Horologiographia: or, the art of dyalling, being the second book of the use of the trianguler-quadrant : shewing the natural, artificial, and instrumental way, of making of sun-dials ... by the trianguler-quadrant : also the use of the same instrument in navigation ...

2

Horologiographia:
OR,
The Art of Dyalling,
BEING
The *Second Book* of the Use of the
Triangular-Quadrant.

Shewing the Natural, Artificial, and Instrumental way, of making of *Sun-Dials*, on any flat Superficies: With plain and easie Directions, to discover their Nature and Affections, by the *Horizontal Projection*.

With the way of Drawing the usual Ornaments on any Plain: Also, a familiar easie way to draw those Lines on the Ceiling of a Room, by the *Trianguler Quadrant*.

Also, the Use of the same Instrument in
NAVIGATION;
Both for *Observation*, and *Operation*.

Performing the use of several Sea-Instruments still in use.

By *John Brown*, Philomath.

London, Printed by *John Darby*, for *John Wingfield*, and are to be sold at his house in *Crutched-Fryers*; and by *John Brown* at the *Sphear* and *Sun Dial* in the *Minories*; and by *John Seller* at the *Hermitage-stairs* in *Wapping*: 1671.

To the Courteous *Reader*.

THou hast here presented to thy view (Courteous Reader) *in this second Part, a plain discourse of* Dialling, *both* Natural, Artificial, & Instrumental. Natural *I call it, from the plain illustration thereof, by the Armilary Sphear of Brass herein described, or by the* Poorman's Dial-Sphear, *as I fancy to call it, being only a moving Horizontal-Dial, and a moving Plain, according to the Figure thereof in the Book annexed, whereby all the Arks, Angles, Scituations and Affections, are very plainly represented to an ordinary capacity.* Artificial *I call it, from the lively delineation of the* Horizontal-projection, *the fittest in my opinion for the making plain the mystery of* Dialling. Instrumental *I call it, from the applying of the* Trianguler-Quadrant, *to the ready resolving all the Arithmetical and Astronomical work,* *needful thereunto; and that to competent exactness, as in the first Part, and also in this second Part is sufficiently seen, in finding the requisites and delineating the hour-lines to small parts, exactly & speedily by the natural Sines, Tangents and Secants on the* Sector *and* Quadrant.

Also, the ready way of finding the Suns Altitude, Hour, Azimuth, Angle of the Plain, and any such business relating to Dyalling, *as in the first Part is largely treated on.*

Further, in this second Part you have Tables *of the* Suns *Declination to every day of the years,* 1, 2, & 3, *after the Bissextile, as near as any extent. Also, a short, but plain direction, how to use the* Trianguler-Quadrant, *at any manner of way of Observation used at Sea; as backward or forward, as the* Davis-Quadrant, *and the* Crofs-staff *is used; also, as* Gunter's Bow *is used both for the* Sun *or* Stars.

Also, how it is used, as a Cinical, or Traverse Quadrant, *with the manner of working*

working the six usual *Problems of plain Sailing by the Natural and Artificial Line of* Sines, Tangents, *and* equal Parts *and* Numbers; *and plainly and conveniently to apply it, to the resolving that hard Question, of Sayling by the Arch of a great Circle, to shew plainly the Longitudes and Latitudes alteration the whole Course or Voyage.*

The Prints of the Lines of Numbers, as you see here inserted, are in part according to Mr. Windgates, *as to a single and broken line of Numbers: But the addition of the line of the Fractional parts of a pound, and the several Gage-points, were never before used as I know of; but do much ease & expedite the Operations by the Line of Numbers, Sines and Tangents. Also, these Scales of Reduction are convenient for the finding the Decimal-fraction, equal to the other Sexagenary-fraction, and are agreeable to those* Tables *in Mr.* Windgates *Book of Arithmetick*, pag. 82.

Also note, that the figure of the Rule *at the beginning of the Book, pasted on a* Board, *is the very same with that spoken of* Chap. XV. Use 28. pag. 397, *of the first Part, and will work all Questions wrought by the* Trianguler-Quadrant, *to exercise them that are out of the way to have them made, and may serve as good directions to the young Instrument-Maker, though these are made too too small a Radius to arrive at exactness.*

The like may I say of the Gunters-*Lines in the* Figures *annexed, yet as large as the* Book *will bear.*

Thus I have given you a brief account of my present Thoughts about this matter, and somewhat more particularly in the First Part, disclaiming all boasting or vain ostentation, knowing that at the next Impression it may be amended in many places; I shall rest and remain, ready to make amends in the making of these, or any other Mathematical Instruments, at my House at the Sphear *and* Sun-Dial *in the* Great Minories.

John Browne.

February 16.
1670.

CHAP. I.

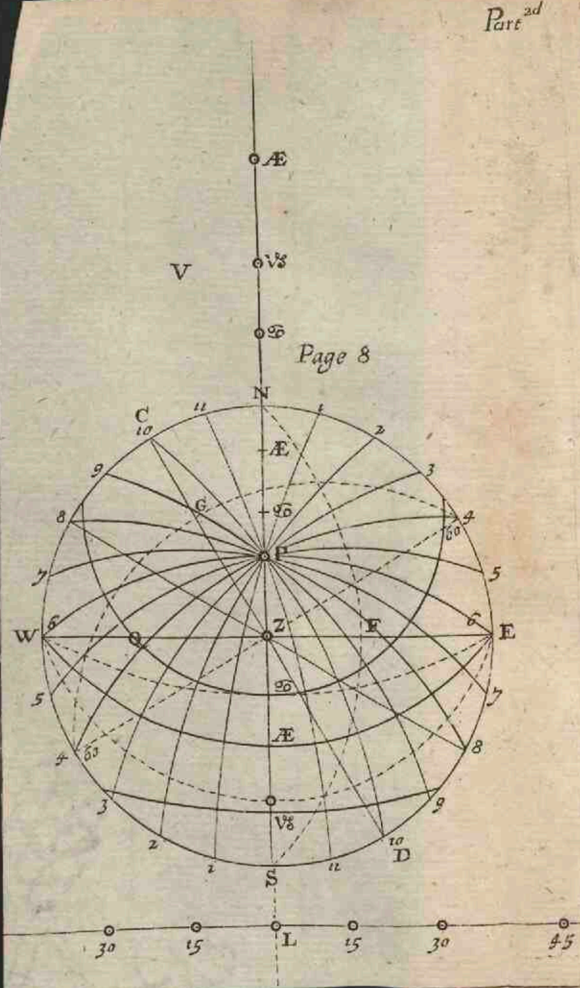
The use of the Trianguler Quadrant, *IN* *Making of* DIALS.

SUn-*Dials* may be made on any Plain, and all kind of Plains are either *Flat*, as *Horizontal*; or *Upright*, or *Leaning*.

The *Horizontal* hath two faces, the one beholding the Zenith, called the Horizontal-Plain; the other, beholding the Nadir, as the Ceiling of a Room is.

The *Upright Plains*, are those that make right Angles with the Horizon, and do behold neither the Zenith or Nadir, but are parallel to them.

The *Leaning Plains* are of two sorts generally; the one called Recliners, beholding the Zenith; the other sort called Incliners,



cliners, beholding the Nadir, as the out-ſide, and in-ſide of a Roof of a Houſe, may repreſent.

The two laſt ſorts, *viz. Upright* and *Leaning*, may be Direct or Declining, *viz.* beholding the South, or North, or Eaſt, or Weſt Point of the Horizon ; or Declining therefrom, *viz.* Declining from South, or North, toward the Eaſt or Weſt.

All which Plains, are lively repreſented by a Sphear, made for that purpoſe, in Braſs or Paſteboard, or by the Projection of the Sphear in *Plano*, *Thus*;

Equal to the Radius of the ſmaller Tangents, deſcribe the Circle E S W N repreſenting the Horizon, croſſing it preciſely in the the Center Z, with the Lines S N and E W, denoting the Points of South and North, Eaſt and Weſt.

Then counting the ſmaller Tangent on the Sector-ſide doubly, as *thus*, calling 5, 10; & 10, 20; & 20, 40; & 30, 60; & 40, 80; & 45, 90; &c. Lay off from Z, towards S, the complement of the Suns Meridian Altitude, in ♋, in ♈, and ♑; for thoſe Points on the Meridian-line, between Z and S; and conſequently the half Tangent of the complement of the Suns Meridian Altitude in every degree of Declination, (if you proceed ſo far).

Then

Then for the Interſections of all thoſe Lines and Parallels of Declination on the North-ſide of the Meridian, *Obſerve*, That the ſame number of degrees and minuts, that any Point is above the Horizon on the South part of the Meridian in Summer, juſt ſo many degrees and minuts is his oppoſite Parallel in Winter below the Horizon.

As thus for Example.

The Sun being in ♋, or 23 deg. 31 min. of Declination North, hath for his Meridian Altitude 62 degrees, and ſo many degrees is his oppoſite Parallel of 23-31, or ♑, below the North part of the Horizon, at midnight. *As thus*;

Let the Center, at the beginning of the Line of Tangents, repreſent the Center Z; and let the Tangent of 45, repreſent the Horizon in the Scheam, *viz*. S. and N.

Then,

As the diſtance from S. to ♑, is 15 deg. taken from 45 toward 0, and laid from S. to ♑ inwards toward the Center Z, as the diſtance was taken from the Tangent of 45, toward the beginning of the Line of Tangents, that repreſents the Center;

So the Point *Cancer* from N. is 15 deg. counted beyond 45, toward the end, below or beyond the Horizon.

Again,

Again,

As S. ♋ is 62 degrees from 45 towards
00;
So is the other Point 62 degrees below N, taken from 45, *viz.* at 76 degrees; which being laid from N, doth over-reach this little page.

So that to draw the Tropick of ♑, the Point ♋ being his opposite, is 28 degrees from Z, or 62 deg. from S; and the other Point of ♑, on the North part of the Meridian, is 62 degrees, counting from 45 doubly also; or 28 degrees from 90, the supposed end of the Tangent, which is naturally infinite, being the Tangent of 76 degrees, or the Semi-tangent of 152, reading the Tangents doubly from the Center; which distance from the Center, to the Tangent of 76; or as half-tangents, 152, laid from Z, gives the Point ♑ on the North-part of the Meridian, below the Horizon; the midst between which two Points of ♑ on the South and North part of the Meridian, is the Center to draw the Tropick of *Capricorn.*

Again, to illustrate this difficulty, to draw the Tropick of *Cancer*, the Suns Meridian-Altitude in ♑, his opposite sign is 15 degrees above the Horizon on the South part of the Meridian,

Meridian, and 15 degrees below the Horizon, on the North-part of the Meridian, *viz.* the Extent from the Center to the Tangent of 52 deg. 30 min. or the Semi-tangent of 105, reading it doubly; being laid from Z, gives the Point ♋ below the Horizon; the middle between which two Points is the Center to draw the Tropick of *Cancer.*

Again, for the Equinoctial or Parallel of ♈; the Meridian Altitude in ♈, is 38-28; and the Meridian Altitude likewise in ♎, his opposite Parallel is 38-28 also; so that if you count 38-28 doubly beyond 45, which will be at the Tangent of 64 degrees and 14 minuts, and take from thence to the Center; this distance laid from Z, shall give the Point Æ below the Horizon, and the the middle between the two Points Æ, is the Center to draw the Æquinoctial.

Then for the Hour-Lines; first, set off the Semi-tangent of 38-28 from Z to P; and the Secant of 38-28 to the same Radius from Z to L, and draw the Line L 45 parallel to E W; then make P L a Tangent of 45 degrees, and lay oft the Tangents of 15-30, and 45, from L both-wayes, as you see in the *Figure.*

Also, As the Sector stands, take out the = Tangents of 60 and 75 severally, and

turn

turn them four times from L both-wayes, and note those Points with 6, 7, 8, 9, 10, 11.

Lastly, Set one Point of the Compasses in L, and open the other to P, and draw the Line W P E for the hour of 6.

Again,

Set one Point in 7-15 degrees from L, and open the other to P, and draw the Hour-line 5 P 5 ; Set the same Extent also in 7, or 5, on the other side of L, and draw the Hour-line 7 P 7, *as the Figure sheweth.*

Then,

Set one Point of the Compasses in 8, 30 degrees from L, and open the other Point to P, and draw the Hour-line 8 P 8, and remove it to the other side of L, and draw the Hour-line 4 P 4 : And so for all the rest in order.

Thus having drawn the Figures ; to draw Lines therein, which shall truly represent any Plain whatsoever, observe the following Rules.

1. The *Horizontal-Plain*, is represented by the Circle E.S.W.N.

2. A *direct South or North-Diall*, is represented by the Line E.Z.W.

3. A *South or a North declining-Plain*, is repre-

represented by the Right-line 60 Z 60, whose Poles are at C and D, declining 30 degrees from S. or N. toward E. or W.

4. An *East or West Plain*, is represented by the Meridian-line of 12, *viz.* S. & N.

5. A *Polar Plain*, is represented by the hour of 6, *viz.* the Line E.P.W.

6. An *Equinoctial Plain*, is represented by the Equinoctial-line E.Æ.W.

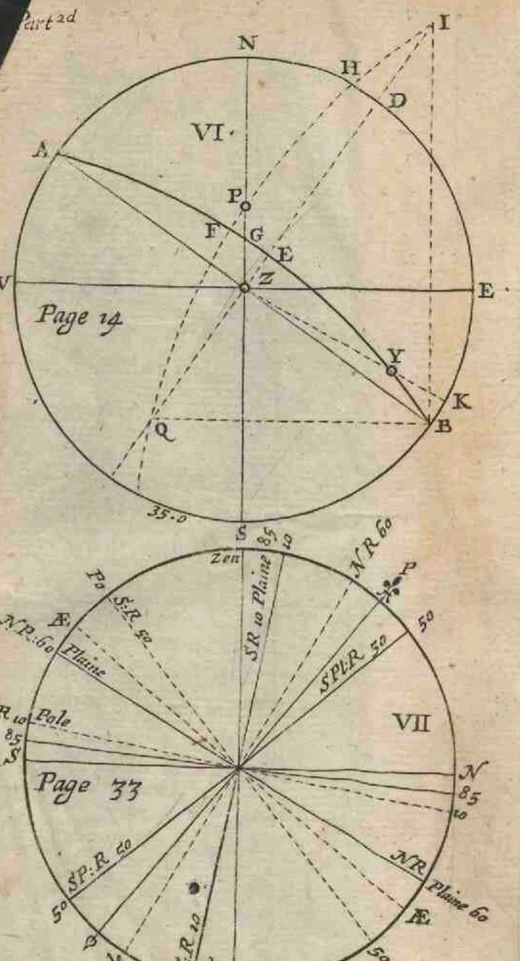
7. Any *Direct Reclining, or Inclining-Plain*, between the two last, is called, *A direct Recliner*, whose Poles are alwayes in the Meridian, and are represented by any Reclining Circle, as the two Circles W. ♋. E. and E. ☉.W. do shew.

8. An *East or West Recliner or Incliner*, represented by the Circle N.F.S.

9. A *Declining and Reclining, or Inclining Polar-Plain*; that is, it so Declines and Reclines, or Inclines, as to lie parallel to the Pole, as the Circle 8 P 8 doth represent.

10. A *Declining Reclining-Plain*, that so Declines and Reclines, as not to fall in the Pole or Equinoctial, as generally they will do, as the Circle 60 G 60 doth represent, which Declines from the South-eastwards, and Reclines 62 deg. which kind of Plains are various and infinite, yet confined to six varieties, as afterward.

Now



Now, the way of Drawing these Scheams, to represent these varieties, is briefly thus, by the Sector.

First, to the Radius of the small Tangents, draw the Circle N. E. S. W. observing this Method, if it be a South Recliner, to set the letter N above, and E on the right hand; and contrarily, in North Recliners; for we meddle not with Incliners till afterwards, (and alwayes observe, that a South Incliner is the same with a North Recliner, and the contrary) then cross that Circle with two Diameters, precisely in the Center, as the Letters shew; then according to your Plains Declination from North or South, toward either East or West, set off the Declination with a Line of Chords or Sines, as before is shewed; and draw that Line for the Perpendiculer Line of the Plain, and laying the same distance as much from E. and W. draw another Line Perpendiculer to the former, representing the Plain; then, on the first Line, *viz.* the Plains Perpendiculer, lay off from Z, the half Tangent of the Plains Reclination from Z to E, and the half Tangent of the complement thereof from Z to Q the contrary way; and the whole Tangent of the complement thereof from Z, contrary to E, on the same Line, extended for

for a Center, to draw the Reclining Circle that represents the Plain.

Lastly, You must draw a Circle through Q and P, (P being alwayes the Semi-tangent of the complement of the Latitude laid alwayes from Z toward N for the North Pole) so as to cut the Primitive Circle N.E.S.W. into two equal parts, as is shewed in the 10th Proposition of the third Chapter; part of which Line, doth represent the Stile-Line of the Dial; which last work shall be again shewed in the *Example*.

Example.

To draw the Scheam for a Plain, Declining from the South to the West 35 *degrees; and Reclining* 20 *degrees, for the Latitude of* 51-30.

First, to the Radius of your small Line of Tangents, being the Latteral distance from the Center to 45, (or larger if you please) draw the Circle N.E.S.W. representing the Horizon, crossing it in the Center with the Lines N.S. & W.E. for the North and South, and East and West Lines.

Then,

Take out the latteral Tangent of half the latitude, *viz.* 19-15, for 38-30, calling the Tangent of 10, the half Tangent of 20; and

and lay it from Z at the Center, to P for the Pole-point.

Then consider the Declination of your Plain, and which way, as here 35 deg. -0′ from the South towards the West; take out the Chord of 35 deg. and lay it from S to C, and from W to A, and from N to D, and from E to B, for the more exact drawing of the Lines A B, C D; the Lines C D representing the Poles of the Plain, and the Line A B the Declining Plain it self; then from Z towards D, lay off the Tangent of 10 deg. (being the half Tangent of 20 degrees, the given Declination) to E.

Also, Take out the Secant of 70 degrees, the complement of 20, to the same Radius; and that laid from the Point E, on the Line D C produced, shall be the Center to draw the Circle A F E B, that represents the Declining, Reclining Plain, that declines 35 degrees, and reclines 20 degrees. *Also*, Lay off half the Tangent of the complement of the Reclination, *viz.* 35 degrees (for the Reclination is 20, the complement whereof is 70, and the half of 70 is 35) from Z to Q.

Then to draw the Line Q P, *do thus*;

Observe how many degrees you count from Z to the Point E, counting from the Center, count so many in the manner of half Tangents

gents from 45; and the latteral distance from thence to the Center, laid from the Center Z, on the Line C D, gives a third Point, *viz.* the Point I; which three Points, Q P I, brought into a Circle, will cut the Circle N.E.S.W. into two equal parts.

Or thus;

The Semi-tangent of the complement of the Reclination to 180 degrees, laid from Z on the Line C D, will find the Point I.

As thus;

The Reclination is 20, the complement 70, being taken from 180 rests 110, whose half is 55, the Tangent of Z I.

Or more briefly thus;

Set one Point of the Compasses in the small Tangent of 45, and count the Reclination from thence in the way of Semi-tangents, both wayes, both above and under 45; and lay one, *viz.* that under 45, from C to Q; and the other, *viz.* that above 45 from D to I; then on the middle Point, between Q and I, last found, raise a Perpendiculer to C D, and in that Line will be the Center to draw I P Q.

Also,

If you count 51-32, the latitude on the Line of Tangents from 45 forwards (as Semi-tangents) and lay it on the Meridian-

Line N S, produced from S, it gives a 4th Point to draw I P Q.

Or,

You may use the Geometrical way, in *Chap.3. Prop.*10. by drawing the Line Q B, and then a perpendiculer Line to Q B, on the Point B, till it intersect C D in I produced: The Pole of which Circle Q F P, is in the Plain at Y, found by laying a Quadrant from H to K, and drawing the Line Z K.

The Scheam thus drawn, then A G represents the distance on the Plain, between the Meridian and Horizon, G E the complement thereof, or his distance from the Plains perpendiculer; P F the Stiles Elevation, F G the distance of the Substile and the Meridian; the Angle F P G, the Inclination of Meridians, E F the distance of the Substile from the Plains perpendiculer, P G the distance on the Meridian of the place from the Pole to the Plain.

Thus you have the Definitions of DIALS, and the way of Drawing the general and particular Scheams for *Dials*; which shall be further illustrated in every particular *Dial*, *viz.* in 16 sorts of *Dials*, wherein I shall be as plain and as brief as the matter will bear.

CHAP.

CHAP. II.

To Draw the Hour-Lines on all Ordinary Dials; the easiest in the first place.

1. *And first for the first Equinoctial-* DIAL.

AN *Equinoctial Plain*, as before is shewed, is that whose plain or flat Superficies lieth parallel to the Equinoctial, and is represented by the Line W Æ E in the general Scheam, and therefore needs no other Scheam to represent it; In which Dial all the Hour-lines are equal one to the other, being just 15 degrees assunder; so that to draw the Hour-lines here, describe a Circle as the Circle 12. 6. 12. 6. and fit the Radius in the Sine of 30 degrees (or the Chord of 60) and take out the parallel Sine of 7 degrees 30 minuts, the half of 15 degrees, and number it from 12 round about, and that ſhall divide the whole Circle into 24 equal parts, for the 24 hours, for the true Hour-lines on the Equinoctial-plain, and is the ſame in all latitudes; only in the ſetting of it, the Poles of it are to be ſet due North and South; the Horizontal-line on the Plain, lying Parallel to the Eaſt and Weſt-points of the Horizon, and the Stile thereof, only a Wyre or ſharp Edge ſtanding perpendicularly on the Center; which being ſo ſet, muſt point directly to the North (and South) Poles of the World. The reclining Dials-Stile pointing to the North-Pole, and the inclining Dials-Stile pointing to the South Pole; then is the Dial truly placed.

To ſet a Plain (or to try whether a Plain be ſet) Polar, or Parallel to the Equinoctial, do thus;

Set the *Triangular-Quadrant* together, (by putting the Tennons of the Looſe-piece into the Mortiſe-holes) and on the Center hang a Thred and Plummet, and apply the Moveable-leg to the Meridian-line on the Plain (which on all *direct Plains* is the ſame with the Perpendiculer as here) with the Head-end uppermoſt; then if the Thred falls

falls right on the complement of the latitude' the Plain lies parallel to the Equinoctial, or elſe not.

But to try the *Inclining Plain*, apply the Looſe-piece to the Plain with the Head-end downwards; or elſe apply the Head-leg to the Plain with the Head-end downwards, and the Thred ſhall cut on 38-30 in *London* latitude, if the Plain be ſet parallel to the Equinoctial.

2. *To draw a Direct Polar-Dial.*

The next Dial, ſhall be a *Direct Polar-Dial*, which is repreſented in the general Scheam by the Hour-line of *6*, *viz.* the Line E P W; And here alſo the Horizontal-line on the Plain, is parallel to the Eaſt & Weſt-points of the Horizon; and the Pole (or Point oppoſite to the Plain) is in the Equinoctial-point.

The Hour-lines, in this Plain, are all parallels, becauſe the Axis, or Stile-line, in all Plains, is parallel to the Poles of the World; and this Plain it ſelf, being ſo parallel, the Stile or Axis therein makes no Angle; therefore the Hour-lines muſt needs be parallels alſo.

And the way of drawing those Hour-Lines, is thus;

First draw the Perpendiculer-line on the Plain, which is done thus by the *Triangu-ler-Quadrant*; Hang a Plummer and Thred on the Center, and apply the Moveable-leg to the Plain, to and fro, till the Thred falls neatly on 60|0, and draw that Line along by the Moveable-leg, which shall be a true Horizontal-line on any reclining Plain; and a Perpendiculer-line thereunto, is the perpendiculer Line on the Plain.

Or else;

When the Sun shineth (the Sun begins in the Pole of the Plain) hold up a Thred and Plummet, till the shadow of the Thred fall on the Plain, making two Points in that shadow at the remotest distance asunder; then a Line drawn through those two points shall be a true Perpendiculer-line, (this shall need no more Repetition).

This is general for *Upright Plains*, but for *Recliners*, the Sun must be in the Pole of the Plain; then the shadow of the Plumb-line is the Perpendiculer. This Perpendiculer-line in these Plains, ought to be just in the midst thereof, being the Hour-line for 12; draw also, at any convenient distance, two Hori-

zontal-

zontal-lines, Perpendiculer to the hour 12; then consider what Hours shall be the first and last hour, which in no latitude can well be more than 10 hours, *viz.* from 5 in the morning till 7 at night, *viz.* 5 hours on a side; then take the measure on the Plain, from 12 in the Horizontal-line, to the place that you intend for 7 or 5, and make it a = Tangent of 75; then is the Sector set to a fit Radius, to fit and fill the Plain with the hours you resolve to put on.

Then,

The several = Tangents of 60-45, 30 & 15, laid both wayes from 12 on both the Horizontal-lines, shall give you Points whereby to draw all the Hour-lines in their true places.

Also,

The = Tangent of 45, shall be the true breadth of the Plate that must be a Stile to this Dial; or the length of an upright Wyre set any where in the Line 12.

Note,

That for the hours under 45, you may take = 45 from the small Tangents, and make it a = Tangent of 45 in the great Tangents; and then take of = Tangent of 30 & 30, for 2 & 10; and the = Tangent of 15 for 11 & 1; and if you want them above 45, then take the = Tangent of

60 & 60 from the small Tangents, and turn that Extent 4 times from 12 both wayes, on both the Horizontal-lines, and those shall be the Points for 8 in the forenoon, and 4 afternoon.

And lastly,

The = Tangent of 75, taken and turned 4 times from 12 to 7 in the morning, and to 5 in the afternoon, will fit and fill a Plain of 4 foot in breadth, with a Sector of one foot, shut.

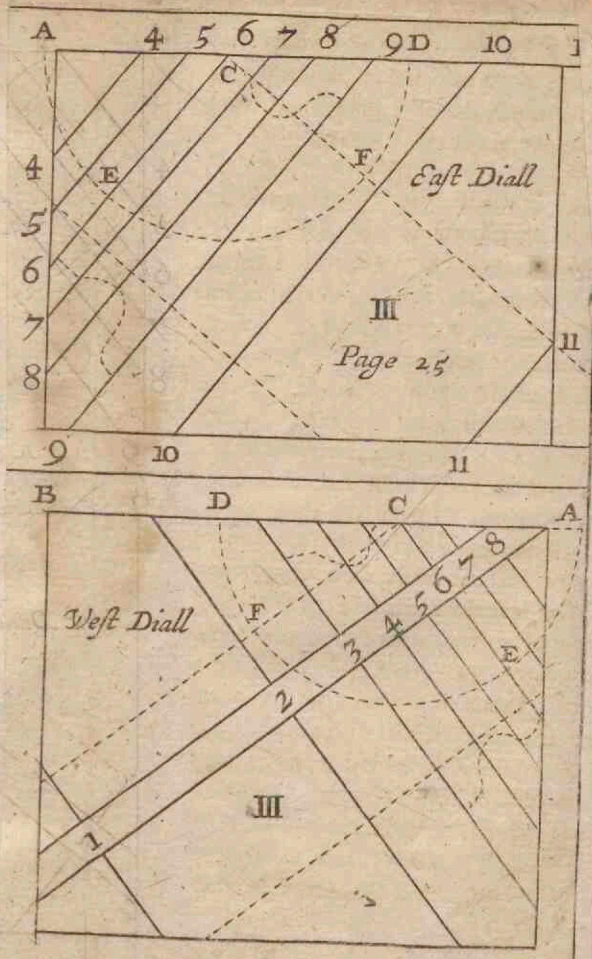
3. *To draw a Direct East or West-DIAL.*

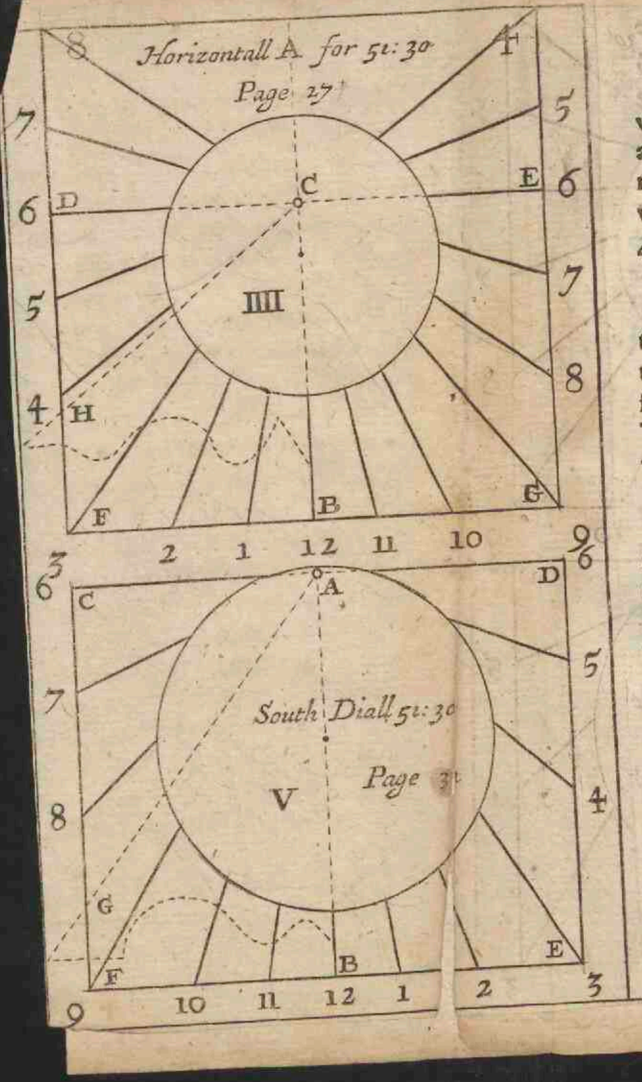
The next Dial, in the third place, is the *Direct East or West-Dial*, which is represented in the general Scheam by the Line N Z S, whose Poles are in the Line E Z W, whose Plain also is = to the Pole, & drawn in the same manner as the ***Polar Dial*** was; yet with this difference, the Equinoctial-line, whereon to prick the hours, is not the Horizontal-line, but is thus found.

First, by the 3d of the 5th Chapter, or 2d of the 18th Chapter, Draw a Horizontal-line on the upper part of the Plain, as A B; and divide that Line into 3 parts, counting one third part from A to C; then on C, as a Center, draw a Semi-circle as large as you can,

can, as AEFD, which distance of the Compasses, make a = Sine of 30 degrees; and take out the Sine of half the latitude, and lay it from the South-corner of the semi-Circle at A, to E; and draw the Line CE for 6 a Clock hour-line: Then lay the = Sine of half the complement of the latitude from the North-end of the Semi-circle at D to F, and draw the Line CF for the Equinoctial-line, and another = to it. (*Or*, you might draw these Lines by the *Trianguler-Quadrant*, by applying the flat-side to the Wall, and making the Thred to play on 38-30, and 51-30, counting from 60|0 on the Loose-piece and Moveable-leg, as by applying it, you will see better than many words can dictate). Then having the Equinoctial-lines, and the Hour-line of 6, appoint also the place where 1 or 11 shall be, then make that distance, *viz.* C 1, in the West-dial, or C 11, in the East-dial, a = Tangent of 75 degrees; and the Sector so set, lay off the = Tangents of 75, 60, 45; and if you will not move the Sector, take = Tangent out of the great Line that is right against 30 & 15 in the little Line of Tangents, or see, by the = Line of Lines, what the great Tangent of 30 & 15 is, and take one 4th part,

Thus;





Thus;

You may take the Tangents under 45, when the Sector is ſet to the ſmall Tangent, and by turning 4 times, you have the remainder of the great Tangent above 45; when the Sector is ſet to the great Line of 45, as in the *Polar Dial.*

Or elſe;

Alter the Sector to the Radius of 45 in the great Tangent that goes but to 45, and take out the = Tangents of 30, and lay it from 6 both wayes, for 4 & 8; and the = Tangent of 15, and lay it from 6, both wayes, for 7 & 5.

And laſtly,

By all thoſe Points, draw Lines = to 6, for the Hour-lines required; and number the Eaſt-dial with the morning-hours, and the Weſt with the afternoon-hours, the Stile is to be a Plate, or an upright Point; the top of whoſe edge, or point, is to be equal to the Tangent of 45, as the Sector ſtood to prick down the Hour-lines.

4. *To draw the Horizontal-Plain.*

The fourth Plain next, in a natural order of eaſineſs to apprehend as I judge, is the *Horizontal Dial*, that lies with its plain = to to the Horizon; and the Zenith is the Pole thereof, represented by the primitive Circle S.N.E.W. in the general Scheam, wherein only the Hour, Arks, and Stile is required.

The Stiles Elevation is alwayes equal to the Latitude, and therefore given; the Substile is alwayes in the Hour 12, being the Meridian-line.

The Hour-lines are found by this general Canon;

As the Sine of 90, the right Angle P N 1, to the Sine of P N, a side alwayes equal to the Latitude or Stiles elevation 51-30; *See the General-Scheam.*

So is the Tangent of the Angle N P 1, 15; or N P 2 30, &c. the Angles at the Pole, to the Tangent of N 1 a side, or N 2 a second side, the several Hour-arks on the Plain required; found by the Artificial Sines and Tangents, as fast as one can write them down.

Thus;

The Extent of the Compasses, from the Sine of 90, the Sine of the latitude 51-30, being laid the same way from the Tangent of 15, shall reach to the Tangent of 11-50; and if you turn the Compasses the other way

from

from the Tangent of 15, it shall give the Tangent of 71-6, for the hour of 5 as well as 11; which Numbers being gathered into a *Table*, and laid off by Chords or Sines in a Semi-circle, shall be the true Hour-points to draw the Lines by.

But I shall not insist further thereon, but shew how to draw it more readily, and as truly by the Sector, *thus*;

First, draw a streight Line (in the Meridian, if the Plain be fixed) for 12, as the Line A B; then design a Point in that Line to serve for a Center, as at C; then on the Center C, erect a Perpendiculer-line to A B, and draw it through the Center C, for the two 6 a clock Hour-lines, as the Line D E; then draw two Lines equally distant from, and = to the first Line A B, on either side, as large as the Plain will give leave, as D F and E G; (which may commonly serve for margents to put the figures in).

See the General Scheme.

Then,

Take the distance C D, and make it a = Secant of 00, and take out the = Secant of the complement of the latitude, and lay it from D to F, and from E to G, on the two Parallel-Lines, and draw the Line F G.

Then lastly,

Fit D F, or E G, as a = Tangent of 45, and take out the = Tangents of every 3 deg.

and

and 45 minuts, counting from 45; and closing the Compassing, and lay them both wayes, from both the sixes, on both the = Lines, for all the morning hours from 3 to 9; and for all the afternoon hours and quarters from 3 to 9; then take out B E, or B G, and make this also a = Tangent of 45, and take out the former = Tangents, and lay them both wayes from B, on the Line F G, for the mid-day-hours and quarters, from 9 to 3 afternoon; and by those Points draw for the hours and quarters required.

For pricking down the Stile, *Note*, That the = Tangent of 38-30, the complement of the latitude, as the Sector stands for the Noon hours, laid from D to H, gives a Point to draw it truly by; or the Sine of 51-30 the latitude, laid from B at nearest distance about H, as the Sector stood for the morning-hours will do as well. The Stile is to be a Plate, or a bended Wyre, cut or bended according to the Angle H C B, and erected Perpendicularly on the Line 12, so long, as the Sun being 62 degrees high may cause the shadow thereof to reach the hour of 12; and then set duly North & South, and Horizontal, the shadow will shew the true hour of the day. *Note the Figure.*

Note

Note also, That a *Horizontal Dial* drawn for any one latitude, may serve for any other latitude North or South, elevating or depressing the Stile, till it look to the Pole-point; that is, by making it to recline Northward, or Southward, as much as the difference of the latitudes, *viz.* that the Dial was made for, and that wherein it is to be used, shall be.

5. *To draw a North or South Plain.*

The next Plain to this, and most like it, is the *Direct North and South Dial*; whose Plain lies = to the prime Virtical, or Circle of East and West, and its Poles in the South and North part of the Horizon, and represented by the Line E Z W, in the general Scheam, whose Stile is alwayes equal to the complement of the Latitude, as the Horizontals was equal to the Latitude, and consequently given.

The Hour Arks on the Plain, are found by the former Canon, viz.

As the Sine of 90, *viz.* the Angle P Z E, is to the Sine of the Side P Z, the Colatitude or Stiles Elevation;

So is the Tangent of the Angles at the Pole Æ P 1, Æ P 2, &c. to the Tangents

gents of the Sides Z 1, Z 2, Z 3, &c.

The Arks on the Plain, found as before by Artificial Sines and Tangents; and being drawn into a *Table*, to be laid off by Chords, or Sines, or by the Sector,

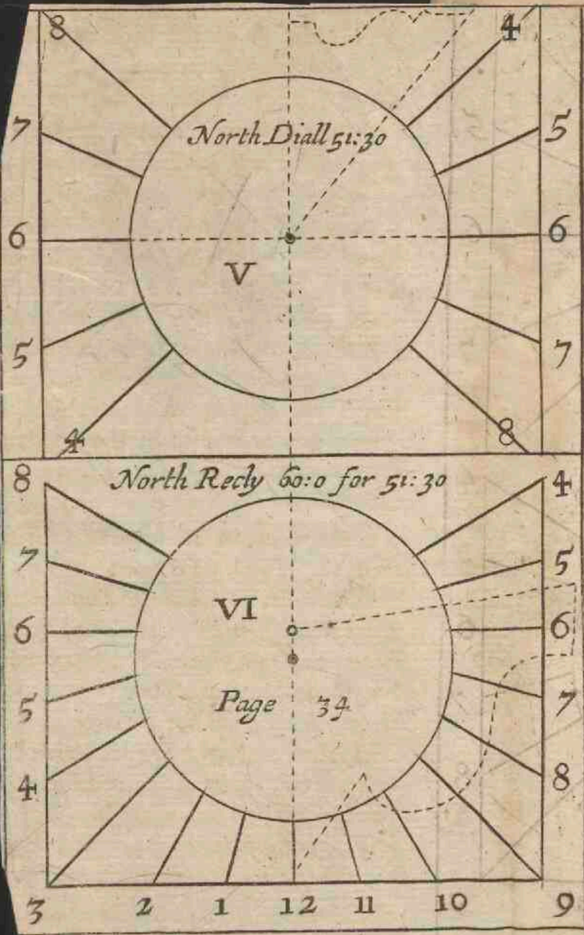
Thus;

Draw a Perpendiculer-line for the Subſtile, or 12 a clock Line; and in that Line deſign a Point for a Center, as the Point A in the Line A B; through which Point A, draw another Line, croſſing the former at Right Angles, for a Horizontal-line, and the two ſixes, as you did in the Horizontal; then, on each ſide, and equi-diſtant from 12, make two Lines = to A B, as marginal-lines, as C F and D E; The diſtance A D, of the Parallel make a = Secant of 00, and take out the = Secant of 51-30, the latitude of the place, and lay it from C to F, and from D to E, and draw the Line F E; then make D F a Tangent of 45, and lay off the hours and quarters as you did in the Horizontal in all reſpects.

Alſo,

Make B F a = Tangent of 45, and lay off the = Tangents of every hour and quarters (if you pleaſe) from B, both wayes, toward E and F; and by thoſe Points draw Lines for the hours required.

The



The Angle of the Stile may be laid off by Sines, Tangents, or Chords, as before is shewed, to the quantity of the complement of the Latitude, and may be a Plate or Wyre, as you please, as the Angle G A B.

The *North Dial* is the same with the *South*, for manner of making, only the Noon-hours are neglected, and the Morning and Evening-hours, both before and after 6 on each side only inserted; and the Center of the Dial for that cause appointed in the middle of the Plain, and not on the upper-part, as in the South, and the Stile-points upwards (as in the South it points downwards). *Note the Figures.*

6. *To draw the Hours on a Direct Recliner.*

The next Plain to be considered, being also Direct, but not Erect, or Upright, but Leaning from you; and may be either a North or South Recliner;

That is thus;

As the Poles, of a Direct South Plain, are in the meeting-point of the Meridian and Horizon, *viz.* the Point S. in the general Scheam; and the Point N, in the same Scheam, is the Pole of the North Plain; and the Point Z, is the Pole of the Horizontal Plain.

So

So the Pole of these Plains is a Point in the Meridian, elevated as many degrees above the Horizon, as the Plain shall recline from the Zenith, or upright toward the Horizon.

As thus ;

Suppose the Hour-circle of 6 in the general Scheam, to represent a Reclining Plain, the Point Æ, in the Meridian, is the Pole of it, being as many degrees above the Horizon S, as P is below the Zenith Z.

So also is P the Pole to the North Reclining Plain W Æ E; for the Point P, is as much above the Horizon N, as Æ is below the Zenith Z.

Thus you see what the Pole of a Plain means, *viz.* a Point 90 degrees every way from it.

Now therefore North *Direct Recliners* have their Poles any where between Z & N, and South *Direct Recliners* have their Poles any where between Z & S, according to the degrees and minuts of their Reclination.

This being premised, for drawing the Hour-lines, observe, That for South *Recliners Direct*, the difference between the Reclination and the complement of your Latitude, is alwayes the Stiles height for that reclining Plain.

But note, That when the Reclination is more than the complement of the Latitude, that then the contrary Pole is elevated, *viz.* the North Pole on South Recliners.

But for North Recliners, the sum of the Co-latitude, and the Plains reclination is alwayes the Stiles elevation; but note, when the Sun is above 90, then the complement to 180 is the Stiles elevation; but it must be turned the other way, *viz.* contrary to the nature of a North Recliner, for the Stile will look downwards in the North Recliner, and upwards in his opposite South Incliner.

