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SOLAR DYNAMIC HEAT PIPE DEVELOPMENT AND ENDURANCE TEST

CONTRACT NO. 9 - X6H - 8102L - 1
MONTHLY TECHNICAL PROGRESS REPORT NO. 5

30 SEPTEMBER TO OCTOBER 28, 1987

PREPARED FOR
LOS ALAMOS NATIONAL LABORATORY
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DISCLAIMER

I. Introduction

The Space Station requires a high level of reliable electric power. The baseline approach is to utilize a hybrid system in which power is provided by photovoltaic arrays and by solar dynamic power conversion modules. The organic Rankine cycle (ORC) engine is one approach to solar dynamic conversion. The ORC provides the attributes of high efficiency at low temperature and compact simple designs utilizing conventional techniques and materials. The heat receiver is one area which must be addressed in applying the proven ORC to long life applications such as the Space Station. Heat pipes with integral thermal energy storage (TES) canisters and a toluene heater tube are the prime components of the heat receiver from the Phase B preliminary design. This contract is a task order type addressing the design, fabrication and testing of a full scale heat pipe. The contract was initiated on April 16, 1987. Sundstrand has specific responsibilities in each task. Los Alamos National Laboratory (LANL) in turn has the prime contract responsibility to NASA-LeRC.

Task 1 - Transient Tests with the Phase B Heat Pipe

The objective of these tests is the determination of the operating characteristics and power input limits of the heat pipe under conditions corresponding to reacquisition of the sun during emergence from eclipse or conditions corresponding to initial startup of the solar dynamic power system. The heat pipe designed and fabricated under NASA contract NAS3-24666 will be used for these tests. The tests will be conducted by LANL in a vacuum test facility. After completion of these tests, the heat pipe is to be disassembled, inspected and analyzed. Sundstrand's responsibilities for Task 1 are:

1. Review LANL test plans.
2. Witness (at our option) and analyze all tests.
3. Witness disassembly of the heat pipe.
4. Upon receipt of the canisters from the disassembled heat pipe, perform chemical and metallurgical analysis on the canisters and LiOH salt.

Task 2 - New Heat Pipe Design Fabrication and Testing

The objective of this task is to design, fabricate and performance test a new heat pipe with thermal energy storage and a simulated toluene heater. Structural analysis and a random vibration test of the complete assembly are to be performed. Performance characterization by test is to be conducted before and after the dynamic testing. Sundstrand's responsibilities for Task 2 are:

1. Design and fabricate flight weight thermal energy storage canisters with a thermocouple well to allow for monitoring the phase change material temperature during testing.
2. Review LANL's heat pipe analyses and test plans.
3. Develop specifications of input heat flux and design vibration spectrum.
4. Design, fabricate, analyze and checkout vibration test fixture.
5. Perform a random vibration test in each of three mutually orthogonal axes.
6. Witness and analyze heat pipe performance tests conducted by LANL.

Task 3 - Endurance Testing

The objectives of this task is to perform a six-month continuous thermal cycling test of the new heat pipe with TES charge and discharge cycles corresponding to a typical space station orbital cycle. Post test physical, chemical and metallurgical analysis of the heat pipe assembly is to be performed. Sundstrand's responsibilities for Task 3 are:

1. Review LANL instrumentation, test plans and test data.
2. Perform post-test chemical and metallurgical analyses on the canisters and LiOH.

Task 4 - Toluene Heater Tube

The objectives of this task, to be performed solely by Sundstrand are:

1. Design and fabricate a supercritical reverse flow heater for use with toluene.
2. Modify an existing toluene flow facility to accommodate testing and characterization of the toluene heater.
3. Perform a series of tests to determine the heat transfer and flow characteristics of the toluene heater.

Task 5 - Reporting

Sundstrand's responsibilities are:

1. Prior to the initiation of any testing, submit a test plan for the approval of the LANL Project Manager.

2. Support LANL at oral briefings at LeRC or a location to be specified by the LANL Project Manager.
3. Provide (8) copies of a written final report giving each task objective, approach, design, fabrication and testing details to LANL at the completion of the total program.

II. Technical Progress Summary

Overview

This report covers the period from September 30 to October 28, 1987. The primary activities were the fabrication of a 72-inch long toluene heater tube, a vibration fixture and a dummy heat pipe. Additional activities included the submittal of the vibration and heater tube performance test plans to LANL for their approval. Figure 1 shows the Sundstrand program schedule and milestones.

Task 1 - Transient Tests on the Existing Phase B Heat Pipe

Testing was completed and reported in Reference 1. Analysis of the TES canisters is on hold pending Phase B heat pipe disassembly.

Task 2 - New Heat Pipe Design, Fabrication and Testing

Heat Pipe Vibration

The design of heat pipe vibration fixture was completed and reported in Reference 2. A copy of vibration fixture drawing was sent to LANL for their review. The fabrication of the vibration fixture is in progress and it is scheduled to be delivered in the first week of November 1987.

