(III) **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 Spanis, 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.
others in a more western one, although the difference is small. And likewise some decline to the northeast more than others, and others to the northwest. And in this as in all other particulars, which shall be stated below, all the needles may agree. For the magnitude of the error of all will be known in every place.

Accordingly you are to know that sailing from the meridian of the Island of Corvo or any other of the Azores in which the needle points exactly towards the pole, going toward the west the needles decline to the northwest, and sailing from the same meridian toward the east, they decline to the northeast. They are said to northeast because the amount by which they deviate from the pole is toward the northeast, and when they deviate from the pole toward the northwest, they are said to northwest. And the more the ships depart from the supposed meridian, the more the needles northeast or northwest, according to the direction in which they sail.

And it should be borne in mind also that on a ship departing from the said island along a parallel, over 90° of longitude the needles will continue to increase in their northeasting or northwesting and passing beyond 90° on the same parallel, by the same proportion which they had northwested, they will begin to be corrected, until they have sailed another 90°, which will be in the 180th degree of longitude from the said island. And they will be exactly in the antipodes, and the meridian exactly opposite to that in the same parallel, and the needles would again seek the pole exactly as they did in the island and meridian from which the voyage began, as proposed, pursuing their voyage by the same route until they returned to the same island from which they had first started, if this were possible (which it is not). In the same order and proportion they will again make their differences as in the first 180°, namely that up to the first 90°, the needles would continue to northeast and from that point onward they would begin to correct themselves so that when the ship had returned to the point and island from which it had first set out, they would again seek exactly the pole without northeasting or northwesting. And because the navigators following their courses on the zero-meridian of the north and south, find that the needles deviate from the pole, some of them hold an error, and it is that they think that, pursuing such a voyage, the needles northeast or northwest: It is said that although a ship sails on a meridian from one pole to the other never would the needles by which such a ship is governed northwest or northeast.

Since they find that they deviate from the pole, as in truth they do, and since such a deviation from the pole does not approach the northeast or the northwest, it cannot be said that it northeasts or northwests, nor is this deviation inconvenient, because the deviation which brings us into error is not that from the pole but from the meridian. And that this may be clear let the following be taken as an example: That if a ship were on the equator and the needle by which it was governed neither northeasted nor northwested, it is certain that it would seek the pole without indicating or seeking the northeast nor the northwest, nor our zenith, nor our antipodes, and this is because, it being true, it would not depart either towards the northeast or towards the northwest, and being on the equator it would not deviate toward our antipodes nor toward our zenith, because the point which the needle seeks is always
on the horizon on which the pole holds, by being on the equator as is stated. And inasmuch as this supposition is true, it must be remembered that the needle at no place or point on the sphere seeks exactly the pole except when it is on the equator for only there does it hold it on the horizon. And changing from the equator, by the amount the pole would be above or below the horizon the needle departs from it. So that if a ship with such a needle sailed from the equator on a meridian as far as 90°, if it were possible to place the pole in the zenith the needle would seek the pole in a point which would be separated from the pole itself 90°. Because the point which it would seek would be on the horizon of that which is below the pole; this would be the equator. But although the distance from the pole were 90°, not on this account would it depart from the meridian little or much, and not separating from it, it would decline neither to the northeast nor to the northwest; nor from such a deviation would there result error or harm because, as stated above, the deviation from the meridian is what places us in error and false beginnings and endings, and not that from the pole.

And in order that we may know how much the needles northeast or northwest, it is fitting to make an instrument in the manner and form of the figure which you will find in the present chapter, and which should be very round and flat, and so large that it may be divided into 360°, which are to be indicated with a rule, so that being taken from the center thereof, they will be indicated only on the circumference. And from the point at which you would wish that the needle point to the pole, you will begin to graduate on both sides beginning at one and ending in the line which you would indicate as the equator at 90°. And from the other pole toward the equator you would be able to graduate as many more, although it is not necessary. And after having graduated, indicate in the center with a compass a circle so large that the needle may be enclosed in it so that it may be fixed in the instrument. And you will make a half circle of iron or of steel or of some other substance which will be very round and flat and symmetrical, and will not be larger than the shadow it casts, and be drawn with the compass of the size of half the circumference of the instrument, and have sharp points greater than will fit the size of the half circle, so that the excess will drive into the instrument and keep it straight. And one point is to be placed at the point in which the needle indicates the north pole and the other where it points to the south pole.

And having thus made this instrument, if you should wish to make a determination with it at noon so that the half circle casts a direct shadow without any deviation, and if you are where the Sun is between you and the arctic pole, have the Sun enter on the side on which the needle points to the north pole. And if the Sun should be between you and the south pole, do the reverse. And if you thus desire to take the shadow, you have to move the instrument around to one side or the other without any regard to the needle until the half circle casts the shadow directly as said. And if, having thus taken the shadow, the needle should indicate the pole at the point at which the point of the circle should be, it would be true without northeasting because when the Sun arrives at each of the meridians, it casts a shadow or ray on those which below such a meridian are precisely at the pole, and for this reason every time that the needle agrees with the shadow or ray at noon you will have to con-
sider it true and all that the needle disagrees will be error. However, if the needle, the shadow being thus taken, should not indicate the pole on the point in which the point of the mid-circle should be, you will stretch a thread passing through the center of the needle and the point of the rose until it cuts the graduation. I say that the thread should pass over the point at which the needle indicates the pole very precisely and that you should count the degrees from the point of the circle to the point at which the thread cuts, and the (number of) degrees will be the amount which the needle northeasts according to the side on which it deviates, and for this much care must be taken in determining noon precisely, because all the error in determining it will appear in the count of this instrument. And we shall determine noon with an hourglass or some other universal manner, etc., which is very precise and not one connected with the Sun, and counting with the sand the hours which are in the night and subtracting them from 24 which make up the natural day, those which remain will be those which there will be in the whole day from Sun to Sun in the region in which they were. Knowing how many there are at the beginning of the day, one has to count with the same glass noting the Sun and having counted, the mean or the half will be noon.

