

A correction of Errors

lar and difference of latitude are proportionable. Whereof it followeth that so oft as one of these equal parts of the difference of latitude is contained in the segment of the rumb betwixt the two places (which before wee shewed to be so oft as a degree of the meridian in the globe, is contained in the segment of the rumb betwixt the same places in the globe) so oft is one of the said equal parts of the perpendicular aforesaid (that is a degree of the æquinoctiall) contained in the segment of the same rumb betweene the foresayd crossing or ende of the perpendicular, and the æquinoctiall. Therefore Locke how many degrees of the æquinoctiall there are found in the segment of the rumb of the two places, so many score legues is the distance of those two places, which was to be demonstrated.

Thus haue you a way infallible to find out the distance betweene any two places measured in their rumb: which because it is then onely their true distance (that is the shortest space betwixt the vpon the superficies of the terrestriall globe) when both places lie north and south each from other, or east and west, hauing no latitude: whereas otherwise the segment of the rumb betweene the two places is alwaies greater (yea sometimes greater by halfe and more, in places farre northwardes or southwardes) then the true distance: I thought good also here to sette downe the way to finde out the true distance of any two places, wherein I haue bene, and yet am publikely charged with my promise, and meane at this time to discharge my selfe thereof.

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in the sea Chart.

The true distance betwixt two places is the arch of a great circle intercepted betwixt them, which is thus to be found out.

If both places haue no latitude (as when they are both vnder the æquinoctiall) and one of them also no longitude, the longitude of the other being lesse, or not more then 180. degrees: the longitude is the distance.

But if the longitude be greater then 180. degrees, subtract it out of 360. the remainder is the distance.

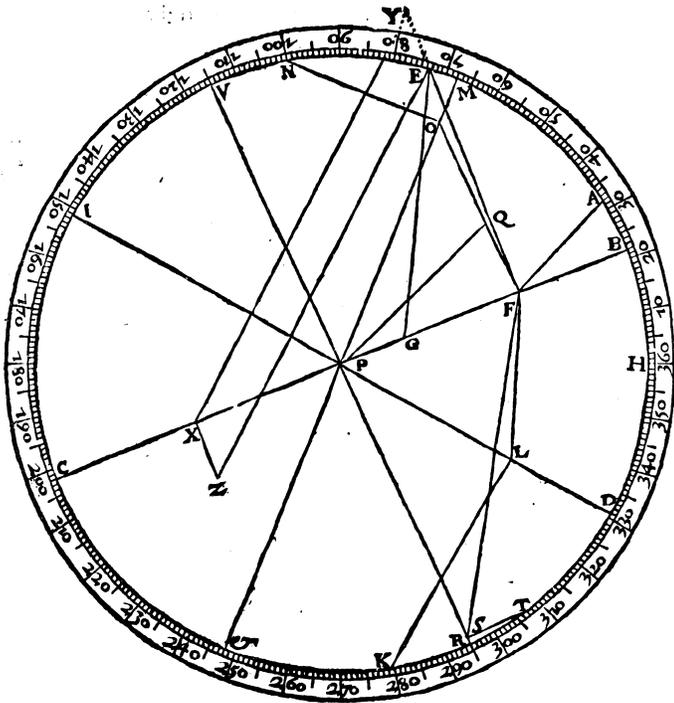
If both places haue either none or the same longitude (as when they are in the same semicircle of the meridian betweene the poles) and one of them onely haue latitude, that latitude is the distance. But if both places agreeing in longitude haue latitudes also of like denomination (as both northerly, or both southerly) subtract the lesser latitude out of the greater, the distance remaineth. If one place haue northerly latitude, and the other southerly, adde them together, the summe is the distance.

If one or both places haue latitude, and differ also in longitude: in a great circle diuided exactly into degrees (with figures set to euery fifth or tenth degree) note the longitudes of both places.

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Now if one place onely haue latitude, drawe a diameter from the longitude thereof, noted in the circle, and with your compasses take so many degrees and minutes in the same circle, as that latitude containeth: then setting one foote of the compasses

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ses in the longitude of that place, with the other make a pricke in the circle, which may be called the poynt of latitude. From this poynt draw a line perpendicular, crossing the diameter drawne from the longitude of that place. Take with your compasses the distance of this crossing, from the poynt of the other places longitude, noted in the circle, and leauing one foote in the sayde crossing, with the other make a pricke, in the foresaid diameter: take the distance of this pricke from the poynt of latitude noted in the circle. Then setting one foote of the compasses in that poynt of the circle where the degrees beginne to be numbred, the other foot extended that way, which the nũbers proceed, shal shewe you in the circle the distance of the places.

