THE SEAMANS SECRETS.

Deuided into 2.partes,wherein is taught the *three kindes of Sayling, Horizontall,Paradoxicall,and fayling vpon a great* Circle: also an Horizontal Tyde Table for the eafie finding of *the ebbing and flowing of the Tydes, with a Regiment newly calcula–* ted for the finding of the Declination of the Sunne and many *other most necessary rules and information, not heretofore set fourth by any.*

Newly corrected by the author *John Davis* of *Sandridge*, neere *Dartmouth*, in the Countie of *Devon*. Gent.

Imprinted at London by Thomas Dawfon, dwelling neere the three Cranes in the Vinetree, *and there to be solde.* 1607.

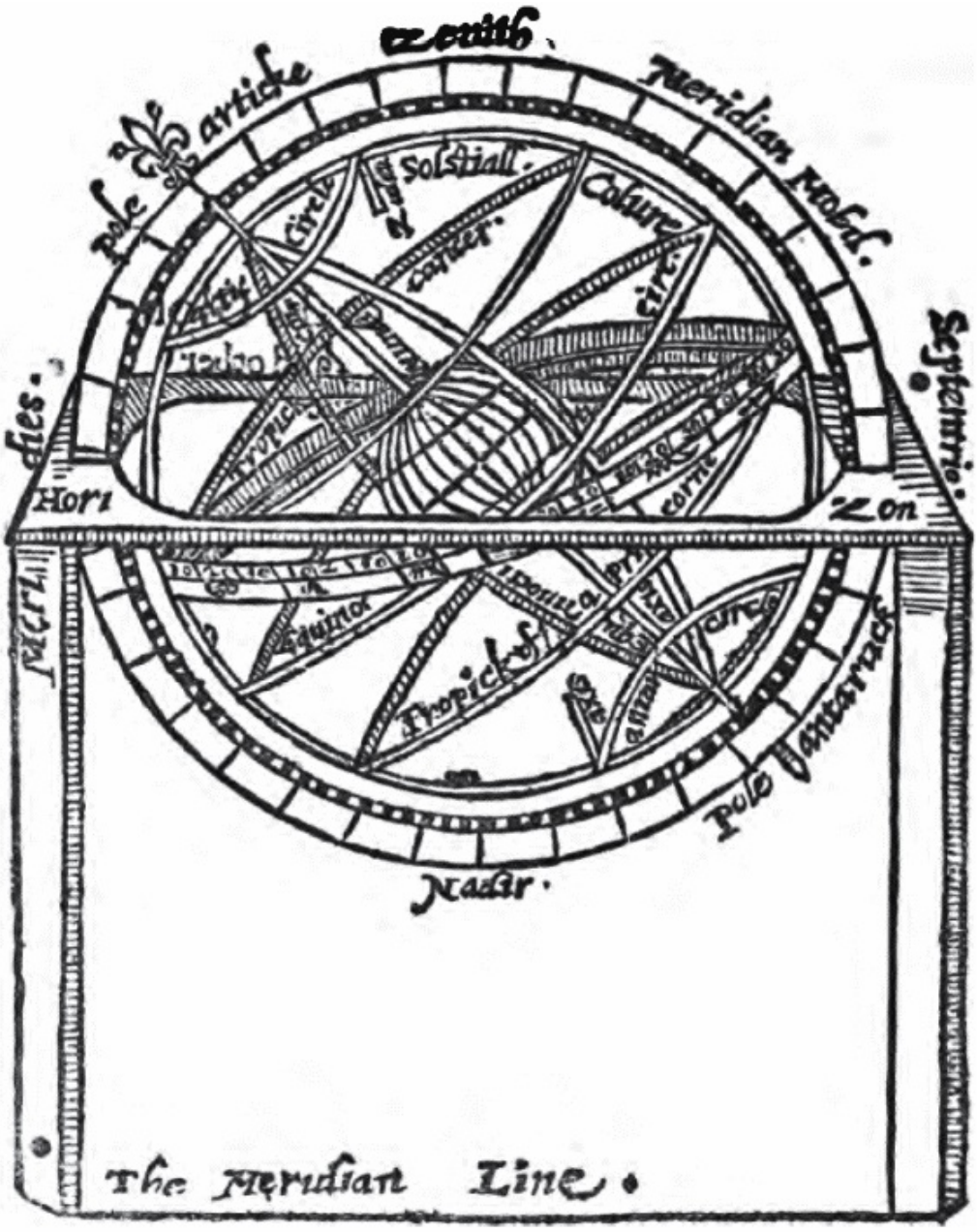
[FACSIMILE OF THE 1607 FRONTISPIECE]

THE
SECOND PARTE OF
THIS TREATISE OF
NAVIGATION.

WHEREIN IS TAVGHT THE NA-
ure and moft neceffary vfe of the Globe,
with the Circles, Zones, Climates, and other
diftinctions to the perfect vfe
of Sayling.

By which moft excellent Inftrument is performed
all that is needfully required to the
full perfection of all three kindes
of Nauigation.

[QUASI–FACSIMILE]


Zenith.
Meridian moſt.
pole artick
Solſtiall.
Colure
Septentrio.
dies.
Hori
Zon
Tropick
Equinox
Nadir.
pole Antartick
The Meridian Line.

THE

SECOND BOOKE OF THE SEAMANS SECRETS.

What is the Sphere ?

The Sphere is the solide body contained vnder one superficies, in the middest whereof there is a point or prick, which is the center of the Sphere from whence all right lines drawn to the circumference are equal the one to the other, whereby it is to be vnderstood that the centre of the Sphere is euenly placed in his midst, as that it hath like distance from al parts of the Circumference. And forasmuch as the Sphere is an instrument demonstrating vnto vs the vniversall ingine of the world, we must therefore vnderstand this center to be this terrestrial Globe wherein we haue our being, which compared to the celestiall Globe or heauēly circumference doth beare proportiō, as ye center to his circles, which earthly globe by the diuine mightie workmanship of God doth admirably hang vpon his center, being of equal distance from al parts of the circumference.

What are the distinctions of the Sphere ?

The Sphere is distinguished by tenne circles, whereof sixe are great circles, and 4 are lesser circles : whereof there are only 8 described vpon the body of the Globe, limiting the zones and motion of ye planets, as the Equinoctiall, the Ecliptick, Equinoctiall Colure, the Solsticiall Colure, the Tropick of Cancer, the Tropick of Capricorne, the Artick Polar Circle, and the Antartick Polar Circle. The Horizon and Meridian are not described vpon the body of the Globe,

but artificially annexed therevnto for the better perfection of his vse.

Which are the Great Circles and which the lesser?

The Equator, the Ecliptick, the 2 Colures, the Meridian and the Horizon are great circles, because they diuide the sphere into 2 equal parts.

The 2 Tropickes, the Polar circles, are lesser circles, because they diuide ye sphere into 2 vnequall partes.

What is the Equator or Equinoctiall ?

The Equinoctial is a great circle deuiding ye Sphere into 2 equal parts, leaning the one halfe towards the North, and the other halfe towardes the South, and is equally distant from both the Poles of the worlde 90 degrees, placed euenly betweene them, and described vpon them, this line crosseth the Horizon in the true points of East and West, and hath alwaies his own half aboue the Horizon, vnless it be vnder either of the Poles, for there the Equator is in the Horizon: it crosseth the Meridian at right Spherick Angles, and it also crosseth the Ecliptick line in the first minute of Aries and Libra, deuiding the Ecliptick and Horizon, and is also by them deuided into two equall partes. This line is also deuided into 360 equall partes or degrees, which are the degrees of Longitude,[1] beginning the account in the point of Aries, reckoning towards the East, concluding the number 360 in the place where the first account began: viz. where the Equator doth intersecte the Ecliptick in the first minute of Aries, vnder which Meridian S. Michels[2] one of the yls of the Assores to be placed in the geographical desumption[3] of the terrestriall Globe.

[1] Now called Right Ascension, and reckoned in *h. m. s.*

[2] See page 284, note.

[3] " Desumption" may be from " desume", an obsolete word for "to borrow". The first meridian, reckoning from St. Michael's, is thus borrowed from the idea of the first point of Aries being the initial point of celestial longitude.

What is the vse of the Equator ?

The vse of the Equinoctiall is to know the declination of the Sunne, Moone, and Stars, whereby the latitude of places is giuen, for that portion of the Meridian which is contayned betweene the Equator and the Center of the Sunne, Moone, or Starres, is their declination : also by the Equinoctiall is knowne the Longitude of places, for a quarter of a great Circle being drawne from the Pole to the place whose Longitude is desired, and so continued to the Equinoctiall, that degree and minute in which the quarter circle doeth touch the Equator, is the Longitude of the same place, or if you bring any place (that is described vpon the Globe) whose Longitude you would knowe, vnder the Meridian of the Globe, that degree of the Equinoctiall that is then likewise directed vnder the Meridian is the Longitude desired. When the Sunne cometh vpon the Equator, then the daies and nights are of one length through the whole worlde ; and then the Sunne riseth vpon the true point of East, and setteth upon the true point of West, and not els at any time. This circle being fixed in the firmament is moued with the first mouer in euery 15 degrees, by which accompt in 24 howers his motion is perfourmed. And here note that the degrees of the Equinoctiall have a double application, the one to time, and the other to measure : in respect of time 15 degrees make an houre, so that euery degree contayneth but 4 minutes of time, but when his degrees have relation to measure, then euery degree containeth 60 minuts being 20 leagues, of that euery minute standeth for a mile after our English accompt.[1]

But this allowance of 20 leagues to euery degree of the Equinoctiall, in sayling, or measuring of distances vpon the East and West Corses, is onely when you are vnder the same,

[1] It is not quite clear how Davis reckoned the length of his nautical mile. See *ante*, p. 257.

because the Equinoctiall beying a parallell, is likewise a great circle, and euery degree of a great circle is truly accompted for 20 leagues, or 60 miles.

But in the rest of the parallells where either of the Poles are eleuated aboue the Horizon, if there you saile or measure vpon ye Corses of east or west, there are not 20 leagues to be allowed to euery degree, because such parallells are lesser circles, therefore they haue the fewer number of leagues to euery degree : so that the further you depart from the Equator the lesser are the parallells, and the lesser that any parallell is, the lesser are his degrees, because euery circle containeth 360 degrees, and as the circles and degrees are diminished in their quantitie, in like sorte the distance answerable to such degrees must abate as their circles do decrease. And further know that the Equator is the beginning of al terrestrial Latitude, and the declination of the celestiall bodies.

What is the Ecliptick ?

The Ecliptick line is a great circle deuiding the Sphere into 2 equall partes, by crossing the Equator in an oblique sort, deuiding him, and being deuided by him into 2 equall parts, bending from the Equator towards the North and South 23 degrees and 28 minutes, beyng in the first minute of Cancer and Capricorne, there determining the Tropical limits, this line likewise deuideth the Zodiac by longitude into 2 equal partes, and is deuided togither with the Zodiac into 12 equall portions called signes, and euery of these signes is deuided vpon the Ecliptick into 30 equall partes or degrees, so that this line is deuided into 360 degrees, vpon which line the center of the Sunne doth continually mooue: this circle is described vpon his proper poles, named the Poles of the Zodiac, being in all his partes 90 degrees from either of them.

The Zodiac is a circle[1] contrary to all the other, for they are mathematicall lines, consisting only of length, without breadth or thicknes: but the Zodiac hath latitude or bredth 12 degrees,[2] whose limits are 6 degrees[3] of either side of the Ecliptick, wherein the Sun, Moone and Planets performe their motions and reuolutions, the center of the Sun onely keeping vpon the Ecliptick, but the other Planets have sometime North latitude, and sometime South latitude. And here you must vnderstand that the latitude of the Planets or Starres is that portion of the Eclipticall Meridian which is contained betweene [the] center of the Planet or Star and the Ecliptick line, and their longitude[4] is that portion of the line Ecliptick, which is contained betweene the said Meridian and the Eclipticall Meridian that passeth by the poles of the Zodiac and the first minute of Aries.

The 12 deuisions or signes of the Zodiac are these, Aries ♈, Taurus ♉, Gemini II, Cancer ♋, Leo ♌, Wirgo ♍, Libra ♎, Scorpio ♏, Sagittari ♐, Capricorne ♑, Aquarius ♒, Pisces ♓ : and these are their characters that stand by them.

