Reviews

I

Sovremenniye Tektonicheskiye Dwizheniya Zemnoy Kori I Metodi Ikh Izucheniya (Recent tectonic movements of the Earth's crust and methods of their study); Published by Academy of Sciences of the USSR, Moscow, 1961; 160 pp.; Russian with English summary of each article; Price 93 Kopeks.

This publication, issued by the USSR Academy of Sciences under the editorship of Academician Prof. I. P. Gerasimov and the geographer U.A. Mescheryakov, contains 12 articles, which have been presented to the meeting of the Commission on "Recent Crustal Movements" of the I.U.G.G. They cover both the slow secular movements like the rise of the Baltic Basin after the removal of the load of Pleistocene ice therefrom, and the more spectacular orogenic movements in the active volcanic and mountain areas. The studies, which include precise levelling, geodetic mapping and detailed geomorphologic studies, have been carried out in several areas of the USSR and the results are given in these reports by various groups of investigators.

The first two papers by Mescherikov and Sinyagina is a general discussion of the problems of recent crust movements, the methods of study and the connection between geomorphology and tectonics. Matzkova reviews the recent movements in western Russia, especially the velocity of the secular uplift in the Baltic region. In another paper, Setunskaya examines the results of recent studies in the Lepaya-Sverdlovsk area on the Russian platform. Gorelov describes the movements in the eastern part of Russian plains, *i.e.*, the area between Kazan and Gorky in the north to Stavropol in the south in the Caucasus. The western and southern Urals region is treated by Rozhdestvensky and Zhurenko. The Buzuluk depression along the Samara River in SE Russia is treated by Chernysheva and this is shown to be rising since the Pliocene and being dissected by the denudational agencies. The results of precise levelling in the Chelyabins—Kurgan region and the recent movements in the Semipalatinsk-Alma Ata area of Central Asia (Kazakhstan) are discussed by Filkin and Finko respectively. The latter is interesting in that it includes the Kazakh platform, the Balkhash depression and the Tien Shan mountains where different movements are taking place at the same time. Precise levelling in the area of Baskunchak salt dome in the Caspian lowland where a movement of 1 to 0·5 mm per year has been detected, is described by Pevnev. Rantsman shows the connection between geomorphology and the recent seismicity of the Central Asian mountain area, *viz.*, Tien Shan and Pamir-Alai. The last article reviews the recent movements along the sea coasts of the USSR by Ionin and others; the map attached to the paper shows that most of the shores are emergent (along Black Sea, Arctic Ocean and western Kamchatka) while the Caspian and the Vladivostok coast of south eastern Siberia are sinking.

The papers are in Russian, each with a short English summary. There are maps and sections accompanying the papers. The reviewer would command this collection of authoritative papers to the attention of those interested in the subject—geodesists, geologists geographers and others, as these studies are of interest not only to scientists but also to

sociologists and even politicians who would be concerned with disappearing or newly appearing land. He would also point out that practically no work is being done on Pleistocene and recent geology in India in spite of the Geological Survey growing enormously during the last decade. The study of recent geological formations and coast lines will inevitably lead to the deciphering of present day movements which have far-reaching consequences, including the sinking uplift and erosion of coast lines, shifting of river courses and changes of various types on the land surface.

M. S. KRISHNAN

II

Elements of Dynamic Meteorology by A. H. Gordon, pp. xxi + 217; figs. 81; Physical Science Texts (General Editor : Sir Graham Sutton); The English Universities Press Ltd., London; 25 sh.

Except in the United States of America, the opportunities for making a career in Meteorology is limited. Hence only a small number of Universities offer a full degree course in Meteorology. The various National Services are, therefore, obliged to train their staff within their respective services, usually within a comparatively short period. These services will find the book under review to be very useful for the training of meteorological personnel. It provides a broad but brief introduction to the difficult subject of Dynamic Meteorology.

