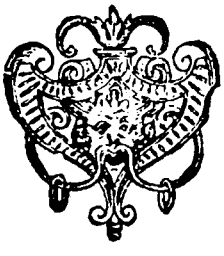
Certaine

ERRORS IN NAVIGATION,

Ariſing either of the or-*dinarie erroneous making* or vſing of the ſea Chart, Compaſſe, Croſſe ſtaffe, and Tables of declination of the Sunne, and *fixed Starres detected and corrected.*

By E. W.



Printed at London by Valentine Sims. 1599.

ORIGIN OF MERIDIONAL PARTS

FIRST TABLE OF MERIDIONAL PARTS published by Edw. WRIGHT in his Treatise *"CERTAINE ERRORS IN NAVIGATION"* London, 1599.

There is no treatise on cartography or on navigation in which the work of Edw. WRIGHT entitled :- *Certaine Errors in Navigation* is not mentioned ; the first edition of this work was published in 1599, and a second edition followed in 1610 (1).

We believe, however, that not all of the authors have been able directly to consult WRIGHT'S book and that many of them, on account of the present extreme rarity of copies, have had to reproduce quotations which had already been extracted and which were consequently not always original. It is thought, therefore, that it would be serving a good purpose to reprint, in the *Hydrographic Review*, the two parts of the work which refer in particular to nautical cartography namely :-

(1) The Preface, in which WRIGHT not only enounces and explains clearly for the first time the law according to which the meridian of a chart should be graduated, but in which he gives also most interesting facts and notes on the well-known controversy relating to the origin of charts based on meridional parts ;

(2) The Table of meridional parts for every 10' as originally published in the first edition of 1599 (2).

The reproduction given below in fac-simile has been prepared from the copy of the first edition (1599) in the British Museum (Press Mark G. 7312). We are indebted for the photostat for this reproduction to the courtesy of the Director of the British Museum, to whom the Directing Committee of the International Hydrographic Bureau expresses its hearty thanks.

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(1) In ROBERTSON'S *Elements of Navigation* (4th Edition 1780 - Extracts from which have been translated into French by Captain MARGUET. Ed. Challamel, 1918) it is stated that "in 1657 a third edition was published by Joseph MOXON". WRIGHT died in 1615.

(2) For calculating his Tables WRIGHT first took a degree at the Equator as the initial element m and took the length of the degree of the meridian comprised, for instance, between latitudes 27° and 28° equal to m secant 28° ; he then added these lengths together in order to obtain the distances of the parallels to the Equator. He forwarded the first Table thus compiled to BLUNDEVILLE previous to 1594. Further, he noted that the smaller the initial element selected, the greater would be the accuracy obtained for what we call the integral. In 1599, therefore, he no longer adopted the degree, but 10' as the initial element. Finally in 1610, in the second edition of his book, he adopted one minute of arc and had the patience to calculate the length for each minute of the meridian of the chart up to 89°59', always taking the minute comprised between latitudes φ and $\varphi+1'$ to be equal to sec. $(\varphi+1')$; which, he declared, gave a slightly greater value. He worked out values for the secants to the fourth place of decimals. He did not work to an element smaller than the minute, for instance 10", and in this he was justified, for the error in the meridional parts of his table is only 0.8 in 5966 at latitude 70° and is still only 2 units and 1/10th at 80° and 50 units in 107,696 at 85°, and thus is entirely negligible in practice. (*Histoire générale de la Navigation du XV^e^ au XX^e^ siècle*, by Captain F. MARGUET, "*Revue Maritime*", Paris, October 1930).

The Præface

To the Reader.

THE Art of Nauigation (as it is called) though it hath now beene in vſe ſome thouſands of yeeres, yet how far it is at this day, from the perfection which is and were to be deſired, wee would ſcarce beleeue (as a wonder, that a thing of ſo great commoditie, ſhould no more bee ſought into, in ſo many ages:) but that, both the Bookes of the learned are extant, to teſtifie, and reaſon (approoued by often triall) dooth plainely ſhew, that the principall meanes, and inſtruments this Art vſeth, haue beene thus long ſo farre from this perfection, that contrariwiſe they haue beene, and are much ſtained, with many blots and blemiſhes of error, and imperfection.

1 The ſea chart the beſt meane the mariner hath to knowe the courſe from place to place, (as it hath beene hitherto generally made) is ſo faulty in the very foundation and groundworke thereof (that is in the geometricall lineaments of the meridians, paralels, and rumbes deſcribed therein) that hereof there may ariſe ſo groſſe error, as may cauſe the mariner to miſſe one, two, yea three whole points of the compaſſe (and more ſometimes in a farre northerly nauigation) in finding the courſe from place to place. Whereof it may alſo be neceſſarily inferred, that following the direction of his chart in ſuch ſort as hath beene vſed for finding the diſtances of places, he may erre one half, yea three quarters and more ſometimes in thoſe northerne partes: in taking the diſtance to be twice, thrice, yea foure times greater then indeede it is

2 The Compaſſe (the chiefeſt inſtrument for keeping the courſe ſhewed by the chart) by the variation neglected, as by

* ſome it hath beene may cauſe you erre an whole point or two in the courſes of diuerſe places: and not rightly vſed hath bred much confuſion in many parts of the chart in laying out many places in falſe courſes: which muſt needs folow when the chart is made according to the direction ſhewed by the pointes of the Compaſſe without abatement or allowance anſwerable to the variation in euery place. This may eſpecially bee ſeene in thoſe places where the variation is greateſt, as vpon the coaſt of Florida, Noua Francia, and New found land; where ſome alſo ſeeking to auoyd this inconuenience, haue fallen into an other as ill or worſe than the former, in making a double ſcale of latitude. And thus one error as a fruitfull mother breeding another, and one abſurditie admitted drawing many with it: it will manifeſtly appeare by exact diſcourſe out of theſe groundes (what partly through the falſe proiection of the chart, and partly through neglecting, or not rightly vſing the variation of the Compaſſe) that it can not otherwiſe be but that the ordinary charts are in many places much like an inextricable labyrinth of error, out of which it will be very hard for a man eaſily to vnwinde himſelf.

M. Peter de Medina, 6. booke, 3. chap.

Hereto accord the often experiments and vſuall practiſe of many wel experienced and iudicial mariners and ſea men of our time, who confeſſe, that in ſailing from the weſt Indies to the Azores, they haue often fallen with thoſe Hands, when by their account according to the chart they ſhould haue beene 150. or 200. leagues to the Weſtwards of them. The like hath beene found in ſayling from the Azores for Vſhent, as I haue alſo partly ſeene in the little experience I haue had at ſea, where we were comme within ſight of that Iland, when by account of the ordinary chart we ſhould haue beene 50. leagues ſhort of it.