Note also by the way, That when the South Recliner reclines equal to the complement of the Latitude, it is called a Direct Polar Dial, or rather an Equinoctial in respect of his Poles, (but I mind not to be singular).

And when the Reclination of a North Recliner, is equal to the Latitude, then the Stiles height is just 90 degrees; and the Plain, called an Equinoctial-plain, or rather Polar, in respect of his Poles, (being first in order treated on).

Thus understanding, and right conceiving what the Plains are, the drawing of any of them is the same with the North and South; for the Stiles height is alwayes to be

counted

counted the complement of the Latitude, and by consequence you have the Latitude.

As thus for Example. Comparing the reading, and Figure VII.

Suppose a Plain recline from the Zenith toward the North part of the Horizon 10 degrees, his Pole is 10 degrees above the Horizon; and then 10 taken from 38-30, there remains 28-30, for the Stiles Elevation; or the Latitude to draw it as a Horizontal Dial; and 61-30 for the Latitude for which place you are to draw a Direct Erect South Dial.

Again,

Suppose a South Recliner, recline 50 degrees, being more than 38-30, the Co-latitude; then take the Co-latitude from thence, and there remains 11-30 for the Latitude or Stiles height, to draw a Horizontal Dial by; and 78-30 for a Latitude to draw a South Dial by; but the Cock must look up to the North, therefore must be turned the other way.

Again,

For a North Recliner, reclining 60 degrees; 60 & 38-30, added, makes 98-30, whose complement to 180, is 81-30, the

Stiles height; but the contrary way, as you may well perceive by the Horizontal.

As once more thus;

Suppose a North Plain recline 85 degrees; that, and 38-30, added, makes 123-30, whose complement to 180, is 56-30, the Stiles height: but put the contrary way, as a South Incliner, being almost a Horizontal Dial; so that to draw this Dial, let 56-30 be the Stiles height, or Colatitude; then, 33-30, is the Latitude to draw a Direct South Dial by.

Or,

You may count the Stiles height the Latitude, and then draw it as a Horizontal-Dial, by taking out the Secant of the Colatitude, and the work will be the same; As in the *Figure* North Reclining 60 degrees.

7. *To draw a Direct East or West-Recliner.*

This Plain being a Direct Plain also, and taking no cognizance of Declination, (otherwise should have come after); is only an East or a West Plain, reclining or falling from you; or inclining, or falling to you;

you; and the Poles of these Plains are in the prime Vertical, or Circle of East and West, as the other were in the Meridian; and this Plain is represented by the pricked Circle N F S, reclining 45 degrees, whose Pole is at Q 45 degrees above W; for the drawing of which, it will not be amiss, but very convenient to draw a particular Scheam by the last Rule in the 17 Chapter.

As thus;

With 45 degrees of the small Tangents, draw the Circle N.E.S.W. crossing it in the Center with the Lines W E, S N; then lay off the half Tangent of 38-30, from Z to P; and the half Tangent of the Reclination 45, from Z to E, and from Z to Q, and draw the Circles N E S, and F P Q; in which Scheam, P F represents the Stile, F G the distance of the Substile from the Meridian, and G P F the Angle between the two Meridians, *viz.* Z P N of the place, Q P F of the Plain. All which requisites are thus found out by the Artificial, or Natural Sines and Tangents.

1. *And first for the Stiles Elevation.*

As the Sine of 90 N Z, to the Sine of Z E, the Reclination 45;
So is the Sine of N P the Latitude 51-32, to the Sine of P F, the Stiles height, 33-37.

To work this by the Trianguler Quadrant, or Sector, do thus;

As — sine of N P, the Latitude 51-32, to = sine 90 Z E;
So is = sine of Z E, the Reclination 45, to — sine of P F 33-17, the Stiles height.

2. *For the Distance of the Substile from* 12, *thus, by Artificial Sines and Tangents.*

As the Tangent of the Reclination, Z E 45, to sine of E N 90;
So is the Tangent of the Stiles elevation, P F 33-37, to the sine of F G 41-40, the distance of the Substile from 12.

Or,

Or, by Natural Sines and Tangents, thus;

As — sine 90, to = Tangent of the Reclination 45;
So is = Tangent of the Stiles height 33-37, to — sine of the Substile from 12, 41-40. *For,*

If you only take the Tangent of 33-37, from the Moveable-leg, and measure it on the Sines from the Center, it shall reach to the sine of 41-40, the Substiles distance from 12.

3. *For the Inclination of Meridians, thus;*

As the sine of the Latitude NP 51-32, to the sine of PFG 90;
So is the sine of the Substile from 12, GF 41-40, to the sine of GPF 58-7, the Angle between the two Meridians.

By Natural Lines thus;

As — sine of the Substile 41-40 GF, to = sine of the Latitude 51-32 NP;
So is = sine of 90 PFG, to — sine of GPF 58-7, the Incliner.

If this Rule fails, use a less Radius, or a = Answer, as is largely shewed before.

Thus having found the Requisites, proceed to draw the Dial thus;

First consider the Scheam, where you shall find the Reclining Plain to be represented by the Line S E N, as the upper-edge thereof; S Z N is the Horizontal-line and Meridian-line also; N or G is the place where the Meridian cuts the Plain, being in the Horizon; Therefore here the Hour-line of 12 is a Horizontal-line, and the Sun being in the South part of the Meridian, doth cast his shadow Northwards; and being in the East, casts his shadow Westwards: Therefore laying the Scheam before you, as the Plain reclines from you, you shall see that the Meridian must lie to the right-hand from Z, toward N; and the Substile upwards from N, towards E, at F. And the the Stile must look upwards, as the Angle G P F doth plainly shew; and the morning-hours are chiefly fit for the Plain, because the Sun rising Eastward, is opposite to the Plain. Thus the Affections and Scituations of the Cardinal-lines are naturally and demonstratively shewed; the Delineation followes.

 First,

First,

Draw the Horizontal-line S N; and on Z, as a Center, deſcribe a Semi-cirle as S E N, and from N toward E lay off 41-40, the diſtance of the Subſtile from 12, and draw the Line Z F for the Subſtile; alſo beyond that, from F to E, prick off 33-17, and draw that Line for the Stile-line.

Then for drawing the Hour-lines, you muſt firſt make the *Table* of Equinoctial-diſtances, or Angles at the Pole, *thus*;

Firſt, in all Direct Plains, it is orderly thus; 3-45, for the firſt quarter of an hour from 12; 7-30, for half an hour; 11-15, for three quarters; and 15 degrees for an hour; and ſo ſucceſſively to 90: So alſo will it be in all Plains, whoſe inclination of Meridians is juſt 15, 30, 45, 60, 75, or 90 degrees, being even whole hours; and near as well, when it falls on an even quarter of an hour alſo. But when it doth not as here, then the beſt Rule or Method I know is *thus*;

Firſt, ſet down 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, & 12, as in the *Table* following.

Then right againſt 12, ſet down the Inclination of Meridians; then ſubſtract 15 degrees

degrees for every hour; and 3-45 for every quarter, as often as you can, ſetting down the remainder; then draw a Line a-croſs, and what the laſt number remaining wants of 15, or 3-45 (for hours, or hours and quarters) ſet down on the other ſide below the Line, as you ſee in the *Table* following; and ſo proceed, adding of 3-45 to that ſum, for every quarter; or, 15 degrees for every whole hour, till you come to 90 both wayes; ſo is the *Table* of Hour-Arks at the Pole, compleated for all Hours that can come on this Dial, or on any other.

The

The Table.

	91 52	8	01 53
2	88 07		05 38
	84 22		09 23
	80 37		13 08
	76 52	7	16 53
1	73 07		20 38
	69 22		24 23
	65 37		28 08
	61 52	6	31 53
12	58 07		35 38
	54 22		39 23
	50 37		43 08
	46 52	5	46 53
11	43 07		50 38
	39 22		54 23
	35 37		58 08
	31 52	4	61 53
10	28 07		65 38
	24 22		69 23
	20 37		73 08
	16 52	3	76 53
9	13 07		80 38
	09 22		84 23
	05 37		88 08
	01 52	2	91 53

Thus you see that the Substile falls on near a quarter past 8, or 3 hours 3 quarters and better from 12; then if you will, by the former Canon, you may find all the Hour-Arks on the Plain.

Thus;

As the sine 90, to the sine of the Stiles height 33-37;
So is the Tangent of the Hours, in the *Table* last made, called Arks, at the Pole 31-53 for 6, to the Tangent of the respective Hour-Arks at the Plain from the Substile 90-0 for 6.

More brief thus;

As the sine of 90, to the sine of the Stiles Elevation;
So is the Tangent of the Hour from 12, to the Tangent of the Hour from the Substile.

Which being brought into a *Table*, may be pricked down in a Semi-circle by Sines, or a Line of Chords, from the Substile on the Plain.

But I prefer this Geometrical way before it thus;

Having drawn 12, the Substile and Stile, draw

draw alſo a Line at any convenient diſtance parallel to 12, as D I; then at any convenient diſtance from the Center Z, draw a Line Perpendiculer to the Subſtile quite through the Plain, as the Line K L.

Then,

Take the neareſt diſtance from that meeting Point at F, to the Stile-line, and make it a = Tangent of 45; then the = Tangent of every hour and quarter, as in the *Table* taken from the Sector, and laid from F the right way, as the hours go, ſhall be the true Points whereby to draw the Hour-lines required.

But in regard that this way will ſometime be troubled with Excurſions in ſome of the hours, you may help it thus; Having drawn ſome hours, as ſuppoſe 6 & 3; or 6 & 9; or indeed any 2 hours, 3 hours diſtance aſſunder, as here 6 & 9; take the diſtance between 6 and 9, and lay it from the Center to N on the Meridian, and draw the Line 9 N = to 6 at length, beyond 12; Then, as before, make 6-9 a = Tangent of 45, and lay off every hour and quarter, as in the South Erect Dial, both wayes from 6. *Alſo*, make N 9 a = Tangent of 45, and do likewiſe laying the hours both wayes from N, and you ſhall have Points enough to draw the Dial by. *Other-*

Otherwise, make these Dials thus.

Count the complement of the Latitude where the Dial is to ſtand, for the *Latitude*; And the complement of the Reclination for a new *Declination*; and then draw them as Upright Decliners by the following Rules, and you ſhall do as well and ſpeedily as any way. *But note*, That all Eaſt Recliners, are North-eaſt Decliners; and Weſt Recliners, are North-weſt Decliners; And Eaſt and Weſt Incliners (being the under faces) are South-eaſt, and South-weſt Decliners.

Alſo note, That if you draw your Scheam true, and large, you may from thence Geometrically find the Subſtile, Stile, Inclination of Meridians, and every hours diſtance on the Plain, by Scale and Compaſs, *thus*; As Captain *Lankford* hath ſhewed.

Firſt, For the Stiles Elevation ſet off a Quadrant or quarter, as W.N. from B to I; then a Rule laid from Z to I, cuts the Plain at A; then a Rule laid from A, to P & F, cuts the Circle at O and L; The Ark O L, is the Stiles Elevation, and meaſured by fit Chords, gives 33-17.

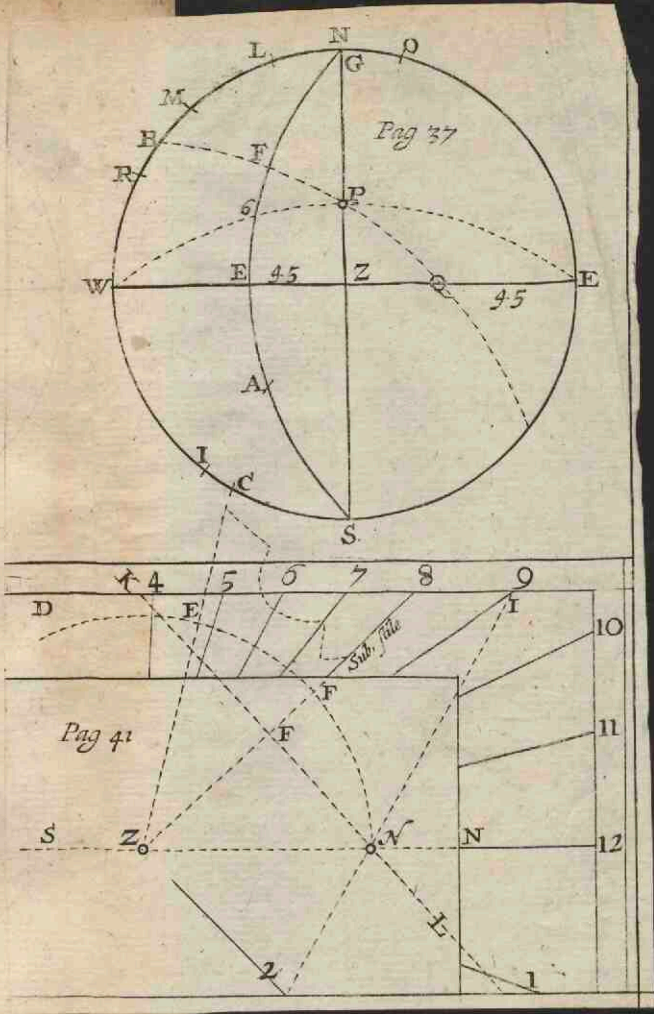
Secondly, For the diſtance of the Subſtile from 12, a Rule laid from Q to F, cuts the Limb

Limb or Circle at M, the Ark MN meaſured on fit Chords, gives 41-40, the Subſtile from 12.

Thirdly, For the Inclination of Meridians, a Rule laid from P to A, in the Limb gives C; the Ark WC 58-7, is the Angle between the two Meridians.

Fourthly, To find the Hour-Arks on the Plain; a Rule laid from Q to the interſecting of every Hours Ark (in the Scheam) and the Plain as here, a Rule laid from Q to 6, cuts the Limb at R, the Ark MR 19-0 is the diſtance of 6 from the Subſtile on the Plain; and ſo for all others, as 12 & 6 is NR 60-40, both hours and quarters if you have them truly drawn on a large general Scheam, as Mr. *Lankford* hath done.

Thus much for *Direct Plains*, both *Erect* and *Reclining*, before I come to ſpeak of *Decliners*; It will not be amiſs to ſhew how to find the *declination of a Plain*, both by the Sun-ſhine, or without, by a Magnetical-Needle, as followeth.



CHAP. III.

To find the Declination of any PLAIN.

FOr finding the Declination of a Plain, the most easie way is by a Magnetical-Needle, fitted according to Mr. *Failes* way, in the *Index* of a *Declinatory* (as he calls it) being 180 degrees of a Semi-circle, divided on an Oblong-Board, or Quadrant, or a longer Needle in a square Box, (or) fitted with Hinges and a Cover; after all which wayes, you may have them made at the sign of the *Sun-dial* in the *Minories*, by *John Brown*; or of any other manner you shall think fit.

But, to our *Trianguler Quadrant*, is a Box and Needle also to be fitted of another form, in some things more convenient.

Whose form is thus;

First, in a piece of Box 5 inches long,

2 ½ broad, and 6 tenths of one inch thick; is a hole made near 4 inches long, 1 inch ¾ broad, and 4 tenths deep for a Needle to play in; about 50 degrees at each end; with braſs-hinges, and a cover, and a brace to keep the lid upright, & an Axis of Thred, and a Plummet playing in the lid, and a Horizontal and a South-dial, drawn on the Box and Cover; alſo a haſp and glaſs to keep the Needle cloſe covered, and on the bottom a Grove one tenth of an inch deep, made juſt as broad as one leg of the Sector is.

The uſe whereof is thus;

Put your Box and Needle, on that leg of the Sector, as will be moſt convenient for your purpoſe; the Nor h or croſs-end of the Needle toward the Wall, when it is a South decliner; and the contrary when it is applyed to a North decliner, as the playing of the Needle will tell you better than many words; then open or cloſe the Rule, till the Needle play right over the Line in the bottom of the Box, (unleſs there be variation, then you muſt allow for it Eaſtwards or Weſtwards what it is). Then, I ſay, the quantity of the Angle in degrees and minuts the Sector ſtands at, above or under 90, is the degrees and minuts of Declination; being counted from 00 in the little Semi-circle, as complements to the Angle of opening; as in the 4th *Use* of the 5th *Chapter* is largely and plainly ſhewed.

Thus you have the quantity of degrees and minuts of Declination: but to determine which way, conſider *thus*;

If the Needle will ſtand ſtill in the middle, when the North-end is toward the Wall, then the firſt denomination is South, if not North.

Again,

When you know where North and South is, you may reſolve which way the Eaſt and Weſt is; For, obſerve alwayes, if the North be before you, then the Eaſt is on the right-hand, and the Weſt on the left; and contrarily, If the South be before you, the Weſt is on the right-hand, and the Eaſt on the left.

Then,

If the Sun, being in the Eaſt-point of the Horizon, can look on the Plain, it is a South-eaſt Plain; but if it beholds it when in the Weſt-point, it is a South-weſt Plain.

Likewiſe,

If the Croſs-end of the Needle will not ſtand toward the Wall (the Needle playing well) and the Sun being due Eaſt, beholds the Plain, then it is ſo many degrees North-eaſt; but if it cannot look on the Plain, being due Eaſt, then it is a North-weſt Plain, declining ſo many deg. as the Sector ſtands at, under or above 90, being alwayes the complement of the Angle the legs of the Sector ſtand at, and found by taking the Angle the legs ſtand at, from 90, when the Angle is leſs than 90.

Or,

Taking 90 out of the Angle, when it ſtands at an Angle above 90 degrees. as a look at the little Semi-circle on the Head ſheweth.

Example.

Suppoſe I come to a Wall, and putting the Box and Needle on the Leg of the Sector, and applying the other Leg to the Wall (or on a ſtreight piece of Wood, applied to the Wall, becauſe of the Walls unevenneſs); and open or cloſe the Legs, till the Needle playes right over the Meridian-line, drawn on the bottom of the Box; then, I ſay, the complement of the Angle the Legs of the Sector ſtands at, being alwayes what it wants of, or is above 90 degrees, is the degrees of Declination; and the Coaſt which way, the Needle and Suns being Eaſt and Weſt, tells you.

For,

If the North or Crofs-end of the Needle be toward the Wall, it is a South Plain; and if the Sun, being in the East, can behold it, then it is South-east; if not, a South-west Plain.

A ready way of counting the Angle found, may be thus;

Take the = diftance between Center and Center, in the middle of the innermoft-lines, and lay it latterally from the Center, and count two degrees more than the Point fheweth, after the manner of Chords from 90 (at the fine of 45) toward the Compafs-point, and that fhall be the degrees and minuts required.

Example.

Suppofe the Legs are fo opened, that the = diftance between the two Centers, makes the — fine of 25; then, I fay, the Lines do ftand at an Angle of 50 degrees, and the Legs at 48, two degrees lefs, the complement whereof is 42; as if you count thus from 45, you will find, 40 from 45 is 10, 35 is 20, 30 is 30, 25 is 40, and 2 degrees more makes 42, the thing defired.

But,

If you like not the abating of two degrees, then the = distance taken just between the two legs right against the Centers, shall be just the — sine of 24 degrees, or 42, counting after the manner of Chords, *viz.* every 5 degrees on the Sines, for 10 on the Chords backwards from 45 of the Sines, which is 90 in Chords.

Or,

If you use the first Rule, of the 4th *Use* of the 5th *Chapter*, *viz.* by taking the — Sine of 30, and put one Point of the Compasses in the middle Center in the Tangent-line, and apply the other to the Line of Sines, you shall find it reach to the sine complement of the Angle the Lines stand at, *viz.* 40 degrees and 2 degrees more, *viz.* 42, is the Angle or thing desired; as practice with consideration will make easie.

Thus, by the Needle, you may find the declination of a Wall, which in cloudy weather may stand you in good stead; or to prove a declination taken by the Sun, to prevent mistakes. And if nothing draw the Needle from its right position, but that it play well, and you find the Angle truly, you may come to less than half a degree:

And this convenience it hath, that it carries the Needle a competent distance from the Wall, to prevent that attraction; but if it happen to be so near a Meridian, or East and West-plain, that the Angle, by the Sector, cannot well be taken; then you may only apply the side of the Box and Needle to the Wall, and the Needle it self will shew the Declination, on the degrees on the bottom of the Box.

Yet for exactness, the way by the Sun is alwayes the best, where you may come to make a good Observation, and then the Needle only is not to be trusted to; a better way with opportunity offering it self,

To find a Declination of a Wall by the Sun.

For this purpose you (must or) ought to have another Thred and Plummet, which Thred may be a fine even small Pack-thred, and it is convenient to have it ready hanged up near the Wall, so far off, as the *Triangular-Quadrant* may pass along between it and the Wall, that you may not be troubled to hold it up, and lay it down, and be annoyed with the inconveniencies of your hand shaking, and time wasting, to more uncertainty than needs be.

Also,

Also,

You muſt needs take notice of the two Meridians, *viz.* one of the place which is the Meridian, or 12 a clock; to which place, when the Sun or a Star comes, it is ſaid to be in the Meridian.

And the other is the Meridian of the Plain, in which Line the Pole-point of every Plain is, being 90 degrees diſtant from the Plain every way, and in all upright-Dials their Pole is in the Horizon; and that degree of Azimuth in which the Pole-point lies, counted from South or North toward Eaſt or Weſt, is alwayes the declination thereof; ſo that by finding the Suns Azimuth at any time, and the diſtance of the Sun at the ſame time from the Meridian of the Plain, is gotten the declination.

The Azimuth of the Sun from the Meridian of the place, is found by the 26, 27, 28, 30, 32, 34, 39 *Uſes* of the 15th *Chapter.*

But the Azimuth of the Sun from the Meridian of the Plain, is found by applying the Head-leg againſt the Plain Horizontally, ſlipping it to and fro, till the ſhadow of the Thred, hung (or held) up, play right over the Center of the *Trianguler-Quadrant* on the Head-leg; then what deg. ſoever the thred cuts, counted from 60|0 on the Looſe-piece (being the Perpendiculer or Pole-point of the Plain) ſhall be the Azimuth of the Sun from the Meridian of the Plain.

This is the Operation; the Application or Uſe is worded ſeveral wayes by ſeveral men; I hope I ſhall do it as fully, and as briefly as ſome others.

The Sun, to our appearance, paſſeth from Eaſt, by the Meridian, to the Weſt every day; therefore in the morning it wants of coming to the Meridian; at noon it is for a moment juſt in the Meridian, and in the afternoon it is paſt the Meridian of the place.

Even ſo it begins to ſhine on, and is directly againſt, and leaveth to ſhine upon moſt Plains, when it begins to ſhine upon, or is not directly againſt; I ſay, it wants of coming to the Pole or Meridian of the Plain. When it is directly againſt the Plain, then it is in the Meridian or Pole of the Plain; when it is paſt, it is paſt, or begins to leave the Plain.

Which Three Varieties I intend thus briefly to expreſs;

Azimuth Want, or W in the morning only; Azimuth Direct at noon; Azimuth

paſt

past, or P being in the afternoon.

The other Three Varieties let be Shadow Want, Shadow Direct, Shadow Past; all which may be in several Plains at several times; that is to say, at morning, noon, and night.

These Observations, and Cautions premised, the Rule is thus;

1. If the Azimuth and Shadow are both wanting, or both past; substract the lesser out of the greater, and the *residue* is the Declination. But if one want, and the other be past, then the *sum* of them is the Declination.

2. If the Sun come to the Meridian of the Plain, before it come to the Meridian of the place, it is an East Plain. But if it come to the Meridian of the place, before it come to the Meridian of the Plain, it is a West Plain.

3. If the *sum* or *remainder*, after Addition or Substraction, be under 90, it is a South-east, or South-west Plain, declining so many degrees, as the *sum* or *residue* is. But if the *sum* or *remainder* be above 90, it is a North-east or a North-west Plain, and the complement of the *sum* or *remainder* to

180,

180, is the quantity of Declination North-east, or North-west.

4. If the *sum* or *remainder* be 00, it is just South; If 90, just East or West. But, If it be 180, it is a direct North Plain.

It shall be further Explained by two or three Examples.

Suppose that on the first of *May*, in the forenoon, I come and apply the Head-leg of the *Triangular-Quadrant* to the Wall, and holding of it level, the shadow of the Thred, held up steady, cuts the Center and 60 degrees on the Moving-leg; that is, 60 deg. want; which I presently set down in a Paper ready prepared, *thus*;

May 1, 1669. *Forenoon.*

Shadow ——60—00 want.
Altitude——20--00
Azimuth——94—00 want.

Substract.—34—00—South-east.

Then, as soon as possible, or rather by some body else, at the same moment, find the Suns Altitude, which suppose to be 20 degrees; (but if you are alone, and have a

Thred ready hanged up; then take the Altitude first, and the ſhadow will be had preſently after, the Thred hanging ſteadily) and ſet that down alſo, as here you ſee.

Then by the 26th *Uſe* of the 15th *Chapter*, you ſhall find the Suns Azimuth at that time and Altitude to be 94 degrees, and after Subſtraction remains 34-0, for the Walls declination Eaſtward, becauſe the remainder is under 90, and the Sun comes to the Meridian of the Plain, before it comes to the Meridian of the place, or South.

Again,

In a morning, *June* 13, I obſerve the Altitude, and find it 15 degrees, and inſtantly the ſhadow, and find it to be 10 degrees paſt the Plain, *viz.* on the Looſe-piece, toward the Head-leg, I ſet both Altitude and Shadow, with the day and time down *thus*;

June 13, *Forenoon.*

Altitude —	15—0	
Shadow —	10—0	Paſt.
Azimuth —	109—0	Want.
Sum is —	119—0	
	180—0	
	061—0	North-eaſt.

And

And then find the Azimuth at that time and Altitude to be 109 degrees; here the terms being unlike, I add them together, and the *ſum* being above 90, I know it muſt be a North Plain; and becauſe the Sun comes to the Plain before it comes to the Meridian of the place, it is North-eaſt; and the complement of 119 to 180, is 61-0 North-eaſt.

Again,

June 13, *Afternoon.*

Altitude —	15—0	
Shadow —	20—0	Want.
Azimuth —	109—0	Paſt.
Sum is —	129—0	
	180—0	
	051—0	North-weſt.

Suppoſe the ſame day, in the Afternoon, I find the Suns Altitude 15-0, and the ſhadow 20 degrees want; the Azimuth at the ſame Altitude, and the ſame day, will be near the ſame number of degrees; but in the Afternoon it is paſt the South, or Meridian of the place; here alſo it is a North-plain, becauſe the ſum is above 90; and a North-

North-west, becauſe it is againſt the South, before it comes to be right againſt the Plain.

But if you happen to come when the Sun is in the Meridian of the Plain, then the Suns Azimuth is the Declination, East or Weſt, as the Azimuth is.

Alſo,

If you take the ſhadow, when the Sun is juſt in the South, or Meridian of the place, the ſhadow is the Declination; if it is paſt the Plain, it is Eaſtward; if it wants, it is Weſtwards.

Thus I have (I hope) ſhewed the true manner of finding the Declination of a Wall by the Sun ſhining on the Plain, as plainly and as briefly as the matter will bear, ſpeaking to young *Tiroes* therein.

It may be done alſo, by obſerving when the Sun juſt begins to ſhine on a Chimny, or Wall, or high place you cannot for the preſent come near, conceiving the Sun to be then juſt 90 degrees from the Meridian of the place wanting, or juſt when it leaves it being then 90 degrees paſt the Plain, then take the Altitude and Azimuth, and work accordingly to the former Rules.

CHAP.

CHAP. IV.

To Draw a South, or North Erect Declining-Dial.

FOr better illuſtrations ſake, I will draw a particular Scheam for this Dial alſo, as I did for the Eaſt Recliner; whoſe Declination let it be 20 degrees declining from the South toward the Weſt, in the latitude of 51-32 for *London*.

The Scheam is drawn by the former directions; the Pole of the Plain being at D, declining 20 degrees from S toward W, and the Plain it ſelf is repreſented by the Line A B; the Circuler pricked Line D H P C is a certain Meridian drawn through the three given Points D P C, whoſe Center will be in the interſection of the Plain A B, and the Tangent Line for the hours, which being drawn, whatſoever Z H is in the half Tangents, Z ⊙ is the complement thereof, in the ſame half Tangents.

The

The Scheam thus drawn, Z H is the Substile, P H is the Stile, Q Z the distance of 6 from 12, H P Z the inclination of Meridians, or Angle between the two Meridians, *viz.* of the Place P Z, and of the Plain P H, found by the following Canons.

By Artificial Sines and Tangents.

1. *First for the Substile from* 12.

As the sine of 90 Z N, to the sine of the Declination N C 20 degrees;
So is the Co-tangent of the Latitude P Z 38-28, to the Tangent of Z H 15-12.

2. *For the Stiles Elevation.*

As the sine of 90 Z N, to the Co-sine of the Plains Declination N A 70-0;
So is the Co-sine of the Latitude Z P 38-28, to the sine of P H 35-46, the Stiles Elevation.

3. *For the Distance between* 6 *&* 12.

As the sine of 90 Z W, to the sine of the Plains Declination W A 20-0;
So is the Tangent of the Latitude N P 51-32, to the Tangent of A Q, the Co-tangent of 6 from 12, 23-18.

Or

Or thus;

As Co-tangent Latitude ZP 38-28, to the sine 90 ZPQ;
So is S. declination WZA 20-0, to the Tangent of QA 23-18.

4. *For the Inclination of Meridians.*

As the sine of the Latitude ZÆ 51-32, to the sine of 90 ZS;
So is the Tangent of the declination SD 20-00, to the Tangent of ÆK 24-56, the Inclination of Meridians.

Or,

As Co-sine Latitude 38-28 PZ, to the sine 90 PHZ;
So is the sine of the Substile ZH 15-12, to the sine of ZPH 24-56, I M.

5. Then having made a Table of Arks at the Pole, by this Canon you may find the Hour-Arks on the Plain.

Thus;

As the sine of 90 PK, to the sine of the Stiles height PH 35-46;
So is the Tangent of the Hour from 12, 19-56 for I, ÆI, to the Tangent of the Hour from the Substile on the Plain, H I, 12-14.

But

But I prefer the way by *Tangents* before it, as followeth.

All these requisites may be found by the general Seale and Sector, the Canons whereof in brief are thus;

By the Trianguler-Quadrant and Sector.

Subſtile.

As — Co-tang. Lat.	38-28	Z P,
To = ſine 90	90-00	Z N;
So = ſine Declination	20-00	N C,
To — I Subſtiler	15-12	Z H.

Stile.

As — Co-ſine Lat.	38-28	Z P,
To = ſine 90	90-00	Z N;
So = Co-ſine declin.	70-00	N A,
To — ſine Stile	35-46	P H.

Diſtance between 6 & 12.

As — ſine Declin.	20- 0	W A,
To = ſine of 90	90- 0	Z W;
So is = C.T. of Lat.	51-32	N P,
To — C.T. 6 & 12	23-18	A Q.

Tangent 66-42.

Inclinations of Meridians.

As — I declination 20- 0 S D,
To = fine Latitude 51-32 Z Æ;
So = fine 90 90-00 Z S,
To — T. Inclin. Merid. 24-56 Æ K.

These Requisites are also found by the particular Quadrant, very really and truly, for that Latitude the Rule is made for, in this manner.

1. *First, for the Substile.*

Lay the Thred to the complement of the Plains declination, counted on the Azimuth Line, and on the degrees it giveth the Substile from 12, counting from 60|0 on the Moveable-leg.

Example.

The Thred laid to 70, the complement of 20 on the degrees, gives 15-12 for the Substile.

2. *For the Stiles height.*

Take the distance between 90, and the Plains declination on the Azimuth-line, and measure it on the particular Scale from the beginning, and it shall give the Angle of the Stiles Elevation above the Substile, 35-46.

3. *For*

3. *For the Inclination of Meridians.*

Take the Subſtile from the particular Scale of Altitudes, and meaſure on the Azimuth-line from 90, and it ſhall give the complement of the Inclination of Meridians, or the Angle counting from 90. *viz.* here 24-56.

4. *To find the Angle between* 12 *&* 6.

Take the Plains Declination from the particular Scale of Altitudes (leſs by the ſine of the Declination, to a Radius equal to 45 minuts of the firſt degree on the particular Scale of Altitudes), and lay it from 90 on the Azimuth Scale, and to the Compaſs-point lay the Thred, then on the Line of degrees, the Thred gives the complement of 6 from 12, counting from 60 toward the end, as here it is in this Dial 23-18.

Alſo, the requiſites may be found Geometrically by the Scheam, thus;

As,

1. A Ruler laid from D to H in the Limb, gives F; the Ark CF is the Subſtile.

2. A Ruler laid from ⊙ to P in the Limb gives I, the Ark AI is the Stiles height.

3. A Rule laid from P to ⊙, cuts the Limb at T; the Ark T E is the Inclination of Meridians.

Or,

A Rule laid from P to K, cuts the Limb at L; then S L is the Inclination of Meridians.

4. A Rule laid from D to Q, cuts the Limb at 6, the Ark C 6, is the Angle between 12 and 6.

5. A Rule laid from D, to the intersection of any other Hour-line, with the Plain A B on the Limb, gives Points, whose distances from C, are their Angles from 12, or their distances from F, or their Angles from the Substile.

To Delineate the Dial by the Sector.

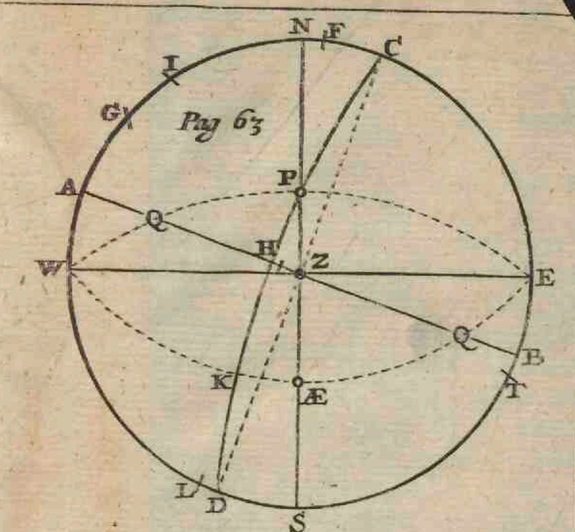
Thus by any of these wayes, having gotten the Requisites, proceed to draw the Dial thus;

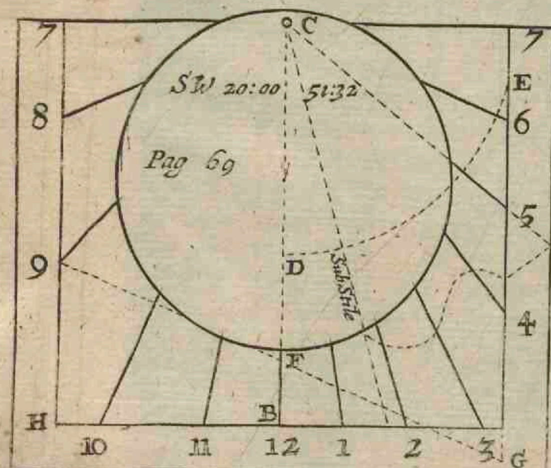
First, Draw a Perpendiculer-line on the Plain C B, by a Thred and Plummet; then if it be a South Decliner, at the upper-end make a Center, as C; and on that Center describe the Arch of a Quadrant, as the Arch D E on the Center C; then in that Arch by Sines

Sines or Chords lay off from D the Subſtile, and upon the Subſtile, the Stiles height; and the Hour-line of 6 by the Angle between 12 and 6; and draw thoſe Lines as you ſee in the Figure, contrary to the Coaſt of Declination; then draw two Lines parallel to 12, as 6 G, and 12 H; then fit the diſtance of the Parallels from 12, in the Secant of the Plains declination 20; and take out the = Secant of the Latitude 51-32, and lay it from 6 to G, and from G on the Line of 12 to F, & draw the Line G F to H, which Line is a = to the Hour-line of 6; then make F G Radius, or the = Tangent of 45; and before you prick off the Hours, take out the = Tangent of the Inclination of Meridians; and if it reach from F to the Subſtile, on the Line F G, your work done is true, elſe not.

Then,

Take out the = Tangent of 30, & 15, and the reſpective quarters, and *&c.* as before; then make 6 G a = Tangent of 45, and do likewiſe as before, in the Horizontal and South Dials, and to thoſe Points draw the Hour-lines required.





2. *To Draw the Hour-lines on a North-Declining Dial.*

The Requisites, as Substile, and Stile, Inclination of Meridians, 6 & 12, are found the same way, and by the same Rules, as the South Decliners are done. But when you come to delineate the Dial, there is some alteration; which I conceive is best seen by an Example, as Northeast declining 35 deg. Lat. 51-32, at *London.*

First, as before, draw a Perpendiculer-line for 12 a Clock, as A B; then about the middle, or toward the lower-part of that Line, as at C, make a Point for a Center, as C; then on the Center C describe the Arch of a Circle, that way, from the Line A B, as is contrary to the Coast of declination, as if the Plain declines Eastward, as here, draw the Arch Westward from A B, as B D; and the contrary way in Northwest plains; and on that Ark lay down the Substile from 12, and the Stiles height above the Substile, and the Hour of 6, by the Angle of 6 & 12; and then, by those Points and the Center, draw these Lines.

Then, at any distance, draw a Line = to 12, (or A B) as the Line E F, and make

that

that diſtance a = Secant of 35, the declination; the Sector ſo ſet, take out the = Secant of the Latitude 51-32, and lay it on the Parallel-line from 6 to 9, then make 6-9, the meaſure the Compaſs ſtands at, a = Tangent of 45; and take out the = Tangent of 15-30, &c. and lay them both wayes from 6, upwards and downwards; alſo, for the hour of 10, as the Sector ſtands, take out the = Tangent of 60, and turn it 4 times from 6 on the Line E F; and (when you want it) the = Tangent of 75, and turn that alſo 4 times from 6, for 11 a Clock-line; and then by thoſe Points, draw Lines for the Hours required.

CHAP. V.

To Draw the Hour-Lines on a Dial falling near the Meridian, whose Stile hath but a ſmall Elevation, and therefore no Center.

THe former *Examples* may be ſufficient to the conſiderate, to draw any Erect Declining-Dial having a Center; but when the Stile happens to be leſs than 15 deg. of Elevation; then, if it be not augmented by caſting away the Center, the uſefulneſs, and handſomneſs of the Dial is loſt; now if you draw the Dial by the former Rules on a *Table*, and cut off ſo much, and as many Hours as you care for, the work is performed.

But then you ſhall find, that long Rulers and Lines will be wanting for a ſmall Dial; there-

therefore I prefer this way following by the Sector, general in all Dials.

Lat.	51-32	
	d. mi.	
S.W.	80-25	
Sub.	38- 4	
Stile	5-56	
6 & 12	38-51	
I. M.	82-30	12
	75-00	
	67-30	1
	60-00	
	52-30	2
	45-00	
	37-30	3
	30-00	
	22-30	4
	15-00	
	10-30	5
	00-00	—
	07-30	6
	15-00	
	22-30	7
	30-00	
	37-30	8

First, on or near the North Edge of the Plain, in far South decliners, (but near to the South-edge of the Plain, in far North-decliners) draw a perpendicular-Line, representing the Hour-line of 12, as the Line A B in our *Example*, being a Southwest declining 80 deg. 25 min. then, in the upper-part of that Line, in South-decliners; or about the middle, or lower-part in North-decliners, appoint a Center, as here at A; then upon A, as a Center, as large as you may, draw an Arch as B D; and in that Arch, or rather by a Tangent-line, lay off the Substile from B to D, and draw the Line A D, as an obscure Line, for the present

only

only to be ſeen; and upon that, the Stile-line, as before: Then at any convenient places, as far from the Center as you can, draw two Lines Perpendiculer to the Subſtile, as the Lines C E, F G, for two contingent Lines, (antiently and properly ſo called); then by the Inclination of Meridians, by the directions in the Eaſt and Weſt Recliner, being the 7th Dial in the 2d *Chapter*, make the *Table* of Hour-Arks at the Pole, by ſetting down againſt 12, 82-30; and taking out 7-30 for every half hour, till you come to 00 at the Subſtile; and then by adding 7-30 for every half hour, and 15 for every hour, to 8 ½, as long as the Sun ſhines; which in regard it falls on an even half hour, is the moſt eaſie, and fits the Points in the Tangent ready made for hours and quarters.

The next work, is to reſolve what hours ſhall come on the Plain, as will be beſt determined by the diſcreet Orderer, or Surveyor, or experimental Dialiſt, as here 8 and 1; and for thoſe two hours, mark the upper contingent Line in two places where you would have them to be, as at E and C; then take the — Tangent of 37-30 for 8, from the ſmall Tangents, and add it to the — Tangent of 67-30, the Tangent for 1; and

and behold! it makes the —Tang. of 72-33.

Then,

Take the whole ſpace C E, and make it a = Tangent of 72-33; then take out the = Tangent of 67-30, and lay it from C to H; and take alſo in the ſame common-line, right againſt the ſmall Tangent of 37-30, which is in the large Tangent 10-50, the = Tangent of 10-50, taken for 37-30, being laid from E, the place for 8, will meet juſt at H; which Point H, is the true place for the Subſtile, to fit and fill the Plain, with the hours determined.

Then,

The Sector ſo ſet, Take out all the = Tangents above 45, as in the *Table*, and lay them the right way from H, toward C, and E; then take out = Tangent of ſmall 45; and ſetting one Point in H, ſtrike the touch of an Arch, as at I; then make H I a = Tangent in great 45, and take out the = Tangents of the reſt of the hours under 45, as in the *Table*, and lay them both wayes from H, becauſe the Subſtile falls on an even half hour.

Then,

Draw the Line H K, = to the firſt Line A D, for the true Subſtile; then make H K Radius, or the Tangent of 45, and take out the Parallel Tangent of 5-56, the Stiles height,

height, and lay it from K to L; then take H I, the first Radius, and setting one Point in L, draw the touch of an Ark as by M; then draw a Line by the Convexity of the Arches by I and M, for the true Stile-line.

