provides the driving force for positioning the heliostat azimuth and elevation axis. Each axis is driven by a DC motor (1/6 HP) and the axis position is identified by a 13-bit incremental encoder.
D. Support Pedestal: 10' tall and 20" in diameter houses the electronic controls for the heliostat. Input power is 110V, 60 cycles.
E. Drilled Pier Foundation: 10' deep and 36" in diameter reinforced concrete with 8 top-exposed support bolts.

III. Operating Description

Each computer-controlled heliostat is a sun-tracking mirror. Sunlight strikes the heliostat and is reflected to the elevated (at the top of the 300 foot tower) receiver/boiler that absorbs the heat and converts water to steam.



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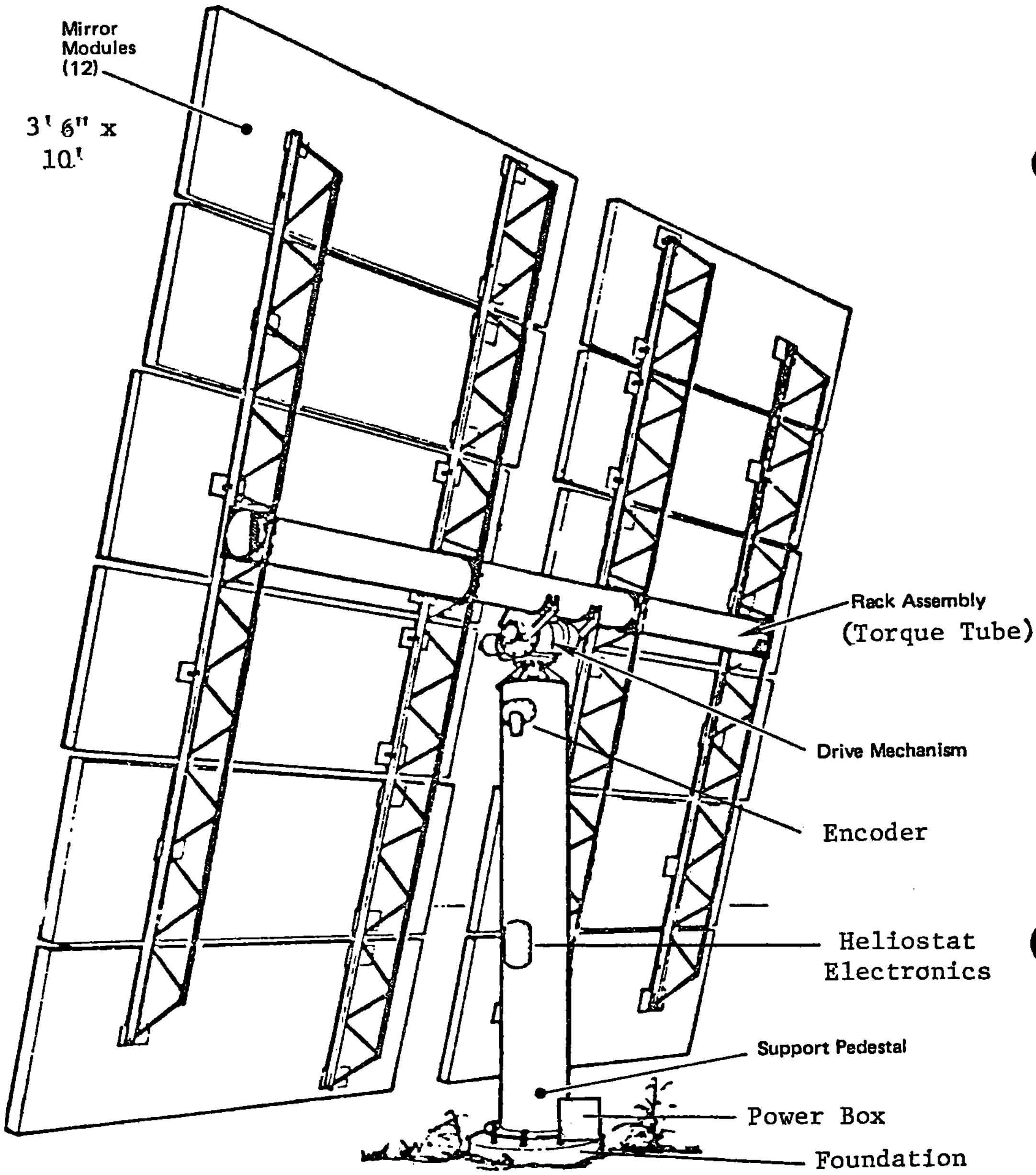
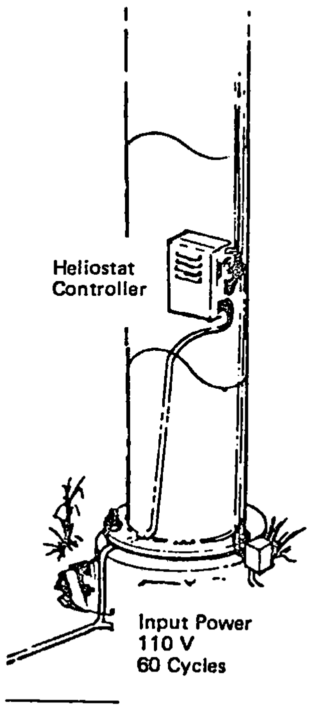
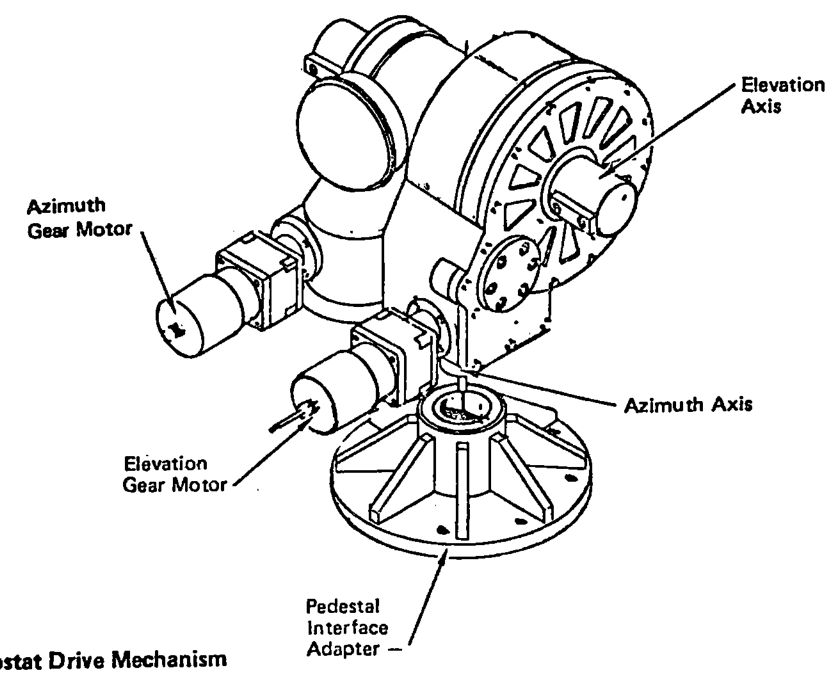


Heliostat Assembly



Pedestal Showing Heliostat Controller



Heliostat Drive Mechanism

RECEIVER TOWER

I. General Statistics

A. Tower:

1. Height: 298 feet
2. Weight: 202 tons (not including receiver panels)
3. Material: Steel
4. Foundation: 1,500 tons concrete buried approximately 25 feet below surface.

B. Receiver:

1. Dimension: 45 feet high, 23 feet in diameter
2. Number of panels: 24 (18 boiler panels and 6 pre-heater panels).

II. Specific Statistics

A. Receiver panels:

1. Function: Provide a vessel in which water can be converted to super-heated steam by thermal energy from the heliostat field.
2. Dimensions: Each panel is 45 feet high and 35 inches wide; composed of seventy ½ inch diameter tubes (internal diameter: 0.269 inch).
3. Panel weight: 4,000 lbs.
4. Tube material: Incoloy 800. An iron, nickel, chrome alloy with a melting point of 2540-2600°F.
5. External panel coating: Pyromark paint - high absorbtivity coating.
6. Maximum operating metal temperature: 1150°F.
7. Operational thermal expansion: 3-4 inches vertically, 1 inch horizontally.
8. Life expectancy: Greater than 30 years.

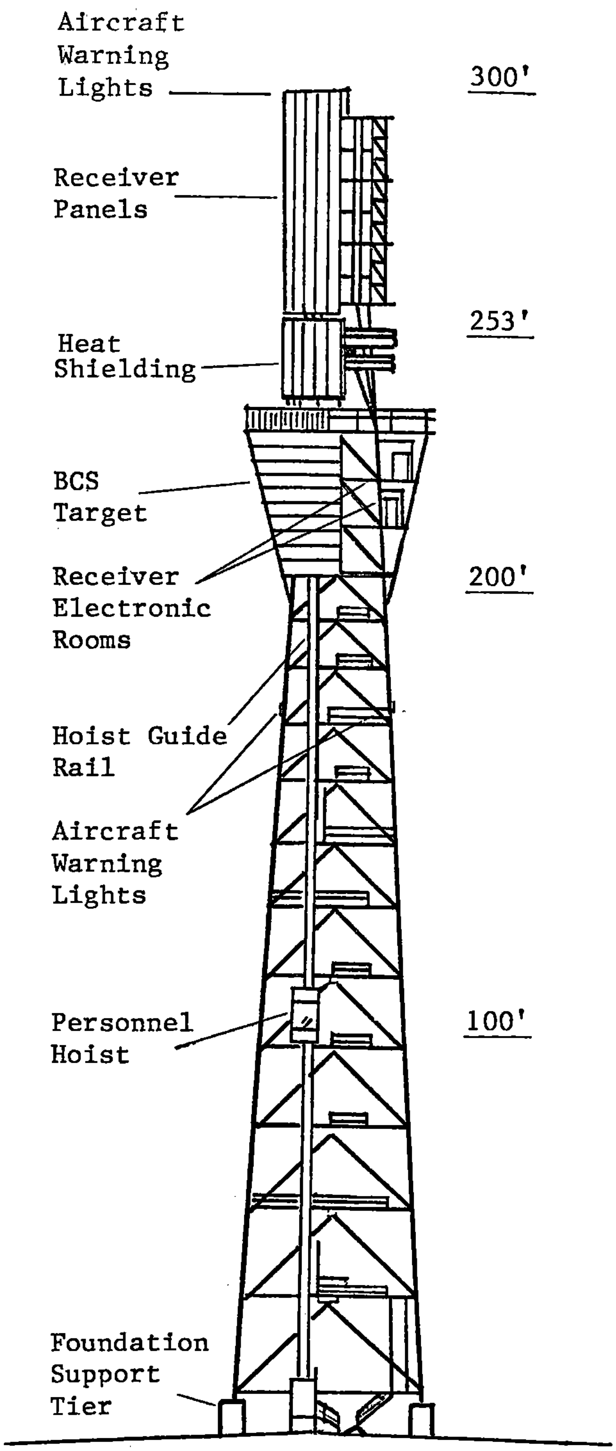
B. Operational Steam:

1. Direction of flow: Vertically upward through receiver panels.
2. Temperature: 960°F
3. Pressure: 1510-1570 psi
   (NOTE: Feedwater is extensively demineralized.)

C. Beam Characterization System (BCS) Targets:

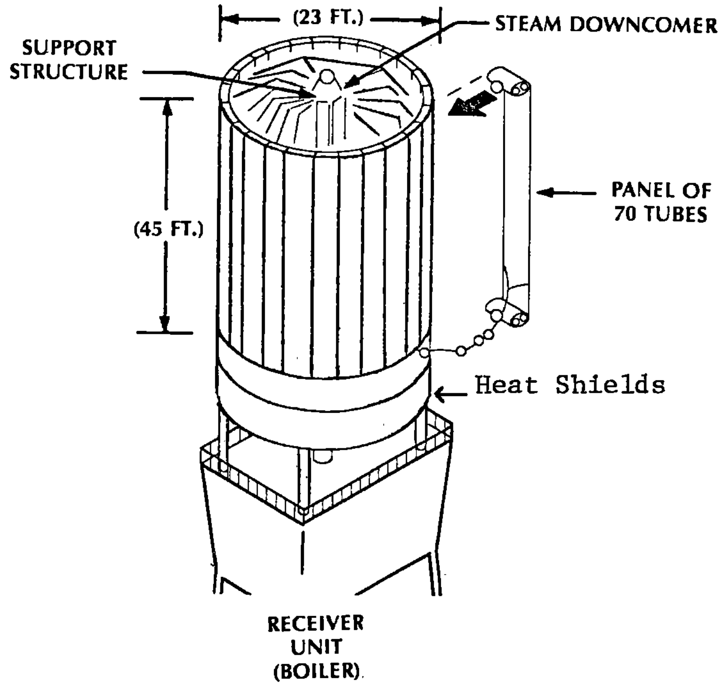
1. Function: Four targets in conjunction with four BCS field cameras and the Master Control System, perform periodic calibration and alignment of individual heliostats.
2. Dimensions: North and South Targets: 31 ft. high by 36-50 ft. wide - East and West Targets: 31 ft. high by 28-40 ft. wide.
3. Panel composition: 6061-T6 Aluminum.
4. External coating: Heat resisting white paint (Koppers Co., #A-1639-66) stable at 250-300°F with a lifetime greater than one year.

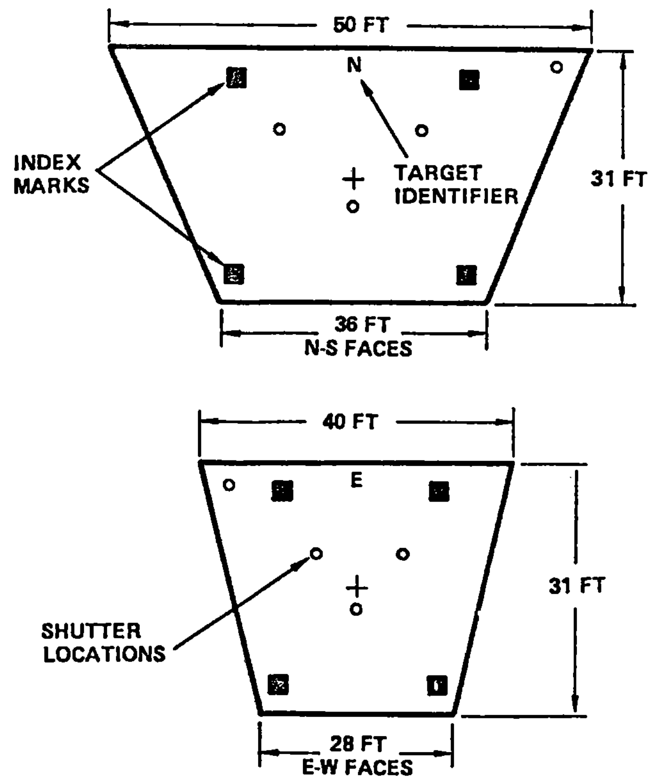
8



RECEIVER TOWER

(Looking East)





BCS Targets

THERMAL STORAGE

I. General Statistics:

A. Dimensions:
1. A steel tank 45 feet deep (at outside edge), 60 feet in diameter, with a volume of 149,288 cubic feet. The circumference of 204 feet will expand three inches when the system is fully heated.
2. Walls are 1/4" to 1 1/8" steel with 12" of insulation.
3. Roof is aluminum plus 2 feet of insulation.

B. Contents:
1. 4,532 tons of crushed granite from San Bernardino County.
2. 2,266 tons of sand from the Monterey Bay area.
3. 239,600 gallons of Caloria HT-43 oil manufactured by Exxon.

II. Specific Statistics:

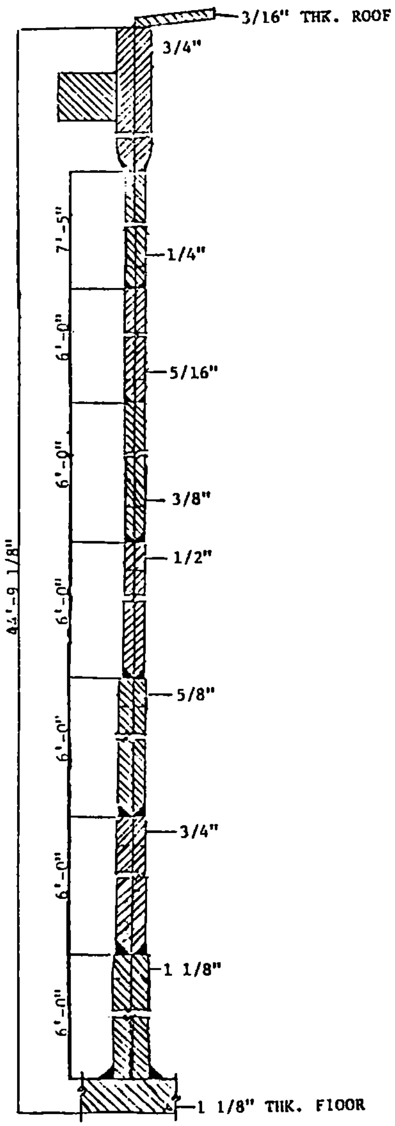
A. Caloria HT-43 Oil:
1. A petroleum oil about the consistency of mineral oil when cold.
2. Decomposes at a rate of 48 lb/hr. at 580°F, producing waste gases that are non-condensible such as methane, ethane, and hydrogen.

B. Temperatures:
1. During the charging and extraction processes, the system fluid flows through the rock at a temperature range from 435 to 580°F.
2. A de-superheater lowers the input steam temperature from 960 to 600°F before the steam goes into the charging heat transfer system.
3. Steam from thermal storage goes into the turbine at 525°F (380 psia).

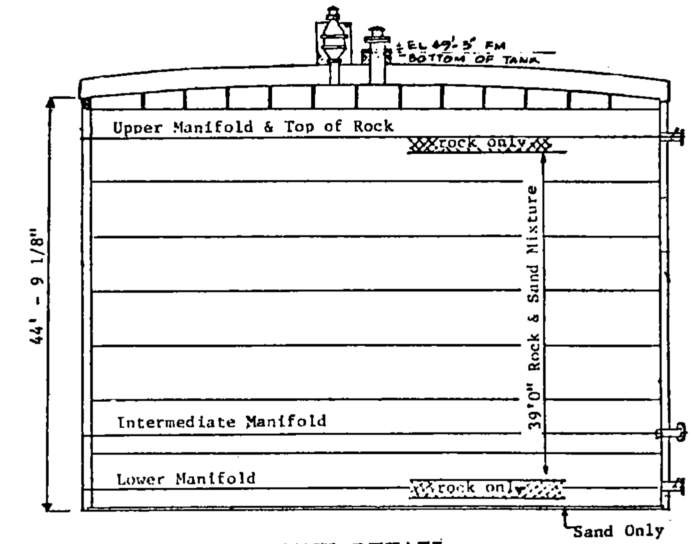
C. Charging/Discharging Rates:
1. Charging rate: To 6.6 MWe for 4.2 hours.
2. Discharging rate: To 7 MWe for 4 hours.

III. Operating Description:

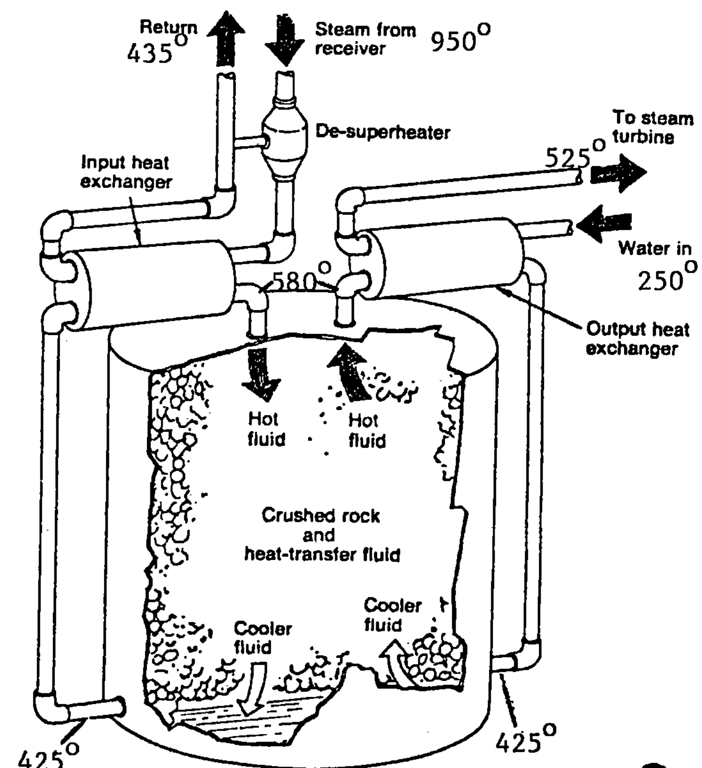
The thermal storage unit is a vertical cylindrical tank filled with a sand/rock mixture through which caloria passes. Hot caloria is introduced at the top and passes downward through the tank. As the oil flows through the rock and sand mixture, it transfers its heat to the rock and sand and is cooled to the low temperature of 535°F. The process is repeated until the thermal storage unit is fully charged. The thermal storage unit is designed to store thermal energy by condensing receiver generated steam. It can also serve as a source of thermal energy for a simultaneous steam generation while the receiver is in operation. An ullage maintenance unit (UMU) will flare decomposition gases such as methane, ethane, and hydrogen. The decomposed gas from the thermal storage unit is scrubbed concurrently in the UMU with heptane. The heavier hydrocarbons are absorbed by the heptane and recycled to the thermal storage unit. The heptane also maintains the thermal storage unit system pressure.



WALL DETAIL



TANK DETAIL



TEMPERATURE DETAIL

TURBINE GENERATOR

I. General Statistics

A. Manufacturer: General Electric
B. Equipment cost: $2,120,372.28
C. Weight: 214,280 lbs. or 107.14 tons
D. Turbine generator length: 36'9.94"
E. Turbine width: 14'
F. Generator width: 7'8"
G. Maximum gross output: 12.8 MWe

II. Specific Statistics

A. Rated generator capacity: 13.8 KV (14.23 MVA), grounded wyeconnected, 3 phase, 60 Hz. The short circuit ratio of the generator at maximum output is 0.58 or greater. Operates at power factors of 0.90 lagging to 0.95 leading without exceeding the guaranteed temperature rise (to be determined later).

