ENGINEERING RESEARCH INSTITUTE
UNIVERSITY OF MICHIGAN
ANN ARBOR

PROGRESS REPORT

For

1 January 1954 to 1 April 1954

UPPER-ATMOSHPERE WIND, TEMPERATURE, AND PRESSURE MEASUREMENT

REPORT NO. C-6

By

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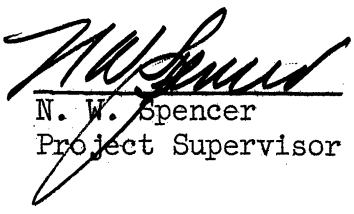
Project Engineer

Submitted to the Geophysics Research Division, Air Force Cambridge Research Center, Cambridge, Massachusetts. The work reported herein is of a preliminary nature and the results are not necessarily in final form.

Approved by



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Project 2096

U. S. AIR FORCE, AIR FORCE CAMBRIDGE RESEARCH CENTER
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PERSONNEL EMPLOYED DURING THE PERIOD OF REPORT

W. G. Dow	Consultant	
H. V. Dada	Data Analyst	Part-time (student)
J. A. Foster	Research Assistant	Part-time (student)
P. Hogan	Data Analyst	Part-time (student)
G. Hok	Consultant	
W. G. Kartlick	Research Technician	
A. A. Kirsons	Data Analyst	Part-time (student)
D. L. McCormick	Machinist	
T. Pattinson	Research Technician	Part-time (student)
H. F. Schulte	Project Engineer	
H. S. Sicinski	Research Physicist	
N. W. Spencer	Project Supervisor	

ABSTRACT

The present status of the wind-vane development program is discussed and a favorable outcome is indicated.

The results of a life test on the flashing light system are presented and the progress on other phases of instrumentation construction for the June, 1954, Aerobee missile is described.

A technical paper on rocket instrumentation was accepted for publication in the Proceedings of the I.R.E. during the quarter.

UPPER-ATMOSPHERE WIND, TEMPERATURE, AND PRESSURE MEASUREMENT

INVESTIGATIONS BEING UNDERTAKEN

1. Wind Vanes

The data obtained from the recent series of Supersonic Wind Tunnel tests* were analyzed during this period. The results confirmed the preliminary estimate that the wind-vane cross section be of the order of 0.002 inch if adequate response is to be obtained. Similarly, the approximate upper limit on the moment of inertia of the entire rotating mass(wind vane, bearing, and transducer) was experimentally confirmed.

The tests also verified the theoretical prediction that the angle between the wind vane and the cone axis can have a maximum limiting value of twice the cone's angle of attack, provided that the angle of attack is not greater than the half-angle of the cone. This is an important factor since it ultimately determines the maximum angle throughout which the instrumentation must be able to provide useful data.

Regarding accuracy of measurement, the wind-tunnel tests indicated a lack of adequate reproducibility of results for angle measurement to 1 part in 500. This was anticipated in view of the particular bearing design and to some extent the transducer system utilized on this first model. The experience gained in these preliminary tests and in later bench testing of new bearing designs and circuit modifications indicates, at this time, that the design and construction of a bearing and transducer system to provide the requisite accuracy and reproducability can be achieved.

The wind-vane bearing design must comply with the following requirements:

1. Minimum friction,
2. Minimum lateral bearing-play,
3. Minimum end bearing-play,
4. Minimum rotating mass,
5. Suitable configuration for attachment of transducer element.

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* Progress Report C-5, December, 1953, Contract No. AF 19(604)-545.

At present, emphasis has been placed on the development of a bearing system using two synthetic sapphire "center jewels" and a 0.060-inch-diameter shaft of hardened ground, and polished drill rod which passes through the precision-ground center holes in the jewels. When assembled, the system has the appearance of a tiny, two-bearing line shaft, with the wine vane attached to one end of the shaft and the transducer element attached to the other.

Shaft rotation is translated into an electrical signal by the variation in capacitance between a small metallic paddle affixed to the rotating shaft and a fixed plate or plates mounted nearby. This small variable capacitor is connected across a high-Q, parallel-resonant, tuned circuit which is inductively coupled to a crystal-controlled, constant output signal generator. A shunt-connected, vacuum-tube diode detector is also connected across the tank circuit and acts as a peak-reading, vacuum-tube voltmeter. Intially the tank circuit is tuned off-resonance and then as the capacitance varies in accordance with shaft rotation, the tank circuit is tuned closer to or farther from resonance, depending, of course, upon the magnitude and sign of the capacitance change. If the energizing voltage to the coil remains constant, the peak-reading VTUM will provide a rectified d-c output voltage whose magnitude will vary as the tank-circuit tuning is varied and thus it is possible to calibrate angular degreees of shaft rotation directly in terms of a d-c voltage.

Investigation of the d-c stability and reproducibility of this circuit are now in progress. Wind-tunnel tests indicate the presence of a small amount of noise fluctuation (approximately 1 part in 250) and a certain amount of d-c shift. This latter phenomenon is apparently associated with the change in pressure in the wind-tunnel section during the supersonic run. Laboratory vacuum equipment will be used to study and minimize this effect.

