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LOW FREQUENCY FLUCTUATIONS IN THE EARTH'S MAGNETIC FIELD

FINAL REPORT

UNIVERSITY OF SOUTH CAROLINA
DEPARTMENT OF ELECTRICAL ENGINEERING

THE UNIVERSITY OF SOUTH CAROLINA

LOW FREQUENCY [illegible] IN THE EARTH'S

MAGNETIC FIELD

Certain aspects of important physical phenomena occuring in our universe can be observed through interactions with our earth's atmosphere. Much is yet to be learned about how our atmosphere reacts to natural and man induced disturbances. Particularly in the plasma regions where the interactions between electric fields and matter are pronounced one has a means of studying the effects of solar and other extraterrestrial natural events as well as man-induced events. Man-induced events may include high altitude nuclear explosions and rocket blasts.

Extraterrestrial and terrestrial events, like solar activity and high altitude nuclear explosions, couple to our earth's magnetic field through interactions in the ionosphere. A study of the small induced variations (micropulsations) in our earth's magnetic field and in telluric currents give us further means of studying the various phenomena associated with these events.

This project was directed toward the design of an experiment and the development of instrumentation and measuring techniques useful for observing micropulsations in the magnetic field strength and in the related telluric currents. The program, by necessity, required auxiliary tests and measurements to validate the test environment. The latter included specifically a further study of the geological and topological features of the area and measurements of the electrical characteristics to evaluate the area's suitability for the principal program of study.

This program provided the basis for research topics which led to master's degrees for two of the students who participated in the project. The one thesis related to the evaluation studies of the test sites or areas, and the other thesis related to the design of a magnetometer which made use of the Hall effect in a semiconductor.

Incorporated in the measurements were large coils of wire of four and eight turns encompassing areas up to 27 square-kilometers and also telluric lines in arrays in which some electrodes were more than one mile from the reference electrode. The subject of the thesis research may be described, somewhat oversimplified, as follows.

Signals were launched from a pair of test electrodes and the induced signals were picked up by the receiving array and analyzed to compare the amplitudes and phases with the theoretical values predicted when electrical homogeneity was assumed. A second parallel part of the approach involved mapping the electrical field in the vicinity of a pair of earth electrodes into which a signal was fed. Comparisons were again made between the experimental mapping and theoretical mapping. Finally a limited amount of observations of telluric currents were recorded and some typical patterns were observed but the results were rather nonconclusive.

The areas evaluated proved to be reasonably suitable for magnetic and telluric measurements with some qualification. The Fort Jackson site appeared to be exceedingly vulnerable to lightning which frequently destroyed the telluric lines, the loops, and often seriously damaged instruments which were sometimes more than a mile from the pickup element but tied by connecting lines. On the other hand, during a period of two or more years of telluric measurements at the site of the University Hydromagnetic and Telluric Research Station, no serious lightning damage was encountered although the two sites are not separated by much more than about 3 miles. Otherwise, the sites are about equally suitable.

Work done to develop a high sensitivity magnetometer fulfilled the research requirement for another master's degree. A study was made to determine the feasibility of employing the Hall effect for measuring very small variations in magnetic fields. The Hall sensor used was a very small semiconductor device commercially produced and it served for checking theory and techniques. The Hall-effect method lends itself to the use of flux gating, the use of flux collectors, and simultaneous measurements or rapid scanning of field components. The Hall magnetometer with its auxiliary equipment is reasonably portable and can be built with moderate means.

From this study it was concluded that construction of a Hall-effect magnetometer with a sensitivity of one gamma (The earth's field is approximately 0.5×10^5 gamma) was feasible. This sensitivity is about two orders of magnitude poorer than nuclear-precession and radiation-pumped magnetometers. The Hall effect gives a response which is direct reading while coils and several other methods give time rate of variations in the magnetic field. The research student recommended that such a magnetometer be developed for installation at the University Hydromagnetic and Telluric Research Station, but this has not been pursued further for lack of any students sufficiently interested in continuing the work.

Personnel Involved

Professor J. Hubert Noland, Department of Electrical Engineering. Professor Noland's primary interests in this project involve instrumentation, filter design, and computer analysis of results obtained.

Associate Professor J. Edwin Sees, Department of Electrical Engineering. Professor Sees has been primarily concerned with the physical phenomena of earth currents and magnetic field micropulsations and attempts to correlate these with other natural or man-made occurrences.

Mr. Frederick W. Ford, graduate student in Electrical Engineering, received financial support under this project from September 1964 through July 1965. His research was primarily concerned with the Telluric currents in the earth. He received the degree of Master of Science in Electrical Engineering in August of 1965.

Mr. Randolph Davis, graduate student in Physics, received support from September 1964 through June of 1966. His work included development of a Hall-effect Magnetometer for three-dimensional field measurements. He received the degree of Master of Science in Physics in June of 1966 and is now associated with the Solar Forecast Center of the Air Force.

Mr. Nai-li Ku, graduate student in Electrical Engineering, received support from June of 1965 through August of 1966. His work included assistance with the design of the electronic equipment for the Hall-effect Magnetometer. He has since received the Master of Science degree from the University of South Carolina and is now a candidate for the Doctor's degree at the University of Minnesota.

Publications

The following theses were prepared by graduate students supported by this project:

Davis, Randolph R., "The Evaluation of a Hall Magnetometer for Detecting Geomagnetic Micropulsations."

Ford, Frederick W., "Electric Field Vectors Associated with Telluric Currents at Columbia, S.C."

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13. ABSTRACT

This project was directed toward the design of an experiment and the development of instrumentation and measuring techniques useful for observing micropulsations in the magnetic field strength and in the related telluric currents.

14. KEY WORDS

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