The 7 planets that keepe within the limit of the Zodiac are these : Saturne ♄, Jupiter ♃, Mars ♂, Sol ☉, Venus ♀, Mercury ☿, Luna ☽; Saturne performes his course through all the degrees of the Zodiac once in euery 30 yeeres, Jupiter in 12 yeeres, Mars in 2 yeeres, the Sunne in 365 dayes and 6 houres, being one yeere, Venus and ☿ as the Sunne, and the Moone performeth her course in 29 dayes and about 8 houres, through all the degrees of the Zodiac.

And note that this naturall motion of the Planets in the Zodiac is from the West toward the East, the diurnall motion is violent, caused by the first mouer, or primum mobile, who in euery 24 houres doth performe his circular motion from the East to the West, carying with him al other inferiour bodies whatsoeuer.

[1] A zone? [2] 16 degrees. [3] 8 degrees.

[4] Now called right ascension.

What is the vse of the Zodiac ?

By the Zodiac and Ecliptick is knowne the Longitude and Latitude of any Celestial body, either Planets or fixed Starres, for a quarter of a great circle drawne from the pole of the Zodiac to the center of any Planet or Star, and so continued vntill it touch the Ecliptick ; that degree and minute where the said quarter circle toucheth the Ecliptick, is the longitude of the said body, which is to be accompted from ye first minute of Aries, for the longitude of Aries is the portion of the Ecliptick line, which is contayned betweene the eclipticall meridian passing by the poles of the Zodiac, and the first minute of Aries, and the ecliptical meridian which passeth by the poles of the Zodiac and the center of any Planet or Starre.

When the Planets are vpon the North side of the Ecliptick, they haue North latitude, and being South from the Ecliptick they haue South latitude.

Also the motions of the Planets, the time of any Eclipse, and the Sun's declinatio' by his place in the Ecliptick, are knowne by this circle, whose vse is very ample and to great purpose, for all astronomicall considerations.

What are the Colures ?

The Solstitiall Colure is a great circle passing by the Poles of the world, and the poles of the Zodiac, and the Solsticial points or first minute of ♑ (Capricorne) and ♋ (Cancer), cutting the Equinoctiall at right Spherick angles, in his 90 and in his 270 degrees.

The Equinoctiall Colure is likewise a great circle passing by the poles of the world and the Equinoctiall point of ♈ (Aries), and ♎ (Libra), and crosseth the equator in his first and 18 degrees, and these Colures doe intersect each other in the poles of the world to the right spherick angles.

What is the use of the Colures ?

Their vse is to distinguish the 4 principall seasons of the yere, Spring, Summer, Autumne, and Winter, deuiding the Equator and Ecliptick into 4 equall parts ; also that arke of the Solsticiall Colure which is included betweene the first minute of ♋ (Cancer) and the Equinoctiall is the Sunne's greatest declination towarde the North; the like arke being betweene the tropicall point of ♑ (Capricorne) and the Equator, is the Sunne's greatest South declination, being in these our daies 23 degrees 28 minutes.

What is the Tropick of Cancer ?

The Tropick of ♋ (Cancer) is one of the lesser circles deuiding the sphere into two vnequal parts, and is described vpon the pole Artick a parallell to the Equator 23 degrees 28 minutes from him, being the farthest limit of the Ecliptick bending towards the North, to which when the Sunne commeth, the daies are the longest to all those that inhabit in the North partes of the worlde, and shortest to the Southern inhabitants : betweene this circle and the Equator are included the 6 septentrionall signes ♈, ♉, ♊, ♋, ♌, ♍, in which signes during the time that the Sunne abideth, being from the 11 of March to the 13 of September,[1] he hath North declination, and then is the spring and summer to all such as inhabite in the North partes of the worlde : this circle doth touch the Ecliptick in the first minute of ♋, where the Sun beginneth his returne toward the South, where-vpon it tooke name Tropick, which signifieth conuersion or returne, by which point of the Ecliptick, the diurnall motion describeth this Circle.

What is the Tropick of Capricorne ?

The Tropick of ♑ (Capricorne), is one of the lesser circles

[1] Old Style. Now 20th March and 22nd September.

deuiding the sphere into 2 vnequall partes, and is described vpon the pole Antartick, a parallell to the Equinoctiall 23 degrees 28 minutes from him, being the farthest bending of the Ecliptick towards the South, to which when the Sunne commeth, the daies are then longest to all those that inhabite in the South parts of the worlde, and shortest to the Northern inhabitants : betweene this circle and the Equator are included the 6 southern signes ♎, ♏, ♐, ♑, ♒, ♓, in which signes during the time that the sunne abideth, being fro' the 13 of September to the 11 of March,[1] he hath South declination, and then is the Spring and the Summer to all such as inhabite the South partes of the worlde : and Autumne and Winter to all the inhabitants in the North partes of the worlde. This circle toucheth the Ecliptick in the first minute of ♑, by which point the diurnall motion describeth this parallel.

What is the vse of the Tropicks ?

By the Tropicks the Sun's declination is known, as also the tropicks by the Sunnes farthest motion towards the North and South, for so much as the Tropicks are distant from the Equator, so much is the sunnes greatest declination : and such as is the Suns greatest declining, such is the distance betweene the Tropicks and the Equator : they are also the limits of the burning zone, separating the burning and temperate zone, for betweene the two Tropicks is contayned the burning Zone.

What is the Artick polar Circle ?

The artick Polar Circle is one of the lesser circles deuiding the sphere into two vnequall partes, and described vpon the Pole Artick in parallell to the Tropick of ♋, having such distance from the pole as the Tropick hath from the

[1] Old Style. Now 20th March and 22nd September.

Equator, being 23 degrees 28 minutes, vpon which circle the Artick pole of the Zodiac is placed, which beying fixed in the firmament by the vertue of the first moouer is carried about with the heauens, by which motion this circle is described.

What is the Antartick polar Circle ?

The Antartick polar circle is opposite to the Artick, and parallel to the Tropick of ♑, being in all respects of such distance and description from and about the pole Antartick as the Artick polar circle is about the pole Artick.

What is the vse of the Artick and Antartick polar Circles ?

The vse of the 2 polar Circles is to show the distance of the poles of the Zodiac from the poles of the World ; for so much as the Solsticiall points are distant from the Equator, so much are the poles of the Zodiac from the poles of the Worlde : the circles doe also deuide and limit the temperate and frozen zones, for betweene the Tropick of ♋ and the Artick polar circle is contayned the Northern temperate zone, and betweene the Artick polar circle and the pole Artick, that is within the Artick polar circle, is contained the Northern frozen zone. Also betweene the Tropick of ♑ and the Antartick polar circle is included the Antartick frozen zone, and these are all the circles that are described vpon the body of the Globe.

What is the Meridian ?

The Meridian is a great circle passing by the poles of the Worlde, and by your Zenith, deuiding the Horizon into 2 equall parts, in the points North and South, it also deuideth the sphere with al the parallel circles therein contained into 2 equall partes, crossing them at right spherick angles. And this Meridian is not fixed in the firmament as the rest

of the circles are, for, if it were, then should it be mooued with the first mouer as the rest are, but it is not so : therefore the Meridian is manifested vpo' the Globe, by a circle or ring of copper fastened vnto the Globe, vpon the 2 poles, so that the Globe moueth round vpon his 2 poles within the Meridian. This Meridian is graduated in euery of his quarters into 90 degrees, by which his vse is perfourmed : and note that one Meridian may have many Horizons, yet euery Horizon hath but one Meridian, for if you trauaile South or North you keepe still vpon the same Meridian, yet in euery sencible differences of distance you shall enter into a change of Horizons, for there be as many Horizons as there be sencible differences of distance, and there be as many Meredians as there be sencible differences of distance, so that the difference be not vpon the points North and South, but this copper Meridian annexed to the Globe is to be applyed to all differences and distances whatsoeuer, as amply as if the number were infinite.

What is the vse of the Meridian ?

The vse of the Meridian is to know the highest ascending of the Sun, Moone, or Starres from the Horizon, for when they bee vppon the Meridian then are they farthest from the Horizon, and then is the most conuenient time to take the altitude of the Sunne or Starres, thereby to finde the Poles eleuation.

By the Meridian of your Globe is known the latitude and longitude of any place upon the Globe contained, for if you bring any place vnder the Meridian, the degrees of the Meridian do shew the latitude of the same, and that degree of the Equator which the Meridian doth crosse is the longitude, &c.

What is the Horizon ?

The Horizon is a great circle deuiding the heauens into 2 equall partes, the one half being aboue the Horizon is

alwaies in sights the other half is not seene, being under the Horizon, and therefore is called the finitor or limit of our sight ; for where the heauens and seas seeme to ioyne together, that is the Horizon : the Horizon is not fixed in the firmament, and yet is a fixed circle constant to his proper latitude, but because in the Globe one and the same Horizon may perfourme whatsoeuer is required to all the eleuations, the Horizon is so artificially annexed to the Globe, that by the motion of the Meridian, in the same there faulleth nothing in his vse, and the Horizons in all respects distinguished, as is the Sea Compasse. There are two kindes of Horizons, a right Horizon and an oblique Horizon. When the Poles are in the Horizon then it is a right Horizon, for then the Equator doth cut the Horizon to right angles, making a right Sphere and a right Horizon. An oblique Horizon is where either of the Poles are eleuated aboue the same, for then the Equator doth cut the Horizon to vnlike angles, making an oblique Sphere and an oblique Horizon, and although the Horizons be divers and many in number, for euery sencible difference of distance hath his proper Horizon, yet is the Horizon of the Globe so conueniently annexed there vnto, as that by the mouing of the Meridian in the Horizon, and by the Globe's motion in the Meridian, both the Horizon and Meridian are to be applyed as proper to all places whatsoeuer, and note that the place where you are is alwayes the center of the plaine superficiall Horizon.

What is the vse of the Horizon ?

The Horizon is the beginning of all altitude, for whatsoeuer is aboue the Horizon is sayd to haue altitude more or lesse, and by the Horizon such altitudes are giuen with helpe of the crosse staffe, for placing the crosse staffe at your eye, if by the one end of the transuersary you see the Horizon, and by the other end (at the same instant) you see the body observed, then doth the transuersary show vpon the

staffe the altitude desired. By the horizon the nauigable courses from place to place are likewise known, as also the quantitie of the rising and setting of the Sunne, Moone, and Starres, whereby is knowne the length of the daies and nights in all climats, and at all seasons. By the Horizon is knowne vpon what degree of Azumuth the Sun, Moone, or Starres are, when they may be seene, in what part of the Heauen soeuer, whereby the variation of the Compasse is found, and the Poles altitude may at all seasons be given.

Are these all the circles appertaining to the Globe ?

There are other circles which are fixed and doe properly appertaine to euery particular Horizon, as Azumuths, Almicanters,[1] the Artick and Antartick circles.

What are the circles of Azumuth ?

Circles of Azumuth, or verticall circles, are quarters of great circles, concurring together in the Zenith, as the meridians do in the pole, and are extended from the Zenith to euery degree of the Horizon, &c. And because they cannot be conueniently described vpon the Globe to bee apply ed to all horizons, therefore vpon the Meridian of the Globe there is a peece of copper artificially placed, to be remoued to any degree of the Meridian at pleasure, which peece of copper representeth the Zenith, and must alway be placed so many degrees from the Equator as the Pole is eleuated from the horizon: and vnto this zenith there is ioyned a quarter of a great circle called *Quarta altitudo*,[1] the end whereof doth continually touch the horizon, and is so ioyned to the Zenith, as that it may be moued round about vpon the horizon, and to euery part thereof at your pleasure. This *Quarta altitudo* is deuided into 90 degrees,

[1] Now called the Quadrant of Altitude. It is generally graduated so as to measure 18° *below* the horizon, that being the position of the crepusculum or twilight circle, where dawn begins and twilight ends.

being the distinction of all altitude, and beginneth the accompt from the horizon, which is the beginning of altitude, and concludeth 90 degrees in the Zenith, being the end and extreme limit of all altitude.

What are Almicanters ?

Almicanters[1] are circles of altitude, are parallel circles to the horizon, and are described ypon the Zenith as the parallels to the equator, are described vpon the Poles, of which circles there are 90 answerable to the distinctions of the *Quarta altitudo*, which are the degrees contained betweene the horizon and zenith ; these circles cannot be described vpon the Globe to bee applyed to euery horizon, but they are distinguished by the circular motion of the *Quarta altitudo*, for if I desire to see the Almicanter circle of 10 degrees, by mouing the *Quarta altitudo* round about the horizon, the Zenith degree of their quarter circle doth show the Almicanter desired in what eleuation soeuer.

