

NEUDRUCKE VON SCHRIFTEN UND KARTEN
ÜBER
METEOROLOGIE UND ERDMAGNETISMUS

HERAUSGEGEBEN VON
PROFESSOR DR. G. HELLMANN.

❖ 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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INHALT

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FRANCISCO FALERO Del Nordestear de la Agujas (1535)	6 „
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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 Ermittlung 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

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 Experimentes³⁾. 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 Amplonius 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 Exemplaré 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

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 Barnabite 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 Magnetnadel 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 Magnetnadel, sondern indirekt auch die Methode selbst geliefert zu haben scheinen; denn diese bestand einfach darin, dass man an einer sonnenuhrartigen Vorrichtung mit Magnetnadel 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 Magnetnadel 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

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 Schattenazimuthe bei korrespondirenden Sonnenhöhen Vor- und Nachmittags; 3) in der Beobachtung dieser Azimuthe 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 Ermittlung für die Schifffahrt 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 Alexâdrino. Tirados novamente do Latim em lingoagem pello Doutor Pero Nunes, Cosmographo del Rey Dõ João ho terceiro deste nome nosso Senhor. E acrescêtos de muitas annotaçõs 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 declarão todas as principaes duuidas de navegação. Cõ as tauoas do movimento do Sol: e da su declinaçãõ. E o regimêto 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“.

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

JOÃO DE CASTRO: Observações 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 João 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. João 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. João 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, João de Castro als den bedeutendsten Vertreter der

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 Infanten 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 Köpke 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 Índia 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 Índia. Segundo MS. Autographo. Publicado por Diogo Köpke. 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 Índia 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 kombinirt 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 $\frac{3}{4}^\circ$. Man darf diese Differenzen nicht einmal ganz als Fehler der Messungen ansehen, da ja, abgesehen von anderen Ungenauig-

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 einigemal 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 $71^\circ 50'$ 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 Thatsache und erklärt sich einfach dadurch, dass seine Magnetnadel nicht an einer horizontalen Achse aufgehängt war, sondern auf einer vertikalen.

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 Oeffentlichkeit. 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 Ortrov (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 Ortrov einen sinnstörenden Fehler begangen hat, der in der vorliegenden Wiedergabe des Briefes natürlich vermieden wurde.¹¹⁾

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 sphaera 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 Newe 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 newe 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“ einverleibt, dieselbe ist aber auf so stark durchscheinendem Papier gedruckt, dass die photographische Reproduktion 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 newe 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 Inklination 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 Havenvinding*. — 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 Schifffahrt und giebt eine Anleitung zur Bestimmung derselben mittels des Azimuthal-Kompasses. 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 (*IMENEPETIAH 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

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 Lehnsherr 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 Maharne 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 Gasser noch zu denjenigen zählt, die im XVI. Jahrhundert mit der magnetischen Deklination nicht bekannt waren,

so bemerke ich ausdrücklich, dass Gasser die magnetische Abweichung kannte; denn in der „Praefatio“ (Bl. Aij 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 Taisnierio 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 Adsigerius 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.

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 Amplonianischen Handschriften-Sammlung zu Erfurt unbekannt geblieben sind (Cod. Amplon. Q 325, Q 351, Q 387), steigt ihre Gesamtzahl auf 20. Nach dem von Amplonius 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 Amplonianischen 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 Interpunktion dürfte, 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 Ortroy 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 reproducirten 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

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, Comptroller of her* | Maieities Raue: Robert Norman | wiheth increase of worship in | perfecte felicitie. | Endet auf Bl. 4^a. 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 | ferue 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.iiij.): Hier beginnen die Tafeln, auf jeder Seite ein Monat.
- Bl. 29^a (S.j.): How to vse the Sunnes De- | *clination, for knowing the elia-* | *tion of the Pole.* |
- Bl. 30^a (S.ij.): 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.ij.): 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.

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, existirt 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 cognoissance 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 Pilote Hydrographe de sa Majesté, Examineur des Pilottes . . . 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 précisément à midy.
 Chap. XVI. Second moyen de trouver la Variation par deux observations faites, au Soleil en égale hauteur sur l'Horizon l'une devant, & l'autre apres midy.
 Chap. XVII. Troisième moyen de trouver la Variation de l'Aiguille aimantée par deux observations faites l'une au lever, & l'autre au coucher du Soleil.
 Chap. XVIII. Quatrième moyen de trouver la Variation du Compas par vne observation faite au lever, ou bien au coucher du Soleil par l'Amplitude.

Chap. XIX. Cinquième & dernier moyen de trouver la Variation à toute heure du iour & de la nuit 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 DISCOVERS | of the Variation | of the *Cumpas*, or | *magneticall* | *Needle*. | Wherein 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. 30^b steht:

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

Das Buch zählt im Ganzen 30 unbez. Quartblätter.

¹⁹ Nach Bierens de Haan (Bibliographie Néerlandaise 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.

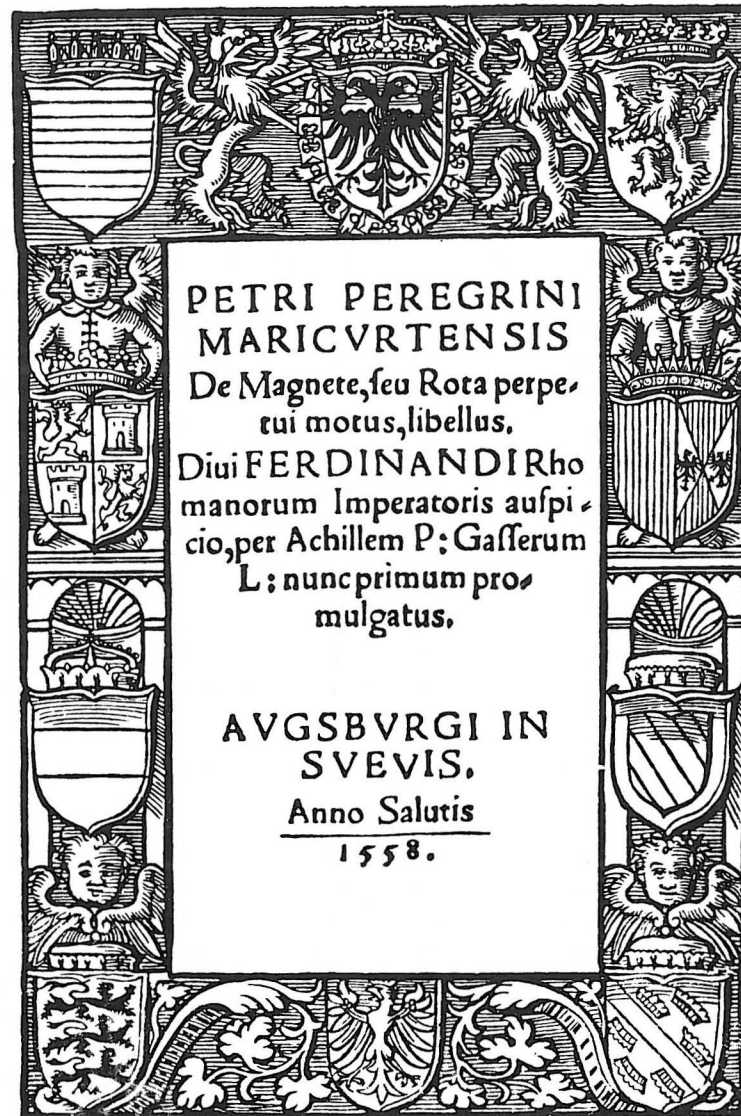
²⁰ Vgl. meine Notiz „S. Stevin's *AIMENYPETIKH*“ in der von L. A. Bauer herausgegebenen Quartalschrift „Terrestrial Magnetism“ (II, 1897, S. 72—73).

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.



EPISTOLA PETRI PEREGRINI DE MARICOURT
AD SYGERUM DE FOUCAUCOURT MILITEM
DE MAGNETE.

Iste tractatus de magnete duas partes continet, quarum Prima, decem Capitulis completur, 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 meridiandem 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 artificio 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 noticia principio est iucundum; et in tenebris orbitat, et obfuscat bonorum natura, donec in communis deductionis radium erigatur. Amore ergo tui conscribam, sermone plano, que vulgo studentium penitus sunt ignota: attamen non nisi 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, appellem 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 proVectis viatoribus non modici erunt iuamenti.

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 complere 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, unigeneitate, pondere et virtute: Color autem ipsius debet esse ferreus, lividus, mixtus indico, seu colore celestino, ut sit quasi ferrum politum, ab aëre corrupto infectum. Talem enim lapidem nunquam vidi absque magno effectum. Talis autem, ut plurimum, invenitur in partibus septemtrionalibus, et affertur a nautis, in omnibus partibus maris septemtrionalibus, utpote Normannie, Picardie et Flandrie. Debet autem lapis iste esse unigeneus 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 unigeneitatem, 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 septemtrionalis, nominatur; reliquum

(2)

3 0

vero, antarticus sive meridionalis: sic, et in isto lapide, penitus intelligas duo puncta, unum septemtrionale, reliquum vero meridionale. Ad istorum duorum punctorum generalem inventionem, multiplice 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 septemtrionalis, et alius meridionalis, cuius probationem in sequenti Capitulo videbis.

Alius autem modus inventionis istorum punctorum melior est, ut videas [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 simili modo, in oppositam partem lapidis, punctum invenias oppositum. Quod si recte feceris, et lapis sit unigeneus et electus, puncta erunt recte, tamquam poli in spera, opposita.

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

Visa arte cognitionis polorum lapidis in genere, quis autem sit septemtrionalis, 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 aque, ut sit lapis in primo vase sicut nauta in navi; vas autem primum sit in secundo spatioso, sicut navis in flumine fluctuans: et dico, spatioso, 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 quousque 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 horizonti 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 quorundam fatuitas dicentium quod si scamonea choleram, ratione similitudinis, attrahat, ergo magnes magnetem, magis quam ferrum, attrahet quod falsum supponunt, cum sit verum sicut patet experimento.

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 movetur 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, quousque 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 patiente fiat unum, 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 septentrionem, ut prius. Fractura enim non tollit proprietates partium lapidis, si sit unigenus; 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, septentrionalis erit, que sit C: erit ergo iste lapis CD: primus lapis AB sit agens, CD patiens; sicque vides quod due partes duorum lapidum, que, ante separationem, in uno lapide erant continue, post separationem, una invenitur septentrionalis, altera meridionalis. Quod si rursus eedem partes approximentur, una alteram attrahet, quousque sibi iungantur in puncto \widehat{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 patiente, secundum hunc ordinem: ABCD, ut \widehat{BC} sint punctum unum: in hac enim unione retinetur, seu salvatur idempinitas partium extremarum, in similitudine qua erant primo. A enim, septentrionale est in tota linea, sicut erat in divisa; eodem modo D meridionale, sicut erat in ipso patiente 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 \widehat{DA} sint unum punctum: tunc remanebit idempinitas partium extremarum, sicut primo, antequam unirentur; C namque punctus septentrionalis erit, B vero meridionalis, sicut prius B, C erant, divisi.

Si autem fieret aliter, non salvaretur hec idempinitas, seu similitudo parcium. 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 \widehat{AC} sint in puncto uno; D (quod erat meridionale antequam unirentur) requirit, in hac linea totali, quod B, reliqua extremitas, sit septentrionalis, que prius tamen erat meridionalis, [et] ecce dissipatur idempinitas, seu similitudo prior. Vel si ponas B meridionale, sicut erat antequam unirentur, requiretur quod D, altera pars, septentrionalis existat, cum tamen fuisset meridionalis; et sic ibi non servatur idempinitas, 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

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

Patet ergo ex his quare pars meridionalis septentrionalem attrahit, et e converso; et quare meridionalis meridiem, et septentrionalis septentrionalem, nequaquam per naturam.

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

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 meridiem quam ad partem septentrionalem, ut patet per iam dicta, existimare cogimur, non solum a parte septentrionali, verum etiam a meridionali virtutem influi in polos lapidis, magis quam a locis minere. Cuius signum evidens est, quod, ubicumque homo fuerit, videt, ad oculum, huius lapidis motum, secundum situm sui orbis meridiani. Omnes autem orbis meridiani in polis mundi concurrunt; quare, a polis mundi, poli magnetis virtutem recipiunt. Et ex hoc apparet manifeste quod non ad stellam nauticam movetur, cum ibi non concurrant orbis 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, estimates. 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 stylus leviter affixus, in suo puncto, in lapide, ut lapis, sine difficultate, super eos possit moveri. Quo facto, experiaris si lapidis partes equaliter ponderant.

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volvendo ipsum leviter super dictos stilos; et hoc pluries, et in pluribus horis diei facies, sagaci industria. Quo facto, lapidem dispone in orbe meridiano super suos stilos, in polis lapidis leviter affixos, ut moveatur ad modum armillarum, ita quod polorum ipsius elevatio et depressio 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, imperitiae tuae, potiusquam naturae, defectus imputetur. In hoc autem situ, seu modo positionis, virtutes lapidis huius estimo conservari proprie, et in reliquis sitibus celi virtutem eius obsecari, 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, quae, ex cognitione operationis naturalis ipsius dependent. Sumatur magnes rotundus et inveniatur poli, ut dictum est, et elimetur inter duos polos in duabus partibus, ut sit lapis, sicut sphaera compressa inter polos, ut minorem locum obtineat. Hic quidem lapis, sic preparatus, inter duas cassulas, in modum speculi, recludatur in medio; et cassulae ad invicem sic iungantur, quod ulterius non aperiantur, et ut aqua non subingrediatur. Preparentur cassulae cum cola ad hoc apta, et sint cassulae ex ligno levi. Quo facto, pone cassulas, sic aptatas, in vase magno pleno aqua, in quo sint partes duae mundi, scilicet meridionalis et septentrionalis, invente et signate: et designentur per filum extensum a parte septentrionali 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 lineae 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 quaelibet, in partes nonaginta dividatur, ut sint, in universo, partes CCCLX, in tota circumferentia cassularum: et inscribe partes in ea, sicut in

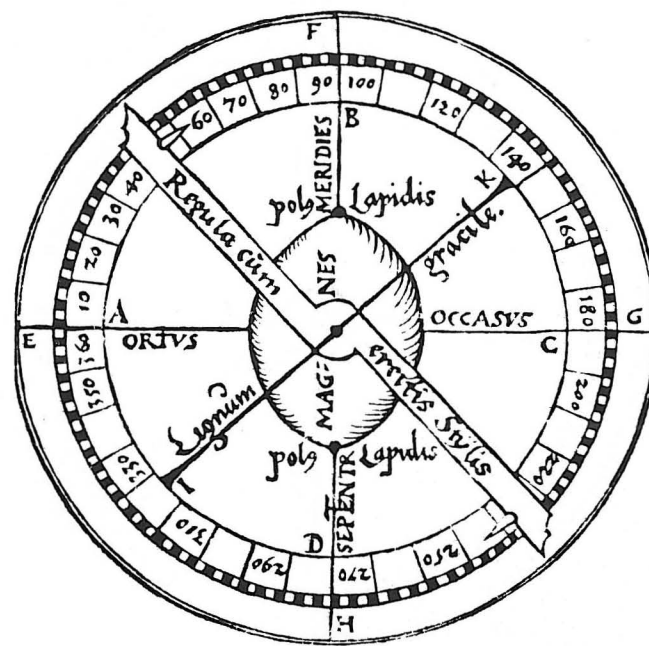
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dorso Astrolabii consueverunt inscribi. Erit insuper regula tenuis et levis super cassulas sic inscriptas, ad modum regule in dorso Astrolabii. Loco tamen pinnularum, erigantur orthogonaliter duo stili super capita regule.

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 cassulae 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.

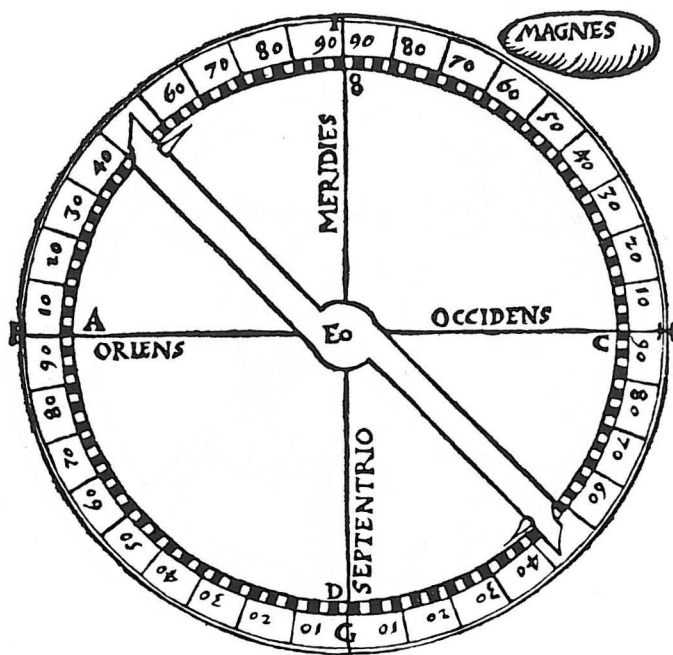
Cognosces autem, per Azimuth, horas, et Ascendens, et Ascensiones, et cuncta quae oportet, secundum doctrinam Astrolabii, complete. Huius autem Instrumenti formam praesens doctrina demonstrat.



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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 materiei 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 alius stilus argenteus, vel eneus, 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 occidents, in eodem;



et addatur ei regula de materia transparenti, cum stilis in summitatibus erectis. Tunc approximabis quam partem magnetis vis, sive septemtrionalem sive meridionalem crystallo, 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.

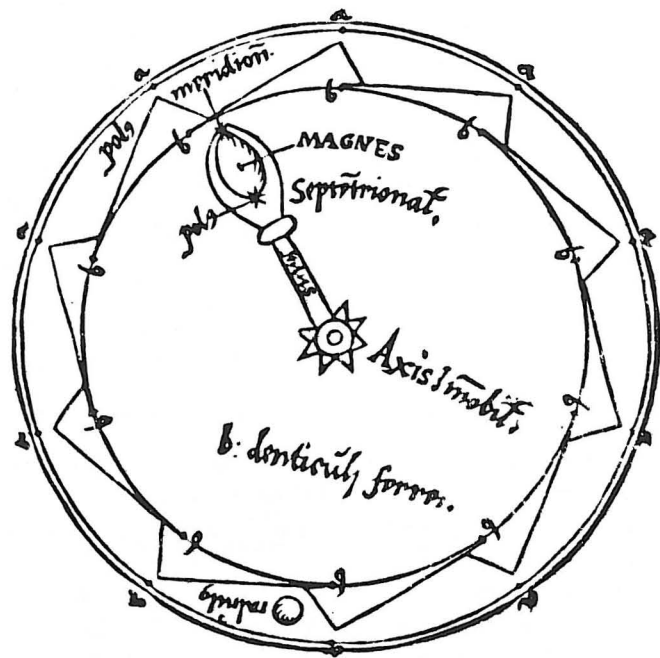
Per hoc Instrumentum diriges gressus tuos ad civitates et insulas, et loca mundi quecumque, et ubicumque fueris, in terra vel in mari, dummodo longitudes et latitudes ipsorum sint tibi note.

Qualiter autem ferrum stet in aere per virtutem lapidis in libro de Operibus Speculorum 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 advertabant, 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

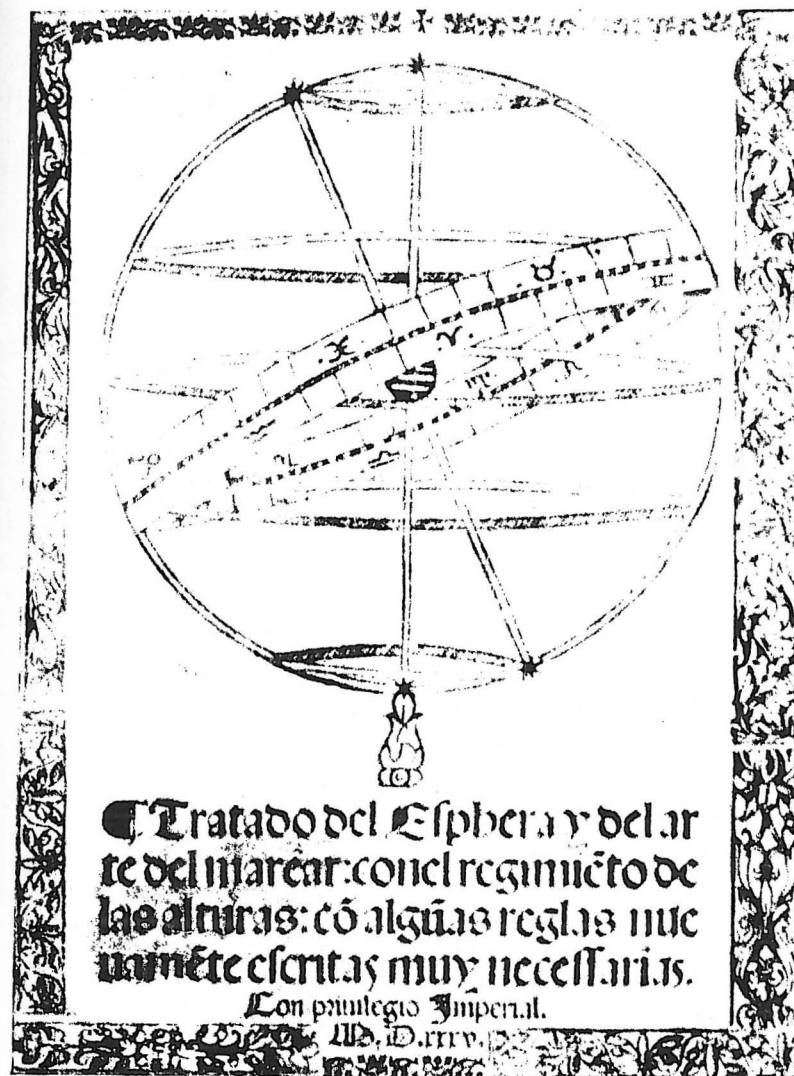


transierit, ad partem meridionalem accedat; que eum potius fugabit quam attrahet, ut patet per regulam superius traditam: sicque erit quilibet denticulus in tractu perpetuo, fugaque perpetua. Et ut velocius suum Rotula exerceat officium, infra cassulas reclude calculum parvum, rotundum, eneum vel argenteum, 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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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 precisamēte lo que ellas nordestean y noruestean. I allēde de lo dicho se seguirā otras vtilidades como saber p̄cisamēte por q̄ r̄ubo nauegan: lo q̄l sabido seguirā p̄cisamete sus derrotas sin yerro ni rodeo y t̄abiē alūbrara mucho pa saber lo q̄ nauegā por longitud.