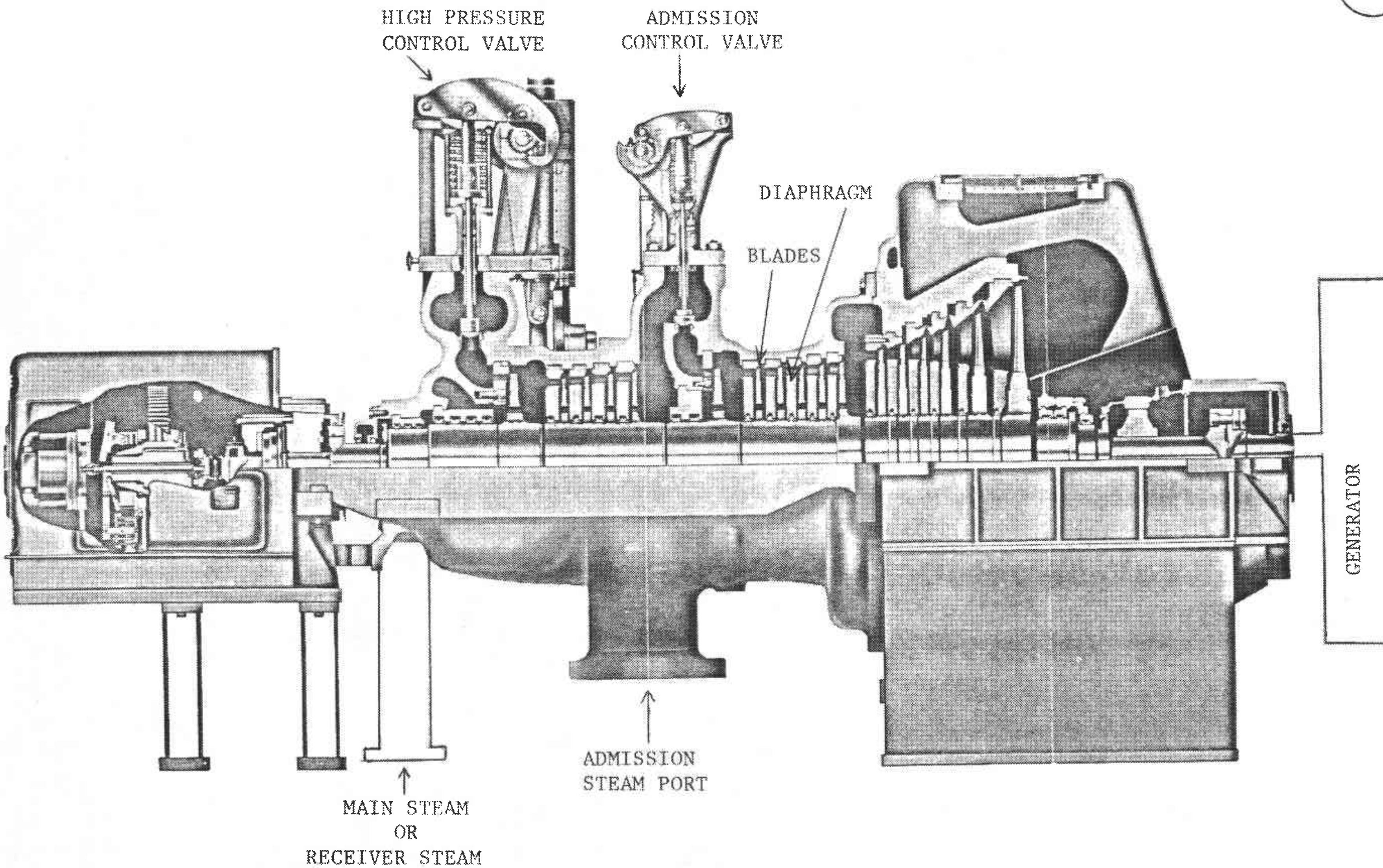
B. Electrical power devices required for operation and control of turbine:
1. AC bearing oil pump (2)
2. DC emergency bearing oil pump
3. DC starter for emergency oil pump
4. Vapor extractor
5. Turning gear
6. Gland exhauster pump
7. Hydraulic fluid pump (2)
8. Filter motor
9. Hydraulic fluid heaters
10. Motor valve operators
11. Speed-load control motor

C. During normal operation, the plant generator, auxiliary transformer, and 33kv lines are interconnected thereby allowing the generator output to accommodate the plant auxiliary electrical load plus provide a net power production to the grid.

D. Back-up power: Prior to turbine startup, power can be drawn directly from the grid as required to supply the plant startup auxiliary load. The 125 volt DC system is a battery powered system designed to provide reliable power to critical components (turbine DC lube oil pump and solenoid operators on control and isolation valves) which must be maintained in an operational status even when the primary AC power is lost. The unit is rated and guaranteed at 12.8 MWe gross electrical output at a 2.5 inch Hg condenser back pressure at a throttle steam inlet condition of 960^{o}F, 1465 psia, and flow-rate of 112,140 lb/hr (Mode 1 operation). It operates at a synchronous speed of 3600 rpm and is directly coupled to a 13.8 KV generator. The unit is configured with four steam extraction ports for feedwater heating. The unit is also guaranteed to produce 8.0 MWe gross at a 2.5 inch Hg condenser back pressure at an admission steam inlet condition of 525^{o}F, 385 psia and flow-rate of 105,000 lb/hr (Mode 6 operation).

III. Operating Description

The steam turbine is an automatic admission, single flow, extraction, condensing unit capable of accepting steam through the main control valves, through the admission control valves or through both inlets simultaneously under the operating conditions (Modes) defined for the plant. The turbine is comprised of a rotational shaft on which stages of blades are attached and contained in a high pressure casing. Incoming steam passes through these blade discs and forces the shaft to rotate. Turbine exhaust steam is routed through a condenser, where it is condensed and pumped back to the receiver to be recycled into steam. The turbine shaft is connected to the generator which is a rotating magnet within a coil. The rotating magnet induces electricity in the coil. The electricity that is generated is connected to the electrical grid for distribution.


HIGH PRESSURE CONTROL VALVE
ADMISSION CONTROL VALVE
DIAPHRAGM
BLADES
GENERATOR
ADMISSION STEAM PORT
MAIN STEAM OR RECEIVER STEAM

MASTER CONTROL BUILDING

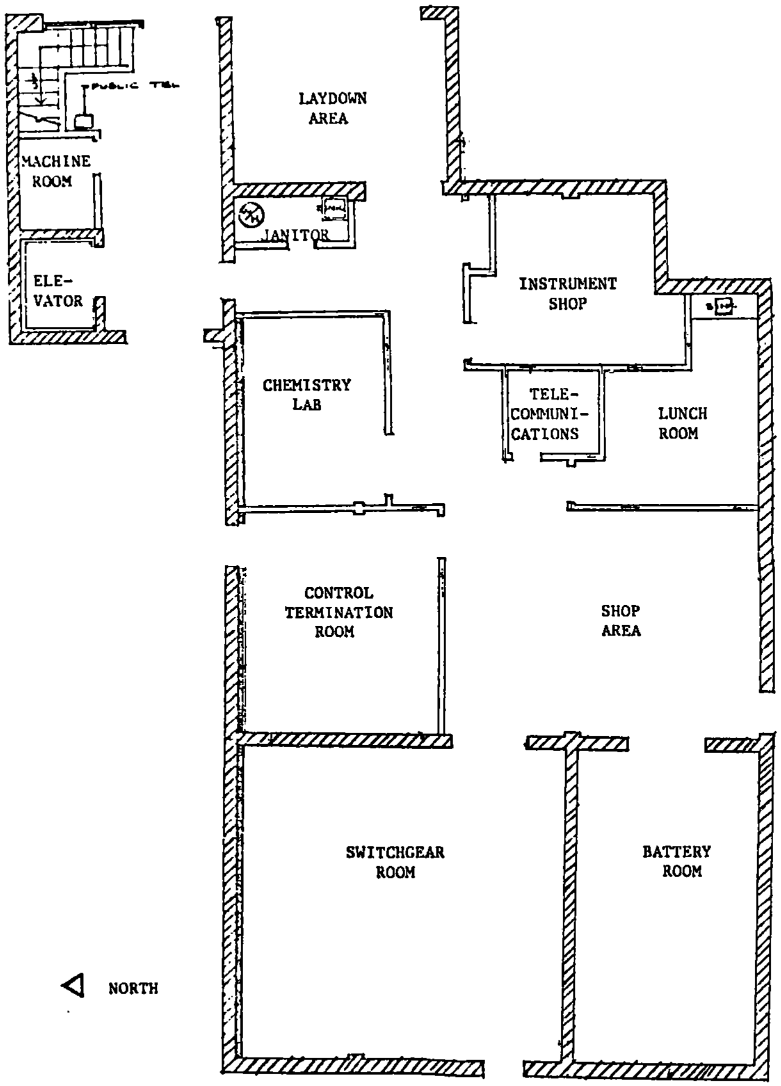
I. General Description of Rooms

A. First Floor:
1. Machine Room: Contains the elevator apparatus, hydraulic pumps.
2. Laydown Area: Disassembly area.
3. Chemistry Lab: Used in analyzing the quality of feedwater.
4. Control Termination Room: Contains computer equipment for the plant controls.
5. 480 Volt Switchgear Room: Contains electrical equipment used in operating motors and other electrical equipment (air compressors, pumps, valves, etc.).
6. Battery Room: Contains batteries for the emergency control equipment (the ultimate backup in case of power failure).
7. Shop Area: Contains spare parts for maintenance and repair of plant equipment.
8. Telecommunications: Switchboards for automatic telephone systems.
9. Instrument Room: A repair room for the plant instruments.

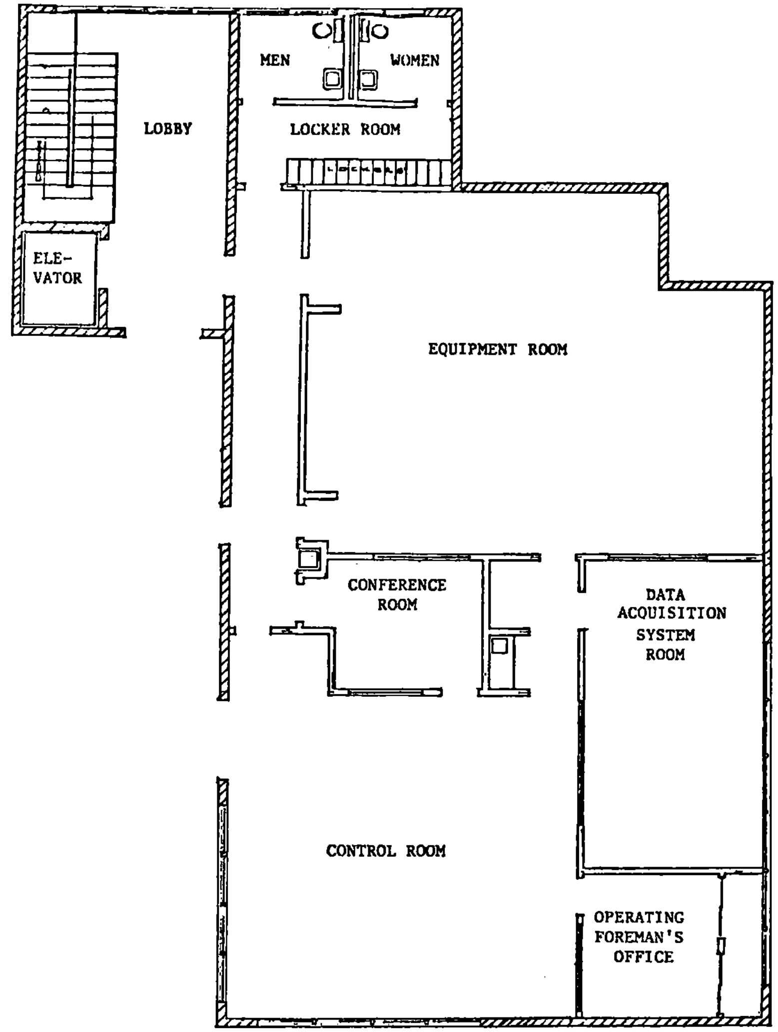
B. Second Floor:
1. Equipment Room: The five computer systems and their hardware are installed in this room.
2. Conference Room: For visitors and conferences containing windows looking into the Equipment Room and the Control Room.
3. Control Room: The control operators are stationed in this room with computer terminals to operate the plant.
4. Operating Foreman's Office: For the designated chief operator of the plant.
5. Data Acquisition System Room: Project participants, DOE and other contractors, can receive operational information on the plant from computer terminals installed in this room.

II. Specific Description of Computer System

A. There are four MODCOMP (made by Modular Computer Company) computers installed at the plant. Two control the heliostats, one controls the plant, the other monitors the plant.
1. Beckman Instruments provided the Distributed Process Control, control consoles and corresponding peripheral equipment.
2. McDonnell Douglas is the integrating contractor and together with Southern California Edison provided the control logic (equations) to tell the computer how to run the pumps, valves, etc. (the plant excluding the heliostats).
3. Martin Marietta provided the control logic to run the heliostats.

