

A nevv quadrant, of more naturall, easie, and manifold performance, than any other heretofore extant framed according to the horizontall projection of the sphere, with the uses thereof. By C.B. maker of mathematic instruments in metall.

Brookes, Christopher, fl. 1649-1651.

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A NEVV QUADRANT, OF More Naturall, Eaie, and Manifold Performance, than any other heretofore Extant; Framed according to the Horizontall Projection of the Sphere, with the Ues thereof.

By C. B. Maker of Mathematic Intruments in METALL.

LONDON, Printed in the Yeare 1649.

TO My Singular good Friend Mr. WILLIAM BADILEY, Mariner, and a lover of the Mathematics.

Worthy Sir,

HAVING diligently inquired the reacon of the projection of the Sphere into plaine, as the ground of all Mathematic Intruments (the making whereof in Metall is my Trade and Livelihood) and compared the everall manners; I found none o genuine, imple, eaie, and manifoldly uefull, as is the Horizontall; which lively repreenteth the Globe rectified to ome certaine elevation, and naturally performeth the ues thereof. And having likewie compared the everall Quadrants, and pocket Intruments hitherto made, and finding them all pieced up with many unnaturall and forced lines and diviions, preuppoing an exact diligence both in the Calculator, and in the workman; and yet the performance difficult, troubleome, and tedious: I bethought my elf whether out of the Horizontall projection I might not by ome mal alteration frame a Quadrant, that might remedy the defects of all the former Intruments, and that with greater eae and certainty. And having by the help of God happily attained my deired intent, my many repects repreented you under whoe Approbation and Patronage I might end out into public view this my new Quadrant, with the many Ues thereof; as being one to whom I tand obliged for your love and manifold favours to mee both at Sea in divers Voiages, and at land; and who through your skill in the Mathematicall Sciences are able to judge and patronize the firt attempts of

Your affectionately devoted Servant, C. B.

THE Description of the Quadrant, and the parts thereof.

The limbe of the Quadrant divided into 90 Degr. representeth the Horizon.

That ide of the Quadrant where the Sights are, is the Meridian, or XII a Clocke line, unto which is joynd the cale of Moneths with every fift Day, untill they grow o little toward the Solticeas, that they cannot bee ditinguihed. This cale hath five Rowes, the midt whereof hath the very ame diviions which are on the Meridian line: The two next on both ides are for the parts of the Moneths, which in the two outermot Rowes are noted by their firt Letters.

The other ide of the Quadrant hath on it the cale of Altitudes above the Horizon.

The hort Arching lines within the Quadrant beide the Meridian, are Houre-lines, noted by their Figures, both for the forenoone, and afternoon; and halfe Houre lines: each halfe houre containing 30 min. of an hour, or Deg. 7. 30. Of thee Horary lines, thoe which erve in the morning before the Sunne is full Eat, or in the evening pat the Wet, (which is onely in Summer halfe yeare) are revered. And all the Hour lines are noted with two Figures; whereof the upper next the Center and cale of Altitudes, erve for the afternoon; and the lower for the forenoon. The two Arches which croe the Houre lines, and meet at the beginning of the Horizon and cale of Altitudes, are two Quarters of the Ecliptic, and are divided into 90 Degr. a piece, in which are noted the XII Signes by their proper Characters, namely on the upper next the Center are & , the Summer or Northerne Signes: and on the lower next the Horizon are & , the Winter or Southerne Signes, and contain 30 Degr. a piece. This is the Circle of the Sunnes annuall motion.

The long Arches, which beginning at the Scale of moneths in the Meridian betwixt the two Quarters of the Ecliptic, croe all the Houre lines, are the parallels of Declination, or the Semidiurnall Arches of the Sunne; the middlemot of which is the Equinoctiall, the outermot above is the Tropick of , and the outermot below is the Tropick of : although between the Equinoctiall and each Tropick Innumerable parallels are undertood to be contained, yet thoe which are in the Intrument drawne, at every econd Degree of Declination, may be ufficient to direct the eye in tracing out an imaginary parallel from every point given in the Scale of moneths.

The Equinoctiall and every tenth parallel are for ditinction ake made omewhat groer than the ret, and all the Summer parallels at the Eat and Wet line are continued reveredly back unto the Horizon.

