A STUDY OF GEOMAGNETIC MICROPULSATIONS

A thesis submitted to the University of Auckland in partial fulfilment of the requirements for the Degree of Doctor of Philosophy

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Owê war sint verswunden . alliu mîniu jâr?
Ist mir mîn leben getroumet . oder ist ez wâr?
Daz ich ie wânde daz . iht wære, was daz iht?
Dar nâch hân ich geslâfen . und enweiz es niht?
Nû bin ich erwachet, ...

Walther von der Vogelweide

(early 13th Century)

PREFACE

When micropulsations were first suggested to me as an interesting subject for a Ph.D. thesis I was a little dubious, for until that time I had specialized in theoretical nuclear physics. There was also no tradition of micropulsation study in the Physics Department, to which I was attached, although Earth currents were being recorded at the University's Radio Research Centre at Ardmore. However, some reading and discussion soon convinced me of the interest of the subject and I commenced work with the general intention of investigating the origin of micropulsations. It was hoped my work would tie in with the setting up of a complete recording station at Ardmore, which is now taking place, and this has to some extent influenced the content of the thesis.

The sketch review arising from my initial reading of the literature showed that micropulsations most probably arose from hydromagnetic waves generated somewhere in the outer part of the Earth's atmosphere. I soon decided there was no difficulty as far as the generation of these hydromagnetic waves was concerned, and concentrated on what I thought was the more basic problem - that of their transmission to Earth. At the same time I kept up a part-time study of the possibility of micropulsations coming from charged particle gyration in the geomagnetic field.

My study of charged particle radiation did not ultimately lead to anything original, since I found, after some time, that all the relevant results were already available. On the other hand, my work on the transmission properties of Alfvén waves, in particular, led to results of some interest. These are summarized in the accompanying abstract and presented in full in the last chapter (Chapter 5). The preceding chapters of the thesis, with the exception of Chapter 3, are largely concerned with basic geomagnetism, review

material, and the setting-up of the transmission problem. The sketch review already mentioned has been made the basis of a more thorough review in chapter 2. To the best of my knowledge no comparable review has been published, and until early this year (Bleil (Editor), 1964) no referenced review has been available at all.

Chapter 1 is an introductory chapter dealing mainly with the basic geomagnetic situation; it also helps justify the assumption made later of a general level of hydromagnetic waves in the outer atmosphere. Hydromagnetic theory is treated in greater detail in chapter 4, as far as it enters micropulsation theory, and the production of hydromagnetic waves by gyrating charged particles is discussed. The short third chapter contains sufficient theory for the combination of Earth current and micropulsation observations, and briefly touches on the effect of a coastline on micropulsations.

Much of the presentation in this thesis is peculiar to myself, but originality is claimed only for the work in chapter 5.

Rationalized MKS units have been used throughout and, while there is some small duplication of symbols, no difficulty should be experienced with the notation. I have not used harmonic in its strict sense, but I think it is clear what is meant. References are listed at the back of the thesis and are indicated in the text by name(s) and year of publication. Most of the diagrams were prepared by myself (!), but I have included some from other sources. Those not acknowledged in the text are as follows:

Figure 2.3 McNicol and Mainstone (1963)

Figure 2.4 Obayashi and Jacobs (1958)

Figure 2.6 Heacock and Hessler (1963)

Figure 2.7 Campbell and Matsushita (1962)

The Xerox reproductions of figure 2.5 are disappointing and the reader will find the original much clearer.

A useful paper which I saw after the thesis was typed is that by Carl Greifinger and Phyllis Greifinger, Journal of Geophysical Research, vol. 70, p. 2217; 1965. This paper deals specifically with the transmission of micropulsations through the lower ionosphere (see comment at end of section 5.5.1.)

In TIME magazine of January 8th, 1965, under 'Books for Burning', the president of the Modern Language Association (U.S.A.) was quoted on the Ph.D. thesis: "Given the task of writing on a subject that interests nobody in a book that nobody will read, the candidate approaches his task with repugnance and he fulfils it often with loathing". I am grateful to my supervisor Dr J. R. Storey, for his making nonsense of this statement in my case, for continual encouragement, and for innumerable helpful suggestions. Professor P. W. Burbidge helped me with a number of interesting discussions. Many thanks are due to Vivien Baxter who, so attractively, typed and duplicated the thesis. Finally, I can say that without the spare time made available to me at home I doubt if I could ever have hoped to complete the work required for this Ph.D.

H.C.T.S

July, 1965.

CONTENTS

ABSTRACT

The general properties of micropulsations are reviewed, together with some theories of their origin. A particular study is made of the hydromagnetic wave theory and of the probability of these waves being produced by gyrating charged particles in the magnetosphere. The conditions are discussed under which gyration-induced hydromagnetic waves have frequencies within the micropulsation range. Assuming the production of Alfvén waves by some process in the magnetosphere, a layer model is developed to investigate the transmission of these waves down along the Earth's magnetic field lines to the ionosphere. One feature of this model is a realistic ionospheric termination, in which a phase shift and amplitude reduction may be introduced into back reflected waves. Calculations using the model indicate a definite harmonic structure associated with micropulsations and only a small variation of frequency with geomagnetic latitude; they also provide a good explanation of the frequency structure and diurnal variation of 'pearls'.