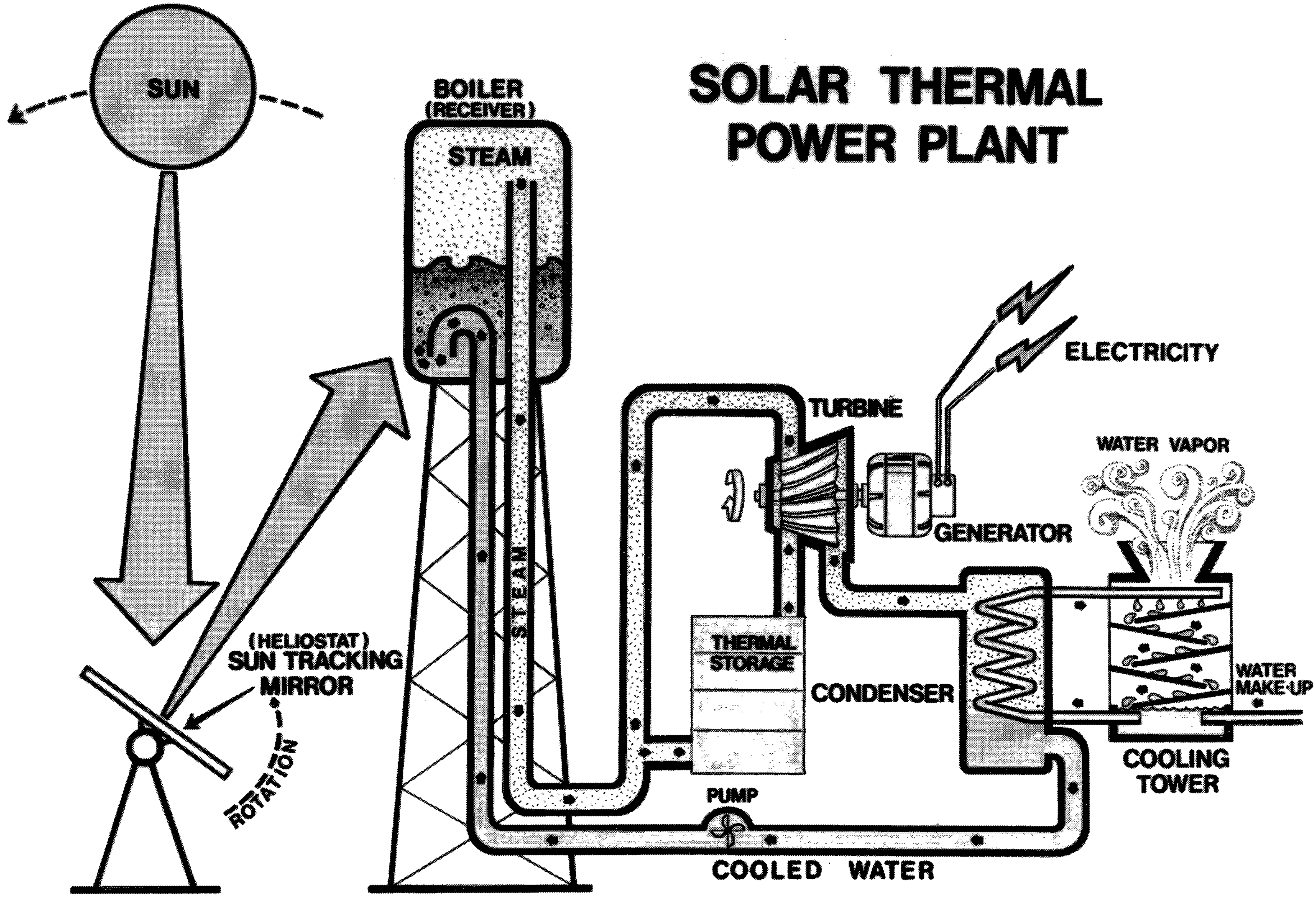


FIRST FLOOR PLAN

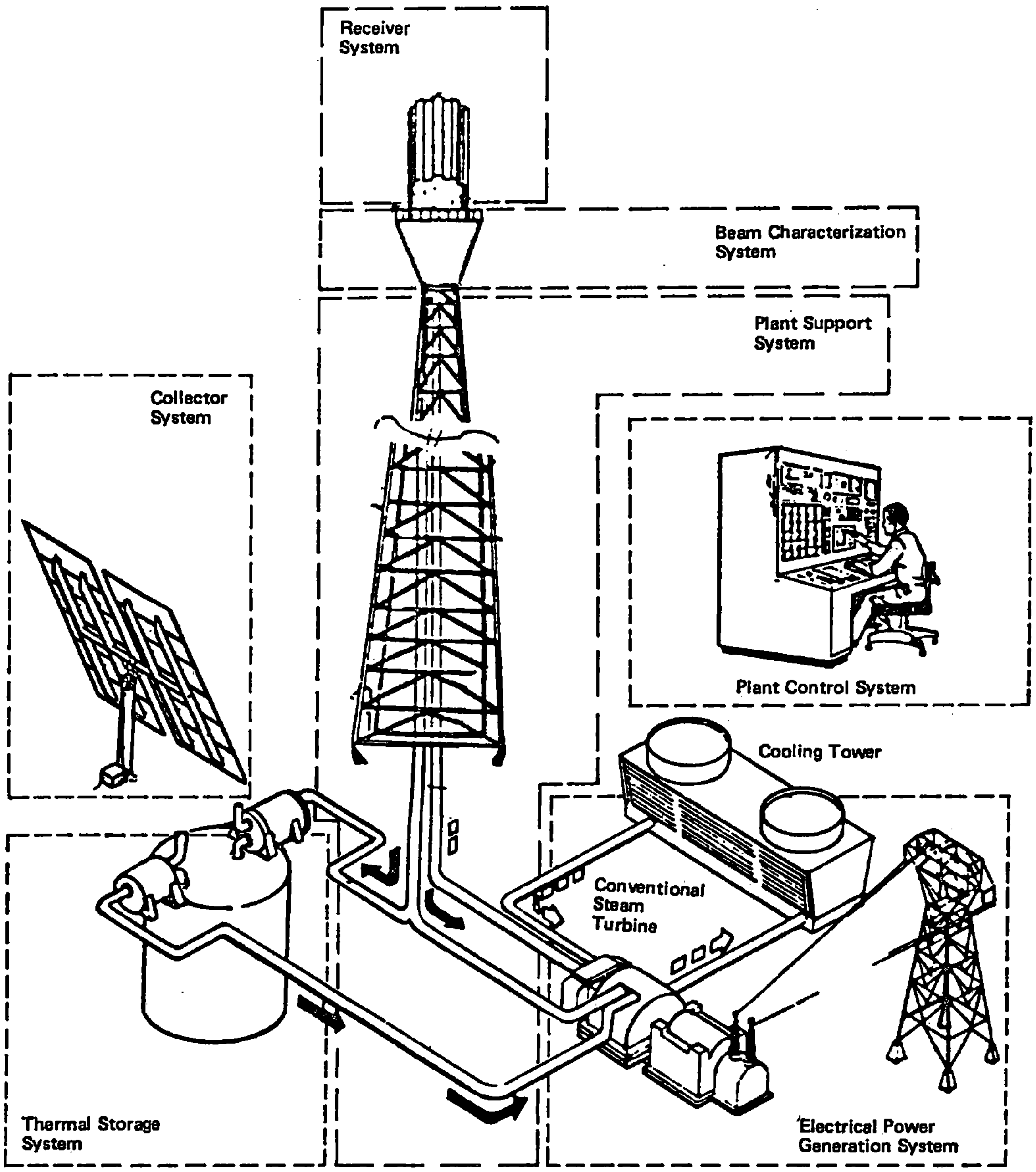


SECOND FLOOR PLAN

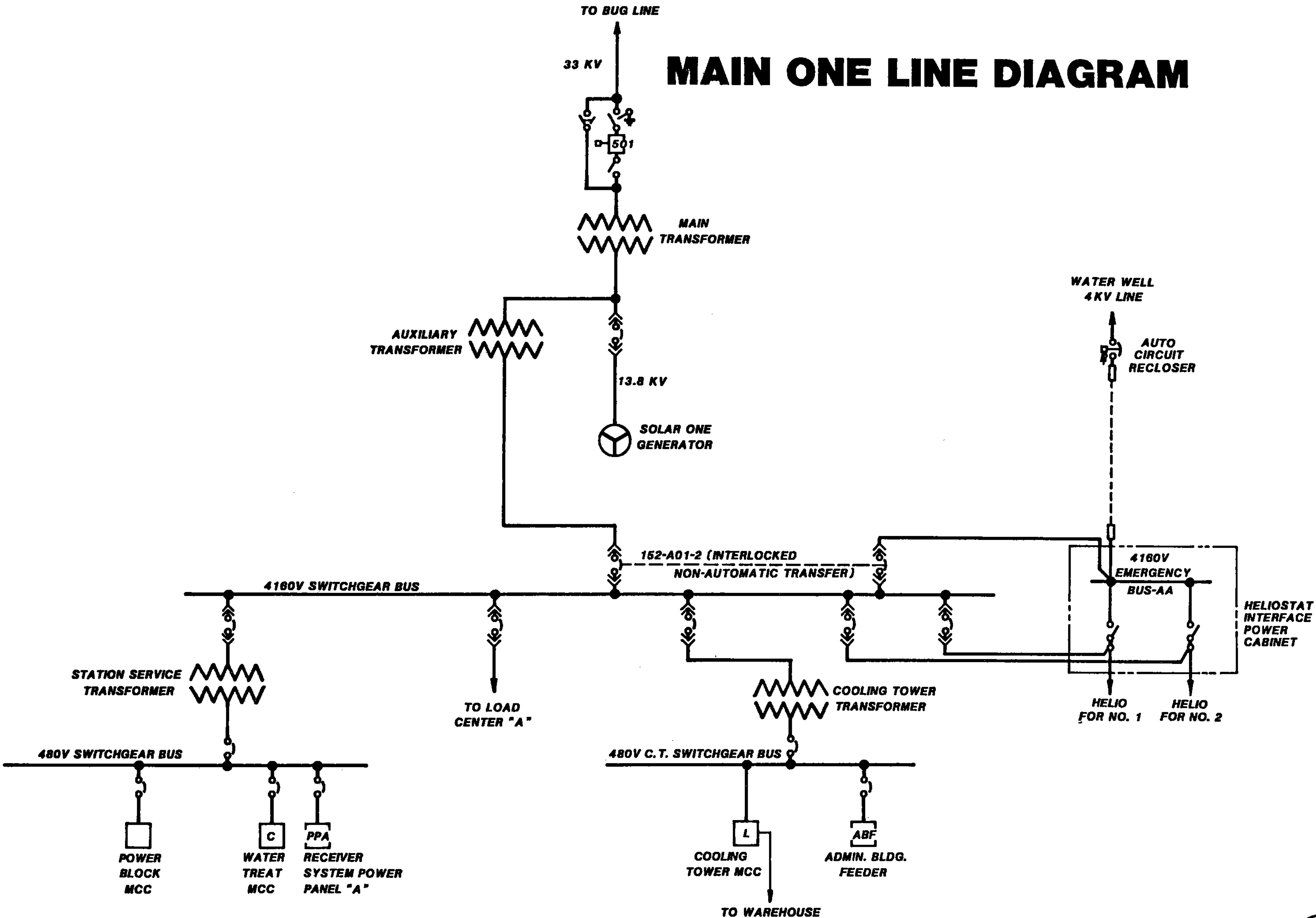
SOLAR THERMAL POWER PLANT



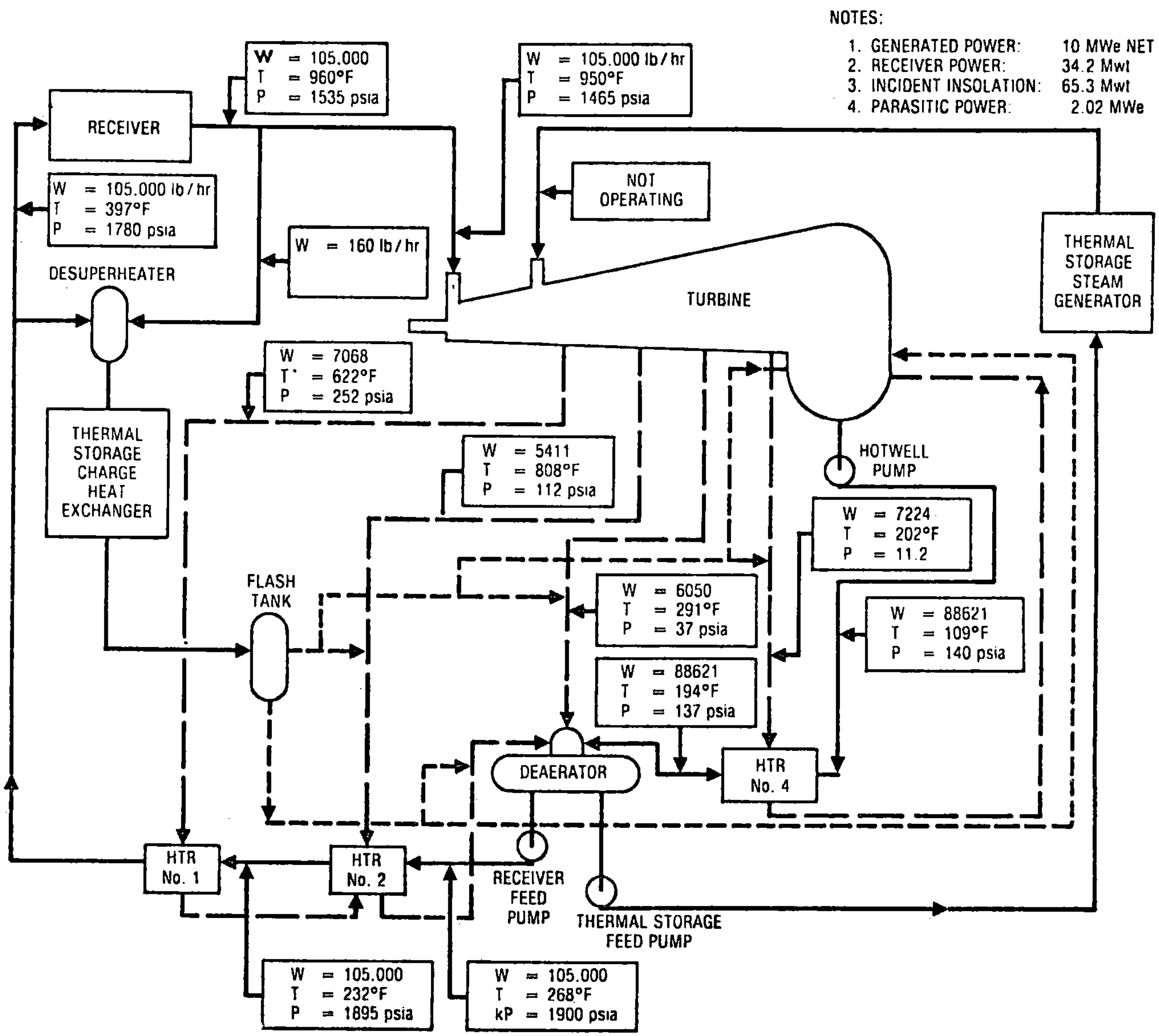
PLANT SYSTEM SCHEMATIC

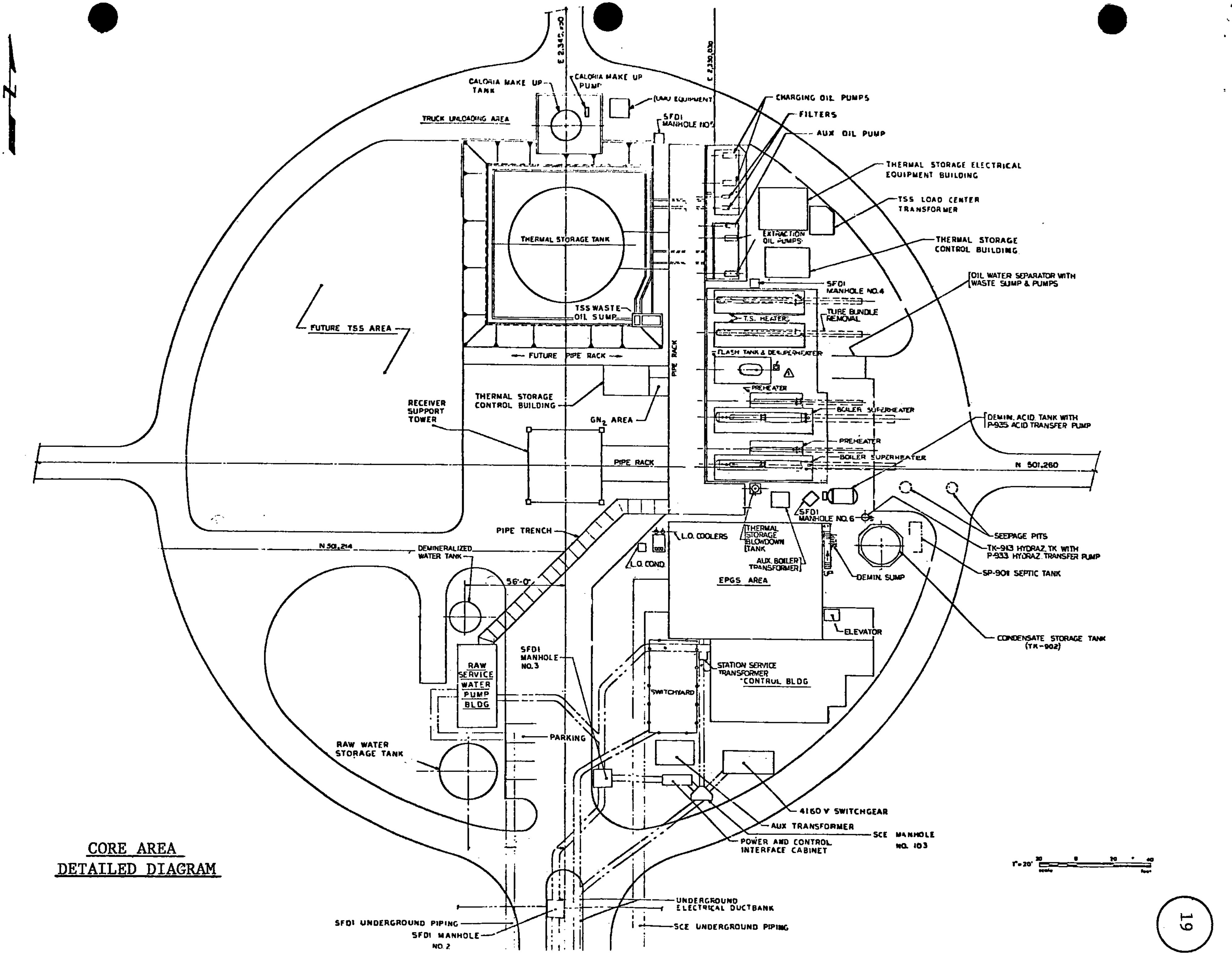


MAIN ONE LINE DIAGRAM



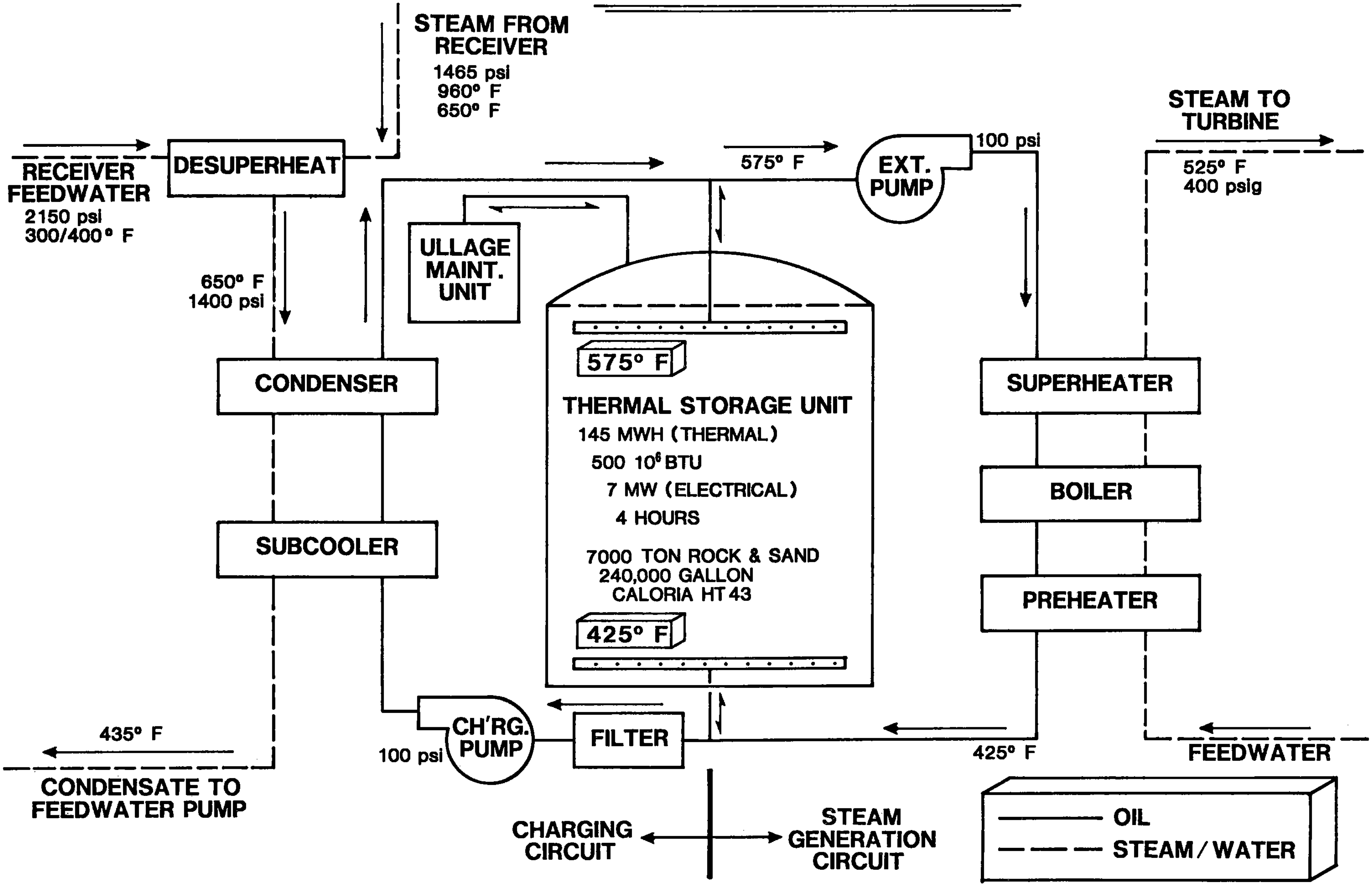
STEAM FLOW DIAGRAM



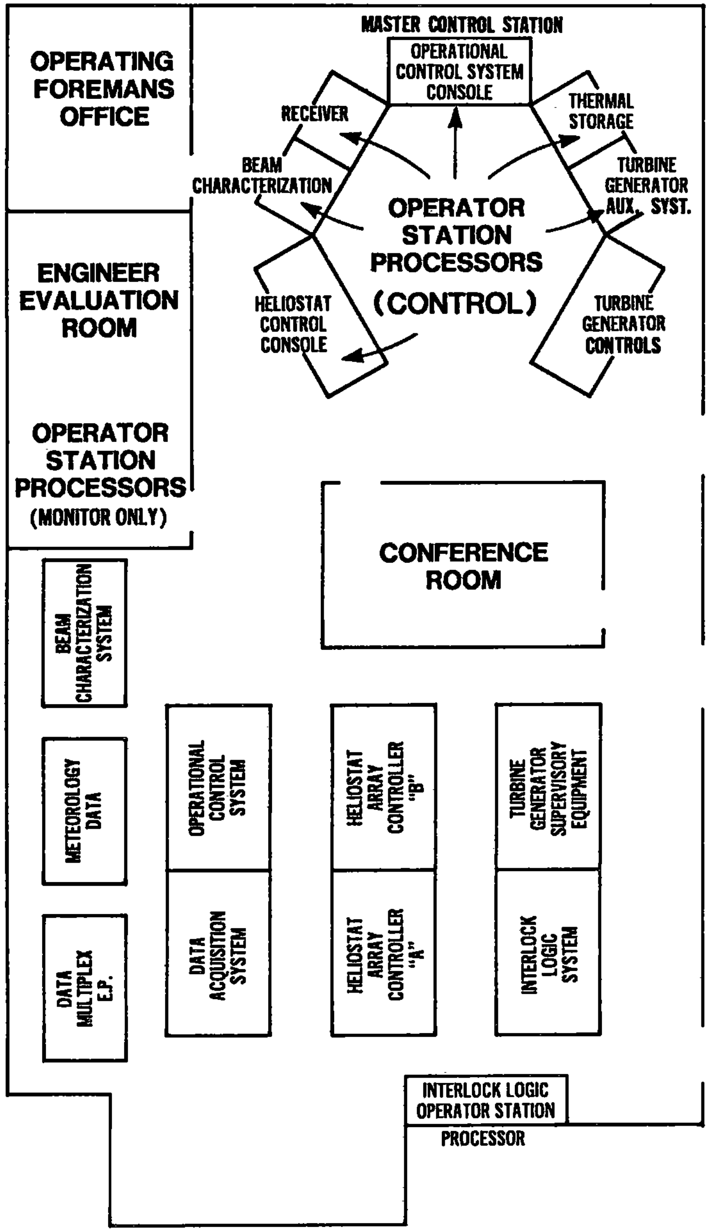


CORE AREA DETAILED DIAGRAM

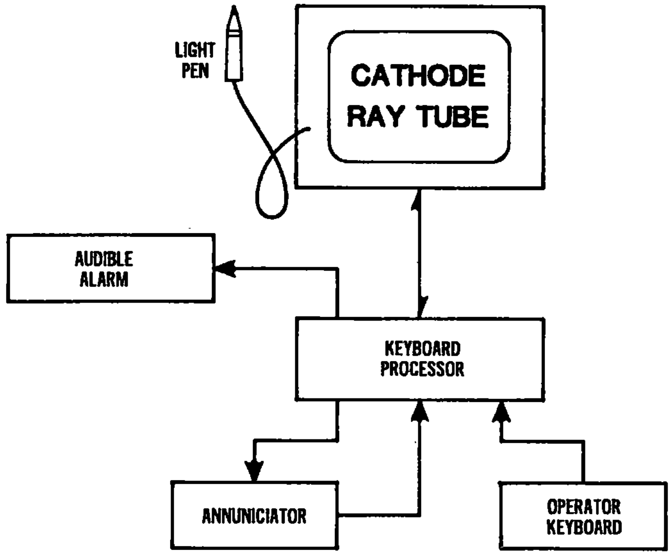
THERMAL STORAGE SYSTEM



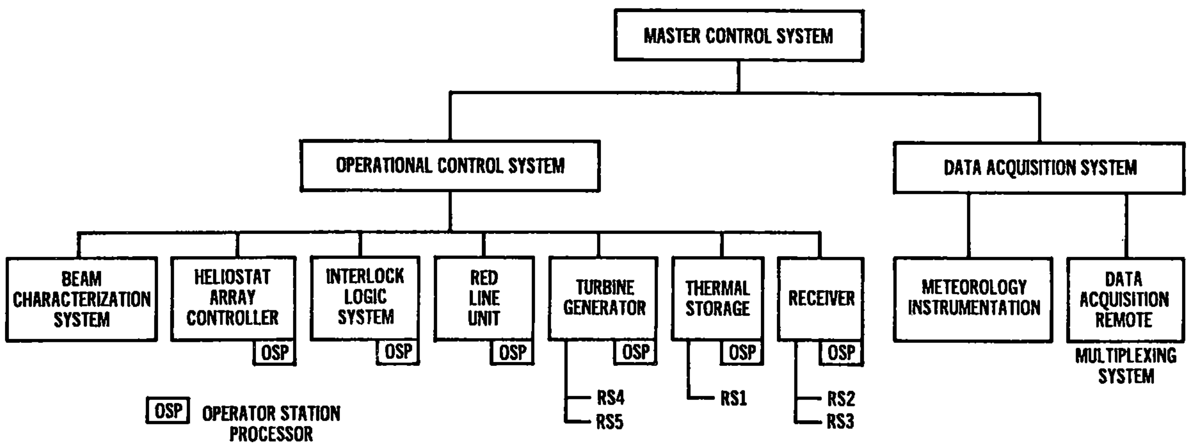
SOLAR ONE GENERATING STATION



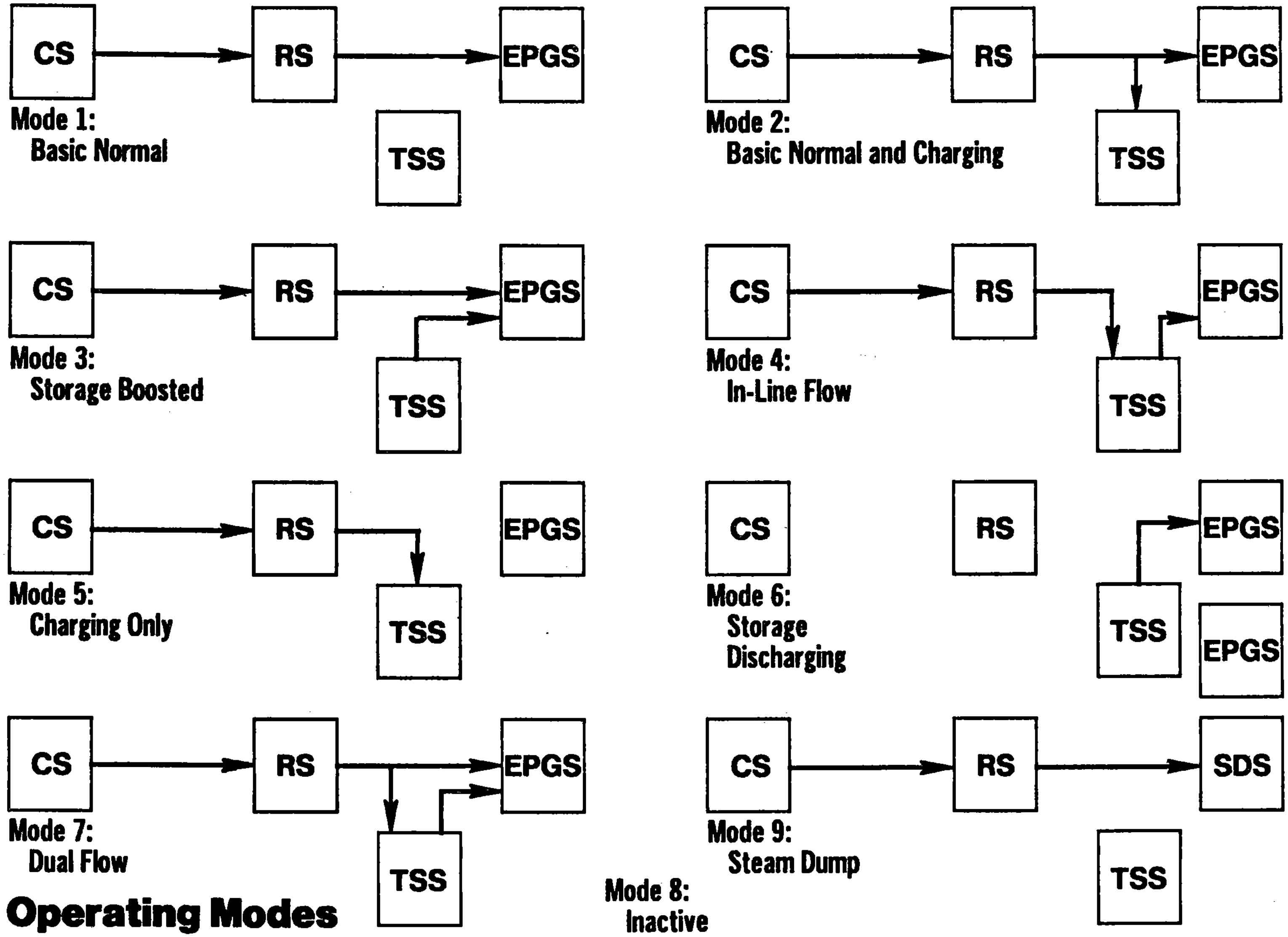
MASTER CONTROL SYSTEM PHYSICAL LAYOUT



TYPICAL OPERATOR STATION PROCESSOR

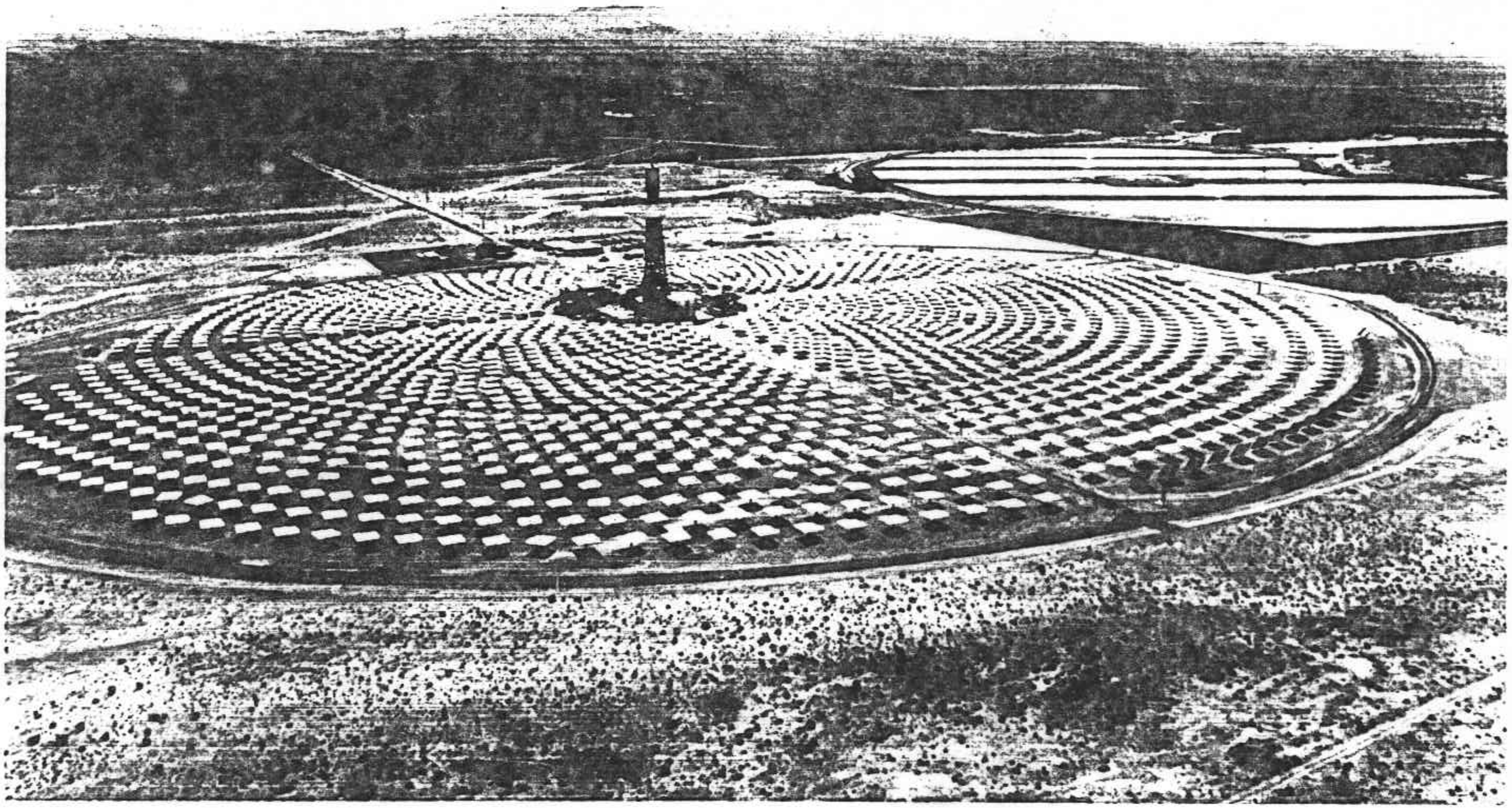


MASTER CONTROL SYSTEM HIERARCHY



Operating Modes

SOLAR 10-MWe PILOT PLANT



MAR 1981

TABLE OF CONTENTS

SOLAR 10 MWe PILOT PLANT

I. General Statistics

A. Participants and Cost Figures:

SOLAR ONE COST FIGURES (ESTIMATED)

Item	Department of Energy	Southern Calif. Edison	L.A. Dept. of Water & Power	Calif. Energy Commission	Total
Construction of Solar Portion: heliostats, tower, thermal storage, master control	$120,000,000	$	$	$	$120,000,000
Construction of Non-Solar Portion: electrical generation equipment		17,840,000	3,660,000		21,500,000
Participant Services:					
Land		250,000			250,000
Plant integration and startup; technical support and plant operating procedures		520,000	130,000		650,000
Project reviews and information dissemination		964,000	241,000	800,000	2,005,000
TOTAL CONSTRUCTION COSTS	$120,000,000	$ 17,840,000	$ 3,660,000	$	$141,500,000
TOTAL PARTICIPANT SERVICES		1,734,000	371,000	800,000	2,905,000
TOTAL COSTS	$120,000,000	$ 19,574,000	$ 4,031,000	$ 800,000	$144,405,000

(NOTE: Operation and Maintenance cost figures are now being calculated and negotiated and will be available at a later date.)

B. Major Contractors:

1.	Martin Marietta	Heliostats
2.	McDonnell Douglas	Master Control, System Design Integration
3.	Stearns-Roger	A/E Services
4.	Rocketdyne of Rockwell Int'l.	Receiver, Thermal Storage
5.	Townsend and Bottum	Construction Manager
6.	General Electric	Turbine Generator

C. Project Schedule:

1.	Start Site Construction	September 1979
2.	Information Center Completed	July 1980
3.	Turbine Roll and Initial Operating Date	First Quarter 1982
4.	Two Year Experimental Test Phase	1982 - 1984
5.	Three Year Power Production Phase	1984 - 1987

II. Specific Statistics:

A. Plant Rating:

1. 10 MWe for 7.8 hours - summer solstice
2. 10 MWe for 4 hours - winter solstice
3. 7 MWe for 4 hours from Thermal Storage

B. Geographic Features:

1. Minimum temperature: January - 10°F (-12.2°C); July - 73°F (23°C)
2. Maximum temperature: January - 60°F (16°C); July - 115°F (46.1°C)
3. Latitude: 34.86 degrees North
4. Longitude: 116.83 degrees West
5. Elevation: 1946 feet above mean sea level
6. Approximately 3600-4000 hours of sunlight per year or 9.8-10.9 hours per day.

C. Size of Plant:
   1. 1900 feet from north to south.
   2. 2500 feet from east to west.
   3. 130 acres: 72 acres for the heliostat field; 58 acres for the power plant, control and administration buildings, construction laydown area and miscellaneous smaller areas.

D. Power to the Grid:
   1. Maximum power to the grid:
      a. 10.8 MWe (Operating Mode 1)
      b. 12.5 MWe gross; 1.7 MWe parasitic
   2. Maximum estimated daily energy:
      a. 112 MWe-hr - June 21
      b. 48 MWe-hr - December 21
   3. Annual estimated energy generation:
      a. 26,000 MWe-hr - 365 day operation

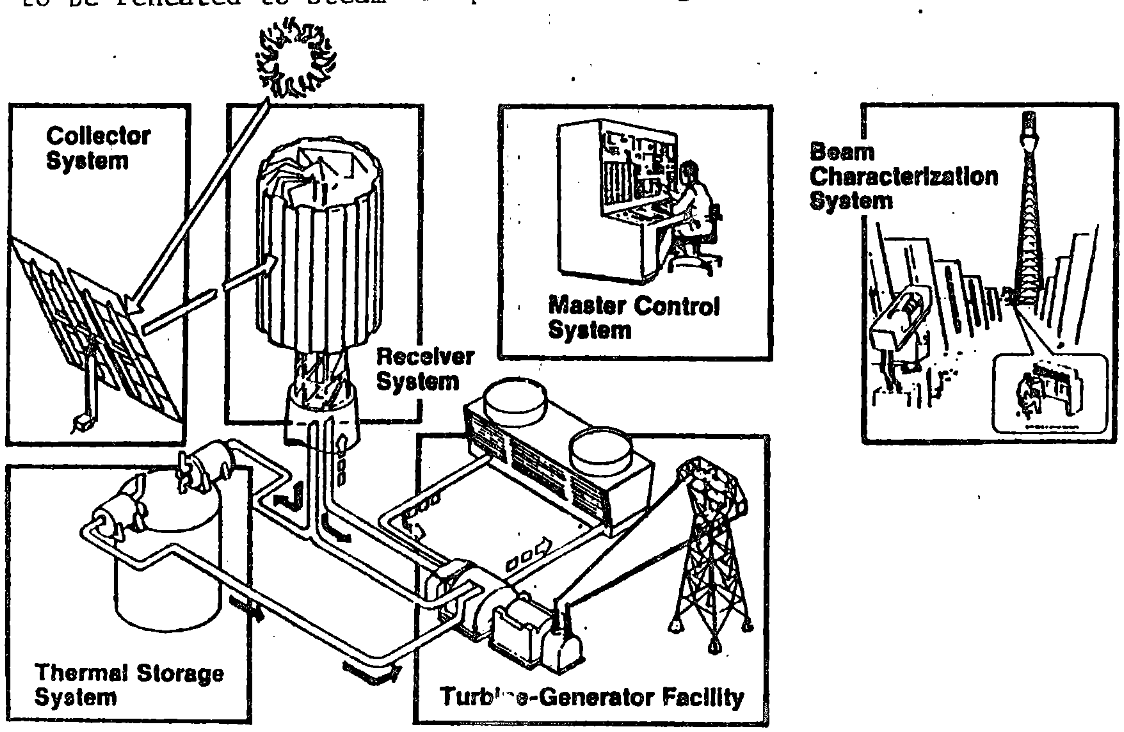
E. Gross Plant Efficiency:
   1. 17.4% - Noon on June 21.
   2. 15.4% - 2/PM on December 21.

F. Water Usage: Approximately 220 acre feet of water per year for pilot plant operation and heliostat washing.

G. Use of Electricity: 20% of electrical energy will go to the Los Angeles Department of Water and Power with 80% to Southern California Edison.

II. Operating Description:

Sunlight strikes the heliostat and is reflected on to a tower-mounted receiver/boiler which absorbs the heat and turns water to steam. The steam is then directed to a conventional turbine generator where electrical power is produced. During periods when excess steam is available, it is directed to the thermal storage tank and later extracted during periods when sufficient sunlight is not available. After use, the steam is condensed back to water so that it can be pumped back up the tower to be reheated to steam and put to work again.



HELIOSTAT

I. General Statistics

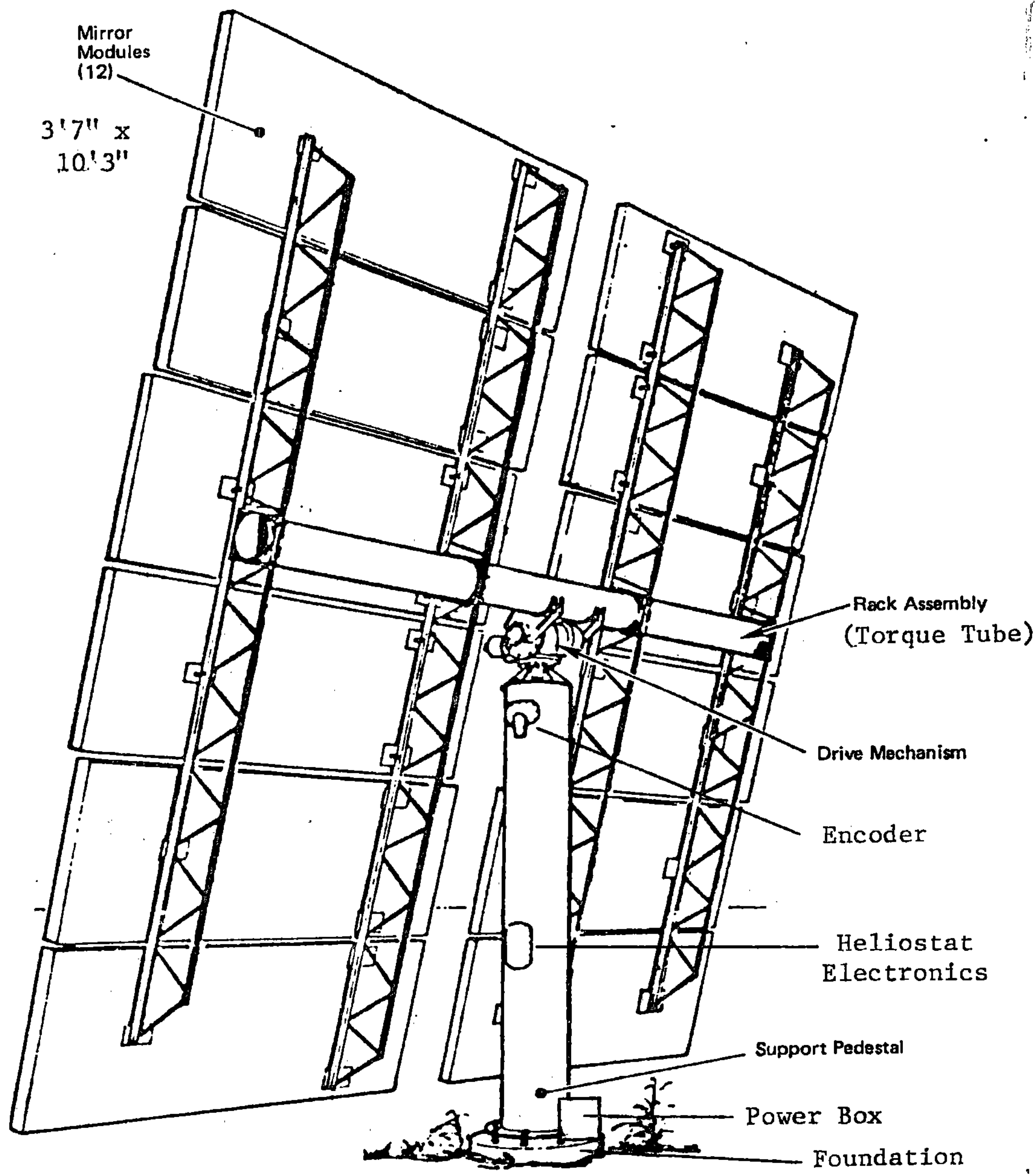
A. Total heliostats in field: 1,818 (578 in south field and 1,240 in north field).
B. Heliostat measurements: 22'6" x 22'7" consisting of 12 mirror panels each measuring 120.3 inches long by 43.3 inches wide or 3'7" x 10'3".
C. Slightly concave: 1/2" by 10' length and width.
D. Reflective area: 430 square feet or 39.9 square meters.
E. Weight total: 4,132 total lbs. or 2,546 lbs. for the rack assembly, 923 lbs. for the drive mechanism, 601 lbs. for the support pedestal and 62 lbs. for the cable and electronics.
F. Global rotation: Azimuth $\pm$ 270° and Elevation $\pm$ 95°.
G. Cost: $15,000 each (approximately).
H. Efficiency rating: 90%.
I. Life expectancy: 30 years.
J. Cleaning procedure: To be determined later.

II. Specific Statistics

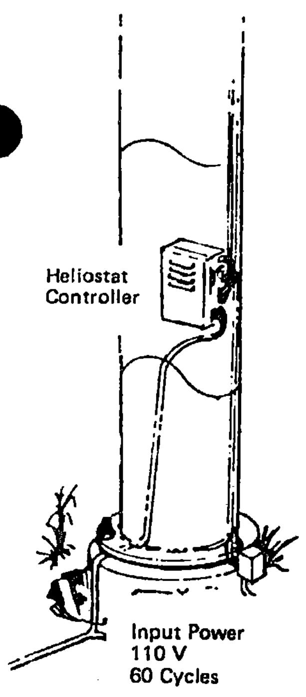
A. Mirrors: Each panel consists of a second surface (silver backing) glass mirror bonded to an aluminum honeycomb core (2 1/2" thick). This core is bonded to a steel enclosure pan and sealed with an environmental edge seal. The heliostats are turned in a stow position (or mirror surface down) when the winds exceed 36 mph and during adverse weather conditions. They are capable of withstanding 50 mph winds in the vertical position and 90 mph winds in the stow position without tipping over.
B. Heliostat Rack Assembly: Rack consisting of four bar joists riveted to a 12 inch diameter torque tube, which constitutes the heliostat elevation axis. Mirror module is mounted to the bar joists in three places.
C. Drive Mechanism: Provides the driving force for positioning the heliostat azimuth and elevation axis. Each axis is driven by a DC motor (1/6 HP) and the axis position is identified by a 13-bit incremental encoder.
D. Support Pedestal: 10' tall and 20" in diameter houses the electronic controls for the heliostat. Input power is 110V, 60 cycles.
E. Drilled Pier Foundation: 10' deep and 36" in diameter with 8 top-exposed support bolts.

II. Operating Description

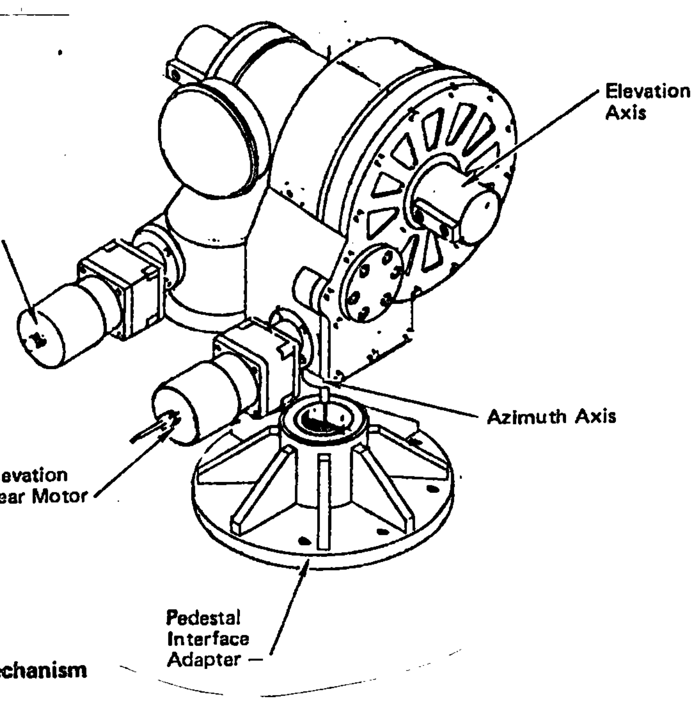
Each computer-controlled heliostat is a sun-tracking mirror. Sunlight strikes the heliostat and is reflected to the elevated (at the top of the 300 foot tower) receiver/boiler that absorbs the heat and turns water to steam.



Heliostat Assembly



estal Showing Heliostat Controller



Heliostat Drive Mechanism

RECEIVER TOWER

I. General Statistics

A. Tower:
1. Height: 298 feet
2. Weight: 202 tons (not including receiver panels)
3. Material: Steel
4. Foundation: 1,500 tons concrete buried approximately 25 feet below surface.

B. Receiver:
1. Dimension: 45 feet high, 23 feet in diameter
2. Number of panels: 24 - 18 boiler panels and 6 pre-heater panels.