Then,

Take the nearest distance from the Point K, to the Line I M, and make it a ⧧ Tangent of 45, the greater Radius, and take out the ⧧ Tangents, as in the *Table*, and lay them from K both wayes; and then lastly, by those Points draw Lines from the hours required.

Note, That if in striving to put too many hours, the sum of the two extream hours come to above 76, it will make the hours too close together, and put you to much more trouble.

Also note, If your Rule prove too small, then take the half of the sum of both the Tangents, and turn the Compasses twice.

Also, If you be curious, you may use the Natural Logarithm Tangents, instead of the Line of Tangents, but this will serve very well.

This is a general way of augmenting all manner of Dials, when the Stiles height is low, as under 15 degrees; and as ready a way, as you meet with in any Author whatsoever.

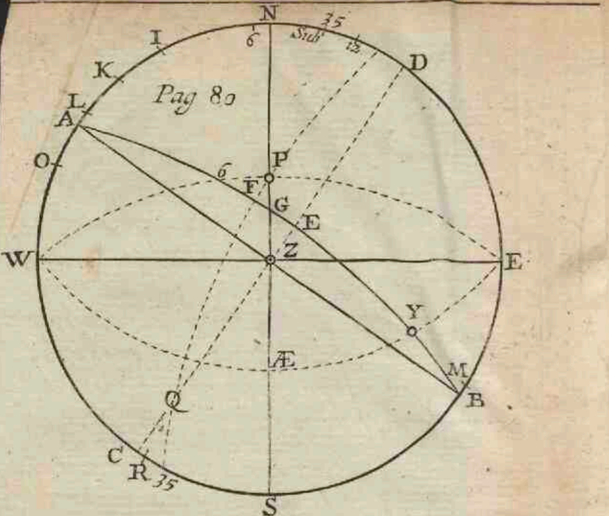
CHAP.

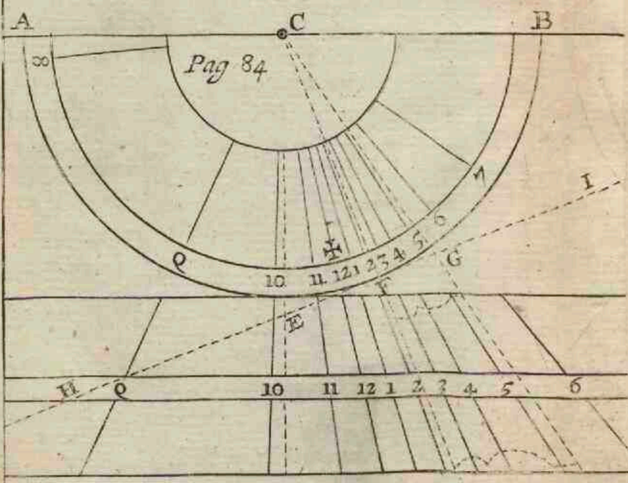
CHAP. VI.

To Draw the Hour-Lines on Declining Reclining Dials.

FOR the compleat and true drawing of these Dials, that you may plainly see their Affections and Properties, it will be necessary to have a Scheam for every variety; in doing whereof, I shall follow the Method that Mr. *Wells*, of *Deptford*, used in his *Art of Shadows*; which will comprehend any sort of Reclining and Declining Dial, under 6 varieties, *viz.* 3 South Recliners, and 3 North Recliners (the Inclining being their opposites, and no other, as afterwards is shewed).

Wherein I shall be very brief, yet sufficiently plain, to a Mathematical *Genius*, and render the Canons, by Artificial and Natural Sines and Tangents, and draw the Dial by the Sector, the fittest Instrument for that use; With other occurrent Observations,





vations, as they come in place, and the way by the Scheam Geometrically alſo.

1. And firſt for a South-Declining, Reclining Dial, declining from the South toward the Weſt 35 degrees, and reclining from the Zenith 20 degrees, being leſs than to the Pole, *viz.* falling from you, between the Zenith and the Pole: As the Circle A E B, repreſenting the Reclining Plain, plainly ſheweth P being the Pole, and Z the Zenith.

The manner of drawing this Scheam, is plainly ſhewed before, (*Chap.* 1.) both generally and particularly for the drawing of Dials, and the ***Example*** there, is the very Scheam for this Dial; wherein you may further conſider, That the Perpendiculer-line is right before you, and when you look right on this Plain that declines Southweſt, the North is before you on the left hand, the South behind you on the right hand 35 degrees, the Eaſt on the right hand, the Weſt on the left; the Line C D the perpendiculer-line right before you, repreſenting the Perpendiculer-line on the Plain, A B the Horizontal-line, Z E the quantity of Reclination, P F the Stiles Elevation above the Plain, having the South Pole elevated above the lower-part of the Plain, becauſe the

North-

North-Pole is behind the Plain, E G the distance on the Plain, between the Plains perpendiculer, and the Meridian, (being to be laid Eastwards, as the Dial-draught sheweth, besides that general Rule before hinted, that whensoever a Plain declines Eastward, the Substile Line must stand Westward, and the contrary; for the Arch whereon to prick the Substile,and Stile is alwayes to be drawn on that side of the Plain, which is contrary to the coast of declination) E F the distance from the Substile and Perpendiculer, to be laid the same way ; G F the distance on the Plain, from the Substile to the Meridian, to be laid the same way also ; the Angle F P G, is the Inclination of Meridians ; All which Requisites are found by these Canons Arithmetically, or by the Artificial and Natural Sines and Tangents.

1. *To find the Distance of* 12, *from the Perpendiculer* E G, *or Horizon* A G, *by the second Axiome of Mr.* Gellibrand, *viz. that the Sines of the Base and Tangent of the Perpendiculer are proportional.*

By

By the Sector and Quadrant.

As sine 90 Radius,	Z D	90—00
To Tang. of Declin. Plain	N D	35—00
So sine of Reclin. Plain	Z E	20—00
To Tang. of Perp. & 12	E G	13—28
Whose complement	A C	76—32

is the distance from the East-end of the Horizon to 12.

As — Tangent of	N D	35— 0
To = Sine of	Z D	90— 0
So = Sine of	Z E	20— 0
To — Tangent of	E G	13—28, the

distance of 12, from the Perpendiculer.

2. *To find the Distance on the Meridian, from the Pole to the Plain,* P G, *by the 3 Propositions of Mr.* Gellibrand, *the Sines of the Sides are proportional to the Sines of their opposite Angles.*

By the Quadrant and Sector.

As the sine of the Perpendiculer from 12	G E	13-28
To the sine of declination	G Z E	35-00
is the sine of 90	G E Z	90- 0
he sine of the distance the Meridian, from the Plain to the Zenith —	G Z	23-55

As

As — sine 90- 0 GEP,
To = sine 35- 0 GZE;
So = sine 13-28 GE,
To — sine 23-55 GZ, which taken
from 38-28 gives PG 14-33.

Which being taken from 38-28, the distance on the Meridian from the Pole to the Zenith, leaveth the distance on the Meridian of the place, from the Pole to the Plain, *viz.* 14-33, as a help to get the next.

3. *To find the Height of the Stile above the Plain* P F.

In the two Triangles Z G E, and P G F, which are vertical, by the second Consectary of Mr. *Gellibrand*; If two Perpendiculer Arks subtend equal Angles, on each side of the meeting, then the Sines of their Hypothenusaes, and Perpendiculers are proportional, (and the contrary); for the Angles Z G E, and P G F are equal Angled at G, and Z E, and P F, are both two perpendiculer Arks on the Plain A B.

Therefore,

As the sine of the Hypothenusa G Z, to the sine of the Perpendiculer Z E;
So is the sine of the Hypothenusa P G, to the sine of the Perpendiculer P F, and the contrary.

Then thus, by the Quadrant and Sector.

As ſine of the Arch of the Merid. from the Zenith to the Plain,	ZG 23-57
To ſine of the Reclination	ZE 20 00
So is the ſine of the Arch on the Meridian, from the Pole to the Plain	PG 14-33
To ſine of the Stiles height	PF 12-13

As — ſine of PG 14-33
To = ſine of ZG 23-58
So = ſine of ZE 20-00
To — ſine of PF 12-13

4. *To find the Diſtance of the Subſtile from the Meridian,* GF.

In the ſame Vertical Triangle, having the ſame acute Angle at the Baſe, the Tangents of the Perpendiculers, are proportional to the Sines of the Baſe, by the ſecond *Axiome* of Mr. *Gellibrand.*

Therefore,

Therefore, by the Quadrant and Sector.

As the Tang. of the Reclin. ZE 20- 0
To the ſine of the Diſtance
on the Plain, from the } GE 13-28
Perpend. to the Merid.
So is the T. of the Stils height PF 12-13
To the S. of the Subſt. fr. 12 FG 7-58

As — ſine of GE 13-28
To = Tang. of ZE 20- 0
So = Tang. of PF 12-13
To — ſine of FG 7-58

5. *To find the Angle between the two Meridians, of the Place and Plain,* viz. *the Angle,* PFG.

By the third Propoſition of Mr. *Gellibrand,* it is proved, That the Sines of the Sides are proportional to the Sines of their oppoſite Angles, and the contrary.

Therefore, by the Quadrant and Sector.

As the ſine of the Diſt. on the
Merid. from the Pole to Plain } PG 14-33
To the S. of 90, the opp. Angle PFG 90-00
So is the S. of the Subſt. fr. 12, FG 07-58
To the S. of the Inclin. Merid. FPG 33-28

As ≡ ſine of the ſide	07-58	F G
To = ſine of the ſide	14-33	P G
So = ſine of the Angle	90-00	P F G
To — ſine of the Angle	33-28	F P G

The Angle between the 2 Meridians.

By Angle of Inclinations of Meridians, make the *Table* of the Hour-Angles at the Pole, by the Directions, *Chap.*2. which being made as in the *Table*, draw the Dial in this manner;

Upon A B, the Horizontal-line of your Plain, deſcribe the ſemi-circle AEB, and from the Perpendiculer-line C E of the Plain, lay off 13-28 Eaſtward for the 12 a clock Line, on the Plain, or the complement thereof 76-32, from the Eaſt-end at B to +, & draw the Line C +.

Again, Set further Eaſtward from 12, 7-58, the diſtance of the Subſtile from 12, to F, and draw the Line C F for the Subſtile; and beyond that,

12	33-28
1	18-28
2	3-28
Sub.	
3	11-32
4	26-32
5	41-32
6	56-32
7	71-32
8	86-32
9	78-28
10	63-28
11	48-28
12	33-28

ſet off from F 12-13, the Stiles height above the Subſtile to G, and draw C G alſo.

Then,

Draw a contingent Line perpendiculer to the Subſtile C F, as far from the Center as you can, as the Line H I; then take the neareſt diſtance from the point F, to the Line C G, and make it a = Tangent of 45; then the Sector being ſo ſet, take out the = Tangents of all the Hour-Arks in the *Table*, and lay them both wayes from F toward H and I, as they proceed; then Lines drawn from the Center C, and thoſe Points ſhall be the Hours required.

Or,

Having in that manner pricked down 12, 6 & 3 (or any other Hours 3 hours diſtant) draw two Lines on each ſide 12 = to 12, and meaſure the diſtance from 6 to 3 in the =, and lay it from C the Center on the Line 12; and by thoſe two Points draw a third Line, = to the 6 a clock-line; then 6-3, and 12-3, made a = Tangent of 45, ſhall be the two Radiuſſes to lay off the Hour-lines from 6 & 12, as before in the former Dials. And the = Tangent of Inclination of Meridians, doth prove the truth of your Work here alſo, as well as in the Decliners Erect.

But note, That this Dial is better to be augmented by the losing the Hours of 8 and 9 in the morning, which makes the Hours more apparent, as you see.

Also, the Requisites formerly found, may Geometrically be found by the Scheam, being large and truly drawn, as before is shewed in the other Dials. *Thus*,

1. A Rule laid from Q, the Pole-point of the Plain, to G the Point of 12 on the Plain, gives in the Limb the point 12; D 12, 13-28, is the distance of 12 a clock-line on the Plain from the Plains perpendiculer-line Z D, (and to be laid from the perpendiculer-line on the Plain Eastwards in the Dial); and the distance on the Limb from A to 12, is the Meridians distance from the East-end of the Horizontal-line on the Plain, namely 76-32.

2. A Rule laid from Q to F, on the Limb, gives the Point Sub, for the Substile; and the Ark Sub. 12, 7-58, is the distance from 12, or the Ark Sub. D 21-26, the distance from the Perpendiculer.

3. A Rule laid from Q to 6, the place where the 6 a clock hour-line on the Scheam cuts the Plain, gives on the Limb the Point 6, the Ark 6 12, 25-38, or 6 D, 38-56, is the distance of the Hour-line of 6 on the Plain,

Plain, from the Hour-line 12, or the Perpendiculer.

4. A Rule laid from Y, the Pole-point of the Circle Q F P, to P & F, on the limb, gives two points I K, and the Ark I K is the Stiles Elevation 12-13.

5. A Rule laid from P to Y on the limb, gibes the Point M; E M is the Inclination of Meridians: or, a Rule laid from P, to the interſection of the Circle P F Q, and the Equinoctial-line, gives a Point in the Limb near C, which Ark C S, is more naturally the Angle between the two Meridians, 33-28.

Or,

If you like the way of referring this Plain to a new Latitude, and to a new Declination in that new Latitude,

Then thus by the Scheam;

6. A Rule laid from E, to P and G, in the Limb gives L and O; the Ark L O is the complement of the new Latitude, being the Ark P G, the ſecond requiſite, in the former Calculation being 14-33, the diſtance on the Meridian from the Pole to the Plain.

7. A Rule laid from G to Q on the limb, gives R, the Ark S R is the new declination in that new Latitude, 32-37.

Or elſe find it by this Rule;

As ſine of 90, to the Co-ſine of the Reclination, or Inclination;
So is the ſine of the old Declination, to the ſine of the new, in this *Example*, being 32-37, and generally the ſame way as the old Declination is.

Only obſerve,

That when the North-pole is Elevated on South Recliners, you muſt draw them as North-decliners; and North-weſt and North-eaſt incliners, that have the South-pole Elevated, you muſt draw them as South-eaſt and Weſt-decliners, which will direct as to the right way of placing the Subſtile, and Hour of 6 from 12.

In this place I ſhall alſo inſert the general way, by Calculation, to find the new Latitude, as well as new Declination:

Which is thus;

As Radius, or Sine of 90, to the Co-ſine of the Plains old Declination;
So is the Co-tangent of the Reclination, or Inclin. to the Tang. of a 4th Ark.

Then,

In South Recliners, and in North Incliners, get the difference between this 4th Ark, and the Latitude of your place, and the complement of that difference is the new Latitude: if the 4th Ark be leſs then the old Latitude, then the contrary Pole is Elevated; but if it be equal to the old Latitude, it is a Polar-plain.

But in South Incliners, and in North Recliners, the difference between the 4th Ark, and the complement of the Latitude of the place (or old Latitude) ſhall be the new Latitude, when the 4th Ark and old Latitude is equal, it is an Equinoctial-plain.

Thus in this Example;

As ſine 90, to Co-ſine of 35, the old Declination;
So is Co-tangent of 20, the Reclination to 66-03, for a 4th Ark; from which taking 51-32, the old Latitude, reſts

14-31,

14-31, the complement of the new Latitude, which will be found to be 75-29, the new Latitude.

By which new Latitude, and new Declination, if you work as for an Erect Dial, you shall find the same Requisites, as by the former Operations you have done; and the distance of the Perpendiculer and Meridian will set all right.

The Second Variety of South Recliners, reclining just to the Pole.

1. The Scheam is drawn, as before, to the same Declination, and the same way, *viz.* 35 degrees Westward, and reclines 33-3′. Now, to try whether such a Plain be just a Polar-plain or no, use this Proportion:

By the Sector;

As the sine of 90	D A	90- 0
To Co-sine of Declin.	N A	55- 0
So Co-tang. of Reclin.	D E	56-57
To Tang. of Latitude	N P	51-32

As

As — Co-ſine Declination N A 55-00
To = ſine of A D 90-00
So is = Co-tang. of Reclin. D E 56-57
being taken from the ſmall Tangents,
To — Tangent of N P 51-32
being meaſured from the Center on the ſame ſmall Tangents.

Which 4th Ark, if it hit to be right the Latitude, then it is a declining Polar-plain, or elſe not.

2. If you have a Declination given, to which you would find a Reclination to make it Polar, then reaſon thus:

By the Sector;

As the Co-ſine of the Declin. A N 55- 0
To the Radius or Sine of A D 90- 0
So is the Tang. of the Lat. P N 51-32
To the Co-tang. of the Reclin. D E 56-57

As — Tangent of N P 51-30
To = Sine of A N 55-00
So = Sine of A D 90-00
To — Tangent of D E 56-57

3. If

3. If the Reclination were given, and the Declination required to make it a Polar, then the Canon may be thus;

By the Sector ;

As the Co-tang. of the Reclin.	D E	56-57
To the Radius, or Sine of	A D	90-00
So is the Tang. of the Lat.	N P	51-32
To the Co-sine of the Declin.	N A	55-00

As — Co-tang. Reclination	D E	56-57
To = sine of	A D	90-00
So — Tang. of Latitude	N D	51-32
To = Co-sine of Declination	N A	55-00

But by the Scheam, these three Operations are found by drawing the Scheam.

1. For if the Line or Circle, representing the Plain, cut the Pole P, it is a *Polar-Dial.*

2. If A B, the Co-declination, be given, then draw the Circle A P B, and it gives E; then Z E is the Reclination, measured by half Tangents; or a Rule laid from A to E on the Limb, gives an Ark from B; which measured on fit Chords, is the Reclination.

3. If

3. If P, the Pole-point, and ZE the Reclination, be given; then, with the distance ZE, on Z as a Center, draw an Ark of a Circle in that Quadrant which is contrary to the Coast of Declination, observing the letters in the Scheam; then by the Convexity of that Ark, and the Pole-point P, draw the Circle PE, cutting the Limb into two equal parts, which are the points A & B, the declination required.

This being premised, there are two things requisite to be found, before you can draw the Dial, viz. *the Substile from the Perpendiculer or Horizon, and the Inclination of Meridians.*

1. And first for the Substile, by the Sector.

As the sine of	PEZ	90-0
To the Co-sine of the Lat.	PZ	38-28
So the sine of the Declination	PZE	35-00
To the sine of Substile from Perp.	PE	20-54

As — sine of Declination	PZE	35-0
To = sine of	PEZ	90-0
So = sine of Co-latitude	PZ	38-28
To — sine of Substile from Perp.	FE	20-54

The

The diſtance of the Subſtile from the Perpendiculer, whoſe complement 69-06, is the Elevation above the Horizon.

Or,

A Rule laid from Q to P, gives I; DI is 20-54.

2. For the Inclination of Meridians, ſays

By the Sector.

As the Co-ſine of the Latitude	P Z	38-28
To the ſine of	P E Z	90-00
So the ſine of the Reclin.	Z E	33-03
To the Co-ſine of Incl. Mer.	Z P E	61-15
Whoſe complement	Z P Q	28-45

is the Inclination of Meridians required.

As — ſine of Reclination	Z E	33- 3
To = Co-ſine of Latitude	P Z	38-28
So = ſine of 90	P E Z	90-00
To — Co-ſine of Incl. Mer.	Z P E	61-15
Whoſe complement	Q P Z	28-45

is the Inclin. of Meridians required.

Or,

A Rule laid from P to Y, gives M; EM is 28-45, the Inclination of Meridians.

The Scheam being true drawn, which being one degree and 15 minuts leſs than 30, the quantity of two hours, I ſet 1-15 againſt 2; and by continual addition of

15

15 deg. to 1-15, and the increase thereof, I make up the one half of my *Table*, as followeth.

8	88—45
	81—15
9	73—45
	56—15
10	58—45
	51—15
11	43—45
	36—15
12	28—45
	21—15
1	13—45
	6—15
2	1—15
	8—45
3	16—15
	23—45
4	31—15
	38—45
5	46—15
	53—45
6	61—15
	68—45
7	76—15

Again,

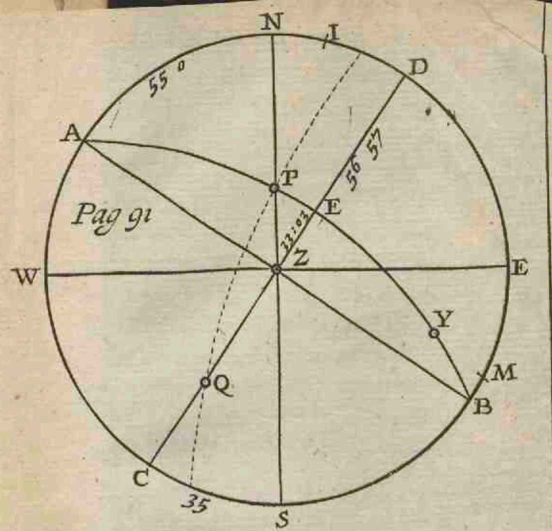
If I take 15, the quantity in degrees of one Hour, out of 28-15, the Inclination of Meridians; there remains 13-45, for the first Hour on the other-side of the Substile.

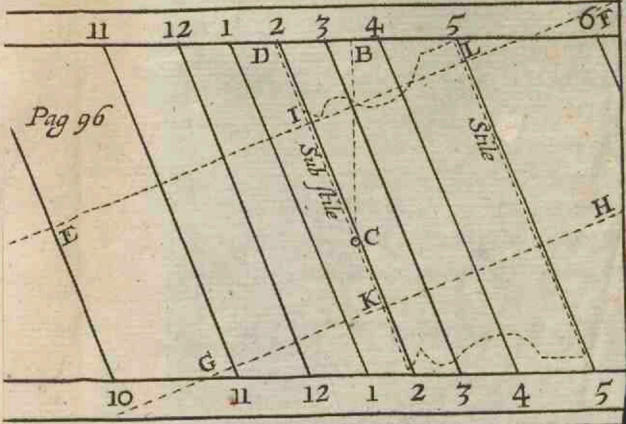
Then again, by continual addition of 15 degrees to 13-45, and the increase thereof, I make up the other half.

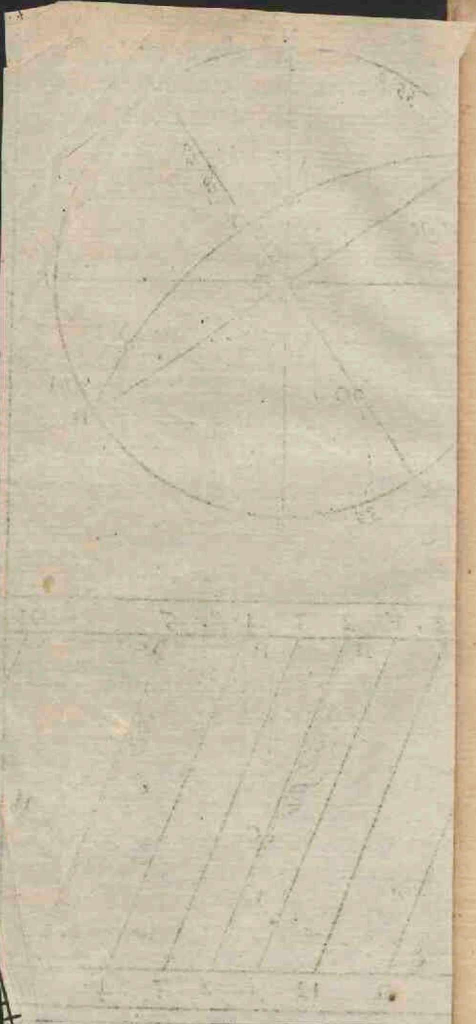
Or else, Against 12, set 28-45, and add 15 successively to it, & its increase, till it come to 90; *Then*, to 13-45, the residue of 15, taken from 28-45; add 15 as often as you can to 90, and thus is the *Table* made.

To draw the Dial.

First, Draw a perpendiculer Line on your Plain, as C B, by crossing the Horizontal-line at Right Angles; then







then from the perpendiculer-Line lay off from the upper-end, toward the left-hand (as the Scheam directs, Z D being the Perpendiculer, and Z N the Meridian, and E P on the Plain, the distance between, being toward the left hand) 20-54, for the Substile-line, as C D; then on that Line (any where) draw two perpendiculer Lines quite through the Plain, crossing the Substile at right Angles, for two Equinoctial-lines, as E F, & G H.

Then consider what hours shall be put on your Plain, as here is convenient, from 10 in the morning, to 6 afternoon; (though the Sun may shine on it from 8 to 7, but then the Lines will be too close together, and the Radius too small). And also where you would have those two utmost hours to be, as at E and F on the upper Equinoctial-line; or, at G & H on the lower contingent-line.

Then,

Take the — Tangent of 58-45, in the *Table* for 10, and add it to the — Tangent of 61-15 for 6, on the Line of small Tangents, and you shall see the Compass-point to reach to the Tangent of 73-55, the sum of both the two extream hours, which happening under 76, will be convenient and

and handſome, in their diſtances aſſunder.

Then,

Take the whole diſtance E F, or G H, and make it a = Tangent of 73-55; then the Sector ſo ſet, take out the = Tangent of 58-45, and lay it from the point E to I, on the Equinoctial-line; Alſo, take out the = Tangent 61-15, and lay it from the point F; and if your work be true, it muſt needs meet in the point I; then draw the Line I K for the true Subſtile, and from thence lay the = Tangent of 45, to draw a Line near 5, for the Stiles Elevation, parallel to I K the Subſtile; for being a Polar-plain it hath no Elevation, but what you pleaſe to augment it to, as here from I to L.

Then,

As the Sector ſtands, prick on all the whole hours, halfs, and quarters, according to the Numbers in your *Table*, at leaſt thoſe that be above 45; and for thoſe under 45, make = Tangent of 45 in ſmall Tangents, a = Tangent of 45 in the great Tangents, and then the Sector ſhall be ſet to that Radius, which is moſt convenient for your uſe.

Note,

That this way of Augmenting the Stile, is general in all Dials.

3. *The third Variety of South-Recliners.*

The next and laſt kind of *South Recliners,* are ſuch as recline, or fall from you below the Pole, *viz.* have their Plains lying between the Pole and the Horizon, as by the Scheam is more apparent.

In which work, the drawing the Scheam, and the things required, are the ſame as in the firſt *Example,* as the *Figure,* and following words, do make make manifeſt.

The *Example* here, is of a Plain that declines from the South toward the Weſt 35 degrees, and reclines upon its proper Azimuth Z E, 60 degrees from the Zenith.

1. Having drawn the Scheam, then firſt for the diſtance of the Meridian from the Perpendiculer, or Horizon.

By the Sector, or Quadrant.

As the ſine of	Z D	90-00
To the Tangent of Declination	N D	35-00
So the ſine of Reclination	Z E	60-00
To the Tang. of Perp. & Merid.	E G	31-12

As

As — Tangent of Declination	N D	35-00
To = ſine of 90	Z D	90-00
So = ſine of Reclination	Z E	60-00
To — Tang. of Perp. & Merid.	E G	31-12

Whoſe complement is 58-48 A G, the diſtance between the Weſt-end of the Horizontal-line, and the Meridian.

Or by the Scheam ;

A Rule laid from Q to G, cuts the limb at L ; then D L, and A L, are the Arks required ; D L from Perpendiculer, and A L from the Horizon.

2. To find P G, the Ark on the Meridian from the Pole to the Plain.

By the Sector.

As ſine of	A D	90- 0
To Co-tang. of the Reclin.	D E	30- 0
So Co-ſine of the Declination	A N	55- 0
To Tang. of diſt. Plain & Horiz.	N G	25-19

As — Co-tangent Reclin.	E D	30- 0
To = ſine of 90	A D	90- 0
So = ſine of Reclination	A N	55- 0
To — Tang. diſt. on Mer. P. Hor.	N G	25-19

 Which

Which being taken from NP 51-32, leaveth GP 26-13, the distance on the Meridian from the Pole to the Plain, or the complement of the new Latitude.

Or,

A Rule laid from E, to P and G, gives on the limb 2 Points, whose distance between, is *ab* 26-13, the Ark required.

3. To find the Stiles Elevation above the Plain.

By the Sector.

As sine dist. Merid. Horizon.	GA 58-48
To Co-sine Declination	AN 55-00
So sine dist. Pole to Plain	GP 26-13
To sine Stiles Elevation	PF 25-02

As — sine of GP 26-13
To = sine of GA 58-48
So = sine of AN 55-00
To — sine of PF 25-02

Being found by the Scheam, by laying a Rule from Y, to P and F, on the limb, gives the distance between being 25-02, the Stiles Elevation,

4. To

4. *To find the Subſtile from* 12.

By the Sector.

As Co-tang. of the Declin.	A N	55-00
To S.diſt.on Mer.fr.Pl.to Hor.	N G	25-19
So Tang. of the Stiles height	P F	25-02
To S. of the Subſtile from 12	F G	8-05

As — Co-tang.of Declin.Plain	A N	55-00
To = S.diſt.on Mer.fr.Pl.to Hor.	NG	25-19
So — Tang.of the Stiles height	P F	25-02
To = S. of the Subſtile from 12	F G	08-03

By the Scheam, a Rule laid from Q, to G and F on the limb, gives L and M 8-3; Or elſe, the Ark M D, is the diſtance of the Subſtile from the Perpendiculer 23-19.

5. *To find the Inclination of Meridians.*

By the Sector.

As the ſine of the diſtance. on Mer. from Pole to Plain	P G	25-19
To the ſine of the Angle	G F P	90-00
So the ſine of diſt.of Sub.fr.12	G F	08-03
To the ſine of the Incl.of Mer.	G P F	18-27

As — sine GF 08-03
To = sine PG 25-19
So = sine GFP 90-00
To — sine GPF 18-27

By the Scheam, a Rule laid from P to Y, on the limb, gives O, the Ark E O is 18-27; the Inclination of Meridians, by help of which, to make the *Table of Hour-Arks* at the Pole, as before is shewed, and as in the *Table* following.

12	18—27	8- 3			
	10—57		7	86—33	81-52
1	3—27	1-27		85—57	
	——— -	Subst.	8	78—27	64-10
	4—03			70—57	
2	11—33	4-58	9	63—27	40-20
	18—03			55—57	
3	26—33	11-55	10	48—27	25-36
	34—03			40—57	
4	41—33	20-35	11	33—27	15-33
	48—03			25—57	
5	56—33	32-45	12	18—27	8- 3
	64—03				
6	71—33	51-45			
	78—03				

To

To draw the Dial.

First, for the Affections, consult the Scheam, wherein, laying the Perpendiculer-line C D right before you, you see that the Substile, and the Meridian, are to be laid from the Perpendiculer toward the left-hand, the Substile lying between the Perpendiculer and the Meridian, and the Stile or Cock of the Dial must look upwards, the North-Pole being Elevated above this Plain, which will guide all the rest.

Then,

First, draw the Horizontal-line A B, and on C as a Center raise a Perpendiculer, and set off by Chords, Sines, or Tangents, the Meridian or 12 a clock Line, the Substile, and Stile, as exactly as you may; and draw the Lines 12 C, Substile C, and Stile C.

Then,

As far from the Center C, as you conveniently may, draw a long Line perpendiculer to the Substile, as the Line E H F; then setting one Point of a pair of Compasses in H, open the other till it touch the Stile-line at the nearest distance.

Then,

Make this diſtance a = Tangent of 45, and take out the = Tangents of every whole Hour, as in the Table, as far as the Tangent of 76 will give leave; and then from the Center C, to thoſe Points draw Lines for the even whole Hours; then to any one whole Hour, as ſuppoſe the Hour-line of 3; draw two = Lines equally diſtant on both ſides the Line of 3, as I K, L M.

Then,

Count any way 3 hours, and 6 hours from 3, as here 12, and 9, ſo as the = line may croſs the 3 remoteſt hours, as here you ſee 9 and 12 a clock Hour-lines do croſs the = line at I and K; then take the diſtance I K, and lay on the Hour-line of 3 from C to N, and draw I N L = to 9 C; Which Work doth conſtitute the Parallellogram K I L M.

Then laſtly,

Make K I, and N I, = Tangents of 45, and prick off every hour, half, and quarter (and minut if you pleaſe) on the two Lines I K, and I L, from K and N both wayes, as before is already ſhewed in the *Erect Decliners,*

Note

Note also,

That to supply the defect on the other side, when the point M falls out of the Plain, the distance from I, to the Hour-point from 11, will reach from L to 7, and from I to 10, from L to 8. This is general in all Dials.

Also note, If you like not to lay off the first Hours by the Tangents, having made the *Table*, as before, you may soon find the Hour-Arks on the Plain for 3 Hours, as here 3, 12, and 9; Or, 4, 1, and 8, which would have made the Parallellogram more square, and consequently more better, and then to draw the rest by the Sector. Thus you may see how your Work accords; The way by the Table and Contingent-line, and the way by the Sector on the Parallellogram, or by Calculation, & at last use the Mystery of Dialling made plain and ready, to an ordinary capacity.

Of North Declining Recliners.

The other kind, *viz.* North Declining Recliners, have also three Varieties; as those, 1. That fall back or recline between the Zenith

nith and Equinoctial: 2d. Those that recline to the Equinoctial: And 3d. Those that recline below the Equinoctial. And first of the first Variety, reclining less then to the Equinoctial.

The drawing the Scheam, is the same as in the former, except in the placing of the Points and Letters; For first, these Plains behold the North-part of the Horizon, and then when you look on the Plain, the South is before you, and the West on your right-hand, and the East on the left; then the South and North are alwayes opposite, and the point P, representing the Elevated Pole of the place, which with us being North, must be placed towards N downwards, as before in South Recliners it was upwards.

Also,

It is necessary in the Scheam, to draw the Equinoctial-line, by laying the half Tangent of 51-32 from Z to Æ; then the Secant of 38-28, the complement of Z E, laid from Æ on the Line S N, shall be the Center to draw E Æ W for the Equinoctial-Circle.

Thus the Scheam being drawn, to find the Requisites, *thus*;

1. *For the Meridians Elevation, or distance from the Perpendiculer,* A G, *or* G E.

By the Sector.

As ſine 90 Radius	Z D	90-0
To Tangent Declination Plain	S D	55-0
So ſine Reclination Plain	Z E	20-0
To Tangent Merid. & Perpend.	G E	26-2

As — Tangent of Declin.	S D	55- 0
To = ſine of Radius	Z D	90- 0
So = ſine of Reclination	Z E	20- 0
To — Tang. of 12 from Perp.	G E	26-02

Whoſe complement A G, 63-58, is the Meridians Elevation above the Eaſt-end of the Horizon.

By the Scheam, A Rule laid from Q to G, on the Limb gives L; then D L and A L are the Arks required.

2. *To find the Diſtance on the Meridian; from the Pole to the Plain* G P.

By

By the Sector.

As sine declin. of the Plain	GZE	55- 0
To sine dist. of Mer. & Perp.	GE	26.02
So sine of the Radius	GEZ	90-00
To sine of dist. on Merid. from Pole to Plain	GZ	32-03

As — sine of	GEZ	90- 0
To = sine of	GZE	55- 0
So = sine of	GE	26- 2
To — sine of	GZ	32-03

Which added to 38-28 ZP, makes up GP to be 70-31. Or, By the Scheam, A Rule laid from E, to P and G, gives on the limb *ab*; the Ark *ab* is 70-31.

3. To find the Stiles height above the Plain PF.

By the Sector.

As sine of distance on Mer. from Zenith to the Plain	GZ	32-03
To sine of the Plains Reclin.	ZE	20-00
So sine of dist. on Mer. from Pole to the Plain	GP	70-31
To sine of the Stiles Elevat. above the Plain	PF	37-01

As the — sine	G P	70-31
To the — sine	G Z	32-03
So the — sine	Z E	20-00
To the — sine	P F	37-01

By the Scheam.

A Rule laid from Y, to P and F, on the limb gives *c* and *d*, the Stiles height.

4. *To find the distance of the Substile from the Meridian* G F ; *when it is above* 90 *deg. take the comp. to* 108 *deg.*

By the Sector.

As Tangent of the Reclin.	Z E	20-00
To sine of dist. of 12 from Perp.	G E	26-02
So Tang. of the Stiles Elevat.	P F	37-01
To sine of the Substile from 12	G F	65-24

As — sine	E G	26-02
To — Tangent	Z E	20- 0
So — Tangent	P F	37-01
To — sine	G E	65-24

By the Scheam.

A Rule laid from Q to G and F, gives on the limb L F, the Ark required.

5. *To*

5. *To find the Inclination of Meridians* FPG.

By the Sector.

As ſine diſt. on Merid. from Pole to Plain	G P	70-31
To ſine Radius oppoſite Angle	GFP	90-00
So ſine diſt. on Plain from 12 to Subſtile	G F	65-24
To ſine of the Inclin. of Mer.	G P F	74-38

As — ſine	G F	65-24
To = ſine	G P	70-31
So = ſine	G F P	90-00
To — ſine	G P F	74-38

By the Scheam.

A Ruſe laid from P to Y, on the limb gives g, the Ark E g is 74-38, the Inclination of Meridians.

Or,

A Rule laid from P to K, gives h, S h is the Inclination of Meridians, by which to make the *Table* as before is ſhewed, and as followeth.

To

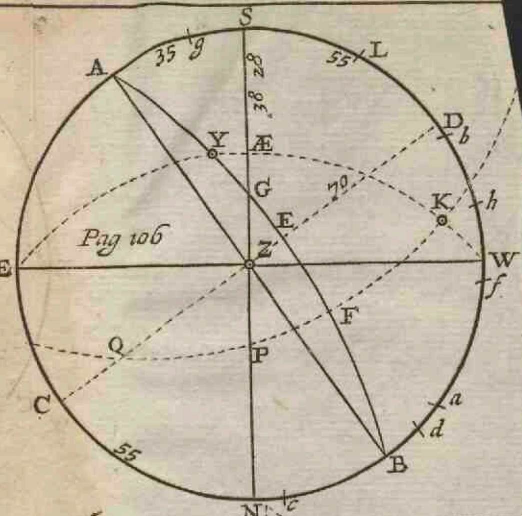
3	29—38
2	44—38
1	59—38
12	74—38
11	89—38
10	75—22
9	60—22
8	45—22
7	30—22
6	15—22
5	0—22
4	14—38

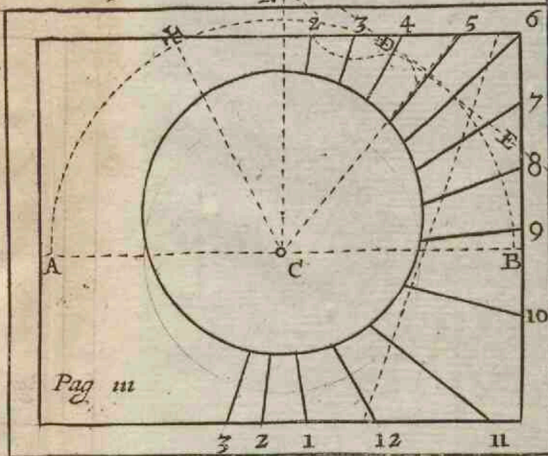
To draw the Dial.

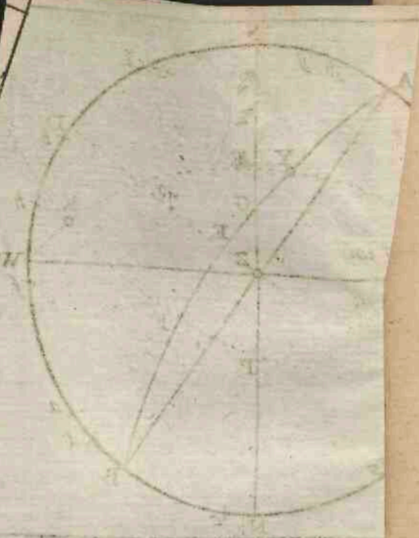
For drawing the Dial, consult with the Scheam, laying the Plain A E B, and his Perpendiculer C D right before you; then note, S N is the Meridian-line, Z E the Plains perpendiculer, with the Meridian G on the left-hand, and the Subſtile F on the right-hand.

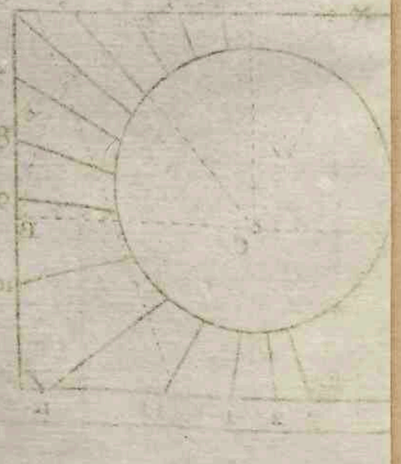
Alſo note, That the Sun being in the South at S, caſts his beams, and conſequently the ſhadow of the Stile into the North; So that though G be the true Meridian found, yet it is the North-part that is drawn as an Hour-line; but the Subſtile, and other Hours, are counted from the South-end thereof, as the *Table* and the *Figure of the Dial*, do plainly make manifeſt; being drawn in this manner.

Firſt, draw the Horizontal-line A B, then on C, as a Center, draw a ſemi-circle equal to 60 of the Chords, and lay off the Meridian, Subſtile, and Stile, in their right Scituations, as laſt was declared; then draw thoſe lines, and to the Subſtile erect a Perpendiculer, as D E; then take the Extent, or









or nearest distance from the place where the Perpendiculer or Contingent-Line last drawn, cuts **12** and the Stile-line, and make it a = Tangent of 45; Then is the Sector set, to lay off all the Hours by the = Tangents of the Arks in the *Table*, except 11 and 10, which do excur.

