ENGINEERING RESEARCH INSTITUTE
THE UNIVERSITY OF MICHIGAN
ANN ARBOR

Quarterly Status Reports Nos. D-1, D-2

IONOSPHERE ELECTRON AND ION DENSITIES BY BI-POLAR PROBE TECHNIQUE

1 April 1956 to 31 October 1956

This report, not necessarily in final scientific form, is intended for the internal management uses of the contractor and the Air Force.

Prepared by

N. W. Spencer

Project 2521

GEOPHYSICS RESEARCH DIRECTORATE
AIR FORCE CAMBRIDGE RESEARCH CENTER
AIR RESEARCH AND DEVELOPMENT COMMAND
CONTRACT NO. AF 19(604)-545

November 1956

ABSTRACT

A review of the theory developed following preliminary experiments conducted several years ago has been initiated, and consideration has been given to the general problem of instrumenting a rocket for probe experimentation.

A broad outline of the necessary tasks leading to a first experiment has been developed.

PERSONNEL CONTRIBUTING DURING THE REPORTING PERIOD

R. L. Boggess	Project Engineer
W. G. Dow	Consultant
G. Hok	Consultant
T. Muller	Technician
N. W. Spencer	Project Supervisor

INTRODUCTION

This report is the first of a series of reports dealing with a research program oriented in the direction of making measurements of ionospheric properties at altitudes attainable with Aerobee or Cajun rockets in various possible configurations.

The measurements are to be made employing the basic principles of a Langmuir probe. Through use of this device it is expected that determinations of quantities including electron and ion concentrations, electron temperature, and perhaps energy distribution may be made with significant precision.

Several years ago the Electrical Engineering Department of The University of Michigan conducted, under U. S. Air Force sponsorship, a series of preliminary measurements based upon this same principle. The experiments performed employed very elementary techniques and equipment, under environmental conditions which were far from desirable due to, for example, inappropriate geometry and priority of other experimentation.

The experiments were conducted on a V-2 rocket, and although outwardly successful and interesting, the environmental conditions noted were such as to make data analysis possible only through the employment of very questionable assumptions. However, the results obtained demonstrated that the approach offered considerable promise and thus served to intrigue the experimenter further. Consequently, a considerable effort was made to assess the correctness of the experiment by developing a theoretical approach that would make possible further experiments in which the environment could more readily be established and controlled. The concept of a bi-polar probe was encountered during the theoretical study.* It was of course realized that the rocket experiments conducted were, in fact, bi-polar probes, with their simple single probe mounted at the rocket nose and with the rocket body fulfilling the role of the second probe.

Although the theoretical study was concluded at a reasonable point, further experimentation was not continued for several reasons, including the lack of sufficient altitude capability of the available rocket vehicle and inability to control the probe environment sufficiently well.

---

*The theoretical study and data analysis were recorded in the following:

Upper Air Research Program Report No. 3, "Dynamic Probe Measurements in the Ionosphere," by Hok, Spencer, Reifman, and Dow, Engineering Research Institute, The University of Michigan, and Air Force Cambridge Research Center.

Today, however, the picture in both these regards is considerably altered, and additionally it can be argued that there is renewed interest in atmospheric properties at higher altitudes. Aerobee rockets now make possible the penetration of the F layers, and extensive experience in rocket instrumentation will make possible the attainment of a nearly ideal geometry, thus seemingly removing major obstacles to a successful and significant probe experiment.

This status report is concerned with the introductory phase of the renewed program. The interval has been utilized for broad planning and feasibility considerations which have now been completed. The level of effort or expenditure of contract funds has not warranted quarterly reporting and thus it has been considered advisable to combine the two initial reports into one.

INVESTIGATIONS BEING UNDERTAKEN AND PLANNED

The program with which this report is concerned has been organized with reference to the following tasks, the order not necessarily an indication of priority:

a. Review of previous probe work.
b. Reassessment of the theoretical basis for the experiments and continuation of theoretical development.
c. Initiation of development of certain instrumentation items known to be needed.
d. Preliminary laboratory studies of simple probes in plasmas.
e. Consideration of gross probe geometries in terms of possible rocket configurations.

Items a and b pertain to a study and reevaluation of Hok's report dealing with the earlier probe work. The validity is not doubted but the necessity for continuing the theoretical studies initiated there is obvious. In addition, the state of the art of rocket instrumentation and particularly advances in understanding of gaseous conduction processes make it desirable to reassess the report's developments in the light of more recent thinking.

Item c refers to the breadboarding of particular items such as d-c amplifiers which are most likely to be employed in any probe instrumentation. In general the task during this reporting period has been to establish an amplifier somewhat similar to those employed in other continuing rocket work in connection with alphatron ionization-gage measurements. Thus a system with loop gain of the order of 20,000 or more is desired, affording the possibility of various degrees of negative feedback to effect the desired overall system gain.

Item d refers to the initiation of relatively simple laboratory experiments employing probes. The first steps taken were with existing mercury-pool-

type tubes with fixed wire probes. Typical probe curves of the expected significances were obtained; however, certain difficulties believed to be associated with the moving cathode spot were encountered.

The last topic refers to consideration of possible probe and rocket configurations in the physical sense. Review of the earlier work reemphasized problems associated with restrictions in the strictly electrical sense imposed by the presence of the rocket body and by the necessity of accepting geometries dictated largely by aerodynamic considerations. Thus it has been decided that it is essential to establish an instrumentation arrangement that will make possible ejection of the probe experiment and associated equipment from the rocket at an altitude well below the desired range of measurement. Several restrictions are immediately removed (and some relatively minor ones imposed), making it possible, for example, to use a spherical configuration. Work on this phase of the program has not progressed beyond the sketching stage.

FUTURE WORK

Work on this program will continue on the basis of the above listed topics at an accelerated rate. The nature of the work makes it difficult to predict precise performance, but orderly progress requires tentative scheduling. Accordingly, present budgeting and availability of suitable personnel permit an estimate that it may be possible to conduct a first rocket-borne probe experiment during the late spring of 1957. It is desirable that the experiment have the following specific objectives: establish the engineering feasibility and soundness of the expected instrumentation ejection system, establish the workability of the requisite but as yet undetermined telemetering system, and carry an elementary probe experiment intended primarily to produce information that will point the way toward a more ideal experiment by validating or invalidating certain fundamental assumptions.

It is planned that an Aerobee rocket be used for this first experiment, with a minimum payload to facilitate the attainment of maximum altitude. The detailed requirements of the launching will be determined at a later date.

PERSONNEL, ADMINISTRATION, AND FISCAL INFORMATION

The personnel employed in this research are individuals who are likewise associated with other GRD upper-atmosphere research programs concerned with the measurement of pressure, temperature, and density. Similarly, much of the necessary laboratory equipment employed for other work can be used for this endeavor.

The original funds budgeted for the work have been expended as of the end of this double reporting period; however, the work will continue using the newly added funds. The expenditure level (average) per month has not been definitely established.

There were no significant communications or equipment purchases during the reporting period.