And as concerning the courſes from place to place, I haue obſerued that ſome of our maſters take a wiſe courſe, in not truſting to thoſe courſes which are ſhewed by their charts. But firſt getting themſelues into the height or paralel of the place to which they are going: and withall; knowing aſſuredly whether they be more eaſtward or weſtward than that place; they then proceed

alwayes heedfully keeping themselues vnder that parallel, till they come to the place desired. Then which way of sayling there is none indeed more certaine and infallible for the sure finding of the place assigned: but it hath this inconuenience, that it maketh the way longer then otherwise it should be, if the streight course were kept.

But to returne to that from whence we haue a little digressed, by these experiments and practise of the skilfullest mariners it is manifest that they themselues do often find the imperfections of their charts, in shewing the courses and distances of manie places each from other. Whereto we may adioyne the experience of the best Hydrographers of our time: who dayly making their Charts after the accustomed manner with streight lined rumbes and degrees of latitude, euerie where equall, haue found such difficulties in labouring to bring their marine descriptions to some due correspondence of trueth in the courses, heights and distances, that tyred herewith in the end, they haue holden it for impossible, to make the chart agree in all these with the globe. Wherein notwithstanding they erre, by making too generall a conclusion, in houlding that to bee simply impossible, which cannot be done by such a way & meanes as they know and vse.

3 The Crosse staffe (the principall instrument, that hath at sea beene most generally vsed, for obseruing the altitudes of the Sunne, or starres thereby to know more assuredly the latitude, and so to examine and rectifie the account of the course, kept by direction of the Compasse vpon the chart) if there be not abatement made answerable to the eccentricitie of the eye (that is to the distance wherewith the center or point wherein the sight beames concurre within the eye is further backward then the end of the staffe) may through neglect of this abatement cause error in taking the height obserued to be greater then indeed it is. by 10,20,30, min. yea an whole degree and more sometimes, if the height be much, the staffe small, and the eccentricitie of the eye great.

4 But both this staffe, and all other instruments (though neuer neuer so well made and vsed) can doe vs but small pleasure, for finding the latitude at sea, if the declination of the Sunne or starres which we obserue be not also knowne. To this end therefore there haue beene made tables of the declinations, both of the Sunne and fixed starres: yet such as euen that which hath beene publikely commended as not differing from trueth in any place aboue one minute (I meane the regiment of the Sunne set forth by R.N.) doth notwithstanding differ from trueth in manie places 10, 11, or 12, minutes. And as for the fixed starres, scarce one of them hath his declination truly set downe and agreeablie to obseruation. Yea euen the Pole-starre it self, though it be better knowne, and more obserued by the most part of seamen then all the rest: and indeed as it mought be vsed (being to be obserued at any time of the night all the yeare long) might stand them in as much stead for finding the latitude as most of the rest: yet in the bookes of nauigation that are most common amongst English mariners, the distance thereof from the Pole is made to be 38 minutes more then it should be. No marualle therefore if the mariners complaine (as I haue heard them sometimes) that they cannot make their obseruations of the latitude by the Sunne and this starre to agree.

Neuher is there more trueth to be looked for in the declinations of many other principall fixed starres, published in those bookes, diuerse of them erring from truth one, two yea (some of them) three whole degrees and more, as in the treatise following shall be shewed. And these errors in the declinations of the Sunne and fixed starres not onelie I, but also the R. W. Sir Christopher Heydon knight, and the noble Lord of Kundstrupp, Tycho Brahe, founder of Vraniburg, with the gracious Prince William Landtgraue of Hassia, father of him that now is, haue often found by many and most diligent obseruations, with large and exact instruments, wherin both minutes and half minutes might be easily discerned. Notwithstanding, if anie stand in doubt hereof, I wish that he himself also would bestow no lesse cost, time and diligence, to make often heedfull and exact obseruation then either the Prince of Hassia, or

Tycho Brahe, or at least but as my self haue done, and then let him beleeue that he shall see to be true with his owne eyes.

These errors therfore in the Chart, Compasse, Crosse staffe, and declinations of the Sunne and starres, I haue in the treatise following laboured to reforme to the vtmost (yea rather beyond the vtmost) of my poore abilitie, neglecting other studies and courses that might haue beene more beneficiall to mee: which may argue my good will to haue proceeded further, to the amendment of such other faultes and imperfections as yet remaine besides those that are alreadie specified, and that especially in two pointes, that is, in the courses and longitudes of places.

The reforming of the Chart in reducing all places from those varying courses wherein now they are set downe to the true positions they haue each from other, by separating the variation (wherewith they are in the ordinarie Charts for the most part intermingled) were a busie peece of worke: yet such as were most worthie, and necessarie to be laboured in, as without which the Charts mappes, and globes, or any other Hydrographical, or Geographicall descriptions, cannot be freed from many intricate absurdities, wherewith now they must needs in many parts be pestered: because the courses and positions of places are in them set downe as they were obserued by the varying Compasse, without separating the variation afterwards, that so the true courses and positions of places might be knowne.

The longitude also would well deserue both labour and cost to be both skilfully and liberally bestowed, for the finding thereof: whereby it were possible to bring it to that passe (the motions of the Sunne, and Moone, and places of the fixed starres being verified, whereof that noble Tycho Brahe affoordeth great hope) that the industrious and willing minded mariner might be capable thereof, in such sort, that for the most part, when the moone and fixed starres appeare, hee might bee able hereby to know what longitude he is in (euen at sea) more truly then many haue done by their dead reckoning, in saying out of the bay of Mexico to the Azores, or from Newfound land to England, or almost from the Azores to England. But on land, the longitude might by this meanes be found, as exactly as the latitude hath beene by many obseruers at sea. And so, opportunities of obseruation with meete instruments on shore not being neglected, (especially in long voyages farre Eastward or Westward) many most notorious errors in the longitudes of places would soone be corrected, where with the most excellent arts of Geographie, & Nauigation are verie much blemished. For who that loueth truth, can patiently endure to heare the Mariners common, and constant complaint of 150, or 200 leagues error in the distance betweene the bay of Mexico and the Azores: or (that which is yet most intollerable and monstrous) of 600 leagues difference in the distance betweene Cape Mendosino and Cape California, some making that distance to be 12 or 13 hundred leagues, where others will haue it, and that more probablie, to be no more then sixe or seuen hundred.

But forasmuch as the charge, though not great (to speake of) of prouiding meete meanes for supplie of these wants in the courses and longitudes, but chiefly in the latter, exceedes the meane abilitie of the most part of them that are most addicted to these vngainfull studies (I must not say vngratefull, albeit in these dayes they proue most vnprofitable to their greatest louers:) Therefore for my part they are like to rest, as they are vntouched, and onely commended vnto a kinde of hope (whether vaine or no I know not) of some Mecœnas at length of munificent spirit to be raised vp, though not to do as that magnificall Tycho in his Vraniburg, as well by his owne high reach of wit and learning, as by a bountifull hand to his assistants and followers, yet at least to haue some due consideration, both of these, and of such other wants and imperfections as yet remaine in so great and excellent an art as this of Nauigation is, that it may haue some increase, like as Astronomie hath much aduancement by Tycho Brahe alone, who for his deserued renowne cannot be too oft named.