Note that upon the right etimation of that imaginary parallel, the manifold ue of this Intrument doth epecially rely; becaue the true place of the Sunne all that day is in ome part or point of the ame Circle.

And note that in this Intrument, the direct Horary lines, and parallels before their reverion, hew the houre of the day like a direct South upright Diall: And the Arches of them revered erve like a direct North upright Diall.

Ue I. To finde the Declination of the Sun every day.

Seek the day propoed in the Scale of moneths very exactly, & mark upon what point it falleth in the middle Row of that Scale, or (which is all one) in the Meridian, for there is the Declination of the Sunne from the Equinoctiall, either North or South: which if it fall not directly upon a parallel, but in the pace between two, uppoing

each halfe of that pace to containe 60 minutes, estimate with your eye proportionally what minute the point giveth.

Example 1. What is the Sunnes Declination upon Novemb. 13? the day will fall in the pace after 20 Degrees, from the Equinoctial Southward, about 30 minutes: Wherefore the Sunnes Declination is 20. 30 South.

Example 2. What is the Sunnes Declination upon August 19? the day wil fal in the pace after 8 Degrees, from the Equinoctial Northward, one Degree and about 40 minutes: Wherefore the Suns Declination is 9. 40. North.

Note that the Declination thus found is to be kept in minde all the day.

Ue II. To finde the Semidinunall Arch, or parallel Circle in which the Sunne moveth every day.

Seeke out the true point of the Sunnes Declination upon the Meridian by Ve I: then from that point by the etimation of your eye, trace out an imaginary parallel: which when it commeth to the East and West line (as in all Northerne parallels it doth) is to bee revered unto the Horizon or Limbe at the same proportionable distance as before. This operation requireth exact diligence.

Ue III. To finde the time of the Sunes Rising and Setting every day.

Seek out the imaginary parallel, or Semidiurnal Arch of the Sun for that day by Ve II, and marke where it meeteth with the Horizon; for that is the very point of the Sunnes rising and setting, and the Hour-lines on both sides of it, (by proportioning the distance reasonably, according to 30 minutes for halfe an houre) will shew the time of the Sunnes rising and setting.

Thus at London, Novem. 13. the Sun will be found to rise at 9 min. before 8, and to set at 9 min. after 4. Also August 19, the Sunne will be found to rise 12 min. after 5. and to set 12 min. before 7.

Ue IV. To finde the Sunns Amplitude, Ortive and Occaive: that is, how many Degrees of the Horizon the Sunne riseth and setteth from the true East and West points every day.

The imaginary parallel of the Sunne, together with the time of the Sunnes rising, and setting, sheweth upon the Horizon the Degree of his Amplitude from East and West, which in all the Northerne parallels is on the North side, and in the Southerne on the South side.

Thus at London, Novem. 13. the Ampl. Ort. will be found 34 Degrees. Also Aug. 19. the Ampl. Ort. will be found 15. 10.

Ue V. To find the Length of every day and night.

Double the houre of the sunnes-setting, and you shall have the Length of the day: or double the houre of the sunnes-rising, and you shall have the Length of the night.

Ue 6. To know the reason and manner of the Increasing and Decreasing of the Dayes and Nights throughout the whole yeare.

When the Sunne is in the Equinoctial, it riseth and setteth at 6 a Clocke: But if the Sunne be out of the Equinoctial, declining toward the North, the Intersection of the parallel of the Sunne with the Horizon is before 6 in the morning, and after 6 in the evening; and the Diurnall Arch greater than 12 houres, and so much more great, the greater the Northerne Declination is. Again, if the Sunne be declining toward the South, the Intersection of the parallel of the Sunne with the Horizon is after 6 in the morning, and before 6 in the evening; and the Diurnall Arch less than 12 hours, and by so much less, the greater the Southern Declination is.