Nordestear y noruestear las agujas no es otra cosa sino lo q̄ ellas se apartan del meridiano en que estan: el q̄l ellas no muestran precisamente sino quando puntualmete demādan el polo: y este segū los mareantes solamente le demandan precisamente quādo estan en el meridiano de las yslas δ los açores; y las mas precisas le demādan en el de la del cueruo segun esperiencia de algunos; porq̄ por la diuersidad de los azeros y de las piedras de ceuar no demandan todas el polo en vn meridiano; ante vnas en vno mas oriētal 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 q̄ adelante se dira se pueden conformar todas las agujas; porque se conocera la cantidad del yerro de todas en todo lugar.

Para lo q̄l 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 occidente las agujas noruestean; y nauegando desde el mismo meridiano á oriente nordestean. Dizese q̄ nordestean porq̄ lo que ellas se apartan del polo es azia el nordeste; y quando se apartan del polo azia el norueste dizese que noruestea; y quāto mas las naos se apartā del meridiano p̄supuesto | tato mas las agujas nordestea o noruestea; segū la pte para q̄ se apartā; aun q̄ es de tener q̄ partiedo vna nao δ la dicha ysla; y nauegādo por vn paralelo q̄ esta xc grados de logitud las agujas yra siēpre acrecētado en su nordestear o noruestear; y passādo adelāte de lo xc grados por el mismo paralelo por la misma pporciō q̄ ouiesen nordesteado

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lo tornariā a emēdar q̄ q̄ndo ouiesen nauegado otros xc grados q̄ estariā en el clxxx grados de lōgitud de la ysla q̄ se ha dicho: y justamēte estariā en el antipoda y meridiano oposito δ lla en el mismo paralelo | las agujas tornariā a demādar p̄cisamēte el polo como le demādaūā en la ysla y meridiano de q̄ empeço su viaje como se ppuso prosiguiēdo su viaje por la misma δ rrota hasta tornar a la ysla de dōde auia de primero partido si possible fuesse q̄ no es; por el mismo ordē y proporciō tornariā hazer sus difereñias como en los clxxx grados primeros q̄ hasta los primeros xc grados yriā las agujas nordesteādo y dellos adelāte lo tornariā a emēdar. de manera q̄ quādo la nao ouiesse tornado al p̄uto y ysla de dōde ouiesse de primero partido; tornariā a demādar p̄tualmete el polo sin nordestear ni noruestear. y porq̄ los nauegātes siguiēdo sus derrotas por meridiano o de norte y sur hallā q̄ las agujas se apartā del polo; alguos dellos tiene vn yerro: y es q̄ piēsan q̄ siguiēdo tal viaje las agujas nordestea o noruestea: se dize q̄ aun que vna nao nauegue por vn meridiano desde vn polo hasta el otro jamas las agujas cō q̄ tal nao se rigiesse noruesteariā ni nordesteariā. Porq̄ aun q̄ hallē q̄ se apartā del polo como es verdad q̄ hazē; porq̄ el tal apartamiēto del polo es sin allegarse al nordeste ni al norueste no se puede δ zir q̄ nordestea ni noruestea ni el tal apartamiēto es incōueniēte: porq̄ el apartamiento q̄ nos trae en yerro no es el del polo sino el δ l meridiano: y para q̄ esto sea manifesto se pone por exēplo: q̄ si vna nao estuuiesse en la eq̄nocial y el aguja cō q̄ se rigiesse estuuiesse verdadera que ni nordestease ni noruestease: cierto es que puntualmente demandaria el polo sin que le señalasse δ demandasse azia el nordeste ni azia el norueste, ni azia nuestro zenich ni azia nuestros antipodas: y esto es porq̄ 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 horizonte en el qual tiene el polo por estar en la equinocial como es dicho. E como quiera q̄ este presupuesto sea verdadero se ha δ 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 horizonte. E mudandole de la equinocial todo lo que el polo estuuiera arriba o abaxo del horizonte 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 fuesse q seria poner el polo por zenich el aguja θ mandaria el polo en punto que se apartaria del mismo polo xc grados: porque el punto que ella demadaria estaria en el horizonte del que esta debaxo del polo; el qual seria la equinocial. Mas aun q el apartamiento del polo fuesse 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 yerros y falsos principios y fines y no el del polo.

E para que sepamos lo que las agujas nordestean y noruestean conuene 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 empeçando en vno 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 necessario: y despues de graduado señalar en el cetro con compas vn circulo tan grande que abierto se pueda encajar 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 linque en el instrumento para que se tenga derecho; y la vna punta se ha de poner en el punto en que el aguja señalar el polo artico y la otra en el en que señalar el antartico.

Y hecho assi el instrumento | quando quisieredes obrar con el endeçalde 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 señalar el polo artico; y quando el sol estuuiere entre vos y el polo antartico hazed al contrario. E quando quisieredes assi tomar la sombra; aueys de rodear el instrumento a la vna parte o á la otra sin auer respecto ninguno al aguja hasta que el medio circulo vos haga

la sombra derechamente como es dicho. E si tomada assi la sombra el aguja señalar 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 vezes que el aguja concertare con la sombra o rayo de medio dia; aueys de tener que esta verdadera; y todo lo que el aguja discrepare sera yerro. Por tanto quando el aguja tomada assi la sombra no señalar el polo en el punto en que estuuiere 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 señalar 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 veynte y quatro que ay en vn dia natural | las que restaren será 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 començar 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 θ llas sera el meridiano p̄ciso; y esta es muy buena regla assi por ser verdadera; como porq̄ puede seruir mas vezes al dia q̄ 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

lo mismo en poniendose; y el medio de las dos sombras por fuerça sera el meridiano. E todas las vezes que el aguja señalar el polo en el tal meridiano que assi ouieredes tomado en el instrumēto estara verdadera; que no nordesteara ni noruesteara; y quando no señalar 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 señalar 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 señalar el polo hasta la graduaciō. E quado el hilo cayere por la linea diametral señalada en el instrumento precisamente; si la nao estuviere en el paralelo en que el sol estuviere 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 pūto 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 estuviere en el paralelo en que el sol aquel dia estuviere. E quado la nao estuviere 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 quadrante; 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 practicado y estas bastan.



PEDRO NUNES

ESTROMENTO DE SOMBRAS.

E porque nenhũa cousa se pode alcançar em Astrologia e cosmographia: se não prosupondo a noticia doutras cousas ja sabidas que se tomão por fundamento: as quaes se ainda quisesemos resolver 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 ouer sol: necessario nos será fazer outro tanto. E porq̄ não vejo cousa que no mar possamos leuar: que sendo indiferente a todalas alturas do polo: nos possamos della mais aproueitar q̄ da agulha q̄ 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 cousas per fundamento juntamente cō a demonstração mathematica darey dous modos p̄ que a altura do polo se possa alcançar. E sera o primeiro presupōdo que a agulha vay justa ao polo sem nordestear nē noresteear. Mas o segundo sera ajudādome toda via da agulha se estamos no mar. E isto quer ella nordestee quer noreste: e posto que não saibamos se faz mudança: ou se ha non faz q̄ he não ter meridiano: antes p̄ esta arte que darey poderemos saber se nordestea quer norestea: e per quātos graos se aparta do verdadeiro meridiano. Pera as quaes cousas teremos hũa lamina circular de algũa materia solida e de conforme grossura q̄ com ho tempo nã faça mudança: 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 q̄ ho repartão em quartas: e no centro poremos hũ estilo perpêdicular sobre a mesma lamina p̄a nos amostar pera q̄ parte vāo as sombras: e em qualquer dos semidiametros em igual distância do centro e da circūferencia: faremos sobre hũ pôto hũ pequeno circulo que se cauara quanto baste: pera que embaixo em outro centro q̄ responde ao de cima: sobre q̄ se fez o peq̄no circulo q̄ se cauou possa andar liuremente hũa agulha como a dos relogios acostumbrados e pela mesma arte sera feito este peq̄no circulo e acabado com seu espelho encima: mas a agulha sera mais comprida e mais sotil e per baixo della jra a linha q̄ responde ao diametro do circulo grãde que se graduou: per modo que delle não discrepe cousa algũa: e porque nos ha de ser necessario endereçar 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 saibanos de certo que esta dereita com os diametros do circulo peq̄no e do grãde q̄ 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 balanças serem torneadas e de eyxos dobrados e muy liures; e se sem embargo de ho assi fazermos: acharmos que a lamina não fica ao ouliuel acrecentarlheemos 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 algũa arte que fique direita he a mesma tenção: posto que a que se fez pera sua Alteza de Marfil: com as balanças torneadas e de eyxos dobrados: era tam prima que nenhũa cousa discrepava 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. Nã he necessario auer nelle mais que hũ circulo grãde graduado que representara ho horizôte: 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 horizôte. E porque ho vso destes estromêtos he pera situarmos ho sol neste globo em respeito de nosso zenit como elle esta no ceo: ao tẽpo 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 direita com os pontos que estam sobre ho seu diametro: e notaremos por quãtos 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 começãdo do encôtro do horizonte q̄ he o pôto onde acabou a cõta dos graos da sombra: cõtaremos os graos da altura do sol q̄ achamos no estrolabio e no fim poremos pôto: o q̄l representara o sol: e assi ficara situado e respeito de nosso zenit no globo como no ceo. E querêdo saber q̄nta seja a altura do polo pa mais craramêto pcedermos: porey todalas cõtengencias: e sera a primeira estãdo o sol na banda do norte que he ter declinação setentrional: e nos rumos do sul e seguirseham as outras. Esta ho sol nos rumos da bãda do sul: segue-se 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 nouêta: tirando a declinação: e tẽdo 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 hũa das Ilhas das canareas, e logo fiz prestes a lamina e estormento de sombras, de que o muito excelente principe o Iffante dom Luis me fez mercê, com grande desejo de verificar duas cousas: a primeira, se nesta Ilha variauum as agulhas, ou não, por ser practica 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 governa.

Primeira consideração antes do meo dia.

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

Segunda consideração antes do meo dia.

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

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

Primeira consideração depois do meo dia.

Estando o sol em altura de 61 graos †

ho estilo lançou a sombra 53 graos
contando do norte pera a banda de leste:
foi logo o arco 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 dabrill, todo o dia foy o vento oesnoroste fresco;
governamos 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 arco 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 arco 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.

Notação.

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 necessa-
riamente 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
ocasião 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 detreminada-
mente auer de aueriguar o verdadeiro lugar onde defire a sombra, de sorte
que, balanceando muito a naao, podemos facilmente errar atee dous graos,
mas hindo queda e asossegada, 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, hũa dellas estando da
banda do norte das ilhas, e a segunda achandome já da banda do sul, em
ambas se vereficou nordestearem as agulhas cinco graos e $\frac{1}{2}$ atee 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 algũa, mas ferem directamente nos
verdadeiros polos do mundo, e daqui veo chamarem a este promontorio cabo
das agulhas, significando não fazerem já aqui nenhũa differença: ao tempo
que vimos a terra, eu me fazia á Ré della 120 legoas, e o Piloto 110.

Notação famosa e muito proueitosa.

Acharme já nestas prayas tão deseidas dos nauegantes, e com ter
passados tantos Receos, tantos sobresaltos, tantas fortunas de tamanho e tão
tem pestuoso gôlfão, me dá lugar e occasião de dizer algũa cousa da longura
deste caminho, materia certamente não menos fermosa e grande que prouei-
tosa, a qual até qui mais se póde dizer ser profiada que sabida; e Porque
pera a determinação e sentença desta duuida se requiere concorrerem assi
demonstrações 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 occano, grande e infinito mar, trarey aqui as Rezões que de hũa 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 triumpho o dia doje em toda a europa, e sobretudo aprouado 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 differença de meredianos; Pelo que será justo darmos fé a estormento de tamanha auctoridade, e o que por elle se achar auer de ser o certo.

Começa a proua.

Na cidade de lisboa, assi como muitas vezes tenho experimentado, nordesteão 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 nordesteão 5 graos $\frac{1}{2}$, e deste lugar até á linha æquinoctial não fazem algũa mudança ou differença. Porém, passando daquy e correndo na volta do Brasil, começa a variação hir crescendo pouco a pouco, de sorte que, achandonos 130 legoas pera leste do cabo de sancto Agostinho e em altura de 9 graos, as agulhas nordesteão 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 esperanza, vão as agulhas endireitando pouco a pouco, e desandando os graos que até qui tinham 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 crescendo a variação, até chegarmos ás prayas da India, onde o norte das agulhas se desuia do Polo do mundo pera a banda de noroeste 11 graos, que valem $\frac{1}{2}$

(4)

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

Primeira operação ante o meo 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 oras e mea.

Segunda operação ante o meo 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 oras e $\frac{3}{4}$.

Terceira operação ante o meo 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 oras e mea.

Primeira operação depois de meo 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 arco de depois de meo dia igual ao dante meo dia, pello que fica manifesto não variarem as agulhas nenhũa cousa neste lugar.

Segunda operação de depois de meo 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 oras $\frac{1}{4}$.

Foy logo nesta operação o arco de depois de meo dia igual ao dante meo dia, pello que fica manifesto neste lugar não variarem as agulhas.

Terceira operação depois de meo 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 oras $\frac{1}{4}$.

Foy logo nesta operação o arco de depois de meo dia igual ao dante meo dia, pello que fica manifesto neste lugar não variarem as agulhas.

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

4 *

(5)

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 nenhũa, mas ferem directamente nos verdadeiros polos do mundo, como por tantas e tão conformes operações se tem mostrado

Este dia quis obrar com o estormento das sombras pera verificar a variação das agulhas, e sendo menos de 11 oras, a sombra do estilo hia muito alem da linha do meo dia, pello que, mandando vir algũas agulhas pera as cotejar com o estormento, acheyas tão desconcertadas, que foy cousa espantosa, porque onde hũa fazia o leste, a outra mostrava 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 operações, o ferro do qual berço chamaua a ssy as agulhas, e as fazia desviar desta maneira; do que tirey que hũa operação 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 algũas outras que fiz na parajem do Brasil, onde achey notaues differenças, que foy por as fazer perto donde estaua algũa 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 dagosto quis saber o que variauaõ as agulhas neste porto de Moçambique, e fiz as operações seguintes:

Primeira operação ante o meo dia.

Estando o sol em altura de 16 graos
ho estilo lançou a sombra 76 graos $\frac{1}{2}$
contando do sul pera a banda daloeste.

Segunda operação ante o meo 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 meo 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 meo dia.

Estando o sol em altura de 56 graos $\frac{3}{4}$

ho estilo lançou a sombra 39 graos
contando do sul pera a banda daloeste.

Primeira operação depois de meo dia.

Estando o sol em altura de 56 graos $\frac{3}{4}$
ho estilo lançou a sombra 25 graos $\frac{1}{2}$
contando do sul pera a banda de leste:

Foy logo nesta operação o arco dante o meo dia mayor que o de depois de meo dia 13 graos $\frac{1}{2}$, os quaes partidos pello meo, vem á parte 6 graos $\frac{3}{4}$, 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 pera a banda de leste:

Foy logo nesta operação o arco dante meo dia mayor que o de depois de meo dia 14 graos, cuja metade são 7, que he a quantidade que a agulha neste lugar norestea.

Terceira operação depois de meo dia.

Estando o sol em altura de 42 graos $\frac{1}{2}$
ho estilo lançou a sombra 48 graos
contando do sul pera a banda de leste:

Foy logo nesta operação o arco dante meo dia mayor que o de depois de meo dia 13 graos $\frac{1}{2}$, os quaes partidos, vem á parte 6 graos $\frac{3}{4}$, que he a quantidade que neste lugar agulha norestea.

Quarta operação depois de meo dia.

Estando o sol em altura de 16 graos
ho estilo lançou a sombra 63 graos $\frac{1}{2}$
contando do sul pera a banda de leste:

Foy logo nesta operação o arco dante o meo dia mayor que o de depois de meo dia 13 graos, os quaes partidos pello meo, 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 variação das agulhas, e em todas as operações me sahio 6 graos $\frac{1}{2}$ e 6 graos $\frac{3}{4}$ a quantidade que agulha noresteaua; e todo o tempo que neste porto estiuemos, ventárão os ventos leuantes, tirando dous 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 horizonte, 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 arço 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 $\frac{1}{2}$, 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 verificou o norestear das agulhas, porque se fez esta experiencia por duas vias muy diuersas: a hũa dellas foy a via costumada, que he pella quantidade que huns arços são mayores dos outros, de que me tenho aproueitado neste caminho; e a outra he pello 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 arço do horizonte 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 porquanto 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 nacimiento 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 contraio 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 norestear da agulha á operação que fiz tomando a differença dos arços; e daquy se tira que he falsa a openião daquelles que dizem no dia do equinoctio nacerlhes o sol em leste de suas agulhas, pois em nenhũa maneira pode acontecer por caso da variação que fazem geralmente.

Primeiro Roteiro da Costa da India, 1538—1539.

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

Andando por este ilheo e sobindo ao monte que está da banda do Norte pera marcar e ver como jaziam os outros ilheos e baxos com ele, me aconteceu 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 tamanho 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 do monte pondo a agulha em cima de todolos penedos e pedras, mas nunca fez nenhuma variação, somente achei hum penedo apar do outro da mesma natureza, posto que neste nam dava a rosa tamanha 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 Sueste: 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 apropiava ao penedo estando suspendida nas mãos em cima dele.

Nam val ho argumento que dixer qu'estes penedos eram da especie do manhete, porque se o foram, cortando deles alguns pedaços e trazendo-os pera derredor da agulha fizeram mover a rosa da frol de lis, do que vi a experiencia em contraio, 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 frol de lis bolia comsigo. 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 propriadade 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

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 variacão 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 aquellas cousas que jazem sugeitas e debaxo da jurdição das artes mathematicas, a deccraração e puntualidade he grandemente necessario, deccraro 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 relogio 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 merediana da lamina, e notei onde a sombra do estilo cortava o circulo, e loguo incontinente a tirei e a cevou o piloto; dipois d'estar cevada a pus em seu lugar, e endereitando-a como fiz dantes com a linha merediana 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 relogio 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 embargo das regiões serem tam diferentes a propriadade das pedras parece ser huma mesma

Notação.

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

(10)

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 consideraçõis, em todas comprendi Norestear 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 consideraçõis e em todas achei ho arco 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 tamanha mudança; e se por ventura me argoirem que eu e ho Doutor julgamos mal a deferença dos arcos quando juntamente fizemos as operações no Rio do Paguode, respondo que inda isto averia por mais, errarmos em .4. operações e estes erros virem tam justos, que em todos achamos ho arco 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 consideraçõis 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 composiçãõ deles ser ferrenha, e per esta causa atraerem pera si o ferro da agulha desviando ho do seu natural lugar

Largura do nacimiento 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 diretamente 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 Oessudueste.

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 cheguado alguma cousa ao rumo que á quarta. Do que se segue que Norestea casi quarta e meia.

(11)

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 emmendar 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 desvairadas pedras e por tanto cada hum tiraria pera a parte onde a vertude e propiedade da pedra ha enderençasse, mas inquerindo deste caso o piloto, jurou-me que todas tres 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 horizonte, 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, tomando 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 tomando 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 legua ao mar.

Em quanto eu fazia estas operações 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 horizonte e graduação do estrelabio, e achou que apontando por cima da terra estava hum grao e meio sobre ho horizonte.

(12)

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

.1. Operação ante meio dia.

Estando o Sol em altura de30. graos.
A sombra do nhomam estava42. graos.
casi, contando do Norte pera Oeste.

.2.^a Operação ante meio dia.

Altura do Sol35. graos; —
De sombra36. 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 Sol40. graos; —
De sombra31. graos. $\frac{1}{2}$;
contando do Norte pera Oeste.

.1.^a Operação dipois de meio dia.

Altura do Sol40. graos; —
De sombra53. graos. $\frac{1}{2}$;
contando do Norte pera Leste.

Foi loguo nesta operação ho arco 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 dipois de meio dia.

Altura do Sol35. graos;
De sombra59. graos;
contando do Norte pera Leste.

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

.3.^a Operação dipois de meio dia.

Altura do Sol30. graos; —
De sombra63. graos. $\frac{1}{2}$;
contando do Norte pera Leste.

(13)

Foi loguo nesta operação ho arco 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 arco 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 Noroeste.

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 arco de dipois de meio dia ser igual ao dante meio dia; do que se segue que fere diretamente 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 quantidade pequena que a meu ver poderia ser dous 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 quantidade 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 arco de dipois de meio dia mayor que ho dante meio dia, se bem oulhamos o nascimento do sol, casi tres quartas; das quais he o meio quarta o meia casi, que he a quantidade qu'esta agulha nesta operação e nas outras que sam feitas com ela, Norestea.

Currelario.

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

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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 operaçoens seguintes.

Primeira operação ante meo dia.

Estando o sol em altura de. — 38. graaos $\frac{1}{4}$. O stillo lançou a sombra. — 70. graaos. Contando do Norte pera oeste.

Segunda operação ante meo dia.

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

Terceira operação ante meo dia.

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

Primeira operação depois do meo 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 meo dia, maior que o dante meo dia. 2. graaos $\frac{1}{2}$. cuja ametade he. 1. graao $\frac{1}{4}$. que he o que neste lugar agulha norestea.

Segunda operação depois de meo 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 meo dia. maior que ho

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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 operaçāo 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.