For,

If you prick the Nocturnal-Hours 12, 1, 2, 3; and draw them through the Center, on the other side, they shall be the Hours of 12, 1, 2, 3, 4, *&c.* on the North-part of the Plain, where they are only used. As for the Hours of 10 and 11, do *thus*;

Draw a Line = to any one Hour, which = line may conveniently cut those Hour-lines.

As,

Suppose the Line *6 12*, which is = to the Hour-line of 3; then make the distance from 9 to 12, or from 6 to 9, in that Line last drawn, a = Tangent of 45, and lay off hours and quarters, or else the whole Hours, by the distances from 9 to 7, and 8 for 10 and 11, turning the Compasses the other way from 9; then to all those Points Lines drawn, shall be the Hour-lines required.

Or,

Or,

Having only the hours of 3, 6, & 9, & 12 in a Parallellogram, design the rest by Sector.

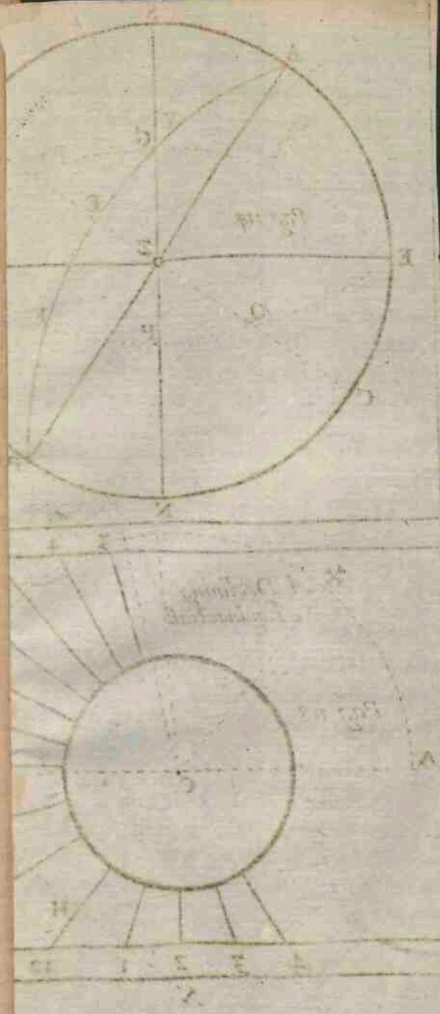
The Second Variety of North-Recliners, Reclining to the Equinoctial.

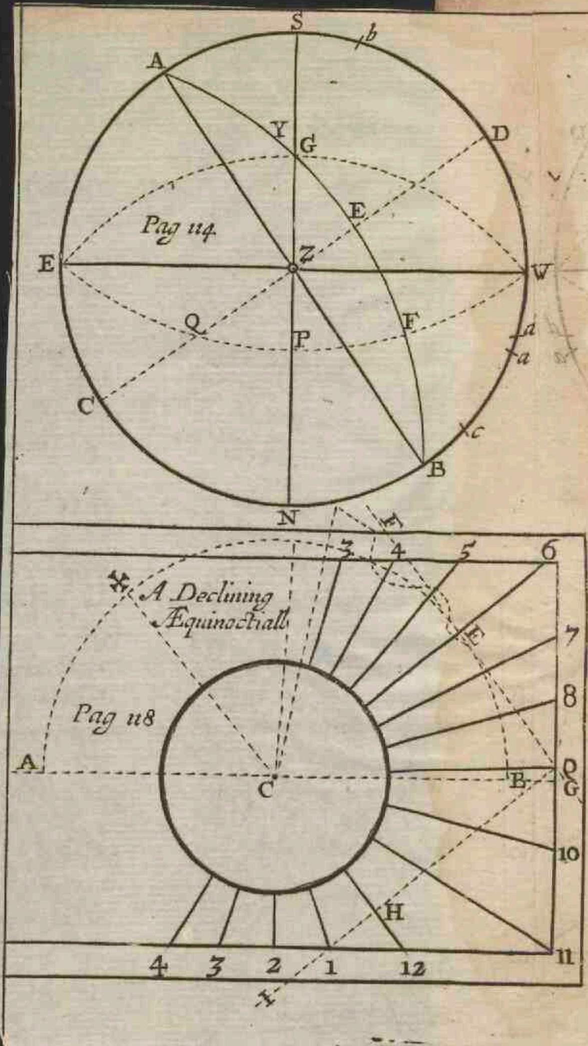
By the bare drawing of the Scheam, you see, that the Circle A E B, representing the reclining Plain, doth cut the Meridian just in the Equinoctial; Now to try by Arithmetick, whether it be a just Equinoctial-plain, or no, say:

1. By the Sector.

As the sine of 90	A D	90- 0
To Tang. of the Reclination	D E	54-10
So Co-sine of Declin. Plain	A S	35- 0
To Co-tang. of the Latitude —	S G	38-28

As — Tangent Reclination	D F	54-10
To = sine 90	A D	90- 0
So = Co-sine of Declination	A S	35- 0
To — Co-tang. of the Lat.	S G	38-28





Which happening so to be, it is a declining Equinoctial, or Polar in respect of its Poles, which are in the Poles of the World.

2. If the Declination were given, and to it you would have a Reclination, to make it Equinoctial.

By the Sector;

As the Co-sine of the Declin.	A S	35- 0
To the Co-tang. of the Lat.	S G	38-28
So is the sine of 90	A D	90-00
To the Co-tang. of the Reclin.	D E	54-10

As the — Co-tang. Lat.	S G	38 28
To the = Co-sine Declin.	A S	35-00
So the = sine Radius	A D	90-00
To the — Co-tang. Reclin.	D E	54-10

By the Scheam.

The Points A B of Declination, being given, and the Point G on the Meridian, if you draw the Reclining Circle A G B, it will intersect the Perpendiculer at E; then the measure of Z E is the Reclination, measured by half-Tangents, or by Chords, by laying a Rule from A, to E on the limb, gives *a*; the Chord B *a*, is the Reclination 35-50.

3. *But*

3. *But on the contrary, if the Reclination be given, and a Declination required, to make an Equinoctial Plain; Then contrarily say thus,*

By the Sector.

As Co-tang. of the Reclin.	ED	54-10
To sine of 90	AD	90-00
So Co-tang. of the Latitude	SG	38-28
To Co-sine of the Declin.	SA	35-00

As — Co-tang. Reclin.	ED	54-10
To = sine	AD	90- 0
So — Co-tang. Latitude	SG	38-28
To = Co-sine Declination	SA	35-00

But by the Scheam.

By the Point G, and the touch of an Arch about E, draw the Circle G E, to cut the limb into two equal parts, and you have the Points A B.

4. *The Plain thus made, or proved to be Equinoctial; to find the Meridians Elevation above the Horizon,* A G; *Or, his Distance from the Perpendicular* E G.

By the Sector.

As sine of 90	ZEG	90- 0
To sine of dist. on the Mer. from Z, to the Plain	GZ	51-30
So sine of Declin. of the Plain	GZE	55- 0
To sine of dist. on the Plain from Perpend. to Merid.	GE	39-54

As —— sine	GZE	55- 0
To = sine	ZEG	90- 0
So = sine	GZ	51-32
To —— sine	GE	39-54

Whose complement is A G 50-06, the Elevation above the Horizon.

By the Scheam.

A Rule laid from Q to G, gives *b* on the limb, D B is 39-54, as before.

5. *To find the Stiles Elevation above the Substile on the Plain.*

By the Sector.

As sine of the Latitude	GZ	51-32
To sine of the Reclination	ZE	35-50
So sine of dist. Mer. Pole to Plain	GP	90-00
To sine of the Stiles Elevation	PF	48-24

As — sine 90	G P	90- 0
To = sine Latitude	G Z	51-32
So = sine Reclinátion	Z E	35-50
To — sine Stiles height	P F	48-24

By the Scheam.

A Rule laid from Y to F on the limb, gives C, N C is 48-24, the Stiles height.

The distance of the Substile from 12, in these Equinoctial Dials, is alwayes 90 degrees; for a Rule laid from Q, the Pole of the Plain, to G, on the limb gives *b*; a Rule also laid from Q to F, the Substile, on the limb gives *d*; the Ark *b d*, is 90 degrees, both for the distance of the Substile from 12, and also for the Inclination of Meridians, for the Substile stands on the hour of 6, being part of the Circle E P W, which is the hour of 6, 90 degrees distant from the hour of 12.

Or,

A Rule laid, as before, from Y to P, on the limb, gives N; the Ark E N, or W N, is 90, for the Inclination of Meridians.

Which being just 90, the *Table* is easily made, *viz.* 15, 30; 45, 60; 75, 90; twice repeated, from 12 to 6 both way s.

To draw the Dial.

On the Horizontal-line A B, draw an obſcure Semi-circle, and ſet off the Meridian, as the Scheam ſheweth, *viz.* 50 degrees 6 min. above the Eaſt-end of the Horizontal-line; but make viſible only the North-end thereof, as the line C 12; Then 90 degrees from thence, toward the right-hand, as the Scheam ſheweth, when the Perpendiculer-line is right before you, draw a Line that ſerves both for 6 and the Subſtile, as C 6. Alſo, lay off the Chord of 36-47 from 6 to 9, and draw the Line C 9 alſo, which is found by Calculation, as before is ſhewed.

Or thus;

Draw a Line = to 12, or Perpendiculer to 6, being in this Dial all one, as the Line F E G; then ſetting one Point in E the Subſtile, take the neareſt diſtance to the Stile-line, and it ſhall reach from E to G, the Point for 9.

The ſame diſtance E G lay alſo on the line 12, from C to H, and draw the line G H I; then make E G a = Tangent of 45, and lay off the = Tangents of 15-30-45, both wayes from E, as hath been often ſhewed.

Alſo,

Also,

Make the diſtance of H G a = Tangent of 45, and lay the ſame = Tangents both wayes from H, and to thoſe Points draw the Hour-lines required.

The third Variety of North-Recliners.

This third and laſt ſort of *North-Recliners*, are thoſe that recline beyond the Equinoctial, that is, lie between the Equinoctial and the Horizon; and it differs ſomewhat from the other five before, in the Scheam and Operation alſo.

For firſt, the Ark of the Plain is extended below the Horizon, till it meet with the North-part of the Meridian below the Horizon at H; and the Center of the Ark A Q B, is in the Line Z D, as much diſtance from Q, as the Secant of 65 deg. to the Radius of the Scheam, being the complement of Z Q 25-0; Here alſo the ſame requiſites are to be found as in the other Dials.

1. *First, for the Meridians Elevation above the Horizon*, A G.

By the Sector ;

As ſine 90	ZD	90-00
To Tang. Declin. Plain	SD	55-00
So ſine Reclin. Plain	ZE	65-00
To Co-tang. Elevation Merid.	GE	52-18

As — Tangent Declin.	SD	55- 0
To = ſine 90	ZD	90- 0
So = ſine Reclination	ZE	65- 0
To — Co-tang. Merid, Elev.	GE	52-18

Whoſe complement GA 37-42, is the Meridians Elevation above the Horizon.

By the Scheam ;

A Rule laid from Q to G, gives on the limb a ; then D a is the diſtance from the Perpendiculer 52-18 ; and A a the diſtance from the Horizon 37-42.

2. *To*

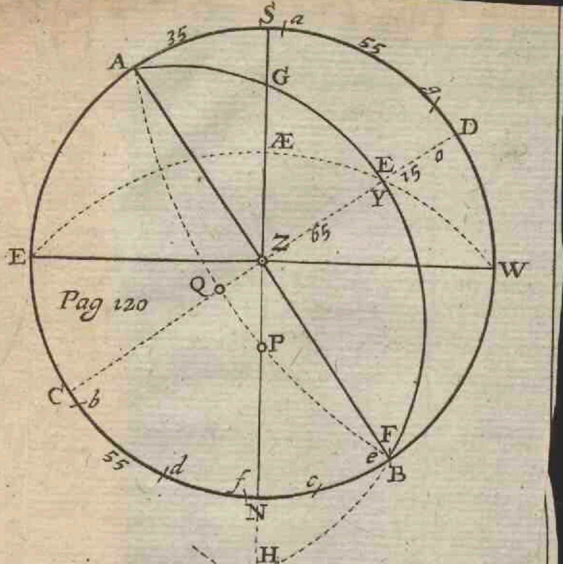
2. *To find the Distance on the Meridian from the Pole to the Plain* GP.

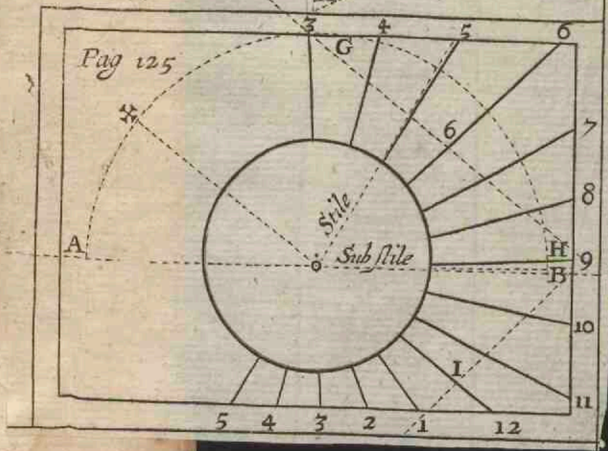
By the Sector.

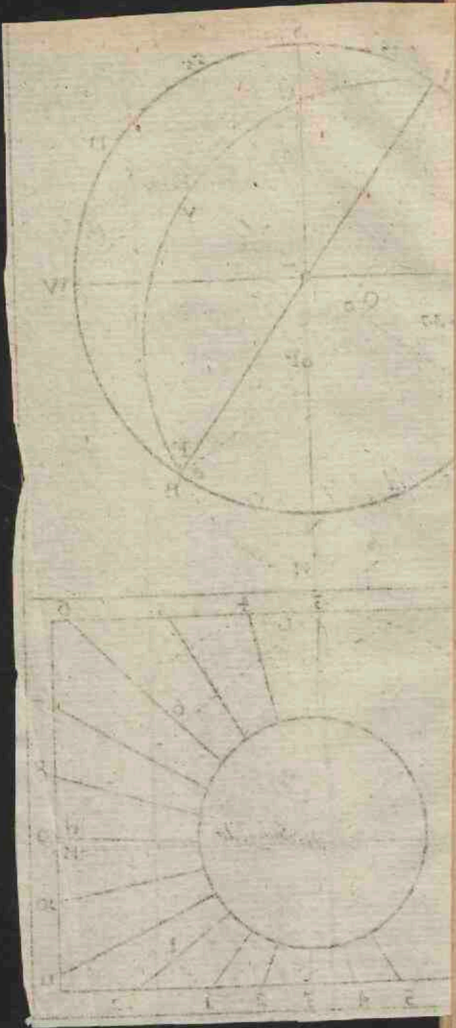
As sine of AD Radius, or sine of	AD	90- 0
To Co-tang. of Reclin. Plain	DE	25- 0
So Co-sine of Declin. Plain	AS	35- 0
To Co-tang. dist. on Merid. from Plain to Zenith	SG	14-58

As — Tang. of	ED	25- 0
To = sine of	AD	90- 0
So = sine of	AS	35- 0
To — Tang. of	GS	14-58

Whose complement 75-02 G Z, added to Z P, the complement of the Latitude, makes 113-30, for the distance of the North-pole P, on the Meridian of the place, from (the North-pole P, to) the Plain below the Equator at G; which being more than 90, find the complement thereof to 180, *viz.* 66-30, being the distance on the Meridian from P the Pole, to the Plain on the North-part of the Meridian, *viz.* P H, found on the Scheam, by laying a Rule from E or W, to P.







P and H, on the limb gives *b* and *c*; the Ark *b c* is 66-30, the distance on the Meridian from the Pole to the Plain.

3. *To find the Stiles height above the Plain* P E.

By the Sector.

As the sine dist. Mer. from Zenith and Plain	G Z	75-02
To the sine of the Reclin. Plain	Z E	65-00
So the sine dist. Mer. from the Pole to the Plain	P H	66-30
To the sine of the Stiles Elev.	P F	59-21

As —	G Z	75- 0
To =	Z E	65- 0
So —	P H	68- 0
To =	P F	59-21

By the Scheam.

A Rule laid from Y, to P and F on the limb, gives *d* and *e*; the Ark *d e* is 59-21, the Stiles Elevation.

4. *To*

4. *To find the Substile from* 12, viz. F G *from the South part, or* H F *from the North part.*

By the Sector.

As Tang. Reclin. of the Plain	Z E	65-00
To Co-sine dist. Mer. & Horiz.	E G	52-18
So Tang. of the Stiles Elevat.	P F	59 21
To sine of the Substile from North part Merid.	F H	38-30

As sine dist. Mer. from Perp.	E G	52-18
To Tang. of the Reclin.	Z E	65-00
So Tang. of the Stiles height	P E	59-21
To sine of the Substile from 12	F H	38-30

By the Scheam.

A Rule laid from Q, to H and F, on the limb, gives *f* and *e*; the Ark *f* and *e*, is the Substiles distance on the Plain from 12.

5. *To find the Angle between the two Meridians,* viz. P F, *and* P H.

By the Sector.

As sine dist. Mer. fr. Pole to Plain	P H	65-00
To sine of 90 Radius	P F H	90-00
So sine of dist. from Subst. & 12	F N	38-30
To sine of Inclin. Merid.	F P N	42-45

As

As — sine of	P F N	90-00
To = sine of	P N	65-00
So = sine of	F N	38-30
To — sine	F P H	42-45

By the Scheam.

A Rule laid from P to Y, on the limb gives *g*, then W *g* is the Angle of the Inclination of Meridians, *viz.* 42-45 ; by which make the *Table*, as is several times before shewed, and as followeth.

12	42-45	
1	57-45	
2	72-45	
3	87-45	
4	77-15	
5	62-15	
6	47-15	42-55
7	32-15	
8	17-15	
9	02-15	1-56
10	17-15	
11	2-15	
12	42-45	

To draw the Dial.

On the Horizontal-line A B, describe a Semi-circle, and lay off the Meridians Elevation, in its proper place, as the Scheam directs ; and then the Substile, and Stile, beyond the Perpendiculer, as by laying the Perpendiculer-Line of the Scheam right before you ; then the Line A Z B, represents the Horizon ; the Line Z G, the Meridian on the South-part ; and Z H, on the North-part ;

part; the Line Z F, repreſents the Subſtile near the Horizon: which things being obſerved, and the method thereof underſtood, it will prove better than dry Rules, or Precepts, without ſuch repreſentations, and far more eaſie to apprehend and conceive in the imagination.

Then prick down the Hours of 9 & 6, by the *Table* on the Contingent-line, as before, or on the Semi-circle, having Calculated only thoſe two Hour-lines, by the general Canon.

Then,

Draw a Line = to 12, at any convenient diſtance from it, as G H; *Then,* take the diſtance between 6 and 9 in that = Line, and lay it from the Center to I, on the 12 a clock Hour-line, and draw the Line H I; then make the diſtances G H, and I H, ſeverally one after another, = Tangents of 45; and take out the = Tangents of 45, 30, 15; and lay them both wayes from 12 and 6, on thoſe two Lines, as hath been often ſhewed, in the former Dials; then lines drawn to thoſe Points, ſhall be the Hours required.

CHAP.

CHAP. VII.

Of Declining and Inclining-PLAINS.

INclining *Plains* are but the under faces of *Recliners*, beholding the Nadir, at the ſame Angle that the Recliners behold the Zenith.

And the making of them differs nothing from the Recliners already mentioned; and all the Requiſites, as Meridians Elevation, Subſtiles diſtance from 12, and the Stiles Elevation, & the Hour diſtances, are the ſame both in the Incliner, as they were in the Recliner, and have the ſame Numbers alſo ſet to the Hour-lines; So that in drawing of theſe Dials that have Centers, if you draw all the 24 Hours, you then draw 4 Dials at once; as thus, in the *Example* of the declining Equinoctial, being a North declining Eaſt 55 degrees, and reclining 35-50. If you draw the 24 hours, being done at the ſame time and

and ſtroke, by drawing the Hour-lines through the Center on the other-ſide, and the Subſtile and Stile alſo, as here you ſee in the Dial annexed, being the Equinoctial-Dial, belonging to the ſecond Variety of North Recliners declining Eaſtward 55, and reclining 35-50; the Lines drawn through the Center, and complemented to 12, is a South-eaſt declining, and Inclining 35-50.

Alſo,

If you turn the Paper, and look againſt the light, and then the North-eaſt becomes a North-weſt Decliner 55, and reclining 35-50; and the South-eaſt becomes a South-weſt, Declining and Inclining as much.

Thus you ſee, that every Draught of a Dial will ſerve for 4 Plains, that is for the place you draw it, and his oppoſite; and for another Plain, declining as many degrees the contrary way, and reclining as much alſo, and for the oppoſite thereunto, as by the two Draughts of the two ſides, may plainly be ſeen to appear. And the like holds in all ſorts, as Upright Decliners alſo.

As a North-eaſt and a North-weſt, a South-eaſt and a South-weſt, declining 30; one Dial drawn round about, ſerves all 4 Dials; But note, that no South Erect or Inclining Dial, can have the Sun to ſhine on any

any Hour-line that falls above the Horizontal-line; and those hours on the North-recliners, that fall below the Horizontal-line, belong also to the South Dials.

But for a plain general Rule, to know what hours belong to any Plain whatsoever in any Latitude, do thus.

To know what Hours belong to any Plain.

First, draw a general Scheam to your Latitude, as this is done for 51-32; and mark the 4 Cardinal-points with E.W.N. & S. as is usual for setting the Scheam right before you.

Then,

For all Declining Upright Dials, draw only a streight Line for the Plain, Perpendiculer to the Line that doth represent the Pole of the Plain, counting so many degrees as the Declination of the Plain shall happen to be from S. or N. toward E. or W. then all the Hour-lines of the Scheam that that Line of the Plain shall interfect, are the Hour-lines proper to that Plain.

1. *Example.*

The Line E and W, being Perpendiculer to S and N, the Poles of a South and North-plains plain; doth therefore represent a South-plain on one side, and a North-plain on the other.

Therefore,

If you conceive the Sun to be in *Cancer*, and going of his Diurnal Motion, at his Rising about a quarter before 4, beholds the North-side of the Line E W, and continueth so to do till 25 minuts after 7; and then it shines on the South-plain till 35 minuts after 4, and then begins again to shine on the North-plain, and so continues till Sun setting.

But when the Sun is in the Equinoctial, it beholds the South-plain at the Rising, being at 6 a clock in the morning; and shines on it all day, till Sun set, being at 6 at night; and then the North Dial is useless.

2. *For a Declining-Plain.*

Suppose 30 degrees South-east; first set the Scheam in his right scituation for a South-east Plain; then if you count 30 degrees from S toward E, for the Pole of the Plain; and 30 degrees from W toward S, or from E toward N, and draw that Line that shall represent the Plain; then you shall find that the Sun being in *Cancer* will begin

gin to ſhine on this Plain, juſt a quarter before 5 in the morning, and continue till near half an hour after 2.

But about the middle of *January*, it will ſhine on it till a quarter after 4, *viz.* till Sun ſet; and all the hours after 2, belong to the North-weſt Plain that declines 30 degrees, and one hour in the morning alſo, *viz.* from a quarter before, till three quarters after 4.

The like work ſerves for any Decliner whatſoever, in any Latitude.

3. *But for Decliners and Recliners.*

Draw a long Line, as A B, and croſs it with a Perpendiculer in the Center C, and lay off from C, toward A and B, the Tangent of 45; or the Semi-tangent of 90, equal to the largeneſs of your Scheam; then lay off the Semi-tangent of the Reclination from C to D, up and down, both wayes; then take out the Secant of the complement of the Reclination, which will be a Radius to draw the Arks A D B, which Paper you muſt cut out, and apply the two Points of the Paper A D B D, to the two Points of Declination of the Plain, noted in the Scheam with A and B; that is, put A to A, and

and B to B; then the round or convex-edge of the Paper, represents the reclining Plain; and the same edge, on the other part next the Horizon Southwards, represents the South-west Incliner.

Example.

Suppose I make the Paper A D B, to recline 35-50, the Reclination of the Equinoctial-plain; then, first set the Scheam right before you in its right scituation, and putting the Points A, in the Paper, on A on the Scheam; and B in the Paper, to B on the Scheam; I shall find it to be even with the reclining Circle A E B; then following the Tropick of *Cancer*, I find that it shines on the North Recliner from the Rising till near 2, at which time it leaves the North-recliner declining Eastward, and begins to shine upon the opposite Plain, *viz.* the South-west Incliner, declining 55-0, and reclining 35-50, and so continues till Sun-set.

But note, That if the Line that represents the Plain, cuts the Tropick twice, as the Line E W for a North-plain; then, though the Sun leave the Plain in the morning, it will shine on it again in the afternoon.

Note also, That a North-east Recliner, is represented by the other Convex-edge of the

Paper, as here a North-east Decliner 55, and Inclining 35-50, the Sun will ſhine but till 3 quarters after 8 in *Cancer*; but in *Capricorn* it ſhines till half an hour after 9, and comes no more on it that day: And *note alwayes*, That when it leaves any Plain, that then it begins to ſhine on his oppoſite, as here the oppoſite to this North-eaſt Incliner, is the South-weſt Recliner, being repreſented by the ſame Line or Circle A D B, that the North Recliner was: Only, you muſt count that ſide of the Line next to the Horizon, the Inclining-plain; and that ſide next the Zenith, the Reclining-plain; For, the Line that repreſents it, having no bredth, can be no otherwiſe diſtinguiſhed, unleſs you will make a material, Armilary Sphear, of Paſtboard or Braſs, as the following Diſcourſe doth plainly demonſtrate, in theſe ſeveral Operations, for the better conceiving of theſe Mathematical Excercitations.

Thus you have the way of making all manner of *Sun Dials*, upon any plain Superficies, the Axis of the World being the ſuppoſed Stile to all theſe Plains; As for thoſe curioſities of Upright Stiles, and Eliptical Dials, and drawing of Dials by the Horizontal, or Equinoctial Dials, you have them in the Works of Mr. *Samuel Foſter*, and

and others; and in *Kerkers Ars magna*, *&c.* But I intended not a Volumn of Shadows, but only a further improvment of the *Trianguler-Quadrant*, as you will see in the next *Chapter*, of drawing the Furniture or Ornament of Dials; which being but seldom used, I shall here crave an Apology for the brevity therein, fearing, lest that to the young Practitioner it may seem somewhat hard to conceive, though to the exercised in these matters it may be plain enough.

Then for a Conclusion, you shall have an easie Mechanick way, to draw a Dial on the Ceiling of a Room, that lieth Flat or Horizontal, which will be very good for Painters or Plaisterers, to Ornament a Room withal, and is not yet treated on that way, as ever I read of.

CHAP. VIII.

To furnish any Dial, with the usual Mathematical Ornaments by the Trianguler-Quadrant, as Parallels of the Suns Declination, or the Suns place, or length of the Day, to find the Horizontal and Virtical Lines, and Points, to draw the Azimuths, and Almicanters; the Jewish, Italian & Babylonish Hours, and 12 Houses on any Plain before mentioned.

1. *To draw the Tropicks, or Parallels of the Suns Declination, or the length of the Day Artificial, on any Dial.*

THe speediest and easiest way for this, is by the *Trygon*, or by the *Trianguler-Quadrant*, (which is a proper *Trigon*) the Axis

Axis or Stile being first set into the Dial; For, if you apply the Moveable-leg to the Axis, and extend a Thred of a competent length, fastened in the Center of the *Trianguler-Quadrant*, and cause it to cut the Suns place in the Line of the Suns place, or the Line of the Suns Rising, at an even, whole, or half hour, in the Hour-line for the length of the Day; or the degree of Declination in the degrees; and at the same time the Notch, or place, where you intend the Nodus or Apex shall be: Then, I say, if the Thred shall be extended to touch the Plain, and the Superficies of the *Trianguler-Quadrant*, and any one of the fore-mentioned Points on the Rule, and the place of the Nodus, you may find Points as many as you please on both sides of the Substile, by which Points, by the help of a thin Rule that will bend to them, you may draw these Parallels of the 12 Signs, length of the Day, or Suns Declination required; one of which Lines, *viz.* the Equinoctial-line, or ♈ and ♎ on the Signs; or the Line for 12 hours, the length of the Day, will be a streight Line.

But note, That if it be a Perpendiculer Stile, whose upper Point, or Apex, is to be the Nodus to give the Shadow; then you must strain a Thred very hard, or apply a Rule for the present whereon to rest the Moving-leg on, instead of the Axis; or, else you may do it thus, as Mr. *Gunter* sheweth.

First, to make the Trygon, if the Rule or Quadrant prove too large for your small Dial.

On a sheet of Pastboard, or Slate, draw a long streight Line, as A B; to which Line erect two Perpendiculers, one at the upper, and the other at the lower end, as C D, and E F; then make A B a Tangent of 45 degrees, (then having first made these little *Tables* that follow, by the *Trianguler-Quadrant*, which is only the Suns Declination, at his entrance into the whole Signs, or at an even half-hour of Rising); lay of both wayes from B, the Tangents of the Suns declination at ♈ ♉ ♊ ♋, as in the *Table* following; and draw Lines to these Points from the Center A, as in the Figure annexed; and then set the marks to them, and this is the *Trigon*. Figure I.

Suns declinations for the Parallels of the length of the Day.

Hours	Declin
16-26	23-31
16- 0	21-41
15- 0	16-55
14	11-37
13	5-53
12	0-00
11	5-53
10	11-37
9	16-55
8	21-41
7-34	23-31

For the Signs of the Zodiack.

Signs.		Declin.
♋		23-31
♌	♊	20-14
♉	♍	11-31
♈	♎	0-00
♓	♏	11-31
♒	♐	20-14
♑		23-31

Declinations.

5- 0
10- 0
15- 0
20- 0
23-31 both ways

Then from the Center A, any way on the Line C D, at such a convenient distance as you think may fit the Plain, set off the Point G; then making G A Radius of 45 Tang. set off on A B from A, the Tang. of the Stiles Elevation to F, and draw the Line F G, as an obscure Line.

Then

Then come to the *Dial Plain*, and measure from the Center to the place on the Substile-line, where you would have your remotest Line of the sign ♋ or ♑ to pass; and take this distance between your Compasses, and carry it in, above, or below the Line F G, first drawn and produced to ♋, or ♑, till you find one Point to stay in A ♋, and the other in A G, so as to draw a Line = to F G first drawn; if that doth not fit, then dele F G, and draw this = to it in its stead, to fit and fill the Plain with the Tropicks to your mind, to make them large and yet convenient.

Then note, The point G represents the Center of the Dial; A G is the length of the Stile from the Center to the Nodus; a Perpendiculer let fall from A to F G, shews the point H; G H is the measure on the Substile-line on the Plain from the Center to the Horizontal-line, H A is the Perpendiculer height of the Stile; A the Apex or top of the Stile or Nodus to give the shadow.

Then,

Draw a Line from G, = to A B, as I K; and any where between A B, draw L M = to A G; and wheresoever F G cuts L M, make a mark as at M; then make L M a = sine of 90 degrees, and the Sector so

set

ſet, take out the ſine complements of the Arks at the Pole for every hour, and lay them from L towards M, on the Line L M, and to all thoſe Points, draw Lines from G, and mark them with 12, 1, 2, 3, 4, *&c.* as in the *Table.*

Or elſe,

Take the meaſure from G to F, and lay it on the Dial from the Center on the Subſtile, and draw that Line preciſely Perpendiculer to the Subſtile, for the true Equinoctial-line on the Plain.

Then,

The meaſure from the Center of the Dial, to the croſſing of every Hour-line, and the Equinoctial-line, taken and laid from G, to the Line A B, gives Points to draw the Hour-lines on the *Trygon*; As in the *Figure.*

Wherein you may note,

That if the Subſtile happens to fall on an even, whole, or half hour, then one Line will ſerve on both ſides of the Subſtile; but if not, you muſt draw as many more, and ſet Figures to them, to avoid confuſion.

Then, I ſay, that the ſeveral diſtances from G, to the croſſings of thoſe Hour-lines laſt drawn on the *Trygon*; and the Signs being laid on their correſpondent Hour-lines from the Center of the Dial, ſhall give

Points

Points in those Hour-lines, to draw the signs of the Zodiack, with a thin Rule that will bend to those Hyperbolick Sections.

The same way serves to draw the Parallels of the length of the Day, if you lay the distunce from G, the crossings of the pricked Lines and Hours on the *Trygon*, and is as true as any other way by Calculation, which must afterward be performed by protraction in this manner.

Thus you have the way to proportion the Height of the Stile, to fit the Plain, and the place of the Horizontal-line in all *Erect-Dials*, which is alwayes Perpendiculer to 12, and drawn through that point a-cross the Plain; And this way of drawing the Signs, is general in all Plains whatsoever, that will admit them.

II. *To find the Horizontal-line in all manner of Plains.*

First, The Horizontal-plain can have none, nor many other both Reclining and Inclining, whose Reclination or Incliuation is above the complement of the Suns Meridian Altitude in ♑, if the Stile have any considerable Altitude.

In

In all other Plains, the best Mechanick way is thus;

The Dial being set in (or, as in) his place, apply the Moveing-leg to the top of the Stile & one corner of it to the Plain; and at the same time let the Thred play evenly on 60|0, and the corner at the Plain will make as many marks as you please to draw it by.

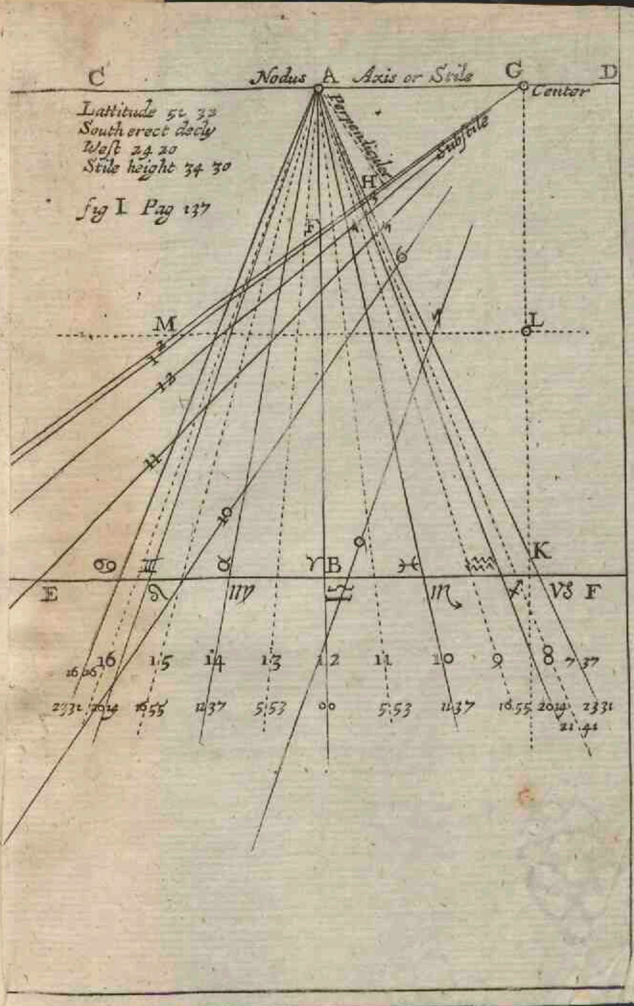
Otherwise note,

That wheresoever the Hour-line of 6, and the Equinoctial-line do meet, there is one Point: Then find at what hour and minute the Sun doth Rise or Set at, in the beginning of any other whole Sign, most remote from the first Point, and that shall be another; and so as many as you please to draw that Line by: This is general for all Plains:

To find that Point by the Trianguler-Quadrant.

Lay the Thred to the Sign given, and in the Hour-line is the hour and minut required; Thus the Sun being in ♈, riseth and setteth at 6, or 1 quarter of a minut before, or after; and in ♉ at just 5, and sets at 7; in ♊ at 9 minuts after 4, or sets 9 minuts before 8: The like for Winter signs.

III. *To*



III. *To draw the old unequal Hours.*

The unequal, Jewiſh, or Planetary hours, divide the Day, be it long or ſhort, into 12 equal Hours; for the drawing of which, in the Equinoctial the common hours gives Points. For the Tropicks do *thus*;

Divide the number of minuts in the longeſt and ſhorteſt dayes by 12; *viz.* divide 986, the minuts in one day in ♋ at *London*, by 12, the Quotient is 82 ½; and divide 454, the number of minuts in one day at *London* in ♑, and the Quotient ſhall be 37′ ¾; then if you faſten an Index, or lay a Rule to the Center, and to every 1 hour and 22′ ½ in ♋ from 12; and to every 37′ ¾ in ♑, it ſhall give Points to draw the Jewiſh or Planetary hours required, according to this *Table*, thus made for *London*, by the Line of Numbers; againſt 12 ſet 6, and the reſt in order as the day proceeds, for our 12 is the 6th hour, according to the Jewes.

A Table

A Table to divide the Planetary hours in ♋ and in ♑, for London, 51-32 *Latitude.*

H ♑ M	hou	H ♋ M
8 43	1	5 10
9 28	2	6 31
10 16	3	7 52
10 44	4	9 15
11 22	5	10 37
12 00	6	12 00
12 37	7	1 22
1 15	8	2 44
1 53	9	4 06
2 31	10	5 29
3 8	11	6 51
3 47	12	8 13

To make this Table readily by the Line of Numbers.

Extend the Compasses from 16-26, the length of the longest day in hours and minuts to 1, the same Extent shall reach the contrary way from 60, to 986, the Number of minuts in one day.

Or rather,

As 1 hour, to 60 minuts;
So is 16 hours 26′, to 986 minuts.

Then,

As 1, to 82 minuts $\frac{1}{4}$;
So is 2, to 164 minuts $\frac{1}{2}$;
So is 3, to 246 minuts $\frac{3}{4}$.

Or you may say,

As 12, to 1; So is 986 to 82-2, the minuts in 1 hour.

Which

Which properly is one hour 22 minuts, the length of one hour in *Cancer*; then the second hour, is 2 hours 44 $\frac{1}{2}$; the third hour is 4 hours and 6′ $\frac{3}{4}$ from 12; and so for the rest, as in the foregoing *Table* for *London*.

But if you draw the Parallels, of the length of the day in the Dial, you shall find these hours to cross the even Hour-lines and quarters in the Parallels for 15 and 9 hours, as well as in the Equinoctial.

IV. *To draw the Italian or Babylonish-Hours.*

First, draw the common Hours, and the Parallels of the Signs, or rather the length of the day; Then note, that these Hour-lines meet with the common hours in the Equinoctial; only the Italians who account from Sun-setting, call our 12 in the Equinoctial 18; And the Babylonians, who reckon from the Sun-rising, call our 12 in the Equinoctial 6 hours.

Then to mark these in the Tropicks, do thus;

The Sun being in either of the Tropicks, doth rise in ♋, two hours 13 minuts before 6; and in ♑, so many hours and minuts after

after 6; therefore if you count 2 hours and 13 minuts before 12 in ♑, and 2 hours and 13 minutes after 12 in ♋, and there make 2 pricks, and a Rule laid to those 2 Points, shall cut 12 in the Equinoctial for the 6th hour from the Suns Rising, or the 18th from his last Setting, and so successively 13 minuts after every hour.

A Table to draw the Italian hours from Sun-setting in the Parallels of 16, 12, & 8 Hours.

H.	8	12	16
7	11	1	3
8	12	2	4
9	1	3	5
10	2	4	6
11	3	5	7
12	4	6	8
13	5	7	9
14	6	8	10
15	7	9	11
16	8	10	12
17	9	11	1
18	10	12	2
19	11	1	3
20	12	2	4
21	1	3	5
22	2	4	6
23	3	5	7
24	4	6	8

But, if you draw the Parallels of the length of the Day, then you shall find the 18th hour after Sun Setting, to cut the Hour-line of 10 in the Parallel of the Day, being 8 hours long, and 12 in the Parallel of 12 hours long; and the common Hour-line of 2 in the Parallel of 16 hours long, and so successively for the rest, for so many hours from the last Sun-setting: For, from 6 the last night in the Equinoctial, to 12 this noon, is 18 hours;

but in ♑, from 47′ after 3 at Sun-ſet, to the next noon, is 20 hours and 13′, as in the *Figure* foregoing.

But for the *Babyloniſh*-hours, who reckon by equal hours from the Sun Riſing, as before, count 2 hours and 13 minutes after 6 in ♑; and 2 hours and 13′ before 6 in ♋; and juſt 6 in ♈, and that ſhall draw the Line of the Suns riſing; then count 3 hours and 13′ after 6 in ♑, and 7 in ♈, and 1 hour 13′ before 6 in ♋; and that ſhall be the firſt hour after Sun riſing, and ſo ſucceſſively till night.

But if you uſe the Parallel of the length of the day, the work is eaſier; for then 5, 7, and 09, in the Parallels of 16, 12, and 8 hours, ſhall be Points for the firſt from Sun-riſing; and 6, 8, and 10, ſhall ſhew the ſecond hour from Sun-riſing, and ſo forwards, as in the *Table* following.

V. *To draw the Azimuth-Lines.*

For the *Horizontal-Dial*, on the foot of the Perpendiculer Stile, as on a Center, deſcribe a Circle; and then divide that Circle into 32 Points of the Compaſs, or Rumbs, or 360 degrees, and Lines drawn from the foot of the Stile to thoſe Points, ſhall

Hour from rising	Paral of 16 hours	Paral of 12 hours	Paral of 8 hours
1	5	7	9
2	6	8	10
3	7	9	11
4	8	10	12
5	9	11	1
6	10	12	2
7	11	1	3
8	12	2	4
9	1	3	5
10	2	4	6
11	3	5	7
12	4	6	8
13	5	7	9
14	6	8	10
15	7	9	11
16	8	10	12

ſhall be the Azimuth or Virtical Circles required, counting the Meridian, or 12 a Clock Line, as South, and the reſt in order.

