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ÜBER
METEOROLOGIE UND ERDMAGNETISMUS
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* No. 10 *

RARA MAGNETICA

1269—1599

P. DE MARICOURT F. FALERO P. NUNES J. DE CASTRO
G. HARTMANN M. CORTÉS G. MERCATOR R. NORMAN
W. BOROUGH S. STEVIN

Mit einer Einleitung



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EINLEITUNG.

Die vorliegende Nummer der „Neudrucke“ bringt unter dem Titel „RARA MAGNETICA“ eine Vereinigung der seltensten und zugleich wichtigsten Schriften über den Erdmagnetismus aus der ersten Periode seiner Entwicklung, die mit dem Ausgang des XVI. Jahrhunderts, d. h. vor dem Erscheinen von William Gilbert's grundlegendem Werke „De Magnete“, ihren Abschluss findet. Unsere Sammlung könnte daher auch den Titel führen: RARA MAGNETICA ANTE-GILBERTIANA.

Ein jedes der hier reproducirten Stücke ist selten oder schwer zugänglich, einige dürfen sogar zu den literarischen Raritäten gerechnet werden, die nur sehr wenigen der jetzt lebenden Forscher auf erdmagnetischem Gebiete zu Gesichte gekommen sein werden. Es hat deshalb schon die blosse Ermittelung und die Beschaffung des Materials nicht geringe Mühen verursacht.

Die zur Erläuterung der einzelnen Stücke nothwendigen Erklärungen kann ich diesmal kürzer fassen, da ich in einer unlängst erschienenen Abhandlung „Die Anfänge der magnetischen Beobachtungen“ viele der hier in Betracht kommenden Fragen bereits eingehender erörtert habe. Ich werde diese Arbeit im Folgenden kurzweg mit dem Worte „Anfänge“ citiren¹⁾.

PETRUS PEREGRINUS DE MARICOURT: De Magnete. — Der Brief über den Magneten, den der aus der Picardie stammende Edelmann Pierre de Maricourt am 12. August 1269 unter den Wällen von Lucera²⁾ an seinen Freund und Nachbarn Syger de Foucaucourt schrieb, ist die älteste abendländische

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Abhandlung über den Magnetismus und zugleich eines der frühesten Zeugnisse für die Anfänge experimenteller Forschung im Mittelalter.

Ueber den Schreiber des Briefes ist leider fast nichts bekannt. Aus dem Beinamen „Peregrinus“ erfahren wir, dass er eine Kreuzfahrt mitgemacht hat, und sein Zeitgenosse Roger Bacon lobt ihn als einen in allen naturwissenschaftlichen und technischen Disciplinen wohlbewanderten „Magister“ und als einen Meister des Experimentes⁴⁾). Aus der „Epistola“ selbst geht hervor, dass er noch andere physikalische Werke schreiben wollte oder geschrieben hat, nämlich einen „Tractatus, in quo docebimus phisica componere instrumenta“ (Cap. I im I. Theil) und ein „Liber de operibus speculorum“ (Cap. II im II. Theil).

Der Brief de Maricourt's fand in Abschriften ziemlich grosse Verbreitung und wurde noch bis in die zweite Hälfte des XVI. Jahrhunderts viel gelesen, obwohl man zu der Zeit auf erdmagnetischem Gebiete schon weitere Fortschritte gemacht hatte. Auch in Deutschland war die „Epistola Petri Peregrini de magnete“ sehr wohl bekannt. Allein der Erfurter Arzt und Gelehrte Ampronius Ratinck besass zu Anfang des XV. Jahrhunderts vier verschiedene Kopien derselben, von denen drei noch erhalten sind, und ein Jahrhundert später scheint Georg Hartmann in Nürnberg durch eben diese Schrift bei seinen magnetischen Studien wesentlich beeinflusst worden zu sein. Der Lindauer Arzt Achilles Gasser besass ebenfalls eine Peregrinus-Handschrift, mit der er nicht nur seinen Landsmann Joachim Rheticus (vor 1540) bekannt machte⁴⁾), sondern die er, mit einer Einleitung und Nachschrift versehen, im Jahre 1558 sogar durch den Druck veröffentlichte. Dieses Büchlein, dessen Titel ich in Facsimile weiter unten wiedergebe, ist heutigen Tages so selten geworden, dass sich 1871 der Fürst Baldassare Boncompagni veranlasst sah, nachzuforschen, wieviel Exemplare davon noch vorhanden seien. Er machte 13 ausfindig; da er aber 3 Exemplare übersehen hat, giebt es im Ganzen mindestens 16, von denen sich 7 in Deutschland befinden⁵⁾). Jene Druckschrift gab sogar die Veranlassung zu einem Plagiat, das der aus dem Hennegau stammende Jean

→ DE MARICOURT ←

Taisnier (oder Taisner) beging, indem er 1562 ein „Opusculum perpetua memoria dignissimum de natura magnetis . . .“ veröffentlichte, das fast wörtlich mit der „Epistola“ übereinstimmt, ohne dass Peter Peregrinus noch dessen Herausgeber Gasser genannt werden⁶⁾.

Von den weiteren Schicksalen der „Epistola“ sei noch Folgendes erwähnt. Im Jahre 1681 glaubte M. Thévenot einer von ihm gesehenen Handschrift mit dem Titel „Epistola Petri Adsigerii, in super rationibus naturae Magnetis . . .“ entnehmen zu können, dass man schon 1269 die magnetische Deklination (im Betrage von 5°) gekannt habe. Erst 1835 wies W. Wenckebach nach, dass eine Randbemerkung aus späterer Zeit in der Leidener Handschrift der „Epistola“ zu jenem Irrthum Thévenot's die Veranlassung gegeben, und 1868 zeigte T. Bertelli noch gründlicher, dass alle anderen Handschriften diese Marginalie nicht enthalten. Der andere von Thévenot in die Literatur eingeschleppte Fehler, als Verfasser der „Epistola“ einen Petrus Adsigerius anzunehmen, hat sich trotz der Arbeiten von Wenckebach und Bertelli fast bis auf unsere Tage erhalten: ein unwissender Abschreiber hatte aus *ad Sigerum* einen *Adsigerius* gemacht⁷⁾.

Nachdem bereits 1795 T. Cavallo einige Bruchstücke des Leidener Codex der „Epistola“ und 1838 G. Libri die Pariser Handschrift derselben veröffentlicht hatte⁸⁾), gab 1868 der bereits genannte Barnabit Timoteo Bertelli eine auf die Vergleichung von neun Handschriften basirte kritische Textausgabe mit Varianten und reichhaltigem Commentar heraus. Diese Textrevision liegt dem vorliegenden „Neudruck“ zu Grunde. Ich habe aber nach den von Bertelli aus zwei Vaticanischen Handschriften später (1871) mitgetheilten abweichenden Lesarten an etwa einem Dutzend von Stellen noch Verbesserungen vorgenommen⁹⁾.

Den Inhalt der „Epistola“ eingehend zu analysiren wäre hier nicht der Ort. Ich kann dem Leser nur dringend empfehlen, den eigenartigen Reiz, den ihre Lectüre gewährt, sich nicht entgehen zu lassen. Die wichtigsten Errungenschaften in der Lehre vom Magneten, die de Maricourt seinem Freunde mittheilt, beziehen sich auf die Unterscheidung und Erkennung

der beiden Pole, auf die vertheilende Wirkung des Magneten, auf die Anziehung ungleichnamiger Pole sowie auf die Verbesserung des Schiffskompasses. Die am Ende des Briefes vorgetragene Idee eines magnetischen Perpetuum mobile war allerdings eine Verirrung, für die wir aber mehr das Jahrhundert, als den Verfasser selbst verantwortlich machen müssen. Man findet übrigens eine recht gute Darstellung des Inhalts der „Epistola“ in dem modernen Werk von Park Benjamin „The intellectual rise in electricity“ (London 1895. 8°. S. 165—186). Der Verfasser geht aber in seiner Bewunderung de Maricourt's darin zu weit, dass er alle Lehren über den Magnetismus, die der Brief erwähnt, als Entdeckungen des Briefschreibers ansieht, während doch kein Zweifel darüber bestehen kann, dass viele dieser Thatsachen schon vor ihm bekannt waren. Dafür spricht zur Genüge die Aehnlichkeit der Lehren vom Magneten, die sich bei Gelehrten finden, die vor oder gleichzeitig mit de Maricourt gelebt haben, wie Vincent de Beauvais, Albertus Magnus, Roger Bacon und Jean de S. Amand.

FRANCISCO FALERO: Del Nordestear de las Agujas.— Dieses Kapitel aus Francisco Falero's „Tratado del Esphera y del arte del marear“ (Sevilla 1535) enthält die erste gedruckte Anleitung zur Bestimmung der magnetischen Deklination, deren Vorhandensein und räumliche Verschiedenheit im September 1492 von Christoph Columbus entdeckt worden war (vgl. „Anfänge“ S. 1 u. 12).

Die Methode der Deklinationsbestimmung bestand anfänglich, wie schon die Notiz im Tagebuch des Columbus vom 17. September 1492 lehrt, einfach darin, dass man von der Bussole aus nach dem Polarstern visirte und so die Abweichung der Magnettadel auf der Kompassscheibe festzustellen suchte. Eine solche alhidadenartige Absehvorrichtung findet sich ja auch schon in der Epistola Petri Peregrini (II. Theil, I. Cap.) angegeben. Dass dabei keine grosse Genauigkeit erzielt werden konnte, erscheint selbstverständlich.

Eine Verbesserung in der Methode zur Bestimmung der Missweisung auf See war also ein erstes Erforderniss, sollte die seit des Columbus Zeiten mit soviel Liebe und Beharrlichkeit versuchte Lösung des Längenproblems

auf magnetischem Wege zur Wirklichkeit werden. Ein Sevillaner Apotheker Felipe Guillen, von dem wir sonst leider nichts wissen, war es, der in dieser Absicht eine neue und bessere Methode der Deklinationsbestimmung ersann. Dabei ist es interessant zu beobachten, dass die vorzugsweise in Deutschland gefertigten Sonnenuhren mit Kompass dem spanischen Gelehrten nicht bloss die passende Magnettadel, sondern indirekt auch die Methode selbst geliefert zu haben scheinen; denn diese bestand einfach darin, dass man an einer sonnenuhrartigen Vorrichtung mit Magnettadel das magnetische Azimuth der Sonne bei gleicher Höhe Vor- und Nachmittags durch den Schatten eines central gestellten Stiftes oder Gnomons bestimmte. Die halbe Differenz der Azimuthe, die von N über O nach S und von N über W nach S bis zu je 180° gezählt wurden, war die gewünschte Abweichung der Magnettadel von der Mittagslinie.

Felipe Guillen, der dieses Instrument (*brújula de variación*) 1525 dem König von Portugal, João III, überreichte und dafür reichlich belohnt wurde, hat leider nichts Schriftliches über dasselbe hinterlassen; er scheint in Portugal, wo das Instrument gute Aufnahme fand, geblieben zu sein. Aber dem spanischen Kosmographen und Piloto mayor, Alonso de Santa Cruz, der sich selbst viel mit der Idee der Lösung des Längenproblems mittels der Bussole beschäftigt hat (vgl. diese „Neudrucke“ No. 4, Einleitung S. 17), verdanken wir eine genaue Beschreibung des Instrumentes, die ich a. a. O. („Anfänge“ S. 24) abgedruckt habe.

Der Erste nun, der brauchbare Methoden zur Bestimmung der magnetischen Deklination durch den Druck bekannt gab, war Francisco Falero oder Faleiro, ein Portugiese in Diensten der spanischen Marine, dem wir auch das erste wirkliche Lehrbuch der Navigation verdanken. Dieses Werk ist so ausserordentlich selten, dass man an seiner Existenz bisweilen gezweifelt hat. Selbst Martin Fernandez de Navarrete, der gelehrte Verfasser der „Biblioteca marítima española“ (Madrid 1851. 8°. Bd. I S. 459) hat es nie zu Gesicht bekommen. Jetzt besitzt die Biblioteca Nacional in Madrid ein Exemplar desselben, und Dank der gütigen Vermittelung des Herrn A. Arcimis

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bin ich in der Lage, weiter unten ein Facsimile von dessen Titel zu geben. Das Werk ist von Juan Cromberger zu Sevilla in gothischen Typen gedruckt und enthält 52 unbezeichnete Quartblätter.

Im achten Kapitel des zweiten Theiles mit der Ueberschrift „Del nordestear de las agujas“ wird, zum ersten Male in einem Druckwerke, die Thatsache der Missweisung ausführlich besprochen. Sodann giebt der Verfasser drei Methoden zu ihrer Bestimmung an. Dieselben sind wahrscheinlich an der Hand des Instrumentes von Felipe Guillen entworfen, dessen aber nirgends Erwähnung geschieht. Sie bestehen 1) in der Azimuthbestimmung der Magnetnadel am wahren Mittag, wenn der Schatten des Stiftes nach N fällt; 2) in der Beobachtung der Schattenazimuth bei korrespondirenden Sonnenhöhen Vor- und Nachmittags; 3) in der Beobachtung dieser Azimuth bei Sonnen-Aufgang und Untergang.

PEDRO NUNES: Estromento de Sombras. — Bald nach Falero hat Pedro Nunes, der 1537 auf das wirkliche Vorhandensein einer Missweisung und die Nothwendigkeit ihrer Ermittelung für die Schiffahrt gleichfalls entschieden hinwies, das Guillen'sche Instrument einfach dadurch verbessert, dass er eine Vorrichtung zur Beobachtung der Sonnenhöhe hinzufügte, gleichzeitig aber auch eine neue Methode zur Breitenbestimmung zu jeder beliebigen Tageszeit angab. Man findet beide Methoden auseinandergesetzt in der sehr seltenen Schrift: „Tratado da Sphera com a Theorica do Sol e da Lua. E ho primeiro liuro da Geographia de Claudio Ptolemeo Alexádrino. Tirados novamente do Latim em lingoagem pello Doutor Pero Nunes, Cosmographo del Rey Dō João ho terceiro deste nome nosso Senhor. E acrecētados de muitas annotaçōes e figuras per que mais facilmente se podem entender. Item dous tratados que o mesmo Doutor fez sobre a carta de marear. Em os quaes se decrarão todas as principaes duuidas de navegaçō. Cō as tauoas do movimento do Sol: e da su declinaçō. E o regimēto da altura assi ao meyo dia: como nos outros tempos“ (Lisboa, German Galharde 1537. Fol.), zu der noch als Nachtrag in demselben Jahre und bei demselben Drucker erschien „Tratado em defensam da carta de marear com o Regimento da altura“.

→ DE CASTRO ←

Auszüge aus beiden Werken giebt Joāo de Andrade Corvo in dem auf S. 14 citirten „Roteiro de Lisboa a Goa por D. Joāo de Castro“ (S. 42 bis 46, 383).

JOĀO DE CASTRO: Observaçōes Magneticas. — Es bot sich nun bald eine ausgezeichnete Gelegenheit, beide 1533 zu Evora von P. Nunes erstmalig versuchten Methoden aufs eingehendste zu prüfen. Der Infant Dom Luiz, der von Pedro Nunes selbst mathematisch-astronomischen Unterricht erhalten hatte und allen nautischen Fragen grosses Interesse entgegenbrachte, überwies ein solches Instrument seinem Studiengenossen und Freund Joāo de Castro, der eines der 11 Schiffe befehligte, die 1538 nach Ostindien segelten, mit dem Auftrage, dieses Instrument sowie die neue Methode der Breitenbestimmung genau zu prüfen und zu untersuchen. Joāo de Castro, der nachmalige vierte Vizekönig von Indien, hat seine Aufgabe aufs glänzendste gelöst. Er ermittelte — um hier bloss der magnetischen Seite zu gedenken — nicht bloss die Missweisung so oft als möglich, sondern er machte auch allerlei Beobachtungen über die Methode selbst, über den Einfluss der Magnetnadeln und ihrer Magnetisirung auf die erhaltenen Deklinationswerthe, über magnetische Störungen, über die Deviation des Kompasses u. s. w., ja er wurde auch der Entdecker des Gesteinsmagnetismus, von dem bei uns vor dem XVII. Jahrhundert nicht die Rede gewesen ist. Joāo de Castro setzte seine Beobachtungen auch auf der Fahrt längs der Westküste von Vorder-Indien und in das Rothe Meer fort, so dass wir aus den Jahren 1538—1541 eine Reihe von 43 Deklinationsbestimmungen besitzen: die erste Reihe dieser Art, die uns überkommen ist. Dieser ausgezeichnete Seemann führte über alle seine nautischen, magnetischen, meteorologischen und hydrographischen Beobachtungen sehr ausführliche Tagebücher, die unstreitig den grössten und werthvollsten Schatz derartiger Aufzeichnungen aus der ersten Hälfte des 16. Jahrhunderts enthalten und des eifrigen Studiums aller derjenigen werth sind, welche die Geschichte der physikalischen Geographie oder der Nautik im genannten Jahrhundert zu schreiben beabsichtigen. Ich stehe nicht an, Joāo de Castro als den bedeutendsten Vertreter der

→ EINLEITUNG ←

wissenschaftlichen Erforschung des Meeres im ausgehenden Zeitalter der Entdeckungen zu erklären.

Die von João de Castro auf den Seereisen während der Jahre 1538–1541 geführten Logbücher oder „Roteiros“, die er seinem Auftraggeber, dem Infant Dom Luiz, übersandt hatte, waren drei Jahrhunderte lang in den Archiven Portugals so gut wie unbenutzt liegen geblieben, bis sie durch Nunes de Carvalho, Diogo Körpe und João de Andrade Corvo ans Licht gezogen und veröffentlicht wurden. Die bezüglichen Publikationen sind folgende:

1. Roteiro de Lisboa a Goa por D. João de Castro. Annotado por João de Andrade Corvo. Lisboa 1882. 8°, mit Karten und Abbildungen;
2. Primeiro Roteiro da Costa da India desde Goa até Dio: Narrando a viagem que fez o Vice-Rei D. Garcia de Noronha em socorro desta ultima cidade. 1538–1539. Por Dom João de Castro, Governador e Vice-rei, que depois foi, da India. Segundo MS. Autographo. Publicado por Diogo Körpe. Porto 1843. 8°, mit Porträts und Abbildungen, sowie einem Atlas von Karten und Plänen;
3. Roteiro em que se contem a viagem que fizeram os Portuguezes no anno de 1541, partindo da nobre cidade de Goa atee Soez, que he no fim, e stremidade do Mar Roxo. Com o sitio, e pintura de todo o syno arabico por Dom Ioam De Castro, decimo terceiro governador, e quarto viso-rey da India pelo Doutor Antonio Nunes de Carvalho . . . Paris 1833. 8°, mit Porträts und einer Karte, sowie mit einem Atlas von Karten und Plänen.

Alle drei Roteiros enthalten die ausführlichen Protokolle über seine magnetischen Messungen, von denen ich eine Auswahl unten mittheile. Gewöhnlich wurden mehrere Azimuthbestimmungen Vor- und Nachmittags gemacht, die entsprechenden mit gleicher Sonnenhöhe kombiniert und so auch mehrere Werthe für die Abweichung der Magnetnadel gewonnen. Dieselben stimmen ziemlich gut unter einander überein; denn die Unterschiede schwanken nur zwischen 0 und $\frac{3}{4}$ °. Man darf diese Differenzen nicht einmal ganz als Fehler der Messungen ansehen, da ja, abgesehen von anderen Ungenauig-

→ HARTMANN ←

keiten, die durch die Fortbewegung des Schiffes verursachten wirklichen Verschiedenheiten im Betrage der Missweisung gar nicht berücksichtigt werden konnten.¹⁰⁾

Eine übersichtliche Zusammenstellung der von João de Castro gemachten Deklinationsbestimmungen giebt der oben genannte João de Andrade Corvo (S. 404–411), der an dieser Stelle auch ähnliche Beobachtungen von Vicente Rodrigues, Gaspar Reimão und Aleixo da Motta aus aus dem XVI. Jahrhundert mittheilt.

GEORG HARTMANN: Neigung der Magnetnadel. — Der Brief Georg Hartmann's an den Herzog Albrecht von Preussen vom 4. März 1544 enthält die Nachricht von seiner Entdeckung der magnetischen Inklination und von der ersten Bestimmung der Deklination auf dem Festlande. Das Original befindet sich auf dem Kgl. Staatsarchiv in Königsberg und wird mit Erlaubniss dieser Behörde hier zum ersten Mal in Facsimile reproducirt. Durch den Druck wurde das Schreiben schon früher einmal veröffentlicht: zuerst von J. Voigt in Raumer's Historischem Taschenbuch II, 1831, sodann von H. W. Dove im Repertorium der Physik II, 1838 und zuletzt noch einmal von J. Voigt, zugleich mit anderen Briefen Georg Hartmann's, im „Briefwechsel der berühmtesten Gelehrten des Zeitalters der Reformation mit Herzog Albrecht von Preussen“ (Königsberg 1841. 8°).

Da dieser inhaltreiche Brief bis zum Jahre 1831 im Königsberger Archiv vergraben und unbeachtet gelegen hat, konnte er auf die Entwicklung der Lehre vom Erdmagnetismus natürlich keinen Einfluss ausüben, so dass als Entdecker der magnetischen Inklination überall Robert Norman galt, der zuerst 1576 den Betrag dieser Inklination für London zu 71° 50' bestimmte. Nach dem Wortlaut jenes Schreibens kann indessen darüber kein Zweifel sein, dass Hartmann das Phänomen der Inklination entdeckt hat. Wenn seine Messung derselben ausserordentlich ungenau ausfiel, so ändert das nichts an der Thatache und erklärt sich einfach dadurch, dass seine Magnetnadel nicht an einer horizontalen Achse aufgehängt war, sondern auf einer vertikalen.

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Sodann enthält der Brief die Nachricht von der frühesten Bestimmung der magnetischen Deklination auf dem Festlande, die Georg Hartmann ums Jahr 1510 in Rom ausgeführt hat; vgl. „Anfänge“ S. 4—7.

Der sonstige Inhalt des Schreibens bringt in magnetischer Beziehung nichts Neues, und wenn Dove (a. a. O. S. 134—136) seiner Zeit Georg Hartmann die Entdeckung mehrerer Elementargesetze über die magnetischen Pole u. s. w. zuschreiben wollte, so erklärt sich dieser Irrthum dadurch, dass Dove die älteren Schriftsteller über den Magneten, insbesondere den Brief von Pierre de Maricourt nicht kannte. Das „alte Pergamentbuch“ von dem Hartmann erzählt, dass es ihm „in dem Bauernkriege überkommen“, ist offenbar nichts anderes, als die „Epistola Petri Peregrini“, aus der er von der Idee eines magnetischen Perpetuum mobile erfuhr und die ihm bei seinen magnetischen Versuchen mannigfache Anregung gegeben zu haben scheint.

GERHARD MERCATOR: *De Ratione Magnetis circa Navigationem.* — In diesem Briefe Gerhard Mercator's an den Bischof von Arras finden wir zum ersten Male die Ansicht ausgesprochen und begründet, dass die Erde einen magnetischen Pol besitzt, während man bis dahin gewöhnlich der Meinung war, dass sich die Magnetnadel nach dem Himmelspol oder nach dem Polarstern richte; „a polis mundi poli magnetis virtutem recipiunt“ heisst es schon in der „Epistola Petri Peregrini“ (I. Theil, Cap. X).

Dieses wichtige Schreiben Mercator's hat ein ähnliches Schicksal gehabt, wie jenes von Georg Hartmann: es kam erst in diesem Jahrhundert an die Öffentlichkeit. A. Breusing fand eine Abschrift des lateinischen Originals in der Göttinger Bibliothek und veröffentlichte sie 1869 in deutscher Uebersetzung (Gerhard Kremer gen. Mercator, der deutsche Geograph. Duisburg. S. 13—15), während die lateinische Abschrift zum ersten Male von F. van Ortry (L'oeuvre géographique de Mercator. Bruxelles 1893. 8°. S. 83—84) publicirt wurde. Ein Vergleich dieser Veröffentlichung mit dem Göttinger Manuscript (Cod. MS. hist. 657 XIII) ergab mir, dass Ortry einen sinnstörenden Fehler begangen hat, der in der vorliegenden Wiedergabe des Briefes natürlich vermieden wurde.¹¹⁾

→ CORTES ←

Da Mercator auch später noch mehrfach seine Ideen über den magnetischen Erdpol in Schriften und Karten zum Ausdruck brachte, sind seine diesbezüglichen Studien doch nicht so ganz ohne Einfluss auf die Weiterentwicklung des Erdmagnetismus geblieben, wie z. B. diejenigen von Georg Hartmann. In einer Erläuterungsschrift¹¹⁾ zu verschiedenen Globen, die Mercator für den Kaiser Karl V. verfertigte (1552), widmete er die ersten vier Kapitel derartigen magnetischen Fragen (*Esse polum aliquem magnetis et ubi sit. Inquisitio longitudinis ac latitudinis poli magnetis. Inventio longitudinis per magnetem. Invenire magnetis declinationem quolibet loco per globum*), und in seiner Weltkarte führte er den Nullmeridian durch den magnetischen Pol. Dass Mercator auf die Festlegung dieses Poles ganz besonderen Werth gelegt hat, zeigt auch sein schönes Bild, das auf Veranlassung seines Freundes F. Hogenberg in Köln gefertigt wurde, auf dem er mit dem Zirkel den magnetischen Pol auf einem Erdglobus absetzt.

MARTIN CORTÉS: *De la Piedra Yman.* — Obwohl bereits 1537 Francisco Falero in seinem Lehrbuch der Astronomie und Nautik das Vorhandensein der magnetischen Deklination gelehrt und Methoden zu deren Bestimmung gegeben hatte, machte 1545 Pedro de Medina in seiner „Arte de navegar“ doch noch allerlei Zweifel gegen dieselbe geltend. Es war daher ein entschiedenes Verdienst von Martin Cortés, dass er im „Breve compendio de la sphera y de la arte de navegar“ (Sevilla 1551. Fol.) der Magnetnadel und deren Abweichung einen ausführlichen Abschnitt widmete, den ich hier auch um deswillen reproducire, weil er die älteste genaue Beschreibung des Schiffskompasses und dessen Verfertigung enthält.

Da mir die erste Ausgabe vom Jahre 1551 nicht zugänglich war, habe ich ein Exemplar der zweiten vom Jahre 1556 zur Herstellung des Facsimiledruckes benutzen müssen.¹²⁾

Die Ansichten über den magnetischen Pol, die Martin Cortés im 5. Kapitel äussert, sind viel unklarer als die Mercator's, dem die Priorität in dieser Frage zukommt, selbst wenn man annimmt, dass Martin Cortés sein Buch im Manuscript bereits 1545 vollendet hatte, wie er in der Vorrede angiebt.¹³⁾

ROBERT NORMAN: *The Neue Attractiue.* — Dieses epochemachende Buch enthält die Nachricht von der (abermaligen) Entdeckung der magnetischen Inklination und von der ersten Messung derselben. Es ist zugleich das älteste Druckwerk rein erdmagnetischen Inhalts.

Von dem Verfasser wissen wir nur, dass er praktischer Seemann und Instrumentenmacher war — „*Hydrographer*“ nennt er sich selbst — und ausserdem noch ein Segelhandbuch „*Safeguarde of Saylers*“ veröffentlichte, das er 1590 aus dem Holländischen übersetzte.¹⁴⁾

Das Werk „*The neue Attractiue*“, das er Wm. Borough, damals „Comptroller to the navy“ widmete, fand grossen Beifall und erlebte mindestens vier weitere Ausgaben (1585, 1596, 1614, 1720). Trotzdem ist dasselbe jetzt so selten geworden, dass man es nur in wenigen englischen Bibliotheken antrifft, und auf dem Kontinente höchstens in der allerletzten Ausgabe. Bei der grossen Seltenheit und Wichtigkeit des Werkes hätte ich gern einen Facsimiledruck der ersten Ausgabe dem vorliegenden Heft der „*Neudrucke*“ einverlebt, dieselbe ist aber auf so stark durchscheinendem Papier gedruckt, dass die photographische Reproduction unmöglich war. Ich habe mich deshalb damit begnügen müssen, Titel und Figuren der ersten Ausgabe in Facsimile wiederzugeben, den Text aber in der Fassung der letzten Ausgabe vom Jahre 1720 zu belassen, die Whiston besorgt hat. Die Widmung und Einleitung wurden als minder wichtig, die am Schluss folgenden „*necessarie rules*“ (Tafeln der Deklination der Sonne etc.) als überflüssig — wenigstens für den vorliegenden Zweck — ganz weggelassen.¹⁵⁾

WILLIAM BOROUGH: *A Discours of the Variation.* — Wie schon der Titel besagt („and is to be annexed to the neue Attractiue of R. N.“) bildet diese Schrift eine Ergänzung zur vorigen, mit der sie in demselben Verlage wohl gleichzeitig erschienen sein mag.

Während Robert Norman hauptsächlich die Inklinations behandelt, giebt William Borough ausführliche Anweisungen zur Bestimmung der Deklination und bespricht die Wichtigkeit derselben für die Navigation auf Grund seiner eigenen Erfahrungen. Im Grunde genommen sind es nur

weitere Ausführungen der schon 1535 von Francisco Falero gegebenen Regeln.¹⁶⁾

Der „*Discours*“ scheint mit dem „*Attractiue*“ zusammen vier Ausgaben erlebt zu haben (1581, 1585, 1596 und 1614), später aber nicht mehr gedruckt worden zu sein; in Folge dessen ist Borough's Werk noch seltener geworden als Norman's.¹⁷⁾

Aus dem schon oben genannten Grunde war es auch hier nicht möglich, einen Facsimiledruck der ersten Ausgabe zu veranstalten. Geeigneter hierzu war die dritte vom Jahre 1596, von der die Bibliothek der Royal Society in London ein Exemplar besitzt, das mir Dank der gütigen Vermittelung der Herren Rücker und Symons zu diesem Zwecke gütigst zur Verfügung gestellt wurde.¹⁸⁾

William Borough (1536–1599) stammte aus Northam in Devonshire und war ein praktischer Seemann, der schon 1553 eine Reise nach dem Norden Russlands machte. Man besitzt von ihm noch einige Reiseberichte und Kartenskizzen. Später wurde er „*Comptroller to the Navy*“ (vgl. Dict. of Nat. Biography V, 404).

SIMON STEVIN: *De Haveninding.* — Diese überaus selten gewordene Schrift des grossen holländischen Mathematikers enthält das älteste Verzeichniß von Werthen der magnetischen Deklination (für 42 Orte), erläutert die grosse Bedeutung der Kenntniß der Deklination für die Schiffahrt und giebt eine Anleitung zur Bestimmung derselben mittels des Azimuthalkompasses. Ich reproducire hier nur den zuerst und den zuletzt genannten Abschnitt nach dem einzigen mir bekannt gewordenen Exemplar, das die Königliche Bibliothek im Haag besitzt.¹⁹⁾

Aus der gleichzeitig erschienenen und von Hugo de Groot (Grotius) besorgten lateinischen Uebersetzung (*THEATRUM PETRIKUM sive portuum investigandorum ratio*) erfährt man, dass Graf Moritz von Nassau, Prinz von Oranien, als Admiral der holländischen Flotte den Mathematiker Simon Stevin — der übrigens in der holländischen Originalausgabe als Verfasser nirgends genannt ist — zur Abfassung der Schrift veranlaßt hat, weil er von

→ EINLEITUNG ←

der Wichtigkeit der Kenntniss der magnetischen Deklination für den Seemann überzeugt war. Auf des Prinzen Geheiss erschien das kleine Buch gleichzeitig in holländischer, lateinischer, englischer und französischer Sprache.²⁰⁾

Als Gewährsmann für die Werthe der Deklination wird in der Einleitung der in Amsterdam lebende calvinistische Prediger und Geograph P. Plancius genannt, der diese Angaben für eine geographische Karte gesammelt hatte (1592), die aber verloren gegangen zu sein scheint.



ANMERKUNGEN.

¹⁾ Meine Abhandlung „Die Anfänge der magnetischen Beobachtungen“ erschien zuerst in der Zeitsch. d. Gesellsch. f. Erdkunde zu Berlin, XXXII. Band, Heft 2, und sodann gesondert: Berlin, W. H. Kühl 1897. gr. 8°. 27 S. Eine französische Uebersetzung derselben brachte das „Bulletin de la Société Belge d'Astronomie“, II 1897.

²⁾ Lucera oder Nocera ist eine Stadt in Apulien, die 1269 von Karl von Anjou, der wahrscheinlich Pierre de Maricourt's Lehns Herr war, belagert und genommen wurde. Maricourt ist ein kleiner Ort in der Picardie, Département de la Somme, wo auch Foucaucourt liegt.

³⁾ Roger Bacon (1214–1294) nennt den „magister Petrus de Maherne Curia“ in seinem „Opus tertium“, das erst 1859 von J. S. Brewer herausgegeben wurde, einen „dominus experimentorum“ und fügt hinzu: „et ideo scit naturalia per experientiam, et medicinalia, et alkimistica, et omnia tam coelestia quam inferiora . . .“ (S. 46).

⁴⁾ Vgl. „Anfänge“ S. 22.

⁵⁾ Die Gasser'sche Ausgabe der „Epistola Petri Peregrini“, deren Titel unten in Facsimile wiedergegeben ist, enthält 7 Bogen kl. 4° und 4 Figuren im Text. Titel, Widmung an Kaiser Ferdinand und Praefatio nehmen die ersten 11 Bl. in Anspruch, in der Mitte von Bl. 11 b beginnt die Epistola, welche auf Bl. 23a endet.

Da Herr T. Bertelli (Cristoforo Colombo, scopritore della declinazione magnetica. Roma 1892. Fol. S. 61) Achilles Gässer noch zu denjenigen zählt, die im XVI. Jahrhundert mit der magnetischen Deklination nicht bekannt waren,

→ ANMERKUNGEN ←

so bemerke ich ausdrücklich, dass Gässer die magnetische Abweichung kannte; denn in der „Praefatio“ (Bl. Aijj verso) sagt er, dass die Meinung (Cardan's), die Magnetnadel müsse 5° abweichen, weil der Polarstern einen solchen Polabstand besitzt, falsch sei, da ja P. Apian eine solche von 11° gefunden habe (vgl. „Anfänge“ S. 8). —

Ausser den von B. Boncompagni (Bull. d. Bibliografia e di Storia delle Scienze Matematiche e Fisiche IV S. 332–339) namhaft gemachten 13 Exemplaren der Gasser'schen Ausgabe der „Epistola“ weiss ich noch die der Hofbibl. in Karlsruhe, der Stadtbibl. in Hamburg und des Herrn Latimer Clark in London zu nennen.

⁶⁾ Opusculum perpetua memoria dignissimum, de natura magnetis, et ejus effectibus Authore Ioanne Taisnier Hannonio Coloniae, apud Ioannem Birckmannum. Anno M.D.LXII (8. 2 Bl. 86 S. 1 Bl.; auf der Rückseite des Titels und auf dem letzten Blatt das Portrait des Verfassers in seinem 53. Lebensjahre).

⁷⁾ Die Angabe Thévenot's findet sich in seinem „Recueil de Voyages“ (Paris 1681. Fol. S. 29). Die wichtige Arbeit von W. Wenckebach „Over Petrus Adsgierius en de oudste waarnemingen van de afwijking der magneetnaald“ steht in Mulder's Natuur-en Scheikundig Archief 1835 (auch gesondert erschienen, 23 S. in 8°) und wurde 1865 von T. Hooiberg ins Französische übersetzt (Annal. d. Mat. Pura ed Applicata VII, Roma 1865. 8°.).

⁸⁾ Tiberius Cavallo veröffentlichte in seinem Buche „A Treatise on Magnetism“ (2nd ed. London 1795. 8°. Suppl. S. 37–63) die wichtigsten Stellen der „Epistola Petri Peregrini“ zugleich mit einer engl. Uebersetzung derselben, während der Pariser Codex dieses Briefes (Fonds Latin 7378 A) von G. Libri in der „Histoire des sciences mathématiques en Italie“ (Paris 1838. 8°. II S. 487–502), allerdings mit 78 Lücken, zum Abdruck gebracht wurde.

⁹⁾ Die grundlegenden Arbeiten von Timoteo Bertelli über die „Epistola Petri Peregrini“ sind folgende:

1. Sopra Pietro Peregrino di Maricourt e la sua Epistola de Magnete. Memoria Prima. In Boncompagni's Bull. d. Bibliogr. e d. Storia delle Scienze Mat. e Fis. I, 1868, S. 1–32.
2. Sulla Epistola di Pietro Peregrino di Maricourt e sopra alcuni trovati e teorie magnetiche del secolo XIII. Memoria Seconda. Ebenda I, 1868, S. 65–99, 101–139, 319–420; 4 Tafeln.
3. Intorno a due Codici Vaticani della Epistola de Magnete di Pietro Peregrino di Maricourt ed alle prime osservazioni della declinazione magnetica. Ebenda IV, 1871, S. 303–331.

→ EINLEITUNG ←

Diesen drei Arbeiten hat der Fürst B. Boncompagni zahlreiche Fussnoten bibliographischen Inhalts hinzugefügt, die mit B. B. unterzeichnet sind.

Bertelli hat 17 verschiedene Abschriften der Epistola als noch vorhanden nachgewiesen; da ihm aber die 3 in der Ampronianischen Handschriften-Sammlung zu Erfurt unbekannt geblieben sind (Cod. Ampron. Q 325, Q 351, Q 387), steigt ihre Gesamtzahl auf 20. Nach dem von Ampronius um 1412 eigenhändig angelegten Verzeichniss seiner Bibliothek besass er damals noch einen „Tractatus de magnete Peregrini“ im Cod. math. 29, der aber jetzt nicht mehr in Erfurt vorhanden ist. Vgl. W. Schum, Beschreib. Verzeichniss der Ampronianischen Handschriften-Sammlung zu Erfurt. Berlin 1887. gr. 8°. S. 802.

Bezüglich der Textgestaltung der Epistola im vorliegenden „Neudruck“ sei noch erwähnt, dass das mittelalterliche e für ae (z. B. prime statt primae) beibehalten worden ist. Die Interpunktionsdürfte, wie ich erst nachträglich bemerkt habe, zu italienisch sein. Die 3 Figuren im Text sind, ebenso wie der Titel, Facsimiles derjenigen in der Gasser'schen Ausgabe vom Jahre 1558.

¹⁰⁾ Die einzelnen Auszüge aus den drei Roteiros von João de Castro sind dadurch von einander zu unterscheiden, dass jeder derselben mit ausläuft.

¹¹⁾ F. van Ortry schreibt: „invenio Dantiscum in gradu fere septentrionalius reddi“ statt „invenio Dantiscum 1 gradu“.

Die erst 1868 von Van Raemdonck herausgegebene Schrift Mercator's „Declaratio insigniorum utilitatum quae sunt in globo terrestri, coelesti, et annulo astronomico ad invictissimum Romanum Imperatorem Carolum Quintum“ (St. Nicolas 1868. 8°. Publications extraordinaires du cercle archéologique du Pays de Waas. No. 5) enthält die oben genannten vier Kapitel.

¹²⁾ Diese Ausgabe umfasst 95 bezeichnete und 3 unbez. Blätter; sie wurde, wie die erste vom Jahre 1551, von Anton Alvarez in Sevilla gedruckt.

¹³⁾ Der Erste, der von zwei magnetischen Polen auf der Erde sprach, war der Venetianer Livio Sanuto (Geografia distinta in XII libri. Ne' quali, altra l'esplicatione di molti luoghi di Tolomeo, e della Bussola, e dell' Aguglia . . . Vinegia, Zenaro 1588. Fol.). Seine Ausführungen sind aber sehr weitschweifig und unklar.

¹⁴⁾ Am Ende des Werkes von W^m. Borough, A Discours of the Variation . . . London 1581. 4°. liest man: „These Instruments are made by Robert Norman, and may be had at his house in Ratclif“. Da dieser Satz in der hier reproduzierten dritten Ausgabe des Borough'schen Werkes vom Jahre 1596 fehlt, wird man annehmen dürfen, dass R. Norman inzwischen gestorben war.