¶

laus des adl & nurey 1544 noemberge

Euer freylich genad zucht an in vrom schreybe, zu wissen die krafft
vnd tugent (des magnete) / so ist die: Mat. den legenden zucht
zu nurey genad hat (welche tugent als man zuweil heize den
freylich genad wolt mitzule) / wo ist nun der ~~ein~~ ein schiffen
kann vorfassen) / das selbe Ding sein ist teichtlich zu vorstehen /
so man selbe mit der handarbeit anzeigt / das mit der schiffen
yoch vnd ist das recht zuwenden / so mit mittel / selbe den
freylich genad in schiffen zu weise) / vnd zum ersten also.
Eyn selbe magnet / hat in in offe krafft vnd tugent / das er an eyne
ort das eyser zu sich zucht / vnd an den andern ort gegen vber
an dem magnete / so treybt vnd scharbt er das eyser von sich.
Das ist kleidlich zu vorsehen) / so man nimbt eyn nadel hantken
an eyne faden / vrom man den magnete) das zu halt vnd
das ort welches die nadel zu sich zucht / das selbe ist ein
magnete das mitzule) ort ~~vnd~~ man die zubele an den
zunge in den ampfer) / das mit an scharbt) / so lasen die
selbe) zungen mit dem zubele mit dem mittel zu / sonder
das mittzucht zu / das ist zu vorzuden) an diesen magnete)
So ist aber die nadel halt zu dem magnete an das ort /
welches dem vromen ort geradt entzogen ist / so zucht der magnet
die nadel so selbst mit mecz zu sich sonder treybt vnd plestis
von sich / vnd das selbe ort / das die nadel also von sich
treybt / das selbe ort das ist das mittzucht) an dem magnete)

und wenn man die 7 gebale an den zimble mit den selbigen ort
verfährer / so lafen die gebale mit gelde der mitternacht / sonder
gelde dem mittag / Voch ist an dem magneten sein vñes großer sich
zu vermindern / Das die zimble vor mit verfahrere mit gerade
lafen der mitternacht zu / sonder werden sich ab von der rechten
mittag d' aber mitternacht linie) und keze sich gelde dem anfang
zu / in etliche landen umb 5 grad / wie ich solches selbes finden
und gefücht / hab zu der zeit / zu rom / do eine fruchtbar
marktzuff gumprecht vñ sein ff 0: bruder bei ein ander zu rom
warde) / Aber die zu november finde ich das solches anfang
ist 10 grad / und in andern orten) mecz aber minder / solches
man sich abzeit mit einer feurigen stüble under dem steslein
in dem compasse angezigt welches stüble / wie man sich abwege
mit gerade auff die mitternacht zuigt / sonder lendet sich bezund
gelde dem anfang ~~der~~ andern) / so finde ich auch dass an dem
magnete) / Das es sich ~~verändert~~ verändert von der mitternacht und
lendet sich gelde dem anfang / umb 9 grad mecz aber minder
wie ich es geret hab / sonder es zündet auch vnder sich / dass es also
zu verweyden / nach mache ein zimble ein finger lang dar mit
flüssig rothweitz oder wasser was recht auff eine spritzende stoffe
stehet / also das solches nicht mit sich zu der ebenen rage / sonder in
geden) oder gleich in der was stee / so ist aber der orter ein
westweitz / so gleich welches ort ist / so bleibt der zimble mit mecz

wagrecht stee / sonder sich vnder sich etwa umb 9 grad mecz und
minder / wofür was umb der d' stoffe / Grad ist Ko. Mat. mit
wasser in zu zeit) / ~~11~~ ¹² ~~dem~~ ^{dem} orten) hab ich Ko. Mat. angezigt
zu finde) welches ort an dem magneten ist das ort gelde der
mitternacht / und welches ort gelde mittag / das hab ich Ko. Mat.
also probirt / Ich liff mir herbringen ein große schüssel
voller wassers / ein her ist ein feurige klein) hölzene schüssel /
das liff ich mitte auff dem wasser stamme) und leget den
magneten sein demach bei ein in das schüssel) / so ist aber ein
mit runde welches ort an dem magneten mitternacht) / so keze
sich das schüssel gerade umb auff dem wasser und stammet also
mit dem ort welches ist mitternacht an sein) / bis es kom an
den ort der schüssel) / so das wasser in st) / und so oft ist
das schüssel runde in der mitte des wassers stelle) / so keze
der ort der ich finde ~~der~~ ^{der} mitternacht) / so will ich
also das zu schüssel) ~~ist~~ ^{ist} stee) / sonder werden sich
verändert / und / ~~stamm~~ ^{stamm} ~~der~~ ^{der} mitternacht) / so ist aber ein den
magneten bezuiff ~~nam~~ ^{nam} ~~der~~ ^{der} westweitz mit dem selbigen
ort) (welches ymmer gelde der mitternacht zu eylet und stamm)
das gebale an zimble / so keze sich das zimble mit gelde der
mitternacht) / wie Ko. Mat. vorwart) / solt ich hab) / sonder keze
sich gelde dem mittag) / Kom mir schenke) was seer sich Ko. Mat.
an orter probirt sich vor runde)

In dem feure hat es für die Mat. an dem ein züngle ein
 fingers lang und steht auf ein sprache stellt / und hat mit
 mehrer seite solches züdwelt das der die seite solches
 mit anzuzeu / so ist das züngle für und für gelofft / und sich
 bewegt dem auffgang der sonne / bis vnder in auffgang
 für und für so lang es ist die seite vnder das von dem sab
 ist auch seligam zu sehen // (es hat ein alt primata prof in
 dem parze krieg überkommen) / in welche ist auch fide die kraft
 des magneten / wie zu mache ein instrument durch den magneten
 welches sich für und für bewegt in gleichem form zeit und wege
 wie sich der hünd bewegt / also das wie der hünd sich in der
 stunde gmal und das etwas sich bewegt / das ist als ob ein
 met mit dem magneten ist gericht / auch dergleichen mag zeit vnder
 stunde sich bewegt / so von es mit sich selbst halten
 So ist ein für die Mat. mit die probe verstand / so bewegt
 die Mat. von mir den offte magneten sein zu haben / so gab
 es die Mat. offte an dem / es hat eine die Mat. zu der dritte
 mal die stün malle segenke / habe mir einer die Mat. abwechsel
 zu antwort habe / soll die Mat. malle mich dass / so ist zu zeigen
 arbeits teglich müße abwechsel in wechsel / und ein magere seite
 von mir zu haben / Also sprach die Mat. zu mir / als wüste da zu
 mal mit / das in zween magneten hatt / dan aller erst es ist in grooz zu
 wech / also segetet es die Mat. den magneten / dan die mich in ma
 chlich bewegt hat / und vnder es ist erpffund von jens / so
 die Mat. bewegt zu wissen / was es bewegt der zeit feruach für die
 Solche prob alle ein über f. g. mal auch machen mo dass
 etwa ein gutes stückle magneten hat / das so die ist / alles
 dergleichen zu wech zu zeigen

Georgio barthina vicario sancti sebaldi noremberge

laus deo adi 4 Marcij 1544 noremberge

Euer fürstlich Gnad zeigt an in ihrem Schreiben zu wissen die Kraft und Tugend
 des Magnetes, so ich königliche Majestät den letzteren 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 klärllich zu
 erweisen, so man nimmt eine Nadel hängend an einem Faden, wenn man den Magnetem
 darzu hält; und das Ort, welches die Nadel zu sich zeucht, dasselbige ist am Magnetem
 das mittägliche Ort, und wenn man die Gäbele an dem Züngle in den Compassen darmit
 anstreicht, so laufen dieselbigen Züngle mit dem Gäbele nicht dem Mittag zu, sondern
 der Mitternacht zu. Das ist zu verwundern an diesem Magnetem. So ich aber die
 Nadel halte zu dem Magnetem 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 bläß's von sich, und dasselbige Ort, das die Nadel also von sich treibt, dasselbige Ort
 das ist das mitternächliche Theil an dem Magnetem, und wenn man die Gäbele an dem
 Züngle mit demselbigen Ort verstreicht, so laufen die Gäbele nicht gegen die Mitter-
 nacht, sondern gegen den Mittag. Noch ist an dem Magnetstein dieses größer sich zu
 verwundern, daß die Züngle darmit verstreichen nicht gerade laufen der Mitternacht zu,
 sondern wenden sich ab von der rechten Mittag- oder Mitternachtlinie 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 euer 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 alzeit mit einem schwarzen Strichle unter dem Gläse in den Compassen angezeigt,
 welches Strichle, wie man sieht, allewege nicht gerade auf die Mitternacht zeigt,
 sondern lenket sich herum gegen den Aufgang.

Zu dem anderen, so finde ich auch dieß an dem Magnetem, 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. Dieß ist also zu
 erweisen. Ich mache ein Züngle eines fingers lang, das nur fleißig wagrecht oder
 wasserwagrecht auf einem spitzen Stiff steht, also daß solches nirgends sich zu der
 Erde neige, sondern an beiden Orten gleich in der Wage stehe, so ich aber der Verter
 eins verstreich, 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.

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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 Schüssel, das ließ ich mitten auf dem Wasser schwimmen, und legte den Magneten fein gemacht hinein in das Schüssel. Da ich aber nun nicht wußte, welcher Ort an dem Magneten mittnächig war, da kehret sich das Schüssel gerade um auf dem Wasser und schwimmt also mit dem Ort, welcher ist mittnächig am Stein, bis er kam an den Bord der Schüssel, da das Wasser in war, und so oft ich das Schüssel wieder in die Mitte des Wassers stellte, und fehrt den Ort, den ich gefunden hatte, gegen die Mitternacht, so blieb doch also das Schüssel 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 immerdar gegen die Mitternacht zueilte und schwamm) das Gábele am Zünge, da kehrt sich das Zünge nicht gegen die Mitternacht, wie Königl. Majestät vermeinten, sollte thun haben, sondern fehrt 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 Zünge eines Fingers lang, und gestellt auf einen spitzigen Stift, und habe mit meinen beiden Händen solches zugebedekt, daß doch die Hände solches nicht anrührten. Da ist das Zünge 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 darvon 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 begehrt 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 begehren solchen von mir zu haben. Also sprach Königliche Majestät zu mir lachend: ich wußte dazumal nicht, daß ihr zwei Magnete hättet, denn allererst bis ich's jetzt gewahr bin worden. Also schenkte ich Königl. Majestät den Magneten, dargegen mich ihre Majestät ehrlich begabt hat, und wieder Brief empfangen von Prag, da Königl. Majestät begehrt 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 Stückle Magnet hat, das da gut ist, ist alles leichtlich zuwege zu bringen.

Georgius Hartmann Vicarius Sancti Sebaldi Noremberge.



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 quotiescunque navigatorias chartas inspicerem, 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 anxium, propterea quod navigatorias omnes, quibus plurimum castigari posse sperabam geographicos errores, nimium viderem a scopo aberrare, cepi ego diligentius errorum causas perquirere, potissimamque 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 longitudinisve 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 maritimas terras ex inventis navigationum cursibus depingerent, alioqui nec sibi nec geographicis aliquo modo satisfactoris. 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

descriptis exquisitissime, inuenio Dantiscum 1 gradu fere septentrionalius reddi quam reuera existat, unde colligo lingulae nauticae extensionem Dantisci — 5 gradibus amplius declinare a vero septentrione quam in Walchria. Vicinis autem Walchriae 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, quousque 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. Tuae obtulimus, cum enim juxta navigationum decursus ex Europa factos Canadam pinxisset hydrographus, quisquis fuërit, 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 latitudinum Canadae Europaeque adscriptarum differentia possemus demonstrare, si pro rei magnitudine temporis suppeteret copia. Sed quoniam multa essent alia, et quidem difficilia in navigationum chartarumque marinarum castigationem dicenda, satis erit R. D. Tuae 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. Tuae me commendatum cupio, quam foelicissime valere cupio, Lovanii pridie Mathiae, anno 1546.

R^mie D. T.

semper devotissimus



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Breue compendio de la sphaera y de la arte de nauegar con nuevos instrumentos y reglas exemplificado con muy subtiles demonstraciones: compuesto por Martin Cortes natural de burjalaro; en el reyno de Ziragon y de presente vezino de la ciudad de Ladiz: dirigido al inuictissimo Monarcha Carlo Quinto Rey de las Wespaña. etc. Señor Muestro.



Ad maximum fortissimum inuictissimumq; Ca
rolum Casarem huius nominis quintum illeq; hon
sus de lanibna episcopi dnuisten. disticon

Casares olim iactabas Romo triumphos
Definemat maius Carolus imperium.

5 *

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Proprie-
dades de
la piedra
y man.

Cap. liij. de la virtud y propiedad de la piedra y man.



La piedra y man segun escrive el cardenal cusano tiene esencia y virtud y operacion. La virtud es egedrada de la esencia: de la esencia y virtud nasce la operacion: de manera que comunicando la piedra su virtud al fierro por razon desta haze al fierro que se mueva aunque entre el y ella este vna taza de plata o vna tabla o otra cosa semejante. La fuerza atractiua de la piedra y man haze ala natural eza del fierro estar en si y con quietud tanto que conser graue y poderoso no diziende por que la naturaleza de este fierro no queda en si mas vñese con la naturaleza de la piedra: la qual pesce que se va extendiendo: donde vemos que por esta vniõ sucede no solo atraer este fierro mas este a otro y otro a otro y se haze vna sarta como muestra la experencia. San augustin se marauillo segun escrive en los libros de la ciudad de dios por que sobre vn vaso vio vn fierro menearse meneado la piedra y man de baro del vaso: llamase magnes por que el inueto de ella asi se llamaua: el qual (segun escrive plinio) esta en la india orientel guardado ganado traya el calzado clauado y ferrado por de baro (seria como esclopes de gascuña o cuecos de castilla.) En el bordon traya punta o regaton de fierro: y hallandose sobre vna cantidad desta piedra no podia mouer los pies ni leuantar el cayado o bordõ: pues como vn rato ygnorase la causa poco a poco vino a entenderlo que fasta alli no entendia y conosciõ la propiedad de la piedra y la virtud atractiua que tenia: su color no difiere de

Cusano
Cardi. li.
5. excitati
onum.

Platina
de vita sũ
mo ponti
ficum.

pli. li. 36
ca. 16.

Sotinus.

magnes
i
nento
z de
ta picora.

Linco
el
pecico
de
piedra
y
man.

halla
se
piedra
y
man
en
españa

La pic-
dra y man
de dina
marca la
mejor.

La pic-
dra y man
da virtud
al fierro.

de fierro antes por esta causa fue llamado fierro bino. La mejor piedra y man es de color cerulea la qual color a vezes tiene la mar: hallaron se cinco especies o diferencias de piedra y man: la primera ethiõpica: la segunda manesica de macedonia contermino a los que van al lago de boeicia: la quarta troade cerca de alexandria: la quinta y manesica de asia: mas agora se halla en otras diuersas partes: ay la en espanya en muchos lugares: hallase en sierra morena junto ala villa de la calera que es de la orde de santiago en la provincia de leon. En vna sierra de moron tierra del code de v: ena ay gran cantidad de ella y en otras partes. La mas comun piedra y dela que mas vñamos es de la isla de lelua del seõor de pomblin: la que yo tengo por mejor es de dinamarca. Esta y las de mas tienen virtud propria de atraer asi el fierro: verdad es que teanredes escrive que en ethiõpia se halla otro genero de yman que aparta y desecha de si el fierro. El comẽtador niega que la piedra y man atrayga asi el fierro: mas dize que el fierro por natural inclinacion se mueue ala piedra como a su natural lugar: por vna cantidad que la piedra ipuene en el fierro. Allende desta virtud y propiedad que tiene de atraer asi el fierro: tiene otra y es que da al fierro virtud y potencia para que señale los dos puntos del orizonte do le corta el meridiano: que es los dos vñetos norte y sur: esta virtud se halla mas intensa en solas dos partes de la piedra: y estas partes siempre estan opuestas: y asi son contrarias en la operacion: por que tocado

Theange
des.

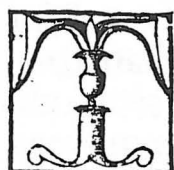
Aucrois.

Utilidad
de esta pic-
tra.

el fierro cō la vna y puesto do se pue da mouer li-
ozemente señalara el norte: y otro fierro toca-
do con la otra parte señalara el sur: haziendo es-
ta experiencia se sabe qual parte de la piedra
corresponde al norte: aq̄ los marineros llaman
cara dela piedra y qual al sur. Es tā necessaria
esta piedra q̄ sin ella la nauigaciō ieria falta r̄i
cierta: porque ella da vida al aguja: y el aguja
guia al piloto pa q̄ d̄ dia acierte: y d̄ noche no y
yerre. Muestra a cercar el mūdo: da a conoscer
los viētos: y pues estā necessaria el aguja d̄mos
orden y manera como se ha de hazer por que
podria ser que en el viaje faltase: o se perdiēse.

Capitulo. iiii. dela fabrica dela agu-
ja: o buxola de nauigar.

Fabrica
de la aguja.



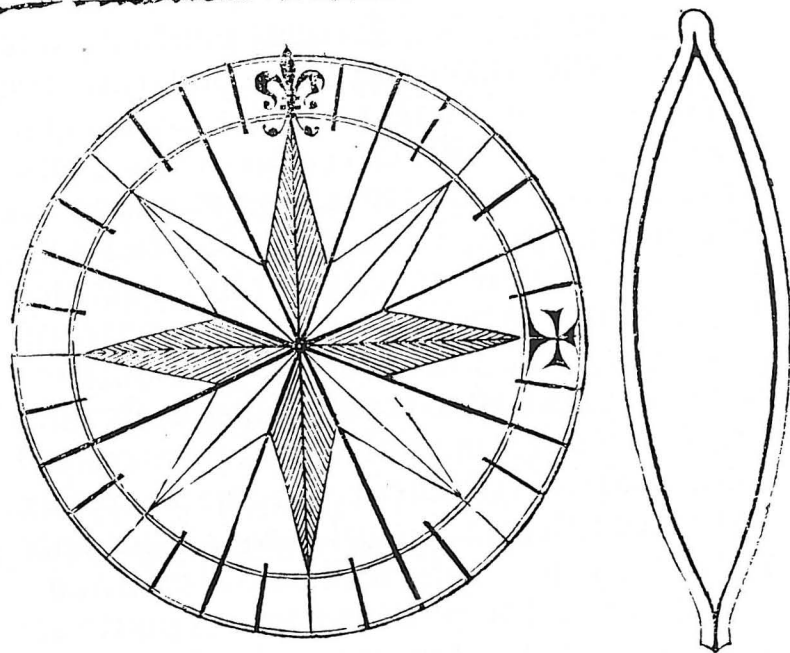
Me se vn papel como d̄ naypes: y
de se en el vn circulo de quantidad d̄
vna mano poco mas o menos: ē el q̄l
se han de pintar los.32. vientos con
las colores y en la orden q̄ dimos en el primero
y segundo cap. de los vientos y dela carta: no
oluidando de señalar el norte con vna flor de
lys: y el leuante con vna cruz: y d̄ mas d̄sto ca-
da vno segū su phantasia los hermoseara y a-
graciara: despues por la pte bara d̄ste papelō
se ha d̄ dar vna linea q̄ste d̄rechamēte bara de
la d̄l norte sur: la qual sera señal para el asētar
los fierros o azeros: y despues se ha de tomar
vno filo hierro: o azero tā grueso como vn alfi-
ler gordo: o segū el tamaño d̄l redōdo d̄l papel
rosa: aguja o buxola que ya se puede llamar:
este

Este fierro se ha de doblar: y q̄ cada vna d̄ las p-
tes y gualmēte sea tan luenga como el diame-
tro d̄la buxola y mas la q̄rta parte. Los cabos
o puntas d̄stos fierros: o azeros se han d̄ apre-
tar y ajustar: y en los medios se hā d̄ abzir o ap-
tar vno d̄ otro hasta q̄ los cabos vēgan a ygua-
lar con las extremidades del diametro de la
buxola: y así quedarā los azeros quasi en figu-
ra oual. Estos fierros se hā de apegar por la p-
te bara dela buxola d̄ manera q̄ sus extremi-
dades: o puntas vengā precisamēte por la li-
nea d̄l norte sur: y para fixar los así se hā d̄ cov-
bir con vn papel delgado engrudado: d̄rando
las p̄tas o extremidades d̄l fierro d̄scubiertas.
Y estas extremidades se hā d̄ tocar en la piedra
y man en esta manera: la pte q̄ esta abaxo de la
flor d̄ lys se ha d̄ refregar en aq̄lla pte de la pie-
dra q̄ correspōde al norte (segū se d̄ixo en el capi-
tulo pasado) y esto bastaua para la p̄fection d̄l
aguja: pero algunos q̄eren 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 d̄l fierro cō la piedra pa q̄ la virtud d̄mō-
stratiua sea engēdrada se ha d̄ hazer dando cō
vn martillo algūos golpes en aq̄lla pte d̄la pie-
dra q̄ se ha d̄ tocar: esa saber en el norte: o en el sur:
y allí le saldrā vn̄as barbas d̄de se ha d̄ refregar
la p̄ta d̄l fierro: como q̄en lo amolase: y q̄dar le
hā apegadas algūas d̄las d̄ichas barbas d̄la pie-
dra: y así tocados y pegados los fierros ha se d̄
tomar vna p̄ta d̄ latō: d̄ figura piramidal q̄ es

baro ancha y arriba haze punta : ésta se haze redonda o ochauada como mejor parece y por lo baxo o ancho se ha de barrenar con vn taldro y el barreno ha de ser de forma piramidal y ha de entrar en la piramide hasta medio o algun poco mas. Este piramide aque los marinos por la mayor parte dizen chapitel ha de tener de alto vn dedo de traues o segun el aguja fuere y ha de encaxar por el centro de la bruxola como la punta salga por la parte alta y alli se ha de pegar y bien fixar: despues se ha de tomar vna cara redonda de madera hecha entor no donde el aguja pueda estar sin tocar en las paredes de la cara y ha de ser tan alta como el semidiametro del aguja: el suelo desta cara ha de estar postizo por que se pueda quitar y tornar a poner para tomar a tocar con 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 derecha hazia arriba: y sobre esta punta ha de andar la rosa o bruxola asentando sobre la punta el agujero del chapitel: y porque no le entre viento por la parte de arriba se ha de cobrir esta cara con vn vidrio: y asi tocada de la piedra y puesta sobre la punta señalara la parte del norte y por consiguiente todos los otros vientos. Es bien notar q despues de tocada el aguja en qualquier destas maneras si allegan la parte del norte de la piedra al norte del aguja el norte del aguja se allegara a ella: y si la allegan ala parte del sur del aguja

Nota.

huyra della y por el contrario si allegan el sur de la piedra al sur del aguja se allegara a ella: y si al norte huyra. Esto se entienda estando la aguja libre como se ha de asentar: y es tambien esta buena señal para conoser q sea el norte y el sur de la piedra. Allende desto ha de poner esta cara en otra sobre dos círculos enaxados vno en otro: q sirvan 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 advertir q la punta de la piramide o chapitel y su agujero y la punta sobre q anda esten derechos y tambien la rosa q no declina a vna ni a otra parte: y si fuere mas ligera de lo que es menester hagan la punta sobre que anda algo mas bota:



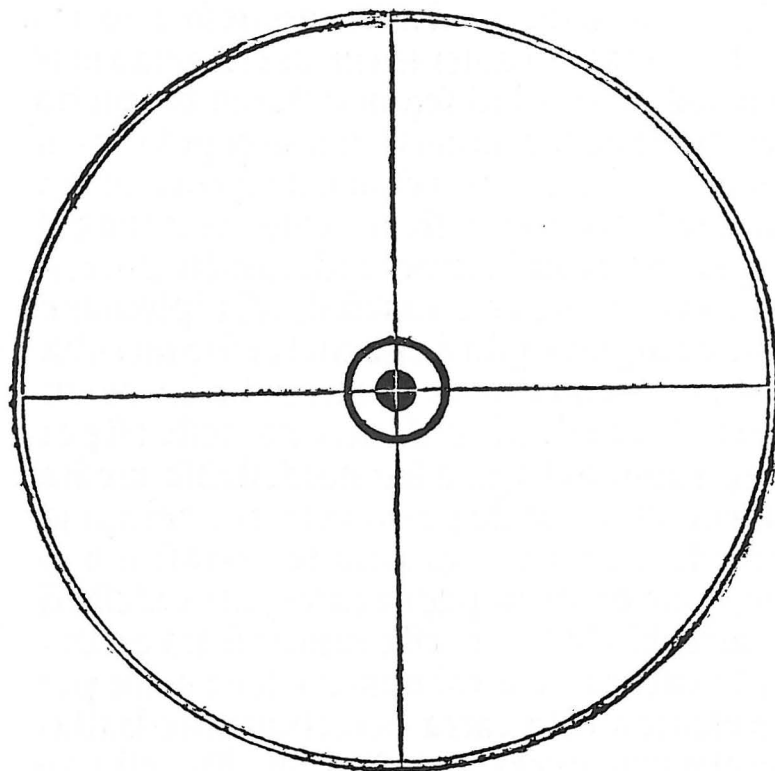
Capítulo . v . de vn effecto que tiene el aguja que es nordestear y noruestear.