For all *Erect Dials*, both Direct or Decliners, deal with the Declination of the Plain, as you did with the Inclination of Meridians; and at the Meridian, or 12, ſet the Plains declination; and then for Rumbs, take 11 deg. 15′ as often as you can; and what the laſt number wants of 11-15, ſet on the other ſide of the Subſtile, and to that add 11-15 till you have enough, as in the *Table* annexed for a *Dial*, whoſe declination was 35 degrees Weſtwards.

 Then

Then make the Perpendiculer height of the Stile Radius, or Tangent of 45, and on the Horizontal-line lay off the = Tangents of the Rumbs last made, in the *Table*, from the foot of the Stile their right way, and draw Lines through those Points, all Parallel to 12, for the Rumbs, or Virtical Circles required; on the Meridian write South, and the rest in their due order.

Points.	D.	*M*
S. E.	80	00
S. E. by S.	68	45
S. S. E.	57	30
S. by E.	46	15
South.	35	00
S. by W.	23	45
S. S. W.	12	30
S. W. by S.	1	15
Substile —	—	—
S. W.	10	00
S.W. b. W.	21	15
W. S. W.	32	30
W. by S.	43	45
West.	55	00
W. by N.	66	15
W. N. W.	77	30
N.W. b.W.	88	45
N. W.		

To draw the Azimuth or Virtical-Circles on Reclining, or Inclining-Plains.

In all Reclining, or Inclining Plains, these Azimuths, virtical Circles, or Rumbs, do meet in a Point (called the Vertical Point) found in the Meridian, or 12 a clock Line, right over (in Incliners) or under (in Recliners) the Apex or top of the Stile,

Stile, that is to give the ſhadow, when ſet in its right place, right over the Subſtile-line; And as far off the foot of the Stile (being a Point in the Subſtile, Square, or Perpendiculer to the Apex or top of the Stile) in a Vertical Line drawn through the foot of the Stile, = to the Perpendiculer Line of the Plain), as the Co-tangent of the Reclination, making the Perpendiculer height of the Stile to be Radius or Tangent of 45 degrees.

Alſo, The Co-tangent of the Reclination of the Plain, to the ſame Radius, laid from the foot of the Stile, in the ſame Virtical-Line, ſhall give the Point in the Vertical-line, to draw the Horizontal-line by; for a Rule laid to this Point, and the croſſing the Equinoctial-line and hour of 6, ſhall draw the true Horizontal-line.

Then make the diſtance between this Point, and the meeting of the Equinoctial and 6, a = Tangent of the Weſt or Eaſt Azimuth in the *Table*, and then the Sector is ſet, to lay off all the reſt, by taking the = Tangents of the Numbers in the *Table*, and laying them from the Vertical-point in the Horizontal-line, both wayes on the Horizontal-line.

For, from hence you may note, That the Sun, being in the Equinoctial, doth riſe and ſet near 6 ; and alſo doth riſe near the Eaſt-point, and ſet near the Weſt; therefore the ſame Point in the Dial, muſt be for the hour 6 in the morning ; and the Eaſt Azimuth, or the hour 6 at night, and the Weſt Azimuth, according as the Plain declines Eaſtwards or Weſtwards.

Then Right Lines drawn from the Vertical-point in the Meridian, and to all theſe Points in the Horizontal-line, ſhall be the Azimuth-lines required.

A thus for *Example* in the *Figure* annexed, being the Third ſort of South-Recliners before-going ; Declining 35 degrees South-weſt, and Reclining 60 degrees, C H is the Subſtile, C G the Stile, H the Foot of the Stile, I K the Vertical-line drawn through the foot of the Stile I, the Vertical-point in the croſſing of 12 (and the Vertical-line) and yet right under G the Apex (conſidering the Reclination) and the raiſing of G the Apex,Square, or Perpendiculer to H the foot of the Stile ; Then, I ſay, a Plumb-line let fall from G, will reſt in I,the Vertical-point; The Dial being ſet in its due place.

Then G H, the Perpendiculer height, made a = Tangent of 45 ; H I is the Co-tangent of the Reclination, *viz.* 30 ; and H K the Tangent of the Reclination 60, being

ing the Vertical-point in the Horizontal-line, from whence to lay the = Tangents, of the Rumbs in the *Table* last made, into the Horizontal-line.

Then Lines drawn from the Vertical-point I, to those Points in the Horizontal-line, shall be the Rumbs or Points of the Compass, Vertical Circles, or Azimuths required.

Otherwise,

When you have made the Tables of the Angles at the Zenith, as before, you may by this Canon make Tables of Angles at the Vertical-point, between the Vertical-line and the Rumb, to be drawn on the Plain.

As the sine of 90,
To the Co-sine of Reclination, or Inclination;
So the Tangent of the Angle at Zenith,
To the Tangent at the Vertical.

This Table being made, you may set one Point in the Vertical-point, and describe a Circle to any Radius, and therein prick off from the Vertical-line, the several Chords of the Rumbs, as in the Table you shall make by the last Canon.

A Table, shewing at what Hour and Minute the Sun is in, in an even Azimuth, or Point of the Compaß in ♑, ♈, ♋; for 51-32.

Degr.	Rumbs.	Alt. ♋	H. M.	Alt. ♈	H. M.	Alt. ♑	H. M.
00-00	South	62-00	12-00	38-28	12-00	15-00	12- 0
11 15	S. by E.	61 39	11 38	37 58	11 24	14 17	11 16
22 30	S. S. E.	60 33	11 15	36 19	10 48	12 05	10 27
33 45	S.E.b.S	58 31	10 46	33 29	10 10	8 17	9 33
45 00	S. E.	55 40	10 17	29 22	9 28	3 00	8 39
56 15	S.E.b.E	51 35	9 42	23 51	8 42		
67 30	E. S. E.	46 06	9 02	16 56	7 51		
78 45	E. by S.	39 03	8 15	8 49	6 57		
90 00	East.	30 38	7 21	0 0	6 00		
78 45	E. by N.	21 21	6 24				
67 30	E. N. E.	11 10	5 19				
56 15	N.E.b E	3 48	4 18				
45 00	N.E.						
33 45	N.E.b.N						
22 30	N. N. E						
11 15	N. by E						
00 00	North.						

Lastly, by help of this Table, being general for all Dials in the Latitude 51-32, it is done thus;

First note, The Table doth shew the hour and minut, together with the Suns Altitude in ♑, ♈, and ♋, when the Sun is just on an an even Rumb, or Point of the Compaſs; ſo that having drawn the hours, and quarters of hours (by the Sector eaſie to do) through the Plain in light Lines, make pricks in ♑, ♈, and ♋, as the Table ſheweth.

Then you ſhall ſee that a Rule laid to the Vertical-point, and any one of thoſe three Points ſhall cut the other two, if the former Lines be true, and you eſtimate the minuts well.

Note, That this laſt Table in the Equinoctial, is thus readily made, by Sines and Tangents.

As the ſine of 90, to the ſine of the Latitude;
So is the Tangents of the Azimuths from the
  Meridian, being the firſt column in the
  Table,
To the Tangent of the Angle between the
  Meridian, and Azimuth Line on the E-
  quator, which are the numbers in the
  6th column, reduced into hours and
  minuts.

So that you ſee the Azimuth of 45, or Rumb of S.E. will croſs the Equinoctial at 28 minuts paſt 9, as in the Table; which Table is eaſily made by the Trianguler-Quadrant, by the Rules in *Chap.* XV.

VI. *To*

VI. *To describe the Almicanters, or the Parallels of the Suns Altitude above the Horizon.*

First, on the Equinoctial, these Lines shewing the Suns Altitude, cannot be expressed.

On the *Horizontal Dial* they are Circles, making the Perpendiculer height of the Stile Radius, or Tangent of 45; prick off on the Hour-line 12, from the foot of the Stile, the = Tangent of 10, 20, 30, 40, 50, 60, &c. Then one Point of a pair of Compasses set in the foot of the Stile, and the other opened to 10, 20, 30, &c. draw those Circles for the Parallels of the Altitude required.

For all *Erect Dials*, whether Direct or Declining, they are best done *thus*;

If the Stile be in, and right set, then the distance from the Nodus, to the crossing of the Horizontal-line, and Azimuth-line, on which you would prick down the Altitudes shall be the = Tangent of 45; then the Sector so set, the = Tangents of 10, 20, 30, &c. laid from the Horizontal-line on the respective Azimuths, shall be Points to draw the Parallels of Altitude by (or by applying the

the Rule to the Nodus and Plain, and the Thred to the Almicanter) as afterward is plainly shewed.

But if the Stile is not in, then the Secants to the same Numbers and Radius, that pricked down the Azimuth Lines, shall be the several Radiusses to use as before; where you may note, That the Suns Meridian Altitude in the whole even Signs, will help to prove the truth of your work.

The East and West *Erect Dials*, are fitted with Parallels of Altitude in the same manner; for the Perpendiculer height of the Stile, is a Tangent of 45, and the = Tangents of 11-15, 22-30, 33-45, &c. laid from the foot of the Stile in the Horizontal-line, draws down-right Lines for the Azimuths; and the Secant of 11-15, 22-30, 33-45, &c. shall be the several Radiusses to prick off the = Tangents of 10, 20, 30, 40, 50, 60, (or what you will) on those Perpendiculer Azimuth Lines, for the Almicanters, or Parallels of Altitude required.

But for *Declining Reclining Plains*, you must first draw the Azimuth Lines, as before is shewed, and then find also the length of the Axis of the Horizon, as Mr. *Gunter* calls it, which is thus done;

Make

Make the length of the Perpendiculer-Stile a = Tangent of 45, *viz.* G H *Fig.*II. then H I is the Co-tangent of the Reclination, and H K the Tangent of the Reclination; and then, as the Sector ſtands, the Secant of the complement of the Reclination, ſhall be the length of the Axis of the Horizon required, *viz.* G I, or by the Sines and Tangents Artificial.

As the ſine of the Reclination, to the ſine of 90;
So is the length of the Stile on the Line of Numbers, being taken in inches and 100 parts, to the length of the Axis in the ſame parts.

Which is an imaginary Diagonal Line, reaching from the Apex to the Vertical-point.

This being found, you muſt find the Angles between this Axis and the Horizontal-line, on every particular Azimuth; and laſtly, the diſtance between the Vertical-point, and the Parallels of Altitude, on every particuler Azimuth laſt drawn.

For the doing whereof, you muſt work as you did before, to lay off the Signs, or the Parallels of the length of the Day, for theſe Almi-

Almicanters, bear the ſame reſpect or proportion to the Horizon, as the Parallels of the length of the day have to the Equator, and are deſcribed in the ſame manner, as followeth. *See Figure* III.

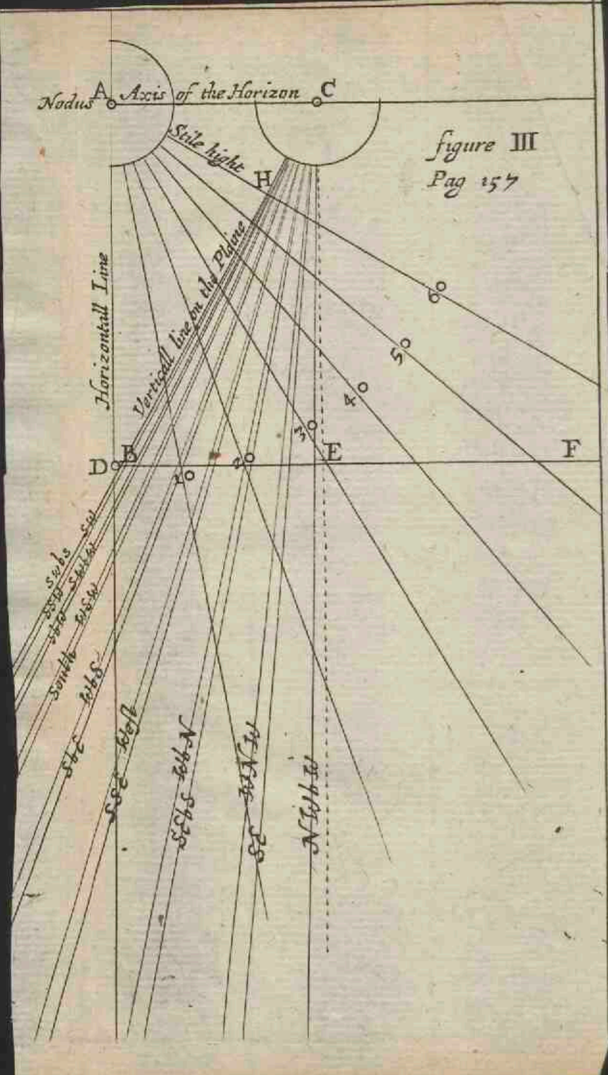
Firſt, draw the Line A B, and make A B a Chord of 60, and ſweep the Arch of a Circle, and lay off 10, 20, 30, &c. and draw the Lines from A the Center, and mark them with 10, 20, 30, 40, 50, 60, the even 10th degrees; or, 45 for equal, 26-34 for double, 11-19 for 5 times, the length of the ſhadow and object, or what you pleaſe.

Then,

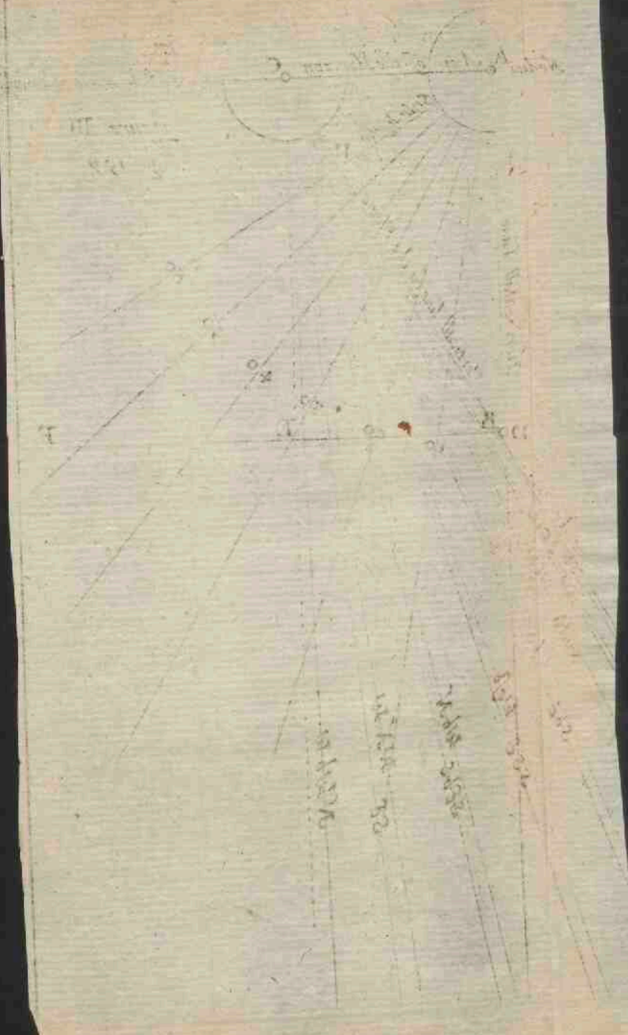
Draw A C Perpendiculer to A B, and lay off the length of the Axis of the Horizon from A to C; then make A C the Coſine of the Reclination, and as the Sector ſtands, take out the ſine of the Reclination, and lay it from A to D, and this will be the diſtance from the Apex to the Horizon; Alſo, the ſine of 90 ſhall reach from C to D, the diſtance between the Vertical-point and the Horizon; alſo the neareſt diſtance from A to C D, is the Perpendiculer height of the Stile A H.

Then,

Take the diſtance from I, the Vertical-point



Nodus A
Axis of the Horizon
C
Stile hight
H
figure III
Pag 157
Horizontall Line
Verticall line on the Plaine
D B
E
F
1
2
3
4
5
6
swbs
sw
ssw
swbw
South
wsw
sbe
wbs
sse
West
Nwbw
ssE
Nwbn
NW
se
NWbN



point on the Plain, to the Horizon on every particular Azimuth Line, and lay them in the *Trygon*, or III *Figure*, from C to the Horizontal-line A D, produced if need be; and draw those obscure Lines, as in the *Figure*, and mark them with the Names of the Rumbs, to avoid confusion; then is your *Trygon* made ready for use.

Then,

Take the distance from C in the *Trigon*, to every crossing of the Azimuth-line and Almicanter, and lay it on the Plain from the Vertical Point I, on its proper Azimuth, finishing one Almicanter before you meddle with another, and the work with patience and diligence will be performed; the lines are to be drawn from Point to Point, with a steady hand, or a bending thin Ruler, being Conical Sections.

Note,

That when the Vertical-line of the Plain falls on an even Azimuth, then half the number of Rumbs will serve, being laid each way on both sides at once.

Or,

Having a *Table* of the Angles at the Zenith, the same as you made to draw the Azimuth-lines, draw a Line at any convenient distance, Parallel to A C; the further from

from A C, the larger and better, as D E F in the *Figure*; and note, where C D crosses the last Line E F, as at D; make D E a Parallel sine of 90, and lay off the sine complements of the Angles at the Zenith in the Table, from E towards D, and draw and mark the Lines, as in the *Figure.*

Otherwise,

The Stile being fixed, and the Dial set in its place where it must be, or at least set to the same Reclination, and Declination that it must be; then if you apply the side of the Trianguler Quadrant to the Nodus, and the corner at the end of the same edge that toucheth the middle of the Nodus to the Plain; and at the same time, the Thred and Plummet playing neatly on the Almicanter you would draw, you may find as many Points, and mark them as you please, without all the former trouble, and it may be every whit as true; if the under-side be inconvenient, you may use the upper; only be sure, that the side you apply, and the Thred and Plummet play at the Angle of the Almicanter required.

VII. *To draw the Circles of Position, or Houses.*

The Circles of Position, or 12 Houses, meet and cross one another in the crossing of the Meridian and Horizon; therefore the Horizon is the begining of the 1st and 7th Houses, beginning at the East, and reckoning under the Earth, by *Imum Cœli*, to the Descendant, or 7th House, at the West-part of the Horizon; and so to *Medium Cœli*, the beginning of the 10th House, to the Ascendant, or Horoscope, the beginning of the 1st House.

To draw these on the Horizontal-Dial, where they are Parallel Lines to the Hour 12, do thus;

Take the distance from the Apex to the Equinoctial-line, and make it a = Tangent of 45; then the = Tangent of 30 degrees laid both wayes on the Equinoctial, shall give Points to draw Lines by, = to 12, for the Houses required.

For all *Upright Dials* and *Recliners* with Centers, streight Lines drawn from the meeting of the Meridian-line and Horizon, to every two hours, counting from 12 on the

the Equinoctial, ſhall be the Houſes or Circles of Poſition required.

For *Eaſt and Weſt Dials*, take the Radius as before, *viz.* from the Apex to the Equinoctial-line on the Plain, which here is the Meridian (and but the length of the Stile) a Tangent of 45; then the = Tangents of 30, 60, and laid from 6 on the Equinoctial-line, gives Points to draw Lines Parallel to the Horizon, for the Houſes required.

For *Eaſt and Weſt Recliners*, the Perpendiculer height of the Stile made a Secant of 0; then the Secant of the Stiles Elevation, ſhall be Radius to prick off the = Tangents of 30, 60, on the Equinoctial-line from the foot of the Stile, whereby to draw Lines Parallel to the Horizon for the Circles of Poſition required.

All theſe Lines may moſt elegantly and eaſily be drawn and expreſſed, on a large Ceiling, with competent exactneſs in this manner following.

Firſt provide a Quadrant of Braſs, or thin Wood, of about a foot Radius, or 14, 15, or 16 inches; alſo, a Semi-circle of Braſs, of about half an inch broad, and about an inch leſs Radius than the Quadrant: the Semi-circle muſt have at each end, ſomewhat more than to make up 180 degrees,

 to

to nail to the *Transum*, or stroke of the Window, where your Glass is to lie.

Also, to one Ray of the *Quadrant* must be fastened two strong Wyres, to fasten the *Quadrant* to play after the manner of a Casement, one Point in the Ray of the *Qua-*

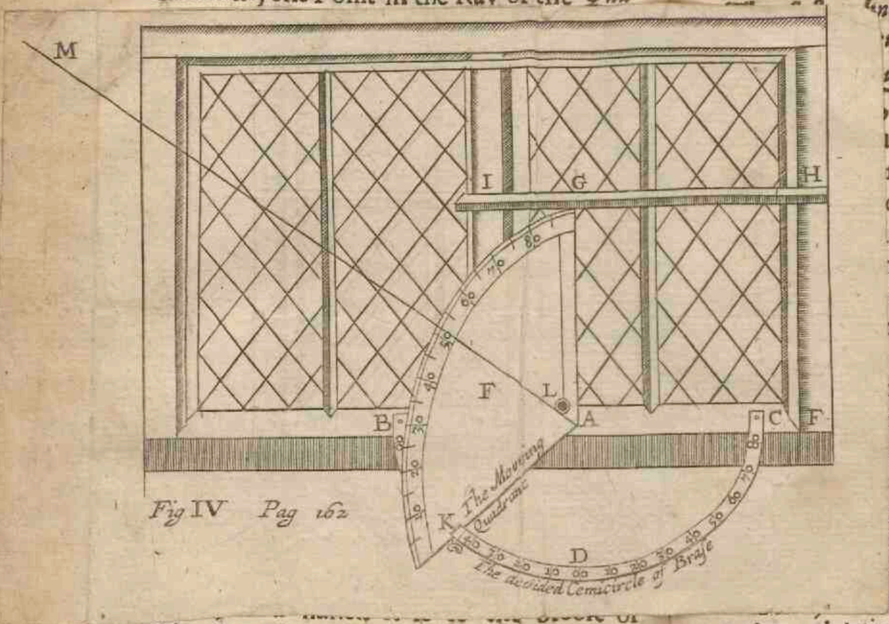


Fig IV Pag 162

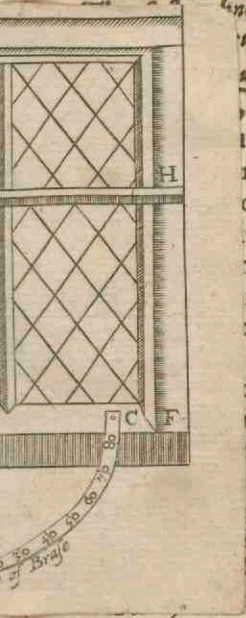
Transum of the Window, by putting two little bits of Wood under the ends, that the *Quadrant* may play evenly and smoothly on the

the Semi-circle- t
quite the half-ro
useful.
Then is the *In*
ration.

tude, and Azim
Latitude you d
First, set the

the Semi-circle- to almoſt the half-round, for quite the half-round will not be neceſſary, or uſeful.

Then is the *Inſtrument* ſet fit for its Operation.



...nd the Declination, or rather ...ue Meridian-line.

...*uadrant* till the edge be juſt
..., and at the ſame inſtant get
...ith; then if you count ſo
...ns Azimuth is, on the Braſs
...om the place the *Quadrant*
...ght way, a Line drawn from
...e Semi-circle, or *Quadrant*,
... is the true Meridian Line;
...u muſt carefully find by two
... and then mark it with Ink
...on the Braſs Semi-circle, to
...nce, in ſetting the *Quadrant*
...imuth, at every hour and
... Points you intend to draw
...; which a crooked Rule ſet
...ſemi-circle, to paſs to and fro
...*rant*, will make eaſie.
...ng a *Table* of the Suns Altitude, and Azimuth, at every hour in that Latitude you draw the Dial for;

First, ſet the *Quadrant* to the Azimuth at the to nail to the *Transum*, or stroke of the Window, where your Glass is to lie.

Also, to one Ray of the *Quadrant* must be fastened two strong Wyres, to fasten the *Quadrant* to play after the manner of a Casement, one Point in the Ray of the *Quadrant* next the Center, sticking in the hole where you intend the Glass shall lie; and the other end fastened to a piece of Wood nailed on the two upright Posts of the Window, so that howsoever you turn the *Quadrant*, fixed on those two Points, it may be precisely Perpendiculer, the Semi-circle playing all the while through a hole in the other Ray of the *Quadrant*, that lies Horizontally; having a Skrew to stay the *Quadrant* at any Azimuth, as in *Figure* IV, is plainly expressed to your view.

Then having degrees on the Semi-circle, and also on the *Quadrant*, and having fitted the *Quadrant* on his Points to play precisely Perpendiculer, which the Plummet in the *Quadrant* will shew, by turning it round about, and put in the Semi-circle through the hole in the Horizontal Ray of the *Quadrant*, and nailed it so to the Stoole or *Transum* of the Window, by putting two little bits of Wood under the ends, that the *Quadrant* may play evenly and smoothly on the

the Semi-circle- to almoſt the half-round, for quite the half-round will not be neceſſary, or uſeful.

Then is the *Inſtrument* ſet fit for its Operation.

Then firſt, to find the Declination, or rather the true Meridian-line.

Turn the *Quadrant* till the edge be juſt againſt the Sun, and at the ſame inſtant get the Suns Azimuth; then if you count ſo much as the Suns Azimuth is, on the Braſs Semi-circle, from the place the *Quadrant* ſtands at, the right way, a Line drawn from the Center of the Semi-circle, or *Quadrant*, to that place, is the true Meridian Line; which place you muſt carefully find by two or three tryals, and then mark it with Ink or otherwiſe, on the Braſs Semi-circle, to count from thence, in ſetting the *Quadrant* to the Suns Azimuth, at every hour and quarter in thoſe Points you intend to draw on the Ceiling; which a crooked Rule ſet to 00, on the Semi-circle, to paſs to and fro with the *Quadrant*, will make eaſie.

Then, having a *Table* of the Suns Altitude, and Azimuth, at every hour in that Latitude you draw the Dial for;

Firſt, ſet the *Quadrant* to the Azimuth at the

the hour, counted the right way from the marked Meridian-line on the Semi-circle, and there skrew it fast; Then extend the Thred fastened in the Center of the *Quadrant*, till it cut the Altitude of the Sun at the same hour and Azimuth, on the degrees of the *Quadrant*, and extending the Thred to the Ceiling, make a mark for that Hour and Altitude; that Point at that time, gives the true place where the reflected spot will fall, at that Hour, Azimuth, and Altitude on the Ceiling of the Room.

This work repeated as many times as there be hours and quarters in the Summer, and Winter Tropicks, for about 5 hours, (and in the Equinoctial, and any where between, if you please) shall give Points enough to draw the Dial, and also the Tropicks, and Azimuths, and Altitudes also, if it were convenient to mark it; *Or*, to any other Altitude you mind to have at that Azimuth, all at once, or at most with two slips of the Thred; the *Italian*, *Babylonish*, or *Jewish*-Hours, as easily drawn by Points found in the other Lines.

Also, On the Meridian-line, you may add the day of the month, or any thing that depends on the Suns Meridian Altitude; which work being well done, and drawn with

with ſmoth Lines, and well ornamented, would be a comely & pleaſant Ornament to a Ceiling, and far cheaper then ſome fret Ceilings are done, and more uſeful.

Laſtly, When all is done, to put the Glaſs in right, the Foile being firſt rubbed off, to to cauſe it to give but one ſpot, let the Superficies of the Glaſs lie juſt ſo high as the Center of the *Quadrant* was, in the drawing the Lines, and put ſome Putty under it, and the Sun ſhining, make it to play right on the true Hour, Altitude, and Azimuth; or, if it be juſt at noon, then bend it on the Putty with your finger, till it fall juſt on the Meridian, and day of the Month alſo in the Meridian-line.

Alſo note, That look what Altitude the Sun hath at any time, the ſame will the reflected Altitude be, at the ſame time, if the Glaſs lie true, which two Obſervators at the ſame time may carfully prove.

The making of the *Tables* of the Suns Altitude and Azimuth, is very largely ſhewed in the 15th *Chapter*, *Uſe* the 37th and 38th, where you have wayes both general and particular, for any one or more Latitudes.

The Figure Explained.

A, the place on the *Transum* for the Glass to lie on, and in the middest thereof one Point, in the Ray of the *Quadrant*, is to play: I H, a piece of Wood to be nailed fast at H and I, for the other Point to play in at G: L, the hole for the Plummet to play in, being cut through the thin *Quadrant*: B and C, the ends of the Semicircle, nailed on the *Transum* or Stoole: K, the hole in the *Quadrant* for the Semicircular-Ring to pass through: F E, the Posts of the Window: D, the beginning of the degrees on the Semi-circle: A M, a Thred extended from the Center of the *Quadrant* to the Ceiling.

Thus you have the usual wayes of *Dialing* in a competent measure, plainly, and practically handled, which may be useful to many a Learner; and I hope will be as well accepted, as with freewill (though with little ability, and less leisure) readily imparted.

A Table of the Suns Azimuth from the South, at every Hour and Quarter, 51-32.

	♋	♊ ♌	♉ ♍	♈ ♎	♓ ♏	♒ ♐	♑
	D. M.	D. M.	D. M	D. M	D. M	D. M	D. M
12	00 00	00 00	00 00	00 00	00 00	00 00	00 00
	07 10	05 53	5 37	4 55	03 54	03 53	3 52
	14 22	13 24	11 10	9 40	07 57	07 40	7 10
	21 27	19 53	16 44	14 13	12 11	11 10	10 37
11 1	27 54	26 00	22 13	18 52	16 22	14 45	14 13
	34 14	32 01	27 32	23 22	20 15	18 17	17 38
	40 12	37 40	32 41	27 41	24 06	21 53	20 59
	45 39	43 04	37 32	32 08	29 44	26 30	24 25
10 2	50 51	47 57	42 05	36 24	31 50	28 52	27 49
	55 31	52 41	47 04	40 30	35 35	32 18	31 00
	61 43	57 11	50 51	44 26	39 10	35 39	34 17
	64 11	61 18	54 33	48 13	42 36	38 50	37 34
9 3	68 10	65 16	58 47	51 56	46 02	42 04	40 36
	71 52	69 56	62 33	55 33	49 25	45 16	43 40
	75 26	72 37	66 10	58 59	52 43	48 21	46 42
	78 48	76 05	69 38	62 22	55 55	51 22	49 49
8 4	82 00	79 20	72 57	65 40	59 00	54 22	
	85 08	82 42	76 12	68 53	62 08		
	88 10	85 38	79 23	72 06	65 12		
	91 09	87 50	82 28	75 03	68 12		
7 5	94 05	91 34	85 30	78 06	71 10		
	96 51	94 25	88 27	81 09			
	99 38	97 16	91 25	84 06			
	102 25	100 07	94 22	87 04			
6 6	105 08	102 54	97 12	90 00			
	107 52	104 58	100 02				
	110 36	108 26	103 00				
	113 18	111 14	105 54				
5 7	116 03	114 03					
	118 50	116 54					
	121 41	119 47					
	124 29	122 37					
4 8	127 24						
	130 28						

A Table of the Suns Altitude, at every Hour and Quarter in each Sign, for 51-32.

	♋	♊♌	♉♍	♈♎	♓♏	♒♐	♑
	D.M	D.M	D.M	D.M	D.M	D.M	D.M
12	62 90	58 42	50 00	38 28	27 00	18 18	14 59
	61 50	58 34	49 52	38 24	26 54	18 13	14 55
	61 25	58 09	49 31	38 07	26 40	18 00	14 38
	60 41	57 29	49 00	37 38	26 15	17 37	14 20
11	59 43	56 34	48 12	36 58	25 40	17 06	13 52
	58 32	55 26	47 10	36 07	24 02	16 26	13 10
	57 04	54 06	46 02	35 06	23 59	15 38	12 35
	55 29	52 36	44 38	33 56	22 58	14 49	11 30
10	53 45	50 55	43 12	32 37	21 51	13 38	10 36
	51 52	49 07	41 33	31 10	20 33	12 27	9 20
	49 54	47 12	39 46	29 36	19 10	11 09	8 9
	47 50	45 12	37 56	27 54	17 35	9 44	6 41
9	45 42	43 06	36 00	26 07	15 58	8 13	5 16
	43 30	40 57	33 55	24 14	14 14	9 49	3 41
	41 16	38 45	31 50	22 16	12 27	4 54	2 04
	39 00	36 30	29 40	20 14	10 32	3 07	0 17
8	36 41	34 13	27 31	18 08	8 35	4 15	
	34 22	31 55	25 09	15 59	6 30		
	32 02	29 13	22 56	13 46	4 27		
	29 42	27 16	20 37	11 33	2 17		
7	27 23	24 56	18 18	09 17	0 06		
	25 03	22 36	15 58	06 58			
	22 45	20 16	13 38	04 40			
	20 28	17 58	11 18	02 20			
6	18 11	15 41	09 00	00 00			
	15 56	13 25	06 41				
	13 44	11 11	04 23				
	11 35	8 59	02 08				
5	9 32	6 50	00 06				
	7 23	4 44					
	5 26	2 41					
	3 36	0 41					
4	1 32						

The

The Description and some Uses of the Sphear for Dialling, and for the better understanding of the general and particular Scheams.

NExt the Foot and Semi-circle Frame for supporting of it, you may consider;

1. The fixed Horizon, to which the Foot is fastened with 4 skrews, numbred and divided into 360 degrees, or four 90 deg. whose count begins at the Dividees side of the Meridian-Circle.

2. The Meridian Circle, whose fore-side at the Nadir-point stands in the Center of the Foot; this is also divided into 4 90s, and begins to be numbered at the South and North part of the Horizon, upwards toward the Zenith, and downwards toward the Nadir; which Circle is alwayes fixed as the Horizon is.

3. The Equinoctial Circle, made fast at the East and West Points of the Horizon, moving up and down upon the Meridian-Circle, according to the Elevation of the Equinoctial

Equinoctial in any Latitude; this is divided likewise into four 90^s, & numbred from the Meridian each wayes to the East and West Points of the Horizon.

4. On the Meridian Circle, is set 2 moveable Poles, to be elevated or depressed fit to the Latitude of any place; on the Fiducial-edge of which, is fastened the Thred, representing the Axis of the World, at any Elevation of the Pole.

5. On the 2 Pole Points, is fastened the Hour Circle, which delineates or represents the motion of the Sun, or any fixed Star, moving in its supposed Diurnal motion about the Poles of the World, and may not improperly be called the moveable Meridian Circle, or Hour Circle, divided as before.

6. The Moveable Horizon, that moveth about to any Azimuth, and slideth or moveth in the fixed Horizon.

7. The Plain, fixed in 2 opposite Points to the moving Horizon; being set, either Horizontal, when it lies Parallel to the fixed Horizon; or Erect, when Perpendiculer thereunto; or set to any Reclination or Inclination, by help of the Semi-circle of Reclination, fastened to the backside of the Plain in the 2 Poles thereof.

8. You

8. You have the upper moving Semi-circle, in turning about of which, whatever degree the fore-side of the Semi-circle cuts, the Perpendiculer-point cuts the complement thereof, and to be called the upper-Semi-circle, or Circle alwayes Perpendiculer to the Plain.

9. There ought to be a Thred fastened in the Center of the Plain, to be extended to any Altitude or Azimuth required.

Thus much for Description, repeated again in short *thus*;

The Horizon; The Meridian; The Equinoctial Circles; The 2 Pole Points, and Axis; The Hour Circle, or Moveable Meridian; The Moveable Horizon; The Plain; The Semi-circle of Reclination; The upper Semi-circle, and, The Thred.

Note also, Every Circle is divided into 4 times 90, and numbred the most useful way.

Also, on the Plain is set the 12 Months, and every single Day; on which every respective day, if you extend the Thred, then in the degrees, is the Suns Right Ascention in degrees (on the innermost Circle, the same in hours and quarters) from the next Equinoctial-point, on the Line of Declination, his mean Declination; on the Line of the

the Suns place, his mean true place, sufficiently true for any illustration in Mathematical practice.

The Uses whereof in some part follow.

1. To rectifie the Sphear to any Latitude, count the Elevation of the Pole on the Meridian Circle, from the Horizon upwards, and downwards from the North and South parts of the Horizon ; and there make fast, with the help of the small skrew, the Fiducial-edge of the Poles Points, carrying the Hour Circle fixed upon them, then the Pole is rightly elevated.

2. Count the complement of the Poles Elevation on the Meridian, from the South part of the Horizon, and to it set the divided side of the Equinoctial Circle, then is that rectified also (in the Northern Hemisphere, or in the Southern, if you call the North Pole the South Pole).

3. Extend the Thred or Axis passing through the Center to the South Pole, and there make it fast, and then the Sphear is rectified for many Uses in that Latitude.

Use I.

Use I.

The Day of the Month being given, to find the Suns true Place.

Lay the Thred in the Center of the Plain on the day of the Month, and in the Line of the Suns place, you have his place.

Example.

On the 5th of *November*, it is 23 degrees in ♐; or if the Suns place be given, look for that, and just against it, in the Months, is the day required.

Example.

The Suns place being 15 degrees ♌, I look for it in the Line of his place, and just against it I find *July* 28 day.

Use II.

To find his Declination any day.

Look for the day given, and right against it in the Line of Declination, is his due Declination required.

Example.

August the 5th; The Declination is 14 degrees 5 minuts from the next Equinoctial-point, *viz.* ♎.

Note, In the Northern Sines, or Summer-time,

time, the Sun hath North declination; or in Southern Sines, or Winter-months, the Sun hath South declination. Or if you have the Suns declination, find that in the Line Declination, and right against it in the Months is the day required.

Example.

21 degrees South declination, beginning from the Equinoctial towards the Winter Solstice, I find *Novemb.* 15. The like work had been, if the Suns place had been given, to find his declination.

Use III.

The day given, to find the Suns Right-Ascention.

This is usually reckoned from ♈ to ♈, round, in 24 hours; but twice 12 is as useful, and then it is *thus*;

Find the day amongst the Months and Dayes, and just against it, in the time of Hours, is the Suns Right Ascention; (but *note*, it is not right figured for this use) counting onwards from ♈, or the 10th of *March*, to the 13th of *Septemb.* and from thence to *Aries* again; Likewise the degrees are to be reckoned from ♈ onwards, as the Months proceed.

Example.

Example.

On the 12 of *May*, what is the Suns Right Aſcention? Lay the Thred on the 12th of *May*, and in the Line of Hours it cuts 9-57′ counting from *Aries* onwards; or in degrees 59-15, counting as before. Thus, if any one of theſe 4 general things be given, the other may be found.

Uſe IV.

The Suns Declination and Latitude being given, to find the Suns Meridian Altitude.

The Sphear being rectified, count the declination on the Meridian, from the Equinoctial, that way the declination is, either North or South; and where the count ends, there is the Meridian Altitude required for that day, or Declination.

Example.

June 11. Declination 23-30′; Count 23-30, from 38-30, the place where the Equinoctial ſtands, for 51-30 Latitude, and the account will end at 62 degrees, the Suns Meridian Altitude at that Declination Northwards: But, if it had been 23-30 South Declination; then count as much from the Equinoctial downwards, and the

count

count will end at 15 degrees, for the Suns Meridian Altitude, at 23-30 South Declination.

Use V.

The Suns Declination and Latitude being given, to find the Suns Rising or Setting, and Amplitude, East or West.

Count the Suns declination on the Hour-Circle towards his proper Pole, that is South-declination toward the South-Pole, and North-declination towards the North-Pole; and thereunto lay the Thred that is fastned in the Center; then bring the Hour-circle and Thred both together, till the Thred touch the Horizon; then the Thred on the Horizon shews the Amplitude, and the divided-side of the Hour-Circle, shews the Suns Rising and Setting on the Equinoctial, counting the Meridian alwayes 12, and the 2 East and West-points 6, and 15 degr. for an Hour, and every deg. 4 min.

Example.

June 11. Declination 23-30, the Sun Riseth at 13′ before 4, and the Amplitude is near 40 deg.

Again,

April 10. Declination 11-30, the Amplitude is 18-30 from the East to the North, and Riſeth at 5, the Hour-circle cutting 15 degrees on the Equinoctial.

Uſe VI.

The Declination & Latitude, & Suns Altitude given, to find both Hour & Azimuth.

Rectifie the Sphear, and ſet the Plain horizontal; that is, Level or Parallel to the Horizon; then apply the Thred to the Declination, counted the right way on the Hour-circle; then turn the Hour-circle and upper Semi-circle about, till the Thred cuts the degrees of Altitude in the upper Semicircle, and the Hour-circle, ſhews the hour in the Equinoctial, and the Semi-circle cuts the Suns Azimuth in the deg. on the Horizon or Plain.

Example.

Declination 10, Latitude 51-30, and the Suns Altitude 30; the hour will be 8-27, and the Azimuth 66, from South Eaſtwards if in the morning, or the contrary if in the afternoon.

Uſe VII.

The Hour, or Azimuth, and the Suns Declination given, to find the Altitude.

The Sphear rectified, as before, and the Hour

Hour being given, ſet the Hour-Circle to the hour on the Equinoctial; then bring the Thred to the Declination, counted on the Hour-circle; then bring the upper Semi-circle, till the fore-ſide do juſt touch the Thred, and the Thred on the Semi-circle, ſhall ſhew the Altitude required; and on the Horizon, the Azimuth at that Hour, and Altitude.

But if the Azimuth be firſt given, then ſet the upper Semi-circle thereunto, counted on the fixed Horizon; then the Thred laid to the declination, on the Hour-circle, and turned about till it touch the upper Semi-circle, there it ſhews the Altitude; and the Hour-circle on the Equinoctial, ſhews the hour.

Uſe VIII.

To find the Suns Height in the Vertical-Circle.

Set the upper Semi-circle to the Eaſt or Weſt-Point, or 90 degrees of Azimuth; then lay the Thred to the declination on the Hour-circle, and then bring it and the Thred together, till it juſt touch the upper Semi-circle, and it ſhall there ſhew the Altitude at Eaſt or Weſt required.

