

CONTENTS

Authors' Preface to the English Edition	iii
Editor's Preface to the English Edition	v
Chapter 6 Mathematical Description of Turbulence.	
Spectral Functions	1
11. Spectral Representations of Stationary Processes and	
Homogeneous Fields	1
11.1 Spectral Representation of Stationary Processes	1
11.2 Spectral Representation of Homogeneous Fields	16
11.3 Partial Derivatives of Homogeneous Fields. Divergence	
and Curl of a Vector Field	23
12. Isotropic Random Fields	29
12.1 Correlation Functions and Spectra of Scalar	
Isotropic Fields	29
12.2 Correlation Functions and Spectra of Isotropic	
Fields	35
12.3 Solenoidal and Potential Isotropic Vector Fields	49
12.4 One-Point and Two-Point Higher-Order Moments of	
Isotropic Fields	58
12.5 Three-Point Moments of Isotropic Fields	75
13. Locally Homogeneous and Locally Isotropic	
Random Fields	80
13.1 Processes with Stationary Increments	80
13.2 Locally Homogeneous Fields	93
13.3 Locally Isotropic Fields	98
Chapter 7 Isotropic Turbulence	113
14. Equations for the Correlation and Spectral Functions of	
Isotropic Turbulence	113
14.1 Definition of Isotropic Turbulence and the	
Possibilities of its Experimental Realization	113
14.2 Equations for the Velocity Correlations	117
14.3 Equations for the Velocity Spectra.	123
14.4 Correlations and Spectra Containing Pressure	130
14.5 Correlations and Spectra Containing the	
Temperature	136

15. The Simplest Consequences of the Correlation and Spectral Equations	141
15.1 Balance Equations for Energy, Vorticity, and Temperature-Fluctuation Intensity.	141
15.2 The Loitsyanskii and Corrsin Integrals	146
15.3 Final Period of Decay of Isotropic Turbulence	152
15.4 Experimental Data on the Final Period of Decay. The Decay of Homogeneous Turbulence	162
15.5 Asymptotic Behavior of the Correlations and Spectra of Homogeneous Turbulence in the Range of Large Length Scales (or Small Wave Numbers)	169
15.6 The Influence of the Spectrum Singularity on the Final Period Decay	174
16. Self-Preservation Hypotheses	177
16.1 The von Kármán Hypothesis on the Self-Preservation of the Velocity Correlation Functions	177
16.2 Less Stringent Forms of the von Kármán Hypothesis . . .	181
16.3 Spectral Formulation of the Self-Preservation Hypotheses	185
16.4 Experimental Verification of the Self-Preservation Hypotheses	189
16.5 The Kolmogorov Hypotheses on Small-Scale Self-Preservation at High Enough Reynolds Numbers. . .	197
16.6 Conditions for the Existence of Kolmogorov Self-Preservation in Grid Turbulence	204
16.7 The Meso-Scale Quasi-Equilibrium Hypothesis. Self-Preservation of Temperature Fluctuations	210
17. Spectral Energy-Transfer Hypotheses	212
17.1 Approximate Formulas for the Spectral Energy Transfer	212
17.2 Application of the Energy Transfer Hypotheses to the Study of the Shape of the Spectrum in the Quasi-Equilibrium Range	225
17.3 Application of the Energy-Transfer Hypotheses to Decaying Turbulence behind a Grid	235
17.4 Self-Preserving Solutions of the Approximate Equations for the Energy Spectrum	237
18. The Millionschikov Zero-Fourth-Cumulant Hypothesis and its Application to the Investigation of Pressure and Acceleration Fluctuations	241
18.1 The Zero-Fourth-Cumulant Hypothesis and the Data on Velocity Probability Distributions	241
18.2 Calculation of the Pressure Correlation and Spectra . . .	250
18.3 Estimation of the Turbulent Acceleration Fluctuations . .	256