Doubtles there is no man (cõsidering that the art of Astronomy, which mounteth up vnto the heauẽs doth minister aid vnto the

this of Nauigation which courseth vpon the waters) can denie the excellencie thereof, or the profitablenesse either. But if he will, my purpose is not to stand vpon it, nor to conuince him by reasons, by records, or by the more wonderfull discoueries in this our age, made to the furthest parts of all the earth, and round about the whole compasse of the same, whereby we haue beene made partakers of the most rare and richest commodities and treasures of the vtmost Indies, and Ilandes of the world, and they likewise haue participated with vs (or els they haue had the more wrong) in the most precious treasures of heauenly trueth. All which, and much more then can bee thought of, or now spoken, performed chiefly (next vnder Gods prouidence) by the rules and directions of this art, who seeth not that by how much the more excellent, and vnto mankinde abundantly profitable it is, so much the lesse ought any notorious error to be tolerated therein, and so much the more ought all whome it may concerne (yea but in good will onely, if it may do good) to endeuour themselues that it may be brought to the highest pitch of perfection. I know not then if any one be vnto so excellent an enterprise drawne on, to giue the best furtheraunce in him lyeth, why he should for his labour fall into any daunger of reprehension at all. Yet it may be, I shall be blamed by some, as being to busie a fault-finder my self. For when they shall see their Charts and other instruments controlled, which so long time haue gone for currant, some of them perhappes will scarcely with pacience endure it. But they may be pacified, if not by reason of the good that ensueth hereupon, yet towards me at the least, because the errors I poynt at in the chart, haue beene heretofore poynted out by others, especially by Petrus Nonius, out of whom most part of the first Chapter of the Treatise following is almost worde for worde translated; I for my part desiring rather that faults should be found by others then by my self, and labouring much more, as for a thing much better, and farre more needfull, and profitable to be a fault mender, then a fault-finder.

Or els I may so much the more be misliked, because in seeking to amend, some will thinke I take vpon me too much: For some will say, and of those perhappes that haue beene employed in sea affayres all their life long, that all this we go about is more then needs. For they without all this ado, haue euer performed their charge with good successe and are now too olde to giue eare to these innouations. But other seafaring men, who acknowledge the need hereof, are ashamed peraduenture to receyue (as it were) either correction from the schooles, or direction from the land and therefore stick not to condemne Vniuersities and all in comparison of their manifold experiments. Others also as more indifferent for the matter, will haue a fling yet at the person, thinking this reformation which is professed, to spring out of other mens fountaines. Which all (because we are now about a worke of amendment) must also (if they will heare reason) amend their opinions. For the first which seeme most vnreasonable, do not consider being addict to these vnreformed instruments, how like they are vnto those auncient maisters of shippes, whom M. Bourne maketh report of, who not many yeares since, wedded likewise to their accustomed vsage, haue mocked them that haue vsed Charts, or Crosse staues, saying they cared not for their sheepes skinnes, they could keepe a better account vpon a bourd: and them that obserued the Sunne or starres for finding the latitude, they would call sunshooters, and starre shooters, and aske if they had hit it. But marke what commeth hereof: for one of these maisters was he as I take it, of whom an ancient seaman (yet liuing as I thinke) once tolde me, who hauing vndertaken the charge of conducting a shippe from England to Saint Michaels (the first of the Azores) and after long seeking, vnt able to find that Iland, for shame and sorrow cast himselfe ouerbourd. Wherefore these men if they consider it well, haue no cause to boast of successe without skill, but to thanke God for both, that is, for their great and often good happe and safetie, and for their skill also were it smaller then indeed it is. For I will do them no wrong, but do freely graunt and acknowledge, that from any one place to other, the course, height and distaunce may be truly set downe

in

in the ordinarie Chart, wherein the Rumbes are right lines, and the degrees of latitude euery where aquall: and ſo by that Chart they may ſaile truely inough from hence to Ruſſie *or* Iſland, *or any other place. But if by the way they ſhould croſſe ouer from the one to the other, following the direction that their Chart ſheweth them, they cannot but erre a great deale, either in courſe, or diſtance, or both, eſpecially in thoſe Northerly nauigations. Why then ſhould they where there is daunger of wandring, refuſe help of any that is willing to ſhewe a better courſe? But to come vnto thoſe that may obiect I do but* actũ agere, *in doing no more then hath beene done alreadie by* Gerardus Mercator, *in his vniuerſall mappe many yeares ſince: and in publiſhing ſomething already publiſhed by* Iodocus Hondius, *in his greater mappe of the world and of Europe, now of late: I muſt aunſwere, that indeed by occaſion of that mappe of* Mercator, *I firſt thought of correcting ſo many and groſſe errors and abſurdities as hereafter are ſhewed in the Sea chart, by increaſing the diſtances of the Parallels, from the equinoctiall towards the Poles, in ſuch ſort, that at euery point of latitude in the Chart, a part of the Meridian might haue the ſame proportion to the like part of the Parallel, that it hath in the globe. But the way how this ſhould be done, I learned neither of* Mercator *nor any man els. And in that poynt I wiſh I had beene as wiſe as he in keeping it more charily to my ſelf. For ſo perhappes it might haue beene more beneficiall vnto me: neither ſhould any man haue had cauſe to thinke at the firſt ſight of the fourth Chapter of this booke, that all I haue there ſet downe is ſtolne out of one of the foreſaid mappes of* Iodocus Hondius. *But were I brought before a Iudge, I ſhould for my abſolution, and* Iodocus *his condemnation, make the contrarie to appeare, and that by his owne confeſſion in his letters to me, and to a friend of mine which I haue to ſhewe written in Latine with his owne hand: To me his writing in Engliſh is thus much in effect.*

viz. The booke of the Sea-chart.

I heare that you are ſomewhat offended with me, becauſe I haue taken thoſe fewe things out of your hand-written booke, whereas I promiſed you that I would not publiſh it: which alſo I would in no wiſe doe without your leaue. For it ſomething grudged my conſcience, euen to publiſh this little, if the diſtance of places would haue ſuffered me conueniently to ſend letters vnto you. I was purpoſed to haue ſet this forth vnder your name: but I feared that you would be diſpleaſed therewith, becauſe I haue but rudely and without elegancie tranſlated it into Latine. Truely I tolde all my friends plainly that you are the Author thereof, and I tell them ſo ſtill, &c.