Muchas y diuersas son las opiniones que he oydo y en algunos modernos escriptores leído a cerca del nordestear y noruestear de las agujas - y así parecer ninguno da en el fiel y pocos en el blanco. Dizen nordestear quando el aguja enseña del norte hazia el nordeste. Y noruestear quando del norte declina hazia el norueste. Para entendimiento destas diferencias que las agujas diffieren del polo - hase de imaginar (estando en el meridiano donde las agujas señalan el polo) un punto baxo del polo del mundo - y este punto este fuera de todos los cielos contenidos baxo del primer mobile. El qual punto o parte del cielo tiene una virtud attractiua que atrahe así el fierro tocado con la parte de la piedra y más correspondiente a aquella cierta parte del cielo imaginada fuera de todos los cielos mouidos del primer mobile: por que si en qualquier de los cielos mouidos se imaginase mouerse ya el punto attractiuo al mouimiento del primer mobile - y por consiguiente el aguja haria el mesmo mouimiento en veinte y quatro horas: no se vee así: luego este punto no esta en los cielos mouibles - ni tan poco esta en el polo - por que si en el estuuiesse - el aguja no nordestearia ni noruestearia: luego la causa del nordestear y noruestear - o apartarse del polo del mundo es - que estando en el dicho meridiano - el punto attractiuo y el polo estan en aquel mismo meridi

ano - y señalando el aguja el punto - señala derecha mente el polo: y caminando de aquel mismo meridiano al leuante (como el mundo sea redondo) va se quedando el polo del mundo a la mano izquierda: y el punto de la virtud attractiua nos estara a la mano derecha (que es hazia el vieto nordeste) y quanto mas al leuante caminaremos mayor nos parecera la distancia hasta llegar a nouenta grados y allí sera lo que mas nordesteara: y pasando de allí mas adelante - nos parecera que se va allegando el punto attractiuo a la linea meridiana: y al tanto yra el aguja emendando el nordestear hasta tornar al mismo meridiano - en la parte opposita de lo començaron: y entonces les estara el punto attractiuo sobre el polo del mundo - y señalara el aguja derechamente por el: y pasando de allí adelante quedara el polo del mundo a la mano derecha - y el punto attractiuo a la mano izquierda: y así començara el aguja a noruestear - accrecientandolo hasta llegar de allí a los nouenta grados: y allí sera lo mas que noruesteara. Porque tomando hazia el meridiano del punto attractiuo - se yra emendando hasta tornar al mesmo meridiano donde partio - y allí señalara el aguja el polo del mundo derechamente por el punto attractiuo: que perpendicular esta baxo del polo. E si de allí tornasen a caminar hazia el occidente - quedaria el polo a la mano derecha - y el punto attractiuo a la mano izquierda: y así noruestearia

el aguja. Esta es la causa del nordestear y noruestear de las agujas. No se ha de entender que este nordestear y noruestear sea uniforme segun lo que se aparta del meridiano do el aguja enseña bien: antes a los 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 círculos intersecantes en la sphaera. Así que son las diferencias como las de las declinaciones del sol / q̄ cerca de los equinoccios son grandes / y cerca de los solisticios pequeñas: todo lo qual euidentemente parescera en la figura siguiente: que es vn círculo al qual diuidē dos diámetros en quatro partes yguales cortandose por el centro en angulos rectos: y del punto centro (q̄ polo sedize) sale vn meridiano mouible y en el anda vna aguja también mouible cercando el círculo. Esta el punto attractiuo algo apartado del polo del mudo / y del sale vn hilo el qual siempre ha de pasar por el norte sur del aguja: y estando el aguja en el meridiano del punto attractiuo que pasa por el polo / señalara el polo: y fuera del nordesteara / o noruesteara apartando se del meridiano vero que sale del polo del mundo. Es opinion de algunos marineros que el meridiano (do enseñan las agujas el polo) pasa por la ysla de santa maria / y otros por la ysla del cueruo en los açores.

De monstracion del nordestear.

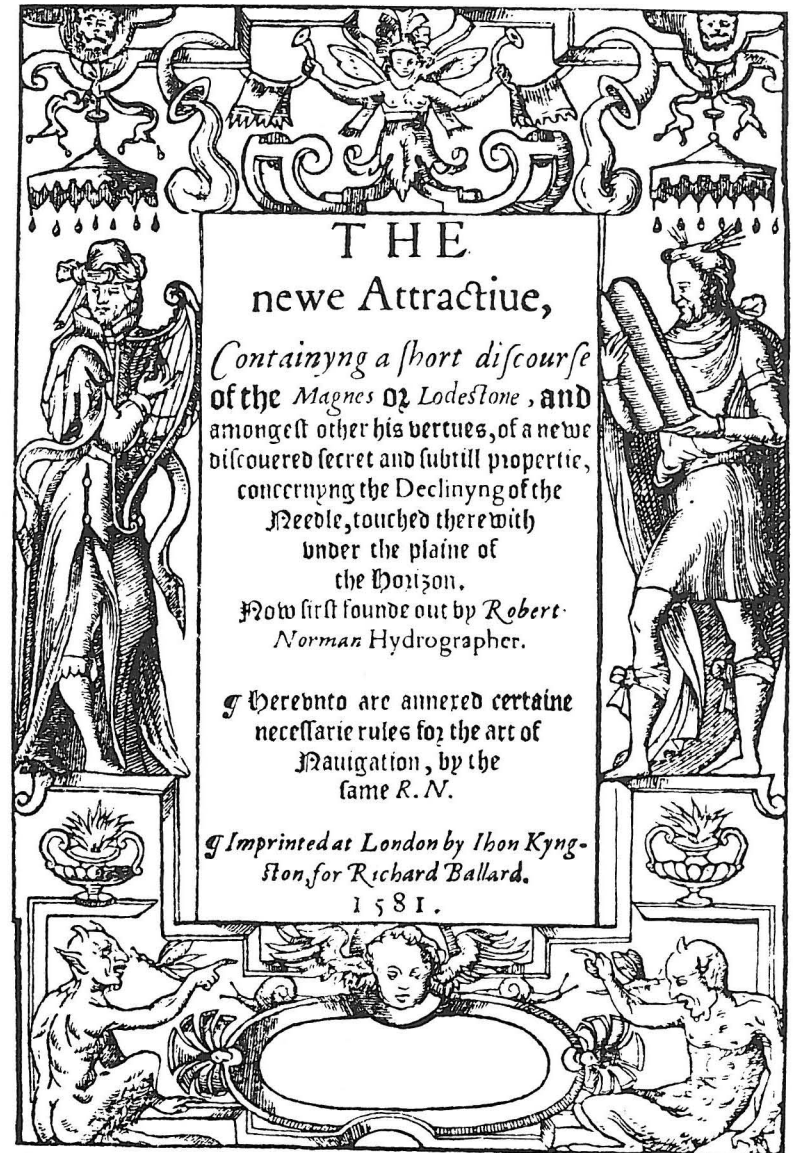


Pues el inconueniente es notorio digo q̄re medie cōtiēpo la prudēcia / y no se de scuyd en el viaje vsando siempre de la experiēcia q̄ les traera mas puecho que las subtiles y limadas questiones destes secretos naturales. Desta manera el sabio piloto ha de saber por experiēcia lo que la buena aguja (sin defecto de

Ji

los que algunas suelen tener) nordestea o no-
ruestea de vn puerto a otro. Así que sepa de
tal lugar a tal lugar el aguja nordestea / o no-
ruestea vn tãto (si quier sea media quarta mas
o menos quantidad segun distaren del dicho
meridiano do las agujas señalan el polo) y en
la nauegacion dara el resguardo q̄ en el tal vía
je nordesteare o noruesteare en los vientos del
aguja: y sera caminar verdaderamente por los
vientos q̄ la carta cierta señala. Exemplo: naue-
gãdo de alguna ysla q̄ este en el dicho meridia-
no / o de otra qualquier parte: en busca de vn
puerto q̄ les este al verdadero nordeste: si por
aquei camino el aguja les nordesteare media
quarta: nauegando por los vientos del aguja
nordeste media quarta al norte: seria su naue-
gar (saluo otros impedimentos) al nordeste q̄
la carta señala: y por este rumbo se ha de ha-
zer 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 nauegaciõ-
para lo qual es cosa conueniente que los sa-
bios y experimentados pilotos hiziesen no-
tas de los resguardos del nordestear: y norues-
tear que ay de puerto a puerto: y hecha copia
laciõ destas notas llevarla por regimiento en
los nauios: y no curen de emendar las agujas
apuntando los 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 en las cartas dos graduaciones /
espe

especialmente q̄ para saber lo que en cada luy-
gar el aguja se apta del verdadero meridiano /
se puede facilmente hazer instrumẽto q̄ lo seña-
le ò dia por el sol y de noche por las estrellas.



THE
newe Attractiue,

*Containyng a short discourse
of the Magnes or Lodesstone, and
amongest other his vertues, of a newe
discouered secret and subtill propertie,
concernyng the Declinyng of the
Needle, touched there with
under the plaine of
the Horizon.
Now first founde out by Robert
Norman Hydrographer.*

*¶ Herebnto are annexed certayne
necessarie rules for the art of
Navigation, by the
same R. N.*

*¶ Imprinted at London by Iohn Kyng-
ston, for Richard Ballard.
1581.*

The New Attractive.

CHAP. 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 Goodness, 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 massive 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 Compass 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 Ferraro*, from whence our Mariners daily bring of them, and are called there, *Calamita Preta*, that is to say, *the Black Magnes*; 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 sold; and oftentimes to *Valentia*, *Alicante*, and *Lisbone*.

All these Stones are different 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 fundry 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 contrari-

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 impress, and rest quietly in his massive and solid Body; which when it hath received by touching the Stone, it is indued with the very same Property and Operations in all respects (though not in so great Force) as the Stone it self.

The vitall and natural Spirit and Operation of the Loadstone.

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 likewise, 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, saith, 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 miraculous Matter.

Others have written, that in those Parts, where the *Magnes* groweth in the Sea, it is of such 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 writtten by those 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 those 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 distributive, 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 Nails 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 Nail) 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 Success. Nevertheless, by Experience in all things, wherein consisteth 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 Nail, and touch the Head of it with the *North* Parte of the *Magnes* or *Loadstone*; then take the same Nail, and beat it with a Piece of Wood lightly into some Post 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 Nail.) This done, take another like Nail, 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 Nail, 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 stone nothing diminished of his force. But it is necessary in proofe of this matter, that ye have a very good stone.

ons to
one by
ther by
ue of this
s.
Furthermore, concerning the other properties of this stone, if you put it in a dry dish and sette it to swimme in a tub of Water, it will turne the dish about, and the North parts of the stone, after many swarings too and fro, will rest, and directly shew the line of *Variation*, or imagined *Attractive* point.

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

And further ye shall note as a speciall point, that the North point of *A spec* 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 stone that answereth to the north of the needle, is properly the South part of the Stone.

CHAP. II.

Of the diuers opinions of those that have written of the Attractive point, and where they have 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 reason's 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 have all shot wide, and none touched the marke. The marke I meane here, is the point *Attractive*, or rather, as shall be said hereafter more at large, the point *Respective*.

This point aunciently called the *Attractive* point hath bene by some imagined to be in the moving spheres 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 being 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 erroneous 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 sixt Chapter.

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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 should not the Compasse or Needle shew the same effect in moouing 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 *Attractive* point, but he doth not allowe of the variation of the compasse or needle, but saith, 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 chiefeft cause why they have gone so farre wide from the *Attractive* 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.

CHAP. III.

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

HAuing 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: infomuch that to the Flie of the Compasse, which before was made equall, I was still

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constrained to put some small peece of waxe in the South part thereof, to counterpoise 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 fixe inches long, which needle after I had pollished, cut off at Just length, and made it to stand leuell upon the pinne, so that nothing rested but onely the touching of it with the stone: when I had touched the same, presently the north part thereof *Declined* downe in such fort, that beeing constryained to cut away some of that part, to make it equall againe, in the end I cut it too short, and so spoyled the needle wherein I had taken so 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 advised 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.

CHAP. IV.

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

TAKE a small Needle of Steele wier, of five or fixe inches long, the smaller and the finer mettall the better, and in the middle thereof (croffe the same) by the best meanes you can, fixe as it were a small Axeltree of yron or brasse, of an inch long, or thereabout, and make the ends thereof very sharpe, whereupon the Needle may hang leuell, and play at his pleasure.

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 same instrument to bee placed upon a foot of convenient height, with a plumme line to sette it perpendicular.

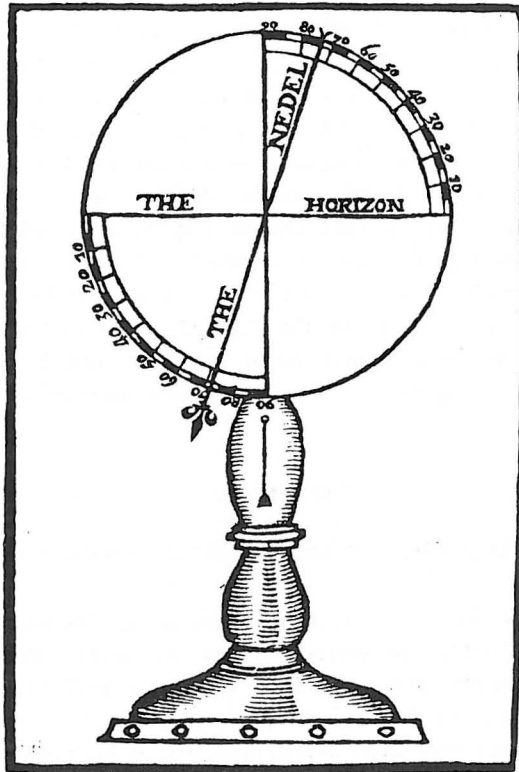
Then in the Center of the same Instrument, place a peece of Glasse hollowed, and against the same Center upon some place of Brasse that may be fixed upon the foot of the Instrument, fit another peece of Glasse, in such

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forte that the sharpe endes of the Axeltree beeing borne in these two Glaffes, 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 leuell with the Horizon, or beeing turned, may stand and remaine



at any place that it shall be sette: which being done, touch the faide Needle with the *Magnes* stone, 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 obfervation 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.

CHAP. V.

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

BEcaufe the opinions of men are divers, and the arguments of many againft reason, peradventure there are some will say, that I am deceived even in the ground and chieft point of this my purpose, alledging (as some have already done without reason) that this *Declining* of the needle is caufed by some pondrous substance that it received from the Stone, and not (as I take it) proceede of the fimple vertue and fecret influence thereof, becaufe the stone it felfe wherein the vertue remaineth and is nourifhed, is weightie.

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

Take three or foure fmall peeces of yron or Steele wyer, and putting them in a fine gold Ballance, counterpoife them juftlie with Leade: Then take them out and touch them well with the stone, that they may receive the vertue thereof: And after weigh them againe in the fame ballance, with the fame leade, and you fhall finde them to weigh no more then before they were touched, though every one of them have received vertue fufficient 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 fhould not the South point of the needle, being touched with the contrary end of the Stone, have the fame declining Southwardes, beeing all one Stone, and one vertue? Or why doth not this fuppofed heavier end, fall perpendicular to the Center, as by reason it fhould, and not covet a certaine fcituation befide it, ballancing it felfe up and downe, till it have found the fame? These arguments may answer this matter. For touch the Needle with what part of the Stone you lifte, that end of the Needle that fheweth the North will alwaies decline.

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CHAP. 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 consisteth 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. Perchance 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 proved. But because there is a certayne point that the Needle alwayes respecteth or sheweth, being voide and without any *Attractive* propertie: in my judgment this poynt ought rather to bee called the point *Respective*.

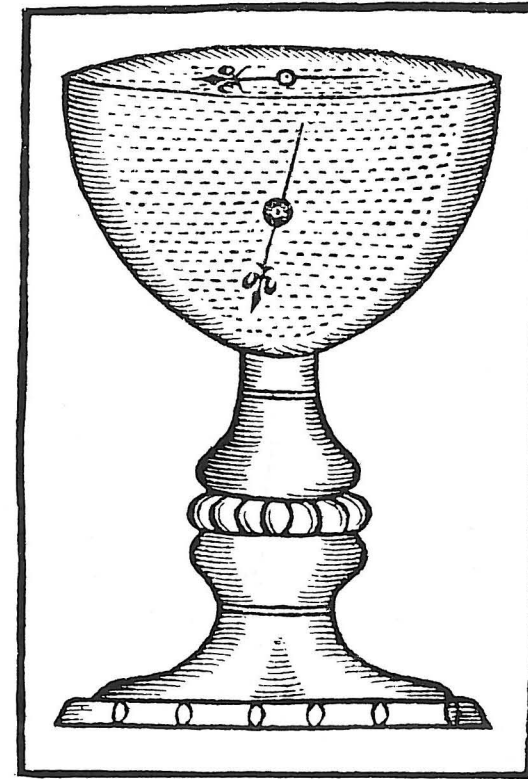
And further if it may be proved, that there is no *Attractive* or drawing propertie in that poynt, the power and action in that poynt condemned, then of necessity the power and propertie, without any external cause, remayneth onley in the Stone and after in the needle, being touched with it, having the 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 sufficiently beare the wyer on the water, so as the same Corke rest in the middle of the wyer.

Then you shall take a deepe Glaffe, 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 circumspactly by little and little, untill the wyer with the Corke be so fitted, that it may remaine under the superficies

of the water two or three inches, both ends of the wyer lying leuell with the superficies of the water, without ascending or descending, like to the beame of a payre of ballance being 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 presently turne it selfe upon his owne Center, shewing the aforefay'd *Declining* propertie, without descending to the bottome, as by reason it should, if there were any *Attraction* downewards, the lower part of the water being neerer that point, then the superficies thereof.

And as this may proove no *Attraction* or drawing downewards in like manner the Corke being so made, that it may sinke 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 list, you shall finde that it will not be drawne from his place, neyther to the one side, nor the other, whereas if there were any such *Attractive* point as have beene imagined, either in the earth by vertue of huge Rockes of the *Magnes* Stone neere the Pole, or otherwise in the heaven, or wherefoever, 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 necessity be drawne in time to some side.

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 be in the *Stone*, and in the needle, by the vertue received of the *Stone*, which vertue must be imagined to be turned, borne, and depending upon his owne Center, as shall be shewed in the next Chapter.

CHAP. VII.

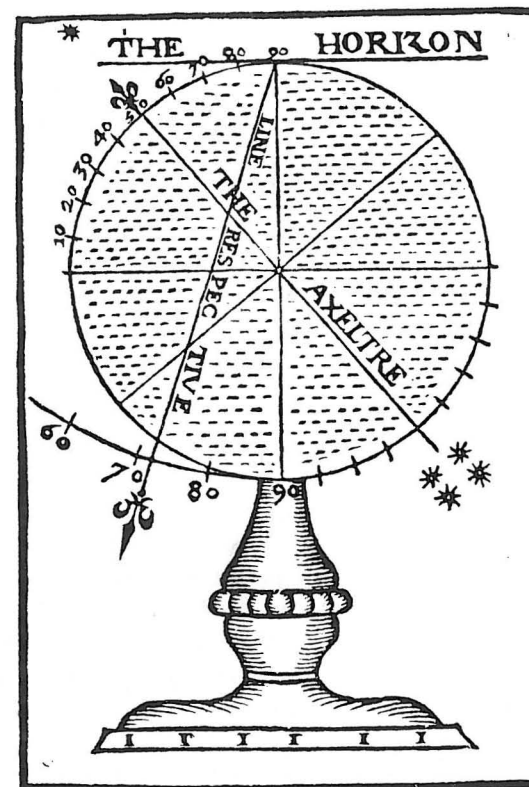
Of the Poynt Respective, where it may be by greatest reason imagined.

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 be 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 forth,

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 assigned.

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



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

And altho' the Needle of the Compasse, by reason of the weight of the heave flie, cannot *Decline*, as his propertie is, but falselie 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 observation 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 free lie in the stone, to shewe this point Respective: and in the Needle, by vertue and power received of the Stone: and not forced or constrained by any Attraction in heaven or earth.