Take for example the cittie of *London*, and *Saint Thomas* Iland, which lieth right vnder the æquinoctiall line, in 32 degrees of longitude. The longitude of *London* admit: to be 22 degrees, the latitude 51 degrees, 32 minutes. Marke the longitudes of *Saint Thomas* Iland and of *London* with *A* and *B*. From the longitude of *London*. (because *London* hath also latitude) draw the diameter *BC*. Hauing taken with the compasses the latitude of *London* in the circle, set one foote in *B*, and with the other make the pricke *E* in the circle, and draw the perpendicular *EF*, crossing the diameter *BC* at *F*. Make *FG* equall to *FA*. which is the distance of *Saint Thomas* Iland from the sine of *London*'s latitude. Then *GE* shall bee the line subtending the distance of those two places. Taking therefore the length of *GE* with the compasses, and setting one

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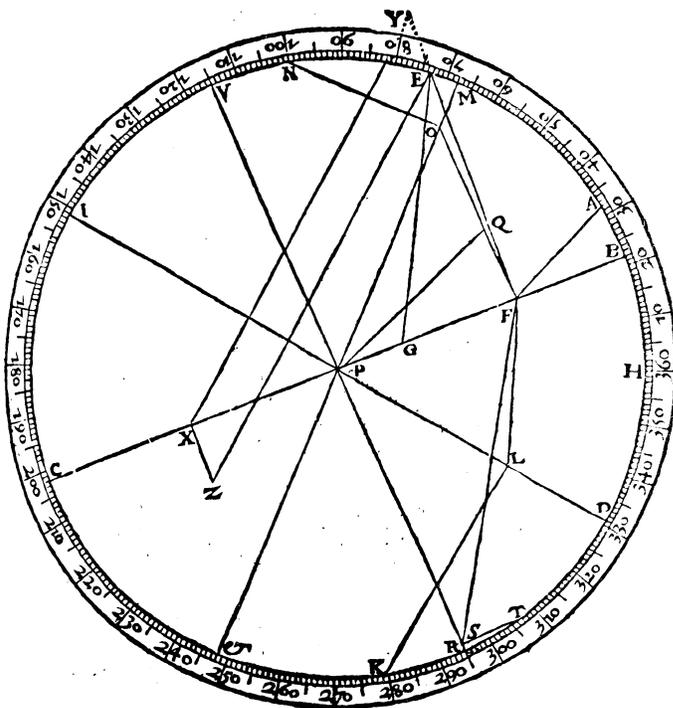
foote in H (where the degrees beginne) the other stretched forwardes in the circle, will poynte you out the distaunce of Saint Thomas Ilande and London, 52 degrees of a great circle, and about one halfe, that is, 1050 leagues, or 3150 english miles.

If both places haue latitude, do the like for both places as before you did for the one place hauing latitude, till you have crossed both diameters with perpendiculars: then take with your compasses the distance of those crossings, Now if both their latitudes bee of one denomination (that is, both northerly or both southerly) and equal, sette one foote of the compasses where the degrees begin to be numbred in the circle, and the other foote extended therein, that way which the numbers succede will shew you the distance.

As for example, London and Cape Blanco (neare the coast of new found land) haue both northerly and almost equal latitude of 51 degrees, 32 minutes. Having therefore drawne as well the diameters BC and DE, from B determining the longitude of London (viz. 22 degrees) and from the poynt of the longitude of Cape Blanco (which admittes to be 331 degrees, as also the perpendiculars or lines of both their latitudes, EF, and KL, (as before was shewed) crossing the diameters in F and L. The distance FL taken with the compasses, and translated into the circle (as the former example) will shew you the distance of Cape Blanco from London, to bee almost 31 degrees, of a great circle that is 620 leagues, or 1860 miles.

If the latitudes be not both equal, and also of one

in the sea Chart.



one denomination, leauing one foote of the compasses in the crossing of the sine or perpendicular descending from the poynt of the greater latitude, with thother foot make a prick in the same diameter, wherein that crossing is: Then if the latitudes be