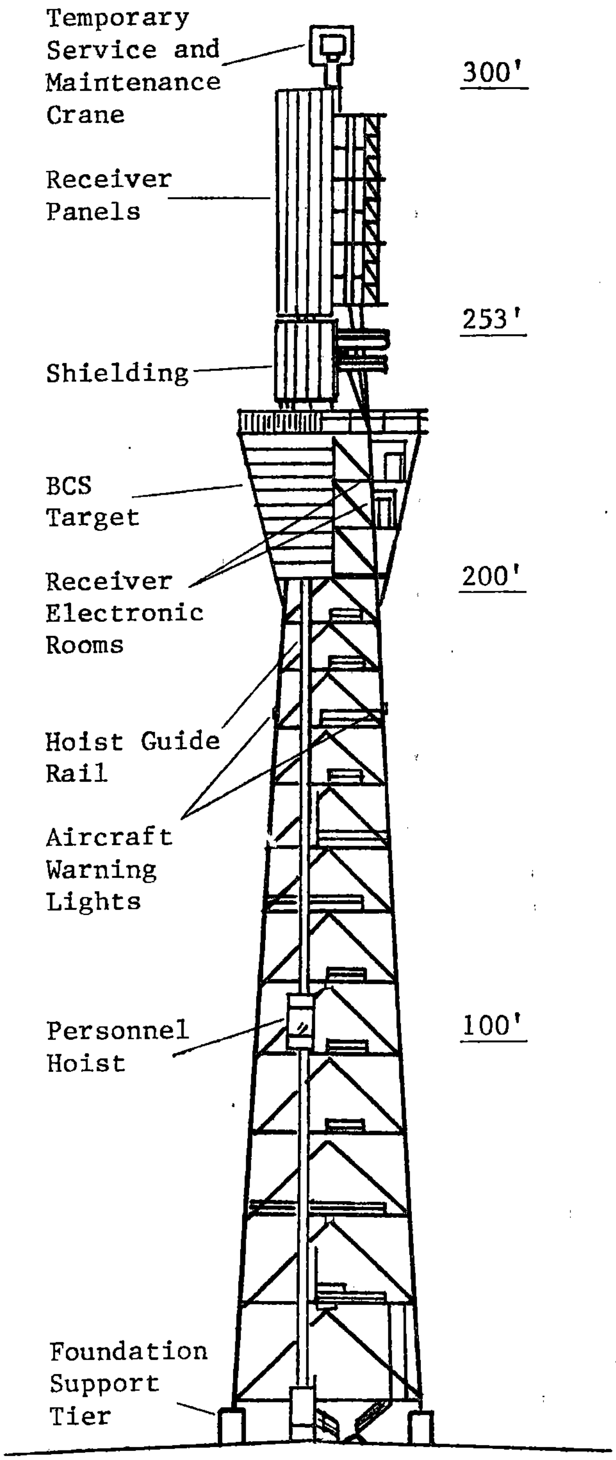
II. Specific Statistics

A. Receiver panels:
1. Function: Provide a vessel through which water can be passed to absorb thermal energy from heliostat field and be evaporated to steam.
2. Dimensions: Each panel is 45 feet high and 35 inches wide; composed of 70 1/2 inch diameter tubes (internal diameter: 0.269 inch).
3. Panel weight: 4,000 lbs.
4. Material: Incoloy 800 (see below for composition), externally coated with Pyromark paint.
5. Maximum operating metal temperature: 1150°F.
6. Operational thermal expansion: 3-4 inches vertically, 1 inch horizontally.
7. Life expectancy: Greater than 30 years.

B. Incoloy 800:
1. Composition:
   Iron - 44.7%
   Nickel - 30.8%
   Chromium - 22.8%
   Magnesium - 0.8%
   Titanium - 0.4%
   Aluminum - 0.3%
   Silicon - 0.2%
   (Percentages by weight)
2. Density: 0.29 lb/in^3
3. Thermal conductivity: 85 Btu/hr-ft-°F/in
4. Melting point: 2540-2600°F

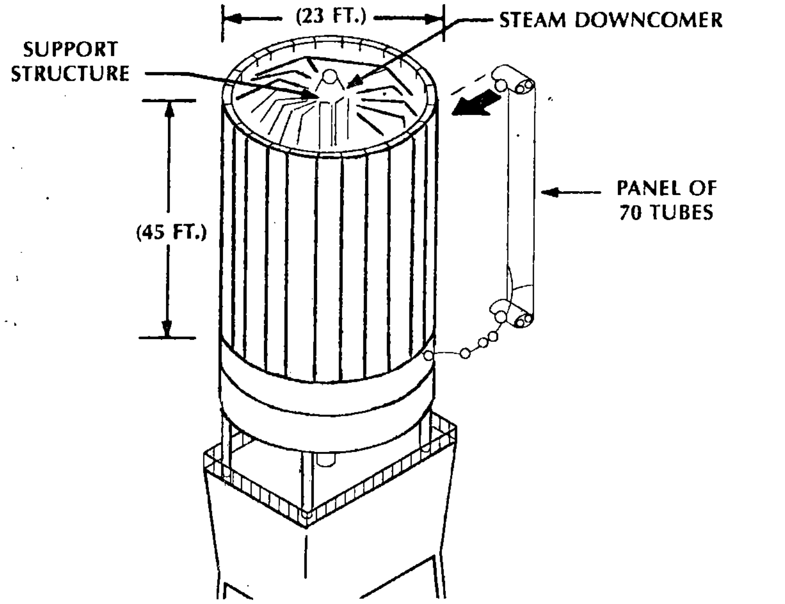
C. Operational Steam:
1. Direction of flow: Vertically upward through panels.
2. Temperature: 960°F
3. Pressure: 1510-1570 psi
   (NOTE: Feedwater is extensively demineralized.)

D. Beam Characterization System (BCS) Targets:
1. Function: Four targets aid in periodic calibration and alignment of individual heliostats, in cooperation with the 4 BCS field cameras and the Master Control System.
2. Dimensions: North and South targets: 31 ft. high by 36-50 ft. wide - East and West targets: 31 ft. high by 28-40 ft. wide. Composed of 20 individual panels, largest panels are 3 ft. by 20 ft., with remaining panels shorter in length as necessary.
3. Panel composition: 6061-T6 Aluminum.
4. External coating: Similar to Nextel paint (by 3M corporation), flat white, stable at 250-300°F with a lifetime greater than one year.

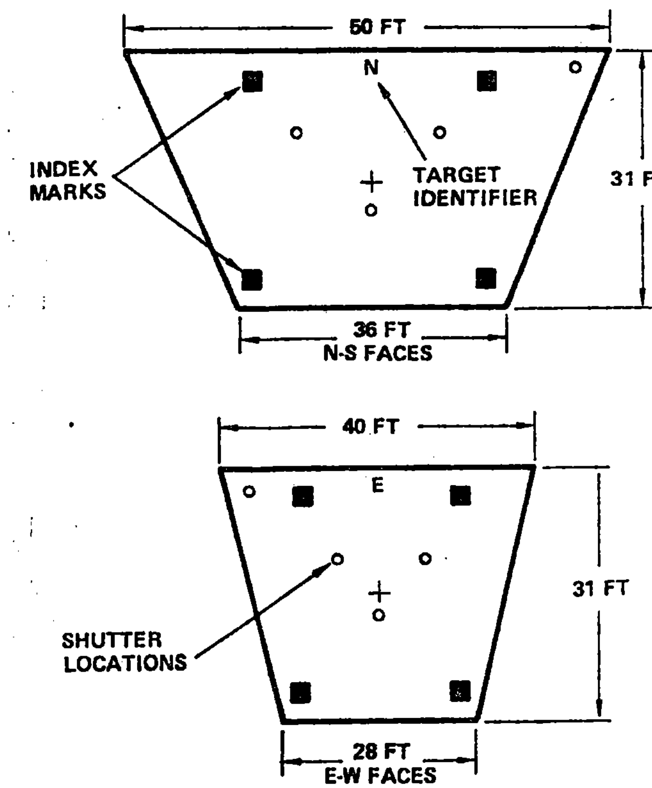


RECEIVER TOWER

(Looking East)



RECEIVER UNIT (BOILER)



BCS Targets

THERMAL STORAGE

I. General Statistics

A. Dimensions:

1. A steel tank 45 feet deep, 65 feet across containing 149,288 cubic feet, with a circumference of 204 feet and will expand 3" when fully charged.
2. Walls are approximately 14 inches thick containing steel and insulation.
3. Roof is aluminum plus 2 feet of insulation.

B. Contents:

1. 4,532 tons of crushed granite from San Bernardino County.
2. 2,266 tons of sand from the Monterey Bay area.
3. 239,600 gallons of Caloria HT-43 oil manufactured by Exxon.

II. Specific Statistics:

A. Caloria HT-43 Oil:

1. A petroleum light lube oil.
2. Decomposes at a rate of 48 lb/hr. at 580°F, producing waste gas that is non-condensible such as methane, ethane and hydrogen.

B. Temperatures:

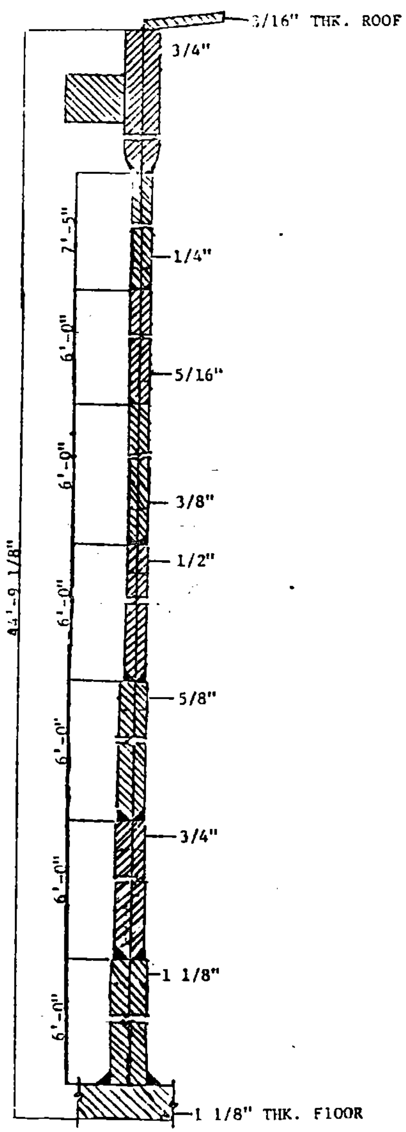
1. During the charging and extraction processes, the system fluid flows through the rock at a temperature range from 435 to 580°F.
2. A de-superheater lowers the input steam temperature from 960 to 600°F before the steam goes into the charging heat transfer system.
3. Steam from thermal storage goes into the turbine at 525°F (380 psia).

C. Discharge Power:

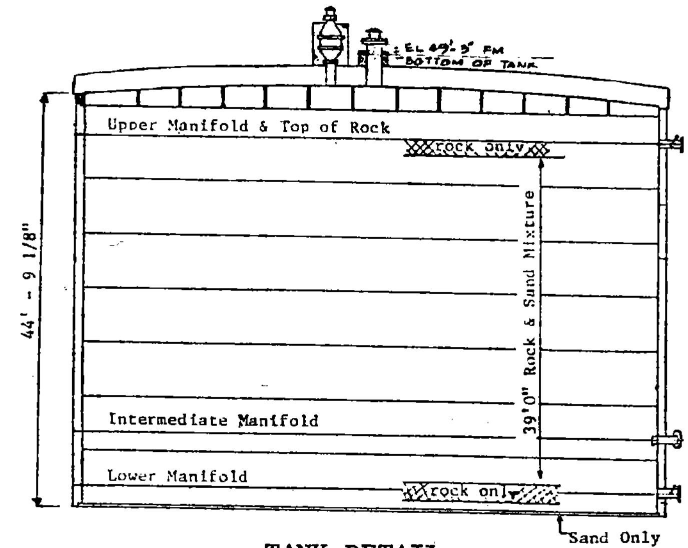
1. Thermal storage can discharge at a maximum rate equivalent to 7 MWe power production for 4 hours and will stay charged for 7 days at that capacity.
2. Discharge time 4 hours; Extractable capability 145 MWHt; Charging rate 1.5 to 31.6 MWt; Discharge rate 1.7 to 33.3 MWt.

III. Operating Description:

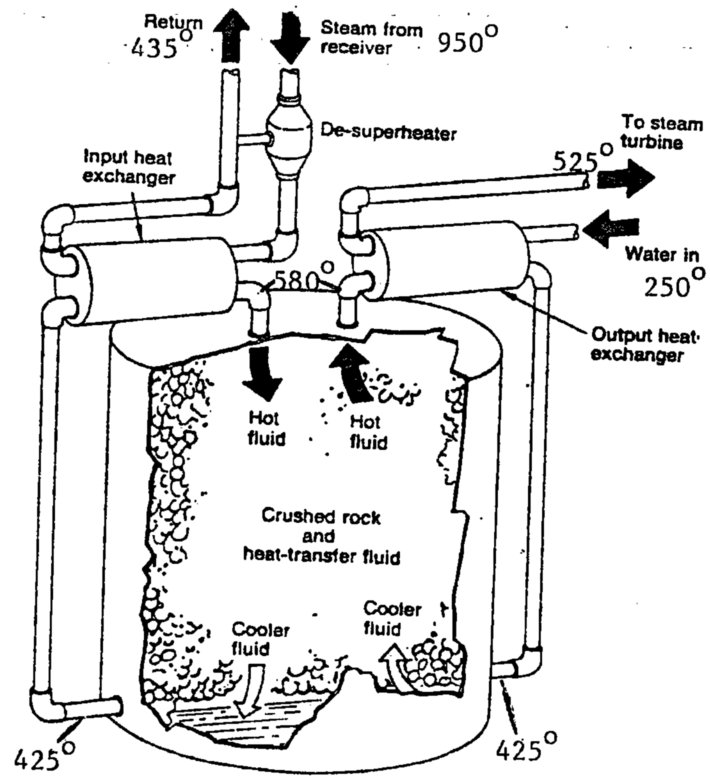
The thermal storage unit is a vertical cylindrical tank filled with a sand/rock mixture through which caloria passes. Hot caloria is introduced at the top of the tank and passes downward through the tank. As the oil passes through the rock and sand mixture, it transfers its heat to the rock and sand and is cooled to the low temperature of 535°F. The process is repeated until the thermal storage unit is fully charged. The thermal storage unit is designed to absorb and store thermal energy by condensing receiver generated steam and to serve as a source of thermal energy for a simultaneous or subsequent steam generation process. An ullage maintenance unit will dispose of gases such as methane, ethane and hydrogen by catalytic combustion as well as introducing heptane as a pressurizing agent to prevent ingress into the system.



WALL DETAIL



TANK DETAIL



TURBINE GENERATOR

I. General Statistics

A. Manufacturer: General Electric
B. Equipment cost: $2,120,372.28
C. Weight: 214,280 lbs. or 107.14 tons
D. Turbine generator length: 36'9.94"
E. Turbine width: 14'
F. Generator width: 7'8"
G. Maximum turbine output: 12.8 MWe

II. Specific Statistics

A. Rated generator capacity: 13.8 KV (14.23 MVA), grounded wyeconnected, 3 phase, 60Hz. The short circuit ratio of the generator at maximum output is 0.58 or greater. Operates at power factors of 0.90 lagging to 0.95 leading without exceeding the guaranteed temperature rise (to be determined later).

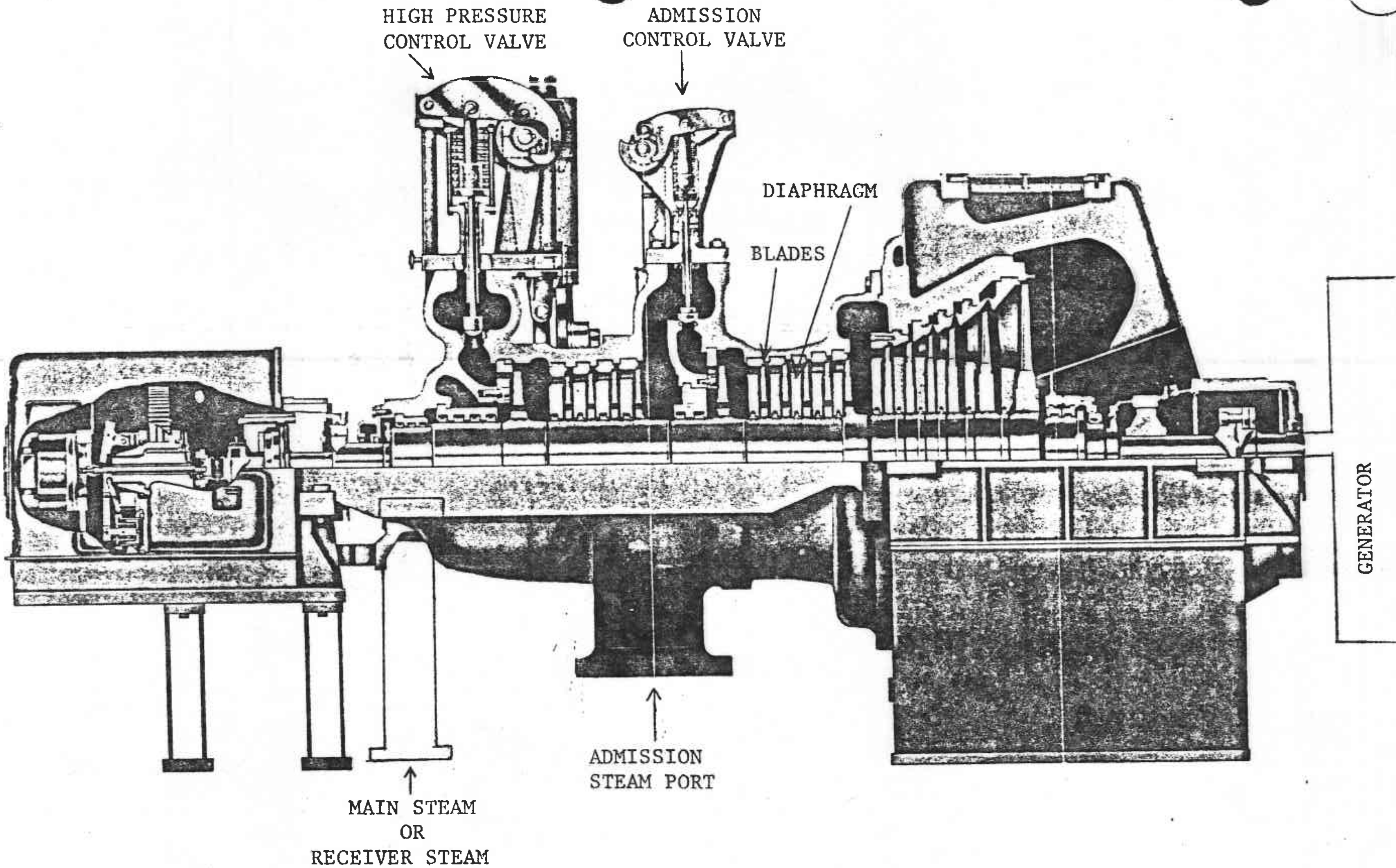
B. Electrical power devices required for operation and control of turbine:
   1. AC bearing oil pump (2)
   2. DC emergency bearing oil pump
   3. DC starter for emergency oil pump
   4. Vapor extractor
   5. Turning gear
   6. Gland exhauster pump
   7. Hydraulic fluid pump (2)
   8. Filter motor
   9. Hydraulic fluid heaters
   10. Motor valve operators
   11. Speed-load control motor

C. During normal operation, the plant generator, auxiliary transformer, and 33kv line are interconnected thereby allowing the generator output to accommodate the auxiliary electrical load plus provide a net power production to the grid.

D. Back-up power: Prior to turbine startup, power can be drawn directly from the grid as required to supply the plant startup auxiliary load. The 125 volt DC system is a battery powered system designed to provide reliable power to critical components (turbine DC lube oil pump and solenoid operators on control and isolation valves) which must be maintained in an operational status even when the primary AC power is lost. The unit is rated and guaranteed at 12.8 MWe gross electrical output at a 2.5 inch Hg condenser back pressure at a throttle steam inlet condition of 960^{o}F, 1465 psia, and flow-rate of 112,140 lb/hr (Mode 1 operation). It operates at a synchronous speed of 3600 rpm and is directly coupled to a 13.8 KV generator. The unit is configured with four steam extraction ports for feedwater heating. The unit is also guaranteed to produce 8.0 MWe gross at a 2.5 inch Hg condenser back pressure at an admission steam inlet condition of 525^{o}F, 385 psia and flow-rate of 105,000 lb/hr (Mode 6 operation).

III. Operating Description

The steam turbine is an automatic admission, single flow, extraction, condensing unit capable of accepting and admitting steam either through the main control valve or through the automatic admission control valves or through both valves simultaneously under the operating conditions (Modes) defined for the plant. The turbine is a shaft within a high pressure casing on which windmill-like blades are attached. The blades are located all around the shaft forming a blade disc, one after the other. Incoming steam is allowed to "blow" through these blade discs and the shaft is forced to rotate. The turbine shaft is connected to the generator which is a rotating magnet within a coil of wire. As the shaft is turned, the magnet turns inside the coil, inducing electricity in the coil. The electricity is allowed to flow to the electrical system. The steam is then passed through to a condenser, where it is condensed back into water and the water is pumped around to the receiver to be made into steam once again.



GENERAL ELECTRIC

MASTER CONTROL BUILDING

I. General Description of Rooms

A. First Floor:

1. Machine Room: Contains the elevator apparatus, hydraulic pumps.
2. Laydown Area: Disassembly area.
3. Chemistry Lab: Analyzes the quality of feedwater.
4. Control Termination Room: Computer equipment for the plant controls.
5. 480 Volt Switchgear Room: Contains electrical equipment which runs the motors and/or the plant apparatus (air compressors, pumps, valves, etc.).
6. Battery Room: Contains batteries for the emergency control equipment (the ultimate backup in case of power failure).
7. Shop Area: Contains spare parts for maintenance and repair of plant equipment.
8. Telecommunications: Switchboards for automatic telephone systems, both Edison's private exchange and Continental Telephone.
9. Instrument Room: A repair room for the plant instruments.