IT is most manifest in all the works of Nature, or Creatures that God hath made, that whatsoever Qualitie, Propertie, or Vertue is found in them, by Creation, that is to bee holden for their 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 subject, whereunto they appertaine not: I say that man offendeth God much, for not beleiving his Power to be sufficient in his Creatures.

I will not offer to dispute with the *Logicians*, in so many pointes as heere they might seeme to over-reach mee in Naturall causes. But that this stone hath wholly 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 whatsoever, it is already sufficiently proved.

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 proved, 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 answer 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 second 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 *Esdras*, and wish them to read over his fourth booke: and there they shall see how hee was answered at Gods handes by his Angel, for his curious Questions asked and demanded.

Nowe therefore, as I have before declared, that diuers haue whetted their wits, yea, and dulled them, as I have mine, and yet in the end have bene 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 invifible Vertue, piercing all thinges, and stayed by nothing, be it Wall, Boorde, Glasse, or any thing whatsoever.

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

Stone in the middle thereof: Whose center is the center of his aforefaid Vertue. And this I have partly proved, and made Visible to be seene 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.

CHAP. 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 apparant 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 sayde 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 sixt Chapter, even by the same proportion, that it sheweth in the needle Horizontally.

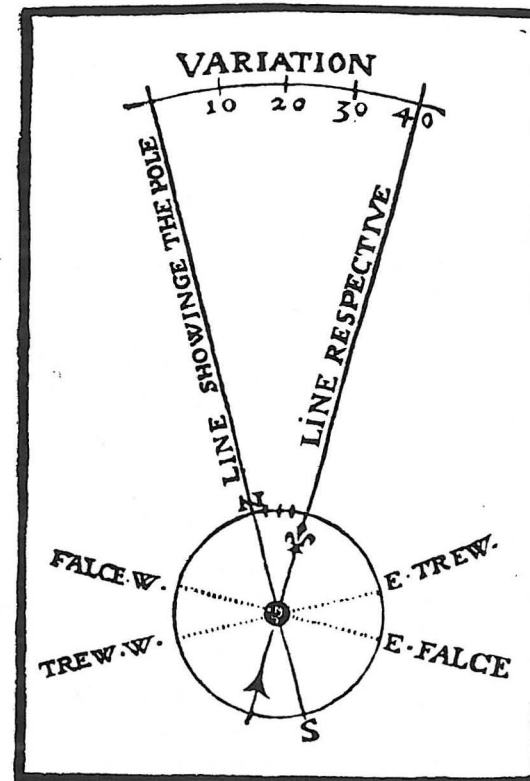
This *Variation* is no other thing, then a certaine parte or portion of a Circle, contained betwixt two straight lines proceeding both from one Center, which may be imagined to be the Center of the Needle, and from thence both extending and going directly forth: One to the Pole or Axeltree of the world,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

This *Variation* is adjudged by divers Travellers to be by equal proportion, but herein they are much deceived: 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 moste false and erroneous Rule. For there is neither proportion nor Uniformity in it, but in some places swift and sudden, and in some places slowe.

It is saide 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 also. But this is not found to be so.

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

Pole Artick, to *Meta Incognita*, it varieth more in parte of the laft of the way, then in
and point
Respective,
by vertue of
the Stone,
paffeth be-
twene Sillie
and New-
foundland.
3 parts of the firft, and in thofe partes it is found to be fuddaine. Further it
is found betweene the *North Cape* and *Vaigatz* very ftrange, in recoyling and
comming backe againe to the Westwardes of the Pole, before it hath fully
accomplifhed two poyntes of Variation in the compaffe. So that at *Vaigatz*
it varyeth to the Westwards, as it doth at *Newfoundland*. And this comming
backe againe, before it hath accomplifhed foure poynts of the Compaffe, is very
ftrange, and againft the opinions of all that have before written.

Pedro de Medina (as I have faid in the fecond Chapter) was doubtfull of
the Variation, faying: that if the Compaffe 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 thefe dayes.

For in 18 or 20 years that I haue trauelled the Seas, being daylie conuerfant
with many of them, and diligent in Enquiring of Variation of the places, where
I have not been my felfe, I could never finde two of them in one truth, except
for the Trauailes from hence Northwards and North Eaftwardes. But I fuppofe
the greateft Occafion thereof is by lacke of exacte Infruments for that purpofe.
Wherefore I have deviſed one very neceffarie.

And further, becaufe this Variation is divers, and is found fometimes to
the Eaftwards, and fometimes to the Westwards of the Pole, I will declare what
the Variation is here in *London*, by mine owne obferuation, and in other places,
as I haue groffely gathered of ſome Travellers, reckoning, or beginning at the
ancient bound or great *Meridian*, that paffeth by the Ifle of *Saint Michaell* in
the *Açorres*: where it is faide, that the Needle fheweth directly the Pole, and
the *Respective* point both in one line. But this is not found to be fo.

True it is, that the North poynt of the common Compaffe, fheweth the
Pole very neere in that *Meridian*, but the bare Needle fheweth about 4 Degr.
50 Min. to the Eaftwards of the Pole. So that you muſt underſtand alwayes
the difference betweene the common Compaffe and the Needle, to be at the
leaſt 1 third part of a point, and of ſome more: becaufe the greateſt parte of
the common Sayling Compaffes, hath the Needle fet in the Flye, half a poynt,
or 2 third parts, to the Eaftwards of the North, and ſome 3 quarters of a poynt,
and others at a whole poynt; and ſome againe, are fet directly under the
Flower-de-Luce, or North of the Compaffe: thoſe are called *Meridional-compaffes*,
becaufe they fhewe 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 twently 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 Compaffes.
by which they haue made their Obferuations. 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 affigned, it remaineth alwayes
one, ſtill permanent and abyding. And therefore I wiſh the Marrayner to make
diligent obferuation of this Variation in diuers places, as he ſhall Travell, by
ſome exact Infrument for the purpofe. For it may be greatly for his aide,
againſt he come there another time, eſpecially in ſuch places where the Variation
is fwifte, as in theſe North parts. And becaufe the common Compaffe is partaker
of this Variation and Declining, as the Needle is, I will ſomewhat fhew of the
fundry forts and makings of them, with the inconueniences that may grow by
them, and by yll plats, made by theſe diuers fortes of Compaffes.

CHAP. X.

*Of the common Compaffes, and of the divers different fortes and makings of
them, with the inconveniences that may growe by them, and the Plats made
by them.*

OF theſe common Sayling Compaffes, I finde heere (in *Europa*) five fundry
fortes or ſets. The firſt is of *Levant*, made in *Scicile*, *Genoia*, and *Venice*:
And theſe are all (for the moſt parte) made Meridionally, with the Wyers
directlye ſette under the South, and North of the Compaffe: And therefore,
duely fhewing the poynt *Respective*, in all places, as the bare Needle. And by
this Compaffe 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 Eaftwards
of the North of the compaffe, and alſo ſome at a whole point: and by theſe
Compaffes they make both the Plats and Rutters for the Sound.

Thirdly, there hath beene made in this Countrey particularly, for Saint *Nicholas* and *Ruscia*, Compaffes fet at 3 feconds of a point, and the first Plats of that Difcoverie were made by this Compaffe.

Fourthly the Compaffe made at *Sevill*, *Lisbone*, *Rochell*, *Bourdeaux*, *Roan*, and heere in *England*, are moſte commonly fet at halfe a point: And by this Compaffe are the Plats of the Eaſt and Weſt *Indies* made for their Pylotes, and alfo 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 fortes of theſe Compaffes different eache from other, as before I have declared. And the Mayſter or Maryner Sayling by theſe Compaffes of fundry forts, may thereby fall into great perill, and the reaſon is, becauſe that of long time theſe Compaffes haue been uſed, and by them the Marine Plats haue bene deſcribed of fundry fortes, every one according to the Compaffe of that Countrey.

If then he take not the Compaffe of the ſame fetts or making that the Plat was made by, then his Carde or Plat will fhewe him one Courſe, and the Compaffe when he thinketh he goeth well, will carry him another way. And thus, when he thinketh to fall with the Place that his Carde fheweth him, he ſhall be as farre wide, as the Compafs 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 Compaffe of one pariſh, and a Plat of another: I meane that they have a reſpect, as near as they may, to Sayle by a Compaffe of that countrey, where his Plat was made.

Yet many there are that uſe our Compaffe 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 Compaffe, if he ſee it; I ſay the Compaffe may be good, and yet not good for him, except his Plat be agreeable: As for Example: A *Levant* Compaffe is a good Compaffe, to uſe with a *Levant* Plat, but it differeth from our Compaffe halfe a point

more Eaſterly. And others there are of *Danske*, that differ from ours 1 halfe point more Weſterly, and yet being uſed in their kinde, are good Compaffes.

And therefore I conclude, that generally the beſt Compaffe is this forte fet at one halfe point, becauſe the major parte of Compaffes 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 Compaffe hath ſeemed to looſe his Force, and to waxe weak and Dull. I judge the cauſe 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 reſreſhed therewith. And againe, the Pinne that beareth the Flye, may be ſo dilled 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 Wrying-Tables, untill you may ſee the toppe thereof: and then the Compaffe will be better for a high-Sea. And thus by ſharpening and dulling of the Pinne you may make your Compaffe 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
Attractive of R. N.

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



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



Having of late gentle (Reader) received from the expert Artificer, Robert Normá, his booke entituled: The new Attraſtiue (who of the great good wil & affection he beareth, hath attribued in his dedication, ~~that which I acknowledge not to be due~~) in the which amongſt other diuers vertues & properties of the Magnes of Loadſtõe, he entreateth of the declining of the Needle touched therewith, from the plain of the Horizon, (a matter neuer before found or writte of by any.) For the further behoue & benefite of all traualers and Sea-men, I took occaſiõ to enlarge the ſame with this diſcourſe of the Variation of the Compaſſe , wherein I haue handled the whole variety of that ſubieſt, both practically, and Mathematically, 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 imperfections in Nauigation, and perceiuing that al thoſe that haue as yet gon about to giue rules in that art, haue left this (being a principall point, and euen the ground of all the reſt) vntouched, or at leaſt ſo ſlightly handled the ſame, that little or no benefite could be gather'd thereby: I haue heere ſet downe the ſundry waies to obſerue the ſame at all times & places, that the inconuenience being known, might be cõſidered off, and auoided Wherin, although my chiefeſt intent hath been to pleaſure thoſe that ſhal haue occaſion to put the thing in praſtiſe by their owne trauaile and experience, yet becauſe ſome of the rules are deducted from the

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fountaines

The pface.

fountaines of the Mathematical Sciences, and wrought by the Doctrine of Signes and Triangles, which maye seeme strange in our English tongue, & wherewith 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. Wherefore I wold haue al Sea-mē to vse such diligence in their trauals, that no opportunity be omitted whe, or wher any obseruatiō may be made, either for the variatiō, or latitude 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 eleuations, a plaine Astrolabe exactly made, & a crosse staffe are sufficient. (The Globe wer also a very good & necessary instrument: for besides many pleasant conclusions that may be tried by it, it doth lighten very much the conceits: for vnderstanding diuers importūt points, but it is too troubleſome (or otherwise not fit for euery Marriner) to be caried to the sea. Vnto the which may be added the Topographical instrumēt, for taking of distances, & making descriptions vpon the land. With these instruments, and the sailing compas and Manne plate, (which are alwaies to be vnderstood the principal and most necessarie instrument for Nauigatiō, for by them only any voyage may be made, but without them no Nauigation can be performed,) the whole world may be traualled, discouered, and described. These are sufficient for a perfecte Mariner, and more then these wer superfluous, only the running glasses, leads, lines,

and

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and such like appendances, of other excepted.

But to haue all these instruments, and not to vnderstand the grounds how to vse the, were a great vanity. Therefore I wish al sea-men & traualers, that desire to be cunning in their professiō, first to seek knowledge in Arithmatike, & Geomaty, which are the groundes of all sciences, and certain arts, of the which ther is written in our English tongue, sufficient for an industrious & willing minde to attaine to great perfection: whereby hee may not onely iudge of Instruments, Rules, & precepts giuen by other, but also be able to correct them, & to deuise new of himself. And this not onely in Nauigation, but in al Mechanical Sciences. As by the studious practise and exercise in these Arts, haue attained to rare & singular knowledge: In Architecture Vitruuius the Romain, in painting that famous German 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. Having 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, & shoals in the sea, with the depths, & other necessarie notes obserued in his owne trauals, perticularly & effectually according vnto the truth (which is the chiefest part required in a perfecte 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 themselves, 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 from another, which can neuer be so perfect, as the descriptions that are made vpon the present sight and view of places, albeit he be neuer so skilfull and cunning, it shall so carrie the same by memorie, how much les the by the vnskilfull: by this meāse card makers set down they know not what,

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as maye appeare by the descriptions of their owne coastes, which are verie grossly and vnperfectly done, whereas the marin Plats ought to be descibed by such as can giue reason, & shew obseruation of euery perticularitie contained in the same, as well for the latitude of places, as the lying by the compasse of the Capes, Head-landes, pointes, Ilandes, Baias, Rocks, Sholds, &c. one from an other, and the distancces between them. The errorrs of those descripiōs, 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 errorrs 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 Hydrographical, 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 reducing into one commodious volume, the dyuerse Plats and descriptions, made by diuers & sundry men. But amongst al those that haue made Geographical descriptions, I cānot a little meruel at Gulielmus Postellus, who being a famous learned man, a great traualer and Cosinographer, & 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, the from him so famous a Doctor, hath also in the imagined Countreies about the Norrh Pole, so corrupted it with his fond dreames, & fātales inscriptions, attributing to those

The Preface.

supposed lands, diuers people, as the Georgians & Hyperboreians, and assigning there to bee the highest hilles of the world, and the people dwelling on them, to haue the cōtinuall light of the Sun, Sueta, Zemlia found by the englishmen, An. 1550. the holy Land, the place of the chiefest felicity, the Hiperboreā fields, & therefore the felicity of the Moluccas, with many other ridiculous absurdities: That by the grosse errorrs of this learned man in these matters, I am taught, that whatsoever fame goeth, or opiniō is conceiued of any man for profound learning, and smooth deliuering of their conceits, or whatsoever great promises are by the selues made in these artes, to iudge of thē 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, whereas in al other hetherto made & extant, there are great errorrs. Therefore, such as otherwise cannot from time to time calculate their declinatiōs, according to y^e place of the Sunne to be giuen by the Ephemerides, 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 Lincolne house the 26. of September.

Anno. 1581.

William Borough.

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Of the Variation of the Com- passe or magneticall Needle.

Chapter. 1.



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

The Magneticall Meridian, is to be vnderstood a great
circle passing by the Zenith and the Pole of the Magnes,
deuiding the Horizon into two equall parts crossing the
same at opposite points: which intersections or crossings,
are thewed by the Needles, or Wiers of the Compass, tou-
ched 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 diui-
ding the same into two equall partes, and it is saide to bee
giuen when the distaunce thereof from the true Meridian
is knowne.

The Azimuth of the Sunne vpon equall eleuations
in forenoone or afternoone, haue equall distaunces from
the true Meridian, so that the middle point of the whole
distaunce of any two Azimuths obserued vpon equal ele-
uations in forenoone or afternoone, is the true Merid.

This distaunce of Azimuths, is found vpon the Instru-
ment

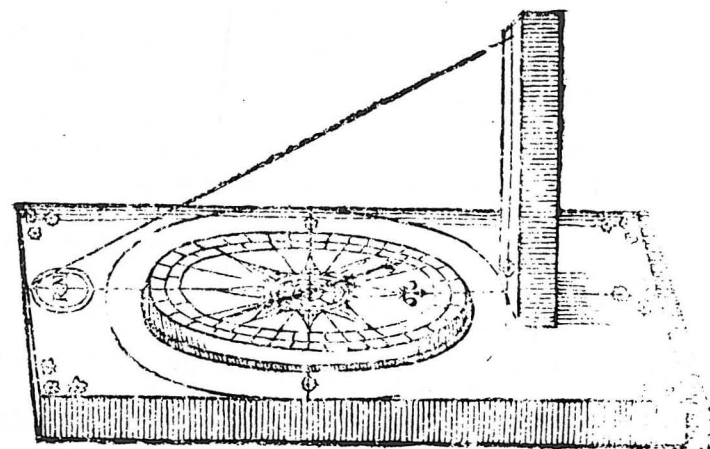
Of the Compass.

ment of Variation, by adding together the Variations of
the suns shadowe, at equal eleuations in the forenoone and
afternoone. The halfe whercof is the distaunce of the A-
zimuths from the true Meridian: 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 Meridian.

Or els subtracting the lesser variation of the Sunnes
shadowe, from the greater (at equall eleuations) the halfe
of the remainder shall bee the true Variation of the Needle
from the Meridian.

But the Azimuth of the Sunne being other wise giuen,
and the Variation of the shadowe likewise giuen, the diffe-
rence betwene them, is the variation of the Needle.

The Variation of the Sunnes shadowe, I call the Ho-
rizontall distaunce betwene 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 vpon some steele, or other thing that is flat, so as it may stand leuell, & the Plummet in the Standard which is placed at the North end of the fixed Flye, 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 parte of the Instrument to the top of the Standard, is the chiefest string to giue the sunnes shadowe which must be so directed by turning the Instrumentes South side to the Sunne wards, that the shadowe of the same maye fall directly longst vpon the lyne of south and North in the fixed Flye, so; if 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 vpright, 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 Flye, may bee so placed that it agree fully with the shadowe of the former lyne, and the lyne of south and North in the fixed Flye, in such sort that both the shadowes may be as it were hidden in the said line of the Flye: which you may do aptly by turning the said hoope, and remoouing the same lyne at either side of it, as you shall see cause.

The Instrument being duly placed in forme aforesaid, it differs nothing from the Compass of Variation, but onely in this point, that whereas the Flye of the compass of Variation, is so turned by vertue of the Magneticall

Of the Compass.

wiers, that the North point thereof dooth shewe the Pole of the Pagnes, or line of Variation. In this Instrument, the North point of the Needle dooth supplie that, which the North point of the compass should doo. And the North point of the Flye 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 Compass in any place, the eleuation of the Pole, and situation of the Meridian vnknowne.



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

Take your Astrolobe, and obserue duely 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 minuts, 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 vpon the line of the south and north in the fixed Flye.

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 vnto y same in the fixed Flye, that is to say, haue many degrees it is from the North of the fixed Flye, 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 Flye is from the North point of the Needle, either Eastwards or Westwards as you shall finde the same. Thus may you obserue diuers times, vpon severall degrees of the Sunnes eleuation

Of the Variation

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 towards the sunne, as it was in the forenoone (soe auoiding 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, soe knowing the true latitude of the place: all which you shall set downe in soyme following.

Example.

In Limehouse the sixteenth of October. Anno. 1580.

Forenoone.			Afternoone.			Variation of the Needle from the Pole or Axes.
Elevation of the Sunne.	Variation of the shadowe from the North of the Needle to the Westwards.		Elevation of the Sunne.	Variation of the shadowe from the North of the Needle to the Eastwards.		
Deg.	Deg.	Min.	Deg.	D.	M.	D. M.
17	52	35	17	30	0	11 17½
18	50	8	18	27	45	11 11½
19	47	30	19	24	30	11 30
20	45	0	20	22	15	11 22½
21	42	15	21	19	30	11 22½
22	38	0	22	15	30	11 15
23	34	40	23	12	0	11 20
24	29	35	24	7	0	11 17
25	22	20	25	From N. to W. 0.8.		11 14

The

Of the Compasse.

The elevation of the Sunne vpon the Meridian. 25.d. 58'. the declination 12.d. 30'. which I adde to the elevation, because the Sunne hath south declination, and therof 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 great variation of a shadowe vpon any degree of the Sunnes elevation, is to be taken the lesser of the same degrees elevation, whether it bee in the forenoone or afternoone (except the same variations bee both one way from the North of the Needle, which then are to be added) the halfe of the remainder, is the variation of the Needle, or Compasse, from the Pole or true Meridian.

In the former obseruations, I do finde the greatest variation in the forenoone, soe at 17.d. elevation, the variation is 52.d. 35'. from North to West: And at the same elevation in the afternoone, 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. 17½'. Soe 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 Needle sheweth. And therefore the Needle or Compasse varieth from the true north, 11.d. 17½'. to the eastwards.

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 soe 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 Needle or compasse by the former obseruations, are set out towards the right hande against euery degrees elevation, and conferring them altogether,

Of the Variation

I doe finde the true variation of the Needle of Compass at Limehouse to be about 11. d. $\frac{1}{2}$ or 11. d.; which is a point of the Compass full of little more. So that in a Compass whose wires are set directly vnder the signe de Luce, the North, and by West, and South and by East pointes doe 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.



In the former declaration, the onely waye to trie the variation, is by comparing of the severall correspondent obseruations of the Sunnes elevation in the forenoone, with those of the afternoone, so that if the Sunne should be obscured, or by any other occasion like obseruation cannot be made in the afternoone, then the former rule giueth not the desired purpose. Therefore I thought good to shew, howe by any one obseruation in the fore or afternoone, 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 thing 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 Globe so stande duely according to the elevation 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 pick in the Ecliptick of the globe. And placing the Quadrant of altitude or moueable verticall, at the verticall point or Zenith, take the elevation of

Of the Compasse.

of the sunne obserued by the Astrolabe or other Instrument at the time proposed, and note it iustly 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 picke you made for the place of the sunne in the Eclipticke, 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 distance of the sunne from the true Meridian of that place, which you shall compare with the variation obserued vpon the Instrument at that instante 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 shall subtract the lesser from the greater, the remainder sheweth the Variation. And if the variation vpon the Instrument be greater then the true distance of the Azimuth from the Meridian found vpon the globe, the same surplus is to be accounted for variation: vpon the contrary 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 afternoone. This precept needeth no further demonstration, then the instrument it selfe, the Globe I meane.

But for example of the worke, I take the first obseruation, in the former Chapter specified, made at Limehouse, the sixteenth of October. 1580. in the forenoone, which is 17. d. elevation & variation 52. d. 35' from North to West.

First I set my Globe at 51. d. 32'. for the elevation of the Pole. Secondly, I take the place of the Sun. 2. d. 55'. m. and note it vpon the Eclipticke. Thirdly, I note vpon the Quadrant of altitude, the elevation 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 picke in the

Of the Variation

the Eclipticke for the place of the Sunne, do agree in the
with the elevation noted upon the quadrant of altitude, &
find the true azimuth thewed by the same quadrant vpon
the Horizon to bee nearest, about $41\frac{1}{2}$ from the Meridian
and conferring the same with the variation found vpon
the Instrument $52\text{ d. }35'$. I finde the difference $11\text{ d. }15'$
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 azi-
muth 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 $11\frac{1}{2}$ from
North to East, or South to West.