¹⁵⁾ Ich gebe hier zunächst eine genauere bibliographische Beschreibung der ersten Ausgabe von Robert Norman's Buch „The newe Attractiue“ nach dem

→ ANMERKUNGEN ←

Exemplar in der Bibliothek des Herrn Latimer Clark, F. R. S., in London, das er mir freundlichst geliehen hat:

- Bl. 1^a Der unten in Facsimile wiedergegebene Titel. Bl. 1^b leer.
- Bl. 2^a (mit der Signatur A.ij.): To the right worshipfull Maister | Willyam Borrough, Compiroller of her | Maiesties Naue: Robert Norman | wiſheth encrease of worship in | perfecte felicitie. | Endet auf Bl. 4^c. Bl. 4^b leer.
- Bl. 5^a (B.i.): To the Reader. — Unterzeichnet am Schluss von 6^b: R. N.
- Bl. 7^a The Magnes or Lodestones | challenge. | — (10 Verszeilen).
- Bl. 8^a The Mariners iudgment (4 Verszeilen). The Marchantes verdict (4 Verszeilen). Bl. 8^b leer.
- Bl. 9^a (C.j.) mit der Seitenzahl 1: The newe Attractiue. (Geht bis S. 26, black letter, Kapitelüberschriften antiqua cursiv, initiales florentes). Nun folgen 17 Blätter ohne Pagination, deren Inhalt astronomisch-nautischer Natur ist. Dieser Theil beginnt mit einem besonderen Titel auf
- Bl. 22^a Here after followeth a | Table of the Sunnes Declination, commonly called a Regiment for | the Sunne, exactly Calculated unto | the Minute, by the true place of the | Sunne, whose greatest Declination | for this age, is 23. Degrees, | 28. Minutes, and maie | serue for 30. yeres | without great | errour. | * * * |. (Dieser Titel steht innerhalb desselben Holzschnittrahmens, wie der Haupttitel des ganzen Werkes).
- Bl. 22^b leer. Bl. 23^a (F.ij.): Hier beginnen die Tafeln, auf jeder Seite ein Monat.
- Bl. 29^a (S.j.): How to vſe the Sunnes De- | clination, for knowing the eliu- | tion of the Pole. |
- Bl. 30^a (S.i.): Hereafter followeth three Tables | the firste is of the coniunction of the Sunne and | Moone: the seconde of their oppositions: exactly | drawn out of Ioannes Stadius Epheme- | rides: and the third of the Prime | and mouable Feastes. |
- Bl. 31^a leer. Bl. 31^b beginnen die Tafeln, die bis Bl. 33 reichen.
- Bl. 34^a (S.i.): The contentes of the | Kalender. |
- Bl. 38^b The contentes of this booke.
- Bl. 39^b leer, aber mit einem aufgeklebten Zettel, der die Aufschrift trägt: Faultes escaped in Printyng.

Im Ganzen sind es also 39 Quartblätter; möglicherweise fehlt noch ein letztes leeres Blatt, so dass das Werk aus 10 Quartbogen bestünde. —

Nach den von mir angestellten Erkundigungen sind in den öffentlichen Bibliotheken Grossbritanniens nur folgende Exemplare des Norman'schen Buches vorhanden.

⇒ EINLEITUNG ⇲

British Museum, London: 1581, 1585, 1596, 1614, 1720, (1721?); die erste Ausgabe aber unvollständig.
Bodleian Library, Oxford: 1581, 1585.
Royal Society, London: 1596.
University Library, Edinburgh: 1614.
University Library, Cambridge: 1720.

Die Ausgabe vom Jahre 1721, die der gedruckte Bücherkatalog des British Museum aufführt, existiert wahrscheinlich gar nicht; denn die als Beigabe zu Whiston's *Longitude* vom Jahre 1721 (vgl. diese „Neudrucke“ Nr. 4 Einleitung S. 23, Anmerkung 9) erschienene Ausgabe, die möglicherweise auch gesondert verkauft wurde, trägt die Jahreszahl 1720. Das British Museum besitzt also wahrscheinlich diese letzte Ausgabe sowohl gesondert (1720), als auch zusammen mit Whiston's *Longitude* (1721). —

Wie selten jetzt die Werke von Norman und Borough geworden sind, geht auch daraus hervor, dass der Londoner Antiquar B. Quaritch in einem kürzlich ausgegebenen Kataloge für ein stark defectes Exemplar von Norman-Borough in der ersten Auflage 7 £ 10 s. fordert!

¹⁶ Es ist interessant zu beobachten, wie lange sich die ursprünglich von Guillen, Falero und Nunes vorgetragenen Methoden der Deklinationsbestimmung in der nautischen Literatur erhalten haben. So veröffentlichte um 1589 Andrés de Rio Riaño einen „Tratado de vn instrumento por el qual se conocerá la nordestacion ó noroestacion de la aguja de marear navegando: por la mayor altura del Sol ó de otra Estrella; ó por dos alturas iguales: y de la vtilidad que de él se a de seguir“ (s. l. e. a. 4°. 28 Bl.) und noch 1666 erschien in Dieppe „L'art de naviger perfectionné par la cognissance de la variation de l'aimant (Dieppe, Nic. du Buc 1666. 4°. 4 unbez. Bl., 220 bez. S., 4 unbez. Bl., mit Kupfern im Text und beweglichen Kompassscheiben), in welcher der Verfasser G. Denys („Prêtre Pilotte Hydrographie de sa Majesté. Examinateur des Pilotes . . . et Professeur Royal d'Hydrographie à Dieppe“) die alten Methoden in der breitesten und weitschweifigsten Weise wieder vorbringt.

Seine fünf Methoden der Deklinationsbestimmung sind nämlich folgende:
Chap. XV. Premier moyen de trouver la Variation de l'Aimant précisement à midi.
Chap. XVI. Second moyen de trouver la Variation par deux observations faictes, au Soleil en égale hauteur sur l'Horizon l'vene devant, & l'autre apres midi.
Chap. XVII. Troisième moyen de trouver la Variation de l'Aiguille aimantée par deux observations faictes l'vene au lever, & l'autre au coucher du Soleil.
Chap XVIII. Quatrième moyen de trouver la Variation du Compas par vne observation faictte au lever, ou bien au coucher du Soleil par l'Amplitude.

⇒ ANMERKUNGEN ⇲

Chap. XIX. Cinquième & dernier moyen de trouver la Variation à toute heure du iour & de la nuict par l'Azimuth.

Merkwürdigerweise enthält dieses für den praktischen Seemann bestimmte Buch von G. Denys keinerlei Zusammenstellung der damals bekannten Werthe der Deklination.

¹⁷⁾ Nach dem Dictionary of National Biography V S. 404 soll es noch eine Ausgabe vom Jahre 1611 geben, was mir zweifelhaft erscheint, da Norman's Buch in diesem Jahre keine neue Auflage erlebte und beide Werke doch stets zusammen erschienen.

¹⁸⁾ Die erste Ausgabe von W. Borough's Discours hat in derselben Holzschnittumrahmung, wie bei Norman, folgenden Titel in Typendruck:

A DISCOVRS | of the Variation | of the Cumpas, or | magneticall | Needle. | Wherin is Mathematically shewed, | the manner of the obseruation, | effectes, and application | thereof, made by | W. B. | And is to be annexed to | The newe Attractiue | of R. N. | 1581. |

Am Schluss von Bl. 30b steht:

Imprinted at London for Richard | Ballard, and are to be sold at his shop | at Saintc Magnus corner in Themes | Streete. Anno. 1581. |

Das Buch zählt im Ganzen 30 unbez. Quartblätter.

¹⁹⁾ Nach Bierens de Haan (Bibliographie Neéerlandaise Historique-Scientifique. Rome 1883. 4° S. 264) soll das holländische Original noch zwei Ausgaben erlebt haben: Leyden 1621 und 1624.

Die erste Ausgabe, deren Titel hier in Facsimile wiedergegeben ist, zählt 28 Quartseiten, die von S. 3 an paginirt sind. Die auf der Schlussseite vermerkte Fehlerverbesserung ist im vorliegenden Neudruck natürlich berücksichtigt worden.

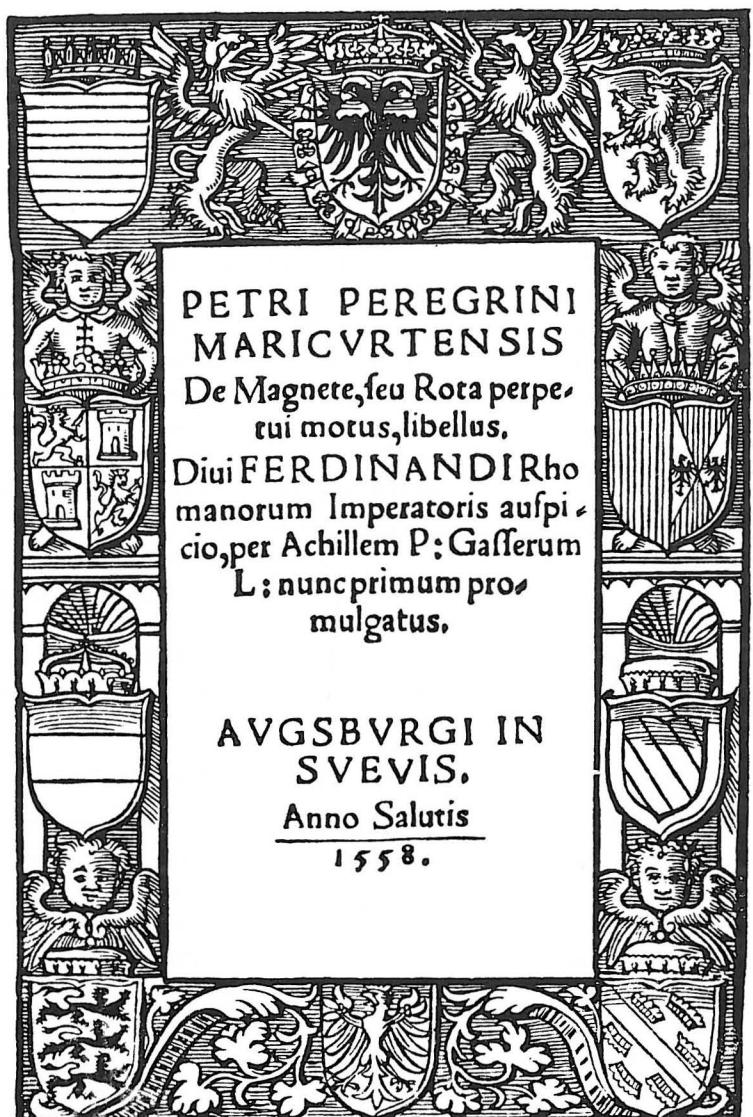
²⁰⁾ Vgl. meine Notiz „S. Stevin's AIMENEYPETIKH“ in der von L. A. Bauer herausgegebenen Quartalschrift „Terrestrial Magnetism“ (II, 1897, S. 72—73).

Die englische Uebersetzung (The Haven finding Art. London 1599. 4°) besorgte Edward Wright, über den Herausgeber der französischen (Le Trouve-port. Leyde 1599. 4°) habe ich nichts in Erfahrung bringen können.

Schliesslich mag nicht unerwähnt bleiben, dass auch in den gesammelten Werken S. Stevin's (Wisconstige Gedachtenissen. Leyden 1608. 2 Bde. Fol. und in der französischen Uebersetzung: Les Oeuvres Mathématiques de Simon Stevin de Bruges. Par Albert Girard. Leide 1634. Fol.) die kleine Schrift über die Kunst, die Häfen zu finden, zum Abdruck gelangt ist.

Berlin, im November 1897.

G. HELLMANN.



PETRI PEREGRINI
MARICVRTENSIS
De Magnete, seu Rota perpe-
tui motus, libellus.
Divi FERDINANDI Ro-
manorum Imperatoris auspi-
cio, per Achillem P: Gasserum
L: nunc primum pro-
mulgatus.

AVGSBVRGI IN
SVEVIS.
Anno Salutis
1558.

PISTOLA PETRI PEREGRINI DE MARICOURT
AD SYGERUM DE FOUCAUROU MILITEM
DE MAGNETE.

Iste tractatus de magnete duas partes continet, quarum Prima, decem Capitulis compleatur, et tribus Secunda. Primum Capitulum Prime partis est de operis intentione: Secundum vero, qualis debeat esse huius operis artifex: Tertium, de cognitione lapidis: Quartum, de scientia inventionis partium lapidis: Quintum, de scientia inventionis polorum in lapide; quis eorum sit septentrionalis, et quis meridionalis: Sextum, qualiter magnes attrahat magnetem: Septimum, qualiter ferrum, tactum cum magnete, ad polos mundi vertatur: Octavum, qualiter magnes ferrum attrahat: Nonum, quare pars septentrionalis meridionalem attrahat, et e converso: Decimum, de inquisitione, unde magnes, virtutem naturalem, quam habet, recipiat.

Partis vero Secunde sunt ista Capitula:

Primum Capitulum, de compositione Instrumenti, quo scitur azimuth solis et lune, et cuiuslibet stelle, in orizonte: Secundum est de compositione alterius Instrumenti melioris, eiusdem officii: Tertium, de Rote artifitio compositionis perpetui motus.

CAP. I. PRIME PARTIS: DE INTENTIONE OPERIS.

Amicorum intime, quandam magnetis lapidis occultam virtutem, a te interpellatus, rudi narratione tibi reserabo utcumque. Nihil enim, apud Philosophos, absque noticie principio est iucundum; et in tenebris orbitat, et obfuscatur bonorum natura, donec in communis deductionis radium erigatur. Amore ergo tui conscribam, sermone plano, que vulgo studentium penitus sunt ignota: attamen nonnisi de manifestis huius lapidis in hac epistola trademus scientiam, eo quod hec traditio pars erit tractatus, in quo docebimus phisica componere instrumenta: de occultis huius lapidis tractare, spectat ad artem lapidis sculpture. Et, licet opera, de quibus quesivisti, appelle manifesta, erunt tamen inextimabilia, et vulgo quasi illusiones et fantasmata; et ideo, quo ad vulgum,

(1)

secreta sunt: astrologis autem et naturalibus satis erunt manifesta, et ipsis erunt solatium, et proiectis viatoribus non modici erunt iuvamenti.

Ex hiis igitur colligatur huius operis intentio.

CAP. II. QUALIS DEBET ESSE HUIUS OPERIS ARTIFEX.

Scito, carissime, quod oportet huius operis artificem scire rerum naturas, nec inscium ipsum esse motuum celestium, sed oportet ipsum esse industriosum in opere manuum, ad hoc quod ostendat, per opus eius, effectus mirabiles. Nam per suam industriam, ex modico, poterit errorem corrigere, quod in eternum, per naturalem et mathematicam solas non faceret, si manuum careret industria. In occultis enim operibus, multum indigemus industria manuali, et, ut plurimum, sine ipsa, nihil possumus facere completum: multa namque subiacent imperio rationis, que manu completere non possumus.

Ex hiis ergo qualis debeat esse huius operis artifex patet.

CAP. III. DE COGNITIONE LAPIDIS.

Cognoscitur autem iste lapis quatuor differentiis, scilicet, colore, unigenitatem, pondere et virtute: Color autem ipsius debet esse ferreus, lividus, mixtus indico, seu colore celestino, ut sit quasi ferrum politum, ab aere corrupto infectum. Talem enim lapidem nunquam vidi absque magno effectu. Talis autem, ut plurimum, invenitur in partibus septentrionalibus, et affertur a nautis, in omnibus partibus maris septentrionalibus, utpote Normannie, Picardie et Flandrie. Debet autem lapis iste esse unigenitus in substantia, quoniam qui habet maculas rubiginosas, et foramina per loca, non est electus: et vix invenitur magnes, sine scabiositate tali. Lapis ergo, qui, propter sui unigenitatem, et subtilium partium bonam compaginem efficitur ponderosus, ponderosior existit in pretio. Virtus autem ipsius, per fortem ferri et magni ponderis attractionem (cuius modum attractionis inferius narrabo) dignoscitur. Quando ergo lapidem cum his differentiis inveneris, hunc habeas, si possis.

Patet ergo ex quibus differentiis eliciatur huius lapidis cognitio.

CAP. IV. DE SCIENTIA INVENTIONIS PARTIUM LAPIDIS.

Scire debes quod hic lapis in se gerit similitudinem celi (cuius modum probationis inferius docebo patenter experiri): et ideo, cum in celo sint duo puncta, notabiliora ceteris, eo quod spera celestis supra ea volvitur, tamquam supra axes, quorum unum, polus articus, seu septentrionalis, nominatur; reliquum

(2)

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vero, antarticus sive meridionalis: sic, et in isto lapide, penitus intelligas duo puncta, unum septentrionale, reliquum vero meridionale. Ad istorum duorum punctorum generalem inventionem, multiplici industria poteris devenire: et est modus, ut rotundetur, cum artificio quo rotundantur cristalli et alii lapides; et postea ponatur acus vel ferrum oblongum, gracile in modum acus, supra lapidem: et, secundum longitudinem ferri, signetur linea lapidem dividens per medium: postea ponatur acus vel ferrum in alio situ supra lapidem, signatum linea, et, secundum verum situm, eodem modo lapidem signa cum linea; et, si vis, facies hoc in pluribus locis vel sitibus, procul dubio omnes linee huius [lapidis] in duo puncta concurrent, sic ut omnes orbes mundi meridiani in duos concurrunt polos mundi oppositos. Scito tunc quod unus est septentrionalis, et alias meridionalis, cuius probationem in sequenti Capitulo videbis.

Alius autem modus inventionis istorum punctorum melior est, ut videoas [scilicet] locum, in lapide rotundato, ut dictum est, ubi summitas acus vel ferri frequentius, vel fortius adheret: erit enim hic locus, unus ex punctis, inventis per iam dictum modum.

Ut ergo precise habeas punctum unum in lapide, frange de acu vel ferro modicum, et sit oblongum ad spissitudinem duarum unguium, et pone supra locum, in quo punctus, modo iam dicto, inventus est: et si steterit orthogonaliter supra lapidem, erit, procul dubio, ibi punctus quesitus; si non, moveas ergo ipsum, donec orthogonaliter steterit. Quo facto, illic signa punctum: et simil modo, in oppositam partem lapidis, punctum invenias oppositum. Quod si recte feceris, et lapis sit unigenitus et electus, puncta erunt recte, tamquam poli in spera, opposita.

CAP. V. DE SCIENTIA INVENTIONIS POLORUM IN LAPIDE: QUIS EORUM SIT SEPTENTRIONALIS, ET QUIS MERIDIONALIS.

Visa arte cognitionis polarum lapidis in genere, quis autem sit septentrionalis, et quis meridionalis, cognosces per hunc modum: Sume vas ligneum, rotundum, ad modum cippi vel parapsidis, et in eo pone lapidem, ita videlicet quod duo puncta lapidis sint equidistantia limbo vasis, et tunc istud, cum lapide intus posito, pone in alio magno vase pleno aqua, ut sit lapis in primo vase sicut nauta in navi; vas autem primum sit in secundo spatiose, sicut navis in flumine fluctuans: et dico, spatiose, ne per contactum ipsius ad limbum magni vasis, naturalis motus lapidis impediatur. Hic enim lapis, sic positus, volvet

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suum parvum vas quoisque polus septemtrionalis lapidis, in directo, septemtrionali celi, et meridionalis, in directo, meridionali steterint. Qui scilicet, si millesies amoveatur, millesies ad suum locum revertetur, nutu Dei. Et cum partes septemtrionis et meridiei sint in celo note, erunt note, per illas, in lapide, eo quod quelibet pars lapidis erit in directo sue partis celi.

CAP. VI. QUALITER MAGNES TRAHIT MAGNETEM.

Habita cognitione quis polus, in lapide, sit septemtrionalis, et quis meridionalis, signa polos cum sculpturis ut cognoscas eos quotienscumque oportuerit. Et si vis postea videre qualiter lapis lapidem attrahat, duos lapides preparatos ut dictum est, in hunc modum adaptabis: et pone unum in suo vase ut fluctuet, sicut nauta in navi; et sint puncta, iam inventa, equidistantia orizonti vel limbo vasis, quod idem est: alterum vero lapidem in manu teneas. Et approxima partem septemtrionalem lapidis, quem tenes, parti meridionali lapidis natantis in vase; sequetur enim, lapis natans, lapidem quem tenebis, quasi volens ei adherere. Et si partem meridionalem lapidis quem baiulas, e converso, parti septemtrionali lapidis natantis pretenderis, accidet illud idem, videlicet quod natans sequetur lapidem quem tenebis. Scito ergo, pro regula, quod pars septemtrionalis, in lapide, partem meridionalem attrahit in alio lapide, et meridionalis septemtrionalem. Quod si e converso feceris, scilicet quod septemtrionalem septemtrionali approximes, lapis, quem in manu baiulas, lapidem natantem fugare videbitur, et si meridionalem meridionali iungas, idem accidet: et hoc ideo est quia pars septemtrionalis appetit meridionalem; quare septemtrionalem fugare videbitur, cuius signum est quod similiter meridionali iungetur.

E converso autem accidet de parte reliqua, scilicet meridionali, quod, si pretendatur meridionali lapidis natantis, videbis eam fugare; cum tamen non faciat, sicut dictum est, de parti septemtrionali ad meridionalem. Ex hoc evacuatur quorumdam fatuitas dicentium quod si scamonea cholera, ratione similitudinis, attrahat, ergo magnes magnetem, magis quam ferrum, attrahet quod falsum supponunt, cum sit verum sicut patet experientia.

CAP. VII. QUALITER FERRUM, TACTUM CUM MAGNETE, AD POLOS MUNDI VERTATUR.

Et notum est omnibus expertis, quod, cum ferrum oblongum tetigerit magnetem, et ligno levi, vel festuce, fuerit affixum, et aque imponetur, una pars

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movebitur ad stellam, quam nauticam vocant, eo quod prope polum est: nam veritas est, quod non movetur ad stellam dictam, sed ad polum, cuius probationem afferimus in suo Capitulo: pars vero reliqua ad partem celi movebitur reliquam. Que autem pars ferri ad quam partem celi moveatur, scias, quod pars ferri, que meridionalem partem lapidis tetigerit, ad septemtrionalem partem celi vertetur. E converso autem erit de parte ferri, quam pars septemtrionalis lapidis tetigerit, scilicet quod, ad meridionalem partem celi vertetur, et est res miranda non intelligenti causam motus ferri: huius vero experientia nos verum dixisse probavit.

CAP. VIII. QUALITER MAGNES FERRUM ATTRAHAT.

Si autem, secundum naturalem appetitum lapidis, velis ferrum fluctuans, sive natans super aquam attrahere, vide partem septemtrionalem ferri, et ei approxima partem meridionalem lapidis, eam enim insequitur; vel, e converso, parti meridionali ferri porrige septemtrionalem lapidis, eam enim sine resistentia attrahet. Si autem facias e converso, quod parti septemtrionali ferri septemtrionalem lapidis approximes, ferrum fugare videbitur, quoisque pars meridionalis eidem ferro coniungatur; et similiter de parte reliqua idem intelligas. Si autem violentia fiat partibus, quod videlicet pars ferri meridionalis, que cum septemtrionali lapidis tacta fuit, tangatur cum parte meridionali lapidis; vel illa, que cum meridionali tacta fuit, que etiam meridionalis in ferro appellatur meridionali lapidis iungatur, alterabitur virtus in ferro de facili, et fiet meridionale quod fuit septemtrionale in eo, et e converso: et causa huius est impressio ultimi agentis, confundentis et alterantis virtutem primi.

CAP. IX. QUARE PARS SEPTEMTRIONALIS MERIDIONALEM ATTRAHIT, ET E CONVERSO.

Pars autem septemtrionalis lapidis meridionalem attrahit, et e converso, ut dictum est; in cuius attractione, lapis fortioris virtutis agens est; debilioris vero patiens. Huius autem rei causam per hanc viam fieri existimo: agens enim intendit suum patiens non solum sibi assimilare, sed unire, ut ex agente et paciente fiat unus, per numerum. Et hoc potes experiri in isto lapide mirabili in hunc modum: Sume lapidem unum, quem fingas AD, in quo sit A septemtrionale, D vero meridionale; et ipsum in duas partes divide, ut fiant duo lapides ex eo: postea lapidem, quem A tenet, aque expones ut fluctuet; videbis quod A vertetur

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ad septemtrionem, ut prius. Fractura enim non tollit proprietates partium lapidis, si sit unigenitus; et sic oportet quod pars huius lapidis in ipsa fractura, que sit B, meridionalis existat. Hic ergo lapis, de quo nunc dictum est, fingatur AB: de reliquo autem lapide, quem D tenet, si aque exponatur, videbis quod D erit meridionale ut primo, quia vertetur ad meridiem, si aque exponatur. Pars vero reliqua, ex parte fracture, septemtrionalis erit, que sit C: erit ergo iste lapis CD: primus lapis AB sit agens, CD patiens; sicutque vides quod due partes duorum lapidum, que, ante separationem, in uno lapide erant continue, post separationem, una invenitur septemtrionalis, altera meridionalis. Quod si rursus eadem partes approximentur, una alteram attrahet, quoque sibi iungantur in puncto BC, ubi fractura fuit: unde quantum est de naturali appetitu, fiunt unum corpus, ut primo; cuius signum est, [quod] si illic cemententur, habebunt easdem operationes quas primo exercebant.

Agens ergo, ut vides experimento, intendit suum paciens sibi unire; hoc autem fit ratione similitudinis inter ea. Oportet ergo, cum B iungatur C, virtute attractionis, fiat una linea, ex agente et paciente, secundum hunc ordinem: ABCD, ut BC sint punctum unum: in hac enim unione retinetur, seu salvatur idemperitas partium extremarum, in similitudine qua erant primo. A enim, septemtrionale est in tota linea, sicut erat in divisa; eodem modo D meridionale, sicut erat in ipso paciente diviso, sic etiam est in ipso unito: B, C vero, efficiuntur idem.

Et eodem modo accidet si A iungatur cum D, ut due linee fiant una, virtute unionis ipsius attractionis, secundum hunc ordinem: CDAB, ut DA sint unum punctum: tunc remanebit idemperitas partium extremarum, sicut primo, antequam unirentur; C namque punctus septemtrionalis erit, B vero meridionalis, sicut prius B, C erant, divisi.

Si autem fieret aliter, non salvaretur hec idemperitas, seu similitudo parcum. Vides enim quod si C iungatur cum A, quod est contra expertam veritatem, ut ex illis duabus lineis fiat una linea, secundum hunc ordinem: BACD, ut AC sint in puncto uno; D (quod erat meridionale antequam unirentur) requirit, in hac linea totali, quod B, reliqua extremitas, sit septemtrionalis, que prius tamen erat meridionalis, [et] ecce dissipatur idemperitas, seu similitudo prior. Vel si ponas B meridionale, sicut erat antequam unirentur, requiretur quod D, altera pars, septemtrionalis existat, cum tamen fuisset meridionalis; et sic ibi non servatur idemperitas, neque similitudo: oportet enim quod illud quod iam conversum est ex duobus in unum, sit in eadem specie cum agente; quod sic non esset, si natura istud impossibile eligeret. Idem autem inconveniens accidit, si iungas D cum

B, ut fiat una linea, secundum hunc ordinem: ABDC, ut patet intuenti. Natura autem, que tendit ad esse, et agit meliori modo quo potest, eligit primum ordinem actionis, in quo melius salvatur idemperitas, quam in secundo.

Patet ergo ex his quare pars meridionalis septemtrionalem attrahit, et e converso; et quare meridionalis meridionalem, et septemtrionalis septemtrionalem, nequaquam per naturam.

CAP. X. DE INQUISITIONE UNDE MAGNES VIRTUTEM NATURALEM, QUAM HABET, RECEPIAT.

Quidam autem debiles inquisitores opinati sunt quod virtus qua agit magnes in ferrum, fit in locis mineralibus, in quibus magnes invenitur, unde dicunt quod, licet ferrum ad polos mundi moveatur, hoc tamen non est, nisi quia minera lapidis in illis partibus situatur. Isti autem ignorant, quod, in diversis mundi partibus, lapis dictus invenitur, ex quo sequitur quod ad diversa mundi loca moveretur, quod falsum est. Et rursus ignorant quod locus sub polis sit inhabitabilis, eo quod medietas anni sit ibi dies, et medietas nox; quare ab illis locis ad nos posse portari magnetem, fatuum est estimare. Preterea cum ferrum, vel lapis, vertatur tam ad partem meridionalem quam ad partem septemtrionalem, ut patet per iam dicta, existimare cogimur, non solum a parte septemtrionali, verum etiam a meridionali virtutem influi in polos lapidis, magis quam a locis minere. Cuius signum evidens est, quod, ubicunque homo fuerit, videt, ad oculum, huius lapidis motum, secundum situm sui orbis meridiani. Omnes autem orbes meridiani in polis mundi concurrunt; quare, a polis mundi, poli magnetis virtutem recipiunt. Et ex hoc appareat manifeste quod non ad stellam nauticam movetur, cum ibi non concurrent orbes meridiani, sed in polis; stella enim nautica, extra orbem meridianum cuiuslibet regionis semper invenitur, nisi bis, in completa firmamenti revolutione. Ex hiis ergo manifestum est quod a partibus celi, partes magnetis virtutem recipiunt.

Ceteras autem partes lapidis merito estimare potes, influentiam a reliquis celi partibus retinere, ut non sic solum polos lapidis a polis mundi, sed totum lapidem a toto celo, recipere influentiam et virtutem, estimes. Quod tibi tali modo consulo experiri: Rotundetur lapis, et inveniantur poli in eo; et post dispone, super duos stilos acutos, lapidem, ita, quod cuilibet polo sit unus stilus leviter affixus, in suo puncto, in lapide, ut lapis, sine difficultate, super eos possit moveri. Quo facto, experiaris si lapidis partes equaliter ponderant.

volvendo ipsum leviter super dictos stilos; et hoc plures, et in pluribus horis diei facies, sagaci industria. Quo facto, lapidem dispone in orbe meridianu super suos stilos, in polis lapidis leviter affixos, ut moveatur ad modum armilarum, ita quod polorum ipsius elevatio et depressione sit secundum elevationem et depressionem polorum celi, in regione in qua fueris. Et si tunc lapis moveatur secundum celi motum, gaudeas te esse assecutum secretum mirabile; si vero non, imperitie tue, potiusquam nature, defectus imputetur. In hoc autem situ, seu modo positionis, virtutes lapidis huius estimo conservari proprie, et in reliquis sitibus celi virtutem eius obceceri, seu ebetari, potiusquam conservari puto. Per hoc autem Instrumentum excusaberis ab omni horologio; nam per ipsum scire poteris Ascensus in quacumque hora volueris, et omnes alias celi dispositiones, quas querunt Astrologi.

SECUNDE PARTIS. CAP. I. DE COMPOSITIONE INSTRUMENTI QUO SCITUR AZIMUTH SOLIS ET LUNE, ET CUIUSLIBET STELLE IN ORIZONTE.

Visis operibus naturalibus magnetis, accedamus manifestare ingenia, que, ex cognitione operationis naturalis ipsius dependent. Sumatur magnes rotundus et inveniantur poli, ut dictum est, et elimetur inter duos polos in duabus partibus, ut sit lapis, sicut spera compressa inter polos, ut minorem locum obtineat. Hic quidem lapis, sic preparatus, inter duas cassulas, in modum speculi, recludatur in medio; et cassule ad invicem sic iungantur, quod ulterius non aperiantur, et ut aqua non subingrediatur. Preparentur cassule cum cola ad hoc apta, et sint cassule ex ligno levi. Quo facto, pone cassulas, sic aptatas, in vase magno pleno aqua, in quo sint partes due mundi, scilicet meridionalis et septemtrionalis, invente et signate: et designentur per filum extensum a parte septemtrionali vasis, usque ad partem meridionalem. Dimitte igitur cassulas fluctuare, et sit super eas lignum gracile, in modum diametri; move ergo lignum illud super cassulas, donec linee meridionali, prius invente, et per filum designate sit equidistans, aut eadem [linea] cum ipsa. Quo facto, secundum situm illius ligni, sic situati, signa lineam in cassulis; et erit perpetua linea meridionalis in omni regione. Illa ergo linea, per aliam, ipsam orthogonaliter secantem, per medium dividatur, et erit linea orientis et occidentis: et sic habebis quatuor quartas, in cassulis actualiter signatas, quatuor mundi partes designantes, quarum quelibet, in partes nonaginta dividatur, ut sint, in universo, partes CCCLX, in tota circumferentia cassularum: et inscribe partes in ea, sicut in

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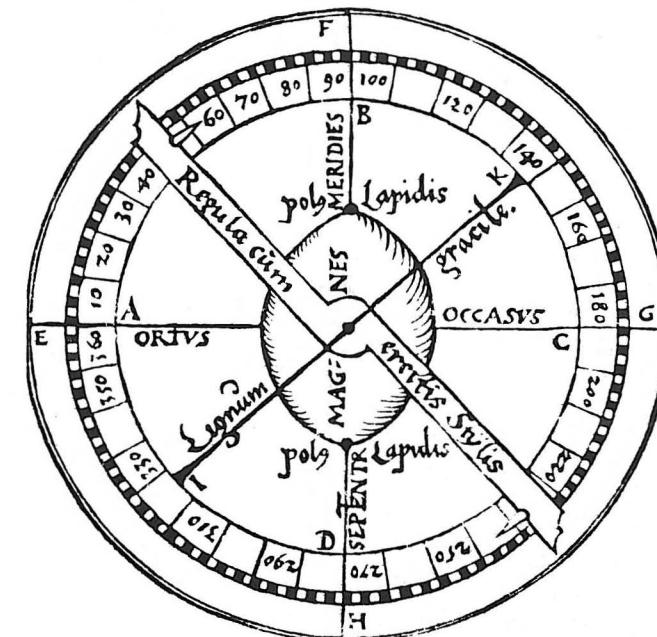
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dorso Astrolabii consueverunt inscribi. Erit insuper regula tenuis et levis super cassulas sic inscriptas, ad modum regule in dorso Astrolabii. Loco tamen pinnularum, erigantur orthogonaliter duo stili super capita regule.

Si ergo habere volueris azimuth Solis, de die, pone cassulas in aqua, et dimitte eas moveri, donec in suo situ quiescant; ibique eas tene firmiter cum manu una, et cum reliqua move regulam donec umbra stili cadat secundum longitudinem ipsius; et tunc caput regule, ex parte Solis, ostendet Azimuth Solis. Si fuerit ventus, cooperiantur cassule cum aliquo vase, donec suum situm habeant.

De nocte vero, idem facies ad Lunam et Stellas, per visum: movebis enim regulam, donec summitates stilorum, et Luna vel Stella, sint in eadem linea; summitas enim regule ex parte stelle ostendet Azimuth ipsius, sicut prius.

Cognosces autem, per Azimuth, horas, et Ascendens, et Ascensiones, et cuncta que oportet, secundum doctrinam Astrolabii, complete. Huius autem Instrumenti formam presens doctrina demonstrat.

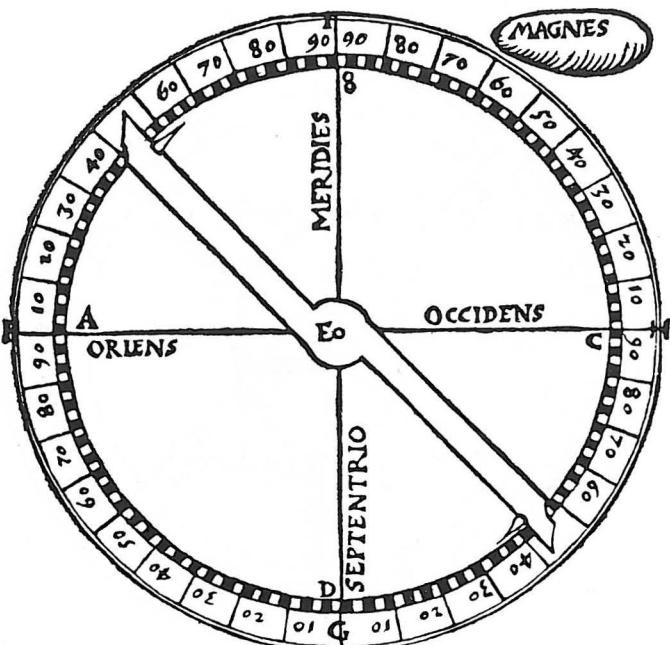


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CAP. II. DE COMPOSITIONE INSTRUMENTI MELIORIS, OFFICII EIUSDEM.

In hoc autem Capitulo dicemus tibi modum compositionis alterius Instrumenti melioris, et certioris effectus. Fiat vas ligneum, vel eneum, vel cuiuscumque volueris materie solide, et sit ad modum pixidis tornatum, parum profundum, et sit competenter amplum: et aptetur super illud cooperculum de materia transparenti, sicut est virtum vel cristallus. Si totum etiam vas fuerit de materia transparenti, melius erit. Disponatur igitur, in medio ipsius vasis, axis gracilis de ere, vel de argento, applicans extremitates suas duabus partibus pixidis, videlicet superius et inferius; sintque foramina duo in medio axis, orthogonaliter se respicientia, et transeat unus stilus ferreus, ad modum acus, per alterum illorum foraminum, et per alterum, transeat aliis stiliis argenteis, vel eneis, intersecans ferrum orthogonaliter. Cooperculum vero dividatur in quartas primo, et quelibet quartarum, in partes nonaginta, ut docebatur in alio Instrumento; et signetur septemtrio et meridies, et oriens et occidens, in eodem;



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et addatur ei regula de materia transparenti, cum stiliis in summitatibus erectis. Tunc approximabis quam partem magnetis vis, sive septemtrionalem sive meridionalem cristallo, donec acus ad ipsum [*magnetem*] moveatur, et ab ipso virtutem recipiat. Hoc facto, pixidem volve, donec una summitas acus steterit in directo septemtrionis in Instrumento, ex parte septemtrionali celi. Quo peracto, volve regulam ad Solem, de die, et ad Stellas, de nocte, modo supra dicto.

Per hoc Instrumentum diriges gressus tuos ad civitates et insulas, et loca mundi quecumque, et ubicumque fueris, in terra vel in mari, dummodo longitudes et latitudines ipsorum sint tibi note.

Qualiter autem ferrum stet in aere per virtutem lapidis in libro de Operibus Specularum narrabimus. Et hec est iam dicti Instrumenti descriptio.

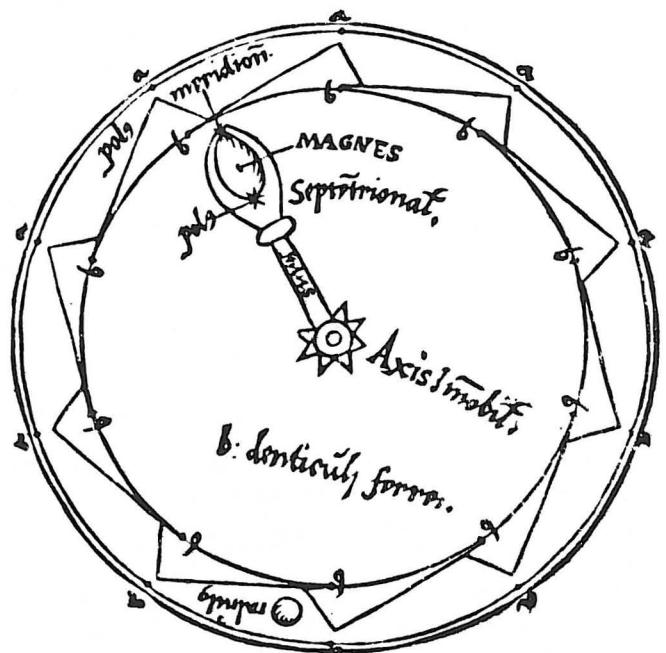
CAP. III. DE COMPOSITIONE ROTE.

In hoc autem Capitulo tibi revelabo modum componendi rotam continue mobilem, mirabili ingenio: in cuius inventione multos vidi vagos, ac labore multiplici fatigatos. Non enim advertebant, per virtutem seu potentiam huius lapidis, ad huius magisterium posse deveniri.

