PREFACE

Buoyancy forces arise as a result of variations of density in a fluid subject to gravity, and produce a wide range of phenomena of importance in many branches of fluid mechanics. Progress in this field has been made largely through the desire to solve very practical problems, arising for instance in meteorology or in hydraulic engineering. This emphasis on particular applications has meant that parallel developments have often been made in different disciplines without much cross reference to related work, and some results, well understood in one context, are less familiar in another where they might be used to advantage. In this book I have attempted to write a coherent account of the various fluid motions which can be driven or influenced by the presence of small density differences. It is intended as a general introduction to the subject and its literature, in which the physical understanding of the phenomena is emphasized, rather than the applications on the one hand or detailed mathematical theory on the other.

The selection of subject matter must always be a personal one, however, and my own research interests have certainly influenced the topics chosen and the amount of space given to each of them. I have worked with laboratory models of small scale processes in the ocean and atmosphere, and so laboratory and geophysical examples come most readily to mind, but comparisons have also been made with results from various fields of engineering where possible. I have been particularly interested in two problems, those of buoyant convection, and mixing in stably stratified fluids. The sections on these topics cover a larger fraction of the available material (though much of this in the latter field is still rather speculative), while other subjects which have a much firmer foundation in the published literature are treated only to the extent needed to provide a background for the understanding of more complicated processes. An

outline of the general plan of the book is given in the opening section of chapter 1.

Some phenomena which might be implied by the title chosen for this book have been arbitrarily omitted; I have taken this to mean effects which are due *primarily* to *small* density variations in an ordinary fluid such as water. Thus waves at a free surface are not considered in detail, nor are bubbles and particles in a liquid, except insofar as they produce small changes in the mean density. For the most part we will be concerned with miscible fluids, so that surface tension phenomena receive little attention. Flows in porous media are mentioned only in passing, in the context of numerical experiments in thermal convection, and not much is said about conditionally unstable motions (such as convection in clouds, when the release of latent heat dominates the buoyancy). The effects of compressibility are ignored too, after some discussion of the conditions under which a compressible fluid may be treated as incompressible. Perhaps the most important restriction on the scope is that no explicit results are given for rotating stratified fluids. This implies that the natural phenomena of interest are small enough or fast enough for the Coriolis forces due to the earth's rotation to be negligible compared with the buoyancy and inertia forces.

Many people have helped in various ways during the preparation of this book. I am grateful to Professor O. M. Phillips for suggesting that I should write it, to Professor G. K. Batchelor for his encouragement both as head of my department and as editor of this series, and to the British Admiralty and the U.S. Office of Naval Research for supporting my research during the years I have been learning about stratified fluids. T. H. Ellison, H. B. Fischer, P. B. Rhines and J. D. Woods, as well as many colleagues and students in Cambridge and Woods Hole, have made helpful comments on parts of the manuscript; and I owe a special debt to H. E. Huppert and S. A. Thorpe who read the whole of an earlier draft and did much to clarify the presentation. I acknowledge with thanks Mrs Glynis Coulson and Mrs Susan Gray who did the typing, P. F. Linden who assisted with the proofs, and last but not least, my wife and family for their forbearance during the months when my attention was even more divided than usual.

I am indebted to those who have permitted the reproduction of their photographs and diagrams, and who in many cases have supplied original prints. Permission to reproduce figures was received from the editors of the following journals:

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Advances in Geophysics
Science
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Cambridge J. S. TURNER
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Note to the 1979 reprint

The basic concepts underlying this subject have not changed greatly in the six years since this book first appeared, though there has been a rapid growth in the literature related to the applications. It did not seem appropriate at present to attempt a fully revised edition, and I have made only minor corrections of points which have come to my attention, mainly of typographic errors, before reprinting. A short, selective, annotated bibliography of recent papers and review articles has been added, to allow readers to bring themselves up to date on specific topics discussed in the text.

Canberra J. S. T.
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