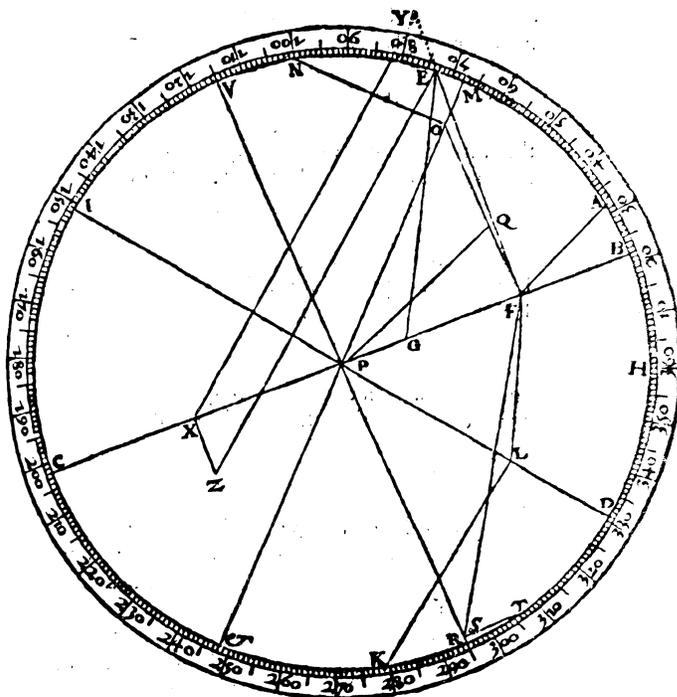
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be both of one denomination, take with the compasses the length of the perpendicular or sine drawne from the poynnt of the lesser latitude : and setting one foote in the poynnt of the greater latitude, with the other make a pricke in the perpendicular descending from it, that is, in the line thereof: Take the distance of this pricke from the former, made in the diameter: This distance transferred into the circle (as in the first example) will giue you the distance of the places giuen.

As *London* and *Hierusalem* haue both northerly and vnequall latitudes, *Hierusalem*s latitude being onely 32 degrees. First therefore note in the circle both their longitudes: the longitude of *London* (*viz.* 22 degrees) as before with B: The longitude of *Hierusalem* (68 degrees) note with M. Let the perpendicular or the lines of the latitudes of *London* and *Hierusalem*, E F, and N O be drawne as in the former examples. Make F P equal to O F, and P Q equal to N O. The space betwixt P and Q taken with the compasses, and then both feet set in the circle (in such sort as the first example was shewed) shall containe betweene them the desired distance of *Hierusalem* from *London*, 38 degrees, and about 3 that is 774 leagues, which are 2325 miles.

But if the latitudes be of diuers denominations, (that is, one northerly and the other southerly) continue forth the perpendicular (that crosseth the diameter, wherin the forefayd prick was made) till it be equal to both perpendiculars, that is, to the sines of both latitudes. The distance of the end

in the sea Chart.



ende of this continued perpendicular from the pricke aforesayd in the diameter, taken with the compasses, and translated into the graduated periphery of the circle (as before) will shewe you how

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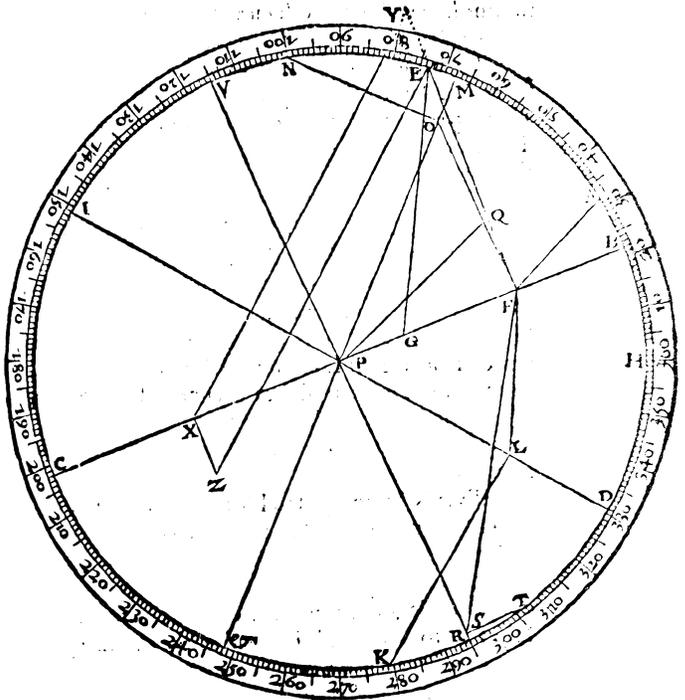
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many degrees of a great circle are contained between both places. To shew this matter with one example, suppose you would know how farre *Cusco* in *Peru* is from *London*. Let the longitude of *Cusco* be 295 degrees, the latitude 11 degrees southerly: The longitude of *London*, as before, 22 degrees, the latitude 51 degrees, 32 minutes. From both these longitudes noted in the circle with B and R, draw the diameters, as before BC, and R V: as also the perpendiculars or sines of their latitudes EF, and TS. Make HK equal to FS, the distance of those lines, and HY equal to SJ, the sine of *Cuscoes* latitude. Take the distance YX betweene the feete of the compasses, and set them both in the circumference of the circle, as in the first example, so shall you finde that there are betwixt *London* and *Cusco* almost 97 degrees, of a great circle that is 1940 leagues or 5820 miles.