Ad huius Rote compositionem seu constructionem, compones cassulam argenteam, ad modum cassule speculi concavam, subtili artificio intrinsecus laboratam, cum sculpturis et perforaturis, quas facies sola pulchritudinis causa, et alleviationis ponderis: quanto enim levior erit, tanto velocius movebitur. Ita tamen perforabis, quod oculus ignari infra cassulas non percipiat quod ibi subtiliter inseretur. Interius autem sint claviculi vel denticuli ferrei, unius ponderis, limbo affixi, declines, propinqui ita, ut non distet unus ab alio plus quam unius fabe, vel ciceris spissitudo. Sit autem rotula dicta, in pondere suarum partium, uniformis; et tunc axem affigas per medium, supra quem volvatur Rotula dicta, axe omnino immobili existente; cui videlicet axi stilus addatur argenteus; affixus eidem, inter duas cassulas collocatus, in cuius summitate magnes situetur in hunc modum preparatus: rotundetur, et inveniantur poli, ut dictum est; postea in modum ovi figuretur, polis intactis, et in duabus partibus intermediis oppositis aliquantulum elimetur, ut sit compressus, ad hoc quod minorem locum occupet, ne parietes cassule, motu Rotule, interius tangat. Quo sic disposito, supra stilum collocetur, ut lapis in annulo, sitque polus septemtrionalis versus denticulos Rotule aliquantulum inclinatus, ut virtus ipsius, non diametraliter, sed cum quadam inclinatione, in ferreos denticulos influat; ut cum quilibet denticulus ad polum septemtrionalem venerit, et modicum ex impetu Rotule, illum

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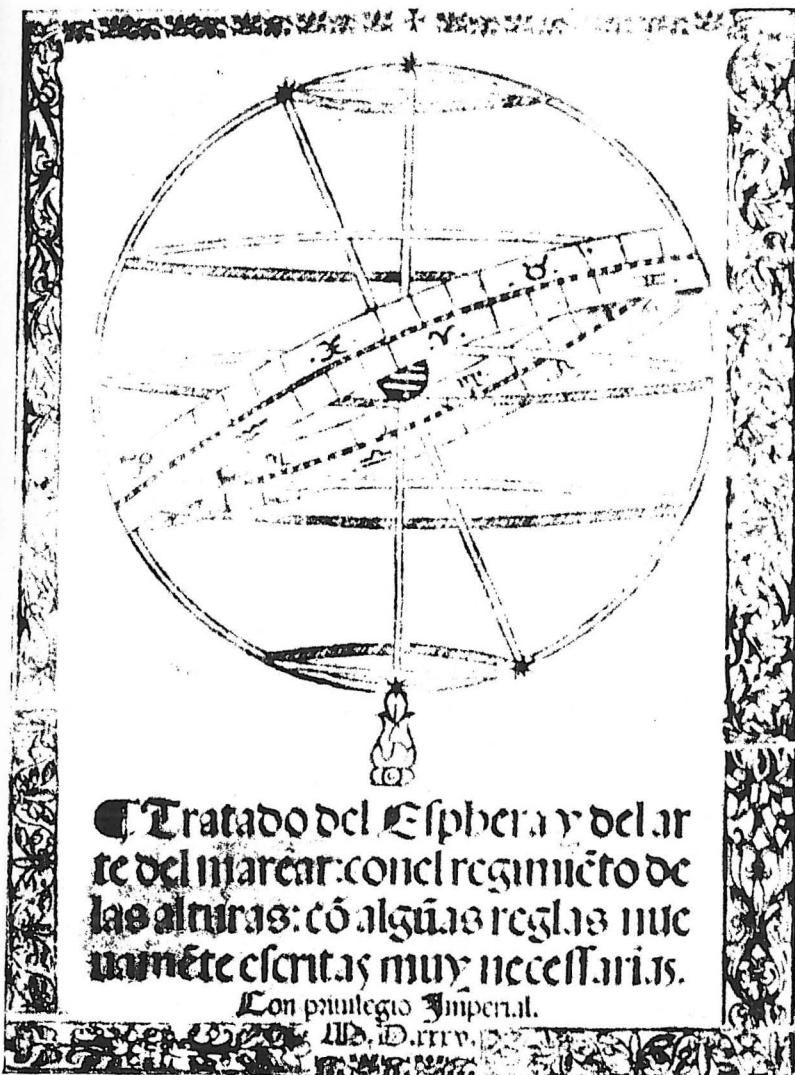


transierit, ad partem meridionalem accedat; que eum potius fugabit quam attrahet, ut patet per regulam superius traditam: sicque erit quilibet denticulus in tractu perpetuo, fugaque perpetua. Et ut velocius suum Rotula exerceat officium, infra cassulas reclude calculum parvum, rotundum, eneum vel argenteum, tante quantitatis, quod inter duos quoslibet denticulos capiatur; ita quod, cum Rota elevabitur, cadat calculus in partem oppositam. Quare, cum motus Rote in unam partem sit perpetuus, etiam casus calculi erit, in partem oppositam, receptus inter quoslibet duos denticulos, perpetue; quia, sua ponderositate, petens centrum terre, faciet iuvamentum, denticulosque non sinet in directo lapidis quiescere. Sint autem loca inter denticulos, convenienter incurvata, ut apte capiant calculum in parte sui casus, ut presens demonstrat descriptio. Vale — Actum in castris, in obsidione Lucerie, anno Domini MCCLXIX, viii die Augusti. — Explicit iste Tractatus.



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Tratado del Esfera y del arte del marear: con el regimiento de las alturas: cõ algunas reglas muy útiles escritas muy necessarias.

Con privilegio Imperial.

FRANCISCO FALERO

DEL NORDESTEAR DE LAS AGUJAS.

El nordestear de las agujas pone á los mareantes en muchas dudas: de las quales podrá salir cō saber precisamente lo que ellas nordestean y noruestean. I alléde de lo dicho se seguirá otras vtilidades como saber pcisamēte por q rúbo nauegan: lo ql sabido seguirá pcisamēte sus derrotas sin yerro ni rodeo y tābiē alubrara mucho pa saber lo q nauegā por longitud.

Nordestear y noruestear las agujas no es otra cosa sino lo q ellas se apartan del meridiano en que estan: el ql ellas no muestran precisamente sino quando puntualmente demandan el polo: y este segū los mareantes solamente le demandan precisamente quādo estan en el meridiano de las yslas d̄ los açores; y las mas precisas le demādan en el de la del cueruo segun esperiencia de algunos; porq por la diuer- sidad de los azeros y de las piedras de ceuar no demandan todas el polo en vn meridiano; ante vnas en vno mas oriental y otras en otro mas occidental; aun que la diferencia es poca. E assi mismo vnas nordestean mas que otras; y lo mismo noruestean; y en esto como en todo lo demas con lo q adelante se dira se pueden conformar todas las agujas; porque se conocera la cantidad del yerro de todas en todo lugar.

Para lo ql aueys de saber que nauegando desde el meridiano de la ysla del cueruo o de otra qualquiera de las de los açores en que el aguja puntualmente demanda el polo yendo á ocidente las agujas noruestean; y nauegando desde el mismo meridiano á oriente nordestean. Dizese q nordestean porq lo que ellas se apartan del polo es azia el nordeste; y quando se apartan del polo azia el norueste dízese que noruestea; y quanto mas las naos se apartā del meridiano psupuesto | tanto mas las agujas nordestea o noruestea; segū la pte para q se aparta; aun q es de tener q partiendo vna nao d̄ la dicha ysla; y nauegado por vn paralelo q esta xc grados de lógitud las agujas yra siépre acrecetado en su nordestear o noruestear; y passando adelante de lo xc grados por el mismo paralelo por la misma pporciō q ouiescen nordesteados

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lo tornaria a emēdar q qndo ouiesen nauegado otros xc grados q estaria en el clxxx grados de lógitud de la ysla q se ha dicho: y justamēte estaria en el antipoda y meridiano oposito dlla en el mismo paralelo | las agujas tornaria a demādar pcisamēte el polo como le demādañ en la ysla y meridiano de q empeço su viaje como se ppuso prosiguiendo su viaje por la misma drrota hasta tornar a la ysla de dode auia de primero partido si possible fuese q no es; por el mismo orde y proporcio tornaria hazer sus diferēzas como en los clxxx grados primeros q hasta los primeros xc grados yriā las agujas nordesteados y dellos adelante lo tornaria a emēdar. de manera q quādo la nao ouiesse tornado al puto y ysla de dode ouiesse de primero partido; tornaria a demādar p̄tualmēte el polo sin nordestear ni noruestear. y porq los nauegates siguiendo sus derrotas por meridiano o de norte y sur hallā q las agujas se aparta del polo; alguos dellos tiene vn yerro: y es q piésan q siguiendo tal viaje las agujas nordestea o noruestea: se dice q aun que vna nao nauegue por vn meridiano desde vn polo hasta el otro jamas las agujas cō q tal nao se rigiesse noruestearia ni nordestearia. Pórq aun q halle q se aparta del polo como es verdad q hazē; porq el tal apartamiento del polo es sin allegarse al nordeste ni al norueste no se puede d̄cir q nordestea ni noruestea ni el tal apartamiento es incōueniente: porq el apartamiento q nos trae en yerro no es el del polo sino el d̄l meridiano: y para q esto sea manifiesto se pone por exēplo: q si vna nao estuviessse en la eq̄nocial y el aguja cō q se rigiesse estuviessse verdadera que ni nordestease ni noruestease: cierto es que puntualmente demandaria el polo sin que le señalle ó demandasse azia el nordeste ni azia el norueste, ni azia nuestro zenich ni azia nuestros antipodas: y esto es porq por estar verdadera no se apartaria azia el nordeste ni azia el norueste; y por estar en la eq̄nocial no se apartaria azia nuestros antipodas ni azia nuestro zenich; porque el aguja el punto que demanda siempre le demanda en el orizonte en el qual tiene el polo por estar en la equinocial como es dicho. E como quiera q este presupuesto sea verdadero se ha d̄ tener que el aguja en ningun lugar ni punto del esphera demanda puntualmente el polo sino estando en la equinocial; porque solamēte en ella le tiene en el orizonte. E mudandole de la equinocial todo lo que el polo estuviere arriba o abaxo del orizonte se aparta el aguja del. De manera que si vna nao con la tal aguja nauegasse desde la equinocial por vn meridiano hasta

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xc grados si possible fuese q seria poner el polo por zenich el aguja demandaria el polo en punto que se apartaria del mismo polo xc grados: porque el punto que ella demandaria estaria en el orizonte del que esta debaxo del polo; el qual seria la equinocial. Mas aun q el apartamiento del polo fuese xc grados ni por esso se apartaria del meridiano poco ni mucho; y no se apartado del no nordestearia ni noruestearia; ni de tal apartamiento se seguiria yerro ni daño; porque como es dicho el apartamiento del meridiano es el que nos pone en yertos y falsos principios y fines y no el del polo.

E para que sepamos lo que las agujas nordestean y noruestean conuiene hazer un instrumento de la manera y forma de la figura que en el presente capitulo hallareys: que sea muy redondo y plano y tan grande que se pueda diuidir en 360 grados; los cuales se han de señalar con vna regla; de manera que siendo sacados desde el centro del | solamente sean señalados en la circunferencia. y desde el punto en q quisieredes q el aguja señale el polo empeçareys a graduar de ambas partes empezando en uno y acabando en la linea que señalardes por equinocial en nouenta. y desde el otro polo hasta la equinocial podreys graduar otros tantos; aunque no es necesario: y despues de graduado señalar en el cetro con compas vn circulo tan grande que abierto se pueda encaxar en el el aguja: de manera que este fija en el instrumento; y hareys un medio circulo de hierro o de azero | o de otra cualquiera cosa que sea muy redondo y plano y parejo | y que no tenga mas grossor que quanto haga sombra; y sea sacado con compas del tamaño de la media circunferencia del instrumento; y tenga las puntas agudas; de mas de lo que cupiere al tamaño del medio circulo | para que aquella demasia se hinque en el instrumento para que se tenga derecho; y la vna punta se ha de poner en el punto en que el aguja señale el polo artico y la otra en el en que señale el antartico.

Y hecho assi el instrumento | quando quisieredes obrar con el endreçalde al medio dia de manera que el medio circulo haga la sombra derecha sin torcimiento alguno; y quado estuuieredes en parte que el sol este entre vos y el polo artico hazed que entre el sol por la parte en que el aguja señale el polo artico; y quando el sol estuuiere entre vos y el polo antartico hazed al contrario. E quando quisieredes assi tomar la sombra; ueys de rodear el instrumento a la vna parte o à la otra sin auer respecto ninguno al aguja hasta que el medio circulo vos haga

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la sombra derechamente como es dicho. E si tomada assi la sombra el aguja señalare el polo en el punto en que estuuiere la punta del circulo estara verdadera sin nordestear; porque el sol quando allega à cada vno de los meridianos echa la sombra o rayo à los que debaxo del tal meridiano estan precisamente al polo y por esta causa todas las veces que el aguja concertare con la sombra o rayo de medio dia; ueys de tener que esta verdadera; y todo lo que el aguja discrepare sera yerro. Por tanto quando el aguja tomada assi la sombra no señalare el polo en el punto en que estuuiera la punta del medio circulo | echareys vn hilo que passe por el centro del aguja y por la punta de la rosa hasta cortar la graduacion: digo que passe el hilo por encima del punto en que el aguja señalare el polo muy precisamente; y contareys los grados que ouiere desde la punta del circulo hasta el punto en que cortare el hilo; y los grados que ouiere sera lo que el aguja nordestea: segun la parte para que se apartare: y para esto cumple tener mucha vigilancia en conocer puntualmente el medio dia; porque todo lo que se errare en conocello | se errara en la cuenta deste instrumento. y el medio dia conosceremos con relox de arena o de otra manera assi como vniuersal etc que sea muy preciso: y no destos de sol acostumbrados: y con el de arena contando con el las horas que ouiere en la noche: y sacandolas de veinte y cuatro que ay en vn dia natural | las que restaren serā las que aura en todo el dia de sol a sol en la region en que estuuieren; y sabido las que ay en el dia comenzar se han a contar con el mismo relox en apuntando el sol; y contadas las medias o mitad sera medio dia.

Tambien es buena manera de conocer el meridiano facilmente con el mismo instrumento tomando la sombra del sol vna ora o dos o tres etc ante de medio dia y señalar en que parte del instrumento cae; y otro tanto tpo despues de medio dia como de primero se tomo ante; tornar a tomar la sombra entiendese que este el sol en tanta altura despues de medio dia quanta estaua ante quādo se tomo la primera sombra. y señaladas las dos sombras | el medio dillas sera el meridiano pciso; y esta es muy buena regla assi por ser verdadera; como porq puede seruir mas vezes al dia q las otras: y no puede auer yerro en ella si bien se guarda el orden della.

Tambien conosceremos con este instrumēto el meridiano para saber nosotros lo que el aguja nordestea o noruestea; poniendo en el centro del vn astil y señalar la sombra en el instrumento en saliendo el sol; y

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lo mismo en poniendose; y el medio de las dos sombras por fuerça sera el meridiano. E todas las veces que el aguja señalare el polo en el tal meridiano que assi ouieredes tomado en el instrumēto estara verdadera; que no nordesteara ni noruesteara; y quando no señalare el polo en el tal meridiano contareys los grados que ouiere desde el meridiano que aueys tomado y señalado entre las dos sombras hasta el punto en que el aguja señalare el polo; y los grados que ouiere del vno al otro sera lo que el aguja se apartare del meridiano.

Tambien poniendo las puntas del medio circulo o dos astiles en los dos extremos ó puntas de la linea señalada en este instrumento por equinocial; y en saliendo el sol o en poniendose puntualmente concertar el instrumento; de manera que el circulo o astiles hagā la sombra que vaya por linea recta de la vna punta del circulo à la otra. Hecho esto echareys vn hilo que corte por el centro y punta del aguja; y por el punto en que el aguja señalare el polo hasta la graduaciō. E quado el hilo cayere por la linea diametral señalada en el instrumento precisamente; si la nao estuuiere en el paralelo en que el sol estuuiere aquel dia; el aguja estara verdadera. E si el hilo cortare la graduacion fuera de la linea diametral todos los grados que ouiere desde la linea hasta el punto en que el hilo cortare la graduacion sera lo que el aguja nordesteara o noruesteara segun la parte de la linea o meridiano a que se apartare; y esto como es dicho sera quando la nao estuuiere en el paralelo en que el sol aquel dia estuuiere. E quado la nao estuuiere en otro paralelo toda la distancia q ouiere del paralelo de la nao al paralelo del sol se ha de acrecentar o sacar de los grados que entre el hilo y el meridiano del instrumento ouiere segun la parte para que el hilo y aguja se apartare del meridiano; y lo que restare sera lo que el aguja nordesteara etc: Y estas son mejores maneras de conocer el meridiano y nordestear de las agujas que por la mayor altura del sol tomada con el quadratē; porque el sol a medio dia tiene tan poca altura mas de la que tiene vn poco ante y despues de medio dia que dificultosamente se puede conocer precisamente el meridiano: y mas porque estas reglas nos siruen muchas vezes al dia. E porque ay otras maneras y reglas para saber el meridiano no se ponen aqui otras que hasta agora no se han praticado y estas bastan.



PEDRO NUNES

ESTROMENTO DE SOMBRA.

E porque nenhūa cousa se pode alcançar em Astrologia e cosmographia: se não prosupondo a noticia doutras couosas ja sabidas que se tomão por fundamento: as quaes se ainda quisesemos resoluer nos principios donde nacerão: necessariamente jriamos parar em estromentos. Por tanto se queremos saber a altura do pollo assi no mar como na terra: em todo tempo que ouuer sol: necessario nos será fazer outro tanto. E porq não vejo cousa que no mar possamos leuar: que sendo indiferente a todalas alturas do polo: nos possamos della mais aproueitar q da agulha q representa ho horizōte em toda parte: e estrolabio e globo que representa o vniuerso e ho regimento da declinação do sol que he comū a todallas as alturas. Por tanto ajudandome destas couosas per fundamento juntamente cõ a demonstraçō mathematica darey dous modos p que a altura do polo se possa alcançar. E sera o primeiro presupôdo que a agulha vay justa ao polo sem nordestear nē noreste. Mas o segundo sera ajudadome toda via da agulha se estamos no mar. E isto quer ella nordestee quer noreste: e posto que não saibamos se faz mudanca: ou se ha non faz q he não ter meridiano: antes p esta arte que darey poderemos saber se nordestea quer noreste: e per quatos graos se aparta do verdadeiro meridiano. Pera as quaes couosas teremos hū lamina circular de algūa materia solida e de conforme grossura q com ho tempo nā faça mudanca: e sera boa de latão como sam as do estrolabio assi planas: mas mais grossas graduaremos o circulo em 360 partes e lançarlheemos seus diametros q ho repartão em quartas: e no centro poremos hū estilo perpendicular sobre a mesma lamina pa nos amosstrar pera q parte vāo as sombras: e em qualquero dos semidiametros em igual distācia do centro e da circūferencia: faremos sobre hū pôto hū pequeno circulo que se cauara quanto baste: pera que embaixo em outro centro q responde ao de cima: sobre q se fez o peqēno circulo q se caou possa andar liuremente hū agulha como a dos relogios acustumados e pela mesma arte sera feito este peqēno circulo e acabado com seu espelho encima: mas a agulha sera mais comprida e mais sotil e per baixo della jra a linha q responde ao diametro do circulo grāde que se graduou: per modo que delle não discrepe cousa algūa: e porque nos ha de ser necessario enderençar esta agulha sobre a dita linha justamente: pera mais justificaçam poremos dous pôtos pretos nas paredes desta caixa da agulha em dereito do seu diametro pera que tendo endereçado a agulha a estes pôtos saibamos de certo que esta dereita com os diametros do circulo peqēno e do grāde q ambos vā per dereito. Nas costas desta lamina defronte do centro encastoaremos hum pião grande e pesado laurado a torno: pera que me-

tendo a dita lamina nas balanças e caxa da agulha acostumada: fique sojugada por causa do peso e não saya do ouliuel: e as balâcas seram torneadas e de eyxos dobrados e muy liures: e se sem embargo de ho assi fazermos: acharmos que a lamina não fica ao ouliuel acrecentarheemos pella parte de dentro algum peso onde comprir para que finalmente nos fique perfeitamente ouliuelada: porque nam sendo assi não nos serue. E por tanto se parecer melhor que esta lamina se pendure per algúia arte que fique dereita he a mesma tençao: posto que a que se fez pera sua Alteza de Marfil: com as balanças torneadas e de eyxos dobrados: era tam prima que nenhūa cousa discrepanava tendo mais de hum palmo de diametro. Teremos mais hum globo perfeitamente redondo e de tal grandeza que os graos sejam manifestos e quanto mayor tanto melhor. Nā he necessario auer nelle mais que hū circulo grāde graduado que representara ho horizonte: e outro que represente ao meridiano: tera seus eyxos nos polos do horizonte: e auera hum meridiano de latão: dentro do qual tera o globo mouimento sobre os polos do horizonte. E porque ho vso destes estromētos he pera situarmos ho sol neste globo em respeito de nosso zenit como elle esta no ceo: ao tēpo que queremos tomar a altura do polo: faremos isto per esta arte. Poremos ho estromento da agulha ao sol: e andaremos com ella ate que a agulha fique dereita com os pontos que estam sobre ho seu diametro: e notaremos por quātos graos se aparta a sombra da linha do meyo dia: e pello estrolabio saberemos per quantos graos esta o sol alçado sobre ho horizonte. Tomaremos entam ho globo que não he necessario que seja ao sol: e contaremos pello horizonte: começando do encontro do meridiano os graos da sombra: e moueremos ho globo ate pormos ho fim da conta no meridiano sobre que se faz ho movimento pello qual meridiano assi situado começādo do encōtro do horizonte q̄ he o pôto onde acabou a cōta dos graos da sombra: cōtaremos os graos da altura do sol q̄ achamos no estrolabio e no fim poremos pôto: o q̄l representara o sol: e assi ficara situado ē respeito de nosso zenit no globo como no ceo. E querēdo saber q̄nta seja a altura do polo pa mais craramēt pcedermos: porey todalas cōtingencias: e sera a primeira estādo o sol na banda do norte que he ter declinação setentriional: e nos rumos do sul e seguirseham as outras. Esta ho sol nos rumos da bāda do sul: seguese pello septimo documento que estamos antre ho sol e o polo do norte: tomaremos com o compaso ho que ha do sol ao polo: que he o que fica de nouēta: tirando a declinação: e tēdo situado ho sol no globo pello modo sobre-dito: farei circulo sobre o ponto do sol: pera a parte onde o angulo que se faz no zenit he obtuso: a qual he pera ho norte: e o pôto onde cortar ao meridiano do globo: sera ho lugar do polo: e tirando este arco que ha entre o zenit e ho polo de nouenta: ficara a altura sobre ho horizonte.



JOÃO DE CASTRO

OBSERVAÇÕES MAGNETICAS.

Roteiro de Lisboa a Goa, 1538.

Sabbado treze de abril, amanhecendo, vimos a palma, que he hūa das Ilhas das canareas, e logo fiz prestes a lamina e estormento de sombras, de que o muito excelente princepe o Iffante dom Luis me fez mercê, com grande deseio de verificar duas couisas: a primeira, se nesta Ilha variauam as agulhas, ou não, por ser pratica de muitos pilotos que neste lugar e merediano feria o norte de suas agulhas no verdadeiro polo do mundo; e a segunda, se era verdadeira e punctual a regra que nos deu o doctor Pero nunez, pera em toda a ora do dia em que fizer sombra sabermos a leuação do polo; com o qual estromento fez as seguintes considerações, sendo todo este dia o vento calma, que a naao não gouernaua.

Primeira consideração antes do meu dia.

Estando o sol em altura de	57 graos
ho estílo lançou a sombra	71 graos
contando do norte pera a banda daloeste.	

Segunda consideração antes do meu dia.

Estando o sol em altura de	61 graos
ho estílo lançou a sombra	64 graos
contando do norte pera a banda daloeste	

Tendo por esta maneira vereificado a altura do sol a toda a ora, esperei que depois de meu dia tornasse o sol ás duas alturas em que o tomei pela menhā, pera me certificar do que fazião as agulhas no merediano destas ilhas, e passou desta maneira.

Primeira consideração depois do meu dia.

Estando o sol em altura de	61 graos
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ho estilo lançou a sombra 53 graos
contando do norte pera a banda de leste:
foi logo o arquo dante o meo dia maior que o de depois de meo dia per
esta operação 11 graos, os quaes partidos pello meo, ficão 5 graos $\frac{1}{2}$, que he
a quantidade que neste lugar a agulha nordestea.

Segunda consideração depois do meo dia.

Estando o sol em altura de 57 graos
ho estilo lançou a sombra 60 graos
contando do norte pera leste:
foi logo nesta operação o arco de depois de meo dia 11 graos, os quaes
partidos pello meo, virão á parte 5 graos $\frac{1}{2}$, que he a quantidade que neste
lugar a agulha nordestea

Segunda feira 15 dabil, todo o dia foy o vento oesnoroeeste fresco;
gouernamos ao sul quarta do sudueste. Este dia fiz as operações seguintes.

Primeira operação dante o meo dia.

Estando o sol em altura de 56 graos
ho estilo lançou a sombra 80 graos
contando do norte pera a banda daloeste.

Segunda operação dante o meo dia.

Estando o sol em altura de 67 graos
ho estilo lançou a sombra 65 graos
contando do norte pera a banda daloeste.

Primeira operação depois do meo dia.

Estando o sol em altura de 67 graos
ho estilo lançou a sombra 53 graos
contando do norte pera a banda de leste:

Foi logo nesta operação o arquo dante o meo dia maior que o de depois de
meo dia 12 graos, e a sua ametade 6, que he a quantidade que neste lugar
agulha nordestea.

Segunda operação depois de meo dia.

Estando o sol em altura de 56 graos
ho estilo lançou a sombra 68 graos
contando do norte pera a banda de leste:
Foi logo nesta operação o arquo dante o meo dia maior que o de depois de

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meo dia 12 graos, os quaes partidos pello meo, virão 6, que he a quantidade
que ha agulha nordestea.

Notaçao.

Posto que as operações deste dia viessem tão conformes e igoaes, nem
por isso deuemos julgar facilmente o misterio do nordestear das agulhas, nem
menos fazer regra certa que na longura do caminho que se contheem do
ponto onde sabbado, que forão treze dias deste mês, fiz as outras operações,
atee onde me acho oie segunda feira 15 do ditto mês, aia agulha necessariamente
de fazer mudança de $\frac{1}{2}$ grao. Como quer que a sombra do estilo
tenha pouco repouso por a circunferencia do circulo graduado, ao que dá
occaſão o muito bullir da naao, e tambem como venta hum pouco rijo, a
lamina perde a perfeição e iusto oliuel, por se distemperarem as ballanças,
o que tudo iuntamente faz muito embaraço ao sentido, pera detremindamente
auer de aueriguar o verdadeiro lugar onde defire a sombra, de sorte
que, balanceando muito a naao, podemos facilmente errar ate douz graos,
mas hindo queda e assossegada, quem tiuer honesta extimatiua não poderá
errar passante de meo grao. E porque estas duas operações de que acima
fallo, forão feitas no merediano das Canareas, a saber, húa dellas estando da
banda do norte das ilhas, e a segunda achandome já da banda do sul, em
ambas se vereficou nordestear as agulhas cinquo graos e $\frac{1}{2}$ ate 6, fica
falsa a opinião dos que dizem que no merediano destas ilhas fere a agulha
nos verdadeiros pollos do mundo

Este cabo das agulhas he o lugar onde os Pilotos tem por maxima que
as suas agulhas lhe não varião cousa algúia, mas ferem directamente nos
verdadeiros polos do mundo, e daqui veo chamarem a este promontorio cabo
das agulhas, significando não fazerem já aqui nenhüa diferença: ao tempo
que vimos a terra, eu me fazia á Ré della 120 legoas, e o Piloto 110.

Notaçao famosa e muito proueitosa.

Acharme já nestas prayas tão deseijadas dos nauegantes, e com ter
passados tantos Receos, tantos sobresaltos, tantas fortunas de tamanho e tão
tem pestuoso gôlfão, me dá lugar e occaſão de dizer algúia cousa da longura
deste caminho, materia certamente não menos fermosa e grande que proueitosa,
a qual até qui mais se pôde dizer ser profiada que sabida; e Porque
pera a determinação e sentença desta duuida se requere concorrerem assi
demostrações dos mathematicos, como a pratica e openião dos pilotos e

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homens do mar, que de muitos annos a esta parte laurão por este occidente, grande e infinito mar, trarey aqui as Rezões que de húa parte e outra tenho comprehendido e alcançado com estormento de sombras inuentado pello doctor Pero nunez, famoso mathematico entre os que vivem em nossos tempos, e feito por mãos de Johão gonçaluez, cujo engenho triumpha o dia doje em toda a europa, e sobretudo aprovado pelo muito excelente Principe o Iffante dom Luis, o qual antre outras muitas mercês que de sua alteza recebi pera esta Jornada, foy este estormento com o qual vimos a alcançar a leuação do polo a toda a ora do dia, e assi a verdadeira variação que fazem as agulhas, e pella tal variação a longura das terras e diferença de meridianos; Pelo que será justo darmos fé a estormento de tamanha auctoridade, e o que por elle se achar achar de ser o certo.

Começa a proua.

Na cidade de lisboa, assi como muitas vezes tenho experimentado, nordestão as agulhas 7 graos, e dahi nauegando caminho do brasil, como somos com as Ilhas das Canareas endireitão as agulhas 1 grao $\frac{1}{2}$, de maneira que nestas ilhas nordestão 5 graos $\frac{1}{2}$, e deste lugar até á linha æquinoctial não fazem algúia mudança ou diferença. Porém, passando daquy e correndo na volta do Brasil, começa a variação hir crecendo pouco a pouco, de sorte que, achandonos 130 legoas pera leste do cabo de sancto Agostinho e em altura de 9 graos, as agulhas nordestão 10 graos inteiros, e dês dahi vão fazendo maiores mudanças sempre pera a parte do nordeste, até sermos obra de 230 legoas á Ré das Ilhas de Tristão da Cunha e em altura de 31 graos $\frac{1}{2}$, que será no merediano que se aparta 2 graos pera o oriente do merediano que passa pello cabo de são vicente, onde he o termo de toda a variação das agulhas, a qual chega até 19 graos $\frac{1}{2}$ ou 20: e logo passando este merediano por diante, caminho do cabo de bõa esperança, vão as agulhas endireitando pouco a pouco, e desandando os graos que até qui tinhão andado ou variado, o qual effecto fazem até sermos tanto auante como o ponta primeira da terra do natal, que está em altura de 32 graos, onde as agulhas punctualmente com o seu norte e frol de lis ferem no verdadeiro polo do mundo; mas caminhando deste lugar pera a India, fazem as agulhas esta variação ao contrario, furtandose o seu norte ou frol de lis pera a banda do noroeste, e quanto maes himos andando, tanto vay crecendo a variação, até chegarmos ás prayas da India, onde o norte das agulhas se desvia do Polo do mundo pera a banda de noroeste 11 graos, que valem $\frac{1}{2}$

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Quarta feira 3 de Julho foi o vento nordeste; gouernamos ao noroeste; tornando a demandar ha terra, ás dez horas fomos com ella: este dia fiz as operações seguintes.

Primeira operação ante o meu dia.

Estando o sol em altura de 16 graos
ho estilo lançou a sombra 50 graos
contando do sul pera a banda daloeste; e a este tempo erão oito horas e meia.

Segunda operação ante o meu dia.

Estando o sol em altura de 25 graos
ho estilo lançou a sombra 39 graos $\frac{1}{2}$
contando do sul pera a banda daloeste: erão a este tempo 9 horas e $\frac{1}{2}$.

Terceira operação ante o meu dia.

Estando o sol em altura de 31 graos $\frac{1}{2}$
ho estilo lançou a sombra 25 graos
contando do sul pera a banda daloeste: erão a este tempo 10 horas e meia.

Primeira operação depois de meu dia.

Estando o sol em altura de 31 graos $\frac{1}{2}$
ho estilo lançou a sombra 25 graos
contando do sul pera a banda de leste; e a este tempo era 1 ora $\frac{1}{2}$.

Foy logo nesta operação o arquo de depois de meu dia igoal ao dante meu dia, pello que fica manifesto não variarem as agulhas nenhúa cousa neste lugar.

Segunda operação de depois de meu dia.

Estando o sol em altura de 25 graos
ho estilo lançou a sombra 39 graos $\frac{1}{2}$
contando do sul pera a banda de leste: a este tempo erão 2 horas $\frac{1}{2}$.

Foy logo nesta operação o arquo de depois de meu dia igoal ao dante meu dia, pello que fica manifesto neste lugar não variarem as agulhas.

Terceira operação depois de meu dia.

Estando o sol em altura de 16 graos
ho estilo lançou a sombra 50 graos
contando do sul pera a banda de leste; e a este tempo erão 3 horas $\frac{1}{2}$.

Foy logo nesta operação o arquo de depois de meu dia igoal ao dante meu dia, pello que fica manifesto neste lugar não variarem as agulhas.

Este dia ao meu dia tomey o sol, e na mayor altura se aleuantaua sobre o orizonte 36 graos; a declinação deste dia era 22 graos, de que se segue

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estarmos em 32 daltura, que he na ponta primeira da terra do natal; donde fica manifesto que neste merediano que passa pello ditto ponto, não varião as agulhas cousa nenhña, mas ferem directamente nos verdadeiros polos do mundo, como por tantas e tão conformes operaçōes se tem mostrado

Este dia quis obrar com o estormento das sombras pera verificar a variação das agulhas, e sendo menos de 11 horas, a sombra do estilo hia muito alem da linha do meu dia, pello que, mandando vir algúas agulhas pera as cotejar com o estormento, acheyas tão desconcertadas, que foy couisa espan-tosa, porque onde húa fazia o leste, a outra mostraua o norte. Isto me teue muito suspensso, até que entendi a causa, e foy hum berço que estaua no mesmo lugar, onde eu queria fazer as operaçōes, o ferro do qual berço chamaua a ssy as agulhas, e as fazia desvariar desta maneira; do que tirey que húa operaçōe que fiz a trinta dias de Junho no merediano que está pera leste do cabo das agulhas 5 graos $\frac{1}{2}$, a qual achey que me vinha muito desconcertada, e assy algúas outras que fiz na parajem do Brasil, onde achey notaues differenças, que foy por as fazer perto donde estaua algúia peça de artelharia, anchoras, ou qualquer outro ferro, como me passaua a todas as partes da nao, buscando lugar conueniente a esta obra.

A seis de agosto quis saber o que variauão as agulhas neste porto de Mocambique, e fiz as operações seguintes:

Primeira operação ante o meu dia.

Estando o sol em altura de 16 graos
 ho estilo lançou a sombra 76 graos
 contando do sul pera a banda daloeste.

Segunda operação ante o meu dia.

Estando o sol em altura de 42 graos $\frac{1}{2}$
 ho estilo lançou a sombra 61 graos $\frac{1}{2}$
 contando do sul pera a banda daloeste.

Terceira operação ante o meu dia.

Estando o sol em altura de 53 graos
ho estilo lançou a sombra 48 graos
contando do sul pera a banda daloeste.

Quarta operação ante o meu dia.

Estando o sol em altura de 56 graos

ho estilô lançou a sombra 39 graos
contando do sul para a banda daloeste.

Primeira operação depois de meo dia.

Estando o sol em altura de 56 graos ;
 ho estilo lançou a sombra 25 graos !
 contando do sul para a banda de leste;

Foy logo nesta operação o arquo dante o meu dia mayor que o de depois de meu dia 13 graos $\frac{1}{2}$, os quaes partidos pello meu, vem á parte 6 graos $\frac{1}{4}$, que he a quantidade que neste lugar agulha norestea.

Segunda operação depois de meo dia.

Estando o sol em altura de 53 graos
 ho estilo lançou a sombra 34 graos $\frac{1}{2}$
 contando do sul para a banda de leste:

Foy logo nesta operaçao o arquo dante meu dia mayor que o de depois de meu dia 14 graos, cuja metade são 7, que he a quantidade que a agulha neste lugar porestea.

Terceira operacão depois de meo dia.

Estando o sol em altura de 42 graos ;
 ho estilo lançou a sombra 48 graos
 contando do sul pera a banda de leste;

Foy logo nesta operaçao o arco dante meo dia mayor que o de depois de meu dia 13 graos $\frac{1}{2}$, os quaes partidos, vem á parte 6 graos $\frac{1}{2}$, que he a quantidade que neste lugar agulha norestea.

Quarta operacão depois de meo dia.

Estando o sol em altura de 16 graos
 ho estilho lançou a sombra 63 graos
 contando do sul pera a banda de leste:

Foy logo nesta operação o arco dante o meu dia mayor que o de depois de meu dia 13 graos, os quaes partidos pello meu, vem á parte 6 graos $\frac{1}{2}$, que he a quantidade que neste lugar a agulha norestea.

Sesta feira 9 dagosto torney a verificar a variaçao das agulhas, e em todas as operaçoes me sahio 6 graos $\frac{1}{2}$ e 6 graos $\frac{1}{4}$ a quantidade que agulha noresteaua; e todo o tempo que neste porto estiuemos, ventárao os ventos leuantes, tirando douis dias que ouue hum pouco de ponente.

Operação feita pello nascimento e poimento do sol, pera alcançarmos a variação das agulhas.

Este dia apontando o sol no orizonte, ho estilo lançou a sombra na lamina encima da linha de leste oeste do circulo graduado, a saber, 90 graos do sul ou do norte pera oeste; e quando o sol se queria pôr, ho estilo lançou a sombra 74 graos $\frac{1}{2}$, contando do sul pera leste.

Foy logo nesta operação o arco dante meo dia mayor que o de depois de meo dia 15 graos $\frac{1}{2}$, os quaes partidos pello meo, vem á parte 7 graos $\frac{1}{4}$, que he a quantidade que neste lugar agulha norestea.

Notação sobre a variação das agulhas por duas vias.

Da operação deste dia, que forão 24 dagosto, se segue que oje foy o dia em que per maes prouas se vereficou o noresteear das agulhas, porque se fez esta experiencia por duas vias muy diuersas: a hñia dellas foy a via costumada, que he pella quantidade que huns arcos são mayores dos outros, de que me tenho aproprouitado neste caminho; e a outra he pelo nascimento do sol ou poimento sómente, a qual Regra não será geral, mas particular, e só áquelles que viuem em esphera Recta, ou quasi Recta, como eu estaua o dia doje; porque, como já tenho ditto na operação de quinta feira 22 dagosto, aos que tem esphera Recta acontecerá sempre, que o arco do orizonte que fica antre o sol quando nasce e a equinoctial, ao qual chamão os mathematicos largura do nascimento do sol, seja igoal á declinação que ouuer esse dia: e por quanto o dia doje temos 7 graos, 50 minutos, de declinação, se caso fôra que minha agulha julgara direito, e ferira nos verdadeiros polos do mundo, ho estilo lançara a sombra, no nascimento do sol, 7 graos, 50 minutos, de oeste pera o sul; mas a sombra do estilo cahio sobre a linha de leste oeste, ou 90 graos da linha de norte sul, que he o mesmo, Porque doutra maneira seguirse hia que o tal dia era o do equinoccio, pois o sol lhe naceo em leste; se o contrario negar a variação das agulhas, séguesse logo que, pois minha agulha amostrou que o sol nacia na linha equinoctial de meu circulo, avendo de nacer 7 graos, 50 minutos, apartado della pera o norte, que estes 7 graos, 50 minutos, norestea; e por esta maneira vem esta consideração conforme no noresteear da agulha á operação que fiz tomando a diferença dos arcos; e daquy se tira que he falsa a openião daquelles que dizem no dia do equinoccio nacerlhes o sol em leste de suas agulhas, pois em nenhña maneira pode acontecer por caso da variação que fazem geralmente.

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Primeiro Roteiro da Costa da India, 1538—1539.

Da propiadade que tem duas pedras deste ilheo (de Chaul).

Andando por este ilheo e sobindo ao monte que está da banda do Norte pera marquar e ver como jaziam os outros ilheos e baxos com ele, me aconteceo hum caso muito pera maravilhar e foi desta maneira. Pondo eu a agulha em cima de hum grande penedo pera ver como se corria o ilheo, supito deu a rosa huma volta e pos o Norte onde dantes tinha o Sul. Quando isto vi cuidando que lhe vinha este desconcerto d'estar a rosa fora do pião ergi-a pera a concertar, e como a tirei da pedra supito tornou a dar a volta e pos o Norte em seu lugar. Ora vindo a conhecimento qu'este caso tamnho nacia da calidade e natureza da pedra, a pus e tirei muitas vezes e de todas fazia a mesma operação. Espantado eu muito deste acontecimento corri a mayor parte du monte pondo a agulha em cima de todos penedos e pedras, mas nunca fez nenhuma variaçam, somente achei hum penedo apar do outro da mesma natureza, posto que neste nam dava a rosa tamnho volta; mas demorando-me qualquer marca que tomava ao Noroeste quarta da Loeste, como punha ha agulha no penedo loguo a mesma marca me demorava ao Sudueste: de modo que supitamente variava .7. quartas; porem o primeiro penedo fazia quasi dobrada ha operaçom, porque a marca que fora dele me demorava ao Noroeste quarta da Loeste, pondo a agulha em cima me ficava demorando ao Sul quarta do Sueste, que são .12. quartas de variação. Esta mudança tam descomunal nam somente se causava quando a agulha estava assentada na pedra, mas tanto que se apropincava ao penedo estando suspendida nas mãos em cima dele.

Nam val ho argumento que dixer qu'estes penedos eram da especie de manhete, porque se o foram, cortando deles alguns pedaços e trazendo-os pera derredor da agulha fizeram mover a rosa da frof de lis, do que vi a experiencia em contrario, por quanto mandando cortar muitos pedaços grandes e pequenos e chegando-os ao Norte dagulha e di passando-os per todalas partes de sua circumferencia, nenhum movimento se fazia nem a frof de lis bolia consiguo. E tambem se estes penedos foram da especie de manhete, certo he que chamaram o ferro e aço pera si, mas eles nam tem esta propiadade por que fiz eu nisto todalas provas com ferros e agulhas e outras cousas d'aço que se requerem a esta operação. Loguo nenhum dos

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argumentos he bom nem se deve de receber: mas esta duvida com ha do ilheo de Nagam fiquem pera detreminar Apolo.

Nota que estes penedos tem os sinaes que se seguem. O primeiro onde a agulha faz mayor variaçao he hum pouco agamelado, fazendo no meio huma certa concavidade; e o segundo tem humas grandes fendas que ho atravessam de parte a parte; e ambos estam muito vezinhos, e jazem ambos na chapada do monte qu'está da banda do Norte, a qual está sobre ha aberta ou degolada que vai per entraambos os montes

Notação da mudança da agulha do meu estromento.

