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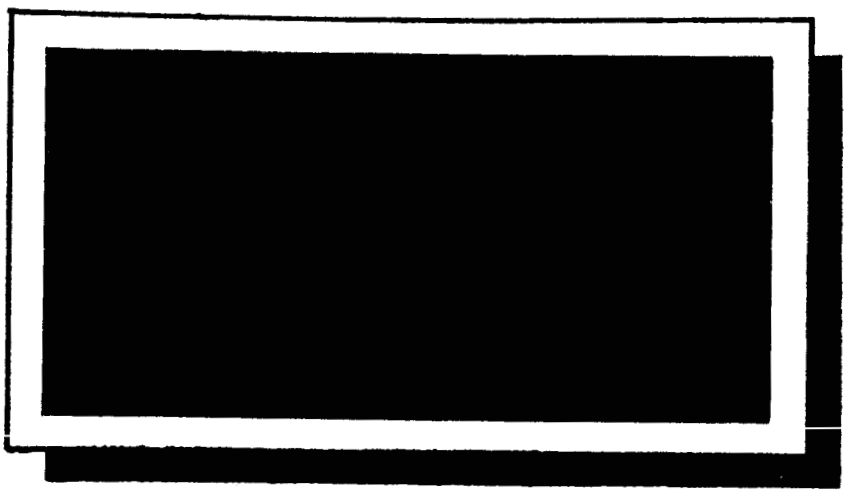

CENTER FOR SPACE RESEARCH
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

NASA SUNBLAZER GRANT NASr-249

Sixth Progress Report

October 1 to December 31, 1965

CSR PR-5255-7

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SIXTH QUARTERLY PROGRESS REPORT

For the Period

October 1 to December 31, 1965

on

NASA SUNBLAZER GRANT NASr-249

DSR Project 5255

To The

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Office of Grants and Research Contracts

Submitted by: J. V. Harrington
Principal Investigator

Introduction

During this period work has continued on the spacecraft mechanical, thermal, and orientation design and electronic packaging. In addition, vibration, shock, and acceleration testing specifications have been written and initial test will be conducted in the next reporting period. The change of the on-board transmitter frequencies to those compatible with the El Campo solar array has occasioned a substantial amount of transmitter redesign.

1. Mechanical Design

Vehicle

Precision springs for the separation tests have been ordered from two vendors. One set of springs are to be made from 0.055 inch diameter round music wire, another from 0.062 inch square chrome silicon wire. An associated testing fixture was designed and sent out for machining. Springs and related separation fixtures may then be examined and the relative merits of various proposals compared.

The design of the thermal-mechanical mock-up of the electronic system was finalized, and various sub-assemblies were machined. The total assembly has been fitted into the platform-radiator in preparation for mechanical and thermal tests.

A special hub for preventing axial rotation of a mast-supported sail was designed, machined, and installed on the preprototype assembly.

Thermal

Discussions with IIT Research Institute have stimulated a proposal from IIT to perform qualitative tests on space-stable surface finishes that may be useful to Sunblazer's thermal control design.

Separation Devices

Initial design of the separation system depended on the action of a time-delayed ignition explosive bolt. Inquiries concerning the design and fabrication of this device were sent out to various manufacturers, only to learn of prohibitive costs. Under consideration at present are several systems to replace the explosive bolt. Most promising of these are gas-pressure actuators, either using commercial ball-lock separators or high pressure-slow leak trigger mechanisms.

Dampers

Some initial design work has been done to enable the construction of a special pendulum device to measure the effects of a magnetic-induction damping system.

Optical Rotation Sensor and Servo System

A review of various read-out systems for correlating angular position and time and/or angular acceleration rates was completed. As a result of this review, an electrical system is being constructed to modify the action of the quadrant electrometer torquer. This system should provide a means of measuring the light pressure torque on the model by applying a known

counter-torque on the quadrant electrometer torquer which is capable of establishing an equilibrium in the model.

A design has been completed to replace the existing fiber axes adjustments. The present axes adjustments were not independent in their action, since a change in the z axis caused an error in the x and y axes.

Central Experiment

A thermal-vacuum encapsulation system which includes an external flow control has been designed, constructed, and tested. This apparatus enables the molding of special materials which will be used in the construction of high voltage insulators.