The field covered includes the elements of thermodynamics and of the dynamics of the atmosphere. It is written practically in the form of lecture notes for those who, while possessing only a rudimentary knowledge of calculus, have attained a certain maturity of mind. If they are interested in knowing the full implications of the various results appearing in the book, they will have to go to some of the regular text books on Dynamic Meteorology some of which are listed in this book under Bibliography.

The book contains twelve chapters of 15-20 pages each—Behaviour of Dry Air; Behaviour of Moist Air; Hydrostatic Equilibrium; The Equations of Motion; Trajectories and Streamlines; Balanced and Unbalanced Flow; Circulation and Vorticity; The Long-wave Equations; Thicknesses and Contours; Balanced Frictional Flow; Sutcliffe Development Technique; Numerical Prediction. The subject matter of the last two chapters is presented very well though rather briefly.

It is unfortunate that the book lacks problems at the end of each chapter, designed to drill in the various points of importance covered in the chapter. There is a lack of mathematical rigour in some of the derivations. But inspite of this, the book will be found useful. Apparently Mr. Gordon has used the material contained in the book for training many batches of Technical and Professional Assistants.

The book is free from printing errors. It is good value for 25 sh., when one takes into consideration the prevailing high cost of book-production.

P. R. PISHAROTY

III

Hydrodynamics of Oceans and Atmospheres by Carl Eckart; Pergamon Press, Oxford, London, New York, Paris, 1960; pp. xi + 290; Price 63 sh.

"...Classical hydrodynamics is concerned, almost exclusively, with the motion of a homogeneous compressible fluid. It has been conspicuously unsuccessful in explaining meteorological and oceanographic phenomena, presumably for this reason". These sentences from the first paragraph of the above book, which has seventeen chapters and an Appendix on Mercator's Co-ordinates, give a clue to the author's mind. The stratification of the atmosphere endows it with a stability that is completely lacking in a homogeneous fluid. This is also true of the earth's oceans. There has so far been no systematic theory of the motion of a stably stratified fluid. The author makes a bold attempt to remedy this want.

After stating the basic hydrodynamic equations, the conservation of energy is expressed in terms of energy density and the energy flux. Chapter II is on Perturbation Equations. Only the first two of the successive approximations of perturbation theory designated as the Zeroth and the first order terms of an infinite series are considered here though the importance of second and higher orders is recognised. The first order perturbation equations of motion are three in number corresponding to the second law of motion, the conservation of mass (*i.e.*, equation of continuity) and the second law of thermodynamics. One of the simple solutions, though trivial in a physical sense, corresponds to the barotropic case, which is shown to function in much the same way as an additive constant of integration. Although the solutions of the first order represent motions that change with time, they have also solutions corresponding to steady states. These steady motions for which all time derivatives are zero are discussed in Chapter III. Mean pressure over the years has been analysed into three components: the barotropic component corresponding to zero-order state; the second, the zonal component, does not exceed one per cent of pressure and may be treated as a perturbation of the zero-order; the third tesseral component is only one half per cent of pressure. The equations corresponding to free steady state are solved for cases with and without rotation and for plane and spherical level surfaces. A brief reference is made to second-order instability and secular equation is derived. A first integral of the secular equation is shown to be an approximate form of Bernoulli's theorem. The notion of thermobaric motion is introduced. Hadley's hypothesis of zonal heating is discussed. According to the author there is a-priory doubt concerning the validity of the hypothesis of zonal heating.

Chapter IV—The field equations—is the key chapter for the remaining part of the book. The author derives a set of basic equations and introduces field variables $\mathbf{U}$, P, and Q for use instead of the first order quantities of velocity, pressure and entropy. These occur in the expression

$$E = \frac{1}{2c_0} \left(\mathbf{U}^2 + P^2 + N^2Q^2\right)$$

E is designated as the external energy density. N has the dimensions of a frequency and is a function of gravitational altitude. This notation enables the author to simplify the differential equations considerably. Replacing the first order quantities in the perturbation equations of motion by these field variables, he derives the three field equations which form the basis of all further discussion in the book. A new important parameter Γ is introduced in these equations. N and Γ are shown to summarise the small scale dynamics and large scale kinematics of the adiabatic expansion respectively.