Por quanto em aquelas couzas que jazem sujeitas e debaxo da jurdiçao das artes matematicas, a decraraçao e puntualidade he grandemente necessario, declaro que dipois de chegar á India e estar em Guoa, se perdeo ha agulhinha deste meo estromento, a qual foi feita pelo grande Joham Gonçalvez, polo que busquei muitas agulhas de relogios e mandei fazer algumas sem nenhuma me satisfazer, até que acaso dei com huma que servia em hum relgio de Alemanha, muito comprida e ligeira que me contentou muito, e loguo pera a por no estromento tive este modo; primeiro que cevasse esta agulhinha pu-la no piam e casa onde avia d'andar, endereitando-a com a linha meridiana da lamina, e notei onde a sombra do estilo cortava o circulo, e loguo incontinente tirei e a cevou o piloto; dipois d'estar cevada a pus em seu lugar, e endereitando-a como fiz dantes com a linha meridiana ou Norte Sul da lamina, a sombra do estilo cortou o circulo no mesmo lugar onde ho avia cortado de primeiro ante de se cevar a agulhinha.

Disto fiquei muito pensativo, porque o relgio donde tirei esta agulha foi feito em Alemanha e lá avia de ser cevada a agulha, com suas pedras de manhete; ora a pedra com que ao presente a toquou o piloto de novo, hera desta costa da India, e sem embarguo das regiões serem tam diferentes a propiadade das pedras parece ser huma mesma

Notação.

Nestas operaçoes que tenho ouservado de .13. de Dezembro até oje, que sain .23. do dito mez, acho duas couzas muito pera notar. A primeira he que estando no Rio do Paguode de Baçaim achei por .4. operaçoes, que fiz em hum dia, que a agulha do meu estromento Noresteava .10. graos . $\frac{1}{2}$., sendo estas operaçoes feitas com grande cuidado, e a todas esteve presente

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o Doutor Lois Nunes, jazendo a galé tam queda que a sombra do estilo nam fazia mudança pera nenhuma parte. Ora achando-me ao presente nesta barra de Baçaim onde tenho tomado tantas consideraçōis, em todas compreendi Norestar a mesma agulha .12. graos . $\frac{1}{2}$., e por quanto ao primeiro dia esta deferença me espantou muito, nam a quiz aprovar até fazer sobre isto muitos isames, os quais foram que .3. dias arrêo fiz muitas consideraçōis e em todasachei ho arquo de dipois de meio dia maior que o dante meio dia .25. graos; ametade deles são .12. $\frac{1}{2}$., que he o que nesta barra a agulha Norestea.

Certamente que he cousa muito forte em tam pequena distancia de caminho, e nhum mesmo merediano fazer a agulha taminha mudança; e se por ventura me argoirem que eu e ho Doutor julgamos mal a deferença dos arquos quando juntamente fizemos as operaçōes no Rio do Paguode, respondo que inda isto averia por mais, errarmos em .4. operaçōis e estes erros virem tam justos, que em todos achamos ho arquo da tarde mayor que ho da manhã .20. graos . $\frac{1}{2}$.. A isto nam sei assinar outra causa salvo que como quer que fiz estas consideraçōis muito pegado com a terra onde tinha por vezinho hum rochedo e penedia, ja pode ser estes penedos serem da especia e natureza do manhete, ou a materia e composição deles ser ferrenha, e per esta causa atraerem pera si o ferro da agulha desviando ho do seu natural lugar

Largura do nacemento do sol na barra de Baçaim.

Ha .24. de Dezembro de .1538. naceo o Sol .37. graos escassos de Leste pera o Sul; o estilo lançou a sombra outros .37. graos de Oeste pera o Norte.

E pola agulha .A. naceo o Sol direitamente a Lessueste.

E loguo pola agulha .B. naceo o Sol ao Sueste quarta de Leste.

E trazendo outra agulha do piloto a qual se chame .C. naceo por ela o Sol entre o Sueste e a quarta de Leste sua vezinha, tomando alguma cousa mais do rumo que da quarta.

Estando o Sol pera se por o estilo lançou a sombra .13. graos largos, contando de Leste pera o Norte.

E pola agulha .A. se pos o Sol a Oessueste.

Mas pola agulha .B. se pos o Sol justo a Loeste quarta do Sudueste.

E loguo pola agulha .C. se pos o Sol entre Oeste e a quarta do Sudueste sua propinqua, mais chegando alguma cousa ao rumo que á quarta. Do que se segue que Norestea casi quarta e meia.

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Notação.

Vendo tamanhas diversidades nestas .3. agulhas imaginei qu'estas diferenças podiam nacer dos ferros das agulhas estarem desviados do Norte e frol de lis, como muitas vezes se costuma a fazer pera se emendar a variação que fazem; polo que abri todas tres e lhes vi muito bem os ferros os quais estavam direitos e muito justos com o Norte e frol de lis das agulhas. Fora desta duvida entrei noutra, e foi parecer me que estas agulhas seriam cevadas com devairadas pedras e por tanto cada hum tiraria pera a parte onde a vertude e propiadade da pedra ha enderençasse, mas inquerindo deste caso o piloto, jurou-me que todas eram tocadas com huma soo pedra, e loguo em minha prezença as cevou todas tres, as quais tornaram a julgar como dantes, o que me deu a entender qu'a variação que fazem as agulhas he causada da materia do ferro, e nam da natureza do manhete, e que segundo o ferro for mais ou menos aceiro, assi fará incrinar a frol de lis da agulha pera aquele lugar onde tem sua natural incrinação

Nascimento do sol.

.1.

Ha .10. de Janeiro de .1539. estando o Sol no primeiro ponto de Acario, em apontando no orizonte, o estilo lançou a sombra .33. graos de Oeste contando pera o Norte; loguo naceo o Sol este dia .33. graos de Leste contando pera o Sul.

.2.

Mas pola agulha .A. naceo o Sol a Lessueste, tomado a meu joizo e do piloto obra que .4. graos pera Leste.

.3.

E pola agulha .B. naceo o Sol ao Sueste quarta de Leste tomado pera a banda de Leste obra de .4. graos.

.4.

E loguo pola agulha .C. naceo o Sol entre o rumo do Sueste e a quarta de Leste, mais chegado á quarta que ao rumo. Esta largura do nascimento do Sol tomei estando ao Norte destes ilheos casi huma leguaao ao mar.

Em quanto eu fazia estas operaçōis estava o piloto com o estrelabio na mão pera ao tempo que o Sol se descobrisse per cima da terra, a qual era alta, notar como lhe nacia pelo orizonte e graduação do estrelabio, e achou que apontando por cima da terra estava hum grao e meio sobre ho orizonte.

Este mesmo dia .10. de Janeiro estive surto por ventar todo dia o Noroeste, e fiz as operaçōis seguintes.

.1. Operação ante meio dia.

Estando o Sol em altura de 30. graos.
A sombra do nhomam estava 42. graos.
casi, contando do Norte pera Oeste.

.2.ª Operação ante meio dia.

Altura do Sol 35. graos; —
De sombra 36. graos. $\frac{1}{2}$;—
contando assi mesmo do Norte pera Oeste até o ponto ou grao do circulo onde dava a sombra do estilo.

.3.ª Operação ante meio dia.

Altura do Sol 40. graos; —
De sombra 31. graos. $\frac{1}{2}$;—
contando do Norte pera Oeste.

.1.ª Operação depois de meio dia.

Altura do Sol 40. graos; —
De sombra 53. graos. $\frac{1}{2}$;—
contando do Norte pera Leste.

Foi loguo nesta operação ho arquo de dipois de meio dia mayor que ho dante meio dia .22. graos; he o meio deles .11., os quais he a cantidade que neste lugar a agulha Norestea.

.2.ª Operação depois de meio dia.

Altura do Sol 35. graos;
De sombra 59. graos;
contando do Norte pera Leste.

Foi loguo nesta operação ho arquo de dipois de meio dia mayor que ho dante meio dia .22. graos. $\frac{1}{2}$; he a sua ametade .11. graos. $\frac{1}{4}$.. que he a cantidade que neste lugar a agulha Norestea.

.3.ª Operação depois de meio dia.

Altura do Sol 30. graos; —
De sombra 63. graos. $\frac{1}{2}$;—
contando do Norte pera Leste.

Foi loguo nesta operação ho arquo de dipois de meio dia mayor que o dante meio dia .22. graos; ho meio deles será .11. graos, os quais neste lugar a agulha Norestea.

Poimento do sol.

Estando o Sol pera se por, o estilo lançou a sombra .11. graos de Leste pera o Norte, ou .79. graos contando do Norte pera Leste, que he o mesmo; do que se segue por-se o sol .11. graos da linha da-Loeste pera o Sul.

Foi loguo nesta operação cotejando-a com a do nascimento do Sol, ho arquo de dipois de meio dia mayor que ho dante meio dia .22. graos; de que he o meio .11. graos, que a agulha neste lugar Noroestea.

Mas pola agulha .A. pos-se o sol a Oessudueste, e a joizo do piloto e meu tomava obra de .4. graos pera a linha da-Loeste.

Loguo tomado o nascimento e poimento do sol por esta agulha, acharemos ho arquo de dipois de meio dia ser igual ao dante meio dia; do que se segue que fere direitamente nos verdadeiros polos do mundo.

E loguo pola agulha .B. se pos o sol a Loeste quarta do Sudueste, e tomava pera a banda da-Loeste huma cantidade pequena que a meu ver poderia ser douz ou tres graos.

Loguo por esta agulha considerando o nascimento e poimento do sol, acharemos ho arco de dipois de meio dia ser mayor que ho dante meio dia duas quartas; das quais he o meio huma quarta, que he a cantidade qu'esta agulha, em esta operação e nas outras que atras tenho ouservado por ela, Norestea.

Ora pola agulha .C. pos-se o sol entre o rumo da-Loeste a quarta do Sudueste.

Loguo por esta agulha foi ho arquo de dipois de meio dia mayor que ho dante meio dia, se bem oulharmos o nascimento do sol, casi tres quartas; das quais he o meio quarta o meia casi, que he a cantidade qu'esta agulha nesta operação e nas outras que sam feitas com ela, Norestea.

Currelario.

Destas operaçōis que fiz oje .10. de Janeiro de .1539. per onde vim a conhecimento que a agulha de meu estromento Noroestea .11. graos, se segue que em hum mesmo merediano pode a agulha Nordestear e Norestar mais e menos, o que se prova por esta maneira: na Ilha do Paguode de Baçaim

achei que Noresteava esta agulha .10. graos . $\frac{1}{4}$., e em Baçaim .12. graos . $\frac{1}{2}$., e aguora tanto avante como estes Ilheos de Dabul, Norestea .11. graos, jazendo estes tres lugares debaxo de hum merediano; polo que parece cousa justa imaginarmos qu'estas tais variações sejam causadas dalguns particulares e propios segredos, os quais a natureza poderosa tenha guardados em suas grandes e secretas ofecinas.

Roteiro des a India até Soes, 1541.

A. vij. de Março de .1541. stando em Çuaquem, me fui pella menhaã a terra, e assentando meu stromento em huum monte muito chão, sem mais o mouer, nem bollir com elle, fiz as operaçōens seguintes.

Primeira operação ante meu dia.

Estando o sol em altura de — 38. graaos $\frac{1}{2}$. O stillo lançou a sombra. — 70. graaos. Contando do Norte pera oeste.

Segunda operação ante meu dia.

Altura do sol. — 50. graaos. De sombra do stillo. — 60. graaos $\frac{1}{2}$. Contando do Norte pera Oeste.

Terceira operação ante meu dia.

Altura do sol. — 55. graaos. De sombra do stillo. — 55. graaos. Contando do Norte pera Oeste.

Primeira operação depois do meu dia.

Altura do sol. — 55. graaos. De sombra do stillo. — 57. graaos $\frac{1}{2}$. Contando do Norte pera Leste.

Foi logo nesta operação o Arco de depois de meu dia, maior que o dante meio dia. 2. graaos $\frac{1}{2}$. cuja ametade he. 1. graao $\frac{1}{2}$. que he o que neste lugar agulha norestea.

Segunda operação depois de meu dia.

Altura do sol. — 50. graaos. De sombra do stillo. — 63. graaos. Contando do Norte pera Leste.

Foi logo nesta operação o arco de depois de meu dia. maior que ho

dāte meo dia. 2. graaos $\frac{1}{2}$. A sua metade. 1. graao $\frac{1}{2}$. que he a cantidade,
que neste lugar agulha norestea.

Terceira operaçam depois de meo dia.

Altura do Sol. — 38. graaos $\frac{1}{2}$. De sombra do stillo. — 72. graaos $\frac{1}{2}$.
Contando do Norte pera Leste.

Foi logo nesta operação o arco de depois de meo dia, maior que o
dante meo dia 2. graaos $\frac{1}{2}$. he a sua metade. 1. graao $\frac{1}{2}$. que he a cantidade,
que neste lugar a agulha norestea.

¶

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Lans des art & marq 1544 noemberge

Euer frēstlich genet zum an in mein schreyde, zu wissen die krafft
vnd iugent des magnete, so ist das den legenden geschilderte verhofftay
da nōthet gewis hab / welche tiuent auf dem grāige heilige erde
frischheit genet wolt mitangle, wo ist nu den ~~die~~ ~~die~~ inn schiffen
kum mochte? Den satz die seyn fil leichtlich zu vorstenden,
so man solle mit der handarbeit anzaget / dan mit der schiff
doch nicht ist das best furwende / so mir mittelst / solches anzen
frischheit genet im schiff zu weise / Und zum ersten alfo...
Eign isthod magnet / hat in in offe krafft und iugent / das er an einen
ort das eyen zu sich ziehet / vnd an dem andern ort gegen vber
an dem magnete / da treybt und sifchet er das eyen von sich.
Das ist klevet zu weisen / So man nimbt eyn nadel hantken
an eyne faden / wenn man den magnete dar zu hält und
das ort welches vber ~~welt~~ zu sich ziehet / das selbig ist am
magnete das mittelst ort ~~welt~~ man die nadel an den
zimble in den kompassstiel dar mit an streicht / So lafen die
selbig zimble mit dem gebek mit dem mittel zu sonder
der mitternacht zu / das ist zu weizend / an dien magnete,
Szo ist aber die nadel fahrt zu dem magnete an das ort,
welches dem vorigen ort geradt entgegen ist / So zeigt die magnete
die nadel so selbig mit mes zu sich sonder treybt und ziefet
vom sich / vnd das selbig ort / das die nadel alfo von sich
treybt / das selbig ort das ist das mitternacht tuyl an dem magneten

Und wenn man die gebete am zimole mit den stihen o. r.
rechteckig / so lafen die gebete mit gegen der mitternacht / sonder
gegen dem mittag / Mocht ist an dem magneten stijn vffes großer sich
zu verändern / Und die zimole war mit weisirthe mit geraden
laufen der mitternacht zu / sonder werden sich ab von der ersten
mittag o. aber mitternacht linie und keiner sich gegen den anfang
zu / in etliche lenden umb 5 grad / wie ich solcher selbs füden
und gesicht / hab / zu der zeit / zu com / da einer frischheit aus
marchen aufgerichtet und seyn ff d. brüder bei ein ander zu com
wurde / aber die zu vorneberg finde ich das polfer aufstieg
ist 10 gradt / und an andre o. t. mer aber minder / solches
wurde auch abgezett mit einem schwierigen stiche unter dem steyn
in dem compaste angezeigt welches stiche / wie man sieh abwege
mit geradt auf die mitternacht zu geht / sonder lendet sich geraden
gegen den anfang / an ander / sie finde sich auf d. j. an dem
magnete / Und es ist ~~etliche~~ verändert von der mitternacht und
lendet sich gegen den anfang / umb 9 grad mer aber minder
wie ich als genet hab / sonder es gehet auch unterschied / dass ist also
zu vermeiden / ist magde ein zimole eß finger langt war in
fleißig rechteckig oder wassere mag recht auf einer spiegelten stieff
stieff / also das solches meistern sich zu der ersten nacht / sonder im
ander o. t. steht in der nacht abse / so ist aber der other eß
westreich / ist stieff welches o. t. ist / so bleibt war zimole mit mer

wagrecht abse / sonder fett unterschaff ohne com g. grad mer und
minder / wassere war com g. grad / hund ist bei platt mit
wassere an zu gang / ~~etliche~~ o. t. hab ist bei platt anfang
zu finde welches o. t. an dem magneten stijl war o. t. gegen der
mitternacht / und welches o. t. gegen mittag / das hab ist Es. M. t.
also probet / das liff mir berichten eyn gross schiffel
faller wassers / nun her ist ein fein fleissig hohes schiffel /
das liff ist mitte auf dem wassere gewonne / und leget den
magneten fein garnet bin ein in das schiffel / da ist aber min
mit wenige welches o. t. an magneten mitternacht war / da keiner
sich das schiffel geanttumb auf dem wassere und gewinnt alfo
mit dem o. t. rocken ist mitternacht an / liff es kom an
der poest der schiffel ob das wassere in ff / und so oft ist
das schiffel wieder in die mitte des wasseres stelle / da keiner
der o. t. von sich ~~etliche~~ o. t. der mitternacht / so willt eng
also das ~~etliche~~ schiffel ist abse / sonder werden sich
verändert / und / wenn ~~etliche~~ der mitternacht / so ist aber min den
magneten fezzans ~~etliche~~ nam das westreich mit dem stihen
o. t. (welches juncular gen) der mitternacht zu ejlet und gewonne
das gebete am zimole / da keiner sich das zimole mit gegen der
mitternacht / wie Es. M. t. wassere / solt ihm fahre / sonder keiner
sich gegen den mittag / Eben ist schiefel was see sich Es. M. t.
an o. t. probt sich vor vorberste

13^m dem feste hab ich für den Mat. antheil ein zweyde gross
 finger langt und gestelt auf jed spitzig stift und hab mit
 mehre peile felde solches zu decken das durch die fende solches
 mit anzutreten ob ist das zweyde für und für gekloppet und sich
 manegt vom aufgang durch den mittag bis wider in aufgang
 für und für so tunc off ist die fende wider das von ihm hab
 et auf selgam zu seien // ob hat er als primata prae in
 dem heilige zeit überkommen / in welcher ob auf fide die kraft
 des magnetis / wie zu magne / ist es instrument durch den magnet
 naches sich für und für manegt in gleicher form zeigt und zeigt
 wie sich der hund wendet / also das rute der hund sich in zu
 junde) egual und das erzt auf sich manegt / das mit auf des istz
 mit in den magnetis zu gericht / auf oberbez mass zeigt und zeigt
 stande) ist brecht wendet / ob von ic mit fel recht halten
 So ist nun für ~~der~~ ~~der~~ mit eye proben verstandt / ob wendet
 Es: Mat. von mi / den auf dem magnetis prae zu habe / ob gab
 ob Es: Mat. offe anwoht / ob hat erz Es: Mat. zu den orten
 mal auf prae wolle schenke / habe mir über Es: Mat. abwech
 zu anwoht habe / soll Es: Mat. wolle mich auf / so ist zu magne
 arbeit teglich wölle gebraude in wezimbi / was min angeze pfele
 von mir zu habe / Also sprach Es: Mat. zu ^{erwerbt} / ich wiste da zu
 mal mit / das in groen magnetis habt / dan aller erst bis auf ^{zu} groar zu
 wozd / also schenke ich Es: Mat. den magnetis / Dan ~~der~~ wile ic zu
 eilig magne sat / und wider kiff empfinge von jordan / ob
 Es: Mat. magne zu wissen / was ist magne der zeit furwurk f^{ür}
 Solche jordan alle ein vor f d. vol auf machen mo Es: Mat.
 etwa ein gutes stücke magne sat / aus so vñ ic / ist alles
 langlich zu wozd zu jordan

laus deo adi 4 Marcij 1544 noremberge

Euer fürstlich Gnad zeigt an in ihrem Schreiben zu wissen die Kraft und Tugend
 des Magneten, so ich königliche Majestät den legteren gehaltenen Reichstag zu Nürnberg
 gewiesen habe, welche Tugend auch von ganzem Herzen eure fürstliche Gnad wollte
 mittheilen, wo ich nur das in Schriften könnte verfassen, denn solche Dinge sind viel
 leichter zu verständigen, so man solche mit der Handarbeit anzeigt, denn mit der Schrift.
 Jedoch will ich das beste fürwenden, so mir möglich, solches eurer fürstlichen Gnaden
 in Schriften zu weisen.

Und zum ersten also: Ein jeglicher Magnet hat in ihm diese Kraft und Tugend,
 daß er an einem Ort das Eisen zu sich zeucht, und an dem andern Ort gegenüber an
 dem Magnetem, da treibt und schiebt er das Eisen von sich. Das ist klarlich zu
 erweisen, so man nimmt eine Nadel hängend an einem Faden, wenn man den Magneten
 darzu hält; und das Ort, welches die Nadel zu sich zeucht, dasselbe ist am Magneten
 das mittägliche Ort, und wenn man die Gabele an dem Züngle in den Compassen darmit
 anstreicht, so laufen dieselbigen Züngle mit dem Gabele nicht dem Mittag zu, sondern
 der Mitternacht zu. Das ist zu verwundern an diesem Magneten. So ich aber die
 Nadel halte zu dem Magneten an das Ort, welches dem vorigen Ort gerad entgegen
 ist, so zeucht der Magnet die Nadel daselbst nicht mehr zu sich, sondern treibt's und
 blaßt's von sich, und dasselbe Ort, das die Nadel also von sich treibt, dasselbe Ort
 das ist das mitternächtige Theil an dem Magneten, und wenn man die Gabele an dem
 Züngle mit demselbigen Ort verspreicht, so laufen die Gabele nicht gegen die Mitter-
 nacht, sondern gegen den Mittag. Noch ist an dem Magneten dieses grösster sich zu
 verwundern, daß die Züngle darmit verstrichen nicht gerade laufen der Mitternacht zu,
 sondern wenden sich ab von der rechten Mittag- oder Mitternachlinie und kehren sich
 gegen den Aufgang zu, in etlichen Ländern um 6 Grad, wie ich solches selbst gefunden und
 gesucht habe, zu der Zeit zu Rom, da einer fürstliche Gnad Markgraf Gumprecht und
 sein f. G. Bruder bei einander zu Rom waren, aber hier zu Nürnberg finde ich, daß
 solcher Ausschlag ist 10 Grade, und an anderen Orten mehr oder minder. Solches wird
 auch allzeit mit einem schwarzen Striche unter dem Gläsle in den Compassen angezeigt,
 welches Striche, wie man sieht, allewege nicht gerade auf die Mitternacht zeigt,
 sondern lenket sich herum gegen den Aufgang.

Zu dem anderen, so finde ich auch dies an dem Magneten, daß er sich nicht allein
 wendet von der Mitternacht und lenket sich gegen den Aufgang, um 9 Grad mehr oder
 minder, wie ich es gemeldet habe, sondern er zeucht auch unter sich. Dies ist also zu
 erweisen. Ich mache ein Züngle eines Fingers lang, das nur fleißig wagrecht oder
 wasserwagrecht auf einem spitzigen Stift steht, also daß solches nirgends sich zu der
 Erde neige, sondern an beiden Orten gleich in der Wage stehe, so ich aber der Verte
 eins verspreich, sei gleich welches Ort sei, so bleibt das Züngle nicht mehr wagrecht
 stehen, sondern fällt unter sich etwa um 9 Grad mehr oder minder. Ursach, warum das
 geschieht, habe ich Königl. Majestät nicht wissen anzuzeigen.

Zu dem dritten habe ich Königl. Majestät angezeigt zu finden, welches Ort an dem Magneten sei das Ort gegen die Mitternacht, und welches Ort gegen Mittag. Das habe ich Königl. Majestät also probirt. Ich ließ mir herbringen eine große Schüssel voller Wassers; nun hatte ich ein feines kleines hölzernes Schüsselchen, das ließ ich mitten auf dem Wasser schwimmen, und legte den Magneten fein gemacht hinein in das Schüsselchen. Da ich aber nun nicht wußte, welcher Ort an dem Magneten mittnächtig war, da kehrte sich das Schüsselchen gerad um auf dem Wasser und schwamm also mit dem Ort, welcher ist mittnächtig am Stein, bis er kam an den Bord der Schüssel, da das Wasser in war, und so oft ich das Schüsselchen wieder in die Mitte des Wassers stellte, und kehrte den Ort, den ich gefunden hatte, gegen die Mitternacht, so blieb doch also das Schüsselchen nicht still stehen, sondern wendete sich wieder um und schwamm gegen die Mitternacht. Da ich aber nun den Magneten herausnahm und bestrich mit demselbigen Ort (welches immer gegen die Mitternacht zueilt und schwamm) das Gäbele am Jüngle, da kehrt sich das Jüngle nicht gegen die Mitternacht, wie Königl. Majestät vermeinten, sollte thun haben, sondern kehret sich gegen den Mittag. Kann nicht schreiben wie sehr Königl. Majestät an dieser Probe sich verwunderte.

Zu dem vierten habe ich vor Königl. Majestät genommen ein Jüngle eines Fingers lang, und gestellt auf einen spitzigen Stift, und habe mit meinen beiden Händen solches zugedeckt, daß doch die Hände solches nicht anührten. Da ist das Jüngle für und für gelaufen und sich bewegt vom Aufgang durch den Mittag bis wieder im Aufgang, für und für so lange, bis ich die Hände wieder davon thun habe. Ist auch seltsam zu sehen. Ich habe ein altes Pergamentbuch in dem Bauernkriege überkommen, in welchem ich auch finde die Kraft des Magneten; wie zu machen sei ein Instrument durch den Magneten, welches sich für und für bewege in gleicher Form, Zeit und Weil, wie sich der Himmel bewegt; also daß wie der Himmel sich in 24 Stunden einmal um das Erdreich sich bewegt, daß auch alles dies Instrument mit dem Magneten zugerichtet, auch gleicher Maas Zeit und in 24 Stunden sich herumbeweg, davon ich nicht viel wollte halten. Da ich nun vor Königl. Majestät mit diesen Proben bestand, da begehrte Königl. Majestät von mir einen Magnetstein zu haben. da gab ich Königl. Majestät diese Antwort: Ich habe euer Königl. Majestät zu dem dritten Male diesen Stein wollen schenken, haben mir euer Königl. Majestät allwegen zu Antwort gegeben, euer Königl. Majestät wolle mich des, so ich zu meiner Arbeit täglich muß gebrauchen, nicht berauben, und nun begehrten solchen von mir zu haben. Also sprach Königliche Majestät zu mir lachend: ich wußte dazumal nicht, daß ihr zwei Magnete hättest, denn allererst bis ich's jetzt gewahrt bin worden. Also schenkte ich Königl. Majestät den Magneten, dagegen mich ihre Majestät ehrlich begabt hat, und wieder Brief empfangen von Prag, da Königl. Majestät begehr zu wissen, was ich Weiteres der Zeit hernach gefunden hätte. Solche Proben alle kann euer f. G. wohl auch machen, wo euer f. G. etwa ein gutes Stück Magnet hat, das da gut ist, ist alles leichtlich zuwege zu bringen.

Georgius Hartmann Vicarius Sancti Sebaldi Noremberge.



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GERHARD MERCATOR

De ratione magnetis circa navigationem.

R^{mo} Dno Antonio Perrenoto Atrebatum Episcopo dignissimo Gerardus Mercator Rupelmodanus S. P.

Subinde mirari soleo R^{me} praesul quotiescumque navigationias chartas inspicrem, qui fieri possit ut navigationum cursus justa locorum distantia emensi, aliquando majorem faciant eorundem latitudinalem differentiam quam vere existat, nonnunquam e diverso minorem, iterumque saepius in justam latitudinis differentiam propositorum locorum excurrant. Ea res cum diutius me teneret anxiū, propterea quod navigatorias omnes, quibus plurimum castigari posse sperabam geographicos errores, nimium viderem a scopo aberrare, cepi ego diligentius errorum causas perquirere, potissimumque inveni in magnetis ignorata conditione consistere. Non enim in idem semper vergit punctum ubique terrarum lingula quae magneti attrita est, ut opinantur naucleri simulatque hydrographi, sed ad omnem latitudinis longitudinis mutationem alio atque alio dirigitur, quare fit ut quivis cursus, verbi gratia qui in ortum vergit atque occasum a vero illo cursu nunc in meridiem paulatim magis ac magis deflectat, itaque littora sensim faciat quae debeant esse septentrionaliora, quemadmodum in littoribus Africae a Gaditano freto Carthaginem usque videre est, nunc in boream deviet, adeoque in austrum magis diducat littora quod e diverso Carthagine Gades navigantibus evenit. Rectius igitur de navigandi ratione indicandum erat hydrographis, qui maritimā terras ex inventis navigationum cursibus depingerent, alioqui nec sibi nec geographicis aliquo modo satisfacturis. Quo igitur sit loco punctus ille, quem tantopere sectatur magnes, quantum nunc licet R^{mae} D. T. in genere palam faciemus. Primum hoc experientia constat uno eodemque loco a vero septentrione in eandem semper partem declinare lingulam nauticam. In coelo igitur punctus hic nequaquam erit, nam cum praeter cardinem omne coeli punctum circumducatur, necessario modo hac modo illac oberraret lingula ad sui in coelo puncti diurnam circumductionem, itaque in utramque vicissim partem declinaret, quod negat experientia. In terra igitur quae fixa manet hic punctus investigandus est. Separatis itaque justa longitudine Walchria insula Zelandica ac Dantisco, littoribusque intermediis ex nauclerorum sententia

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descriptis exquisitissime, invenio Dantiscum 1 gradu fere septentrionalius reddi quam revera existat, unde colligo lingulae nauticae extensionem Dantisci — 5 gradibus amplius declinare a vero septentrione quam in Walchria. Vicinis autem Walchiae locis 9 gradibus lingulam a vero septentrione recedere in ortum didici. Declinabit itaque lingula haec Dantisci 14 gradibus. Jam si per utrumque observationis locum ducantur circuli maximi secundum eam quae inventa est declinationem ab utriuslibet meridiano, reperietur hujusmodi circulorum intersectio fere in longitudine 168 graduum, latitudinis vero 79, atque hic magnetis polum esse necesse est. Sub hoc itaque meridiano quoties erit lingula ipsum septentrionem indicabit, verum si ab eo (qua parte propinquior est Europae) in orientem navigetur continuo magis magisque in orientem declinabit a vero septentrione, idque sub majori latitudine amplius, quounque ad quadrantis longitudinem ventum erit, hinc deinceps inclinatio minuetur pari modo, donec 168 graduum longitudinis meridianum attigerit, unde contraria ratione in occidentem vergere incipit lingula usquedum longitudinis quadrantem expleverit, reliquum longitudinis disparem hujusmodi meridiani lingulaeque cursum ad aequalitatem reducit. Quod autem haec nostra consideratio in hunc fere modum se habeat, testis est Canadae illa descriptio, quam R. D. Tuue obtulimus, cum enim juxta navigationum decursus ex Europa factos Canadam pinxit hydrographus, quisquis fuérit, distributis latitudinum gradibus proxime Europam pro ejus exigentia, coactus fuit aliam latitudinis scalam Canadae suae adponere, quod inclinata in occasum a septentrione lingula locorum latitudines experientia majores faceret, quare in boream magis latitudinum numeros promovere coactus est. Medio igitur uspiam loco Canadam inter Europamque necesse est communem mundo magnetique meridianum existere. Atqui hunc, polumque magnetis eo fere loci consistere quo diximus, considerata Canadae longitudine, ex latitudinem Canadae Europaeque adscriptarum differentia possemus demonstrare, si pro rei magnitudine temporis suppeteret copia. Sed quoniam multa essent alia, et quidem difficilia in navigationum chartarumque marinorum castigationem dicenda, satis erit R. D. Tuue spero universae ejus speculationis fundamentum magnetis polum utcunque indicasse. Si quando gravioribus contingat sublevari oneribus, statui hanc rem justo opere prosequi et absolvere. Interim R. D. Tuue me commendatum cupio, quam foelicissime valere cupio, Lovanii pridie Mathiae, anno 1546.

R^{ma}e D. T.



semper devotissimus

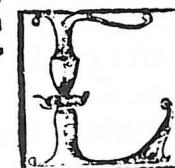
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Breue compendio de la sphera y de la arte de nauigar con nuevos instrumentos y reglas exemplificado con muy subtiles demonstraciones compuesto por Martin Lortes natural de burjalaro; en el reyno de Zragon y de presente vezino de la ciudad de Cadiz dirigido al invictissimo Monarca Carlo Quinto Rey de las Espanas etc. Señor Muestro.



Proprie-
dades de la
piedra y
man.



Cap. iij. d la virtud y propriedad d la piedraymá.

Cusano
Cardi. li.
S. expositi
orum.

Platina
de vita su
mo ponni
ficum.

Hallase
piedra y
man en
espana

La pie
dra y man
de dina
marca la
mejor.

Plin. li. 36
ca. 16.

Sotcas.

Cuando la piedra y mā segū escriue el cardenal cusano tiene essēcia virtud y opació. La virtud es egēdrada d la essecia: d la essecia y virtud nasce la operació: d manera q comunicādola la piedra su virtud al fierro por razó dsta haze al fierro que se mueua aunque entre el y ella este vna taça de plata o vna tabla o otra cosa semejante. La fuerça atractiuia d la piedra y man haze al natural eza dls fierro estar en si y cō qetud tāto q ser graue y pōderoso no dsciede porq la naturaleza dste fierro no qda enl mas rñese cōla natural eza d la piedra: la ql pesce q se va extēdiédo: dnde vemos q por esta vnió sucede no solo atraer este fierro mas este a otro y otro a otro y se haze vna sarta como muestra la experiecia. Sicut augustin se marauillo segū escriue en los libros d la ciudad de dios porq sobre vn vaso vio vn fierro menearse meneando la piedra y mā dbarri picora. Yo dí vaso: llamasé magnes porq el inuētor de lla así se llamaua: el ql (segū escriue plinio) estādo en la india oriental guardado ganado trayado el calçado clauado y ferrado por dbaro (sería como esclopes d gascuña o cuecos d castilla.) En el bordón trayado punta o regaton d fierro: y hallándose sobre vna qntidad dsta piedra no podía mouer los pies ni leuantar el cayado o bordo: pues como vn rato ygnorase la causa poco a poco vino a entēderlo q hasta allí no entēdia y conoscio la propiedad d la piedra y la virtud atractiuia qtenia: su color no difiere d la del

El fierro átes por esta causa fue llamado fierro binio. La mejor piedra y man es de color ceruleo la qual color a veces tiene la mar: hallaron cinco especies o differēcias d la piedra y mā: la primera ethiopica: la segunda manesca de macedonia contermino alos que van al lago d boveyda ala mano derecha: la tercera lechío de boecia: la qrtá troade cerca d alexándria: la qnta y manesca dasia: mas agora se halla en otras diuersas partes ay la en españa en muchos lugares hallase en sierra morena juto ala villa d la calera que es d la ordē de santiago en la provincia d leon. En vna sierra d moron tierra del cōde de vreña ay gran qntidad dlla y en otras partes. La mas comū piedra y dela q mas usamos es dela isla de lelua del señor de pomblin: la q yo tengo por mejor es de dinamarca. Esta y las de mas tienen virtud propia d atraher así el fierro: verdad es q teanpedes escriue que en ethiopia se halla otro genero d y man q aparta y desecha d si el fierro. El comētadur niega q la piedra y man atraiga así el fierro mas dice q el fierro por natural inclinació se mueve a la piedra como a su natural lugar por vna qlidad q la piedra imprime enl fierro. Allende dsta virtud y propriedad q tiene d atraher así el fierro tiene otra y es q da al fierro virtud y potencia pa q señale los dos pútos d l orizote do le corta el meridiano qdlos dos viétos norte y sur: esta virtud se halla mas intesa en solas dos ptes d la piedra y estas ptes siempre estā oppuestas: y así sō cōtrarias en la operació porq tocado

el fierro cō la vna y puesto do se pue da mover
libremente señalara el norte: y otro fierro toca-
do con la otra parte señalara el sur: haziēdo es-
ta experienzia se sabe qual parte de la piedra
corresponde al norte aq los marineros llaman
Talibad
estapiedra
esta pie-
tra. cara dela piedra y qual al sur. Es tā necessaria
esta piedra q sin ella la nauigaciō feria falta ri-
certa: por que ella da vida al aguja: y el aguja
guia al piloto pa q dīa acierte: y dī noche no y-
erre. Muestra a cercar climūdo da a conocer
los viētos: y pues estā necessaria el aguja dīmos
orden y manera como se ha de hazer por que
podria ser que en el viaje faltase o se perdiese.

C Capítulo. iiiij. dela fabrica dela agu- ja o bruxola de nauigar.

Fabricas
la aguja.

Tomes en un papel como dī naypes: y
de se en el un circulo de quantidad dī
una mano poco mas o menos - ē el ql
se han de pintar los. 32. vientos con
las colores y en la orden q dīmos en el primero
y segundo cap. de los vientos y dela carta: no
oluidando de señalar el norte con una flor de
lys: y el leuante con una cruz: y dī mas dīsto ca-
da uno segū su phantasia los hermoseara y a-
graciara: despues por la pte bara dīste papel
se ha dī dar una linea qste dīrechamēte haro de
la dīl norte sur la qual sera señal para el asētar
los fierros o azeros: y despues se ha de tomar
un filo fierro o azero tā grueso como un alfi-
ler gordo o segū el tamaño dīl redodo dīl papel
rosa aguja o bruxola que ya se puede llamar:

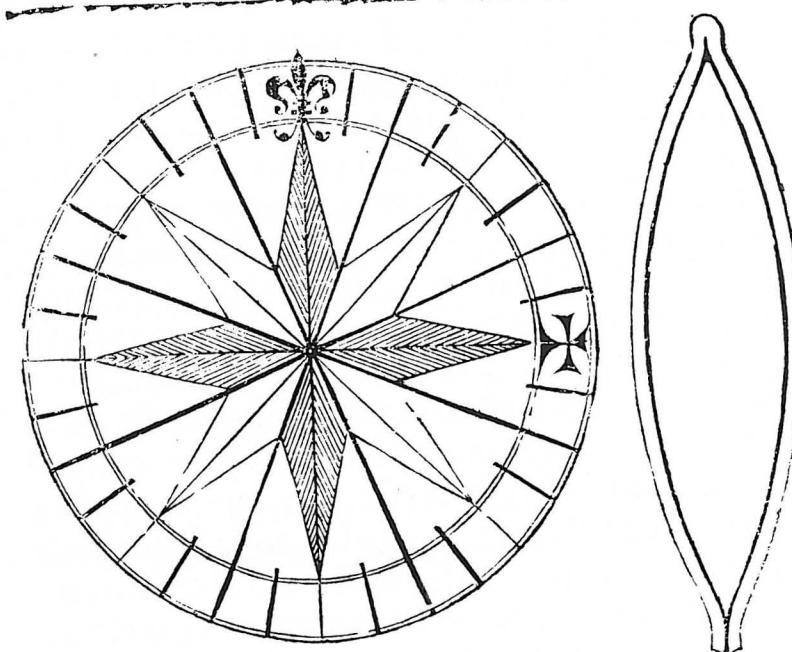
este

Este fierro se ha de doblar y q cada vna dīlas p-
tes y qualmēte sea tan luenga como el diametro
dīla bruxola y mas la qrtā parte. Los cabos
o puntas dīstos fierros o azeros se han dī apre-
tar y ajustar: y en los medios se ha dī abrir o ap-
tar uno dī otro hasta q los cabos vengan a ygu-
lar con las extremidades del diametro de la
bruxola: y asi quedará los azeros quasi en figu-
ra oval. Estos fierros se ha dī de apagar por la p-
te baxa dīla bruxola dī manera q sus extremi-
dades o puntas vengan precisamente por la li-
nea dīl norte sur: y para fixar los asi se ha dī co-
brir con un papel delgado engrudado dīrando
las pūtas o extremidades dīl fierro dīscubiertas.
Y estas extremidades se ha dī tocar en la piedra
y man en esta manera la pte q esta abaxo de la
flor dī lys se ha dī refregar en aquella pte de la pie-
dra q correspōde al norte (segū se dīo en l capi-
tulo pasado) y esto bastaua para la pfectiō dī
aguja: pero algunos querian para su perabūban-
cia tocar la otra parte del fierro con aquella p-
te de la piedra que corresponde al sur: y tam-
biē bastaua tocar cō sola esta parte. Este toca-
miēto dīl fierro cō la piedra pa q la virtud dīmō
stratua sea engēdrada se ha dī hazer dando cō
un martillo algūos golpes en aquella pte dīla pie-
dra q se ha dītocar: esa saber en l norte o en l sur:
y allí le saldrā vnas barbas dīde se ha dī refregar
la pūta dīl fierro como q en lo amolase: y qdar le
ha apegadas algūas dīlas dichas barbas dīla pie-
dra: y asi tocados y pegados los fierros ha se dī
tomar una pūta dīlatō dī figura piramidal q es

baro ancha y arriba haze punta : ésta se haze redonda o ochauada como mejor paresce y por lo barco o ancho se ha de barrenar con vn tala dro y el barrenjo ha de ser de forma piramidal y ha de entrar en el piramide hasta medio o algun poco mas. Este piramide aque los marine ros por la mayor pte dizen chapitel ha de tener de alto vn dedo de traues o segun el aguja fure: y ha de encarar por el centro dela bruxola como la punta salga por la parte alta: y alli se ha de pegar y bien firar: despues se ha de to mar vna caxa redonda de madera hecha entorno donde el aguja pueda estar sin tocar en las paredes dela cara y ha de ser tan alta como el semidiametro del aguja: el suelo desta caxa ha de estar postizo por que se pueda qtar y tornar a poner para tornar atocar co la piedra los azeros (a q dizen ceuar) quando sea menester: por q no le falte ala aguja la virtud. En el medio del suelo desta cara se ha de poner vna punta de hilo de laton aguda y drecha hazia arriba: y sobre esta pûta ha de andar la rosa o bruxola asentando sobre la punta el agujero del chapitel: y porque no le entre viento por la parte d arriba se ha de cobrir esta cara con vn vidrio: y asi tocada dela piedra y puesta sobre la pûta señalara la parte del norte y por consiguiente todos los otros vientos. Es bien notar q despues de tocada el aguja en qualquier dtas maneras si allegan la parte del norte d la piedra al norte del aguja el norte del aguja se allegara a ella: y si la allegan ala parte d sur del aguja

huya

huya della y por el contrario si allegan el sur d la piedra al sur del aguja se allegara a ella: y si al norte huya. Esto se entiende estando la aguja libre como se ha de asentar: y es tambien esta buena señal para conocer q sea el norte y el sur dela piedra. Allende esto ha de poner esta cara en otra sobre dos circulos enerados uno en otro: q siruan para que no penda el aguja aun que penda la nao: y tambien esta cara ha de tener su cubierta de madera para q guarde la otra: y ha de aduertir q la punta d la piramide o chapitel y su agujero y la pûta sobre q âda esten derechos y tambiê la rosa q no dcine a vna ni a otra parte: y si fuere mas ligera dlo que es menester hagan la punta sobre que anda algo mas bota:



C Capítulo, v., de vn effecto que tiene el aguja que es nordestear y noruestear.