The design and manufacturing of a dummy heat pipe was completed. The plan is to checkout the vibration fixture using the dummy heat pipe in the second week of November 1987.

A vibration test plan for the heat pipe was prepared and submitted for LANL review and approval. LANL's comments have been received and are being incorporated into the test plan.

Task 4 - Toluene Heater Tube (THT)

Disc Fin Heater Tube

The major components of the disc fin heater tube are shown in Figure 2. The center body, thermal standoff assemblies, flange, end cap were assembled and the necessary weld joints were performed. The toluene passage of the disc fin heater tube passed the 1970 psi proof pressure requirement after completion of the welding operation. All toluene passage

weld joints were also successfully helium leak checked (1 x 10^{-6} scc/sec) after completion of the proof pressure test. The radiographic examination of the weld joints was performed. The toluene passages of the heater tube were cleaned per the Sundstrand precision cleaning specification, CP 14.57-01. The heater tube is being instrumented with thermocouples. The heater tube will be installed in the fluidized bed after completion of the thermocouple installation.

Longitudinal Fin Design

The contour grinding of the strip material to meet the required fin configuration is still being investigated.

A revised fabrication concept for the longitudinal fin design is being investigated. It consists of a single piece thermal standoff which would eliminate the problem of achieving a metallurgical joint with the fins. One method of providing the outer tube diameter is shown in Figure 3.

Toluene Heater Tube Test Facility

The fluidized bed was received at Sundstrand in the third week of October 1987. It is being installed in the toluene test cell. The plan is to check out the test facility and begin the disc fin heater tube performance test in the middle of November 1987.

Task 5 - Test Plans

The heat pipe vibration and the heater tube test plans were submitted to LANL for their review and approval.

Work Planned for the Next Reporting Period

Task 2

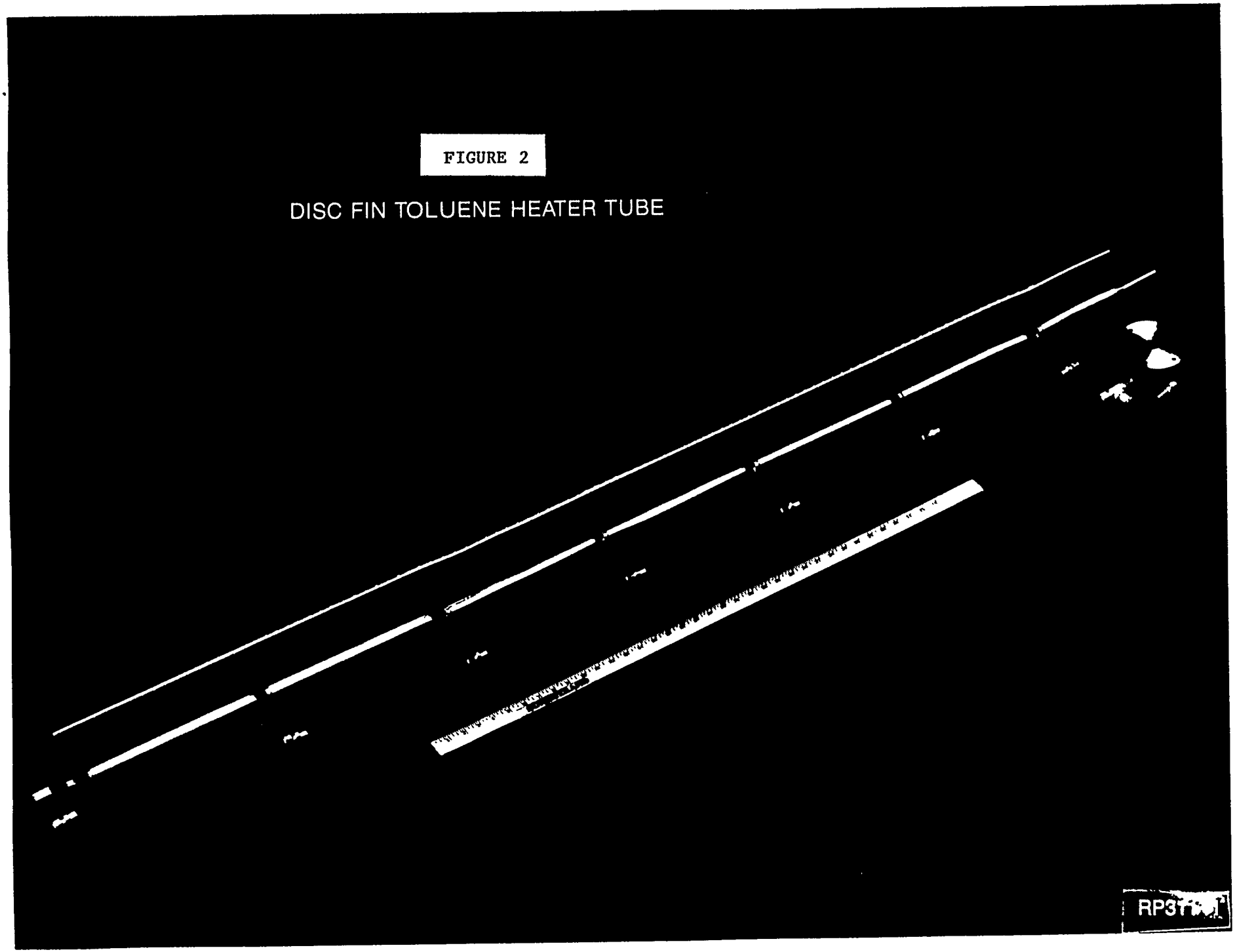
- Receive vibration fixture and perform dynamic check-out test
- Receive heat pipe from LANL for dynamic testing
- Perform random vibration test on the LANL heat pipe