And in his Letter to maſter Briggs *now profeſſor of Geometrie in* Greſham *College, he writeth thus being turned into Engliſh.* I haue written to *M. Wright* in excuſe of my ſelf, I am verie ſorie that he is angrie with me for that cauſe. I pray you learne of him how he is affected towardes me, and write back vnto me, and excuſe me vnto him as much as you can. I would haue publiſhed his whole booke for the common good, if I might haue done it without breach of my faithfull promiſe. And ſurely my conſcience grudged to publiſh euen this little which I haue taken out: but the profit thereof moued me, &c. At *Amſterdam* from the ſigne of the ſick Pope. *The trueth is that at his owne inſtant requeſt, when he wrought here at London, ſome of my friends alſo procured by his flatterie, perſwading me thereto, I was content to let him haue this booke for a fewe dayes to peruſe: he alſo aſſuring me vpon his faith and credit, that he would not publiſh it, or any part thereof without my knowledge and conſent. But how well and honeſtly he hath performed that proteſtation, grounded vpon faith & credit, the world may now ſee: and how thankefull he hath beene to me for that which hath beene ſo profitable and gainfull vnto himſelf, as may appeare by ſo common ſale of his mappes of the world, and of* Europe, Aſia, Africa, *and* America, *(al which had bene yet vnhatched, had he not learned the right way to lay the groundworke of them out of this booke) I my ſelf know too well. But let him go as he is.*

Now if any ſhall think it to be beyond a land-mans skill, to find

finde faults in matters belonging to the ſea mans art and profeſſion they muſt know if they be yet to learne, that one that is but reaſonablie acquainted with Geometrical conceits, may as well, if not better then moſt ſea men, know the nature and propertues of the ſpherical forme of the earth and ſea, with all conſequents and dependaunces thereof. By conſideration of which, the true vnderſtanding and reaſon of the nautical planiſphare or Sea-chart, may by him that hath beene but meanely conuerſant in Mathematicall meditations be better apprehended, then otherwiſe it can by the ſea faring man, though he ſpend his whole life in ſailing ouer all the ſeas in the world. The like may be ſaid of the Croſſe ſtaffe, and Compaſſe, and of the regiments or tables of declination of the Sunne and fixed ſtarres, and of all other principall meanes and inſtruments ſeruing for nauigation. But it is ſtraunge to ſee, the difference of things that in this worlde is made by the difference of hands from which they are to be receyued, howſoeuer the things themſelues be. For let Hannibal *a Captaine diſcourſe of warlike affaires, be it neuer ſo diſorderly and out of reaſon or ſeaſon, yet all (forſooth) muſt needs be of great diſcretion and wiſdome becauſe he hath handled that which he ſpeaketh of. But let* Phormio *a Philoſopher ſpeake of the ſame, at the leaſt in the hearing of* Hannibal, *be his Oration furniſhed & beautified with neuer ſo much reading, learning, iudgement and eloquence, yet muſt he (there is no remedie) be either a foole or a mad man for his hire. So by all likelihoode, the caſe will ſtand with this poore Treatiſe of mine which if it had come forth vnto publike view, from out of the boſome (as once it was like) of a maiſter at ſea, of great reputed excellencie, it had no doubt then found the fauour, which like inough now it ſhall want: all winds then would haue ſweetly blowne it into the pleaſanteſt hauen of euery mans (at leaſtwiſe of euery ſea mans) fauourable entertainment. I ſhall therefore with their patience ſet downe the matter as it was, that none may miſtake a trueth, which is daughter, not onely of time, but of occaſion, as hereby may appeare. It is not vnknowne to ſome of good place and reckoning, that one of the ſkilfulleſt nauiga-*

nauigators (as he was by many accounted) of our time and Nation, who died in Sir Frauncis Drakes *laſt voyage, when he came to that extremitie of ſickneſſe, that he ſaw there was no other way but one with him, was reported to haue gathered and bound together into a bundell all his nautical notes and obſeruations, and to haue caſt them into the ſea. But ſoone after notwithſtanding that foreſaid report, there came more comfortable newes by a Captaine that was familiarly acquainted and conuerſant with him in that voyage, and during the whole time of his ſickeneſſe, in whoſe armes alſo he died: who moning ſome ſpeach vnto him touching ſomething of ſir* Frauncis Drakes *that might then after his death be looked for to be brought to light, concerning Nauigation: Tuſh (ſaith he) for that matter there is not much to be looked for at his hands, hee had little skill in that art. Why? and will your ſelf then do any thing? quoth that Captaine. Whereupon this great nauigator drewe forth a booke out of his boſome, and deliuered it vnto this captaine not long before his death. This booke was ſhewed by the ſame Captaine to the R. Honourable the L. high Admirall of England in the* Cales *voyage, as being made by that famous Nauigator, which his Lordſhip alſo (as it was reported) thought good ſhould be peruſed and publiſhed. Theſe newes moued ſome expectation of that booke: ſo as the right Honourable, and my verie good Lord the Earle of Cumberland, hearing of it, was deſirous alſo to haue a ſight thereof, and remembred me vnto that Captaine, as one not inſufficient to perуſe and correct the ſame. And hereupon the booke was brought vnto his Lordſhip, at the time and place appointed at Weſtminſter, and was there alſo deliuered vnto me, to be peruſed and corrected. Hauing therefor opened it, & beginning a litle to turne ouer the leaues, to take ſome generall view what matter mought be conteyned therein: I firſt eſpied a Diagramme, the like whereof I knewe verie well I had made in a booke of mine. And herewithall I was the more moued to ſee if there were any more that I could know as well as the former: turning ouer therefor two or three leaues more, I preſently eſpied another Diagramme alſo, where-*

with I was as well acquainted, as with the former: for I found not onely the very ſame Diagramme, but (that which made me the more to marualle for the preſent) following alſo in the ſame order as I well remembred it did in my booke. Being therefor yet more earneſtly ſtirred vp hereat, and wondering what the reaſon mought be, that we ſhould thus agree, I betooke my ſelf to the reading of that booke. And looking firſt vpon the firſt leafe thereof, and afterwardes in many other places, I found it euery where to agree with mine, and to be a copie of the ſame booke worde for worde, which I made and preſented vnto his Lordſhip almoſt ſeuen yeares before, as the next morning it plainly appeared both to his Lordſhip and to the captaine himſelf that brought it, by comparing it in all poynts with the originall exemplar of the ſame booke, which I then brought vnto his Lordſhip.

One crone there remaineth which may ſeeme more iuſt then the reſt, and yet had I almoſt forgot it: namely, in that I haue had in this treatiſe no regard of the parallax of the Sunne, both in making and vſing the table of the Sunnes declination. But the refraction of the Sunne making him to appeare higher then he is, may ſtand auntwerable for it without error eaſily obſeruable at ſea. Notwithſtanding, I graunt it to be the exacteſt way (eſpecially on land) to haue conſideration both of paralax and refraction: but firſt there was found by obſeruation, certaine rules of this refraction, (whereto leyſure and other needfull meanes haue not hitherto ſerued me) for as good it is to haue conſideration of neyther, as of the paralax onely: and no great matter if both be neglected at ſea, where (in mine opinion) he quites himſelfe as a verie good obſeruer, that ſhall not in obſeruing the height of the Sunne, or ſtarres, erre more then twiſe ſo much as can ariſe by neglect of both refraction and paralax together. But I feare that whileſt I labour to ſatisfie all, I ſhall offend ſome as making too long a Præface to ſo ſmall a volume, I will therefor haſten to an end, onely ſhewing the ſumme of this treatiſe: which I thought good to offer vnto your view, as a compendious repreſentation of all that followeth, and rather to ſet

ſet it apart by it ſelf, then to include it as I was purpoſed within this præface, which is beyond his bounds alreadie: and therefore here I will commit the fauourable reader as my ſelf, vnto the protection of the Almightie.