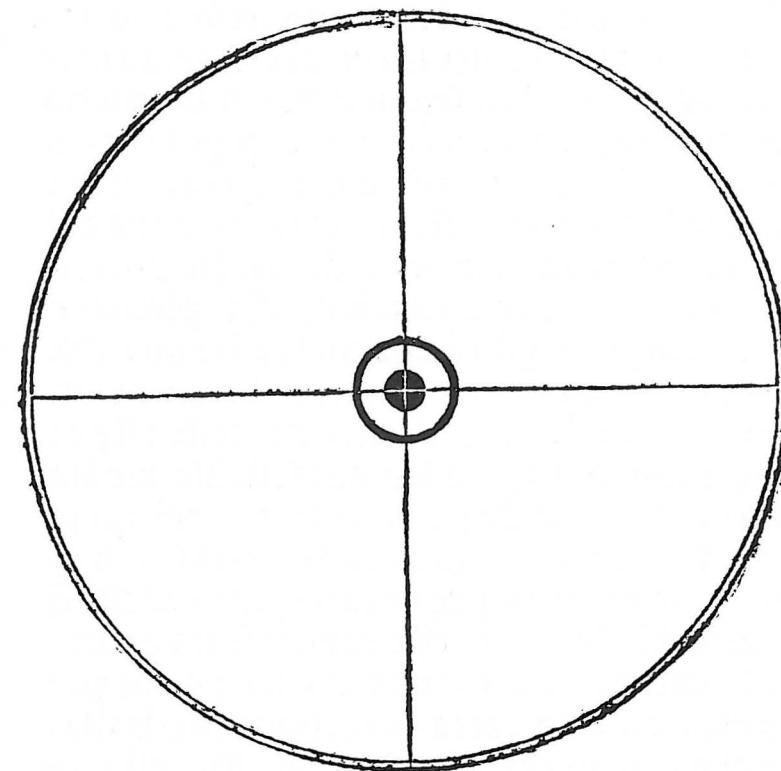


Uchass y diuersas sō las opiniones q̄ he oydo y en algunos modernos escriptores leido a cerca del nordestear y noruestear delas agujas y amí parescer ninguno da en el fiel y pocos en el blāco. Dízen nordestear quando el aguja enseña del norte hazia el nordeste. Y noruestear quādo del norte declina hazia el noroeste. Para entendimēnto destas diferencias que las agujas diffieren del polo hase de imaginar(estando en el meridiano dō las agujas señalan el polo)vn punto baro d̄l polo del mundo y este pūto este fuera de todos los cielos contenidos baro del primer mobile. El qual punto o parte del cielo tiene vna virtud attractiuā q̄ attrahē así el fierro tocado cō la parte dla piedra y mā correspodiēte a aqlla cierta pte del cielo imaginada fuera d̄ todos los cielos mouidos del pmer mobile: porq̄ si en qualqer dlos cielos mouidos se imaginase mouerse ya el pūto attractiu al mouimēto del pmer mobile y por consi guiente el aguja haría el mesimo mouimēto en veite y q̄tro horas: no se vee assi: luego este pūto no esta élos cielos mouibles nítā poco esta enl polo porq̄ si enl estuviessse el aguja no nordste aria ni noruestearia: luego la causa dñ nordestear y noruestear o aptarse d̄l polo dñ mundo es que estando enl dicho meridiano el punto attractiu y el polo estan en aquel mismo meridi-

ano y señalado el aguja el punto señala dñ chamēte el polo: y caminando d̄ aq̄l mismo meridiano al leuante(como el mundo sea redodo) va se quedado el polo del mundo ala mano yzquierda: y el pūto d̄ la virtud attractiu nos estara ala mano derecha(q̄ es fazia el viēto nordoste) y quanto mas al leuante caminaremos mayor nos parecera la distācia hasta llegar a nouenta grados y alli sera lo que mas nordesteara: y pasando de alli mas adelante nos parecera que se va allegando el punto attractiu ala linea meridiana: y al tanto yra el aguja emendando el nordestear hasta tornar al mismo meridiano en la parte opposita de to començaron y entonces les estara el punto attractiu sobre el polo del mundo y señalara el aguja derechamente por el: y pasando de alli a delante quedara el polo del mundo ala mano yzquierda: y así començara el aguja a noruestear acrecientandolo hasta llegar de alli a los nouenta grados: y alli sera lo mas que noruesteara. Porque tornando fazia el meridiano del punto attractiu se yra emendado hasta tornar al mismo meridiano donde partio y alli señalara el aguja el polo del mundo derechamente por el punto attractiu: que perpendicular esta baro del polo. Es si de alli tornasen a caminar fazia el occidente que daria el polo ala mano derecha y el punto attractiu ala mano yzquierda: y así noruestearia

el aguja. Esta es la causa del nordestear y norestear de las agujas. No se ha de entender que este nordestear y norestear sea uniforme segú lo que se aparta díl meridiano do el aguja enseñia bien; antes alos principios que se va apartando del dicho meridiano haze diferencia en cantidad: y lo que despues va acrecentando es poco: y tanto mas poco quanto mas se aparta del dicho meridiano; por que es passion de circulos intersecantes en la sphera. Así que son las differencias como las declinaciones del sol - q cerca delos equinoccios son grandes - y cerca de los solsticios pequeñas: todo lo qual euidentemente parescera en la figura siguiente: que es vn circulo al qual diuidé dos diametros en quatro partes yguales cortandose por el centro en angulos rectos: y del punto centro (q polo sedize) sale vn meridiano mouible y enel anda vna aguja tambié mouible cercando el circulo. Esta el punto attractivo algo apartado del polo del mundo y del sale vn hilo el qual siempre ha de passar por el norte sur díl aguja: y estando el aguja en el meridiano del punto attractivo que pasa por el polo señalará el polo: y fuera díl nordestara o noresteara apartando se díl meridiano vero que sale del polo del mundo. Es opinion dalgunos marineros que el meridiano (do enseñan las agujas el polo) pasa por la ysla d santa maria - y otros por la ysla del cueruo en los açores.

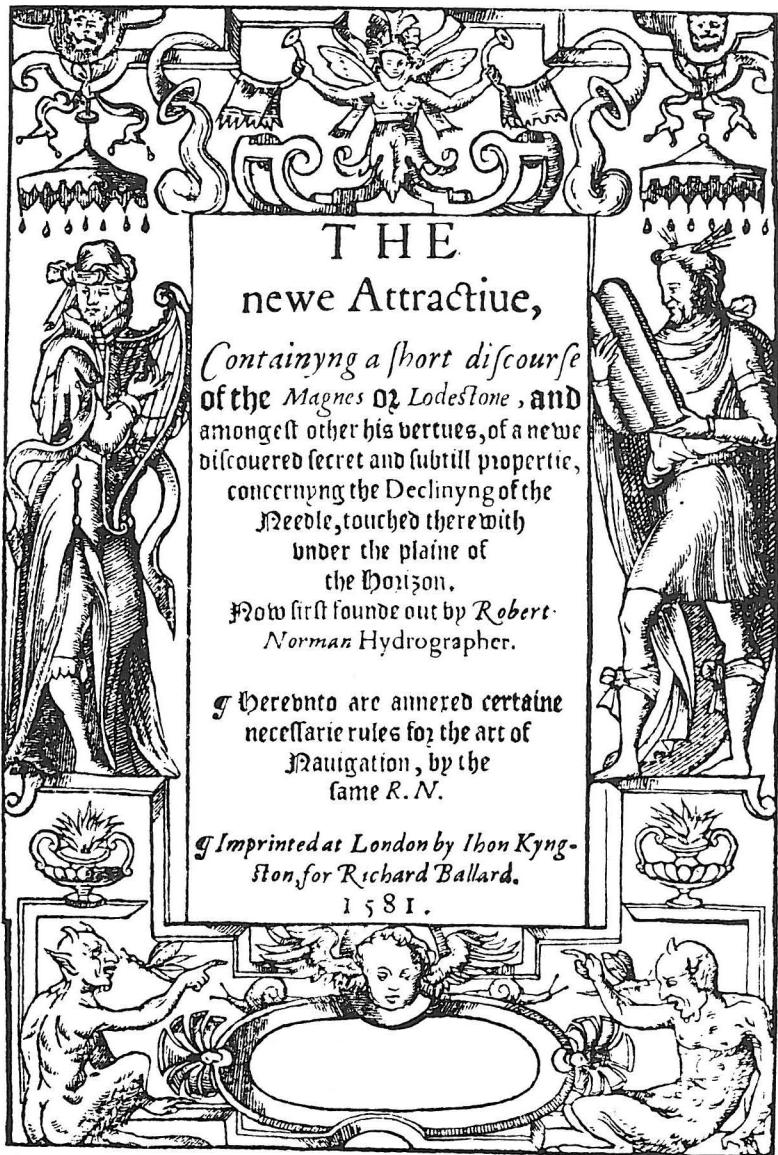
¶ De monstracion del nordestear.



Pues el inconueniente es notorio digo q re medie cōtiēpo la prudēcia - y no se de scuyd enl viaje vsando siempre dla experiecia q les traera mas puecho que las subtilez y limadas questiones destos secretos naturales. D esta manera el sabio piloto ha de saber por experiecia lo que la buena aguja (sin defecto de

los que algunas suelen tener) nordestea o no-
ruestea de vn puerto a otro. Si que sepa de
tal lugar a tal lugar el aguja nordestea - o no
nresteavn tanto(si quiser sea media quartao mas
o menos cantidad segun distaren del dicho
meridiano do las agujas señalan el polo) y en
la nauegacion dara el resguardo q enel tal via
je nordesteare o nresteare en los vientos del
aguja: y sera caminar verdaderamente por los
vientos q la carta cierta señala. Exéplo: nau-
gado de alguna ysla q este enel dicho meridia-
no o de otra qualquier parte: en busca de vn
puerto q les este al verdadero nordeste: si por
aquei camino el aguja les nordestease media
quarta: nauegando por los vientos del aguja
nordeste media quarta al norte: scria su nau-
gar(salvo otros impedimentos) al nordeste q
la carta señala: y por este rumbo se ha de ha-
cer la cuenta dela tal nauegacion: y assi por
los vientos dela carta derechamente halla-
ran el mismo puerto que buscan. Por esta or-
den se han de gouernar en toda la nauegació-
para lo qual es cosa conueniente que los sa-
bios y experimentados pilotos hiziesen no-
tas delos resguardos del nordestear: y nro-
tear q're ay de puerto a puerto: y hecha copia
lació destas notas lleuarla por regimiento en
los naüios: y no curen de emendar las agujas
apuntandolos fierros o azeros a vn lado ni a
otro de do la flor de lys señala: porque causa-
ria muchos inconuenientes: ni menos se de-
ue admitir enlas cartas dos graduaciones
espe

especialmente q para saber lo que en cada lu-
gar el aguja se apta del verdadero meridiano
se puede facilmente hazer instrumeto q lo seña-
le d dia por el sol y de noche por las estrellas.



The New Attractive.

C H A P. I.

Of the Magnes or Loadstone, where they are found, and of their Colours, Weight, and Virtue in drawing Yron or Steele; and of other Properties of the same Stone.

THE *Magnes* or *Loadstone* is found in divers Parts of the World, and most commonly in Yron Mines; and although it be ponderous and weighty, yet it is not found to be of the Yron Ewre, neither conteyneth in it any Mettal of it self, but hath a certain Affinity unto Yron or Steele. It was called *Magnes*, because the first Finder thereof was so named, who (as *Plinie* writeth) was an Herdsman in *East India*.

This Stone (as writeth Cardinal *Cusan*) hath Substance, Virtue, and Operation. His Virtue is conserved and nourished of his Substance: And of this Virtue proceedeth divers strange Effects and Operations, serving to many good Purposes, as specially in the Art of Navigation, without which there could have been no Discoveries by Sea, nor the Parts of the World made known and frequented as now they are; and therefore the Virtue of this Stone, of all others, may be accounted the most precious.

Of these are divers Sorts differing each from other, as well in Goodnes, as in Colour, Weight, and Force, but not in Property, (although many have judged the Variation of the Needle to be according to the Distance of the Mine where the Stone was bred, to the Place where he is used.)

The first and best Sort of these Stones come out of the *East India*, from the Coast of *China* and *Bengalia*, and is of the Colour of Yron, or Sanguine Colour. These Stones are very maffive and weighty, and will draw or lift up the just Weight of it self in Yron or Steel, (if the Stone exceed not a Pound Weight.) And these are of the finest Sort, and are sold commonly for their

(3)

The best Loadstone. proper Weight in Silver in the *East India*, where they grow, because the best and finest are very rare to be found: For it is commonly a sole Stone, lying by himself in the Earth, and no Shell or Piece of another.

Next the best. There is another Sort, of a Reddish Colour, found in *Arabia* and the Red Sea, growing broad and flat, much like to a Tilestone or Slate: This is not so weighty as those of *China*, but it is very near as good, and the Virtue continueth long on the Compas or Needle that is touched with it.

There is likewise of these Stones in *Levant*, in the Isle of *Elba*, hard by a Town in the same Island called *Porto Feraro*, from whence our Mariners daily bring of them, and are called there, *Calamita Preta*, that is to say, *the Black Magne*; because there is another Sort that is White and light, like unto a Piece of dry Fuller's Clay, and is called *Calamita Blanca*.

This *Calamita Blanca* is found always with the other, sticking fast in the Outside thereof like Clay. And this White is forbidden to be used in that Country, because evil Women there do apply it to destroy Conception, whereof this Stone is a great Enemy. Other things are noted of this White *Calamita*, for obtaining of wanton Purposes, which I think not credible, and therefore will omit it. These Black Stones of *Elba* are mingled with White Veins; they are of no great Force, nor their Vertue of long Continuance.

Also there are of these Stones in *High Almaine* that are full of Holes like an Honey-Comb, and lighter than the other, but yet very good: and these are of Yron Colour.

The worſt. Another Sort there is in *Norway*, in the Yron Mines, as in *Longfounde*, and other Places; their Colour is Black, mixed, or as it were interlarded with Grey: These are of the smalleſt Force of any that are found.

I have ſeen also in the Mines of *Carauaca* in *Spain* of a Grey Colour, but of no great Force. These are commonly brought by Horse down to *Sivill* and *Cadis* to be fold; and oftentimes to *Valentia*, *Alicante*, and *Lisbone*.

All theſe Stones are diſſerent one from another, as well in Force, as in Colour and Weight; yet all of one Operation in the Needle, ſhewing one Point *Attractive*, as I have proved my ſelf by three ſundry Sorts of them, which I have; and all drawing Yron to them. Yet the Philosopher *Averroes* writeth, That the *Magnes* draweth not Yron unto it, but the Yron of his natural Inclination moveth to the Stone.

And though this Poſition may ſeem to carry ſome Truth with it, by the bare View of the Sight, when the Yron is lighter than the Stone; yet contrai-

wife you ſhall find that the Stone will move to the Yron, if the Stone be good, and the Yron of greater Weight than the Stone, (ſo that the Weight of the Stone exceed not his *Attractive Strength*.)

Nevertheleſs, we may not thereby take away the vital or lively Spirit from the Stone, and attribute it unto the Yron; for in ſo doing we ſhould do Nature great Wrong. For it is apparent, that the Yron hath no *Attractive Virtue* nor Power of it ſelf, until it have received it of the Stone. But Yron having a certain Affinity, or natural Quality agreeable to the Stone, doth aptly and freely receive his Virtue, and as a Subject, ſuffereth his vital Spirit of the Stone to impref, and reſt quietly in his maſſive and ſolid Body; which when it hath received by touching the Stone, it is indued with the very fame Property and Operations in all respects (though not in ſo great Force) as the Stone it ſelf.

For as the Stone hath Power to ſhew the *Attractive Point*, ſo hath the touched Yron: As the Stone hath two principal Points, ſo hath the Yron. And likewife, as the Stone hath Power to draw Yron to it, ſo will the Yron ſo touched, draw another Yron to it, and impart all theſe Virtues to another Iron in Quality, tho' not in Quantity: And thus in all respects it containeth in it the very Property of the Stone.

Paracelſus writing of the augmenting of the Strength of the *Magnes* Stone, faſh, That if this Stone be laid in the Fire until it be almost red hot, and then taken out and quenched in the Oil of *Crocus Martis*, it will ſo augment and multiply his Force, that it will pull a Nail out of a Wall. But I ſuppoſe he meant not that the Nail ſhould be fast, for then it were a mira culous Matter.

Others have written, that in theſe Parts, where the *Magnes* growtheth in the Sea, it is of much Force, that if any Ships that have Yron in them paſs by, or over them, that they are preſently either stayed, or drawn down to the Bottom by reaſon of the Yron. Not theſe only, but many other Fables have been written by theſe of ancient Time, that have as it were ſet down their own Imaginations for undoubted Truths, and this moſt of all in *Geography* and *Hidrography*, or *Nauigation*. Therefore I wiſh Experience to be the Leader of Writers in theſe Arts, and Reaſon their Rule in ſetting it down, that the Followers be not led by them into Errors, as oftentimes have been ſeen.

True it is, that God is mighty and marvellous in all his Works; yet he doth not allow us to ſay more than Truth of them. And truly, his Power is as greatly ſhewed in the *Magnes*, as in any Stone that he hath created: And who ſo shall go

about curiously to seek out the efficient Cause of his Properties, I suppose the longer he seeketh, the more he shall marvel, and yet never the nearer his Purpose.

The Vertue of the Stone is distributiuē, as many other Virtues are; much comparable unto Musk, that having a sweet Savour or Smell it self, imparteth the same to another thing, as to a Pair of Gloves; and those Gloves give out Savour, and perfume a whole Chest of Cloaths: Even so the Yron that hath received this Virtue of the Stone, will extend and give the same to another, and that Yron to another, and so to many.

And in this Point the Stone is marvellous, that notwithstanding you touch ten thousand Yrons or Nailes with him, every one of them carrying away as much Virtue as will lift up another his like, (so they exceed not the Weight of a Six-penny Nayle) yet the Stone it self will be nothing diminished of his Strength, but continue of one Force.

If I should say here, that by the *Attractive* Strength of a small *Magnes* of two or three Pound Weight, I could lift up, or cause to hang by the Virtue thereof, a thousand Pound of Yron at one Instant, peradventure you would be doubtful of the Succes. Nevertheless, by Experience in all things, wherein confisteth Truth and Reason, of necessity Reason must yield, when Truth is present. And therefore, because you shall not remain doubtful herein, thus you may do it, and only make Proof by two or three Nails, if you will: for the same Success that you have in them, you shall have in all the rest.

Take a common Board Naile, and touch the Head of it with the *North* Parte of the *Magnes* or *Loadstone*; then take the same Nayle, and beat it with a Piece of Wood lightly into some Poste or Timber upwards, so as the Head may hang downwards, (but not with Yron, because the Yron will take away some Part of the Virtue from the Nayle.) This done, take another like Nayle, and touch the Head thereof with the *South* Part of the Stone; and then if you put the Head of it to the Head of the first Nayle, it will hang fast by it a whole yeere or more. And after this manner you may, if you will take the paines, hang a hundred tun of Yron with the vertue of this little stone, and yet the stome nothing diminished of his force. But it is necessarie in prooef of this matter, that ye have a very good stome.

Furthermore, concerning the other properties of this stome, if you put it in a dry dishe and fette it to swimme in a tub of Water, it will turne the dishe about, and the North parts of the stome, after many swarungs too and fro, will rest, and directly shew the line of *Variation*, or imagined *Attractive* point.

Also, if you hang this Stone by a thrid, that it may easilly moue, it will shew the like effects as on the water. And if you haue two stomes, putting the two South partes of them together, the one will fly and turne away from the other, and likewise of the North pointes.

And further yee shall note as a speciall point, that the North point of *A spe-* the Stone touching a Needle, or the wyers of a compasse, will make the same *note*. point touched to shew the South: and contrariwise being touched with the South point, will make the same to shew the North. So as alwaies that part of the stome that answere to the north of the needle, is properly the South part of the Stone.

C H A P. II.

Of the divers opinions of those that haue written of the Attractive point, and where they haue imagined it to be.

THE subtil properties and hid secretes of Nature in the *Magnes*, as also in diuers other things, hath so troubled the wits of the searchers thereof, that alwaies when they came to the upshot, wanting experience, and thereby reasons finger to shew them a direct marke, they were constrained to seek or imagine a marke, where indeed none at all was, and thus shooting as it were in the aire, every man where he thought best, they haue all shot wide, and none touched the marke. The marke I meane here, is the point *Attractive*, or rather, as shall be saide heereafter more at large, the point *Respective*.

This point aunciently called the *Attractive* point hath beene by some imagined to be in the mouing sphères distant from the poles of the world: which opinion *Martin Curtes* in his Book of Nauigation refuting, saith, that if it were so, then the same point beeing carried about the pole by their violent motion, would cause the needle or Compasse touched with the vertue of the Stone, to varie daily in euery place, according to the diurnall motion of the same sphere. But in confuting the erronius opinion, he hath (as it appeareth) fallen into as great an error himself: imagining the point *Attractive* to be beyond the poles of the world, without all the moueable heauens. Which point (saith he) *hath power by Attraction to draw Yron to it, that is touched with the Loadstone*. This error I referre to be discusſed in the fixt Chapter.

Others haue taught this point to be in the earth, nere the North pole, imagining in that part to be some greate rocks of the *Loadstone*, and that by their *Attraction* the compasse or needle is caused to *Respect* or shew that part.

This opinion of all the rest is easiest to be confuted by daily experience: for if the compasse or needle were drawn towards the North part by any *Attraction* of the *Magnes* stones in those parts imagined, why then shold not the Compasse or Needle shew the same effect in mouing towards the Iland of *Elba* in the *Leuant* seas, where are great quantitie of these Stones? and yet Shippes sayling within a myle of this Iland, yea, and into *Porto Feraro*, a Towne of the same Ile, within a quarter of a myle of a huge Rocke of these stones, the Compasse or needle is not found any thing to be drawne or changed, nor the *Attraction* of this huge rocke to extend so farre as one quarter of a myle. And as I haue said by this, so may I say by diuers other places where the *Loadstone* are found in Cliftes and Mines neere to the Sea side, as in *Norway* and other places.

Pedro de Medina, in his booke of Nauigation, is of the opinion of *Martin Curtes*, as touching the *Attractiue* point, but he doth not allowe of the variation of the compasse or needle, but faith, that if the compasse or needle shew not the pole, the fault is in placing the wiers on the flie, and not in any propertie it hath to vary.

These opinions be diuers, but the chiefeſt cause why they have gone fo farre wide from the *Attractiue* point, as I haue aboue ſaid, was because they wanted reaſons fingers to shew them towards the direct marke. By this reaſons finger, I meane a certaine *Declining* propertie under the Horizon, lately found in the needle, which I will entreat of at large.

C H A P. III.

By what meanes the rare and ſtrange Declining of the Needle, from the plaine of the Horizon was first found.

Haung made many and diuers compasses, and uſing alwaies to finiſh and end them before I touched the needle, I found continually, that after I had touched the yrons with the Stone, that preſently the north point thereof would bend or *Decline* downwards under the Horizon in ſome quantitie: iſomuch that to the Flie of the Compaffe, which before was made equall, I was ſtill

constrained to put ſome ſmall peece of waxe in the South part thereof, to counterpoife this *Declining*, and to make it equall againe.

Which effect having many times paſſed my hands without any great regard thereunto, as ignorant of any ſuch propertie in the Stone, and not before hauing heard nor read of any ſuch matter: It chaunced at length that there came to my hands an Instrument to bee made, with a Needle of fiue inches long, which needle after I had polliſhed, cut off at Juſt length, and made it to ſtand levell upon the pinne, ſo that nothing reſted but onely the touching of it with the ſtone: when I had touched the fame, preſently the north part thereof *Declined* downe in ſuch fort, that beeing conſtrayned to cut away ſome of that part, to make it equall againe, in the end I cut it too ſhort, and ſo ſpoyley the needle wherein I had taken fo much paynes.

Hereby beeing ſtroken in ſome choller, I applyed my ſelf to ſeeke further into this effect, and making certayne learned and expert men (my friends) acquainted in this matter, they aduized me to frame ſome Instrument, to make ſome exact tryal, how much the needle touched with the ſtone would *Decline*, or what greatest Angle it would make with the plaine of the Horizon. Whereupon I made diligent proofes: the manner whereof is ſhewed in the Chapter following.

C H A P. IV.

How to finde the greatest Declining of the Needle under the Horizon.

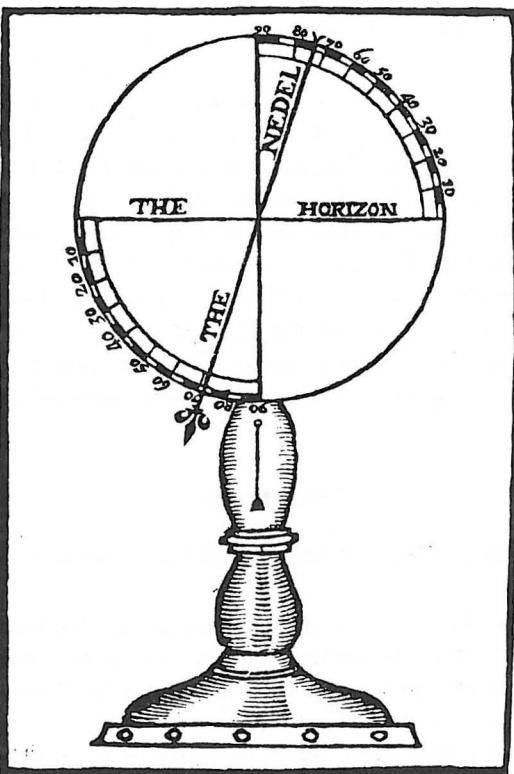
Take a ſmall Needle of Steele wier, of five or fiue inches long, the ſmaller and the finer mettall the better, and in the middle thereof (crosse the fame) by the beſt meanes you can, fixe as it were a ſmall Axeltree of yron or braffe, of an inch long, or thereabout, and make the ends thereof very sharpe, whereupon the Needle may hang levell, and play at his pleaure.

Then provide a round plaine Instrument like an Astrolobe, to be divided exactly into 360 partes, whose diameter muſt be the length of the Needle, or thereabout, and the fame instrument to bee placed uppon a foot of convenient height, with a plumme line to fette it perpendicular.

Then in the Center of the fame instrument, place a peece of Glaffe hollowed, and againſt the fame Center uppon ſome place of Braffe that may be fixed upon the foot of the instrument, fit another peece of Glaffe, in ſuch

forte that the sharpe endes of the Axeltree beeing borne in these two Glasse, the Needle may play freely at his pleasure, according to the standing of the Instrument.

And the Needle must be so perfected, that it may hang upon his Axeltree both ends levell with the Horizon, or beeing turned, may stand and remaine



at any place that it shall be fette: which being done, touch the faide Needle with the *Magnes* stome, and set the Instrument perpendicular by the plumme line, and turne the edge of the Instrument South and North, so as the Needle may stand duley according to the *Variation* of the place: which *Variation* the Needle of his owne propertie would shew, were it not that he is constrained to the contrarie by the Axeltree.

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Then shall you see the *Declination* of the North point of the touched Needle, which for this Citie of *London*, I finde by exact obseruation to be about 71 degrees 50 minutes. The forme of the Instrument heere described with the manner of the declination, I have heere placed that it may be the easier conceived.

C H A P. V.

That in the virtue of the Magnes or Loadstone, is no pondrous or weightie matter, to cause any such declining in the Needle.

Because the opinions of men are divers, and the arguments of many against reason, peradventure there are some will say, that I am deceived even in the ground and chiefest point of this my purpose, alledging (as some have already done without reason) that this *Declining* of the needle is caused by some pondrous substance that it received from the Stone, and not (as I take it) proceede of the simple vertue and secret influence thereof, because the stome it selfe wherein the vertue remaineth and is nourished, is weightie.

I judge the learned will not allowe a Spirit to have any corporall substance or weight, or that it may sensibly be felt: if any should, yet by two conclusions it is easily proved, that the vertue of this Stone containeth in it no waightie matter: and thus found.

Take three or foure small peeces of yron or steele wyer, and putting them in a fine gold Ballance, counterpoise them justlie with Leade: Then take them out and touch them well with the stome, that they may receive the vertue thereof: And after weigh them againe in the same ballance, with the same leade, and you shall finde them to weigh no more then before they were touched, though every one of them have received vertue sufficient to lift up his fellow.

Secondly, if the North poynt of the Needle do *Decline* by any pondrous or weightie matter, in the vertue received by touching the Stone, why then should not the South point of the needle, being touched with the contrary end of the Stone, have the same declining Southwardes, beeing all one Stone, and one vertue? Or why doth not this supposed heavier end, fall perpendicular to the Center, as by reason it shoulde, and not covet a certaine scituacion beside it, ballancing it selfe up and downe, till it have found the same? These arguments may answer this matter. For touch the Needle with what part of the Stone you liste, that end of the Needle that sheweth the North will alwaies decline.

(11)

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C H A P. VI.

A confutation of the common received opinion of the point Attractive.

Seing it is manifest that there is a Declining in the needle and that the same is not caused by any ponderous waightie matter in the vertue received from the stone: it may be demanded, by what means this declining or elevating hapneth, in which of the two poynts confisteth the action or cause thereof.

Peradventure you will say (as other have imagined) that it is in the South point of the Needle, elevated by the *Attractive* vertue of some point of the Heaven that way. Perchaunce you will yeeld it rather to be in the North point of the Needle, which by some *Attractive* point in the Earth, or in the Heavens beyond the Earth that way, is drawne downe and caused to decline, and it *Declining*, of necessity the other South poynt opposite must needs be lifted up.

Your reason towards the earth carrieth some probabilitie, but I prove that there be no *Attractive*, or drawing propertie in neyther of these two partes, then is the *Attractive* poynt lost, and falsly called the poynt *Attractive*, as shall be prooved. But because there is a certayne point that the Needle alwayes respecteth or sheweth, beeing voide and without any *Attractive* propertie: in my judgment this poynt ought rather to bee called the point *Respective*.

And further if it may be proved, that there is no *Attractive* or drawing propertie in that poynt, the power and action in that poynt condemned, then of necelfitie the power and propertie, without any external cause, remayneth onley in the Stone and after in the needle, being touched with it, having the same power and propertie in it, that the Stone hath in every respect.

Now to prove no *Attractive* point neither beneath in the earth, nor Heavens Northwards, nor above in the Heavens Southwards, you shall take a peece of Yron or Steele wier of two inches long or more, and thrust it into a peece of close Corke, as bigge as you think may sufficently beare the wyer on the water, so as the same Corke rest in the middle of the wyer.

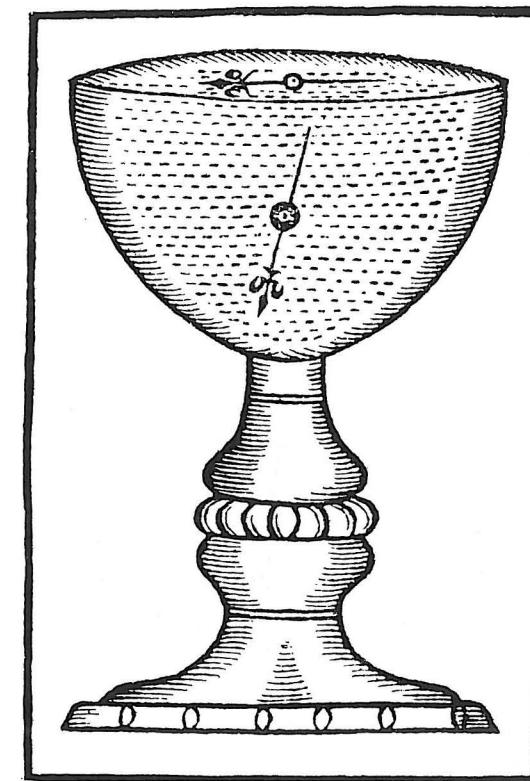
Then you shall take a deepe Glasse, Bowle, Cuppe, or other vessell, and fill it with fayre water, setting it in some place where it may rest quiet, and out of the winde. This done, cut the Corke circumfpectly by little and little, untill the wyre with the Corke be so fitted, that it may remaine under the superficies

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§ . 4 .

of the water two or three inches, both ends of the wyer lying levell with the superficies of the water, without ascending or descending, like to the beame of a payre of ballance beeing equalie poysed at both ends.

Then take out of the same the wyer without mooving the Corke, and touch it with the *Stone*, the one end with the South of the *Stone*, and the other



end with the North, and then set it againe in the water, and you shall see it presentlie turne it selfe upon his owne Center, shewing the aforesay'd *Declining* propertie, without descending to the bottome, as by reason it should, if there were any *Attraction* downwards, the lower part of the water being nearer that point, then the superficies thereof.

(13)

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And as this may prove no *Attraction* or drawing downwards in like manner the Corke being so made, that it may finke very slowly to the bottome, and then taken out and touched with the *Stone*, and put in againe downe to the bottome with your finger, if any *Attractive* drawing were upwards, it would ascend, and come up to the superficies of the water, being neerer to that poynt than the bottome. But I finde by diligent and exact tryall, that it hath no such effect: as in the figure following is demonstrated.

Againe, if you doe fit your wyer with Corke, that after it is touched with the *Stone*, it will swim levell in the superficies of the water, you shall see it turne to shew the true *Variation*, and leaving the same in the middle of the superficies of the water, so long as you lift, you shall finde that it will not bee drawne from his place, neyther to the one fide, nor the other, whereas if there were any suche *Attractive* point as have beeene imagined, either in the earth by vertue of huge Rockes of the *Magnes* Stone neere the Pole, or otherwise in the heaven, or wherefover, by what meanes soever, beeing but the twentieth parte of the force that the Needle touched, hath to shew to *Respective* poynt, it should of neceffitie be drawne in time to some fide.

So that upon these experiments I conclude, that the *Attractive* poynt before imagined, is no where, nor no such thing: and therefore, as most proper, I will call the poynt whereunto the Needle inclineth by vertue of the *Stone*, The point *Respective*, and attribute the whole power of shewing that point to bee in the *Stone*, and in the needle, by the vertue received of the *Stone*, which vertue must bee imagined to bee turned, borne, and depending upon his owne Center, as shall be shewed in the next Chapter.

C H A P. VII.

Of the Poynt Respective, where it may bee by greatest reason imagined.

THIS Poynt *Respective*, is a certayne poynt, which the touched Needle doth alwayes *Respect* or shew, and is found by the declining of the Needle, to bee a pricke in some one parte of a straight Line, declining in this place or Latitude of *London* under the Horizon 71 degrees, and 50 Minutes, as the Figure representeth.

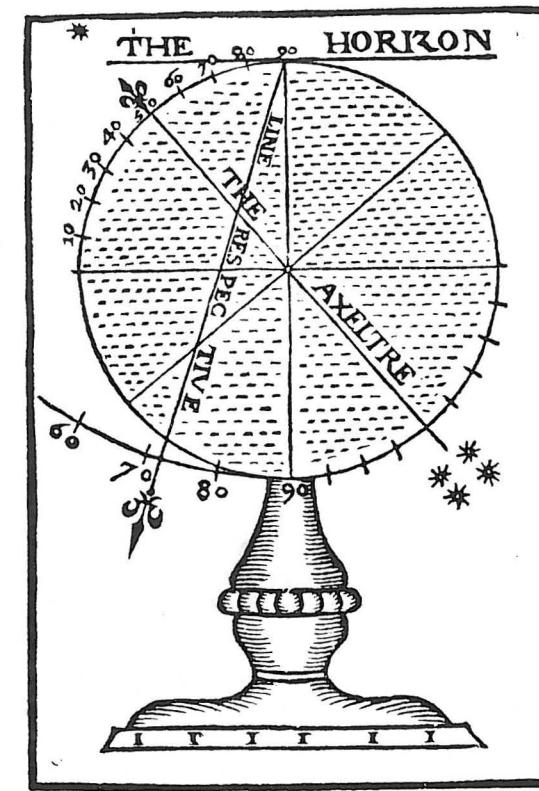
This straight Lyne must be imagined to proceede from the Center of the Needle, into the Globe of the Earth, Extending, and going Directly foorth,

(14)

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both wayes infinitely. But in what part of this Line the point *Respective* is, it is not by this bare Line alone to be answered: no more then it is possible by one bare Angle to know the measure or distance of any place assignd.

And for the finding or certaine assigning of the true place of this point *Respective*, we must leave untill the expert travailer have made certaine obser-



vation of this *Declining* of the Needle in other places. For seeing it is certaine that though in fevall Horizons, the compasse hath fevall *Variations*: yet in any one Horizon the needle *Respecteth* alwayes one onelie point without alteration, as by travaile is truely prooved. So I Judge, that in his *Declining* it keepeth the like order and certaintie in everye place.

(15)

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And altho' the Needle of the Compasse, by reason of the weight of the heavie flie, cannot *Decline*, as his propertie is, but falfelie sheweth the point *Respective* alwaies in the Horizon, as most necessarie so to doo for the Navigation: yet by the meanes and conclusions, which before I have shewed, the diligent traveller having with him a good *Magnes* or *Loadstone*, may by exact obseruation finde the increasing or decreasing of this *Declining* of the Needle, as the travelle shall give occasion.

For I am of this opinion, (and that by great reason) that this *Declining* of the Needle shall be founde by travell to be great or little, according as the distance of the point *Respective*, is from the place where the triall is made: which beeing diligentlie observed in fundrie places, with the certaine *Variation* of the Needle from the Meridian, therby may bee demonstrated and found out the true place of this point *Respective*.

C H A P. VIII.

Certaine proofes that the power and action is wholie and frelie in the stome, to shewe this point Respective: and in the Needle, by vertue and power received of the Stone: and not forced or constrainyd by any Attraction in heaven or earth.

IT is most manifest in all the works of Nature, or Creatures that God hath made, that whatsoeuer Qualitie, Propertie, or Vertue is found in them, by Creation, that is to bee holden for theyr owne. And he that shall, by imagination or conjecture, go about to take these their Properties from them, and attribute the same to any other subiect, whereunto they appertaine not: I say that man offendeth God much, for not beleeving his Power to be sufficient in his Creatures.

I will not offer to dispute with the *Logitians*, in so many pointes as heere they might feeme to over-reach mee in Naturall causes. But that this stome hath wholy and fully in himselfe, Power, Action, Propertie and Vertue of his owne Appetite, to shewe, and to cause the Needle to shewe the point *Respective*, without any *Attractive* qualitie or external cause of Rockes of the *Magnes-Stone*, or by *Attraction* in the Heavens, or elsewhere whatsoeuer, it is already sufficiently prooved.

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Notwithstanding, if these proofes may not content, I will at any time required heerein, satisfie the doubtful, by manifest Experiments. And therefore where no other cause can be probably annexed unto this Stone, the power and action of necessitie is proved in it selfe.

And by the *Declining* of the Needle, is also prooved, that the point *Respective*, is rather in the earth then in the Heavens, as some have imagined; and the greatest reason why they so thought (as I judge) was because they never were acquaynted with this *Declining* in the Needle, which doubtlesse if *Martin Curtes* had knowne, hee would not have judged the *Attractive* point to have bene in the Heavens, or without them, but rather in the Earth.

Now peradventure you will aske mee howe this Stone hath his Power, and how it is engendred: I am no more able to satisfie you heerein, then if you should aske me howe and by what means the celestial Spheres are mooved: but that GOD in his Omnipotent providence hath appointed it so to bee; which may serve for a generall answere to all such curious searchers of the secrete woorks of God in his creatures. As though his Word alone were not a sufficiently Decree and law to all his Works: but binding then to seconde causes, as a thing of necessitie.