19. Dynamic Equations for the Higher-Order Moments and the Closure Problem	260
19.1 Equations for the Third-Order Moments of Flow Variables	260
19.2 Closure of the Moment Equations by the Moment Discard Assumption	267
19.3 Closure of the Second- and Third-Order Moment Equations Using the Millionshchikov Zero-Fourth-Cumulant Hypothesis	271
19.4 Zero-Fourth-Cumulant Approximation for Temperature Fluctuations in Isotropic Turbulence	286
19.5 Space-Time Correlation Functions. The Case of Stationary Isotropic Turbulence	290
19.6 Application of Perturbation Theory and the Diagram Technique	295
19.7 Equations for the Finite-Dimensional Probability Distributions of Velocities	310
20. Turbulence in Compressible Fluids	317
20.1 Invariants of Isotropic Compressible Turbulence	317
20.2 Linear Theory; Final Period of Decay of Compressible Turbulence	321
20.3 Quadratic Effects; Generation of Sound by Turbulence	328
 Chapter 8 Locally Isotropic Turbulence	337
21. General Description of the Small-Scale Structure of Turbulence at Large Reynolds Numbers	337
21.1 A Qualitative Scheme for Developed Turbulence	337
21.2 Definition of Locally Isotropic Turbulence	341
21.3 The Kolmogorov Similarity Hypotheses	345
21.4 Local Structure of the Velocity Fluctuations	351
21.5 Statistical Characteristics of Acceleration, Vorticity, and Pressure Fields	368
21.6 Local Structure of the Temperature Field for High Reynolds and Peclet Numbers	377
21.7 Local Characteristics of Turbulence in the Presence of Buoyancy Forces and Chemical Reactions. Effect of Thermal Stratification	387
22. Dynamic Theory of the Local Structure of Developed Turbulence	395
22.1 Equations for the Structure and Spectral Functions of Velocity and Temperature	395
22.2 Closure of the Dynamic Equations	403

x CONTENTS

22.3	Behavior of the Turbulent Energy Spectrum in the Far Dissipation Range	421
22.4	Behavior of the Temperature Spectrum at Very Large Wave Numbers	433
23.	Experimental Data on the Fine Scale Structure of Developed Turbulence	449
23.1	Methods of Measurement; Application of Taylor's Frozen-Turbulence Hypothesis	449
23.2	Verification of the Local Isotropy Assumption.	453
23.3	Verification of the Second Kolmogorov Similarity Hypothesis for the Velocity Fluctuations	461
23.4	Verification of the First Kolmogorov Similarity Hypothesis for the Velocity Field	486
23.5	Data on the Local Structure of the Temperature and other Scalar Fields Mixed by Turbulence	494
23.6	Data on Turbulence Spectra in the Atmosphere beyond the Low-Frequency Limit of the Inertial Subrange	517
24.	Diffusion in an Isotropic Turbulence	527
24.1	Diffusion in an Isotropic Turbulence. Statistical Characteristics of the Motion of a Fluid Particle	527
24.2	Statistical Characteristics of the Motion of a Pair of Fluid Particles	536
24.3	Relative Diffusion and Richardson's Four-Thirds Law	551
24.4	Hypotheses on the Probability Distributions of Local Diffusion Characteristics	567
24.5	Material Line and Surface Stretching in Turbulent Flows	578
25.	Refined Treatment of the Local Structure of Turbulence, Taking into Account Fluctuations in Dissipation Rate	584
25.1	General Considerations and Model Examples	584
25.2	Refined Similarity Hypothesis	590
25.3	Statistical Characteristics of the Dissipation	594
25.4	Refined Expressions for the Statistical Characteristics of Small-Scale Turbulence	640
25.5	More General Form of the Refined Similarity Hypothesis	650
Chapter 9	Wave Propagation Through Turbulence	653
26.	Propagation of Electromagnetic and Sound Waves in a Turbulent Medium	653
26.1	Foundations of the Theory of Electromagnetic Wave Propagation in a Turbulent Medium	653

26.2	Sound Propagation in a Turbulent Atmosphere.	668
26.3	Turbulent Scattering of Electromagnetic and Sound Waves	674
26.4	Fluctuations in the Amplitude and Phase of Electromagnetic and Sound Waves in a Turbulent Atmosphere	685
26.5	Strong Fluctuations of Wave Amplitude	704
27.	Stellar Scintillation.	721
27.1	Fluctuations in the Amplitude and Phase of Star Light Observed on the Earth's Surface	721
27.2	The Effect of Telescope Averaging and Scintillation of Stellar and Planetary Images	729
27.3	Time Spectra of Fluctuations in the Intensity of Stellar Images in Telescopes	733
27.4	Chromatic Stellar Scintillation	737
 Chapter 10 Functional Formulation of the Turbulence		
	Problem	743
28.	Equations for the Characteristic Functional.	743
28.1	Equations for the Spatial Characteristic Functional of the Velocity Field	743
28.2	Spectral Form of the Equations for the Spatial Characteristic Functional	751
28.3	Equations for the Space-Time Characteristic Functional	760
28.4	Equations for the Characteristic Functional in the Presence of External Forces	763
29.	Methods of Solving the Equations for the Characteristic Functional	773
29.1	Use of a Functional Power Series	773
29.2	Zero-Order Approximation in the Reynolds Number . . .	783
29.3	Expansion in Powers of the Reynolds Number	791
29.4	Other Expansion Schemes	798
29.5	Use of Functional Integrals	802
 Bibliography.		
Supplementary Remarks to Volume 1		
References		
Errata to Volume 1		
Author Index		
Subject Index		