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NASA TECH BRIEF

Marshall Space Flight Center

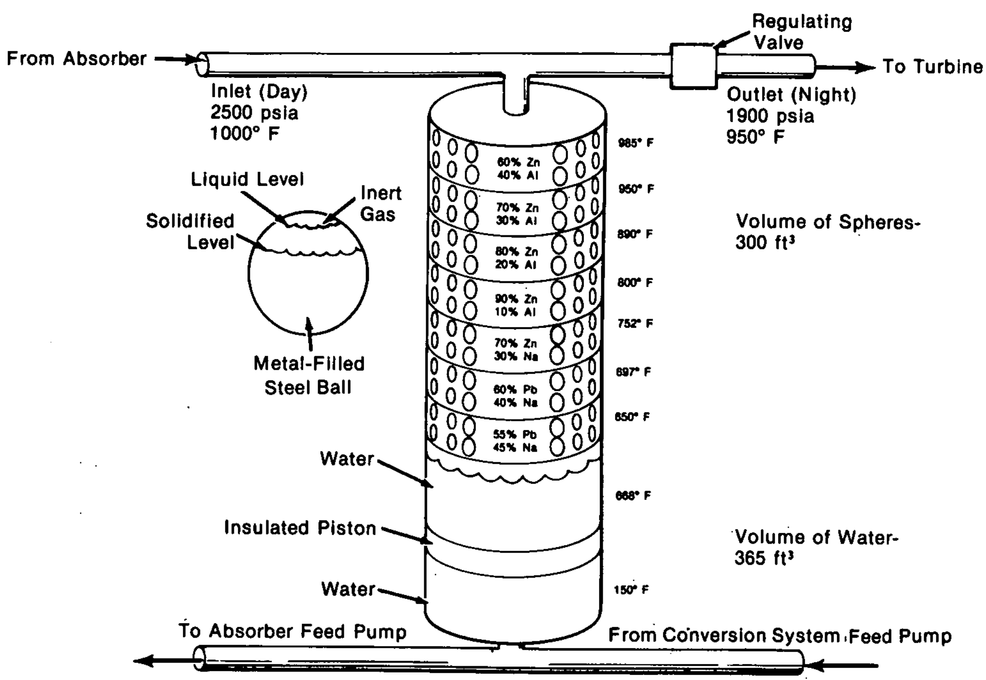
Large-Scale Solar Thermal Collector Concepts

Marshall Space Flight Center has conducted a study to define quantitatively a large-scale solar thermal collector that could be used ultimately to power a steamplant to produce electricity. The collector would consist of two major subsystems: (1) a series of segmented tracking mirrors with two axes of rotation and (2) an absorber mounted on a centrally located tower. A collector for an installation producing 100 kW of electricity (running continuously) was studied first, and the technique was then extended to the design of a system to produce 100 MW of electricity throughout a 12-hour day.

Several computer programs were written to aid in calculating the optimal mirror size, type, geometry, and placement. Other programs were used to determine the resulting performance of the system. The mirror configuration found to be best was a field of flat-plate reflectors oriented so that the reflected rays arrive at a single point, where the absorber is placed. This configuration is frequently referred to as an approximated paraboloid. Each mirror can be rotated about two axes to follow the position of the Sun.

The absorber studied consisted of a low-temperature preheater section and a high-temperature section. Incoming radiation is directed to the preheater where it is reflected along a light pipe with walls having low solar-spectrum absorbance and high infrared absorbance. The light is then reflected to the high-temperature section which has high solar-spectrum absorbance and low infrared emission. The absorber working fluid first passes through the preheating section and then circulates through the high-temperature section.

The calculated absorber efficiency was 90 percent, but 80 percent was used in the study to allow for possible losses in heat transfer. If water is used as the fluid, about 50 percent of the energy is used to heat it,



Energy Storage System

(continued overleaf)

25 percent to boil it, and 25 percent to superheat it to 1,000° F at 2,500 psia (540° C at 17×10^6 N/m^2).

The energy storage concept is shown in the figure. Energy is stored first as the heat of fusion of metal mixtures contained in steel-walled spheres and second in condensed water. To charge the module, steam entering the top gives up its energy and is cooled as it passes through mutually insulated zones of spheres of different-melting-point metal mixtures. It is finally condensed in the lower zone. To discharge the module, the pressure is lowered, and the condensed water begins to boil. The steam is superheated by the metal spheres as it passes up through the module. The following table is a summary of the characteristics of electrical generating plants designed to produce 100 kW (continuous) and 100 MW (12 hours).

CHARACTERISTICS	100-kW Plant (Continuous)	100-MW Plant (12 hours/Day Only)
Reflector Field		
Land Area	2 acres	640 acres
Surface Area	328,000 ft^2	13,000,000 ft^2
Mirror Diameter	15 ft	15 ft
Number of Mirrors	185	70,000
Mirror Spacing (N-S/E-W)	25-32/16-23 ft	25-45/16-30 ft
Reflector Surface/Pointing Accuracy	1/4° / 1/4°	1/10° / 1/10°
Reflector Efficiency	80%	80%
Total Thermal Power	2 MW (average)	600 MW (average)
Tower Height	150 ft	1,500 ft
Absorber		
Diameter (Flat/Spherical)	28/20 ft	70/50 ft
Efficiency	80%	90%
Solar Flux Peak	5,000 W/ft^2	100,000 W/ft^2
Energy Storage		
Efficiency	80%	90%
Capacity	18 hours	6 hours
Al-Zn and Pb-Na Alloys	300/67 (ft^3/tons)	72 K/16.1 K (ft^3/tons)
Pressure Water Volume	365/11.5 (ft^3/tons)	87.5 K/2.75 K (ft^3/tons)
Conversion System Efficiency	30% (assumed)	35% (assumed)
Turbine Inlet Temperature	950° F	1,000° F

Note:

Requests for further information may be directed to:

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Patent status:

Inquiries concerning rights for the commercial use of this invention should be addressed to:

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Categories: 03 (Physical Sciences)
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