N81 30531

NON-HEAT PIPE RECEIVER/P-40 STIRLING ENGINE

R. A. Haglund, Senior Project Engineer
Fairchild Stratos Division
Manhattan Beach, California

ABSTRACT

This project will demonstrate the technology for a full-up hybrid dish-Stirling Solar Thermal Power system by mid 1981 at JPL's Desert Solar Test Facility near Lancaster, California. Overall solar-to-electric efficiency for the dish-Stirling system demonstration is approximately 30%. Hybrid operation is provided by fossil fuel combustion augmentation, which enables the Stirling engine to operate continuously at constant speed and power, regardless of insolation level, thus providing the capability to operate on cloudy days and at night.

The Non-Heat-Pipe Receiver/P-40 Stirling Engine system will be installed and operated on the JPL Test Bed Concentrator. A 25-kW direct-driven induction-type alternator will be mounted directly to the P-40 engine to produce to a 60-Hz, 460-480-volt output.

NON-HEAT PIPE RECEIVER DESIGN

The Non-Heat-Pipe Receiver design is a cavity-type receiver, as illustrated in Figure 1. The primary receiver surface is a conical plate with integral passages for the helium working fluid. The passages are formed by Inconel 617 tubes imbedded in a copper matrix, which in turn is encapsulated in an Inconel 617 sheet. The cone is heated by solar insolation on the surface exposed to the receiver cavity and by combustion gas on the back surface and the regenerator tubes. The receiver is attached directly to the Stirling engine cylinders and regenerator housings.

The combustion system design is based on heavy duty industrial burner technology, scaled to the size and configuration required to assure reliable cold start, stable combustion over the full operating range and uniform heating of the heater tubes extending from the underside of the cone to the engine regenerator manifolds. The combustion air, provided by an electric-motor-driven constant speed blower, is directed through a preheater into the combustion chamber, which contains eight integrally cast venturies, oriented to produce a swirling flow field inside the combustion chamber, providing sufficient residence time to complete combustion and uniform combustion gas temperature upstream of the heater tubes. Fuel is introduced through a jet

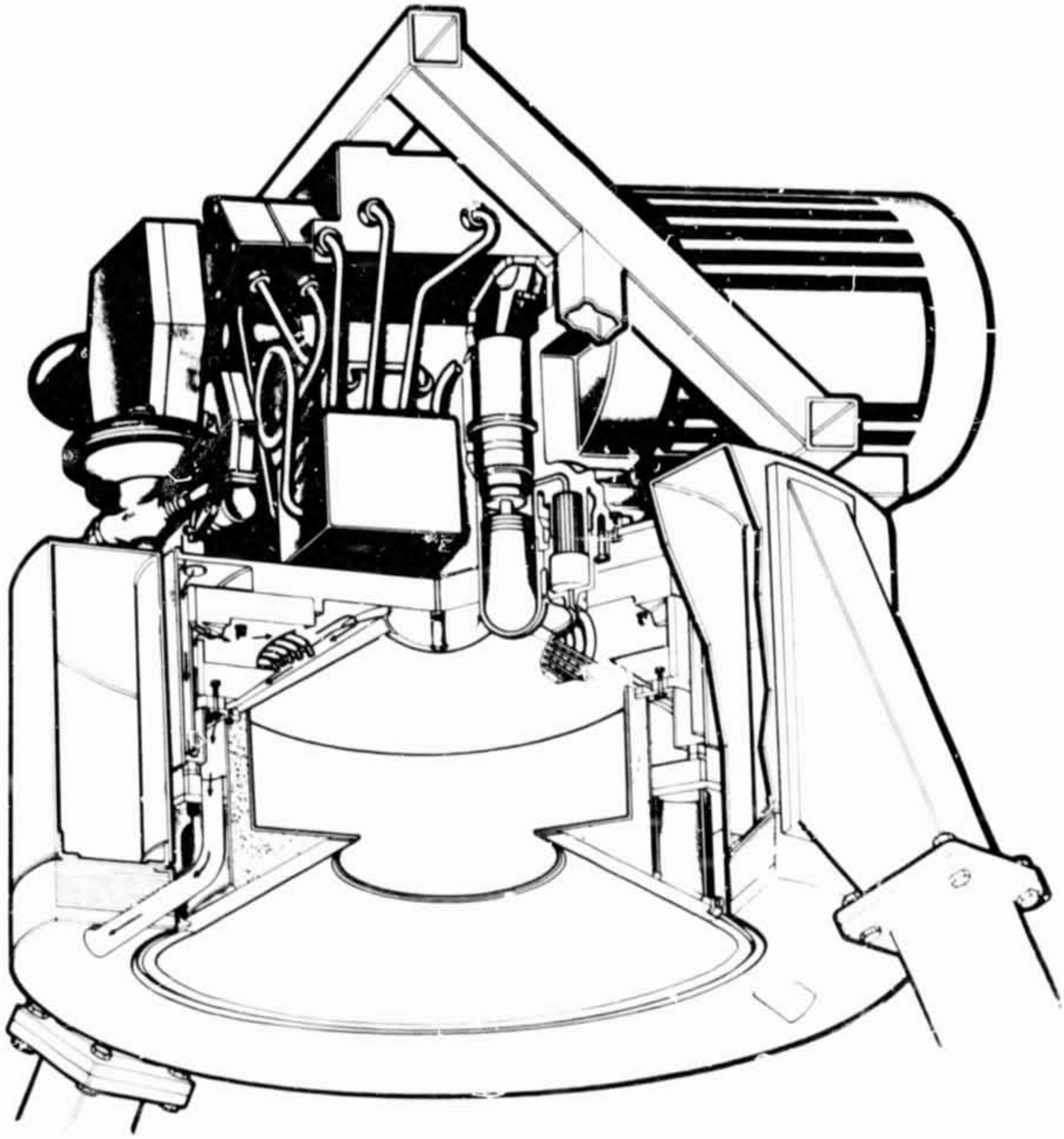

Figure 1. DSSR and P-40 Engine/Alternator

located inside each venturi. Direct electric spark ignition and flame sensing is provided. The flame sensing subsystem causes the main fuel valve to close automatically in the event of flame-out. Automatic restart is provided.

