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Near-Term Brayton Module Status

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Summary

Sanders Associates, Inc. was selected as system integrator for this program with the responsibility of integrating subsystem components and testing a Parabolic Dish Module (PDM) to convert solar energy to grid compatible electric power.

By March 1983 Trade Studies had been completed and the PDM system components were selected. System components were selected on a basis of current and projected performance efficiencies, technology readiness, future production probabilities and prices, current cost and availability. Though the PDM program was originally oriented toward an 11-12 meter reflector with a 15-20 kw electric output, the trade study conclusion led us to downsize the system to include a smaller lightweight reflector and to output a rated 8 kw electric. Potential for this near-term, 8 kw derivative of the PDM is adjudged to be superior to that of a 20 kw system.

Major system components are: 1, the AiResearch/GRI Mark III subatmospheric Brayton cycle power conversion assembly; 2, the LaJet LEC-460 point focusing concentrator; 3, the Abacus 8 kw DC-AC inverter; 4, the Sanders/JPL low pressure, high temperature ceramic matrix receiver; and 5, the Sanders 8086 microprocessor based control system.

The PDM is suited to both grid connected and standalone applications, and it may be fired by solar, fossil, or solar/fossil hybrid means.

Current program plans call for delivery by AiResearch of two engines. The early engine will be utilized in The Development Test Model (DTM) which will be tested in March of 1984 at Sanders, in Merrimack, NH. DTM objectives are to complete:

- System Integration
- Development of Control Algorithms and system operating logic
- Establishment of System Performance Baselines
- Demonstration of System Feasibility

Following the PDM Critical Design Review (CDR) in April 1984, assembly of a Final System will commence. An improved engine will be delivered directly to Sandia Laboratories, Albuquerque, NM and final system integration is scheduled for September 1984. Testing will be concluded in the fourth quarter of calendar 1984.

Status

The Parabolic Dish Module (PDM) Experiment is being conducted by Sanders Associates under contract (956039) with Jet Propulsion Laboratories, Pasadena, Ca. With the major technology development near completion, the contract will be transferred to Sandia National Laboratories, Albuquerque (SNLA), New Mexico, in early 1984 for testing and improvement. Development Test Model (DTM) experiments, design updating, and performance validation tests (PVT) will occur under the aegis of SNLA through calendar 1984. See Figure 1.

The DTM testing in early 1984 is oriented toward completing subsystem integration. The control system will be integrated with the major system components: 1, engine assembly; 2, concentrator controller; 3, inverter; and 4, the operator control terminal. The DTM will be extensively instrumented to collect baseline performance data against which the improved system will be measured in the fall. System feasibility will be demonstrated during these tests and will provide the experimental proof of concept needed to pursue widespread deployment of the PDM system.

The DTM test results will be used to define control and hardware improvements that will be incorporated in the second unit, the PDM, along with the already planned improvements: 1, improved engine; 2, simplified controller; 3, corrosion resistant heat sink exchanger; 4, optimized recuperator ducting; 5, lighter weight receiver; 6, and (tentatively) the electric start.

The validation of system improvements and increased efficiency are primary goals of the PVT. Additionally, the testing of automatic algorithms essential for unattended operation is planned. During extended testing, lifetime and reliability data will be collected to identify improvements necessary for large scale deployment of this new alternate energy source.

The current PDM system is comprised of advanced components which will provide economic conversion of sunlight to grid compatible AC power with the high reliability and low maintenance costs characteristic of Brayton (jet) power plants. The engine is a subatmospheric Brayton cycle engine recently developed by AiResearch Manufacturing Company of California for the Gas Research Institute to drive natural gas fired heating/air conditioning heat pumps. The engine employs air bearings to achieve life expectancies beyond 30,000 hours and advanced versions will operate in the 8 - 10 kilowatt range. While the engine is currently developmental, it has successfully operated several hundred hours and has no major technical uncertainties. The MOD IIIA engine that will be used in the DTM test sequence uses a vacuum air start system. The more advanced MOD IIIB engine uses a shaft-mounted alternator integral to the compressor turbine shaft. This IIIB engine will be capable of automatic electric starting.

The ceramic matrix receiver designed and built by Sanders is an inherently long-life component. Developmental work continues to improve its already high efficiency and to reduce cost to production level goals.