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

The fifth Chapter.



The summe of the woork is to finde the
arke of the Horizon betwene the meri-
dian and the azimuth of the sunne at the
time of the obseruation, which being com-
pared with the variation found in the In-
strument, the difference is the Variation
of the Needle. For attaining of the same arke: First it is
necessarie to haue the arke of the Equinoctiall betwene
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 diuide
by the signe of the elevation of the Equinoctiall (or the
complement of the latitude) the quotient is the versed
sine or half of the Semidiurnall arke, which you shall
note

Of the Compasse.

note for the first number.

Then againe multiplye the signe of the sunnes eleva-
tion at the time of the obseruation, by the whole signe, and
the product diuide by the signe of the elevation of the E-
quinoctial, the quotient subtract from the number you first
noted, the rest is the versed signe of the arke of the distance
betwene the sunne and the Meridian in the paralell
that it is in for the time proposed, in such partes as the se-
midiameter 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 semidiameter of the paralell is the
whole signe, which you may doe thus: Multiply this re-
mainer by the whole signe, the product diuide by the signe
of the complement of the declination (which is the semy-
diameter 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 sign, which you shall
seeke in the Tables of signes, and thereby finding his arke
you shall subtract the same from the Quadrant or 90 d.
the remainder is the arke of the foresaid paralell of the sun,
which is answerable or correspondent in degrees and mi-
nutes, to the arke of the Equinoctiall that you seeke. The
reason of the precept is this.

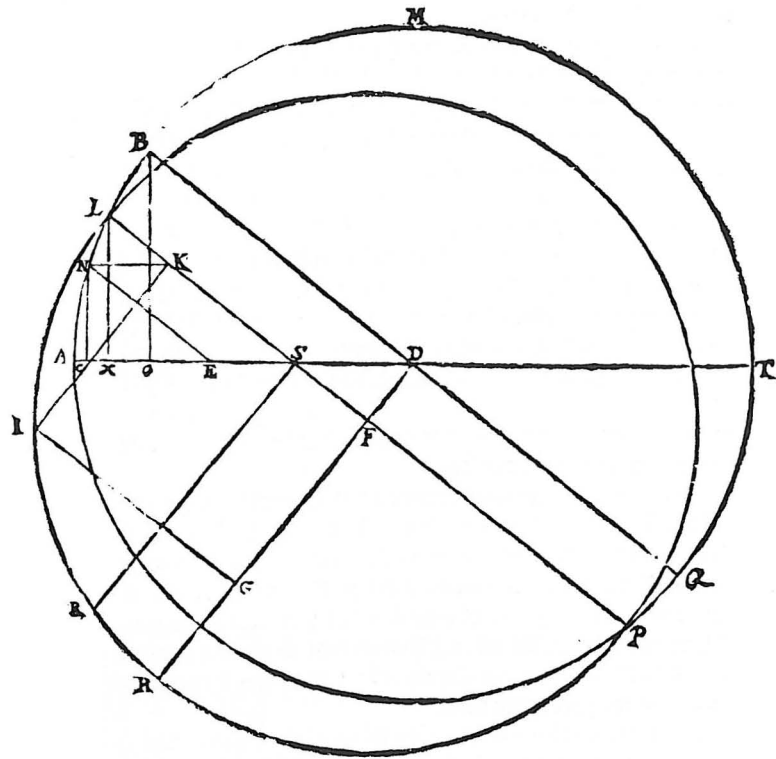
As the right signe of the elevation of the equinoctial, is
in proportion of the right signe of the meridian altitude of
the sunne or any star: so is the whole signe, to the versed
signe of the semidiurnall arke. And againe, as the right sign
of the meridian altitude, is to the right signe of the elevati-
on of the sun or star at the time of the obseruation, so is the
versed signe of the semidiurnall arke of the same, to the ex-
cesse or difference betwene the same versed signe and the
versed signe of the distance from the meridian.

For the better vnderstanding 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 6. of Euclide.

13 2

Let

Of the Variation.



L Et AMT, be 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 paralell of the Sun, which is described vpon the center F at the distance FL, which is the sign of the complement of the declination AB, the arke of the eleuation of the Equinoctiall BO, the first right signe thereof AL, the arke of the meridian altitude LX, the signe thereof, AN, the arke of the Sunnes eleuation

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eleuation 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 thereof SL, the verfed signe of the same. LI, the arke of the Sunnes distance from the Meridian IK, the first right signe thereof, IG, the second right signe which is equal to KF, KL, the verfed signe NE, which is equal to KS, the difference of the two verfed 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 vpon 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.

Rest LK. — 23385.

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

B 3

due

Of the Variation

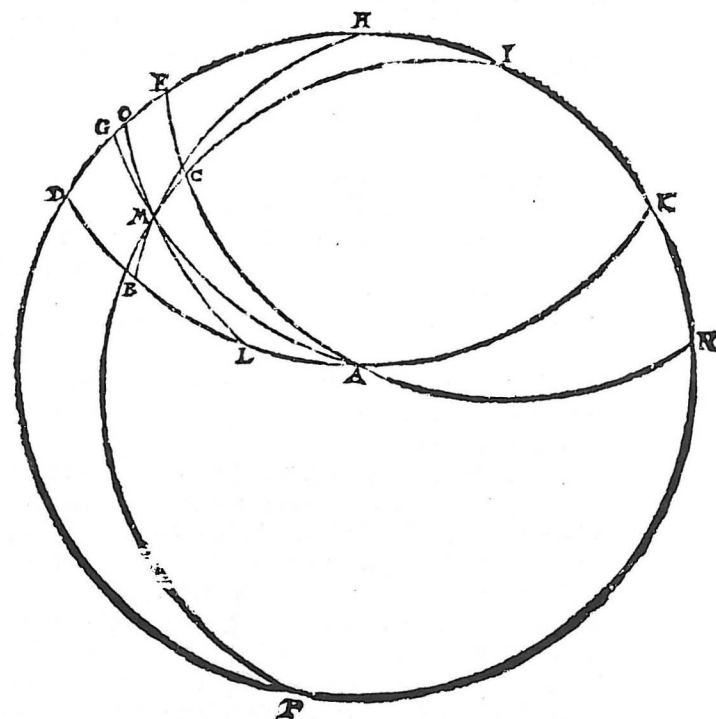
due parts. The same subtracted frō LE. 100000. the whole sine, leaveth KF. or IG. 76048. the second right sine of the same arke, which is the first right sine of the arke IH. which arke you shall finde in the Table of signes to be 49. d. 30'. 24". the complement wherof to the quadrant is 40. d. 29'.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

Nowe having this arke of the Equinoctiall, you must worke as followeth.

Multiplye the sine thereof, by the sine of the complement of the declination, & divide the product by the whole sine, the quotient is the sine of an arke contained betweene the sunne and the Meridian, making right angles with the Meridian. This sine multiplye by the whole sine, the product divide by the sine of the complement of the Sunnes elevation at the time of the obseruation, the quotient shall be the sine of the arke of the Horizon contained betweene the Azimuth of the Sun, and the Meridian, which is the arke that was proposed to be found.

L Et DHNP. bee the Meridian. DAK. the Horizon. LEAN. the Equinoctiall. M. the place of the sunne in the heaven at the time of the obseruation. LMO. the paralell. HMB. the Azimuth or vertical circle passing by the Sunne. AMG. 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 thereof 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 given in the former work. MB. the Elevation of the sunne at the time of the obseruation

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tion. MH. the complement thereof. BD. the Arke of the Horizon intercepted betweene the Azimuth and the Meridian, which is the thing required to be 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. Propositions of his 4. booke of triangles.

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

B 4

given,

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giuen, therefore the fourth shalbe known.

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

The second part of the example.

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

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. eleuation which is 52. d. 35'. I finde it to be lesse, and therefore subtract it, and so haue I the difference 11. d. 3' 38''. And because the obseruation was in the forenoone, and the variation vpon the instrument greater then the arke of the Horizon, 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 promised to be shewed.

But comparing the same arke of the Horizon 41. d. 31' 22'', with the variation found at the correspondit eleuation in the afternoone, which is 30.0'. I subtracte the lesse from the greater, and find the excesse 11. d. 3' 22''. which should be the variation. And because the variation found vpon the Instrument is lesse then the arke of the azimuth vpon the Horizon, I account 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 fore

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forenoone, and that in the afternoone, proceedeth either of the imperfection of the instrument, or negligence of the obseruer. For in the rule there can be no error, being grounded vpon Geometricall demonstration, then which, nothing can be more certaine.

The former precepts and examples do serue when the sunne dooth decline from the Equinotiall either Northwards or southwards. But if the sunne be in the Equinotiall, then the manner of the working is more easie and briefe. For if you multiply the signe of the Sunnes eleuation at the time of obseruation, by the whole signe, and diuide the produce by the signe of the eleuation of the Equinotiall, which is the meridian altitude, the quotient giue the second right signe of the distance of the sun from the meridian, which is the first right signe of the complement of the same arke: and entering 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 eleuation of the sunne at the time of the obseruation, giue the signe of the foresaid arke of distance, what shall the whole signe giue? Multiplie and diuide, the quotient shall be the signe of the arke of the Horizon contained betweene the Azimuth of the Sunne and the Meridian. Which arke being compared with the Variation of the Instrument in manner as before is shewed, giue the variation required.

But the sunne being in the Equinotiall, in the place wher the obseruation is made, be likewise vnder the same circle, then is the variation most easly obserued, for that the Equinotiall is the azimuth of East and West, therfore turning your Instrument onelic to receiue the shadowe of the Sunne, and looking then to the North point of the Needle, if you finde the same to answere 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

Of the Variation

Doe differ from 90. D. the same difference is the variation of the needle.

But admitting the obseruer to be vnder the Equinoctiall, and the sunne to haue Declination, then the proportion of the signe of the complement of the eleuation at the time of the obseruation, vnto the signe of the declination shall be such, as the whole signe, is to the signe of the arke of the Horizon included betweene the Azimuth of East and West, which is the Equinoctiall if so be, 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 Instrument, the difference is the variation.

Diuers other cases might be proposed, and rules giuen for them, which for breuity 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 manner to finde the two beared signes, the one of the Semidiurnall 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 houres and minutes of time, is shewed the iust halfe quantitie of the day. And by the arke of the other likewise reduced, the houre of the day, or the time contained betweene the noonesteed and the instant of the obseruation: as in the same example.

The verbed signe of the Semidiurnall arke, LS is giuen 70386. in such parts as the semidiameter of the equinoctial BD is 100000 therefore I reduce the same into such partes as the semidiameter of the paralll LF. is 100000. and finde it to bee 72095. whiche subtracted from the whole signe LF 100000. there resteth SF 27905. whych 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 Semidiurnall arke LR wherefore subtracting it from the Quadrant LH 90. D. resteth 73. D. 48'.
the

Of the Compasse

The Semidiurnall arke LR the same reduced into partes of time allowing 15. D. for a houre 15'. for a minute, 4 15'' for a seconde of time, and for euery degree 4. minutes of time, for euery minute 4''. and for euery seconde 4''. 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 about written, to be 9. houres 50'. 24''. long.

This example may serue for a general precedent, whiles the equinoctiall is betweene the sunne and the eleuated Pole, but if the sunne bee betweene the eleuated Pole, and the Equinoctiall, then will the verbed signe fall out to bee greater then the whole signe, and the semidiurnall arke to exceede a Quadrant. Wherefore hauing reduced the same into his proportionall partes, as before is shewed: Subtract from it the whole signe, the surplus is the signe of the excess of the Semidiurnall arke aboue a Quadrant, which being added to the Quadrant, giueth the semidiurnall arke.

By the other verbed signe of the distance of the sunne from the Meridian, which is LK. 23952. in such partes as the whole signe or Semidiameter LF is 100000. subtracted from the whole signe, is giuen 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: therefore subtracting the same from 90. D. resteth 40. D. 29'. 36''. the arke of the distance betweene the sunne and the Meridian, which being reduced into partes of time as before, giueth 2. houres 41'. 58''. and the same (because it is in the forenoone) deducted from 12. houres the noonesteed, resteth 9. houres 18'. 2''. the iust instant of the time of the daie.

But if this verbed signe be found to be greater then the whole signe (as it may when the sunne is betweene the Equinoctiall and the eleuated Pole, and before the houre

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or first in the morning, and after the hour of five in the evening) then dooth the arke of distance consequently exceede a Quadrant, the signe of this excess is the surplus of the versed sine above the whole sine. 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 eleuation of the sunne being precisely obserued and latitude knowne) the instant of tyme of the daye is giuen moze exactly, then by any Clocke, Diall, or other Instrument. So if there might be had a portable Clock that would continue true the space of 40. or 50. hures together (if longer tyme the better) then might the difference of longitude of any two places of known Latitudes, which conueniently maye bee trauiled within that tyme, bee also most exactly giuen. And in this sorte trauiiling and obseruing from place to place, might the Longitudes of any Countrie bee perfectly described.

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

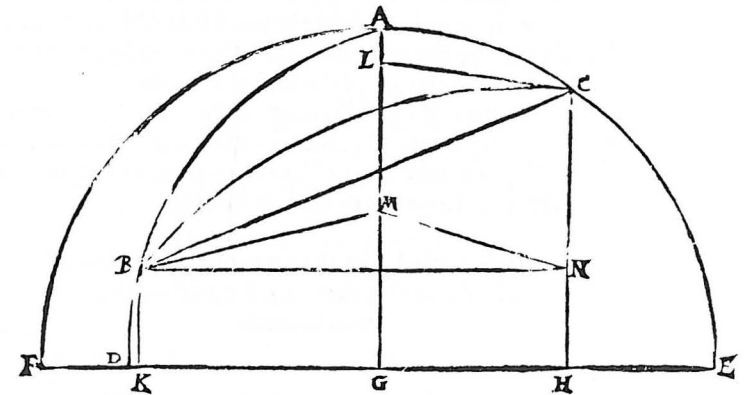
The sixt Chapter.



For the accomplishing of this proposition you are to imagine a sphericall Triangle upon the superficies of the Globe, whose sides must be, first, the portion of arke of the meridian betwene your Zenith and the Pole, which is the complement of the latitude, The second the arke of the verticle circle contained betwene your Zenith & the sun, which is the complement of the suns eleuation at the time of the obseruation.

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The third side is an arke of the circle of declination comprehended betwene the sunne and the eleuated Pole, this arke is found by adding, or subtracting the declination of the sunne, to or from, the Quadrant or 90. d. which must be done with this consideration, 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 add it to the same, so haue you the three sides of the sphericall triangle giuen. When the substance of the worke consisteth in finding the quantitie of the angle of the same triangle at the Zenith, so the complement thereof to the Semicircle or two right Angles, is the Horizontall distance of the Sunnes Azimuth, from the Meridian, which being compared with the variation of the Sunns shadowe vpon the Instrument, giueth 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 obseruation. BD. the eleuation of the Sunne. BA. The complement of the eleuation AC. the complement of the latitude. BC. the arke of the circle of declination, or the

Of the Variation

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 shall be 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 shall be paralell and equall 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 spherick 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 eleuation of the Pole CE . 51 d. 32. the signe thereof CH . 78297. The eleuation 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 eleuation 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 . 62205. equall to MN .

Now

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

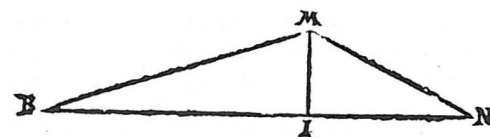
Then out of the chord BC . squared. — 44328512576.

Take the square of NC ————— 2406883600.

Rest the square of BN ————— 21921628976.

The root thereof is 148059. the side BN .

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



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 IB 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.

BM

Of the Variation

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. giue 90376.

Whose arke is 64.d.38'.45". And adding these two arks together, they giue 138.d.28'.23". the ark 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 variatiō 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 thunge 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 seconds, 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 deuisions, and neglecting the proportionall partes of the signes and arkes.

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

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Hypothenuſes were annexed, we should haue an entire Table for the doctrine of triangles, that might worthily be called the table of tables. Which thing though Georgicus Ioachimus Rhericus, haue wel begunne and framed it orderly from ten minutes to ten: yet is it left very rarily, for such as desire the exact truth of things. I haue therefore for mine own ease and vse, calculated the complement of this Table, and almost ended, if for the whole quadrant from minute to minute: which if in the meane time before I haue finished, I shall not finde it extant by any other, I will publish it for the commoditie of all such as shall haue occasion to vse the same for Navigation and Cosmographie.

To find the eleuation of the pole, situation 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.



Whereas in the three laste Chapters, the groundes of the calculations consist in the Eleuation of the Pole to bee giuen, which thung to know is no lesse difficult, then the chiefe matter that is by them required: for the common preceptes, which as yet haue chiefly been giuen for the finding thereof, depend only vpon the obseruation of the Meridian altitude of the Sunne or Starres, or else vpon certaine false and greasse rules of the guards and pole starre. Therefore 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

Of the Variation.

finde the elevation of the Pole, situation of the Meridian, and the variation of the Needle in any place by the Globe.

But this you must alwaies regard, that your two observations may have convenient distance of time between them, the greater the better: So as the higher elevation be not taken neere the Meridian, the lower elevation, the neerer it is taken to the Azimuth of East or West, or to the Horizon the better, with which elevations you are to note the differences of the Sunnes Azimuths or Variations founde by the shadowe vpon the Instrument exactly, for without that the elevations onelie 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 Semi-circles. And also that the Quadrant of altitude (or moouable verticall) be placed dutie vpon the Meridian circle at the Zenith, so as being turned circularlie, it may touch the Horizon equallie in euery part. These things being dutie considered, there needeth not any further regard to be had for placing of the Globe, onelie this you may respect in setting the Pole at adventures about the Horizon, betwixt 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 force it not from one side 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 observations 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 20.0. from the Meridian

Of the Compasse.

bian circle (but the neerer you set the same to the meridian, the more conveniently, without impeachment will your triall be made.) Then giue a prick 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 shall be neere the same) so many degrees as you finde the difference of azimuths betwixt the two elevations by the shadowe of the same, vpon the Instrument of Variation, and laying 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 113.0. of the Equinoctiall of your Globe, (which is a Quadrant, and the greatest declination of the Sun) then you must consider which of the Poles of the world is elevated above your Horizon, and whether your declination be towards, or from that Pole, that is to say, whether the Sun be betwixt the elevated Pole, and the Equinoctiall, or the Equinoctiall betwixt the sunne & the Pole. If the sun be betwixt the Pole and the Equinoctiall, then are you to subtract the declination from 90.0. If the Equinoctiall be betwixt the sun and the Pole, you must adde the declination to 90.0. And take the same remaining or collected number of degrees &c. with your compasses vpon the Equinoctiall. And set the one end of your compass at the prick made vpon your Globe, for the highest observation, and with the other end describe an arke or peece of a circle, vpon the same side of the meridian that your prick is on, from the meridian to the Horizon. Then againe with your compass vnaltered, setting the one foot in the prick for the lowest observation, describe an other peece of a like circle crossing the former: the point of the intersection, or crossing of these 2. circles, is the elevated pole, to the

Of the Variation

Which if you remove the Quadrant of altitude, you shall find what the elevation thereof is. And the point that the same Quadrant sheweth upon the Horizon, is the intersection of the Meridian and the Horizon, the Horizontall distance betwene this intersection, and the azimuth of the lesser observation, subtracted from the Semi circle, or 180. d. leaveth the Horizontall distance of the same azimuth from the true meridian. So have you the elevation of the Pole, and situation of the meridian.

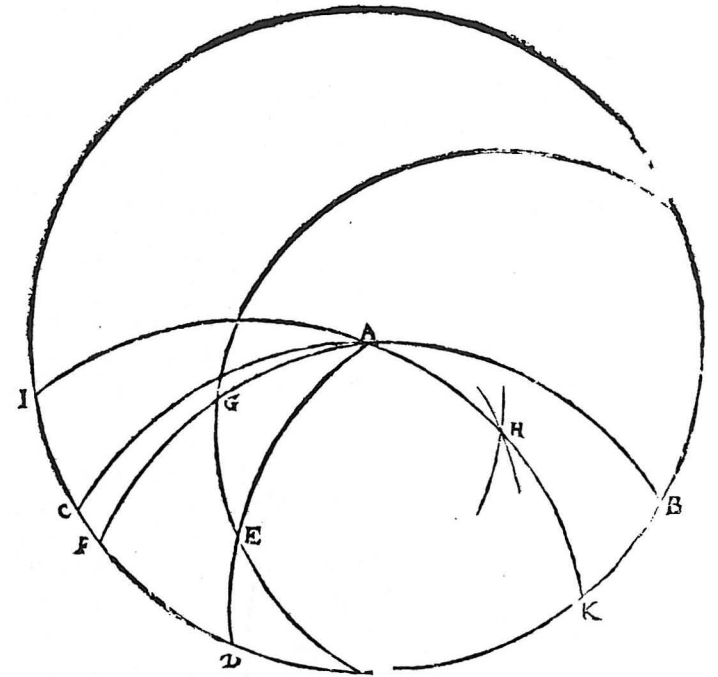
Nowe if you compare the Horizontall distance of the azimuth of the Sunne, from the Meridian at the time of the observation, with the variation by the sunnes shadowe founde vpon the Instrument, at the time of the same observation, and taking the one out of the other, the remainder shall be the true variation, which you are to account, as in the latter ende of the thirde Chapter is shewed. So have you given the elevation of the Pole, the Meridian, and variation of the Needle, the things proposed to be shewed.

EXAMPLE OF TWO OBSERVATIONS made at Limehouse, the 29. of Iulie 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 doone, set one foot of the Compass transferr'd in E. the lesser elevation, and with the other end describe a piece of a circle crossing the former arke at H. this intersection

Of the Variation.

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 eleuation of the Pole KH , 11° there about. And the true Meridian KAI . And from K to D the Horizontall distance 90° , which subtracted from KI , 180° , the semicircle of the Horizon, resteth the arke DI , 89° , the distance of the Azimuth of the first obseruation from the Meridian I . which distance compared with the variation founde vpon the Instrument at the first eleuation 100° , $30'$, and deducted from the same resteth 11° . Therefore I say, the true Meridian shewing the Pole alike is 11° to the Westwardes of the Magneticall Meridian shewed by the Needle, and consequently the Variation of the Needle 11° from the North to the East.