If you had rather keepe within the compasses of the circle, make the perpendicular XZ equal to ST, and proceede with EZ, as you did before with XY.

He that desireth a demonstration of the former rule, let the circle ABCR & C to be the æquinoctial circle: Let him also vnderstand the sines of latitude EF, KL, NO, TS, to stand perpendicularly erect from their diameters of longitude BC, DL, M & VR, and from the plaine of the æquinoctial, and consequently by the 3^e. 27. Ra, or 4. pt. 11. Etc. from the lines FA, FL, FO, FS, which lines are imagined to be in the plaine of the æquino-

in the sea Chart.



æquinoctial, and are the distances of the sines of latitude. Therefore, if FG be made equal to FA (which is a line drawne in the plaine of the æquinoctial from *Saint Thomas* Island to the sine of *Londons* latitude) EG must needs be equal to

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the line subtending the distance of London and S. Thomas Iland by the 2. c 7. Ra. 4. 26. pr. 1. *Eucl.*

Also, because all the sines of latitude (being perpendicular to the same plaine of the equinoctiall) are parallels, by the 5. c 21. *Ram* 6. pr. 11. *Eucl.* Therefore by the 11. c 2. *Ram.* or 35 d. 1. *Enc.* FL is the line subtending the distance of London and Cape Blanco.

Againe, because FP whereto EF is perpendicular is made equall to FO, (the distance of the sines of London and Hierusalem, to which (distance) EF is also perpendicular in the globe) and EQ also equall to NO: Therefore FQ being the difference of the sines of Londons and Hierusalems latitudes: there must needs be the same distance betwixt P and Q that there is betweene the toppes of the sines of Hierusalems and Londons latitudes in the globe.

Lastly, FX being equal to FS (the distance of the sines of latitude of London and Culco in Peru) & XZ perpendicular to FX, and equall to ST the sine of Culcoes latitude: as EF is the sine of Londons latitude and perpendicular to the same line XF: EZ (to which XY is equall by the 6. c 12. e 5 *Ram.* 33. pr. 1. *Eucl.* YE being equall and parallel to XZ must needs be equall to a streight line extended within the globe betweene the points of latitude of Culco and London.

Now out of this demonstration it were an easie matter (if any list take the paines to be so curious) to find out the distance of any two places arithmetically by the doctrine of triangles, hauing alwayes

two

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two sides giuen which are the sines of the complements of the latitudes of the twoo places as OP, FP: LP, FP: RP, FP: AP, FP: together with the angle intercepted that is the difference of their longitudes: whereby FA: FO: FL: FS, the distances of the sines of latitude being found by the 2, 3, 4, 5, *Copernic. de Triangulis planis*, the lines also subtending the distances of the places may most easily be found by the 3. *Copernic. de Triang. plan.* For the squares of the distance of the sines, and of the difference of the sines of their latitudes (if both be northerly or both southerly) or of the summe of the sines of their latitudes (if one be northerly another southerly) are equall to the square of the line subtending the distance of the places 5. c 12. *Ram.* 47. pr. 1. *Eucl.*

With no lesse facilitie also by helpe of the former Tables, and the Canon of Triangles, any twoo places being giuen, there may arithmetically and most exactly be found out, first, by their longitudes and latitudes, the rumbe, and distance measured in the rumbe: secondly, by their distance, and latitudes, the rumbe and difference of longitude: thirdly, by their rumbe, and latitudes, the distance and difference of longitude: fourthly, by their longitudes, rumbe, and one latitude, the other latitude and distance: fifthly, by the rumbe distance and one latitude, the other latitude, and the difference of longitude: or any other nauticall or geographical probleme that by the Chart may mechanically be performed: and the whole Arte of Navigation arithmetically (as some call it) may as easily be pra-

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Asked: So as, hauing onely the longitudes and latitudes of the places (by which, and to which you are to saile) set downe in a Table, you may by arithmeticall calculation onely (if you list take the paines) without any chart, mapp, or globe, shewe the course and distance from anie place to other: and so giue most exact direction for the performance of an whole voyage to any knowne place assigned, how oft soeuer you haue trauesed or bin toiled this way and that way by reason of scant, violent, or contrary windes, or any other occasion.