Example.

At 10 degrees Declination North, it will be East at 16 degrees of Altitude.

Use IX.

To find the Suns Altitude at 6.

Set the Hour-circle to 6 on the Equinoctial, and the Thred to the Declination; then bring the Semi-circle to the Thred, and it ſhewes the Altitude at 6 required.

Example.

At 23-30 Declination, the Altitude 18-15 above the Horizon in North-declination; and as much under in South-declination; for, you muſt obſerve that the ſureſt working is from the upper or divided-ſides of the Rings, on every occaſion to uſe it.

Uſe X.

To find the Hour of the Day, when the Sun ſhineth.

Rectifie the Sphear, and ſet the Plain Parallel to the Equinoctial-circle; then ſet the Meridian-circle due North and South, and the ſhadow of the Axis ſhall on the Plain, ſhew the true hour.

Or,

Or, otherwise thus ;

At the true place of the Suns Declination, on the Hour-circle make a mark, or ſtick the point of a Pin, then turn the Sphear about, till the ſhadow of that mark, fall on the Center; (the Sphear ſtanding Horizontal, as near as may be) then the Hour-circle ſhall, on the Equinoctial, ſhew the hour of the day required.

Note, A ſmall Bead, or knot on the Thred, will do the buſineſs as well as may be.

Thus any the like Queſtions may be wrought for the Stars; or the manner of raiſing the Canon for any Spherical Triangle whatever, to work the ſame exactly by the *Logarithms*.

As thus ;

Suppoſe I would make the Canon, or Propoſition, to find the Suns height in the Vertical Circle at any declination. Firſt, The Sphear being rectified, and the Plate ſet Horizontal, bring the upper Semi-circle to the Eaſt-point, and laying the Thred to the declination on the Hour-circle, bring it and the Thred together, till it juſt touch the upper Semi-circle.

The Rings or Circles ſo ſtanding, and

being great Circles of the Sphear, there is constituted a Spherical-Triangle in this form;

Wherein you have,

Z Æ, 51-30 the Latitude, the Angle at the Equinoctial; and Z E 90, the upper Semi-circle; and A B 23-30, the Declination, part of the Hour-circle; to find B E, part of the upper Semi-circle: Now this being a right-angled Spherical-Triangle, and the parts which are given, being one right Angle, *viz.* The Angle at A, and the Side A B, the Suns Declination; and the Angle at E 51-30, to find the Side B E; Now the Sines of the sides of Spherical-Triangles are proportional to the Sines of their opposite Angles, and the contrary.

Therefore,

As the sine of the Triangle	B E A	51-30
Is to the sine of the Side	A B	23-30
So is the sine of the Angle	B A E	90-00
To the sine of	B E	30-39

And the like for any other, as by comparing the Rules in Mr. *Norwood's Trigonometry*, and the Circles of the Sphear together, the use and convenience thereof will evidently appear unto you.

Only note this plain Obſervation.

That the ſide of a right-Angled Triangle, which ſubtends the Right Angle, is moſt properly called the Hypothenuſa; the other which you make or ſuppoſe Radius, the Baſe. The other, the Perpendiculer. *Or more ſhort,* The Hypothenuſa and Leggs: Therefore if the Hypothenuſa and one Leg be given, the proportion is wrought by Sines alone; but if the two Legs be given, and firſt and ſecond in the Queſtion, then the Proportion is wrought by Sines and Tangents together.

As for Example.

As the ſine of ♈ ♋ 90-00
To the ſine of ♋ Æ 23-31
So is the ſine of ♈ ♉ 30-00
To the ſine of ♉ R 11-31
The Suns Declination in ♉.

Again ſecondly,

As the ſine of ♈ Æ 90-00
To the Tangent of Æ ♋ 23-31
So is the ſine of ♈ R 27 54
To the Tangent of R ♉ 11-31
The Declination as before.

But if the one acute Angle, and his oppo-

 ſite

ſite Leg or Side be given, then the Proportion is made by Sines only, as in the foregoing *Example.*

Again,

In Vertical Triangles that have the ſame acute Angle at the Baſe, as the Triangle P ♉ ♋, and ♈ ♉ R, being equal Angled at ♉; the ſines of the Baſes are proportional to the Tangents of the Perpendiculer, and the contrary.

Likewiſe,

The Sines of the Perpendiculers, as proportional to the Sines of the Hypothenuſaes, and the contrary.

As for Example.

Thus for Perpendiculers and Baſes.

As the ſine of the Baſe	♉ ♋	60-00
To the Tangent of Perpend.	♋ P	66-29
So the ſine of the Baſe	♉ R	11-31
To the Tangent of Perpend.	♈ R	27-54

Or,

As the Tang.	P ♋	the Perpend.	66-29
To the ſine	♉ ♋	the Baſe	60-00
So the Tang.	♈ P	Perpend.	27-54
To the ſine	R ♉	the Baſe	11-31

Alſo

Also for the Second, viz. *Hypothenusaes and Perpendiculers.*

As the sine of Hypothen.	P ♉	78-29
To the sine of Perpend.	P ♋	66-29
So the sine of Hypothen.	♈ ♉	30-00
To the sine of Perpend.	♈ R	27-54

Or the contrary thus ;

As sine of Perpend.	P ♋	66-29
To sine of Hypothen.	P ♉	78-29
So sine of Perpend.	♈ R	27-54
To sine of Hypothen.	♈ ♉	30-00

This being premised, when to use Sines alone, and when to use Sines and Tangents together, you may rectifie the Scheam to your present purpose, and see there how the Triangle lies in its Natural parts, very plain and demonstratively to be apprehended.

The

The uses of the Sphear *IN* DYALLING.

TO this purpoſe, you muſt take notice, That the Sphear is very excellent to demonſtrate that Art; eſpecially all thoſe Dials whoſe Stiles have any competent Elevation.

Therefore, firſt to explain the terms.

The Sphear being rectified to the Latitude; Then, firſt the Plain, or Broad-plate, is to repreſent any Plain howſoever ſcituate, either Horizontal, or Erect Direct, or Direct Reclining or Inclining, or Eaſt and Weſt Erect, or Reclining, or Inclining, or Erect and Declining, or South Declining, or Reclining or Inclining, leſs or more than to the Pole or North Declining; or Re-inclining leſs, to, or beyond the Equinoctial.

Of which in their Order.

1. By *Horizontal* I mean, when the Plain

Plain is ſet even with the fixed Horizon, and the Notch which the Semi-circle of Reclination paſſeth in juſt againſt the Meridian; then if you ſtretch the Axis ſtreight, and bring the upper Semi-circle juſt to touch the Axis; then the Axis, on the Semi-circle, ſheweth the Stiles height; and the Edge of the Semi-circle on the Plain, ſhews the Subſtile to be in the Meridian.

For all the Hour-Arks on the Plain, do thus;

Set the Hour-circle to every hour and quarter on the Equinoctial; and then if you bring the looſe Thred, faſtened in the Center of the Plain, along the Plain till it juſt touch the Hour-circle, then on the Plain it ſhall ſhew the Angle from 12, for that reſpective hour and quarter the Hour-circle ſtands at on the Equinoctial, accounting 3-45 for a quarter, and 7-30 for half an hour, and 15 deg. for every whole hour, as was hinted before.

2. *For an Erect Direct South or North-Dial.*

Juſt as the Plain ſtood before, that is to ſay, the Notches of the Moving Horizon againſt the Meridian; turn the fixed Semi-circle, till the divided side of the Horizon cuts no deg. on the fixed Semi-circle, then the upper-edge of the Plain respects the Zenith, and the lower the Nadir; and the two Notches in the Moveing Horizon (being alwayes the Poles of every Plain) are just in the Meridian; therefore it is a Direct Plain, and Erect, because Upright without any Reclination, as the fixed Semi-circle sheweth. Then being so fixed, and made fast there, pull the Axis streight, and bring the upper Moving Semi-circle just to touch the Thred or Axis; then on the upper and lower Semi-circles, the Axis sheweth the Stiles Elevation; and on the Plain the Semi-circle cuts the Substiles distance from 12, *viz.* 00, because a Direct Plain.

And for all the Hour-Arks on the Plain, set the Hour-circle to every hour, quarter, and half hour on the Equinoctial; and bring the Thred easily along the Plain, till it just touch the Hour-circle; then on the Plain it sheweth the Ark from 12 required.

Also note, The several Triangles made on the Meridian, Equinoctial, and Hour-circle, at every hour it is set unto.

As thus;

Suppose at the Pole, I set P; at the cutting of the Equinoctial, and Meridian, Æ; at at the upper-end, or Zenith, set Z; on the Meridian, and where the Hour-circle cuts the Equinoctial, at 1 & 11, set 15; at 2 & 10, 30; at 3 & 9, 45; at 4 & 8, 60; at 5 & 7, 75; and at 6 & 6, 90.

Then the Triangle runs thus;

As the whole sine P Æ 90-00
To the Tang. of Æ 15 15-00 *one Hour on (the Equinoctial.*
So the sine of P Z 38-30
To the Tang. of Z 11 11-28 *the measure (on the Plain for* 11.1.

The like work serves for all the rest.

But note, Because the Hour-circle cannot pass by 12, you must turn the other-side, or half, for the afternoon hours.

Also note, That if the back-side of the Plain do not well represent the South-side, being the more useful Dial; then if you hold the Sphear with the foot upward, the Zenith becomes the Nadir, and the North Plain a South Plain, to appear more Plain to the apprehension.

3. *For a Direct Reclining Dial.*

For these Dials, set the Plain Direct, as before,

before, and let the upper part of the Horizon cut the Semi-circle of Reclination, according to the Plains Reclination, and there make it faſt; then the Axis drawn ſtreight, and the upper Semi-circle brought to it, ſheweth the Stile and Subſtile; and the Thred and Hour-circle, laid as before, giveth the Hour-Arks on the Plain, and ſheweth alſo how the Proportion runs.

To find any Requiſite alſo you may obſerve for all North-Recliners and South-Incliners, that the complement of Latitude and Reclination put together, doth give the Poles Elevation, or Stiles height, for all thoſe Plains, which ſometime will be above 90 from the South part of the Meridian; and then the complement to 180, is to be ſet from the North part of the Meridian: But if it be a South-Recliner, then ſubſtract the Reclination out of the Comp. Lat. and the remainder is the Stiles Elevation: But if the Reclination be more than the complement Latitude, then ſubſtract the complement Latitude out of the Reclination or Inclination, and the remainder is the Stiles Elevation.

Note alſo, That the upper-face of the Plain, that beholds the Zenith, is the Recliner; and the under-face that beholds the

Nadir

Nadir, is the Inclining-plain. *And note*, That both Plains, *viz.* both Incliners and Recliners have the ſame Requiſites in each of them. But, the hours proper to the Recliner, are not to be put on the Incliner; for when the Sun ſhines on the one, it can't ſhine on the other. Therefore to know what hours are fit for theſe or any Plains whatever, *do thus*;

The Sphear rectified, and the Plain ſet to his true ſcituation, lay the Thred on the Suns declination, on the Hour-circle (according to what time of year you would know when the Sun begins and ceaſes to ſhine on any Plain) and turn the Hour-circle, with the Thred ſo laid, till the Thred do but juſt touch the Plain, and the Hour-circle doth on the Equinoctial, cut the Hour and Minuit required; when the Sun comes on the Eaſt-ſide, and when it goes off from the Weſt-ſide of the Plain.

Example.

Suppoſe you have a Direct North-plain that Reclines from the Zenith towards the Equinoctial 25 degrees, you ſhall find the Stiles Elevation to be 63-30, the Subſtile from 12. The North-Pole to be elevated on the Recliner, and the South-Pole on the Incliner; and that the Sun ſhines on the

North-

North-recliner in the longeſt dayes, *viz.* 23-31, declination, from the Riſing 13′ before 4, till 10; and then it begins to ſhine on the South-incliner, and ſhines till 2 afternoon; then it comes on the North-recliner again, and continues till it ſets.

But in the ſhorteſt dayes, when the Declination is 23-30 towards South, then on the North-recliner it ſhines not at all, but only on the South-incliner, from Riſing to Setting; and ſo doth it all the time the Sun hath South-declination.

This Rule ſerves for all ſorts of *Dials* whatſoever.

Note, That the Circles of the Sphear ſhews the Canon to work this Queſtion exactly, whereof you have a large Diſcourſe in *Wells* his *Art of Shadows*, from *pag.* 391, to 408, in 35 *Chap.*

4. *For a Direct Eaſt or Weſt Erect-Dial.*

The Sphear being rectified to the Latitude, bring the Notch in the Moveing Horizon, to the Eaſt or Weſt-points on the fixed Horizon, *viz.* to 90 degrees; then ſet the Plain Erect, and make it faſt there; then you ſhall perceive the Axis lie cloſe to the Plain, it ſhews the Stile to have no Elevati-

on,

on, but must be set Parallel to the Plain, at any quantity you please, which is to be the Radius of a Tangent-line, whereby to prick down the Hours; and that the Substile or place where the Cock or Stile must stand is in 6, being the Hour-circle, till it be just against the upper Semi-circle, touching the Thred, and in the Equinoctial it cuts 6, the true place where the Stile must stand.

Also, By the fore-going Rule you shall find the Sun shine all the year from the Rising, till 12 on the East-side; and on the West-side from 12, till his Setting.

5. *For an East or West-Recliner.*

Turn the moving Horizon to 90 degrees in the fixed, as before; then set the Plain to his due Reclination, and make it fast there, and pull the Axis streight, and bring the upper Semi-circle just to touch it, and straitway you have the Stile, and Substile, and 12, the Inclination, Meridian, and Hour-Arks on the Plain.

As for Example.

An East-plain reclining from the Zenith towards the Horizon 45 degrees, hath his Meridian, or 12 a clock Line in the Horizon; for if you extend the Thred from the Center to the fore-ſide of the Meridian, juſt there the 12 a clock Line muſt alwayes be, which in this Plain lies in the Horizon. The Subſtile doth lie 41-40 from thence upward, as the upper Semi-circle doth ſhew; the Inclination Meridian is thus found; Bring the Hour-circle, till it ſtand even and parallel to the upper Semi-circle; then on the Equinoctial it cuts 58-7′, the Inclination of the Meridian, with which you muſt make a *Table* of Hours, or Arks at the Pole, to calculate the Arks on the Plain, if you work Arithmetically. But by the Sphear, Set the Hour-circle to the hours on the Equinoctial, and the Thred being brought along the Plain till it touch the Hour-circle, ſhall ſhew on the Plain the Angle from the Horizon or Perpendiculer; or with ſome more trouble, from Subſtile or 12.

Alſo, It ſhews, that the North-Pole is Elevated on the Weſt-reclining; and the South, on the Eaſt-inclining oppoſite thereunto; and that the Recliner in ♋, ſhews from 9 in the forenoon, till 8 at night; and the Eaſt Incliner from the Riſing, till 9 forenoon in Summer; and in Winter, till a 11 in the forenoon.

Now to make theſe Plains, as Erect Decliners, let the complement Latitude become a new Latitude; and the complement Declination a new Declination; then they may become Erect Decliners, as in the next sort following.

6. *Of Erect Decliners East or West.*

By Declination, I mean the quantity of the Angle that the Meridian or Pole of place makes between the Meridian, or Pole of the Plain; therefore to set the Sphear to any Declination, *do thus*;

The Sphear being set to the Latitude, turn the Sphear as well as you can guess, to the scituation of the place; that is, put the North part of the Meridian towards the North; and the South part towards the South; then turn the Notch of the movable Horizon, alwayes to the degrees of the Plains Declination, from North or South, towards either East or West, and Upright also as in Erect Dials: Then is the Plain set to his Declination, *viz.* the distance of the Horizon between the Meridian, or Pole-place, which is alwayes 12 a clock, and the Meridian, and Pole of the Plain, being alwayes just where the Notch is in the Moving Horizon.

Now according to these Rules, A Plain that declines 30 degrees from South to West, The Stiles Elevation is 32-35. The Substile from 12, 21-40. The Inclination of the Meridian 36-24. The South Pole is elevated on the South-side, and the North Pole on the North-side: And the Sun shines on the North-side from Rising, to 8; and on the South-side, from 8 to 7 at night; and on the North again, till Sun-setting, by working as in the former Directions is expressed.

Note, In those Erect Decliners, whose declinations is above 60 degrees, you shall find the Stiles Elevation to be very small; therefore to make it exact, you must use Arithmetical Calculation; for the doing of which, the Sphear, with due consideration, gives the best directions, with these *Proportions* or *Canons.*

As sine 90	ZN	90-00
To sine Declination	NC	30-00
So Co-tangent Latitude	PZ	38-30
To Tang. Subst. from 12.	ZH	21-40
As sine 90	ZN	90-00
To Co-sine Declination	NA	60-00
So Co-sine Latitude	ZP	38-30
To sine Stiles Elevation	PH	32-25

As ſine Latitude	P N	51-30
To ſine 90	P Æ	90-00
So Tangent Declination	N C	30-00
To Tangent Elevation Merid.	Æ I	36-24

As Co-tangent Latitude	Z P	38-30
To ſine of 90	Z P Q	90-00
So ſine Declination	Z I A	30-00
To Co-tang. 6 from 12	A Q	57-50

Note, If you ſet P, at the Pole. Z, at the Zenith. N, at the North-end of the Horizon, at the Declination, or Pole-plain. H, on the Plain, juſt againſt the moving Semi-circle, or Subſtile. A, at the Plain on the Horizon. Æ, on the Equinoctial. I, at the Hour-circle, cutting the Equinoctial, ſet juſt againſt the upper Semi-circle. *Note*, Q is to be ſet on the Plain, right againſt the Hour-circle, being ſet to the Hour.

Having, I ſay, by theſe *Rules*, and the like, made and found the Requiſites, then proceed to draw the Dial thus; by help of a Sector with Sines and Tangents, to 7-5; ſuch as are uſually made.

But for very far Decliners, uſe that help as directed in *Chap*. 4.

The like work ſerves to help all ſorts of

Dials with low Stiles, Polar, and Meridian-Dials alſo.

The other 6 ſorts, yet behind, I ſhall demonſtrate only in two of them, which do properly enough comprehend them all; and the work of one, is as eaſie as the work of the other, eſpecially by the help of the Sphear, where the hardeſt is as plain as the Horizontal. Therefore,

7. *Of Declining, Reclining-Dials.*

1. For *South Recliners*, they may recline ſhort of, to, or beyond the Pole, at any Declination, as the putting up and down the Plain, doth plainly demonſtrate. Therefore, firſt,

Of one that Declines South-weſt 35, *and Reclines* 20 *from the Zenith.*

Set the Notch, or Pole of the Plain to the Declination, and the Reclining Circle to its Reclination, and there make it faſt; then extend the Axis ſtreight, and bring the upper Semi-circle juſt to touch it, and the Hour-circle exactly even with the moving Semi-circle.

Then,

Then,

First, The Axis shews the Stiles height on the Semi-circle to be 12-13.

The Thred brought along the Plain while it touches the Meridian, and that shews the Meridians Elevation above the Horizon, on the North Recliner to be 76-32; or its Depression below the Horizon in South-Recliners, and that from the East-end, as the Sphear sheweth.

Then,

3. The Substile from the Perpendiculer Line of the Plain, is 21-6, as the upper Semicircle sheweth; but from the hour 12, or Meridian 7-58, and stands on the East-side of the Meridian.

The Inclination of the Meridian is 33-29, as the degrees on the Equinoctial, between the Meridian and Hour-circle, shew.

All the Hour-Arks are easily found from the Plains Perpendiculer Eastwards and Westwards, by applying the Thred to the Hour-circle and Plain, being set to the Hours on the Equinoctial.

The South Pole is elevated in the South-Recliner, and the North, on the North Incliner.

If you set Letters to the Sides and Angles, according to the former discourse, you will see how all the Canons in the Arithmetical Calculation lie, as I shewed you before in the Declining Dials. And as again thus;

On the Pole set P. On the Zenith Z. At the West-end of the Plain, set A. At the East-end B. At the South Pole of the Plain C. At the North Pole D. At the East-end of the Horizon E. At the West-end W. At the North-end of the Meridian, set N. At the South-end S. Where the Hour-circle cuts the Plain F. Where the Meridian cuts the Plain G. Where the fixed Semi-circle cuts the Plain, set E. As in the *Figure* before. Then these *Canons* in short run *thus*;

As sine Base	ZD	90-00
To Tang. Perpend.	ND	35-00
So sine of Base	ZE	20-00
To Tang. Perpend.	GE	13-28

Whose complement AG 70-32, is the Meridians elevation.

As sine of the Side	GE	13-28
To sine of the Angle	CZE	35-00
So sine of the Angle	GFZ	90-00
To sine of the Side	GZ	23-57

Which taken from ZP 38-28, leaves 14-33, the distance of the Meridians place from the Pole to the Plain, *viz.* GF.

As

As sine of Hypothen.	GZ	23-57
To sine of Perpend.	ZE	20-00
So sine of Hypothen.	PG	14-33
To sine of Perpend.	PF	12-13
		the Stile.

As Tangent of Perpend.	ZF	20-00
To sine of Base	GE	13-28
So Tangent of Perpend.	PF	12-13
To sine of Base	FG	7-58
		the Substile to 12.

As the sine of the Side	ZE	20-00
To the sine of the Side	GE	13-28
So is the sine of the Angle	PFG	90-00
To the sine of the Angle	FPG	33-28
		Inclin.Merid.

For the Hours in all Dials, say thus;

As sine of 90,
To sine of Stiles height;
So Tangent of the Angle at the Pole,
To Tangent of the Angle on the Plain.

8. *For North Declining Reclining-Dials.*

For these Plains also, you must rectifie the Sphear to the Latitude, and set the Plain to his Declination, and Inclination, which is given,

given, and for which you are to make a North Declining Reclining Dial. As you did in the South-Recliner, so work in all respects, as you shall bring forth the *Quesita's*, either by the Sphear or Arithmetical-Calculation, as is largely shewn. And for a Plain that declines 55 degrees from the North towards the East, and relines 20 from the Zenith, you shall find the Requisites to be as followeth.

1. The Meridians Elevation above the Horizon, is found to be 63 deg. 58 min. But yet observe, You must make use of that part of it which is below the Horizon, because the Sun being Elevated high on the South-part of the Meridian, must needs cast a shadow on the North-part thereof; therefore in drawing the Dial-part, part is only to be made use of for the Sun to shine on.

2. The Stiles Elevation is 37 degrees 00 minuts.

3. The Substile from 12, 65-24; or from the Plains perpendiculer 39-22.

4. The distance of the Meridian of the place from the Pole of the Plain, is 70-33. The Angle between the 2 Meridians 74-38. The Hour-Arks are found by applying of a Thred to the Hour-circle and Plain; the

Hour-

Hour-circle being firſt ſet to the hour on the Equinoctial.

The North Pole is Elevated; and in regard the Plain declines to the Eaſt, the Stile muſt be ſet towards the Weſt, and it ſhines on the Plain in Summer-time, from the Riſing unto 12: But in the Winter-time, but a few hours.

Note alſo, That theſe Declining Reclining-plains, may be referred to a new Latitude and Declination, wherein they ſhall become Upright Decliners, as before is hinted.

The Poor-Mans Dial-Sphear; Or another way to demonſtrate the Myſtery of Dyalling, *both for Declining and Inclining Plains, in a very plain, eaſie way, for one 6th part of the coſt of the other Braſs-Sphear.*

Firſt, as to the Deſcription, and afterward for the Uſe.

AS to the *Deſcription,* the Figure annexed, and a few words ſhall ſuffice; wherein conſider,

Firſt, The plain flat-Board, repreſenting the

the Horizon, as ABCD.

Secondly, The two upright pieces, as East and West-points, as AF, and BF, to support the moving Plain.

Thirdly, The Moving-plain, moving to any Inclination, on the two Points E and F, with 180 degrees upon the Plain, and noted by ABEF.

Fourthly, Also a Brass-circle as G, fastened to the Plain, to set it to any degree of Inclination; and a skrew, as at H, that may stay it steady, when set to any Reclination.

Fifthly. On the middle of the Horizontal-board, is fastened at the Point M, a true Horizontal-Dial, drawn fit for your Latitude, and to turn round on the Point M, as IMKL.

Sixtly, A Thred fastened in L, the Center of the Horizontal-Dial; and in N, the Center of the Plain; to be both a Stile for the Horizontal-Dial, and to represent the Axis of the World; also a small Wood-den-Quadrant will be useful, such a one as half the Plain is, to draw Perpendiculers, and measure Angles, as afterwards in the Uses. The Uses follow.

Use I.

Use I.

To find the Declination of a Plain by the Sun-ſhining.

Apply the ſide A B to the Wall, and hold the Inſtrument level, as by help of a Point Plummet, faſtened at N, and the Point playing right on M, it is eaſie to do; then by the *Trianguler-Quadrant*, having firſt obſerved the true hour, turn the Horizontal-Dial about on the Point M, till the ſhadow of the Thred (or Axis) ſhew the ſame Hour; then the Point on the North-end of the Horizontal-Dial, ſhall ſhew the true Declination of the Plain. For any South Decliner, the uſe is obvious.

But for North-Decliners, you muſt turn the Plain out of the way of the Thred, ſtill keeping the ſame ſide, A B, to the Wall; and if the Horizontal-Dial hinder, put a Parallel-piece between, as your Rule, or any other thing, and you ſhall have the Point give the Declination on the Southern Semicircle on the fixed Horizon.

Use II.

The Declination of any Erect Decliner given, to find the Subſtile, and Stile, Inclination of Meridians, and every hour and quarters diſtance from 12, being the Perpendiculer Line on the Plain.

Firſt, Set the Point at 12 on the Horizontal-Dial, to the Declination of the Plain, toward the Eaſt or Weſt, and ſet the Plain Upright.

Then firſt for the Subſtile.

Apply the ſide of the Quadrant to the Plain, and cauſe the ſhadow of the Thred to play Parallel to the perpendicular Ray of the Quadrant, and at the ſame time it ſhall ſhew on the degrees on the Plain, the true Subſtiles diſtance from 12.

Example.

Suppoſe the Plain decline 20 degrees South-weſt, you ſhall find the Subſtile to be 15 deg. and 12′ from 12, and to ſtand on the Eaſt-ſide of 12, in a South declining Weſt 20 degrees, Latitude 51-30.

Again, for the Stiles Elevation.

Apply the *Quadrant* to the flat of the Plain, on the Subſtile Line, ſo as the Thred may cut the Center of the *Quadrant*; and then the

the Thred ſhall cut on the *Quadrant* 35-46 for the Stiles height.

Again, for the Inclination of Meridians.

The ſhadow of the Thred when it cuts the Subſtile 15 deg. 12′ on the Plain, ſhall on the Horizontal-Dial cut 1 hour 36 min. which reduced to degrees, is 24 deg. 50 min. the Inclination of Meridians.

Again, for every Hours diſtance, in degrees and minuts from 12.

Turn the whole Inſtrument about, (as it is then firſt ſet) till the ſhadow of the Thred ſhall fall on every hour and quarter, and then the ſhadow ſhall cut on the degrees on the Plain, the diſtance of every hour and quarter from 12, for that declination, in degrees and minuts; which you may draw into a *Table*, for your uſe and purpoſe; or hereby examine your more exact Calculation, and prevent all groſs miſtakes in your former work.

Uſe III.

Any Declining North-eaſt, or North-weſt-Dial being given, to find the former Requiſites for thoſe Dials.

In the true proper uſing the Sphear for North-

North-Dials, the Stile ſhould look upwards, which will appear ſo to do, if you turn the Inſtrument the bottom upwards, for the further help to your fancy; but obſerve that the Hour-Arks, and Angles, are the ſame for the North, as for the South, only the difference is in the Scituation, as to the contrary-ſide, and looking upward inſtead of the South Decliner, looking downward, as by turning the Inſtrument appears; ſo that if you draw the Dial as a South-weſt, when you would make a North-weſt; and ſet right figures, and the right way, and then your work is effected to your mind, to the right intent and purpoſe.

Example of a North-Eaſt, 30 *degrees, Latitude* 51-30.

Set the Point at 12, to 30 degrees Weſtward, and apply the Square to the Plain, till it juſt touch the Thred; and on the degrees on the Plain, it cuts 21-40 for the Subſtile; and at the ſame time almoſt half an hour paſt 2 for Inclination of the Meridians; and applying the *Quadrant* to the Subſtile-Line on the Plain, and to the Thred; it cuts 32-35 for the Stiles height, being the ſame, and the ſame way found as for the South Decliner Eaſt.

But observe, That for the Hour-Arks, you must note, That the North-Dial cannot ſhew 12 at Noon, nor any Hours very near Noon, which will be ſeen on the South Decliner Eaſt; Therefore 4 in the morning, is here called 8; and 5 is called 7; and 6 is 6: 7 in the morning, is called 5; and 8 is to be named 4: And if you turn the Inſtrument, that the ſhadow of the Thred may fall on thoſe hours, it will alſo cut on the degrees on the Plain, the true Hour-Arks required.

As thus;

For 8, it ſheweth it not; at 7, it ſheweth 77-00; at 6, it ſheweth 58 deg. 52 minuts; at 5, it cuts on the degrees on the Plain 45-38; at 4 in the morning, it cuts on the Plain 35-27; but the ſhadow falls then on Hour of 8, on the Horizontal-Dial.

Alſo note, That theſe numbers are not laid from the Subſtile, but from the Plains Perpendiculer, which in all Upright Plains is a Perpendiculer Line; and in all other Plains, a Perpendiculer to the Horizontal-Line, drawn on the Plain. And thus proceed with any other; the affections are beſt ſeen when you turn the Inſtrument the upper-part downwards.

Use IV.

To find the Requisites, and to draw the Hours on a far Declining Erect-Dial, S. W. 80.

Set the Point to 80, as before S. W. then the Thred and the Quadrant shall shew 38-2 for the Substile; and 82-8 on the Horizontal, for the Inclination of Meridians; and 6-12, for the Stiles Elevation; and the shadow of the Thred on the Horizontal-Dial, will shew you how close and inconvenient the Hours will be, if not helped by the former directions; and in like manner will the North-East or West be, and likewise helped.

Use V.

To find the Requisites, and Hour-Arks, from the Perpendiculer of a Declining Inclining Plain, with its Affections.

Set the Point at 12 to the Declination, and move the Plain by help of the Arch, or Circle of Brass, to the Inclination, and with the skrew make it fast and steady in that place.

Then for the Substile, Apply the Quadrant to the Plain, and also Perpendiculer

to

to the Axis, as the edge of the Quadrant being thick, will neatly ſhew; then the Thred will ſhew on the degrees on the Plain, the diſtance of the Subſtile from the Perpendiculer, or the complement thereof from the Horizon; which Point note with a ſpot of Ink; for, when the ſhadow of the Thred falls on that ſpot, on the Horizontal Dial, it ſheweth the Inclination of Meridians; that is to ſay, on what hour and minut, the Cock of the Dial ſhould ſtand right over.

Alſo, The Quadrant, applied to the Plain and Thred, on the Subſtile-Line, ſheweth the true Stiles Elevation above the Plain.

And laſtly, making the ſhadow of the Thred to fall on every Hour on the Horizontal-Dial, it ſhall at the ſame time ſhew how many degrees and minuts on the Plain, that Hour-line ought to be from the Perpendiculer, or from the Horizon; and alſo which way, either to the Right or Left, Eaſt or Weſt; or from the Subſtile, or 12; if you will trouble your ſelf to count it, from the place found out for the Subſtile, or 12.

Example of a Plain Declining 30 S.E. *and Inclining* 20.

The Subſtile, by applying the Square, you ſhall find to be 30 degrees on the left-hand of the Perpendiculer Weſtward, and the Inclination of Meridians 48-20, the Stiles height 51-36, and the Meridian on the right-hand of the Perpendiculer-line 11-30 Eaſtward; and the ſhadow of the Thred playing on every hour and quarter, on the Horizontal-Dial, will ſhew on the Plain the quantity in degrees from the Perpendiculer-Line.

Uſe VI.

To find the Requiſites in a North-eaſt Reclining-Dial, and the Hour-Lines.

Set the Inſtrument as before, and find the Subſtile, Stile, and Inclination of Meridians as before; But note, as to the Affections, which way *do thus*;

Turn the Inſtrument the bottom upward, and as near as you can gueſs, turn the Plain to its ſcituation; then you ſhall firſt ſee the Stile to look upward in the North-eaſt Recliner, which before was downward in the South-eaſt Incliner.

Alſo,

Also,

The Subſtile ſtands on the right-hand of the Perpendiculer, 30 degrees Weſtward (for obſerve this alwayes, If a Plain declines Eaſtward, the Subſtile will ſtand Weſtward, and the contrary).

Also note,

That the Meridian-Line is to be drawn quite through the Center on the other-ſide; becauſe, when the Sun is in the Meridian above, it muſt needs caſt the ſhadow of the Axis, or Stile, the contrary way downwards.

Uſe VII.

To find what are the moſt Hours, that the Sun can ſhine on any Plain, whatſoever.

Firſt, on all South Direct, or Declining Inclining-Dials, the mid-day-Meridian is proper to it, unleſs it incline above 75 degrees, and then it becomes uſeleſs in *London* Latitude; then what hour ſoever you can make the Sun to ſhine on the Plain, and Horizontal-Dial both together, (the Sun being at that hour above the Horizon) by bending or turning the Inſtrument any way, (when the Point at 12 is first ſet to the Declination) that, and all thoſe Hours are proper to that Plain, at one time of the year or other.

Alſo note,

That ſeveral Hours that ſerve for the South-plain, do, at ſome time of the year, belong to the North-plain alſo; as by turning the Inſtrument about, you may plainly ſee, either by the Sun-ſhine, or by the Thred, and your Eye cutting the Hour-Lines and the Plain.

Alſo obſerve,

That if you would delineate a South Reclining Plain, you may bring the Plain toward the Thred, till it becomes a Polar-Plain.

But if it Reclines below the Pole, then conceive it to become a North Reclining-Dial, and work as is before directed, and you ſhall obtain your deſire; for the Dials will be the ſame, the one as the other, as before was hinted at, in the Inclining-Plains.

Use VIII.

The Declination of any Plain given, to find what Reclination will make it a Polar-Dial, and the contrary.

Set the North-point to the Declination, and bring the Plain to touch the Thred; then on the Brass Circle is cut the Reclination required.

Or contrary;

Set the Plain to the Reclination given, and then bring the Thred to the Plain, by turning the Horizontal-Dial, and the Point at 12 shall shew the Declination required, to make it Polar.

In like manner you may discover a declining Equinoctial, but not so easily, when the Substile and Meridian are 90 degrees assunder; the Substile being then alwayes in the hour of 6, as by moving the Plain, if the Declination be given; or by moving the Thred, if the Inclination be given, till the Square, touching the Thred, it shall shadow or bourn, just upon 6 on the Horizontal-Dial.

Note also,

That East and West Recliners, and Incliners, are discovered after the same manner; So alſo Direct Recliners, and Incliners, as by moving the Plain to and fro, you ſhall ſee the plain and true reaſon, how the Stile is Elevated or Depreſſed, and how the Hour-lines are inlarged or contracted, according to the Elevation of the Stile.

Alſo,

In Eaſt and Weſt-Dials, that the Stile hath no Elevation, but is parallel to the Plain; and how the Meridian lieth in the Horizon, in Eaſt and Weſt Recliners, and Incliners.

Many more Uſes might be inſiſted on, which I ſhall leave to the ſcruteny of the induſtrious Practitioner, in the *Art of Shadows*.

CHAP.

CHAP. IX.

How to remedy several Inconveniencies in the using of the Artificial Lines of Numbers, Sines and Tangents, as they are usually made.

1. IF the term required happen to be under one degree of Sines and Tangents, then the Line of Numbers will supply it, having due respect to the increase of the Radius, or Caracteristick.

As thus;

As the sine of 90, to the sine of 23-31, the greatest Declination;

So is the sine of 1 deg. 10′, the Suns distance from the Equinoctial, to 0-28, the Declination which falls beyond the end of the Rule.

Now to remedy this, the 1 deg. & 10′,

is 70 minuts; therefore by the Numbers *say*, So is 70 minuts, the Suns distance from the Equinoctial, to 28 the Suns Declination on the Line of Numbers, observing to extend the same way, as from the first to the second term.

2. When you have occasion to use a sine above 90 degrees, then you must count the sine of 80, for the sine of 100; and 70, for 110; and 60, for 120.

So also, the distance from 90 to 60 in the Sines, is the Secant of 30 degrees; and the distance from 90 to 50, is the Secant of 40; or the Point beyond 90, that represents the Secant of 40.

3. If the Extent be too large for your Compasses, as from 45 or 90, to 3 or 4 degrees; then instead of 90 or 45, make use of a Point in the Sines or Tangents right against the middle 1 in the Line of Numbers, where you may have two Brass Center-pins, *viz.* in the Tangent of 5-43, and the sine of 5-45; and the extent from thence backward or forward, shall reach in the Numbers, to the 4th proportional Number required.

Example.

As Tang. 45, to 1-61 in the Numbers;
So is Tang. of 15-0, to 0-43 in the Numbers.

In-

Instead of which, you may *say*, As the Tang. of 5-43, to 1-61 on the Numbers; so is the Tang. of 15, to 0-43 on the Numbers diminishing a Radius; for as Tang. 45 to 1-15, a greater than that; so is the Tang. of 15, to a greater than 15 also, *viz.* 0-43.

Secondly, in Sines & Tangents, or Sines only, where there is another Caution to be observed, As sine 90, to sine 10; so is sine 20, to sine of 3-24 $\frac{1}{2}$.

To work this with small Compasses on a large Line, *do thus*; Note, that at 10 on the Line of Numbers, or Sine of 90, or Tang. of 45, is one compleat Radius; but at the middle 1, on the Line of Numbers, is a place, or Radius, less; wherein the Logarithm Sines, the Characteristick is 8. Again, at the sine of 0-34 $\frac{1}{2}$, the Characteristick is 7, (and at 3 minuts it is 6,) which do note the several decreasings of the Radiusses; Therefore set the distance from one Number given, to the next nearest place against 1, or next Radius, as far from a greater or a less Radius, as your occasion serves, and note the place.

As thus for Example.

In this Operation, the extent from the Point at 5-45 on the Sines, to the sine of 10 degrees, I set the same way from the

Point

Point at 0-34 $\frac{1}{2}$; and note the place, which will be at near 1 degree; then the work is thus; As the place against the middle 1, instead of 90, is to the place last found for 10; so is the sine of 20, to sine of 3 deg. 24′ $\frac{1}{3}$, the 4th term required.

But in those Lines of Numbers, Sines, and Tangents, where the Number is double, this is performed by working a-cross only.

4. When the last term in Tangents happens to be above 45, then the remedy is two wayes,

As thus ;

As sine of 30, to sine of 90;
So is the Tang. of 30, to Tang. 49-07.
which here happens beyond 45.

Apply the end of the Rule, next 90, close and even with any thing on which the Point of the Compasses may stay, till you take from thence to 45, for that distance laid from 45, shall reach to 49-07, reading the Tangents as numbred beyond 45.

Or more neatly thus ;

The Compasses being set from the sine of 30, to the sine of 90; set one Point in the Tangent of 45, and turn the other on the Tangents, and keep it there fixed; then remove the other from 45, and close it to the third term, being here the Tangent of 30; then this last Extent laid from 45, shall reach to 49-07, the Tangent required.

5. When the first term is a Tangent above 45, and the second under 45.

Take the excess of the first Number above 45, and set it the same way from the second Number; then the Extent from the second Number to 45, shall be the true distance between the first and second terms.

Example.

As the Tangent of 51-30, to the Tangent of 30;
So is the Tangent of 40, to Tangent 21-04′.

For the Extent from 45, to 51-30 on the Tangents, set the same way from 30, does reach to about 24-30; then the Extent from thence to 45, shall reach from 40 to 21-04 on the Tangents, the 4th Number required.

Or,

If it had been from a Tangent above 45, to a sine, the same way would have remedied the defect.

6. When the third term exceeds 45 of Tangents, then thus;

Example.

Example.

As ſine 90, to ſine 30;
So is the Tang. of 50, to Tang. of 30-48.

The Compaſſes ſet from the firſt term ſine 90, to ſine of 30 the ſecond, a leſs; then ſet one Point in the Tangent of 45, and extend the other backwards in the Tangents, and note the place, keeping one Point there cloſe, the other to 50 the third term (being above 45, by counting backwards) Then, I ſay, that Extent laid from Tangent 45, ſhall reach to Tangent 30-48, the 4th proportional Tangent required.

If the Proportion had been increaſing, then there had been no trouble at all.

Alſo note,

That working a-croſs, or changing the terms, is a good remedy alſo.

As thus;

As ſine 90, to Tang. 50; which is properly increaſing, for the Tang. of 50 being more than the ſine of 90, yet taken on the Rule from 90 to 40, the complement thereof, as if it were decreaſing;
So is ſine 30, to Tang. 30-48, the contrary way: *Therefore,*
As from the firſt term, properly counting to the ſecond.

7. Laſtly, When one or two Radiuſſes (or Alterations of the Characteriſtick) falls between the firſt and ſecond term.

As thus for Example.

First, By the Line of Numbers only;
As 8000 is to 10, So is 5000 to 6 $\frac{1}{4}$, or 25.

To work this properly, and naturally, the unite on the Numbers ſhould be four times repeated, which is ſeldom more done than twice, as here: But this, and any other, by the Line of Numbers is not interrupted, having a due reſpect to the Number of Places. For to work this, the beſt way, is changing of terms thus; As 8000, to 5000 in the ſame Radius; ſo is 10, to 6-25 in the ſame Radius alſo. Or, without changing; As 8000, to the next 1; ſo is 5000 turning the Compaſſes the ſame way, to 6-25.