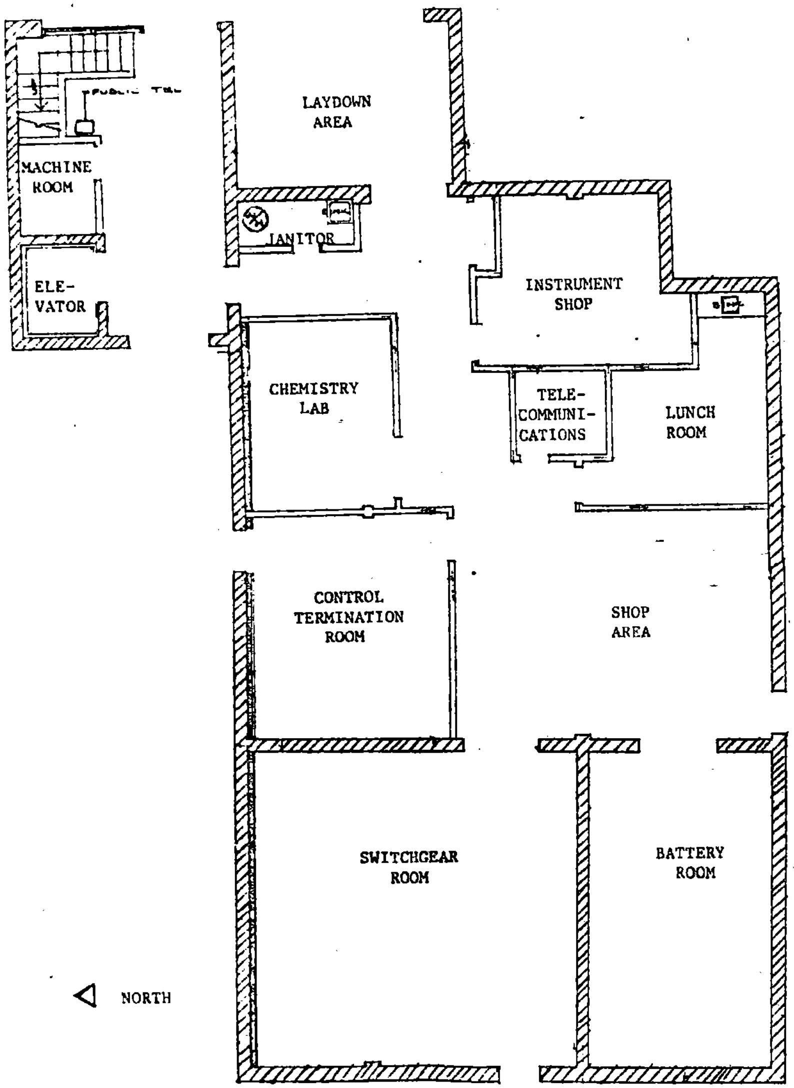
B. Second Floor:

1. Equipment Room: The five computer systems and their hardware are installed in this room.
2. Conference Room: For VIP visitors and conferences with windows looking into the Equipment Room and the Control Room.
3. Control Room: The control operators are stationed in this room with computer terminals to operate the plant.
4. Operating Foreman's Office: For the designated chief operator of the plant.
5. Data Acquisition System Room: The scientific participants, namely DOE and certain contractors, can receive information pertaining to the operation of this plant from computer terminals installed in this room.

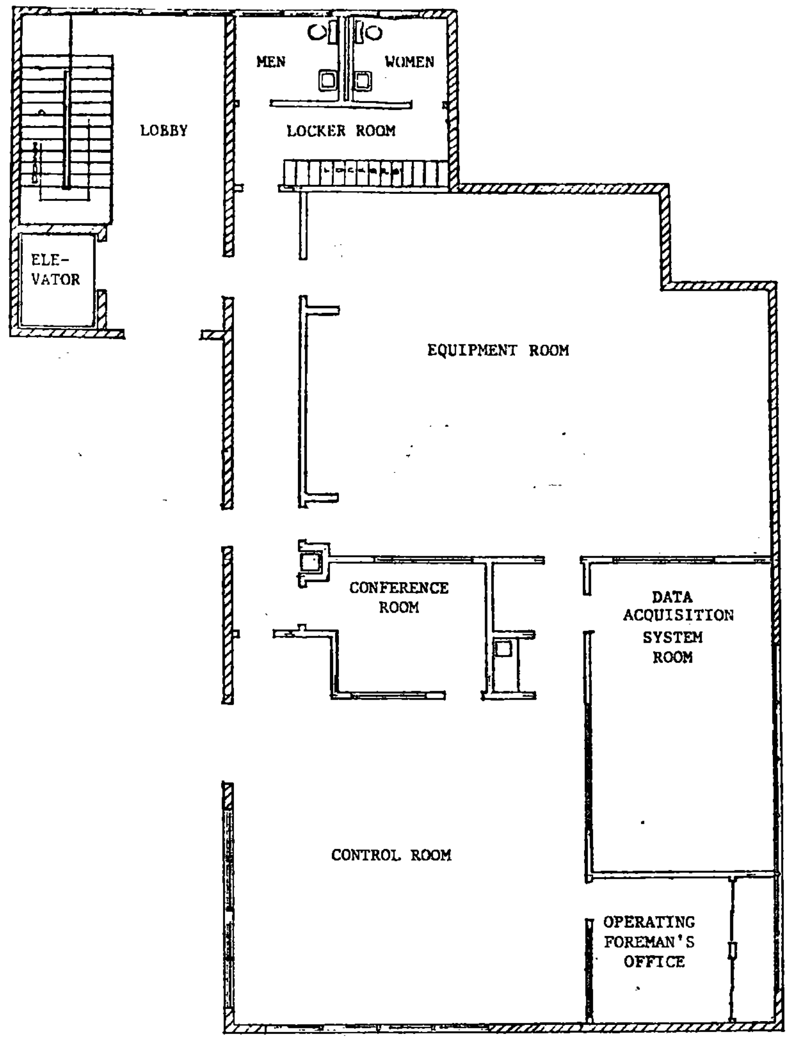
II. Specific Description of Computer System

A. There are four MODCOMP (made by Modular Computer Company) computers installed at the plant. Two will control the heliostats, one will control the plant and one will monitor the plant.

1. Beckman Instruments provided the Distributed Process Control, control consoles and corresponding peripheral equipment.
2. McDonnell Douglas is the integrating contractor and together with Southern California Edison provided the control logic (equations) to tell the computer how to run the pumps, valves, etc. (the plant excluding the heliostats).
3. Martin Marietta provided the control logic to run the heliostats.