Task 4

- Checkout the toluene heater tube test facility
- Begin thermal performance test on the toluene heater tube

FIGURE 2

DISC FIN TOLUENE HEATER TUBE



References

1. 9-X6H-8102L-1 Solar Dynamic heat Pipe Development and Endurance Test Monthly Technical Progress Report No. 1, dated June 26, 1987.

2. 9-X6H-8102L-1 Solar Dynamic Heat Pipe Development and Endurance Test Monthly Technical Progress Report No. 4, dated September 29, 1987.

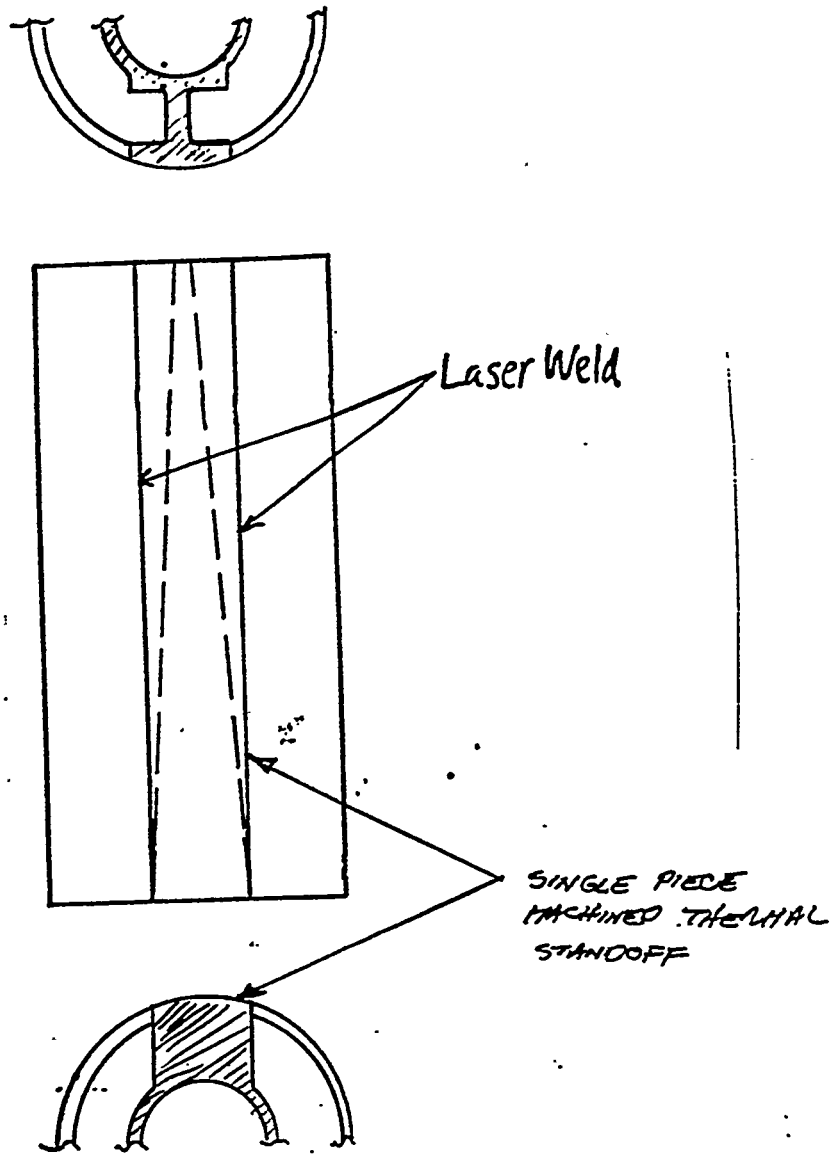


FIGURE 3 - ALTERNATIVE LONGITUDINAL FABRICATION DESIGN