What is the vse of these two circles ?

The *Quarta altitudo* perfourmeth the vse of both by the *Quarta altitudo* and Horizon ; the courses fro' place to place are knowne according to the true Horizontal position as hereafter shall plainly appeare : it also sheweth the degree of Azumuth, and observed altitude of any celestiall body, in what latitude soeuer. By the *Quarta altitudo* and horizon you may describe a paradoxall compasse vpon the Globe. The Pole's height is at all times thereby to be known, and the variation of the Compasse is thereby likewise giuen, as hereafter in the practise you shall be taught.

What are the Article and Antartick circles?

Euery Horizon hath his proper Artick or Antartick circle, those horizons that haue the Pole Artick eleuated aboue

[1] Almicanter is a circle parallel to the horizon, same as a parallel of altitude.

them haue their proper Artick circle, and those that haue the South pole eleuated haue their proper Antartick circle, the quantitie of which circle is according to the Pole eleuation, for if the Polo be much eleuated then is the Artick circle great, for the Poles altitude is the semidiameter of this circle; if the pole be in the Zenith then halfe the heauens is the Artick circle.

What is the vse of this circle ?

If the Sunne, Moone, or any Starres be within this circle they are neuer caried vnder the horizon during the time of their abode therein, whervpon it commeth to passe that such as trauaile far towards the North have the Sunne in continual uiewe, and those that inhabite vnder the pole (if any so doe) the Sun is in continuall sight for sixe moneths together, because the sixe Septentrionall signes are within the Artick circle, the Equator being in the horizon, &c.

There is another small circle which is called Circulus horarius, or the hower circle, to be annexed to the Meridian of the Globe, for the perfection of his vse ; this circle must be deuidcd into 24 equal partes or howers, and those againe into such parts us you please for the better distinction of time : this circle, vpon which pole there must be fastened an Index to moue proportionably, as the sphere upon any occasion shall be moued.

There is also an halfe circle, called the circle of position, which sith it serueth to no great purpose for Nauigation I here omit, and thus is the Globe fully finished for the perfection of this vse.

What are the Poles of the world.

Those are two Poles; the North artick Pole, and the South or Antartick Pole, which poles are immouable prickes fixed in the firmament, whereupon the sphere is moued by vertue of the first mouer, and are the limits of the Axis of the

world, as also the extreme terme or band of all declination, being 90 degrees from all partes of the Equator.

By the raysing of the Pole from the Horizon is knowne the parallell or latitude of our being, it also giueth the quantities of the Artick circle, and the obliquetie of the sphere.

What is the Axis of the world ?

The Axis of the world is a right line passing by the center of the sphere, and limited to the circumference about which the sphere moueth, and is therefore called the Axis of the Sphere ; and as all lines comensurable are limited betweene two pointes or pricks, so is the Axis of the world, and those two limiting pricks are called the Poles of the world.

What are the Poles of the Zodiac ?

The zodiac hath likewise two Poles, Artick and Antartick, being two prickes fixed in the firmament, limiting the Axis of the zodiac, and are distant from the Poles of the world 23 degrees 28 minutes, which Poles by the motion of the Sphere doe describe the Poles circle, perfourming their motion about the Poles of the worlde in euery 24 howers, by vertue of the first mouer. Vpon these poles the Ecliptick and Zodiac is described, also a quarter of a great circle graduated into 90 degrees, beying fastened to either of these Poles and brought to the center of the Star, sheweth by that graduation the latitude of the same Starre, and where the quarter circle toucheth the Ecliptick, that is likewise his longitude, also the 7 planets do perfourme their naturall reuolutions vpon these poles, whose motion is from the West towards the East, contrary to the motion of the first mouer.

What is the Axis of the Zodiac ?

The Axis of the zodiac is a right line passing by the center of the sphere, and limited in the circumference, whose

limiting poyntes are the Poles of the Zodiac, and this Axis is moued by the Sphere as are his Poles.

What are the Poles of the Horizon ?

There are two poles of the Horizon, which are the limits of his perpendicular dimetient, being equidistant 90 degrees from all parts of the Horizon, and are the extreme limits of all altitude. That polo which is in the vpper Hemisphere is called the zenith, and his opposite Pole is called the nadir; they are extended in the firmament bat not fixed in it, for they moue neuer, but remaine alwaies stable to their proper horizon, which could not be if it were fixed in the firmament, for then should they be mooued with the firmament as the rest are. By the helpe of these poles is found the

Azumuth and Almicanter of any celestiall body; for a quarter inch deuided into 90 degrees, and fixed to the Zenith, as is the *Quarta altitudo*, beyng mooued to any celestiall body, doth by those degrees shewe the almicanter or altitude of the same body from the Horizon, and that parte of the Horizon which the quarter circle toucheth, is the Azumuth of the same body, alwaies provided that the Zenith stand answerable to the poles eleuation, that is, so many degrees from the Equator as the Pole is from the Horizon.

How many Zones are there ?

There are 5 zones—2 temperate zones, 2 frozen zones, and one burning zone. The burning zone lieth betweene the two Tropicks, whose latitude is 46 degrees 56 minutes, which zone by auncient Geographers is reported to be not habitable, by reason of ye great heat which there they supposed to be, through the perpendicularitie of the Sunne beames, whose perpetuall motion is within the said zone, but we finde in our trauels, contrary to their reporte, that it is not onely habitable, but very populous, containing many famous and mightie nations, and yeeldeth in great plentie the most purest things that by natures benefits the earth may procreate: twice I have sayled through this zone,[1] which I found in no sorte to bee offensive, but rather comfortable vnto nature, the extremitie of whose heat is not furious but tollerable, whose greatest force lasteth but 6 howers, that is, from 9 of the clocke in the morning vnto 3 in the afternoone, the rest of the day and night is most pleasing and delightful, therefore they did nature wrong in their rash reporte.

Of the frozen Zones.

The frozen zones are contained within the polar circle, the Artick frozen zone within the Artick polar circle, and the

[1] In his voyage in the *Desire*, 1591 to 1593.

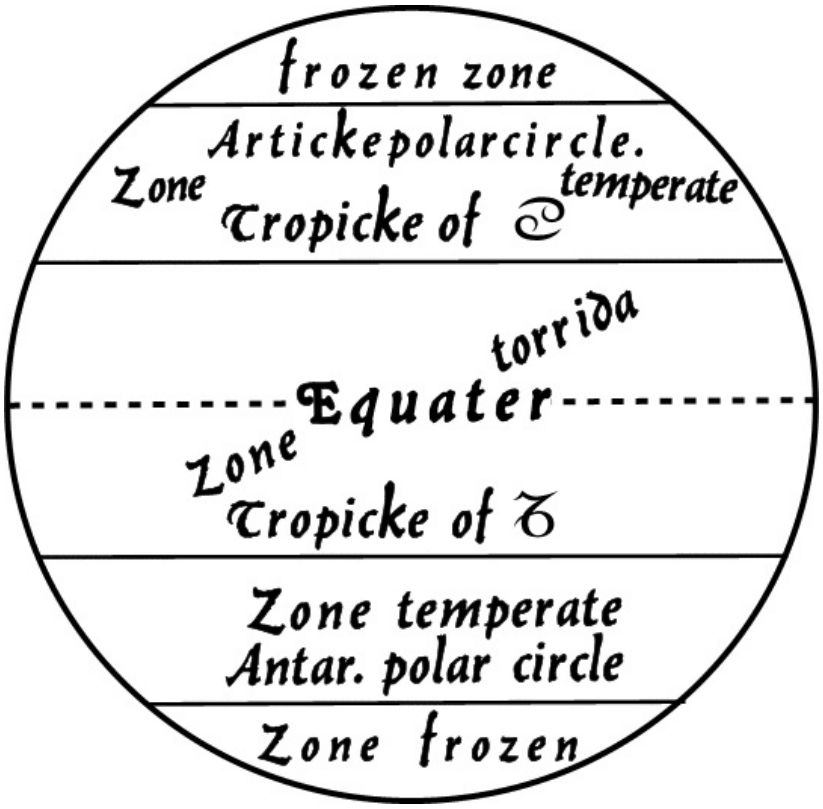
antartick frozen zone within the Antartick polar circle, which are also reported not to be habitable, by reason of the great extremity of colde, supposed to be in those parts, because of the Sunnes far distance from those zones, but in these our dayes we find by experience that the auncient Geographers had not the due consideration of the nature of these zones, for three times I haue been within the Artick frozen zone, where I found the ayre very temperate, yea and many times in calme wether marueilous hot : I haue felt the Sunne beames of as forcible action in the frozen zone in calme neere vnto the shore, as I haue at any time found within the burning zone ; this zone is also inhabited with people of good stature, shape, and tractable conditions, with whom I haue cōuerced and not found them rudly barbarous,[1] as I haue found the Caniballs which are in the straights of Magilane and Southeme parts of America. In the frozen zone I discouered a coast which I named Desolation at the first viewe thereof, supposing it by the loathesome shape to bee wast and desolate, but when I came to anker within the harbours thereof the people presently came vnto me without feare, offering such poore things as they had to exchange for yron nailes and such like, but the Canibals of America flye the presence of men, shewing themselues in nothing to differ from brute beastes: thus by experience it is most manifest that those zones which haue beene esteemed desolate and waste, are habitable, inhabited and fruitfull. If any man be perswaded to the contrary of this truth, he shall doe himselfe wrong in hauing so base an imagination of the excellency of Gods creation, as to think

[1] The experience of the Eskimos, here recorded by Davis, is fully borne out by the accouts of modem explorers. They are singularly contented, notwithstanding the rigorous climate in which they live, and those who have become most intimately acquainted with them in their wild state, like Dr. Kane and Mr. Hall, have borne testimony to their good qualities.

that God creating the world for mans vse, and the same being deuided but into 5 partes, 3 of those partes should bee to no purpose : but let this saying therefore of the Prophet Esayas be your full satisfaction to confirme that which by experience I have truely spoken. “For thus sayeth the Lorde that created heauen, God himselfe that framed the earth and made it, hee that prepared it, hee created it not in vaine, hee framed it to bee inhabited, &c.” Esay. 45, 18.[1]

Of the temperate Zones.

The temperate Artick zone is included betweene the Tropick of ♋ (Cancer), and the Artick Polar circle, whose



latitude or bredth is 42 degrees, 2 minutes, within the which we have our habitation.

[1] Isaiah xiv, 18. “ For thus saith tho Lord that created the heavens, God himself that formed the earth and made it ; he hath established it, he created it not in vain, he formed it to be inhabited.”

The temperate Antartick zone is limited by the tropick of ♑ (Capricorne) and the Antartick Polar circle, and hath breadth or latitude 42 degrees, 2 minutes.

What is a Climate ?

A climate is the space or difference vpon the vpper face of the earthy included between two parallells, wherein the day is sensibly lengthened or shortened half an hower, for as you trauail from the Equator toward the Artick Pole, the Sunne having North declination, the dayes do grow longer and longer, vntill at last the Sunne not setting ynder the horizon, you shall haue continually day, and euery space or distance that altereth the day halfe an hower, is called a climate : these climates take the names from such famous places as are within the said Climates, of which there are 9, as by their distinctions may appeare.

1. The first, passing through Meroe, beginneth in the latitude of 12 de. 45 m. and endeth in 20 d. 30 m. whose bredth is 7 d. 45 m.

2. The second, passing through Syene, beginneth in the latitude of 20 de. 30 m. and endeth in 27 d. 30 m., whose bredth is 7 d.

3. The third, passing through Alexandria, beginneth in the la. of 27 d. 30 m. and endeth in 33 d. 40 m., whose bredth is 6 d. 10 m.