Chapter V is entitled "The Earth's Atmosphere, Oceans and Lakes". In the beginning of this important chapter, the author has summed up the general philosophy of the approximations of different orders by perturbation methods. He recognises that the resolution of an empirical state of fluid motion into zero and higher order terms is to a considerable extent arbitrary. Whatever zero-order state may be chosen as the starting point, the perturbation calculation should really lead to the same end result. It is also a fact that the convergence of the successive approximations may vary depending on the starting point zero-order solution. Also, in practice a few only of the approximations are feasible and it is difficult to select a suitable starting point to obtain rapid convergence as there are few known principles on which to base the choice. In this book studies deal mainly with the first order approximation. The stratification of the oceans and fresh-water lakes and of the atmosphere is considered. Reference is made to the permanent thermocline. Solving the field equations for cases with and without rotation, a direct relation between cyclogenesis and barometric variations is derived. The classical ideas about a rotating earth are implicit in the first order field equations but baroclinic cyclogenesis is not implicit in them.

General theorems concerning the field equations are considered in Chapter VI. The solutions of the field equations are classified into regular, limited and unlimited. The notion of eigensolutions, eigen frequencies or values is introduced. The next stage is to solve the field equations for a representative variety of boundary conditions, driving forces and zero-order states. As the number of such problems combination is too numerous, the solutions are restricted to a selection of the eigensolutions and to consider only those cases in which the fluid is bounded by level surfaces. These are considered in Chapter VII entitled "Formulation of the Major Mathematical Problems". The first set is a pair of ordinary differential equations with altitude as independent variable, called residual equations. The second is a differential equation involving horizontal surfaces. When the Coriolis force is taken into account, the problems become complex and difficult and the author remarks that these difficulties have continued to discourage the development of this fundamental part of oceanographic and meteorological theory.

One of the important approximations in the treatment of these equations by other workers has been neglect of terms involving Ω_H, the horizontal component of the Coriolis vector. The author calls this the traditional approximation. With this, the case of rotation for spherical surfaces leads to Laplace's tidal equation. The solution of field equations without these approximations is extremely complex and not attempted in the present book.

Chapter VIII and IX are devoted to calculations of the isothermal atmosphere without rotation and with rotation respectively. A whole set of terminology is introduced—Wave number and length; horizontal wave number, length; propagation vector, equation and surface trace velocity; pressure impedance, phase-velocity diagram; Rays; Group velocity; diagnostic diagram. A correct grasp of these terms is essential for a proper understanding of all the subsequent discussion in the book. The author has tried to identify solutions corresponding to different boundary conditions with known atmospheric phenomena but this has some inherent limitations due to the idealised atmosphere for which the calculations have been made. These can have some significance when the space and time scales of the phenomena are large enough and the distance from the boundary great enough so that its actual departure from an ideal plane is not very material.

A study of oceans of constant depth for which the N and c have constant values and $\Gamma=0$ is made in Chapter X. The level surfaces are supposed plane and only the case of a vertical axis of rotation has been treated. The analysis closely follows the previous chapter (IX).

Surface waves of the oceanic case correspond to Lamb waves of the atmosphere. A simple approximation corresponds to the case of the internal gravity modes. The modes of a rectangular tank are discussed to illustrate the effects of lateral boundaries.

Chapter XI is entitled 'General Theory of Rays'. The ray theory is of two kinds and in this chapter, the author considers the case where the theory is rigorous only when the differential equations have constant coefficients. He introduces a method of approximation associated with the names of Wentzel, Kramers and Brillouin (W-K-B) and using this, derives explicit equations for the rays and their general properties.

The most important feature of the earth's oceans is its thermocline, a region of rapidly changing temperature and of great stability. Chapter XII is devoted to a study of the implications of this stratification on the eigensolutions. The choice of expression for N appears rather arbitrary and the author is not unaware that it deviates considerably from the empirical curve. But he feels that this would not affect the qualitative discussion of the results. The field equations are discussed first by the ray method and later by the use of residual equations. The latter leads to solutions in terms of Whittaker functions which are rather difficult of computation. He, therefore, resorts to W-K-B approximation.