The ſumme of the Treatiſe following.

THe Treatiſe following containeth foure principall parts, whereof the firſt may be called Hydrographical, wherein are ſet downe the errors of the common Sea chart, with right-lined rumbes and degrees of latitude euery where equall: then the way to auoyd theſe errors is geometrically demonſtrated, and out of this a Table is calculated, and the vſe thereof ſhewed, for the true and eaſie dividing of the Meridians in the Chart into tennes of minutes, or ſixth parts of degrees of latitude, proportionally increaſing towards the Pole. Whereto is adioyned as ariſing from thence the Table of Rumbes ſhewing by what points of longitude and latitude each Rumbe is to be drawne from the equinoctiall, till you come within a minute of the pole: with help of which Table, the Rumbes may in any Chart, Mappe, or Globe, much more truely be deſcribed, then by thoſe mechanicall wayes long ſince publiſhed by Petrus Nonius, *or lately practiſed by ſome Globe-makers in England. After this followeth, a moſt plaine and ſenſible demonſtration of the diſagreement of the common Sea-chart, and of the agreement of the Globe with the chart before deſcribed, the vſe of which chart is ſhewed in the Chapter next following: where alſo (the longitudes and latitudes of any two places being giuen) the way is ſet downe how to find their diſtance, meaſured either in the ſegment of the rumb, or in the arch of the great circle intercepted betweene them both mechanically with ruler and compaſſe, and mathematically by the doctrine of triangles, whereby it may without much difficultie be conceyned, how nauigation might by Arithmetical calculation onely, be performed without Chart or Globe, onely the*

the longitudes and latitudes of places being knowne.

The ſecond principall part of this Treatiſe may be called Magneticall, becauſe it intreateth of the variation of the Compaſſe, ſhewing how the ſame may be found at ſea (the latitude being giuen) by one obſeruation of the Sunnes height and point of the Compaſſe whereupon he is at the ſame inſtant, before or after noone with help of the Globe or Aſtrolabe. Which way of finding the variation is alſo exemplified with a Table of ſuch obſeruations as I tooke both at ſea and on ſhore, in the voyage of the right Honourable the Earle of Cumberland, in the yeare 1589. And becauſe the Globe and Aſtrolabe are ſuch inſtruments, as euery one cannot eaſily haue at Sea, I haue alſo ſhewed how (by the Sunnes point of the Compaſſe, or Magnetical Azimuth, and altitude giuen by obſeruation) the variation may be found, either mechanically, with ruler and compaſſe, or mathematically by the doctrine of triangles, and arithmeticall calculation.

The third part may be called Geometricall, intreating of the Croſſe ſtaffe, and ſhewing how ſuch errors may be auoyded, as haue beene commonly committed in the vſe thereof, either by reaſon of the paralax, or eccentricitie of the eie, or by the height of the eye aboue the water, or by the paralax of the Sunne.

The fourth and laſt part may be called aſtronomical, wherein my chiefe intent was to corect the errors that are in the ordinarie Tables of declination of the Sunne, and fixed ſtarres. To which end there is firſt ſet downe a table of the declination of euery minute of the eclipticke in degrees, minutes & ſeconds, calculated for the greateſt obliquity of the Zodiacke, as it is found by obſeruation in this age 23. deg. 30. min. Whereto is adioyned the vſe thereof for the readie finding of the place of the ſunne by his declination giuen: or contrariwiſe for finding the ſunnes declination, his place being firſt knowne. After this is ſhewed the way and meanes I vſed for exact obſeruation of the ſunnes Meridian altitudes: with a table of thoſe obſeruations, for foure yeares together, that ſo the more certaintie might be had of the declinations and places, and of the whole courſe and

motion

motion of the ſunne: and that by comparing together ſo many obſeruations, the ſunnes eccentricitie and apogeum might more aſſuredly be knowne. By knowledge whereof, the way was layd open for making the Ephemerides of the ſunne there ſet downe: without which the regiment of the ſunne next folowing (which I may commend as free from error obſeruable at ſea, and ſeldome differing one minute from obſeruation on land, and for which principally all the former paines was ouertaken) could not ſo eaſily haue beene made. Now if any ſhall thinke that moſt of this fourth part going before this regiment, might haue beene omitted, as being impertinent to the vſe of mariners, and exceeding their capacitie: I anſwere, that it was not my purpoſe, neither could I in all places, applie my ſelf to the moſt part of ſeamens capacity: knowing many that would not be content with this regiment alone, but that deſired more to know the root from whence this fruit grew: whoſe deſire I was alſo willing to ſatisfie as I could for the preſent, hauing ſeldome had a more conuenient ſeaſon for ſuch a purpoſe. Then followeth a table of 32 principall fixed ſtarres about the aequinoctial, that haue beene moſt commonly knowne, and obſerued by ſeamen, with their declinations corected: and another table of as many more of the notableſt ſtarres about the Pole is thereto annexed, with their diſtances from the pole corected alſo, & verified by diligent obſeruation on land. To theſe is added a table of the ſunnes right aſcenſions (reſolued into houres & minutes) for euery day of the yeare with the vſe therof, for finding at what houre any of thoſe ſtarres commeth to the Meridian at any time of the yeare: that hereby the mariner might know at all times, when they come to the meridian, & ſo the eaſilier learne to know & obſerue them. Laſtly, I thought it not impertinent to adioyne to this treatiſe, that which gaue the firſt occaſion of writing the ſame, that is the right honorable the Earle of Cumberland his voyage to the Azores performed in the yeare 1589. wherein his Lo. tooke the towne and platforme of Fayall. And ſo for further ſatisfaction in euery one of theſe particulars, I referre the friendly reader to the treatiſe it ſelfe now folowing.

Fare well.

A correction of Errors.

Till the Printer had thus farre proceeded, I was purposed to haue published the whole Table before mencioned, in such sort as I had made it, (supposing a Meridian of the nauticall Planisphare to be diuided, beginning at the aequinoctial) into such parts whereof a minute of the aequinoctial containeth 10, 000. and setting downe by which of these parts euerie minute of latitude is to be drawne, till you come within a minute of the Pole.