4. The fourth, passing by Rhodes, beginneth in the la. of 33 d. 40 m. and endeth in 39 d., whose bredth is 5 d. 20 m.

5. The fifth, passing by Rome, beginneth in the la. of 39 d. and endeth in 43 d. 30 m., whose breadth is 3 d. 45 m.

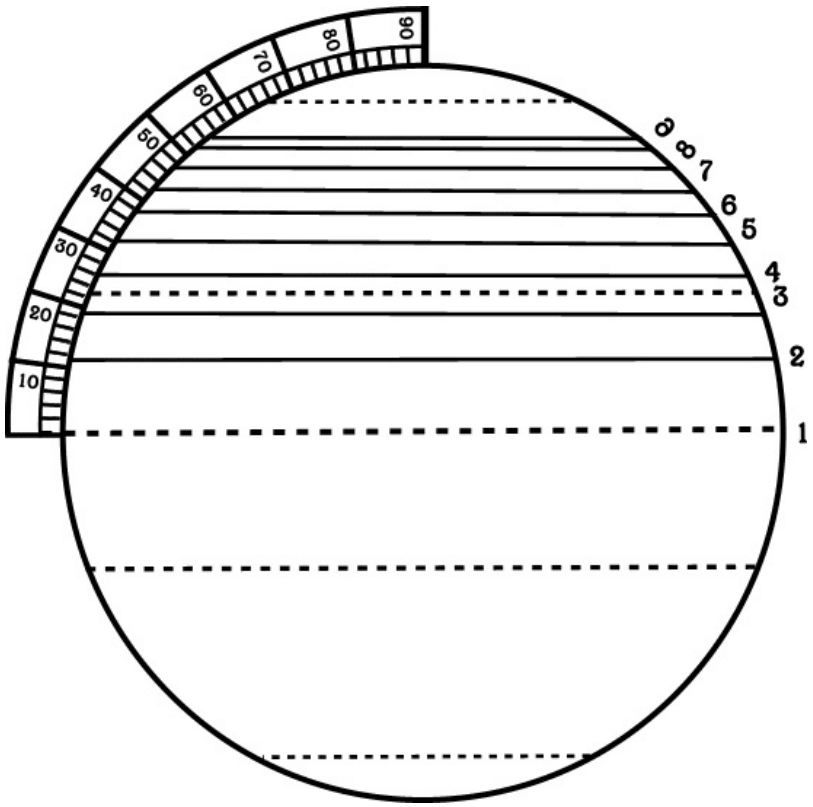
6. The sixt, passing by Boristhines, beginneth in 43 d. 39 m. and endeth in 47 d. 15 m., whose bredth is 3 d. 45 m.

7. The seventh, passing by the Rhipaan mountaines, beginneth in 47 d. 15 m. and endeth in 50 deg. 20 m., whose bredth is 3 d. 5 m.

8. The eight, passing by Meotis or London, beginneth in

50 d. 20 m. and endeth in 52 d. 10 m., whose bredth is 2 d. 50 m.

9. The ninth, passing by Denmark, taketh his beginning in the latitude of 53 d. 10 m. and endeth in the latitude of 55 d. 30 m., and hath in bredth 2 d. 20 m.



If you desire to know how many leagues euery climate is in bredth, allow for euery degree 20 leagues, or 60 miles, and for euery minut a mile, so is the distance given.

Thus have I manifested vnto you all the diuisions and particularities of the Spheres distinction.

What is the vse of the Globe ?

The vse of the Globe is of so great ease, certainty, and pleasure, as that the commendations thereof cannot sufficiently be expressed, for of all instruments it is the most rare and excellent, whose conclusions are infallible, giving

the true line, angle, and circular motion of any corse or trauers that may in Nauigation happen, whereby the longitude and latitude is most precisely knowne, and the certainty of distance very plainely manifested, according to the true nature thereof ; it giueth the variation of the compasse, and the hower or time of the day at all seasons, and in all places. And by the Globe the poles height may at all instants and vpon euery point or azumuth of the Horizon by the Sunnes altitude taken be most precisely knowne, by the certainty of whose excellent vse, the skilful pilot shal receiue great content in his pleasing practise gubernautick.

How are distances measured vpon the Globe ?

When there are 2 places assigned, the distance betweene which you desire to know, with a paire of circular compasses you must doe it in this sort : set one foote of the compasses vpon one of the places, and the other foote vpō the other place, the Compasses so stretched forth, bring vnto the Equator, and as many degrees as may be contained betweene those two points of the Compasse, allowing 20 leagues for euery degree, is the distance desired : or if the places be of such distance as that you cannot with your compasses reach them, then take with the Compasses 5 degrees of the Equator, which is 100 leagues, or 10 degrees for 200 leagues, and so measure how often the distance is contained betweene the said places, if any parte of a degree doth remaine, for halfe a degree allow 10 leagues, for a quarter 5 leagues, &c. ; but if you desire a most exquisite precisenes in measuring to the minute, second and third, then do thus. When your Compasses doth fall vpon any part of a degree, note ye distance betweene the end of that degree and the point of the compasses, then with a paire of conuenient compasses take the distance, then measure the same 60 times vpon the equator (beginning at some certaine place), then consider

how many degrees are cōtained within the measure, and allow euery degree to be a minut or mile, so are the leagues and miles known ; if any parte of a degree remaine ypon this measure of minuts, do as at the firsts measuring the same 60 times vpō the equator, the degrees cōprehended within the measure are seconds ; if any parcell of a degree remaine vpon these seconds do as in the first, and the degrees contained in this measure are thirds, and so you may proceed infinilly.

How may the Globe he rectified answerable to the true position of the heavens for any place, city, or promontory ?

The place being knowne for which you would rectifie the Globe, doe thus bring the place vnder the Meridian, and there consider the latitude thereof: and as many degrees as that place is from the Equator, so many degrees you must eleuate the pole from the Horizon, then bring the Zenith directly ouer the same place, and so is your Globe rectified for the execution of any practise : and without this ordering of the Globe, there is no conclusion to be executed by the same.

How is the longitude of places Knowne by the Globe ?

By turning the Globe within the Meridian, you must bring the Promontory, Bay, Harborow, Citie, or other place (whose latitude and longitude you seeke) precisely vnder the Meridian, there holding the Globe steady, the degree of the meridian that is directly ouer the said place sheweth the latitude thereof, and that degree of the equinoctiall which is directly vnder the Meridian is the longitude of the same place.

How is the Corse found betweene place and place ?

Two places being assigned, the Corse betweene which you desire to know, first seeke the latitude of one of these

places, and rectify the globe answerable vnto the same, as before is taught, then bring that place directly ynder the Meridian and zenith, if both places be vnder your Meridian they then lie North and South, if not, then bring the *Quarta Altitudo* to the other place, and note vpon what part of the Horizon the end of the same toucheth, for that is the precise Horizontall Corse between the said places, but this you must consider, that the Horizontall Corse is not the nauigable corse, vnles the places be of smal distance, for if any place bear Northeast frō me, or East from me, or vpon any other point, North or South excepted, and be distant 500 leagues, if I saile vpon the Horizontall Corse, I shall never arriue vnto the same place.

How then shall the Pilote saile hy the Globe, if the matter be so doubtfull ?

The skilfull Pilote that vseth this excellent instrument doth first consider the place from whence he shapeth his corse and rectifieth the Globe answerable to the same, then bringing the place directly vnder the Meridian and zenith, there holding the Globe steady, bringeth the *Quarta Altitudo* to the place for which he is bound, the end whereof sheweth vpon the Horizon the true Horizontall Corse, vpon which Corse he saileth 20 or 30 leagues, and there maketh a note or pricke by the edge of his *Quarta Altitudo*, according to the true distance proued by Corse, reckoning an altitude as in the vse of a chart ; then he bringeth that prick or note vnder the Meridian, and there considereth the true latitude of his beying, he then rectifieth the globe answerable to the same prick, and keeping the same vnder the Zenith, doth againe turne the *quarta altitudo* to the place for which he is bound, the end whereof sheweth vpon the Horizon the Horizontal Corse ; then sayling as at the first he maketh a note or pricke as before, and thus prosecuting his Corse, shall ariue vnto his desired place ; but in this practise he

shal plainly proue that his Horizontall Corse will differ greatly, and that by his sayling in this sorte, he shall by his notes and pricks describe the true nauigable and neerest Corses betweene the said places. The like methode is to be obserued upon any trauers or forced course whatsoeuer ; and therefore the Pylote must take care, that although the winde be neuer so fauourable, yet he must not prosecute any Horizontall Corse (North and South onely excepted).

Therefore I say the Pylote must take speciall care to consider the distance of places, whether the Horizontall Corse will lead him betweene the said places ; for if places be more then 45 degrees asunder, the Horizontall Corse is not the meane to find those places, vnlesse they lie north and south; for the horizontall course betweene any 2 places is a portion of a great circle, which being of large distance must be perfourmed by great circle nauigation and not by Horizontall Corses ; for the collection of many Horizontall Corses being knit together, doe performe a paradoxall motion altogether differing from a great circle, as for an example, being at Cape Verde, there is a place distant from me 80 degrees, vpon the point Northwest, vnto which place I desire to saile, I therefore bring Cape Verde vnder the Meridian of my Globe, then considering the latitude of the Cape, I rayse the pole answerable to the same, and place the Zenith directly ouer the Cape, then turning the *quarta altitudo* to the point Northwest vpon the Horizon, all such places as the sayde *quarta altitudo* then toucheth doe beare due North west from me; now prosecuting this Corse by the direction of my Compasse, the first day I saile 20 leagues, therefore I make a mark by the edge of the *quarta altitudo*, 20 leagues from the Zenith, then bringing that marke vnder the Meridian, I rectifie the Globe answerable to the latitude thereof ; the next day I saile other 20 leagues vpon the same point, and make a marke as at the first, I bring that marke likewise

vnder the Meridian and rectifie the Globe as before, and by this methode prosecuting the Corse N.W. I shall describe a paradoxall line which will leade me to the North of the place vnto which I would sayle, the farther the distance the greater the difference ; by this order you may describe paradoxall lines vpon all the points of the Compass, but this is to be regarded, that your differences be as small as you may, and that none of them exceed 20 leagues, for by the smallest distinctions is performed the greatest certaintie.

And by the description of these lines you may very manifestly vnderstand the difference of Horizontall paradoxall and great circle Nauigation.

And this may suffice for the sayling vse of the Globe conuenient for the Seamans purpose.

What is the great Circle nauigation ?

Great Circle nauigation is the chiefest of all the 3 kindes of sayling, in whom all the other are contained, and by them this kinde of sayling is performed, continuing a Corse by the shortest distance betweene places, not limited to any one Corse, either horizontall or paradoxall, but by it those Corses are ordered to the full perfection of this rare practise, whose benefites in long voiages are to great purpose, ordering & disposing all horizontall trauerses to a perfect conclusion ; for there are many changes of horizontall and paradoxall Corses in the execution of this practise, so that vpon the shifting of a wind, when that it may seeme that you are forced to an inconuenient Corse by the skill of great Circle sayling, that Corse shall be found the shortest and onely proper motion to perfourme your voiage. And also when with fauourable windes the Pylote shall shape a Corse by his Chart or Compass paradoxall, as the best meane to attaine his porte, he shal by this kinde of sayling finde a better and shorter Corse, and by sufficient demonstration prooue the same, so that without this know-

ledge I see not how Corses may be ordered to their best aduantage ; therefore sith by it perfection of sayling is largely vnderstood, & the error likewise most substantially controled, it may of right chalenge the chiefest place among the practises Gubemantick.[1] The particularities whereof, if I should by an orderly methode labour to expresse, it would be a discourse ouer large for this place, and as I thinke troublesome if the premises be not well vnderstood ; therefore I will now ouerpasse it, vntill a time more conuenient and of better leasure.

Of paradoxall Nauigation.

Paradoxall Nauigation demonstrateth the true motion of the Ship vpon any Corse assigned, in his true nature, by longitude, latitude, and distance, giuiug the full limit or determination of the same, by which motion lines are described neyther circular nor straight, but concurred or winding lines, and are therefore, called paradoxall, because it is beyond opinion that such lines should be described by plaine horizontall motion ; for the full perfection of which practise I purpose (if God permit) to publish a paradoxall Chart, with all conuenient speede, as so will discouer by the same at large, all the practises of paradoxall and great circle nauigation, for vpon the paradoxall Chart it will best serue the Seamans purpose, being an instrumēt portable, of easie stowage and small practise, perfourming the practices of Nauigation as largely and as beneficially as the Globe in all respects ;[2] and all these practises of sayling before

[1] Modern navigators, who turn their attention to Great Circle Sailing as a means of shortening long ocean passages, might learn useful lessons from the subjects treated of by Davis between pages 309 and 314. By taking a terrestrial globe to sea, duly fitted with the quadrant of altitude, they would save themselves much laborious calculation by utilizing this “rare and excellent” instrument under Davis’s instructions.

