Contents

Chapter One THE EARLIEST TRADITIONS

I. Introduction 1
II. The Concept of the Parallelogram of Velocities and Forces 2
III. Leibniz' Concept of a Geometry of Situation 3
IV. The Concept of the Geometrical Representation of Complex Numbers 5
V. Summary and Conclusion 11
Notes 13

Chapter Two SIR WILLIAM ROWAN HAMILTON AND QUATERNIONS

I. Introduction: Hamiltonian Historiography 17
II. Hamilton's Life and Fame 19
III. Hamilton and Complex Numbers 23
IV. Hamilton's Discovery of Quaternions 27
V. Quaternions until Hamilton's Death (1865) 33
VI. Summary and Conclusion 41
Notes 43

Chapter Three OTHER EARLY VECTORIAL SYSTEMS, ESPECIALLY GRASSMANN'S THEORY OF EXTENSION

I. Introduction 47
II. August Ferdinand Möbius and His Barycentric Calculus 48
III. Giusto Bellavitis and His Calculus of Equipollences 52
IV. Hermann Grassmann and His Calculus of Extension: Introduction 54
V. Grassmann's *Theorie der Ebbe und Flut* 60
VI. Grassmann's *Ausdehnungslehre* of 1844 63

VII. The Period from 1844 to 1862 77
VIII. Grassmann's *Ausdehnungslehre* of 1862 and the Gradual, Limited Acceptance of His Work 89
IX. Matthew O'Brien 96
Notes 102

Chapter Four Traditions in Vectorial Analysis from the Middle Period of Its History

I. Introduction 109
II. Interest in Vectorial Analysis in Various Countries from 1841 to 1900 110
III. Peter Guthrie Tait: Advocate and Developer of Quaternions 117
IV. Benjamin Peirce: Advocate of Quaternions in America 125
V. James Clerk Maxwell: Critic of Quaternions 127
VI. William Kingdon Clifford: Transition Figure 139
Notes 144

Chapter Five Gibbs and Heaviside and the Development of the Modern System of Vector Analysis

I. Introduction 150
II. Josiah Willard Gibbs 150
III. Gibbs' Early Work in Vector Analysis 152
IV. Gibbs' *Elements of Vector Analysis* 155
V. Gibbs' Other Work Pertaining to Vector Analysis 158
VI. Oliver Heaviside 162
VII. Heaviside's Electrical Papers 163
VIII. Heaviside's *Electromagnetic Theory* 169
IX. The Reception Given to Heaviside's Writings 174
X. Conclusion 177
Notes 178

Chapter Six A Struggle for Existence in the 1890's

I. Introduction 182
II. The "Struggle for Existence" 183
III. Conclusions 215
Notes 221

Chapter Seven THE EMERGENCE OF THE MODERN SYSTEM OF VECTOR ANALYSIS: 1894–1910

I. Introduction 225
II. Twelve Major Publications in Vector Analysis from 1894 to 1910 226
III. Summary and Conclusion 239
Notes 243

Chapter Eight SUMMARY AND CONCLUSIONS 247
Notes 255

Index 260