But seeing the first groundes of this Art, that is, the obseruations of the latitudes, but especially of the courses at sea, cannot but be farre from such exquisite truth as is to be found in those arithmetical operations: howe exact soeuer you be in the rest of the meanes, you can look for no more truth in conclusion then such as is answerable to the first groundes and principles, out of which the conclusion is gathered. So as the Mariner shall not need to trouble himselfe any further herewith, but only to cast vpon this account vpon the chart truly made (as it is shewd) which of al other is most fit & ready for his ordinarie vse. Now therefore it may be sufficient, onely to shewe how the former Problemes may mechanically be performed vpon the nautical planisphere before described.

First, By the longitudes and latitudes of both places giuen, the rumb and distance may thus be found: drawe parallels by both latitudes: take the distance of these parallels: according to which distance drawe a parallel to the æquinoctiall. Then
from

in the sea Chart.

from the end of the difference of longitude reckoned from the concurse of the rumbes in the æquinoctiall erect a perpendicular crossing the saide parallel: A line drawn by this crossing from the concurse of the rumbes is the rumb of the two places. Now to finde out the distance, take so many degrees of the æquinoctiall as the difference of latitude containeth: and guiding one foote of the compasses in the æquinoctiall, with the other foote carried parallel-wile at equall distance from the æquinoctiall, crosse the rumb newly found out: take the distance of this crossing from the concurse of the rumbes, and set both feete of the Compasses in the æquinoctiall, for the degrees intercepted shew you the distance desired.

Secondly, By the distance & latitudes (knowing which place is more eastwardes, or westwardes) the rumb & difference of longitude is thus found: Take with the compasses so many degrees and minutes of the æquinoctiall, as the difference of latitude containeth: According to that distance draw a parallel to the æquinoctiall, take so many degrees of the æquinoctiall with your Compasses as the distance giuen cometh to: then one foote being set in the concurse of the rumbes in the æquinoctiall, with the other crosse the parallel aforesaide: A line drawne by that crossing from the concurse of the rumbes in the æquinoctiall, giueth you the rumb desired. Then both latitudes being noted in the graduated meridian, therein take their difference with the compasses, and guiding one foote in the æquinoctiall, with the other carried at that
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distance parallel-wise from the æquinoctial, crosse the rumbe of the places : the distance of that crossing from the meridian (that commeth from the common meeting of the rumbes in the æquinoctial) taken with the compasses, and brought to the æquinoctial, shal shew you the difference of longitude. Or a perpendicular to the æquinoctial from that crossing shal poynt you out therein, the difference of longitude.

Thurdly, By the rumb and latitudes (being both northerly or both southerly) the distance and difference of longitude is thus found : Take the difference of latitudes in the æquinoctial: according to that distance draw a parallel to the æquinoctial (as before) crossing the rumb of the two places giuen: take the distance of this crossing from the concurse of the rumbes : Then both feete of the compasses set in the æquinoctial wil shew the distance of the places. The difference of longitude is found as before.

Fourthly, By the longitudes rumb and one latitude (knowing whether it be the lesser or greater) to finde the other latitude, and the distance, do thus : From the concurse of the rumbes in the æquinoctial count the difference of longitude: from hence erect a perpendicular crossing the rumb: the distance of this crossing from the æquinoctial translated into the graduated meridian (setting one foote in the knowne latitude, and extending the other northwardes or southwardes according as the vnknowne latitude is greater or lesser) shal shew you the latitude desired. Now to finde the distance

of the Compasses.

distance worke as before in the first Probleme.

Fiftly, by the rumb, distance, and one latitude, you may finde the other latitude and the difference of longitude after this manner : Take the distance giuen with the Compasses in the æquinoctial: set one foote in the concurse of the rumbes, and with the other crosse the rumb giuen : from this crossing draw a perpendicular to the æquinoctial: the length of that perpendicular taken with the Compasses and brought into the æquinoctial shal shew you the difference of latitude. Thus hauing both latitudes giuen, the difference of longitude may also be found as before Prob. 2.

Nowe in euery one of these problemes there may be some particular cases wherof some diuersitie of working may follow, yet such as can breed but small trouble to him that well shall conceiue the reason of that is already set down in these five former Problemes : which are especially to be applied to such places as are both on the same side of the æquinoctial, and differ also both in longitude & latitude: of which sort is the greatest number, and in which the greatest vlc, and most difficultie of working consisteth. To prosecute euery particularitie at large (whereof some perhaps lesse acquainted with the reason of these mathematical practises may be desirous) would be now for mee too long and tedious. For some taste therefore of the vse of this nauticall planisphere, let thus much for this time briefly suffice.

M

ETTON