

Contents

Introduction	1
1 Theoretical Models of Vortex Rings	5
1.1 Vortex Rings	5
1.2 Equations of Motion. Vorticity, Circulation, and Stream Function	7
1.3 Vorticity Distribution and Velocity Field of a Vortex Ring	9
1.4 Integral Characteristics of a Vortex Ring	11
1.5 Circular Line Vortex of Zero Cross-Section	14
1.6 Vortex Ring with Finite Cross-Section (Lamb's Model)	16
1.7 Hill's Spherical Vortex	21
1.8 Family of Steady Vortex Rings	22
1.9 Translational Velocity of a Vortex Ring	30
2 Hydrodynamic Structure of a Vortex Ring	33
2.1 Experimental Procedure	33
2.2 Hot-Wire Anemometry: Method for Measuring Two-Dimensional Velocity Field	35
2.3 Estimations of Measurement Accuracy of Two-Dimensional Velocity Field with Hot-Wire Probes	42
2.4 Velocity Field of Vortex Ring	49
2.5 Stream Function and Structure of Stream Lines	50
2.6 Vorticity Distribution. Vortex Core. Circulation	51
2.7 Dynamic Characteristics of a Vortex Ring	55
2.8 Other Investigations of Vortex Ring Structure	60
2.9 Comments on Experimental Methods of Studying Velocity Flow Field	63
3 Structure and Parameters of a Family of Vortex Rings Formed on Outflow of a Submerged Jet	67
3.1 Experimental Procedure	68
3.2 Criteria Determining Vortex Ring Formation Process	71
3.3 Basic Properties of Vortex Rings	72
3.4 Vortex Ring Parameters as Functions of Jet Length	73

3.5	Dependence of Vortex Ring Parameters on the Jet Reynolds Number.....	78
3.6	Dependence of Vortex Ring Parameters on the Nozzle Angle of Taper.....	85
3.7	Comparison between Some Conclusions from Theoretical Models of Vortex Rings and Experiment.....	85
4	Vortex Ring Formation.....	89
4.1	Vortex Ring Generation by Impulsive Motion of a Circular Disc.....	89
4.2	Vortex Ring Formation on Outflow of a Submerged Jet	91
5	Motion of Turbulent Vortex Rings.....	105
5.1	Statement of the Problem.....	106
5.2	Laws of Motion of a Turbulent Vortex Ring	108
5.3	Structure of a Turbulent Vortex Ring	113
6	Practical Implementation of Vortex Rings: Extinction of Fires at Gushing Gas and Oil Wells	121
6.1	Origination and Characteristics of Powerful Gas and Oil Gushers.....	121
6.2	Combustion of Gas and Oil Gushers. Conditions of Stabilization and Flame-Out	123
6.3	Determination of Flow Rate of Burning Underexpanded Gas Gushers	123
6.4	Physical Grounds for Extinguishing of a Diffusion Plume by an Air Vortex Ring	130
6.5	Principles of Scale Modeling and Calculation of Amount of Fire Extinguishing Agents.....	139
6.6	Extinguishing of Real Well Fires by a Vortex Ring	140
	References	143
	Index	151