These curious searchers out of the secrets of Nature, further than is requisite that man should knowe for his necessary use, I may compare to *Ezdras*, and wish them to read over his fourth booke: and there they shall see how hee was answere at Gods handes by his Angel, for his curious Questions asked and demanded.

Nowe therefore, as I have before declared, that diuers haue whetted theyr wits, yea, and dulled them, as I have mine, and yet in the end have beene constrained to flye to the corner-Stone: I meane GOD: who (to conclude) hath given Vertue and power to this Stone, proper in it selfe, to shewe one certaine point, by his owne nature and Appetite, and not subject to any other accident in Heaven, nor in Earth, but freely by his owne proper vertue, receyved at his mighty hands in Creation: and by the same vertue, the Needle is turned upon his owne Center, I meane the Center of his Circular and invisible Vertue, piercing all thinges, and stayed by nothing, be it Wall, Boorde, Glasse, or any thing whatsoeuer.

And surely I am of opinion, that if this Vertue could by any meanes be made visible to the Eye of man, it would be found in a Sphericall forme, extending rounde about the Stone in great Compasse, and the dead bodie of the

(17)

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Stone in the middle thereof: Whose center is the center of his aforefaid Vertue. And this I have partly prooved, and made Visible to be feene in some manner, and God sparing mee life, I will heerein make further Experience, and that not curiously, but in the Feare of God, as neere as he shall give mee grace, and meane to annexe the same unto a Booke of Navigation, which I have had long in hand.

C H A P. IX.

Of the Variation of the Needle, from the Pole, or Axeltree of the Earth: and how it is to be understood.

NOW, as the Needle hath this apparent propertie in *Declining* under the Horizon, to shewe the point *Respective*: So it is most manifest, that as in *Declining* it hath property in varying, or departing from the Poles, even as the point *Respective* openeth or sheweth a greater, or lesser distance betwixt the fayde poynt *Respective*, and the Pole or Axeltree of the Earth. And this departing is called *Variation* of the Needle. This is also shewed in the Needle or Wyer, in that conclusion of declining in the Water, as in the fixt Chapter, even by the same proportion, that it sheweth in the needle Horizontally.

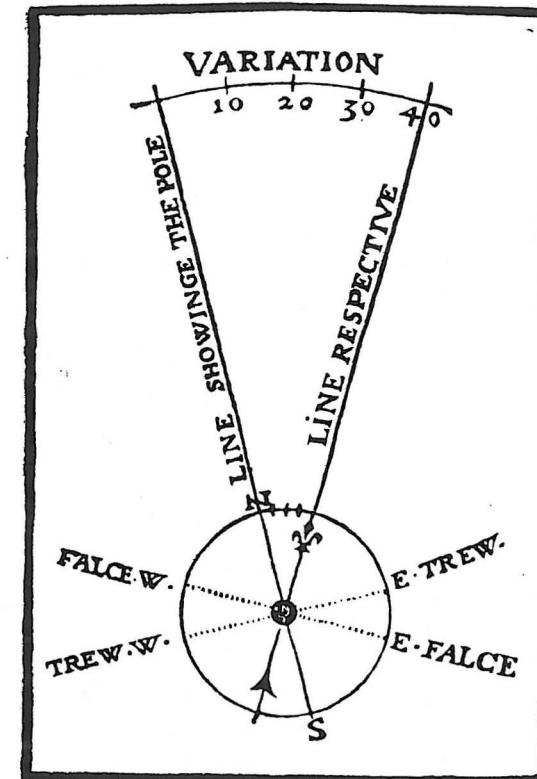
This *Variation* is no other thing, then a certaine parte or portion of a Circle, contained betwixt two straight lines proceeding both from one Center, which may be imagined to be the Center of the Needle, and from thence both extending and going directly foorth: One to the Pole or Axeltree of the world, and the other to the point *Respective*, and this part of Circle contained betwixt these two lines in the Horizon, is faide to be *Variation*.

And further here is to be noted, that alwaies these two Lines have two right Lines, cutting them directly in the Center of the Needle. The one of them crossing the *Meridian*, at right Angles in the Center of the Needle, is the true East and West of the Worlde. And the other crossing the line *Respective* at right Angles, is the false East and West that the varying Needle or Compasse sheweth: all which is shewed by this preuent figure following.

This *Variation* is adjudged by divers Travellers to be by equal proportion, but herein they are much deceyued: And therefore it appeareth, that notwithstanding their Travell, they haue more followed theyr Bookes then Experience in that matter. True it is, that *Martin Curtes* doth allowe it to bee by propor-

tion, but it is a mooste falfe and erroneous Rule. For there is neither proportion nor Uniformity in it, but in some places swift and tudden, and in some places slowe.

It is said to be proportional or uniforme, when in the increasing or decreasing of a degree of Variation, is found one certaine number of Leagues or



Myles, going, increasing, or decreasing, in one Parallel or Latitude, by like equal proportion, and that if the Variation be doubled, going by one Parallel, so shall the leagues or miles alto. But this is not found to be so.

For in going from *Silly* to *Newfoundland*, which is not 600 Leagues, it is found that the Needle doth varie more in 200 Leagues, when you come neere that Countrey, then it doth in 400 Leagues of your first way. And also going

Because the Line of the Needle that sheweth the

*Pole Artick, to Meta Incognita, it varieth more in parte of the last of the way, then in
and point
Respective,
by vertue of
the stone,
passeth be-
tweene Sillie
and New-
foundland.*

3 parts of the first, and in those partes it is found to be fuddaine. Further it is found betweene the *North Cape* and *Vaigatz* very strange, in recyoling and comming backe againe to the Westwardes of the Pole, before it hath fully accomplished two poyntes of Variation in the compasse. So that at *Vaigatz* it varyeth to the Westwards, as it doth at *Newfoundland*. And this comming backe againe, before it hath accomplished foure poynts of the Compasse, is very strange, and against the opinions of all that have before written.

Pedro de Medina (as I have said in the seconde Chapter) was doubtfull of the Variation, saying: that if the Compasse did varye, the fault might bee in the making thereof, the Wyers or Needle not being well placed: yet hee was a Learned man, and a gread Traveller to the West Indies. But it appeareth that he had no more regard to the Variation, then many Mariners in these dayes.

For in 18 or 20 years that I haue trauelled the Seas, being daylie conuersant with many of them, and diligent in Enquiring of Variation of the places, where I have not been my selfe, I could never finde two of them in one trueth, except for the Trauailes from hence Northwards and North Eastwardes. But I suppose the greatest Occasion thereof is by lacke of exacte Instruments for that purpose. Wherefore I have devised one very necessarie.

And further, because this Variation is divers, and is found sometimes to the Eastwards, and sometymes to the Westwards of the Pole, I will declare what the Variation is here in *London*, by mine owne obseruation, and in other places, as I haue grossly gathered of some Travellers, reckoning, or beginning at the ancient bound or great *Meridian*, that passeth by the Isle of *Saint Michael* in the *Agorres*: where it is faide, that the Needle sheweth directly the Pole, and the *Respective* point both in one line. But this is not found to be so.

True it is, that the North poynt of the common Compasse, sheweth the Pole very neere in that *Meridian*, but the bare Needle sheweth about 4 Degr. 50 Min. to the Eastwards of the Pole. So that you must understand alwayes the difference betweene the common Compasse and the Needle, to be at the least 1 third part of a point, and of some more: because the greatest parte of the common Sayling Compasses, hath the Needle set in the Flye, half a poynt, or 2 third parts, to the Eastwards of the North, and some 3 quarters of a poynt, and others at a whole poynt; and some againe, are set directly under the Flower-de-Luce, or North of the Compasse: those are called *Meridional-compasses*, because they shewe directly the Pole, in the great *Meridian*: as the bare Needle

doth, which *Meridian* must needs be at the least an hundred, or an hundred and twenty Leagues to the Westwards of the Ile of *S. Michaell*.

And therefore to write of the Variation of places, by the common Reportes of Maryners that have travelled Southwards and Westwards from hence, it shall be as uncertaine, as are the divers makings of these common Compasses, by which they haue made their Obseruations. And therefore I will omit it, and speake only of this place or Citie of *London*, whose Latitude I finde to be 51 degrees, 32 min. and the Variation of the Needle from this *Meridian* of the Pole to be 11 Degrees, 15 Minutes.

And although this Variation of the Needle be found in Trauell to be diuers and chaungeable, yet at any Land or fixed place assignd, it remaineth alwayes one, still permanent and abyding. And therefore I wish the Marryner to make diligent obseruation of this Variation in diuers places, as he shall Travell, by some exact Instrument for the purpose. For it may be greatly for his aide, against he come there another time, espeially in such places where the Variation is swifte, as in these North parts. And because the common Compasse is partaker of this Variation and Declining, as the Needle is, I will somewhat shew of the fundry forte and makings of them, with the inconueniences that may grow by them, and by yll plats, made by these diuers forte of Compasses.

C H A P. X.

Of the common Compasses, and of the divers different sortes and makings of them, with the inconveniences that may growe by them, and the Plats made by them.

OF these common Sayling Compasses, I finde heere (in *Europa*) five fundry forte or fets. The first is of *Levant*, made in *Scicile*, *Genoüa*, and *Venice*: And these are all (for the most parte) made Meridionally, with the Wyers directlie sette under the South, and North of the Compasse: And therefore, duely shewing the poynt *Respective*, in all places, as the bare Needle. And by this Compasse are the Plats made, for the most part of all the *Levants* Seas.

Secondly, there are made in *Danske*, in the Sound of *Denmarke*, and in *Flanders*, that have the Wyers set at 3 quarters of a point to the Eastwards of the North of the compasse, and also some at a whole point: and by these Compasses they make both the Plats and Rutters for the Sound.

Thirdly, there hath beeene made in this Countrey particulary, for Saint Nicholas and Ruscia, Compasses set at 3 seconds of a point, and the first Plats of that Discouverie were made by this Compasse.

Fourthly the Compasse made at Sevill, Lisbone, Rochell, Bourdeaux, Roan, and heere in England, are mooste commonly set at halfe a point: And by this Compasse are the Plats of the East and West Indies made for their Pylotes, and also for our Coastes neere heereby, as France, Spayne, Portugall, and England: and therefore best of these Nations to bee used, because it is the most common forte that is generally used in these Coastes. And againe, it is faide, that the Middle hazard is best.

I speake thus, because there are so many sortes of these Compasses different eache from other, as before I have declared. And the Mayster or Maryner Sayling by these Compasses of fundry sortes, may thereby fall into great perill, and the reasoun is, because that of long time these Compasses haue been used, and by them the Marine Plats haue bene described of fundry sortes, every one according to the Compasse of that Countrey.

If then he take not the Compasse of the same fetts or making that the Plat was made by, then his Carde or Plat will shewe him one Course, and the Compasse when he thinketh he goeth well, will carry him another way. And thus, when he thinketh to fall with the Place that his Carde sheweth him, he shall be as farre wide, as the Compasse he hath Sayled by, is different from that his Plat was made by.

This is the ground and cause of many inconveniences, which is now too late to be generally reformed: Therefore I wish the Mariner to have a great regard unto this, as a principal poynt in Navigation, and not to Sayl by a Compasse of one parish, and a Plat of another: I meane that they have a respect, as near as they may, to Sayle by a Compasse of that countrey, where his Plat was made.

Yet many there are that use our Compasse with Levant Plats: but I suppose without good Consideration therein, they shall make but wide reckonings. And this hath bene sufficiently of late experimented, by our Mariners that have used Levant.

Peradventure there are some will say, that he knoweth a good Compasse, if he fee it; I say the Compasse may be good, and yet not good for him, except his Plat be agreeable: As for Example: A Levant Compasse is a good Compasse, to use with a Levant Plat, but it differeth from our Compasse halfe a point

more Easterly. And others there are of Danske, that differ from ours i halfe point more Westerly, and yet being used in their kinde, are good Compasses.

And therefore I conclude, that generally the best Compasse is this forte set at one halfe point, because the major parte of Compasses and Plats doth not differ from this above one quarter of a point: except the two abovenamed, Levant, and Danske.

I have heard many say, that have travelled farre to the Southwardes, that the Compasse hath seemed to loose his Force, and to waxe weak and Dull. I judge the caufe is not by reason of the farre distance from the North-Pole, but rather by beeing long absent from the Stone: for not being touched or refreshed therewith. And againe, the Pinne that beareth the Flye, may be so dulled with long using, that the Flye is as it were stayed, that it cannot play as it would, if it were sharpe.

Therefore, if you make it sharpe with a whet-stone, you shall finde it remedied. And also when you finde it light, or too Tickle, you may dull the poynt of the Pinne, with the leafe of payr of Wryting-Tables, untill you may see the toppe thereof: and then the Compasse will be better for a high-Sea. And thus by sharpening and dulling of the Pinne you may make your Compasse fitte for all Weathers.



A
DISCOURSE
OF THE VARIATION
of the Compasse, or
Magneticall
Needle.

Wherein is Mathemati-
cally shewed, the manner of
the observation, effects, and ap-
plication thereof, made
by W. B.

And is to bee annexed to the newe
Attractiue of R. N.

Imprinted at London by
E. Allde for Hugh Astley,
dwelling at S. Magnus
Corner. 1596.



To the trauailers, Sea-men , and
Mariners of England.



Auing of late gentle (Reader) receiuied
from the expert Artificer, Robert Normā,
his booke entituled: The new Attractiue
(who of the great good wil & affection he
beareth, hath attribuited in his dedication,
~~that which I acknowledge not to be due~~) in
the which amōḡ other diuers vertues & properties of the
Magnes of Loadstōe, he entreateth of the declining of the
Nēdle touched therwith, from the plain of the Horizon,
(a matter never before found or write of by any.) For the
further behoue & benifite of all trauailers and Sea-men, I
took occasiō to enlarge the same with this discourse of the
Variation of the Compasse , wherein I haue handled the
whole variety of that subiect, both practically, and Mathi-
matically, to the end I might partly satisfie both the vulgar
and also the learned sort. For knowing the variation of the
Compasse, to be the cause of many errors and imperfected
ions in Nauigation, and perceiving that al those that haue as
yet gon about to give rules in that art, haue left this (being
a principall point, and even the ground of all the rest) vn-
touched, or at least so slightly handled the same, that little
or no benefite could be gathered thereby: I haue heere set
downe the sundry waies to obserue the same at all times &
places, that the inconuenience being known, might be cō-
sidered off, and auoided Wherin, although my chiefeſt in-
tent hath been to pleasure thoſe that ſhal haue occation to
put the thing in practiſe by their owne trauile and expe-
rience, yet because ſome of the rules are deduced from the
fountaines

A2

The preface.

fountaines of the Methematical Sciences, and wrought by the Doctrine of Signes and Triangles, which maye seeme strange in our English tongue, & wherwith few Sea-men are yet acquainted, I may seeme to haue missed of my first good meaning, but I wold wish the to choose that which is plain and conformable to their capacities, & make their profit thereof, and for the rest vnderstand, that of such obseruations as they themselves cannot presently apply to the purpose, by others, that are throughly instructed in these Mathematical supputations, or by themselves when they shall attaine to the knowledge therof, may be inferred such effectuall matter, as is by theſe rules & precepts promised. Wherfore I would haue al Sea-men to vſe ſuch diligēce in their trauals, that no opportunity be omitted whē, or whē any obſeruation may be made, either for the variatiō, or latitudē of places, or any other necessary point incident to Nauigation, & therof to keep continuall notes & memorial. For these obſeruations there needeth not many troublesome instruments, onely for the variation, the new instrument in the end of this treatise I preferre before all other. And for elecutions, a plaine Astrolobe exaq̄tly made, & a croſſe ſtattle are sufficient. The Globe wer also a very good & neccellari instrument, for beſides many pleasant concluſions that may be tried by it, it doth lighten very much the conceits: for vnderstanding diuers important points, but it is too troublous, or otherwise not fit for euery Mariner) to be carried to the ſea. Vnto the which may be added the Topographical instrument, for taking of diuſtances, & making deſcriptions vpō the land. With theſe instruments, and the ſailing compas and Marine plate, (which are alwaies to be vnderſtood the principal, and moſt neccellari instrument for Nauigation, for by them only any voyage may be made, but without them no Nauigation can be performed,) the whole worlde may be traauled, diſcouered, and diſcribed. These are ſufficient for a perfeſte Mariner, and more then these wer ſuperfluous, only the running glasses, leads, lines, and

The Preface.

and ſuch like appendances, of other excepted.

But to haue all theſe instruments, and not to vnderſtānd the grounds how to vſe the, were a great vanity. Therfore I wold al ſea-men & traualers, that deſire to be cunning in their profelſio, firſt to ſeek knowledge in Arithmatike, & Geomentry, which are the groundes of all ſciences, and cer-tain arts, of the which ther is written in our English tong, ſufficient for an induſtrious & willing minde to attaine to great perfection: whereby hee may not onely iudge of Inſtrumentes, Rules, & precepts given by other, but alſo be able to correct them, & to deuile new of himſelf. And this not onely in Nauigation, but in al Mechanical Scien-ces. As by the ſtudious practiſe and exercise in theſe Arts, haue attained to rare & ſingular knowledge: In Architec-ture Vitruvius the Romain, in painting that famous Ger-main Albertus Durerus: and in building of ſhips, Mathew Baker our country-mā & others in other faculties, as they haue bene moſt ſkilfull herein, ſo haue they excelled. Ha-ving theſe helps & groundes, with the instruments before ſpecified, a Mariner may be able to make deſcriptiō in plat of the coaſts and countries, & of the banks, rocks, & ſtoids in the ſea, with the depths, & other neccellari notes obſerued in his owne trauals, particularly & effectuall according vnto the truthe, (which is the chiefest part required in a perfect Mariner.) And not be alwaies tied to the reportes of other, or to the Portugale, or ſpaniſh Marin plats, which are made by the card-maker of thoſe countries, men that are no traualers themſelues, but doe al things therein, by information, & vpon the credite of others, which onely commit to memory the forme & maner of the ſea coaſts, with making ſome few notes of the lying of one place fro another, which can never be ſo perfect, as the deſcriptions that are made vpō the preſent ſight and view of places, albeit he be never ſo ſkilfull and cunning, that al ſhallo carrie the ſame by memorie, how much les the by the vnskillful: by this meaſurē card makers ſet down they know not what,

The Preface.

as maye appeare by the descriptions of their owne coastes, which are verie grossly and vnpertectly done, whereas the marin Plats ought to be described by such as can give reason, & shew obseruation of euery particularite contained in the same, as well for the latitude of places, as the lying by the compasse of the Capes, Head-landes, pointes, llandes, Baies, Rocks, Sholdes, &c. one from another, and the distances between them. The errors of those descriptiōs, I may not attribute to the card-makers, but to the vnskilful seamen of those countries, for if they were otherwise, as they haue been accounted the most skilfull of the world, those errors could not haue cōtinued as they do: tru it is, that for their great trauals, they haue been worthily famous aboue all other nations, till now at length our Country-man Sir Frances Drake, for valarous attempt, prudent proceedings & fortunat performing his voyage about the world, is not onely become equall to any of them that liue, but in fame farre surmounteth them all. But those card-makers, and al other that collecte and gather Hydrographicall, and Geographical descriptions of other mens trauals or reports: as their paines may be great, and deserue due cōmendatiōs, so their doings may bring cōmoditie diuersly. And in this behalf Abrahamus Ortelius in his Theatrum, hath deserued immortall praise, for collecting together, and reduc-^{ing} into one commodious volume, the dyuerse Plats and descriptions, made by diuers & sundry men. But amongst al those that haue made Geographical descriptions, I canot a little meruelat Gulielmus Postellus, who being a famous learned man, a great traauer and Colinographer, & deane of the Kinges professors in the Vniuersity of Paris, in his vniuersal Map, An. 1580 besides that, it is generally handled after suche a grosse and confused manner, that it might seeme rather to haue come from some rude vnskilfull, then from him so famous a Doctor, hath also in the imagined Countries about the North Pole, so corrupted it with his fond dreams, & fatastical inscriptions, attributing to those suppo-

The Preface.

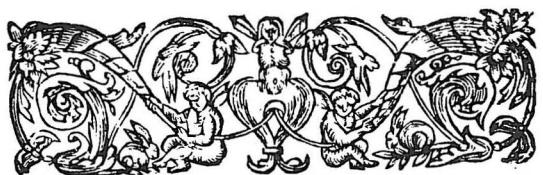
supposed lands, diuers people, as the Georgians & Hyperborians, and assigning there to bee the highest hillies of the world, and the people dwelling on them, to haue the cōtinuall light of the Sun, Sueta, Zemlia found by the englis-
men, An. 1550. the holy Land, the place of the chiefest felicity, the Hiperboreā filds, & therfore the felicity of the Moluccas, with many other ridiculous absurdities: That by the grose errors of this learned man in these matters, I am taught, that whatsoeuer fame goeth, or opiniō is conceiued of any man for profound learning, and smooth deliuering of their conceits, er whatsoeuer great promises are by the selues made in these artes, to iugde of the according to the works that come frō thē, & not otherwise to be deceiued.

For auoiding prolixitie in this my Preface to so small a volume, I referre thee gentle Reader, to the worke it selfe. Yet by the way it shall not be amisse, that I cōmend vnto you the Table of the Suns declinatiō (or Regiment) made by R.N. which is calculated for the present time, & differeth not from the truth in any place aboue one minute, wheras in al other hetherto made & extant, there are great errors. Therefore, such as otherwise cannot from time to time calculate their declinatiōs, according to þ place of the Sunne to be giuen by the Ephemeredes, and table of declination of Reinholdus, may boldly vse this regiment for 20 yeares, without any sensible error. And so wishing my trauals in this treatise, may do such good as I meant, I commit the same to your gentle constructions,
& your selues to the Almighty. At Linch-
ouse the 26. of September.

Anno. 1581.

William Borrough.

A 4



A Table of the chapters contained in the Treatise.

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tion.

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at any place, the elevation of the Pole, & the scituacion of
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The fourth chap.
The elevation of the pole, and place of the Sunne giuen,
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Meridian, the variation of the Needle, at any place by the
Sunne, vpon two obseruations, either in forenoone or af-
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The ninth chap.
Of the point Respectiue.

The tenth chap.
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scription of countries, caused by the variatio of the Com-
paske.

The twelfth chap.
Of the instrumentes and rules of Navigation.



¶ Of the Variation of the Compasse or magneticall Needle.

Chapter. 1.

THE Variation of the Needle or Compasse, is properly the Arke of the Horizon contained betweene the true Peridian of any place, & the Magneticall Peridian of the same, and is denominated to bee Easterly, or Westerly, according to the position of the Magneticall Peridian to the Eastwardes, or Westwardes of the true Peridian: And may be accounted either from the North parte, or the south parte therof, but upon opposite points it hath contrary denominations.

The Magneticall Meridian, is to be understood a great circle passing by the Zenith and the Pole of the Magnes, dividing the Horizon into two equal parts crossing the same at opposite points: which intersections or crossings, are shewed by the Needles, or wiers of the Compas, touch'd with the Magnes or the Loadstone.

The Azimuth of the Sunne is a great circle, passing by the Zenith, and the true place of the Sunne: crossing the Horizon at right angles in opposite points, and dividing the same into two equal parts, and it is said to bee given when the distance thereof from the true Peridian is knowne.

The Azimuth of the Sunne upon equal elevations in forenoone or afternoone, have equal distances from the true Peridian, so that the middle point of the whole difference of any two Azimuths observed upon equal elevations in forenoone or afternoone, is the true Perid.

This difference of Azimuths, is found upon the Instrument

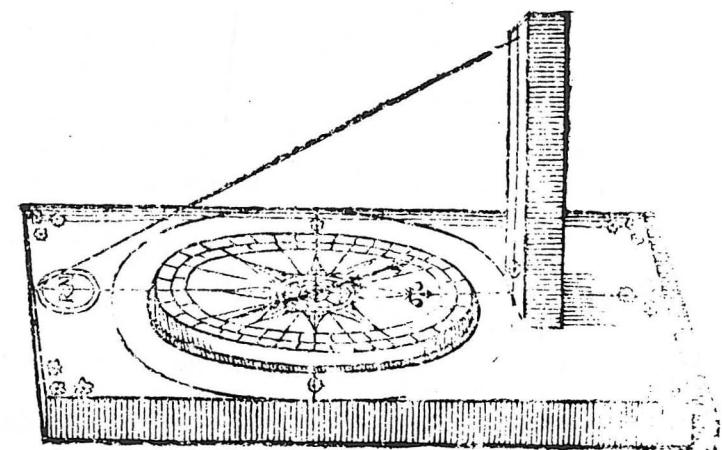
Of the Compasse.

ment of Variation, by adding together the Variations of the sunnes shadowe, at equal elevations in the soorenene and afternoone. The halfe wherof is the distance of the Azimuths from the true Peridian: the which compared with either of the same Variations of the sunnes shadowe, the difference shall bee the Variation of the Needle, from the true Peridian.

Or els subtracting the lesser variation of the Sunnes shadowe, from the greater (at equal elevations) the halfe of the remainder shall bee the true Variation of the Needle from the Peridian.

But the Azimuth of the Sunne being otherwise given, and the Variation of the shadowe likewise given, the difference betweene them, is the variation of the Needle.

The Variation of the Sunnes shadow, I call the Horizontal distance betweene the Azimuth of the Sunne, and the Magneticall circle, which are represented in the Instrument, by the shadowe of the line, and the Needle.



Of the Variation
The second Chapter.

The manner how to vse the instrument
of Variation.



First you must place the instrument upon some stoele, or other thing that is flat, so as it may stand leuell, & the Plummier in the Slander which is placed at the North end of the fixed Flie, may fall perpendicularly, with the line in the same Standard.

You must haue regard that in remouing the instrument to the sunne as hee goeth about, it may alwayes stande leuell as aforesaid.

You are then to consider, that the string that reacheth from the south part of the Instrument to the top of the Standard, is the chiefe string to giue the sunnes shadowe which must be so directed by turning the Instruments South side to the Sunne wards, that the shadowe of the same may fall directly longst vppon the lyne of south and North in the fixed Flie, soz it ought not to crosse or decline from the same lyne in any part, but if it do, you must seeke to reforme it, by setting the Standard more upright, or remouing it at the south end.

Then must you also see, that the string that is fastned to the hoope of Brass that inuironeth the fixed Flie, may bee so placed that it agree justly with the shadowe of the former lyne, and the lyne of south and North in the fixed Flie, in such sort that both the shadowes may be as it were hidde[n] in the said line of the Flie: wher you may do aptly by turning the said hoope, and remouing the same lyne at either side of it, as you shall see cause.

The Instrument being duly placed in forme aforesaid, it differeth nothing from the Compasse of Variation, but onely in this point, that whereas the Flie of the compasse of Variation, is so turned by vertue of the Magneticall

W.L.S.

Of the Compasse.

wiers, that the North point therof dooth shew the Pole of the Magnes, or line of Variation. In this Instrument, the North point of the Needle dooth supple that, which the North point of the compasse shoulde doo. And the North point of the Flie which is fixed in the bottome of the Instrument, dooth alwaies aunswere to the shadowe that the Sunne giueth.

The third Chapter.

How to finde the variation of the Needle or Compasse at any place, the elevation of the Pole, and scituacion of the Meridian ynkowne.



When you would obserue the variation in any place, you must begin in the forenoon the sooner the better, and the more effectually may your obseruations bee, bee thus,

Take your Astrolabe, and obserue diuine the height of the Sunne, for your more ease it shall be best for you to note the same, when it agreeth to be iust vpon a degree, without any consideration of minutes, or fractions, and at the instant of the same height, turne your instrument to the Sunne, so as the shadowe of the lines, may fall iustly vppon the line of the south and north in the fixed Flie.

Then, when the Needle doth stand, looke directly ouer the North point of the Needle, what degree and fraction, (if there be any) doth answer unto y same in the fixed Flie, that is to say, howe many degrees it is from the North of the fixed Flie, which you shall note diligently, and maye say, that so many degrees, &c. is the variation of the Sunnes shadow from the North, as the North point of the Flie is from the North point of the Needle, either Eastwards or Westwards as you shall finde the same. Thus may you obserue divers times, vpon severall degrees of the Sunnes elevation

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elevation. And like as you do in the forenoone, so must you also obserue the Sunnes elevation in the afternoone vpon the same degree of height, and with the same side of the Astrolabe and Index turned towardes the sunne, as it was in the forenoone (so avoideing of error that may bee in the Instrument) noting at euery height, what you finde the variation. And when the Sunne commeth to the Meridian, it shall be good that you exactly obserue his elevation vpon the same, soz knowing the true latitude of the place: all which you shall set downe in sozme following.

Example.

In Limehouse the sixteenth of October. Anno. 1580.

Forenoone.			Afternoone.		
Elevation of the Sunne.	Variation of the shadowe frō the North of the Needle to the Westwards.	Elevation of the Sunne.	Variation of the shadowe frō the North of the Needle to the Eastwards.	Variation of the Needle frō the Pole or Axes.	
Deg.	Deg.	Min.	Deg.	D.	M.
17	52	35	17	30	0
18	50	8	18	27	45
19	47	30	19	24	30
20	45	0	20	22	15
21	42	15	21	19	30
22	38	0	22	15	30
23	34	40	23	12	0
24	29	35	24	7	0
25	22	20	25	Frō N. tow. o. 8.	
				II	14

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The elevation of the Sunne vpon the Meridian. 25 d. 58'. the declination 12 d. 30'. which I add to the elevation, because the Sunne hath south declination, and the of amounteth 38 d. 28'. the elevation of the equinoctiall, the which I subtract from 90, d. the rest is 51 d. 32'. the elevation of the Pole Artike.

Now are you to consider, that out of the greate variation of a shadowe vpon any degree of the Sunnes elevation, is to be taken the lesser of the same degrees eluation, whether it bee in the forenoone or afternoone (except the same variations bee both one way from the North of the Neede, which then are to be added) the halfe of the remauner, is the variation of the Neede, or Compasse, from the Pole or true Meridian.

In the former obseruations, I do finde the greatest variation in the forenoone, for at 17 d. elevation, the variation is 52 d. 35'. from North to West: And at the same elevation in the forenoone, I finde the variation to bee but 30 d. 0'. from North to East. I take the lesser out of the greater, and finde remaining 22 d. 35'. the halfe thereof is 11 d. 17 1/2'. So must I say to the Pole Articke, and true Meridian line that passeth to the pole by our Zenith at London, to the Westwards of the North that the Neede sheweth. And therfore the Needles or Compas varith from the true north, 11 d. 17 1/2', to the eastwardes.

Also at 25 d. elevation in the forenoone, the variation is 22 d. 20' from North to West, at the same elevation in the afternoone, the variation is 0 d. 8' from North to West. Now because the variations are both one waye, (that is to the Westwards) I adde them together (and so ought you to doe, as often as you finde the variations so to agree) & I finde that they amount to 22 d. 28' the halfe thereof is 11 d. 14'. which is the variation.

The variations of the Neede or compas by the former obseruations, are set out towardes the right hande against every degrees elevation, and conserning them altogether,

Of the Variation

I das finde the true variation of the Needle or Compas at Limehouse to be about 11.d. 10' or 11.d., which is a point of the Compasse full or little moze. So that in a Compas Whiche wiers are set directly under the stowre de Luce, the North, and by West, and South and by East pointes doo shew the true Meridian.

The elevation of the Pole, and place of the Sunne, giuen, how vpon the Globe, to find the variation of the Needle by any one obseruation, either in forenoone or afternoone.

The fourth Chapter.



¶ the former declaration, the onely waye to tri the variation, is by comparing of the severall corespondent obseruations of the Sunnes elevation in the sozeneone, with those of the afternoone, so that if the Sunne shoule be obscured, or by any other occasion like obseruation cannot be made in the afternoon, then the former rule giueth not the desired purpose. Therfore I thought god to shew, hows by anis one obseruation in the fore or afternoon, the elevation of the Pole & place, of the Sunne giuen, you may knowe the true Meridian and the variation of the needle from the same in any place which thin may be done and aptly demonstrated vpon the Globe, but most exactly calculated by the Table of signes.

To finde out the variation vpon the Globe, you must first set your Globz to stande dueley according to the eleuation of the Pole at the place proposed. Then seeke in the Ephemerides, for the true place of the Sunne that day, and note it with some small prick in the Ecliptick of the globe. And placing the Quadrant of altitude or moueable verticall, at the verticall point or Zenith, take the eleuation

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Of the Compasse.

of the sunne obserued by the Astrolobe or other Instrument at the time proposed, and note it iustlye vpon the same Quadrant of altitude. Then turne your Globe and Quadrant towards that parte of the Horizon that the sun was in at the time of the obseruation, till the pricke you made for the place of the sunne in the Ecliptike, concurre and agree iustly with the eluation marked in the sayde Quadrant of altitude: so shall you see the Quadrant shew you vpon the Horizon, the Azimuth and distane of the sunne from the true Meridian of that place, which you shall compare with the variation obserued vppon the Instrument at that instant of the Sunnes elevation. And if they agree and concurre iust, then shall you be in the true and common Meridian, which sheweth the Pole of the world, and Pole of the Magnes or Loadstone. But if they differ, you shal subtract the lesser from the greater, the remainer sheweth the variation. And if the variation vpon the Instrument be greater then the true distane of the Azimuth from the Meridian found vpon the globe, the same surplus is to be accounted for variation: vpon the contrarie side of the Meridian: if it be lesse, it is to be accounted on the same side of the Meridian that the variation is taken, whether it be in the forenoone or afternoon. Thys precept needeth no further demonstration, then the instrument it selfe, the Globe I meane.

But for example of the worke, I take the fircke obseruation, in the former Chapter specified, made at Limehouse, the sixteenth of October. 1580, in the forenoone, which is 17.d. eleuation & variation 12.d. 35' from North to West.

First I set my Globe at 51.d. 32' for the eleuation of the Pole. Secondly, I take the place of the Sun. 2.d. 55'.m. and note it vpon the Ecliptike. Thirdly, I note vpon the Quadrant of altitude, the eleuation of the sunne. 17.d. This done, I moue the quadrant of altitude towards the East of the Horizon, and turne the Globe till the pricke in

v.

the

Of the Variation

The Eclipticke for the place of the Sunne, do agree iustly, with the elevation noted upon the quadrant of altitude, & find the true azimuth shewed by the same quadrant vpon the Horizon to bee nearely about 41° from the Meridian: and consering the same with the variation found vpon the Instrument 52.0.35'. I finde the difference 11.0.15' and because the obseruation is noted to be in the forenoone from the North to the West, or South to the East, and the variation vpon the Instrument greater then the azimuth found on the Globe, I account the same from the North to the East, or from the south to the West. So I conclude the variation at Limehouse to be about 11.0. from North to East, or South to West.

How to finde the Variation by Arithmetical calculation vpon any one obseruation in the forenoone or afternoone, the latitude of the place, and declination of the Sunne being giuen.

The fift Chapter.



The summe of the woork is to finde the arke of the Horizon betweens the meridian and the azimuth of the sunne at the time of the obseruation, which being compared with the variation found in the Instrument, the difference is the Variation of the Needles. For attaining of the same arke: First it is necessarie to haue the arke of the Equinoctiall betweens the sunne at the time of the obseruation, and the meridian, which arke is thus found.

Multiply the signe of the Sunnes Meridian altitude for the day proposed by the whole signe, the product deuide by the signe of the elevation of the Equinoctiall (or the complement of the latitudo) the quotient is the versed signe or shaft of the Semidiurnall arke, which you shall

Note

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Note for the first number,

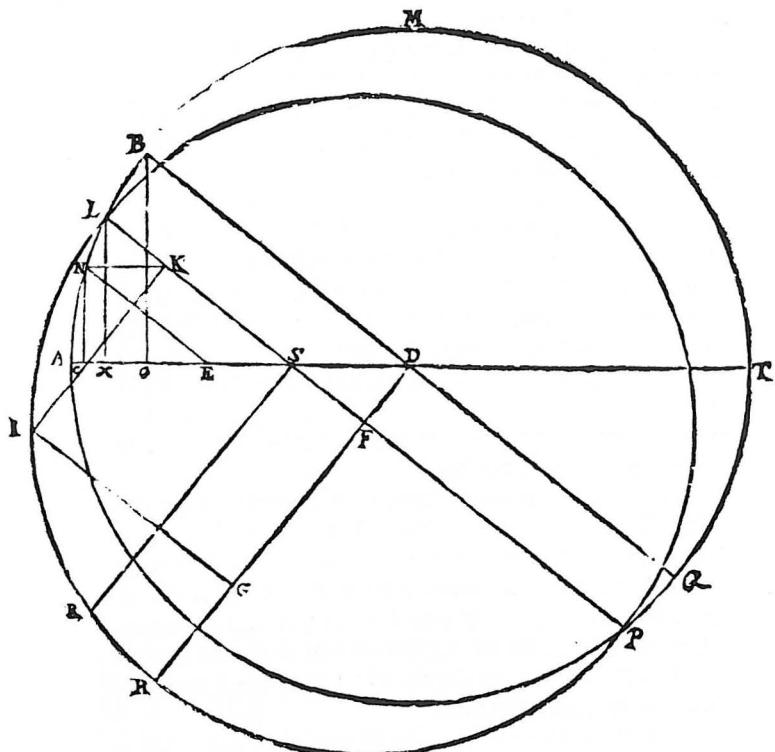
Then againe multiplie the signe of the sunnes elevation at the time of the obseruation, by the whole signe, and the producte deuide by the signe of the elevation of the Equinoctiall, the quotient subtract from the number you first noted, the rest is the versed signe of the arke of the distance betweene the sunne and the Meridian in the paralloll that it is in for the time proposed, in such partes as the semidiiameter of the Equinoctiall is the whole signe: but it is necessarie before you apply it any further, to reduce it into such partes as the semidiiameter of the paralell is the whole signe, which you may doe thus: Multiply this remayner by the whole signe, the producte deuide by the signe of the complement of the declynation (which is the semidiameter of the paralell) the quotient is the versed signe in his proportionall partes.

This versed signe thus reduced and subtracted from the whole signe, leaueth the second right signe, which you shal seeke in the Tables of signes, and thereby finding his arke you shall subtract the same from the Quadrant or 90. d. The remayner is the arke of the soe said paralell of the sun, which is answerable or correspondent in degrees and mynutes, to the arke of the Equinoctiall that you seeke. The reason of the precept is this.

As the right signe of the elevation of the equinoctiall, is in proportion of the right signe of the meridian altitude of the sunne or any star: so is the whole signe, to the versed signe of the semidiurnall arke. And again, as the right signe of the meridian altitude, is to the right signe of the elevation of the sun or star at the time of the obseruation, so is the versed signe of the semidiurnal arke of the same, to the excessse or difference between the same versed signe and the versed signe of the distance from the meridian.

For the better understanding of the premises, I haue set downe this figure following, and wish the Reader to consider of the same with the 4. Pro. of the 5. of Euclide.

Of the Variation.



Let AMT bee the meridian circle. BDQ the common section of the meridian, and Equinoctiall theyr plaines, which is also the diameter of both circles. ADT the plaine of the Horizon, LHP the parallel of the Sun, which is described vpon the center F at the distance FL which is the signe of the complement of the declination AB the arke of the elevation of the Equinoctiall BO the first right signe thereof AL the arke of the meridian altytude LX the signe thereof AN the arke of the Sunnes eluation

Of the Compasse.

eluation at the time of the obseruation. NC. the signe thereof BD. the whole signe in respect of the former arkes and signes LR the Semidiurnall arke of the paralell. RS. the first right signe therof SL the versed signe of the same. LI the arke of the Sunnes distanice from the Meridian IK the first right signe thereof IG the second right signe which is equall to KF KL the yeareld signe NE whch is equall to KS. the difference of the twoo versed signes. LS. and LK LF the whole signe in respect of the arkes and signes of the paralell.

Now as BO is to LX so is BD to LS. And as LX to NC so is LS to NE. Or else thus, As BO to NC so is BD to NE.

Example.

The 16. of October 1580. in Limehouse.

The eleuation of the pole Articke 51.d.32'. The declination of the sunne 12.d.30'. The eleuation of the sunne obserued in the forenoone 17.d.0'. The variation of the shadow vpō the instrument 52.d.35' from north to west.

38.28'. 90.0'. 25.58'.

BO. BD. LX. LS.

If 62205 giue 100000. — then 43784. giueth 70386.

38.28'. 90.0'. 17.0'.

BO. BD. NC. NE.

Againe, if 62205. giue 100000. 2937. shall giue 47001.

Now out of LS. — 70386.

take NE — 47001.

Reft LK. — 23385.