[2] These remarks show that Davis saw the necessity for giving the sea man and pilot some better chart than the plane chart then in use, so as

mentioned, may in a generall name be aptly called Navigation Geometrically because it wholy consistetb of Geometricall demonstratiue conclusions.

But there is another knowledge of Nauigation, which so farre excelleth all that is before spoken, or that hath hitherto beene vulgarly practised, as the substance his shadow, or as the light surpasseth the thick obscured darknesse ; and this sweete skill of sayling may well be called Nauigation arithmetically because it wholly consisteth of Calculations, comprehended within the limit of numbers, distinguishing Corses not onely vpon the points of the Compasse, but vpon every degree of the Horizon, and giueth the distance of any trauers for the particular eleuation of minutes ; yea, and lesser partes assure your selfe : it giueth longitudes and latitudes to the minute, second, and thirds in so great certaintie, as that by no other meanes the like can be perfourmed : it teacheth the nature of Angles and Triangles, as well Sphericall as plaine, superficiall and solide commensurations, the effect of lynes straight, circular, and paradoxall; the quantities and proportions of parallells, the nature of Horizons, with euery particular distinction of any alteration whatsoeuer that may in Nauigation be required, to a most wonderfull precise certaintie; for there can nothing be required that by this heauenly hermonie of numbers shall not be most copiously manifested to the Seamans admiration and great content :[1] the orderly practise

to relieve him from the crude method of working an ordinary day's work by fidgeting out the courses and distances by means of a rudely constructed globe, and then plotting them on an erroneously graduated chart. Davis's "paradoxall chart", which he proposed to publish, was probably some scheme for representing the globe on a flat surface, with due regard to the convergence of the meridians, thus giving approximately the relative sizes of the miles of latitude and those of longitude.

[1] Davis had evidently made some discovery of a means of handling figures, whereby the pilot might be able to navigate by the surer method of calculation. This discovery he terms "Navigation arithmeti-

whereof, to the best of my poore capacitie, I purpose to make known, if I may perceiue my paines already taken to be receiued in good parte, which I distrust not but all honest minded Seamen and Pylots of reputation will gratefully embrace, onely in regarde of my friendly good will towards them, for it is not in respect of my paines but of my loue, that I would receiue fauourable curtesie.[1]

How may the Poles height be knowne by the Globe ?

There are diuers waies to find the poles height by the Globe, as well from the Meridian as vpon the same, but sith before I haue sufficiently taught how, by the Sunnes Meridian altitude, the poles height may bee found, I will therefore in this place speake no further thereof, but for the other kinds it may be knowne as followeth.

How by the Sunes rising or setting the Poles height may be knowne.

By your Compasse of variation, or some magneticall instrument, obserue at the sunne rising, ypon what degree of the horizon the center toucheth, according to the true horizontall position of the Magnet, all variation duely considered; that being knowne, search in the tables of the Ephimerides for the Sunnes place in the Ecliptick at the time of your obseruation, then bring that place or degree of the Ecliptick

al", meaning probably, in the first place, a traverse table and a table of meridional parts, and then some method of numbers similar to that which Napier gave to the world a few years later, in the shape of logarithms.

[1] This passage shows how well Coleridge had caught the spirit of England's Elizabethan naval worthies, when he put into the mouth of his "Ancient Mariner", the words :—

> "He prayeth best, who loveth best
> All things both great and small ;
> For the dear God who loveth us
> He made and loveth all."

wherein you finde the Sunne to be to the Horizon, and moone the Meridian of the Globe as occasion requireth, vntill that obserued degree of the Horizon and the Sunnes place in the Ecliptick doe iustly touch together, for then is the pole in his due Eleuation, as by the intersection of the Horizon and Meridian may appear : in like sort you may find the Poles altitude by any knowne fixed Starre in the Horizon.

To finde the poles height by the Sunne vpon any point of the Compasse.

By the Compasse of variation, rectified to the true horizontall position, obserue the Sunne, vntill he come to any point thereof at your pleasure, and in the same instant take the Suns height from the Horizon, then bring the *quarta altitudo* to that point of the Compasse vpon the Horizon of the Globe where you obserued the Sunne to be, there holding the *quarta altitudo* steady, mooue the Globe, vntill you bring the degree of the Ecliptick (wherein the Sunne is at the time of your obseruation) vnto the edge of the *quarta altitudo*, if it fall vpon that degree of altitude, as was the Sunnes obserued height ; then doth the Pole stand to his true Eleuation, but if it agree not you must eleuate or depresse the Pole, as occasion requireth, rectifying the Zenith answerable therevnto. And, againe, make trial, as at the first, bringing the place of the Sunne to the *Quarta altitudo*, and setting the same vpon the obserued point of the Compasse, vntill it agree in all respects with your obseruation, and then the Meridian showeth in his intersection with the Horizon the eleuation of the Pole from the Horizon.

To find the Poles height by any giuen Azumuth by the Sun being aboue the Horizon.

By your magnetical instrument or compasse of variation obserue the azumuth of the Sun at any time in the forenoon or afternoone, the neerer the Sun is to the Horizon the

better shal be your obseruation, and at the same instant take the height of the sun from the Horizon, keep these two numbers in memory, and note that the Azumuth be obserued according to the true position of the Horizon, by hauing good regard to the variation of ye compas, then bring the *quarta altitudo* to the place of the Sun in the Ecliptick, and set that degree of the Sunnes place in the Ecliptick vpon the obserued degree of altitude, by the graduation of the *Quarta altitudo* ; and if the ende thereof at the same instant do all right vpon the obserued degree of Azumuth then is the Pole in his due Eleuation : if not, then raise or lay the pole, as occasion requireth, alwaies regarding that you place the Zenith answerable to the Poles altitude, and then againe bring the Sunnes place to his altitude vpon the *Quarta altitudo,* and looke againe whether the ende thereof do touch the obserued degree of Azumuth vpon the Horizon ; if not, you must prosecute this order, vntill at one instant the place of the Sunne be vpon his true almicanter, by the edge of the *Quarta altitudo,* and that the end of the *quarta altitudo* doe also touch the obserued degree of Azumuth vpon the Horizon, for then is the Pole in his true eleuation, as by the Meridian and Horizon will appeare.

To find the Poles height by the Sunne by any two giuen Azumuths and altitudes, not regarding the true horizontall position or needles variations.

Because there may great errors be cōmitted in the former obseruations, vnlesse the Compasse be perfectly well rectified, so as it may respect the true partes or distinctions of the Horizon, it is not amisse to enforme you how, without regard of variation, the Poles height may be found. Therefore by your Magneticall instrument or Compasse of variation obserue the Sunnes azumuth, without regard of the true horizontall position, and at the same instant obserue also his altitude from the Horizon, keepe those two numbers

in memory, then after the Sun hath moued a point or two points of the compasse, more or lesse at year discretiō, obserue again his Azumuth and altitude, as at the first, then consider the arke of the Horizon through which the Sunne hath moued between these two obseruations, for by the two obseruations of the Sunnes altitude, and by the degrees of Azumuth through which the Sunne hath moued the Poles height is thus knowne. First set the Globe to the eleuation of the place wherein you are, as neere as you can gesse, and bring the Zenith to the like latitude from the Equator as the poles eleuation is from the Horizon, then bring the *quarta altitudo* to the place of the Sunne vpon the Ecliptick for the time of your obseruation, there place the Sunne vpon the first obserued altitude by the degrees of the *quarta altitudo*, and note the degree of the Horizon which the *quarta altitudo* then toucheth : this done, bring the Sunnes place to the second obserued altitude, by mooning the *quarta altitudo* and the Globe vntill the degree of the Sunnes place in the Ecliptick and the degree of his altitude vpon the *quarta altitudo* doe meete. Then, againe, consider the degree of the Horizon which the end of the *quarta altitudo* toucheth, and note the ark of the Horizon contained betweene your two obseruations, of howe many degrees it consisteth if it agree with the obseruations made by your Magneticall instrument, then doth the Pole stand in his true altitude, if not, you must either raise or depresse the Pole, and againe prosecute the former practise, vntill you find such azumuths and altitudes vpon the Globe as you found by your Magneticall obseruations, for then the Pole doth stand in his true altitude, and then doth also appeare the true Azumuth of both your obseruatios, which, if it agree not with your compasse, then is your compasse varied, and may hereby bee corrected, so that this doth not onely giue the Poles height, but also the true horizontall position without errour.

To find the Poles height by taking the Suns altitude aboue the Horizon, so that the precise time of any such obseruation be knowne.

If you desire at any time of the day to know the Poles height, as at 8, 9, or 10 of the clocke, etc., marke diligently the time of your obseruation, at what instant you doe obserue the Sunnes altitude from the Horizon ; the time and altitude thus known, bring that place of the Ecliptick wherein the Sunne is at the time of your obseruation directly vnder the Meridian, there, holding the Globe stedie, bring the Index of the *circulus horarius* to the hower of 12, or noone, then mooue the Globe vntill the Index come to the hower of your obseruation, there hold the Globe stedy, then bring the *quarta altitudo* to the place of the Sunne in the Ecliptick ; if it agree with your obserued altitude, then doth the pole stand in his true eleuation, if not, moue the Meridian, by raising or depressing the pole as occasiō requireth, vntil you bring the altitude and the hower to agree, and then you haue the poles height, and by the end of the *quarta altitudo* doth also appeare the degree of azumuth, whereupon the Sun was at the time of your obseruation, and note that in raysing or depressing the pole of the Globe you must also place the Zenith so farre from the Equinoctiall as the pole is from the Horizon, for this is a generall rule, that so much as the pole is eleuated from the Horizon so much is the latitude of the Zenith from the Equator, therefore you must alwaies bring the Zenith and altitude to agree whensoever you alter the Eleuation, be it never so little.

To find the Poles height by any two obseruiations of the Sunnes altitude, not regarding the hower of the day, or any horizontall position of the Magnet, so that you know the distance of time between the said obseruations.

Although there be some difficultie in giuing the true time of any obseruations at sea, by reason of the alteration

of Horizons, and of the needles variation, yet it is a matter most easie by a good hower Glasse, halfe hower Glasse, and minute Glasse, to measure the distance of time betweene any two observed altitudes, you may therefore vpon that ground find the poles height with great facilitie at any time, by the Sunne or any fixed Starre, in this sorte.

Consider in what place of the Ecliptick the Sunne is at the time of your obseruation, bring that place to the Meridian, then with a blackeleade, by moouing the Globe, describe a parallell to the Equator, answerable to the Sunnes diurnall motion and declination for the same instant, then if betweene your obseruations there be an hower, two howers, more or lesse at your pleasure, as by your running glasses may be knowne, you must allowe for euery hower 15 de. of the Equator, for so much ascendeth euery hower, and for euery 4 minutes one degree, and for euery minute $\frac{1}{4}$ of a degree, then knowing by this order how many degrees the sunne is mooned between your 2 obseruations, you must vpon the parallel which you drawe make 2 notes, so many degrees asunder as the Sunne hath mooued betweene your obseruations, which may be done in this sorte : bring the place wherein the Sun is vnder the Meridian, and marke what degree of the Equator is then vnder the Meridian, the Globe so standing vpon your parallell close by the Meridian, make the first note or marke, then turne the Globe, and reckon ye degrees of the Equator that passe vnder the Meridian, vntil so many be past as was your obseruation, there againe holde the Globe stedy and vpon your parallell, close by the Meridian, make your second note or marke ; then knowing the Sunnes altitude at both the obseruations, you must bring the *Quarta Altitudo* to the first note made vpon your parallel, there holding the globe stedy ; the *Quarta Altitudo* and marke agreeing in altitude, bring the *Quarta Altitudo* to the second note, if that do also agree with your former obserued alti-

tude, then doth the Globe stand in his true Eleuation ; if not, you must eleuate or depresse the Pole by discretion, vntill you bring the 2 obserued altitudes of the Sunne to agree with the two markes which you made vpon your described parallell, and then is the Pole at its true eleuation ; and what is spoken of the Sunne, the like may be done by any knowne fixed Starre. I hold this conclusion to be very necessary, pleasant, and easie for the Seamans purpose.[1]

To find the true place of the Sunne in the Ecliptick at all times.