But vpon farther aduice it was thought more meet to abridge the same as followeth, to euery tenth minute, & to cut off throughout the Table the three first figures towards the right hand, meaning not at this time to trouble thee with more then mought be of vse, for the true diuiding of the Meridian in the Sea Chart into degrees, and sixt parts of a degree, without sensible error which may be sufficient for the greatest sort of Sea Charts or Maps, that hitherto haue beene commonly vsed.

This Table is diuided into two columnes, whereof the first containeth degrees, and tennes of minutes, of the Meridian of the nauticall planisphare, beginning at the aquinoctial. The second columne containeth equal parts of the same Meridian, beginning likewise to be numbred from the aequinoctial: (of which parts euery minute of the aequinoctial is vnderstoode to containe 10.) and sheweth how many of these parts are answerable to any degree or Decade of minutes of latitude, in the nauticall Planisphare or Sea Chart.

The vse hereof followeth after the Table.

A Table for the true diuiding

1 Col.	2 Col.	1. Col.	2. Col.	1 Col.	2 Col.
De. Mi.		De. Mi.		De. Mi.	
0 10	100	5 10	3104	10 10	6132
0 20	200	5 20	3205	10 20	6234
0 30	300	5 30	3305	10 30	6335
0 40	400	5 40	3405	10 40	6437
0 50	500	5 50	3506	10 50	6539
1 0	600	6 0	3606	11 0	6641
1 10	700	6 10	3707	11 10	6743
1 20	800	6 20	3808	11 20	6845
1 30	900	6 30	3908	11 30	6947
1 40	1000	6 40	4009	11 40	7049
1 50	1100	6 50	4110	11 50	7151
2 0	1200	7 0	4210	12 0	7253
2 10	1300	7 10	4311	12 10	7355
2 20	1400	7 20	4412	12 20	7458
2 30	1500	7 30	4513	12 30	7560
2 40	1601	7 40	4614	12 40	7662
2 50	1701	7 50	4715	12 50	7765
3 0	1801	8 0	4815	13 0	7868
3 10	1901	8 10	4916	13 10	7970
3 20	2001	8 20	5018	13 20	8073
3 30	2101	8 30	5119	13 30	8176
3 40	2201	8 40	5220	13 40	8279
3 50	2302	8 50	5321	13 50	8382
4 0	2402	9 0	5422	14 0	8485
4 10	2502	9 10	5523	14 10	8588
4 20	2602	9 20	5625	14 20	8691
4 30	2703	9 30	5726	14 30	8794
4 40	2803	9 40	5827	14 40	8897
4 50	2903	9 50	5929	14 50	9001
5 0	3004	10 0	6030	15 0	9104

of the meridians in the Sea Chart.

1. Col. De Mi	2. Col.	1. Col. De Mi	2 Col	1 Col De Mi	2. Col.
15 10	9208	20 10	12358	25 10	15610
15 20	9312	20 20	12464	25 20	15721
15 30	9415	20 30	12571	25 30	15832
15 40	9519	20 40	12678	25 40	15942
15 50	9623	20 50	12785	25 50	16053
16 0	9727	21 0	12892	26 0	16165
16 10	9831	21 10	12999	26 10	16276
16 20	9935	21 20	13105	26 20	16388
16 30	10039	21 30	13213	26 30	16499
16 40	10144	21 40	13321	26 40	16611
16 50	10248	21 50	23429	26 50	16723
17 0	10353	22 0	13537	27 0	16835
17 10	10457	22 10	13645	27 10	16947
17 20	10562	22 20	13753	27 20	17060
17 30	10667	22 30	13861	27 30	17173
17 40	10772	22 40	13969	27 40	17285
17 50	10877	22 50	14078	27 50	17398
18 0	10982	23 0	14186	28 0	17512
18 10	11087	23 10	14295	28 10	17625
18 20	11192	23 20	14404	28 20	17738
18 30	11298	23 30	14513	28 30	17852
18 40	11403	23 40	14623	28 40	17966
18 50	11509	23 50	14731	28 50	18080
19 0	11615	24 0	14840	29 0	18194
19 10	11720	24 10	14950	29 10	18309
19 20	11826	24 20	15060	29 20	18423
19 30	11932	24 30	15170	29 30	18538
19 40	12038	24 40	15280	29 40	18653
19 50	12145	24 50	15390	29 50	18768
20 0	12251	25 0	15500	30 0	18884

A table for the true diuiding

1. Col. De Mi	2 Col.	1 Coll. De Mi	2 Col.	1 Col. De Mi	2 Col.
30 10	18999	35 10	22565	40 10	26358
30 20	19115	35 20	22688	40 20	26489
30 30	19231	35 30	22811	40 30	26621
30 40	19347	35 40	22934	40 40	26752
30 50	19464	35 50	23057	40 50	26884
31 0	19580	36 0	23180	41 0	27017
31 10	19697	36 10	23304	41 10	27149
31 20	19814	36 20	23428	41 20	27282
31 30	19931	36 30	23552	41 30	27416
31 40	20048	36 40	23677	41 40	27549
31 50	20166	36 50	23802	41 50	27683
32 0	20284	37 0	23927	42 0	27818
32 10	20402	37 10	24052	42 10	27953
32 20	20520	37 20	24178	42 20	28088
32 30	20639	37 30	24304	42 30	28223
32 40	20757	37 40	24430	42 40	28359
32 50	20876	37 50	24556	42 50	28495
33 0	20995	38 0	24683	43 0	28632
33 10	21115	38 10	24810	43 10	28769
33 20	21234	38 20	24938	43 20	28906
33 30	21354	38 30	25065	43 30	29044
33 40	21474	38 40	25193	43 40	29182
33 50	21594	38 50	25321	43 50	29320
34 0	21715	39 0	25450	44 0	29459
34 10	21836	39 10	25579	44 10	29598
34 20	21957	39 20	25708	44 20	29738
34 30	22078	39 30	25837	44 30	29878
34 40	22199	39 40	25967	44 40	30018
34 50	22321	39 50	26097	44 50	30159
35 0	22443	40 0	26228	45 0	30300

of the meridians in the sea Chart.