Then if LF. 97629. the signe of 77.d.30'. the comple-
ment of the declination, giue LF. 100000 then IK. 13385
giueth IK. 23952. the yeareld signe of the Arke IL. is his

Of the Variation

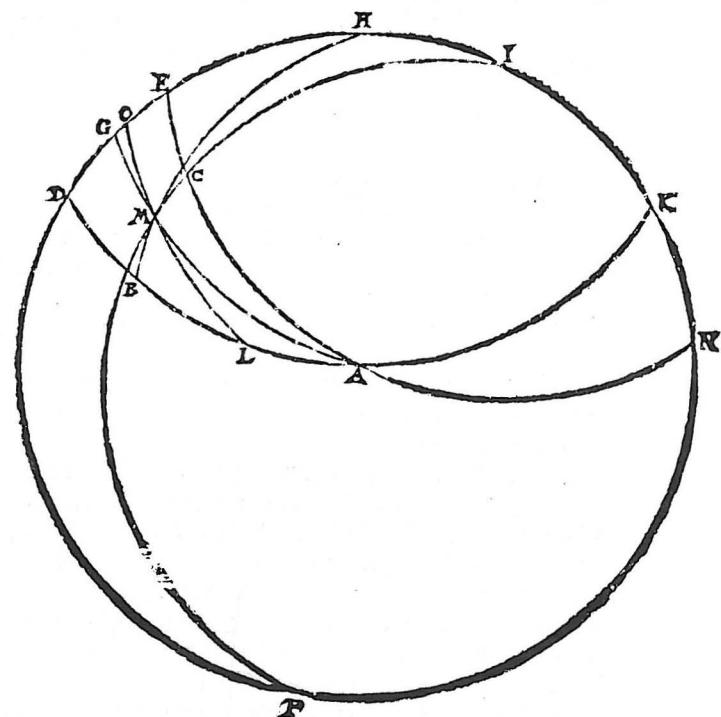
due parts. The same subtracted frō LF. 100000. the whole signe, leaueth KF. or LG. 76048. the second right signe of the same arke, which is the first right signe of the arke IH. which arke you shall finde in the Table of signes to be 49. d.30'.24". the complement wherof to the quadrant is 40. d.29'.36". the arke IL. of the paralell betweene the sun & the meridian, whose correspondent arke in the Equinoctiall, is the arke that was sought.

¶owe having this arke of the Equinociall, you must
worke as followeth.

Multiply the signe therof, by the signe of the comple-
ment of the declination, & devide the product by the whole
signe , the quotient is the signe of an arke contained be-
tweene the sunne and the Peridian, making right angles
with the Peridian. This signe multiplye by the whole
signe, the product devide by the signe of the complement of
the Sunnes elevation at the time of the observation, the
quotient halfe the signe of the arke of the Horizon contain-
ed betweene the Azimuth of the Sun, and the Peridian,
which is the arke that was proposed to be found.

L Et DHNP. bee the Meridian. DAK. the Horizon.
EAN. the Equinoctiall. M. the place of the sunne in
the heauen at the time of the obseruation. LMO. the pa-
rallel. HMB. the Azimuth or verticall circle passing by the
Sunne. **A MG**. a great circle imagined to passe by the
sunne, and to croſſe the meridian at right angles. **IMP**. a
great circle passing by the poles of the world, and place of
the sunne at the time of the obſeruation, commonly called
the circle of houres, or circle of declination. **CM**. the south
declination of the sunne. **MP**. the complement therof to
the quadrant. **MG**. the arke betweene the sunne and the
Meridian of the former imagined circle. **AMGMO**. the
Arke of the sunnes paralell. **EC**. the correspondent arke
of the Equinoctiall, which are giuen in the former work.
MB. the Eleuation of the sunne at the time of the obſerua-
tion.

Of the Company.



tion. *MH.* the complement thereof. *BD.* the Arke
of the Horizon intercepted betweene the Azimuth and
the Meridian , whiche is the thing required to bee
found.

In this figure the Reader is to consider the manner of the sphericall triangles, and to compare the signes of their sides, according to the doctrine of Copernicus, in the 14. Chapter of his first booke, & of Regiomontanus, his 25 and 27. Prepositions of his 4. books of triangles.

As PC, is to CE, so is PM, to MG, but three of them are given.

Of the Variation

giuen, therefore the fourth shalbe knownen.

And as HM. is to MG so is HB to BD the arke that
is sought, which by three fifts giuen is likewise giuen

The second part of the example.

90.0°	40.29' 36"	77.30'
PC.	EC.	PM.
If 100000, giue 64935.—then 97629. giueth 63395.		
37.0°	90.0°	41.31' 22"
HM.	MG.	HB.
Againe, if 95630, giue 63395.—100000, giueth 66291,		BD

Whose arke BD, 41.d 31' 22", is the Horizontall distance of the Azimuth of the Sun from the Meridian, the thing that was sought.

Nowe comparing the same with the variation founde
vpon the Instrument at the instant of 17. d. elevation
which is 52.d 35'. I finde it to be lesse, and therefore sub-
tract it, and so haue I the difference 11.d 3' 38". And be-
cause the obseruation was in the forenoone, and the varia-
tion vpon the instrument greater then the arke of the Ho-
rizon, betweene the sunnes azimuth and the Meridian,
therfore I conclude that the variation is 11.d 3' 38". fro
South to West, or North to East, which is the thing pro-
mised to be shewed.

But comparing the same arke of the Horizon 41.d. 31'
22". with the variation found at the corespondent eleva-
tion in the afternoone, which is 30°. I subtract the les-
ser from the greater, & find the excesse 11.d. 31' 22' which
shoulde be the variation. And because the variation found
vpon the Instrument is lesse then the arke of the azi-
muth vpon the Horizon, I accouut the variation on the
same side of the Meridian, which is from South to West,
or North to East.

This varietie betweene the obseruation made in the
foxe

Of the Compasle.

forenoone, and that in the afternoone, procedeth either of
the imperfection of the instrument, or negligence of the ob-
server. Soz in the rule there can be no error, being grou-
ded vpon Geometrical demonstration, then which, no-
thing can be more certaine.

The former precepts and examples do serue when the
sunne dooth decline from the Equinociall either North-
wards or southwards. But if the sunne be in the Equinoctiall,
then the manner of the woorking is more easie and
briefe. Soz if you multiply the signe of the Sunnes ele-
vation at the time of obseruation, by the whole signe, and
deuide the producte by the signe of the elevation of the E-
quinodal, which is the meridian altitude, the quotient
giueth the second right signe of the distance of the sun from
the meridian, which is the first right signe of the comple-
ment of the same arke: and entring the Table of signes
with it you shall finde his arke, which if you subtract from
the Quadrant or 90. d. leaueth the arke of the distance of
the sunne from the meridian. And hauing the same worke
thus. If the signe of the complement of the elevation of the
sunne at the time of the obseruation, giue the signe of the
foresaid arke of distance, what shall the whole signe gyue?
Multiplie and deuide, the quotient shalbe the signe of the
arke of the Horizon contained betweene the Azimuth of
the Sunne and the Meridian. Which arke being compa-
red with the Variation of the Instrument in manner as
before is shewed, giueth the variation required.

But the sunne being in the Equinociall. in the place
wher the obseruation is made, he likewise vnder the same
circle, then is the variation most easilie obserued, for that
the Equinociall is the azimuth of East and West, there-
fore turning your Instrument onelie to receive the sha-
dowe of the Sunne, and looking then to the North point
of the Needles, if you finde the same to aunswere to the
Quadrant or 90. d. you shall bee in the Meridian of the
Magnes, which passeth by the Poles of the world, but if it
doe

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doe differ from 90. d. the same difference is the variation of the needle.

But admitting the obseruer to be under the Equinoctiall, and the sunne to haue Declination, then the proportion of the signe of the complement of the elevation at the hunc of the obseruation, vnto the signe of the declination shall be such, as the whole signe, is to the signes of the arke of the Horizon included betwene the Azimuth of East and West, which is the Equinoctiall it selfe, and the azimuth of the sun for the time of the obseruation, the complement wherof giueth the true Meridian, which complement you may compare with the variation shewed vpon the Instrumenent, the difference is the variation.

Divers other cases might be proposed, and rules given for them, which for brevity I omit.

But one thing I thought good to admonish you by the way, that whereas I haue shewed in the first parte of this proposition, the maner to finde the twoo barsed signes, the one of the Hemidiurnall arke, the other of the arke of the distance of the sunne from the Meridian. By the first the semidiurnall arke being found and reduced into hours and minutes of time, is shewed the iust halfe quantite of the day. And by the arke of the other likewise reduced, the houre of the day, or the time contained betwene the noonesteed and the instant of the obseruation: as in the same example.

The barsed signe of the Hemidiurnall arke, LS is given 70386. in such parts as the semidiameter of the equinoctiall BD is 100000. therfore I reduce the same into such partes as the semidiameter of the parallel LF, is 100000. and finde it to bee 72095. whiche subtracted from the whole signe LF 100000. there resteth SF 27905. whiche is the seconde right signe of the semidiurnall arke LR. and the right signe of RH 16.d. 12'. which is the complement of the Hemidiurnall arke LR wherefore subtracting it from the Quadrant LH 90.d. resteth 73.d. 48'.

the

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The Hemidiurnall arke LR the same reduced into partes of time alowing 15.d. for a houre 15' for a minute, & 15" for a seconde of time, and for euerie degree 4. minutes of time, for euerie minute 4". and for euerie second 4". ec. I finde the time of that arke from the time ascendent, to the Meridian, which is halfe the day, to be 4.houres 55' 12". and consequently the whole day being the 16. of October aboue written, to be 9.houres 50' 24" long.

This example may serue for a general precedent, whiles the equinectiall is betwene the sunne and the elevated Pole, but if the sunne bee betwene the elevated Pole, and the Equinectiall, then will the versed signe fall out to bee greater then the whole signe, and the semidiurnall arke to exceede a Quadrant. Wherefore having reduced the same into his proportionall parts, as before is shewed: subtract from it the whole signe, the surplus is the signe of the excede of the Hemidiurnall arke aboue a Quadrant, which being added to the Quadrant, giueth the semidiurnall arke.

By the other versed signe of the distance of the sunne from the Meridian, which is LK. 23952. in such partes as the whole signe of Semidiameter LF is 100000. subtracted from the whole signe, is given KF. 76048. the seconde right signe of the same arke of distance, and the first right signe of 49.d. 30'. 24". which is the complement of the arke of the sunnes distance from the Meridian: wherefore subtracting the same from 90.d resteth 40.d. 29'. 36". the arke of the distance betwene the sunne and the Meridian, which beeing reduced into partes of time as before, giueth 2.houres 41'. 58". and the same (because it is in the forenoon) deducted from 12. houres the noonesteed, resteth 9.houres 18'. 2". the iust instant of the time of the daie.

But if this versed signe be found to be greater then the whole signe (as it may when the sunne is betwene the Equinectiall and the elevated Pole, and before the houre

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or sirs in the morning, and after the houre of stre in the evening) then dooth the arke of distance consequentie exceede a Quadrant, the signe of this excesse is the surplus of the versed signe aboue the whole signe. Whose arke added to the Quadrant, giueth the arke of the sunnes distance from the meridian , and reducing the same into partes of time, is giuen the instant of time of the obseruation.

As by this meanes (the elevation of the sunne beeing
precisely obserued and latitude knowne) the instant of
tyme of the daye is gyuen more exactlie , then by anie
Clocke, Diall, or other Instrument. So if there might be
had a portable Clock that would continue true the space of
40. or 50. houres together (if longer tyme the better) then
might the difference of longitude of any two places of
knownen Latitudes, which conveniently maye bee tra-
uailed within that tyme, bee also most exactly gluon. And
in this sorte trauailing and obseruing from place to place,
might the Longitudes of any Countrie bes perfectly de-
scribed.

Another waie most generall, how to finde the Variation by one observation, either in the forenoone or afternoone, the elevation of the Pole, and declination of the sunne being giuen.

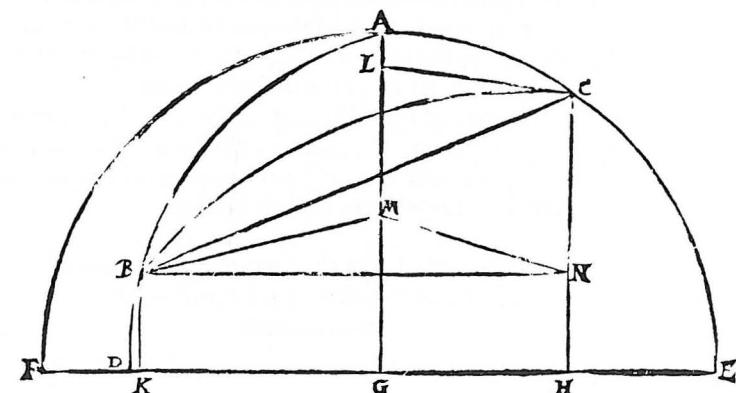
The sixt Chapter.



For the accomplishing of this preposition you are to imagine a spherical triangle upon the superficies of the Globe, whose sides must be, First, the portion of a circle at the meridian between your Zenith and the Pole, which is the complement of the latitude. The second the arke of the verticle circle contained between your Zenith & the sun, which is the comple-
ment of the sun's elevation at the time of the observation.

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The third side is an arke of the circle of declination comprehendēd betwēne the sunne and the elevated Pole, this arke is found by adding, or subtracting the declination of the sunne, to or from, the Quadrant or 90.0. which must be done with this consideracion, that if you be on the same side of the Equinoctiall that the sunne is , you are to subtract the declination from the Quadrant. If on the other side, to ad it to the same, so haue you the three sides of the sphericall triangl given. Then the substance of the woake consisteth in finding the quantitie of the angle of the samis triangle at the Zenith, for the complement thereof to the Hemicircle or two right Angles, is the Horizontal distance of the Sunnes Azimuth, from the Meridian, which beeing compared with the variation of the Sunnes shadowes vpon the instrument, giuelth the thing required.



Let FACE. be the Meridian, wherein A. the Zenith, C
the Pole. AD. the verticall circle of Azimuth of the
Sunne passing by B. the place of the Sunne at the tyme of
the obseruition. BD. the elevation of the Sunne. BA.
The complement of the elevation AC. the complemet
of the latitudo. BC. the arke of the circle of declination, or
the

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the chord of the same arke, FGE, the plaine of the Horizon.

Now from the three angles of the triangle ABC let fall 3. perpendicular lines to the plaine of the Horizon AG CH and BK and by the 6. of the 11. of Euclide, these three lines shalbe paralels.

Then let fall a perpendicular line from C vpon AG in the point L from B another perpendicular vpon the same line AG at the point M. And from the same point M erect a perpendicular line to N, which shalbe paralell and equal to LC. Then ioine B and N together. So haue you a right lined triangle BMN whose angle at M is equall to the angle A of the spherickall triangle ABC. By the 4. definition of the 11. Euclide, for the like reason is of obtuse angle, as of acute or sharpe. And the sides thereof BM and MN, are giuen BM the signe of BA, and MN equal to LC the signe of CA. And the third side BN is founde by subtracting the square of NC from the square of the chord BC, as in the 47. of the first of Euclide.

And in the right lined triangles, the three sides beeing giuen, the angles are also giuen, by the 44 45. &c. of the first of Regiomontanus, and by the 7. proposition of the 13. chapter of Copernicus his first booke.

For example I take the former obseruation of the 16. of October. 1580, and worke as followeth.

The elevation of the Pole CE, 51d.32, the signe therof CH.78297. The elevation of the sunne BD, 17.d. 0', the signe thereof BK. 29237. The Arke BC, 102.d. 30'. the chord thereof BC. 155970. The complement of the elevation of the sunne BA.73.d.0', the signe thereof BM 95630. the complement of the Latitude AC, 38.d.28' the signe thereof LC.52205. equall to MN.

Now

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Nowe out of CH.78297. subtract NH. equall to BK. 29237. Rest NC. 59060.

Then out of the chord BC squared. — 44328512576,
Take the square of NC — 2406883600.

Rest the square of BN — 21921628976.
The root therof is 148059 the side BN.

So are the three sides of the triangle giuen. $\begin{cases} BN.148059 \\ MN.62205 \\ BM.95630 \end{cases}$



Now I finde the angle MI. subtract from the square of BM the bigger side, which is 9145096900. the square of MN, the lesser side, which is 3869462025. Rest 5275634875, which deuided by the base BN. 148059, giueth 35631, the halfe thereof 56214 is IN. the lesser case or shorter part of the base deuided by the perpendicular line MI, falling vpon the same from the obtuse angle M, which subtracted from the whole base BN 148059 leaueth 1B 91845, the greater case or longer part thereof.

Now it is manifest that these two cases or parts of the base BI and IN are the signes of the two sharpe angles IMB and NMI made of the obtuse angle M by the perpendicular falling from the same angle to the base, and the arkes of them ioined together, are the quantity of the obtuse angle NMB.

Therefore to reduce them to the numbers of the signes first for the greater case BI making BM the whole signe, say.

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BM. BM. BI. BI.
If 95630. giue 100000.— then shall 91845. giue 96042.

The arke therof is 73.d.49'.38''. Againe for the lesser case, making MN. the whole signe, say.

MN. MN. IN. IN.
If 62205. giue 100000.— then 56214. giueth 90376.

Whose arke is 64.d.38'.45''. And adding these two arks together, they giue 138.d.28'.23''. the arke or quantity of the obtuse angle NMB equal to the spherical angle BAC and deducting it from the Semicircle 180.d. there resteth 41.d.31'.37''. the angle FAD the Horizontal distance of the Sunnes Azimuth from the meridian, and subtracting that from 52.d.35. the variation found vpon the instrument from north to west in the forenoone, resteth 11.d.3'.23''. the variation of the Needle from the meridian, the thinge that was proposed to be found. And comparing the same with the afternoons obseruation, you shal find it 11.d.31'.37''. the cause of this difference I haue declared in the former chapter.

If the Reader bee delighted with varietie of demonstration of this matter, let him peruse the 34 Proposition of the 4. of Regiomontanus, and the 13. Proposition of the 14. Chapter of the first booke of Copernicus.

But whereas you see this calculation to differ from the former in some odde secondes, the reason thereof is not as it might be taken the different nature of the rules, but in working thereof, omitting the fractions in the devisions, and neglecting the proportionall partes of the signes and arkes.

In these examples I haue vsed the abridged Table of 100000. the wholie signe, which though it giue some ease in the working, yet it is not so exact as that of 10000000. of Erasmus Reinholdus. Unto the which, with his Canon secundus answerable to the same, if the third canon of the Hypo-

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Hypothenusaes were annexed, wee shold haue an entier Table for the doctrine of triangles, that might worllye be called the table of tables. Which thing though Georgius Joachimus Rheticus, haue wel begunne and strained it orderly from ten minutes to ten: yet is it left very rawly, for such as desire the exact truth of things. I haue therefore for mine owne easse and vse, calculated the complement of this Table, and almost ended, if for the whole quadrans from minute to minute: which is in the meane time before I haue finished, I shall not finde it extant by anie other, I wil publish it for the commoditie of al such as shall haue occasion to vse the same for Navigation and Cosmographie.

To find the elevation of the pole, scituacion of the Meridian, and variation of the Needle, at any place by the sun, vpon two obseruations either in forenoone or afternoone.

The seventh Chapter.


Hereas in the thre laste Chapters, the groundes of the calculations consist in the Elevation of the Pole to bee giuen, which thing to know is no lesse difficult, then the chiche matter that is by them required: for the common preceptes, which as yet haue chiefly been giuen for the finding therof, depend only vpon the obseruation of the Meridian altitude of the Sunne or Starres, or else vpon certaine false and grete rules of the guards and pole starre. Therfore I haue thought good that as I haue shewed the way to knowe the variation, vpon any one obseruation, either in forenoone or afternoone, the latitude of the place presupposed: So likewise vpon two obseruations by the sunne, either in forenoone or afternoone, to set downe the way and manner howe to finde

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finde the elevation of the Pole, situation of the Meridian, and the variation of the Needles in anie place by the Globe.

But this you must alwaies regard, that your two observations may haue conuenient distance of time between them, the greater the better: So as the higher elevation be not taken neare the Meridian, the lower elevation, the nearer it is taken to the Azimuth of East or West, or to the Horizon the better, with which elevations you are to note the difference of the Sannes Azimuths or Variations founde by the shadowe vpon the Instrument exactly, for without that the elevations ouerlie are in vaine.

First it is requisite that your Globe be so fitted, that the meridian circle and the Horizon do crosse each other at right angles, and deuide themselves equallie into Hemispheres. And also that the Quadrant of altitude (or moouable verticall) be placed driticly vpon the Meridian circle at the Zenith, so as beeing turned circularlie, it may touch the Horizon equallie in euerie part. These things beeing driticly considered, there needeth not anie further regard to be had for placing of the Globe, onelie this you may respect in setting the Pole at aduentures aboue the Horizon, between it and the Zenith, that the meridian circle may cut the Horizon in iust degrees, so may your Quadrant of altitude be placed in your Zenith iustly vpon a degree also.

Then must you fasten your Globe to the Horizon, so as it may remaine immouable, but in fastning the same you must regarde that you forre it not from one ende of the Horizon to another, but that it rest equidistant in the same, and hauing your Globe thus disposed, it is ready for you to applie your obseruations vpon, which you shall thus doe.

First, take your highest elevation, and note it vpon your Quadrant of altitude, and place the ende of the said Quadrant vpon the Horizon at 10.15. or 20. d. from the Meridian circle (but the nearer you set the same to the meridian, the more conueniently, without impeachement will your triall bee made.) Then giue a pricke vpon the Globe in the azimuth, that the Quadrant sheweth at the degree of the elevation noted vpon the Quadrant, then againe note the lesser elevation vpon the Quadrant of altitude, and remoue the same vpon the Horizon, (from that place wher it was first fixed, towards the azimuth of East or West (which shalbe neerest the same) so many degrees as you finde the difference of azimuths betwene the two elevations by the shadowe of the same, vpon the instrument of Variation, and stayng your quadrant of altitude vpon that point of the Horizon, note also your lesser elevation in the same azimuth vpon your Globe. Thus done, you must haue a pair of Calliper Compasses, such as may conveniently reach to 113.d. of the Equinoctiall of your Globe, (which is a Quadrant, and the greatest declination of the Sun) then you must consider whiche of the Poles of the world is elevated aboue your Horizon, and whether your declination be towards, or from that Pole, that is to say, whether the Sun be betwene the elevated Pole, and the Equinoctiall, or the Equinoctiall betwene the sunne & the Pole. If the sun be betwene the Poles and the Equinoctiall, then are you to deduct the declination from 90. d. If the Equinoctiall be betwene the sun and the Pole, you must adde the declination to 90. d. And take the same remaining or collected number of degrees &c. with your compasses vpon the Equinoctiall. And set the one end of your compas at the pricke made vpon your Globe, for the highest obseruation, and with the other end discrcribe an arke or piece of a circell, vpon the same side of the meridian that your pricke is on, from the meridian to the Horizon. Then againe with your compas unaltered, setting the one foot in the pricke for the lowest obseruation, describe an other piece of a like circell crossing former:the point of the intersection, or crossing of these 2. circles, is the elevated pole, to the

Of the Compasse.

bian circle (but the nearer you set the same to the meridian, the more conueniently, without impeachement will your triall bee made.) Then giue a pricke vpon the Globe in the azimuth, that the Quadrant sheweth at the degree of the elevation noted vpon the Quadrant, then againe note the lesser elevation vpon the Quadrant of altitude, and remoue the same vpon the Horizon, (from that place wher it was first fixed, towards the azimuth of East or West (which shalbe neerest the same) so many degrees as you finde the difference of azimuths betwene the two elevations by the shadowe of the same, vpon the instrument of Variation, and stayng your quadrant of altitude vpon that point of the Horizon, note also your lesser elevation in the same azimuth vpon your Globe. Thus done, you must haue a pair of Calliper Compasses, such as may conveniently reach to 113.d. of the Equinoctiall of your Globe, (which is a Quadrant, and the greatest declination of the Sun) then you must consider whiche of the Poles of the world is elevated aboue your Horizon, and whether your declination be towards, or from that Pole, that is to say, whether the Sun be betwene the elevated Pole, and the Equinoctiall, or the Equinoctiall betwene the sunne & the Pole. If the sun be betwene the Poles and the Equinoctiall, then are you to deduct the declination from 90. d. If the Equinoctiall be betwene the sun and the Pole, you must adde the declination to 90. d. And take the same remaining or collected number of degrees &c. with your compasses vpon the Equinoctiall. And set the one end of your compas at the pricke made vpon your Globe, for the highest obseruation, and with the other end discrcribe an arke or piece of a circell, vpon the same side of the meridian that your pricke is on, from the meridian to the Horizon. Then againe with your compas unaltered, setting the one foot in the pricke for the lowest obseruation, describe an other piece of a like circell crossing former:the point of the intersection, or crossing of these 2. circles, is the elevated pole, to the

which

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which if you remooue the Quadrant of altitude, we shall find what the elevation thereof is. And the point that the same Quadrant sheweth vpon the Horizon, is the intersection of the Meridian and the Horizon, the Horizontall distance betwene this intersection, and the azimuth of the lesser obseruation, subtracted from the Hemisphare, or 180° leaueth the Horizontall distance of the same azimuth from the true meridian. So haue you the elevation of the Pole, and scituacion of the meridian.

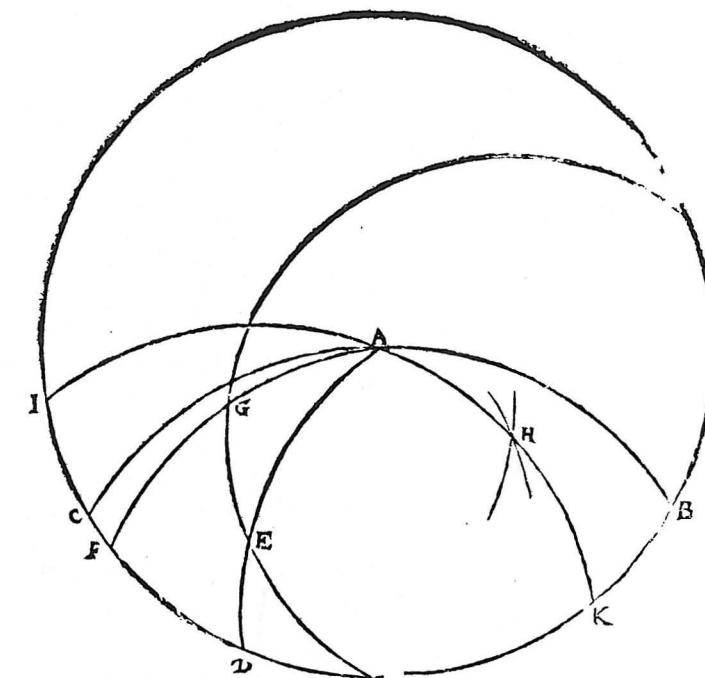
Nowe if you compare the Horizontall distance of the azimuth of the Sunne, from the Meridian at the time of the obseruation, with the variation by the sunnes shadowe founde vpon the Instrument, at the time of the same obseruation, and taking the one out of the other, the remainer halfe the true variation, which you are to account, as in the latter ende of the thirde Chapter is shewed. So haue you giuen the elevation of the Pole, the Meridian, and variation of the Needel, the thinges preposed to bes shewed.

EXAMPLE OF TWO OBSER- VATIONS MADE AT LIMEHOUSE, THE 29. OF JULIE 1581. IN THE FORENOONE.

The first elevation 21.d.0'. Variation 100.d.30' from North to West. The second elevation 50.d.0'. Variation 48.d.0' from North to West. Difference of the Azimuth 52.d.30'. The Declination 16.d.14'. Northerlie.

Let IDB be the Horizon of the Globe, CAB the Meridian circle, FGA the Azimuth of the greater elevation shewed by the Quadrant of altitude vpon the Horizon at F, 10.d. from the meridian circle of the globe C. FG the greater elevation marked vpon the Globe at G. FD the

Of the Compasse.



the difference of the Azimuth vpon the Horizon. 52. d.
30'. E. the prick of the lesser elevation marked vpon the
Globe in the Azimuth AED.

Then opening your Compasses to 73.d.46' of the Equinoctiall (which is the complement of the declination) and setting one end vpon G. the point of the greater elevation, describe with the other ende, an arke or piece of a circle at H.

This done, set one foot of the Compas vnto E. the lesser elevation, and with the other end describe a piece of a circle crossing the former arke at I. thus intersecting

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on shall be the elevated Pole.

Then set the Quadrant of altitude unto the point H, and it will shew the Meridian to crosse the Horizon at K. So shall you haue the elevation of the Pole KH, 51.0.1.03 there about. And the true Meridian KA. And from K to D the Horizontall distaunce 90.0., which subtracted from KI, 180.0. the semicircle of the Horizon, resteth the arke DI.89.0. $\frac{1}{4}$. the distaunce of the Azimuth of the first obseruation from the Meridian I. which distaunce compared with the variation founde bypon the Instrument at the first elevation 100.0.30'. and deducted from the same resteth 11.0. $\frac{1}{4}$. Therefore I say, the true Meridian shewing the Pole arke is 11.0. $\frac{1}{4}$ to the Westwardes of the Magnetical Meridian shewed by the Needle, and consequentlie the Variation of the Needle 11.0. $\frac{1}{4}$ from the North to the East.

In this example the declination is subtracted from the Quadrant, because the sunne is betwene the Equinociall and the elevated pole, but if the Equinoctiall were betweene the elevated pole and the Sunne, then shoulde you adde the declination to the Quadrant, and with that distaunce taken bypon the Equinociall with your compasses, proceed as in the former example.

These examples that I haue shewed, and such like experimenteries to bee doone bypon the Globe, are easie to bee conceived, and the reasons verie manifest; but the truthe of the matter consisteth in the exactnesse of the instrumentes, and the orderlie application and handling of them.

I might heere haue annexed the manner, how bypon two obseruations of the Sunnes elevation in tozemoone or afternoone, and difference of the Azimuthes, to calculate the Premises more exactlie by the Table of Signes and doctrine of sphericall Triangles: but that it is a verie tedious waie, and my meaning is rather to gyue the Reader a profe of the pleasant vse of these calculations (which

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(which I thinke I haue sufficientlie doone in the former Chapters) then to cloie him at the first with the hard and painfull practise of manie examples. Notwithstanding for the satisfaction of some, I will briefly set downe the grounde and summe of the worke, which is this.

The Complements of your two elevations, are two sides of a sphericall triangle not rectangle. The angle by these two knowne sides contained at the Zenith, is giuen by the difference of the Azimuthes or Variations bypon the instrument. Wherefore by the 28. of the 4. of Regiomontanus the third side (which is the arke comprehended betwene the two elevations) and the other angles mate be giuen.

Then haue you another like triangle, whose three sides are these: the first, one of the foresaid complements of elevation: the second, the arke of the circle of declination, betwene the Sun at the instant of the same elevation, and the Elevated pole. The third side is an arke of the Meridian betwene the Zenith and the pole: which is the complement of the elevation of the pole, or latitude of the place.

The two first sides are alwaies giuen. For finding the third side, it is necessarie to knowe the angle that the two giuen sides containe, which is the difference of two angles, whereof one is an angle of the first Triangle giuen, the other an angle contained betwene the arke of the circle of declination, and the third side of the first Triangle, which angle is diuersely found, and being founde and substracted from the other angle, or that from it, the difference is the Angle of this other Triangle: And so haue you in the Sphericall Triangle two sides, and the angle by the same two sides contained giuen. And by the same 28. of the fourth of Regiomontanus the third side is founde, the complement whereof is the elevation of the pole.

And the elevation of the pole, and declination of the Sunne

Of the Variation

Sum being giuen, the fourth Chapter sheweth by one obseruation, to finde the variation of the Neede.

Of the Pole of the Magnes.

The eight Chapter.

Divers learned men haue indged, and set down as a truth (grounded vpon reporte) that the meridian common to the Pole of the world, & the Pole of the Magnes (that is to say, where the Needle touched with the Magnes, sheweth the Pole of the world directly) passeth at the Ilands of the Acores, or neare there about, (but I finde by great probability, that it shoulde be to the Westwards of thase Ilands.) From which meridian at the Acores, I account the beginning of Longitudes, and find our Meridian of London, to be from the same, 23.0. $\frac{1}{2}$ our Latitude as before said, 51.0.32', and the variation of the Compas or Needle, 11.0. $\frac{1}{2}$, from the North to the eastwards. Now vpon these grounds I finde by calculation, the Pole of the Magnes, or the intersection of the two Magneticall meridians, vpon the superficies of the earth, to bee from the Pole artik 25.0.44'. & in longitude 180.0. that is to say, 25.0.44' in the former common meridian, on the other side of the Pole.

It may bee happylie that some of you will be desirous to know the way how this Magneticall Pole is found out, that you may applie the same to like purpose heereafter. Therefore I thought good to set downe the manner of the former calculation, by helpe of the declinations in the figure following.

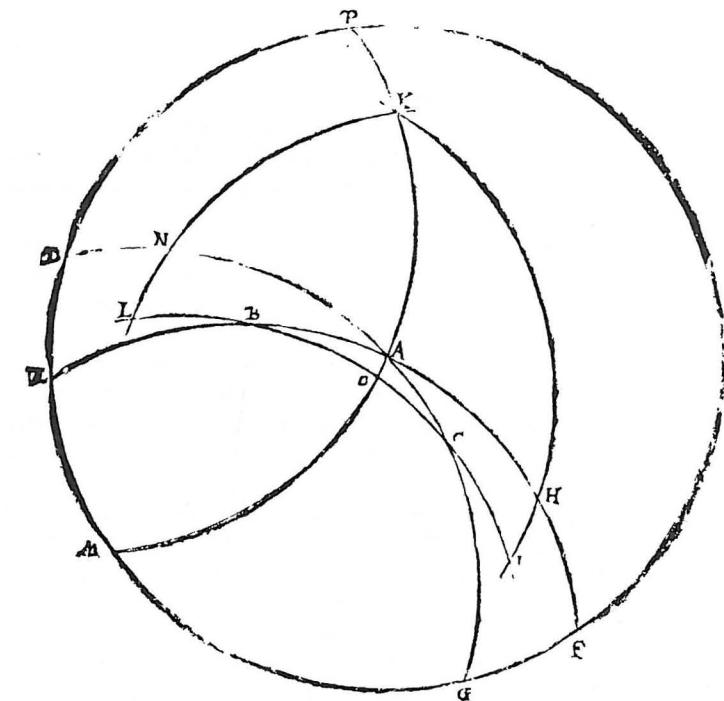
Example.

Let A be the Pole Artike, PEF the Equinoctial, DAG the common Meridian of the Pole Artik, and Pole of

Of the Compasse.

the Magnes EA the meridian for London,

LO the Magneticall meridian of London, B, for the place of London. HI the quantitie of the angle of Variation at the ende of the quadrants BH and BI, C the inter-



section of the two magnetical meridians CL and CN two Quadrants of the saide Magneticall circles, including the arke LN the quantity of the angle at C. PAM the Semicircle of a Meridian crossing the Magneticall Meridian of London in the point O, at right angles.

Make out the quadrants IHK and I NK so shall they crosse themselves with the quadrant OAK at the point K
Nov.

Of the Variation

Now haue you ABC a sphericall triangle, two angles whereof, and the common containing side of them, are giuen ABC. 11.d. 1. the angle of variation at London. BAC. 156.d. 30'. the complement of the angle DAE (the difference of the longitudes) to 2 right angles. And the side AB. 38.d. 28'. the cōplement of the latitude of Londō.

And in a spherical triangle, not rectangle, whose two angles are giuen, and their common containing side, the other angle and sides shall be knownen, by the 31. of the 4. of Regiomontanus.

Wherfore the arke AC, the distance of the two poles shalbe giuen, which is the thing required.

For as the signe of BH is to the signe of HI, so is the signes of BA to the signe of AO. & thre of them being giuen, the 4. is found.

$$\begin{array}{cccc} 90.0'. & 11.15'. & 38.28'. & 6.58'. \\ BH & HI & BA & AO \end{array}$$

If 100000. giue 19509.—then 62205. giueth 12135.

Now as AK is to AA (the signes I meane) so is KO to OI, but the three first are known AK & AH, by their cōplements, and KO the quadrant: therefore the 4. is giuen.

$$\begin{array}{cccc} 83.2'. & 51.32'. & 90.0'. & 52.4'. \\ KA & HA & KO & OI \end{array}$$

If 99261. giue 78297.—then 100000. giueth 78879. And as BA is to BO, (the complement of the arke OI, last found) so is AE, to EM, the quauitie of the angle BAO.

$$\begin{array}{cccc} 38.28'. & 37.56'. & 90.0'. & 81.12'. \\ AB. & BO & AE & EM \end{array}$$

If 62205. giue 61474.—then 100000. giueth 98824

So hauing EM. 18.d. 12'. the quauitie of the angle BAO I substracte the same from EG. 156.d. 30'. the quauitie of the whole angle BAC rest MG. 75.d. 18'. the quauitie of the angle CAG, to the which is eqnall the oposite angle FAD. And as AG. is to PD. so is AK to KN.

Of the Compasse.

$$\begin{array}{cccc} 90.0'. & 75.18'. & 83.2'. & 73.46'. \\ AP & PD & AK & KN \end{array}$$

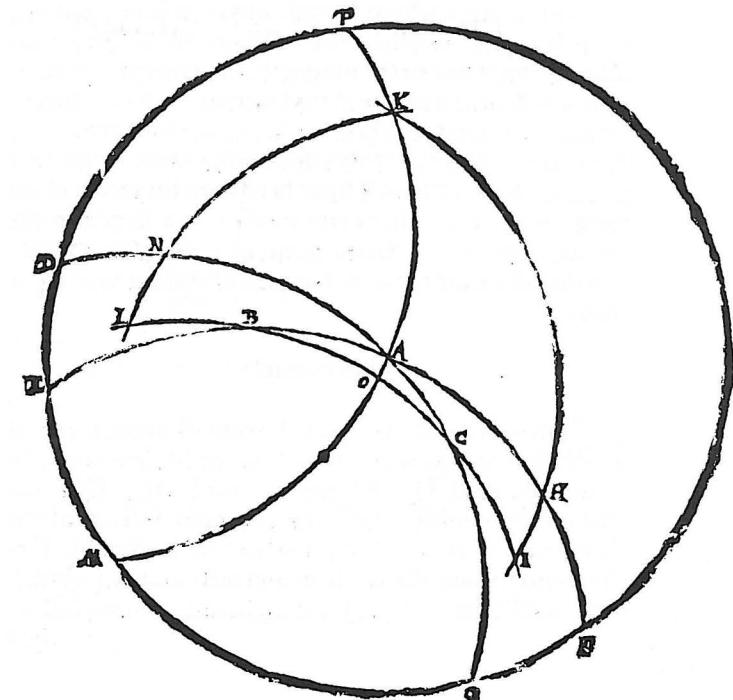
If 100000. giue 96726.—then 99261. giueth 96011.

The complement of which arke KN is NL. 16.d. 14'. the quantitie of the angle ABC. And as NL. is to NC. so is AO to AC. Wherfore I say.

$$\begin{array}{cccc} 16.14'. & 65.8'. & 25.44'. & AC. \\ NL & NC & AO & AC. \end{array}$$

If 27954. giue 100000.—then 12135. giueth 43410.

Which is the distance of the pole of the Magnes from the Pole artike vpon the former Hypothesis, the thing that was sought. Of



Of the Variation

Of the point Respective.

The ninth Chapter.

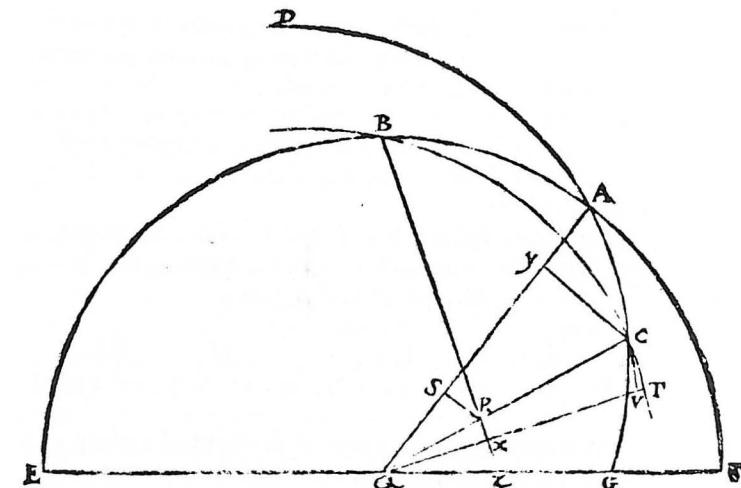
In this shewed in the former Chapter, upon the groundes therein specified, the place of the Pole of the Magnes upon the superficies of the earth: thers resteth now to be declared of the point respective, wher it shoulde be, by the new propertie found of the declining of the Needles, beeing at this place for London, 71.d.50'. as in the former treatise by R. Norman.

First it is to be considered, that as the Magnetical meridians do crosse themselves at their pole before specified; so do their plaines likewise crosse in a right line, passing by the said Pole, and the center of the earth. Then producing a straight line in the magnetical plaine of London, declining from the plaine of the Horizon 71.d.51'. Where the same doth crosse with the former common section of the two plaines, thereby reason shoulde the poynt Respective bee. Which intersection I finde to be from the center of the earth 1085 miles (after that rate of 60 to a degrē in the equator, and 3436.1. for the Semidiameeter of the Earth) and the distance of the same from the axis of the world 471 miles.

For example.