But to call it ſo, and not 625, your reaſon muſt guide you more than precepts.

But in uſing Sines and Tangents, the way in the third remedy will fit you.

Example. As ſine 90, to 1 degree (or under); ſo is ſine 30 degrees, to ſine 30 minuts. This being too wide an Extent for the Compaſſes, the third Rule is a remedy for it; which on a large Radius ſeveral times

repeated,

repeated, as in Mr. *Oughtred*'s *Circles of Proportion*, is as easie as may be; being sure to remember the number of Radiusses between the first and second term, that you may have so many between the third and fourth term also.

Much more might have been said as to this; but this Observation being alwayes kept, That as the Extent from the first term to the second, is either increasing or decreasing; So alwayes must the Extent be from the third to the fourth, increasing or decreasing, in like manner, when you use Sines and Tangents; And Numbers also, except, as before, in a few particuler Rules; then you will be truly resolved.

The end of the Book of Dyalling.

AN

AN APPENDIX

To the Use of the Triangular-Quadrant IN NAVIGATION.

Where it performs the Uses of the *Davis-Quadrant*, the *Cross-Staff*, Bow, *Sinical-Quadrant*, and *Sector*, with as much ease and exactness as any, or all of them, will do in *Observation* or *Operation*, Naturally or Artificially.

Being first thus Contrived, and made by *John Brown*, dwelling at the sign of the *Sphear* and *Sun-Dial* in the *Minories*, near to *Aldgate*, London.

London, Printed by *John Darby*, for *John Wingfield*, and are to be sold at his house in *Crutched Fryers*; and by *John Brown* at the *Sphear* and *Sun Dial* in the *Minories*; and by *John Selle* at the *Hermitage-stairs* in *Wapping*. 1671.

CHAP. I.

The Deſcription thereof FOR *SEA-USES.*

THe Deſcription of the *Inſtrument*; is largely and plainly ſet down in the *Firſt Part*, and *Firſt Chapter*.

But, in regard that is the general Deſcription of all the Lines that can conveniently be put on, and thoſe neceſſary for this uſe being far leſs, I ſhall repeat the Deſcription again, as far as concerns the uſe thereof for Sea-Obſervations.

1. Firſt for length, it ought to be two foot long at leaſt, when ſhut together, and not above 3 foot at any time for Sea-uſes; (but for Land-uſes it may be 6, 8, 10, or 12 foot in length, to find Altitudes or diſtances to Seconds of a degree certainly).

2. The Form of it is the ſame, as before, *viz.* an opening Joynt of about an inch and quarter, or half quarter broad each Leg; and 6 tenth parts of an inch in thickneſs, with a Looſe-piece of the ſame length, breadth, and thickneſs, to make it an Equilateral-Triangle. *As the Figure ſheweth.*

3. The Lines neceſſary for Sea-uſes are, firſt, the 180 degrees upon the moving-Leg and Looſe-piece, numbred as before is ſhewed. Alſo, 60 degrees on the innermoſt-edge of the Looſe-piece. The Kalendar of Months and Dayes, and degrees of the Suns Place, and Right Aſcention, on the moveable-Leg.

For the ſpeedy and ready finding the Suns place, and declination, which you may do to a minut at all times, by help of the Rectifying Table, and Aſtronomical Cautions of Time and Longitude.

Alſo, on the Head-leg, is the general Scale of Sines and Lines, to the great and leſſer Radius, *as in the Figure.* And thus much will ſerve both for Obſervation and Operation, as in the following Diſcourſe will fully appear.

4. To this Inſtrument doth chiefly belong the Sights for the Obſervations at Sea, where

where the Horizon is made uſe of in the taking the Sun or Stars Altitude.

And to this Inſtrument belongs the Index and Square, that makes it a moſt compleat Sinical-Quadrant, for the plain and eaſie reſolving of all plain Triangles.

Alſo, a weighty Plummet and Thred, and a pair of large Wood or Braſs Compaſſes for Operation.

Thus much for Deſcription, being all put on one ſide only, unleſs you ſhall be pleaſed to add the Artificial Numbers, Sines, and Tangents on the outer-edge, and a Meridian-line, and his Scale on the inner-edge; and Natural Sines, and Natural Verſed-Sines on the Sector-ſide: But theſe as you pleaſe.

CHAP. II.

The use of the Trianguler-Quadrant in Observation.

THat the Diſcourſe may be plain, and brief,and general; there are 10 terms to be named and deſcribed, before I come to the *Uſes* and *Examples*, which are as followeth.

1. Firſt, the Head-leg of the Inſtrument in which the Braſs-Rivit is fixed, and about which the other Leg turns, as A B, in the *Figure*; on which Leg, the general Scale of Sines and Lines are uſually ſet.

2. The moveable-Leg, on which the Months and Dayes be, as in the *Figure*, noted by B D; which Leg turns about the Head-Leg.

3. The Looſe-piece that is joyned to the Head, and moving-Leg, by two Tennons at each end thereof, noted by D A in the *Figure*.

4. The

4. The Head-Center, or Center-pin on the round-part of the Head-leg, being Center to the 60 degrees on the in-ſide of the Looſe-piece; which Point is known by B, in the *Figure*.

5. The Leg-Center, being near the end of the Head-leg, which is the Center to the degrees on the moving-Leg, and out-ſide of the Looſe-piece, being in all 180 degrees; and noted in the *Figure* by the Letter C.

6. The great Radius, or greater Line of Sines, iſſuing from the Leg-Center toward the Head, having the Tangents on the moveable-Leg to the ſame Radius; and the meaſure from the Leg-Center to the Tangent on the moving-Leg, a Secant to the ſame Radius; as C E in the *Figure*.

7. The little Radius that iſſues from the Leg-Center toward the end, having the Tangents, on the out-ſide of the Looſe-piece to the ſame Radius, and the meaſure from the Center to thoſe Tangents for Secants to the ſame Radius; as C F.

8. The Turning Sight alwayes to be ſkrewed to the Head, or Leg-Center, known by his ſhape and ſkrew-hole, as

9. The ſliding Horizon-ſight to ſlide on the moving-Leg and Looſe-piece, noted with its bigneſs and hole to look through, as

10. The ſhadow Sight, and 2 others, to pin the Inſtrument together, which you may call the Object-Sights, alwayes fixed in the two holes at the ends of the moving-Leg, and the Head-leg; and the ſhadow-Sight is to ſet to and fro to any place required; noted in the *Figure* with and the other two with And

Thus you have their Name and Deſcription at large, which in brief take thus for eaſie remembring.

1. The Head-Leg. 2. The Moveable-Leg. 3. The Looſe-Piece. 4. The Head-Center. 5. The Leg-Center. 6. The great Radius. 7. The leſs Radius. 8. The turning-Sight. 9. The Horizon ſliding-Sight. 10. The ſhadow-Sight, and the two Object-Sights; the open-part in one is next to, and the other remoter from the Rule, to anſwer to the upper or lower-hole in the turning-Sight, according as you pleaſe to uſe them in Obſervation.

Thus much for the *Terms*, the *Uſes* follow.

Uſe I.

To find the Suns, or a Stars Altitude, by a forward Obſervation, as by a Fore-ſtaff.

Skrew the turning-Sight to the Head-Center,

Center, and put the object-Sight into the hole at the end of the Head-leg, and put the ſliding Horizon-ſight on the in-ſide of the Looſe-piece; Then ſetting the turning-ſight to your eye, and holding the Looſe-piece in your right-hand, and the moveable-Leg toward your body, then with your Thumb on the right-hand, thruſt upwards, or pull downwards the Horizon-ſight, till you ſee the Sun through the Object-ſight, and the Horizon through the Horizon-ſight; then the degrees cut by the Line on the middle of the Horizon-ſight, ſhall ſhew the true Altitude required.

Alſo obſerve, That if you like to uſe the upper or lower-edge of the Horizon-ſight, inſtead of the ſmall bar a-croſs the open-hole, after the manner of the ends of a Fore-ſtaff, that then the degrees and minuts cut by the edge of the Braſs, is the Altitude required, to be counted as it is figured from the Object-ſight, toward the Horizon-ſight; the degrees between them being the Angle required.

Note alſo, That if the Altitude of the Sun, or Star, be above 30 degrees, you will find it a hard matter, to behold the Horizon and Sun with a bare roling the ball of the eye only, and a ſtirring of the head, will eaſily cauſe a ſtirring of the hand, which will ſpoil the exactneſs of Obſervation, unleſs the Inſtrument ſhall be fixed to a Ball-ſocket and Three-legged-ſtaff, which is not uſual at Sea.

Therefore to remedy this, you may obſerve with the open oval-hole in the turning-ſight ſet to the eye, or taking the turning-ſight quite away; Obſerve juſt as you do with a Fore-ſtaffe, ſetting the round part of the head, to the hollow-part beſide your eye, ſo as the Head-Center-pin may be as near the very ſight of your eye as poſſibly as you can; which Center is the Center to the degrees now uſed in a forward way of Obſervation. Or, rather uſe this way when the Weather will ſuffer, by a Thred and Plummet, which I ſhall add as a ſecond *Uſe.*

Uſe II.

To obſerve the Sun or a Stars Altitude, by a forward Obſervation, uſing the Thred and Plummet.

Skrew the turning-ſight to the Head-Center, as before, and put the two Object-ſights into the two holes at the two ends of the Rule; and on the Leg-Center-pin hang the Thred with a weighty Plummet of two pound,

pound, or above a pound at leaſt.

Then hold up the *Trianguler-Quadrant*, ſetting the ſmall-hole on the turning-ſight cloſe to your eye; and if the Sun, or Star, be under 25 degrees high, then look to the Sun or Star through the turning-ſight, and that object-ſight, which ſtands in the end of the moveable-Leg, letting the Thred and Plummet play between your Thumb and Fore-finger, as a Brick-layers Plummet in his Plum-Rule doth in a bendid hole, that you may keep it in order whilſt you look at the Sun or Star, and the weighty Plummet will pull the Thred ſtreight, and let you know by feeling which way it is playing, till it playeth evenly and truly, whilſt you have the Object preciſely in the midſt thereof, whether it be Sun, Moon, or any Star, or other Object, whoſe Altitude you would obſerve; Then, I ſay, when the Plummet playes well, and you behold the Object right, bend back the *Quadrant*, and ſee what the Thred cuts on the degrees on the moveable-Leg, which ſhall be the true Altitude required; And in my opinion, muſt needs be more exact than any other way of a forward Obſervation, becauſe you are not troubled to mind the Horizon and Sun both at at once.

An

An Objection may be, *The boisterous Winds, and the rouling of the Ship, will hinder ſuch an Obſervation.*

Anſw. So it will any other way, though happily not ſo much.

Again, I anſwer, One Object is better and more certainly ſeen, than two at any time together; and though the Wind blow hard, if you can ſtand to obſerve at all, the heavy Plummet will be ſure to draw the Thred Perpendiculer; and for ought I know, you may come as near this way as any other; however this, at moſt times, may confirm and prove the other, and may be uſeful in Rivers, and Harbours, and miſty-Dayes, when you may ſee the Sun well enough, but not the Horizon at all.

Uſe III.

To find the Suns Altitude by a backward Obſervation, as with a Back-ſtaff, or Davis-*Quadrant.*

Skrew the turning-ſight to the Leg-Center (or Center to the degrees on the moveable-Leg); and ſet the object-ſight to the long ſtroke by 00-60 on the out-ſide of the Looſe-piece, and put the ſliding Horizon-ſight on the out-ſide of the moveable-Leg; then

then hold the Object-ſight upwards, and the ſmall-hole in the piece turning on the edge (or to the ſmall-hole in the middle) of the Horizon-ſight (which you pleaſe) cloſe to your eye; and looking through that hole, and the middle-hole of the turning-ſight, to the true Horizon, turning your ſelf about, and lifting up, or preſſing down the Horizon-ſight, cloſe to the moveable-Leg, till the ſhadow of the upper-edge of the ſhadow-ſight, being next to the Sun, fall at the ſame time juſt on the middle of the turning-ſight; Then, I ſay, the edge or middle of the Horizon-ſight, that you looked through, ſhall cut the true Altitude of the Sun required.

Being the ſame way as you do obſerve with a *Davis-Quadrant*, or *Back-ſtaff*.

Uſe IV.

To find the Suns Diſtance from the Zenith, by the Triangular-Quadrant.

Skrew the turning-ſight to the Leg-Center, and put the Object-ſight, whoſe oval-hole is remoteſt from the *Quadrant*, in the hole in the end of the Head-Leg, or rather in a hole on the general Scale, between the turning-ſight, and the Sun; and put the Horizon-

Horizon-ſight on the out-ſide of the moveable-Leg; then hold the turning-ſight toward the Sun, and the ſmall-hole in the edge of the Horizon-ſight to your eye; then look through that hole and the turning-ſight, till you ſee the ſhadow, the Object-ſight, to fall juſt on the turning-ſight, or the ſhadow of the turning-ſight to fall juſt on the object-ſight, which is all one, though the firſt be more eaſie, becauſe you ſhall ſee the Horizon through the turning-ſight, and that, both at once; Then, I ſay, the degrees cut by the Horizon-ſight, ſhall be the Suns diſtance from the Zenith required; Being the very ſame work, and done in the ſame manner, and producing the ſame Anſwer, *viz.* the Suns diſtance from the Zenith, that the *Davis-Quadrant* doth.

Note, That this way you may obſerve very conveniently, till the Sun be 20 degrees diſtance from the Zenith; and by the adding of a 60 Arch, as in *Davis Quadrant*, or to 45 will be enough, it will do as well as any *Davis Quadrant*, being then the ſame thing.

But I conceive, the complement of the Altitude being the ſame, will do as well; which Altitude is better found by this Inſtrument, than the diſtance from the Zenith

by

by a *Davis Quadrant* is, as in the next Use will be seen.

Use V.

To find the Suns Altitude when near the Zenith, or above 90 degrees above some part of the Horizon.

In small Latitudes, or in places near the Equinoctial, or under it; the Sun will be found to be in, or near the Zenith: and if you count from some part of the Horizon, above 90 degrees distant from it; then instead of setting the sliding Object-sight, to the long stroke at 00 on the Loose-piece, you must set it 30 degrees more towards the Head-leg; then observe, as you did before, and whatsoever the Horizon-sight cuts, you must add 30 degrees more to it, and the *sum* shall be the true Altitude required.

Example.

Suppose that in the Latitude of 10 deg. North, on the 10th of *June*, when the Suns Declination is 23 degrees and 31 min. Northward; Suppose that at noon, I observe the Suns Meridian Altitude, skrewing the Turning-sight to the Leg-Center, and setting the Object-sight to the 30 degrees on the Loose-piece, near the end of the Head-leg, and the Horizon-sight on the movable-Leg; then

then hold up the *Quadrant*, with the ſhadow-ſight toward the Sun, and the ſmall-hole in the Horizon-ſight toward your eye, and look to the Horizon through that, and the turning-ſight, the ſhadow of the right-edge of the ſhadow-ſight, that cuts the degree of 30, at the ſame time falling on the middle of the turning-ſight, you ſhall find the Horizon-ſight to cut on 46-29 minuts; to which if you add 30, the degrees, the ſhadow-ſight is ſet forwards, it makes up 76-29, the Suns true Altitude on that day in that Latitude; 76-29 the Meridian Altitude, and 23-31 the Declination, added together, make 100 deg. 00; from which taking 90, there remains 10, the Latitude of the place.

1. *In this Obſervation, firſt you may note this*, That if you had ſtood with your back toward the South, you would have had 103 degrees and 31 minuts, for the ſliding Horizon-ſight would have ſtayed at 73 degrees 30; to which if you add 30, it makes 103-31; which a *Davis Quadrant* will not do.

2. In the holding it, you may lean the head of the Rule to your breaſt, and command it the better, as to ſteady holding.

3. You

3. You may turn the Turning-ſight about, to any convenient Angle, to make it fit to look through to the Horizon, and alſo to receive the ſhadow of the ſhadow-ſight.

If the brightneſs of the Sun offend the eyes, you may eaſily apply a red or a blue Glaſs, to darken the Sun beams, and the Sights may be painted white, to make a ſhadow be ſeen better.

Uſe VI.

To find the Latitude at Sea, by a forward Meridian Obſervation of the Altitude, according to Mr Gunter's *Bow.*

Skrew the Turning-ſight to the Leg-Center, and ſet the ſhadow-ſight to the Suns-Declination, and the Horizon-ſight to the moving Leg (or Looſe-piece), and the Turning-ſight to your eye; then let the ſhadow-ſight cut the Horizon, and the Horizon-ſight the Sun, moving it higher or lower till it fits; then whatſoever the ſight ſheweth, adding 30 degrees to it, is the Latitude of that place required.

Example.

Suppoſe on the 10th of *March*, when the Declination is only 10′ to the North-

Q ward,

ward, as in the first after Leap-year it is ; then set the edge, or stroke on the middle of the shadow-sight to 10′ of Declination toward the Head, and the Horizon-sight, on the same Leg toward the end, and slide only the Horizon-sight till it cuts the Sun, and the other the Horizon; then suppose t shall stay at 21-30: then if you count the degrees between the two Sights, it will amount to the Suns Meridian Altitude; but if you add 30 degrees to what the Sight cuts, it shall give the Latitude of the place where the Observation was made for 21 and 30, to which if you add 30, it makes 51-30, the Latitude of *London*, the place where the Observation was made.

Note here, That in small Latitudes the Sun will be very high, in Summer time especially, and then the sliding-sight, must be set on the loose peice.

As thus for Example.

Suppose on the 10th of *May* 1670, when the Declination is 20-7 in the Latitude of 30 Degrees, I observe at a Meridian Altitude, I shall find the sliding-sight to stay at 00. on the loose peice; then it is apparent that 30 added to 0, makes but 30 degrees for the Latitude required.

But if the sliding-sight shall happen to

pass

pass beyond 00 on the loose peice, then whatsoever it is you must take it out of 30, and the remainder is the Latitude required.

Example.

Suppose on the 11th of *June* 1670 you were in the Latitude of 10 degres to the Northward, and standing with your back to the North, as you must needs do in all forward Observations in more Northern Latitudes, you shall find the sight to pass just 20 deg. beyond 00 on the Loose peice; therefore 20 taken from 30 the residue is 10, the Latitude required.

Again.

Suppose that in the same place you had obserеved on the 11th of *December*, when the Sun is most Southwards, if you set the one sight to 23-31 Southwards against the 11th of *December*; then if you observe forwards with your face toward the South, as before, you shall find the moving-Sight to stay at 20 degrees beyond 00 on the Loose-piece; then, I say, 20 taken from 30, rests 10, the Latitude required, because the sight passed beyond 30 on the Loose-piece.

Lastly, if the Moving-sight shall happen to pass above 30 degrees beyond 00 on the Loose-piece, when the other Sight is set to the Suns Declination, and you observe with your face toward the South (part of the Meridian); then, I ſay, the Latitude is Southwards as many degrees as the Moving-ſight ſtands beyond 30, on the Looſe-piece toward the Head-leg.

So that the general Rule is alwayes, in North Latitudes (obſerving the Suns Meridian Altitude, to find the Latitude, by a forward Obſervation, according to Mr. *Gunters Bow*), your face muſt be toward the South; Although that thereby in ſome Latitudes, the Altitude may ſeem to be (as indeed it is above the South-part of the Horizon) above 90 degrees.

Then,

If the ſliding-ſight ſtay any where on the Moving-leg, or Looſe-piece, ſhort of 00, add it alwayes to 30, and the ſum ſhall be the true Latitude North; if it paſs beyond 00, then ſo much as it doth, take out of 30, and the remainder is the Latitude North; but if it ſhall ſtay juſt at 30 on the Looſe-piece, then the Latitude is 00; but if it paſs beyond 30, then ſo much as it is, the Latitude is Southward.

The ſame Rule ſerves, if you were in South Latitude, then you muſt in forward Obſervations, to find the Latitude, as with a *Gunters Bov*, ſtand with your face to the

North,

North, and in ſetting the fixed-ſight to the Declination, you muſt count South Declination toward the Head; becauſe thoſe that have Southern-Latitude, have their longeſt dayes, when thoſe that live in Northern-Latitude have their ſhorteſt dayes.

The ſame Rule ſerves for the Stars alſo, for being in North-Latitudes; and obſerving a Latitude forwards, have your face alwayes toward the South, and ſet one Sight to the Declination, counting the Stars Northern or Southern Declination, the ſame way as the Suns,(and the contrary in South-Latitude); then holding your eye cloſe to the great-hole of the Turning-ſight, ſlide the Moving-ſight till its middle-bar or edge (as is moſt convenient) cuts the Star, and the other the Horizon; then whatſoever the edge of the Moving-ſight cuts ſhort of 0, added to 30, or beyond 00, taken out of 30, ſhall be the Latitude required.

Example.

Suppoſe the middle-Star of ***Orions-Girdle***, whoſe Declination is 1-28 South, being in the Meridian, I ſet one Sight to 1-28 of South-declination; and ſlipping the other-ſight till it cuts the Star, the fixed-ſight being ſet to the Horizon, you ſhall find it ſtay in the Latitude of 51-30, at 21-30 on the Moving-

Moving-leg, which added to 30, makes 51-30.

Note, That if the corner of the Inſtrument be inconvenient for the ſight to ſlide on, as for about 5 degrees it will, then you may remedy it by ſlipping the Sight ſet to the Declination 10 degrees more, any way that is convenient, increaſing or decreaſing; *But then note*, That inſtead of adding even 30, to what the Moving-ſight ſtayeth at, you muſt add 10 degrees more, *viz.* 40, when you ſlip it towards the end of the Moving-leg; or 10 degrees leſs, *viz.* 20 degrees, when you ſlip it 10 degrees more toward the Head, as is eaſie to conceive of.

Uſe VII.

To find the Latitude at Sea, by a backward Meridian Obſervation, according to the way of Mr. Gunter's *Bow.*

Skrew the Turning-ſight to the Leg-Center, and ſet the ſliding-Horizon-ſight to the Suns Declination (the middle or edge of it, as you can beſt like of) and the Shadow-ſight on the Looſe-piece, or Moving-leg, with your face alwayes to the North, in North Latitudes; or ſuppoſing your ſelf to be ſo, though it may be you are not.

Then,

Then looking through the hole in the Horizon-ſight (ſtanding at the Declination) and the Turning-ſight to the Horizon, with your hand gently ſlide the ſhadow-ſight till the ſhadow fall juſt on the middle of the Turning-ſight, as you do in obſerving the Altitude with a *Davis Quadrant*; then, I ſay, whatſoever the ſhadow-ſight ſhall ſtay at under 0, add to 30; or over 0, take out of 30, and the ſum or remainder, ſhall be the Latitude North: but if it happen to ſtay at juſt 30, the Latitude is 00; if beyond, it is ſo much to the Southwards: This is only the converſe of the former, and needs no *Example*, but a few words to demonſtrate it; which may be thus,

In the way of an Example.

Suppoſe that on the 11th of *December*, in ſayling toward the *Eaſt-Indies*, about the *Iſle of St. Matthews*, ſuppoſing our Ship to be in North-Latitude, I ſet the Horizon-ſight to 23-31, South Declination; and the Shadow-ſight on the Looſe-piece, then ſtanding with my face to the North, as another then would do, as at other times, and looking through the Horizon, and Turning-ſight to the North-part of the Horizon, I find the ſhadow-ſight when it playes well over the Turning-ſight, to ſtay at 33 degrees on the Looſe-piece.

Then,

Conſider that the diſtance between the wo Sigh ts, is the Altitude of the Sun above the South-part of the Horizon; which if you do count on the *Triangular-Quadrant*, you will find to be 36-29, and 33, which put together, make 69-29, for the Suns Meridian Altitude; to which if you add 23-31, his declination, it makes 93-00 the diſtance of the North-Pole and Zenith, or 3 degrees of South Latitude; for had you been juſt under the Equinoctial, the Altitude would be 66-30; or had you been more Northward, it would have been leſs; therefore by conſidering, you may ſoon ſee the reaſon of the Operation.

Alſo,

If the Shadow-ſight be too near the corner, or too far from the Turning-ſight to caſt a clear ſhadow; then, ſet the Horizon-ſight that ſtands at the Declination 10, 20, or 30 degrees more toward the end of the Moving-leg, and you ſhall ſee the inconvenience removed; but then you muſt take 10, 20, or 30 degrees leſs than the ſhadow-ſight ſheweth, for the reaſon aboveſaid.

The reaſon why even 30 is added, is be-

cauſe

cause that o degrees of Declination, stands at 60 on the Moving-leg, instead of 90, or 00.

Note, If you had rather move the lower-sight than the upper, then count like Latitudes and Declinations from 00 on the Loose-piece toward the Head-leg, and unlike the contrary, and then set the shadow-sight fixed there; then observing, as in a back-Observation, the Horizon-sight shall shew the complement of the Latitude required, without any adding of 30.

Thus you see, That the *Trianguler-Quadrant*, containing 180 degrees in a *Triangle*, brings the shadow-sight near the Center, and with one manner of figuring, gives the Suns Altitude above the Horizon, backwards or forwards, and his distance form the Zenith, and the Latitude of the place South or North, or North or South, backwards or forwards, by the Sun or Stars, by one side only, as conveniently and with fewer Cautions, and as exactly, if well used, as any other Instrument whatsoever; So that by this time you see it is a *Fore-staff*, *Quadrant*, and *Bow*. The other *Uses* follow.

Use VIII.

Uſe VIII.

To find the Latitude by a Meridian Obſervation, by the Thred and Plummet, by the Sun or Stars.

This way of Obſerving without a Horizon, muſt be done by an *Aſtrolabe*, which is a Plummet it ſelf, or elſe with a Plummet fitted to another Inſtrument, and at ſome times may do better ſervice than the Horizon, and for an Altitude barely, is ſhewed already.

For the Latitude thus;

Count the Declination, which is the ſame with the Latitude, from 00 on the Looſe-piece toward the Moveable-leg; and contrary Declinations, both of Sun or Stars, count the other-way toward the Head-leg, and thereunto ſet the edge of the Horizon-ſight, that hath the ſmall-hole on it.

Then let the Sun-beams ſhine through the ſmall-hole on the Turning-ſight, to the ſmall-hole on the Horizon-ſight, the Thred and Plummet duly playing, ſhall ſhew the Latitude of the place required.

But if you look at a Star, having the ſame Declination, then ſet your eye to the Horizon-ſight, and behold the Star through the Turning-ſight, and the Thred ſhall fall

on

on the Latitude required, when you look toward the South, being in Northern Latitudes.

So also, When you turn your face toward the North, in obſerving thoſe Stars, it is beſt done when they come to the Meridian below the Pole; but for their coming to the Meridian above the Pole, then their Declination is increaſed by the quantity of their diſtance from the Pole, or the complement of their Declination.

As thus;

The Declination of the Pole-Star, when in the Meridian below the Pole, is 87-20 from the Equinoctial; but when the ſame Star is on the Meridian above the Pole, then it is 92 deg. 40′ diſtant from the ſame Northern part of the Equinoctial.

So that if you make 60 on the moveable-leg, to repreſent the North-pole; then you may count or obſerve any Star that is 25 degrees diſtant from the Pole, both above or below the Pole; then adding 30 degrees to what the Thred falls on, ſhall be the true Latitudes complement required; becauſe you have removed the Pole from 90 to 60, 30 degrees backward.

Example.

Example.

The declination of the uppermoſt Star in the *great Bears back*, is 63-45; that is, 26-15 below the Pole; or, 25 degrees 17 minuts above the Horizon, when on the Meridian below the Pole; but the ſame Star, when on the South-part of the Meridian, is 77-47 above the Horizon, or 26-15 above the Pole.

Therefore,

The Star being below the Pole, you may ſet the hole in the middle of the Horizon-ſight, to the Declination, counting 90 the Pole, and looking up to the Star, as uſually, the Plummet will fall on 38-28, the Latitudes complement required.

Again,

The ſame Star being on the South-part of the Meridian, above the Pole, I count 60 on the Moving-leg for the Pole, and 26-15 beyond that Pole further, *viz.* to 86-15, which is as far as you can well go, counting 60 the Pole; then obſerving, as you did before, you ſhall find the Thred to play on 08-28, the Latitudes complement required, for the diſtance between 08-28, and 86-15 is 77-47, adding 30 degrees, becauſe of 60 inſtead of 90, for the Pole-point.

Note,

Note, That the Thred playing near the corner, may prove ſomewhat troubleſome to obſerve, without help of another perſon; but if you will be exact in this or any other Obſervation, a Staff and a Ball-ſocket, ſhould be applied to this, as well as to other Inſtruments, to ſtand ſteady and ſure in the time of Obſervation.

Theſe wayes are ready and eaſie, without taking notice of thoſe Regulations and Cautions, which are to be obſerved in finding the Altitude, barely, as in the *Seamans Kalender*, and Mr. *Wrights Errors in Navigation*, is plainly ſeen.

But if you know them all, and had rather uſe thoſe Rules in thoſe Books; then, I ſay, a Thred and Plummet by this Inſtrument, will do as conveniently as any other, or the three Sights and Horizon, as before is ſhewed, to find the Altitude.

CHAP.

CHAP. III.

To Rectifie the Table of the Suns Declination.

THus much as for the way of *Observation*; now, that your *Operation* may be true alſo, it is neceſſary that you have a *Table* of the Suns Declination, for the *firſt*, *ſecond*, and *third year*, after the *Leap-year*.

But in conſideration, that the *ſecond* after the *Leap-year*, is a mean between the other *three*; I have made a *Table* for that, and the Months on the *Triangular-Quadrant* are agreeable thereunto; and for the *firſt*, *third*, and *Leap-year*, have added a *Rectifying Table* to bring it to a minut at leaſt to the real truth, wherein I have followed the Suns place, according to Mr. *Streets* Table of the Suns place, for 1666.

In

In which *Table*, you have degrees and minuts; and a prick after, notes a quarter of a minut; and two pricks, half a minut; and three pricks, three quarters of a minut more.

Now, by the Rule, you may count to a minut, and the *Rectifying Table* tells you how many minuts more you must add to, or substract from the degrees and minuts the *Table* or *Rule* shall shew it is, in the *second year*.

A *Table*

A Table of the Suns Declination every day at Noon for London *in the year 1666, the second year after the Leap-year, according to Mr.* Street's *Tables of Longitude.* Calculated by *John Brown*, 1668.

Month Days.	Janu.	Febr.	March	April.	May.	June.
	D. M.	D.M.	D.M.	D.M.	D. M.	D.M.
1	21 45···	13 50··	03 29·	08 31·	18 02	23 11
2	21 36	13 30··	03 05··	08 53·	18 17·	23 14··
3	21 25··	13 10·	02 42	09 15·	18 32	23 18·
4	21 14··	12 49···	02 18·	09 36···	19 46···	23 21
5	21 03··	12 29	01 54···	09 58	19 01	23 23···
6	20 51	12 08·	01 31	10 19··	19 14···	23 26
7	20 40	11 47·	01 07	10 40···	19 28·	23 27···
8	20 27··	11 25···	00 43·	11 01	19 41·	23 29·
9	20 15	11 04·	S. 19···	11 22	19 54··	23 30·
10	20 01···	10 43	N. 04··	11 42···	20 07	23 30···
11	19 48·	10 21	00 27···	12 03	20 19	23 31
12	19 34··	09 59·	00 51··	12 23	20 31	23 30··
13	19 20·	09 37	01 15	12 43·	20 42··	23 30
14	19 06	01 15	01 38··	13 03	20 54	23 29
15	18 51	08 52	02 02··	13 22·	21 04·	23 27··
16	18 35···	08 29···	02 26	13 42	21 15·	23 15··
17	18 20·	08 07··	04 49·	14 01	21 25·	23 23
18	18 04	07 44···	03 13	14 20	21 35	23 20··
19	17 48	07 22	03 36	14 38·	21 44·	23 17·
20	17 31·	06 59	03 59··	14 57	21 53·	23 14
21	17 14··	06 36	04 22··	15 15	22 01···	23 10
22	16 57·	06 13	04 45··	15 33	22 10·	23 05··
23	16 40	05 50	05 08···	15 50···	22 17···	23 01
24	16 22·	05 26··	05 32	16 08	22 25·	22 55···
25	16 03···	05 03·	05 34··	16 25·	22 32··	22 50·
26	15 45	04 39···	06 17·	16 42	22 39	22 44
27	15 27	04 16·	06 40	16 58··	22 45··	22 37···
28	15 08	03 52··	07 02··	17 14··	22 51··	22 31
29	14 49		07 25	17 30···	22 57	22 23···
30	14 29··		07 47	17 47	23 02	22 16·
31	14 10·		08 09·		23 06··	

A Table of the Suns Declination every day at Noon, &c.

Month Days.	July.	Augu.	Septem	Octob.	Novem	Decem
	D. M.	D.M.	D.M.	D.M.	D.M.	D.M.
1	22 09	15 14.	04 26..	07 12..	17 37...	23 07.
2	22 00.	14 56	04 03...	07 35.	17 35...	23 12
3	21 51.	14 37..	03 40...	07 58...	18 10.	23 16
4	21 42..	14 19.	03 17.	08 20.	18 25..	23 19..
5	21 33	14 00...	02 54.	08 42..	18 41.	23 22.
6	21 23.	13 41..	02 31	09 04...	18 56.	23 25
7	21 13.	13 22.	02 08..	09 27	19 10...	23 27.
8	21 02..	13 03	01 44.	09 49	19 25.	23 28..
9	20 52	12 43.	01 20...	10 11	19 39.	23 30
10	20 41	12 23	00 57.	10 32..	19 53	23 30...
11	20 29.	12 02...	N 34	10 53...	20 06.	23 31
12	20 17.	11 43	N 10..	11 15.	20 19	23 30..
13	20 05	11 21..	S 13.	11 36.	20 31...	23 30
14	19 52...	11 02	00 36...	11 57	20 44	23 29
15	19 39..	10 41..	01 00...	12 18.	20 55...	23 27
16	19 26...	10 20..	01 24	12 38...	21 07	23 25.
17	19 13.	09 59.	01 47..	12 59.	21 18.	23 22.
18	18 59.	09 38	02 10...	13 20	21 28...	23 19..
19	18 44...	09 16...	02 34..	13 39...	21 38...	23 16
20	18 30.	08 55.	02 58	13 59.	21 48..	23 11...
21	18 15...	08 33..	03 21.	14 19	21 58	23 07..
22	18 00..	08 11..	03 44..	14 38	22 07	23 02..
23	17 45..	07 49...	04 08	14 57..	22 15..	22 57
24	17 29.	07 27..	04 31..	15 16	22 23..	22 51..
25	17 13..	07 05..	04 54..	15 35	22 31	22 44...
26	16 57	06 43	05 18	15 53.	22 38.	22 38
27	16 40..	06 20..	05 41	16 11.	22 45	22 30..
28	16 24	05 57..	06 04	16 29.	22 51..	22 23.
29	16 06..	05 35.	06 27	16 46...	22 57.	22 15
30	15 49.	05 12..	06 49..	17 03...	23 02..	22 05..
31	15 32			17 20.		21 57..

A *Rectifying Table of the minuts and quarters that are to be added or substracted from the fore-going Table of the Suns Declination, made for the second year after Leap-year, for every day at noon in the Meridian of* London.

M.	D.	1 year	3 year	L. year.	M.	D	1 year	3 year	L. year.
January.	05	ſ. 2..	a. 2...	a. 5...	*July.*	05	ſ. 2..	a. 2..	s. 05
	10	ſ. 3	a 3.	a. 6..		10	ſ. 3	a. 2...	s. 06
	15	ſ. 3..	a. 3..	a. 7		15	ſ. 3.	a. 3	s. 06...
	20	ſ. 4	a. 4	a. 8.		20	ſ. 3..	a. 3..	s. 07.
	25	ſ. 4..	a. 4.	a. 9..		25	ſ. 3...	a. 4	s. 08..
	30	ſ. 4...	a. 5.	a. 9...		30	ſ. 4	a. 4.	s. 09.
February.	05	ſ. 5	a. 5..	a. 10	*August.*	05	ſ. 4.	a. 4..	s. 09...
	10	ſ. 5.	a. 5..	a. 10.		10	ſ. 4..	a. 4...	s. 10
	15	ſ. 5..	a. 5...	a. 10..		15	ſ. 5	a. 5	s. 10..
	20	ſ. 5...	a. 5...	a. 10..		20	ſ. 5.	a. 5.	s. 11
	25	ſ. 5...	a. 5...	a. 11		25	ſ. 5..	a. 5.	s. 11.
	28	ſ. 6	a. 5...	a 11..		30	ſ. 5...	a. 5..	s. 11..
March.	05	ſ. 6.	a 5..	ſ. 12	*September.*	05	s. 5...	a. 5...	s. 11...
	10	a. 6..	ſ 5..	a. 12..		10	s. 5...	a. 5...	s. 12
	15	a. 6.	ſ 5.	a. 12		15	a. 6..	s. 6..	a. 12.
	20	a. 5..	ſ. 5.	a. 11...		20	a. 6..	a. 5...	a. 12..
	25	a. 5...	ſ. 5	a. 11..		25	a. 5...	s. 5	a. 11
	30	a. 5...	ſ. 4...	a. 11.		30	a. 5..	s. 4...	a. 11..
April.	05	a. 5..	ſ. 4...	a. 11	*October.*	05	a. 5..	a. 4..	a. 11..
	10	a. 5..	ſ. 4..	a. 10..		10	a. 5.	s. 4...	a. 11
	15	a. 5...	ſ. 4..	a. 10		15	a. 4...	s. 5	a. 10..
	20	a. 5	ſ. 4..	a. 09		20	a. 4...	s. 5...	a. 10
	25	a. 4...	ſ. 4...	a. 08		25	a. 4...	s. 5.	a. 09..
	30	a. 4..	ſ. 4	a. 07...		30	a. 4..	s. 4..	a. 09
May.	05	a. 3..	ſ. 3..	a. 7	*November.*	05	a. 4	s. 4	a. 08
	10	a. 3	ſ. 3	a. 6		10	a. 3	s. 3..	a. 07
	15	a. 2...	ſ. 2	a. 5..		15	a. 2..	s. 3.	a. 06
	20	a. 2	ſ. 1...	a. 4		20	a. 2	s. 2..	a. 05
	25	a. 1..	ſ. 1..	a. 3		25	a. 1...	s. 2	a. 03..
	30	a. 1	ſ. 1	a. 2		30	a. 1..	s. 1..	a. 02
June.	05	a. 0..	ſ. 0...	a. 1	*December.*	05	a. 1	s. 0...	a. 01..
	10	a. 0	ſ. 0..	a. 0		10	a. 0	s. 0	a. 00.
	15	ſ. 0..	a. 0	ſ. 0..		15	a. 0.	a. 0.	s. 01
	20	ſ. 1	a. 1	ſ. 2		20	s. 0..	a. 1.	s. 02
	25	ſ. 1..	a. 1.	ſ. 3		25	s. 0...	a. 1..	s. 03
	30	ſ. 1...	a. 1..	ſ. 4		30	s. 1	a. 2	s. 04...
		1665 1669 1673	1667 1671 1675	1668 1672 1676	For these years,		1665 1669 1673	1667 1671 1675	1668 1672 1676

A Table of the Magnitudes, Right Ascention in Hours and Minuts, and Degrees and Minuts, and the Declination North or South of 33 fixed Stars.

N.	*Names of the Stars.*	M.	R. Asc. D.	R. Asc. M.	R. Asc H	R. Asc M.	Decli. D	Decli. M.	N. S.
01	Pole-Star, or last in little Bear.	2	7	53	0	32	87	33	N.
02	Andromedas Girdles	2	12	31	0	50	33	50	N.
03	Medusaes head	3	41	27	2	46	39	35	N.
04	Perseus right side	2	44	30	2	58	48	33	N.
05	Middle of the Pleides	5	51	22	3	26	23	06	N.
06	Bulls eye	1	64	0	4	16	15	48	N.
07	Hircus or Goat	1	72	44	4	51	45	36	N.
08	Orions left foot	1	74	30	4	58	8	38	S.
09	Mid-star in Orions Girdle	2	79	45	5	19	1	28	S.
10	Orions right shoulder	2	84	5	5	36	7	18	N.
11	Auriga, or Waggoner	2	84	45	5	39	44	56	N
12	Great Dog	1	97	24	6	30	16	13	N.
13	Castor, or Apollo	2	108	00	7	12	32	30	N.
14	Little Dog	1	110	20	7	21	6	6	N.
15	Pollux, or Hercules	2	110	25	7	22	28	48	N.
16	Hydraes heart	1	137	36	9	10	7	10	S.
17	Lyons heart	1	147	30	9	50	13	39	N
18	Great Bears fore-guard	2	160	48	10	43	63	32	N
19	Lyons tayl	1	172	45	11	31	16	32	N.
20	Virgins Spike	1	196	43	13	07	9	11	N.
21	Last in great Bears tayl	2	203	36	13	34	51	5	N.
22	Arcturius	1	209	56	14	00	21	4	N.
23	Little Bears fore-guard	2	222	46	14	52	75	36	N.
24	Brightest in the Crown	3	231	00	15	24	27	43	N.
25	Scorpions heart	1	243	23	16	09	25	37	S.
26	Hercules head	3	254	40	16	59	14	51	N.
27	Lyra, or Harp	1	276	17	18	25	38	30	N.
28	Eagle, or Vulture	1	293	28	19	35	8	1	N.
29	Swans tayl	2	307	30	20	30	44	5	N
30	Dolphins head	3	307	53	20	32	15	0	N.
31	Pegassus mouth	1	321	50	21	27	8	19	N
32	Fomahant	3	339	30	22	38	31	17	S.
33	Pegassus lower wing	2	358	50	23	55	13	22	N

As for Example.