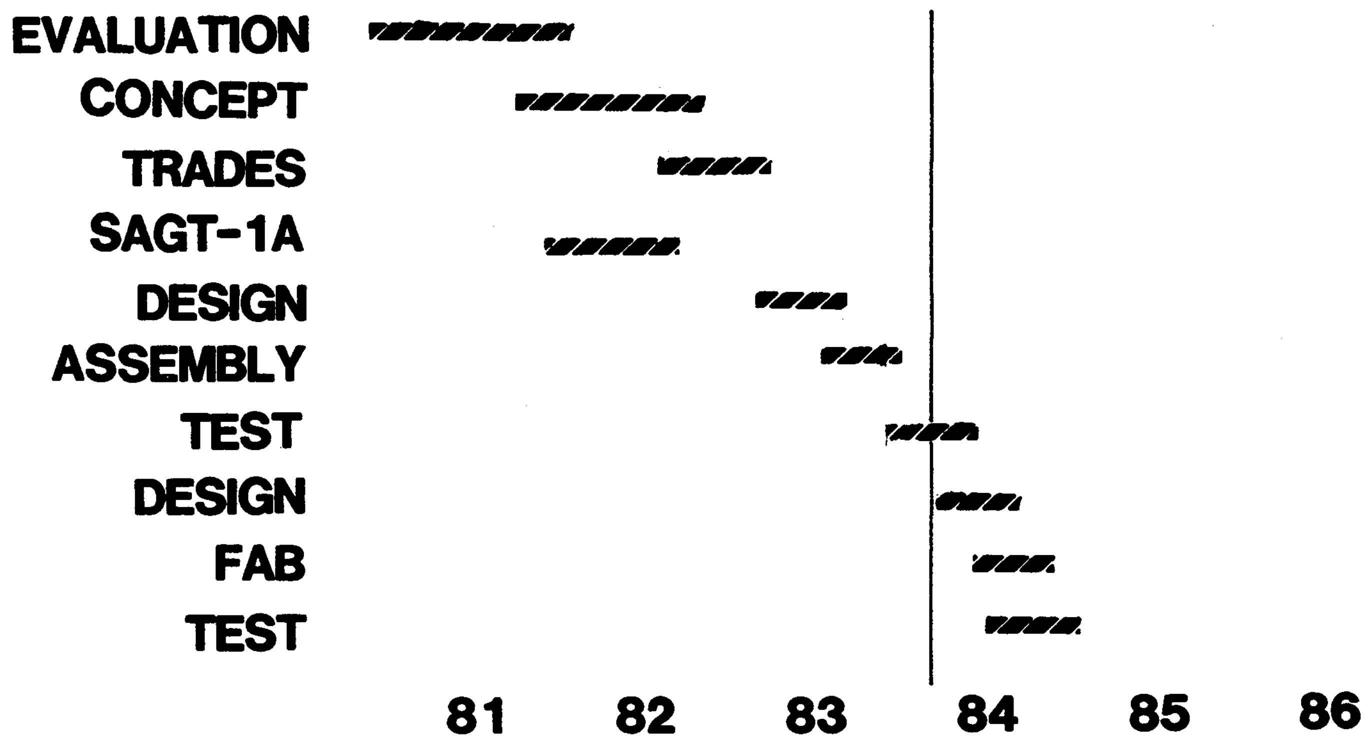


Figure 1. Parabolic Dish Module (PDM) Experiment is Nearing Completion

The lightweight concentrator is equivalent to a 7.4 meter diameter dish and employs 24 closely packed quasi-spherical circular facets to reflect the solar energy through an 8 inch (diameter) aperture into the receiver. The dish has been built in moderate quantities (700+) and meets design to cost (DTC) goals.

The PDM uses an integrally mounted shaft-speed 8 kw permanent-magnet alternator with torque characteristics that allow it to double as a starting motor. The DTM 5 kw alternator from which the 8 kw version is derived has performed reliably during engine testing.

The inverter uses microchips to digitally synthesize the grid-locked output AC from the rectified alternator output. The inverter logic allows signals from the system controller to vary inverter input power requirements and thereby control engine loading.

The PDM control system operates as an executive processor to command the subsystem on-board controllers (concentrator, inverter, and start sequencer.) The controller that was developed for the DTM test will communicate to the operator via a video terminal and will offer a high degree of flexibility to facilitate the developmental testing. Production controllers will be programmed to a more restricted command menu and will consolidate functions to reduce system cost.

