INTRODUCTION

Chapter I Geography to Magellan

Greek mathematics and astronomy leading to geodesy and cartography. The Portuguese voyages of exploration. The ideas of Columbus in the context of his times. The circumnavigation of the globe.

Contents

Chapter 2 Numerate Navigators without Science

The magnetic compass and the development of dead reckoning navigation in the Mediterranean. The Portuguese application of dead reckoning and ancient methods of latitude determination to Atlantic exploration.

Chapter 3 Three Necessary Mathematical Inventions Meridional parts and Mercator's projection. Spherical trigonometry. Logarithms. Tables from the Almagest onwards.

Chapter 4 A New Way of Thought

The discovery in the seventeenth century of the power of mathematical physics. Kepler, Galileo, and Newton, leading to Faraday, Maxwell, and Hertz, and thus to electronics. Boolean algebra and computer logic. The recent relevance of relativity and quantum theory to navigation.

Chapter 5 A Political History of the Longitude

Longitude as a confine of empire in the sixteenth century. Two centuries of prizes for finding the longitude. Louis XIV and the Académie des Sciences. Charles II 5

Ι

4I

2I

56

75

CONTENTS

and the Greenwich Observatory. Parliament and the Board of Longitude. The international adoption of Greenwich as the standard for longitude and time.

Chapter 6 The Great Pursuit of the Longitude

Geodesy from the seventeenth century and the determination of longitude on land. The rise of cartography. The lunar distance, the chronometer, and the related evolution of precision instruments to enable the determination of longitude at sea.

Chapter 7 Astronomical Navigation with Sextant and Chronometer 107 The evolution of methods of sight reduction and their application to navigation from the late eighteenth century. The bubble sextant and other special features of astronomical navigation in the air.

Chapter 8 Victoriana

The three subjects of this chapter: Magnetic and gyromagnetic compasses in metal ships and aircraft, tidal prediction, and lighthouses, all cover a period far more extended than the Victorian era; but they still bear the print of Victorian science.

Chapter 9 Self-Containment

Gyroscopes, gyrocompasses, gyroscopic instruments and control systems; inertial navigation systems and self-contained navigation.

Chapter 10 The Homing Quality of Radio

The evolution of radio direction-finding systems. The radio bearing as an aid to navigation. The application of the homing quality to navigation by radio, culminating in aeroplane automatic landing systems.

Chapter II The Seeing Quality of Radio

The development of radar to detect enemy aircraft and ships. Its application to the navigation of combat aircraft and other weapon-delivery systems, collision avoidance, traffic control, range-finding, map-reading, and storm detection.

Chapter 12 Radio, Apollonius, and Professor Doppler

Systems which provide navigation data by measuring the time (or phase) difference between signals from different sources, and those which employ the Doppler effect. The application of such systems (including satellites) to navigation of vehicles of all kinds.

85

128

155

176

222

202

Chapter 13 The Path of Minimum Time	243
The evolution of the pursuit of minimum time (or fuel, or cost) from sailing wit the tide or wind to the scientific routeing of ships and aircraft.	
Chapter 14 A Game of Chance The development in modern times of a scientific approach to the analysis of the objectives of the navigation and the efficient pursuit of them. The dependence of this approach on probability theory. The probability approach to safety, as in modern air traffic control systems. Computer algorithms which find most probable position.	264
Chapter 15 On the Price of Annuities Modern analysis of the cost-effectiveness of navigation systems is derived from a paper on the price of annuities by Halley published in 1693.	283
Chapter 16 Past, Present, and Future	291
LIST OF REFERENCES	299
ACKNOWLEDGEMENTS	303
INDEX	305

н х