Because it is most necessarily required in the former practises, that the Sunnes true place in the Ecliptick be at all times knowne, I thinke it not amisse to enforme you how the same may be done.

The chiefest and most certaine meane to know the same is by the tables of the Ephimerides, but, those tables wanting, the Seaman may in this sort doe it : by the Regiment seeke out the declination of the Sunne, that being knowne bring the zenith vpon the Meridian, so many degrees and minutes from the Equator as is the Sunnes declination, there moue the globe vntill some degree of the Ecliptick

[1] These several problems to find the Pole's height or the latitude, by help of the globe and compasses, show great ingenuity,—truly what Carlyle defines as talent—"the capacity for taking trouble". Before the existence of logarithmic tables, these appear to have been the only methods. In these days of chronometers, the compass has ceased to be an instrument used in the determination of geographical positions at sea ; but Davis followed the good old sea adage—"When you can no better do, to an anchor (compass) you must come." All these problems on the globe are given in the early books on navigation, and may be even now worked out with advantage by the student as a means of acquiring a comprehensive grasp of the true principles of spherical trigonometry. See *Robertson's Elements of Navigation*, vol. i. Book VI, Sec. v, p. 346 (London, 1796).

doe come directly vnder the point of the Zenith, for that is the Sunnes place ; you must further consider whether it be betweene March and June, for then you must finde the degree in that quarter of the Ecliptick contained betweene ♈ (Aries) and ♋ (Cancer) ; if it bee betweene June and September, you must finde the degree in that quarter of the Ecliptick contained betweene ♋ (Cancer) and ♎ (Libra), so of the rest.

It may also be knowne vppon the Horizon of the Globe by a Calender Circle that is there described, in this sort : first search the day of your moneth wherein you desire to know the Sunnes declination, and directly against the same degree which standeth for that day, doth also stand the degree of the Zodiac, wherein the Sun is at the same time, in a circle representing the Zodiac, and described vpon the Horizon.

But if it be Leape yeere, you must not take the precise day of the moneth wherein you seeke the Suns place, but the next day following, and against that day seeke the declination.

To find the Poles height by any two knowne fixed starres.

When you see any 2 fixed Starres which you know to bee both at one instant in the Horizon, vpon your Globe searche for those Starres. and bring one of them to touch the Horizon of the Globe, if the other doe not likewise touch the Horizon, you must raise or depresse the Pole by discrete mouing of the Meridian, vntill you bring both those Starres to be at one instant in the Horizon, for then the Globe doth stand to his true eleuation.

To finde the Poles height by any two knowne fixed Stars another way.

When you see any fixed Starre that you know to be in the Horizon, you must presently take the height of some

other Starre, that you likewise know, before the first be risen fro the horizon, then vpon your Globe search for the Star that you obserued in the horizon, bring that star to the horizon of the globe, then holding the globe stedy, bring the *quarta altitudo* to the other Starre, whose altitude you obserued ; if it agree vpon the *quarta altitudo* with the obserued altitude, then the Globe doth stand to his true eleuation ; if not, you must by discretion rayse or lay the Pole vntill you find the one Starre in the Horizon, and the other vpon his true obserued altitude, for then the Pole doth stand to his true eleuation.

To finde the Poles height at anytime by any 2 knowne fixed Starres.

With your crosse staffe take the distance of any two stars from your Zenith, which must be done with as much expedition as may bee ; their distances so known, with a paire of cōpasses, measure so many degrees vpon the Equator, as is the distance of the first obserued Starre ; with an other paire of compasses doe the like for the second obserued Starre ; vpon the first Starre set one point of the compasses that tooke his distance, and vpon the second Star set likewise one foote of the compasses that tooke his distance ; bring the other two feete of the compasses to meete together, there make a marke, for that is the parallell wherein you be, and that mark is the Zenith ; bring it to the Meridian by moouing the Globe, and there wil appeare the latitude desired, for so many degrees and minuts as that marke is from the Equator, so much is the Pole eleuated aboue the Horizon. This conclusion the Seaman ought to haue in good esteeme.

To know the precise hower at all times by the Sunne.

For the finding of the hower of the day by the Globe, it is necessary that the Poles height be first knowne ; there-

fore set the Pole to his true eleuation, and the zenith to his answerable latitude ; then bring the place of the Sunne in the Ecliptick vnder the Meridian, there holding the Globe stedy, place the Index of the *Circulus horarius* vpon 12 of the clock or noone ; your Globe thus ordered, then with your Crosse staffe take the Sunnes height from the Horizon ; that being knowne, you must bring the place of the Sun to the *quarta altitudo*, by mouing the Globe and *quarta altitudo* vntil the place of the Sunne doe agree with the obserued altitude, there holding the Globe that hee mooue not, the Index doth shew vpon the *circulus horarius* the true hower desired.

To find the hower of the night by any knowne fixed Starre.

Set the Globe to his true altitude, and the Zenith to his answerable latitude; you must also place the Index of the *circulus horarius* vpō the houre of 12 or noone, by bringing the Sunnes places vnder the Meridian, etc., as before you did by the Sunne, then take the height of any knowne fixed Starre ; bring that Starre to the *quarta altitudo*, by mouing the Globe and *quarta altitudo* vntill the Starre come to his true obserued altitude, there holding the Globe stedie, the Index doth showe vpon the *circulus horarius* the true time of your obseruation.

To know the length of the daies and nights, at all times, and in all places.

The place and time being giuen wherein you desire to know the length of the day or night, first set the Globe to his altitude for the place, then search the place of the Sunne in the Ecliptick for the time wherein you seeke the daies length, bring that place of the Sunne vnder the Meridian, there holding the Globe that he moue not ; place the index of the *circulus horarius* vpon the hower of 12, or noone, then turne the Globe vntill you bring the place of

the Sun to touch the East part of the horizon, there holding the Globe, you shall see by the Index of the *circulus horarius* the true time of the Sunnes rising ; then bring the place of the Sunne to the West parte of the Horizon, and you shall there see the true time of the Sunnes setting, wherby the length of the day and night doth most plainely appeare. And this may suffice for the vse of the Globe necessary for the Seamans purpose.

I might here recite the triple rising and setting of the Starres, Cosmice,[1] Acronyce,[2] and Heliace,[3] the ascentions right and oblique, the dawning and twylight, howers equall and vnequall, ordenary and planetary, daies naturall and artificiall, the triple rising of the Sunne Equinoctiall and Solsticiall, Circles of position with their vse and nature, the horoscope aud domifying[4] distinctions of the heauens, the planets, their motions, retrogradiatiōs and excentricitie of their orbs, horologie, and many other most pleasant conclusions ; but because they doe in no sort appertaine to the Seamans vse, I therefore omit them, as matters more troublesome then profitable for him, expecting from some learned Mathematician a worke of worthy esteeme, wherin these and many other excellent conclusions shall by cunning demōstration be made knowne vnto vs.

Of the Crosse staffe and his demonstration.

The Crosse staffe[5] is an artificiall instrument, geometri-

[1] Cosmical—rising or setting with the sun.

[2] Acronycal—rising at sunset, and setting at sunrise.

[3] Heliacall—emerging from, or passing into, the light of the sun.

[4] Domifying, an astrological term meaning dividing or housing the heavens.

[5] The Cross Staff was first described by Werner (see Appendix A.), and next by Cortes and Medina. There were many forms of it, one invented by Gemma Frisius, another by Wagenaar, another by Hood. They are described, in detail, by Blundeville in his *Art of Navigation*, pages 666 to 672. The cross staff of Gemma Frisius was too long for use on board ship. That of Coignet was three to four feet long.

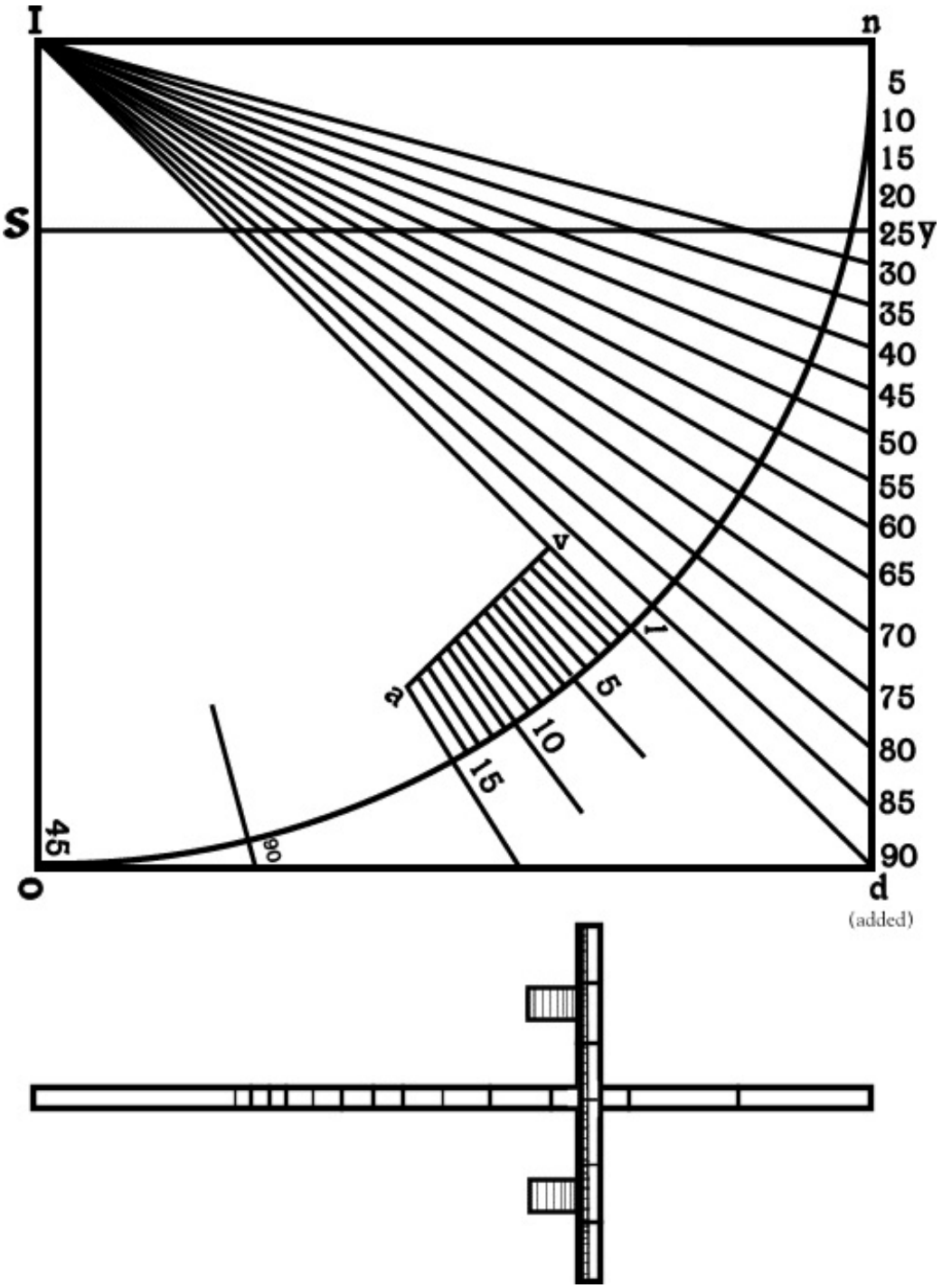
cally proiected into that forme as an instrument of greatest ease and exactest vse in Nauigation, by which in any naturall disturbance of wether (the Sun or Stars appearing) the Poles height may be knowne, when the Astrolabie or quadrant are not to be vsed. Conueying the vse of the quadrant from the beame of the Sunne to the beame of the eye, for whereas by the quadrant the sun beame perceiuing the Dioptra sheweth his height, so by the crosse staffe the beame of the eye conueyed to the Sunne or Starre, doth likewise giue their height. The demonstration whereof is thus:

Make a plaine square consisting of 4 right angles, as is the square, *I, o, d, n*; the angle *I* shal be assigned the Center of the quadrant, where placing one foote of your Compasses, stretch the other foote to the angle *n,* and therewith describe a quarter of a circle, as is the arke *o, d, n*; then from the center *I* to his opposite angle h, drawe a right line, by which line the quadrant *o, d, n,* is diuided into 2 equall partes ; in the point *d* deuide the arke *d, n,* into 90 equall partes, drawing from the center I lines through euery of those diuisions touching in the line *n, h,* as by this figure appeareth ; then consider the length of your transuersary,[1] and take halfe thereof, laying it vpon the line *I, o,* in the point *S* ; from that point *S* drawe a parallell to the line *I, n*, as is the line *S, y;* and as that line doth intersect the diuisions of the halfe quadrant, so shalbe the degrees of the crosse staffe, and note that the sides of the square must be as long as the staffe that is graduated.

