II) Francisco Falero—During the great age of discovery which followed the voyages of Columbus, Spain and Portugal took an important part in maritime enterprises and the exploration of lands beyond the sea. These ventures were responsible for the improvement of instruments and methods of navigation and the production of charts and maps. At that time it was widely believed that the determination of longitude at sea could be obtained from magnetic data, particularly from those of the declination, a belief which persisted throughout the seventeenth century and encouraged the making of many magnetic observations which, although useless as far as longitude-determinations were concerned, at least furnished data of great value in advancing knowledge of geomagnetism.

The first person who announced practical methods of determining the magnetic declination in printed form was Francisco Falero or Faleiro, a Portuguese in the service of the Spanish Navy, to whom we are indebted for the first real manual of navigation. This work entitled "Tratado del esphera y del arte del marear; con el regimiêto de la altura; cõ algúas reglas nueuamête escritas muy necessarias," is extremely rare—so rare in fact that its existence has sometimes been doubted. The National Library in Madrid, however, possessed a copy and Hellmann was enabled to reproduce its title-page which we in turn present herewith in Plate 2. (A free translation of the title is as follows: "Treatise on the sphere and the art of navigation with manual of altitudes with some very necessary written rules. With imperial privilege. A. D. 1535.") The work was printed in gothic type and consists of 52 unnumbered folio pages. In the eighth chapter of the second part under the title "Del nordestear de las agujas," a translation of which we present (page 80), magnetic declination is discussed in detail for the first time in print and three methods are given for its determination, namely (1) by the azimuth-determination of the magnetic needle at true noon when the shadow of the pin falls to the north, (2) by observation of the shadow-azimuths at corresponding altitudes of the Sun before and after noon, (3) by observation of the azimuth at sunrise and sunset.¹ These methods are perhaps intended for an instrument (brújula de variación) devised by Filipe Guillen although no mention is made of it.

Filipe Guillen, an ingenious apothecary of Seville, who presented this instrument to the King of Portugal, João III, in 1525, has left nothing in writing concerning it. For its accurate description, we are indebted to the Spanish cosmographer and major pilot Alonzo de Santa Cruz, who took much interest in the efforts to determine the longitude from the variation of the compass.²

¹G. Hellmann, Terr. Mag., 4, 81-83 (1899).
²P. F. Mattelay ("Bibliographical History of Electricity and Magnetism," p. 70, London (1922)), points out that the magnetic charts devised by Alonzo de Santa Cruz, although based on very imperfect observations, antedated by more than 150 years the work of Edmond Halley.
Martin Cortes—Although as early as 1537 Francisco Falero, in his "Manual of astronomy and nautical science" had taught the existence of the magnetic declination and given methods for its determination, Pedro de Medina raised all kinds of doubts against it in his "Arte de navigar." It was, therefore, a real service which Martin Cortes rendered in his "Breve Compendio de la sphera y de la arte de Navigar" (Seville, 1551) by devoting a detailed chapter to the magnetic needle and its variation which Hellmann reproduced in his "Rara Magnetica" because it contains the earliest exact description of the marine compass and its construction. As no copy of the first edition of Cortes' book (1551) was available, Hellmann was obliged to use the second edition (1556) for producing the facsimile which appeared in his "Neudrucke." The ideas regarding the magnetic pole which Martin Cortes expresses in Chapter 5, are much more obscure than those of Mercator, who has the priority in this matter, even if we suppose that Martin Cortes completed the manuscript of his book as early as 1545, as he states in the preface.

The title-page, reproduced on page 85, is from the second edition of "Breve compendio de la sphera etc." as published in "Neudrucke von Schriften und Karten über Meteorologie und Erdmagnetismus" No. 10, by G. Hellmann. A free translation is as follows: "Brief compendium of the sphere and the art of navigation with new instruments and rules exemplified by many clever demonstrations; composed by Martin Cortes, a native of Bujalaroz in the Kingdom of Aragon and at present residing in the city of Cadiz; addressed to the most invincible Monarch Charles V, King of the Spains, our Master."

The writer wishes to express his obligation to Prof. A. Duperier of Imperial College of Science and Technology, London, for carefully examining these two translations and suggesting corrections for a number of obscure passages.

TREATISE ON THE SPHERE AND THE ART OF NAVIGATION

Francisco Falero

Part II, Chapter 8—On the northeasting\(^1\) of the needles

The northeasting of the needles causes navigators many doubts, from which they may be freed by knowing precisely how much the needles northeast or northwest. In addition to this, other advantages will follow, such as knowing exactly in what direction they are sailing. Knowing this they will follow exactly their courses without error or wandering, and also it will help much to a knowledge of the longitude in which they are navigating.

The northeasting and northwesting of the needles are nothing else than their deviation from the meridian in which they are. They do not show this exactly except when they seek accurately the pole. And they seek this exactly, according to navigators, only when they are in the meridian of the islands of the Azores, and the most precise seek it in that of the Island of Corvo, according to the experience of some. Because, by reason of the differences of steels and of the lodestones, they do not all seek the pole in the same meridian, but some in a more eastern and

\(^1\)That is, the declination of the compass-needle from the true north towards the east, and correspondingly for northwesting.