And in thoe places of the Ecliptic in which the Sunne mot peedily changeth his Declination, the Length alo of the day is mot altered; and where the Ecliptic goeth mot parallell to the Equinoctiall, changing the Declination lowly, the length of the day is but little altered. As for Example; When the Sun is neare unto the Equinoctiall on both ides, the dayes Increate and alo Decrease uddenly and apace; becaue in thoe places the Ecliptic inclineth to the Equinoctiall in a manner like a traight Line, making enible Declination. Againe, when the Sunne is neare his greatest Declination, as in the height of Summer, and the depth of Winter, the dayes keep for a good time, as it were, at one tay; becaue in thee places the Ecliptic is in a manner parallel to the Equinoctiall, the Length of the day differeth but little, the Declination carce altering; and becaue in thoe two times of the year, the Sunne tandeth as it were till at one Declination, they are called the Summer Soltice, and Winter Soltice. Wherefore wee may hereby plainly ee, that the common received opinion, that in every moneth the dayes doe equally increae, is erroneou. Alo wee may ee, that in parallels equally ditant from the Equinoctiall, the day on the one ide is equall to the night on the other ide.

Ue VII. To take the height of the Sunne above the Horizon.

Hold the edge of the Quadrant againt the Sunne, o that the Sunnes Ray or Beam may at once pae through the hole of both the ights; then hall the thread with the Plummet hew the Sunnes Altitude.

Ue VIII. To finde the Houre of the day, or what a clock it is.

Having the imaginary parallel or Semidiurnall Arch of the Sunne, already found and conceived in your minde by Ve II, take the Sunnes height above the Horizon, then tretching the thread over the cale of Altitudes, et the Bead to the Altitude found, move your thread untill the Bead exactly falleth upon the imaginary parallel, for there is the houre fought; and that is the true place of the Sun in the Quadrant at that time; to bee etimated upon the Horary lines, either direct, or revered, according as the parallel is.

Ue IX. To finde the Sunnes Azumith or Horizontall ditance from the foure Cardinall points.

The Bead being et to the houre of the day, as was hewed in the e next before, the thread hall in the Limbe cut the Eat or Wet Azumith; that is, how many Degrees of the Horizon the verticall Circle in which the Sunne is, is ditant from the Eat and Wet points: The complement of which number giveth the Azumith from the South Meridian, if the Bead fell in the right parallels: But if the Bead fall upon the revered parts, the Azumith is to be accounted from the North Meridian.

Ue X. To finde the Meridian Altitude of the Sunne every day.

Stretch the thread over the Meridian, and et the Bead to the true Declination of the Sunne therein; then apply the thread to the cale of Altitudes; and the Bead hall give the Meridian Altitude ought.

Ue XI. To finde at what time the Sunne commeth to bee full Eat or Wet every day in Summer.

This is hewen by oberving at what houre the imaginary parallel meeteth with the Eat and Wet line, at which it beginneth to reveere.

Ue XII. To finde how high the Sunne is above the Horizon at any houre, every day.

Set the Bead to the point in which the imaginary parallel of that day croeth the

houre given: then applying the thread to the scale of Altitudes, mark upon what Degree the Bead falleth; the same shall be the Altitude of the Sun required.

Ue XIII. To finde how high the Sunne is being in any Azimuth aigned every day: and also at what houre.

Set the Bead to the point in which the imaginary parallel of that day croeth the Azimuth aigned; There also shall be the houre ought: Then applying the thread to the scale of Altitudes, marke upon what Degree the Bead falleth; The same shall be the Altitude of the Sun required.

These two last Ues serve for the Delineation of the ordinary Quadrants, as that of Gemma Frius, Munter, Clavius, Mater Gunter, &c. and also of Rings, Cylinders, and other Topical Instruments; and for the finding out of the houre by a mans shadow, or by the shadow of any Gnomon, either perpendicular, or else parallel to the Horizon.

Ue XIV. To finde the Sunnes Longitude, or place in the Ecliptic.

The imaginary parallel of the day being exactly traced will cut in the Ecliptic the Signe and Degree wherein the Sunne is: and note, that each emicircle of the Ecliptic is doubly noted with Characters of the Signes; the first and third Quarters goe forward from the Equinoctial point unto the Meridian, containing 90° & 180° : the second and fourth Quarters goe backe from the Meridian unto the Equinoctial point, containing 270° & 360° .