Performance Goals

The following performance goals have been identified by JPL for the Non-Heat-Pipe Receiver design:

Concentrator diameter (active)	10 m
Geometric concentration ratio	2000
Peak insolation (1 kW.m^2)	76.5 kW
Concentrator efficiency (clean)	0.83
Total error (slope plus pointing)	3 mr
Fossil fuel combustor peak input to helium	70.0 kW_t
Combustor turndown ratio	10:1
Working fluid temperature (helium)	650°C to 815°C (1200° to 1500°F)
Peak engine pressure (helium)	17 Mpa to 20 Mpa (2500 to 3000 psi)

The expected thermal efficiency of the receiver is 90 percent and 85 percent at 650°C (1200°F) and 815°C (1500°F) helium temperature respectively.

Program Status

The receiver has been completed and delivered to JPL for further test and evaluation prior to shipment to United Stirling for engine integration tests. Combustion and heat transfer tests have been conducted at Fairchild Stratos Division in Manhattan Beach, California and were carried out jointly by JPL, Fairchild and the Institute of Gas Technology. Test objectives included evaluation and demonstration of cold start, combustion stability and energy release at various power levels, combustion air preheat, pressure drop, fuel/air ratios and heat transfer. Reliable cold start performance, full design output power and turndown capability have been demonstrated. The general arrangement of the combustion test is illustrated in Figure 2.

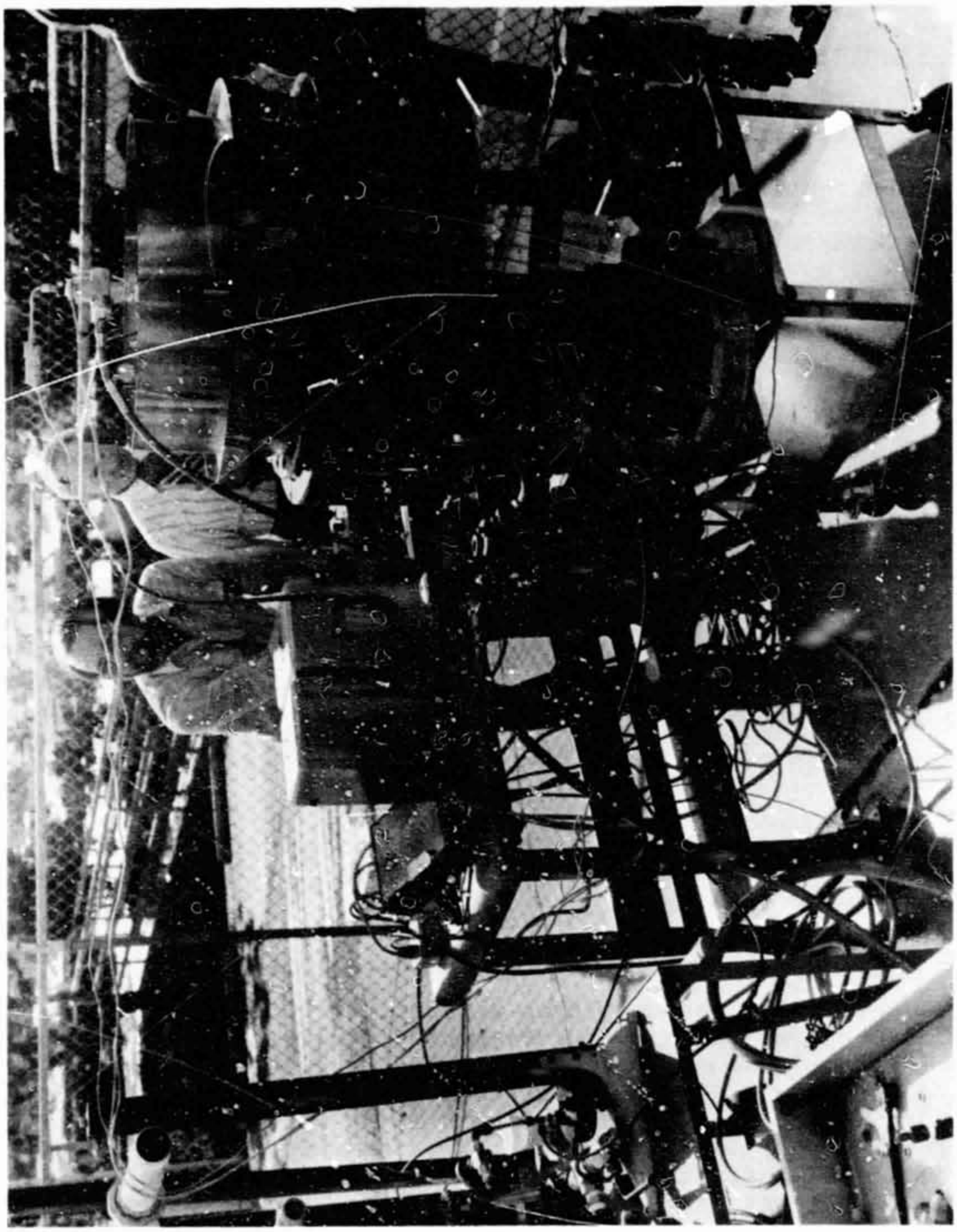

Figure 2. DSSR Test Setup