Also a good way to determine easily the meridian with the same instrument is to take the shadow of the Sun one hour, or two, or three, etc., before noon and to note on what part of the instrument it falls, and at similar times after noon as previously it was taken before (noon). Taking again the shadow, see to it that the Sun is at as great an altitude after noon as it was before when the first shadow was taken. Noting the two shadows, the mean of them will be the exact meridian. And this is a very good principle as being true, as also it may serve more times per day than the others and there may be no error in it, if the order of it is well observed.

You will also know with this instrument the meridian by determining how much the needle northeasts or northwests; placing in the center thereof a pin (shaft) and indicating the shadow on the instrument as the Sun rises and also as it sets, and the mean of the two shadows will necessarily be the meridian. And every time that the needle points to the pole in such a meridian which you have taken in the instrument, it will be true—it will neither northeast nor northwest. And if it does not point to the pole in such a meridian, you will count the degrees that there are from the meridian which you have taken and indicated between the two shadows, up to the point at which the needle points to the pole; and the degrees between them will be the amount which the needle will diverge from the meridian.

Also place the points of the half circle or two pins at the two ends or points of the line indicated on the instrument as the equinoctial, and at sunrise or sunset carefully adjust the instrument so that the circle or pins cast a shadow which goes in a straight line from one point of the circle to the other. Having done this you will draw a thread cutting the center and point of the needle and through the point at which the needle points to the pole to the graduation. And if the thread falls on the diametral line indicated on the instrument precisely—if the ship should be on the parallel on which the Sun should be that day—then the needle will be true. And if the thread should cut the gradua-
The thread cuts the graduation at the point where the needle northeasts or northwests according to the side of the line or meridian from which it deviates. And this, as has been said, will be when the ship is on the parallel on which the Sun would be that day. And if the ship should be on another parallel, all the distance from the parallel of the ship to the parallel of the Sun must increase or decrease from the degrees which will be between the thread and the meridian of the instrument according to the side on which the thread and the needle depart from the meridian, and the remainder will be the amount which the needle will northeast, etc. And these are better ways of determining the meridian and the northeasting of the needles than by the higher altitude of the Sun taken with the quadrant, because the Sun at noon has so little more altitude than it has a little before and after noon that it is difficult to determine precisely the meridian; and more because this method serves us many times a day. And although there are other ways and rules for determining the meridian, no others are given here since they have not yet been tried and these suffice.

BRIEF COMPENDIUM ON THE SPHERE AND ART OF NAVIGATING

MARTIN CORDES

Chapter 3—On the virtue and property of the lodestone

The lodestone according to the Cardinal Cusanus has essence, virtue, and operation. The virtue is engendered by the essence; from the essence and virtue is born the operation, so that the stone communicating its virtue to the iron for this reason causes the iron to move although between them there be a silver dish or plate or something similar. The attractive force of the lodestone causes the nature of the iron to join with it and at rest so much that although heavy and weighty it does not fall because the nature of the iron does not remain in it but joins with the nature of the stone which seems to extend whence we see that by this union it happens that it not only attracts this iron but this to another, and another to another and thus is formed a chain* as experience has shown. St. Augustine was surprised as he has written in the books of "De Civitate Dei": because on a plate he saw a bit of iron agitated when the lodestone was moved about under the plate.

It is called a magnet after the name of its discoverer who (according

*Or string of beads.

†The passage referred to is Book 21, Chapter 4, of "De Civitate Dei." It is as follows: "When I first saw it (refers to the attraction of the magnet) I was thunderstruck (vehementer inhorrui), for I saw an iron ring attracted and suspended by the stone; and then, as if it had communicated its own property to the iron it attracted, and had made it a substance like itself, this ring was put near another and lifted it up, and as the first ring clung to the magnet, so did the second ring cling to the first. A third and fourth were similarly added, so that there hung from the stone a kind of chain of rings with their hoops connected, not interlinking, but attached together by their outer surface. Who would not be amazed by this virtue of the stone, subsisting, as it does, not only in itself, but transmitted through so many suspended rings and binding them together by invisible links?

"Yet far more astonishing is what I heard about the stone from my brother in the episcopate, Severus, bishop of Milevis. He told me that Batharianus, once Count of Africa, when the bishop was dining with him, produced a magnet, and held it under a silver plate on which he placed a bit of iron; then as he moved his hand with the magnet under the plate, the iron upon the plate moved about accordingly. The intervening silver was not affected at all, but precisely as the magnet was moved backward and forward below it, no matter how quickly, so was the iron attracted above. I have related what I have witnessed, I have related what I was told by one whom I trust as I trust my own eyes."—Dod's translation, Edinburgh (1871).