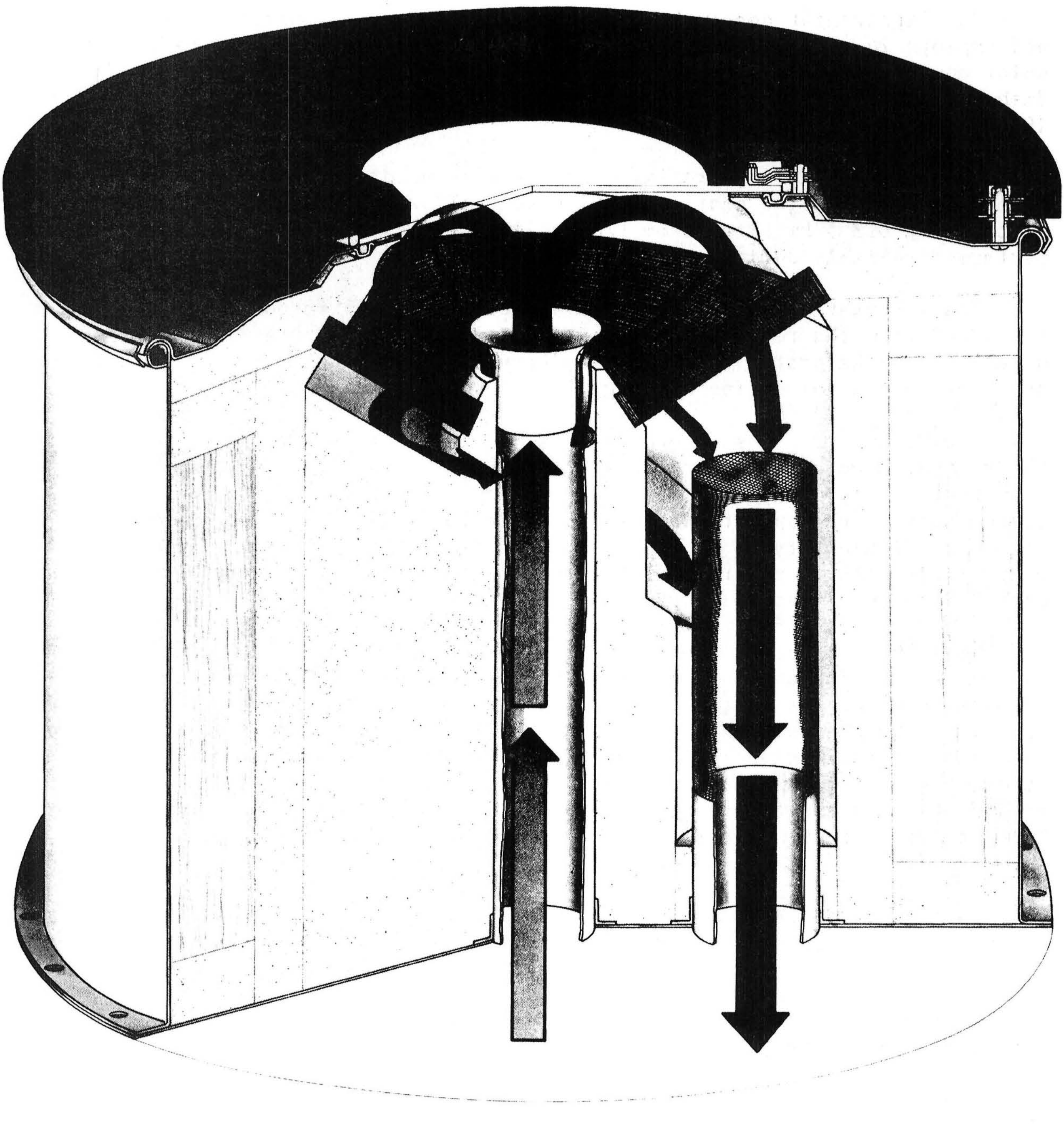
The DTM receiver is shown in cutaway Figure 2. It is conceptually similar to the follow-on receiver that will be used with the PDM. Preheated air enters through a central inlet duct and flows through the radiation cavity to the segmented honeycomb silicon carbide panels. The honeycomb panels are heated to approximately 1850°F by the concentrated sunlight that enters the receiver through the fused quartz window. As the 1200°F preheated air flows through the honeycomb, it is further heated to 1600°F. The hot air is then collected in the tapered plenum and delivered to the outlet duct via a stainless steel particulate filter.

The front of the receiver is protected by a passive graphite shield assembly that is inexpensive and requires no parasitic power.

Two DTM receivers have been assembled; one is being used for development tests -- the other has been delivered to AiResearch for integration into the power conversion assembly (PCA).

Packaging and aperture/cavity modifications will be incorporated into the PDM receiver to reduce its weight and improve its thermal performance.

The solar concentrator for the PDM system is an LEC-460, supplied by Lajet Energy Company of Abilene Texas. In this application the PCA is, at 1300#, heavier than the design load for the concentrator. The concentrator was, therefore, analyzed to determine the modifications that would be required to sustain the heavier PCA and expected snow loads. The structure proved to be generally adequate and only limited modifications were required



MEETS DESIGN TO COST GOALS

Figure 2. Low Pressure-Brayton Cycle Solar Receiver

to meet the desired safety margins with the heavier loading. The modifications have been incorporated and the concentrator is currently being assembled and installed at Sanders' Merrimack, NH facility. Installation will be complete by mid-January and characterization will occur during the ensuing four weeks before DTM testing.