Because the staffe should be of vnreasonable length to contain more then 60 degrees, therefore to keepe him in due forme for the ease of his vse, and that the complement of 90 degrees should be contained vpon the staffe, the

[1] The transversary is the cross-piece. It is also called a transome. On the cross staff described by Michel Coignet, there were three transversaries of different lengths.

other 30 are artificially proiected vpon the trausuersary as by this demonstration appeareth, & in this sort consider the length of your staffe from that point *S* to the last inter-



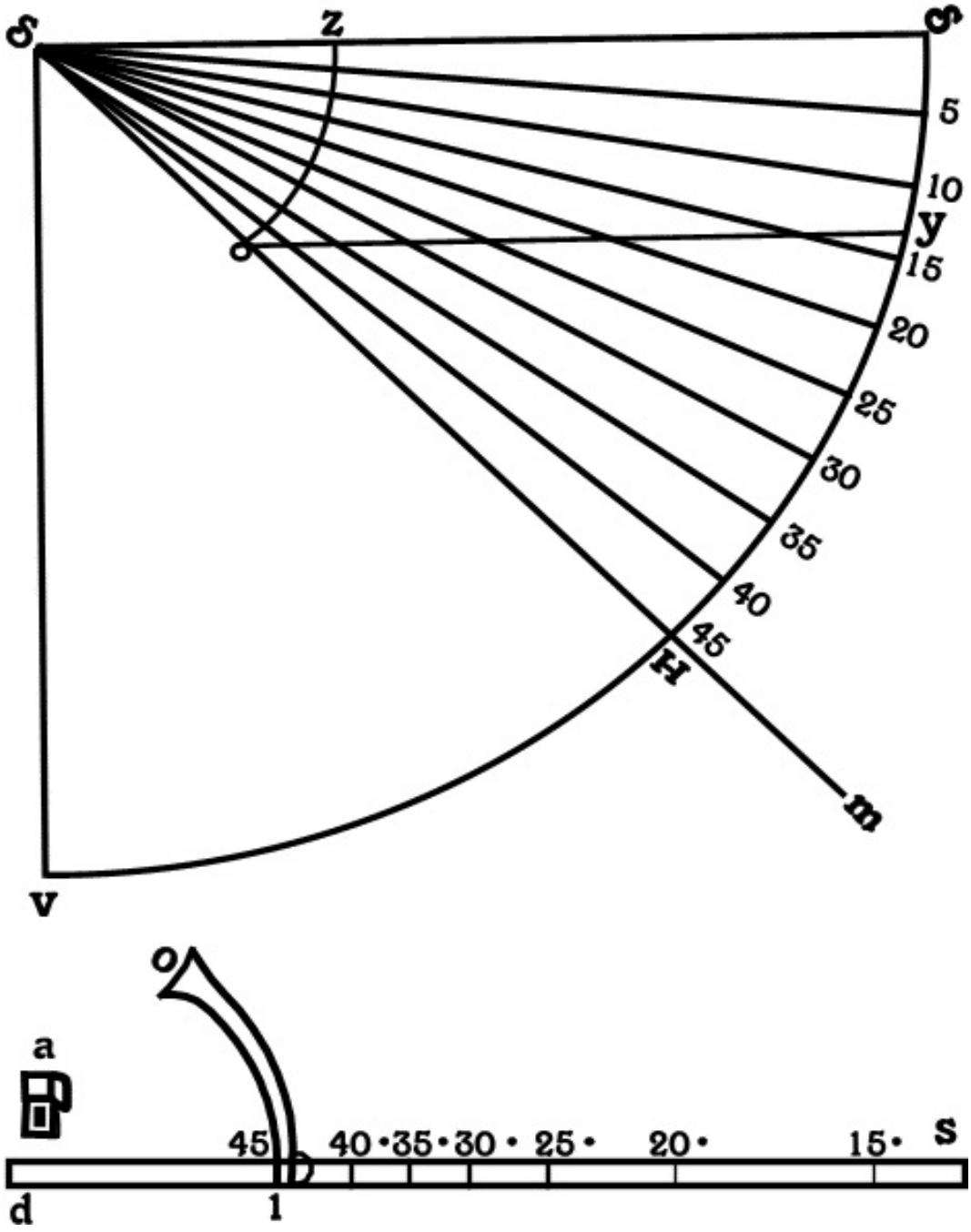
section which endeth in 30 degrees, lay downe the length of the line *I*, *h*, at the point of *v* ; from that point drawe a right line, cutting the line *I*, *h*, to right angles, as is the line *v*, *a*, being iust the length of halfe the transuersary ; then deuide the arke *o*, *d*, into 45 equall partes, accompting from the point d to the point *o* ; then from the angle *I*, drawe right lines to the first 15 of those partes, and as those lines doe cut the lyne *v*, *a*, so must the transuersary be graduated on both his partes, whereunto vanes being framed, your staffe is finished to your vse.

There is a staffe of another proiection, which I find by practise to be an instrument of very great ease and certaintie at the Sea, the Sun not being more then 45 degrees aboue the Horizon, whose vse is contrarie to the other before demonstrated ; for by this staffe the beame of the Sunne shadowing vpon the transuersary, doth thereby giue the height most precisely, not regarding how to place the center of the staffe to the eye, for the correction of the parrallar of the sight, and without looking vpon the Sun, whose demonstration is thus:

Drawe 2 right lines, cutting each other at right angles, as doe the lines *d*, *v*, and *d*, *s* ; vpon the angle d, describe a quarter circle, as is the arke *v*, *s*, deuide that quadrant into 2 equall partes by the line *d*, *n*, cutting the quadrant into the point *h*, deuide the arke *v*, *s*, into 45 equall partes or degrees, drawing lines from the center *d* to euery of those diuisions ; then from the point *I*, bring the third part of the line *d*, *s*, vpon the center *d*, describe an ark of a circle, as is the arke *I*, *o*, which is for the transuersary of this staffe, and the line *d*, *s*, is for the staffe ; then from the point o, where the vpper ende of the transuersary toucheth the line *d*, *n*, drawe a parallell to the line *d*, *s*, as is the line *o*, *y* ; and as that line doth cut the lines drawne from the center d, so must the staffe d, s, be graduated, laying it vpon the line o, y, putting that part of the staffe wher the

point *I* toucheth vpon the point *o*, and then from the point *I*, lay downe the degrees, as are the intersections vpon the line *o*, *y*, and so is the staffe graduated.

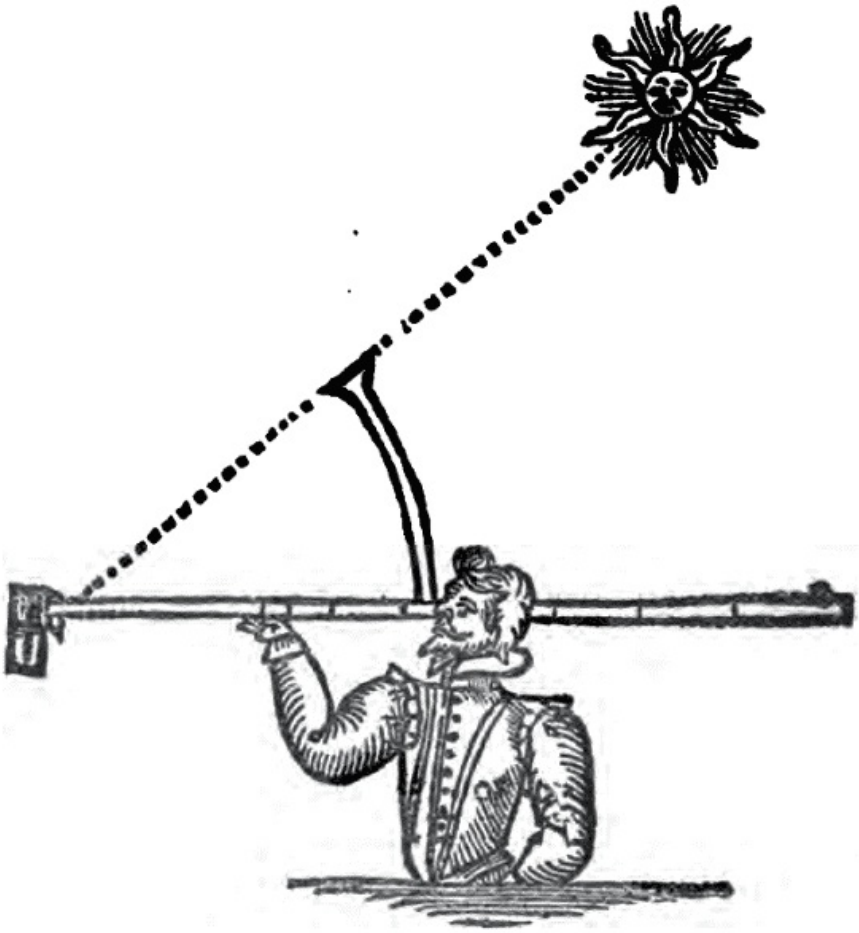
The transuersary at the point *i* must haue an artificiall



hole made for the staffe to runne in, as other staues haue, also there must bee a plate of brass with a soccat to be set to the cēter of the staffs, as is the figure *a*, in the midst wherof there must be a slitte, through which the sight must be conueied to the Horizon, and this plate must receiue the shadowe of the transuersary, and so the staffe is finished.

How is the vse of this Staffe ?

The vse of this staffe is altogether contrary to the other, for the center of this staffe, where the brass plate is fastened,



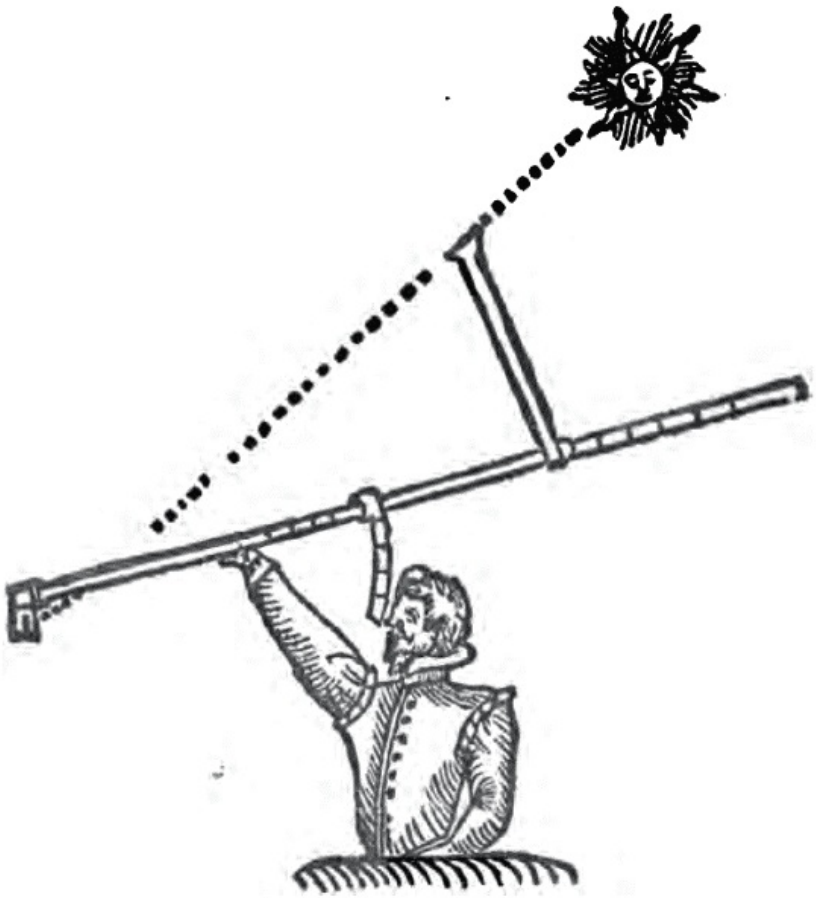
must be turned to that part of the Horizon which is from the Sunne, and with your backe toward the Sunne, by the lower edge of the halfe crosse, and through the slitte of the

plate you must direct your sight onely to the Horizon, and then moouing the transuersary as occasion requireth, vntill the shadow of your vpper edge of the transuersary doe fall directly vpon the said slitte or long hole, and also at the same instant you see the Horizon through the slitte, and then the transuersary sheweth the height desired.