To find the Suns Declination for the year 1670, on the 12th day of *May*: First, if you divide 70 (being the tens only of the year of our Lord by 4, rejecting the 100's) you shall find 2, as a remainder, which notes it to be the second after Leap-year; and if 0 remain, then it is Leap-year.

Then,

Look in the Table of Declination for 1666, the second after Leap-year, as the year 1670 is, and find the Month in the head of the Table, and the day on one side, and in the meeting-point you shall find 20 deg. 31 min. for the Declination on that day at noon required.

Or,

If you use the *Trianguler Quadrant*, extend the Thred from the Center over the 12th of *May*, and you shall find it to cut in the degrees just 20 deg. 31 min. the true Declination for that year and day.

Note, That if you have occasion to use the Declination before noon, then observe that the difference between stroke and stroke, is the difference of Declination for one day; and by consequence, one half of that

that ſpace for half a day; and a quarter for a quarter of a day, &c.

As thus for Example.

Suppose I would have the Suns Declination the 18th of *August* 1666, at 6 in the morning; here you muſt note, that the 18th ſtroke from the beginning of *August*, repreſents the 18th day at noon juſt.

Now the time required being 6 hours before noon, Lay the Thred one fourth part of the diſtance for one day, toward the 17th day, and then in the degrees, the Thred ſhall cut on 9-43′, whereas at noon juſt, it will be but 9-38 ; and the next, or 19th day at noon, it is 9 degrees 16 min. and 3 quarters of a min. as the three pricks thus ... in the Table doth plainly ſhew; but by the Rule, a minut is as much as can be ſeen, and ſo near with care may you come.

Note alſo farther,

That if you ſhall uſe it in places that be 4 hours, 6 or 8, 10 or 12 hours more Eaſtward, or Weſtward in Longitude, the ſame Rule will tell you, the minuts to be added in Weſtern-Longitudes, or to be ſubſtracted in Eaſtern-Longitudes, as Reaſon and Experience will dictate unto you with due conſideration.

As for Example.

To find the Suns Declination for the year 1670, on the 12th day of *May*: First, if you divide 70 (being the tens only of the year of our Lord by 4, rejecting the 100s) you shall find 2, as a remainder, which notes it to be the second after Leap-year; and if o remain, then it is Leap-year.

Then,

Look in the Table of Declination for 1666, the second after Leap-year, as the year 1670 is, and find the Month in the head of the Table, and the day on one side, and in the meeting-point you shall find 20 deg. 31 min. for the Declination on that day at noon required.

Or,

If you use the ***Trianguler Quadrant***, extend the Thred from the Center over the 12th of *May*, and you shall find it to cut in the degrees just 20 deg. 31 min. the true Declination for that year and day.

Note, That if you have occasion to use the Declination before noon, then observe that the difference between stroke and stroke, is the difference of Declination for one day; and by consequence, one half of

that

that ſpace for half a day; and a quarter for a quarter of a day, &c.

As thus for Example.

Suppoſe I would have the Suns Declination the 18th of *Auguſt* 1666, at 6 in the morning; here you muſt note, that the 18th ſtroke from the beginning of *Auguſt*, repreſents the 18th day at noon juſt.

Now the time required being 6 hours before noon, Lay the Thred one fourth part of the diſtance for one day, toward the 17th day, and then in the degrees, the Thred ſhall cut on 9-43′, whereas at noon juſt, it will be but 9-38; and the next, or 19th day at noon, it is 9 degrees 16 min. and 3 quarters of a min. as the three pricks thus ... in the Table doth plainly ſhew; but by the Rule, a minut is as much as can be ſeen, and ſo near with care may you come.

Note alſo farther,

That if you ſhall uſe it in places that be 4 hours, 6 or 8, 10 or 12 hours more Eaſtward, or Weſtward in Longitude, the ſame Rule will tell you, the minuts to be added in Weſtern-Longitudes, or to be ſubſtracted in Eaſtern-Longitudes, as Reaſon and Experience will dictate unto you with due conſideration.

For if being Eaſtwards, the Sun comes to the Meridian of that place before it comes to the Meridian of *London* ; then lay the Thred as in morning hours : But if the place be to the Weſtwards where it comes later, then lay the Thred ſo many hours beyond the Noon-ſtroke for *London*, as the place hath hours of Weſtern-longitude more than *London*, counting 15 degrees for an hour, and 4 minuts for every degree ; and then ſhall you have the Declination to one minut of the very truth.

But if it happens to be the Leap-year, or the firſt or third year after the Leap-year, then *thus* ;

Suppoſe for the 5th of *October* 1671, being the third after Leap-year, I would have the Declination.

Firſt, if you lay the Thred over the 5th of *October*, in the degrees, it gives 08 deg. 42 minuts .. , for the Declination in the ſecond year after Leap-year ; then, becauſe this is the third year, look in the *Rectifying-Table* for the 5th of *October*, and there you find *s*. 4 .., for ſubſtract 4 minuts and a half from 8-42 .. reſts 8-38, the true declination required for the 5th of *October* 1671. The like work ſerves for any other day or year ; but for every 5th and 10th

day,

day, you have the Declination ſet down in a *Table* for all 4 years, to prove and try the truth of your Operations; and by that, and the Line of Numbers, or the Rule of Three, you may continue it to every day by this proportion.

As 5 dayes, or 120 hours, to the difference of Declination in the *Table*, between one 5th day and another;

So is any part of 5 dayes, or 120 hours, to the difference in Declination to be *added* or *ſubſtracted* to the 5 dayes Declination immediately fore-going the day required.

Example.

Suppoſe for the 18th of *February* 1669, the firſt after Leap-year, I would know the Declination by the *Table* made to every 5th day only; On the 20th of *February*, I find 6-53 ½; On the 15th day, 8-47; the difference between them is 1-53 ½; then the Extent of the Compaſſes from 5, the Number of dayes, to 1-53 .. the minuts difference (counted properly every 10th for 6 minuts) ſhall reach from 3, the dayes from 15 toward 18, to 1 degree 7 minuts and a half, which taken from 8-47′, the Declination for the 15th day, leaves 7 degrees 38 minuts and a half, the true Declination

nation for the 18th day of *February*, in the first after Leap-year.

Or, by the Line of Numbers thus;

The Extent from 5, the difference in dayes, to 113 ½, the difference in min. for 5 dayes, shall reach from 3, the difference in dayes, to 68, the difference in minuts for 3 dayes, to be added or substracted, according to the increasing or decreasing of the Declination at that time of the year.

Proved thus;

If you substract 5′ ½ from 7 deg. 44… the declination in the second year, there remains 7 deg. 38′ ½, the Declination for the 18th of *February*, 1669.

These *Tables* may serve very well for 30 years, and not differ 6 minuts in Declination about the Equinoctial, where the difference is most; and in *June* and *December* not at all to be perceived.

Thus you may by the *Rule* and *Rectifying Table*, find the Suns Declination to a minut at any time, without the trouble of Calculation.

CHAP.

CHAP. IV.

The use of the Trianguler-Quadrant in the Operative part of Navigation.

Use I.

To find how many Leagues, or Miles, answer to one Degree of Longitude, in any Latitude between the Equinoctial and Pole.

FIrst, it is convenient to be resolved how many Leagues or Miles are in one Degree in the Meridian or Equinoctial, which Mr. *Norwood* and Mr. *Collins* hath stated about 24 leagues, or 72 miles.

Or.

If you keep the old number, making the miles greater, *viz.* 60 miles, or 20 leagues; then the proportion, by the Numbers, Sines and Tangents, runs *thus*;

As

As Sine 90, to 20 on the Numbers for leagues;
So is Co-ſine of the Latitude, to the leagues, on the Numbers, contained in one degree of Longitude in that Latitude.

But in Miles, to have the Anſwer, work thus;

As Sine 90, to 60 on Numbers;
So Co-ſine Latitude, to the number of miles.

Example, Latitude $51^{\circ}\ 32'$.

As Sine 90, to 60;
So Sine 38-28, to 37 miles $\frac{30}{100}$.

But by the Triangular-Quadrant, or Sector, work thus;

Take the latteral 20 for leagues (or 60 for miles) from the Line of Lines from the Center downwards; and make it a parallel in the ſine of 90, laying the Thred to the neareſt diſtance.

Then,

The neareſt diſtance from the Co-ſine of the Latitude, to the Thred, meaſured latterally from the Center, ſhall ſhew the true number of Leagues required.

Example.

Example, Latitude 51° 32′;

As — 60, to = fine of 90;
So = fine of 38-28, to — 37-30, on the Lines.

As — 20, to = fine of 90;
So is = fine of 38-28, to — 12-40 for Leagues.

Or,

As — 24, to = fine of 90;
So is = fine of Co-lat. to — 15, the number of Leagues, after the experiment made by Mr. *Norwood*, of which true meaſure you may read more in the *Second Part* of the *Plain Scale*, by Mr. *Collins*.

Or,

If you multiply the Natural Sine of the Co-lat. by 2, it gives the Leagues; or by 6, it gives the Miles in one degree, cutting off the Radius from the Product.

Note alſo, That if you take the Natural-Number of the Secant of the Courſe or Rumb, and multiply it by 2, cutting off the Radius from the Product, it ſhall give the Leagues required, to raiſe one degree, at the rate of 20 Leagues to one Degree of a great Circle.

Use II.

To find how many Leagues, or Miles, answer to Raise, or to Depress the Pole one degree on any Rumb from the Meridian.

First, by the Artificial Sines, Tangents, and Numbers.

As the Co-sine of the Rumb from the Meridian, to 20 Leagues (or 24 Leagues) on the Numbers;
So is the sine of 90, to the number of Leagues required.

Which, when you have sayled on that Rumb, you shall raise or depress the Pole one degree.

But by the Trianguler-Quadrant, thus;

As — 20, taken from the Line of Lines, or any equal parts, to the = Co-sine of the Rumb, laying the Thred to the nearest distance.
So is the = sine of 90, or nearest distance from sine 90, to the Thred, to — Number of Leagues required, to sayl on that Rumb, and to raise the Pole one degree.

Use III.

To find how many Miles or Leagues answer to any number of degrees in any parallel of Latitude.

Suppose you sayling in the Latitude of 48 degrees, have altered your Longitude 30 degrees, and would then thereby know how many leagues you had sailed.

First, bring (or reduce) the 30 degrees to Leagues, by multiplying them by 20, or 24, (the leagues resolved to be in one degree) which makes 600, (or 720).

Then by the Numbers and Sines.

The Extent from the sine of 90, to 42 the Co-sine of the Latitude, shall reach the same way, from 600 on the Numbers, to 400 the leagues required; or from 720, to 480, according to Mr. *Norwood.*

By the Triangular-Quadrant.

Take — 600 from the Line of Lines, or any equal parts, and make it a = in the sine of 90, laying the Thred to the nearest distance.

Then,

The nearest distance from the sine of 42,

(the

(the Co-ſine of the Latitude to the Thred) and it ſhall give 400 on the Lines, or equal parts, the leagues required.

Which is thus more briefly ;

As — 600, to = ſine 90 ;
So is = ſine 42, to — 400, as frequently before.

Uſe IV.

To work the ſix Problems of Plain Sayling by Gunter's *Lines on the edge, or the Trianguler-Quadrant.*

Note, That in this *Art of Navigation,* or *Plain Sayling,* that the Angle that any degree of the Quadrant, or Point of the Compaſs makes with the Meridian, or North and South-line, that is called the Rumb or Courſe.

But the Angle that it maketh with the Eaſt and Weſt-line, or parallel, is called the complement of the Rumb or Courſe.

Note, That in plain Triangles, the Sines and Tangents give Angles, and the Numbers give Sides.

Note alſo, That in *Plain Sayling,* the diſtance run, or Courſe, is the ſame with the Hypothenuſa in plain Triangles.

Alſo

Also note, That the difference of Latitude is counted on the Meridian, and the difference of Longitude or Departure from the Meridian, is counted on the Equinoctial, or on a Parallel of Latitudes.

One of which Lines, in plain Triangles, is called the Base; and the other, the Perpendiculer. The Base being a sine, and the Perpendiculer a sine complement.

Note also, That in North Latitude, Sailing Southerly, the Latitude doth decrease; therefore you must substract the difference in Latitude, from the Latitude you parted from; but if you sayl Northerly, then you must add it to the Latitude you parted from: The like in South Latitudes.

But when one Latitude is South, and the other North, then you must add them both together.

Note also, That the difference in Latitude and Longitude, (and Departure) when given in degrees, are to be reduced to Leagues, by multiplying by 20, and counted alwayes on the Line of Numbers, or equal-parts, when you use the *Trianguler-Quadrant*.

So then in using the *Index* and *Square* in Plain Sailing, the distance sayled, is alwayes counted on the *Index* from the Center.

The Courſe is counted on the degrees from the Head toward the Looſe-piece.

The Difference of Latitude on the Head-Leg, from the Leg-center to the Head.

The Departure or Longitude, is counted on the Square.

The complement of the Courſe or Rumb is counted on the degrees, beginning at 00 on the Looſe-piece.

When your number of Leagues exceed 100, you muſt double the Numbers on the Index, the Square, and Head-leg, or count 10 for a 100, &c.

Problem I.

The Courſe, and Diſtance run on that Courſe, being given, to find the difference in Latitude, and Departure, or difference in Longitude.

As ſine of 90, to the diſtance run (or Leagues ſayled) on the Line of Numbers;

So is Co-ſine of the Courſe or Rumb, to difference in Latitude on the Numbers.

Again, for the Longitude or Departure.

So is the ſine of the Courſe, to the Departure, or difference in Longitude.

By

By the Trianguler-Quadrant.

As — Leagues ſailed, to = ſine 90, laying the Thred to the neareſt diſtance ;
So = Co-ſine of the Rumb or Courſe, to — difference in Latitude. *Or,*
So is = ſine of the Rumb or Courſe, to = Departure, or difference in Longitude.

By the Index and Square, after the manner of a Synical Quadrant, thus ;

Set the Index (being put over the Leg-Center-pin) to the Courſe counted on the degrees from the Head, toward the Looſe-piece.

Then ſlide the Square perpendiculer to the Head-leg, till the divided edge thereof cuts the diſtance run on the Index ; then ſhall the Index, on the Square, give the Departure or Difference in Longitude ; and the Square on the Head-leg, ſhall ſhew the Difference in Latitude.

Problem II.

The Course and Difference of Latitude given, to find the Distance run, and Departure.

As Co-sine of Course, to the Difference in Latitude ;
So is sine 90, to the Distance run.

Then,

As sine of 90, to the Distance run ;
So is sine of Course, to the Departure.

By the Triangular-Quadrant, without the Square.

As — difference of the Latitude, to = Co-sine of the Course ;
So = sine 90, to — distance run.
So is = sine of the Course, to the Departure.

With the Index and Square, thus ;

Set the Index to the Course, and the Square to the difference in Latitude ; then on the Index, is cut the Distance ; and on the Square, the Departure.

Problem III.

Problem III.

The Courſe and Departure given, to find the diſtance run, and difference of Latitude.

As ſine Courſe, to the departure on Numbers;
So is ſine 90, to the diſtance.

Again,

As the ſine 90, to diſtance run;
So is Co-ſine Courſe, to difference in Latitude.

By the Triangular-Quadrant.

As — Departure taken from any fit Scale, to = Co-ſine of the Courſe;
So is = ſine 90, to — diſtance run on the ſame Scale.
So is = ſine of the Courſe, to the difference in Latitude.

With the Index and Square.

Set the Index to the Courſe, and ſlide the Square perpendiculer to the head-leg, till the Index cuts the departure on the Square; then the Index ſheweth the Diſtance, and the Square the Latitude on the Head-leg, counting from the Center.

Problem IV.

The Diſtance run, and difference in Latitude given, to find the Courſe and Departure.

As the Leagues run, to ſine 90;
So the difference in Latitude, to Co-ſine Courſe.

Again,

As ſine 90, to the diſtance run;
So is ſine of the Courſe, to the Departure.

By the Trianguler-Quadrant.

As — Radius, or a ſmall ſine of 90, to = diſtance run on the Line of Lines;
So is = difference in Latitude, to Co-ſine of the Courſe, meaſured on the ſmall Sine.
So is — ſine of the Courſe, to the = departure, carried = in the Lines.

By the Index and Square.

Set the Square to the difference in Latitude, and move the Index till the Square cuts the diſtance run on the Index; then ſhall the Index ſhew on the Square, the Departure; and on the Degrees, the Courſe required.

Problem V.

Problem V.

The Distance run, and Departure given, to find the Course and Difference in Latitude.

As the Distance run, to sine 90 ;
So is the Departure, to sine of the Course.

Then,

As sine 90, to the Distance run ;
So is Co-sine Course, to the Difference in Latitude.

By the Trianguler-Quadrant.

As — distance run, to = sine 90 ;
So — departure, to = sine of the Course.
So is = Co-sine Course, to — difference in Latitude.

By the Square and Index.

Slide the Square and Index, till the Index cuts the Departure on the Square, and the Square cuts the Distance run on the Index ;

Then,

On the Degrees, the Index shall shew the Course ; and on the Head-leg, the Square shall shew the difference in Latitude.

Problem VI.

The Difference of Latitude, and the Departure given, to find the Course and Distance run.

As the Difference in Latitude, to 45 degrees;
So the Departure, to the Tangent of the Course.

Again,

As sine Course, to the Departure;
So is sine 90, to the Distance run.

By the Trianguler-Quadrant.

As — Radius, or Tangent of 45, to = Difference in Latitude;
So is = Departure, to — Tangent of the Course on the Loose-piece from whence you took 45.

Then,

As — Departure, to = sine of the Course;
So is = 90, to — Distance run.

By the Index and Square.

Set the Square to the Difference in Latitude, on the Head-leg, counted from the Center; and bring the Index to cut the Departure

Departure on the Square; then the Square on the Index ſhews the diſtance; and the Index, on the degrees, gives the Courſe required.

In all theſe 6 *Problems*, which Mr. *Gunter* makes 12 *Problems*, of *Plain Sayling*, I have ſet no *Example*, nor drawn no figure, becauſe the way by the Index and Square is ſo plain; and of it ſelf makes a figure of the work: For the Index is alwayes the Diſtance run, the Hypothenuſa, or Secant: The Square ſheweth the Departure; and the Line of Lines on the Head-leg, the difference of Latitude: And you may not only perform the work, but alſo ſee the reaſon thereof, being a help to the fancy of young Learners in theſe Nautical Operations: And if your Square playes true, you may be more exact than you can by Scale and Compaſs, and much more quick and ready; not only in this, but any thing elſe in right-Angled plain Triangles, as in Heights and Diſtances, and the like.

Uſe V.

The uſe of the Meridian Line, and his Scale.

Theſe ſix Problems of *Plain Sayling for*

ſhort

ſhort Diſtances, may come very near the matter; as in making a Traverſe of the Ships way from place to place Coaſting, as in the Streights, and the Channel, and the like: But for *great Diſtances*, it is not ſo certain as the Sayling by *Mercators Chart*; therefore to that purpoſe the Meridian-line was invented, to reduce degrees on the Globe, to degrees in *Plane*, as Mr. *Wright* hath largely ſhewed.

On the innermoſt-edge of the Rule, or Trianguler-Quadrant, you may have a Meridian-line ſo large, as to have half an inch for one degree of the Equinoctial; and the inches for meaſure, to go along by it; or rather you may have it lie near to the Line of Lines on the Head-leg, as you ſhall think moſt convenient, for then it will be the ſame as Mr. *Gunter*'s is, and perform his very Operations, as near as may be, after his way, by the Thred and Compaſſes, or Index and Compaſſes.

Problem I.

Problem I.

Two places being propounded, one under the Equinoctial, the other in any Latitude, to find their Meridional difference in degrees and minuts, or 100 parts.

Look for the Latitude of the place, scituate out of the Equinoctial in the Meridian-line, and right against in the equal-parts is the Meridional difference of those two places.

Example.

Let the River of *Amazones*, under the Equinoctial, be one place ; and the *Lizard*, in the Latitude of 50 degrees North, another place ; look for 50 on the Meridian-line, and right against it, on the equal-parts, is 57-54, for 57 degrees 54 minuts ; or in Decimal parts of a degree 57-90.

Problem II.

Any two places having both Southerly or Northerly Latitude, to find the Meridional difference between them.

Extend the Compasses on the Meridian-line, from one of the Latitudes to the other ; the same Extent laid from the beginning of the

the Scale of equal-parts, by the Meridian-line, ſhall reach to the Meridional difference required.

Or,

The meaſure from the leaſt Latitude, to the beginning on the Meridional-line, ſhall reach the ſame way from the greater, to the difference on the equal-parts.

Example.

If the Latitude of one place be 30 degrees, and the other 50 degrees; Extend the Compaſſes from 30 to 50 on the Meridian-line, and that Extent ſhall reach on the equal-parts, from the beginning of the Line, to 26 degrees 26 minuts.

Problem III.

When one place hath South Latitude, and the other North Latitude, to find the Meridional difference.

Extend the Compaſſes from the beginning of the Line of Meridians, to the leſſer Latitude; then that Extent applied the ſame way on the Meridian-line from the greater Latitude, ſhall ſhew on the Scale of equal-parts the Meridional difference required.

Example.

Example.

Suppose one Latitude be 10 deg. South, and the other 30 deg. North; The Extent from 0 to 10 degrees, shall reach from 30, to 41° 31′, the Meridional degrees required.

Problem IV.

The Latitudes of two places, together with their difference in Longitude being given, to find the Rumb directing from one to the other.

As the Meridional difference in Latitude, to the difference in Longitude;
So is the Tangent of 45, to the Tangent of the Rumb or Course.

Example.

Let one place be in the Latitude of 50 North, the other in 15 deg. and 30 min. North, as the *Lizard-point*, and *St. Christophers*; and let the difference in Longitude be 68 degrees, 30 minuts; and let the Rumb, leading from the *Lizard* to *St. Christophers*, be required.

First, by the Meridian-line, and the Scale of Equal-parts, by *Problem* II. find the Meridional difference in Latitudes, which in our *Example* will be 42 degrees, and 12 parts of a 100.

Then,

Then,

The Extent on the Line of Numbers, from 42 degrees and 12 minuts, the Meridional difference in Latitude, to 68 degrees and 50 minuts, the difference in Longitude shall reach the same way from the Tangent of 45, to the Tangent of 58 degrees and 26 minuts, the Rumb from the Meridian of the *Lizard* Westwards, being two degrees, and better, beyond the 5th Rumb from the Meridian.

By the Triangular-Quadrant thus ;

As the — Tangent of 45, taken from the Loose-piece, is to the = Meridional-difference in Latitudes on the Line of Lines ;

So is the = difference in Longitudes, to the — Tangent of the Course 58 degrees 25 minuts.

But by the Index and Square, this is wrought very easily and demonstratively thus ;

Count the Meridional difference of Latitudes on the Head-leg down-wards from the Center, as 42 and 12 on the Line of Lines, and set the Square to it.

Then,

Then,

Count the difference of Longitudes on the Square, *viz.* 68-50, and to that Point lay the Index; and then the Index on the degrees ſhall cut the complement of the Courſe, *viz.* 31-35, or 58-25, if you count from the Head.

Having been ſo large in this, I ſhall contract the reſt.

Problem V.

By the two Latitudes and the Rumb, to find the Diſtance on the Rumb.

As the Co-ſine of the Rumb, to the true difference of the Latitudes, (on the Numbers);

So is the ſine of 90, to the diſtance on the Rumb required, (on the Numbers).

Being given in degrees and Decimal parts, and brought to Leagues by multiplying by 20, or 24, according to Mr. *Norwood*, as before.

Note alſo, That the true difference of Latitudes, is found by Subſtraction, of the leſs Latitude out of the greater.

By

By the Quadrant.

As — true difference of Latitudes, to
= Co-ſine of the Courſe or Rumb ;
So is = ſine of 90, to — diſtance on
the Rumb (in the ſame Line of Lines).

The Index and Square is uſed as in the ſecond Problem of *Plain Sayling.*

Problem VI.

By the two Latitudes, and diſtance between two places given, to find the Rumb.

As the diſtance ſayled, in the degrees and 100 parts, counted on the Lins of Numbers, is to the true difference of Latitudes, found as before, by Subſtraction ;
So is the ſine of 90, to the Co-ſine of the Rumb required.

As — ſine of 90, to = diſtance ſailed ;
So is = difference of Latitudes, to — Coſine of the Courſe.

By the Index and Square, work as in Problem IV. of *Plain Sayling.*

Problem VII.

Both Latitudes and the Rumb given, to find the difference of Longitude.

As the Tangent of 45, to the Tangent of the Rumb;
So is the Meridional difference of Latitudes, to the difference of Longitude required.

As — Tangent of 45, to = Tangent of the Rumb, (first laid on the Lines from the Loose-piece);
So is the — Meridional difference of Latitudes, to the difference of Longitudes.

By the Index and Square, work as in the 4th Problem last past.

Problem VIII.

By one Latitude, Distance and Rumb, to find the other Latitude.

As sine 90, to the Co-sine of the Rumb;
So is the distance, to the true difference of Latitude.

As — Co-sine of the Course, to = sine 90;
So is = distance, in degrees and parts, on the Lines, to the — true difference in Latitudes, to be added or substracted from the Latitude you are in, according as you

have increaſed, or depreſſed the Latitude in the Voyage.

By the Index and Square, work as in the 5th Problem laſt paſt, or 2d of *Plain Sayling*.

Uſe VI.

To find the diſtance of places on the Globe of Earth and Sea; Or, Geography by the Triangular-Quadrant.

Problem I.

When two places are ſcituated under the ſame Meridian (or Longitude) and on the ſame ſide of the Equinoctial; then ſubſtract the leſſer Latitude out of the greater, and the remainder ſhall be the diſtance in degrees required, counting 20 (or 24) Leagues to a degree on every great Circle of the Sphear.

Problem II.

When one place is on one ſide of the Equinoctial, and the other on the other ſide; and yet both on one Meridian, as was the former; then the two Latitudes (*viz.* the North-latitude, and the South-latitude) added together, ſhall give the diſtance in degrees required.

Problem III.

Problem III.

When the two places differ only in Longitude, and are both under the Equinoctial, then substract the lesser Longitude from the greater, and the residue is the distance in degrees.

Problem IV.

When the two places have both one Latitude, or near it, North or South, and differ only in Longitude.

Then work thus;

As sine 90, to Co-sine of the (middle) Latitude;
So is the sine of half the difference in Longitude, to the sine of half the distance.

By the Triangular-Quadrant, or Sector.

As — Co-sine of the mean Latitude, to the = sine of 90, laying the Thred to the nearest distance;
So is = sine of half the difference in Longitude, to — sine of half the distance.

Problem V.

When both places have different Longitudes and Latitudes, as these Three Wayes following.

I Way.

When one place hath no Latitude, and the other North or South, with difference in Longitude also; then,

As ſine 90, to Co-ſine of difference in Longitude;
So the Co-ſine of the Latitude, to the Co-ſine of the diſtance required.

By the Triangular-Quadrant, thus;

As — Co-ſine of difference in Longitudes, to the = ſine of 90;
So the = Co-ſine of the Latitude, to the = Co-ſine of the diſtance.

II Way.

When both the places have either North or South Latitude, that is, both toward one Pole; then thus,

As the ſine of 90, to the Co-ſine of the difference in Longitude;
So the Co-tangent of the leſſer Latitude, to Tang. of a 4th Ark.

Which 4th Ark, muſt be taken out of the complement of the greater Latitude, when the difference of Longitudes is leſs than a Quadrant, or added to it when more, then the

the ſum or difference ſhall be a 5th Ark.

Then,

As the Co-ſine of the 4th Ark, to Co-ſine of the 5th Ark;
So is the ſine of the leſſer Latitude, to the ſine of the diſtance.

By the Triangular-Quadrant.

As — Co-ſine of difference in Longitudes, to = ſine of 90;
So is the = Co-tangent of the leſſer Latitude, taken from the Looſe-piece, and laid from the Center, and from thence taken parallelly to the — Tangent of a 4th Ark, which do with, as before is ſhewed, to find a 5th Ark.

And then,

As the — Co-ſine of the 4th Ark, to the = Co-ſine of the 5th Ark;
So is the — ſine of the leſſer Latitude, to = Co-ſine of the diſtance.

III Way.

But when one Latitude is on one ſide the Equinoctial, and the other on the other-ſide, viz. *one having North-latitude, and the other South. Then,*

As the ſine of 90, to the Co-ſine of the difference in Longitude;

So is the Co-tangent of one Latitude, to the Tangent of a 4th Ark.

Which taken out of the other Latitude, and 90 deg. added, when the difference of Longitude is less than a Quadrant, but added to it if more than a Quadrant, and that sum or difference shall be the 5th Ark,

Then,

As the Co-sine of the 4th Ark, to the Co-sine of the 5th Ark;
So is the sine of the Latitude, first taken, to the Co-sine of the distance in degrees.

By the Trianguler-Quadrant, or Sector;

As the — Co-sine of the difference of Longitudes, to = sine of 90;
So the = Co-tangent of one Latitude (being first taken from the Loose-piece, or Moveable-leg, and laid from the Center downwards, and from thence taken parallelly) to the — Tangent of a 4th Ark.

Which 4th Ark you must do with, as before, to obtain a 5th Ark.

Then,

As — Co-sine of the 4th Ark, to = Co-sine of the 5th Ark;
So — sine of the Latitude, first taken, to = Co-sine of the distance.

That

That is, when the 4th Ark is substracted; or, to the Co-sine of the comp. distance when added.

Example.

Suppose I would know how far it is from the *Lizard*, to the *Cape of Good Hope*; the *Lizard* having 50 degrees of North-latitude, and the *Cape of good Hope* 35 degrees of South-latitude, and the difference in Longitude 30 degrees.

As the sine of 90, to the Co-sine of the difference in Longitude 30, being best counted from 90 backwards;
So is the Co-tangent of 50, (*viz.* at 40) to 36 degrees 01 minut, a 4th Ark.

Then 90 degrees, and 35 degrees, the other Latitude added, makes 125; from which sum, taking the 4th Ark, remains 88-59, for a 5th Ark.

Then say,

As the Co-sine of the 4th Ark 36-1, to the Co-sine of the 5th Ark 88-59;
So is the sine of 50, the Latitude first taken, to the Co-sine of the distance 89 deg. 3 min. the nearest distance in the Arch of a great Circle.

Note, That here you will have occasion to make use of that help mentioned *p.*218, *Sect.*3. As thus for instance.

The Proportion being as the Co-sine of 36-1, to the Co-sine of 88-59; which is all one, as the sine of 54 and 59, to the sine of 1 degree and 1 minut, which is too large for ordinary Compasses, on ordinary *Gunters* Rules; therefore first lay the distance from the sine of 90, to the sine of 54 and 59, the same way from the sine of 5 degrees and 45 minuts, and note the place.

Also, Lay the distance from the sine of 90, to the sine of 50, the same way from the sine of 5 degrees and 45 minuts; and note that place also.

Then,

As the Extent first noted for 54-59, is to 1 degree and 1 minut, the Co-sine of 88-59;

So is the second mark noted for 50, to 89-3, the distance in degrees required.

Which multiplyed by 72, gives the distance in the Arch of a great Circle, *viz.* 6412 miles Statute-measure; Or, 5340 miles, whereof 60 make one degree, on a great Circle on the superficies of the Sea.

Uſe VII.

To find the diſtance of places by the Natural Verſed Sines in the way of a Sector on the Triangular-Quadrant, being much more eaſie than the two former wayes.

Firſt, by the Pen, find the ſum and difference of the complements of the two Latitudes, and count that ſum and difference on the verſed Sines latterally, and take the diſtance between your Compaſſes, and make it a parallel verſed Sine of 180 degrees.

Or, by the Triangular-Quadrant.

If you have not the Line ſet on from the Leg-center, then the ſmall Line of Sines beyond the Leg-center, being doubled, will do the work, by taking the diſtance between the ſum and difference, and ſetting one Point in the Center-prick at two times the Radius of the Sines from the Leg-center; and then laying the Thred to the neareſt diſtance, or the Line of Right Aſceneions under the Months, is a fit Line.

Then,

Take out the = difference of Longitude, and

and that ſhall reach latterally from the difference to the diſtance required.

Example.

London and *Jeruſalem*, two places in North Latitude; *London* 51-32, *Jeruſalem* 32-0, whoſe two complements 38-28 and 58 added, make 96-28 for a ſum, and one taken from the other, leave 19-32 for a difference.

Now the -— diſtance between the verſed Sines of 96-28, and 19-32, make a = verſed Sine in 180, keeping the Sector ſo, or laying the Thred to the neareſt diſtance, (and noting where it cuts in degrees).

Then,

The = diſtance between 47, the difference of Longitude between the two places, ſhall reach on the verſed Sines from 19-32, the difference to 39-14, the diſtance required; which, at 72 miles to a degree, makes 2805 miles.

Note, This one Rule comprehends all the *Three laſt Wayes*, and is not troubled with half ſo many Cautions as the former.

Uſe VIII.

Use VIII.

Having the Latitudes and Distance of two places, to find their Difference in Longitude.

Find the sum and difference of the two Co-latitudes, as before, by Addition and Substraction; count them on the versed Sines, and take the — distance between, and make it a = versed Sine of 180.

Then,

The — distance, between the difference and distance on versed Sines, shall stay at the = difference in Longitudes required.

Example.

Let one place be *Burmudas Isle*, and the Latitude thereof 32-25; let the other place be the *Lizard-point*, and the Latitude thereof 50 degrees; the Co-latitudes are 57-35 and 40-0; the sum of them is 97-35; the difference between them is 17-35. The distance in the great Circle, according to Mr. *Norwood*, is 44-30, or 886 Leagues, counting 20 leagues to one degree.

Then,

The — distance between the versed Sines of 17-35, and 97-35 made a = versed Sine of 180, the Sector is set.

Then,

Then,

The —— diſtance taken between 44-30, and 17-37 on the verſed Sines, and carried parallelly, ſhall ſtay at 55, the difference in Longitude required between thoſe two places.

CHAP. V.

Of Sayling by the Arch of a great Circle.

IN the Book called, *The Geometrical Seaman*, by Mr. *Phillips*, is a very ready Figure to ſhew in a Quadrant, or more, by what Longitudes and Latitudes a Ship is to paſs in any long-run, which is contained under 90 degrees, or 120 difference of Longitude, and the two places having both North Latitude.

Which Figure, or Quadrant, is neatly and readily performed by the Trianguler-Quadrant, *thus*;

Upon

Upon the back-ſide of the Index, before ſpoken of, may be graduated from the Center, two Tangent-Lines, one equal to the Radius on the Looſe-piece, the other to the Radius on the Moving-leg; then in the uſe, count the fiducial Line in which the Leg-Center-pin ſtands, alwayes for the Meridian of one place; and ſome where in that Line, according to the latitude thereof, counting the Leg-center the Pole of the World; and the Index being hung thereon, by the Tangents prick down the Latitude; there, I ſay, knock in a Pin to ſtay a Thred for one place; then, on the degrees, count the difference of Longitude from the Head-leg, and lay the Index to it, and bring the Thred faſtened, as before, till on the Index it cuts the degree and part of the other Latitude, and there make the Thred faſt with another Pin in the Looſe-piece.

Then,

If you move the Index to any degree of Longitude between thoſe places, the Thred ſhall cut on the Index the degree of Latitude that anſwers unto it; or if you make the Thred cut any degree of Latitude, the Index gives the Longitude required for that Latitude.

Note,

Note, If the Latitude be ſmall, as between 10 and 30, the ſmall Tangents are moſt convenient; but if it be between 40 and 80, the greater Tangent Line is beſt.

Note, That two Threds and a pair of Compaſſes may ſerve; but the Index is much better and quicker in Operation.

Example.

Let the two places be the *Summer-Iſlands* and the *Lizard-point*; the ſame *Example* that you find in Mr. *Norwood*, pag. 126; and in Mr. *Phillip*'s *Geometrical-Seaman*, *pag*. 55. that you may the more readily compare the truth thereof by their Operations.

The Latitude of the *Lizard Point* is 50 degrees, the Longitude is 10.

The Latitude of the *Summer Iſlands* is 32-25, the Longitude is 300.

The Difference of Longitudes is 70, as is computed by their Obſervation.

Then,

Hanging or putting the Center-hole of the Index over the Leg-center-pin, and counting the fiducial-line on the Head-leg for the Meridian of one place, count on the Tangent Line on the Index the Co-tangent of one Latitude, as ſuppoſe the Latitude of the *Lizard-point* (the Center alwayes coun-

ted

ted as 90) and there knock in a Pin in a small hole to hang a Thred on.

Then count 70 degrees, the difference in Longitude, on the degrees from the Head-leg, and there stay it; then draw the Thred put over the first Pin, till it cut the complement of the other Latitude, and by help of another Pin stay it there, which you may conveniently do by one of the sliding-sights; then the Thred being so laid, slide the Index to every single degree, or fifth degree of Longitude, and then the Thred shall shew on the Index, the Co-tangent of the Latitude answerable to that degree of Longitude, as in the *Table* annexed.

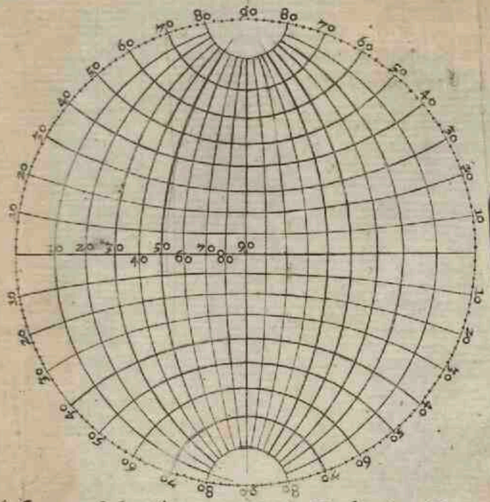
Also, If you would have equal degrees of Latitude, and would find the Longitude according to it; then slide the Index to and fro till the Thred cuts on the Index an even degree of Latitude; then on the degrees you have the difference of Longitude from either place.

Also note, That the drawing of one Line only on the *Triangular Instrument* in the beginning, according to the directions of laying of the Thred; with the Thred and Compasses, will perform this work also.

The Table.

Long	D.L.	Latitude
300	09	32—25
305	05	35—52
310	10	38—51
315	15	41—24
320	20	43—34
325	25	45—24
330	30	46—54
335	35	48—07
340	40	49—04
345	45	49—47
350	50	50—15
355	55	50—31
360	60	50—33
05	65	50—23
10	70	50—00

If this work fit not any case that may happen, there is another way mentioned in *Page* 75 of the *Geometrical Seaman*, by the *Steriographick Projection*; and that *Scheam* is drawn the same way, as the *Horizontal-Projection* for *Dyalling* was, and somewhat easier; and any two Points given, in a Circle,



A figure of the Stereographick Projection Pag

Circle, you may draw a great Circle to cut them, and the first Circle into two equal parts, by the directions in *Page* 15; And the Application thereof you have very plainly in Mr. *Phillips* his Book, to which I refer you, having said more than at first I intended, which was chiefly the use thereof in *Observation* only.

So for the present I conclude this Discourse, and shall endeavour a further Advantage in the next Impression, according as Time and Opportunity shall offer. *Farewel*.

The End of the Second Part.

The *Table* of the *Things* contained in this *Second Part*.

To

FINIS.

Errata *for the Second Part.*

PAge 6. line 10. for *100*, read *10*. P. 18. l. 10. f. H, r. *the ends of the Arch* Q P. p.22.l.14.f. *begins*, r. *being*. p.15.l.27.f. *Latitude*, r. *Co-latitude* p.34.l.8.f. *Sun*, r. *sum*. p.39.l.24.f. *incliner*, r. *inclination of Meridians*. p. 61. l.23. f. *place*, r. *plain*. p.62.l.20.f. ☉ r. Q. p.66.l.2.f.I, r.T. p.69. l.7.f.12.r.7. p.92 l.22.r. *gives a mark near* E, *whose measure on the Limb from* B. p.87. l.8. f. *gibes*, r. *gives*. l.11. add *at* R *near* C. p 93.l.25 f.FE. r.PE. p.100.l.21. add c d *next gives*. p. 101.l 6.f.8-5, r. 8-3 p.105.l 19.f. *use*, r. *have*. p.108.l.6 f. *Pole*, r. *Zenith*. p.112. l.3. f. *cuts* 12, r. *cuts the substile*. p.113.l.19.f. DF, r. DE. l.19.f. T. r. CT. Also in l.18. r. CT. p.122 l.6.f.E, r. F. p.122.l.13,14, 15,16, add *Sine*. p 128.l.26.f.I, r.L. p.139. l.21. add, *as in this Example*. p.140.l.6. add *to*. p.170. l.10.f. *divides*, r. *divided*. p.181.l.20.f. *popsition*, r. *proportion*. p.119.l.27.f. *from*, r. *on*. p.193.l.6. f. *being*, r. *bring*. p.197 l.4. f. *elevation*, r. *inclination*. p.200 l.24. f. C, r. G. p.204.l.3.f. F, r E. p 209. add in the last line, *or by the upper part of the Plain*. p.124.l.18. add, *or remove the Thred to turn it further when it reclines beyond the Pole*. p.238.l.7. add *of*. l. 20. add *but*. p.247. l.13. r. *and much better in small Latitudes*. p. 248. l.5. f. *wo*, r. *two*. p.251.l.14.f. 20, r. 33. Also, l.17. f. 40, r. 27.

Advertiſements.

The uſe of theſe, or any other Inſtruments concerning the Mathematical Practice, or further Inſtructions in any part thereof, is taught by *John Colſon* near the Hermitage-ſtairs.

Alſo by *Euclide Speidwel*, dwelling near to *White-Chappel* Church in Capt. *Canes* Rents, or at the Cuſtom-houſe.

Alſo, by ***William Northhall*** Mariner, dwelling at the Crooked-Billet in Meeting-houſe Alley on Green-Bank near *Wapping*.

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