The control system is organized as an executive processor (EP) to expedite the DTM testing and follow-on PVT at Albuquerque. By configuring and programming the EP to use the existing on-board controllers in the inverter, start sequencer, and concentrator, duplication of effort was avoided. This approach reduces contract cost by allowing us to hold to a compressed schedule and complete testing in 1984. Eventually, however, the control system functions will be reallocated to reduce hardware costs and achieve DTC targets. According to Figure 3, the EP:

1, communicates with the operator via CRT or hand-held terminal;

2, commands and monitors the inverter and concentrator;

3, commands the fuel valve and start sequencer:

4, monitors the engine, safety circuits, and weather; and

5, relays data to the recorder for subsequent analysis.

Conclusion

Over the course of this contract, the system has evolved from concept to hardware that will be practical in the near term, figure 4. The smaller 8 kw system that has been developed will provide the market base to support the development of larger systems as more advanced components become available.

By our commitment to the aggressive schedule of Figure 5, we will advance toward the generation of substantial quantities of truly renewable energy and take a crucial step toward the DOE goal of reducing America's energy vulnerability by the year 2000.

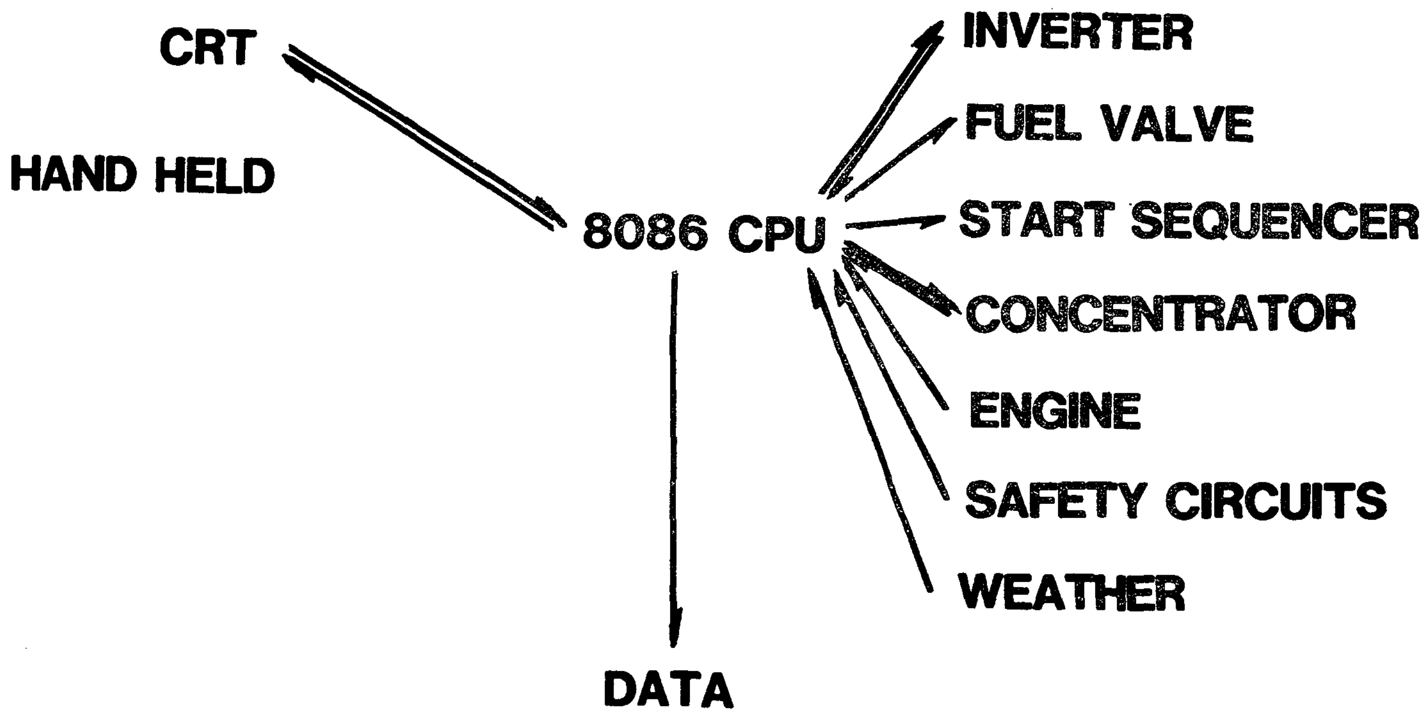


Figure 3. Control System Executive Processor

PARABOLIC DISH MODULE DESIGN

HAS EVOLVED FROM CONCEPT	TO NEAR TERM PRACTICALITY
pressurized receiver	atmospheric receiver
11 meter dish	7.5 meter dish
regenerated	recuperated
15 - 20 kW	7 - 8 kW
computer controlled	8086 mp

Figure 4. System Evolution

INSTALLING 8,000 kW BY 12/85

1,000 units on line by 6/86

2,500 units built by 12/86

5,000 units per year in '87 -

Figure 5. Development Schedule Objective