CONTENTS

Preface 5

I. Systems of the fluid mechanical type 9
1. Approximation of the equations of fluid mechanics by models with a small number of parameters 9
2. Motion of an ideal homogeneous fluid on a spherical surface 11
3. Model of geophysical flow 12
4. Non-linear systems of the fluid mechanical type 14
4.1. Definition and fundamental properties 14
4.2. The equivalence of motion of an ideal incompressible fluid and of the mechanical gyroscope 15
4.3. Equations of convective motion 16
4.4. Equations of convective motion in the field of Coriolis' force 19
4.5. Lorenz's model 21
5. Statistical description of systems of the fluid mechanical type 24
5.1. The probability density distribution 24
5.2. The equation of probability diffusion 26
5.3. Noise in systems of the fluid mechanical type 28
6. Systems of the fluid mechanical type and the cascade process of energy transfer 31
7. Model of the cascade process of energy transfer with two quadratic integrals. Energy spectrum of two-dimensional turbulence 35

II. Hoff's solution of the general Navier-Stokes equation 39

III. Bifurcation and the Navier-Stokes equation 43

IV. Selected treatises on the qualitative theory of dynamic systems 47
1. Examples of bifurcation of multi - dimensional dynamic systems 47
2. Homoclinic curve and structure 50
3. Smale's horseshoe 51
4. Consequence of the fundamental theorem of Smale's horseshoe 55

V. Non-standard sets in fiiud mechanics 57
1. Topological dimension 57
2. Hausdorff's dimension 58
3. Fractals and turbulence 59

VI. The origin and structure of Lorenz's attractor 65
1. The strange attractor in Lorenz's model 65
2. Chaotic motions in Lorenz's model. Periodic and aperiodic orbits 67

VII. Selected treatises in chaotic dynamics 72
1. Hyperbolicity 72
2. Hyperbolicity and the stochastic properties of dynamic systems 73
3. Hyperbolicity and statistical mechanics 75
4. Dynamic stochasticity 77

VIII. Lie's groups and the fluid mechanics of an ideal fluid 78
1. Hamilton's formalism on Lie's groups. The generalized rigid body 78
2. Equations of motion of the generalized heavy gyroscope 81
3. Applications to fluid mechanics 84
3.1. Lamb's equation 84
3.2. Ertel's invariant 86
4. Stability of plane stationary flows 86
4.1. Criterion of stability 86
4.2. Stability of Kármán's vortex street 89
4.3. Parallel flow in a plane 90
4.4. Flow on an annuloid 90
5. Predictability of hydrodynamic fields 90

IX. Algebraic methods in the theory of turbulent diffusion 96
1. Circuits and algebras of observables. The minimum Lie-Jordan algebra of observables 96
2. Non-canonic transition between two Hamiltonians 97
3. The minimum algebra of observables in a kinetic model of turbulent diffusion 99
4. Statistical model of the semi-empirical theory of turbulent diffusion 101
5. The role of the kinetic equation for particle density in the theory of turbulent diffusion 104
6. Remarks on the character of the kinetic equation of turbulent diffusion 105

X. Appendix 107
On the covariant formulation of the law of particle transfer in a field of turbulence 107

Acknowledgement and Retrospective 111
References 112
Russian summary 114
Czech summary 116