1 Col.		2 Col.
De	Mi	
45	10	30442
45	20	30584
45	30	30726
45	40	30869
45	50	31013
46	0	31156
46	10	31301
46	20	31445
46	30	31590
46	40	31736
46	50	31882
47	0	32028
47	10	32175
47	20	32322
47	30	32470
47	40	32618
47	50	32767
48	0	32916
48	10	33066
48	20	33216
48	30	33367
48	40	33518
48	50	33670
49	0	33822
49	10	33975
49	20	34128
49	30	34282
49	40	34436
49	50	34591
50	0	34746

1 Col.		2 Col.
De	Mi	
50	10	34902
50	20	35058
50	30	35215
50	40	35373
50	50	35531
51	0	35690
51	10	35849
51	20	36009
51	30	36169
51	40	36330
51	50	36491
52	0	36654
52	10	36816
52	20	36980
52	30	37144
52	40	37808
52	50	37473
53	0	37639
53	10	37806
53	20	37973
53	30	38141
53	40	38309
53	50	38478
54	0	38648
54	10	38819
54	20	38990
54	30	39162
54	40	39334
54	50	39508
55	0	39682

1. Col.		2 Col.
De	Mi	
55	10	39857
55	20	40032
55	30	40208
55	40	40385
55	50	40563
56	0	40741
56	10	40921
56	20	41101
56	30	41282
56	40	41463
56	50	41646
57	0	41829
57	10	42013
57	20	42198
57	30	42384
57	40	42570
57	50	42758
58	0	42946
58	10	43135
58	20	43325
58	30	43516
58	40	43708
58	50	43901
59	0	44095
59	10	44289
59	20	44485
59	30	44681
59	40	44879
59	50	45078
60	0	45277

A table for the true diuiding

1 Col.		2 Col.
De	Mi	
60	10	45478
60	20	45679
60	30	45882
60	40	46085
60	50	46290
61	0	46496
61	10	46703
61	20	46911
61	30	47120
61	40	47330
61	50	47541
62	0	47754
62	10	47967
62	20	48182
62	30	48398
62	40	48616
62	50	48834
63	0	49054
63	10	49275
63	20	49497
63	30	49720
63	40	49945
63	50	50171
64	0	50399
64	10	50628
64	20	50858
64	30	51090
64	40	51323
64	50	51557
65	0	51793

1 Coll.		2 Col.
De	Mi	
65	10	52030
65	20	52269
65	30	52510
65	40	52752
65	50	52995
66	0	53241
66	10	53487
66	20	53736
66	30	53986
66	40	54237
66	50	54491
67	0	54746
67	10	55003
67	20	55262
67	30	55522
67	40	55784
67	50	56049
68	0	56315
68	10	56583
68	20	56853
68	30	57124
68	40	57398
68	50	57674
69	0	57953
69	10	58233
69	20	58515
69	30	58800
69	40	59086
69	50	59375
70	0	59667

1 Col.		2 Col.
De	Mi	
70	10	59960
70	20	60257
70	30	60555
70	40	60856
70	50	61159
71	0	61465
71	10	61774
71	20	62085
71	30	62399
71	40	62716
71	50	63035
72	0	63357
72	10	63682
72	20	64011
72	30	64342
72	40	64676
72	50	65014
73	0	65354
73	10	65698
73	20	66045
73	30	66396
73	40	66750
73	50	67107
74	0	67468
74	10	67833
74	20	68202
74	30	68574
74	40	68950
74	50	69331
75	0	69715

SOME REMARKS ON THE MERCATOR CHART (1569).

REMARK A.

a) A copy of the Chart of the World by MERCATOR mentioned in the above Preface, is in the *Bibliothèque Nationale* of Paris ; a facsimile of this Chart is given in JOMARD's work entitled : *Les Monuments de la Géographie ou Recueil d'anciennes Cartes publiées en fac-similé.* Another fascimile, on a smaller size, appears in the *Géographie du Moyen-Age*, by LELEWEL.

The dimensions of MERCATOR's Chart of the World are : 2×1.26 metres (78.74×49.6 inches) (M. FIORINI : *Le projezioni delle carte geografiche*, Bologna, 1881).

b) From information supplied to the Bureau by M. DE LA RONCIÈRE, Conservateur de la Bibliothèque Nationale in Paris, and Vice-President of the Société de Géographie, a second original copy of MERCATOR's Chart of 1569 exists in Breslau and a third one in Nürnberg.

The International Hydrographic Bureau communicated with the Chief of the Nautische Abteilung in Berlin on this subject, and he kindly informed the Bureau that, from investigations made by his Department, only one copy of Gerhard MERCATOR's Chart published in 1569 is in existence in Germany ; this copy is in the Library of the City of Breslau. From this original, the Gesellschaft für Erdkunde of Berlin caused a certain number of heliographic fac-similes to be made in 1891 by the Imperial Printing Office, and put them on sale through the agency of the publishing firm of KÜHL in Berlin. The firm of KÜHL is no longer in existence and the reproductions are no longer to be found on the market, even second-hand.

So far as the other Nürnberg specimen of MERCATOR'S original Chart is concerned, nothing could be learnt about it ; but, in this connection it is recalled that Supplement N° 182 to *Petermanns Mitteilungen* included an article entitled : *Gerhard Merkator und die Geographen unter seinen Nachkommen* (Gerhard MERCATOR and the Geographers who followed him), by AVERDUNK and Dr J. MÜLLER-REINHARD, published by Justus Perthes, Gotha, 1914.

In this article MERCATOR'S work is fully dealt with, but, herein also, no allusion whatsoever is made to any original chart in Nürnberg.

REMARK B.

In its collection of historical documents the International Hydrographic Bureau has a reproduction of the Map of the World on MERCATOR's projection by Jodocus HONDIUS (*See* page 90 of the photostat reproduced above). However, the facsimile in the possession of the Bureau is that of a later edition issued at Amsterdam in 1608, the only known copy of which is in the Library of the Royal Geographical Society, London.

(Publications of the Royal Geographical Society : *Reproductions of Early Engraved Maps* - I. *The Map of the World on Mercator's Projection, by Jodocus Hondius, Amsterdam, 1608* - London, 1927).

REMARK C.

With reference to the first chart published on MERCATOR's projection, it is interesting to quote the following details extracted from the *Fac-simile Atlas to the Early History of Cartography*, by A. E. NORDENSKIOLD, Stockholm, 1889 :

"The first map on this projection, which has exercised such powerful influence on the progress of navigation, was published in 1569 by Gerhard MERCATOR. A long inscription on the map explains the principle of the new method of projection and its use for navigation, although the mathematical principles on which it is based, and the Tables necessary for its construction, were first published by Edw. WRIGHT in his important work : *The Correction of Certaine Errors in Navigation detected and corrected*, London 1599 ; 2d edition 1610.

of the meridians in the sea Chart.

1 Col.		2 Col.
De	Mi	
75	10	70104
75	20	70497
75	30	70894
75	40	71295
75	50	71703
76	0	72114
76	10	72530
76	20	72951
76	30	73377
76	40	73808
76	50	74245
77	0	74687
77	10	75134
77	20	75588
77	30	76047
77	40	76512
77	50	76984
78	0	77462
78	10	77947
78	20	78438
78	30	78937
78	40	79442
78	50	79955
79	0	80476
79	10	81004
79	20	81541
79	30	82085
79	40	82639
79	50	83201
80	0	83773

1 Col.		2 Col.
De	Mi	
80	10	84354
80	20	81945
80	30	85546
80	40	86158
80	50	86781
81	0	87415
81	10	88061
81	20	88719
81	30	89389
81	40	90073
81	50	90771
82	0	91483
82	10	92210
82	20	92952
82	30	93711
82	40	94486
82	50	95280
83	0	96091
83	10	96923
83	20	97775
83	30	98648
83	40	99544
83	50	100464
84	0	101409
84	10	102380
84	20	103380
84	30	104409
84	40	105471
84	50	106565
85	0	107696

1. Col.		2 Col.
De	Mi	
85	10	108865
85	20	110075
85	30	111328
85	40	112630
85	50	113982
86	0	115389
86	10	116856
86	20	118389
86	30	119993
86	40	121675
86	50	123444
87	0	125209
87	10	127180
87	20	129272
87	30	131498
87	40	133879
87	50	136437
88	0	139200
88	10	142205
88	20	145497
88	30	149139
88	40	153213
88	50	157834
89	0	163176
89	10	169501
89	20	177259
89	30	187284
89	40	201513
89	50	226223
90	0	*Infinite*

The vse of the former Table.