Finding by practise the excellencie of the Crosse Staffe aboue all other instruments to satisfie the Seamans expectation, and also knowing that those instruments whose degrees are of largest capacitie are instruments of most certaintie. I haue uery carefully laboured to search a good and demonstrable meane how a crosse staffe might be proiected, not onely to containe large degrees, but also to auoide the vncertaintie of the sight, by disorderly placing of the staffe to the eye, which demonstration I haue found, and haue had the instrument in practise, as well vnder the Sun as in other climates, but because it hath a large demonstration with manifold vses I heere omit to manifest the same, purposing to write a particular treatise[1] thereof, notwithstanding his forme and vse, by picture I haue thought good to expresse. This staffe is a yard long, hauing two halfe crosses, the one circular, the other straight, the longest not 14 inches, yet this staffe doth contain the whole 90 degrees, the shortest degree being an inch and $\frac{3}{4}$ long, wherein the minuts are particularly and very sensibly laid down, by which staffe, not regarding the parallar of your sight, nor looking vpon the Sunne, but onely vpon the Horizon, the Sunnes height is most precisely known, as well and as easily in the Zenith as in any other part of the heauen. Then which instrument (in my opinion) the Seaman shall not finde any so good, and in all climates of so great certaintie, the inuention and demonstration whereof I may boldly chalenge to appertaine

[1] This treatise was never printed. Davis seems to have been much hurried in writing the latter part of the *Seaman's Secrets*. He was probably about to go to sea again.

ynto my selfe (as a portion of the talent which God hath bestowed vpon me) I hope without abuse or offence to any.[1]

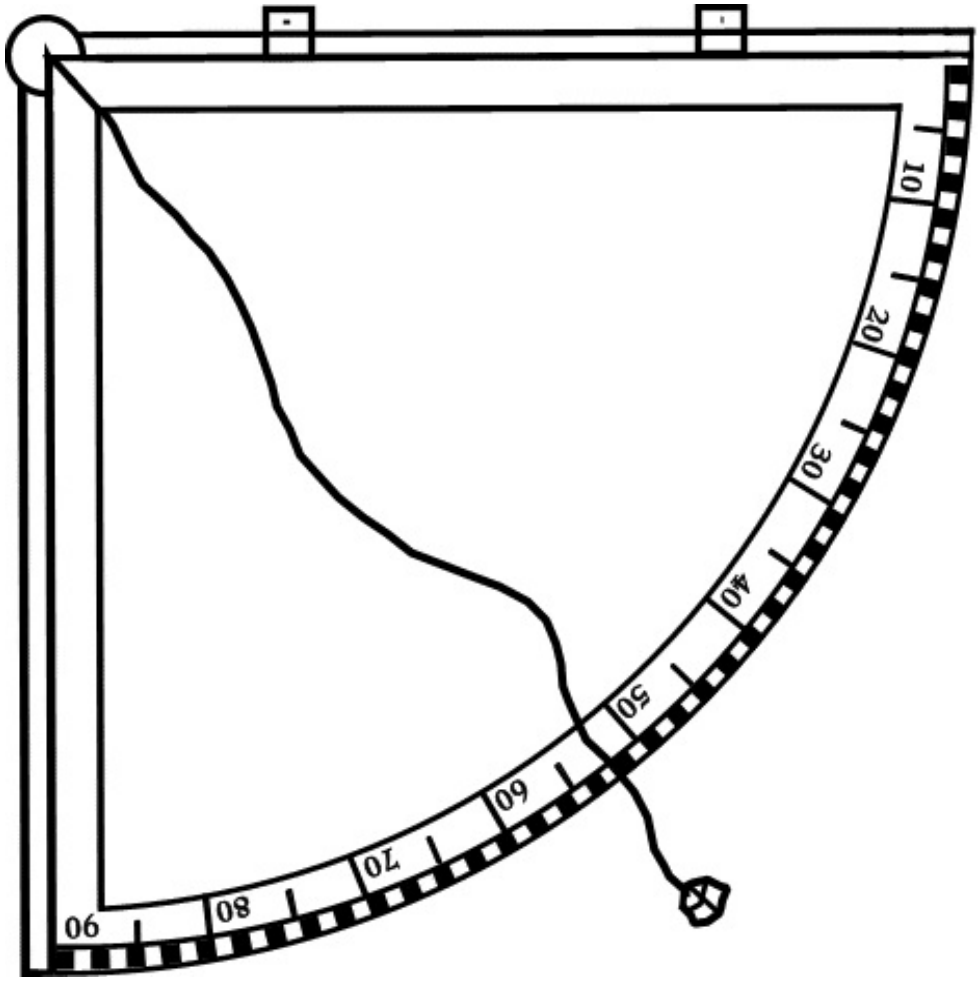


Of the Quadrant

A Quadrant is the fourth part of a circle, containing 90 degrees, and representeth the distance between the Horizon and Zenith, being an excellent instrument vpon the shore, to perfourme any Astronomical obseruations, but for a Seaman it is to no purpose : and although there may be very much written of the commodious and excellent vses of the Quadrant, yet not being an apt instrument for Sea obseruations, it shall be from my purpose to write further thereof,

[1] The back staff, invented by Davis, was the forerunner of Davis's quadrant, called by the French "Quartier Anglais".

and therefore the onely laying downe of his forme may at this present suffice.

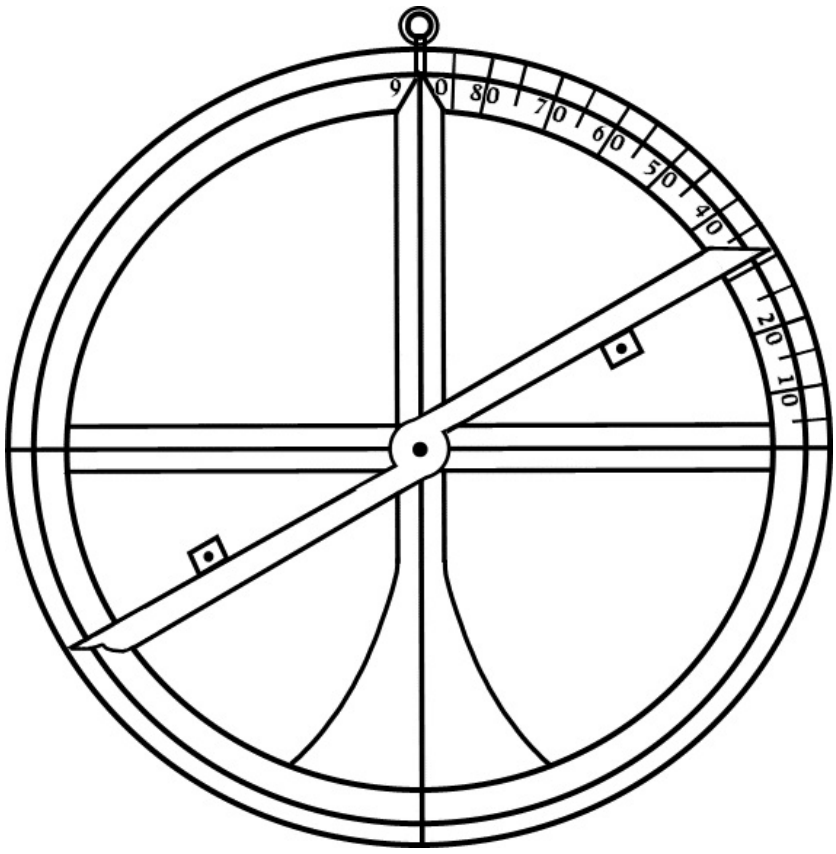


Of the Astrolabie.

An Astrolabie is the representation of a great circle contayning foure quadrants, or 360 degrees, which instrument hath beene in long vse among Seamen, and is an excellent instrument being rightly vnderstoode and ordered, but sith the vulgare Astrolabie w(ith) his vse is to euery Seaman sufficiently knowne, it should be vaine labour for me to lay downe his vse and demonstration ; therefore by his fourme it shall suffice to expresse him.[1]

[1] There have been many treatises on the astrolabe, most of which are referred to in Appendix A.

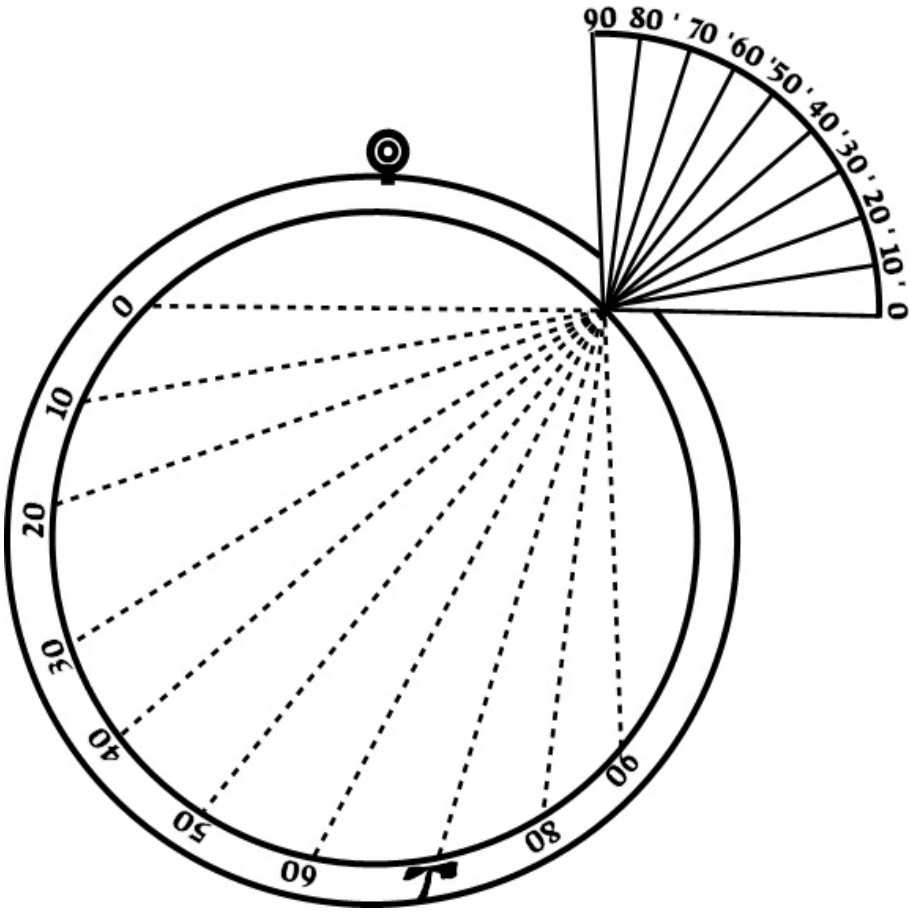
There hath been great paines taken by many for the enlarging of the degrees contained in the Astrolabie, among which there is a proiection to conuey the degrees of a quadrant into the concauity of an Astrolabie, where by these degrees shall be double to any other Astrolabie of



the same quantities so that the Sunne beame pearcing a hole made in the side of the Astrolabie is thereby caried to the degree noted in the opposite concaue part, as by his forme may appeare.

Also my selfe labouring in the same matter, haue found a meane wherby an Arke of a quadrant, whose side is 10 foote, may be conueied into an Astrolabie 10 inches diameter, whose dioptra shall cut his lymbe to right angles, and shall perfourme the complement of 90 degrees as amply and as effectually as by the quadrant it may in any sort be done.

Whose demonstration, together with the demonstration of my Staffe, I purpose, God willing, at large to manifest. But there can be no inuention that can establish the certainty of the vse of either Quadrant or Astrolabie at the Sea, for vnlesse it be in very smoothe water, there can be no certainty of any obseruation by those instruments wherby the Seaman may rest assured of the la(titude) which he seeketh, but the obseruations made by the crosse staffe are without all distrust of error, and therefore no instrument may compare with the excellencie of this crosse staffe for the Seamans vse.



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