The earth's actual atmosphere differs considerably from isothermal and in particular has a high-altitude region where the temperature increases seemingly without limit. Chapter XIII is devoted to a discussion of this type of atmosphere which is known as thermosphere with a constant positive temperature gradient. The fundamental difference between the two appears in the nature of the eigensolutions. In the isothermal case, the rays are straight lines extending to infinity while in thermosphere the rays are generally curved and run between finite limiting altitudes. The manner in which rotation about a vertical axis modifies the rays is discussed.

In Chapter XIV, the general theory of the residual equations is discussed. Six general theorems are derived concerning the phase paths. Sturm's well-known formula and certain oscillation theorems are derived.

The general theorems are utilised in Chapter XV to deduce some of the properties of the eigensolutions for the thermosphere derived earlier.

The wave equation for spherical level surface without rotation is treated in Chapter XVI. The solution is expressed in terms of Legendre functions and the first few eigensolutions are listed and the velocity fields corresponding to these are examined for regularity at the poles. For an ocean bounded by vertical shores also, the solution is expressed in terms of Legendre functions.

Chapter XVII, the concluding chapter of this book is entitled "Spherical Level Surfaces with Rotation". Earlier, reference has been made to the mathematical difficulties of this general case but by neglecting the horizontal component of the angular velocity of the planet which is the traditional approximation, the equation reduces to the well known Laplace's tidal equation. Even this form is not easy of solution and a second derivation yielding more flexible equation is given. The eigensolutions independent of longitude and therefore representing zonally—symmetric oscillations are first considered. These are expressible in terms of spherical wave functions. Rossby considered the periodic disturbance of a uniform zonal stream on a rotating planet and with various simplifying assumptions deduced the phase velocity of the wave. The waves are propagated from east to west and this suggests that they are identical with the oscillations of the second kind. Haurwitz dealt this problem in greater detail and

his result becomes identical with the author's under certain conditions. The author hence concludes that there is little doubt that the Rossby waves are essentially identical with Laplace's oscillations of the second kind.

The above is a brief summary of the contents of the book. A few observations are now made on impressions gathered while going through this interesting and valuable book. Numerous studies of the equations of motion as applied to the atmosphere and oceans have been made but a unified treatment explaining clearly the implications of the different approximations and assumptions has been lacking. Besides, there is no single book at present which gives a systematic and connected dynamical treatment of the stably stratified atmosphere and oceans. The present book largely meets this need, though it is restricted to a study of the simpler cases only.

The field equations developed in the joint paper by the author and H. J. Ferris in Reviews of Modern Physics, 1956 and their application to atmosphere and oceans form the basis of treatment in this book. It can also be said that it is a book on perturbation method of solving the atmospheric equations of motion, though the first order of perturbation only is studied. The study in the book no doubt largely corresponds to nearly idealised states or models of the atmosphere and oceans, but this only serves to indicate both the complexity of the problems and also what features can be explained even with these approximations. The author's discussion of the 'traditional approximation' of neglecting the horizontal component of the Coriolis parameter is of considerable value and significance and shows the equations of motion in their true perspective. With this approximation, he is able to identify different types of waves and his treatment of Laplace's oscillations and bringing out the connection between this and Rossby waves is of considerable significance and interest. In accepting the results of discussion of the thermocline in Chapter XII where the author has used an arbitrary expression for N because it has the advantage that many calculations can be made analytically and that qualitative results are not affected, the assumptions made should carefully be noted and kept in view.

The treatment in the book is mainly mathematical and rigorous but the physical basis is not lost sight of. Any one familiar with methods of mathematical physics will find the book of interest and easy to follow but the ordinary reader will find it rather difficult to go through the maze of symbolism, notations and techniques without special effort. Addition of an appendix explaining the notation and various technical terms would be greatly helpful to the reader.