A new insulator mold has been designed which compensates for excessive shrinkage. Machining and finishes of these parts will be to rigid tolerances to provide the best surface resistivity possible on the insulator.

2. Testing

Realistic vibration, shock, and acceleration specifications have been written and immediate testing has been planned. All the shock, vibration, and acceleration fixtures have been completed. A workable "know-how" using Stresscoat has been achieved on a number of test pieces in static testing. Support equipment for monitoring strain gages are available through a strain gage consultant if stress levels in test warrant such investigation. Camera equipment for taking pictures of stresscoat patterns and the additional equipment for high-speed

photography of the separation mechanism test have been obtained. Facilities for testing and monitoring separation have been completed.

A number of different design solar sails have been made to determine their feasibility and mechanical integrity.

The design of various methods of damping, despinning, and altitude control have been investigated.

3. R.F. Electronics

A basic change in the frequencies of the proposed Sunblazer R.F. system is causing a considerable amount of transmitter redesign. In order to be compatible with the solar array at El Campo, the Sunblazer on-board transmitter frequencies were changed to 75mc and 225mc. Therefore, the R.F. electronics effort has been primarily concerned with the characterization of the new low-voltage transistors at 75mc and the redesign to the new system frequencies of the basic power amplifier, power divider, frequency multiplier, and local oscillator circuits. In addition, a considerable amount of test equipment was made operational and some preliminary antenna testing conducted.

By the use of a transfer function bridge, complete small signal characterization of all two port active and passive networks is now possible. The optimization of linear small signal amplifiers has been reduced to a series of admittance measurements. Using this technique, a cascade of small signal amplifiers was designed and tested. Single frequency operation of

this circuit indicated a 40db gain, one watt nominal power output over the temperature range -50° C to +90° C, with a 10db design margin. In the higher power amplifiers, the above-mentioned technique yields only approximate results, since the device parameters are a function of output level.

The basic 50 watt power amplifier reported in the previous quarterly progress report, has been frequency scaled to 75mc. Substantial improvement in circuit gain was realized. In a 75 percent collector efficiency circuit similar in design to the previous amplifier, only 3.75 watts of input power were required. The effective combination of the outputs of two such devices is at present under study. A transformer push-pull circuit appears to be useful but had an efficiency of only 48 percent. Because of the dearth of high-frequency transformers, considerable effort has been expended in the construction and test of miniature high-frequency, high-power, balanced transformers. This effort is expected to continue for most of this report period.

At the present time, a 75mc version of the 100mc 1kw, 10 diode varactor circuit is under construction. This circuit utilizes a unique push-pull diode balancing arrangement. A theoretical model of this circuit has been proposed and is under study. In the varactor area, as well as in the power amplifier design, new test equipment was designed and constructed for the evaluation of experimental 75mc circuits.

The first frequency stability measurements were made for the spacecraft local oscillator and timing systems. In a temperature-controlled environment, a short-term frequency stability of 5 parts in 10^{-10} was observed. However, this design requires several watts of d.c. oven power and is not consistent with the spacecraft power budget. Present effort is directed at obtaining a temperature-compensated circuit that will require a minimum of environment control.

4. Antenna Development

A series of antenna pattern measurements of the proposed Sunblazer payload were taken. An aluminum prototype structure, with a hollow, radially-supported, cylindrical sail was used as the test package. The radiating elements were matched into the connecting transmitter with a V.S.W.R. of less than 1.5 to 1. Pattern measurements were then taken at both 100mc and 300mc. The radiating elements of 100mc were two quarter wave length antennae spaced 20 inches apart across the diameter of the test package. For this arrangement a classical dipole pattern was obtained. At the higher frequency a 22.5cm square loop antenna was mounted 20cm forward of the front panel. This structure had a +4db axial gain with an off-axis pattern similar to that of a dipole. Both the 100mc and 300mc antenna patterns appear satisfactory for the engineering prototype with only slight modification due to the recent frequency change.

5. Stabilization

Stabilization studies have been made on two systems: (1) a spinning system with a radiation torquer and (2) a spinning system with a damper.

The study of the radiation torquer has centered on a computer program for sail design. Results have shown that a sail will produce the proper torques under the conditions for which it is designed. Curves have been generated showing the most important torque between 0° and 90° from the Sunblazer axis to the sun line.

Design considerations for the spinning system with the damper have been developed and the basic operation of the system is understood.