But because neare unto both Tropicks (namely from May 11, to July 10, in the height of Summer, and from November 13, to Januarie 12 in the depth of Winter) the Declination altereth so lowly, that the true place of the Sunne in the Ecliptic cannot be distinguished with any certainty, worke according to this foure-fold Rule following.

1. Before June 10, out of the number of dayes from May 0, subtract 11: the remains shall be the Degrees of 34 : thus for June 3, (because there is all May and three dayes of June) ay $34 - 11 = 23$, the place of the Sunne.

2. After June 10, out of the Number of dayes from June 0, subtract 10: the remains shall be Degrees of 33 : thus for July 3, ay $33 - 10 = 23$, the place of the Sun.

3. Before December 13, out of the Number of dayes from November 0, subtract 13: the remains shall be Degrees of 33 : thus for December 3, ay $33 - 13 = 20$, the place of the Sun.

4. After December 13, out of the Number of dayes from December 0, subtract 13: the remains shall be Degrees of 34 : thus for January 3, ay $34 - 13 = 21$, the place of the Sunne.

Ue XV. To find the Sunns Right Ascension every day.

Having by Ue XIV. found the place of the Sunne in the Ecliptic, mark diligently upon what houre, and as neare as you can estimate what minute it falleth, counting the houres in the first and third Quarters of the Ecliptic, from the Equinoctial point; but in the second and fourth Quarters, from the Meridian: and adde thereto in the second Quarter ix houres, in the third twelve houres, and in the fourth eighteen houres: so shall you have the Sunnes Right Ascension, not in Degrees, but in time, which is more proper for use.

Example, in 6° the Sunnes Right Ascension will be eight houres, one halfe, and about three minutes; that is H: 8: 33. min. reckoning 30 for halfe an houre.

Ue XVI. To find the Houre of the Night by the Starres.

For this, I have et a little Table of five knowne Stars dipered round about the Heavens, with their Declination and Right Acenion for Anno Dom. 1650. Namely the left houlder of Orion, noted O. The heart of the Lion, noted . Arcturus noted A: the Vulture volant, noted V. The end of the wing of Pegaus, noted P.

The Table.	Declinat.	Rec. A.
O	5 59 N	H5 6,5
	13 39 N	9 50
A	21 4 N	14 00
V	8 1- N	19 34
P	13 15 N	23 55, 5

The Operation is thus; firt by the height of the Starre taken, and the parallel of its Declination exactly traced, eek out the houre of the Starre from the Meridian, as before was taught for the houre of the Day by the Sunne. Secondly, out of the Right Acenion of the Starre, ubduct the Right Acenion of the Sun; the remain• heweth how long time from the Noone before the ame tarre commeth into the Meridian. Latly, if the Starre be not yet come to the Meridian, out of the houre of the Starres comming into the Meridian, ubduct the houre of the Starre: but if the Star be pat the Meridian, adde both the houres together; o hall you have the true houre of the Night.

Note, that if the hours out of which you are to ubduct bee leer than the other, you mut adde unto them 24.

Ue XVII. To finde out the MeridianLine upon any Horizontall plaine.

About the middle of your plaine deccribe a Circle; and in the Center thereof erect a traight Piece of Wire perpendicularly. When the Sunne hineth, note the point of the Circle which the hadow of the Wire cutteth, which I therefore call the hadow point; and intantly by Ve IX. eeke the Sunnes Azumith from the South or North: keepe it in minde. Then from the hadow point, if your obervation be in the foorenoon, reckon upon the circle an Arch equall to the Azumith kept in minde, that way the Sunne moveth, if the Azumith bee South: Or the contrary way if it bee North. But if your obervation bee in the afternoone, reckon the North Azumith that way the Sunne moveth; Or the South Azumith the contrary way.

Latly, through the end of the Azumith and the center, protract a Diameter for the Meridian line ought: which you may note with S. at the south end, and with N. at the North end.

You may alo note the point of the Circle Diametrally oppoite to the hadow point with un; because it is the Azumith place of the Sun, at the moment of your obervation.

Ue XVIII. To finde the Declination of any Wall or plaine.