2. Flashing Light System

Life tests on the flashing light system used for photographic illumination have shown that the energy-storage capacitor originally chosen for use in this system is not adequate. The energy-storage unit consists of two paralleled, 1-microfarad, 600-volt, metallized-paper capacitors, charged to a peak value of 460 volts. The capacitors are discharged through the flash tube in approximately 1 millisecond to a level of 20 volts. The measured discharge current has a peak value of about 20 amperes per capacitor. In virtually all cases of failure, the capacitance slowly decreases in value until the capacitor is virtually an open circuit. It is assumed that the extremely thin metallic film (0.000 003 inch) cannot withstand the high current surges present in the application.

Since the metallized capacitors were chosen primarily for their small size, the substitution of larger conventional paper capacitors requires some redesign of the power-supply package, which is now in progress.

3. Gyroscope Testing

To facilitate final gyroscope balancing and testing, a dust-resistant enclosure was constructed to allow balance adjustments to be made with less chance of bearing contamination. The box contains a large, sloping, glass front for observation, a gyro control panel, and an externally mounted blower which supplies filtered air at a slight positive pressure, the object being to minimize admission of airborne dust and lint through the hand-hole access area.

The box is now in use and final adjustments are now in progress on one of the two Bendix J-8 gyroscopes to be flown in the June, 1954, Aerobee.

4. Instrumentation Construction

Fabrication of the many components and sections of this project's instrumentation for the forthcoming Aerobee firing is proceeding approximately on schedule.

RESEARCH REPORTS, PUBLICATIONS, AND OTHER SCIENTIFIC ACTIVITIES

1. Publications

a. A paper entitled "Rocket Measurements of Upper-Atmosphere Ambient Temperature and Pressure in the 30 to 75-Kilometer Region", by H. S. Sicinski, N. W. Spencer, and W. G. Dow* was published in the February, 1954, issue of the Journal of Applied Physics.

b. A paper entitled "Rocket Instrumentation for Reliable Upper-Atmosphere Temperature Determination" by N. W. Spencer, H. F. Schulte and H. S. Sicinski was accepted for publication in the Proceedings of the Institute of Radio Engineers. (Summary: This paper briefly describes rocket-borne electronic equipment which has been developed and utilized in the determination of ambient atmospheric pressure and temperature. In the design of the equipment, emphasis has been placed on reliability of operation, and on the ability to produce data of significant accuracy. Typical resulting curves of amibient pressure and temperature are presented.)

2. Scientific Report

A Scientific Report on the Paschen's Law Experiment flown on the September, 1951, University of Michigan Aerobee (USAF 18)** is nearing completion. The report will be abstracted, also, for publication in a suitable technical journal.

3. Technical Meetings and Visits

Professor W. G. Dow and Mr. N. W. Spencer attended the February, 1954, meeting of the Upper Atmosphere Rocket Research Panel held in Washington, D.C.

A two day meeting was held on February 25 and 26, 1954, at the University of Michigan to discuss critically the results and the methods employed at present for measurement of upper-atmosphere amibient temperature, pressure, and density. The meeting was attended by the following:

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* Progress Report C-4, October, 1953, Contract No. AF 19(604)-545.
**Progress Report A-8, October, 1953, Contract No. AF 19(122)-55.

Air Force Cambridge Research Center
M. Dubin
R. A. Minzner

Naval Research Laboratory
R. J. Havens

University of Michigan - Aeronautical Engineering Department - Signal Corps Project
F. L. Bartman
L. M. Jones
M. H. Nichols
E. J. Schaefer

University of Michigan - Electrical Engineering Department - Air Force Project
J. A. Foster
H. F. Schulte
H. S. Sicinski
N. W. Spencer

Members of this project also participated in discussions with Mr. Minzner and Mr. Dubin concerning specific details of the forthcoming Aerobee aspect-missile firing in which both agencies will have equipment. A tentative firing date during the week of June 14, 1954 (subject to range availability) was agreed upon.

FUTURE PLANS

Maximum effort will be expended on completion and testing of the instrumentation to be flown in the June, 1954, Aerobee. Since the next reporting period includes the tentative firing date, the field trip and firing will also be included in the forthcoming activities.

PERSONNEL AND ADMINISTRATION

The following personnel change occurred during the period of this report:

a) Mr. H. V. Dada was added to the staff and will do part-time data analysis and computational work. He received his M.S.E. in Electrical Engineering from the University of Michigan and is presently studying for the Ph. D.

Formation of the Advisory Committee* to discuss pertinent project matters has been completed. The committee consists of:

W. G. Dow, Professor of Electrical Engineering
R. G. Folsom, Professor of Mechancial Engineering and Director of Engineering Research Institute
M. H. Nichols, Professor of Aeronautical Engineering
N. W. Spencer, Project Supervisor

The Holloman Air Development Center Flight Determination Laboratory was contacted on March 3, 1954, concerning the status of the additional missile-velocity data (to facilitate "T"-day analysis) this project requested in September, 1953.**

FISCAL INFORMATION

As of March 31, 1954, approximately forty-three percent of project funds available and anticipated as of September 1, 1953, will be expended. Since existing funds are budgeted to December 31, 1954, the rate of expenditure continues to be satisfactory.

PROPERTY ACQUIRED DURING THE PERIOD

Following is an unofficial list of property acquired during the period of this report:

a) Binolcular microscope

b) Routine miscellaneous supplies.

* Progress Report C-5, December, 1953, Contract No. AF 19(604)-545.
** Progress Report C-4, October, 1953, Contract No. AF 19(604)-545.