Le the circles be as in the last demonstration, then shal BC be the distanee of the pole of the Magnes from the Zenith B. And Q. the center of the Earth. QA. the axis of the worlde. QC the common section of the Magnetical playnes. BZ. the lyne of the Needles Declination crossing the said common section at R. (which is the point Respective.) QT a straigthe line crossing BZ. at right

Of the Compasse.



right angles in X, QR. the distanee of the point Respective from the center of the earth, RS. the distanee thereof from the axis. First it is requisite to knowe the quantity of the arke BC, which is thus found, as the signe of the angle AEC 11.d. 15' hath vnto the signe of the arke AC, 25 d.44'. So hath the signe of the angle BAC. 156.d.30' (which is al one with the signe of the angle BAD, the difference of Longitude 23.d.30') to the signe of the arke BC which is 62.d.46'. Now as QV is to QC so is QX to QR. But the three first are knownen QV, the second right signe of the arke CT 9.d.4'. (the difference of the Arke BT, 71, d.50'. And BC 62.d.46.) Then QC the Semidiameeter or whole signe, and QX, the second right signe of the arke BT. Wherfore QR shall be given by the 4. of the sixt of Euclide,

80.56'.
QV

90.0'.
QC

18.10'.
QX
QR
if

Of the Variation

If 98.750 giue 100000 — then 31178. giueth 31572.

So haue I QR in such parts as the Semidiameter of the earth. QC is 100000. which (beeing reduced into miles, accounting 3436. for the semidiameter of the earth) do giue 1084 miles and $\frac{1}{2}$. which is the distaunce of the poynt respectiue R from the center of the earth Q ypon the former Hypothesis of the variation & declination of the magnetical needle.

Aagine, as QC is to CY so is QR to RS wherefore QC and QR being giuen as before, and CY the signe of the ark CA likewise knownen RS shalbe giuen.

90.0'. 25.44'.
QC CY QR RS
If 100000. giue 43410. — then 31572. giueth 13705.

Which being in the partes of the signes, I reduce into miles as before and find the same 470. miles, and $\frac{1}{2}$. which is the distaunce of the point respectiue R from the axis of the world QA. By the former Hypothesis.

The tenth Chapter.

Of the application of the variation, to the vse of Nauigation.



Upon the Hypothesis of the pole of the Mag-
nites on the superficies of the earth, and the
point Respectiue in the bodye thereof, ac-
cording to the former calculations, might
bee inferred many pleasant conclusions,
both for the longitude & latitude of places.

But as touching the point Respectiue by the declinacion
of the needle, seeing this is the first and onely experiment
that hath beene made of it, I cannot inserre any further
matter therof, than that which I haue already set down,
vntill by obseruations in other places, wee finde howe it
will hold.

And

Of the Compasse.

And as for the variation, if it were generally regular
and certaines, as in some parte it seemeth to be: (that is to
saye, from hence Westwardes to Meta Incognita, Newe-
found-land, Florida, and that part of the coast of America)
then might there beginen by it generall rules, commodi-
ous for the vse of Nauigation.

And by the same Hypothesis of the Pole of the magnes
at 25.44'. from the Pole of the world, the greatest varia-
tion of the needle in the Equinoctiall, should be (at 90.0.
of Longitude) 25.44'. from North to East, and conse-
quently the greatest variation in the Paralell of 70.0.
should be (at the Longitude of 128.0.51') from North to
East 8.0.14'. And in the meridiian of 180.0. of longitude
betweene the two Poles (the Pole articke I meane) & the
supposed Pole of the Magnes, there shold the North point
of the needle or compasse respecting his own pole, shew the
south, and the south point the North pole of the world.

But in my trauailes to the North east partes, I haue
found this position of the Magneticall Pole cleane rever-
sed: soz where as the angle of Variation from hence East-
wardes in the Paralell of 70.0. should increase and grow
wider, till it came to 8.0.14'. from North to East as be-
fore. At the Iland Vaugas being in longitude from Lon-
don. 58.0. and in the same Paralell of 70.0. where, by the
former Hypothesis, the variation should be 49.0.22'. from
North to East. I finde the needle to varie 7. degrés from
North to West. And the like effect I haue found by divers
obseruations in sundry other places of the East partes.
Whiche obseruations with many more that I haue caused
to be made, and dayly procure to be done in divers other
Countries, I reserve, with intent (if it be possible) to find
some Hypothesis for the salving of this apparent confused
irregularitie.

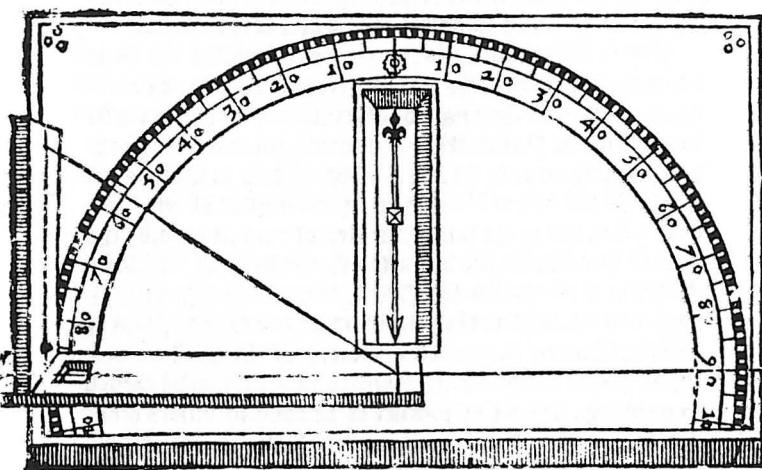
At Ratisbona or Regensburg in Bavaria, being in lati-
tude 48.0.52' & in longitude 36.0.20'. where, by the for-
mer position of the Magneticall Pole at 25.0.44'. the
varia-

Of the Variation

Variation shoulde 16.d.44'. from North to East. Gerardus Mercator found the same to be onely 11. as I gather by his placing of the Magneticall Pole at 16.d. 22'. from the Pole artike, vpon his obseruation made at that place: which confirmeth the retrograde qualitie in the variation from hence Eastwards, as aforesaid.

To which strange varietie, I haue here plainly proposed, to end that the learned soe might consider therof, and sharpening their wits, see what probable causes & grounds they can assigne for the same. For considering it remayneth alwaies constant without alteratio in every severall place, there is hope it may be reduced into method & rule.

A new Instrument for the Variation.



Because I haue founde some imperfections in the syde
Instrument for the variation (which notwithstanding
doth far excell the compasses of variation heretofore vsed
for that purpose) I haue here set downe the forme of a new
Instrument

Of the Compasse.

Instrument wherein all scruple of doubts and defectes that might growe by other is quite auoyded. Which beeing once exactlie placed with the needle vpon the line of south and north, will serue without removing for a whole daies obseruation, the Index onely beeing carried about wyth the Sunne, to giue the degrees of Azimuth upon the Instrument by the shadowe of the line thereof, and is otherwise to bee vsed according to the prescript rules of the former Instrument.

Of the inconueniences and defectes in sayling, and in description of Countries, caused by the variation of the Compasse.

The eleuenth Chapter.



In all Sea Chartes generally, which are made without consideration of the variation, are committed great errors and confusion. For, either the partes therein contained, are framed to agree in their latitudes by the skals thereof, & vsed from the true courses that one place beareth from another by the Compasse, or else in setting the partes to agree in their due courses, they haue placed them in false latitudes, or abridged, or ouerstretched the true distances betweene them.

In the Marine Plat made for Newfoundland, the course set downe from Sillie to Cape Raso is due West, which is found to be soe our common sayling Compasse, whose wiers are set: a point from North to East, notwithstanding Sillie being in latitude 50. d. lytle moze. Cape Raso in Newfoundland is found to bee but in 46.d.; which is 3.d. lesse then the latitude of Sillie.

To make a shew of reformation of this errore, caused by the variation and setting of the wiers in the (Compasse) or to giue a light of that difference in longitude, they haue

Of the Variation

have placed in the plat againste that coast a newe scale of Latitude, some vpon the line of South and North, and some other haue placed the same vpon the line of North Northeast, and South Southwest (because the pointe of the Compasse sheweth the Poles neare in that place) and haue furnished the degrees thereof agreeable to the Latitude of Cape Ralo : and by that meanes haue had a double scale of latitude, one for the Easter coasts, the other for that West. But how farre the same hath bene from reforming the error, or giuing any helpe to Navigation, you may easly iudge.

Others, to auoyde that error of the difference in Latitude in that voyage and course, haue vsed Compasses, whose wiers haue bene sette dyrectly vnder the North poynt, and thereby sayling West from Sillie, haue fallen to the Northwardes of Cape Ralo about 50 leagues, and in latitude neare 49.0.

Some other haue vsed in the same voyage to place a blanke flie vpon their sayling compasse, which they haue remoued from time to time, as they haue iudged the variation hath altered: by which way, albeit they may seeme to keepe themselves neerer the parallel, yet the same in Navigation worketh the greatest confusione of all other, & therefore is to be utterly abolished.

In our voyages from hence Eastwards to S. Nicholas in Russia, and to the Narue in Liuonia &c. The Parine Platcs of the coastes are described by our Common sailing Compasse, with consideration of the variations at dyuers places, whereby the true meridians reformedly set down, declyning from the parallel Meridians of the plat, doe necessarie widen Northwardes, and straigthen to the Southwardes, contrarie to the true forme and nature of meridians. And yet notwithstanding, that is the best meanes hitherto knownen, to reforme in Plat, the errors that else would growe by the strange variations that way.

And

Of the Compasse.

And altho these places serue verie well for those Navigationes, yet by meanes of the variations considered, the forme of thos coastes is so distorsed from the ryght shape it shoulde haue, beeing cruelly described vpon the globe or otherwise in plaine, according to the true latitude and longitude: That whereas the Narue (beeing in Latitude 59.0. and in Longitude from the Meridian of London 26.0.10') shoulde from S. Nicholae 9.0.40' in longitude to the Westwardes (S. Nicholas beeing in Latitude 64.0.35', and in longitude from London 35.0.50') In the sailing Plat it is brought to bee in the meridian of Colmogorod, (which is in latitude 94.0.20', and in longitude from London 37.0.45') which is 1.0 55 to the eastwards of the meridian of S. Nicholas.

Into the Mediterranean Sea, and in the coastes there, wherein great reason shoulde be the perfectest descriptions of the world, for that in those partes haue bene the seates and abodes of the most famous and learned men in all ages, we see notwithstanding in the marine Plats of those partes, grosse errors committed, through want of knowledge of the variation, and the use thereof, in which they haue not accounted of 3.4.0 5. degrees error in the latitude of places.

But those defects of the latitudes haue bene very well reformed, by the famous and learned Gerardus Mercator (whom I honoure and esteeme as the chiese Cosmographer of this time) in his uniuersall Map, which though hee haue made with sailing lincs, & dedicated to the use of Seame, yet for want of consideration of the variation, the same is moore fit for such to beholde, as study in Cosmographie, by reading authours vpon the lande, then to be vsed in Navigation at the sea.

There is also in the same uniuersall Mappe, and likewise in all other moderne Maps of the North parts of Europe, a great fault, by placing two Wardhouses distant one from the other above 20 d. in longitude, whereas

Of the Variation

indeed they are but one thing, and no such distaunce betwene them. This erroz hath growen by taking Wardhouse, and the Sea costes, from thence to S. Nicolas Vau-gatz, and the Ob &c. out of the Map of of that worthy tra-vauer, M. Anthonic Lenkinsons his journey to Boghart & Persia, &c. In the which I placed that boyder of the Sea coast, and for some causes went no further Westwarde in that description, then Wardhouse which is in latitudo 70. d., and in longitude from London 29. d. Wherefore to accomplish the whole border of that coast, hee was so-
ced to seeke some other description to sygne with it, and
ooke as appeareth the Map of Olaus Magnus of the north
Countries, wherein he found likewise Wardhouse, but
falsely placed in latitude about 19. d. too much & in longi-
tude as much too little, the which, although he might take
to be the same specified in Maister Lenkinsons Map, yet
he was constrained to seperat them the said distaunce of
20. d. in longitude (or to leaue there so much superfluous
roome) other wise he shold haue thrust the South partes
of those Countries togeather, and confounded the whole
description.

And albeit he had had the entire sailing Plat, that w^ere
vse for those parts, yet if hee had not knownen the secret ef-
fect of the Variation in the making thereof, he might haue
fallen into the like absurdite or w^ere. But of those costes
and of the inward partes of the Countries, Russia, Mus-
couia, &c. I haue made a perfect Plat and description, by
mine owne experiance in sundrie voyages and trauailes,
both by Sea and Land, so and stro in those parts, which I
gane to her Maiestie in Anno 1578.

Besides these and like imperfections proceeding of the
Variation, there is yet another inconuenience, which ob-
tentures encrafth the former errores, and that is, the
divers placing of the wiers, fixed to the flie of the Com-
pas.

This varietie of setting the wiers, hath caused great
confu-

Of the Compasse.

confusion in Navigation, and in other accountes of Sea
carres: for when it is sait, that from such a head land, to
such a place, in such a course, or at such a place the Mariner
byon such a point of the Compasse maketh the full sea,
it is requisite to bee deuined, by what Compasse the
observation was made, whereas if the wiers had not bene
altered from the North poynct of the flie, which I wilsh
had never bene any where, thense doublets had beene avoy-
ded.

If he purposeth therefore all men that will make Hydro-
graphicall descriptions for the vse of sailing, to haue speci-
all regard of the Compasse by which these observations
are made, and if they collecte notes made by land or Com-
passes of divers sortes, they ought to reduce all the varie-
ties unto somm certayne, and to gine notice of the same
in their Plat: And not to make a confused mingle man-
gle by syning together all varieties of observations,
notes, and reports, as the Portugales and Spaniards haue
done, in compounding these North partes of the w^ere,
with their owne discoueries, without consideration of the
divers sortes of the severall compasses by which they were
made.

Also it importeth all masters, Pilots, and others by
what name soever, that shall give directions in Naviga-
tion, to looke cire inspectly to the setting of the wiers of
the Compasse by which they shill sygle, that the same
Compasse be correspondent to the lines of the Sea Carde
that they shall vse: that is to say, that it be of the same
set for the variation, that the Compasse to is of, by which
the carde was made.

I am syng to shew in this our countrey, acquainted
our selues conuainly in our observations and Naviga-
tions, with the Compasse: whose wiers are set at , a point
from North to East, I meane in the description, that I
shall make to apply the same agreeable to the said Com-
pass, and wold use the like without alteration (and al-

Of the Variation

In the straight lines in Sea Cards) if I should saile round about the worlde to make the description therof, but alway with regarde of the severall variations of every place wher the same shoulde be obserued.

Of the Instruments and rules in Navigation.

The Twelfe Chapter.



Amongst the rules and Instrumentes for Navigation, all such are vaine & to small purpose, wherin the true meridian is presupposed to beginuen by the Magneticall Needle, without due consideration of the Variation, for that they are all grounded upon false suppositionis. Hæreby it commeth to passe that one Michael Coignet of Antwerp, in his New instruction (as hee termeth it) of the most excellent and necessarie points of Navigation, wherin he sheweth the making and use of a Nauicall Hemisphere, which he preferreth before all other Sea Instruments, is very chidishly abused. For whereas he pretendeth by it, to give the elevation of the Pole, and the houre and instant of the time of the date, by any one observation in any plac: besides that, it is of all other that hath heretofore bee[n] used at Sea, the most tedious and vnit for that purpose: it is also by reason of the variation not considered, meere false and erronius. For the true Meridian (which is the grounde of his purpose, as farre to soke as the thinge hee promiseth to gine by the same. The like may be sayd of all other instrumentes made vpon the same grounde, whether they serue for the sea or land.

The same autho[r] in the 4. Chapter of his booke, entreated of sailing vpon the pointes of the Compasse, sayngh, that in sayling South or North he shall passe by the poles

g

Of the Compasse.

of the world, and keepe vnder ens Meridian, till hee come to the place from whence he first departed. And vpon the points of East and West out of the Equinoctiall, hee shall saile vnder a Paralell, till hee retorne to the place from whence he went. But in sailing vpon the point of North East, he shall describe a spirall line inclining by little and little towards the Pole, as in his demonstration therof in the same Chapter appeareth. But for want of due con- sideration of the variation, his rules, reasons, and demon- strations, and such others hitherto giuen for like purposes are fruulous and false.

For if he direct his sailing by the Compasse (as of necessitie he must, beeing the onely instrument for that purpose) it is manifest, that whether hee saile North or South, East or West, or by what other point so euer, the Compasse not respecting alwaies the Pole of the Worlde, as hee supposeth, but some other pointe or points distant from the same, shall lead him accordanlie, whereby hee shall neither keepe vnder one Meridian, nor vnder one paralell of latitude, neither make such a spirall line to the Pole of the worlde, as he demonstrateth. His fault in setting downe these rules is so much the greater, in that hee acknowledgeth in the Chapter next before the variation at Antwerpe, to be about 9.0. from North to East according to Mercatoris position, of the Magnetical Pole, which he also confirmeth by his owne experiance.

But it seemeth he hath followed that excellent Mathematician Petrus Norius, especially concerning the sailing vpon the points of East and West. For he, in his first booke of the rules and Instrumentes of Navigation, enforceth himselfe to prove and demonstrate, that in sailing East or West out of the Equinoctiall, the course is performed by peeces of great circles, and yet describeth a paralell. But howe that maye stande with the principles of Geometrie, I referre the iudgement to the expert Mathematicians, for it is like as a circle shoulde bee

Of the Variation

made of straight lines, which is impossible.

It appeareth in the discourse that hee hath made of these matters, that hee had not a right iudgement of the nature of the Compasse in sailing (admitting the same to shew the Pole without Variations) for if he had, he would never haue entered in such a Labyrinth as he did. But hee thought it a great absurditie that the Compasse in euery Horizo[n] shoud shew the Meridian & Poles of the worlde in the points of North and South, and by the pointes of East and West, to shew in the Horizon the verticall and Equinoctiall East and West, (beeing a great circle) and yet in sailing East or West, except in the Equinoctiall, it shoud perfourme but a paralell.

But it is to bee understande, that albeit the pointes or lines of the Compasse do alwaies in every Horizon represent great circles in the Heavens, the pointes of South and North the Meridian, and the pointes of East and West the verticall circle of East and West, each crossing other at right angles, and likewise of the pointes. (The reason whereof is, because the Compasse lieth every where leuell with the Horizon, so as a perpendicall line descending from the center thereof at right angles with the playne of the same, will alwaies fall vpon the center of the earth, and consequently bee the Semidiameter of a great circle) so tht wchereover the Compasse bee carried, these circles are supposed to bee carried about wch it, and the viewe of euery thing in the Horizon, represented by the pointes thereof, is likewise in great circles: Yet in sailing by the Compasse, the pointes of South and North onely, describe great circles generallie, whch are the Meridians, and the pointes of East and West, describe a great circle in the Equinoctiall angle: in all other places out of the Equinoctiall, they describe but Paralells. And the sailing vppon anie other point of the Compasse from anye place, describeth a spirall line, according to the angle it maketh with the Meridian. And heereby in sailing vpon the pointes

Of the Compasse.

points of East or West, out of the Equinoctiall,) the North point alwaies respecting the pole (the course perfourmeth a Paralell, according to the distaunce of the center of the Compasse from the pole. The manner thereof you may perceiue by fastning a small thid or Virginall wier at the Pole of a Globe, or center of a circle, whch shall represent a mouable Meridian to be carried about the globe or circle, and fire vpon the same, a small flie of a Compasse, so as the line of South and North be answerable to the thid or wier, and the North point thereby alwaies respect the North pole: then in turning the thid about the Globe or circle, vpon the Pole or center, if the center of the flie be out of the equinoctiall, (betweene it and the Pole) albeit the pointes of East and West, crossing the same line and mooneable meridian at right angles, doe shewe the verticall East and West vpon the Globe, whch is a great circle, yet in carrying the same flie vpon the thid or mouable meridian about the pole or center, you shall by the center of the same flie describe but a Paralell according to the distaunce thereof from the Pole of the Globe, or center of the circle not unlike the circular motion of a horse drawing in a Mill, who though he looke forth straight in a right line, yet being fastned to the beam of the Mill, is forced to make his course in a circle, whose semidiameter is the length of the beam contained betweene the horse and the center of your mill or milpost.

And as in the Equinoctiall, the line of South and North in the Compasse (by supposition representing the Meridian) is paralell to the Axis of the earth, (whch is the common section of all the Meridian plaines,) and the line of East and West, crossing the same axis of right angles, representeth the vertical East and West, which is the Equinoctiall, imagining to descend from the center of the Compasse a line, to fall perpendicularlie, and at right angles with the axis of the worlde (which shalbee at the center of the earth) and in sailing East or West by the com-

passe,

Of the Variation

pass, the imagined perpendicular line being carried about with the same (making alwaies right angles with the axis) shall describe the plaine of the Equinoctiall, Equidistant from the Poles of the worlde, and at right angles with the axis: and the point of the same line at the center of the Compasse, the circumference of the Equinoctiall, byon the superficies of the Sea: so beeing from the Equinoctiall on either side, imagining the line of south and North in your Compasse, to represent alwaies the Axis of the Worlde, and to lie Paralell with it, the line of East and West must cross the same axis alwaies at right angles: And supposing a line to fall from the center of your Compasse to the axis of the Worlde, making right angles with the same axis. In sayling East or West, that imagined line beeing carried about with the Compasse (alwaies at right angles with the axis) shall describe the plaine of a paralell, equidistant to the plaine of the Equinoctiall, and the point thereof at the center of the Compasse, the circumference of the paralell upon the superficies of the sea: which Paralell should be represented by the points of East & West of the compasse, if the line of South and North of the same, were Paralell to the axis of the Poles, as was supposed, but it is not. And therefore, as they decline one from the other, so doth the verticall circle of East and West shewyd by the Compasse, decline from the parallel circle euerie where.

The angle of which declination is alwaies equall to the latitude of the place, or distaunce of the Paralell from the equinoctiall.

But as I haue already sufficiently declared, the compasse sheweth not alwaies the Pole of the worlde, but varrieth from the same diversely, and in sailing describeth circles accordingly. Which thing, if Petrus Nonius and the rest that haue written of Navigation, had ioyntly considered in the tractation of their rules and Instrumentes, then might they haue beeene more auailable to the use of

Navigation

Of the Compasse.

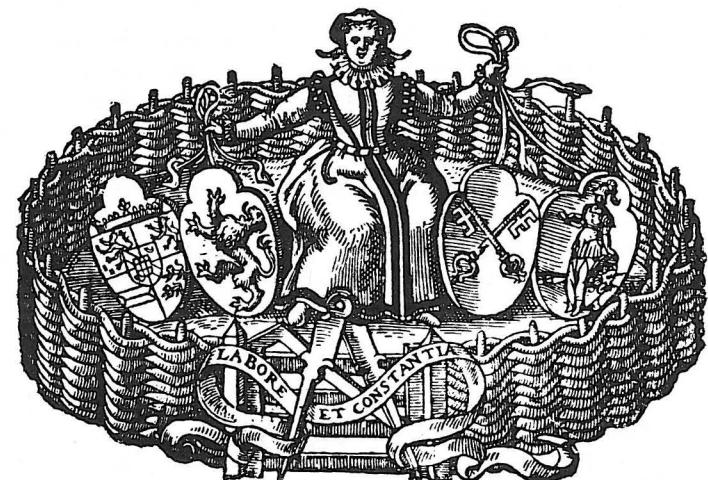
Nauigation, but they percluing the difficultye of the thing, and that if they had dealt therewith, it would haue vsterlie ouerwhelmed their former placible conceites, with Pedro de Medina (who as it appeareth hauing some small suspition of the matter, reasoneth very clarkly, that it is not necessarie that such an absurdtie as the Variation, should bee admittyd in such an excellent art as Nauigation is) they haue all thought best to passe it ouer with Glence. But I hope such as intend hereafter to write of

Nauigation, will either frame their rules, precepts, and instruments, with regard of the Variation, as heerin I haue shewed, or else easie themselues of that trauaille, for as god none, as vs postales.

FINIS.



D E
H A V E N-
V I N D I N G.



TOT LEYDEN,
IN DE DRUCKERYE VAN PLANTIJN,
BY CHRISTOFFEL VAN RAVELENGHIEN,
Gefworen drucker der Vniuersiteyt tot Leyden.

c i o. i o. i c.

Met privilege.

TAFEL DER NAELD-
WIISINGHEN.

		Ofering.	Breede.	Langde.
Eerste percx op de noort- fijde	Een der Vlaemsche Eylanden Corvo.	tr. (1).	tr. (1).	tr. (1).
	Opt Vlaemsh Eylant Sancta Maria.	o. o.	N 37. o.	o. o.
	Neffens het Eylant Maio.	3. 20.	N 37. o.	8. 20.
	By t'Canarische Eylant Palma.	4. 55.	N 15. o.	11. 20.
	By Cabo de Roca by Lisbona.	6. 10.	N 28. 30.	16. 20.
	Het westerlickste van Yrlandt.	10. o.	N 38. 55.	24. 30.
	Engelants eint.	11. o.	N 52. 8.	24. 12.
	Een mijl oostwaert van Pleymouth.	12. 40.	N 50. 21.	28. o.
	By Timouth in zee.	13. 24.	N 50. 18.	30. o.
	Londen in Engelant.	12. 40.	N 55. o.	33. o.
Tweede percx op de noort- fijde	Het voorlant van Engelant.	11. 30.	N 51. 24.	34. 6.
	Amsterdam.	11. o.	N 51. 8.	35. 40.
		9. 30.	N 52. 20.	39. 30.
Westering.				
Tweede percx op de noort- fijde	Helmshuy by westen de Noortcaep in Finmarck.	o. o.	N	60. o.
	Noortcaep in Finmarken.	o. 55.	N 71. 25.	61. 30.
	Noorkin.	2. o.	N 71. 10.	63. 30.
	Sint Michiel in Russia genaemt Archangel.	12. 30.	N 64. 54.	83. 30.
	De zuyderlicke straat van Vaygats.	24. 30.	N 69. 30.	103. o.
	Langenes in Nova Zembla.	25. o.	N 73. 20.	100. 30.
	Willems Eylant by Nova Zembla.	33. o.	N 75. 35.	110. o.
	Yfhouck in Nova Zembla.	27. o.	N 77. 12.	120. 30.
	Het winterhuys in Nova Zembla.	26. o.	N 76. o.	120. 30.

		Ofering.	Breede.	Langde.
Eerste percx op de zuytfijde	Ver-grootende ooste-ring	Op 105. Spaensche mijlen westwaert van Cabo Sant Augustin en Brasilia.	tr. (1).	tr. (1).
		By Cabo S. Augustin in Brasilia.	o. o.	Z.
		Zuyt en noort met Cabo das Almas in Guinea.	3. 10.	Z. 8. 30.
		Noortwest wel foo noordelick vande Eylanden van Trifstan da Cuncha.	12. 15.	Z. o. o.
Tweede percx op de zuytfijde	Ver-cleennende ooste-ring	Noortwest wel foo westelick vande voorscreven Eylanden.	19. o.	Z. 31. 30.
		Zuyt en noort met Cabo de Bona esperance.	15. o.	Z. 31. 30.
			2. 30.	Z. 35. 30.
				57. o.
Westering.				
Tweede percx op de noort- fijde	Ver-grootende weste-ring	Op 17. duytsche mijlen van Cabo das Aguillas oostwaert.	o. o.	Z.
		Ontrent 5. mijlen in zee vant lant Natal.	4. 30.	Z. 33. o.
		Byde Baixos da India.	11. o.	Z. 22. o.
		Mofambique.	11. o.	Z. 14. 50.
		Inden inwijck van S. Augustin in Madagascar.	13. o.	Z. 23. 30.
		Zuyt van Cabo Sant Romain.	16. o.	Z. 28. o.
		Inden inwijck van Anton Gil in Madagascar.	15. o.	Z. 16. 20.
		34. Duytsche mijlen zuytoost van S. Brandaon.	22. o.	Z. 19. 20.
		Goa een vermaerde coopstat in India.	15. 10.	N 15. 30.
		Cochin.	15. o.	N 9. 45.
Tweede percx op de noort- fijde	Ver-cleennende weste-ring	25. Duytsche mijlen west ten noorden vande zuytwesthouck van Samatra.	6. o.	Z 5. 28.
		Bantan een coopstadt in India.	4. 45.	Z 6. o.
		Het Eylant Lubock.	2. 25.	Z 6. 10.
		De zuytwesthouck vant Eylant Balij.	1. 30.	Z 8. 40.
		De mont der Rivier van Cantan in China.	o. o.	N 23. o.
		Bunam 46. Duytsche mijlen van het oostende van Iava na het oosten.	o. o.	Z
				160. o.

(3)

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*Hoemen het noortpunt en naeld-
vvysing vindt.*

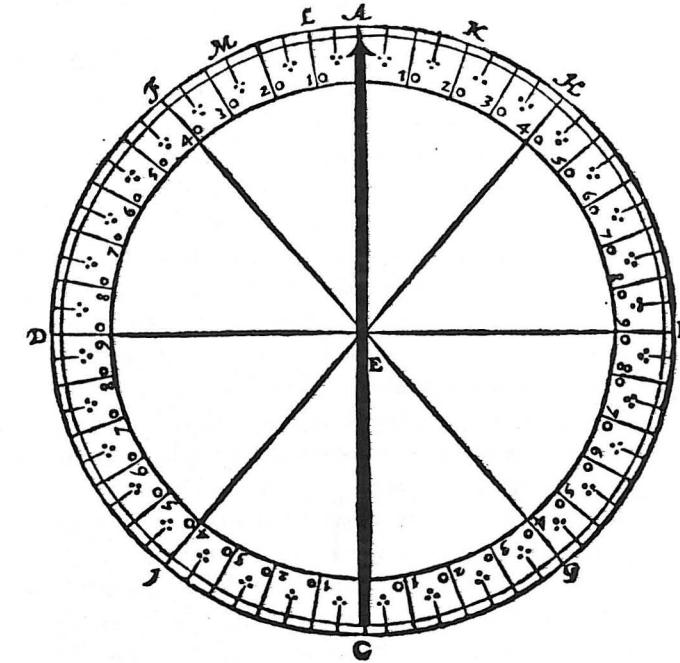
HOE wel het vinden der naeldwijsing (daer af wy hier vooren dickwils gheseyt hebben) an velen bekent is, nochtans fullen wy daer af schrijven voor de ghene diet niet en weten.

Anghesien men hier begeert te vinden de afwijcking der naelde vante noorden, soo soucken eerst het noortpunt, om de naeldwijsing daer by te verlijcken. De manier der vinding vante selve noortpunt in een beweghende schip op zee, heeft groote ghemeenschap mette manier der vinding vante noortpunt, of vande middachslijn opt vast lant, ende mach onder anderen aldus uijtgherecht worden: Men doet int zeecompas de leli recht overcommen metten noortende vante stael, of vande zeynhaelde daer onder ligghende: Of noch beter machmen in plaets vande leli, een naelde self boven opt papier vast legghen, deelende t'rondt van tselve papier in fijn 360. tr. beginnende ande naeldens noortpunt als hier onder het rondt A B C D, waer in de naelde beteykent is met A C, vaftghemaect wefende opt selve papier, E is tmiddelpunt: Tgebruyck hier me is dusdanich: Ghelyck den Stierman int soucken der breedte, wacht tot dat de middach ghecommen is, te weten tot dat de schaeu van een hangfnoer of rechtfnoer, overcomt mette lini die hy in fijn compas voor de middachslijn houdt, alsoo fal hy hier doen, uijtghenomen dat hy begint 3. + of 5. uijren of meer voor middach alsdan, acht nemende op wat trap en ghedeelte van dien de schaeu des hangfnoers wijst, bevint die, neem ick, opden 40. tr. gheteyckent F, fulcx dat G E F, de schaeu bediet, ende nemende alsdan de Sonnens hooghde, bevint die, by voorbeelt, van 25. tr. welcke hy, metsgaders de 40. tr. tot ghedachtnis opteyckent: Wachtende voorts

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soo lang na middach, tot dat de Son weerom ghedaelt is tot op de selve hooghde alfvooren van 25. tr. fal fien waer de schaeu vante hangfnoer alsdan opt papier wijst, twelck sij, neem ick, 40. tr. over dander fijde, als an H, fulcx



dat I E H, de schaeu bediet. Dit soo fijnde, t'middel des boochs F H, als A, is tbegeerde noortpunt, ende want de naelde daer recht op wijst, foo en heeftse in dat voorbeelt gheen wijcking, dan wijst recht noort. Maer soo inde voorf. ervaring na middach de schaeu vante hangfnoer niet ghewesen en hadde 40 tr. over dander fijde van A, maer by voorbeelt alleenelick 20 tr. tot K; In fulcken ghevalle deelten den booch F K, doende 60. tr. door tghedacht in tween an L, fulcx dat L F, L K, elck doen 30. tr. Twelck foo fijnde, L ist noortpunt, ende de begeerde naeldwijcking daer af is oostering van L tot A 10. tr.

Maer by aldien inde voorf. ervaring na middach, de schaeu vante hangfnoer ghewesen hadde op L, dats 30. tr. van F, foo deelten den booch F L,

(5)

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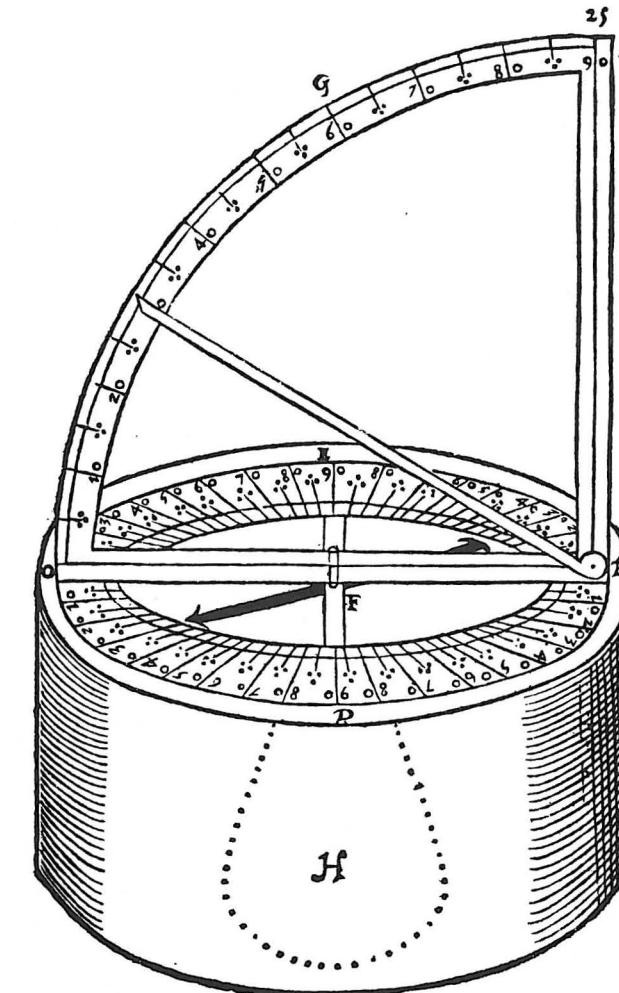
doende 30. tr. doortghedacht in tween an M, fulcx dat M F, M L, elck doen 15. tr. twelck foo fijnde, M is tnoortpunt, ende de begeerde naeldwijcking daer af, wesende oostering van M tot A 25. tr. ende alsoo met alle voorbeelden. Maer foo de naelde alleen draeyde, fonder an een papier ghehecht te fijn als hier vooren, ende dat de trappen op den cant vande caffe gheteyckent waren, ghelyck wel ghedaen wort: Tghebruyck is daer me alfvooren, midts datmen ten tijde der ervaring, de caffe keert tot dat de naelde opt begin der trappen wijst.

Ander fijnder die nemen een * soppich vierendeel ronts, wiens fichteinander-splat, niet teghenstaende de beweaghlycet des schips, altijt in waterpas blijft, deur fulcke manier als int volghende gheseyt sal worden. Hier me vintmen de Sonnens hooghde met haer sopbooch beyde tseffens: De form daer af mach dufdanich wesen: A B C bediet een vierendeel ronts, staende rechthouckich opt rondt B D C E, gheudeelt in fijn 360. trappen, twelck het fichtemderplat beteyckent, fijn middelpunt is F, waer op twierendeelronts draeyen can, ende op dattet alfins rechthouckich blijft opt voorf. rondt B C D E, soo comt van deen en dander fijde een steunsel, als van G tot by D en E, vast ghemaect an twoorf. vierendeelrōts, om daer me te drayen. Voort isser int rondt B D C E een glas, en daer onder fijn seylnaelde, foo lanck alsse ten langsten inde caffe bequame-lick vallen mach, ende heeft de selve caffe van binnen heur 360. tr. daer de punt der naelde scherpelick op wijsen mach, overcommende die 360. tr. met dander 360. tr. boven opt fichteinanderstont. Defen tuych is deur de vondt van Reyner Pieterz. hanghende ghemaect op twee verscheyden assen, na de manier der zeecompaffen, op dat alsoo het rondt B D C E, inde beweginghen vant schip altijt ewewijdich vanden fichtemder blijve: Ende op dattet selve noch meerder seker-heydt hebbe, foo worter onder een ghewicht an vervougt gheteyckent H, van 25. of 30. pont, of foo veel als de grootheyt vanden tuych vereyscht.

Tis oock te ghedencken oirboir te wesen, dattet vierendeelrants tijnder plaets recht overende staende, over deen en dander fijde evefwaer fij, dat is de fijde van F na C, foo swaer as van F na B, twelckmen weten can mits twierendeelrondts af te nemen, ende te hanghen met G neerwaert an een draet, vast gemaect int middel van B C by F, ende alsdan falmen vande swaerste fijde so veel af vijlen, tot dat de reghel B C in waterpas hangt.

Angaende ymant mocht dencken, dat de * wifreghel in verscheyden plaeften hooger of leegher ghedraeyt, te groote verandering int ghewicht mocht geven, daer af en is gheen merckelick seyl te verwachten, om tgroot ghewicht van H, ende de lichticheyt der wifreghel.

De ghebruyck daer af, om t'noortpunt en naeldwijcing te vinden, is dufdanich: Men begint, gelijck in deerste wijfe, ettelicke uijren voor middach, draeyende



den tuych tot dat de naelde opt begin des ronts wijst, daer na keertmen het vierendeel ronts foo lang herwaerts en derwaerts, tot dat de Son deur de

fichtgaetkens schijnt: Twelck soo fijnde, men bevint, neem ick, dat den ondersten cant of wijser vant vierendeelronts, wijst int fichteundersplat opden 40. trap, ende de hooghde der Son, die int vierendeelronts angewesen wort van, neem ick, 25. tr. welcke men, mitgaders de 40. tr. tot gedachtnis opteyckent. Wachtende voort soo lang na middach, tot datmen de Son deur den seluen tuych ghedaelt vindt tot opde felve hooghde alfvooren van 25. tr. men keert alsdan den stoel ter eender en ander fijde, tot dat de Son deur de fichtgaetkens schijnende, de naelde weerom wijst opt begin des ronts: Twelck soo fijnde, t'middelste punt des boochs int fichteundersplat tusschen deerste en tweede ervaring, is tgesochte noortpunt: Ende soo veel de naelde alsdan daer af wijckt, dats de begeerde naeldwijcking, gelijck int eerste voorbeelt wat breeder van fulcx ghefeyt is.

Deur tghene hier boven ghefeyt is vande ervaring mette Son des daechs, mach derghelijcke verstaen worden ende gheschien met yder vaste sterre des nachts, die ghebruyckende al oft de Son waer: maer niet de Maen, eensdeels om heur rassche eyghen loop, ten anderen om tgroot * verscheenficht datse heeft van weghen sij t'eertrijck foo na is.

Merckt noch datmen voor den middach twee drie vier of meer ervaringhen mach doen: Als by gelijcknis, deerste wesende de Son boven den fichteinder 10. tr. inde tweede 15. tr. inde derde 20. tr. ende doende dergelijcke drie ervaringen op fulcke hooghden na middach, foo bevintmen hoe deen met dander overcomt, ende alsmen alsins een felve noortpunt crijcht, tgheeft den Stierman meerder betrouwien op sijn werck.

Seylende een Stierman van oost na west of van west na oost, t'can ghebeuren dat hy opden tijt van 10. of 12. uijren tusschen deerste ervaring en de laetste, een trap of meer verandering der naeldwifsing crijge, waer uyt wijder volghen can, dattet noortpunt ghevonden deur deerste voormiddachsche ervaring, en de laetste namiddachsche, niet overcommen en fal mettet noortpunt gevonden deur de laetste voormiddachsche ervaring, en deerste namiddachsche, fonder nochtans dat den Stierman int werck ghefeylt heeft. Dit hem foo ontmoetende, hy can daer uijt ramen hoe veel op seker uijren varens de naeldwifsing verandert, ende daer op giffing maken, om trechte noortpunt en naeldwifsing met noch meerder sekerheyt te hebben. Tfelve canmen oock weten deur de naeldwifsing ghevonden op voorgaende daghen, ende die verleken mette wifsing des teghenwoordighen dachs.