The book gives no ready answer to problems of atmospheric dynamics but provides the basis and background approach which would be helpful in their solutions. It also helps in a better understanding of the anatomy of the equations of motion.

The printing and get up of the book are of the usual high standard associated with Pergamon Press. There are a few obvious misprints but these are mostly minor.

The book on the whole is a valuable contribution on the dynamics of the atmosphere and oceans.

K. N. RAO

IV

Handbook of Meteorological Instruments, Part II—Instruments for Upper Air Observations, pp. 209, 47 diagrams, 51 plates; Air Ministry M.O. 577, published by Her Majesty's Stationery Office, London, 1961; Price £ 1 - 5 s.

This book, issued by the British Meteorological Office, contains detailed information on the design, installation, operation and maintenance of meteorological instruments of all kinds used for upper air observations. The volume constitutes Part II and is in continuation of the previous volume Part I which was published in 1956 and dealt with meteorological instruments used for surface observations.

There are eleven chapters in the book and in its 209 pages a surprisingly large amount of information on the subject has been well presented. Chapter I gives a brief account of the history of the development of the methods and instruments used for upper air measurements and provides the necessary background against which the present state of progress of the subject can be viewed. The next two chapters deal with the principles of upper wind measurements and equipment required for pilot-balloon observations such as pilot balloons, pilot-balloon theodolites and computing devices.

In the fourth and fifth chapters general principles and theory of radar technique, latest types of radars and auxiliary equipment are described and methods of their use for upper air measurements are given. The London M.O. radar-theodolite system has been described in detail but the principles of other systems such as the Lugeon-Nobile System, Echosonde etc have also been indicated. Chapter 6 deals with radio-wind direction-finding systems and different types of radio-theodolites as well as atmospheric direction-finders used for the detection or measurement of atmospherics.

The next three chapters (Chapters 7, 8 and 9) are devoted to radio-sondes and considerable attention has rightly been given to principles of radio-sonde design, different types of radio-sondes, their calibration etc. The London Meteorological Office radio-sondes and the calibration plant used are described in detail. Sources of errors in radio-sonde measurements are also briefly discussed. Some space is also devoted to application of radio-sonde technique to atmospheric electric measurements as well as to ozone measurements. In this connection it is interesting to note that reference to the fan type radio-sonde developed in India and to potential gradient and conductivity measurements in the free atmosphere in this country, has been made. One, however, misses similar references to considerable amount of other work that has been done on the development of upper air instruments in this country.

The penultimate chapter deals with instruments for meteorological observations from aircraft such as aneroid barometers, aircraft thermometers and psychrometers. Frost-point hygrometers and infra-red hygrometers and method of their use, testing and maintenance have also been described in some detail. The final chapter is of special interest to cloud physicists. Here, methods of measurement in cloud physics such as instruments for measuring water-content and size distribution of particles in clouds and measurement of atmospheric nuclei have been briefly dealt with. A brief account of the application of radar technique to the study of cloud and precipitation has also been included in this chapter.

The Handbook covers a fairly wide range and gives a fund of useful information. Descriptions of the latest types of instruments are clear and concise and they have been very well illustrated and explained by means of diagrams and photographs. The Handbook contains as many as 47 diagrams and 51 plates which are all clear and well produced. At the end of the

eleven chapters, a welcome feature is a rich bibliography containing 142 references. This will be of immense value to those readers who are in need of more detailed information in respect of any particular subject. The bibliography is followed by a short glossary of technical terms for the benefit of the non-specialist readers. A fairly exhaustive index concludes the volume. The book is excellently printed.

Although majority of the instruments and equipment dealt with in this Handbook are those used at stations in Britain, the publication will serve as a fairly comprehensive guide and reference book and will be found very useful by those in charge of upper air observations as well as by instrumental meteorologists all over the world. The British Meteorological Office are to be congratulated on the compilation of this Handbook.

K. S. AGARWALA