THe vse of this table for making the sea Chart, is this: ouerthwart the midst of the plaine superficies, whereuppon you will draw the lineaments of the Chart, describe a right line, (representing the equinoctiall circle) which you shall diuide into 360 parts or degrees, and crosse the same squrewise with right lines, by euery fift or tenth degree. Then take with your compasses the length of half the equinoctiall, (that is, 180 degrees) and setting one foote of your compasses in the mutuall intersection of the equinoctiall, with the perpendicular or meridian that passeth by either end of the equinoctiall, with the other foote make a pricke in the same perpendicular or meridian: the space contained betwext this pricke and the equinoctial, diuide first into three equall parts, and euerie one of these into other three, so haue you nine in all: and again euery one of these into three, so haue you 27 parts, and euerie one of these parts diuide into foure, so haue you 108 parts: And againe (if there bee space inough) diuide euerie one of these into 10 or 100. so shall you haue 1080, or 10800 parts. Then note euerie fift and tenth part with blacke lead, and set figures at them, beginning at the equinoctiall, and from thence proceeding northwardes and southwardes. Then looke what numbers stand ouer against each degree in this Table (omitting alwaies one or two of the first figures towardes the right hand) and at the same numbers of parts in the perpendiculars, make prickes on either side the equinoctiall: by which (pricks) draw right lines equidistant from the equinoctiall, for they shall be the parallels

"A full-size fac-simile of this Chart by MERCATOR, 1569, was published by JOMARD, and a copy on a considerably reduced scale by LELEWEL. The map scarcely appears to have been duly appreciated even by MERCATOR'S nearest friends and admirers.

"Walter GHYMM enumerates it among his works, but evidently without any idea of its real importance. Neither WAGHENAER nor Willem BARENTS employ it for the charts they published during the latter part of the 16th century. The length of time the reform introduced by *Magna Mercatoris* and WRIGHT'S *Errors of Navigation*, needed for its general adoption is made evident from the circumstance that all charts in *De Lichtende Columne ofte Zee-Spiegel*, published in Amsterdam by Jan JANSZ in 1653 and by Pieter Goos in 1658, are still drawn on the rectangular projection of MARINUS.

"The only printed maps of the 16th century known to the author, which are drawn on MERCATOR'S projection are :

"1569 : MERCATOR'S large map : *Nova et aucta orbis terrae descriptio ad usum navigantium emendata, accomodata..... Aeditum autem est opus hoc Duysburgi an. D.* 1569 *mense Augusto.* Its dimensions are : 2.0 × 1.26 m. A full-size fac-simile is published by JOMARD, but unfortunately with omission of several of the important inscriptions, for which LELEWEL'S *Géographie du Moyen-Age*, II. p. 225, may be consulted.

"1599 : A map of Henricus HONDIUS in *Navigatio ac Itinerarium Johannis Hugonis Linscotani.....* Hagae-Comitis 1599 (N. fig. 61). Among the other maps in this work one (*Delineatio chartae trium navigationum per Batavos ad Septentrionalem plagam*) is constructed on the equidistant polar-projection.

"1599 : The handsome map in Richard HAKLUYT'S *Principal Navigations*, 2d edition (N. T. L.), which is supposed to be the "new map" of which SHAKESPEARE speaks in *'Twelfth Night'* (Act III, Sc. 2). Mr. C. H. COOTE suggests that Edward WRIGHT is the true author of this map. It is one of the best general maps of the world of the 16th century. (Comp. *The voyages and works of John Davis the Navigator*, by Albert Hastings MARKHAM. Works issued by the Hakluyt Society, London, 1880, p. LXXV).

"The following Table shows how nearly the constants of the nets of graduations in the oldest maps constructed on MERCATOR'S projection, are calculated :

DISTANCE TO THE EQUATOR IN EQUATORIAL DEGREES

Parallel at	*Calculated for Mercator's projection (Assuming the Earth to be spherical)*	*On Mercator's map of 1569. (Jomard's copy)*	*On Hakluyt's map of 1599.*	*On Hondius' map of 1599.*
10°	10,05	10,1	10,1	10,1
20°	20,42	20,3	20,9	20,9
30°	31,47	31,0	31,3	32,0
40°	43,71	42,8	43,1	—
50°	57,91	56,5	57,2	—
60°	75,45	73,3	74,4	—
70°	99,43	96,3	99,0	—
80°	139,59	135,2	139,1	—

"As may be perceived, but little remains to be desired regarding the agreement between the numbers of the 2rd column and the corresponding numbers on HAKLUYT'S map. On this map the equatorial degree is = 0,55 m. m., and the greatest difference between the calculated and the observed equatorial distance only 1,05 × 0,55 = 0.6 m. m. At 80° the error amounts to 0,27 m. m. and, at 70°, to 0,24 m. m. On MERCATOR'S map the differences at 10° and 20° are insignificant. At 30° the distance from the equator falls short of the calculated number by 0,47, at 40° by 0,91, at 50° by 1,41, at 60° by 2,15, at 70° by 3,15 and at 80° by 4,39 equatorial degrees. Such a degree has here a length of 1,73 m. m. An error occurs, gradually increasing towards the pole, and evidently arising from the imperfection of the mathematical resources of the map-constructors in the middle of the 16th century. MERCATOR seems to have calculated the length of the intervals between every tenth degree of the parallel by means of the approximate formula :

$$P_{\varphi} + 10 - P_{\varphi} = \frac{10}{Cos\,(\varphi + 5)}$$

"The unity here is the length of the equatorial degree, and P_φ the equatorial distance on the map at the latitude φ.

"By this formula the following numbers are obtained :

DISTANCE FROM EQUATOR IN EQUATORIAL DEGREES.

The parallel at	*Calculated*	*Mercator's map (Jomard's copy).*
10°	10,04	10,1
20°	20,39	20,3
30°	31,42	31,0
40°	43,63	42,8
50°	57,77	56,5
60°	75,20	73,3
70°	98,86	96,3
80°	137,50	135,59

"Even here the agreement is not so complete as might have been expected, but the differences can be explained by engraving-errors or by stretchings in the paper."