The afet way (because the Magneticall Needle is apt to be drawne awry) will be by an Intrument made in this manner. Provide a rectangular board about ten Inches long, and five broad: in the midt whereof, croe the breadth, trike a Line perpendicular to the ides; and taking upon it a Center, deccribe a Circle interecting the ame Line, in two oppoite points, to be noted with the Letters T. and A: divide each emicircle into two Quadrants, and every Quadrant into 90 Degrees, beginning at the points T and A, both wayes; the firt Quad. beginning on the left hand of T.

the second Quadrant on the right hand: the third Quadrant above it toward A: And lastly, the fourth Quadrant. And in the Center erect a Wier at right Angles.

The use of this Instrument. Apply the long side of the board next T to the Wall when the Sunne shineth upon it, holding it parallel to the Horizon, that it may represent an Horizontall plaine. Marke what Degree the shadow of the Wier cutteth in the Circle; and instantly seek the Sunnes Azimuth, either South or North: Reckon it on the Circle from the shadow to the Meridian, as was taught in the Use next before, noting that end with the Letter contrary to that of the Azimuth: as if the Azimuth be South, note it N. and the opposite end S; if the Azimuth be North, note it S, and the opposite end N: whereby also you have the East and West sides: So shall the Arch S A. or N A. give the Declination of the plaine, and the point A, the east or quarter into which it is.

Example, June 2 in the forenoone, applying the instrument to a wall, I found the shadow in 23 Degr. of Quadr. 2. and the height of the Sunne was 26 Degrees, whereby I found the Azimuth to be North 84 Degr. which reckoned from the shadow against the Sunne, fell upon 61 Degr. in Quad. 1. for one end of the Meridian; and the Opposite end which is N. upon 61 Degr. in Quad. 3. And A was on the East side of N. Wherefore the Declination of that Wall is 61 Deg. from the North Eastward.

Use XIX. To finde the Declination of an upright wall by knowing the time of the Sunnes coming to it, or leaving it. And contrariwise, the Declination of an upright Wall being known to finde at what time the Sunne will come into it.

Because the Declination of a plain is an arch of the Equinoctiall intercepted between the Horizontall section of the plaine: and the East or West points: Or else (which is all one) between the Meridian, and A, the axis of that Horizontall section. Watch till you see the Center of the Sunne just even with the edge of the Wall: then instantly take the Sunnes Azimuth from East or West, by Use IX. the same is the Declination of the wall.

Likewise if the Declination be given, reckon it upon the Limbe of your Quadrant from the East and West point; and the thread being applied to the end of that Arch, hal in the Sunns imaginary parallel for that day, cut the hour and time desired.

Use XX. Certaine advertiements necessary for the use of the Quadrant in the night.

In which Questions as concerne the night, or the time before Sunne-rising, and after Sunne-setting, the instrument representeth the lower Hemisphere, wherein the Southern Pole is elevated. And therefore the parallels which are above the Equinoctiall toward the Center, shall be for the Southerne or winter parallels: and those beneath the Equinoctiall, for the Northerne or Summer parallels: and the East shall be counted for West, and the West for East; altogether contrary to that which was before, when the Instrument represented the upper Hemisphere.

Use XXI. To finde how many Degrees the Sunne is under the Horizon at any time of the night.

Seek the Declination of the Sunne for the day proposed by Use I. and at the same Declination on the contrary side of the Equinoctiall imagine a parallel for the Sunne that night; and marke what point of it is in the very hour and minute proposed: Set the bead to that point; then applying the thread to the scale of Altitudes, marke upon what Degree the bead falleth: for the same shall shew how many Degrees the Sunne is under the Horizon at that time.

Use XXII. To finde out the length of the Crepusculum, or Twi-light.

It is commonly held that Twilight is so long as the Sunne is not more then 18 degrees, under the Horizon, the question therefore is, at what time the Sunne cometh to be 18 Degrees under the Horizon any night.

Seek the Sunnes declination for the time propoed, and at the same declination, on the contrary side of the Aequinoctiall, imagine a paralel for the Sunne that night: then set the bead at 18 degrees in the scale of Altitudes; and carry the thread about till the bead fall upon the imagined parallell: for there shall be the houre or time ought.

And in this very manner you may find the time or houre of the night at any other depreion of the Sunne under the Horizon.

FINIS.