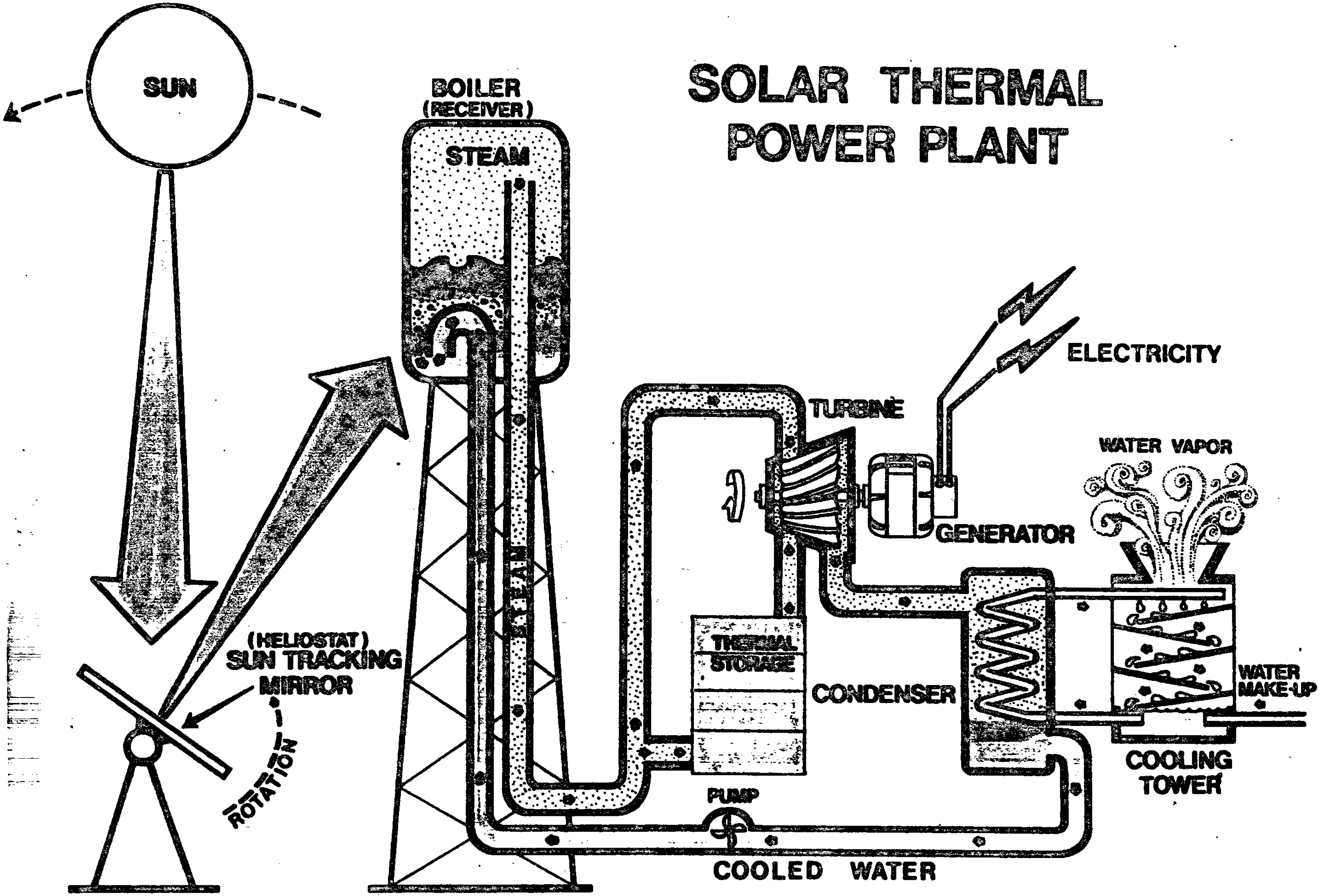


FIRST FLOOR PLAN

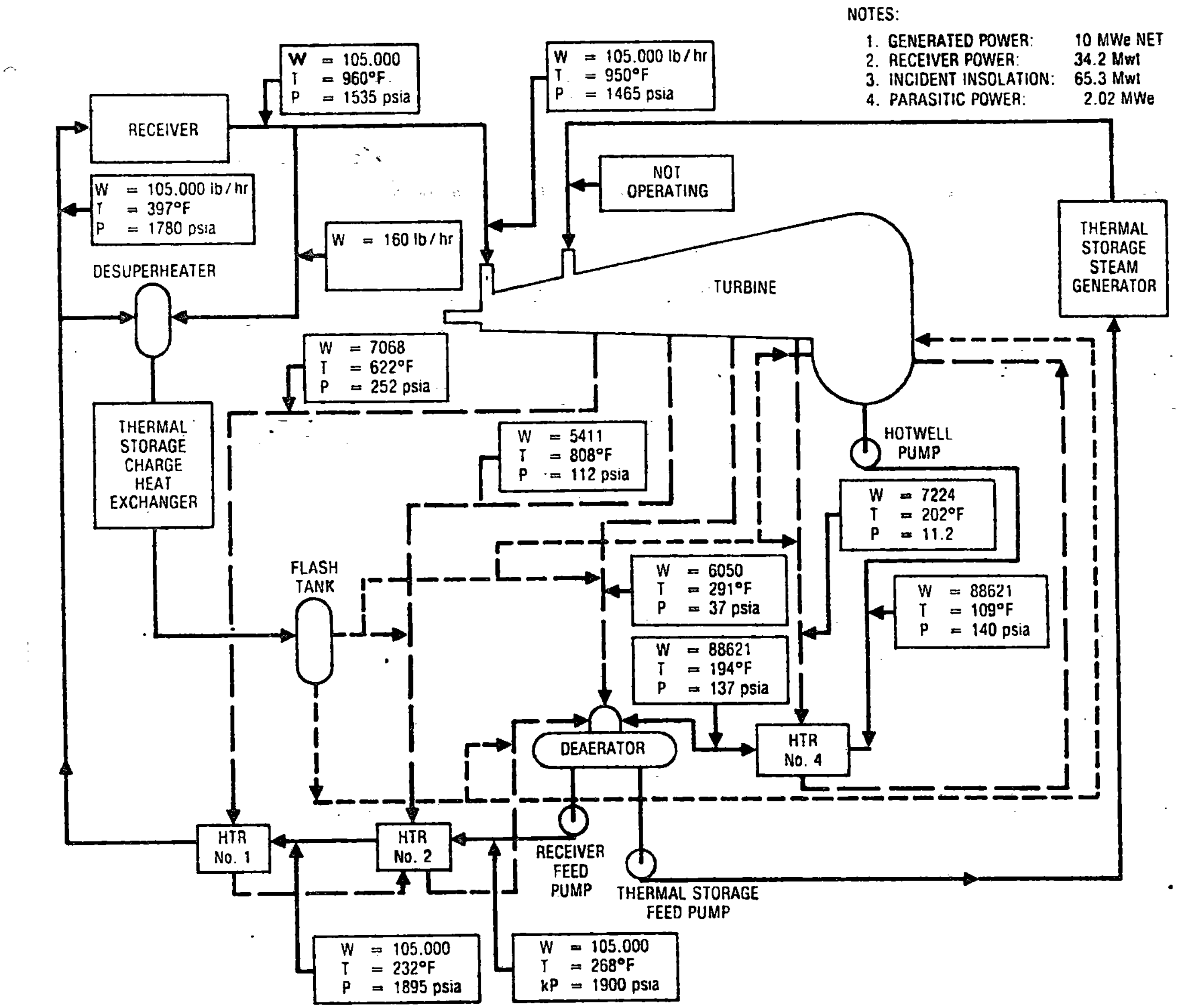


SECOND FLOOR PLAN

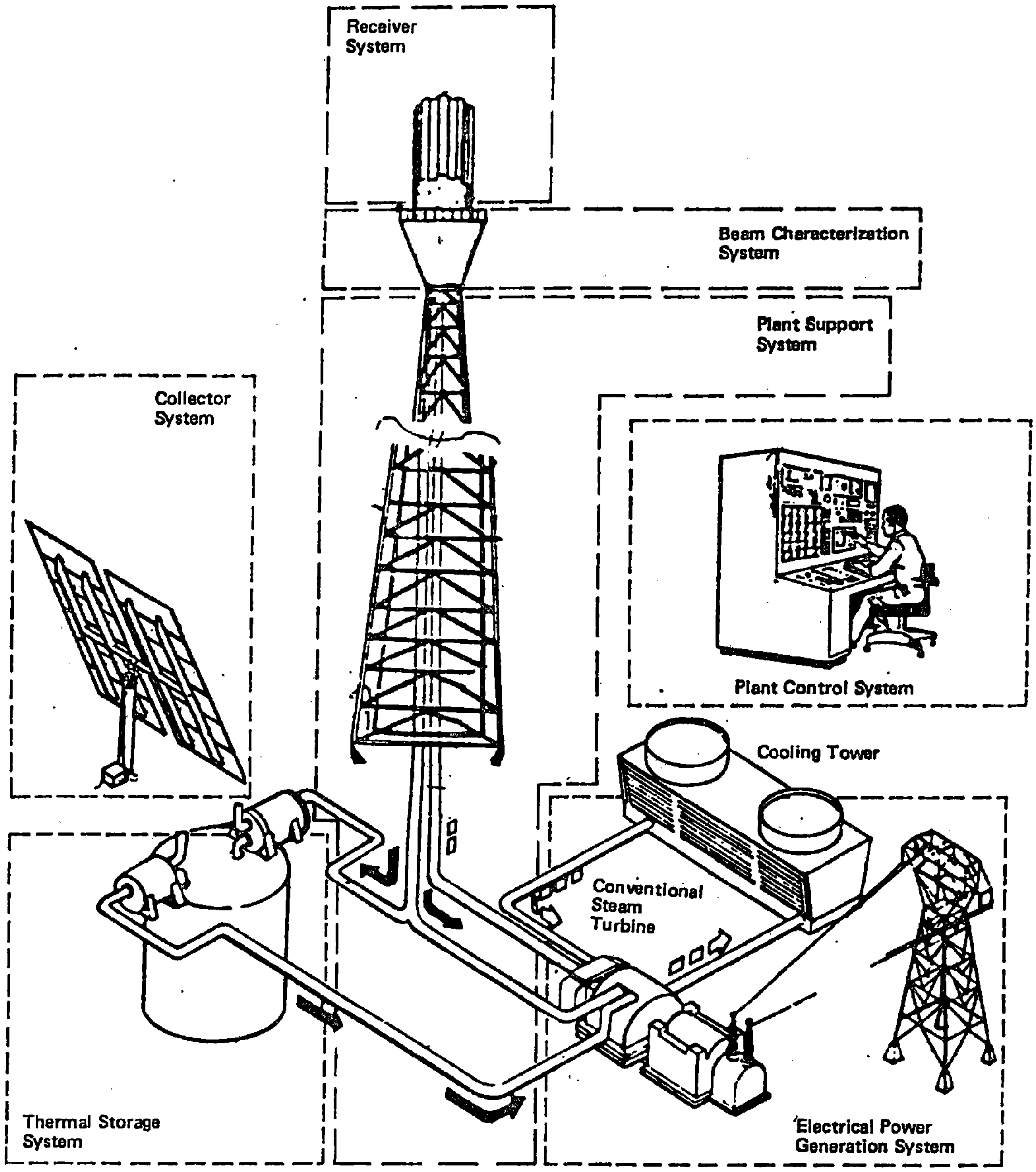
SOLAR THERMAL POWER PLANT

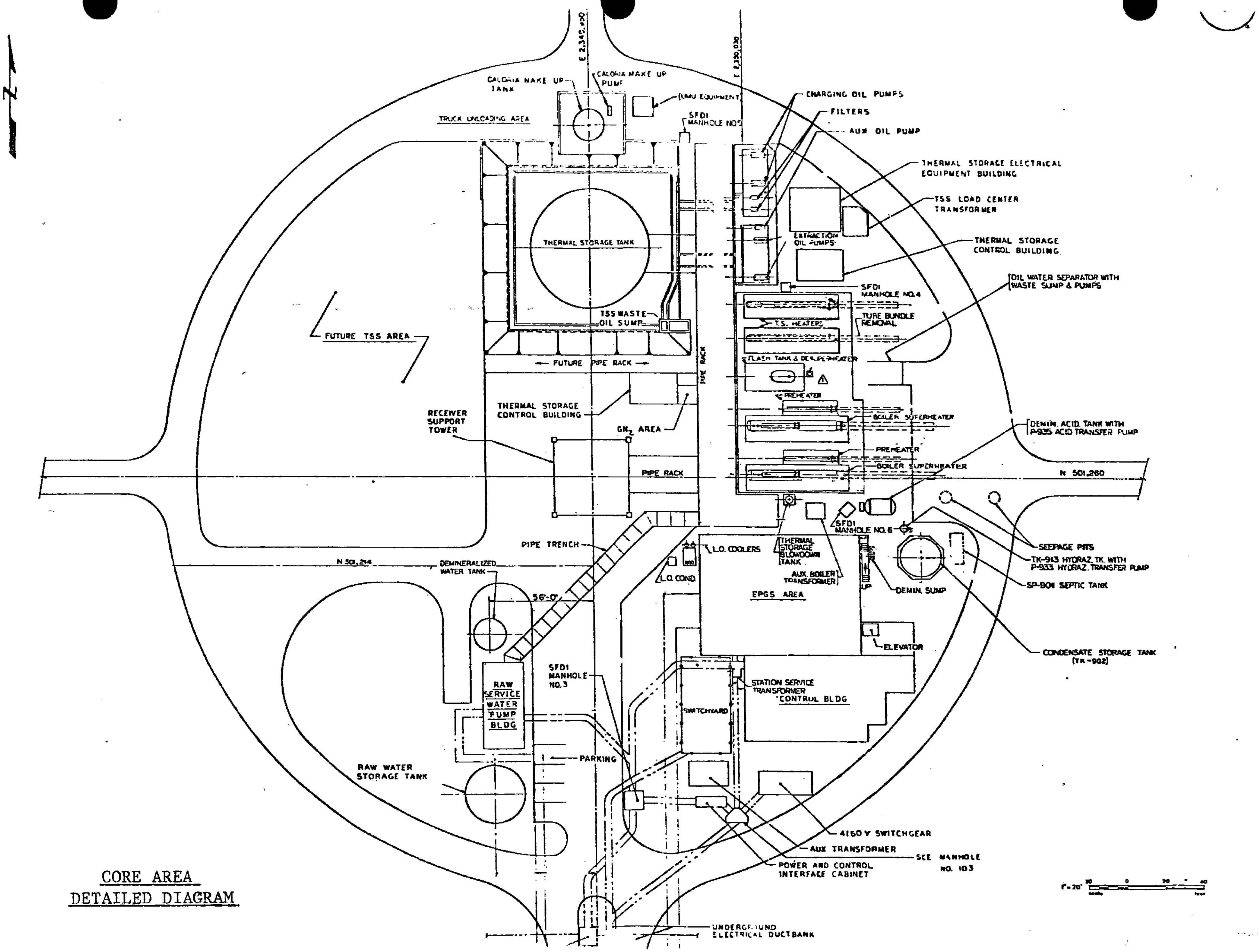


STEAM FLOW DIAGRAM



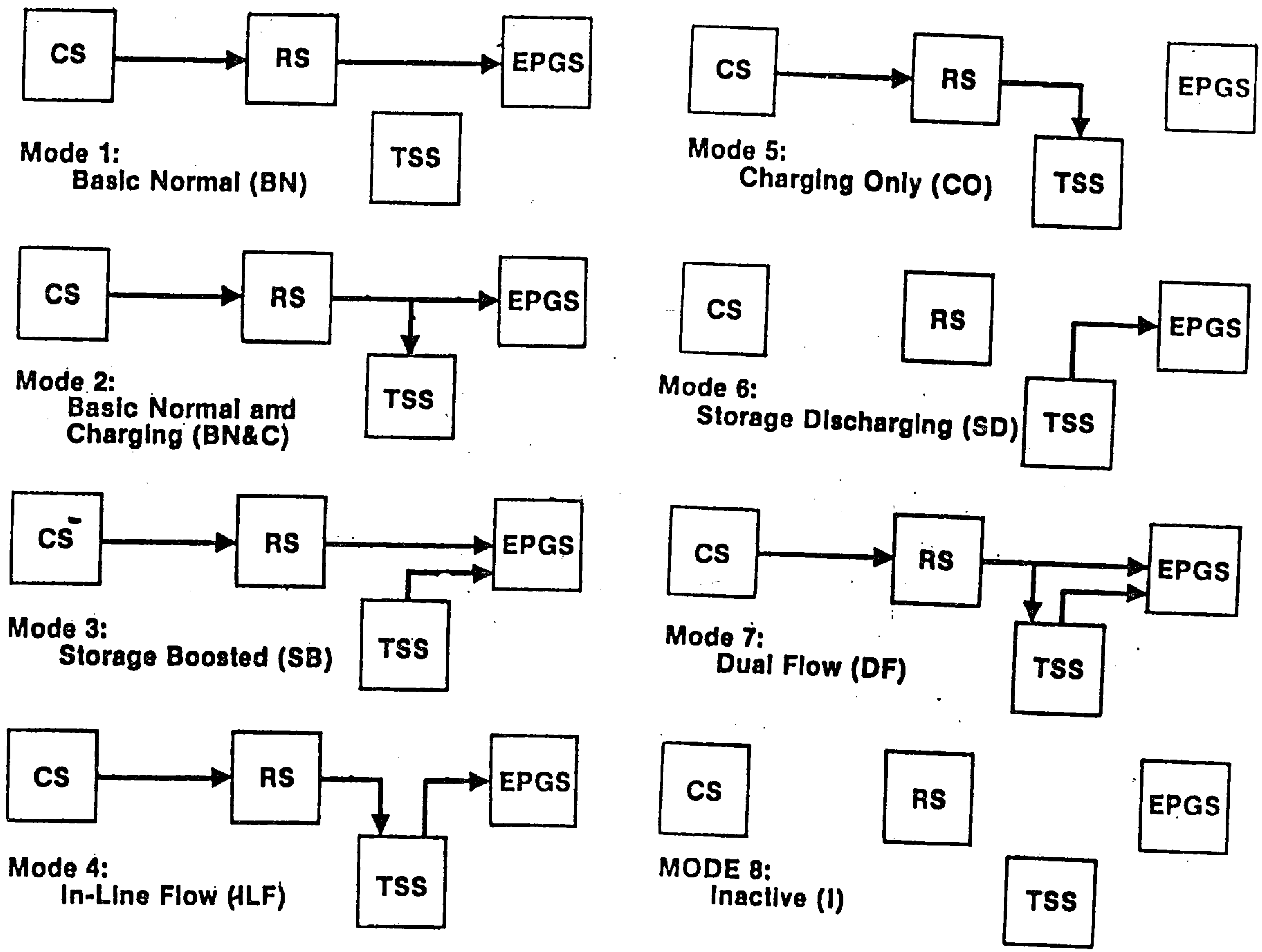
PLANT SYSTEM SCHEMATIC



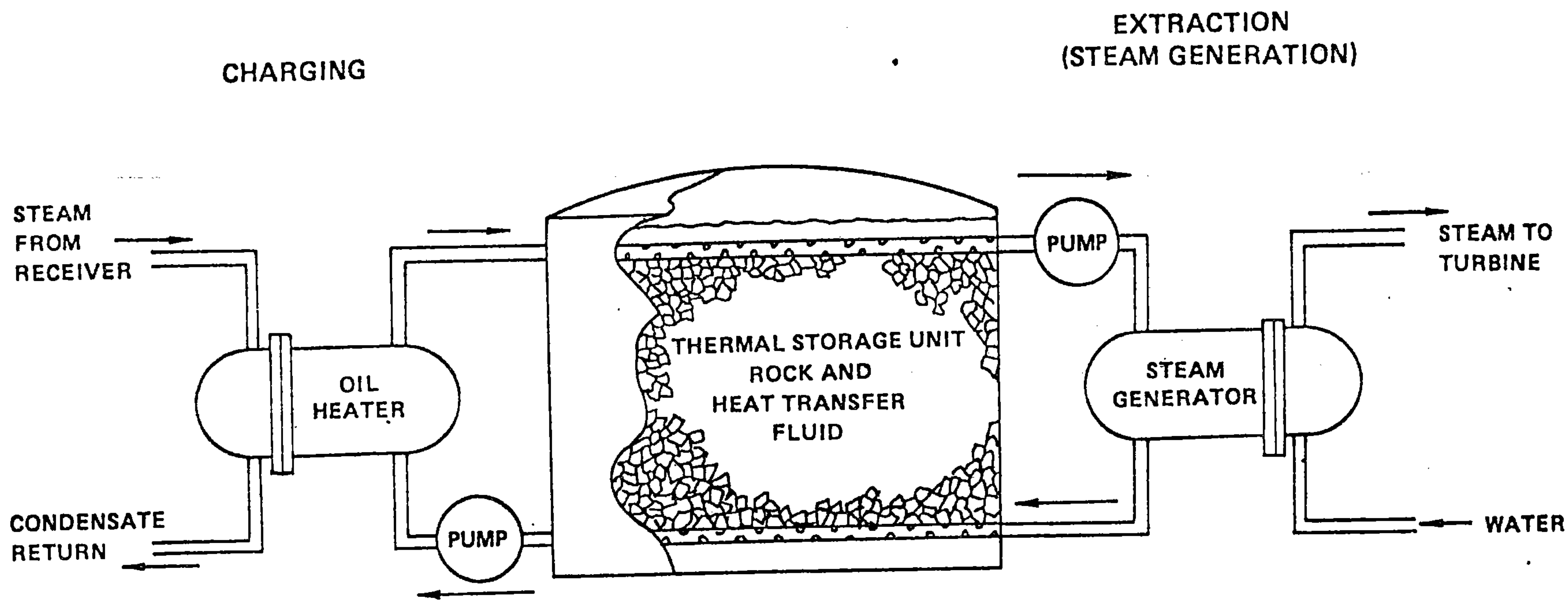


CORE AREA DETAILED DIAGRAM

SYSTEM OPERATING MODES



SOLAR ONE THERMAL STORAGE SUBSYSTEM



~ 10/80

File @ 10/24/80

for 10/30 Dedication

SOLAR 10-MWe PILOT PLANT

General Information

- Plant Capacity:

  10 MWe Net From Receiver Steam
  7 MWe Net From Thermal Storage Steam
  1 MWe Auxiliary Power (Varies Dependent on Plant Capacity)
  Thermal Efficiency Ranges From 10-15% (Sunlight To Field, Electric Power Out)

- Main Turbine Steam Conditions:

  115,000 lb/hr
  1515 psi
  950° F

- Thermal Storage System:

  Capacity:

  28 MWH (7 MW For 4 Hours)

  Steam Conditions:

  110,000 lb/hr
  415 psi
  500 °F

- Turbine - Generator:

  Dual Admission Ports (Receiver & Thermal Storage Steam Respectively)
  Capacity - 12.5 Megawatts (Design Maximum)

- Turbine Roll Date:

  December 1, 1981 (Plant Operational)

- Test Programs:

  Experimental Tests (2 Yrs) -
  Prove Central Receiver Concept
  Feasibility & Evaluate Capital Costs
  O & M Expenses & Operation.

  Power Production Tests (3 Yrs) -
  Optimize Plant O & M in a Commercial Role

  Consider Other Possible Applications
  Process Steam (Distillation, Oil Field Injection, etc.)

Collector System

- Total Number Of Heliostats 1,818 (21,816 Mirror Modules)
- Heliostat Reflective Area: 430 Ft^2 (12 Mirror Modules Per Heliostat)

Collector System - Continued

- o Heliostats Automatically Track The Sun (Each Controller Positions The Reflective Assembly Utilizing Pre-Programed Coordinates)

- o Mirrors Will Proceed To Stow (Glass Surface Horizontal To Ground) On Command When Encountering High Winds Or Emergency Shutdown

- o Collector Field Area:
  75 Acres, The Property Is Owned By Southern California Edison

- o The Field Diameter 2,588 Ft. (At Widest Point)

Receiver System

- o Tower Height: 300 Ft.

- o Receiver Height: 47 Ft.

- o Receiver Diameter: 23 Ft.

- o 24 Receiver Panels

  6 Preheat Panels, 18 Superheat Panels. Seventy - ½" O.D. Tubes/Panel (Max Tubewall Temperature = 1050 ^{o}F. Material Is Incoloy 800, Chosen For Its Mechanical Properties At High Temperatures)

- o Foundation:

  Spread Footing, Buried Approximately 25 feet down; 1,500 Ton Concrete Base With Walls Culminating In The Four Visible Corner Support Piers

- o The 2nd, 3rd, And 4th Tower Sections Were Lifted In Place The First Week In November. The Approximate Weight Of The Core Is 13 Tons (Without Panels).

Thermal Storage System

- o Tank Size:

  60 Ft. Diameter By 44 Ft. 9 1/8 Inch Straight Side (Volume - Approximately 126,530 Ft ^{3} Or 946,000 Gallons)

- o Foundation:

  6 Ft. Of Special Light-Weight Concrete (Chosen For Its Insulating Properties To Reduce Heat Loss To The Ground)

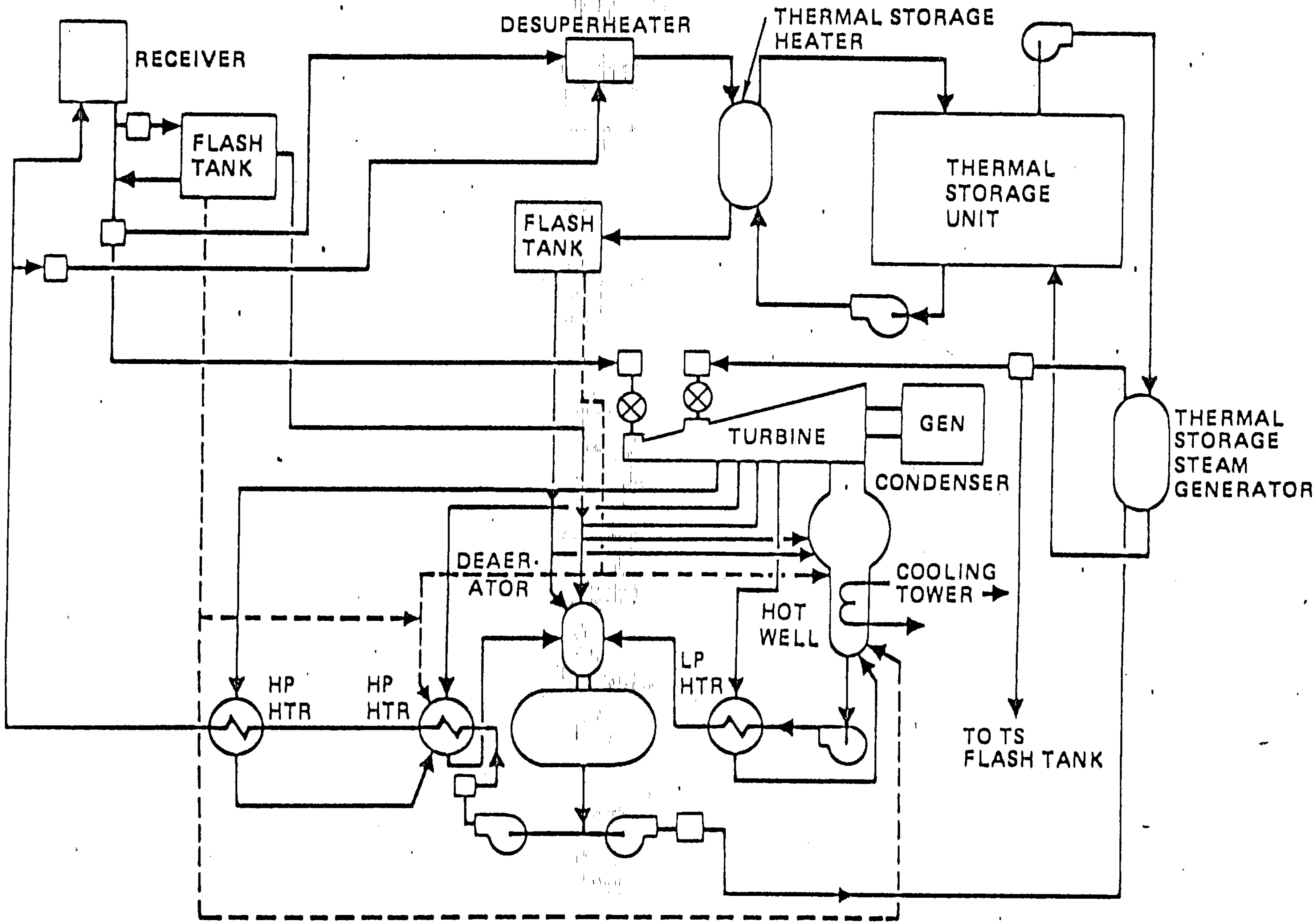
- o Tank Will Be Filled With Caloria HT43 (580^{o} F) And Rock To Act As A Heat Storage Vessel

Water Consumption (Annual Basis With A Load Factor Of 55%)

- o Receiver Make up: 2 GPM

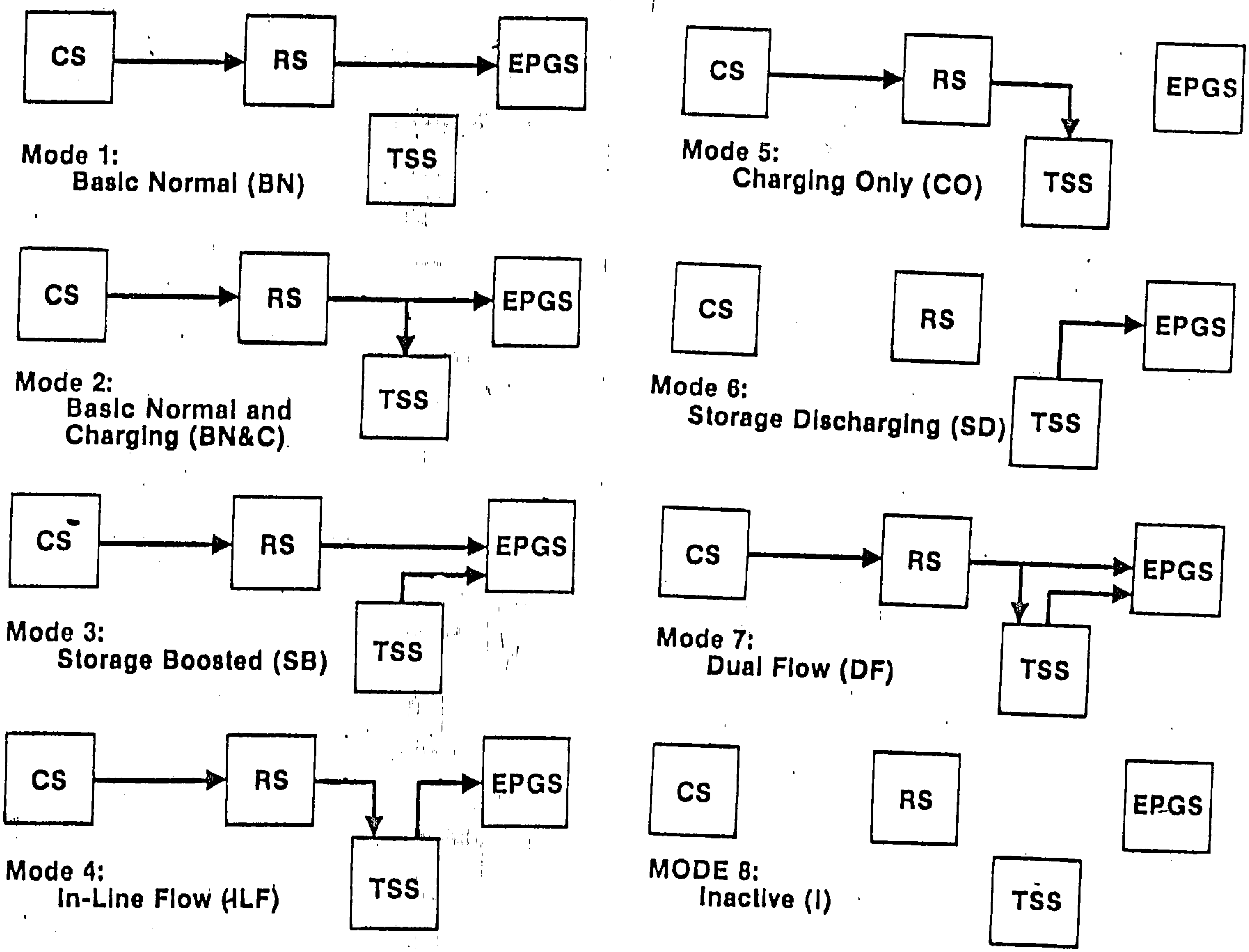
- O Cooling Tower : Blowdown: 22 GPM
  Evaporation And Drift: 71 GPM

SIMPLIFIED 10 MWe PILOT PLANT SYSTEM SCHEMATIC



SYSTEM OPERATING MODES

CS = Collector System
RS = Receiver System
EPGS = Electric Power Generating System
TSS = Thermal Storage System



Mode 1:
Basic Normal (BN)

Mode 2:
Basic Normal and Charging (BN&C)

Mode 3:
Storage Boosted (SB)

Mode 4:
In-Line Flow (ILF)

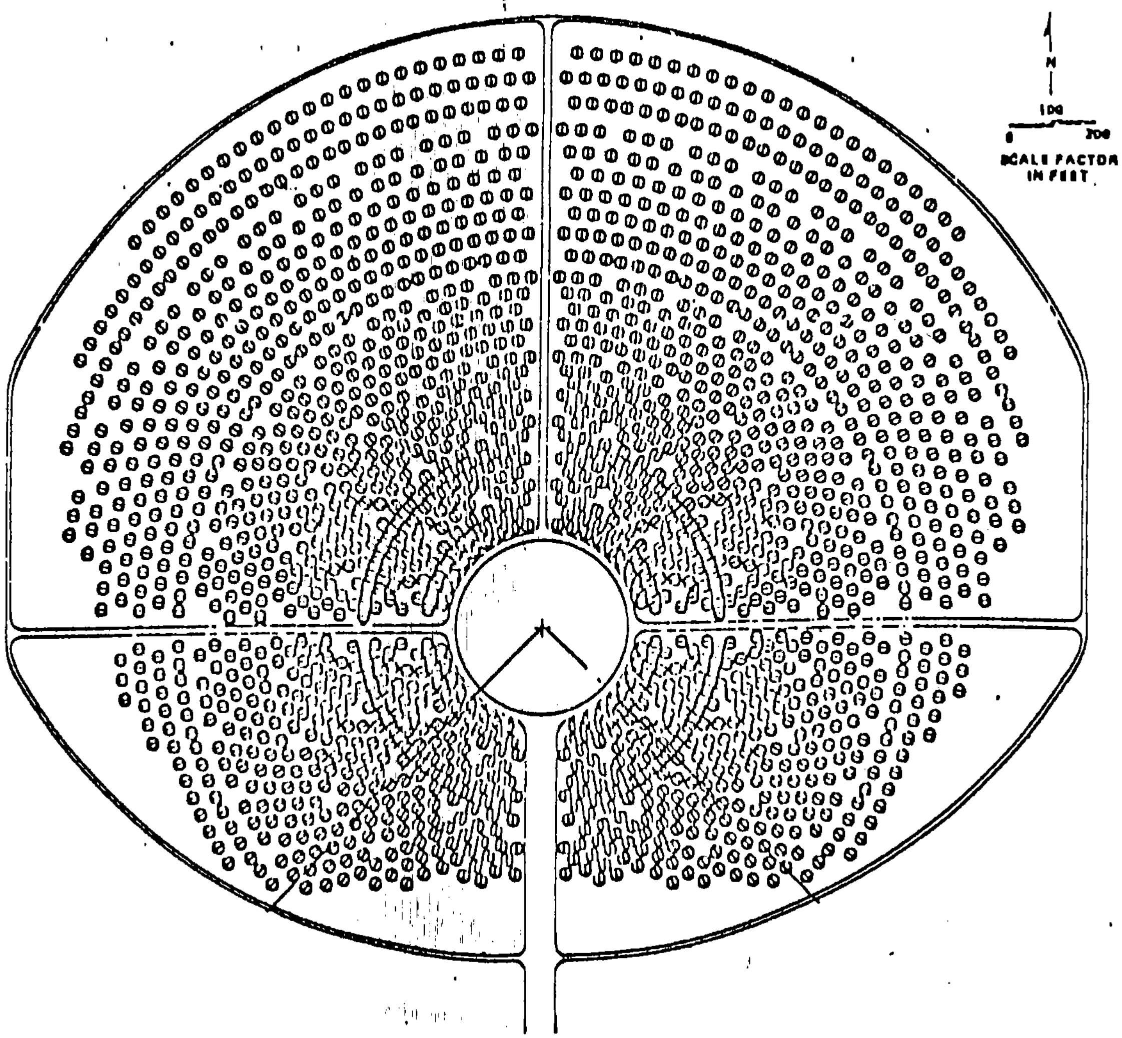
Mode 5:
Charging Only (CO)

Mode 6:
Storage Discharging (SD)

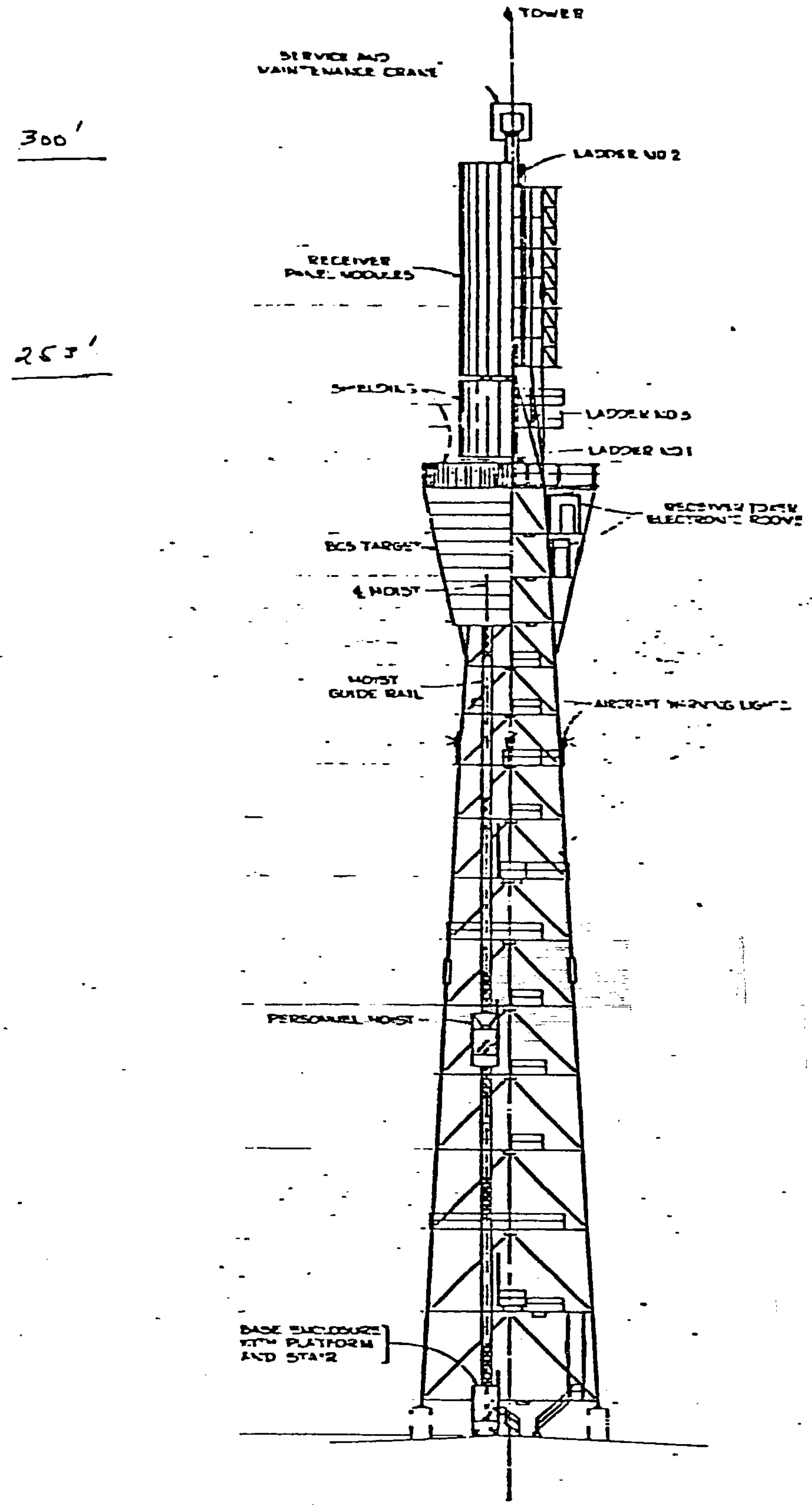
Mode 7:
Dual Flow (DF)