In this example the declination is subtracted from the Quadrant, because the sunne is betwene the Equinotiall and the elevated pole, but if the Equinotiall were betwene the elevated Pole and the Sunne, then should you adde the declination to the Quadrant, and with that distance taken vpon the Equinotiall with your compasses, proceed as in the former example.

These examples that I haue shewed, and such like experimentes to be doone vpon the Globe, are easie to be conceiued, and the reasons verie manifest: but the truth 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 vpon two obseruations of the Sunnes eleuation in fozenone or afternoone, and difference of the Azimuthes, to calculate the Zenithes more exacte by the Table of Signes and doctrine of sphericall Triangles: but that it is a tedious waie, and my meaning is rather to geue the Reader a proofe of the pleasaunt vse of these calculations (which

Of the Compass.

(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 grounds and summe of the worke, which is this.

The Complements of your two eleuations, 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 vpon the instrument. Therefore by the 28. of the 4. of Regiomontanus the third side (which is the arke comprehended betwene the two eleuations) and the other angles may be giuen.

Then haue you another like triangle, whose three sides are these: the first, one of the foresaid complements of eleuation: the second, the arke of the circle of declination, betwene the Sun at the instant of the same eleuation, 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 eleuation 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 subtracted 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 eleuation of the Pole.

And the eleuation of the Pole, and declination of the

Of the Variation

sun being giuen, the fourth Chapter sheweth by one obseruation, to finde the variation of the Needle.

Of the Pole of the Magnes.

The eight Chapter.



Divers learned men haue iudged, 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 nere there about, (but I finde by great probabilitie, that it should be to the Westwards of these Ilands.) From which meridian at the Acores, I account the beginning of Longitudes, and finde our Meridian of London, to be from the same, $23^{\circ}.52'$ our Latitude as before said. $51^{\circ}.32'$ and the variation of the Compass or Needle, $11^{\circ}.57'$ from the North to the eastwards. Now vpon these grounds I finde by calculation, the Pole of the Magnes, or the intersecion of the two Magneticall meridians, vpon the superficies of the earth, to be from the Pole artic $25^{\circ}.44'$ & in longitude 180° . that is to say, $25^{\circ}.44'$ in the former common meridian, on the other side of the Pole.

It may bee happie 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 hereafter. Therefore I thought good to set downe the manner of the former calculation, by helpe of the declinations in the figure following.

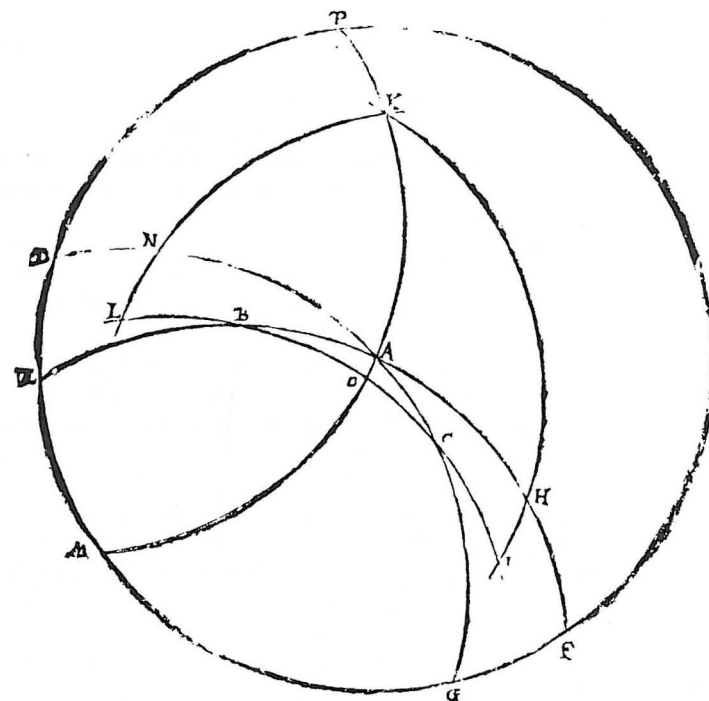
Example.

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

Of the Compasse.

the Magnes EA the meridian for London,

LOI 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-



secion of the two magneticall meridians CL and CN two Quadrants of the saide Magneticall circles, including the arke LN the quantitie of the angle at C. PAM the Semi-circle of a Meridian crossing the Magneticall Meridian of London in the point O. at right angles.

Make out the quadrants IHK and INK so shall they crosse themselues with the quadrant OAK at the point K

Now

Of the Variation

Now haue you ABC a spherick triangle, two angles whereof, and the common containing side of them, are giuen $ABC. 11. d. \frac{1}{2}$, 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 complement of the latitude of London.

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

Wherefore the arke AC , the distance of the two poles shall be giuen, which is the thing required.

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

90.0'.	11.15'.	38.28'.	6.58'.
BH	HI	BA	AO

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 & AI , by their complements, and KO the quadrant: therefore the 4 is giuen.

83.2'.	51.32'.	90.0.	52.4'.
KA	HA	KO	OI

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 quantitie of the angle BAO .

38.28'.	37.56'.	90.0'.	81.12'.
AB.	BO	AE	EM

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

So hauing $EM. 18. d. 12'$, the quantitie of the angle BAO I substracte the same from $EG. 156. d. 30'$, the quantitie of the whole angle BAC rest $MG. 75. d. 18'$, the quantitie of the angle CAO . to the which is equal the opposite angle PAD . And as AP . is to PD . so is AK to KN .

Of the Compasse.

90.0'.	75.18'.	83.2'.	73.46.
AP	PD	AK	KN

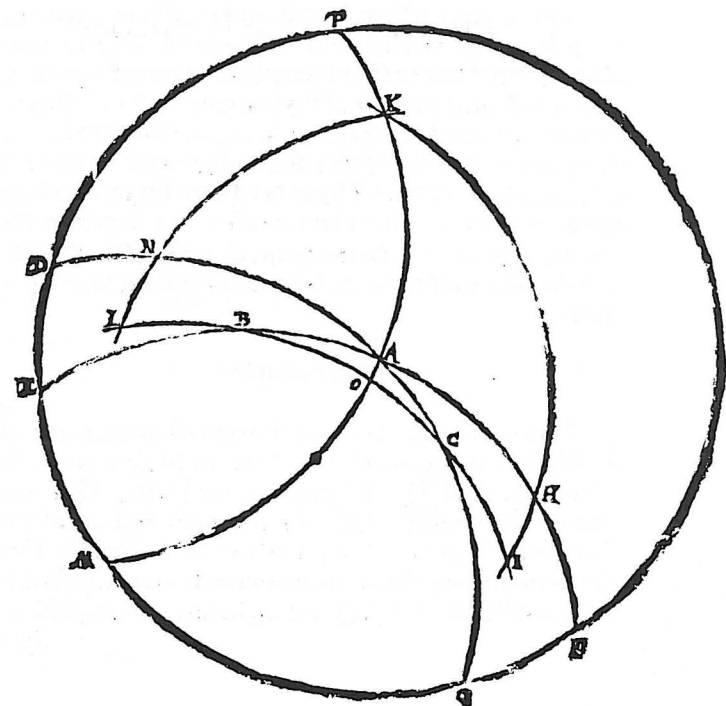
If 100000. giue 96726. — then 99261. giueth 96011.

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 . Wherefore I say.

16.14'.	65.8'.	25.44'.	AC.
NL	NC	AO	

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.



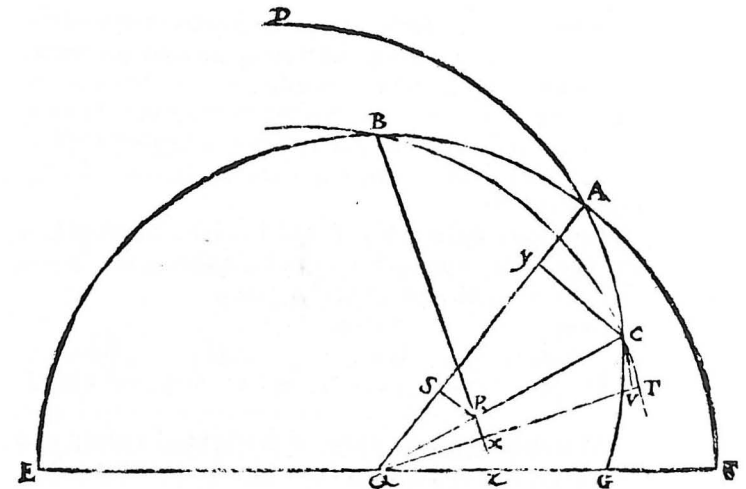
Having shewed in the former Chapter, upon the groundes therein specified, the place of the Pole of the Magnes upon the superficies of the earth: there resteth now to be declared of the point respective, wher it should be, by the new proprietie found of the declining of the Needle, being at this place for London, $71.0.50'$. 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. When producing a straight line in the magneticall plaine of London, declining from the plaine of the Horizon $71.0.51'$. where the same doth crosse with the former common section of the two plaines, thereby reason shoulde the point Respective be. Which intersection I finde to be from the center of the earth 1085 miles (after that rate of 60 to a degree in the equator, and 3436 . for the Semidiameter of the Earth) and the distance of the same from the axis of the world 471 miles.

For example.

Let the circles be as in the last demonstration, then shall BC be the distance of the pole of the Magnes from the Zenith B . And Q . the center of the Earth. QA . the axis of the world. QC the common section of the Magnetical plaines. BZ . the lye of the Needles Declination crosseing the said common section at R . (which is the point Respective.) QT a straight line crosseing BZ . at right

Of the Compasse.



right angles in X , QR . the distance of the point Respective from the center of the earth, RS . the distance thereof from the axis. If it is requisite to knowe the quantity of the arke BC , which is thus found, as the signe of the angle AEC $11.0.15'$. hath vnto the signe of the arke AC , $25.0.44'$. So hath the signe of the angle BAC . $15.0.30'$. (which is al one with the signe of the angle BAD , the difference of Longitude $23.0.30'$.) to the signe of the arke BC which is $62.0.46'$. Now as QV is to QC so is QX to QR . But the three first are known QV , the second right signe of the arke CT $9.0.4'$. (the difference of the Arke BT , $71.0.50'$. And BC $62.0.46'$.) Then QC the Semidiameter or whole signe, and QX , the second right signe of the arke BT . Wherefore QR shall be given by the 4. of the sixth of Euclide.

$80.56'$	$90.0'$	$18.10'$	QR
QV	QC	QX	15

Of the Variation

If 98.750 giue 100000 — then 3178. 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. $\frac{1}{2}$ for the semidiameter of the earth) do giue 1084 miles and $\frac{1}{2}$. which is the distance of the poynt respectiue R from the center of the earth Q vpon the former Hypothesis of the variation & declination of the magneticall needle,

Againe, as QC is to CY so is QR to RS wherefore QC and QR being giuen as before, and CY the sign of the ark CA likewise known 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 distance 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 Navigation.



Vpon the Hypothesis of the pole of the Magnes on the superficies of the earth, and the point Respective in the bodye thereof, according to the former calculations, might bee inferred many pleasaunt conclusions, both for the longitude & latitude of places.

But as touching the point Respective by the declining of the Needle, seeing this is the first and onely experiment that hath bene made of it, I cannot inferre any further matter thereof, than that which I haue already set down, vntill by obseruations in other places, wee finde howe it will holde.

And

Of the Compasse.

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

And by the same Hypothesis of the Pole of the magnes at 25.44' from the Pole of the worlde, the greatest variation of the Needle in the Equinoctiall, should be (at 90. d. of Longitude) 25.44' from North to East, and consequently the greatest variation in the Paralell of 70 d. should be (at the Longitude of 128. d. 51') from North to East 81. d. 14'. And in the meridian of 180. d. of longitude betweene the two Poles (the Pole articke I meane) & the supposed Pole of the Magnes, there should the North point of the needle or compasse respecting his own pole, be to 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 reuersed: for where as the angle of Variation from hence Eastwardes in the Paralell of 70. d. should encrease and grow wider, till it came to 81. d. 14'. from North to East as before. At the Island Vaigats being in longitude from London. 58. d. and in the same Paralell of 70. d. where, by the former Hypothesis, the variation should be 49. d. 22' from North to East. I finde the Needle to varie 7. degrees from North to West. And the like effect I haue found by diuers obseruations in sundry other places of the East partes. Which obseruations with many more that I haue caused to be made, and dayly procure to be done in diuers other Countries, I reserve, with intent (if it be possible) to find some Hypothesis for the saluing of this apparant confused irregularitie.

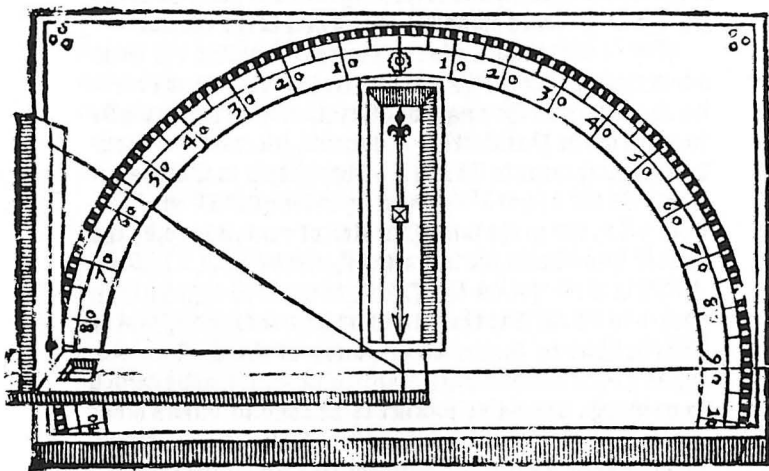
At Ratisbona or Regensburg in Buaria, being in latitude 48. d. 52' & in longitude 36. d. 20'. where, by the former position of the Magneticall Pole at 25. d. 44'. the varia

Of the Variation

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

Which strange varietie, I haue heere plainly proposed, to the end that the learned sort might consider therof, and sharpening their wits, see what probable causes & grounds they can assigne for the same. For considering it remaineth alwaies constant without alteration in euery seuerall 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 former Instrument for the variation (which notwithstanding doth far excell the compasses of variation heretofore used for that purpose) I haue here set downe the forme of a new Instrument

Of the Compasse.

Instrument where in all scruple of doubts and defects that might growe by other is quite auoyded. Which beeing once exactly 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 wylth the Sunne, to giue the degrees of Azimuth vpon the Instrument by the shadowe of the line thereof, and is otherwise to be used 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.



All Sea Chartes generally, which are made without consideration of the variation, are committed great errors and confusion. For, either the partes therein containd, are framed to agree in their latitudes by the scales thereof, & wrested from the true courses that one place beareth from another by the Compasse, or else in setting the partes to agree in their true courses, they haue placed them in false latitudes, or abridged, or over stretched the true distaunces betweene them.

In the Marine Plats made for Newfoundland, the course set downe from Sillic to Cape Rasco is due West, which is found to be so for our common sayling Compasse, whose wiers are set a point from North to East, notwithstanding Sillic being in latitude 50. v. lyttle more. Cape Rasco in Newfoundland is found to be but in 46. d. which is 3. d. lesse then the latitude of Sillic.

To make a shew of reformation of this error, 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 against 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 point of the Compasse sheweth the Pole nearest in that place) and haue furnished the degrees thereof agreeable to the Latitude of Cape Rasó: 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 Nauigation, you may easily 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 point, and thereby sayling West from Sillie, haue fallen to the Northwardes of Cape Rasó about 50. leagues, and in latitude nere 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 nearer the paralell, yet the same in Nauigation worketh the greatest confusion 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 Liouonia &c. The Marine Plate of the coastes are described by our Common sailing Compasse, with consideration of the variations at diuers places, whereby the true meridians reformably set down, declining from the paralell Meridians of the plat, doe necessarie toiden Northwardes, and straighten to the Southwardes, contrarie to the true forme and nature of meridians. And yet notwithstanding, that is the best meanes hitherto knowen, to reforme in Plat, the errors that else would growe by the strange variations that way.

And

Of the Compasse.

And albeit these places serue verie well for those Nauigations, yet by meanes of the variations considered, the forme of those coastes is so distorted from the ryght shape it shoulde beare, being truly described vpon the globe or otherwise in plaine, according to the true latitude and longitude: What whereas the Narue (being in Latitude 59.0. and in Longitude from the Meridian of London 26.0.10.) shoulde be from S. Nicholas 9.0.40' in longitude to the Westwardes (S. Nicholas being in Latitude 64.0.35' and in longitude from London 35.0.50') In the sailing Plat it is brought to be in the meridian of Colmogorod, (which is in latitude 54.0.20' and in longitude from London 37.0.45') which is 1.0.55. to the eastwardes of the meridian of S. Nicholas.

Into the Mediterranean Sea, and in the coastes thereof, wherein great reason shoulde be the perfectest description of the woylde, for that in those partes haue bene the seats 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, though want of knowledge of the variation, and the vse 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 reforme, by the famous and learned Gerardus Mercator (whom I honoz and esteeme as the chiefe Cosmographer of this time) in his vniuersall Map, which though hee haue made with sailing lines, & dedicated to the vse of Seame, yet for want of consideration of the variation, the same is more fit for such to beholde, as study in Cosmographie, by reading authozs vpon the lande, then to be vsed in Nauigation at the sea.

There is also in the same vniuersall 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 about 20.0. in longitude, whereas

D 2 in

Of the Variation

indeede they are but one thing, and no such distaunce betweene them. This error hath growen by taking Wardhouse, and the Sea coastes, from thence to S. Nicolas Vau-gats, and the Ob &c. out of the Map of that worthy tra-uailer, M. Anthonie Lenkinsons his journey to Boghar & Persia, &c. In the which I placed that border of the Sea coast, and for some causes went no further Westwardes in that description, then Wardhouse which is in latitude 70. d. and in longitude from London 29. d. Therefore to accomplish the whole border of that coast, hee was forced to seeke some other description to ioyne with it, and tooke 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 longitude as much too little, the which, although he might take to be the same specified in Maister Lenkinsons Map, yet he was constrained to separate them the said distaunce of 20. d. in longitude (or to leaue there so much superfluous room) other wise he should haue thurst the South partes of those Countries together, and confounded the whole description.

And albeit he had had the entire sailing Plat, that w^old be for those parts, yet if hee had not knowen the secret effect of the Variation in the making thereof, he might haue fallen into the like absurditie or worse. But of those coasts and of the inward partes of the Countries, Russia, Muscouia, &c. I haue made a perfect Plat and description, by mine owne experience in sundrie voyages and trauailes, both by Sea and Land, too and fro in those parts, which I gaue to her Maie^{ty} in Anno 1578.

Besides these and like imperfections proceeding of the Variation, there is yet another inconuenience, which oftentimes exceedeth the former errors, and that is, the diuers placing of the wires, fixed to the stile of the Compass.

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

Of the Compass.

confusion in Navigation, and in other accountes of Sea causes: for when it is said, that from such a head land, to such a place, in such a course, or at such a place the wire upon sicke a point of the Compass maketh the full Sea, it is requisite to bee demanded, by what Compass the obseruation was made, whereas if the wire had not bene altered from the North point of the stile, which I thinke had neuer bene any where (these doubted had bene auoyded).

If besides therefore all men that will make Hydrographicall descriptions for the vse of sailing, to haue speciall regards of the Compass by which these obseruations are made, and if they collecte notes made by sundry Compasses of diuers settings, they ought to reduce all the varieties into some one certaine, and to giue notice of the same in their Plat: And not to make a confused mingle mangle by ioyning together all varieties of obseruations, notes, and reports, as the Portugales and Spaniards haue done, in compounding these North partes of the world, with their owne discoueries, without consideration of the diuers settings of the seueral compasses by which they were made.

Also it importeth all maisters, Pilots, and others by what name soeuer, that shall giue directions in Navigation, to looke circumspectly to the setting of the wires of the Compass by which they shall saile, that the same Compass be correspondent, to the lines of the Sea Card that they shall vse: that is to say, that it be of the same set for the variation, that the Compass is of, by which the cards was made.

And being we haue in this our countrey, acquainted our selues continually in our obseruations and Navigations, with the Compass: whose wires are set at a point from North to East, I intene in the description that I shall make to apply the same agreeable to the said Compass and would vse the like without alteration (and al-

Of the Variation

to the straight lines in Sea Cards) if I should saile round about the world to make the description thereof, but a way both regarde of the severall variations of every place where the same should be obserued.

Of the Instruments and rules in Navigation.

The Twelwe Chapter.



Amongst the rules and Instrumentes for Navigation, all such are vaine & to small purpose, wherein the true meridian is supposed to be giuen by the Magnetical Needle, without due consideration of the Variation, for that they are all grounded vpon false suppositions. Whereby it cometh to passe that one Michael Coignet of Antwerp, in his New instruction (as hee termeth it) of the most excellent and necessarye points of Navigation, wherein he sheweth the making and vse of a Nautical Hemisphere, which he preferreth before all other Sea Instruments, is very childishly abused. For whereas he pretendeth by it, to giue the elevation of the Pole, and the houre and instant of the time of the daie, by any one obseruation in any place: besides that, it is of all other that hath hitherto bene used at Sea, the most tedious and unfit for that purpose: it is also by reason of the variation not considered, meere false and erroneous. For the true Meridian (which is the grounde of this purpose, as farre to seeke as the thinge hee promiseth to giue 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 authoꝝ in the 4. Chapter of his booke, entreating of sailing vpon the pointes of the Compasse, sayth, that in sailing South or North he shall passe by the poles

Of the Compasse.

of the world, and keepe vnder one Meridian, till hee come to the place from whence he first departed. And vpon the points of East and West out of the Equinodiall, hee shall saile vnder a Paralell, till hee returne to the place from whence he went. But in sailing vpon the point of North or East, he shall describe a spirall line inclining by little and little towards the Pole, as in his demonstration thereof in the same Chapter appeareth. But for want of due consideration of the variation, his rules, reasons, and demonstrations, and such others hitherto giuen for like purposes are friuolous and false.

For if he direct his sailing by the Compasse (as of necessity he must, being 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 World, as hee supposeth, but some other pointe or points distant from the same, shall lead him accordingly, 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 world, 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. d. from North to East according to Mercators position, of the Magnetical Pole, which he also confirmeth by his owne experience.

But it seemeth he hath followed that excellent Mathematician Petrus Nonius, especially concerning the sailing vpon the points of East and West. For he, in his first booke of the rules and Instrumentes of Navigation, enterceth himselfe to proue and demonstrate, that in sailing East or West out of the Equinodiall, the course is perfoꝛmed by peeres 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 should be

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 be wth the Pole without Variations) for if he had, he would never haue entered in such a Labyrinth as he wd. But hee thought it a great absurditie that the Compasse in euery Horizon, should be wth the Meridian & Poles of the worlde by the pointes of North and South, and by the pointes of East and West, as though in the Horizon the verticall and Equinoctiall East and West, (being a great circle) and yet in sailing East or West, except in the Equinoctiall, it should performe but a paralell.

But it is to be obseru'd, that albeit the pointes or lines of the Compasse do alwaies in euery Horizon represent great circles in the Heaues, 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 euery where leu^l wth the Horizon, so as a perpendicall line descending from the center thereof at right angles wth the plaine of the same, will alwaies fall vpon the center of the earth, and consequently be the Semidiameter of a great circle) so th^t it wheresoener the Compasse be carried, these circles are supposed to be carried about wth it, and the viewe of euery thing in the Horizon, represented by the pointes thereof, is likewise in great circles: But in sailing by the Compasse, the pointes of South and North onely, describe great circles generallie, w^{ch} are the Meridians, and the pointes of East and West, describe a great circle in the Equinoctiall onely: in all other places out of the Equinoctiall, they describe but Paralels. And the sailing vpon any other point of the Compasse from any place, describeth a spirall line, according to the angle it maketh wth the Meridian. And heereby in sailing vpon the
pointes

Of the Compasse.

pointes of East or West, out of the Equinoctiall,) the North point alwaies respecteth the pole (the course performeth a Paralell, according to the distance of the center of the Compasse from the pole. The manner thereof you may perceiue by fastning a small thrid or Virginall w^{ier} at the Pole of a Globe, or center of a circle, which shall represent a moueable Meridian to be carried about the globe or circle, and fixe vpon the same, a small flie of a Compasse, so as the line of South and North be answerable to the thrid or w^{ier}, and the North point thereby alwaies respect the North pole: then in turning the thrid about the Globe or circle, vpon the Pole or center, if the center of the flie be out of the equinoctiall, (betwene it and the Pole) albeit the pointes of East and West, crossing the same line and moueable meridian at right angles, doe shewe the Verticall East and West vpon the Globe, which is a great circle, yet in carrying the same flie vpon the thrid or moueable meridian about the pole or center, you shall by the center of the same flie describe but a Paralell according to the distance thereof from the Pole of the Globe, or center of the circle not vnlike 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 beame of the Mill, is forced to make his course in a circle, whose semidiameter is the length of the beam contained betwene the horse and the center of your mill or millpost.

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, (which 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 verticall East and West, which is the Equinoctiall, imagining to descend from the center of the Compasse a line, to fall perpendicallie, and at right angles wth the Axis of the worlde (which shall be 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, vpon the superficies of the Sea: so being 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 crosse the same axis alwayes 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 being 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 vpon 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 y other, so doth the verticall circle of East and West shewed by the Compasse, decline from the paralell circle euerie where.

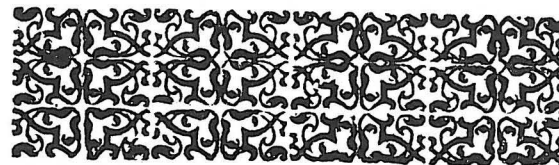
The angle of which declination is alwaies equall to the latitude of the place, or distaunce of the Paralell from the equinoctiall.

But as I haue already sufficiently declared, the compasse sheweth not alwaies the Pole of the worlde, but varieth from the same diuersely, and in sailing describeth circles accordingly. Which thing, if Petrus Nonius and the rest that haue witten of Nauigation, had ioyntly considered in the tractation of their rules and Instrumentes, then might they haue bene more auailable to the use of **Nauig**

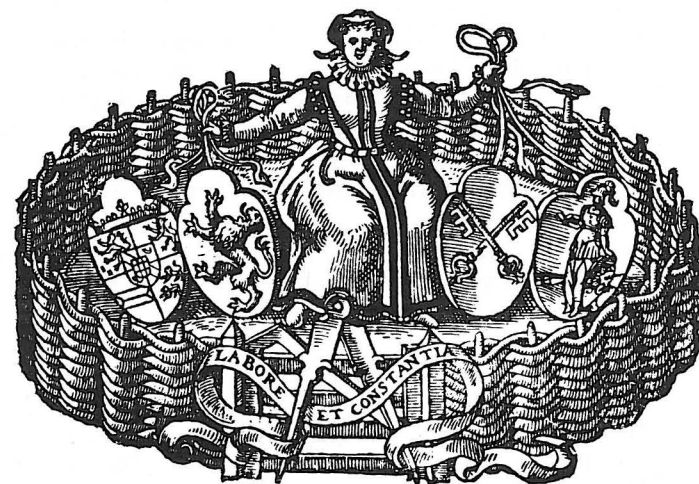
Of the Compasse.

Nauigation, but they perceiuing the difficultye of the thing, and that if they had dealt therewith, it would haue vtterlie ouerwhelmed their former plausible conceits, with Pedro de Medina (who as it appeareth hauing some small suspicion of the matter, reasoneth very clarkly, that it is not necessaris that such an absurditie as the Variation, should bee admytted in such an excellent art as Nauigation is) they haue all thought best to passe it over with Silence. 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 heerein I haue shewed, or else ease themselves of that trauaile, for as good none, as vniuersally profitable.

FINIS.



DE
HAVEN-
VINDING.



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

cl. 1. 10. 10.

Met Priuilegie.

TAFEL DER NAELD- WIISINGHEN.

		Oftering.	Breede.	Langde.	
		tr. (1).	tr. (1).	tr. (1).	
Eerfte percx opde noort- fijde	Ver- groot- tende oofte- ring	Een der Vlaemfche Eylanden Corvo.	0. 0.	N 37. 0.	0. 0.
		Opt Vlaemfch Eylant Sancta Maria.	3. 20.	N 37. 0.	8. 20.
		Neffens het Eylant Maio.	4. 55.	N 15. 0.	11. 20.
		By t'Canarifche Eylant Palma.	6. 10.	N 28. 30.	16. 20.
		By Cabo de Roca by Lisbona.	10. 0.	N 38. 55.	24. 30.
	Ver- cleen- nende oofte- ring	Het wefterlickfte van Yrlandt.	11. 0.	N 52. 8.	24. 12.
		Engelants eint.	12. 40.	N 50. 21.	28. 0.
		Een mijl ooftwaert van Plymouth.	13. 24.	N 50. 18.	30. 0.
		By Timouth in zee.	12. 40.	N 55. 0.	33. 0.
		Londen in Engelant.	11. 30.	N 51. 24.	34. 6.
	Het voorlant van Engelant.	11. 0.	N 51. 8.	35. 40.	
	Amftterdam.	9. 30.	N 52. 20.	39. 30.	
		Wefte- ring.			
Twee- de percx opde noort- fijde	Ver- groot- tende wefte- ring	Helmfhuy by weften de Noortcaep in Finmarck.	0. 0.	N	60. 0.
		Noortcaep in Finmarken.	0. 55.	N 71. 25.	61. 30.
		Noorkin.	2. 0.	N 71. 10.	63. 30.
		Sint Michiel in Ruffia genaemt Arch- angel.	12. 30.	N 64. 54.	83. 30.
	Ver- cleen- nende wefte- ring	De zuyderlicke ftraet van Vaygats.	24. 30.	N 69. 30.	103. 0.
		Langenes in Nova Zembla.	25. 0.	N 73. 20.	100. 30.
		Willems Eylant by Nova Zembla.	33. 0.	N 75. 35.	110. 0.
		Ythouck in Nova Zembla.	27. 0.	N 77. 12.	120. 30.
	Het winterhuys in Nova Zembla.	26. 0.	N 76. 0.	120. 30.	

(2)

		Oftering.	Breede.	Langde.	
		tr. (1).	tr. (1).	tr. (1).	
Eerfte percx op de zuyt- fijde	Ver- groot- tende oofte- ring	Op 105. Spaenfche mijlen weftwaert van Cabo Sant Auguftin en Brafilie.	0. 0.	Z.	0. 0.
		By Cabo S. Auguftin in Brafilia.	3. 10.	Z. 8. 30.	6. 0.
		Zuyt en noort met Cabo das Almas in Guinea.	12. 15.	Z. 0. 0.	29. 0.
		Noortweft wel foo noordelick vande Eylanden van Triftan da Cuncha.	19. 0.	Z. 31. 30.	30. 0.
		Noortweft wel foo weftelick vande voorfcreven Eylanden.	15. 0.	Z. 31. 30.	36. 0.
	Ver- cleen- nende oofte- ring	Zuyt en noort met Cabo de Bona efperance.	2. 30.	Z. 35. 30.	57. 0.
				Wefte- ring.	
		Op 17. duytsche mijlen van Cabo das Aguillas ooftwaert.	0. 0.	Z.	60. 0.
		Ontrent 5. mijlen in zee vant lant Natal.	4. 30.	Z. 33. 0.	66. 0.
		Byde Baixos da India.	11. 0.	Z. 22. 0.	79. 30.
Twee- de percx opde zuyt- fijde (uyt- geno- men Goa Co- chin en Can- tan)	Ver- groot- tende wefte- ring	Mofambique.	11. 0.	Z. 14. 50.	81. 40.
		Inden inwijck van S. Auguftin in Madagafcar.	13. 0.	Z. 23. 30.	83. 0.
		Zuyt van Cabo Sant Romain.	16. 0.	Z. 28. 0.	86. 20.
		Inden inwijck van Anton Gil in Ma- dagafcar.	15. 0.	Z. 16. 20.	91. 0.
		34. Duytsche mijlen zuytooft van S. Brandaon.	22. 0.	Z. 19. 20.	110. 0.
	Ver- cleen- nende wefte- ring	Goa een vermaerde coopftat in India.	15. 10.	N 15. 30.	120. 0.
		Cochin.	15. 0.	N 9. 45.	121. 0.
		25. Duytsche mijlen weft ten noorden vande zuytwefthouck van Samatra.	6. 0.	Z. 5. 28.	147. 0.
		Bantan een coopftadt in India.	4. 45.	Z. 6. 0.	150. 0.
		Het Eylant Lubock.	2. 25.	Z. 6. 10.	155. 0.
	De zuytwefthouck vant Eylant Balij.	1. 30.	Z. 8. 40.	157. 0.	
	De mont der Rivier van Cantan in China.	0. 0.	N 23. 0.	160. 0.	
	Bunam 46. Duytsche mijlen van het oofte van Iava na het oofte.	0. 0.	Z.	160. 0.	

(3)

*Hoemen het noortpunt en naeld-
vwyfing vindt.*

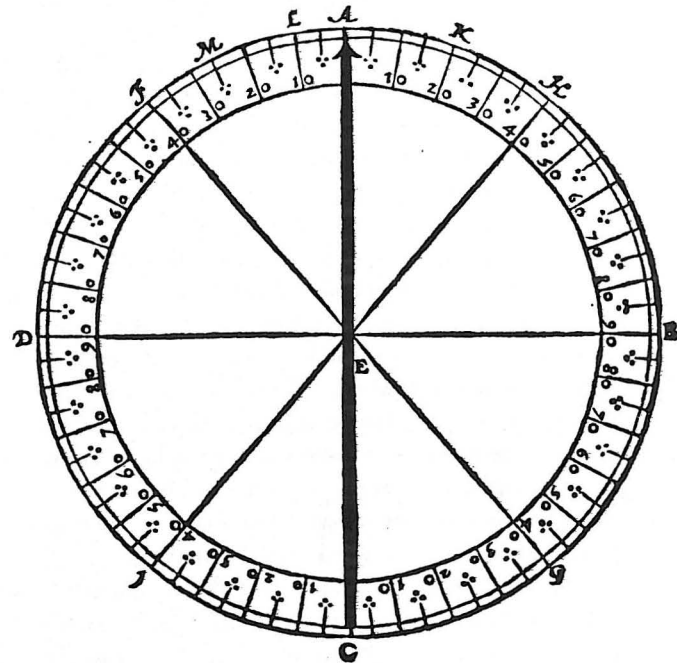
HOE wel het vinden der naeldwijfing (daer af wy hier vooren dickwils ghefeyt hebben) an velen bekent is, nochtans fullen wy daer af fchrijven voor de ghene diet niet en weten.

Anghefien men hier begeert te vinden de afwijcking der naelde vant noorden, foo fouctmen eerft het noortpunt, om de naeldwijfing daer by te verlijcken. De manier der vinding vant felve noortpunt in een beweghende fchip op zee, heeft groote ghemeenfchap mette manier der vinding vant noortpunt, of vande middachslin opt vaft lant, ende mach onder anderen aldus uijtgherecht worden: Men doet int zeecompas de leli recht overcommen mettet noortende vant ftael, of vande zeylnaelde daer onder ligghende: Of noch beter machmen in plaets vande leli, een naelde felf boven opt papier vaft legghen, deelende t'rondt van t'felve 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 felve papier, E is tmiddelpunt: Tgebruyck hier me is dufdanich: Ghelijck den Stierman int foucken der breedte, wacht tot dat de middach ghecommen is, te weten tot dat de fchaeu van een hangfnoer of rechtfnoer, overcomt mette lini die hy in fijn compas voor de middachslin houdt, alfoo fal hy hier doen, uijtghenomen dat hy begint 3. 4. of 5. uijren of meer voor middach alfdan, acht nemende op wat trap en ghedeelte van dien de fchaeu des hangfnoers wijft, bevint die, neem ick, opden 40. tr. gheteyckent F, fulcx dat G E F, de fchaeu bediet, ende nemende alfdan de Sonnens hooghde, bevint die, by voorbeelt, van 25. tr. welcke hy, metfgaders de 40. tr. tot ghedachtis opteyckent: Wachtende voorts

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foo lang na middach, tot dat de Son weerom ghedaelt is tot op de felve hooghde alfooren van 25. tr. fal sien waer de fchaeu vant hangfnoer alfdan opt papier wijft, twelck fij, neem ick, 40. tr. over dander fijde, als an H, fulcx



dat I E H, de fchaeu bediet. Dit foo fijnde, t'middel des boochs F H, als A, is tbegeerde noortpunt, ende want de naelde daer recht op wijft, foo en heeftse in dat voorbeelt gheen wijcking, dan wijft recht noort. Maer foo inde voorf. ervaring na middach de fchaeu vant hangfnoer niet ghewesen en hadde 40 tr. over dander fijde van A, maer by voorbeelt alleenelick 20 tr. tot K; In fulcken ghevalle deeltmen 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 ift noortpunt, ende de begeerde naeldwijcking daer af is ooftering van L tot A 10. tr.

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

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doende 30. tr. doortghedacht in tween an M , fulcx dat $M F$, $M L$, elck doen 15. tr. twelck soo sijnde, M is tnoortpunt, ende de begeerde naeldwijcking daer af, wefende ooftering van M tot A 25. tr. ende alfoo met alle voorbeelden. Maer soo de naelde alleen draeyde, sonder an een papier ghehecht te sijn als hier vooren, ende dat de trappen op den cant vande caffè gheteyckent waren, ghelijck wel ghedaen wort: Tghebruyck is daer me alfvooren, midts datmen ten tijde der ervaring, de caffè keert tot dat de naelde opt begin der trappen wijft.

* *Quadrantem Azimutalem seu verticalem cuius planū horizontale.*

Ander sijnder die nemen een * foppich vierendeel ronts, wiens sichteinanderfplat, niet teghenstaende de beweeghlicheyt des schips, altijd in waterpas blijft, deur fulcke manier als int volghende gheseyt sal worden. Hier me vintmen de Sonnens hooghde met haer fopbooch beyde tfeffens: De form daer af mach dusdanich wesen: $A B C$ bediet een vierendeel ronts, staende rechthouckich opt rondt $B D C E$, ghedeelt in sijn 360. trappen, twelck het sichteinanderfplat beteyckent, sijn middelpunt is F , waer op tvierendeelronts draeyen can, ende op dattet alfins rechthouckich blijft opt voorf. rondt $B C D E$, soo comt van deen en dander sijde een steunfel, als van G tot by D en E , vast ghemaect an tvoorf. vierendeelrōts, om daer me te drayen. Voort iffer int rondt $B D C E$ een glas, en daer onder sijn feynaelde, soo lanck alffe ten langsten inde caffè bequamelick vallen mach, ende heeft de selve caffè van binnen heur 360. tr. daer de punt der naelde scherpelick op wijfen mach, overcommende die 360. tr. met dander 360. tr. boven opt sichteinanderstont. Defen tuych is deur de vondt van Reyner Pieterfz. hanghende ghemaect op twee verscheyden affen, na de manier der zeecompaffen, op dat alfoo het rondt $B D C E$, inde beweginghen vant schip altijd ewewijlich vanden sichteinder blijve: Ende op dattet selve noch meerder sekerheyt hebbe, soo wort onder een ghewicht an vervought gheteyckent H , van 25. of 30. pont, of soo veel als de grootheyt vanden tuych vereyft.

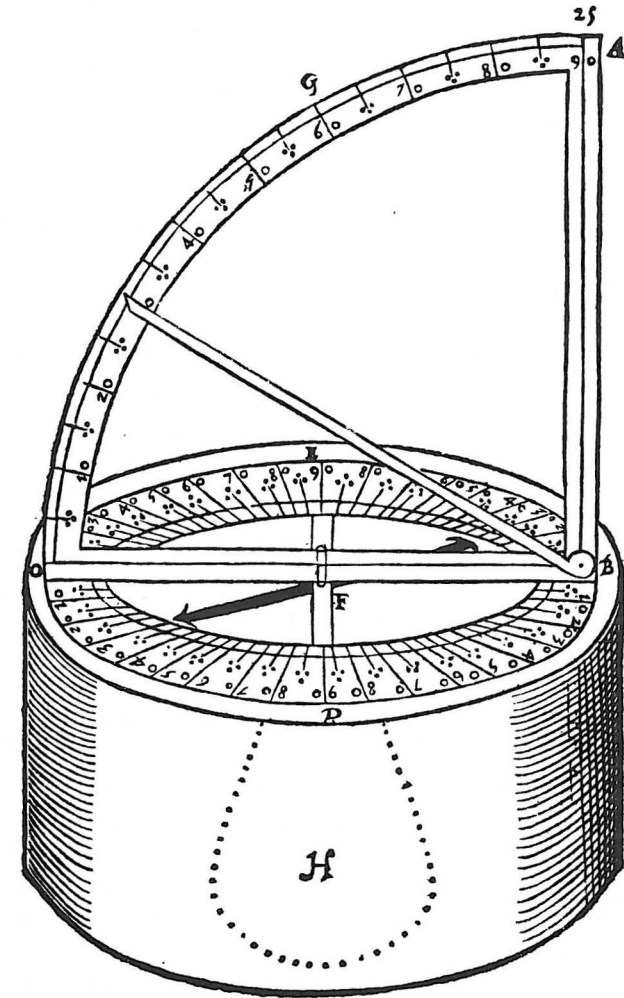
Tis oock te ghedencken oirboir te wesen, dattet vierendeelronts tñjnder plaets recht overende staende, over deen en dander sijde eveswaer sij, dat is de sijde van F na C , soo swaer as van F na B , twelckmen weten can mits tvierendeelronds af te nemen, ende te hanghen met G neerwaert an een draet, vast gemaeft int middel van $B C$ by F , ende alfdan salmen vande svaerfte sijde so veel af vijlen, tot dat de reghel $B C$ in waterpas hangt.

* *Alidada.*

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

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De ghebruyck daer af, om t'noortpunt en naeldwijfing te vinden, is dusdanich: Men begint, gelijk in deerste wijse, ettelicke uijren voor middach, draeyende



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

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fichtgaetkens schijnt: Twelck foo sijnde, men bevint, neem ick, dat den ondersten cant of wijfer vant vierendeelronts, wijft int fichteindersplat opden 40. trap, ende de hooghde der Son, die int vierendeelronts anghewefen wort van, neem ick, 25. tr. welcke men, mitfgaders de 40. tr. tot gedachtnis opteyckent. Wachtende voort foo lang na middach, tot datmen de Son deur den feluen tuych ghedaelt vindt tot opde felve hooghde alfooren van 25. tr. men keert aldan den stoel ter eender en ander sijde, tot dat de Son deur de fichtgaetkens schijnende, de naelde weerom wijft opt begin des ronts: Twelck foo sijnde, t'middelste punt des boochs int fichteindersplat tuffchen deerste en tweede ervaring, is tgesochte noortpunt: Ende foo veel de naelde aldan daer af wijckt, dats de begeerde naeldwijcking, gelijk int eerste voorbeelt wat breeder van fulcx ghefeyt is.

Deur tghene hier boven ghefeyt is vande ervaring mette Son des daechs, mach derghelijcke verfaen worden ende gheschien met yder vastte fterre des nachts, die ghebruyckende al oft de Son waer: maer niet de Maen, eenfdeels om heur raffche eyghen loop, ten anderen om tgroot * verfcheensicht datie heeft van wegghen sij t'eertrijck foo na is.

Merckt noch datmen voor den middach twee drie vier of meer ervaringhen mach doen: Als by gelijknis, deerste wefende 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 als men alsins een felve noortpunt krijcht, tgheeft den Stierman meerder betrouwen 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 tuffchen deerste ervaring en de laetste, een trap of meer verandering der naeldwijfing krijge, waer uyt wijder volghen can, dattet noortpunt ghevonden deur deerste voormiddachsche ervaring, en de laetste namiddachsche, niet overcommen en sal mettet noorpunt gevonden deur de laetste voormiddachsche ervaring, en deerste namiddachsche, sonder nochtans dat den Stierman int werck ghefeylt heeft. Dit hem foo ontmoetende, hy can daer uijt ramen hoe veel op feker uijren varens de naeldwijfing verandert, ende daer op giffing maken, om trechte noortpunt en naeldwijfing met noch meerder fekerheyt te hebben. Tfelve canmen oock weten deur de naeldwijfing ghevonden op voorgaende daghen, ende die verleken mette wijfing des teghenwoordighen dachs.