MODE 8:
Inactive (I)

SOLAR 10 MWe PILOT PLANT



TOTAL FIELD POWER
~ 45 MWT



RECEIVER TOWER

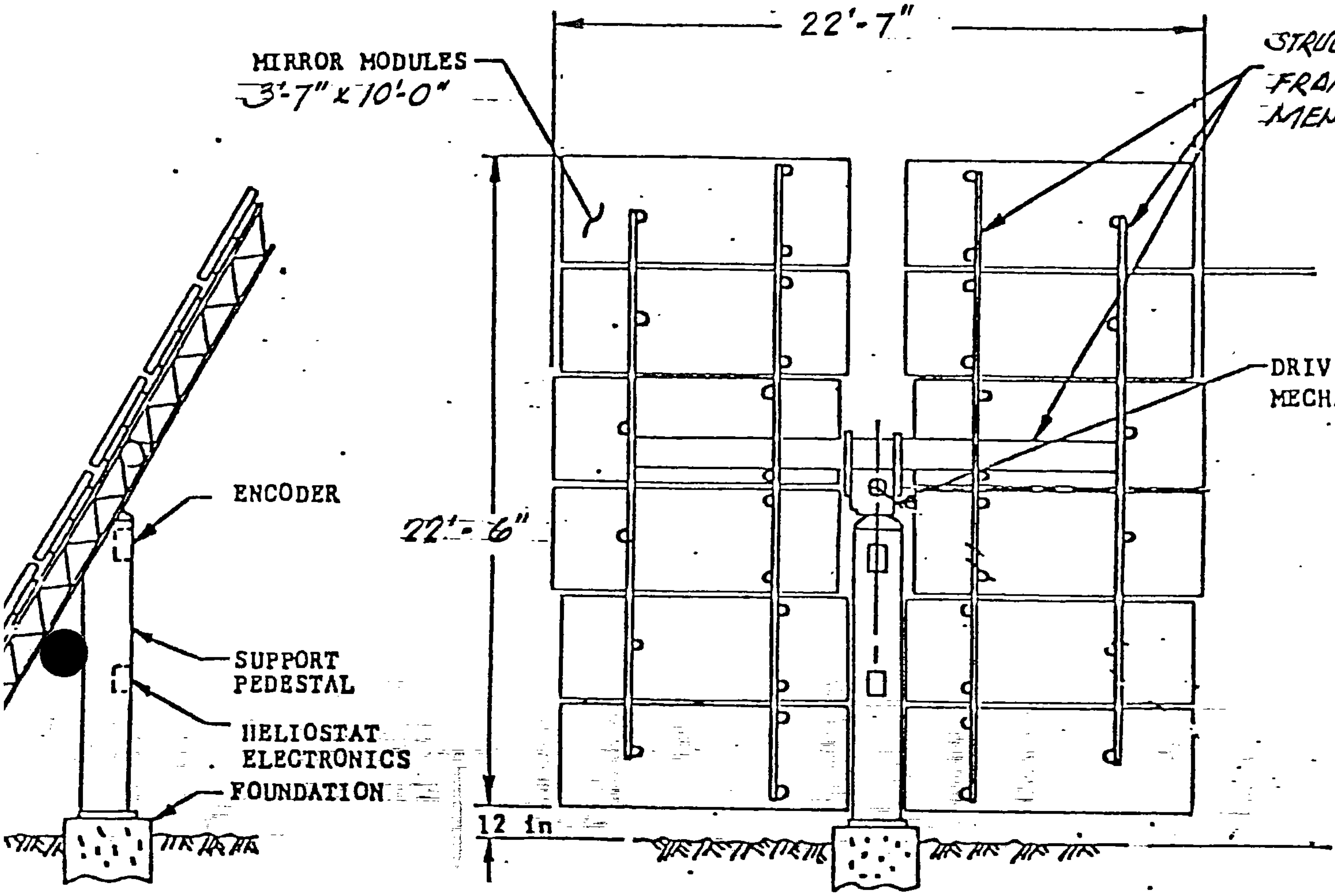
(LOOKING EAST)

(ADAPTED FROM SFDI DRAWING)

Martino
10-28-80

TOWNSEND AND BOTTUM, INC

CONSTRUCTORS · CONSTRUCTION MANAGERS · FOR THE POWER INDUSTRY



TOTAL WEIGHT - 4132 lbs

- 1818 TOTAL HELIOSTATS
- 21,816 MIRROR MODULES
  = 18 ACRES OF REFLECTIVE SURFACE AREA
  = THE AREA OF 14 FOOTBALL FIELDS

TYPICAL HELIOSTAT

(ADAPTED FROM A MARTIN-MARIETTA SKETCH)

morino

4/18/78

FACT SHEET

SOLAR ONE

A 10-Megawatt Solar Thermal Central Receiver Pilot Plant

PROGRAM DESCRIPTION: A 10-megawatt pilot plant, scheduled to be completed in 1981, will be the nation's first electric generating station powered directly by solar energy and connected to a utility grid. Edison, the Los Angeles Department of Water and Power, and the California Energy Commission were jointly selected by the U.S. Department of Energy (formerly Energy Research and Development Administration) to join in a cooperative effort to build and operate the pilot solar facility.

The pilot plant will utilize the central receiver concept. Sunlight is reflected off a group of sun-tracking mirrors (heliostats) to concentrate on a receiver/boiler that produces steam to generate electricity. Heat storage is used to extend the power plant's usefulness through early evening hours.

LOCATION: Located near Southern California Edison's Cool Water Generating Station in Daggett, approximately 12 miles southeast of the City of Barstow.

UNIT SIZE: 10-Megawatts Net Electric Output.

UTILITY RESPONSIBILITY: Furnish Pilot Plant Site
- 130 Acres
- Flat, Dry, Maximum Sunshine

Furnish Tie-In to Electric Network
- Pole Line from Pilot Plant to Cool Water Switchyard
- Electric Energy Transmitted Through Edison System
- 20% of Output Exchanged to Los Angeles DWP

Furnish Steam Turbine-Electric Generator and Auxiliaries
- 10-MW Net Electric Output
- Conventional Evaporative Cooling Towers

Operate and Maintain the Entire Pilot Plant
- Five Year Test Period

Engineer Visitor's Information Center

GOVERNMENT RESPONSIBILITY: Design and Construct the Solar Portion of the Pilot Plant Including:
- Heliostats (Sun-Tracking Mirrors)
  Approximately 2,000 Required
  Multi-faceted Glass Mirrors of Approximately 400 Square Feet

(over)

- Receiver (Boiler)
  Boiler Tubes Mounted Around Entire Circumference
  Once-through to Superheat Fluid Circuitry
- Thermal Storage
  Heated Oil Stored in Tanks
  Tanks Also Filled with Gravel and Rocks
- Master Control System
  Interface Control System to Tie Turbine-generator, Heliostat, Receiver, and Thermal Storage Systems Together
- Construct Visitor's Information Center

ENERGY COMMISSION RESPONSIBILITY: Dissemination of Technical Information
Review of Siting Procedures
Coordinating Efforts of Public Agencies

OWNERSHIP: Solar Portion: DOE
Turbine-Generator Portion: Edison-80%; DWP-20%

PROJECTED COSTS: Solar Portion: Approximately $110 Million
Turbine-Generator Portion: Nearly $15 Million

ESTIMATED WORK FORCE: Up to 500 workers during peak construction period. The operating personnel required are estimated to be 20.

WATER USAGE: Approximately 220 acre-ft. of water per year for pilot plant cooling and heliostat washing.
Water required for pilot plant will be diverted from that presently used for other Edison operations.
No additional pumping is contemplated.

PROJECT SCHEDULE:

Start Site Construction	- January 1979
Complete Construction	- April 1981
Initiate Plant Operation	- September 1981

TESTING PERIOD: 5 years

PILOT PLANT OBJECTIVES: To establish the technical feasibility of a solar thermal power plant of the central-receiver type including repowering applications.
To obtain sufficient development production and operating data to indicate the potential overall economics of commercial power plants of similar design.
To determine the environmental impact of solar thermal central receiver plants.

Revision No. 5
April 18, 1978

Approved by:

Project Director
U.S. Department of Energy

Deputy Project Director
Southern California Edison Co.

Rev 6 1/79

FACT SHEET

SOLAR ONE PROJECT

A 10-Megawatt Solar Thermal Central Receiver Pilot Plant

PROGRAM DESCRIPTION:

A 10-megawatt pilot plant, scheduled to be completed in 1981, will be the nation's first central receiver electric generating station powered directly by solar energy and connected to a utility grid. Edison, the Los Angeles Department of Water and Power, and the California Energy Commission were jointly selected by the U.S. Department of Energy to join in a cooperative effort to build and operate the pilot solar facility.

The pilot plant will utilize the central receiver concept. Sunlight is reflected off a group of sun-tracking mirrors (heliostats) to concentrate on a tower-mounted receiver/boiler that produces steam to generate electricity. Heat storage is used to extend the power plant's usefulness through early evening hours.

LOCATION:

Located near Southern California Edison's Cool Water Generating Station in Daggett, approximately 12 miles southeast of the City of Barstow.

UNIT SIZE:

10-megawatts net electric output.

UTILITY RESPONSIBILITY:

Furnish pilot plant site
- 130 acres
- Flat, dry, maximum sunshine

Furnish tie-in to electric network
- Pole line from pilot plant to Cool Water switchyard
- Electric energy transmitted through Edison system
- 20% of output exchanged to Los Angeles DWP

Furnish steam turbine-electric generator and auxiliaries
- 10-MW net electric output
- Conventional evaporative cooling towers

Operate and maintain the entire pilot plant
- Five-year test period

Engineer Visitor's Information Center

GOVERNMENT RESPONSIBILITY:

Design and construct the solar portion of the pilot plant including:
- Heliostats (sun-tracking mirrors)
  Approximately 1600-1800 required
  Multi-faceted glass mirrors of approximately 450 square feet each

- Receiver (boiler)
  - Boiler tubes mounted around entire circumference
  - Once-through to superheat water circuitry
- Thermal storage
  - Heated oil stored in tanks
  - Tanks also filled with gravel and rocks
- Master Control System
  - Interface control system to tie turbine-generator, heliostat, receiver, and thermal storage systems together
- Construct Visitor's Information Center

ENERGY COMMISSION RESPONSIBILITY: Dissemination of technical information
Review of siting procedures
Coordinating efforts of public agencies

OWNERSHIP: Solar portion: DOE
Turbine-generator portion: Edison-80%; DWP-20%

PROJECTED COSTS: Solar portion: approximately $108 million
Turbine-generator portion: nearly $15 million

ESTIMATED WORK FORCE: Up to 500 workers during peak construction period. The operating personnel required are estimated to be 20.

WATER USAGE: Approximately 220 acre-ft. of water per year for pilot plant cooling and heliostat washing.
Water required for pilot plant will be diverted from that presently used for other Edison operations.
No additional pumping is contemplated.

PROJECT SCHEDULE:

Start Site Construction	June 1979
Complete Construction	April 1981
Initiate Plant Operation	September 1981

TESTING PERIOD: 5 years

PILOT PLANT OBJECTIVES:
To establish the technical feasibility of a solar thermal power plant of the central-receiver type including repowering applications.
To obtain sufficient development production and operating data to indicate the potential overall economics of commercial power plants of similar design.
To determine the environmental impact of solar thermal central receiver plants.

Revision No. 6
January 26, 1979

Approved by: Richard H. Schweinberg
Project Director
U.S. Department of Energy

Joseph N. Reeves
Deputy Project Director
Southern California Edison Co.

9/79 Rev 8
Fact Sheet file

FACT SHEET

SOLAR ONE PROJECT

A 10-Megawatt Solar Thermal Central Receiver Pilot Plant

PROGRAM DESCRIPTION: A 10-megawatt pilot plant, scheduled to be completed in 1981, will be the nation's first central receiver electric generating station powered directly by solar energy and connected to a utility grid. Edison, the Los Angeles Department of Water and Power, and the California Energy Commission were jointly selected by the U.S. Department of Energy to join in a cooperative effort to build and operate the pilot solar facility.

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LOCATION: Located near Southern California Edison's Cool Water Generating Station in Daggett, approximately 12 miles southeast of the City of Barstow.

UNIT SIZE: 10-megawatt net electric output.

UTILITY RESPONSIBILITY:

Furnish pilot plant site
- 130 acres
- Flat, dry, maximum sunshine

Furnish tie-in to electric network
- Pole line from pilot plant to Edison's electrical distribution system.
- 20% of output exchanged to Los Angeles DWP

Furnish steam turbine-electric generator and auxiliaries
- 10-megawatt net electric output
- Conventional evaporative cooling tower

Operate and maintain the entire pilot plant
- Five-year test period

Engineer Visitor's Information Center

GOVERNMENT RESPONSIBILITY: Design and construct the solar portion of the pilot plant including:
- Heliostats (sun-tracking mirrors)
  Approximately 1800-2000 required
  Multi-faceted glass mirrors of approximately
  450 square feet each

- Receiver (boiler)
  Boiler tubes mounted around entire circumference
  Once-through to superheat water circuitry
- Thermal Storage
  Heated oil stored in tanks
  Tanks also filled with gravel and rocks
- Master Control System
  Interface control system to tie turbine-generator, heliostat, receiver, and thermal storage systems together
- Construct Visitor's Information Center

ENERGY COMMISSION RESPONSIBILITY: Dissemination of technical information
Review of siting procedures
Coordinating efforts of public agencies

OWNERSHIP: Solar portion: DOE
Turbine-generator portion: Edison-80%; DWP-20%

PROJECTED COSTS: Solar portion: approximately $108 million
Turbine-generator portion: nearly $15 million

ESTIMATED WORK FORCE: Up to 300 workers during peak construction period. The operating personnel required are estimated to be 34.

WATER USAGE: Approximately 220 acre-feet of water per year for pilot plant cooling and heliostat washing.
Water required for pilot plant will be diverted from that presently used for other Edison operations.
No additional pumping is contemplated.

PROJECT SCHEDULE:

Start Site Construction	- Sept. 1979
Information Center Completed	- Jan. 1980
Turbine Roll and Initial Operating Date	- Dec. 1981

TESTING PERIOD: 5 years

PILOT PLANT OBJECTIVES: To establish the technical feasibility of a solar thermal power plant of the central-receiver type including repowering applications.
To obtain sufficient development production and operating data to indicate the potential overall economics of commercial power plants of similar design.
To determine the environmental impact of solar thermal central receiver plants.

Approved by: Richard H. Schweinberg
Project Director
U.S. Department of Energy

J. N. Reeves
Deputy Project Director
Southern California Edison Company

Revision No. 8
September 17, 1979

Rev 9
12/15/79

FACT SHEET

SOLAR ONE PROJECT

A 10-Megawatt Solar Thermal Central Receiver Pilot Plant

PROGRAM DESCRIPTION: A 10-megawatt pilot plant, scheduled to be completed in 1981, will be the nation's first central receiver electric generating station powered directly by solar energy and connected to a utility grid. Edison, the Los Angeles Department of Water and Power, and the California Energy Commission were jointly selected by the U.S. Department of Energy to join in a cooperative effort to build and operate the pilot solar facility.

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- Flat, dry, maximum sunshine

Furnish tie-in to electric network
- Pole line from pilot plant to Edison's electrical distribution system.
- 20% of output exchanged to Los Angeles DWP

Furnish steam turbine-electric generator and auxiliaries
- 10-megawatt net electric output
- Conventional evaporative cooling tower

Operate and maintain the entire pilot plant
- Five-year test period

Engineer Visitor's Information Center

GOVERNMENT RESPONSIBILITY: Design and construct the solar portion of the pilot plant including:
- Heliostats (sun-tracking mirrors)
  - Approximately 1800 required
  - Multi-faceted glass mirrors of approximately 430 square feet each

- Receiver (boiler)
  Boiler tubes mounted around entire circumference
  Once-through to superheat water circuitry
- Thermal Storage
  Heated oil stored in tanks with gravel and rocks
- Master Control System
  Interface control system to tie turbine-generator, heliostat, receiver, and thermal storage systems together
- Construct Visitor's Information Center

ENERGY COMMISSION RESPONSIBILITY:	Coordinating efforts of public agencies Minimizing institutional barriers to solar power Review of siting procedures
OWNERSHIP:	Solar portion: DOE Turbine-generator portion: Edison-80%; LADWP-20%
PROJECTED COSTS:	Solar portion: approximately $118 million Turbine-generator portion: approximately $21.5 million
ESTIMATED WORK FORCE:	Up to 300 workers during peak construction period. The operating personnel required are estimated to be 36.
WATER USAGE:	Approximately 220 acre-feet of water per year for pilot plant cooling and heliostat washing. Water required for pilot plant will be diverted from that presently used for other Edison operations. No additional pumping is contemplated.
PROJECT SCHEDULE:	Start Site Construction - Sept. 1979 Information Center Completed - May. 1980 Turbine Roll and Initial Operating Date - Dec. 1981
TESTING PERIOD:	5 years
PILOT PLANT OBJECTIVES:	To establish the technical feasibility of a solar thermal power plant of the central-receiver type including repowering applications. To obtain sufficient development production and operating data to indicate the potential overall economics of commercial power plants of similar design. To determine the environmental impact of solar thermal central receiver plants.

Approved by:

R. N. Schweinberg
Project Director
U.S. Department of Energy

J. N. Reeves
Deputy Project Director
Southern California Edison Company

Revision No. 9
December 15, 1979

AMM:FS

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FACT SHEET

SOLAR ONE PROJECT

A 10-Megawatt Solar Thermal Central Receiver Pilot Plant

PROGRAM DESCRIPTION: A 10-megawatt pilot plant, scheduled to be completed in 1981, will be the nation's first central receiver electric generating station powered directly by solar energy and connected to a utility grid. Edison, the Los Angeles Department of Water and Power, and the California Energy Commission were jointly selected by the U.S. Department of Energy to join in a cooperative effort to build and operate the pilot solar facility.

The pilot plant will utilize the central receiver concept. Sunlight is reflected off a group of sun-tracking mirrors (heliostats) to concentrate on a tower-mounted receiver/boiler that produces steam to generate electricity. Heat storage is used to extend the power plant's usefulness through early evening hours.

LOCATION: Located near Southern California Edison's Cool Water Generating Station in Daggett, approximately 12 miles southeast of the City of Barstow.

UNIT SIZE: 10-megawatt net electric output.

UTILITY RESPONSIBILITY: Furnish pilot plant site
- 130 acres
- Flat, dry, maximum sunshine

Furnish tie-in to electric network
- Pole line from pilot plant to Edison's electrical distribution system.
- 20% of output exchanged to Los Angeles DWP

Furnish steam turbine-electric generator and auxiliaries
- 10-megawatt net electric output
- Conventional evaporative cooling tower

Operate and maintain the entire pilot plant
- Five-year test period

Engineer Visitor's Information Center

GOVERNMENT RESPONSIBILITY: Design and construct the solar portion of the pilot plant including:
- Heliostats (sun-tracking mirrors)
  Approximately 1800 required
  Multi-faceted glass mirrors of approximately
  430 square feet each

- Receiver (boiler)
  Boiler tubes mounted around entire circumference
  Once-through to superheat water circuitry
- Thermal Storage
  Heated oil stored in tanks with gravel and rocks
- Master Control System
  Interface control system to tie turbine-generator, heliostat, receiver, and thermal storage systems together
- Construct Visitor's Information Center

ENERGY COMMISSION RESPONSIBILITY: Coordinating efforts of public agencies
Minimizing institutional barriers to solar power
Review of siting procedures

OWNERSHIP: Solar portion: DOE
Turbine-generator portion: Edison-80%; LADWP-20%

PROJECTED COSTS: Solar portion: approximately $118 million
Turbine-generator portion: approximately $21.5 million

ESTIMATED WORK FORCE: Up to 300 workers during peak construction period.
The operating personnel required are estimated to be 36.

WATER USAGE: Approximately 220 acre-feet of water per year for pilot plant cooling and heliostat washing.
Water required for pilot plant will be diverted from that presently used for other Edison operations.
No additional pumping is contemplated.

PROJECT SCHEDULE:

Start Site Construction	- Sept. 1979
Information Center Completed	- July 1980
Turbine Roll and Initial Operating Date	- Dec. 1981

TESTING PERIOD: 5 years

PILOT PLANT OBJECTIVES: To establish the technical feasibility of a solar thermal power plant of the central-receiver type including repowering applications.
To obtain sufficient development production and operating data to indicate the potential overall economics of commercial power plants of similar design.
To determine the environmental impact of solar thermal central receiver plants.

Approved by:

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